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Construction and Installation Summary for Fiscal Year 1992 of the Hydraulic Head Monitoring Stations at Oak Ridge National Laboratory, Oak Ridge, Tennessee

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EXECUTIVE SUMMARY

During FY 1992, as part of the Hydraulic Head Monitoring Station (HHMS) Project, three multiport wells (HHMS 12, 13, and 14) were constructed along or near the boundaries of Waste Area Grouping (WAG) 2 at Haw Ridge water gap. The purpose of this report is to document well construction and multiport component installation activites.

The hydraulic head monitoring stations (HHMS) are well clusters and single multiport wells that provide data required for evaluation of the transition between shallow and deep groundwater systems and of the nature of these systems. This information is used for required characterization of the hydrologic framework as dictated by state and federal regulatory agencies. Groundwater contaminants may move laterally across WAG boundaries or offsite; they may also move in a vertical direction. Because the HHMS Project was designed to address otential contamination problems, the project provides a means for defining the bounds of the uppermost aquifer; identifying potential pathways for offsite contamination for shallow, intermediate, and deep groundwater flow; and evaluating the capacity for contaminant transport in intermediate and deep groundwater flow systems. Consequently, this project provides necessary background information required to perform risk assessments. To date, including activities described in this report, 14 HHMSs have been constructed throughout Melton Valley in and around the perimeters of WAGs 2, 4, 5, 6, 7, and 10.

Construction and installation activities for each FY 1992 HHMS consist of (1) coring to approximately 400 ft, (2) core logging, (3) acquiring borehole geophysical log data, (4) acquiring flowmeter data, (5) developing the multiport well design by using the data obtained from each borehole, and (6) installing a multiport system. Initially, in the 1985 and 1988 drilling phases, each HHMS was designed as a well cluster that contained three wells of varying depths. Because of problems in purging and associated recovery times as well as poor vertical resolution of hydraulic heads (Dreier and Toran 1989), it was decided that the HHMS design should be changed to a multiport system. Using this system, the FY 1992 HHMSs can provide from 7 to 10 vertically distributed water samples per well and very detailed hydraulic head profiles.

FY 1993 activities will include preparing the wells for sampling, collecting selected samples, collecting monthly and quarterly hydraulic head profiles, and running hydraulic conductivity tests on selected sampling zones. Data from these wells provide useful information for WAGs 2, 10, 5, and 4 and for the Oak Ridge National Laboratory groundwater operable unit remedial investigation.

1. INTRODUCTION AND BACKGROUND

During FY 1992, as part of the Hydraulic Head Monitoring Station (HHMS) Project, three multiport wells were constructed along or near the boundaries of Waste Area Grouping (WAG) 2. The purpose of this report is to document well construction and multiport component installation activites.

The hydraulic head measuring stations (HHMS) are well clusters and single wells that provide data required for evaluation of the transition between shallow and deep groundwater systems and of the nature of these systems. This information is used for required characterization of the hydrologic framework as dictated by state and federal regulatory agencies. Groundwater contaminants may move laterally across WAG boundaries or offsite; they may also move in a vertical direction. Because the HHMS Project was designed to address potential contamination problems, the project provides a means for defining the bounds of the uppermost aquifer; identifying potential pathways for offsite contamination for shallow, intermediate and deep groundwater flow; and evaluating the capacity for contaminant transport in intermediate and deep groundwater flow systems. Consequently, this project provides necessary background information required to perform risk assessments. To date, including activities described in this report, 14 HHMSs have been constructed throughout Melton Valley in and around the perimeters of WAGs 2, 4, 5, 6, 7, and 10. (Fig. 1).

Initially, in the 1985 and 1988 drilling phases, each HHMS was designed as a well cluster that contained three wells. The wells had 20 ft open intervals at depths of approximately 80 ft (the shallow well), 200 ft (the intermediate well), and 400 ft (the deep well). Because of problems in purging and associated recovery times as well as poor vertical resolution of hydraulic heads (Dreier and Toran 1989), it was decided that the HHMS design should be changed. The new design consists of a single well with multiple monitoring ports; it is described further in Sect. 4.

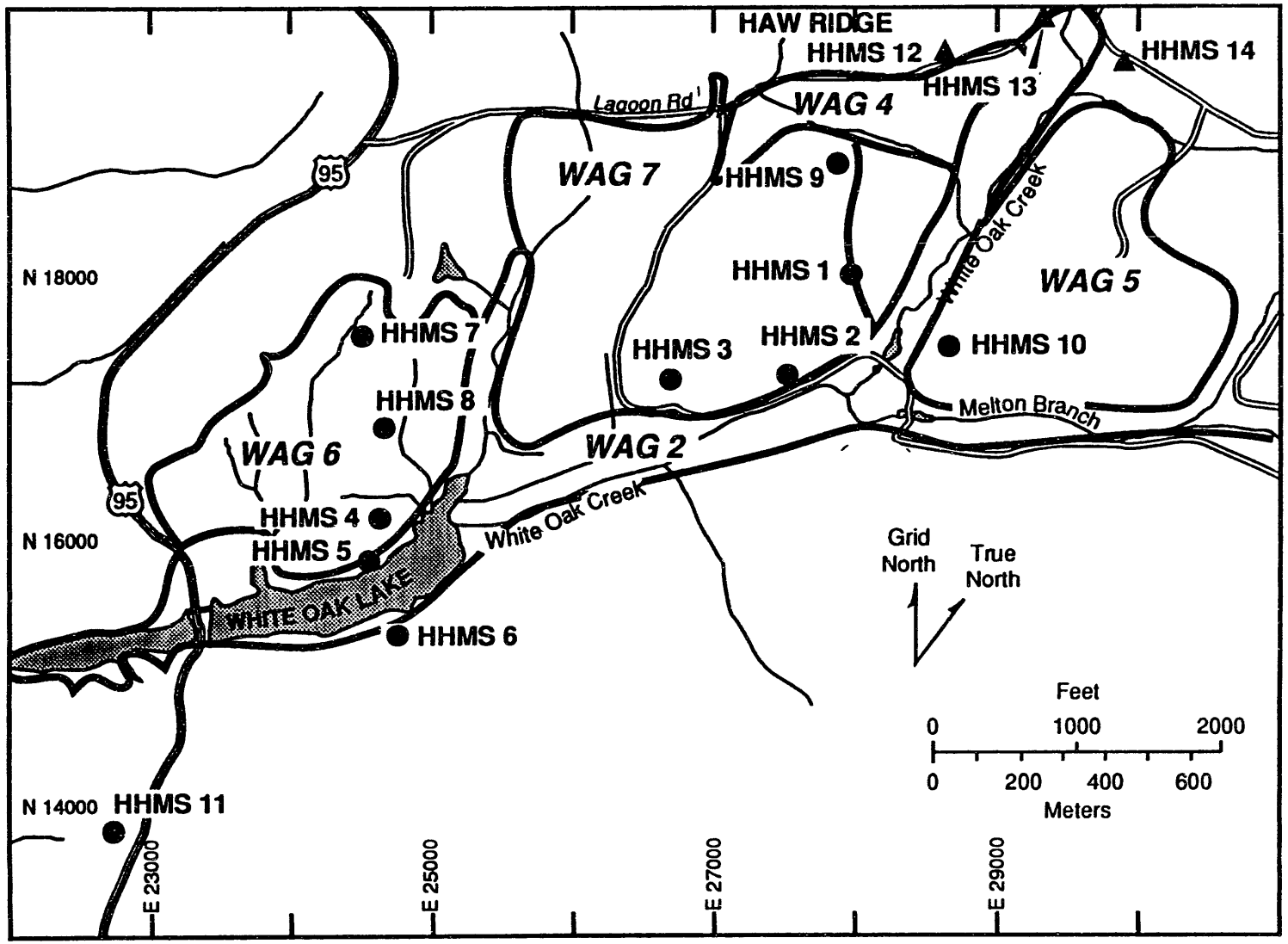

Fig. 1. Location of existing hydraulic head monitoring stations. Official ORNL well numbers are as follows: HHMS 1 = 927, 928, and 929; HHMS 2 = 930, 931, and 932; HHMS 3 = 933, 934, and 935; HHMS 4 = 936, 937, and 938; HHMS 5 = 939, 940, and 941; HHMS 6 = 942, 943, and 944; HHMS 7 = 945, 999, and 1000; HHMS 8 = 1001, 1002, and 1003; HHMS 9 = 1004, 1005, and 1006; HHMS 10 = 1007; HHMS 11 = 1008, 1009, and 1010; HHMS 12 = 4010; HHMS 13 = 4011; HHMS 14 = 4012

2. WELL DESIGN

2.1 LOCATION

The HHMSs constructed in FY 1992 (HHMS 12, 13, and 14) are located near the southern edge of Haw Ridge in the vicinity of White Oak Creek (Fig. 1). The locations for HHMSs 13 and 14 were chosen specifically so that they would straddle White Oak Creek along an approximate Oak Ridge National Laboratory (ORNL) grid-east trend. In addition, HHMSs 13 and 14 are as close as possible to the creek, but maintain a Category I location classification. Category I sites are those at which a low probablitiy for encountering radioactive contaminantion exists (Environmental Compliance Divison 1988). HHMS 12 was chosen specifically to be along-strike of HHMS 13 and 14 but at a greater distance from White Oak Creek. Thus, the three wells sample approximately the same stratigraphy but show different spatial relationships to White Oak Creek. Data collected from these HHMSs will provide information that complies with the overall objectives of the HHMS project:

- To spatially define the deep, intermediate, and shallow groundwater flow systems and to characterize interactions between these systems (HHMSs 12, 13, and 14).
- To characterize the boundary between the Bethel Valley and Melton Valley Groundwater Operable Units (HHMS 13).
- To characterize groundwater-surface water interactions near White Oak Creek (HHMSs 13 and 14).
- To characterize along-strike flow patterns under the influences of Haw Ridge and White Oak Creek (HHMSs 12, 13, and 14).
- To provide hydrostratigraphic information on the Pumpkin Valley Shale and Rome Formation (HHMSs 12, 13, and 14) and part of the Chickamauga Group (HHMS 13).
- To characterize the geologic structures that may be responsible for the orientation and location of White Oak Creek. The geologic features influence the hydrology of WAG 2 and may be an influence on WAG 10 hydrogeology (HHMSs 12, 13, and 14).

2.2 WELL CONSTRUCTION

Each FY 1992 HHMS consists of a single 3.65-in. corehole with 7-in.-OD surface casing installed at least 5 ft into competent rock. The boreholes were cored continuously from immediately below the surface casing to a total depth of around 400 ft. The sequence of work for the drilling contractor is specified in the work release given to Highland Drilling Co. by Construction Engineering. Well construction information is presented in Table 1, and coring activity logs for HHMSs 12, 13, and 14 are presented in Appendices A, B, and C, respectively. Construction activity at the three sites proceeded without incident except as noted here.

- For HHMS 13, an optional 4-in. casing was installed inside the 7-in. casing to guide the drill rods and to provide stability to the hole. The 4-in. casing was set at 44.5 ft.
- At a depth of 335 ft, HHMS 13 began producing water at a fairly continuous rate of approximately 25 gal/min. Discharge continued throughout the drilling of the borehole. The discharge water was screened for radiological contaminants and none were detected. HHMSs 12 and 14 also showed flowing artesian behavior; however, the flow rates were on the order of less than 5 gal/d and presented no drilling difficulties.

Table 1. Borehole construction information for Hydraulic Head Monitoring Stations 12, 13, and 14

HHMS 12		HHMS 13		MMHS 14	
11-in. casing*:	4.0 ft	11-in. casing*:	8.5 ft	11-in. casing*:	7.5 ft
7-in. casing*:	53.0 ft	7-in. casing*:	41.0 ft	7-in. casing*:	27.0 ft
4-in. casing*:	no	4-in. casing*:	44.5 ft	4-in. casing*:	no
Total depth:	400.2 ft	Total depth:	440.6 ft	Total depth:	430.0 ft
Grid system:	X-10	Grid system:	X-10	Grid system:	X-10
Northing:	19589.9 ft	Northing:	19964.0 ft	Northing:	19713.2 ft
Easting:	28650.4 ft	Easting:	29385.4 ft	Easting:	29792.7 ft
Ground surface elevation:	817.3 ft	Ground surface elevation:	783.3 ft	Ground surface elevation:	785.9 ft
Top of pad:	817.9 ft	Top of pad:	783.8 ft	Top of pad:	786.5 ft
Top of steel casing:	819.4 ft	Top of steel casing:	785.4 ft	Top of steel casing:	788.6 ft
Top of MP casing:	819.1 ft	Top of MP casing:	785.1 ft	Top of MP casing:	788.2 ft
Start date:	2/20/92	Start date:	2/7/92	Start date:	2/28/92
Finish date:	4/6/92	Finish date:	5/27/92	Finish date:	6/2/92
Official ORNL well no.	4010	Official ORNL well no.	4011	Official ORNL well no.	4012

*All casing depths measured from ground surface.

- The depth of HHMS 13 was extended to 440 ft so that it could sample Chickamauga Group rocks below the Copper Creek Thrust fault. Similarly, the total depth of HHMS 14 was extended to 430 ft so that a deformation zone also observed in HHMS 13 and associated with the Copper Creek Thrust Fault could be sampled.
- In HHMS 12, the borehole walls collapsed at a depth of 370 ft before the well could be geophysically logged. Subsequently, the well was reopened, and drill rods remained in the hole until installation of the multiport components. Thus, there are no geophysical logs between 370 and 400 ft.

3. HYDROGEOLOGIC DATA

As part of the total well design package, core samples were retrieved, described, and archived in Building 7042. In addition, geophysical logs were obtained from each borehole (Table 2). Lithologic and structural descriptions from these data are given for HHMSs 12, 13, and 14 in Appendices D, E, and F, respectively. Geologic correlations between boreholes were determined from this data. Figure 2 shows stratigraphic correlations between the wells as determined from the natural gamma ray log. All three boreholes begin in the Pumpkin Valley Shale and penetrate the Rome Formation. HHMS 13 totally penetrates the Rome Formation and extends through the deformation associated with the Copper Creek Thrust Fault into the underlying Moccasin Formation of the Chickamauga Group. Figure 3 shows a geologic map with cross section of the area near the FY 1992 HHMS. In this interpretation, which is consistent with available data, there is no high-angle White Oak Creek Fault parallel to the bed of White Oak Creek. Rather, observed displacements of stratigraphic units on either side of White Oak Creek are attributed to warping over discontinuous imbricate fault (horse) structures above the Copper Creek Thrust Fault. Additional descriptions of the stratigraphic units and geologic structure of the Oak Ridge area are given in Hatcher et al. (1992).

After geophysical logs were acquired from each well, an electromagnetic borehole flowmeter log was also run in each borehole. The flowmeter was recently developed and refined at the TVA Engineering Laboratory at Norris, Tennessee; general information on the flowmeter is given in Young et al. (1991). The flowmeter is used to indicate the depths at which water enters the borehole (presumably the locations of fractures). Water entering the borehole through a fracture contributes to the total flow measured in the borehole. By observing and measuring the vertical distribution of flow rate changes, it is possible to identify hydraulically active fractures. Flowmeter data collected for this project are given in Appendix G. Results from the flowmeter log were best for HHMS 12, and two fractures were identified from this well (Appendix G, HHMS 12 pump test). The flowmeter was of limited use for identifying or confirming the presence of suspected hydraulically active fractures for HHMSs 13 and 14. Because the flow rates of the artesian system at HHMSs 13 and 14 were greater than feasible injection or pump rates, the data from these boreholes show only the maximum depth of these large flow rates. Any additional flow contribution above these depths cannot be detected.

Table 2. Geophysical logs obtained from Hydraulic Head Monitoring Stations 12, 13, and 14[a]

Well	General logs	Nuclear logs	Electric logs	Other logs
HHMS 12	Caliper Deviation	Formation Compensated Neutron Natural gamma	Fluid resistivity SP[b] Single point resistance Long-short-normal resistivity	Full waveform sonic Temperature
HHMS 13	Caliper Deviation	Formation Compensated Neutron Natural gamma	Fluid resistivity SP Single point resistance Long-short-normal resistivity	Full waveform sonic Temperature
HHMS 14	Caliper Ceviation	Formation Compensated Neutron Natural gamma	Fluid resistivity Fluid conductivity SP Single point resistance Long-short-normal resistivity	Full waveform sonic Temperature

[a]Geophysical logs are stored in digital format at the ORNL geophysical log acquisition center, Building 3504.
[b]SP = self potential log.

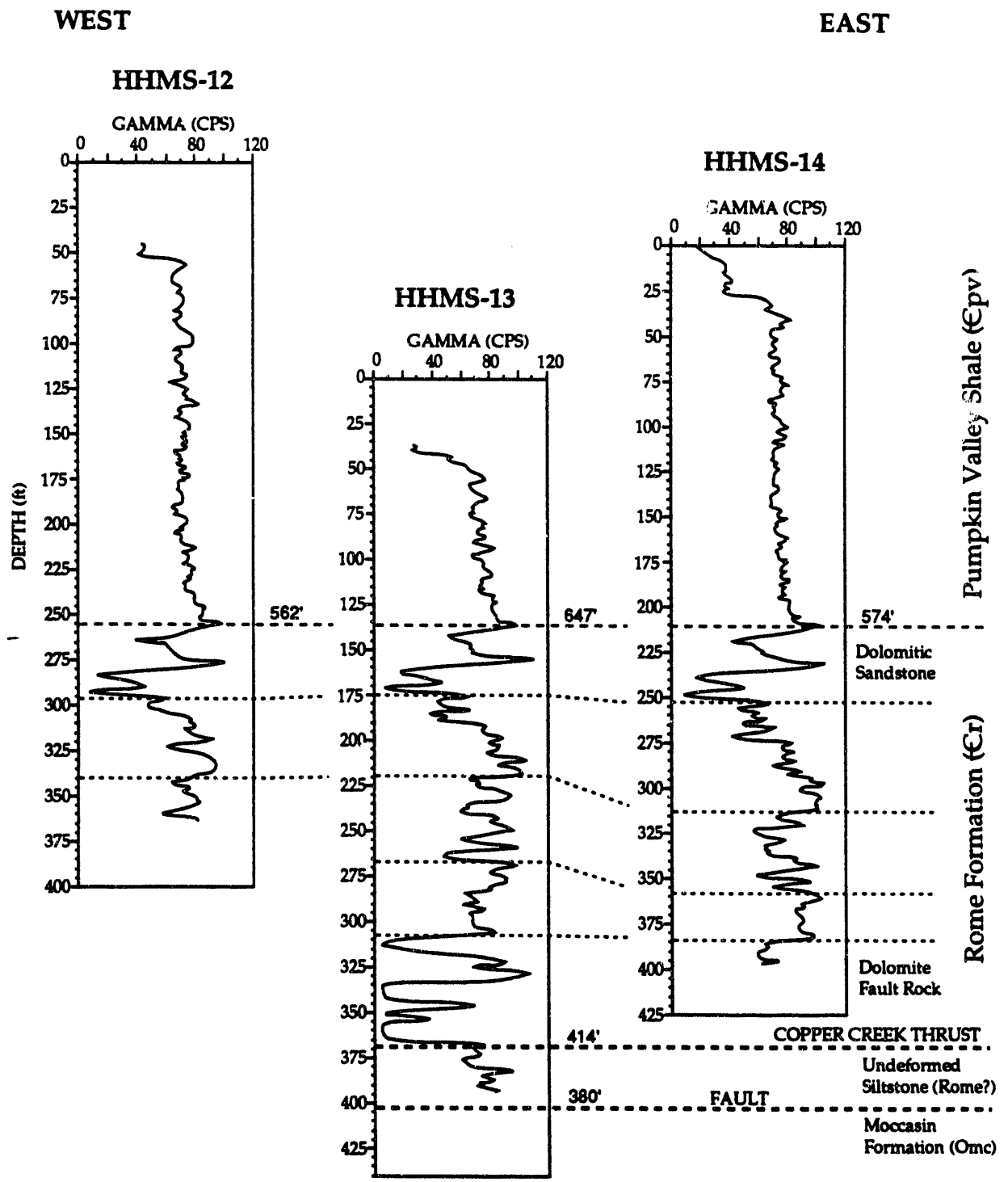

Fig. 2. Stratigraphic correlation between Hydraulic Head Monitoring Stations 12, 13, and 14. Cross section datum is to the top of the Cr. Elevations in feet above MSL are given for formation contacts and the Copper Creek Thrust.

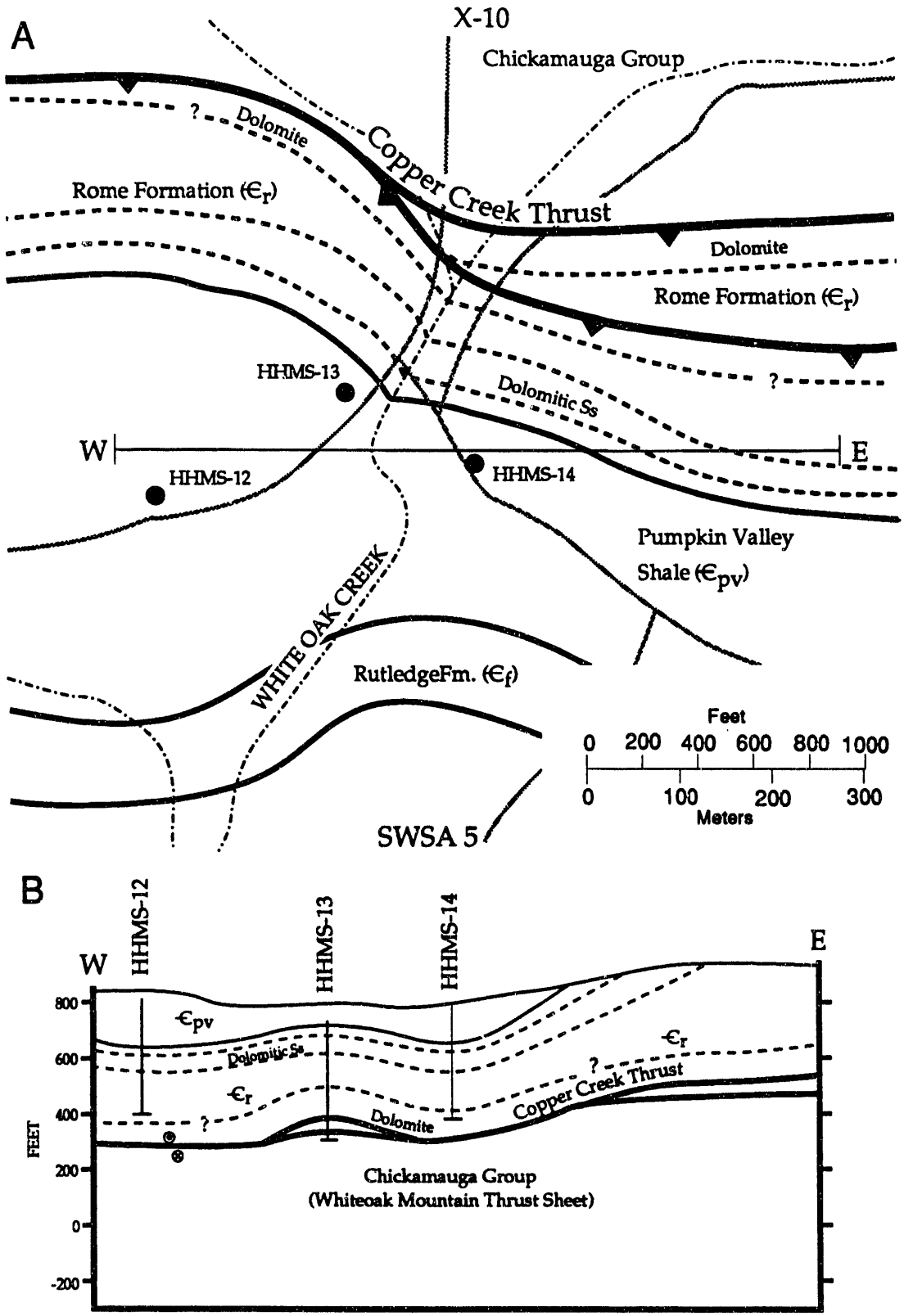

Fig. 3. Geologic map and cross section of area near Hydraulic Head Monitoring Systems 12, 13, and 14. Borehole data is projected into the line of section.

4. MULTIPORT DESIGN

The HHMS multiport wells use components designed by Westbay Co., Inc. Under this system, zones of interest are isolated from each other by a series of packers fitted around a 1.5-in.-diam polyvinyl chloride casing (Fig. 4). Within specified sampling zones, fluid pressure data and water samples are collected with specialized probes that are lowered to the zones of interest. The probes access the formation through a measurement port coupling in the MP casing. The sampling zones also contain a pumping port, which allows the interval to be purged.

On the basis of core samples, geophysical logs, and flowmeter results, seven to ten sampling zones, each 10 to 25 ft long, were selected in each well (Fig. 5). The zones were chosen for potential sampling of at least one of the following features: (1) fluids from fractures or fracture zones, (2) matrix fluids with long residence times, (3) potential changes in fluid chemistry with depth, (4) potential water chemistry signatures associated with a particular rock type, and (5) water chemistry correlations between wells. The sampling zones and rationales for choosing each zone are listed in Tables 3–5 for HHMSs 12, 13, and 14.

Fractures with the potential for hydraulic activity were initially identified during core examination by noting either the presence of chemical precipitation (such as the presence of euhedral crystal precipitates) or dissolution features on fracture surfaces. These data were then compared with geophysical log data and flowmeter results. Specifically, the fluid resistivity and flowmeter logs proved the most useful for identifying hydraulically active fractures. The fluid resistivity log showed several distinct jogs on the log signature, presumably the result of a fluid of different composition having entered the borehole through a fracture at the specified depth. Any sharp change in flow noted on the flowmeter log (Appendix G) was attributed to water entering the borehole through a fracture. Fractures identified from core as well as from flowmeter and fluid resistivity results also show a tube wave anomaly on the full-waveform sonic log; however, similar anomalies also occur that do not appear to correlate with water-producing fractures. Thus the sonic (and self potential logs) were used only as evidence of the presence of a fracture that had been identified by other means. A less reliable but locally successful (Dreier and Toran 1989) method of identifying fractures is through the use of cross plots. For this project, neutron/gamma ray and neutron/acoustic velocity cross plots were constructed, and potential zones of secondary porosity were identified. These are noted in Tables 3–5.

Stratigraphic and lithologic data were obtained primarily from core sampling and from the gamma ray and neutron geophysical logs. These data were then used to choose zones for sampling water chemistry associated with a particular rock type or rock unit and to compare water chemistry between wells that come from the same stratigraphic interval.

The sampling zones are isolated from each other by one to two additional zones containing measurement ports, from which only fluid pressure data are collected (Fig. 4). Although it is possible to obtain water samples from these zones, the zones do not contain pumping ports, and it is not possible to purge these intervals. Thus these zones have limited value for characterizing water chemistry. Through the use of data from both sampling and measurement zones, it is possible to acquire a very detailed hydraulic head profile (18–21 measurements) from each well. The multiport completion designs for HHMSs 12, 13, and 14 are included in Appendix H.

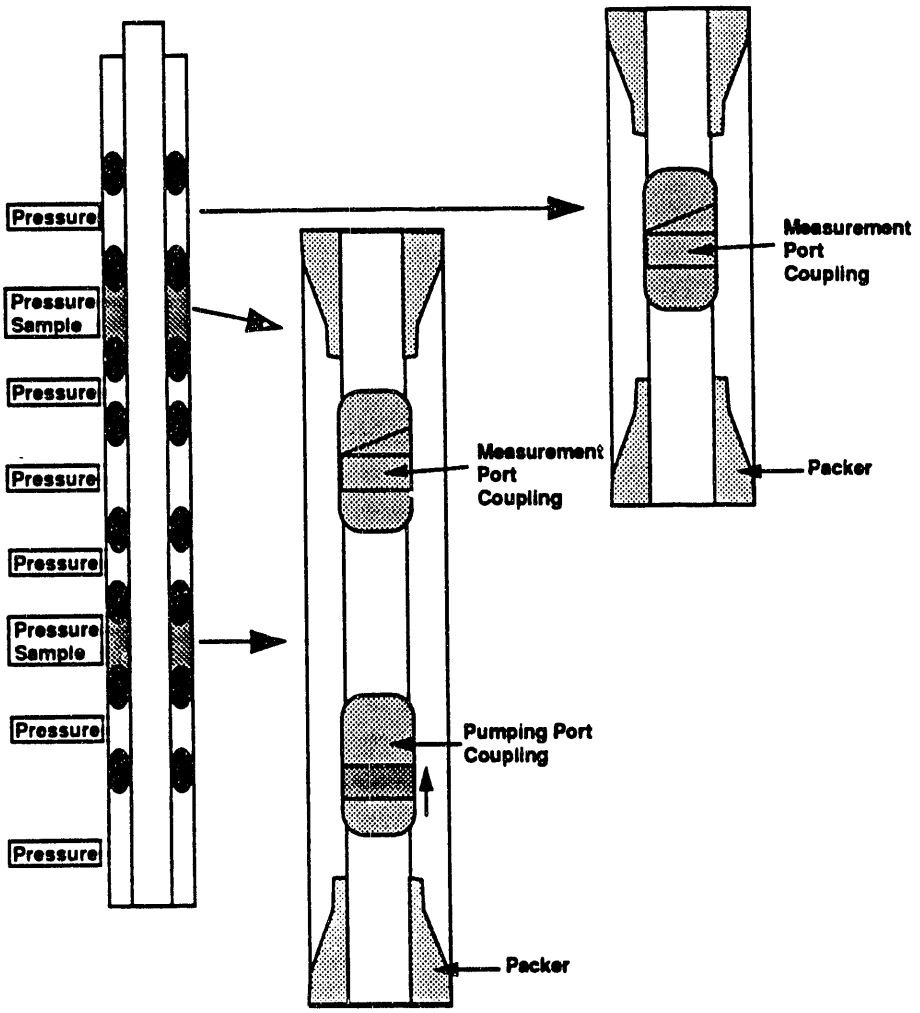

Fig. 4. Generalized multiport well design.

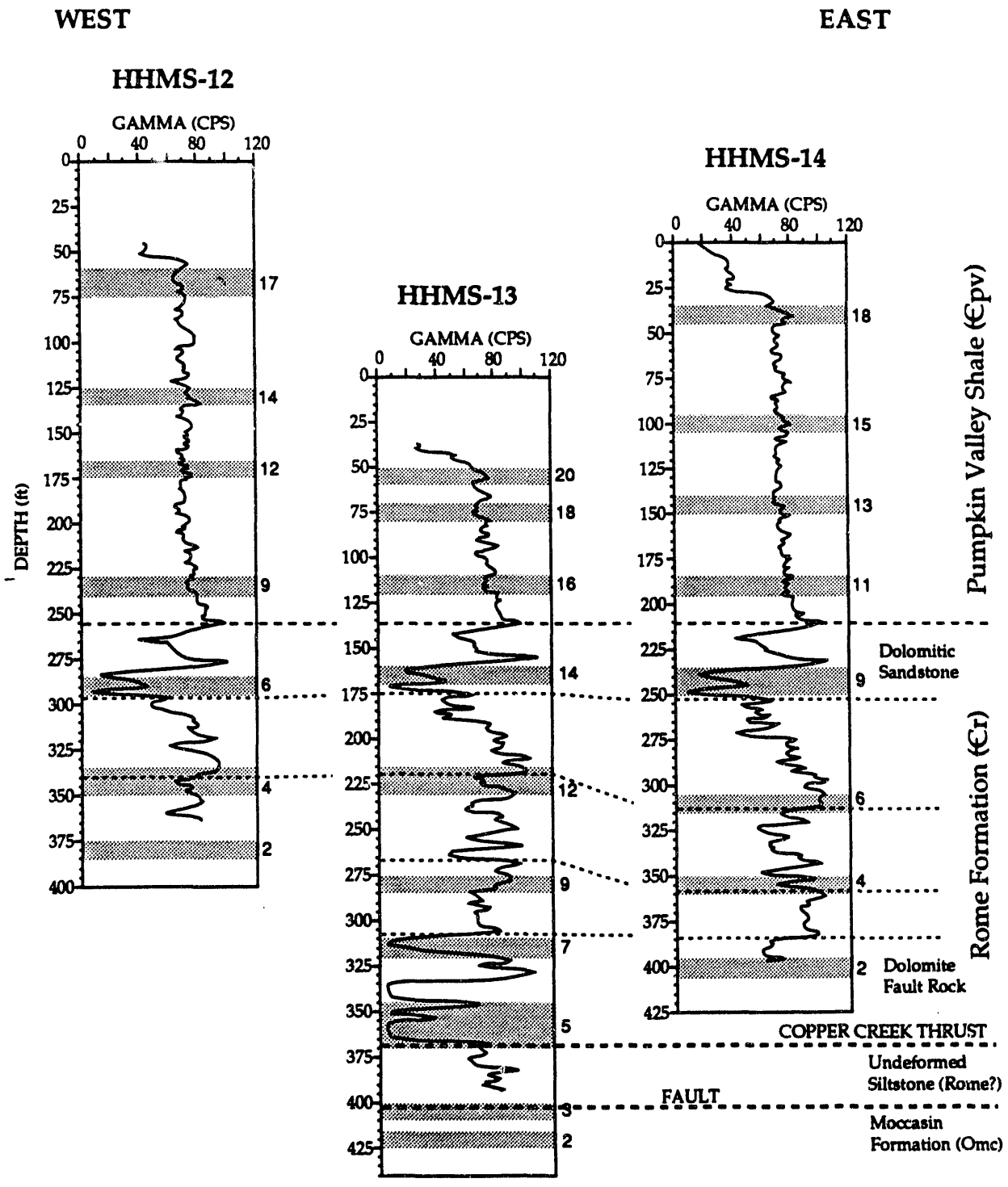

Fig. 5. Sampling zones for Hydraulic Head Monitoring Stations 12, 13, and 14. Shaded regions are sampling zones.

Table 3. Sampling zones for Hydraulic Head Monitoring Station 12

Zone[a]	Multiport zone[b]	Depth (ft)[c]	Samp. port	Purpose	Logs/Core
1	17	60–75	70	Sample top of well below casing. Permeable zone, fracture.	*core:* Red iron staining on fractures 67′ & 72′. *logs:* Sonic disrupted (permeable zone) 40–65′ caliper 68–72′. *flowmeter:* Shift between 69 & 70′.
2	14	125–135	130	Sample 2nd permeable zone (distinguishable from top zone by sonic character).	*core:* Broken core. *logs:* Sonic less broken, but still disrupted (still permeable?) 65–135′, relative high neutron/velocity x-plot log (permeable?).
3	12	165–175	170	Sample fault zone with evidence for dissolution.	*core:* Dissolution on fault 168 folded zone. Poor recovery near base of zone (175+′). *logs:* Sonic 170–175′, two high peaks neutron/velocity x-plot log (secondary porosity).
4	9	230–240	235	Sample base of Pumpkin Valley Sh. Also sampled in HHMSs 13a & 14. Largest caliper deflection in well.	*core:* Crush zone in shale. Gouge 233′ & 235′. *logs:* Sonic, 232–235′ caliper 232–235′ (may be tight?), temperature inflection at 240′, large! Neutron/velocity x-plot log high 230–235′ (secondary porosity).
5	6	285–295	290	Sample dolomitic Ss in same stratigraphic horizon as HHMSs 12 & 14. This is the source of artesian water in this well.	*core:* Cavities with crystals 288′, 293.5′, & 294′ cataclastic zone 294.2′. *logs:* Sharp fluid resistivity & conductivity change at 287′, started flowing artesian, temperature inflection 287′, gamma high in fault zone 285′, no sonic. Large variations in neutron/velocity x-plot log. *flowmeter:* Shift between 287′ & 290′.
6	4	335–350	342	Sample same horizon in HHMSs 13a & 14. Fault zone in shale (more extensive in this well). Appears tight in other wells, but evidence of water here. Also dolomitic Ss stringers in this well.	*core:* Crystals on fractures 345.8′, 346′, 346.2′, 347.5′, and 348.5′. Cataclastic zone 342′. Fault parallel to core 346–360+′. *logs:* Sonic 332–338′ (different place than crystals). Large variation in neutron/velocity x-plot log, low at top of zone highs around 340′. *flowmeter:* Shift between 343 & 345′.
7	2	375–385	380	Sample bottom of hole (equiv. to HHMS 13a).	*core:* Possible fault rock? *logs:* None—hole collapsed at 370′.

[a]Preliminary well monitoring zone number.
[b]Multiport zone number.
[c]Depth measured from ground surface, not corrected for borehole deviation.

Table 4. Sampling zones for Hydraulic Head Monitoring Station 13

Zone[a]	Multiport zone[b]	Depth (ft)[c]	Samp. port	Purpose	Logs/core
1	20	49–61	55	Sample fracture in stronger bioturbated portion of Pumpkin Valley Fm.	*core:* Broken portion (in chips). *logs:* Sonic disturbance from 45′–70′.
2	18	69–81	75	Add resolution to Pumpkin Valley samples.	*core:* Three fractures with crystals 74.4′, 74.6′, & 76.5′; change from shale to bioturbated. *logs:* Change in sonic character from permeable zone above to less below.
3	16	109–121	115	Sample fracture in lower Pumpkin Valley.	*core:* Gouge chips at 115′. *logs:* Caliper at 115′ along with sonic 114–116′. There is a change in sonic behavior between this zone and zone 1.
4	14	159–171	165	Sample dolomitic sandstone in upper Rome Fm. (same stratigraphic horizon as sampled in HHMSs 12 & 14).	*core:* Crystals on fractures 162′, 165′, & 167′. Fault zone w/ gouge 161′ and cataclasis 168–169′. *logs:* Gamma highs in fault zones, large changes in neutron/velocity x-plot log (low permeability? No sonic signature).
5	12	214–231	220	Sample near same horizon in HHMSs 12 & 14. Low permeability? Shale with faulting.	*core:* Faulted red shale, two fractures with dissolution at 225′ & 233′. Samples zone with fractured stringers of dol Ss in Sh. *logs:* Sonic 212–218′ along with weak caliper.and strong change in SP. Moderate negative shift from neutron/velocity x-plot log baseline (low permeability?).
6	9	274–286	280	Sample fracture (possible fault).	*core:* Zone of broken shale. *logs:* Caliper 278–281′, sonic 277–282′.
7	7	309–321	315	Sample same stratigraphic horizon as bottom of HHMS 14. Top of dolomite fault rock.	*core:* Fractures 316′ & 319′. Cataclastic dolomite. *logs:* Large rise in gamma at base (shale?). Relative high on neutron/velocity x-plot log (secondary porosity?).
8	5	344–371	350	Sample major fault zone/fracture (large water producing zone). Likely to be communicating with zone 7 since all in dol & sh fault rock.	*core:* Bottom of 60′ fault zone of fractured dolomite and lesser shale. vuggy dissolution in dolomite. Base of fault at 366′. *logs:* Caliper at 352′ and 362–365′, sonic at 348–355′ and 362–364′, large neutron/velocity x-plot lows 345–350′ and 360–363′. *flowmeter:* Produces 25.3 gpm at top of zone and 20.5 gpm at base of zone.
9	3	399–411	405	Sample fault zone below horse. See if this water is similar to zone 8 (fault rock), zone 10 (Omc) or both.	*core:* Numerous sites of disolution, vuggy 400–405′ in cataclastic zone. *logs:* No logs.
10	2	414–426	420	Sample bottom of well (Omc).	*core:* Limestone & shale (Omc) xtal at 424′. *logs:* No logs. *other:* Through base of Copper Creek Thrust and into Ordovician Mocassin Fm.

[a]Preliminary well monitoring zone number.
[b]Multiport zone number.
[c]Depth measured from ground surface, not corrected for borehole deviation.

Table 5. Sampling zones for Hydraulic Head Monitoring Station 14

Zone[a]	Multiport Zone[b]	Depth (ft)[c]	Samp. Port	Purpose	Logs/core
1	18	34–46	40	Sample top of hole at bottom of casing, permeable zone.	*core:* Broken core. *logs:* Sonic "broken" character to 60′ (permeable zone). Zone also present to 65′ on neutron/velocity x-plot log; has higher baseline (secondary porosity).
2	15	94–106	100	Sample 2nd permeable zone?	*core:* Shale/slstn. *logs:* Sonic: 2nd zone frequently broken 60–130′ (2nd permeable zone?).
3	13	139–151	145	Sample representative zone in Pumpkin Valley Shale.	*core:* Shale/slstn. *logs:* No sonic.
4	11	184–196	190	Sample base Pumpkin Valley and fault at 190′. Same sample horizon as HHMSs 12 & 13a.	*core:* Gouge 190′. *logs:* Sonic 187–190′, caliper 187–190′, high in neutron/velocity x-plot log (secondary porosity).
5	9	234–251	240	Sample base of dol. Ss, same stratigraphic horizon as HHMSs 12 & 13a.	*core:* Dissolution along fractures 241.5′, 243.5′, & 246′. Fault zone 247–251′. *logs:* No sonic, gamma high in fault zone, large SP change. High in neutron/velocity x-plot log (2nd porosity).
6	6	304–316	310	Sample possible tight zone (shale) near same stratigraphic horizon as HHMSs 12 & 13a zones.	*core:* Minor faulting in shale 313′. *logs:* Sonic 305–310 (shale?), SP? rise at base of zone.
7	4	349–361	355	Sample fault zone. This zone at same stratigraphic horizon as bottom of HHMS 12.	*core:* Cataclasite 357′. *logs:* Sonic 355–358′, SP drop at base of zone.
8	2	394–406	400	Sample top of dolomite fault rock (same horizon as zone in HHMS 13a). Flowing artesian water 396–425′.	*core:* Dissolution along fractures 390′ & 395′. Vugs in dolomite fault rock 395–398′ & 399–400′. Gouge 397′. *logs:* Sonic 395–?′, SP drop at top of zone. Sharp change in fluid resistivity & conductivity at 398′ (water produced here). *flowmeter:* Change in flow from 18.4 to 23.3 L/min between 400 and 405′.

[a]Preliminary well monitoring zone number.
[b]Multiport zone number.
[c]Depth measured from ground surface, not corrected for borehole deviation.

5. SUMMARY

In summary, during FY 1992, three wells have been constructed in the vicinity of WAG 2 that can provide from seven to ten vertically distributed water samples and very detailed hydraulic head profiles. FY 1993 activities will include preparing the wells for sampling, collecting selected samples, collecting monthly or quarterly hydraulic head profiles, and running hydraulic conductivity tests on selected sampling zones. Data from these wells provide useful information for WAGs 2, 4, 5, and 10 and the Bethel Valley and Melton Valley Groundwater Operable Unit remedial investigation.

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Appendix A

CONSTRUCTION ACTIVITY LOG FOR HHMS 12

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 12	3/19/92-4/9/92	John Switek	1 of 7

	Time	Depth (ft)		Recovery		
Run	End	From	To	Drilled	Footage	%	Comments
1	Mar 19, 1992	54.6	59.1	4.5	0.2	.04	**Pumpkin Valley Shale.** Vertical, high angle bedding
2		59.1	59.9	0.8	0.3	37	Vertical, high angle bedding
3	5:15	59.9	63.9	4.0	0.2	.05	Vertical, high angle bedding
4	Mar 20, 1992	63.9	67.1	3.2	2.8	87	Dip flattening, bioturbated zone=Lower P.V.
5	9:50	67.1	68.7	1.6	1.0	62	Shale and silt, high angle dip at bottom
6	11:07	68.7	72.9	4.2	2.1	50	
7	Mar 23, 1992	72.9	73.9	1.0	0.7	70	
8	9:50	73.9	78.9	5.0	5.1	102	Nice solid sticks, massive bedding
9		78.9	83.9	5.0	4.4	88	Nice solid sticks, massive bedding
10	1:40	83.9	87.6	3.7	1.1	30	Shale, broken up
11		87.6	89.2	1.6	1.4	87	Mixed shale and siltstone
12		89.2	93.1	3.9	3.4	87	Mixed shale and siltstone
13		93.1	93.9	0.8	0.6	75	Mixed shale and siltstone
14	5:05	93.9	97.1	3.2	3.3	103	Mixed shale and siltstone
15	Mar 24, 1992	97.1	99.8	2.7	2.5	89	Mixed shale and siltstone
16	9:45	99.8	100.7	0.9	0.8	89	All shale

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 12	3/19/92–4/9/92	John Switek	2 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
17		100.7 to 103.5	2.8	2.5	92	Mostly shale
18		103.5 to 108.6	5.1	5.1	100	Mostly shale
19		108.6 to 113.5	4.9	4.2	86	Mostly shale
20		113.5 to 117.5	4.0	3.0	75	Mostly shale
21		117.5 to 122.7	5.2	4.4	85	Shale and siltstone
22	4:58	122.7 to 123.5	0.8	0.7	87	Shale and siltstone
23	Mar 25, 1992	123.5 to 128.5	5.0	4.8	96	Shale and siltstone
24	10:25	128.5 to 131.7	3.2	1.8	86	Shale and siltstone
25		131.7 to 133.5	1.8	1.8	100	Shale
26	2:30	133.5 to 136.8	3.3	2.8	85	Shale and siltstone
27		136.8 to 139.8	3.0	2.65	95	Shale and siltstone
28	Mar 26, 1992	139.8 to 143.5	3.7	3.5	95	Bioturbated shale and siltstone
29		143.5 to 149.6	6.1	6.1	100	Bioturbated shale and siltstone
30		149.6 to 151.0	1.4	1.2	86	Bioturbated shale and siltstone
31		151.0 to 153.7	2.7	2.7	100	Bioturbated shale and siltstone
32		153.7 to 163.7	10.0	9.8	98	Bedded shale and siltstone
33		163.7 to 171.5	7.8	8.0	102	siltstone and shale

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 12	3/19/92-4/9/92	John Switek	3 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
34	Mar 27, 1992	171.5 to 172.0	0.5	0.2	40	Broken core
35		172.0 to 173.7	1.7	1.0	59	Bedded siltstone and shale
36		173.7 to 178.7	5.0	5.0	100	Bedded siltstone and shale
37		178.7 to 183.7	5.0	5.0	100	Bedded siltstone and shale
38	1:30	183.7 to 188.7	5.0	5.0	100	Bedded siltstone and shale
39		188.7 to 193.7	5.0	4.7	94	Bedded siltstone and shale
40		193.7 to 203.7	10.0	9.95	99.5	Bedded siltstone and shale. Massive bioturb sh/slt 195-200 feet
41	Mar 30, 1992 10:40	203.7 to 212.3	8.6	8.5	99	
42		212.3 to 213.7	1.4	1.4	100	Mostly shale
43		213.7 to 223.3	9.6	9.6	100	Solid core sticks, fractures near bottom
44	4:42	223.3 to 233.35	10.05	10.05	100	Mostly shale
45	Mar 31, 1992	233.35 to 239.6	6.25	6.0	98	Shale and siltstone
46		239.6 to 243.7	4.1	3.3	80	Mostly shale
47		243.7 to 248.7	5.0	4.0	80	Shale turning into shale/sandstone
48		248.7 to 250.8	2.1	2.1	100	Sandy siltstone and shale, broken
49	3:58	250.8 to 253.7	2.9	2.5	86	Sandy siltstone and shale

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 12	3/19/92-4/9/92	John Switek	4 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
50		253.7 to 258.3	4.6	4.8	104	Sandstone and shale, fault. **Rome Formation at 254.6 feet.**
51	Apr 1, 1992	258.3 to 259.2	0.9	0.9	100	Thin bedded sandstone and shale
52		259.2 to 259.3	0.1	0.1	100	Thin bedded sandstone and shale
53		259.3 to 263.7	4.4	4.4	100	Hard dolomitic sandstone
54		263.7 to 265.4	1.7	1.7	100	Hard dolomitic sandstone
55		265.4 to 265.6	0.2	0.2	100	Hard dolomitic sandstone
56	4:30	265.6 to 273.7	8.1	8.1	100	Hard dolomitic sandstone, some shale
57	Apr 2, 1992	273.7 to 281.8	1.9	1.75	92	Hard dolomitic sandstone, some shale
58		281.8 to 283.7	1.9	1.75	92	Hard dolomitic sandstone
59		283.7 to 287.9	4.2	4.5	107	Fractured dolomitic sandstone, broken
60	4:55	287.9 to 293.7	5.8	5.8	100	Fractured dolomitic sandstone, Crystal filled cavity at bottom.
61	Apr 3, 1992 10:33	297.3 to 300.0	6.3	6.1	97	Fractured dolomitic sandstone, Crystal filled cavity at top, crushed zones 294 & 299 feet

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 12	3/19/92-4/9/92	John Switek	5 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
62		300.0 to 300.1	0.1	0.1	100	Hard dolomitic sandstone
63	3:15	300.1 to 303.8	3.7	3.7	100	Hard dolomitic sandstone
64		303.8 to 310.0	6.2	5.7	92	Varigated sandstone and shale
65	Apr 6, 1992	310.1 to 310.9	0.9	0.5	55	Broken dolomitic sandstone fragments. Well making water over weekend, a trickle
66		310.9 to 311.4	0.5	0.8	160	Hard dolomitic sandstone
67		311.4 to 312.2	0.8	0.8	100	Hard dolomitic sandstone, gray, pink
68	11:00	312.2 to 312.6	0.4	0.4	100	Hard red sandstone
69		312.6 to 313.8	1.2	1.2	100	Hard red sandstone
70		313.8 to 316.9	3.1	2.6	84	Hard red siltstone/sandstone
71		316.9 to 320.2	3.3	2.9	88	Hard red siltstone/green shale, vertical bedding
72		320.2 to 323.8	3.6	3.4	94	Hard red siltstone/green shale, vertical bedding
73		323.8 to 331.9	8.1	8.3	102	Red sand/siltstone, top half. Bottom half green, cherty siltstone

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 12	3/19/92-4/9/92	John Switek	6 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
74		331.9 to 333.9	2.0	2.0	100	Green siltstone
75		333.9 to 337.6	3.7	2.6	70	Red and green siltstone/sandstone
76	4:55	337.6 to 340.6	3.0	3.2	107	Broken red siltstone
77		340.6 to 341.9	1.3	1.0	77	Broken sandstone and shale
78		341.9 to 344.0	2.1	2.1	100	Red sandstone
79	1:18	344.0 to 349.1	5.1	5.1	100	Red sandstone, broken, high angle parting
80	1:55	349.1 to 349.8	0.7	0.5	71	Red sandstone/siltstone broken.
81		349.8 to 354.0	4.2	4.4	105	Red sandstone-Green sandstone on either side of vertical fault. Green sandstone only at bottom
82	4:25	354.0 to 360.5	6.5	6.5	100	Red sandstone-Green sandstone on either side of vertical fault to357.2
83		360.5 to 364.0	3.5	3.6	103	Green sandstone/fault gouge/red sandstone
84	9:35	364.0 to 374.0	10.0	9.9	99	Red, pink, grey sandstone

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 12	3/19/92-4/9/92	John Switek	7 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
85		374.0 to 381.0	7.0	7.1	101	Grey sandstone and grey shale, High angle fault 1.3 ft
86		381.0 to 384.0	3.0	3.1	103	Grey sandstone 1.5ft, grey shale 1.6 ft.
87		384.0 to 393.6	9.6	9.6	100	Grey homogenous mudstone with sand beds and stringers
88	4:56	393.6 to 400.2	6.6	6.7	101	Grey homogenous mudstone with sand beds and stringers
TD	TD	TD	TD	TD	TD	Total depth of well. End of log

Appendix B

CONSTRUCTION ACTIVITY LOG FOR HHMS 13

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 13	2/21/92-3/13/92	John Switek	1 of 7

	Time	Depth (ft)		Recovery		
Run	End	From	To	Drilled	Footage	%	Comments
1		42.0	44.5	2.5	1.15	60	Pumpkin Valley Shale. Started late Feb. 21 only 1 run
2	Feb 24, 1992	44.5	48.5	4.0	1.0	25	Feb 24. Sandbagging hole
3		48.5	54.5	6.0	0.2	.03	Core very broken up
4		54.5	64.5	10.0	0	0	No recovery
5		64.5	66.5	2.0	1.48	74	
6		66.5	69.2	2.7	2.45	94	
7	3:15	69.2	74.5	5.3	4.5	85	
8	3:45	74.5	77.0	2.5	2.5	100	Core still broken but better recovery
9	4:47	77.0	84.5	7.5	7.35	98	Good core massive rock
10	5:28	84.5	86.8	2.3	2.1	91	Good core
11	10:00 Feb 25, 1992	86.8	92.5	5.7	5.5	96	Water pump problems, 1 pull in AM
12		92.5	93.4	0.9	0.3	33	
13		93.4	94.5	1.1	0.4	36	
14		94.5	100.7	6.2	5.9	95	
15	1:00	100.7	104.5	3.8	4.8	126	
16		104.5	105.7	1.2	1.0	83	

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 13	2/21/92-3/13/92	John Switek	2 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
17		105.7 to 109.5	3.8	3.5	92	
18	5:00	109.5 to 112.6	3.1	3.0	97	Water overflowing pit because of rain
19	Feb 26, 1992	112.6 to 114.5	1.9	1.65	87	Talked w/Bob Werner re core recovery and containment
20		114.5 to 119.5	5.0	4.0	80	
21		119.5 to 123.8	4.3	4.25	98	
22		123.8 to 125.2	1.4	1.4	100	
23		125.2 to 129.1	3.9	3.8	97	
24	4:15	129.1 to 131.9	2.8	2.8	100	Mushroom plunger fell off rig, running w/out it
25		131.9 to 133.8	1.9	1.66	87	
26	Feb 27, 1992	133.8 to 136.8	3.0	3.0	100	Spent 1 hr 15 minutes getting new mushroom plunger on rig
27		136.8 to 137.1	0.3	0.4	133	Pulled rods and changed bit
28	1:22	137.1 to 143.6	6.5	6.5	100	Sandstone core **Rome Formation at 137.5 feet.**
29	4:10	143.6 to 149.1	5.5	5.5	100	
30	Feb 28, 1992	149.1 to 154.4	5.3	5.3	100	
31		154.4 to 155.3	0.9	0.9	100	

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 13	2/21/92-3/13/92	John Switek	3 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
32	9:40	155.3 to 158.0	2.7	2.7	100	
33		158.0 to 163.5	5.5	5.4	98	
34		163.5 to 164.7	1.2	1.3	108	Open fractures in sandstone
35		164.7 to 169.2	4.5	4.5	100	Blew hose on core extruder
36	2:40	169.2 to 174.7	5.5	5.5	100	
37	Mar 2, 1992	174.7 to 182.9	8.4	8.2	98	fault gouge ? at bottom
38	9:32	182.9 to 184.5	1.6	1.5	90	
39		184.5 to 189.3	4.8	4.8	100	
40		189.3 to 192.3	3.0	2.8	93	
41		192.3 to 194.3	2.0	1.9	95	Reddish sandstones
42		194.3 to 197.5	3.2	3.3	103	
43	3:05	197.5 to 200.6	3.1	3.1	100	Dark red ss at bottom of pull
44		200.6 to 204.5	3.9	3.8	97	
45	Mar 3, 1992	204.5 to 208.5	4.0	4.0	100	
46		208.5 to 212.0	3.5	3.5	100	
47		212.0 to 214.5	2.5	2.4	96	
48		214.5 to 217.7	3.2	2.6	81	

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 13	2/21/92-3/13/92	John Switek	4 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
49		217.7 to 220.3	2.6	2.8	108	
50		220.3 to 222.6	2.3	2.3	100	Very broken up core
51		222.6 to 224.2	1.6	1.5	94	Very broken up core
52		224.2 to 227.9	3.7	3.8	103	
53		227.9 to 234.5	6.6	6.6	100	
54	5:15	234.5 to 237.6	3.1	3.65	118	
55		237.6 to 238.1	0.5	0.5	100	
56		238.1 to 240.5	2.4	2.4	100	
57		240.5 to 242.8	2.3	2.3	100	
58		242.8 to 244.5	1.7	1.7	100	
59		244.5 to 249.2	4.7	4.4	94	Massive, bioturbated beds, bottom very broken
60	5:10	249.2 to 250.4	1.2	1.0	83	Rig maintenance. Pulled rods put new bit on
61	Mar 5, 1992	250.4 to 252.4	2.0	0.5	25	Soft crumbly zone
62		252.4 to 254.4	2.0	2.0	100	
63		254.4 to 255.4	1.0	1.0	100	
64		255.4 to 261.3	5.9	5.7	97	

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 13	2/21/92-3/13/92	John Switek	5 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
65		261.3 to 264.4	3.1	3.1	100	Fault features
66	2:55	264.4 to 270.3	5.9	5.9	100	
67		270.3 to 274.5	4.2	4.2	100	
68		274.5 to 278.8	4.3	3.8	88	
69	Mar 6, 1992	278.8 to 282.9	4.1	3.2	78	Rainy
70		282.9 to 284.5	1.5	1.6	107	
71	10:40	284.5 to 288.6	4.1	4.1	100	
72		288.6 to 293.7	5.1	5.1	100	Red Sandstone
73		293.7 to 294.5	0.8	0.7	88	Two pull markers were marked 73. All subsequent pulls were corrected by adding 1
74	Mar 9, 1992	294.5 to 297.7	3.2	3.1	95	Rob calculated this pull from 293.7 feet and labeled it pull 73. Brown shale & siltstone
75		297.7 to 301.5	3.8	2.7	71	Brown shale & siltstone. Fold, fault zone
76		301.5 to 304.5	3.0	2.9	97	Crushed zone
77		304.5 to 306.7	2.2	2.2	100	Crushed zone at bottom
78		306.7 to 309.7	3.0	2.9	97	Crushed zone at top. Carbonate ?

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 13	2/21/92-3/13/92	John Switek	6 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
79		309.7 to 314.5	4.8	4.8	100	Carbonate, solid sticks
80	Drilled 3/9/92 pulled 3/10/92	314.5 to 324.5	10.0	10.0	100	Carbonate, solid sticks
81		324.5 to 327.2	2.7	2.4	89	Carbonate, solid sticks, shale at bottom
82		327.2 to 329.4	2.1	2.1	100	Soft,gummy shale
83		329.4 to 334.5	5.2	5.2	100	Shale then Dolomite, well making clear water (not in field notes)
84		335.5 to 344.2	9.7	9.7	100	Dolomite. Driller said well started making a lot of water when this pull made (not in field notes)
85		344.2 to 349.9	5.7			Bottom 2 feet very broken. Dolomite
86		349.9 to 350.0	0.1	0.1	100	Soft drilling dolomite, spongy
87	Mar 11, 1992	350.0 to 352.1	2.0	0.9	45	Soft drilling dolomite, spongy
88		352.1 to 354.5	2.4	0.9	37	Soft drilling dolomite, spongy
89		354.5 to 359.5	5.0	5.0	100	Hard dolomite
90	1:58	359.5 to 364.5	5.0	4.5	90	Cavity 360 -363, Broken bits of dolomite. top of solid stick looks like sponge

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 13	2/21/92-3/13/92	John Switek	7 of 7

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
91	3:20	364.5 to 369.5	5.0	5.0	100	Solid dolomite, open fractures at top
92	4:43	369.5 to 374.5	5.0	5.0	100	Solid sticks
93		374.5 to 383.8	9.3	9.3	100	Hard sandstone
94		383.8 to 384.5	0.7	0.7	100	Hard sandstone
95		384.5 to 385.4	0.9	0.9	100	Hard sandstone. Bit worn out, changed bit 2:30 - 5:00
96	Mar 13, 1992	385.4 to 394.5	9.1	9.1	100	Red and grey sandstone & shale
97	11:15	394.5 to 400.0 (TD)	5.5	5.5	100	Red and grey sandstone & shale
97.5	3:55	400.0-404.6 ft	4.6	4.6	100	Mixed lithologies and colors
98	9:55 May 27, 1992	404.6-414.6 ft	10.0	10.0	100	Mixed limestone and calcareous shale. **Chickamauga Formation at 404.0 feet.**
99		414.6-424.6 ft	10.0	10.0	100	Limestone and calcareous shale
100		424.6-434.6 ft	10.0	10.0	100	Calcareous shale and limestone
101		434.6-440.6 ft	6.0	5.95	99.1	Limestone and calcareous shale
TD	TD	TD	TD	TD	TD	End of Log

Appendix C

CONSTRUCTION ACTIVITY LOG FOR HHMS 14

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 14	4/15/92-5/5/92	John Switek	1 of 6

	Time	Depth (ft)		Recovery		
Run	End	From	To	Drilled	Footage	%	Comments
1	Apr 15, 1992	29.6	30.8	1.2	0.8	66	**Pumpkin Valley Shale** Grey shale and siltstone pieces
2		30.8	35.8	5.0	2.0	40	Mostly grey shale pieces
3	Apr 16, 1992	35.8	40.8	5.0	3.6	72	Brown shale some siltstone pieces
4		40.8	45.8	5.0	3.2	64	Shale or mudstone
5		45.8	50.8	5.0	4.3	86	Shale, siltstone
6		50.8	54.5	3.7	2.5	67	Siltstone, mudstone, shale
7		54.5	55.8	1.3	0.5	38	Shale, mudstone
8	Drilled Apr 16 Pulled Apr 17, 1992	55.8	65.8	10.0	4.0	40	Shale, minor siltstone
9		65.8	70.1	4.3	3.3	77	Mudstone and siltstone
10		70.1	75.8	5.7	3.3	56	Shaley mudstone and minor siltstone
11		75.8	80.8	5.0	2.3	46	Siltstone and shale
12		80.8	85.8	5.0	4.0	80	Interbedded Siltstone and shale all shale at bottom
13	Apr 20, 1992	85.8	90.8	5.0	4.1	82	Siltstone, minor shale. Fold.
14	11:45	90.8	95.0	4.2	3.0	71	Mudstone
15		95.0	95.8	0.8	0,7	87	Mudstone

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 14	4/15/92-5/5/92	John Switek	2 of 6

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
16		95.8 to 95.9	0.1	0.3	300	Mudstone
17	2:47	95.9 to 100.8	4.9	4.6	94	Mudstone
18		100.8 to 105.8	5.0	4.0	80	Mudstone going to interbedded siltstone and shale
19		105.8 to 115.8	10.0	10.2	102	Silty mudstone
20	Apr 20, 1992	115.8 to 120.8	5.0	4.3	86	Shales and siltstones
21		120.8 to 125.6	4.8	4.0	83	Siltstones and shales
22		125.6 to 133.8	8.2	7.8	95	Siltstones (sand) and shales
23		133.8 to 135.8	2.0	2.0	100	Silt/sandstone and shale
24	Apr 22, 1992	135.8 to 139.1	3.3	3.3	100	Silt/sandstone and shale
25		139.1 to 145.8	6.7	6.7	100	Silt/sandstone and shale
26		145.8 to 155.8	10.0	10.0	100	Silty mudstone going to silt/ sandstone and shale
27	2:15	155.8 to 161.0	5.2	5.2	100	Shale and siltstones
28		161.0 to 165.6	4.6	3.5	76	Shale and siltstones
29		165.6 to 170.4	4.8	3.8	79	Shale, siltstone, mudstone
30	Apr 23, 1992	170.4 to 175.8	5.4	5.5	102	Silty/sandy mudstone
31		175.8 to 180.6	4.8	4.5	94	Silty mudstone

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 14	4/15/92-5/5/92	John Switek	3 of 6

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
32		180.6 to 185.1	4.5	4.0	89	Interbedded siltstone and shale
33		185.1 to 185.8	0.7	0.6	86	Siltstone and shale
34	2:23	185.8 to 189.9	4.1	3.7	90	Shale, siltstone, sandstone
35		189.9 to 193.2	3.3	2.1	64	Shale, sandy siltstone
36		193.2 to 195.8	2.6	2.5	96	Shale, sandy siltstone
37	Apr 24, 1992	195.8 to 199.3	3.5	3.6	103	Shale, sandy siltstone
38		199.3 to 203.5	4.2	3.3	79	Shale, sandy siltstone
39		203.5 to 205.8	2.3	2.6	113	Sandy siltstone, shale
40		205.8 to 215.8	10.0	9.5	95	Sandstone, some shale. **Rome Formation at 215.0 feet.**
41	Apr 27, 1992	215.8 to 221.0	5.2	5.2	100	Dolomitic sandstone
42		221.0 to 225.8	4.8	4.8	100	Dolomitic sandstone
43		225.8 to 235.8	10.0	10.0	100	Dolomitic sandstone
44	3:20	235.8 to 245.8	10.0	10.0	100	Dolomitic sandstone
45	3:55	245.8 to 245.9	0.1	0.1	100	Dolomitic sandstone and shale. Lodged in core barrel sideways.
46		245.9 to 255.8	9.9	9.9	100	Dolomitic sandstone

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 14	4/15/92-5/5/92	John Switek	4 of 6

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
47	2:45	255.8 to 265.8	10.0	10.0	100	Dolomitic sandstone, mixed TB ss/sh bottom 3.2 ft.
48		265.8 to 272.0	6.2	6.2	100	Dolomitic sandstone
49	Apr 29, 1992	272.0 to 275.8	3.8	3.1	82	Dolomitic sandstone
50	10:54	275.8 to 280.5	4.7	3.9	83	Red and green sandstone shale and mudstone
51		280.5 to 280.8	0.3	0.3	100	Red sandstone
52		280.8 to 285.8	5.0	5.3	106	Red and grey sandstone
53		285.8 to 295.6	9.8	9.8	100	Red dolomitic sandstone
54	Pulled Apr 30, 1992	295.6 to 305.6	10.0	10.3	103	Grey sandstone and shale
55	9:57	305.6 to 314.9	9.3	9.2	99	Grey, red sandstone and shale
56	10:35	314.9 to 315.6	0.7	0.7	100	Sandstone broken by parting
57		315.6 to 325.6	10.0	9.9	99	Grey and pink ss/ds
58		325.6 to 328.3	2.7	2.7	100	Red ss/ds
59	4:20	328.3 to 333.0	4.7	4.7	100	Red ss/ds
60	May 1, 1992	333.0 to 335.8	2.8	2.8	100	Red ss/ds
61	10:00	335.8 to 343.9	8.1	8.1	100	Red grey ss/ds, homogenized rock
62	10:40	343.9 to 345.8	1.9	1.6	84	Red grey ss/ds, shale

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 14	4/15/92-5/5/92	John Switek	5 of 6

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
63		345.8 to 350.2	4.4	4.6	105	Grey ss/ds, some shale
64		350.2 to 355.8	5.6	5.6	100	Grey ss/ds, homogenized rock
65	4:25	355.8 to 365.8	10.0	10.0	100	Grey ss/ds, homogenized rock
66		365.8 to 373.7	7.9	8.1	103	Grey sandstone, brown shale, mudstone
67		373.7 to 375.8	2.1	2.2	105	Brown mudrock
68		375.8 to 375.9	0.1	0.1	100	Grey sandstone
69		375.9 to 381.7	5.8	5.5	95	Sandstone and shale
70	2:00	381.7 to 385.8	4.1	4.2	102	Shale and sandstone
71		385.8 to 390.1	4.3	4.3	100	Faulted sandstone
72	May 5, 1992	390.1 to 394.7	4.6	4.5	98	Pink-red sandstone
73	10:46	394.7 to 395.8	1.1	1.3	118	Pink sandstone
74		395.8 to 404.2	8.4	8.4	100	Fault rock. Water 397.6-398.4 ft
75	May 29, 1992	404.2 to 405.5	1.3	1.2	92	Gray sandstone and black shale, fault rock
76		405.5 to 415.5	10.0	10.1	101	Massive gray-black homogenous fault rock
77	Jun 02, 1992 3:05	415.5 to 422.4	6.9	6.9	100	Gray-black fault rock then red and gray sandstone

HHMS CORE DRILLING LOG

Well	Date	Logged by	Page
HHMS 14	4/15/92-5/5/92	John Switek	6 of 6

	Time	Depth (ft)		Recovery		
Run	End	From To	Drilled	Footage	%	Comments
78	4:07	422.4 to 426.3	3.9	3.3	85	Red sandstone and shale
79		426.3 to 430	3.7	2.1	57	Black shale, dolomite? at bottom
TD	TD	TD	TD	TD	TD	TD End of Log

Appendix D

LITHOLOGIC AND STRUCTURAL CORE LOGS FOR HHMS 12

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page 1 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
1	0.2	54.6 to 59.1	**Pumpkin Valley Shale** Red brown shale (5YR2.5/2) and siltstone (N6). Siltst laminated. Trace fossils, glauconite.	70
2	0.3	59.1 to 59.9	Red brown shale (5YR2.5/2) with minor siltstones (N6). Siltst laminated, hummocky. Bioturbated, glauconite.	70
3	0.2	59.9 to 63.9	Red brown shale (5YR2.5/2) with minor siltstones (N6). Siltst laminated, hummocky. Bioturbated, glauconite.	70
4	2.8	63.9 to 67.1	Grey brown (5YR2/1), red brown shale (5YR2.5/2) with silt stringers. Homogenous, massive bedding. 0.5ft section at 65 ft is bedded shales and silts. Bioturbated, glauconite.	70
5	1.0	67.1 to 68.7	Interbedded shale (5YR2.5/2) and siltstone (N6). Homogenous, massive bedding and hummocky bedding. Bioturbated, glauconite.	60
6	2.1	68.7 to 72.9	Red brown (5YR2.5/2) , greenish (glauconite) looking, massive bedded, bioturbated mudstone. Bedding relics apparent in upper 1 ft.	60
7	0.7	72.9 to 73.9	Red brown (5YR2.5/2), greenish looking (glauconite), massive bedded, bioturbated mudstone.	75
8	5.0	73.9 to 78.9	Red brown (5YR2.5/2), greenish looking (glauconite), massive bedded, bioturbated mudstone. Laminated silts at 77ft	60
9	4.4	78.9 to 83.9	Red brown (5YR2.5/2), greenish looking (glauconite), massive bedded, bioturbated mudstone. Minor bedded siltstones coming in.	60
10	1.1	83.9 to 87.6	Interbedded siltstones (N6) and brown shales (5YR2.5/2). Parallel laminated to hummocky bedding. Glauconite, bioturbation.	50

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page 2 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Run No.	Length Ft	Depth (Ft) from to	Description	Shale %
11	1.4	87.6 to 89.2	Grey (5YR2/1), red brown shale (5YR2.5/2) and siltstone (N6). Bedding broken by structure and bioturbation but appears laminar and hummocky. Glauconite.	65
12	3.4	89.2 to 93.1	Red brown (5YR2.5/2) shale and siltstone (N8). Bedding indistinct from bioturbation. Glauconite.	65
13	0.6	93.1 to 93.9	Red brown (5YR2.5/2) shale and siltstone (N8). Bedding indistinct from bioturbation. Glauconite.	70
14	3.3	93.9 to 97.1	Red brown (5YR2.5/2) shale and minor siltstone (N8). Bedding indistinct from bioturbation. Glauconite.	80
15	2.5	97.1 to 99.8	Red brown (5YR2.5/2) shale and minor siltstone (N8). Bedding indistinct from bioturbation. Glauconite.	80
16	0.8	99.8 to 100.7	Red brown (5YR2.5/2) shale. Glauconite.	95+
17	2.5	100.7 to 103.5	Red brown (5YR2.5/2) shale and siltstone (N8). Siltstone content increasing downward. Bioturbation and glauconite.	60
18	5.1	103.5 to 108.6	Gray shale (5YR2/1) with silt stringers. Bioturbation and glauconite.	80
19	4.2	108.6 to 113.5	Gray, massive bedded shale (5YR2/1) with silt stringers.	80
20	3.0	113.5 to 117.5	Gray, massive bedded shale (5YR2/1) with silt stringers.	90
21	4.4	117.5 to 122.7	Gray, massive bedded shale (5YR2/1) with silt stringers becoming increasingly bedded and silty. Silt beds indistinct, hummocky. Bioturbated, glauconite.	50
22	0.7	122.7 to 123.5	Gray interbedded silt and shale (N5). Lenticular bedding.	50

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page 3 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
23	4.8	123.5 to 128.5	Interbedded gray shale (N5) and siltstone (N6). Siltstones laminated and hummocky. Bioturbation and glauconite.	65
24	1.8	128.5 to 131.7	Interbedded brown black (5YR2/1) shale and siltstone (N6). Siltstone beds laminar, hummocky. Glauconite.	70
25	1.9	131.7 to 133.5	Brown black (5YR2/1) shale. Silt/sandstone/conglomerate bottom 0.5 feet. Glauconite.	90
26	2.8	133.5 to 136.8	Brown black (5YR2/1) shale. Minor silt/sandstone beds are laminated, lenticular, glauconitic and bioturbated.	80
27	2.85	136.8 to 139.8	Brown black (5YR2/1) shale. Siltstone (N6) disseminated in stringers, massive bedding. Pure shale 137 feet.	80
28	3.5	139.8 to 143.5	Brown black (5YR2/1) to (5YR2/2) shale. Siltstone (N6) disseminated in stringers, massive bedding. Laminar bedded siltstone bottom 0.7 feet.	65
29	6.1	143.5 to 149.6	Brown black (5YR2/1) to (5YR2/2) shale. Siltstone (N6) disseminated in stringers, massive bedding. Siltstone beds top 0.8 ft and lower 2.3 ft, lenticular. Solid stick 144.6 - 146.5.	70
30	1.2	149.6 to 151.0	Brown black (5YR2/1) shale. Siltstone beds (N6) lenticular, cross bedded, glauconite, bioturbated	70
31	2.7	151.0 to 153.7	Brown black (5YR2/1) shale. Siltstone (N6) disseminated in stringers, massive bedding, lenticular bedding lower 1 ft. Glauconite, bioturbated.	75
32	10.0	153.7 to 163.7	Interbedded Brown black (5YR2/1) shale and siltstone (N6). Siltstone disseminated in shale and also lenticular, laminated. Glauconite, bioturbation.	50

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page 4 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
33	8.0	163.7 to 171.5	Interbedded siltstone (N6) and brown black (5YR2/2) shale. Siltstones laminated, lenticular. Bioturbation and glauconite.	40
34	0.2	171.5 to 172.0	Interbedded siltstone (N6) and brown black (5YR2/2) shale. Siltstones laminated. Bioturbation and glauconite.	50?
35	1.0	172.0 to 173.7	Red brown shale 2.5YR2.5/4 with minor laminated siltstone beds. Glauconite.	70
36	5.0	173.7 to 178.7	Interbedded Red brown shale 2.5YR2.5/4 and siltstones (N6). Siltstones laminated, lenticular, hummocky. Glauconite, bioturbation.	50
37	5.0	178.7 to 183.7	Interbedded siltstones (N6) and red brown shale 2.5YR2.5/4. Siltstones laminated, cross bedded. Steep bedding 182 -183 may be depositional.	40
38	5.0	183.7 to 188.7	Interbedded siltstones (N6) and red brown shale 2.5YR2.5/4. Siltstones laminated, lenticular, hummocky or cross bedded. Glauconite, bioturbation.	45
39	4.7	188.7 to 193.7	Interbedded siltstones (N6) and red brown shale 2.5YR2.5/4. Siltstones laminated, lenticular, hummocky. Glauconite, bioturbation.	45
40.1	1.5	193.7 to 195.2	Interbedded siltstones (N6) and red brown shale 2.5YR2.5/4. Siltstones laminated, lenticular. Glauconite, bioturbation.	50
40.2	5.2	195.2 to 200.7	Mixed shale/silt 2.5YR2.5/4 with minor silt stringers (N6). Conglomerates in upper foot and various places elsewhere. Glauconite, bioturbation.	80

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page: 5 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
40.3	3.0	200.7 to 203.7	Interbedded siltstones (N6) and red brown shale 2.5YR2.5/4. Siltstones laminated, lenticular, cross bedded. Glauconite, bioturbation.	45
41	8.5	203.7 to 212.3	Interbedded siltstones (N6) and red brown shale (2.5YR2.5/4). Massive bioturbated zone top 2 ft. Solid shale 211.6-212.3. Siltstones laminated, lenticular, cross bedded. Glauconite, bioturbation.	50
42	1.4	212.3 to 213.7	Brown shale (2.5YR2.5/4) with minor siltstones towards the bottom. Shale appears faulted. Siltstones laminated, lenticular. Glauconite, bioturbation.	80
43.1	6.3	213.7 to 220.0	Interbedded siltstones (N6) and brown shale (2.5YR2.5/4). Siltstones laminated, lenticular. Glauconite, bioturbation. Broken looking bedding 216-217 and 219-220ft.	45
43.2	2.3	220.0 to 222.3	Homogenous looking shale/siltstone (2.5YR2.5/4). Solid stick fault bound? top and bottom? Pure shale bottom 0.9 ft.	60
44	10.05	222.3 to 233.35	Brown shale (2.5YR2.5/4) with minor siltstones. Siltstones laminated, lenticular. Glauconite. Bottom 0.5ft chewed up looking shale.	70
45.1	0.7	233.35 to 234.0	Brown shale (2.5YR2.5/4) broken at top.	95
45.2	4.5	234.0 to 239.6	Interbedded Brown shale (2.5YR2.5/4) and siltstone (N6).Siltstones laminated, lenticular and hummocky. Bedding broken in places. Glauconite.	65
46	3.3	239.6 to 243.7	Brown shale (2.5YR2.5/4) with minor siltstones. Pure shale 241.2 ft. Siltstones laminated, lenticular and hummocky. Glauconite.	80

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page 6 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
47.1	1.3	243.7 to 245.0	Brown shale (2.5YR2.5/4) with minor siltstone stringers. Crushed at top but rest of core in one piece. Glauconite.	90
47.2	3.7	245.0 to 248.7	Interbedded Brown shale (2.5YR2.5/4) and silt/sandstone (N6). Silt/sandstone lenticular and laminated.	60
48	2.1	248.7 to 250.8	Interbedded silt/sandstone (N6) and Brown shale (2.5YR2.5/4). Silt/sandstone lenticular to broken blocky at bottom	40
49	2.5	250.8 to 253.7	Interbedded silt/sandstone (N6) and brown shale (2.5YR2.5/4), (5YR2/1). Silt/sandstone lenticular, laminated, disturbed. Bioturbated, glauconite.	50
50	4.8	253.7 to 258.3	Interbedded silty dolomitic sandstone (N6) and brown shale (5YR2/1). Sandstone lenticular disturbed, structurally and by bioturbation. **Rome Formation at 254.6 feet.**	50
51	0.9	258.3 to 259.2	Interbedded dolomitic sandstone (N6) and brown shale (5YR2/1). Broken up.	35
52	0.1	259.2 to 259.3	Dolomitic sandstone (N6) with brown shale (5YR2/1) on each end.	20
53	4.4	259.3 to 263.7	Hard dolomitic sandstone (N6 to N4). Bedding parallel to lenticular, broken or bioturbated. Stylolites common in bottom 1 ft.	0
54	1.7	263.7 to 265.4	Hard dolomitic sandstone (N6 to N5). Bedding thick, indistinct. Stylolitic at the top1 ft.	0
55	0.2	265.4 to 265.6	Hard dolomitic sandstone (N6 to N5). Bedding indistinct.	0
56	8.1	265.6 to 273.7	Hard dolomitic sandstone (N6 to N5). Bedding thick, massive. Zone from 268.2 to 272.0 looks to have been crushed.	0

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page 7 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
57	8.1	273.7 to 281.8	Hard dolomitic sandstone (N6 to N5) with minor thin interbeds of shale (5YR2.5/1). Sandstone beds thin to thick some mottling like bioturbation but might be structural. Bottom 2 ft coarser.	10
58	1.9	281.8 to 283.7	Hard dolomitic sandstone (N6). Bedding massive.	0
59	4.5	283.7 to 287.9	Hard dolomitic sandstone (N6). Bedding massive, broken and fractured. Stylolites.	0
60	5.8	287.9 to 293.7	Hard dolomitic sandstone (N6). Bedding thick, massive. Cavities 287.9-290.0, 293.4-293.7 (calcite crystals).	0-5
61	6.1	293.7 to 300.0	Hard dolomitic sandstone (N6) broken by fractures and stylolites. Bedding appears thick, massive. Cavity at the top with calcite crystals. Shale partings may be slide planes.	0-5
62	0.1	300.0 to 300.1	Hard dolomitic sandstone (N6).	0
63	3.6	300.1 to 303.7	Hard dolomitic sandstone (N6). Bedding appears thick, massive defined by stylolites. 301.4-302.7 appears strained.	0
64	5.7	303.7 to 310.0	Interbedded green black (5G2/1), pink (10R4/1), gray (N6) sandstones and green black (5G2/1) and red (10R3/2) shales. Bedding medium to thick but broken up.	40
65	0.5	310.0 to 310.9	Dolomitic sandstone pieces N6). Bedding not discernable.	0
66	0.8	310.9 to 311.4	Hard dolomitic sandstone (5YR6/1). Bedding massive.	0
67	0.8	311.4 to 312.2	Hard dolomitic sandstone (5YR6/1) top, (5R4/2) bottom. Bedding massive.	0
68	0.4	312.2 to 312.6	Hard dolomitic sandstone (5R4/2). Bedding massive.	0

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page 8 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
69	1.2	312.6 to 313.8	Hard red sandstone (5R4/2 to 5R6/2). Massive bedding.	0
70	2.6	313.8 to 316.9	Hard red siltstone/fine sandstone (10R4/2). Massive bedding.	0
71	2.9	316.9 to 320.2	Hard red siltstone/fine sandstone (10R4/2) and green (5GY2/1) shale/siltstone. Bedding almost vertical.	20
72	3.4	320.2 to 323.8	Hard red siltstone/fine sandstone (10R4/2) and green (5GY2/1) shale/siltstone. Bedding almost vertical.	30
73.1	4.75	323.8 to 328.55	Hard red siltstone/fine sandstone (10R4/2). Massive bedding.	0
73.2		328.55 to 331.9	Green (5GY2/1) cherty shale/siltstone. Massive bedding. Looks sericitized.	0
74	2.0	331.9 to 333.9	Green (5GY2/1) shale/siltstone. Massive bedding. Looks deformed..	0
75	2.6	333.9 to 337.6	Red siltstone/fine sandstone (10R4/2). Massive bedding. Bottom 1 foot crushed.	0
76	3.2	337.6 to 340.6	Red siltstone/fine sandstone (10R4/2). Massive bedding. Fell apart when moved to core box.	0
77	1.0	340.6 to 341.9	Green (5GY2/1) shale/siltstone brown sandstone (5YR3/3) in pieces	20
78	2.1	341.9 to 344.0	Red (10R4/2) sandstone. Bedding appears thin to medium at high angles of dip. Shale partings may be slip planes.	5
79	5.1	344.0 to 349.1	Red (10R4/2) sandstone. Bedding appears thin to medium at high angles of dip. Shale partings may be slip planes.	5
80	0.5	349.1 to 349.8	Red (10R4/2) sandstone /siltstone. Broken up, split down the middle by vertical fault.	20
81	4.4	349.8 to 354.0	Red (10R4/2) sandstone and green (5GY2/1) sandstone on either side of a vertical fault. Shale slide planes.	20

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page 9 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
82.1	3.2	354.0 to 357.2	Red (10R4/2) sandstone and green (5GY2/1) sandstone on either side of a vertical fault. Shale slide planes.	40
82.2	3.3	357.2 to 360.5	Green (5GY2/1) sandstone and shale partings. Bedding at high angles, thin to thick beds.	45
83.1	0.8	360.5 to 361.3	Green (5GY2/1) sandstone and shale partings. Bedding at high angles, thin to thick beds.	20
83.2	0.6	361.3 to 361.9	Green (5GY2/1) gouge then red (10R4/2) gouge. Dip at 0°	95
83.3	2.1	361.9 to 364.0	Red (10R4/2) shaley looking fault rock with minor beds of grey (N6) sandstone at the bottom.	80
84	10.0	364.0 to 374.0	Grey (N6) to greenish (10GY2/1) sandstone interbedded with homogenous beds of green and red shale and sandstone that look strained. Sandstone bedding looks thick to massive where intact.	40
85.1	3.2	374.0 to 377.2	Red (10R4/2) shale/mudstone homogenized with sandstone stringers top 1ft, pure shale for the rest. Bedding appears thick to massive.	70
85.2	3.9	377.2 to 381.0	Interbedded dolomitic sandstone (N6) and shale (N4). Medium to massive bedding.	40
86.1	1.4	381.0 to 382.4	Dolomitic sandstone (N6) with shale (N4) partings. Medium to thick bedded.	20
86.2	1.7	382.4 to 384.0	Grey (N4) homogenized and strained looking shale with some sand. Massive bedding	95+
87	9.6	384.0 to 393.6	Grey (N4) mudstone/sand mixture, minor bedded sandstones. Massive bedded, homogenous.	70

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page 10 of 10
HHMS 12	3/19/92 -4/9/92	J. SWITEK	

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
88	6.7	393.6 to 400.2	Grey (N4) mudstone/sand mixture, minor bedded sandstones. Massive bedded, homogenous.	50
TD	TD	TD	Total depth of well. End of log.	TD

HHMS CORE STRUCTURE LOG

Well		Dates	Logged by	Page
HHMS 12		3/19-4/9/92	J. Switek and B. Couzens	1 of 4
Run	**Number of Fractures/ Faults**	**Bedding Dip @ Depth ° @ /ft**	**Fracture/Fault/Structure Location, Dip and Description**	
1		70-90/59.1	Filled fractures.	
2		70-90/59.1	Poor recovery; slick surfaces.	
3		70-90/63.9	Poor recovery; slick surfaces. Filled fractures perpendicular to bedding, at least 2 sets. ~	
4	1/0	70-80/64	Red stained fracture at 67 ft. Core broken up top 2 ft. Filled vertical fractures.	
5		60-70/67.1	Filled fractures 67.1-67.5 ft. Core massive top, broken at bottom. Beds appear folded.	
6	1/0	80-90/69	Red stained fracture 72 ft. Core broken above.	
7	1/0	65/73	Red stained fractures 72.7'.	
8		70-80/76	Bioturbated	
9		70-80 top, flattening toward bottom	Bioturbated	
10		50-60	Top broken up. Slick surfaces.	
11	0/1	40-50	Slick surfaces. Small fault around 88.7 ft.	
12		50-60	Slick surfaces.	
13		20-30		
14		30-40	Slick surfaces where broken.	
15		60	Slick surfaces.	
16		60	Slick surfaces.	
17		40-50	Slick surfaces.	
18		30-40	Slick surfaces.	
19		30	Slick surfaces.	
20		30-40	Slick surfaces.	
21		20-30	Healed fractures in siltstones especially 119-119.5 ft.	
22		10-20	Slick surfaces.	
23		20-30	Slick surfaces.	
24		20-30	Slick surfaces. Badly broken in places.	
25		20	Filled fractures 133-133.5.	
26		45	Filled fractures.	
27	0/1	20-30	Gouge zone 137.3-137.6, badly broken. Filled fractures.	
28		30	High angle (~70°) filled fracture 141.4-142 ft. Slick surfaces.	

HHMS CORE STRUCTURE LOG

Well	Dates	Logged by	Page
HHMS 12	3/19-4/9/92	J. Switek and B. Couzens	2 of 4

Run	Number of Fractures/ Faults	Bedding Dip @ Depth ° @ /ft	Fracture/Fault/Structure Location, Dip and Description
29		30	Filled fracture 145 ft dipping 35°. Slick surfaces.
30	0/1	30	Slick surfaces. Broken zone 149.8-150.1 ft. (gouge?)
31		30	Slick surfaces.
32	1/2	20-30	Slick surfaces. Prominent high angle (60°), partially filled fracture 161.2 - 162.1. Shale/fault zone ~163.0 ft. Slight dissolution along fault 168.7 ft.
33		30	Interbedded sh/slts. Folding 166.7-167.0, 170.1-170.5, 171.0-171.3 ft.
34		30	Broken badly, poor recovery.
35			Broken badly, poor recovery, bedded. Slick surfaces.
36		30	Small, healed, high angle fractures in siltstone beds, Small faults, affecting 1-2 beds. Slick surfaces.
37		30 top to 45 middle to 30 bottom	Small, healed, high angle fractures in siltstone beds. Slick surfaces.
38	0/1	30 decreasing to 20	Small, healed, high angle fractures in siltstone beds. Slick surfaces. Gouge zone 188 ft.
39		20 first ft then > to 35	Small, healed, high angle fractures in siltstone beds especially 189.5 ft.
40			Small, healed, high angle fractures in siltstone beds. Slip surfaces 198.6-198.9 ft.
41	0/1	35 /211.5	Small, healed, high angle fractures in siltstone beds. Slick surfaces. Gouge/fault zone 212.0 ft.
42	0/1	40 /213.5	Gouge zone/ fault 213.0 ft Small, healed, high angle fractures in siltstone beds.
43	0/5	Bedding disturbed	Small, healed, high angle fractures in siltstone beds. Broken zone 216.2-217.2 ft. Faults (thin w/ small displacement) 218.5-218.9, 219.1-220.0, 219.7-220.2, 220.2-220.3 dipping 60°, 75°, 80°, 75°.
44	0/1	30	Small, healed, high angle fractures in siltstone beds. 0.5 ft gouge at 233 ft.

HHMS CORE STRUCTURE LOG

Well	Dates	Logged by	Page
HHMS 12	3/19-4/9/92	J. Switek and B. Couzens	3 of 4

Run	Number of Fractures/ Faults	Bedding Dip @ Depth ° @ /ft	Fracture/Fault/Structure Location, Dip and Description
45	0/3	40/235.0	Small, healed, high angle fractures in siltstone beds. Crushed zone 233.35, 234.1-234.5. Fault 235.3-235.4. Minor crushed zone 239.6 ft.
46	0/1	10/240.2 40/241.0	Crushed and sheared shale 239.6-240.0. Fault gouge at 242.8-243. ft.
47		35/248	Crushed zone at 243.7-243.9.
48		55/250.2	Top broken up.
49	1/1	60-70/250.8 30/253.7	Small, healed, high angle fractures in siltstone beds. Gouge at 252.7. Fault with hackly, fluted surfaces, open 253.0-253.7.
50.1	0/1	35/257.4	Prominent fault continued from above 253.7-255.2, open, partially dolomite crystal lined.
50.2	0/1		Sandstone beds badly broken bottom 1.5 ft, gouged shale bed there. Rome Formation.
51	2/0	35/259.2	2 open fractures upper 0.5 ft.
52			Fractures in hard sandstone.
53	0/1	35/260.8	Filled fractures, Vertical fault 261.2-263.8 filled with minerals.
54	0/1		Filled fractures, Vertical fault 263.8-264.8, continued from above, filled with minerals.
55			Filled fractures.
56		35/267.0 20/273.0	Filled fractures. Crushed zone 268-272, healed and recemented. Stylolites.
57		~0/281.8 30/273.7	Filled fractures.
58			Filled fractures.
59		20/285	Filled fractures.
60	1/0	Not Applicable	Filled fractures. Cavities, open fracture 287.9-290.0, crystal lined cavity bottom 293.5-293.7 ft.
61	1/2	35/294.2 30/298.5	Crystal lined cavity 293.7-294.0. cataclastic zone 294-294.2 & 299.0-299.8.
62			Numerous filled fractures.
63	0/1		Filled fractures Cataclastic zone 300.1-302.7 ft.
64	0/2	60/305.4 20/309.6	Filled fractures. Gouge 305.6 and 308 ft.
65		NA	Core broken up

HHMS CORE STRUCTURE LOG

Well	Dates	Logged by	Page
HHMS 12	3/19-4/9/92	J. Switek and B. Couzens	4 of 4

Run	Number of Fractures/ Faults	Bedding Dip @ Depth ° @ /ft	Fracture/Fault/Structure Location, Dip and Description
66		35/311.4	Filled fractures
67		35/312.2	
68		35/312.6	Filled fractures
69	2/0	?	Open fractures at 313.0. xtals 313.5 ft.
70	1/0	45/316.0	xtals on fracture 316.5 ft.
71	0/1	High angle contact	Fault 318.3 to bottom, contact between red and green rock almost vertical.
72	0/1	High angle contact	Fault entire length of pull, contact between red and green rock almost vertical.
73	0/1		Gouge at 331 ft.
74			Small healed faults.
75	0/1	50/335.0	Fault rock.
76	0/1	High angle contacts	Fault rock.
77	1/0	0-15/ 340.9	Rock broken up but pieces show many open fractures near 340.9 ft. At least 4 sets 2 parallel parting and 2 high angle to parting.
78	0/1	65/343.0	Fault rock/cataclasite 341.9-342 ft.
79	5/1	High angle contacts	Fault parallel to core 346-349 ft. Numerous fractures all with xtals cutting perp. to fault: 348.5, 347.5, 346.2, 346, 345.8 ft.
80	0/1	High angle contacts	Fault parallel to core.
81	1/1		Fault parallel to core, red one side and green the other. Fracture w/ xtals 352 ft.
82	0/1		Core split by high angle fault.
83	1/2	60/362.6	Fault gouge 361.3-361.9 and 362.6-363.7 ft. Dolostone slightly fractured possibly open.
84		60/364.0	Filled fractures in dol. Ss. beds
85	0/1	40/376.0 40/380.5	Gouge 375-376.5 ft. Many fractures occur in the dolomitic sandstones.
86	0/1	40/382.0	Gouge 393.5 ft. Fractures and minor faulting in the sandstones.
87		35/389.6	isolated vugs.
88		0-20	vugs in middle of pull.
TD		TD	TOTAL DEPTH = 400.2 FT. END OF LOG

Appendix E

LITHOLOGIC AND STRUCTURAL CORE LOGS FOR HHMS 13

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	1 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
1	1.1	42.0 to 44.5	**Pumpkin Valley Shale.** Dark brown shale (10YR3/2) and grey siltstone (N6). Thin to medium bedded. Siltstones lenticular. Bioturbation, glauconite.	70
2	1.0	44.5 to 48.5	Brown shale (10YR3/2) and grey siltstone (N6). Medium bedded, siltstones parallel laminated. Bioturbation, glauconite.	50
3	0.25	48.5 to 54.5	Greenish siltstone (5Y5/5), medium bed, glauconite, mica	10
4	0	54.5 to 64.5	No recovery	
5	1.5	64.5 to 66.5	Interbedded mudstone and shale (5YR2.5/2) and siltstone (N6). Medium lenticular to hummocky beds. Parallel laminated siltstones. Bioturbation, glauconite.	50
6	2.5	66.5 to 69.2	Interbedded brown shale (5YR2.5/2) and siltstone (N6). Thin to medium lenticular beds. Bioturbation, glauconite.	30
7	4.1	69.2 to 74.5	Interbedded siltstone (N6) and brown shale (5YR2.5/2). Thin to medium lenticular, hummocky beds. Siltstones parallel laminated. Bioturbation, glauconite.	45
8	2.9	74.5 to 77.0	Interbedded brown shale (5YR2.5/2) and siltstone (N6). Thin to medium lenticular beds. Bioturbation, glauconite.	75
9.1	4.1	77.0 to 81.1	Massive bedded, homogenous mudstone (5YR2.5/2) with minor beds and stringers of siltstone. Heavy bioturbation, glauconite.	85
9.2	3.4	81.1 to 84.5	Thin to medium interbeds of mudstone and shale (5YR2.5/2) and siltstone (N6). Siltstones lenticular. Bioturbation, glauconite.	65

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	2 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
10	2.0	84.5 to 86.8	Thin to tick interbeds of mudstone and shale (5YR2.5/2) and lenses and stringers of siltstone (N6). Heavy bioturbation, glauconite.	70
11	5.6	86.8 to 92.5	Thin to medium interbeds of mudstone and shale (5YR2.5/2) and siltstone (N6). Siltstones lenticular to hummocky, laminated. Heavy bioturbation in places. Glauconite. Silt increases downward.	60
12/13	0.6	92.5 to 94.5	Brown shale (5YR2.5/2) with siltstone stringers. One thick bed, Trace fossils.	90
14	5.8	94.5 to 100.7	Interbedded siltstone (N6) and shale and mudstone (5YR2.5/2). Siltstone and shales in thin to thick lenticular, parallel laminated beds. Mudstones thick bedded and homogenous. Heavy bioturbation, glauconite.	50
15	3.85	100.7 to 104.5	Massive bedded, homogenous, silty mudstone (5YR2.5/2). Heavy bioturbation, glauconite.	80
16	1.0	104.5 to 105.7	Massive bedded, homogenous, silty mudstone (5YR2.5/2). Heavy bioturbation, glauconite.	90
17	3.5	105.7 to 109.5	Interbedded brown shale and mudstone (5YR2.5/2) and siltstone (N6) lenses and stringers. Thin to thick beds. Bioturbation, glauconite.	75
18	3.00	109.5 to 112.6	Interbedded brown shale (5YR2.5/2) and siltstone (N6) lenses and stringers. Thin to medium beds. Siltstones parallel and cross laminated. Bioturbation, glauconite. Becomes siltier downward.	55
19	1.65	112.6 to 114.5	Interbedded brown shale and mudstone (5YR2.5/1) with disseminated silt and siltstone beds (N6). Thick to medium beds. Bioturbation, glauconite.	70

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	3 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
20	4.0	114.5 to 119.5	Interbedded siltstone (N6) and shales (5YR2.5/1). Thin to medium beds. Siltstones lenticular, wispy, parallel laminated. Bioturbation, glauconite.	45
21	4.25	119.5 to 123.8	Interbedded brown shale and mudstone (5YR2.5/1) and lenticular siltstones (N6). Thin to medium beds. Bioturbation, glauconite.	70
22	1.4	123.8 to 125.2	Interbedded brown shale (5YR2.5/2) and lenticular siltstones (N6). Thin to medium beds. Bioturbation, glauconite.	70
23	3.8	125.2 to 129.1	Interbedded brown shale and mudstone (5YR2.5/1, /2) and siltstones (N6). Thin to massive beds. Siltstones lenticular with parallel laminations. Pull contains two fining upward cycles. Bioturbation, glauconite.	65
24	2.8	129.1 to 131.9	Interbedded brown shale and mudstone (5YR2.5/1) and lenticular siltstone, disseminated silt (N6). One fine conglomerate bed 129.2-129.3 ft. Mudstones thick to massive bedded. Bioturbation, glauconite.	70
25	1.66	131.9 to 133.8	Homogenous, silty/sandy mudstone (5YR2.5/1) going into shale at bottom. Thick to massive bedding.	70
26	3.00	133.8 to 136.8	Thick bedded shale (5YR2.5/1) top 1.3 ft, then thick bedded muddy sandstone (N5). Bioturbation, glauconite.	50
27	0.4	136.8 to 137.1	Muddy sandstone (N5). Bioturbation, glauconite.	20
28.1	0.8	137.1 to 137.9	Interbedded sandstone (N5) and sandy mudstone/shale (10YR2/0). Thin to lenticular bedding. **Rome Formation at 137.5 feet.**	20
28.2	1.4	137.9 to 139.3	Fine grained, medium bedded, gray (N6) dolomitic sandstone	5

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	4 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
28.3	3.4	139.3 to 142.7	Homogenous, massive bedded, Gray (N5) dolomitic sandstone /mudstone. Heavily bioturbated and stylolitic.	0
28.4	0.9	142.7 to 143.6	Massive, fine to medium grained, gray (N6) dolomitic mudstone.	0
29	5.5	143.6 to 149.1	Thick to massive bedded, fine to medium grained, gray (N6) dolomitic sandstone. Some bioturbation.	0
30	5.3	149.1 to 154.4	Thick bedded, fine to medium grained, gray (N6-N5) dolomitic sandstone. Some bioturbation.	5
31	0.9	154.4 to 155.3	Thick bedded, medium grained, gray (N6-N5) sandy dolostone and sandy mudstone. Homogenized by bioturbation or structurally.	0
32	2.7	155.3 to 158.0	Interbedded medium grained dolomitic sandstone (N6) and shale (5YR2/2). Thin to medium lenticular bedding. Some bioturbation.	15
33	5.4	158.0 to 163.5	Thick to massive bedded, medium to coarse grained dolomitic sandstone. Very hard.	0
34	1.2	163.5 to 164.7	Hard, massive bedded, medium grained, gray (N6) dolomitic sandstone.	0
35	4.5	164.7 to 169.2	Hard, massive bedded, medium grained, gray (N6) dolomitic sandstone. Becomes slightly darker towards the bottom. Abundant shale partings in the bottom 0.6 ft.	5
36.1	3.6	169.2 to 172.8	Hard, massive bedded, medium grained, gray (N5) dolomitic sandstone.	0
36.2	1.0	172.8 to 173.8	Thick bedded, crushed and homogenized carbonate and shale fault rock (10R6/2)	10
36.3	0.7	173.8 to 174.5	Intermixed hard, gray (N6) dolostone and shale (N3) partings. Possibly tectonic.	20

HHMS CORE LITHOLOGY LOG

Well		Dates		Logged by	Page
HHMS 13		5/15/92 -7/31/92		J. Switek	5 of 13
Pull No.	Length Ft	Depth (Ft) from to	Description		Shale %
37	8.2	174.5 to 182.9	Interbedded thin to thick bedded, medium to coarse grained dolomitic sandstone (N6) and shale partings. Bioturbation in the shale zones. Bottom 1.3 ft mottled, bottom 0.1 ft crushed shale.		20
38	1.6	182.9 to 184.5	Interbedded thin to thick lenticular beds of hard, medium grained, gray (N6) dolomitic sandstone and black (N2) shale. Shales appear tectonic.		30
,39	4.8	184.5 to 189.3	Hard, massive bedded, medium grained dolomitic sandstone (N6). Dark shale (N3) gouge zone from 186.9 to 187.7ft.		10
40.1	1.2	189.3 to 190.5	Hard, massive bedded fine to coarse grained gray (N6) dolomitic sandstone.		0
40.2	1.8	190.5 to 192.3	Thin interbedded red (5R4/2) fine to coarse grained sandstone and shale (2.5YR2.5/2).		10
41	1.9	192.3 to 194.3	Thin to medium bedded, red fine to coarse grained sandstone (5R4/2) and shale (2.5YR2.5/2). Bottom 0.3 ft is gray (N5) dolomitic sandstone.		25
42	3.3	194.3 to 197.5	Thin to thick bedded, medium grained, gray (N5) dolomlitic sandstone with shale partings (N3) becoming abundant in the bottom 1.3 ft.		15
43.1	2.2	197.5 to 199.7	Thin to medium bedded, medium to coarse grained, gray (N5) sandstone. Thin, black shale (N3) partings. Conglomerate bed at 199 ft. Some bioturbation.		15
43.2	0.9	199.7 to 200.6	Hard, massive bedded, fine grained, pink (5R8/2) to red (5R3/4) sandstone.		0
44	3.8	200.6 to 204.5	Massive, fine grained, red (5R3/4) sandstone. Red (10R4/2) shale bottom 1ft.		10

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	6 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
45	4.0	204.5 to 208.5	Massive to medium bedded, fine to medium grained, red (5R3/4) sandstone with shale bits in it. Turns gray bottom 0.5 ft.	5
46	3.5	208.5 to 212.0	Massive to thick bedded, fine to medium grained, gray (N5-N4) dolomitic sandstone. Bottom 2 ft mottled, bioturbated.	0
47	2.4	212.0 to 214.5	Massive, fine to medium grained, gray (N5) mottled, muddy dolomitic sandstone.	0
48	2.6	214.5 to 217.7	Massive, brown (10YR2/2) shale and 0.9 ft of interlaminated sand and shales at the top. Sandstone stringers at the bottom.	95
49.1	1.7	217.7 to 219.4	Massive, gray (N3) shale with silt stringers and lenses. Bioturbation or tectonic disruption.	90
49.2	0.9	219.4 to 220.3	Thick bedded, medium grained, pink (10R4/2) sandstone.	5
50	2.2	220.3 to 222.6	Interbedded fine to medium grained, pink (5R8/2), dolomitic sandstone and gray (N4) shale. Bedding thick to medium, lenticular. Micaceous, bioturbation.	35
51	1.8	222.6 to 224 2	Thin to medium bedded, fine to medium grained, gray (N6) dolomitic sandstone with dark gray (N4) partings.	15
52	3.9	224.2 to 227.9	Thin to thick bedded, medium to fine grained, pink (5R8/2) to gray (N6) dolomitic shales and shales (N3). Lenticular bedding, bioturbated zones.	10
53.1	3.0	227.9 to 230.9	Massive bedded, medium to fine grained, mottled gray (N4) sandy mudstone. Homogenized, bioturbation or depositional.	0

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	7 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
53.2	2.1	230.9 to 233.0	Thick to thin bedded, medium to coarse grained, gray (N6) dolomitic sandstone with shale partings (N4). Sandstone looks broken and stylolitized in places but core is solid.	5
53.3	1.5	233.0 to 234.5	Massive, medium grained, pink (10R5/1) dolomitic sandstone.	0
54.1	0.65	234.5 to 235.1	Massive, medium grained, pink (10R5/1) dolomitic sandstone.	0
54.2	2.7	235.1 to 237.8	Thin to thick bedded, fine to medium grained, red (10R4/1) dolomitic sandstone and thin red shales (10R4/2). Micaceous.	20
55	0.3	237.8 to 238.1	Medium bedded, medium grained, red (10R4/2) dolomitic sandstone. Micaceous.	0
56	2.4	238.1 to 240.5	Massive bedded, medium grained, red (10R4/2), micaceous, dolomitic sandstone. Shale partings (10R3/1) at about 240 ft.	5
57	2.3	240.5 to 242.8	Massive to medium bedded, medium to coarse grained, red (10R3/1) dolomitic sandstone and homogenous mudstone. Micaceous. Coarse white grains in mudstone.	5
58	1.7	242.8 to 244.5	Massive to thick bedded, fine to coarse grained, red (10R3/1) dolomitic sandstone and homogenous mudstone. Coarse white grains in mudstone.	0
59	4.7	244.5 to 249.2	Massive bedded, homogenous red (10R3/1) mudstone, bedded shales (10R3/1) and calcareous sandstones (10R5/1). Coarse white grains in mudstone.	15
60	1.2	249.2 to 250.4	Medium lenticular bedded, medium grained, pink (10R6/1) dolomitic sandstone with minor shale (10R3/1) partings.	5

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	8 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
61	0.5	250.4 to 251.4	Medium bedded, medium grained, gray (N6) dolomitic sandstone. Poor recovery.	5
62	2.0	251.4 to 254.2	Medium to thin bedded, medium grained, gray (N6) to pink (10R6/1) dolomitic sandstone. Bioturbation or dewatering features, lenticular bedding. Poor recovery, probably at the bottom.	5
63	0.9	254.2 to 255.4	Medium bedded, medium grained, gray (N5) dolomitic sandstone. Lenticular bedding.	0
64.1	1.4	255.4 to 256.8	Thick to medium bedded, fine to medium grained, gray (N5) dolomitic sandstones with minor shale partings. Lenticular beds.	5
64.2	3.4	256.8 to 260.2	Massive bedded, homogenous mudstone with white coarse grains. Top and bottom are gray/green (5G5/2), rest is red (10R3/2). Mudstone contains clasts of sandstone. One bed of medium grained sandstone in the middle of the pull.	0
64.3	0.9	260.2 to 261.3	Massive bedded, fine to medium grained, red (10R61) dolomitic sandstone.	0
65	2.8	261.3 to 264.4	Massive bedded, fine to medium grained, gray (N6) dolomitic sandstone with tectonically derived black (N1) and red (10R3/1) mudstones (gouge).	0
66.1	1.0	264.4 to 265.5	Massive bedded, fine to medium grained, gray (N6) dolomitic sandstone and stringers of black gouge (N1).	0
66.2	2.9	265.5 to 268.4	Interbedded red shales and mudstones (10R3/1) and sandstones (10R5/1). Laminated to medium bedded. Zones of bioturbated mudstones. Sandstones medium to fine grained.	25

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	9 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
66.3	2.2	268.4 to 270.3	Massive bedded, homogenous mudstone and shale (N4). Changed into gray (N5) dolomitic sandstone bottom 0.5 ft.	15
67.1	2.2	270.3 to 272.5	Thick to medium bedded, fine to medium grained, gray (N5) dolomitic sandstone with shale stringers. Appears to show fining upwards cycles. Bioturbation, lenticular beds.	5
67.2	2.0	272.5 to 274.5	Thin interbedded red sandstones (10R6/1) and shales (10R4/1). Lenticular bedding, bioturbation. Sandstones fine to medium bedded.	50
68	3.6	274.5 to 278.8	Thin interbedded gray (N6) sandstones and red shales (10R4/1). Much bioturbation, becomes more noticeably red towards the bottom.	65
69	2.9	278.8 to 282.9	Interlaminated red sandstones (10R6/1) and shales (10R4/1). Heavily affected by structure.	65
70	1.4	282.9 to 284.5	Massive bedded, fine to medium grained, gray (N6) to pink (10R6/1) dolomitic sandstone.	0
71	4.1	284.5 to 288.6	Thin to medium interbedded, gray (N6) dolomitic sandstone and gray to red shales (N4-10R3/2). Lenticular beds, bioturbation.	30
72.1	0.9	288.6 to 289.5	Thin to medium bedded, red dolomitic sandstones (10R6/1) and shale (10R3/2). Medium grained sandstone. Glauconite.	40
72.2	4.1	289.5 to 293.7	Massive bedded, medium grained, red (10R6/1 to 10R4/1) dolomitic sandstone.	0
73	0.8	293.7 to 294.5	Massive bedded, medium grained, red (10R5/1) dolomitic sandstone.	0
74	3.8	294.5 to 297.7	Thin to medium bedded, medium grained, gray (N6) dolomitic sandstone. Minor shale partings increasing downwards. Orange lined fractures.	15

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	10 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
75	3.1	297.7 to 301.5	Thin interbedded to interlaminated red (10R6/2), medium to coarse grained, dolomitic sandstones and shales (10R4/2)	40
76.1	1.6	301.5 to 303.1	Medium interbedded shales (N4) and sandstones (N6). Becomes shalier towards the bottom. Bioturbation.	60
76.2	1.3	303.1 to 304.5	Massive bedded mudstone (N4) with medium grained sandstone clasts and beds. Mostly homogenous.	0
77.1	0.4	304.5 to 304.9	Massive homogenous mudstone (N4) as above.	0
77.2	1.9	304.9 to 306.7	Thick bedded, medium grained, pink (10R6/2) dolomitic sandstone and minor thin red shales (10R4/2). Bottom 0.4 ft all shale (10YR3/1).	20
78	2.7	306.7 to 309.7	Top 0.3 ft N3 shale. Rest is massive bedded, medium grained, pink (10R6/1) dolomitic sandstone.	5
79	4.9	309.7 to 314.5	Massive bedded, fine to medium grained, pink (10R6/1) dolomitic sandstone. Rock looks shattered, especially between 310-312 ft, but is solid.	0
80.1	5.2	314.5 to 319.7	Massive to thick interbeds of medium grained, pink (10R6/1) dolomitic sandstone and homogenous mudstone (N4) containing sandstone clasts.	0
80.2	4.8	319.7 to 324.5	Massive homogenous gray (N4) mudstone with sandstone clasts and stringers. Bottom 0.3 ft is massive, gray (N6) dolomitic sandstone.	0
81.1	1.0	324.5 to 325.5	Massive bedded, medium to fine grained, gray (N6) dolomitic sandstone, grades to shale at the bottom.	5
81.2	1.7	325.5 to 327.2	Dark shale (N3) mostly broken up. Medium grained, dolomitic sandstone at the top of pull.	90

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	11 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
82	2.2	327.7 to 329.4	Dark gray (N3) to brown (5YR2/1) shale. Apparently massive but core broken up.	100
83.1	3.2	329.4 to 332.6	Dark gray (N2) to brown (5YR2/2) shale.	100
83.2	1.5	332.6 to 334.5	Massive bedded, fine to medium grained, gray (N6-N5) dolomitic sandstone. In places looks to have been shattered but core is solid. Bottom 1 ft is vuggy.	0
84	9.7	334.5 to 344.2	Massive, homogenous, gray and red (N6-10R6/1) dolomitic sandstone. Rock appears shattered but core is solid. Vuggy.	0
85.1	2.3	344.2 to 346.5	Massive, homogenous, calcareousm, gray (N4) mudstone.	0
85.2	3.4	346.5 to 349.9	Massive, calcareous fault rock. Soft and vuggy. Tan (5YR2/1)	0
86	0.2	349.9 to 350.1	Soft, vuggy, calcareous fault rock. Red (10R2.5/2).	0
87	0.7	350.1 to 352.1	Soft, crumbly, calcareous fault rock. Red (10R2.5/1).	0
88	0.9	352.1 to 354.5	Crumbly calcareous fault rock, poor recovery. Gray (N6) turns tan (10YR7/1).	0
89	5.0	354.5 to 359.5	Laminated carbonate, soft and vuggy, tan (10YR7/1).shattered looking in places.	0
90	5.0	359.5 to 364.5	Laminated carbonate, soft and vuggy, tan (10YR7/1). Cavity 362.9 to 363.4 ft. Sharp contact with darker (10YR6/1) more solid looking rock at 364..4 ft	0
91.1	1.5	364.5 to 366.0	Massive, shattered looking carbonate, but solid core. Vuggy, tan (5YR6/1)	0
91.2	3.5	366.0 to 369.5	Massive to medium bedded, medium grained, gray (N6) dolomitic sandstone. Some bioturbation.	0

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	12 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
92	5.0	369.5 to 374.5	Massive to medium bedded, medium grained, gray (N6) dolomitic sandstone.	0
93	9.3	374.5 to 383.8	Massive to medium bedded, medium grained, gray (N6) dolomitic sandstone in places mottled. Minor shale partings, stylolites. Turns pink bottom 0.6 ft.	5
94	0.8	383.8 to 384.5	Massive bedded, fine grained, pink (10R6/2) dolomitic sandstone.	0
95	0.9	384.5 to 385.4	Massive bedded, fine grained, pink (10R5/2) dolomitic sandstone.	0
96.1	9.0	385.4 to 393.4	Massive bedded, fine grained, pink (10R5/2) dolomitic sandstone and red shale (10R4/2).	35
96.2	1.0	393.4 to 394.5	Thick bedded, fine grained, gray (N5-N4) dolomitic sandstone and shale (N4).	55
97.1	4.6	394.5 to 399.1	Thin to thick interbeds of fine grained, gray (N6) dolomitic sandstones and shale/mudstones (N4). Becomes shalier downwards.	55
97.2	0.9	399.1 to 400.0	Medium interbeds of medium grained, pink (10R5/2) dolomitic sandstone and red shale (10R3/2). Lenticular bedding.	50
97.1	2.3	400.0 to 402.3	Brown mudstone/shale and spongy looking rock full of holes (10R6/6). Calcareous except for spongy rock. Thin to medium beds.	65
97.2	2.3	402.3 to 404.6	Gray calcareous shale and spongy looking rock (N4). Thin to thick beds.	65
98.1	5.5	404.6 to 410.1	Homogenous mixture of calcareous shale (10R4/2). Thick to massive beds of jumbled block conglomerate. Could be sedimentary but modified by structure. Turns grey (N5) in the bottom 2 ft. **Ckickamauga Group at 404.0 feet.**	45

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 13	5/15/92 -7/31/92	J. Switek	13 of 13

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
98.2	4.5	410.1 to 414.6	Limestone (N5-N6) interlaced with calcareous shale (N4). Thick to massive bedding. Recrystallized fossils, esp. 414.0-414.2 ft	20
99	10.0	414.6 to 424.6	Limestone (N6) and calcareous shale (N4). Thin to massive lenses and beds. Beds of fossil grainstones 418.0-418.7 ft.	40
100	10.0	424.6 to 434.6	Calcareous shale (N4) and limestone (N6). Thin to massive lenses and beds. Fossils and beds of fossil grainstone.	65
101	6.0	434.6 to 440.6	Limestone (N6) and calcareous shale (N4). Thin to massive lenses and beds. Beds of coarse fossil fragment grainstones. Pink calcite filling fossils, cavities and fractures.	45
TD	TD	TD	TD End of Log	TD

HHMS CORE STRUCTURE LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek and B. Couzens	1 of 4

Run	Number of Fractures/ Faults	Bedding Dip @ Depth ° / feet	Fracture/Fault/Structure Location, Dip and Description
1		10-20/30.8	Core broken up.
2		10-20/ where seen	Core broken up.
3	0/1		Core broken up. Possible fault 39.5 to 40.0 ft.
4		25/41.3	Crush zone 41.6-42.6 and bottom 0.5 ft.
5		25/45.8 20/50.8	
6		25/54.5	
7		Can't determine	Slick surfaces at bottom.
8		20/56.0 20/65.0	Slick surfaces.
9		25/67.7	Many filled fractures in siltstone beds.
10	0/1	30/71.0	Crushed zone about 1 ft from bottom, filled fractures in siltstone.
11		Hi angle near top, 40/80.0	Filled fractures in siltstone beds.
12		55/81.4 50/84.0	Filled fractures in siltstone beds. Slick surfaces.
13		35/86.2	Filled fractures in siltstone beds. Broken zone (w/ gouge) at 90.5 ft.
14	0/1	40/91.2	Gouge 94.8-95 ft. Unbroken core (Bioturbated).
15		40/95.8	Unbroken core.
16		40/95.9	Unbroken core.
17		40/97.1 25/100.3	Filled fractures in mudstones.
18	0/1	35/102.4	Filled fractures in siltstone beds. Several thin gouge zones 103-105 ft.
19	0/2	35/112.6	Two parallel faults (70°) 115.0-115.6 ft. Filled fractures at top and near fault.
20	0/1	20/117.2 15/120.2	High angle fault (>80°) 117.2-117.9. Filled fractures in mostly in siltstone beds. Slick surfaces.
21		25/124.5	Vein filled fractures in siltstones. Slick surfaces.
22		35/127.0	Filled fractures in coarse beds. Slick surfaces.
23		35/135.0	

HHMS CORE STRUCTURE LOG

Well		Dates	Logged by	Page
HHMS 14		4/15-5/5/92	J. Switek and B. Couzens	2 of 4
Run	**Number of Fractures/ Faults**	**Bedding Dip @ Depth ° / feet**	**Fracture/Fault/Structure Location, Dip and Description**	
24		25/137.2	Filled fractures in coarse beds.	
25		25/146.5	Filled fractures in siltstones.	
26		25/155.0	Filled fractures in siltstones.	
27			Filled fractures in siltstones.	
28		35/162.4	Slick surfaces.	
29		30/168.9	Slick surfaces. Some filled fractures in siltstones.	
30		35/172.4	Filled fractures in coarse beds.	
31	0/1	25/178.0	Slick surfaces. Gouge zone 180-180.6 ft.	
32		30/184.7	Broken zone to 182.0 ft. Fractures in siltstone, slick surfaces.	
33		45/185.8	Slick surfaces.	
34	0/1	40/186.9	Gouge 189.9 ft. Poor recovery of plastic, mushy shale. Slick surfaces.	
35		40/192.5	Crush zone 192.6-192.8 ft. Filled fractures in coarse beds.	
36		42/193.8	Filled fractures in coarse beds, 195.3-195.5 ft. Slick surfaces.	
37		23/196.6	Filled fractures.	
38		30/200.5	Broken zone 203-203.5. Fractures in coarse beds.	
39		20/205.0		
40		35/215.2	Filled fractures.	
41		35/216.8	Filled fractures.	
42		30/225.8	Filled fractures.	
43		35/229.9	Filled fractures.	
44	2/0	25/243.0	Dissolution along fractures 241.5 & 243.5 ft.	
45	1/0		Dissolution along fracture 246 ft. Slick surfaces on shale.	
46	1/0	30/247.3	Fault zone 247.5-251.5 ft . Dissolution along fractures 252.5 ft.	
47	0/1	28/261.2	Pervasive fracturing. Fault at 262.8 ft., motion in shale.	
48	2/1	35/269.6	Xtal lined fractures 272 ft. Dissolution along fracture 270 ft. Fault at 268.6	
49	2/1		Fault zone 275.2-275.8 and 272.0-273.4 ft. Xtals on fractures 272 & 273.5 ft.	

HHMS CORE STRUCTURE LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek and B. Couzens	3 of 4

Run	Number of Fractures/ Faults	Bedding Dip @ Depth ° / feet	Fracture/Fault/Structure Location, Dip and Description
50	0/2	0-15/276.0 30/280	Gouge 279 ft. and 280.2 - 280.5 ft.
51		30/280.6	Filled fractures.
52		40/281.4	Filled fractures.
53	0/1	30/295.6	Filled fractures, gouge 294 ft.
54	0/1	23/302.4	Filled fractures. Gouge 298.0-298.5 ft.
55		Varies 0-15° in shale. 35/313.5	Minor faulting evident, inches to centimeters, in the shale/sandstone beds. All fractures filled.
56		Undulose but 20-30°	Core broken numerous partings (11/0.7 ft).
57	0/1	35/320.7	Fault 316.0-317.0 ft. Filled fractures.
58		30/326.0	Filled fractures.
59		32/329.0	Filled fractures.
60	1/1	0-45	Fault 335.5 ft. Open fractures lined with clear and orange crystals 335 ft.
61	1/0	0-10/336.0, 40/342.5	Open orange and crystal lined fractures 336.7-337.5 ft. Bioturbated.
62	0/1	40/345	Fault 343.9 ft.? Filled fractures in sandstone beds.
63		45/346.1, 20/349.4	Filled fractures in dol. Ss.
64		30/355.5	Filled fractures in dol. Ss. Bioturbated.
65.1	0/1	45/357.0	Cataclasite 357.4 ft. Fracturing in coarse beds.
65.2		NA	
65.3		40/375.5	
66		35/366.6 40/370.4	Filled fractures.
67		40/375.8	
68			
69	0/2		Fault 380.7 ft. Gouge 381.7 ft. Filled fractures in coarse beds. Slick surfaces.
70	0/1	45/384.3	Gouge zone 385.7-385.8 ft.
71		58/386.6 60/389.0	Numerous small faults.
72	1/1	70/394.0	4 faults in a zone 390.3-392.0 ft, all filled with minerals. Dissolution along fracture 390.1 ft.
73	2/0	Not determined	Dissolution along two fractures 394.8 ft.

HHMS CORE STRUCTURE LOG

Well		Dates	Logged by	Page
HHMS 14		4/15-5/5/92	J. Switek and B. Couzens	4 of 4
Run	**Number of Fractures/ Faults**	**Bedding Dip @ Depth ° / feet**	**Fracture/Fault/Structure Location, Dip and Description**	
74	FAULT ROCK	Not applicable	Vuggy dolomite 395-398 and 399-400 ft. Water maker. Gouge 397 ft.	
75	-	40/405 but variable	No fractures but some crystal lined pits in the core. Rock appears to have been strained but is solid.	
76	Healed fault ~414 ft. Whole pull may be fault rock	50/405.6 45/411.3	Prominent slip/parting planes at 408.4, 408.8, 411.3 and 414.6 ft. Plane at 414.6 ft striated and crystal lined. Overall appearance of rock is strained but core is solid. Bedding variable, at times indistinct. Slip planes cut apparent bedding.	
77	Top 0.85 ft is fault rock	60/417 55/420 50/422	Top 0.85 ft is same as rock in the above pull. After that, core isd normal bedded rock with some filled fractures.	
78	Healed fractures and fault	35/424	Bedding cut by fault 423.0-423.7ft. Filled and open fractures. Mostly solid core.	
79			Solid shale. Bottom 0.8 ft vuggy, crystalline rock	
TD	TD	TD	TD End of Log	

Appendix F

LITHOLOGIC AND STRUCTURAL CORE LOGS FOR HHMS 14

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek	1 of 10

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
1	0.8	29.6 to 30.8	Pumpkin Valley Shale. Green black (5G2/1) shale and minor siltstone (N6). Lingula fossils, mica. Broken up	70
2	2.0	30.8 to 35.8	Green black (5G2/1) shale and minor siltstone (N6). Mica, parallel bedding in silt stringers	90
3	3.6	35.8 to 40.8	Red brown (10YR2/2) shale/mudstone with minor siltstones. Mudstones thick bedded, mica, glauconite.	70
4	3.2	40.8 to 45.8	Brown (5Y2.5/2 -5YR2.5/2) shale/mudstone. Thick to massive bedded	90
5	4.3	45.8 to 50.8	Brown (5Y2.5/2) shale/mudstone and bedded siltstone.Shale top 0.6 ft, Interbedded silt/ mudstone 0.9 ft then mixed mudstone. Shale and mudstone thick to massive bedded, siltstone thin to medium bedded. Siltstone bioturbated, lenticular, glauconite, mica.	60
6	2.5	50.8 to 54.5	Green (5G2/1) shale, with stringers of siltstone. Mostly a mudstone mix of shale and siltstone. Bioturbated.	75
7	0.5	54.5 to 55.8	Green (5G2/1) shale/mudstone. Bioturbated.	60
8	4.0	55.8 to 65.8	Green (5G2/1) and brown (10R2/2) shale with minor silt beds. Shales thick to massive, siltstones thin to medium bedded. Bioturbated.	80
9	3.3	65.8 to 70.1	Siltstones (N6) and brown (10R2/2) shales. Siltstone increases downward. Thin to medium beds. Bioturbated. Siltstone beds lenticular, hummocky.	35
10	3.3	70.1 to 75.8	Brown (10R2/2) shale and mudstone. Bedded siltstones at the top. Shale/mudstones thick to massive, siltstones thin to medium. Bioturbated.	60

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek	2 of 10

Full No.	Length Ft	Depth (Ft) from to	Description	Shale %
11	2.3	75.8 to 80.8	Siltstones (N6) and brown (10R2/2) shales. Siltstones dominate top and bottom. Siltstones thin to medium beds.	40
12	4.0	80.8 to 85.8	Brown (10R2/2) shale and interbedded siltstone (N6). Becomes all shale bottom 1.5 ft. Siltstones thin to medium, Shales medium to massive beds. Glauconite, lenticular, conglomerate bed.	50
13	4.1	85.8 to 90.8	Siltstones (N6) and brown (5Y2.5/1) shales. Thin to thick beds. Siltstones lenticular and parallel bedded. Glauconite, bioturbation, mica.	40
14	3.0	90.8 to 95.0	Brown (5Y2.5/1) shaley mudstone. Minor siltstone stringers. Bedding massive. Bioturbation, glauconite.	90
15	0.7	95.0 to 95.8	Brown (5Y2.5/1) silty mudstone and siltstones (N6). Thin to medium beds. Siltstone bedding parallel, disrupted, bioturbated, glauconite, mica.	65
16	0.3	95.8 to 95.9	Brown (5Y2.5/1) silty mudstone. Minor siltstone stringers. Bioturbated, glauconite, mica.	75
17	4.6	95.9 to 100.8	Brown (5Y2.5/1) silty mudstone to shaley mudstone. Massive beds. Glauconite, bioturbation, mica.	85
18.1	1.5	100.8 to 102.3	Brown (5Y2.5/1) shaley mudstone. Massive beds. Glauconite, bioturbation.	85
18.2	2.5	102.3 to 105.8	Interbedded siltstones (N6) and brown (5Y2.5/1) shales. Thin to medium beds.	40
19	10.2	105.8 to 115.8	Brown (5Y2.5/1) silty mudstone, heavily bioturbated and homogenized. Minor bedded siltstones are lenticular, parallel bedded. Bedding medium to massive. Glauconite, mica.	45

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek	3 of 10

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
20	4.3	115.8 to 120.8	Brown (5Y2.5/1) shales and interbedded siltstones (N6). Thin to thick beds. Bedding lenticular. Bioturbation, glauconite.	65
21	4.0	120.8 to 125.6	Siltstones (N6) and brown (5Y2.5/2) shales. Bedding thin to thick. Siltstones parallel, lenticular. Bioturbation, glauconite.	45
22	7.8	125.6 to 133.8	Siltstones (N6) and brown (5Y2.5/2) shales. Sand in siltstones. Bedding thin to medium. Lenticular, parallel, laminated bedding. Coarse beds increasing toward the bottom. Bioturbation, glauconite.	40
23	2.0	133.8 to 135.8	Silt/sandstone (N6) and brown (5Y2.5/2) shales. Thin to medium lenticular beds. Bioturbation, glauconite.	40
24	3.3	135.8 to 139.1	Silt/sandstone (N6) and brown (5Y2.5/2) shales. Thin to medium beds. Beds lenticular, parallel. Bioturbation, glauconite.	30
25	6.7	139.1 to 145.8	Silt/sandstone (N6) and brown (5Y2.5/2) shales. Thin to medium beds. Lenticular beds. Bioturbation, glauconite.	40
26.1	3.5	145.8 to 149.3	Brown (5Y2.5/1) silty mudstone. Massive beds. Bioturbation, glauconite.	80
26.2	6.5	149.3 to 155.8	Brown (5Y2.5/2) shales and siltstone (N6), thin to medium beds. One thick bed brown (5Y2.5/2) silty mudstone. Bioturbation, glauconite.	50
27	5.2	155.8 to 161.0	Brown (5YR2.5/2) shales and siltstone (N6), thin to medium beds. Bioturbation, glauconite.	65

HHMS CORE LITHOLOGY LOG

Well		Dates		Logged by	Page
HHMS 14		4/15-5/5/92		J. Switek	4 of 10
Pull No.	Length Ft	Depth (Ft) from to	Description		Shale %
28	3.5	161.0 to 165.6	Brown (5YR2.5/2) shale top 0.8 ft, then interbedded brown (5YR2.5/2) shales and silt/sandstone (N6). Thin to medium lenticular beds. Increasing proportion of silt/sand toward the bottom. Bioturbation, glauconite.		65
29	3.8	165.6 to 170.4	Brown (5YR2.5/1) mudstone and interbedded brown (5YR2.5/2) shales and silt/sandstone (N6). Massive mudstones, shales/siltstones thin to medium bedded. Bioturbation, glauconite.		70
30	5.5	170.4 to 175.8	Brown (5YR2.5/1) silty/sandy mudstone, massive beds. Minor interbedded brown (5YR2.5/2) shales and silt/sandstone (N6), thin to medium beds but bedding is mostly indistinct. Bioturbation, glauconite.		60
31	4.5	175.8 to 180.6	Brown (5YR2.5/1) silty mudstone becoming increasingly shaley toward the bottom. Massive beds. Bioturbation, glauconite.		70
32	4.0	180.6 to 185.1	Brown (5YR2.5/1) silty mudstone top 1 ft turning to interbedded siltstone (N6) and shale (5YR2.5/1). Thin to medium beds, parallel laminar siltstone beds. Bioturbation, glauconite.		60
33	0.6	185.1 to 185.8	Interbedded brown (5YR2.5/2) shales and silt/sandstone (N6). Thin beds. Bioturbation, glauconite.		70
34.1	1.8	185.8 to 187.6	Brown (5YR2.5/2) shale with minor interbedded siltstones. Shales massive, siltstones thin beds. Bioturbation, glauconite.		80
34.2	1.6	187.6 to 189.1	Sandstone (N6) and interbedded shale (5YR2.5/2). Thin to medium beds, parallel laminar, lenticular, hummocky beds. Bioturbation, glauconite.		15

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek	5 of 10

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
34.3	0.2	189.1 to 189.9	Brown (5YR2.5/2) plastic shale with pieces stuck in it. Bedding not apparent.	100
35	2.1	189.9 to 193.2	Brown (5YR2.5/1) shale interbedded with sandy siltstone (N6). Shale thin to thick bedded, siltstone thin to medium bedded. Glauconite.	70
36	2.5	193.2 to 195.8	Brown (5YR2.5/1) shale and interbedded sandy siltstone (N6). Thin to thick beds, siltstones lenticular, parallel laminated. Shale increases downward. Bioturbation, glauconite.	60
37	3.6	195.8 to 199.3	Brown (5YR2.5/1) mudstone and shale and interbedded sandy siltstone (N6). Thin to thick beds, siltstones lenticular, parallel laminated. Bioturbation, glauconite.	60
38	3.3	199.3 to 203.5	Brown (5YR2.5/1) shale and interbedded sandy siltstone (N6). Shaley top, coarse beds near bottom. Thin to thick lenticular bedding. Bioturbation, glauconite.	55
39	2.6	203.5 to 205.8	Sandy siltstone (N6) and interbedded brown (5YR2/2) shale. Thin to thick lenticular bedding. Bioturbation, glauconite. Conglomerate bed 204.7-204.9	45
40	9.5	205.8 to 215.8	Sandstone (N6) and blackish shale (N2). Bedding thin to massive at the bottom. Lenticular bedding to 210.7 ft. TBss/sh facies top, ss/ds bottom 1.2 ft. **Rome Formation at 215.0 feet.**	20
41	5.2	215.8 to 221.0	Hard dolomitic sandstone (N6-N4), ss/ds facies, massive beds with dark brown shale (10YR2/0) partings. Thick to massive beds. Bottom 2.5 ft darker.	1
42	4.8	221.0 to 225.8	Hard dolomitic sandstone (N6-N5), ss/ds facies, massive beds with dark brown shale (10YR2/0) partings.	1

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek	6 of 10

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
43	10.0	225.8 to 235.8	Hard dolomitic sandstone (N6-N4), ss/ds facies, massive beds with dark brown shale (10YR2/0) partings. Shale increases slightly bottom 3 ft.	5
44	10.0	235.8 to 245.8	Hard dolomitic sandstone (N6-N5), ss/ds facies, medium to coarse grains, massive beds with dark brown shale (10YR2/0) partings.	1
45	0.1	245.8 to 245.9	Dolomitic sandstone (N6) and brown (10YR2/0) shale. Medium beds.	20
46	9.9	245.9 to 255.8	Dolomitic ss/ds sandstone (N6-N5) with N4 partings. Thick to massive bedding. Dark grey gouge zone lined with crystalline material in a sheet, Calcite? Fault rock, recemented 250-251.3 ft. Bottom 2.5 ft TB ss/sh facies.	2
47.1	6.8	255.8 to 262.6	Dolomitic ss/ds sandstone (N6-N5) with N4 partings. Thick to massive bedding. N4 shale.	20
47.2	3.2	262.6 to 265.8	TB ss/sh interbedded sandstone (N6) and shales (N4). Thin to thick beds.	30
48	6.2	265.8 to 272.0	Dolomitic ss/ds sandstone (N6-N5) with N4 shale partings. Thick to massive bedding. Broken zone bottom 1 ft. Crystal lined fractures.	5
49	3.1	272.0 to 275.8	Dolomitic ss/ds sandstone (N6) with N4 shale partings. Thick to massive bedding. Crystal lined fractures.	5
50	3.9	275.8 to 280.5	Interbedded grey (N6) and red (10R4/1) sandstones and red (10R3/1) and green (5G4/1) shales and mudstones. Thin to medium beds, worm trails, bioturbated, lenticular beds may be cross bedded.	35
51	0.3	280.5 to 280.8	Red (10R5/0) dolomitic sandstone, medium grained.	0

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek	7 of 10

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
52	5.3	280.8 to 285.8	Grey (N6) and red (10R5/0) dolomitic sandstone with N4 shale partings. Medium to coarse grained.	10
53	9.8	285.8 to 295.6	Red (10R5/0) dolomitic medium to fine grained sandstone, grey (N6) at top. Massive bedding. Partings the same color as beds. Some beds of green (5G4/1) occur at various places. Fossils? bottom 0.7 ft.	10
54.1	8.3	295.6 to 303.9	Red (10R5/0) dolomitic sandstone top 1.7 ft then grey (N6), partings (N4), Medium grained some conglomerate. Bioturbation, some partings varicolored.	5
54.2	1.7	303.9 to 305.6	Brown mudstone (5Y2.5/1) with minor sand/siltstone lenses and stringers. Bioturbation, glauconite.	80
55.1	7.1	305.6 to 312.7	Interbedded brown mudstone (5Y2.5/1) and brown shale (2.5YR2.5/4) with minor sand/siltstone lenses. Bedding massive, bioturbation, glauconite.	80
55.2	2.2	312.7 to 314.9	Thick to massive bedded red dolomitic sandstone (10R5/0). Minor shale parting. Medium grained.	1
56	0.7	314.9 to 315.6	Thin to medium bedded sandstone (10R5/0) broken by many shale (5Y2.5/1) partings.	15
57	10.0	315.6 to 325.6	Massive bedded grey (N6) to red (10R5/0-5R6/2) medium grained dolomitic sandstone. Zones show thin beds that have been disrupted with some brecciation. Sparkly green and red shale 321.2-321.7ft	10
58	2.7	325.6 to 328.3	Massive bedded, medium grained, red (10R3/1) dolomitic sandstone.	0
59	4.7	328.3 to 333.0	Thick to massive bedded, medium to coarse grained, red (5R3/4) dolomitic sandstone. Shale partings.	5

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek	8 of 10

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
60	2.8	333.0 to 335.8	Thick to massive bedded, medium grained red (5R3/4) dolomitic sandstone with shale partings of the same color.	5
61.1	3.6	335.8 to 339.4	Thick to massive bedded, medium to coarse grained red (5R3/4) dolomitic sandstone, becomes coarser bottom 1 ft. Sandstone becomes laced with green shale?	5
61.2	4.5	339.4 to 343.9	Massive, homogenous fault rock? sand/mudstone, predominantly red (5R3/4) intricately interlaced with green. Green (5G3/2) partings.	10
62	1.6	343.9 to 345.8	Medium bedded medium to coarse grained grey (N6) dolomitic sandstone. Brown shale (5Y2.5/2) top 0.2 ft.	30
63	4.6	345.8 to 350.2	Thin to thick bedded, fine to coarse grained grey (N6) dolomitic sandstone. Thinner beds lenticular. Shales (N4). Glauconite.	30
64	5.6	350.2 to 355.8	Thin to thick bedded, fine to coarse grained grey (N6) dolomitic sandstone top and bottom. 351.0 to 354.0 ft is homogenous fault rock? sand/mudstone, predominantly red (5R3/4) intricately interlaced with green. Green (5G3/2) partings.	30
65.1	1.6	355.8 to 357.4	Medium to coarse grained grey (N6) dolomitic sandstone interbedded with brown shale (5Y2.5/2). Thin to medium lenticular bedding. Glauconite.	45
65.2	6.2	357.4 to 363.6	Grey (N5) fault rock? sand/mudstone. Homogenous, massive bedding. Some pockets of bedded rock included, especially 359.2-359.7 ft.	0
65.3	2.2	363.6 to 365.8	Medium to coarse grained grey (N6) dolomitic sandstone interbedded with brown shale (5Y2.5/2). Thin to medium lenticular bedding.	30

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek	9 of 10

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
66.1	3.4	365.8 to369.1	Interbedded thick to medium bedded, medium to coarse grained grey sandstone (N6) and brown shale (5Y2.5/2). Bioturbation.	20
66.2	4.7	369.1 to 373.7	Massive bedded mottled grey and brown (N6, 5Y2.5/2) sandy mudstone, heavily bioturbated. Interbedded with minor thin to medium bedded, medium to coarse grained sandstone.	50
67	2.2	373.7 to 375.8	Interbedded, lenticular bedded sandstones (N6) and shales (5Y2.5/2). Heavily bioturbated but bedding still present.	75
68	0.1	375.8 to 375.9	Grey (N6) medium grained sandstone.	0
69	4.2	375.9 to 381.7	Interbedded, thin to medium bedded, medium to coarse grained sandstone (N6) and brown shales, (10YR2/2). Lenticular bedding. Core becomes more shale rich with depth. Bioturbated.	50
70	4.2	381.7 to 385.8	Interbedded, thin to massive bedded brown shale (10YR2/2) and thin to medium grained, lenticular bedded sandstone (N6).	70
71	4.3	385.8 to 390.1	Thick to massive bedded, medium to coarse grained dolomitic sandstone (N6). Top 0.8 ft broken and recemented into a solid piece. Bedding in tact for rest of pull but broken into blocks by numerous fractures like cleavage, but core is solid.	0
72.1	1.5	390.1 to391.6	Massive coarse grained dolomitic red (10R5/1) sandstone with minor shale partings (10R3/2). Parallel laminations.	5
72.2	3.0	391.6 to 394.7	Thick to massive, coarse graines red (10R4/2) dolomitic sandstone. Some very coarse beds. Parallel laminations	5

HHMS CORE LITHOLOGY LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek	10 of 10

Pull No.	Length Ft	Depth (Ft) from to	Description	Shale %
73	1.3	394.7 to 395.8	Massive bed of pink dolomitic sandstone (10R5/1), 1 shale parting.	5
74	8.4	395.8 to 404.2	Massive, homogenous strained fault rock. Generally grey (N6-N4) looking. Minor zones of bedded coarse to medium grained, thin bedded sandstone (N6) and brown shale (10YR2/2) above and below homogenous fault rock. Bedded material shows obvious strain.	25
75	1.2	404.2 to 405.5	Mostly gray, medium grained sandstone (N6) mixed with black shale (N4). Overall appearance massive, homogenized	25
76	10.1	405.5 to 415.5	Gray, sandy mudstone (N3) overall. Minor discrete beds of medium grained sandstone, becomes more sand rich at the bottom. Massive, homogenous beds.	70
77.1	0.85	415.5 to 416.35	Gray medium grained sandstone (N5) with stringers of shale mixed in. Same as pull above.	30
77.2	3.95	416.35 to 420.3	Massive red (10R4/2), medium grained, micaceous sandstone. Carbonate cement top 2.6 ft. Slightly darker (10R4/1) bottom 1.5 ft.	5
77.3	2.1	420.3 to 422.4	Interbedded shale (N4) and medium to fine grained sandstone (N5). Medium to thick beds. Turns red bottom 1 ft. Carbonate cement 421-422 ft.	40
78	3.3	422.4 to 426.3	Interbedded red (10R4/2) fine to medium grained sandstone and shale (10R3/2) Laminated to thick bedded.	30
79	2.1	426.3 to 430.0	Top 0.3 ft same as pull 78 above. Then black shale (N2) with sand stringers. Bottom 0.8 ft vuggy, black dolomite (N2).	80
TD	TD	TD	TD End of Log	TD

HHMS CORE STRUCTURE LOG

Well		Dates	Logged by	Page
HHMS 14		4/15-5/5/92	J. Switek and B. Couzens	1 of 4
Run	**Number of Fractures/ Faults**	**Bedding Dip @ Depth ° / feet**	**Fracture/Fault/Structure Location, Dip and Description**	
1		10-20/30.8	Core broken up	
2		10-20/ where seen	Core broken up	
3	0/1		Core broken up. Possible fault 39.5 to 40.0 ft.	
4		25/41.3	Crush zone 41.6-42.6 and bottom 0.5 ft.	
5		25/45.8 20/50.8		
6		25/54.5		
7		Can't determine	Slick surfaces at bottom.	
8		20/56.0 20/65.0	Slick surfaces	
9		25/67.7	Many filled fractures in siltstone beds.	
10	0/1	30/71.0	Crushed zone about 1 ft from bottom, filled fractures in siltstone	
11		Hi angle near top, 40/80.0	Filled fractures in siltstone beds.	
12		55/81.4 50/84.0	Filled fractures in siltstone beds. Slick surfaces.	
13		35/86.2	Filled fractures in siltstone beds. Broken zone (w/ gouge) at 90.5 ft.	
14	0/1	40/91.2	Gouge 94.8-95 ft. Unbroken core (Bioturbated)	
15		40/95.8	Unbroken core.	
16		40/95.9	Unbroken core.	
17		40/97.1 25/100.3	Filled fractures in mudstones.	
18	0/1	35/102.4	Filled fractures in siltstone beds. Several thin gouge zones 103-105 ft.	
19	0/2	35/112.6	Two parallel faults (70°) 115.0-115.6 ft. Filled fractures at top and near fault.	
20	0/1	20/117.2 15/120.2	High angle fault (>80°) 117.2-117.9. Filled fractures in mostly in siltstone beds. Slick surfaces.	
21		25/124.5	Vein filled fractures in siltstones. Slick surfaces.	
22		35/127.0	Filled fractures in coarse beds. Slick surfaces.	
23		35/135.0		

HHMS CORE STRUCTURE LOG

Well		Dates	Logged by	Page
HHMS 14		4/15-5/5/92	J. Switek and B. Couzens	2 of 4
Run	**Number of Fractures/ Faults**	**Bedding Dip @ Depth ° / feet**	**Fracture/Fault/Structure Location, Dip and Description**	
24		25/137.2	Filled fractures in coarse beds.	
25		25/146.5	Filled fractures in siltstones.	
26		25/155.0	Filled fractures in siltstones.	
27			Filled fractures in siltstones	
28		35/162.4	Slick surfaces	
29		30/168.9	Slick surfaces. Some filled fractures in siltstones.	
30		35/172.4	Filled fractures in coarse beds.	
31	0/1	25/178.0	Slick surfaces. Gouge zone 180-180.6 ft.	
32		30/184.7	Broken zone to 182.0 ft. Fractures in siltstone, slick surfaces.	
33		45/185.8	Slick surfaces.	
34	0/1	40/186.9	Gouge 189.9 ft. Poor recovery of plastic, mushy shale. Slick surfaces.	
35		40/192.5	Crush zone 192.6-192.8 ft. Filled fractures in coarse beds.	
36		42/193.8	Filled fractures in coarse beds, 195.3-195.5 ft. Slick surfaces.	
37		23/196.6	Filled fractures.	
38		30/200.5	Broken zone 203-203.5. Fractures in coarse beds.	
39		20/205.0		
40		35/215.2	Filled fractures.	
41		35/216.8	Filled fractures.	
42		30/225.8	Filled fractures.	
43		35/229.9	Filled fractures.	
44	2/0	25/243.0	Disolution along fractures 241.5 & 243.5 ft.	
45	1/0		Disolution along fracture 246 ft. Slick surfaces on shale.	
46	1/0	30/247.3	Fault zone 247.5-251.5 ft . Disolution along fractures 252.5 ft.	
47	0/1	28/261.2	Pervasive fracturing. Fault at 262.8 ft., motion in shale.	
48	2/1	35/269.6	Xtal lined fractures 272 ft. Disolution along fracture 270 ft. Fault at 268.6	
49	2/1		Fault zone 275.2-275.8 and 272.0-273.4 ft. Xtals on fractures 272 & 273.5 ft.	

HHMS CORE STRUCTURE LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek and B. Couzens	3 of 4

Run	Number of Fractures/ Faults	Bedding Dip @ Depth ° / feet	Fracture/Fault/Structure Location, Dip and Description
50	0/2	0-15/276.0 30/280	Gouge 279 ft. and 280.2 - 280.5 ft.
51		30/280.6	Filled fractures.
52		40/281.4	Filled fractures.
53	0/1	30/295.6	Filled fractures, gouge 294 ft..
54	0/1	23/302.4	Filled fractures. Gouge 298.0-298.5 ft.
55		Varies 0-15° in shale. 35/313.5	Minor faulting evident, inches to centimeters, in the shale/sandstone beds. All fractures filled.
56		Undulose but 20-30°	Core broken numerous partings (11/0.7 ft).
57	0/1	35/320.7	Fault 316.0-317.0 ft. Filled fractures.
58		30/326.0	Filled fractures.
59		32/329.0	Filled fractures.
60	1/1	0-45	Fault 335.5 ft. Open fractures lined with clear and orange crystals 335 ft.
61	1/0	0-10/336.0, 40/342.5	Open orange and crystal lined fractures 336.7-337.5 ft. Bioturbated.
62	0/1	40/345	Fault 343.9 ft.? Filled fractures in sandstone beds.
63		45/346.1, 20/349.4	Filled fractures in dol. Ss.
64		30/355.5	Filled fractures in dol. Ss. Bioturbated.
65.1	0/1	45/357.0	Cataclasite 357.4 ft. Fracturing in coarse beds.
65.2		NA	
65.3		40/375.5	
66		35/366.6 40/370.4	Filled fractures.
67		40/375.8	
68			
69	0/2		Fault 380.7 ft. Gouge 381.7 ft. Filled fractures in coarse beds. Slick surfaces.
70	0/1	45/384.3	Gouge zone 385.7-385.8 ft.
71		58/386.6 60/389.0	Numerous small faults.
72	1/1	70/394.0	4 faults in a zone 390.3-392.0 ft, all filled with minerals. Dissolution along fracture 390.1 ft.

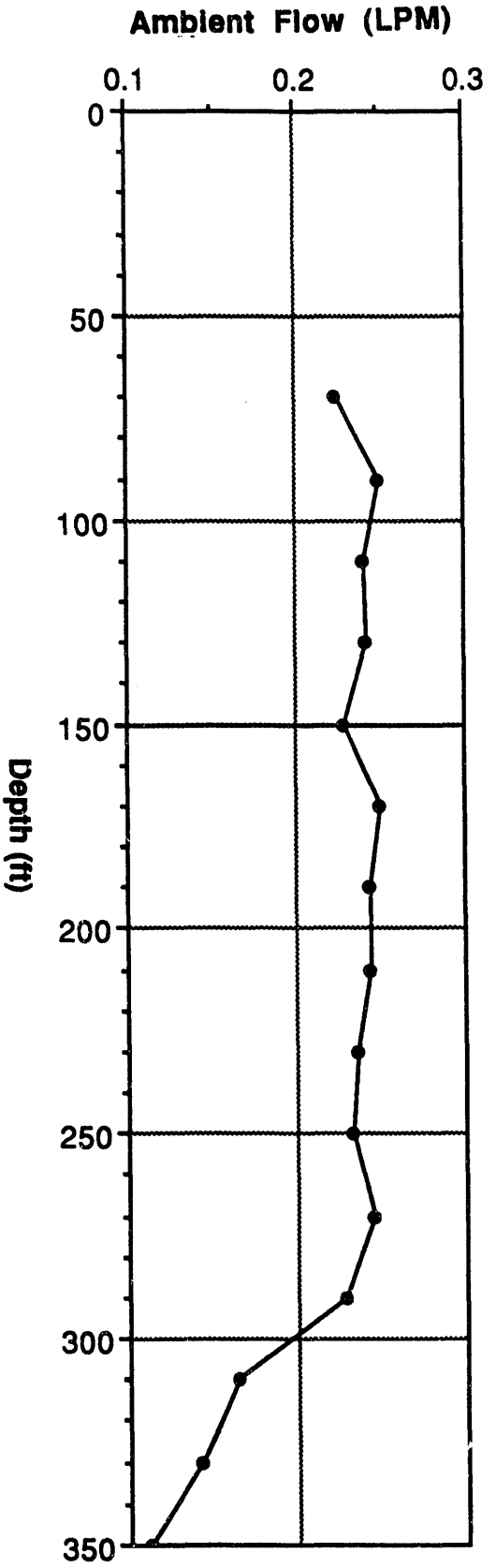
HHMS CORE STRUCTURE LOG

Well	Dates	Logged by	Page
HHMS 14	4/15-5/5/92	J. Switek and B. Couzens	4 of 4

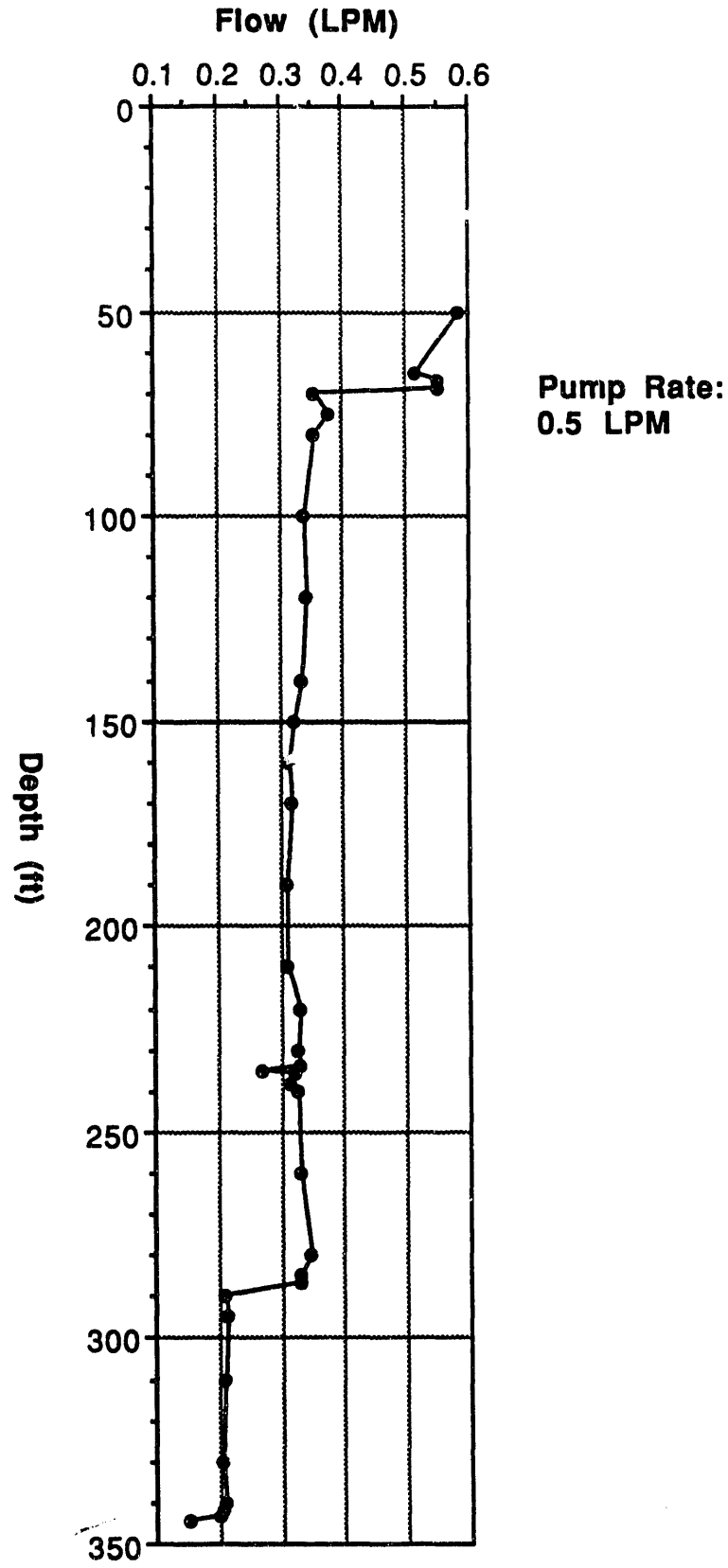
Run	Number of Fractures/ Faults	Bedding Dip @ Depth ° / feet	Fracture/Fault/Structure Location, Dip and Description
73	2/0	Not determined	Disolution along two fractures 394.8 ft.
74	FAULT ROCK	Not applicable	Vuggy dolomite 395-398 and 399-400 ft. Water maker. Gouge 397 ft.
75	-	40/405 but variable	No fractures but some crystal lined pits in the core. Rock appears to have been strained but is solid.
76	Healed fault ~414 ft. Whole pull may be fault rock	50/405.6 ft 45/411.3 ft	Prominent slip/parting planes at 408.4, 408.8, 411.3 and 414.6 ft. Plane at 414.6 ft striated and crystal lined. Overall appearance of rock is strained but core is solid. Bedding variable, at times indistinct. Slip planes cut apparent bedding.
77	Top 0.85 ft is fault rock	60/417 ft 55/420 ft 50/422 ft	Top 0.85 ft is same as rock in the above pull. After that, core isd normal bedded rock with some filled fractures.
78	Healed fractures and fault	35/424 ft	Bedding cut by fault 423.0-423.7ft. Filled and open fractures. Mostly solid core.
79			Solid shale. Bottom 0.8 ft vuggy, crystalline rock
TD	TD	TD	TD End of Log

Appendix G

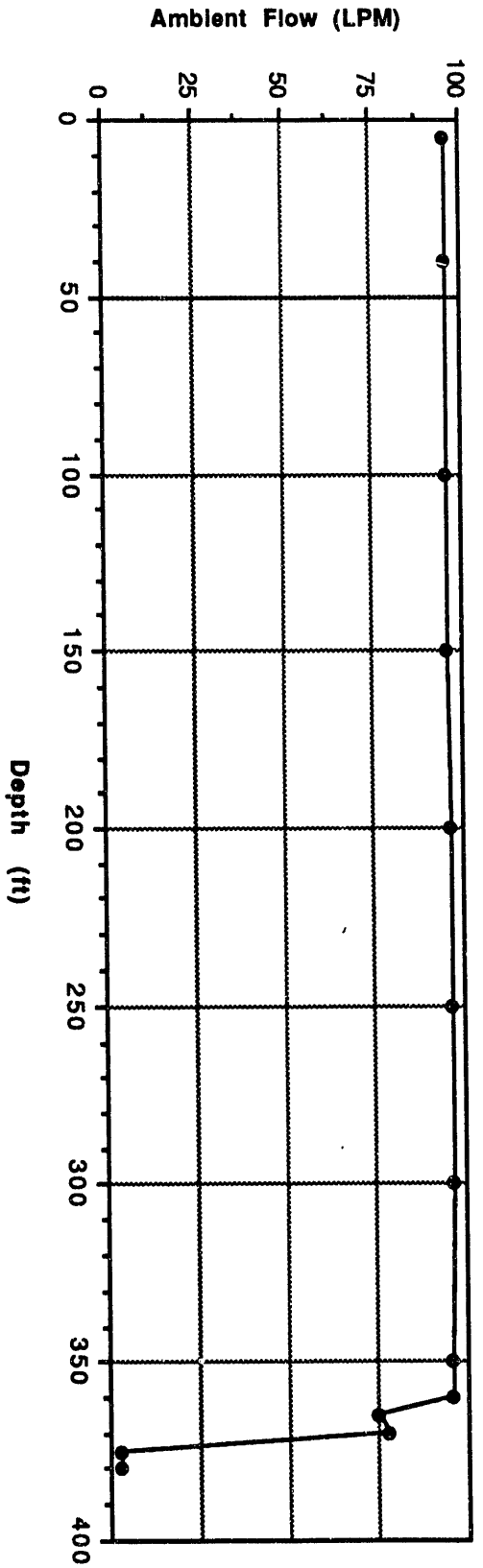
FLOWMETER DATA FOR HHMSs 12, 13, AND 14



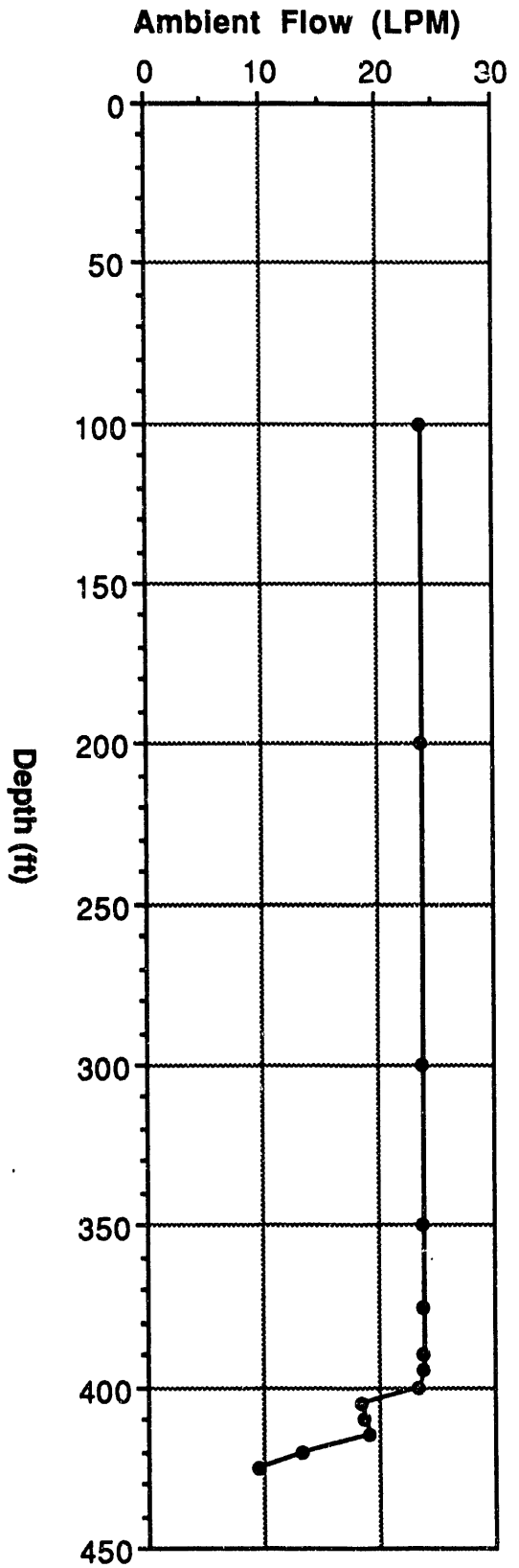
HHMS 12 Ambient Flowmeter Survey.



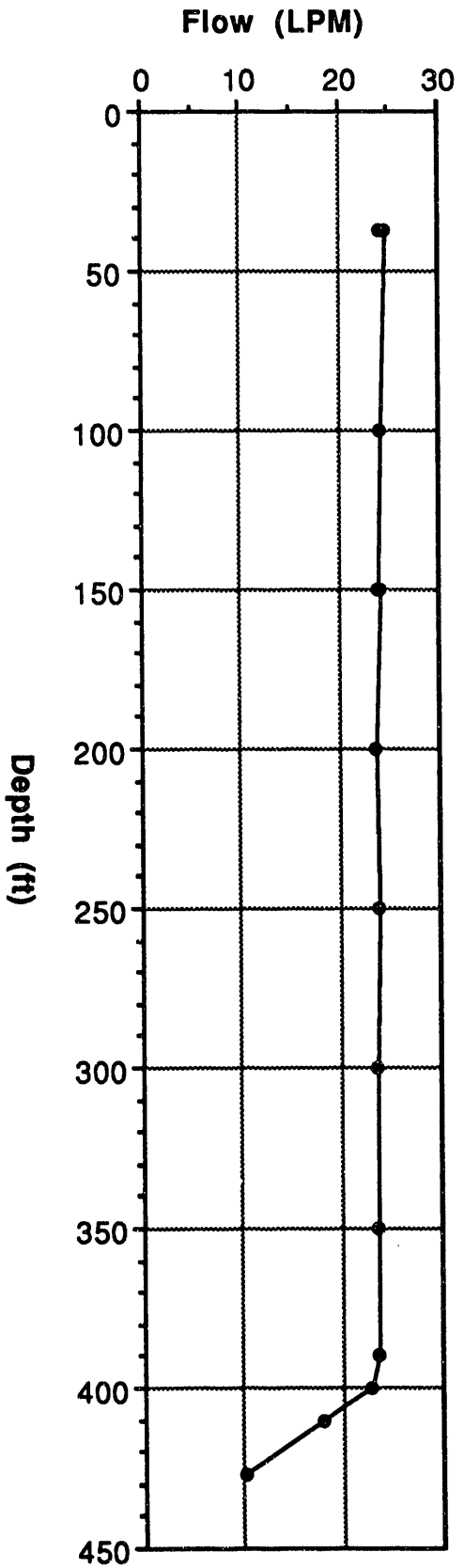
HHMS 12 Pump Test Flowmeter Survey.



HHMS 13 Ambient Flowmeter Survey.



HHMS 14 Ambient Flowmeter Survey.



HHMS 14 Pump Test Flowmeter Survey.

Appendix H

MULTIPORT COMPLETION DESIGN FOR HHMSs 12, 13, AND 14

WELL: HHMS-12
INSTALLATION DATE: 7/7-13/92
TOP OF MP: 819.1 (ft.)
GROUND ELEVATION: 817.3 (ft.)
DEPTH OF SURFACE CASING: 53.0 (ft.)

	COMPLETION ZONE			MEASUREMENT PORT			PUMPING PORT	
Zone Number	Interval Depth (ft. bgs)	Interval True Depth (ft. bgs)	Interval Elevation (ft.)	Port Depth (ft. bgs)	Port True Depth (ft. bgs)	Elevation (ft. amsl)	Port Depth (ft. bgs)	Port True Depth (ft. bgs)
1	389-396	388.3 - 395.2	429.0 - 422.1	391.12	390.36	426.94		
2	**374-386**	**373.3 - 385.3**	**444.0 - 432.0**	**381.08**	**380.37**	**436.93**	**386.10**	**385.37**
3	354-371	353.4 - 370.3	463.9 - 447.0	366.03	365.39	451.91		
4	**334-351**	**333.5 - 350.4**	**483.8 - 466.9**	**345.97**	**345.43**	**471.87**	**350.99**	**350.42**
5	299-331	298.6 - 330.5	518.7 - 486.8	315.90	315.47	501.83		
6	**284-296**	**283.7 - 295.6**	**533.6 - 521.7**	**290.82**	**290.48**	**526.82**	**295.84**	**295.48**
7	269-271	268.7 - 270.7	548.6 - 546.6	275.77	275.47	541.83		
8	244-266	243.8 - 265.7	573.5 - 551.6	255.71	255.47	561.83		
9	**229-241**	**228.8 - 240.8**	**588.5 - 576.5**	**235.65**	**235.46**	**581.84**	**240.67**	**240.47**
10	204-226	203.9 - 225.8	613.4 - 591.5	215.59	215.43	601.87		
11	179-201	178.9 - 200.9	638.4 - 616.4	190.53	190.42	626.88		
12	**164-176**	**163.9 - 175.9**	**653.4 - 641.4**	**170.48**	**170.40**	**646.90**	**175.49**	**175.40**
13	139-161	139.0 - 160.9	678.3 - 656.4	150.43	150.37	666.93		
14	**124-136**	**124.0 - 136.0**	**693.3 - 681.3**	**130.36**	**130.32**	**686.98**	**135.38**	**135.34**
15	99-121	99.0 - 121.0	718.3 - 696.3	110.30	110.28	707.02		
16	79-96	79.0 - 96.0	738.3 - 721.3	90.24	90.23	727.07		
17	**59-76**	**59.0 - 76.0**	**758.3 - 741.3**	**70.18**	**70.17**	**747.13**	**75.20**	**75.19**
18	50-56	50.0 - 56.0	767.3 - 761.3	55.14	55.13	762.17		

*All depths except for "True Depth" are measured along the length of the borehole with no correction for borehole deviation.
*Sampling zones are shown in bold.

WELL: HHMS-13
INSTALLATION DATE: 6/15-17/92
TOP OF MP: 785.1 (ft.)
GROUND ELEVATION: 783.3 (ft.)
DEPTH OF SURFACE CASING: 44.5 (ft.)

!! this is an unsurveyed approximation !!

COMPLETION ZONE				MEASUREMENT PORT			PUMPING PORT	
Zone Number	Interval Depth (ft. bgs)	Interval True Depth (ft. bgs)	Interval Elevation (ft.)	Port Depth (ft. bgs)	Port True Depth (ft. bgs)	Elevation (ft. amsl)	Port Depth (ft. bgs)	Port True Depth (ft. bgs)
1	429-435	428.9 - 434.9	354.4 - 348.4	431.10	430.98	352.32		
2	**414-426**	**413.9 - 425.9**	**369.4 - 357.4**	**421.06**	**420.95**	362.35	**426.08**	**425.97**
3	**399-411**	**398.9 - 410.9**	**384.4 - 372.4**	**406.01**	**405.91**	377.39	**411.02**	**410.92**
4	374-396	373.9 - 395.9	409.4 - 387.4	385.96	385.88	397.42		
5	**344-371**	**344.0 - 370.9**	**439.3 - 412.4**	**350.90**	**350.84**	432.46	**360.92**	**360.85**
6	324-341	324.0 - 341.0	459.3 - 442.3	335.84	335.79	447.51		
7	**309-321**	**309.0 - 321.0**	**474.3 - 462.3**	**315.79**	**315.75**	467.55	**320.81**	**320.76**
8	289-306	289.0 - 306.0	494.3 - 477.3	300.74	300.71	482.59		
9	**274-286**	**274.0 - 286.0**	**509.3 - 497.3**	**280.70**	**280.67**	502.63	**285.71**	**285.68**
10	254-271	254.0 - 271.0	529.3 - 512.3	260.65	260.63	522.67		
11	234-251	234.0 - 251.0	549.3 - 532.3	245.60	245.58	537.72		
12	**214-231**	**214.0 - 231.0**	**569.3 - 552.3**	**220.56**	**220.54**	562.76	**230.57**	**230.56**
13	174-211	174.0 - 211.0	609.3 - 572.3	195.48	195.47	587.83		
14	**159-171**	**159.0 - 171.0**	**624.3 - 612.3**	**165.41**	**165.40**	617.90	**170.43**	**170.42**
15	124-156	124.0 - 156.0	659.3 - 627.3	145.35	145.34	637.96		
16	**109-121**	**109.0 - 121.0**	**674.3 - 662.3**	**115.29**	**115.28**	668.02	**120.30**	**120.30**
17	84-106	84.0 - 106.0	699.3 - 677.3	95.24	95.23	688.07		
18	**69-81**	**69.0 - 81.0**	**714.3 - 702.3**	**75.19**	**75.18**	708.12	**80.20**	**80.20**
19	64-66	64.0 - 66.0	719.3 - 717.3	65.15	65.14	718.16		
20	**49-61**	**49.0 - 61.0**	**734.3 - 722.3**	**55.11**	**55.11**	728.19	**60.13**	**60.13**

*All depths except for "True Depth" are measured along the length of the borehole with no correction for borehole deviation.
*Sampling zones are shown in bold.

WELL: HHMS-14
INSTALLATION DATE: 6/23-25/92
TOP OF MP: 786.2 (ft.)
GROUND ELEVATION: 785.9 (ft.)
DEPTH OF SURFACE CASING: 27.0 (ft.)

	COMPLETION ZONE			MEASUREMENT PORT			PUMPING PORT	
Zone Number	Interval Depth (ft. bgs)	Interval True Depth (ft. bgs)	Interval Elevation (ft.)	Port Depth (ft. bgs)	Port True Depth (ft. bgs)	Elevation (ft. amsl)	Port Depth (ft. bgs)	Port True Depth (ft. bgs)
1	409-420	408.8 - 419.8	377.1 - 366.1	411.17	411.01	374.89		
2	**394-406**	**393.8 - 405.8**	**392.1 - 380.1**	**401.14**	**400.97**	**384.93**	**406.15**	**405.99**
3	364-391	363.8 - 390.8	422.1 - 395.1	376.07	375.91	409.99		
4	**349-361**	**348.8 - 360.8**	**437.1 - 425.1**	**356.01**	**355.85**	**430.05**	**361.03**	**360.87**
5	319-346	318.9 - 345.8	467.0 - 440.1	331.00	330.84	455.06		
6	**304-316**	**303.9 - 315.9**	**482.0 - 470.0**	**310.90**	**310.75**	**475.15**	**315.92**	**315.76**
7	279-301	278.9 - 300.9	507.0 - 485.0	285.84	285.69	500.21		
8	254-276	253.9 - 275.9	532.0 - 510.0	265.78	265.64	520.26		
9	**234-251**	**233.9 - 250.9**	**552.0 - 535.0**	**240.73**	**240.60**	**545.30**	**250.75**	**250.61**
10	199-231	198.9 - 230.9	587.0 - 555.0	220.68	220.55	565.35		
11	**184-196**	**183.9 - 195.9**	**602.0 - 590.0**	**190.47**	**190.35**	**595.55**	**195.49**	**195.37**
12	154-181	153.9 - 180.9	632.0 - 605.0	165.39	165.28	620.62		
13	**139-151**	**138.9 - 150.9**	**647.0 - 635.0**	**145.34**	**145.24**	**640.66**	**150.35**	**150.25**
14	109-136	108.9 - 135.9	677.0 - 650.0	120.29	120.20	665.70		
15	**94-106**	**93.9 - 105.9**	**692.0 - 680.0**	**100.24**	**100.16**	**685.74**	**105.25**	**105.17**
16	74-91	73.9 - 90.9	712.0 - 695.0	80.19	80.12	705.78		
17	49-71	49.0 - 70.9	736.9 - 715.0	60.14	60.09	725.81		
18	**34-46**	**34.0 - 46.0**	**751.9 - 739.9**	**40.09**	**40.05**	**745.85**	**45.10**	**45.06**

*All depths except for "True Depth" are measured along the length of the borehole with no correction for borehole deviation.
*Sampling zones are shown in bold.

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