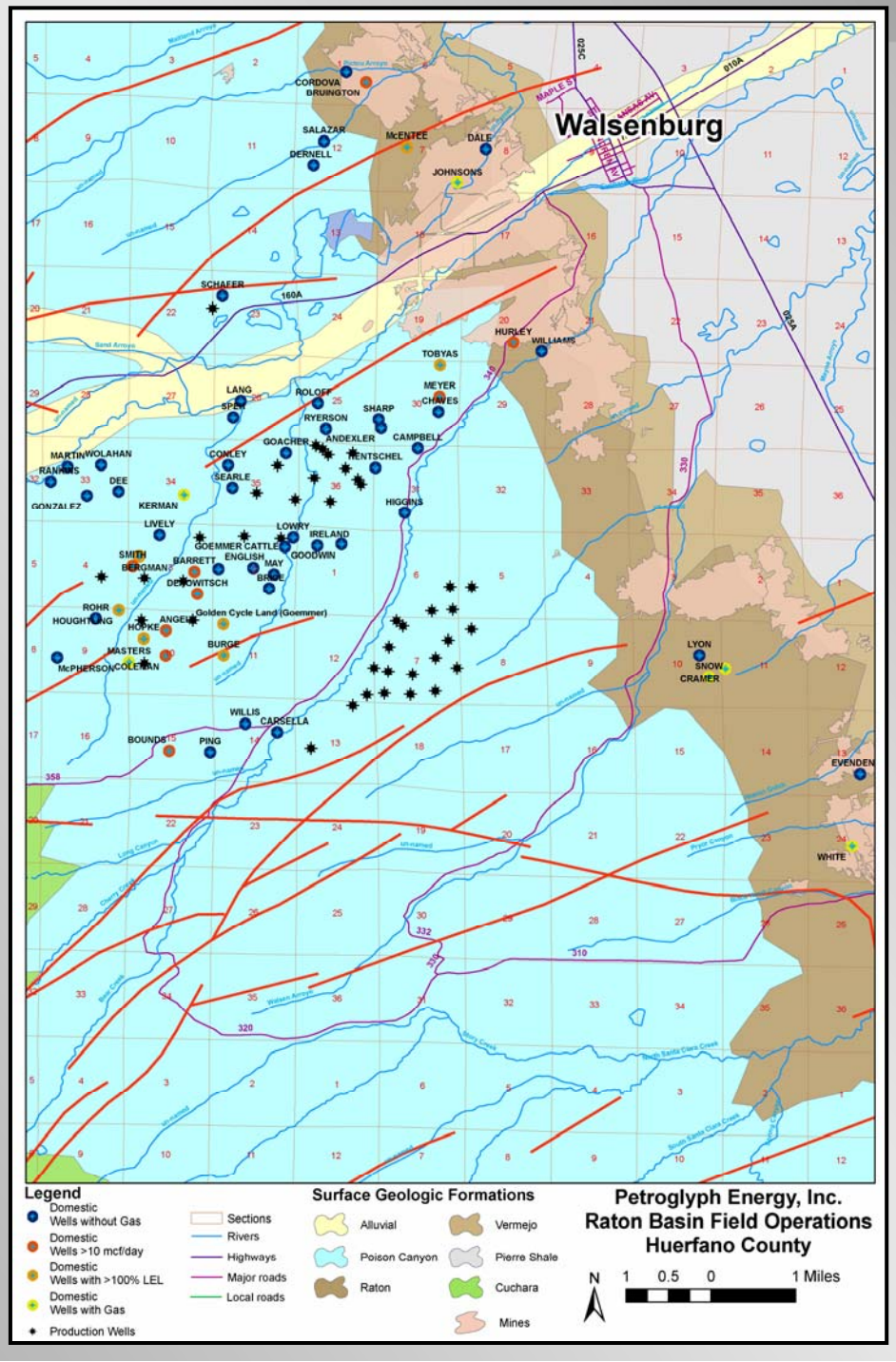
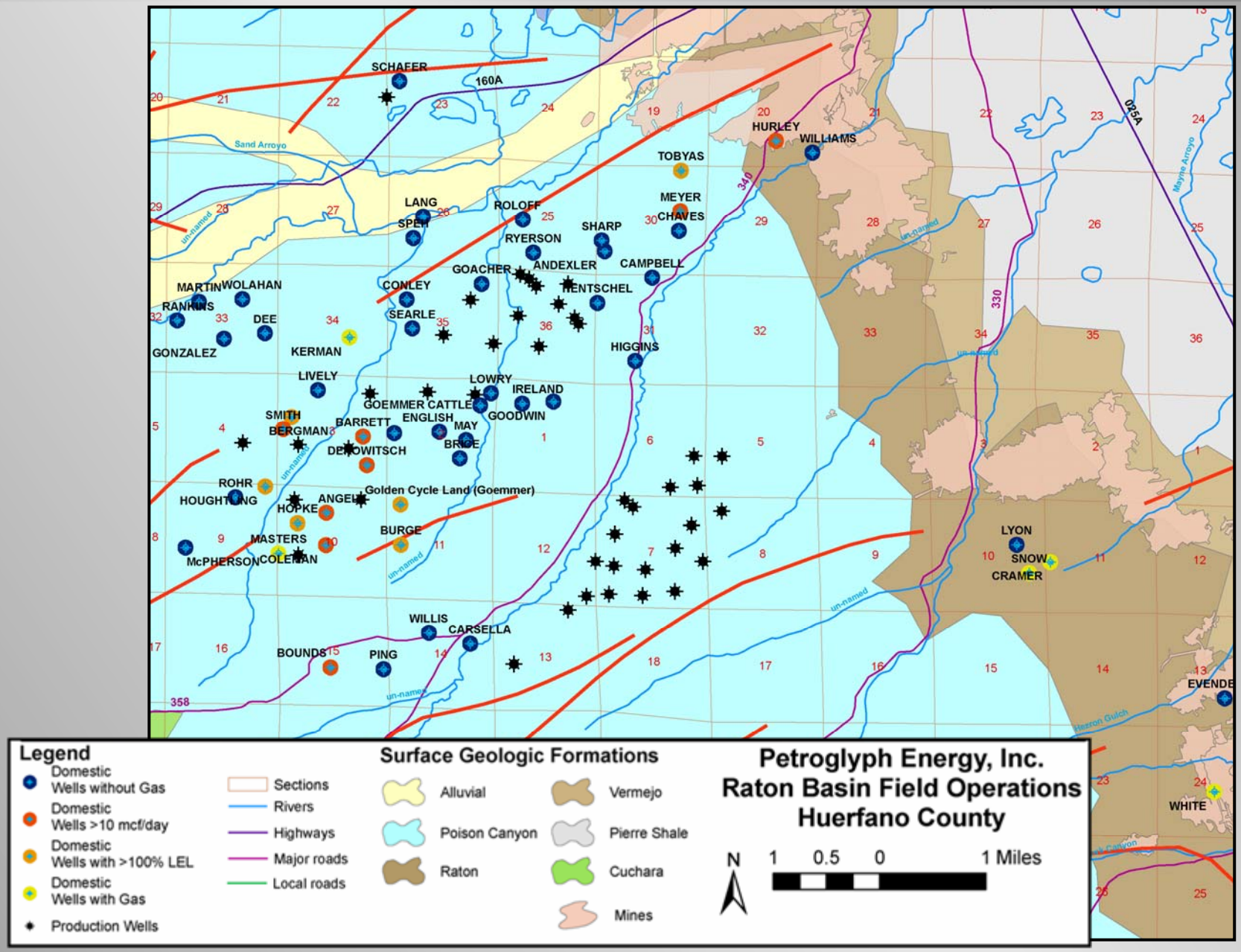
Methane Investigation, Monitoring, and Mitigation Program

Petroglyph Energy Inc.
Little Creek and Bear Creek
Huerfano County, CO

www.norwestcorp.com

NORWEST
Applied Hydrology




SCHAEFER
160A
Sand Arroyo
HURLEY
WILLIAMS
035A
TOBYAS
MEYER
CHAVES
LANG
SPELL
ROLOFF
SHARP
RYERSON
ANDEXLER
CAMPBELL
GOACHER
HENTSCHEL
CONLEY
SEARLE
MARTIN
WOLAHAN
RANKINS
DEE
GONZALEZ
KERMAN
HIGGINS
LIVELY
LOWRY
IRELAND
GOEMMER CATTLE
GOODWIN
ENGLISH
MAY
BARRETT
SMITH
BERGMAN
BRIDE
DEMOWITSCH
ROHR
HOUGHTALING
ANGEL
HOPKE
Golden Cycle Land (Goemmer)
BURGE
MASTERS
McPHERSON
COLEMAN
LYON
SNOW
CRAMER
WILLIS
CARSELLA
BOUNDS
PING
EVENDE
WHITE
Mayne Arroyo
Herron Gulch
un-named
340
330
Legend
Domestic Wells without Gas
Domestic Wells >10 mcf/day
Domestic Wells with >100% LEL
Domestic Wells with Gas
Production Wells
Sections
Rivers
Highways
Major roads
Local roads
Surface Geologic Formations
Alluvial
Poison Canyon
Raton
Vermejo
Pierre Shale
Cuchara
Mines
Petroglyph Energy, Inc.
Raton Basin Field Operations
Huerfano County
N
1 0.5 0 1 Miles

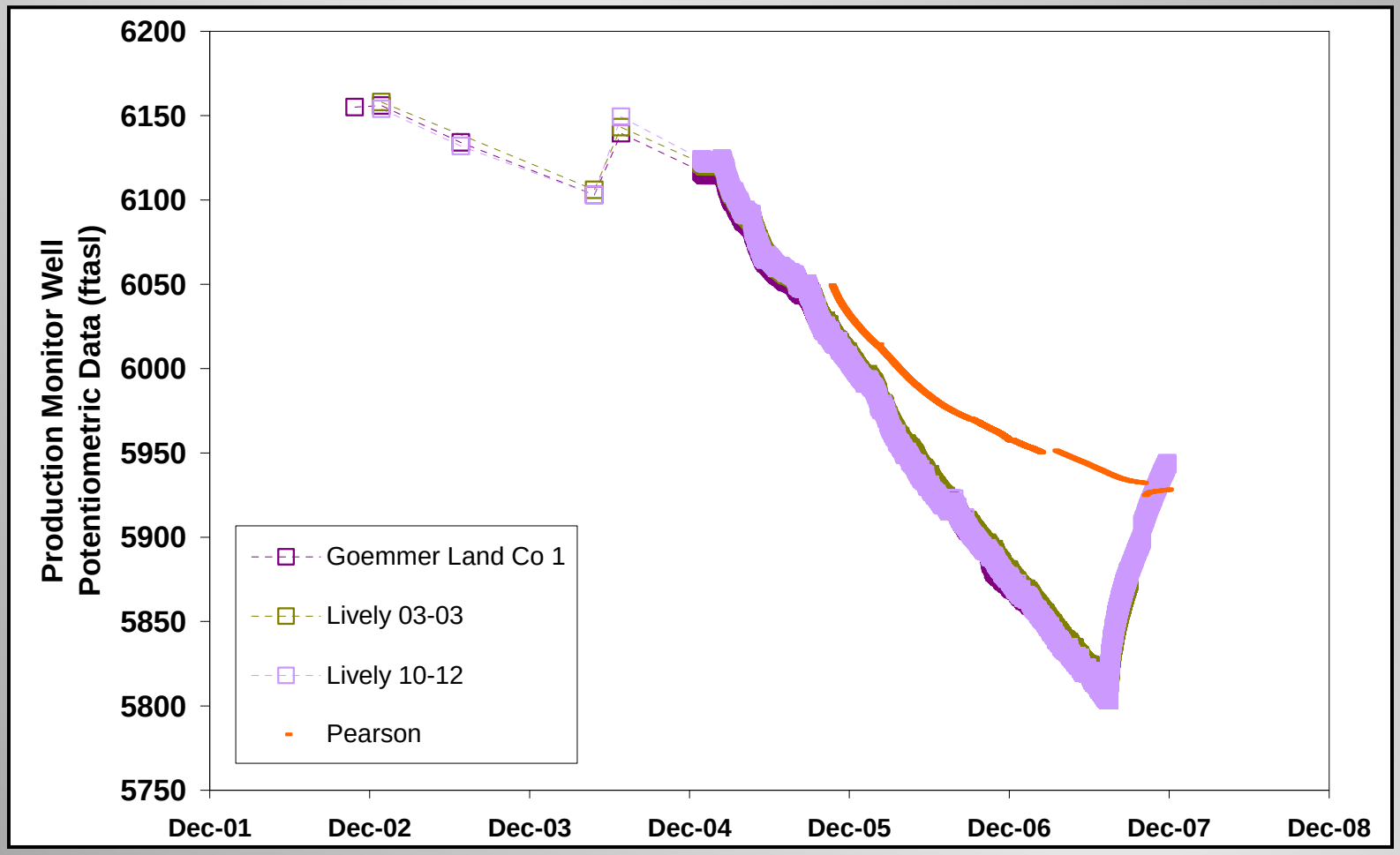
Current Monitoring

- Currently Monitoring 54 locations
  - 39 in near vicinity on bi-weekly schedule
  - 15 near outcrop/north on monthly schedule
  - 10 monitored for water levels
  - 4 have pressure transducers
    - Meyer, Barrett, Coleman, Bergman

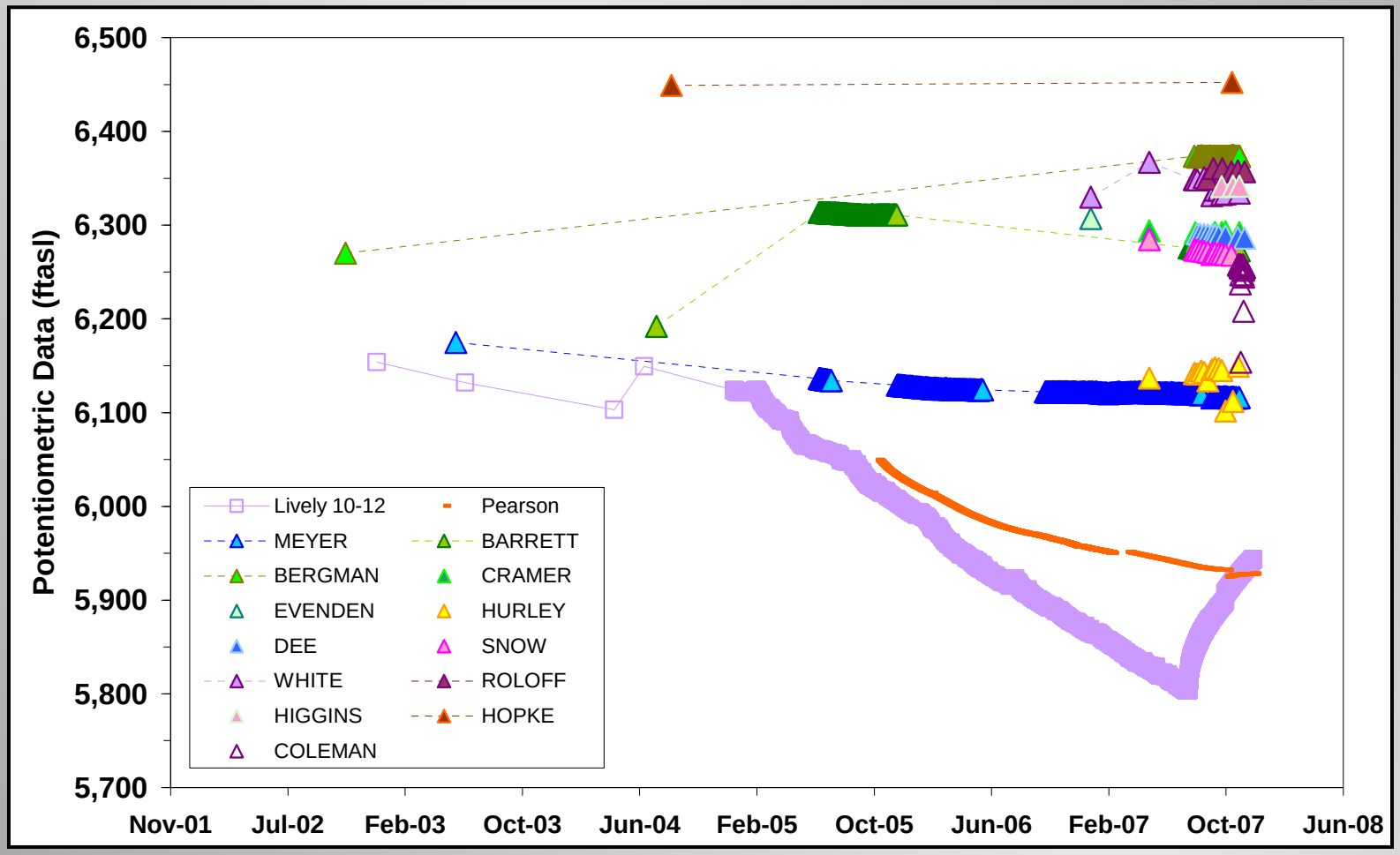
Additional Future Monitoring

- Continue Monitoring 54 locations
- Helicopter survey of area including outcrop
  - Semi-annually
- Methane flow monitoring for:
  - Smith, Coleman (continuous)
  - Bounds, Bruington, and Angley (Weekly)
- Continuous monitoring of production and monitor wells

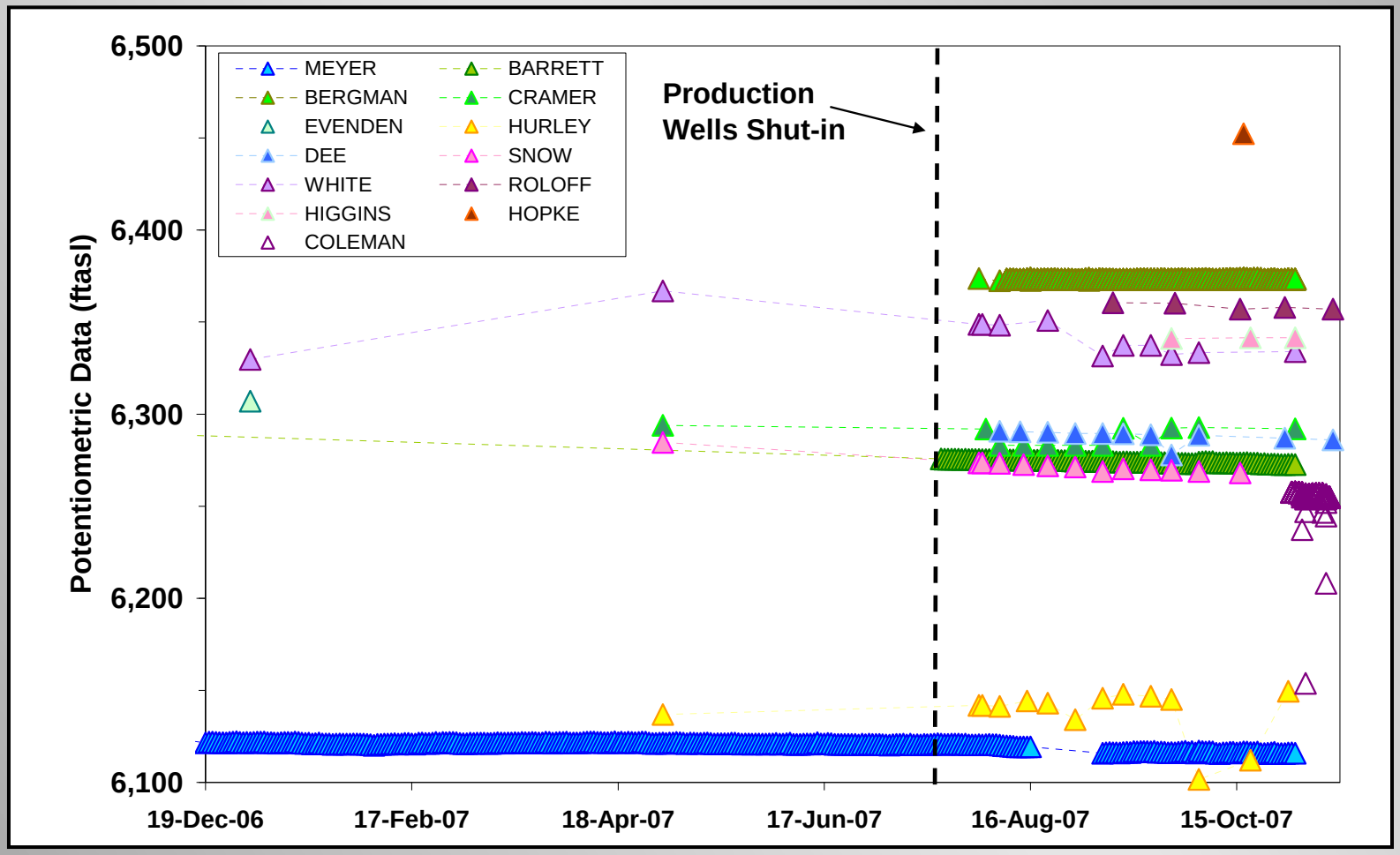
Production Monitor & Domestic Well Potentiometric Data



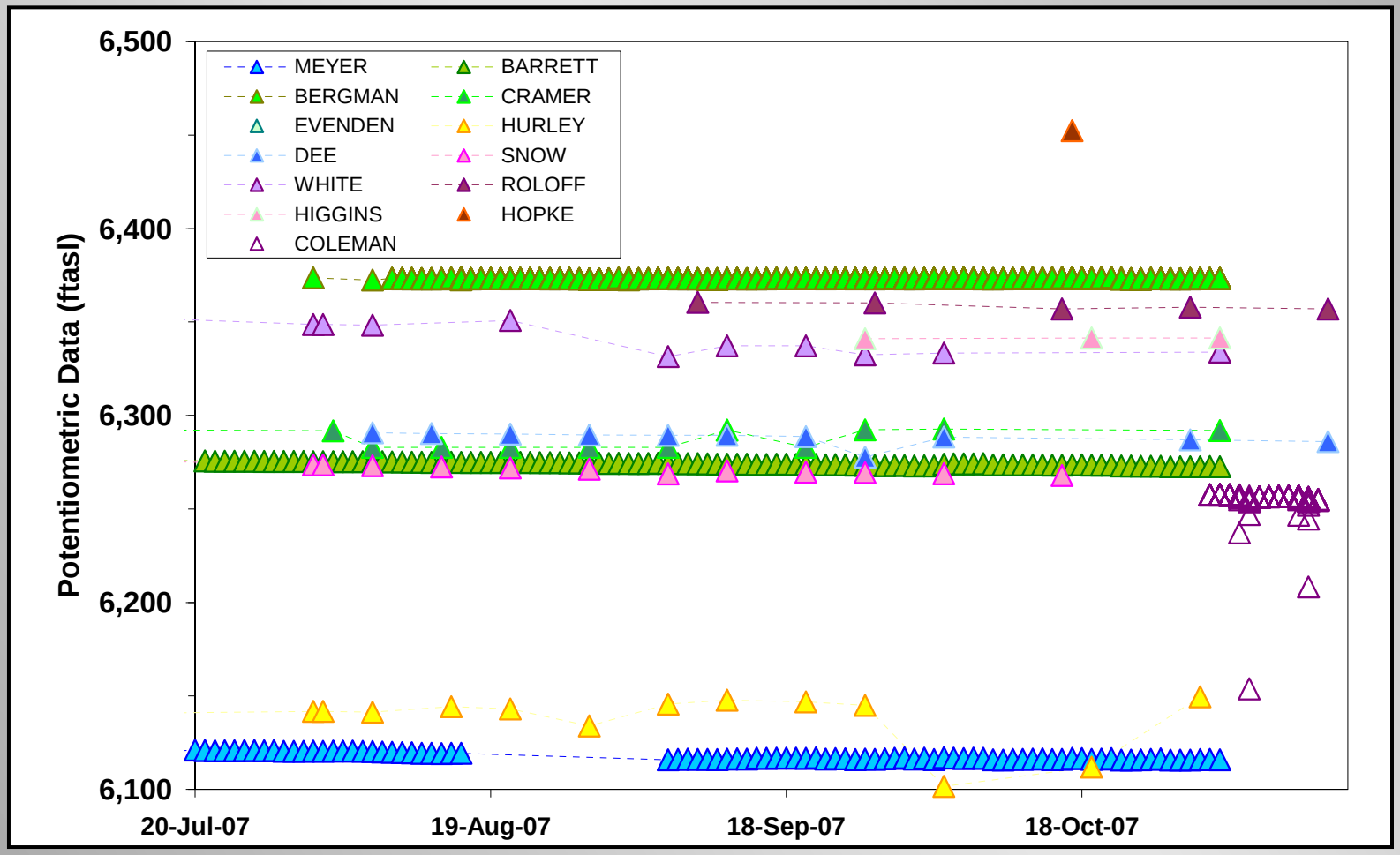
Production Monitor & Domestic Well Potentiometric Data

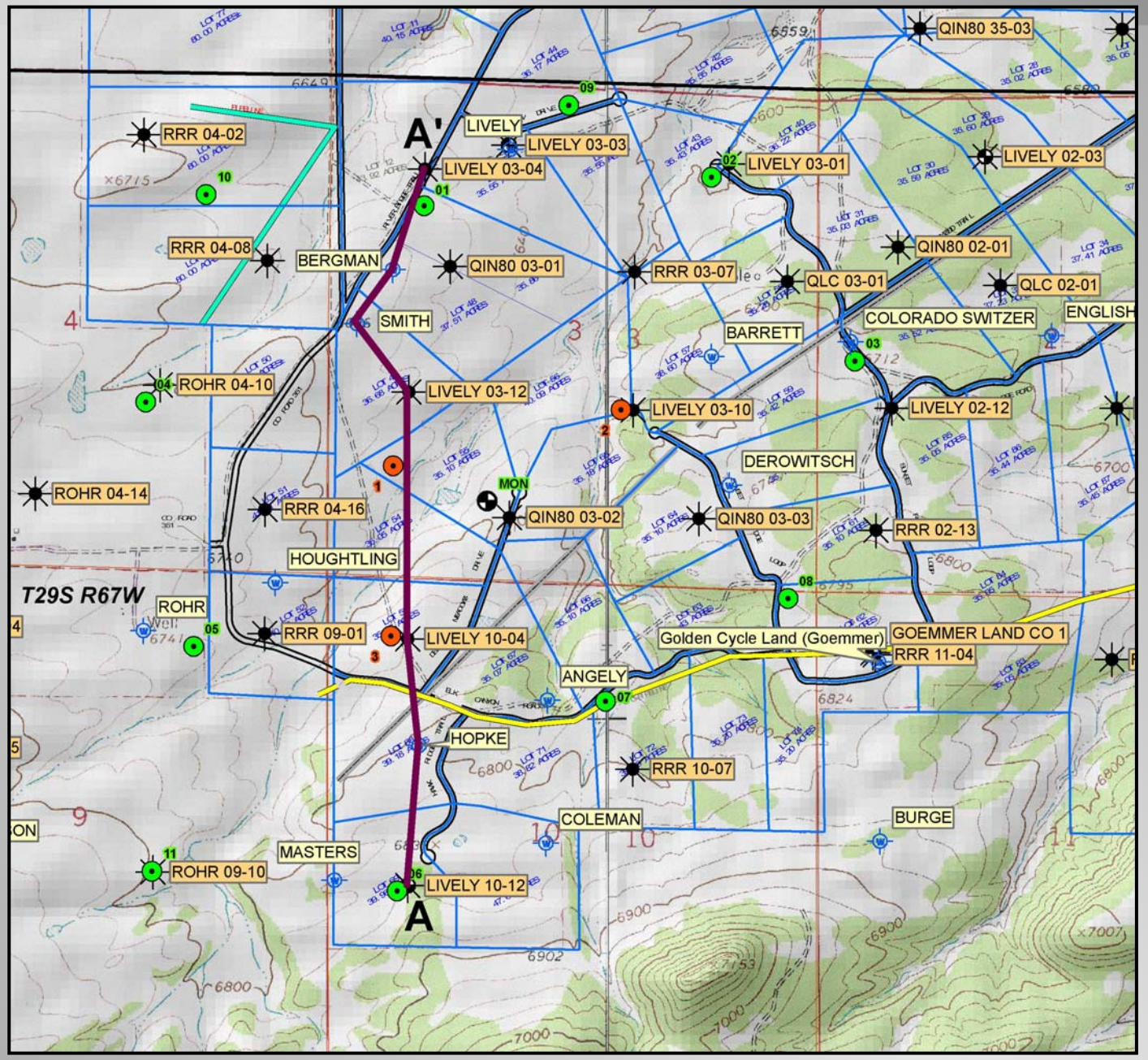


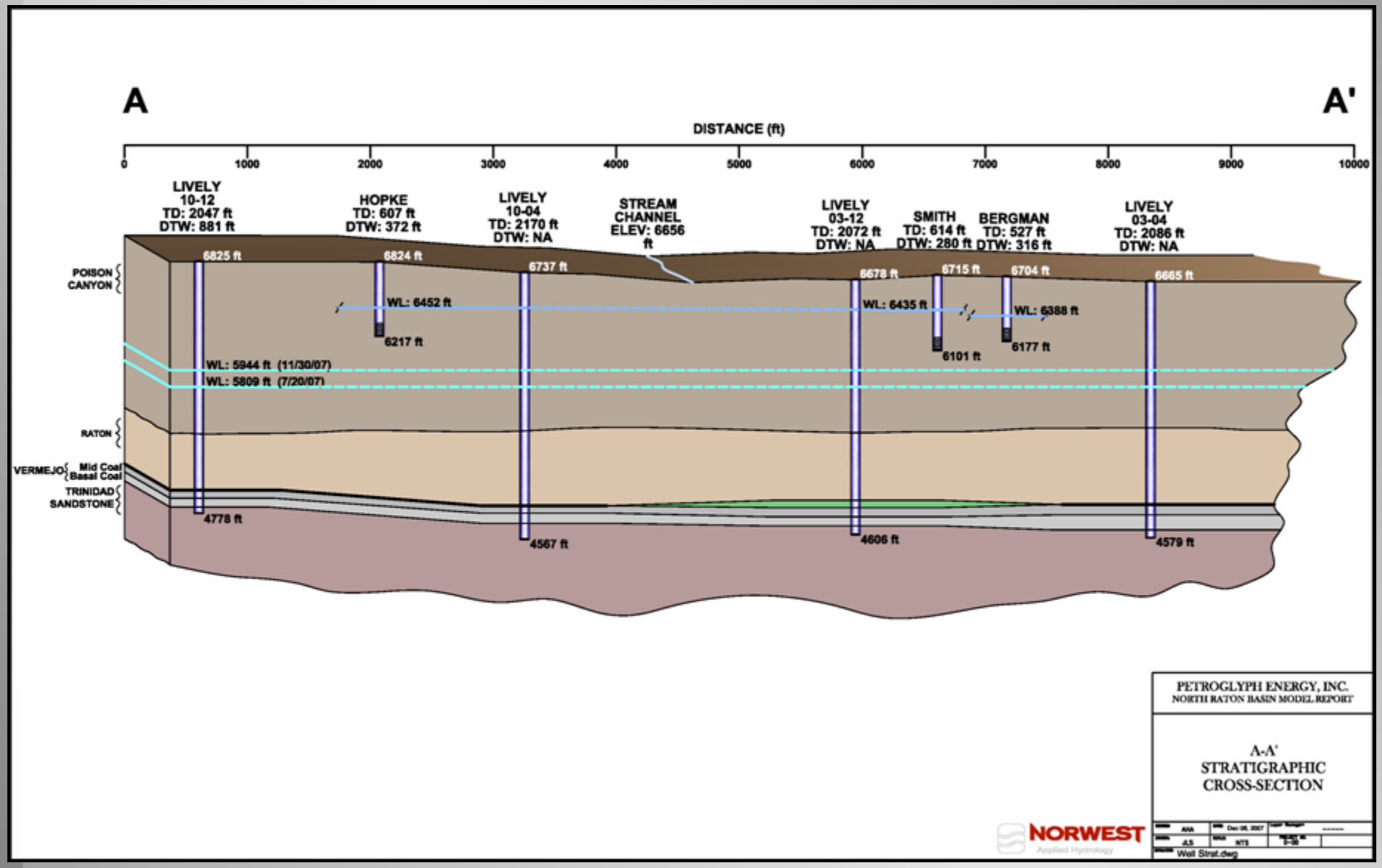
Domestic Well Potentiometric Data



Domestic Well Potentiometric Data




A'
A
LIVELY
LIVELY 03-03
LIVELY 03-04
LIVELY 03-01
LIVELY 02-03
QIN80 35-03
RRR 04-02
RRR 04-08
BERGMAN
QIN80 03-01
RRR 03-07
QIN80 02-01
QLC 03-01
QLC 02-01
COLORADO SWITZER
ENGLISH
BARRETT
SMITH
ROHR 04-10
LIVELY 03-12
LIVELY 03-10
LIVELY 02-12
DEROWITSCH
ROHR 04-14
RRR 04-16
MON
QIN80 03-02
QIN80 03-03
RRR 02-13
HOUGHTLING
T29S R67W
ROHR
RRR 09-01
LIVELY 10-04
Golden Cycle Land (Goemmer)
GOEMMER LAND CO 1
RRR 11-04
ANGELY
HOPKE
RRR 10-07
COLEMAN
BURGE
MASTERS
ROHR 09-10
LIVELY 10-12


A
A'
DISTANCE (ft)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
LIVELY 10-12
TD: 2047 ft
DTW: 881 ft
HOPKE
TD: 607 ft
DTW: 372 ft
LIVELY 10-04
TD: 2170 ft
DTW: NA
STREAM CHANNEL ELEV: 6656 ft
LIVELY 03-12
TD: 2072 ft
DTW: NA
SMITH
TD: 614 ft
DTW: 280 ft
BERGMAN
TD: 527 ft
DTW: 316 ft
LIVELY 03-04
TD: 2086 ft
DTW: NA
6825 ft
6824 ft
6737 ft
6678 ft
6715 ft
6704 ft
6665 ft
WL: 6452 ft
WL: 6435 ft
WL: 6388 ft
6217 ft
6101 ft
6177 ft
WL: 5944 ft (11/30/07)
WL: 5809 ft (7/20/07)
POISON CANYON
RATON
VERMEJO
Mid Coal
Basal Coal
TRINIDAD SANDSTONE
4778 ft
4567 ft
4606 ft
4579 ft
PETROGLYPH ENERGY, INC.
NORTH RATON BASIN MODEL REPORT
A-A'
STRATIGRAPHIC
CROSS-SECTION
NORWEST
Applied Hydrology
Well Strat.dwg

Poison Canyon Aquifer

- USGS Water-Supply Paper 1805 (McLaughlin 1966)
  - Confined aquifer
  - Periodic extended draughts with decrease in water well yields & not meeting needs
  - “Yields small quantities of water to wells and springs in western part of county.”
  - Associated with “perennial water shortages”

Poison Canyon Transmissivity Calculations

Pump Test Data From SEO Drillers Records and Theis Solution Transmissivity Results									
Well ID	**Pumping Rate (gpm)**	**Depth Water Encountered (ftbls)**	**SWL (ftbls)**	**Pumping WL (ftbls)**	**Elapsed Time (min)**	**T (ft^2/min)**	**Estimated Saturated Thickness (ft)**	**K (ft/d)**	**Permeability (md)**
Angely	6	563	330	700	150	0.0032	142	0.45	168
Bergman	10	420	289	527	180	0.0085	107	0.91	337
Derowitsch	9	585	535	681	180	0.0085	89	0.76	280
Hopke	13	528	381	607	90	0.0112	79	0.89	329
Kerman	7	235	200	460	90	0.0052	232	1.21	450
Conley	12	313	146	348	180	0.0121	35	0.42	156

Permeability calculated from 2.7 ft/day per darcy @ fluid density equal to 62.4 lb/ft^3

Poison Canyon - Confined Aquifer

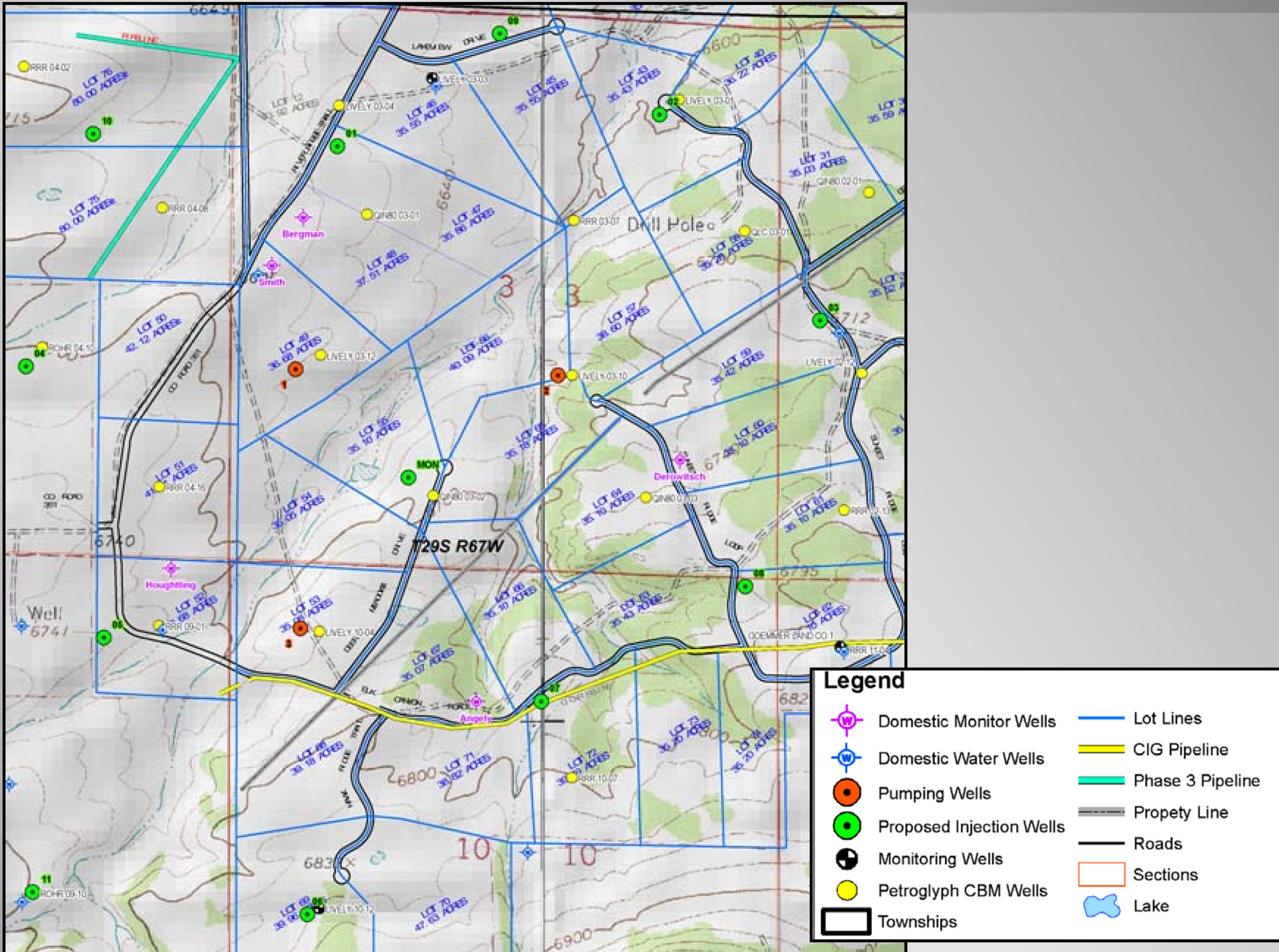
Well Owner	Depth First Water Encountered (ftbls)	Static Water Level (ftbls)	Rise In Head (ft)
Angely	563	330	233
Barr	340	249	91
Barrett	838	515	323
Bergman	420	289	131
Campbell (Kuntz)	384	214	170
Conley	313	146	167
Derowitsch	585	535	50
English	232	200	32
Goodwin	436	235	201
Higgins	287	195	92
Hopke	528	381	147
Kerman	235	200	35
Martin	497	280	217
Meyer	550	400	150
Roloff	138	135	3
Ryerson	93	45	48
Smith	516	280	236
Wolahan	294	183	111

Elevation of Confined Layer?

Landowner	Elevation (z)	TD	TD Elevation	Gas	>100% LEL	>10 mcf/day
BARRETT	6734	865	5869	Yes	Yes	Yes
MASTERS	6845	847	5998	Yes	No	No
COLEMAN	6845	823	6022	Yes	Yes	Yes
ANGELY	6775	706	6069	Yes	Yes	Yes
DEROWITSCH	6750	681	6069	Yes	Yes	Yes
SMITH	6715	614	6101	Yes	Yes	Yes
HOUGHTLING	6732	607	6125	Yes	Yes	No
KERMAN	6597	467	6130	Yes	No	No
ENGLISH	6638	507	6131	No	No	No
BERGMAN	6704	527	6177	Yes	Yes	No
HOPKE	6824	607	6217	Yes	Yes	No
GOODWIN	6702	467	6235	No	No	No
CONLEY	6590	348	6242	No	No	No
MAY	6694	443	6251	No	No	No
SEARLE	6610	305	6305	No	No	No
GOEMMER CATTLE	6624	145	6479	No	No	No
RANKINS	6642	110	6532	No	No	No
LOWRY	6605	40	6565	No	No	No
COLORADO SWITZER	6710	140	6570	No	No	No
CARSELLA	6798	160	6638	No	No	No
WILLIS	6858	216	6642	No	No	No
McPHERSON	6860	210	6650	No	No	No
BURGE	6916	210	6706	Yes	Yes	No
BOUNDS	7184	323	6861	Yes	Yes	Yes

Aquifer Testing

- Monitor Well & Select Injection Wells
  - Rate step test
    - Test range of rates ~15 min per rate
    - Optimum pumping rate/time for long term test
  - 24 to 72 hr constant rate drawdown test
    - Monitor water and gas flows
    - Hydraulic conductivity
    - Specific storage (cross-borehole interference)
      - Monitor pressure at nearby domestic wells
      - Monitor pressure at mitigation injection/production wells


T29S R67W
Drill Pole
Legend
Domestic Monitor Wells
Domestic Water Wells
Pumping Wells
Proposed Injection Wells
Monitoring Wells
Petroglyph CBM Wells
Townships
Lot Lines
CIG Pipeline
Phase 3 Pipeline
Propety Line
Roads
Sections
Lake