A Department of Energy (DOE)-funded field laboratory dedicated to furthering the study of Enhanced Geothermal Systems

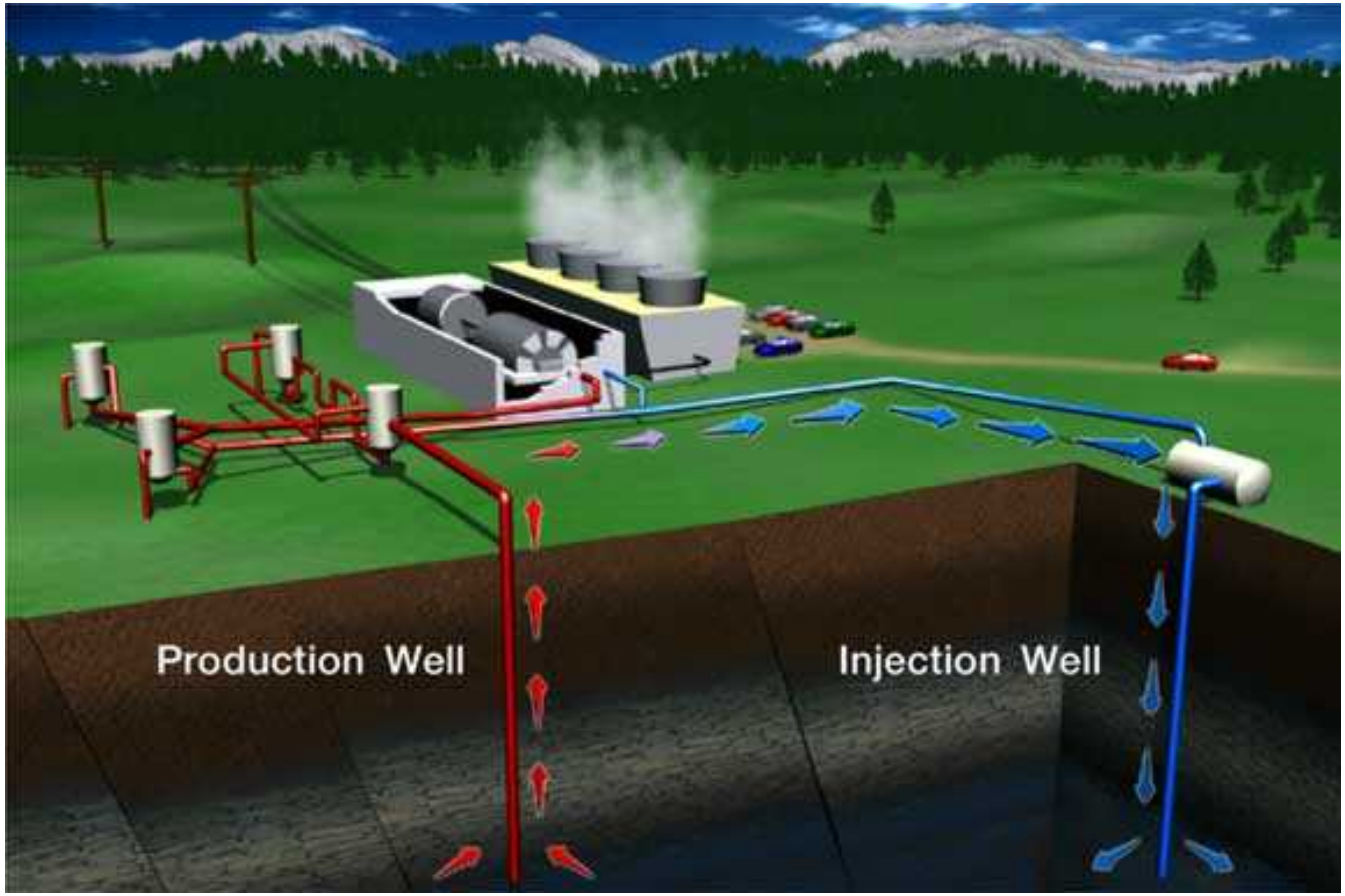
SAND2017-11825PE

FALLON FORGE Geothermal Research Observatory

Fallon FORGE - *Frontier Observatory for Research in Geothermal Energy* – Development of Enhanced Geothermal Systems (EGS)

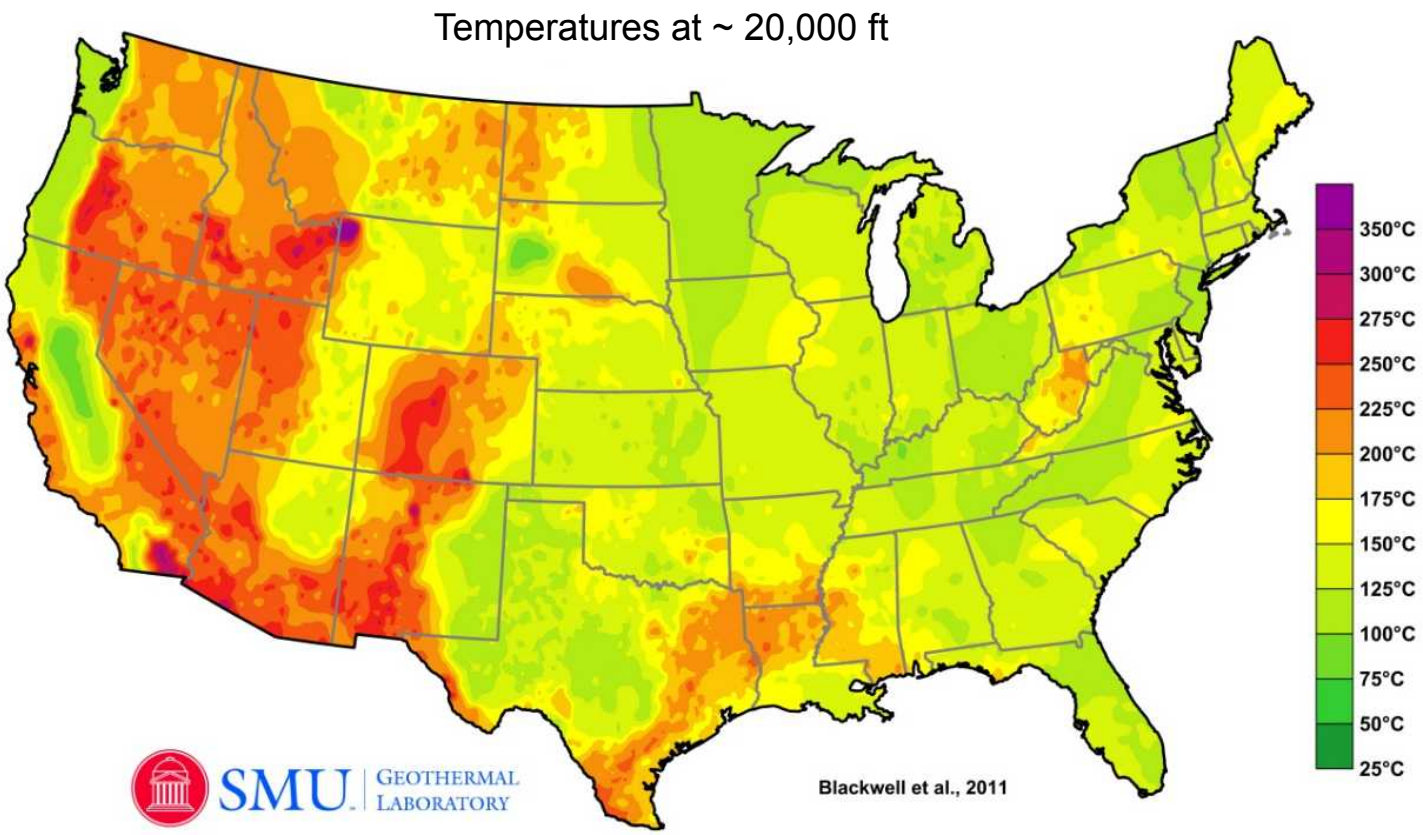
Today Geothermal Power is Produced by Mining Hot Water and/or Steam

FALLON FORGE Geothermal Research Observatory



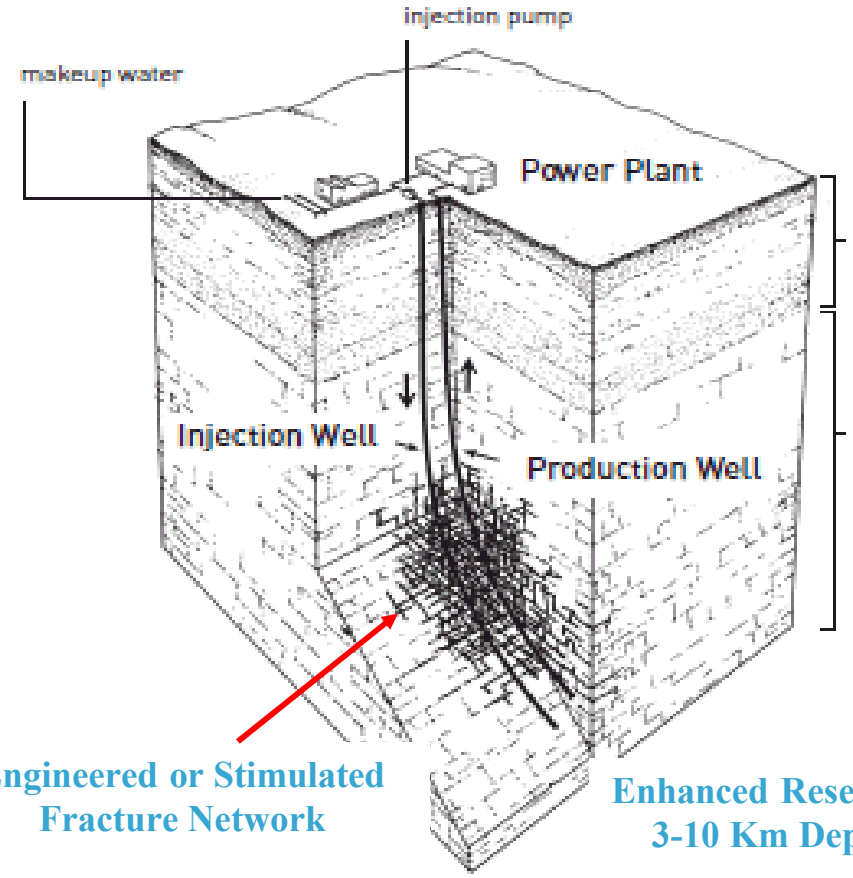
Requires heat and good permeability in the same location

There is a Vast Heat Source in the United States, Particularly in the West



Hot rocks can be found everywhere if you drill deep enough – but good permeability does not exist everywhere

Enhanced Geothermal Systems (EGS) Offer Promise



From *The Future of Geothermal Energy,* 2006

- Artificially create permeability (fracture network) through hydraulic stimulation of high temperature, low permeability crystalline rock.
- Transfer heat to land surface by circulating water through the fracture network via injection and production boreholes.
- EGS could provide more than 100 GW for the American people; the equivalent of 100,000,000 homes! (from U.S. Department of Energy)

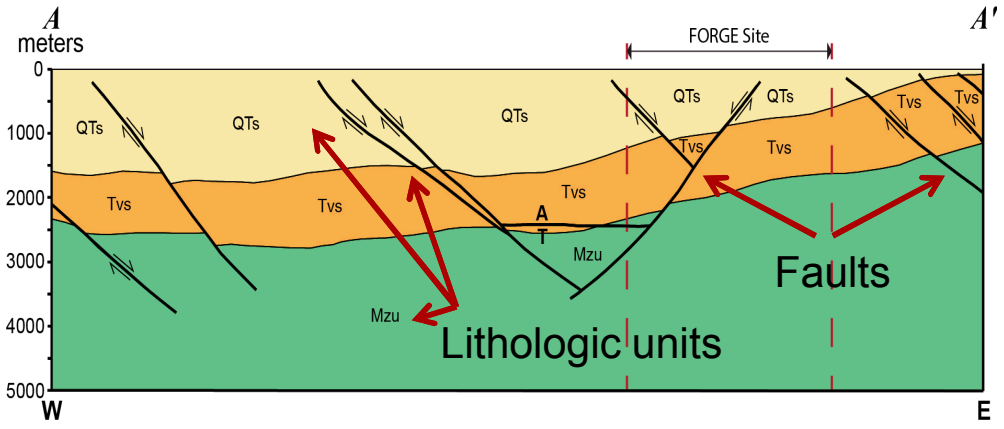
Future – Geothermal Energy Produced by Mining Heat

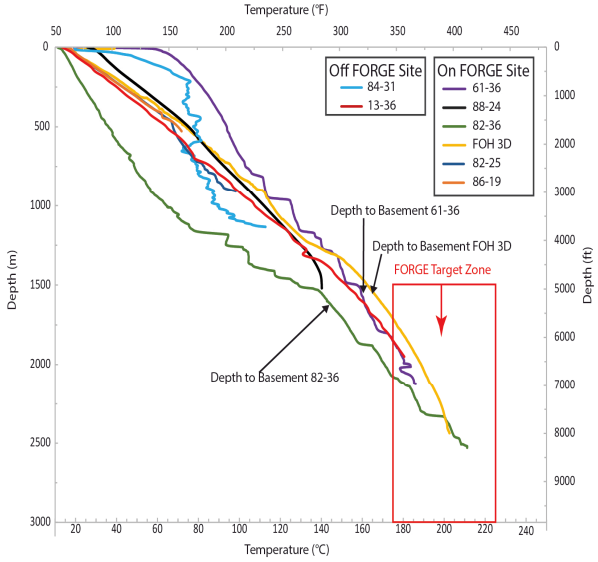
The FORGE Initiative

- FORGE will be a dedicated site to develop, test, and improve technologies in an ideal EGS environment
- Develop thorough understanding of EGS
- Comprehensive instrumentation
- Rapid dissemination of data
- Provide Path to Commercialization

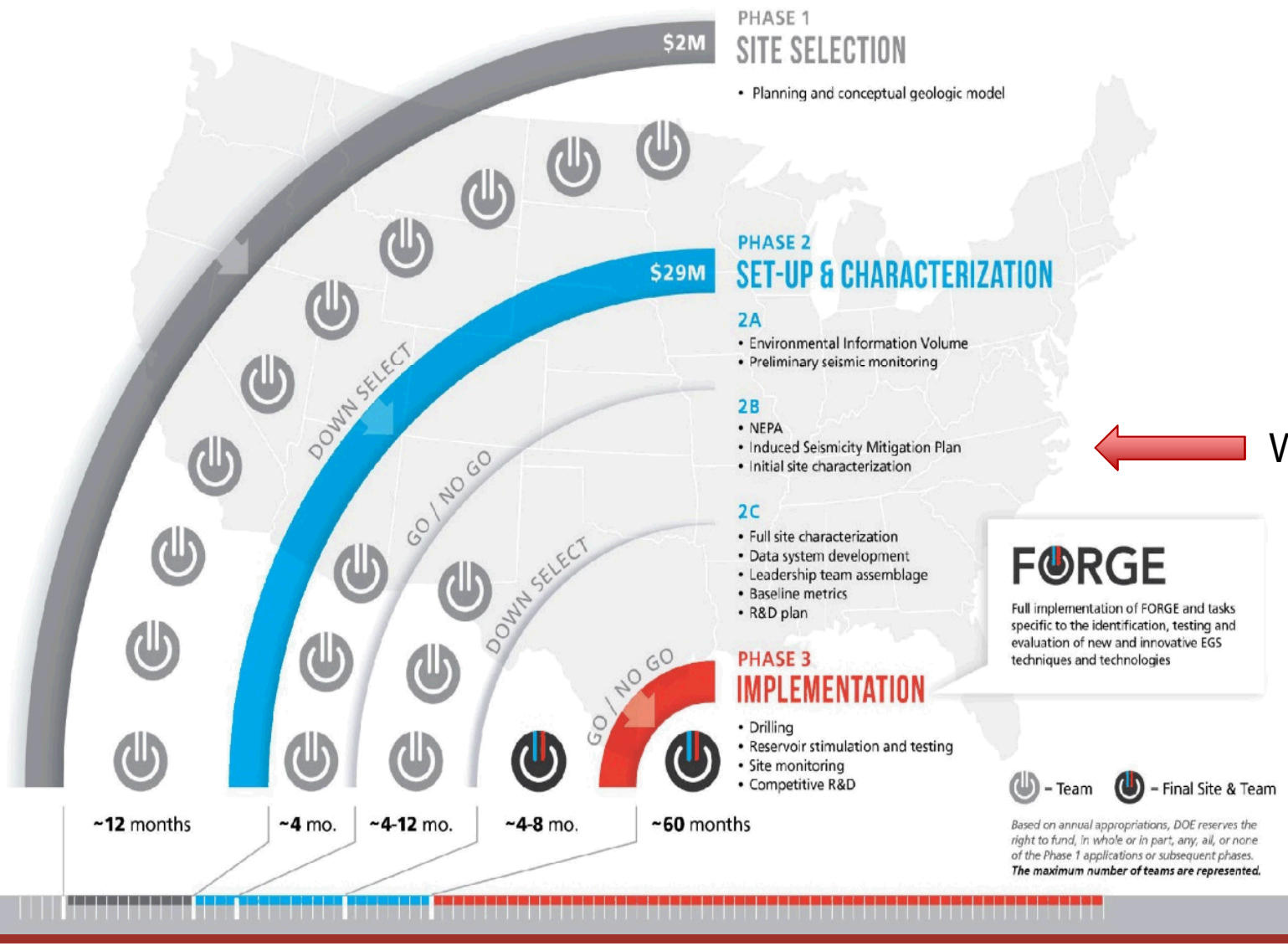
Requirements for the FORGE Site

- Good understanding of the subsurface
- High temperatures (~350-450 °F)
- Low permeability
- Target formation between 5,000 and 13,000 feet depth
- Not located within an operational geothermal field
- Target formation: crystalline rock



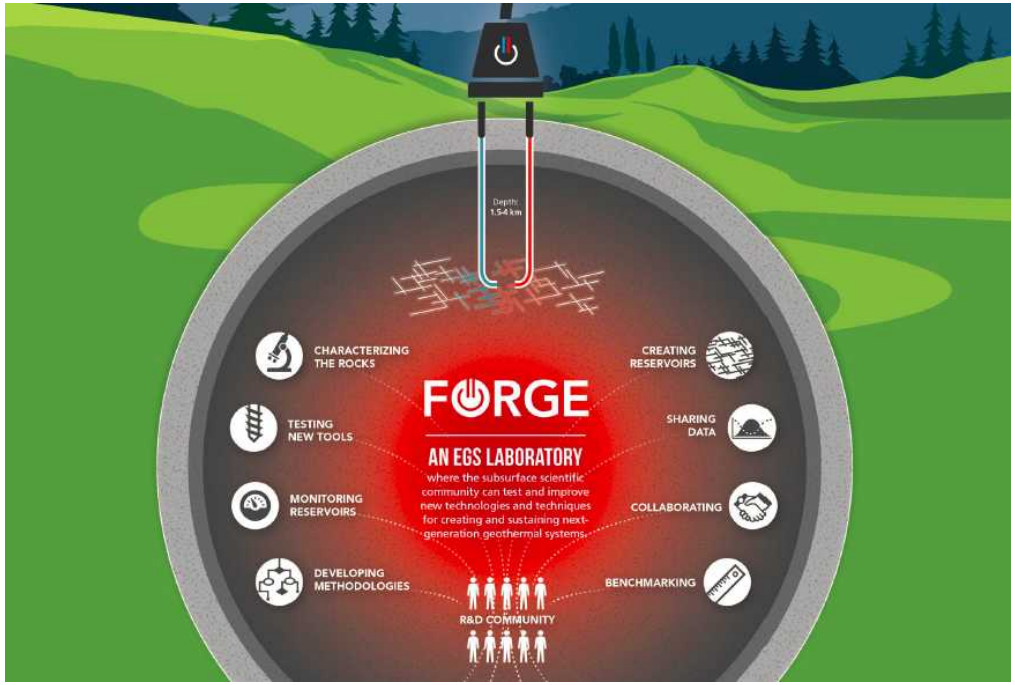


FORGE Timeline



We are here

The Fallon FORGE Team is Qualified and Experienced



FALLON FORGE Geothermal Research Observatory

BERKELEY LAB

Sandia National Laboratories

University of Nevada, Reno

nbmg

ITASCA™

USGS science for a changing world

GeothermEx A Schlumberger Company

EMPS inc.

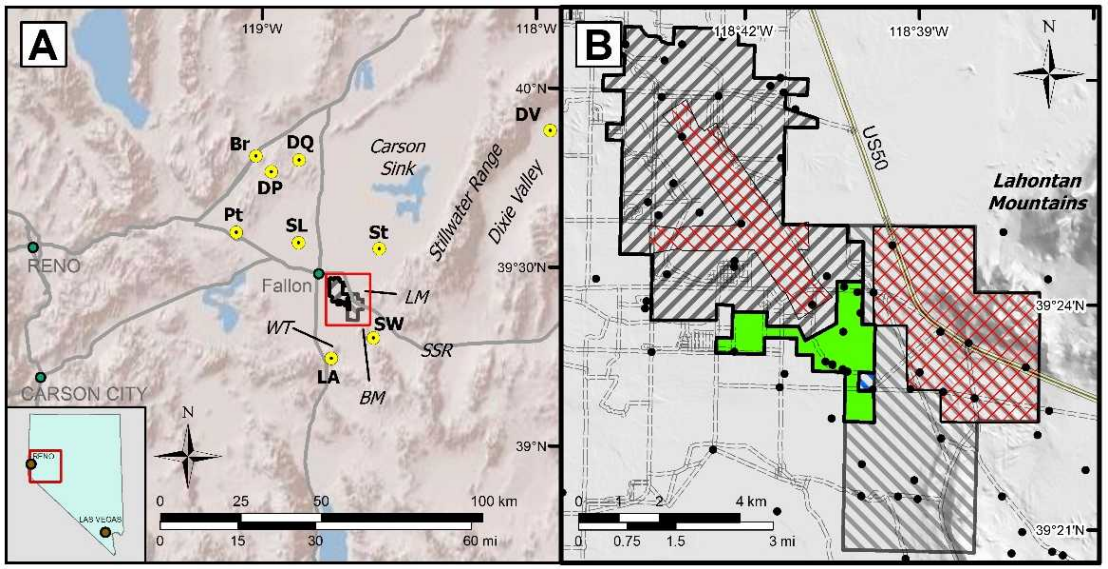
Innovate Geothermal

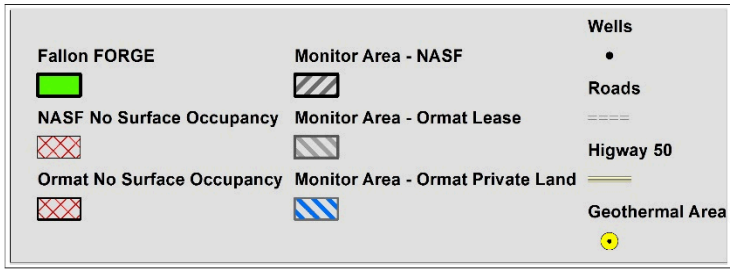
Hi-Q Geophysical Inc.

ORMAT

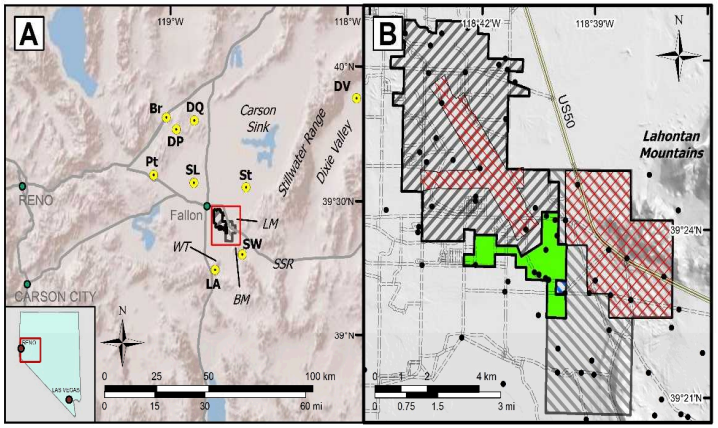
Fallon is the Ideal Location for FORGE

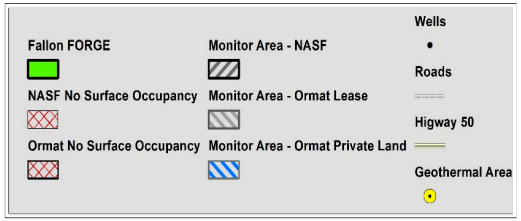
- Land status secure
  - Naval Air Station Fallon (NASF)
  - Ormat leased and owned land
  - ~1.7 square miles FORGE site
  - ~15 square miles monitoring area
- Existing infrastructure
- Regional geologic setting
- Long History of exploration and abundant available data
  - Geologic
  - Geochemical
  - Geophysical
- Temperatures
- Permeability
- Potential crystalline targets and reservoirs
- No hydrothermal system

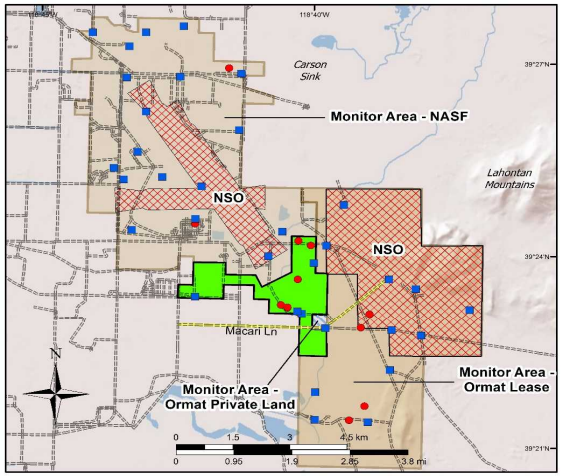


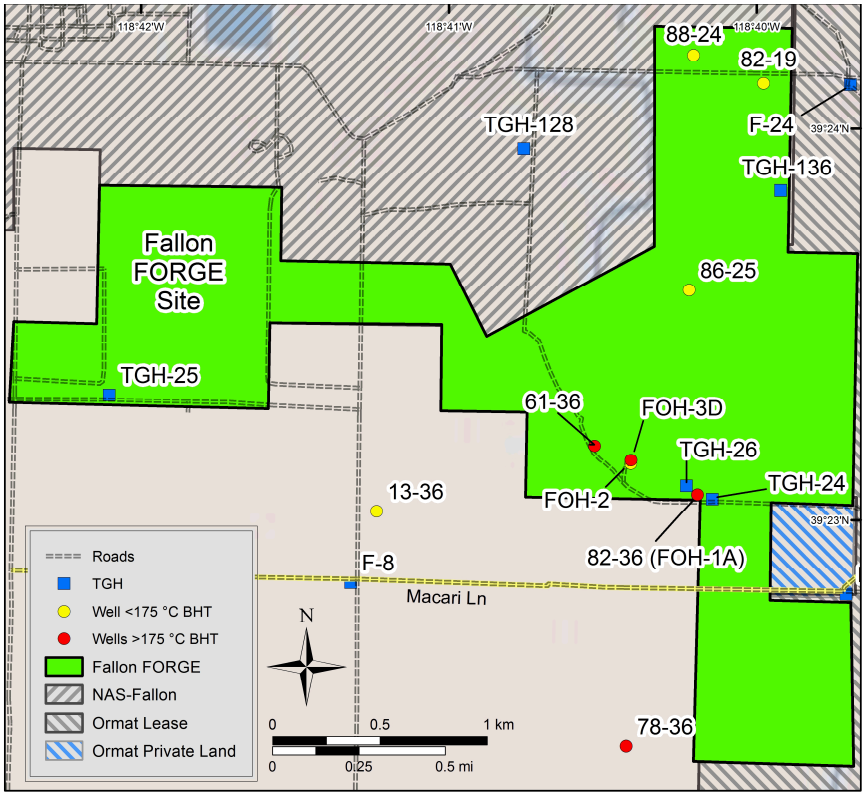


The Fallon Site

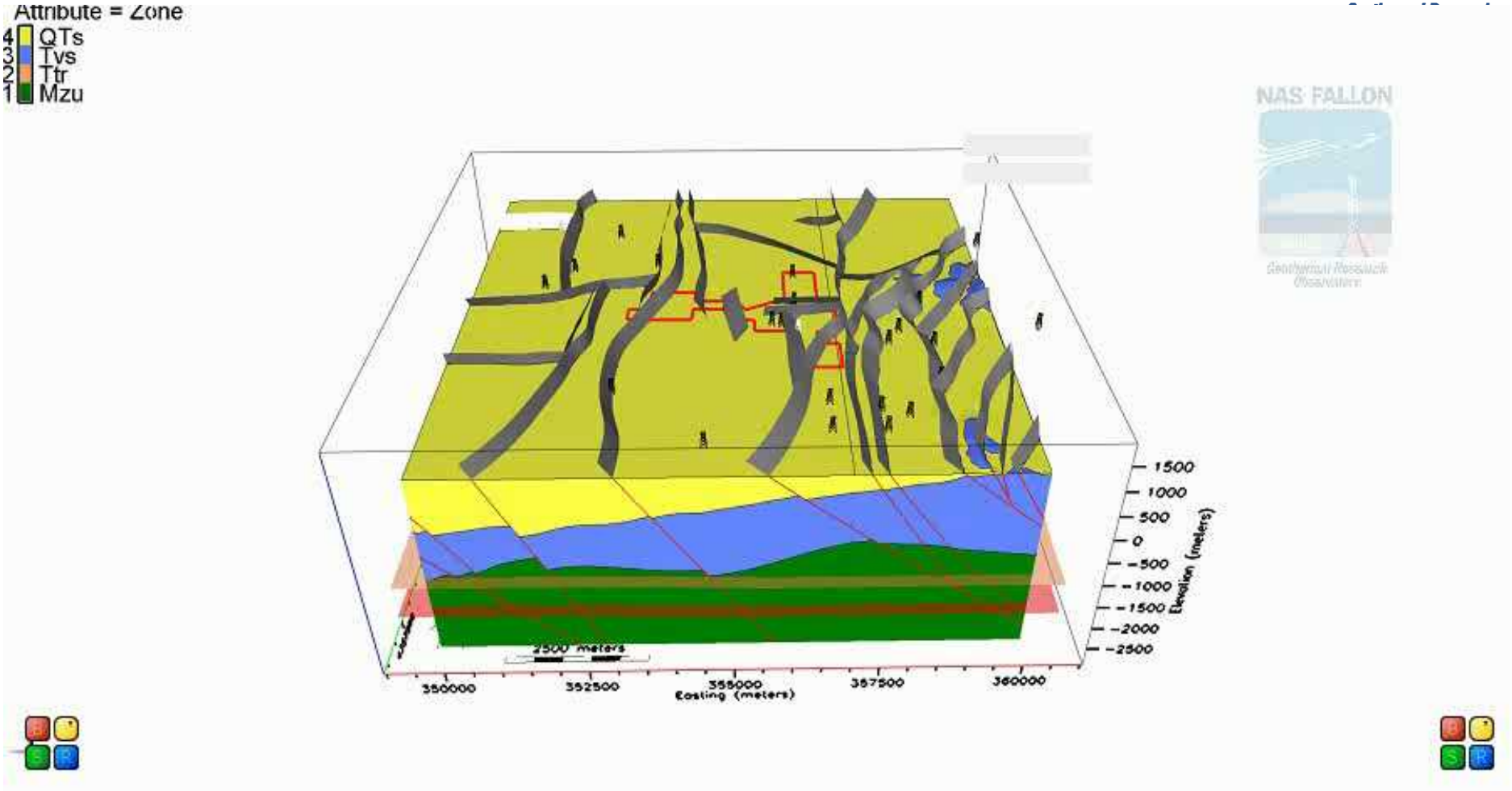








3-D Geologic Model – Video



FORGE Will Benefit the Fallon Community

- Fallon and Churchill County will host a world-class research facility
- Fallon FORGE will play a major role in unlocking a vast source of clean, renewable energy – *for Nevada and the Nation*
- Fallon and Churchill County will be the focal point of geothermal research
- Local businesses (contractors, motels, restaurants, etc.) will benefit
- FORGE will provide educational and employment opportunities for local students

Recent Outreach Activity Highlights

Established strong relationships and garnered enthusiastic support a federal leaders:

- Mayor, City of Fallon; City Engineer/Director of Public Works
- County Manager, Churchill County
- Superintendent, Churchill County School District
- Executive Director, Churchill County Economic Development Authority
- Tribal Chairman and Council, Fallon Paiute-Shoshone Tribe
- Nevada State Assembly member Robin Titus; Nevada State Senators James Settelmeyer, Pat Spearman
- Nevada Governor's Office of Energy; Nevada Governor's Office of Economic Development; Nevada Division of Minerals
- Offices of U.S. Senators Dean Heller, Catherine Cortez Masto; Rep. Mark Amodei (District and DC staff)

Participated in events to raise awareness:

- Tabled at Geothermal Resource Council/Geothermal Energy Association Annual Meeting – spoke with many scientists and technology developers
- Tabled at Geothermal Day at the Nevada State Capitol – spoke with policymakers about importance of EGS
- Tabled at Fallon Cantaloupe Festival – spoke with hundreds of community members about the initiative
- At her request, provided tour of Fallon FORGE site to Senator Catherine Cortez Masto

Developed connections to support education and outreach programs:

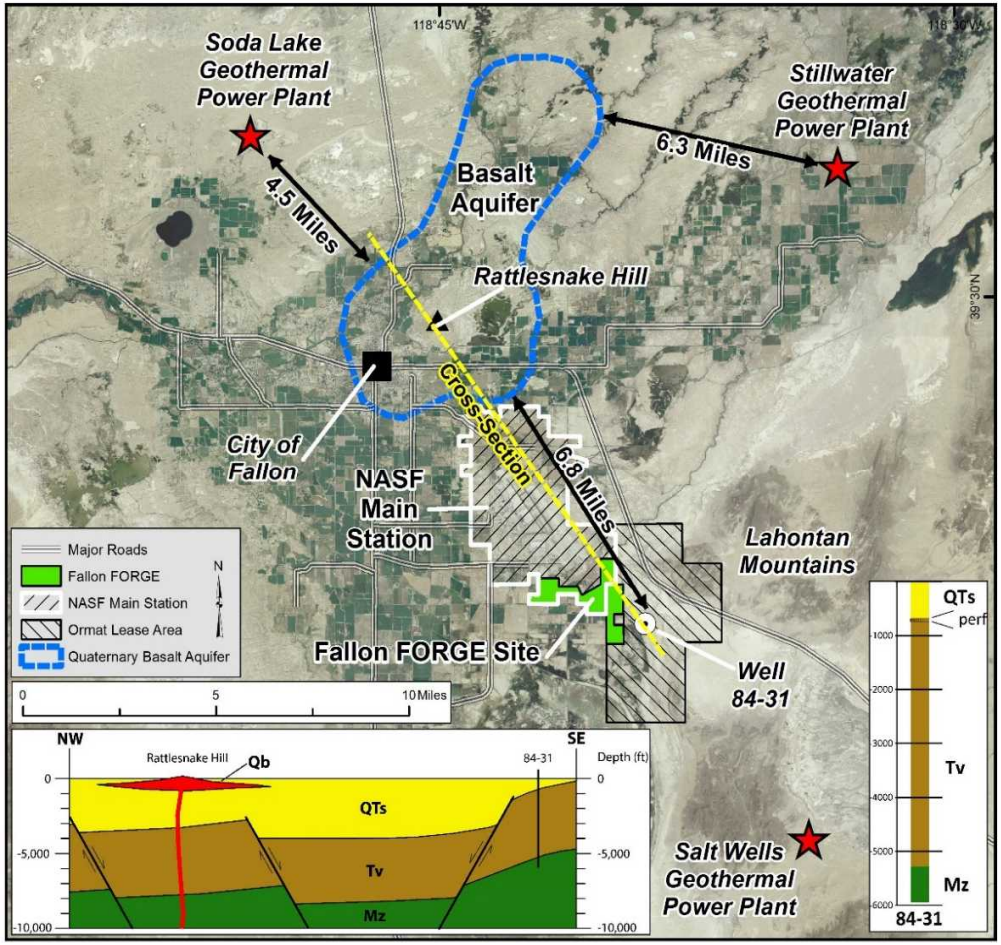
- Churchill County Museum and Archives – interested in partnering to develop exhibits around EGS, including access to research information (i.e., data monitoring stations, adult learning and project update presentations)
- Lawrence Hall of Science – world-renowned science education experts will help develop afterschool STEM and in-classroom learning curricula
- William N. Pennington Life Center – interested in serving as resource for community to learn about Fallon FORGE

FALLON FORGE is Committed to Addressing Local Concerns

- Water Use and Sources
  - Drinking water
  - Agricultural water
- Impact on NAS Fallon Mission
- Induced Seismicity

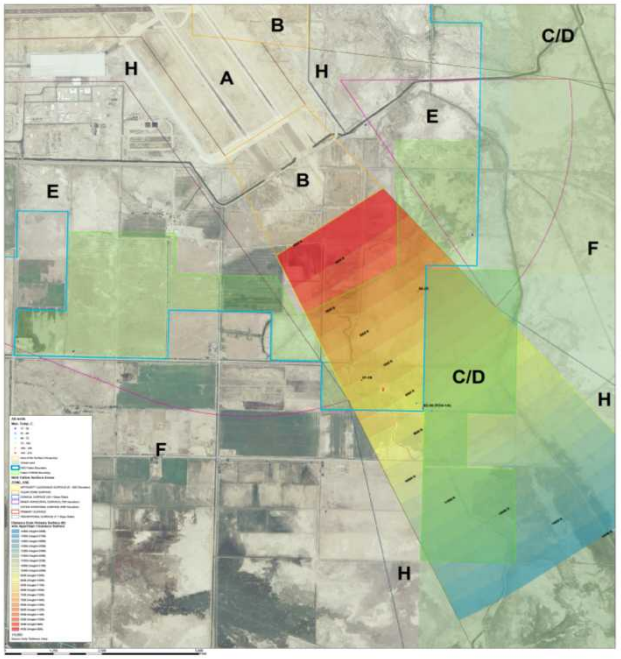
Water Resources

- FORGE will not draw water from Fallon basalt aquifer
- City of Fallon draws water from ~1 million year old basalt aquifer, which does not extend into the FORGE site
- FORGE water will be drawn from well 84-31 (~6.8 miles from the Fallon basalt aquifer)
- 84-31's aquifer is not connected to any ground water aquifers used by the community
- Maximum depth of Fallon basalt aquifer is ~750 feet.
- FORGE will be drilled to depths from 1 to 2.5 miles.
- 84-31's aquifer does not meet drinking water standards due to chemistry



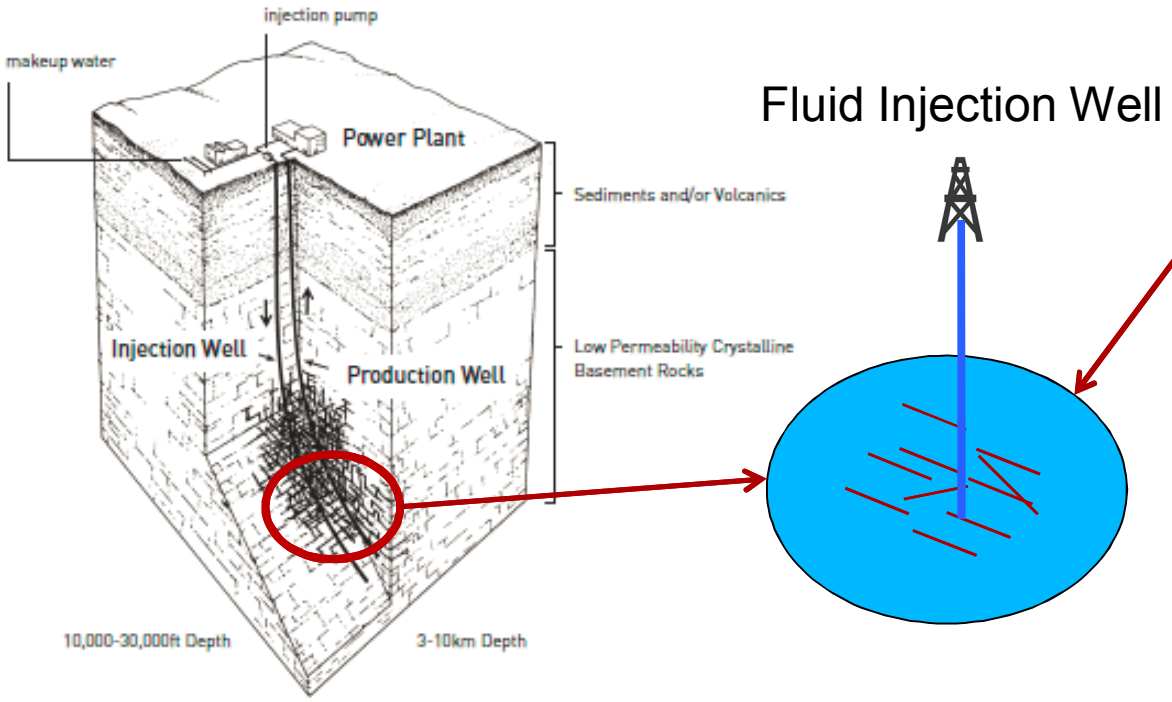
Avoiding Impacts to NAS Fallon Mission

- Structures outside “Clear Zones”
- Restricted structure height
- Follow all FAA & Naval Flight Information Group rules
- Follow Navy vetting process for site access
- No structures to remain after project completion
- Navy represented in project management team
- Transmitting devices and lighting to comply with Navy rules



All activities are performed at the discretion of the NAS Fallon Commanding Officer – Who must remain ever vigilant of flight safety concerns and mission accomplishment

Fallon FORGE is Designed to Minimize Induced Seismicity



Past experiences in geothermal operations have shown that amount and magnitude of induced seismicity (and any resulting ground shaking) is minimal and can be controlled

WE UNDERSTAND FALLON

- Extensive characterization of fractures and faults before operations begin
- Injection only into zones with small fractures with small slip areas
- No injection near large fractures or faults

WE MONITOR AND CONTROL THE OPERATIONS

- Continuous real-time monitoring of micro-seismicity and ground shaking
- Operations will stop before induced micro-seismicity becomes a potential problem

Fallon FORGE is Different From Oklahoma Oil and Gas Operations

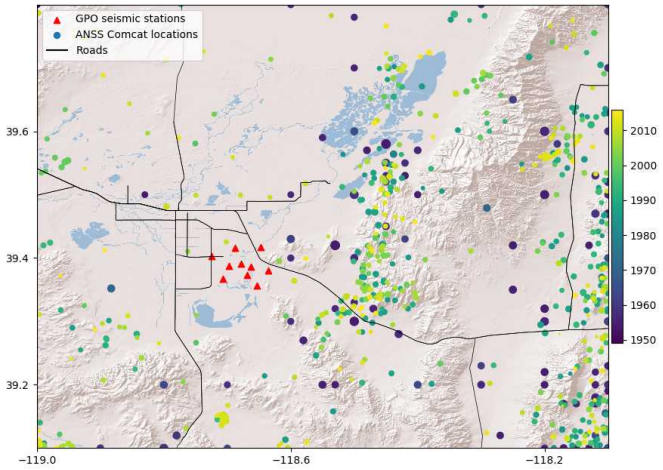
	Injected Volume (gallons/minute)	No. of Wells in Target Area	Duration of Injection
Oklahoma	~800 thousand	Thousands	Years
Fallon	~0.8	3	Weeks/Days
Difference	1 million times less	1000 times less	10-100 times less

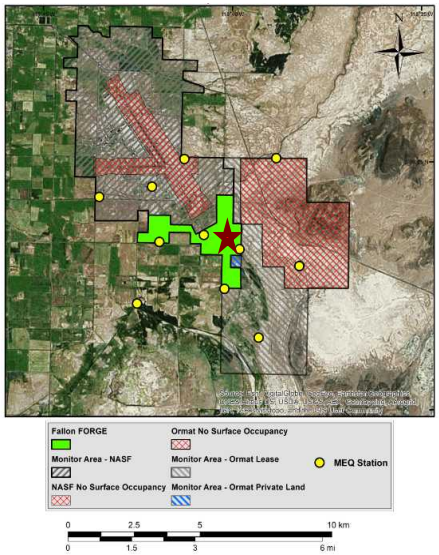
- We do advanced seismic monitoring
- We map major faults and avoid them
- We do not only inject - we circulate to equalize pressure and avoid intersecting large faults
- We follow the DOE Protocol to minimize and closely monitor any seismicity

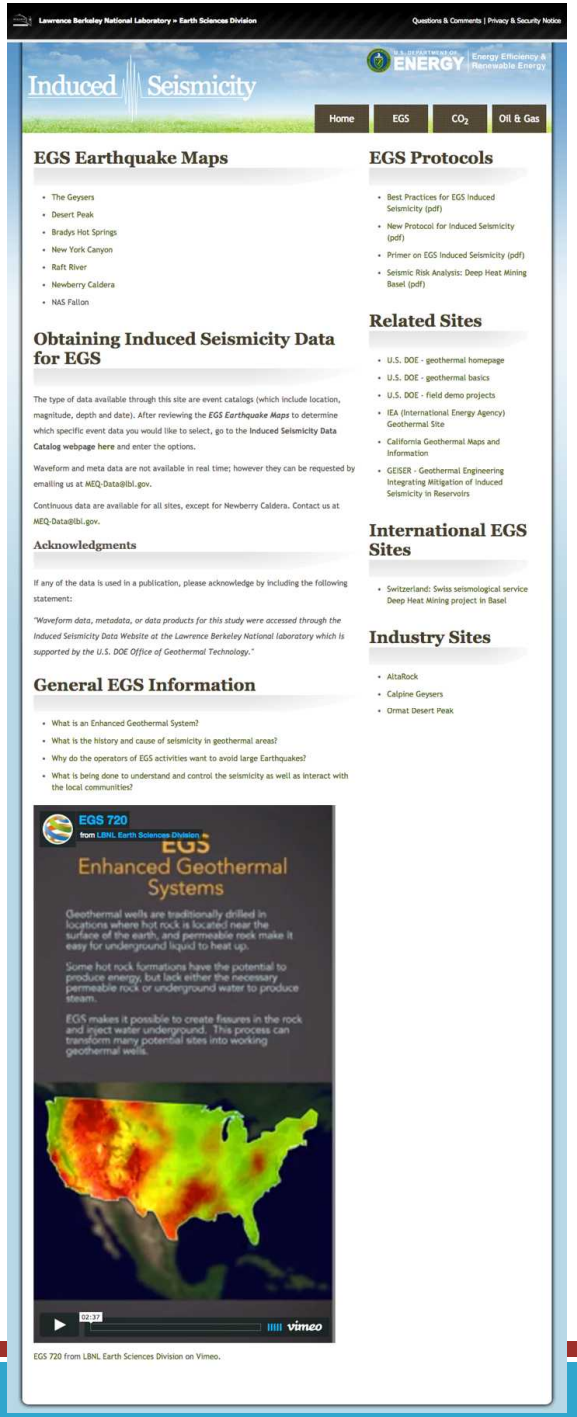
Induced Seismicity Mitigation Plan (ISMP)

7 steps are considered for an ISMP:

1. Screening: Local geology, infrastructure and population
2. Public outreach to Stakeholders
3. Develop limits for ground vibration/noise: infrastructure assessment
4. Real-time Seismic Monitoring: 10 station network up and running
5. Probabilistic Seismic Hazard Analysis
6. Risk Analysis JK2
7. Mitigation Plans: modify injection, strengthen infrastructure where necessary, public communication (outreach)







Slide 20

JK2 Ernie, could you clarify the differences between steps 5 and 6, please?
J. Ole Kaven, 10/24/2017

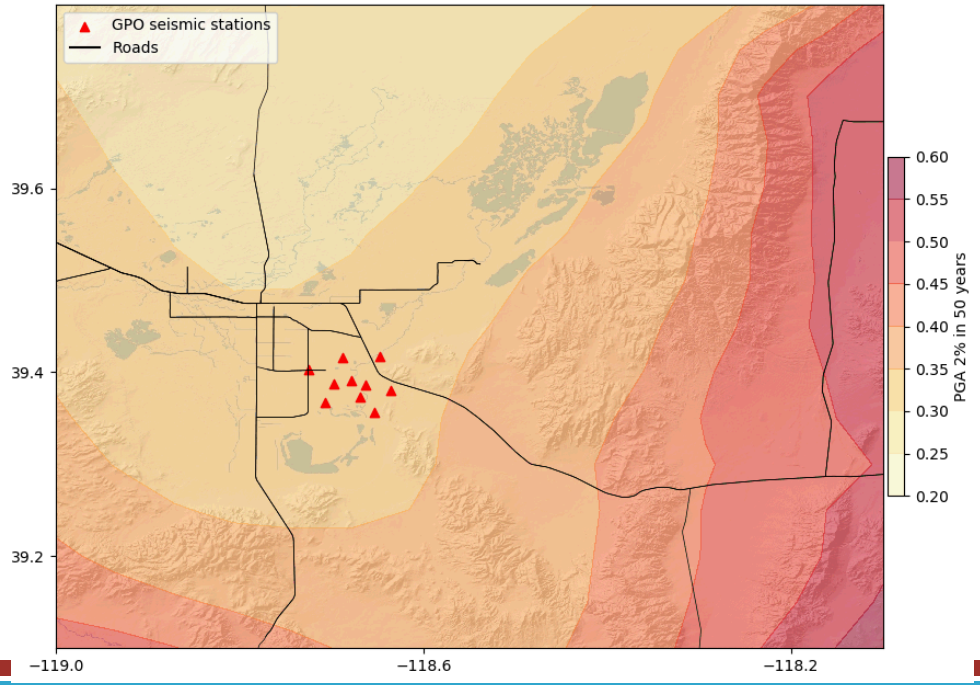
Induced Seismicity Mitigation Plan (ISMP)

7 steps are considered for an ISMP:

1. Screening: Local geology, infrastructure and population
2. Public outreach to Stakeholders
3. Develop limits for ground vibration/noise: infrastructure assessment
4. Real-time Seismic Monitoring: 10 station network up and running
5. Probabilistic Seismic Hazard Analysis
6. Risk Analysis JK4
7. Mitigation Plans: modify injection, strengthen infrastructure where necessary, public communication (outreach)

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Design range for maximum ground shaking at the Fallon FORGE site



Slide 21

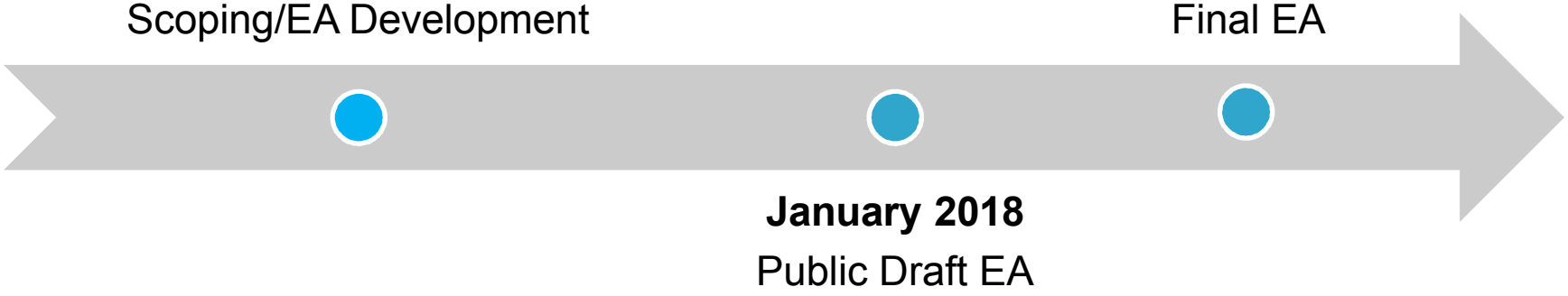
JK4 Ernie, could you clarify the differences between steps 5 and 6, please?
J. Ole Kaven, 10/24/2017

Phase 3 Environmental Assessment

- EA is being prepared by the FORGE team for the Bureau of Land Management
- Satisfies the NEPA requirements for Phase 3
- The 2011 Salt Wells EIS analyzed most potential environmental impacts from new well drilling and pads
- The EA will analyze the EGS component
- The Navy and Churchill County will likely be cooperating agencies.

Phase 3 Environmental Assessment

- The public draft EA is expected to be released in early January 2018
- The final EA is anticipated in March 2018



Send EA questions to peter.gower@empsi.com

FALLON

FORGE
U.S. Department of Energy

Geothermal Research Observatory

Questions?