Vermont and New England Approach to Seismic Hazard Assessment

Surficial Geologic Maps

Shear Wave Velocity Measurements

Hazard Maps

Critical Facilities

Laurence R. Becker, Vermont State Geologist

Special Thanks to NESEC and NESEC State Geologists and EERI

FEMA

IMPROVING SEISMIC HAZARD ASSESSMENT IN NEW ENGLAND THROUGH THE USE OF SURFICIAL GEOLOGIC MAPS AND EXPERT ANALYSIS

Geological Society of America Special Paper 493, Chap 11

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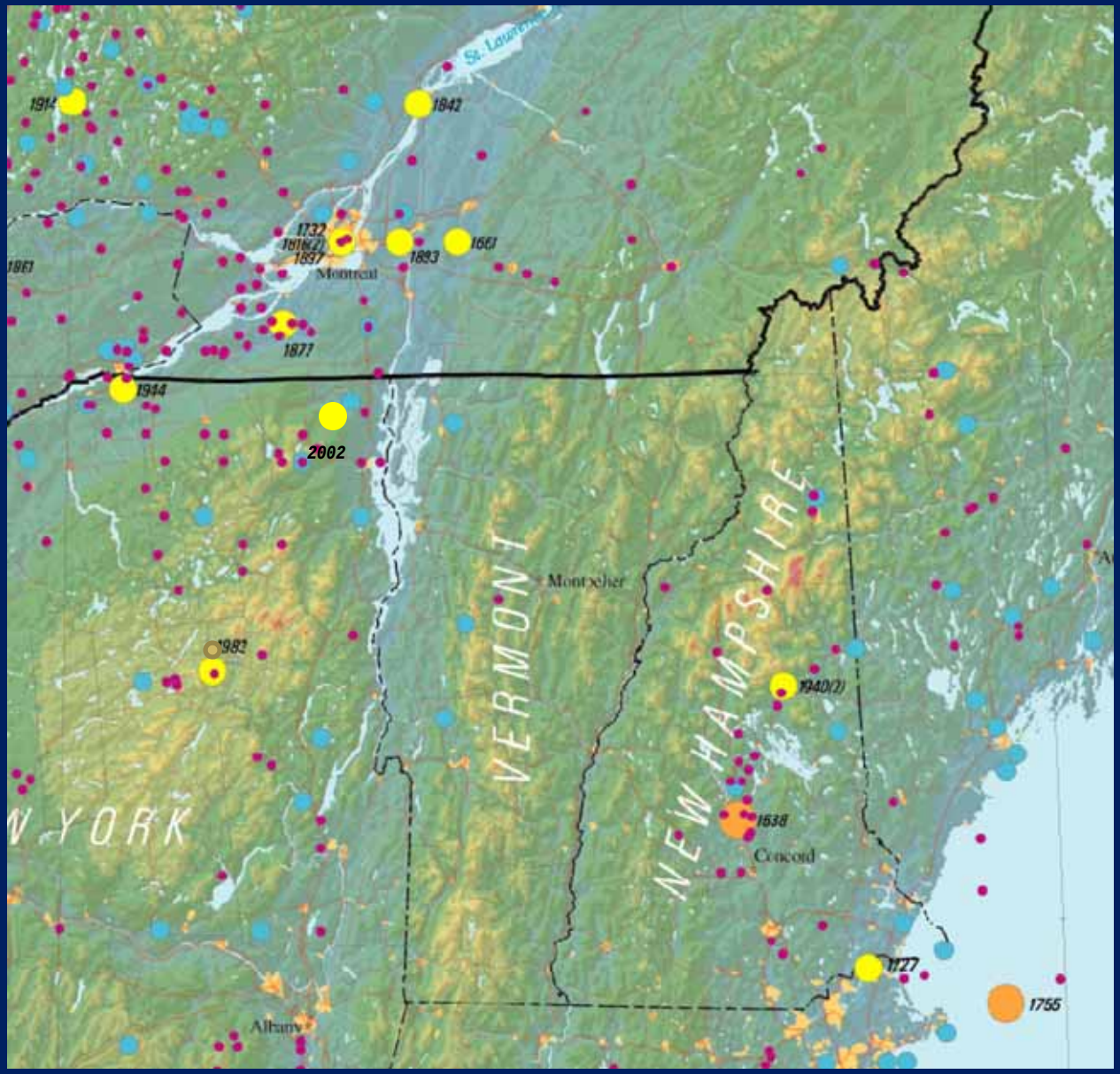
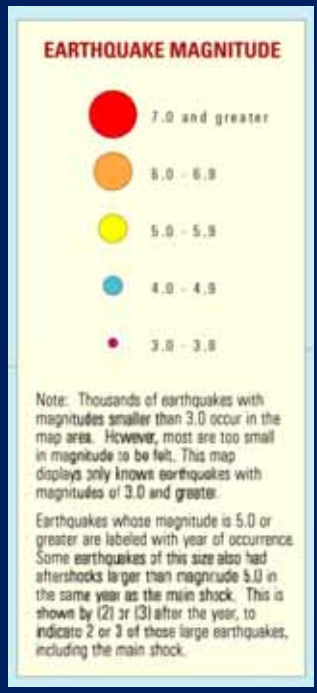
Topics

- Hazard and Risk to the Built Environment
- NEHRP Classes
- Shear Wave Velocity
  - Cadwell (2003) Surficial Materials Classes
- Connecticut Example comparison to Wald
- Vermont – Burlington / Colchester Quads
- Critical Facility Meetings





After:
U.S. Geological Survey
Earthquakes In and Near the Northeastern U.S, 1638- 1998
(Wheeler et. al., 2001)
Added:
Plattsburgh, NY, April 2002; 5.1 Magnitude approximate loc.

NEHRP CLASSES

TABLE 1. NATIONAL EARTHQUAKE HAZARD REDUCTION PROGRAM (NEHRP) SITE CLASSIFICATION CATEGORIES

NEHRP site classification category	Description	Average shear-wave velocity to 30 m (m/s)
A	Hard rock	>1500
B	Firm to hard rock	760–1500
C	Dense soil, soft rock	360–760
D	Stiff soil	180–360
E	Soft clays	<180

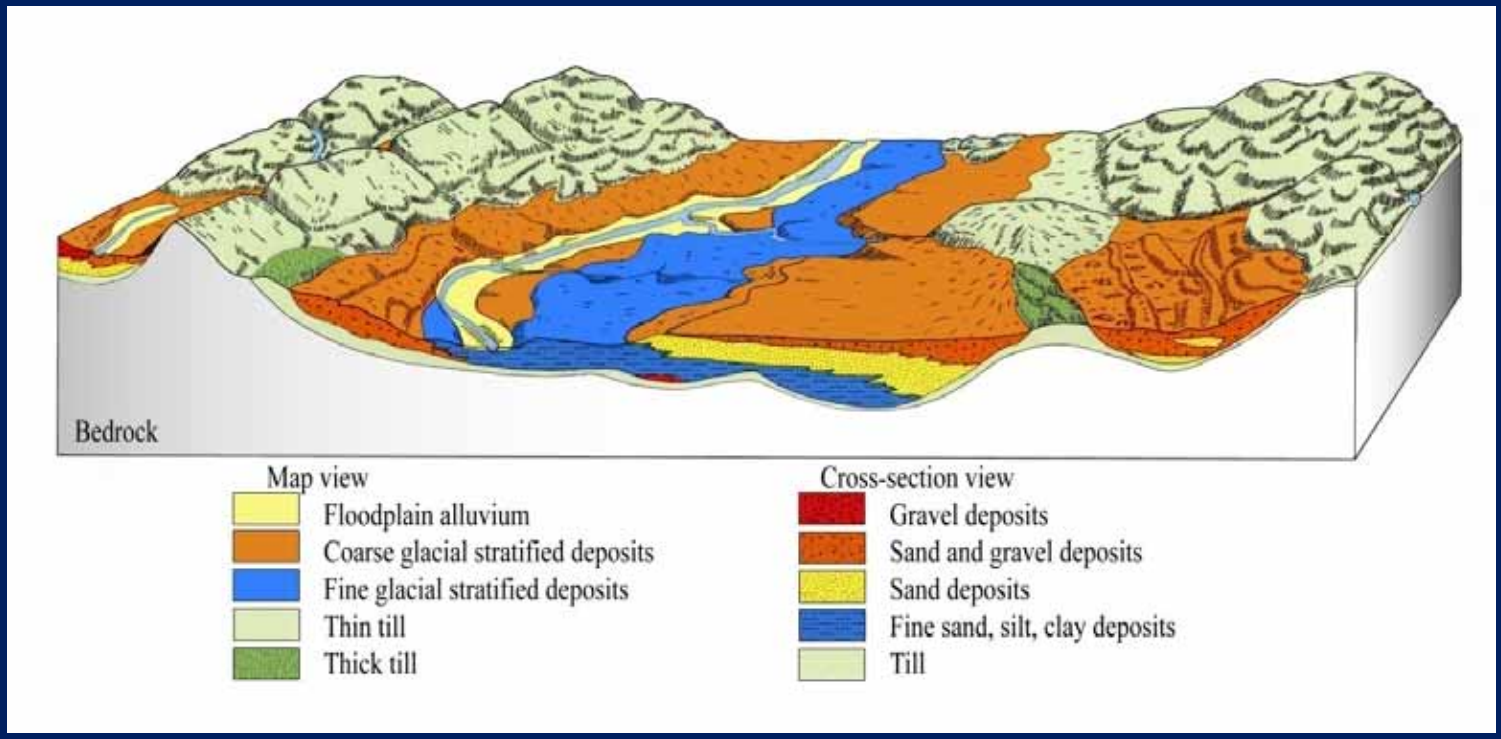
Note: NEHRP Recommended Provisions for Seismic Regulations for New Buildings (1994).

Shear Wave Velocity Cadwell Assigned Classes

TABLE 2. RANGE OF SHEAR-WAVE VELOCITIES IN METERS PER SECOND (M/S), NEW YORK COUNTIES (CADWELL, 2003)

Surficial material	Onondaga (m/s) (*n*)	Rensselaer (m/s) (*n*)	Dutchess (m/s) (*n*)	Columbia (m/s) (*n*)	Westchester (m/s) (*n*)	Mean (m/s)
Fill	76–181 (8)				150–364 (8)	175
Outwash	84–117 (4)	197–308 (3)	75–324 (5)	367–368 (2)	149–700 (10)	231
Kames	100–704 (3)	91–411 (3)	82–445 (6)	383–539 (7)	271 (1)	305
Lake sand	95–133 (4)	86–350 (6)	82–254 (6)	568–569 (2)	164 (1)	287
Lake silt and clay	157–478 (7)	70–1114 (7)	82–467 (4)	370–419 (3)	233–363 (2)	312
Alluvium	105–125 (3)	137 (1)	109–437 (3)	427–518 (2)	183 (1)	216
Till	232–1077 (11)	106–675 (4)	109–797 (8)	371–1163 (6)	194–1311 (7)	664
Swamp					152–219 (2)	186

Note: *n*—number of seismic lines.



Block Diagram Depicting
Connecticut Surficial Materials on the Landscape (Stone et al., 1992).

TABLE 3. NATIONAL EARTHQUAKE HAZARD REDUCTION PROGRAM (NEHRP) CLASSIFICATIONS HARTFORD COUNTY, CONNECTICUT*

NEHRP	Description
A	Crystalline rock and till (till <4.5 m thick)
B	Sedimentary rock and till (till <4.5 m thick)
C	Thick till (>4.5 m thick)
D	Glacial outwash sand and gravel
E	Glacial lake clays and fines; stacked units involving fines c/f; f/c; s/f; postglacial deposits (saturation and subunit dependent); AF

Note: c—coarse-grained deposits; f—fines (fine sand, silt, and clay); s—sand; AF—artificial fill; postglacial deposits—alluvium and swamp.

*Classifications are Hartford County specific and geographically variable, dependent on the geologic setting, degree of saturation, and environment of deposition. County- and material-specific shear-wave velocity data are needed for more accurate assessments.

CONN AND MASS

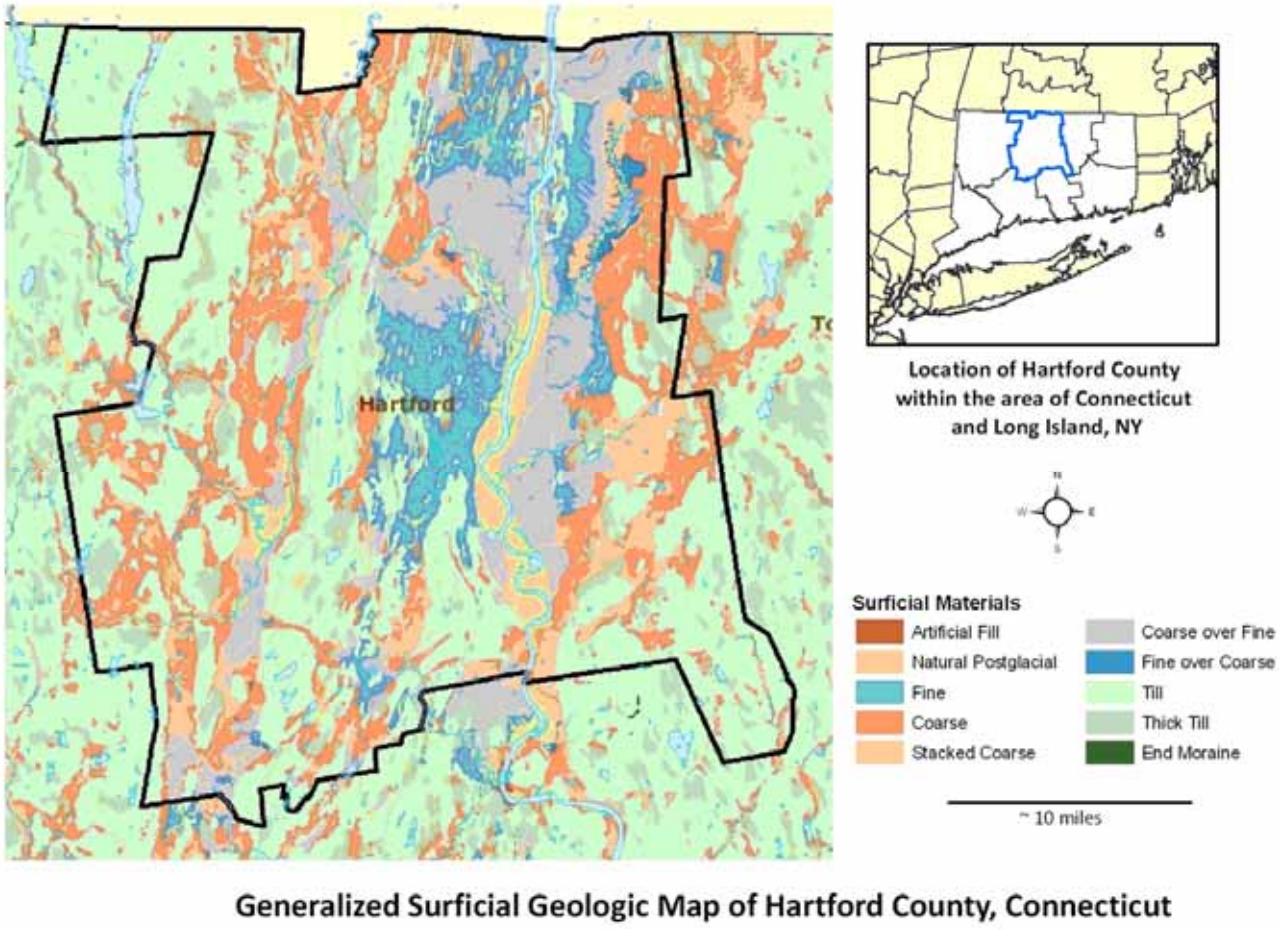
Glacial Lake Clays and Fines

Coarse over Fine
Fine over Course
Sand over Fine
Loose Talus
Artificial Fill
Alluvium
Swamp

TABLE 4. MASSACHUSETTS NATIONAL EARTHQUAKE HAZARD REDUCTION PROGRAM (NEHRP) CLASSIFICATIONS*

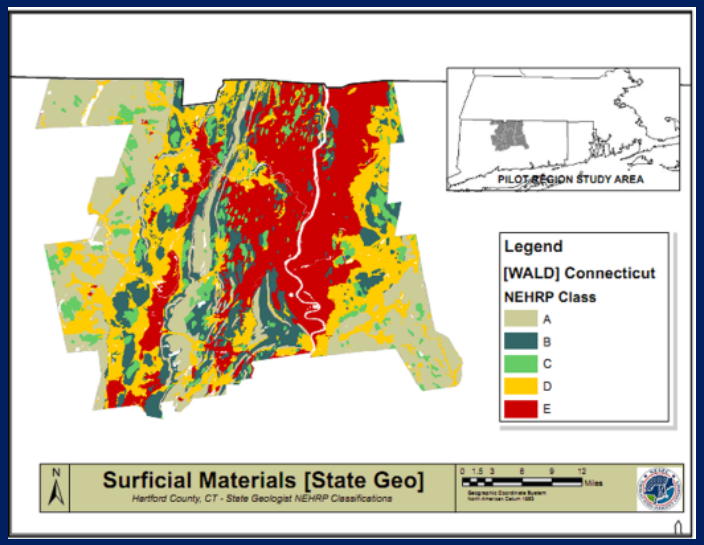
NEHRP	Description	Maps units included	Rationale
A	Crystalline igneous and metamorphic rocks and thin till (<10–15 ft thick)	Crystalline igneous and metamorphic rock outcrops, shallow bedrock, and areas of thin till over crystalline rocks	High-strength, indurated rocks with highest shear-wave velocities
B	Sedimentary rocks and thin till (<10–15 ft thick)	Sedimentary rocks of Mesozoic age consisting of shale, sandstone, siltstone, and conglomerate, and areas of thin till over sedimentary rocks	Moderate-strength rocks with some weathering, not as indurated as crystalline rocks
C	Thick till (3–4.5 m thick)	Thick till usually associated with drumlins	Compact to fairly compact heterogeneous mixture of cobbles, sand, silt, and clay
D	Glaciofluvial sand and gravel and alluvial-fan deposits	Coarse stratified glacial and alluvial-fan deposits	Coarse-grained unlithified sand and gravel deposited in upland areas outside the limits of glacial Lake Hitchcock (300 ft elevation contour)
E	Glacial lake clays, coarse-grained deposits overlying fines, loose talus, and artificial fill	Coarse stratified deposits overlying lake clays, silts, and fine sands; fine stratified deposits of Lake Hitchcock; talus; inland dunes; stream terrace deposits; swamp deposits; floodplain alluvium; artificial fill	Loose, unlithified deposits *including varved clays, coarse* deposits overlying varved clays, stream terrace and floodplain alluvium with probable shallow water table, saturated swamp deposits, and loose artificial fill

*Classifications are specific to the 24-quadrangle area in the Connecticut River Valley and are interpreted from the surficial geology as mapped by Stone and DiGiacomo-Cohen (2010). Actual shear-wave velocities may vary over short geographic distances and depend on grain-size distribution, stacking of units in the third dimension, and level of saturation.

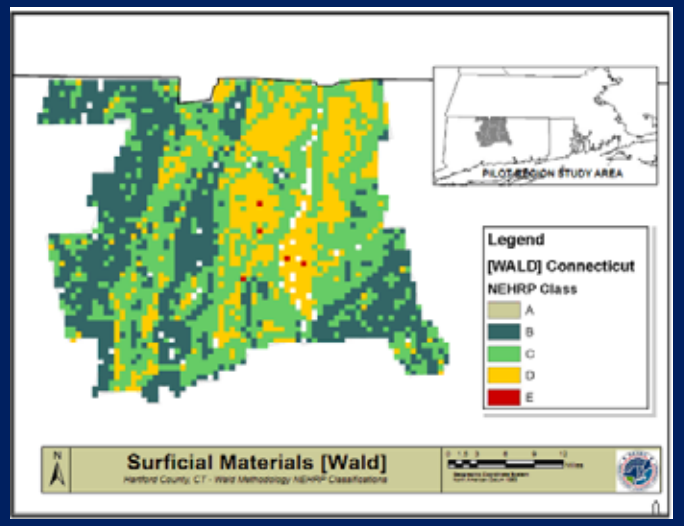


Generalized Surficial Geologic Map of Hartford County, Connecticut

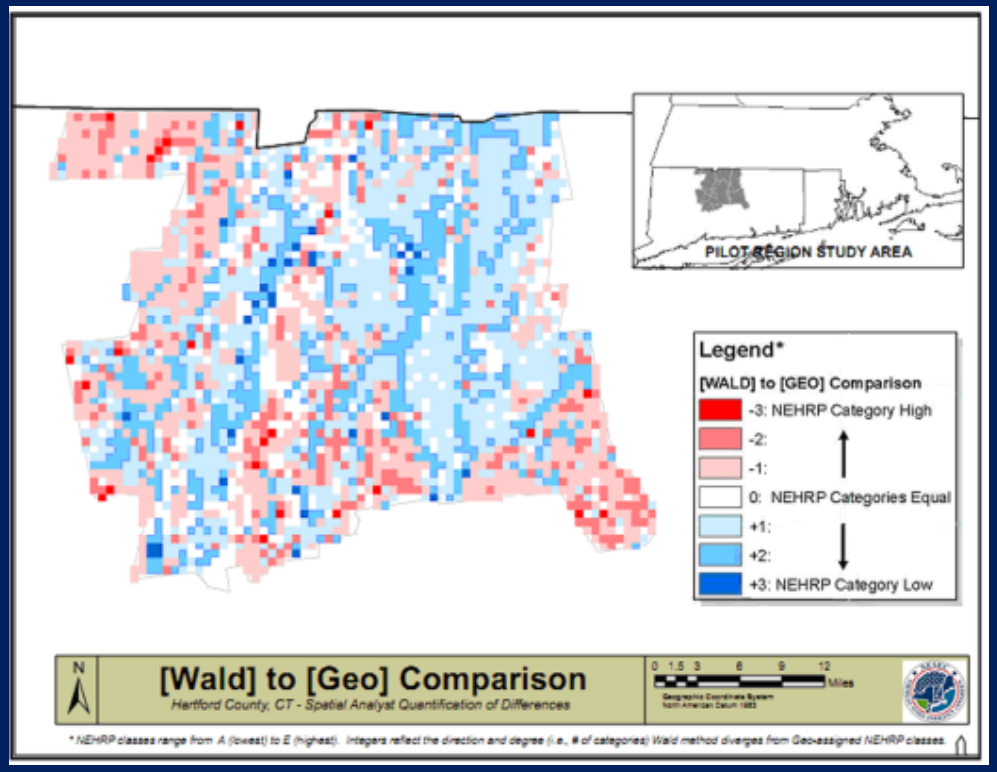
Generalized Surficial Geologic Map of Hartford County, Conn (Generalized from Stone et al., 1992).



CONN



Plus & Minus Represent Wald Divergence from State Geologists



Example:
+ 3 indicates Wald low by 3 NEHRP Categories

Wald Underestimates Hazard

VERMONT GEOLOGICAL SURVEY SEISMIC HAZARD FOR THE BURLINGTON AND COLCHESTER, VERMONT, USGS 7.5 MINUTE QUADRANGLES

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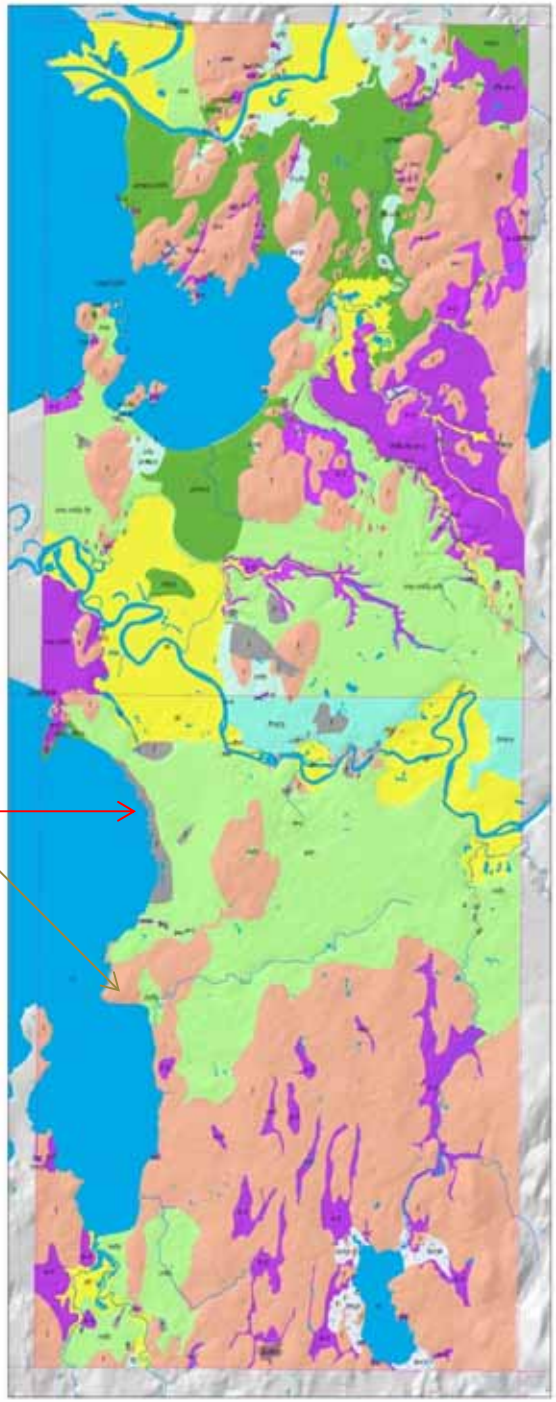
Study Objectives

- Provide Regional Mapping of Seismic Hazard Potential
- Inform Critical Facilities Managers of Seismic Hazard Potential
- Develop GIS Compatible Databases Supporting Project Outputs

Burlington



Surficial Materials Map of the Burlington and Colchester Quadrangles, NW Vermont

by

Stephen Wright

- Fill
- Alluvium
- Wetland
- Quarry
- Medium Sand, Pb Sand, Gravel
- Medium to Fine Sand
- Fine Sand
- Fine to Coarse Sand
- Very Fine Sand, Silt, Clay
- Till

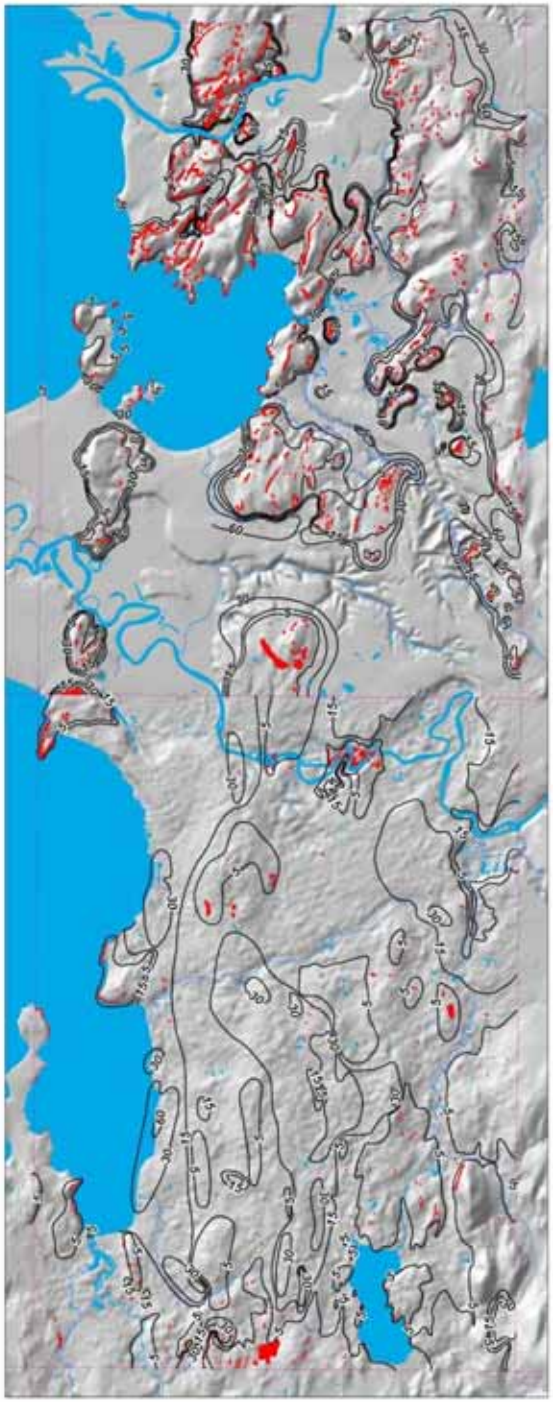
- Streams
- Lakes
- Quadrangle

Kilometers

0 1 2 3

N

GS 05/15/12



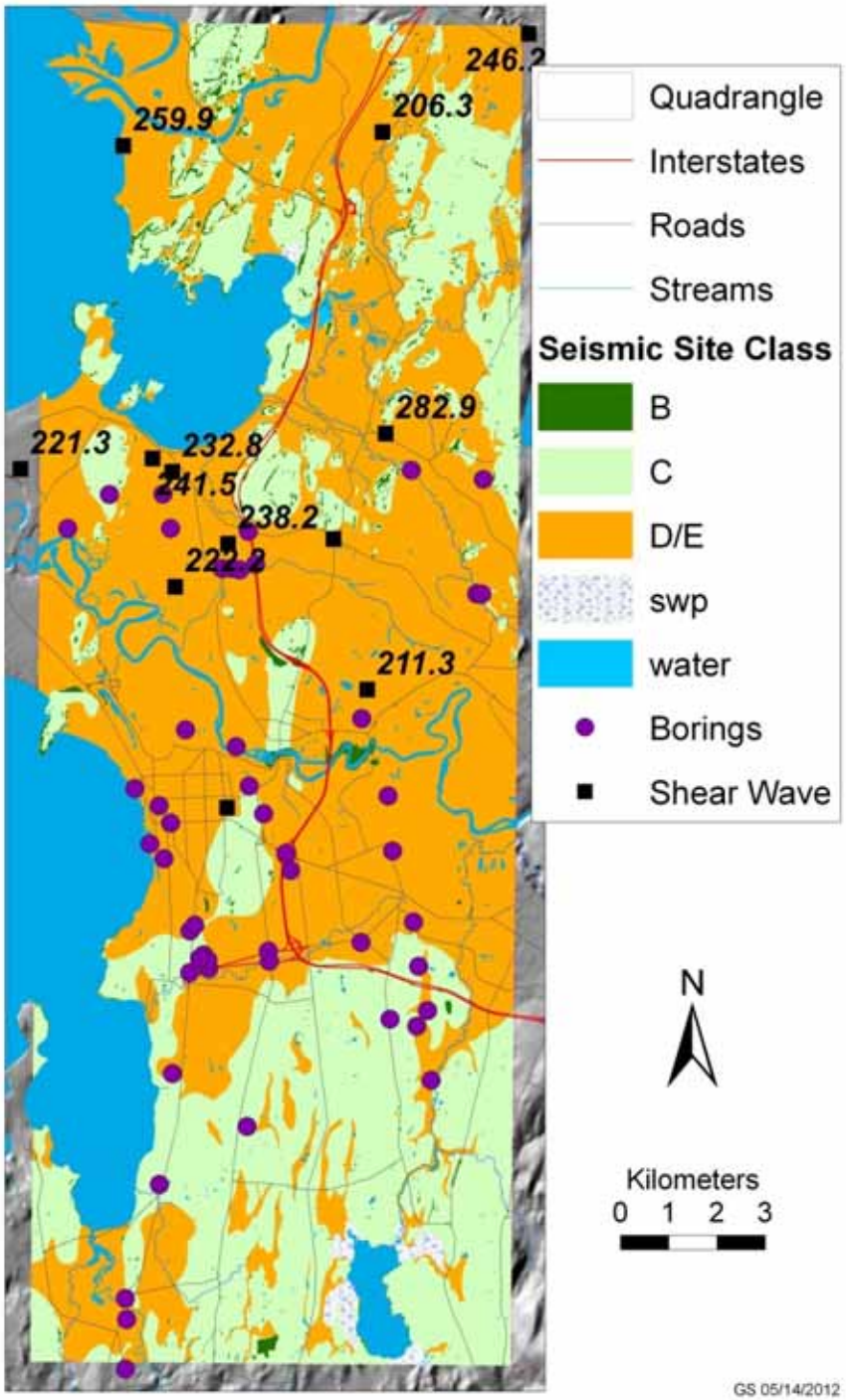
Depth to Bedrock
Contours are at 5, 15, 30, and 60 meters.

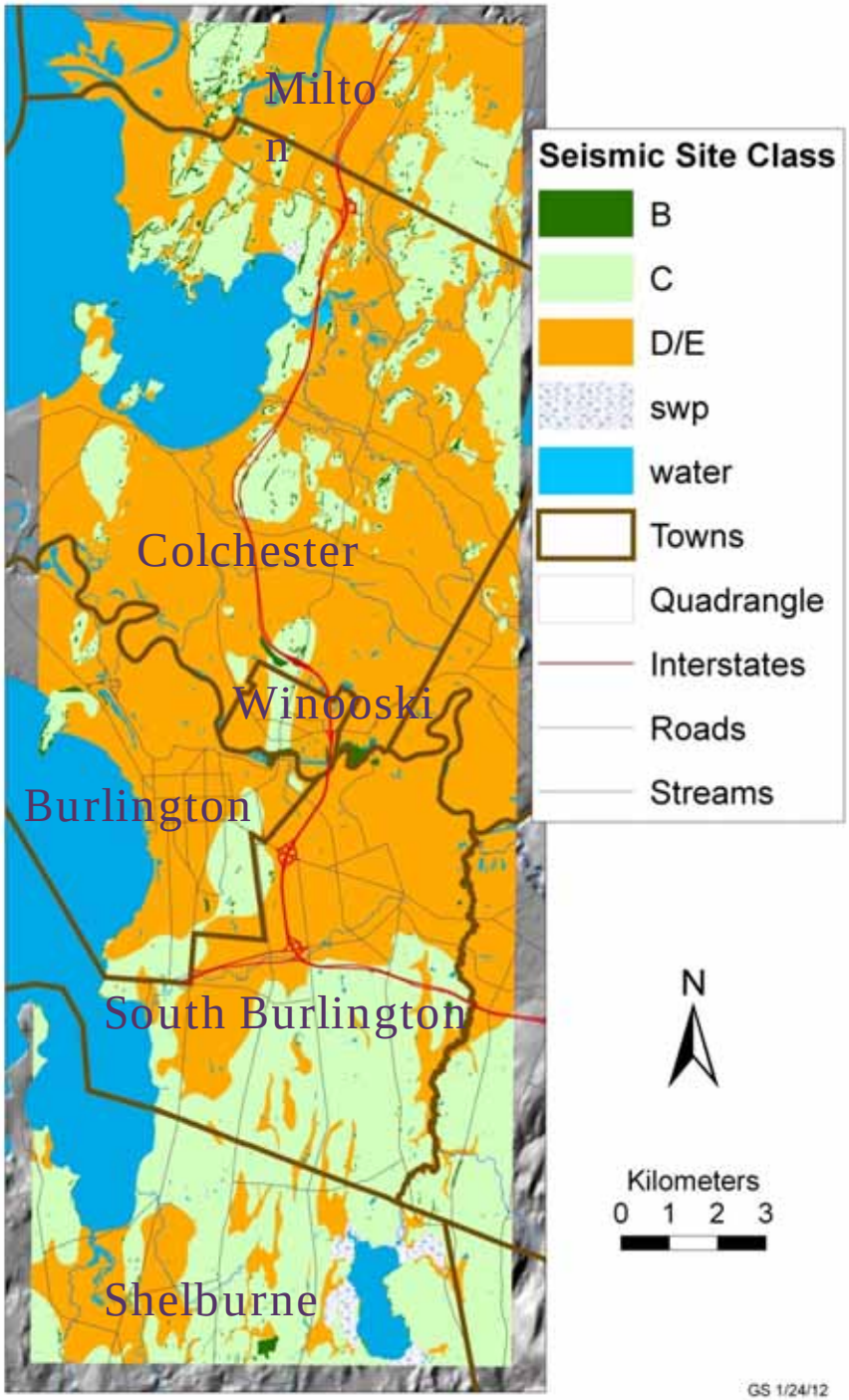
Depth to Bedrock
Rock Outcrop
Streams
Quadrangle

N

Kilometers
0 1 2 3

GS 1/24/12


246.2
259.9
206.3
282.9
221.3
232.8
241.5
238.2
222.2
211.3
Quadrangle
Interstates
Roads
Streams
Seismic Site Class
B
C
D/E
swp
water
Borings
Shear Wave
N
Kilometers
0 1 2 3
GS 05/14/2012


Milton
Colchester
Winooski
Burlington
South Burlington
Shelburne
Seismic Site Class
B
C
D/E
swp
water
Towns
Quadrangle
Interstates
Roads
Streams
N
Kilometers
0 1 2 3
GS 1/24/12

Presentation to: Critical Facility Managers

- Educational Hazard Maps
- Critical Facilities are informed of Hazard
- HAZUS-MH indicates there can be damage
- Critical Facilities plan for all Hazards
- FEMA 74 - Non-Structural Mitigation