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GTSP

Global Energy Technology Strategy Program

Balancing CCS and Groundwater Use in a Carbon-Constrained Future

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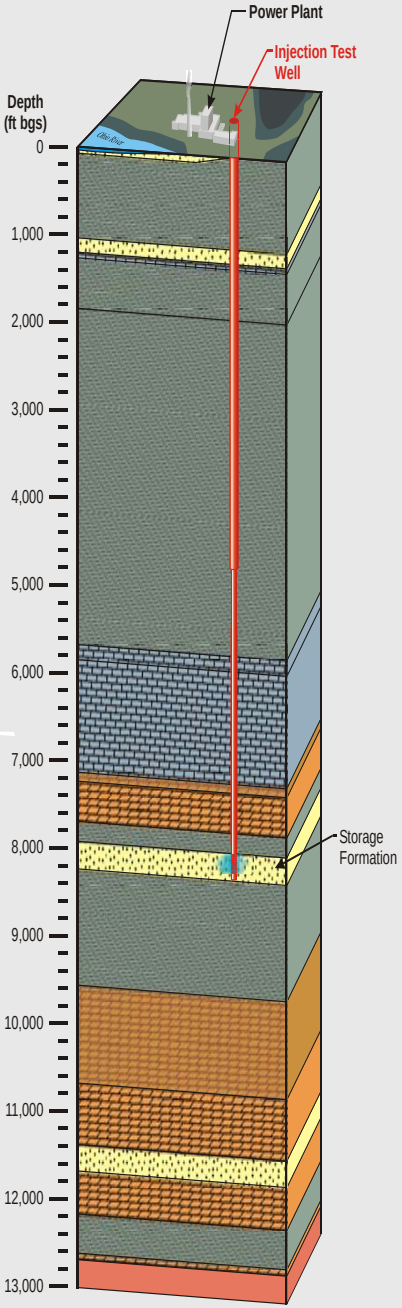
Key Terms and Concepts

- Underground sources of drinking water (**USDWs**) – Many other communities withdraw their drinking water from subsurface aquifers. Typically these are relatively shallow (< 500m)
- **Overburden** – Comprises the hundreds or thousands of meters of geologic strata separating a geologic storage formation from the USDWs overlying it
- **Caprock** – The very bottom layer(s) of overburden, immediately overlying the storage formation and providing an impermeable layer that prevents CO_2 from moving out of the storage formation
- Deep saline formations (**DSFs**) – Often these formations are much deeper than sources of potable water, and contain waters with such high total dissolved solids (**TDS**) levels that they are nonpotable, and often unsuitable for agricultural or industrial uses
- The Safe Drinking Water Act (**SDWA**) of 1974 establishes US EPA's authority to regulate injection into the subsurface for protection of USDWs
- The regulations of the Underground Injection Control (**UIC**) program were implemented in 1980 to set forth a core set of operational standards to ensure USDW protection.



Theoretical vs. achievable capacity

- To date, most analysis focused on theoretical storage capacity at national and regional scales

- Moving forward requires a finer-scale understanding of regional variations and constraints on the theoretical resource
  - Practical / technical – e.g., incompetent caprock, local lithologic or structural variations impacting storage
  - Economic – e.g., low injectivities, too many wells requiring remediation, high costs associated with other necessary risk mitigation activities
  - Regulatory – e.g., lower salinities than allowable, local or regional statutory limitations under UIC

- These constraints may all serve to decrease the total amount of storage capacity actually achievable

Salinity constraints analyzed

Geologic storage capacity constrained by assuming the following TDS levels required for CO_2 injection:

- **No constraint (0 mg/L)**

  This reflects the theoretical mass of CO_2 a given volume of geologic media may be able to store. Many published storage volume estimates are unconstrained by salinity and fall in this category

- **Potable and near-potable waters (> 5,000 mg/L)**

  Analyzed here as a proxy for waters that are potable, near-potable or useful for industrial or agricultural applications

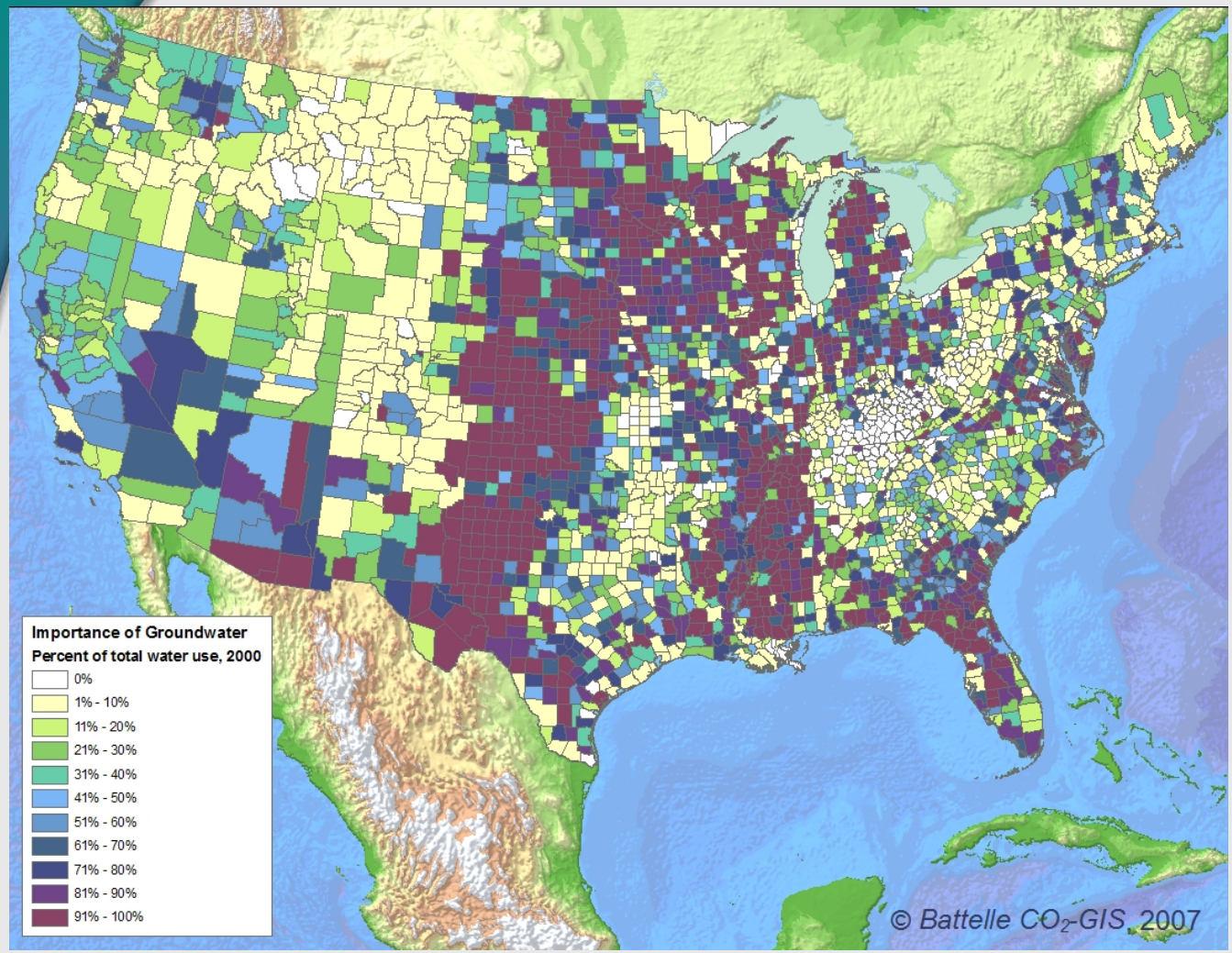
- **Current regulatory constraint (>10,000 mg/L)**

  Reflects current UIC definition of an underground source of drinking water (USDW) and by extension, the current minimum TDS required for CO_2 storage without applying for an exemption to this limit

- **Seawater (> 35,000 mg/L)**

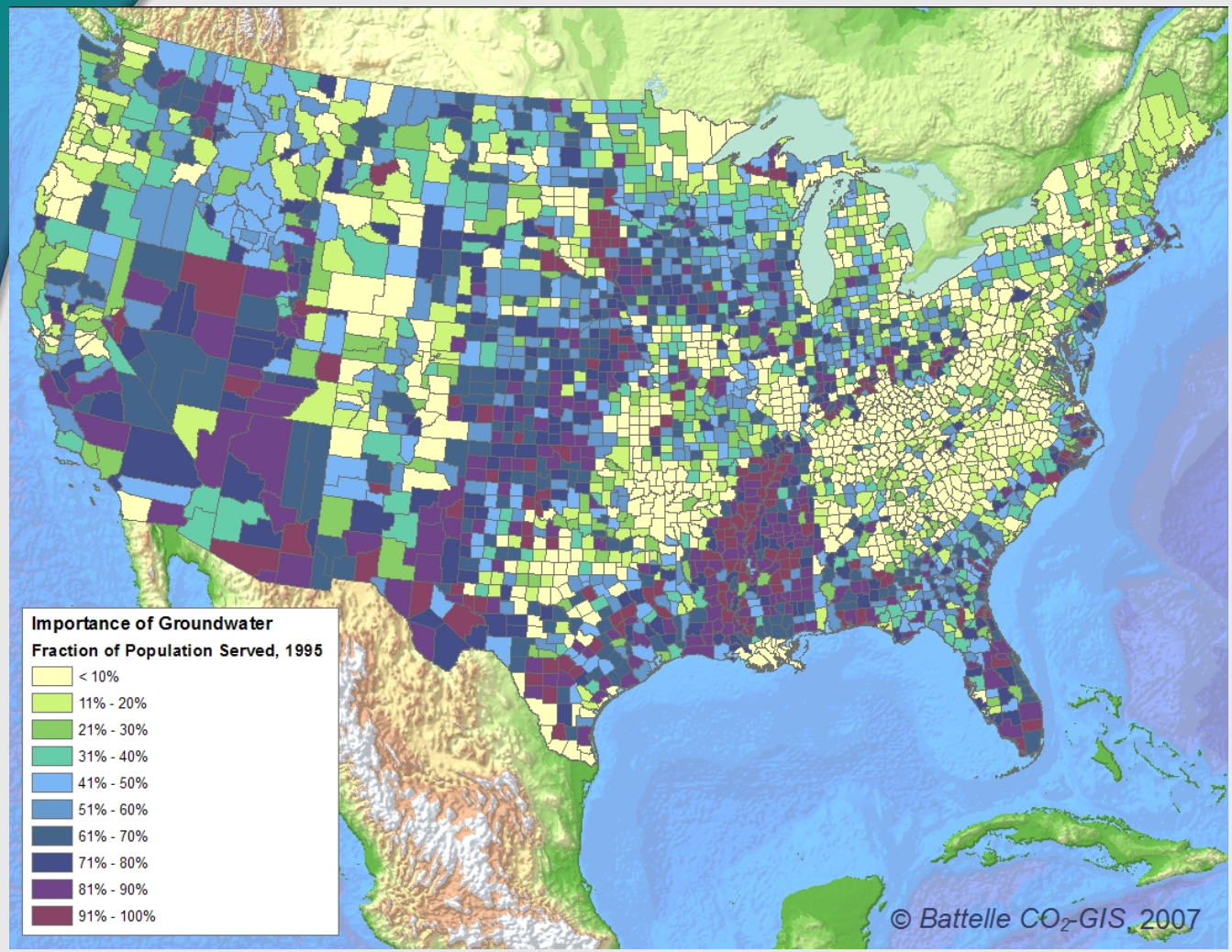
  Approximate TDS of seawater, used here as a proxy for formations that might be considered as economically viable water sources for desalination projects

Groundwater Supplies a Significant Fraction of Total Water Use



- Underground sources of drinking water (USDWs) are already protected and cannot be used for CCS under most circumstances
- These formations tend to be far shallower than the depths and formations suitable for CO_2 injection
- However, future use of saline groundwaters to feed desalination facilities may conflict with use of deeper, nonpotable waters for CO_2 storage

A Large Fraction of the U.S. Drinking Water is Supplied by Groundwater



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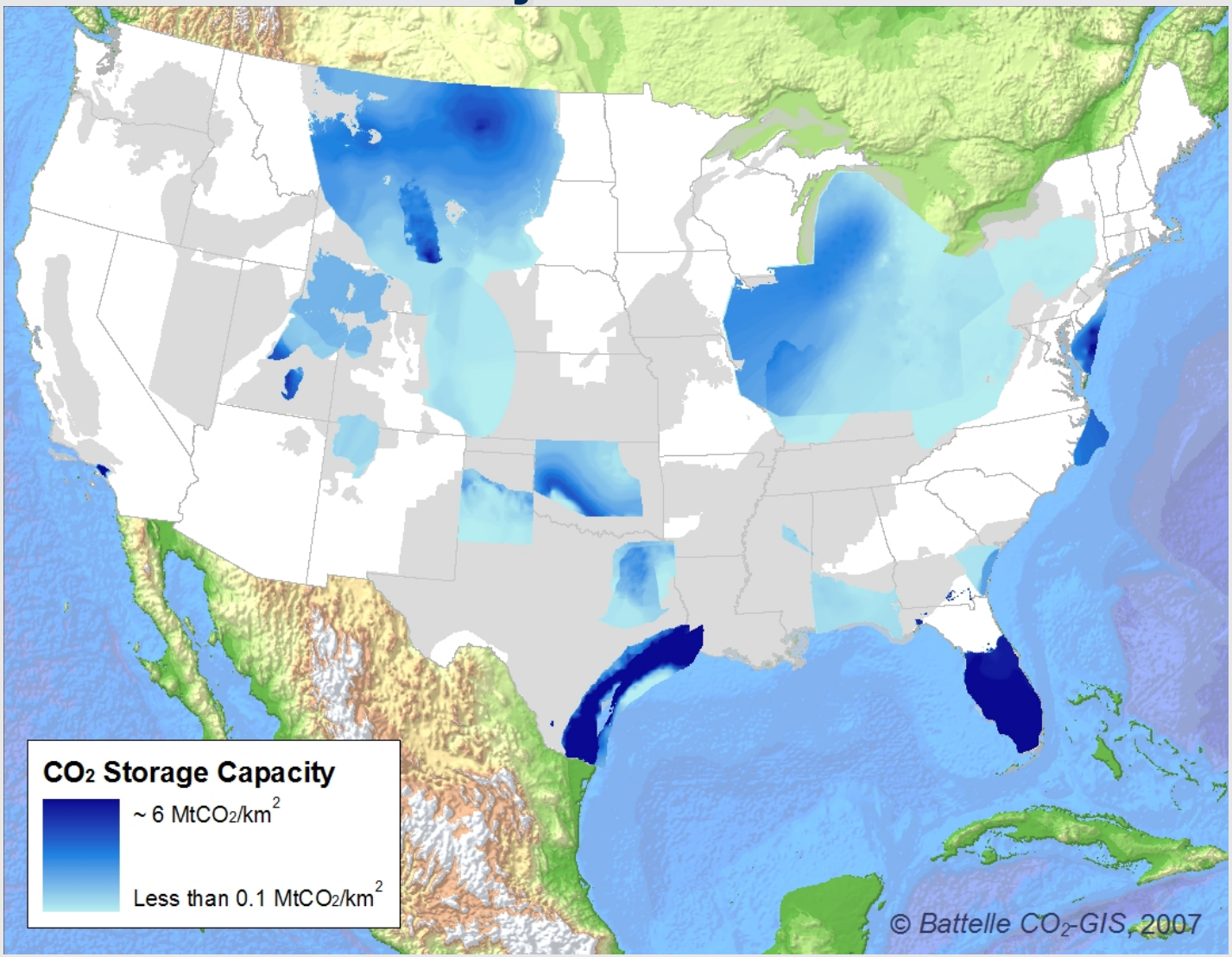
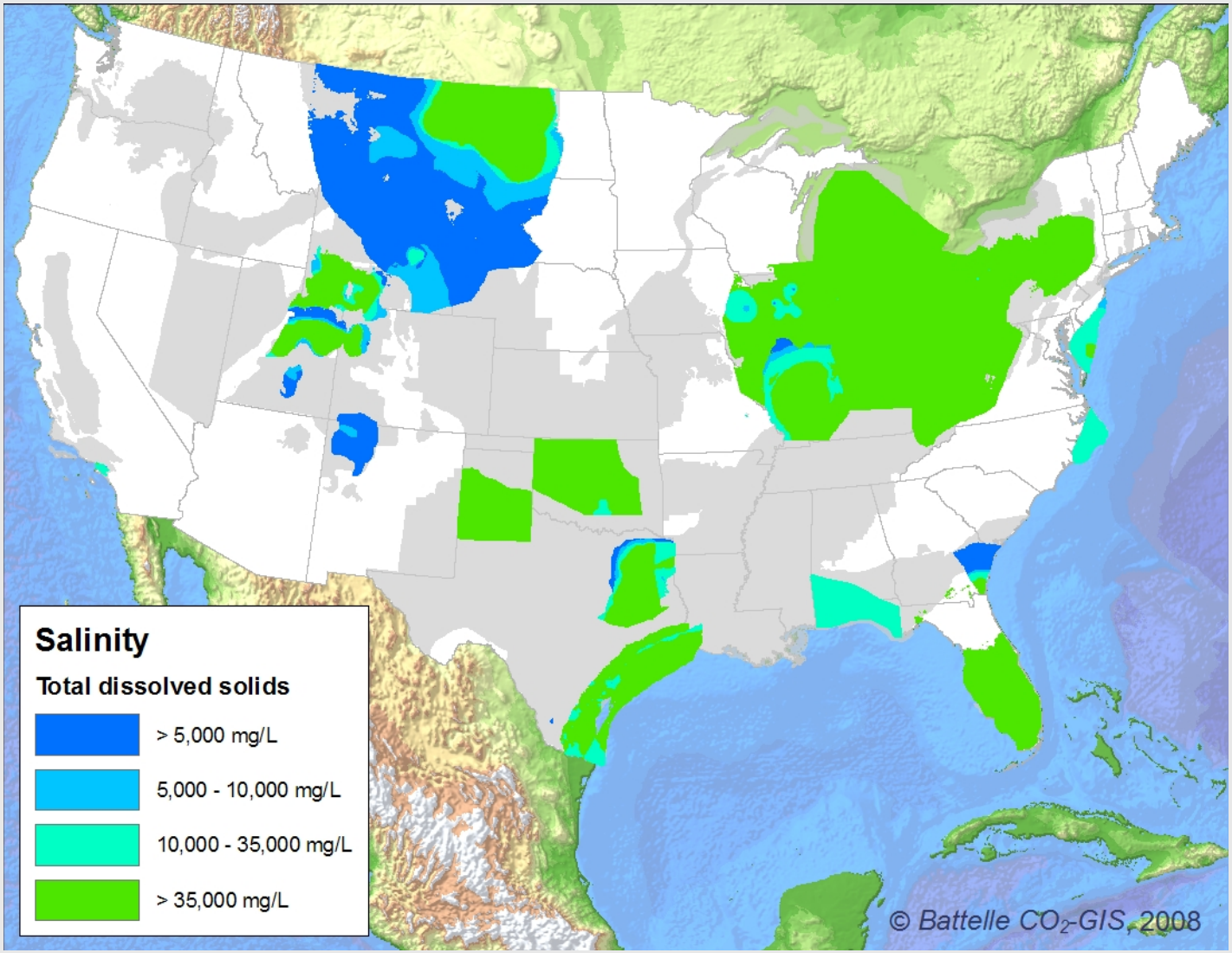
Analysis caveats

- This analysis is designed to assess potential distribution and magnitude of impacts associated with a set of hypothetical salinity constraints
- This is a preliminary, high level assessment of the potential impacts of one possible constraining factor (salinity)
- Develops a preliminary framework for examining potential impacts on the accessible U.S. CO_2 storage resource at a regional level, using available data
  - Higher resolution data is needed to perform more detailed and comprehensive regional or national assessments
- Not a substitute for detailed data and analyses that will likely be needed at the local site / project level

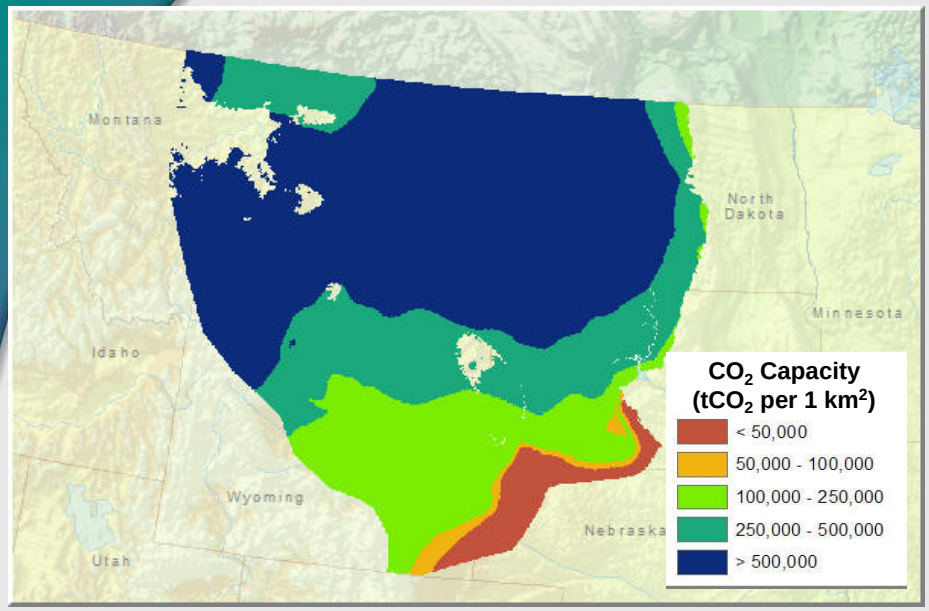
Unconstrained capacity for major U.S. DSFs

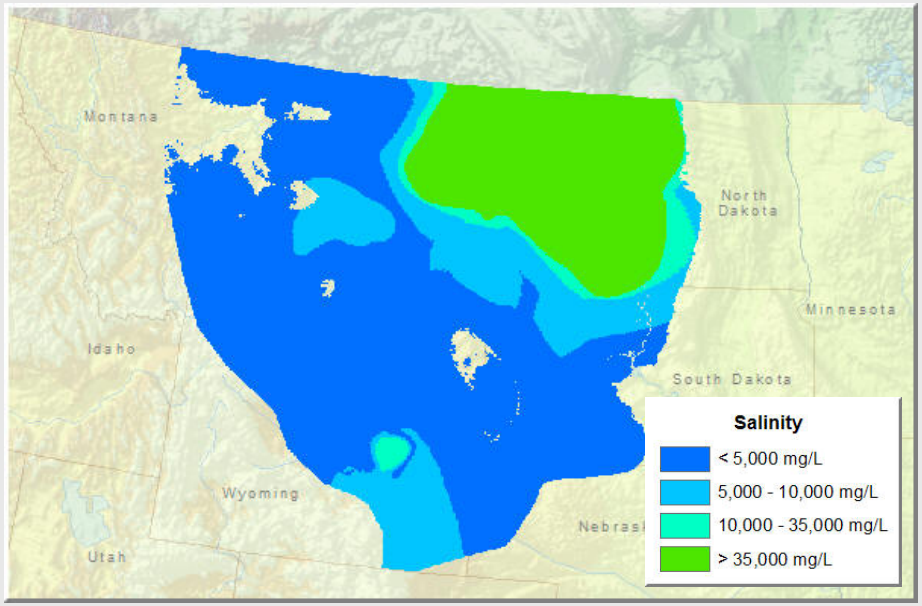


Salinity zones for 18 major U.S. DSFs



Capacity evaluated for each salinity zone (example: Madison Group)





Impact of various salinity constraints upon available capacity in the Madison Group

TDS Required for Storage	Available Capacity ($MtCO_2$)	Change in Capacity from Unconstrained (Published Technical) Capacity
0 mg/L	405,000	--
5,000 mg/L	218,000	46% ↓
10,000 mg/L	153,000	62% ↓
35,000 mg/L	139,000	66% ↓

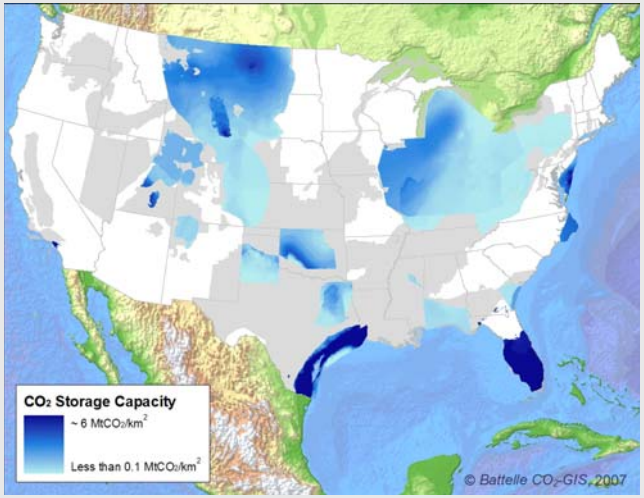
Resulting available capacities

Deep Saline Formation	Total Capacity ($MtCO_2$)			
	0 mg/L	5,000 mg/L	10,000 mg/L	35,000 mg/L
Arbuckle	56,200	56,200	56,200	53,700
Cape Fear	4,700	1,900	1,700	1,100
Cedar Keys / Lawson	176,000	176,000	176,000	176,000
Fox Hills	23,100	0	0	0
Frio	159,000	159,000	159,000	143,000
Glen Canyon	57,400	47,900	41,700	36,100
Granite Wash	9,300	9,300	9,300	9,300
Jasper	103,000	103,000	103,000	88,600
Lower Potomac	39,100	39,100	38,400	2,800
Madison	405,000	218,000	153,000	139,000
Morrison	5,800	500	0	0
Mt Simon	252,000	252,000	251,000	234,000
Oriskany	4,100	4,100	4,100	4,100
Paluxy	6,700	5,700	4,400	2,700
Repetto	3,800	3,800	3,700	100
St Peter	9,000	8,200	7,200	4,400
Tuscaloosa	7,400	7,400	7,400	*
Woodbine	16,400	16,400	16,400	14,700

Estimating overall storage resource impacts

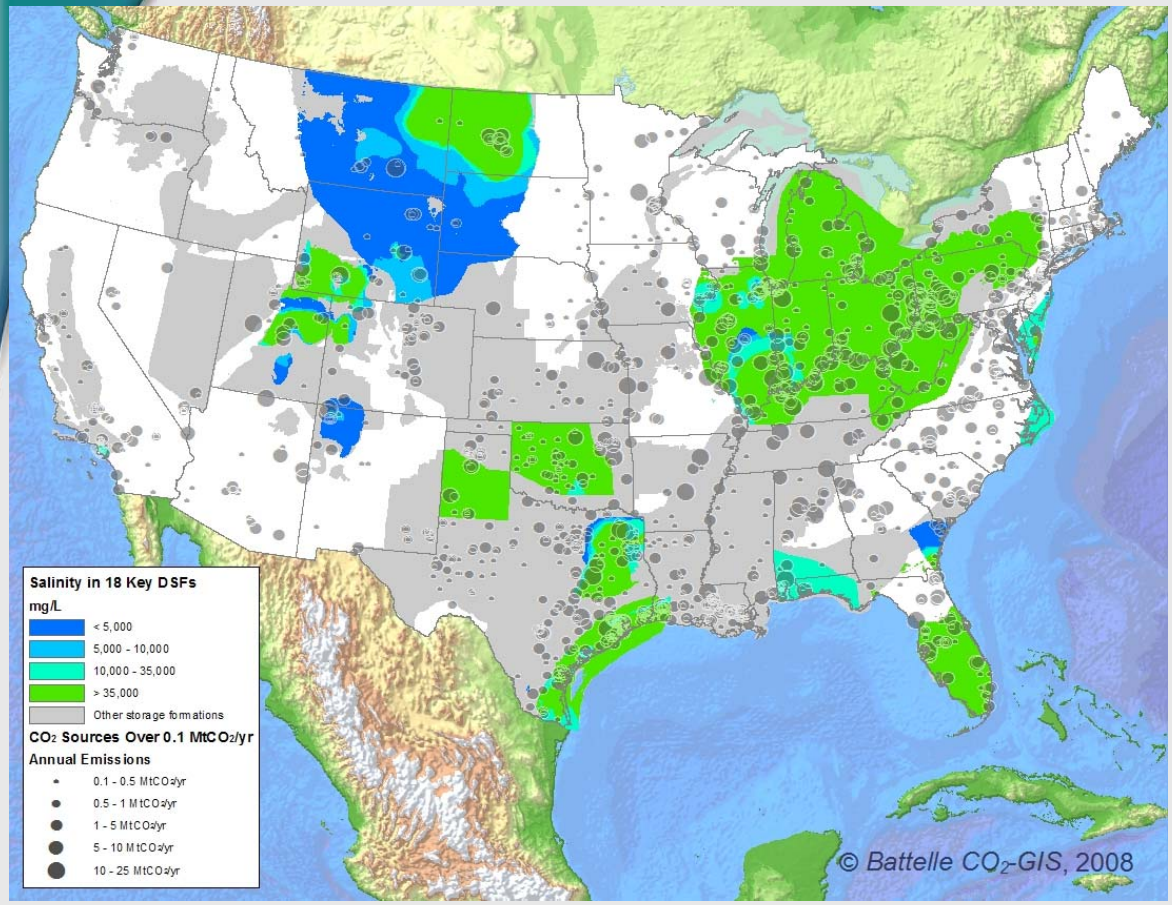
Minimum TDS Allowed for CO_2 Storage	Capacity within 18 Key U.S. DSFs ($MtCO_2$)	Change in Capacity from Unconstrained (Published Technical) Capacity	Change in Equivalent Number of Capturing 1000 MW IGCC Served*
0 mg/L	1,338,000	--	--
>5,000 mg/L	1,109,000	17% ↓	573 ↓
>10,000 mg/L	1,033,000	23% ↓	763 ↓
>35,000 mg/L	910,000	32% ↓	1070 ↓

* Represents change in available capacity based on the lifetime storage requirement for the number of plants shown (8 $MtCO_2$/y for 50 yr design lifetime)



- Total unconstrained CO_2 storage capacity in these 18 DSFs: approximately 1,338 $GtCO_2$
- However, by counting capacity only in those areas of each formation with salinities that exceed the UIC definition of a USDW (>10,000 mg/L TDS) results in a total capacity of 1,033 $GtCO_2$

Implications for U.S. CCS deployment vary regionally

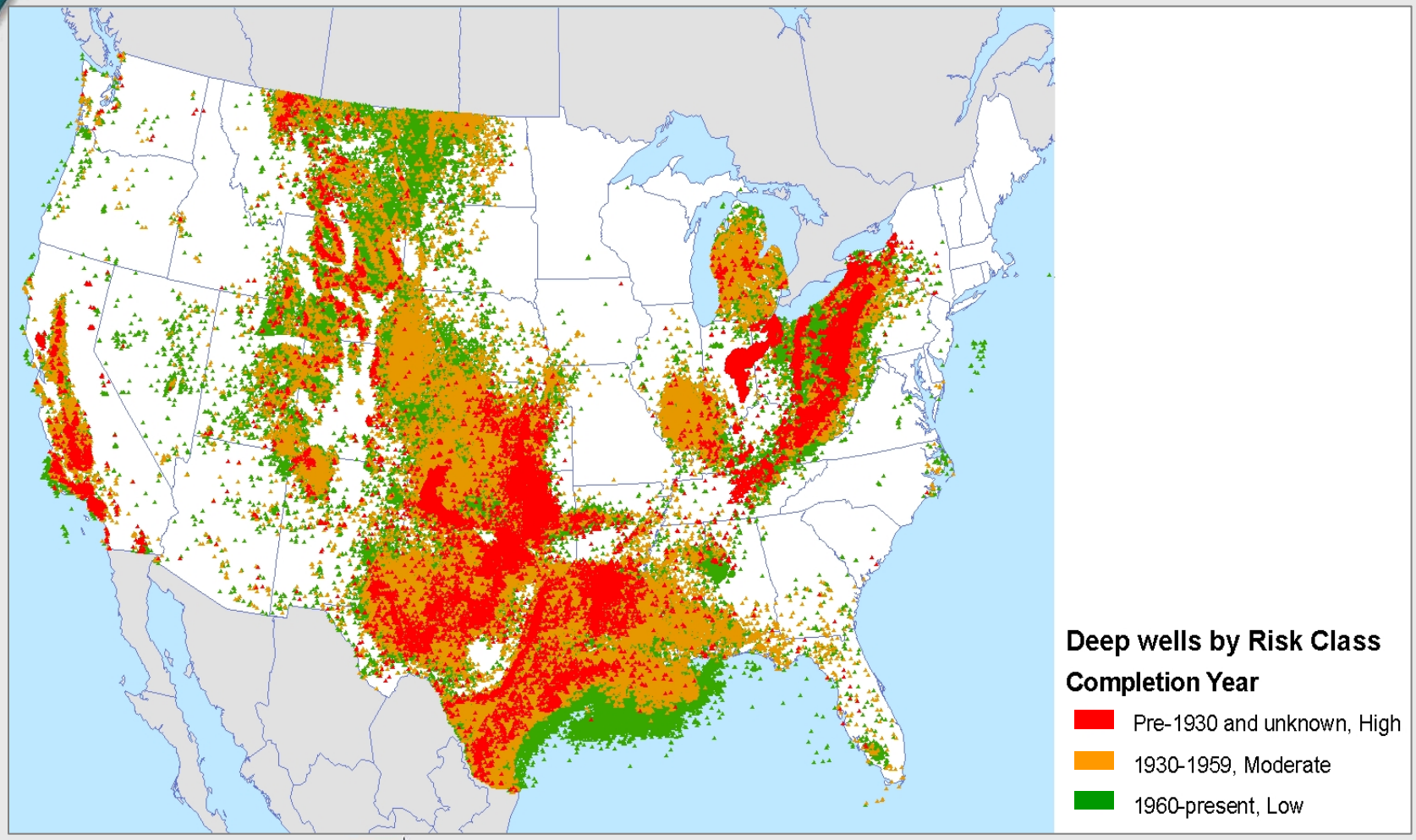


- The regions most sensitive to changes in salinity constraint (within the range analyzed here) are most widespread in the western U.S.
- Impacts from constraint variation appear to be less significant in the Ohio River Valley and Midwest regions, where formation waters more commonly exceed 35,000 mg/L

Conclusions & continuing research

- This analysis was designed as a first step toward a framework for understanding the complex trade-offs between designating geologic formations for use as CO_2 storage formations and preserving them for other uses
- However, a deeper understanding of where conflicts may arise over the use of these waters for CCS versus other uses is needed in order to incorporate the demand for either or both of these use categories for a given region
- This will yield a more nuanced and truer-to-life picture of where storage resources may be truly constrained by salinity requirements, and where this issue is of less urgency

Other potential applications of this approach



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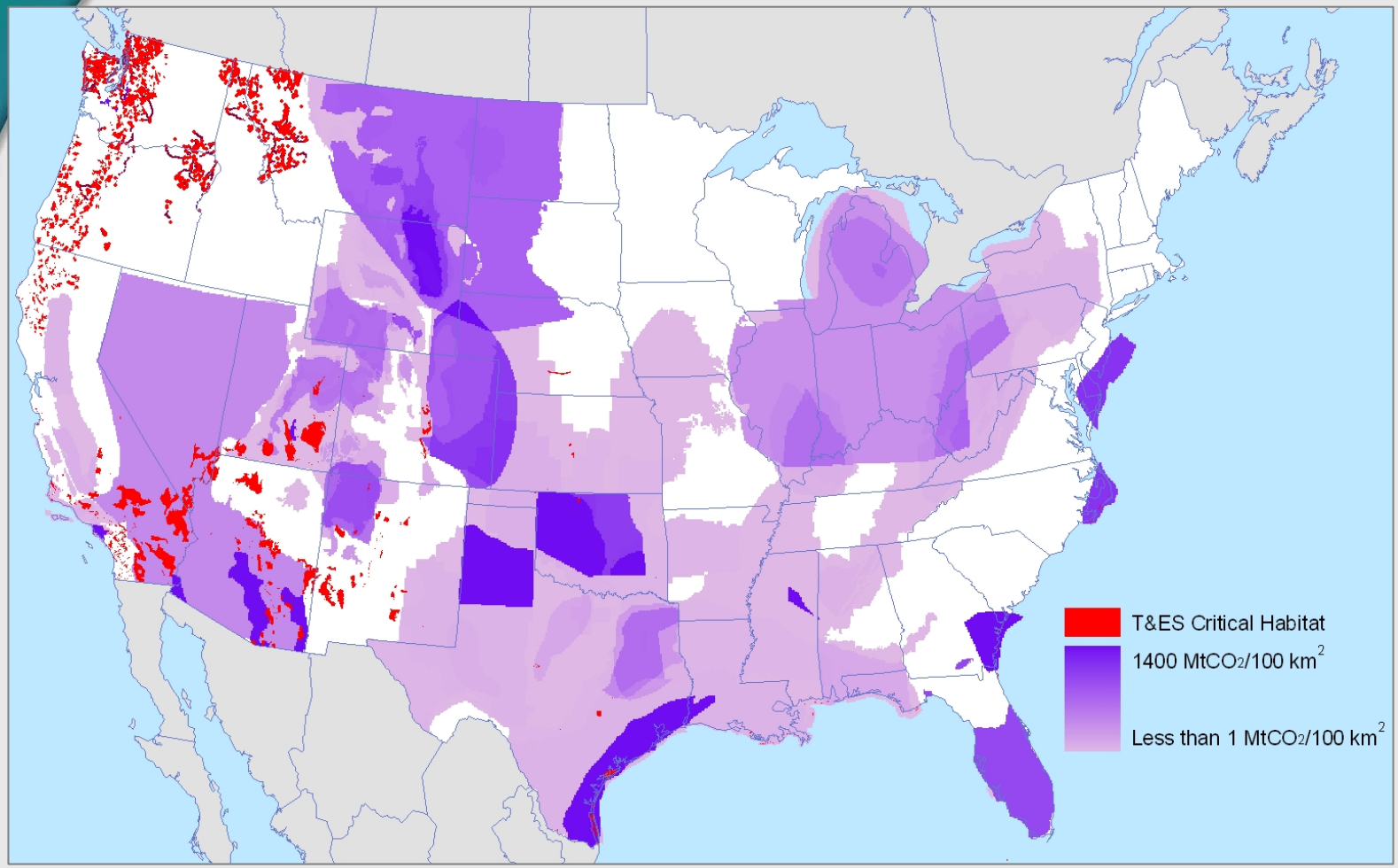
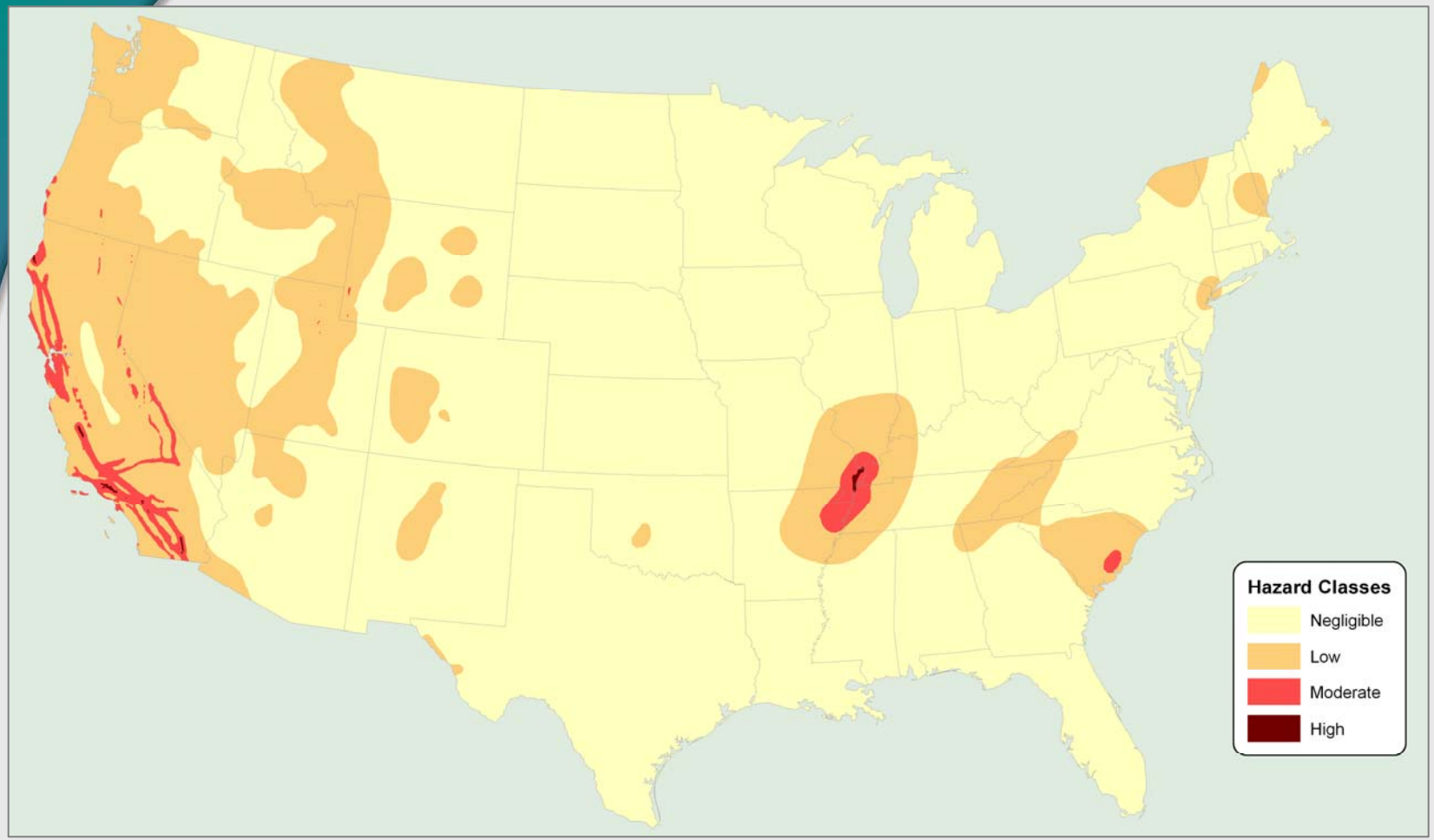
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