ADVANCED GEOLOGICAL SERVICES

3 Mystic Lane
Malvern, PA19355
(610) 722-5500 (ph.)
(610) 722-0250 (fax)

January 8, 2012
AGS Ref.: 12-289-1

Mr. Steve Snyder
Groundwater Sciences Corporation
2601 Market Street, Suite 310-1
Harrisburg, Pennsylvania

Subject: Borehole Geophysical Investigation Results
Harley Davidson Site
York, Pennsylvania

Dear Mr. Snyder:

Advanced Geological Services (AGS) completed a borehole geophysical investigation for Groundwater Sciences Corporation on December 10, 2012 at the Harley Davidson Site in York, Pennsylvania. Geophysical data were collected in four monitoring wells that included MW-138a, MW-141a, MW145a, and MW147a. The wells were logged to depths of approximately 319 feet, 301 feet, 218 feet, and 233 feet, respectively. These wells were located at various locations throughout the site.

Objectives

The primary objective of this investigation was to locate potential fracture zones and bedding planes in the wells and to determine the structural orientation of these features. The borehole geophysical data provided information regarding the depth and vertical extent of fractures, fracture zones, and bedding planes, the dip and azimuth of these features, and their relation to the local bedding characteristics.

Geophysical Equipment

AGS used an optical televiewer (OTV) by Mount Sopris Instruments, Inc. to collect data in each of the four wells.

Borehole Geophysical Theory

Optical Televiewer Log

The optical televiewer log provides an oriented, high-resolution, 360-degree photographic

image of the borehole. The oriented image of the borehole is presented in unwrapped format on the log. Results from this tool provide location and orientation information of features such as fractures, lithologic contacts and cavities. The OTV digitizes 256 measurements around the borehole every 0.02 feet along the length of the borehole. Since the acquired image is digitized and properly oriented with respect to borehole deviation and tool rotation, it allows data processing to provide accurate strike and dip information of fractures and other structural features.

Logging Procedures

The logging procedures conducted at the site followed typical downhole protocol. Initially, the instrument was attached to a cable head at the end of a 1-conductor wireline. The "zero" depth was established at the appropriate benchmark (top of casing), and the recording mode of operation was initiated. The probe was lowered at approximately 3 feet per minute through the total depth of the well. The recording mode was terminated when the probe touched the bottom of the well or an obstructing surface.

Well Construction Information

The upper sections of the wells were constructed of 6" I.D. steel casing. The casing extended to varying depths below top of casing (TOC), which is the typical reference point used by AGS when logging wells. TOC at each well was 2-4 feet above ground surface.

Results

The geophysical well logs collected in wells MW-138a, MW-141a, MW145a, and MW147a are presented in Appendix A of this report. As stated, the depths of all logs are referenced to the top of casing. The data from the wells have been placed in three tracks on the figures, where track 1 contains the instrument azimuth and tilt data, track 2 presents the original OTV images, and track 3 shows the optical televiewer image data with annotations and structural information.

We have included a Fracture Category Ranking System description for each feature. The Fracture Category Ranking System is used to group optical televiewer structures into four categories (1 to 4) that are based on fracture continuity and fracture aperature, or opening size. The larger the category number the more significant the fracture.

The OTV amplitude log is presented in unwrapped format. It represents a 360 degree view of the borehole cylinder that has been opened vertically, and placed flat on the page. Given this format, any dipping surface such as a fracture plane or bedding interface will be represented

by a sine wave. As the dip of the interface increases so does the amplitude of the sine wave. The dip angle is obtained by incorporating the borehole size information from caliper logs. The azimuth is obtained from gyroscope information that is continuously collected during the OTV logging operation. Typically, AGS will process the OTV data by fitting a sine curve to an interpreted televiewer fracture to estimate the dip and azimuth of the interface.

Well MW-138a

The following table provides a list of important borehole features that were detected in well MW-138a. The information listed in the tables reflects the log data presented in Appendix A.

Table 1: Well MW-138a Bedrock Structures

Well MW-138a						
Depth (feet)	Azimuth (degrees)	Dip (degrees)	Structural Category (fracture rank)			
			1	2	3	4
260	310	27	X			
261	304	27	X			
261.5	305	29	X			
269	146	67	X			
271	178	54	X			
275	305	26	X			
278	294	39	X			
279	297	38	X			
284	349	18	X			
285	87	71	X			
288	306	29	X			
293	315	27	X			
294	311	29	X			
296	308	33	X			
297	287	26	X			
298	308	24	X			
305	123	86	X			
310	311	33	X			

Depth	Azimuth	Dip	1	2	3	4
312	315	31	X			
313	320	24	X			
314	329	26	X			
315	330	26	X			
316	308	26	X			
317	330	31	X			

The data from MW-138a indicated several important borehole features or characteristics on the OTV log. AGS did not observe the presence of any significant fractures or fracture zones in the well. The fractures and bedding planes exhibited very small aperatures or openings, and they appeared to be very "tight" and indurated, for the most part. AGS observed several, tight, near-vertical fractures between 301 feet and 309 feet in the well. They exhibited a continuous, yet "wavy" character on the images, that suggests possible rock movement after their formation.

The bedding planes observed on the logs have a relatively consistent azimuth and dip throughout the logged section. Azimuth values range from approximately 285 degrees to 315 degrees (approximately west-to-northwest), and dip values range from approximately 25 degrees to 35 degrees. These features were placed on the logs and annotated with azimuth and dip values. Several "outliers" were present, however, they were probably due to calcite-filled micro-fracturing within the limestone. In addition, AGS noticed several color changes within the formations, and changes in formation character, as shown and annotated on the log. Areas where gouging and irregular fracturing were present at a few locations. AGS noticed that the rocks have a more "massive" character between 258 feet and 278 feet, and a more "bedded" character from 278 feet to the bottom of the hole.

Well MW-141a

The following table provides a list of important borehole features that were detected in well MW-141a. The information listed in the tables reflects the log data presented in Appendix A.

Table 2: Well MW-141a Bedrock Structures

Well MW-141a						
Depth (feet)	Azimuth (degrees)	Dip (degrees)	Structural Category (fracture rank)			
			1	2	3	4
212	133	71	X			
214	182	72	X			
215	154	57	X			
223	147	51	X			
228	69	79	X			
232	139	58	X			
240	131	69	X			
251	265	29	X			
252	261	29	X			
257	256	26	X			
258	263	26	X			
258.5	264	24	X			
259	265	26	X			
260	270	26	X			
263	221	24	X			
264	226	29	X			
268	253	26	X			
277	290	20	X			
279	244	22	X			
280	247	20	X			
287	265	26	X			
288	268	24	X			
295	268	14	X			
297	62	76	X			
299	258	18	X			

The data in well MW-141a indicated the presence of very competent, indurated materials, with

Again, the fractures and bedding planes exhibited very small openings, and they appeared to be very "tight". AGS observed several, tight, sub-vertical fractures between 234 feet and 240 feet in the well, as well as some microfractures between 269 feet and 274 feet.

The bedding planes observed on the logs have a relatively consistent azimuth and dip throughout the logged section. Azimuth values range from approximately 220 degrees to 290 degrees (approximately southwest), with the predominant number of values being near 260 degrees (west). Dip values range from approximately 20 degrees to 29 degrees. These features were placed on the logs and annotated with azimuth and dip values. Several fractures were detected whose azimuth and dip values averaged approximately 145 degrees (southeast) and 62 degrees, respectively. They are high angle fractures.

In addition, AGS noticed moderate color changes within the formations, and changes in formation character, as shown and annotated on the log. Areas where gouging and irregular fracturing were present at a few locations, such as 234 feet and 240 feet. An area of fine microfracturing was present between 269 feet and 274 feet. AGS noticed that the rocks have a more "massive" character above 250 feet, and a more "bedded" character below 250 feet.

The OTV log from MW-141a exhibited a large number of angled scars or cuts that are due to the drilling process. They represent cuts from the drill bit, and they tend to obscure the formation data somewhat at certain depth intervals.

Well MW-145a

The following table provides a list of important borehole features that were detected in well MW-145a. The information listed in the tables reflects the log data presented in Appendix A.

Table 3: Well MW-145a Bedrock Structures

Well MW-145a						
Depth (feet)	Azimuth (degrees)	Dip (degrees)	Structural Category (fracture rank)			
			1	2	3	4
217.5	183	16	X			
219	175	14	X			

Depth	Azimuth	Dip	1	2	3	4
221	175	14	X			
222	159	14	X			
224.5	164	11	X			
227.5	0	0	X			

The data in well MW-145a again indicates that no significant fractures or fracture zones were present. AGS noticed a borehole opening that is centered at 206.5 feet. It is approximately 1-foot in vertical dimension and is positioned at the western part of the borehole. AGS also noted the presence of in-filled fractures between 219 feet and 233 feet. Many of these features are roughly vertical and possess varying widths and pathways. A noticeable change in color was also observed at 219 feet.

The predominant fracture/bedding plane azimuth and dip values range from approximately 160 degrees to 180 degrees, and 11 degrees to 16 degrees, respectively. Again, the data in MW-145a indicates very competent, indurated materials with no significant fractures or fracture zones.

The OTV tool "sat down" at 233 feet on two attempts to lower the tool to the bottom of the hole. AGS decreased the centralizer width in separate passes in the borehole, however, we could not log below a depth of 233 feet. Apparently, there is an obstruction in the hole at this depth.

Well MW-147a

The following table provides a list of important borehole features that were detected in well MW-147a. The information listed in the tables reflects the log data presented in Appendix A.

Table 4: Well MW-147a Bedrock Structures

Well MW-147a						
Depth (feet)	Azimuth (degrees)	Dip (degrees)	Structural Category (fracture rank)			
			1	2	3	4
207	255	18	X			
207.5	303	18	X			
210	305	11	X			
212	270	31	X			
212.5	249	26	X			

The data in well MW-147a also indicates that no significant fractures or fracture zones were present. AGS noticed a large borehole opening that is located between 213 feet to 218 feet, and possibly deeper. It is at least 5 feet in vertical dimension and is observed over the full 360 view of the instrument. Unfortunately, we were unable to pass through this feature as we logged down.

AGS also noted the presence of in-filled fractures between 201 feet and 213 feet. Many of these features are roughly vertical and possess varying widths and pathways.

The predominant fracture/bedding plane azimuth and dip values range from approximately 250 degrees to 300 degrees (west), and 11 degrees to 31 degrees, respectively. Again, the data in MW-147a indicates very competent, indurated materials with no significant fractures or fracture zones.

Data Quality

The quality of the geophysical logs was very good, the responses were consistent, and the log responses repeated well during test runs for quality control. The data collection and interpretation methodologies used in this investigation are consistent with standard practices applied to similar geophysical investigations. The correlation of geophysical responses with probable subsurface features is based on the past results of similar surveys although it is possible that some variation could exist at this site.

If you have any questions, please contact me at 610-722-5500. It was a pleasure working with you on this project, and I look forward to conducting geophysical investigations for you in the future.

Sincerely,

Peter T. Miller, Ph.D., P.G.
Senior Geophysicist

Encl.: Appendix A - Geophysical Well Logs
Appendix B – Fracture Category Ranking

ADVANCED GEOLOGICAL SERVICES

3 Mystic Lane
Malvern. PA 19355
610-722-5500
610-722-0250 fax

Optical Televiewer Log

CO Groundwater Sciences, Inc.
WELL MW-138a
FLD Lawrence Road
TWP Lawrence Twp
STE Pennsylvania
FILING No

CLIENT Groundwater Sciences, Inc.
WELL ID MW-138a
SITE
CITY York **STATE** Pennsylvania

LOCATION
SEC TWP RGE

OTHER SERVICES

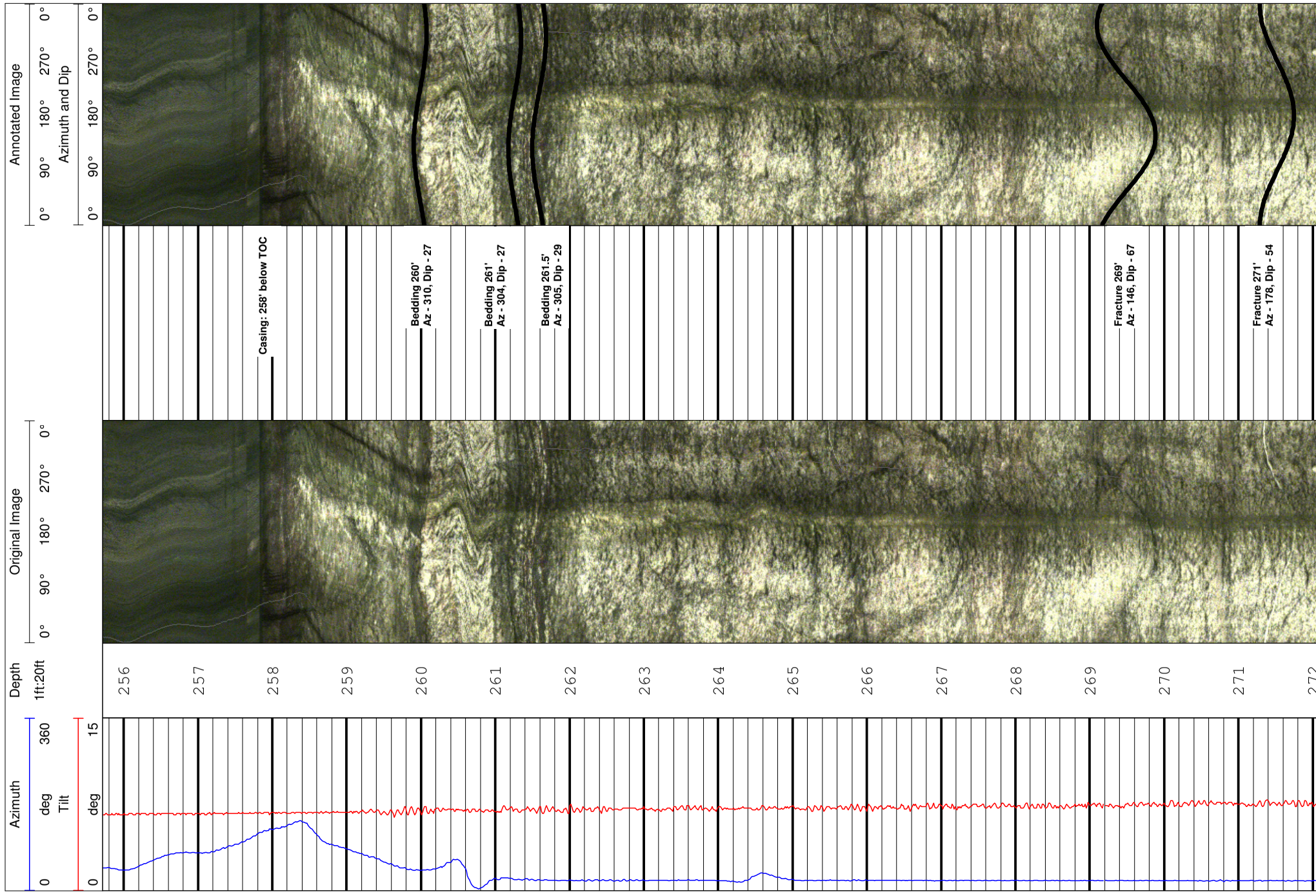
PERMANENT DATUM: _____ ELEVATION _____ K.B.

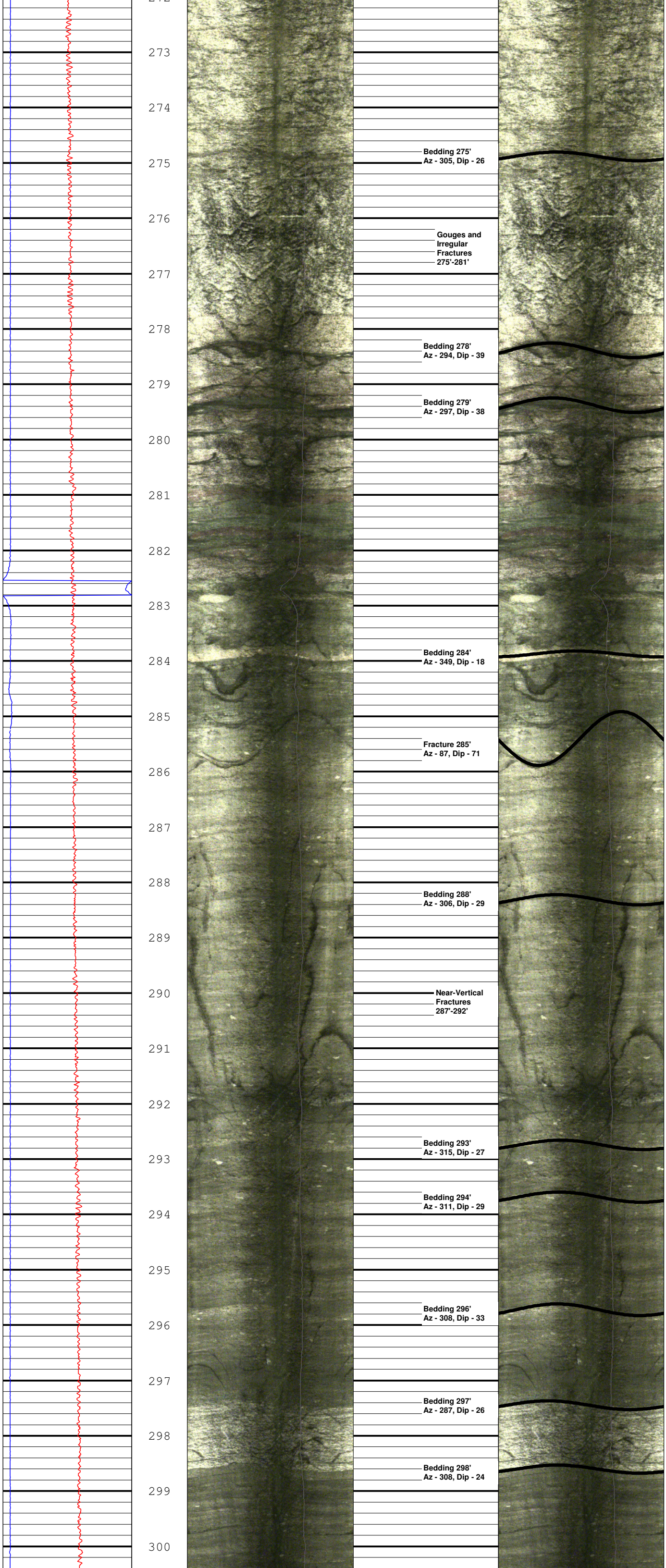
LOG MEAS. FROM: Top of Casing ABOVE PERM. DATUM _____ D.F.

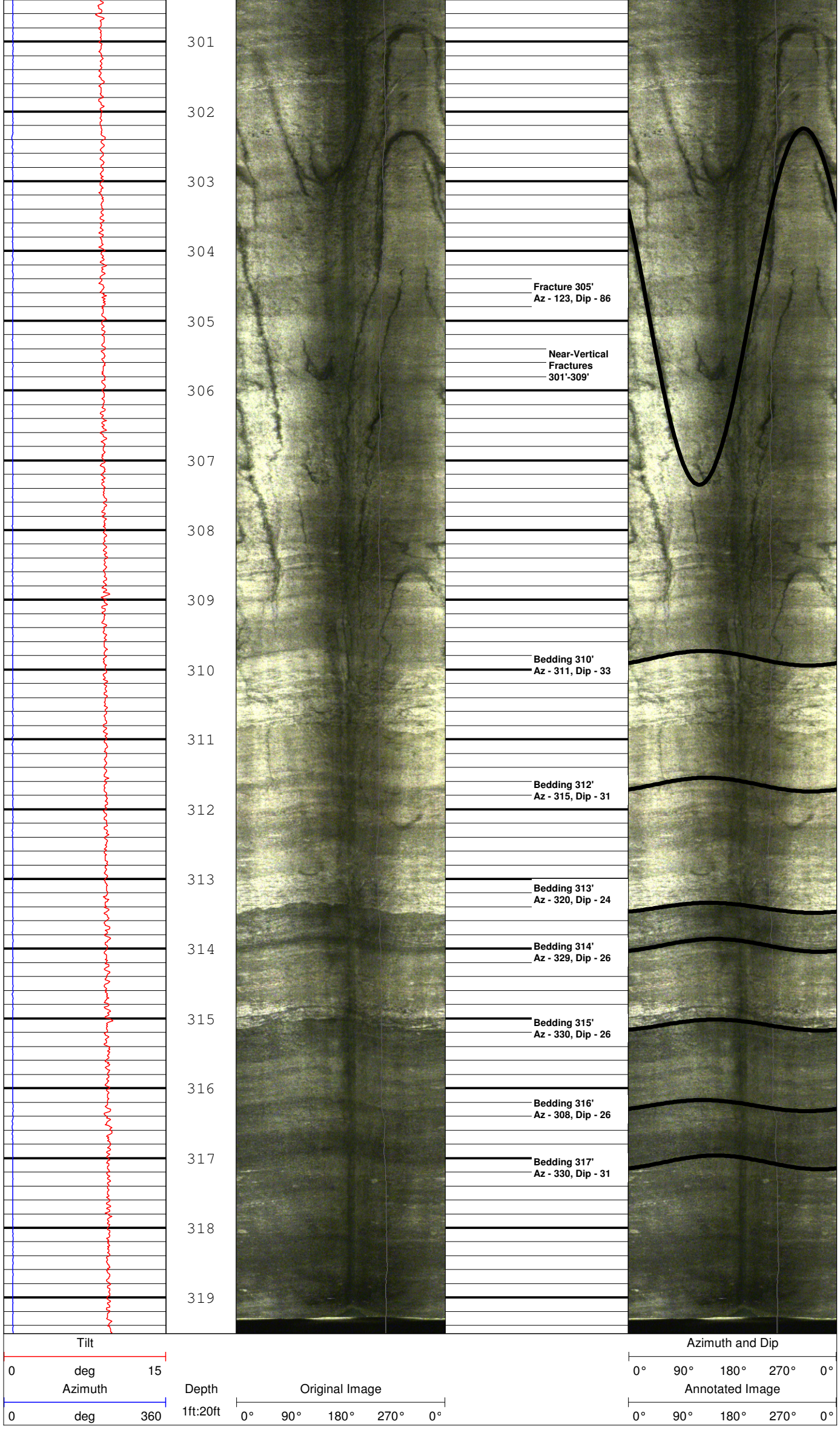
DRILLING MEAS. FROM: _____ G.L.

DATE	January 7, 2013	TYPE FLUID IN HOLE	
RUN No		SALINITY	
TYPE LOG		DENSITY	
DEPTH-DRILLER		LEVEL	
DEPTH-LOGGER		MAX. REC. TEMP.	
BTM LOGGED INTERVAL	319 feet below TOC		
TOP LOGGED INTERVAL	258 feet below TOC		
OPERATING RIG TIME			
RECORDED BY	P. Miller		
WITNESSED BY			

REMARKS:




272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
Bedding 275'
Az - 305, Dip - 26
Gouges and
Irregular
Fractures
275'-281'
Bedding 278'
Az - 294, Dip - 39
Bedding 279'
Az - 297, Dip - 38
Bedding 284'
Az - 349, Dip - 18
Fracture 285'
Az - 87, Dip - 71
Bedding 288'
Az - 306, Dip - 29
Near-Vertical
Fractures
287'-292'
Bedding 293'
Az - 315, Dip - 27
Bedding 294'
Az - 311, Dip - 29
Bedding 296'
Az - 308, Dip - 33
Bedding 297'
Az - 287, Dip - 26
Bedding 298'
Az - 308, Dip - 24


301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
Fracture 305'
Az - 123, Dip - 86
Near-Vertical
Fractures
301'-309'
Bedding 310'
Az - 311, Dip - 33
Bedding 312'
Az - 315, Dip - 31
Bedding 313'
Az - 320, Dip - 24
Bedding 314'
Az - 329, Dip - 26
Bedding 315'
Az - 330, Dip - 26
Bedding 316'
Az - 308, Dip - 26
Bedding 317'
Az - 330, Dip - 31
Tilt
0 deg 15
Azimuth
0 deg 360
Depth
1ft:20ft
Original Image
0° 90° 180° 270° 0°
Azimuth and Dip
0° 90° 180° 270° 0°
Annotated Image
0° 90° 180° 270° 0°

ADVANCED GEOLOGICAL SERVICES

3 Mystic Lane
Malvern. PA 19355
610-722-5500
610-722-0250 fax

Optical Televiewer Log

CO Groundwater Sciences, Inc.
WELL MW-141a
FLD Harley Davidson Site
CTY York
STE Pennsylvania
FILING No

CLIENT Groundwater Sciences, Inc.
WELL ID MW-141a
SITE
CITY York **STATE** Pennsylvania

LOCATION
SEC TWP RGE

OTHER SERVICES

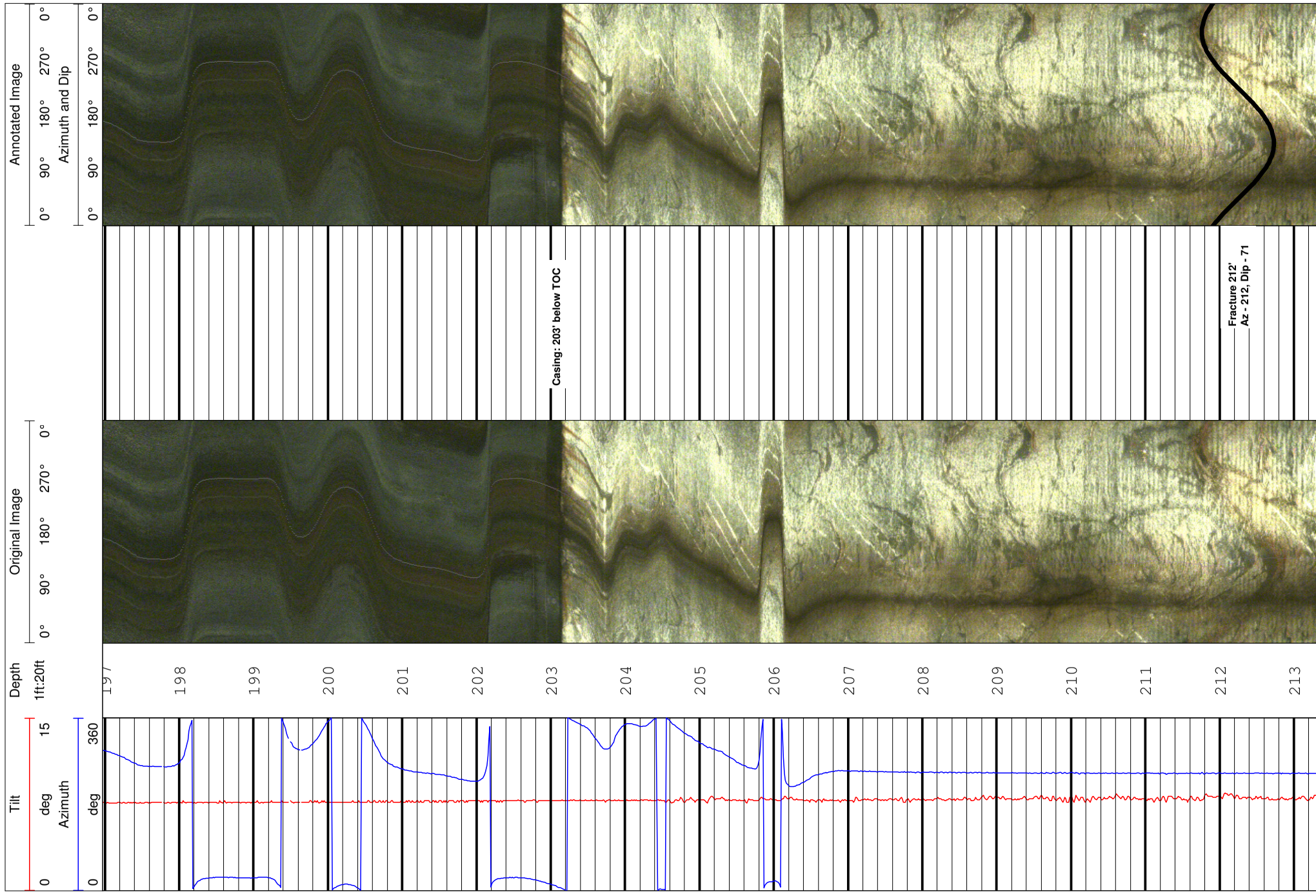
PERMANENT DATUM: _____ ELEVATION _____ K.B.

LOG MEAS. FROM: Top of Casing ABOVE PERM. DATUM _____ D.F.

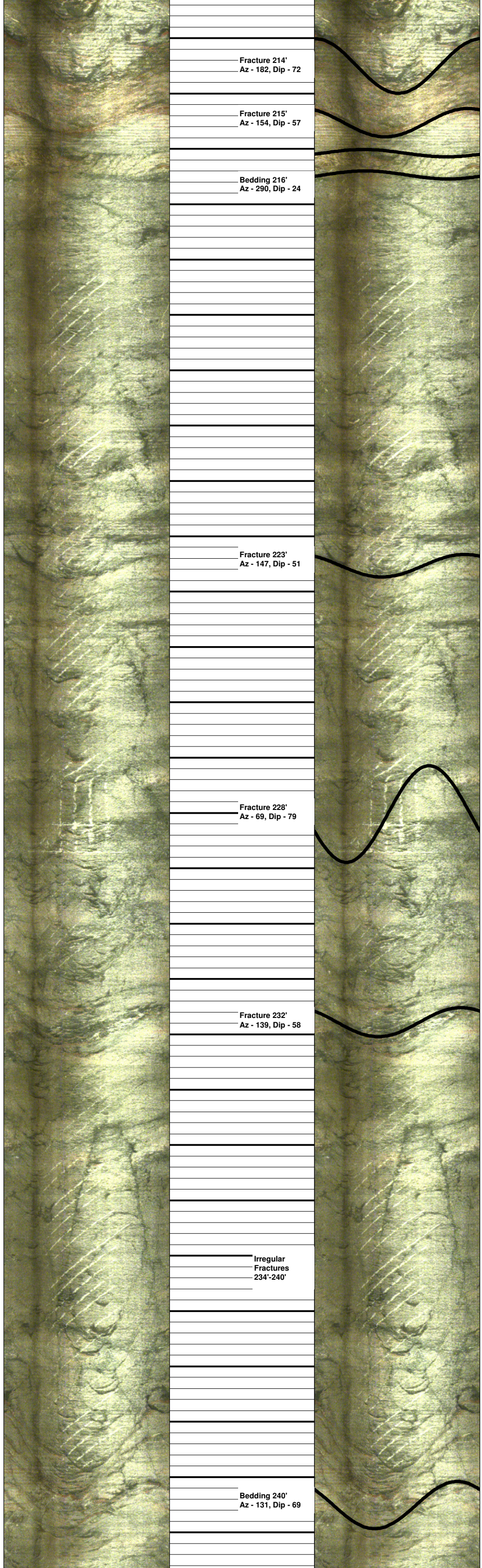
DRILLING MEAS. FROM: _____ G.L.

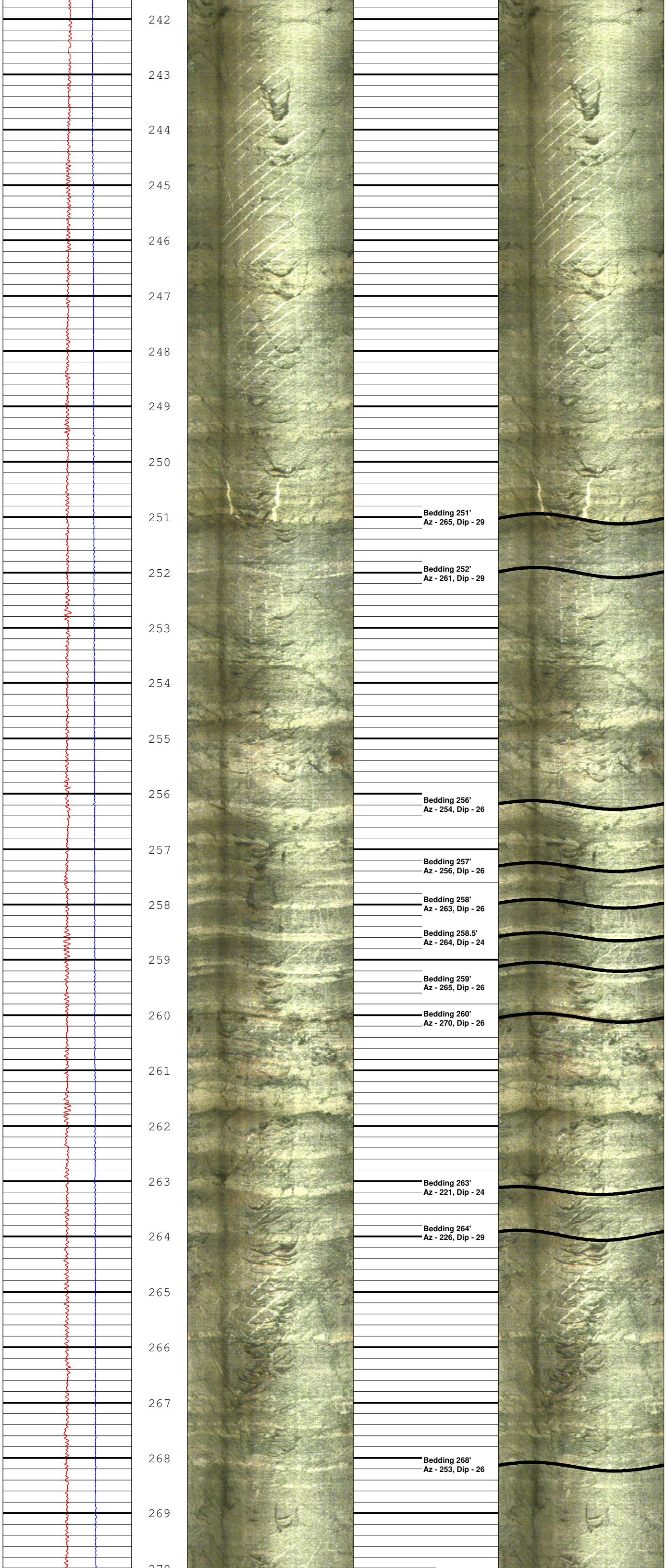
DATE	January 7, 2013	TYPE FLUID IN HOLE	
RUN No		SALINITY	
TYPE LOG		DENSITY	
DEPTH-DRILLER		LEVEL	
DEPTH-LOGGER		MAX. REC. TEMP.	
BTM LOGGED INTERVAL	301 feet below TOC		
TOP LOGGED INTERVAL	203 feet below TOC		
OPERATING RIG TIME			
RECORDED BY	P. Miller		
WITNESSED BY			

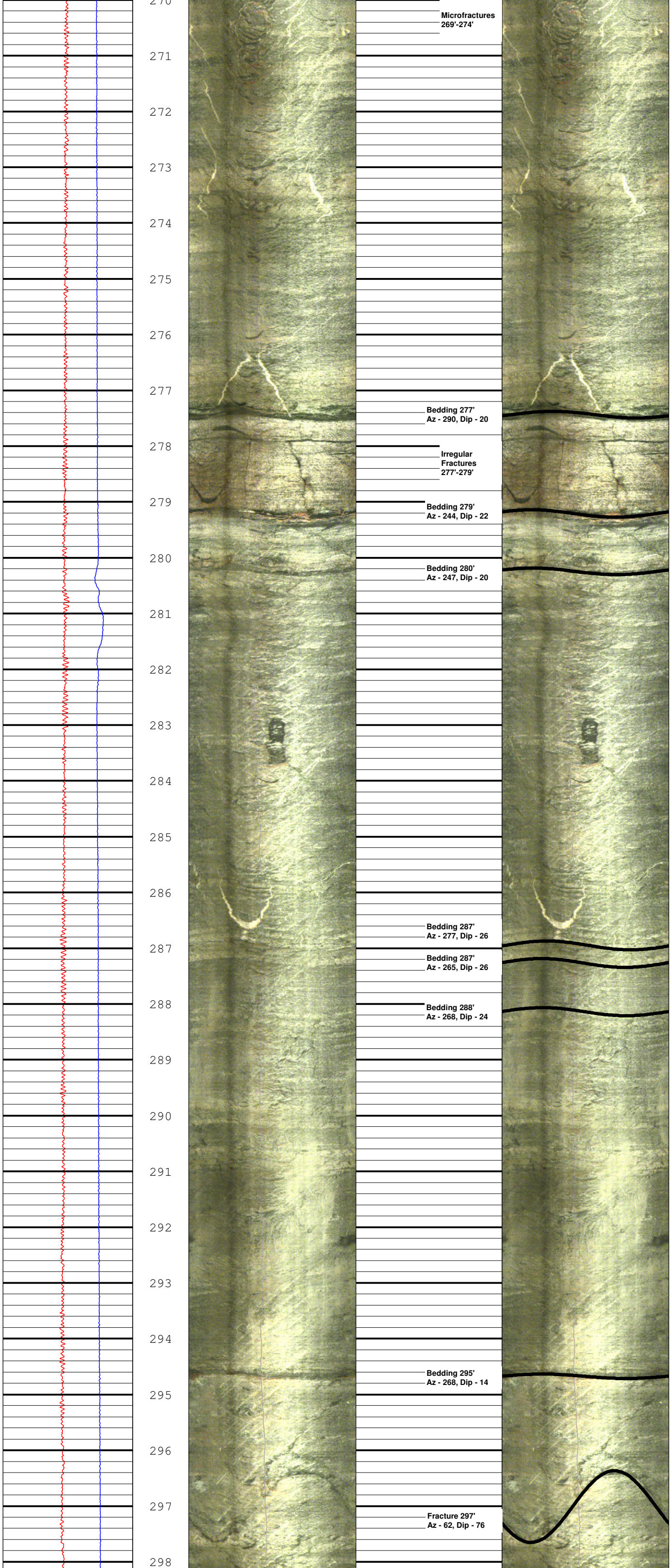
REMARKS:

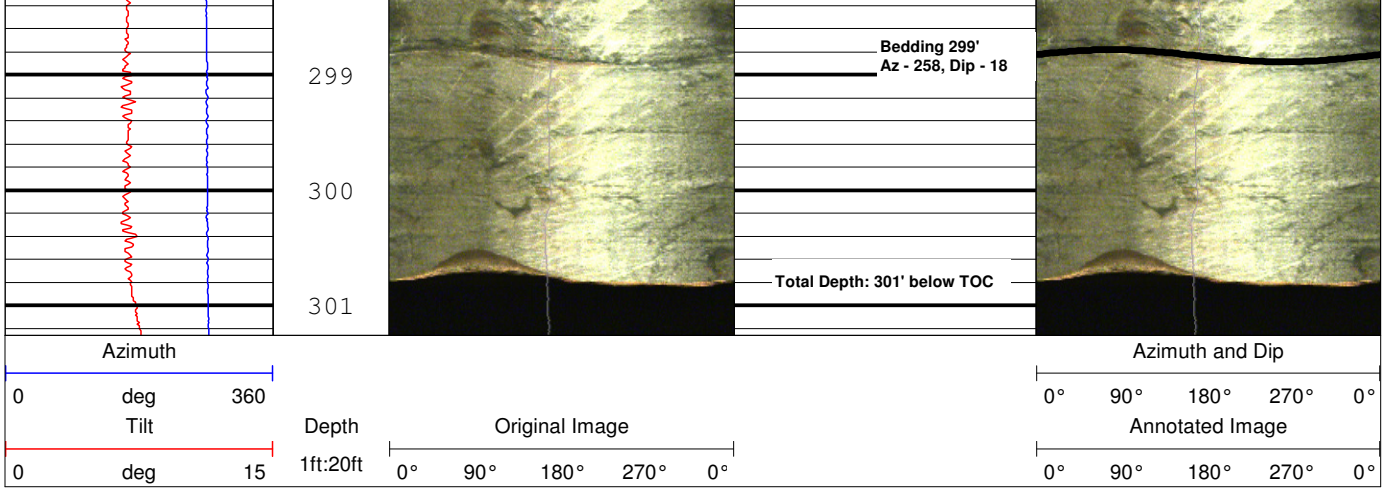


214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241




242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
Bedding 251'
Az - 265, Dip - 29
Bedding 252'
Az - 261, Dip - 29
Bedding 256'
Az - 254, Dip - 26
Bedding 257'
Az - 256, Dip - 26
Bedding 258'
Az - 263, Dip - 26
Bedding 258.5'
Az - 264, Dip - 24
Bedding 259'
Az - 265, Dip - 26
Bedding 260'
Az - 270, Dip - 26
Bedding 263'
Az - 221, Dip - 24
Bedding 264'
Az - 226, Dip - 29
Bedding 268'
Az - 253, Dip - 26


270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
Microfractures
269'-274'
Bedding 277'
Az - 290, Dip - 20
Irregular
Fractures
277'-279'
Bedding 279'
Az - 244, Dip - 22
Bedding 280'
Az - 247, Dip - 20
Bedding 287'
Az - 277, Dip - 26
Bedding 287'
Az - 265, Dip - 26
Bedding 288'
Az - 268, Dip - 24
Bedding 295'
Az - 268, Dip - 14
Fracture 297'
Az - 62, Dip - 76


299
300
301
Bedding 299'
Az - 258, Dip - 18
Total Depth: 301' below TOC
Azimuth
0
deg
360
Tilt
0
deg
15
Depth
1ft:20ft
Original Image
0°
90°
180°
270°
0°
Azimuth and Dip
0°
90°
180°
270°
0°
Annotated Image
0°
90°
180°
270°
0°

ADVANCED GEOLOGICAL SERVICES

3 Mystic Lane
Malvern. PA 19355
610-722-5500
610-722-0250 fax

Optical Televiewer Log

CO Groundwater Sciences, Inc.
WELL MW-145a
FLD Harley Davidson Site
CTY York
STE Pennsylvania
FILING No

CLIENT Groundwater Sciences, Inc.
WELL ID MW-145a
SITE
CITY York **STATE** Pennsylvania

LOCATION
SEC TWP RGE

OTHER SERVICES

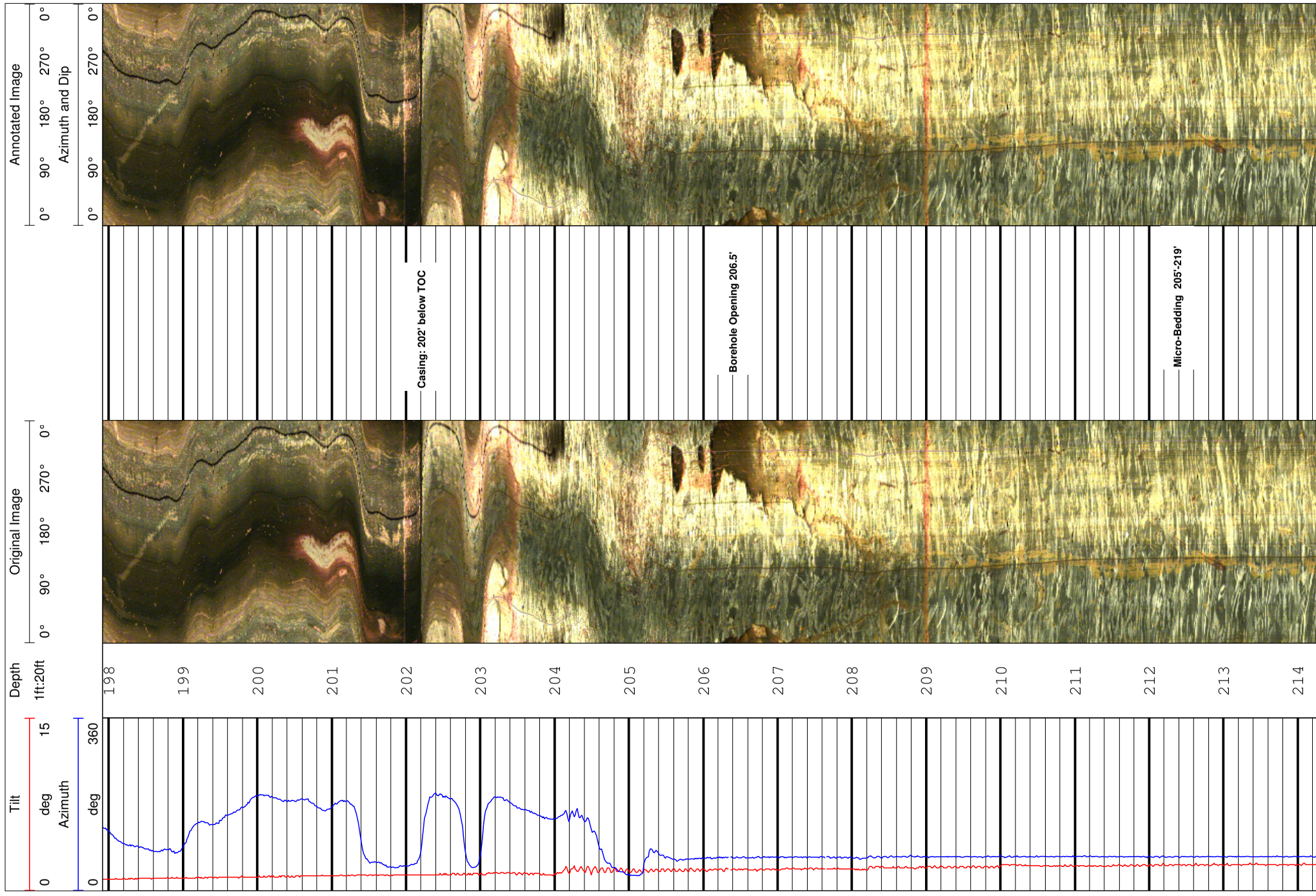
PERMANENT DATUM: _____ ELEVATION _____ K.B.

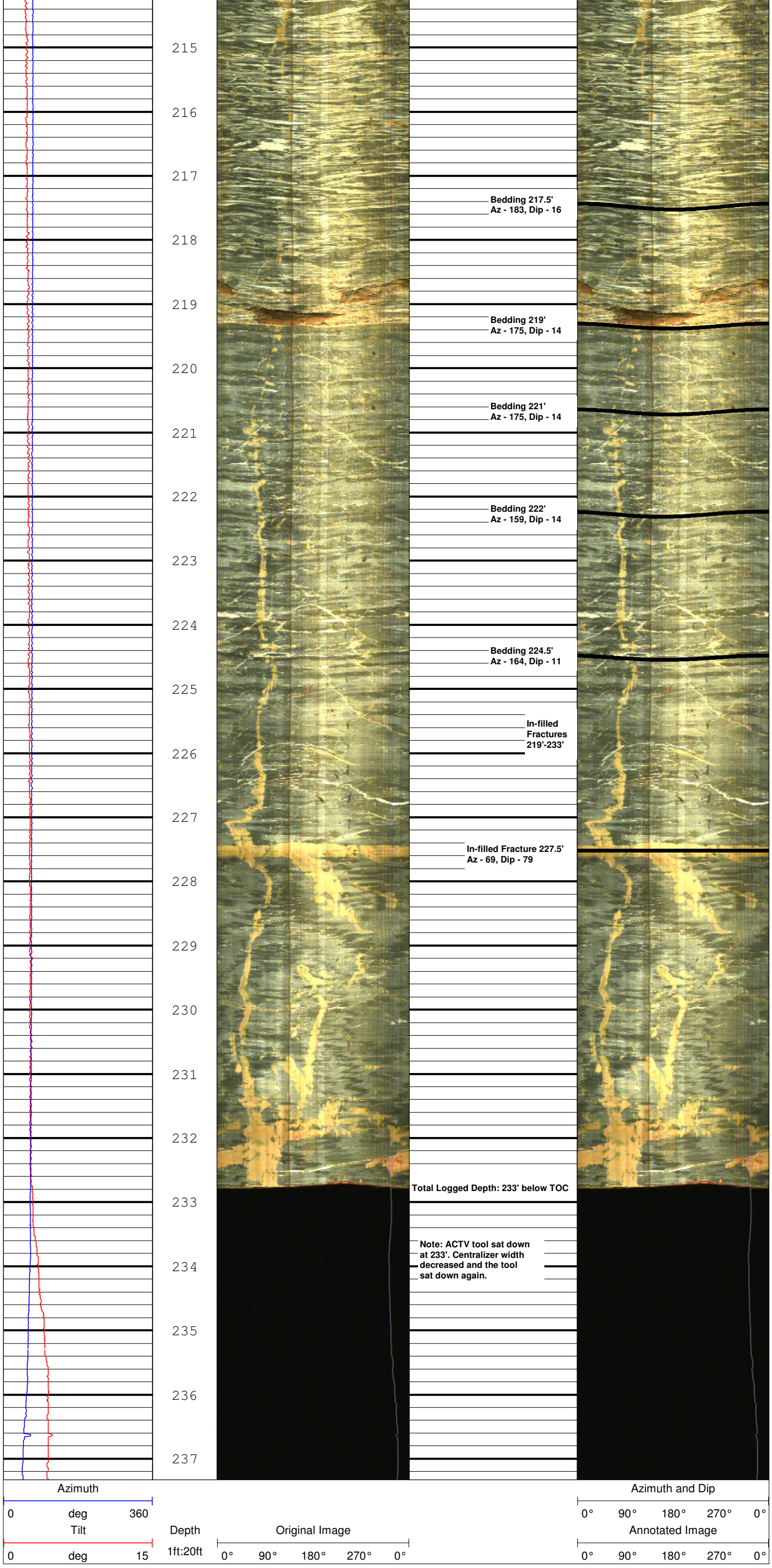
LOG MEAS. FROM: Top of Casing ABOVE PERM. DATUM _____ D.F.

DRILLING MEAS. FROM: _____ G.L.

DATE	January 7, 2013	TYPE FLUID IN HOLE	
RUN No		SALINITY	
TYPE LOG		DENSITY	
DEPTH-DRILLER		LEVEL	
DEPTH-LOGGER		MAX. REC. TEMP.	
BTM LOGGED INTERVAL	233 feet below TOC		
TOP LOGGED INTERVAL	202 feet below TOC		
OPERATING RIG TIME			
RECORDED BY	P. Miller		
WITNESSED BY			

REMARKS:




215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
Bedding 217.5'
Az - 183, Dip - 16
Bedding 219'
Az - 175, Dip - 14
Bedding 221'
Az - 175, Dip - 14
Bedding 222'
Az - 159, Dip - 14
Bedding 224.5'
Az - 164, Dip - 11
In-filled
Fractures
219'-233'
In-filled Fracture 227.5'
Az - 69, Dip - 79
Total Logged Depth: 233' below TOC
Note: ACTV tool sat down
at 233'. Centralizer width
decreased and the tool
sat down again.
Azimuth
0 deg 360
Tilt
0 deg 15
Depth
1ft:20ft
Original Image
0° 90° 180° 270° 0°
Azimuth and Dip
0° 90° 180° 270° 0°
Annotated Image
0° 90° 180° 270° 0°

ADVANCED GEOLOGICAL SERVICES

3 Mystic Lane
Malvern. PA 19355
610-722-5500
610-722-0250 fax

Optical Televiewer Log

CO Groundwater Sciences, Inc.
WELL MW-147a
FLD Harley Davidson Site
CTY York
STE Pennsylvania
FILING No

CLIENT Groundwater Sciences, Inc.
WELL ID MW-147a
SITE
CITY York **STATE** Pennsylvania

LOCATION
SEC TWP RGE

OTHER SERVICES

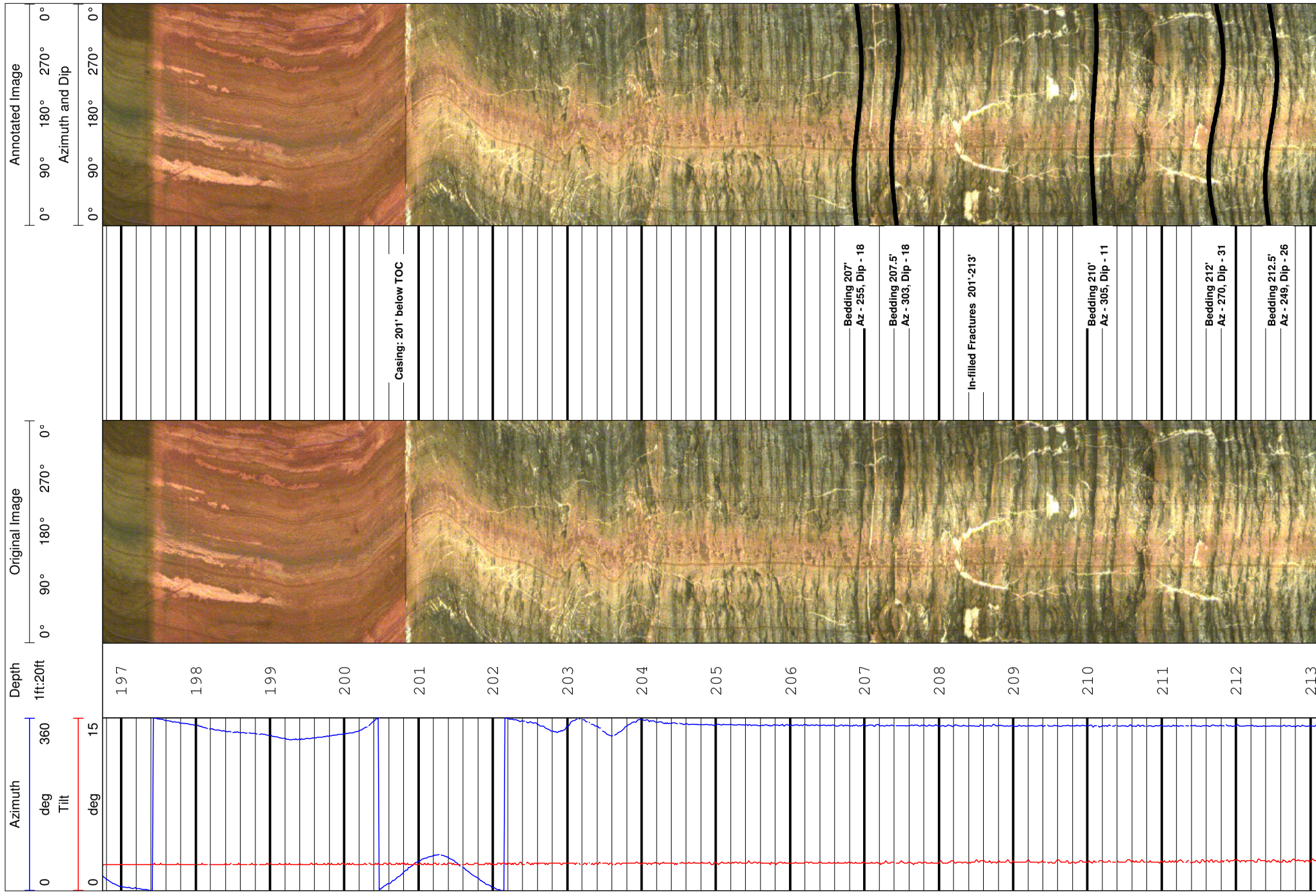
PERMANENT DATUM: ELEVATION K.B.

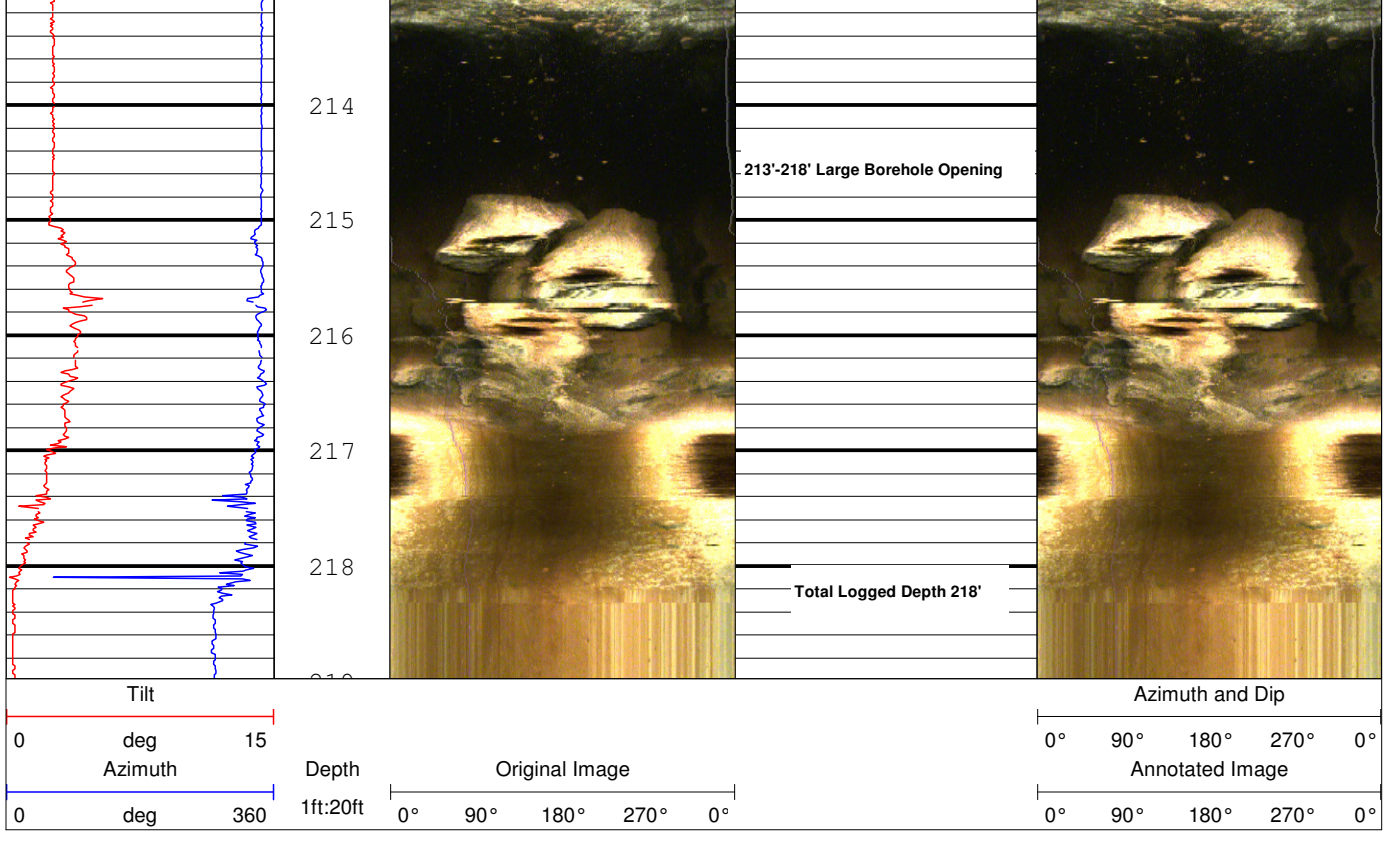
LOG MEAS. FROM: Top of Casing ABOVE PERM. DATUM D.F.

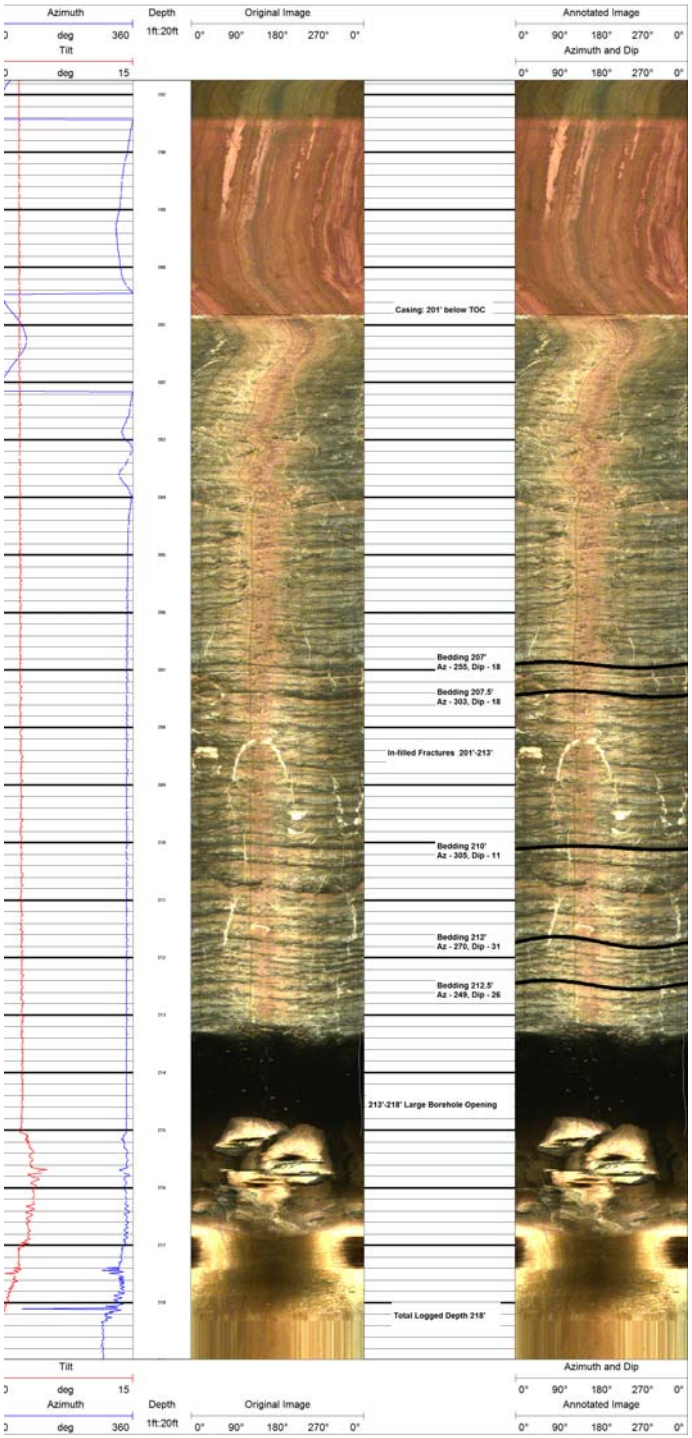
DRILLING MEAS. FROM: G.L.

DATE	January 7, 2013	TYPE FLUID IN HOLE	
RUN No		SALINITY	
TYPE LOG		DENSITY	
DEPTH-DRILLER		LEVEL	
DEPTH-LOGGER		MAX. REC. TEMP.	
BTM LOGGED INTERVAL	218 feet below TOC		
TOP LOGGED INTERVAL	201 feet below TOC		
OPERATING RIG TIME			
RECORDED BY	P. Miller		
WITNESSED BY			

REMARKS:




214
215
216
217
218
213'-218' Large Borehole Opening
Total Logged Depth 218'
Tilt
0 deg 15
Azimuth
0 deg 360
Depth
1ft:20ft
Original Image
0° 90° 180° 270° 0°
Azimuth and Dip
0° 90° 180° 270° 0°
Annotated Image
0° 90° 180° 270° 0°


Azimuth
deg
360
Tilt
deg
15
Depth
1ft:20ft
Original Image
0°
90°
180°
270°
0°
Annotated Image
Azimuth and Dip
Casing: 201' below TOC
Bedding 207'
Az - 255, Dip - 18
Bedding 207.5'
Az - 303, Dip - 18
In-filled Fractures 201'-213'
Bedding 210'
Az - 305, Dip - 11
Bedding 212'
Az - 270, Dip - 31
Bedding 212.5'
Az - 249, Dip - 26
213'-218' Large Borehole Opening
Total Logged Depth 218'