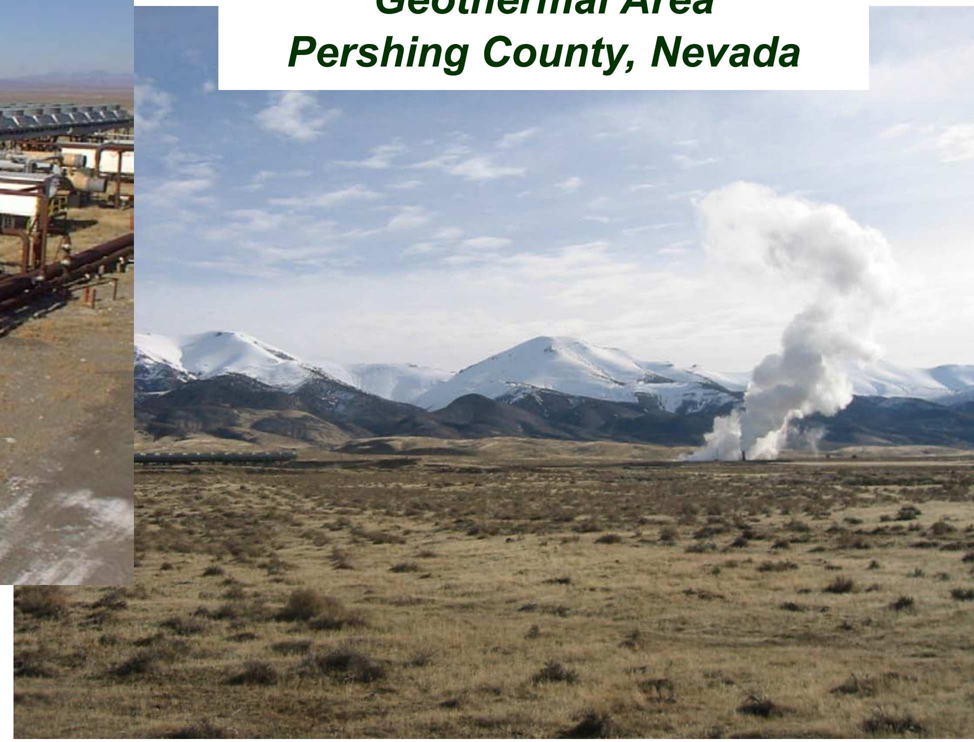
Geothermal Technologies Program
Validation of Innovative Exploration Technologies
May, 2010 Peer Review



Humboldt House–Rye Patch
Geothermal Area
Pershing County, Nevada

Application of 2D VSP Imaging Technology to the Targeting of Exploration and Production Wells in a Basin and Range Geothermal System

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Richard Ellis, Princ. Inv.
Presesco Energy, LLC

Project Overview

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- ***Timeline:***
  - Start Date: January 29, 2010
  - End Date: December 31, 2011
  - Percent Complete: 2%
- ***Budget:***
  - Total: $4,211,229
    - DOE share: $2,277,081
    - Presco share: $1,934,148
- ***Funding for FY 2010: $2,045,145***
  - DOE share: $1,244,039
  - Presco share: $801,106
- ***Barriers:*** permitting, dynamic cooling of wellbores, re-entry/deepening of existing wells
- ***Partners:***
  - APEX/HIPoint Reservoir Imaging (VSP, processing)
  - Optim, LLC (surface seismic, processing)
  - ThermaSource/Drlg Contractor (drilling, testing)
  - UNR-Louie (seismic interpretation)
  - Waibel, Blackwell (interpretation)

Relevance and Impact of Research

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Objective:

- A novel 2D VSP imaging technology and patented processing techniques will be used to create accurate, high-resolution reflection images of a classic Basin and Range fault system in a fraction of previous compute times

Impact:

- Fundamentally, the technology is being used to reduce targeting risk in fault-controlled geothermal systems, reducing finding and development (F&D) costs. Lower F&D costs augur lower levelized costs of geothermal power.

Innovation:

- Dynamic wellbore cooling using coiled-tubing will facilitate the use of this technology in a variety of geothermal environments
- Multicomponent geophones convert analog signal to digital signal onboard, which is then transmitted digitally to the surface, reducing noise and data loss
- Fiber-optic wireline permits vastly larger bandwidth and data volumes to be transmitted to the surface in real-time
- Long vertical and horizontal apertures permit greater signal recovery below the Valley Fill, based on synthetic, finite-difference modeling of the range front geometry
- Patented upward continuation of the wavefield permits use of robust, time-domain processing algorithms (deconvolution, statics, NMO, amplitude, etc), greatly reducing compute times and improving the reflection image

Project Scientific and Technical Approach

- **Project, located in a classic Basin and Range setting, heretofore plagued by high exploratory and development risk**
  - Limited, medium-enthalpy resource developed (approx 6 MW)
  - Prior resource development, based on poor reservoir characterization, failed due to inconclusive subsurface information and very poor seismic imaging
- **New LIDaR and high-resolution aeromagnetic data, along with prior gradient holes, reservoir tests and extensive surface and geochemical work, suggest the Range Front model clearly operative, chemical temperatures of 500-525 deg F present, and up to 8 miles of faulting prospective for ultimate development**
- **How can we improve targeting of the high-enthalpy resource and thereby manage finding and development costs?**

Area of Investigation - Regional

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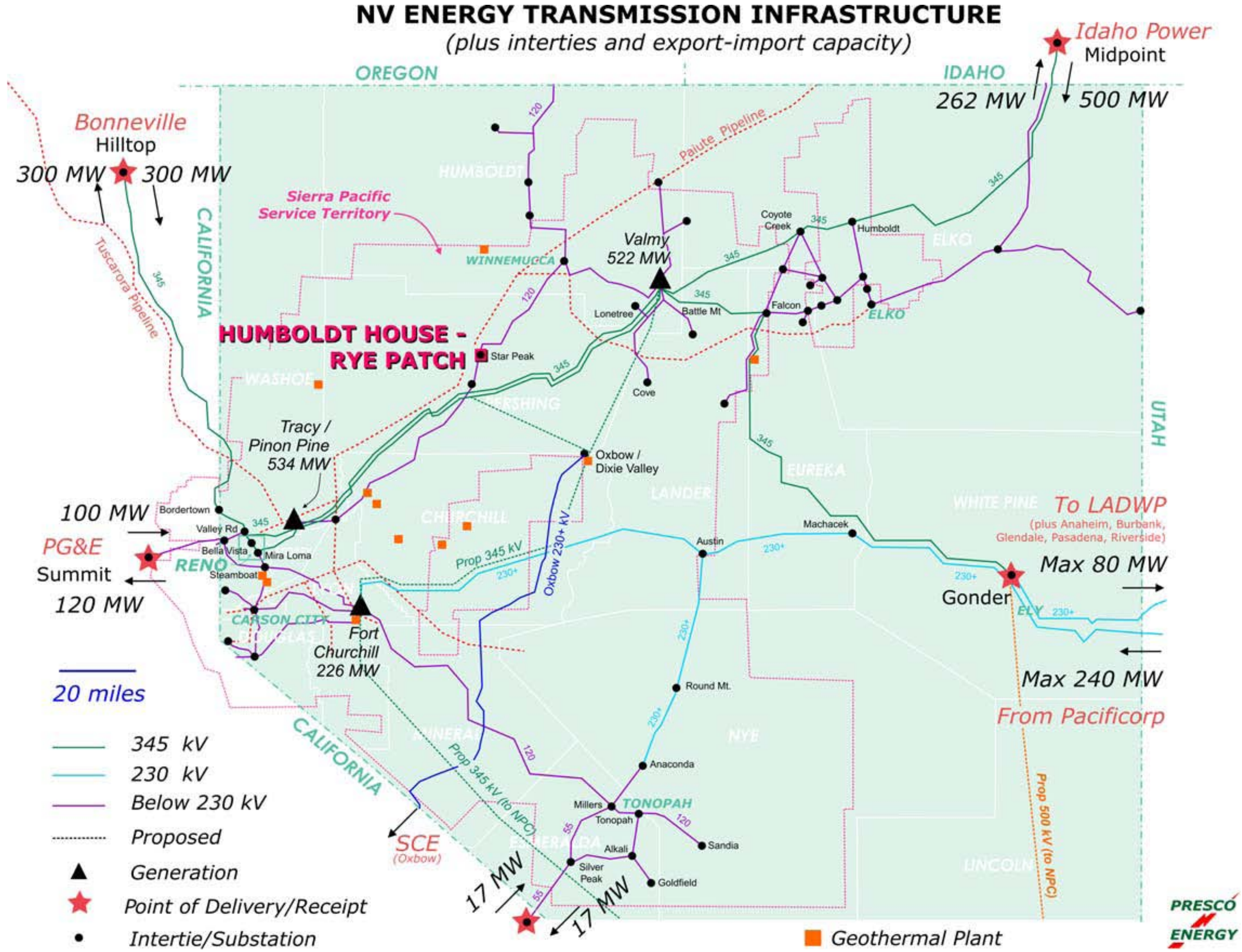

Area of Investigation - Project

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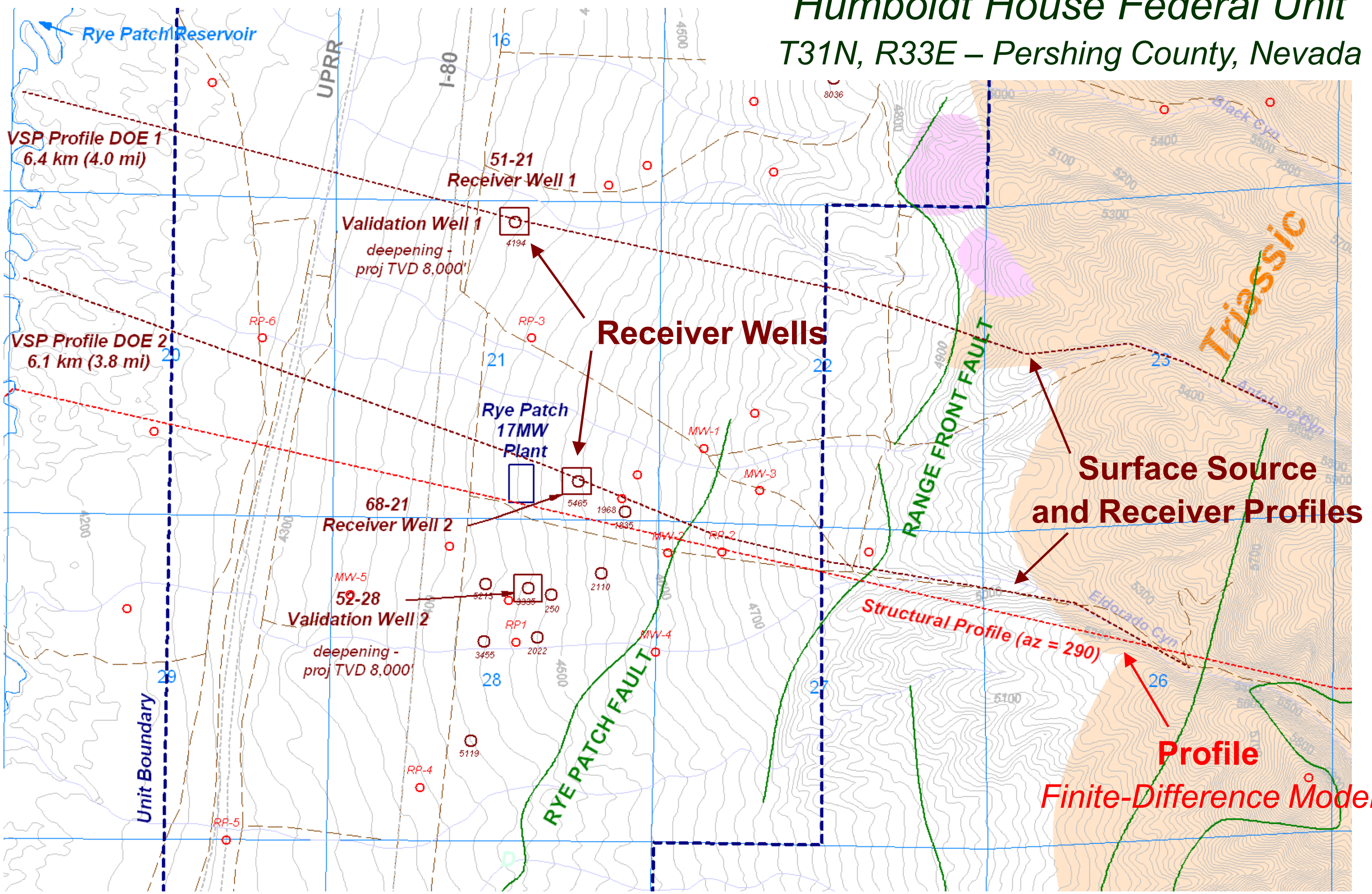
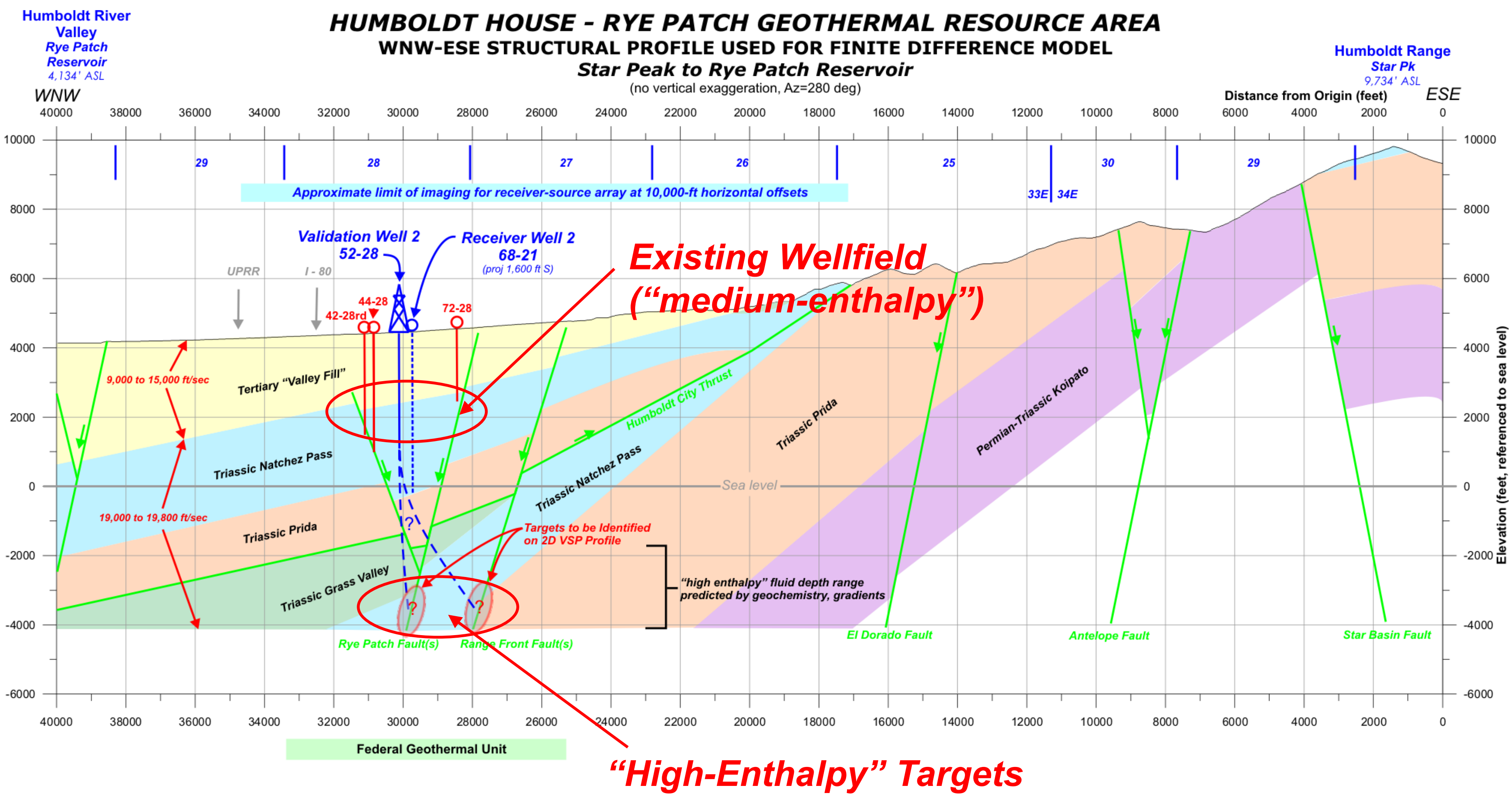
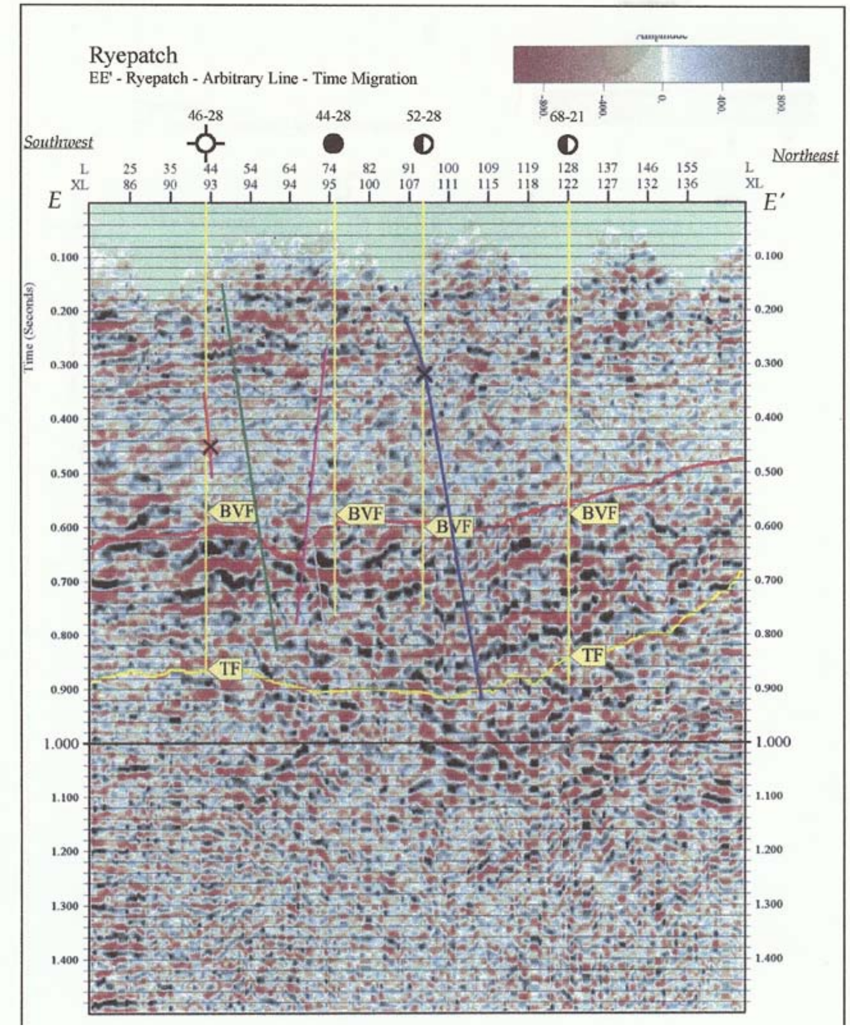


Structural Profile

Block Model used for Finite-Difference Modeling of Seismic Response



"Old Technology"



Surface Seismic Profile

(3D, 1997)

- Same area of DOE profiles
- Very poor energy penetration below Valley Fill (VF)
- VF lithologies alternately absorptive or dispersive (clays, tuffs, boulders, etc)
- Poor first breaks and static solution
- Distorted raypaths
- Very poor "interpretibility"

Project Scientific and Technical Approach

- Finite-difference forward model of the Range Front at the site confirms the feasibility of reflection imaging below the Valley Fill
- Strong west dip of formations and Range Front faults at Humboldt House presents a logistical challenge, requiring long offsets
- The VSP profiling technique of HiPoint Reservoir Imaging was optimized for implementation in this environment
  - Extended vertical and horizontal apertures facilitate higher resolving power: higher multiplicity, higher frequency
  - Surface seismic will be recorded along the VSP profiles for comparison and refinement of velocity models

Finite-Difference Modeling

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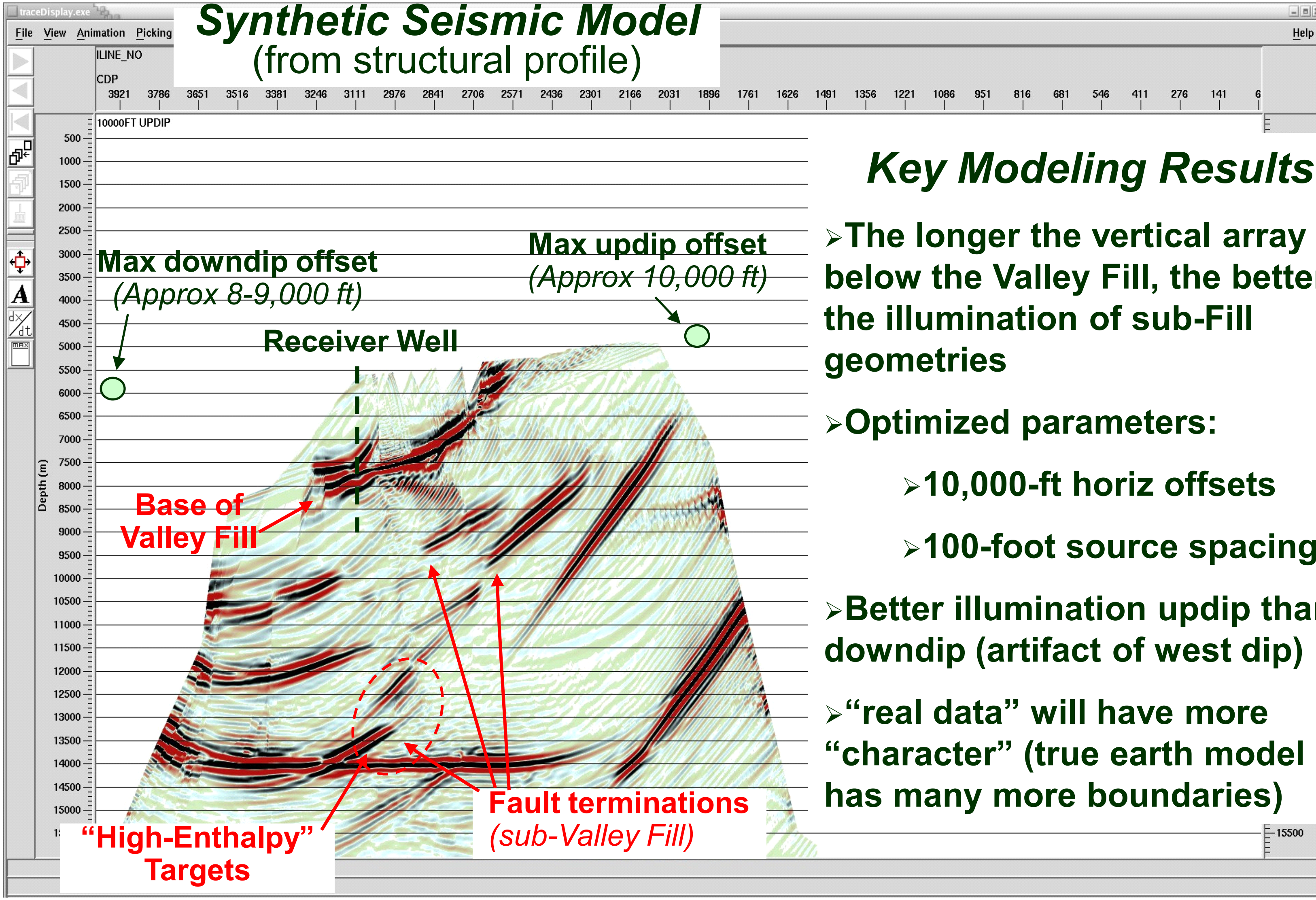

Key Modeling Results

- The longer the vertical array below the Valley Fill, the better the illumination of sub-Fill geometries
- Optimized parameters:
  - 10,000-ft horiz offsets
  - 100-foot source spacing
- Better illumination updip than downdip (artifact of west dip)
- "real data" will have more "character" (true earth model has many more boundaries)

Innovation – Equipment

- 3-Component Geospace DS-150 Geophone
  - Lightweight, digital, wall-locking
  - Signal digitized onboard, then transmitted digitally
    - Dramatically reduces noise and data loss
- Deployed on fiber-optic wireline
  - Sufficient bandwidth (unlike copper) to transmit all data real-time
- Drawback: temp limit of 270 deg F

- Vertical array deployed from wireline truck
- Uses crane-supported wheel
- Make-up at approximately 1 minute per level
- Deploys at 30 meters per minute

Innovation – Field Acquisition and Deployment

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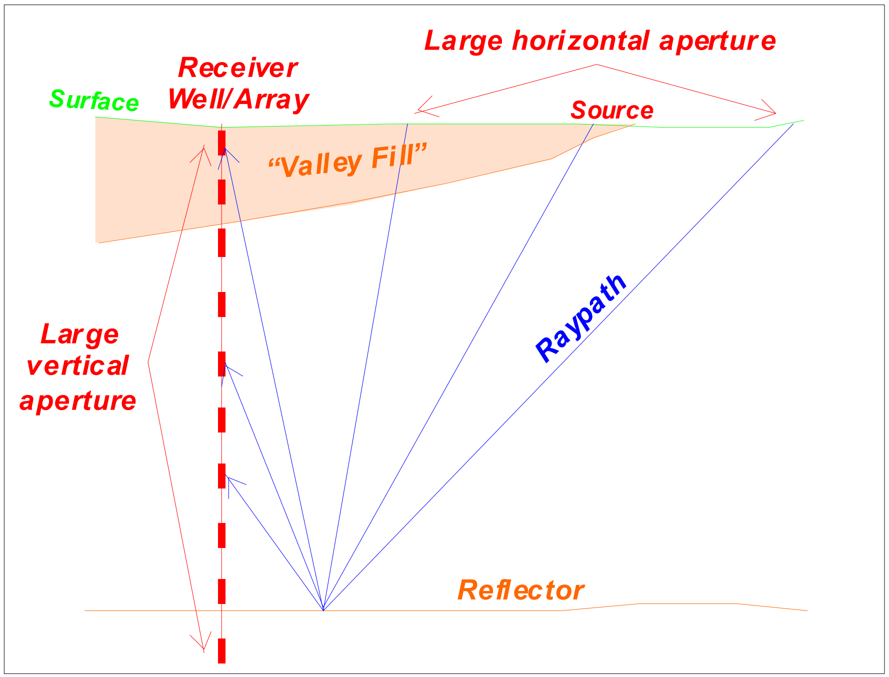
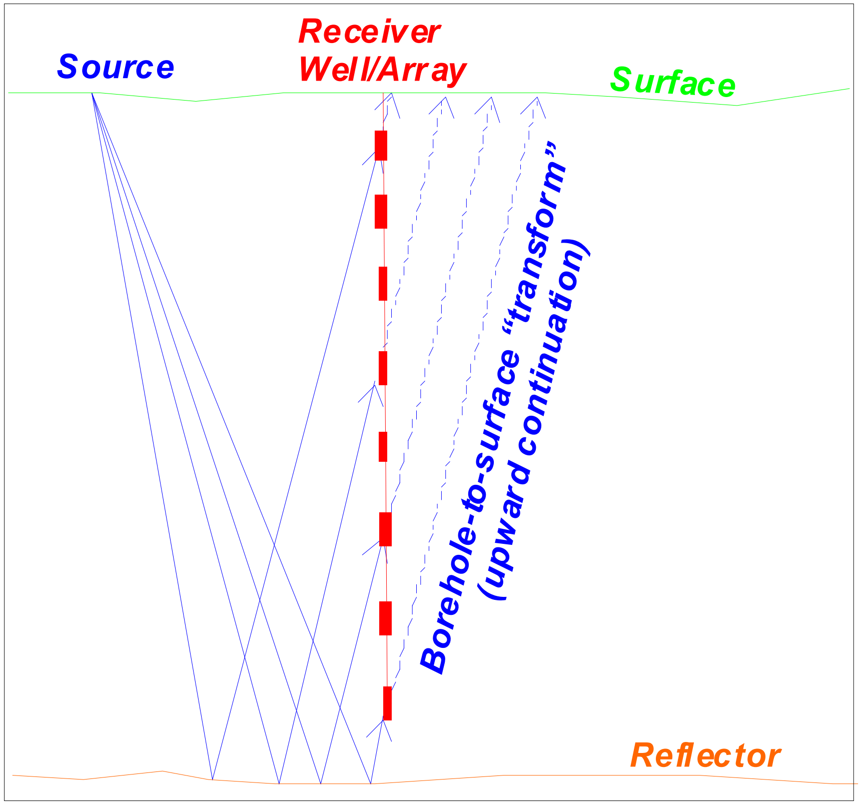


- Large, spatially dense vertical aperture
  - Large number of multicomponent phones – up to 4,000 feet
  - Deployed on lightweight, fiber-optic wireline
  - High-volume, high-bandwidth
- Large, spatially dense horizontal aperture
  - Vibration points at 110-foot spacing
  - Up to 10,000 feet either side of receiver well
- High-multiplicity, high-frequency
- Surface seismic data will be recorded for comparison to borehole data

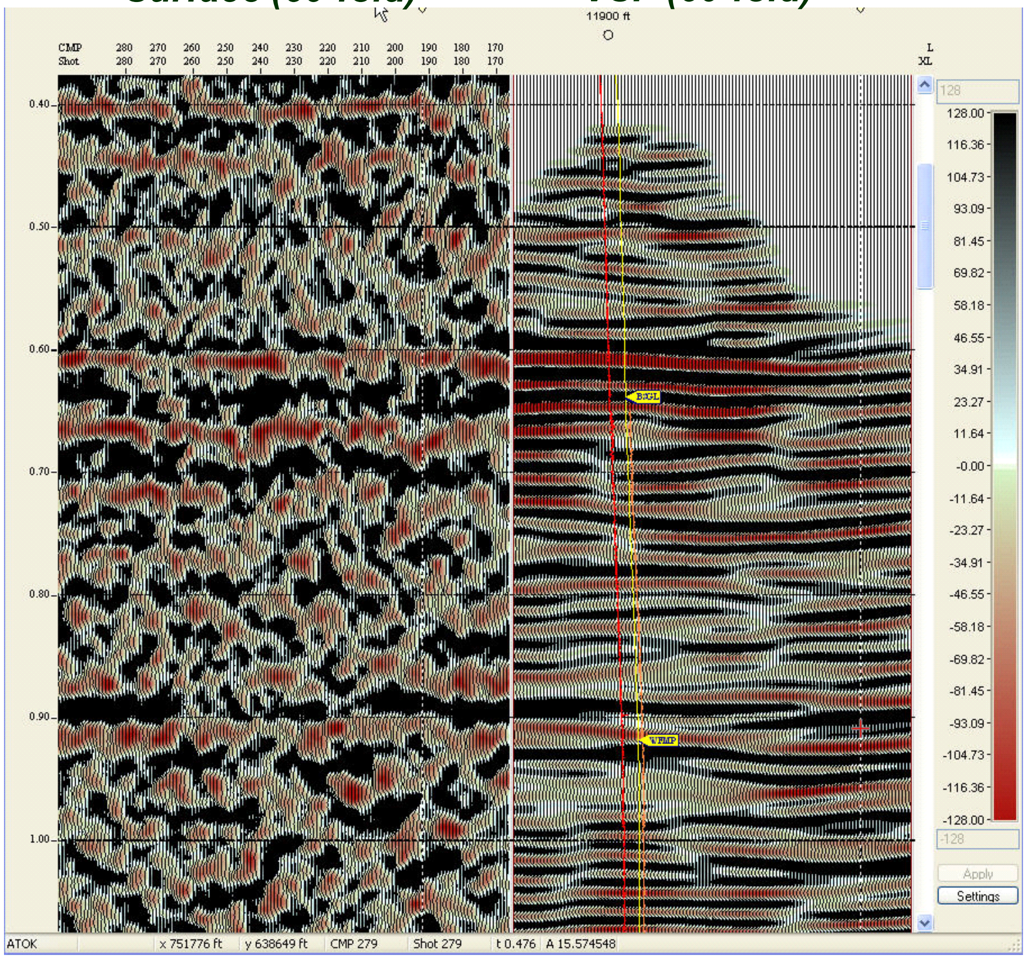
Innovation – Processing



- Borehole seismic data are transformed to surface seismic data using patented upward-continuation of wavefield
- Facilitates use of powerful surface-consistent, time-domain algorithms – statics, decon, NMO, amplitude
- Processing flow occurs in fraction of previous (borehole seismic) compute times

Expected Outcome – Surface vs Borehole Seismic

Surface (60-fold) **VSP (60-fold)**



- Both datasets acquired in same location in W Texas
- Near-surface known to create high-amplitude reverberations, absorbing energy and compromising reflection quality
- VSP relatively unaffected because receivers deployed below "trapping zone"
- Frequency content of VSP data at least twice that of surface data

Receiver and Validation Wells

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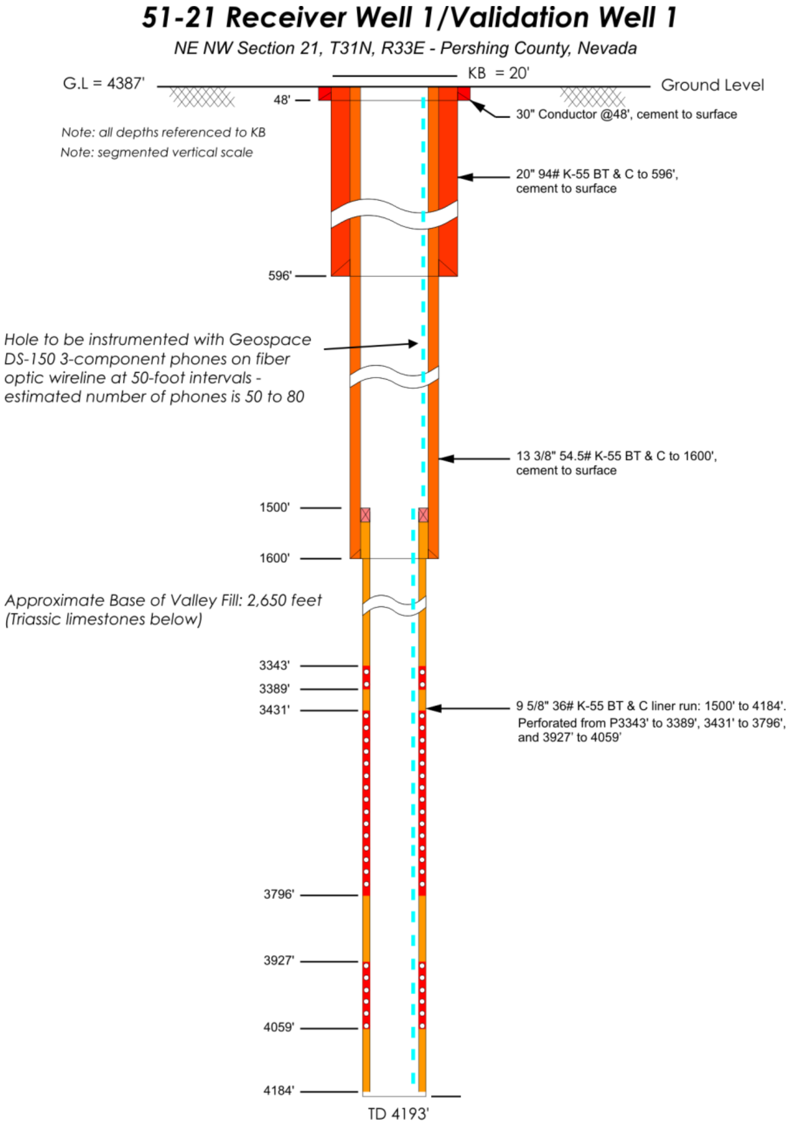
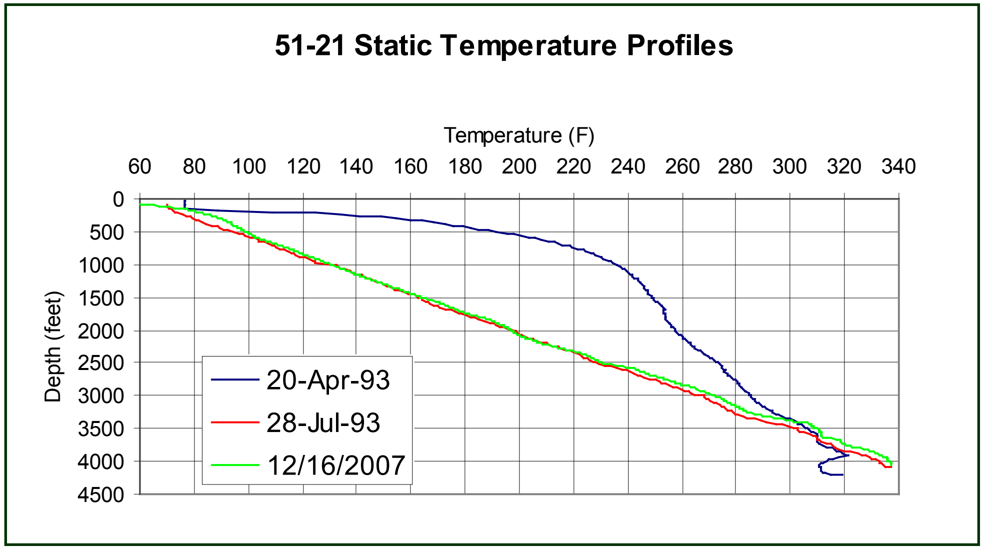


- **Well to be instrumented with up to 80 geophones (at 50-ft intervals)**
  - Up to 35 geophones below Valley Fill
- **Well to be used for validation (Phase II)**
  - Large-diameter to TD (4,193 ft)
  - Conductive gradient to TD (7.6 deg/100 ft)
  - Reach 400 deg F at 800 ft below TD
  - Reach 500 deg F at 2,200 ft below TD



Progress To-Date

- **Phase I – underway as of January 29, 2010 start date**
  - **Task I: Wellbore Re-Heat Tests Complete**
    - Purpose: ensure wellbore temperature at least 10% below sensor (geophone) limit of 270 deg F
    - Protocol: Cold water pumped into receiver wells 51-21 and 68-21, temperature logged to TD
    - Conclusion: Even with adequate surface pressure, cannot displace hot water at depth from surface
    - New protocol developed for "dynamic cooling":
      - coiled-tubing (CT) unit will displace hot water at TD in both receiver wells
      - receivers and fiber line will then be "strapped" to CT and deployed to depth
      - survey will proceed, CT will be used to pump in cold water, temperature will be monitored with onboard sensors
  - **Task I: Permitting (in progress)**
    - Purpose: meet NEPA and archaeological/cultural permit requirements for seismic survey
    - Protocol: cultural resource management firm deployed to survey seismic profiles for historic/prehistoric sites, inventory and record sites for BLM
    - Expected outcome: profile locations will be adjusted to avoid impacts to cultural and species sites
    - Timing: permit approval expected by end of May, 2010

Strategy and Expected Outcomes – FY 2010

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- **Phase I tasks** (total duration, with overlaps, of 6 months)
  - Permitting, wellbore-re-heat tests: 2 months
  - Field Acquisition: 1 month
  - Processing: 2 months
  - Interpretation, Modeling, Targeting: 2 months
  - Key Milestone/Decision Point:
    - Interpretation and Targeting: does the reflection image identify a specific element of the Range Front geometry – e.g. fault intersection at high-enthalpy depth - that is appropriate for targeting from the existing wells?
      - If no target identified, is there additional processing/interpretation required?
      - If no target achievable from one of the existing wells, is the second well usable?
      - If neither well usable, what new location is required and can it be substituted?
- **Phase II tasks** (total duration of 4 months)
  - Permitting, wellwork final design/costing: 2 months
  - Initial validation well – 51-21 - drilling and completion, rig-test: 2 months
  - Key Milestone/Decision Point:
    - Result of Validation Well No. 1: does the well confirm the targeting model developed from the innovative technology?
    - Did the well prove the existence of the high-enthalpy resource?
    - Does the well justify Validation Well No. 2?

Project Organization and Management

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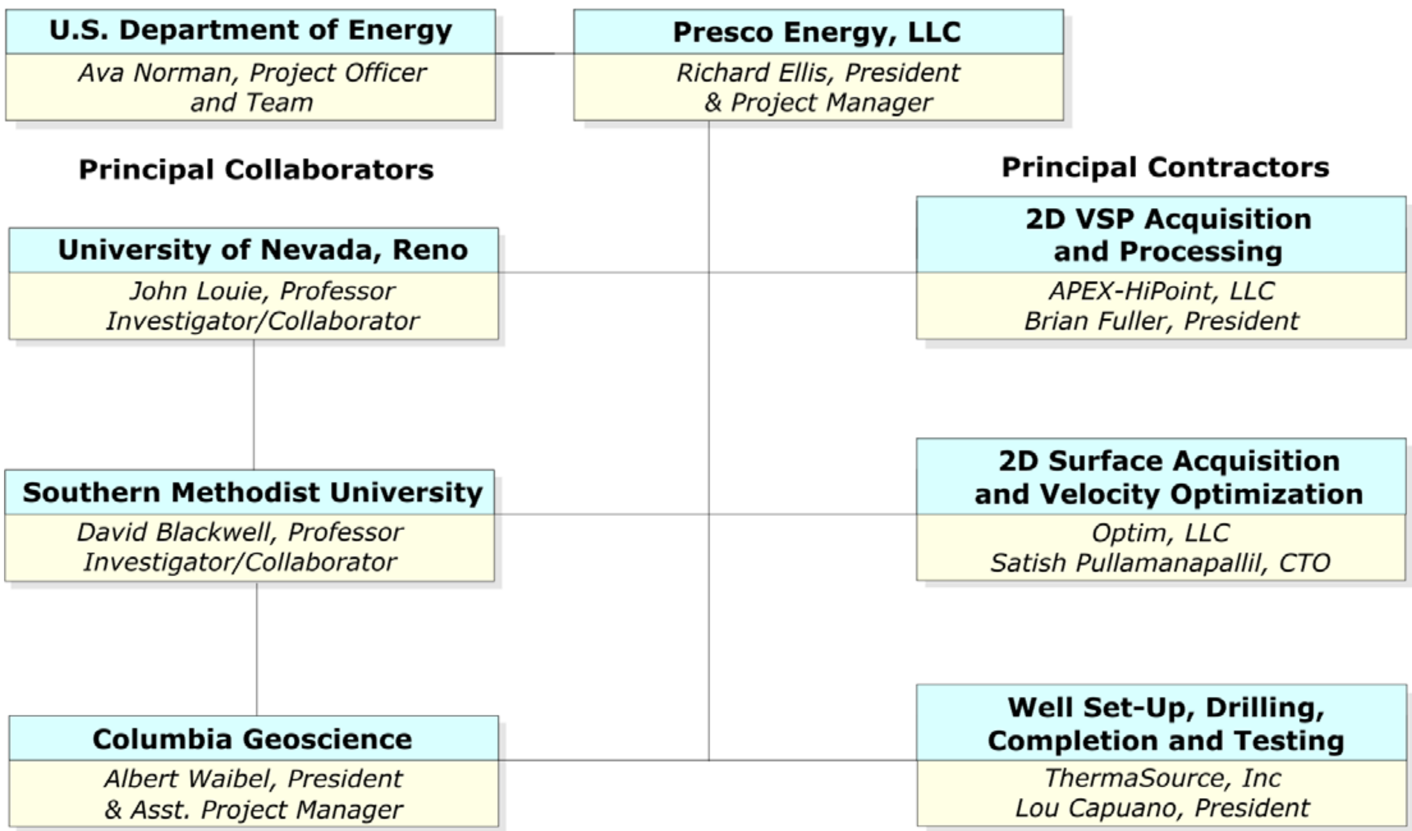
HUMBOLDT HOUSE - RYE PATCH GEOTHERMAL PROJECT

Pershing County, Nevada

Project Organizational Structure



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“Application of 2D VSP Imaging Technology to the Targeting of Exploration and Production Wells in a Basin and Range Geothermal System”

Project Management and Responsibilities

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Task	Project Activity	Responsible Entity(ies)
	- PHASE 1 -	***Resource Evaluation***
1.1	Permitting, Design and Wellbore Re-Heat Tests	Presco, ThermaSource
1.2.1	Field Acquisition	HiPoint, Optim, Vendor
1.2.2	Processing	HiPoint, Optim
1.3	Interpretation, Modeling and Targeting	Presco, HiPoint, UNR, SMU
	- PHASE 2 -	***Drilling***
2.1	Permitting, Wellwork Design and Final Costing	ThermaSource, Presco
2.2.1	Drill and Complete Validation Well 1	ThermaSource, Vendors, Presco
2.2.2	Drill and Complete Validation Well 2	ThermaSource, Vendors, Presco
2.3	Review, Analyze and Report Results of Phase 2	Presco, ThermaSource, UNR, SMU
	- PHASE 3 -	***Well Testing***
3.1	Permitting, Design and Contracting of Well Testing	ThermaSource, Vendors, Presco
3.2	Mobilization and Construction of Test Sites	ThermaSource, Vendors
3.3	Test of Validation Well 1	ThermaSource, Vendors
3.4	Test of Validation Well 2	ThermaSource, Vendors
3.5	Report of Validation, Well Capacities, Resource Additions	Presco, SMU, ThermaSource, UNR
3.6	Presentation to DOE, Industry and Academic Forums	Presco, SMU, UNR

Project Milestones and Timeline

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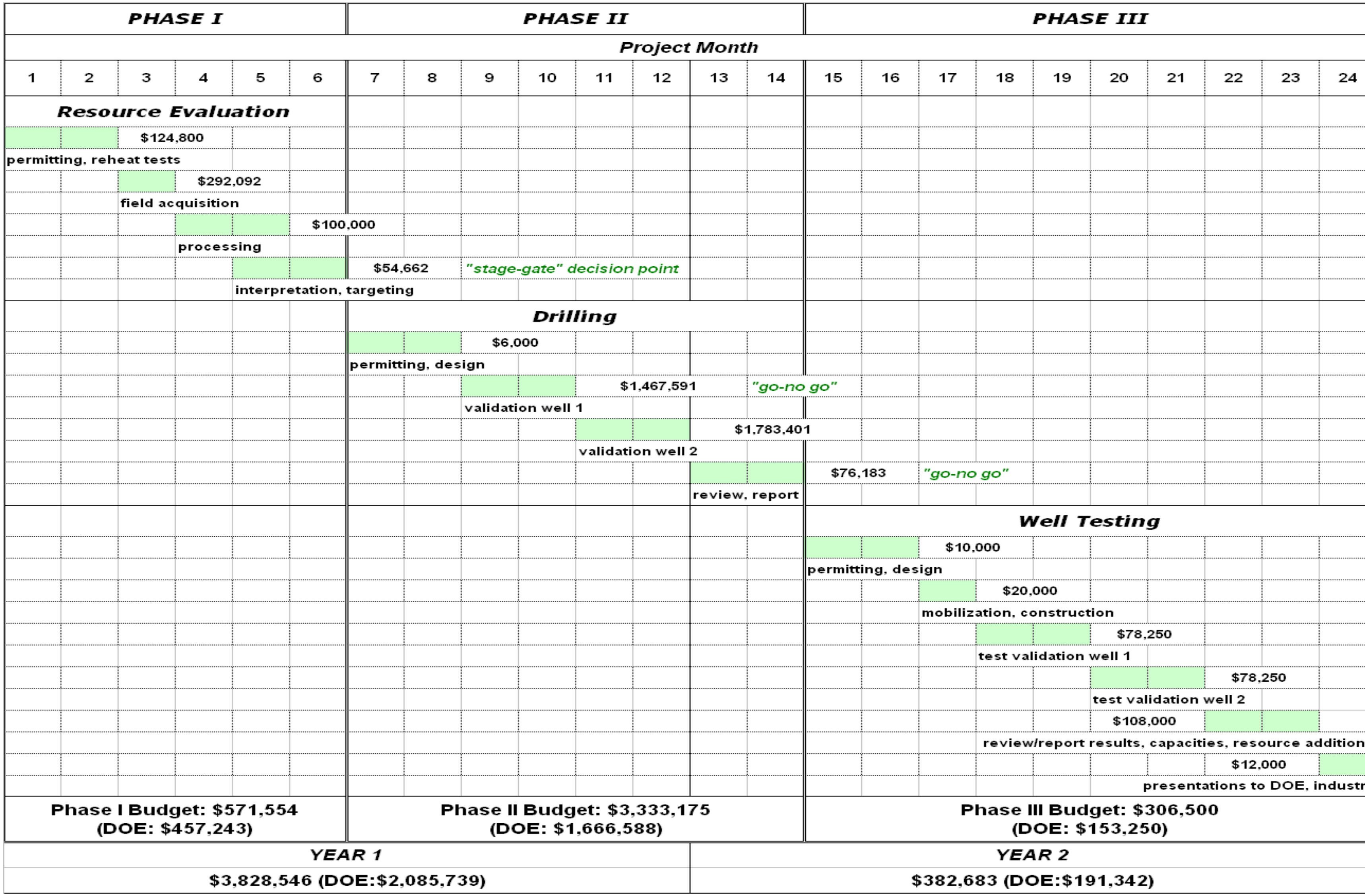

Project Summary

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- Technology innovation directly targets a recurrent problem with seismic imaging in the greater Basin and Range
  - If successful, will have broad areal applicability
- Project protocols – Phases I, II and III - can be implemented quickly and relatively inexpensively because of the extensive infrastructure at the site
- Principal drawbacks to application
  - Temperature limits of geophones (high-temperature phones limited in number)
  - Requires existence of wellbores at strategic locations along target zone
- Principal impact of expected outcome
  - Materially reduces targeting risk and therefore lowers LCOE and finding-and-development cost