DATE: July 18, 2010

TO: Mr. Victor Gregoire
Kean Miller Hawthorne D'Armond McGowen & Jarman LLP
301 Main St., 22^{nd} floor, One American Place
Baton Rouge, LA 70801

Ms. Shelby Wilson
King & Spalding, LLP
1100 Louisiana, Suite 4000
Houston, TX 77002

FROM: Mary L. Barrett, Ph.D.
639 Stephenson St.
Shreveport, LA 71104

RE: Barrett Supplemental Report, *VPSB v. LL & E et al.,* East White Lake Field, Vermilion Parish, LA; Electric Log Interpretation of the Chico Aquifer, T15S-R1E

Dear Mr. Gregoire and Ms. Wilson,

Below is a summary of my expert opinions to evaluate the accuracy of the Milner 2009 paper relied upon in the recent deposition of CEI vs. the accuracy of the Pisani opinion which has used older work of the 1970s to understand shallow groundwater in the Chico Aquifer below 100'. Although CEI did not provide the Milner paper in its produced documents, I obtained a copy of this report on Friday, July 16, 2010. My opinion also considers the Miller deposition of where he states that groundwater sampled at 460' from the Union water supply well serves as the background for all of these Chico waters.

To evaluate the above reports' description of the shallow groundwater conditions of the Chico below 100', I have completed my own interpretation of electric logs available for T15S-R1E (21 logs, with one other log not legible). Seven of those logs (5 of older vintage, 2 of later vintage) are from section 16, VPSB lands. I downloaded and viewed other nearby wells (listed in the Table) that look very similar, but I did not further evaluate them. I additionally looked at Milner's log interpretation in the East White Lake area and his electric log assumptions concerning resistivity measurements to interpret water chemistry. Attached behind the marked log copies are copies of e-mail letters I have sent to Mr. Milner questioning his interpretation in this specific area. These letters have just been sent this weekend, so I have not received a response from the LA Geological Survey yet.

My interpretations and opinions are based on information available in these logs. All of the logs were produced in my original documents. Table 1 lists the studied shallow logs. The logs' information starts anywhere from 118 ft to about 280 ft below the surface and provide information about the Chico Aquifer in this area. Following this written summary, I have attached copies of the upper parts of the logs where I have "zoned" or divided up the Chico for correlation purposes to about a depth of 800 to 900 ft.

My expert opinions are as follows.

Electric Log Interpretation of the Chico Aquifer, T15S-R1E

1) The SP curve on the left side of the log is limited in its use to determine lithology here. This is because freshwater muds were used to drill the wells, and this does not create enough of an electrical difference with the fresh and brackish sediment for the SP curve to work properly. Therefore, the curves on the right side of the depth column, the resistivity curves, are used to determine both lithology and water chemistry. The deep resistivity (long normal or induction) curve is used to determine water quality, and both resistivity curves and their separation (the shallow and deep resistivity curves) are used to determine lithology. Milner 2009 does not state whether he considered curve separation in his lithology determination.

2) From about 120 ft (the shallowest log available) downward to about 800 ft, the Chico is divided into 3 major zones based on the resistivity patterns. I have drawn and labeled these zones on the attached logs. Only the most shallow well in section 16 (SN 970723, VPSB A-37) which begins at 120 feet has a "shale" (actually clay or mud sediment at this depth, not a shale rock) that goes downward to 140 ft. All the other logs start below this shale.

3) The three zones exist in T15S-R1E, although some logs lose a clear definition between zones 2 and 1. The depths I have given are most specific to section 16, the VPSB land. The zones are as follows, from top to bottom (please refer to marked logs for exact depths in each well):

A. Zone 1—a sand zone which occurs from the general depths of 140 ft to 310 ft. The long-normal (deep) resistivity readings from this zone range from less than 8 up to16 ohm-m. This sand contains brackish water, not freshwater.

B. Zone 2—an interbedded shale and sand zone which occurs from the general depths of 310 ft to usually 480 ft. This zone consists of varying resistivity every few to several feet due to the layering of lithologic types. Usually the resistivity readings are less than 12 ohm-m, but these readings cannot be used to semi-quantify water chemistry due to this zone consisting of thin sand beds and shale. The shale lithology prevents using resistivity for water chemistry calculations without more data.

C. Zone 3—a sand zone which occurs from the general depths of usually 480 ft to around 750 ft, followed downward by a sharp transition into decreasing resistivity readings of 3-4 ohm-m and less. This sand contains freshwater which transitions downward into brackish and then saline waters below the USDW. The lower boundary marked for Zone 3 is based on the defined state-wide lower boundary for a USDW derived from logs, the value of 3 ohm-m or less in sand (not shale). Zone 3 has the highest deep resistivity readings of the three zones. Regionally, only Zone 3 has values that approach or exceed 40 ohm-m, the value Milner (2009) used to delineate freshwater sands. Within T15S-R1E, only 8 of 21 logs in this Zone 3 sand reach a value of 40 ohm-m or greater (SN 102229, 55680, 76494,74913, 55970, 90884, 62923, and 107275). None of the 7 logs from section 16 VPSB lands reach a value of 40 ohm-m in Zone 3. This relative comparison of water resistivity values from the same Zone 3 indicates that water quality varies even within the best part of the Chico aquifer, and the section 16 groundwaters in Zone 3 are not as high quality as other areas (although fresh, see discussion below).

4) Milner (2009) used 40 ohm-m as a log resistivity cutoff value to represent about 1000 ppm TDS, a freshwater. This is too high of a value. To use the deep resistivity curve to semi-quantify water chemistry in sands, the following calculations/assumptions must be made:

A. One must convert the log resistivity readings, a function of the sand and water resistivity, to that of a resistivity value representing water only. This is done by the use of a formation factor (F) in converting the log resistivity reading to the water resistivity value. Milner used the formation factor value of 4 that was published by Turcan (1966) for the these Pleistocene sands of southwestern Louisiana, a good beginning assumption; and

B. One must convert the water resistivity (or its inverse, water conductivity) into a water salinity or total dissolved solids. Here, Milner referenced works and conversions that assumed the water salinity was totally derived from sodium and chloride, more true for deep formation fluids, but not true for shallow groundwaters of Louisiana. Shallow groundwaters have a mixture of ions. The more correct conversion in the published literature for Louisiana shallow groundwater aquifers is Turcan (1966) who established a relationship between water conductivity and measured salinity in Louisiana aquifers. Therefore, Milner's use of 40 ohm-m is not correct as a freshwater baseline for these sands.

5) The Union water supply well, located near the VPSB #A-2 (SN 26749, has shallow log), has freshwater (564 ppm TDS) at its reported screened depth of 460 ft (water supply well information from well file SN 972569). The VPSB A-2 log indicates the reason that the Union water supply well was screened at this depth is because this is Zone 3, the best water quality of the Chico. The section 16 wells of Zone 3 reach deep resistivity log values above 20 ohm-m to near 36 ohm-m.

6) My expert opinion is that the deep resistivity log value of 20 ohm-m should be used as the cutoff for freshwater (approximately 1000 ppm) in these electric logs. Turcan's work on conversion of water quality to conductivity (inverse of resistivity) for Louisiana freshwater aquifers indicate the best water resistivity value to represent the 1000 ppm cutoff is a water resistivity value of about 6 ohm-m. To convert this water resistivity to a log reading requires the use of a formation factor. Turcan (1966) published the value of 4 as the formation factor for the Pleistocene of southwest Louisiana (includes the Chico). This calculates to a deep resistivity log reading of about 24 ohm-m (see my appendix with these formulas and calculations). However, to be even more conservative, I have used a log resistivity cut-off value of 20 ohm-m which corresponds to **a formation factor of 3.3**. Thus, **the number of 20 ohm-m is a more accurate**

deep resistivity log value for the freshwater cutoff value of 1000 ppm TDS, taking in to account what is known from our section 16 logs and the water supply well.

7) Using assumptions above, the Zone 1 sand groundwaters of section 16 have a calculated salinity range from about 1200 ppm to at least 2300 ppm TDS. As stated previously, the deep resistivity reading for the Zone 1 sands range from less than 8 to about 16 ohm-m. The electric log value of 8 ohm-m calculates to a water salinity of 2307 ppm TDS; the electric log value of 16 ohm-m calculates to a water salinity of 1208 ppm TDS. Values less than 8 ohm-m indicate more saline waters.

8) Using assumptions above, the Zone 3 higher-quality sand groundwaters of section 16 have a calculated salinity range of about 550 ppm up to the freshwater cutoff of 1000 ppm TDS. The higher water quality electric log resistivity readings range from 20 ohm-m to 36 ohm-m. As described above, the 20 ohm-m electric log value and a 3.3 formation factor value is used with Turcan's conversion of water resistivity (or water conductivity) to derive the approximate 1000 ppm (calculated 991 ppm) TDS. The high log resistivity value of 36 ohm-m calculates to a salinity of 568 ppm TDS.

9) The Louisiana Geological Society publications used by Pisani agree with my log evaluations in that brackish water sands are above the freshwater sands of the Chico in section 16. Milner's regional work (2009) is incorrect in his mapping of freshwater sands as applied to this area.

References Cited

Milner, L. R., and C. Fisher, 2009, Geological characterization of the Chicot/Atchafalaya aquifer region: Southwest Louisiana; Water Resources Series no. 4, Louisiana Geological Survey.

Turcan, A. N., Jr., 1966, Calculation of water quality from electric logs, theory and practice: Water Resources Pamphlet no. 19, Louisiana Geological Survey and Louisiana Department of Public Works, 23 pp.

Serial number	Well Name	Section
36203	(Humble) Mixon #1	3
90884	(Texaco) Mixon #1	3
55970	(McDermott) Gastenet #1	8
37352	(Humble) Mixon #2	10
24642	(Union) La Furs #A-4	15
26174	(Union) VPSB #A-1	16
26749	(Union) VPSB #A-2	16
27166	(Union) VPSB #A-3	16
27581	(Union) VPSB #A-4	16
28116	(Union) VPSB #A-5	16
970723	(Union) VPSB #A-37	16
971154	(Union) VPSB #A-39	16
23537	(Union) W. White Heirs #1	17
27677	(Union) Vig-Gastinel #1	17
74913	(Shell) Humble Fee #1	18
55680	(Union) La Furs #2	21
22328	(LL&E) La Furs #1	22
76494	(Austral) La Furs #B-1	24
102229	(Exxon) Humble Fee #A-1	27
107275	(Exxon) Humble Fee #A-2	27
47914 *	(Union) La Furs #1	28
62923	(Conoco) La Furs #1	28

*this well log of poor quality, not used

TABLE 1. Listing of shallow electric logs from T15S-R1E that were used in this evaluation. Logs were marked to define Zones 1, 2, 3 in this study and are included in this report. Other logs viewed from the region but not correlated and zoned were: 28681, 29177, 50906, 67061, 71726, 153312.

WELL LOGS

See original log in Barrett produced documents for entire log.

Zones are marked with colored lines and labeled w/depths.

The blue color in the middle column marks the extent of sands which contain freshwater (interpreted as 20 ohm-m or greater, deep resistivity curve)

Calculations of Salinity from Log Readings

Symbols + terms

- R_w is resistivity of water (ohms-m^2/m - log term shortens to "ohm-m")
- R_o is resistivity from log, deep resistivity curve
- FF is formation factor
- C_w is the conductivity of water (umhos/cm)

Formulas

① $R_o / FF = R_w$

② $C_w = 10{,}000 / R_w$

③ $TDS_{ppm} = [C_w]^{0.93}$ Turcan (1966)

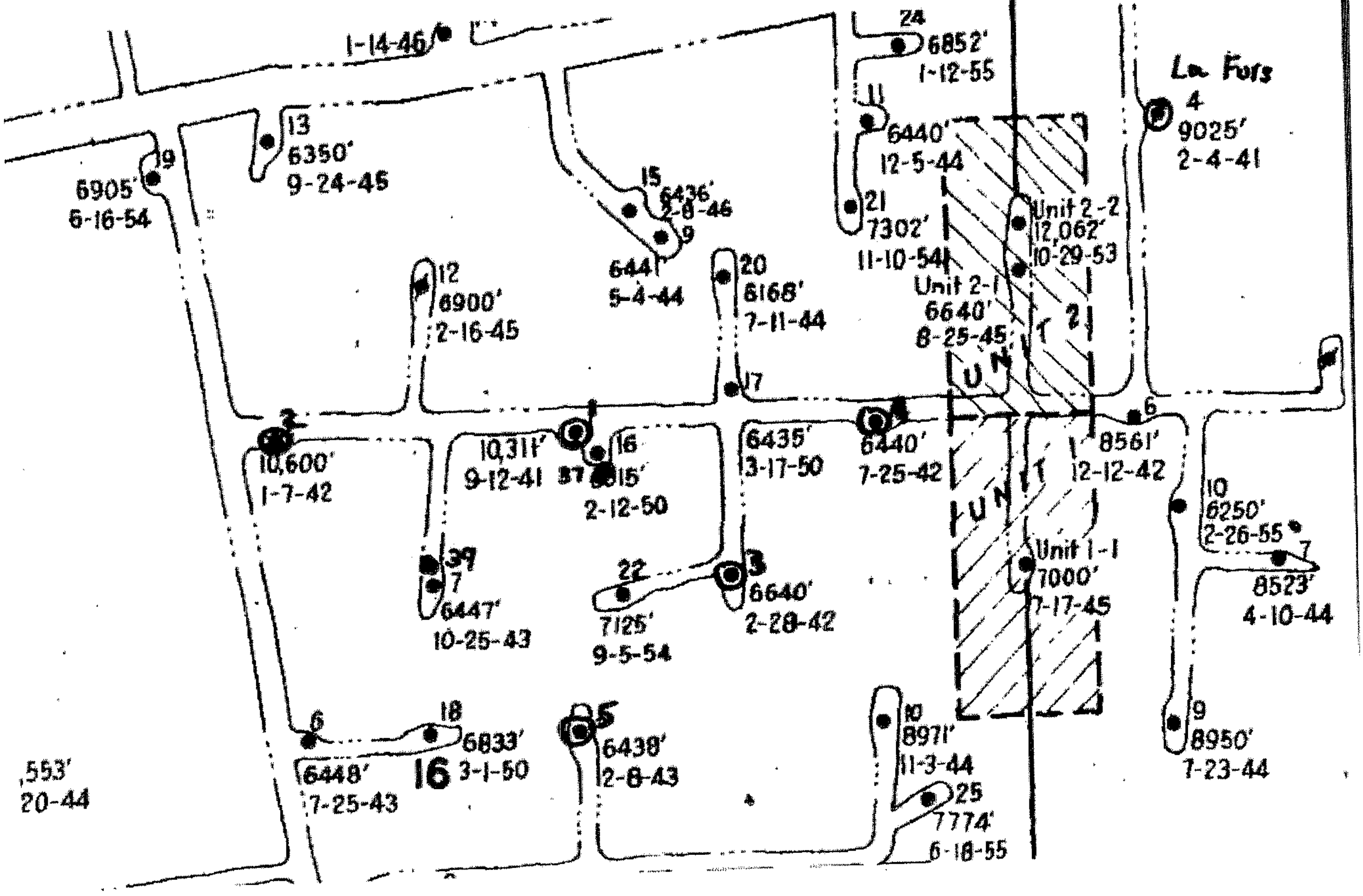
For 1000 ppm TDS cut-off of 20 ohm·m (log reading)

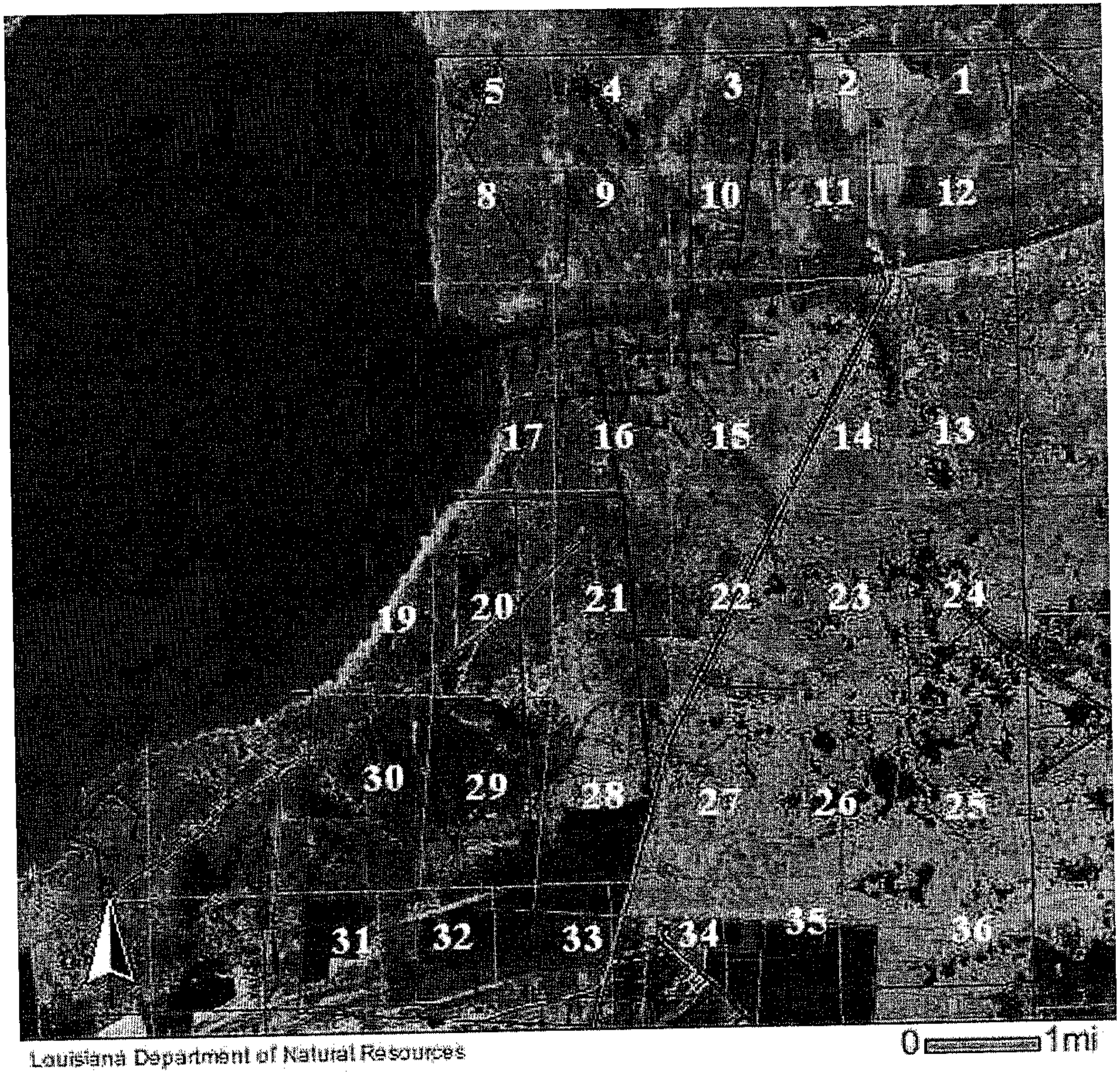
① $20/3.3 = 6.0$

② $10{,}000/6.0 = 1666$

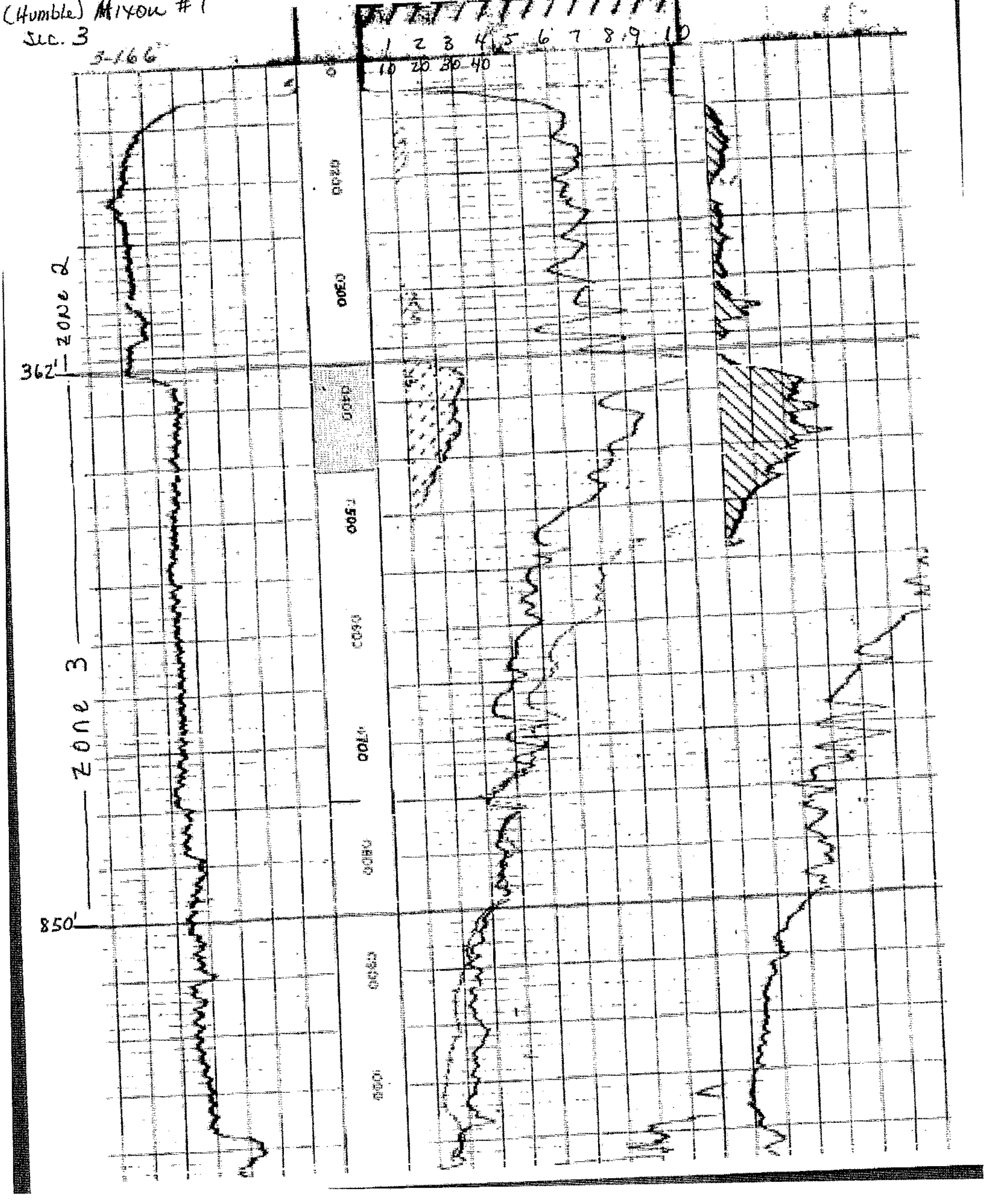
③ $[1666]^{0.93} = 991$ ppm TDS

VPSB shallow logs

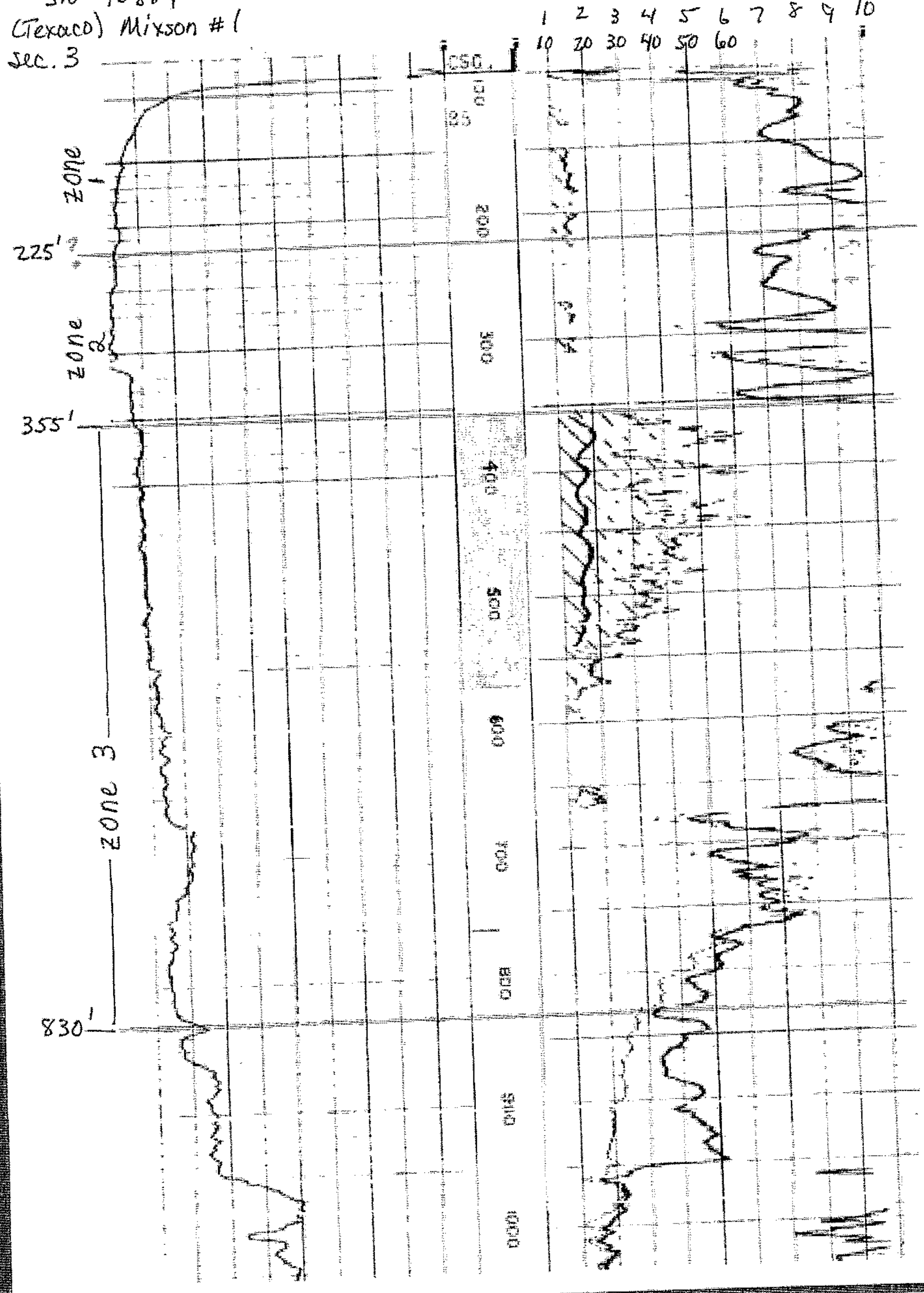



5 4 3 2 1
8 9 10 11 12
17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36
0 1mi
Louisiana Department of Natural Resources

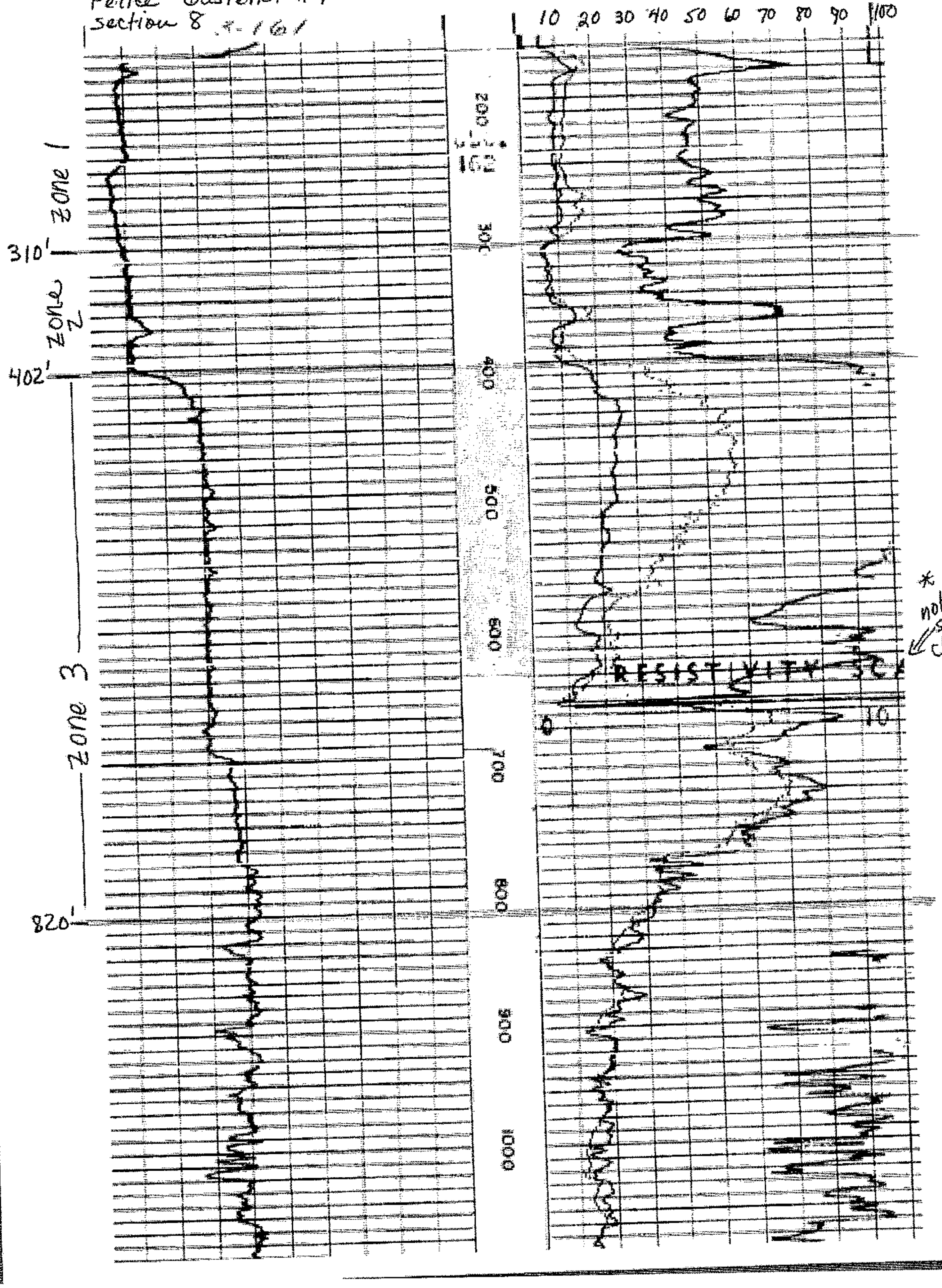
SN 36203
(Humble) Mixon #1
Sec. 3



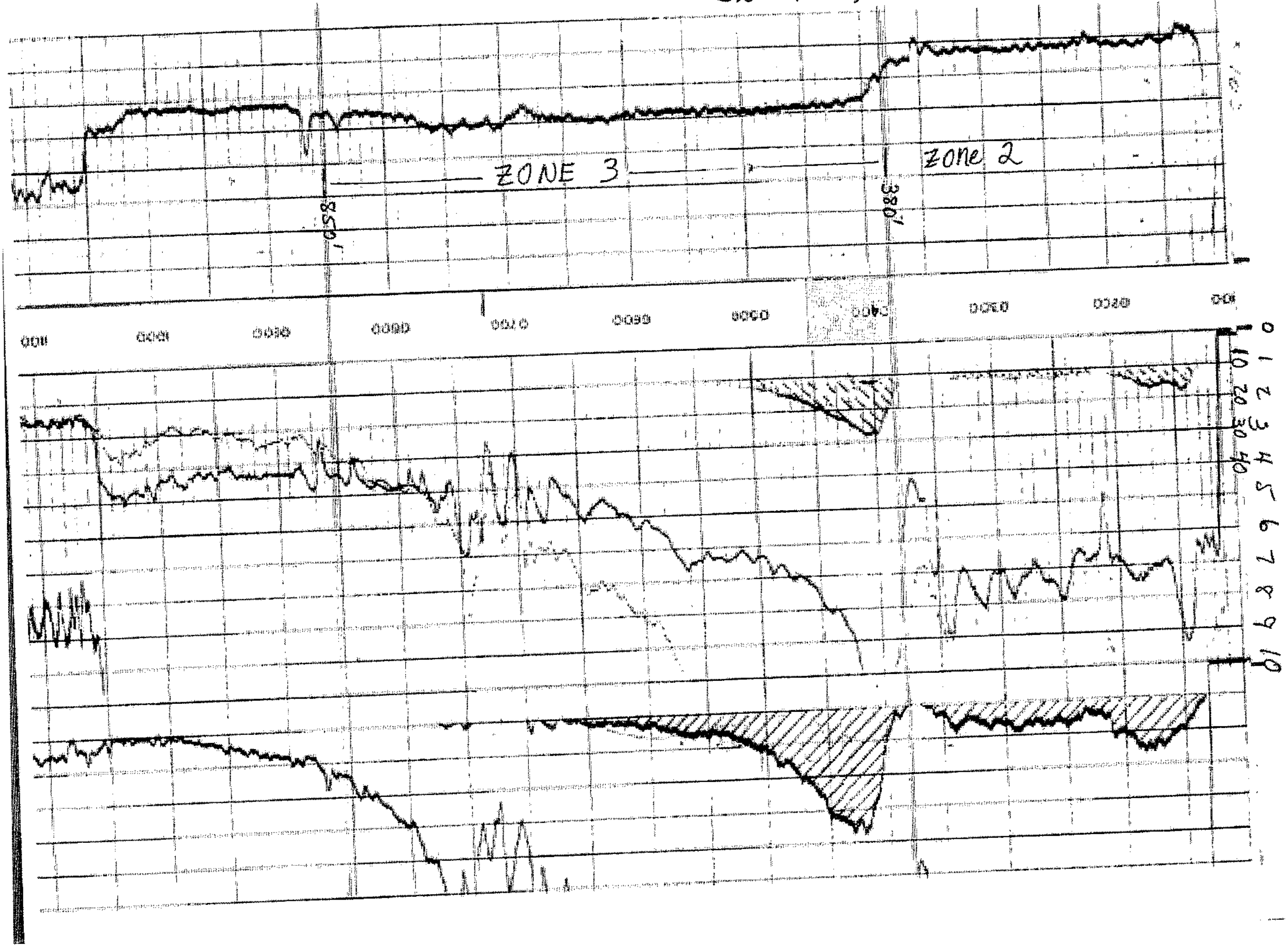
SN 90884
(Texaco) Mixson #1
Sec. 3



SN 55970 (McDermott)
Felice Gastenet #1
Section 8 T-161



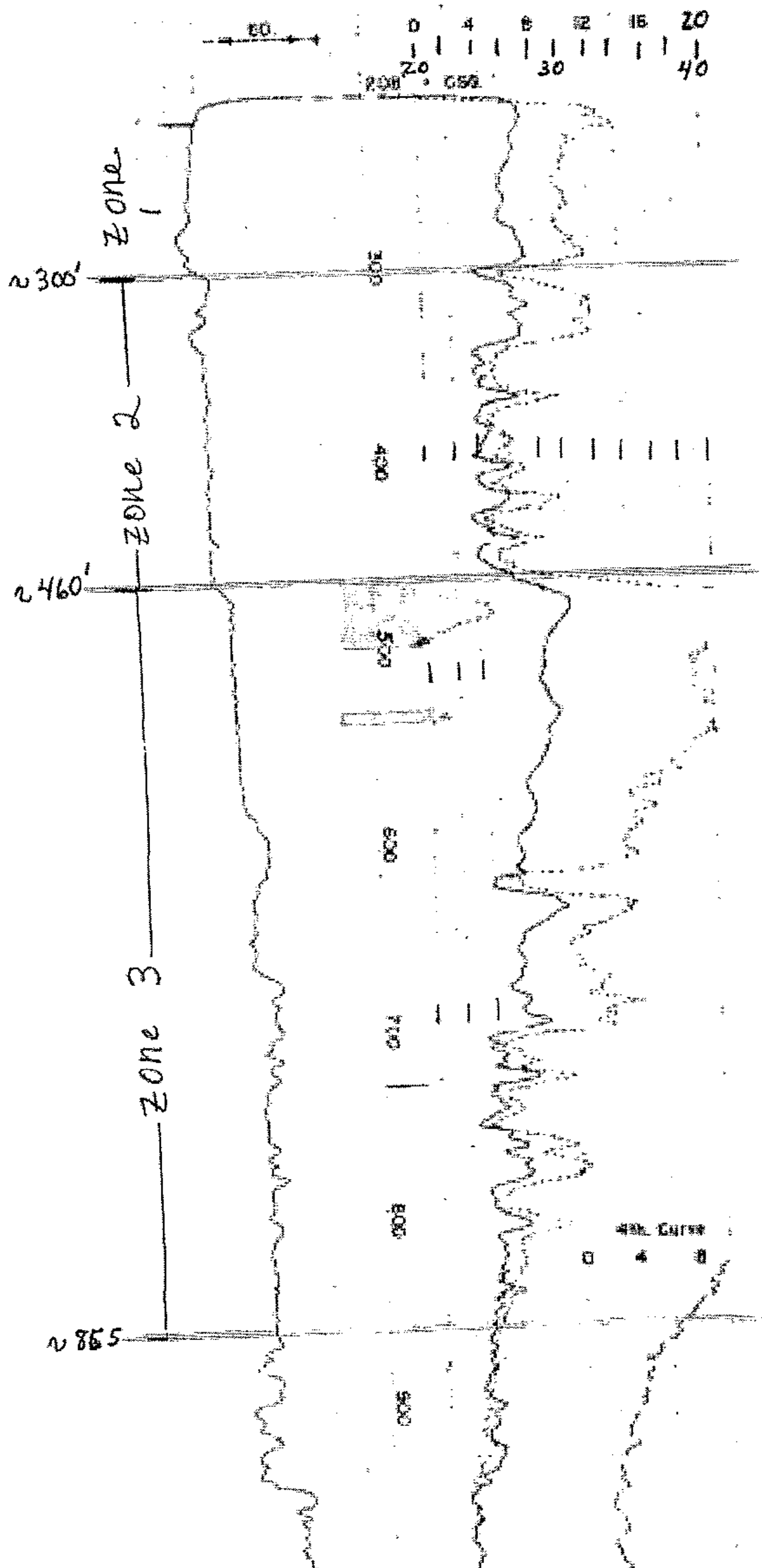
SN 37352, Mixon # 2, sec. 10 (Humble)



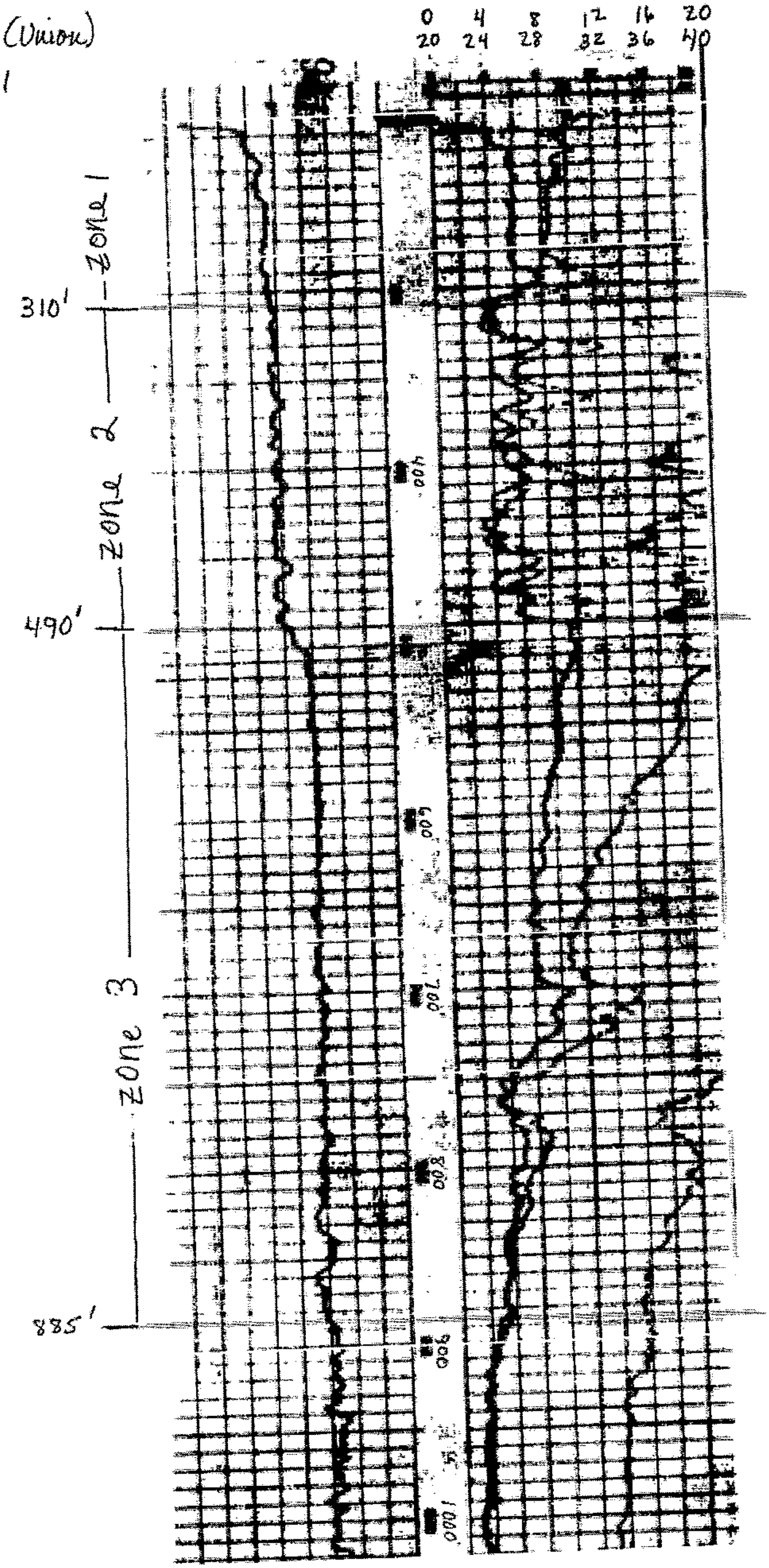
SN 24642 (Union)

Sec 15

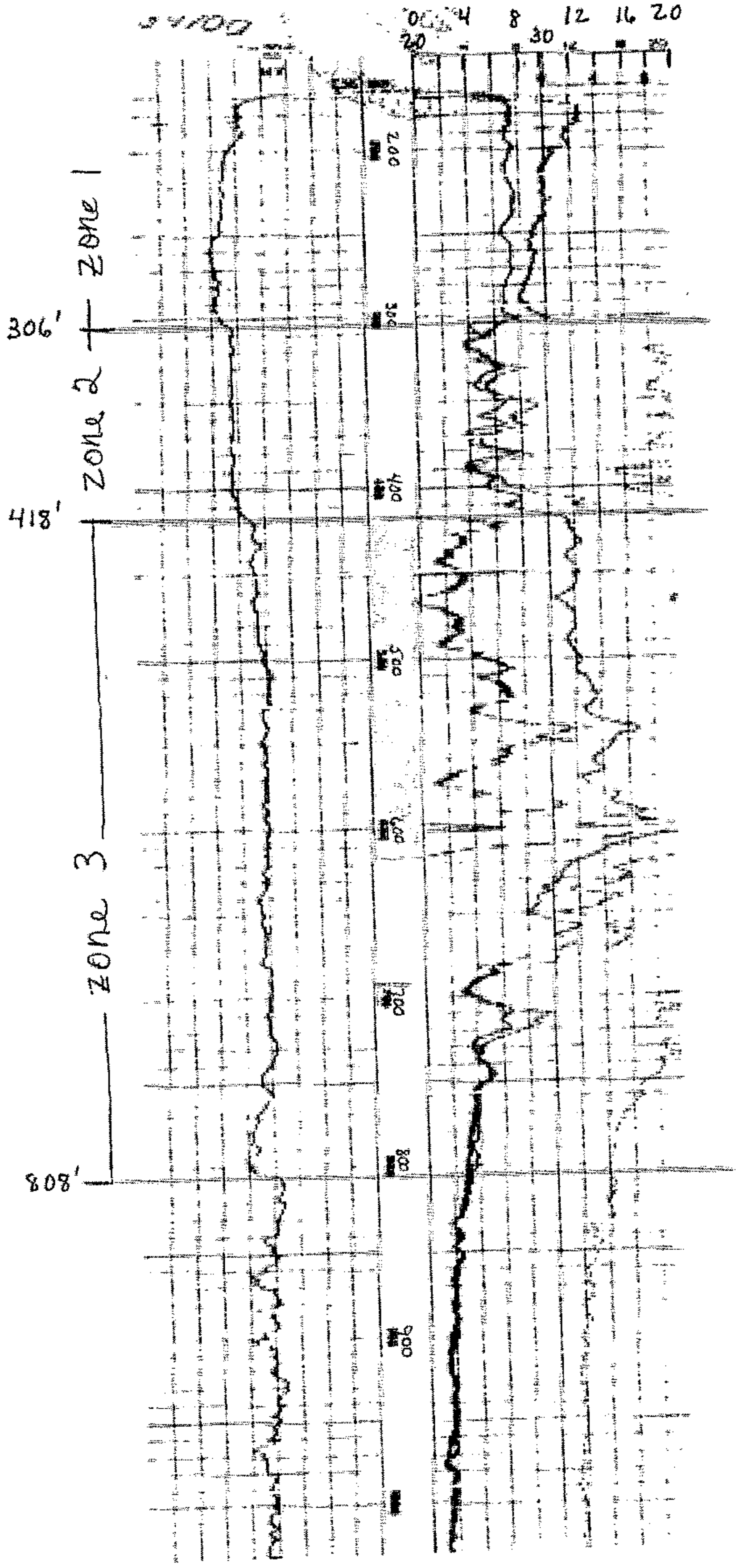
LA Furs # A-4



SN 26174 (Union)
VPSB # A-1
sec. 16



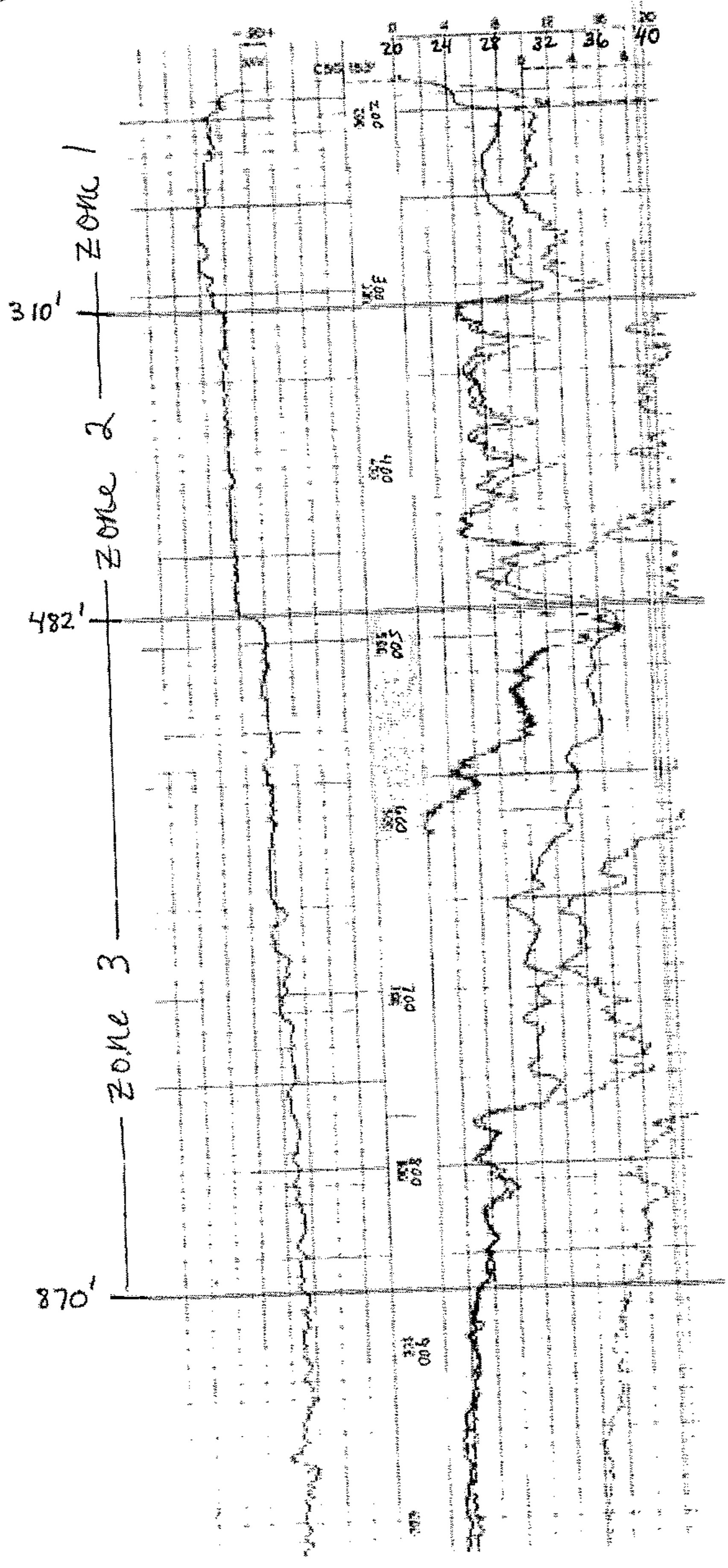
SN 26749 (Union)
VPSB # 2-A
sec. 16



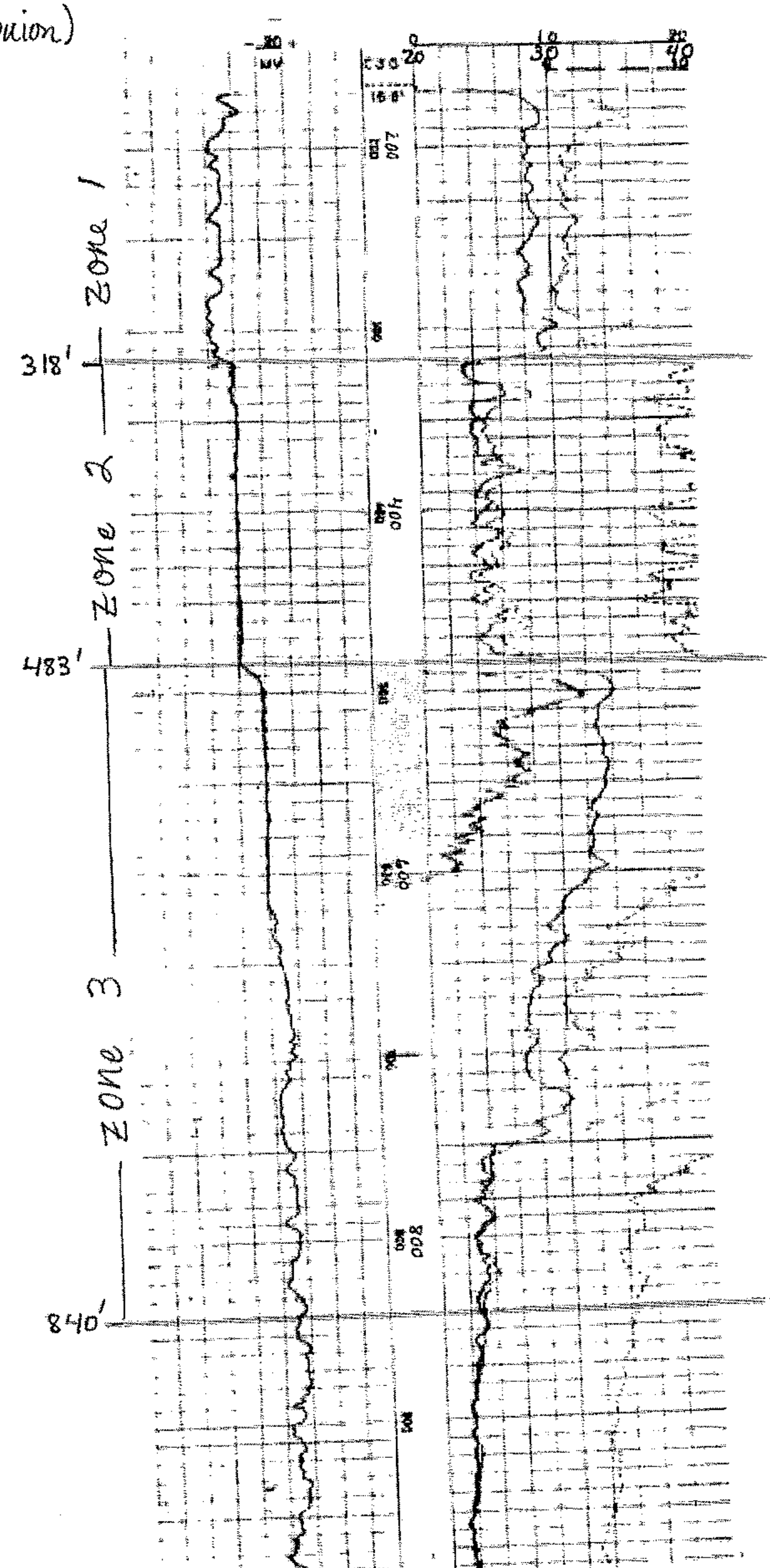
SN 27166 (Union)

VPSB # 3-A

Sec. 16



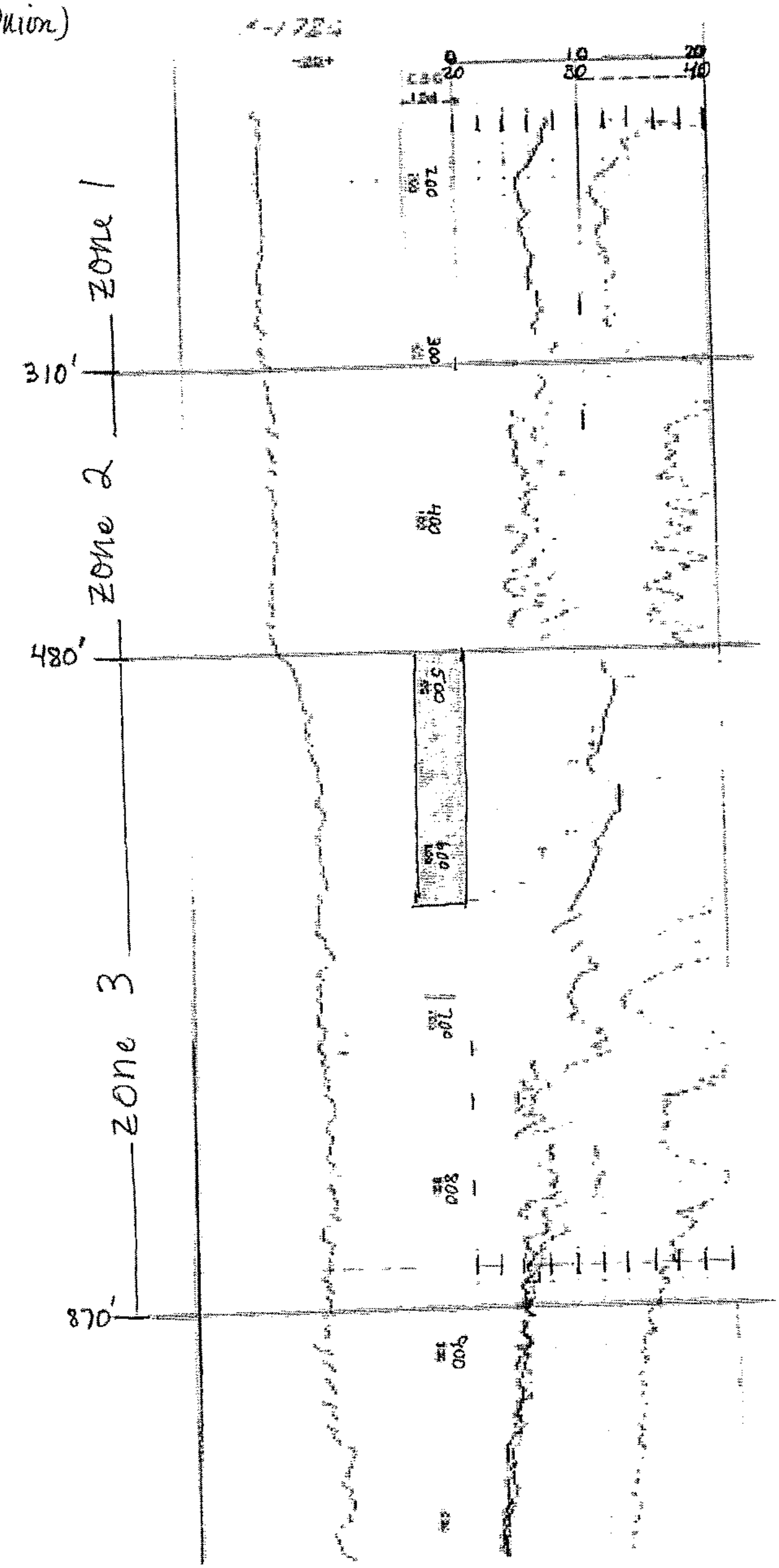
SN 27581 (Union)
VPSB # 4-A
Sec. 16



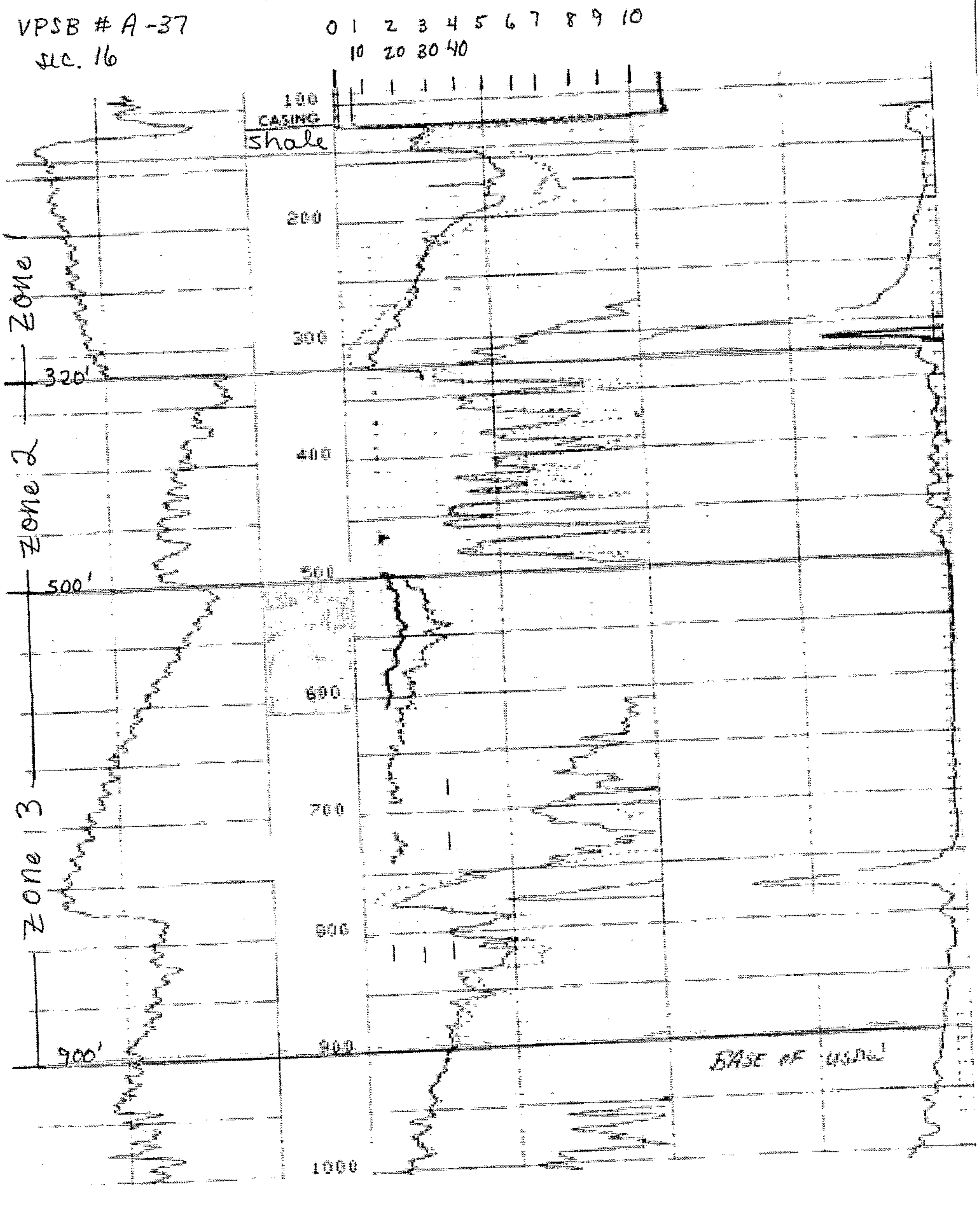
SN 28116 (Union)

VPSB #5-A

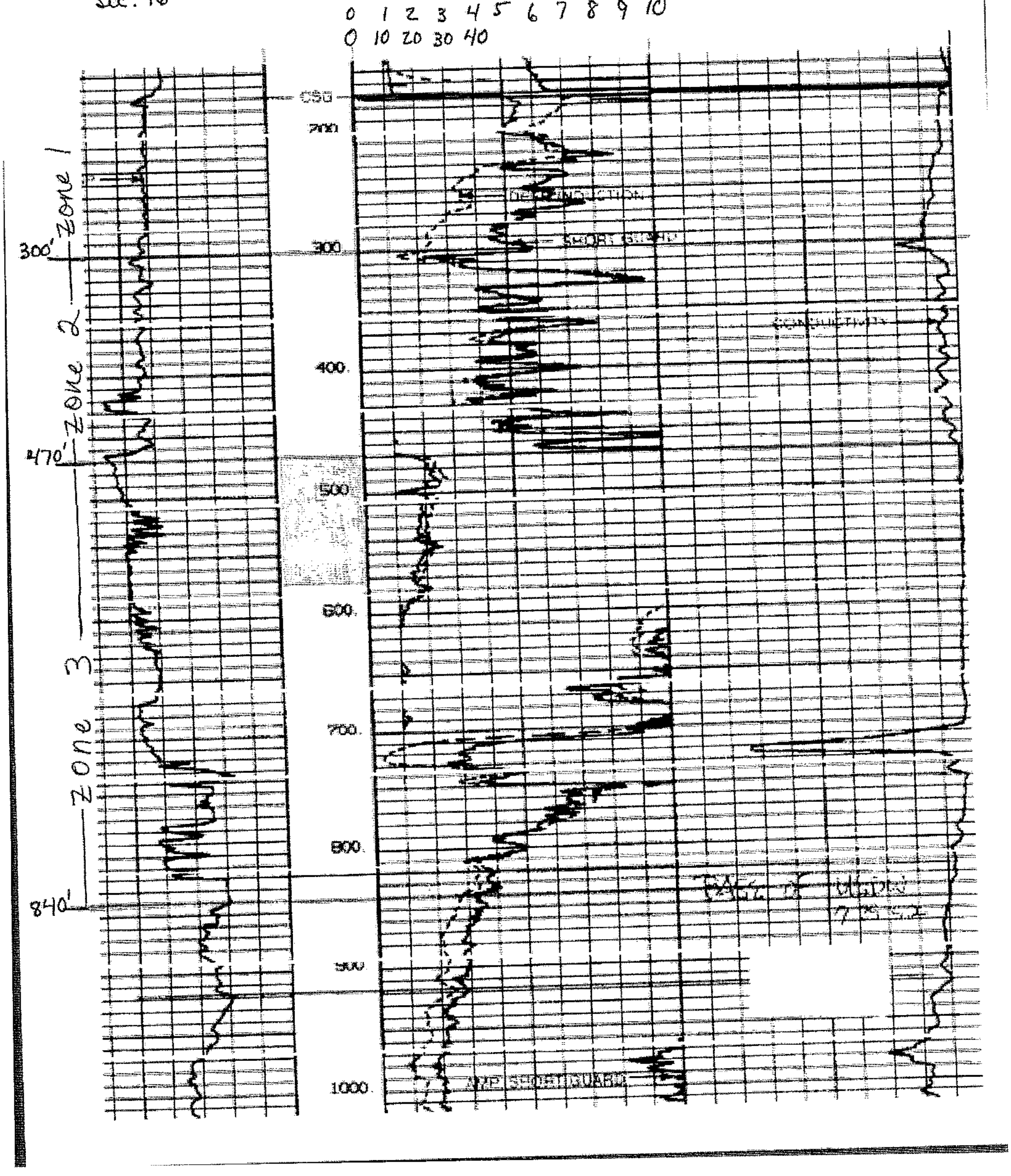
Sec. 16



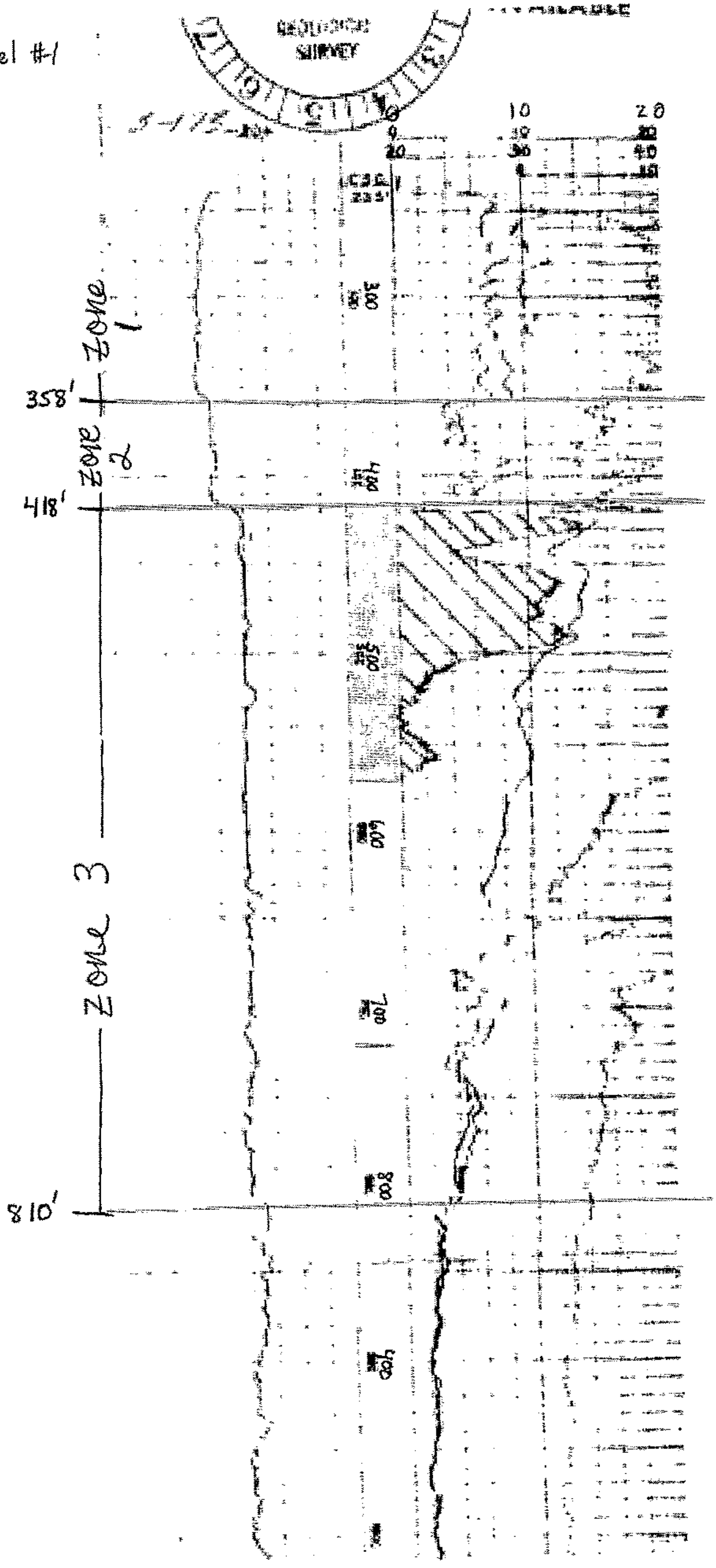
SN 970723 (Union)
VPSB # A-37
sec. 16



SN 971154
(Union) VPSB # A-39
sec. 16



SN 27677
Vigenaux-Gastinel #1
sec. 17
(Union)

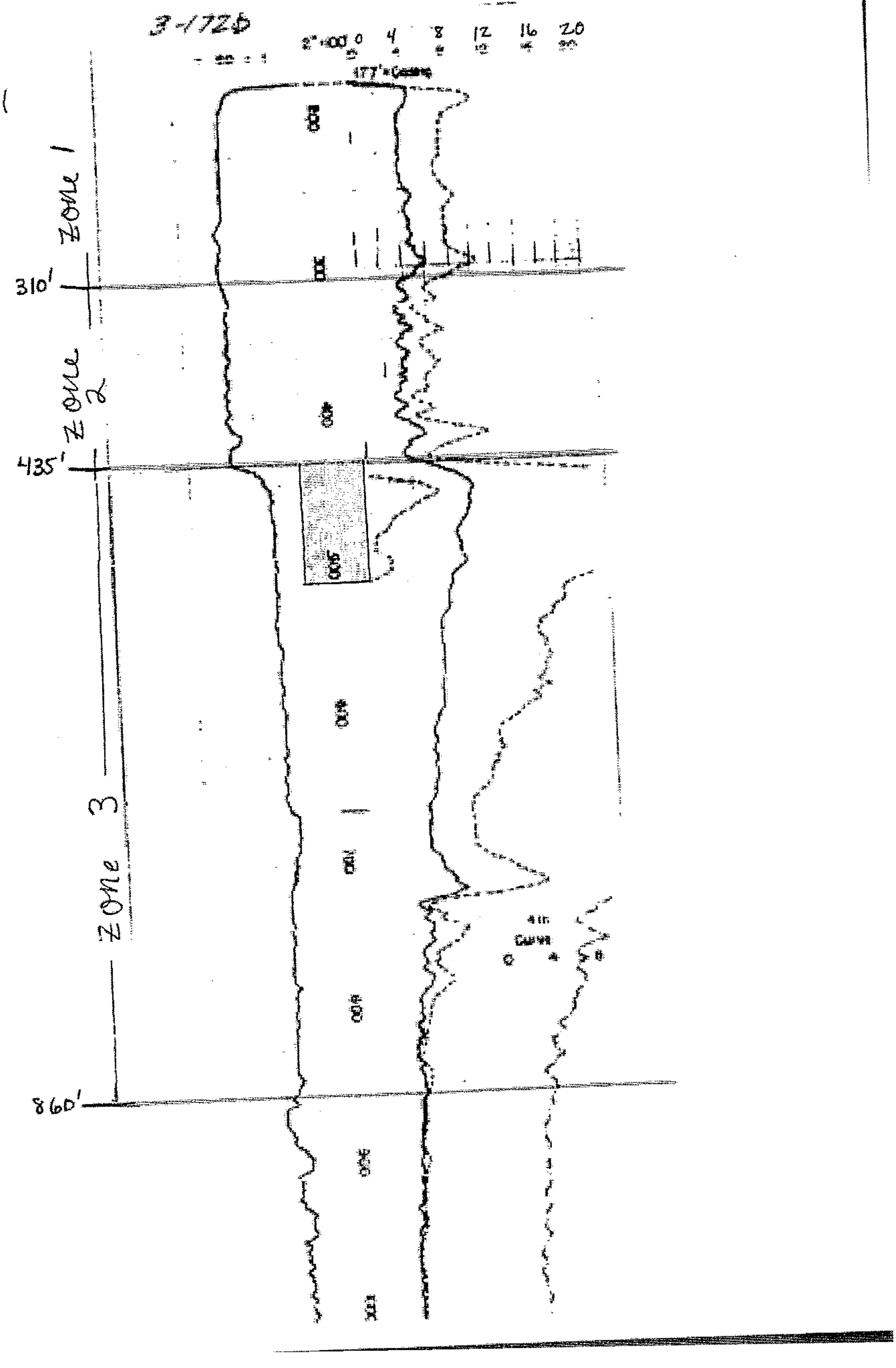


SN 23537

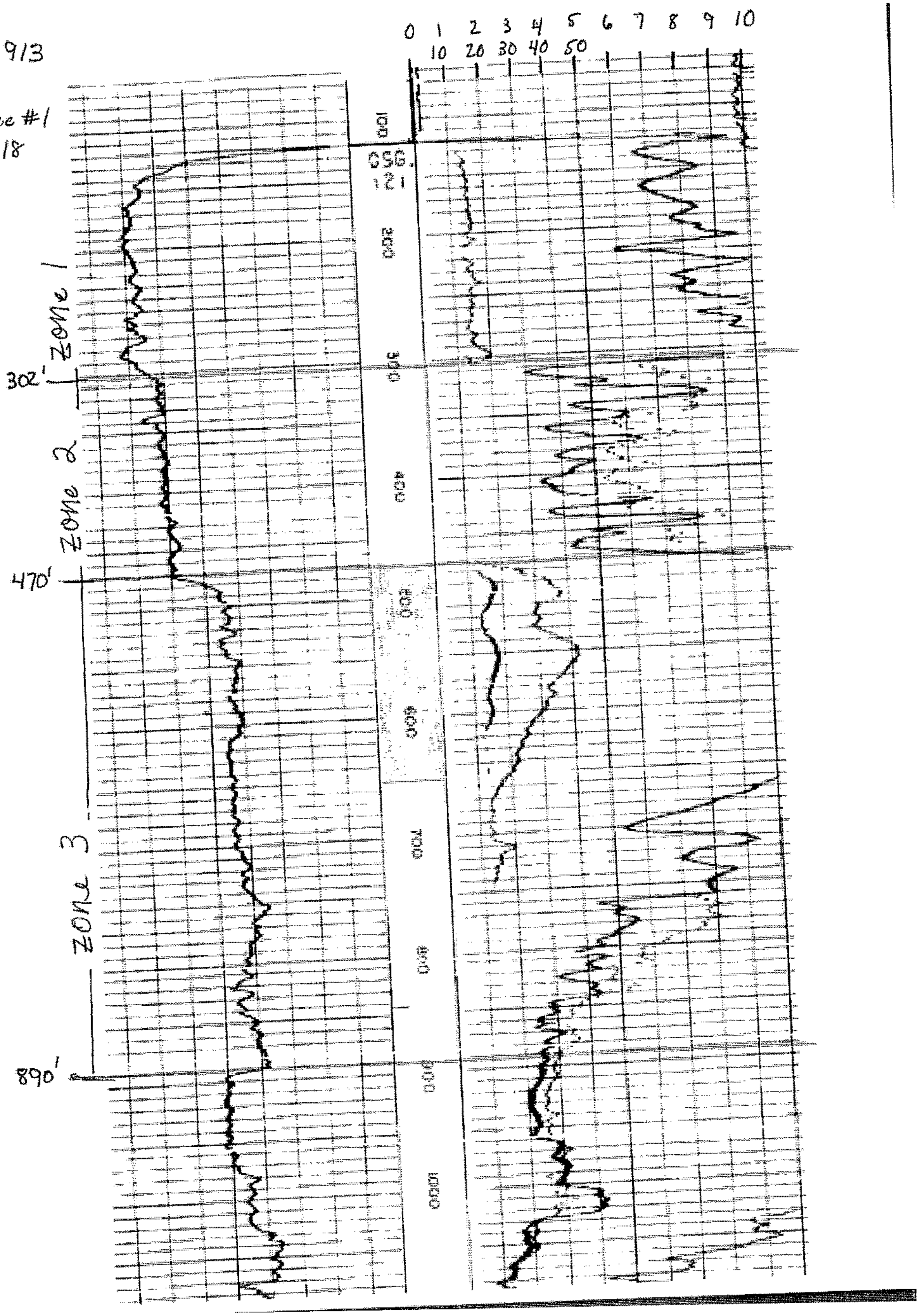
Vaion, Walter

White Heirs #1

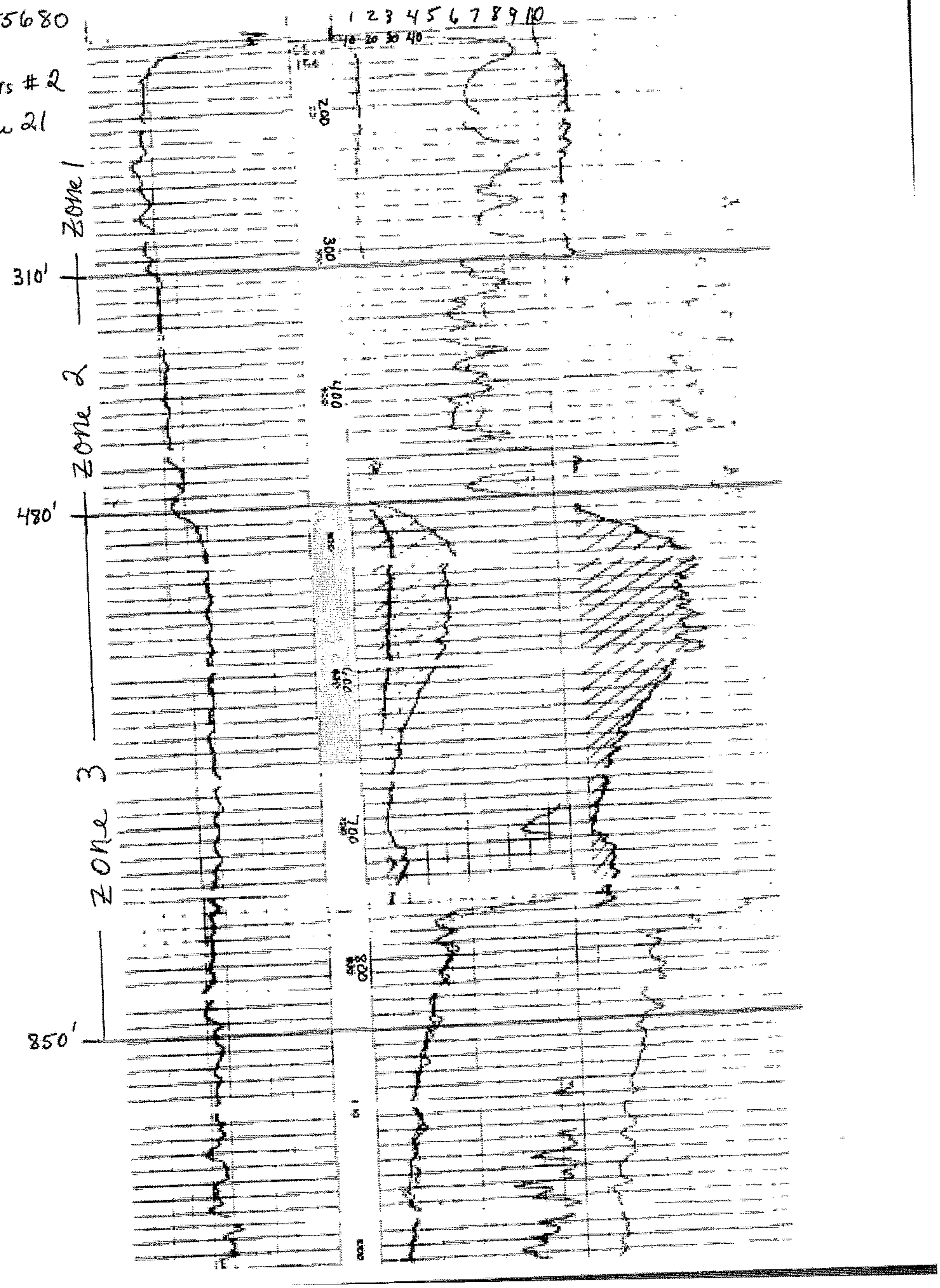
sec. 17



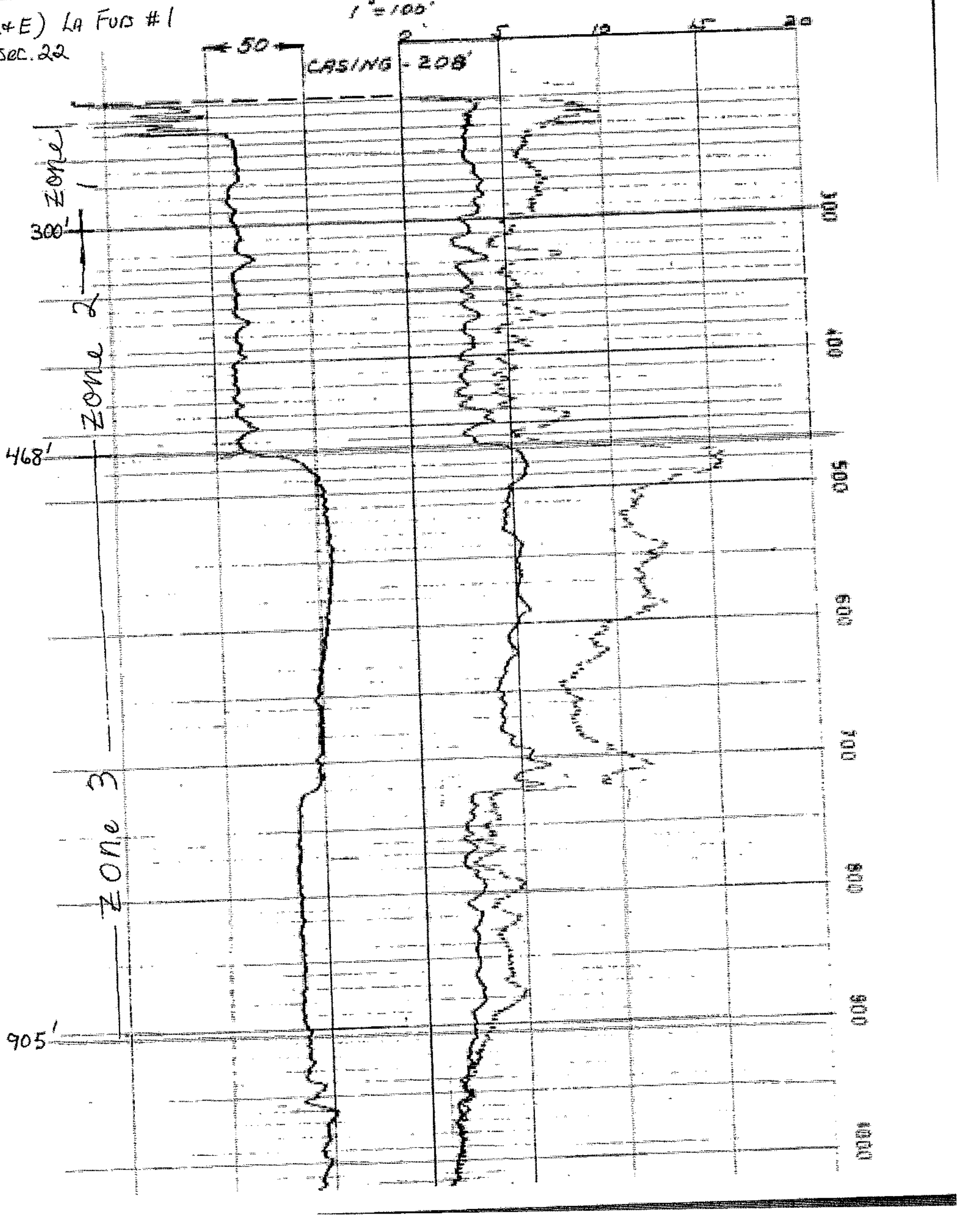
SN 74913
(Shell)
Humble Fee #1
section 18



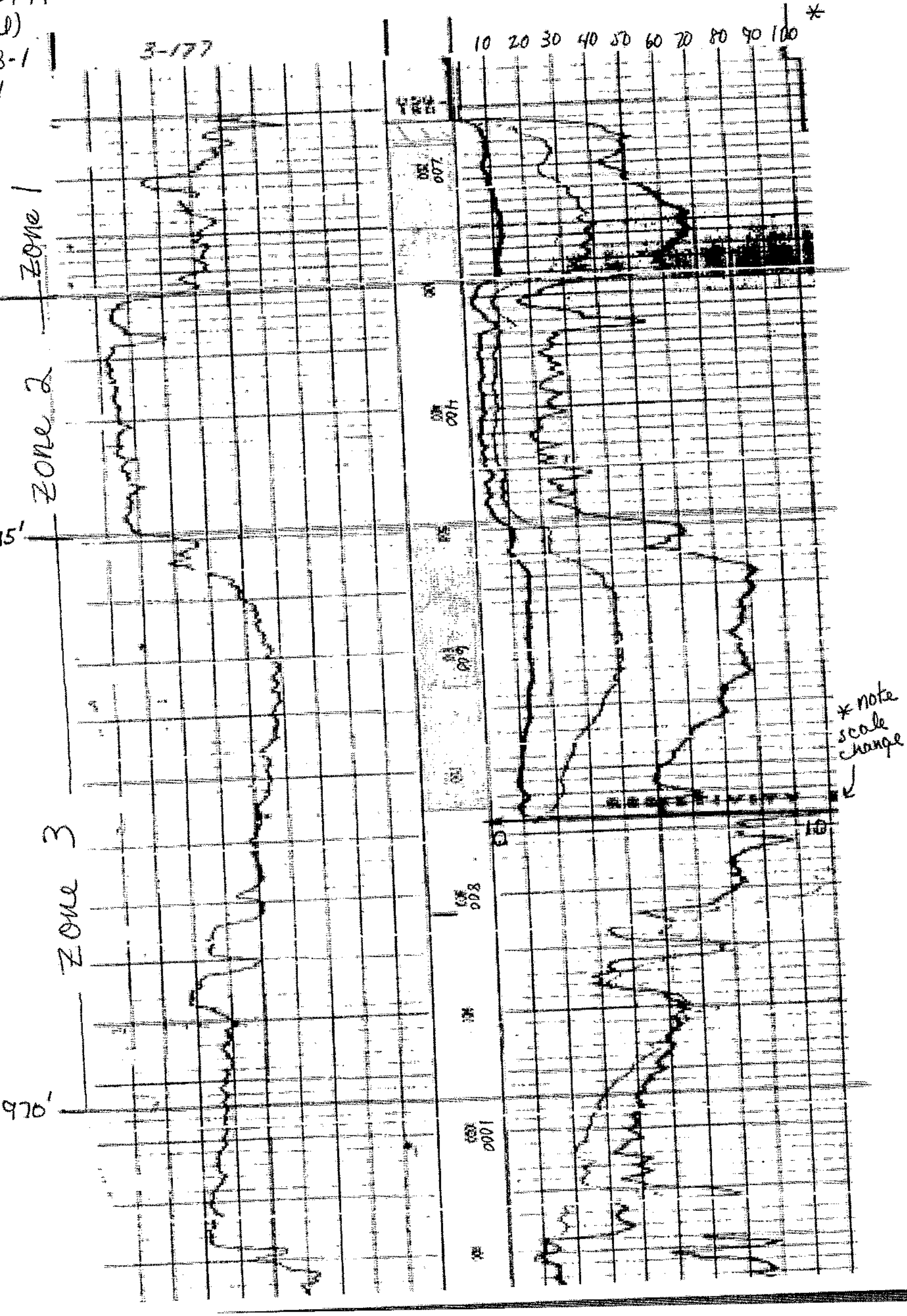
SN 55680
(Union)
La Furs # 2
section 21



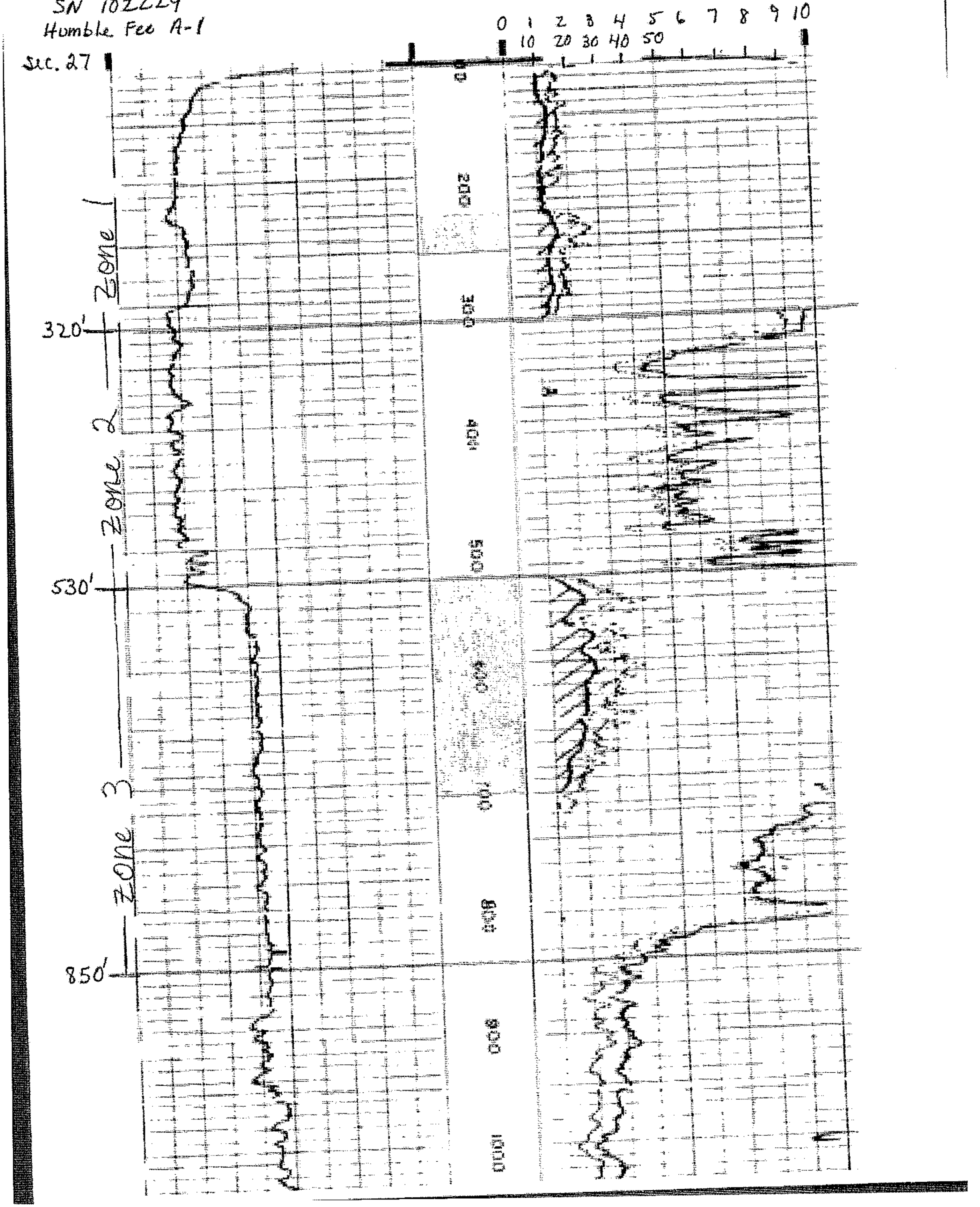
SN 22328
(LL+E) La Furs #1
Sec. 22



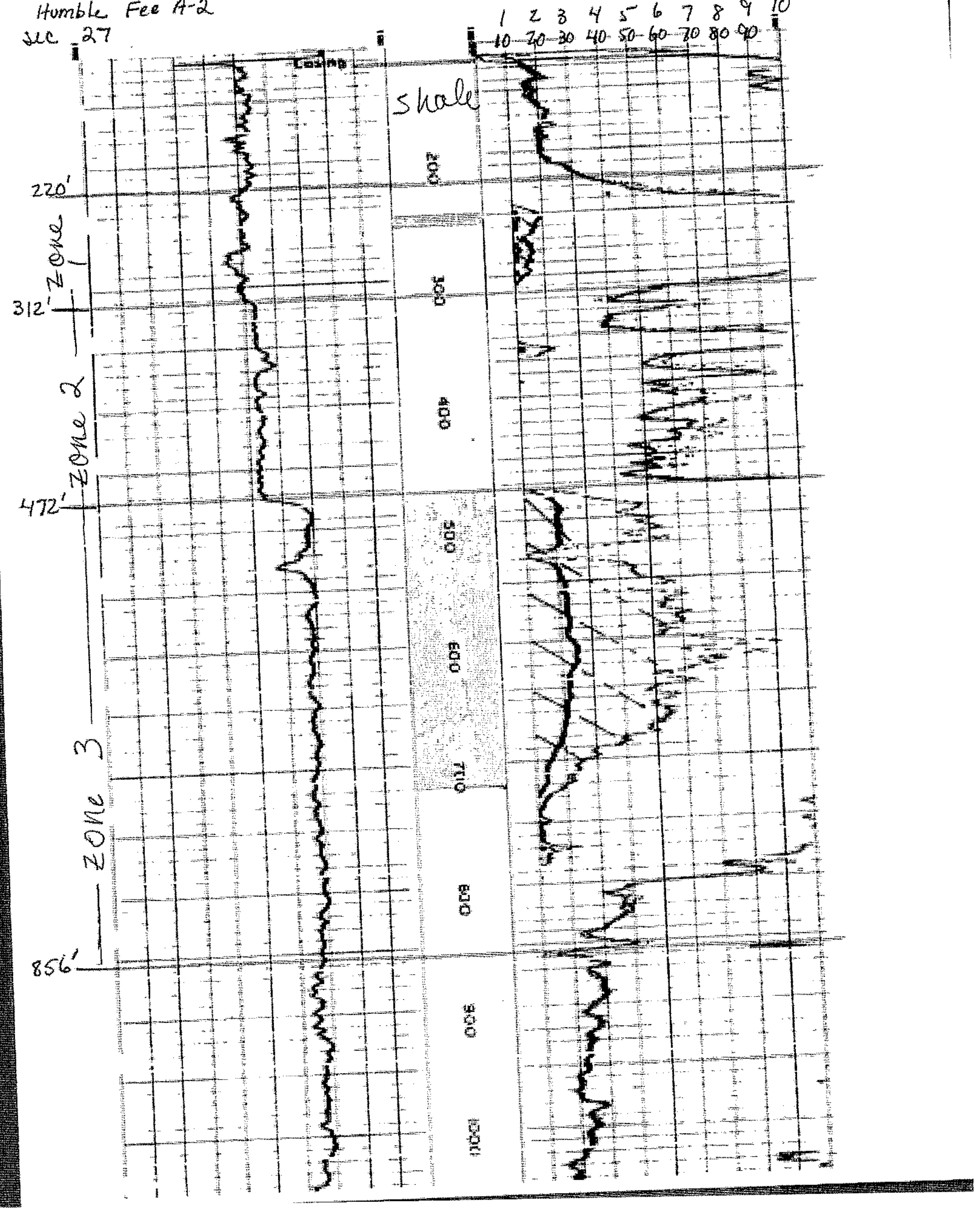
SN 76494
(Austral Oil)
LA Furs B-1
sec. 24



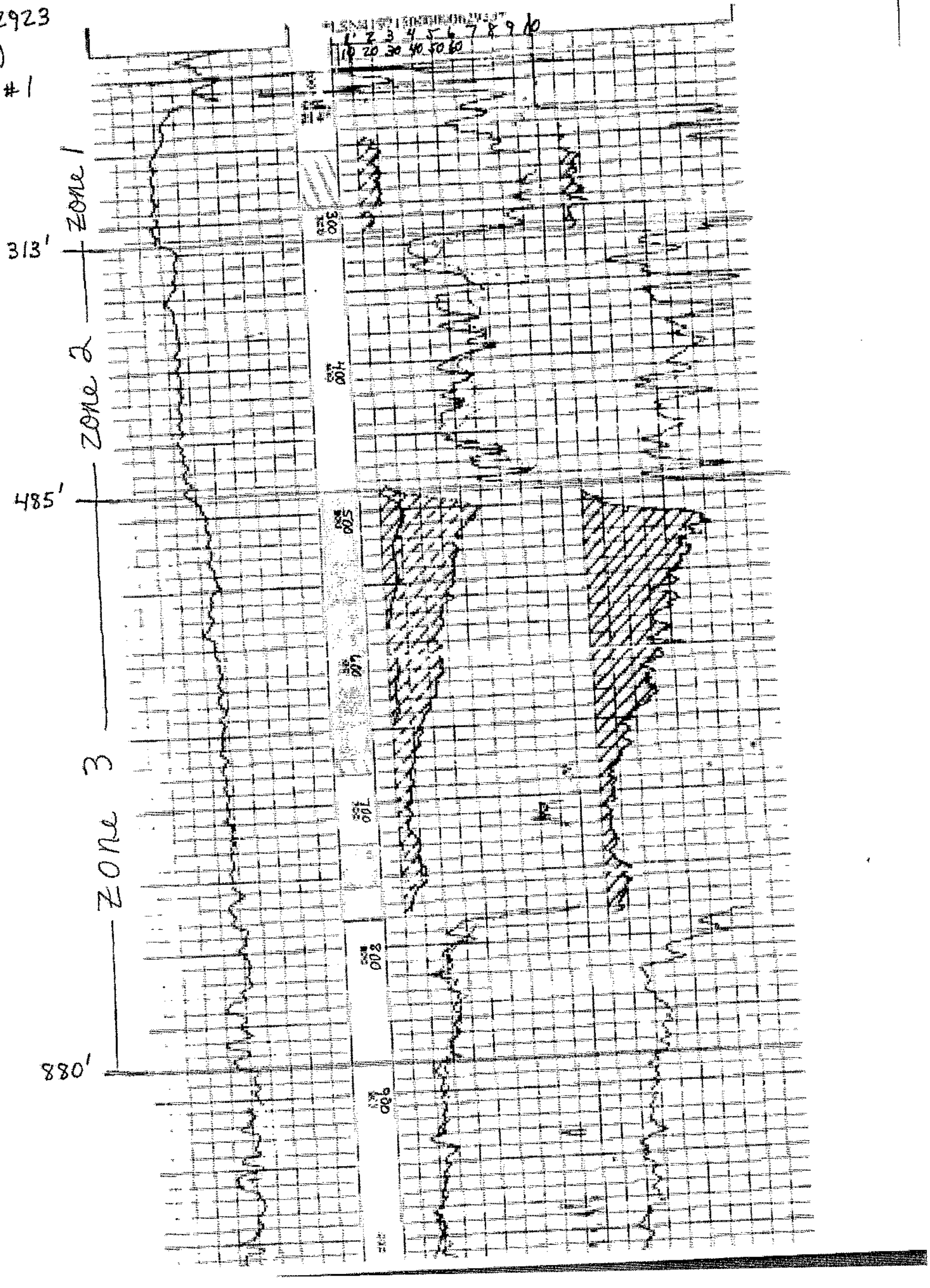
SN 102229
Humble Fee A-1
Sec. 27



SN 107275
Humble Fee A-2
sec 27



SW 62923
(Conoco)
La Fors #1
Sec. 28



Questions, Water Resource series no. 4

Mary Barrett

Sent: Saturday, July 17, 2010 12:15 AM

To: lmilne1@lsu.edu

Cc: hammer@lsu.edu; cjohn@lsu.edu

Attachments: 47914.pdf (378 KB) ; 90884.pdf (618 KB) ; 76494.pdf (1 MB) ; 102229.pdf (1023 KB) ; 107275.pdf (1 MB) ; 62923.pdf (628 KB)

Dear Mr. Milner,

I am writing to ask very specific and important questions about your publication of 2009, WR Series no. 4. I have copied the others so that if you are not able to answer these questions, I request that others may assist me in evaluating the publication specifics. I hope that you will view my questioning as only that, because I very much need to understand your interpretations of some old electric logs in your Plate No. 12. Along with these questions I am sending SONRIS copies of the referred-to logs for your convienence, although you may have better copies in some instances.

Specifically, I am going to ask you about the southern part of section E-E' and two logs you interpreted, especially about the shallow section you refer to as freshwater sands (over 40 ohms-m) of the "upper Chico". I know yours was a regional study and you looked at many logs, but I appreciate your close attention about this area interpretation. Here are the questions:

1) First, log serial number 47914, La Furs #1, sec.28-T15S-R1E. The SONRIS copy is the worst of the 25 wells I have studied from this T and R, but I have sent it. I note there is a resistivity scale change at about 800', so above this we are dealing with an ohm-m scale of 0-100. My question is, which exact resistivity curve did you read (not looking at conductivity column to far right) of the 2 resistivity curves visible to me? If it is the curve on right, I think you are reading the amplified 16" normal (different from the 16" normal), not the 64" normal. I am going to send SN 76494 (sec. 24, T15S-R1E) as an example, to note that usually we have 3 resistivity curves at the 0-100 ohm-m scale. The one we want, the dashed 64" normal (in this sort of setting, usually in middle), isn't really clear on the LA Furs #1, but that might be my bad copy.

Because, if the curve to far right is the deep resistivity, that would mean values of 80-100+ ohm-m, and I have rarely seen that in any of the other 25 wells from this T and R (nor from the near-area other T and R). I think I do not have the middle dashed curve on my copy.

2) Next, log serial number 90884, Texaco's Leo Mixon no. 1, sec. 3-T15S-R1E. Please note that you have mapped the entire section above about 650' as greater than 40 ohm-m (freshwater). In this log, we have the type of scale that first reads 0-10, and then doubles back on itself and reads 10-100 ohm-m. The only section that is above 40 ohm-m that I find is from about 360'-520'. Is that what you see? Above 360', the resistivity is actually reading around 15 ohm-m, and the separation of resistivity curves rule this out as a shale. It is part of the sandy aquifer, but the water quality is less, more brackish. Your section in the report does not draw this. Could you give me your interpretation of this? If indeed you have generalized for the sake of a regional cross-section, then I fully understand but certainly need to know this.

3) I know you recognized that in almost all of these old wells, the SP curve is not helpful as to sand/shale above about 800' due to the fact that freshwater drilling

mud is used. When deciding where your clays were in the logs from resistivity, did you use both deep and shallow resistivity curves to help? Otherwise, how did you know if it was not actually a water quality change of regional significance?

4) The placement of your faults, except where there is surface evidence is just truly schematic, correct? You had no faults drawn in any of your wells, and the displacement of sands, clays you show could simply be stratigraphic. When the faults were placed in places without surface or log evidence, from fault maps derived at much deeper depths, did anyone account for the dip of the fault to understand where it would be if indeed it made it to these shallow sections?

Thank you in advance, Mr. Milner. I would not quiz you so if it were not important for me to understand the basis for your interpretations. To further clarify my point about that first well, LA Furs # 1, I have attached three other logs from secs. 27 & 28 to illustrate the typical log response of good logs (SN 62923, SN 102229, SN 107275). I would certainly appreciate you looking at them to see if it follows what you have drawn on the regional cross-section.

Here is what I see--the logs (my data starts 100'+) in the upper Chico actually shows a water quality zonation: 1) An uppermost sandy zone of moderate quality; 2) a middle zone consisting of layered sand and shale where sands have a much lower water quality, and 3) the lower zone of the higher water quality (sands with 20-40+ ohms-m). Then the upper Chico transitions downward into waters of 3 ohm-m or less. Within these upper Chico zones are different layers of water chemistry, some fresher, some more brackish. This is what I would expect to find as saltwater encroaches into fresh water. But it is mis-leading to me to see in your interpretation this whole thing mapped as "fresh water aquifer" as greater than 40 ohms-m.

Again, thanks for your time. I look forward to hearing from you at your earliest convienence.

Regards,
Mary Barrett, Ph.D.
Professor Emeriti of Geology
Centenary College of Louisiana

FW: Questions, Water Resource series no. 4

Mary Barrett

Sent: Saturday, July 17, 2010 1:54 PM

To: lmilne1@lsu.edu

Cc: hammer@lsu.edu; cjohn@lsu.edu

Attachments: 47914.pdf (378 KB) ; 90884.pdf (618 KB) ; 76494.pdf (1 MB) ; 102229.pdf (1023 KB) ; 107275.pdf (1 MB) ; 62923.pdf (628 KB)

Mr. Milner,
I want to add to my comments from my earlier email concerning the La Furs # 1, sec. 28, SN 47914. I have looked as similar-era old logs to try to get at what the log's main problem is--in this SONRIS copy, there is no numerical scale given for the resistivity above 800'. Also, when I compare the not-numbered resistivity line scale at the top, there are 4 lines, which means this log is only going to give the 2 curves we see. Therefore, we are not seeing an amplified 16" normal common to this age log. (And, as I know you understood, the very far right column is lateral resistivity, not conductivity which I wrote, and we are not talking about that curve).

So, this log that you had in you interpretation is of extremely poor quaility in SONRIS, as one cannot read the scale nor clearly see the dashed long normal curve in the shallow section. The curve to the right is probably the long normal, though. Based on curve values in other close-by wells, I do not interpret the scale to be 0-100, but 0-50 is more likely. If you have a better log copy, send it.
Thanks,
Mary Barrett

From: Mary Barrett
Sent: Saturday, July 17, 2010 12:15 AM
To: lmilne1@lsu.edu
Cc: hammer@lsu.edu; cjohn@lsu.edu
Subject: Questions, Water Resource series no. 4

↓ repeated previous (1st) e-mail, not printed

Dear Mr. Milner,

I am writing to ask very specific and important questions about your publication of 2009, WR Series no. 4. I have copied the others so that if you are not able to answer these questions, I request that others may assist me in evaluating the publication specifics. I hope that you will view my questioning as only that, because I very much need to understand your interpretations of some old electric logs in your Plate No. 12. Along with these questions I am sending SONRIS copies of the referred-to logs for your convienence, although you may have better copies in some instances.

Specifically, I am going to ask you about the southern part of section E-E' and two logs you interpreted, especially about the shallow section you refer to as freshwater sands (over 40 ohms-m) of the "upper Chico". I know yours was a regional study and you looked at many logs, but I appreciate your close attention about this area interpretation. Here are the questions:

1) First, log serial number 47914, La Furs #1, sec.28-T15S-R1E. The SONRIS copy is the worst of the 25 wells I have studied from this T and R, but I have sent it. I note there is a resistivity scale change at about 800', so above this we are dealing with an ohm-m scale of 0-100. My question is, which exact resistivity curve did you read (not looking at conductivity column to far right) of the 2 resistivity curves visible to me? If it is the curve on right, I think you are