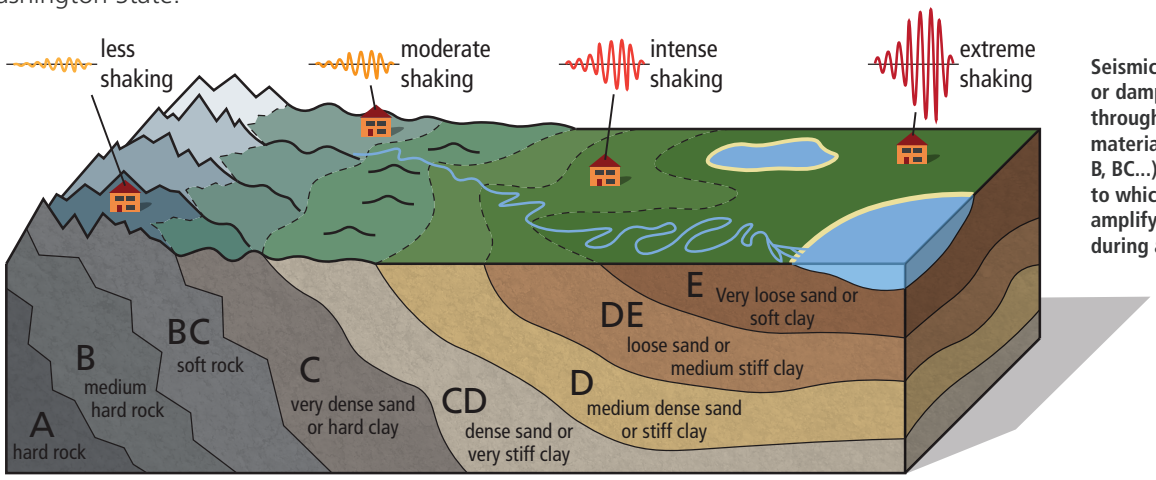
WASHINGTON STATE DEPT OF NATURAL RESOURCES
WASHINGTON GEOLOGICAL SURVEY

SCHOOL SEISMIC SAFETY PROJECT

The **School Seismic Safety Project (SSSP)** is a multi-year statewide effort by the Washington Geological Survey (WGS) and the Office of Superintendent of Public Instruction (OSPI) to assess the seismic vulnerability at Washington schools. The project aims to measure site class—a critical design parameter for seismic retrofits and new building construction—at all public school campuses in Washington State.



Seismic waves are amplified or damped when traveling through different geologic materials. Site class (labels A, B, BC...) predicts the degree to which soil or bedrock may amplify or dampen shaking during an earthquake.

SOIL AMPLIFICATION DURING EARTHQUAKES

The most destructive seismic waves produced during an earthquake are shear waves (side-to-side shaking) and surface waves (large waves that travel along the surface of the Earth). As these seismic waves spread outward from the epicenter of an earthquake, they are amplified or dampened depending on the material they pass through. In general, softer soils and sediments produce more shaking than harder soil or bedrock.

SITE CLASS: MEASURING SOIL AMPLIFICATION

Site class is an estimate of the degree to which the soil and rock properties of a given location will amplify shaking during an earthquake. Site class is a national standard defined by the the National Earthquake Hazards Reduction Program (NEHRP) that is incorporated into all major building codes, including the American Society of Civil Engineers (ASCE) and state and international building codes.

Site class can be determined by measuring how fast shear waves travel through the upper 30 m (~100 ft) of soil and rock, a measurement known as the time-averaged shear wave velocity down to 30 m or 100 ft (we abbreviate this as the symbol $\overline{V}_S$). Soft soils that amplify earthquake shaking exhibit low $\overline{V}_S$ values, while hard soils and bedrock that shake less exhibit high $\overline{V}_S$ values (see table on right).

Site class definitions based on table 20.2-1 in ASCE 2022. $\overline{V}_S$ is the time-averaged shear wave velocity down to 30 m (~100 ft). Ground shaking amplification generally increases with lower measured $\overline{V}_S$.

Site class	Material description	$\overline{V}_S$ (ft/sec)	Ground shaking amplification
A*	Hard rock	>5,000	Low
B*	Medium hard rock	3,000–5,000	
BC	Soft rock	2,100–3,000	
C	Very dense sand, hard clay	1,450–2,100	
CD	Dense sand, very stiff clay	1,000–1,450	
D	Medium dense sand, stiff clay	700–1,000	
DE	Loose sand, medium stiff clay	500–700	
E*	Very loose sand, soft clay	<500	High

* Site classes A, B, and E have additional diagnostic criteria.

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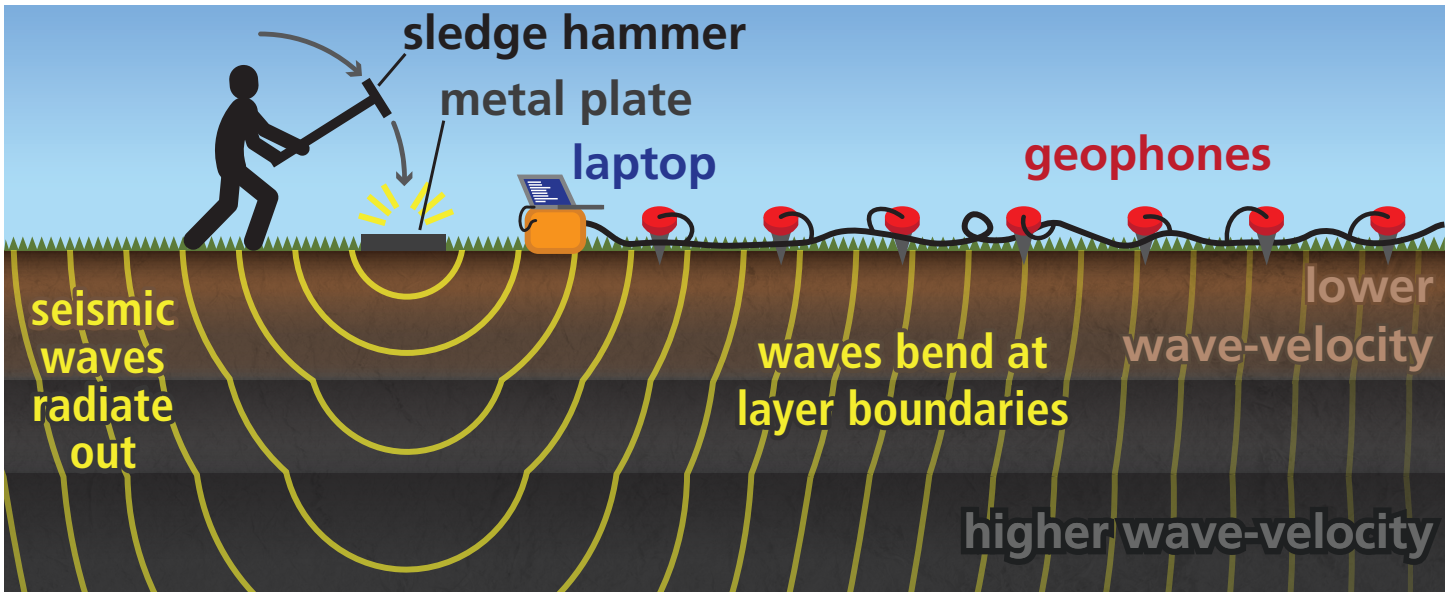
HOW WE MEASURE $\bar{V}_S$

For each campus, we select a site located on representative geologic material while also considering the possible influence of ambient seismic noise—for example, noise from roads or construction. After laying out a ~250 ft (~76 m) array of geophones (ground motion sensors), we collect two types of data. One type is for a technique called Multi-Channel Analysis of Surface Waves (MASW), which involves striking the ground with a sledge hammer to produce seismic waves that propagate through the subsurface and are recorded along the array of geophones (see figure below). The second type of data is a passive recording of ambient ground vibrations for a technique called Microtremor Array Measurements (MAM). Both datasets are used to calculate a single $\bar{V}_S$ for that site using specialized software.

A WGS scientist generates seismic waves by striking a metal plate with a sledge hammer. The waves are recorded by an array of geophones visible on the ground in the background.



Schematic showing how the MASW site classification method works. The strike of a sledge hammer produces seismic waves that propagate through the subsurface and are recorded along an array of geophones. $\bar{V}_S$ can then be calculated from these recordings.

IDENTIFYING NATURAL HAZARDS

Our team also identifies previously mapped geologic hazards that may affect each school. The following hazards are considered:

Lahars—Dangerous mudflows thar occur when a landslide or eruption rapidly melts snow and ice on a volcano

Tsunami—A powerful and destructive series of ocean waves caused mainly by earthquakes and landslides

Faults—Fractures in the Earth's crust that produce earthquakes

Landslides—Dangerous downhill movements of rock, soil, or debris

More information on geologic hazards is available on the WGS website (dnr.wa.gov/programs-and-services/geology/geologic-hazards-and-environment).