

Geothermal Prospecting:

U.S. Navy's Geothermal Program Office

by

**Andrew Sabin, PhD, PG
Director, Geothermal Program Office
China Lake NAWS**

GovEnergy August 15-18, 2010 Dallas Convention Dallas, Texas

Outline

- Mission
- Resource management at Coso
- Exploration
 - tools
 - examples
 - results

Mission

- Manage geothermal on DoD installations
- Explore for and oversee development of geothermal

10 USC 2917 – “The Secretary of a military department may develop... any geothermal energy resource within lands under the Secretary’s jurisdiction.”

10 USC 2916 – “The Secretary of a military department may sell... electrical energy generated from alternate energy...under the [Secretary’s] jurisdiction.”

I. Resource Management

- Coso
- NAS Fallon
- Hawthorne Army Depot



Coso: Pre-Production, 1970

- Young volcanic field
- Lots of interesting features, e.g., hot springs, mud pots, fumaroles
- No “commercial” resource
- If resource exists, its only in volcanic cover
- Basement rocks are cold and unfractured
- Government should not waste its time



Coso geothermal field: facts



Coso geothermal field: facts



- China Lake NAWS
- 3rd party P/PV development contract
- Operator, Terra-Gen has 831 MW installed capacity of solar, wind and geothermal in US
- 270 MW installed - 3rd largest geothermal field in N. America
- Largest renewable energy producer on DoD land
- ~150 production size wells in the system
- \$380 million revenue to Navy
- Plans to integrate solar to augment parasitic load

Coso: Section 16 PV Array

- Unsolicited proposal by Terra-Gen 640 acres
- “contract” ground
- Utilize 230 kV line
- Off take at Kramer Junction
- Negotiated revenue



II. Exploration



➤ CALIFORNIA

- China Lake NAWS
- Marine Corps Air Ground Combat Center, Twenty-nine Palms, CA
- Naval Air Facility El Centro
- Chocolate Mountain Aerial Gunnery Range (MCAS Yuma)

➤ NEVADA

- Naval Air Station Fallon/Dixie Valley
- Hawthorne Army Ammunition Depot

➤ UTAH

- Hill Air Force Base

➤ OTHERS

- Guam
- Camp Lemonier, Djibouti
- Hawaii

Exploration Phases

PHASE 1

- Literature search/data review
- Reconnaissance investigation: mapping, sampling, analysis

PHASE 2

- Potential fields acquisition and interpretation
- Shallow T (TGH) drilling (Seabees)
- Remote sensing and/or additional geophysics (e.g., seismic, resistivity)
- Detailed mapping and neotectonics

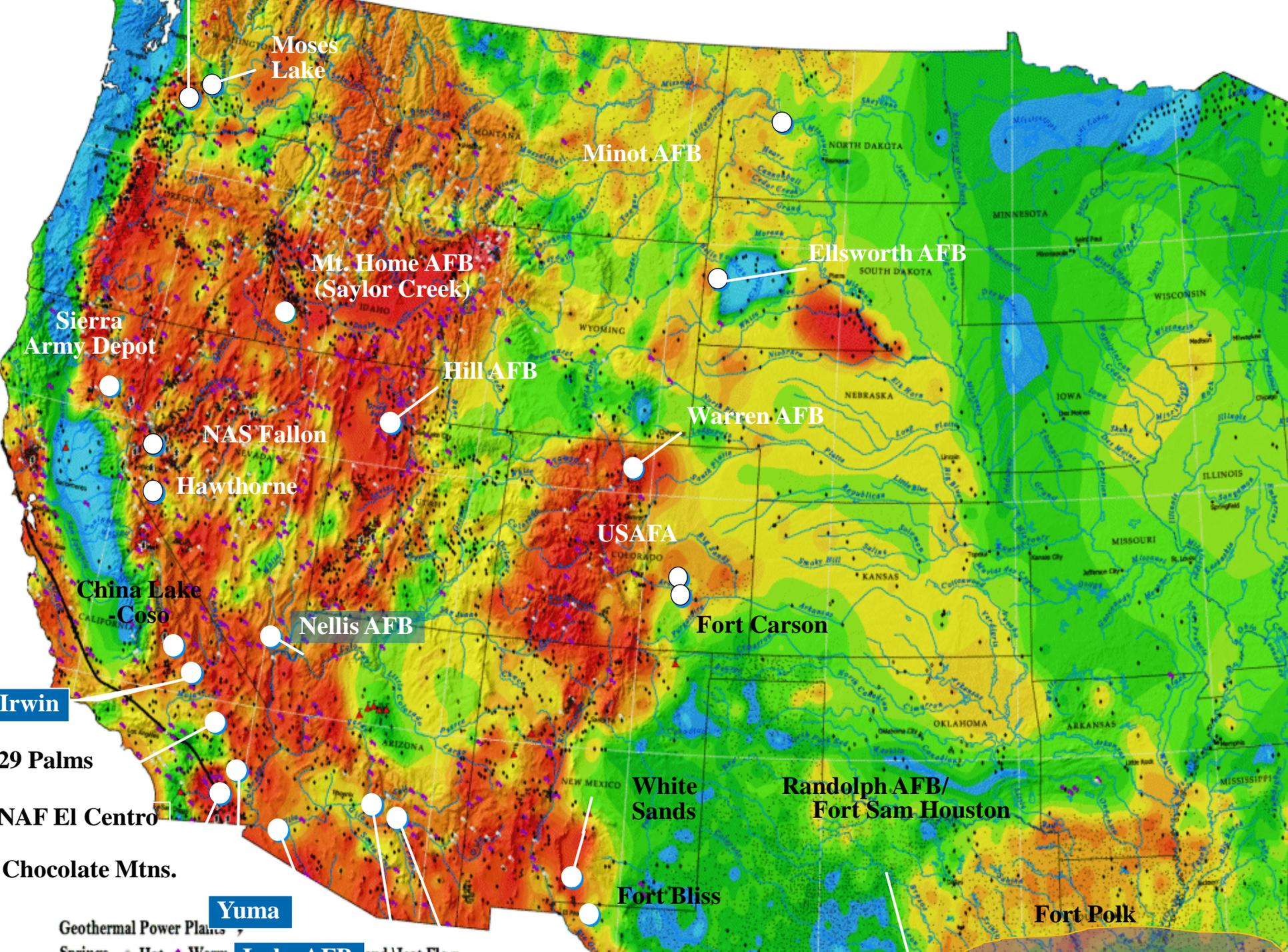
PHASE 3

- Intermediate to deep geophysical test holes (“slim” holes)

Tools

- Remote sensing
- Geophysics
- Geochemistry
- Mapping
- Modelling
- Drilling: 2m probes, THG, intermediate-deep “test” holes





Moses Lake

Minot AFB

Ellsworth AFB

Mt. Home AFB
(Saylor Creek)

Sierra
Army Depot

Hill AFB

Warren AFB

NAS Fallon

Hawthorne

USAFA

Fort Carson

China Lake
-Coso

Nellis AFB

Irwin

29 Palms

NAF El Centro

Chocolate Mtns.

Yuma

White Sands

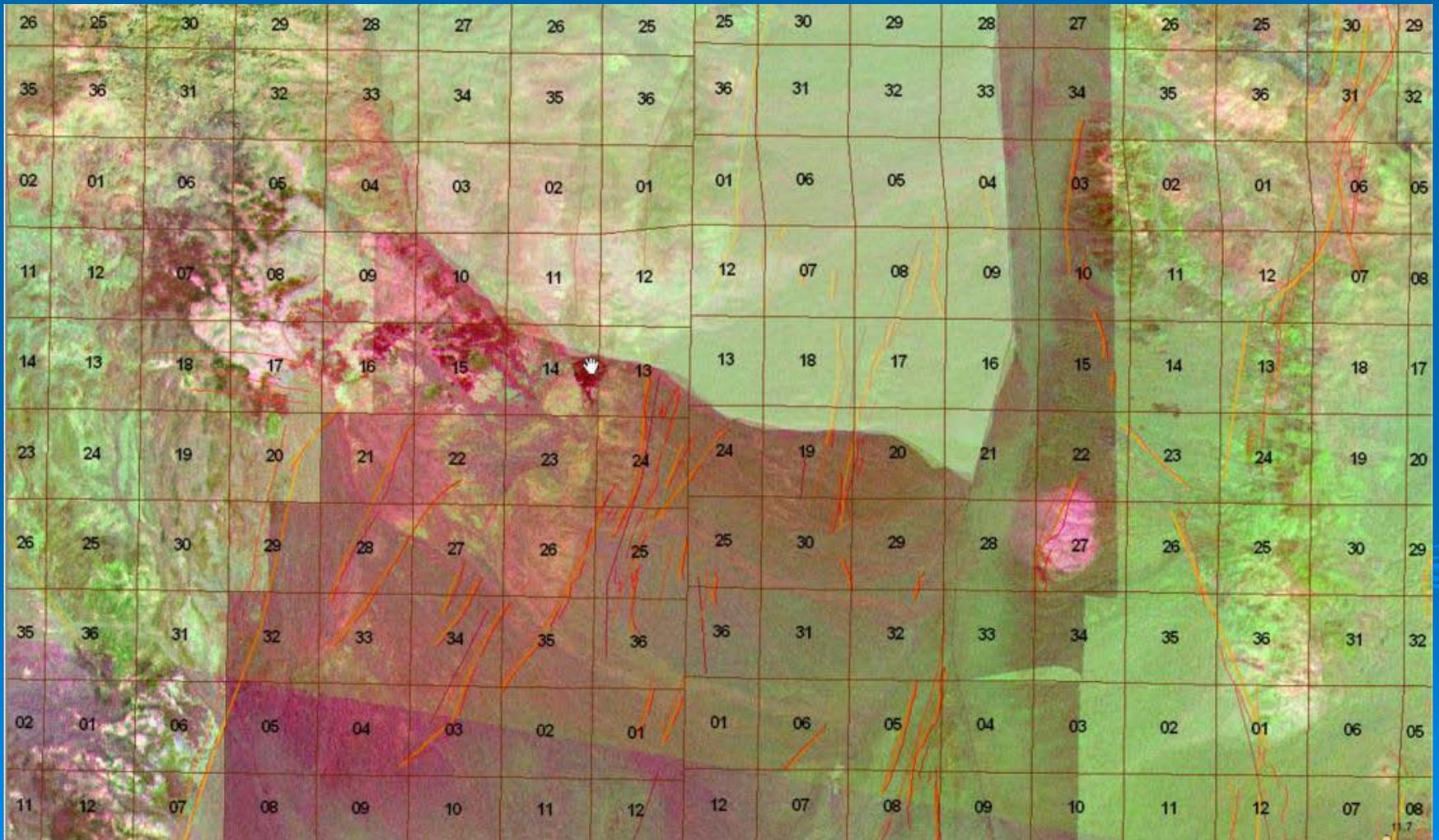
Randolph AFB/
Fort Sam Houston

Fort Bliss

Fort Polk

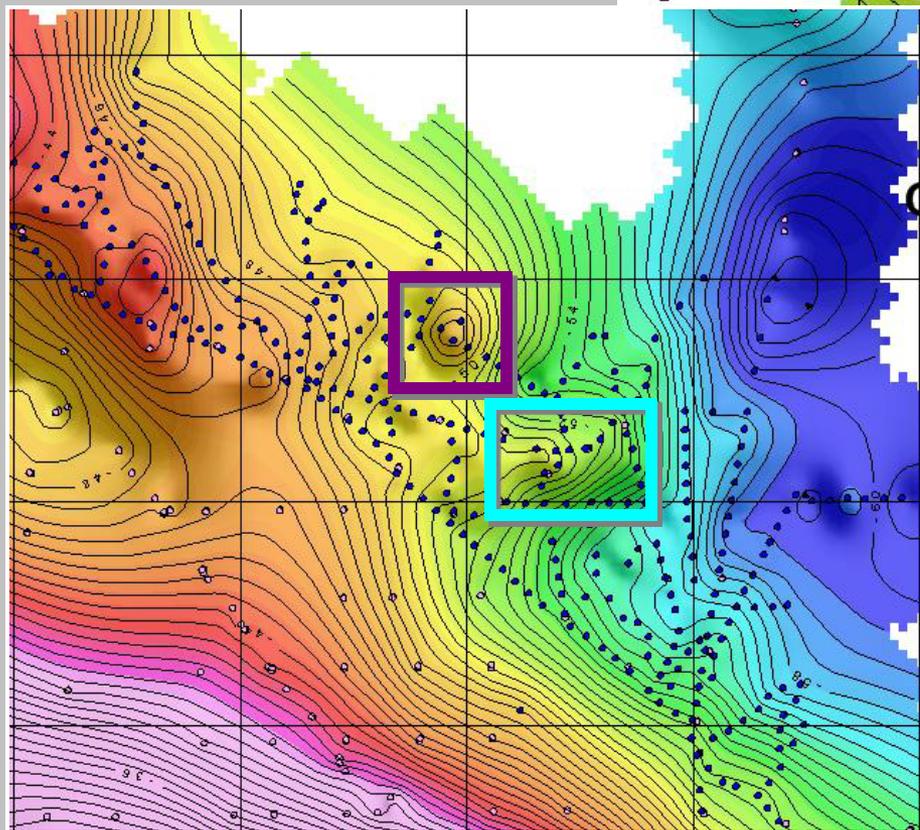
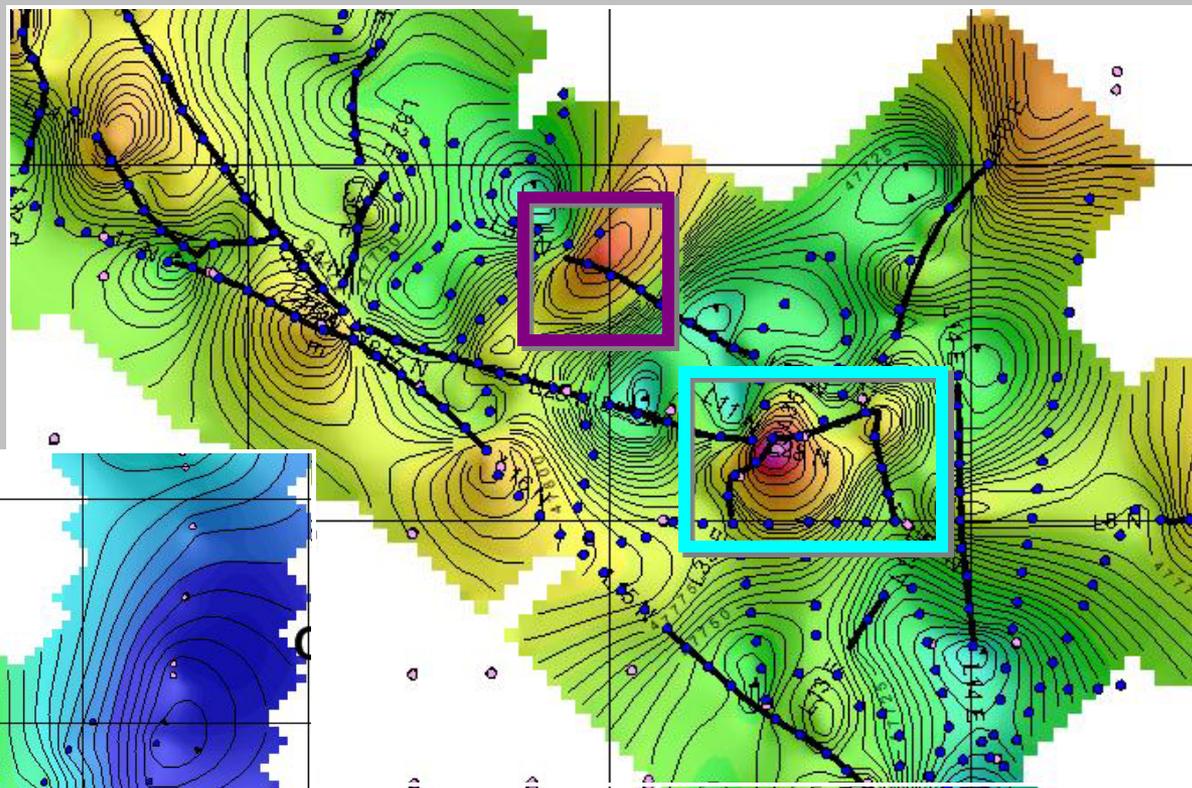
Geothermal Power Plants
Springs: Hot Warm Cold AFB and West Fl...

Remote Sensing Data



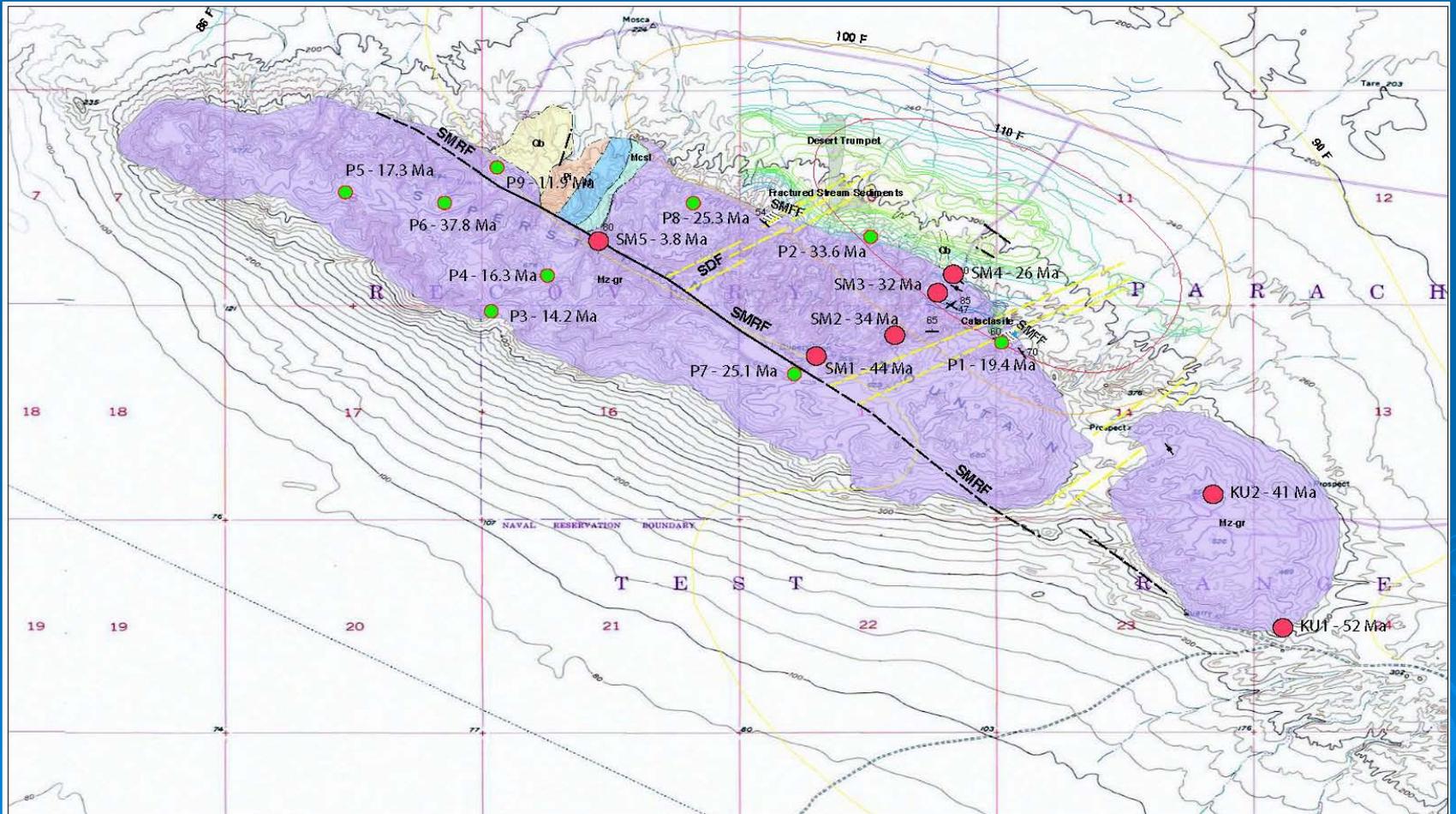
Right: RTP
magnetics

Below: Regional
CBA 2.67 g/cc



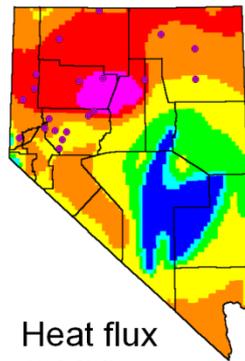
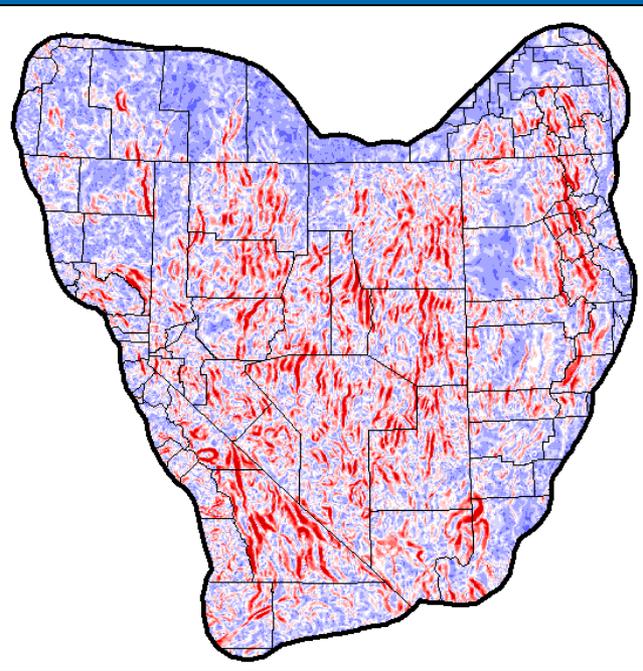
The two different colored
boxes show correlated
highs from both datasets
respectively

Mass & Heat Advection



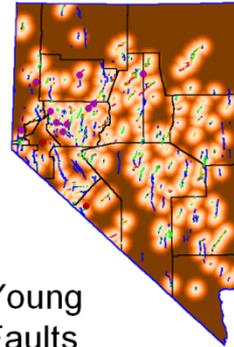
Improved geothermal favorability maps:

- maintain database of geothermal systems
- search and obtain digital data as “evidence”



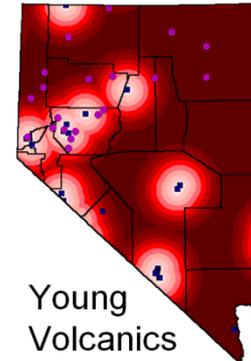
Heat flux
(SMU)

+



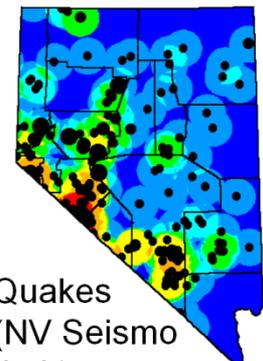
Young
Faults
(NBMG/USGS)

+



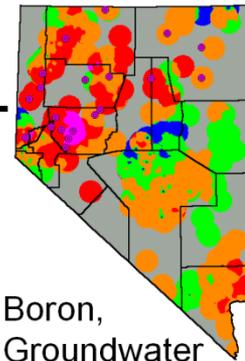
Young
Volcanics
(USGS)

+



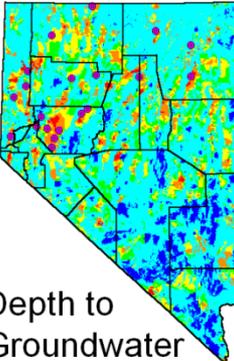
Quakes
(NV Seismo
Lab)

+



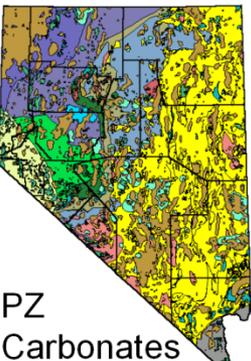
Boron,
Groundwater
(NWIS)

+



Depth to
Groundwater
(NWIS)

+

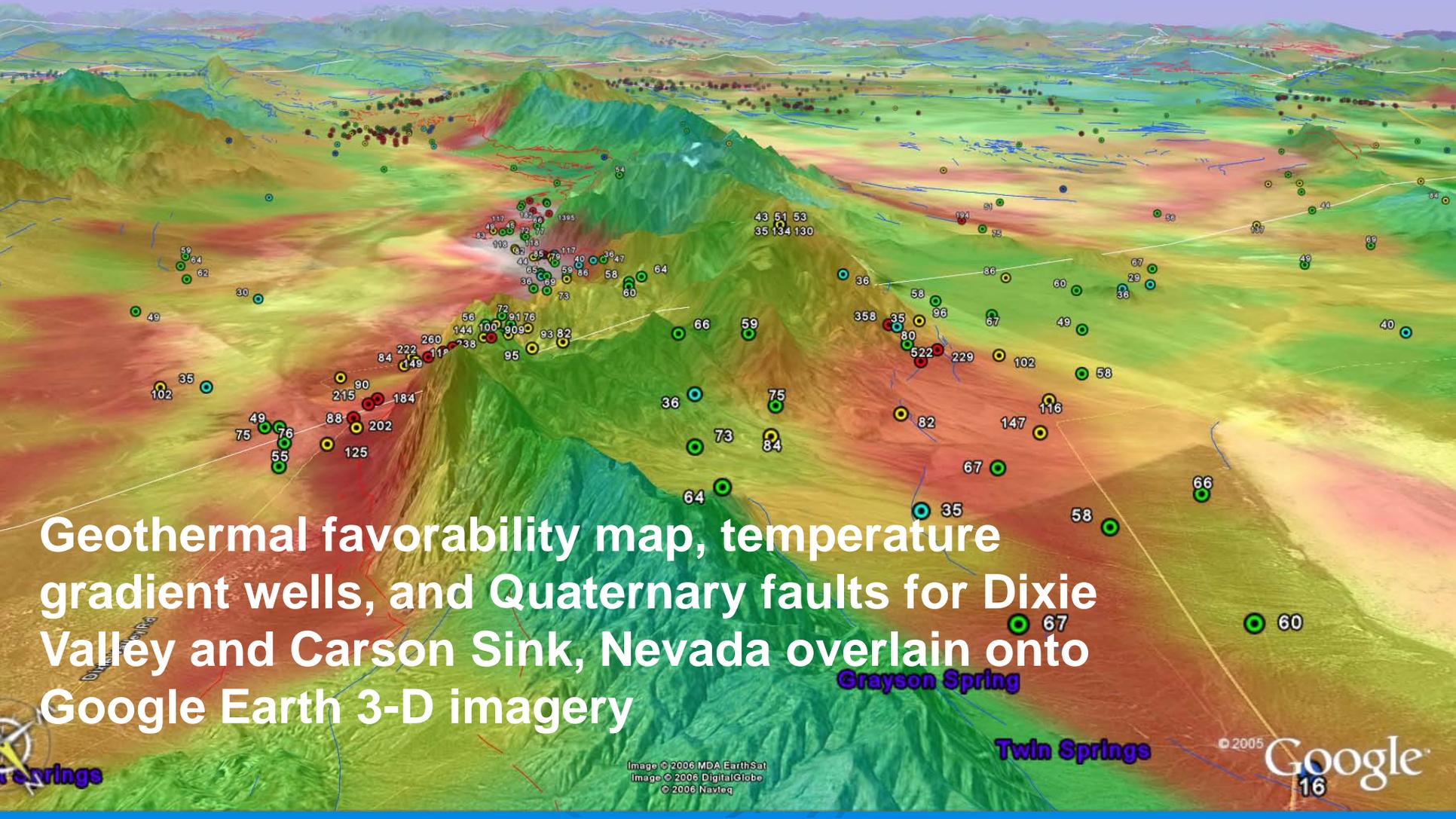


PZ
Carbonates
(NBMG)

LAYER	CONTRAST
Groundwater	3.07
Faults	2.53
Boron	2.03
Young Ages	1.98
Carbonates	1.58
Heat Flux	1.40
Earthquakes	1.02

Statistical Methods
Weights-of-Evidence
Logistic Regression
Fuzzy Logic

Digital databases can be overlain onto world map engines such as Google earth for rapid visualization and assessment



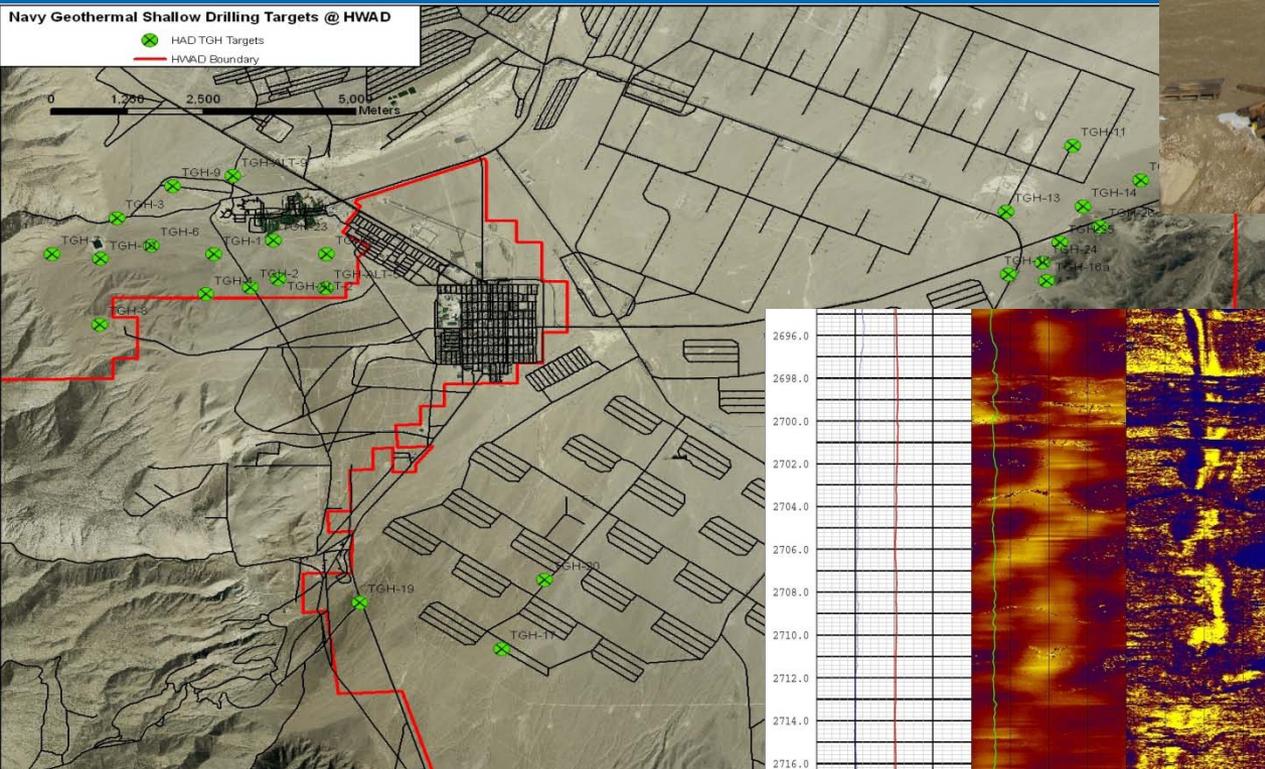
Geothermal favorability map, temperature gradient wells, and Quaternary faults for Dixie Valley and Carson Sink, Nevada overlain onto Google Earth 3-D imagery

Test Drilling



Hawthorne Ammunition Depot

- \$700k funding from DOA for shallow drilling
- ~\$2.4M funding from DOA for intermediate/deep drilling
- 1-2 intermediate holes to be drilled in August/September timeframe



• 3rd party resource assessment to validate geothermal resource

- 2009/10 exploration, including 2m probes, performed by GPO and UNR-GBCGE identified ~ 26 shallow targets

- TGH's drilled as of August 15

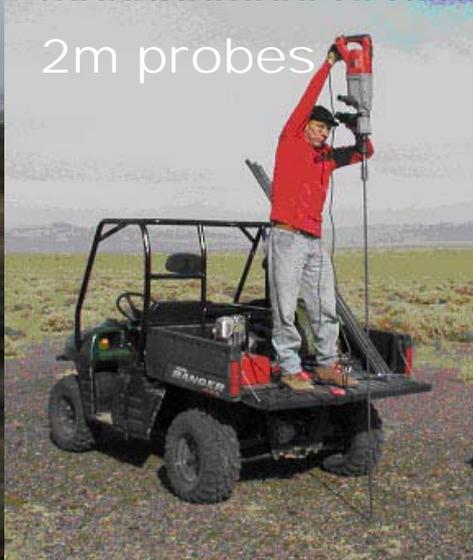
- Anomalous temperatures

HAD TGH -14a - 192 F @ 180'

HAD TGH -12 - 175 F @ 500'

- GPO to establish field office at NAS Fallon for management of exploration at NAS Fallon and

2m probes



HWD Eastern Magazine Area: Preliminary Data

Temperature (F)

D. Meade, GPO

200.0000

50.0000

100.0000

150.0000

0.0000

100.0000

200.0000

300.0000

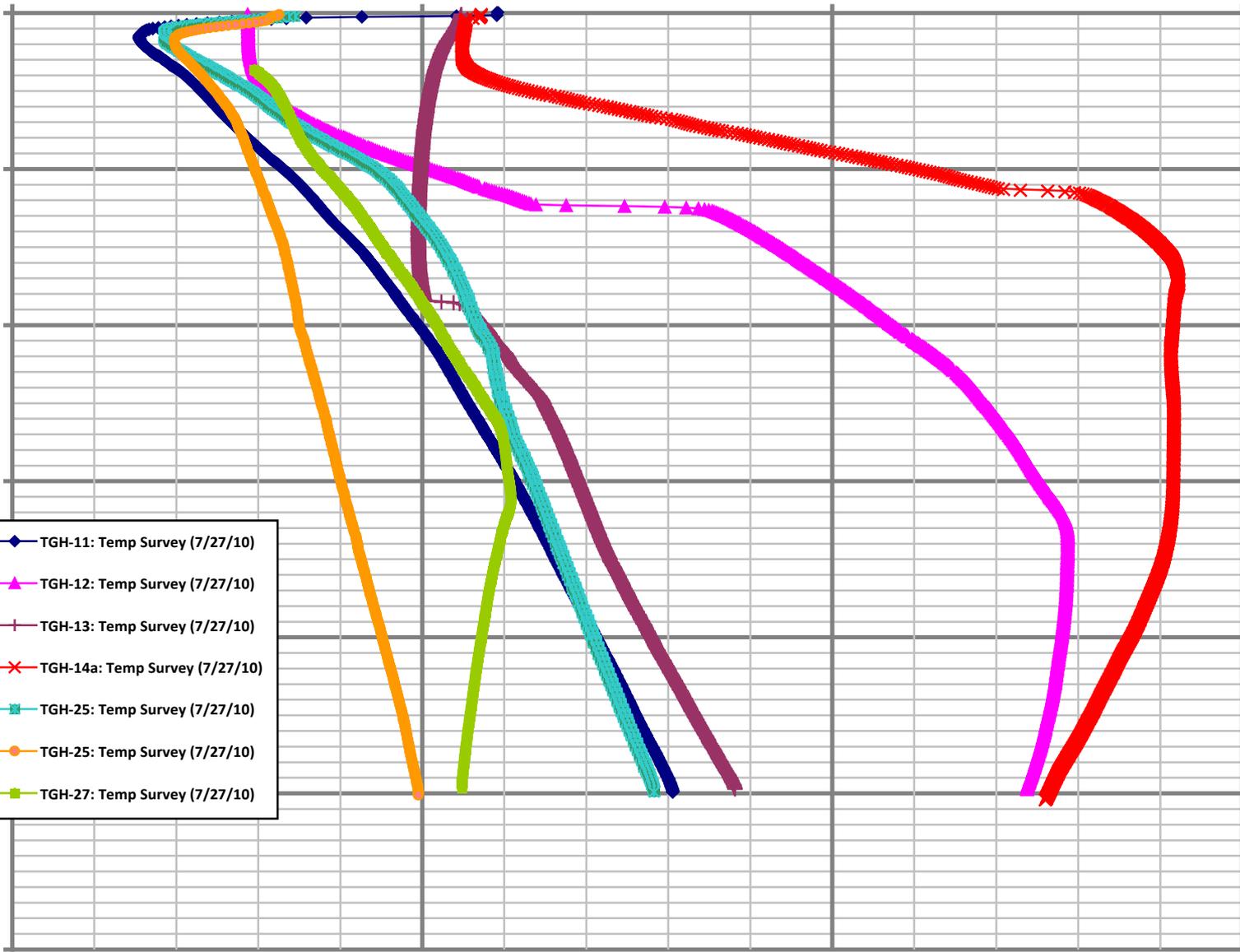
400.00

500.00

600.0000

Depth (ft, b.g.l.)

- TGH-11: Temp Survey (7/27/10)
- TGH-12: Temp Survey (7/27/10)
- TGH-13: Temp Survey (7/27/10)
- TGH-14a: Temp Survey (7/27/10)
- TGH-25: Temp Survey (7/27/10)
- TGH-25: Temp Survey (7/27/10)
- TGH-27: Temp Survey (7/27/10)

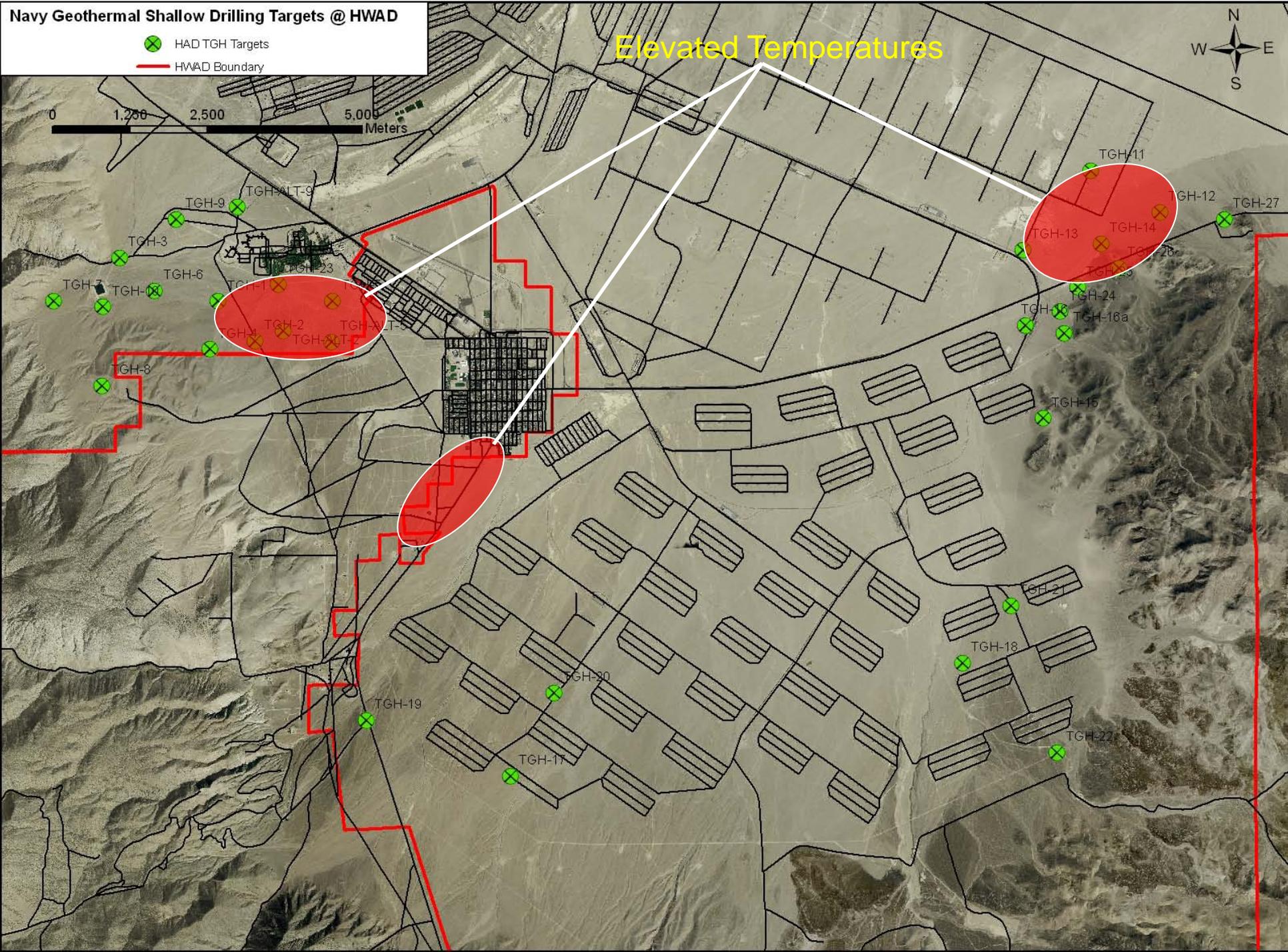


Navy Geothermal Shallow Drilling Targets @ HWAD

-  HAD TGH Targets
-  HWAD Boundary

0 1,250 2,500 5,000 Meters

Elevated Temperatures



Development

Example: Hawthorne Army Depot, NV

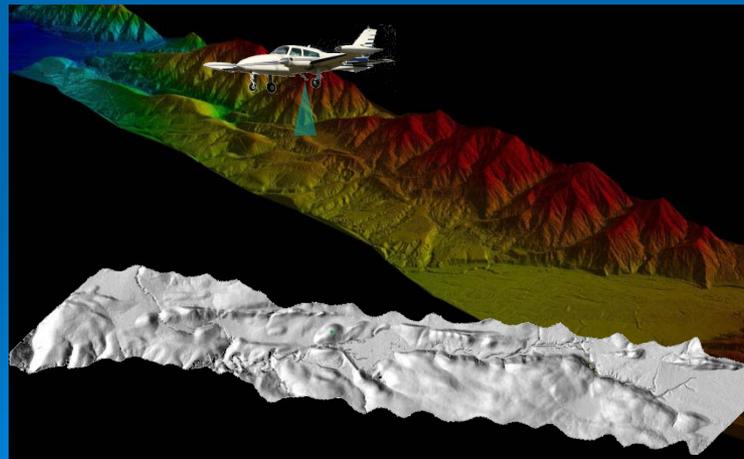
- MOA
- Industry forum
- Industry feedback
- Source selection team
- RFP
- Pre-qualify 3rd party investors
- Negotiations
- Award
- oversight



Fallon: Geothermal Exploration

ARRA - IDIQ TGH contract

- \$1.4M for 20-500 ft. holes
- Locations submitted to NAS Fallon June 9th for clearance
- Drilling to start mid-July/early August upon site approvals
- Drilling costs to date lower than originally anticipated – should be able to drill ~40-50 holes for \$1.4M



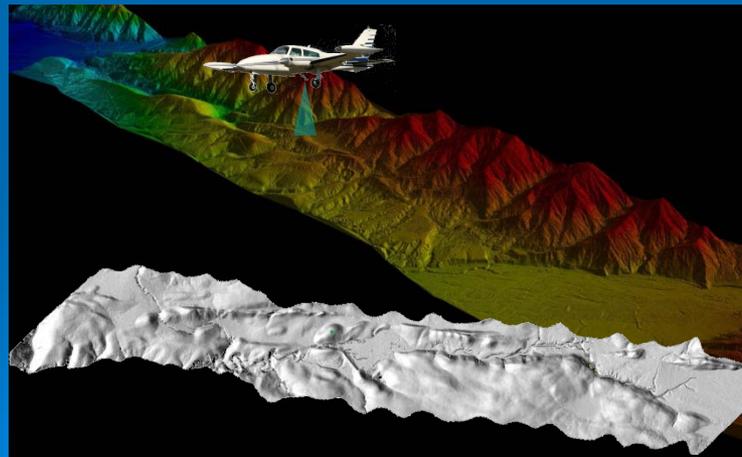
Fallon: Geothermal Exploration

ARRA - IDIQ Intermediate-Deep Drilling Contract

- \$5.5M of ARRA for 2-3 intermediate drill sites

ARRA – Tech Val (in lieu of BAA)

- Contract pending award for \$1.2M to acquire LiDAR and Hyperspectral-remotely sensed data for BR-16, BR-17, BR-19, and Dixie Valley. Shallow probe (2m) surveys to be completed as well.



Fallon: Navy-Ormat Development Contract

Development

- Contract signed w/ Ormat NV, Dec., 2005
- 82-36 Well Drilled to 9500' in 2008
- Next contract milestone is power generation by December 2012

Exploration

- ARRA funds available in 2009 and 2010
- self-perform, LiDAR, hyperspectral, shallow T probes
- TGH drilling - ongoing
- Int/deep drilling – to follow



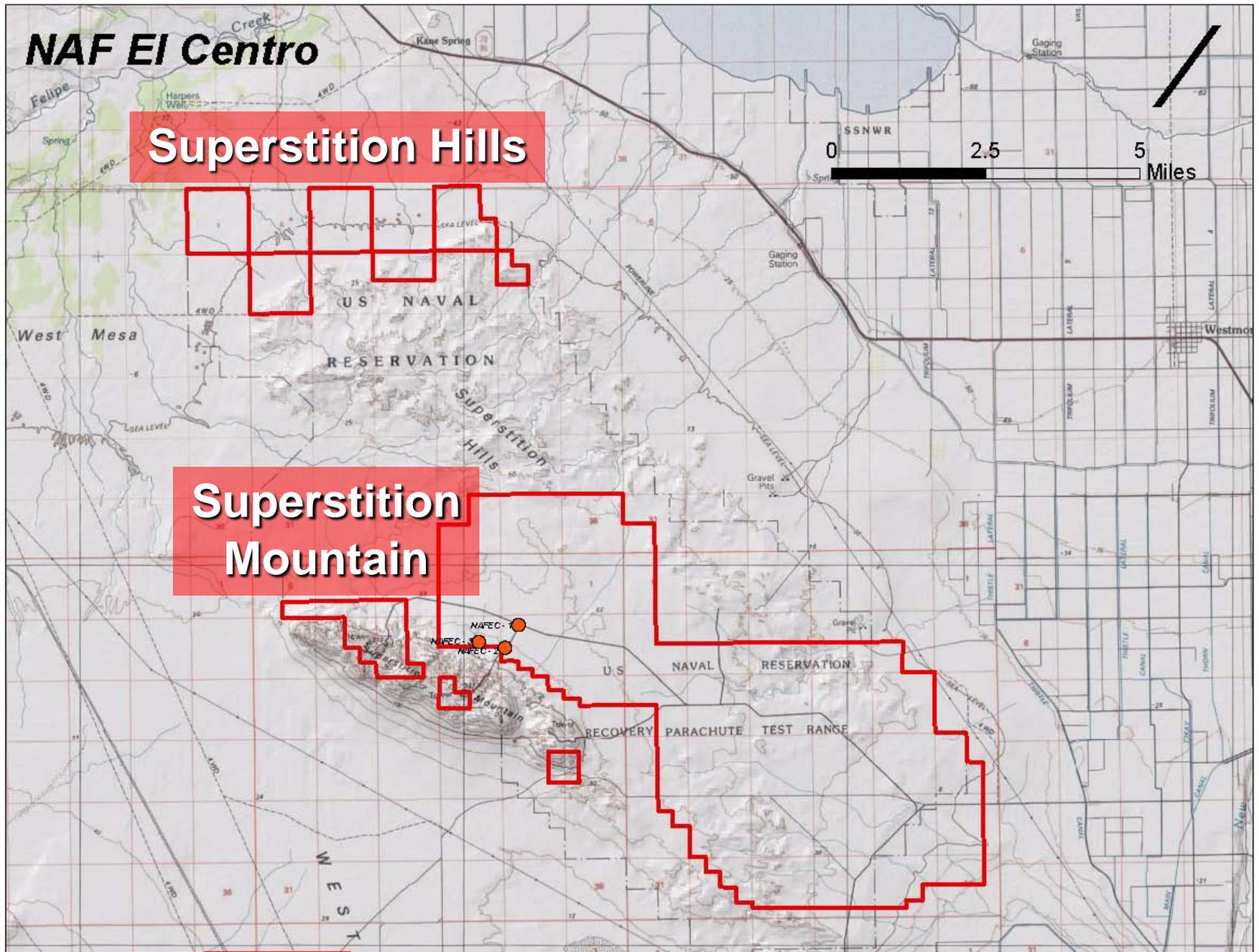
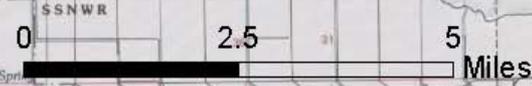


Naval Air Facility El Centro

NAF El Centro

Superstition Hills

Superstition Mountain



STATUS:

- ✓ Two test holes completed – Dec 2008
- ✓ 3rd test hole targeted – May 2009
- ✓ Drilling contract in place – May 2010
- Drill third test hole – Pending CATEX
- On completion of 3rd test hole - Go/NoGo
- Anticipate that Industry Forum is justified

Naval Air Facility El Centro

Bombing Target Range 101

171F @ 2280ft

NAFEC-1

187F @ 2140ft

NAFEC-2

NAFEC-3

Superstition Mountain

NAF El Centro Geophysical Test Hole Sites

- Completed 2008
- To Drill 2009/10

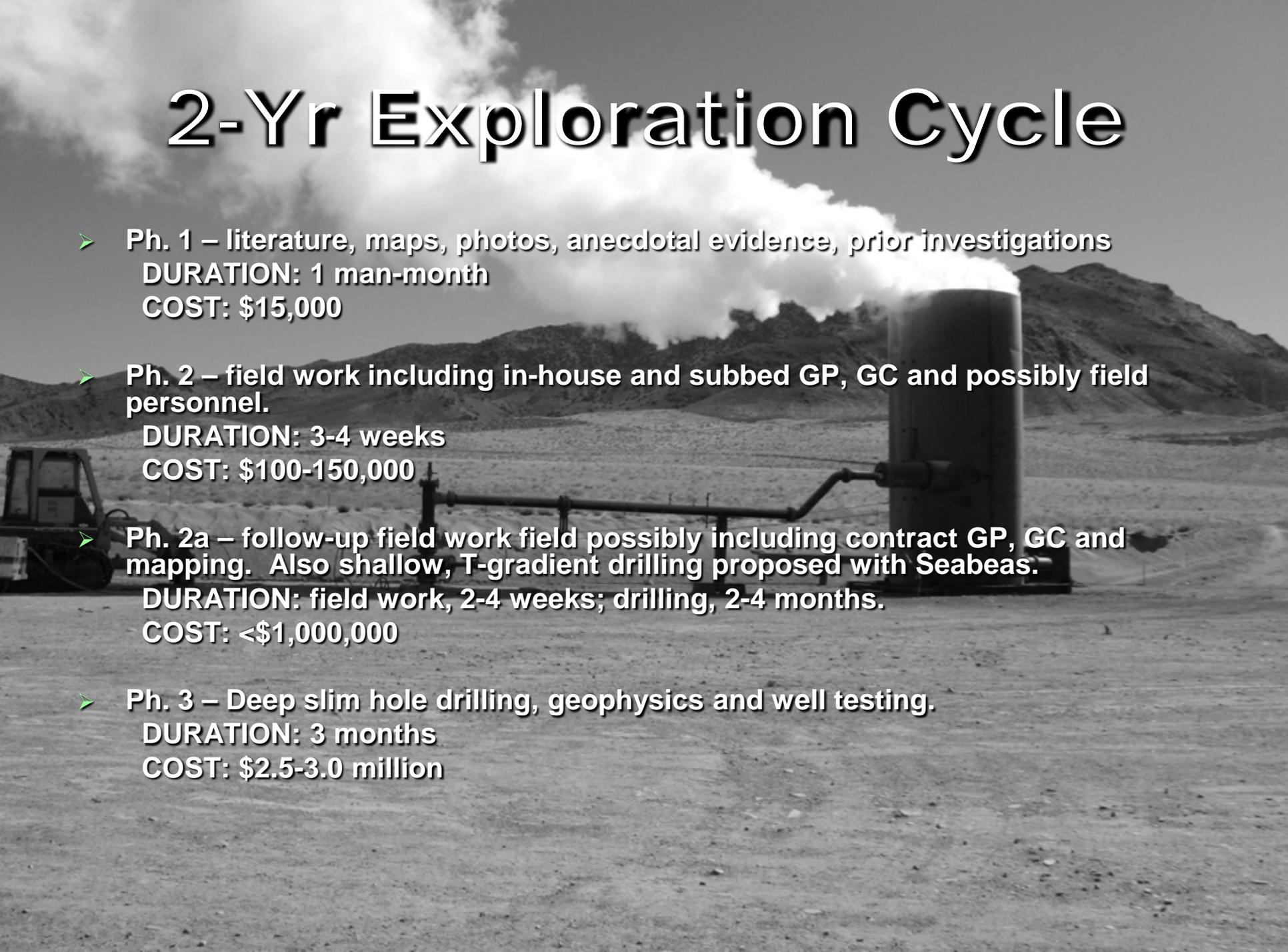
SP Contours	Faults	Military Lands
-30 - -20	— Certain	
-19 - 0	- - - Approximate	Lithology
1 - 20	- - - Faneros (2005)	Cataclasite
21 - 40	Isotherms	Qs
41 - 60	— 110 F	Qb
61 - 80	— 100 F	Pi
81 - 100	— 90 F	Mvp
101 - 120	— 86 F	Mcsi
121 - 140		Mz-gr

Geology from Dibblee (1954),
Faneros (2005) and GPO (2005).

0 500 1,000 1,500 2,000 Meters

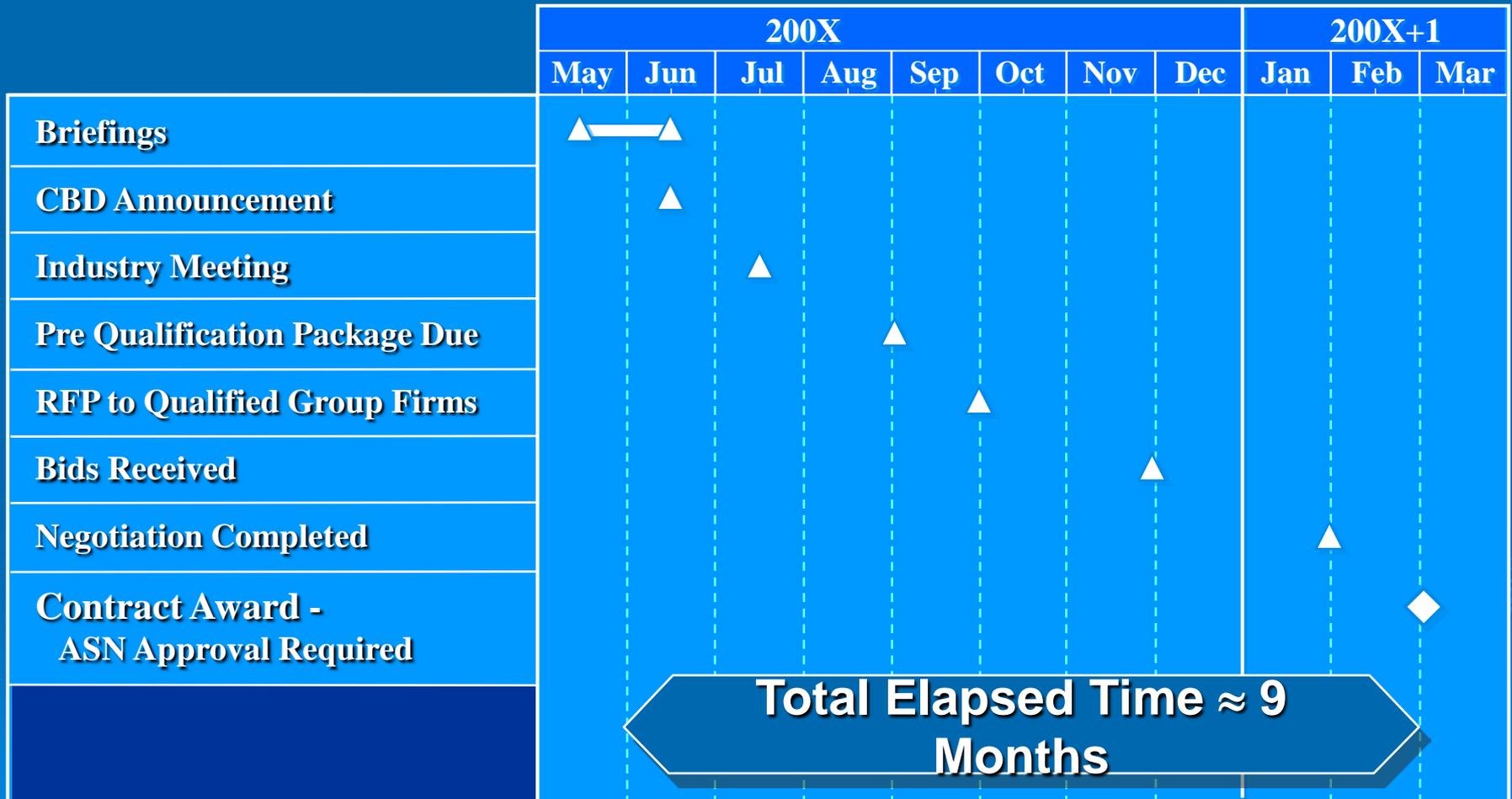


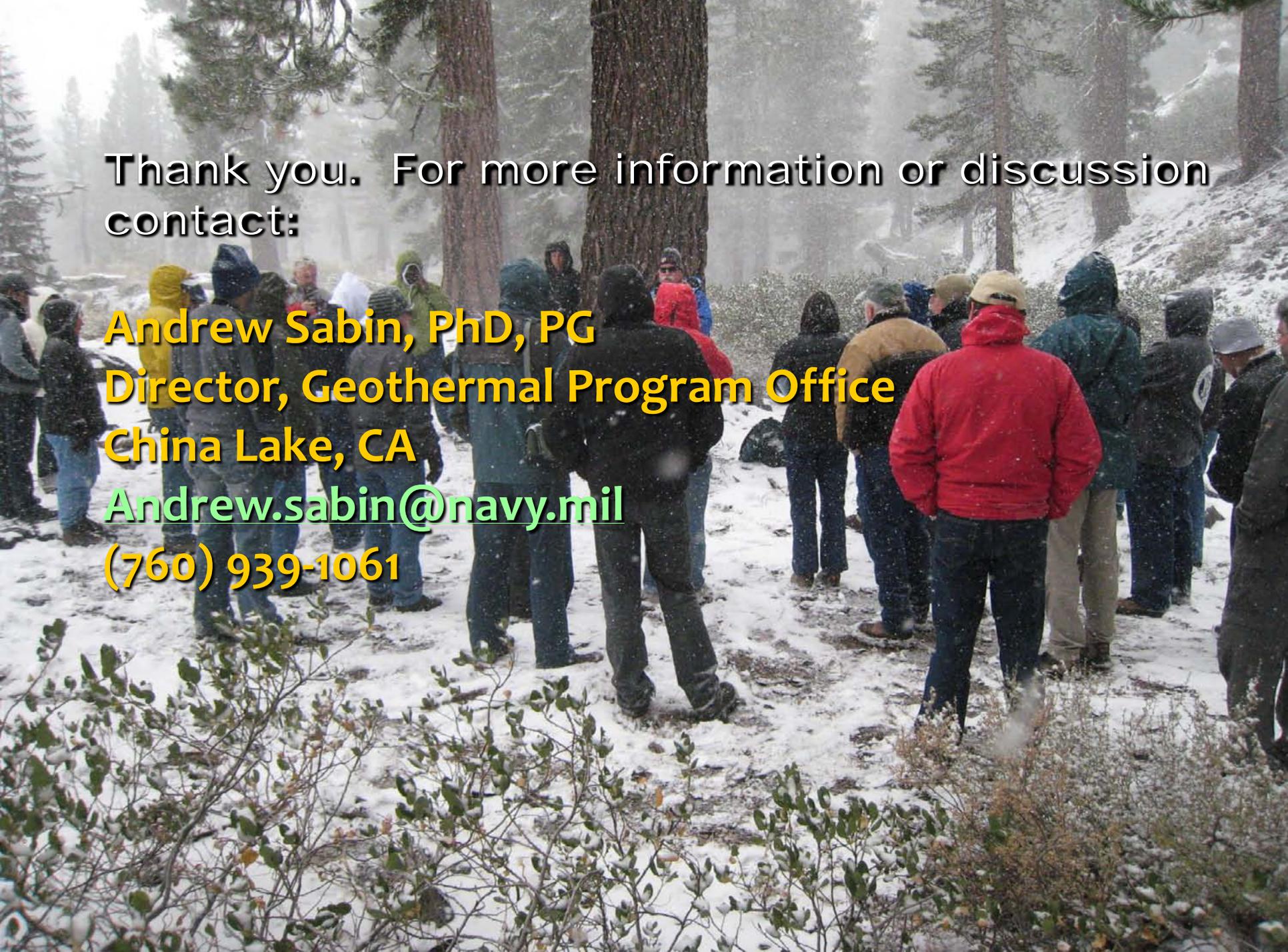
2-Yr Exploration Cycle



- **Ph. 1 – literature, maps, photos, anecdotal evidence, prior investigations**
DURATION: 1 man-month
COST: \$15,000
- **Ph. 2 – field work including in-house and subbed GP, GC and possibly field personnel.**
DURATION: 3-4 weeks
COST: \$100-150,000
- **Ph. 2a – follow-up field work field possibly including contract GP, GC and mapping. Also shallow, T-gradient drilling proposed with Seabeas.**
DURATION: field work, 2-4 weeks; drilling, 2-4 months.
COST: <\$1,000,000
- **Ph. 3 – Deep slim hole drilling, geophysics and well testing.**
DURATION: 3 months
COST: \$2.5-3.0 million

Project Milestones - Leading to Contract Award



A group of people, mostly men, are standing in a snowy forest. They are wearing winter jackets, hats, and gloves. The ground is covered in snow, and there are large trees in the background. The scene is misty or foggy, suggesting a cold, overcast day. The people are gathered in a loose circle, possibly for a meeting or a presentation.

Thank you. For more information or discussion
contact:

Andrew Sabin, PhD, PG
Director, Geothermal Program Office
China Lake, CA
Andrew.sabin@navy.mil
(760) 939-1061

A long, straight road stretches from the foreground into the distance, leading the eye towards a range of blue mountains under a clear sky. The road is flanked by sparse, dry vegetation. The overall scene is desolate and evocative of a journey or a path of progress.

“I wonder why progress looks so much like destruction.”

-John Steinbeck, 1960