Union County Hydrogeology Project

Annual Progress Report

2013-2014

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Introduction

This report is Zeigler Geologic Consulting, LLC's (ZGC) annual progress report for the Union County Hydrogeology Project, sponsored by the Northeastern Soil and Water Conservation District. This report builds on data and observations previously presented in Zeigler (2011, 2013), Zeigler et al. (2013) and Rawling (2013). During the 2013-2014 fiscal year, ZGC measured static water level in 50 wells in January, began revisions of the four 1:50,000 scale quadrangles for the Dry Cimarron valley, obtained 19 water chemistry samples, 11 radiocarbon and four tritium dating water samples, examined geophysical logs from nine additional petroleum wells in the county and downloaded data from six data recorders. Here we describe the progress in each of these tasks, but refrain from in-depth interpretation of data. A final report with detailed interpretations and integration of all data sets will be produced at the culmination of this project in 2016.

Static Water Level Measurements

Beginning in 2007, depth to water has been measured in fifty wells spread across the county in January (minimum pumping) and August (maximum pumping). A 300 ft steel tape is used for most of the wells and a 500 ft steel tape for wells deeper than 300 ft. For open casing wells, we use a well level sounder (maximum length of 300 ft). The measuring point, or height of the entrance to the well above land surface, is subtracted from the total depth measurement such that the final static water level for all wells is calculated relative to the land surface. Measurements are repeated until two values that are within 0.5 ft of one another are obtained. Four wells have been removed from the study for various reasons (going dry, casing disintegrating, etc.): 20N 35E 11.333, 23N 35E 16.121, 25N 35E 30.222, 27N 35E 13.111 and 28N 36E 28.131. Ten wells have been added to the study: Bannon Oak Canyon, Bannon Tollgate, Bennett #1, Bennett #3, Harris West, Harris East, Burchard #1, Bennefield #1, Bennefield #2 and Bennefield #3. Each of these only has a single or two measurements, but these wells will be tracked for the next few years.

Of the wells that have been tracked, 27 show an overall increase in the water level and 27 show a decline (numbers include wells dropped from the study in 2012 through 2014). Individual

hydrographs for each well are found in Appendix I. Water level trends were determined using only the January measurements in order to avoid potential issues with measurements on wells that had perhaps not fully recovered after having pumps turned off. Average increase is 1.0 ft and the average decline is 1.5 ft, each over seven years.

Geographically, wells that show a decline are located primarily around the Sedan and Seneca Valley areas, with a smaller area of decline east of Gladstone (Figure 1, Table 1, Appendix II). If static water levels are compared only between January of 2013 and January of 2014, some small changes in trends are notable (Figure 2). For example, the Gladstone area, while seeing a falling water table overall, actually rose slightly from 2013 to 2014. The Capulin-Sierra Grande area, which was previously a rising water table area, is now one of falling water levels. The Sedan and Seneca areas are still areas of decline, but the western fringes of these areas are actually showing slight increases in water levels. Wells closer to the state line are still recording declines.

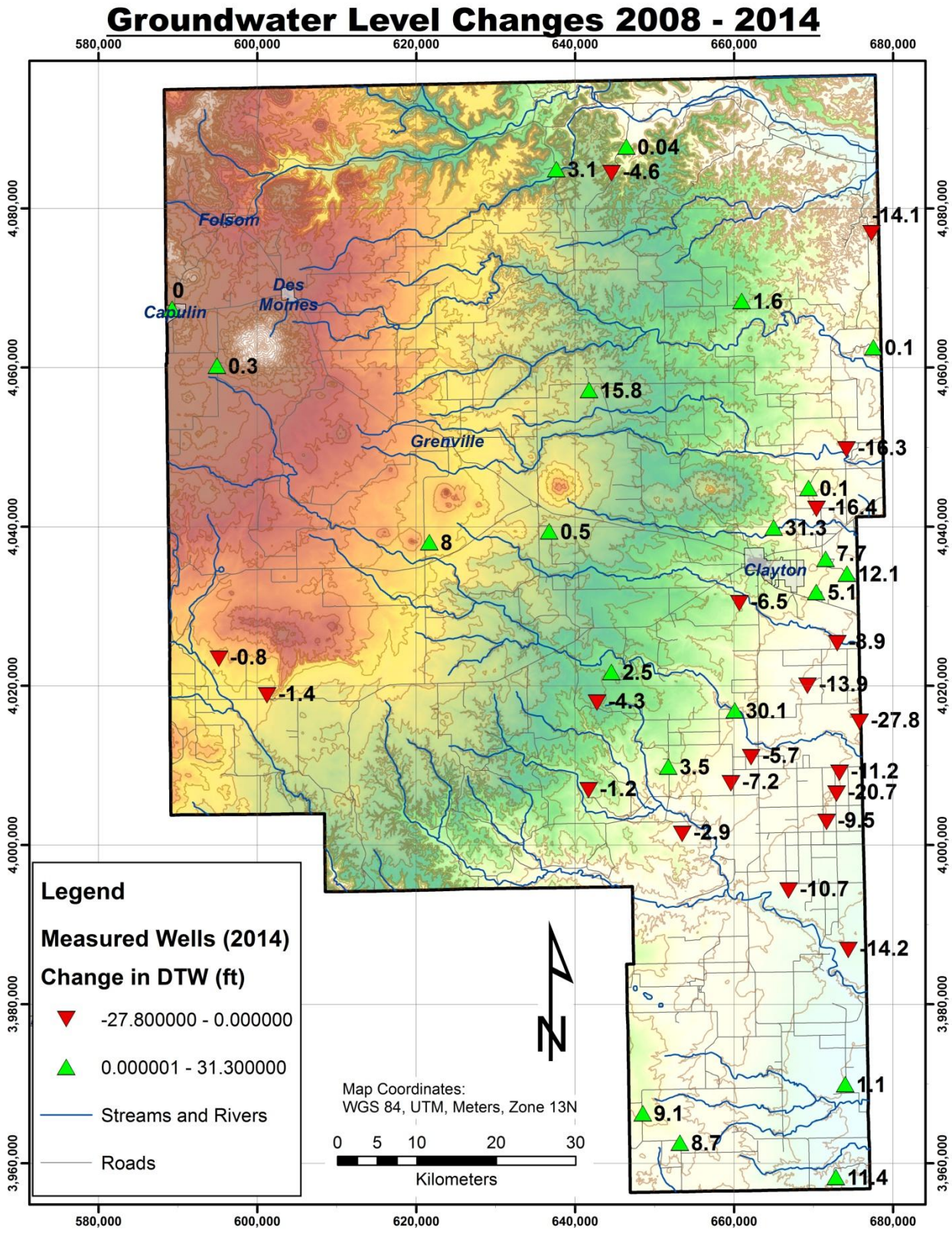


Figure 1. Changes in static water level from January 2008 to January 2014.

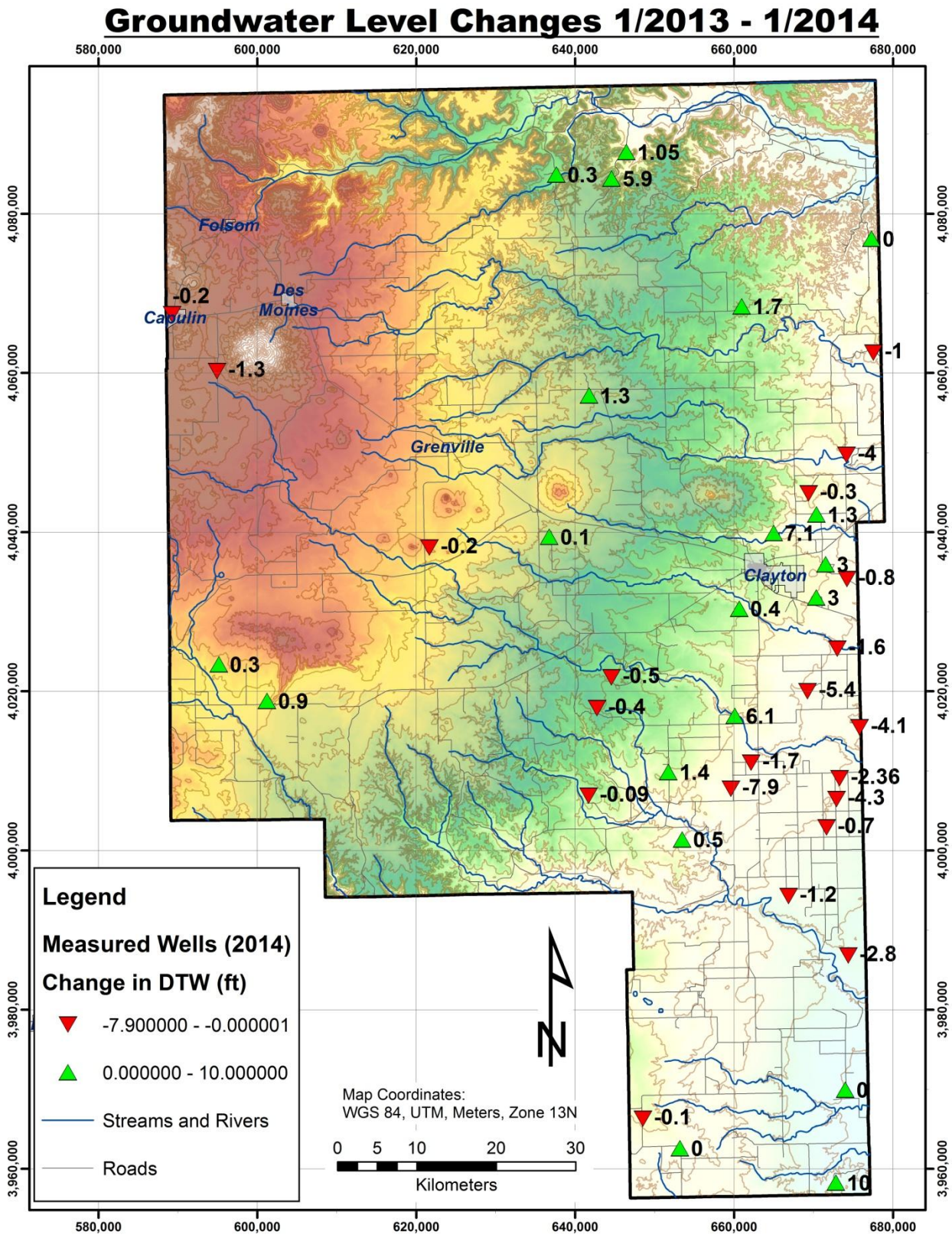


Figure 2. Changes in static water level from January 2013 to January 2014.

Water Chemistry

Approximately two liters of water were collected for basic water chemistry analyses of major cations and anions from each of 19 wells across the county, but with a focus on the Dry Cimarron valley. Wells were allowed to flow for 10 minutes prior to collecting a sample if the well was off upon arrival. For stock tanks where the windmill was actively pumping on arrival, a sample was collected within a few minutes. Open casings were bailed repeatedly before a sample was collected. The analytical work was conducted by Hall Environmental of Albuquerque and analyses included the cations calcium (Ca), sodium (Na), magnesium (Mg) and potassium (K), and the anions carbonate (CO_3), bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl) (Figures 3 and 4).

Each of the ions analyzed for can provide information about groundwater-rock unit interactions. A brief overview of each ion was covered in the annual report for 2013 (based on Hem, 1985) and we recommend Hem's (1985) *Study and Interpretation of the Chemical Characteristics of Natural Waters* for an in-depth review of groundwater chemistry. The 2013 ZGC Annual Report also includes a brief overview of ion chemistry in groundwater.

The chemistry of the water in each well reflects primarily the bedrock unit(s) that the well is drawing water from (Figures 3 and 4). These wells appear to be screened along most of their length, such that wells that penetrate more than one geologic unit will have mixed waters. In general, water from wells that are completed in the Dakota Group contain higher abundances of carbonate, bicarbonate, calcium (Ca) and magnesium (Mg). Water from wells completed in the Jurassic Morrison Formation contain significant quantities of sodium (Na) and potassium (K), and water from wells that penetrate units with black shale (Dakota Group, Graneros Shale) contain sulfate.

These differences in chemistry reflect the differences in mineralogy among these bedrock units. Dakota Group sandstones are cemented with calcite, which can dissolve to provide CO_3, HCO_3, Ca and Mg. Black shales, which are commonly interbedded with sandstone in the Dakota Group, and constitute the primary lithology of the Graneros Shale, contain gypsum, a calcium sulfate, which provides sulfate (SO_4). The Morrison Formation is rich in feldspars, which can contain sodium and potassium, providing these two cations. Wells that include a mixture of

waters from the Dakota Group and the Morrison will thus include some proportion of all the ions expected for those waters.

Three wells were resampled from the 2013 sampling round to test for temporal changes in groundwater chemistry: 22.34.10.444 by old Clapham, 31.33.25.331 in the Dry Cimarron and a Ute Creek surface sample. The Clapham and Ute Creek surface samples show little change from 2013 to 2014. The Dry Cimarron sample shows a small increase in sulfate, calcium and magnesium. Wells completed in alluvium and Triassic Chinle Formation sediments along the Dry Cimarron show the greatest variety in chemistry. Wells completed in the Dakota (± Ogallala sediments) show a moderately wide range of ion concentrations, but are still relatively well clustered.

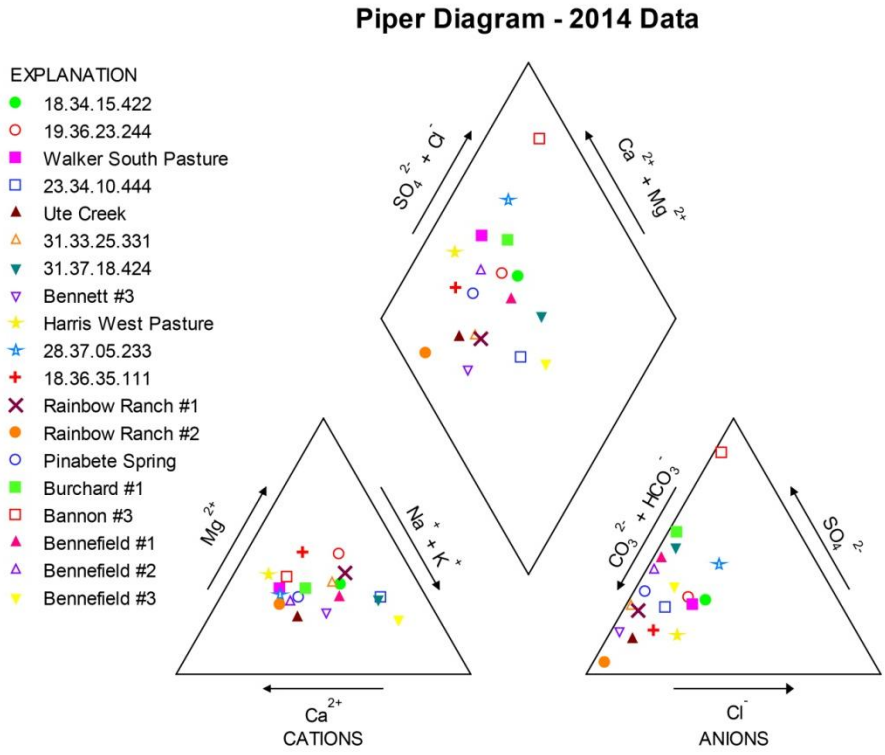


Figure 3. Piper diagram for water chemistry samples collected January and June of 2014 from Union County.

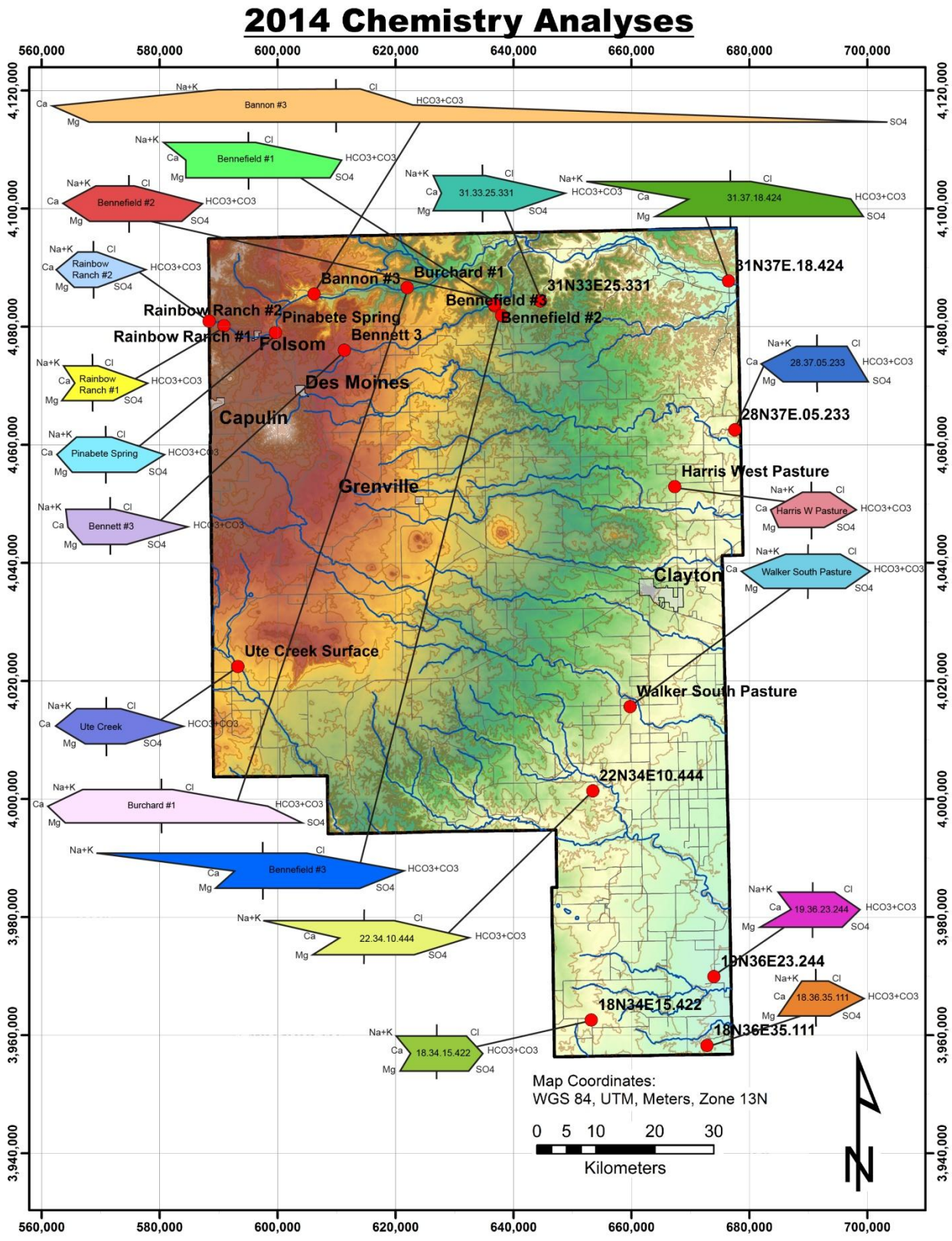


Figure 4. Stiff diagrams for well waters sampled in 2014. The dimensions of the polygon reflect relative abundances of the different ions.

Carbon-14 and Tritium Dates

We collected two liters of water (one primary sample, one duplicate sample) from each of nine wells in the northern third of the county (Figure 4). Nitric acid (HNO_3) was added to each sample as a preservative and the samples were analyzed for Carbon-14 by Beta Analytic, Inc. in Miami, Florida. Samples collected for analysis of tritium were analyzed by the Tritium Laboratory at the University of Miami. We are still awaiting results from two water samples sent for tritium analysis.

Groundwater age is related to the rate at which water migrates through the subsurface. It is important to remember that water molecules may enter and leave the system via cross-formational flow and that any given mass of groundwater will exchange water molecules with masses of water on all sides of it (Bethke and Johnson, 2008). Hence, a mass of water that entered the groundwater and had a single age associated with it will end up with many of those particles dispersed, rather than traveling entirely as a discrete package. A groundwater sample, therefore, is an average of the ages of all of the molecules of water contained in that sample (Bethke and Johnson, 2008). The distribution of these ages for each sample may include much older molecules and much younger molecules, and may be heavily skewed in one direction or the other. Dating methods, including Carbon-14 (^{14}C), generally include the assumption that the groundwater mass is acting as a closed system after it infiltrates below the water table. ^{14}C is used for materials that are assumed to be less than 50,000 years old and has a half-life of 5,730 years. Tritium is a radioactive isotope that has a very short half-life of just 12.3 years. It is most commonly used to determine relative age of waters that are less than fifty years old (Clark and Fritz, 1997). Tritium is produced both as a natural byproduct of interaction of cosmic radiation with the stratosphere and comes into the water cycle by precipitation, but also was produced anthropogenically in large volumes during testing of thermonuclear bombs in the 1950s. The majority of the bomb-produced tritium has decreased significantly such that most modern dating is reflecting the natural tritium signal (Clark and Fritz, 1997). To date, we have collected four samples for tritium analyses, two of which are still being processed. For the other two wells, the well on Jordan Road (24.23.11.213) returned a result of no measurable tritium. The second well on Major Creek Road (22.34.10.444) returned a result of 1.57 Tritium Units (TU), which is equivalent to approximately 20 year old water. This means that the Jordan well has received no

measurable young recharge whereas the Major Creek well has received some within the last 20 years.

For this study, geochemical interactions with the host rocks in the Dakota Group and Morrison Formation are unlikely to contribute significant amounts of "dead" carbon due to a lack of significant quantities of carbonate rocks. The ^{14}C samples were chosen in order to focus on the transition from the southern part of the county into the Dry Cimarron valley and to explore age relationships along the length of the Dry Cimarron. Samples obtained from the southern rim of the Dry Cimarron valley follow the pattern of ^{14}C samples from the rest of the county with a mix of older and younger ages that seem to be randomly distributed across the area. The oldest date so far occurs at a windmill near the head of Travesser Canyon (9,250 years). Samples obtained from wells along the Dry Cimarron valley itself appear to show a trend of younging to the east with the youngest date in the county near the Oklahoma state line (101 years). The youngest data so far obtained for the county comes from a spring at the far west end of the county, west of Folsom (80 years). A spring southeast of Capulin has waters that yielded a radiocarbon age of 800 years old. The spring occurs at the base of a basalt flow and may include a mixture of older waters coming up from the underlying Dakota Group and younger waters moving through fractures in the basalt. The prolonged drought in the region has meant far less new water entering the system and may account for the spring water age being older than might be expected.

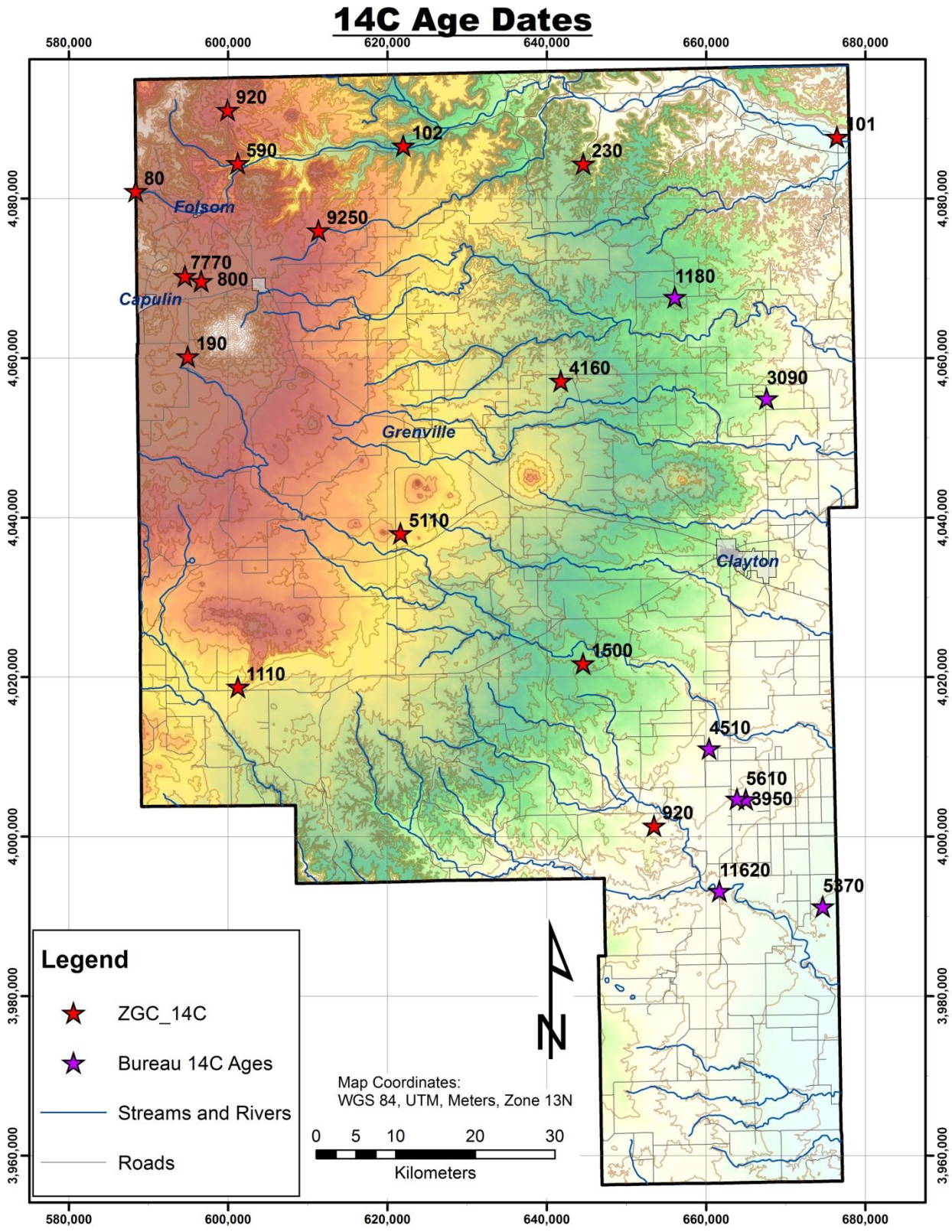


Figure 5. ^{14}C age determinations representing average residence time of groundwater in aquifer units.

The apparent lack of a trend of younger waters to the east obtained across Union County suggest that the aquifer units (Dakota Group, Morrison Formation) are more internally partitioned than might otherwise be expected. In addition, complex folding of the rocks in the subsurface brings older rocks units closer to the surface.

Geologic Mapping

We have revised the existing geologic maps of the 1:50,000 quadrangles that encompass the western half of the Dry Cimarron valley (previously published as Baldwin and Muehlberger, 1959) and are continuing revision of the eastern half. Maps that have had in-field revisions completed are currently being digitized. The Raton-Capulin volcanic field and related features dominate the headwaters of the Dry Cimarron valley with multiple stacked basalt flows that overlap one another as well as older Mesozoic rocks. Within the Dry Cimarron valley itself, outcrop exposures include (in ascending age order): Triassic Chinle Formation, Jurassic Entrada (=Exeter) Sandstone, Jurassic Morrison Formation, Cretaceous Lytle Sandstone, Glencairn Formation and Dakota Group. The Chinle Formation is dominantly red to purple siltstones and fine sandstones with some mudstones and conglomerates. This unit is folded into broad, open anticlines and synclines. The Entrada Sandstone is a bright yellow to white eolian sandstone with large scale trough crossbeds that has a variable thickness created by infilling of the folded Chinle surface. The Morrison Formation includes green, blue and purple mudstones with occasional channel sandstones. The Lytle Sandstone outcrops as a prominent white to yellow band about two-thirds of the way up the slope. It is coarse grained with pebbles scattered throughout its thickness as well as crossbeds. It grades upwards into the claystone-dominated Glencairn Formation. The transition between the two units is often marked by a bed rich in gryphaeid oyster shells.

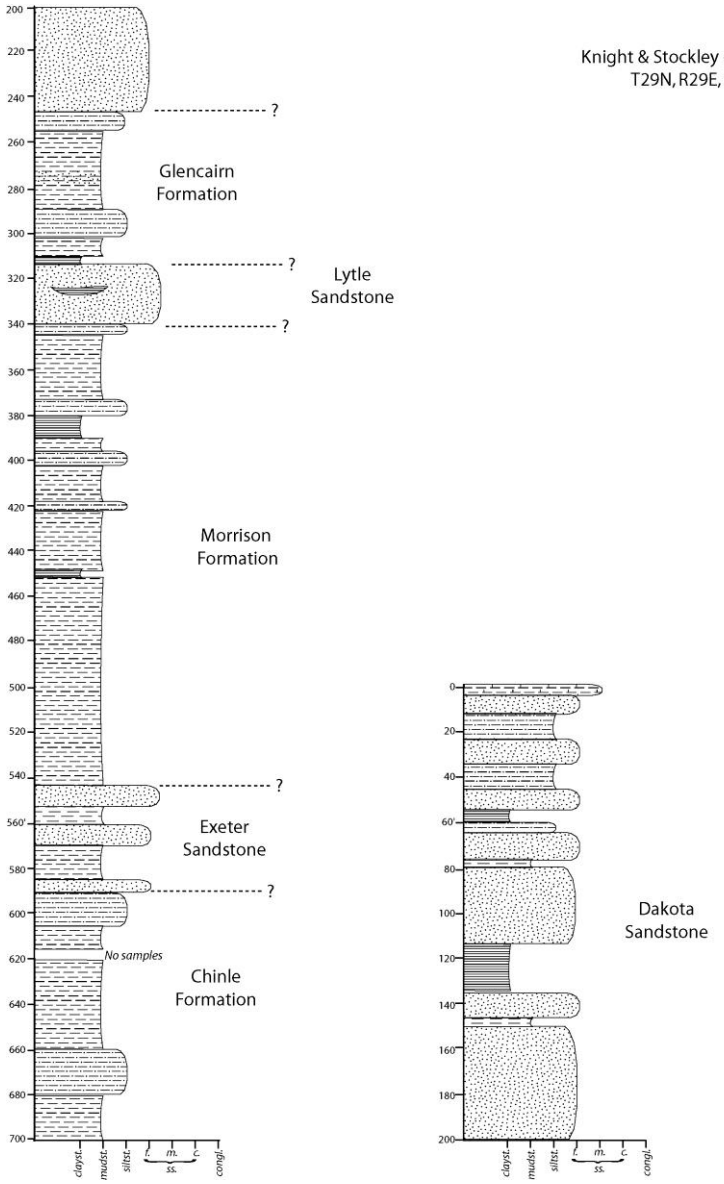
The Dakota Group consists of a lower thick sandstone unit, a middle shale unit, and an upper sandstone unit. The lower sandstone is the Mesa Rica Sandstone and represents deposition in a braided river/fan system. The shale unit, termed the Pajarito Formation, contains oyster shell fragments and most likely was deposited under shallow marine conditions and the upper

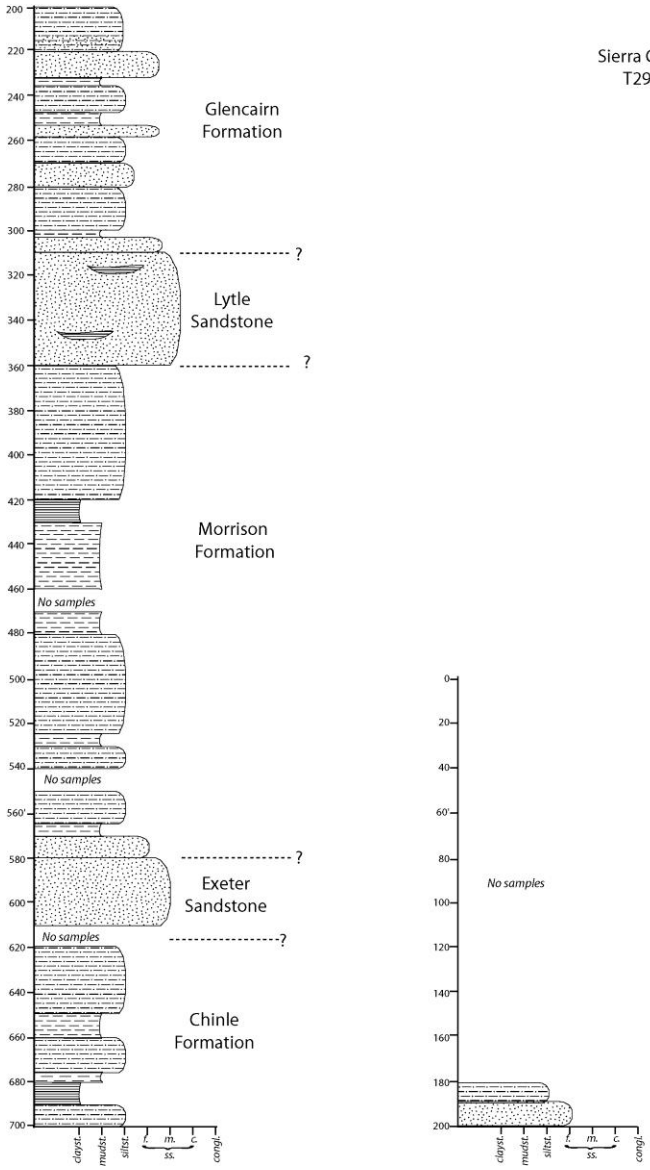
sandstone is called the Romeroville Sandstone and is a complex sequence of beach sands, bar deposits and thin shales representing slightly deeper water conditions. Above the Romeroville Sandstone is the Graneros Shale, which consists of dark gray shales and mudstone with thin limestone beds in the middle part of the unit. Often these thin limestone beds are full of oyster shells from inoceramids, shark teeth and can retain impressions of ammonoid shells.

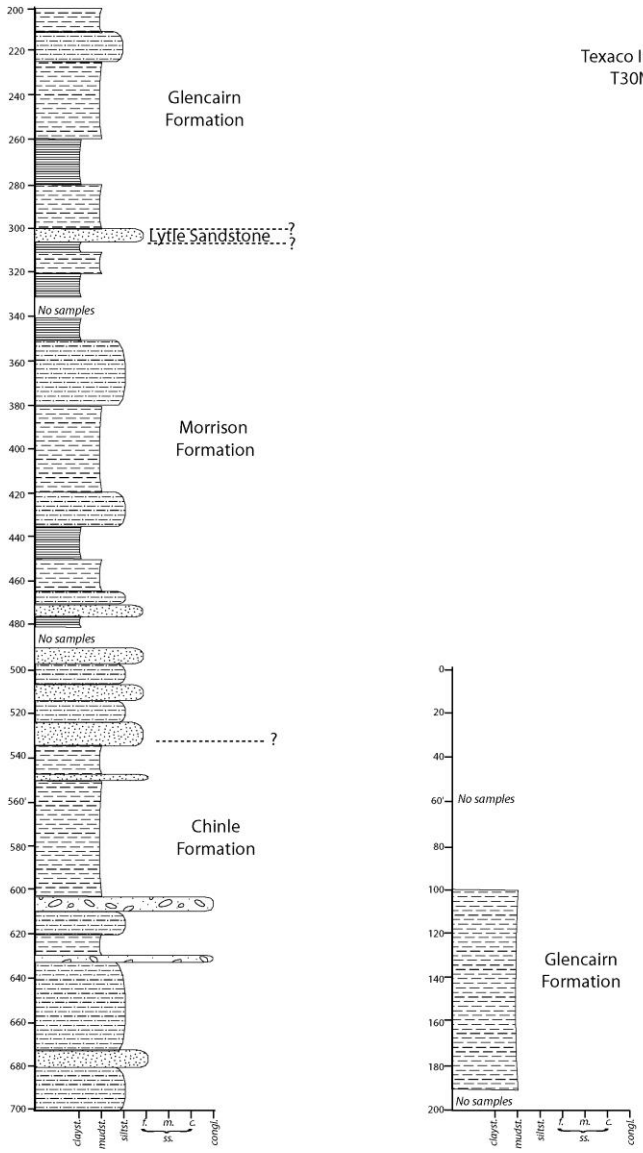
Geologic mapping of the county is ongoing. Further revisions will be presented in subsequent reports.

Petroleum Well Cuttings and Subsurface Analysis

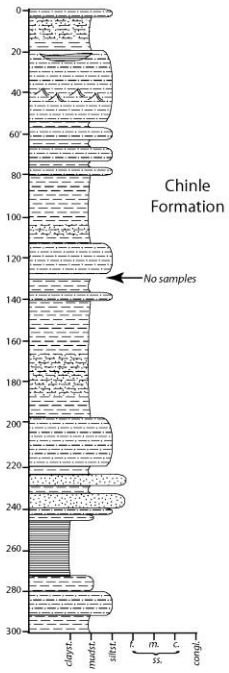
Cuttings and logs were examined from nine wells that create a cross-section line that runs north from Sierra Grande into the Dry Cimarron and then east along the Dry Cimarron to near the Oklahoma state line (Figures 6 and 7). Wells that provide information for the north-south part of the cross-section include the Texaco #1 J.M. Bennett, Knight & Stockley Schmitt #1 and Sierra Grande Rogers #1. Wells drilled in the Dry Cimarron were spudded in the Triassic Chinle Formation and so no information is available regarding the younger rock units. Wells depicted here include the Trend Petroleum #1 Brown, Bubble Valley Hopkinson #1, Hopkinson #1 Fee, Harvest Queen #1 and #1B and the Gregg Oil Co. #1 Harris. These wells demonstrate the lateral variability of rock units within the Chinle Formation. The three wells near Sierra Grande provide an excellent example of the variation in thickness of the Exeter Sandstone, which appears to be absent in the Texaco #1 J.M. Bennett well, as well as thickness variations in the Lytle Sandstone and potential paleotopography on the Glencairn Formation. All of these observations provide insight into the dimensions and relative positions of potential aquifer units in the subsurface, but we caution against attempting to use these data to predict the depth and size of an aquifer unit.


Knight & Stockley - Schmitt #1
T29N, R29E, Sec. 4
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560'
580
600
620
640
660
680
700
?
Glencairn
Formation
?
Lytle
Sandstone
?
Morrison
Formation
?
Exeter
Sandstone
?
No samples
Chinle
Formation
clayst.
mudst.
siltst.
f.
m.
c.
ss.
congl.
0
20
40
60'
80
100
120
140
160
180
200
Dakota
Sandstone

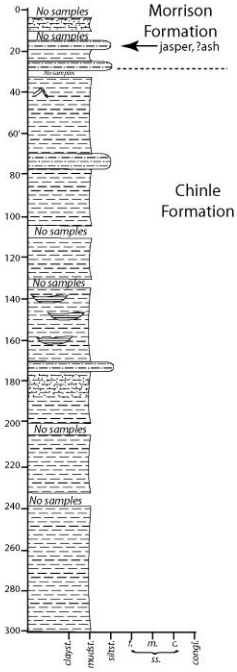

Sierra Grande Rogers #1
T29N, R29E, Sec. 4
Glencairn Formation
Lytle Sandstone
Morrison Formation
Exeter Sandstone
Chinle Formation
No samples
No samples
No samples
No samples
?
?
?
?
clayst.
mudst.
siltst.
f.
m.
c.
ss.
congl.


Texaco Inc. #1 J.M. Bennett
T30N, R29E, Sec. 27
Glencairn Formation
Lytle Sandstone
No samples
Morrison Formation
No samples
Chinle Formation
No samples
Glencairn Formation
claystone
mudstone
siltstone
f. ss.
m. ss.
c. ss.
conglomerate

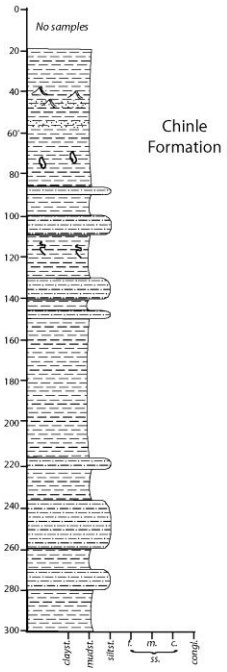
Bubble Valley - Hopkinson #1
T32N, R31E, Sec. 34



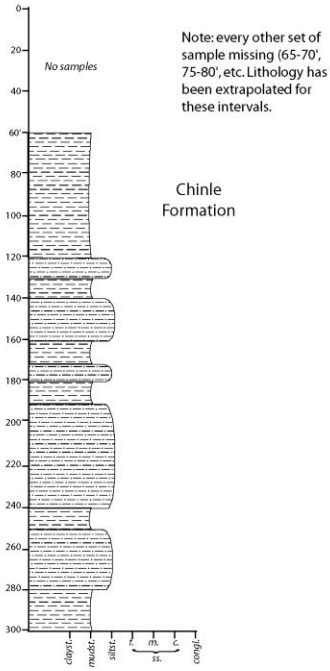
Trend Petroleum #1 Brown
T32N, R31E, Sec. 29



Harvest Queen #1-B
T32N, R34E, Sec. 30



Harvest Queen #1
T32N, R34E, Sec. 26



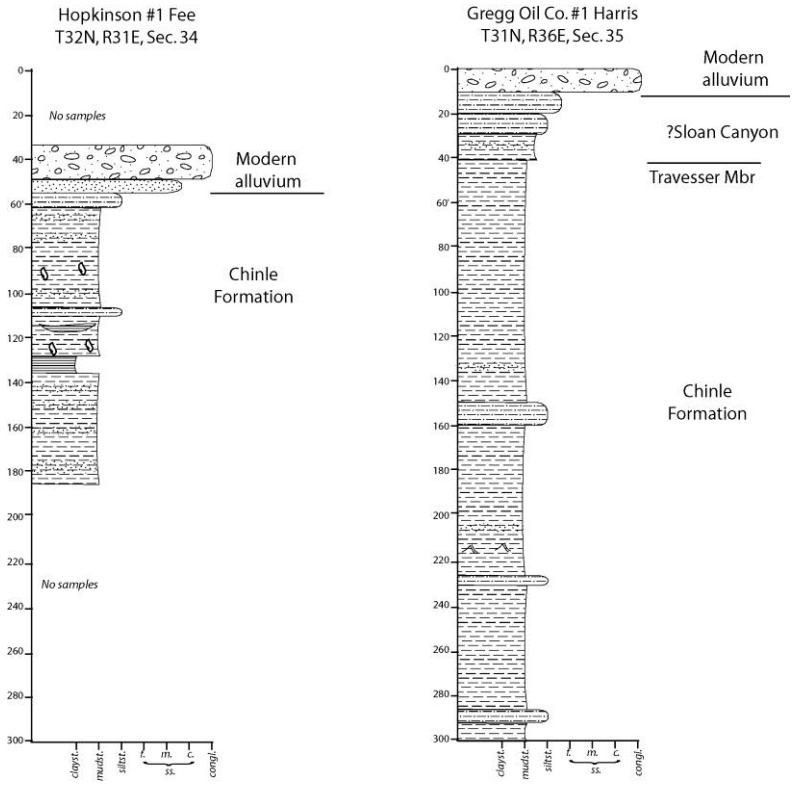


Figure 6. Interpretive stratigraphic columns for petroleum exploration wells from Sierra Grande north into the Dry Cimarron and east to the Oklahoma state line.

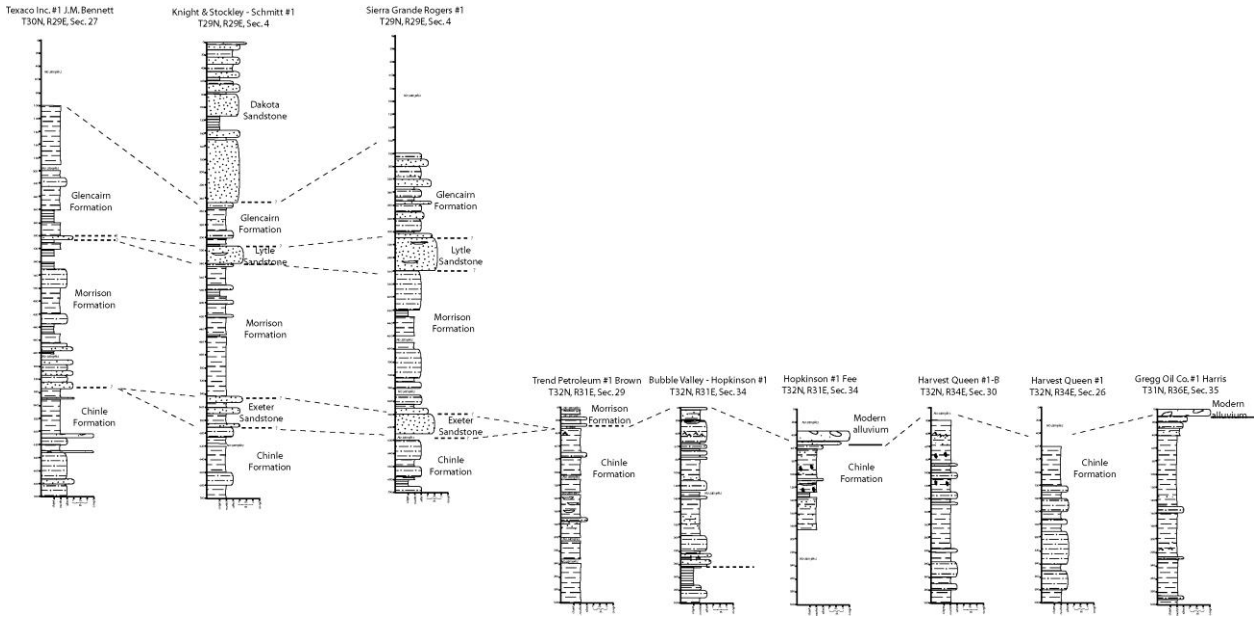
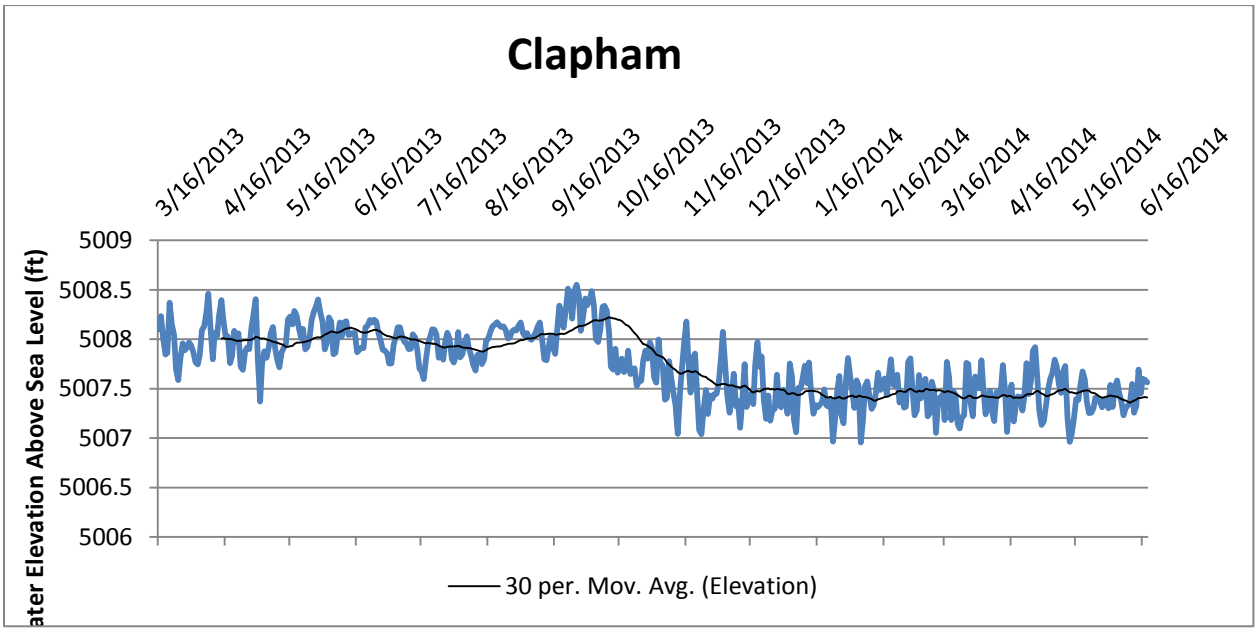
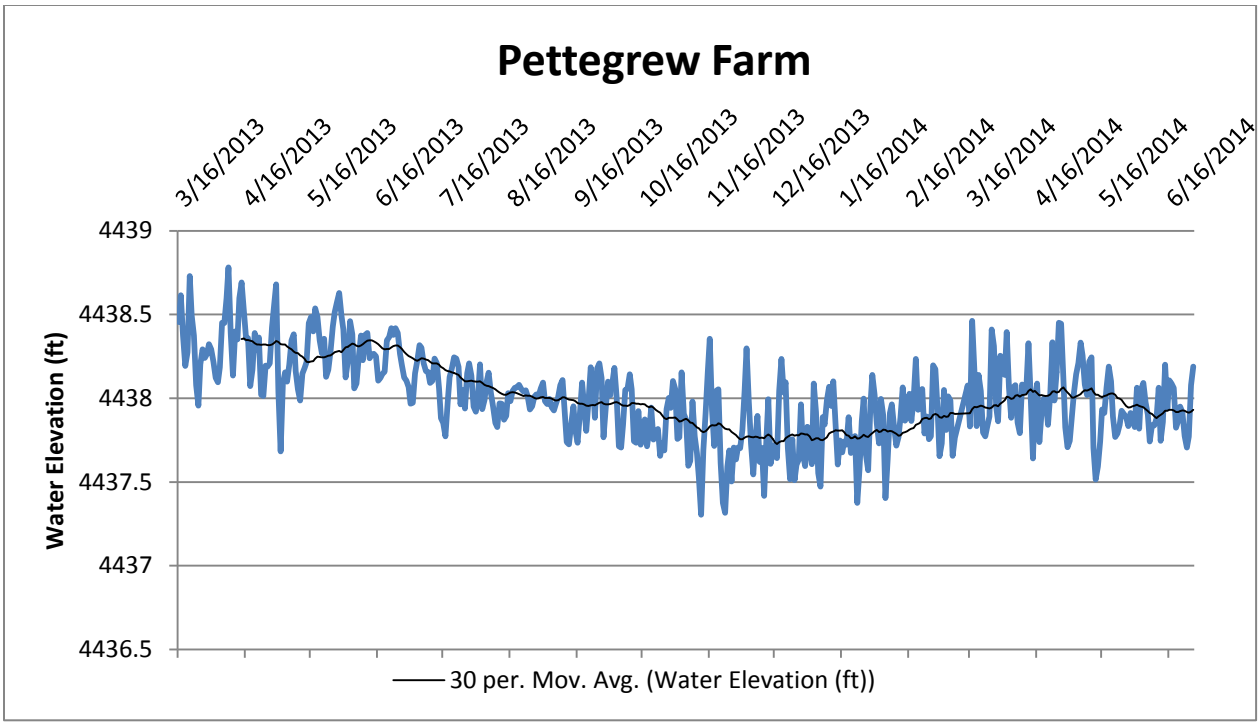


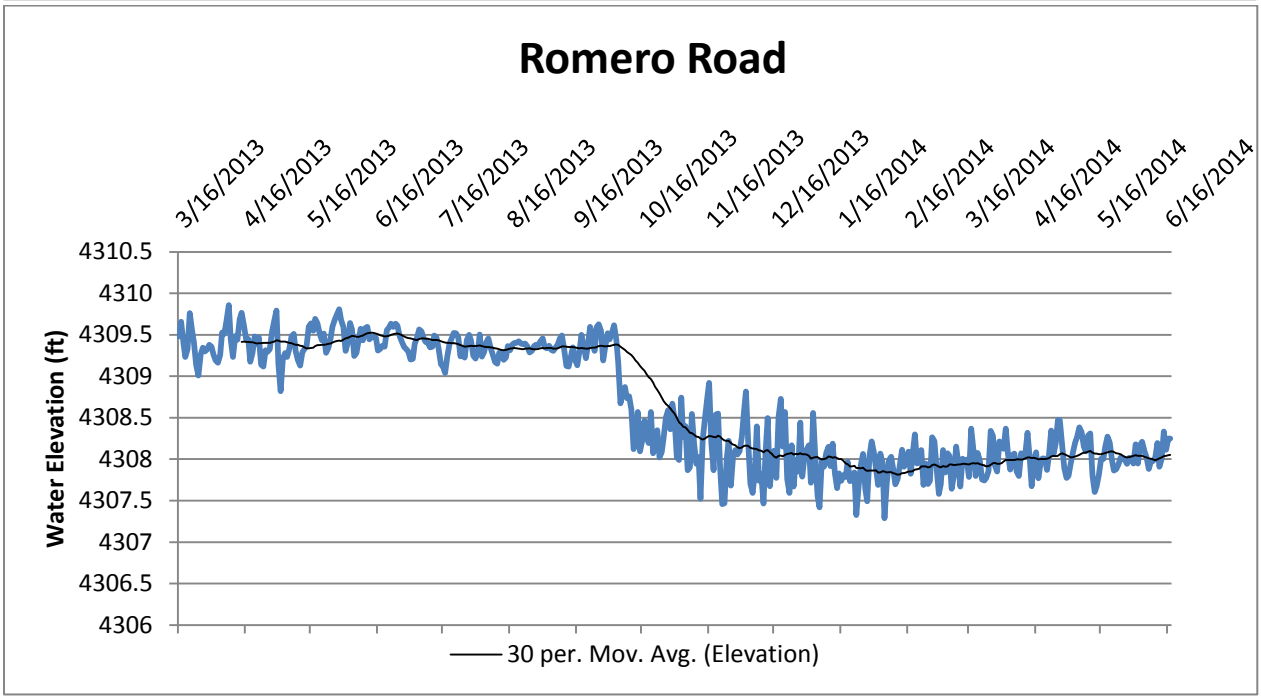
Figure 7. Interpretive stratigraphic columns with possible correlations.

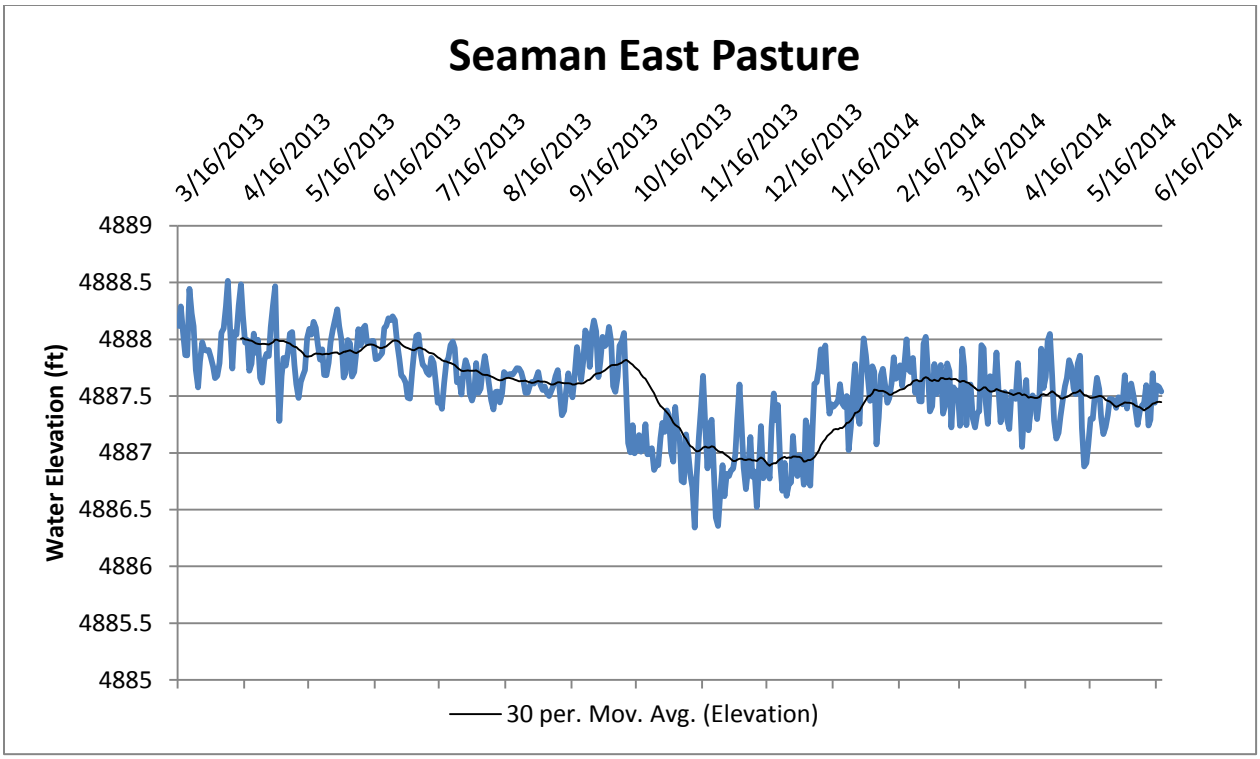
Data Recorders

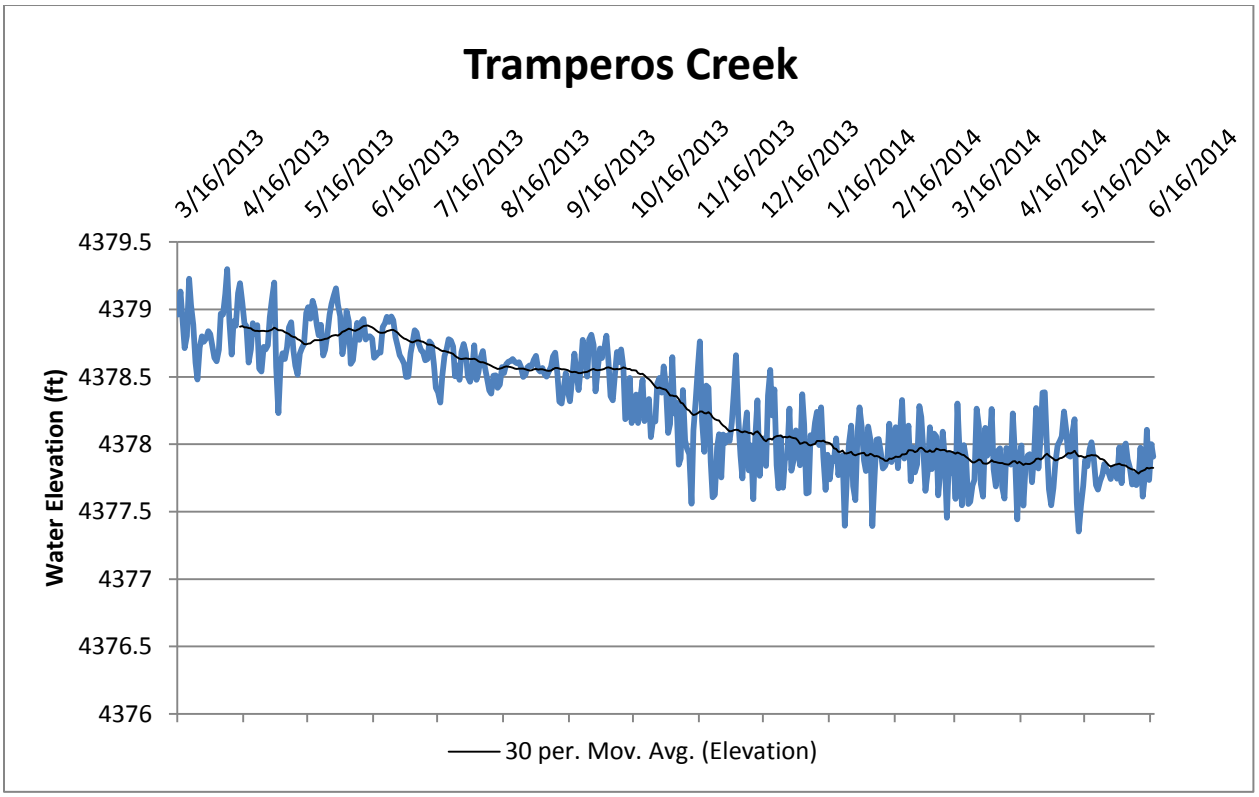
In the spring of 2013, eight data recorders were installed in wells that had been abandoned. The wells were chosen along a northwest-southeast transect that begins at the Texas state line and ends just southwest of Clayton. The data recorders are programmed to record the static water level in each well twice a day (at 6 am and 6 pm). The data recorders are removed from the wells every three months so that the data can be downloaded and then are returned to the wells. Two data recorders were lost in the first six months of operation. The remaining six are still being monitored and have now been in place for a year and three months. Hydrographs for each well appear nearly identical and show primarily a barometric pressure response, with small daily fluctuations (Figure 8). Generally, the data loggers record an overall decline in water levels in the area, which matches the static water level measurements. Pettegrew Farm, Romero Road and Seaman East Pasture all show a small increase in the last few months. This may reflect a displacement of water elsewhere in the aquifer unit versus recharge of those units.




Pettegrew Farm
3/16/2013
4/16/2013
5/16/2013
6/16/2013
7/16/2013
8/16/2013
9/16/2013
10/16/2013
11/16/2013
12/16/2013
1/16/2014
2/16/2014
3/16/2014
4/16/2014
5/16/2014
6/16/2014
4439
4438.5
4438
4437.5
4437
4436.5
Water Elevation (ft)
30 per. Mov. Avg. (Water Elevation (ft))


Romero Road
3/16/2013
4/16/2013
5/16/2013
6/16/2013
7/16/2013
8/16/2013
9/16/2013
10/16/2013
11/16/2013
12/16/2013
1/16/2014
2/16/2014
3/16/2014
4/16/2014
5/16/2014
6/16/2014
4310.5
4310
4309.5
4309
4308.5
4308
4307.5
4307
4306.5
4306
Water Elevation (ft)
30 per. Mov. Avg. (Elevation)


Seaman East Pasture
3/16/2013
4/16/2013
5/16/2013
6/16/2013
7/16/2013
8/16/2013
9/16/2013
10/16/2013
11/16/2013
12/16/2013
1/16/2014
2/16/2014
3/16/2014
4/16/2014
5/16/2014
6/16/2014
4889
4888.5
4888
4887.5
4887
4886.5
4886
4885.5
4885
Water Elevation (ft)
30 per. Mov. Avg. (Elevation)


Tramperos Creek
3/16/2013
4/16/2013
5/16/2013
6/16/2013
7/16/2013
8/16/2013
9/16/2013
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11/16/2013
12/16/2013
1/16/2014
2/16/2014
3/16/2014
4/16/2014
5/16/2014
6/16/2014
4379.5
4379
4378.5
4378
4377.5
4377
4376.5
4376
Water Elevation (ft)
30 per. Mov. Avg. (Elevation)

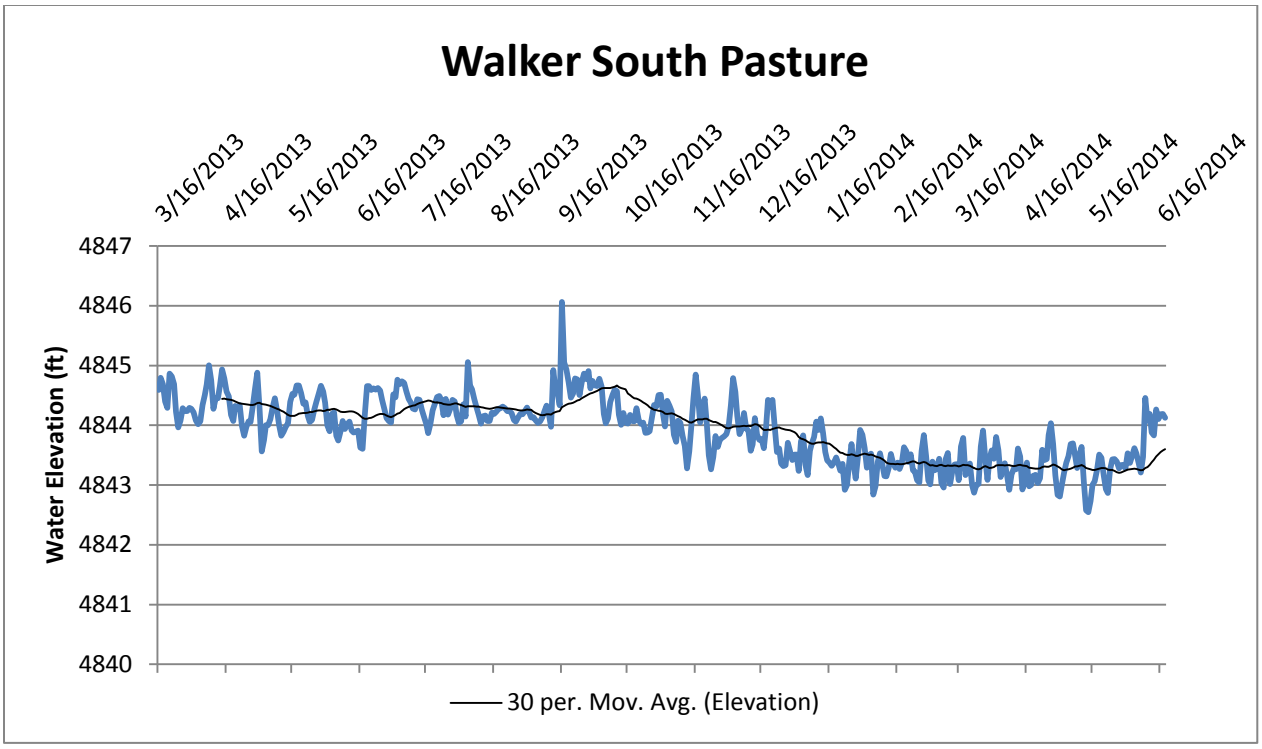

Figure 8. Hydrographs for data loggers installed in eastern Union County from March 2013 to June 2014.

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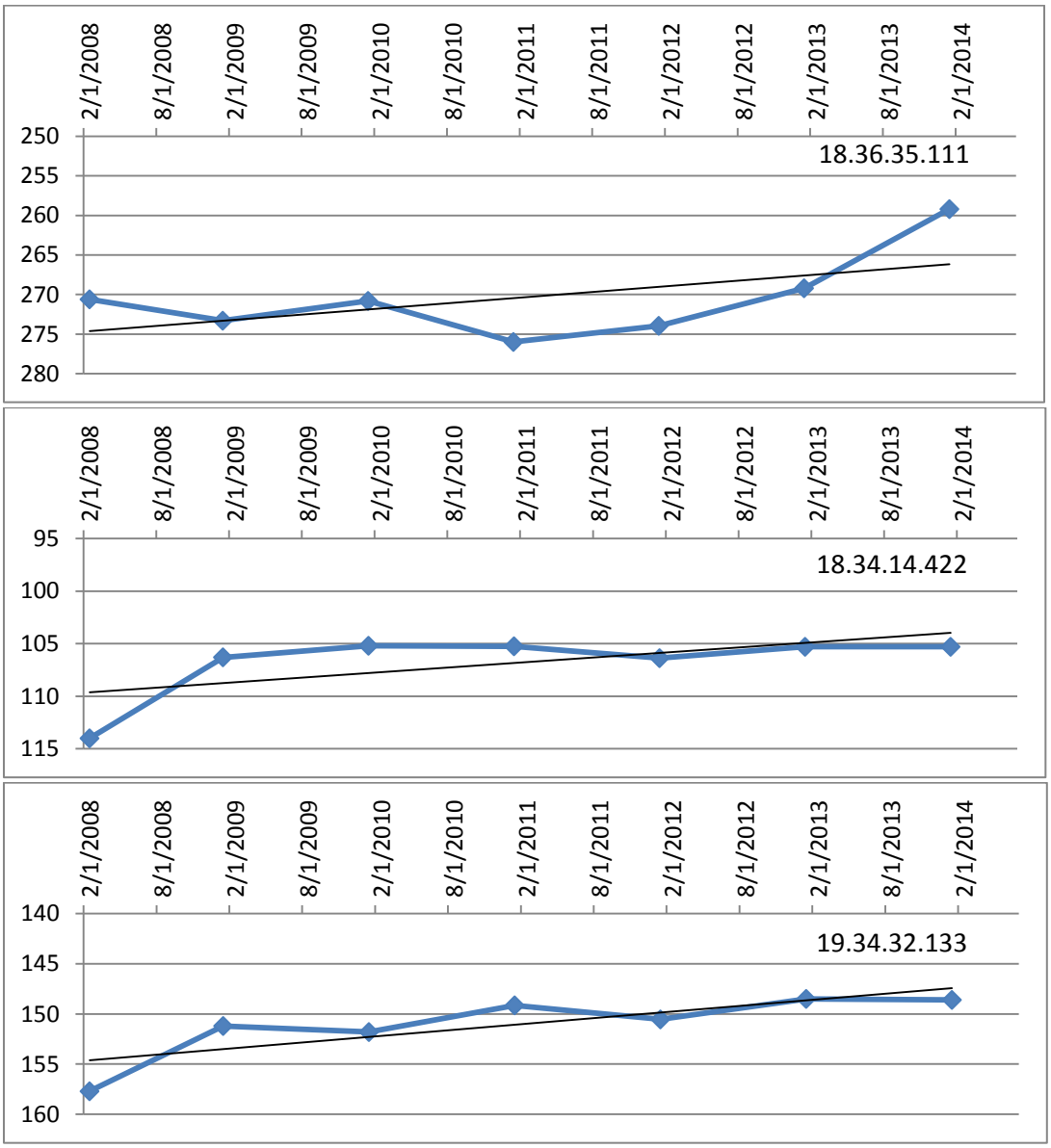
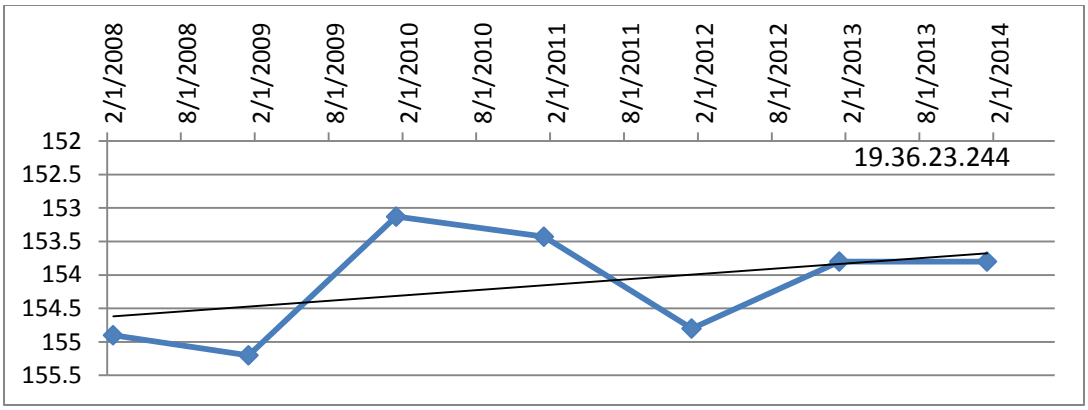
Appendices

Appendix I: January Static Water Level Measurements 2008-2014

** Denotes well removed from study.

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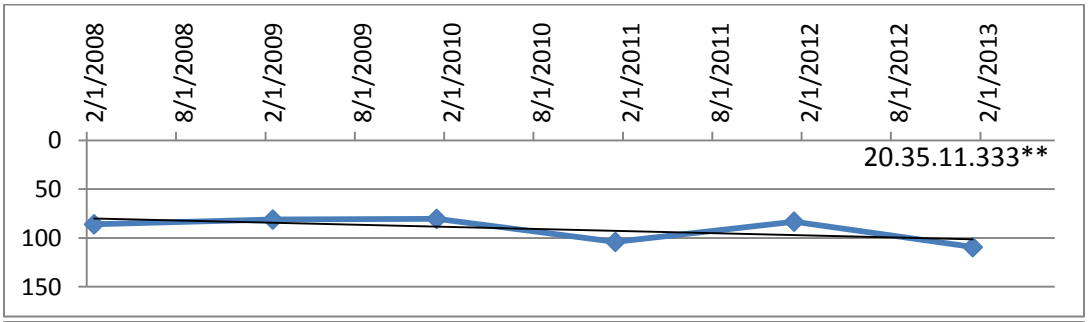
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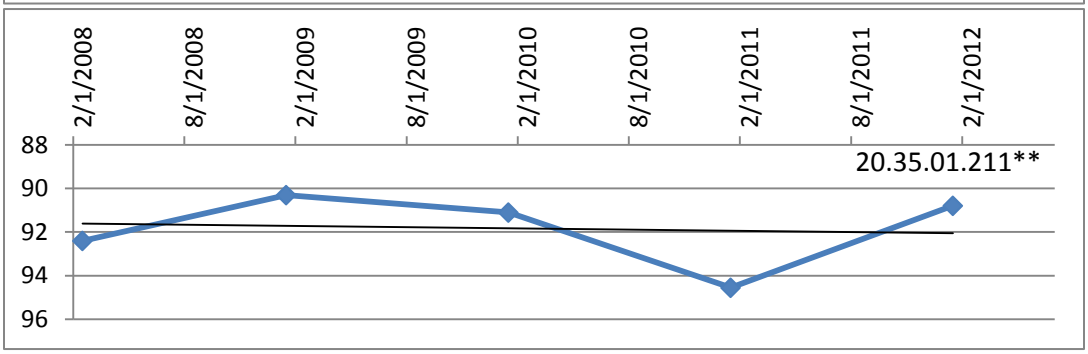
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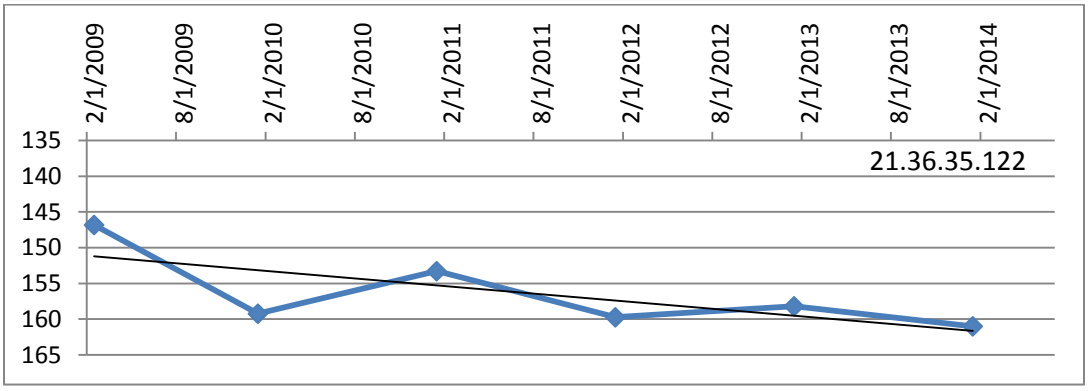
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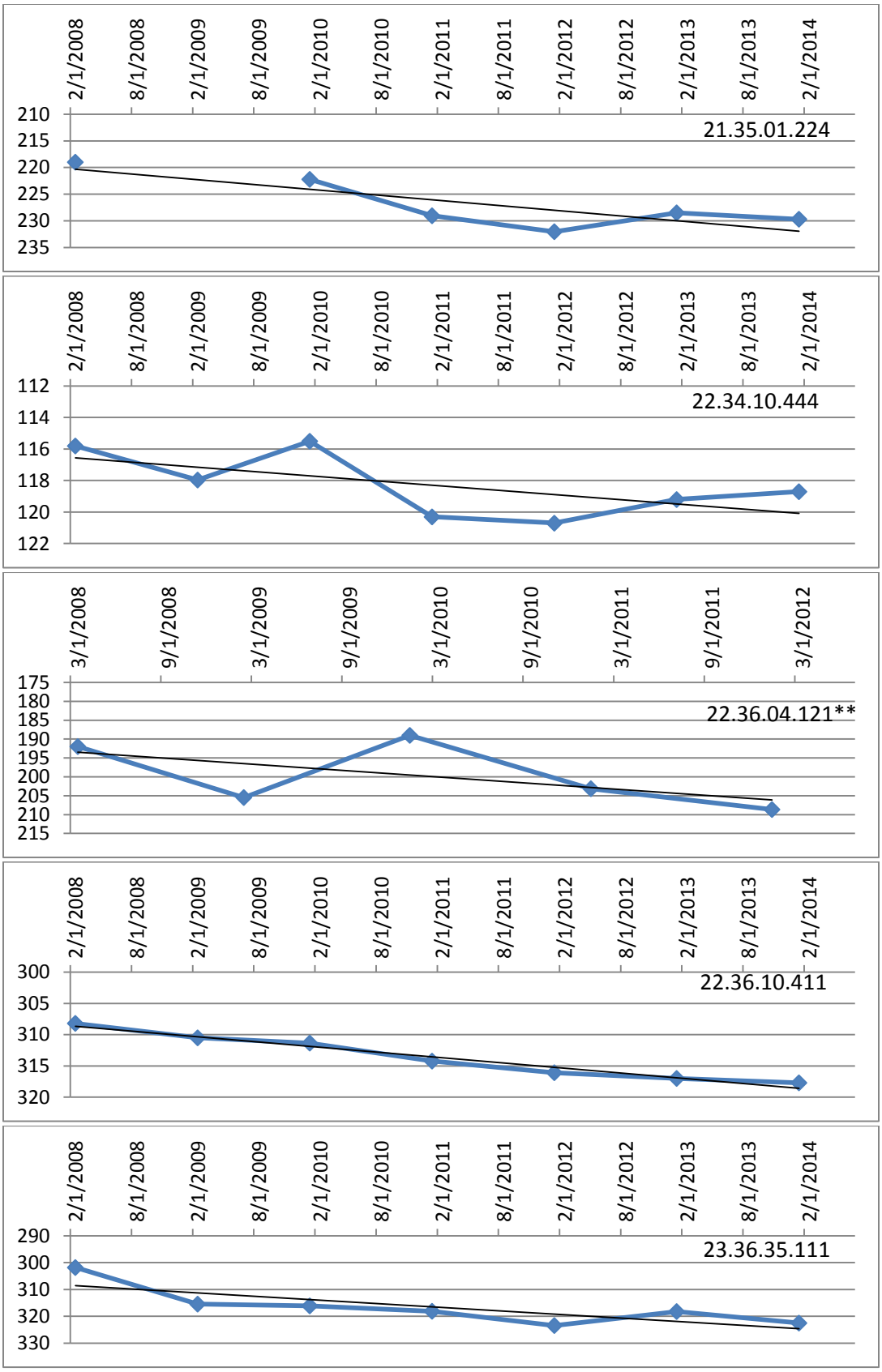
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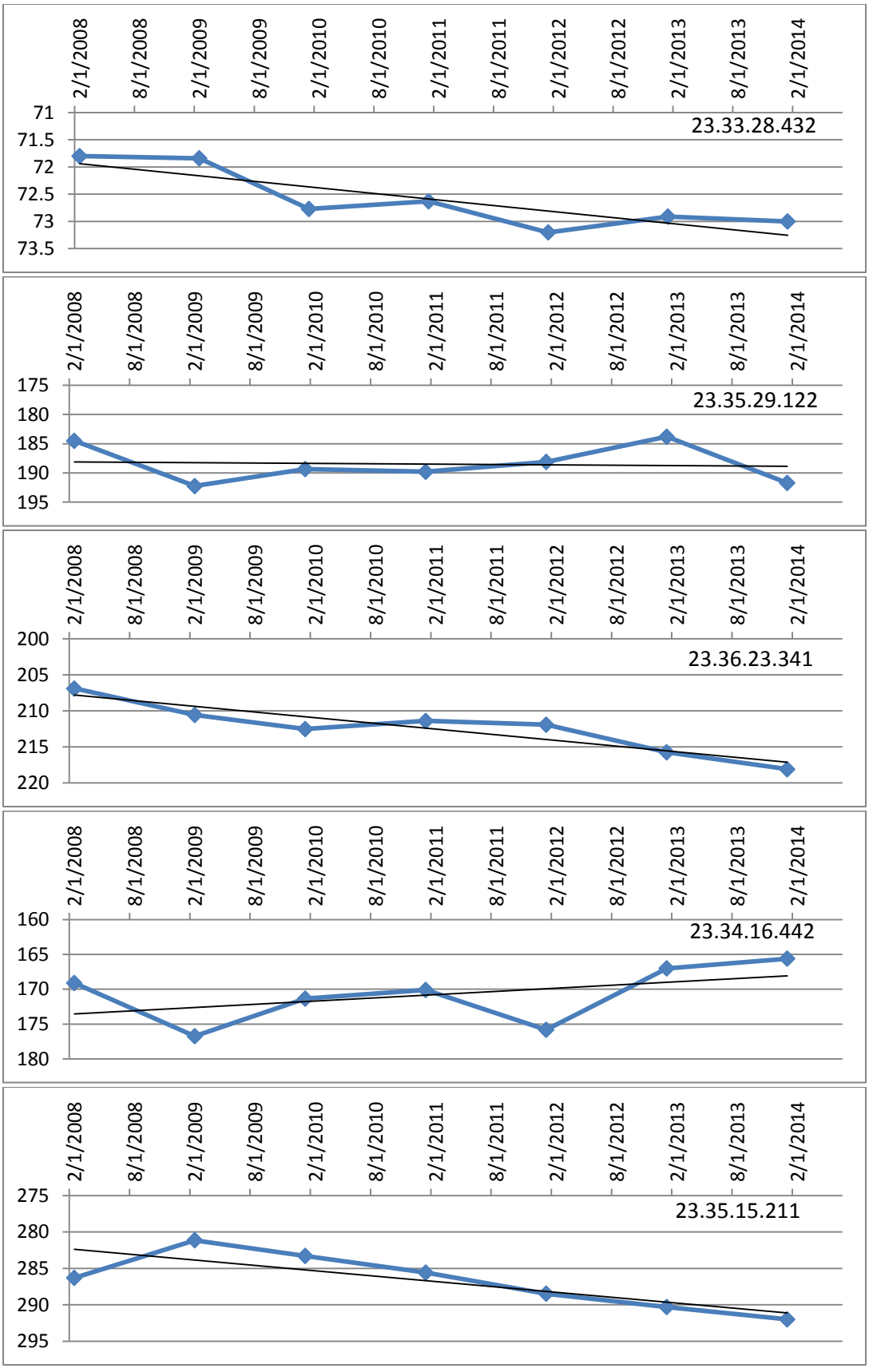
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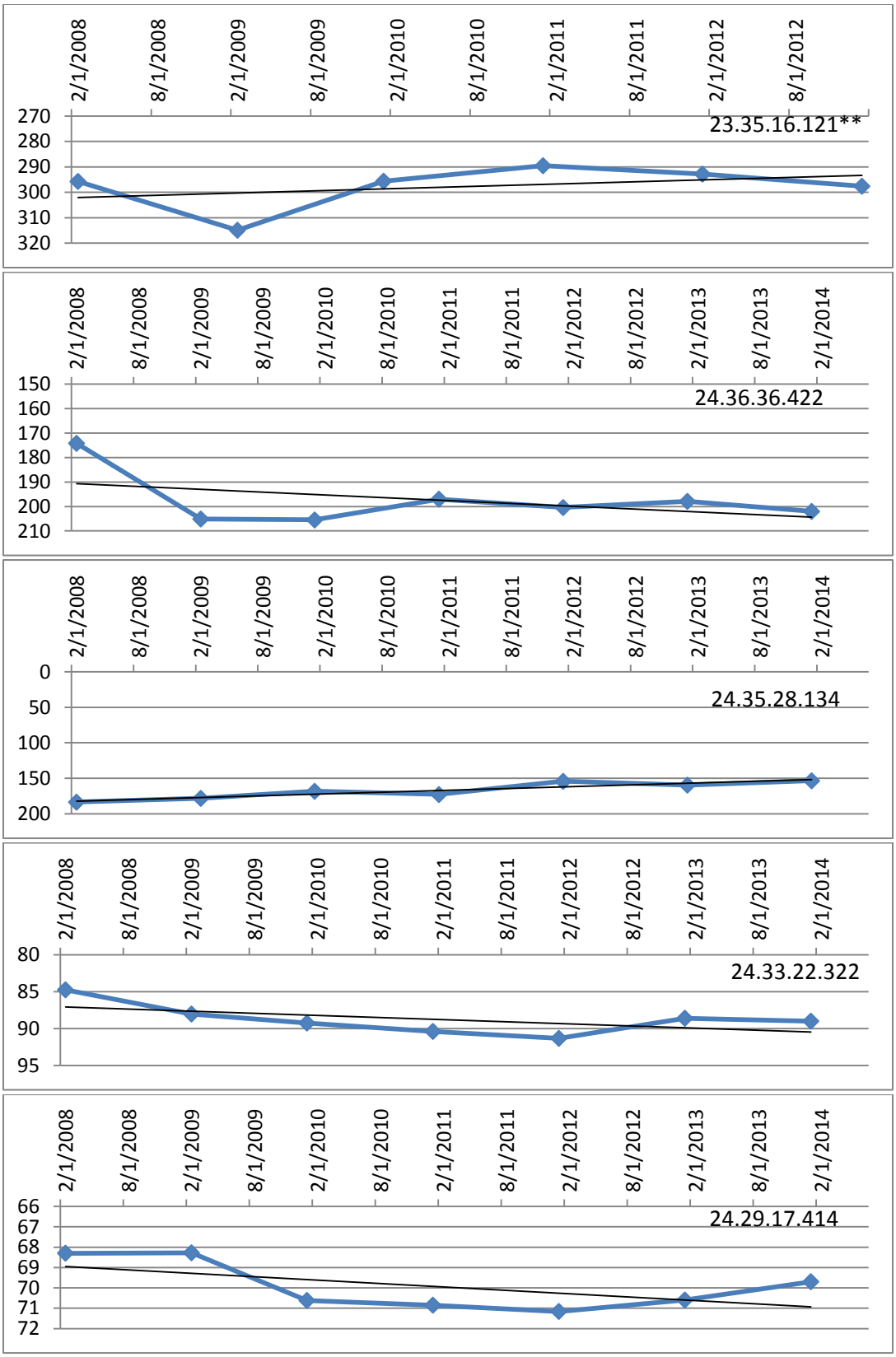
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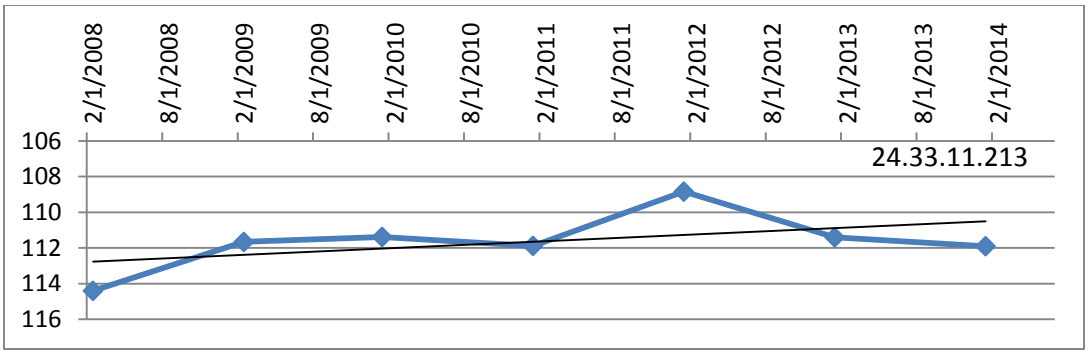
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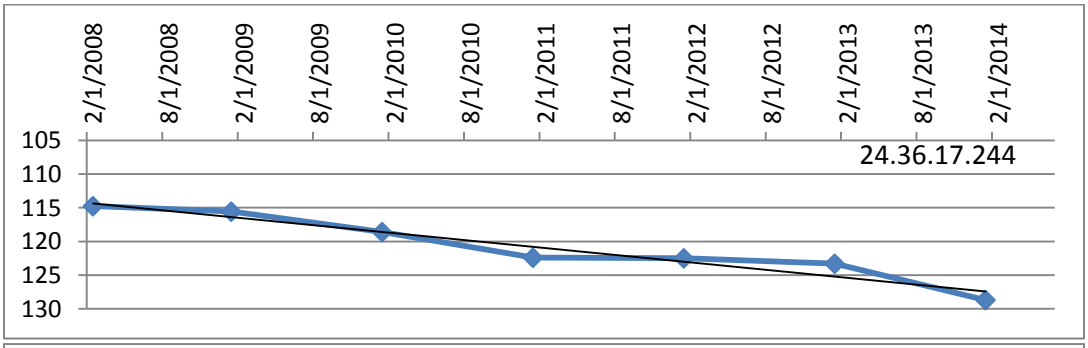
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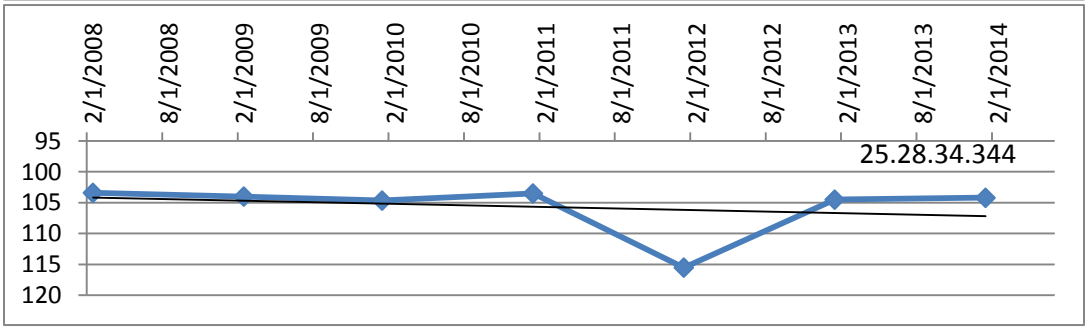
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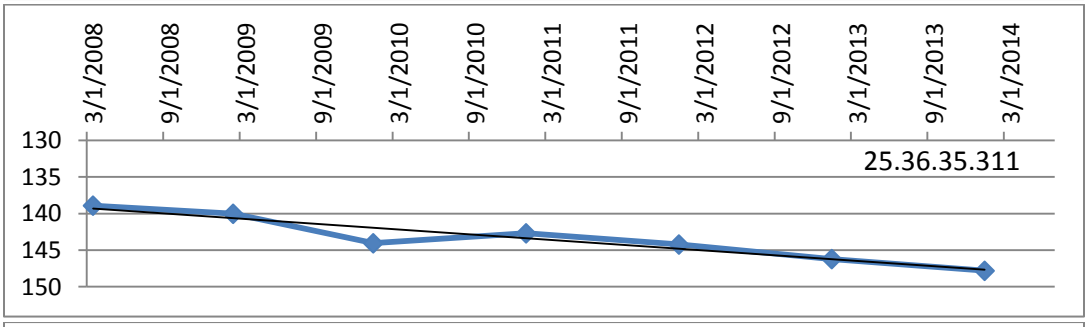
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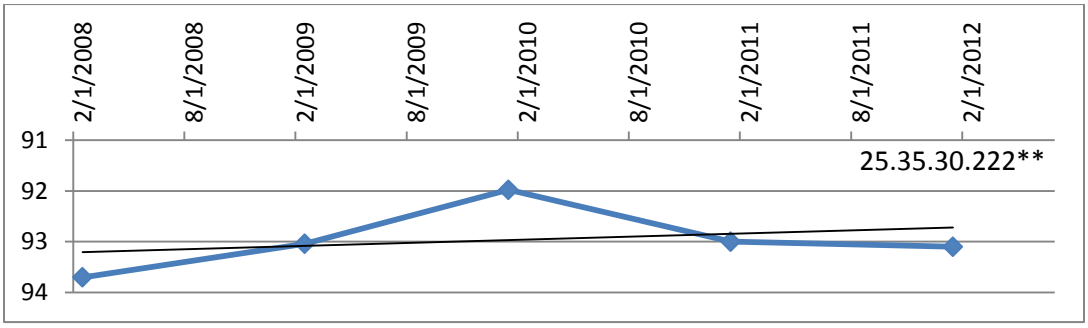
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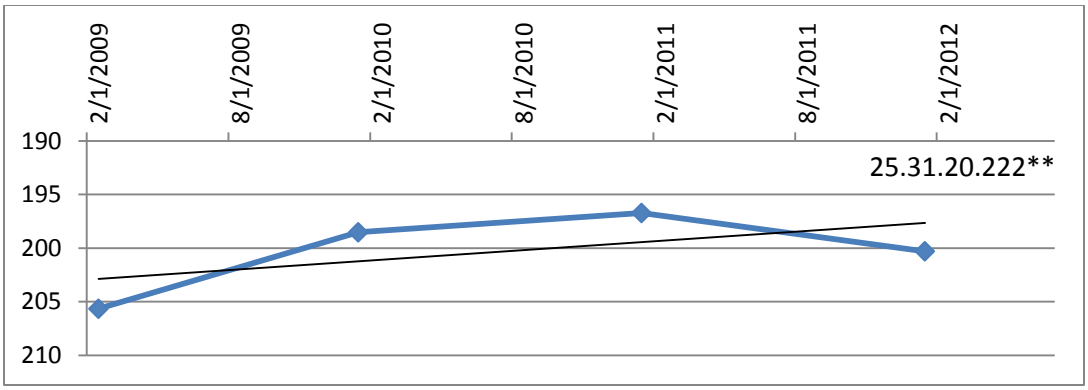
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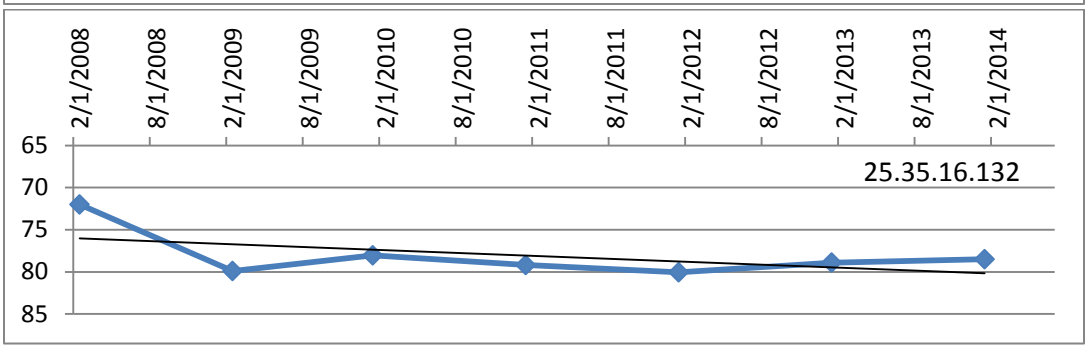
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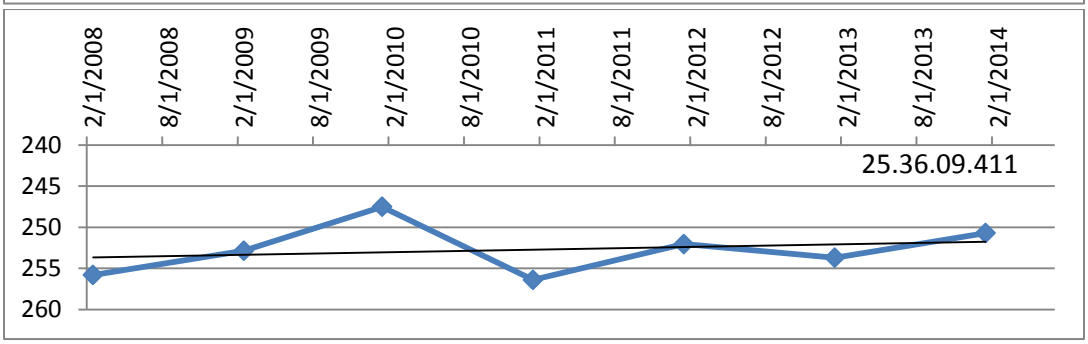
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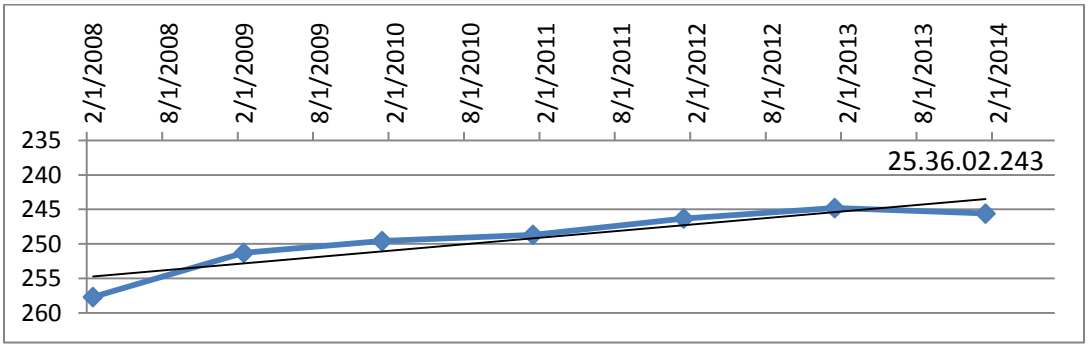
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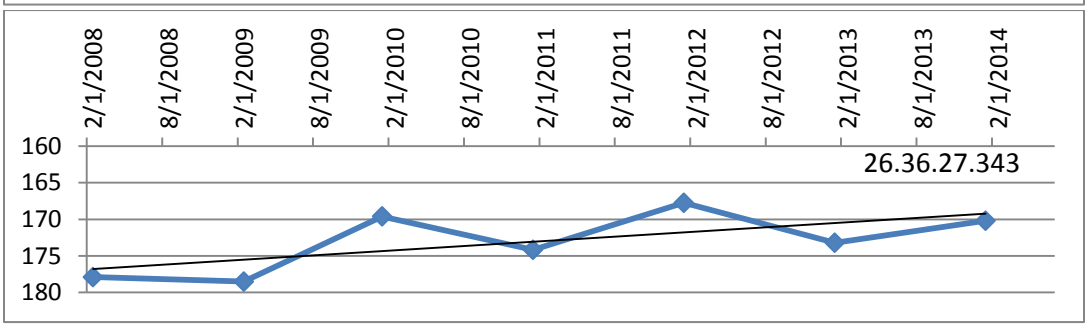
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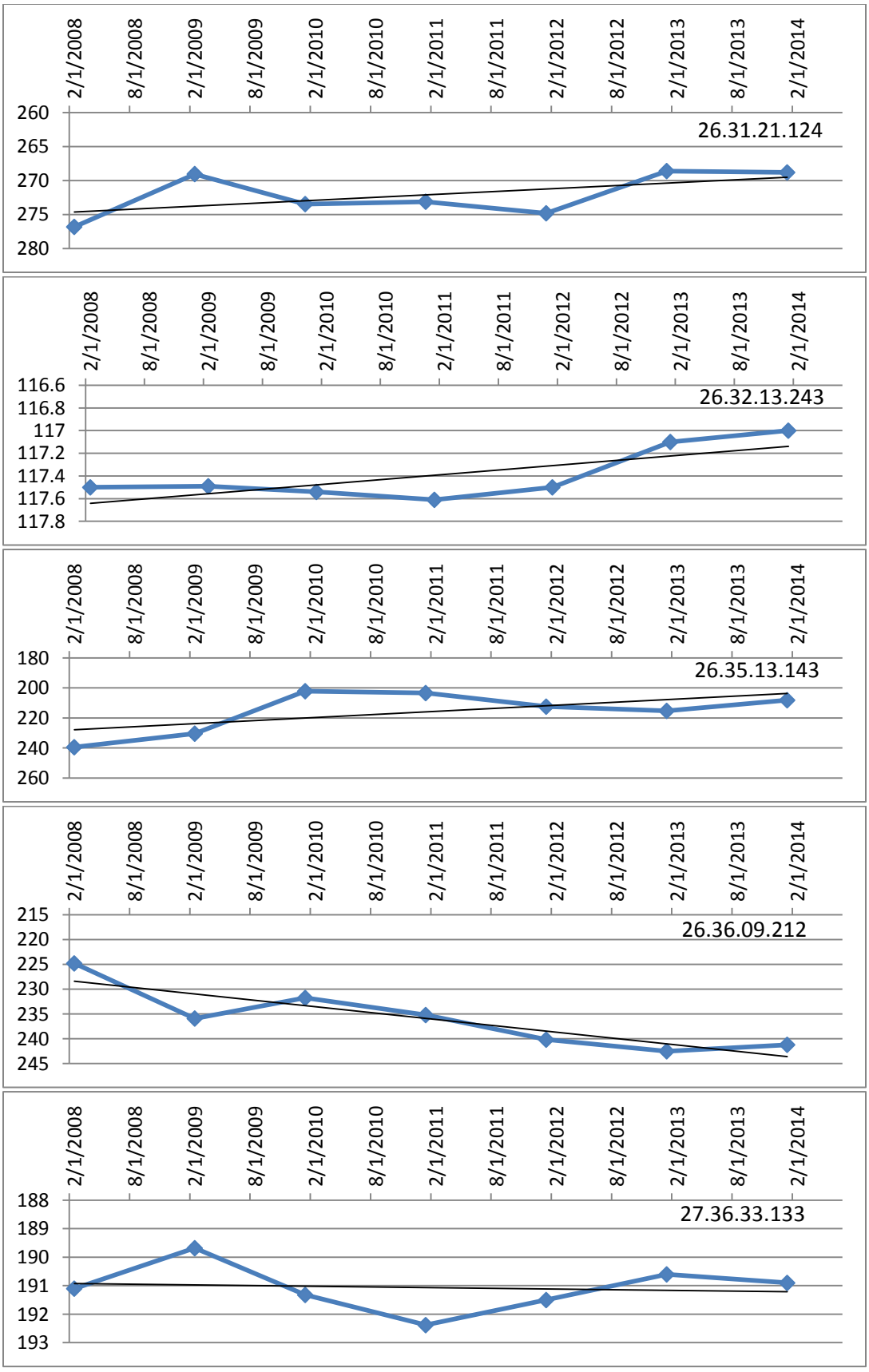
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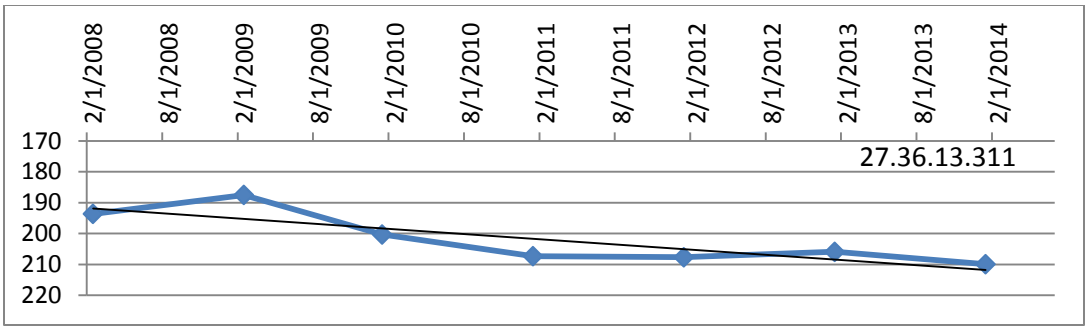
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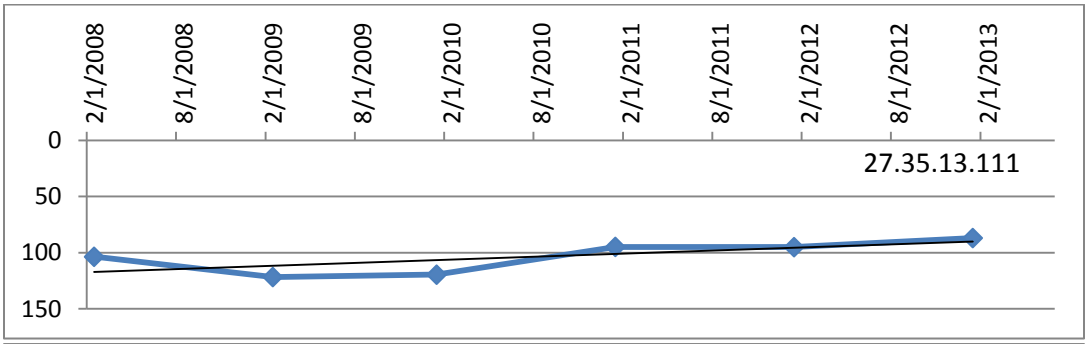
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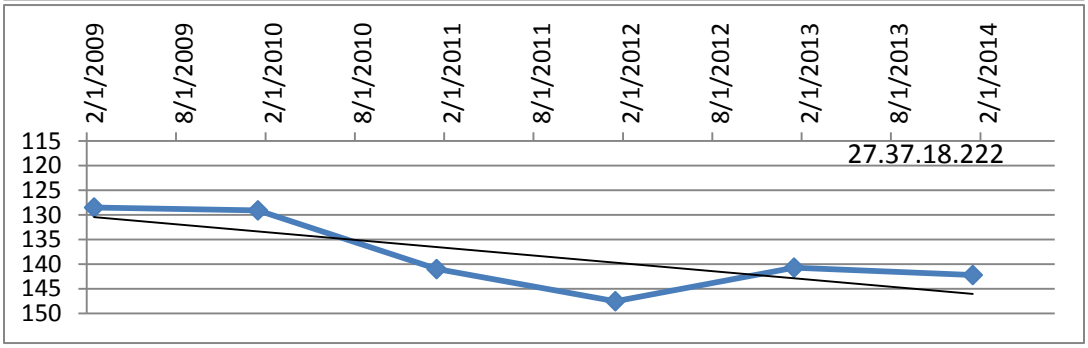
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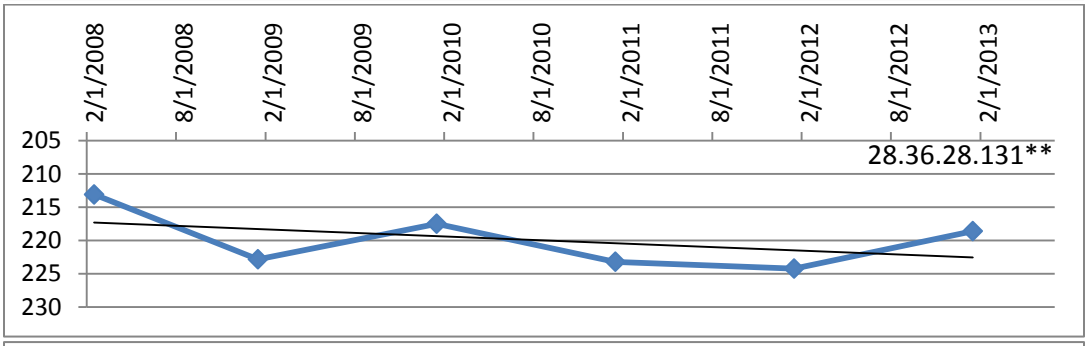
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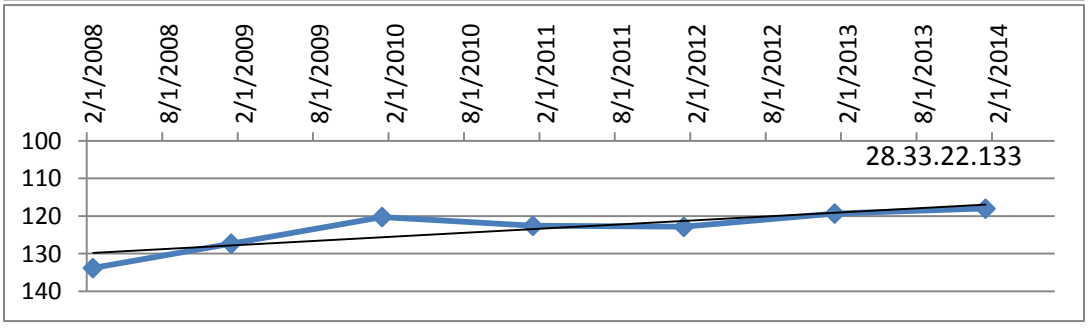
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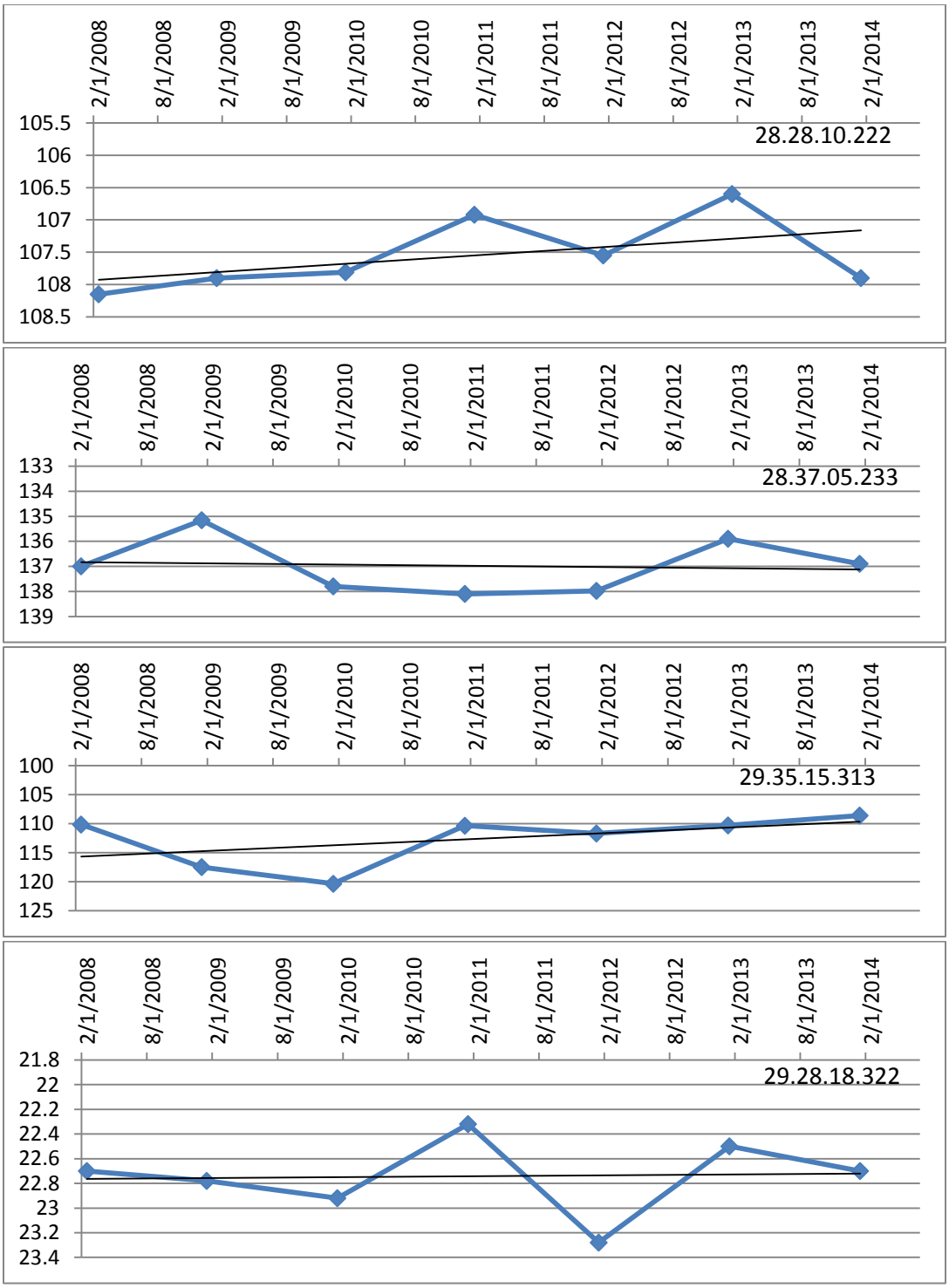
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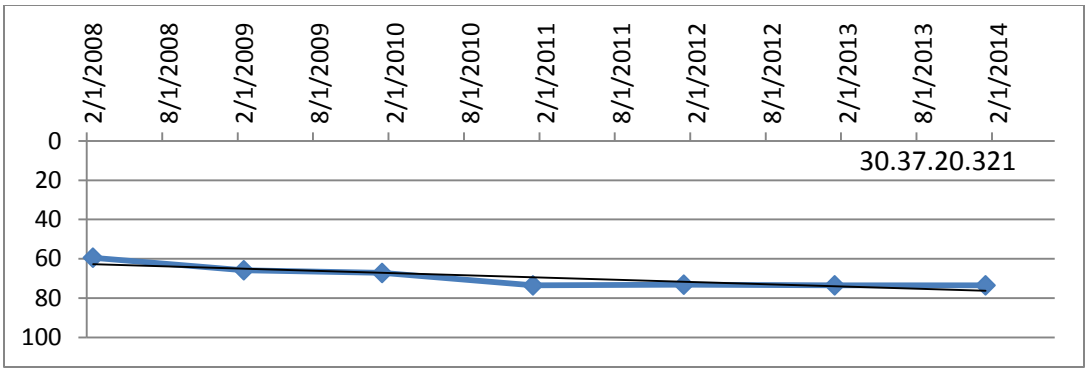
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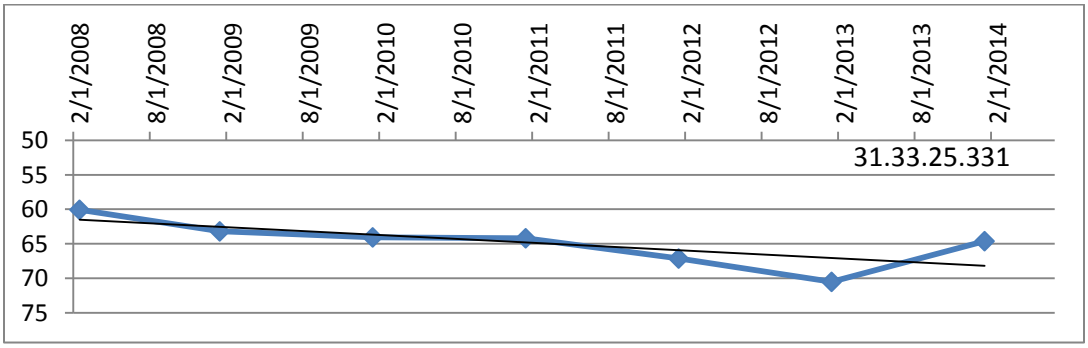
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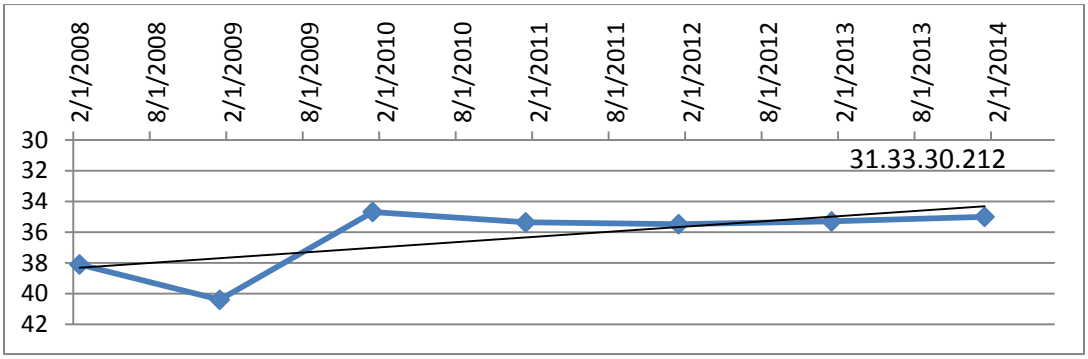
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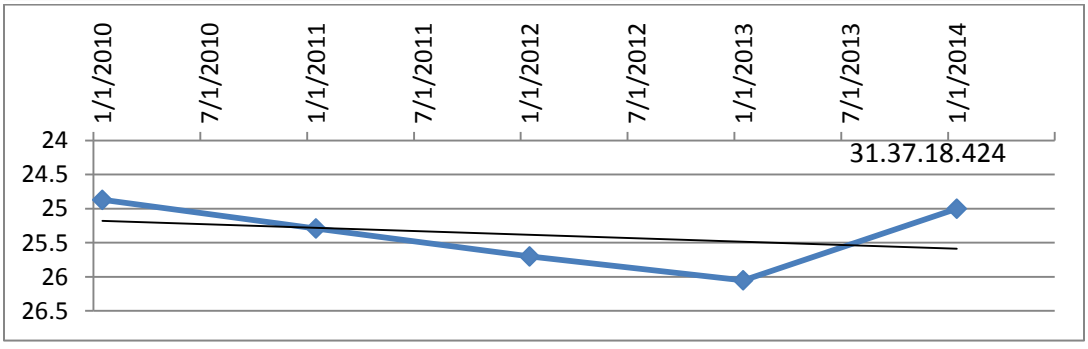
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Appendix II: January Static Water Level Measurements

Individual well static water level measurements from January 2008 through January 2014.

LOCAL ID & ELEVATION	DATE	DEPTH TO WATER	Delta Depth	Years	Rate
18N36E35.111	2/18/2008	270.6	11.4	7	1.63
4465'	1/30/2009	273.3			
Centerville	1/5/2010	270.8			
	1/1/2011	275.99			
	1/3/2012	273.95			
	1/6/2013	269.2			
	1/3/2014	259.2			
18N34E15.422	2/18/2008	114	8.7	7	1.24
4764'	1/30/2009	106.3			
Ione South	1/6/2010	105.2			
	1/7/2011	105.25			
	1/3/2012	106.38			
	1/6/2013	105.3			
	1/3/2014	105.3			
19N34E32.133	2/18/2008	157.7	9.1	7	1.30
4883'	1/30/2009	151.2			
Ione North	1/1/2010	151.8			
	1/1/2011	149.14			
	1/3/2012	150.54			
	1/6/2013	148.5			
	1/3/2014	148.6			
19N36E23.244	2/6/2008	154.9	1.1	7	0.16
4360'	1/30/2009	155.2			
Romero	1/1/2010	153.13			
	1/1/2011	153.43			
	1/3/2012	154.8			
	1/6/2013	153.8			
	1/3/2014	153.8			
20N35E11.333	2/18/2008	85.9	-23.4	6	-3.90
4558'	2/24/2009	81			

Rat bastard	1/10/2010	80.35			
	1/1/2011	103.91			
	1/7/2012	83.17			
	1/6/2013	109.3			
20N35E01.211	2/18/2008	92.4	1.61	5	0.32
Tompkins Rd	1/30/2009	90.3			
	1/20/2010	91.1			
	1/13/2011	94.55			
	1/3/2012	90.79			
21N36E35.122	2/24/2009	146.82	-14.18	6	-2.36
4450'	1/12/2010	159.24			
Speer Rd	1/14/2011	153.29			
	1/7/2012	159.74			
	1/6/2013	158.2			
	1/4/2014	161			
21N35E01.224	2/18/2008	219	-10.7	6	-1.78
4570'	2/16/2009				
Proffitt Rd	1/11/2010	222.22			
	1/14/2011	229.05			
	1/2/2012	232.04			
	1/6/2013	228.5			
	1/4/2014	229.7			
22N34E10.444	2/26/2008	115.8	-2.9	7	-0.41
4765'	2/16/2009	117.96			
Betty's homestead	1/11/2010	115.5			
	1/11/2011	120.3			
	1/3/2012	120.7			
	1/6/2013	119.2			
	1/5/2014	118.7			
22N36E04.121	3/4/2008	192	-16.68	5	-3.34
4611'	2/9/2009	205.5			
Vandiver Rd	1/13/2010	189.04			
	1/13/2011	203.16			
	1/2/2012	208.68			

22N36E10.411	2/19/2008	308.2	-9.5	7	-1.36
4558'	2/9/2009	310.51			
Cowen South	1/13/2010	311.35			
	1/13/2011	314.23			
	1/2/2012	316.08			
	1/6/2013	317			
	1/4/2014	317.7			
23N36E35.111	2/19/2008	301.8	-20.7	7	-2.96
4611'	2/9/2009	315.44			
Cowen Middle	1/11/2010	316.1			
	1/12/2011	318.1			
	1/2/2012	323.42			
	1/6/2013	318.2			
	1/4/2014	322.5			
23N33E28.432	2/26/2008	71.8	-1.2	7	-0.17
5020'	2/16/2009	71.84			
Clapham	1/12/2010	72.77			
	1/15/2011	72.63			
	1/3/2012	73.2			
	1/6/2013	72.91			
	1/5/2014	73			
23N35E29.122	2/26/2008	184.5	-7.2	7	-1.03
4794'	2/24/2009	192.24			
Anderson Rd	1/13/2010	189.32			
	1/15/2011	189.79			
	1/3/2012	188.1			
	1/6/2013	183.8			
	1/4/2014	191.7			
23N36E23.341	2/19/2008	206.9	-11.2	7	-1.60
4761'	2/9/2009	210.56			
Cowen North	1/15/2010	212.52			
	1/20/2011	211.4			
	1/2/2012	211.91			
	1/6/2013	215.74			
	1/4/2014	218.1			
23N34E16.442	2/26/2008	169.1	3.5	7	0.50

4925'	2/16/2009	176.74			
Thomas South	1/14/2010	171.35			
	1/20/2011	170.1			
	1/3/2012	175.82			
	1/6/2013	167			
	1/5/2014	165.6			
23N35E15.211	2/26/2008	286.3	-5.7	7	-0.81
4797'	2/24/2009	281.13			
Furlow East	1/25/2010	283.29			
	1/15/2011	285.58			
	1/3/2012	288.47			
	1/6/2013	290.3			
	1/4/2014	292			
23N35E16.121	2/26/2008	295.7	-1.9	-6	0.32
4812'	2/3/2009	314.9			
Furlow West	1/12/2010	295.62			
	1/14/2011	289.52			
	1/3/2012	292.83			
	1/6/2013	297.6			
	1/4/2014				
24N36E36.422	2/19/2008	174.2	-27.8	7	-3.97
4720'	2/13/2009	205.1			
Dixon Rd	1/15/2010	205.48			
	1/13/2011	196.99			
	1/6/2012	200.42			
	1/6/2013	197.9			
	1/4/2014	202			
24N35E28.134	2/27/2008	183.5	30.1	7	4.30
4643'	2/16/2009	178.17			
Thomas Hwy	1/15/2010	168.25			
	1/16/2011	172.79			
	1/3/2012	154.19			
	1/6/2013	159.5			
	1/5/2014	153.4			
24N33E22.322	2/27/2008	84.75	-4.25	7	-0.61
5410'	2/11/2009	88.03			

Ringbone Rd	1/15/2010	89.25			
	1/15/2011	90.39			
	1/4/2012	91.33			
	1/6/2013	88.6			
	1/7/2014	89			
24N29E17.414	2/28/2008	68.3	-1.4	7	-0.20
5760'	2/4/2009	68.28			
Triple M	1/16/2010	70.62			
	1/12/2011	70.85			
	1/4/2012	71.16			
	1/6/2013	70.6			
	1/7/2014	69.7			
24N33E11.213	2/27/2008	114.4	2.5	7	0.36
5675'	2/4/2009	111.66			
Jordan Rd	1/16/2010	111.38			
	1/15/2011	111.88			
	1/6/2012	108.84			
	1/6/2013	111.4			
	1/7/2014	111.9			
24N36E.12.111	8/16/2007	137.64			
4668'	2/5/2008	146.07			
	8/12/2008	NA			
	2/5/2009				
24N36E17.244	2/16/2008	114.76	-13.94	7	-1.99
4707'	1/17/2009	115.57			
Burrows Rd	1/15/2010	118.6			
	1/23/2011	122.41			
	1/6/2012	122.5			
	1/6/2013	123.3			
	1/5/2014	128.7			
25N28E34.344	2/28/2008	103.4	-0.8	7	-0.11
5960'	2/4/2009	104			
Grinde Rd	1/14/2010	104.65			
	1/13/2011	103.5			
	1/6/2012	115.5			
	1/6/2013	104.5			

	1/7/2014	104.2			
25N36E.35.311	3/5/2008	138.9	-8.9	7	-1.27
4682'	2/13/2009	140.01			
Campsey Rd	1/14/2010	144.04			
	1/15/2011	142.68			
	1/6/2012	144.21			
	1/6/2013	146.2			
	1/5/2014	147.8			
25N35E30.222	2/27/2008	93.7	0.6	5	0.12
5007'	2/13/2009	93.04			
Leavitt Rd	1/13/2010	91.98			
	1/23/2011	93			
	1/6/2012	93.1			
	1/7/2014				
25N31E20.222	2/4/2009	205.65	5.36	4	1.34
	1/13/2010	198.52			
Snyder Rd	1/13/2011	196.72			
	1/4/2012	200.29			
25N35E16.132	2/27/2008	72	-6.5	7	-0.93
5045'	2/26/2009	79.9			
John Gard's	1/14/2010	78.04			
	1/12/2011	79.19			
	1/6/2012	80.05			
	1/6/2013	78.9			
	1/5/2014	78.5			
25N36E09.411	2/27/2008	255.8	5.1	7	0.73
4850'	2/11/2009	252.86			
Texline Hwy	1/14/2010	247.5			
	1/13/2011	256.4			
	1/6/2012	252.05			
	1/6/2013	253.7			
	1/8/2014	250.7			
25N36E.02.243	2/27/2008	257.7	12.1	7	1.73
4810'	2/11/2009	251.29			
Rawhide South	1/15/2010	249.58			

	1/14/2011	248.68			
	1/6/2012	246.31			
	1/6/2013	244.8			
	1/8/2014	245.6			
26N36E.27.343	2/27/2008	177.9	7.7	7	1.10
4810'	2/11/2009	178.51			
Rawhide North	1/15/2010	169.6			
	1/13/2011	174.17			
	1/6/2012	167.75			
	1/6/2013	173.2			
	1/8/2014	170.2			
26N31E.21.124	2/28/2008	276.8	8	7	1.14
6010'	2/4/2009	269.04			
Grenville	1/21/2010	273.45			
	1/14/2011	273.1			
	1/4/2012	274.8			
	1/6/2013	268.6			
	1/7/2014	268.8			
26N32E.13.243	2/28/2008	117.5	0.5	7	0.07
5600'	2/4/2009	117.49			
Perico Creek Rd	1/23/2010	117.54			
	1/12/2011	117.61			
	1/4/2012	117.5			
	1/6/2013	117.1			
	1/7/2014	117			
26N35E.13.143	2/2/2008	239.4	31.3	7	4.47
4850'	2/4/2009	230.38			
Apache Valley	1/21/2010	202.1			
	1/12/2011	203.34			
	1/6/2012	212.38			
	1/6/2013	215.2			
	1/10/2014	208.1			
26N36E.09.212	2/2/2008	224.8	-16.4	7	-2.34
4792'	2/11/2009	235.9			
Booster Station	1/12/2010	231.76			
	1/12/2011	235.2			

	1/6/2012	240.16			
	1/6/2013	242.5			
	1/8/2014	241.2			
27N36E.33.133	2/28/2008	191.1	0.2	-7	-0.03
4892'	2/11/2009	189.68			
Kenton Hwy	1/12/2010	191.32			
	1/11/2011	192.38			
	1/6/2012	191.5			
	1/6/2013	190.6			
	1/8/2014	190.9			
27N36E13.311	2/29/2008	193.6	-16.3	7	-2.33
4776'	2/11/2009	187.47			
Creeds Chapel	1/8/2010	200.29			
	1/2/2011	207.3			
	1/6/2012	207.66			
	1/6/2013	205.9			
	1/8/2014	209.9			
27N35E.13.111	2/2/2008	103.6	16.7	6	2.78
4963'	2/28/2009	121.66			
Mock Rd	1/5/2010	119.54			
	1/14/2011	94.8			
	1/5/2012	95.02			
	1/6/2013	86.9			
	1/8/2014				
27N37E.18.222	2/9/2009	128.5	-13.7	5	-2.74
4718'	1/9/2010	129.08			
Seneca Valley	1/15/2011	141			
	1/6/2012	147.52			
	1/6/2013	140.7			
	1/8/2014	142.2			
28N36E28.131	2/2/2008	213.1	-5.5	6	-0.92
4905'	1/31/2009	222.83			
Kenton Hwy	1/12/2010	217.49			
R. Baker?	1/3/2011	223.2			
	1/5/2012	224.23			
	1/6/2013	218.6			

	1/8/2014				
28N33E.22.133	2/10/2008	133.8	15.8	7	2.26
5546'	1/21/2009	127.3			
Garcia Rd	1/6/2010	120.22			
	1/7/2011	122.55			
	1/4/2012	122.83			
	1/6/2013	119.3			
	1/9/2014	118			
28N28E.10.222	2/28/2008	108.15	0.25	7	0.04
6814'	1/31/2009	107.9			
Kennedy Rd	1/6/2010	107.81			
	1/20/2011	106.92			
	1/4/2012	107.55			
	1/6/2013	106.6			
	1/6/2014	107.9			
28N37E.05.233	2/2/2008	137	0.1	7	0.01
4811'	1/30/2009	135.16			
Billy Mock	1/7/2010	137.8			
	1/8/2011	138.1			
	1/5/2012	137.98			
	1/6/2013	135.9			
	1/6/2014	136.9			
29N35E.15.313	2/10/2008	110.15	1.55	7	0.22
5180'	1/31/2009	117.48			
Atencio Rd	1/7/2010	120.36			
	1/8/2011	110.36			
	1/4/2012	111.69			
	1/6/2013	110.3			
	1/9/2014	108.6			
29N28E.18.322	2/28/2008	22.7	0	7	0.00
6890'	1/31/2009	22.78			
Capulin	1/9/2010	22.92			
	1/6/2011	22.32			
	1/4/2012	23.28			
	1/6/2013	22.5			
	1/6/2014	22.7			

30N37E20.321	2/2/2008	59.42	-14.08	7	-2.01
4720'	2/3/2009	65.82			
Stone house	1/7/2010	67.2			
	1/8/2011	73.53			
	1/5/2012	73.17			
	1/6/2013	73.5			
	1/6/2014	73.5			
31N33E25.331	2/10/2008	60.05	-4.55	7	-0.65
5372'	1/31/2009	63.18			
Bechtel	1/8/2010	64.05			
	1/9/2011	64.18			
	1/5/2012	67.12			
	1/6/2013	70.5			
	1/6/2014	64.6			
31N33E.30.212	2/10/2008	38.1	3.1	7	0.44
5120'	1/31/2009	40.4			
Lake Hwy	1/8/2010	34.68			
	1/8/2011	35.36			
	1/5/2012	35.48			
	1/6/2013	35.3			
	1/6/2014	35			
31N37E.18.424	1/6/2010	24.87	-0.13	5	-0.03
4356'	1/5/2011	25.29			
Wiggins Rd	1/5/2012	25.7			
	1/6/2013	26.05			
	1/6/2014	25			
Bannon Oak Canyon	1/6/2013	21.7	-3.1	2	-1.55
	1/6/2014	24.8			
Bannon Tollgate	1/6/2013	73.67	-0.33	2	-0.16
	1/6/2014	74			
Bennett #1	1/8/2013	152.3	-0.1	2	-0.05
open casing	1/9/2014	152.4			
Bennett #3	1/8/2013	75.9	0.2	2	0.10

Travesser Crk	1/9/2014	75.7			
Harris West	1/8/2014	104.4			
Seneca					
Harris East	1/8/2014	198.6			
Seneca					
Mock house	1/8/2014	190.4			
Seneca Crk					
Tramperos Creek	4/1/203	87.1			
*data recorder	1/6/2014	88			
Effie's					
*data recorder	1/6/2014	189.1			
Burchard #1	3/12/2014	19.78			
	6/23/2014	20.2			
Bennefield #1	6/27/2014	30.8			
Bennefield #2	6/27/2014	19.5			
Bennefield #3	6/27/2014	20.05			

Appendix III: Union County Well Cuttings 2014

Hopkinson #1 Fee (34-32N-31E, TD: 300', irrigation well)

0-35' No samples.

35-45' Loose gravel. Includes basalt, micrite?, red fine sandstone, gold medium sandstone. Some loose quartz sand, medium to very coarse grained, subrounded, poorly sorted. [90% gravel, 10% sand]

45-48' Ditto 35-45'.

48-51' Ditto 35-45, with higher proportion of red fine sandstone.

51-55' Loose sand and granules. Sand is medium to very coarse, subrounded, poorly sorted. Both granules and sand include quartz, basalt, pale orange fine sandstone, red siltstone. Reddish brown siltstone, +HCl. [70% loose material, 30% siltstone]

55-61.5' Ditto 51-55', dominantly reddish brown siltstone, ~HCl. [85% siltstone, 15% loose material]

61.5-67.5' Reddish brown mudstone with micrite granules, +HCl. [100% mudstone]

67.5-75.5' Reddish brown mudstone, some micrite granules, moderately well cemented, ++HCl. [100% mudstone]

75.5-79' Reddish brown mudstone with abundant micrite granules, +HCl. [100% mudstone]

79-86' Reddish brown mudstone, moderately well cemented, +HCl. [100% mudstone]

86-93.5' Reddish brown mudstone, moderately to well cemented, some micrite granules, rare pale green calcrete nodules, +HCl. [100% mudstone]

93.5-100' Reddish brown mudstone with micrite granules, ~HCl. [100% mudstone]

100-107' Reddish brown mudstone with large micrite granules, +HCl. [100% mudstone]

107-110' Reddish brown mudstone, +HCl. Orange-red silty mudstone, ~HCl. [60% brown, 40% orange]

110-113' Ditto 107-110'. [80% brown, 20% orange]

113-118' Purplish brown mudstone with pale red mottling and streaking, ~HCl. [100% mudstone]

118-124' Pale green muddy claystone, ++HCl. Brown mudstone, +HCl. [80% green, 20% brown]

124-130' Reddish brown mudstone with rare pale green nodules, +HCl. [100% mudstone]

130-137' Reddish brown claystone with rare pale green mottles, +HCl. [100% claystone]

137-142' Reddish brown mudstone, pale green mottles and streaks, + HCl. [100% mudstone]

142-148' Reddish brown mudstone, some micrite granules, +HCl. [100% mudstone]

148-154' Reddish brown mudstone, common micrite granules, ++HCl. [100% mudstone]

154-160' Reddish brown mudstone, +HCl. [100% mudstone]

160-163' Reddish brown mudstone, common micrite granules, +HCl. [100% mudstone]

163-168' Reddish brown mudstone, some micrite granules, +HCl. [100% mudstone]

168-175' Reddish brown mudstone, abundant micrite granules, +HCl. [100% mudstone]

175-185' Reddish brown mudstone, common micrite granules, +HCl. [100% mudstone]

185-300’ No samples

Gregg Oil Co. #1 Harris (35-31N-36E, TD: 3639’)

0-10’ Loose gravel. Includes calcrete, very pale red siltstone, micrite granules. [100% loose material]
10-20’ Pale gray siltstone to fine sandstone, +HCl. [100% siltstone]
20-30’ Pale gray siltstone, abundant loose silt and mud powder, +HCl. [100% siltstone]
30-40’ Pale gray silty mudstone, +HCl. [100% mudstone]
40-50’ Pale green and reddish brown mottled mudstone, +HCl. [100% mudstone]
50-60’ Pale red and pale green mottled mudstone, +HCl. [100% mudstone]
60-70’ Pale reddish brown and pale green mottled mudstone, +HCl. [100% mudstone]
70-80’ Ditto 60-70’. [100% mudstone]
80-90’ Ditto 60-70’. [100% mudstone]
90-100’ Ditto 60-70’. [100% mudstone]
100-110’ Ditto 60-70’. [100% mudstone]
110-120’ Ditto 60-70’. [100% mudstone]
120-130’ Ditto 60-70’. [100% mudstone]
130-140’ Pale reddish brown and pale green mottled mudstone, rare micrite granules, +HCl. [100% mudstone]
140-150’ Ditto 60-70’. [100% mudstone]
150-160’ Pale reddish brown siltstone with some green mottling, ~HCl. [100% siltstone]
160-170’ Pale reddish brown mudstone, well cemented, +HCl. [100% mudstone]
170-180’ Orange-brown mudstone, moderately well cemented, ~HCl. [100% mudstone]
180-190’ Ditto 160-170’. [100% mudstone]
190-200’ Ditto 60-70’. [100% mudstone]
200-210’ Pale reddish brown and pale green mottled mudstone, rare micrite granules, +HCl. [100% mudstone]
210-220’ Reddish brown mudstone, micaceous, ripple laminated, -HCl. [100% mudstone]
220-230’ Reddish brown mudstone, +HCl. Pale green siltstone, -HCl. [85% mudstone, 15% siltstone]
230-240’ Orange-brown mudstone, -HCl. [100% mudstone]
240-250’ Ditto 230-240’. [100% mudstone]
250-260’ Reddish brown mudstone with some green mottles, -HCl. [100% mudstone]
260-270’ Reddish brown and pale green mottled mudstone, -HCl. [100% mudstone]
270-280’ Reddish brown mudstone, -HCl. [100% mudstone]
280-290’ Reddish brown mudstone, -HCl. Pale green siltstone, -HCl. [60% mudstone, 40% siltstone]
290-300’ Reddish brown and olive green mottled mudstone, -HCl. Very pale green siltstone, +HCl. [85% mudstone, 15% siltstone]

Harvest Queen M&E Co. #1-B Everett Like (30-32N-34E, TD: 1000')

0-20' No samples.
20-40' Pale red mudstone with rare pale green mottles, +HCl. [100% mudstone]
40-60' Pale red mudstone with pale green mottles, some micrite nodules, +HCl. [100% mudstone]
60-70' Pale red mudstone with pale green mottles, +HCl. [100% mudstone]
70-80' Pale red mudstone, rare calcrete nodules, +HCl. [100% mudstone]
80-90' Pale red mudstone, some pale green mottles, -HCl. Pale green siltstone, +HCl. [90% mudstone, 10% siltstone]
90-100' Reddish brown mudstone, minor green mottling, +HCl. [100% mudstone]
100-110' Reddish brown siltstone, +HCl. [100% siltstone]
110-120' Reddish brown mudstone, rare cylindrical burrows, +HCl. [100% mudstone]
120-130' Reddish brown mudstone, +HCl. [100% mudstone]
130-140' Reddish brown siltstone, +HCl. [100% mudstone]
140-150' Reddish brown mudstone, -HCl. Pale green siltstone, +HCl. [90% mudstone, 10% siltstone]
150-160' Reddish brown mudstone, -HCl. [100% mudstone]
160-170' Reddish brown mudstone as well rounded little grains (overwashed?), -HCl. [100% mudstone]
170-180' No samples.
180-190' Reddish brown mudstone as well rounded little grains, +HCl. [100% mudstone]
190-200' Reddish brown mudstone with some pale green mottles, as well rounded little grains, +HCl. [100% mudstone]
200-210' Reddish brown mudstone with rare green mottles, -HCl. [100% mudstone]
210-220' Reddish brown mudstone with green mottles, +HCl. Orange-red siltstone, +HCl. [80% mudstone, 20% siltstone]
220-230' Ditto 210-220'. [85% mudstone, 15% siltstone]
230-240' Ditto 210-220'. [85% mudstone, 15% siltstone]
240-250' Pale reddish brown siltstone with rare green mottles, +HCl. [100% siltstone]
250-260' Ditto 240-250'. [100% siltstone]
260-270' Pale reddish mudstone with rare green mottles, +HCl. [100% mudstone]
270-280' Pale reddish brown siltstone with rare green mottles, -HCl. [100% siltstone]
280-290' Pale red mudstone, +HCl. [100% mudstone]
290-300' Pale red mudstone, +HCl. [100% mudstone]

Harvest Queen Co. #1 Everett Like (26-32N-34E, TD: 1220')

0-60' No samples.
60-65' Reddish brown mudstone, poorly cemented, some green calcrete nodules, +HCl. [100% mudstone]
65-70' No samples

70-75’ Ditto 60-65’. [100% mudstone]
75-80’ No samples.
80-85’ Very pale red nodular mudstone, bioturbated?, +HCl. [100% mudstone]
85-90’ No samples.
90-95’ Very pale red mudstone, somewhat nodular/bioturbated, poorly cemented, +HCl. [100% mudstone]
95-100’ No samples
100-105’ Pale red mudstone with rare very small pale green mottles, poorly cemented, +HCl. [100% mudstone]
105-110’ No samples.
110-115’ Ditto 100-105’. [100% mudstone]
115-120’ No samples.
120-125’ Pale reddish brown mudstone with rare green mottles, +HCl. Pale green siltstone, +HCl. [90% mudstone, 10% siltstone]
125-130’ No samples.
130-135’ Pale reddish brown mudstone, ~HCl. [100% mudstone]
135-140’ No samples.
140-145’ Pale reddish brown to brownish red siltstone, rare green mottles, +HCl. [100% siltstone]
145-150’ No samples.
150-155’ Ditto 140-145’. [100% siltstone]
155-160’ No samples.
160-165’ Reddish brown mudstone with rare green mottles, +HCl. [100% mudstone]
165-170’ No samples.
170-175’ Very pale red siltstone with very small calcrete nodules, +HCl. [100% siltstone]
175-180’ No samples.
180-185’ Reddish brown mudstone, poorly cemented, +HCl. [100% mudstone]
185-190’ No samples.
190-195’ Reddish brown siltstone, ~HCl. [100% siltstone]
195-200’ No samples.
200-205’ Reddish brown siltstone, rarely micaceous, +HCl. White to pale light brown siltstone (very crystalline), +HCl. [85% reddish brown, 15% white]
205-210’ No samples.
210-215’ Reddish brown siltstone, +HCl. [100% siltstone]
215-220’ No samples.
220-225’ Ditto 210-215’. [100% siltstone]
225-230’ No samples.
230-235’ Reddish brown siltstone, ~HCl. [100% siltstone]
235-240’ No samples.
240-245’ Reddish brown mudstone, ~HCl. [100% mudstone]

245-250’ No samples.
250-255’ Reddish brown siltstone, -HCl. [100% siltstone]
255-260’ No samples.
260-265’ Reddish brown siltstone, rarely micaceous, +HCl. [100% siltstone]
265-270’ No samples.
270-275’ Pale reddish brown siltstone with minor very pale red mottling, +HCl. [100% siltstone]
275-280’ No samples.
280-285’ Purplish brown mudstone, well cemented, +HCl. [100% mudstone]
285-290’ No samples.
290-295’ Reddish brown mudstone, +HCl. [100% mudstone]
295-300’ No samples. 3

Bubble Valley – Hopkinson #1 (34-32N-31E, TD: 302’)

0-6’ Very pale reddish brown to very pale red siltstone, micaceous, -HCl. Reddish brown mudstone, ~HCl. [70% siltstone, 30% mudstone]
6-16’ Pale brown mudstone with abundant micrite granules, very pale red to pale green mottling, +HCl. [100% granular mudstone]
16-19’ Pale brown mudstone with common micrite granules, very pale green mottling, +HCl. [100% mudstone]
19-22’ Pale brown siltstone with pale reddish white mottles, micaceous, rare micrite granules, +HCl. [100% siltstone]
22-25’ Reddish brown siltstone with pale reddish white to pale green mottles, micaceous, +HCl. Dark brown claystone, -HCl. [90% siltstone, 10% claystone]
25-28’ Pale red siltstone with very pale red mottles, micaceous, +HCl. [100% siltstone]
28-31’ Reddish brown siltstone with common micrite granules to pebbles, pale green mottles, +HCl. [100% siltstone]
31-34’ Ditto 28-31’. [100% siltstone]
34-38’ Ditto 28-31’. [100% siltstone]
38-43’ Pale reddish brown siltstone, micaceous, ripple laminated, ++HCl. [100% siltstone]
43-48’ Ditto 38-43’. [100% siltstone]
48-53’ Pale reddish brown siltstone, micaceous, locally very well cemented (almost crystalline), +HCl. Reddish brown mudstone, ~HCl. [85% siltstone, 15% mudstone]
53-58’ Reddish brown siltstone, micaceous, +HCl. Brown mudstone, -HCl. [80% siltstone, 20% mudstone]
58-63’ Reddish brown siltstone, micaceous, ripple laminated, +HCl. Brown mudstone, rare green mottles, micaceous, -HCl. [80% siltstone, 20% mudstone]
63-68’ Ditto 58-63’. [60% siltstone, 40% mudstone]
68-73’ Reddish brown siltstone, micaceous, +HCl. Brown mudstone, -HCl. [90% siltstone, 10% mudstone]

73-76’ Ditto 58-63’. [75% siltstone, 25% mudstone]
76-80’ Reddish brown mudstone, ~HCl. [100% mudstone]
80-83’ Reddish brown mudstone, some very pale green mottling, some micrite granules, locally brecciated texture, +HCl. [100% mudstone]
83-88’ Ditto 80-83’. [100% mudstone]
88-91’ Ditto 80-83’. [100% mudstone]
91-95’ Reddish brown mudstone, rare very pale green mottling, +HCl. [100% mudstone]
95-100’ Reddish brown mudstone, some pale green mottling, +HCl. [100% mudstone]
100-105’ Reddish brown mudstone, +HCl. [100% mudstone]
105-110’ Reddish brown mudstone, rare micrite granules, rare very pale red mottles, +HCl. [100% mudstone]
110-120’ Reddish brown siltstone, +HCl. Brown mudstone, -HCl. [80% siltstone, 20% mudstone]
120-122’ Reddish brown siltstone, micaceous, -HCl. [100% siltstone]
122-124’ Pale reddish brown siltstone, +HCl. Brown siltstone, very well cemented, micaceous, ~HCl. [50% reddish brown, 50% brown]
124-128’ No samples.
128-135’ Reddish brown and pale green mottled mudstone, -HCl. [100% mudstone]
135-139’ Reddish brown siltstone, +HCl. Very pale green siltstone, very well cemented, +HCl. [60% reddish brown, 40% green]
139-153’ Reddish brown mudstone with large pale green mottles, +HCl. [100% mudstone]
153-156’ Reddish brown mudstone, mottling occurs as patches of pale green speckling, +HCl. [100% mudstone]
156-160’ Reddish brown and very pale green mottled mudstone, +HCl. [100% mudstone]
160-165’ Reddish brown mudstone with pale green mottles and patches of green speckling, +HCl. [100% mudstone]
165-175’ Reddish brown mudstone with very pale green mottling, some micrite granules, +HCl. [100% mudstone]
175-185’ Dark reddish brown mudstone, some pale green mottling, rare micrite granules, +HCl. [100% mudstone]
185-191’ Reddish brown and pale green mottled mudstone, +HCl. [100% mudstone]
191-196’ Ditto 185-191’. [100% mudstone]
196-201’ Pale red siltstone with some pale green mottling, +HCl. [100% siltstone]
201-206’ Very pale red siltstone with reddish white mottling, very well cemented, +HCl. [100% siltstone]
206-210’ Pale red siltstone, some pale green mottling, very well cemented, +HCl. [100% siltstone]
210-214’ Reddish brown siltstone with some pale green mottling, micaceous, well cemented, +HCl. [100% siltstone]
214-220’ Pale red siltstone, micaceous, +HCl. [100% siltstone]

220-224’ Reddish brown and pale green mottled mudstone, +HCl. [100% mudstone]
224-230’ Very pale red quartz arenite, very fine grained, subrounded, 98% Q, 2% muscovite, >15% clay matrix, hematite cement, +HCl. Brown mudstone, +HCl. [80% sandstone, 20% mudstone]
230-236.5’ Ditto 224-230’, some micrite granules. [50% sandstone, 50% mudstone]
236.5-240’ Very pale red quartz arenite, very fine grained, subrounded, 98% Q, 2% muscovite, >15% clay matrix, hematite cement, +HCl. [100% sandstone]
240-244’ White siltstone, -HCl. Reddish brown mudstone, -HCl. [80% siltstone, 20% mudstone]
244-251’ Pale purple claystone, -HCl. [100% claystone]
251-261’ Pale purple claystone, some pale green mottles, -HCl. [100% claystone]
261-272’ Ditto 244-251’. [100% claystone]
272-275’ Pale purple claystone, -HCl. Purplish brown and very pale green mudstone, well cemented, -HCl. [70% claystone, 30% mudstone]
275-280’ Pale purple to bluish purple and very pale purple mottled mudstone, -HCl. [100% mudstone]
280-286’ Pale purple siltstone, some very pale purple mottling, -HCl. [100% siltstone]
286-290’ Pale purple and very pale green siltstone, -HCl. [100% siltstone]
290-299’ Pale purple and very pale green siltstone, -HCl. Pale purple mudstone, -HCl. [80% mudstone, 20% siltstone]
299-302’ Very pale purple mudstone, very well cemented, locally some micrite granules, -HCl. [100% mudstone]

Sierra Grande Rogers #1 (4-29N-29E, TD: 2800’)

[Very little sample in each bag, overwashed – probably missing portion of the fine fraction]
0-180’ No samples.
180-190’ Pale green siltstone, rare micrite granules, -HCl. [100% siltstone]
190-200’ Very pale green quartz wacke, fine grained, subrounded, well sorted, 95% Q, 5% L (incl. black opaques, green clay rip-ups?), >15% clay matrix, includes kaolinite stars locally, +HCl. [100% sandstone]
200-210’ Pale green siltstone, locally very well cemented, -HCl. [100% siltstone]
210-220’ Pale green siltstone, some micrite granules, -HCl. [100% siltstone]
220-230’ White quartz wacke (mostly as loose grains), fine to medium grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, locally includes kaolinite stars, +HCl. [100% sandstone]
230-240’ Pale green siltstone, locally very well cemented, ~HCl. Reddish brown mudstone, -HCl. [90% siltstone, 10% mudstone]
240-250’ Ditto 230-240’. [60% siltstone, 40% mudstone]

250-260’ Pale green siltstone, locally very well cemented, ~HCl. Reddish brown mudstone, -HCl. Loose sand, fine to medium grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?). One pebble of pale green siltstone with silt-sized *pyrite* crystals. [60% sand, 35% siltstone, 5% mudstone]

260-270’ Pale green siltstone, locally very well cemented, -HCl. [100% siltstone]

270-280’ Medium gray siltstone to fine quartz wacke, fine grained, subrounded, well sorted, 100% Q, >15% clay matrix, includes kaolinite stars, -HCl. [100% silt-fine sandstone]

280-290’ Very pale green and very pale red siltstone, very well cemented, -HCl. [100% siltstone]

290-300’ Ditto 280-290’. [100% siltstone]

300-310’ White quartz wacke, fine to medium grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, locally includes kaolinite stars, +HCl. Pale green mudstone, +HCl. [90% sandstone, 10% mudstone]

310-320’ White quartz wacke (mostly as loose grains), fine to medium grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, locally includes kaolinite stars, -HCl. [100% sandstone]

320-330’ White quartz wacke (partly as loose grains), fine to coarse grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, locally includes kaolinite stars, -HCl. Pale green mudstone, +HCl. [90% sandstone, 10% mudstone]

330-340’ White quartz wacke (mostly loose grains), fine to coarse grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, locally includes kaolinite stars, -HCl. [100% sandstone]

340-350’ White quartz wacke (mostly loose grains), fine to coarse grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, locally includes kaolinite stars, -HCl. Pale green mudstone, +HCl. [90% sandstone, 10% mudstone]

350-360’ White quartz wacke (mostly loose grains), fine to coarse grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, locally includes kaolinite stars, -HCl. [100% sandstone]

360-370’ Very pale gray siltstone, well cemented, -HCl. [100% siltstone]

370-380’ Very pale gray siltstone (mostly loose grains), -HCl. [100% siltstone]

380-390’ Very pale green siltstone (some loose grains), -HCl. [100% siltstone]

390-400’ Very pale green siltstone, -HCl. [100% siltstone]

400-410’ Very pale gray siltstone, -HCl. [100% siltstone]

410-420’ White siltstone, very well cemented, -HCl. [100% siltstone]
420-430’ Pale gray claystone, -HCl. (Only one item in sample bag.) [100% claystone]
430-440’ Pale green mudstone, +HCl. [100% mudstone]
440-450’ Pale green mudstone, very well cemented, +HCl. [100% mudstone]
450-460’ Ditto 440-450’. [100% mudstone]
460-470’ No samples.
470-480’ Pale gray mudstone, well cemented, +HCl. [100% mudstone]
480-490’ Pale gray siltstone, very well cemented, -HCl. [100% siltstone]
490-500’ Ditto 480-490’. [100% siltstone]
500-510’ Ditto 480-490’. [100% siltstone]
510-520’ Pale green and pale brown siltstone, well cemented, -HCl. White siltstone, mostly as loose grains, -HCl. [95% green and brown, 5% white]
520-530’ Pale reddish brown siltstone, -HCl. Olive green mudstone, +HCl. [60% siltstone, 40% mudstone]
530-540’ Olive green siltstone, -HCl. White siltstone, +HCl. [75% green, 25% white]
540-550’ No sample in bag.
550-560’ Pale gray siltstone, +HCl. [100% siltstone]
560-570’ Very pale red mudstone, +HCl. White siltstone, +HCl. [70% mudstone, 30% siltstone]
570-580’ White quartz wacke (mostly as loose grains), fine grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, locally includes kaolinite stars, -HCl. [100% sandstone]
580-590’ Pale yellow quartz sand, medium grained, subrounded, very well sorted, 100% quartz, one fragment includes clay matrix and kaolinite stars, +HCl. [100% sandstone] ←Je?
590-600’ Ditto 580-590’. [100% sandstone]
600-610’ Ditto 580-590’. [100% sandstone]
610-620’ No sample in bag.
620-630’ Pale reddish brown siltstone, +HCl. [100% siltstone]
630-640’ Ditto 620-630’. [100% siltstone]
640-650’ Ditto 620-630’. [100% siltstone]
650-660’ Pale red mudstone, +HCl. [100% mudstone]
660-670’ Ditto 620-630’. [100% siltstone]
670-680’ Pale red siltstone, +HCl. Pale green mudstone, -HCl. [90% siltstone, 10% mudstone]
680-690’ Medium gray claystone, +HCl. [100% claystone]
690-700’ Pale gray siltstone, +HCl. [100% siltstone]

Texaco Inc. #1 J.M. Bennett (27-30N-29E, TD: 2868’)
0-100’ No samples.
100-110’ Medium gray mudstone, -HCl. [100% mudstone]
110-120’ Ditto 100-110’. [100% mudstone]

120-130’ Ditto 100-110’. [100% mudstone]
130-140’ Ditto 100-110’. [100% mudstone]
140-150’ Ditto 100-110’. [100% mudstone]
150-160’ Ditto 100-110’. [100% mudstone]
160-170’ Ditto 100-110’. [100% mudstone]
170-180’ Ditto 100-110’. [100% mudstone]
180-190’ Ditto 100-110’. [100% mudstone]
190-200’ No samples.
200-210’ Reddish brown mudstone, ~HCl. [100% mudstone]
210-220’ Pale reddish brown siltstone, -HCl. [100% siltstone]
220-230’ Reddish brown siltstone, -HCl. Pale green mudstone, -HCl. [70% mudstone, 30% siltstone]
230-240’ Pale green mudstone with reddish brown mottles, ~HCl. [100% mudstone]
240-250’ Reddish brown and pale green mottled mudstone, -HCl. [100% mudstone]
250-260’ Ditto 240-250’. [100% mudstone]
260-270’ Dark reddish brown and very pale green claystone, -HCl. [100% claystone]
270-280’ Ditto 260-270’. [100% claystone]
280-290’ Reddish brown and pale green mottled mudstone, -HCl. [100% mudstone]
290-300’ Ditto 280-290’. [100% mudstone]
300-310’ Dark reddish brown and very pale green claystone, -HCl. White quartz wacke, fine grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, -HCl. [50% claystone, 50% sandstone]
310-320’ Dark reddish brown and pale green mudstone, -HCl. [100% mudstone]
320-330’ Very pale green claystone, -HCl. [100% claystone]
330-340’ No samples.
340-350’ Greenish gray claystone, -HCl. [100% claystone]
350-360’ Pale green siltstone with dark reddish brown mottles, -HCl. [100% siltstone]
360-370’ Pale green siltstone, well cemented, +HCl. [100% siltstone]
370-380’ Pale green siltstone, well cemented, ++HCl. [100% siltstone]
380-390’ Greenish gray mudstone, +HCl. [100% mudstone]
390-400’ Reddish gray to medium gray mudstone, +HCl. [100% mudstone]
400-410’ Pale greenish gray mudstone, +HCl. [100% mudstone]
410-420’ Medium gray mudstone, +HCl. [100% mudstone]
420-430’ Reddish gray siltstone, ~HCl. [100% siltstone]
430-440’ Reddish gray siltstone, ~HCl. Greenish gray claystone, -HCl. [70% siltstone, 30% claystone]
440-450’ Greenish gray claystone, +HCl. [100% claystone]
450-460’ Reddish brown mudstone, ~HCl. [100% mudstone]

460-470’ Pale greenish gray siltstone, -HCl. Reddish brown mudstone, ~HCl. [80% siltstone, 20% mudstone]

470-480’ Dark reddish brown and very pale green claystone, -HCl. White quartz wacke, very fine to fine grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, +HCl. [60% claystone, 40% sandstone]

480-490’ No samples.

490-500’ Dark reddish brown and very pale green siltstone, -HCl. White quartz wacke, very fine to fine grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, +HCl. [60% siltstone, 40% sandstone]

500-510’ Dark reddish brown and very pale green claystone, -HCl. White quartz wacke, very fine to fine grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, kaolinite stars locally, +HCl. [80% siltstone, 20% sandstone]

510-520’ Ditto 500-510’. [60% siltstone, 40% sandstone]

520-530’ Pale green siltstone, -HCl. Pale red to white quartz wacke, very fine to fine grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, kaolinite stars locally, +HCl. [90% sandstone, 10% siltstone]

530-540’ Reddish brown mudstone, well cemented, +HCl. Pale red to white quartz wacke, very fine to fine grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, kaolinite stars locally, +HCl. [80% mudstone, 20% sandstone]

540-550’ Reddish brown mudstone, well cemented, micaceous, some pale green mottles, -HCl. Pale red to white quartz wacke, very fine to fine grained, subrounded to subangular, moderately well sorted, 95% Q, 5% L (incl. micrite granules, green clay-rip ups, red chert?), >15% clay matrix, kaolinite stars locally, +HCl. [90% mudstone, 10% sandstone]

550-560’ Reddish brown mudstone, well cemented, micaceous, some pale green mottles, +HCl. [100% mudstone]

560-570’ Ditto 550-560’. [100% mudstone]

570-580’ Ditto 550-560’. [100% mudstone]

580-590’ Ditto 550-560’. [100% mudstone]

590-600’ Ditto 550-560’. [100% mudstone]

600-610’ Reddish brown mudstone, well cemented, micaceous, some pale green mottles, +HCl. Medium gray micrite granule conglomerate, well cemented, -HCl. [70% conglomerate, 30% mudstone]

610-620’ Reddish brown and pale green siltstone, ~HCl. [100% siltstone]

620-630’ Reddish brown and pale green mudstone, +HCl. [100% mudstone]

630-640’ Reddish brown and pale green siltstone, well cemented, micaceous, +HCl. Medium gray micrite granule conglomerate, well cemented, -HCl. [90% siltstone, 10% conglomerate]

640-650’ Reddish brown and pale green siltstone, well cemented, micaceous, +HCl. [100% siltstone]

650-660’ Ditto 640-650’. [100% siltstone]

660-670’ Ditto 640-650’. [100% siltstone]

670-680’ Reddish brown and pale green siltstone, well cemented, micaceous, +HCl. White quartz arenite, very fine to fine grained, subrounded, well sorted, 95% Q, 5% L (incl. muscovite, green clay-rip ups), <15% clay matrix, +HCl. [80% sandstone, 20% siltstone]

680-690’ Reddish brown and pale green siltstone, well cemented, micaceous, +HCl. [100% siltstone]

690-700’ Ditto 680-690’. [100% siltstone]

Knight and Stockley – Schmitt #1 (04-29N-29E, TD: 2800’)

0-10’ White calcrete with variable texture, ++HCl. Very pale yellowish green quartz wacke, very fine to fine grained, subrounded, moderately well sorted, 100% Q, >15% matrix (locally very abundant), +HCl. [70% calcrete, 30% sandstone]

10-20’ Pale gray siltstone, well cemented, organic material locally, -HCl. Very pale orange to brownish orange quartz wacke, silt to fine grained, subrounded, well sorted, 100% Q, >15% matrix, hematite coatings, -HCl. [60% siltstone, 40% sandstone]

20-30’ Ditto 10-20’. [60% siltstone, 40% sandstone]

30-40’ Ditto 10-20’. [70% siltstone, 30% sandstone]

40-50’ Ditto 10-20’. [80% siltstone, 20% sandstone]

50-60’ Black shale, -HCl. Gray siltstone, very well cemented, -HCl. Grayish red to white to yellowish orange quartz wacke/arenite, fine grained, subrounded to subangular, well sorted, 100% Q, about 15% matrix, abundant hematite and manganese locally, -HCl. [50% sandstone, 40% black shale, 10% siltstone]

60-70’ Gray siltstone, very well cemented, -HCl. Grayish red to white to yellowish orange quartz wacke/arenite, fine grained, subrounded to subangular, well sorted, 100% Q, about 15% matrix, abundant hematite and manganese locally, -HCl. [50% sandstone, 50% siltstone]

70-80’ Gray mudstone, well cemented, -HCl. Grayish red to white to yellowish orange quartz wacke/arenite (primarily as loose sand), fine grained, subrounded to subangular, well sorted, 100% Q, about 15% matrix, abundant hematite and manganese locally, -HCl. [90% sandstone, 10% mudstone]

80-90’ Grayish red to white to yellowish orange quartz wacke/arenite (primarily as loose sand), fine grained, subrounded to subangular, well sorted, 100% Q, about 15% matrix, abundant hematite and manganese locally, -HCl. [100% sandstone]

90-100’ Ditto 80-90’. [100% sand]
100-110’ Ditto 80-90’. [100% sand]
110-120’ Black to brownish black shale, -HCl. Grayish red to white to yellowish orange quartz wacke/arenite (primarily as loose sand), fine grained, subrounded to subangular, well sorted, 100% Q, about 15% matrix, abundant hematite and manganese locally, -HCl. [60% shale, 40% sand]
120-130’ Medium gray shale, -HCl. [100% shale]
130-140’ Medium gray mudstone, -HCl. Grayish red to white to yellowish orange quartz wacke/arenite (primarily as loose sand), fine grained, subrounded to subangular, well sorted, 100% Q, about 15% matrix, abundant hematite and manganese locally, -HCl. [85% shale, 15% sand]
140-150’ Pale yellowish green mudstone, -HCl. Pale red and locally very dark gray quartz wacke/arenite (mostly as loose sand), fine grained, subrounded to subangular, well sorted, 100% Q, about 15% matrix, abundant hematite and manganese locally, -HCl. [85% sandstone, 15% mudstone]
150-160’ Pale tan quartz arenite/wacke (primarily as loose sand), fine grained, subrounded, well sorted, 100% Q, about 15% matrix, -HCl. [100% sand]
160-170’ Ditto 150-160’. [100% sand]
170-180’ Ditto 150-160’. [100% sand]
180-190’ Ditto 150-160’. [100% sand]
190-200’ Pale tan quartz wacke (primarily as loose sand), fine grained, subrounded, well sorted, 100% Q, > 15% matrix, -HCl. [100% sand]
200-210’ Ditto 150-160’. [100% sand]
210-220’ Ditto 150-160’. [100% sand]
220-230’ White quartz arenite/wacke (primarily as loose sand), fine grained, subrounded, well sorted, 100% Q, about 15% matrix, -HCl. [100% sand]
230-240’ Reddish brown and very pale green mudstone, -HCl. White quartz arenite/wacke (primarily as loose sand), fine grained, subrounded, well sorted, 100% Q, about 15% matrix, -HCl. [90% sand, 10% mudstone]
240-250’ Reddish brown and very pale green siltstone, -HCl. White quartz arenite/wacke (primarily as loose sand), fine grained, subrounded, well sorted, 100% Q, about 15% matrix, -HCl. [60% sand, 40% siltstone]
250-260’ Reddish brown mudstone, -HCl. White siltstone, very well cemented, +HCl. [50% mudstone, 50% siltstone]
260-270’ Very pale green mudstone, -HCl. [100% mudstone]
270-280’ Reddish brown and very pale green mudstone with granules of rip-up clasts, +HCl. [100% granular mudstone]
280-290’ Reddish brown and very pale green mudstone, +HCl. [100% mudstone]
290-300’ Very pale red and pale green siltstone, mottled, -HCl. [100% siltstone]

300-310’ Very pale green mudstone with small mottles of hematite, -HCl. Reddish gray siltstone, -HCl. [90% mudstone, 10% siltstone]

310-320’ Black shale, -HCl. Very pale gray wacke, fine to medium grained, subrounded, moderately sorted, 95% Q, 5% L (includes green clay rip-ups, red chert), >15% clay matrix, -HCl. [85% sandstone, 15% shale]

320-330’ Pale green claystone, -HCl. Very pale gray wacke, fine to medium grained, subrounded, moderately sorted, 95% Q, 5% L (includes green clay rip-ups, red chert), >15% clay matrix, -HCl. [90% sandstone, 10% claystone]

330-340’ Very pale gray wacke (primarily as loose sand), fine to medium grained, subrounded, moderately sorted, 95% Q, 5% L (includes green clay rip-ups, red chert), >15% clay matrix, -HCl. [100% sandstone]

340-350’ Reddish brown mudstone with some green mottling, -HCl. White siltstone, very well cemented, -HCl. [60% mudstone, 40% siltstone]

350-360’ Reddish brown and very pale green mudstone, -HCl. [100% mudstone]

360-370’ Ditto 350-360’. [100% mudstone]

370-380’ Reddish brown mudstone with some green mottling, -HCl. White siltstone, very well cemented, -HCl. Dark gray siltstone, -HCl. [50% white siltstone, 30% mudstone, 20% dark gray siltstone]

380-390’ Very pale red and very pale green claystone, -HCl. [100% claystone]

390-400’ Reddish brown mudstone with some green mottling, -HCl. White siltstone, very well cemented, -HCl. Dark gray siltstone, -HCl. [60% mudstone, 30% white siltstone, 10% dark gray siltstone]

400-410’ Very pale green mudstone with some red mottling, -HCl. White siltstone, very well cemented, -HCl. [85% mudstone, 15% siltstone]

410-420’ Very pale green and reddish gray mudstone, +HCl. White siltstone, very well cemented, -HCl. [90% mudstone, 10% siltstone]

420-430’ Ditto 410-420’. [90% mudstone, 10% siltstone]

430-440’ Greenish gray mudstone, +HCl. [100% mudstone]

440-450’ Gray mudstone, +HCl. Dark gray shale, -HCl. [85% mudstone, 15% shale]

450-460’ Gray to reddish gray mudstone, +HCl. Dark gray shale, -HCl. [90% mudstone, 10% shale]

460-470’ Reddish gray and pale green mudstone, -HCl. Pale gray mudstone, very well cemented, +HCl. [80% reddish gray, 20% pale gray]

470-480’ Pale gray mudstone, well cemented, -HCl. Red jasper granules. [100% mudstone]

480-490’ Greenish gray and reddish brown mudstone, ~HCl. Jasper granules. Bright white anhydrite? Ash? Fibrous and powdery, breaks easily. [85% mudstone, 15% anhydrite?]

490-500’ Medium gray mudstone, well cemented, ~HCl. White calcite? +HCl. [95% mudstone, 5% anhydrite?]

500-510’ Greenish gray and reddish brown mudstone, ~HCl. Bright white anhydrite? Ash? Fibrous and powdery, breaks easily. [85% mudstone, 15% anhydrite?]

510-520’ Gray mudstone, +HCl. White pumice? Clay-like with a few grains scattered through, -HCl. [95% mudstone, 5% ash?]

520-530’ Greenish gray and reddish brown mudstone, ~HCl. White ash? Much harder than other material, -HCl. [95% mudstone, 5% ash?]

530-540’ Greenish gray and reddish brown mudstone, ~HCl. Bright white anhydrite? Ash? Fibrous and powdery, breaks easily. [90% mudstone, 10% anhydrite?]

540-550’ Greenish gray and reddish brown mudstone, ~HCl. Pale tan quartz wacke, fine grained, subrounded, well sorted, 95% Q, 5% L (includes green clay rip-ups), >15% matrix, rare kaolinite stars, some hematite coatings, +HCl. Two large fragments of ash? Very fibrous and brittle. [80% mudstone, 15% sandstone, 5% ash?]

550-560’ Reddish brown and pale green mudstone, +HCl. Brownish orange quartz wacke, fine to medium grained, subrounded, moderately sorted, 90% Q, 10% L (incl. green rip-ups, micrite granules), >15% clay matrix, abundant goethite. [60% mudstone, 40% sandstone]

560-570’ Very pale red quartz wacke (primarily as loose sand), fine grained, subrounded, well sorted, 100% Q, about 15% clay matrix. [100% sand]

570-580’ Very pale green and reddish brown mudstone, -HCl. Gray mud encasing mudstone – surface contamination or unwashed samples? [100% mudstone]

580-590’ Reddish brown and very pale green mudstone, -HCl. Very pale red quartz wacke (primarily as loose sand), fine grained, subrounded, well sorted, 100% Q, about 15% clay matrix. [80% sand, 20% mudstone]

590-600’ Very pale gray siltstone, very well cemented, micaceous (muscovite), +HCl. [100% siltstone]

600-608’ Very pale gray to very pale red siltstone, very well cemented, micaceous, +HCl. [100% siltstone]

608-617’ Very pale greenish gray mudstone, ripple laminated, micaceous, locally includes micrite granules, +HCl. [100% mudstone]

617-620’ No samples.

620-630’ Reddish brown mudstone, ripple laminated, some pale green mottling, micaceous, locally includes micrite granules, +HCl. [100% mudstone]

630-640’ Ditto 620-630’. [100% mudstone]

640-650’ Ditto 620-630’. [100% mudstone]

650-660’ Ditto 620-630’. [100% mudstone]

660-670’ Reddish brown siltstone to very fine sandstone, micaceous, rip-up clasts, locally micrite granules, +HCl. [100% siltstone]

670-680’ Reddish brown siltstone, micaceous, ripple laminated, +HCl. [100% siltstone]

680-690’ Reddish brown mudstone, micaceous, ripple laminated, +HCl. [100% mudstone]

690-700’ Brownish red mudstone, ripple laminated, some pale green mottles, +HCl. [100% mudstone]

Trend Pet. Inc. #1 Brown (29-32N-31E, TD: 3586’)

[Samples very overwashed – not much material in each bag for many of the levels. HCl results and percentages will not be accurate.]

0-5’ No samples in bag.

5-10’ Dark greenish gray mudstone, some micrite granules. [90% mudstone, 10% micrite granules]

10-15’ No samples in bag.

15-20’ Reddish brown siltstone, +HCl. Red jasper fragments. Sparry gypsum. Ash? [80% sandstone, 20% jasper, ash]

20-25’ Reddish brown mudstone, -HCl. [100% mudstone]

25-30’ Reddish brown siltstone, speckled appearance, +HCl. [100% siltstone]

30-42’ No samples.

42-47’ Reddish brown mudstone, -HCl. [100% mudstone]

47-50’ Reddish brown mudstone with pale green mottles, ~HCl. [100% mudstone]

50-55’ Reddish brown mudstone, +HCl. [100% mudstone]

55-60’ Very pale red mudstone with reddish white mottles, -HCl. [100% mudstone]

60-65’ Ditto 55-60’. [100% mudstone]

65-70’ Reddish brown mudstone with pale green mottles, -HCl. [100% mudstone]

70-77’ Reddish brown siltstone with pale green mottles, -HCl. [100% siltstone]

77-80’ Reddish brown mudstone, -HCl. [100% mudstone]

80-85’ Reddish brown mudstone with pale green mottles, ~HCl. [100% mudstone]

85-90’ Reddish purple mudstone, ~HCl. [100% mudstone]

90-95’ Reddish brown mudstone with pale green mottles, micaceous, -HCl. [100% mudstone]

95-100’ Ditto 90-95’. [100% mudstone]

100-105’ Ditto 90-95’, +HCl. [100% mudstone]

105-110’ No samples.

110-115’ Ditto 100-105’. [100% mudstone]

115-120’ Ditto 90-95’. [100% mudstone]

120-125’ Reddish brown mudstone with pale green mottles, ~HCl. [100% mudstone]

125-130’ Ditto 120-125’. [100% mudstone]

130-135’ No samples.

135-140’ Dark gray shale, +HCl. Reddish brown mudstone, +HCl. White siltstone to fine sandstone, hematite stains, +HCl. Micrite granules. [50% shale, 40% mudstone, 10% siltstone]

140-145’ Dark gray shale, +HCl. Reddish brown mudstone, +HCl. Micrite granules. [70% mudstone, 30% shale]

145-150’ Ditto 140-145’. [70% mudstone, 30% shale]
150-155’ Ditto 140-145’. [90% mudstone, 10% shale]
155-160’ Ditto 140-145’. [95% mudstone, 5% shale]
160-165’ Reddish brown mudstone, rare very pale red mottles, +HCl. [100% mudstone]
165-170’ Dark gray shale, +HCl. Reddish brown mudstone, +HCl. [90% mudstone, 10% shale]
170-175’ Reddish brown siltstone with reddish white mottles, +HCl. [100% siltstone]
175-180’ Brown mudstone with abundant micrite granules, +HCl. [100% granular mudstone]
180-185’ Ditto 175-180’. [100% granular mudstone]
185-190’ Brown mudstone with abundant micrite granules, +HCl. Reddish brown mudstone, +HCl. [85% brown, 15% red]
190-195’ Reddish brown mudstone, +HCl. [100% mudstone]
195-200’ Reddish brown mudstone, micaceous, +HCl. [100% mudstone]
200-205’ No samples.
205-210’ Ditto 195-200’. [100% mudstone]
210-215’ Ditto 195-200’. [100% mudstone]
215-220’ Ditto 195-200’. [100% mudstone]
220-230’ Reddish brown mudstone with pale green mottles, micaceous, +HCl. [100% mudstone]
230-235’ Ditto 195-200’. [100% mudstone]
235-240’ No samples.
240-245’ Reddish brown mudstone with reddish white mottles, ~HCl. [100% mudstone]
245-255’ Ditto 240-245’. [100% mudstone]
255-265’ Reddish brown mudstone, +HCl. [100% mudstone]
265-275’ Ditto 255-265’. [100% mudstone]
275-285’ Pale red mudstone, brecciated texture, +HCl. [100% mudstone]
285-295’ Ditto 275-285’. [100% mudstone]
295-305’ Reddish brown mudstone with very small pale green mottles, +HCl. [100% mudstone]