Repository Site Selection Criteria and Constraints

Presented to:
Nuclear Waste Technical Review Board

Presented by:
Ken Skipper
U.S. Geological Survey
Office of Groundwater

March 7, 2012
Albuquerque, New Mexico

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Overview

- USGS Mission and Organization
- Retrospective Review of 1st Repository Siting Process
- New Siting Process
  - Disqualifying conditions for early screening process
  - Potential adverse conditions to be considered in an early screening process
- Geo-Policy Considerations
- Who are “Consenters” ?
- Information Updates Since Culmination of the 1st Repository Siting Process
- Summary
- Nation’s Challenge
- Questions?

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USGS Mission

Serves the Nation by providing reliable and **impartial** scientific information to describe and understand the Earth including health of our ecosystems and environment; the impacts of climate and land-use change, minimize loss of life and property from natural disasters; inform water, biological, energy, and mineral resources management; and to enhance and protect quality of life.

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USGS Yucca Mountain Project Branch Closeout

- YMPB established over 20 years ago solely for YM site characterization and subsequent activities
- Disbanded September 30, 2010
- Preservation of scientific information
  - Approx. 450 boxes of records transferred to DOE Office of Legacy Management, Las Vegas, NV
  - Approx. 75 boxes “agency” records retained in USGS Denver office
  - Drill core and lab specimens transported to Sample Management Facility located Area 25, Nevada Test Site
- All contracts terminated
- USGS federal employees retired, relocated to other agencies, or assigned to other USGS missions

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Closeout -- continued

- Completed several in process reports and activities in the areas of: seismicity, geochemistry, precipitation, erosion, and vol. II Geological Society of America memoir summarizing the hydrology and geochemistry of YM area (in final review)
- Request to DOE to utilize non-expended funds for USGS Lessons Learned Report and update USGS publications bibliography (1992 - present)

Retrospective Review of First Repository Siting Process

"Ensure future siting efforts are informed by past experience"

-Blue Ribbon Commission
January 2012
Final Report

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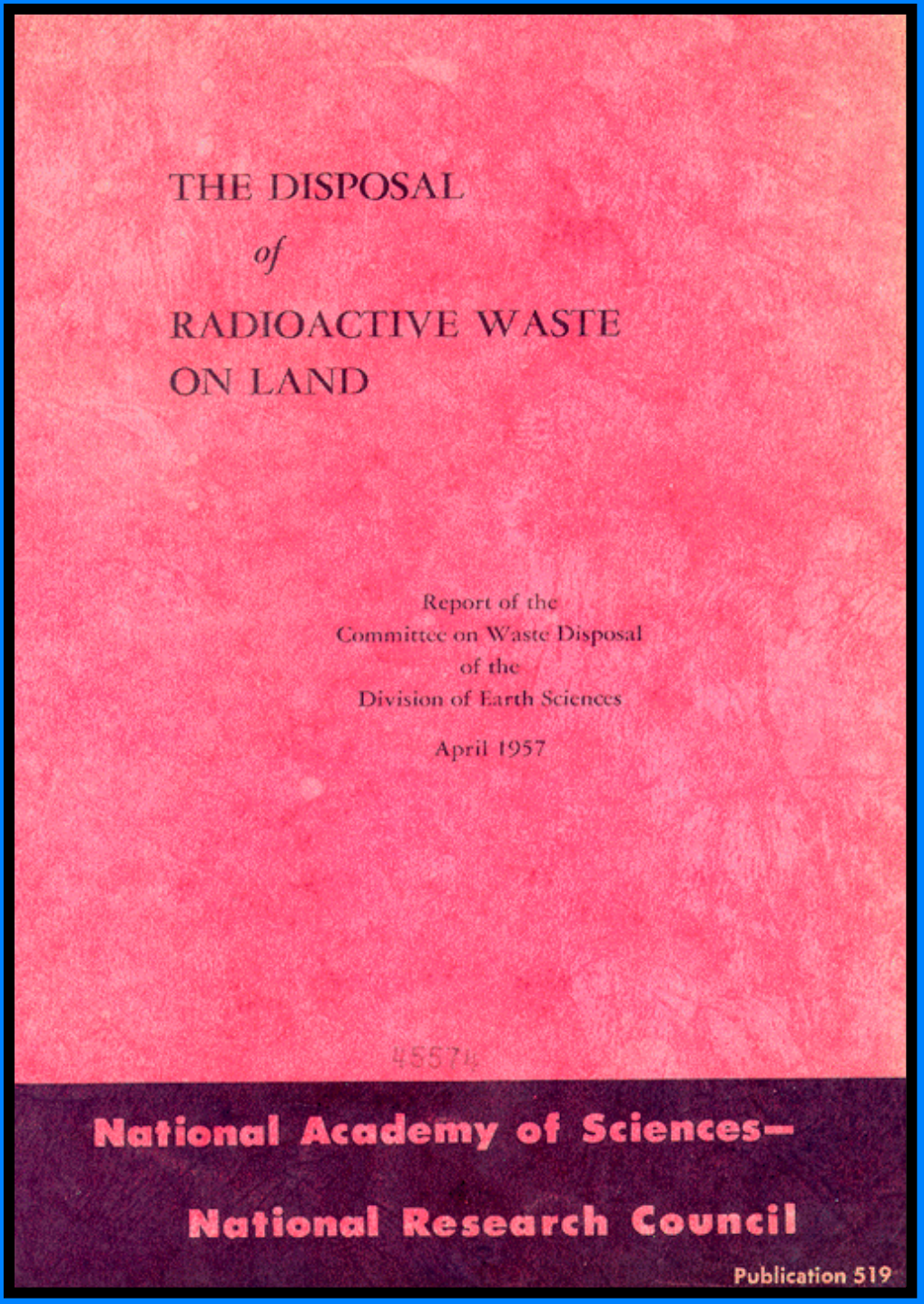

The NAS/NRC report concluded that concept of geologic disposal of radioactive waste provided the best alternative.

The initial reports concluded that salt deposits seemed most promising as a host geologic medium.

Note that most of the high-level waste at the time was in liquid form.

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Scientific Activities
1957 to 1987

Note: Prior to Nuclear Waste Policy Act Amendment of 1987 designating Yucca Mountain as the only site for future study-consideration for geologic repository

- Numerous scientific reports completed by leading authorities at USGS, National Labs, academic institutions, Atomic Energy Commission contractors, and State geological surveys
- Studies included:
  - Rock type specific (i.e. claystones, shales, salt, granite, basalt)
  - Regional, area, site specific (N. Atlantic Coastal Plain, arid regions, Appalachian Basin)
  - Consideration for various disposal concepts (very deep boreholes, geometric array of shallow to moderate depth boreholes, shallow mined chambers, cavities with man-made barriers, and explosion cavities)
- Reports include published and unpublished works, select examples included in background information

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Retrospective Key Points

- Significant scientific information and thought went into 1st repository siting process
- Extensive scientific information available
- Review to today's scientific state of understanding
- Process to validate findings and conclusions
- Starting point for new repository siting process

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New Siting Process

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Blue Ribbon Commission January 2012 Final Report

"Encourage expression of interest from a large variety of communities that have potentially suitable sites"

"**Develop a set of basic initial siting criteria** – these criteria will ensure that time is not wasted investigating sites that are clearly unsuitable or inappropriate."

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Disqualifying Conditions for Early Screening Process

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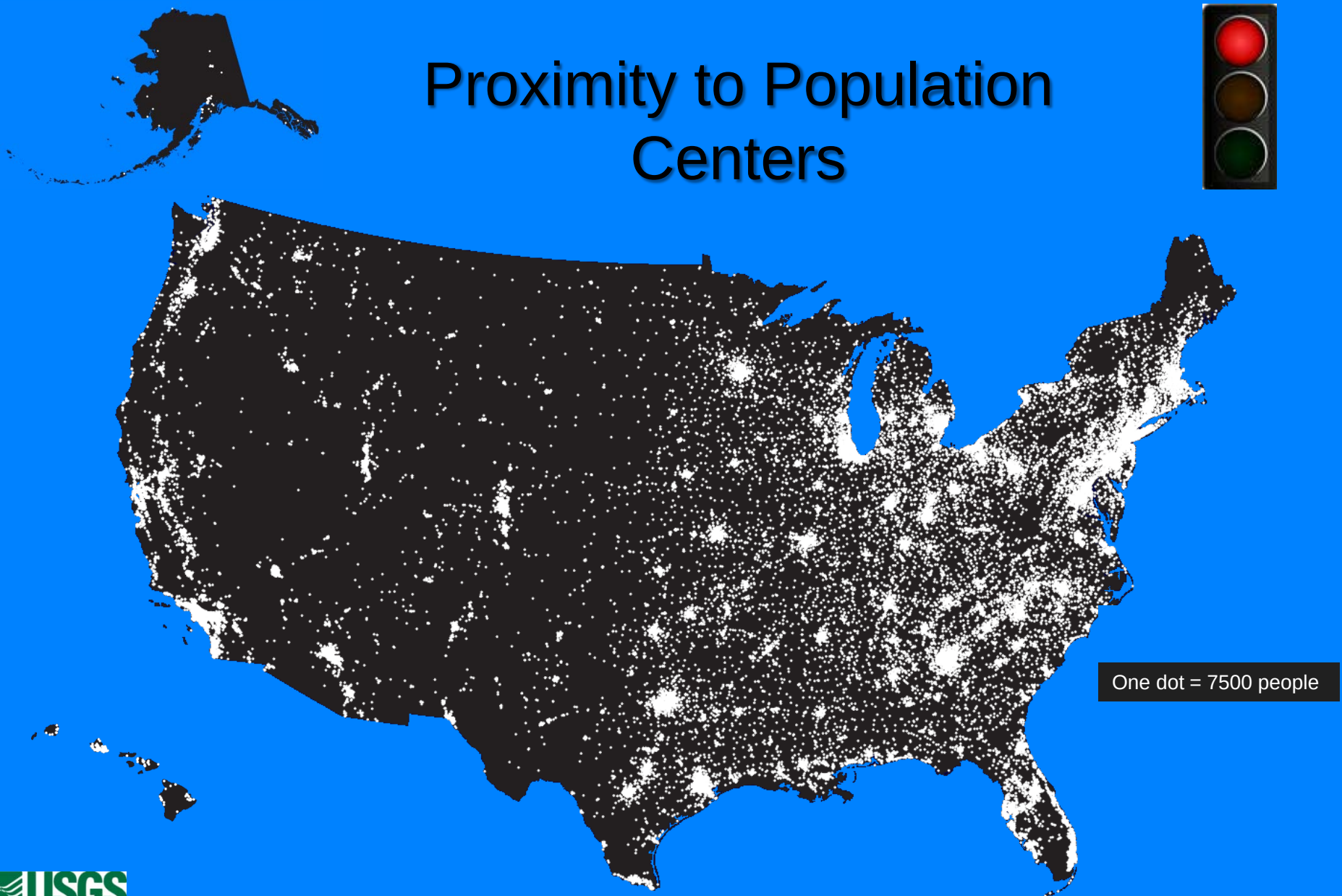
2010 POPULATION DISTRIBUTION

Proximity to Population Centers



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Original Data 2010 Census

Potentially Active Volcanoes

Volcanic Hazards Risk Too Great

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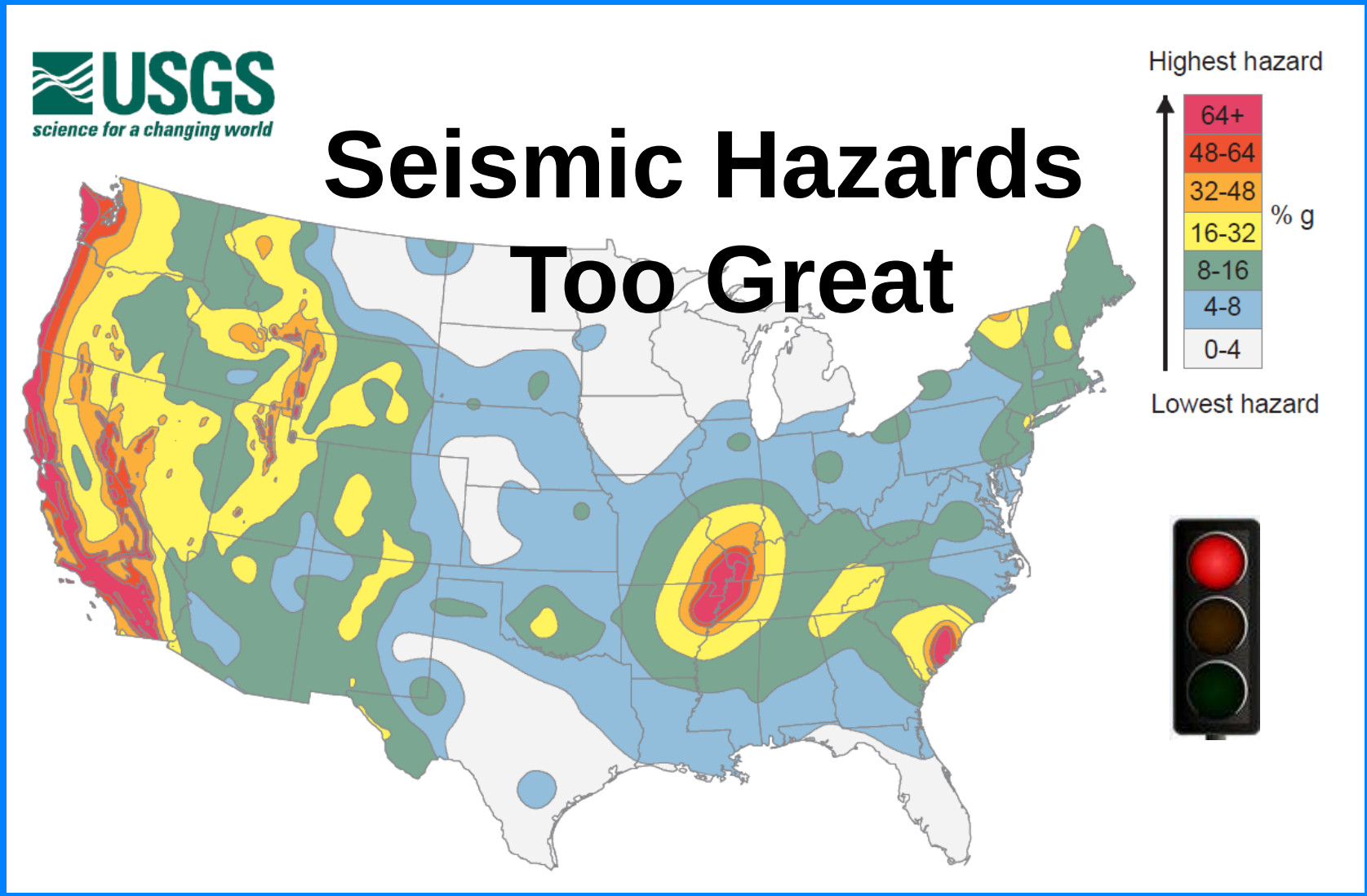
Data from USGS Cascade Volcano Observatory, 2012

Seismic-Hazard Map



Data from USGS Earthquake Hazards Program, 2008

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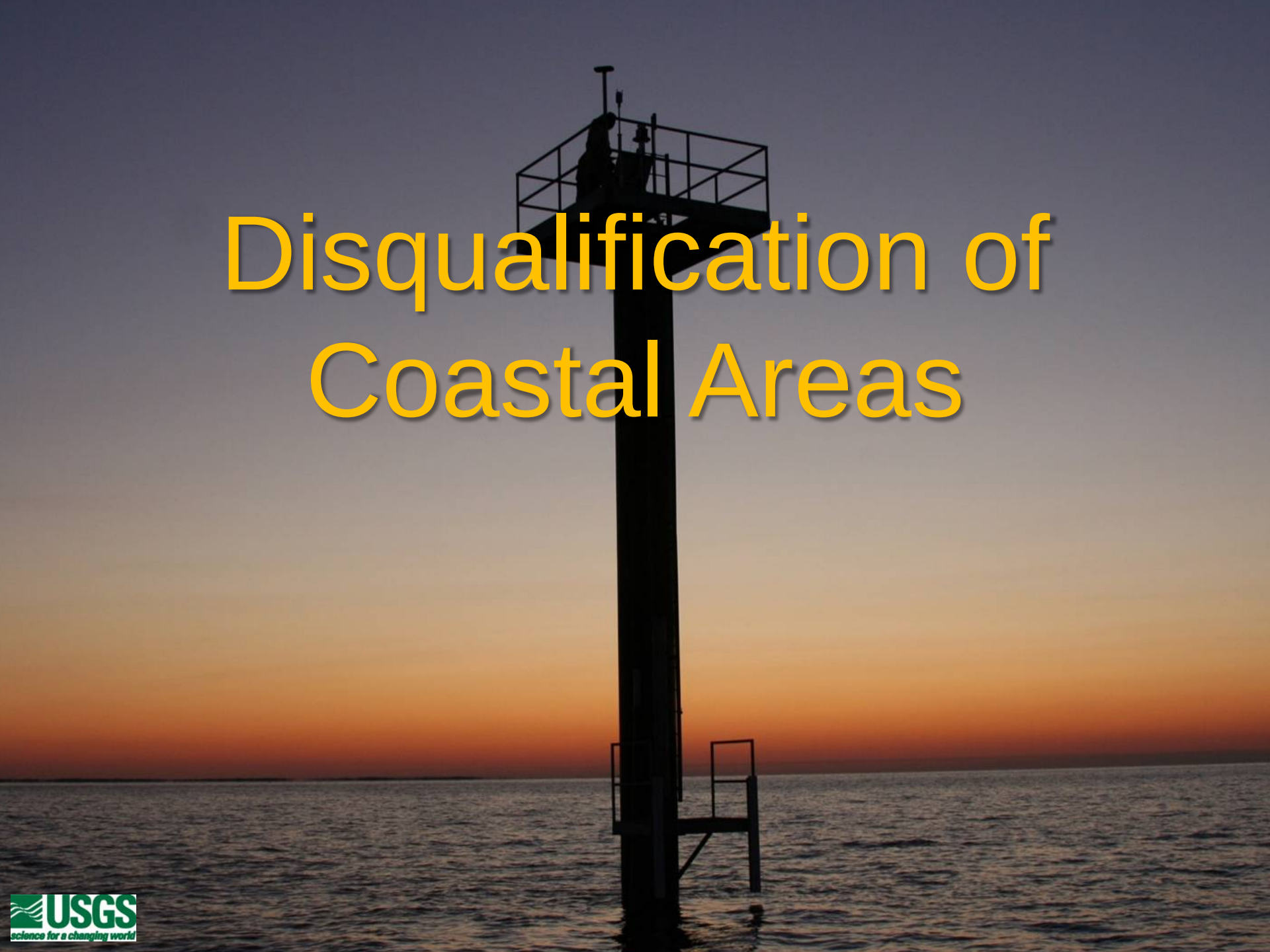
Disqualification of
Coastal Areas
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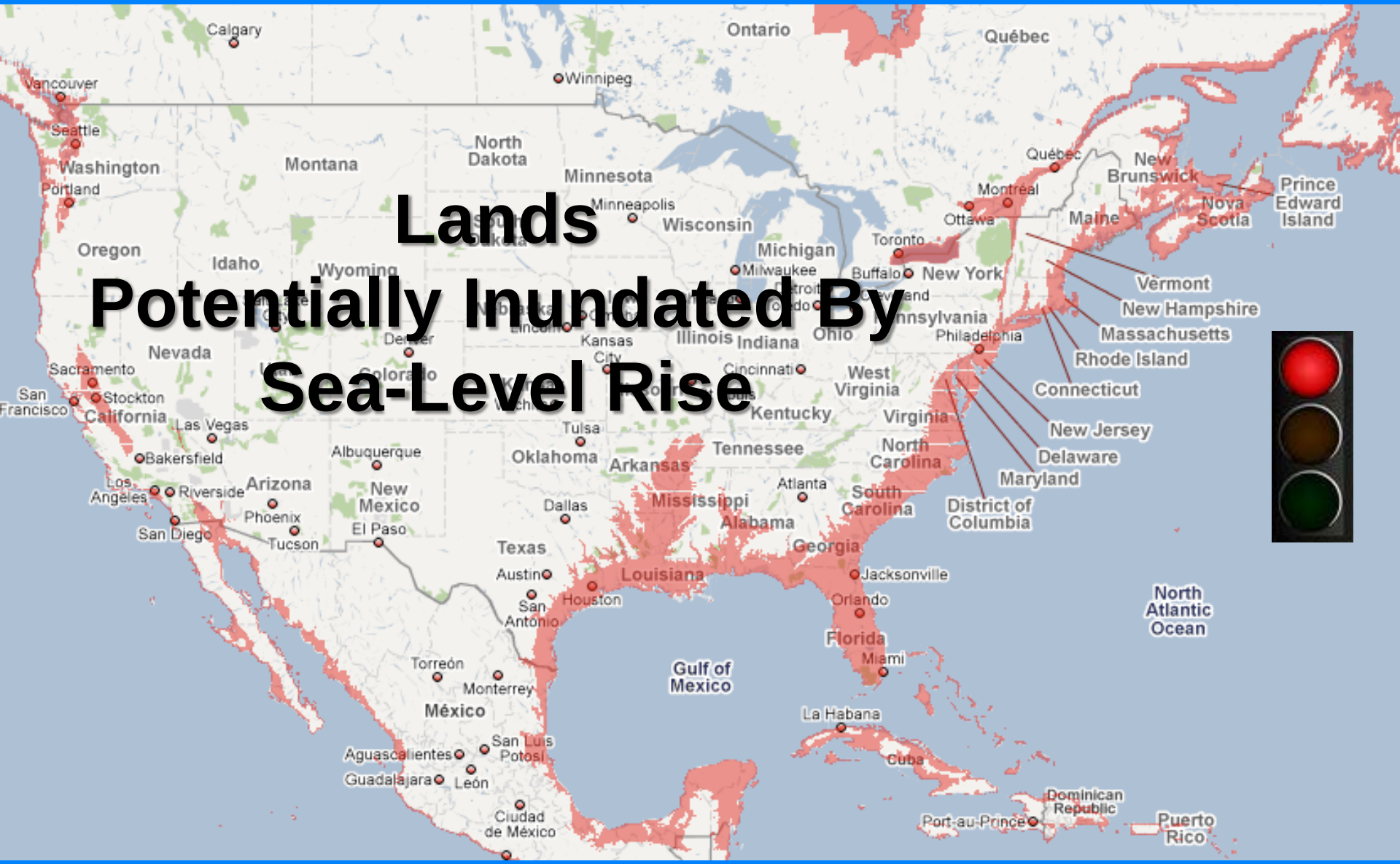
80-Meter Rise in Sea Level



Single Event Sea-Level Rise

- Storm Related (Surge – Seiche)
- Tsunami

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Examples of Potentially Adverse Conditions to be Considered in Early Screening

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Past, Current, & Future Energy & Mineral Resource Areas

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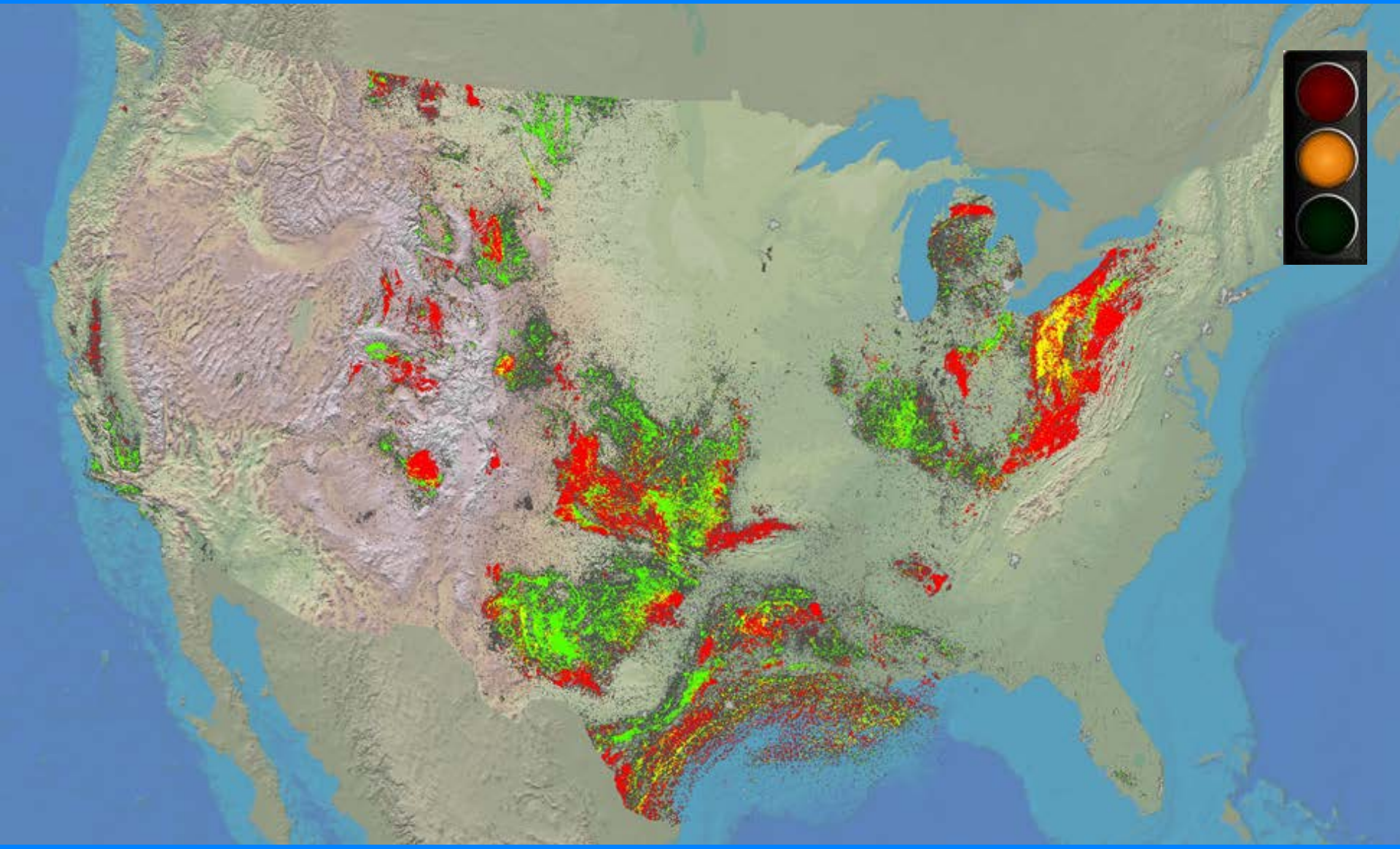
Areas of Historical Oil & Gas Exploration and Production



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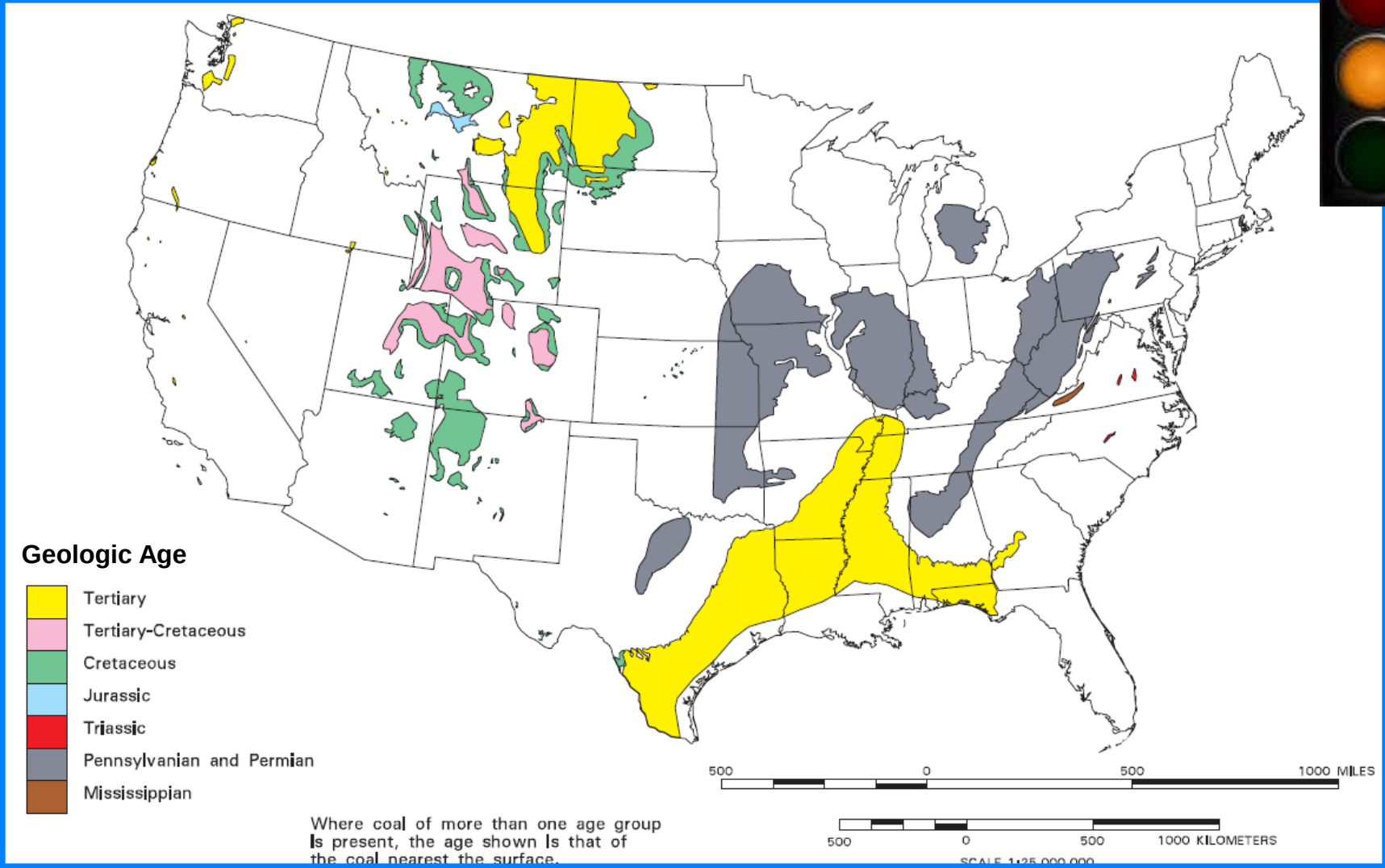
Data from USGS CERSC, DDS-69-Q, 2008

Coal Resources



Data from USGS OFR 96-92

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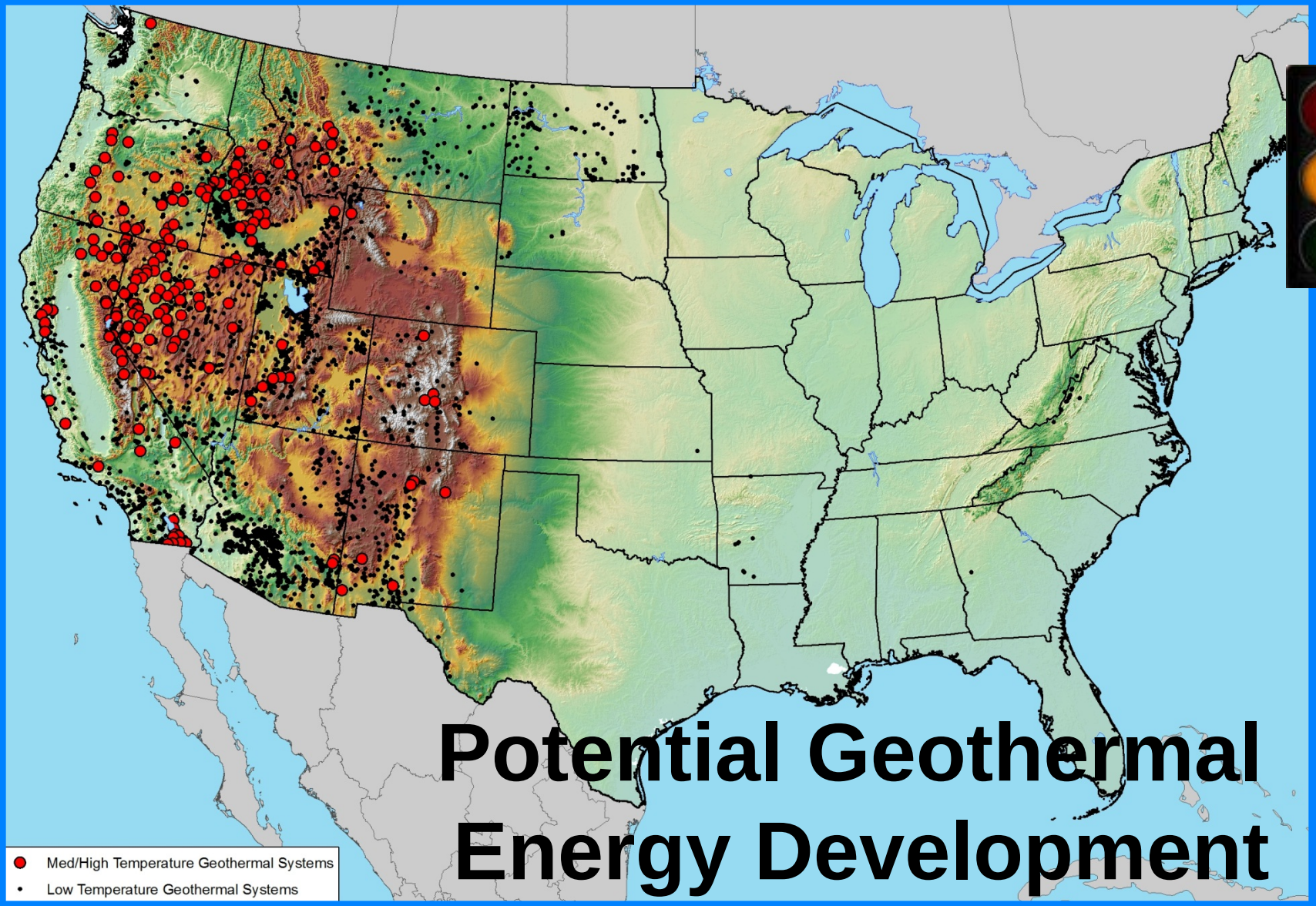
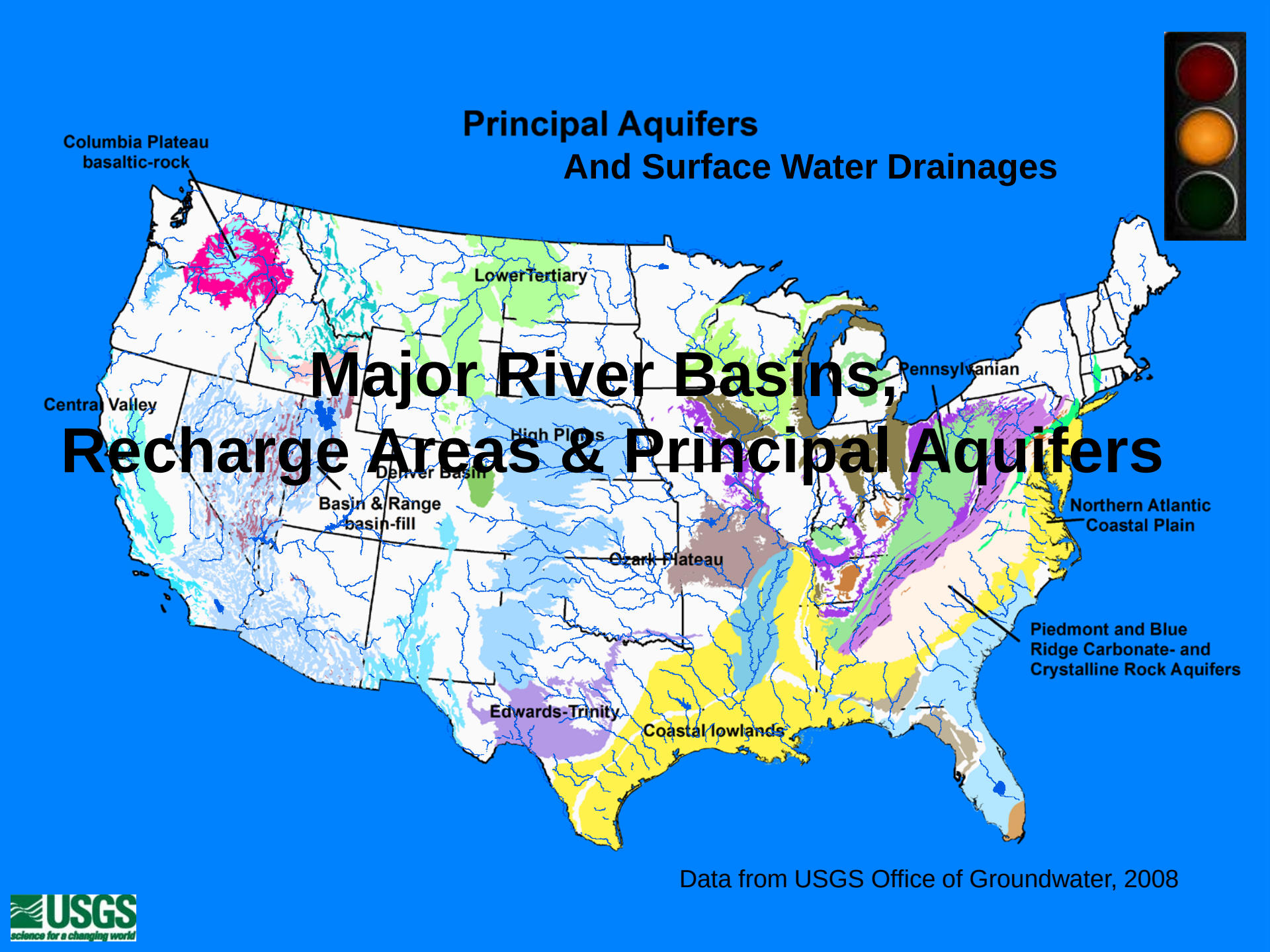
Low-, Medium-, and High-Temperature Geothermal Systems



Data from USGS Energy Resources Program, 2012


Principal Aquifers
And Surface Water Drainages
Columbia Plateau basaltic-rock
Lower Tertiary
Pennsylvanian
Central Valley
High Plains
Denver Basin
Basin & Range basin-fill
Northern Atlantic Coastal Plain
Ozark Plateau
Piedmont and Blue Ridge Carbonate- and Crystalline Rock Aquifers
Edwards-Trinity
Coastal lowlands
Major River Basins,
Recharge Areas & Principal Aquifers
Data from USGS Office of Groundwater, 2008
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Summary & Conclusions
New Siting Process

- Identify disqualifying and potentially adverse conditions to be used in early screening process
- Early screening process
  - Utilize GIS based maps to provide a scientific basis enabling identification of regions and areas for
    - Disqualification and removal from siting consideration
    - Additional evaluation and consideration as a potential host site
  - Identifies potentially suitable regions and areas
  - Narrows search to identify consenting jurisdiction on prequalified regions and areas
  - Satisfies BRC objective ensuring that time/resources are not wasted investigating sites that are clearly inappropriate

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Geo-Policy Considerations

- Natural barriers/engineered barriers or both?
- Isolation time period?
  - 10,000 – 1M yr.
- Retrieval option?
  - If so, for how long?
- Disposal concept?
- Unsaturated zone/saturated zone or both?

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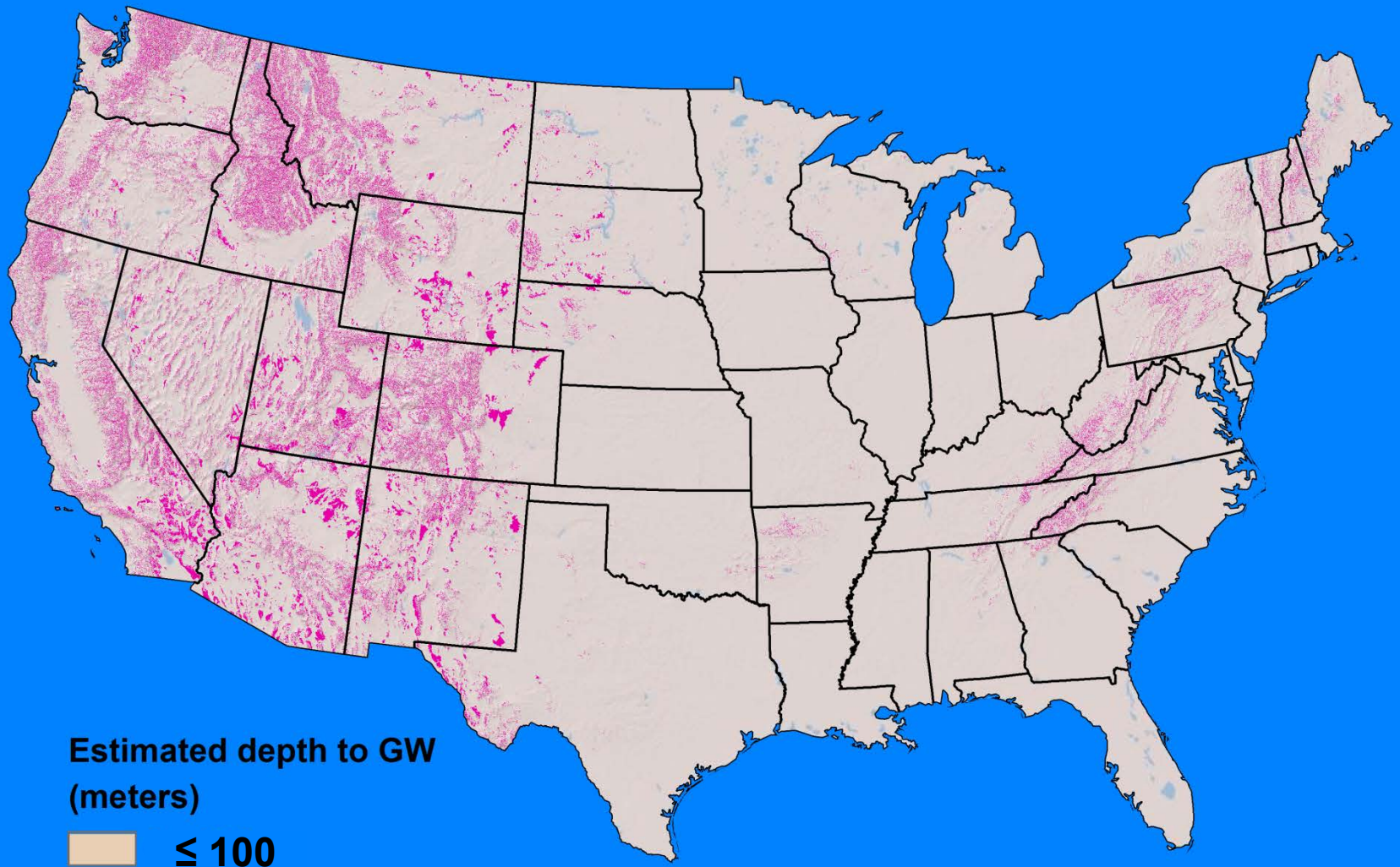
Generalized Depth to Groundwater



Original data from USGS NWIS
Modeled data from Fan and others, 2007

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Who Are “Consenters”?

“… consent ultimately has to be answered by potential host jurisdiction, using whatever means and timing it sees fit.”

“…willingness of affected units of government – the host states, tribes, and local communities – to enter into legally binding agreements with the facility operator, where these agreements enable states, tribes, and communities to have confidence that they can protect the interests of their citizens.”

-Blue Ribbon Commission

January 2012

Final Report

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Representation of Multi-Resource Users

- Traditional government entities (tribes, states, and local communities) potentially too limited
- Perhaps a broader community of stakeholders including current and future multi-resource users more appropriate
  - For example, consenters hypothetically could include downstream basin and principal aquifer water-resource users

Examples of Information to be Updated Since Culmination of the First Repository Siting Process

- Geologic information
- Energy and Mineral development
- Water Resources
- Seismicity
- Climate Change
- Land Use
- Critical Habitat and Ecosystems

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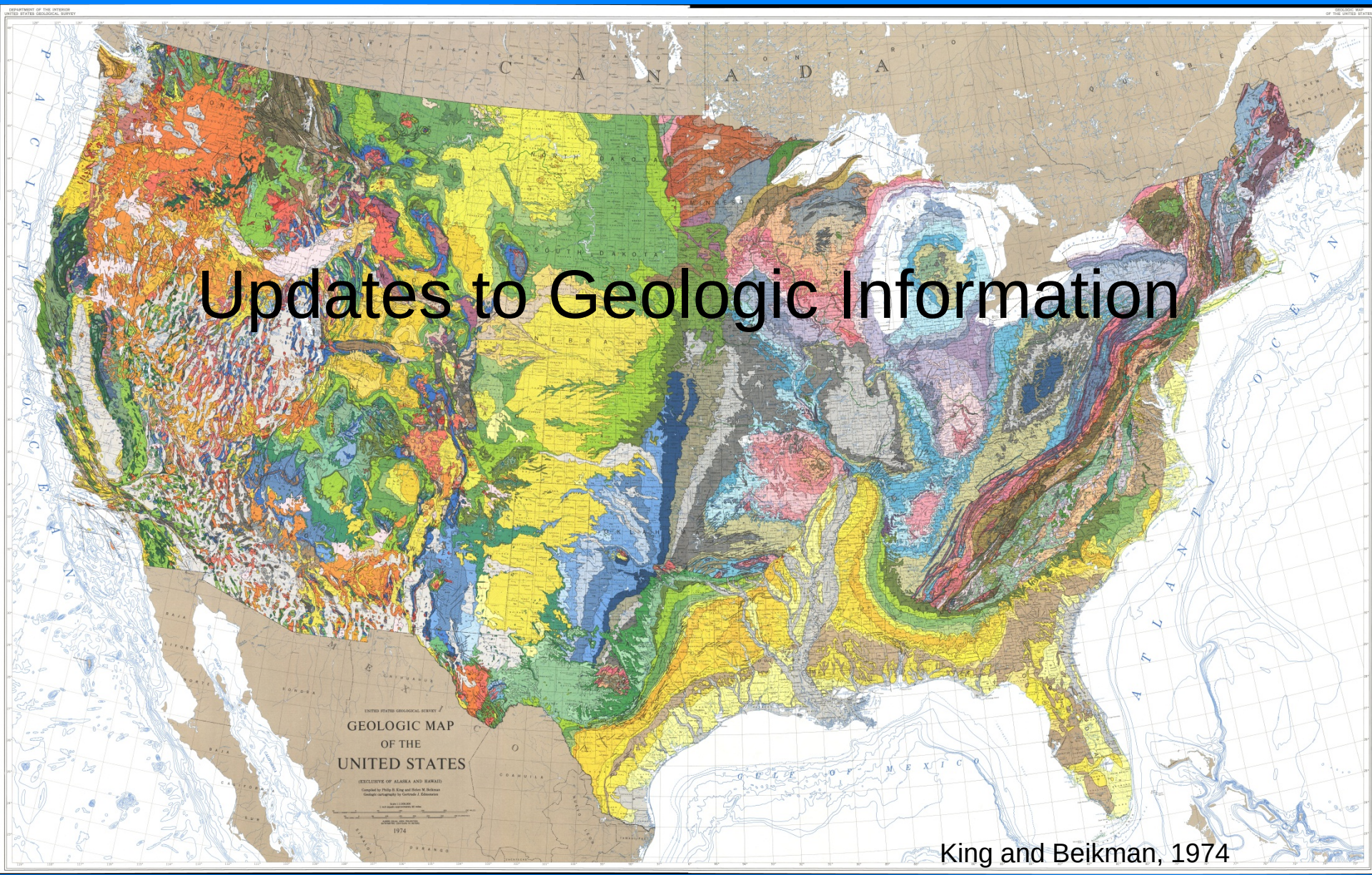
Geology of the U.S.



New Energy Exploration & Development

Recent Technological Advances
Now Being Utilized to Recover Resources Previously Not Economically Recoverable

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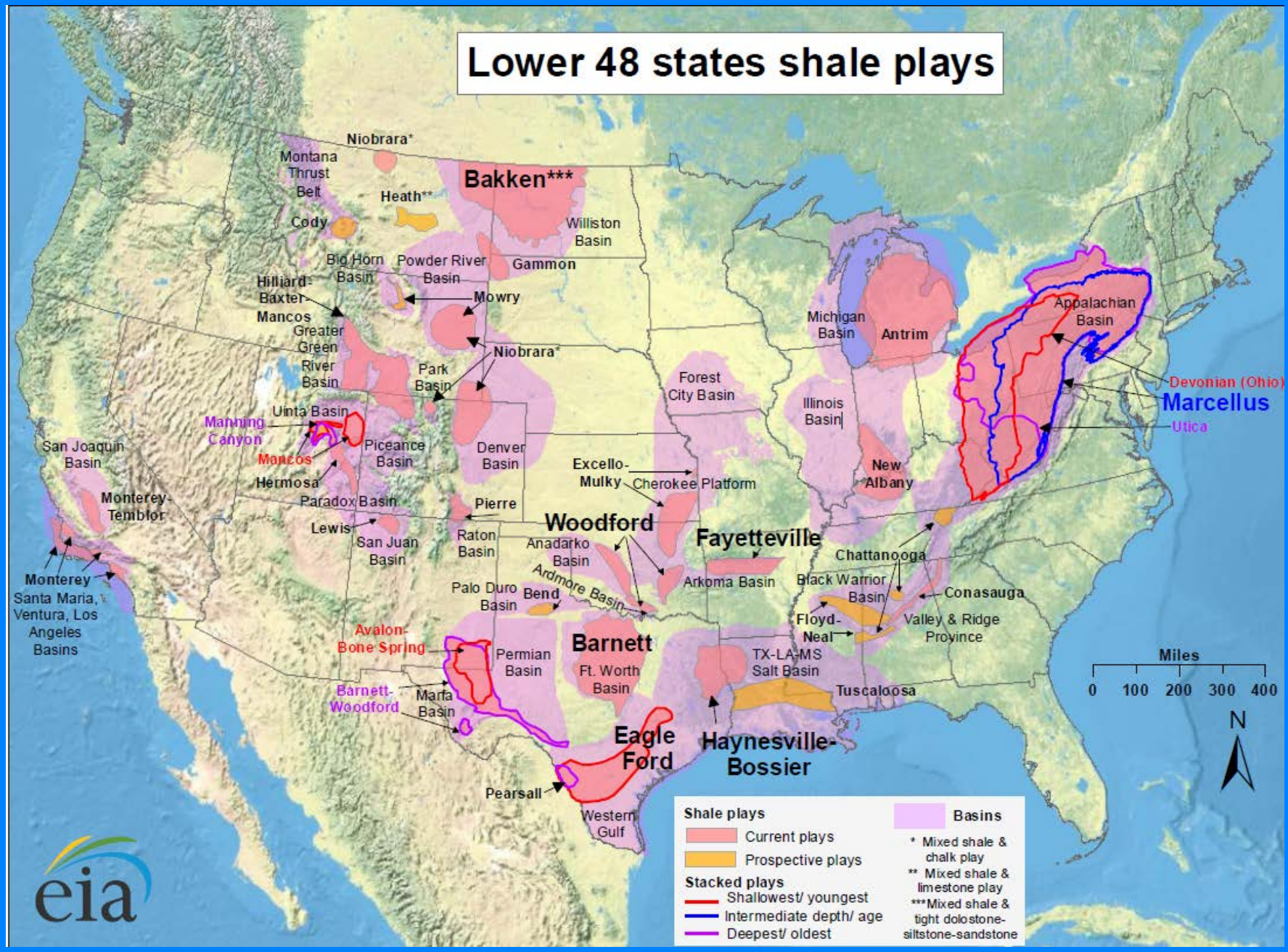
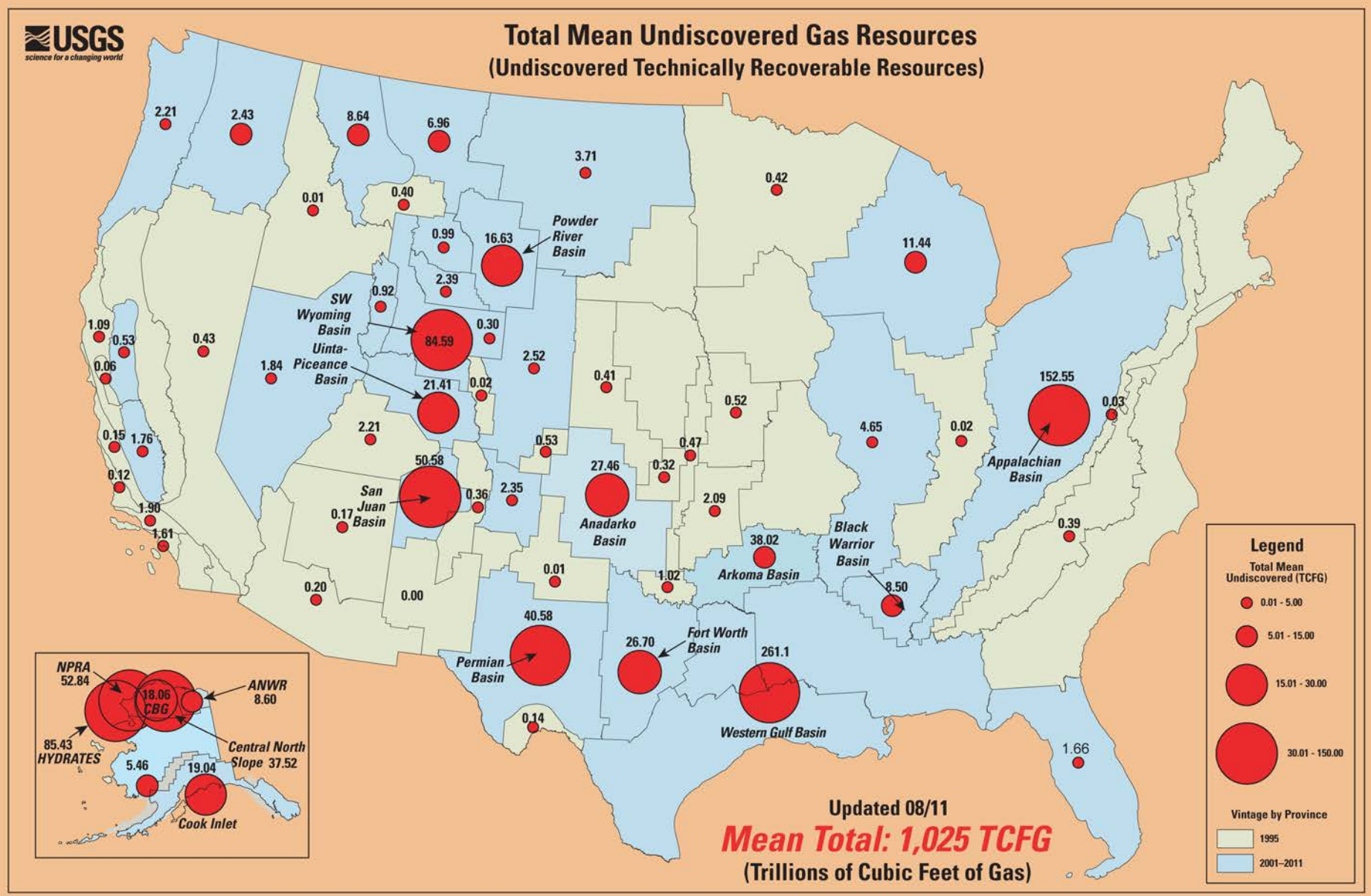


Energy Information Administration based on data from various published studies
Updated May 9, 2011



From USGS Energy Resources Program, 2011

Future Uncertainty on the Nation's Continued Reliance on Traditional Energy Sources: Coal?

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Mining of Metals and Industrial Minerals

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Principal Rare Earth Elements Deposits

Data from USGS SIR 2010-5220

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Demands on Water Resources

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And Water Quality
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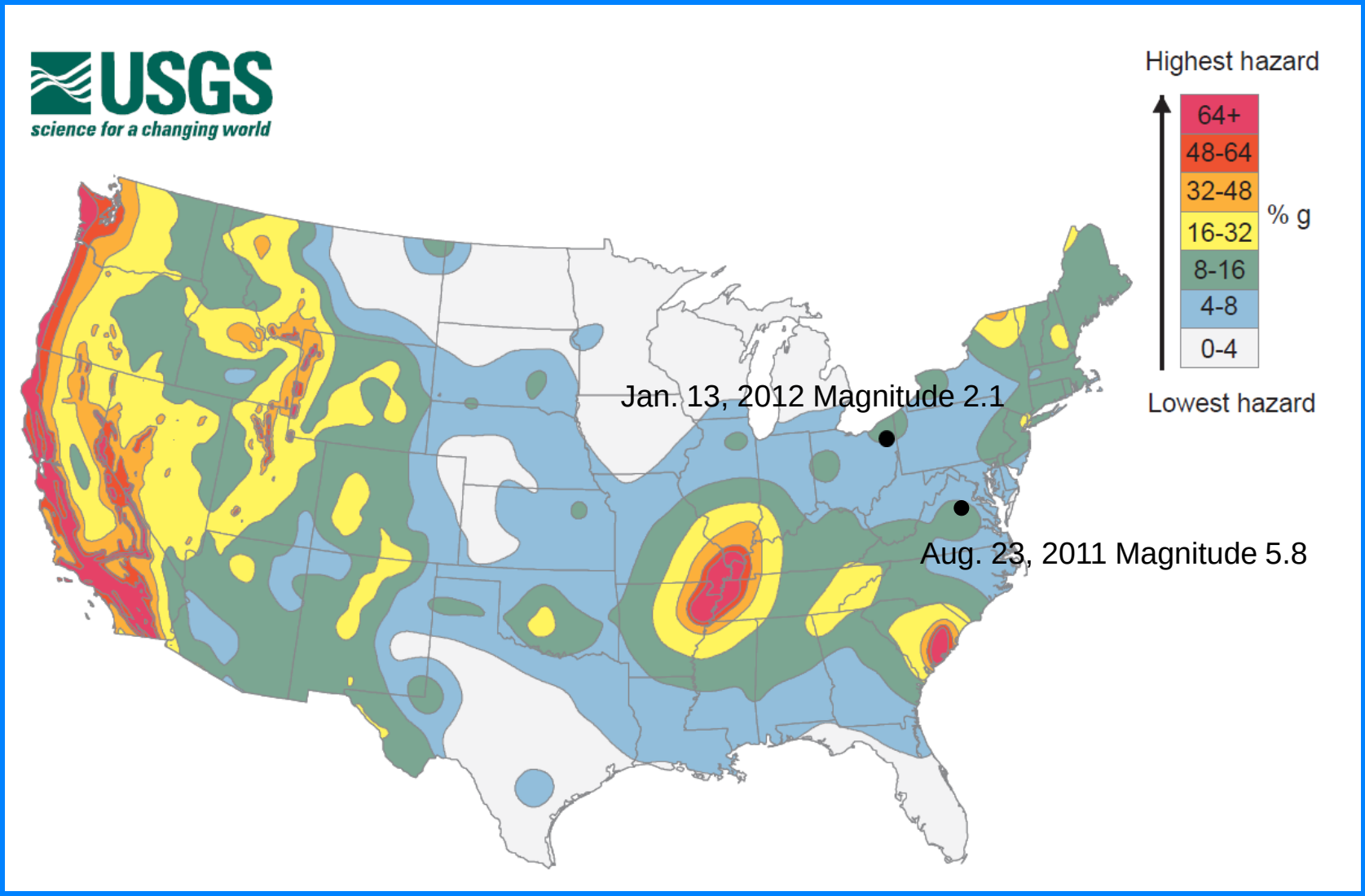
Seismic-Hazard Map for the U.S.



Data from USGS Earthquake Hazards Program, 2008

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Hydraulic Fracturing - Induced Seismicity?

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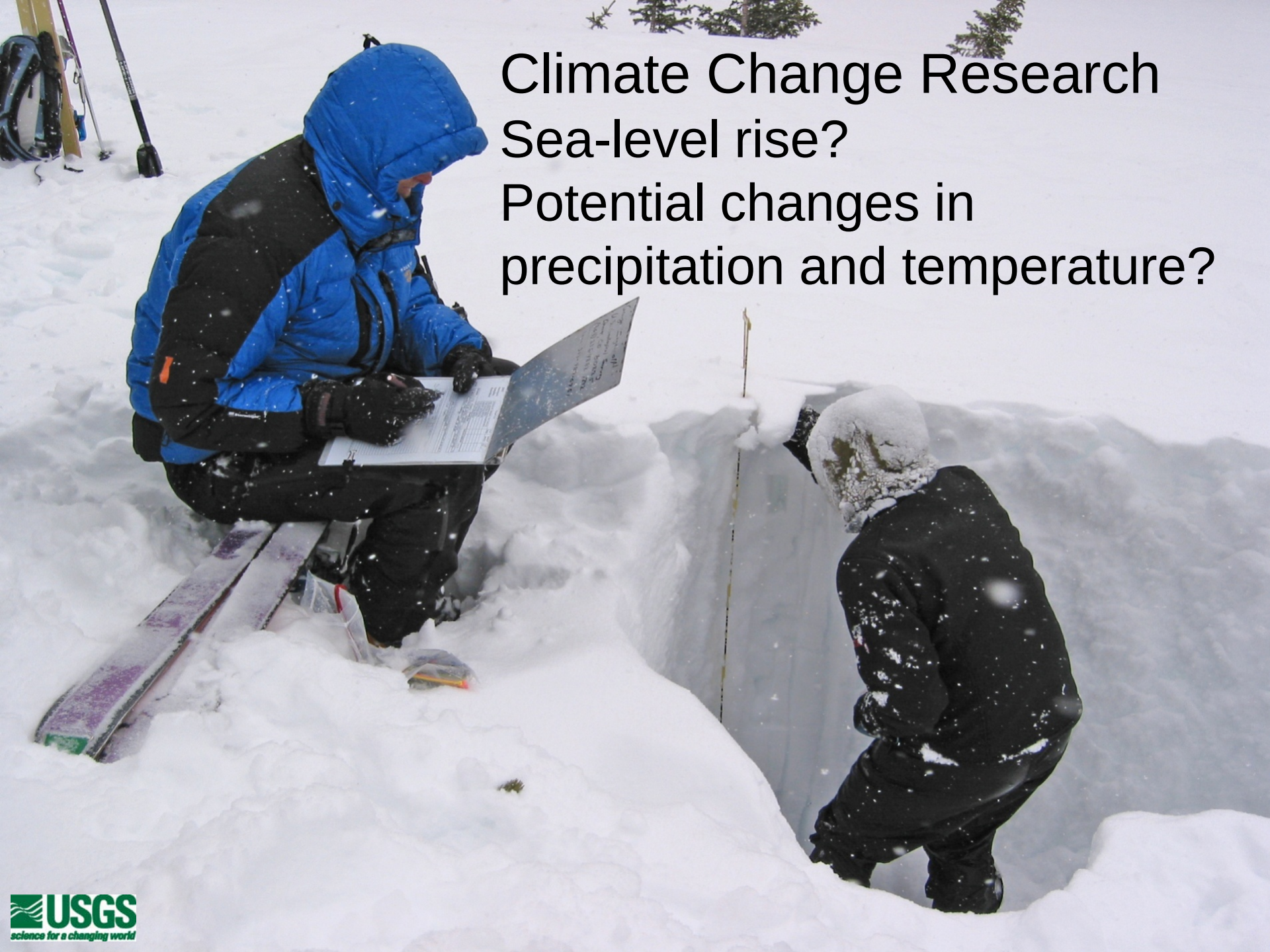
Climate Change Research
Sea-level rise?
Potential changes in
precipitation and temperature?
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Incompatible Land Uses Resulting in Conflict

Increased Pressures on Critical Ecosystems, Species, & Habitats

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Summary

- 1st repository siting process relied upon extensive Earth science inputs
- Scientific review of the 1st repository siting process legacy documents is needed to determine if the conclusions reached previously are still valid based on our present-day scientific understanding
- Implementation of early screening processes and supporting GIS platforms to distinguish earth, natural science, and land-use attributes will provide a scientific basis enabling identification of areas for:
  - Disqualification and removal from siting consideration
  - Additional evaluation and consideration as a potential site

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Summary -- continued

- A comprehensive early screening process that identifies disqualifying and adverse conditions will:
  - Standardize the process for identifying potentially acceptable sites
  - Be economically advantageous and provide for optimal utilization of resources
  - Maximize efficiencies in the licensing process
- Numerous Geo-Policy considerations: scientific/technical informed consensus needed
- Technological advances and long-term demand will continue to propel energy and minerals development

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Summary -- continued

- Increased competition over the Nation's land uses and finite natural resources will be a challenge to the new repository siting process
- 15- to 20-year site selection process anticipated (BRC, 2012); therefore siting criteria requires a futuristic approach to remain viable

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Nation’s Challenge

- Develop an efficient and scientifically informed process leading to a site selection that has “consent” of appropriate governmental entities as well as current and future multi-resource users and is accepted by the public

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Questions?

Background Information

- USGS organization chart
- Siting consideration miscellaneous example maps
  - Map illustrating areas where subsidence has been attributed to the compaction of aquifer systems caused by ground-water pumpage (USGS FS 165-00)
  - Map illustrating areas of evaporite rocks – salt and gypsum and karst from evaporite rock and carbonate rock (USGS FS 165-00)
  - Coal mine and facilities map (USGS Map I-2654)
- Resource update example maps
  - Major Metal Producing Areas
  - Major Industrial Mineral Producing Areas part I
  - Major Industrial Mineral Producing Areas part II
  - Principal Aquifers, Major River Drainages, and Crops and Grains

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Background Information for 1st Repository Siting Process

- A comprehensive summary of the 1st repository siting process can be found in:

  Geological Society of America Memoir 199, Vol. 1, *The Geology and Climatology of Yucca Mountain and Vicinity, Southern Nevada and California,* 2007 (introduction, pages 1-3)

- Selected examples of 1st repository siting process reports and publications

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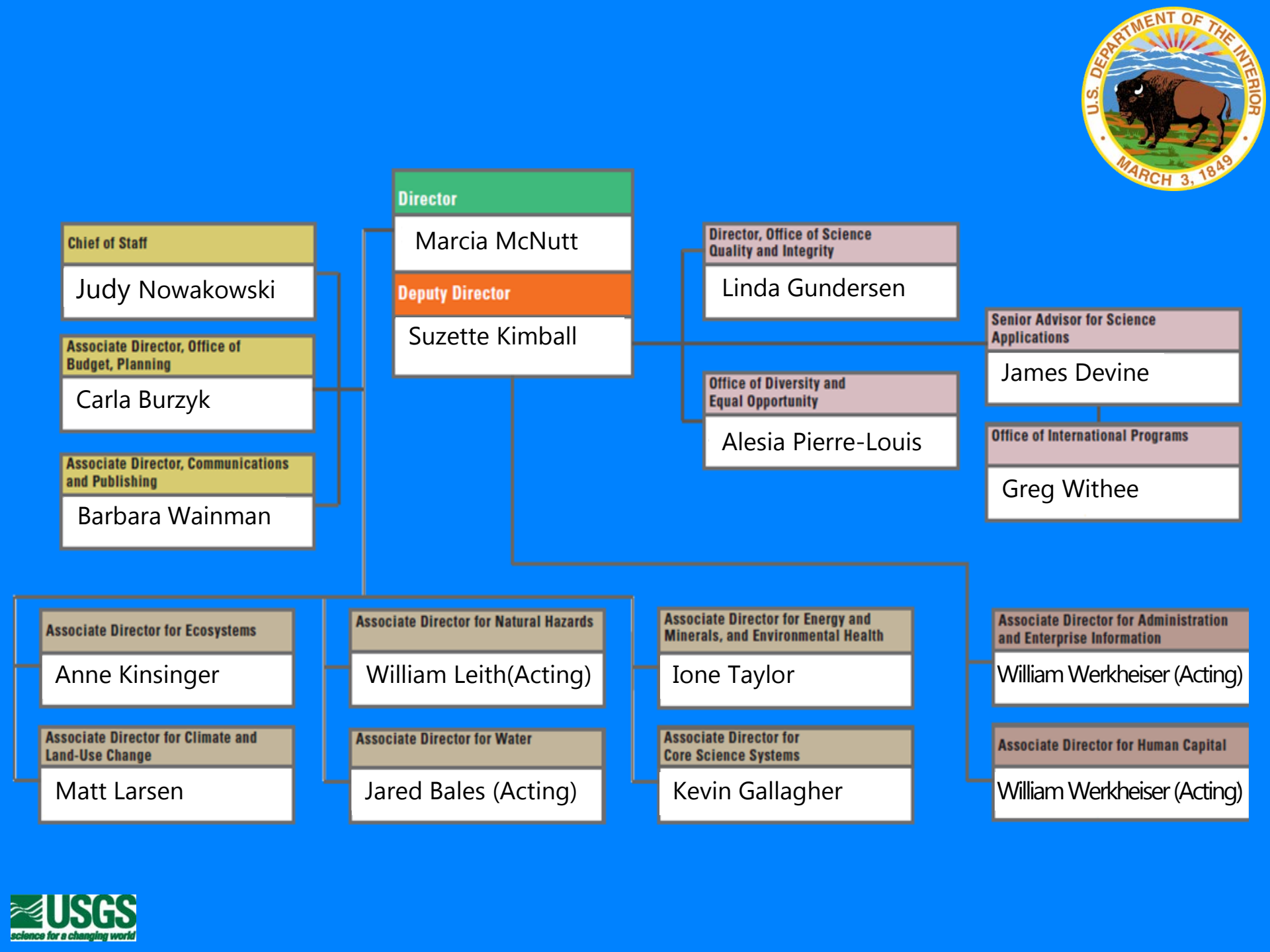
Director
Marcia McNutt
Deputy Director
Suzette Kimball
Chief of Staff
Judy Nowakowski
Associate Director, Office of Budget, Planning
Carla Burzyk
Associate Director, Communications and Publishing
Barbara Wainman
Director, Office of Science Quality and Integrity
Linda Gundersen
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Senior Advisor for Science Applications
James Devine
Office of International Programs
Greg Withee
Associate Director for Ecosystems
Anne Kinsinger
Associate Director for Climate and Land-Use Change
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Associate Director for Natural Hazards
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Jared Bales (Acting)
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Ione Taylor
Associate Director for Core Science Systems
Kevin Gallagher
Associate Director for Administration and Enterprise Information
William Werkheiser (Acting)
Associate Director for Human Capital
William Werkheiser (Acting)

Siting Consideration
Miscellaneous Example Maps

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Areas Where Subsidence has been Attributed to The Compaction of Aquifer Systems Caused by Groundwater Pumpage

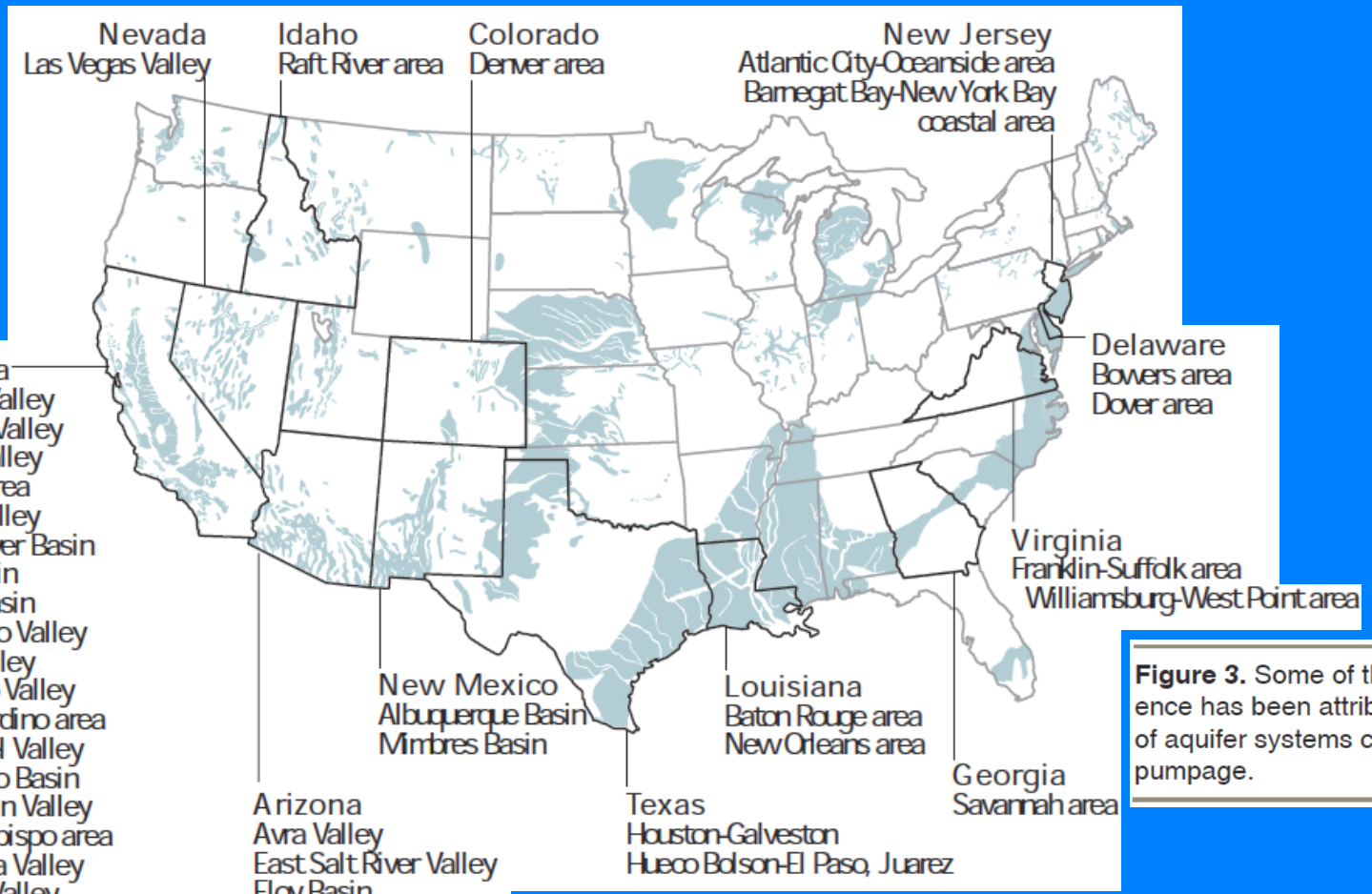

Figure 3. Some of the areas where subsidence has been attributed to the compaction of aquifer systems caused by ground-water pumpage.

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From USGS FS 165-00

Areas of Evaporite rocks—Salt and Gypsum and Karst from Evaporite Rock and Carbonate Rock

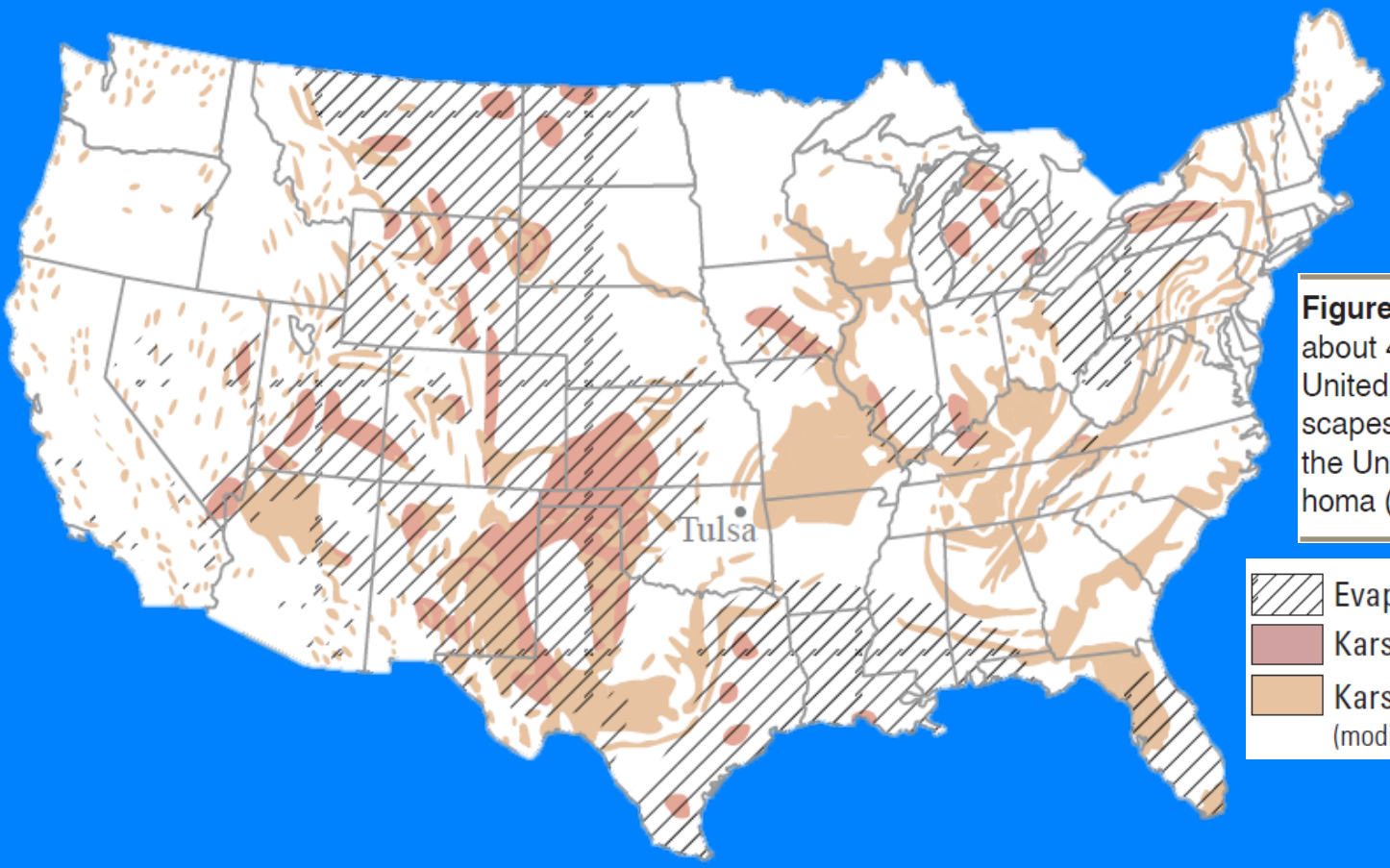

Figure 9. Salt and gypsum underlie about 40 percent of the contiguous United States. Carbonate karst landscapes constitute about 40 percent of the United States east of Tulsa, Oklahoma (White and others, 1995).

Evaporite rocks—salt and gypsum
Karst from evaporite rock
Karst from carbonate rock
(modified from Davies and Legrand, 1972

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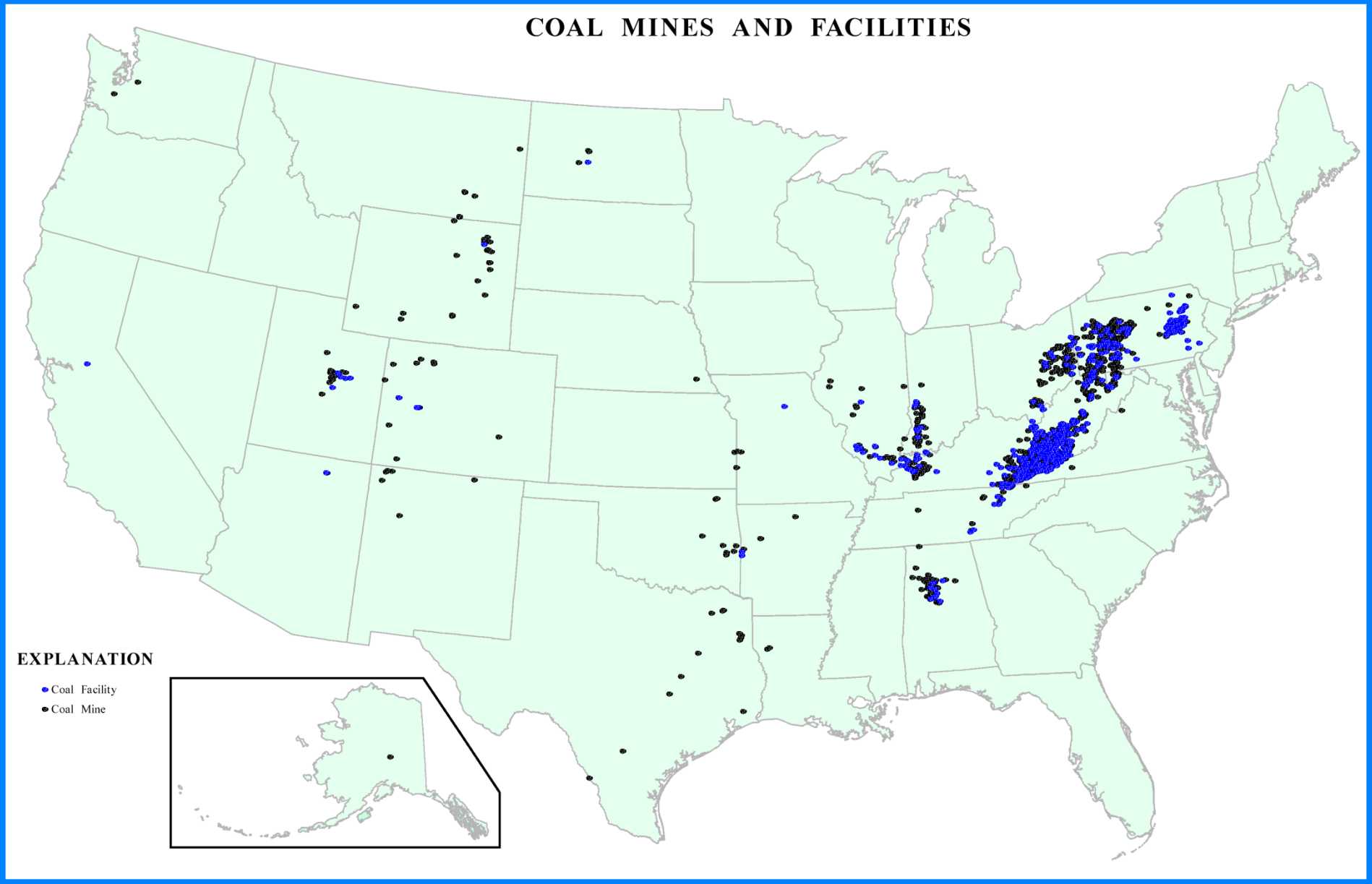
From USGS Fact Sheet 165-00

COAL MINES AND FACILITIES



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Data from USGS Map I-2654

Resource Update Example Maps

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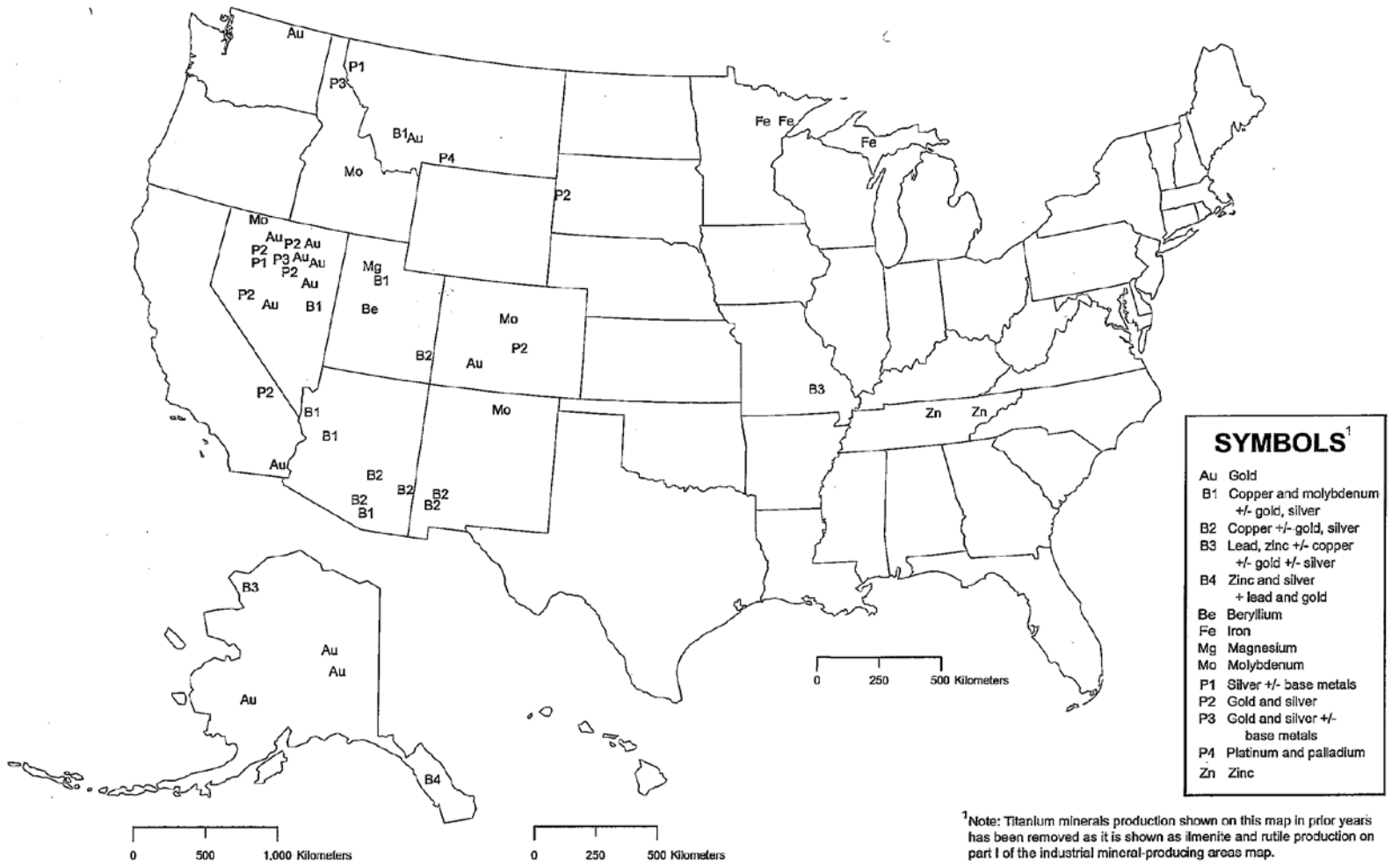
MAJOR METAL-PRODUCING AREAS



SYMBOLS[1]

Au	Gold
B1	Copper and molybdenum +/- gold, silver
B2	Copper +/- gold, silver
B3	Lead, zinc +/- copper +/- gold +/- silver
B4	Zinc and silver + lead and gold
Be	Beryllium
Fe	Iron
Mg	Magnesium
Mo	Molybdenum
P1	Silver +/- base metals
P2	Gold and silver
P3	Gold and silver +/- base metals
P4	Platinum and palladium
Zn	Zinc

[1]Note: Titanium minerals production shown on this map in prior years has been removed as it is shown as ilmenite and rutile production on part I of the industrial mineral-producing areas map.

Data from USGS Mineral Commodity Summaries, 2012

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MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART I

Data from USGS Mineral Commodity Summaries, 2012

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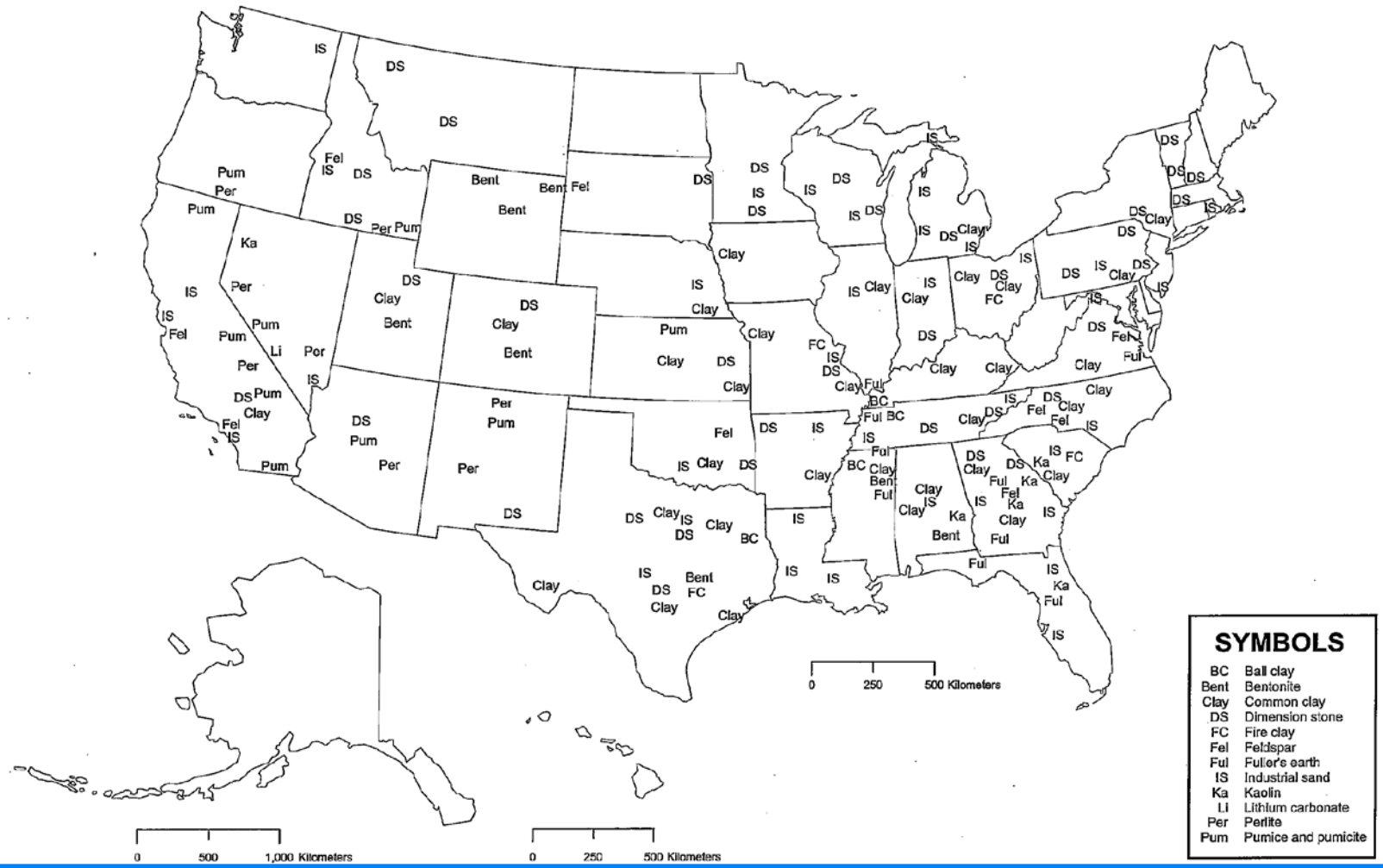
MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART II



Data from USGS Mineral Commodity Summaries, 2012

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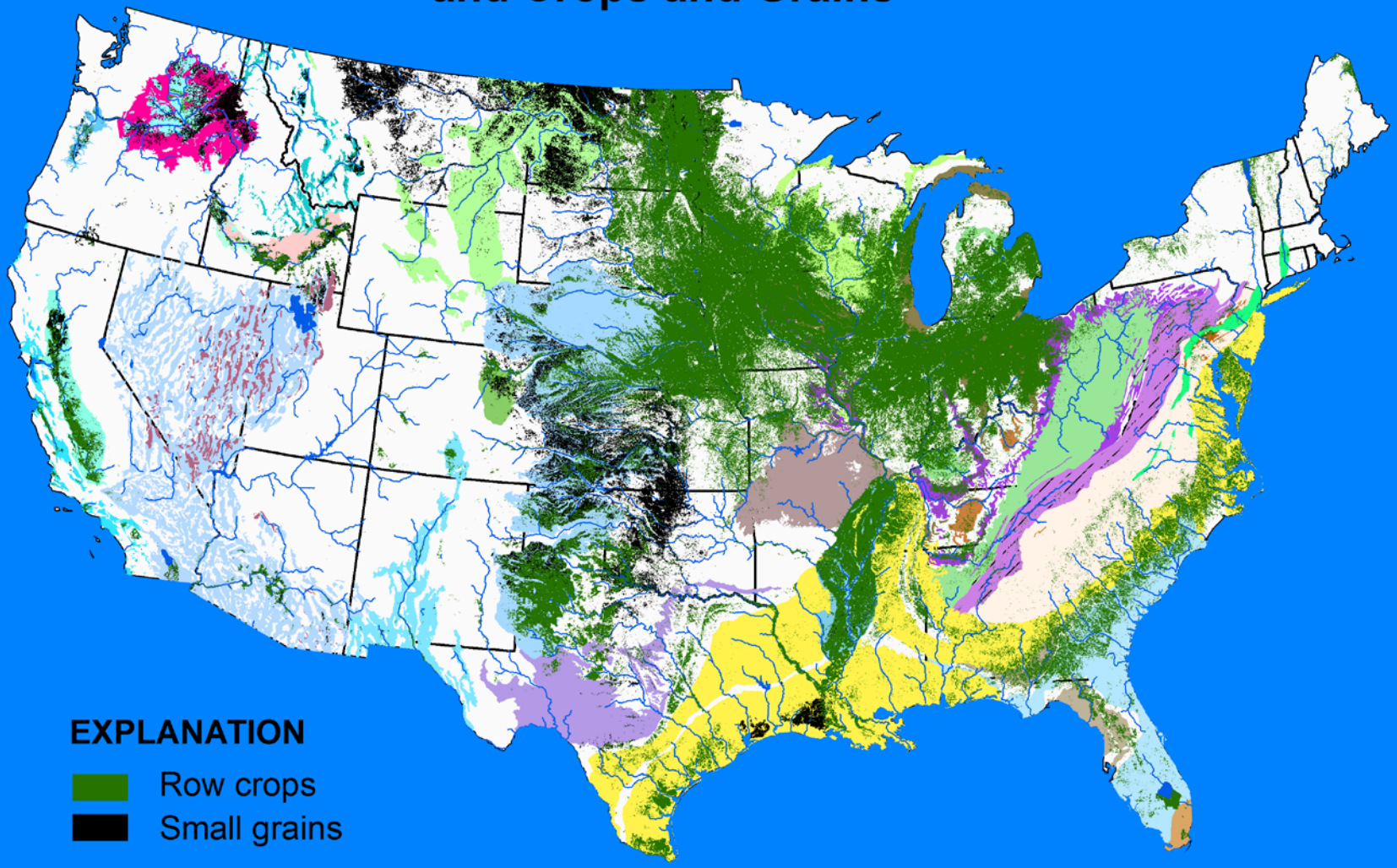
Principal Aquifers, Surface Water Drainages, and Crops and Grains



Original crop data from the National Land Cover Dataset
Enhancements by USGS NAWQA Program, 2005

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Background Information for 1st Repository Siting Process

- Selected examples of 1st repository siting process reports and publications follow

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SUMMARY OF ROCK SALT DEPOSITS IN THE UNITED STATES AS POSSIBLE DISPOSAL SITES FOR RADIOACTIVE WASTE*

By

W. G. Pierce and E. I. Rich

May 1958

Trace Elements Investigations Report 725

This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature. It is not for public inspection or quotation.

*This report concerns work done on behalf of the Division of Reactor Development of the U. S. Atomic Energy Commission.

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

GEOLOGIC SUMMARY OF THE APPALACHIAN BASIN, WITH REFERENCE TO THE SUBSURFACE DISPOSAL OF RADIOACTIVE WASTE SOLUTIONS*

By

George W. Colton

June 1961

Report TEI-791

This report is preliminary and has not been edited for conformity with Geological Survey format and nomenclature.

*Prepared on behalf of the U. S. Atomic Energy Commission.

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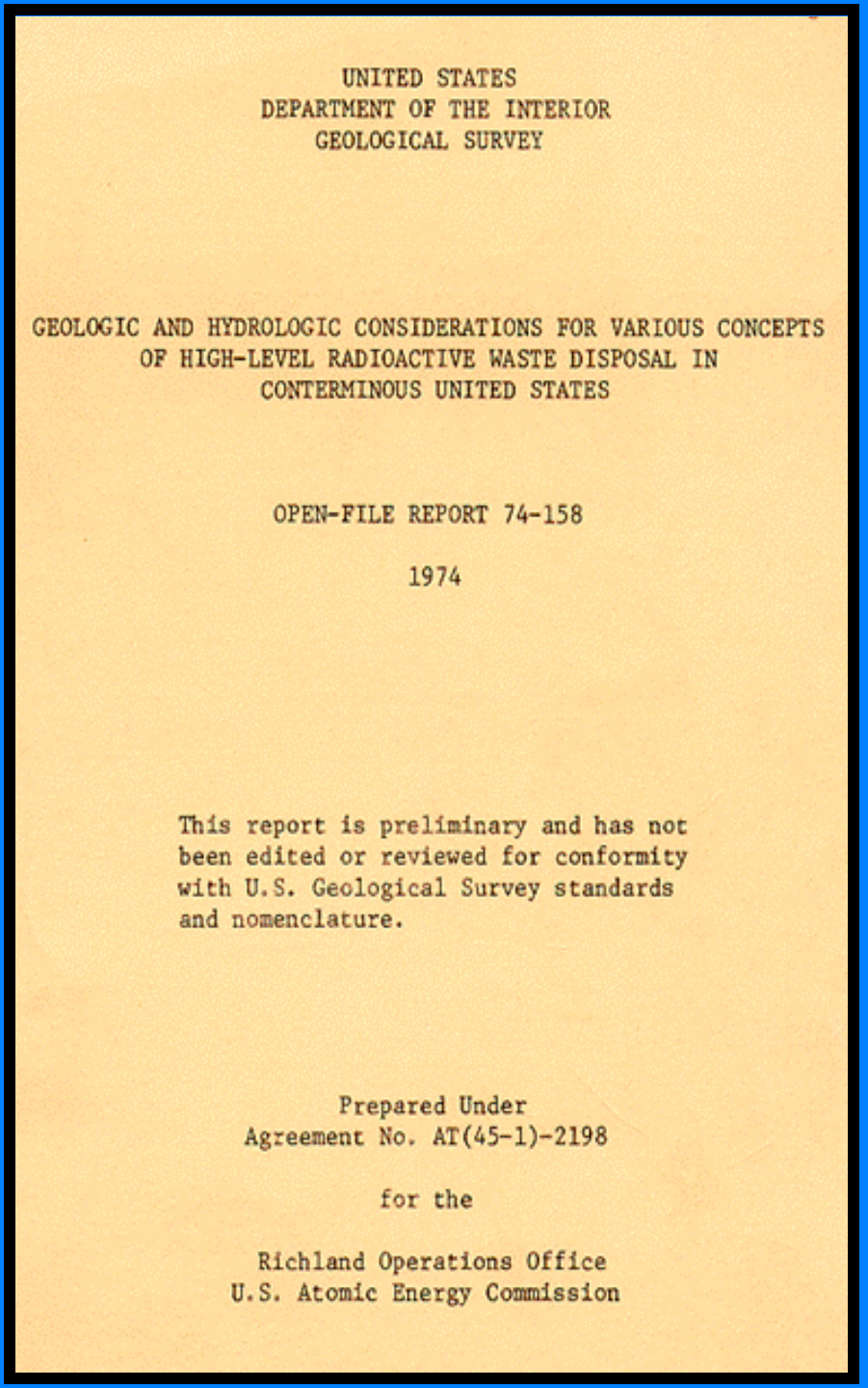

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GEOLOGIC AND HYDROLOGIC CONSIDERATIONS FOR VARIOUS CONCEPTS OF HIGH-LEVEL RADIOACTIVE WASTE DISPOSAL IN CONTERMINOUS UNITED STATES

OPEN-FILE REPORT 74-158

1974

This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

Prepared Under
Agreement No. AT(45-1)-2198

for the

Richland Operations Office
U.S. Atomic Energy Commission

This 1974 report cites 30 previous reports on radioactive waste disposal and proposes several optimal considerations:

Hydrologic isolation was paramount, and therefore, low permeability rock and a virtually fault-free site were recommended.

The site should have a low seismic risk;

low possibility of flooding by rising sea level;

low potential hazard for surface or groundwater regimes in glacial or pluvial climates; and

low potential for exhumation by erosion.

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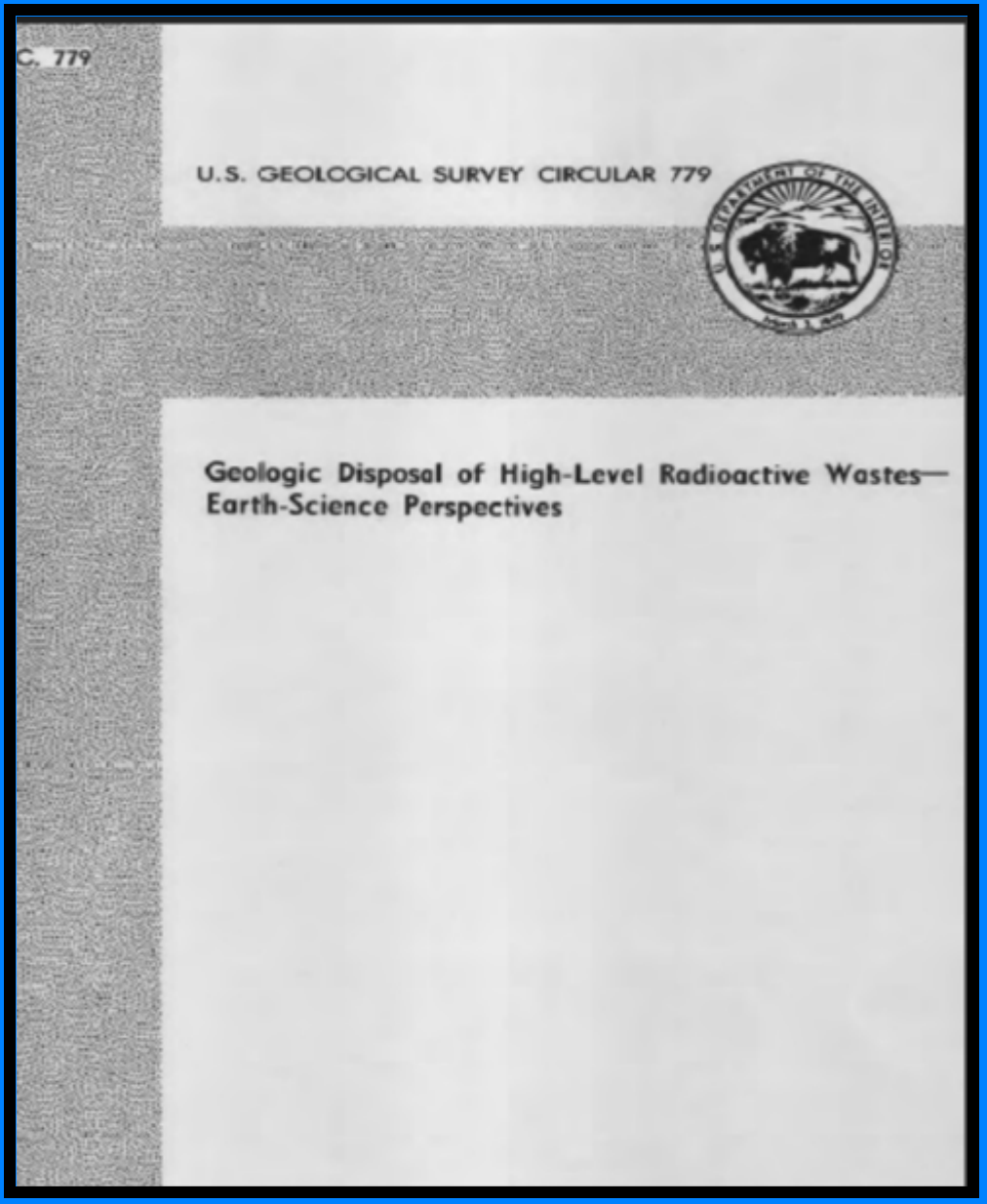
C. 779

U.S. GEOLOGICAL SURVEY CIRCULAR 779

Geologic Disposal of High-Level Radioactive Wastes—
Earth-Science Perspectives

Many questions regarding the behavior of Salt need to be resolved (solubility, retrievability, mechanical strength, etc.)

Other media such as shales and crystalline rocks need to be evaluated.

Thick unsaturated zones need to be considered

Better investigative tools need to be developed (e.g. groundwater dating > 40,000 yrs)

More research on the short- and long-term ability of a repository to localize escape of radionuclides

Bredehoeft, England, Stewart, Trask, and Winograd, 1978

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CIRC. 779

GEOLOGICAL SURVEY CIRCULAR 779

Geologic Disposal of High-Level Radioactive Wastes—Earth-Science Perspectives

2nd printing 1979

CIRC. 847

GEOLOGICAL SURVEY CIRCULAR 847

U.S. Geological Survey Research in Radioactive Waste Disposal—Fiscal Year 1979

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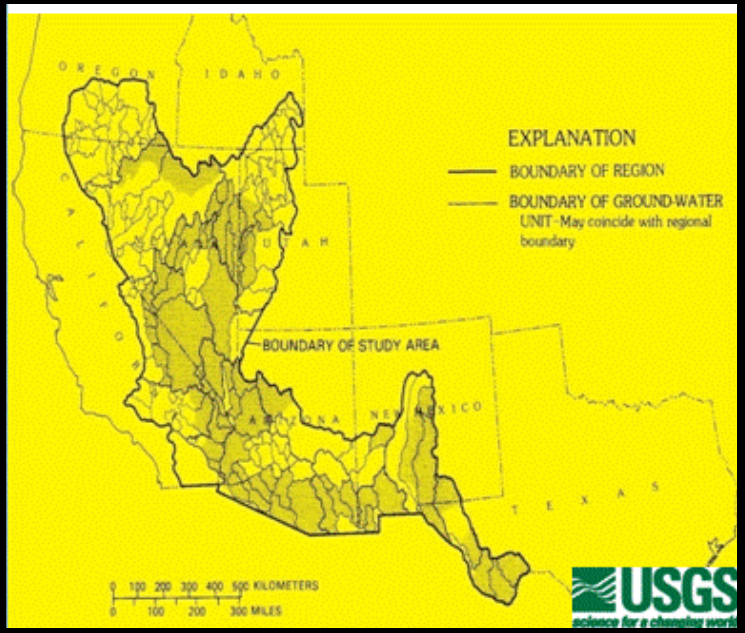
Studies of Geology and Hydrology in the Basin and Range Province, Southwestern United States, For Isolation of High-Level Radioactive Waste—Basis of Characterization and Evaluation

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1370-A

Prepared in cooperation with the States of Arizona, California, Idaho, Nevada, New Mexico, Texas, and Utah

USGS science for a changing world

In 1981, The USGS and 7 state agencies began evaluating the Basin and Range province for possible sites for the disposal of high-level radioactive waste. The results were published in a series of 8 USGS Professional Papers.



USGS science for a changing world

SUMMARY OF NORTHERN ATLANTIC COASTAL PLAIN HYDROLOGY AND ITS RELATION TO DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE IN BURIED CRYSTALLINE ROCK - A PRELIMINARY APPRAISAL

By Orville B. Lloyd, Jr., Jerry D. Larson and Robert W. Davis

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 85-4146

Raleigh, North Carolina
1985

UNITED STATES DEPARTMENT OF INTERIOR

GEOLOGICAL SURVEY

Exploration of Crystalline Rocks for Nuclear Waste Repositories: Some Strategies for Area Characterization

by

N. J. Trask[1], E. H. Roseboom[1], R. D. Watts[1], and M. S. Bedinger[2]

Open-File Report 86-379

Prepared in cooperation with U.S. Department of Energy

This report is preliminary and has not been reviewed for conformity with U. S. Geological Survey editorial standards and stratigraphic nomenclature.

1. Reston, VA
2. Lakewood, CO

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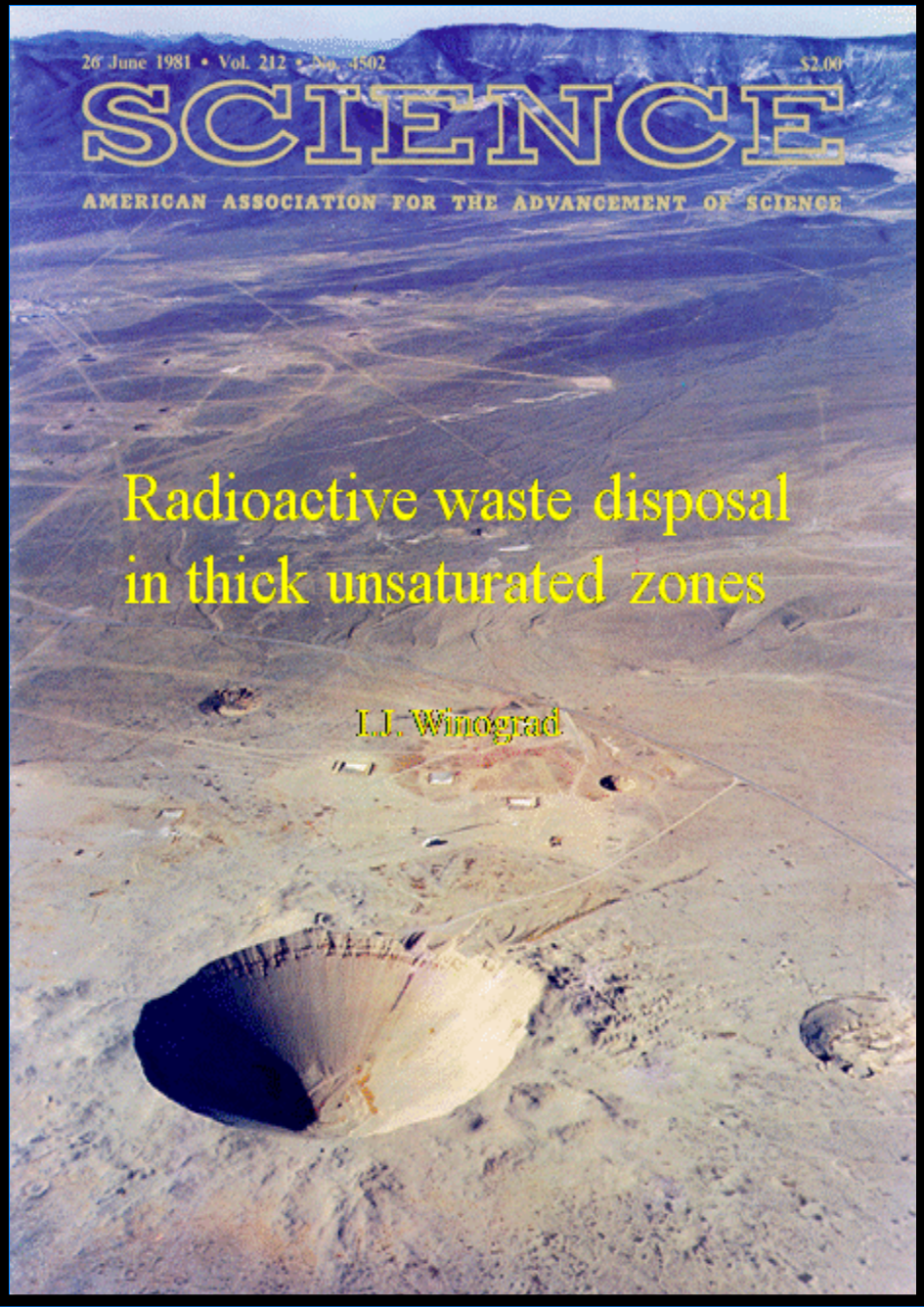

CIRC. 903

GEOLOGICAL SURVEY CIRCULAR 903

Disposal of High-Level Nuclear Waste Above the Water Table in Arid Regions

E.H. Roseboom, Jr.

1983

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