Appendix 6. Location, physical characteristics, borehole-geophysical logs and interpreted structures for well Gates 1.

The Gates Pond Site is located in Berlin, MA along I-495. There are four wells. The wells are approximately ±100 meters away from Gates Pond, which is the Town of Hudson, MA. The Town of Hudson commissioned the drilling of the wells in attempt to find a clean and sustainable groundwater source to augment their surface supplies. No such source was found so all four wells remain open. The wells produced five gallons per minute or less based on drillers pumping tests. Three wells were investigated for this study. They are named gates1.051507, gates2.062607 and gates3.071807.

The overburden material at the site is glacial till, with thicknesses less than 3 meters. The till is composed of a nonsorted, nonstratified matrix of sand with some clay, silt and boulders. The bedrock is schist of the Nashoba Formation. The Nashoba is a fine to medium grained, and well foliated, gray to silvery-gray quartz-mica schist that may contain biotite, garnet and sillimanite. All wells are cased approximately four meters into the bedrock.

The well gates1.051507 was the first well logged in this study. It was logged from May 15 through 18, 2007. Heat pulse flow meter tests were run on June 21, 2007. The well is reported to be 265 meters deep; however it was found to be only 179 meters deep. It is possible that that the lower 90 meters collapsed in the year between drilling and logging or the well has become otherwise obstructed. The well casing was approximately 7.3 meters in length with about 3 meters of glacial overburden. A total of 255 fractures were identified in this well. Of the total fractures 166 are tectonic joints, 26 are subhorizontal unloading joints and 63 are FPF.

The water table in the well was approximately 5.7 meters below ground surface. For the heat pulse flow meter testing, the well was pumped for three hours during which time the water level was drawn down 0.07 meters. Heat pulse flow meter testing revealed five flowing fractures at 19.0, 21.7, 25.0, 73.7, and 106.4 meters depth. Of the flowing fractures two are FPF, two are tectonic joints and one is subhorizontal.

Appendix 6, continued. Midpoint depth, strike and dip of features identified in optical televiewer log, fracture type and heat pulse flowmeter data from Gates 1 (azimuth and dip reported using right hand rule convention; t = tectonic fractures, s = sheeting joints, p = foliation parallel fractures). Flow data shown under pumping conditions have been normalized.

Site ID:	gates1.051507			
Location:	"Gates Pond I" Berlin, MA			
Elevation (m)	90			
Reported Yield (gpm)	5			
Rock Type:	Nashoba Formation Schist			
Depth to water:	18.67	ft	5.69	m
Depth of casing:	24	ft	7.32	m
Depth of well:	588	ft	179.22	m
Land surface to MP:	2.25	ft	0.69	m

Fractures						Ambient			Pump at 0.5 gpm		
number	depth (m)	depth (ft)	Azimuth	Dip	Type	Flow (y/n)	gpm	notes	Flow (y/n)	gpm	notes
1	7.70	25.3	247	60	p	n	0		n	0.50	
2	7.84	25.7	186	58	p	n	0		n	0.50	
3	8.00	26.3	192	30	p	n	0		n	0.50	
4	8.10	26.6	93	85	t	n	0		n	0.50	
5	9.71	31.9	22	20	s	n	0		n	0.50	
6	9.79	32.1	260	10	s	n	0		n	0.50	
7	10.12	33.2	140	59	t	n	0		n	0.50	
8	10.16	33.3	118	78	t	n	0		n	0.50	
9	10.19	33.4	132	58	t	n	0		n	0.50	
10	10.67	35.0	252	29	p	n	0		n	0.50	
11	10.83	35.5	334	70	t	n	0		n	0.50	
12	11.20	36.8	317	68	t	n	0		n	0.50	
13	12.18	40.0	88	75	t	n	0		n	0.50	
14	13.36	43.8	73	69	t	n	0		n	0.50	
15	13.95	45.8	238	73	p	n	0		n	0.50	
16	14.10	46.3	247	80	p	n	0		n	0.50	
17	14.49	47.6	84	24	s	n	0		n	0.50	
18	14.98	49.2	189	69	p	n	0		n	0.50	
19	15.34	50.3	199	70	p	n	0		n	0.50	
20	15.67	51.4	21	79	p	n	0		n	0.50	
21	15.71	51.5	187	70	p	y	-0.03	flow in	n	0.50	
22	15.93	52.3	186	76	p	n	-0.03		n	0.50	
23	16.36	53.7	190	71	p	n	-0.03		n	0.50	
24	17.04	55.9	40	75	t	n	-0.03		n	0.50	
25	17.61	57.8	71	72	t	n	-0.03		n	0.50	
26	18.36	60.2	140	11	s	n	-0.03		n	0.50	
27	18.96	62.2	256	57	p	n	-0.03		n	0.50	
28	19.03	62.5	260	65	p	n	-0.03		y	0.50	flow in
29	19.10	62.7	261	67	p	n	-0.03		n	0.22	
30	19.31	63.4	265	70	p	n	-0.03		n	0.22	
31	19.65	64.5	262	72	p	n	-0.03		n	0.22	
32	19.74	64.8	265	75	p	n	-0.03		n	0.22	
33	20.20	66.3	116	30	t	n	-0.03		n	0.22	
34	20.26	66.5	222	74	p	n	-0.03		n	0.22	
35	21.00	68.9	77	64	t	n	-0.03		n	0.22	
36	21.01	68.9	349	61	t	n	-0.03		n	0.22	
37	21.23	69.7	97	32	t	n	-0.03		n	0.22	
38	21.43	70.3	348	35	t	n	-0.03		n	0.22	
39	21.73	71.3	7	55	t	y	-0.17	flow in	y	0.22	flow in
40	22.27	73.1	193	70	p	n	-0.17		n	0.00	
41	22.87	75.0	193	78	p	n	-0.17		n	0.00	
42	22.96	75.3	6	25	s	n	-0.17		n	0.00	
43	23.72	77.8	272	85	t	n	-0.17		n	0.00	
44	24.09	79.0	17	72	t	n	-0.17		n	0.00	
45	25.00	82.0	323	47	t	n	-0.17		n	0.00	
46	25.05	82.2	331	45	t	y	-0.3	flow in	y	-0.09	flow in
47	25.87	84.9	336	45	t	n	-0.3		n	-0.09	
48	25.96	85.2	315	50	t	n	-0.3		n	-0.09	
49	27.73	91.0	111	76	t	n	-0.3		n	-0.09	
50	28.94	94.9	156	39	t	n	-0.3		n	-0.09	

Appendix 6, continued. Midpoint depth, strike and dip of features identified in optical televiewer log, fracture type and heat pulse flowmeter data from Gates 1 (azimuth and dip reported using right hand rule convention; t = tectonic fractures, s = sheeting joints, p = foliation parallel fractures). Flow data shown under pumping conditions have been normalized.

51	29.81	97.8	335	57	t	n	-0.3	n	-0.09
52	30.51	100.1	317	64	t	n	-0.3	n	-0.09
53	30.74	100.9	137	70	t	n	-0.3	n	-0.09
54	31.65	103.8	280	62	p	n	-0.3	n	-0.09
55	32.67	107.2	295	68	t	n	-0.3	n	-0.09
56	32.86	107.8	285	72	t	n	-0.3	n	-0.09
57	32.97	108.2	292	73	t	n	-0.3	n	-0.09
58	33.49	109.9	292	66	t	n	-0.3	n	-0.09
59	34.29	112.5	281	77	t	n	-0.3	n	-0.09
60	34.54	113.3	320	10	s	n	-0.3	n	-0.09
61	34.56	113.4	267	70	t	n	-0.3	n	-0.09
62	35.25	115.7	280	66	t	n	-0.3	n	-0.09
63	35.28	115.8	286	64	t	n	-0.3	n	-0.09
64	35.37	116.1	59	28	t	n	-0.3	n	-0.09
65	35.47	116.4	90	37	t	n	-0.3	n	-0.09
66	35.87	117.7	265	65	p	n	-0.3	n	-0.09
67	35.90	117.8	297	74	t	n	-0.3	n	-0.09
68	36.13	118.5	285	72	t	n	-0.3	n	-0.09
69	36.74	120.6	87	7	s	n	-0.3	n	-0.09
70	37.13	121.8	273	64	t	n	-0.3	n	-0.09
71	37.57	123.3	119	37	t	n	-0.3	n	-0.09
72	38.34	125.8	65	37	t	n	-0.3	n	-0.09
73	38.41	126.0	91	46	t	n	-0.3	n	-0.09
74	38.43	126.1	291	70	t	n	-0.3	n	-0.09
75	38.49	126.3	102	50	t	n	-0.3	n	-0.09
76	38.98	127.9	133	33	t	n	-0.3	n	-0.09
77	39.63	130.0	292	72	t	n	-0.3	n	-0.09
78	40.03	131.4	117	51	t	n	-0.3	n	-0.09
79	41.36	135.7	314	71	t	n	-0.3	n	-0.09
80	41.65	136.6	324	70	t	n	-0.3	n	-0.09
81	42.10	138.1	313	76	t	n	-0.3	n	-0.09
82	42.34	138.9	324	66	t	n	-0.3	n	-0.09
83	42.62	139.8	331	75	t	n	-0.3	n	-0.09
84	43.32	142.1	322	76	t	n	-0.3	n	-0.09
85	43.84	143.8	324	70	t	n	-0.3	n	-0.09
86	44.67	146.6	346	68	t	n	-0.3	n	-0.09
87	46.60	152.9	74	55	t	n	-0.3	n	-0.09
88	47.25	155.0	114	61	t	n	-0.3	n	-0.09
89	47.78	156.8	106	60	t	n	-0.3	n	-0.09
90	48.75	159.9	101	70	t	n	-0.3	n	-0.09
91	49.10	161.1	79	67	t	n	-0.3	n	-0.09
92	49.31	161.8	97	61	t	n	-0.3	n	-0.09
93	49.42	162.2	103	67	t	n	-0.3	n	-0.09
94	50.46	165.6	57	69	t	n	-0.3	n	-0.09
95	50.77	166.6	77	59	t	n	-0.3	n	-0.09
96	51.15	167.8	11	71	t	n	-0.3	n	-0.09
97	51.44	168.8	33	64	t	n	-0.3	n	-0.09
98	51.67	169.5	27	65	t	n	-0.3	n	-0.09
99	52.10	171.0	26	63	t	n	-0.3	n	-0.09
100	52.29	171.6	11	67	t	n	-0.3	n	-0.09
101	53.02	174.0	352	66	t	n	-0.3	n	-0.09
102	53.31	174.9	351	70	t	n	-0.3	n	-0.09
103	53.86	176.7	349	74	t	n	-0.3	n	-0.09
104	55.13	180.9	323	74	t	n	-0.3	n	-0.09
105	55.69	182.7	349	66	t	n	-0.3	n	-0.09
106	56.53	185.5	289	23	s	n	-0.3	n	-0.09
107	56.67	186.0	132	76	t	n	-0.3	n	-0.09
108	57.10	187.3	154	59	t	n	-0.3	n	-0.09
109	57.37	188.2	351	42	t	n	-0.3	n	-0.09
110	57.68	189.3	180	46	p	n	-0.3	n	-0.09
111	57.91	190.0	160	43	t	n	-0.3	n	-0.09
112	58.17	190.8	331	70	t	n	-0.3	n	-0.09
113	58.27	191.2	181	37	p	n	-0.3	n	-0.09
114	58.53	192.0	205	43	p	n	-0.3	n	-0.09

Appendix 6, continued. Midpoint depth, strike and dip of features identified in optical televiewer log, fracture type and heat pulse flowmeter data from Gates 1 (azimuth and dip reported using right hand rule convention; t = tectonic fractures, s = sheeting joints, p = foliation parallel fractures). Flow data shown under pumping conditions have been normalized.

115	58.83	193.0	2	26	t	n	-0.3		n	-0.09	
116	59.12	194.0	330	33	t	n	-0.3		n	-0.09	
117	65.19	213.9	291	58	t	n	-0.3		n	-0.09	
118	66.36	217.7	22	17	s	n	-0.3		n	-0.09	
119	66.64	218.6	285	62	t	n	-0.3		n	-0.09	
120	69.40	227.7	262	52	p	n	-0.3		n	-0.09	
121	72.44	237.7	92	35	t	n	-0.3		n	-0.09	
122	73.24	240.3	270	0	s	n	-0.3		n	-0.09	
123	73.70	241.8	222	21	s	y	0	flow out	y	0.00	flow out
124	73.75	242.0	83	60	t	n	0		n	0.01	
125	74.67	245.0	270	0	s	n	0		n	0.01	
126	74.79	245.4	75	64	t	n	0		n	0.01	
127	75.45	247.5	241	17	s	n	0		n	0.01	
128	75.50	247.7	71	50	t	n	0		n	0.01	
129	75.71	248.4	79	37	t	n	0		n	0.01	
130	75.98	249.3	235	60	p	n	0		n	0.01	
131	76.24	250.2	137	9	s	n	0		n	0.01	
132	76.35	250.5	206	41	p	n	0		n	0.01	
133	76.69	251.6	52	34	t	n	0		n	0.01	
134	76.86	252.2	33	66	t	n	0		n	0.01	
135	77.09	252.9	78	62	t	n	0		n	0.01	
136	77.17	253.2	30	66	t	n	0		n	0.01	
137	77.46	254.1	114	60	t	n	0		n	0.01	
138	77.62	254.7	14	60	t	n	0		n	0.01	
139	77.73	255.0	72	53	t	n	0		n	0.01	
140	77.78	255.2	251	57	p	n	0		n	0.01	
141	78.24	256.7	7	70	t	n	0		n	0.01	
142	78.39	257.2	58	39	t	n	0		n	0.01	
143	78.97	259.1	63	67	t	n	0		n	0.01	
144	79.36	260.4	87	55	t	n	0		n	0.01	
145	79.42	260.6	74	63	t	n	0		n	0.01	
146	79.95	262.3	73	47	t	n	0		n	0.01	
147	80.10	262.8	67	65	t	n	0		n	0.01	
148	80.69	264.8	322	35	t	n	0		n	0.01	
149	81.12	266.2	253	65	p	n	0		n	0.01	
150	81.23	266.5	85	46	t	n	0		n	0.01	
151	81.88	268.6	90	49	t	n	0		n	0.01	
152	82.18	269.6	93	53	t	n	0		n	0.01	
153	82.52	270.8	84	56	t	n	0		n	0.01	
154	82.97	272.2	103	43	t	n	0		n	0.01	
155	83.87	275.2	275	51	t	n	0		n	0.01	
156	83.98	275.5	186	7	s	n	0		n	0.01	
157	84.18	276.2	247	44	p	n	0		n	0.01	
158	84.93	278.7	284	63	t	n	0		n	0.01	
159	87.07	285.7	254	47	p	n	0		n	0.01	
160	87.50	287.1	223	39	p	n	0		n	0.01	
161	87.81	288.1	258	36	p	n	0		n	0.01	
162	88.53	290.5	165	49	p	n	0		n	0.01	
163	88.89	291.6	90	72	t	n	0		n	0.01	
164	89.16	292.5	90	60	t	n	0		n	0.01	
165	89.57	293.9	277	68	t	n	0		n	0.01	
166	89.85	294.8	240	57	p	n	0		n	0.01	
167	90.09	295.6	242	36	p	n	0		n	0.01	
168	90.77	297.8	86	51	t	n	0		n	0.01	
169	92.21	302.5	263	78	t	n	0		n	0.01	
170	92.43	303.3	270	73	t	n	0		n	0.01	
171	93.30	306.1	120	38	t	n	0		n	0.01	
172	94.05	308.6	78	29	t	n	0		n	0.01	
173	96.76	317.5	277	49	t	n	0		n	0.01	
174	98.16	322.1	60	29	t	n	0		n	0.01	
175	98.88	324.4	257	74	p	n	0		n	0.01	
176	99.32	325.9	73	42	t	n	0		n	0.01	
177	99.59	326.8	64	53	t	n	0		n	0.01	
178	99.63	326.9	242	78	p	n	0		n	0.01	

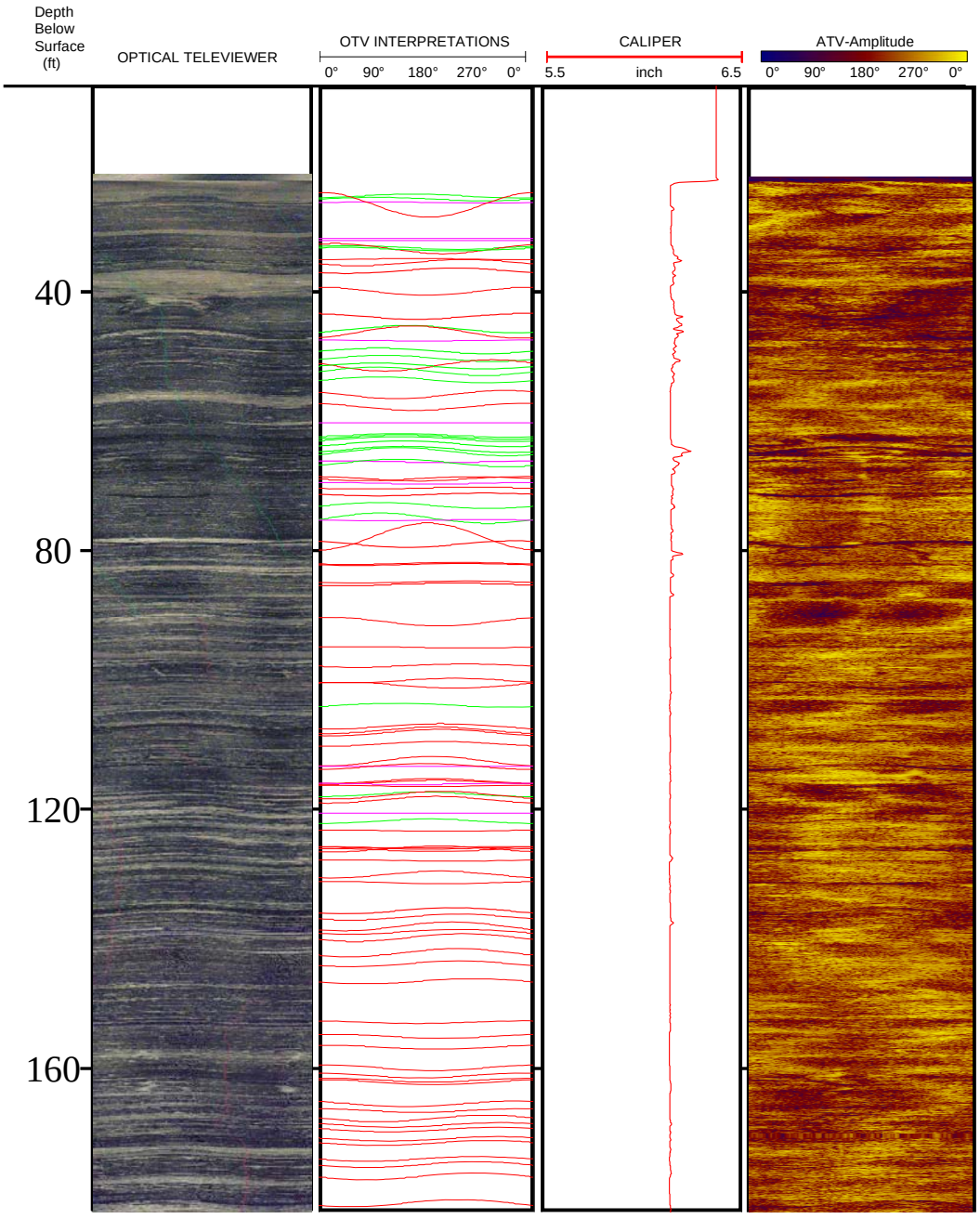
Appendix 6, continued. Midpoint depth, strike and dip of features identified in optical televiewer log, fracture type and heat pulse flowmeter data from Gates 1 (azimuth and dip reported using right hand rule convention; t = tectonic fractures, s = sheeting joints, p = foliation parallel fractures). Flow data shown under pumping conditions have been normalized.

179	101.82	334.1	234	75	p	n	0	n	0.01	
180	102.47	336.2	232	73	p	n	0	n	0.01	
181	103.85	340.7	239	61	p	n	0	n	0.01	
182	104.33	342.3	49	59	t	n	0	n	0.01	
183	104.66	343.4	62	54	t	n	0	n	0.01	
184	106.40	349.1	211	76	p	n	0	y	0.01	flow in
185	110.84	363.7	42	37	t	n	0	n	0.00	
186	111.48	365.8	204	75	p	n	0	n	0.00	
187	111.65	366.3	51	34	t	n	0	n	0.00	
188	112.47	369.0	315	10	s	n	0	n	0.00	
189	112.79	370.1	207	73	p	n	0	n	0.00	
190	114.68	376.3	234	28	p	n	0	n	0.00	
191	114.91	377.0	340	29	t	n	0	n	0.00	
192	115.06	377.5	14	42	t	n	0	n	0.00	
193	116.35	381.8	213	70	p	n	0	n	0.00	
194	116.85	383.4	269	28	p	n	0	n	0.00	
195	117.03	384.0	244	62	p	n	0	n	0.00	
196	117.47	385.4	327	21	s	n	0	n	0.00	
197	118.15	387.7	286	35	p	n	0	n	0.00	
198	118.67	389.4	346	32	t	n	0	n	0.00	
199	118.81	389.8	329	41	t	n	0	n	0.00	
200	118.99	390.4	35	31	t	n	0	n	0.00	
201	119.23	391.2	301	22	s	n	0	n	0.00	
202	120.02	393.8	304	44	t	n	0	n	0.00	
203	120.10	394.1	335	24	s	n	0	n	0.00	
204	120.57	395.6	267	21	s	n	0	n	0.00	
205	121.21	397.7	5	25	s	n	0	n	0.00	
206	121.80	399.6	261	23	s	n	0	n	0.00	
207	121.93	400.0	173	18	s	n	0	n	0.00	
208	122.58	402.2	136	16	s	n	0	n	0.00	
209	123.58	405.5	279	58	t	n	0	n	0.00	
210	124.04	407.0	296	59	t	n	0	n	0.00	
211	124.53	408.6	182	64	p	n	0	n	0.00	
212	124.67	409.0	260	12	s	n	0	n	0.00	
213	125.12	410.5	169	76	t	n	0	n	0.00	
214	125.28	411.0	275	54	t	n	0	n	0.00	
215	125.54	411.9	164	65	t	n	0	n	0.00	
216	125.71	412.4	28	8	s	n	0	n	0.00	
217	125.92	413.2	105	72	t	n	0	n	0.00	
218	126.26	414.3	159	81	t	n	0	n	0.00	
219	126.64	415.5	183	67	p	n	0	n	0.00	
220	126.82	416.1	160	48	t	n	0	n	0.00	
221	127.21	417.4	224	56	t	n	0	n	0.00	
222	127.99	420.0	130	73	t	n	0	n	0.00	
223	128.52	421.7	158	66	t	n	0	n	0.00	
224	129.54	425.0	171	43	p	n	0	n	0.00	
225	130.45	428.0	199	42	p	n	0	n	0.00	
226	131.55	431.6	313	77	t	n	0	n	0.00	
227	131.88	432.7	15	74	t	n	0	n	0.00	
228	132.43	434.5	173	69	t	n	0	n	0.00	
229	132.70	435.4	173	77	t	n	0	n	0.00	
230	132.93	436.1	166	77	t	n	0	n	0.00	
231	133.86	439.2	182	66	p	n	0	n	0.00	
232	134.55	441.5	164	67	t	n	0	n	0.00	
233	134.79	442.2	188	66	p	n	0	n	0.00	
234	136.73	448.6	196	69	t	n	0	n	0.00	
235	137.54	451.3	172	70	t	n	0	n	0.00	
236	138.42	454.2	180	69	p	n	0	n	0.00	
237	139.95	459.2	317	68	t	n	0	n	0.00	
238	140.16	459.9	318	75	t	n	0	n	0.00	
239	140.70	461.6	231	51	p	n	0	n	0.00	
240	145.29	476.7	267	69	p	n	0	n	0.00	
241	148.22	486.3	269	58	t	n	0	n	0.00	
242	149.36	490.1	286	42	t	n	0	n	0.00	

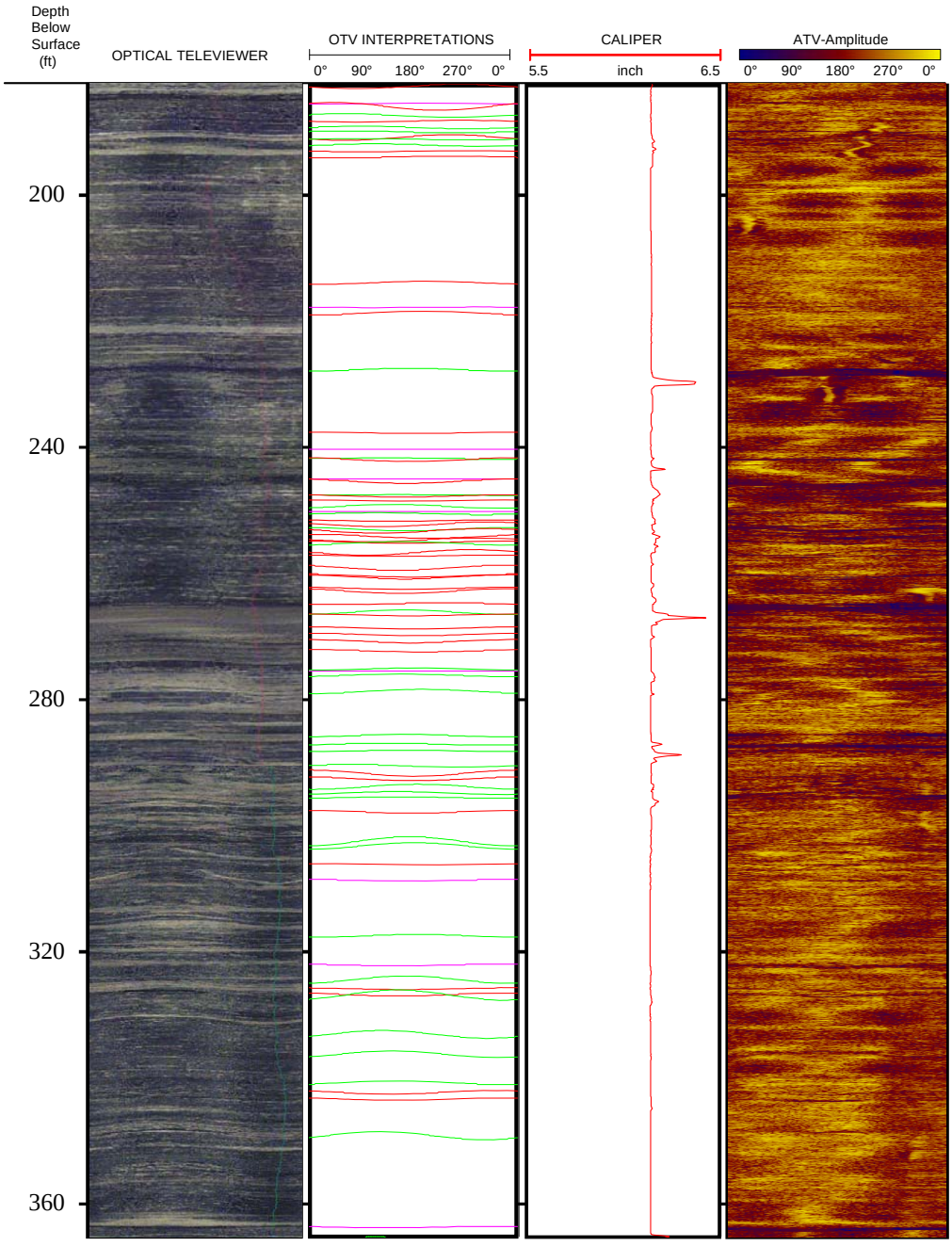
Appendix 6, continued. Midpoint depth, strike and dip of features identified in optical televiewer log, fracture type and heat pulse flowmeter data from Gates 1 (azimuth and dip reported using right hand rule convention; t = tectonic fractures, s = sheeting joints, p = foliation parallel fractures). Flow data under pumping conditions have been normalized.

243	149.47	490.4	285	44	t	n	0	n	0.00
244	150.03	492.2	273	63	t	n	0	n	0.00
245	151.16	496.0	303	53	t	n	0	n	0.00
246	154.89	508.2	264	71	t	n	0	n	0.00
247	155.31	509.6	276	70	t	n	0	n	0.00
248	157.01	515.1	257	64	p	n	0	n	0.00
249	157.38	516.4	275	58	t	n	0	n	0.00
250	161.06	528.4	273	69	t	n	0	n	0.00
251	161.37	529.4	80	75	t	n	0	n	0.00
252	161.91	531.2	263	52	p	n	0	n	0.00
253	163.30	535.8	326	86	t	n	0	n	0.00
254	163.75	537.3	148	76	t	n	0	n	0.00
255	166.32	545.7	218	54	p	n	0	n	0.00

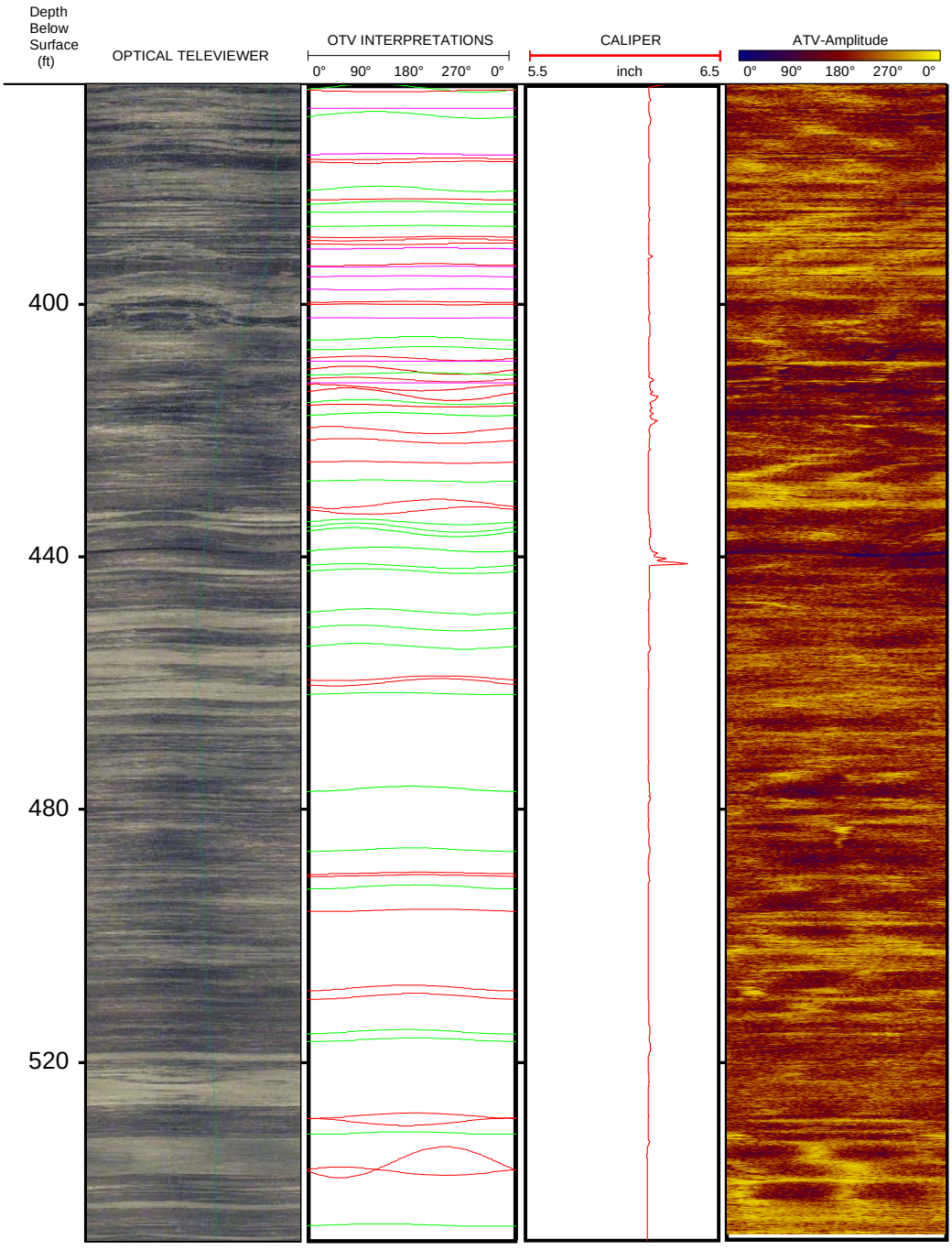
Appendix 6, continued. Interpreted features for Gates 1. Optical televiewer interpretations indicated by color: orange – subhorizontal sheeting joint; magenta – tectonic joint; red – foliation parallel fracture (FPF); cyan – transmissive subhorizontal sheeting joint; green – transmissive tectonic joint; grey – transmissive foliation parallel fracture (FPF). OTV – optical televiewer; ATV – acoustic televiewer.



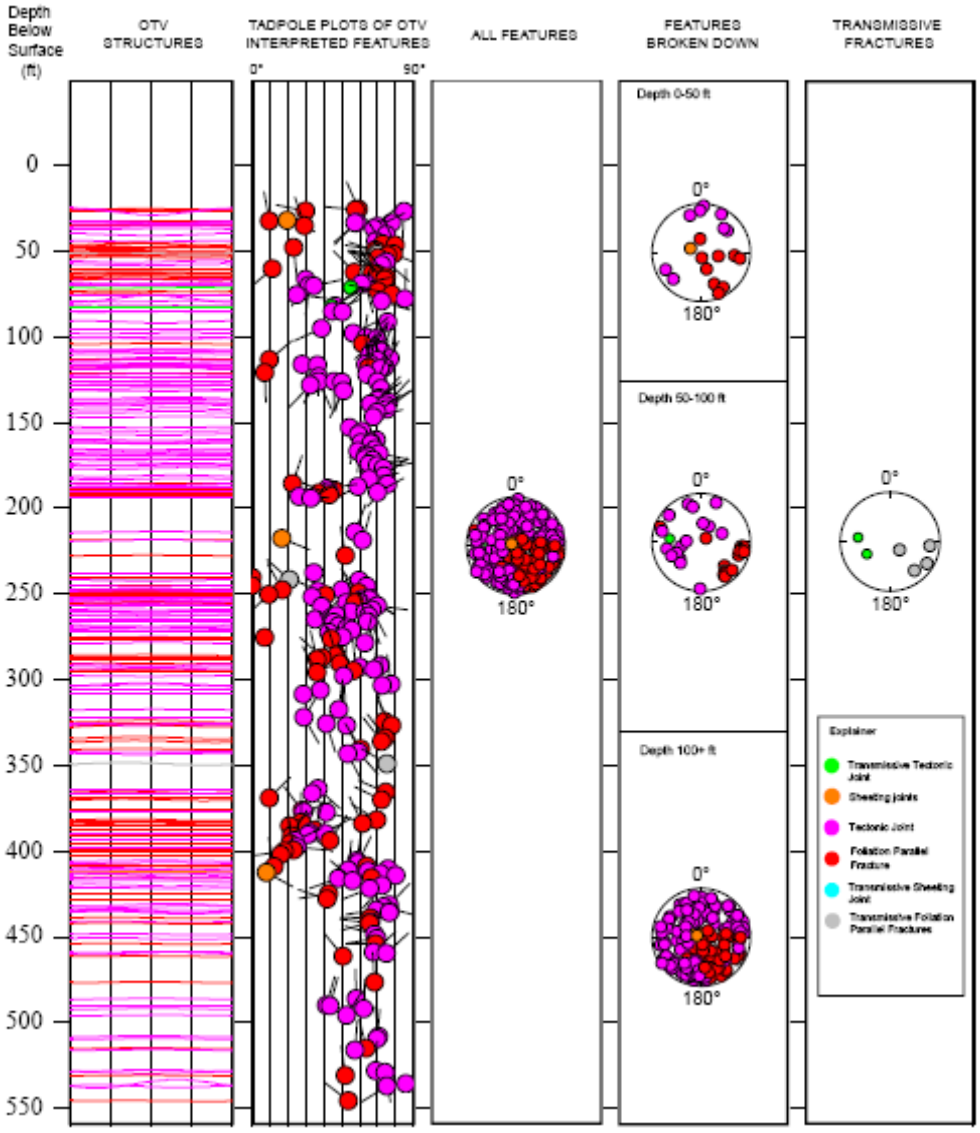
Appendix 6, continued. Interpreted features for Gates 1. Optical televiewer interpretations indicated by color: orange – subhorizontal sheeting joint; magenta – tectonic joint; red – foliation parallel fracture (FPF); cyan – transmissive subhorizontal sheeting joint; green – transmissive tectonic joint; grey – transmissive foliation parallel fracture (FPF). OTV – optical televiewer; ATV – acoustic televiewer.



Appendix 6, continued. Interpreted features for Gates 1. Optical televiewer interpretations indicated by color: orange – subhorizontal sheeting joint; magenta – tectonic joint; red – foliation parallel fracture (FPF); cyan – transmissive subhorizontal sheeting joint; green – transmissive tectonic joint; grey – transmissive foliation parallel fracture (FPF). OTV – optical televiewer; ATV – acoustic televiewer.



Appendix 6, continued. Tadpole plots and stereoplots of interpreted optical televiewer (OTV) structures for Gates 1. In the tadpole plot depth is plotted along the y-axis and magnitude of the dip plotted on the x-axis. The tail of the tadpole points in the direction of the dip, relative to true north, which is toward the top of the page. The stereonets represent poles to planar features plotted on a lower-hemisphere equal-area stereonet. Stereonets use right hand rule convention. Colors on the OTV structures plot correspond to those in the tadpole explanation.



Appendix 6, continued. Composite log for Gates 1 of natural gamma, fluid resistivity, fluid temperature and heat pulse flowmeter data under ambient and stressed (pumping) conditions. For the heat pulse flowmeter data collected under pumping conditions, the well was pumped at 0.5 gallons per minute and the data have been normalized.