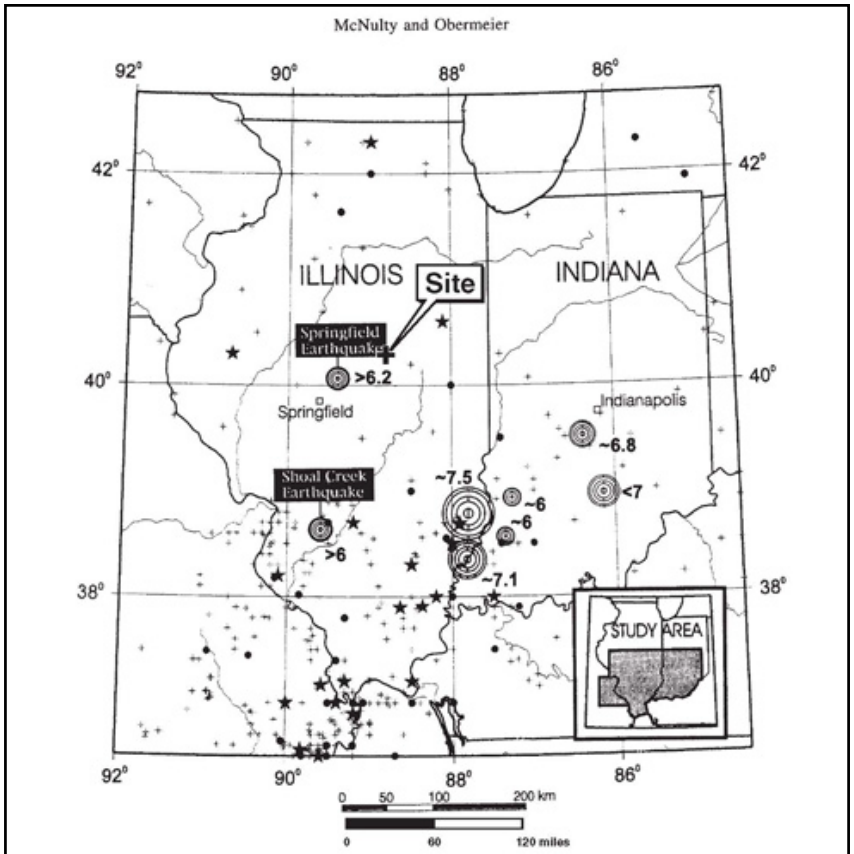
EGC ESP
Paleoliquefaction Investigations

Prepared for the

U. S. Nuclear Regulatory Commission (USNRC)

MAY 19, 2004

(300.340c.083)



A star represents a magnitude of 5 or higher. A solid circle represents a magnitude between 4.5 and 5. A plus sign represents a magnitude between about 2.3 and 4.5. Historical earthquake data are from USGS/NEIC Global Hypocenter Data Base CD-ROM (Version 3.0). Concentric circles show estimated energy centers of large prehistoric earthquakes. The estimated moment magnitude, M, for a prehistoric earthquake is located near the circle.

Note:
Epicenters of historical earthquakes are shown for the time period 1804-1992

From McNulty and Obermeier (1999)

Seismic Hazards Report for the EGC ESP Site

Epicenters of Historical Earthquakes and Estimated Energy Centers of Large Prehistoric Earthquakes in Site Region

Figure B-1-1

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Outline

- Source Characterization Issues
- Previous Investigations
- EGC ESP Field Program
- Criteria for Origin of Clastic Dikes
- Conclusions

Paleoliquefaction

- Earthquake-induced liquefaction:

  Process by which saturated, granular sediment temporarily loses it strength in response to strong ground motion and compacts resulting in an increase in pore water pressure. If pore water pressure exceeds overburden pressure, the sediment may behave as a viscous fluid and flow up to the ground surface, forming a number of distinctive sedimentary features (e.g., sand blows, dikes, and sills).

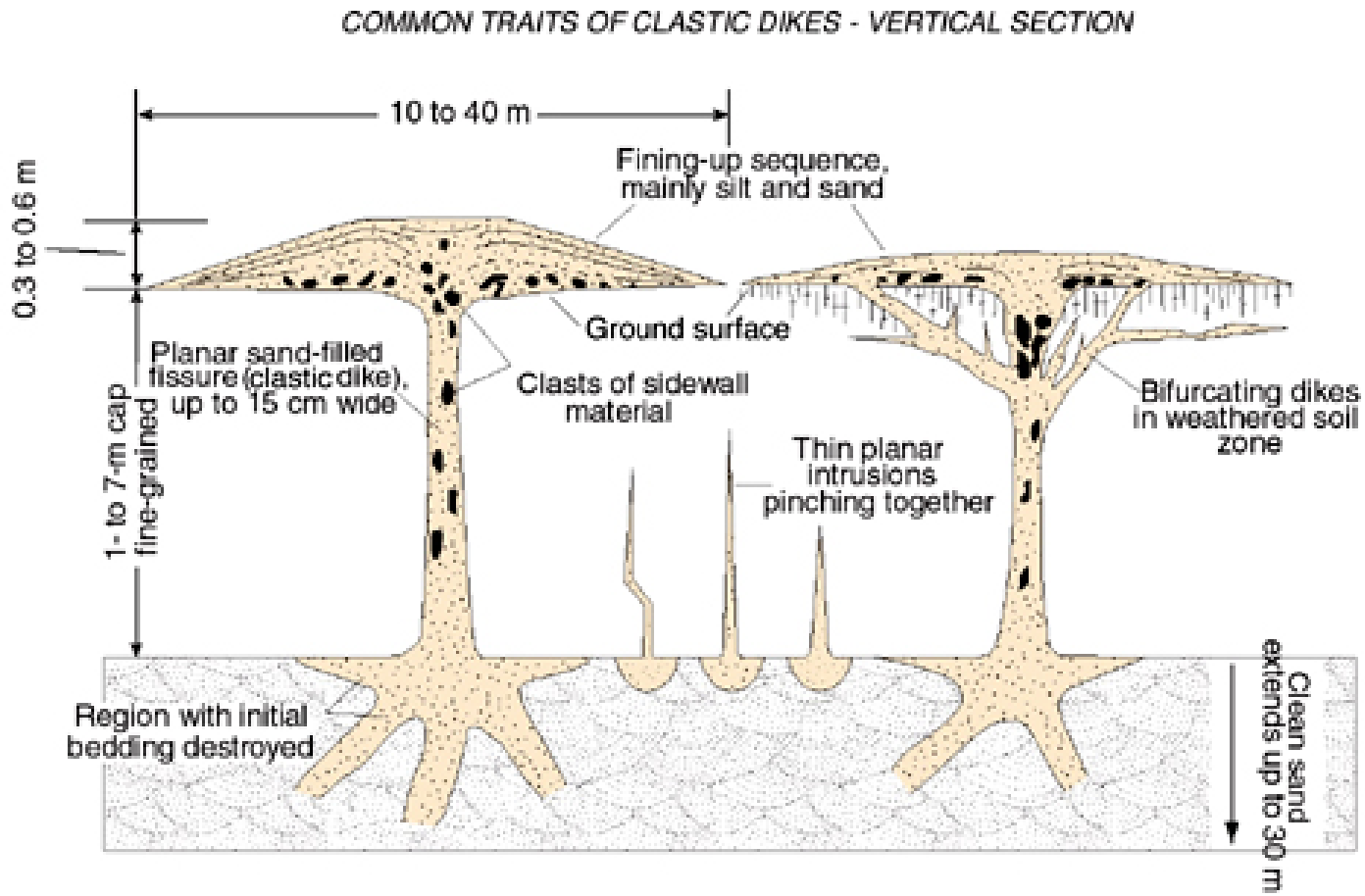

Figure 4. Schematic cross sectional view of sand boil, which is evidence of the occurrence of liquefaction. (From Obermeier [1999])

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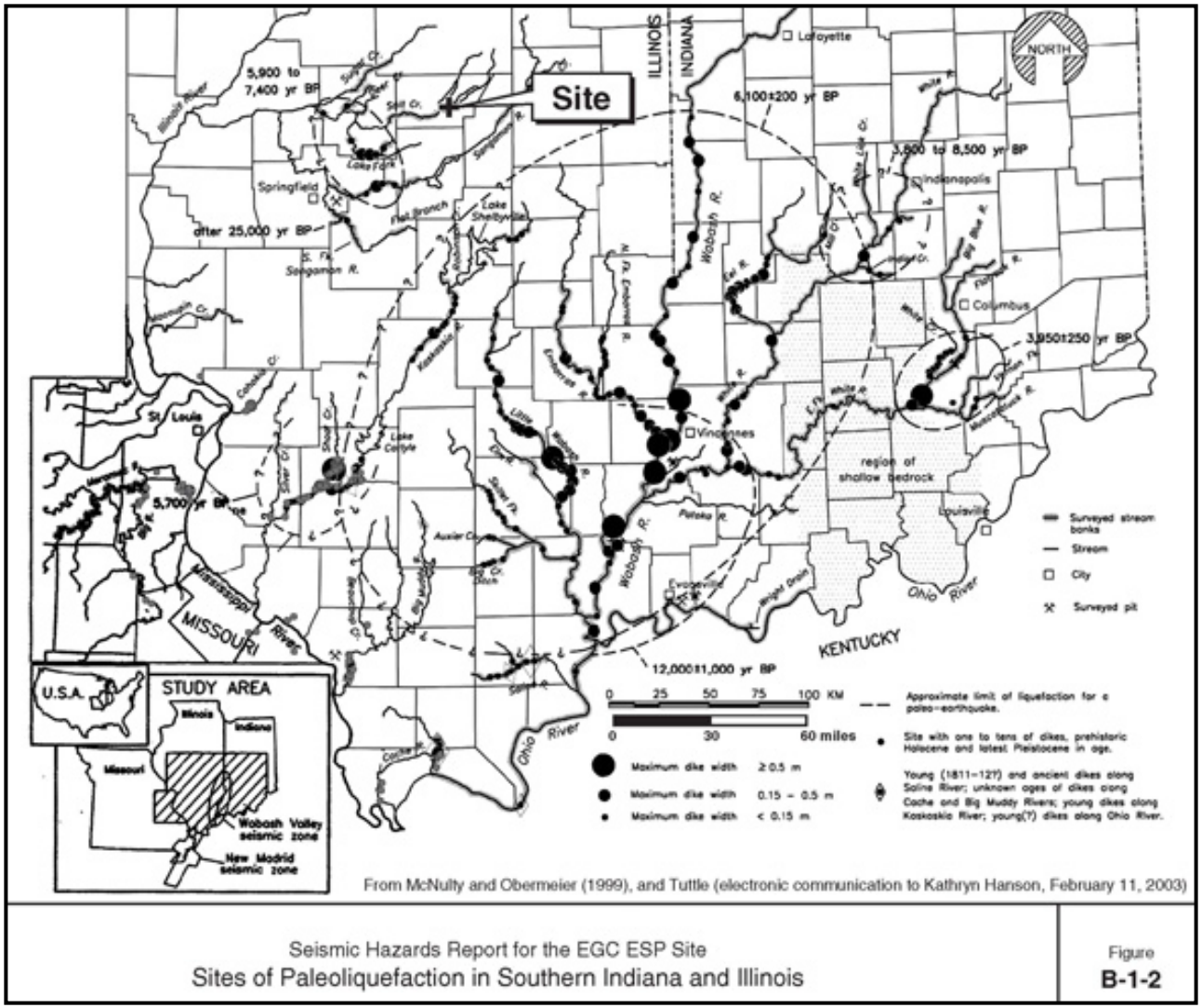
Source Characterization Issues

- Evidence for strong Holocene/late Pleistocene ground shaking
- Tectonic Source
- Strength of Shaking-Magnitude of Event

Evidence for Strong Ground Shaking



From McNulty and Obermeier (1999), and Tuttle (electronic communication to Kathryn Hanson, February 11, 2003)

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Sites of Paleoliquefaction in Southern Indiana and Illinois

Figure B-1-2

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Tectonic Source

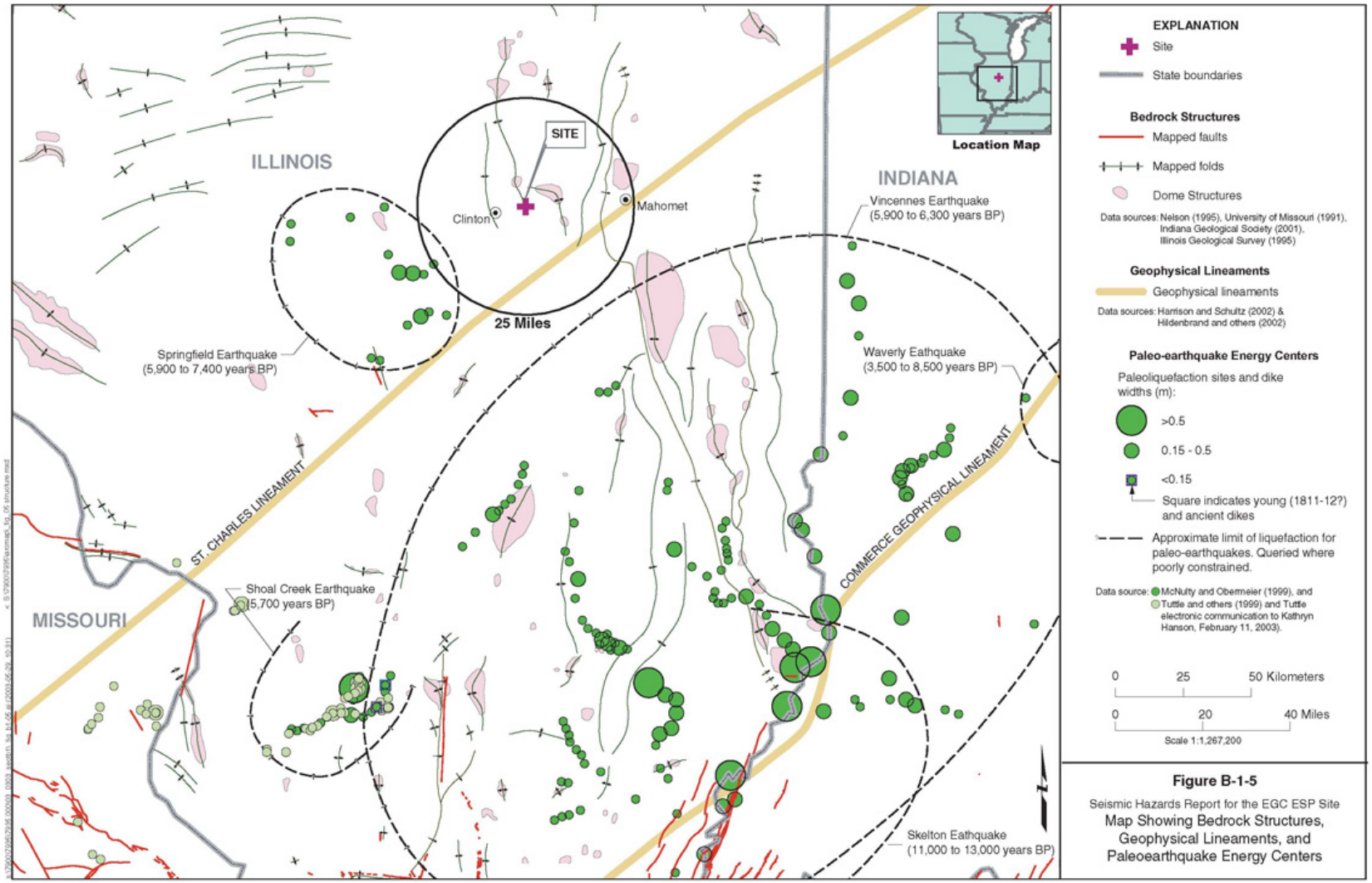

Figure B-1-5

Seismic Hazards Report for the EGC ESP Site
Map Showing Bedrock Structures, Geophysical Lineaments, and Paleoearthquake Energy Centers

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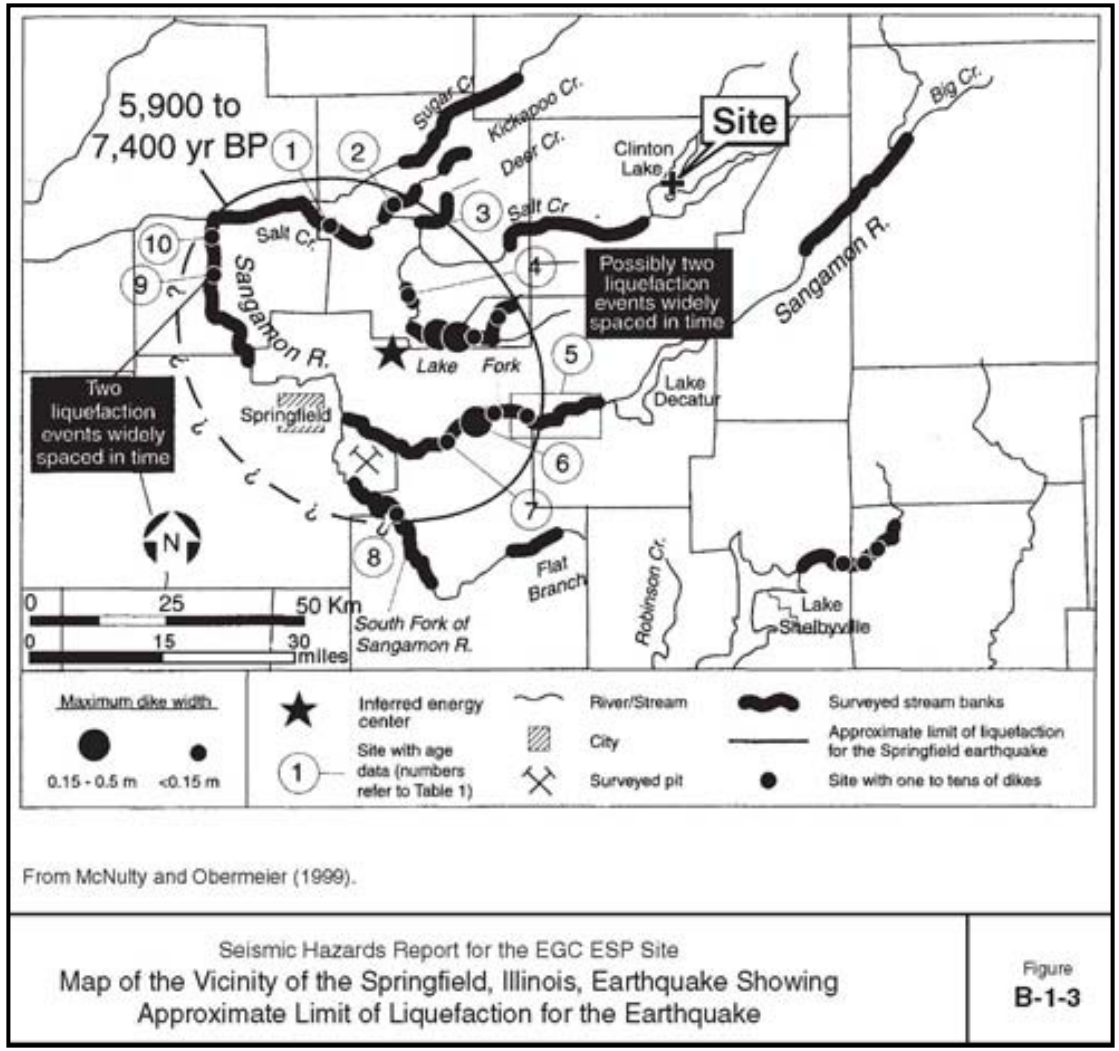
Magnitude Estimates

- Magnitude Bound method
  - Range of liquefaction effects (Rmax)
- Back-analysis using geotechnical data to estimate ground motions required to induce liquefaction
  - Cyclic Stress method
    - site-specific geotechnical data and magnitude scaling factors
    - Energy-stress method
  - Energy-based solution (Green/Mitchell)
    - Attenuation relationship and NEHRP site amplification factors
    - Advantage-circumvents the need for MSF and K_o (overburden pressure)

Springfield Event



From McNulty and Obermeier (1999).

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Map of the Vicinity of the Springfield, Illinois, Earthquake Showing Approximate Limit of Liquefaction for the Earthquake

Figure B-1-3

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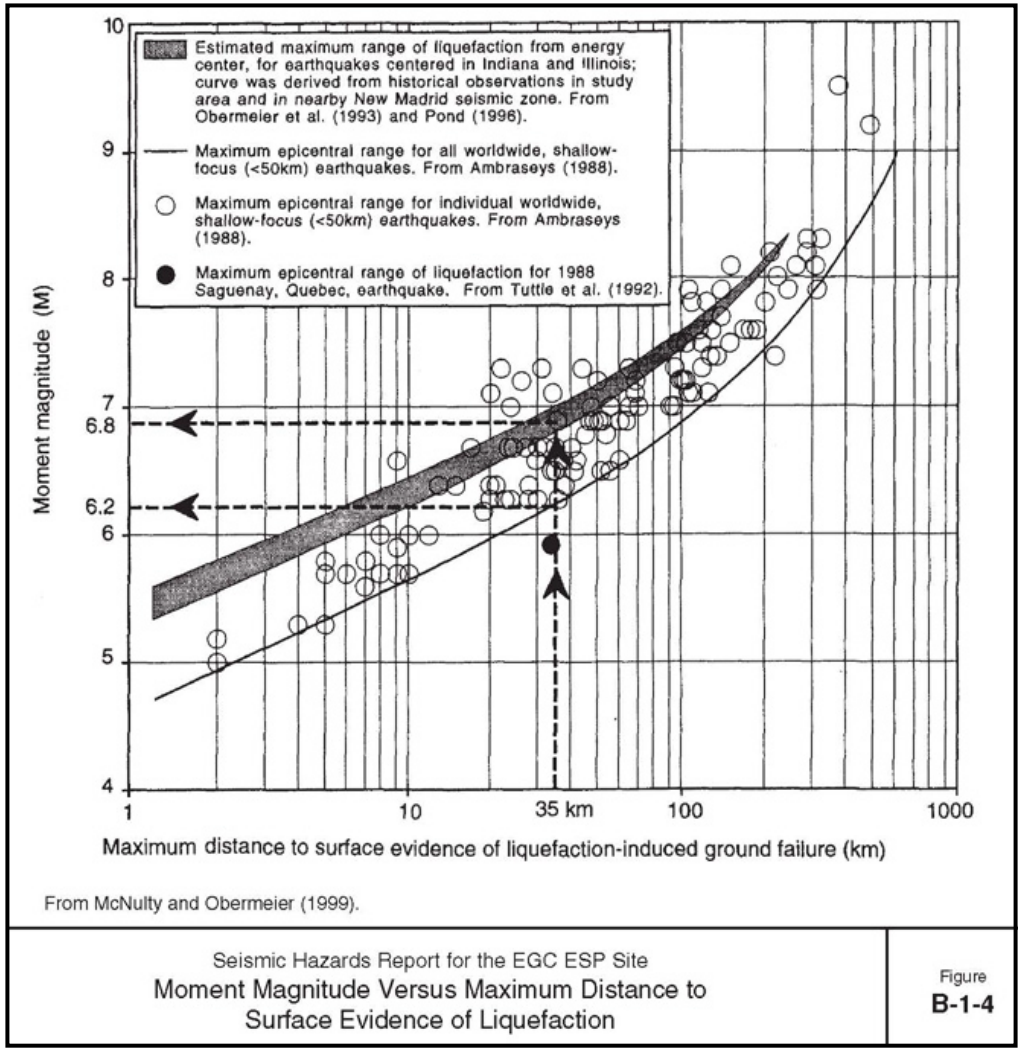
Estimated Magnitude Springfield Event Magnitude Bound Method



From McNulty and Obermeier (1999).

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Moment Magnitude Versus Maximum Distance to Surface Evidence of Liquefaction

Figure B-1-4

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Vincennes Earthquake-Wabash Valley

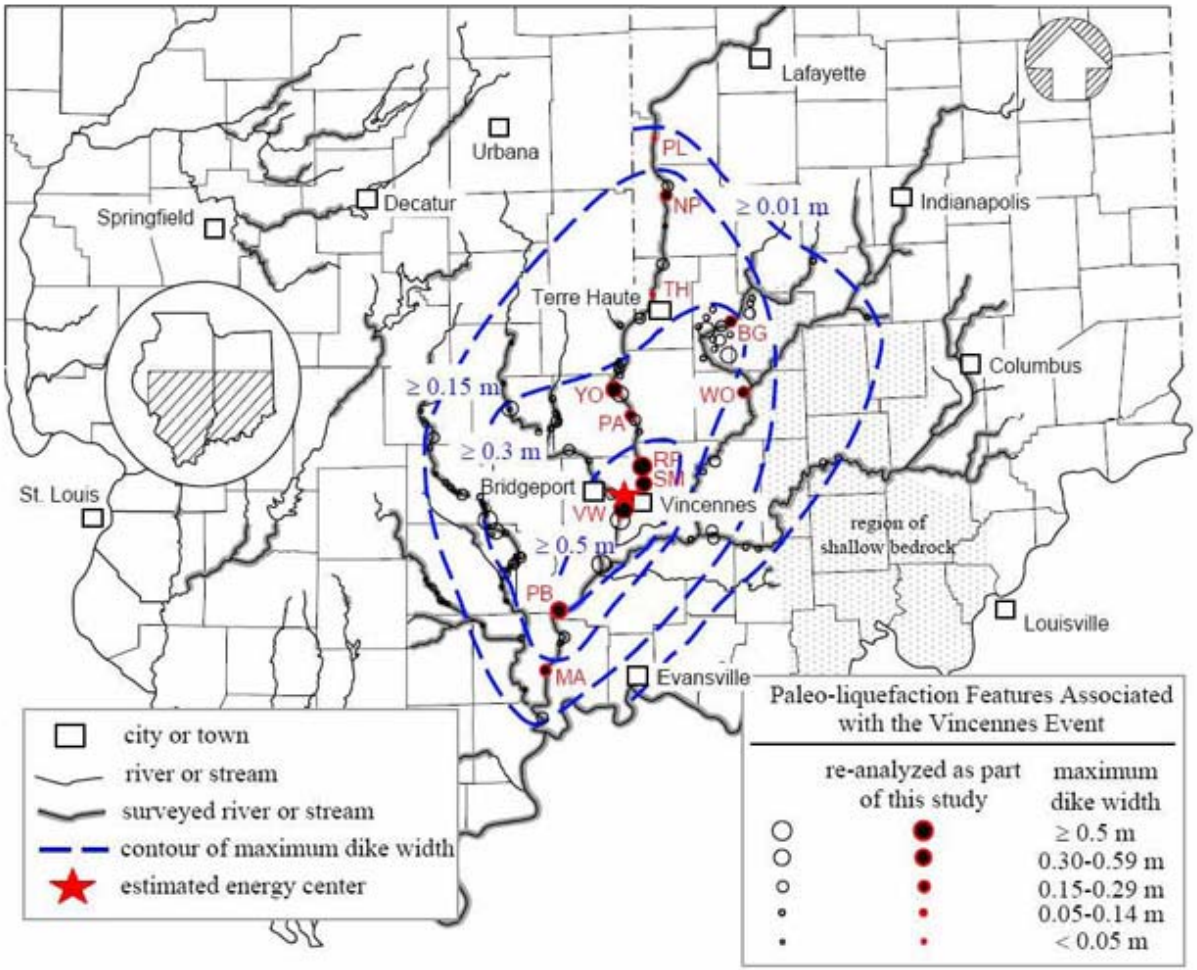

Figure 8. Map of southern Indiana/Illinois and the twelve paleoliquefaction sites analyzed in this study.

From Green et al., 2004

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Vincennes Earthquake- Wabash Valley Estimated Magnitude

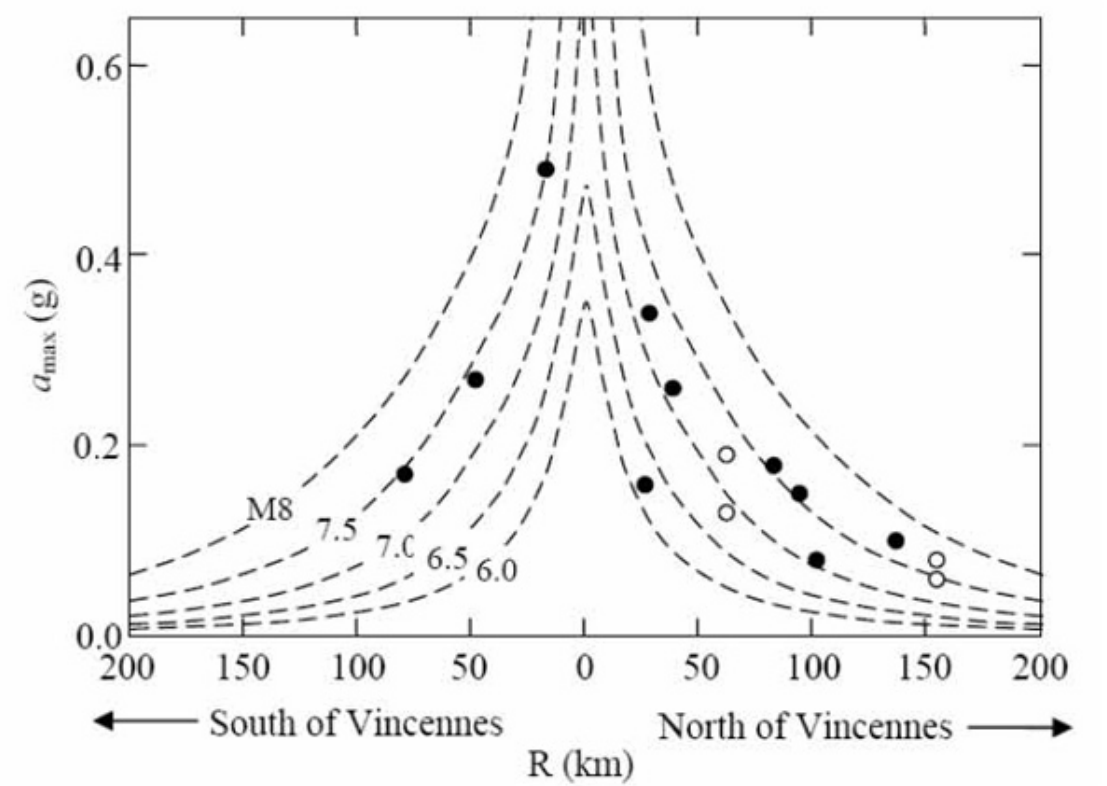


Figure 10. Regional assessment of the magnitude of the Vincennes earthquake. Open circles are for sites where multiple interpretations were made.

From Green et al., 2004

Single large earthquake

Large earthquake and smaller earthquakes- similar location and temporally clustered

Several small earthquakes in same general region at about the same time

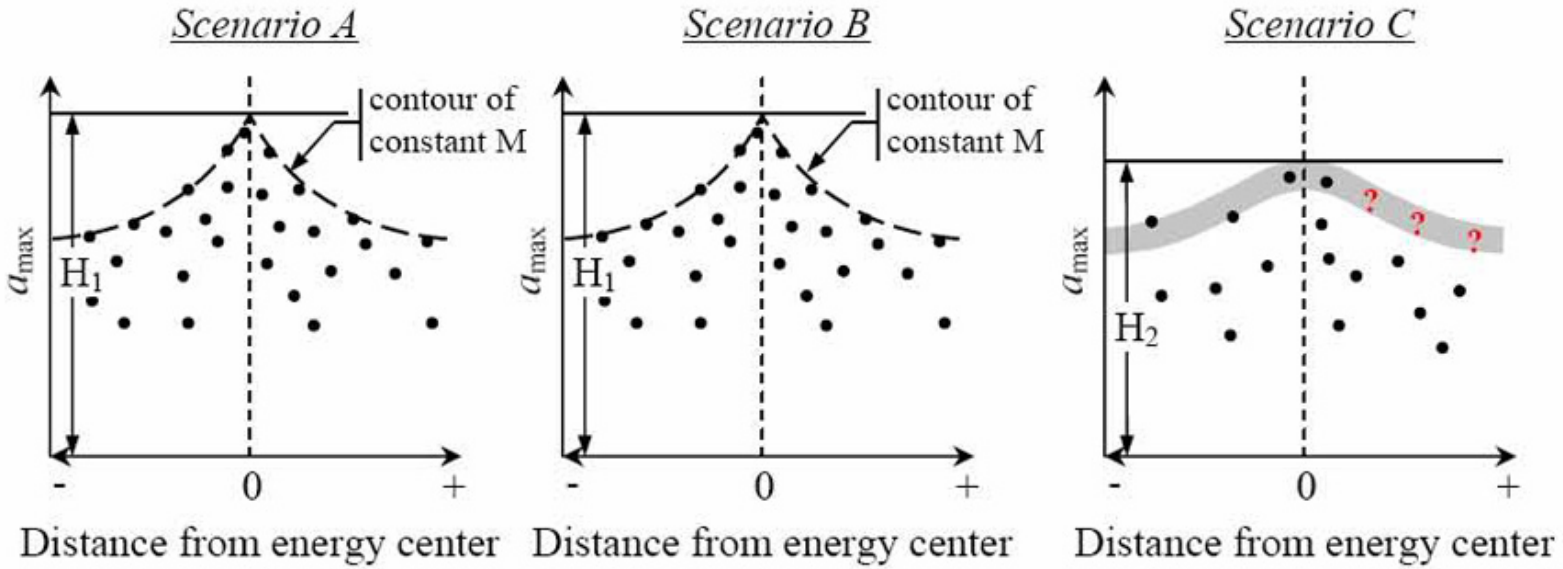


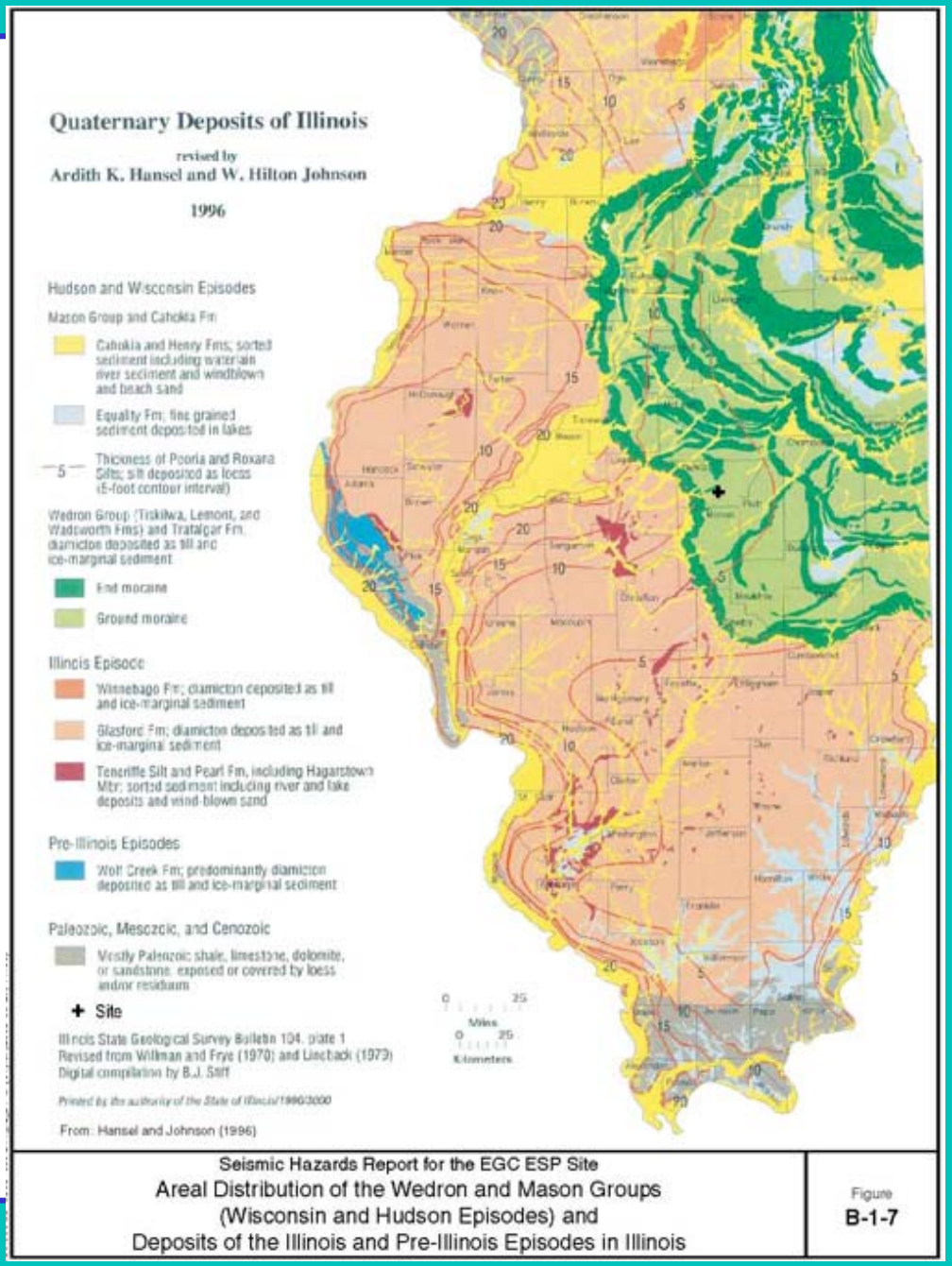
Figure 9. Illustration of potential scenarios that may occur when integrating the results from back-calculations of multiple paleoliquefaction sites in regionally assessing the magnitude of the paleoearthquake.

From Green et al., 2004

Constraints and Uncertainties

- Factors related to Field Observations, ground failure mechanisms, and field setting
  - Completeness of record (spatial and temporal)
  - Ability to discern features in plan view
  - Dating resolution
- Factors related to liquefaction susceptibility
  - Aging, density, paleo-groundwater conditions
- Factors related to seismicity
  - MSF, values of pga from empirical data
- Valididy of In-Situ Testing Techniques
  - Completeness of record (spatial and temporal)
  - Ability to discern features in plan view

Quaternary Deposits of Illinois



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Areal Distribution of the Wedron and Mason Groups (Wisconsin and Hudson Episodes) and Deposits of the Illinois and Pre-Illinois Episodes in Illinois

Figure B-1-7

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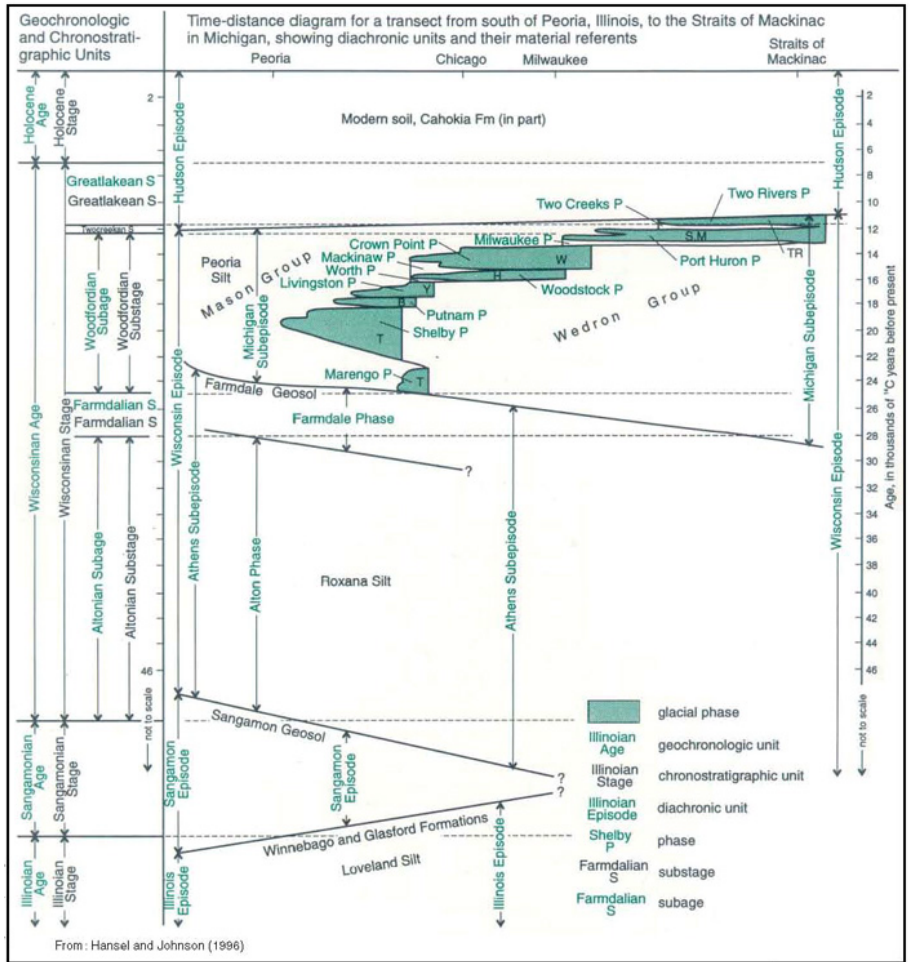
Lake Michigan Lobe Chronostratigraphy



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Geochronologic Units, Chronostratigraphic Units and Diachronic Units in the Lake Michigan Lobe

Figure
B-1-9

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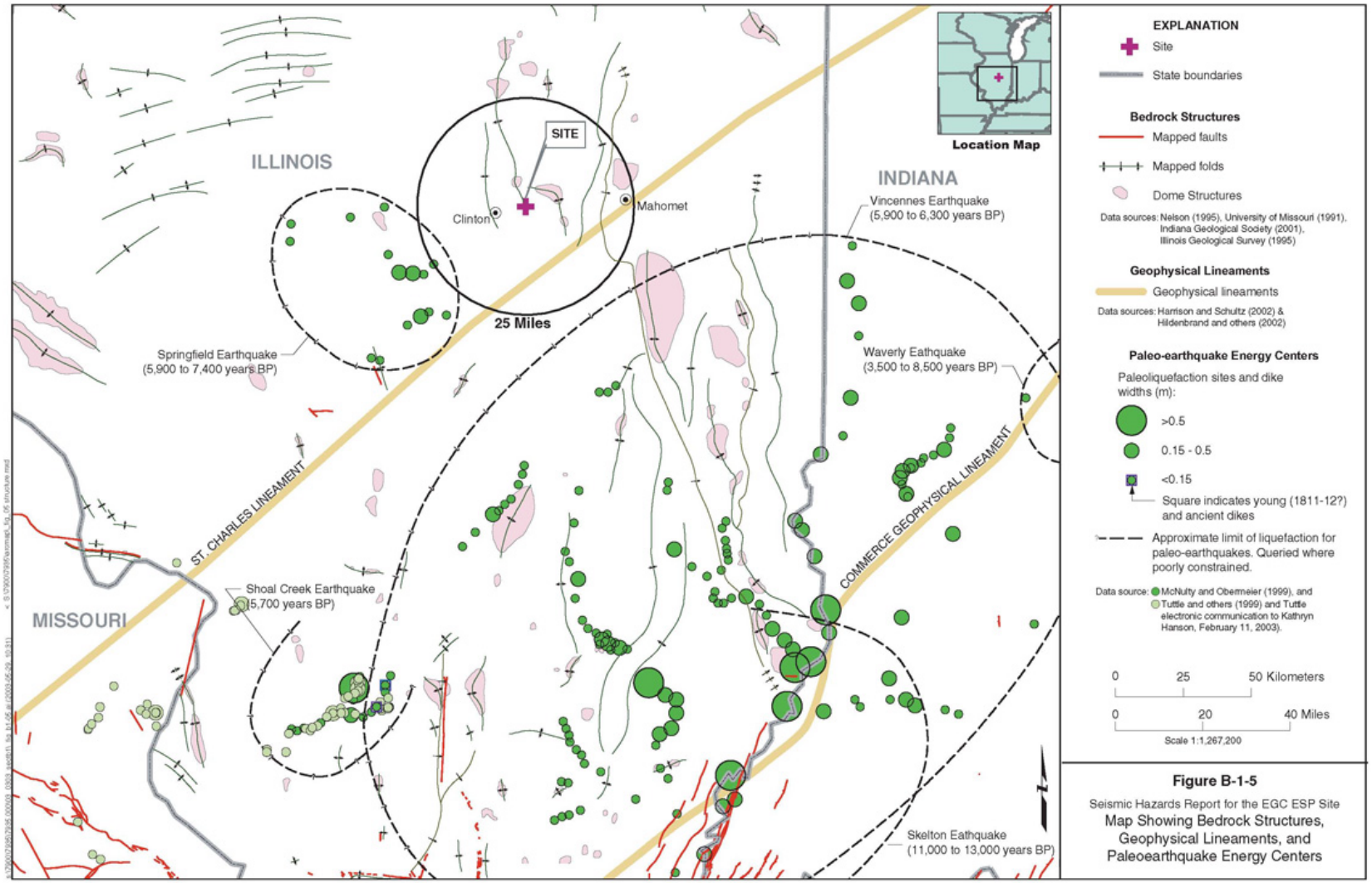

Figure B-1-5

Seismic Hazards Report for the EGC ESP Site
Map Showing Bedrock Structures, Geophysical Lineaments, and Paleoearthquake Energy Centers

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EGC ESP Field Investigations

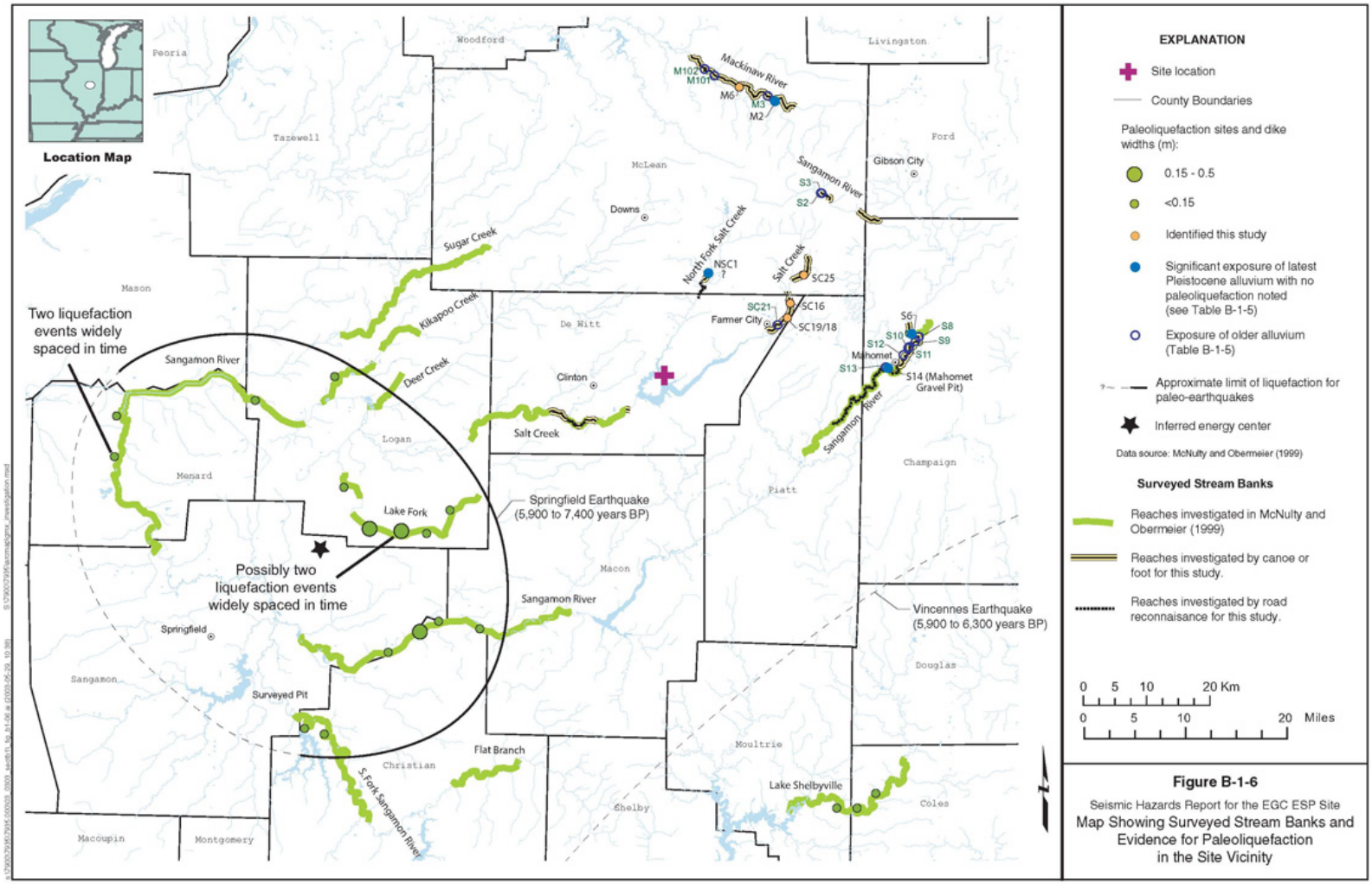

Figure B-1-6

Seismic Hazards Report for the EGC ESP Site
Map Showing Surveyed Stream Banks and Evidence for Paleoliquefaction in the Site Vicinity

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Field Mapping Approach

- Identify reaches of the larger streams where Henry Formation is mapped
- Use Soil Conservation Service maps to identify locations where deposits of latest Pleistocene to Holocene are present
- Use 1:24,000 scale topographic maps
  - to identify older terrace surfaces and locations along drainages where older deposits would likely be exposed
  - Gravel pits

Quaternary Deposits in Site Vicinity

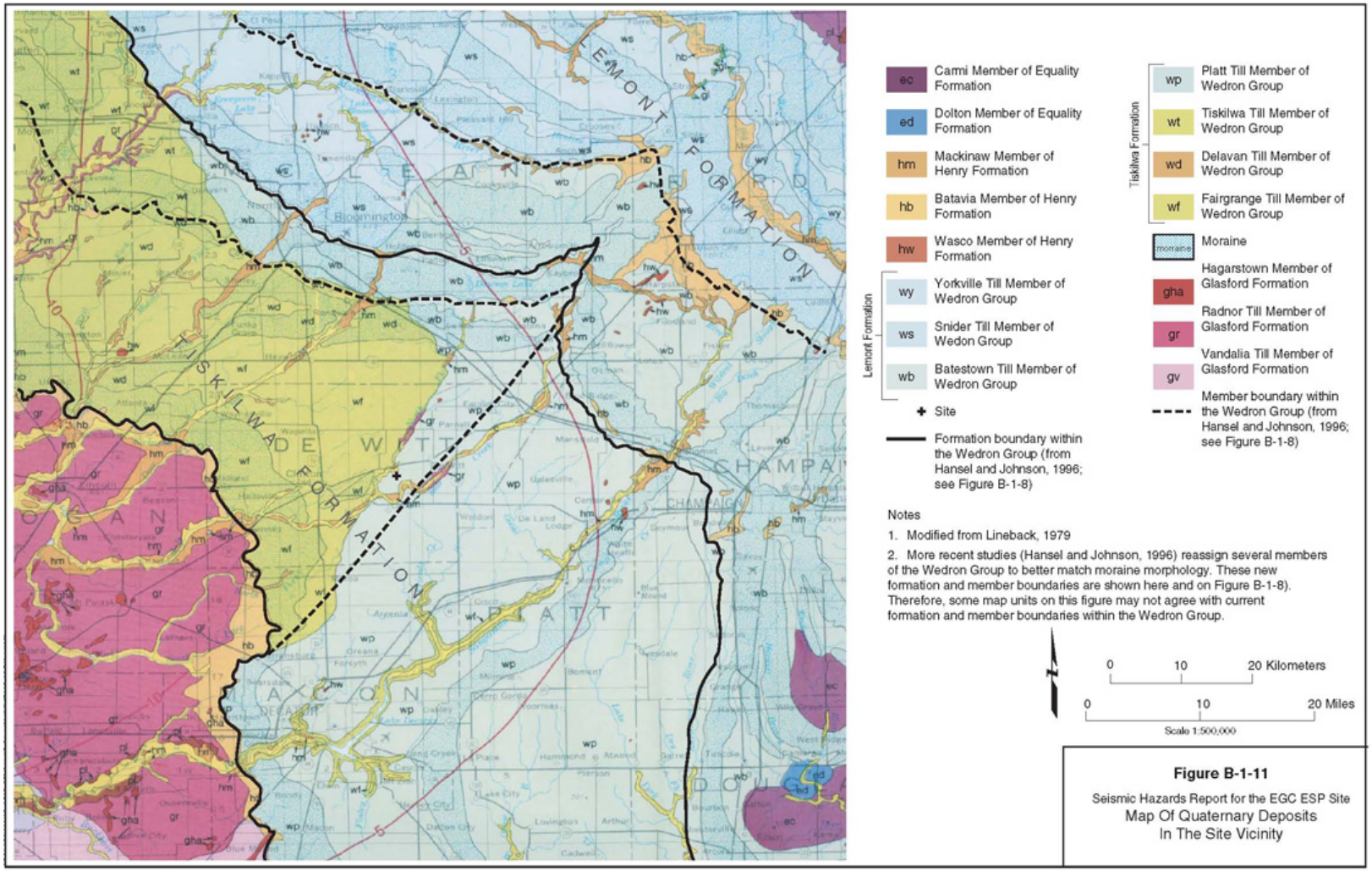

Figure B-1-11

Seismic Hazards Report for the EGC ESP Site
Map Of Quaternary Deposits
In The Site Vicinity

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