PNNL-24279

Geothermal Power Generation and CO2 Capture Co-Production

May 2016

DJ Heldebrant

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Geothermal Power Generation and CO_2 Capture Co-Production

AOP PROJECT 27342

Q2 FY15

David J. Heldebrant

Key Accomplishments and Milestones

	Milestone	Progress	Met or Unmet	Explanation if Unmet
Q1 FY15	Provide detailed project management plan with refined scope per DOE discussions	Submitted	Met	
Q2 FY15	Complete detailed site-specific geothermal resource report	3/31/2015	Unmet	Work in progress
Q3 FY15	Revised site-specific process simulation complete with site conditions	6/30/2015	Unmet	Work in progress
Q4 FY15	Completion of final techno-economic analysis of candidate site	9/30/2015	Unmet	Work yet to begin

Key Accomplishments and Milestones Cont.

- Started site-specific analysis of geothermal data at Hot Pot
  - Acquired project files from GTO on Hot Pot Phase 1 (Oski Energy)
  - Synthesis of seismic, gravimetric and shallow gradient wells data
  - Examination of local geology including areas near the North Valmy plant site that were not considered in the Oski Hot Pot project
  - Investigation of development rights status for the site

- Started site-specific analysis of North Valmy Power Station
  - Information on plant configuration, power generation, and fuel use gathered from EIA database and plant heat rate calculated
  - Reviewed internet information concerning future operation of the North Valmy Station and environmental targets
  - Ambient conditions assumed to be similar to Winnemucca, NV for which National Oceanic & Atmospheric Administration data was obtained
  - Constructed a detailed ASPEN Plus® model of a subcritical power plant's steam cycle and matched North Valmy's heat rate with it
  - Drafted an itemized question list for discussion with plant operator to estimate benefit of geothermal heating of boiler feedwater

Expectations for Next Quarter

- Schedule on site visit to North Valmy (Nevada) for on site analysis and discussions with local geotechnical experts and coal plant operator

- Perform a site-specific geology and resource analysis of a candidate site
  - Contact site operator to get specific information on steam cycle configuration, flows
  - Investigate local geology to underpin a more site-specific cost analysis for geothermal development wells at the North Valmy / Hot Pot site

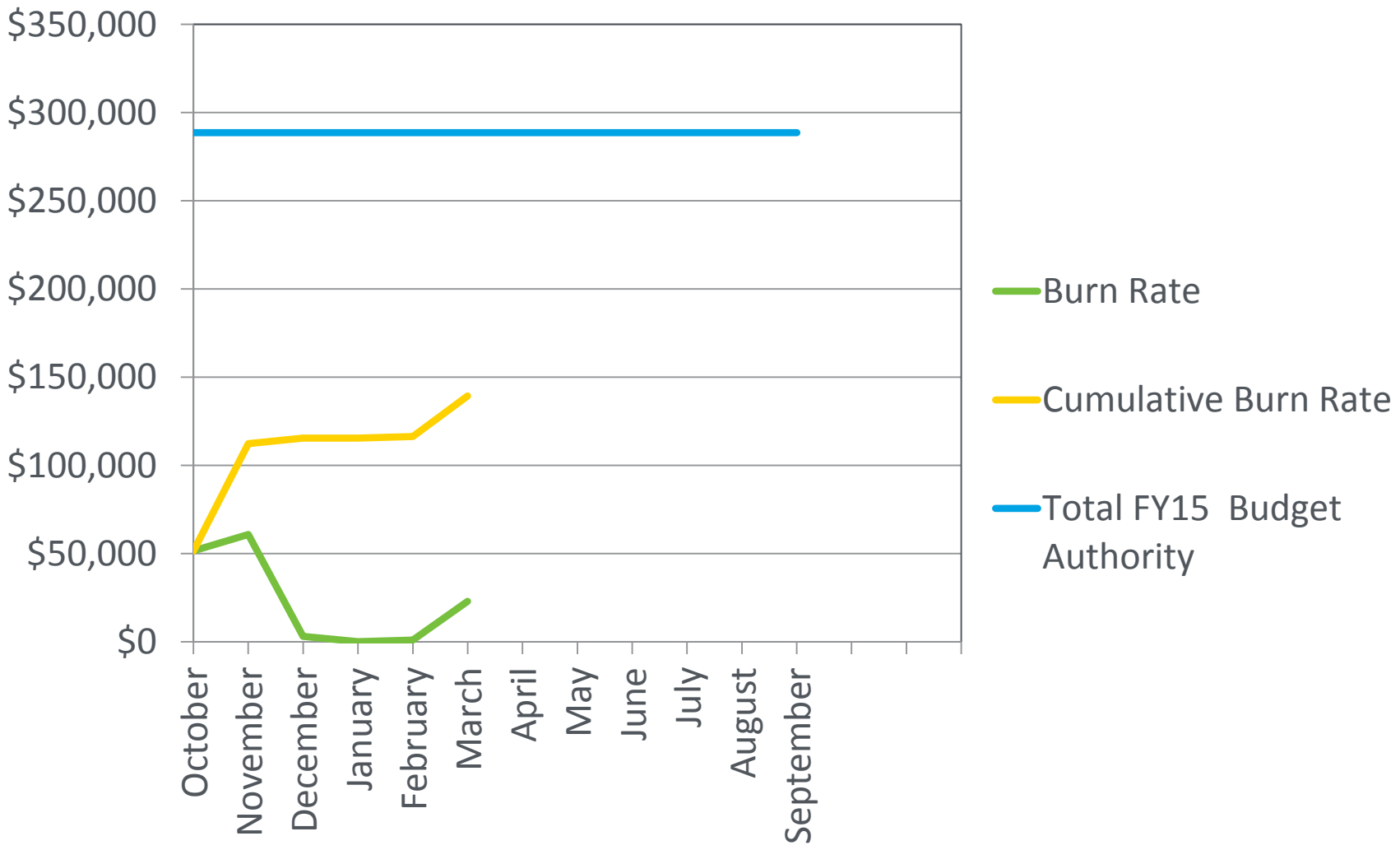
- On-site visit with plant operator to discuss findings from EIA database for potential hybridization strategies.
    - For geothermal water for boiler feed water preheating obtain
      - Steam extraction conditions and deaerator pressure
      - Condenser operating conditions
    - Reduction of cooling water temperature for increased vacuum in the condenser
    - Integration of ORC into the existing plant infrastructure

Spending as of Q2 FY15

		Total FY14 Budget Authority					Unspent Money at Lab	
	Project ID	FY14 New Budget Authority	FY13 Carryover NOT Including Forward Funding	Forward Funding Portion of FY13	Money Received by Lab in FY15 AOP	Total Money Spent in FY15	Unspent Uncommitted	Unspent Committed
DOE Data	1.1.0.10	$0	-	N/A	$0	-	-	-
Lab Data	1.1.0.10	$0	N/A	$0	$142,864	$87,795	$0	$0

- Describe any inconsistencies: received $115k in March FIN plan FY15
- Program was on a stop work starting Q1 through Q2 until funding arrived in February
- Cumulative project cost (FY14-15) as of this quarter: $350,676

Burn Rate by Month



Data Submissions

Data Element	Data Type	Date Collected (projected or actual)	Date Submitted (projected or actual)
Task 1: Site-specific geothermal resource and industrial site mapping	DOC file and independent Jpeg images	Projected for March 31, 2015	Projected March 31, 2015
Task 2: Coal Power plant with geothermal plant model	PPT file	Projected for June 30, 2015	Projected June 30, 2015
Task 3: Technoeconomic analysis	DOC and PPT files	Projected September 30, 2015	Projected September 30, 2015
Task 4: Project management	DOC and PPT files	Quarterly and Annual Reporting	Quarterly and Annual Reporting

Study Directions

- Detailed site-specific configuration of North Valmy Power Station.
  - The detailed plant configuration will be used to modify the current steam cycle model to more accurately match the North Valmy plant performance. Additionally, sized equipment will be generated for the cost estimation.
  - If the plant can benefit from cooling water temperature reduction, specific equipment can be designed and cost estimated for that purpose.
  - The value of ORC integration can also be assessed.

- Refinement of existing assumptions regarding feasibility for geothermal development at the Hot Pot site
  - Projection of required wellfield infrastructure.
  - Preliminary wellfield cost analysis.
  - This work will be iterative based on the site-specific configuration work for the geothermal integration at North Valmy station.

EIA Reported Characteristics of the North Valmy Generating Station

Boiler & Steam Cycle

- Pulverized coal, wall fired, dry ash, subcritical steam cycle power plant
  - Two boilers
    1. B&W unit with nameplate of 277.2 MW and seasonal capacity of 254 MW. Operational Dec. 1981
    2. Foster Wheeler with nameplate of 289.8 MW and seasonal capacity of 268 MW. Operational May 1985
  - Two steam turbine generator sets – Subcritical assumed from heat rate TBD with North Valmy personnel.

- Entire plant nameplate capacity
  - Unit 1 (Operational 12/1981) 277.2 MW
  - Unit 2 (Operational 5/1985) 298.2 MW

- Operational capacity
  - Unit 1 - 254 MW
  - Unit 2 - 268 MW

- Firing
  - Both units are wall fired

2014 Operational Characteristics and Fuel Source

- Generation by Unit (Source EIA: Form 923 – 2014M)
  - MWH/yr / 8760 hours/yr
  - Unit 1 - 174.9 MW
  - Unit 2 - 139.7 MW
  - Total - 314.6 MW

- Generation by Fuel Type
  - Bituminous coal - 130.0
  - Distillate Oil - 1.5
  - Subbituminous coal - 183.1

- Rail supplied combination of 40 bituminous and 60 wt% subbituminous
  - Bituminous coal from SUFCO mine in UT and West Elk mine in CO
  - Subbituminous from Black Butte and Leucite Hills WY mines
    - Properties of the 2 coals are similar as shown in the table

Source: EIA Form 923 2014M

Coal Type	Quantity Short Tons	Heating Value Btu/lb	Sulfur wt%	Ash Content	Cost $/ MMBtuH
Bituminous	630,040	11,300	0.440	8.34	2.20
Subbituminous	1,086,364	9,569	0.437	8.69	2.88

Emission Controls

- Zero Liquid Discharge to groundwater by evaporation (Source: Nevada Division of Environmental Protection Permit NV96015; 2011)
  - 5 ponds are 25 acres * 8 ft and 1 pond of 33 acres * 12 ft deep
  - All water wastes from plant including cooling tower and water blowdowns, storm water, sanitary waste are discharged to these ponds

- Ash Landfill (Source: North Valmy Power Plant Industrial Landfill - Class III; Nevada Department of Environmental Protection)
  - Fly and Bottom Ash stored at onsite landfill.

- NOx: Low NOx Burners with overfire air

- Particulate: Baghouse filters with reverse air pulse

- Mercury: Baghouse filters

- SO_2: Dry sorbent injection (lime) on Unit 2 only

- Low sulfur coal combustion on Unit 1.

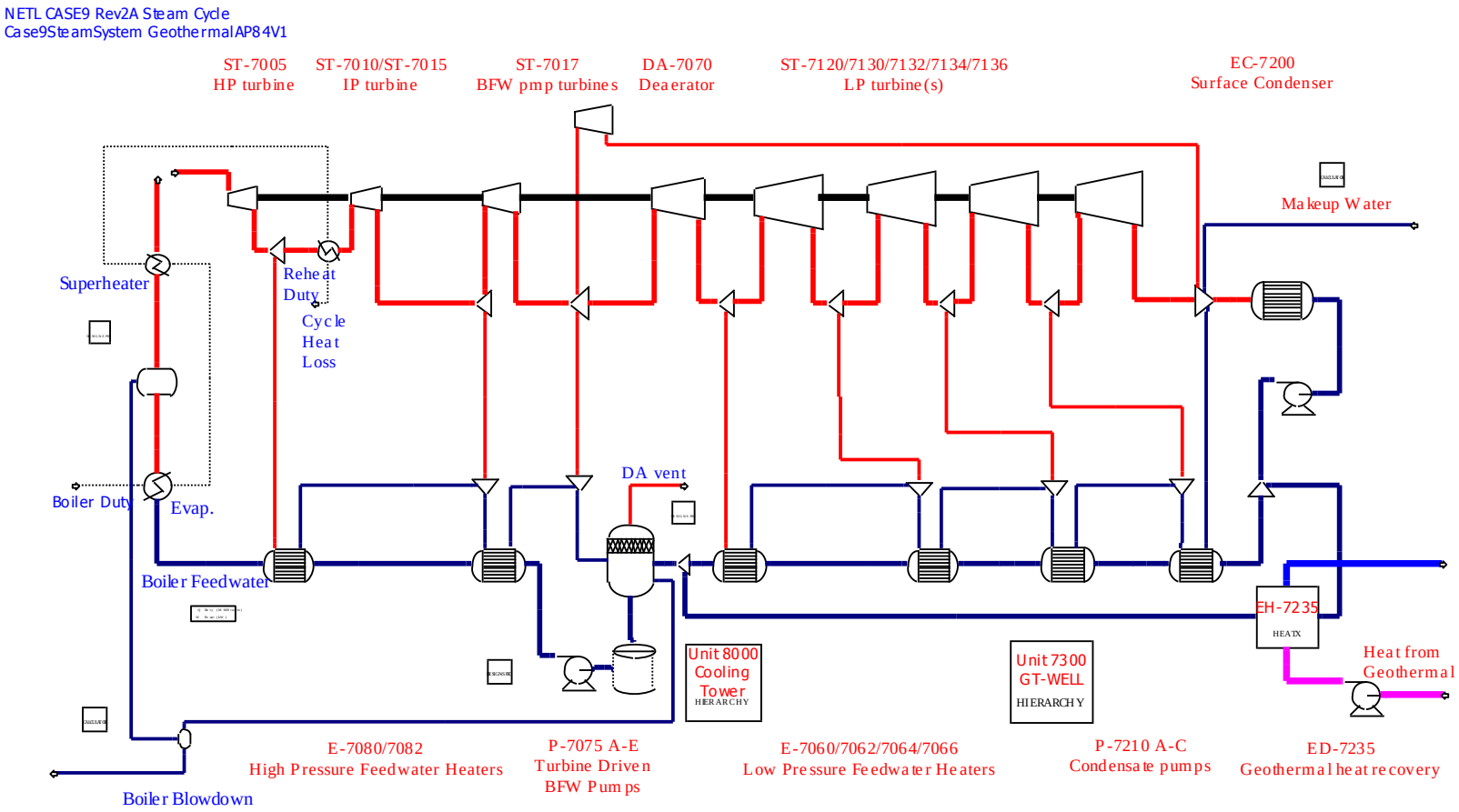
Heat Rate Calculation by Unit and by Fuel Type

- Unit 2 is newer but possibly has greater fan requirements from the spray drier that Unit 1 doesn't have.
- Both units are 15-16% less efficient (31-32%) than the NETL Case 9 efficiency of 36.8%.
- That is in part due to the low steam turbine efficiencies of the time and possibly due to higher site condition temperatures.

Reported Fuel Type Code	Elec Fuel Consumption MMBtu	Net Generation (Megawatthours)	Apparent MW	Apparent Heat Rate	Apparent Efficiency
BIT	12,723,607	1,139,251	130.05	11,168	31%
DFO	144,379	13,022	1.49	11,087	31%
SUB	17,267,217	1,603,637	183.06	10,768	32%

North Valmy Steam Cycle Simulated Using ASPEN Plus

(To be confirmed with North Valmy personnel)



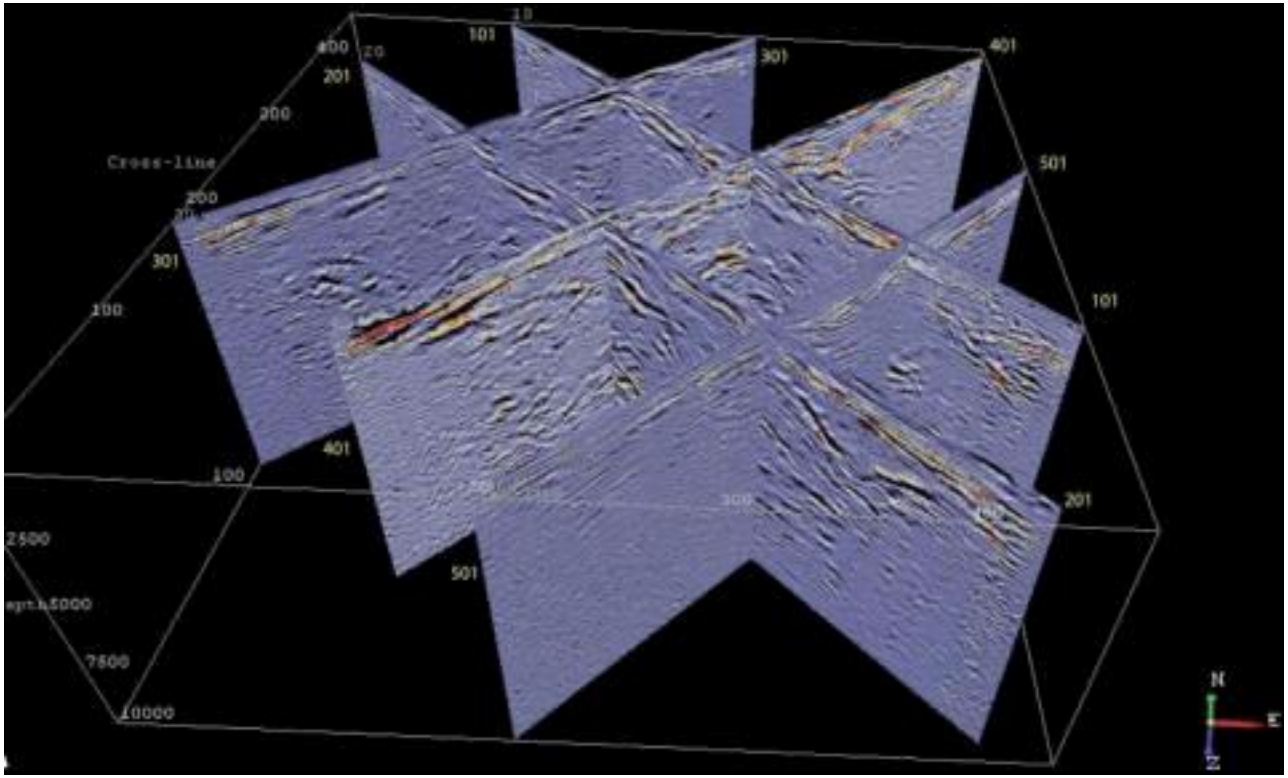
Information Desired from North Valmy Personnel

- Steam Cycle characteristics
  - Feed water heater no. and extraction steam pressures
  - Condenser operating conditions
  - Electric or steam driven BFW pumps
  - Deaerator pressure

- Auxiliary power losses
  - Fans, BFW pumps, Misc.

- Seasonal power demands, to determine viability of boiler feed water preheating power gains and other hybridization strategies

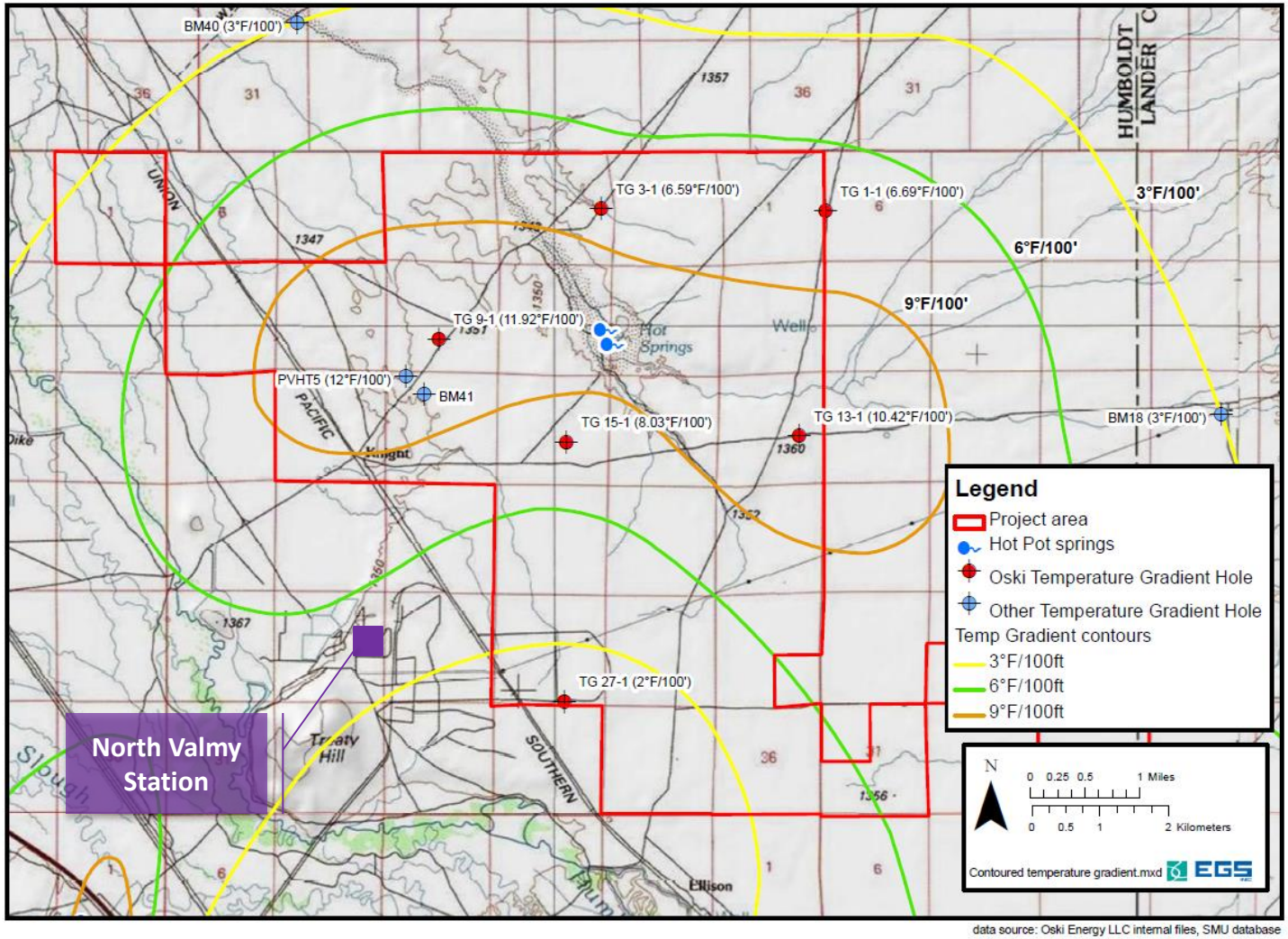
Site-Specific Analysis of the Geothermal Energy Data at Hot Pot, Phase 1 (Oski Energy, LLC)



Gridded seismic lines at the Hot Pot Project

(Photo taken from www4.eere.energy.gov/geothermal/projects/71 Oski Energy)

Hot Pot, Phase 1 Gradients & Proximity to NVGS

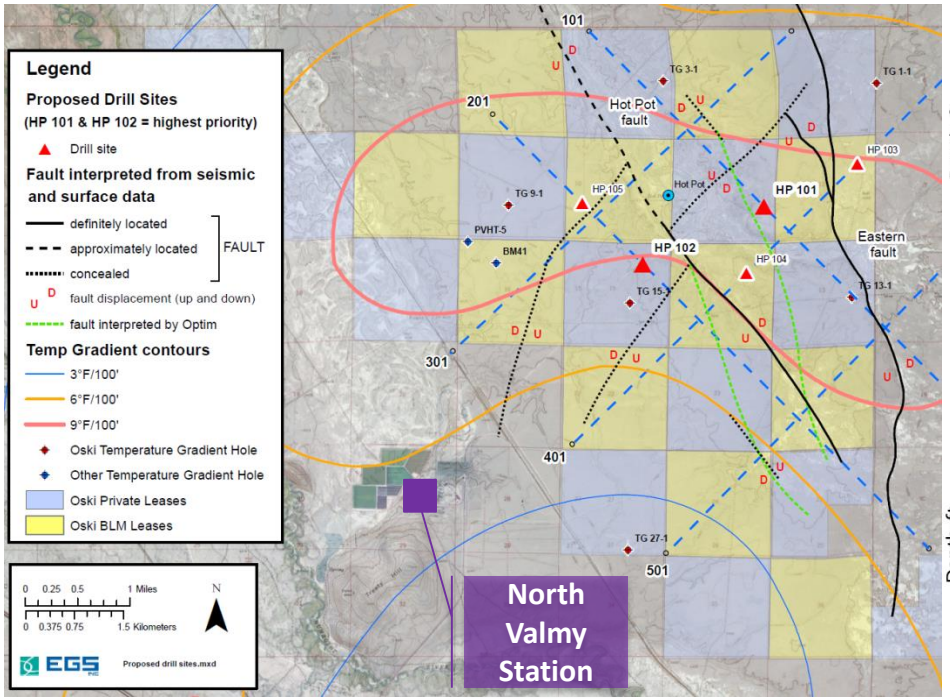


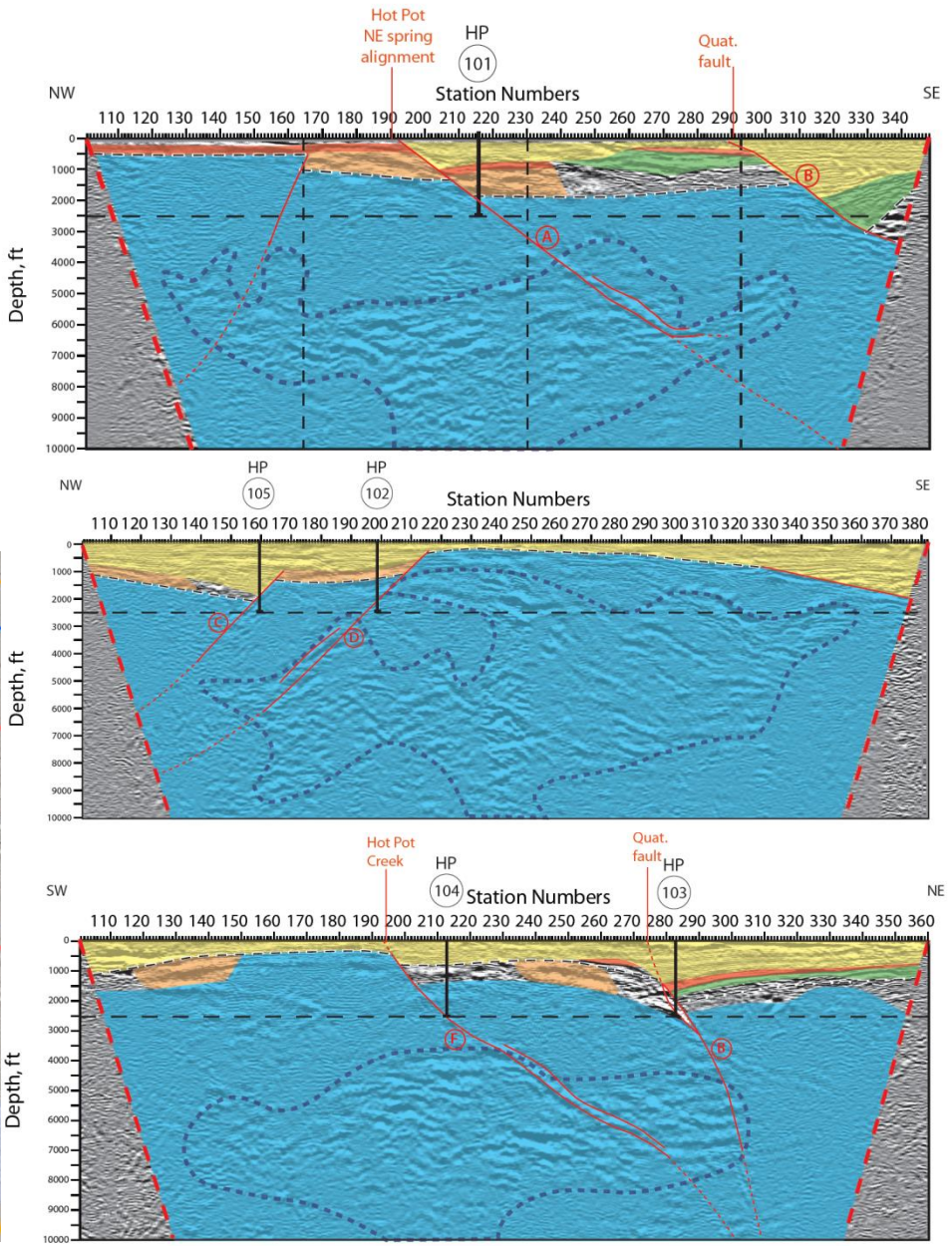
data source: Oski Energy LLC internal files, SMU database

Figure 8: Hot Pot Contoured Temperature Gradient Map

Hot Pot, Phase 1 Drilling Recommendations

- Oski Energy, LLC recommended slimhole drilling program (below) places highest priority wells 2-3 miles from North Valmy station
- Sites selected to intersect transmissive faults seen in Phase 1 seismic interpretations (right)
- HP 102 or a location closer to NVGS being investigated in Q3





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