

APPENDIX: Spreadsheet of Geologic Hazards and Their Causative and Associative Factors

GEOLOGIC HAZARD	DOMINANT FACTORS		DOMINANT ASSOCIATIVE FACTORS		CAUSATIVE AND ASSOCIATIVE FACTORS					
	Primary	Secondary	Primary	Secondary	Bedrock	Surficial Materials	Topography / Geomorphology	Location	Climate	Site History
Expansive clay soils	Surficial materials	–	Bedrock	Climate	Any (source-rocks are shale/claystone with smectite clay content)	Clay-rich, plastic, smectite clay content	Any	Any	Any (most problematic in arid or semi arid, or seasonal)	Any
Expansive clay bedrock	Bedrock	–		Climate	Shale/claystone with smectite clay content	Any (Residual soils are clay-rich, plastic, smectite clay content)	Any	Any	Any (most problematic in arid or semi arid, or seasonal)	Any
Heaving bedrock	Bedrock	Surficial materials		Climate	Interbedded shales, claystone with smectite clay content. Beds of variable swell potential dipping > 30 deg.	< 10 ft. thick (residual soils are often clay-rich, expansive)	Any (steeply-dipping beds may be indicated by parallel ridgelines)	Any	Any (most problematic in arid or semi arid, or seasonal)	Any
Expansive alkali soils	Surficial materials	Climate	Topography / geomorphology	Site history	Any	Soils with SAR ≥ 13	Any (concentrated on slopes above valley floors, flood plains with low water tables)	Any	Semi-arid to arid	Any (commonly associated with irrigated farmland)
Frost action	Climate	Surficial materials	Location	Topography / geomorphology	Any	Silt- and clays most susceptible, coarse sands and gravels not susceptible	Any (most common in low-lying land, shallow or flat topography - shallow water table)	More northerly latitudes, and locations at altitude	Snow or polar (significant lengths of time both below and above freezing temperature)	Any
Carbonate karst	Bedrock	–	Topography / geomorphology	Surficial materials	Carbonate rock (limestone, dolomite, marble, chalk)	Any (residual soils are usually rich in clay and chert)	Karst topography (caves, fissures, blind valleys, closed drainages, depressions etc.)	Any	Any (more advanced karst development in warmer and more humid climates)	Any
Evaporite karst	Bedrock	–	Topography / geomorphology	Surficial materials	Evaporite rock (gypsum, anhydrite, halite)	Any (residual soils are usually rich in evaporite minerals)	Any (closed drainages and depressions are indicative)	Any	Any	Any
Subsidence due to underground mining	Location	–	–	–	Any	Any	Any	Regions of underground mining	Any	Any
Subsidence due to fluid withdrawal	Location	–	–	–	Any	Any	Any (often associated with large tectonic basins)	Regions of water/hydrocarbon extraction	Any	Any
Collapsible soils	Surficial materials	Climate	Topography / geomorphology	–	Any (may be sourced from weak sedimentary or evaporite rock)	Sand and silt-rich sediments with clay AND/OR evaporite soils. Uncompacted and dry.	Alluvial fans, debris flow deposits at slope bases; loess deposits on plains and leeward hill slopes	Any	Semi-arid to arid	Previously uncompacted
Organic soils and peat	Surficial materials	Climate	–	–	Any	Soils or sediments with organic content, peat	Any	Any	Temperate or snow (cool and wet)	Any
Sensitive clays	Surficial materials	Site history	–	–	Any (highly sensitive clays are associated with marine deposition - fine sedimentary rocks)	Clays	Any	Any	Any	Previously undisturbed
Permafrost	Climate	–	Location	Topography / geomorphology	Any	Any	Any (high mountain regions in conterminous U.S.)	Almost exclusively Alaska and Canada (northerly latitudes), apart from high mountain regions in conterminous U.S.	Polar (significant lengths of time below freezing)	Any
Saline Soils	Surficial materials	Climate	Topography / geomorphology	Bedrock	Any (may be sourced from anhydrite or halite)	Salt-bearing soils	Any (concentrated in low-lying areas, basins of slopes, valley floors, floodplains)	Any (commonly associated with land near to the coast)	Semi-arid to arid	Any (commonly associated with irrigated farmland)
Gypsiferous Soils	Surficial materials	Climate	Bedrock	Topography / geomorphology	Any (source-rock is gypsum)	Gypsiferous soils	Any (concentrated in low-lying areas, basins of slopes, valley floors, floodplains)	Any	Semi-arid to arid	Any
Sulfate soils	Surficial materials	Climate	Topography / geomorphology	Bedrock	Any (may be sourced from gypsum or pyrite-bearing rock)	Sulfate-bearing soils (gypsiferous, pyritic or from other source)	Any (concentrated in low-lying areas, basins of slopes, valley floors, floodplains)	Any	Semi-arid to arid (wet and humid climates forces sulfates to deeper strata)	Any (fertilizers and industrial effluents contribute)
Acid sulfate soils	Surficial materials	Topography / geomorphology	Location	–	Any (may be sourced from pyrite-bearing rock)	soils containing pyrite, waterlogged or shallow water table	Low-lying, waterlogged coastal areas (estuaries, salt marshes, swamps)	Coastal areas (brine groundwater)	Any	Any
Sulfide rock	Bedrock	–	Location	Site history	Pyrite-bearing (carbonaceous shales, argillaceous rocks from anoxic depositional env., igneous rock, coal and metal-ore deposits)	Any	Any	Any (associated with regions of coal or metal-ore mining)	Any (more rapid weathering in warmer and wetter climates)	Any (commonly associated with coal or metal-ore mines)
Sulfide mine tailings	Surficial materials	–	Site History	Location	Any	Mine tailings from coal or metal-ore mines	Any	Regions of coal or metal-ore mining	Any (more rapid weathering in warmer and wetter climates)	Mine tailings dump
Unstable rock slopes	Topography / geomorphology	Surficial materials	Climate	–	Any	Exposures of rock	Slopes	Any	Any (slope movements may be more common in wet or seasonal climates)	Any
Unstable soil slopes	Topography / geomorphology	Surficial materials	Climate	–	Any	Soil	Slopes	Any	Any (slope movements may be more common in wet or seasonal climates)	Any
Unstable shale slopes	Topography / geomorphology	Surficial materials	Climate	–	Shale; interbedded shale	Exposures of shale	Slopes	Any	Any (slope movements may be more common in wet or seasonal climates)	Any
Talus	Surficial materials	–	Topography / geomorphology	Location	Any	Talus	Slopes and slope-bases beneath rock outcrops	Any (most common in mountainous regions)	Any	Any
Seismic activity	Location	–	–	–	Any	Any	Any	Regions of seismic activity	Any	Any
Active volcanic hazards	Location	–	–	–	Any	Any	Any	Areas close to active volcanoes	Any	Any
Inactive volcanic hazards	Location	–	Bedrock	Surficial Materials	Extrusive igneous rocks (basalt, andesite, rhyolite)	Bentonite clays (weathered volcanic ash)	Any	Areas of historic volcanic activity	Any	Any
Surface Water Hazards	Climate	–	Topography / geomorphology	–	Any	Any	Flood plains, valleys, canyons	Any	Any climate with periods of intense rainfall (producing excess surface water)	Any
Coastal hazards	Location	–	–	–	Any	Any	Any	Coastal regions	Any	Any
Naturally Occurring Asbestos	Bedrock	Surficial materials	Location	–	Ultramafic host rocks (eg. serpentinite)	Serpentine soils (magnesium-rich; calcium, potassium, phosphorus-poor)	Any	Asbestos known to occur in Eastern and southwestern US (have asbestos maps)	Any	Any