

APPALACHIAN OIL PURCHASERS, INC.

CK 983800

November 11, 2015

Mr. Zachary Stevison, Geologist, UIC Section
West Virginia Department of Environmental Protection
Office of Oil and Gas
601 57th Street, SE
Charleston, WV 25304

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

RE: Permit Renewal for the BW #4 Class IID Commercial Disposal Well, UIC2D732523

Dear Mr. Stevison:

Please find enclosed the required original UIC permit application package for the Permit Renewal of the Class IID injection well, BW #4, which includes a check for \$550 for the application fee and groundwater protection plan (GPP).

If you have any questions regarding this matter, please feel free to contact me at (304) 665-2461.

Sincerely,

Ashleigh Strahler, Senior Project Engineer, Ohio River Valley
Appalachian Oil Purchasers, Inc.
157 Lower Eureka Lane
Saint Marys, West Virginia 26170

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

State of West Virginia
Department of Environmental Protection - Office of Oil and Gas
Well Operator's Report of Well Work

Handwritten signature

API 47-073-02523 County Pleasants District Washington
Quad Raven Rock 7 1/2 minute Pad Name NA Field/Pool Name NA
Farm name BW Well Number 4
Operator (as registered with the OOG) Appalachian Oil Purchasers, LLC
Address 157 Lower Eureka Lane City St. Marys State WV Zip 26170

As Drilled location NAD 83/UTM Attach an as-drilled plat, profile view, and deviation survey
Top hole Northing 4358508.86 Easting 478743.08
Landing Point of Curve Northing NA Easting NA
Bottom Hole Northing NA Easting NA

Elevation (ft) 640 feet GL Type of Well ☐ New ☒ Existing Type of Report ☐ Interim ☒ Final
Permit Type ☐ Deviated ☐ Horizontal ☐ Horizontal 6A ☒ Vertical Depth Type ☒ Deep ☐ Shallow
Type of Operation ☐ Convert ☐ Deepen ☐ Drill ☐ Plug Back ☐ Redrilling ☐ Rework ☐ Stimulate
Well Type ☒ Brine Disposal ☐ CBM ☐ Gas ☐ Oil ☐ Secondary Recovery ☐ Solution Mining ☐ Storage ☐ Other _____
Type of Completion ☒ Single ☐ Multiple Fluids Produced ☐ Brine ☐ Gas ☐ NGL ☐ Oil ☐ Other _____
Drilled with ☐ Cable ☒ Rotary

Drilling Media Surface hole ☒ Air ☐ Mud ☐ Fresh Water Intermediate hole ☐ Air ☐ Mud ☐ Fresh Water ☐ Brine
Production hole ☒ Air ☐ Mud ☐ Fresh Water ☐ Brine
Mud Type(s) and Additive(s)

Date permit issued 8/13/10 Date drilling commenced 11/17/10 Date drilling ceased 2/3/11
Date completion activities began 2/9/11 Date completion activities ceased 4/2/11
Verbal plugging (Y/N) NA Date permission granted NA Granted by NA

Please note: Operator is required to submit a plugging application within 5 days of verbal permission to plug

Freshwater depth(s) ft 150 feet Open mine(s) (Y/N) depths No
Salt water depth(s) ft 450 feet Void(s) encountered (Y/N) depths No
Coal depth(s) ft 370 feet Cavern(s) encountered (Y/N) depths No
Is coal being mined in area (Y/N) No

Reviewed by: _____

Received stamp
SEP 1 2011
Office of Oil and Gas
WV Dept. of Environmental Protection

API 47-073 - 02523 Farm name BW Well number 4

CASING STRINGS	Hole Size	Casing Size	Depth	New or Used	Grade wt/ft	Basket Depth(s)	Did cement circulate (Y/N) * Provide details below*
Conductor	24"	20"	115'	New	94	NA	Yes
Surface	17.5"	13-3/8"	506'	New	54.5	NA	Yes
Coal	12-3/8"	9-5/8"	1800'	New	40	NA	Yes
Intermediate 1	8-3/4"	7"	5176'	New	23	NA	No
Intermediate 2							
Intermediate 3							
Production	6-1/4"	4-1/2"	7457'	New	11.6	NA	No
Tubing							
Packer type and depth set		Baker Model D packer set at 6885'					

Comment Details

CEMENT DATA	Class/Type of Cement	Number of Sacks	Slurry wt (ppg)	Yield (ft ³ /sks)	Volume (ft ³)	Cement Top (MD)	WOC (hrs)
Conductor	20"			1.18		Surface	
Surface	13-3/8"			1.18		Surface	
Coal	9-5/8"			1.26		Surface	
Intermediate 1	7"			1.41		3020' by CBL	
Intermediate 2							
Intermediate 3							
Production	4-1/2"			1.18		3830'	
Tubing							

Drillers TD (ft) 7,503 feet Loggers TD (ft) 7,498 feet
Deepest formation penetrated Queenston Shale Plug back to (ft)
Plug back procedure NA

Kick off depth (ft) NA

Check all wireline logs run ☒ caliper ☒ density ☐ deviated/directional ☐ induction
☒ neutron ☒ resistivity ☒ gamma ray ☐ temperature ☐ sonic

Well cored ☐ Yes ☒ No Conventional Sidewall Were cuttings collected ☒ Yes ☐ No

DESCRIBE THE CENTRALIZER PLACEMENT USED FOR EACH CASING STRING 4.5" casing string had centralizers placed every 3 joints

WAS WELL COMPLETED AS SHOT HOLE ☐ Yes ☒ No DETAILS

WAS WELL COMPLETED OPEN HOLE? ☐ Yes ☒ No DETAILS

WERE TRACERS USED ☐ Yes ☒ No TYPE OF TRACER(S) USED

RECEIVED
SEP 11 2013
Office of Oil and Gas
WV Dept. of Environmental Protection

PERFORATION RECORD

Please insert additional pages as applicable.

Please insert additional pages as applicable.

[illegible]

API 47- 073 - 02523 Farm name BW Well number 4

PRODUCING FORMATION(S)

DEPTHS

Saltwater injection - NA TVD MD

Please insert additional pages as applicable.

GAS TEST ☐ Build up ☐ Drawdown ☐ Open Flow

OIL TEST ☐ Flow ☐ Pump

SHUT-IN PRESSURE Surface psi Bottom Hole psi DURATION OF TEST hrs

OPEN FLOW Gas Oil NGL Water GAS MEASURED BY
mcfpd bpd bpd bpd ☐ Estimated ☐ Orifice ☐ Pilot

LITHOLOGY/ FORMATION	TOP DEPTH IN FT NAME TVD	BOTTOM DEPTH IN FT TVD	TOP DEPTH IN FT MD	BOTTOM DEPTH IN FT MD	DESCRIBE ROCK TYPE AND RECORD QUANTITY AND TYPE OF FLUID (FRESHWATER, BRINE, OIL, GAS, H ₂ S, ETC)
See Attachment 1	0		0		

Please insert additional pages as applicable.

Drilling Contractor Waco Oil and Gas

Address PO Box 397 City Glenville State WV Zip 26351

Logging Company Weatherford

Address 100 Leetsdale Dr., Suite A City Leetsdale State PA Zip 15056

Cementing Company BJ Service Company

Address 837 Philippi Pike City Clarksburg State WV Zip 26301

Stimulating Company N/A

Address City State Zip

Please insert additional pages as applicable.

Completed by Ashleigh Strahler

Telephone (740) 371-5328

Signature Ashleigh Strahler Title Operations Engineer Date 8/24/16

Submittal of Hydraulic Fracturing Chemical Disclosure Information

Attach copy of FRACFOCUS Registry

Attachment 1

<u>Lithology/Formation</u>	<u>Depth</u>
Big Injun	1150'-1190'
Berea	1580'-1620'
Ohio Shale	1650'-1720'
Onandoga	5140'-5380'
Oriskany	5380'-5510'
Helderberg	5510'-5860'
Salina	5860'-6320'
Lockport	6419'-6753'
Rochester	6753'-7000'
Dayton	7000'-7012'
Brassfield	7084'-7121'
Clinton	7140'-7259'
Medina	7297'-7328'
Queenstone	7328'-7503'

Received
SEP 17 2016

Office of Oil and Gas
WV Dept of Environmental Protection

TABLE OF CONTENTS

1. Copy of Existing BW #4 UIC Permit
2. WV DEP Check List
3. Sections 1-5
4. Section 6
5. Section 7
6. Section 8
7. Section 9
8. Section 10
9. Section 11
10. Section 12
11. Section 13
12. Section 14
13. Section 15
14. Section 16

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

**COPY OF THE ORIGINAL
UIC CLASS IID PERMIT
FOR BW #4 WELL**

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection



west virginia department of environmental protection

Office of Oil and Gas
601 57th Street, SE
Charleston, WV 25304
(304) 926-0450
Fax (304) 926-0452

Randy C. Huffman, Cabinet Secretary
dep.wv.gov

December 3, 2010

Appalachian Oil Purchasers, Inc.
114 Lower Eureka Lane
St. Marys, WV 26170

47-073-02523

RE: Underground Injection Control (UIC) Permit #2D0732523
Request for minor modification of UIC permit

Your request to revise requirements #5 and #27 of the existing UIC permit #2D0732523 has been approved by this agency based on the addition for more frequent monitoring and analysis of fluids being injected and more frequent reporting of results. Also, the reporting of all wells to be serviced by the UIC well during the sampling period. Under 47CSR13-13.20.b more frequent monitoring or reporting by the permittee is considered a "minor modification" of the UIC permit and therefore can be modified without a draft permit and public notice / public review.

Specifically, requirements #5 and #27 of the UIC permit shall read:

(#5) This permit is for authorization of injection of only fluids as defined for Class II wells in 47CSR13-4.2. The fluids to be injected shall only be from those sources listed in the permit application. Additional sources of fluids may be approved upon written request by the permittee. However, permittee's acceptance of additional sources of fluid(s) shall be deemed approved provided that such fluid(s) meet all Class II injection standards and the permittee reports within five (5) business days the source, API number and formation(s) for the sources added during the previous week. Accepting any fluid that does not meet Class II injection standards is grounds for revocation of this permit.

(#27) In order to ensure compliance with the permit, permittee may choose to:

A) Monthly collect and analyze a composite / representative fluid sample from water brought to the facility from each operator and associated wells testing for pH, Iron, Manganese, Chlorides, Sodium, TOC, and Barium. Each sample must list the formation(s) that the water came from. Test results must be submitted to the Office of Oil and Gas; or

Promoting a healthy environment.

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

- 20th of the following month*
- B) (1) Semi-monthly collect and analyze a continuous composite sample from the line delivering the fluids from the gathering facility to the disposal well, testing for pH, Iron Manganese, Chlorides, Sodium, TOC, and Barium.
- (2) Report the results of the sampling conducted the previous month and all sources of fluid accepted by the permittee that month by API number and formation(s). Such reports shall be submitted by the twentieth day of the following month.

The modifications listed above will present more stringent options to the permittee and would thus be within the requirements for a minor modification. Furthermore, it is acceptable to add any additional testing parameters OOG deems necessary.

Sincerely,



James Peterson
Environmental Resource Specialist / Permitting

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection



ORIGINAL

west virginia department of environmental protection

Office of Oil and Gas
601 57th Street SE
Charleston, WV 25304
(304) 926-0450
(304) 926-0452 fax

Joe Manchin III, Governor
Randy C. Huffman, Cabinet Secretary
dep.wv.gov

UIC Permit

APPALACHIAN OIL PURCHASERS, INC.
114 LOWER EUREKA LANE
ST. MARYS, WV 26170-

Dear Applicant:

Enclosed you will find Underground Injection Control Permit Number UIC2D0732523 dated November 01, 2010. Be advised that the duration of the permit is for a period of five (5) years.

Also be advised that all conditions established by UIC Permit Number UIC2D0732523 either expressly or incorporated by reference, must be strictly adhered to. All monitoring forms shall be submitted to the Office of Oil and Gas in the manner and frequency prescribed. The monitoring forms will be compared with the scope of permitted activity to verify compliance.

Please review the permit carefully and be aware of all permit conditions. Compliance of all permit conditions will be strictly enforced.

The operation of this injection well facility in general, including maintenance of all related surface equipment, shall be conducted so as to preclude any unlawful discharge of waste materials into the surface or ground waters of the state.

James Martin
Chief,
Office of Oil and Gas

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

Enclosures as stated

UNDERGROUND INJECTION CONTROL PERMIT
FOR
DEPARTMENT OF ENVIRONMENTAL PROTECTION,
OFFICE OF OIL AND GAS AND DIVISION OF WATER AND WASTE MANAGEMENT
FOR
CLASS II COMMERCIAL DISPOSAL WELL

This document consists of the Underground Injection Control (UIC) Permit required by the Department of Environmental Protection, Office of Oil and Gas, and Division of Water and Waste Management. The permittee is allowed to engage in underground injection in accordance with the terms and conditions of this permit based upon an approved UIC Permit.

The Underground Injection Control Permit No. UIC2D0732523 consists of Forms WW-3A and WW-3B and the terms and conditions below:

1. The underground injection activity authorized by this permit shall not allow the movement of fluid, as per (47CSR13-2.26), containing any contaminant into any subsurface area other than that which is specified and may not cause a violation of any primary drinking water regulation promulgated under 40 CFR Chapter 1, Part 141 or any water quality standard promulgated by the Department of Environmental Protection.
2. This permit is issued in accordance with the provisions of Article 11 and 12, Chapter 22 of the Code of West Virginia and the Legislative Rule 47CSR13.
3. All reports required by this permit shall be submitted to the Office of Oil and Gas with the exception to paragraph 4 below.
4. The following activities require the immediate cessation of facility operations and prompt notification of the Director of Water and Waste Management (47CSR13-13.6.d and 47CSR13-13.12.1.6).
 - a) Any monitoring or other information which indicates that any contaminant has caused or may cause an endangerment to an underground source of drinking water.
 - b) Any non-compliance with a permit condition or any malfunction of the injection system which may cause fluid migration into or between underground sources of drinking water; and
 - c) Any non-compliance which may endanger health and environment.

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

5. This permit is for authorization of injection of only fluids as defined for Class II wells in 47CSR13-4.2. The fluids to be injected shall only be from those sources listed in the permit application. Additional sources of fluids may be approved upon written request by the permittee.
6. The permit must satisfy the requirements of the Office of Oil and Gas regarding any corrective action needed on all known wells penetrating the injection zone within the area of review.
7. Any production well within a ¼ mile radius of disposal well# 47-073-02523 which does not have cemented production casing shall be plugged immediately upon becoming inactive. Any temporary inactive well shall be monitored at a frequency and by a method prescribed by the Office of Oil and Gas upon notice by the permittee of such activity. Any well shut-in more than one (1) week shall be considered inactive.
8. The area of review is designated as a 1 / 4 mile radius around the injection project.
9. This permit approves the Clinton and Medina Sandstone formations for injection from 7,166' to 7,341'.
10. The maximum wellhead injection pressure shall be established at 2,258 PSI.
11. The permittee shall provide for security at the injection facility to guard against illegal or unauthorized dumping and injection at the injection facility. A gated security fence shall be maintained around the permitted well system.
12. The permittee shall monitor the 2 7/8" X 4 1/2" and 4 1/2" X 9 5/8" casing annuli with pressure sensitive devices or with such a method as approved or required by the Office of Oil and Gas to allow early detection on any leaks from the injection zone or casing. The results of such monitoring shall be reported on Form WR-40.
13. Authorization to inject is contingent upon submission and approval of the Office of Oil and Gas Form WR-37 for each well. Construction modifications from the proposed work plan (O&G Form WW-3) and mechanical integrity will be evaluated at this time. Operational conditions will be finalized at this time. Upon approval of Form WR-37, conditions established on this form are incorporated by reference as conditions of this permit. FORM WR-37 SHALL BE SUBMITTED WITHIN 30 DAYS OF THE EFFECTIVE DATE OF THE UIC PERMIT.
14. If a mechanical integrity test should fail, the permittee shall cease operation/injection and shut-in the well immediately until repaired or permanently plugged and abandoned per regulation. The well must be repaired or permanently plugged within 90 days of the failure date. If repaired, the well must be re-tested making sure to submit a WR-37 Form to the Office of Oil and Gas. The Office of Oil and Gas shall be notified 24 hours in advance of the re-test date to witness said test.
15. A well head pressure gauge shall be installed and maintained on the injection tubing / casing to facilitate inspection and ensure compliance of maximum injection pressures as approved on Oil and Gas Form WR-37. A daily reading of the injection pressure shall be taken and reported monthly on Form WR-40 to the Office of Oil and Gas.

RECEIVED
Office of Oil and Gas
NOV 18 2015
Department of
Environmental Protection

16. The permittee shall sample and analyze any water source within a one mile radius of the injection well upon the request of the Office of Oil and Gas. Analyses shall cover all parameters listed on Attachment A of this permit. The Office of Oil and Gas may require additional parameters to be analyzed if necessary. Results of all analyses shall be submitted to the Office of Oil and Gas. Permittee shall submit a letter of explanation for any parameter which exceeds the ranges listed on Attachment A.
17. All injection lines shall be inspected, maintained, operated and monitored to allow early detection of any leakage and so that the occurrence of leaks will be minimized.
18. Pipeline(s) connecting UIC above-ground storage tank stations and permitted underground injection control well (UIC2D0732523) shall be tested for integrity at least once every five years reporting results on Form WR-37 to this agency.
19. Permittee shall monitor / sample water sources #18, #35, #38, #44, and #45 listed on the permit application on a semi-annual basis for the following parameters; Barium, Iron, Manganese, Sodium, Total Dissolved Solids, Total Suspended Solids, Chlorides, and pH. Such monitoring shall be conducted on an annual basis once background data is established with approval of the Office of Oil and Gas. May 1st & Nov 1st.
20. The permittee shall fulfill the requirements of the Office of Oil and Gas regarding maintaining financial responsibility and resources to close, plug, and abandon permitted wells. An additional five-thousand dollar performance bond shall be maintained on permitted UIC well #47-073-02523.
21. The herein-described activity is to be extended, modified, added to, made, enlarged, acquired, constructed or installed, and operated, used and maintained strictly in accordance with the terms and conditions of this permit; with the information submitted with the Permit Application No. UIC2D0732523 with the plan of maintenance and method of operation thereof submitted with such application(s); and with any applicable rules and regulations promulgated by the Department of Environmental Protection.
22. This permit is issued in accordance with the provisions of Article 11 and 12, Chapter 22, of the Code of West Virginia and Legislative Rule 47CSR13.
23. Failure to comply with the terms and conditions of this permit, with the plans and specifications submitted with the Permit Application No. UIC2D0732523 and with the plan of maintenance and method of operation thereof submitted with such application(s) shall constitute grounds for the revocation or suspension of this permit and for the invocation of all the enforcement procedures set forth in Article 11 and 12, Chapter 22, of the Code of West Virginia and Legislative Rule 47CSR13.
24. The operation of this injection well facility in general, including maintenance of all unrelated surface equipment, shall be conducted so as to preclude any unlawful discharge of waste materials into the surface or ground waters of this State.

RECEIVED
Office of Oil and Gas

NOV 18 2015

DEPARTMENT OF
Environmental Protection

25. The permittee must satisfy the requirement of the Office of Oil and Gas for plugging and abandonment of permitted injection wells in such a manner as to ensure that no fluid movement occurs either from the injection zone into an underground source of drinking water or from one underground source of drinking water to another.
26. Permittee shall implement a manifesting system to record all loads hauled to the facility making sure to document the source of the waste fluid and hauler identification. The Office of Oil and Gas shall approve the instrument, prior to the transportation of any fluids.
27. Permittee must ensure that monthly composite / representative fluid sample is taken from water brought to the facility from each operator and associated wells testing for pH, Iron, Manganese, Chlorides, Sodium, and Barium. Each sample must list the formation(s) that the water came from. Test results must be submitted to the Office of Oil and Gas.

78 Microbi

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

ATTACHMENT A

Injection Fluid Analyses Parameters

<u>Parameter</u>	<u>Ranges</u>
PH	>2 – 10
TDS	0 - 265,000 mg/l
TSS	0 - 1000 mg/l
Aluminum	0 - 10 mg/l
Arsenic	0 – 10 mg
Barium	0 – 1500 mg/l
Cadmium	0 – 2 mg/l
Chromium	0 – 1 mg/l
Iron	0 – 1000 mg/l
Lead	0 – 7.5 mg/l
Magnesium	0 – 5000 mg/l
Manganese	0 – 15 mg/l
Potassium	0 – 5000 mg/l
Sodium	0 – 110,000 mg/l
Zinc	0 – 15 mg/l
Surfactants	0 – 10 mg/l
TKN	0 – 25 mg/l
Oil and Grease	0 – 100 mg/l
TOC	0 – 10,000 mg/l
COD	0 – 30,000 mg/l
Acidity	0 – 500 mg/l
Chloride	0 – 250,000 mg/l
Sulfate	0 – 500 mg/l
Cyanide	0 – 1 mg/l
Phenols	0 – 10 mg/l
Calcium	0 – 60,000 mg/l
BNA – Extractables	Trace
Purgeable Aromatics	Trace
Purgeable Halocarbons	Trace
PCBs	<MDL or 50 ppm

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

CHECKLIST FOR FILING A UIC PERMIT APPLICATION

Please utilize this checklist to ensure you have prepared, completed, and enclosed all required documentation and payment to ensure a timely review of your submittal.

Operator	Appalachian Oil Purchasers, Inc.		
Existing UIC Permit ID Number	UIC2D0732523	UIC Well API Number	47-073-02523

Office of Oil and Gas Office Use Only	
Permit Reviewer	
Date Received	
Administratively Complete Date	
Approved Date	
Permit Issued	

Please check the fees and payment included.

Fees		Payment Type	
UIC Permit Fee: \$500	☒	Check	☒
Groundwater Protection Plan (GPP) Fee: \$50.00	☒	Electronic	☐
		Other	☐

Please check the items completed and enclosed.

- ☒ Checklist
- ☒ UIC-1
 - ☒ Section 1 – Facility Information
 - ☒ Section 2 – Operator Information
 - ☒ Section 3 – Application Information
 - ☒ Section 4 – Applicant/Activity Request and Type
 - ☒ Section 5 – Brief description of the Nature of the Business
 - ☒ CERTIFICATION
- ☒ Section 6 – Construction
 - ☒ Appendix A Injection Well Form
 - ☒ Appendix B Storage Tank Inventory
- ☒ Section 7 – Area of Review
 - ☒ Appendix C Wells Within the Area of Review

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

- ☒ Appendix D Public Service District Affidavit
- ☒ Appendix E Water Sources
- ☒ Appendix F Area Permit Wells
- ☒ Section 8 – Geological Data on Injection and Confining Zones
- ☒ Section 9 – Operating Requirements / Data
- ☒ Appendix G Wells Serviced by Injection Well
- ☒ Section 10 – Monitoring
- ☒ Section 11 – Groundwater Protection Plan (GPP)
- ☒ Appendix H Groundwater Protection Plan (GPP)
- ☒ Section 12 – Plugging and Abandonment
- ☒ Section 13 – Additional Bonding
- ☒ Section 14 – Financial Responsibility
- ☒ Appendix I Financial Responsibility
- ☒ Section 15 – Site Security Plan
- ☒ Appendix J Site Security for Commercial Wells
- ☒ Section 16 – Additional Information
- ☒ Appendix K Other Permit Approvals

***NOTE: For all 2D wells an additional bond in the amount of \$5,000 is required.**

Reviewed by (Print Name): Ashleigh Strahler

Reviewed by (Sign): Ashleigh Strahler

Date Reviewed: 11/13/15

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

SECTIONS 1-5

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

 WEST VIRGINIA DEPARTMENT OF ENVIRONMENTAL PROTECTION OFFICE OF OIL AND GAS 601 57th Street, SE Charleston, WV 25304 (304) 926-0450 www.dep.wv.gov/oil-and-gas	UNDERGROUND INJECTION CONTROL (UIC) PERMIT APPLICATION
UIC PERMIT ID # <u>UIC2D07322523</u> API # <u>47-073-02523</u> WELL # <u>BW #4</u>	

Section 1. Facility Information

Facility Name: BW #4	
Address: 157 Lower Eureka Lane	
City: Saint Marys	State: WV Zip: 26170
County: Pleasants	
Location description: Located approximately 3/4 of a mile off State Route 2. Turn into the "Greenhouse" driveway and continue past the barns and Forest City Lake (see attached directions). There is a green gate with sign prior to entering the lease road to the well site. Proceed back the lease road to the well site. The BW#4 well is located between French Creek backwater and the mountain.	
Location of well(s) or approximate center of field/project in UTM NAD 83 (meters): Northing: 4358508.86 Easting: 478743.08	
Environmental Contact Information: Name: Robert Douglas Title: Environmental Field Specialist Phone: (304) 665-2461 Email: robert.douglas@enlink.com	

Section 2. Operator Information

Operator Name: Appalachian Oil Purchasers, LLC	
Operator ID: 494496193	
Address: 157 Lower Eureka Lane	
City: Saint Marys	State: WV Zip: 26170
County: Pleasants	
Contact Name: Derrick Lamp	Contact Title: Foreman, Brine Operations
Contact Phone: (304) 665-2461	Contact Email: derrick.lamp@enlink.com

Received
SEP - 7 2016
Office of Oil and Gas
WV Dept. of Environmental Protection

Section 3. Applicant Information

Ownership Status: ☐ PRIVATE ☒ PUBLIC ☐ FEDERAL ☐ STATE
☐ OTHER (explain):

SIC code: ☒ 1311 (2D, 2H, 2R) ☐ 1479 (3S) ☐ OTHER (explain):

Section 4. Applicant / Activity Request and Type:

- A. Apply for a new UIC Permit: ☐ 2D ☐ 2H ☐ 2R ☐ 3S
B. Reissue existing UIC Permit: ☒ 2D ☐ 2H ☐ 2R ☐ 3S
C. Modify existing UIC Permit: ☐ 2D ☐ 2H ☐ 2R ☐ 3S
(Submit only documentation pertaining to the modification request)
2D COMMERCIAL FACILITY: ☒ YES ☐ NO

Section 5. Briefly describe the nature of business and the activities to be conducted:

Appalachian Oil Purchasers, LLC is a crude oil purchaser and pipeline company involved in midstream oil and gas activities in the Appalachian Basin. Appalachian Oil Purchasers, LLC also operates two commercial Class D injection wells in West Virginia to dispose of oil and gas fluid wastes associated with the drilling, completion, stimulation, and production of oil and natural gas in the area. The two commercial Class D injection wells are the BW #4 (UIC2D0732523) and the Greens Run #1 (UIC2D0732540) and are located within Pleasants County, West Virginia.

Oil and gas fluid wastes are unloaded into large storage tanks at EnLink's Eureka facility, located at 157 Lower Eureka Lane, St. Marys, WV. The fluid wastes are then pumped via pipeline to the BW #4 surface facility storage tanks, located at the BW #4 well site. Waste fluids are then injected into the Clinton and Medina sandstones in the BW #4 well for disposal.

Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

CERTIFICATION

All permit applications must be signed by a responsible corporate officer for a corporation, by a general partner for a partnership, by the proprietor of a sole proprietorship, or by a principal executive or ranking elected official for a public agency, or a ¹duly authorized representative in accordance with 47CSR13-13.11.b.

A. Name and title of person applying for permit:

Print Name: Steve Cornelison
Print Title: Director operations

B. Signature and Date.

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Signature: [Signature]
Date: 11-13-15

¹ A person is a duly authorized representative if:

The authorization is made in writing by a person described in subdivision 47CSR13-13.11.a.

The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of the plant manager, operator of a well or a well field, superintendent, or position of equivalent responsibility.

The written authorization is submitted to the Director.

RECEIVED
Office of Oil and Gas
NOV 18 2015

WV Department of
Environmental Protection

SECTION 6

Section 6 – Construction:

1. An aerial map, surface facility drawing from the SPCC plan, and photographs depicting the BW#4 Class IID surface facility location with valving and piping have been submitted. The surface facility consists of the wellhead, filters, and treatment system, and tank battery facility which includes two– 21,000 gal. single walled, steel tanks and a secondary containment system. The dimensions of the secondary containment system is 20' X 62' with 41" walls. See SPCC plan for more details.
2. Attached is a detailed wellbore schematic of the existing BW #4 injection well as it has been drilled and completed. Geophysical logs were previously submitted.
3. A revised WR-35 is attached.
4. Appendix A through Appendix K have been updated in the WV DEP Permit Application document, which is attached.
5. Open-hole and cased-hole geophysical logs were run the BW #4 injection well. On December 23, 2010, A Weatherford Gamma ray, collar locator, and cement bond log was run on the 7" intermediate casing string and the top of cement is at 3,020 feet. On January 25, 2011, a Weatherford Directional Survey and Gamma ray-Induction log was run on the BW#4 well. The directional survey showed some deviation of about 100 feet to the North. The BW #4 well was then drilled to a total depth of 7,498 feet and open-hole geophysical logs were run through the proposed Clinton and Medina injection zone. Weatherford ran the logs on February 2, 2011 and these logs included a Gamma ray-Compensated Neutron, Photo Density log and a Gamma ray – Dual Laterolog. Copies of all geophysical logs were submitted to the WV DEP.
 - a. An analysis of the injection zone indicates the Clinton sandstone occurred from depths of 7,140 to 7,259 feet and porosity ranged from 3 to 12 percent. The Medina sandstone is from a depth of 7,297 to 7,328 feet and porosities were from 8 to 10 percent. Permeability data is normally obtained by cores, which were not taken on the BW#4 well. Permeability in the producing areas of the Clinton and Medina sandstones typically range from 0.1 to 5 millidarcies.
 - b. There are multiple confining layers within the BW #4 injection well. These confining layers include: The Rochester Shale from 6,753 to 7,000 feet, the Dayton Limestone from 7,000 to 7,012 feet, the Brassfield Limestone from 7,084 to 7,121 feet, and the Lockport Dolomite, which occurs at depths from 6,419 to 6,753 feet. Additional confining layers directly above these confining zones would include the Salina Group, which has several bedded salts and anhydrite units within it. Permeability of the confining layers are less than 0.1 of a millidarcies and the porosities are less than 2 percent. These multiple confining layers of shale, dense dolomite, salt, and anhydrite will prevent upward migration of the injectate out of the permitted injection zone. Additionally, the multiple layers of steel casing strings (of which, three of these strings are cemented to the surface), will prevent any potential migration of injected fluids into the USDWs.

Received
SEP -7 2010

Office of Oil and Gas
WV Dept. of Environmental Protection

APPENDIX A

Injection Well Form

1) GEOLOGIC TARGET FORMATION <u>Clinton and Medina sandstones</u>			
Depth <u>7,140</u>	Feet (top) <u>7,328</u>	Feet (bottom)	
2) Estimated Depth of Completed Well, (or actual depth of existing well):		<u>7,498</u>	Feet
3) Approximate water strata depths:	Fresh <u>150</u> Feet	Salt <u>450</u> Feet	
4) Approximate coal seam depths:	<u>370 feet</u>		
5) Is coal being mined in the area?	Yes ☐	No ☒	
6) Virgin reservoir pressure in target formation	<u>2,270</u> psig	Source	<u>Instantaneous shut-in pressure from hydraulic fracturing job</u>
7) Estimated reservoir fracture pressure	<u>3,000</u>		psig (BHFP)
8) MAXIMUM PROPOSED INJECTION OPERATIONS:			
Injection rate (bbl/hour)	<u>11 (actual injection rates for August 2015)</u>		
Injection volume (bbl/day)	<u>172 (actual injection rates for August 2015)</u>		
Injection pressure (psig)	<u>2,247 (average injection pressure for August of 2015)</u>		
Bottom hole pressure (psig)	<u>Calculated bottom hole pressure is 5,732</u>		
9) DETAILED IDENTIFICATION OF MATERIALS TO BE INJECTED, INCLUDING ADDITIVES:			
The BW #4 saltwater disposal well injects oil and gas fluid wastes including production brine, flow back from hydraulic frac jobs, and pit water. The only additive the injectate is treated with a scale inhibitor called Gypton T-92 (see attached MSDS sheets) and is injected at 0.422 gallons per every 100 barrels of brine.			
Temperature of injected fluid: (°F)	<u>Typically 60 degrees, but varies based on seasonal weather</u>		
10) FILTERS (IF ANY)			
Appalachian Oil Purchasers, LLC uses both bag and cartridge filters on their treatment of the injectate. The bags are five micron filters and the cartridges are 10 micron filters.			
11) SPECIFICATIONS FOR CATHODIC PROTECTION AND OTHER CORROSION CONTROL			
Appalachian Oil Purchasers, LLC does not use cathodic protection, but the annulus of the BW #4 injection well has corrosion inhibitor in it and the injection pipeline is fiberspar (see attached information), so there is no need for cathodic protection on the injection pipeline.			

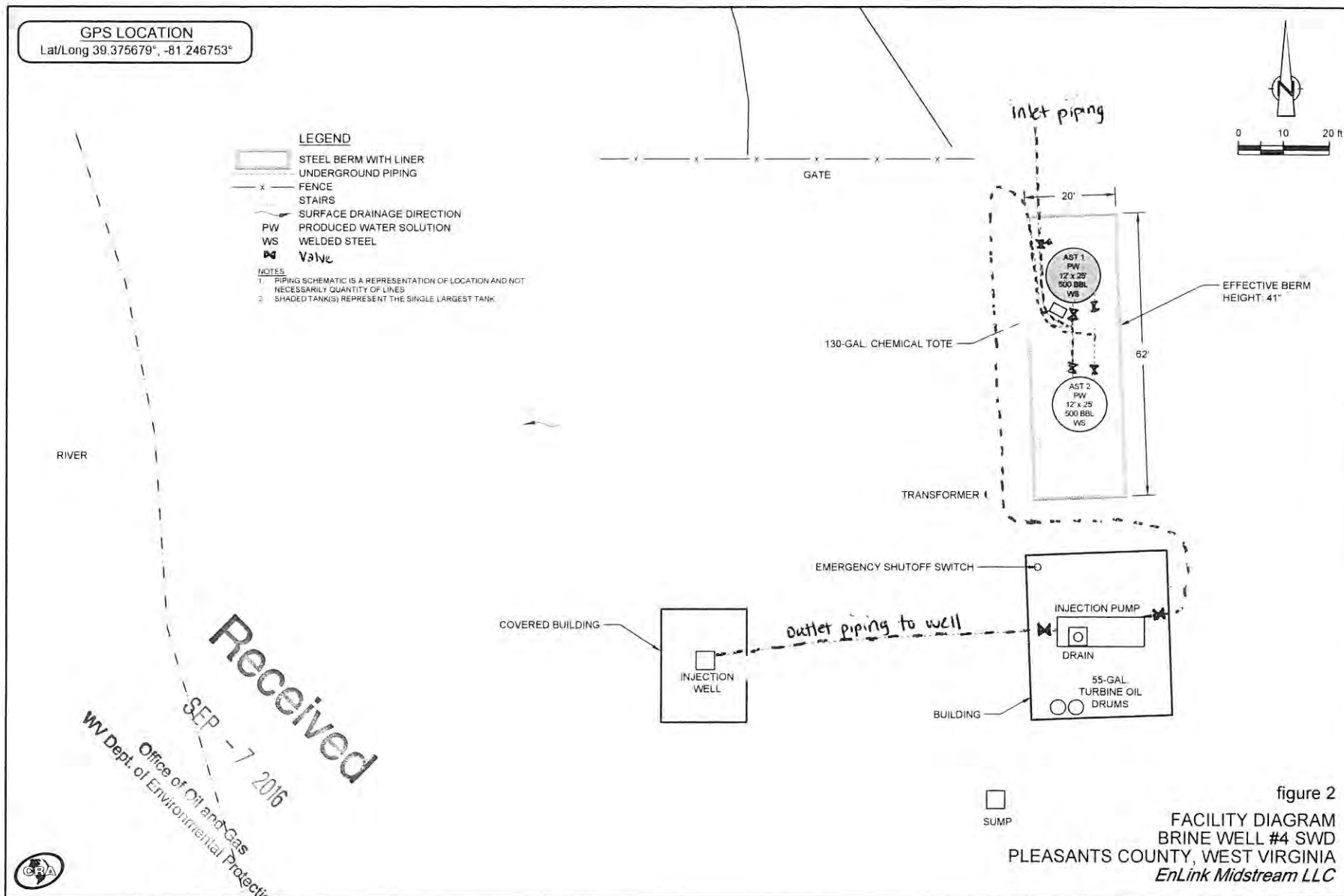
APPENDIX A (cont.)

12. Casing and Tubing Program

TYPE	<u>Size</u>	<u>New or Used</u>	<u>Grade</u>	<u>Weight per ft. (lb/ft)</u>	<u>FOOTAGE: For Drilling</u>	<u>INTERVALS: Left in Well</u>	<u>CEMENT: Fill-up (Cu. Ft.)</u>
Conductor	20"	New	H-40	94	140'	115'	Cemented to surface
Fresh Water	13-3/8"	New	J-55	54.5	550'	506'	Cemented to surface
Coal	9-5/8"	New	N-80	40	1885'	1800'	Cemented to surface
Intermediate 1	7"	New	J-55	23	5253'	5176'	Calculated cement fill-up is 2,345 feet.
Intermediate 2							
Production	4-1/2"	New	S-80	11.6	7500'	7457'	Calculated cement fill-up is 3,627 feet.
Tubing	2-7/8"	New	J-55	6.5		6885'	
Liners							

TYPE	<u>Wellbore Diameter</u>	<u>Casing Size</u>	<u>Wall Thickness</u>	<u>Burst Pressure</u>	<u>Cement Type</u>	<u>Cement Yield (cu. ft./sk)</u>	<u>Cement to Surface ? (Y or N)</u>
Conductor	24"	20"			Type 1	1.18	Y
Fresh Water	17.5	13-3/8"			Type 1	1.18	Y
Coal	12-3/8"	9-5/8"			Type 1	1.26	Y
Intermediate 1	8-3/4"	7"			Type 1	1.41	N
Intermediate 2							
Production	6-1/4"	4-1/2"			Type 1	1.18	N
Tubing		2-7/8"			Not cemented		
Liners							

PACKERS	Packer #1	Packer #2	Packer #3	Packer #4
Kind:	Baker Model D			
Sizes:	2-7/8" x 4-1/2"			
Depths Set:	6885'			





Google earth

feet
meters

200
60



Received

MAR 23 2016

Office of Oil and Gas
WV Dept. of Environmental Protection



Received

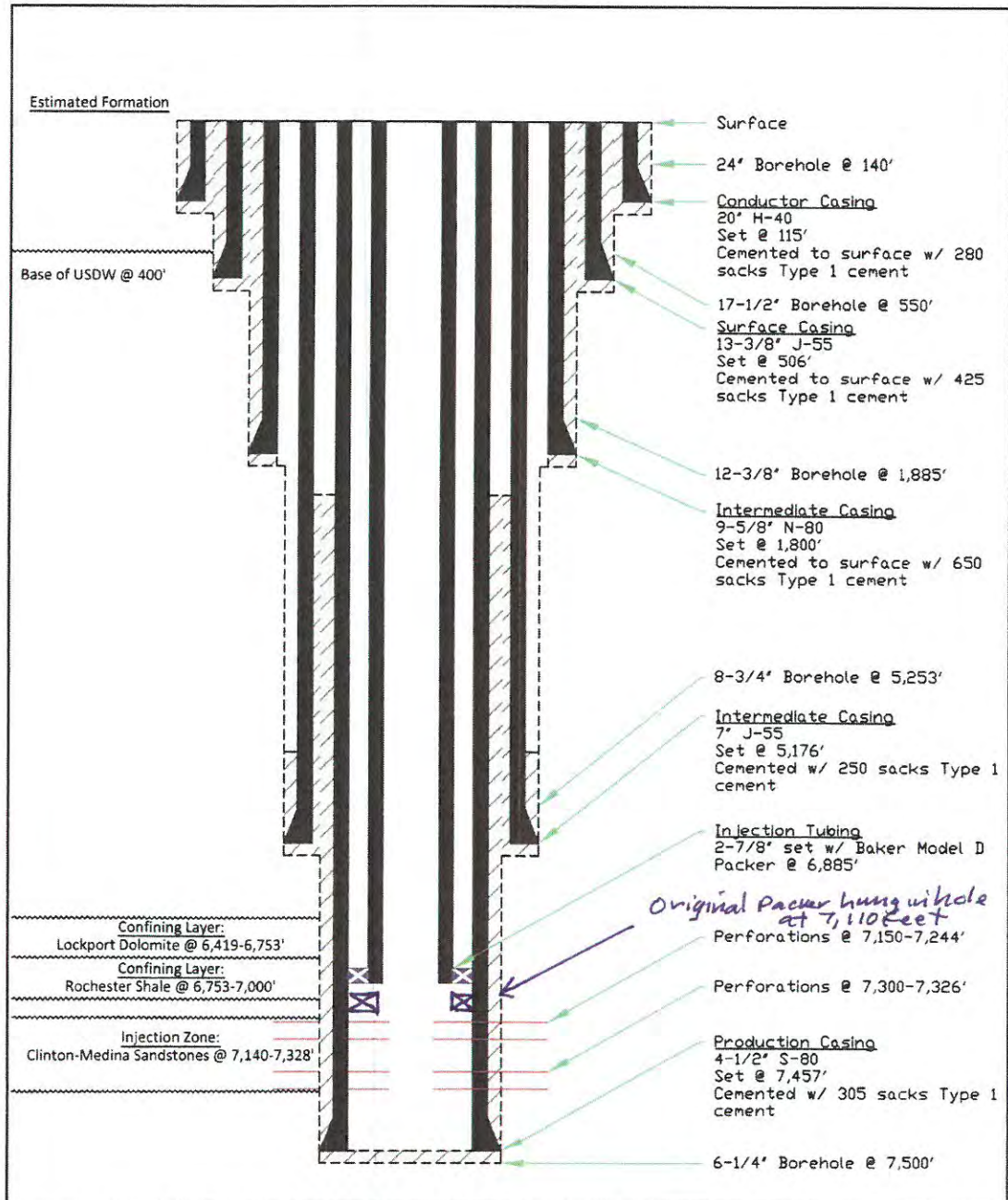
BW #4 Well

Goog



NOV 15 2015
BW #4 Well
Environmental Protection

Goog



ALL CONSULTING, LLC		ALLCONSULTING GOVERNMENT RELATIONS • ENERGY • PLANNING • TECHNOLOGY ENGINEERING • ENVIRONMENTAL © 2014 All Consulting, LLC			
ENLINK BW #4 INJECTION WELL PLEASANTS COUNTY, WEST VIRGINIA UIC 2D0732523; API 47-073-02523		SIZE A	DWG NO. 1		
PN #	9/10/2015	SCALE	NTS	WT	SHEET 1 OF 1
CADFILE C:\Users\jlapkin\Documents\Workstation\Projects\ENLINK\BW #4\BW #4 - Wellbore Diagram.dwg 10/12/2015 3:21:00 PM					

Received

SEP -7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

Material Safety Data Sheet

Gyptron® T-92

1. PRODUCT AND COMPANY IDENTIFICATION

Product name Gyptron® T-92
Product use Scale Inhibitor
Manufacturer Champion Technologies, Inc.
P.O. Box 450499
Houston, TX, 77245
USA
Telephone 1-281-431-2561 (Champion)
In case of emergency 1-800-424-9300 (CHEMTREC)
1-703-527-3887 (CHEMTREC - International)

2. HAZARDS IDENTIFICATION

Physical state liquid
Color Clear. Amber.
Emergency overview WARNING!
Flammable. Harmful. Irritant. Keep away from heat, sparks and flame.

Potential health effects

Inhalation Possible risk of irreversible effects.
Ingestion Possible risk of irreversible effects. Irritating to mouth, throat and stomach.
Skin Possible risk of irreversible effects. Irritating to skin.
Eyes Irritating to eyes.
Chronic effects No known significant effects or critical hazards.

See toxicological information (section 11)

3. COMPOSITION/INFORMATION ON INGREDIENTS

<u>Name</u>	<u>CAS no.</u>	<u>Weight %</u>
Methanol	67-56-1	10 - 30
Sodium phosphate ester salt	Proprietary	10 - 30

4. FIRST AID MEASURES

Eye contact Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Get medical attention.

Skin contact Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Continue to rinse for at least 10 minutes. Get medical attention.

Inhalation Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Get medical attention. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway.

Ingestion Wash out mouth with water. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Do not induce vomiting unless directed to do so by medical personnel. Get medical attention. Never give anything by mouth to an unconscious person.

Protection of first-aiders	No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.
Notes to physician	No specific treatment. Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

5. FIRE-FIGHTING MEASURES

Flash point	82 °F (27.8 °C), Pensky-Martens. Closed cup
Flammability of the product	Flammable liquid. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. Runoff to sewer may create fire or explosion hazard.
<u>Extinguishing media</u>	
Suitable	Use dry chemical, CO2, water spray (fog) or foam.
Not suitable	Do not use water jet.
Special exposure hazards	Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.
Hazardous combustion products	carbon dioxide, carbon monoxide, nitrogen oxides, phosphorus oxides
Special protective equipment for fire-fighters	Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.
Special remarks on fire hazards	Not available.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see section 8).
Environmental precautions	Avoid contact of spilled material with soil and prevent runoff entering surface waterways. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods for cleaning up

Small spill	Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble or absorb with an inert dry material and place in an appropriate waste disposal container. Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor.
Large spill	Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see section 13). Use spark-proof tools and explosion-proof equipment. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see section 1 for emergency contact information and section 13 for waste disposal.

7. HANDLING AND STORAGE

Handling	Use only with adequate ventilation. Put on appropriate personal protective equipment (see section 8). Wear appropriate respirator when ventilation is inadequate. Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Avoid contact with eyes, skin and clothing. Avoid breathing vapor or mist. Do not enter storage areas and confined spaces unless adequately ventilated. Eliminate all ignition sources. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. To avoid fire or explosion, dissipate static electricity during transfer by grounding and bonding containers and equipment before transferring material. Empty containers retain product residue and can be hazardous. Do not reuse container. Workers should wash hands and face before eating, drinking and smoking.
Storage	Store in accordance with local regulations. Store in a segregated and approved area. Keep container in a well-ventilated area. Store in the original container or an approved alternative made from a compatible material. Keep tightly closed when not in use. Separate from oxidizing materials. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Personal protection

Hands	Use chemical-resistant, impervious gloves.
Eyes	Safety eyewear should be used when there is a likelihood of exposure.
Body	Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Respiratory	If during normal use the material presents a respiratory hazard, use only with adequate ventilation or wear appropriate respirator. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Occupational exposure limits

<u>Component</u>	<u>Source</u>	<u>Type</u>	<u>PPM</u>	<u>MG/M3</u>	<u>Notes</u>
Methanol	OSHA PEL	TWA	200 ppm	260 mg/m3	
	NIOSH REL	TWA	200 ppm	260 mg/m3	SKIN
	NIOSH REL	STEL	250 ppm	325 mg/m3	SKIN
	ACGIH TLV	TWA	200 ppm	262 mg/m3	SKIN
	ACGIH TLV	STEL	250 ppm	328 mg/m3	SKIN

SKIN - Skin absorption can contribute significantly to overall exposure.

Engineering measures	Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.
Hygiene measures	Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Wash contaminated clothing before reusing. Emergency baths, showers, or other equipment appropriate for the potential level of exposure should be located close to the workstation location.
Environmental exposure controls	Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state	liquid
-----------------------	--------

Color	Clear. Amber.
Odor	Not available.
Odor threshold	Not available.
Boiling/condensation point	Not available.
Pour point	-40 °F (-40.0 °C)
Flash point	82 °F (27.8 °C), Pensky-Martens. Closed cup
Flammable limits	Lower: Not available. Upper: Not available.
Auto-ignition temperature	Not available.
pH	4.0 - 5.0, Method (neat)
Evaporation rate	Not available.
Solubility	Water
Vapor density	Not available.
Relative density	1.2482 - 1.2816 @ 60 °F (15.6 °C)
Vapor pressure	Not available.
Viscosity	Dynamic: 25 - 35 cPs @ 75 °F (23.9 °C)
Octanol/water partition coefficient (LogPow)	Not available.

Note: Typical values only - not to be interpreted as sales specifications

10. STABILITY AND REACTIVITY

Stability	The product is stable.
Hazardous polymerization	Under normal conditions of storage and use, hazardous polymerization will not occur.
Conditions to avoid	Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.
Materials to avoid	oxidizing materials
Hazardous decomposition products	Under normal conditions of storage and use, hazardous decomposition products should not be produced.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

<u>Substance</u>	<u>Test type</u>	<u>Species</u>	<u>Dose</u>
Methanol	LD50 Oral	Rat	5,600 mg/kg
	LD50 Oral	Mouse	5,800 mg/kg
	LD50 Oral	Rabbit	14,200 mg/kg
	LC50 Inhalation	Mouse	41000 ppm
	LC50 Inhalation	Rat	64000 ppm
	LC50 Inhalation	Rabbit	81,000 mg/m3
	LD50 Dermal	Rabbit	15,800 mg/kg

Irritation/Corrosion

RECEIVED
Office of Oil and Gas
NOV 18 2015

WV Department of
Environmental Protection

Not available.

Target organ effects Methanol: Ingestion may cause blindness.

Carcinogenicity

None of the components are listed.

12. ECOLOGICAL INFORMATION

Environmental effects No known significant effects or critical hazards.

Other adverse effects None known.

13. DISPOSAL CONSIDERATIONS

Waste disposal The generation of waste should be avoided or minimized wherever possible. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe way. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Disposal should be in accordance with applicable regional, national and local laws and regulations. Refer to Section 7: HANDLING AND STORAGE and Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION for additional handling information and protection of employees.

14. TRANSPORT INFORMATION

Refer to the bill of lading or container label for DOT or other transportation hazard classification. Additionally, be aware that shipping descriptions may vary based on mode of transport, shipment volume or weight, container size or type, and/or origin and destination. Consult your company's Hazardous Materials / Dangerous Goods expert or your legal counsel for information specific to your situation.

15. REGULATORY INFORMATION

HCS Classification

Component

Methanol
Sodium phosphate ester salt

Classification

Irritant., Target organ effects, Occupational exposure limits
Irritant.

U.S. Federal regulations

CERCLA: Hazardous substances - Reportable quantity:

Substance

Methanol

Reportable quantity

5000 lbs

Product Reportable quantity

41,876 lb, 3,977 gal US

Substance

Methanol

Product spills equal to or exceeding the threshold above trigger the reporting requirements under CERCLA for the listed hazardous substance. Report the spill or release to the National Response Center (NRC) at (800) 424-8802.

SARA Title III Section 302 Extremely hazardous substances (40 CFR Part 355):

None of the components are listed.

SARA 311/312 MSDS distribution - chemical inventory - hazard identification:

Immediate (acute) health hazard. Delayed (chronic) health hazard. Fire hazard.

SARA 313 - Supplier notification

Component

Methanol

CAS no.

67-56-1

Weight %

10 - 30

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

Clean Water Act (CWA) 307:

None of the components are listed.

Clean Water Act (CWA) 311:

None of the components are listed.

Clean Air Act (CAA) 112 accidental release prevention:

None of the components are listed.

Clean Air Act (CAA) 112 regulated flammable substances:

None of the components are listed.

Clean Air Act (CAA) 112 regulated toxic substances:

None of the components are listed.

State regulations

Massachusetts Substances: The following components are listed: Methanol.

New Jersey Hazardous Substances: The following components are listed: Methanol.

Pennsylvania RTK Hazardous Substances: The following components are listed: Methanol.

California Prop. 65

Not available.

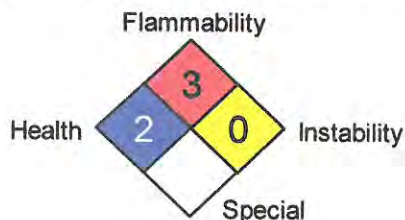
International regulations

United States inventory (TSCA 8b): All components are listed or exempted.

Canada inventory (DSL): All components are listed or exempted.

16. OTHER INFORMATION

National Fire Protection Association (U.S.A.):



Prepared by	Product Stewardship (1-281-431-2561)
Date of issue	06/03/2010
Date of previous issue	06/03/2010
Version	3.0

Disclaimer

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

RECEIVED
Office of Oil and Gas

NOV 18 2015

Department of
Environmental Protection



Material Safety Data Sheet

PACKER INHIBITOR

HEALTH	*	2
FLAMMABILITY		3
PHYSICAL HAZARD		0
PERSONAL PROTECTION		

1. Product and Company Identification

Material name	PACKER INHIBITOR
Patent Number	Not available
Revision date	June-21-2011
Version No.	4
CAS #	Mixture
Product use	Corrosion Inhibitor
Manufacturer information	Clearwater™ International L.L.C. 100 Leetsdale Industrial Drive Leetsdale, PA 15056 US CHEMTREC 1-800-424-9300/703-527-3887
Emergency	CHEMTREC 1-800-424-9300/703-527-3887
Supplier information	Clearwater™ International L.L.C. 100 Leetsdale Industrial Drive Leetsdale, PA 15056 US
Supplier emergency telephone number(s)	CHEMTREC 1-800-424-9300/703-527-3887

2. Hazards Identification

Emergency overview	Will be easily ignited by heat, spark or flames. Irritating to respiratory system. Prolonged exposure may cause chronic effects.
OSHA regulatory status	This product is considered hazardous under 29 CFR 1910.1200 (Hazard Communication).
Potential health effects	
Routes of exposure	Inhalation. Skin contact. Ingestion. Eye contact.
Eyes	This product causes eye burns. Risk of serious damage to eyes. Do not get this material in contact with eyes.
Skin	Causes skin burns. Do not get this material in contact with skin.
Inhalation	Causes burns. Prolonged inhalation may be harmful. Irritating to respiratory system. Do not breathe dust/fume/gas/mist/vapors/spray.
Ingestion	Ingestion may produce burns to the lips, oral cavity, upper airway, esophagus and possibly the digestive tract. May cause delayed lung damage. Do not ingest. Components of the product may be absorbed into the body by ingestion.
Target organs	Eyes. Gastrointestinal tract. Lungs. Respiratory system. Skin.
Chronic effects	Shortness of breath. May cause delayed lung damage.
Signs and symptoms	Discomfort in the chest. Shortness of breath. Cough.
Potential environmental effects	Components of this product are hazardous to aquatic life. May cause long-term adverse effects in the environment.



CLEARWATER™
Engineered Chemistry®

3. Composition / Information on Ingredients

Components	CAS #	Percent
Acetic Acid	64-19-7	7 - 13
Methanol	67-56-1	40 - 70
Ammonium bisulfite	10192-30-0	15 - 40

4. First Aid Measures

First aid procedures

Eye contact

Immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation develops or persists.

Skin contact

Wash off with soap and water. Get medical attention if irritation develops or persists.

Inhalation

If breathing is difficult, remove to fresh air and keep at rest in a position comfortable for breathing. Get medical attention immediately.

Ingestion

If swallowed, seek medical advice immediately and show this container or label. Do not induce vomiting without medical advice.

Notes to physician

In case of shortness of breath, give oxygen. Keep victim warm. Symptoms may be delayed.

General advice

In case of shortness of breath, give oxygen. Keep victim warm. Call a physician if symptoms develop or persist. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire Fighting Measures

Flammable properties

Flammable by OSHA criteria. Containers may explode when heated. Runoff to sewer may cause fire or explosion hazard.

Extinguishing media

Suitable extinguishing media

Water. Foam. Dry chemical. Carbon dioxide (CO₂).

Unsuitable extinguishing media

Do not use a solid water stream as it may scatter and spread fire.

Protection of firefighters

Specific hazards arising from the chemical

Fire may produce irritating, corrosive and/or toxic gases.

Protective equipment and precautions for firefighters

In the event of fire and/or explosion do not breathe fumes. Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask. If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also consider initial evacuation for 800 meters (1/2 mile) in all directions. ALWAYS stay away from tanks engulfed in flame. Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Withdraw immediately in case of rising sound from venting safety devices or any discoloration of tanks due to fire. Move containers from fire area if you can do it without risk. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Use water spray to cool unopened containers. Cool containers with flooding quantities of water until well after fire is out.



CLEARWATER™
Engineered Chemistry®

6. Accidental Release Measures

Personal precautions

Ensure adequate ventilation. Keep people away from and upwind of spill/leak. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ventilate closed spaces before entering. Keep unnecessary personnel away. Stay upwind. Keep out of low areas.

Environmental precautions

Prevent further leakage or spillage if safe to do so. Do not contaminate water.

Methods for containment

Eliminate all ignition sources (no smoking, flares, sparks, or flames in immediate area). Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Use water spray to reduce vapors or divert vapor cloud drift. Prevent entry into waterways, sewers, basements or confined areas.

Methods for cleaning up

Should not be released into the environment.

Large Spills: Dike far ahead of liquid spill for later disposal. Use a non-combustible material like vermiculite, sand or earth to soak up the product and place into a container for later disposal. After removal flush contaminated area thoroughly with water.

Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean contaminated surface thoroughly.

Never return spills in original containers for re-use.

7. Handling and Storage

Handling

Do not handle or store near an open flame, heat or other sources of ignition. Use only with adequate ventilation. Wash thoroughly after handling. Avoid prolonged exposure.

Storage

Prevent electrostatic charge build-up by using common bonding and grounding techniques. Store in a closed container away from incompatible materials.

8. Exposure Controls / Personal Protection

Exposure limits

ACGIH

Components

Components	CAS #	TWA	STEL	Ceiling
Methanol	67-56-1	200 ppm	250 ppm	Not established
Acetic Acid	64-19-7	10 ppm	15 ppm	Not established

OSHA

Components

Components	CAS #	TWA	STEL	Ceiling
Methanol	67-56-1	200 ppm	Not established	Not established
Acetic Acid	64-19-7	10 ppm	Not established	Not established

Engineering controls

Ensure adequate ventilation, especially in confined areas.

Personal protective equipment

Eye / face protection

Do not get this material in contact with eyes. Wear chemical goggles. Face-shield.



CLEARWATER
Engineered Chemistry

Skin protection

Do not get this material in contact with skin. Do not get this material on clothing. Wear chemical protective equipment that is specifically recommended by the manufacturer. It may provide little or no thermal protection. Use chemical splash goggles and face shield (ANSI Z87.1 or approved equivalent). Protective gloves. Impervious gloves. Structural firefighters protective clothing provides limited protection in fire situations ONLY; It is not effective in spill situations.

Respiratory protection

Wear positive pressure self-contained breathing apparatus (SCBA). When workers are facing concentrations above the exposure limit they must use appropriate certified respirators.

General hygiene considerations

Do not get this material in contact with eyes. Do not get this material in contact with skin. Do not get this material on clothing. When using do not eat or drink. Keep away from food and drink. Handle in accordance with good industrial hygiene and safety practice.

9. Physical & Chemical Properties

Appearance	Liquid.
Color	yellow - amber
Odor	Not assigned.
Odor threshold	Not available
Physical state	Liquid.
Form	Liquid.
pH	5 - 8
Melting point	-29.2 °F (-34.15 °C) estimated
Freezing point	Not available
Boiling point	129.2 °F (54.44 °C) estimated
Flash point	80 °F (26.7 °C)
Evaporation rate	Not available
Flammability	Not available.
Flammability limits in air, upper, % by volume	Not available
Flammability limits in air, lower, % by volume	Not available
Vapor pressure	Not available
Vapor density	Not available
Specific gravity	0.97 - 1
Relative density	0.9849 g/cm ³ estimated
Solubility (water)	Not available
Partition coefficient (n-octanol/water)	Not available
Auto-ignition temperature	390.2 °F (199 °C) estimated
Decomposition temperature	Not available
VOC	42.8 % estimated

10. Chemical Stability & Reactivity Information

Chemical stability	Risk of ignition. Stable at normal conditions.
---------------------------	--



CLEARWATER
Engineered Chemistry®

Conditions to avoid	Heat, flames and sparks.
Incompatible materials	Peroxides. Strong oxidizing agents. Strong acids. Caustics.
Hazardous decomposition products	Irritants. Toxic gas. May include oxides of nitrogen. May include oxides of phosphorus.
Possibility of hazardous reactions	Hazardous polymerization does not occur.

11. Toxicological Information

Acute effects	Acute LD50: 10386 mg/kg estimated, Rat, Oral Acute LD50: 11503 mg/kg estimated, Rat, Dermal Acute LC50: 35 mg/l/4h estimated, Rat, Inhalation Causes burns.
----------------------	--

Component analysis - LD50

Toxicology Data - Selected LD50s and LC50s

Acetic Acid	64-19-7	Inhalation LC50 Rat: 11.4 mg/L/1H; Oral LD50 Rat:3310 mg/kg; Dermal LD50 Rabbit:1060 mg/kg
Methanol	67-56-1	Inhalation LC50 Rat: 83.2 mg/L/4H; Inhalation LC50 Rat:64000 ppm/4H; Oral LD50 Rat:5628 mg/kg; Dermal LD50 Rabbit:15800 mg/kg

Local effects	Irritating to respiratory system.
Chronic effects	Hazardous by OSHA criteria. Prolonged or repeated exposure may cause lung injury. Prolonged exposure may cause chronic effects.
Carcinogenicity	Not expected to be hazardous by OSHA criteria.
Neurological effects	Not expected to be hazardous by OSHA criteria.

12. Ecological Information

Ecotoxicity	LC50 1273 mg/L estimated, Fish, 96,00 Hours,
--------------------	--

Ecotoxicity - Freshwater Fish Species Data

Acetic Acid	64-19-7	96 Hr LC50 Pimephales promelas: 88 mg/L [static]; 96 Hr LC50 Lepomis macrochirus 75 mg/L
Methanol	67-56-1	96 Hr LC50 Pimephales promelas: 28100 mg/L [flow-through]; 96 Hr LC50 Oncorhynchus mykiss: 13200 mg/L

Ecotoxicity - Microtox Data

Acetic Acid	64-19-7	5 min EC50 Photobacterium phosphoreum: 8.8 mg/L; 15 min EC50 Photobacterium phosphoreum: 8.8 mg/L; 25 min EC50 Photobacterium phosphoreum: 8.8 mg/L
Methanol	67-56-1	5 min EC50 Photobacterium phosphoreum: 43000 mg/L; 15 min EC50 Photobacterium phosphoreum: 40000 mg/L; 25 min EC50 Photobacterium phosphoreum: 39000 mg/L

Ecotoxicity - Water Flea Data

Acetic Acid	64-19-7	24 Hr EC50 Daphnia magna: 95 mg/L
-------------	---------	-----------------------------------

Environmental effects	Harmful to aquatic life.
------------------------------	--------------------------

Ecotoxicity - Freshwater Fish Species Data

Acetic Acid	64-19-7	96 Hr LC50 Pimephales promelas: 88 mg/L [static]; 96 Hr LC50 Lepomis macrochirus 75 mg/L
Methanol	67-56-1	96 Hr LC50 Pimephales promelas: 28100 mg/L [flow-through]; 96 Hr LC50 Oncorhynchus mykiss: 13200 mg/L

Ecotoxicity - Microtox Data

Acetic Acid	64-19-7	5 min EC50 Photobacterium phosphoreum: 8.8 mg/L; 15 min EC50 Photobacterium phosphoreum: 8.8 mg/L; 25 min EC50 Photobacterium phosphoreum: 8.8 mg/L
Methanol	67-56-1	5 min EC50 Photobacterium phosphoreum: 43000 mg/L; 15 min EC50 Photobacterium phosphoreum: 40000 mg/L; 25 min EC50 Photobacterium phosphoreum: 39000 mg/L

Ecotoxicity - Water Flea Data

Acetic Acid	64-19-7	24 Hr EC50 Daphnia magna: 95 mg/L
-------------	---------	-----------------------------------



CLEARWATER™
Engineered Chemistry®

13. Disposal Considerations

Waste codes

D001: Waste Flammable material with a flash point <140 F

U.S. - RCRA (Resource Conservation & Recovery Act) - U Series Wastes - Acutely Toxic Wastes & Other Hazardous Characteristics

Methanol

67-56-1

waste number U154 (Ignitable waste)

Disposal instructions

Dispose of this material and its container at hazardous or special waste collection point. Do not allow this material to drain into sewers/water supplies. If discarded, this product is considered a RCRA Ignitable waste, D001. Incinerate the material under controlled conditions in an approved incinerator. Do not Incinerate sealed containers. Dispose in accordance with all applicable regulations.

14. Transport Information

Department of Transportation (DOT) Requirements

Basic shipping requirements:

Proper shipping name Flammable liquids, n.o.s. (Methanol)

Hazard class 3

UN number UN1993

Packing group III

Additional information:

Packaging non bulk 202

Packaging bulk 242

ERG number 128



Department of Transportation (DOT) Requirements

Bulk

Basic shipping requirements:

Proper shipping name Flammable liquids, n.o.s. (Methanol)

Hazard class 3

UN number UN1993

Packing group III

Additional information:

Packaging non bulk 202

Packaging bulk 242

ERG number 128





CLEARWATER™
Engineered Chemistry®

Canadian Transportation of Dangerous Goods (TDG) Requirements

Basic shipping requirements:

Proper shipping name	FLAMMABLE LIQUID, TOXIC, N.O.S. (Methanol)
Hazard class	3
Subsidiary hazard class	6.1
UN number	UN1992
Packing group	III
Additional Information:	
Special provisions	16
ERG number	128



IMDG

Basic shipping requirements:

Proper shipping name	FLAMMABLE LIQUID, TOXIC, N.O.S. (Methanol)
Hazard class	3
Subsidiary hazard class	6.1
UN number	1992
Packing group	III



IATA

Basic shipping requirements:

Proper shipping name	Flammable liquid, n.o.s. (Methanol)
Hazard class	3
UN number	1993
Packing group	III



15. Regulatory Information

Labelling

Contains Acetic Acid, Ammonium bisulfite, Methanol

US federal regulations This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

FEMA (Flavor and Extract Manufacturers Association) - FEMA Numbers

Acetic Acid	64-19-7	2006
-------------	---------	------

U.S. - CERCLA/SARA - Section 313 - Emission Reporting

Methanol	67-56-1	1.0 % de minimis concentration
----------	---------	--------------------------------

U.S. - FDA - Direct Food Additives

Methanol	67-56-1	21 CFR 173.250
----------	---------	----------------

U.S. - FDA - Food Additives Generally Recognized as Safe (GRAS)

Acetic Acid	64-19-7	21 CFR 184.1005
-------------	---------	-----------------



CLEARWATER™
Engineered Chemistry®

Occupational Safety and Health Administration (OSHA)

29 CFR 1910.1200 hazardous chemical Yes

CERCLA (Superfund) reportable quantity

Methanol: 5000.0000

Ammonium bisulfite: 5000.0000

Acetic Acid: 5000.0000

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories
Immediate Hazard - Yes
Delayed Hazard - Yes
Fire Hazard - Yes
Pressure Hazard - No
Reactivity Hazard - No

Section 302 extremely hazardous substance No

Section 311 hazardous chemical Yes

Inventory status

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	No
Canada	Domestic Substances List (DSL)	No
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	No
Europe	European Inventory of New and Existing Chemicals (EINECS)	No
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	No
Korea	Existing Chemicals List (ECL)	No
New Zealand	New Zealand Inventory	No
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	No

A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)

International regulations

Canada - WHMIS - Ingredient Disclosure List

Acetic Acid	64-19-7	1 %
Ammonium bisulfite	10192-30-0	1 %
Methanol	67-56-1	1 %



CLEARWATER™
Engineered Chemistry®

State regulations

This product does not contain a chemical known to the State of California to cause cancer, birth defects or other reproductive harm.

U.S. - Massachusetts - Right To Know List

Acetic Acid	64-19-7	Present
Ammonium bisulfite	10192-30-0	Present
Methanol	67-56-1	Present

U.S. - Minnesota - Hazardous Substance List

Acetic Acid	64-19-7	Present
Methanol	67-56-1	Skin

U.S. - New Jersey - Right to Know Hazardous Substance List

Acetic Acid	64-19-7	sn 0004
Ammonium bisulfite	10192-30-0	sn 0090
Methanol	67-56-1	sn 1222

U.S. - Pennsylvania - RTK (Right to Know) List

Acetic Acid	64-19-7	Environmental hazard
Ammonium bisulfite	10192-30-0	Environmental hazard
Methanol	67-56-1	Environmental hazard

U.S. - Rhode Island - Hazardous Substance List

Acetic Acid	64-19-7	Toxic; Flammable
Methanol	67-56-1	Toxic; Flammable

U.S. - Texas - Effects Screening Levels - Long Term

Acetic Acid	64-19-7	10 ppb ESL; 25 µg/m3 ESL
Methanol	67-56-1	200 ppb ESL; 262 µg/m3 ESL

U.S. - Texas - Effects Screening Levels - Short Term

Acetic Acid	64-19-7	100 ppb ESL; 250 µg/m3 ESL
Methanol	67-56-1	2000 ppb ESL; 2620 µg/m3 ESL

16. Other Information

HMIS® ratings

Health: 2*
Flammability: 3
Physical hazard: 0

NFPA ratings

Health: 2
Flammability: 3
Instability: 0

Prepared by

Amanda L. Ruston
4420 South Flores Road
Elmendorf, Texas 78112
210-626-0850

Disclaimer

THIS PRODUCT'S HEALTH AND SAFETY INFORMATION IS PROVIDED TO ASSIST OUR CUSTOMERS IN ASSESSING COMPLIANCE WITH HEALTH, SAFETY AND ENVIRONMENTAL REGULATIONS. THE INFORMATION CONTAINED HEREIN IS BASED ON DATA AVAILABLE TO US, AND IS BELIEVED TO BE ACCURATE, ALTHOUGH NO GUARANTEE OR WARRANTY IS PROVIDED OR IMPLIED BY THE COMPANY IN THIS RESPECT. SINCE THE USE OF THIS PRODUCT IS WITHIN THE EXCLUSIVE CONTROL OF THE USER, IT IS THE USER'S RESPONSIBILITY TO DETERMINE THE CONDITIONS OF SAFE USE. SUCH CONDITIONS MUST COMPLY WITH ALL GOVERNMENTAL REGULATIONS.

Issue date

June-21-2011

MSDS sections updated

Product and Company Identification; Alternate Trade Names



FIBERSPAR TECH NOTES

Product, service and cost savings information from the leader in spoolable pipeline systems

Frequently asked questions about Fiberspar LinePipe™



What are the primary applications of LinePipe?

LinePipe is ideal for new flowline installations, especially in corrosive environments onshore. LinePipe is also the most cost-effective way to permanently remediate existing flowlines and

restore them to full strength and full flow.

Is LinePipe compatible with oilfield fluids?

Generally, yes. A table of recommended usage for Fiberspar LinePipe is provided in the document Fiberspar LinePipe Engineering Guide, which is available on request or online at www.fiberspar.com.

How are end terminations made, or lengths of LinePipe joined?

Fiberspar patented connectors use mechanical compression and O-ring seals, and do not rely on glue, epoxies or threads cut in the laminate. Connectors can be supplied with any flange, or are made in a pipe-to-pipe joining configuration, or any other end fitting to fit customer configuration. Fiberspar connectors have a design safety factor of more than four times the pipe operating rating, and the fitting techniques are compatible with normal field operations. Personnel can be quickly trained to fit Fiberspar connectors.

Can customized end fittings be supplied?

Yes. A full range of standard connectors is available for most situations, but Fiberspar connectors can be terminated to suit any customer installation, e.g., threaded, flanged or weld neck.

Does Fiberspar LinePipe meet all applicable regulatory standards?

When a spool of Fiberspar LinePipe arrives on location, it has been subjected to the industry's most extensive quality assurance testing and is fully qualified and certified for oil, water, gas or multi-phase service. Fiberspar LinePipe meets or exceeds the most stringent industry specifications, including those for the American Petroleum Institute (API), the American Society of Testing and Materials (ASTM), the Canadian Standards Association (CSA) and the Energy Resources Conservation Board (ERCB), formerly the Alberta Energy and Utilities Board (AEUB), standards. The permitted applications under CSA and ERCB regulations also were expanded for LinePipe to include gas service up to 800 ANSI pressure rating, and H₂S applications where the partial pressure of H₂S does not exceed 7.25 psi (50 kPa). If any Canadian applications need help with filing instructions for LinePipe using a routine pipeline permit under ERCB guidelines, contact Fiberspar technical services in Canada at 403.265.9900.

Does LinePipe design comply with standards such as API 15S?

Yes. Details are contained in the document Fiberspar LinePipe Engineering Guide, which is available online at www.fiberspar.com. In addition, LinePipe meets or exceeds ASTM and ISO 9001 specifications, and the internal specifications of ExxonMobil, Shell, Pemex and other major oil companies.

What are the flow characteristics of Fiberspar LinePipe, and how are they calculated?

Fiberspar LinePipe improves performance by meeting and, in many cases, exceeding the flow rates of conventional steel lines of comparable diameter. That's because the smooth internal thermoplastic pressure barrier of the LinePipe improves flow by reducing frictional losses. In higher flow regimes, the LinePipe's smooth internal surface and the minimal use of connectors also reduce turbulence. Furthermore, the smooth interior surface is highly wear resistant, making improved flow properties sustainable for many years. Fiberspar recommends that a "C" factor of 150 be used in the Hazen-Williams formula for friction pressure drop calculations. Friction flow factors for other commonly used formulas are contained in Fiberspar LinePipe product data sheets available at www.fiberspar.com. Where highly abrasive flow is expected, tests are recommended to establish wear life.

How does LinePipe perform in erosive flow?

Industry testing has shown that thermoplastics provide a generally superior resistance to abrasive fluid flows when compared to steel. In tests performed to date, LinePipe outperformed steel in erosion, but testing of specific fluids would be required to set an exact limit for velocities. Without carrying out specific testing, a conservative approach to erosive flow is to use the same velocity limits as for steel.

What is the operational temperature range?

Fiberspar LinePipe is engineered for a 20-year design life in two operating temperature ranges: -29°F (-34°C) to 140°F (60°C) and -29°F (-34°C) to 180°F (82°C).

Can Fiberspar LinePipe be pigged and what types are suitable?

Yes. Although the design of Fiberspar LinePipe is such that it may never be necessary, the product can easily be pigged to remove deposits and blockages. However, as the thermoplastic pressure barriers in Fiberspar LinePipe are softer than steel, aggressive sharp-edged, scraper-type pigs can damage the ID and should be avoided. Only soft and typical low-to-medium foam or urethane cup-type pigs should be used. Fiberspar can provide inside diameter information for the pipe and fittings so that your preferred pig supplier can properly size and recommend a pig for your application.

Can LinePipe be used for CO₂ and supercritical CO₂?

In contrast to carbon steel pipelines which are destroyed by corrosive fluids, Fiberspar LinePipe is unaffected by CO₂, or even supercritical CO₂. Since thermoplastics are not completely impermeable, small amounts of CO₂ can permeate through the liner. This permeation is on the order of 0.001% of the total flow, and not normally detectable.

What are Fiberspar recommendations for applications that include cyclic service, vibration and pulsation?

Fiberspar has developed field-proven procedures to ensure the productive flow of its LinePipe remains unaffected in applications where service cycles, vibration and pulsation are present. Applications, such as high-pressure water injection and some oil and gas producers that

employ triplex, centrifugal or other types of pumps or operations that induce pressure cycling, may require additional measures to prevent long-term pipe damage or degradation. Applications that will operate on positive displacement or other high-pressure pumps, which also will cycle frequently during the day, must be reviewed to determine if any additional safety factors are warranted. Generally, Fiberspar recommends that for applications operating at greater than 70% of the pressure rating of the LinePipe with pumps cycling on and off more than twice a day, an additional safety factor of 0.5 is applied to the pressure rating of the product. Fiberspar Engineering, however, will provide application-specific advice whenever vibration, pulsation or cycling may be expected.

What are the client and customer contractor responsibilities?

Fiberspar LinePipe arrives on location ready to be installed by some of the industry's most experienced and qualified installation technicians. At the location, Fiberspar furnishes relevant equipment, pipe/fittings, along with highly trained installers and on-site supervision. The client, in turn, provides:

- All dirt work (open and close ditches)
- Backhoe/dozer for deployment
- Off-loading pipe at location
- Loading of empty reels for return to Fiberspar
- All boring and road crossings
- Ensuring line is hydrotested prior to the initiation of production
- Client contractor shall provide assistance to Fiberspar Service Technician for fitting installation and pipe deployment

If, however, the customer prefers to use its in-house crews or designated contractors for installation, Fiberspar can train them in Fiberspar's installation techniques and best practices.

What are the advantages of hydrotesting?

An integral part of the industry-leading quality assurance program of Fiberspar LinePipe is long-term hydrostatic strength testing, which is designed to ensure product integrity for the design life of the system. Every spool of LinePipe is hydrotested at 1.5 x maximum pressure rating before it leaves our factory. Since every foot of pipe delivered to the field has already passed this hydrotest, the follow-up hydrotest after installation ensures any problems associated with handling and deployment are identified and corrected before placing the line in service. This method has proven to ensure long-term, trouble-free installations. In Canada, a 24-hour hydrotest at 1.25 MOP is required before pipeline commissioning.

What is the effect of storage at low temperatures?

LinePipe can be stored at temperatures down to -50°F (-45°C). Precautions need to be taken to ensure that no liquids are left in pipe to be stored where freezing is possible. Expansion of freezing liquids can permanently damage LinePipe. Precautions against very low temperatures such as covering or indoor storage should also be taken.

How long can LinePipe be stored?

Fiberspar has conducted tests proving that LinePipe can be stored on a spool for more than two years with no detrimental effect on the pipe. This is subject to the low temperature provision, and particular care should be taken when storing in freezing temperatures that water does not enter the pipe. When storing LinePipe, the ends should be sealed to prevent rainwater entry.

How does LinePipe stand up to UV light?

UV light does cause slow degradation of epoxy resin, but because the UV rays are absorbed by the outer layer, these only affect the pipe surface, and Fiberspar pipe has a UV inhibitor in the surface layers. Any UV effect is, therefore, limited to the outermost surface and is mainly cosmetic. This outer layer will continue to protect the main laminate thickness with no further deterioration. The overall effect on the pipe strength is insignificant, and the pipe can continue to be used at full-rated pressure even if this cosmetic effect is apparent.

What lengths of spoolable LinePipe does Fiberspar offer?

One of the most pronounced benefits of Fiberspar LinePipe is its arrival from the factory ready for installation in long, continuous lengths, dramatically reducing install time and costs. Fiberspar LinePipe is available in North America in sizes between 2 1/2 in. and 6 in. Depending on its size, Fiberspar LinePipe is delivered to site without joints or connections in lengths up to 2 miles (3.2 km). For additional information consult the Fiberspar Reel Length Table available online within the Deployment Equipment Tech Note.

What are the reel sizes for LinePipe?

Reel sizes are selected depending on the size and pressure rating of the pipe to optimize the quantity on the spool. All LinePipe reels are 8 1/2 ft wide (2.6 m), and are either 12 ft (3.65 m), 14 ft (4.25 m), or 16 ft (4.9 m) in diameter.

How does thermal expansion compare to steel?

Thermal expansion coefficients are about 30% more than steel (about the same as aluminum). However, the stresses induced by temperature change on restrained pipe are much smaller than steel because the modulus is much lower. This property can be used to avoid significant thermal movement, for example, by installing the line under very modest tension when cold. Increasing temperature would then merely offset this tension without pipe movement.

What is the minimum operating bend radius?

The "R" rating for LinePipe is 16.7. The minimum operating bend radius for any pipe size can be calculated by multiplying the pipe outside diameter by 16.7. For example, a 3 1/2-in. nominal 1,500-psi pipe has an OD of 3.57 in. and, therefore, a minimum operating bend radius of 60 inches.

There is much more you should know about the advantages of Fiberspar LinePipe. Contact us for assistance with your specific requirements, or download the Fiberspar LinePipe Engineering Guide at www.fiberspar.com.

Fiberspar LinePipe LLC
Northwoods Industrial Park West
12239 FM 529
Houston TX 77041 USA
Phone: 713.849.2609
Fax: 713.849.9202
E-mail: info@fiberspar.com

Fiberspar LinePipe Canada Ltd.
600, 816 – 7th Avenue S.W.
Calgary, Alberta T2P 1A1
Canada
Phone: 403.265.9900
Fax: 403.266.7111
E-mail: info@fiberspar.com

Fiberspar® spoolable composite pipe and fittings are covered by one or more of the following U.S. Patents: 6,016,845, 5,921,285, 6,148,868, 6,286,558, 6,357,485, 6,804,550, 6,857,452, 7,825,333, 6,004,639, 6,361,290, 6,706,348, 5,988,702, 5,176,180, 5,908,049, 5,913,337 and one or more of the following Canadian Patents: 2,233,295, 2,282,358, 2,321,536, 2,409,304, 2,305,148, 2,233,345. Additional U.S. and Canadian patents are pending.



FS LPJ 4 1/2" 2,250 (E)

4 1/2 Inch Nominal, 2,250 Series Fiberspar LinePipe-J w/HDPE Pressure Barrier & HDPE External Wear Layer

Product Data Sheet (Imperial Units)

ASTM 2996 Designation:

RTRP-11HZ1-4112

Physical Properties:

Fiberspar s/n:

JEFN045026

Geometry		Tensile Modulus	
Outside Diameter (in)	4.79	Axial (psi)	9.65E+05
Inside Diameter (in)	3.57	Hoop (psi)	1.25E+06
Inside Flow Area (in ²)	9.98	Poisson's Ratio	
Total Wall Thickness (in)	0.61	Major	0.49
C/S Area (in ²)	8.06	Minor	0.63
Linear Weight		Thermal Exp. Coeff.	
Linear Weight - Air (lb/ft)	5.06	Axial (in/in -°F)	1.17E-05
Linear Weight - Water (lb/ft)	1.57	Hoop (in/in -°F)	6.75E-06
Net Density (lb/in ³)	0.052	Thermal Conductivity	
Flow Coefficients		(BTU/hour/ft ² - in/°F)	1.92
Hazen - William's	150	Resin T _g	
Darcy-Wiesbach	0.0004	(°C)	125°
Manning	0.009	(°F)	257°

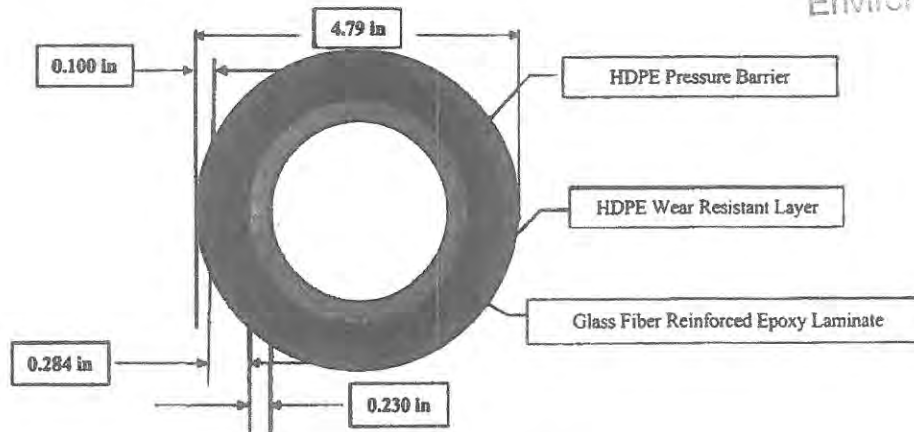
Mechanical Performance:

Maximum Operating Temperature	140 °F		
Minimum Operating Temperature	-29 °F		
		78 °F	140 °F
Max. Recommended Operating Pressure (psi)		2,250	2,250
Nominal Ultimate Burst Pressure (psi)		9,000	7,700
Maximum Recommended Tensile Load (lbs)		23,800	20,400
Nominal Ultimate Tensile Load (lbs)		59,500	51,100
Nominal Ultimate Compressive Load (lbs)		-67,800	-55,600
Nominal Ultimate Collapse Pressure (psi)		1,950	1,950
Minimum Operating Bend Radius (in)		77	77
Minimum Spooling Diameter (in)		132	132

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection





FIBERSPAR TECH NOTES

Product, service and cost savings information from the leader in spoolable pipeline systems

Reliable, full-strength, mechanical connectors for Fiberspar LinePipe™

Join LinePipe sections in the field quickly and easily, using ordinary hand tools.

Fiberspar patented LinePipe connectors use mechanical compression and elastomeric seals, and do not rely on glue, epoxies or threads cut in the laminate. Connectors are easy to install using common hand tools. Personnel can be quickly trained in the proper procedure. Fiberspar connectors have a design safety factor of more than four times the pipe operating rating.

Choose your preferred service-end option.

There are two types of Fiberspar Compression Slip Connectors. Pipe-to-pipe connections are used to join two lengths of LinePipe. Service-end connectors join Fiberspar LinePipe to your system or existing lines. Service-end connectors are available with:

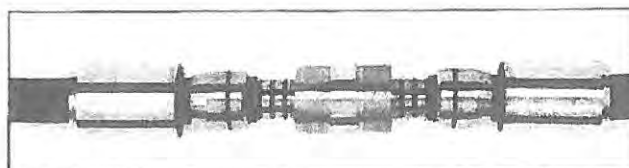
- Weld Prep—Suitable for welding to existing steel lines
- Welded on Flange—300, 600, 900 or 1500 Series ANSI Flanges
- Threaded—8 Round EUE pin or box or API Line Pipe Thread

Custom end-preps are available on request.

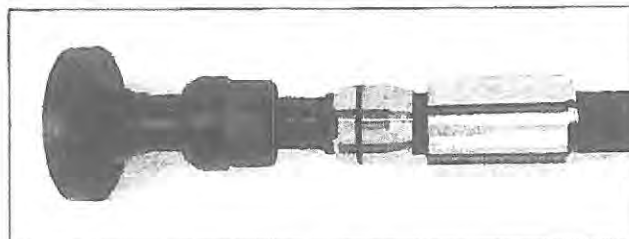
Fiberspar connectors are available in:

- 316 Stainless Steel
- 4140 Alloy Steel
- 1018/1026 Weldable Steel

All standard (non-stainless) connectors are coated for corrosion protection suitable for harsh oilfield environments. Other metal grades and end fitting configuration available upon request.



Above: Pipe-to-pipe connector. Below: Flanged service-end connector.



Fast and simple to install.

A few basic hand tools are all that's required to install Fiberspar connectors. Total assembly time per connector is about 25 minutes or less in most applications. Connectors are easy to handle. Connectors are also reusable.

The combination of Fiberspar LinePipe and our patented connectors offers remarkable benefits unavailable anywhere else. And they all add up to one thing: lower lifecycle costs for your flowlines.

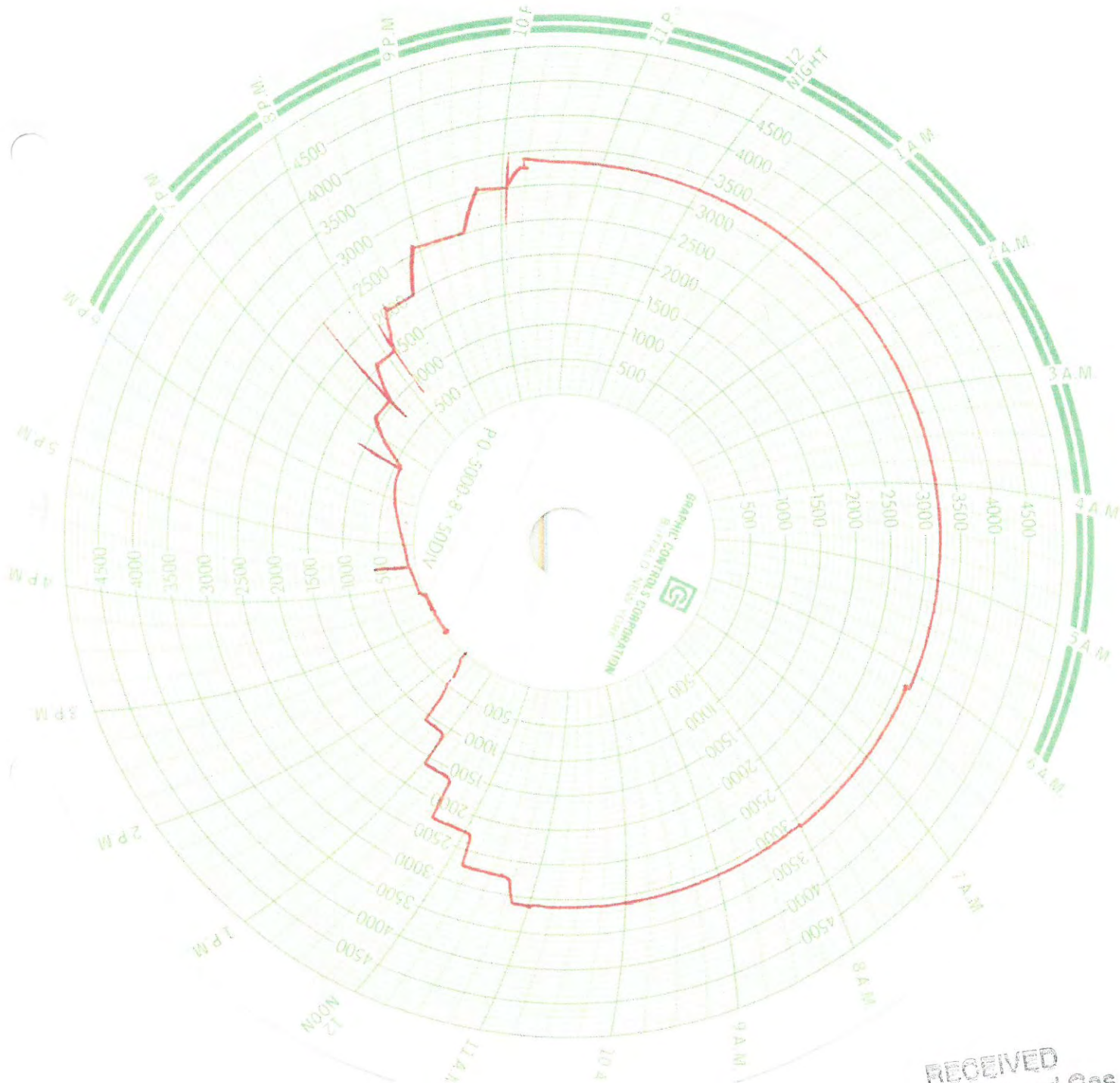
Fiberspar is a leader in composite technology. With 20 years of innovation, we have the experience and resources to help you do the job right. Contact us today for help with your application.

RECEIVED
Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

Fiberspar LinePipe LLC
Northwoods Industrial Park West
12239 FM 529
Houston TX 77041 USA
Phone: 713.849.2609
Fax: 713.849.9202
E-mail: info@fiberspar.com

Fiberspar LinePipe Canada Ltd.
600, 816 – 7th Avenue S.W.
Calgary, Alberta T2P 1A1
Canada
Phone: 403.265.9900
Fax: 403.266.7111
E-mail: info@fiberspar.com

Fiberspar® spoolable composite pipe and fittings are covered by one or more of the following U.S. Patents: 6,016,845, 5,821,285, 6,148,888, 6,286,558, 6,357,485, 6,604,550, 6,657,452, 7,825,333, 6,004,639, 6,361,299, 6,706,348, 5,988,702, 5,176,180, 5,908,049, 5,913,337 and one or more of the following Canadian Patents: 2,233,295, 2,282,358, 2,321,536, 2,408,304, 2,305,148, 2,233,345. Additional U.S. and Canadian patents are pending.



RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

01/01/01

NOV 18 2015

WR-37
REV. 5/01

Date: 12/29/2011

Operator's Well Number BW #4
State 47- County 073 Permit 02523
API Well No.: 47- 073 - 02523

STATE OF WEST VIRGINIA
DEPARTMENT OF ENVIRONMENT-OFFICE OF OIL AND GAS
PRE-OPERATION CERTIFICATE
FOR LIQUID INJECTION OR WASTE DISPOSAL WELL

WELL OPERATOR Appalachian Oil Purchasers, Inc.

Address 157 Lower Eureka Lane
Saint Marys, WV 26170

DESIGNATED AGENT Derrick Lamp

Address 602 Ford Street
Harrisville, WV 26362

GEOLOGICAL TARGET FORMATION Clinton & Median Sandstone Depth 7160 feet(top) to 7326 feet(bottom)

Virgin reservoir pressure in target formation unknown psig

Source of information on virgin reservoir pressure: _____

Perforation intervals 7150'-7244' & 7300'-7326'

Open-hole intervals None

MAXIMUM PERMITTED INJECTION OPERATIONS

Well head injection pressure: 2258 psig

Bottom hole pressure: _____ psig

Volume per hour: _____

DETAILED IDENTIFICATION OF MATERIALS TO BE INJECTED

Liquids to be injected for oil recovery: _____

Wastes to be disposed of: Produced salt water

Additives (Slurry mediums, inhibitors, solvents, oxidizers, deoxidizers, etc.) _____

SPECIFICATIONS FOR CATHODIC PROTECTION AND OTHER CORROSION CONTROL Annulus filled with
corrosion inhibitor fluid.

ADDITIONAL DRILLING AS PART OF THE CONVERSION (Complete form WR-35)

DETAILS ON NEW CASING AND TUBING PROGRAM AS PART OF THE CONVERSION (To be completed below unless the new casing and tubing program is described on a form WR-35, submitted in connection with the permit to which this form WR-37 relates.)

CASING OR TUBING TYPE	SIZE	GRADE	WEIGHT PER FT.	NEW	USED	FOOTAGE USED IN DRILLING	FOOTAGE LEFT IN WELL	CEMENT USED	PACKERS (KIND, SIZE, DEPTH SET)
CONDUCTOR	20"	H-40	94	X		140'	115'	280 sks	
FRESH WATER	13 3/8"	J-55	54.5	X		550'	506'	425 sks	
COAL	9 5/8"	N-80	40	X		1885'	1800'	650 sks	
INTERMEDIATE	7"	J-55	23	X		5253'	5176'	250 sks	
PRODUCTION	4 1/2"	S-80	11.6	X		7500'	7457'	152 sks	
TUBING	2 7/8"	J-55	6.5	X			6885'		baker model D
LINERS									set @ 6885'

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

MECHANICAL INTEGRITY TEST

Test Method: Put corrosion inhibitor on back side of tubing between 2 7/8" and 4 1/2". Got all air bubbles out and pressured up the annulus between 2 7/8" and 4 1/2" to 3400 psi and held it for 30 minutes. Pressure had no noticeable drop on chart or gauge. Joe Taylor was present throughout the entire test.

* The undersigned certifies that the test was performed on December 29, 20 and demonstrated mechanical integrity of the well. The test was witnessed by Joe Taylor representing the Office of Oil and Gas.

Appalachian Oil Purchasers, Inc.

Well Operator

12/29/11

Date

THIS WELL IS AUTHORIZED FOR INJECTION.

Signed James Pelican UIC PROGRAM DIRECTOR

Date 1/3/12

[NOTE: That the mechanical integrity of this well must be demonstrated again within ninety (90) days of five years from this date in order for injection to continue. Please notify the state inspector 24 hours in advance of the test].

Appalachian Oil Purchaser's Inc.

Well Operator

By Bruce H. Hays
Its Operations Manager

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection



Date:

2/29/12

Quoted To

Ship To (if different)

Customer Name:	Ashley Strahler	Customer Name:	
Company Name:	West Virginia Oil Gathering	Company Name:	
Address:		Address:	
City, State, Zip:	26170	City, State, Zip:	
Phone:	740-624-7145	Fax:	
E-Mail:	astrahler@wvog-aop.com	PO#:	

2 - 500 bbl tanks

Containment Ring Size:	Width:	24'	Length:	62'	QTY	Unit Price	Total Price
Half Sheet Kit			45" 12G				\$0.00
Curve Kit (X one)		x	45" 12G		8	\$259.08	\$2,072.64
Straight Kit (X one)		x	45" 12G		8	\$255.69	\$2,045.52
Corner Kit							\$0.00
Sealant	30' roll				3	\$11.53	\$34.59
Walkover	5 step powder coated (meets OSHA standards)				1	\$1,228.81	\$1,228.81
45" Brace Wall Kit					16	\$45.00	\$720.00
Plate Brace Post Brace					16	\$50.85	\$813.60
Cable Clamp					10	\$1.36	\$13.60
Cable					100	\$0.73	\$73.00
Liner Clamp Kit	5' Top Mount				32	\$13.49	\$431.68
30 mil PE Liner	35' x 75'				2,625	\$0.42	\$1,102.50
Gravel Rings	1 segment for every 3' diameter				10	\$40.44	\$404.40
Geotextile 15' x 300' roll					4,500	\$0.15	\$675.00
Trumac Labor & Freight							\$4,800.00
Approx Displacement: 750 bbls with volume of additional tank taken out							\$0.00
Approx Weight: 4300 lbs							\$0.00
							\$0.00
							\$0.00
All Items in Stock for Immediate Delivery							\$14,415.34

Matt McAnally
7901 N. Kickapoo
Shawnee, OK 74804

Direct: (405) 481-8075 ~ Toll Free: (888) 748-5463 ~ Fax: (405) 275-4625 ~
Quote guaranteed for 15 days

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection



RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection



RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

RECEIVED
Office of Oil and Gas

NOV 18 2015 dep

WV Department of
Environmental Protection

SECTION 7

Section 7 – Area of Review

1. A current evaluation of the ¼ mile area of review (AOR) for the BW #4 Class IID injection well has been performed by ALL Consulting (ALL) on September 14, 2015. ALL utilized the West Virginia Department of Environmental Protection's (WV DEP) online oil and gas database and map search features to determine the issuance of new well drilling permits for Pleasants County, West Virginia after the issuance of the BW #4 Class IID permit on March 4, 2011. Since March 4, 2011, a total of 17 new well drilling permits were issued by WV DEP, of which, nine are active oil or gas wells, one was never drilled, and seven have no well status in the database. None of the 17 newly permitted wells are located within the BW #4 ¼ mile AOR, so there have been no changes to the original AOR. Below is the list of the 17 new well drilling permits issued and their status.

API NO.	WELL STATUS
073-02530	Active well
073-02531	Active well
073-02532	Active well
073-02533	Active well
073-02534	Active well
073-02535	Active well
073-02536	Active well
073-02537	Not drilled
073-02538	Active well
073-02539	No status (gas well)
073-02540	Active well (brine disposal)
073-02541	No status (gas well)
073-02542	No status (gas well)
073-02545	No status (gas well)
073-02548	No status (gas well)
073-02549	No status (gas well)
073-02554	No status (gas well)

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

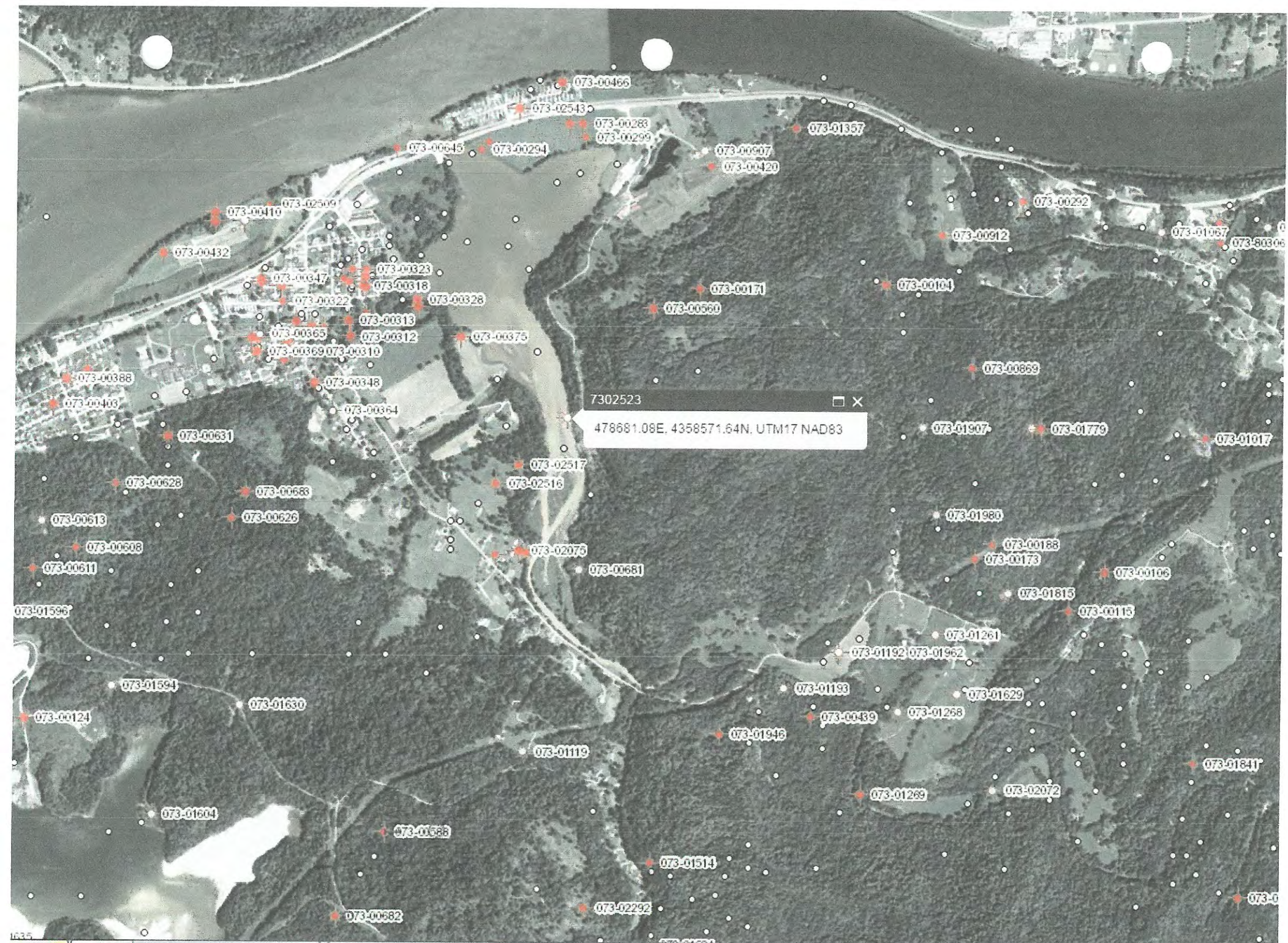
2. Attached is a map showing the current oil and gas wells in the vicinity of the BW #4 well (073-02523). Additionally, included in this Section is all of the previous data and information collected for the initial permit application, which includes the AOR topographic map, the one-mile topographic map showing location of water wells, springs, and surface bodies of water, and all available oil and gas well records within the ¼ mile AOR.

3. Groundwater is obtained from the unconsolidated alluvial aquifer along the Ohio River and from the bedrock aquifers within the Permian and Upper to Lower Pennsylvanian rocks. The Ohio River alluvial aquifer consists of gravel, sand, and silt and is typically less than 90 feet thick. This alluvial aquifer provides the greatest yields of any of the aquifers in this area. The bedrock aquifers occur within predominantly the Dunkard Group of Permian-age and the Pennsylvanian Monongahela Group. Shallow sandstones and siltstones within these two groups can yield groundwater at rates of two to four gallons per minute of potable water and occur at depths of less than 150 feet below the surface. The deepest underground source of drinking water (USDWs) is most likely the Pennsylvanian-aged Cow Run Sandstone, which occurs at depths of less than 430 feet. The Cow Run, however, can occasionally contain hydrocarbons and brine, making it unusable for a water supply.
4. **See attached documents from original permit application.**
5. **See attached documents.**
6. No corrective action is necessary. No other oil and gas wells in the ¼ mile area of review penetrating into or through the existing Clinton and Medina injection zone.
7. Not applicable as this well is not an area permit.

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection



M. Submit well records and or plugging affidavits for all wells within a ¼ mile radius of the proposed well or facility

Eleven wells were identified with the ¼ mile area of review according to state of West Virginia well records. Five of the eleven wells had well records

Table II							
No.	Permit Number	Farm Name and Number	Depth Feet	TD Formation	Status	Comp Date	P&A Date
1	2516	Hammett #4	265		P&A		11/04/2009
2	2517	Hammett #1	350		P&A		10/29/2009
3	30342	Herman Strausburg #1	1,127	Big Injun	P&A		01/20/1950
4	30348	George Hendricks #9	1,568	Berea	P&A		01/12/1950
5	70140	Rebecca Graham #1	Unknown	Big Injun		08/05/1926	
6	90021	Nothing Found					
7	90217	Found Casing and cmt					
8	90218	Nothing Found					
9	90219	Found Casing and cmt					
10	90220	Found sink hole					
11	91313	Found wooden csg					

Old farm line maps were reviewed for the purpose of completeness. It was unclear whether there may have been duplication between the wells identified by the state and the wells on the old arm line maps.

Appalachian Oil Purchasers has made several attempts to identify all wells within the quarter mile area of review. See attached table of field review results.

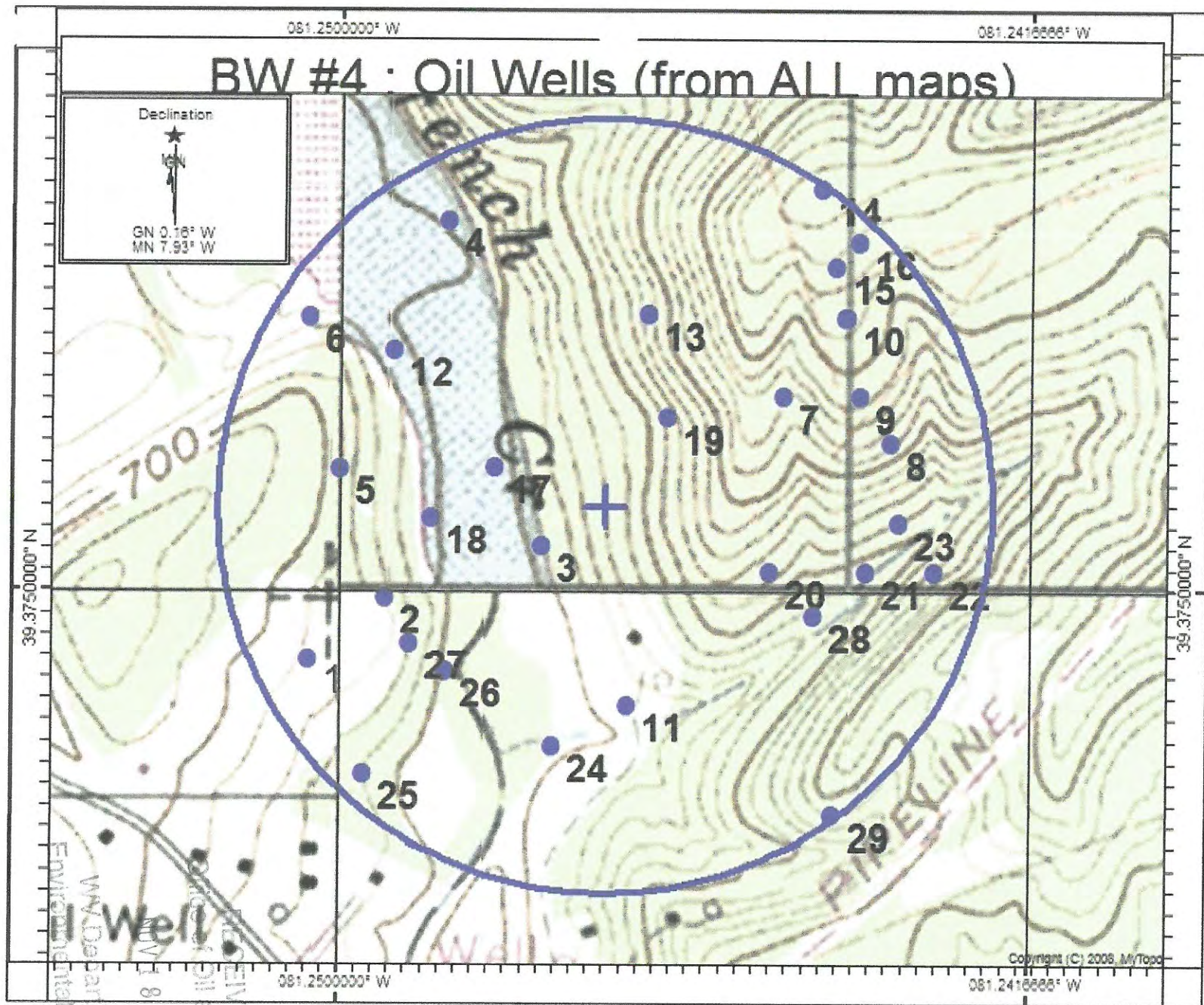
Appalachian Oil Purchasers proposes to:

- 1.) Drill two fresh water monitoring wells (See Attached Map No. 44 and 45)
- 2.) Monitor Malone well.
- 3.) Monitoring and testing to occur semi annually and then eventually annually as directed by the WV UIC.

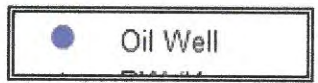
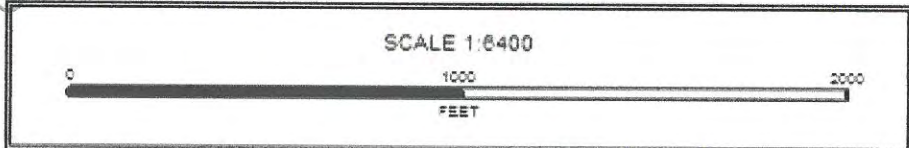
RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection



Office of Oil and Gas
 Environmental Protection
 May 18 2015



Point #	API #	Latitude	Longitude	Description	Documentation
1	4707302516	39°22'27.6617"N	81°15'01.4308"W	Found - Plugged	Yes
2	4707302517	39°22'29.7543"N	81°14'58.0481"W	Found - Plugged	Yes
3	4707330342	39°22'31.4626"N	81°14'51.3407"W	Nothing Found - In Water, Plugged	Yes
4	4707330348	39°22'42.4548"N	81°14'55.4214"W	Nothing Found - In Water, Plugged	Yes
5	4707370140	39°22'34.1056"N	81°15'00.0927"W	Nothing Found - Big Injun well	Yes
6	4707390021	39°22'39.1838"N	81°15'01.4303"W	Nothing Found	No
7	4707390217	39°22'36.5773"N	81°14'40.7493"W	Found casing w/concrete @ app. 600' due W-SW	No
8	4707390218	39°22'35.0117"N	81°14'36.1863"W	Nothing Found	No
9	4707390219	39°22'36.6502"N	81°14'37.2874"W	Found casing w/concrete @ app. 300' due E-NE	No
10	4707390220	39°22'39.2220"N	81°14'38.1082"W	Found sink hole @ app. 175' due NE	No
11	4707391313	39°22'26.1480"N	81°14'47.5440"W	Found wooden casing @ app. 800' SW	No
12	unknown	39°22'38.0149"N	81°14'57.7677"W	Nothing Found	No
13	unknown	39°22'39.2918"N	81°14'46.6735"W	Nothing Found	No
14	unknown	39°22'43.4892"N	81°14'39.1160"W	Nothing Found	No
15	unknown	39°22'40.8561"N	81°14'38.4600"W	Nothing Found	No
16	unknown	39°22'41.6640"N	81°14'37.5254"W	Nothing Found	No
17	unknown	39°22'34.1690"N	81°14'53.3070"W	Nothing Found	No
18	unknown	39°22'32.4052"N	81°14'56.2039"W	Nothing Found	No
19	unknown	39°22'35.8508"N	81°14'45.7553"W	Nothing Found	No
20	unknown	39°22'30.5749"N	81°14'41.4444"W	Nothing Found	No
21	unknown	39°22'30.5648"N	81°14'37.1193"W	Nothing Found	No
22	unknown	39°22'30.6556"N	81°14'34.3296"W	Nothing Found	No
23	unknown	39°22'32.2635"N	81°14'35.7909"W	Nothing Found	No
24	unknown	39°22'24.7651"N	81°14'50.7808"W	Nothing Found	No
25	unknown	39°22'23.7857"N	81°14'58.9867"W	Nothing Found	No
26	unknown	39°22'27.2834"N	81°14'55.5914"W	Nothing Found	No
27	unknown	39°22'28.1971"N	81°14'57.0903"W	Nothing Found	No
28	unknown	39°22'29.1590"N	81°14'39.3769"W	Nothing Found	No
29	unknown	39°22'22.4528"N	81°14'38.6946"W	Nothing Found	No
32	4707300681	39°22'17.9245"N	81°14'49.8751"W	Found - Producing Triad well (Logs included)	Yes
45	4707300560	39°22'47.2200"N	81°14'39.2700"W	Nothing Found - Dry Hole	Yes
46	4707300171	39°22'49.5100"N	81°14'32.6800"W	Nothing Found - Dry Hole	Yes
47	4707380228	39°22'49.5100"N	81°14'32.6800"W	Plugging soon, API will change then (per Rodney Dillion-DEP)	No

APPENDIX C**Wells within the Area of Review**

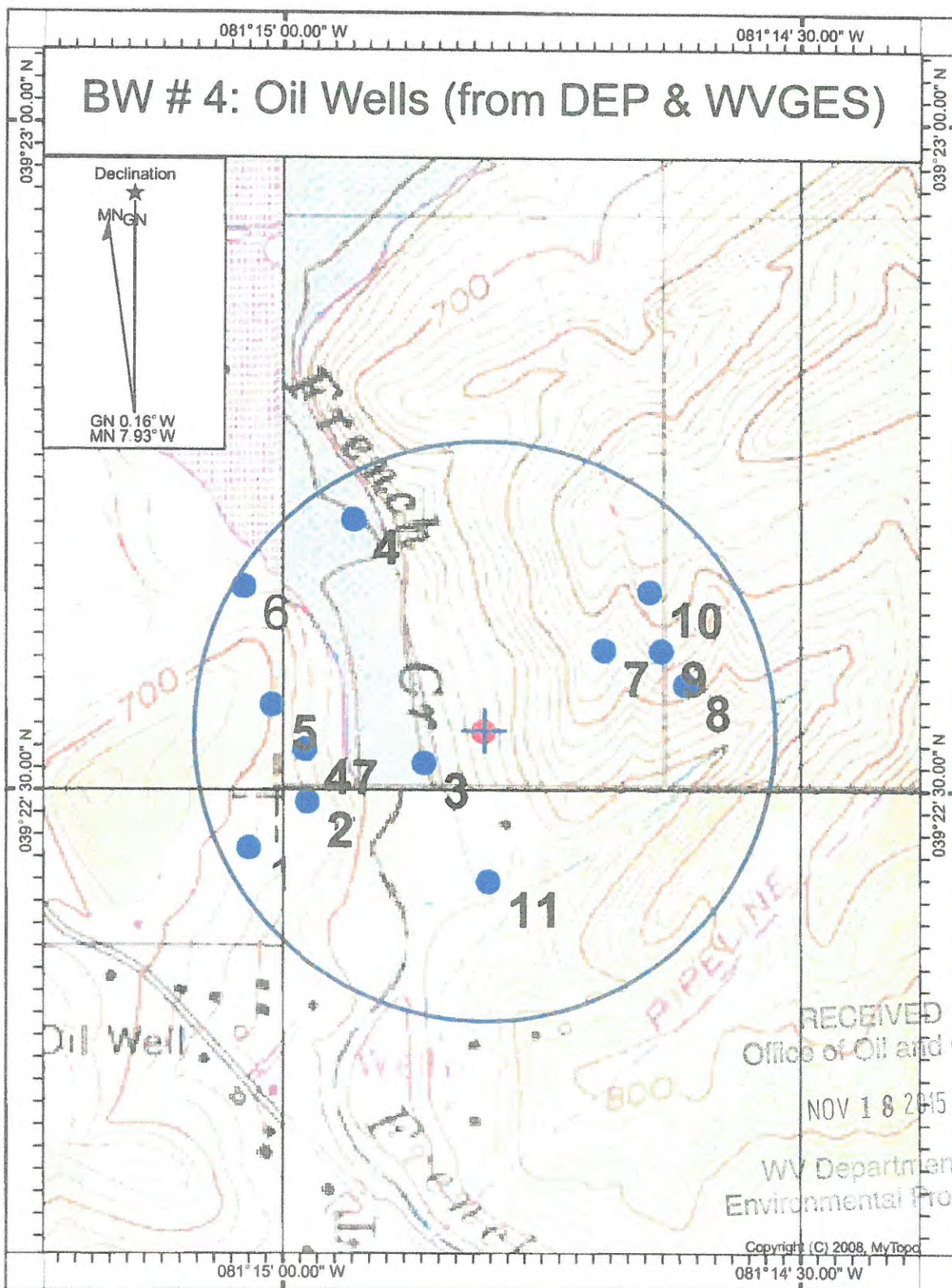
API #	Well Type	Well Status (Active, Abandoned, Shut-in, Plugged)	Northing (UTM NAD 83 Meters)	Easting (UTM NAD 83 Meters)	Penetrate Injection Zone (Y or N)	Penetrate Confining Zone (Y or N)	Total Vertical Depth	Surface Elevation
4707302516	Oil and Gas	Plugged	4358414.0	478432.53	No	No	265 feet	Unknown
4707302517	Oil and Gas	Plugged	4358414.18	488513.46	No	No	350 feet	Unknown
470730342	Oil and Gas	Plugged	4358466.40	478674.09	No	No	1,127 feet	662 feet
470730348	Oil and Gas	Plugged	4358805.53	478577.39	No	No	1,568 feet	720 feet
4707370140	Oil and Gas	Plugged	4358548.45	478464.91	No	No	1,748 feet	822 feet
4707390021	Oil and Gas	Not found	4358705.09	478433.35	No	No	800 feet	Unknown
4707390217	Oil and Gas	Plugged	4358623038	478927.92	No	No	874 feet	980 feet
4707390218	Oil and Gas	Plugged	4358574.82	479036.96	No	No	835 feet	1020 feet
4707390219	Oil and Gas	Plugged	4358625.40	479010.75	No	No	1908 feet	800 feet
4707390220	Oil and Gas	Found	4358704.74	478991.33	No	No	1831 feet	1050 feet
4707391313	Oil and Gas	Found	4358302.32	478764.48	No	No	4605 feet	1056 feet
4707300681	Oil and Gas	Active	4358048.96	478708.01	No	No	2,418 feet	681 feet
4707300560	Oil and Gas	Not found	4358951.37	478964.20	No	No	1,900 feet	869 feet
4707300171	Oil and Gas	Not found	4359021.56	479122.05	No	No	1,264 feet	945 feet
4707300228	Oil and Gas	Plugged	4359021.54	479122.05	No	No	1,885 feet	875 feet

Make as many copies as necessary and include page numbers as appropriate.

Page __ of __



Received
 APR - 4 2016
 Office of Oil and Gas
 WV Dept. of Environmental Protection



SCALE 1:8000

0 1000 2000
FEET

● Oil Well
● BW# 4

Point #	Latitude	Longitude	Description	Documentation	API #	Comments
1	39°22'27.6617"N	81°15'01.4308"W	Found - Plugged	Yes	4707302516	
2	39°22'29.7543"N	81°14'58.0481"W	Found - Plugged	Yes	4707302517	
3	39°22'31.4626"N	81°14'51.3407"W	Nothing Found - In Water	Yes	4707330342	
4	39°22'42.4548"N	81°14'55.4214"W	Nothing Found - In Water	Yes	4707330348	
5	39°22'34.1056"N	81°15'00.0927"W	Nothing Found - Plugged	Yes	4707370140	
6	39°22'39.1838"N	81°15'01.4303"W	Nothing Found	No	4707390021	
7	39°22'36.5773"N	81°14'40.7493"W	Found casing w/concrete @ app. 600' due W-SW	No	4707390217	
8	39°22'35.0117"N	81°14'36.1863"W	Nothing Found	No	4707390218	
9	39°22'36.6502"N	81°14'37.2874"W	Found casing w/concrete @ app. 300' due E-NE	No	4707390219	
10	39°22'39.2220"N	81°14'38.1082"W	Found sink hole @ app. 175' due NE	No	4707390220	
11	39°22'26.1480"N	81°14'47.5440"W	Found wooden casing @ app. 800' SW	No	4707391313	
32	39°22'17.9245"N	81°14'49.8751"W	Found - Producing	Yes	4707300681	Well logs included
45	39°22'47.2200"N	81°14'39.2700"W	Nothing Found - Dry Hole	Yes	4707300560	
46	39°22'49.5100"N	81°14'32.6800"W	Nothing Found - Dry Hole	Yes	4707300171	
47	39°22'49.5100"N	81°14'32.6800"W	Given by Rodney Dillion DEP	No	4707380228	plugging soon, API will change then

RECEIVED
 Office of Oil and Gas
 NOV 18 2015
 RECEIVED
 Office of Oil and Gas
 NOV 18 2015
 Office of Oil and Gas
 Environmental Protection
 NOV 18 2015
 WV Department of
 Environmental Protection

Newell Run

CNG MAP

WASHINGTON
PLEASANTS

RIVER

Belmont

GRANT

39°22'30"

FF4010203

FRANK

GRANT

WASHINGTON

JEFFERSON

WASHINGTON

WASHINGTON

WASHINGTON

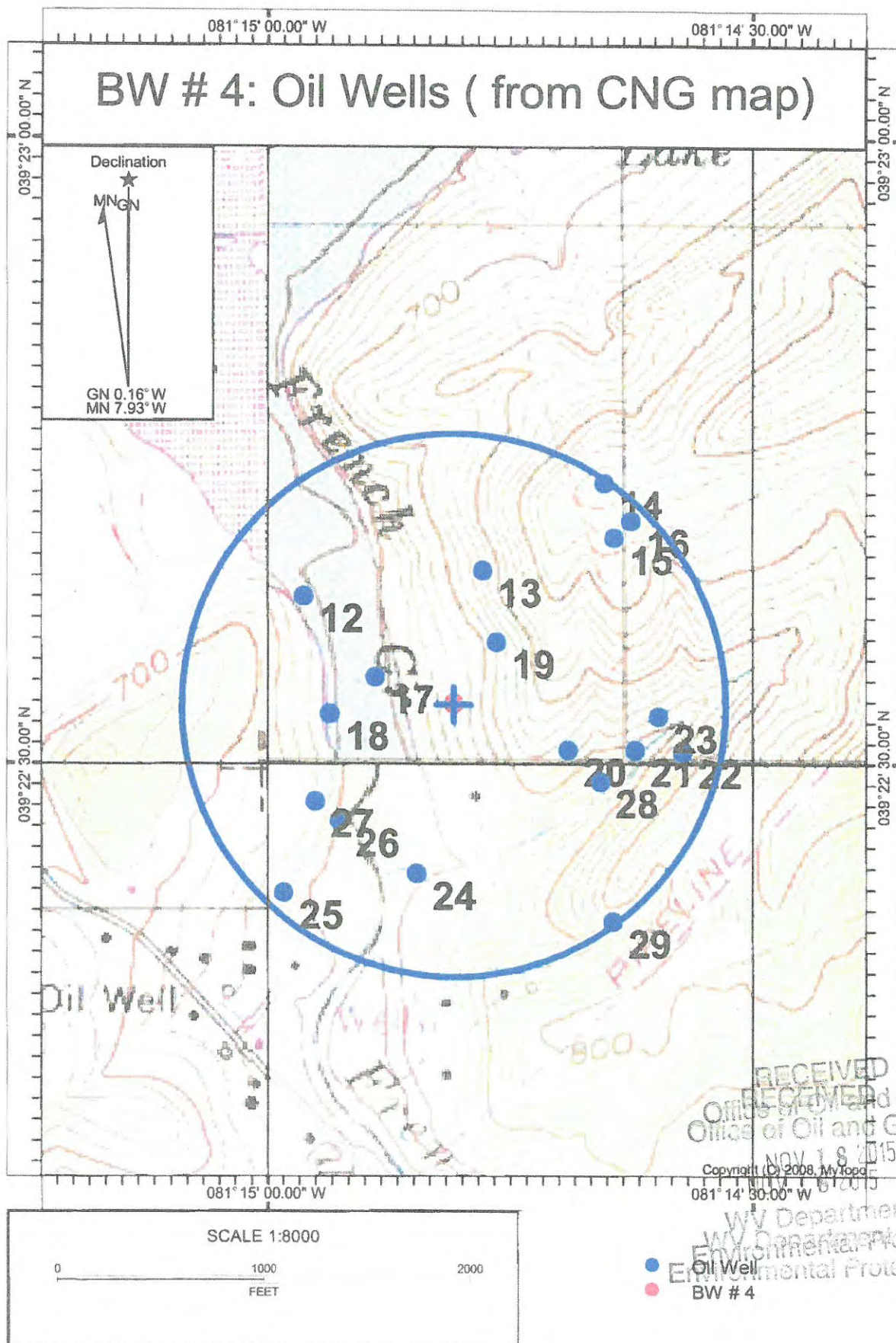
Office of Gas

NOV 18 2013

WV Department of
Environmental Protection

2202

OF SHIPP 1TH



Point #	API #	Latitude	Longitude	Description	Documentation
12	unknown	39°22'38.0149"N	81°14'57.7677"W	Nothing Found	No
13	unknown	39°22'39.2918"N	81°14'46.6735"W	Nothing Found	No
14	unknown	39°22'43.4892"N	81°14'39.1160"W	Nothing Found	No
15	unknown	39°22'40.8561"N	81°14'38.4600"W	Nothing Found	No
16	unknown	39°22'41.6640"N	81°14'37.5254"W	Nothing Found	No
17	unknown	39°22'34.1690"N	81°14'53.3070"W	Nothing Found	No
18	unknown	39°22'32.4052"N	81°14'56.2039"W	Nothing Found	No
19	unknown	39°22'35.8508"N	81°14'45.7553"W	Nothing Found	No
20	unknown	39°22'30.5749"N	81°14'41.4444"W	Nothing Found	No
21	unknown	39°22'30.5648"N	81°14'37.1193"W	Nothing Found	No
22	unknown	39°22'30.6556"N	81°14'34.3296"W	Nothing Found	No
23	unknown	39°22'32.2635"N	81°14'35.7909"W	Nothing Found	No
24	unknown	39°22'24.7651"N	81°14'50.7808"W	Nothing Found	No
25	unknown	39°22'23.7857"N	81°14'58.9867"W	Nothing Found	No
26	unknown	39°22'27.2834"N	81°14'55.5914"W	Nothing Found	No
27	unknown	39°22'28.1971"N	81°14'57.0903"W	Nothing Found	No
28	unknown	39°22'29.1590"N	81°14'39.3769"W	Nothing Found	No
29	unknown	39°22'22.4528"N	81°14'38.6946"W	Nothing Found	No

RECEIVED
 Office of Oil and Gas
 NOV 18 2015
 WV Department of
 Environmental Protection

WR-38
DATE:

API # 47-073-2516-P

STATE OF WEST VIRGINIA
DIVISION OF ENVIRONMENTAL PROTECTION
OFFICE OF OIL AND GAS

AFFIDAVIT OF PLUGGING AND FILLING WELL

AFFIDAVIT SHOULD BE IN TRIPLICATE, one copy mailed to the Division, one copy to be retained by the Well Operator and the third copy (and extra copies if required) should be mailed to each coal operator at their respective addresses.

Farm name: Helen Hammett Operator Well No.: Hammett # 4

LOCATION: Elevation: 888' Quadrangle: Schultz
District: Grant County: Pleasant
Latitude: Feet South of Deg. Min. Sec.
Longitude: Feet West of Deg. Min. Sec.

Well Type: OIL X GAS

Company: WVDEP Plugging
601 57th Street
Charleston, WV 25301

Coal Operator
or Owner

Agent: James Martin

Coal Operator **RECEIVED**
or Owner Office of Oil & Gas

Permit Issued Date: 10/7/09

NOV 23 2009

AFFIDAVIT

STATE OF WEST VIRGINIA,
County of ss:

WV Department of
Environmental Protection

Randy Dustin and Alan Randolph being first duly sworn according to law depose and say that they are experienced in the work of plugging and filling oil and gas wells and were employed by the above named well operator, and participated in the work of plugging and filling the above well, and Rod Dillon Oil and Gas Inspector representing the Director, say that said work was commenced on the 4th day of November, 2009, and that the well was plugged and filled in the following manner:

TYPE	FROM	TO	PIPE REMOVED	LEFT
			No casing in the well	0
Cement	280'	Surface		
Clean out from	Surface to the	1" solid plug	at 285'	
No new oil	Found in the	Well		
Erect a	Monument	With the	API attached	

Description of monument: 7" casing 21' long extended 36" above ground w/the API number attached and that the work of plugging and filling said well was completed on the 18th day of Nov, 2009.

And further deponents saith not.

Sworn and subscribe before me this day of , 19
My commission expires:

Notary Public
Oil and Gas Inspector: Rod Dillon

NOV 27 2009

WR-38
DATE:

API # 47-073-2517-P

STATE OF WEST VIRGINIA
DIVISION OF ENVIRONMENTAL PROTECTION
OFFICE OF OIL AND GAS

AFFIDAVIT OF PLUGGING AND FILLING WELL

AFFIDAVIT SHOULD BE IN TRIPLICATE, one copy mailed to the Division, one copy to be retained by the Well Operator and the third copy (and extra copies if required) should be mailed to each coal operator at their respective addresses.

Farm name: Helen Hammett Operator Well No.: Hammett # 1

LOCATION: Elevation: 858' Quadrangle: Schultz
District: Grant County: Pleasants
Latitude: Feet South of Deg. Min. Sec.
Longitude: Feet West of Deg. Min. Sec.

Well Type: OIL X GAS

Company: WVDEP Plugging
801 57th Street
Charleston, WV 25301

Coal Operator
or Owner RECEIVED

Coal Operator
or Owner Office of Oil & Gas

Agent: James Martin

NOV 17 2009

Permit Issued Date: 10/7/09

AFFIDAVIT WV Department of
Environmental Protection

STATE OF WEST VIRGINIA,
County of ss:

Randy Dustin and Alan Randolph being first duly sworn according to law depose and say that they are experienced in the work of plugging and filling oil and gas wells and were employed by the above named well operator, and participated in the work of plugging and filling the above well, and Rod Dillon Oil and Gas Inspector representing the Director, say that said work was commenced on the 29th day of October, 2009, and that the well was plugged and filled in the following manner:

TYPE	FROM	TO	PIPE REMOVED	LEFT
Cement	350'	252'	340' of 4 7/8" Casing	0
Cement	150'	Surface	366' 2 3/8" Tubing	0
			360' of Rods	
			97' of 7" casing	0
Gel Between	Cement Plugs			
				Well T.D. at 366'
Erect a	Monument	With the	API attached	Surface owner request

Description of monument: 7" casing 21' long extended 36" above ground w/the API number attached
and that the work of plugging and filling said well was completed on the 4th day of October, 2009.

And further deponents saith not.

Sworn and subscribe before me this day of , 19
My commission expires:

Notary Public
Oil and Gas Inspector: Rod Dillon

Office of Oil and Gas
WV Department of
Environmental Protection

NOV 18 2015

NOV 27 2009

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

AFFIDAVIT OF PLUGGING AND FILLING WELL

**AFFIDAVIT SHOULD BE MADE IN TRIPPLICATE. ONE COPY MAILED TO THE DEPARTMENT, ONE COPY TO BE RETAINED BY THE
WELL OPERATOR AND THE THIRD COPY (AND EXTRA COPIES IF REQUIRED) SHOULD BE MAILED TO EACH COAL OPERATOR AT THEIR RESPECTIVE
ADDRESSES.**

COAL OPERATOR OR OWNER	J. R. Bull
NAME OF WELL OPERATOR	Sisteraville, W. Va.
ADDRESS	A COMPLETE ADDRESS
COAL OPERATOR OR OWNER	John S.
NAME OF WELL OPERATOR	18 49
ADDRESS	WELL AND LOCATION
LEASE OR PROPERTY OWNER	Washington District
ADDRESS	Flanagan County
LEASE OR PROPERTY OWNER	Well No. 1
ADDRESS	Berman Strasburg
	Farm

STATE INSPECTOR SUPERVISING PLUGGING

AFFIDAVIT

STATE OF WEST VIRGINIA.

County of Tyler

352

and
being first duly sworn according to law depose and say that they are experienced in the work of
plugging and filling oil and gas wells and were employed by J. E. Ball,
well operator, and participated in the work of plugging and filling the above well, that said work
was commenced on the 12 day of January, 1950, and that the well was plugged
and filled in the following manner:

[illegible]

and that the work of plugging and filling said well was completed on the 20 day of Jan 1950

And further deponents saith not.

Sworn to and subscribed before me this

My commission expires:

Fry Commission expires Nov. 23, 1958

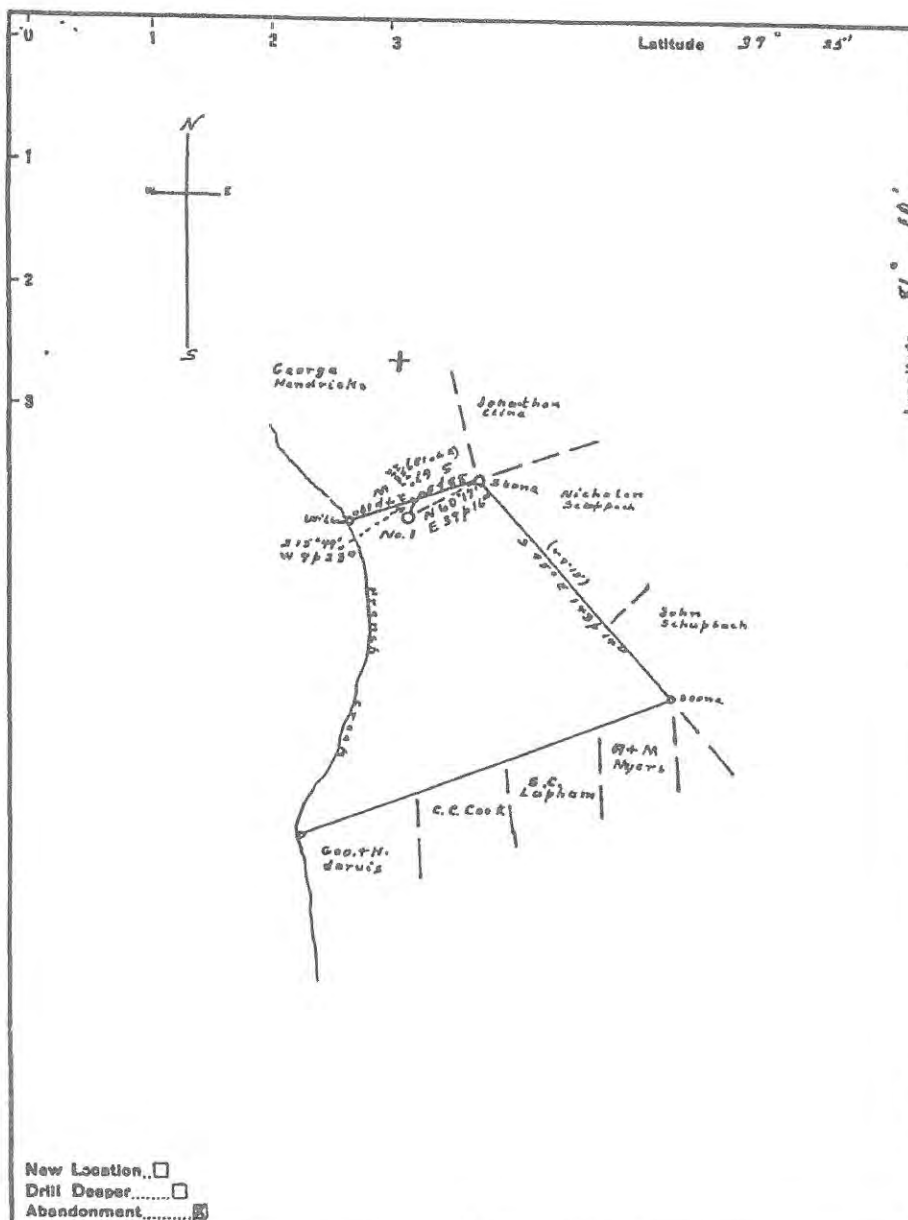
Permit No. PLCB 5746

Environmental Protection

RECEIVED
20 of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection



New Location ☐
 Drill Deeper ☐
 Abandonment ☒

Company J.R. Bull
 Address Sinkersville, W. Va.
 Farm Herman Strausburg
 Tract 1 Acres 120 Lease No. 80279
 Well (Farm) No. 1 Serial No.
 Elevation (Spirit Level) 1667.15'
 Quadrangle St. Marys
 County Pleasants District Washington
 Engineer Don L. Riggle
 Engineer's Registration No.
 File No. 0-6-S.P. 11 Drawing No. 1371
 Date April 15 '48 Scale 1" = 400'

STATE OF WEST VIRGINIA
 DEPARTMENT OF MINES
 OIL AND GAS DIVISION
 CHARLESTON

WELL LOCATION MAP
 FILE NO. PLEAS-342-A

+ Denotes location of well on United States
 Topographic Maps, scale 1 to 62,500, lat-
 itude and longitude lines being represented
 by border lines as shown.

- Denotes one inch spaces on border line
 of original tracing.

RECEIVED
 Office of Oil and Gas

NOV 18 2015

WV Department of
 Environmental Protection

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

AFFIDAVIT OF PLUGGING AND FILLING WELL

AFFIDAVIT SHOULD BE MADE IN TRIPLICATE, ONE COPY MAILED TO THE DEPARTMENT, ONE COPY TO BE RETAINED BY THE WELL OPERATOR AND THE THIRD COPY (AND EXTRA COPIES IF REQUIRED) SHOULD BE MAILED TO EACH COAL OPERATOR AT THEIR RESPECTIVE ADDRESSES.

COAL OPERATOR OR OWNER	J. R. Ball	NAME OF WELL OPERATOR
ADDRESS	Sistersville, W. Va.	COMPLETE ADDRESS
COAL OPERATOR OR OWNER	June 8,	1949
ADDRESS	Washington	District
LEASE OR PROPERTY OWNER	Pleasants	County
ADDRESS	Well No. 9	
	George Hendricks	Farm

STATE INSPECTOR SUPERVISING PLUGGING.

AFFIDAVIT

STATE OF WEST VIRGINIA.

County of Tyler

89:

and
being first duly sworn according to law depose and say that they are experienced in the work of
plugging and filling oil and gas wells and were employed by J. R. Bell
well operator, and participated in the work of plugging and filling the above well, that said work
was commenced on the 4 day of January, 1950, and that the well was plugged
and filled in the following manner:

[illegible]

and that the work of plugging and filling said well was completed on the 12 day of February 1950.

And further deponents saith not.

Sworn to and subscribed before me this 1 day of MAR 1950

My commission expires:

My commission expires Nov. 23, 1923

Perrott No. 345 PL

Permit No. 345 PLEAS

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

WELL RECORD

P1ECS-140 A

Family No. _____

Oil or Gas Well

Company. <u>Canto Oil Co.</u>	Casing and Tubing	Used in Drilling	Left in Well	Packer
Address <u>Box 587, Marietta, Ohio.</u>	Size			
Farm <u>M. E. Correll</u> Acres <u>137</u>	10			Kind of Packer
Location (waters).	12			
Well No. <u>1</u> Elev <u>822</u>	13			
District <u>Union</u> County <u>Plasants</u>	14	<u>1 3/8</u>		Size of
The surface of tract is owned in fee by <u>M. E. Correll</u>	16	<u>2 5/8</u>		
Address	18	<u>3 1/2</u>		Depth set
Mineral rights are owned by	20	<u>4 1/2</u>		
Address	22			Perf. top
Drilling commenced	24			Perf. bottom
Drilling completed <u>2/11/16</u>	26			Perf. top
Date shot <u>2/12/16</u> Depth of shot <u>622'</u>	28			Perf. bottom
Open Flow /10ths Water in _____ Inch	30			
/10ths Merc. in _____ Inch	32			
Volume _____ Cu. Ft.	34			
Rock Pressure _____ lbs. _____ hrs.	36			
Oil _____ bbls, Int 24 hrs.	38			
Fresh water _____ feet _____ feet	40			
Salt water _____ feet _____ feet	42			
	44			
	46			
	48			
	50			
	52			
	54			
	56			
	58			
	60			
	62			
	64			
	66			
	68			
	70			
	72			
	74			
	76			
	78			
	80			
	82			
	84			
	86			
	88			
	90			
	92			
	94			
	96			
	98			
	100			
	102			
	104			
	106			
	108			
	110			
	112			
	114			
	116			
	118			
	120			
	122			
	124			
	126			
	128			
	130			
	132			
	134			
	136			
	138			
	140			
	142			
	144			
	146			
	148			
	150			
	152			
	154			
	156			
	158			
	160			
	162			
	164			
	166			
	168			
	170			
	172			
	174			
	176			
	178			
	180			
	182			
	184			
	186			
	188			
	190			
	192			
	194			
	196			
	198			
	200			
	202			
	204			
	206			
	208			
	210			
	212			
	214			

Formation	Color	Hard or Soft	Top	Bottom	Oil Can or Water	Depth Found	Remarks
Total Depth 1748'							
Pay in Keener 1728' to 1738'							
							

RE
Office of
NO
WVE

[\[Overview\]](#)



RECEIVED
Office of Chief of CAS

NOV 18 2015

WV Dept. of
Environmental Protection

WEST VIRGINIA DEPARTMENT OF MINES

OIL AND GAS DIVISION

PRELIMINARY DATA SHEET NO. 1

File No. _____ Well No. 7

Dineen & Company Company, of St. Marys, W. Va.

on the J. E. Barrett lease Farm

containing 45 acres. Location Washington

District, in Pleasants County, West Virginia

The surface of the above tract is owned in fee by Clyde Read

of St. Marys, W. Va. address, and the mineral rights are owned by

A. H. Low of Drain, Oregon

The oil and gas privileges are held under lease by the above named company, and this well is drilled ~~and completed~~

~~for~~ prior to 1929 issued by the West Virginia Department of Mines, Oil and Gas Division

_____ 1933

Elevation of surface at top of well, _____ Spirit Barometric.

The number of feet of the different sized casings used in the well.

745 feet 8 1/2" size. Wood conductor.

_____ feet _____ size, cas. _____ feet _____ sized cas.

_____ feet _____ size, cas. _____ feet _____ sized cas.

_____ feet _____ size, cas. _____ feet _____ sized cas.

_____ packer of _____ size, set at _____

_____ packer of _____ size, set at _____

_____ in casing perforated at _____ feet to _____ feet.

_____ in casing perforated at _____ feet to _____ feet.

Coal was encountered at _____ feet; thickness _____ inches, and at _____

feet; thickness _____ inches; and at _____ feet; thickness _____ inches.

Lines were used as follows: (Give details) _____

November 4, 1933 _____

_____ Date.

Approved Dineen & Company _____ Owner.

By W. P. Kierulff _____

RECEIVED
Office of Oil and Gas

NOV 18 1933

NOV 6 1933

WV Department of
Environmental Protection

NOTE: All totem poles, totems, and all boy-scouts and all that you would want, that you would want, to be in the district as well as the local system, commonly used in the district.

Environ Mon

I, the undersigned, here certify
 that this map is correct and
 shows all the information to the best
 of my knowledge and belief regarding the
 Oil and gas sections of the Mining Belts of
 West Virginia

Scale 33 1/2' = 1"

J. W. H. [Signature], Engineer

Acknowledged before me a Notary Public
 This 26th day of October 1905

H. P. [Signature] Notary Public
 [Signature]
 My commission expires [Date]

AFFIDAVIT OF PLUGGING AND FILLING WELL

AFFIDAVIT

County of Pleasant

W. B. Patterson

and Howard Beaton

being first duly sworn according to law depose and say that they are experienced in the work of plugging and filling oil and gas wells and were employed by W. H. & A. J. V. Co., well operator, and participated in the work of plugging and filling the above well that said work was commenced on the 5 day of April, 1923, and that the well was plugged and filled in the following manner:

PAID OR TONE RECORD		FILLING MATERIAL			PLUGS USED	CASING	
FORMATION	CONTENTS	FROM	TO	SIZE & KIND	ONE PLUG	ONE CASE	
	total depth		874				
	filled with Red Clay		839				
	Reconnected	A39	829	6 1/4	350	475	
	5 Crushed Stone from Cement						
	filled with red Clay		500				
	Bridge set at 5		250				
	2 above Cement 45 Stone			no 8" casing			
	on Bridge			no tank + mud			
	filled with Clay to surface						
COAL WEASEL				DESCRIPTION OF MONUMENT			
[DATE]				Pier of casing filled with concrete			
[TIME]				three ft along surface - 200			
[NAME]				last with wood - 100			
[OTHER]				there are			

and that the work of plugging and filling said well was completed on the _____

And further deposits with not

Sworn to and subscribed before me this 9th day of January

My commission expires:
January 3rd, 1988

REFERENCE

Office of OI and Case

NOV 18 2015

U.S. Department of
Environmental Protection

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

AFFIDAVIT OF PLUGGING AND FILLING WELL

AFFIDAVIT SHOULD BE MADE IN TRIPLICATE. ONE COPY MAILED TO THE DEPARTMENT. ONE COPY TO BE RETAINED BY THE WELL OPERATOR AND THE THIRD COPY (AND EXTRA COPIES IF REQUIRED) SHOULD BE MAILED TO EACH COAL OPERATOR AT THEIR RESPECTIVE ADDRESSES.

COAL OPERATOR OR OWNER	<u>Patterson + Zinn</u>
ADDRESS	<u>11th S. Market St. Ohio</u>
COAL OPERATOR OR OWNER	<u>Jan. 9 1953</u>
ADDRESS	<u>Jefferson</u>
LEASE OR PROPERTY OWNER	<u>W. D. Patterson</u>
ADDRESS	<u>Well No. 7</u>
	<u>Mass. A. Insurance Farm</u>

STATE INSPECTOR SUPERVISING PLUGGING

AFFIDAVIT

STATE OF WEST VIRGINIA,

County of Pleasants

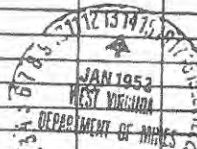
SS:

W. D. Patterson

and Howard Deaton

being first duly sworn according to law depose and say that they are experienced in the work of plugging and filling oil and gas wells and were employed by Patterson + Zinn well operator, and participated in the work of plugging and filling the above well, that said work was commenced on the 9 day of Dec, 1952, and that the well was plugged and filled in the following manner:

SAND OR ZONE RECORD	FILLING MATERIAL			PLUGS USED		CASING	
	FORMATION	CONTENT	FROM	TO	SIZE & KIND	CSG PULLED	CSG LEFT IN
	<u>total depth</u>			<u>900</u>			
	<u>filled with red clay</u>			<u>800</u>			
	<u>2' long 2' diameter</u>				<u>6 1/4</u>	<u>450</u>	<u>350</u>
	<u>5' of shale & sand</u>			<u>600</u>			
	<u>filled with red clay</u>				<u>900' tub & rods</u>		
	<u>bridged at</u>			<u>450</u>			
	<u>2' of shale & sand</u>				<u>no 8 1/4 casing</u>		
	<u>filled with clay to surface</u>						
COAL BEAMS							
(NAME)							
(NAME)							
(NAME)							
(NAME)							



DESCRIPTION OF MONUMENT
Line of casing filled with cement
the plug at a surface case
see 30" square white marking
marking there on

and that the work of plugging and filling said well was completed on Dec, 1952.

And further deponents saith not.

Sworn to and subscribed before me this 9th day of January

My commission expires:
January 3rd. 1956

W. D. Patterson
Howard Deaton
James W. Myers

RECEIVED
Office of Oil & Gas
NOV 1 1953

WV Department of
Environmental Protection

219

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

WELL RECORD

Permit No. P-10-10-10

Oil or Gas Well
(Indicate)

Company Smith, Plarsel, Feick & Co.
Address H. D. No. 2, Walker, W. Va.
Farm J. B. Way et al Acres 60

Casing and Tubing	Used in Drilling	Left in Well	Packers
Size			

Location (waters) Hans Run
Well No. 2 Elev. 800'

16			Kind of Pack
18			
20			Size of

District Union County Wasson
The surface of tract is owned in fee by J. B. Way et al
Address Hollidays Cave

6 1/2	109	0000	Size of
8 1/2	815	0000	
5 1/2	1097	1097	Depth set

Mineral rights are owned by H. Va
Address Hans

8 5/16			
3			Perf. top
2			Perf. bottom

Drilling commenced 1903
Drilling completed 1903
Date Shot From To

License Used			Perf. top
			Perf. bottom

With
Open Flow /10ths Water in Inch
/10ths Merc. in Inch

CASING CEMENTED SIZE No. Ft. Date

Volume Co. Ft.
Rock Pressure lbs. hrs.
Oil lbs. 1st 24 hrs.

COAL WAS ENCOUNTERED AT FEET INCHES

Fresh water feet
Salt water feet

FEET INCHES FEET INCHES
FEET INCHES FEET INCHES

Formation	Color	Hard or Soft	Top	Bottom	Oil, Gas or Water	Depth Found	Remarks
Wood Conductor			0000	15'			
Dunkard Sand				865			
Salt sand			1165	1250			
Big lime			1610	1693			
Kesner Sand			1693	1728			
Injun Sand			1745	1880			
First pay			1763				
Second pay			1765				
Total Depth			1908				

Record by South Penn Natural Gas Co.



RECEIVED
Office of Oil

NOV 18

WV Depa

(Over)

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

AFFIDAVIT OF PLUGGING AND FILLING WELL

AFFIDAVIT SHOULD BE MADE IN TRIPPLICATE, ONE COPY MAILED TO THE DEPARTMENT, ONE COPY TO BE RETAINED BY THE WELL OPERATOR AND THE THIRD COPY (AND EXTRA COPIES IF REQUIRED) SHOULD BE MAILED TO EACH LOCAL OPERATOR AT THEIR RESPECTIVE ADDRESSES.

Nona Smith, Pierce, Feick & Co.
COAL OPERATOR OR OWNER NAME OF WELL OPERATOR
1673 R. D. No. 2 Walker, N. VA.
ADDRESS COMPLETE ADDRESS
September 2nd 1947
COAL OPERATOR OR OWNER WELL AND LOCATION
Union District
ADDRESS
Florence County
LEASE OR PROPERTY OWNER
Well No. 2
ADDRESS L. C. May Farm

STATE INSPECTOR SUPERVISING PLUGGING

AFFIDAVIT

STATE OF WEST VIRGINIA,

County of FlorenceJ. D. Boss

being first duly sworn according to law depose and say that they are experienced in the work of plugging and filling oil and gas wells and were employed by Smith, Pierce, Feick & Co. well operator, and participated in the work of plugging and filling the above well, that said work was commenced on the 14th day of August, 1947, and that the well was plugged and filled in the following manner:

SAND OR ZONE RECORD	FILLING MATERIAL			PISTON USED	CASING	
	CONTENT	FROM	TO		CEG PULLED	CEG LEFT IN
Fill with clay from total depth 1642' to 1673'					X	X
Cement	1673' - 1663'				315 ft	28 ft
SET PERMANENT BRIDGE AT 1280'						
Fill with clay	1280' - 1165'					
Cement	1165' - 1155'					
Lift 6-5/8" casing out at	1097' to 865'					
SET BRIDGE AT 865' and fill with clay as pipe is lifted to	865' - 815'					
Cement	815' - 800'					
Lift pipe to						
SET PERMANENT BRIDGE - 2 bags cement on bridge						
Fill with clay to surface as remainder of pipe is removed						
COAL BEAMS						
HEADS						
FRAMES						
CHAINS						
ROPS						
				DESCRIPTION OF MONUMENT		
				Concrete marker		

and that the work of plugging and filling said well was completed on the 23rd day of August, 1947.

And further deponents saith not.

Sworn to and subscribed before me this 6th day of September, 1947.

My commission expires:

Dec 15, 1948

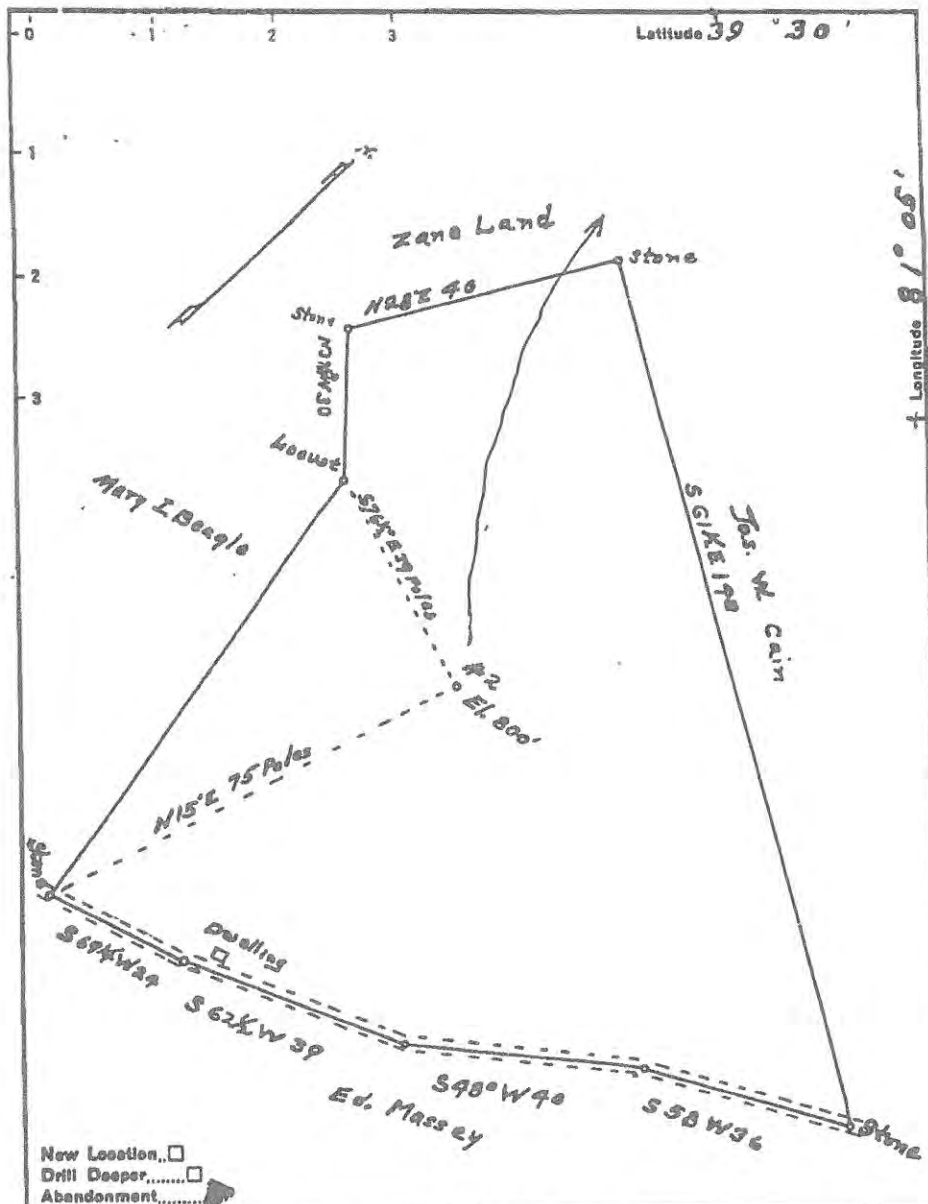
NOTARY PUBLIC, CHARLOTTE, N. C.

Notary Public.

Permit No. PLAS

RECEIVED
OIL AND GAS
NOV 18 2015

WV Department of
Environmental Protection



Company Smith, Pierson, Fair & Coss.
 Address R.O. #2, Walker, W. Va.
 Farm I. C. Way, (now J. B. Way)
 Tract Acres 50 Lease No.
 Well (Farm) No. 2 Serial No.
 Elevation (Spirit Level) 800
 Quadrangle St. Marys
 County Pleasant District Union
 Engineer J.E. Anderson, Woodco
 Engineer's Registration No. 507747
 File No. Drawing No.
 Date Aug. 6 1947 Scale 1 in = 20 poles

STATE OF WEST VIRGINIA
 DEPARTMENT OF MINES
 OIL AND GAS DIVISION
 CHARLESTON

WELL LOCATION MAP FILE NO. PLEAS-219-A

+ Denotes location of well on United States Topographic Maps, scale 1 to 62,500, latitude and longitude lines being represented by border lines as shown.

- Denotes one inch spaces on border line of original tracing.

RECEIVED
 Office of Oil and Gas
 NOV 18 2015

WV Department of
 Environmental Protection

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

AFFIDAVIT OF PLUGGING AND FILLING WELL

AFFIDAVIT SHOULD BE MADE IN TRIPPLICATE. ONE COPY MAILED TO THE DEPARTMENT. ONE COPY TO BE RETAINED BY THE WELL OPERATOR AND THE THIRD COPY (AND EXTRA COPIES IF REQUIRED) SHOULD BE MAILED TO EACH COAL OPERATOR AT THEIR RESPECTIVE ADDRESSES.

COAL OPERATOR OR OWNER G. A. Smith NAME OF WELL OPERATOR
ADDRESS St. Marys, W. Va. COMPLETE ADDRESS
COAL OPERATOR OR OWNER Sent. 24th WELL AND LOCATION 1048
ADDRESS McKin District
LESSOR OR PROPERTY OWNER Pleasant County
ADDRESS Well No. 3
George Shingleton Farm

STATE INSPECTOR SUPERVISING PLUGGING O. C. Howard

AFFIDAVIT

STATE OF WEST VIRGINIA,

County of Pleasant } ss:

Everett Roby and G. A. Smith
being first duly sworn according to law depose and say that they are experienced in the work of plugging and filling oil and gas wells and were employed by Smith & Roby
well operator, and participated in the work of plugging and filling the above well, that said work was commenced on the 2th day of June, 1948, and that the well was plugged and filled in the following manner:

RANGE OR ZONE RECORD	FILLING MATERIAL			PLUGS USED	CASING	
	CONTENT	FROM	TO		COB FULLER	COB LEFT IN
FORMATION	Cement plug	1621	1831	Cement	42'	476'
	Stone	1616	1621			
	Clay	1616	1760			
	Cement	1760	1750			
	Stone	1750	1745			
	Clay	1745	1420			
	Cement	1420	1410			
	Stone	1410	1405			
	Clay	1405	1000			
	Cement	1000	990			
	Cement Plug	450				
	Clay	450 to	surface			
	COAL BEAMS					
BEAMS						
BEAMS						
BEAMS						
BEAMS						
			DESCRIPTION OF MONUMENT			
			Cement & 8" pipe			

and that the work of plugging and filling said well was completed on the 21st day of June, 1948

And further deponents said not:

Sworn to and subscribed before me this 24th day of Sept., 1948

My commission expires:

Dec. 8, 1951

Notary Public.

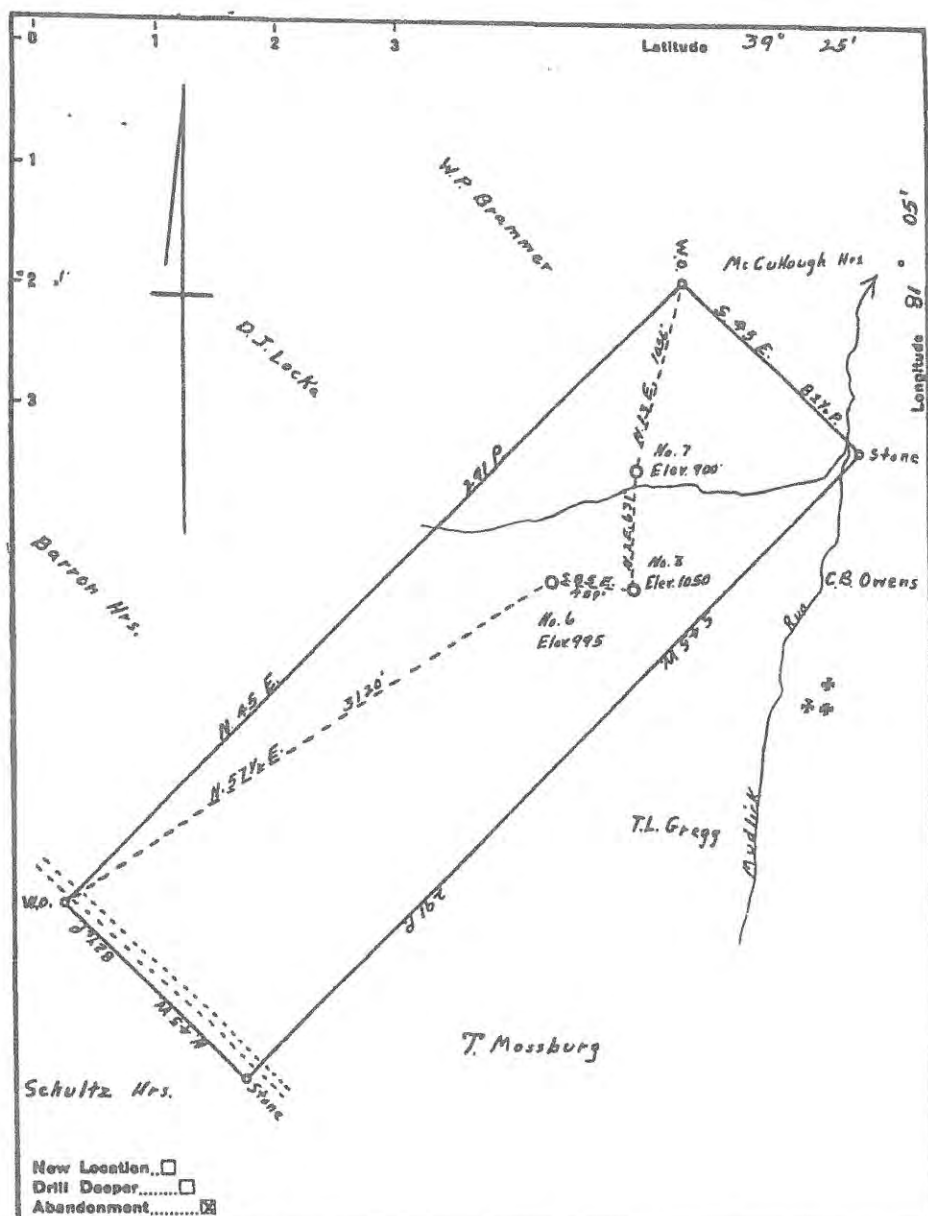
Permit No. PL5A5-220

Office

NOV 1948

WV

Environmental



Company George Shingleton
 Address RFD 35, St Marys, W. Va.
 Farm George Shingleton
 Tract Acres 147 Lease No.
 Well (Farm) No. 3-6-7 Serial No.
 Elevation (Spirit Level) 1050 - 995 - 900
 Quadrangle St Marys
 County Pleasants District Mc Kim
 Engineer A. K. Whitford
 Engineer's Registration No.
 File No. Drawing No.
 Date Sept. 29, 1942 Scale 1" = 40 Feet

STATE OF WEST VIRGINIA
 DEPARTMENT OF MINES
 OIL AND GAS DIVISION
 CHARLESTON

WELL LOCATION MAP

FILE NO. PLEAS-220-A-#3

PLEAS-221-A-#6

PLEAS-222-A-#7

+ Denotes location of well on United States Topographic Maps, scale 1 to 62,500, latitude and longitude lines being represented by border lines as shown.

- Denotes one inch spaces on border line of original tracing.



STATE OF WEST VIRGINIA
DEPARTMENT OF MINES

RECEIVED

SEP 11 1981

Oil and Gas Division

OIL AND GAS DIVISION
W.V. DEPARTMENT OF MINES

OIL AND GAS WELL PERMIT APPLICATION

TO THE DEPARTMENT OF MINES,
Charleston, W. Va.

DATE Aug. 30, 1981

Surface Owner Karl J. Rymer

Company James A. Renner Oil & Gas

Address Route 2 St. Marys, W. Va.

Address Box 106 Bens Run, W. Va. 26135

Mineral Owner Same

Farm Rymer Acres 68

Address _____

Location (waters) Tacketts Run 1056

Coal Owner none

Well No. J O # 3 Elevation 5000

Address _____

District Union County Pleasants

Coal Operator none

Quadrangle BENS RUN

THIS PERMIT MUST BE POSTED AT THE WELL SITE

All provisions being in accordance with Chapter 22, of the W. Va. Code, the location is hereby approved for drilling. This permit shall expire if operations have not commenced by 5-21-82.

INSPECTOR

TO BE NOTIFIED Phil Tracy

ADDRESS Route 23 Alma, W. Va. 26321

PHONE 758-4573

Deputy Director - Oil & Gas Division

GENTLEMEN:

The undersigned well operator is entitled to drill upon the above named farm or tract of land for oil and gas, having fee title thereto, (or as the case may be) under grant or lease dated May 19 1981 by James & Lenora Renner made to James A. Renner and recorded on the 29 day of May 1981 in Pleasants County, Book 164 Page 8.

☒ NEW WELL ☐ DRILL DEEPER ☐ REDRILL ☐ FRACTURE OR STIMULATE

☐ OIL AND GAS WELL ORIGINALLY DRILLED BEFORE JUNE 5, 1963.

The enclosed plat was prepared by a registered engineer or licensed land surveyor and all coal owners and/or operators have been notified as of the above date.

The above named coal owners and/or operator are hereby notified that any objection they wish to make, or are required to make by Section 3 of the Code, must be received by, or filed with the Department of Mines within ten (10) days.

Copies of this notice and the enclosed plat were mailed by registered mail, or delivered to the above named coal operators or coal owners at their above shown respective address _____ day _____ before, or on the same day with the mailing or delivery of this copy to the Department of Mines at Charleston, West Virginia.

PLEASE SUBMIT COPIES OF ALL
GEOPHYSICAL LOGS DIRECTLY TO:

WEST VIRGINIA GEOLOGICAL AND
ECONOMIC SURVEY
P. O. BOX 879
MORGANTOWN, WEST VIRGINIA 26505
AC-304 - 292-6331

Very truly yours,

(Sign Name) _____

Well Operator

Address
of
Well Operator

Box 106 Star Route

Street

Bens Run, W. Va. 26135

City or Town

State

NOV 18 2015

*SECTION 3 . . . If no objections are filed or found by the Department of mines, within said period of ten days from the receipt of notice and plat by the department of mines, to said proposed location, the department shall forthwith issue to the well operator a permit, reciting the filing of such plat, that no objections have been made by the coal operators or found thereto by the department and that the same is approved and the well operator authorized to proceed.

47-073-1313

PERMIT NUMBER

"I have read and understand the reclamation requirements as set forth in Chapter 22, Article 4, Section 12-b and will carry out the specified requirements."

Signed by

James A. Renner

THIS IS AN ESTIMATE ONLY
ACTUAL INFORMATION WILL BE SUBMITTED ON OG-10 UPON COMPLETION.

PROPOSED WORK ORDER TO ☒ DRILL ☐ DEEPEN ☐ FRACTURE-STIMULATE
 DRILLING CONTRACTOR: (If Known) RESPONSIBLE AGENT:
 NAME James Renner NAME James A. Renner
 ADDRESS Box 106 Star Route, W. Va. ADDRESS Box 106 Bens Run, W. Va. 26135
 TELEPHONE 684-7890 TELEPHONE 684-7890
 ESTIMATED DEPTH OF COMPLETED WELL: 5999' ROTARY ☐ CABLE TOOLS ☒
 PROPOSED GEOLOGICAL FORMATION: Shale
 TYPE OF WELL: OIL ☐ GAS ☐ COMB. ☒ STORAGE ☐ DISPOSAL ☐
 RECYCLING ☐ WATER FLOOD ☐ OTHER ☐

TENTATIVE CASING PROGRAM:

CASING AND TUBING SIZE	USED FOR DRILLING	LEFT IN WELL	CEMENT FILL UP OR SACKS - CUBIC FT.
20 - 16			
13 - 10 3/8	200	200 ft to surface	200
9 - 5/8			
8 - 5/8			
7			
5 1/2			
4 1/2	4000	4000	Regulation 1501
3			Perf. Top
2			Perf. Bottom
Liners			Perf. Top
			Perf. Bottom

APPROXIMATE FRESH WATER DEPTHS 150 FEET 1200 SALT WATER FEET
 APPROXIMATE COAL DEPTHS none
 IS COAL BEING MINED IN THE AREA? none BY WHOM?

TO DRILL:

SUBMIT FIVE (5) COPIES OF OG - 1, \$100.00 PERMIT FEE, PERFORMANCE BOND AND PERMANENT COPY OF PLAT.

TO DRILL DEEPER OR REDRILL:

SUBMIT FIVE (5) COPIES OF OG - 1, SHOWING ORIGINAL PERMIT NUMBER AND PERFORMANCE BOND. ON WELLS DRILLED PRIOR TO 1929, A PERMANENT COPY OF THE PLAT AND THE ORIGINAL WELL RECORD MUST ALSO BE SUBMITTED.

TO FRACTURE - STIMULATE:

OIL AND/OR GAS WELL ORIGINALLY DRILLED BEFORE JUNE 5, 1929, FIVE (5) COPIES OG - 1, PERFORMANCE BOND, PERMANENT PLAT AND ORIGINAL WELL RECORD.

OIL AND/OR GAS WELL ORIGINALLY DRILLED ON AND/OR AFTER JUNE 5, 1929, FIVE COPIES OG - 1, SHOWING ORIGINAL PERMIT NUMBER, AND PERFORMANCE BOND.

Required forms must be filed within ninety (90) days of completion for bond release. Inspector to be notified ~~thirty~~ four (24) hours in advance.

The following waiver must be completed by the coal operator if the permit is to be issued within ten days of receipt thereof.

WAIVER: I the undersigned, Agent for Coal Company, Owner or Operator of the coal under this lease have examined and place on our mine maps this proposed well location.
 We the Coal Company have no objections to said well being drilled at this location, providing operator has complied with all rules and regulations in Articles 4, 5, and 7, Chapter 22 of the West Virginia Code.

For Coal Company

Official Title

RECEIVED
Office of Oil and Gas
NOV 18 2015
Department of
Environmental Protection

Form 10-0
(11-55)

Date 6 April 1981
Well No. J-03
AP: No. 61 - 073 - 13/2
State County Permit

#666

STATE OF WEST VIRGINIA
OFFICE OF OIL AND GAS

Company Name James A. Renner O+G Designated Agent James A. Renner
Address Box 106, Bens Run, W.Va. 26135 Address Box 106, Bens Run, W.Va. 26135
Telephone 684-7890 Telephone 684-7890
Lessor Carl Rymer (I.C. Way) Soil Cons. District Upper Ohio
Reclamation to be carried out by James Renner (Agent)
This plan has been reviewed by Upper Ohio SCD. All corrections
and additions become a part of this plan. 9/8/81 Wm. H. Plann
(SCD Agent)

Across Road
Structure _____ (A)
Spacing _____
Page Ref. Manual _____
Structure _____ B.
Spacing _____
Page Ref. Manual _____
Structure _____
Spacing _____
Page Ref. Manual _____

Location
Structure Diversion Ditch (1)
Material Soil
Page Ref. Manual 1:9
Structure Rip-Rap (2)
Material Rock-Stone-Brush
Page Ref. Manual N/A
Structure _____
Material _____
Page Ref. Manual _____

RECEIVED

SEP 11 1981

All structures should be inspected regularly and repaired if necessary.

OIL AND GAS DIVISION
WV DEPARTMENT OF MINES

Reclamation

Treatment Area I

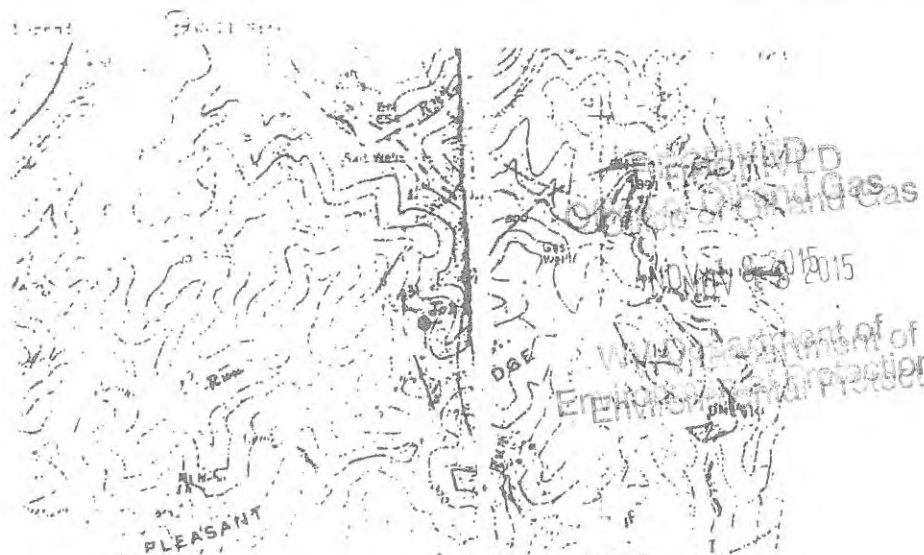
Line _____ Tons/Acre
or pounds to acre _____
Fertilizer 500 lbs/acre
Seed Hay 2 lbs/acre
KY31 Fescue 35 lbs/acre
Redtop 5 lbs/acre

Treatment Area II

Line _____ Tons/Acre
or pounds to acre _____
Fertilizer 500 lbs/acre
Seed Hay 2 lbs/acre
KY31 Fescue 35 lbs/acre
Redtop 5 lbs/acre

Inoculate all legumes with an effective pre- and clover with the proper bacterium. Inoculate with 1/2 recommended amount.

Location Bens Run, W.Va.

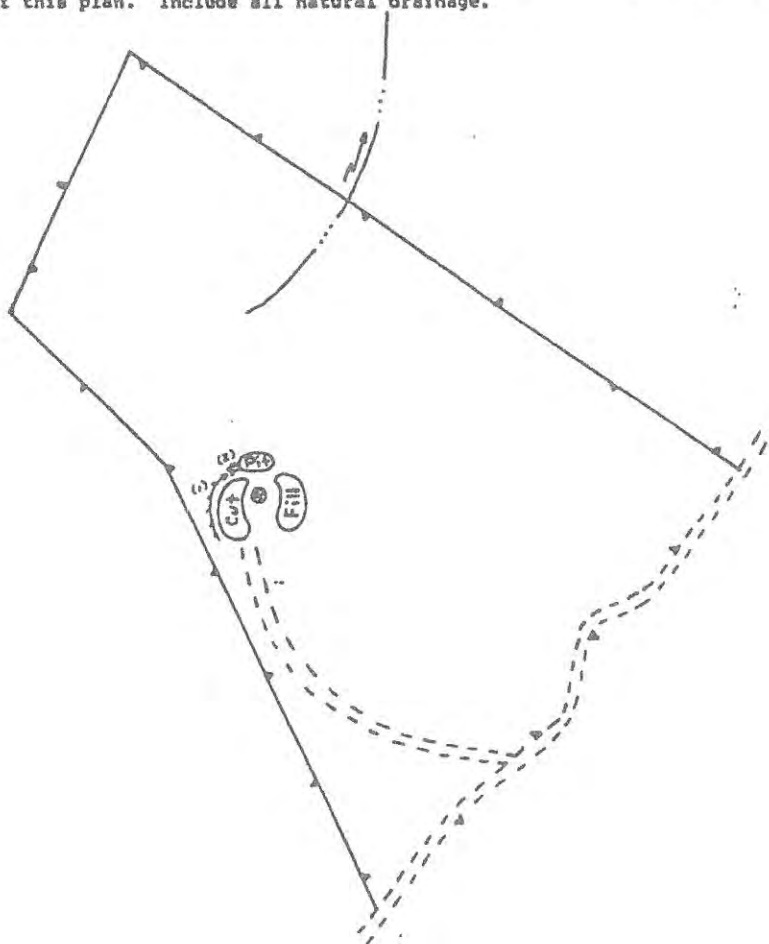


Well Site Plan

Legend: Property Boundary ———
 Road = = = =
 Existing Fence — x — x —
 Planned Fence ———
 Stream ———
 Open Ditch ———

Diversion ———
 Spring ○
 Wet Spot
 Building ■
 Drain Pipe —○—○—○—
 Waterway ———

Sketch to include well location, existing access road, roads to be constructed, wellsite, drilling pits and necessary structures numbered or lettered to correspond with first part of this plan. Include all natural drainage.



- Comments: (1) No Access Road Needed
 (2) Brush and Trees to be Piled at Site
 (3) Location Located on Ridge

Signature: _____ Agent _____ Address _____ Phone Number: _____

Please request landowners cooperation to protect new seeding for one growing season.

RECEIVED
 Office of Oil and Gas
 NOV 18 2015
 WV Department of
 Environmental Protection

FORM 14-209
(Obsolete)
1-83

FILE COPY

RECEIVED

JUN 4 - 1985

PERMIT



1) Date: JUNE 3, 19 85
2) Operator's (Old - 47-073-1313) 30 # 3
Well No. RENNER #4
3) API Well No. 47 - 073-1313-P
State County Permit

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES, OIL AND GAS DIVISION
APPLICATION FOR A WELL WORK PERMIT

OIL & GAS DIVISION
DEPT. OF MINES

- Gas X
- 5) LOCATION: B (If "Gas", Production 1056 / Underground storage / Deep / Shallow X)
Elevation: 1056 / Watershed: PLEASANTS
District: UNION / County: PLEASANTS / Quadrangle: Bens Run 241
- 6) WELL OPERATOR: BENS RUN OIL CO. - John Sims DESIGNATED AGENT JAMES RENNER
Address: BOX 140 / Address: BOX 106M STAR ROUTE
BENS RUN, W. VA. 26135 / BENS RUN, W. VA. 26135
- 8) OIL & GAS INSPECTOR TO BE NOTIFIED
Name: ROBERT LOWTHER
Address: MIDDLEBOURNE, W. VA.
- 9) DRILLING CONTRACTOR:
Name: JAMES RENNER
Address: BOX 106 STAR ROUTE
BENS RUN, W. VA. 26135
- 10) PROPOSED WELL WORK: Drill / Drill deeper / Redrill / Stimulate X
Plug off old formation / Perforate new formation
Other physical change in well (specify)
- 11) GEOLOGICAL TARGET FORMATION, shale
- 12) Estimated depth of completed well, 5999 feet
- 13) Approximate strata depths: Fresh, 150 feet; salt, feet.
- 14) Approximate coal seam depths: none Is coal being mined in the area? Yes / No X
- 15) CASING AND TUBING PROGRAM

CASING OR TUBING TYPE	SPECIFICATIONS					FOOTAGE INTERVALS		CEMENT FILL-UP OR SACKS (Cubic feet)	PACKERS
	Size	Grade	Weight per ft.	New	Used	For drilling	Left in well		
Conductor	10 3/4					200	200 ft to surface	200	Kind
Fresh water									
Coal									Size
Intermediate									Depth set
Production									Perforations:
Tubing									Top Bottom
liners									
4 1/2 casing						4505	4505	400	

OFFICE USE ONLY
DRILLING PERMIT

Permit number 47-073-1313 Frac

Date June 5 19 85

This permit covering the well operator and well location shown below is evidence of permission granted to drill in accordance with the pertinent legal requirements subject to the conditions contained herein and on the reverse hereof. Notification must be given to the District Oil and Gas Inspector, (Refer to No. 8) Prior to the construction of roads, locations and pits for any permitted work. In addition, the well operator or his contractor shall notify the proper district oil and gas inspector 24 hours before actual permitted work has commenced.)

The permitted work is as described in the Notice and Application, plat, and reclamation plan, subject to any modifications and conditions specified on the reverse hereof.

Permit expires June 5, 1987 unless well work is commenced prior to that date and prosecuted with due diligence.

Bond:	Agent:	Plat:	Casing	Fee
210	FIB	MW	MW	110

NOTE: Keep one copy of this permit posted at the drilling location.

See the reverse side of the APPLICANT'S COPY for instructions to the well operator.

Margaret J. [Signature]
Administrator, Office of Oil and Gas

NOV 8 2015
WV Department of Environmental Protection

FORM IV-1

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES, OIL AND GAS DIVISION

DESIGNATION OF AGENT BY WELL OWNER OR OPERATOR

RECEIVED
JUN 4 - 1985

WELL OPERATOR - OWNER - JOHN SIMS - BENS RUN OIL CO.
Address BOX 140
BENS RUN, W. VA. 26135

OIL & GAS DIVISION
DEPT. OF MINES

Pursuant to the provisions of Code 22-4-1k, and subject to the requirements of Regulation 7.01, the undersigned hereby designates the following person to be the agent of the undersigned for the purpose of receiving process, notices, notices, orders and other communications which may be issued under Chapter 22 of the Code of West Virginia:

Designated Agent JAMES RENNER
Address BOX 106 STAR ROUTE
BENS RUN, W. VA. 26135
Telephone 684-7890

The undersigned represents that said designated agent is a bona fide resident of the State of West Virginia, and has agreed to accept the designation. This designation applies to the following wells:

- ☐ all wells owned or operated by the undersigned in West Virginia
☒ the wells listed below (Use space below or reverse side or attach list)

47-073-1313

(COMPLETE AS APPLICABLE)

- ☒ The undersigned is hereby recording an existing designation of agent made prior the initial adoption of Form IV-1.
- ☐ The undersigned is proposing to own or operate wells in West Virginia for the first time, so that this designation should also be considered the registration by the undersigned with the Deputy Director.
- ☐ The undersigned has owned and operated a well or wells in West Virginia since the year _____ but has not heretofore appointed a designated agent.
- ☐ This designation substitutes a new designated agent for the undersigned, who has owned or operated a well or wells in West Virginia since the year 19____.
- The present designated agent of the undersigned, who will continue as such, if he is able, until this new designation has been approved, is -

Agent being replaced _____
Address _____

By: Bens Run Oil Co.
Its: John H. Sims, Manager

ACCEPTED this June 4 1985
James P. Renner
(Signature of designated agent)

Taken, subscribed and sworn to before me this 4th day of June
Notary Public Markus Langford My commission expires June 30 1987
County of Lincoln, State of West Virginia
Well owner or operator must be a responsible officer of the corporation, trustee, individual or legally qualified representative of owner of the well(s).

NOV 18 2015

WV Department of
Environmental Protection

FORM IV-2(A)

1) Date: JUNE 3, 1985
 2) Operator's (47-073-1313 - UTD)
 Well No. Remmer #4
 3) API Well No. 47-134-1313 Fr.
 State County Permit

STATE OF WEST VIRGINIA
 DEPARTMENT OF MINES, OFFICE OF OIL & GAS

NOTICE OF APPLICATION FOR A WELL WORK PERMIT

4) SURFACE OWNER(S) OF RECORD TO BE SERVED

(i) Name CARL J. RYMER
 Address R R # 2
ST. MARYS, W. VA.

(ii) Name _____
 Address _____

(iii) Name _____
 Address _____

5(i) COAL OPERATOR none
 Address _____

5(ii) COAL OWNER(S) WITH DECLARATION ON RECORD:
 Name _____
 Address _____

Name _____
 Address _____

5(iii) COAL LESSEE WITH DECLARATION ON RECORD:
 Name _____
 Address _____

TO THE PERSON(S) NAMED ABOVE: You should have received this Form and the following documents:

- (1) The Application for a Well Work Permit on Form IV-2(B) (or Form IV-4 if the well is to be plugged, which sets out the parties involved in the drilling or other work, and describes the well and its location and, if applicable, the proposed casing and cementing program)
- (2) The plat (surveyor's map) showing the well location on Form IV-6; and
- (3) The Construction and Reclamation Plan on Form IV-9 (unless the well work is only to plug a well), which sets out the plan for erosion and sediment control and for reclamation for the site and access road.

THE REASON YOU RECEIVED THESE DOCUMENTS IS THAT YOU HAVE RIGHTS REGARDING THE APPLICATION WHICH ARE ENUMERATED IN THE "INSTRUCTIONS" ON THE REVERSE SIDE OF THE COPY OF THE APPLICATION (FORM IV-2(B) OR FORM 4, DESIGNED FOR YOU. HOWEVER, YOU ARE NOT REQUIRED TO TAKE ANY ACTION AT ALL.

Take notice that under Chapter 22 of the West Virginia Code, the undersigned well operator proposes to file or has filed this Notice and Application and accompanying documents for a Well Work Permit with the Administrator of the Office of Oil and Gas, West Virginia Department of Mines, with respect to a well at the location described on attached Application and depicted on attached Form IV-6. Copies of this Notice, the Application, the plat, and the Construction and Reclamation Plan have been mailed by registered or certified mail or delivered by hand to the person(s) named above (or by publication in certain circumstances) on or before the day of mailing or delivery to the Administrator.

6) EXTRACTOR RIGHTS

Check and provide one of the following:

- ☐ Included in the lease or leases or other continuing contract or contracts by which I hold the right to extract oil or gas.
☐ The requirement of Code 22-4-1-(c) (1) through (4). (See reverse side for specifics.)

7) ROYALTY PROVISIONS

Is the right to extract, produce or market the oil or gas based upon a lease or leases or other contract or contracts providing for flat well royalty or any similar provision for compensation to the owner of the oil or gas in place which is not inherently related to the volume of oil or gas so extracted, produced or marketed? Yes No

If the answer above is No, nothing additional is needed. If the answer is Yes, you may use Affidavit Form IV-60.

See the reverse side for line item instructions, and for instructions concerning the required copies of the Notice and Application, plat, and Construction and Reclamation Plan.

The truth of the information on the Notice and Application is verified and sworn to and the Notice is signed on behalf of the Well Operator in my County and State by

James A. Remmer & John Sims
 this 4 day of June, 1985.
 My commission expires June 30, 1987.

Shandra K. Langford
 Notary Public, Pleasant County,
 State of West Virginia

WELL OPERATOR BENS RUN OIL - JOHN SIMS
 By James A. Remmer
 Its AGENT
 Address BOX 140
BENS RUN, W. VA. 26135
 Telephone _____

NOV 18 2015
 WV Department of
 Environmental Protection



1) Date: JUNE 3 1975
 2) Operator's Well No. 610-47-073-13330 A 2
 3) API Well No. 47 State West Virginia County Putnam Permit 13330 A 2

STATE OF WEST VIRGINIA
 DEPARTMENT OF MINES, OIL AND GAS DIVISION
 APPLICATION FOR A WELL WORK PERMIT

- 4) WELL TYPE: A Oil ☒ Gas ☒
 B (If "Gas", Production ☐ Underground storage ☐ Deep ☐ Shallow ☒
 5) LOCATION: Elevation: Watershed: PLEASANTS
 District: UNION County: PLEASANTS Quadrangle:
 6) WELL OPERATOR: BENS RUN LIL CO. - John Simpson DESIGNATED AGENT JAMES KEMNER
 Address: BOX 140 Address: BOX 100 STAR ROUTE
BENS RUN, W. VA. 26139 BENS RUN, W. VA. 26139
 8) OIL & GAS INSPECTOR TO BE NOTIFIED: Name ROBERT LOUTHER
 Address: MIDDLEBORNE, W. VA.
 9) DRILLING CONTRACTOR: Name JAMES KEMNER
 Address: BOX 100 STAR ROUTE
BENS RUN, W. VA. 26139
 10) PROPOSED WELL WORK: Drill ☐ Drill deeper ☐ Redrill ☐ Stimulate ☒
 Plug off old formation ☐ Perforate new formation ☐
 Other physical change in well (specify)
 11) GEOLOGICAL TARGET FORMATION: shale
 12) Estimated depth of completed well, 5000 feet
 13) Approximate true depths: Fresh, 150 feet; salt, feet.
 14) Approximate coal seam depths: none Is coal being mined in the area? Yes ☐ No ☒

15) CASING AND TUBING PROGRAM

CASING OR TUBING TYPE	SPECIFICATIONS				FOOTAGE INTERVALS		CEMENT FILLUP OR SACKS (Cable feet)	PACKERS	
	Size	Grade	Weight per ft.	New	Used	For drilling	Left in well	Kind	
Conductor	10 3/4					200	200		
Fresh water								Slam	
Coal								Depth set	
Intermediate								Perforations:	
Production								Top	Bottom
Tubing									
Lines						4500	4500		
4 1/2 CDS 507									

INSTRUCTIONS TO COAL OPERATOR, OWNER, OR LESSEE

The named coal operator, coal owner(s), and coal lessee are hereby notified that any objection they wish to make or are required to make by Code §22-4-3 must be filed with the Department of Mines within fifteen (15) days after the receipt of this Application by the Department.

The following waiver must be completed by the coal operator and by any coal owner or coal lessee who has recorded a declaration under Code §22-4-20, if the permit is to be issued within fifteen (15) days of the filing of the Application.

WAIVER

The undersigned coal operator owner lessee of the coal under this well location has examined this proposed well location. If a mine map exists which covers the area of the well location, the well location has been added to the mine map. The undersigned has no objection to the work proposed to be done at this location, provided, the well operator has complied with all applicable requirements of the West Virginia Code and the governing regulations.

Date: , 19 75

By James Kemner
 Its

RECEIVED
 Coal Owner
 Office of Oil and Gas

NOV 3 8 2015

WV Department of
 Environmental Protection

A-10

FORM IV-2(B)
(Obverse)
7-83

SURFACE OWNER'S COPY

TR. LOPER AND RE-PERMIT



- 1) Date: June 3, 1985
 2) Operator's Well No. 47
 3) API Well No. 47 State W County Permit

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES, OIL AND GAS DIVISION

APPLICATION FOR A WELL WORK PERMIT

- 4) WELL TYPE: A Oil X Gas X
 B (If "Gas", Production / Underground storage / Deep / Shallow X)
 5) LOCATION: Elevation: Watershed:
 District: County: PLUMS MTS Quadangle:
 6) WELL OPERATOR BENS RUN OIL CO. - John Siff DESIGNATED AGENT JAMES KENNER
 Address BOX 106 Address BOX 106 BENS RUN
BENS RUN, W. V. 26135 BENS RUN, W. V. 26135
 8) OIL & GAS INSPECTOR TO BE NOTIFIED
 Name ROBERT LUTHER
 Address MIDDLEBURGH, W. V.
 9) DRILLING CONTRACTOR:
 Name JAMES KENNER
 Address BOX 106 BENS RUN
BENS RUN, W. V. 26135
 10) PROPOSED WELL WORK: Drill / Drill deeper / Redrill / Stimulate X
 Plug off old formation / Perforate new formation
 Other physical change in well (specify)
 11) GEOLOGICAL TARGET FORMATION, shale
 12) Estimated depth of completed well, feet
 13) Approximate strata depths: Fresh, 150 feet; salt, feet.
 14) Approximate coal seam depths: Is coal being mined in the area? Yes / No X

15) CASING AND TUBING PROGRAM

CASING OR TUBING TYPE	SPECIFICATIONS						FOOTAGE INTERVALS		CEMENT FILL-UP OR SACKS (Cubic feet)	PACKERS
	Size	Grade	Weight per ft.	New	Used		For drilling	Left in well		
Conductor	11 5/8									Kind
Fresh water										
Coal										Size
Intermediate										Depth set
Production										
Tubing										Perforations:
Lines										Top Bottom
4" REG 10							4.00	1.00	4.00	

The law requires a comment period for surface owners. However, the permit can be issued in less than 15 days from the filing of the Application if the surface owner(s) of record sign(s) the following "Voluntary Statement of No Objection" on a facsimile of this surface owner's copy of the Application.

VOLUNTARY STATEMENT OF NO OBJECTION

I hereby state that I have read the instructions to surface owners on the reverse side of this Application for a Well Work Permit, and that I have received copies of (1) a Notice of Application for a Well Work Permit on Form IV-2(A), (2) an Application for a Well Work Permit on Form IV-2(B), (3) a survey plat on Form IV-6, and (4) a Construction and Reclamation Plan on Form IV-9, all for proposed well work on my surface land as described therein.

I further state that I have no objection to the planned work described in these materials, and I have no objection to a permit being issued based on those materials.

(For execution by corporation, partnership, etc.)

NAME: _____

By _____

Its _____ Date _____

(For execution by natural persons)

Carl Turner

(Signature)

Date June 3/85

(Signature)

Date _____

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

A11

FORM IV-60
(6-82)

RECEIVED

JUN 4 - 1985

OIL & GAS DIVISION
DEPT. OF MINES



State of West Virginia

OFFICE OF OIL AND GAS
DEPARTMENT OF MINES

DATE: JUNE 3, 19 85
OPERATOR'S (47-073-1313-01d)
WELL NO.:

API NO: 47 - -
State County Permit No.

AFFIDAVIT

State of WEST VIRGINIA
County of PLEASANTS

I, James A. Renner (the designated owner or operator, or authorized representative thereof), after being duly sworn, do depose and say that the undersigned is authorized by the owner of the working interest in the well permit application to which this affidavit is attached do state that he, she, or it shall tender to the owner of the oil and gas in place not less than one-eighth of the total amount paid to or received by or allowed to the owner of the working interest at the wellhead for the oil or gas so extracted, produced, or marketed before deducting the amount to be paid or set aside for the owner of the oil or gas in place, or all such oil or gas to be extracted, produced, or marketed from the well. West Virginia Code 22-4-11(e) (1982).

Signed: James A. Renner

Taken, Subscribed, and sworn to before me this 2 day of June, 1985.

Notary: Clarence K. Langford

My Commission Expires: June 30, 1987

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

IV-35
(Rev 8-81)

RECEIVED
JUN 4 - 1985

OIL & GAS DIVISION
DEPT. OF MINES



State of West Virginia

Department of Mines
Oil and Gas Division

Date JUNE 3, 1985

Operator's (old - 47-073-1313)

Well No. RENNER # 4

Farm RYMER

API No. 47 - 073 - 1313 F

WELL OPERATOR'S REPORT
OF

DRILLING, FRACTURING AND/OR STIMULATING, OR PHYSICAL CHANGE

WELL TYPE: Oil X / Gas X / Liquid Injection / Waste Disposal /
(If "Gas," Production / Underground Storage / Deep / Shallow X /)

LOCATION: Elevation: 1056" Watershed BENS RUN

District: UNION County PLEASANTS Quadrangle BENS RUN, W. VA.
Quad.

COMPANY BENS RUN OIL - John Sims

ADDRESS BOX 140 Bens Run, W. Va. 26135

DESIGNATED AGENT JAMES RENNER

ADDRESS BOX 106 STAR ROUTE - Bens Run, W.

SURFACE OWNER CARL J. Rymer

ADDRESS R R # 2 St. Marys, W. Va.

MINERAL RIGHTS OWNER CARL RYMER

ADDRESS R R # 2 ST. MARYS, W. VA.

OIL AND GAS INSPECTOR FOR THIS WORK ROBBIE

LOWTHER ADDRESS MIDDLEBOURNE, W. VA.

PERMIT ISSUED SEPT. 11, 1981

DRILLING COMMENCED AUG. 31, 1981

DRILLING COMPLETED NOV. 30, 1981

IF APPLICABLE: PLUGGING OF DRY HOLE ON
CONTINUOUS PROGRESSION FROM DRILLING OR
REWORKING. VERBAL PERMISSION OBTAINED
ON

Casing Tubing	Used in Drilling	Left in Well	Cement fill up Cu. ft.
Size 20-16 Cord.			
10 3/4 13-10"	200	200 to surface	200
9 5/8			
8 5/8			
7			
5 1/2			
4 1/2	4505	4505 to surface	400
3			
2			
Liners used			

GEOLOGICAL TARGET FORMATION shale Depth 5999" feet

Depth of completed well 4568 feet Rotary / Cable Tools x

Water strata depth: Fresh 150 feet; Salt none feet

Coal seam depths: none Is coal being mined in the area? no

OPEN FLOW DATA

Producing formation Pay zone depth feet

Gas: Initial open flow Mcf/d Oil: Initial open flow Bbl/d

Final open flow Mcf/d Final open flow Bbl/d

Time of open flow between initial and final tests hours

Static rock pressure psig (surface measurement) after hours shut in

(If applicable due to multiple completion--)

Second producing formation Pay zone depth feet

Gas: Initial open flow Mcf/d Oil: Initial open flow Bbl/d

Final open flow Mcf/d Oil: Final open flow Bbl/d

Time of open flow between initial and final tests hours

Static rock pressure psig (surface measurement) after hours shut in

(Continue on reverse side)

DETAILS OF PERFORATED INTERVALS, FRACTURING OR STIMULATING, PHYSICAL CHANGE, ETC.

NO. 2110 342 2110
L. 2110 342 2110
L. 2110 342 2110

WELL LOG

FORMATION	COLOR	HARD OR SOFT	TOP FEET	BOTTOM FEET	REMARKS Including indication of all fresh and salt water, coal, oil and gas
Med. formation Shale			3700 to 4500		No salt water, sand 1300 no water sand
		soft for 20 ft	3959		salt 1100 No water salt 1200 no gas or oil salt 1300 hard sand
Top soil			0 to 15 feet	Slate	805 - 900
Sand Stone			15 to 32 feet	First Cpw rim	900 - 920
Light sand stone			32 to 60 feet	Slate	920 - 980
Red rock			60 to 100	First Streak Salt sand	900 - 1000
Slate			100 to 150	Slate / shells	1000 - 1100
Lime			150 to 200	2nd. streak salt	1100 - 1120
Bedded rock			200 - 225	slate / limey	1120 - 1200
Shale			225 - 250	3rd. streak salt sand	1200 - 1205
Red Rock			250 - 350	slate	1205 - 1400
Slate			350 - 360	black shells	1400 - 1450
Red Rock			360 - 385	maxim / no oil & gas	1450 - 1600
Sand			385 - 400	Big Lime	1600 - 1680
Lime			400 - 415	Keener / no shows	1680 - 1715
Slate			415 - 435	Engine	1715 - 1865
Red Rock			435 - 500	slate / shells	1865 - 2165
Slate Shales			500 - 592	slate / shells	2165 - 3959
				brown shale	3959 - 3969
				slate / shells	3969 - 4568
Slate Shales			592 - 615		
Slate			615 - 625		
Lime			625 - 635		
Slate			635 - 670		
Stray Sand			670 - 760		
Stray sand					

(Attach separate sheets as necessary)

James Renner
Well Operator

By: agent

Date: June 4, 1985

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

Note: Regulation 2.02(i) provides as follows:
"The term 'log' or 'well log' shall mean a systematic
detailed geological record of all formations, including
any, encountered in the drilling of a well."



Date February 15, 1986
Operator's
Well No. #3
Farm J.O. Rymer
API No. 47 - 073 - 1313

WR-35

3 1986

State of West Virginia

DEPARTMENT OF ENERGY
Oil and Gas Division

DEPARTMENT OF ENERGY
OIL AND GAS

WELL OPERATOR'S REPORT
OF

MAR 2 1 1986 DRILLING, FRACTURING AND/OR STIMULATING, OR PHYSICAL CHANGE

WELL TYPE: Oil / Gas X / Liquid Injection / Waste Disposal /
(If "Gas," Production / Underground Storage / Deep / Shallow X /)

LOCATION: Elevation: 1012 GL Watershed Bens Run
District: Union County Pleasants Quadrangle Bens Run 7.5 min.

COMPANY Bens Run Oil Company
ADDRESS 509-C Locust Ave. Charlottesville, Va 22901
DESIGNATED AGENT James Renner
ADDRESS Box 106 Star Route Bens Run, W.V. 26135
SURFACE OWNER Carl Rymer
ADDRESS Rt. 2 St. Marys W.V. 26170
MINERAL RIGHTS OWNER Carl Rymer
ADDRESS Rt. 2 St. Marys W.V. 26170
OIL AND GAS INSPECTOR FOR THIS WORK Robert Lowther
ADDRESS Middlebourne, W.V.
PERMIT ISSUED 6/5/85 (to stimulate)
DRILLING COMMENCED 8/31/81
DRILLING COMPLETED 11/18/81 FRAC DATE 6/5/85
IF APPLICABLE: PLUGGING OF DRY HOLE ON CONTINUOUS PROGRESSION FROM DRILLING OR REMORKING. VERBAL PERMISSION OBTAINED ON N/A

Casing Tubing	Used in Drilling	Left in Well	Cement fill up Cu. ft.
Size 20-16 Cond.			
13-10 3/4	200'	200'	75 sks (class A) (100 ft)
9 5/8			
8 5/8	1350'	pulled	
7			
5 1/2			
4 1/2	4505	4505	375 sks 11MIX (680 ft)
3			
2			
Liners used			

GEOLOGICAL TARGET FORMATION Devonian Shale Depth 5999' feet
Depth of completed well 4568' feet Rotary / Cable Tools X
Water strata Depth: Fresh 200' ± feet; Salt N/A feet
Coal seam depths: N/A Is coal being mined in the area? no

OPEN FLOW DATA
Producing formation Devonian Shale Pay zone depth 4095' - 4385' feet
Gas: Initial open flow 70 Mcf/d Oil: Initial open flow 0 Bbl/d
Final open flow 20 Mcf/d Final open flow trace Bbl/d
Time of open flow between initial and final tests 72 hours

Static rock pressure 700 psig (surface measurement) after 24 hours shut in
(If applicable due to multiple completion--)

Second producing formation Pay zone depth feet
Gas: Initial open flow Mcf/d Oil: Initial open flow Bbl/d
Final open flow Mcf/d Oil: Final open flow Bbl/d
Time of open flow between initial and final tests hours

Static rock pressure psig (surface measurement) after hours shut in

(Continue on reverse side)

PLEASE 1313

RECEIVED
NOV 18 2015
Oil and Gas

NOV 18 2015

Department of
Environmental Protection

DETAILS OF PERFORATED INTERVALS, FRACTURING OR STIMULATING, PHYSICAL CHANGE, ETC.

Perforations: 4095, 96, 97, 4126, 27, 28, 4266, 67, 68, 4382, 83, 84, 85
86

14 holes .39 diameter, select-fire

Stimulation: 1 mm scf nitrogen
250 gals treated HCL ISIP = 2520 psi
8 perfballs (7/8") 5 min SIP = 2290 psi
Average treating rate = 48mscf/min.

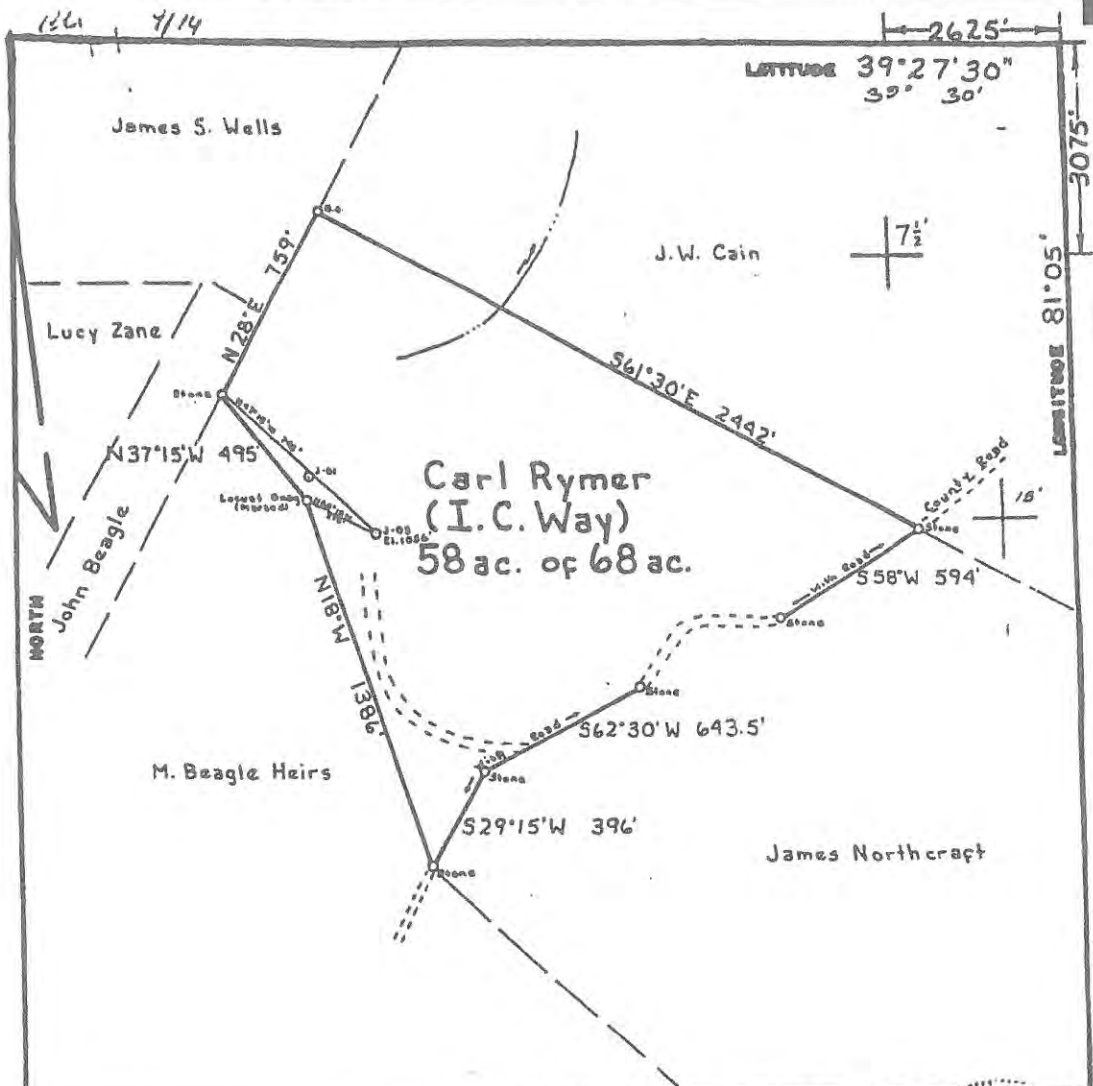
WELL LOG

FORMATION	COLOR	HARD OR SOFT	TOP FEET	BOTTOM FEET	REMARKS Including indication of all fres and salt water, coal, oil and ga
Surface hole			0	1350'	not logged
Siltstone, shale, Tr. Ss.			1350	1446	
Third Salt Sand			1446	1517	
Siltstone, shale, Tr. Ss			1517	1708	Maxton absent
Greenbriar Limestone			1708	1756	
Shale			1756	1762	
Keener Sandstone			1762	1794	
Shale			1794	1817	
Big Injun Sandstone			1817	1932	
Shale			1932	1954	
Squaw Sandstone			1954	1963	
Siltstone & Shale			1963	2305	
Organic Shale (Coffee Sh.)			2305	2325	
Berea Sandstone			2325	2327	No shows
Siltstone & shale			2327	3472	Shi show oil 2834' - 2843'
Organic Shale			3472	3512	Top lower Huron Shale
Siltstone & Shale			3512	T.D.	Show oil @ 3960' Show gas @ 4384' - 4400' Show gas @ 4490'
					Driller's T.D. 4605' Logger's T.D. 4568'

(Attach separate sheets as necessary)

Ben's Run Oil Co.
Well Operator
By: John H. Davis
Date: 2/26/86
NOV 18 2015
WV Department of
Environmental Protection

Note: Regulation 2.02(i) provides as follows:
"The term 'log' or 'well log' shall mean a systematic
detailed geological record of all formations, including
and, encountered in the log of a well."



FILE NO. _____
DRAWING NO. _____
SCALE 1" = 500'
MINIMUM DEGREE OF
ACCURACY 1:200
PROVEN SOURCE OF
ELEVATION Road Int. 1056'

I THE UNDERSIGNED, HEREBY CERTIFY
THAT THIS PLAT IS CORRECT TO THE
BEST OF MY KNOWLEDGE AND BELIEF AND
SHOWS ALL THE INFORMATION REQUIRED
BY LAW AND THE REGULATIONS ISSUED
AND PRESCRIBED BY THE DEPARTMENT OF
MINES.
(SIGNED) William R. Mason
R.P.E. _____ L.L.S. 551



(+) DENOTES LOCATION OF
WELL ON UNITED STATES
TOPOGRAPHIC MAPS
FORM IV-2
10-70



DATE 6 April 19 81
OPERATOR'S WELL NO. 103
API WELL NO. 47-073 1313-Frac.
STATE West Virginia COUNTY Pleasants PERMIT

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

RECEIVED
Office of Oil and Gas

WELL TYPE: OIL ☒ GAS ☒ LIQUID INJECTION ☐ WASTE DISPOSAL ☐
(IF "GAS", PRODUCTION ☐ STORAGE ☐ DEEP ☐ SHALLOW ☐
LOCATION: ELEVATION 1056' WATER SHED Bens Run
DISTRICT Union COUNTY Pleasants
QUADRANGLE Bens Run, W.Va. 7 1/2' Quad.
SURFACE OWNER Carl Rymer (I.C. Way) ACREAGE 58
OIL & GAS ROYALTY OWNER Carl Rymer (I.C. Way) LEASE ACREAGE 68
LEASE NO. _____
PROPOSED WORK: DRILL ☒ CONVERT ☐ DRILL DEEPER ☐ REDRILL ☐ FRACTURE OR
STIMULATE ☐ PLUG OFF OLD FORMATION ☐ PERFORATE NEW
FORMATION ☐ OTHER PHYSICAL CHANGE IN WELL (SPECIFY) _____

PLUG AND ABANDON ☐ CLEAN OUT AND REPLUS ☐
TARGET FORMATION Shale ESTIMATED DEPTH 5999'
WELL OF ADDRESS Bens Run Oil Company DESIGNATED AGENT James A. Renner
Box 140- Bens Run, WVa 26135 ADDRESS Box 106
Bens Run, W.Va. 26135

RECEIVED

IV-27
11/23/81

AUG 12 1983



OIL & GAS DIVISION STATE OF WEST VIRGINIA
DEPT. OF MINES DEPARTMENT OF MINES

Date: August 11 1983
Well No: 1503
API NO: 47-073 1313
State County Permit

Oil and Gas Division
NOTICE OF VIOLATION

WELL TYPE: Oil ☒ / Gas ☒ Liquid Injection ☐ / Waste Disposal ☐
Of "Gas" - Production ☒ / Storage ☐ / Deep ☐ / Shallow ☒
LOCATION: Elevation: 1056 Watershed: Bens Run
District: union County: Pleasants Quadrangle: Bens Run
WELL OPERATOR James A. Renner, OGC DESIGNATED AGENT James A. Renner
Address Box 106 Address Box 106
Bens Run W. Va. 26135 Bens Run W. Va.

The above well is being posted this 11 day of August, 1983, for a violation of Code 22-4-12B and/or Regulation 22-4-7.05, set forth in detail as follows:

(USE REVERSE SIDE OF THIS NOTICE IF NECESSARY)

Failure to Re Claim well site within 6 months
after completion of Drilling
Failure to Identify well by API number
Failure to File Form IV 35 well Record within
90 Days after completion of Drilling

A copy of this notice has been posted at the well site and sent by certified or registered mail to the indicated well operator or his designated agent.

You are hereby granted until August 18, 1983, to abate this violation.

Failure to abate the violation may result in action by the Department under Code 22-4-17 or Code 22-4-18.

Robert A. Lowther
Oil and Gas Inspector

Address middlebourne
W. Va. 26144

Telephone: 758-4764

RECEIVED

NOV 18 2015

WV Department of
Environmental Protection

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

WELL RECORD

Permit No. 84-171Oil or Gas Well.....*dry*.....
(KIND)

Company.....	W. and W. of Deane	Casing and Tubing	Used in Drilling	Left in Well	Packers
Address.....	Rfd. # 3 - Parkersburg	Size			
Farm.....	Cassie M. Dye Acres	16.....			Kind of Packer.....
Location (waters).....		13.....			
Well No.....	5 Elev. 945'	10.....		20'	Size of.....
District.....	Washington County Pleasant	8 1/4.....		100'	
The surface of tract is owned in fee by.....	Cassie M. Dye	6%.....		470'	Depth set.....
Address.....	St. Marys, W. Va.	5 3/16.....			
Mineral rights are owned by.....	Cassie M. Dye	3.....			Perf. top.....
Address.....		2.....			Perf. bottom.....
Drilling commenced.....	April 1940	Liners Used.....			Perf. top.....
Drilling completed.....	Aug July 35, 1940				Perf. bottom.....
Date shot.....	Depth of shot.....				
Open Flow.....	/10ths Water in.....				
.....	/10ths Merc. in.....				
Volume.....					
Rock Pressure.....	lbs.....				
Oil.....					
Fresh water.....	feet.....				
Salt water.....	1180' feet.....				

One to 92.7. 10" casing set

Formation	Color	Hard or Soft

One to 20', 10" Conductor.
Sand rock 20' - 34' 5".
Shale 34' - 90' 1/2. water!
Red rock 90' - 140'. { 100' 1/2. 8" casing
Shale 140' - 163'.
Red rock 163' - 285'.
Shale 285' - 470 top casing run
6" casing on top casing run?
Sand 470 - 505'
Slate 505 - 640'
Sand 640 - 652'.
Slate 652 - 840'
Salt sand 840 - 892.
Shale 892 - 1024
Marine sand 1024 - 1040 }
Slate 1040 - 1124'
Sand 1124 - 1150'.
Slate 1150 - 1208' top of sand
Sand 1208 - 1264'. Total depth



STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

WELL RECORD

Permit No. 2085-208

Oil or Gas Well

(KIND)

Company	Don E. White and Others			Casing and Tubing	Used in Drilling	Left in Well	Packers
Address	Raven Rock, West Va.			Size			
Farm	O.S. Buchanan and Golda DeLong			16			Kind of Packer
Location (waters)	Walnut hill			13			
Well No.	2	Elev.	875	10	18	none	Size of
District	Union	County	Pleasants	8 1/2	185	none	
The surface of tract is owned in fee by	O.S. Buchanan and Golda DeLong			6%	880	880	Depth set
Address	Bens Run, W. Va.			5 3/16			
Mineral rights are owned by	Same			2		1885	Perf. top 1870
Address				2			Perf. bottom 1873
Drilling commenced	Nov. 15, 1944			Liners Used			Perf. top
Drilling completed	Jan 10, 1945						Perf. bottom
Date Shot	Feb. 15th. From 1865 To 1860						
With	200 lbs Gelatin						
Open Flow	/10ths Water in						
	/10ths Merc. in						
Volume	25,000 estimated						
Rock Pressure	400 lb.	lbs.	48				
Oil	1 1/2	bbls., 1st 24 hrs.					
Fresh water	90	feet					
Salt water	1135	feet					

CASING CEMENTED SIZE No. Ft. Date
No coal encountered

COAL WAS ENCOUNTERED AT FEET INCHES
FEET INCHES FEET INCHES
FEET INCHES FEET INCHES

Formation	Color	Hard or Soft	Top	Bottom	Oil, Gas or Water	Depth Found	Remarks
Surface	to 25ft.						
Sand	Grey	soft	25	90			
Limeyslate	grey	solid	90	105			
Slate	blue	soft	105	125			
R. Rock	red	med.	125	175			
Lime	grey	solid	175	190			
sand	grey	"	190	222			
R. Rock	red	Med	222	225			
sand	grey	hard	225	291			
limey	red	solid	291	305			
shelly	grey	"	305	335			
limey	pink	"	335	385			
R. Rock	red	soft	385	442			
lime	light	hard	442	453			
slate	black	soft	453	480			
slate	white	medium	480	550			
R. Rock	red	Med.	550	590			
R. Rock	red (CAVE)	soft	590	660			
W. Slate	white	med.	660	695			
slate	blue	med	695	705			
sand	grey	med	705	735			
shelly	"	"	735	743			
slate	black	"	743	758			
P. Rock	pink	soft	758	787			
slate	white	med.	787	807			
slate	black	med.	807	820			
slate	white	Med.	820	840			
slate	black (SOFT CAVE)	"	840	860			
R. Rock	red	"	860	875			
limey	light	solid	875	880			
slate	white	med.	880	915			
slate	black	med	915	966			
rock	red	med	966	978			
slat	white	med	978	1030			

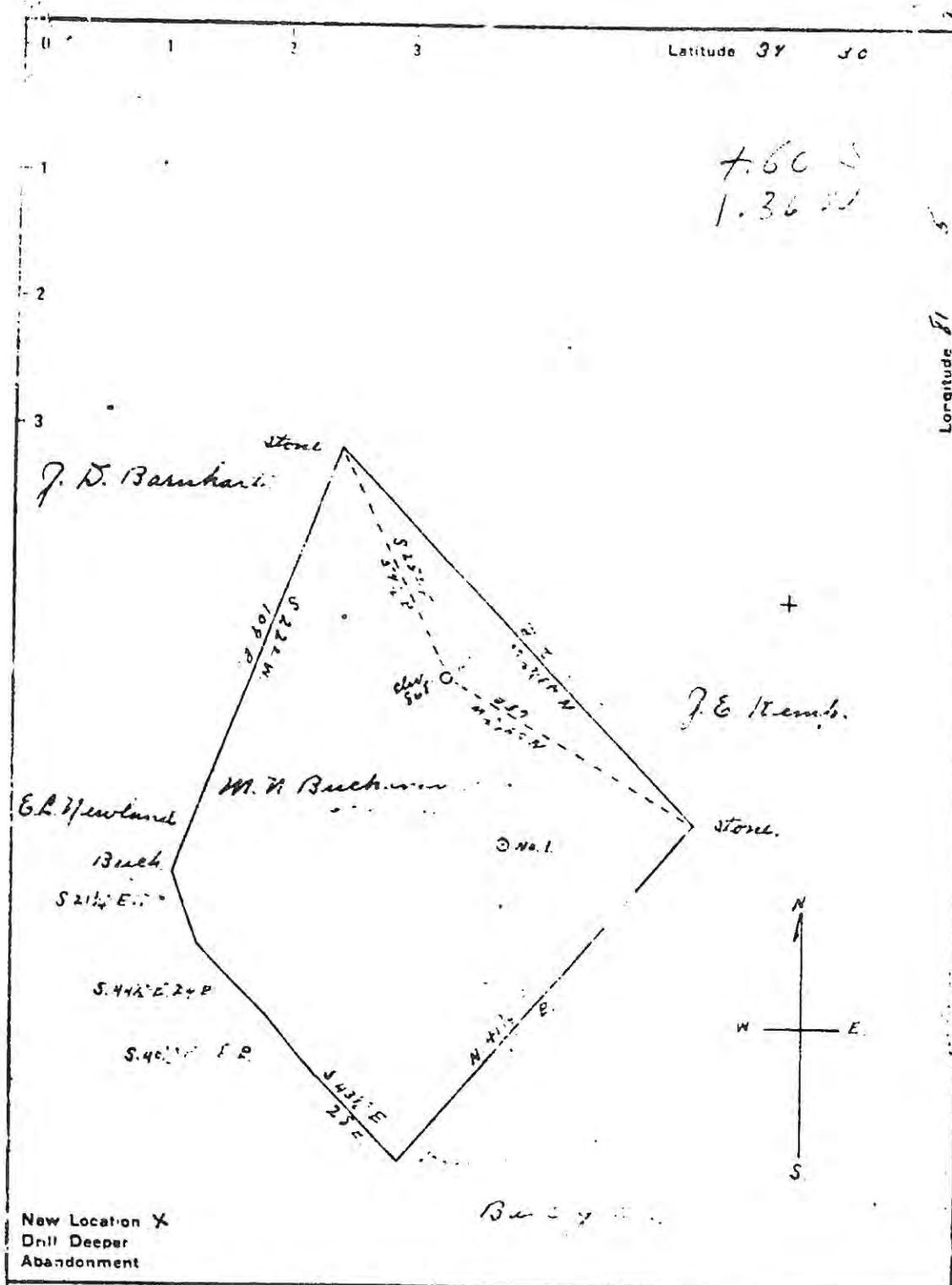
(Over)

Formation	Color	Hard or Soft	Top	Bottom	Oil, Gas or Water	Depth Found	Remarks
slate	brown	med.	1030	1070			
slate	white	light	1070	1095			
sand	grey	med.	1095	1158			
slate	black	med	1158	1210			
slate	brown	med	1210	1242			
sand	light	med	1242	1256			
slate	white	med	1256	1280			
slate	black	soft	1280	1300			
sand	grey	solid	1300	1325			
slate	black	med	1325	1380			
slate	brown	med	1380	1407			
sand	grey	med	1407	1464			
slate	black	med	1464	1490			
sand	grey	med	1490	1522			
shale	black	solid	1522	1544			
sand	grey	med	1544	1564			
slate	black	soft	1564	1609			
Lime	light	hard	1609	1668			
sand	blue	soft	1668	1730			
sand	grey	hard	1730	1885			
			Bottom hole 1885				last 30 ft of Injun sand turned very hard & white

Date Oct 11, 1947

APPROVED Low F. W. [Signature], Owner

By Parton
(Title)



New Location X
Drill Deeper
Abandonment

Company Don E. White & Son
 Address Raven Rock, W. Va.
 Farm M. H. Buchanan
 Tract _____ Acres 64 Lease No. _____
 Well (Farm) No. 2 Serial No. _____
 Elevation (Spot Level) 888
 Quadrangle St. Marys W. Va.
 County Pleasant District Ch. 11
 Engineer Geo. Triplett
 Engineer's Registration No. _____
 File No. _____ Drawing No. _____
 Date Dec. 1, 1944 Scale 30' = 1"

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION
CHARLESTON

WELL LOCATION MAP
FILE NO. PLEAS-228

+ Denotes location of well on United States Topographic Maps, scale 1 to 62,500, latitude and longitude lines being represented by border lines as shown.
 — Denotes one inch spaces on border line of original tracing.



STATE OF WEST VIRGINIA
DEPARTMENT OF MINES
OIL AND GAS DIVISION

WELL RECORD

Permit No. PLEAS-560-D

Oil or Gas Well Dry
(KIND)

Company SOUTH PENN NATURAL GAS COMPANY
Address P. O. Box 1280, Parkersburg, West Virginia
Farm Herman Stursberg Acres 120
Location (waters) French Creek
Well No. 11 - Drilled Deeper Elev 869.46
District Washington County Pleasants
The surface of tract is owned in fee by H. A. Carpenter
Address St. Marys, W. Va.
Mineral rights are owned by J. Franklin Carpenter
Address St. Marys, W. Va.
Deeper Drilling commenced Aug. 18, 1958
Deeper Drilling completed Sept. 15, 1958
Date Shot From To
With
Open Flow /10ths Water in Inch
/10ths Merc. in Inch
Volume 12,937 Cu. Ft.
Rock Pressure lbs. hrs.
Oil bbls., 1st 24 hrs.
Fresh water feet feet
Salt water feet feet

Casing and Tubing	Used in Drilling	Left in Well	Packers
Size			
16			Kind of Packer
18			
10			Size of
8 1/4	685'	685'	
6 1/4	1194-?	1194-?	Depth set
5 3/16			
3			Perf. top
2			Perf. bottom
Liners Used			Perf. top
			Perf. bottom

CASING CEMENTED SIZE No. Ft. Date

COAL WAS ENCOUNTERED AT NONE FEET INCHES
FEET INCHES FEET INCHES
FEET INCHES FEET INCHES

Formation	Color	Hard or Soft	Top	Bottom	Oil, Gas or Water	Depth Found	Remarks
Salt Sand			975	984			
TOTAL DEPTH				988 1/2			
Original drilling completed in year 1910							
COMMENCED DRILLING DEEPER				988 1/2			
Shale			988 1/2	998			
Lime			998	1003			
Shale			1003	1016			
Lime			1016	1032			
Sand			1032	1075			
Lime & Shale			1075	1120			
Shale (Black)			1120	1155			
Lime			1155	1163			
Shale			1163	1171			
Big Lime			1171	1186			
Big Injun			1186	1250			
Shale			1250	1257	Oil	1244-1250	3 Gal. per hour
Sand			1257	1410			
Shale			1410	1425	Gas Show	1264	
Sand			1425	1470			
Shale			1470	1510			
Sand			1510	1522			
Slate & Shells			1522	1900	Gas	1598	12,937 Cu. Ft.
TOTAL DEPTH				1900			



(Over)



RECEIVED

JUN 28 1974

OIL & GAS DIVISION
DEPT. OF MINES

39-30

STATE OF WEST VIRGINIA
DEPARTMENT OF MINES

4-31

Oil and Gas Division

WELL RECORD

Quadrangle St Marys
PLATS - 681
Permit No. 681

Rotary ☒ Oil ☒
Cable _____ Gas _____
Recycling _____ Comb. _____
Water Flood _____ Storage _____
Disposal _____ (Kind) _____

Company <u>Ma Duff Inc</u>	Casing and Tubing	Used in Drilling	Left in Well	Cement fill up Cu. ft. (Sks.)
Address <u>P.O. Box 12551 Nashville Tc 37212</u>	Size			
Farm <u>J. F. Carpenter</u> Acres <u>120</u>	20-16			
Location (waters) <u>French Creek / Ohio River</u>	Cond.			
Well No. _____ Elev. <u>681</u>	13-10"			
District <u>Washington</u> County <u>Pleasants</u>	9 5/8			
The surface of tract is owned in fee by <u>J. Franklin Carpenter</u>	8 5/8			
Address <u>400 Morgan Ave St Marys</u>	7	1463	1463	250'
Mineral rights are owned by <u>W. Va</u>	5 1/2			
Address <u>Same</u>	4 1/2	2413	2413	928'
Drilling Commenced <u>12-20-73</u>	3			
Drilling Completed <u>12-27-73</u>	2	2250	2250	--
Initial open flow _____ cu. ft. <u>7</u> bbls.	Liners Used			
Final production _____ cu. ft. per day <u>7</u> bbls.				
Well open _____ hrs. before test _____ RP.				

Well treatment details: 1600 bbls water, 30,000 lbs 20/40 sand
RDP 1600 PSI, AIR 18BPM, ATP 3100 PSI
1 SIP 1600, 1300 PSI 10 min -- Halliburton
Attach copy of cementing record. - Halliburton

Coal was encountered at _____ Feet _____ Inches
Fresh water _____ Feet _____ Salt Water _____ Feet _____
Producing Sand Ohio shale Depth 2254-2354

Formation	Color	Hard or Soft	Top Feet	Bottom Feet	Oil, Gas or Water	* Remarks
Sandstone			0	224		
Shale			224	456		
Sandstone			456	488		
Shale			488	652		
Sandstone			652	689		
Shale			689	746		
Sandstone			746	802		
Shale			802	892		
Sandstone			892	1238		
Shale/siltstone			1238	2418		

(over)

* Indicates Electric Log tops in the remarks section.

C. 7.5 minute topographic map showing one mile around well or facility

- a. Well location
- b. All known drinking wells
- c. Springs
- d. Surface water bodies

1. Map I shows a quarter mile and a one mile radius around the proposed well. (See Attached Map)

2. **Well Location:** Map I shows the location of the proposed disposal well.

3. **All known drinking wells:** Appalachian Oil Purchasers attempted to identify known water wells by contacting land owners directly. Thirty-four 34 fresh water wells were identified. There was 1 fresh water well within the ¼ mile Area of Review (No. 18).

The majority of the wells are reported not to be used for drinking water, whereas most homes were reported to be on a public water system.

4. **Springs:** Three springs were identified, one spring was within the ¼ mile Area of Review (No. 35)

5. **Surface Water Bodies:** French Creek was the nearest surface water body and was tested.

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

**IDENTIFICATION OF PUBLIC DRINKING WATER SOURCES WITHIN A ONE
MILE RADIUS OF THE BW #4 CLASS IID INJECTION WELL**

ALL Consulting initially contacted the Pleasants County Health & Human Services on September 16, 2015 in St. Marys, West Virginia to identify any public drinking water sources within a one-mile radius or complete the required WV DEP affidavit (see attached letter). On October 27, 2015, ALL Consulting received the attached letter from the Mid-Ohio Valley Health Department and they have informed ALL Consulting that the city of Belmont, West Virginia has their own public water wells. On October 30, 2015, ALL Consulting sent another letter with attached map to the City of Belmont, Belmont City Water Department requesting the identification of any public drinking water sources within the one-mile radius of the BW#4 Class IID injection well. On November 6, 2015, Tom Tomastik of ALL Consulting had a phone conversation with Mr. Bobby Dolson (304) 665-2011 of the Belmont Water Plant and Mr. Dolson did identify two of the City of Belmont public water wells on the one-mile radius map. One of the City of Belmont water wells in on the one-mile line and the second well just inside the one-mile radius line to the northeast of the BW#4 Class IID injection well (see yellow highlighted area on the BW#4 Water Wells Map).

What is also of relevance, is the attached Belmont Water Works map which shows that the location of the BW#4 Class IID injection well is outside of the Source Water Protection Area for the City of Belmont, West Virginia municipal water well field.

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

September 16, 2015

PN 1546

Pleasants County Health & Human Services
Public Health Department
201 2nd Street
St. Marys, WV 26170

Subject: Public Service District Affidavit requirement for WV DEP

To whom it may concern:

On behalf of our client, Appalachian Oil Purchasers, Inc., I am enclosing an affidavit required by WV DEP. This affidavit is to be filled out and notarized by the local county health department attesting to the fact that no publically recorded drinking water sources are within a one mile radius of the existing Class II D injection well facility operated by Appalachian Oil Purchasers, Inc. in Pleasants County, West Virginia. Also enclosed is a map showing the one-mile radius around the existing injection well.

Please complete the enclosed affidavit and return to my attention at the Ohio address listed below. Thank you for your cooperation and assistance in this matter.

Sincerely,



Tom Tomastik, Senior Geologist and Regulatory Specialist
ALL Consulting
10811 Keller Pines Court
Galena, Ohio 43021

Cc: File

Enclosure

RECEIVED
Office of Oil and Gas
NOV 18 2015

WV Department of
Environmental Protection

APPENDIX D

Public Service District Affidavit

Underground Injection Control Permit applicants must identify all publically recorded drinking water sources within a one (1) mile radius of the proposed injection well facility. If no drinking water sources are present within this radius a written affidavit shall be supplied by the local Public Service District (PSD) as ample verification.

"I certify under penalty of law that (state name of business)

Appalachian Oil Purchasers, Inc.

has verified with the public service district (state name of PSD)

that there are no such publically recorded sources.

(Signature of Authorized Representative)

Sworn and subscribed to before me this _____ day of _____, 20____.

_____, my commission expires _____

(Notary Signature)

_____.

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

Public Service Districts

About PSDs

Public service districts or "PSDs" are public corporations established by county commissions with approval of the West Virginia Public Service Commission. These local entities manage the development and maintenance of water, sewage and gas systems covering areas specified by the county commission. They were authorized by the Legislature to help extend services to rural areas and allow municipal water and sewage systems to become more efficient by sharing services and resources with surrounding areas.

Lists of Districts and Members

West Virginia law required each county commission to file annually a list of the names of the public service districts within their respective counties, and names of the current members of each PSD board with the Secretary of State. The filing is due no later than July 1 of each year.

PSD List by County

The list of names of public service districts currently available includes PSDs filed in previous years or updated this year. Members names are not included in the data, but are available for public inspection or copying on the original filings.

Click the icon to view the listing of public service district names arranged by county in Acrobat Reader format. For help with the Reader, go to [Acrobat Reader Help](#).



Related Laws

The requirement for this filings is specified in [West Virginia Code](#). Some sections related to the authority to administer oaths are also included here. To search other parts of the Code, visit the Legislature's web site and select [WV Code](#).

Requesting Information and Copies of County Lists of PSDs

These documents are public information and copies may be ordered. To order a copy, please specify the county or counties for which you want a copy of the entire list.

To request information by e-mail about these filings, click the icon.



To order copies or certified copies on-line, click the icon.



[Executive Records Main Page](#)

[Executive Records Services](#)

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

County	Public Service District	Date Filed
Monongali	Laurel Point Public Service District	06/15/1998
Monongali	Dorsey Knob Public Service District	06/15/1998
Monongali	Cheat View Public Service District	06/15/1998
Monongali	Cheat Neck Public Service District	06/15/1998
Monongali	Canyon Public Service District	06/15/1998
Monongali	Deckers Creek Public Service District	06/15/1998
Monroe		
Morgan	Warm Springs Public Service District	05/22/1998
Nicholas	Nettie Leivasy Public Service District	07/05/2001
Nicholas	Fenwick Mountain Public Service District	07/05/2001
Nicholas	Wilderness Public Service District	07/05/2001
Nicholas	Craigsville Public Service District	07/05/2001
Nicholas	Birch River Public Service District	07/05/2001
Ohio	Ohio County Public Service District	05/20/1998
Pendleton	Pendleton County Public Service District	06/26/1998
Pleasants	None	07/03/2000
Pocahontas		
Preston	PSD No. 1	06/08/1998
Preston	PSD No. 2	06/08/1998
Preston	PSD No. 4	06/08/1998
Preston	Bruceton-Brandonville	06/08/1998
Putnam	North Putnam Public Service District	02/01/2000
Putnam	South Putnam Public Service District	02/01/2000

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection



Mid-Ohio Valley Health Department

605 Cherry Street

St Marys, WV 26170

Phone: 304-684-2461 Fax: 304-684-2845

October 27, 2015

Tom Tomastik
ALL Consulting
10811 Keller Pines Court
Galena, Ohio 43021

Re: Public Service District Affidavit requirement for WV DEP

Dear Mr. Tomastik,

I received your letter and the Appendix D Public Service District Affidavit regarding publically recorded drinking water sources within one mile of the Appalachian Oil Purchasers Class II D injection well near Belmont, WV. I was able to locate the Pleasants County Public Service District office. Their address is:

Pleasants County Public Service District
40 Vaughn Road
St. Marys, WV 26170

Phone: 304-684-9942

I spoke with them and their district does not include the public water wells in Belmont, WV. I found a report in my office files for Belmont Water, PWSID WV 3303701, Pleasants County. I have enclosed two pages from that report that may indicate that the city of Belmont has two water wells that provide water to the City of Belmont that are located within one mile of the Class II D injection well. Please contact the City of Belmont for information on these drinking water sources. Their address is:

City of Belmont
PO Box 375
Belmont, WV 26134

Sincerely,

Chuck Mapes, R.S.

cc: City of Belmont

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

Source of Your Drinking Water - Hydrogeologic Setting

Well Names	Geologic Setting/Sensitivity
Well 1	Alluvial Valley Unconfined - High Sensitivity
Well 2	Alluvial Valley Unconfined - High Sensitivity

The Belmont Water Works water system serves a population of approximately 1,035 people. The supply is from two wells. The wells are pumped to provide an average daily production of about 179,580 gallons per day.

The estimated land area (approximately 398 acres) that contributes water to the wells is depicted in the attached map as the Source Water Protection Area (SWPA). The delineation was completed by the WVBPH using hydrogeological calculations based on available data. The Alluvial Valley areas consist of geologically recent flood plains of larger rivers. These flood plains contain unconfined, fine to coarse-grained slightly silty alluvium.

Physical Integrity of wells

Well Names	Source Integrity
Well 1	Unknown Construction
Well 2	Unknown Construction

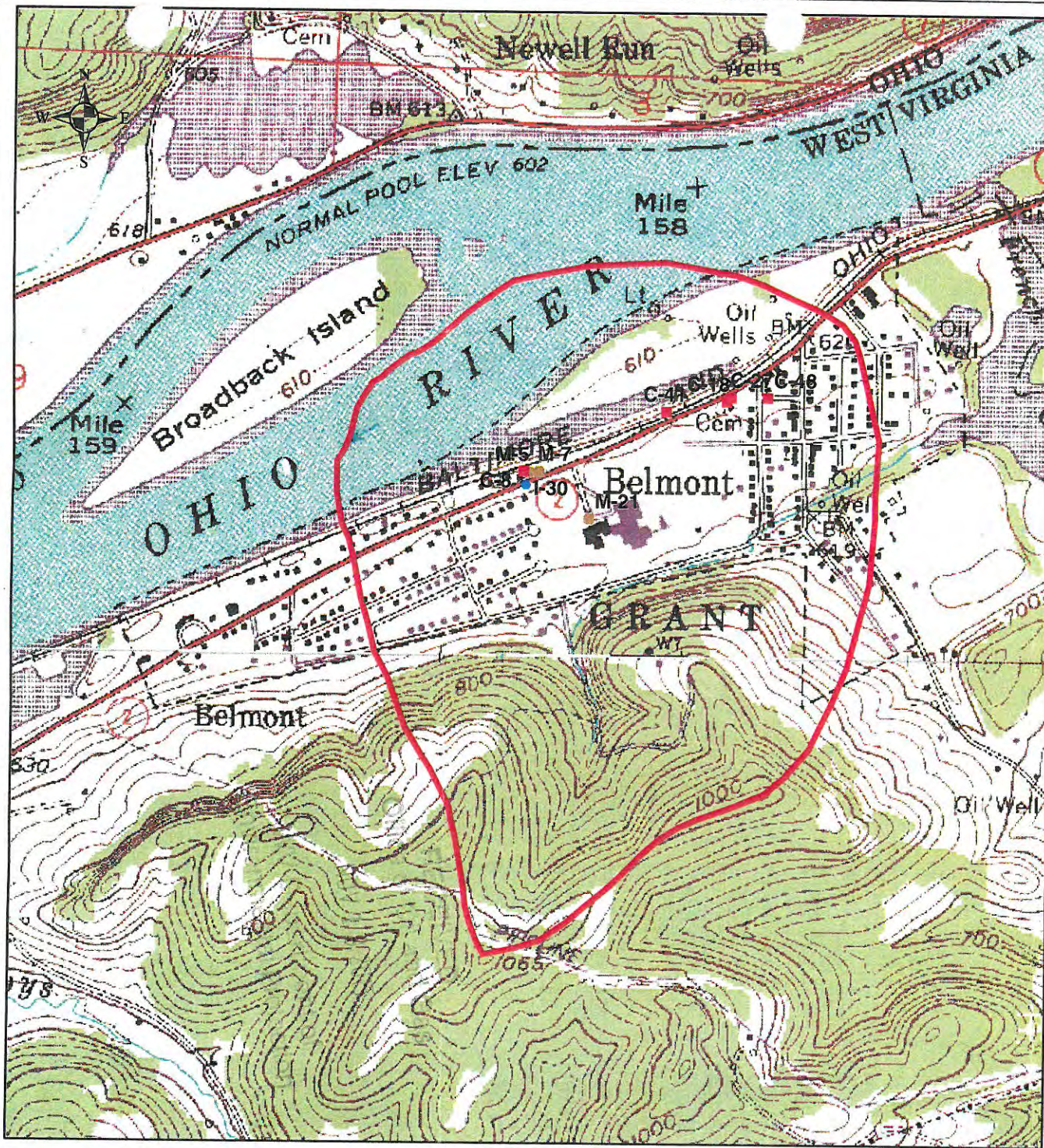
Wells may vary in their construction characteristics and in the geologic rock types in which they occur. The lack of an effective grout and sanitary seals are avenues by which contaminants from nearby surface water bodies or overland runoff can percolate to wells. It is unknown if these wells were constructed to standards using pressure grouting in order to prevent the entrance of surface water. The State has determined that these wells are NOT GWUDI or Ground Water Under the Direct Influence of surface water.

Water Quality and Water Treatment Information

Well Names	Results
Well 1	Meets standards
Well 2	Meets standards

This assessment evaluates contaminants that may enter the water drawn directly from the wells. The contaminants addressed in this assessment include those regulated under the Safe Drinking Water Act as well as those the BPH has determined may present a concern to public health. The water withdrawn from the wells is currently disinfected prior to distribution. Periodic analysis for a variety of bacterial, organic, nitrate, synthetic and inorganic contaminants in the water after treatment have consistently yielded values below the maximum contaminant level (MCL) as

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection



Map Key

Potential Contaminant Sources

- Agriculture
- Commercial
- Industrial
- Municipal
- Residential
- Source Water Protection Area

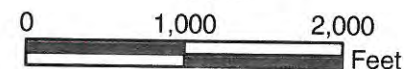


This map is provided as a public service by the West Virginia Bureau for Public Health. The Bureau makes NO representation regarding completeness or accuracy of the data hereon. Efforts are made to verify and update the data used to generate this map. However, with data sets of this size and nature, eliminating all errors is difficult. Thus, the user assumes total responsibility for verification.

Source locations not included for reasons of security

Belmont Water Works WV3303701 Pleasants County

Scale: 1:14,000
Drawn by: ACS
12/17/03



October 30, 2015

PN 1546

City of Belmont
Attn: Belmont City Water Plant
P.O. Box 375
Belmont, WV 26134

Subject: Public Service District Affidavit requirement for WV DEP

To whom it may concern:

On behalf of our client, Appalachian Oil Purchasers, Inc., I am enclosing an affidavit required by WV DEP. This affidavit is to be filled out and notarized by the local county health department attesting to the fact that no publically recorded drinking water sources are within a one mile radius of the existing Class II D injection well facility operated by Appalachian Oil Purchasers, Inc. in Pleasants County, West Virginia. Also enclosed is a map showing the one-mile radius around the existing injection well and the location of the injection well on a satellite image map.

Initially, my request went to the Mid-Ohio Valley Health Department in St. Marys, West Virginia and they have recently informed me that the City of Belmont may have public water wells within one mile of this existing Class II injection well. Please let me know if any of your water wells is within one mile of the Class II injection well and send me a map showing the location of those water wells. If the City of Belmont's water wells are not within one mile radius, please complete the enclosed affidavit and return to my attention at the Ohio address listed below. Thank you for your cooperation and assistance in this matter.

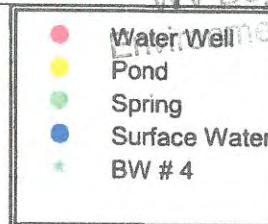
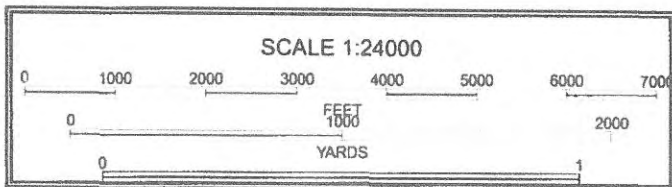
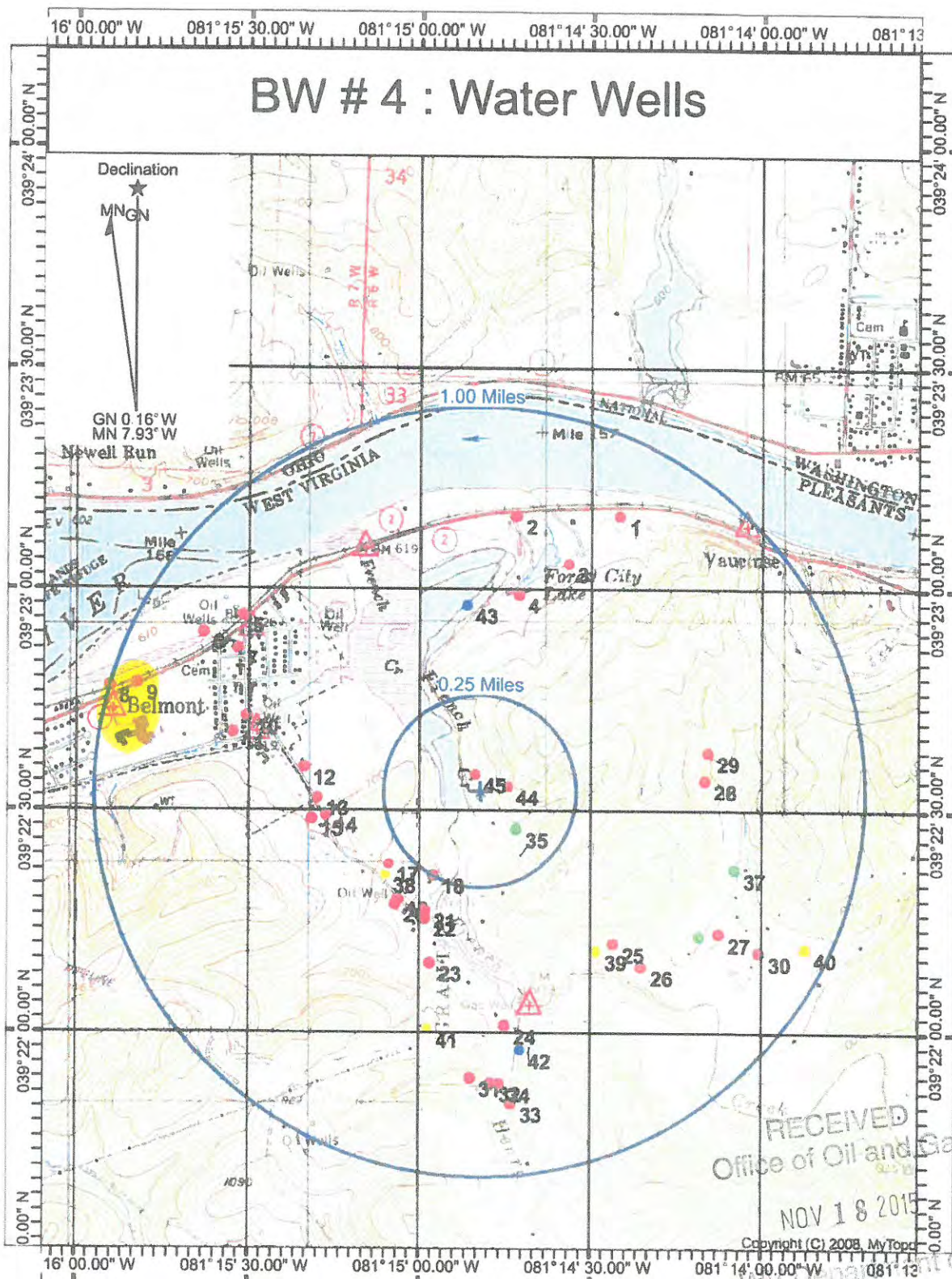
Sincerely,



Tom Tomastik, Senior Geologist and Regulatory Specialist
ALL Consulting
10811 Keller Pines Court
Galena, Ohio 43021

Cc: File
Enclosure

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection



Water Well Data

Well ID	Lat (N)	Long(W)	Depth	Quality	Used	Comments
1 USGS Well 10	39°23'10"	81°14'25"	unknown	n/a	No	
2 USGS Well 9	39°23'10.06"	81°14'49.09"	unknown	n/a	No	
3 Abbott House	39°23'03.61"	81°14'33.98"	unknown	n/a	No	water analysis
4 Abbott Barn	39°22'59.37"	81°14'42.62"	unknown	n/a	Yes	water analysis used for pond water
5 USGS Well 5	39°22'56.51"	81°15'31.05"	unknown	n/a	No	
6 USGS Well 4	39°22'54.27"	81°15'37.90"	unknown	n/a	No	
7 USGS Well 6	39°22'52"	81°18'32"	unknown	n/a	No	
8 USGS Well 1	39°22'46.86"	81°15'54.17"	unknown	clean	Yes	
9 USGS Well 2	39°22'47.31"	81°15'49.38"	unknown	clean	Yes	
10 House # 319 Well	39°22'42.11"	81°15'30.52"	unknown	n/a	No	
11 USGS Well 3	39°22'40.60"	81°15'32.80"	unknown	n/a	No	
12 Mrk 013	39°22'35.92"	81°15'20.35"	unknown	n/a	No	
13 Mrk 014	39°22'31.75"	81°15'17.98"	unknown	n/a	No	
14 Mrk 015	39°22'29.46"	81°15'16.47"	unknown	n/a	No	
15 USGS Well 7	39°22'29"	81°15'19"	unknown	n/a	No	
17 Arnott Well	39°22'22.84"	81°15'05.45"	unknown	dirty	Yes	used for pond water
* 18 J. Malone Well	39°22'21.23"	81°14'57.60"	unknown	n/a	No	water analysis
19 K. Malone Well	39°22'18.09"	81°15'03.82"	unknown	n/a	No	
20 K. Malone Well	39°22'17.38"	81°15'05.30"	unknown	n/a	No	
21 Brown Well	39°22'16.53"	81°14'59.04"	unknown	n/a	No	
22 Brown Well	39°22'15.37"	81°14'59.05"	unknown	n/a	No	
23 Pinkerton Well	39°22'09.45"	81°14'58.19"	unknown	clean	Yes	hand pump used
24 USGS Well 8	39°22'01"	81°14'45"	unknown	n/a	No	
25 Colvin Well	39°22'12.09"	81°14'26.09"	unknown	dirty	No	used to wash cars
26 Colvin Well	39°22'08.99"	81°14'21.17"	unknown	n/a	No	
27 Davies Well	39°22'14.38"	81°14'07.54"	unknown	n/a	No	
28 RLC Well	39°22'34.18"	81°14'09.99"	unknown	n/a	No	
29 RLC Well 2	39°22'37.96"	81°14'09.44"	unknown	n/a	No	
30 Berry Well	39°22'10.90"	81°14'00.45"	unknown	clean	Yes	
31 Mrk 019	39°21'53.86"	81°14'51.02"	unknown	n/a	No	
32 Holmes Well	39°21'53.21"	81°14'47.51"	unknown	n/a	No	
33 Blouir Well	39°21'50.53"	81°14'43.87"	unknown	n/a	No	
34 Holmes Well	39°21'53.20"	81°14'46.12"	unknown	clean	No	

Spring Water Data (same map)

Spring ID	Lat (N)	Long(W)	Depth	Quality	Used	Comments
35 UTI Spring	39°22'27.14"	81°14'43.10"	unknown	n/a	No	water analysis
36 Davies Spring	39°22'13.06"	81°14'11.03"	unknown	n/a	No	
37 Owens Spring	39°22'22.14"	81°14'04.80"	unknown	n/a	Yes	used for washing purposes

Pond Water Data (same map)

Pond ID	Lat (N)	Long(W)	Depth	Quality	Used	Comments
38 Arnott Pond	39°22'22.84"	81°15'04.17"	unknown	n/a	No	water analysis, well is used to fill pond
39 Colvin Pond	39°22'11.10"	81°14'29.18"	unknown	n/a	No	well is used to fill pond
40 Pond 1	39°22'11.48"	81°13'52.48"	unknown	n/a	No	
41 Pond 2	39°22'00.44"	81°14'58.59"	unknown	n/a	No	

Stream Data(same map)

Stream ID	Lat (N)	Long(W)	Depth	Quality	Used	Comments
42 Henry Cp Run	39°22'57.74"	81°14'42.34"	unknown	n/a	No	
43 French Creek	39°22'57.88"	81°14'51.73"	unknown	n/a	No	water analysis

Monitoring Wells (same map)

Well ID	Lat (N)	Long(W)	Depth	Quality	Used	Comments
* 44 Monitoring A	39°22'34.93"	81°14'50.29"	TBD	n/a	No	water analysis
* 45 Monitoring B	39°22'34.93"	81°14'50.29"	TBD	n/a	No	water analysis

Depth of the certain wells are mostly unknown but from talking to the landowners they range from a depth of 30ft to 100ft

Nathan Eschbaugh
WVOG
neschbaugh@wvog-aop.com
740-624-7147

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

APPENDIX E

Water Sources

Operator: Appalachian Oil Purchasers, LLC Year 2016 UIC Permit # UIC2D0732523

Water Source Name		Source # 1	Source # 2	Source # 3	Source #
		Malone Water Well (Location #18)	Monitoring Well #1 (Location #44)	Monitoring Well #2 (Location #45)	
Northing	4358508.86	4358151.37	4358571.09	4358424.94	
Easting	478743.08	478523.46	478729.73	478767.14	
Parameter	Units	Date Sampled = 04/06/2016	Date Sampled = 04/06/2016	Date Sampled = 04/06/2016	
TPH - GRO	mg/L	Not detected	Not detected	Not detected	
TPH - DRO	mg/L	Not detected	Not detected	Not detected	
TPH - ORO	mg/L	0.617	Not detected	Not detected	
BTEX	mg/L	Not detected	Not detected	Not detected	
Chloride	mg/L	41.5	16.9	145	
Sodium	mg/L	NA	NA	NA	
Total Dissolved Solids (TDS)	mg/L	424	368	762	
Aluminum	mg/L	0.219	0.573	Not detected	
Arsenic	mg/L	Not detected	Not detected	Not detected	
Barium	mg/L	0.422	0.0830	0.0961	
Iron	mg/L	2.25	Not detected	Not detected	
Manganese	mg/L	0.150	Not detected	0.0275	
pH	SU	8.02	8.33	8.0	
Calcium	mg/L	58.8	29.7	79.8	
Sulfate	mg/L	16.2	60.1	97.5	
MBAS	mg/L	NA	NA	NA	
Dissolved Methane	mg/L	1.33	Not detected	0.09330	
Dissolved Ethane	mg/L	0.00594	0.0107	0.0136	
Dissolved Butane	mg/L	Not detected	Not detected	Not detected	
Dissolved Propane	mg/L	Not detected	Not detected	Not detected	
Bacteria (Total Coliform)	c/100m L	Not detected	Not detected	Not detected	

Page ___ of ___

Promoting a healthy environment



D. Analysis for all water wells within ¼ mile radius

Ph, TDS, Iron, Manganese, Chlorides, Sodium, and Barium

There is one water well (Malone well No 18) within the ¼ mile radius. Mr. Malone indicated that the well could be used as a monitoring well as necessary.

Thirty four fresh water wells were identified in a one mile area. Most wells were not used as a fresh water source. Very little or no information was available about the date of construction, time of drilling, seasonal variations, or yield for the thirty four wells. Most owners indicated that the water was a very poor quality.

Five fresh water sources were tested as summarized below. All water analysis were performed by Microbac. Microbac is located at 158 Starlite Drive, Marietta, Ohio, phone number 740-373-4071. All results are in mg/l except for pH.

A 1984 study entitled "Ground-Water Hydrology of the Minor Tributary Basins of the Ohio River, West Virginia" was referenced as a general hydrology study of the area. A copy of selected chemical analysis from this study has been included.

Barium ranged from 0.056 to 0.303 mg/l. Iron ranged from 0.405 to 16.300 mg/l. Magnesium (Mg) ranged from 0.066 to 0.686 mg/l. Sodium (Na) ranged from 15.1 to 106.0 mg/l. Ph ranged from 6.66 to 8.56. Total dissolved solids ranged from 210 to 438 mg/l. Chlorides (Cl) ranged from 26.0 to 33.2 mg/l.

Table I - Summary of Fresh Water Testing

	Test Date	Barium	Iron	Mg	Na	pH	TDS	Cl
French Creek	06/01/2010	0.056	0.405	0.194	19.9	8.56	210	27.1
Spring	07/02/2010	0.109	0.484	0.016	33.4	7.50	424	32.3
Malone Well	06/25/2010	0.378	0.683	0.066	106.0	7.38	424	48.8
Abicht house	06/23/2010	0.329	16.300	0.686	39.4	6.66	438	26.0
Abicht barn	06/23/2010	0.303	11.800	0.267	15.1	6.65	288	33.2

A well outside the quarter mile area of review owned by Mr. Greg Arnott has recently permitted sampling of his fresh water well. The results of the sampling will be provided and the Table below updated to reflect the sampling analysis. A letter has also been included regarding contact with Mr. Arnott which expressed his willingness to work with Appalachian Oil Purchasers regarding the testing.

A ground water monitoring plan has been developed. The plan is provided at the back of the application.

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

Date: 07/13/2010

Re: Fresh Water Well Testing
Mr. Greg Arnott Meeting

About 5:00 yesterday (07/12/2010) I had a chance to speak with Mr. Greg Arnott.

I gave to him a paper including the data for all of the testing that will be done to his pond and well, and a map of the well site. He seemed like whatever we had to do was fine with him including sampling. Mr. Arnott proceeded to show me the pond and the well beside it that was covered by a truck topper.

Mr. Arnott told me that he believed there were five wells on the property, one by the pond, another marked by the orange spray paint on top of the casing in the field and the others sort of uncertain. One down over the hill to the right and two to the left, one was plugged and the other two were not. He said that the reason he knows that they are there is because he hit them with the brush hog.

Mr. Arnott also referred me across the street to Kenny Malone who he said knew more about the area than he did. Mr. Arnott told me to come back whenever and get the coordinates to the other wells, and seemed pretty easy to get along with. He said to call if I needed anything. I am working currently on retrieving the coordinates for the other wells. Testing of the pond and the well is taking place right now.

Nathan Eschbaugh
WVOG
neschbaugh@wvog-aop.com
740-624-7147

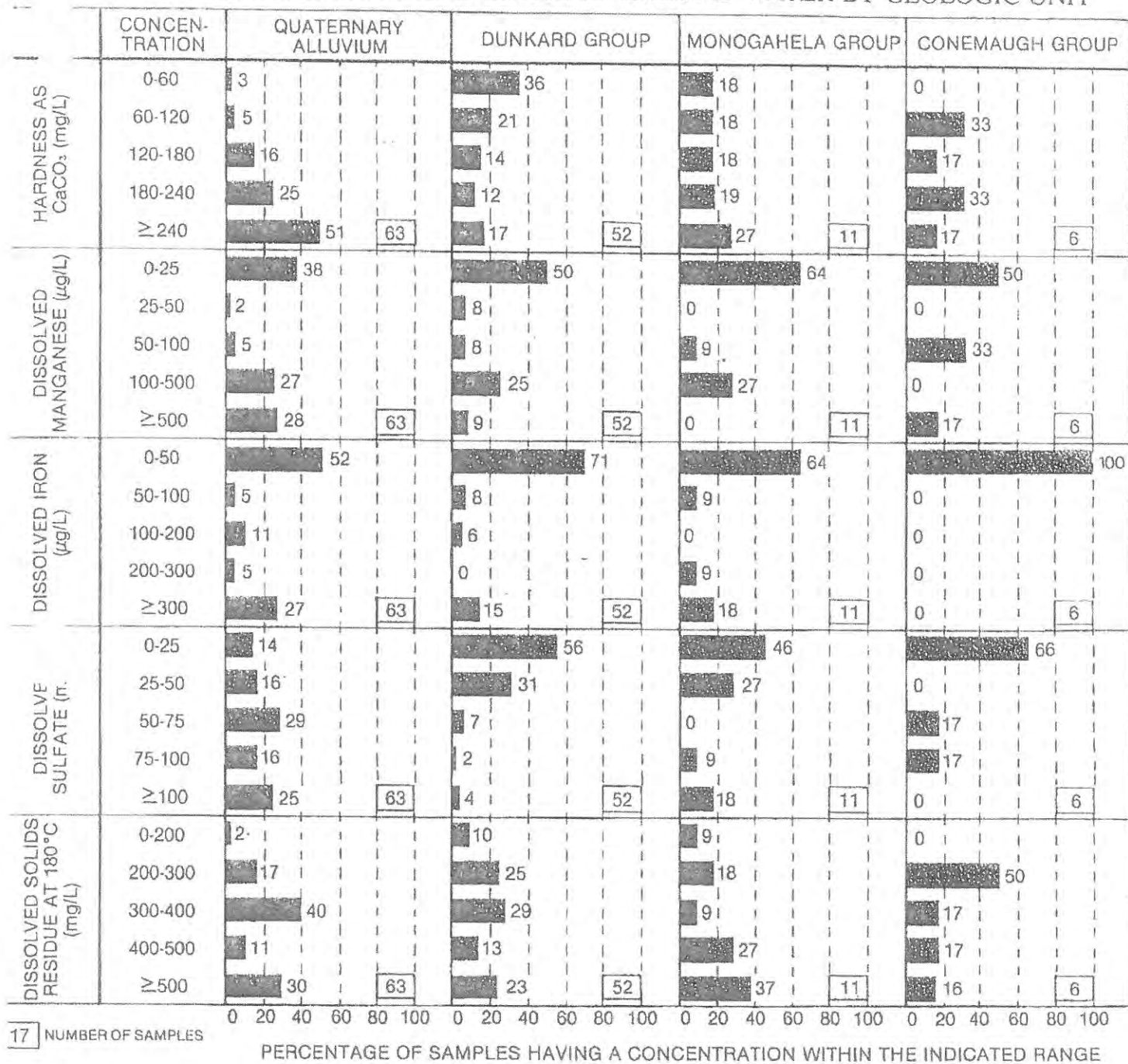
RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

Well depth (m feet)		Specific conductance (μ mho/cm at 25°C)	pH (units)	Hardness as CaCO ₃ (mg/L)	Noncarbonate hardness (mg/L)	Dissolved calcium (mg/L)	Dissolved magnesium (mg/L)	Dissolved sodium (mg/L)	Alkalinity (mg/L)	Dissolved sulfate (mg/L)	Dissolved chloride (mg/L)	Dissolved solids residue at 180°C (mg/L)	Dissolved iron (μ g/L)	Dissolved manganese (μ g/L)
HILLTOP														
Less than 50	Range	NO DATA AVAILABLE												
	Mean	NO DATA AVAILABLE												
	Median	NO DATA AVAILABLE												
	Number of wells	NO DATA AVAILABLE												
50-99	Range	520-1100	7.2-7.4	260-360	25-110	81-120	6.4-37	3.6-82	190-330	31-120	4.9-50	281-692	3-110	2-94
	Mean	755	—	330	69	100	19	24	260	80	20	469	30	25
	Median	680	7.3	330	69	100	14	8.8	240	92	20	452	20	10
	Number of wells	5	5	5	5	5	5	5	5	5	5	5	5	5
Greater than or equal to 100	Range	590-1280	7.0-8.7	9-470	0-190	2.9-120	0.6-41	27-320	150-570	11-310	7.3-130	341-815	3-1700	1-20
	Mean	848	—	220	50	60	18	98	310	81	34	510	200	6
	Median	795	7.6	230	0	60	20	65	280	52	34	453	20	3
	Number of wells	9	9	9	9	9	9	9	9	9	9	9	9	9
HILLSIDE														
Less than 50	Range	NO DATA AVAILABLE												
	Mean	NO DATA AVAILABLE												
	Median	NO DATA AVAILABLE												
	Number of wells	NO DATA AVAILABLE												
50-99	Range	425-880	7.3-8.7	19-320	0-70	5.6-79	1.2-30	18-95	160-400	13-72	3.6-24	262-477	3-2500	2-470
	Mean	640	—	210	18	51	19	54	270	40	18	362	640	150
	Median	628	7.8	240	0	60	22	52	260	38	22	356	40	57
	Number of wells	4	4	4	4	4	4	4	4	4	4	4	4	4
Greater than or equal to 100	Range	490-1000	7.5-8.6	6-230	0-57	1.9-67	3-17	10-220	170-420	9.0-67	4.5-28	306-555	10-30	1-21
	Mean	649	—	120	15	42	11	79	270	31	13	370	20	10
	Median	580	7.6	190	0	50	15	65	240	26	9.2	325	20	3
	Number of wells	5	5	5	5	5	5	5	5	5	5	5	5	5
VALLEY														
Less than 50	Range	325-1500	7.3-8.7	20-280	0-120	6.4-86	1.1-16	15-250	140-320	1.0-39	3.3-320	168-937	10-2600	12-730
	Mean	650	—	110	9	33	6.3	94	200	14	70	386	290	200
	Median	560	7.9	98	0	31	4.9	96	170	15	10	338	30	110
	Number of wells	13	13	13	13	13	13	13	13	13	13	13	13	13
50-99	Range	265-1600	6.5-9.0	2-270	0-48	0.6-68	1-27	6.6-260	54-550	1.0-120	1.2-230	158-758	1-2700	2-3100
	Mean	644	—	100	2	29	6.5	100	260	24	28	375	200	310
	Median	585	7.8	91	0	27	5.8	85	240	18	12	350	20	80
	Number of wells	30	30	30	30	29	29	29	30	30	30	30	30	30
Greater than or equal to 100	Range	330-1525	7.0-8.9	4-290	0	1.5-83	2-21	17-440	130-630	4-40	4.8-92	202-908	3-330	5-150
	Mean	831	—	90	0	26	5.8	170	340	20	41	490	90	50
	Median	732	8.1	40	0	12	2.0	110	330	15	22	432	10	20
	Number of wells	8	8	8	8	8	8	8	8	8	8	8	8	8

RECEIVED
Office of Oil and Gas
NOV 18 2015

WV Department of
Environmental Protection

FIGURE 4—
SELECTED CHEMICAL CHARACTERISTICS OF GROUND WATER BY GEOLOGIC UNIT



RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

LABORATORY REPORT

L10060028

06/04/10 13:24

Submitted By

Microbac Laboratories Inc.

158 Starlite Drive

Marietta , OH 45750

(740) 373-4071

For

Account Name: Ohio Oil Gathering Corp.
Box 430

Frazeyburg, OH 43822
Attention: Mike McKee

Project Number: 2167.001

Project: Misc Samples

Site: _____

Sample Summary

Client ID	Lab ID	Date Collected	Date Received
FRENCH CREEK	L10060028-01	06/01/2010 14:45	06/01/2010

L1_A_PROD_COVER - Modified 02/06/2008
PDF File ID: 1687623
Report generated: 06/04/2010 13:24

RECEIVED
Office of Oil and Gas

NOV 1 Microbac

WV Department of
Environmental Protection

Report Number: L10060028

Report Date : June 4, 2010

Sample Number: L10060028-01
 Client ID: FRENCH CREEL
 Matrix: Water
 Workgroup Number: WG333220
 Collect Date: 06/01/2010 14:45
 Sample Tag: 01

PrePrep Method: NONE
 Prep Method: 3005A
 Analytical Method: 6010B
 Analyst: PDM
 Dilution: 1
 Units: mg/L

Instrument: PE-ICP2
 Prep Date: 06/02/2010 06:37
 Cal Date: 06/02/2010 10:06
 Run Date: 06/02/2010 19:21
 File ID: P2.060210.192124

Analyte	CAS. Number	Result	Qual	RL	MDL
Barium, Total	7440-39-3	0.0561		0.0100	0.00250
Iron, Total	7439-89-6	0.405		0.100	0.0250
Manganese, Total	7439-96-5	0.194		0.0100	0.00500
Sodium, Total	7440-23-5	19.9		0.500	0.250

Sample Number: L10060028-01
 Client ID: FRENCH CREEL
 Matrix: Water
 Workgroup Number: WG333124
 Collect Date: 06/01/2010 14:45

PrePrep Method: NONE
 Prep Method: 9040C
 Analytical Method: 9040C
 Analyst: HJR
 Dilution: 1
 Units: UNITS

Instrument: ORION-4STA
 Prep Date: 06/01/2010 16:25
 Cal Date:
 Run Date: 06/01/2010 16:25
 File ID: OS10060315445201

Analyte	CAS. Number	Result	Qual	RL	MDL
pH	10-29-7	6.56			

Sample Number: L10060028-01
 Client ID: FRENCH CREEL
 Matrix: Water
 Workgroup Number: WG333177
 Collect Date: 06/01/2010 14:45

PrePrep Method: NONE
 Prep Method: 160.1
 Analytical Method: 160.1
 Analyst: HJR
 Dilution: 1
 Units: mg/L

Instrument: OVEN
 Prep Date: 06/02/2010 12:00
 Cal Date:
 Run Date: 06/02/2010 12:00
 File ID: EN.1006021200-05

Analyte	CAS. Number	Result	Qual	RL	MDL
Total Dissolved Solids		210		20.0	10.0

Sample Number: L10060028-01
 Client ID: FRENCH CREEL
 Matrix: Water
 Workgroup Number: WG333320
 Collect Date: 06/01/2010 14:45
 Sample Tag: 01

PrePrep Method: NONE
 Prep Method: 325.2
 Analytical Method: 325.2
 Analyst: DIE
 Dilution: 1
 Units: mg/L

Instrument: SMARTCHEM
 Prep Date: 06/03/2010 10:54
 Cal Date:
 Run Date: 06/03/2010 10:54
 File ID: SC100603003 013

Analyte	CAS. Number	Result	Qual	RL	MDL
Chloride	16987-00-6	27.1		2.00	1.00

1 of 1

RECEIVED
 Office of Oil and Gas

NOV 18 2015

WV Department of
 Environmental Protection

Microbac

LABORATORY REPORT

L10070072

07/07/10 17:31

Submitted By

Microbac Laboratories Inc.

158 Starlite Drive

Marietta, OH 45750

(740) 373-4071

For

Account Name: Ohio Oil Gathering Corp.
Box 430

Frazeysburg, OH 43822
Attention: Mike McKee

Project Number: 2167.001

Project: Misc Samples

Site: _____

Sample Summary

Client ID	Lab ID	Date Collected	Date Received
SPRING	L10070072-01	07/02/2010 10:00	07/02/2010

L1_A_PROD_COVER - Modified 02/06/2008
PDF File ID: 1718346
Report generated: 07/07/2010 17:31

RECEIVED
Office of Oil and Gas
NOV 18 2010
Microbac
WV Department of
Environmental Protection

Report Number: L10070072

Report Date : July 7, 2010

Sample Number: L10070072-01
Client ID: SPRING
Matrix: Water
Workgroup Number: WG336242
Collect Date: 07/02/2010 10:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 3005A
Analytical Method: 6010B
Analyst: FDM
Dilution: 1
Units: mg/L

Instrument: PE-ICP2
Prep Date: 07/06/2010 07:22
Cal Date: 07/06/2010 13:15
Run Date: 07/07/2010 02:24
File ID: P2.070710.022421

Analyte	CAS. Number	Result	Qual	RL	MDL
Barium, Total	7440-39-3	0.109		0.0100	0.00250
Iron, Total	7439-89-6	0.484		0.100	0.0250
Manganese, Total	7439-96-5	0.0161		0.0100	0.00500
Sodium, Total	7440-23-5	33.4	B	0.500	0.250

B Analyte present in method blank

Sample Number: L10070072-01
Client ID: SPRING
Matrix: Water
Workgroup Number: WG336152
Collect Date: 07/02/2010 10:00

PrePrep Method: NONE
Prep Method: 9040C
Analytical Method: 9040C
Analyst: JER
Dilution: 1
Units: UNITS

Instrument: ORION-48TA
Prep Date: 07/02/2010 06:10
Cal Date:
Run Date: 07/02/2010 06:10
File ID: OS10070615400501

Analyte	CAS. Number	Result	Qual	RL	MDL
pH	10-29-7	7.50			

Sample Number: L10070072-01
Client ID: SPRING
Matrix: Water
Workgroup Number: WG336127
Collect Date: 07/02/2010 10:00

PrePrep Method: NONE
Prep Method: 160.1
Analytical Method: 160.1
Analyst: EJR
Dilution: 1
Units: mg/L

Instrument: OVEN
Prep Date: 07/02/2010 13:48
Cal Date:
Run Date: 07/02/2010 13:48
File ID: EN.1007021348-06

Analyte	CAS. Number	Result	Qual	RL	MDL
Total Dissolved Solids		424		20.0	10.0

Sample Number: L10070072-01
Client ID: SPRING
Matrix: Water
Workgroup Number: WG336198
Collect Date: 07/02/2010 10:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 325.2
Analytical Method: 325.2
Analyst: DIH
Dilution: 1
Units: mg/L

Instrument: SMARTCHEM
Prep Date: 07/06/2010 11:10
Cal Date: 07/06/2010 11:06
Run Date: 07/06/2010 11:10
File ID: SC100706003.011

Analyte	CAS. Number	Result	Qual	RL	MDL
Chloride	16887-00-6	32.3		2.00	1.00

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

LABORATORY REPORT

L10060745

07/01/10 08:53

Submitted By

Microbac Laboratories Inc.

158 Starlite Drive

Marietta, OH 45750

(740) 373-4071

For

Account Name: Ohio Oil Gathering Corp.
Box 430

Frazeysburg, OH 43822
Attention: Mike McKee

Project Number: 2167.001

Project: Misc Samples

Site: _____

Sample Summary

Client ID	Lab ID	Date Collected	Date Received
MALONE WATER	L10060745-01	06/25/2010 13:00	06/25/2010

L1_A_PROD_COVER - Modified 02/06/2008
PDF File ID: 1713646
Report generated: 07/01/2010 08:53

RECEIVED
Office of Oil and Gas
NOV 18 2015

VIV
Environment
Microbac
Collection

Report Number: L10060745

Report Date : July 1, 2010

Sample Number: L10060745-01
Client ID: MALONE WATER
Matrix: Water
Workgroup Number: WG335610
Collect Date: 06/25/2010 13:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 3005A
Analytical Method: 6010B
Analyst: PDM
Dilution: 1
Units: mg/L

Instrument: PE-ICP2
Prep Date: 06/28/2010 07:23
Cal Date: 06/28/2010 11:28
Run Date: 06/28/2010 19:14
File ID: P2.062810.191406

Analyte	CAS. Number	Result	Qual	RL	MDL
Barium, Total	7440-39-3	0.378		0.0100	0.00250
Iron, Total	7439-89-6	0.683		0.100	0.0250
Manganese, Total	7439-96-5	0.0660		0.0100	0.00500
Sodium, Total	7440-23-5	106		0.500	0.250

Sample Number: L10060745-01
Client ID: MALONE WATER
Matrix: Water
Workgroup Number: WG335470
Collect Date: 06/25/2010 13:00

PrePrep Method: NONE
Prep Method: 9040C
Analytical Method: 9040C
Analyst: JBK
Dilution: 1
Units: UNITS

Instrument: SMARTCHEM
Prep Date: 06/25/2010 14:45
Cal Date: 06/25/2010 13:34
Run Date: 06/25/2010 14:45
File ID: SC10062913450801

Analyte	CAS. Number	Result	Qual	RL	MDL
pH	10-29-7	7.38			

Sample Number: L10060745-01
Client ID: MALONE WATER
Matrix: Water
Workgroup Number: WG335555
Collect Date: 06/25/2010 13:00

PrePrep Method: NONE
Prep Method: 160.1
Analytical Method: 160.1
Analyst: HJR
Dilution: 1
Units: mg/L

Instrument: OVEN
Prep Date: 06/28/2010 15:15
Cal Date: 06/28/2010 15:15
Run Date: 06/28/2010 15:15
File ID: EN.1006281515-04

Analyte	CAS. Number	Result	Qual	RL	MDL
Total Dissolved Solids		424		20.0	10.0

Sample Number: L10060745-01
Client ID: MALONE WATER
Matrix: Water
Workgroup Number: WG335582
Collect Date: 06/25/2010 13:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 325.2
Analytical Method: 325.2
Analyst: DIH
Dilution: 1
Units: mg/L

Instrument: SMARTCHEM
Prep Date: 06/28/2010 13:07
Cal Date: 06/28/2010 13:04
Run Date: 06/28/2010 13:07
File ID: SC100628004.011

Analyte	CAS. Number	Result	Qual	RL	MDL
Chloride	16887-00-6	48.8		2.00	1.00

1 of 1

RECEIVED
Office of Oil & Gas
Microb
NOV 18 2015
WV Department of
Environmental Protection

LABORATORY REPORT

L10060658

06/28/10 14:14

Submitted By

Microbac Laboratories Inc.

158 Starlite Drive

Marietta, OH 45750

(740) 373-4071

For

Account Name: Ohio Oil Gathering Corp.
Box 430

Frazeyburg, OH 43822
Attention: Mike McKee

Project Number: 2167.001

Project: Misc Samples

Site: _____

Sample Summary

Client ID	Lab ID	Date Collected	Date Received
ABEIGHT HOUSE WELL	L10060658-01	06/23/2010 13:00	06/23/2010
ABEIGHT BARN WELL	L10060658-02	06/23/2010 13:00	06/23/2010

L1_A_PROD_COVER - Modified 02/06/2008
PDF File ID: 1710512
Report generated: 06/28/2010 14:14

RECEIVED
Office of Oil and Gas

NOV 18 2015

Environment
Microbac
Department of
Protection

Report Number: L10060658

Report Date : June 28, 2010

Sample Number: L10060658-01
Client ID: ABBICHT HOUSE WELL
Matrix: Water
Workgroup Number: WG335332
Collect Date: 06/23/2010 13:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 3005A
Analytical Method: 6010B
Analyst: EDM
Dilution: 1
Units: mg/L

Instrument: PE-ICP2
Prep Date: 06/24/2010 14:47
Cal Date: 06/24/2010 10:02
Run Date: 06/24/2010 22:56
File ID: P2.062410.225617

Analyte	CAS. Number	Result	Qual	RL	MDL
Barium, Total	7440-39-3	0.329		0.0100	0.00250
Iron, Total	7439-89-6	16.3		0.100	0.0250
Manganese, Total	7439-96-5	0.686		0.0100	0.00500
Sodium, Total	7440-23-5	39.4		0.500	0.250

Sample Number: L10060658-01
Client ID: ABBICHT HOUSE WELL
Matrix: Water
Workgroup Number: WG335193
Collect Date: 06/23/2010 13:00

PrePrep Method: NONE
Prep Method: 9040C
Analytical Method: 9040C
Analyst: EJR
Dilution: 1
Units: UNITS

Instrument: ORION-4STA
Prep Date: 06/23/2010 16:30
Cal Date:
Run Date: 06/23/2010 16:30
File ID: OS10062509095101

Analyte	CAS. Number	Result	Qual	RL	MDL
pH	10-29-7	6.66			

Sample Number: L10060658-01
Client ID: ABBICHT HOUSE WELL
Matrix: Water
Workgroup Number: WG335277
Collect Date: 06/23/2010 13:00

PrePrep Method: NONE
Prep Method: 160.1
Analytical Method: 160.1
Analyst: TMM
Dilution: 1
Units: mg/L

Instrument: OVEN
Prep Date: 06/24/2010 14:20
Cal Date:
Run Date: 06/24/2010 14:20
File ID: EN.1006241420-04

Analyte	CAS. Number	Result	Qual	RL	MDL
Total Dissolved Solids		438		20.0	10.0

Sample Number: L10060658-01
Client ID: ABBICHT HOUSE WELL
Matrix: Water
Workgroup Number: WG335312
Collect Date: 06/23/2010 13:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 325.2
Analytical Method: 325.2
Analyst: DIH
Dilution: 1
Units: mg/L

Instrument: SMARTCHEM
Prep Date: 06/24/2010 14:38
Cal Date: 06/24/2010 14:36
Run Date: 06/24/2010 14:38
File ID: SC100624004.011

Analyte	CAS. Number	Result	Qual	RL	MDL
Chloride	16887-00-6	26.0		2.00	1.00

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

1 of 2

Report Number: L10060658

Report Date : June 28, 2010

Sample Number: L10060658-02
Client ID: ABEICHT BARN WELL
Matrix: Water
Workgroup Number: WG335332
Collect Date: 06/23/2010 13:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 3005A
Analytical Method: 6010B
Analyst: PDM
Dilution: 1
Units: mg/L

Instrument: PE-ICP2
Prep Date: 06/24/2010 14:47
Cal Date: 06/24/2010 10:02
Run Date: 06/24/2010 23:01
File ID: P2.062410.230157

Analyte	CAS. Number	Result	Qual	RL	MDL
Barium, Total	7440-39-3	0.303		0.0100	0.00250
Iron, Total	7439-89-6	11.8		0.100	0.0250
Manganese, Total	7439-96-5	0.267		0.0100	0.00500
Sodium, Total	7440-23-5	15.1		0.500	0.250

Sample Number: L10060658-02
Client ID: ABEICHT BARN WELL
Matrix: Water
Workgroup Number: WG335193
Collect Date: 06/23/2010 13:00

PrePrep Method: NONE
Prep Method: 9040C
Analytical Method: 9040C
Analyst: HJR
Dilution: 1
Units: UNITS

Instrument: ORION-4STA
Prep Date: 06/23/2010 16:30
Cal Date:
Run Date: 06/23/2010 16:30
File ID: OS10062509100901

Analyte	CAS. Number	Result	Qual	RL	MDL
pH	10-29-7	6.65			

Sample Number: L10060658-02
Client ID: ABEICHT BARN WELL
Matrix: Water
Workgroup Number: WG335277
Collect Date: 06/23/2010 13:00

PrePrep Method: NONE
Prep Method: 160.1
Analytical Method: 160.1
Analyst: TMM
Dilution: 1
Units: mg/L

Instrument: OVEN
Prep Date: 06/24/2010 14:20
Cal Date:
Run Date: 06/24/2010 14:20
File ID: EN.1006241420-05

Analyte	CAS. Number	Result	Qual	RL	MDL
Total Dissolved Solids		288		20.0	10.0

Sample Number: L10060658-02
Client ID: ABEICHT BARN WELL
Matrix: Water
Workgroup Number: WG335312
Collect Date: 06/23/2010 13:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 325.2
Analytical Method: 325.2
Analyst: DHE
Dilution: 1
Units: mg/L

Instrument: SMARTCHEM
Prep Date: 06/24/2010 14:39
Cal Date: 06/24/2010 14:36
Run Date: 06/24/2010 14:39
File ID: SC100624004.012

Analyte	CAS. Number	Result	Qual	RL	MDL
Chloride	16887-00-6	33.2		2.00	1.00

RECEIVED
Office of Oil and Gas

NOV 18 2015

WV Department of
Environmental Protection

LABORATORY REPORT

L10070331

07/19/10 14:11

Submitted By

Microbac Laboratories Inc.

158 Starlite Drive

Marietta, OH 45750

(740) 373-4071

For

Account Name: Ohio Oil Gathering Corp.
Box 430

Frazeysburg, OH 43822
Attention: Mike McKee

Project Number: 2167.001

Project: Misc Samples

Site: _____

Sample Summary

Client ID	Lab ID	Date Collected	Date Received
ARNOTT WELL	L10070331-01	07/14/2010 14:00	07/14/2010
ARNOTT POND	L10070331-02	07/14/2010 14:00	07/14/2010

RECEIVED
Office of Oil and Gas

NOV 1



WV Department of
Environmental Protection

Microbac Laboratories Inc.

Report Number: L10070331

Report Date : July 19, 2010

Sample Number: L10070331-01
 Client ID: ARNOTT WELL
 Matrix: Water
 Workgroup Number: WG337216
 Collect Date: 07/14/2010 14:00
 Sample Tag: 01

PrePrep Method: NONE
 Prep Method: 3005A
 Analytical Method: 6010B
 Analyst: PDM
 Dilution: 1
 Units: mg/L

Instrument: PE-ICP2
 Prep Date: 07/16/2010 06:23
 Cal Date: 07/16/2010 10:31
 Run Date: 07/16/2010 17:40
 File ID: P2.071610.174019

Analyte	CAS. Number	Result	Qual	RL	MDL
Barium, Total	7440-39-3	0.265		0.0100	0.00250
Iron, Total	7439-89-6	6.58		0.100	0.0250
Manganese, Total	7439-96-5	0.121		0.0100	0.00500
Sodium, Total	7440-23-5	5.44		0.500	0.250

Sample Number: L10070331-01
 Client ID: ARNOTT WELL
 Matrix: Water
 Workgroup Number: WG337124
 Collect Date: 07/14/2010 14:00

PrePrep Method: NONE
 Prep Method: 9040C
 Analytical Method: 9040C
 Analyst: JBK
 Dilution: 1
 Units: UNITS

Instrument: ORION-4STA
 Prep Date: 07/15/2010 15:30
 Cal Date:
 Run Date: 07/15/2010 15:30
 File ID: OS10071615041701

Analyte	CAS. Number	Result	Qual	RL	MDL
pH	10-29-7	6.60			

Sample Number: L10070331-01
 Client ID: ARNOTT WELL
 Matrix: Water
 Workgroup Number: WG337069
 Collect Date: 07/14/2010 14:00

PrePrep Method: NONE
 Prep Method: 160.1
 Analytical Method: 160.1
 Analyst: EJR
 Dilution: 1
 Units: mg/L

Instrument: OVEN
 Prep Date: 07/15/2010 15:45
 Cal Date:
 Run Date: 07/15/2010 15:45
 File ID: EN.1007151545-05

Analyte	CAS. Number	Result	Qual	RL	MDL
Total Dissolved Solids		260		20.0	10.0

Sample Number: L10070331-01
 Client ID: ARNOTT WELL
 Matrix: Water
 Workgroup Number: WG337213
 Collect Date: 07/14/2010 14:00
 Sample Tag: 01

PrePrep Method: NONE
 Prep Method: 325.2
 Analytical Method: 325.2
 Analyst: JBK
 Dilution: 1
 Units: mg/L

Instrument: SMARTCHEM
 Prep Date: 07/16/2010 14:03
 Cal Date: 07/16/2010 13:58
 Run Date: 07/16/2010 14:03
 File ID: SC100716004.014

Analyte	CAS. Number	Result	Qual	RL	MDL
Chloride	16887-00-6	13.3		2.00	1.00

1 of 2

RECEIVED
Office of Oil and Gas

NOV 18 2015

Microbac

WV Department of
Environmental Protection

Microbac Laboratories Inc.

Report Number: L10070331

Report Date : July 19, 2010

Sample Number: L10070331-02
Client ID: ARNOTT POND
Matrix: Water
Workgroup Number: WG337216
Collect Date: 07/14/2010 14:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 3005A
Analytical Method: 6010B
Analyst: PDM
Dilution: 1
Units: mg/L

Instrument: PE-ICP2
Prep Date: 07/16/2010 06:23
Cal Date: 07/16/2010 10:31
Run Date: 07/16/2010 17:58
File ID: P2.071610.175809

Analyte	CAS. Number	Result	Qual	RL	MDL
Barium, Total	7440-39-3	0.0737		0.0100	0.00250
Iron, Total	7439-89-6	1.65		0.100	0.0250
Manganese, Total	7439-96-5	0.391		0.0100	0.00500
Sodium, Total	7440-23-5	4.56		0.500	0.250

Sample Number: L10070331-02
Client ID: ARNOTT POND
Matrix: Water
Workgroup Number: WG337124
Collect Date: 07/14/2010 14:00

PrePrep Method: NONE
Prep Method: 9040C
Analytical Method: 9040C
Analyst: JBK
Dilution: 1
Units: UNITS

Instrument: ORION-4STA
Prep Date: 07/15/2010 15:30
Cal Date:
Run Date: 07/15/2010 15:30
File ID: OS10071615044101

Analyte	CAS. Number	Result	Qual	RL	MDL
pH	10-29-7	6.36			

Sample Number: L10070331-02
Client ID: ARNOTT POND
Matrix: Water
Workgroup Number: WG337069
Collect Date: 07/14/2010 14:00

PrePrep Method: NONE
Prep Method: 160.1
Analytical Method: 160.1
Analyst: HJR
Dilution: 1
Units: mg/L

Instrument: OVEN
Prep Date: 07/15/2010 15:45
Cal Date:
Run Date: 07/15/2010 15:45
File ID: EN.1007151545-06

Analyte	CAS. Number	Result	Qual	RL	MDL
Total Dissolved Solids		248		20.0	10.0

Sample Number: L10070331-02
Client ID: ARNOTT POND
Matrix: Water
Workgroup Number: WG337213
Collect Date: 07/14/2010 14:00
Sample Tag: 01

PrePrep Method: NONE
Prep Method: 325.2
Analytical Method: 325.2
Analyst: JBK
Dilution: 1
Units: mg/L

Instrument: SMARTCHEM
Prep Date: 07/16/2010 14:03
Cal Date: 07/16/2010 13:58
Run Date: 07/16/2010 14:03
File ID: SCI00716004.015

Analyte	CAS. Number	Result	Qual	RL	MDL
Chloride	16887-00-6	16.7		2.00	1.00

2 of 2

RECEIVED
Office of Oil and Gas

NOV 18 2015

Microbac

WV Department of
Environmental Protection

GROUND-WATER HYDROLOGY OF THE AREA BORDERING THE OHIO RIVER BETWEEN CHESTER AND WAVERLY, WEST VIRGINIA

By John S. Bader, Melvin V. Mathes, and Robert A. Shultz

U.S. GEOLOGICAL SURVEY

Open-File Report 95-710

Prepared in cooperation with the

WEST VIRGINIA DIVISION OF ENVIRONMENTAL PROTECTION,
OFFICE OF WATER RESOURCES



Charleston, West Virginia

1997

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey, WRD
11 Dunbar Street
Charleston, WV 25301

Copies of the report can be purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Denver Federal Center
Denver, CO 80225

CONTENTS

	<i>Page</i>
Abstract.....	1
1.0 Introduction	2
1.1 Acknowledgments	2
1.2 Purpose and scope of report	2
1.3 Location and general features of project area	3
1.4 Previous investigations	5
1.5 Climate and recharge	7
1.6 Ground-water use.....	10
2.0 Geology and water-bearing characteristics	17
2.1 Consolidated sedimentary rocks	17
2.2 Unconsolidated alluvial deposits	18
3.0 Ground-water system.....	23
3.1 Recharge, movement, and discharge	23
3.2 Hydraulic characteristics of alluvial aquifer	26
4.0 Water quality	32
4.1 Data collection	32
4.2 Water type.....	34
4.3 Chemical constituents	39
4.3.1 Saltwater	39
4.3.2 Iron and manganese.....	43
4.3.3 Hardness	46
4.3.4 Sulfate.....	48
4.3.5 Contaminants	50
4.4 Relation to ground-water movement	52
5.0 Summary	55
6.0 Definition of terms	56
7.0 Selected references	58

ILLUSTRATIONS

	<i>Page</i>
Figure 1.3-1 Map showing location of project area	4
1.4-1 Map showing areas covered by published geologic and hydrologic reports.....	6
1.5-1 Graphs showing mean monthly precipitation (1951-80)	9
1.6-1 Graph showing ground-water withdrawals by county, excluding industrial use	11
1.6-2 Map showing location of public-supply wells	12
 2.2-1 Map showing drillers' logs of selected wells in the alluvium	 19
2.2-2 Geologic section of alluvium at the Sistersville section	22
 3.1-1 Hydrographs of two wells at Sistersville site	 25
3.2-1 Map showing specific capacity	27
3.2-2 Map showing saturated thickness of aquifer	28
3.2-3 Map showing estimated transmissivity	29
3.2-4 Map showing estimated hydraulic conductivity	31
 4.1-1 Map showing location of ground-water sampling sites	 33
4.2-1 Map showing areal distribution of cations and anions	35
4.3.1-1 Map showing areal distribution of dissolved chloride	40
4.3.1-2 Sketch showing relation between freshwater and saltwater	41
4.3.2-1 Map showing areal distribution of dissolved iron	44
4.3.2-2 Map showing areal distribution of dissolved manganese	45
4.3.3-1 Map showing areal distribution of hardness	47
4.3.4-1 Map showing areal distribution of dissolved sulfate	49
4.3.5-1 Map showing areas where selected contaminant concentration exceeds established State limits	 51
4.4-1 Trilinear water-analysis diagram of water samples from the alluvium, bedrock, and Ohio River	 53
 Plates 1-3. Maps showing hydrologic and physical characteristics of selected alluvial wells in:	
1. Ohio, Brooke, and Hancock Counties	36
2. Marshall and Wetzel Counties	37
3. Tyler and Pleasants Counties	38

TABLE

	<i>Page</i>
Table 1.5-1 Mean monthly precipitation and evapotranspiration	8

CONVERSION FACTORS AND VERTICAL DATUM

<i>Multiply</i>	<i>By</i>	<i>To</i>
<i>Length</i>		
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
<i>Area</i>		
square mile (mi ²)	2.590	square kilometer
<i>Volume</i>		
gallon (gal)	3.785	liter
million gallons (Mgal)	3,785	cubic meter
cubic foot (ft ³)	0.02832	cubic meter
cubic mile (mi ³)	4.166	cubic kilometer
acre-foot (acre-ft)	1,233	cubic meter
<i>Flow</i>		
cubic foot per second (ft ³ /s)	28.32	liter per second
gallon per minute (gal/min)	0.06308	liter per second
million gallons per day (Mgal/d)	43.81	cubic decimeter per second
<i>Aquifer characteristics</i>		
gallon per minute per foot [(gal/min)/ft]	0.207	liter per second per meter
foot per day (ft/d)	0.305	meter per day
foot squared per day (ft ² /d)	0.0929	meter squared per day

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{F} = 1.8 \times ^{\circ}\text{C} + 32$$

Sea level : In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level of 1929."

Chemical concentration in water is expressed in milligrams per liter (mg/L) and micrograms per liter (µg/L).

GROUND-WATER HYDROLOGY OF THE AREA BORDERING
THE OHIO RIVER BETWEEN CHESTER AND
WAVERLY, WEST VIRGINIA

By John S. Bader, Melvin V. Mathes, and Robert A. Shultz

ABSTRACT

Ground-water reserves in West Virginia are contained in the consolidated rock underlying the State and in the alluvium bordering the Ohio and Kanawha Rivers. Ground-water use in the study area, which includes all or parts of Hancock, Brooke, Ohio, Marshall, Wetzel, Tyler, and Pleasants Counties in northern West Virginia, was at least 6.3 billion gallons in 1980. The consolidated rock (bedrock) that crops out in the study area is of Pennsylvanian or Permian age. Alluvial deposits in the study area are limited mostly to the flood plain of the Ohio River. The alluvium is not vertically homogeneous; the lower part of the deposits consists of sand and gravel of glacial outwash origin, and the upper deposits consist of clay and silt interspersed with sand stringers. In some areas, the tributary streams have deposited a gravel delta where they enter the valley of the Ohio River. In places, ground water in the alluvium has been degraded by contaminants from industrial waste. Ground water flows from the adjacent hills toward the river. The alluvium and bedrock are hydraulically connected, and the saturated zone is continuous in both rock units. The alluvium is recharged by the following sources: (1) precipitation on the flood plain, (2) inflow from fractures in the bedrock beneath and adjacent to the alluvium, (3) inflow from tributary streams through gravel deltas and bedding-plane partings, and (4) induced inflow from the river. In some ground-water samples, concentrations of iron, manganese, sulfate, arsenic, barium, mercury, and phenols exceeded recommended limits for drinking water established by the West Virginia State Board of Health. Ground-water hardness exceeded 120 milligrams per liter in 91 percent of the samples.

1.0 INTRODUCTION

1.1 Acknowledgments

The authors appreciate the cooperation of the many well owners who provided information about their wells and permitted samples of water to be taken for analysis. The cooperation of many well drillers who provided records and information also is acknowledged. Special appreciation is given to Charles Brown, Jr. and Ray Maxwell. Mr. Brown provided access to his property for drilling eight test wells and loaned equipment and materials to the authors throughout the project. Mr. Maxwell also provided access, material, and assistance on numerous occasions during the project.

1.2 Purpose and Scope of Report

PROTECTION OF PUBLIC WATER SUPPLY IS PRIMARY CONCERN

The geologic and hydrologic properties of an aquifer system must be understood so it can be fully used and protected from overdevelopment and contamination.

Most ground water in West Virginia is derived from two aquifer systems. The most widespread is the system of fractures in the consolidated rock (bedrock) that underlies the State. The other is the narrow band of alluvium that borders the Ohio and Kanawha Rivers. Both aquifer systems can be contaminated by percolation or injection of harmful materials, and both can become uneconomical for water supply by overuse.

This report describes the results of an investigation to improve understanding of the hydrologic properties of the aquifer systems in the study area. Sensible and orderly development of the ground-water resources of an area requires a thorough understanding of the geology and hydrology of the area. The adequacy of a ground-water supply can be affected by many natural and human-induced processes. An understanding of the hydrologic environment can aid in making sound decisions that would protect the ground-water resources of an area from detrimental practices.

The scope of the work included ground-water data collection from numerous sources. Selected wells in the study area were visited. Details of well construction were obtained from the owners and, where possible, depth to water was measured. If available, additional information on well construction was obtained from the driller. Water from many of the wells was analyzed for selected inorganic and organic chemical constituents. Reports from previous studies in the area were obtained, as were reports on other alluvial aquifers in and near the Ohio River drainage. Data also were obtained from the files of the U.S. Geological Survey; the West Virginia Department of Natural Resources, Division of Water Resources, and the West Virginia Department of Health. Those data, together with those collected as part of this project, were analyzed and are reported herein.

Eight test wells were drilled near Sistersville. Water-level data were obtained from all the wells, and physical water-quality data were obtained from most.

1.0 INTRODUCTION--Continued

1.3 Location and General Features of Project Area

PROJECT AREA IS IN NORTHERN WEST VIRGINIA AND
INCLUDES ALL OR PARTS OF SEVEN COUNTIES

The area extends from the Wood County line near Waverly northward to the Pennsylvania border.

The project area is the West Virginia side of the Ohio River valley from the Wood County line near Waverly to the Pennsylvania border near Chester. It includes all or parts of Hancock, Brooke, Ohio, Marshall, Wetzel, Tyler, and Pleasants Counties (fig. 1.3-1).

The area is part of the highly industrialized Ohio River valley. It contains major facilities for the manufacture and processing of steel, glass, ceramics, coal products such as coke and graphite, and chemicals, as well as coal mines, coal-fired, electric-power generating plants, an oil refinery, and a natural gas processing plant. The larger population centers are in the northern panhandle of the State and include Moundsville, Wheeling, and Weirton.

The topography of the area adjacent to the flat Ohio River flood plain is the typical hilly terrain found in the dissected Appalachian Plateaus physiographic province (Fenneman and Johnson, 1946). Maximum relief of the hills is about 600 feet. The flood plain is only about 0.6 mile wide at its widest point. The elevation of the flood plain ranges from about 600 feet above sea level at Waverly to about 700 feet above sea level at Chester. The elevation of the Ohio River in the area is controlled by five locks and dams with the following pool elevations (above sea level): New Cumberland, 664 feet; Pike Island, 644 feet; Hannibal, 623 feet; Willow Island, 602 feet; and Belleville, 582 feet.

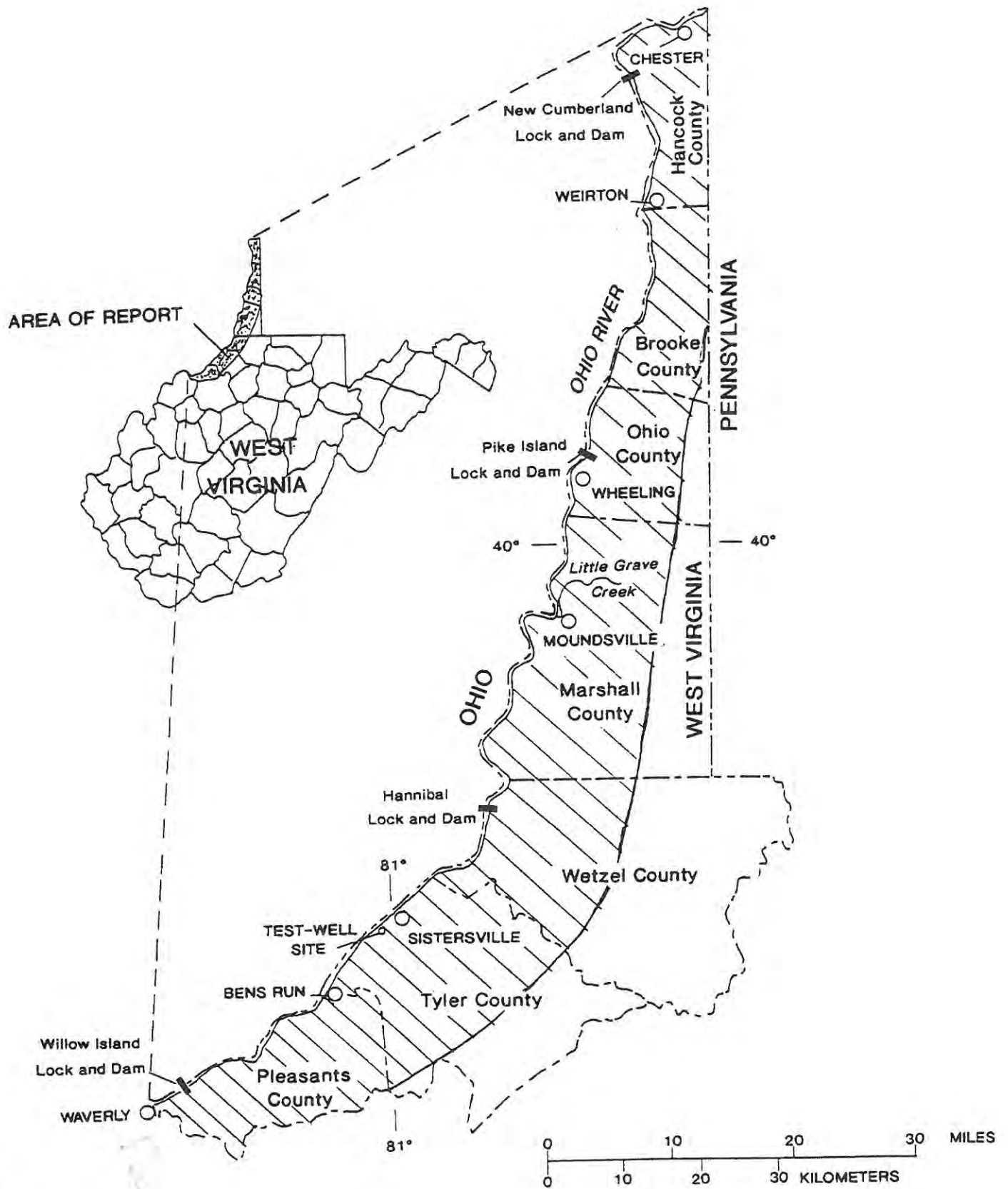


Figure 1.3-1. - - Location of project area.

1.0 INTRODUCTION--Continued

1.4 Previous Investigations

NUMEROUS STUDIES HAVE BEEN MADE OF THE GEOLOGY AND HYDROLOGY OF THE AREA

The geology of the area was studied in detail in the early part of the century, and more recently, the hydrology has been studied in basinwide, countywide, and local projects.

The geology of the study area is described in three county reports by Grimsley (1907 and 1910) and Hennen (1909), and it also is shown on the "1968 Geologic Map of West Virginia" (Cardwell and others, 1968). See figure 1.4-1.

The geologic units beneath the rocks saturated by freshwater are discussed in oil and gas reports of the counties in the project area, including those by Haught (1955a and 1955b) and Cardwell (1978).

A description of the hydrology of the entire Ohio River basin is published in the "Ohio River Basin Comprehensive Survey" (Deutsch and others, 1966; Jordan, 1966). The part of the Ohio River valley that lies in West Virginia is described in the three-part report "Geology and Economic Resources of the Ohio River Valley in West Virginia." The geology is described in Part I by Cross and Schemel (1956), and the ground-water resources are described in Part III by Carlston and Graeff (1955). An atlas by Shultz (1984) describes the geology and ground-water hydrology of the minor tributary basins of the Ohio River. The ground-water hydrology of Ohio County is described in "Occurrence and Availability of Ground Water in Ohio County, West Virginia," by Robison (1964). U.S. Geological Survey Circular 340, "Water Resources of the Wheeling-Steubenville Area, West Virginia and Ohio" by Smith and others (1955) describes both the surface-water and ground-water resources of that area.

Numerous reports that discuss the geology and hydrology of alluvial aquifers outside this project area are available. Some are listed as selected references in this report (section 7.0). Among the most noteworthy are: Gallaher and Price (1966), Crain (1966), Rorabaugh (1946 and 1948), Norris and Fidler (1969), Whitesides and Ryder (1969), Grubb and Zehner (1973), Jeffords (1945), and Norris and Eagon (1971).

LARGER AREAS COVERED BY PUBLISHED GEOLOGIC AND HYDROLOGIC REPORTS

State geologic map (Cardwell and others, 1968)

Ohio River drainage in West Virginia
(Carlston and Graeff, 1955; Cross and
Schemel, 1956; Shultz, 1984)

Ohio River drainage between Pittsburgh and Marietta
(Jordan, 1966; Deutsch and others, 1966)

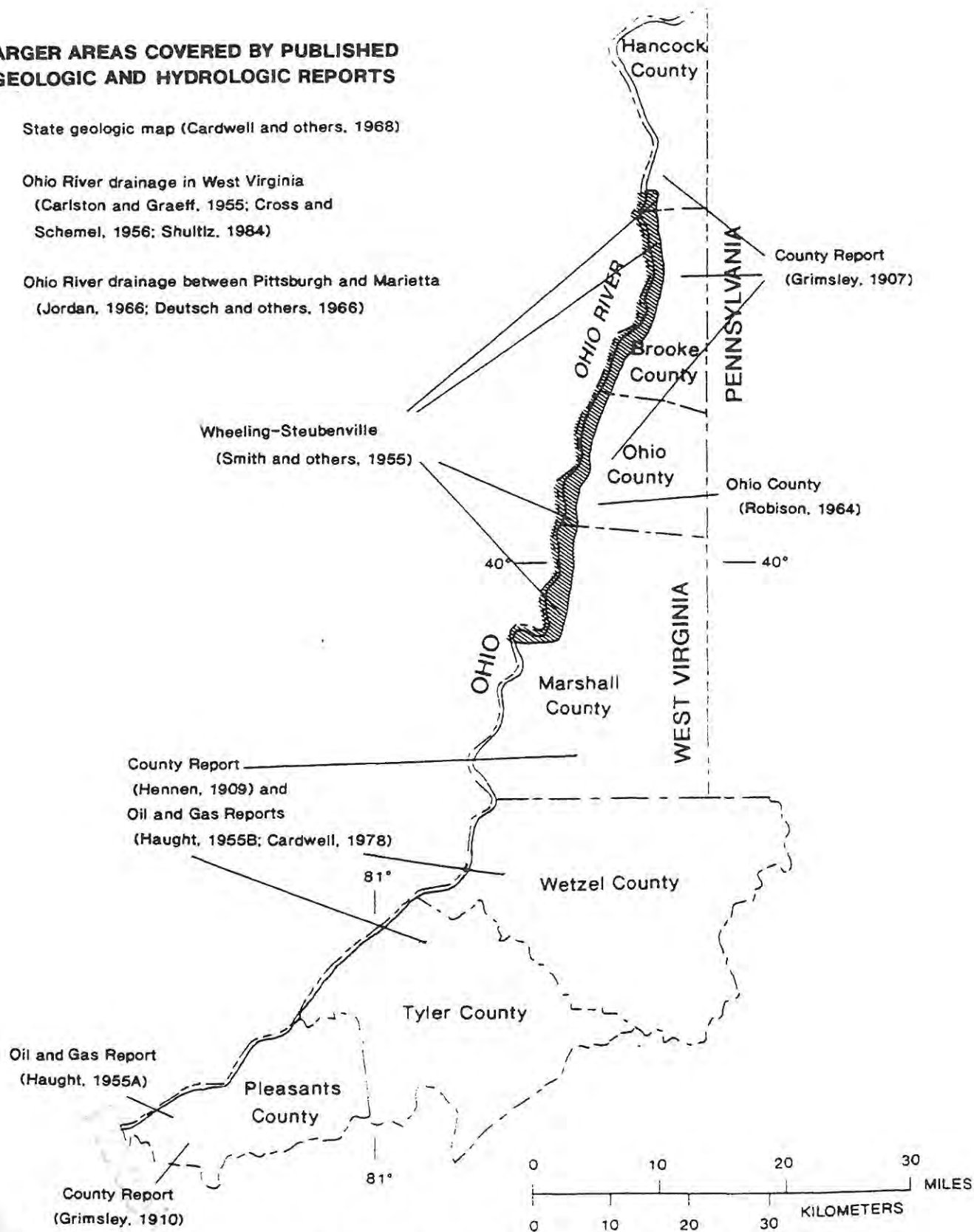


Figure 1.4-1. -- Areas covered by published geologic and hydrologic reports (see selected references for complete citations).

1.0 INTRODUCTION--Continued

1.5 Climate and Recharge

POTENTIAL FOR RECHARGE VARIES SEASONALLY

The potential for recharge to the ground-water reservoir is greater during winter and spring.

Potential for recharge to the ground-water reservoir is greater from November through April than during the rest of the year because precipitation is significantly greater than evapotranspiration during these months. Hydrographs of two wells near Sistersville (fig. 3.1-1) show that the ground-water level is higher during this period. Mean monthly precipitation was at least 1 in. greater than estimated mean monthly evapotranspiration for each of these months (table 1.5-1). Mean monthly precipitation slightly exceeded mean monthly evapotranspiration in May and October and was less than mean monthly evapotranspiration in June, July, August, and September. Mean annual evapotranspiration was estimated to be 27.70 in. Both monthly and annual evapotranspiration were estimated using the Munson P.E. Index method described in Munson (1966).

Recharge from precipitation also varies seasonally because of variations in the form and rate of precipitation, in the condition of the ground surface, and in the density of the forest canopy. During winter and early spring, precipitation is usually less intense and more widespread; thus, it is more conducive to recharge than summer thunderstorms of greater intensity and smaller coverage which are more conducive to runoff. If there is a snow pack, melting often increases soil moisture, except when the ground is frozen. Figure 1.5-1 shows the mean monthly and mean annual precipitation for four locations.

Forest areas reduce the water available for recharge because trees intercept precipitation before it hits the ground, and the ground covering of leaves or litter absorbs a large amount of moisture. Based on two formulas given in Chang and others (1976, p. 78), the forest canopy intercepts 13 to 22 percent of the precipitation. More precipitation is intercepted from May through October when the leaf canopy is full than from November through April. Although the Ohio River flood plain does not have a significant amount of forest area, the adjacent hills are covered mostly by deciduous and mixed forest.

Table 1.5-1.--Mean monthly precipitation and evapotranspiration

Month	Mean monthly precipitation (inches) <i>a,c</i>	Mean monthly evapotranspiration (inches) <i>b,c</i>	Precipitation minus evapotranspiration (inches)
January	2.84	0.27	2.57
February	2.43	.50	1.93
March	3.58	1.21	2.37
April	3.59	2.20	1.39
May	3.81	3.48	-.33
June	3.85	4.18	-.33
July	4.22	4.95	-.73
August	3.83	4.42	-.59
September	3.02	3.09	-.07
October	2.60	1.92	.68
November	2.54	1.00	1.54
December	2.70	.48	2.22

a Modified from National Oceanic and Atmospheric Administration (1982)
for period 1951-80.

b Calculated using Munson P.E. Index (Munson, 1966) for period 1951-80.

c Mean of four sites shown in figure 1.5-1.

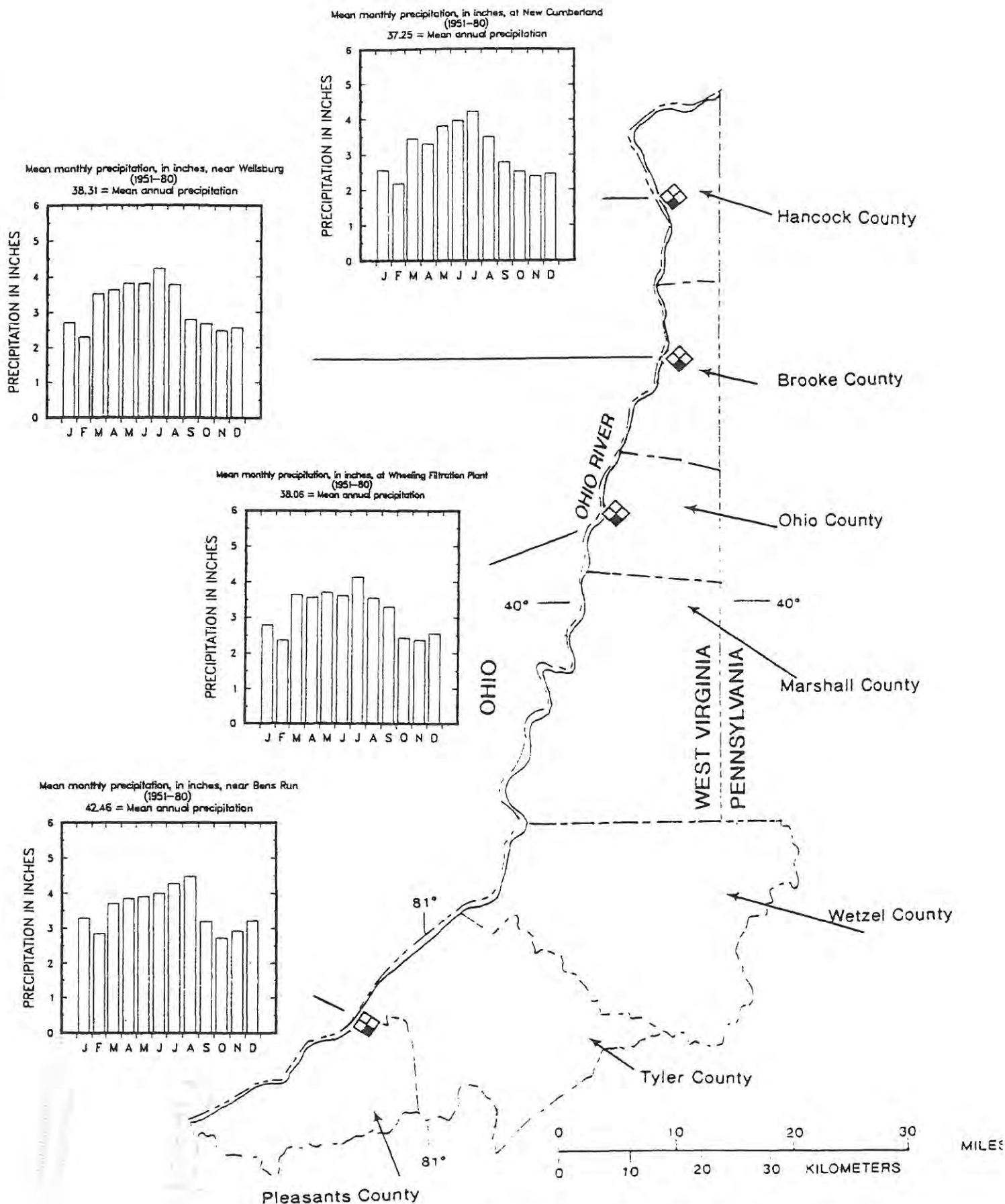


Figure 1.5-1. -- Mean monthly precipitation (1951-80).

1.0 INTRODUCTION--Continued

1.6 Ground-Water Use

MORE THAN 6.3 BILLION GALLONS OF GROUND WATER PUMPED IN 1980

Ground water in the seven-county project area is withdrawn for public supply, industry, mining, and domestic use.

Ground-water use in Hancock, Brooke, Ohio, Marshall, Wetzel, Tyler, and Pleasants Counties was at least 6.3 billion gallons in 1980 for public supply, mining, and domestic purposes according to Stevens and Lessing (1982) (fig. 1.6-1). This includes the entire county areas, but does not include industrial use, for which data are not available.

Nearly 4.0 billion gallons of ground water were withdrawn for public supply in 1983. This does not include pumpage by the smaller facilities supplying mobile-home parks or other small communities. Figure 1.6-2 shows the location of major public-supply wells.

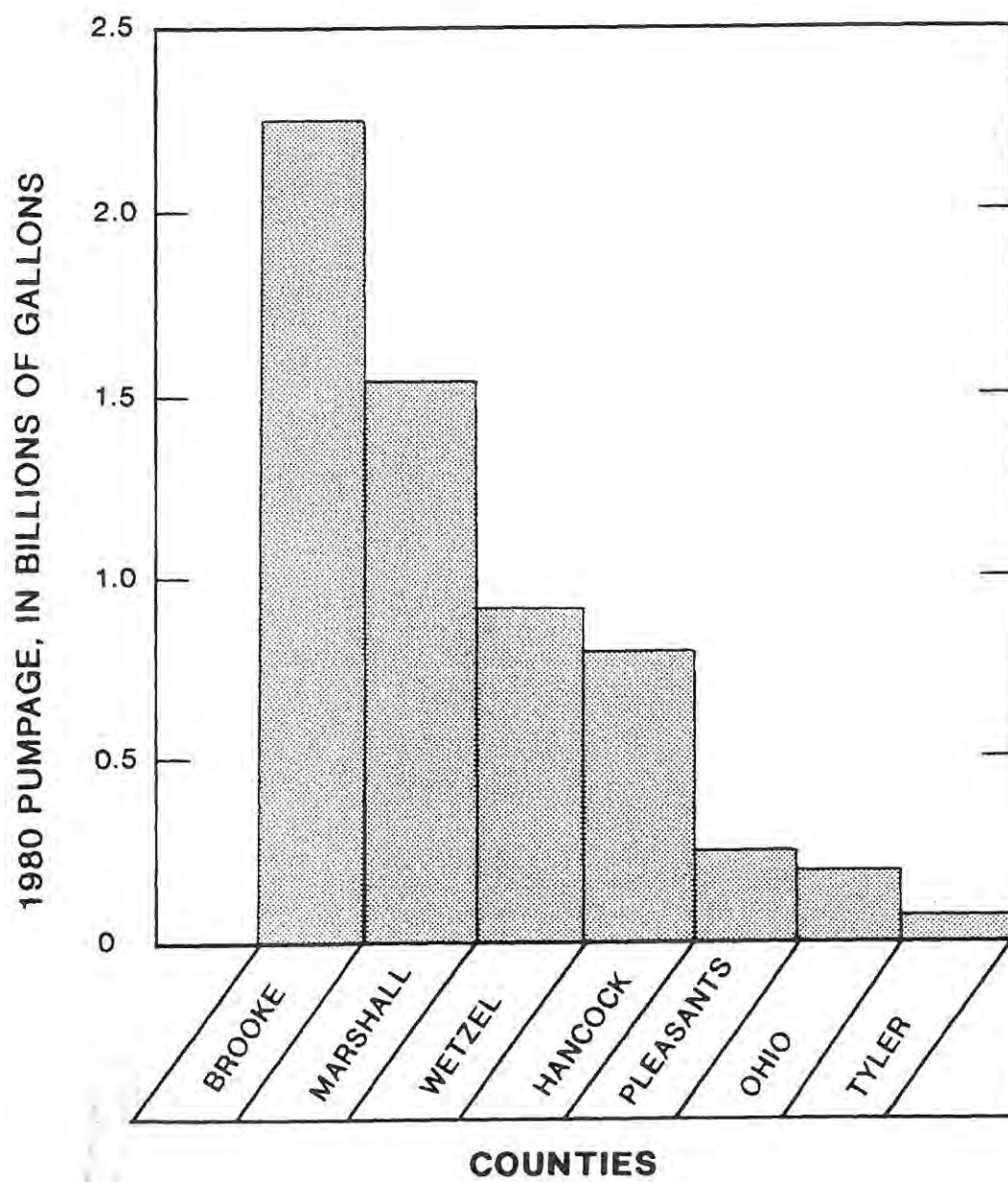


Figure 1.6-1. - - Ground-water withdrawals by county, excluding industrial use.

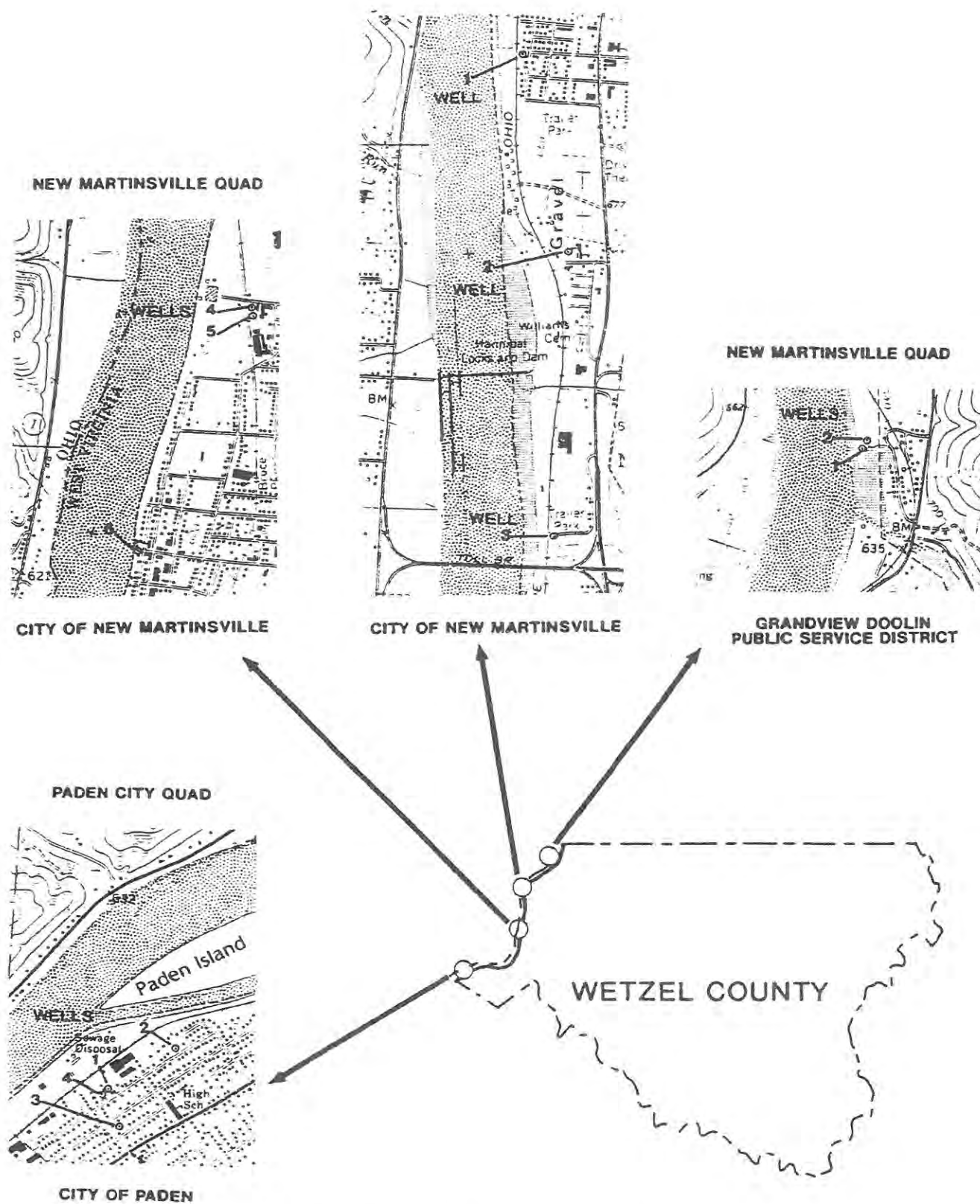


Figure 1.6-2. -- Location of public-supply wells.

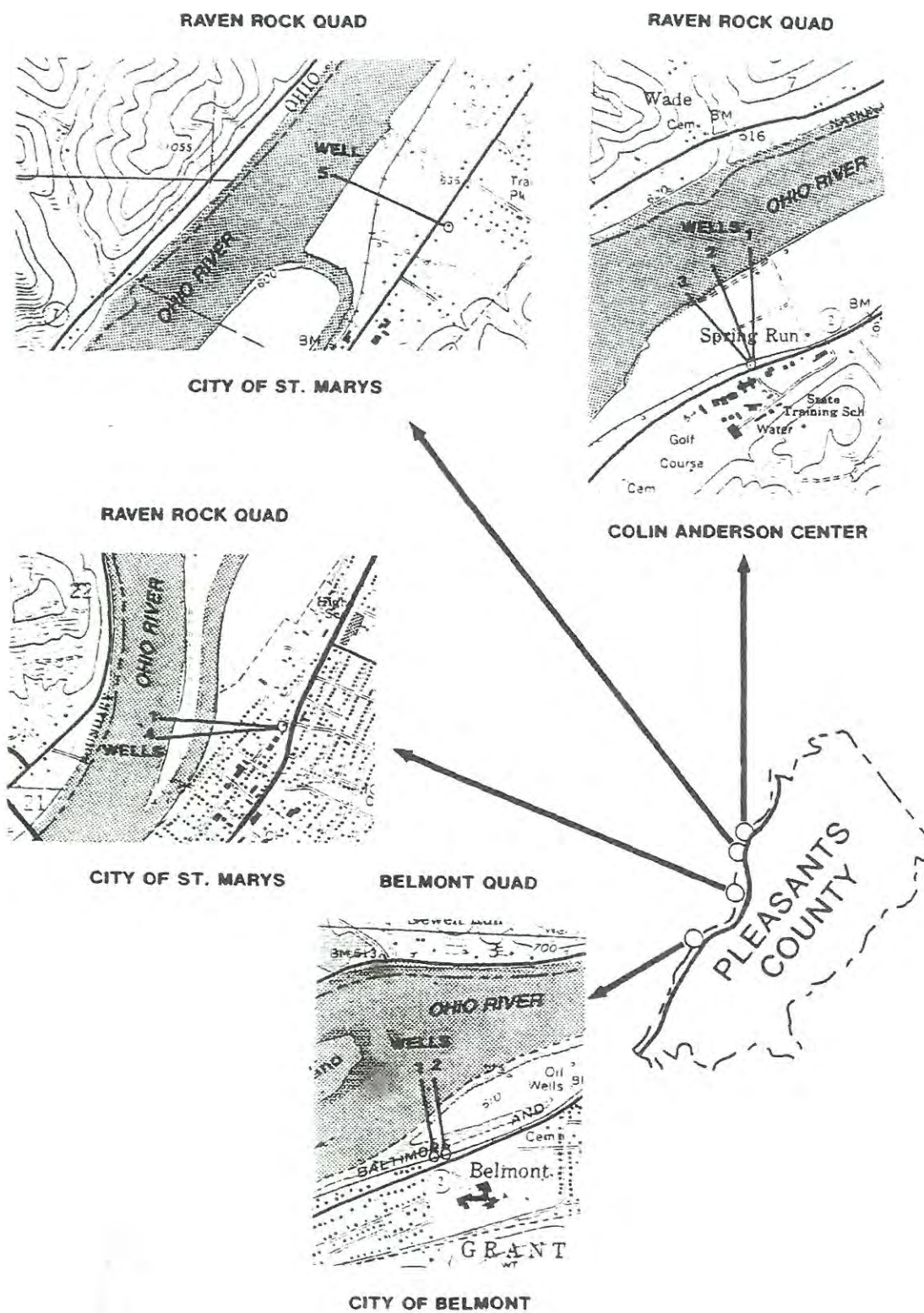


Figure 1.6-2. - Location of public-supply wells (continued).

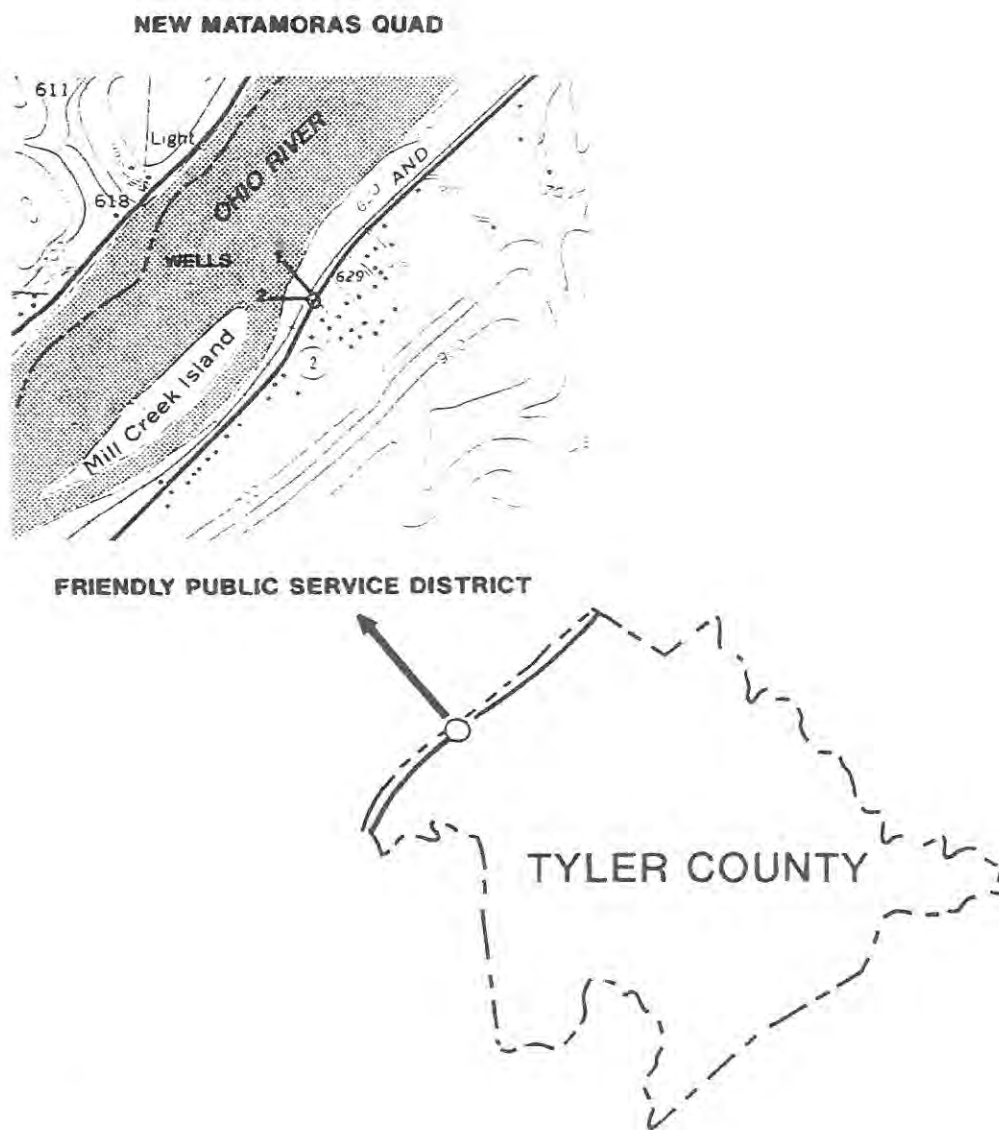


Figure 1.6-2. -- Location of public-supply wells (continued).

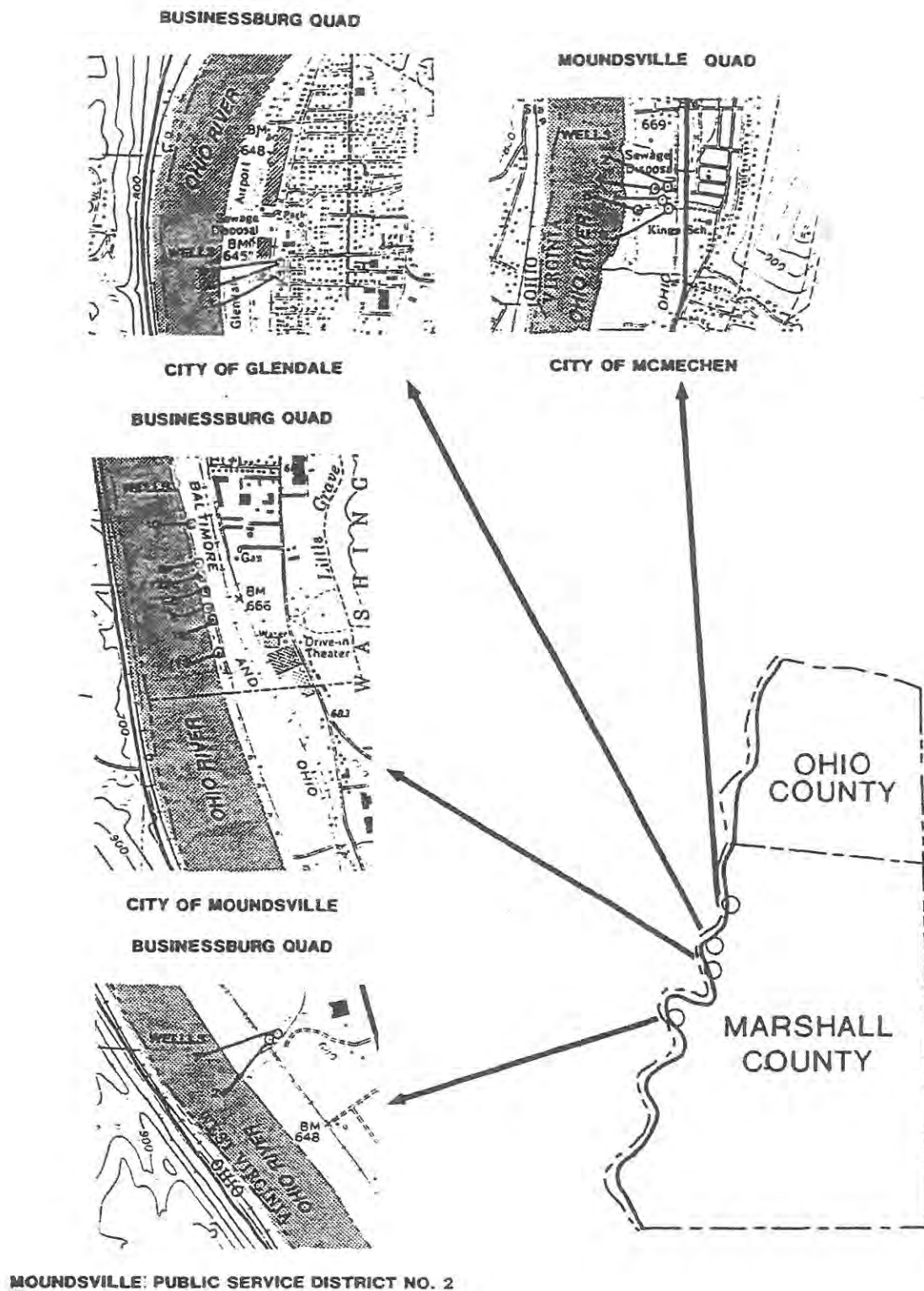


Figure 1.6-2. - - Location of public-supply wells (continued).

2.0 GEOLOGY AND WATER-BEARING CHARACTERISTICS

2.1 Consolidated Sedimentary Rocks

AREA IS UNDERLAIN BY SEDIMENTARY ROCKS

Most of the study area is underlain by sedimentary rocks of Pennsylvanian and Permian age.

The oldest rock unit exposed in the area is the Allegheny Formation of Pennsylvanian age. It is exposed in the valleys and on the lower hillsides in the extreme northern part of the Hancock County and along the axis of the Burning Springs anticline in Pleasants County.

The Conemaugh Group of Pennsylvanian age, which overlies the Allegheny Formation, is the predominant unit exposed in Hancock County and also is exposed on the lower slopes and in the valleys in Brooke County and western Ohio County and along the Burning Springs anticline in Pleasants County.

The Monongahela Group of Pennsylvanian age, overlies the Conemaugh Group and is exposed on the hills in northern Brooke County and in the valleys in Pleasants, Marshall, and Ohio Counties. In Tyler and Wetzel Counties, it is exposed in a few places along the Ohio River.

The Dunkard Group of Pennsylvanian and Permian age, overlies the Monongahela Group and is exposed over most of the area. The major exceptions are all of Hancock County and the northern half of the Brooke County and a narrow band along the Burning Springs anticline in Pleasants County.

Cardwell and others (1968, geologic map) describe the above lithology. The stratigraphic nomenclature used in this report follows the usage of the West Virginia Geological and Economic Survey and does not necessarily conform to that used by the U.S. Geological Survey.

The only major geologic structure in the project area is the north-trending Burning Springs anticline in the western part of Pleasants County. "The structural relief of this anticline is fully 1,800 feet" (Haught, 1955a), bringing rocks of the Allegheny Formation to the surface along its axis. The other structural features in the project area are gentle anticlines and synclines with minor structural relief.

The yield of water from wells that tap the consolidated rock units is typically low, ranging from less than 1 to as much as 300 gal/min. The median yield is about 6 gal/min. The mean specific capacity of wells drilled in the consolidated rocks is about 0.5 (gal/min)/ft of drawdown. Most of the ground water withdrawn from the consolidated sedimentary rocks is derived from secondary permeability features such as bedding-plane partings and fractures.

2.0 GEOLOGY AND WATER-BEARING CHARACTERISTICS--Continued

2.2 Unconsolidated Alluvial Deposits

THE ALLUVIUM, WHICH IS MORE THAN 100 FEET THICK IN SOME PLACES, PROVIDES CONSIDERABLE GROUND-WATER STORAGE

The alluvial deposits of Quaternary age are limited mostly to the flood plain of the Ohio River but contain an estimated 50 billion gallons of ground water.

The alluvium is limited mostly to the flood plain of the Ohio River and ranges in thickness from 0 feet along the hillsides to more than 100 feet in some places near the river. The lower part of the alluvial deposits consists of sand and gravel of glacial outwash origin (Deutsch and others, 1966) and is overlain by a layer of clay and silt of fluvial origin as thick as 30 to 40 feet (fig. 2-2-1). The clay and silt layer contains sand stringers. On the basis of drillers' logs of some test wells near Sistersville, the clay-silt layer thins toward the hills (fig. 2.2-2). In some areas, tributary streams have deposited a gravel delta on the alluvial deposits described above where they enter the valley of the Ohio River. The gravel deltas are in probable hydrologic continuity with the gravel in the Ohio River valley. This situation is believed to be similar to that in southwestern New York described by Crain (1966).

In some localities, the alluvium has been covered with fill such as slag from steel-processing plants, waste from coal mines, or other locally derived waste. This material ranges in thickness from a few inches to 25 feet or more and may contain soluble constituents that could be leached by water percolating to the water table.

The amount of water in storage in the alluvium of the project area can be estimated if certain assumptions are made. The areal extent of the alluvium is estimated to be about 32 square miles. The mean thickness of the saturated sand and gravel aquifer is estimated to be about 36 feet as determined from well logs and water-level measurements. This amounts to about 0.2 cubic mile of saturated aquifer, or about 740,000 acre-feet. **Specific yield**¹ is assumed to be 20.5 percent, based on the **porosity** and **specific retention** of typical sand and gravel aquifers (Heath, 1983). Consequently, the amount of water in storage in the alluvial aquifer within the project area is approximately 152,000 acre-feet or 50 billion gallons.

The ground water in the alluvium is generally in a water-table (**unconfined**) condition. In some localities where the gravel is relatively thin and the overlying clay-silt layer is relatively thick, **semiconfined** conditions may exist. These conditions are more common at higher river stage. Perched water has also been reported in fill overlying the alluvium.

¹ Words that appear in **bold** are found in the "Definition of Terms" section.

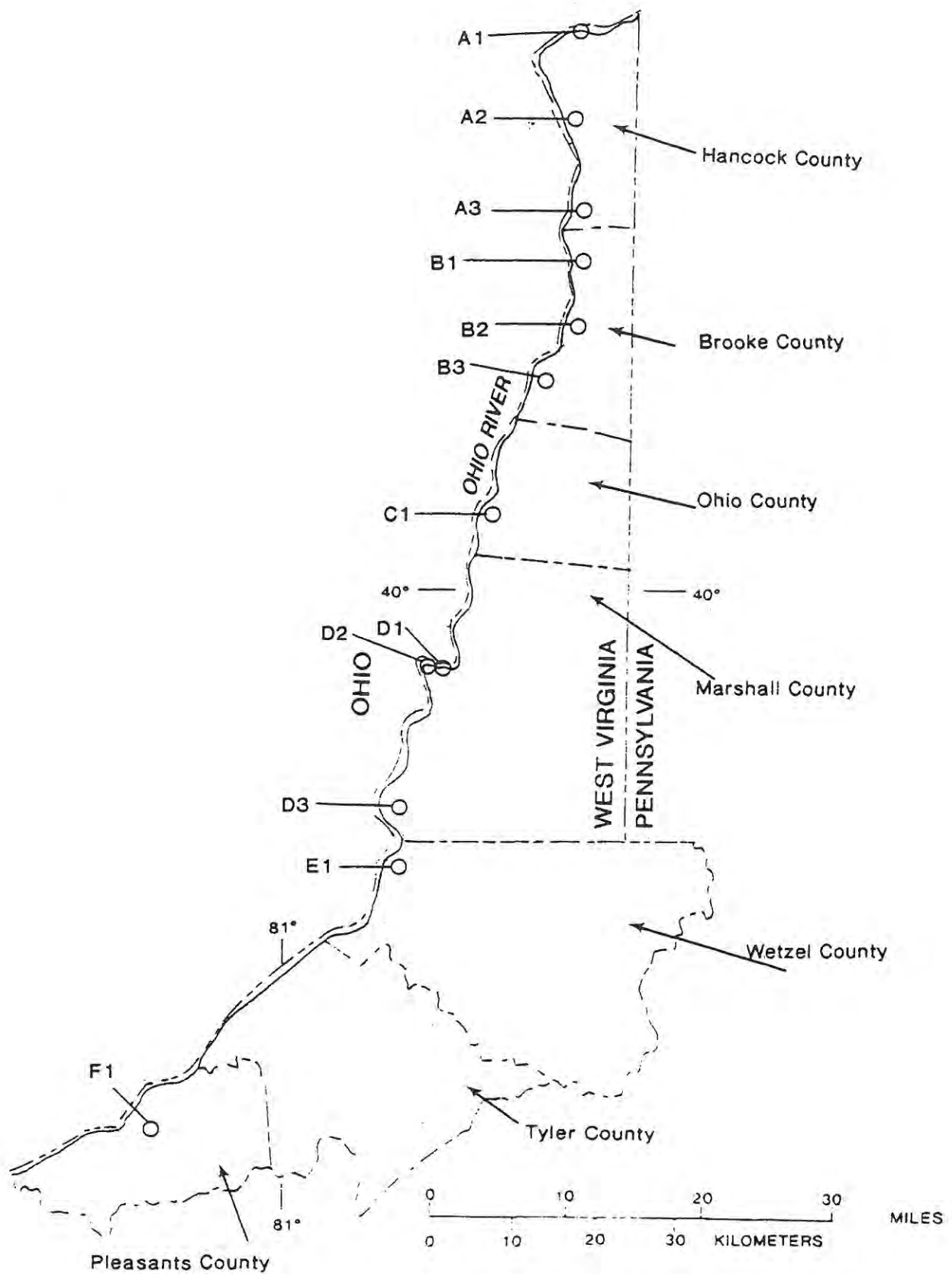


Figure 2.2-1. -- Drillers' logs of selected wells in the alluvium (Carlston and Graeff, 1955).

DEPTH (feet)

A1		
Fill	0	25
Sand and gravel	25	30
Sand and gravel, some clay	30	83
Bedrock	83	-

A2		
Sand, gravel and boulders	0	33.9
Clay (bedrock)	33.9	-

A3		
Sand, gravel, and boulders	0	37.2
Soft shale (bedrock)	37.2	-

B1		
Ashes	0	15
Yellow clay and sand	15	30
Clay, sand, and stones	30	35
Hard clay and sand	35	38
Clay and stones	38	44
Gravel, 7% clay	44	46
Gravel	46	55
Gravel, 4% clay	55	60
Gravel, 7% clay	60	65
Bedrock	65	-

B2		
Loam	0	3
Dry sand, dirt, and gravel	3	27
Coarse sand, gravel, and boulders	27	82

B3		
Cinders and clay	0	15
Clay	15	20
Sand	20	30
Clay and stones	30	35
Gravel and sand	35	55
Sand	55	60
Sand and gravel	60	74
Rock	74	-

C1		
Silt and fine sand	0	8
Coarse gravel, fine sand	8	16
Coarse gravel, boulders, and fine sand	16	26
Coarse gravel, medium sand, and boulders	26	37
Medium gravel, medium sand	37	46.3
Shale (bedrock)	46.3	-

Figure 2.2-1. - - Drillers' logs ... (continued).

D1

Sandy clay	0	-	22
Clay, sand, and gravel	22	-	33
Silt, sand, and gravel	33	-	40
Sand and gravel	40	-	72

D2

Clay	0	-	8
Clay and sand	8	-	31
Clay, sand, and gravel	31	-	40
Gravel and sand	40	-	75
Bedrock	75	-	

D3

Sand, yellow clay	0	-	7
Clay-bound, mixed gravel	7	-	16
Coarse gravel and cobbles	16	-	20
Very coarse gravel and cobbles	20	-	27
Coarse sand, pea gravel and scattered medium and coarse gravel	27	-	33
Fine and medium sand, pea gravel scattered medium gravel	33	-	35
Medium and coarse sand, pea gravel, and scattered medium and coarse gravel	35	-	45
Coarse sand, pea gravel, and scattered medium gravel	45	-	50
Coarse sand, pea gravel, medium gravel, and scattered coarse gravel	50	-	55
Fine to coarse sand, with pea gravel and scattered medium gravel (heaved strongly at 63 feet)	55	-	65
Medium and coarse sand, pea gravel, and medium gravel	65	-	70
Coarse sand, pea gravel, medium gravel, and occasional boulders	70	-	86.8
Blue-green shale (bedrock)	86.8	-	

E1

Topsoil	0	-	4
Sand and gravel and clay	4	-	24
Fine gravel and sand	24	-	44
Coarse gravel and sand	44	-	59
Bedrock	59	-	

F1

Clay	0	-	15
Sandy loam	15	-	55
Sand and gravel	55	-	75
Rock	75	-	

Figure 2.2-1. -- Drillers' logs ... (continued).

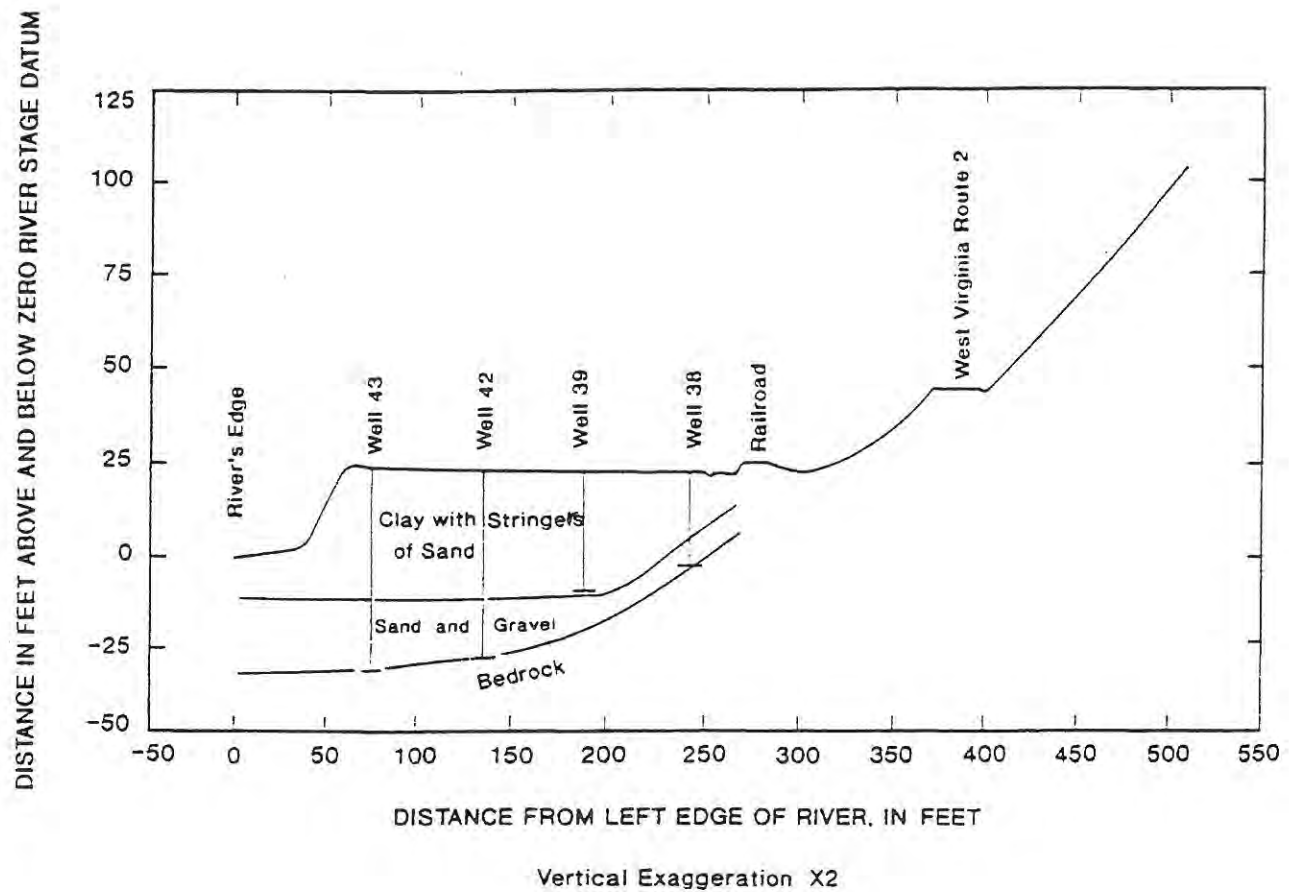


Figure 2.2-2. - - Geologic section of alluvium at the Sistersville section.

3.0 GROUND-WATER SYSTEM

3.1 Recharge, Movement, and Discharge

RECHARGE TO THE ALLUVIUM IS DERIVED FROM SEVERAL SOURCES

Sources of recharge to the aquifer are infiltration of precipitation through the clay-silt layer, inflow through fractures and bedding-plane partings in the bedrock beneath and adjacent to the alluvium, inflow from tributary streams through gravel deltas, and induced inflow from the river.

Part of the precipitation that falls on the surface of the alluvium, as well as some of the overland flow from the bedrock highlands, percolates through the clay-silt layer to recharge the sand and gravel deposits of the alluvium. Although the clay-silt layer overlying the sand and gravel was originally believed to be nearly impermeable (Carlston and Graeff, 1955), water-quality data indicate that water does percolate through this layer into the more permeable sand and gravel zone. As shown by the drillers' logs in figure 2.2-1 (preceding section), the clay-silt layer is not uniform in thickness and composition; thus, the amount and rate of percolation are variable.

Further evidence of percolation through the clay-silt layer is indicated by the abnormally high concentration of sulfate in ground water beneath or near areas containing fill. This indicates that sulfate has been leached from the fill (see section 4.6).

Under natural conditions, ground water flows from the adjacent hills toward the Ohio River. The water level in wells at the Sistersville site remained slightly above the level of the river during this project. Response of the water table in the aquifer system was almost immediate when the level of the river rose or fell, as indicated by river stage and water-level fluctuations shown in figure 3.1-1. Well 43 is about 75 feet from the river's edge and does not penetrate bedrock. Well 34, open only to the bedrock, is about 120 feet downstream from well 43 and about 250 feet from the river. The hydrographs (fig. 3.1-1) indicate that the water level in both wells responds almost identically. The almost instantaneous response of the bedrock well to river-stage fluctuations indicates that the bedrock and the alluvium are hydraulically interconnected. This condition probably exists throughout the study area.

3.0 GROUND-WATER SYSTEM--Continued

3.1 Recharge, Movement, and Discharge--Continued

Some inflow into the alluvium occurs through fractures in the bedrock under the hillsides. The occurrence of open fractures is dependent on stress acting on the rock. Some fractures are located near anticlines (Clark and others, 1976), and a system of bedding-plane partings exists beneath the floor of the valleys (Wyrick and Borchers, 1981). Both of these fractures systems allow recharge to enter the alluvium from the adjacent bedrock.

Tributary streams flowing onto the alluvium from the hills have deposited gravel deltas at the edge of the Ohio River valley. Water flowing from these streams can percolate through the deltas to the gravel under the clay-silt layer. This phenomenon has been described by Crain (1966) in western New York State. Discharge in Little Grave Creek at Moundsville, West Virginia (see fig. 1.3-1), decreased from an estimated 10 ft³/s in the upstream bedrock area to an estimated 0.5 ft³/s downstream on the alluvial flood plain (Friel, E.A., U.S. Geological Survey, oral commun., 1984). Thus, Little Grave Creek appears to be providing considerable recharge to the alluvium.

Man's activities can change the natural ground-water flow pattern and thus affect recharge. Recharge to the alluvium from the Ohio River may occur when the aquifer close to the river is pumped heavily and the ground-water level is drawn below the river level. This recharge is limited to the alluvial area between the river and pumped well. However, under natural conditions the water level in the aquifer is above the river in most places. Furthermore, the permeability of the streambed probably is quite low. In describing conditions in the Scioto River valley in Ohio, Norris and Fidler (1969, p. 45) state: "The vertical permeability of the streambed sediments is thus only about one-thirteenth as high as the vertical permeability measured across the full thickness of the aquifer. A layer of silt, mud, and organic debris, possibly having penetrated no more than a few inches into the underlying sediments, is thought to be chiefly responsible for the relatively low permeability of the streambed." The same conditions have been observed on the Ohio River and probably limit recharge to the alluvium from the river.

Discharge from the alluvium occurs at the riverbed and riverbank from both the saturated and unsaturated zones. Ground water from the saturated zone of the alluvium, which is comprised mostly of sand and gravel, enters the river through its bed. Discharge from the unsaturated zone occurs at the riverbank where water emerges from the thin sand layers in the upper clayey part of the alluvium. The water in that part of the unit can flow horizontally along the sand layers more easily than vertically through the clay and silt layers.

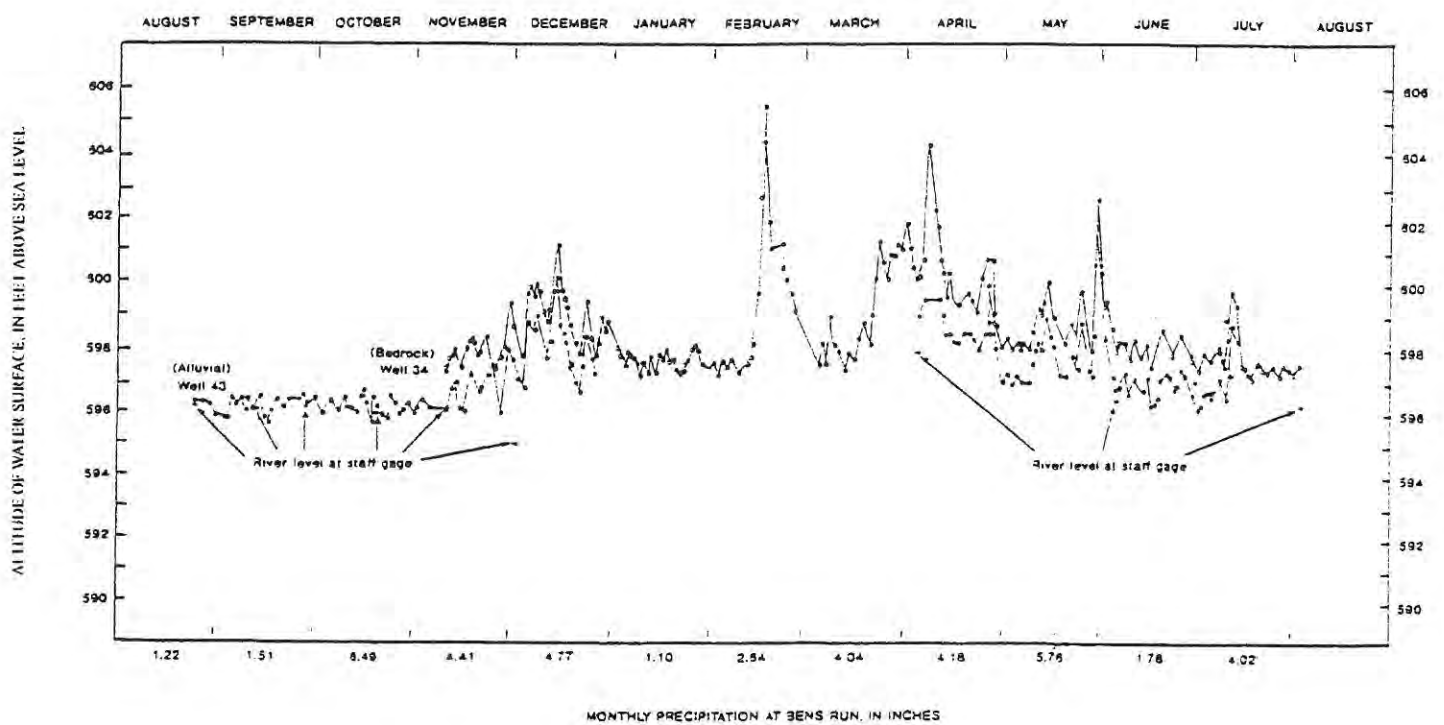


Figure 3.1-1. - - Hydrographs of two wells at Sistersville site.

3.0 GROUND-WATER SYSTEM--Continued

3.2 Hydraulic Characteristics of Alluvial Aquifer

SPECIFIC CAPACITY, SATURATED THICKNESS, TRANSMISSIVITY, AND HYDRAULIC CONDUCTIVITY WERE DETERMINED FOR THE OHIO RIVER ALLUVIUM

The alluvium has the following hydraulic characteristics: Mean specific capacity--49 gallons per minute per foot of drawdown, mean saturated thickness of aquifer--36 feet, mean transmissivity--6,300 feet squared per day, and mean hydraulic conductivity--170 feet per day.

Specific capacity of 65 wells ranged from 7 to 198 (gal/min)/ft with a mean of 49 (gal/min)/ft and a median of 38 (gal/min)/ft (fig. 3.2-1). Specific capacities were obtained from well-site inventories, drillers' records, earlier studies, and consultants' reports. The specific capacities were determined for varying conditions of river stage, well efficiency, and direction of ground-water movement, as well as water-table and semiconfined aquifer conditions. Drawdown for a given yield increases as well screens become partially clogged, and thus well efficiency decreases with time. Induced infiltration from the Ohio River decreases drawdown and increases specific capacity. Some alluvial wells are capable of yielding several hundred gallons of water per minute. Yields of more than one thousand gallons per minute have been reported.

The saturated thickness of the alluvium ranged from 19 to 56 feet with a mean of 36 feet and a median of 34 feet (fig. 3.2-2). These values were obtained during various river stages, which directly affect the water level and thus the saturated thickness. The construction of locks and dams and the consequent raising of the river pools behind these dams has increased the saturated thickness of the alluvium. Saturated thickness was determined by subtracting the depth to the static water level from the depth to bedrock. The effect of confinement upon static water levels was assumed to be minimal for the purpose of estimating saturated thickness.

Estimated transmissivities ranged from 1,100 to 17,000 ft²/d with a mean of 6,300 ft²/d and a median of 5,100 ft²/d (fig. 3.2-3). Transmissivity gives an indication of the rate of movement of ground water. Transmissivities were estimated from the specific capacities of 32 alluvial wells with pumping tests of known duration using the following equation developed by Theis (Bentall, 1963):

EXPLANATION

54 ● Well -- Number is specific capacity in gallons per minute per foot of drawdown

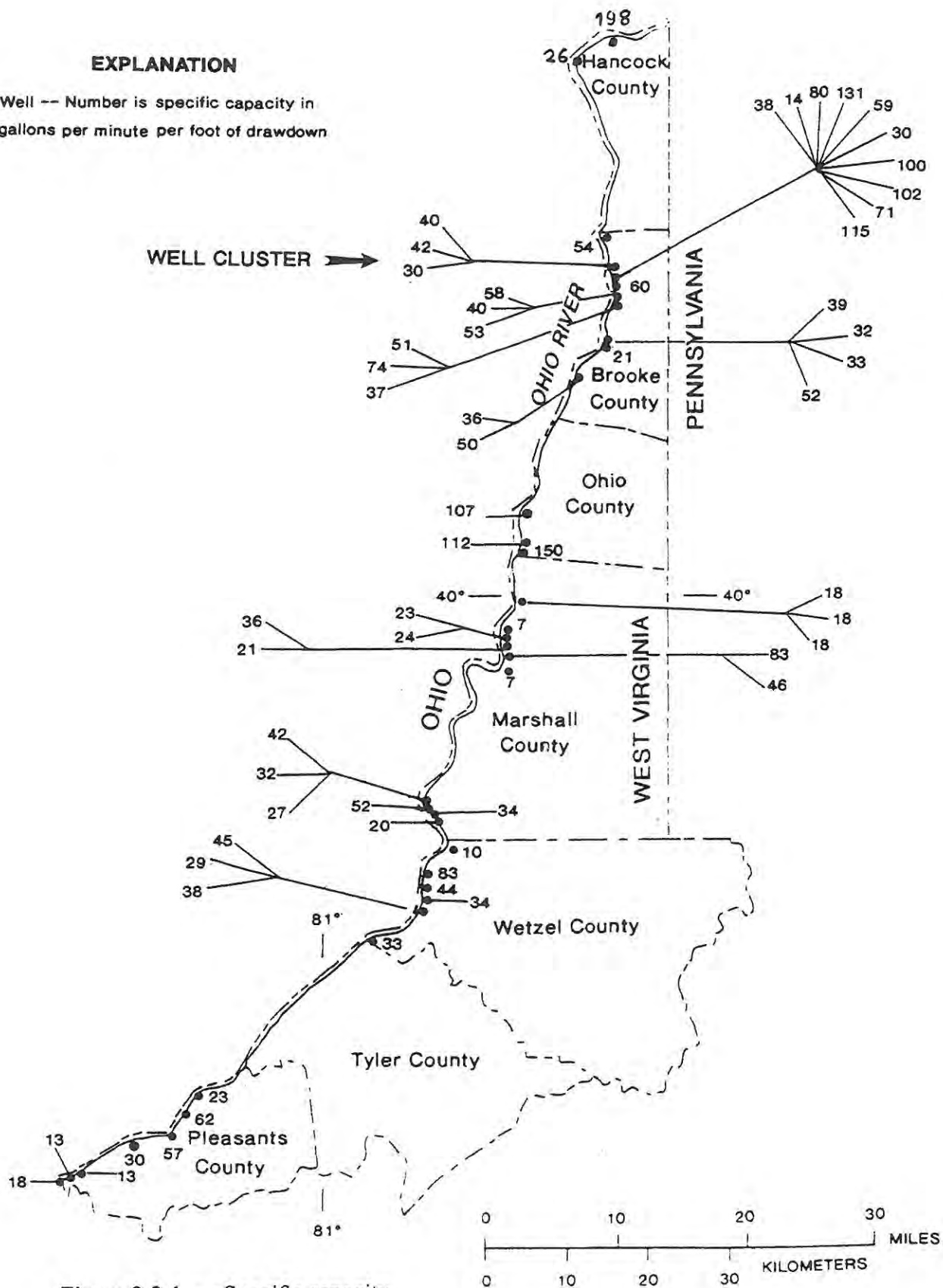


Figure 3.2-1. -- Specific capacity.

EXPLANATION

38 ■ Well -- Number is saturated thickness of alluvial aquifer in feet

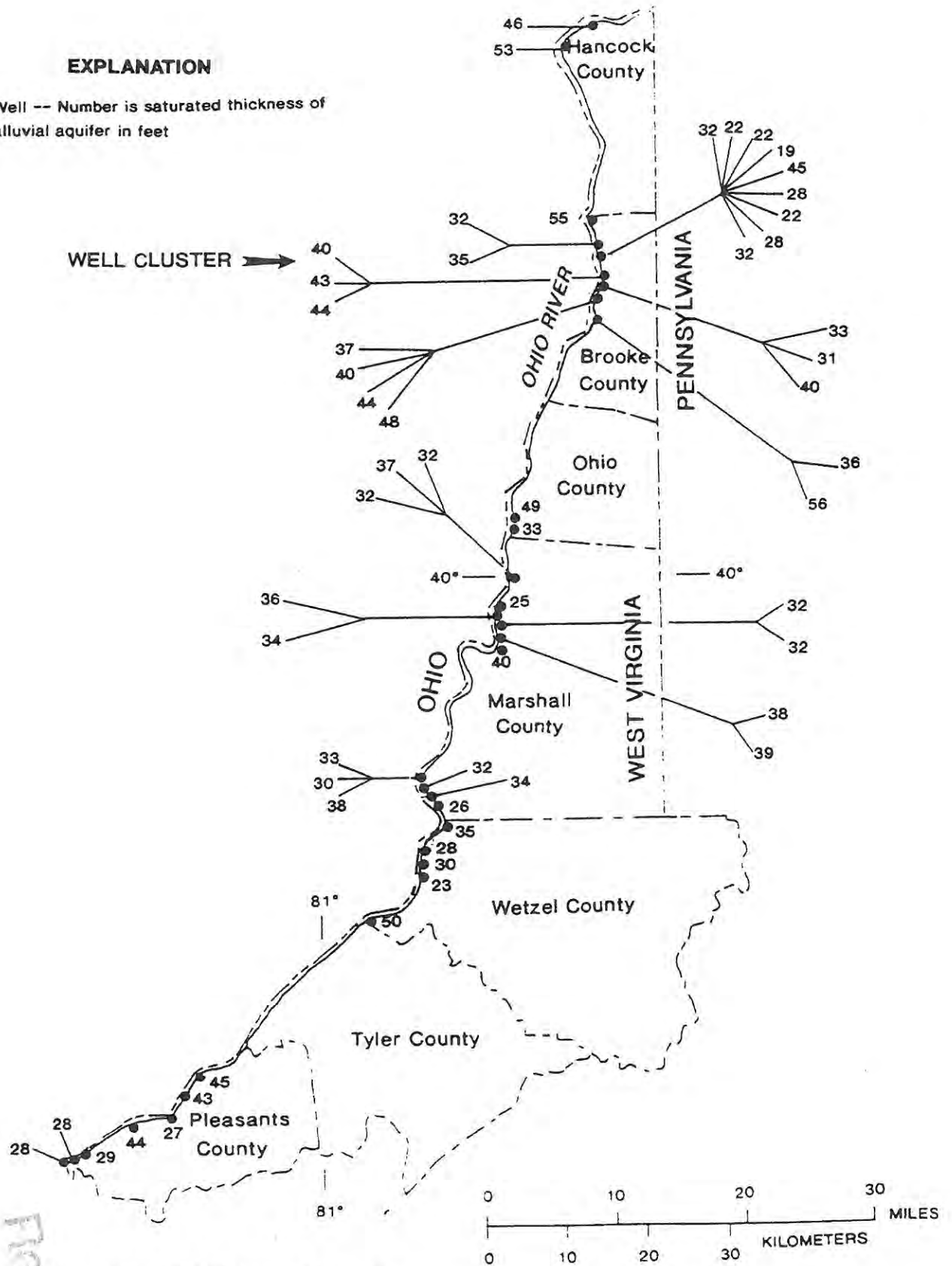


Figure 3.2-2. -- Saturated thickness of aquifer.

EXPLANATION

9200 • Well -- Number is estimated transmissivity in feet squared per day

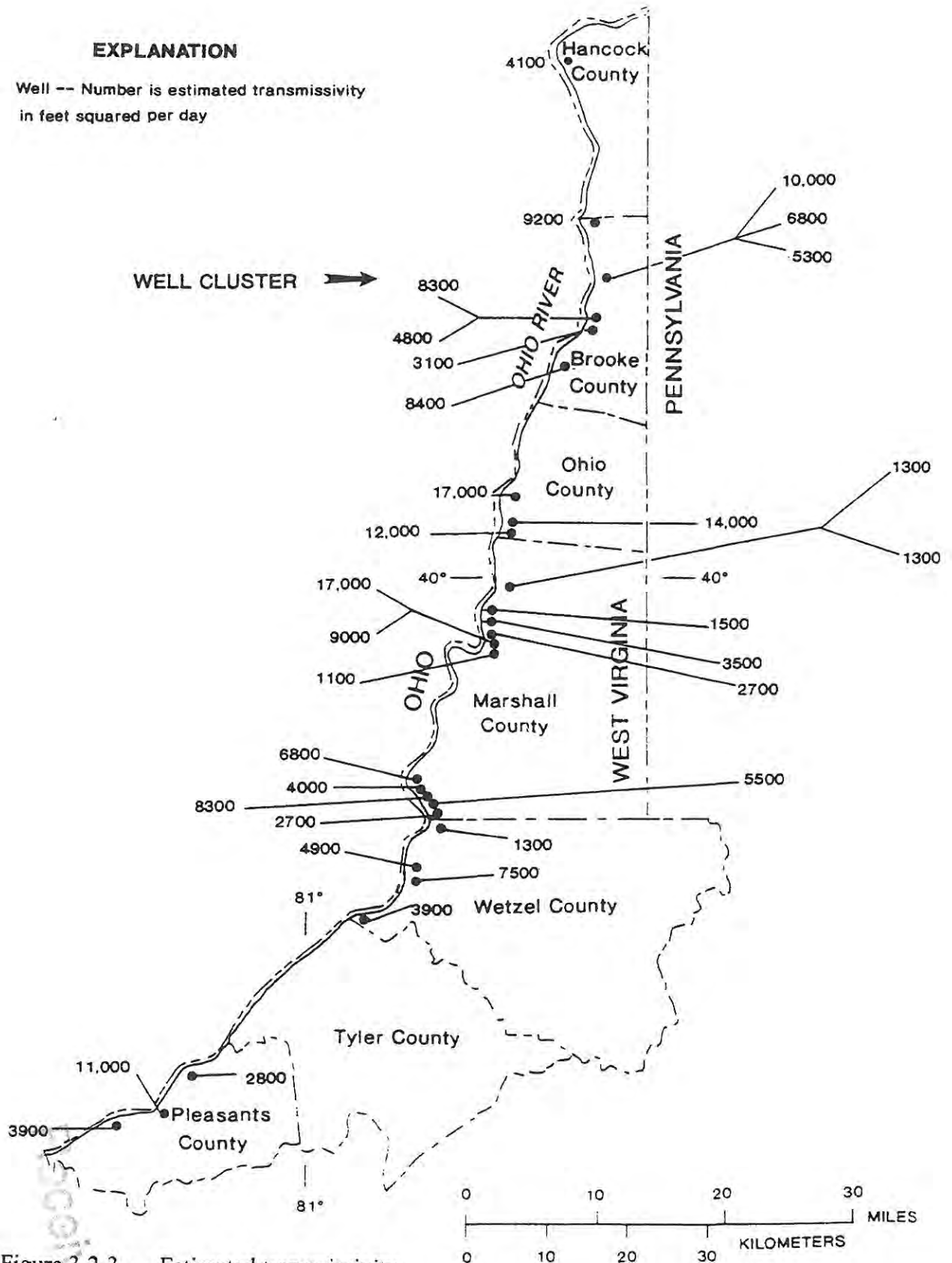


Figure 3.2-3. -- Estimated transmissivity.

3.0 GROUND-WATER SYSTEM--Continued

3.2 Hydraulic Characteristics of Alluvial Aquifer--Continued

$$T' = C(1 \pm 0.3) (1,300 - 264 \log_{10} 5S + 264 \log_{10} t)$$

where: T' is an intermediate value of transmissivity,
 C is the specific capacity of the pumped well,
 S is the aquifer **storage coefficient**, and
 t is the time, in days, that the well was pumped.

The estimated transmissivity is determined graphically from " T' " and " C ". To simplify calculations, well diameter was assumed to be 1 foot, and storage coefficient was assumed to be 0.2.

Several transmissivities reported in previous studies were much higher than those estimated in this report. Reasons for the higher reported transmissivities are (1) pumping tests of insufficient duration, (2) storage coefficients less than 0.2 in some areas, and (3) induced infiltration to the alluvium from the Ohio River.

Hydraulic conductivity was computed for 30 wells by dividing the estimated transmissivity by the saturated thickness. The hydraulic conductivity ranged from 27 to 460 ft/d with a mean of 170 ft/d and median of 140 (ft/d) (fig. 3.2-4). The hydraulic conductivity can be used to compute the **specific discharge** if the **hydraulic gradient** is known. Ground-water movement is in the direction of the hydraulic gradient. Under natural conditions, the hydraulic gradient dips gently from the hills to the Ohio River. The median slope of the water table at the Sistersville site was 0.001 foot/foot during the period April 1983 to November 1984. Withdrawal of large quantities of water from wells close to the Ohio River can reverse this gradient between the pumped wells and the river. The direction and slope of the hydraulic gradient is affected close to lock and dam sites where river pools of different elevations meet abruptly. Sources of recharge such as ponds, lakes, and streams on the alluvial flood plain also affect the hydraulic gradient.

All aquifer characteristics calculated in this report are variable with time and geographical location and should be used with discretion.

EXPLANATION

170 ● Well -- Number is estimated hydraulic conductivity in feet per day

WELL CLUSTER →

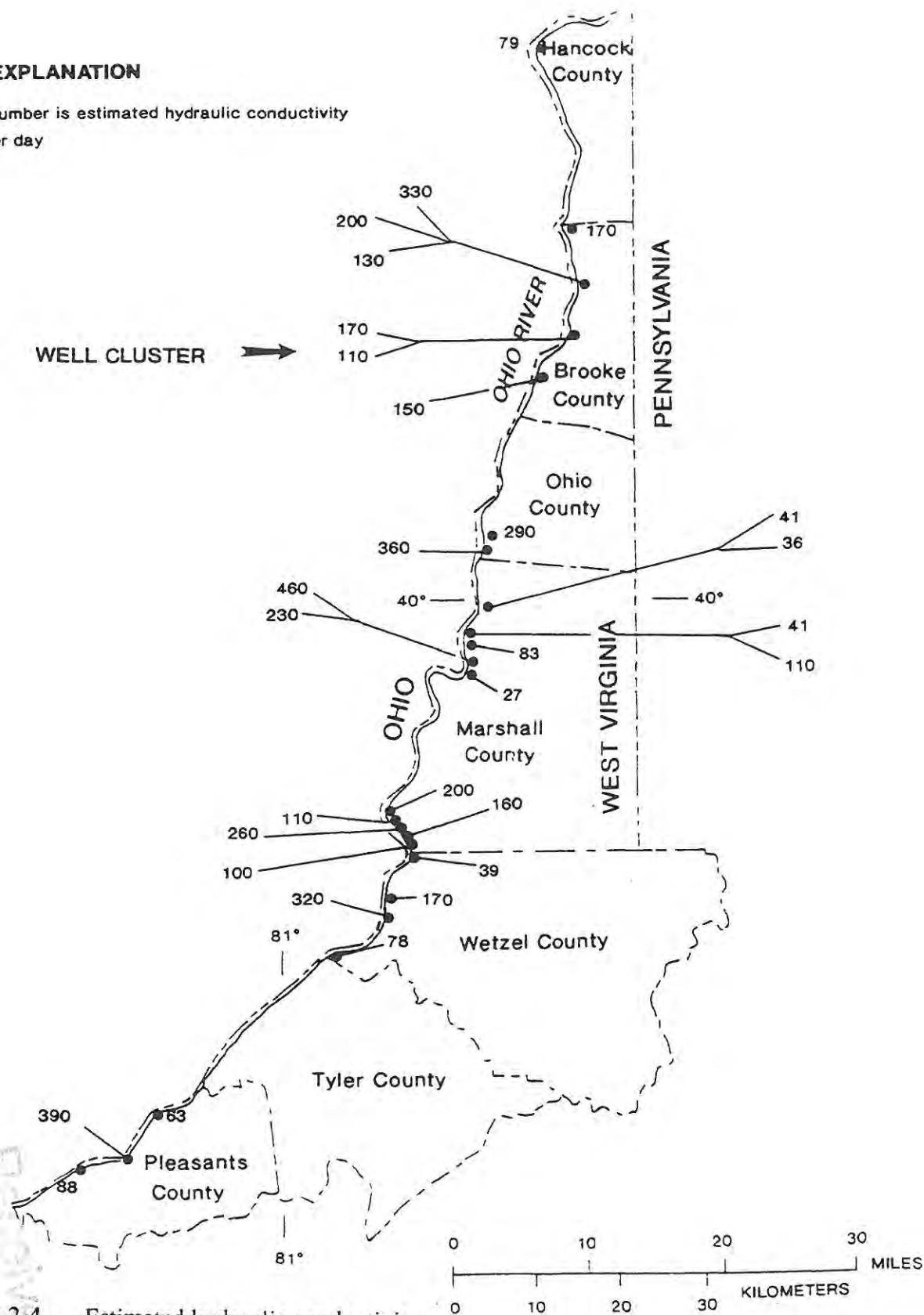


Figure 3.2-4. -- Estimated hydraulic conductivity.

4.0 WATER QUALITY

4.1 Data Collection

GROUND-WATER SAMPLES FROM MORE THAN FIFTY WELLS WERE ANALYZED

Water samples from alluvial wells, bedrock wells on or near the alluvial flood plain, and radial collectors were analyzed.

More than 50 ground-water samples were analyzed during the study. Samples were collected from wells drilled into alluvium, wells drilled into bedrock, and from radial collectors with laterals extending into the alluvium and, in places, under the Ohio River. Analyses included all major cations and anions, several metals, phenols, and dissolved organic carbon. Several additional samples from bedrock wells near the alluvial flood plain were collected during a previous study (Shultz, 1984) and are incorporated into this report. These wells were sampled for major cations and anions and common metals. The locations of sampled wells are shown on figure 4.1-1. Alluvial wells are designated with an "A," bedrock wells with a "B," and radial collectors with an "R." The data collected as part of this study are in the U.S. Geological Survey files.

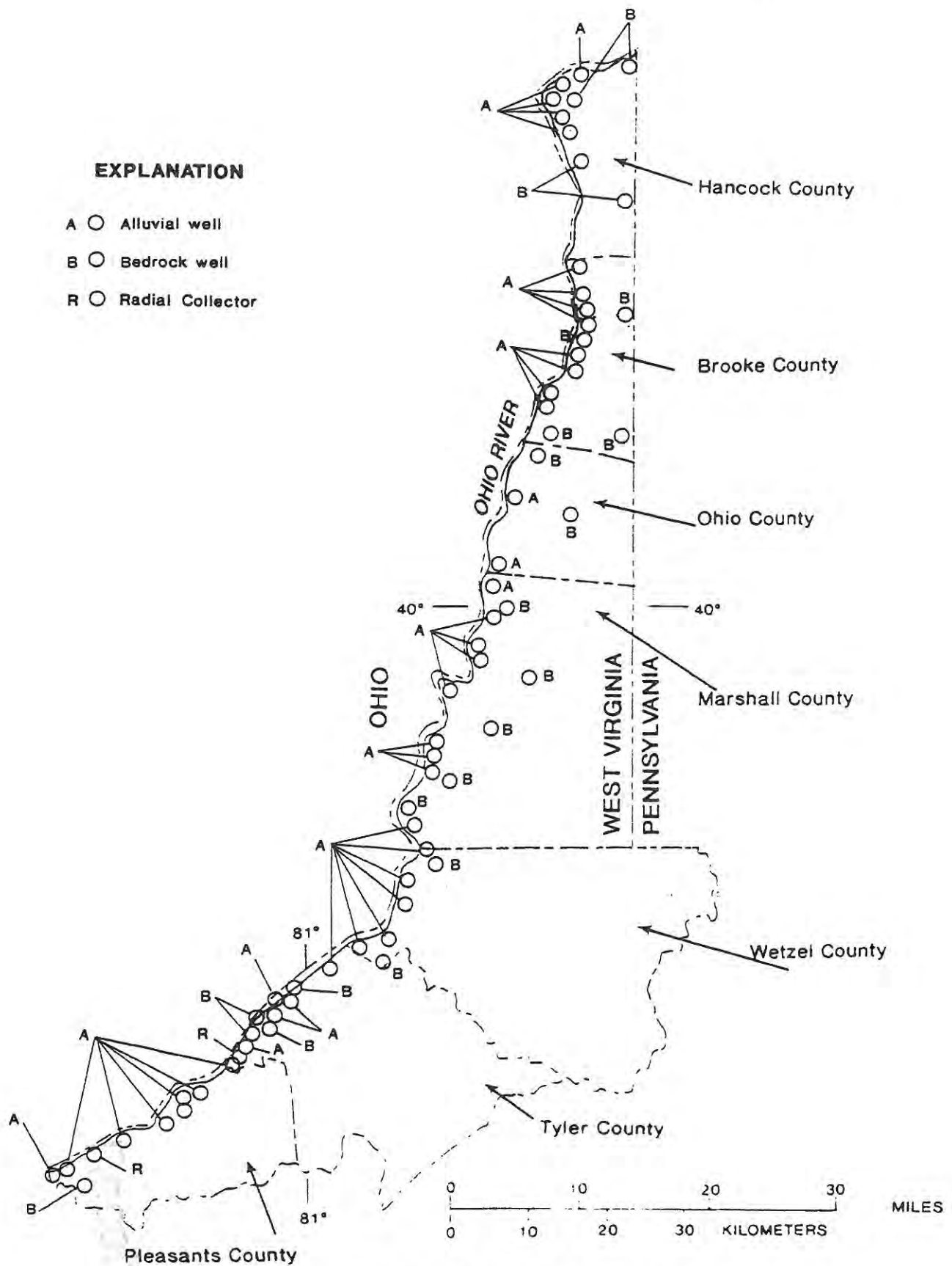


Figure 4.1-1. - Location of ground-water sampling sites.

4.0 WATER QUALITY--Continued

4.2 Water Type

CALCIUM BICARBONATE WAS THE MOST COMMON WATER TYPE

Calcium bicarbonate was the predominant water type in 35 percent of the well samples.

Water type was determined for well samples collected during the study (fig. 4.2-1). Water type is based on predominant cations and anions. Calcium bicarbonate was the most common water type, accounting for 35 percent of the samples. Calcium, with a mixture of bicarbonate and sulfate, was the second most common type, comprising 18 percent of the samples. Ten other water types were present, each totaling 8 percent or less of the samples. These water types included various combinations of calcium, sodium, and magnesium with bicarbonate, sulfate, and chloride.

Calcium was the most predominant cation in 71 percent of the samples. Sodium was the second most common cation and was predominant in 15 percent of the samples. The remaining samples were various mixtures of calcium, sodium, and magnesium, with no single cation predominating.

Bicarbonate was the predominant anion in 50 percent of the samples. Sulfate and chloride were predominant in 9 and 8 percent of the samples respectively. The remaining samples were various mixtures of bicarbonate, sulfate, and chloride, with no single anion predominating.

Saltwater (sodium chloride type water) is a problem in Tyler and Pleasants Counties and in parts of the northern panhandle (see section 4.3). Sulfate is not normally a predominant anion, but can predominate in areas containing fill (see section 4.6).

Plates 1-3 contain more detailed descriptions of the ground-water chemistry.

EXPLANATION

- A ○ Alluvial well
- B ○ Bedrock well
- R ○ Radial Collector

PREDOMINANT CATIONS

- ⊕ Calcium
- ⊕ Sodium
- No predominant cation
(greater than 50 percent)

PREDOMINANT ANIONS

- ⊕ Bicarbonate
- ⊕ Sulfate
- ⊕ Chloride
- No predominant anion
(greater than 50 percent)

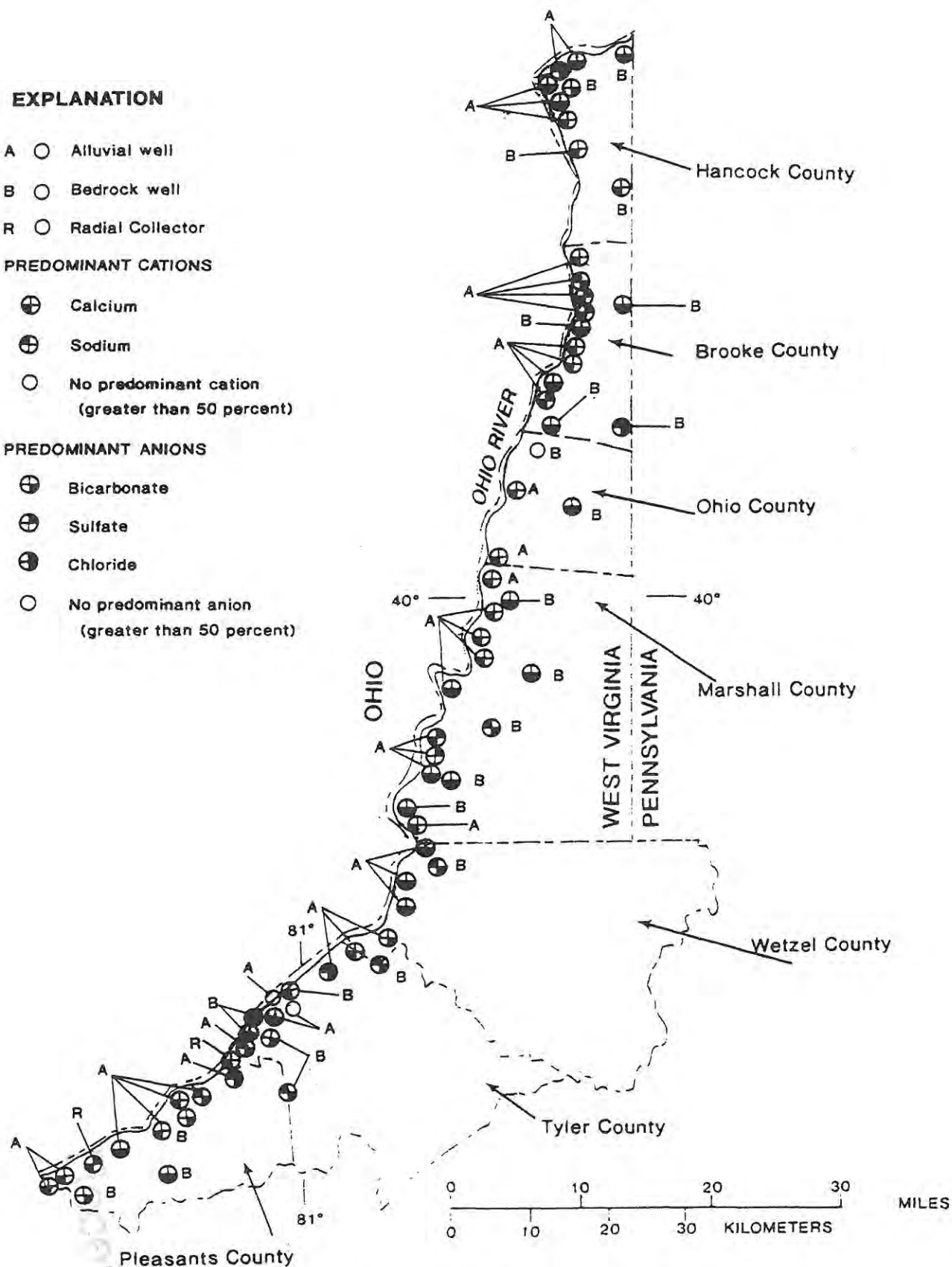
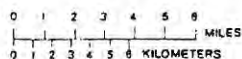
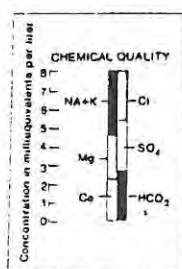


Figure 4.2-1. - - Areal distribution of cations and anions.

EXPLANATION

- Well
- Well, Chemical Analysis Available
- ⊙ Well, Log Available
- ⊙ Well, Chemical Analysis and Log Available



WELL DATA

- | | | |
|--|------------|--|
| Depth to water level, in feet below land surface | 25(11/79) | Month and year of water level measurement |
| Well depth, in feet | D-73 Y-762 | Well yield, in gallons per minute |
| Depth to bedrock, in feet | B-80 SC-54 | Well specific capacity, in gallons per minute per foot of drawdown |

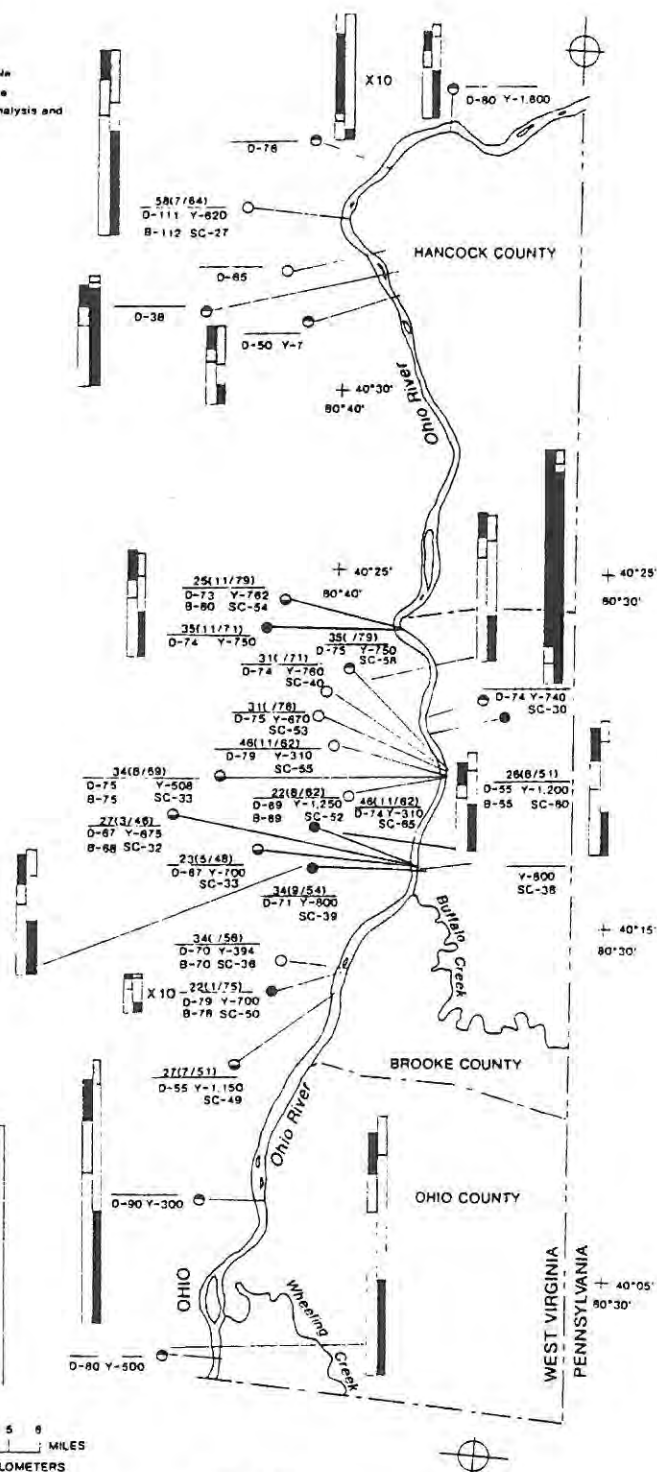


Plate I.--Map showing hydrologic and physical characteristics of selected alluvial wells in Ohio, Brooke, and Hancock Counties.

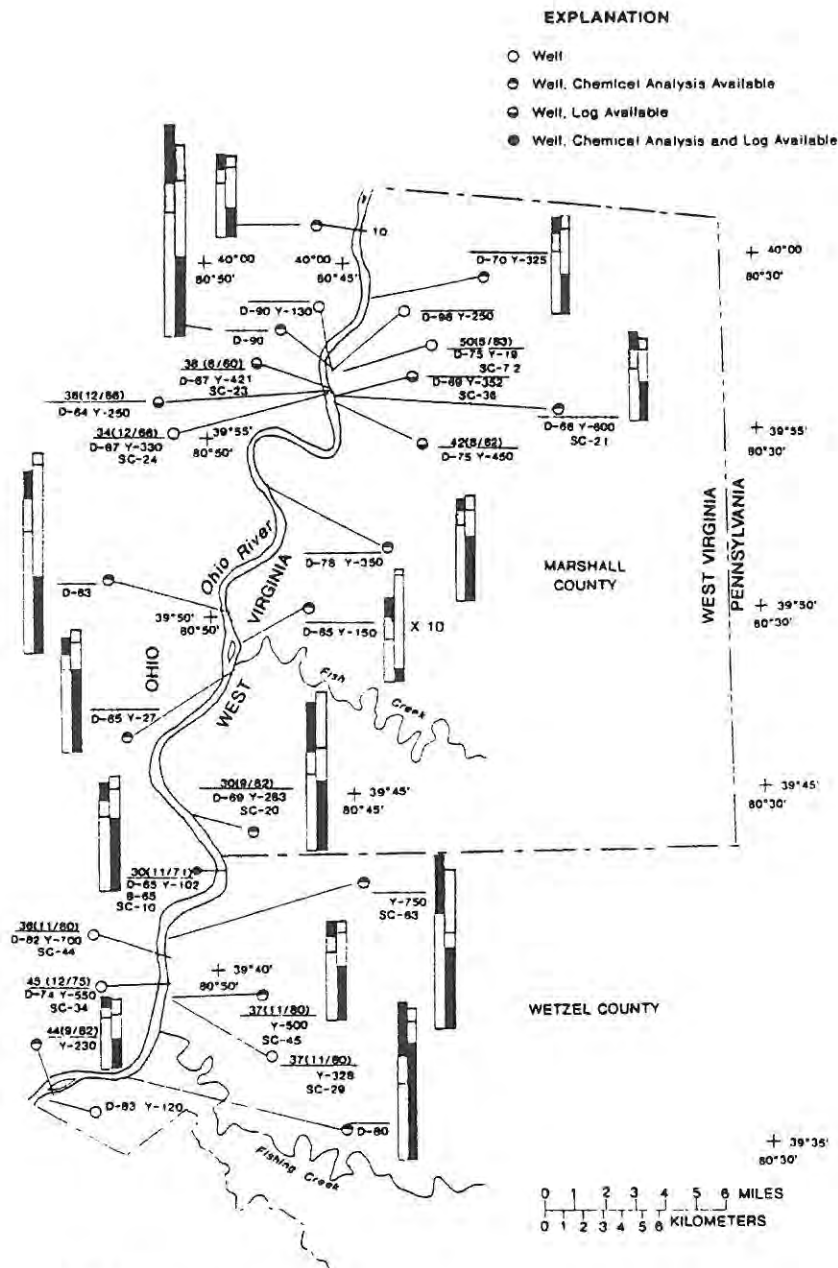


Plate 2.--Map showing hydrologic and physical characteristics of selected alluvial wells in Marshall and Wetzel Counties.

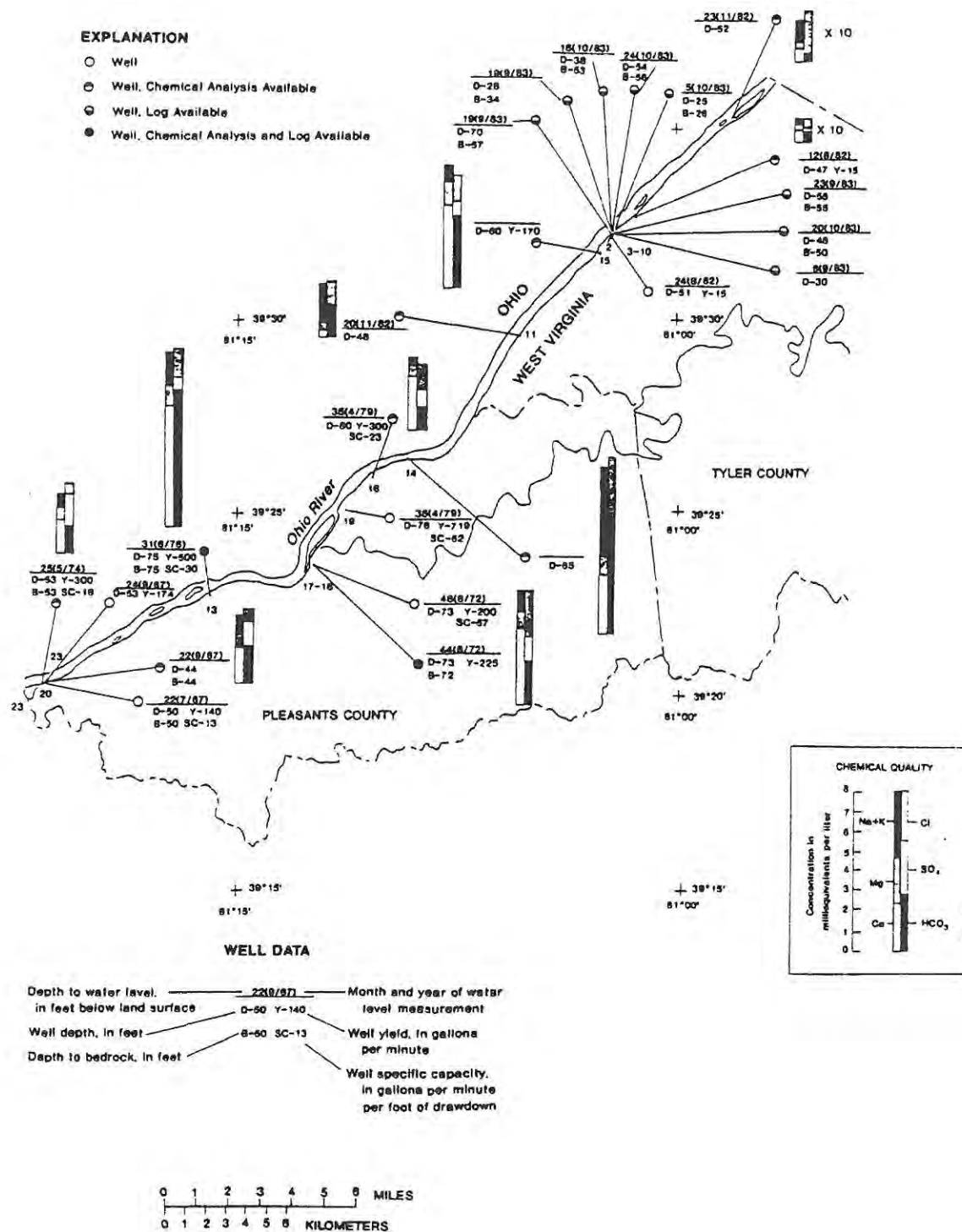


Plate 3.--Map of hydrologic and physical characteristics of selected alluvial wells in Tyler and Pleasants Counties.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents

4.3.1 Saltwater

EIGHT PERCENT OF SAMPLED WELLS CONTAINED SALTWATER

Although saltwater underlies all of the area at varying depth, only eight percent of the sampled wells contained sodium chloride type water.

Sodium chloride was the predominant constituent in 8 percent of the sampled wells. Increasing chloride concentration may be the first indication of saltwater contamination. The West Virginia State Board of Health (1981) recommends a limit of 250 mg/L of chloride for drinking water. Figure 4.3.1-1 shows the areal distribution of chloride concentration in ground water. One area of high chloride concentration is in Tyler and Pleasants Counties. Carlston and Graeff (1955) report that leakage from old oil wells may be contaminating freshwater zones in the Sistersville, Bens Run, St. Marys, Belmont, and Waverly areas.

Saltwater underlies all of the area at depths ranging from land surface to about 500 feet (Foster, 1980). (Foster, 1980) shows locations where it is within 100 feet of the land surface. Factors affecting the depth to saltwater include geology, topography, ground-water circulation, and human activities.

The depth to saltwater is shallower on the alluvial flood plain and in valleys than on hillside or hilltops. Fewer well owners report saltwater contamination on hillsides and hilltops than in valleys. This can be explained by the relation between the fresh ground water and the underlying saltwater and by the circulation of water from areas of recharge to areas of discharge (fig. 4.3-1.2).

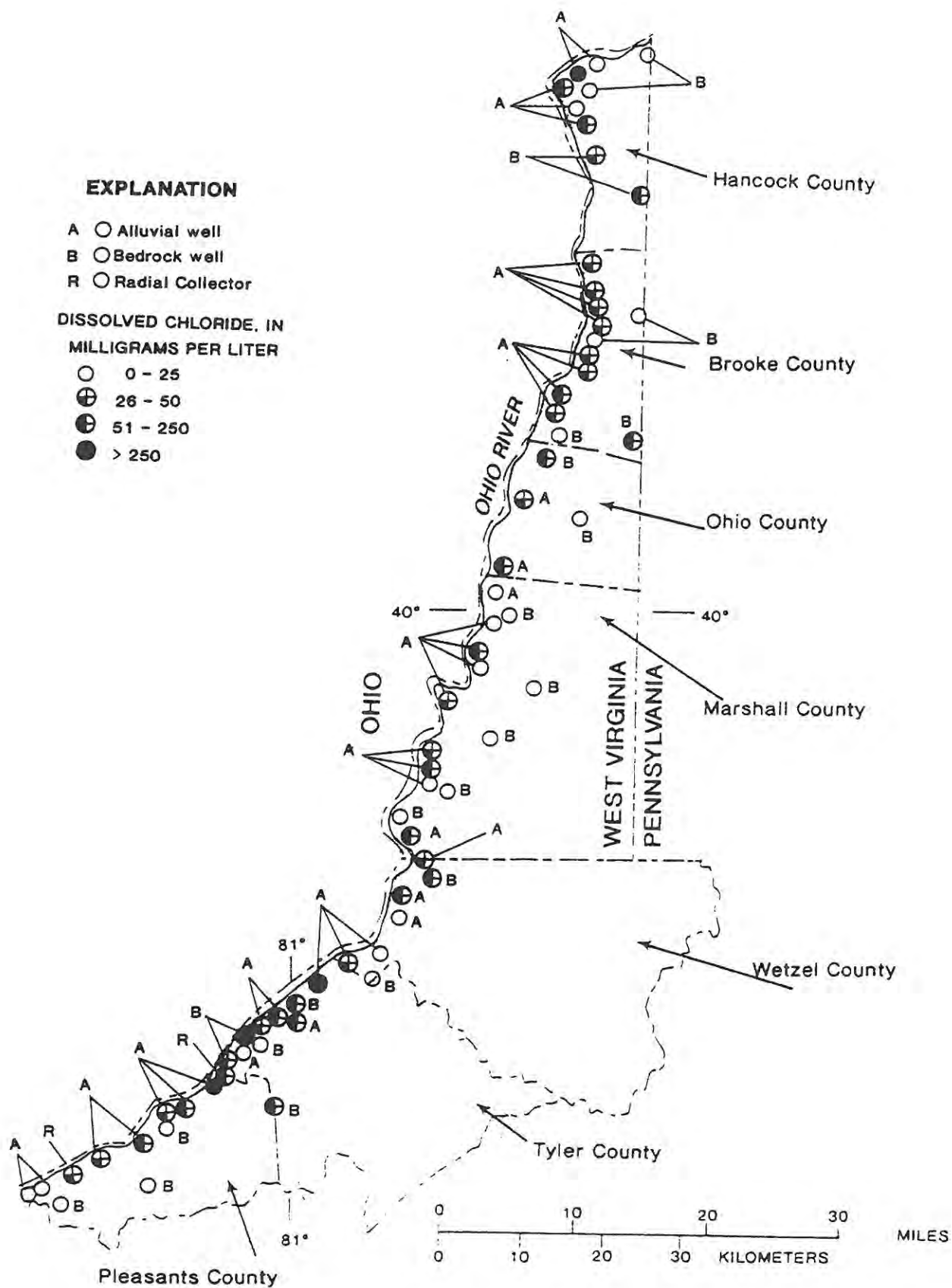
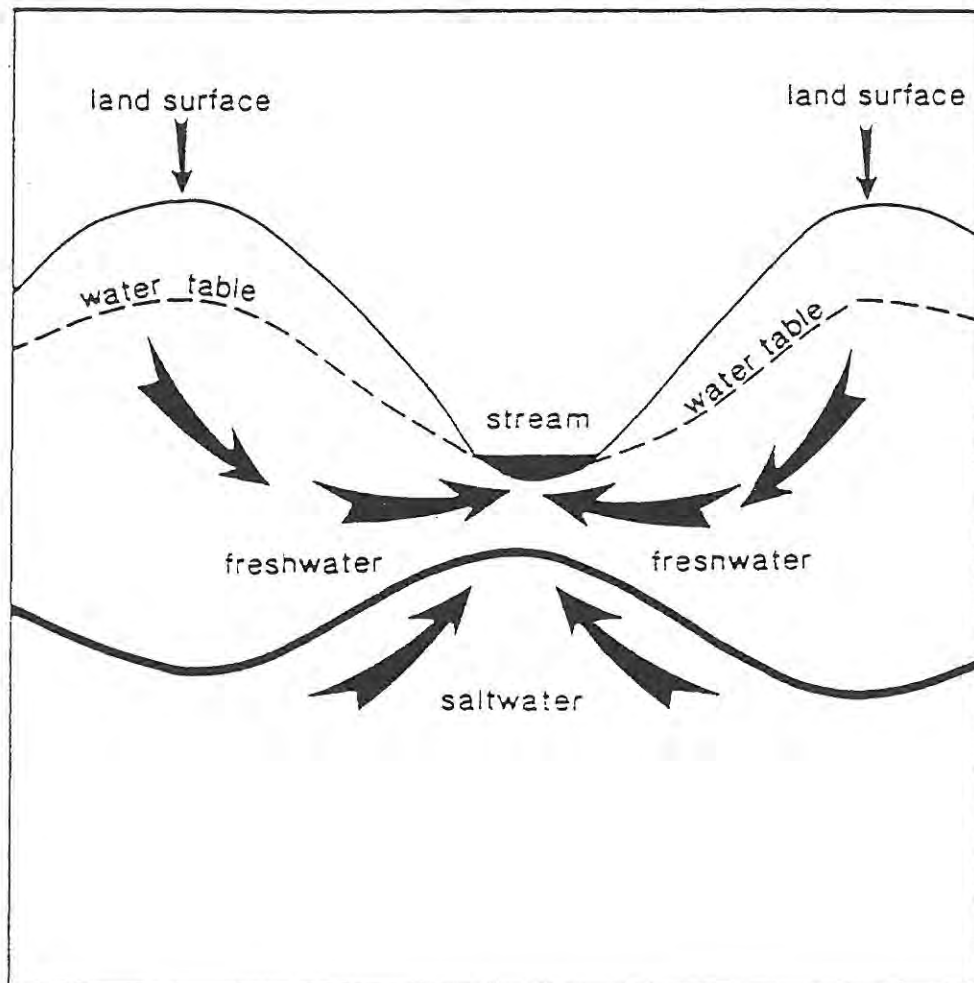


Figure 4.3.1-1. - - Areal distribution of dissolved chloride.



NOT TO SCALE

EXPLANATION



DIRECTION OF GROUND-WATER FLOW

Figure 4.3.1-2. -- Relation between freshwater and saltwater.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.1 Saltwater--Continued

The ground-water circulation in a drainage basin is from recharge areas in the hills to discharge areas in the valleys. The mean altitude of the water table is much higher under the hills, and saltwater is found at greater depth there than elsewhere in the basin. Some of the water percolating downward in the recharge area penetrates deeply enough to become part of the flow system involving the underlying saltwater.

In the discharge areas of the basins, deeper water is moving toward the surface. This water has mixed with the saltwater underlying the region and may be under greater hydraulic head than the overlying freshwater. Therefore, the saltwater moves upward to the surface when it reaches a fracture or well.

Man can also influence the depth to saltwater. Heavy pumping from the overlying freshwater zone can cause upward migration of the saltwater in areas where the saltwater is at shallow depth. Saltwater in oil and gas reservoirs is frequently under sufficient head to flow upward through wells. When deep wells are uncased or improperly cased, contamination of upper freshwater zones may occur (Bain and Friel, 1972). Secondary recovery techniques, such as the injection of carbon dioxide or saltwater under high pressure into deep oil-bearing zones, could cause saltwater to move into the freshwater zone by forcing it toward the surface. This is believed to be the problem around some oil fields in Tyler and Pleasants Counties.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.2 Iron and Manganese

IRON AND MANGANESE POSE A PROBLEM FOR GROUND-WATER USE

Iron and manganese concentrations exceeded State drinking-water limits in many alluvial wells along the Ohio River.

Dissolved iron exceeded the 300 $\mu\text{g/L}$ limit for drinking water (West Virginia State Board of Health, 1981) in 14 of 41 alluvial wells, and dissolved manganese exceeded the 50 $\mu\text{g/L}$ limit for drinking water in 27 of 41 alluvial wells (figs. 4.3.2-1 and 4.3.2-2). Elevated iron and manganese concentrations in drinking water are not serious health hazards, but can cause problems in wells, distribution systems, food processing, and industrial processes.

Elevated iron and manganese concentrations in ground water can cause precipitates to form on well screens and in distribution lines. Iron and manganese can be removed from ground water after it has been withdrawn from a well. Thus, distribution lines usually can be protected from such precipitates, whereas well screens are more difficult to protect. Precipitates of iron and manganese and calcium carbonate clog screens and thus decrease well efficiency. As well efficiency decreases, increased drawdown can lower the water level below the top of the screen. Oxygen brought into contact with the screen further accelerates precipitation. Clogged well screens necessitate expensive cleaning or even the need for new wells (Jeffords, 1945).

The concentration of dissolved iron ranged from less than 3 to 52,000 $\mu\text{g/L}$ for all ground-water samples. The concentration of dissolved manganese ranged from less than 1 to 1,900 $\mu\text{g/L}$. Iron and manganese concentrations were significantly higher in ground water from alluvial wells than in ground water from bedrock wells. The median iron concentration was 50 $\mu\text{g/L}$ in alluvial wells and 16 $\mu\text{g/L}$ in bedrock wells. Likewise, median manganese concentration was 510 $\mu\text{g/L}$ in alluvial wells and 56 $\mu\text{g/L}$ in bedrock wells.

Ground water from some alluvial wells contained a higher concentration of manganese than iron. Hem (1970) states that ground water containing a higher concentration of manganese than iron is uncommon, but is present in wells along the Ohio River in West Virginia.

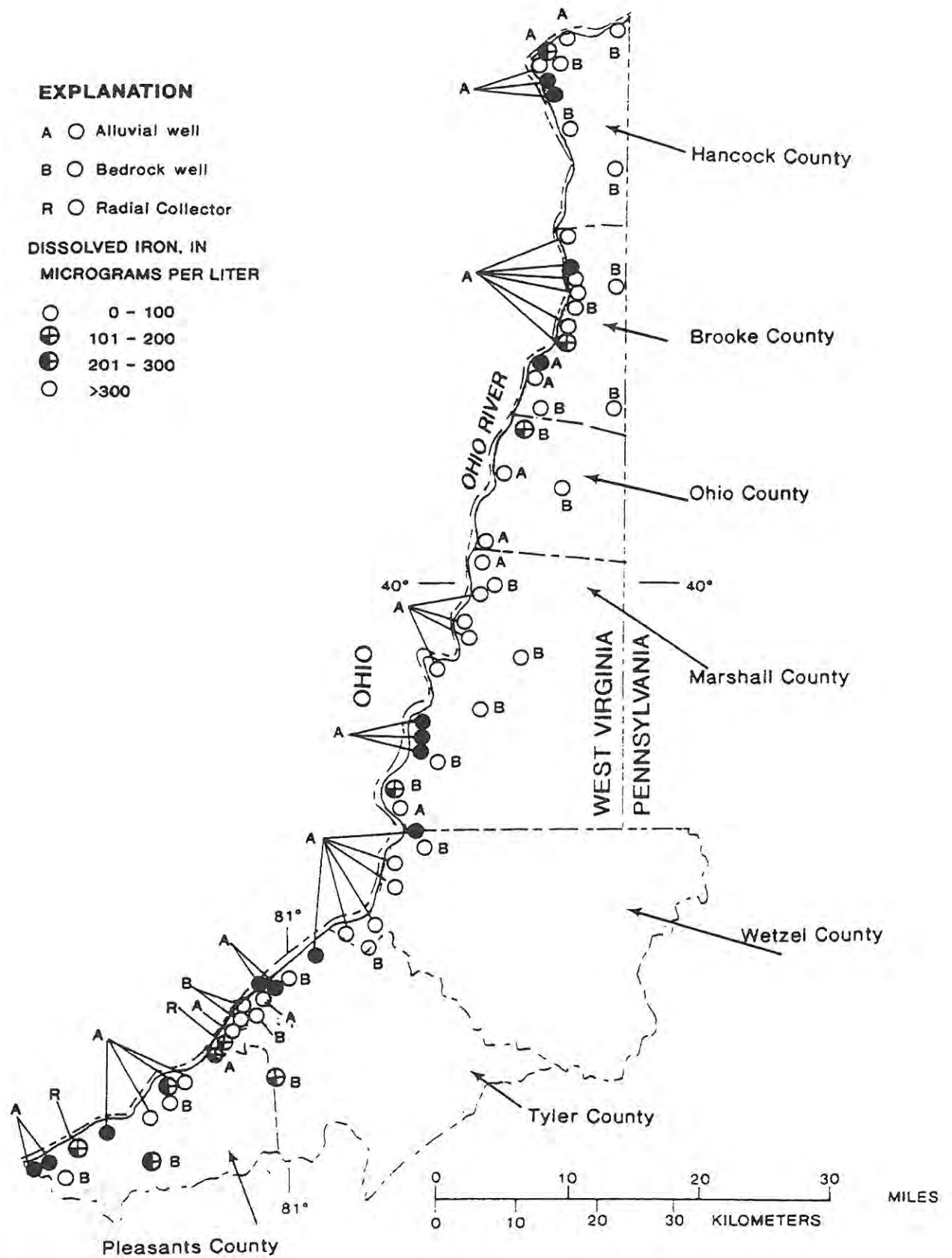


Figure 4.3.2-1. - - Areal distribution of dissolved iron.

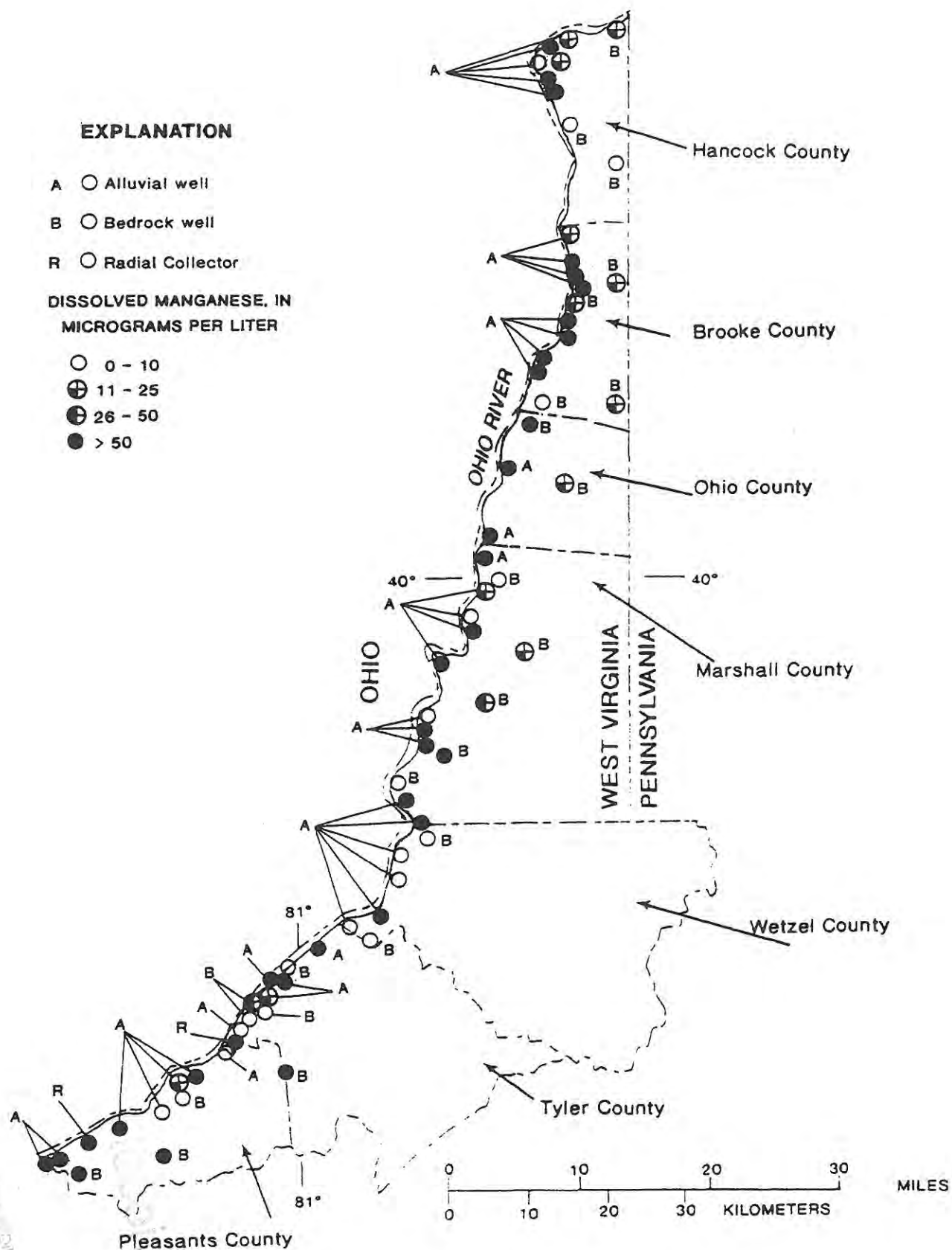


Figure 4.3.2-2. -- Areal distribution of dissolved manganese.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.3 Hardness

HARD WATER IS A COMMON PROBLEM

Hard ground water is found throughout the area and clogs well screens and distribution lines.

Hard water is a common problem throughout the area and is independent of the topographic location of the well or the geologic unit tapped. Hard water can cause well screens and distribution lines to become clogged with iron, manganese, and calcium carbonate precipitates. Ninety-one percent of the ground-water samples had a hardness concentration greater than 120 mg/L. Concentrations ranged from 30 to 1,700 mg/L, and the mean was 290 mg/L. Figure 4.3.3-1 shows the areal distribution of hardness. Hardness is classified by the U.S. Geological Survey (Durfor and Becker, 1964) based on the following ranges of equivalent calcium carbonate concentration in milligrams per liter: 0 to 60 is soft, 61 to 120 is moderately hard, 121 to 180 is hard, and greater than 180 is very hard. Calculations were based on the summation of calcium, magnesium, strontium, iron, aluminum, zinc, manganese, and barium concentrations (American Public Health Association, Inc., 1960, p. 132).

Calcium ions comprised an average of 74 percent of the hardness of each sample and magnesium ions comprised 24 percent. Together they comprised more than 90 percent of the hardness in every sample with one exception. A sample collected near Sistersville contained 52,000 $\mu\text{g/L}$ of iron, which contributed 44 percent of the hardness.

The major source of calcium and magnesium ions probably is limestone. Lithologic analyses of the Ohio River alluvium (Carlston and Graeff, 1955) contain limestone pebbles. Chemically, limestone is classified as a carbonate rock, and pure limestone consists of calcium carbonate. Limestone in this area generally is impure and contains variable amounts of magnesium carbonate; iron carbonate; iron oxide; iron sulfide (pyrite and marcasite); calcium phosphate; and sulfates of calcium, titanium, strontium, and barium. McCue and others (1939) list analyses of limestone samples collected in Ohio, Brooke, Marshall, and Tyler Counties.

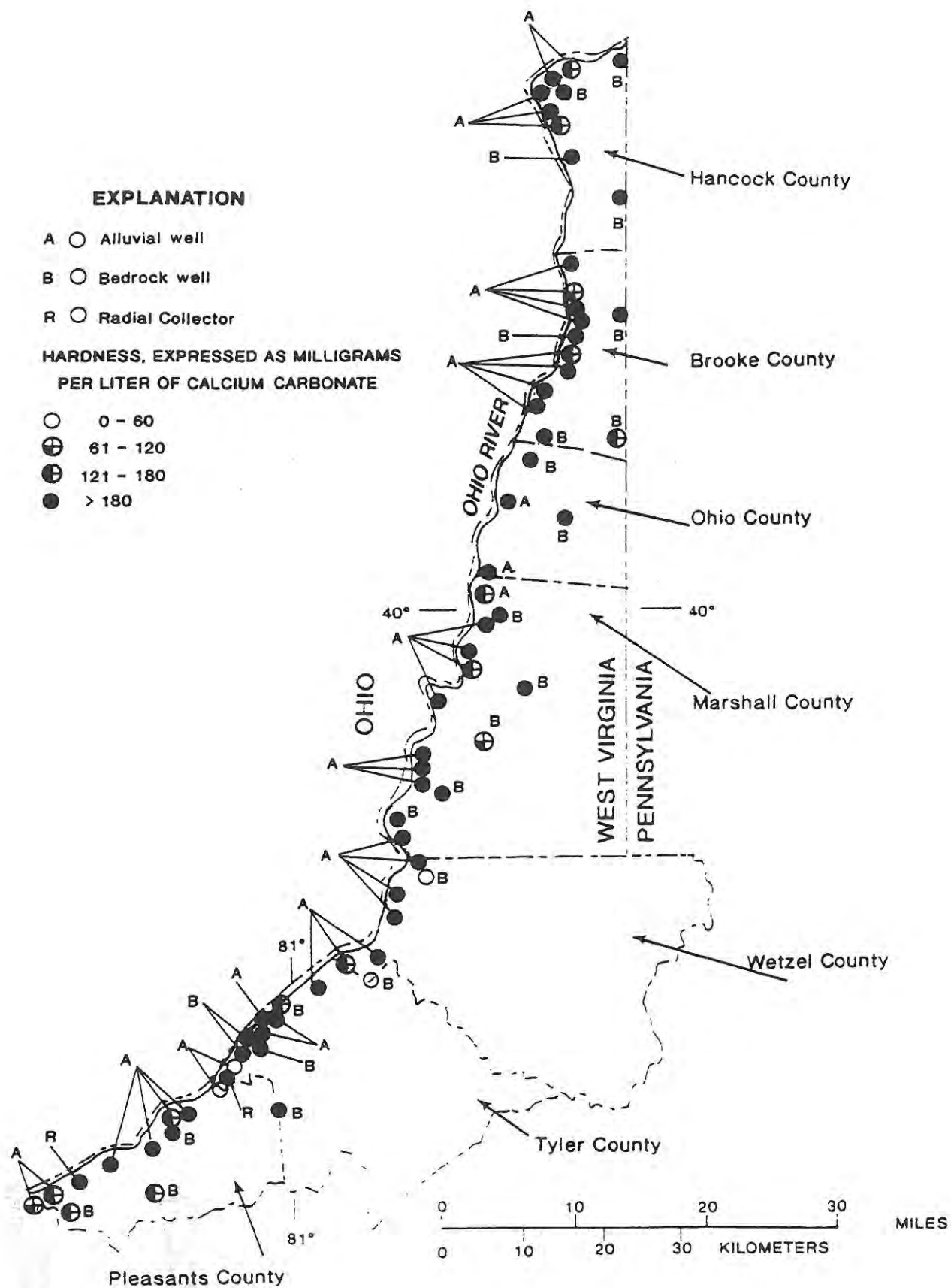


Figure 4.3.3-1. -- Areal distribution of hardness.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.4 Sulfate

FILL MAY CAUSE AN INCREASE IN DISSOLVED-SULFATE CONCENTRATION

An increase in dissolved sulfate may occur where fill is used to level or raise the land surface. Fill is commonly rich in pyrite and other sulfide minerals.

There is a strong correlation between elevated concentration of dissolved sulfate and location of areas containing such fill materials as cinders, fly ash, slag, and other waste associated with coal and steel industries. Five ground-water samples from wells exceeded the 250 mg/L limit of sulfate as recommended by the West Virginia State Board of Health (1981) for public-drinking water. All five wells are located on the alluvial flood plain in or near areas containing fill. The mean sulfate concentration for all samples was 123 mg/L, and values ranged from less than 1 to 2,400 mg/L. Radial collectors with laterals under the river were not included in the calculations because the samples contained a mixture of river water and ground water. Figure 4.3.4-1 shows the areal distribution of sulfate.

Fill is commonly rich in pyrite (FeS_2) and other sulfide minerals. Water percolating through the fill oxidizes the pyrite, which yields sulfate ions that dissolve in the water. Robison (1964) states that elevated sulfate in ground water from wells drilled on the flood plain in Ohio County may be attributed to the common practice of using coal-mine and steel-mill waste as fill.

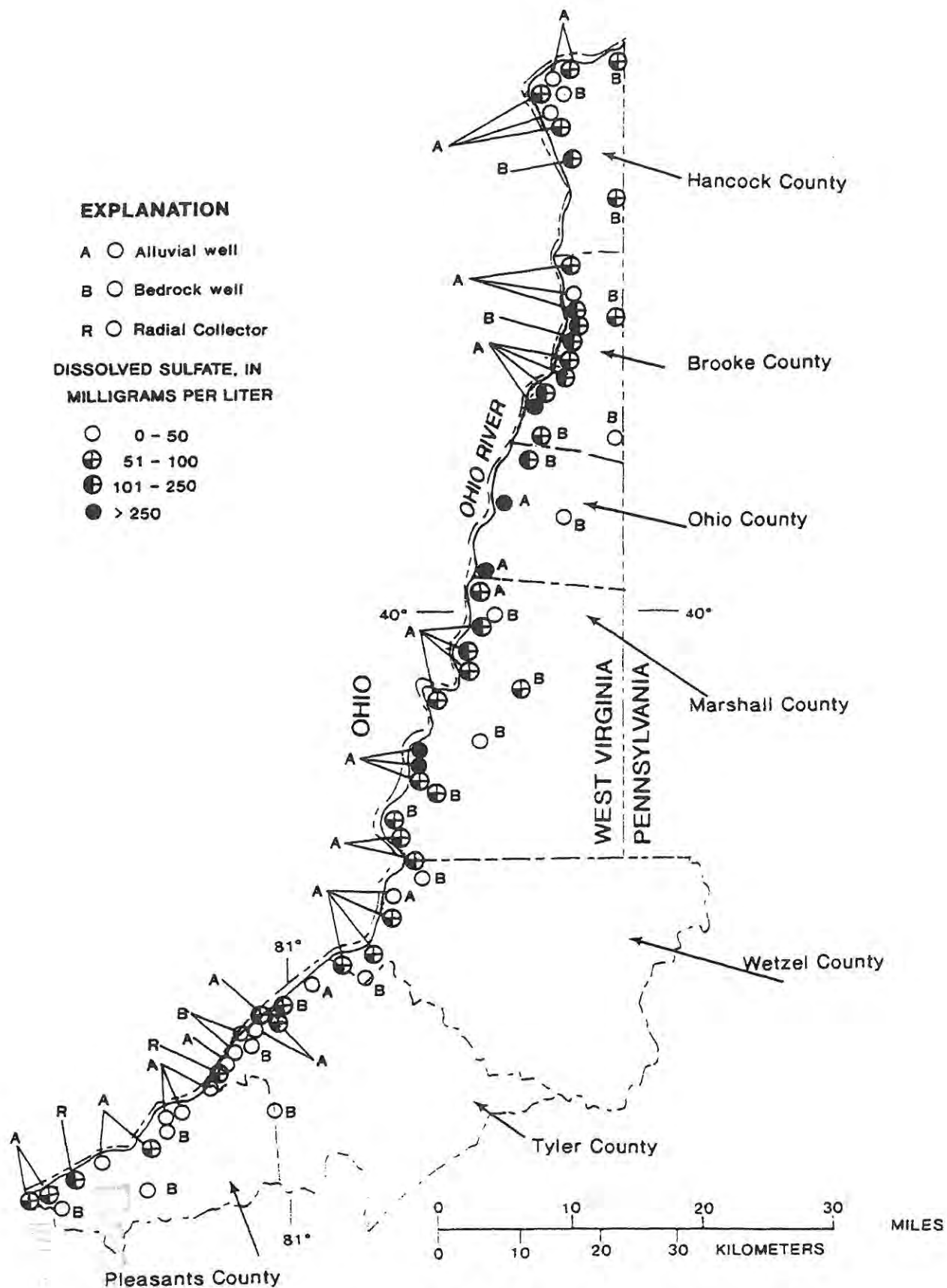


Figure 4.3.4-1. -- Areal distribution of dissolved sulfate.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.5 Contaminants

CONTAMINANTS EXCEEDED STATE DRINKING-WATER LIMITS IN SOME WELLS

Arsenic, barium, mercury, or phenol concentrations exceeded State drinking-water limits in 7 of 50 ground-water samples.

Drinking-water limits, as established by the West Virginia State Board of Health (1981) for contaminants, were exceeded in 7 of 50 ground-water samples (fig. 4.3.5-1). Contaminant limits were exceeded as follows: arsenic, one well; barium, three wells; mercury, two wells; and phenols, three wells. Contaminants analyzed that did not exceed drinking-water limits in any well were cadmium, copper, lead, nitrate, selenium, silver, and zinc.

Concentration of arsenic ranged from 1 to 110 $\mu\text{g/L}$. Arsenic is reportedly not harmful in concentrations up to 1,000 $\mu\text{g/L}$ in drinking water for short-term use; but concentrations as low as 210 $\mu\text{g/L}$ have been reported as poisonous after long-term use (Hem, 1970).

Concentration of barium ranged from 20 to 11,000 $\mu\text{g/L}$; mercury ranged from less than 0.1 to 4.2 $\mu\text{g/L}$; and phenol ranged from less than 1 to 87 $\mu\text{g/L}$. Median concentration for barium in public-water supplies was reported to be 43 $\mu\text{g/L}$ (Durfor and Becker, 1964). Higher concentration of barium is associated with brines or water that has an elevated chloride concentration (Hem, 1959). The occurrence of detectable mercury in ground water is usually associated with industrial or mining waste. Likewise, phenols in water are the result of industrial pollution. Both mercury and phenols are toxic (Doll and others, 1963).

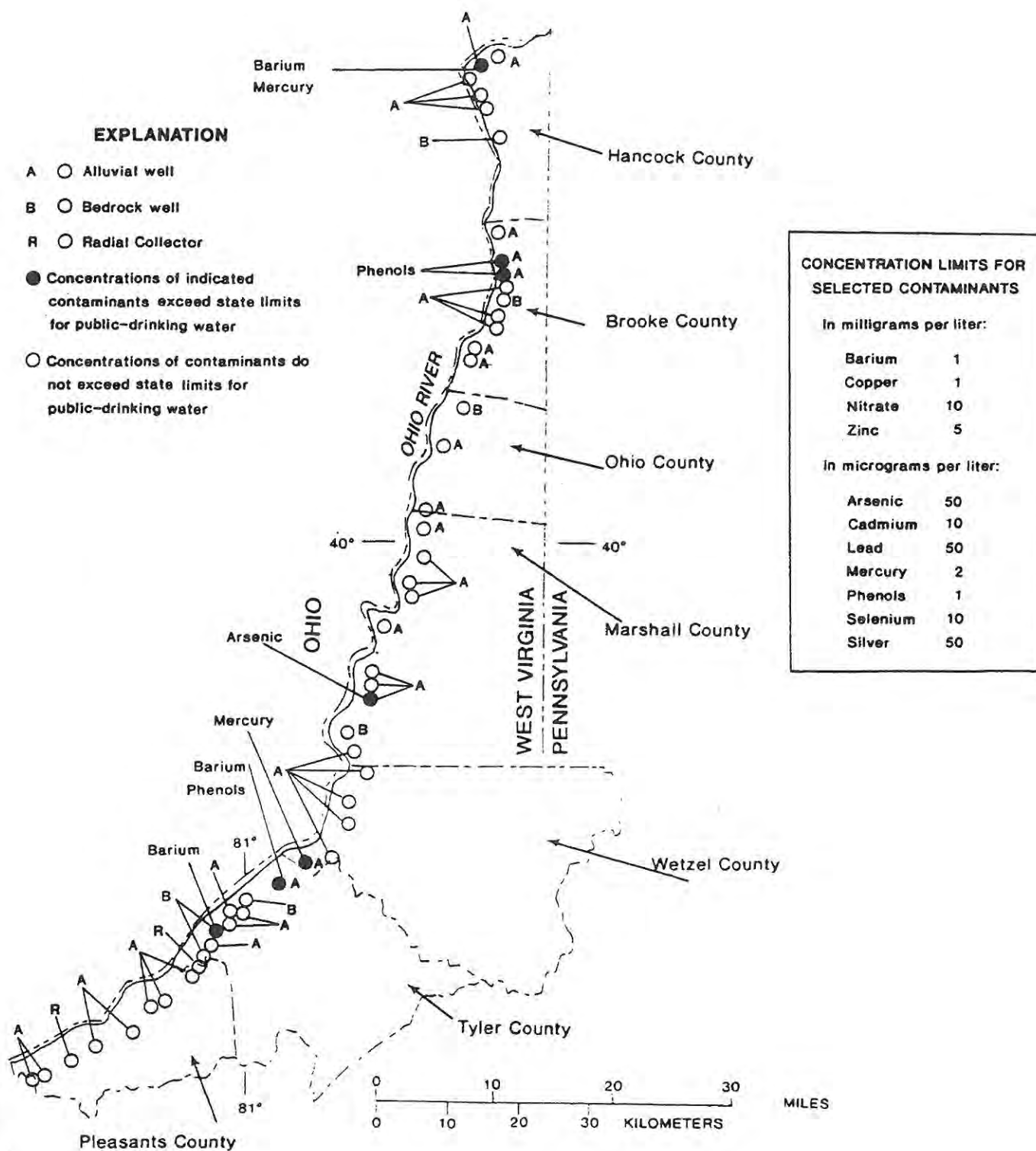


Figure 4.3.5-1. - - Areas where selected contaminant concentration exceeds established State limits (West Virginia State Board of Health, 1981).

4.0 WATER QUALITY--Continued

4.4 Relation to Ground-Water Movement

CHEMICAL QUALITY OF GROUND WATER PROVIDES INFORMATION ON GROUND-WATER MOVEMENT AND RECHARGE

Results of water-quality analyses indicate that (1) ground water flows from the adjacent hills toward the Ohio River; (2) a hydraulic connection exists between the alluvium and bedrock; and (3) precipitation is the major source of recharge to the alluvium.

Ground water flows from the adjacent hills toward the Ohio River. This is supported by changes in the chemical composition of ground water along the flow paths. The mean hardness of ground water from wells drilled into bedrock is as follows: bedrock underlying hilltops--280 mg/L, bedrock underlying hillsides--240 mg/L, bedrock underlying tributary valleys--140 mg/L, and bedrock underlying the Ohio River flood plain--280 mg/L. The decrease in ground-water hardness from hilltop to tributary-valley wells is probably due in part to sodium-calcium exchange. As water moves toward the valleys, it comes into contact with minerals having exchangeable sodium. Sodium has a higher exchange rate than calcium; thus, calcium ions in the ground water are exchanged for sodium ions. The higher ground-water hardness in wells that tap the bedrock underlying the Ohio River valley alluvium is probably due to induced mixing with the harder alluvial water. Ground water from wells open only to the alluvium has a mean hardness of 320 mg/L. When a well that is open to the underlying bedrock is pumped, water in the vicinity of the well may move downward from the alluvium into the bedrock. When this water mixes with water in the bedrock fractures, it causes an increase in hardness of the ground water in the bedrock. The amount of mixing depends on well depth, pumping rate, well efficiency, and local geology.

The trilinear water-analysis diagram in figure 4.4-1 shows the general chemical character of the water from the bedrock, alluvium, and Ohio River. On the central part of the diagram, some of the samples from alluvium and bedrock wells overlap, indicating that mixing of ground water from the two sources has been occurring. In order for the mixing of ground water from alluvium and bedrock to take place, there must be a hydraulic connection. However, only two ground-water samples overlap the group of Ohio River sample.

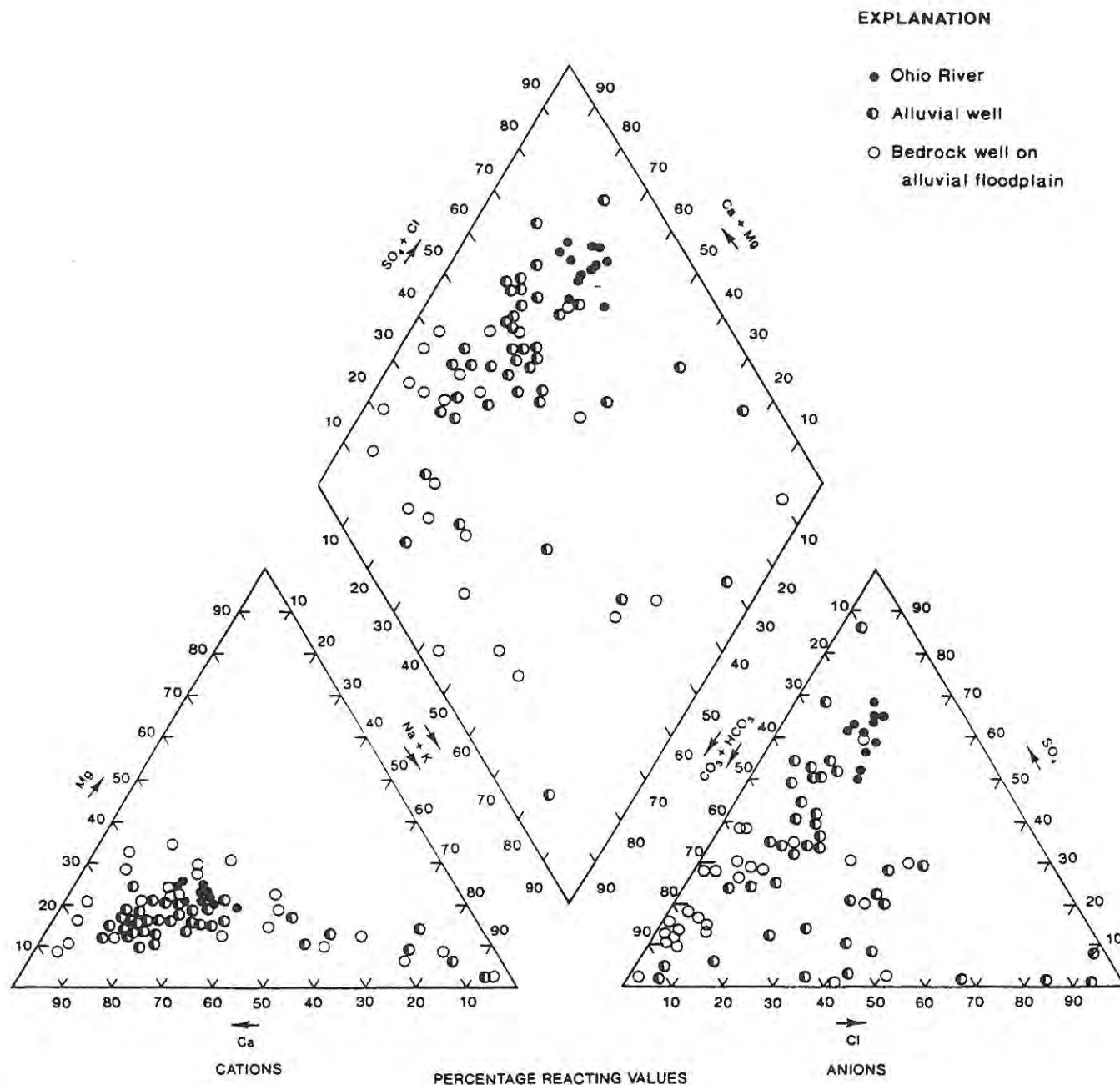


Figure 4.4-1. - - Trilinear water-analysis diagram of water samples from the alluvium, bedrock, and Ohio River.

4.0 WATER QUALITY--Continued

4.4 Relation to Ground-Water Movement--Continued

Sulfate concentration also indicates a hydraulic connection between the alluvium and bedrock. The mean sulfate concentration of ground water from bedrock wells in the hills and tributary valleys was only 48 mg/L, while the mean sulfate concentration for wells open to the bedrock underlying the Ohio River valley alluvium was 100 mg/L. This increase in sulfate concentration may be caused by the mixing of ground water in the bedrock with ground water from the overlying alluvium that has a greater sulfate concentration. One probable source of the higher sulfate concentration in the alluvium is the fill material composed of industrial and mining waste that covers much of the alluvium (see section 4.3.4). Coal piles at coal-fired generating plants and at other industrial sites could be another source of the relatively high sulfate concentration in the alluvium. If sulfate leached from fill and from coal piles is reaching the ground water in the alluvium, precipitation must be an important source of recharge to the alluvium.

5.0 SUMMARY

Ground-water reserves in West Virginia are contained in two aquifer systems. The largest is the system of fractures in the consolidated rock that underlies the State, and the other is the narrow band of alluvium that borders the Ohio and Kanawha Rivers. Ground-water use in Hancock, Brooke, Ohio, Marshall, Wetzel, Tyler, and Pleasants Counties was at least 6.3 billion gallons in 1980 for public supply, mining, and domestic purposes.

The consolidated rock that crops out in the study area is of Pennsylvanian or Permian age and includes the Allegheny Formation, Conemaugh Group, Monongahela Group, and Dunkard Group. Ground-water yields from these rock units are typically low for most wells in the study area. The only major geologic structure is the north-trending Burning Springs anticline in western Pleasants County. The alluvial deposits of Quaternary age are limited mostly to the flood plain of the Ohio River, but are the most productive aquifer system in the area. The lower part of the alluvial deposits consists of sand and gravel of glacial outwash origin and is overlain by clay and silt interspersed with sand stringers. In some areas, the tributary streams have deposited gravel deltas where they enter the valley of the Ohio River. In places, the alluvium has been covered or filled with industrial waste.

Ground water flows from the adjacent hills toward the river. As ground water from the hills enters bedrock underlying the flood plain, it mixes with the ground water percolating through the alluvium. Water-level measurements and water quality indicate that the alluvium and underlying bedrock are hydraulically connected and that the saturated zone is continuous in both rock units.

The alluvium is recharged by the following sources: (1) precipitation on the flood plain, (2) inflow from fractures and bedding-plane partings in the bedrock beneath and adjacent to the alluvium, (3) inflow from tributary streams through gravel deltas, and (4) induced inflow from the river. Precipitation is more likely to recharge the alluvial and bedrock aquifers during the months of November through April.

Drinking-water limits recommended by the West Virginia State Board of Health were exceeded in places by concentrations of iron, manganese, sulfate, arsenic, barium, mercury, and phenols. Hardness exceeded 120 mg/L in 91 percent of the samples. Chemical quality can help explain ground-water movement and recharge. Hardness decreases as the ground water moves through the bedrock from hills to valleys and then increases when it reaches the bedrock beneath the alluvial flood plain. Sulfate leached from fill in the alluvium appears in alluvial wells on the flood plain, indicating that precipitation is a significant source of recharge to the alluvium. Sulfate concentration was higher in bedrock underlying the alluvium than in bedrock underlying adjacent hills. This indicates that a good hydraulic connection exists between bedrock and alluvium. A trilinear water-analysis diagram shows that mixing of ground water from the bedrock and alluvium is occurring.

6.0 DEFINITION OF TERMS

Confined ground water.--Confined ground water is under pressure significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs (Lohman and others, 1972).

Hydraulic conductivity.--A medium has a hydraulic conductivity of unit length per unit time if it will transmit in unit time a unit volume of ground water at the prevailing viscosity through a cross section of unit area, measured at right angles to the direction of flow, under a hydraulic gradient of unit change in head through unit length of flow (Lohman, 1972).

Hydraulic gradient.--The hydraulic gradient is the change in static head per unit of distance in a given direction (Lohman and others, 1972).

Porosity.--The porosity of a rock or a soil is its property of containing interstices or voids and may be expressed quantitatively as the ratio of the volume of its interstices to its total volume (Lohman and others, 1972).

Semiconfinement.--The distinction between confined and unconfined water is entirely gradational. The term semiconfined is used for the intermediate conditions. The material overlying an aquifer may be semipermeable so that water is only semiconfined (Davis and DeWiest, 1966).

Specific capacity.--The specific capacity of a well is the rate of discharge of water from the well divided by the drawdown of water level within the well (Lohman and others, 1972).

Specific discharge.--The specific discharge, or specific flux, for ground water is the rate of discharge of ground water per unit area measured at right angles to the direction of flow (Lohman and others, 1972).

Specific retention.--The specific retention of a rock or soil is the ratio of the volume of water, which the rock or soil, after being saturated, will retain against the pull of gravity to the volume of the rock or soil (Lohman and others, 1972).

Specific yield.--The specific yield of a rock or soil is the ratio of the volume of water which the rock or soil, after being saturated, will yield by gravity to the volume of the rock or soil (Lohman and others, 1972).

Storage coefficient.--The storage coefficient is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head (Lohman and others, 1972).

Transmissivity.--Transmissivity is the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient (Lohman and others, 1972).

Unconfined ground water.--Unconfined ground water is water in an aquifer that has a water table (Lohman and others, 1972).

7.0 SELECTED REFERENCES

- American Public Health Association, Inc., 1960, Standard methods for the examination of water and wastewater (11th edition): New York, 626 p.
- Bader, J.S., 1984, Ground-water hydrology of the Guyandotte River basin, West Virginia: West Virginia Department of Natural Resources, Map report, scale 1:250,000, 1 sheet.
- _____, 1984, Ground-water hydrology of the Tug Fork and Twelvepole Creek basins, West Virginia: West Virginia Department of Natural Resources, Map report, scale 1:250,000, 1 sheet.
- Bader, J.S., Chisholm, J.L., Bragg, R.L., and Downs, S.C., 1980, Water resources of the Guyandotte River basin, West Virginia: West Virginia Geological and Economic Survey River Basin Bulletin 7, 201 p. (In press.)
- Bader, J.S., Mathes, M.V., and Runner, G.S., 1982, Water resources of Tug Fork of Big Sandy River basin, West Virginia, Kentucky, and Virginia, and Twelvepole Creek basin, West Virginia: West Virginia Geological and Economic Survey River Basin Bulletin 8. (In press.)
- Bader, J.S., and others, compilers, 1973, Selected references, ground-water contamination, the United States of America and Puerto Rico: U.S. Geological Survey Open-File Report 74-225, 103 p.
- Bain, G.L., and Friel, E.A., 1972, Water resources of the Little Kanawha River basin, West Virginia: West Virginia Geological and Economic Survey River Basin Bulletin 2, 122 p.
- Bentall, Ray, comp., 1963, Methods of determining permeability, transmissibility and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p. 243-341.
- Cardwell, D.H., 1978, Oil and gas report and map of Marshall, Wetzel, and Tyler Counties, West Virginia: West Virginia Geological and Economic Survey Bulletin 12A, 39 p.
- Cardwell, D.H., Erwin, R.B., and Woodward, H.P., Compilers, 1968, 1968 Geologic map of West Virginia: West Virginia Geological and Economic Survey Map, scale 1:250,000.
- Carlston, C.W., and Graeff, G.D., Jr., 1955, Ground-water resources of the Ohio River valley in West Virginia, pt. III, of Geology and economic resources of the Ohio River valley in West Virginia: West Virginia Geological Survey Volume XXII, p. 1-131.
- Chang, Mingteh; Lee, Richard; and Dickerson, W.H., 1976, Adequacy of hydrologic data for application in West Virginia: West Virginia University Water Research Institute Bulletin 7, series 78, No. 8-3, 1978, p. 78 and 84.
- Clark, W.E., Chisholm, J.L., and Frye, P.M., 1976, Water resources of the Upper New River basin, West Virginia: West Virginia Geological and Economic Survey River Basin Bulletin 4, 87 p.
- Crain, L.J., 1966, Ground-water resources of the Jamestown area, New York, with emphasis on the hydrology of the major stream valleys: New York Conservation Department, Water Resources Commission, Bulletin 58, 167 p.

- Cross, A.T., and Schemel, M.P., 1956, Geology of the Ohio River valley in West Virginia, pt. I of Geology and economic resources of the Ohio River valley in West Virginia, 1956: West Virginia Geological and Economic Survey v. XXII, p. 1-149.
- Davis, S.N., and DeWiest, R.J.M., 1966, Hydrogeology: New York, John Wiley and Sons, Inc., 463 p.
- Davis, R.W., and Matthews, E.W., 1983, Chloroform contamination in part of the alluvial aquifer, southwest Louisville, Kentucky: U.S. Geological Survey Water-Supply Paper 2202, 25 p.
- Deutsch, Morris; Dove, G.D.; Jordan, P.R.; and Wallace, J.C., 1966, Ground-water distribution and potential in the Ohio River basin, *in* the Ohio River basin comprehensive survey, v. VI, Appendix E, Ground water: Corps of Engineers, U.S. Army Engineer Division, Ohio River, Cincinnati, Ohio, report, 197, p., 32 plates.
- Doll, W.L., Meyer, Gerald, and Archer, R.J., 1963, Water resources of West Virginia: West Virginia Department of Natural Resources, Division of Water Resources Report, 134 p.
- Durfor, C.N., and Becker, Edith, 1964, Public water supplies of the 100 largest cities in the United States, 1962: U.S. Geological Survey Water-Supply Paper 1812, 364 p.
- Fenneman, N.M., and Johnson, D.W., 1964, Physical divisions of the United States: U.S. Geological Survey Map prepared in cooperation with Physiographic Commission, U.S. Geological Survey, scale 1:7,000,000.
- Foster, J.B., 1980, Fresh and saline ground-water map of West Virginia: West Virginia Geological Survey Map WV-12, scale 1:250,000, 4 plates.
- Gallaher, J.T., and Price, W.E., Jr., 1966, Hydrology of the alluvial deposits in the Ohio River Valley in Kentucky: U.S. Geological Survey Water-Supply Paper 1818, 80 p.
- Grimsley, G.P., 1907, [Detailed geologic report of] Ohio, Brooke, and Hancock Counties: West Virginia Geological Survey County Report, 378 p., 16 plates.
- _____, 1910, [Detailed geologic report of] Pleasants, Wood, and Ritchie Counties: West Virginia Geological Survey County Report, 352 p., 21 plates.
- Grubb, H.F., 1975, Simulated drawdown for selected well fields in the Ohio River alluvial aquifer: U.S. Geological Survey Water-Resources Investigations 2-74, 38 p.
- Grubb, H.F., and Zehner, H.H., 1973, Aquifer diffusivity of the Ohio River alluvial aquifer by the flood-wave response method: U.S. Geological Survey Journal of Research, v. 1, no. 5, September-October 1973, p. 597-601.
- Haught, O.L., 1955a, Oil and gas report and map of Pleasants, Wood, and Ritchie Counties, West Virginia: West Virginia Geological and Economic Survey Bulletin 11, 21 p.
- _____, 1955b, Oil and gas report and map of Marshall, Wetzel, and Tyler Counties, West Virginia: West Virginia Geological and Economic Survey Bulletin 12, 49 p.
- Heath, R.C., 1983, Basic ground-water hydrology: U.S. Geological Survey Water-Supply Paper 2220, 84 p.
- Hem, J.D., 1959, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 1473, 269 p.
- _____, 1960a, Some chemical relationships among sulfur species and dissolved ferrous iron: U.S. Geological Survey Water-Supply Paper 1459-C, 73 p.

- _____. 1960b, Restraints on dissolved ferrous iron imposed by bicarbonate, redox potential, and pH: U.S. Geological Survey Water-Supply Paper 1459-B, 55 p.
- _____. 1963, Chemical equilibria and rates of manganese oxidation: U.S. Geological Survey Water-Supply Paper 1667-A, 64 p.
- _____. 1964, Deposition and solution of manganese oxides: U.S. Geological Survey Water-Supply Paper 1667-B, 42 p.
- _____. 1970, Study and interpretation of the chemical characteristics of natural water (2d ed.): U.S. Geological Survey Water-Supply Paper 1473, 363 p.
- _____. 1972, Chemical factors that influence the availability of iron and manganese in aqueous systems: Geological Society of America Special Paper 140, p. 17-24.
- Hennen, R.V., 1909**, [Detailed geologic report of] Marshall, Wetzel, and Tyler Counties: West Virginia Geological Survey County Report, 654 p., 12 plates.
- Jeffords, R.M., 1945**, Ground-water conditions along the Ohio Valley at Parkersburg, West Virginia: West Virginia Geological Survey Bulletin 10, 57 p.
- Jordan, P.R., 1966**, Preliminary survey of ground-water distribution and potential in the Ohio River basin, sub-drainage area 3, Upper Ohio River drainage area (area draining to the Ohio River between Pittsburgh and Marietta), *in* Ohio River basin comprehensive survey, v. VI., Appendix E, Ground water: Corps of Engineers, U.S. Army Engineer Division, Ohio River, Cincinnati, Ohio, report, p. 3-1 to 3-13, 2 plates.
- Kernodle, J.M., 1977**, Theoretical drawdown due to simulated pumpage from the Ohio River alluvial aquifer near Siloam, Kentucky: U.S. Geological Survey Water-Resources Investigations 77-24, 39.
- Lohman, S.W., 1972**, Ground-water hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.
- Lohman, S.W., and others, 1972**, Definitions of selected ground-water terms--revisions and conceptual refinements: U.S. Geological Survey Water-Supply Paper 1988, 21 p.
- McCue, J.B., Lucke, J.B., and Woodward, H.P., 1939**, Limestones of West Virginia: West Virginia Geological Survey, v. XII, 560 p.
- Munson, W.C., 1966**, Estimating consumptive use, Munson, P.E., index method, *in* Methods for estimating evapotranspiration: American Society of Civil Engineers Irrigation and Drainage Speciality Conference, Las Vegas, Nevada, November 1966, p. 65-107.
- National Oceanic and Atmospheric Administration, October 1973-November 1983**, Climatological data, West Virginia: National Climatic Center, Asheville, North Carolina. (Issued monthly.)
- _____. 1977, Climate of West Virginia: Asheville, North Carolina, 19 p.
- _____. 1982, Monthly normals of temperature, precipitation, and heating and cooling degree days 1951-80, West Virginia: Asheville, North Carolina, 10 p.
- Norris, S.E., 1970**, The effect of stream discharge on streambed leakage to a glacial outwash aquifer: U.S. Geological Survey Professional Paper 700-D, p. 262-265.
- Norris, S.E., and Eagon, H.B., Jr., 1971**, Recharge characteristics of a watercourse aquifer system at Springfield, Ohio, *in* Ground Water: v. 9, no. 1, p. 30-41.
- Norris, S.E., and Fidler, R.E., 1969**, Hydrogeology of the Scioto River valley near Piketon, south-central Ohio: U.S. Geological Survey Water-Supply Paper 1872, 70 p.

- Patchen, D.G., 1982, Oil and gas activity in West Virginia, 1970-1979: West Virginia Geological and Economic Survey Circular C-29, 187 p.
- Pettyjohn, W.A., 1971, Water pollution by oil-field brines and related industrial wastes in Ohio: Ohio Journal of Science; 71, no. 5, September, p. 257-269.
- Price, P.H., Hare, C.E., McCue, J.B., and Hoskins, H.A., 1937, Salt brines of West Virginia: West Virginia Geological Survey, v. VIII, 203 p.
- Robison, T.M., 1964, Occurrence and availability of ground water in Ohio County, West Virginia: West Virginia Geological and Economic Survey Bulletin 27, 57 p.
- Rorabaugh, M.I., 1946, Ground-water resources of the southwestern part of the Louisville area, Kentucky: U.S. Geological Survey Open-File Report, 39 p.
- _____, 1956, Ground water in northeastern Louisville, Kentucky: U.S. Geological Survey Water-Supply Paper 1360-B, 69 p.
- Shultz, R.A., 1984, Ground-water hydrology of the minor tributary basins of the Ohio River, West Virginia: West Virginia Department of Natural Resources, Map report, scale 1:250,000, 1 sheet.
- Smith, R.C., Doll, W.L., and Stratton, Garland, 1955, Water resources of the Wheeling-Steubenville area, West Virginia and Ohio: U.S. Geological Survey Circular 340, 31 p.
- Stevens, H.C., and Lessing, Peter, 1982, Water use in West Virginia for 1980: West Virginia Geological and Economic Survey Circular C-27, 31 p.
- West Virginia State Board of Health, 1981, Public water-supply regulations: 47 p.
- Whitesides, D.V., and Ryder, P.D., 1969, Effects of pumping from the Ohio River Valley alluvium between Carrolton and Ghent, Kentucky: Kentucky Geological Survey Information Circular 18, 20 p.
- Wyrick, G.G., and Borchers, J.W., 1981, Hydrologic effects of stress-relief fracturing in an Appalachian valley: U.S. Geological Survey Water-Supply Paper 2177, 51 p.

SECTION 8

RECEIVED
Office of Oil and Gas
NOV 18 2015
WV Department of
Environmental Protection

Section 8 – Geological Data on the Injection and Confining Zones:

1. The initial geological investigation conducted on the BW#4 Class IID injection well with the original permit application and was also included in the submittal of the five-year permit renewal package. This included a detailed structural contour map, geological cross sections, and isopach map of the Clinton and Medina sandstones which demonstrates there are no subsurface faults, fracture zones, or seismically-active features within the area. Further, the drilling and completion of both the Greens Run#1 and BW#4 to the Clinton and Medina sandstones are two of the deepest wells drilled in Pleasants County and no subsurface faults, fracture zones, or other geological structural anomalies were encountered during these drilling operations or are present on the open-hole geophysical logs run on these two injection wells. Bader, Mathes, and Shultz (1997) states that “The only major geologic structure in the area is the north-trending Burning Springs anticline in the western part of Pleasants County.” This reference is included.
2. There have been no recorded seismic events located in Pleasants County, West Virginia since 1824 (see attached WVGES documents). Seismicity in the Appalachian Basin is associated with faulting in the Precambrian basement rocks, which are upwards of 5,000 to 6,000 feet below the Clinton and Medina sandstones. In 2012, the U.S. Transportable Array (TA) was deployed to West Virginia and a total of 10 portable passive seismic stations were installed and combined with the permanent seismic station at WVU in Morgantown, WV. Currently, most of the TA stations have been removed and there are only four portable seismic stations remaining in WV as of 2016.
3. ALL Consulting (ALL) has been actively involved in passive seismic monitoring at injection wells in Ohio and Oklahoma and has the experience and expertise to evaluate potential induced seismicity. ALL was involved in the StatesFirst document entitled “Potential Injection-Induced Seismicity Associated with Oil & Gas Development: A Primer on Technical and Regulatory Considerations Informing Risk Management and Mitigation.” ALL staff member, Tom Tomastik, also served on the U.S. EPA UIC National Technical Workgroup for six years and was a member and reviewer on the U.S. EPA report released in 2015 entitled “Minimizing and Managing Potential Impacts of Injection-Induced Seismicity for Class II Disposal Wells: Practical Approaches.” Additionally, Mr. Tomastik was instrumental in the establishment of Ohio’s passive seismic monitoring in 2012 and drafting of the new UIC rules to address the potential for induced seismicity in Ohio after the Northstar #1 injection-induced seismicity in Youngstown, Ohio in late 2011.
4. Open-hole and cased-hole geophysical logs were run on the BW #4 injection well. Log analysis of all of the geophysical logs was performed by Tom Tomastik, Senior Geologist and Regulatory Specialist with ALL. Mr. Tomastik has over 34 years of experience analyzing all types of open-hole and cased-hole geophysical logs both during his career in oil and gas in the Appalachian Basin and as a regulator for the Ohio Division of Oil and Gas Resources Management (see attached resume for his experience and expertise in both logging and induced seismicity). On December 23, 2016, the Ohio Department of Environmental Protection received a letter from the West Virginia Department of Environmental Protection regarding the BW #4 injection well. The letter was received on December 23, 2016, and the Ohio Department of Environmental Protection is currently reviewing the information provided. The letter was received on December 23, 2016, and the Ohio Department of Environmental Protection is currently reviewing the information provided.

ray, collar locator, and cement bond log was run on the 7" intermediate casing string and the top of cement is at 3,020 feet. On January 25, 2011, a Weatherford Directional Survey and Gamma ray-Induction log was run on the BW#4 well. The directional survey showed some deviation of about 100 feet to the North. The BW #4 well was then drilled to a total depth of 7,498 feet and open-hole geophysical logs were run through the proposed Clinton and Medina injection zone. Weatherford ran the logs on February 2, 2011 and these logs included a Gamma ray-Compensated Neutron, Photo Density log and a Gamma ray – Dual Laterolog. Copies of all geophysical logs were previously submitted.

5. The Clinton sandstone is an inter-bedded deltaic sandstone and shale section which was consistently deposited within the Silurian-aged Upper and Lower Cabot Head Shale. The Medina sandstone is also of Silurian-age and is a fine-grained sandstone that is fairly uniform in thickness across the area.
6. An analysis of the injection zone in the BW #4 injection well indicates the Clinton sandstone occurred from depths of 7,140 to 7,259 feet. Total cumulative sand thickness is 80 feet and porosity ranged from 3 to 12 percent. The Medina sandstone is from a depth of 7,297 to 7,328 feet. Cumulative Medina sand thickness is 28 feet and the porosity ranges from 8 to 10 percent. Primary porosity in the Clinton and Medina sandstones are developed by the pore spaces between the sand grains within the sandstone bodies. Very little secondary porosity is seen. Permeability ranges from 0.1 to 5 millidarcies in the Clinton and Medina sandstones.
7. There are multiple confining layers within the BW #4 injection well. These confining layers, which are composed of interbedded shales, limestones, and dolomites. The Rochester Shale is a gray shale that occurs in the BW#4 well from 6,753 to 7,000 feet. The Dayton Limestone or "Little Lime" is a marine limestone that is encountered at depths from 7,000 to 7,012 feet and the Brassfield Limestone or "Packer Shell" is also a marine limestone that occurs at depths of 7,084 to 7,121 feet in the BW#4 well. The Lockport Dolomite is a dolomite which occurs at depths from 6,419 to 6,753 feet in BW#4. Estimated fracture pressures for these confining zones are: 1) Lockport Dolomite – 2,790 psi, 2) Rochester Shale – 2925 psi, 3) Dayton Limestone – 3,030 psi, and 4) Brassfield Limestone – 3,070 psi. Additional confining layers directly above these confining zones would include the Salina Group, which has several bedded salts and anhydrite units within it. These multiple confining layers will prevent upward migration of injectate out of the permitted injection zone. Porosity in any of these confining zones are less than 2 percent and permeability is less than 0.1 millidarcy. Additionally, the multiple layers of steel casing strings (of which three of these strings are cemented to the surface), will prevent any potential migration of injected fluids into the USDWs.
8. Fluid movement within the Clinton and Medina injection zone will be a combination of radial and linear flow. Based on a total thickness of 108 feet of sandstone and an average porosity of 8 percent of the injection zone and current inject rates, fluid migration within the Clinton and Medina injection zones over time will be limited to the $\frac{1}{4}$ mile radius around the well. BW#4 injection well fluid migration calculations were previously supplied to WV DEP.

Received
3/24/2018
Office of Oil and Gas
WV Dept. of Environmental Protection

9. Currently, domestic water is supplied by municipal water suppliers in the area and there are no water wells within the ¼ mile AOR.
10. The BW #4 well injectate is treated with a scale inhibitor called Gyptron T-92 (MSDS sheets were previously included)) and is filtered to assist in chemical compatibility. On that MSDS sheet, it lists methanol as 10-30% by weight concentration and sodium phosphate ester salt as 10-30% by weight concentration. Gyptron T-92 is injected at 0.422 gallons per every 100 barrels of brine.
11. Chemical compatibility of existing in place formation fluids with the injection fluids from various other oil and gas reservoirs present no compatibility issues as the main chemical constituents in the injected brine are naturally-occurring metals, non-metals, and organics (BTEX) that occur from the drilling, completion, and production of oil and natural gas. Some treatment of the injectate at the surface is accomplished to avoid precipitation of other constituents such as iron, bacteria, and scale. Only Class I wells which continuously inject industrial wastes is there an issue with chemical compatibility and original formation fluids.

Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection



Sector Bond - Variable Density Gamma Ray - CCL- PPT

Company Appalachian Oil Purchasers, Inc
Well BW 4
Field Washington District
County Pleasants
State WV

Company Appalachian Oil Purchasers, Inc

Well BW 4

Field Washington District

County Pleasants State WV

Location: API #: 47-073-2523

Other Services

Raven Rock 7.5' Quadrangle

SEC TWP RGE

Permanent Datum Ground Level Elevation 640 FT.

Log Measured From K.B. OF 14 FT.

Drilling Measured From K.B. OF 14 FT.

Elevation

K.B. 654 FT.

D.F. 654 FT.

G.L. 640 FT.

Date	14- Feb -11		
Run Number	One		
Depth Driller	7503 FT.		
Depth Logger	7350 FT.		
Bottom Logged Interval	7331 FT.		
Top Log Interval	7331 FT.		
Open Hole Size	6.250 IN.		
Type Fluid	Water		
Density / Viscosity	N/A		
Max. Recorded Temp	N/A		
Estimated Cement Top	5152 FT.		
Time Well Ready			
Time Logger on Bottom			
Equipment Number	13027		
Location	Weston, WV		
Recorded By	Gary Jr Conrad		
Witnessed By	Ashleigh Strahler		

Borehole Record

Tubing Record

Run Number	Bit	From	To	Size	Weight	From	To
One	6.250 in.	5176 FT.	7498 FT.				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	7 IN.	17 LBS	Surface	5176 FT.
Prot. String				
Production String	4.5 IN.	N/A	Surface	7331 FT.
Liner				

<<< Fold Here >>>

All interpretations of log data are opinions based on inferences from electrical or other measurements. We do not guarantee the accuracy or correctness of any interpretation or recommendation and shall not be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our employees or agents. These interpretations are also subject to our general terms and conditions set out in our current Price Schedule.

Remarks

Rig:Hydricarbon Well Services

Prints: 5

Service Order # 172174

BHT	Bit Size	Surface Pressure	Shut In	Run No	EQUIPMENT DATA	
					Tool Type	Tool No
	N/A	6.50 IN.			Sector Bond	
			N/A			

Database File: 2 14 11 app oil pur bw4 db

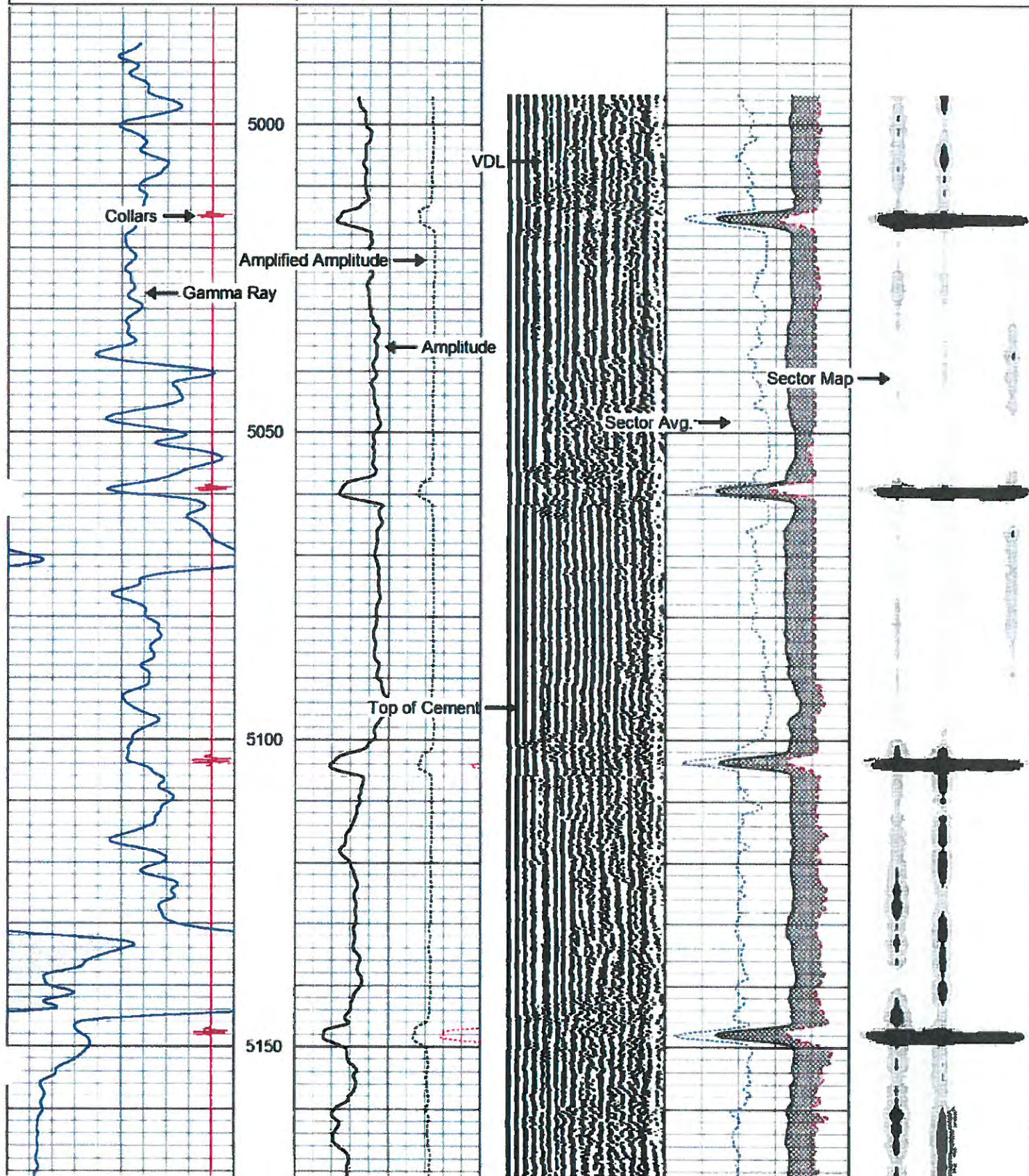
Dataset Pathname: pass7.10

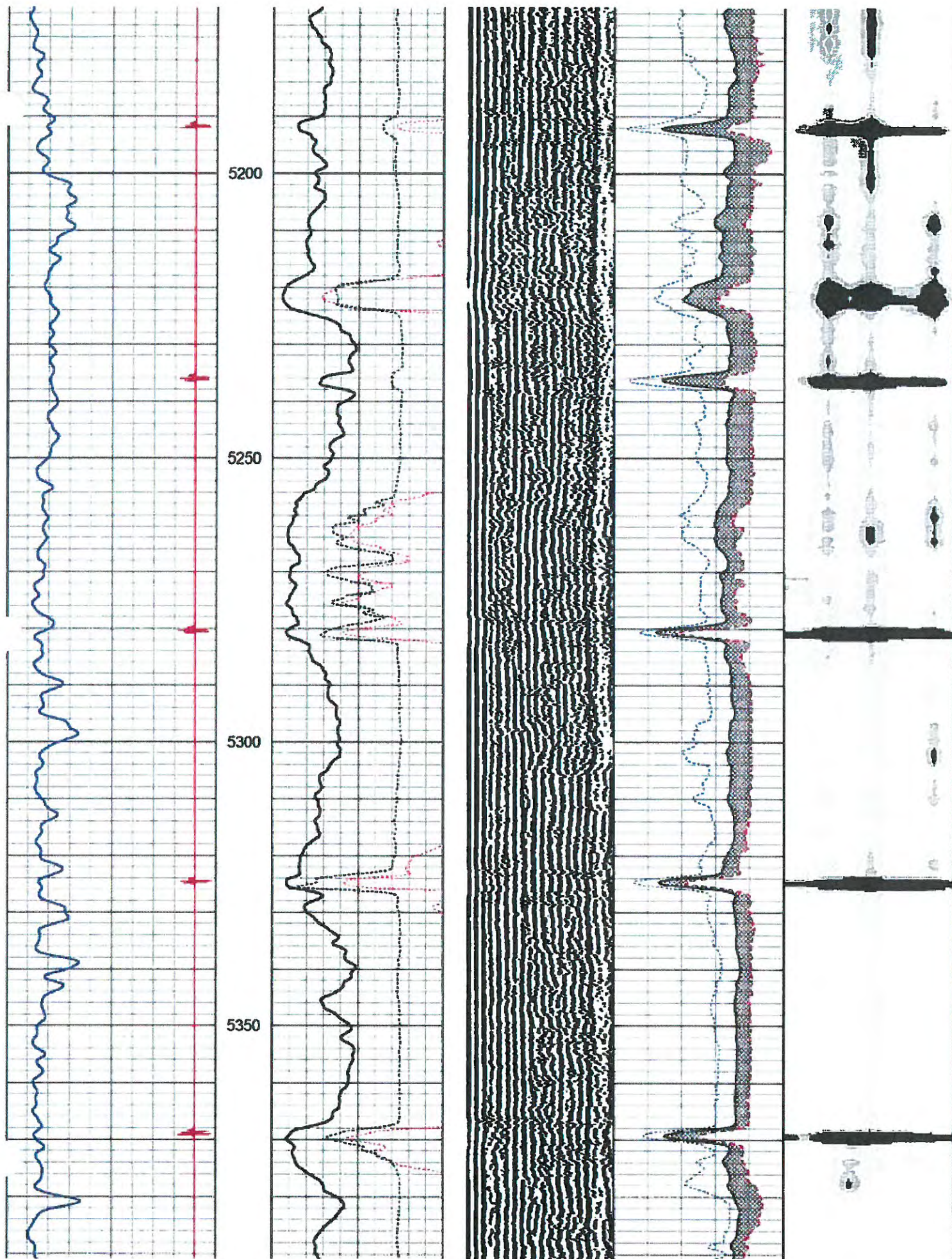
Presentation Format: sectors

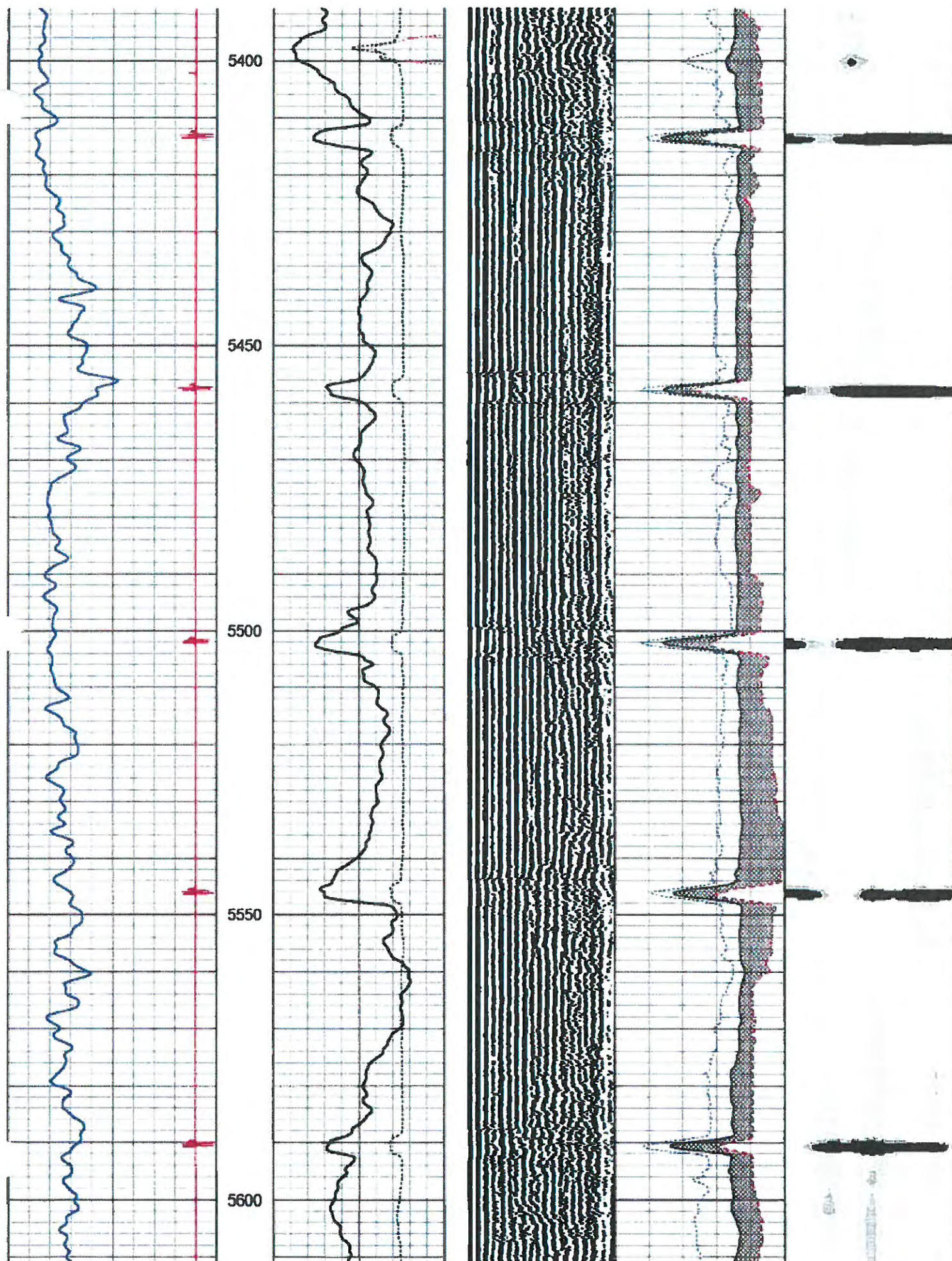
Dataset Creation: Tue Feb 15 09:37:43 2011 by Calc Std Casedhole 07122

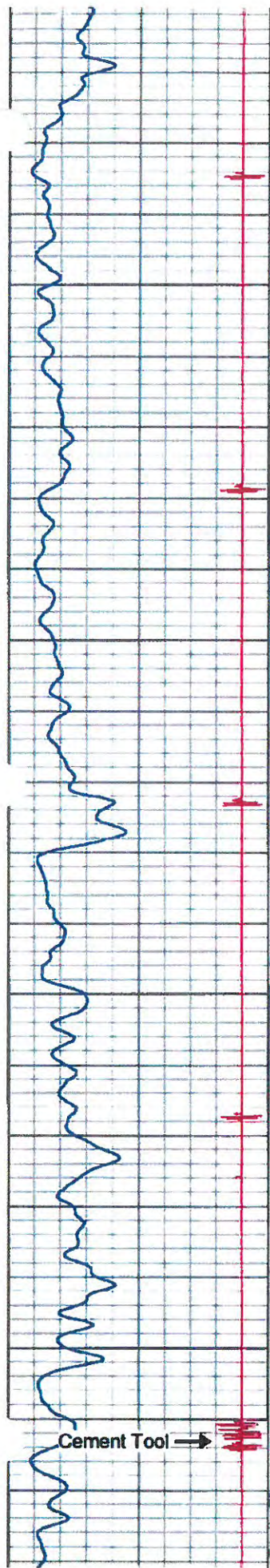
Depth in Feet scaled 1:240

9	Collars	-1	Amplified Amplitude	200	VDL	1200	0	Sector Avg.	100	1	Sector Map	8
0	Gamma Ray	200	0	(mV)	20		0	Sector Max.	100	45		75
10	GR	400	0	Amplitude (mV)	100		0	Sector Min.	100			
			300	TT (usec)	200							
			300	PPT (usec)	200							







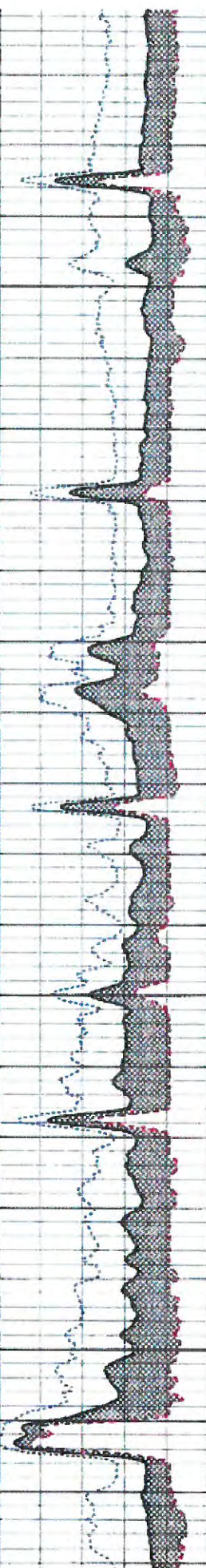
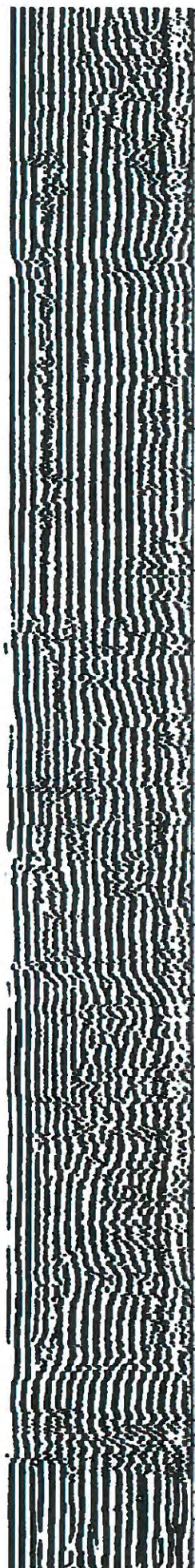
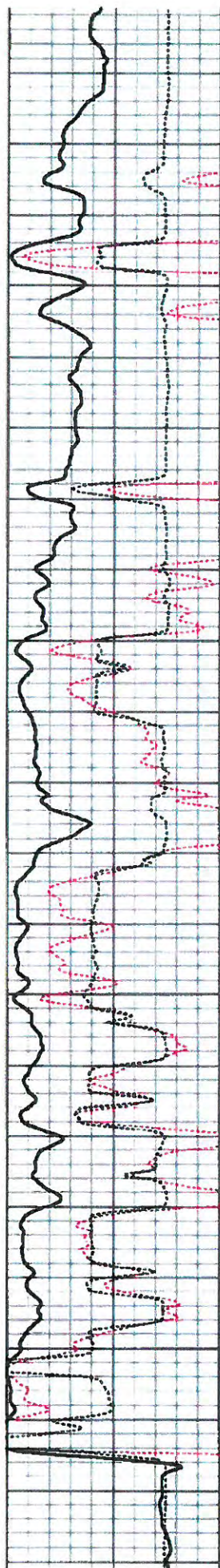


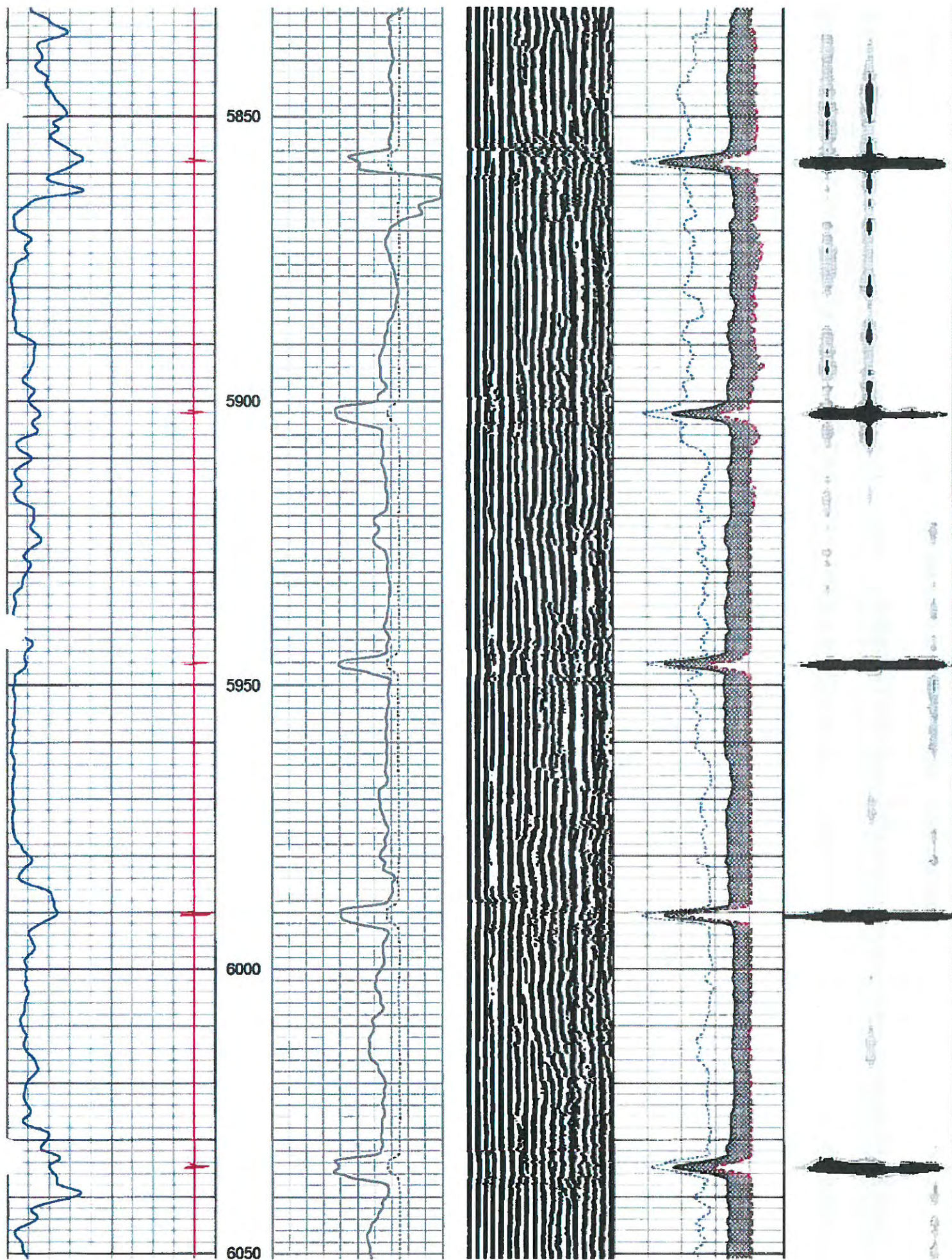
5650

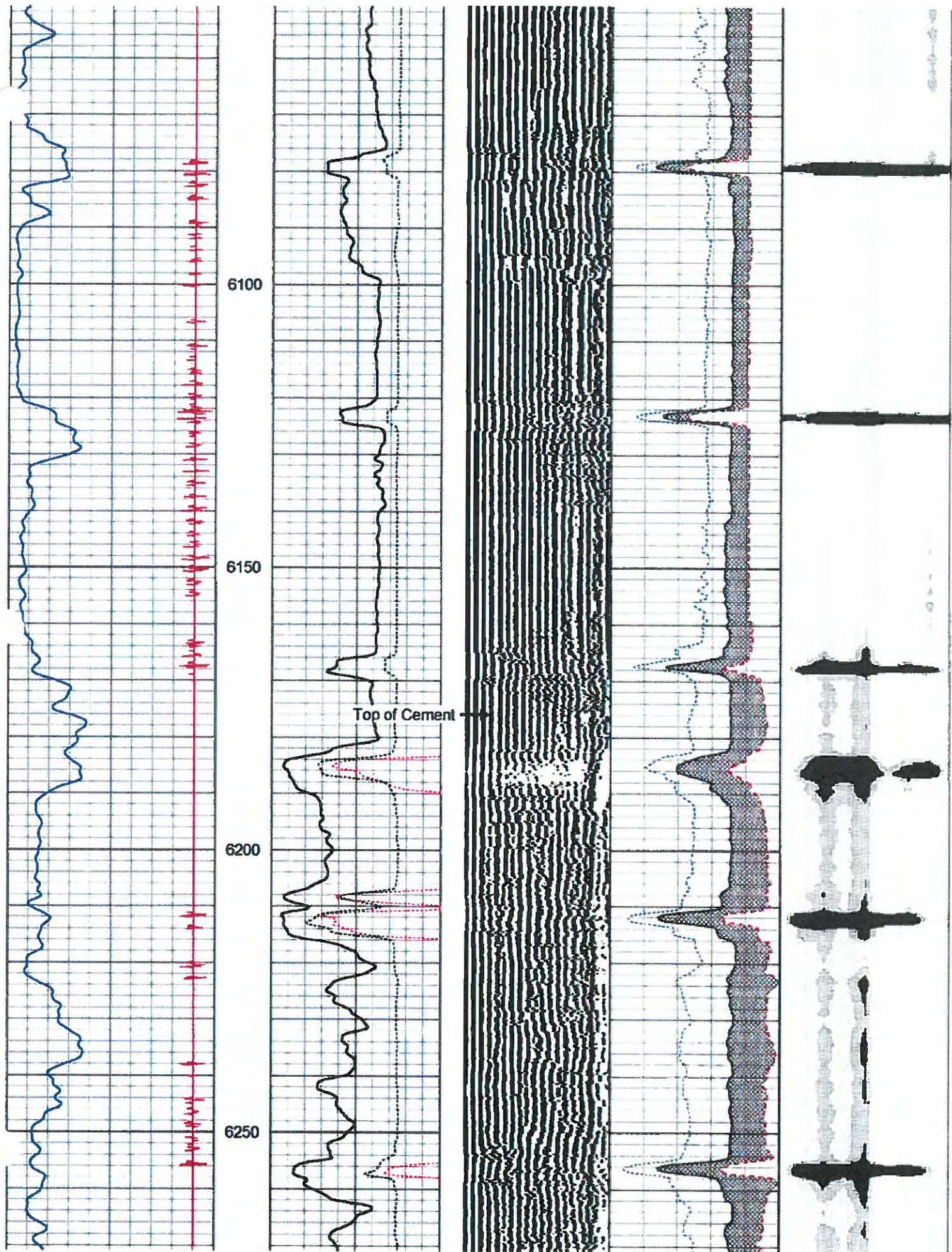
5700

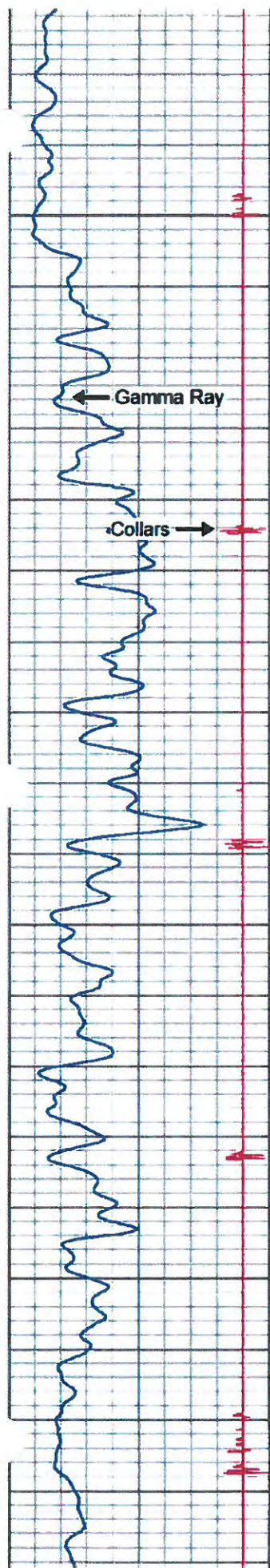
5750

5800







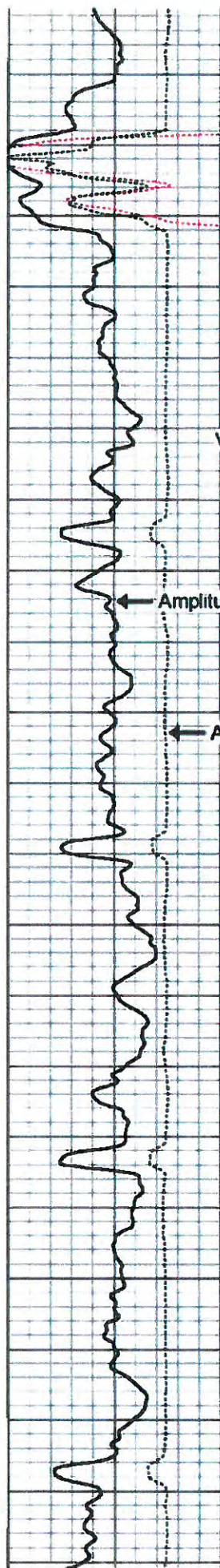


6300

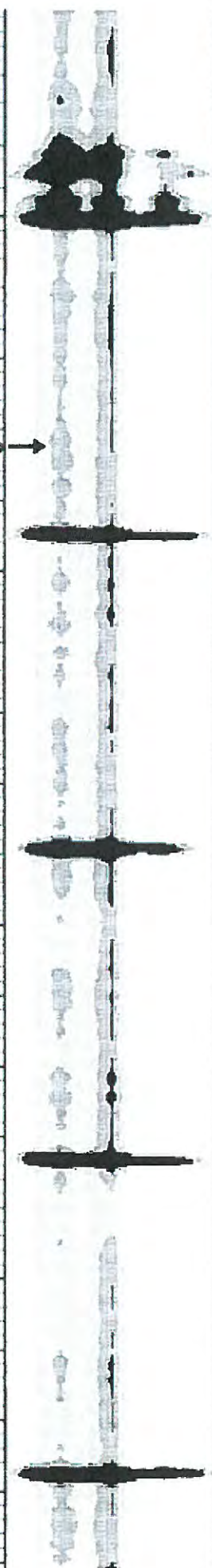
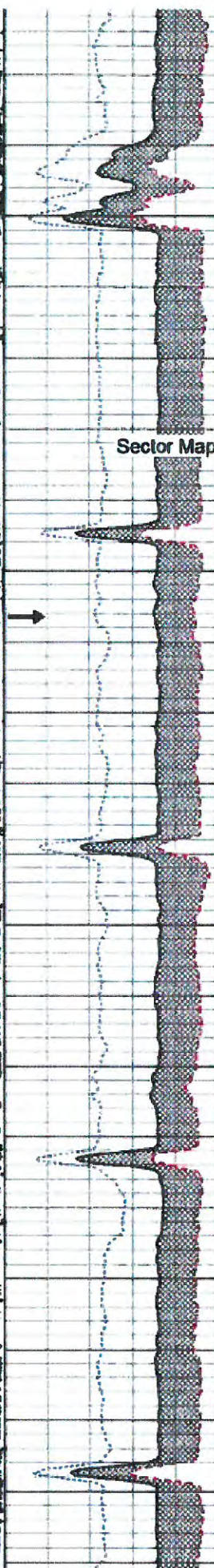
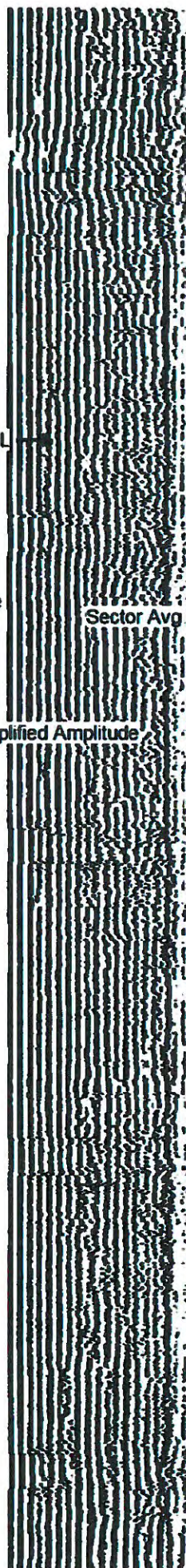
6350

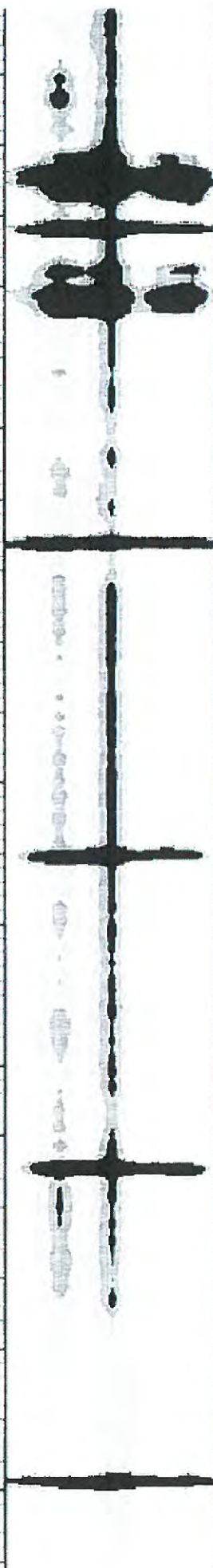
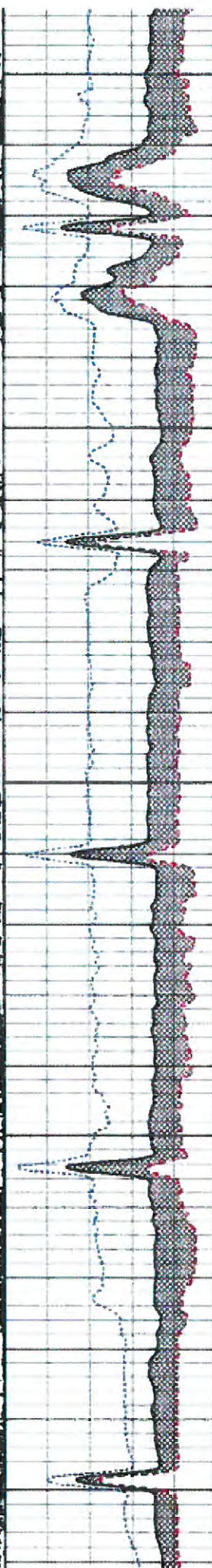
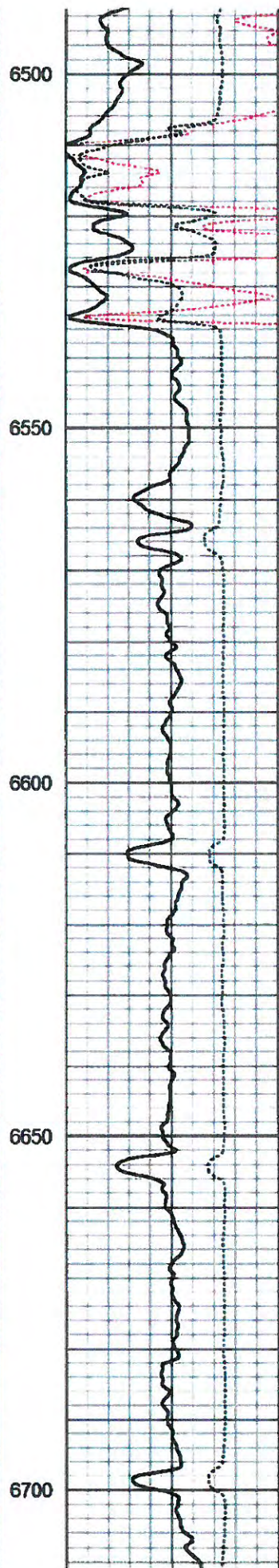
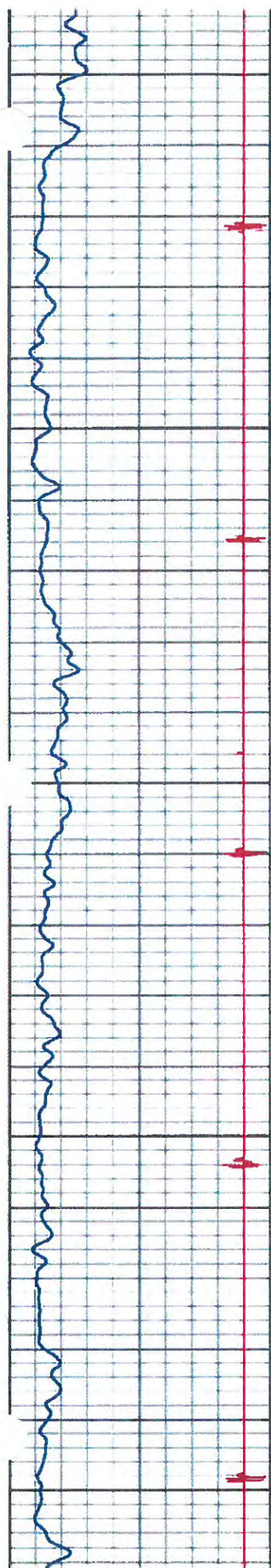
6400

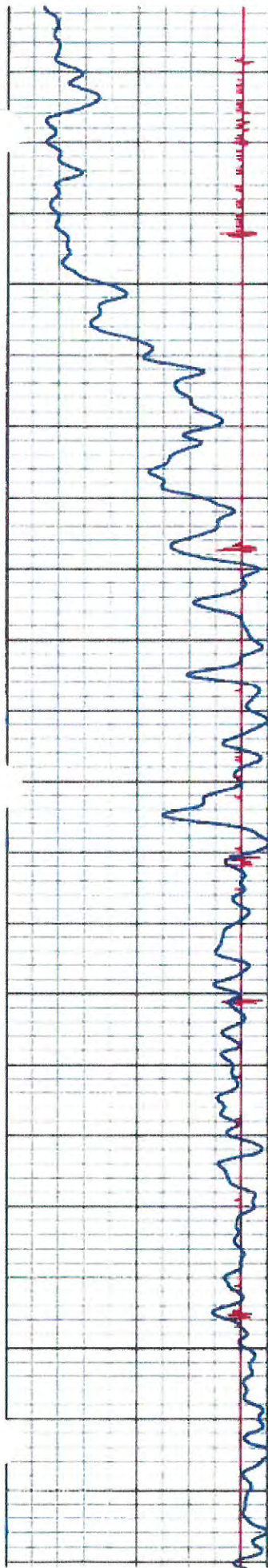
6450



VDL





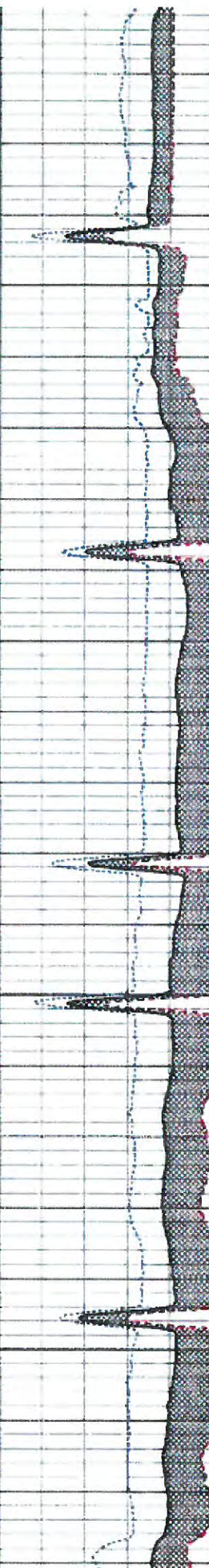
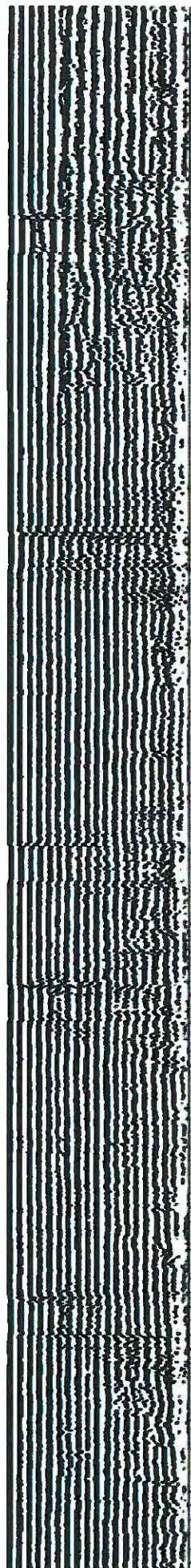
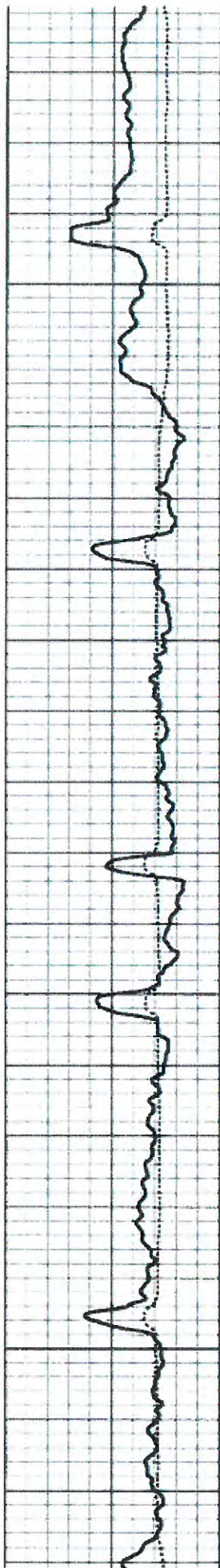


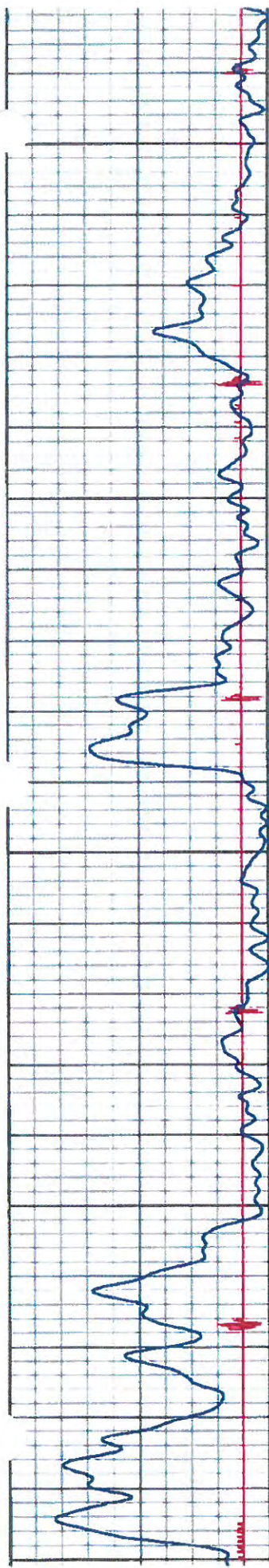
6750

6800

6850

6900





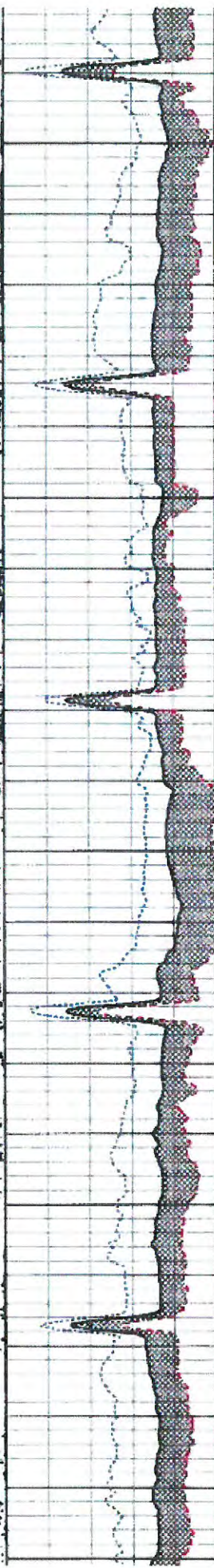
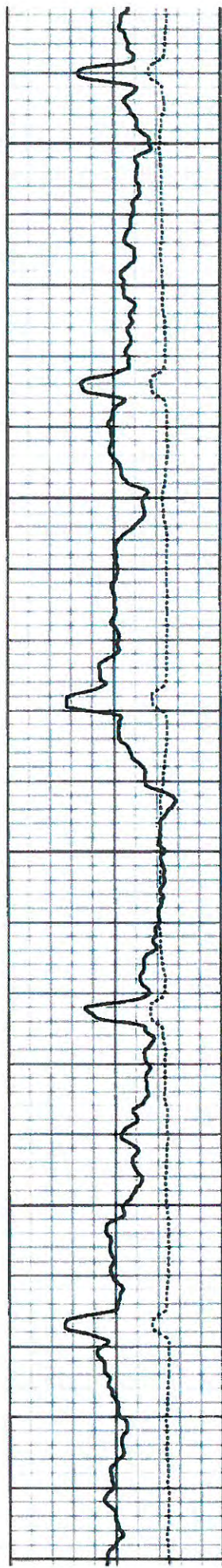
6950

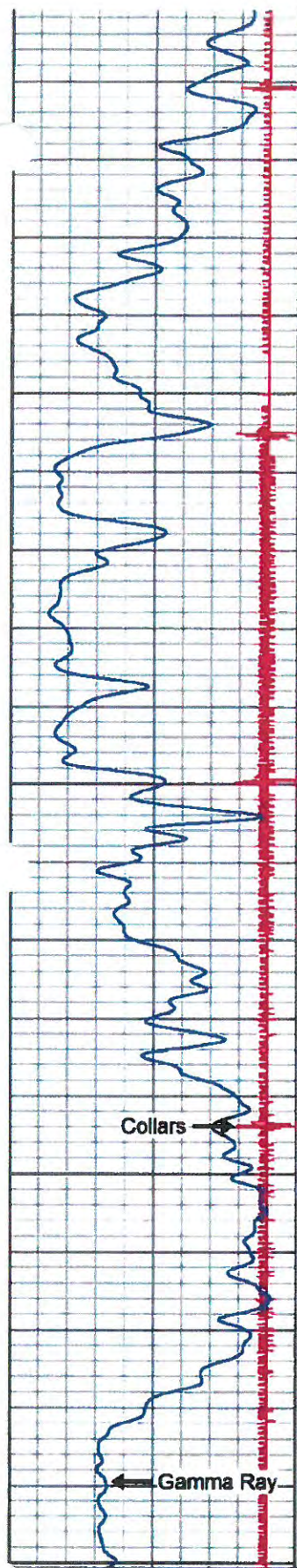
7000

7050

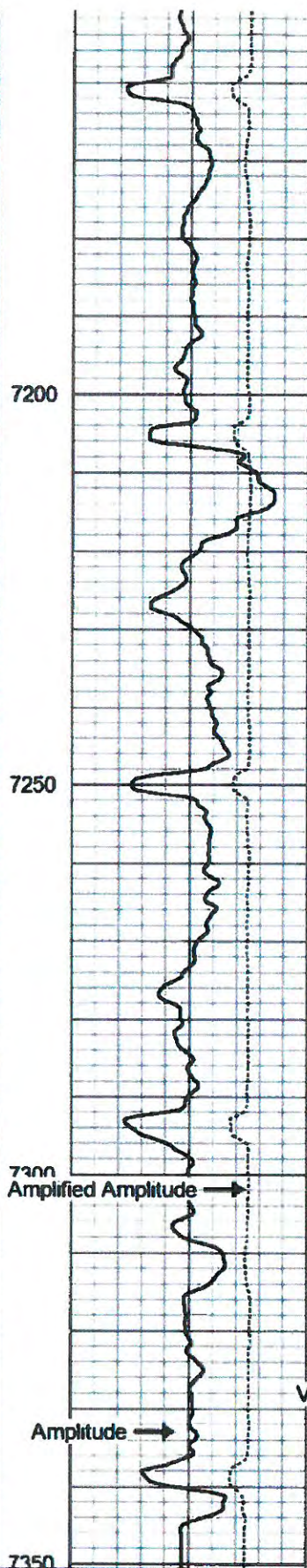
7100

7150

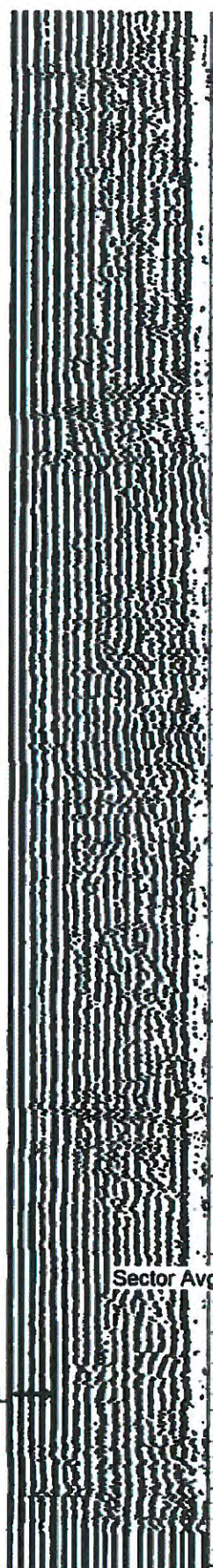




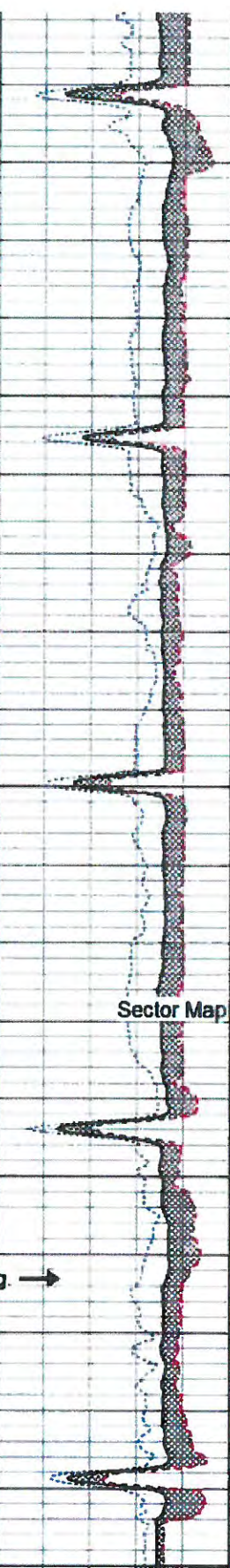
Collars			-1
0	Gamma Ray	200	
200	GR	400	



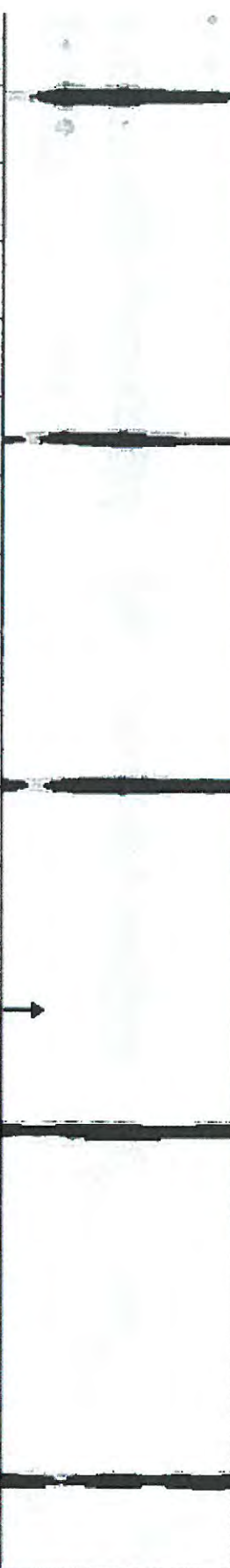
Amplified Amplitude			200
0	(mV)	20	
0	Amplitude (mV)	100	
300	TT (usec)	200	



200	VDL	1200	
-----	-----	------	--



0	Sector Avg.	100	
0	Sector Max.	100	
0	Sector Min.	100	



1	Sector Map	8	
45		75	

Calibration Report

Database File: 2 14 11 app oil pur bw4.db
 Dataset Pathname: pass7.10
 Dataset Creation: Tue Feb 15 09:37:43 2011 by Calc Std Casedhole 07122

Segmented Cement Bond Log Calibration Report

Serial Number: SCBT2_7H-XXXX
 Tool Model: SCBT2.7H
 Performed: Mon Feb 14 17:21:36 2011

Depth: 1111.218 ft
 Casing Diameter: 8.200 in

	References (mv)		Readings (v)		Results	
	Zero	Reference	Zero	Reference	m	b
3'	0.500	72.000	0.015	0.727	83.000	-1.035
5'	0.500	56.495	2.772	1.352	-39.426	109.790
S1	0.000	100.000	0.037	2.137	47.624	-1.756
S2	0.000	100.000	0.214	2.500	43.748	-9.369
S3	0.000	100.000	0.101	2.500	41.692	-4.231
S4	0.000	100.000	-0.029	1.858	52.997	1.531
S5	0.000	100.000	-0.029	1.866	52.783	1.532
S6	0.000	100.000	-0.027	1.353	72.466	1.968
S7	0.000	100.000	-0.028	1.612	60.994	1.707
S8	0.000	100.000	0.004	1.857	53.967	-0.192

Gamma Ray Calibration Report

Serial Number: GRBA2_7H
 Tool Model: GRBA2.7H
 Performed: Wed Jul 16 15:44:58 2008

Calibrator Value: 1.0

Background Reading: 0.0 cps
 Calibrator Reading: 1.0 cps

Sensitivity: 0.5000 /cps

Sensor	Offset (ft)	Schematic	Description	Len (ft)	OD (in)	Wt (lb)
CCL	0.00		Weatherford	1.03	1.44	
			2.75CCent 2 3/4" computalog cent	2.49	2.75	11.90
			CCLL-CTBA2 7H (CTBA2_7H) 2.75CCL/TELEMETRY COMPUTALOG LOGGING CCL	3.40	2.75	40.00

GR	-3.61					
			GR-GRBA2 7H (GRBA2_7H) 2.75" Computalog 6 Pin Gamma Ray	4.76	2.75	40.00



Weatherford®

Dual Laterolog Gamma Ray

COMPANY **Appalachian Oil Purchasers, Inc.**
WELL **BW 4**
FIELD **Washington District**
PROVINCE/COUNTY **Pleasants County**
COUNTRY/STATE **U.S.A. / West Virginia**
LOCATION **Raven Rock 7.5' Quadrangle**
PERMIT NUMBER **47-073-2523**

SEC	TWP	RGE	Other Services	Data Pack
			Photo Density	Sat. E-Mail
			Compensated Neutron	
			Temperature	

API Number

Permanent Datum Ground Level, Elevation 640 feet

Log Measured From K.B. of 14 Ft. above Permanent Datum

Drilling Measured From K.B. of 14 Ft.

Elevations:	feet
KB	654.00
DF	654.00
GL	640.00

Date	02-FEB-2011	
Run Number	Three	
Service Order		
Depth Driller	7503.00	feet
Depth Logger	7498.00	feet
First Reading	7498.00	feet
Last Reading	5166.00	feet
Casing Driller	5205.00	feet
Casing Logger	5176.00	feet
Bit Size	6.250	inches
Hole Fluid Type	Brine	
Density / Viscosity	10.10 lb/USg	
PH / Fluid Loss		
Sample Source	Flowline	
Rm @ Measured Temp	0.10 @ 64.0	ohm-m
Rmf @ Measured Temp		
Rmc @ Measured Temp		
Source Rmf / Rmc		
Rm @ BHT		
Time Since Circulation	6 Hours	
Max Recorded Temp	144.00	deg F
Equipment / Base	13157	Weston
Recorded By	Jason Sprouse	
Witnessed By	Scott Holcomb	
Field Ticket #	3528581	

BOREHOLE RECORD

Last Edited: 02-FEB-2011 14:59

Bit Size inches	6.250	Depth From feet	5176.00	Depth To feet	7498.00
--------------------	-------	--------------------	---------	------------------	---------

CASING RECORD

Type	Size inches	Depth From feet	Shoe Depth feet	Weight pounds/ft
	7.000	0.00	5176.00	17.00

REMARKS

Density matrix was ran on 2.71 Gm / cc
Crew: Steve Kirchberg
All logging speeds were ran at customers request
Fluid Level: Full
Mud filtrate density was ran on 1.0 Gm / cc
Thank You for using Weatherford Wireline Services

In interpreting, communicating or providing information and/or making recommendations, either written or oral, as to logs or test or other data, type or amount of material, or Work or other service to be furnished, or manner of performance, or in predicting results to be obtained, the Contractor will give the Company the benefit of the Contractor's best judgment based on its experience and will perform all such Work in a good and workmanlike manner. Any interpretation of test or other data, and any recommendation or reservoir description based upon such interpretations, are opinions based upon inferences from measurements and empirical relationships and assumptions, which inferences and assumptions are not infallible, and with respect to which professional engineers and analysts may differ. ACCORDINGLY ANY INTERPRETATION OR RECOMMENDATION RESULTING FROM THE SERVICES WILL BE AT THE SOLE RISK OF THE COMPANY, AND THE CONTRACTOR CANNOT AND DOES NOT WARRANT THE ACCURACY, CORRECTNESS OR COMPLETENESS OF ANY SUCH

INTERPRETATION OR RECOMMENDATION, WHICH INTERPRETATIONS AND RECOMMENDATIONS SHOULD NOT, THEREFORE, UNDER ANY CIRCUMSTANCES BE RELIED UPON AS THE SOLE OR MAIN BASIS FOR ANY DRILLING, COMPLETION, WELL TREATMENT, PRODUCTION OR FINANCIAL DECISION, OR ANY PROCEDURE INVOLVING ANY RISK TO THE SAFETY OF ANY DRILLING ACTIVITY, DRILLING RIG OR ITS CREW OR ANY OTHER INDIVIDUAL. THE COMPANY HAS FULL RESPONSIBILITY FOR ALL DECISIONS CONCERNING THE SERVICES.

2 Inch Main Log

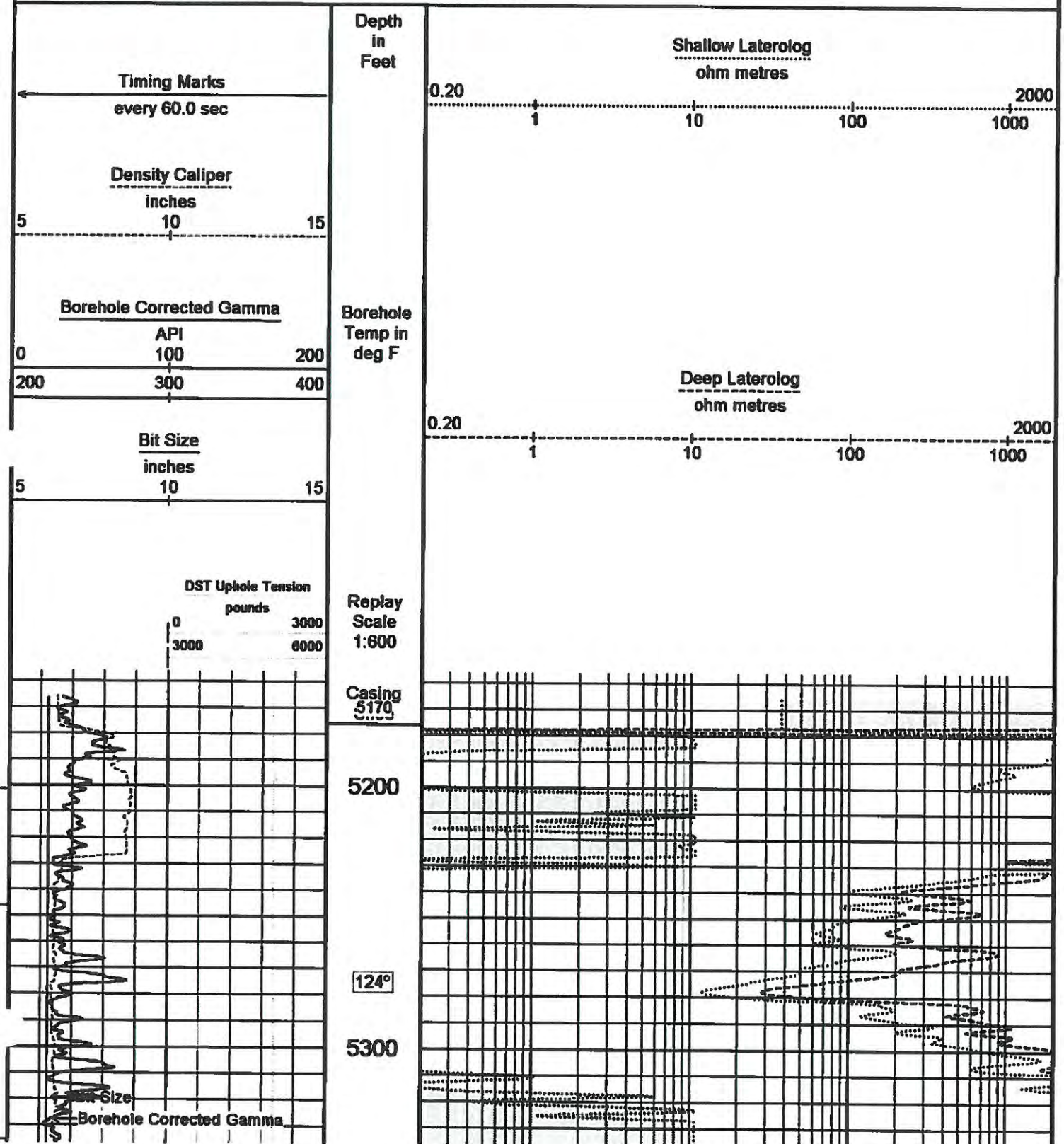
Depth Based Data - Maximum Sampling Increment 10.0cm

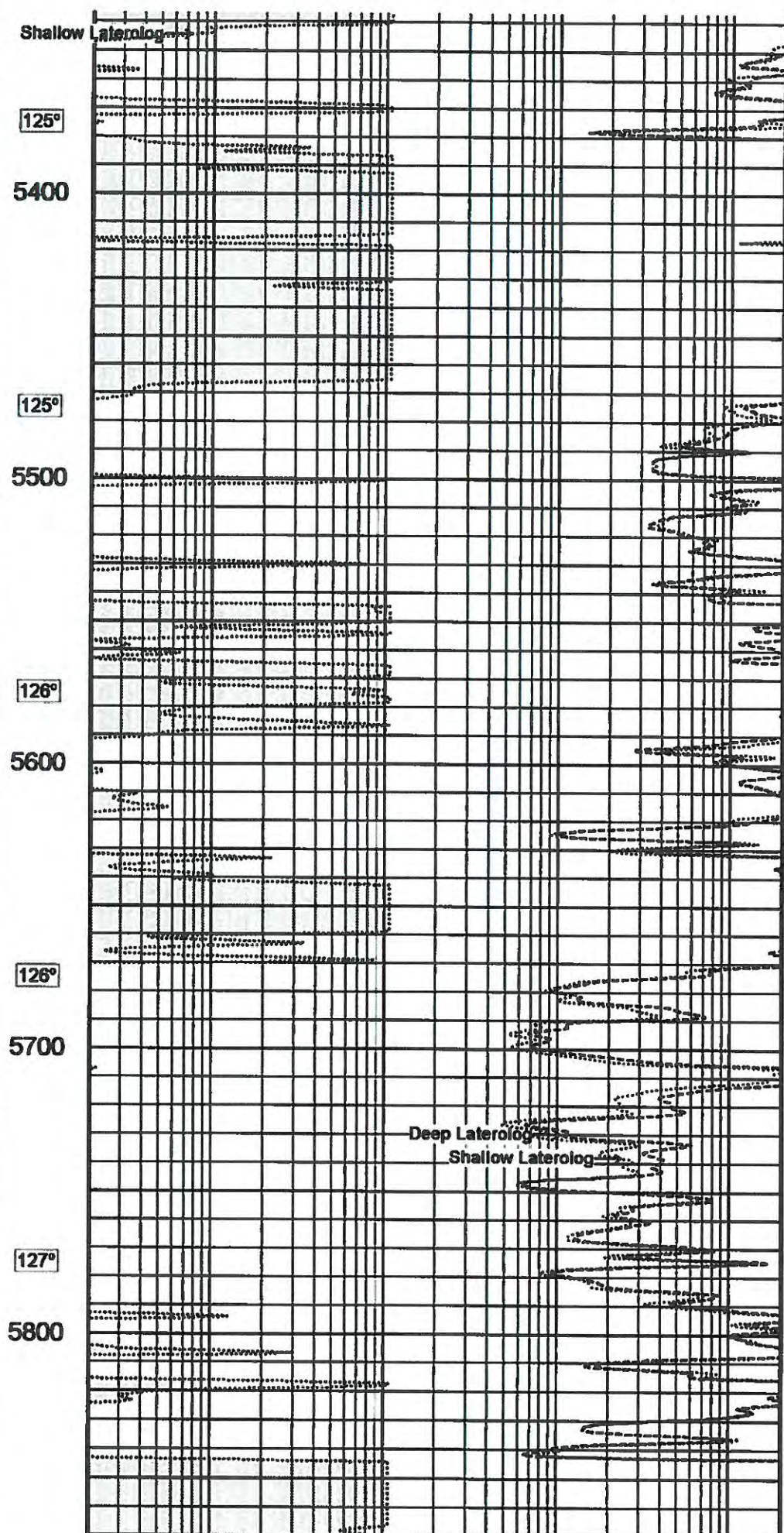
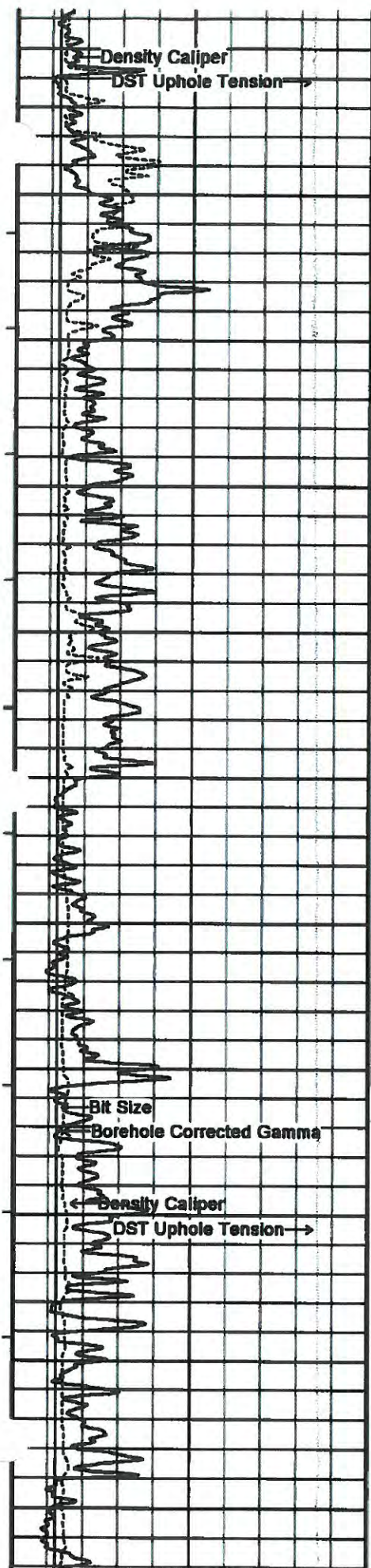
Filename: C:\Users\ASTRAH~1\AppData\Local\Temp\Weatherford PreView\0\BW 4 Up_001.dta

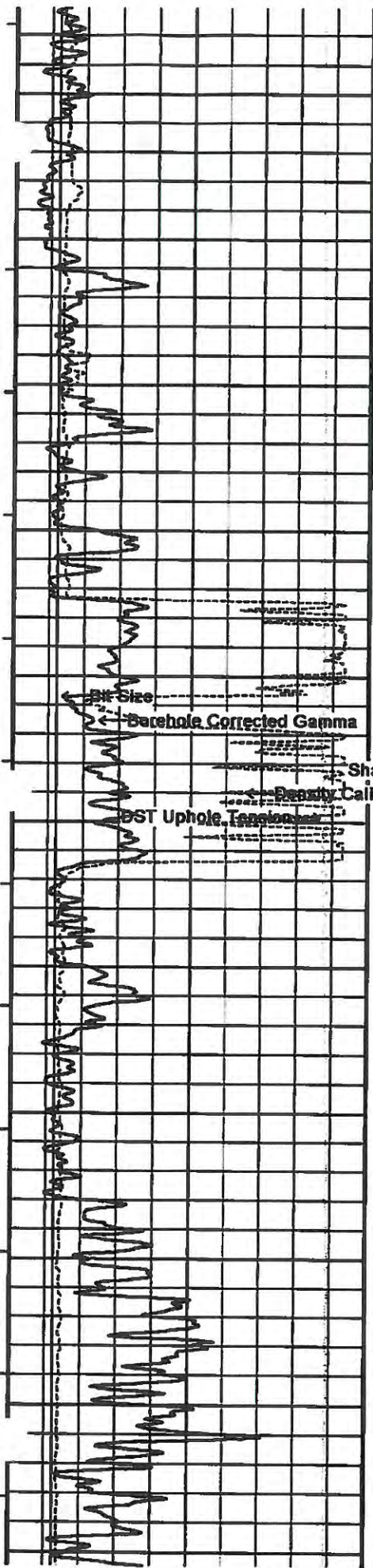
System Versions: Logged with 11.02.2782 Plotted with 13.08.1505

Plotted on 14-SEP-2016 07:41

Recorded on 02-FEB-2011 13:40







127°

5900

128°

6000

128°

6100

129°

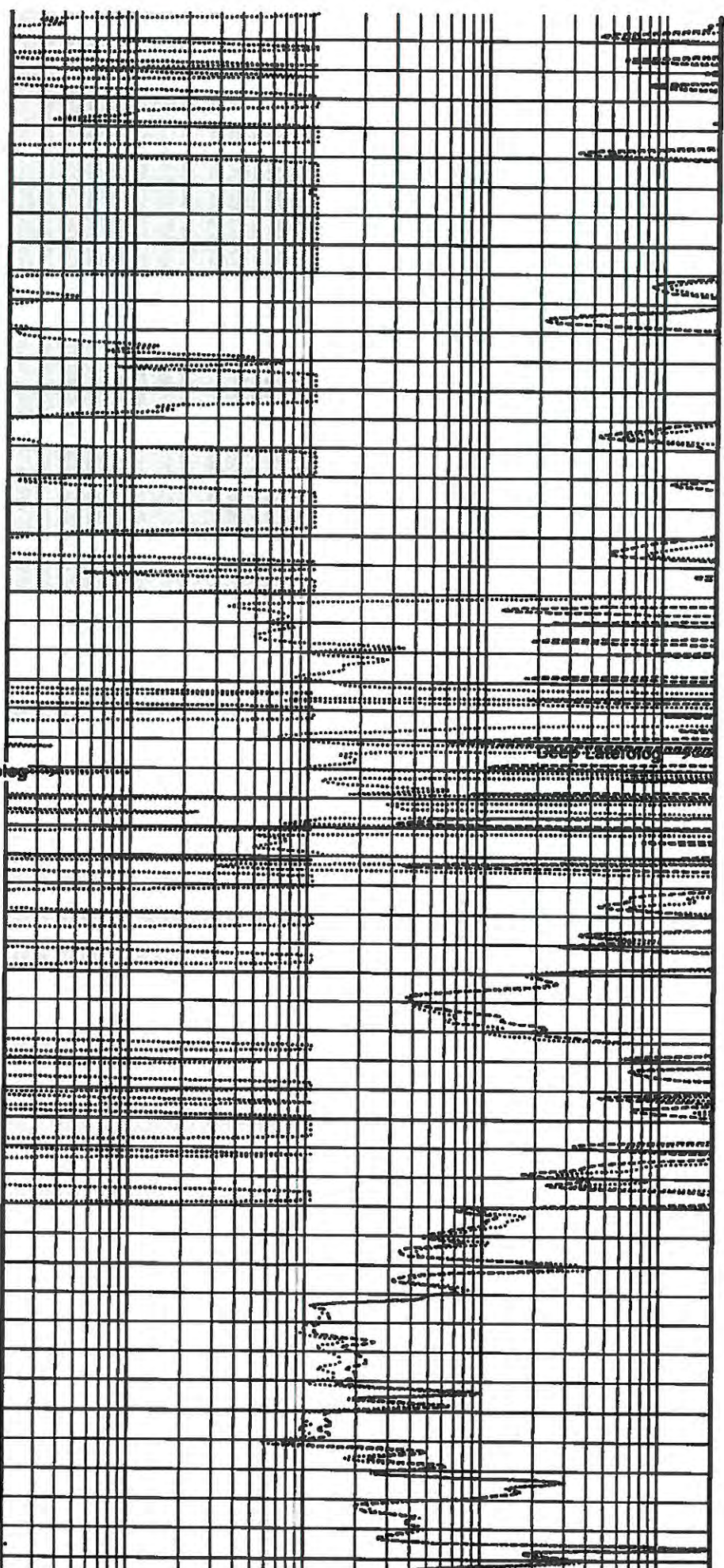
6200

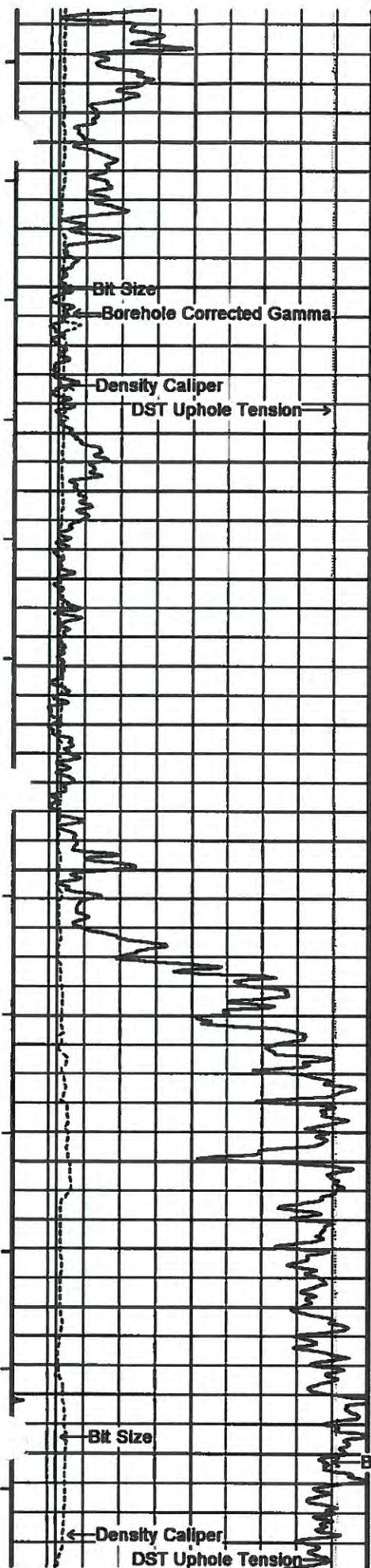
129°

6300

130°

6400





131°

6500

Shallow Laterolog

132°

6600

133°

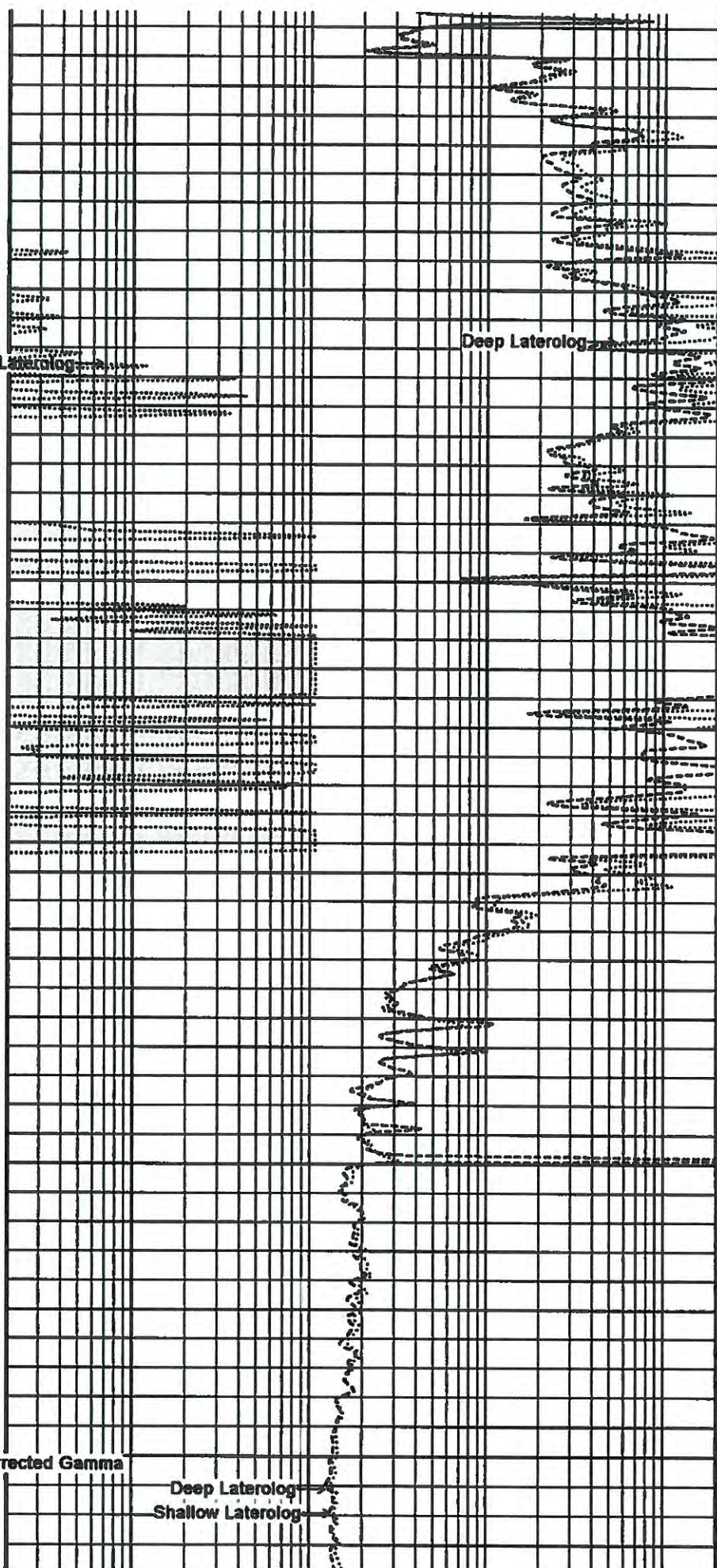
6700

134°

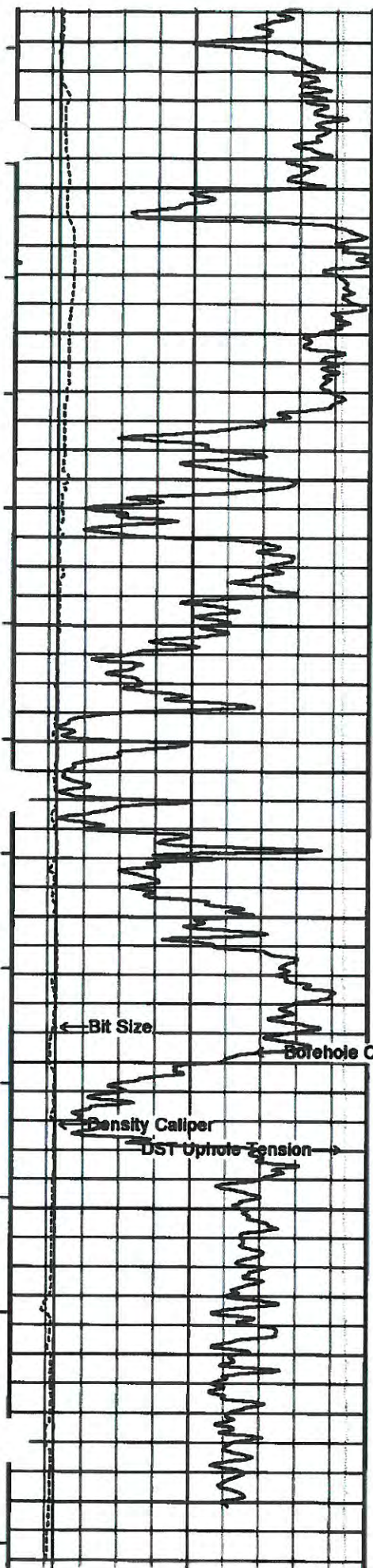
6800

136°

6900
Borehole Corrected Gamma



Deep Laterolog
Shallow Laterolog



138°

7000

140°

7100

141°

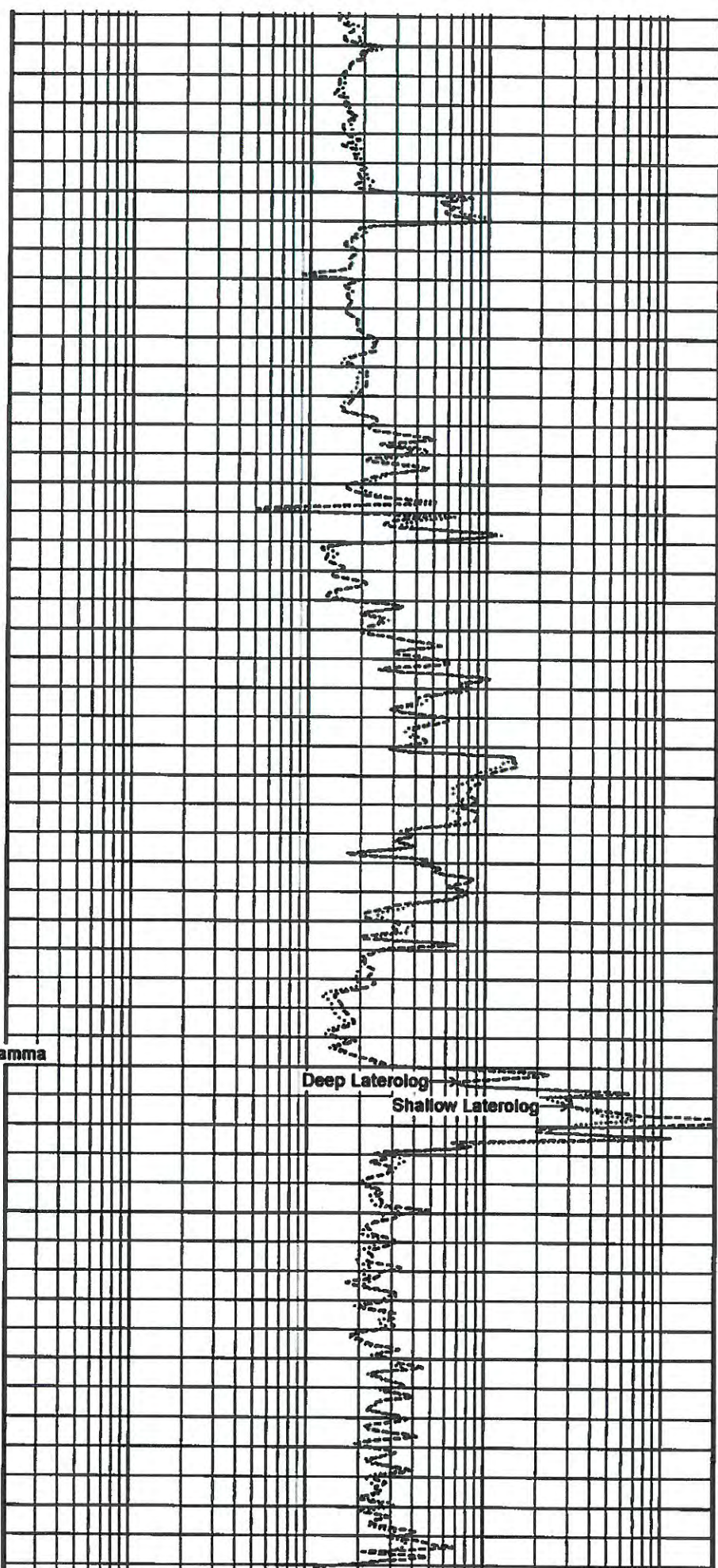
7200

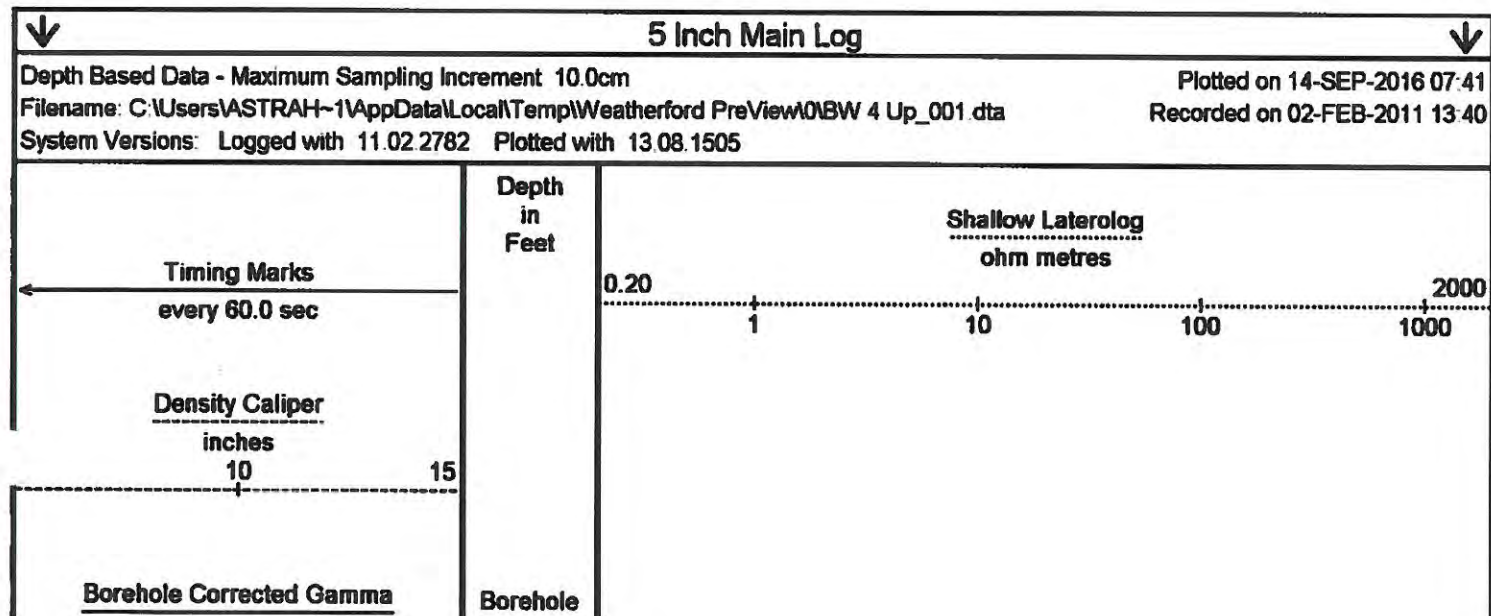
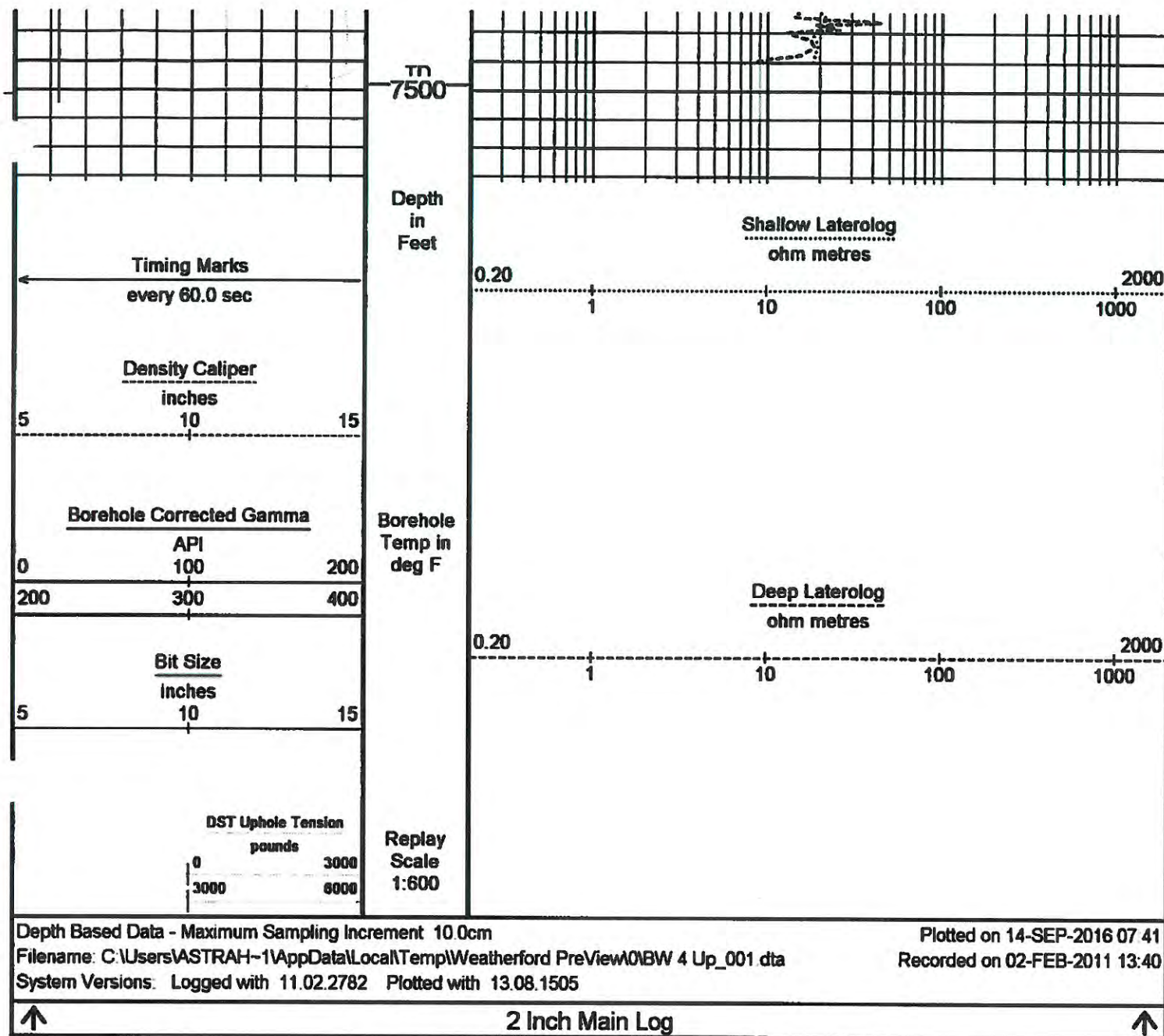
143°

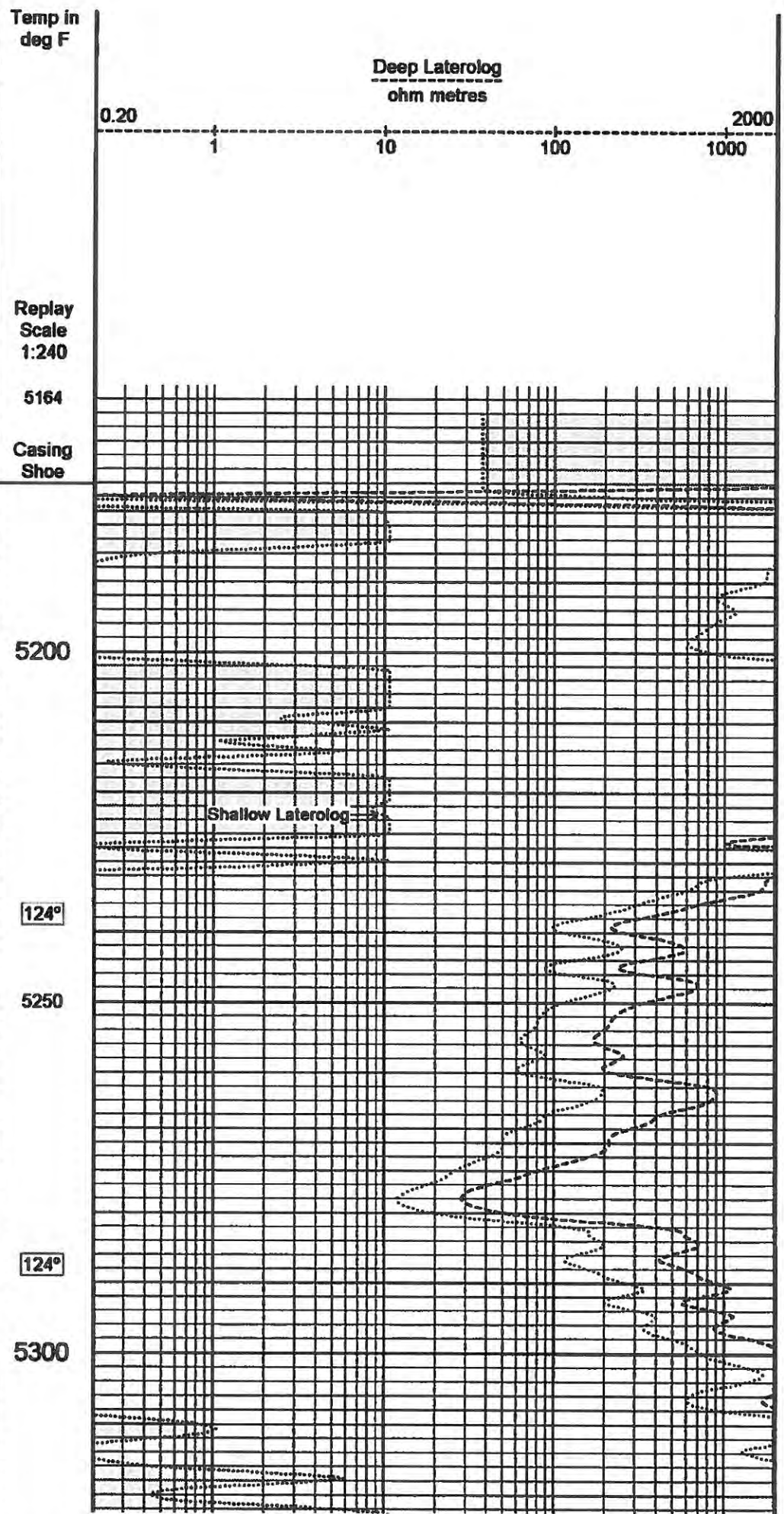
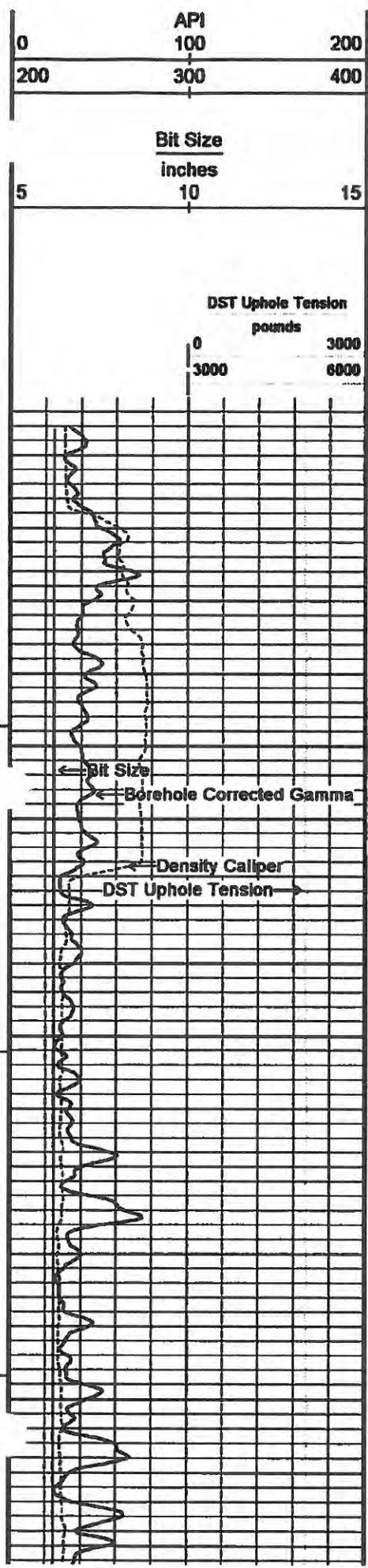
7300

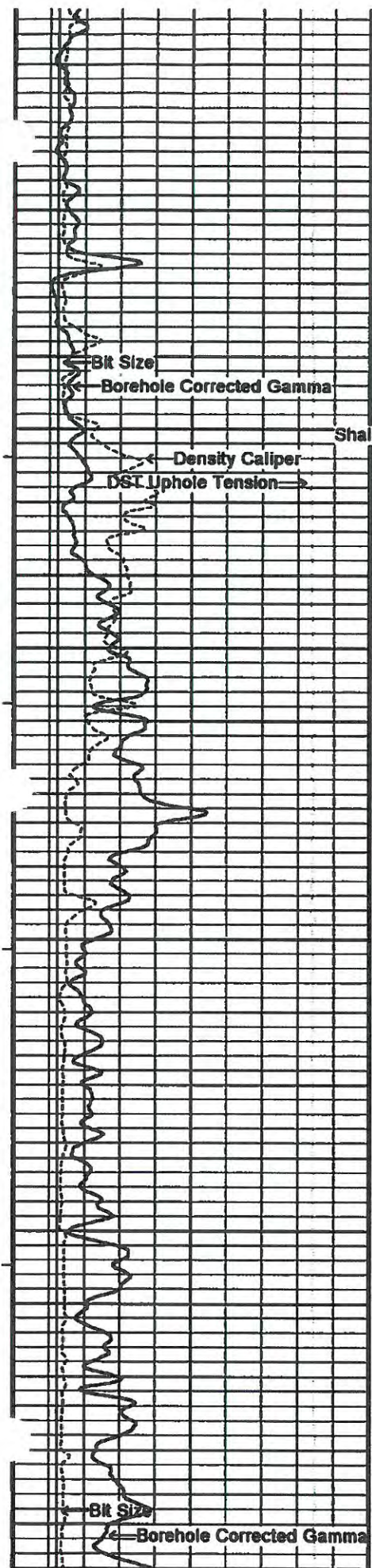
144°

7400









125°

5350

125°

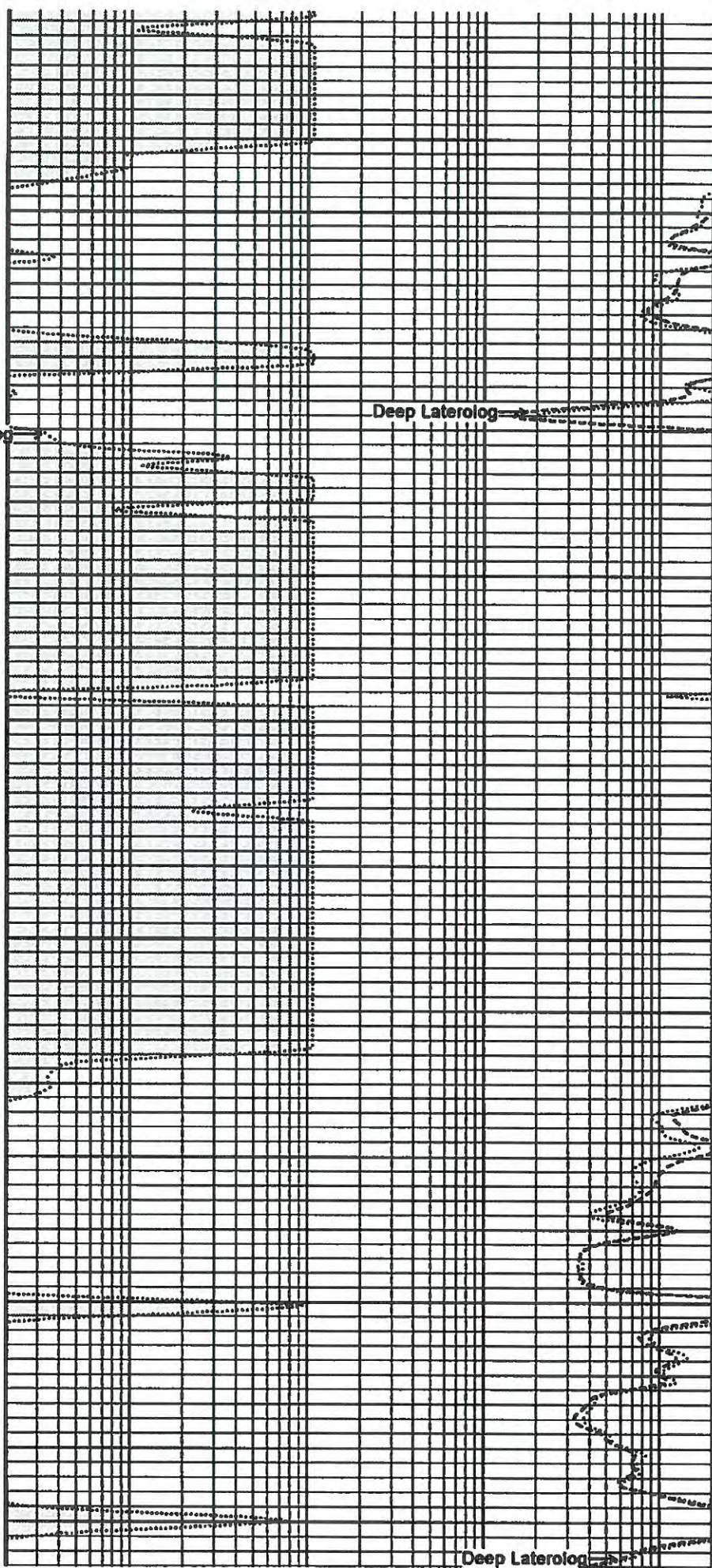
5400

125°

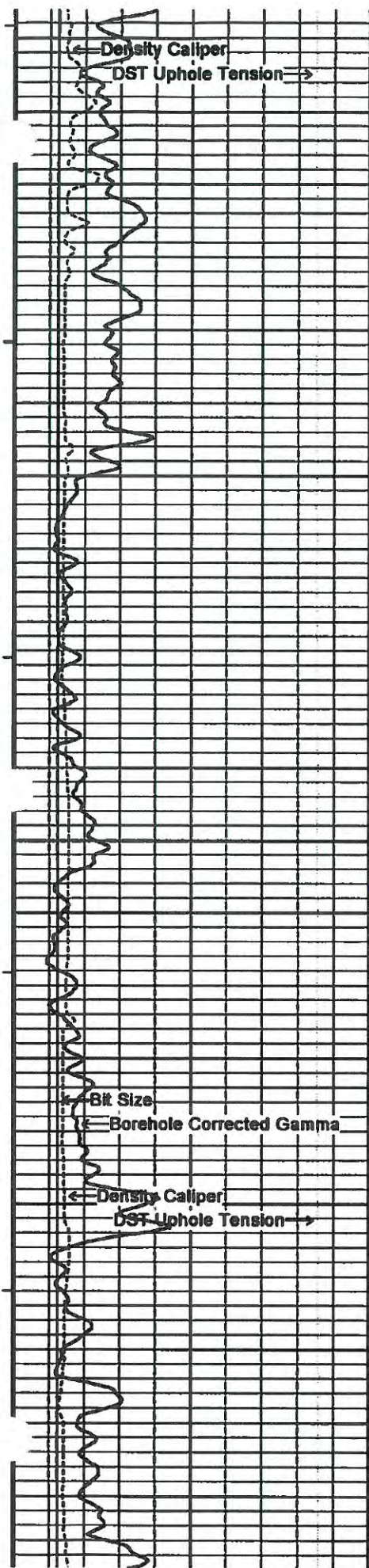
5450

125°

5500



Deep Laterolog



125°

5550

126°

5600

126°

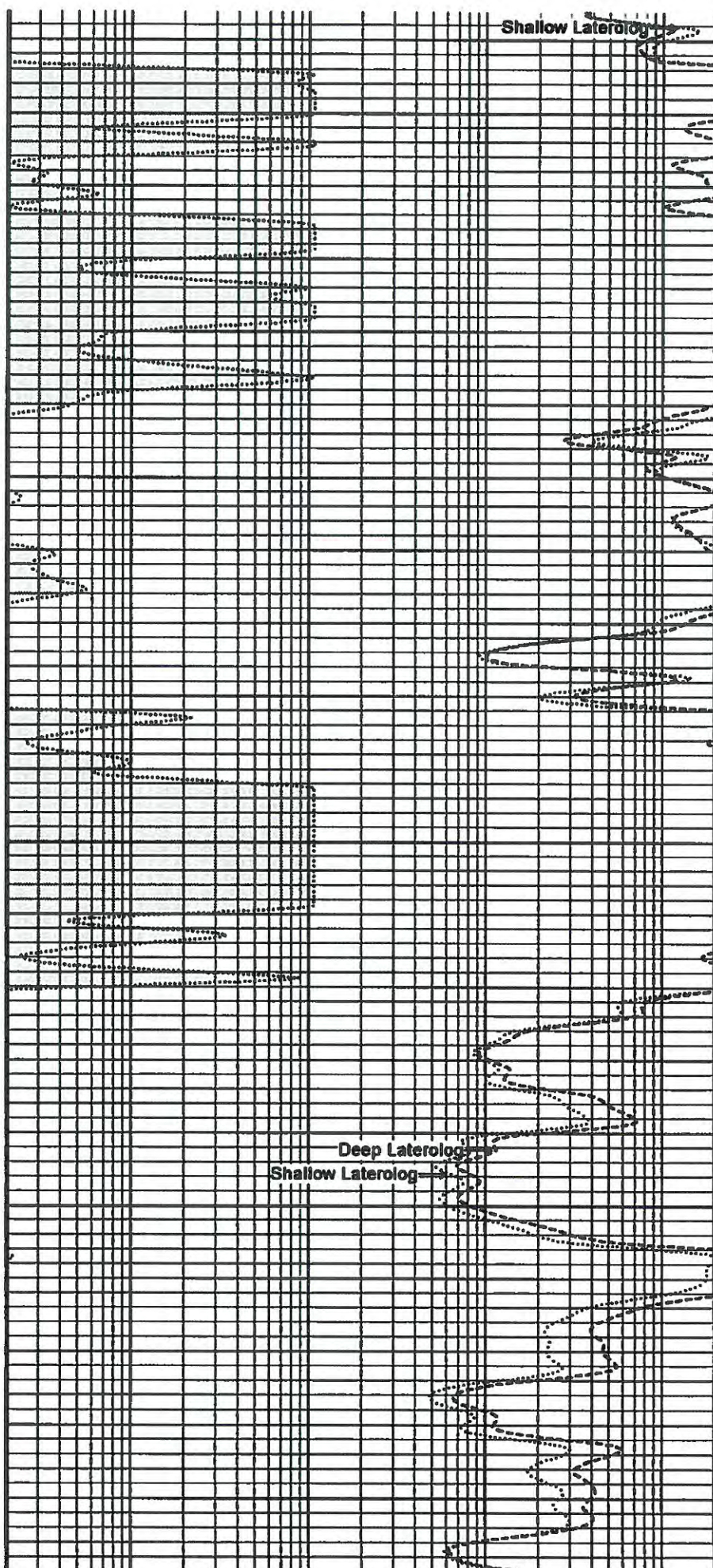
5650

126°

5700

126°

CTCA



Shallow Laterolog

Deep Laterolog

Shallow Laterolog

5130

127°

5800

127°

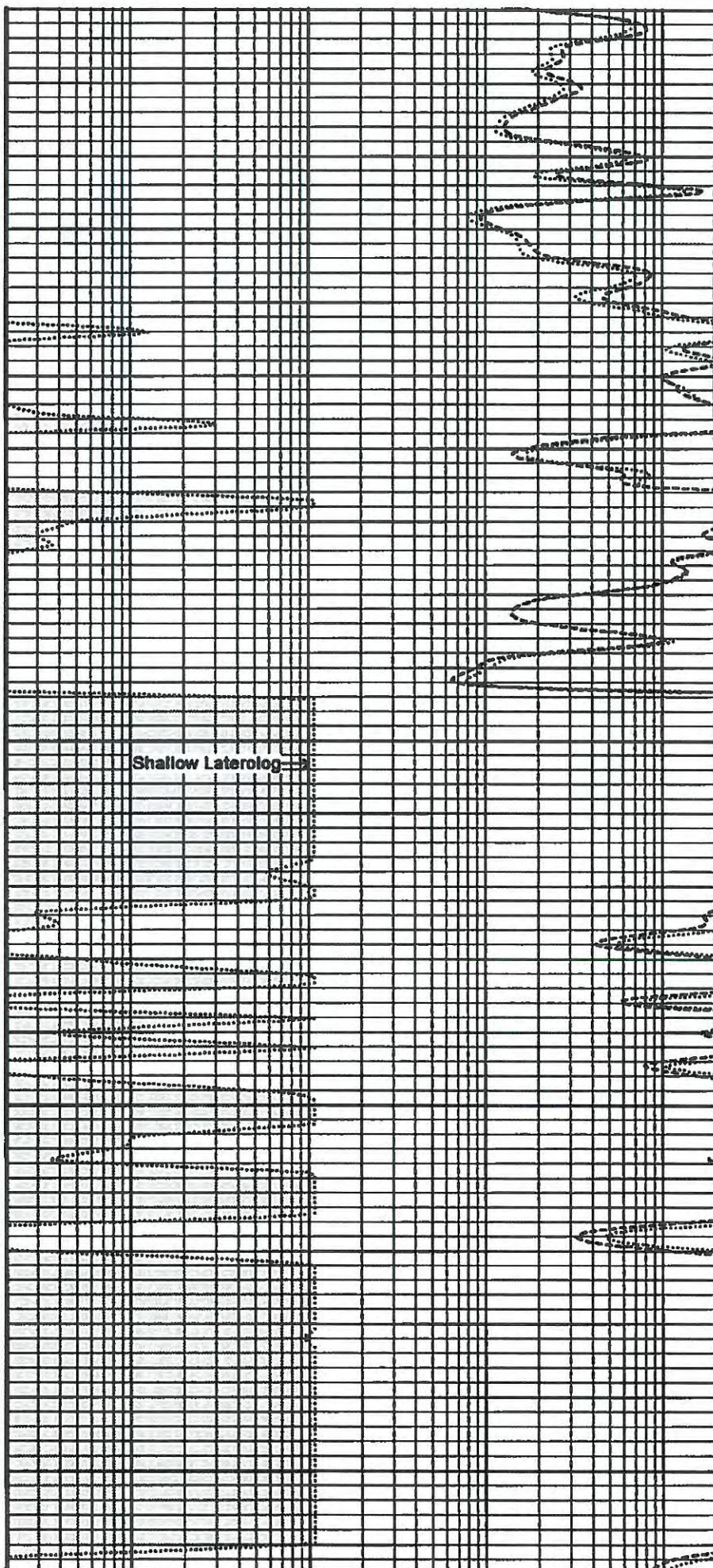
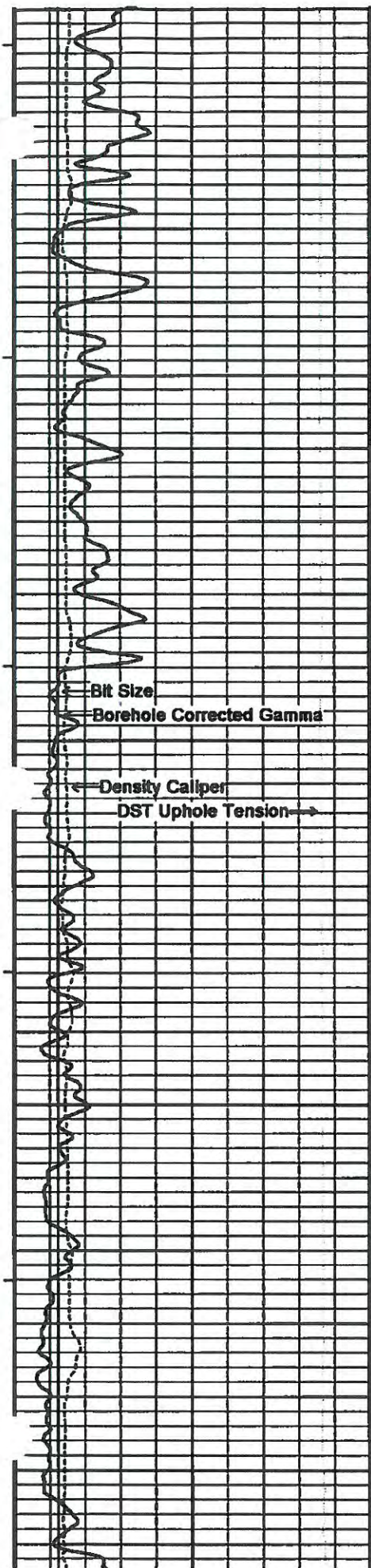
5850

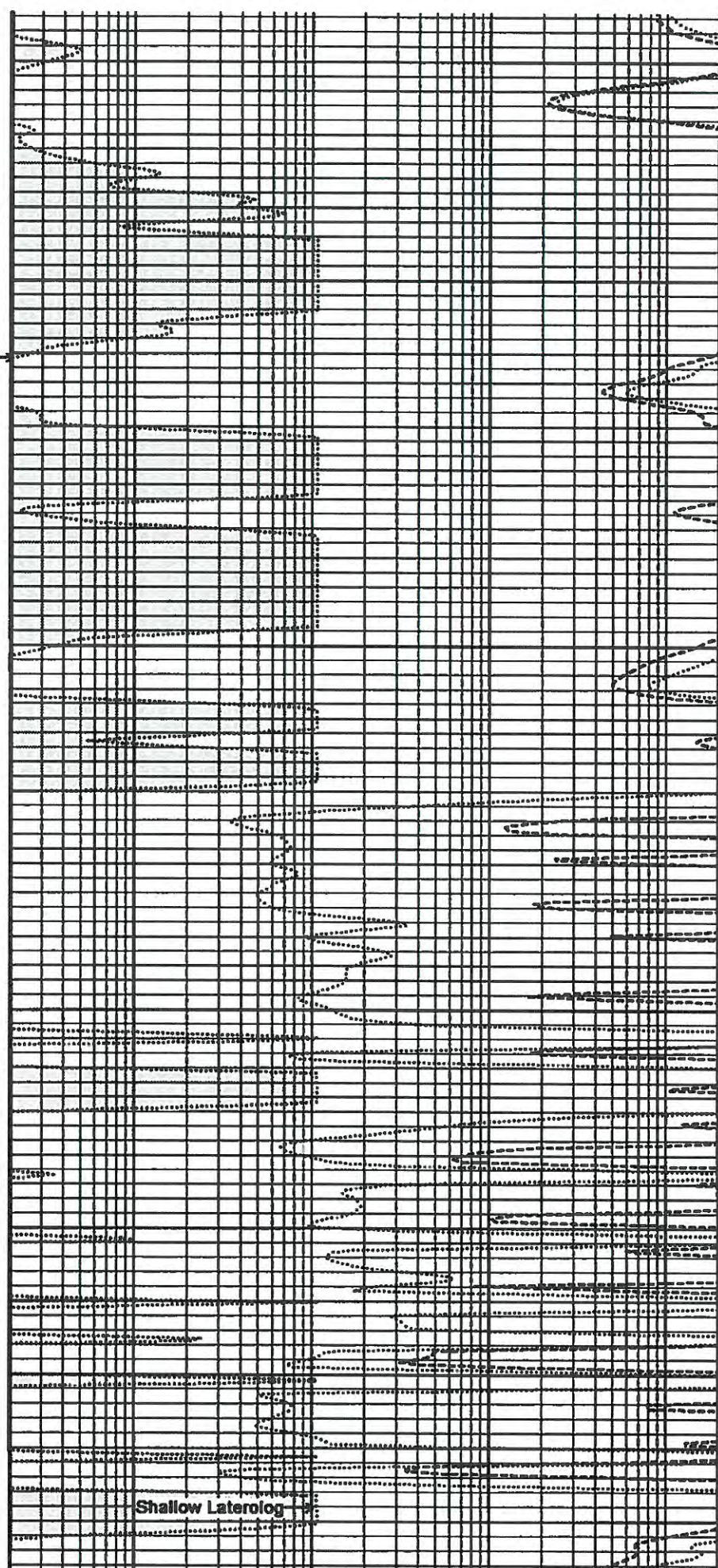
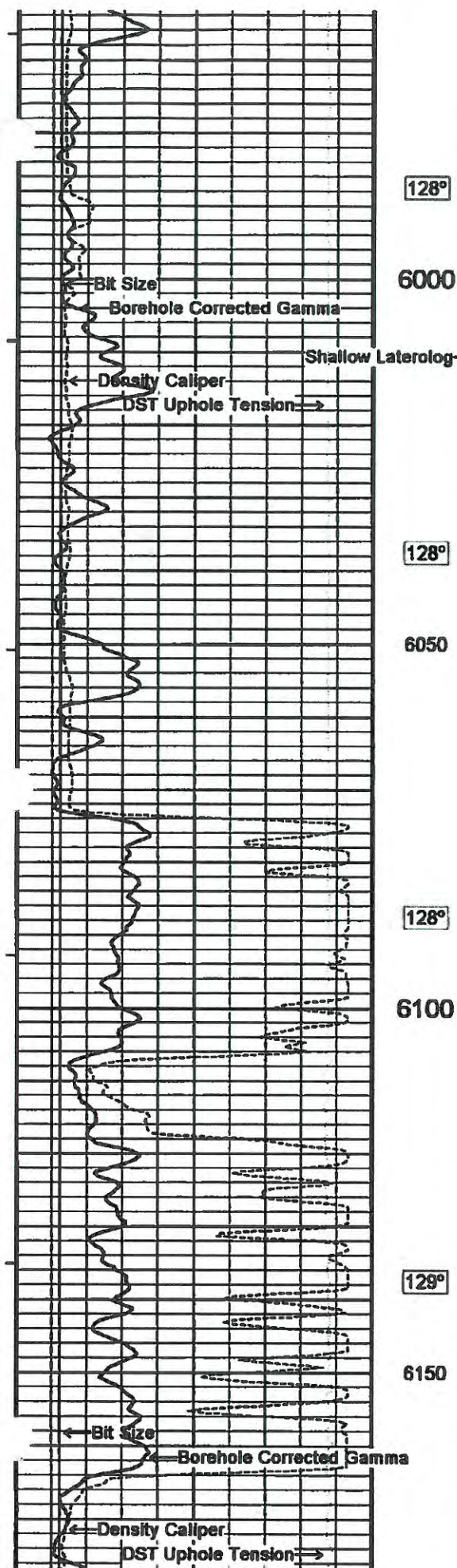
127°

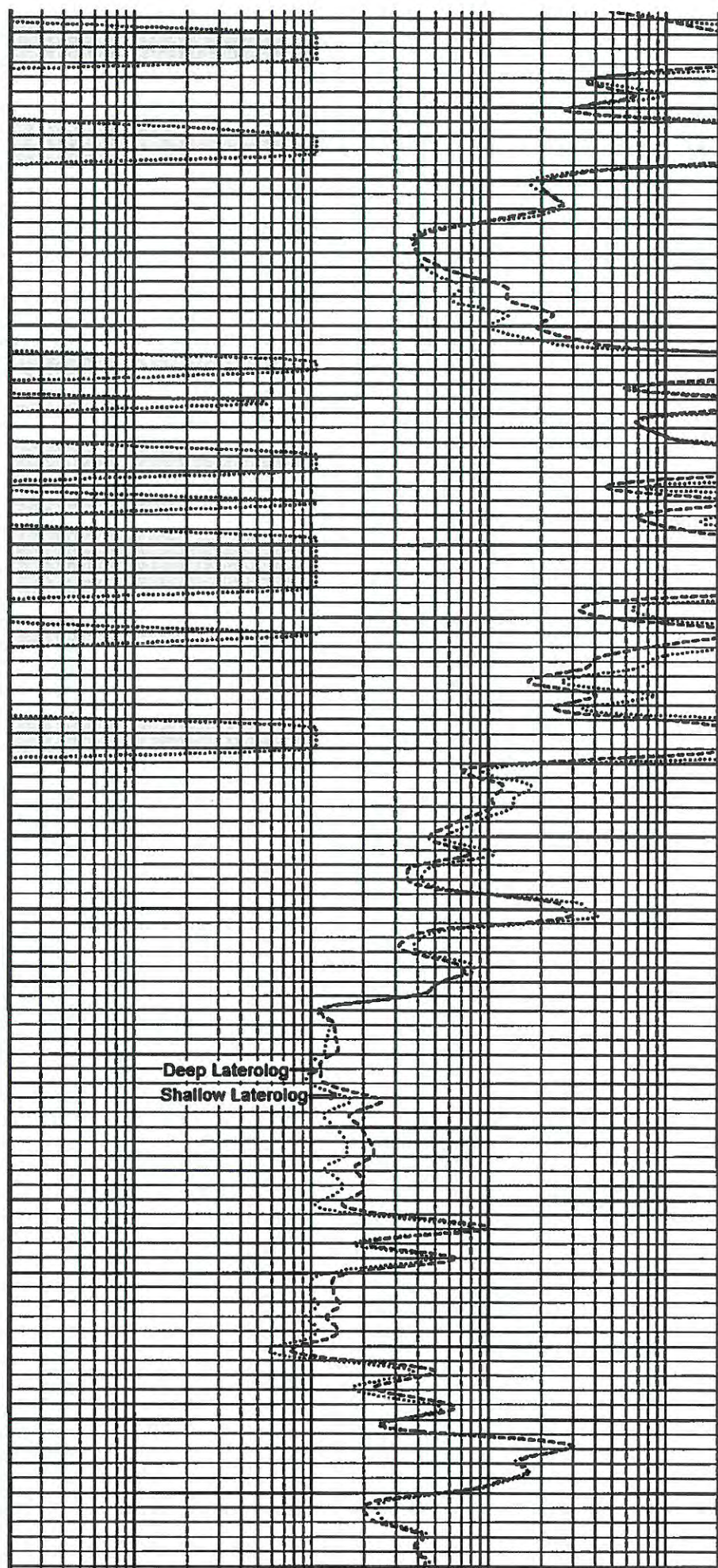
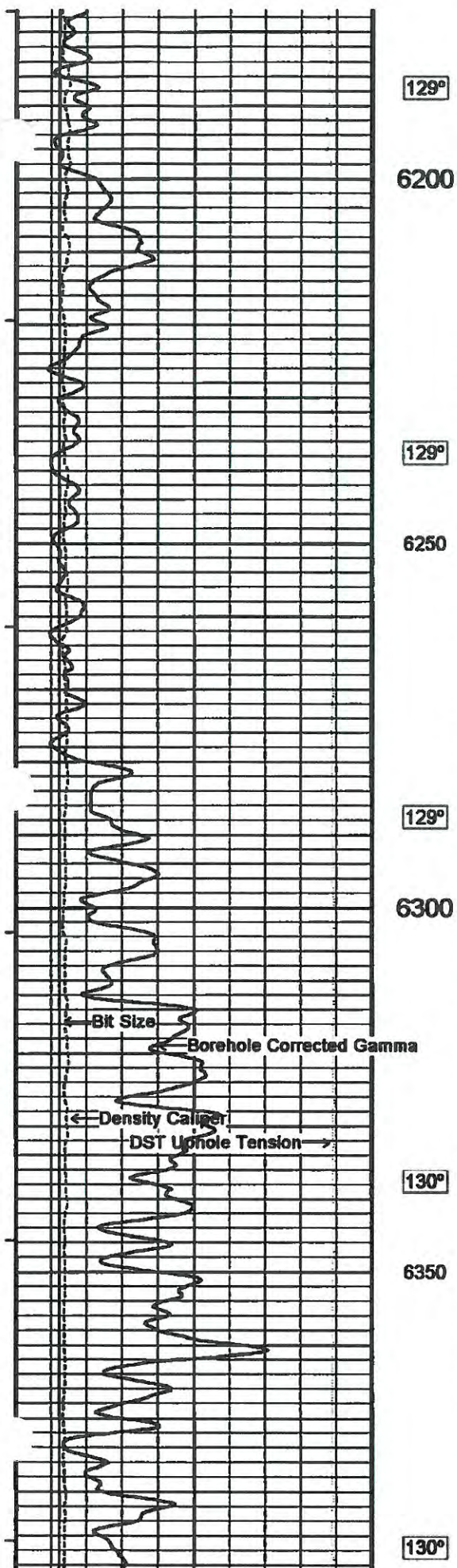
5900

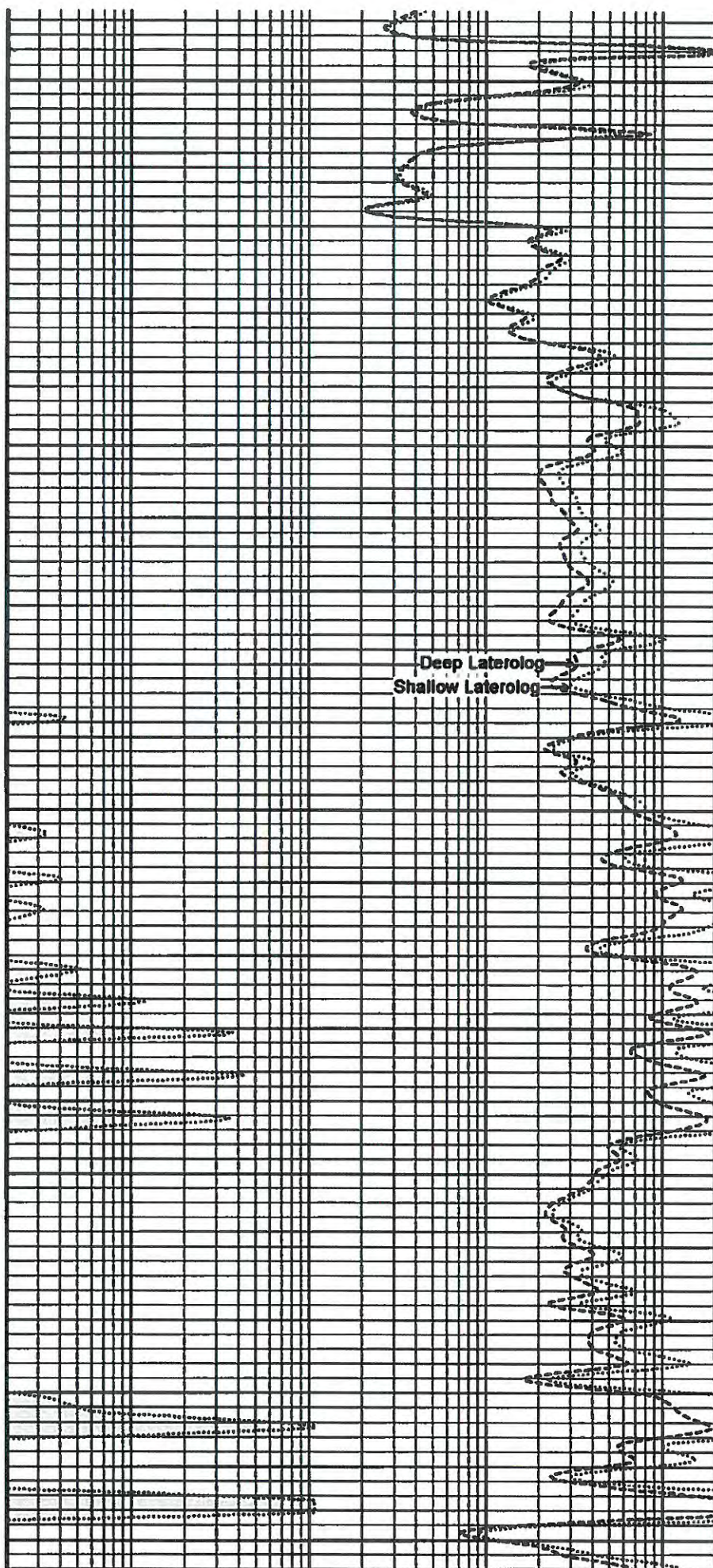
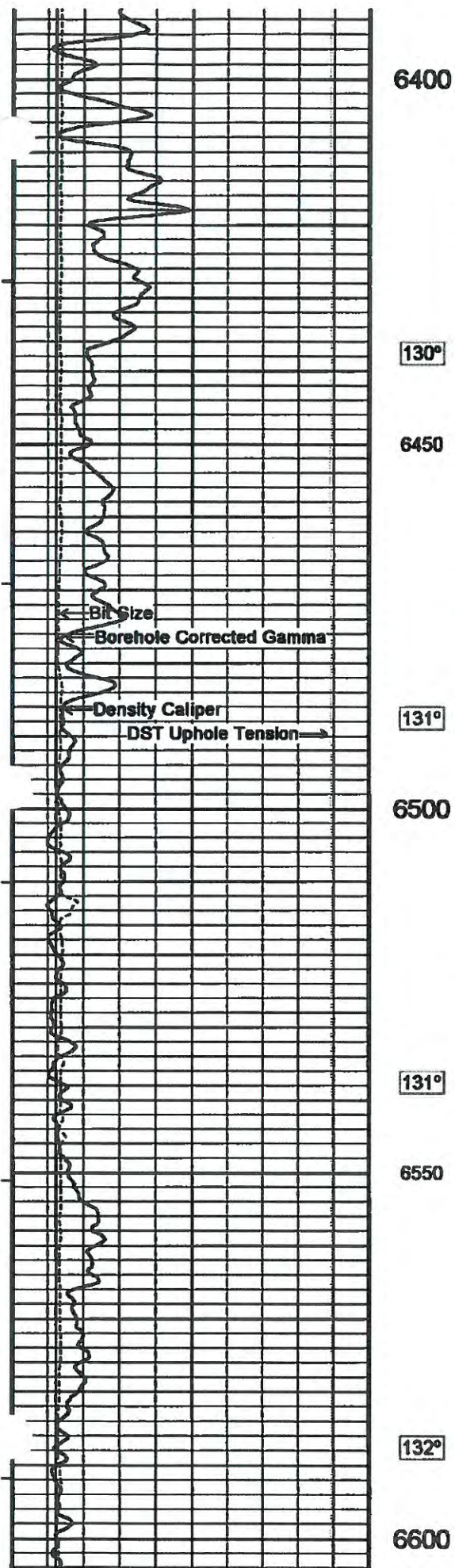
128°

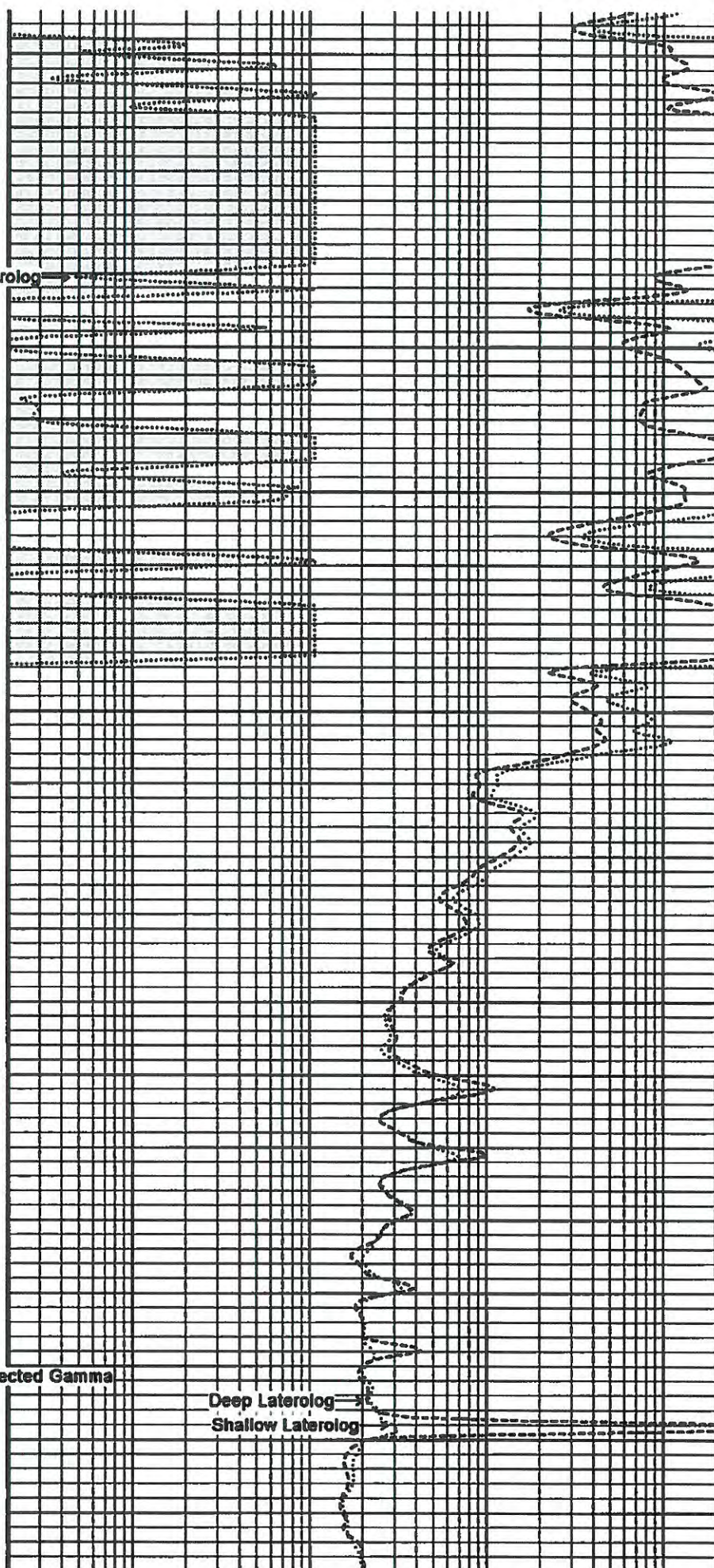
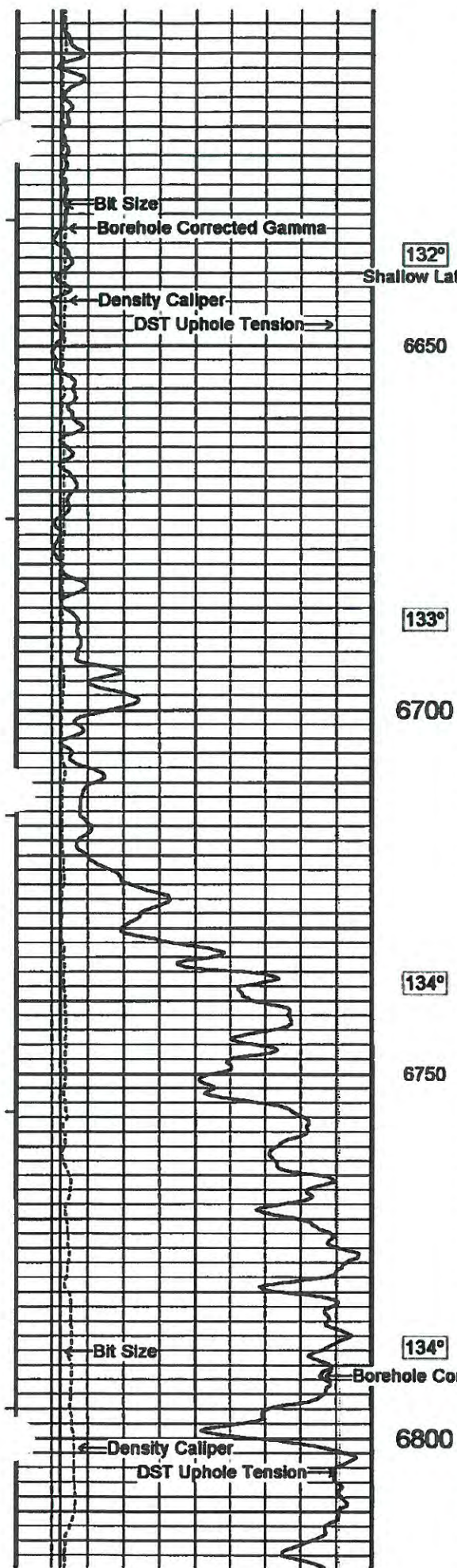
5950

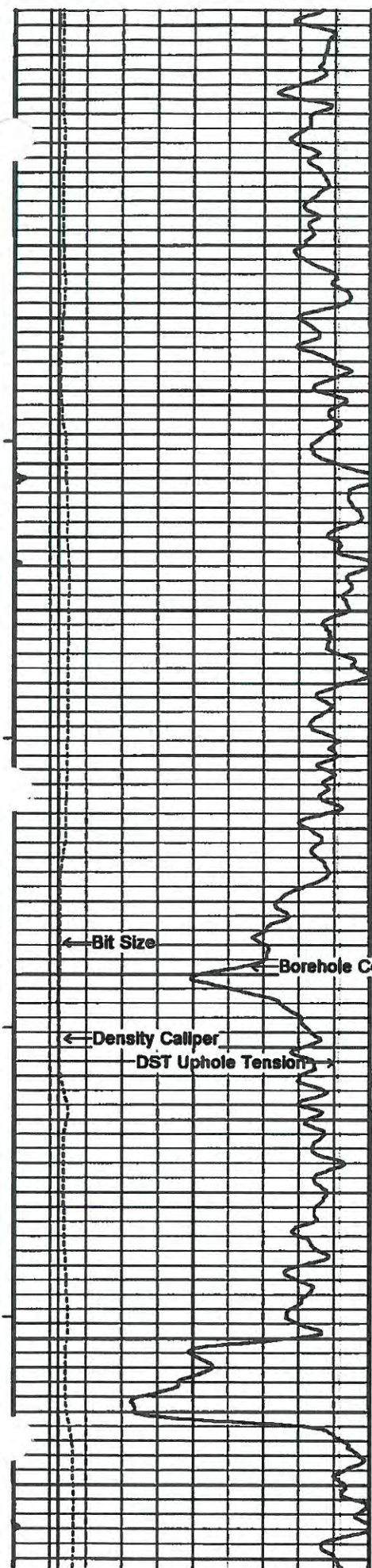












135°

6850

136°

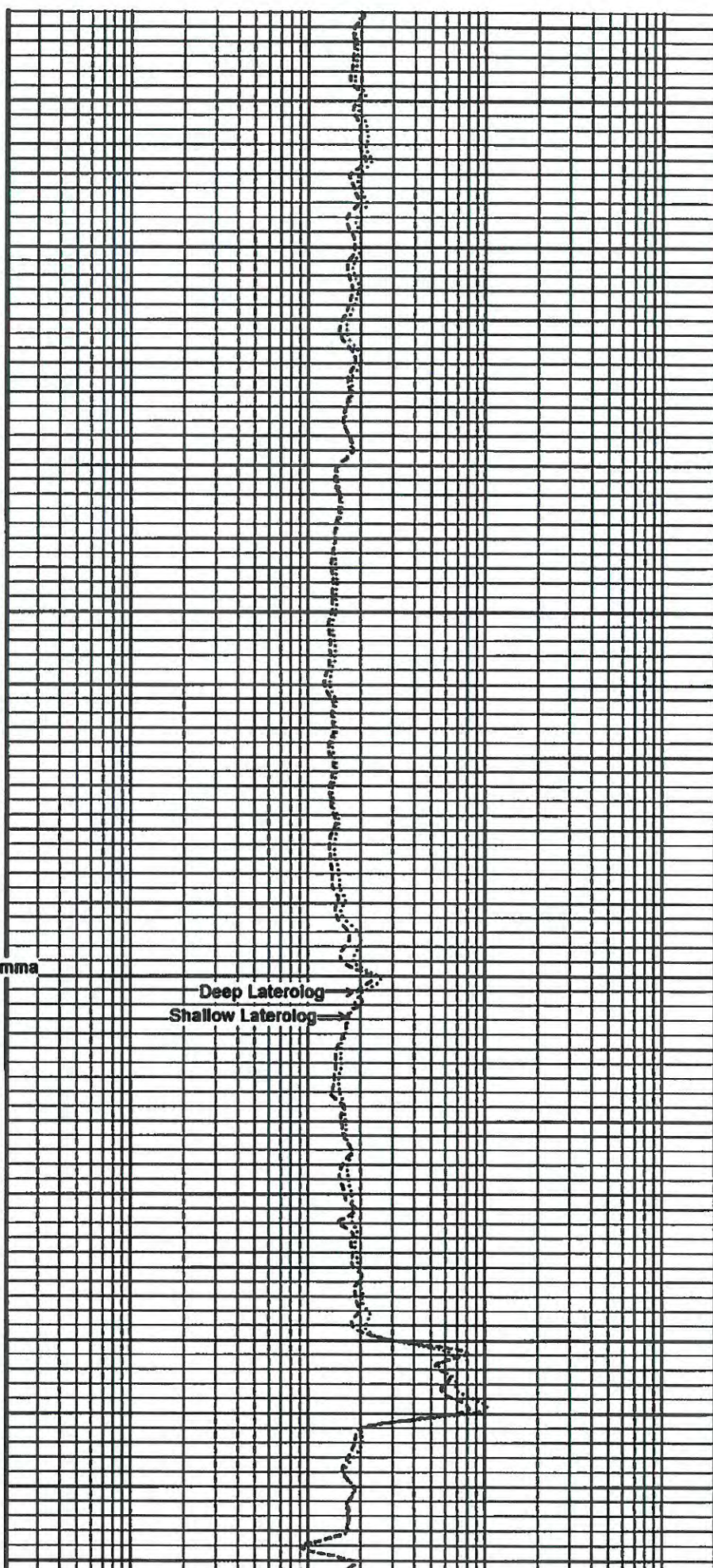
6900

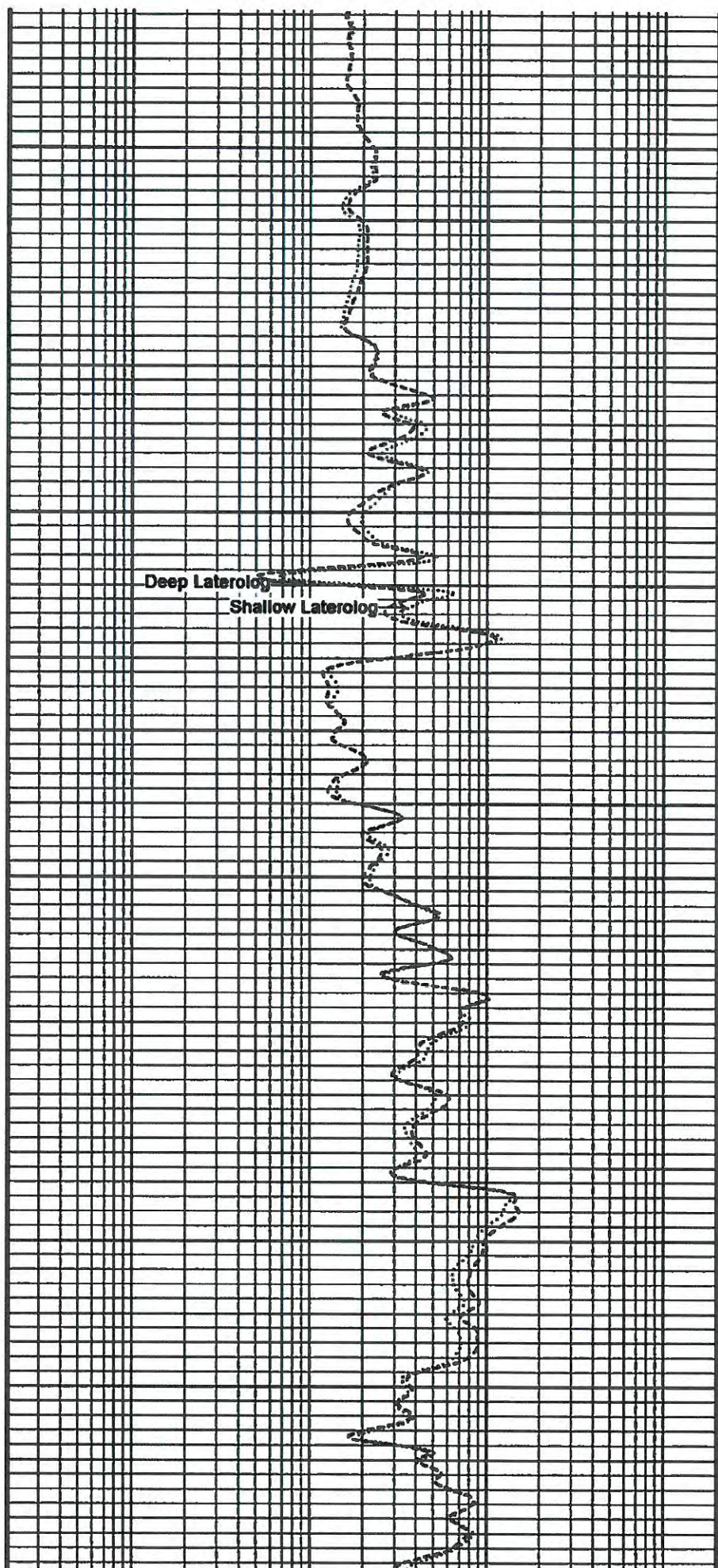
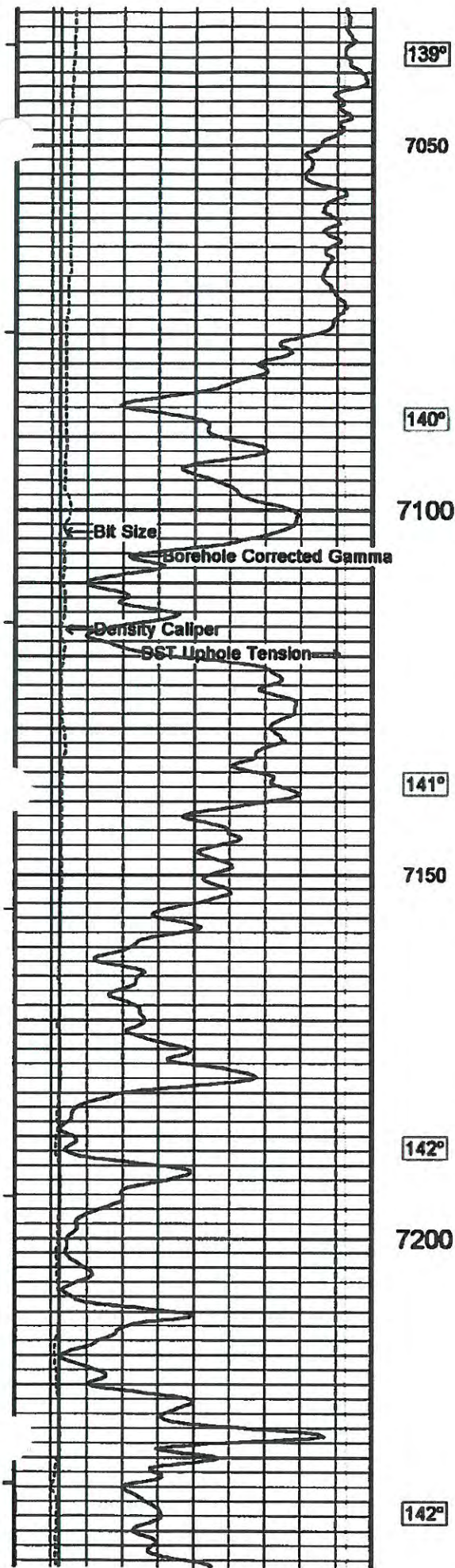
137°

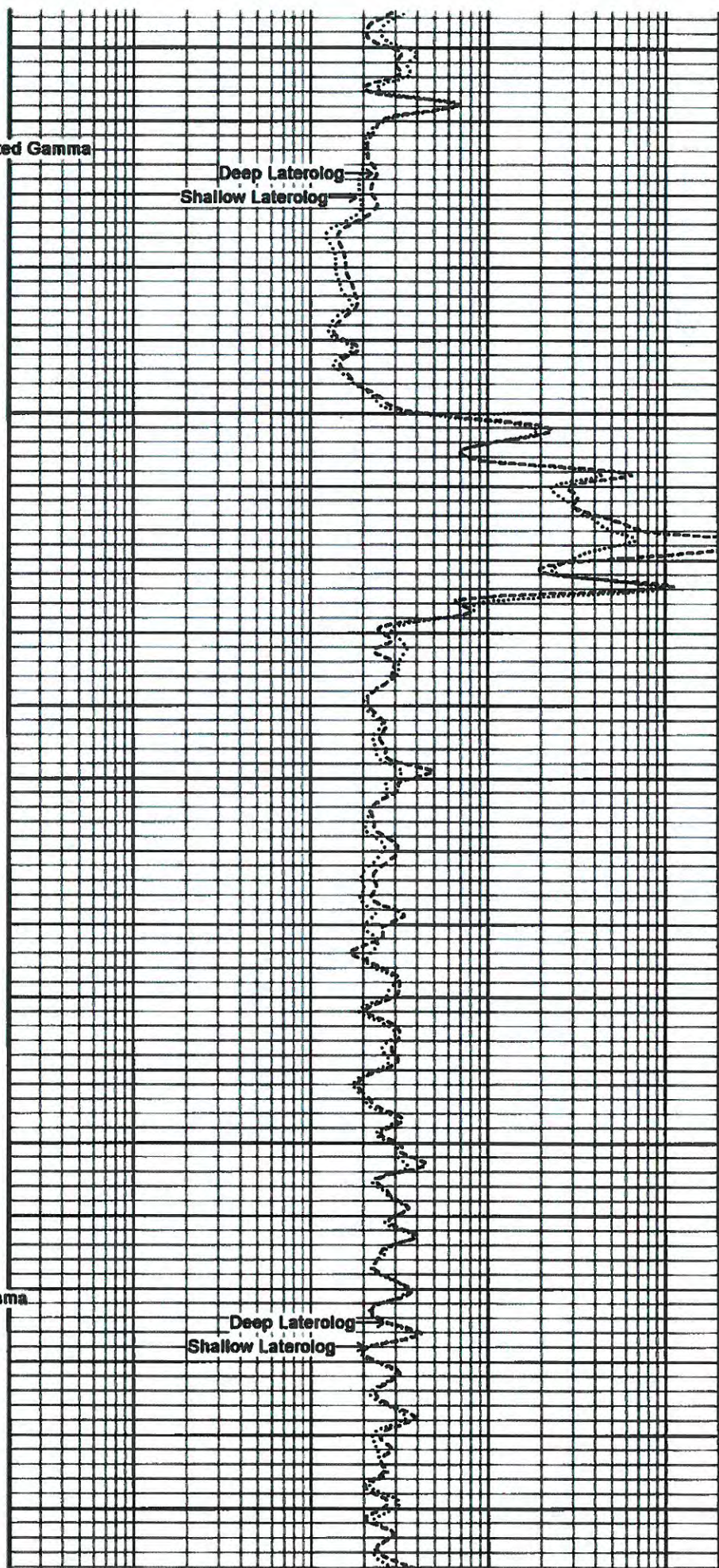
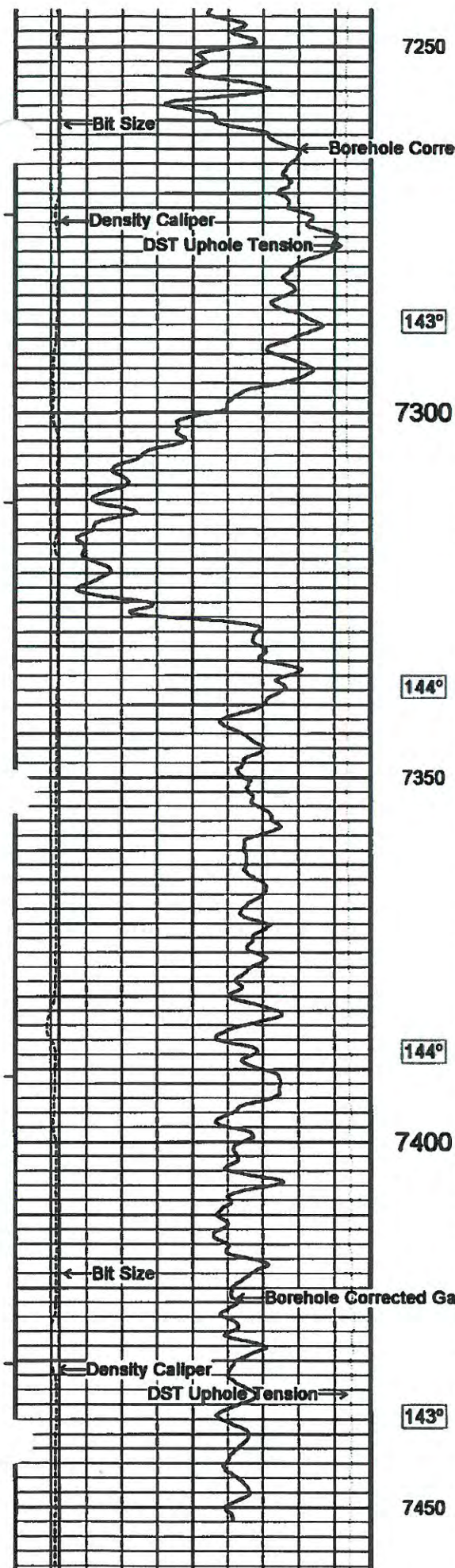
6950

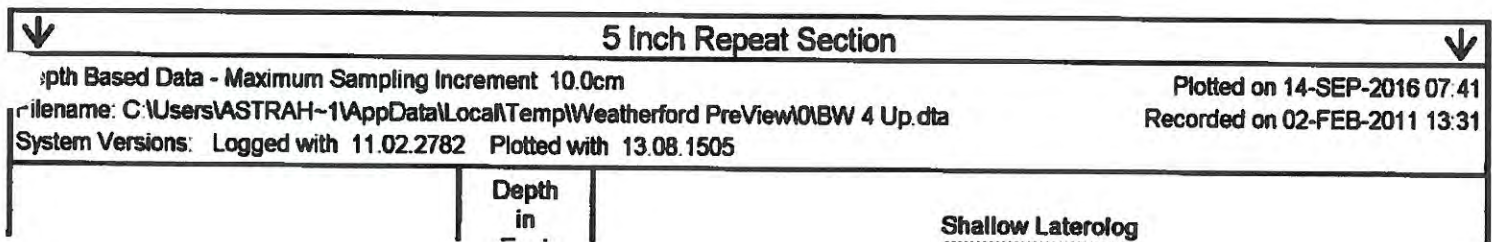
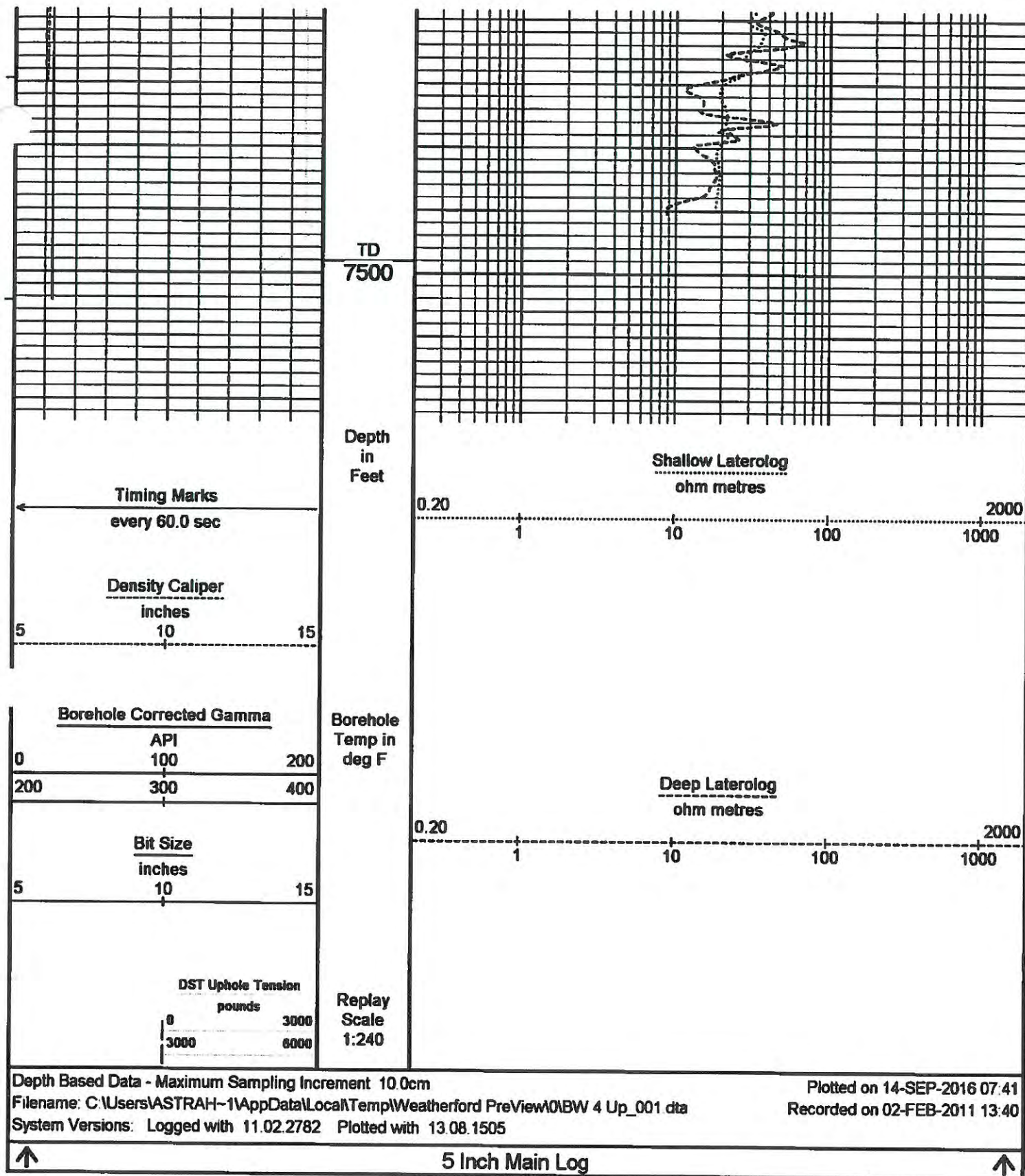
138°

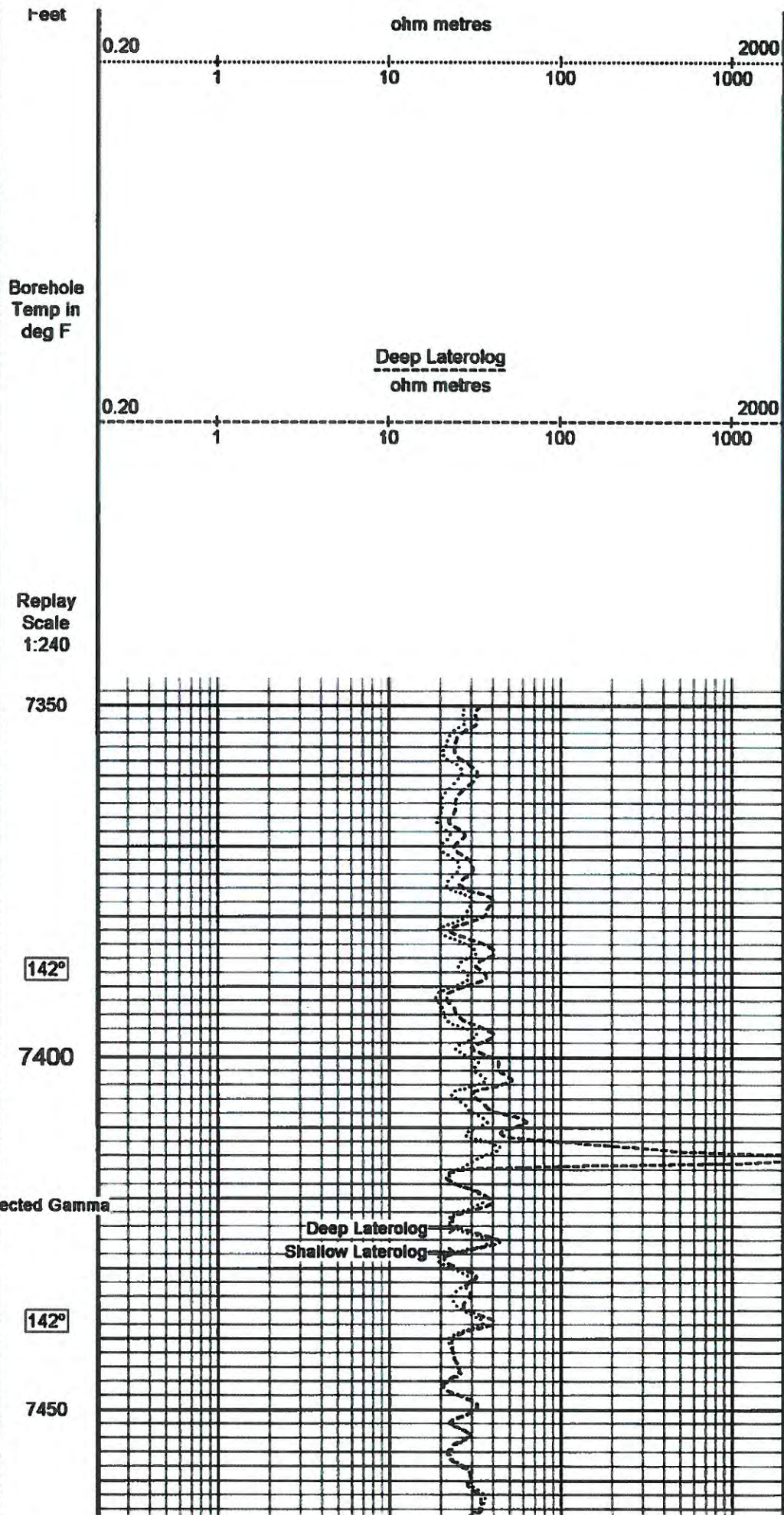
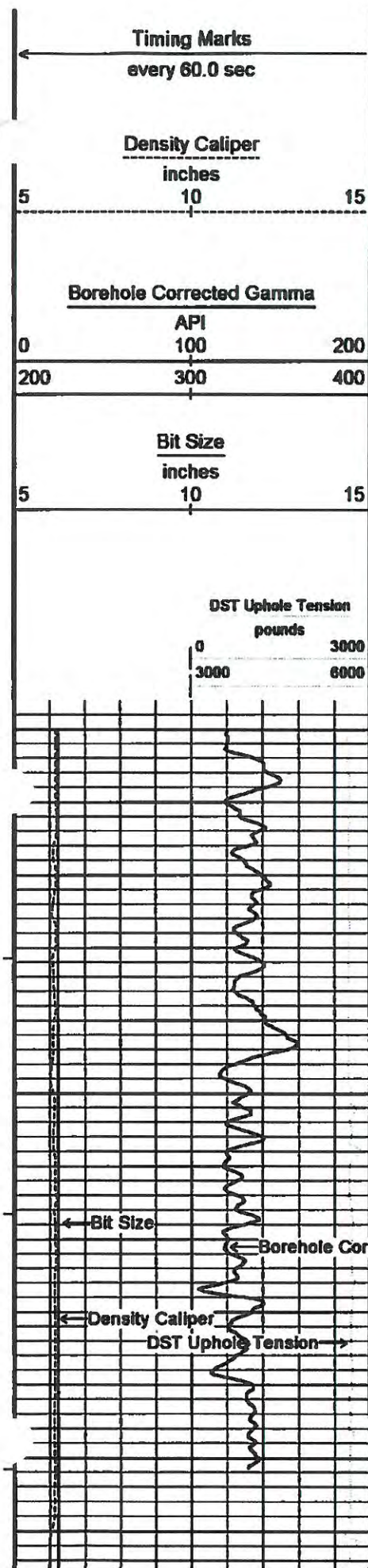
7000

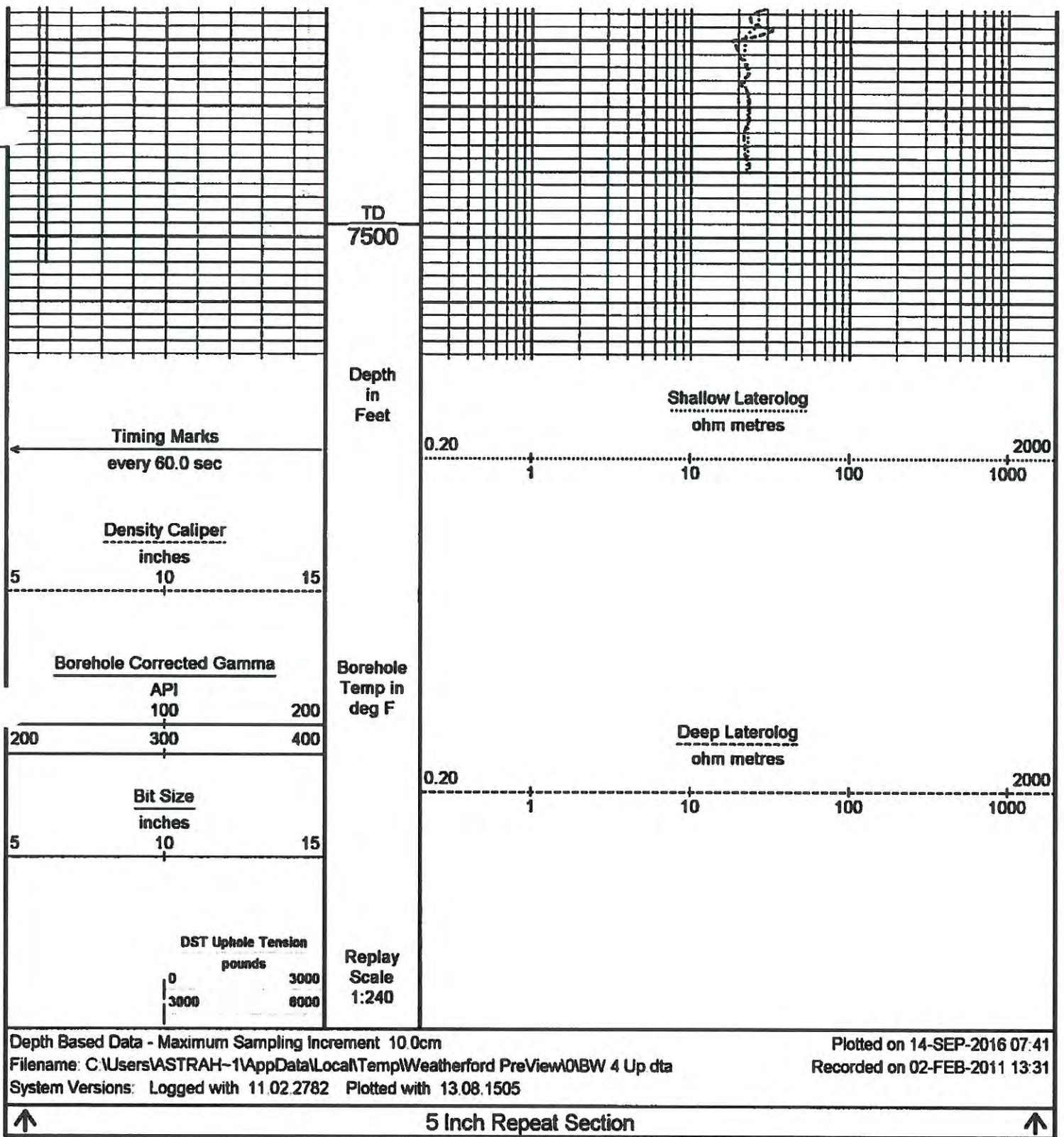












Depth Based Data - Maximum Sampling Increment 10.0cm

Plotted on 14-SEP-2016 07:41

Filename: C:\Users\ASTRAH-1\AppData\Local\Temp\Weatherford PreView\0\BW 4 Up.dta

Recorded on 02-FEB-2011 13:31

System Versions: Logged with 11.02.2782 Plotted with 13.08.1505

BEFORE SURVEY CALIBRATION

C:\Users\ASTRAH-1\AppData\Local\Temp\Weatherford PreView\0\BW 4 Up.dta

General Constants All 000

Last Edited on 02-FEB-2011,12:54

General Parameters

Mud Resistivity	0.100	ohm-metres
Mud Resistivity Temperature	64.000	degrees F
Water Level	0.000	feet
Borehole Fluid Processing	Water Level Switch	

Hole/Annular Volume and Differential Caliper Parameters		
HVOL Method	Single Caliper	
HVOL Caliper 1	Density Caliper	
HVOL Caliper 2	N/A	
Annular Volume Diameter	4.500	inches
Caliper for Differential Caliper	Density Caliper	

Rwa Parameters	
Porosity used	Base Density Porosity
Resistivity used	Deep Laterolog
RWA Constant A	0.610
RWA Constant M	2.150
SW/APOR Tool Source	

Gamma Calibration MCG-C 136

Field Calibration on 01-FEB-2011 08:52

	Measured	Calibrated (API)
Background	63	43
Calibrator (Gross)	2256	1535
Calibrator (Net)	2193	1492

Gamma Constants MCG-C 136

Last Edited on 02-FEB-2011,12:55

Gamma Calibrator Number	44	
Mud Density	1.27	gm/cc
Caliper Source for Processing	Density Caliper	
Tool Position	Eccentred	
Concentration of KCl	0.00	kppm
K Mud Type		
K Mud Concentration		%

SP Calibration MCG-C 136

Field Calibration on 11-JAN-2011,15:10

	Measured	Calibrated (mV)
Reference 1	101.2	100.7
Reference 2	-99.6	-100.5

High Resolution Temperature Calibration MCG-C 136

Field Calibration on 11-JAN-2011,15:10

	Measured	Calibrated(Deg F)
Lower	65.00	66.00
Upper	100.00	101.00

High Resolution Temperature Constants MCG-C 136

Last Edited on

Pre-filter Length	11
-------------------	----

Neutron Calibration MDN-A.B 178

Base Calibration on 11-JAN-2011,15:10
Field Check on

Base Calibration	
	Measured
	Near Far
	3434 104
Ratio	32.868
	Calibrated (cps)
	Near Far
	3714 110
	33.764
Field Calibrator at Base	
	Calibrated (cps)
	1528 2248
Ratio	0.680
Field Check	
	Calibrated (cps)
Ratio	

Neutron Constants MDN-A.B 178

Last Edited on 02-FEB-2011,11:37

Neutron Source Id	703
Neutron Jig Number	033
Epithermal Neutron	No
Caliper Source for Processing	Density Caliper
Stand-off	0.00
Mud Density	1.00

Limestone Sigma	7.10	cu
Sandstone Sigma	4.26	cu
Dolomite Sigma	4.70	cu
Formation Pressure Source	Constant Value	
Formation Pressure	0.00	kpsi
Temperature Source	Constant Value	
Temperature	68.00	degrees F
Mud Salinity	0.00	kppm
Salinity Correction		
Formation Fluid Salinity Source	Constant Value	
Formation Fluid Salinity	0.00	kppm
Barite Mud Correction	Not Applied	

Laterolog Calibration MLE-A.A 2

Base Calibration on 11-JAN-2011,15:12

Field Check on

Base Calibration

Channel	Measured		Calibrated (ohm-m)	
	Resistor 1	Resistor 2	Resistor 1	Resistor 2
Shallow	0.0	974.2	0.0	1327.3
Deep	0.0	974.4	0.0	852.7
Groningen	0.0	678.6	0.0	852.7

Channel	Base Check (ohm-m)	Field Check (ohm-m)
Shallow	0.0	0.0
Deep	0.0	0.0
Groningen	0.0	0.0

Laterolog Constants MLE-A.A 2

Last Edited on 02-FEB-2011,12:55

Profiling Laterolog Type	ohm-m
Laterolog Output Filter	
Profiling Limiter	
Median Filter	
Squasher Start	40000
Shallow Laterolog K Factor	1.3273
Deep Laterolog K Factor	0.8527
Groningen Laterolog K Factor	0.8527
Interference Rejection	60 Hz
SP Connection	SP Bridle Electrode (Lower)
Groningen Connection	Groningen Electrode (Upper)

Borehole Correction Constants

Bridle Type	Standard	
Stand-off	Centered	inches
Caliper Source	Density Caliper	
Hole Size	N/A	inches
Mud Resistivity Source	Temperature Corrected	
Temp. for Rm Corr.	MCG External Temperature	

Apparent Porosity and Water Saturation Constants

Archie Constant (A)	
Cementation Exponent (M)	
Saturation Exponent (N)	
Saturation of Water for Apor	
Resistivity of Water for Apor and Sw	ohm-m
Resistivity of Mud Filtrate for Sw	ohm-m
Source for Rt	
Source for Rxo	

SP Calibration MLE-A.A 2

Field Calibration on 11-JAN-2011,15:13

	Measured	Calibrated (mV)
Reference 1	100.0	100.7
Reference 2	-100.1	-99.4

High Resolution Temperature Calibration MHT-A 26

Field Calibration on 20-NOV-2008,15:55

	Measured	Calibrated(Deg F)
Lower	65.00	66.00
Upper	100.00	101.00

High Resolution Temperature Constants MHT-A 26

Last Edited on

Pre-filter Length 11

Caliper Calibration MPD-B 52

Base Calibration on 01-FEB-2011 10:31
Field Calibration on 01-FEB-2011 10:33

Base Calibration Reading No	Measured	Calibrator Size (in)
1	14505	3.99
2	22944	5.97
3	31696	8.00
4	40416	10.03
5	49183	11.98
6	N/A	N/A

Field Calibration	Measured Caliper (in)	Actual Caliper (in)
	5.96	5.97

Photo Density Calibration MPD-B 52

Base Calibration on 01-FEB-2011,11:35
Field Check on

Density Calibration Base Calibration	Near	Measured Far	Near	Calibrated (sdu) Far
Background				
Reference 1	47757	17098	53306	19389
Reference 2	21977	2257	24963	2524

Field Check at Base	725.3	1027.4
---------------------	-------	--------

Field Check

PE Calibration

Base Calibration	WS	Measured WH	Ratio	Calibrated Ratio
Background	135	614		
Reference 1	13900	47597	0.293	0.321
Reference 2	5582	21864	0.256	0.273

Field Check at Base	134.7	613.6
---------------------	-------	-------

Field Check

Density Constants MPD-B 52

Last Edited on 02-FEB-2011,12:55

Density Source Id	NSD-L-249	
Nylon Calibrator Number	DNC-D-526	
Aluminium Calibrator Number	DAC-D-526	
Density Shoe Profile	8 inch	
Caliper Source for Processing	Density Caliper	
PE Correction to Density	Not Applied	
Mud Density	1.27	gm/cc
Mud Density Z/A Multiplier	1.11	
Mud Filtrate Density	1.00	gm/cc
Dry Hole Mud Filtrate Density	1.00	gm/cc
DNCT	0.00	gm/cc
CRCT	0.00	gm/cc
Density Z/A Correction	Advanced	
Matrix Density (gm/cc)	Depth (ft)	
2.71	0.00	
0.00	0.00	
0.00	0.00	
0.00	0.00	
0.00	0.00	
0.00	0.00	

0.00
0.00
0.00

0.00
0.00
0.00

DOWNHOLE EQUIPMENT

C:\Users\ASTRAH-1\AppData\Local\Temp\Weatherford PreView\0\BW 4 Up.dta

Compact Stiff Bridle Electrode Sub.
MBE-A 50 LG: 12.33 ft WT: 77.2 lb OD: 2.24 in

Compact Stiff Bridle Electrode Sub
MBE-D.A 162 LG: 12.33 ft WT: 77.2 lb OD: 2.24 in

Compact Comms Gamma
MCG-C 136 LG: 8.70 ft WT: 63.9 lb OD: 2.24 in

Compact Linker
MLK-D.A 101 LG: 4.87 ft WT: 30.9 lb OD: 2.24 in

Compact Neutron
MDN-A.B 178 LG: 5.04 ft WT: 50.7 lb OD: 2.24 in

Compact Density/Caliper
MPD-B 52 LG: 9.59 ft WT: 90.4 lb OD: 2.45 in

Compact Upper Guard sub
MUG-B A 197 LG: 8.98 ft WT: 68.3 lb OD: 2.24 in

Compact Laterolog Electrode Sub.
MLE-A.A 2 LG: 12.34 ft WT: 92.6 lb OD: 2.24 in

Compact Lower Guard Sub.
MLG-A 35 LG: 8.00 ft WT: 55.1 lb OD: 2.24 in



53.76 ft
50.86 ft

GGCE - Borehole Corrected Gamma
CGXT - MCG External Temperature

42.43 ft

NPRL - Limestone Neutron Por.

35.19 ft
35.19 ft
35.19 ft
33.26 ft

AVOL - Annular Volume
HVOL - Hole Volume
CLDC - Density Caliper
DPOR - Base Density Porosity

33.26 ft
33.26 ft
33.26 ft
33.20 ft

DEN - Compensated Density
DCOR - Density Correction
MTXD - Matrix density
PDPE - PE

15.58 ft
15.58 ft

DSLL - Shallow Laterolog
DDL - Deep Laterolog

Compact High Resolution Temperature
MHT-A 26 LG: 1.53 ft WT: 13.2 lb OD: 2.24 in

Total Length: 83.71 ft Weight: 619.5 lb



Tool Zero (0.13ft from bottom)
-0.13 ft SMTU - DST Uphole Tension
All measurements relative to tool zero.

COMPANY	Appalachian Oil Purchasers, Inc.
WELL	BW 4
FIELD	Washington District
PROVINCE/COUNTY	Pleasants County
COUNTRY/STATE	U.S.A. / West Virginia

Elevation Kelly Bushing	654.00	feet	First Reading	7498 00	feet
Elevation Drill Floor	654.00	feet	Depth Driller	7503 00	feet
Elevation Ground Level	640.00	feet	Depth Logger	7498 00	feet



Weatherford®

Dual Laterolog
Gamma Ray



Weatherford®

Printed with PreView™

02 02 11 Appalachain Oil BW 4 DLL

**Weatherford**

**Photo Density
Compensated Neutron
Gamma Ray**

COMPANY **Appalachian Oil Purchasers, Inc.**
 WELL **BW 4**
 FIELD **Washington District**
 PROVINCE/COUNTY **Pleasants County**
 COUNTRY/STATE **U.S.A. / West Virginia**
 LOCATION **Raven Rock 7.5' Quadrangle**
 PERMIT NUMBER **47-073-2523**

SEC	TWP	RGE	Other Services	Data Pack
			Dual Laterolog	Sat. E-Mail
			Temperature	

API Number

Permanent Datum Ground Level, Elevation 640 feet	Elevations:	feet
Log Measured From K.B. of 14 Ft. above Permanent Datum	KB	654.00
Drilling Measured From K.B. of 14 Ft.	DF	654.00
	GL	640.00

Date	02-FEB-2011	
Run Number	Three	
Service Order		
Depth Driller	7503.00	feet
Depth Logger	7498.00	feet
First Reading	7498.00	feet
Last Reading	5166.00	feet
Casing Driller	5205.00	feet
Casing Logger	5176.00	feet
Bit Size	6.250	inches
Hole Fluid Type	Brine	
Density / Viscosity	10.10 lb/USg	
PH / Fluid Loss		
Sample Source	Flowline	
Rm @ Measured Temp	0.10 @ 64.0	ohm-m
Rmf @ Measured Temp		
Rmc @ Measured Temp		
Source Rmf / Rmc		
Rm @ BHT		
Time Since Circulation	6 Hours	
Max Recorded Temp	144.00	deg F
Equipment / Base	13157	Weston
Recorded By	Jason Sprouse	
Witnessed By	Scott Holcomb	
Field Ticket #	3528581	

BOREHOLE RECORD

Last Edited: 02-FEB-2011 14:59

Bit Size inches	Depth From feet	Depth To feet
6.250	5176.00	7498.00

Type	Size inches	Depth From feet	Shoe Depth feet	Weight pounds/ft
	7.000	0.00	5176.00	17.00

CASING RECORD**REMARKS**

Density matrix was ran on 2.71 Gm / cc
 Crew: Steve Kirchberg
 All logging speeds were ran at customers request
 Fluid Level: Full
 Mud filtrate density was ran on 1.0 Gm / cc
 Thank You for using Weatherford Wireline Services

In interpreting, communicating or providing information and/or making recommendations, either written or oral, as to logs or test or other data, type or amount of material, or Work or other service to be furnished, or manner of performance, or in predicting results to be obtained, the Contractor will give the Company the benefit of the Contractor's best judgment based on its experience and will perform all such Work in a good and workmanlike manner. Any interpretation of test or other data, and any recommendation or reservoir description based upon such interpretations, are opinions based upon inferences from measurements and empirical relationships and assumptions, which inferences and assumptions are not infallible, and with respect to which professional engineers and analysts may differ. ACCORDINGLY ANY INTERPRETATION OR RECOMMENDATION RESULTING FROM THE SERVICES WILL BE AT THE SOLE RISK OF THE COMPANY, AND THE CONTRACTOR CANNOT AND DOES NOT WARRANT THE ACCURACY, CORRECTNESS OR COMPLETENESS OF ANY SUCH

INTERPRETATION OR RECOMMENDATION, WHICH INTERPRETATIONS AND RECOMMENDATIONS SHOULD NOT, THEREFORE, UNDER ANY CIRCUMSTANCES BE RELIED UPON AS THE SOLE OR MAIN BASIS FOR ANY DRILLING, COMPLETION, WELL TREATMENT, PRODUCTION OR FINANCIAL DECISION, OR ANY PROCEDURE INVOLVING ANY RISK TO THE SAFETY OF ANY DRILLING ACTIVITY, DRILLING RIG OR ITS CREW OR ANY OTHER INDIVIDUAL. THE COMPANY HAS FULL RESPONSIBILITY FOR ALL DECISIONS CONCERNING THE SERVICES.

2 Inch Main Log

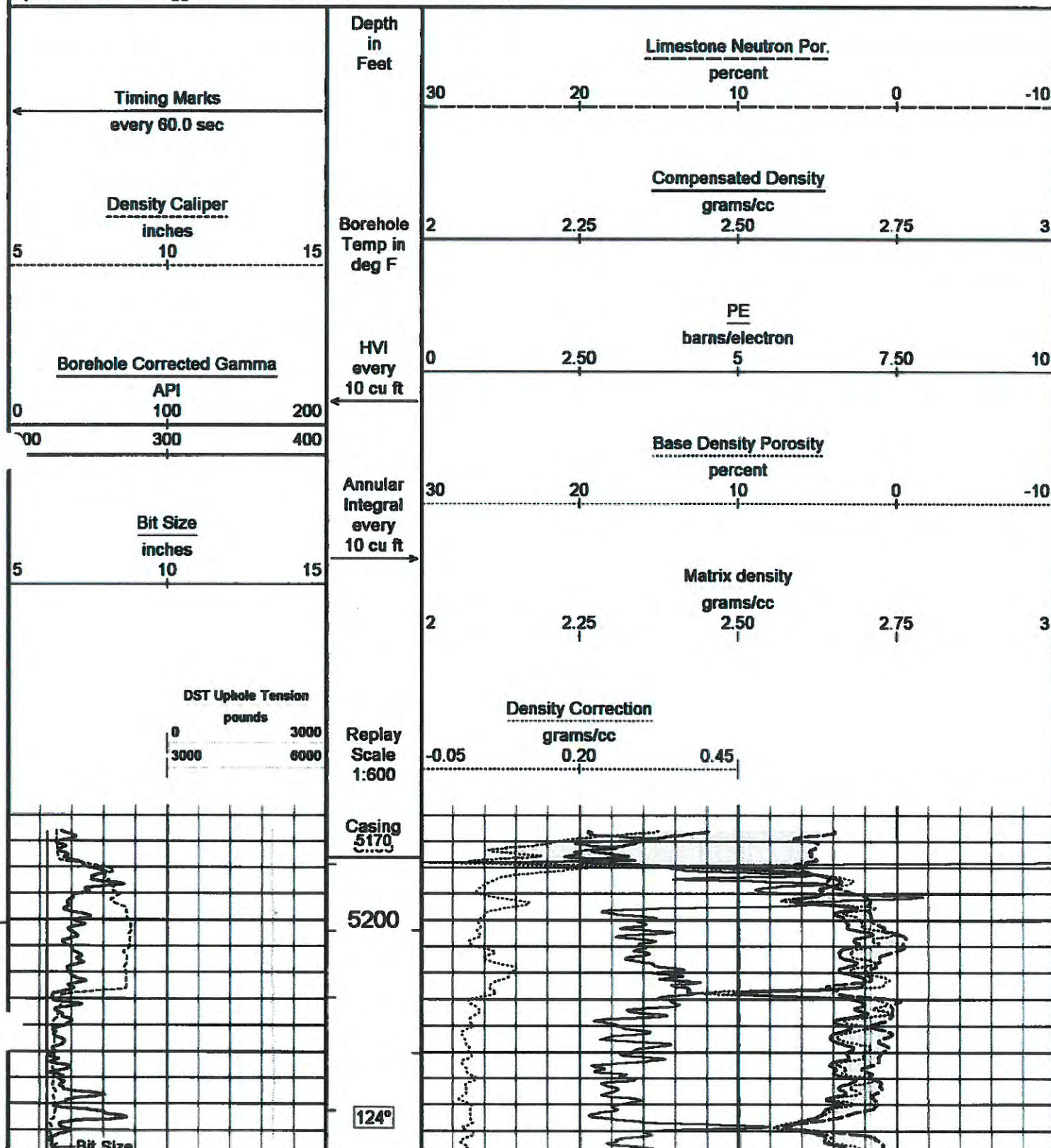
Depth Based Data - Maximum Sampling Increment 10.0cm

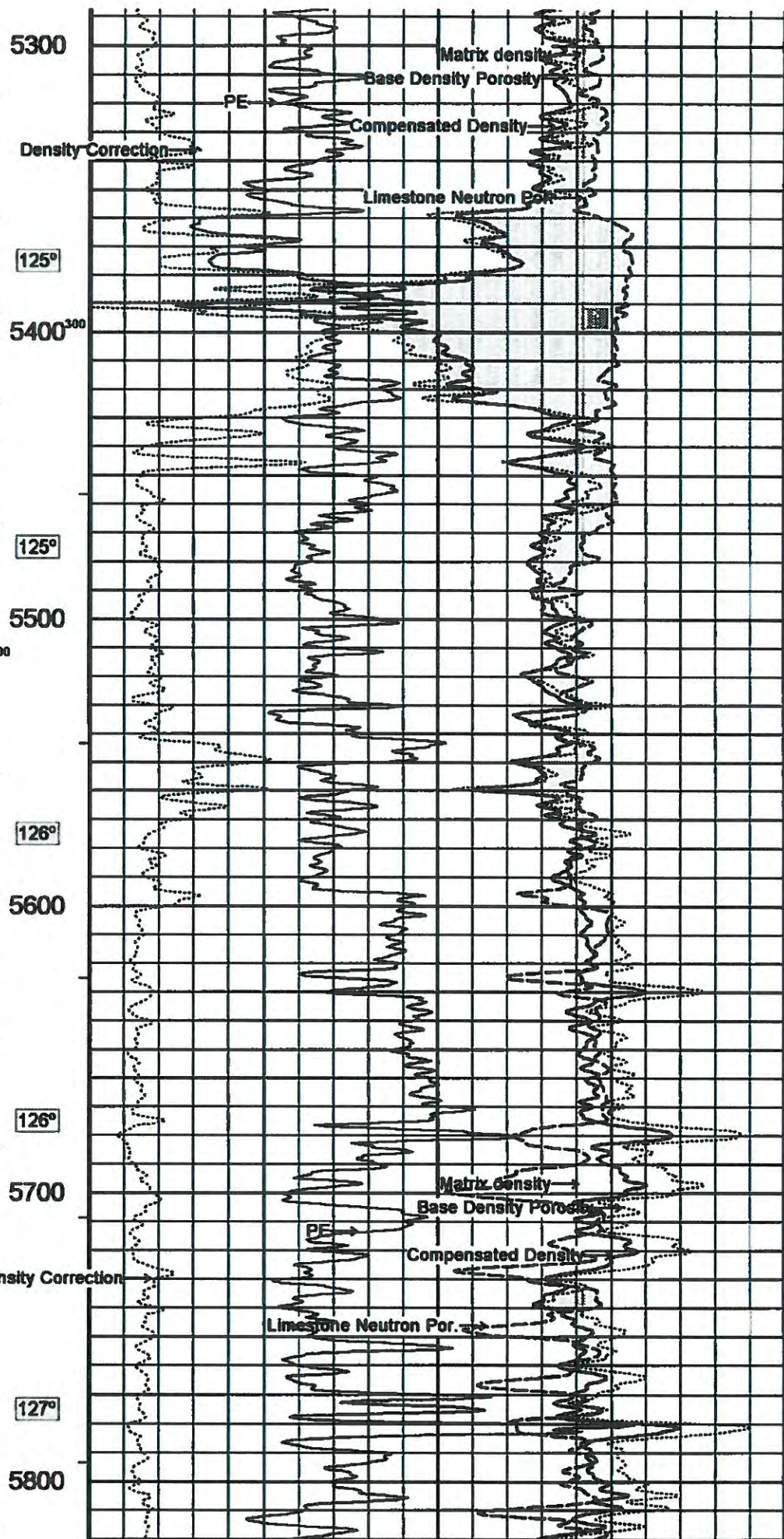
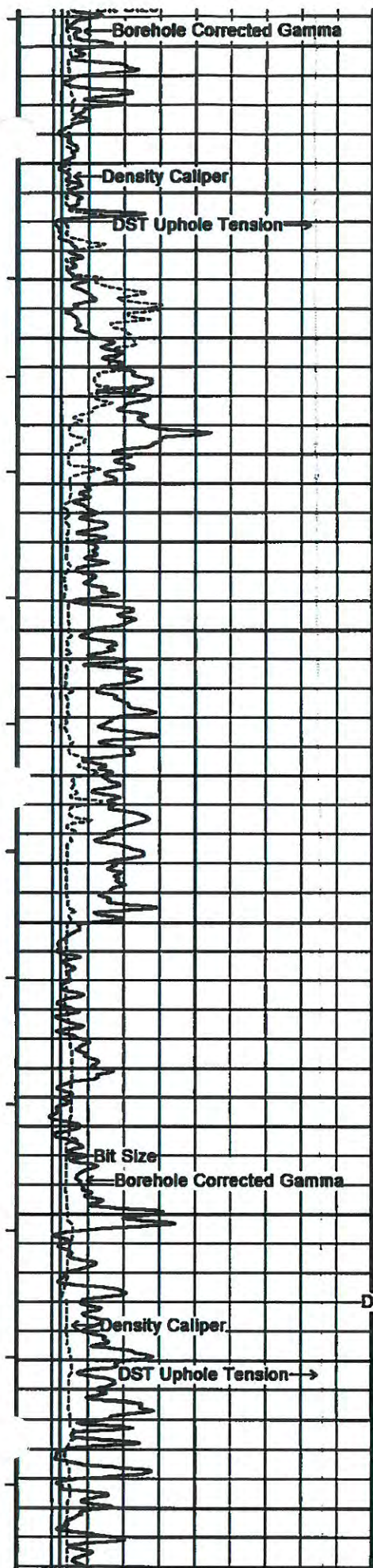
Plotted on 14-SEP-2016 07:42

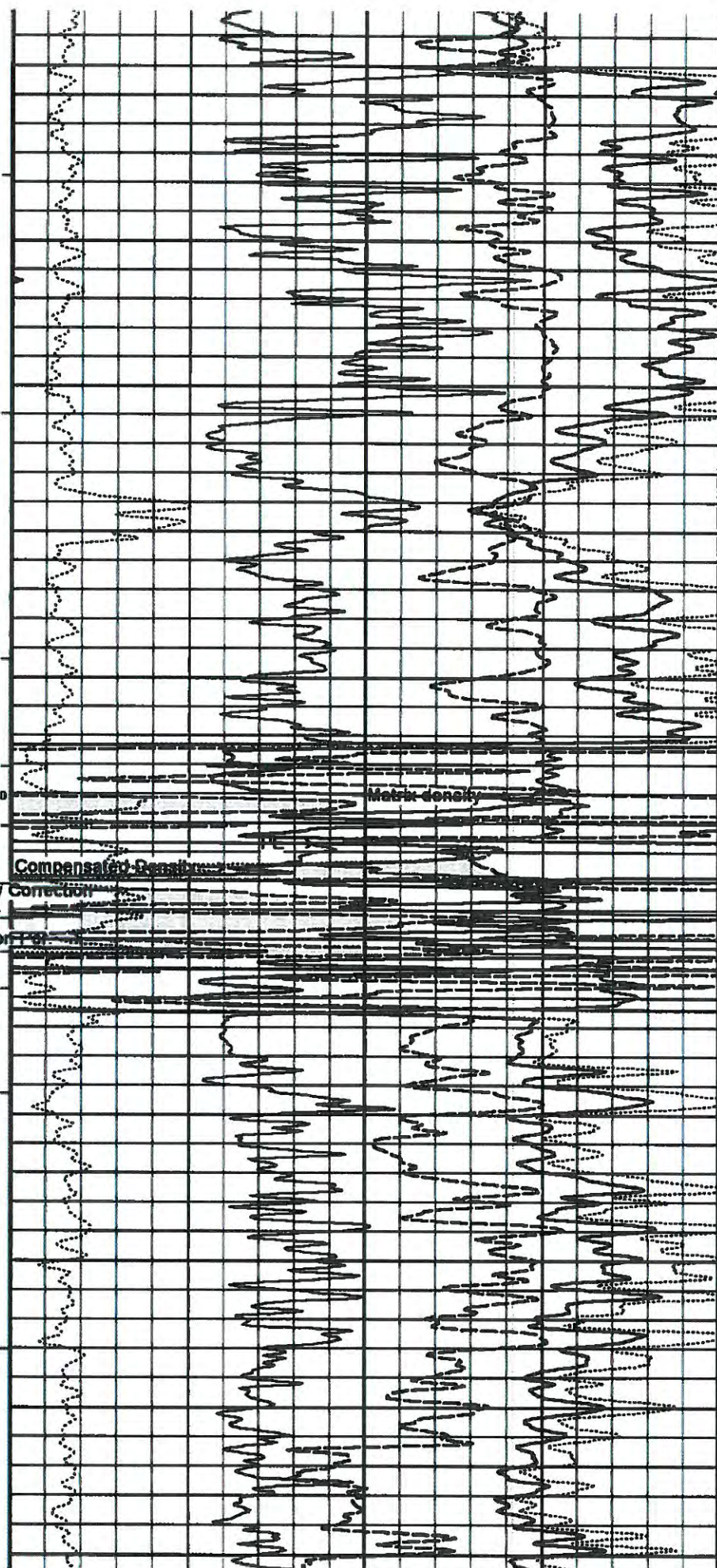
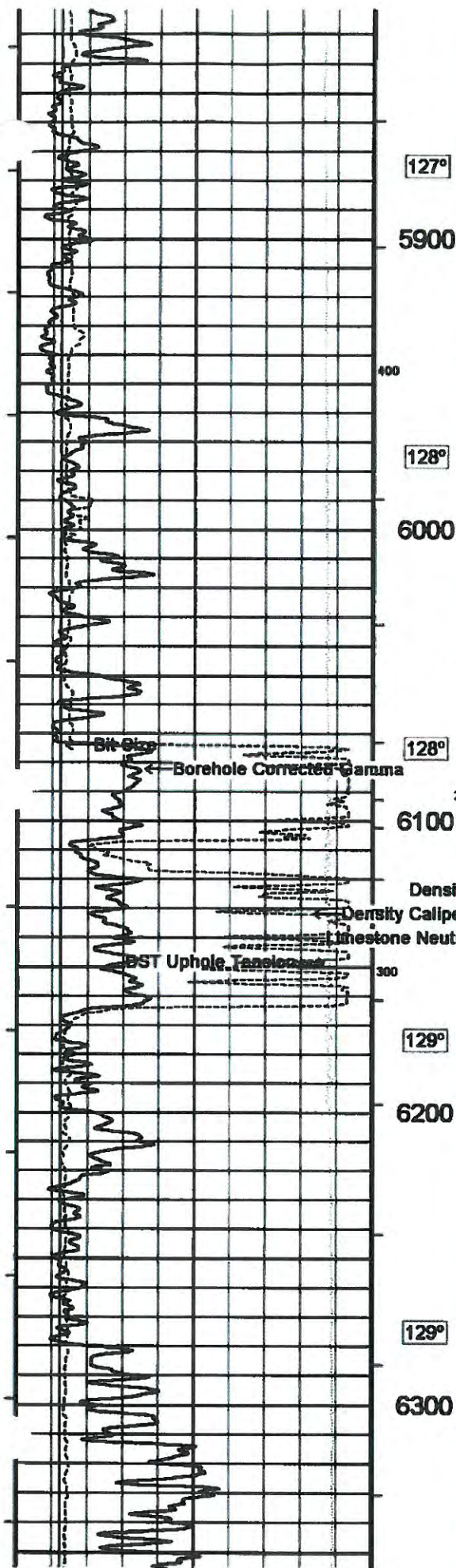
Filename: C:\Users\ASTRAH-1\AppData\Local\Temp\Weatherford PreView\0\BW 4 Up_001.dta

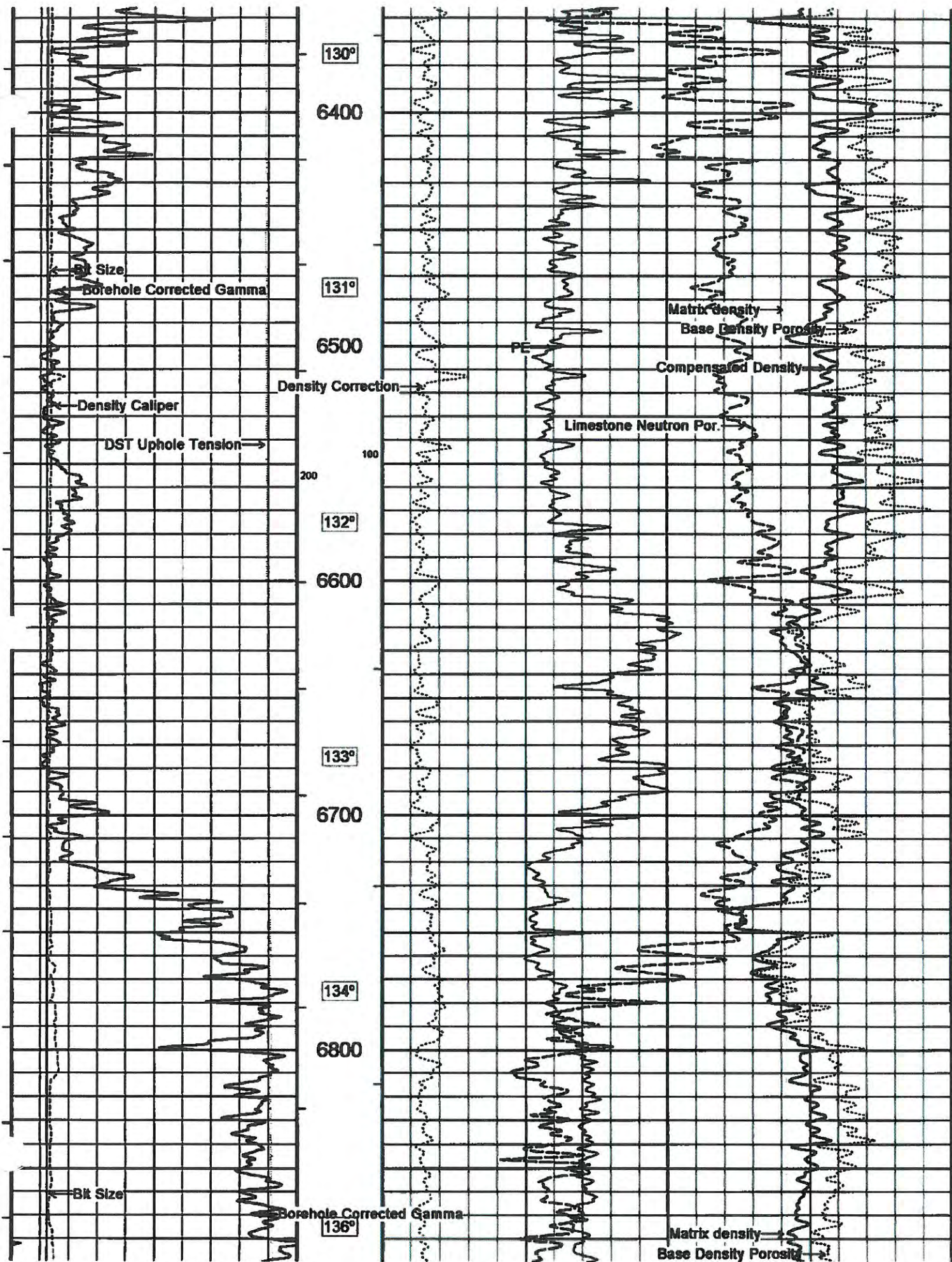
Recorded on 02-FEB-2011 13:40

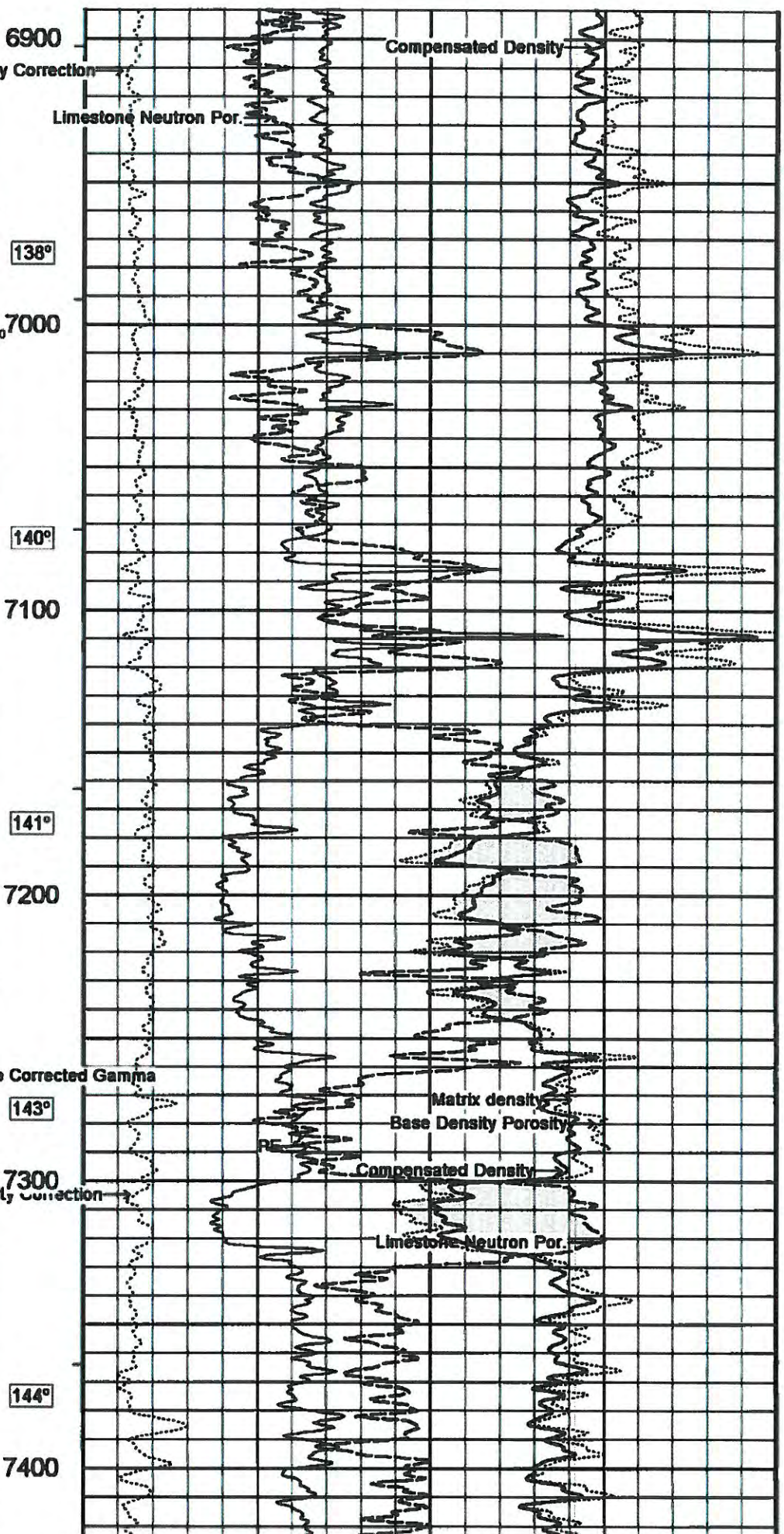
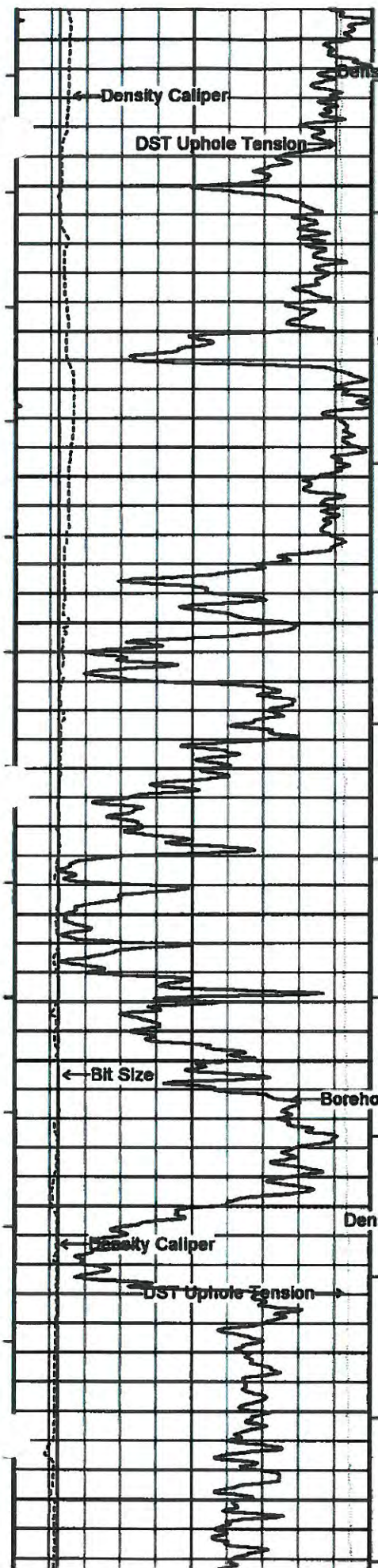
System Versions: Logged with 11.02.2782 Plotted with 13.08.1505

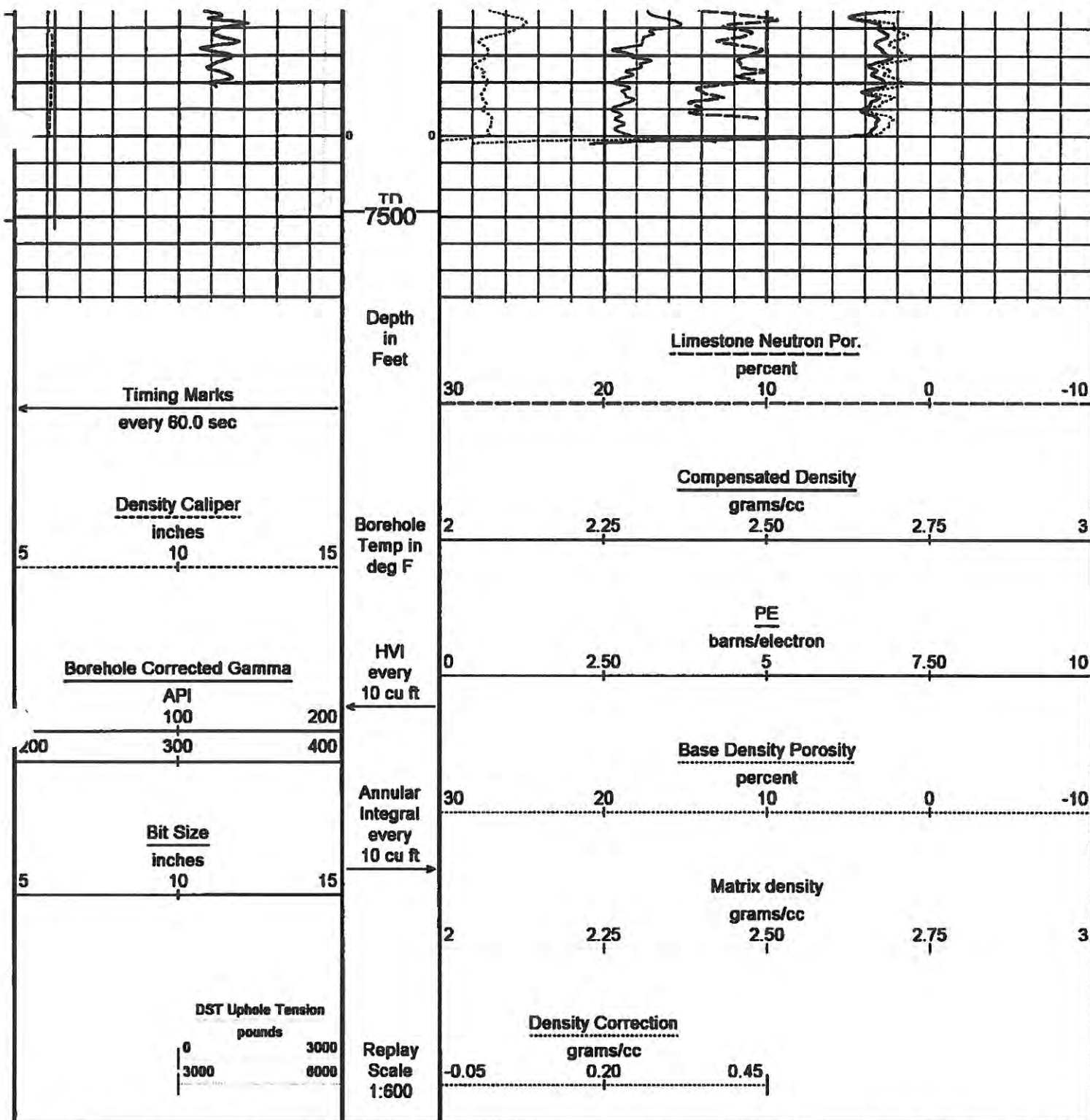












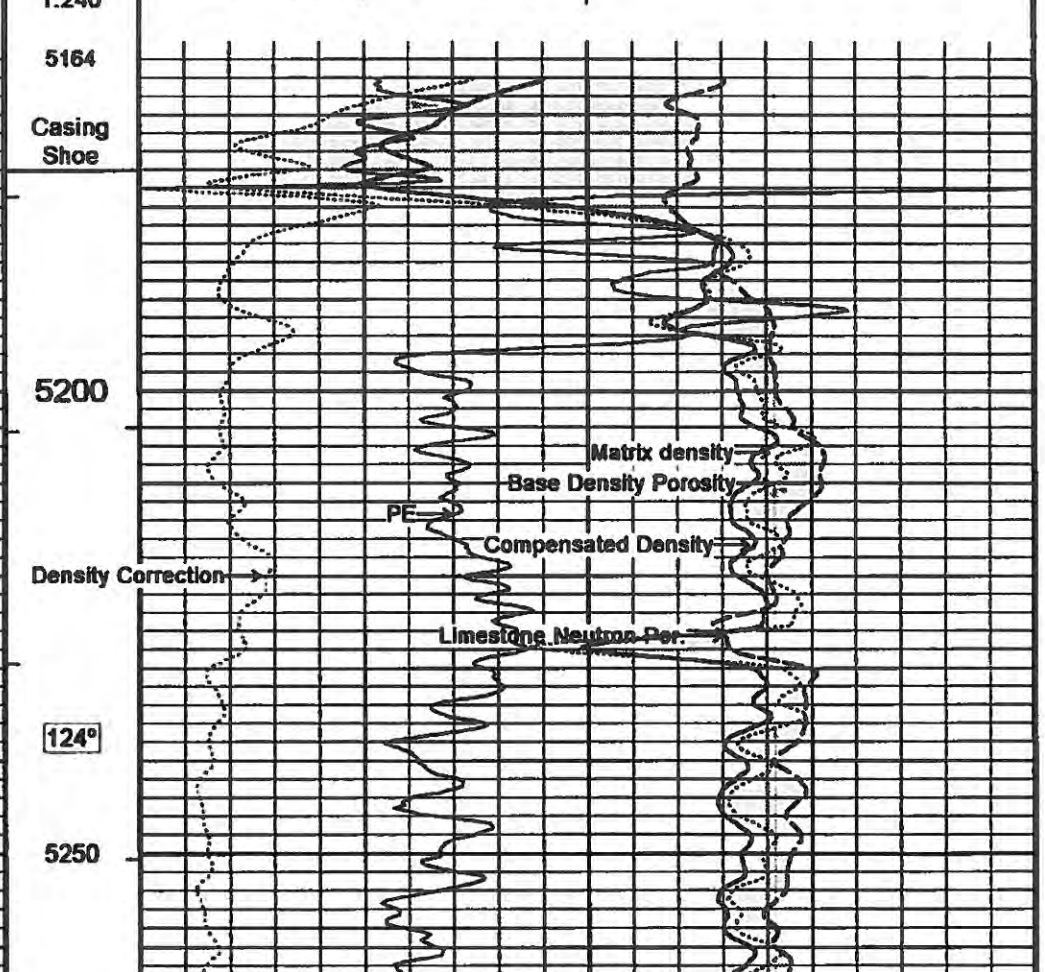
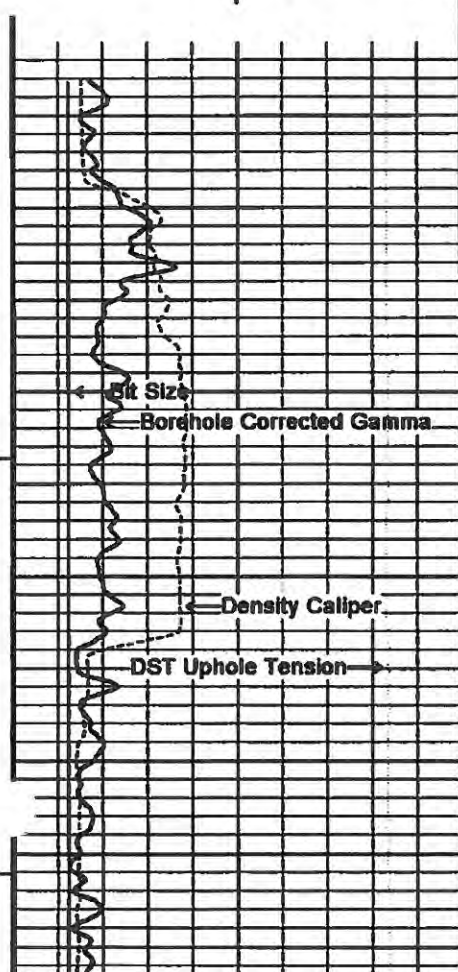
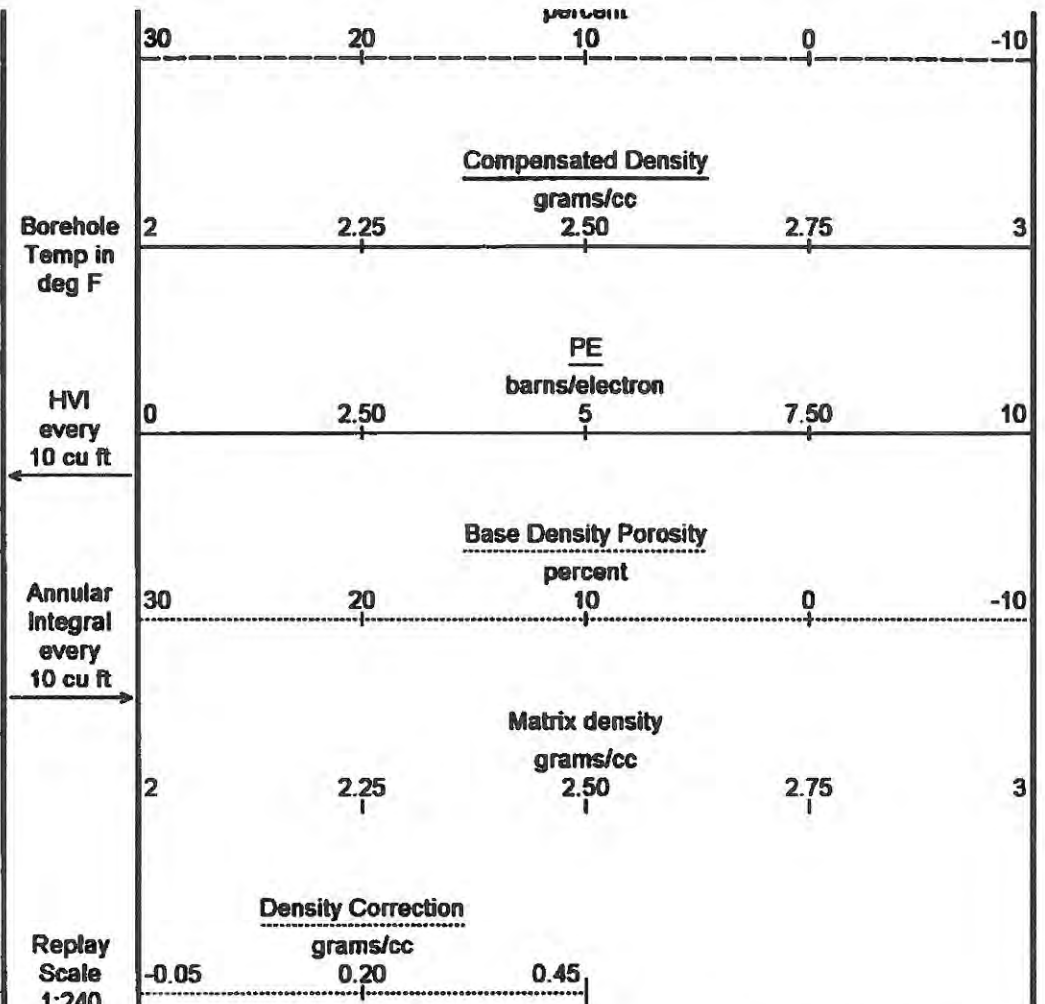
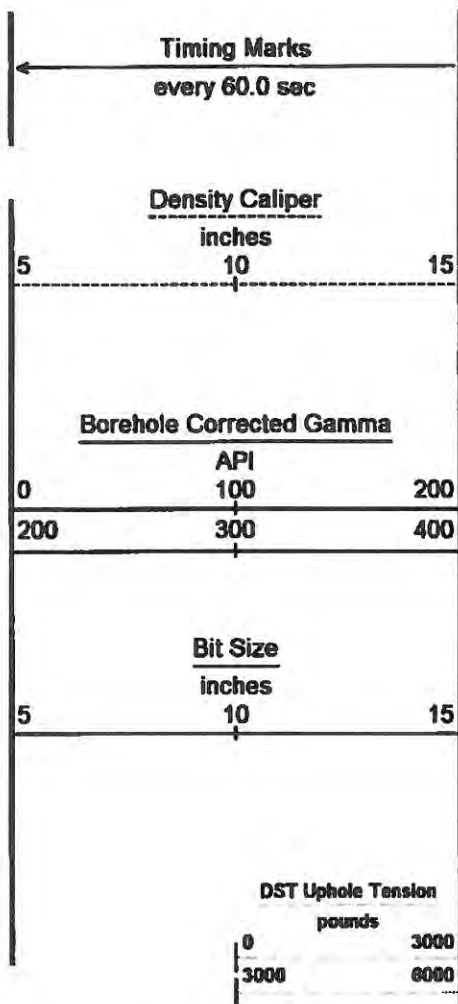
↑ **2 Inch Main Log** ↑

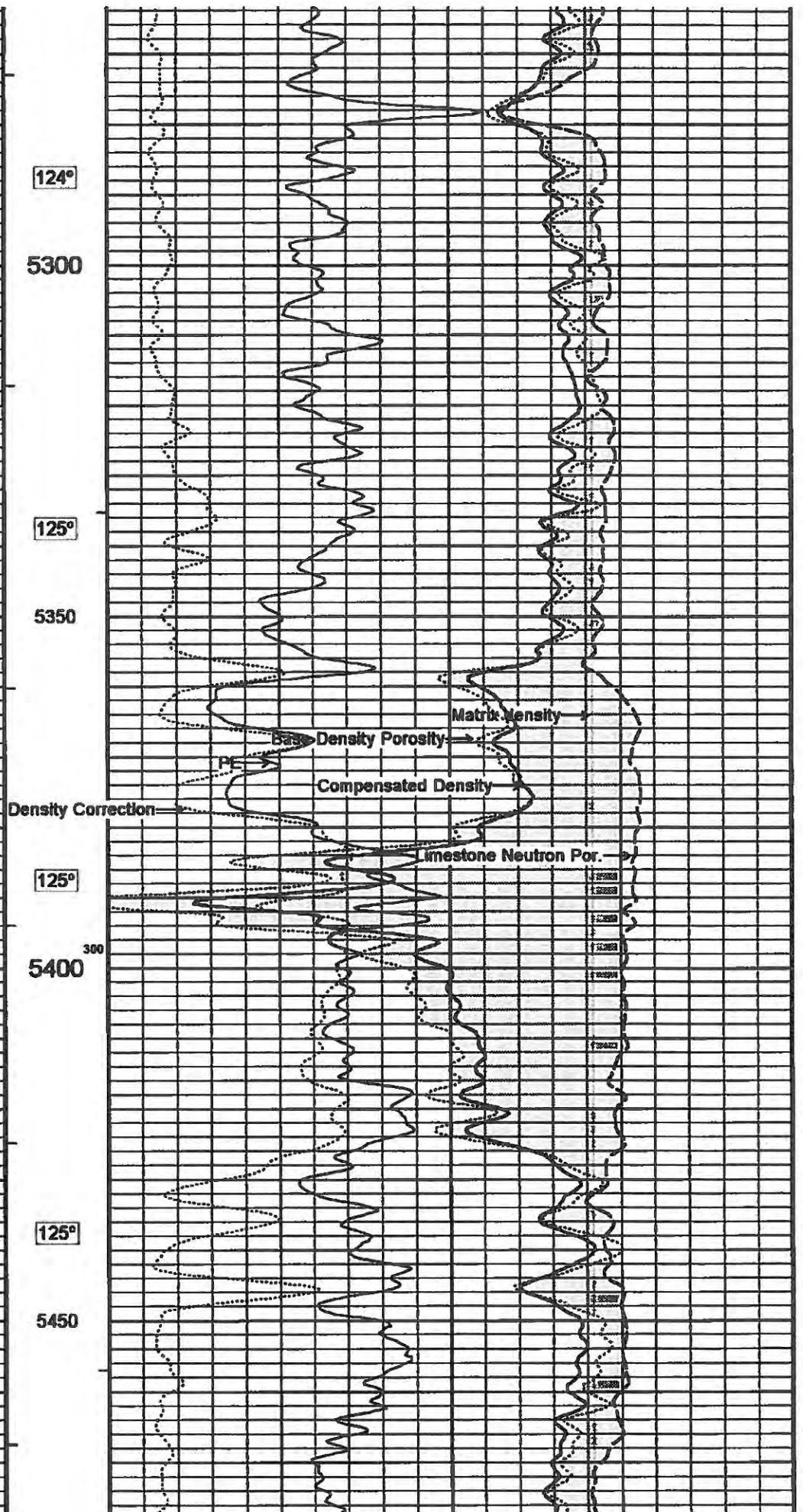
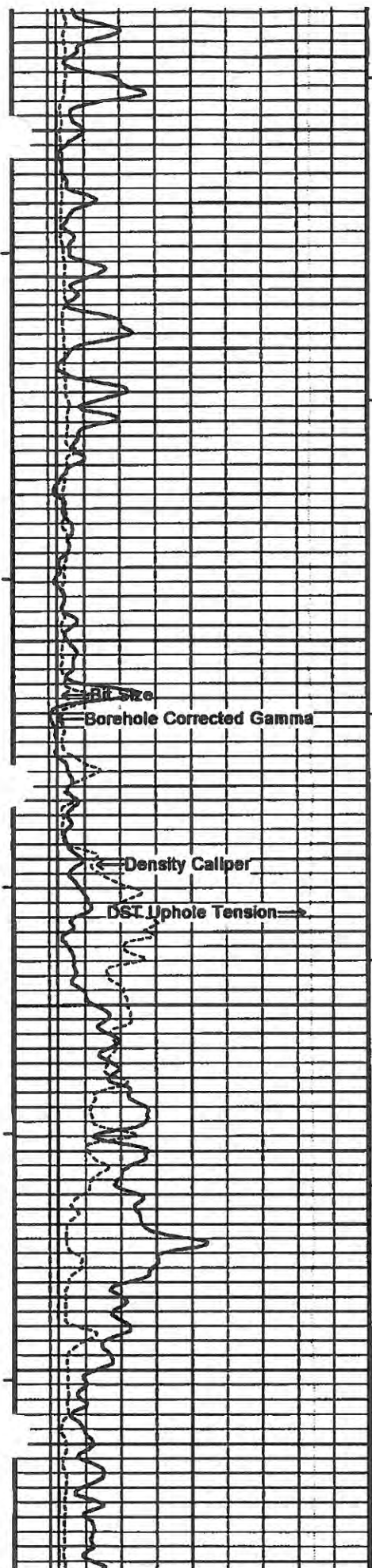
↓ **5 Inch Main Log** ↓

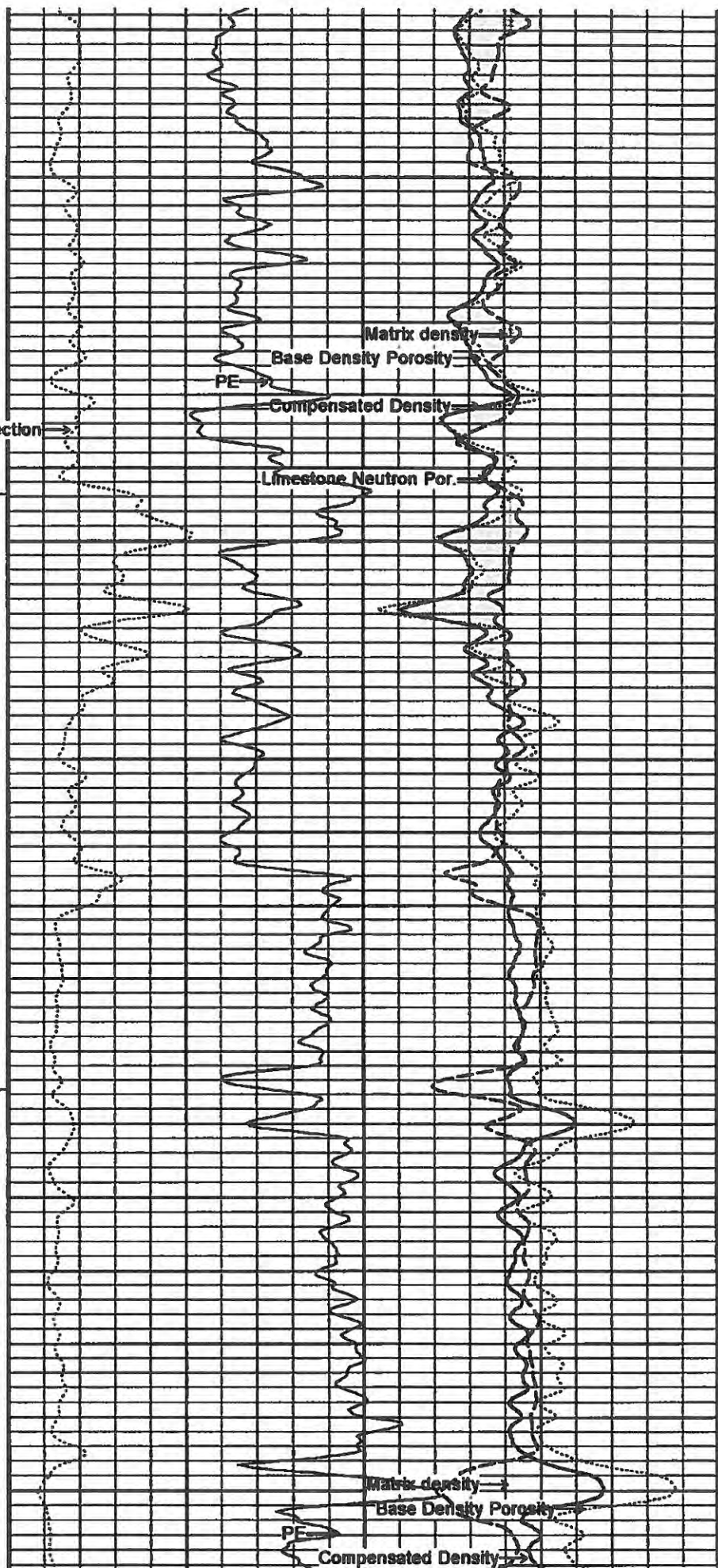
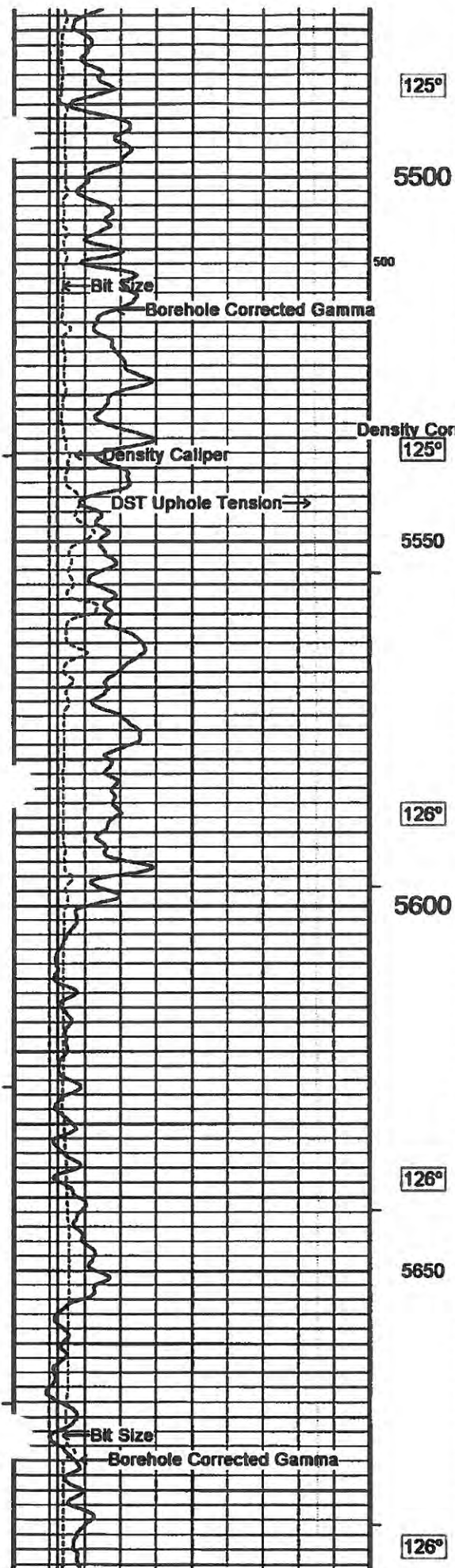
Depth Based Data - Maximum Sampling Increment 10.0cm
 Filename: C:\Users\ASTRAH~1\AppData\Local\Temp\Weatherford PreView\0\BW 4 Up_001.dta
 System Versions: Logged with 11.02.2782 Plotted with 13.08.1505

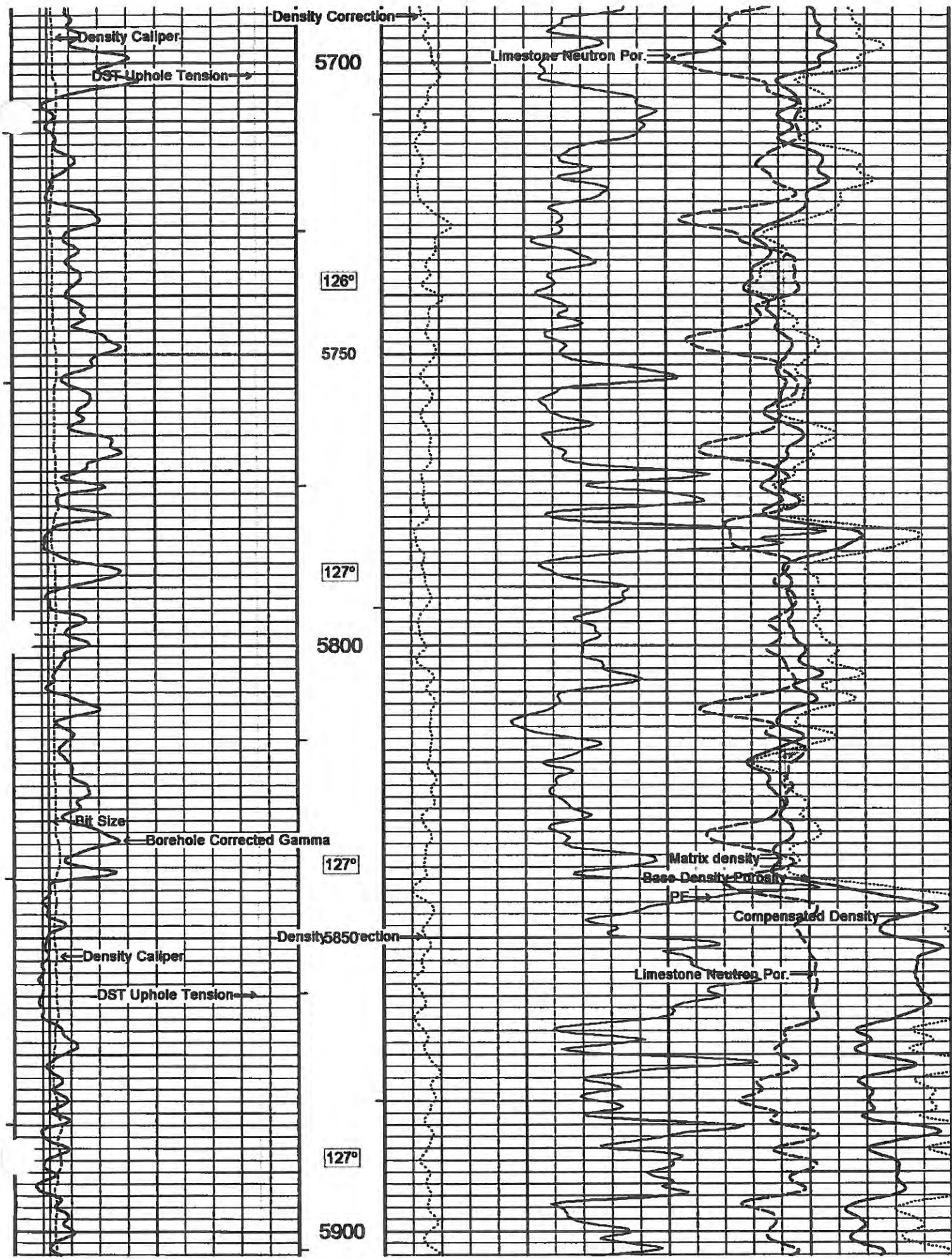
Plotted on 14-SEP-2016 07:42
 Recorded on 02-FEB-2011 13:40

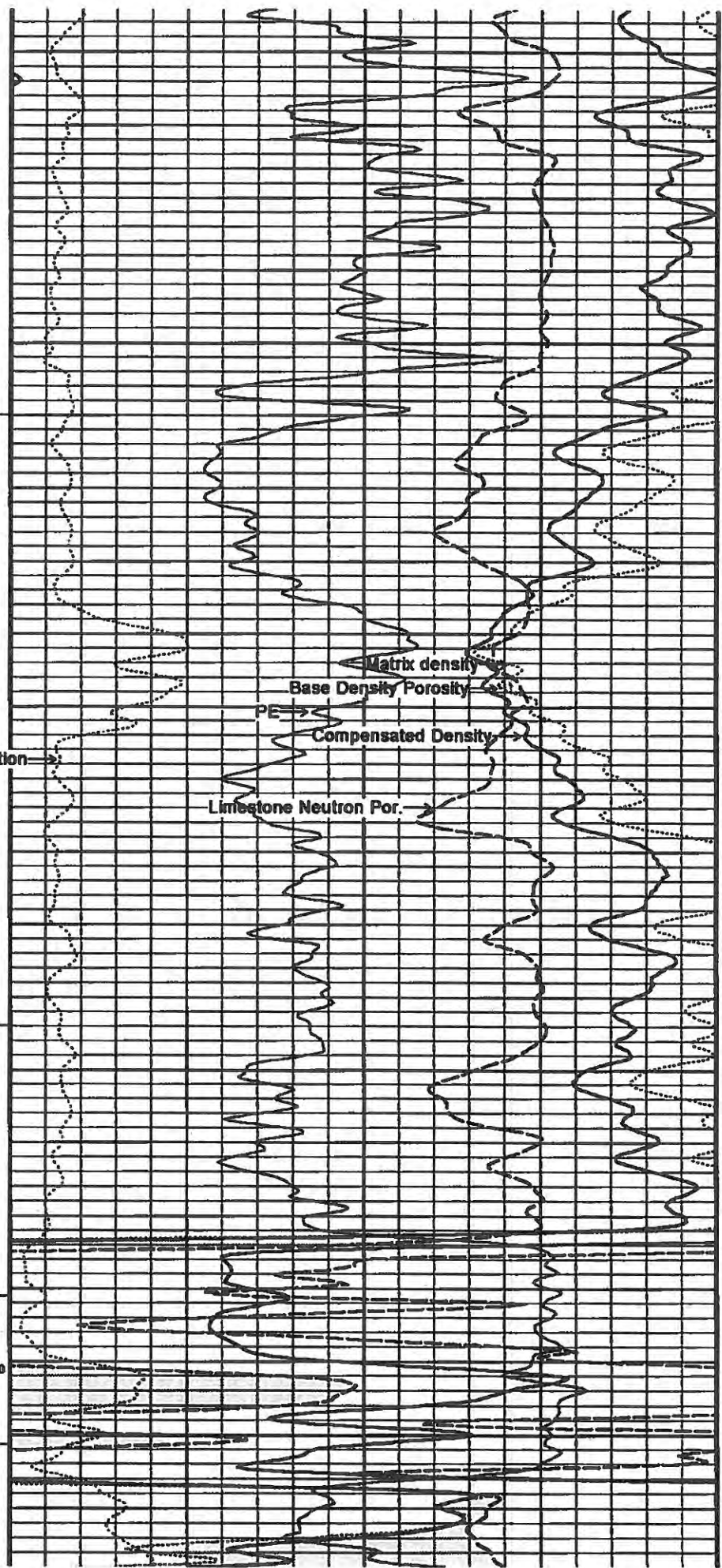
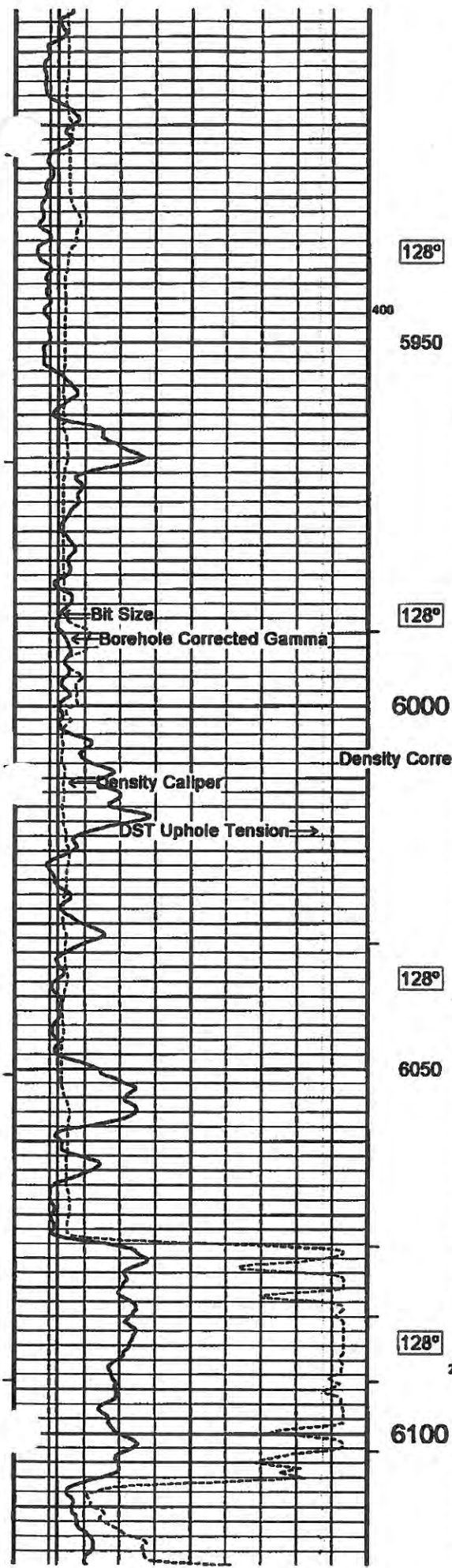
	Depth in Feet	Limestone Neutron Por. percent
--	---------------------	-----------------------------------

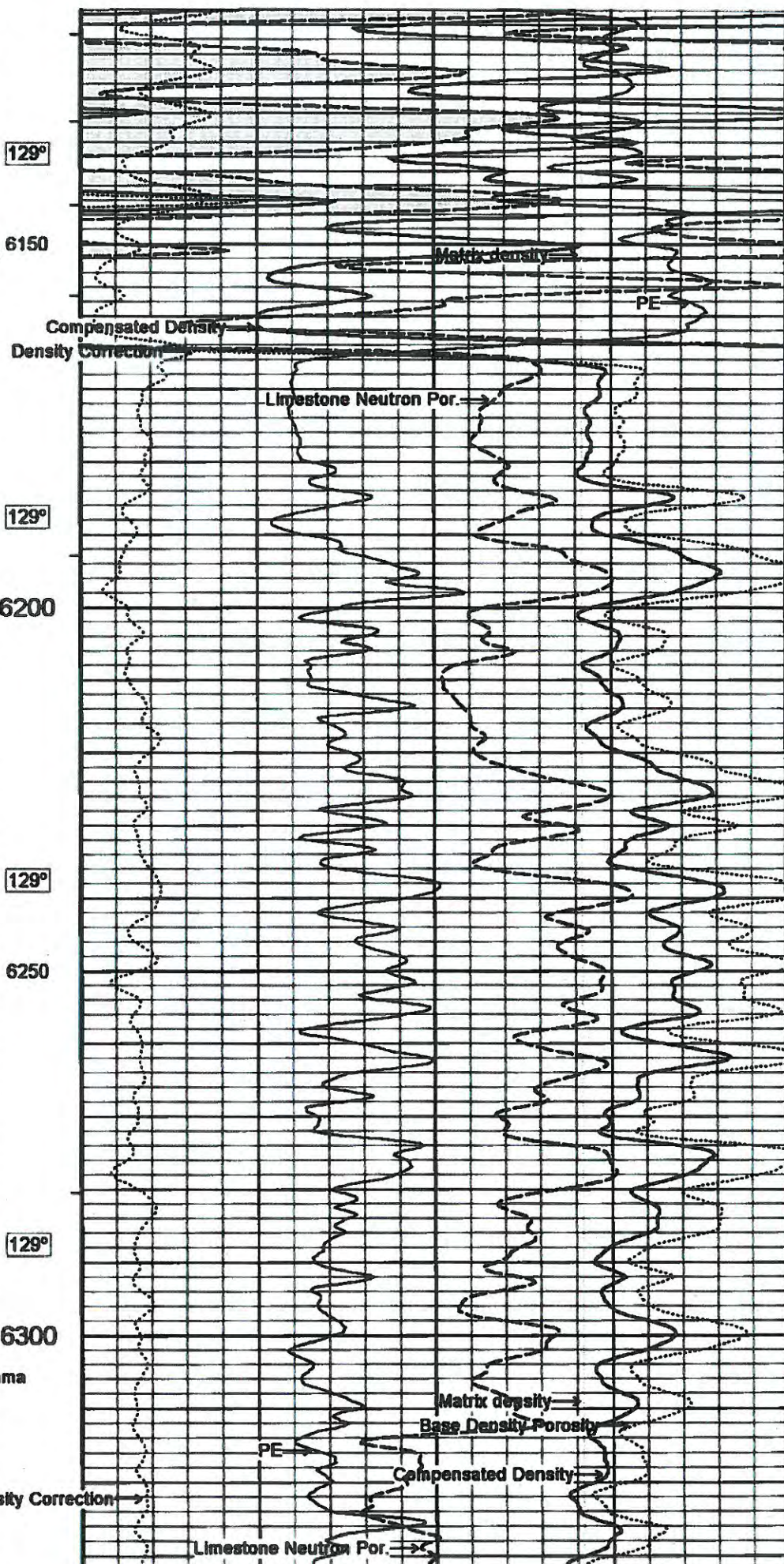
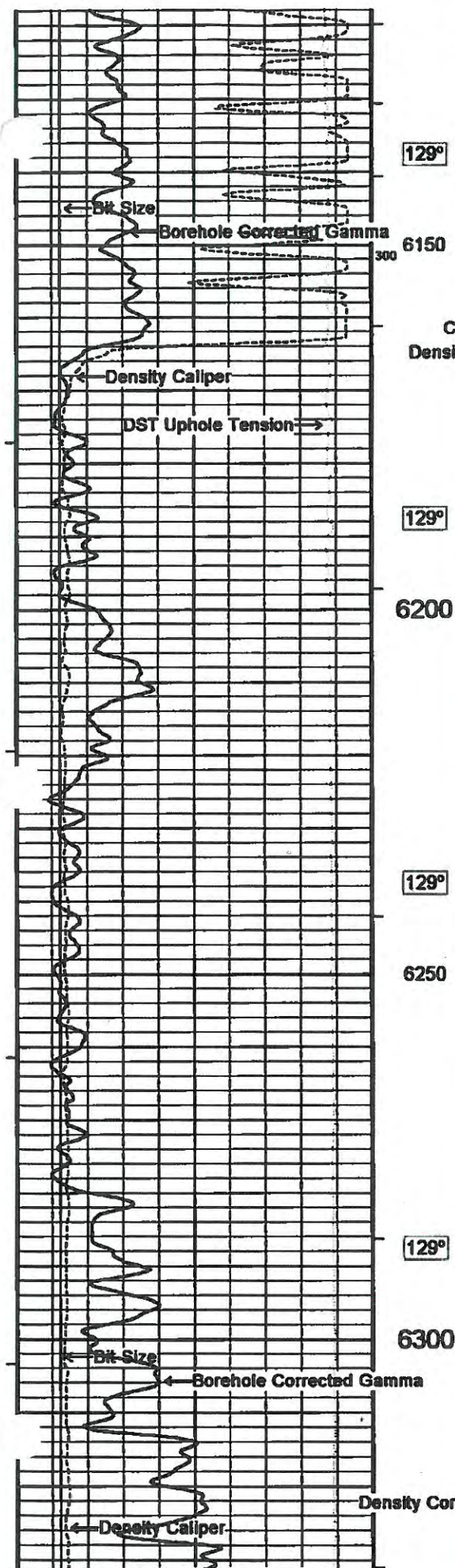


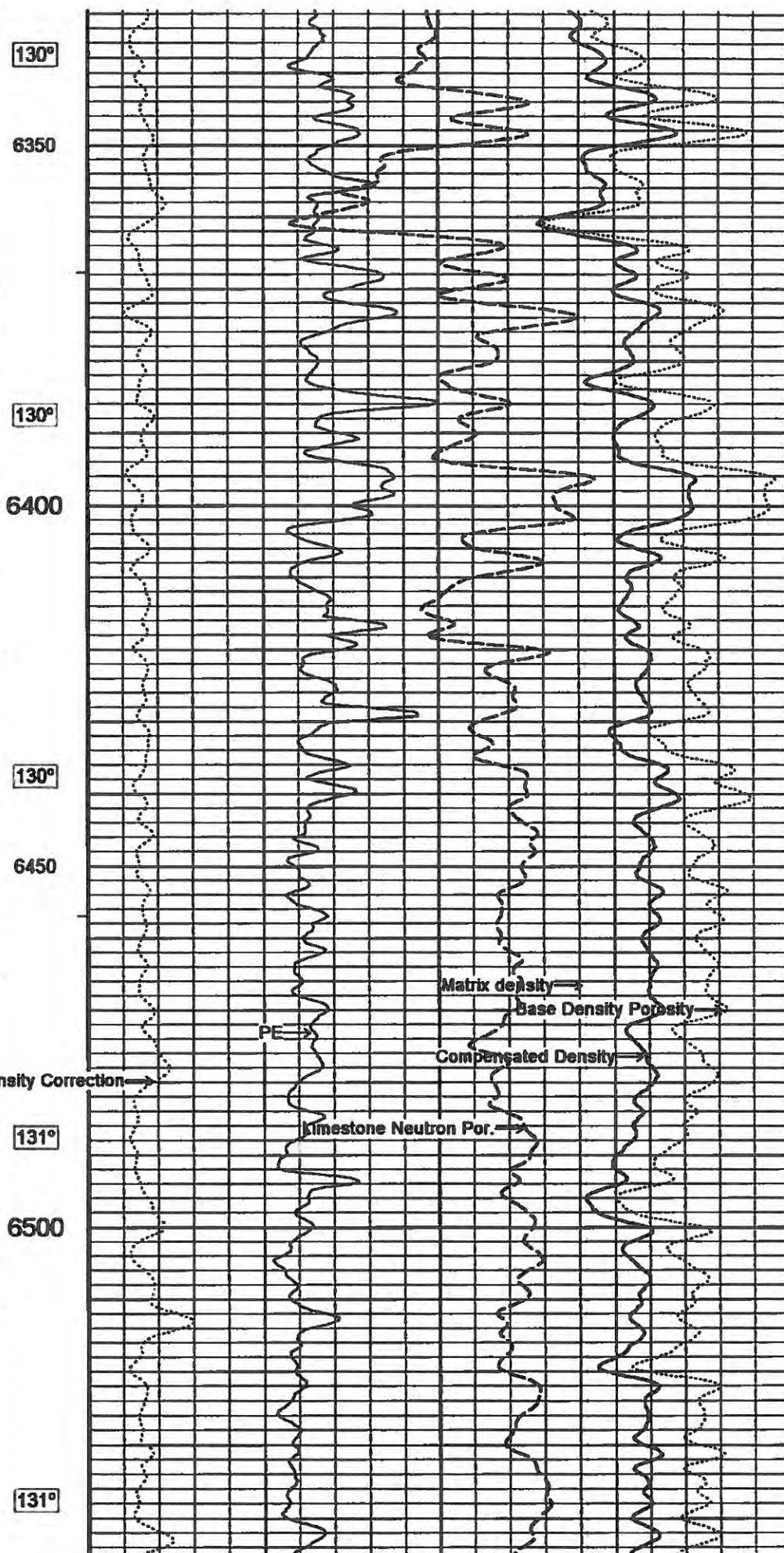
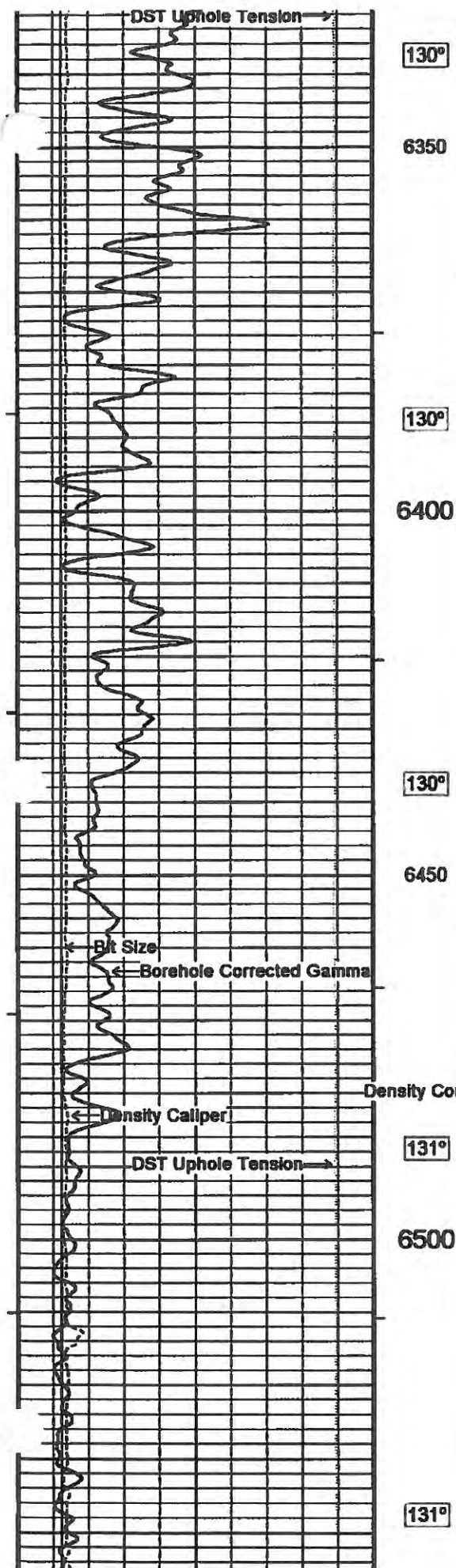


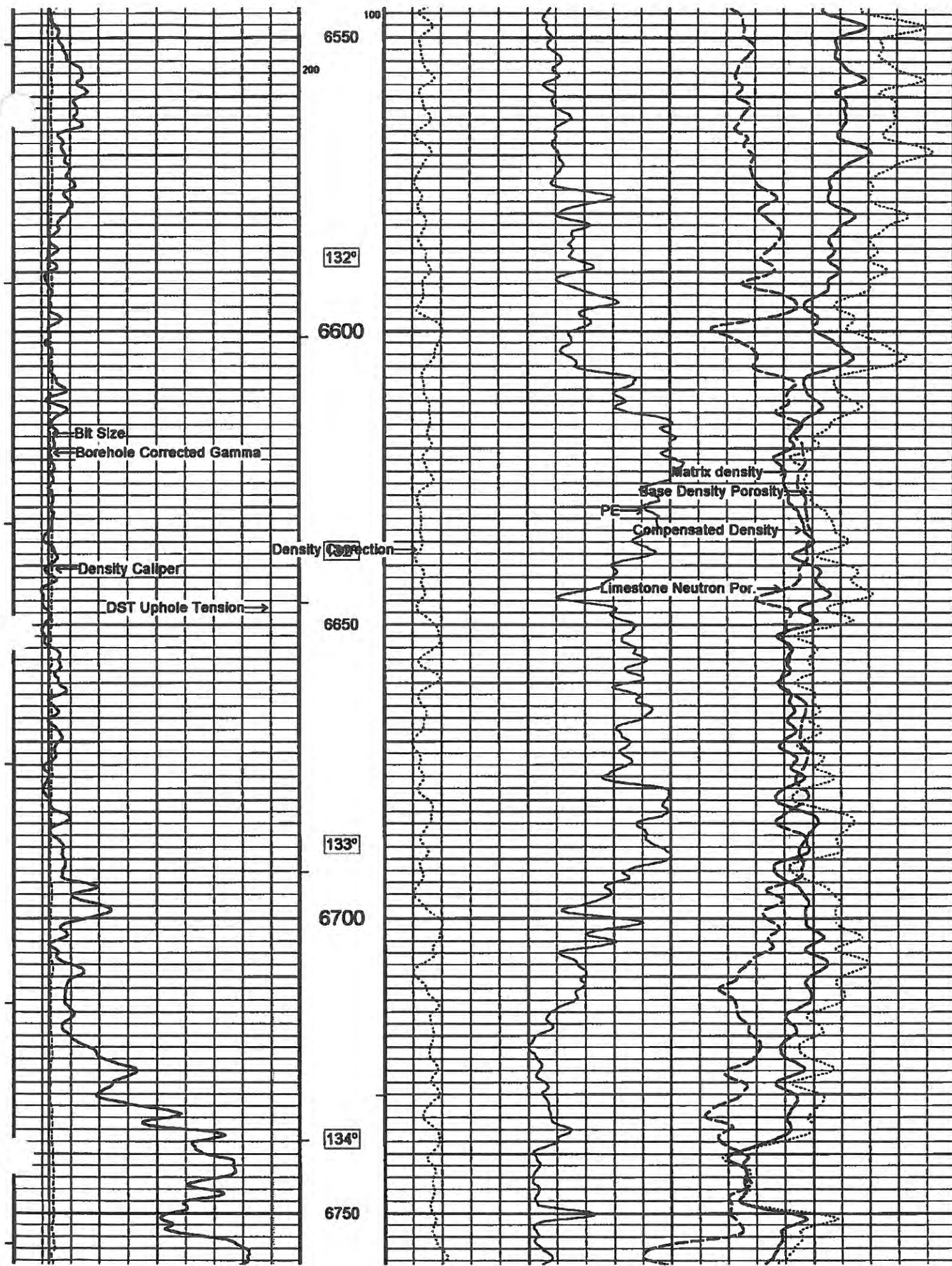


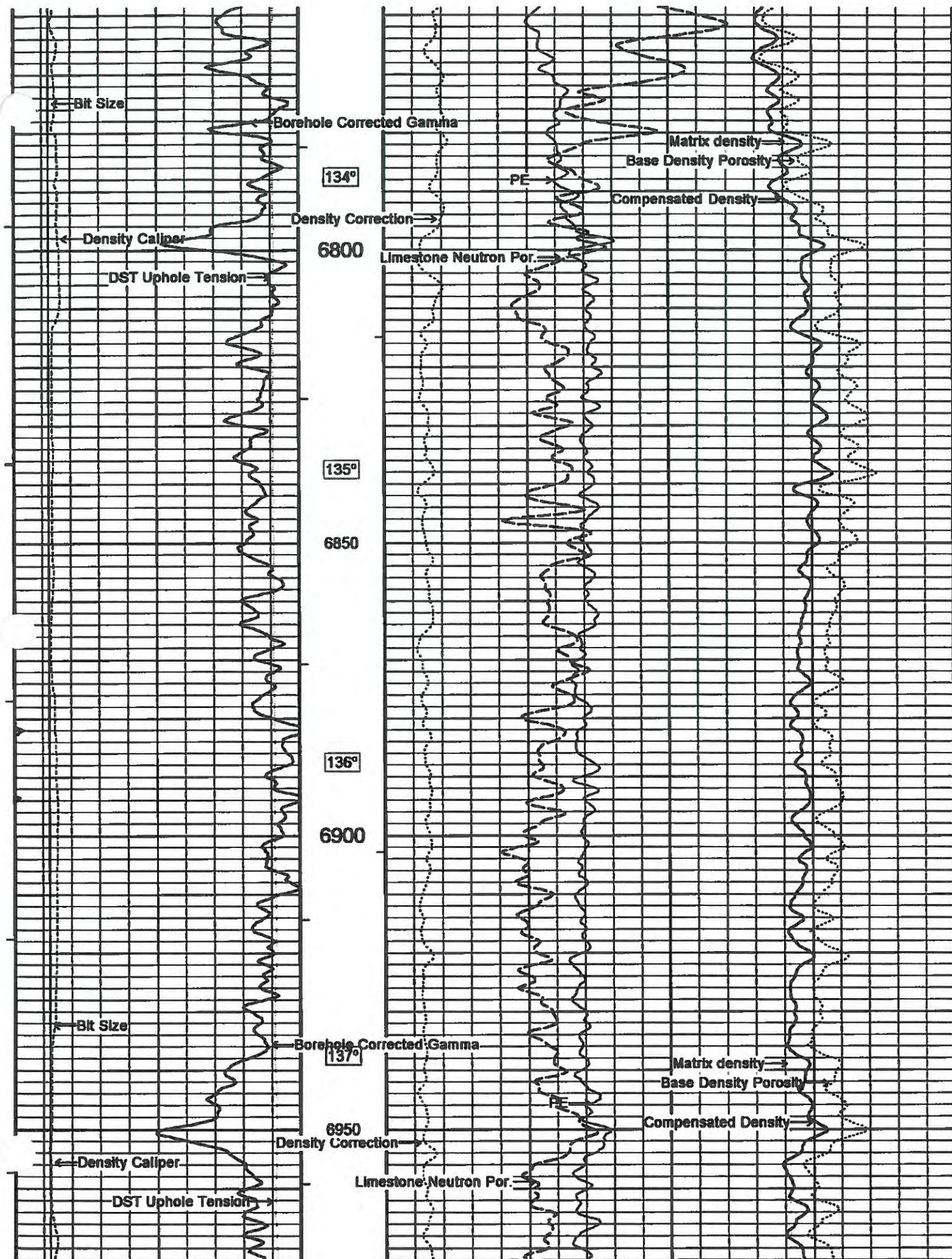


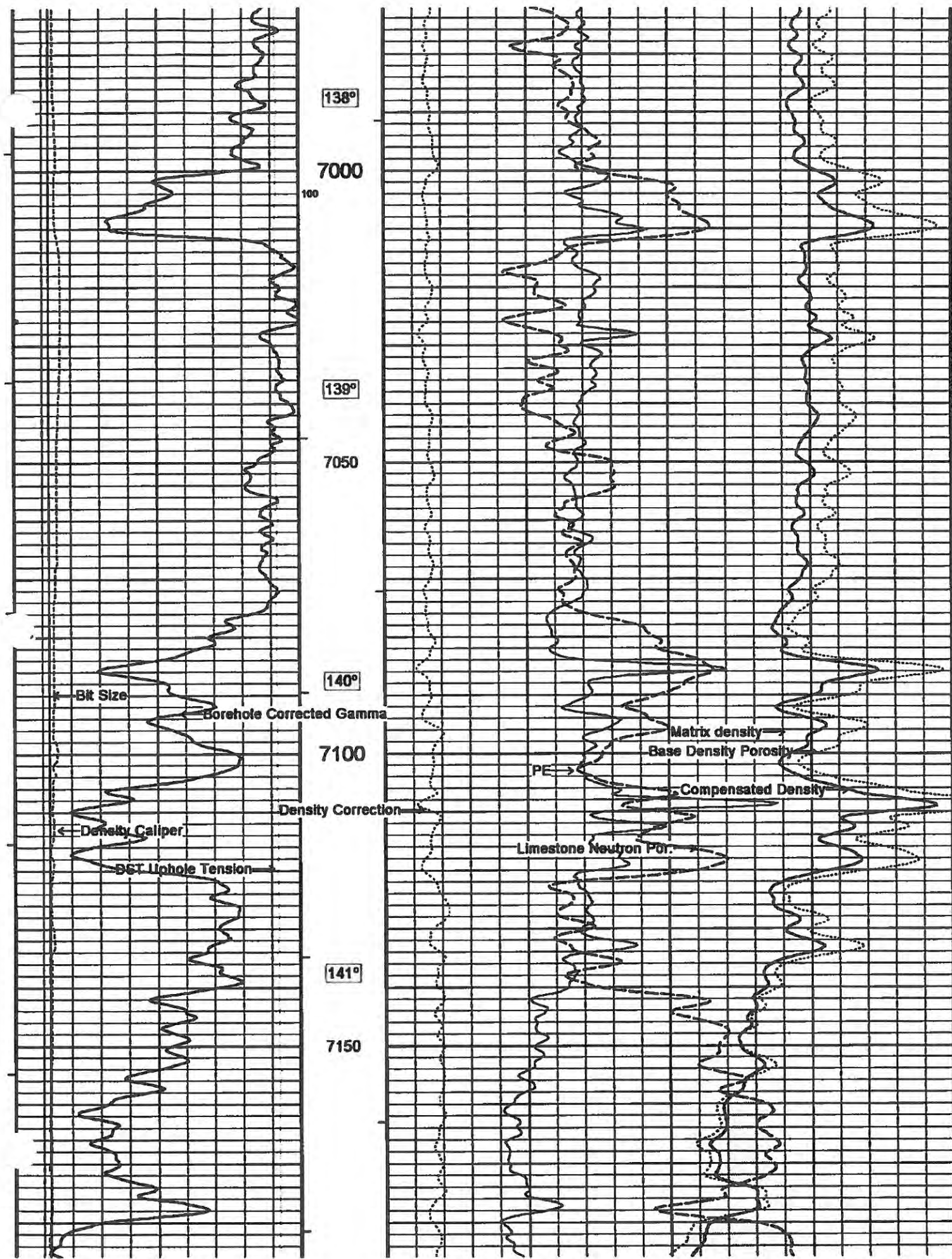


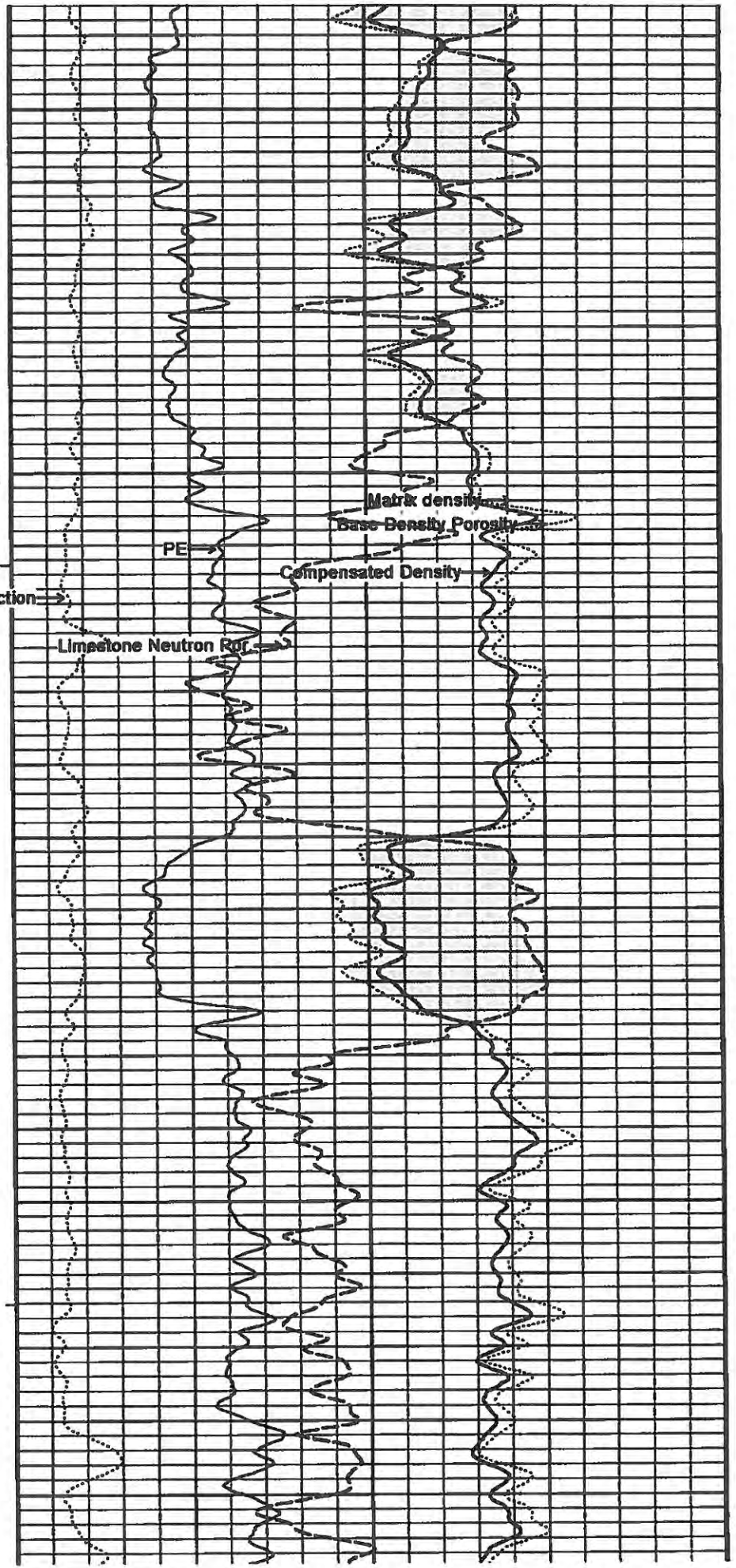
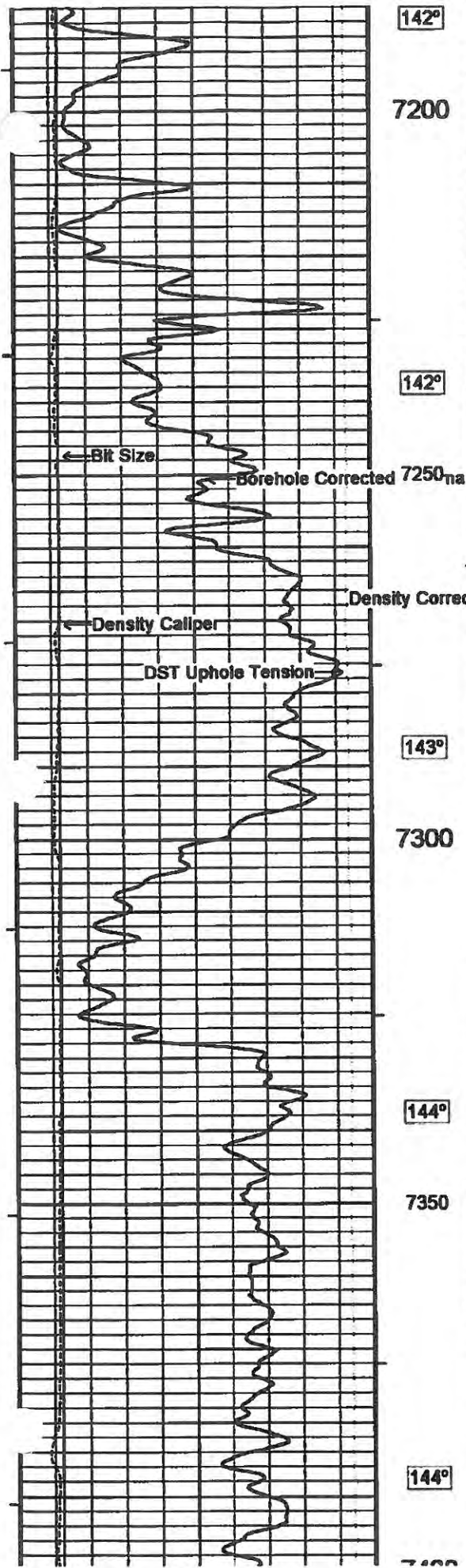


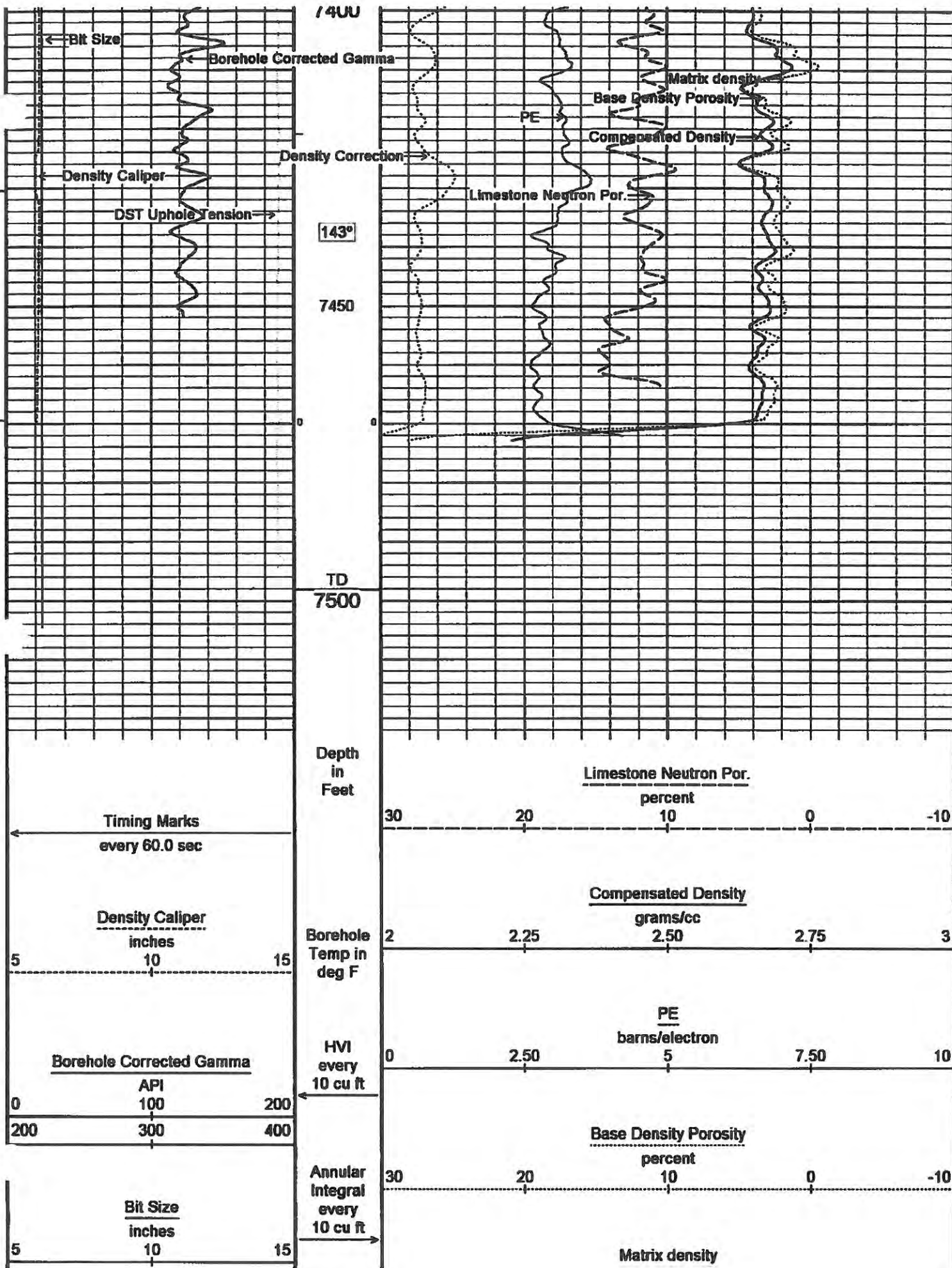


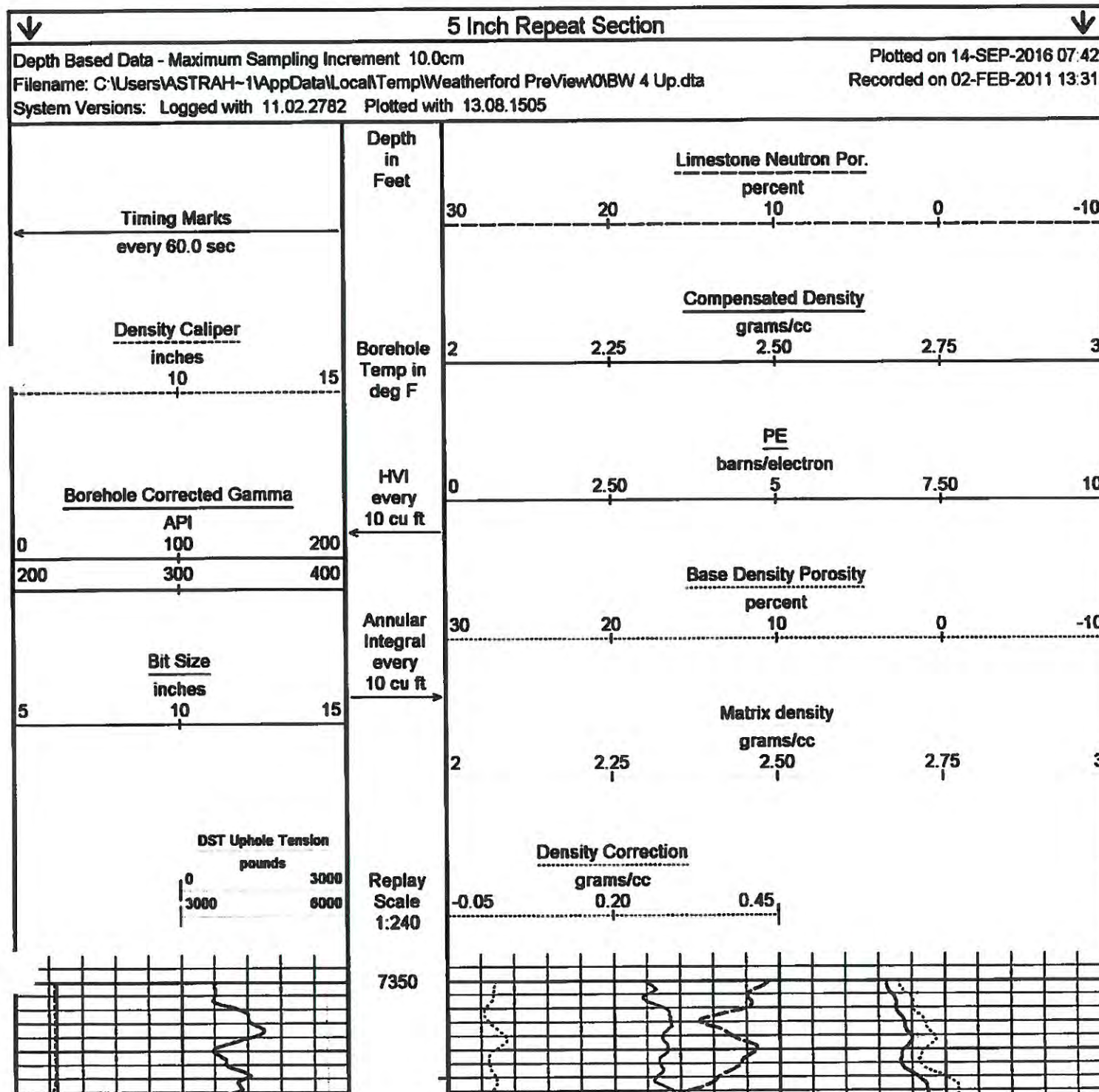
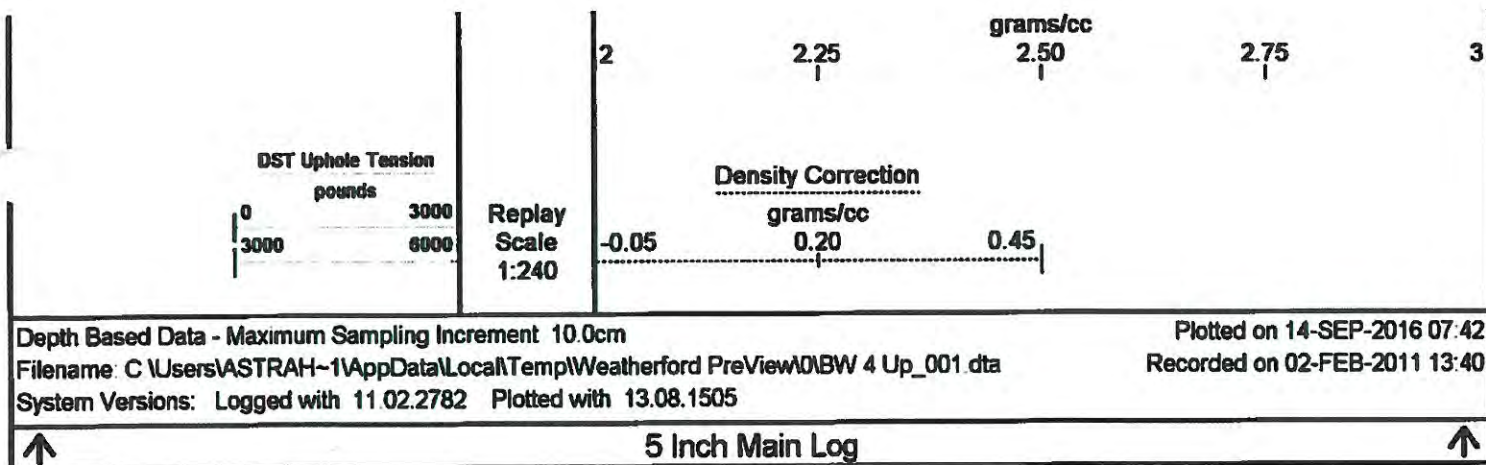


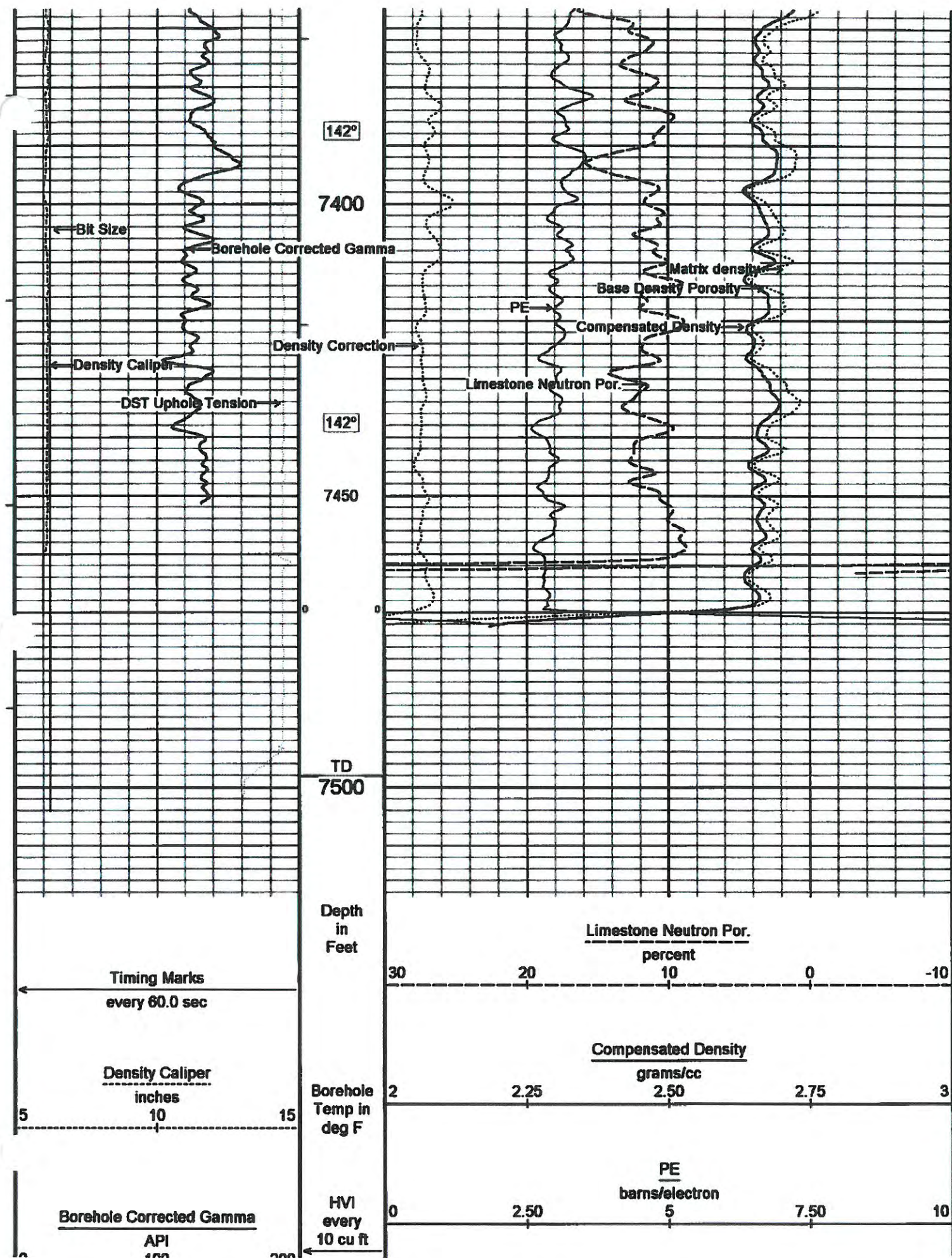


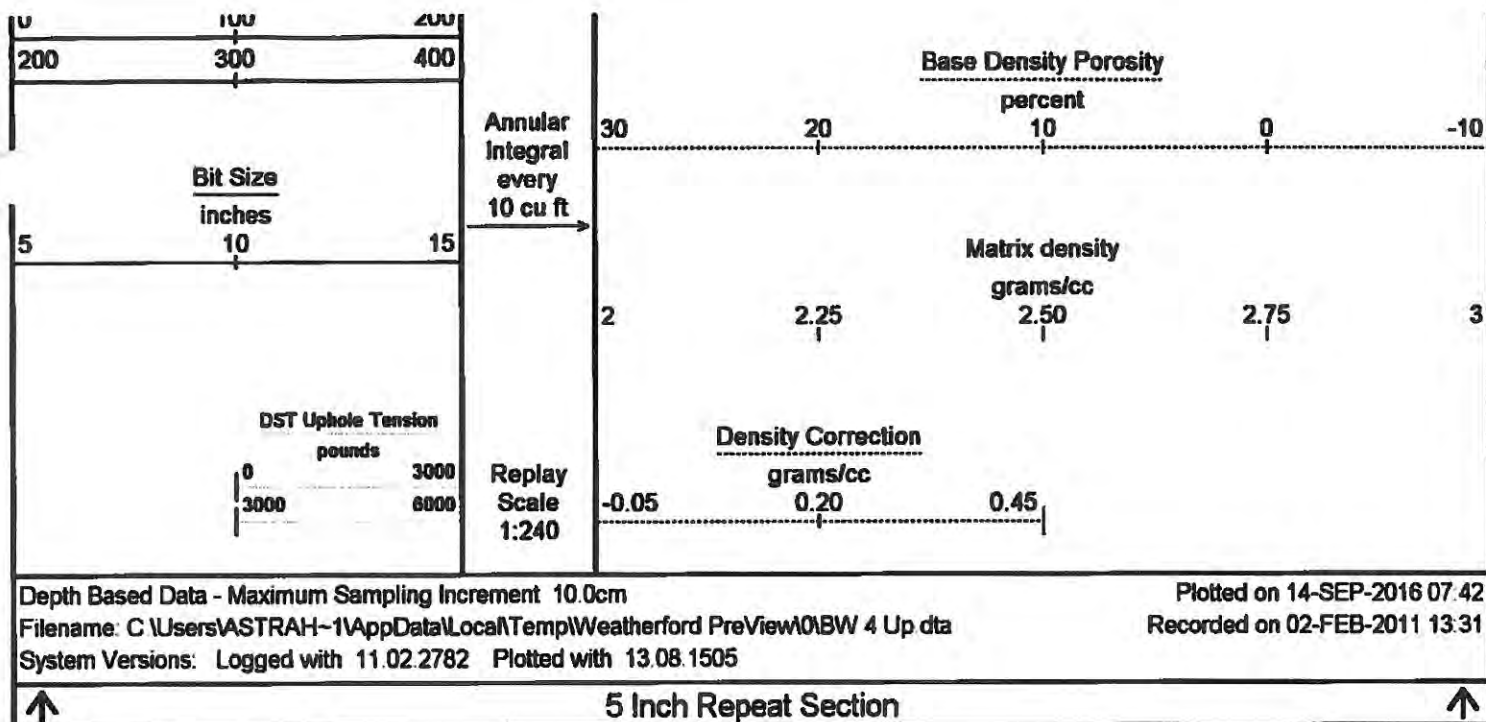












BEFORE SURVEY CALIBRATION

C:\Users\ASTRAH~1\AppData\Local\Temp\Weatherford PreView\0\BW 4 Up.dta

General Constants All 000

Last Edited on 02-FEB-2011,12:54

General Parameters

Mud Resistivity	0.100	ohm-metres
Mud Resistivity Temperature	64.000	degrees F
Water Level	0.000	feet
Borehole Fluid Processing	Water Level Switch	

Hole/Annular Volume and Differential Caliper Parameters

HVOL Method	Single Caliper	
HVOL Caliper 1	Density Caliper	
HVOL Caliper 2	N/A	
Annular Volume Diameter	4.500	inches
Caliper for Differential Caliper	Density Caliper	

Rwa Parameters

Porosity used	Base Density Porosity
Resistivity used	Deep Laterolog
RWA Constant A	0.610
RWA Constant M	2.150
SW/APOR Tool Source	

Gamma Calibration MCG-C 136

Field Calibration on 01-FEB-2011 08:52

	Measured	Calibrated (API)
Background	63	43
Calibrator (Gross)	2256	1535
Calibrator (Net)	2193	1492

Gamma Constants MCG-C 136

Last Edited on 02-FEB-2011,12:55

Gamma Calibrator Number	44	
Mud Density	1.27	gm/cc
Caliper Source for Processing	Density Caliper	
Tool Position	Eccentred	
Concentration of KCl	0.00	kppm
K Mud Type		
K Mud Concentration		%

SD Calibration MCG-C 136

Field Calibration on 11-JAN-2011,15:10

Reference 1	Measured	Calibrated (mV)
Reference 2	101.2	100.7
	-99.6	-100.5

High Resolution Temperature Calibration MCG-C 136

Field Calibration on 11-JAN-2011,15:10

	Measured	Calibrated(Deg F)
Lower	65.00	66.00
Upper	100.00	101.00

High Resolution Temperature Constants MCG-C 136

Last Edited on

Pre-filter Length 11

Neutron Calibration MDN-A.B 178

Base Calibration on 11-JAN-2011,15:10

Field Check on

Base Calibration

	Measured	Calibrated (cps)
	Near Far	Near Far
	3434 104	3714 110
Ratio	32.868	33.764

Field Calibrator at Base

	Calibrated (cps)
	1528 2248
Ratio	0.680

Field Check

Calibrated (cps)

Ratio

Neutron Constants MDN-A.B 178

Last Edited on 02-FEB-2011,11:37

Neutron Source Id	703
Neutron Jig Number	033
Epithermal Neutron	No
Caliper Source for Processing	Density Caliper
Stand-off	0.00 inches
Mud Density	1.00 gm/cc
Limestone Sigma	7.10 cu
Sandstone Sigma	4.26 cu
Dolomite Sigma	4.70 cu
Formation Pressure Source	Constant Value
Formation Pressure	0.00 kpsi
Temperature Source	Constant Value
Temperature	68.00 degrees F
Mud Salinity	0.00 kppm
Salinity Correction	
Formation Fluid Salinity Source	Constant Value
Formation Fluid Salinity	0.00 kppm
Barite Mud Correction	Not Applied

Laterolog Calibration MLE-AA 2

Base Calibration on 11-JAN-2011,15:12

Field Check on

Base Calibration

		Measured	Calibrated (ohm-m)
Channel	Resistor 1	Resistor 2	Resistor 1 Resistor 2
Shallow	0.0	974.2	0.0 1327.3
Deep	0.0	974.4	0.0 852.7
Groningen	0.0	678.6	0.0 852.7

Channel	Base Check (ohm-m)	Field Check (ohm-m)
Shallow	0.0	0.0
Deep	0.0	0.0
Groningen	0.0	0.0

Laterolog Constants MLE-AA 2

Last Edited on 02-FEB-2011,12:55

Profiling Laterolog Type	ohm-m
Laterolog Output Filter	

Froming Limmer
 Median Filter
 Squasher Start 40000
 Shallow Laterolog K Factor 1.3273
 Deep Laterolog K Factor 0.8527
 Groningen Laterolog K Factor 0.8527
 Interference Rejection 60 Hz
 SP Connection SP Bridle Electrode (Lower)
 Groningen Connection Groningen Electrode (Upper)

Borehole Correction Constants
 Bridle Type Standard
 Stand-off Centered inches
 Caliper Source Density Caliper
 Hole Size N/A inches
 Mud Resistivity Source Temperature Corrected
 Temp. for Rm Corr. MCG External Temperature

Apparent Porosity and Water Saturation Constants
 Archie Constant (A)
 Cementation Exponent (M)
 Saturation Exponent (N)
 Saturation of Water for Apor
 Resistivity of Water for Apor and Sw ohm-m
 Resistivity of Mud Filtrate for Sw ohm-m
 Source for Rt
 Source for Rxo

SP Calibration MLE-A A 2

Field Calibration on 11-JAN-2011,15:13

	Measured	Calibrated (mV)
Reference 1	100.0	100.7
Reference 2	-100.1	-99.4

High Resolution Temperature Calibration MHT-A 26

Field Calibration on 20-NOV-2008,15:55

	Measured	Calibrated(Deg F)
Lower	65.00	66.00
Upper	100.00	101.00

High Resolution Temperature Constants MHT-A 26

Last Edited on

Pre-filter Length 11

Caliper Calibration MPD-B 52

Base Calibration on 01-FEB-2011 10:31
 Field Calibration on 01-FEB-2011 10:33

Base Calibration Reading No	Measured	Calibrator Size (in)
1	14505	3.99
2	22944	5.97
3	31696	8.00
4	40416	10.03
5	49183	11.98
6	N/A	N/A

Field Calibration	Measured Caliper (in)	Actual Caliper (in)
	5.96	5.97

Photo Density Calibration MPD-B 52

Base Calibration on 01-FEB-2011,11:35
 Field Check on

Density Calibration Base Calibration	Near	Measured Far	Calibrated (sdu) Near	Far
Background				
Reference 1	47757	17098	53306	19389
Reference 2	21977	2257	24963	2524
Field Check at Base	725.3	1027.4		

Field Check

PE Calibration

Base Calibration	Measured	Calibrated
WS	WH	Ratio
Background	135	614
Reference 1	13900	47597
Reference 2	5582	21864
		0.293
		0.256
		0.321
		0.273

Field Check at Base

134.7 613.6

Field Check

Density Constants MPD-B 52

Last Edited on 02-FEB-2011,12:55

Density Source Id	NSD-L-249
Nylon Calibrator Number	DNC-D-526
Aluminium Calibrator Number	DAC-D-526
Density Shoe Profile	8 inch
Caliper Source for Processing	Density Caliper
PE Correction to Density	Not Applied
Mud Density	1.27 gm/cc
Mud Density Z/A Multiplier	1.11
Mud Filtrate Density	1.00 gm/cc
Dry Hole Mud Filtrate Density	1.00 gm/cc
DNCT	0.00 gm/cc
CRCT	0.00 gm/cc
Density Z/A Correction	Advanced

Matrix Density (gm/cc)	Depth (ft)
2.71	0.00
0.00	0.00
0.00	0.00
0.00	0.00
0.00	0.00
0.00	0.00
0.00	0.00
0.00	0.00
0.00	0.00

DOWNHOLE EQUIPMENT

C:\Users\ASTRAH~1\AppData\Local\Temp\Weatherford PreView\0\BW 4 Up.dta

Compact Stiff Bridle Electrode Sub.
MBE-A 50 LG: 12.33 ft WT: 77.2 lb OD: 2.24 in

Compact Stiff Bridle Electrode Sub.
MBE-D.A 162 LG: 12.33 ft WT: 77.2 lb OD: 2.24 in

Compact Comms Gamma

53.76 ft

GGCE - Borehole Corrected Gamma

MUG-C 136 LG: 8.70 ft WT: 63.9 lb OD: 2.24 in

Compact Linker

MLK-D.A 101 LG: 4.87 ft WT: 30.9 lb OD: 2.24 in

Compact Neutron

MDN-A.B 178 LG: 5.04 ft WT: 50.7 lb OD: 2.24 in

Compact Density/Caliper

MPD-B 52 LG: 9.59 ft WT: 90.4 lb OD: 2.45 in

Compact Upper Guard sub

MUG-B.A 197 LG: 8.98 ft WT: 68.3 lb OD: 2.24 in

Compact Laterolog Electrode Sub.

MLE-A.A 2 LG: 12.34 ft WT: 92.6 lb OD: 2.24 in

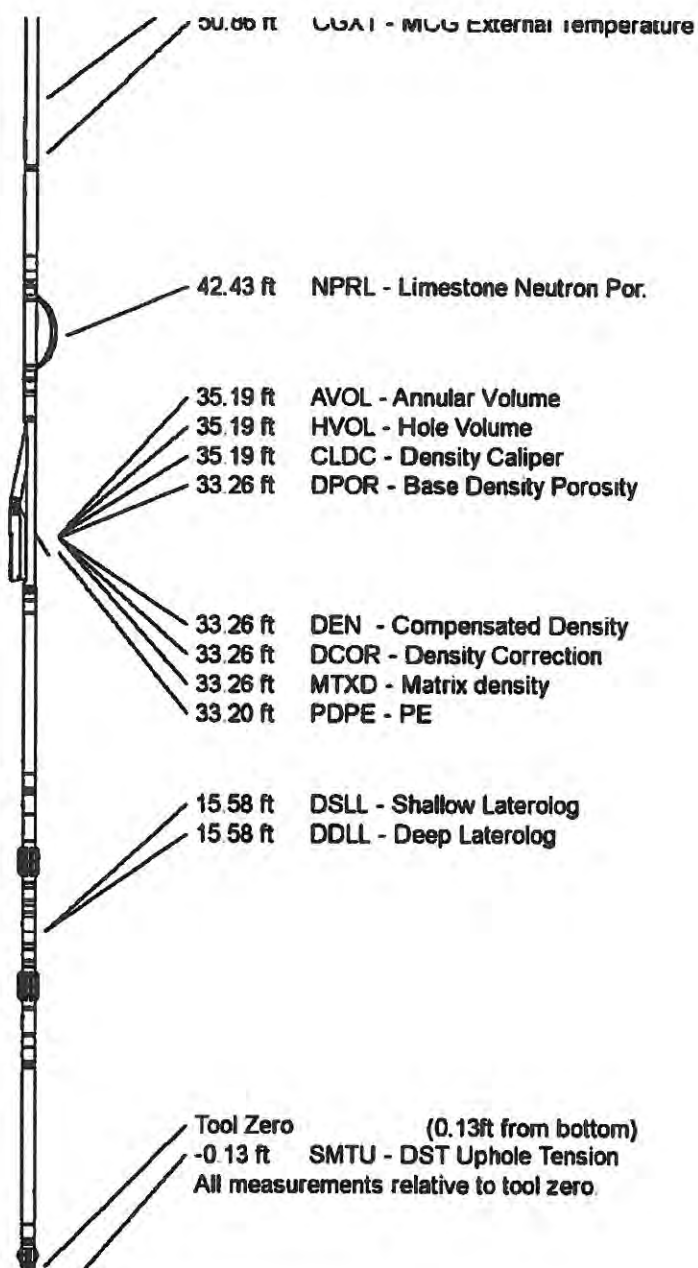
Compact Lower Guard Sub.

MLG-A 35 LG: 8.00 ft WT: 55.1 lb OD: 2.24 in

Compact High Resolution Temperature

MHT-A 26 LG: 1.53 ft WT: 13.2 lb OD: 2.24 in

Total Length: 83.71 ft Weight: 619.5 lb



COMPANY	Appalachian Oil Purchasers, Inc.
WELL	BW 4
FIELD	Washington District
PROVINCE/COUNTY	Pleasants County
COUNTRY/STATE	U.S.A. / West Virginia

Elevation Kelly Bushing	654.00	feet	First Reading	7498.00	feet
Elevation Drill Floor	654.00	feet	Depth Driller	7503.00	feet
Elevation Ground Level	640.00	feet	Depth Logger	7498.00	feet



Weatherford®

Photo Density
Compensated Neutron
Gamma Ray



Weatherford

Printed with PreView™

02 02 11 Appalachian Oil BW 4 DEN NEU

Tom Tomastik

Senior Geologist and Regulatory Specialist

Education

B.S., Geology, Ohio University, 1979

M.S., Geology, Ohio University, 1981

Distinguishing Qualifications

Mr. Tomastik is a professional geologist with over 34 years of diverse expertise and experience in the energy sector, government, and consulting. He has been involved in the planning, drilling, permitting and development of oil and gas and Class II saltwater disposal wells, stray gas investigations, groundwater contamination cases, induced seismicity, seismic monitoring and installation, and expert witness testimony.

Prior to working for ALL Consulting, Mr. Tomastik worked for 25-1/2 years with the Ohio Department of Natural Resources, Division of Mineral Resources Management and the Division of Oil and Gas Resources Management in the Technical Support Services Section and Underground Injection Control Section. As senior geologist, he oversaw the planning, permitting, drilling, and conversion of Class II and Class III injection wells using hydrogeology, geology, and engineering specialization for well construction, completion, and surface facility construction of these operations. Additionally, as lead geologist for the divisions, Mr. Tomastik conducted several hundred alleged groundwater and stray gas investigations related to oil and gas, industrial minerals mining, and coal mining operations in Ohio. Mr. Tomastik also served on several national workgroups, including the U.S. EPA UIC National Technical Workgroup, GWPC Carbon Geosequestration and Hydraulic Fracturing committees, and U.S. EPA Hydraulic Fracturing Technical Workshop on Well Construction/Operation and Subsurfacing Modeling. Currently, Mr. Tomastik is serving on the Ohio Oil and Gas Association's Induced Seismic Workgroup, which is addressing regulatory development of permit conditions for managing potential induced seismicity related to hydraulic fracturing and Class II injection operations in Ohio.

In the 1980s, Mr. Tomastik worked as a consultant involved in the exploration and development of oil and gas wells and Class II injection wells in Ohio with oversight of drilling, cementing, geophysical logging, sample collection and analysis, stimulation and completion, and hydraulic fracturing of these wells. Additionally, he prepared geologic maps, cross sections, and geologic reports for investor-oriented drilling programs. Mr. Tomastik also worked occasionally as a roustabout and pumper and plumbed up wellheads, installed gas pipelines, conducted plugging operations, and produced oil and gas wells.

Received
SEP - 7 2016
Office of Oil and Gas
WV Dept. of Environmental Protection

Tom Tomastik

Relevant Experience

The following information is intended to demonstrate Mr. Tomastik's ALL expertise and experience:

For OOGC Disposal Company, LLP, Mr. Tomastik has prepared and submitted all Class II injection well application documents and public notice requirement for the Black Run Disposal Well #1 in Muskingum County, Ohio Class II saltwater disposal application.

For Viking Energy Corporation, Mr. Tomastik prepared all documents for the five-year permit renewal application for Viking Energy's Class II commercial disposal well in Kanawha County, West Virginia, which included all geological characterization, evaluation of site security and emergency response, and groundwater protection plan.

For Evrol, LLC, Mr. Tomastik prepared all Class II saltwater injection well permit application documents, submitted the application, and oversaw publishing of public notice requirement for the Kelly #1 injection well application in Portage County, Ohio.

For Appalachian Oil Purchasers, Inc., Mr. Tomastik prepared all documents for a the five-year permit renewal application for their Class II commercial disposal well in Pleasants County, West Virginia, which included a geologic characterization and groundwater protection plan.

For the City of Hudson, Mr. Tomastik has been actively engaged in the permitting process of obtaining a permit for the City to drill and complete a Class II salt-solution mining well to provide brine to the City's municipal water treatment plant and for brine to apply in the winter for snow and ice control to the City of Hudson road network.

For a Confidential Client in Ohio, Mr. Tomastik has been actively engaged in evaluating potential Class II SWD injection well siting locations, conducting geological investigations, area of review determinations, and seismic unit installation and monitoring. This includes geophysical logging review and evaluation, AFE and bid quotations from contractors, and providing the client's staff with assistance with the permit application process and interpretation of Ohio's regulatory framework regarding Class II injection wells.

For Red Bird Development, LLC in Ohio, Mr. Tomastik served as geologic consultant on the completion of a Class II injection well in southeastern Ohio. He provided oversight and geologic interpretation of the open-hole geophysical logging operation, selection of perforating depths and stimulation of the injection zones, conducting injectivity testing of the injection zones, and overseeing the setting of the tubing and packer and mechanical integrity testing. Additionally, Mr. Tomastik provided expertise in geological evaluation of other potential, shallower injection zones for the possible development of multiple injection wells on the operator's property. Mr. Tomastik also assisted in creation of a SPCC and ERP plan for this facility.

For EnLink Midstream, Mr. Tomastik served as Project Manager and General Contractor for a Class II injection well workover in West Virginia. Mr. Tomastik provided complete oversight and management of obtaining bids and quotes from multiple contractors, cost estimates and budget

Received
SEP - 7 - 2010
Office of Oil and Gas
WV Dept. of Environmental Protection

Tom Tomastik

for EnLink Midstream for multiple phases of the well workover project, coordination and scheduling of contractors to perform the work, and management of the work being performed at the injection location. This project included drafting of a health and safety plan, holding daily JSA onsite meetings, creation of daily well inspection reports, geophysical logging, inflatable packer installation and removal, removal and replacement of injection tubing string and injection packer using free-standing snubbing unit operations, acid stimulation, and performing and demonstrating mechanical integrity testing and putting the injection well back into operation. Additionally, Mr. Tomastik has provided geological assessments, area of review determinations, completed a drilling and completion AFE for EnLink Midstream on multiple potential injection well siting locations. Mr. Tomastik has also conducted file reviews of existing EnLink Class II wells to provide expertise in evaluation of well performance and treatment.

For a Confidential Client in Ohio, Mr. Tomastik was directly involved in oversight and writing of an Expert Report to address a case of induced seismicity involving a Class II operation in Ohio, which include geological investigation, injection pressure and volume evaluation, and providing recommendations to assist the client with the regulatory agency to get the injection well back into operation.

For the Florida Department of Environmental Protection, Mr. Tomastik assisted in creation of an Expert Report for the investigation of alleged environmental impacts resulting from the drilling and completion of a deep, unconventional horizontal well in Collier County, Florida. This report included geologic and hydrogeologic investigation, well construction and cementing practices evaluation, review and analysis of the well stimulation records, and evaluation of plugged oil and gas wells in the immediate vicinity to investigate the potential avenues for migration of stimulation fluids.

For several Confidential Clients, Mr. Tomastik has been involved in conducting siting investigations, area of review determinations, and possible land acquisitions for proposed Class II well locations in Ohio.

For the Ohio EPA, Mr. Tomastik prepared an Expert Report on the Class I applications submitted by Husky Refining and assisted Ohio EPA in addressing concerns from the Ohio Department of Natural Resources (ODNR).

For the ODNR, Division of Oil and Gas Resources Management (DOGRM), Mr. Tom Tomastik served as senior lead geologist and Underground Injection Control expert for the DOGRM for 25-1/2 years overseeing the permitting activity of all Class II and Class III injection well applications and permit issuance. These work included performing independent reviews of the engineering-designed drilling programs and surface facilities; proposed drilling, casing, cementing, and stimulation plans; conducting hundreds of area of review evaluations to determine the feasibility of injection without corrective action; determinations of deepest underground sources of drinking water (USDWs); and issuance of hundreds of Class II and Class III injection well permits. Mr. Tomastik oversaw all Class II and Class III compliance and enforcement actions, including management of the Underground Injection Control (UIC) database, and review of all UIC well inspection reports. For the last eight years of his career at DOGRM, Mr. Tomastik prepared all

Tom Tomastik

UIC federal grant applications and oversaw grant management and for the last 14 years directly oversaw submittal of all bi-annual 7520 reports to U.S. EPA. Mr. Tomastik served on numerous occasions as DOGRM's technical expert and witness on groundwater investigations before the Ohio Oil and Gas Commission and the Ohio Reclamation Commission and in a number of civil cases before various Ohio county court systems. Mr. Tomastik also was the technical expert for DOGRM and reviewed Class I hazardous and non-hazardous applications and permits-to-operate and Class V applications and prepared comments and made recommendations regarding these applications to Ohio EPA. Additionally, Mr. Tomastik served as a State Member of the U.S. EPA UIC National Technical Workgroup for six years.

For ODNR, Division of Mineral Resources Management (DMRM), Mr. Tomastik conducted hundreds of groundwater investigations of alleged impacts from oil and natural gas industry, coal mining, and industrial minerals mining operations in Ohio. Mr. Tomastik was the project leader and participated in major groundwater dewatering investigations of mining operations near Toledo, Ohio and on Kelleys Island, Ohio and successfully got water supply replacement to almost 50 private residences. Additionally, Mr. Tomastik assisted and was successful in closing the "Bainbridge Incident", where almost 30 private water wells were impacted by stray gas invasion from an overpressurized annulus on a conventional oil and natural gas well in northeastern Ohio. Mr. Tomastik was instrumental with DMRM in acquiring highly technical equipment such as color downhole video cameras and pressure transducers, which enhanced DMRM's ability to quickly resolve groundwater investigation cases with mining and oil and gas industry operators.

As a private consulting geologist, Mr. Tomastik oversaw the drilling and completion of 26 conventional oil and natural gas wells in Ohio and the drilling or conversion of six Class II saltwater injection wells. This work included detailed geologic mapping, cross sections, and report writing, oversight of drilling, cementing, geophysical logging, perforating, hydraulic fracturing, and acid treatment of these wells. Mr. Tomastik also participated in plumbing up wellheads, putting in pipelines, pumping, and plugging oil and natural gas wells in Ohio.

Professional Organizations

American Association of Petroleum Geologists
Ohio Geological Society
Ground Water Protection Council

Received

SEP - 7 2016

Recent Publications and Presentations

Tomastik, T.E. and Cavender, M.J., 1990. Analysis of natural gas production from the Mississippian-age "Second Berea" sandstone in southeastern Ohio, SPE 21288, p. 233-238, SPE Eastern Regional Meeting, Columbus, Ohio, 1990.

Tomastik, T.E. and Wolfe, M., 1991. An evaluation of annular disposal wells in Ohio, Ohio Academy of Science, Centennial Annual Meeting, April 26-28, 1991, Columbus, Ohio, Volume 91, Number 2, p. 31.

Office of Oil and Gas
WV Dept. of Environmental Protection

Tom Tomastik

Whittenmore, D.O. Hodges, D.A. and Tomastik, T.E., 1991, Finger printing and quantifying salinity sources in multicomponent mixtures, 36th Annual Midwest Groundwater Conference, Programs with Abstracts, October 9-11, 1991, Indianapolis, Indiana, p. 58-59.

Tomastik, T.E. and others, 1992. Investigation of active and abandoned Class III salt-solution mining projects in Ohio, Ohio Department of Natural Resources, Division of Oil and Gas, 231p.

Tomastik, T.E., 1994. Investigation of groundwater and soil contamination related to a Class II facility in Portage County, Ohio, U.S. EPA Region V, Class II Meeting, Marshall, Indiana, 9p.

Tomastik, T.E., 1995. History and reservoir analysis of the Berea Sandstone in the Chatham Oil Field, Medina County, Ohio, Ohio Geological Society, Third Annual Technical Symposium, Canton, Ohio, 24p.

Tomastik, T.E., 1996. An examination of the geology of the Bass Islands and Salina Groups in Ohio and its effect on salt-solution mining and underground storage, Solution Mining Research Institute, 1996 Fall Technical Meeting, Cleveland, Ohio 31p.

Tomastik, T.E., 1996. Lower Mississippian – Upper Devonian Berea and equivalent sandstones, *In The Atlas of Major Appalachian Gas Plays*, Appalachian Oil and Natural Gas Research Consortium, U.S. Department of Energy Project, p. 56-62.

Tomastik, T.E., 1997. The sedimentology of the Bass Islands and Salina Groups in Ohio and its effect on salt-solution mining and underground storage, USA, *In Carbonates and Evaporites*, Volume 12, Number 2, p. 236-253.

Tomastik, T.E., 1999. Large potential reserves remain for secondary recovery in Ohio, *In Oil & Gas Journal*, January 18, 1999, p. 70-73.

Tomastik, T.E., 2000. How to identify uphole/behind pipe reserves in existing wells, Ohio Oil and Gas Association 22nd Annual Fall Conference, October 24, 2000, Akron, Ohio 24p.

Tomastik, T.E., 2001. Natural gas cavern storage and the issue of disposal of the fluids, Ground Water Protection Council Annual Meeting, Reno, Nevada, September 22-26, 2001, 3p.

Tomastik, T.E., 2002. Salt deposits in Ohio – Geology, mining, and uses, *In 2001 Report on Ohio Mineral Industries*, compiled by Wolfe, M.E., Ohio Division of Geological Survey, p. 1-7.

Van Oort, M.D., Bair, E.S. and Tomastik, T.E., 2003. Numerical modeling of the effects of a quarry dewatering operation in northwest Ohio, Geological Society of America, 2003 Seattle Annual Meeting, November 2-5, 2003, abstract.

Tomastik, T.E. and others, 2004. Water Rights Dispute – The effects of a quarry dewatering operation in northwest Ohio, 2004 National Ground Water Association Ground Water and Environmental Law Conference, May 5-6, 2004, Chicago, Illinois, p. 139-150.

Received

SEP - 7 2016

Tom Tomastik

Tomastik, T.E., Hodges, D.A. and Scheerens, C.L., 2004. Oilfield complaints in Ohio: Procedures and guidelines for conducting alleged water well contamination investigations, 2004 Ground Water Protection Council Annual Forum, September 18-22, 2004, Charleston, South Carolina, abstract.

Tomastik, T.E. and others, 2004. Aggregate mining in Ohio – The effects of a quarry dewatering operation in northwest Ohio, 2004 American Association of Petroleum Geologists Eastern Section Meeting, October 3-6, 2004, Columbus, Ohio, abstract.

Tomastik, T.E., 2005. Overview of state issues with National Technical Workgroup Products: AOR/ZEI and annular disposal of drilling wastes, Ground Water Protection Council 2005 Annual Forum, September 24-29, 2005, Portland, Oregon, abstract.

Tomastik, T.E., 2006. Water well complaint investigations: What we have learned and what we can recommend, Ohio Environmental Health Association, 2006 Northwest Ohio Environmental Health Association Annual Autumn Education Conference, October 19-20, 2006, Sandusky, Ohio.

Tomastik, T.E. and Benko, T., 2007. Groundwater investigation of potential dewatering and depressurization impacts on Kellys Island, Erie County, Ohio, 2007 National Ground Water Association Ground Water and Environmental Law Conference, July 24-25, 2007, Columbus, Ohio, Paper #4187.

Tomastik, T.E., 2009. Site characterization for CO₂ Geosquestration, 2009 Ground Water Protection Council UIC and Deep Well Conference, January 25-27, 2009, San Antonio, Texas, abstract.

Tomastik, T.E. and Benko, T., 2009. Groundwater investigation of potential dewatering and depressurization impacts on Kelleys Island, Erie County, Ohio, 2009 Ground Water Protection Council Annual Forum, Salt Lake City, Utah, abstract 53.

Tomastik, T.E., 2009. Salt deposits of Ohio – Geology, mining, and uses, 45th Forum on the Geology of Industrial Minerals, "Building the Future", Delaware, Ohio October 4-6, 2009.

Tomastik, T.E. and Bair, E.S., 2010. The "Bainbridge Natural Gas Incident" in Geauga County, Ohio: What really happened! 2010 Ground Water Protection Council Annual Forum, September 26-29, 2010, Pittsburgh, Pennsylvania, abstract 16.

Tomastik, T.E., 2010. Oilfield complaints in Ohio: Procedures for conducting alleged water well contamination cases, 55th Annual Midwest Groundwater Conference, October 4-7, 2010, Columbus, Ohio, abstract.

Tomastik, T.E., 2011. Ohio's regulations on natural gas development and disposal of oilfield wastes, Annual Midwest Workshop in Environmental Health, March 21-24, 2011, Columbus, Ohio.

Received

SEP - 7 2016

Tom Tomastik

Tomastik, T.E., 2011. State investigations of oilfield ground water incidents and their role in advancing regulatory reforms, National Ground Water Association/Ground Water Protection Council Ground Water Summit, May 5, 2011, Baltimore, Maryland.

Tomastik, T.E., 2011. Hydraulic fracturing and water resources in Ohio: How to protect the groundwater through proper well construction and cementing practices, 2011 Ground Water Protection Council Annual Forum, September 24-28, 2011, Atlanta, Georgia.

Tomastik, T.E., 2011. The development of the shale plays and disposal of oilfield wastes in Ohio, Ohio Geological Society, November 3, 2011, Worthington, Ohio.

Tomastik, T.E., 2012. Development of shale plays, hydraulic fracturing, and disposal of oilfield wastes on Ohio. OKI Fracking Groundwater Committee Meeting, March 7, 2012, Cincinnati, Ohio.

Tomastik, T.E., 2012. Development of the shale plays and disposal of oilfield wastes in Ohio, Black Gold Ohio Summit, September 12-13, 2012, Columbus, Ohio.

Bair, E.S. and Tomastik, T.E., 2012. How gas from the English #1 well escaped and invaded residential homes causing one to explode, Geauga County, Ohio, American Association of Petroleum Geologists 41st Annual Eastern Section Meeting, September 22-26, 2012, Cleveland, Ohio, abstract.

Tomastik, T.E., 2012. Risks, benefits, myths, and realities of hydraulic fracturing, American Academy of Environmental Engineers and Scientists, U.S. Clean Energy Challenges Focus on Hydraulic Fracturing 2012 Webinar, September 27, 2012.

Tomastik, T.E., 2013. Preliminary report on the Northstar #1 Class II injection well and seismic events in the Youngstown, Ohio area, Ground Water Protection Council 2013 Underground Injection Control Conference, Aquifer Management & Underground Injection, Sarasota, Florida, January 22-24, 2013, abstract 23.

Tomastik, T.E., 2013. Ohio's new Class II regulations and its proactive approach to seismic monitoring and induced seismicity, Ground Water Protection Council 2013 Underground Injection Control Conference, Aquifer Management & Underground Injection, Sarasota, Florida, January 22-24, 2013, abstract 24.

Tomastik, T.E., 2013. Conducting a stray gas investigation and the use of downhole videography as an investigation tool, Ground Water Protection Council 2013 Stray Gas Incidence & Response Forum, Grapevine, Texas, July 9-11, 2013, abstract 7.

Tomastik, T.E., 2014. An introduction to Class II underground injection wells, Shale Insight™ 2014, Pittsburgh, Pennsylvania, September 24-25, 2014.

Tomastik, T.E., 2014. Water sourcing for shale development in Ohio Shale Insight™ 2014, Pittsburgh, Pennsylvania, September 24-25, 2014.

Received

SEP - 7 2016

Tom Tomastik

Arthur, J. D., Tomastik, T.E. Louis, D., and DeLeon, F., 2014. Disposal wells and shale resource development: A national perspective, Ground Water Protection Council 2014 Annual Forum, Seattle, Washington, October 5-8, 2014, abstract 28.

Tomastik, T.E. and Arthur, J.D., 2014. A proactive approach to induced seismicity: Can the oil and gas industry manage induced seismicity and work in cooperation with the regulatory agencies? Ohio Oil and Gas Association Oilfield Expo and Technical Conference, Cleveland, Ohio, December 3-4, 2014, abstract.

Tomastik, T.E. and Arthur, J.D., 2015. A proactive approach to induced seismicity: Can the oil and gas industry manage induced seismicity and work in cooperation with the regulatory agencies? Ground Water Protection Council 2015 UIC Annual Conference Aquifer Management & Underground Injection, February 9-11, 2015, abstract 10.

Arthur, J.D. Overstreet, D. and Tomastik, T.E., 2015. Class II saltwater disposal wells in Ohio: Understanding the avenue to success, Ground Water Protection Council 2015 UIC Annual Conference Aquifer Management & Underground Injection, February 9-11, 2015, abstract 15.

Tomastik, T.E., Arthur, J.D. and Lowe, C.E., 2015. Class II saltwater disposal wells in Ohio: Understanding the avenue to success, American Institute of Professional Geologists 6th Annual Conference, The role of Hydraulic Fracturing in the Development of the Utica, Marcellus and other Shales of the Appalachian Basin, April 28-29, 2015, abstract.

Arthur, J.D., Tomastik, T.E., Overstreet, D., and Casey, B.G., 2015. Class II disposal well best management practices workshop, Ground Water Protection Council – Interstate Oil and Gas Compact Commission 2015 Annual Meeting, Oklahoma City, Oklahoma, September 27-30, 2015, abstract.

Tomastik, T.E. and Arthur, J.D., 2015. Disposal wells and shale development” A national perspective, *In* Shale Play Water Management September/October 2015, p. 28-33.

Tomastik, T.E., Arthur, J.D., Anderson, K., and Green, W., 2015. A proactive approach to addressing annular pressure issues in the Utica-Point Pleasant shale play, Ohio Oil and Gas Association 2015 Technical Conference and Oilfield Expo, Cambridge, Ohio, November 4-5, 2015.

Arthur, J.D., Tomastik, T.E., Anderson, K., and Green, W., 2016. A proactive approach to addressing annular pressure issues and stray gas migration in the unconventional shale plays, Ground Water Protection Council 2016 UIC Annual Conference, Denver, Colorado, February 23-25, 2016.

Arthur, J.D., Tomastik, T.E., Overstreet, D., and Casey, B.G., 2016. Class II disposal well best management practices workshop, Ground Water Protection Council 2016 UIC Annual Conference, Denver, Colorado, February 23-25, 2016.

Received

SEP - 7 2016

Tom Tomastik

Short Courses and Continuing Education

Water Well Rehabilitation Workshop, Bowser-Morner

Underground Injection Class III and Storage Cavern Well Operator Training, Subsurface Technology

Analysis and Design of Aquifer Tests including Slug Tests and Fracture Flow, National Ground Water Association

Exploration and Evaluation of Fractured Reservoirs, Petroleum Technology Transfer Council

Class I Operator Training, Ground Water Protection Council

Principals of Ground Water, National Ground Water Association

Environmental Forensics: Methods and Applications, National Ground Water Association

Introduction to Well and Wellfield Performance Maintenance and Improvement, Ground Water Science

Water Well Rehabilitation: Water Well Problems/Effective Solutions, In-situ Water Treatment, Subsurface Technologies, Inc.

Improving Hydrogeologic Analysis of Fractured Bedrock Systems, Midwest Geosciences

Injection Well Operator Training, Subsurface Technology and Ground Water Protection Council

U.S. EPA Hydraulic Fracturing Technical Workshop on Well Construction/Operations and Subsurface Modeling, U.S. EPA

Safelands Training

Fundamentals of Seismic Interpretation, Ohio Geological Society

Received

SEP - 7 2016



Photo Density
Compensated Neutron
Gamma Ray

COMPANY	Appalachian Oil Purchasers, Inc.				
WELL	BW 4				
FIELD	Washington District				
PROVINCE/COUNTY	Pleasants County				
COUNTRY/STATE	U.S.A. / West Virginia				
LOCATION	Raven Rock 7 S Quadrangle				
LOCATION NUMBER	47-073-2523				
PERMIT NUMBER					
SEC	TWP	RGE	Chlorine Services	Temperature	Elevations:
API Number:	Permanent Datum Ground Level, Elevation 640 feet				
Log Measured From K B, of 14 ft, above Permanent Datum	Drilling Measured From K B, of 14 ft.				
Date	02-FEB-2011				
Run Number	Three				feet
Service Order	7503.00				feet
Depth Driller	7488.00				feet
Depth Logger	7488.00				feet
First Reading	7488.00				feet
Last Reading	5205.00				feet
Casing Driller	5176.00				feet
Casing Logger	5176.00				feet
Bit Size	6.250				inches
Hole Fluid Type	Brine				
Density / Viscosity	10.10	lb/USG			
PH / Fluid Loss	Flowline				
Run @ Measured Temp	0.10 @ 64.0	chm-in			
Time Since Circulation	144.00	deg F			
Max Recorded Temp	13167	Sproule			
Equipment / Base	13167	Sproule			
Recorded By	Jason Sprouse				
Witnessed By	Scott Holcomb				
Field Ticket #	3526561				



Dual Laterolog
Gamma Ray

COMPANY	Appalachian Oil Purchasers, Inc.				
WELL	BW 4				
FIELD	Washington District				
PROVINCE/COUNTY	Pleasants County				
COUNTRY/STATE	U.S.A. / West Virginia				
LOCATION	Raven Rock 7.5 Quadrangle				
LOCATION NUMBER	47-073-2523				
PERMIT NUMBER	75-073-2523				
SEC	TWP	RGE	Other Services	Indoor Services	Neutron
			Temperature	Temperature	
API Number	Permanent Datum Ground Level, Elevation 640 feet				
Run Number	Log Measured From K.B. of 14 Ft. above Permanent Datum				
Date	Drilling Measured From K.B. of 14 Ft.				
02-FEB-2011					
Run Number	Three				
Depth Driller	7503.00	feet			
Depth Logger	7486.00	feet			
First Reading	7486.00	feet			
Last Reading	5186.00	feet			
Casing Driller	5205.00	feet			
Casing Logger	5178.00	feet			
Bit Size	6.250	inches			
Hole Fluid Type	Brine				
Density / Viscosity	10.10	lb/USG			
PH / Fluid Loss					
Sample Source	Flowline				
Run @ Measured Temp	0.10 @ 64.0	chm-in			
Time Since Circulation					
Max Recorded Temp					
Equipment / Base					
Recorded By					
Field Ticket #					
3526561					

BOREHOLE RECORD			Last Edited: 02-FEB-2011 14:59	
Bit Size inches	Depth From feet	Depth To feet		
6.250	5176.00	7486.00		
CASING RECORD				
Type	Size inches	Depth From feet	Shoe Depth feet	Weight pounds/ft
	7.000	0.00	5176.00	17.00

BOREHOLE RECORD				Last Edited: 02-FEB-2011 14:59
Bit Size	Depth From	Depth To		
inches	feet	feet		
6.250	5176.00	7486.00		
CASING RECORD				
Type	Size	Depth From	Shoe Depth	Weight
	inches	feet	feet	pounds/ft
	7.000	0.00	5176.00	17.00

REMARKS	
Density matrix was ran on 2.71 Gm / cc	
Crew: Steve Kirchberg	
All logging speeds were ran at customers request	
Fluid Level: Full	
Mud filtrate density was ran on 1.0 Gm / cc	
Thank You for using Weatherford Wireline Services	

REMARKS	
Density matrix was ran on 2.71 Gm / cc	
Crew: Steve Kirchberg	
All logging speeds were ran at customers request	
Fluid Level: Full	
Mud filtrate density was ran on 1.0 Gm / cc	
Thank You for using Weatherford Wireline Services	

In interpreting, communicating or providing information and/or making recommendations, either written or oral, as to logs or test or other data, type or amount of material, or Work or other service to be furnished, or manner of performance, or in predicting results to be obtained, the Contractor will give the Company the benefit of the Contractor's best judgment based on its experience and will perform all such Work in a good and workmanlike manner. Any interpretation of test or other data, and any recommendation or reservoir description based upon such interpretations, are opinions based upon inferences from measurements and empirical relationships and assumptions, which inferences and assumptions are not infallible, and with respect to which professional engineers and analysts may differ. ACCORDINGLY ANY INTERPRETATION OR RECOMMENDATION RESULTING FROM THE SERVICES WILL BE AT THE SOLE RISK OF THE COMPANY, AND THE CONTRACTOR CANNOT AND DOES NOT WARRANT THE ACCURACY, CORRECTNESS OR COMPLETENESS OF ANY SUCH

In interpreting, communicating or providing information and/or making recommendations, either written or oral, as to logs or test or other data, type or amount of material, or Work or other service to be furnished, or manner of performance, or in predicting results to be obtained, the Contractor will give the Company the benefit of the Contractor's best judgment based on its experience and will perform all such Work in a good and workmanlike manner. Any interpretation of test or other data, and any recommendation or reservoir description based upon such interpretations, are opinions based upon inferences from measurements and empirical relationships and assumptions, which inferences and assumptions are not infallible, and with respect to which professional engineers and analysts may differ. ACCORDINGLY ANY INTERPRETATION OR RECOMMENDATION RESULTING FROM THE SERVICES WILL BE AT THE SOLE RISK OF THE COMPANY, AND THE CONTRACTOR CANNOT AND DOES NOT WARRANT THE ACCURACY, CORRECTNESS OR COMPLETENESS OF ANY SUCH

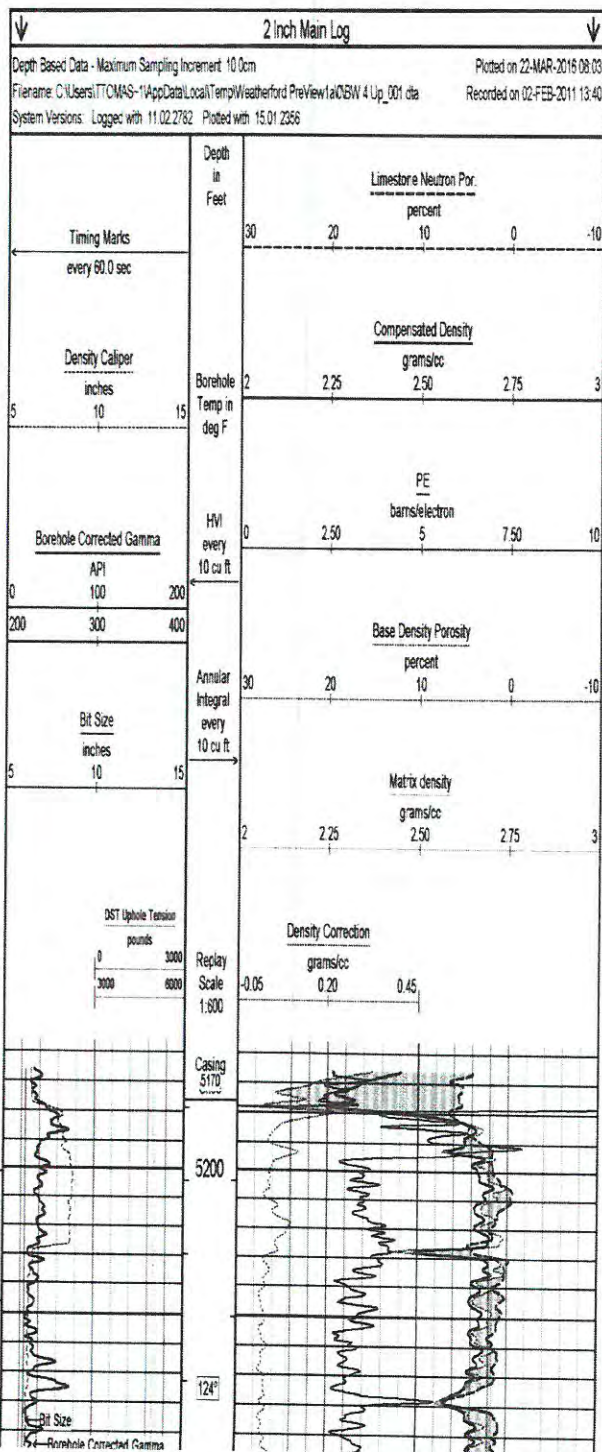
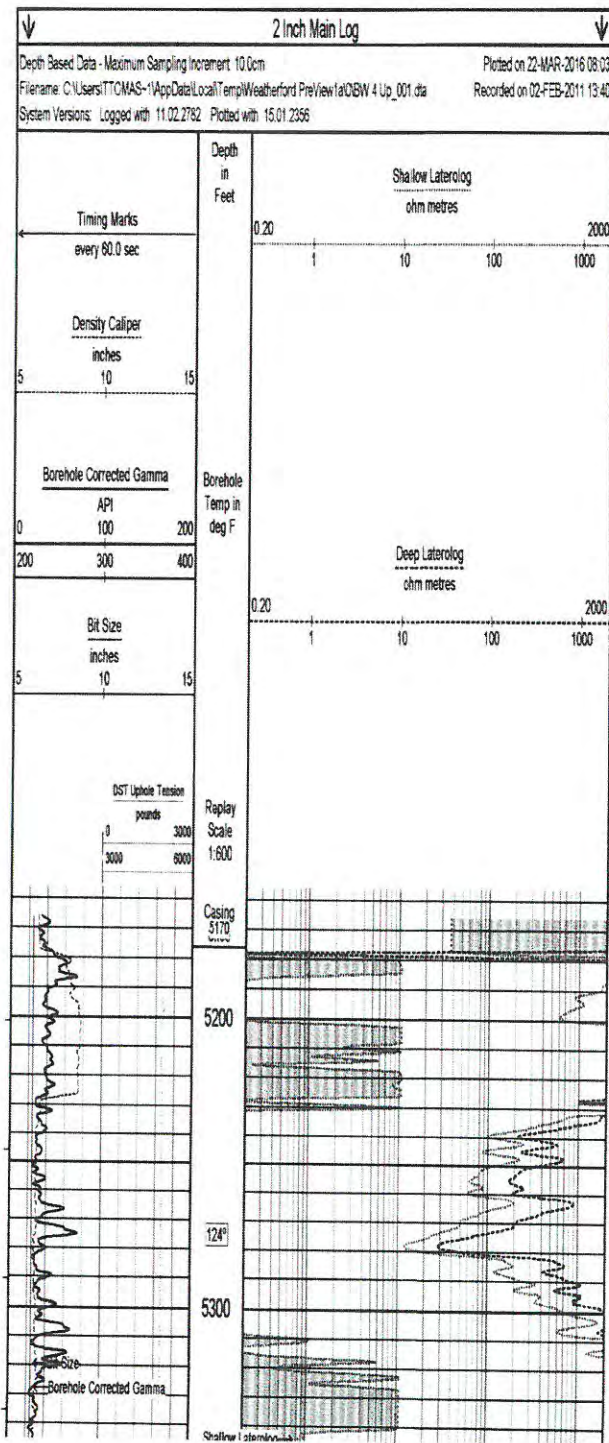
Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

INTERPRETATION OR RECOMMENDATION WHICH INTERPRETATIONS AND RECOMMENDATIONS SHOULD NOT, THEREFORE, UNDER ANY CIRCUMSTANCES BE RELIED UPON AS THE SOLE OR MAIN BASIS FOR ANY DRILLING, COMPLETION, WELL TREATMENT, PRODUCTION OR FINANCIAL DECISION, OR ANY PROCEDURE INVOLVING ANY RISK TO THE SAFETY OF ANY DRILLING ACTIVITY, DRILLING RIG OR ITS CREW OR ANY OTHER INDIVIDUAL. THE COMPANY HAS FULL RESPONSIBILITY FOR ALL DECISIONS CONCERNING THE SERVICES.

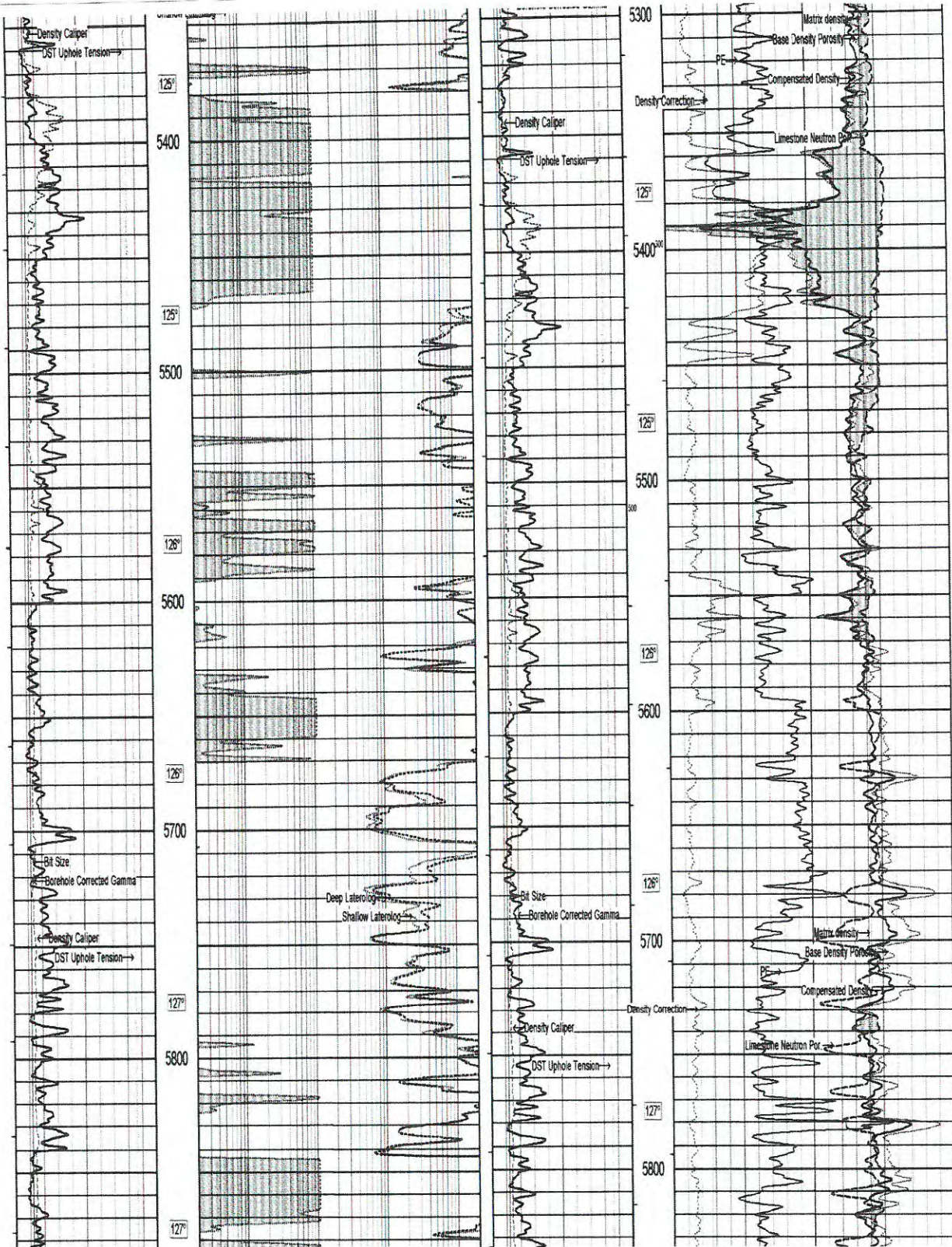
INTERPRETATION OR RECOMMENDATION WHICH INTERPRETATIONS AND RECOMMENDATIONS SHOULD NOT, THEREFORE, UNDER ANY CIRCUMSTANCES BE RELIED UPON AS THE SOLE OR MAIN BASIS FOR ANY DRILLING, COMPLETION, WELL TREATMENT, PRODUCTION OR FINANCIAL DECISION, OR ANY PROCEDURE INVOLVING ANY RISK TO THE SAFETY OF ANY DRILLING ACTIVITY, DRILLING RIG OR ITS CREW OR ANY OTHER INDIVIDUAL. THE COMPANY HAS FULL RESPONSIBILITY FOR ALL DECISIONS CONCERNING THE SERVICES.



Received

SEP - 7 2016

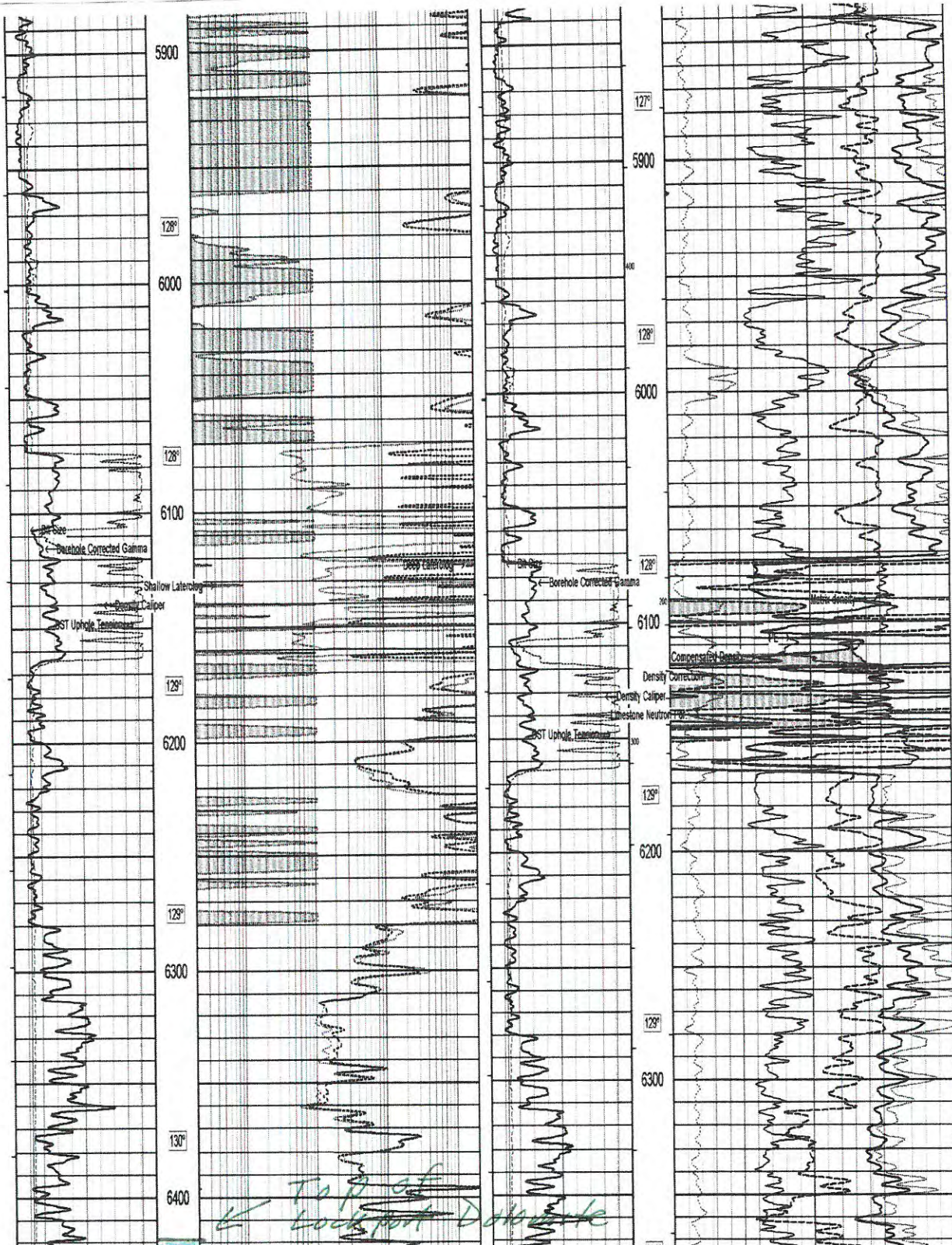
Office of Oil and Gas
 WV Dept. of Environmental Protection



Received

SEP - 7 2016

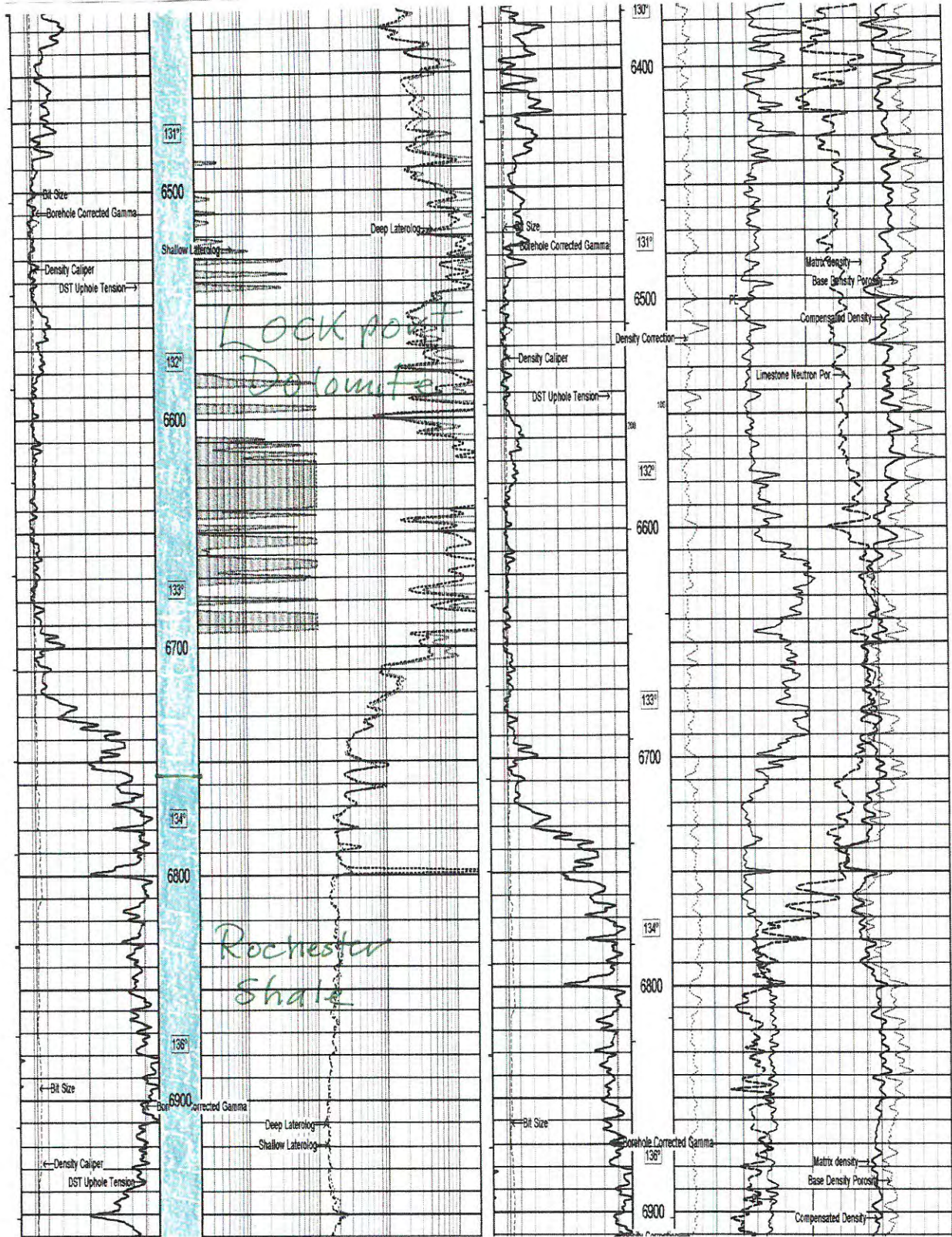
Office of Oil and Gas
WV Dept. of Environmental Protection



Received

SEP - 7 2016

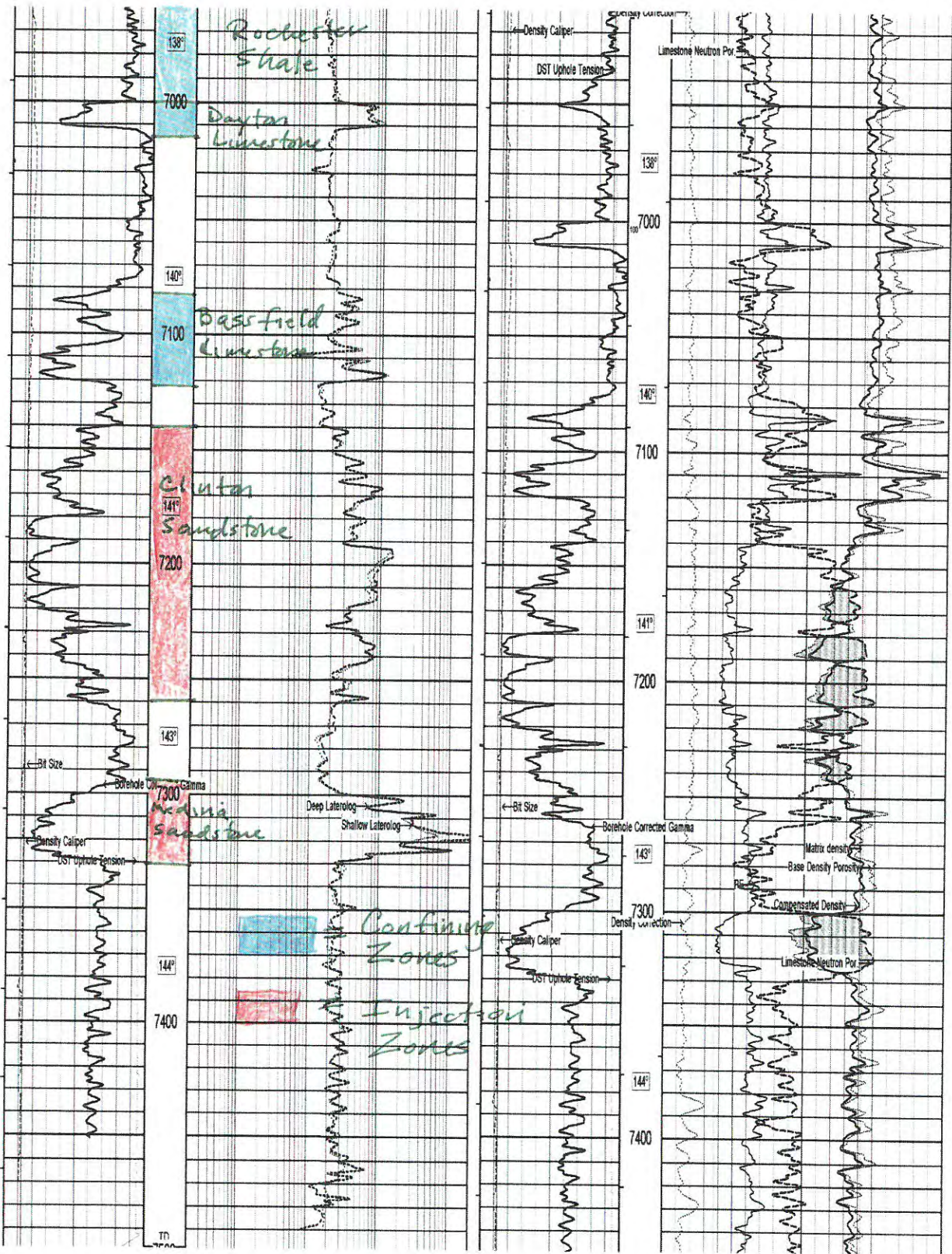
Office of Oil and Gas
WV Dept. of Environmental Protection



Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection



Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

West Virginia Seismicity

Magnitude

- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 +

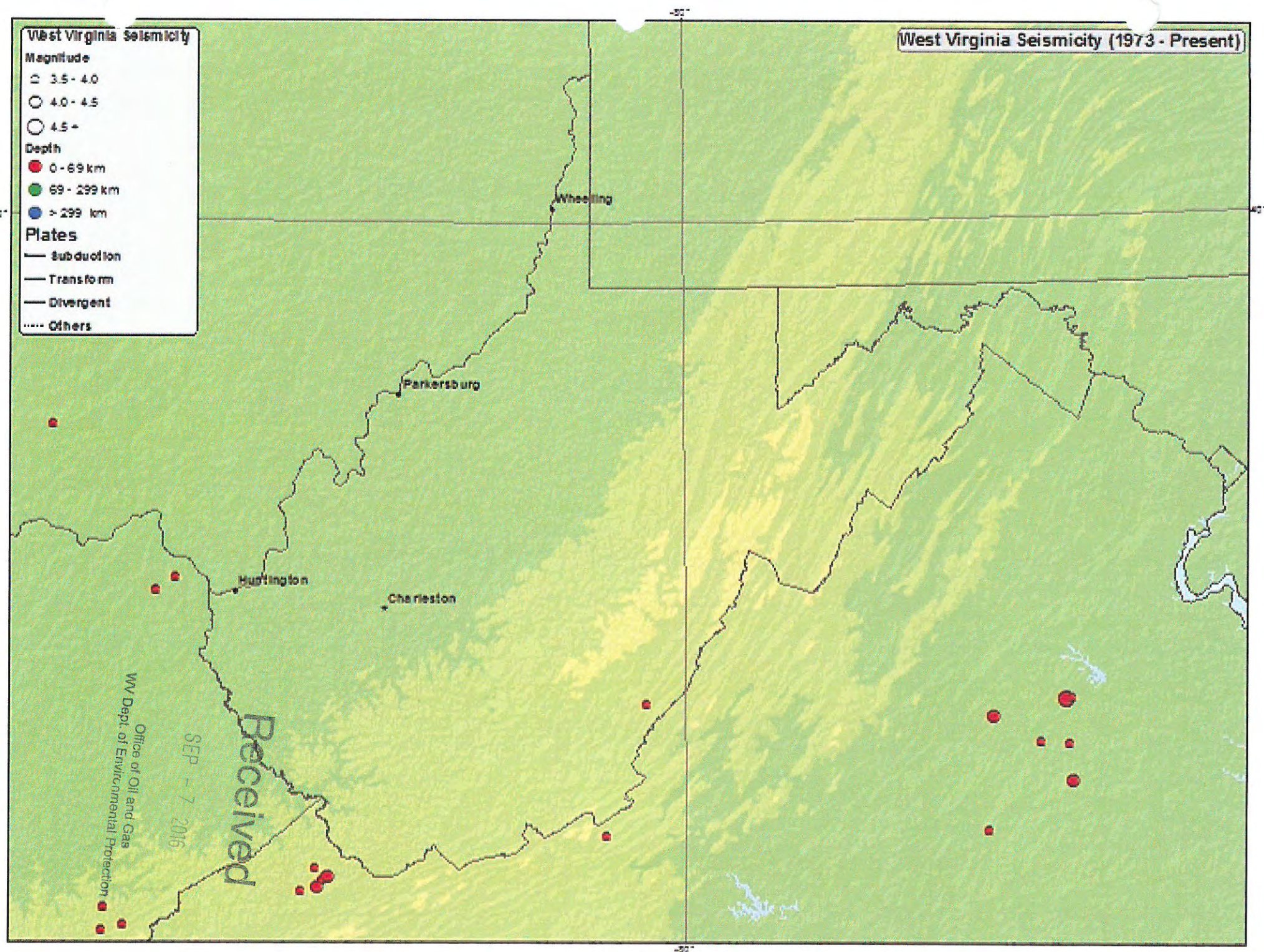
Depth

- 0 - 69 km
- 69 - 299 km
- > 299 km

Plates

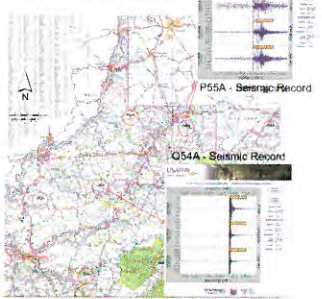
- Subduction
- Transform
- Divergent
- Others

West Virginia Seismicity (1973 - Present)



RECENT EARTHQUAKES IN WEST VIRGINIA

GLENVILLE EARTHQUAKE
7/20/2013 07:38:46 (local)
2.7 Magnitude
Depth: 69,225 ft ± 8,858 ft



Transportable Array Seismic Stations in WV

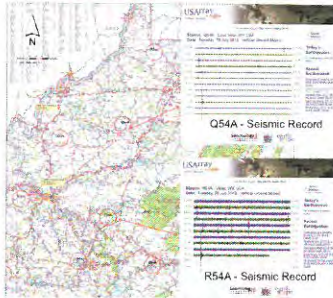
WVGES
GEOLOGY UNDERLIES IT ALL

Regional Structure Map (Spencer et al., 2003)



This earthquake is located within the Rome Trough fault zone. 69,000+ ft depth places it deep within the Trough, at or below the top of the crystalline basement rock and well below any sedimentary rock layers. NOTE: there are no injection wells in Gilmer County and this earthquake originated more than 10 miles below the Marcellus interval.

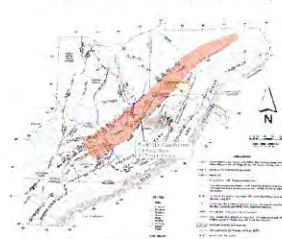
GLENVILLE EARTHQUAKE
7/30/2013 02:09:05 (local)
2.8 Magnitude
Depth: 41,666 ft ± 8,530 ft



Transportable Array Seismic Stations in WV

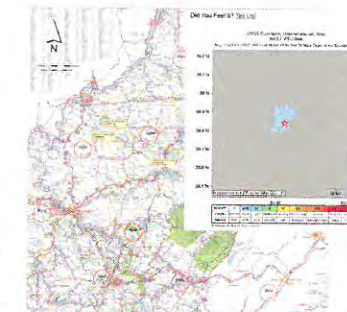
WVGES
GEOLOGY UNDERLIES IT ALL

Regional Structure Map (Spencer et al., 2003)



This second earthquake is located within the Rome Trough fault zone. 42,000 ft depth places it deep within the Trough, at or below the top of the crystalline basement rock and well below any sedimentary rock layers. NOTE: there are no injection wells in Gilmer County and this earthquake originated more than 6 miles below the Marcellus interval.

GLENVILLE EARTHQUAKE
8/16/2013 07:02:21 (local)
2.6 Magnitude
Depth: 20,013 ft ± 11,155 ft



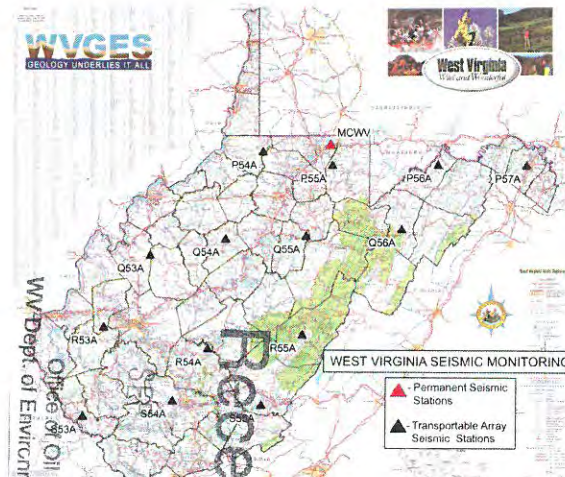
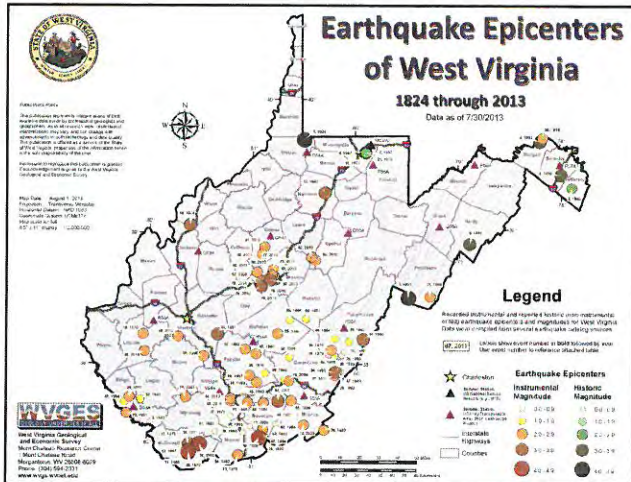
Transportable Array Seismic Stations in WV

WVGES
GEOLOGY UNDERLIES IT ALL

Regional Structure Map (Spencer et al., 2003)



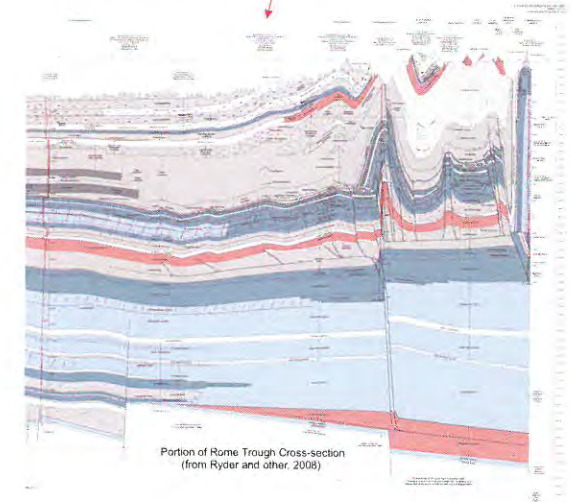
This third earthquake is located within the Rome Trough fault zone. 20,000 ft depth places it deep within the Trough, at or slightly above the top of the crystalline basement rock and possibly within the lower sedimentary rock layers. NOTE: there are no injection wells in Gilmer County and this earthquake originated more than 2.5 miles below the Marcellus interval.



WV Dept. of Oil and Gas
Office of Environmental Protection

2016

Received



**U.S. Seismic Hazard
2% in 50 years PGA**

Hazard (%g)

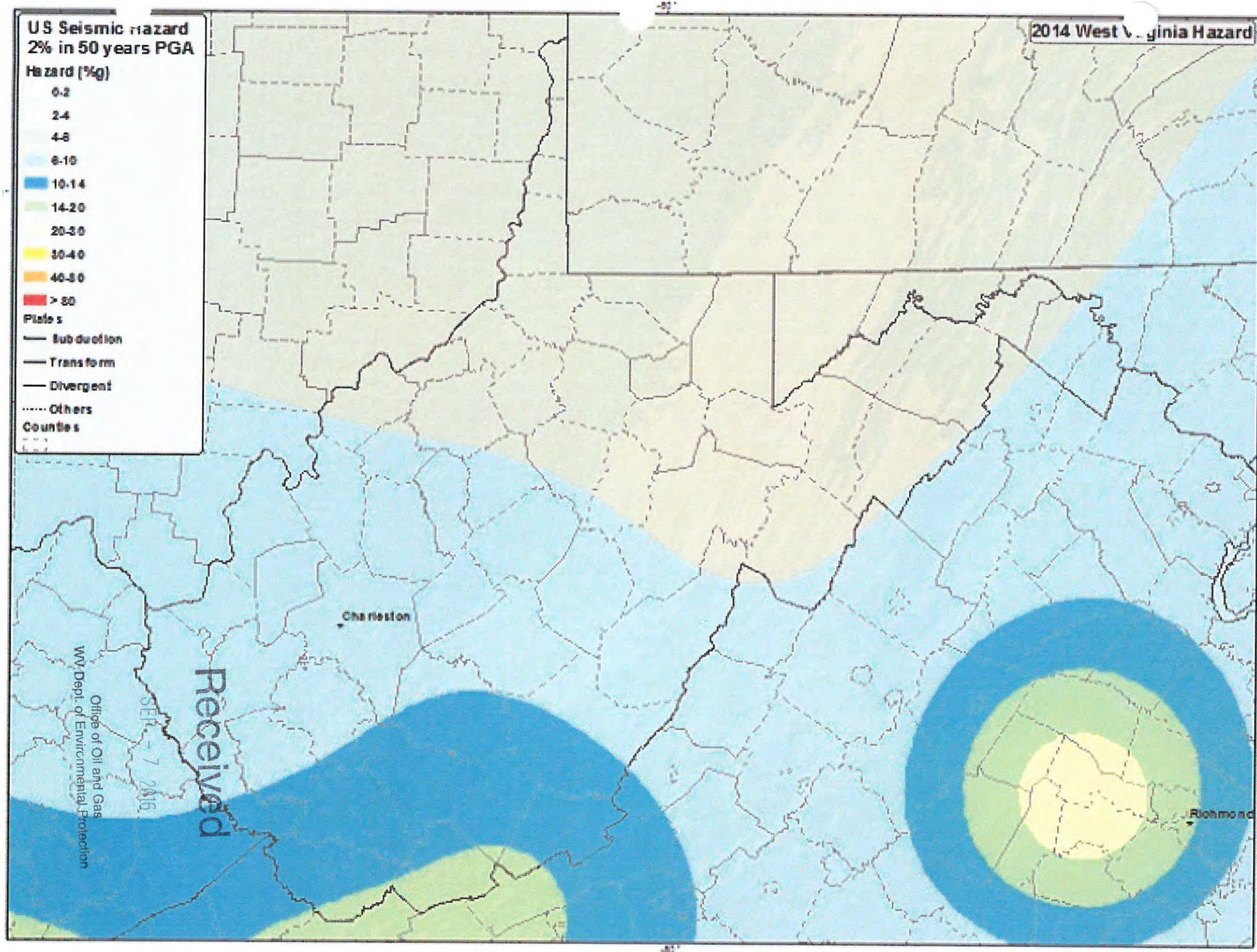
- 0-2
- 2-4
- 4-8
- 8-10
- 10-14
- 14-20
- 20-30
- 30-40
- 40-50
- > 50

Plate s

- Subduction
- Transform
- Divergent
- Others

Counties

2014 West Virginia Hazard



Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

GROUND-WATER HYDROLOGY OF THE AREA BORDERING THE OHIO RIVER BETWEEN CHESTER AND WAVERLY, WEST VIRGINIA

By John S. Bader, Melvin V. Mathes, and Robert A. Shultz

U.S. GEOLOGICAL SURVEY

Open-File Report 95-710

Prepared in cooperation with the

WEST VIRGINIA DIVISION OF ENVIRONMENTAL PROTECTION,
OFFICE OF WATER RESOURCES



Charleston, West Virginia

1997

Received

SEP -7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey, WRD
11 Dunbar Street
Charleston, WV 25301

Copies of the report can be purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Denver Federal Center
Denver, CO 80225

Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

CONTENTS

	<i>Page</i>
Abstract.....	1
1.0 Introduction	2
1.1 Acknowledgments.....	2
1.2 Purpose and scope of report	2
1.3 Location and general features of project area.....	3
1.4 Previous investigations.....	5
1.5 Climate and recharge	7
1.6 Ground-water use.....	10
2.0 Geology and water-bearing characteristics.....	17
2.1 Consolidated sedimentary rocks.....	17
2.2 Unconsolidated alluvial deposits	18
3.0 Ground-water system.....	23
3.1 Recharge, movement, and discharge.....	23
3.2 Hydraulic characteristics of alluvial aquifer.....	26
4.0 Water quality	32
4.1 Data collection.....	32
4.2 Water type.....	34
4.3 Chemical constituents	39
4.3.1 Saltwater	39
4.3.2 Iron and manganese.....	43
4.3.3 Hardness.....	46
4.3.4 Sulfate.....	48
4.3.5 Contaminants.....	50
4.4 Relation to ground-water movement	52
5.0 Summary	55
6.0 Definition of terms	56
7.0 Selected references	58

Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

ILLUSTRATIONS

	<i>Page</i>
Figure 1.3-1 Map showing location of project area.....	4
1.4-1 Map showing areas covered by published geologic and hydrologic reports.....	6
1.5-1 Graphs showing mean monthly precipitation (1951-80).....	9
1.6-1 Graph showing ground-water withdrawals by county, excluding industrial use.....	11
1.6-2 Map showing location of public-supply wells.....	12
 2.2-1 Map showing drillers' logs of selected wells in the alluvium	 19
2.2-2 Geologic section of alluvium at the Sistersville section.....	22
 3.1-1 Hydrographs of two wells at Sistersville site.....	 25
3.2-1 Map showing specific capacity.....	27
3.2-2 Map showing saturated thickness of aquifer	28
3.2-3 Map showing estimated transmissivity	29
3.2-4 Map showing estimated hydraulic conductivity	31
 4.1-1 Map showing location of ground-water sampling sites	 33
4.2-1 Map showing areal distribution of cations and anions	35
4.3.1-1 Map showing areal distribution of dissolved chloride.....	40
4.3.1-2 Sketch showing relation between freshwater and saltwater	41
4.3.2-1 Map showing areal distribution of dissolved iron.....	44
4.3.2-2 Map showing areal distribution of dissolved manganese	45
4.3.3-1 Map showing areal distribution of hardness	47
4.3.4-1 Map showing areal distribution of dissolved sulfate	49
4.3.5-1 Map showing areas where selected contaminant concentration exceeds established State limits.....	 51
4.4-1 Trilinear water-analysis diagram of water samples from the alluvium, bedrock, and Ohio River	 53
 Plates 1-3. Maps showing hydrologic and physical characteristics of selected alluvial wells in:	
1. Ohio, Brooke, and Hancock Counties.....	36
2. Marshall and Wetzel Counties.....	37
3. Tyler and Pleasants Counties.....	38

TABLE

	<i>Page</i>
Table 1.5-1 Mean monthly precipitation and evapotranspiration.....	8

Received

SEP - 7 2016

CONVERSION FACTORS AND VERTICAL DATUM

<i>Multiply</i>	<i>By</i>	<i>To</i>
<i>Length</i>		
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
<i>Area</i>		
square mile (mi ²)	2.590	square kilometer
<i>Volume</i>		
gallon (gal)	3.785	liter
million gallons (Mgal)	3,785	cubic meter
cubic foot (ft ³)	0.02832	cubic meter
cubic mile (mi ³)	4.166	cubic kilometer
acre-foot (acre-ft)	1,233	cubic meter
<i>Flow</i>		
cubic foot per second (ft ³ /s)	28.32	liter per second
gallon per minute (gal/min)	0.06308	liter per second
million gallons per day (Mgal/d)	43.81	cubic decimeter per second
<i>Aquifer characteristics</i>		
gallon per minute per foot [(gal/min)/ft]	0.207	liter per second per meter
foot per day (ft/d)	0.305	meter per day
foot squared per day (ft ² /d)	0.0929	meter squared per day

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{F} = 1.8 \times ^{\circ}\text{C} + 32$$

Sea level : In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level of 1929."

Chemical concentration in water is expressed in milligrams per liter (mg/L) and micrograms per liter (µg/L).

Received

JUN 10 1978

Office of Oil and Gas
NY Dept. of Environmental Protection

GROUND-WATER HYDROLOGY OF THE AREA BORDERING
THE OHIO RIVER BETWEEN CHESTER AND
WAVERLY, WEST VIRGINIA

By John S. Bader, Melvin V. Mathes, and Robert A. Shultz

ABSTRACT

Ground-water reserves in West Virginia are contained in the consolidated rock underlying the State and in the alluvium bordering the Ohio and Kanawha Rivers. Ground-water use in the study area, which includes all or parts of Hancock, Brooke, Ohio, Marshall, Wetzel, Tyler, and Pleasants Counties in northern West Virginia, was at least 6.3 billion gallons in 1980. The consolidated rock (bedrock) that crops out in the study area is of Pennsylvanian or Permian age. Alluvial deposits in the study area are limited mostly to the flood plain of the Ohio River. The alluvium is not vertically homogeneous; the lower part of the deposits consists of sand and gravel of glacial outwash origin, and the upper deposits consist of clay and silt interspersed with sand stringers. In some areas, the tributary streams have deposited a gravel delta where they enter the valley of the Ohio River. In places, ground water in the alluvium has been degraded by contaminants from industrial waste. Ground water flows from the adjacent hills toward the river. The alluvium and bedrock are hydraulically connected, and the saturated zone is continuous in both rock units. The alluvium is recharged by the following sources: (1) precipitation on the flood plain, (2) inflow from fractures in the bedrock beneath and adjacent to the alluvium, (3) inflow from tributary streams through gravel deltas and bedding-plane partings, and (4) induced inflow from the river. In some ground-water samples, concentrations of iron, manganese, sulfate, arsenic, barium, mercury, and phenols exceeded recommended limits for drinking water established by the West Virginia State Board of Health. Ground-water hardness exceeded 120 milligrams per liter in 91 percent of the samples.

Received

SEP - 7 2016
WV Dept. of Environmental Protection
Office of Oil and Gas
WV Dept. of Environmental Protection

1.0 INTRODUCTION

1.1 Acknowledgments

The authors appreciate the cooperation of the many well owners who provided information about their wells and permitted samples of water to be taken for analysis. The cooperation of many well drillers who provided records and information also is acknowledged. Special appreciation is given to Charles Brown, Jr. and Ray Maxwell. Mr. Brown provided access to his property for drilling eight test wells and loaned equipment and materials to the authors throughout the project. Mr. Maxwell also provided access, material, and assistance on numerous occasions during the project.

1.2 Purpose and Scope of Report

PROTECTION OF PUBLIC WATER SUPPLY IS PRIMARY CONCERN

The geologic and hydrologic properties of an aquifer system must be understood so it can be fully used and protected from overdevelopment and contamination.

Most ground water in West Virginia is derived from two aquifer systems. The most widespread is the system of fractures in the consolidated rock (bedrock) that underlies the State. The other is the narrow band of alluvium that borders the Ohio and Kanawha Rivers. Both aquifer systems can be contaminated by percolation or injection of harmful materials, and both can become uneconomical for water supply by overuse.

This report describes the results of an investigation to improve understanding of the hydrologic properties of the aquifer systems in the study area. Sensible and orderly development of the ground-water resources of an area requires a thorough understanding of the geology and hydrology of the area. The adequacy of a ground-water supply can be affected by many natural and human-induced processes. An understanding of the hydrologic environment can aid in making sound decisions that would protect the ground-water resources of an area from detrimental practices.

The scope of the work included ground-water data collection from numerous sources. Selected wells in the study area were visited. Details of well construction were obtained from the owners and, where possible, depth to water was measured. If available, additional information on well construction was obtained from the driller. Water from many of the wells was analyzed for selected inorganic and organic chemical constituents. Reports from previous studies in the area were obtained, as were reports on other alluvial aquifers in and near the Ohio River drainage. Data also were obtained from the files of the U.S. Geological Survey; the West Virginia Department of Natural Resources, Division of Water Resources; and the West Virginia Department of Health. Those data, together with those collected as part of this project, were analyzed and are reported herein.

Eight test wells were drilled near Sistersville. Water-level data were obtained from all the wells, and physical water-quality data were obtained from most.

SEP - 7 2016
Office of Oil and Gas
WV Dept. of Environmental Protection

1.0 INTRODUCTION--Continued

1.3 Location and General Features of Project Area

PROJECT AREA IS IN NORTHERN WEST VIRGINIA AND INCLUDES ALL OR PARTS OF SEVEN COUNTIES

The area extends from the Wood County line near Waverly northward to the Pennsylvania border.

The project area is the West Virginia side of the Ohio River valley from the Wood County line near Waverly to the Pennsylvania border near Chester. It includes all or parts of Hancock, Brooke, Ohio, Marshall, Wetzel, Tyler, and Pleasants Counties (fig. 1.3-1).

The area is part of the highly industrialized Ohio River valley. It contains major facilities for the manufacture and processing of steel, glass, ceramics, coal products such as coke and graphite, and chemicals, as well as coal mines, coal-fired, electric-power generating plants, an oil refinery, and a natural gas processing plant. The larger population centers are in the northern panhandle of the State and include Moundsville, Wheeling, and Weirton.

The topography of the area adjacent to the flat Ohio River flood plain is the typical hilly terrain found in the dissected Appalachian Plateaus physiographic province (Fenneman and Johnson, 1946). Maximum relief of the hills is about 600 feet. The flood plain is only about 0.6 mile wide at its widest point. The elevation of the flood plain ranges from about 600 feet above sea level at Waverly to about 700 feet above sea level at Chester. The elevation of the Ohio River in the area is controlled by five locks and dams with the following pool elevations (above sea level): New Cumberland, 664 feet; Pike Island, 644 feet; Hannibal, 623 feet; Willow Island, 602 feet; and Belleville, 582 feet.

Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

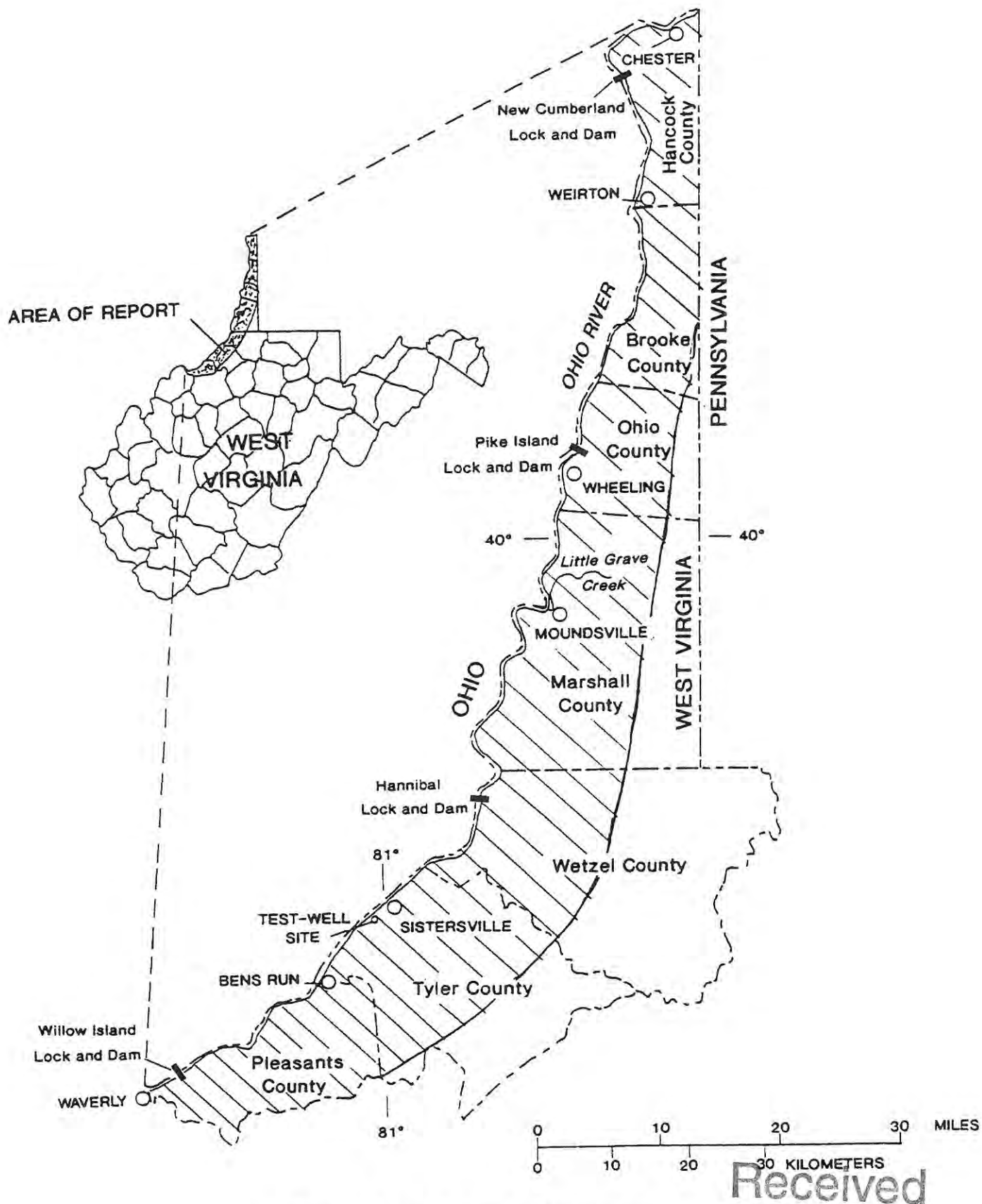


Figure 1.3-1. -- Location of project area.

1.0 INTRODUCTION--Continued

1.4 Previous Investigations

NUMEROUS STUDIES HAVE BEEN MADE OF THE GEOLOGY AND HYDROLOGY OF THE AREA

The geology of the area was studied in detail in the early part of the century, and more recently, the hydrology has been studied in basinwide, countywide, and local projects.

The geology of the study area is described in three county reports by Grimsley (1907 and 1910) and Hennen (1909), and it also is shown on the "1968 Geologic Map of West Virginia" (Cardwell and others, 1968). See figure 1.4-1.

The geologic units beneath the rocks saturated by freshwater are discussed in oil and gas reports of the counties in the project area, including those by Haught (1955a and 1955b) and Cardwell (1978).

A description of the hydrology of the entire Ohio River basin is published in the "Ohio River Basin Comprehensive Survey" (Deutsch and others, 1966; Jordan, 1966). The part of the Ohio River valley that lies in West Virginia is described in the three-part report "Geology and Economic Resources of the Ohio River Valley in West Virginia." The geology is described in Part I by Cross and Schemel (1956), and the ground-water resources are described in Part III by Carlston and Graeff (1955). An atlas by Shultz (1984) describes the geology and ground-water hydrology of the minor tributary basins of the Ohio River. The ground-water hydrology of Ohio County is described in "Occurrence and Availability of Ground Water in Ohio County, West Virginia," by Robison (1964). U.S. Geological Survey Circular 340, "Water Resources of the Wheeling-Steubenville Area, West Virginia and Ohio" by Smith and others (1955) describes both the surface-water and ground-water resources of that area.

Numerous reports that discuss the geology and hydrology of alluvial aquifers outside this project area are available. Some are listed as selected references in this report (section 7.0). Among the most noteworthy are: Gallaher and Price (1966), Crain (1966), Rorabaugh (1946 and 1948), Norris and Fidler (1969), Whitesides and Ryder (1969), Grubb and Zehner (1973), Jeffords (1945), and Norris and Eagon (1971).

Received

SEP - 7 1985

LARGER AREAS COVERED BY PUBLISHED GEOLOGIC AND HYDROLOGIC REPORTS

State geologic map (Cardwell and others, 1968)

Ohio River drainage in West Virginia
(Carlston and Graeff, 1955; Cross and
Schemel, 1956; Shultz, 1984)

Ohio River drainage between Pittsburgh and Marietta
(Jordan, 1966; Deutsch and others, 1966)

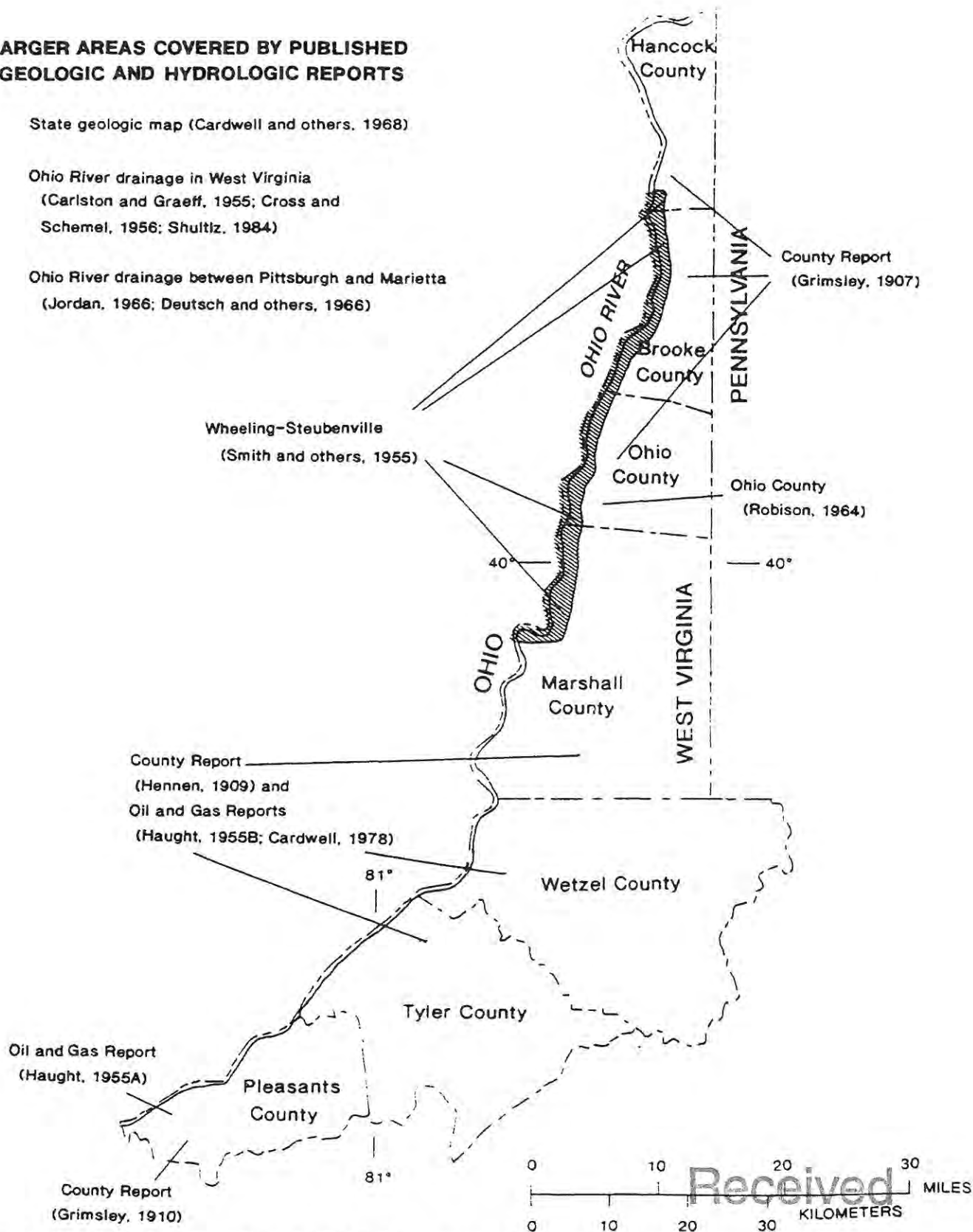


Figure 1.4-1. - - Areas covered by published geologic and hydrologic reports (see selected references for complete citations).

1.0 INTRODUCTION--Continued

1.5 Climate and Recharge

POTENTIAL FOR RECHARGE VARIES SEASONALLY

The potential for recharge to the ground-water reservoir is greater during winter and spring.

Potential for recharge to the ground-water reservoir is greater from November through April than during the rest of the year because precipitation is significantly greater than evapotranspiration during these months. Hydrographs of two wells near Sistersville (fig. 3.1-1) show that the ground-water level is higher during this period. Mean monthly precipitation was at least 1 in. greater than estimated mean monthly evapotranspiration for each of these months (table 1.5-1). Mean monthly precipitation slightly exceeded mean monthly evapotranspiration in May and October and was less than mean monthly evapotranspiration in June, July, August, and September. Mean annual evapotranspiration was estimated to be 27.70 in. Both monthly and annual evapotranspiration were estimated using the Munson P.E. Index method described in Munson (1966).

Recharge from precipitation also varies seasonally because of variations in the form and rate of precipitation, in the condition of the ground surface, and in the density of the forest canopy. During winter and early spring, precipitation is usually less intense and more widespread; thus, it is more conducive to recharge than summer thunderstorms of greater intensity and smaller coverage which are more conducive to runoff. If there is a snow pack, melting often increases soil moisture, except when the ground is frozen. Figure 1.5-1 shows the mean monthly and mean annual precipitation for four locations.

Forest areas reduce the water available for recharge because trees intercept precipitation before it hits the ground, and the ground covering of leaves or litter absorbs a large amount of moisture. Based on two formulas given in Chang and others (1976, p. 78), the forest canopy intercepts 13 to 22 percent of the precipitation. More precipitation is intercepted from May through October when the leaf canopy is full than from November through April. Although the Ohio River flood plain does not have a significant amount of forest area, the adjacent hills are covered mostly by deciduous and mixed forest.

Received

SEP - 7 1967

Table 1.5-1.--Mean monthly precipitation and evapotranspiration

Month	Mean monthly precipitation (inches) <i>a,c</i>	Mean monthly evapotranspiration (inches) <i>b,c</i>	Precipitation minus evapotranspiration (inches)
January	2.84	0.27	2.57
February	2.43	.50	1.93
March	3.58	1.21	2.37
April	3.59	2.20	1.39
May	3.81	3.48	-.33
June	3.85	4.18	-.33
July	4.22	4.95	-.73
August	3.83	4.42	-.59
September	3.02	3.09	-.07
October	2.60	1.92	.68
November	2.54	1.00	1.54
December	2.70	.48	2.22

a Modified from National Oceanic and Atmospheric Administration (1982) for period 1951-80.

b Calculated using Munson P.E. Index (Munson, 1966) for period 1951-80.

c Mean of four sites shown in figure 1.5-1.

Received

SEP - 7 1980

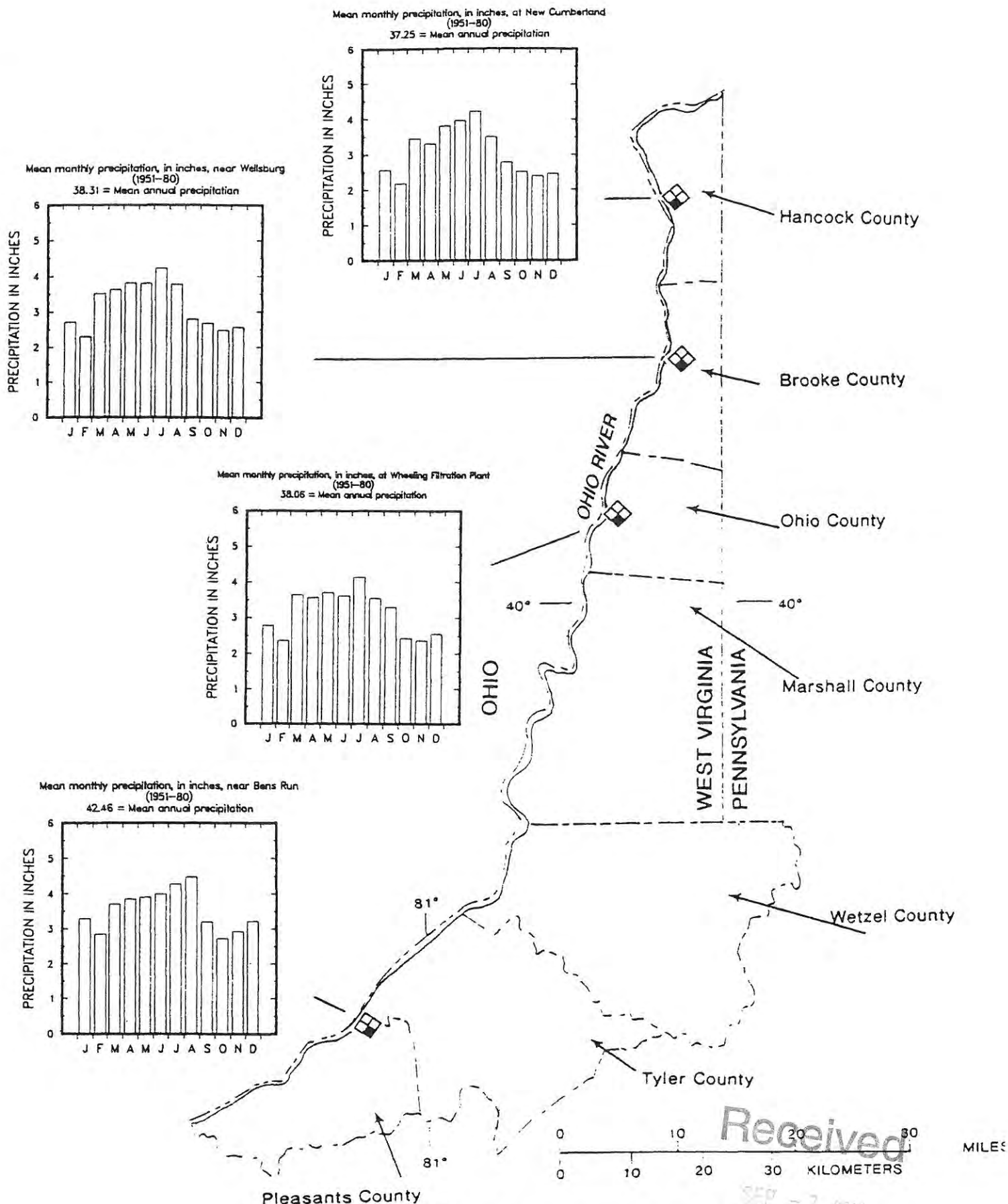


Figure 1.5-1. - - Mean monthly precipitation (1951-80).

1.0 INTRODUCTION--Continued

1.6 Ground-Water Use

MORE THAN 6.3 BILLION GALLONS OF GROUND WATER PUMPED IN 1980

Ground water in the seven-county project area is withdrawn for public supply, industry, mining, and domestic use.

Ground-water use in Hancock, Brooke, Ohio, Marshall, Wetzel, Tyler, and Pleasants Counties was at least 6.3 billion gallons in 1980 for public supply, mining, and domestic purposes according to Stevens and Lessing (1982) (fig. 1.6-1). This includes the entire county areas, but does not include industrial use, for which data are not available.

Nearly 4.0 billion gallons of ground water were withdrawn for public supply in 1983. This does not include pumpage by the smaller facilities supplying mobile-home parks or other small communities. Figure 1.6-2 shows the location of major public-supply wells.

Received

SEP 27 1985

Office of Oil and Gas
WV Dept. of Environmental Protection

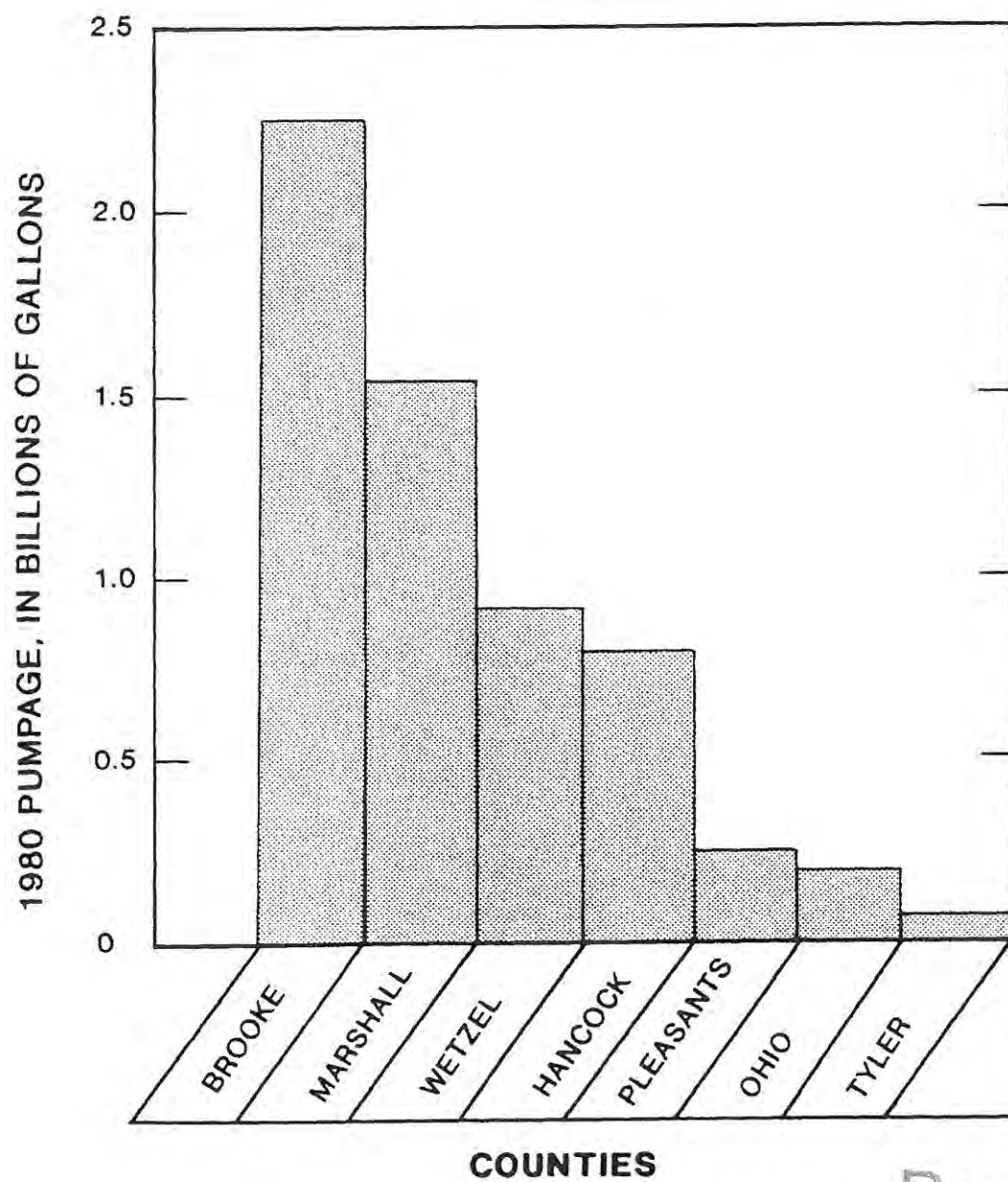


Figure 1.6-1. - - Ground-water withdrawals by county, excluding industrial use.

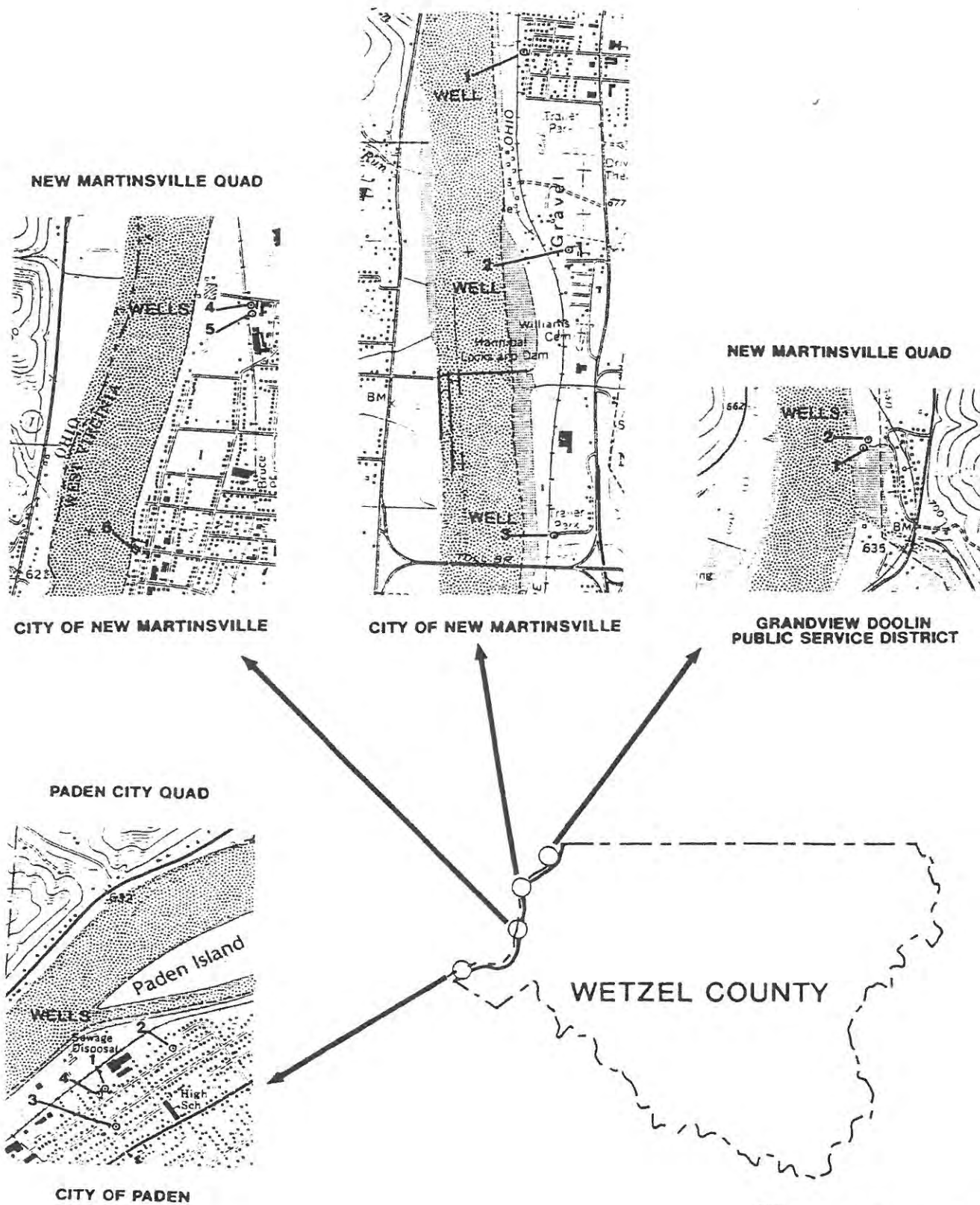


Figure 1.6-2. - - Location of public-supply wells.

Received

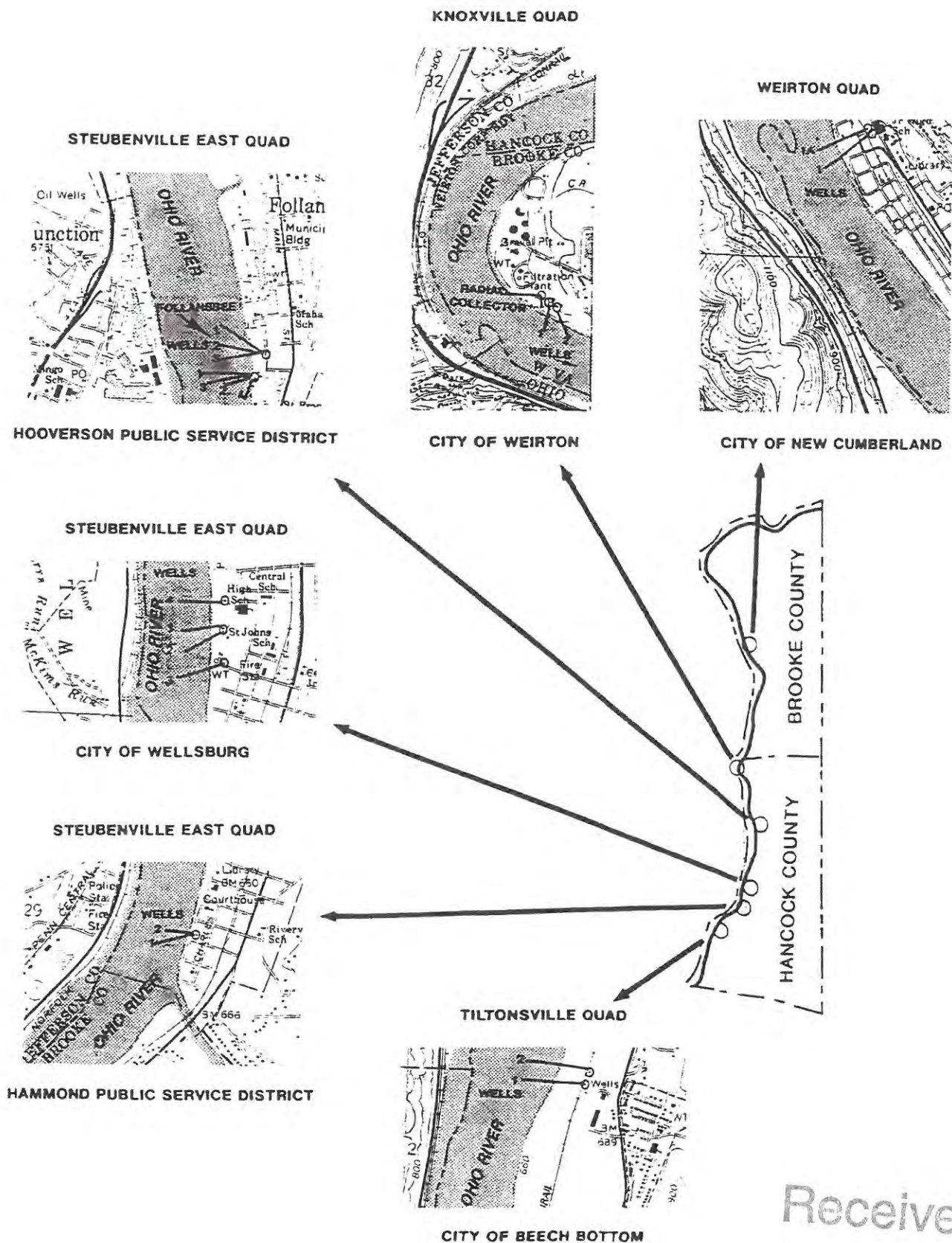


Figure 1.6-2. - - Location of public-supply wells (continued).

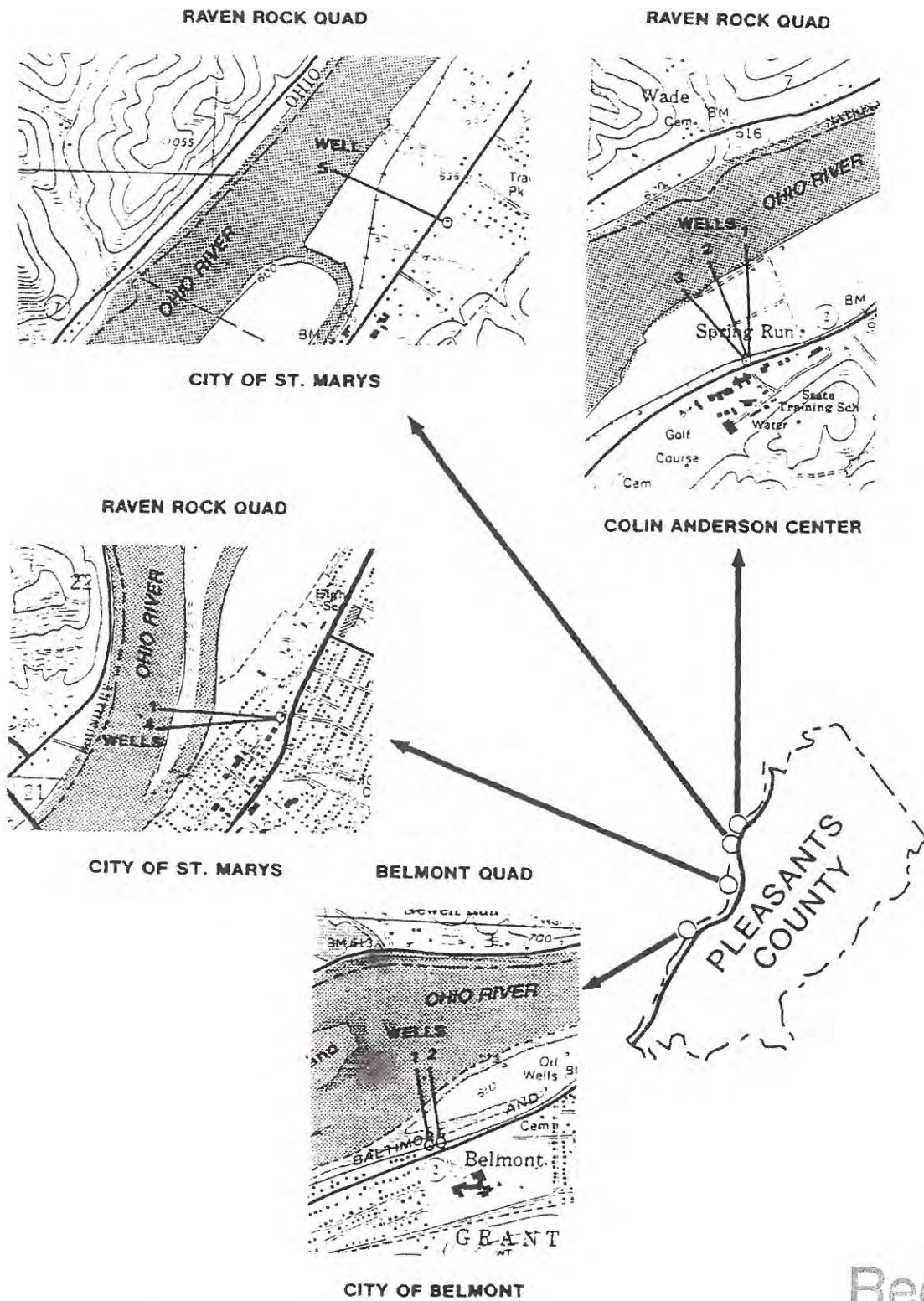


Figure 1.6-2. - - Location of public-supply wells (continued).

Received

SEP - 7 2016

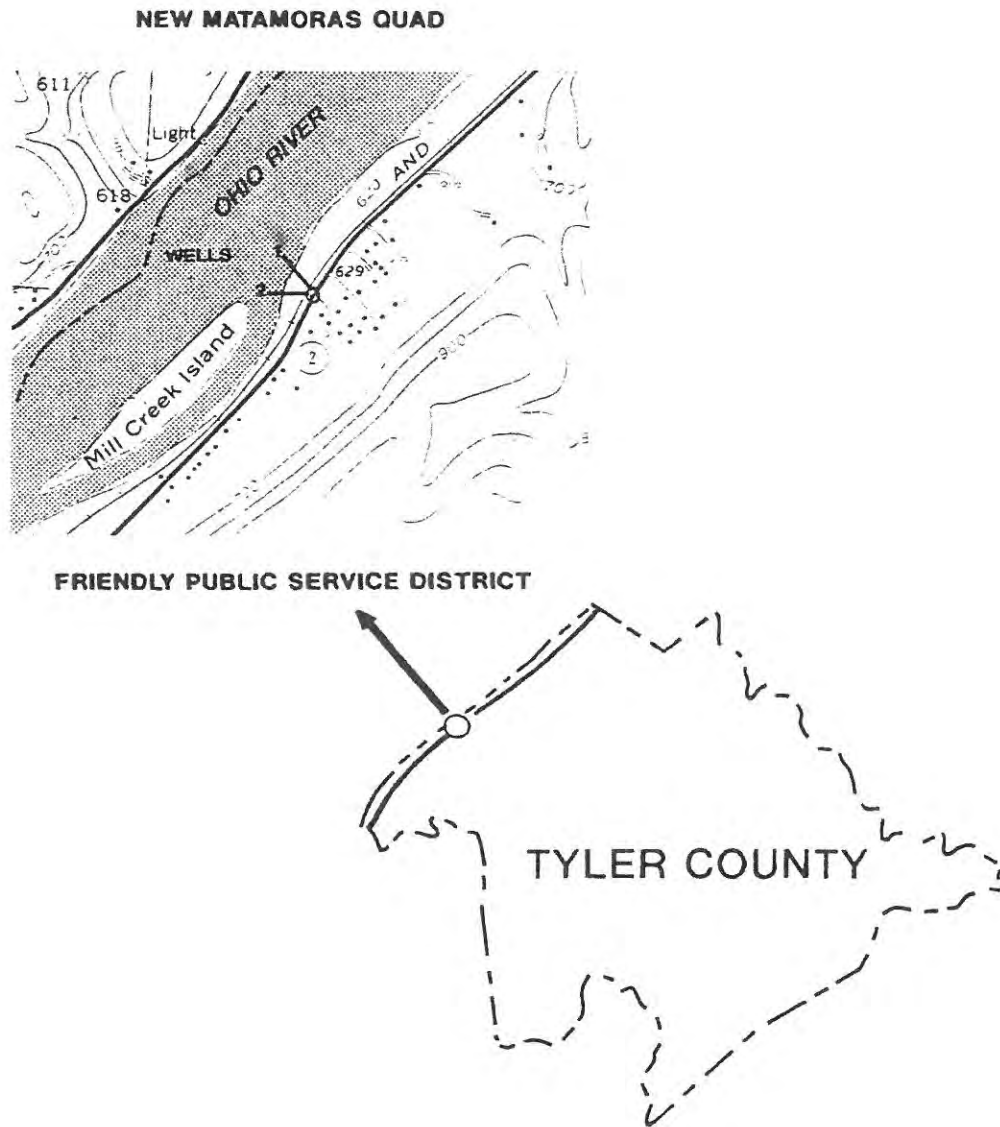
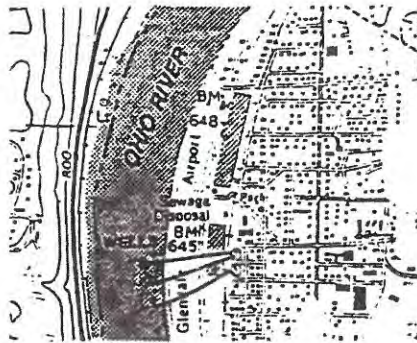
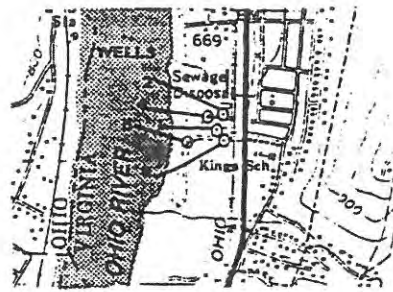


Figure 1.6-2. -- Location of public-supply wells (continued).

BUSINESSBURG QUAD



MOUNDSVILLE QUAD



CITY OF GLENDALE

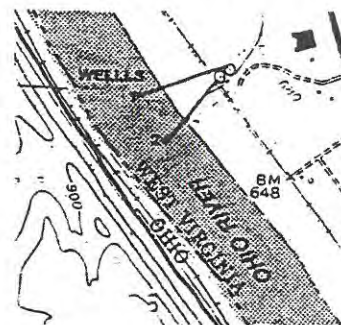
CITY OF MCMECHEN

BUSINESSBURG QUAD



CITY OF MOUNDSVILLE

BUSINESSBURG QUAD



OHIO COUNTY

MARSHALL COUNTY

MOUNDSVILLE: PUBLIC SERVICE DISTRICT NO. 2

Figure 1.6-2. -- Location of public-supply wells (continued).

Received

SEP - 7 1988

2.0 GEOLOGY AND WATER-BEARING CHARACTERISTICS

2.1 Consolidated Sedimentary Rocks

AREA IS UNDERLAIN BY SEDIMENTARY ROCKS

Most of the study area is underlain by sedimentary rocks of Pennsylvanian and Permian age.

The oldest rock unit exposed in the area is the Allegheny Formation of Pennsylvanian age. It is exposed in the valleys and on the lower hillsides in the extreme northern part of the Hancock County and along the axis of the Burning Springs anticline in Pleasants County.

The Conemaugh Group of Pennsylvanian age, which overlies the Allegheny Formation, is the predominant unit exposed in Hancock County and also is exposed on the lower slopes and in the valleys in Brooke County and western Ohio County and along the Burning Springs anticline in Pleasants County.

The Monongahela Group of Pennsylvanian age, overlies the Conemaugh Group and is exposed on the hills in northern Brooke County and in the valleys in Pleasants, Marshall, and Ohio Counties. In Tyler and Wetzel Counties, it is exposed in a few places along the Ohio River.

The Dunkard Group of Pennsylvanian and Permian age, overlies the Monongahela Group and is exposed over most of the area. The major exceptions are all of Hancock County and the northern half of the Brooke County and a narrow band along the Burning Springs anticline in Pleasants County.

Cardwell and others (1968, geologic map) describe the above lithology. The stratigraphic nomenclature used in this report follows the usage of the West Virginia Geological and Economic Survey and does not necessarily conform to that used by the U.S. Geological Survey.

The only major geologic structure in the project area is the north-trending Burning Springs anticline in the western part of Pleasants County. "The structural relief of this anticline is fully 1,800 feet" (Haught, 1955a), bringing rocks of the Allegheny Formation to the surface along its axis. The other structural features in the project area are gentle anticlines and synclines with minor structural relief.

The yield of water from wells that tap the consolidated rock units is typically low, ranging from less than 1 to as much as 300 gal/min. The median yield is about 6 gal/min. The mean specific capacity of wells drilled in the consolidated rocks is about 0.5 (gal/min)/ft of drawdown. Most of the ground water withdrawn from the consolidated sedimentary rocks is derived from secondary permeability features such as bedding-plane partings and fractures.

Received

SEP - 7 2016

Office of Oil and Gas
WV Dept. of Environmental Protection

2.0 GEOLOGY AND WATER-BEARING CHARACTERISTICS--Continued

2.2 Unconsolidated Alluvial Deposits

THE ALLUVIUM, WHICH IS MORE THAN 100 FEET THICK IN SOME PLACES, PROVIDES CONSIDERABLE GROUND-WATER STORAGE

The alluvial deposits of Quaternary age are limited mostly to the flood plain of the Ohio River but contain an estimated 50 billion gallons of ground water.

The alluvium is limited mostly to the flood plain of the Ohio River and ranges in thickness from 0 feet along the hillsides to more than 100 feet in some places near the river. The lower part of the alluvial deposits consists of sand and gravel of glacial outwash origin (Deutsch and others, 1966) and is overlain by a layer of clay and silt of fluvial origin as thick as 30 to 40 feet (fig. 2-2-1). The clay and silt layer contains sand stringers. On the basis of drillers' logs of some test wells near Sistersville, the clay-silt layer thins toward the hills (fig. 2.2-2). In some areas, tributary streams have deposited a gravel delta on the alluvial deposits described above where they enter the valley of the Ohio River. The gravel deltas are in probable hydrologic continuity with the gravel in the Ohio River valley. This situation is believed to be similar to that in southwestern New York described by Crain (1966).

In some localities, the alluvium has been covered with fill such as slag from steel-processing plants, waste from coal mines, or other locally derived waste. This material ranges in thickness from a few inches to 25 feet or more and may contain soluble constituents that could be leached by water percolating to the water table.

The amount of water in storage in the alluvium of the project area can be estimated if certain assumptions are made. The areal extent of the alluvium is estimated to be about 32 square miles. The mean thickness of the saturated sand and gravel aquifer is estimated to be about 36 feet as determined from well logs and water-level measurements. This amounts to about 0.2 cubic mile of saturated aquifer, or about 740,000 acre-feet. **Specific yield**¹ is assumed to be 20.5 percent, based on the **porosity** and **specific retention** of typical sand and gravel aquifers (Heath, 1983). Consequently, the amount of water in storage in the alluvial aquifer within the project area is approximately 152,000 acre-feet or 50 billion gallons.

The ground water in the alluvium is generally in a water-table (**unconfined**) condition. In some localities where the gravel is relatively thin and the overlying clay-silt layer is relatively thick, **semiconfined** conditions may exist. These conditions are more common at higher river stage. Perched water has also been reported in fill overlying the alluvium.

¹ Words that appear in **bold** are found in the "Definition of Terms" section.

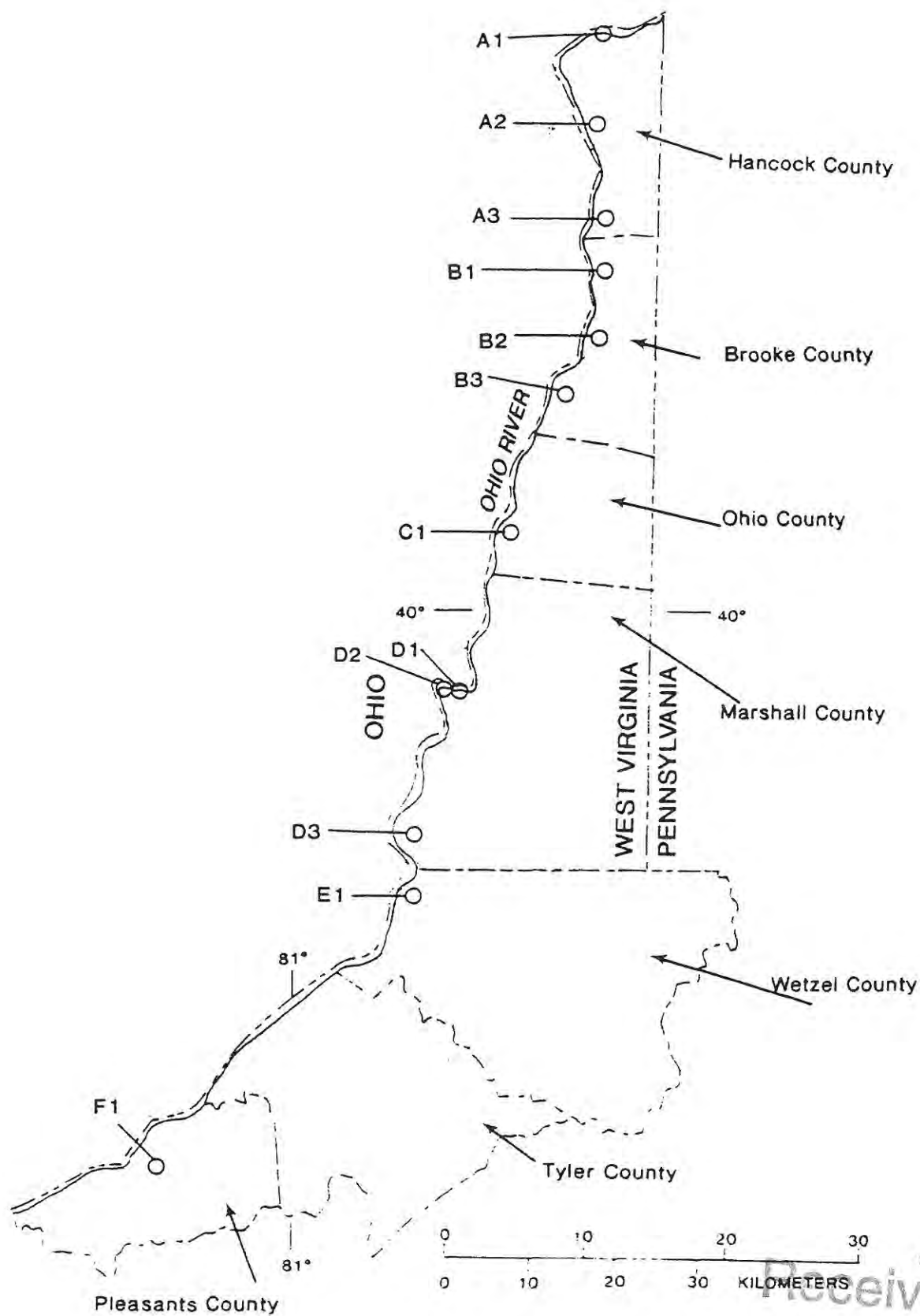


Figure 2.2-1. - - Drillers' logs of selected wells in the alluvium (Carlston and Graeff, 1955).

DEPTH (feet)

A1		
Fill	0	25
Sand and gravel	25	30
Sand and gravel, some clay	30	83
Bedrock	83	-

A2		
Sand, gravel and boulders	0	33.9
Clay (bedrock)	33.9	-

A3		
Sand, gravel, and boulders	0	37.2
Soft shale (bedrock)	37.2	-

B1		
Ashes	0	15
Yellow clay and sand	15	30
Clay, sand, and stones	30	35
Hard clay and sand	35	38
Clay and stones	38	44
Gravel, 7% clay	44	46
Gravel	46	55
Gravel, 4% clay	55	60
Gravel, 7% clay	60	65
Bedrock	65	-

B2		
Loam	0	3
Dry sand, dirt, and gravel	3	27
Coarse sand, gravel, and boulders	27	82

B3		
Cinders and clay	0	15
Clay	15	20
Sand	20	30
Clay and stones	30	35
Gravel and sand	35	55
Sand	55	60
Sand and gravel	60	74
Rock	74	-

C1		
Silt and fine sand	0	8
Coarse gravel, fine sand	8	16
Coarse gravel, boulders, and fine sand	16	26
Coarse gravel, medium sand, and boulders	26	37
Medium gravel, medium sand	37	46.3
Shale (bedrock)	46.3	-

Figure 2.2-1. - - Drillers' logs ... (continued).

Received

DEPTH (feet)

D1

Sandy clay	0 - 22
Clay, sand, and gravel	22 - 33
Silt, sand, and gravel	33 - 40
Sand and gravel	40 - 72

D2

Clay	0 - 8
Clay and sand	8 - 31
Clay, sand, and gravel	31 - 40
Gravel and sand	40 - 75
Bedrock	75 -

D3

Sand, yellow clay	0 - 7
Clay-bound, mixed gravel	7 - 16
Coarse gravel and cobbles	16 - 20
Very coarse gravel and cobbles	20 - 27
Coarse sand, pea gravel and scattered medium and coarse gravel	27 - 33
Fine and medium sand, pea gravel scattered medium gravel	33 - 35
Medium and coarse sand, pea gravel, and scattered medium and coarse gravel	35 - 45
Coarse sand, pea gravel, and scattered medium gravel	45 - 50
Coarse sand, pea gravel, medium gravel, and scattered coarse gravel	50 - 55
Fine to coarse sand, with pea gravel and scattered medium gravel (heaved strongly at 63 feet)	55 - 65
Medium and coarse sand, pea gravel, and medium gravel	65 - 70
Coarse sand, pea gravel, medium gravel, and occasional boulders	70 - 86.8
Blue-green shale (bedrock)	86.8 -

E1

Topsoil	0 - 4
Sand and gravel and clay	4 - 24
Fine gravel and sand	24 - 44
Coarse gravel and sand	44 - 59
Bedrock	59 -

F1

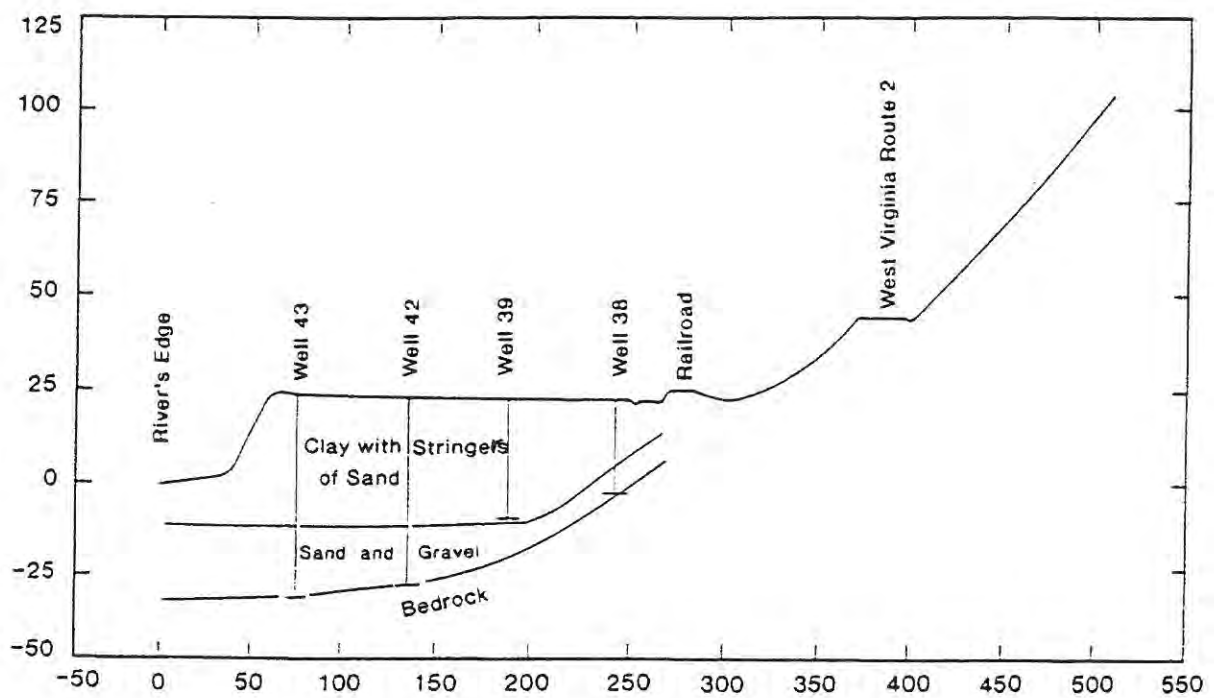
Clay	0 - 15
Sandy loam	15 - 55
Sand and gravel	55 - 75
Rock	75 -

Figure 2.2-1. -- Drillers' logs ... (continued).

Received

SEP - 7 2016

DISTANCE IN FEET ABOVE AND BELOW ZERO RIVER STAGE DATUM



DISTANCE FROM LEFT EDGE OF RIVER, IN FEET

Vertical Exaggeration X2

Figure 2.2-2. - - Geologic section of alluvium at the Sistersville section.

Received

SEP - 7 - 2000

Office of Oil and Gas
WV Dept. of Environmental Protection

3.0 GROUND-WATER SYSTEM

3.1 Recharge, Movement, and Discharge

RECHARGE TO THE ALLUVIUM IS DERIVED FROM SEVERAL SOURCES

Sources of recharge to the aquifer are infiltration of precipitation through the clay-silt layer, inflow through fractures and bedding-plane partings in the bedrock beneath and adjacent to the alluvium, inflow from tributary streams through gravel deltas, and induced inflow from the river.

Part of the precipitation that falls on the surface of the alluvium, as well as some of the overland flow from the bedrock highlands, percolates through the clay-silt layer to recharge the sand and gravel deposits of the alluvium. Although the clay-silt layer overlying the sand and gravel was originally believed to be nearly impermeable (Carlston and Graeff, 1955), water-quality data indicate that water does percolate through this layer into the more permeable sand and gravel zone. As shown by the drillers' logs in figure 2.2-1 (preceding section), the clay-silt layer is not uniform in thickness and composition; thus, the amount and rate of percolation are variable.

Further evidence of percolation through the clay-silt layer is indicated by the abnormally high concentration of sulfate in ground water beneath or near areas containing fill. This indicates that sulfate has been leached from the fill (see section 4.6).

Under natural conditions, ground water flows from the adjacent hills toward the Ohio River. The water level in wells at the Sistersville site remained slightly above the level of the river during this project. Response of the water table in the aquifer system was almost immediate when the level of the river rose or fell, as indicated by river stage and water-level fluctuations shown in figure 3.1-1. Well 43 is about 75 feet from the river's edge and does not penetrate bedrock. Well 34, open only to the bedrock, is about 120 feet downstream from well 43 and about 250 feet from the river. The hydrographs (fig. 3.1-1) indicate that the water level in both wells responds almost identically. The almost instantaneous response of the bedrock well to river-stage fluctuations indicates that the bedrock and the alluvium are hydraulically interconnected. This condition probably exists throughout the study area.

Received

SEP - 7 1976

Office of Oil and Gas
WV Dept. of Environmental Protection

3.0 GROUND-WATER SYSTEM--Continued

3.1 Recharge, Movement, and Discharge--Continued

Some inflow into the alluvium occurs through fractures in the bedrock under the hillsides. The occurrence of open fractures is dependent on stress acting on the rock. Some fractures are located near anticlines (Clark and others, 1976), and a system of bedding-plane partings exists beneath the floor of the valleys (Wyrick and Borchers, 1981). Both of these fractures systems allow recharge to enter the alluvium from the adjacent bedrock.

Tributary streams flowing onto the alluvium from the hills have deposited gravel deltas at the edge of the Ohio River valley. Water flowing from these streams can percolate through the deltas to the gravel under the clay-silt layer. This phenomenon has been described by Crain (1966) in western New York State. Discharge in Little Grave Creek at Moundsville, West Virginia (see fig. 1.3-1), decreased from an estimated 10 ft³/s in the upstream bedrock area to an estimated 0.5 ft³/s downstream on the alluvial flood plain (Friel, E.A., U.S. Geological Survey, oral commun., 1984). Thus, Little Grave Creek appears to be providing considerable recharge to the alluvium.

Man's activities can change the natural ground-water flow pattern and thus affect recharge. Recharge to the alluvium from the Ohio River may occur when the aquifer close to the river is pumped heavily and the ground-water level is drawn below the river level. This recharge is limited to the alluvial area between the river and pumped well. However, under natural conditions the water level in the aquifer is above the river in most places. Furthermore, the permeability of the streambed probably is quite low. In describing conditions in the Scioto River valley in Ohio, Norris and Fidler (1969, p. 45) state: "The vertical permeability of the streambed sediments is thus only about one-thirteenth as high as the vertical permeability measured across the full thickness of the aquifer. A layer of silt, mud, and organic debris, possibly having penetrated no more than a few inches into the underlying sediments, is thought to be chiefly responsible for the relatively low permeability of the streambed." The same conditions have been observed on the Ohio River and probably limit recharge to the alluvium from the river.

Discharge from the alluvium occurs at the riverbed and riverbank from both the saturated and unsaturated zones. Ground water from the saturated zone of the alluvium, which is comprised mostly of sand and gravel, enters the river through its bed. Discharge from the unsaturated zone occurs at the riverbank where water emerges from the thin sand layers in the upper clayey part of the alluvium. The water in that part of the unit can flow horizontally along the sand layers more easily than vertically through the clay and silt layers.

Received

SEP - 7 2015

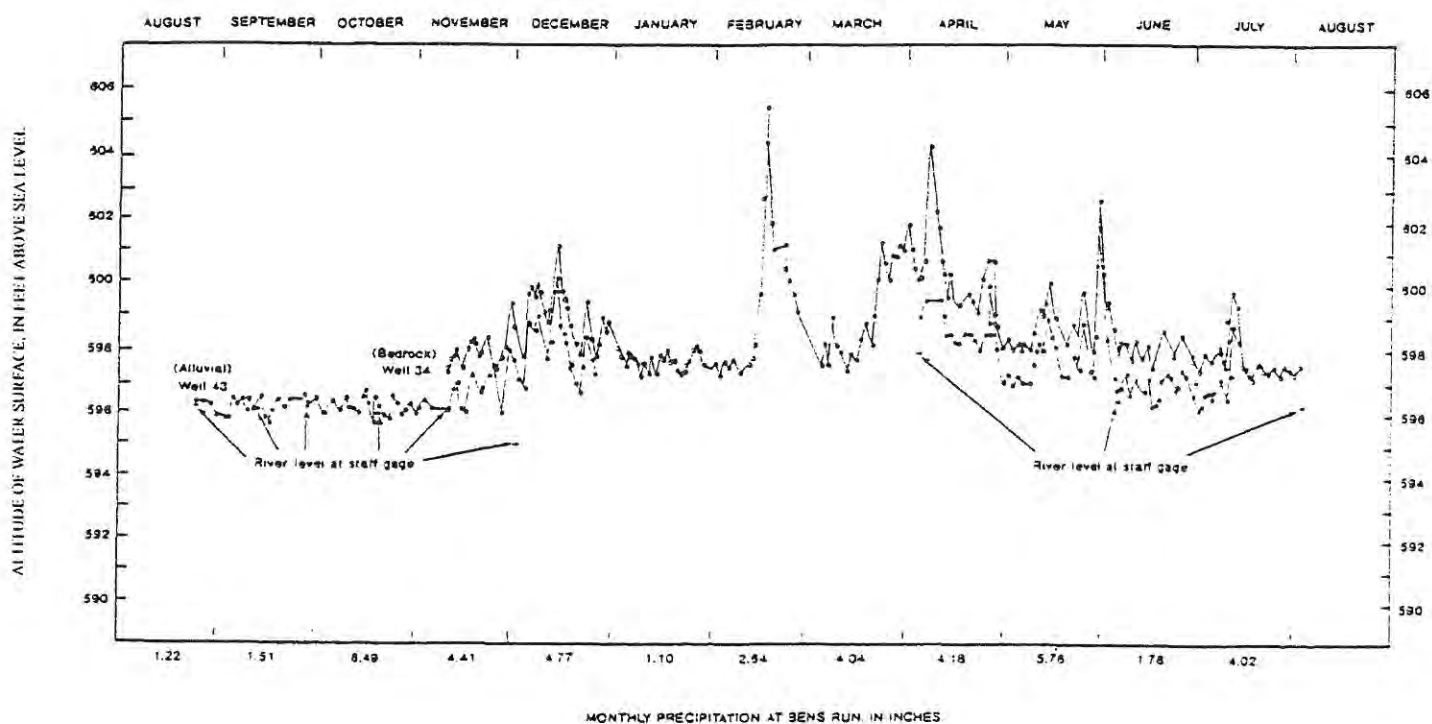


Figure 3.1-1. - - Hydrographs of two wells at Sistersville site.

Received

SEP - 7 1975

3.0 GROUND-WATER SYSTEM--Continued

3.2 Hydraulic Characteristics of Alluvial Aquifer

SPECIFIC CAPACITY, SATURATED THICKNESS, TRANSMISSIVITY, AND HYDRAULIC CONDUCTIVITY WERE DETERMINED FOR THE OHIO RIVER ALLUVIUM

The alluvium has the following hydraulic characteristics: Mean specific capacity--49 gallons per minute per foot of drawdown, mean saturated thickness of aquifer--36 feet, mean transmissivity--6,300 feet squared per day, and mean hydraulic conductivity--170 feet per day.

Specific capacity of 65 wells ranged from 7 to 198 (gal/min)/ft with a mean of 49 (gal/min)/ft and a median of 38 (gal/min)/ft (fig. 3.2-1). Specific capacities were obtained from well-site inventories, drillers' records, earlier studies, and consultants' reports. The specific capacities were determined for varying conditions of river stage, well efficiency, and direction of ground-water movement, as well as water-table and semiconfined aquifer conditions. Drawdown for a given yield increases as well screens become partially clogged, and thus well efficiency decreases with time. Induced infiltration from the Ohio River decreases drawdown and increases specific capacity. Some alluvial wells are capable of yielding several hundred gallons of water per minute. Yields of more than one thousand gallons per minute have been reported.

The saturated thickness of the alluvium ranged from 19 to 56 feet with a mean of 36 feet and a median of 34 feet (fig. 3.2-2). These values were obtained during various river stages, which directly affect the water level and thus the saturated thickness. The construction of locks and dams and the consequent raising of the river pools behind these dams has increased the saturated thickness of the alluvium. Saturated thickness was determined by subtracting the depth to the static water level from the depth to bedrock. The effect of confinement upon static water levels was assumed to be minimal for the purpose of estimating saturated thickness.

Estimated transmissivities ranged from 1,100 to 17,000 ft²/d with a mean of 6,300 ft²/d and a median of 5,100 ft²/d (fig. 3.2-3). Transmissivity gives an indication of the rate of movement of ground water. Transmissivities were estimated from the specific capacities of 32 alluvial wells with pumping tests of known duration using the following equation developed by Theis (Bentall, 1963):

Received

SEP - 7 1988

Office of Oil and Gas
WV Dept. of Environmental Protection

EXPLANATION

54 ● Well -- Number is specific capacity in gallons per minute per foot of drawdown

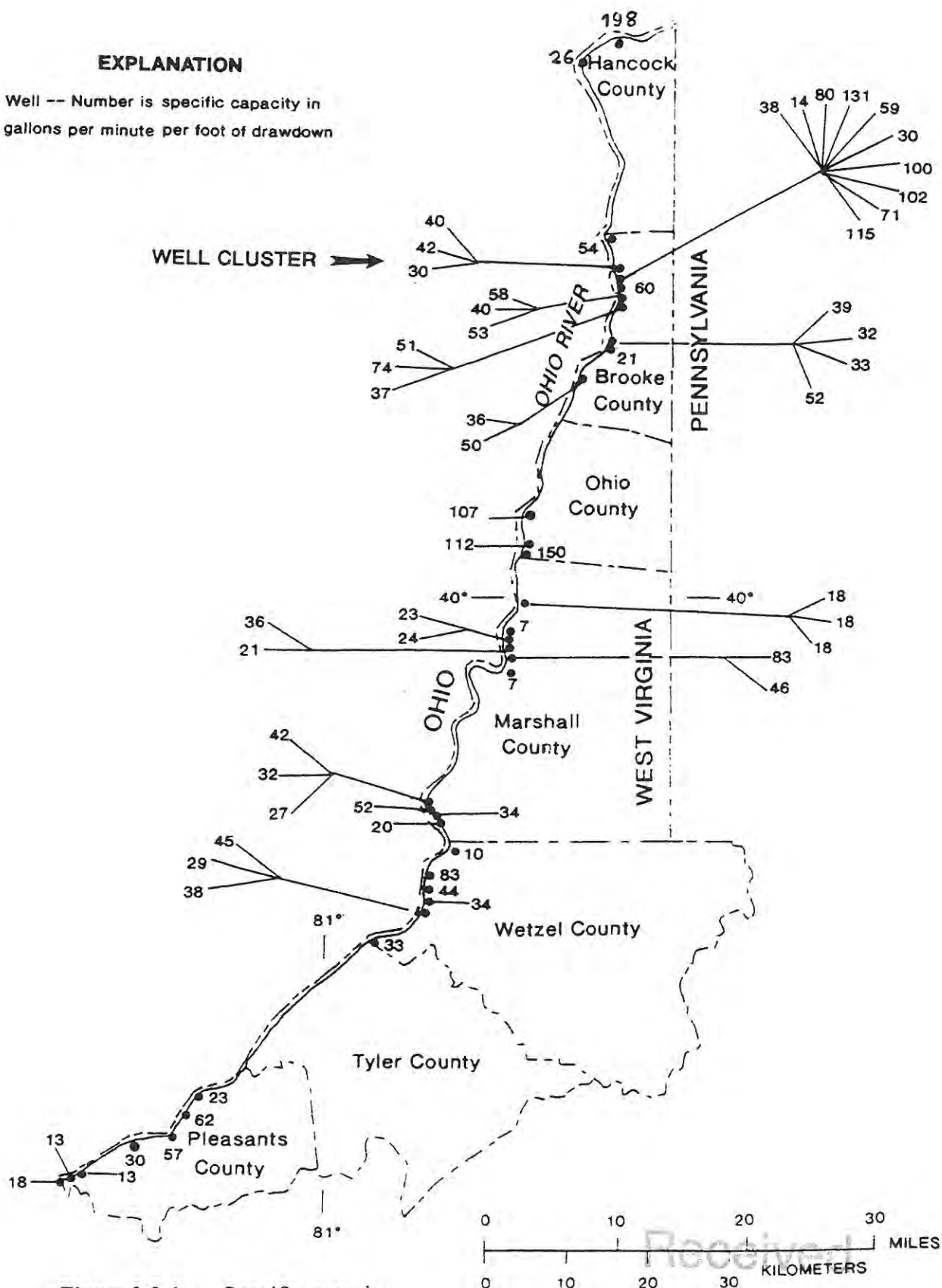


Figure 3.2-1. -- Specific capacity.

EXPLANATION

38 ● Well -- Number is saturated thickness of alluvial aquifer in feet

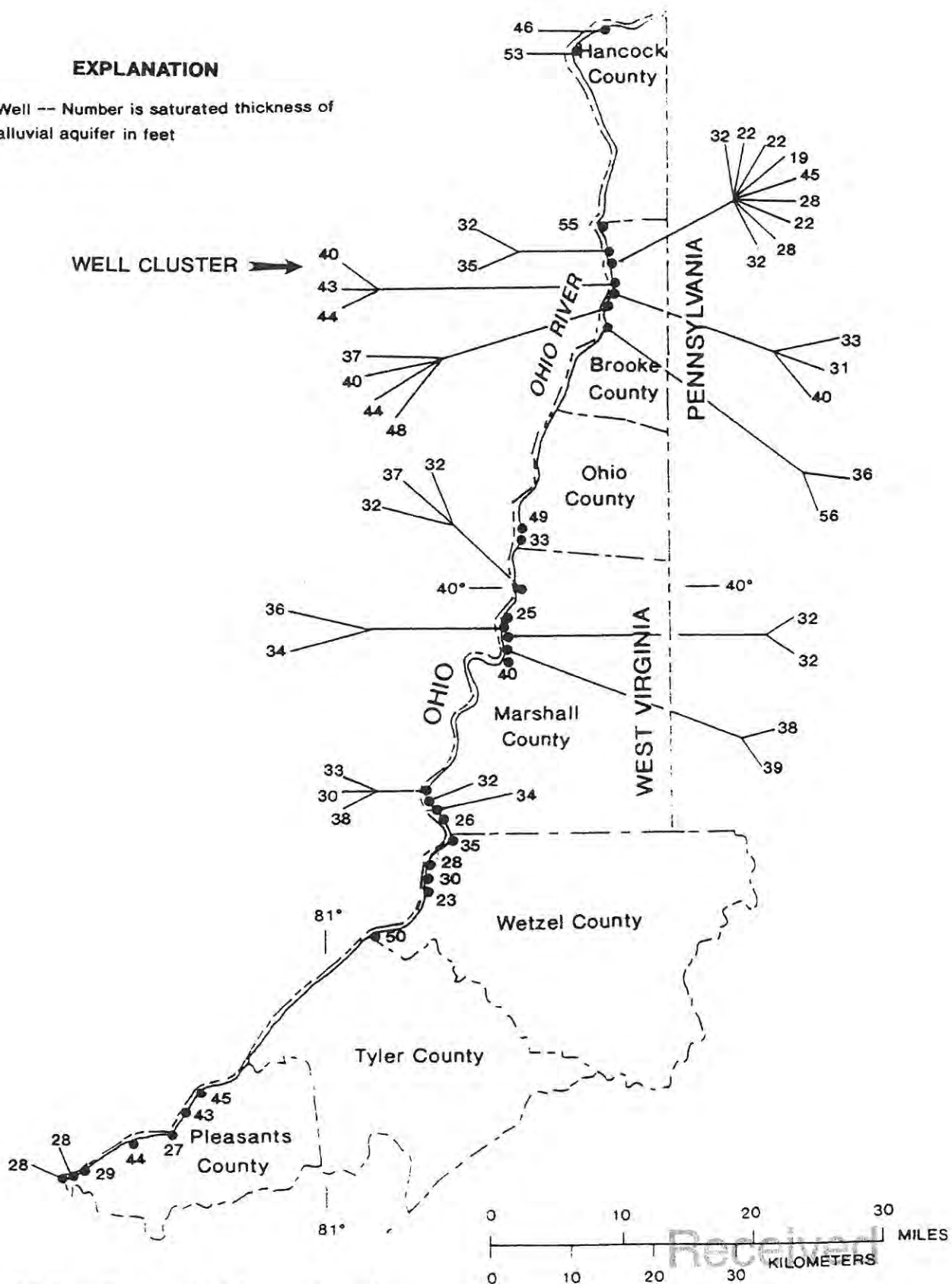


Figure 3.2-2. -- Saturated thickness of aquifer.

EXPLANATION

9200 • Well -- Number is estimated transmissivity in feet squared per day

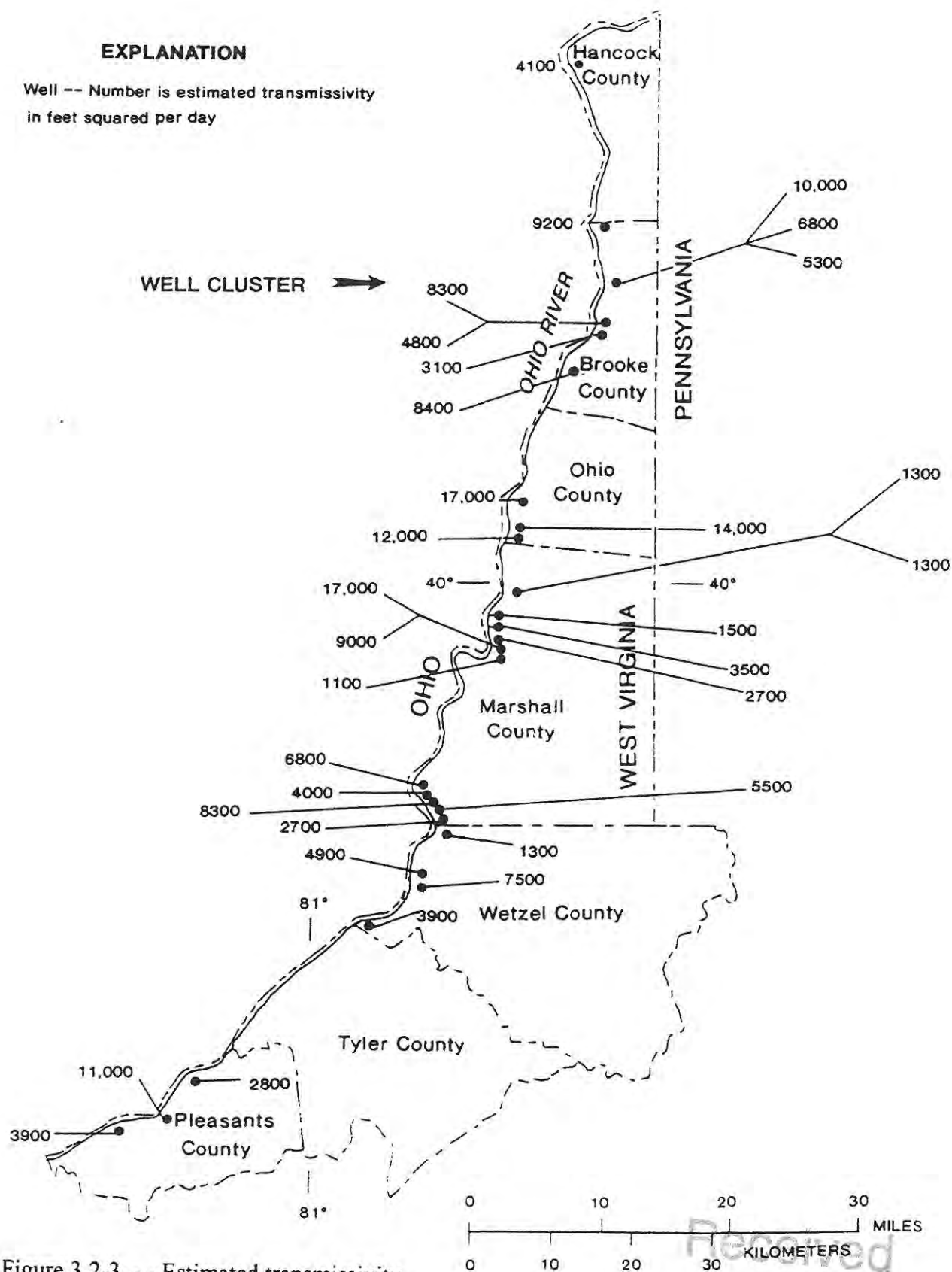


Figure 3.2-3. -- Estimated transmissivity.

3.0 GROUND-WATER SYSTEM--Continued

3.2 Hydraulic Characteristics of Alluvial Aquifer--Continued

$$T' = C(1 \pm 0.3) (1,300 - 264 \log_{10} 5S + 264 \log_{10} t)$$

where: T' is an intermediate value of transmissivity,
 C is the specific capacity of the pumped well,
 S is the aquifer **storage coefficient**, and
 t is the time, in days, that the well was pumped.

The estimated transmissivity is determined graphically from " T' " and " C ". To simplify calculations, well diameter was assumed to be 1 foot, and storage coefficient was assumed to be 0.2.

Several transmissivities reported in previous studies were much higher than those estimated in this report. Reasons for the higher reported transmissivities are (1) pumping tests of insufficient duration, (2) storage coefficients less than 0.2 in some areas, and (3) induced infiltration to the alluvium from the Ohio River.

Hydraulic conductivity was computed for 30 wells by dividing the estimated transmissivity by the saturated thickness. The hydraulic conductivity ranged from 27 to 460 ft/d with a mean of 170 ft/d and median of 140 (ft/d) (fig. 3.2-4). The hydraulic conductivity can be used to compute the **specific discharge** if the **hydraulic gradient** is known. Ground-water movement is in the direction of the hydraulic gradient. Under natural conditions, the hydraulic gradient dips gently from the hills to the Ohio River. The median slope of the water table at the Sistersville site was 0.001 foot/foot during the period April 1983 to November 1984. Withdrawal of large quantities of water from wells close to the Ohio River can reverse this gradient between the pumped wells and the river. The direction and slope of the hydraulic gradient is affected close to lock and dam sites where river pools of different elevations meet abruptly. Sources of recharge such as ponds, lakes, and streams on the alluvial flood plain also affect the hydraulic gradient.

All aquifer characteristics calculated in this report are variable with time and geographical location and should be used with discretion.

Received

EXPLANATION

170 ● Well -- Number is estimated hydraulic conductivity in feet per day

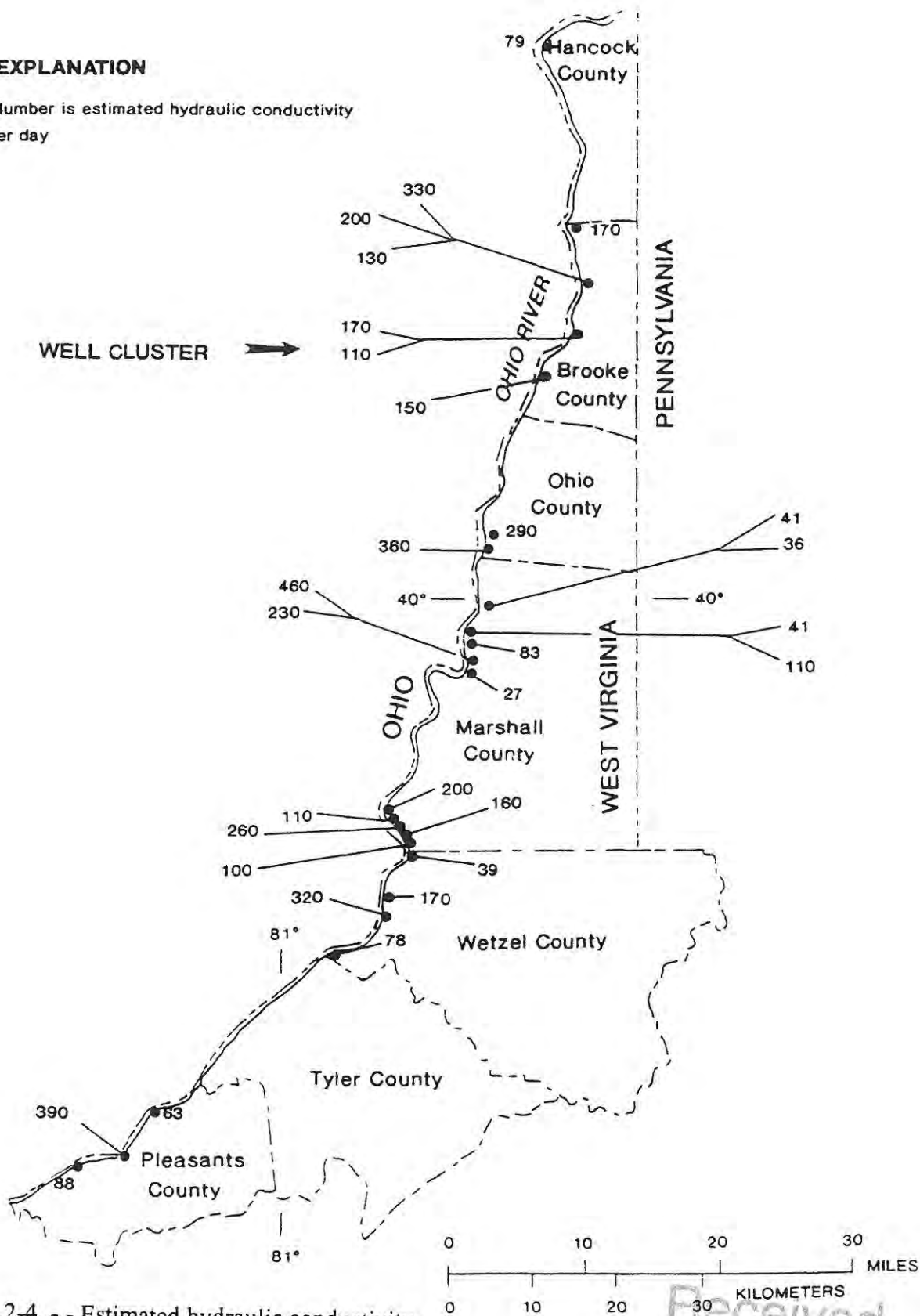


Figure 3.2-4. -- Estimated hydraulic conductivity.

4.0 WATER QUALITY

4.1 Data Collection

GROUND-WATER SAMPLES FROM MORE THAN FIFTY WELLS WERE ANALYZED

Water samples from alluvial wells, bedrock wells on or near the alluvial flood plain, and radial collectors were analyzed.

More than 50 ground-water samples were analyzed during the study. Samples were collected from wells drilled into alluvium, wells drilled into bedrock, and from radial collectors with laterals extending into the alluvium and, in places, under the Ohio River. Analyses included all major cations and anions, several metals, phenols, and dissolved organic carbon. Several additional samples from bedrock wells near the alluvial flood plain were collected during a previous study (Shultz, 1984) and are incorporated into this report. These wells were sampled for major cations and anions and common metals. The locations of sampled wells are shown on figure 4.1-1. Alluvial wells are designated with an "A," bedrock wells with a "B," and radial collectors with an "R." The data collected as part of this study are in the U.S. Geological Survey files.

Received

SEP - 1988

Office of Oil and Gas
WV Dept. of Environmental Protection

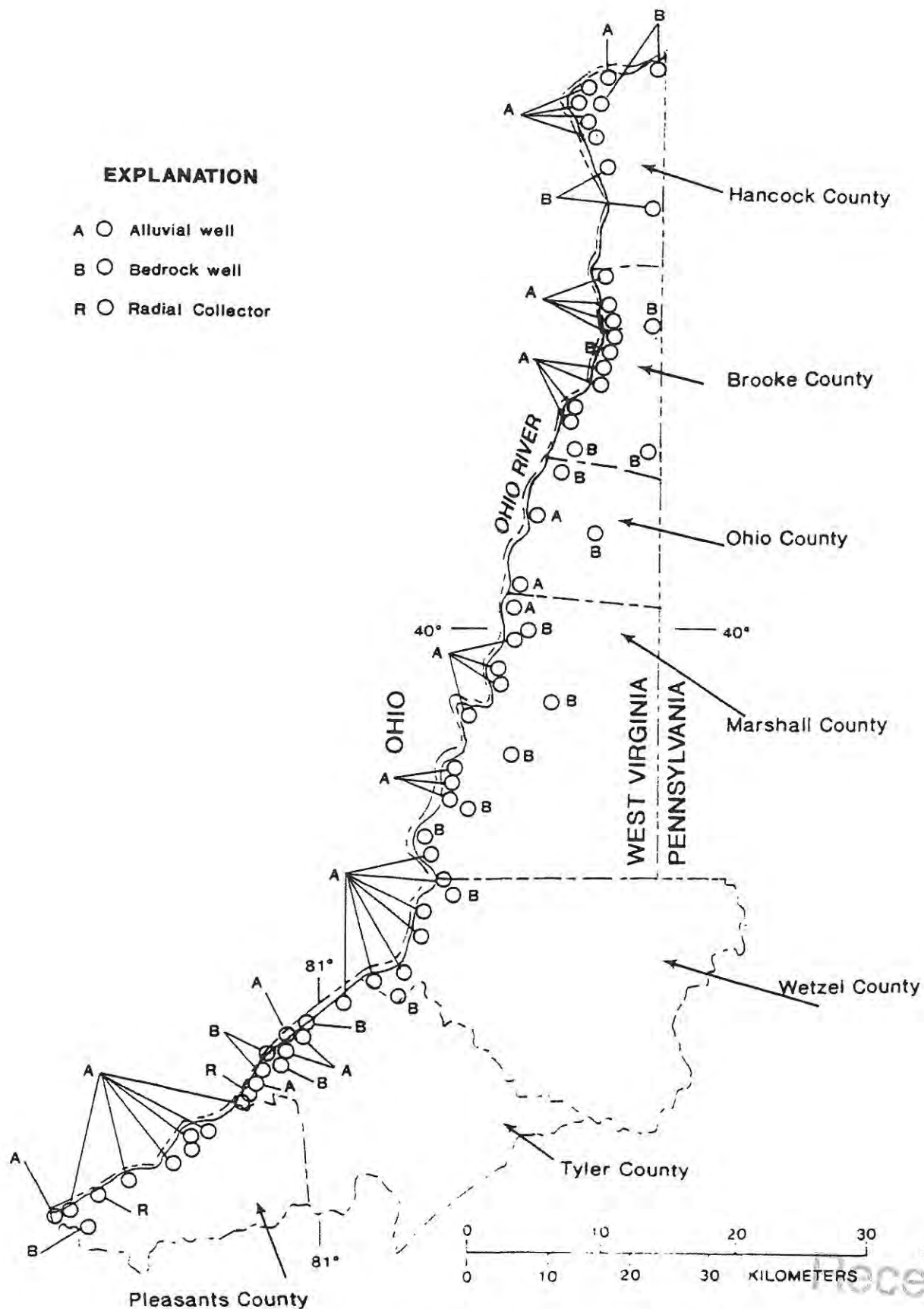


Figure 4.1-1. - - Location of ground-water sampling sites.

4.0 WATER QUALITY--Continued

4.2 Water Type

CALCIUM BICARBONATE WAS THE MOST COMMON WATER TYPE

Calcium bicarbonate was the predominant water type in 35 percent of the well samples.

Water type was determined for well samples collected during the study (fig. 4.2-1). Water type is based on predominant cations and anions. Calcium bicarbonate was the most common water type, accounting for 35 percent of the samples. Calcium, with a mixture of bicarbonate and sulfate, was the second most common type, comprising 18 percent of the samples. Ten other water types were present, each totaling 8 percent or less of the samples. These water types included various combinations of calcium, sodium, and magnesium with bicarbonate, sulfate, and chloride.

Calcium was the most predominant cation in 71 percent of the samples. Sodium was the second most common cation and was predominant in 15 percent of the samples. The remaining samples were various mixtures of calcium, sodium, and magnesium, with no single cation predominating.

Bicarbonate was the predominant anion in 50 percent of the samples. Sulfate and chloride were predominant in 9 and 8 percent of the samples respectively. The remaining samples were various mixtures of bicarbonate, sulfate, and chloride, with no single anion predominating.

Saltwater (sodium chloride type water) is a problem in Tyler and Pleasants Counties and in parts of the northern panhandle (see section 4.3). Sulfate is not normally a predominant anion, but can predominate in areas containing fill (see section 4.6).

Plates 1-3 contain more detailed descriptions of the ground-water chemistry.

EXPLANATION

- A ○ Alluvial well
- B ○ Bedrock well
- R ○ Radial Collector

PREDOMINANT CATIONS

- ⊕ Calcium
- ⊕ Sodium
- No predominant cation
(greater than 50 percent)

PREDOMINANT ANIONS

- ⊕ Bicarbonate
- ⊕ Sulfate
- ⊕ Chloride
- No predominant anion
(greater than 50 percent)

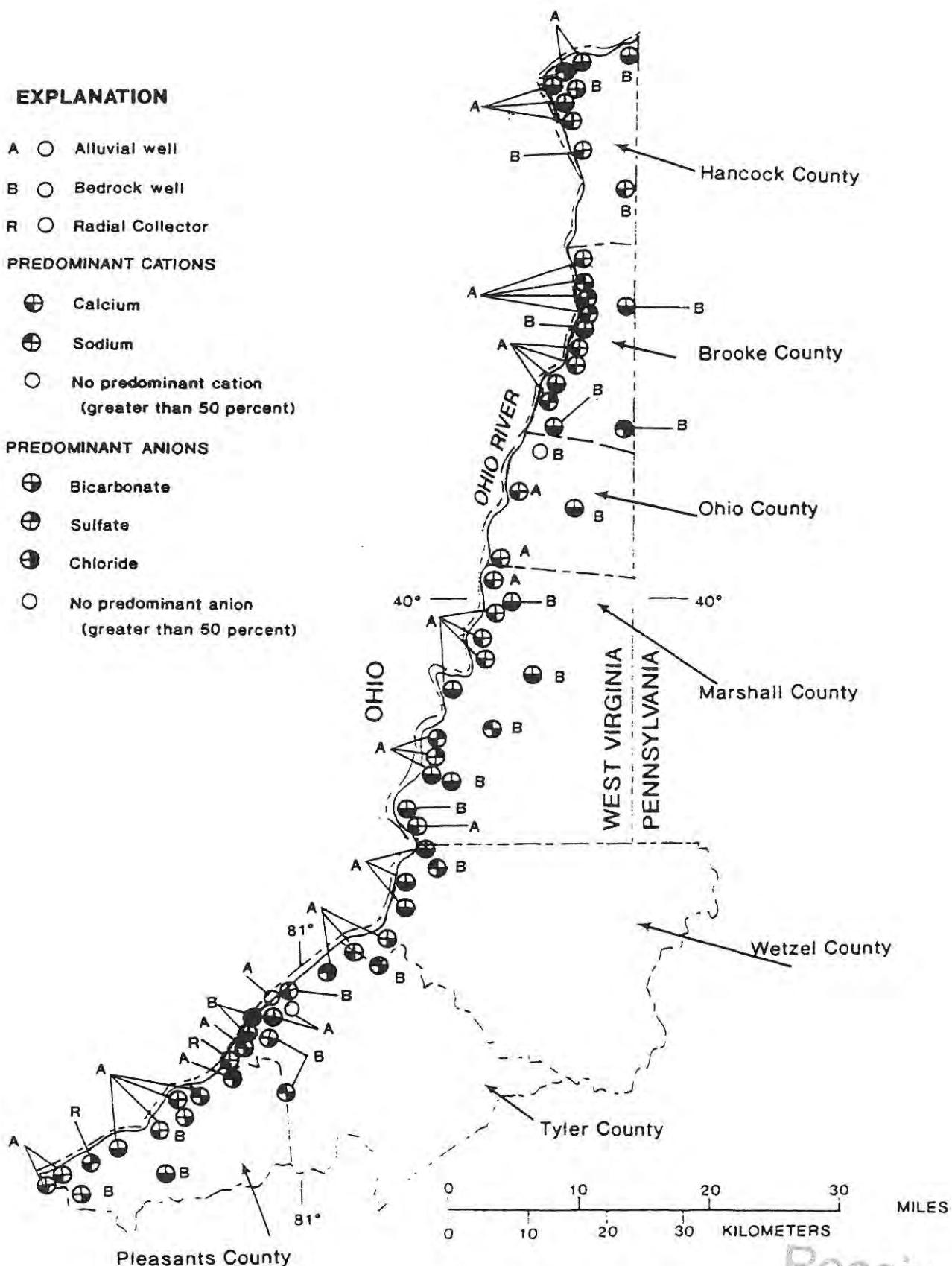
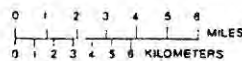
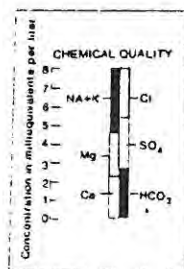


Figure 4.2-1. - - Areal distribution of cations and anions.

EXPLANATION

- Well
- Well, Chemical Analysis Available
- Well, Log Available
- Well, Chemical Analysis and Log Available



WELL DATA

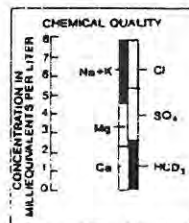
- | | | |
|---|------------|---|
| Depth to water level in feet below land surface | 25(11/79) | Month and year of water level measurement |
| Well depth in feet | D-73 Y-782 | Well yield in gallons per minute |
| Depth to bedrock in feet | B-80 SC-54 | Well specific capacity in gallons per minute per foot of drawdown |

Plate 1 --Map showing hydrologic and physical characteristics of selected alluvial wells in Ohio, Brooke, and Hancock Counties.

☐ Well
☐ Well, Chemical Analysis Available
☐ Well, Log Available
☒ Well, Chemical Analysis and Log Available



Depth to water level, in feet below land surface	3011711	Month and year of water level measurement
Well depth, in feet	0-65 Y-102	Well yield, in gallons per minute
Depth to bedrock, in feet	B-55 SC-10	Well specific capacity, in gallons per minute per foot of drawdown



Received

Plate 2.--Map showing hydrologic and physical characteristics of selected alluvial wells in Marshall and Wetzel Counties.

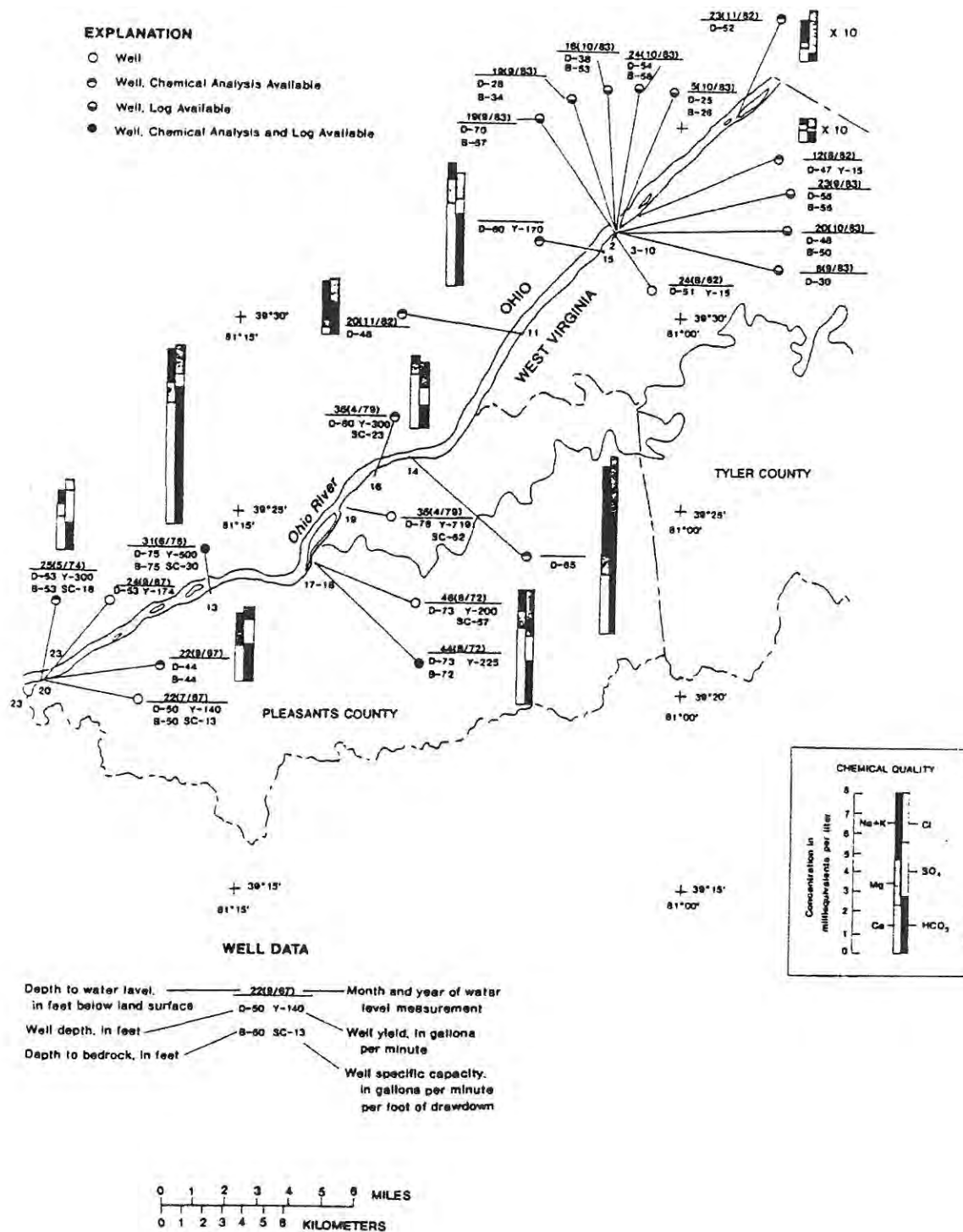


Plate 3.--Map of hydrologic and physical characteristics of selected alluvial wells in Tyler and Pleasants Counties.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents

4.3.1 Saltwater

EIGHT PERCENT OF SAMPLED WELLS CONTAINED SALTWATER

Although saltwater underlies all of the area at varying depth, only eight percent of the sampled wells contained sodium chloride type water.

Sodium chloride was the predominant constituent in 8 percent of the sampled wells. Increasing chloride concentration may be the first indication of saltwater contamination. The West Virginia State Board of Health (1981) recommends a limit of 250 mg/L of chloride for drinking water. Figure 4.3.1-1 shows the areal distribution of chloride concentration in ground water. One area of high chloride concentration is in Tyler and Pleasants Counties. Carlston and Graeff (1955) report that leakage from old oil wells may be contaminating freshwater zones in the Sistersville, Bens Run, St. Marys, Belmont, and Waverly areas.

Saltwater underlies all of the area at depths ranging from land surface to about 500 feet (Foster, 1980). (Foster, 1980) shows locations where it is within 100 feet of the land surface. Factors affecting the depth to saltwater include geology, topography, ground-water circulation, and human activities.

The depth to saltwater is shallower on the alluvial flood plain and in valleys than on hillside or hilltops. Fewer well owners report saltwater contamination on hillsides and hilltops than in valleys. This can be explained by the relation between the fresh ground water and the underlying saltwater and by the circulation of water from areas of recharge to areas of discharge (fig. 4.3-1.2).

Received

SEP - 1981

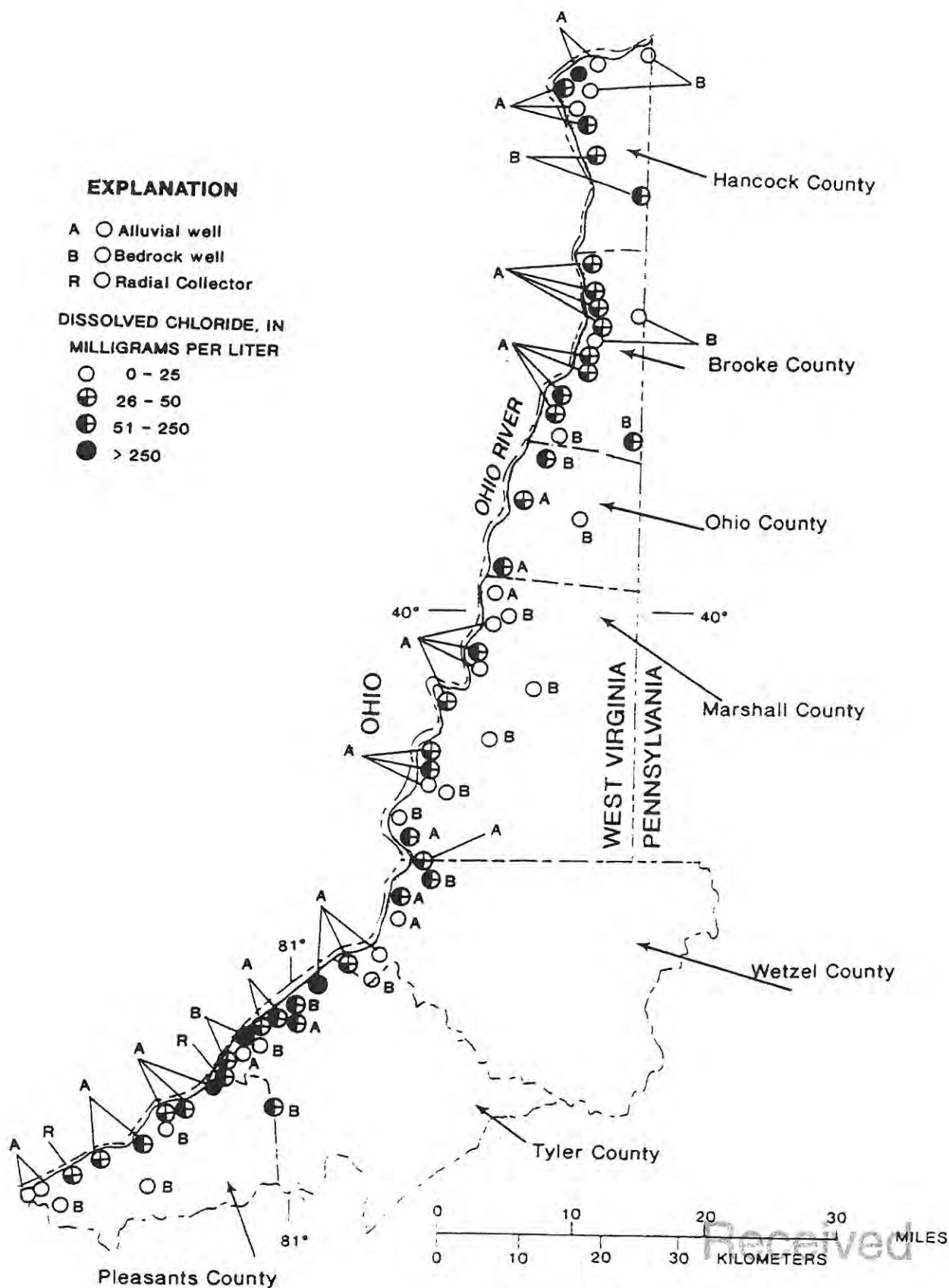
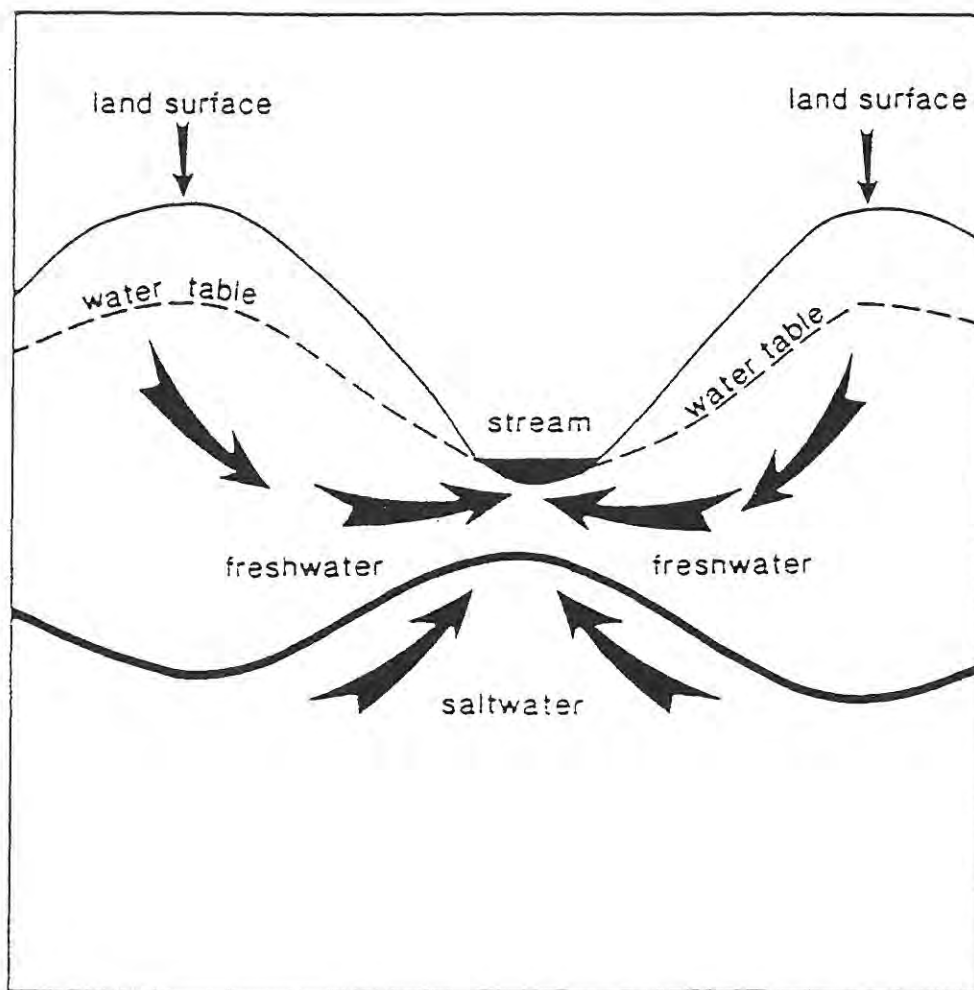


Figure 4.3.1-1. -- Areal distribution of dissolved chloride.



NOT TO SCALE

EXPLANATION



DIRECTION OF GROUND-WATER FLOW

Figure 4.3.1-2. -- Relation between freshwater and saltwater.

Received

JEF - 7 2016

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.1 Saltwater--Continued

The ground-water circulation in a drainage basin is from recharge areas in the hills to discharge areas in the valleys. The mean altitude of the water table is much higher under the hills, and saltwater is found at greater depth there than elsewhere in the basin. Some of the water percolating downward in the recharge area penetrates deeply enough to become part of the flow system involving the underlying saltwater.

In the discharge areas of the basins, deeper water is moving toward the surface. This water has mixed with the saltwater underlying the region and may be under greater hydraulic head than the overlying freshwater. Therefore, the saltwater moves upward to the surface when it reaches a fracture or well.

Man can also influence the depth to saltwater. Heavy pumping from the overlying freshwater zone can cause upward migration of the saltwater in areas where the saltwater is at shallow depth. Saltwater in oil and gas reservoirs is frequently under sufficient head to flow upward through wells. When deep wells are uncased or improperly cased, contamination of upper freshwater zones may occur (Bain and Friel, 1972). Secondary recovery techniques, such as the injection of carbon dioxide or saltwater under high pressure into deep oil-bearing zones, could cause saltwater to move into the freshwater zone by forcing it toward the surface. This is believed to be the problem around some oil fields in Tyler and Pleasants Counties.

Received

SEP 11 2003

Office of Oil and Gas
WV Dept. of Environmental Protection

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.2 Iron and Manganese

IRON AND MANGANESE POSE A PROBLEM FOR GROUND-WATER USE

Iron and manganese concentrations exceeded State drinking-water limits in many alluvial wells along the Ohio River.

Dissolved iron exceeded the 300 $\mu\text{g/L}$ limit for drinking water (West Virginia State Board of Health, 1981) in 14 of 41 alluvial wells, and dissolved manganese exceeded the 50 $\mu\text{g/L}$ limit for drinking water in 27 of 41 alluvial wells (figs. 4.3.2-1 and 4.3.2-2). Elevated iron and manganese concentrations in drinking water are not serious health hazards, but can cause problems in wells, distribution systems, food processing, and industrial processes.

Elevated iron and manganese concentrations in ground water can cause precipitates to form on well screens and in distribution lines. Iron and manganese can be removed from ground water after it has been withdrawn from a well. Thus, distribution lines usually can be protected from such precipitates, whereas well screens are more difficult to protect. Precipitates of iron and manganese and calcium carbonate clog screens and thus decrease well efficiency. As well efficiency decreases, increased drawdown can lower the water level below the top of the screen. Oxygen brought into contact with the screen further accelerates precipitation. Clogged well screens necessitate expensive cleaning or even the need for new wells (Jeffords, 1945).

The concentration of dissolved iron ranged from less than 3 to 52,000 $\mu\text{g/L}$ for all ground-water samples. The concentration of dissolved manganese ranged from less than 1 to 1,900 $\mu\text{g/L}$. Iron and manganese concentrations were significantly higher in ground water from alluvial wells than in ground water from bedrock wells. The median iron concentration was 50 $\mu\text{g/L}$ in alluvial wells and 16 $\mu\text{g/L}$ in bedrock wells. Likewise, median manganese concentration was 510 $\mu\text{g/L}$ in alluvial wells and 56 $\mu\text{g/L}$ in bedrock wells.

Ground water from some alluvial wells contained a higher concentration of manganese than iron. Hem (1970) states that ground water containing a higher concentration of manganese than iron is uncommon, but is present in wells along the Ohio River in West Virginia.

Received

JEP - 1/10/86

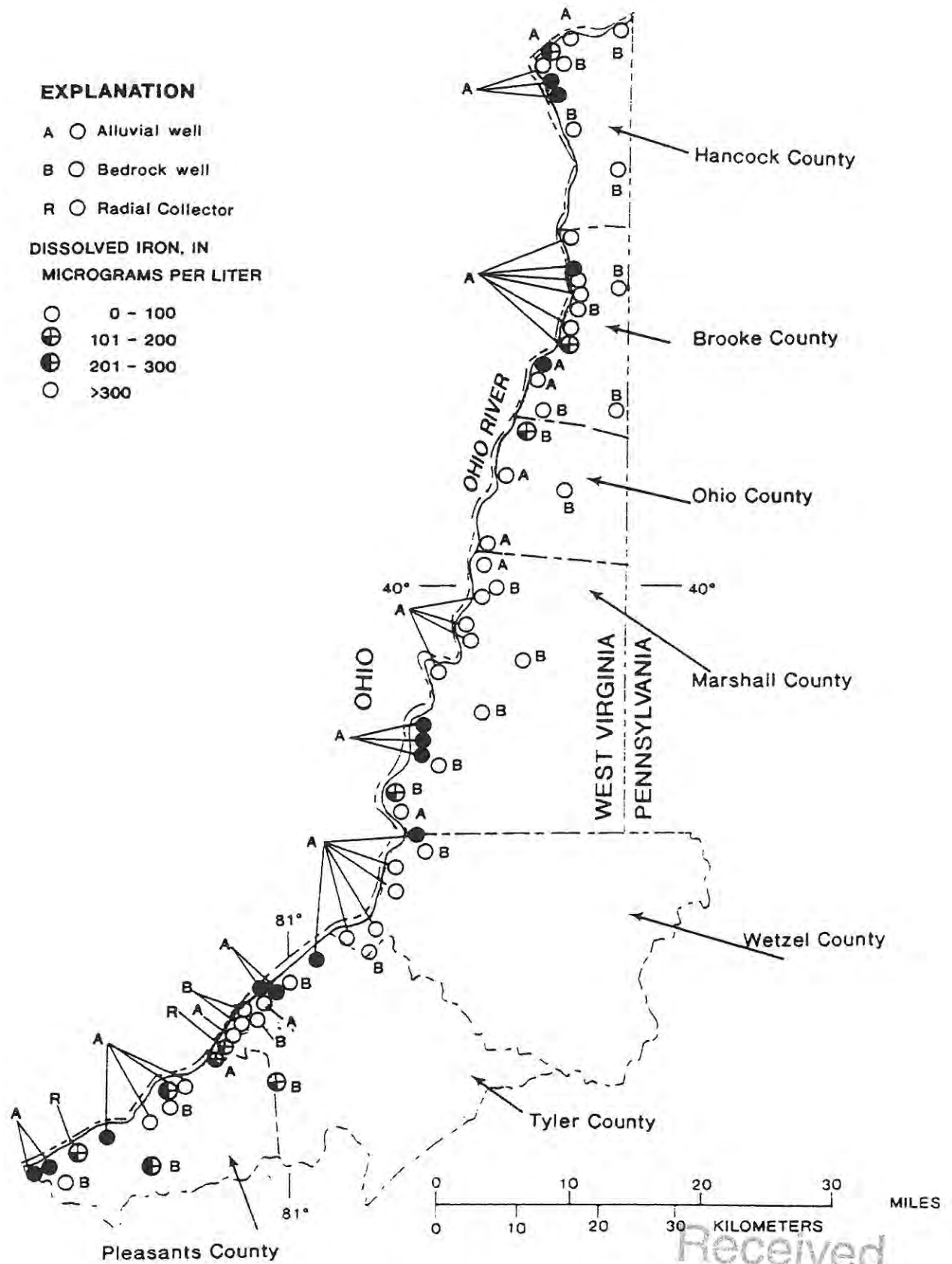


Figure 4.3.2-1. - - Areal distribution of dissolved iron.

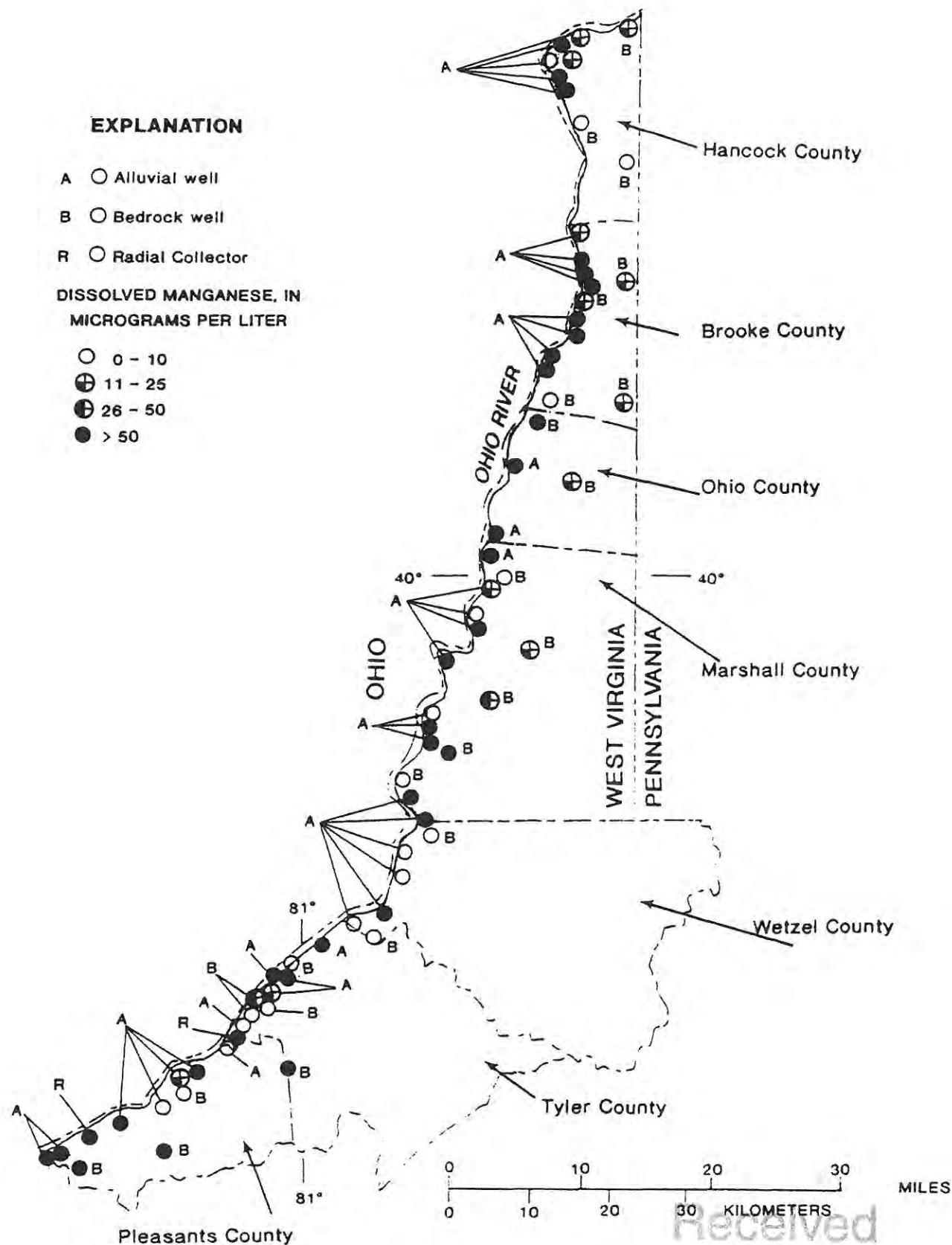


Figure 4.3.2-2. -- Areal distribution of dissolved manganese.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.3 Hardness

HARD WATER IS A COMMON PROBLEM

Hard ground water is found throughout the area and clogs well screens and distribution lines.

Hard water is a common problem throughout the area and is independent of the topographic location of the well or the geologic unit tapped. Hard water can cause well screens and distribution lines to become clogged with iron, manganese, and calcium carbonate precipitates. Ninety-one percent of the ground-water samples had a hardness concentration greater than 120 mg/L. Concentrations ranged from 30 to 1,700 mg/L, and the mean was 290 mg/L. Figure 4.3.3-1 shows the areal distribution of hardness. Hardness is classified by the U.S. Geological Survey (Durfor and Becker, 1964) based on the following ranges of equivalent calcium carbonate concentration in milligrams per liter: 0 to 60 is soft, 61 to 120 is moderately hard, 121 to 180 is hard, and greater than 180 is very hard. Calculations were based on the summation of calcium, magnesium, strontium, iron, aluminum, zinc, manganese, and barium concentrations (American Public Health Association, Inc., 1960, p. 132).

Calcium ions comprised an average of 74 percent of the hardness of each sample and magnesium ions comprised 24 percent. Together they comprised more than 90 percent of the hardness in every sample with one exception. A sample collected near Sistersville contained 52,000 $\mu\text{g/L}$ of iron, which contributed 44 percent of the hardness.

The major source of calcium and magnesium ions probably is limestone. Lithologic analyses of the Ohio River alluvium (Carlston and Graeff, 1955) contain limestone pebbles. Chemically, limestone is classified as a carbonate rock, and pure limestone consists of calcium carbonate. Limestone in this area generally is impure and contains variable amounts of magnesium carbonate; iron carbonate; iron oxide; iron sulfide (pyrite and marcasite); calcium phosphate; and sulfates of calcium, titanium, strontium, and barium. McCue and others (1939) list analyses of limestone samples collected in Ohio, Brooke, Marshall, and Tyler Counties.

Received

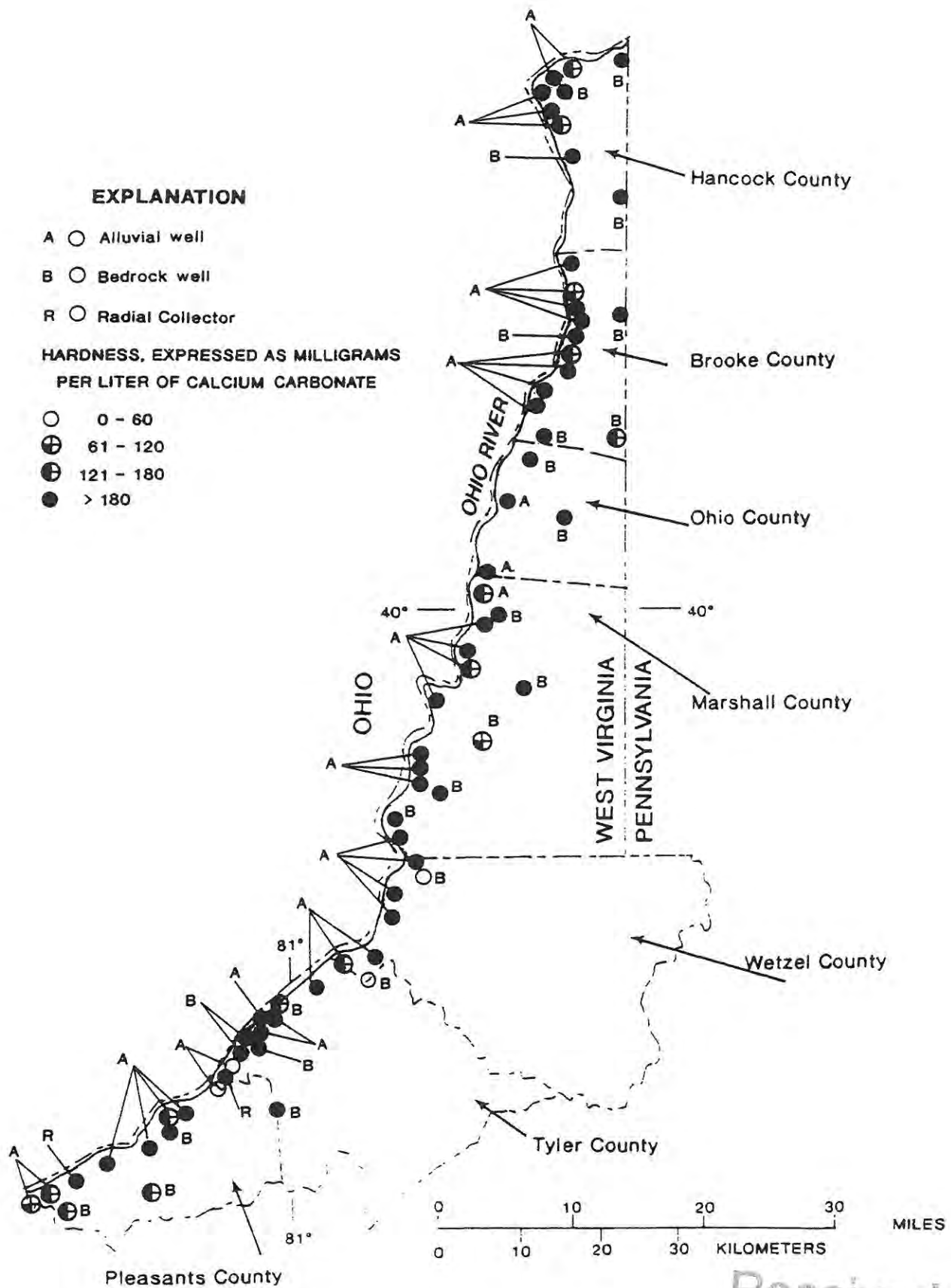


Figure 4.3.3-1. - - Areal distribution of hardness.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.4 Sulfate

FILL MAY CAUSE AN INCREASE IN DISSOLVED-SULFATE CONCENTRATION

An increase in dissolved sulfate may occur where fill is used to level or raise the land surface. Fill is commonly rich in pyrite and other sulfide minerals.

There is a strong correlation between elevated concentration of dissolved sulfate and location of areas containing such fill materials as cinders, fly ash, slag, and other waste associated with coal and steel industries. Five ground-water samples from wells exceeded the 250 mg/L limit of sulfate as recommended by the West Virginia State Board of Health (1981) for public-drinking water. All five wells are located on the alluvial flood plain in or near areas containing fill. The mean sulfate concentration for all samples was 123 mg/L, and values ranged from less than 1 to 2,400 mg/L. Radial collectors with laterals under the river were not included in the calculations because the samples contained a mixture of river water and ground water. Figure 4.3.4-1 shows the areal distribution of sulfate.

Fill is commonly rich in pyrite (FeS_2) and other sulfide minerals. Water percolating through the fill oxidizes the pyrite, which yields sulfate ions that dissolve in the water. Robison (1964) states that elevated sulfate in ground water from wells drilled on the flood plain in Ohio County may be attributed to the common practice of using coal-mine and steel-mill waste as fill.

Received

ST - 1015

Office of Oil and Gas
WV Dept. of Environmental Protection

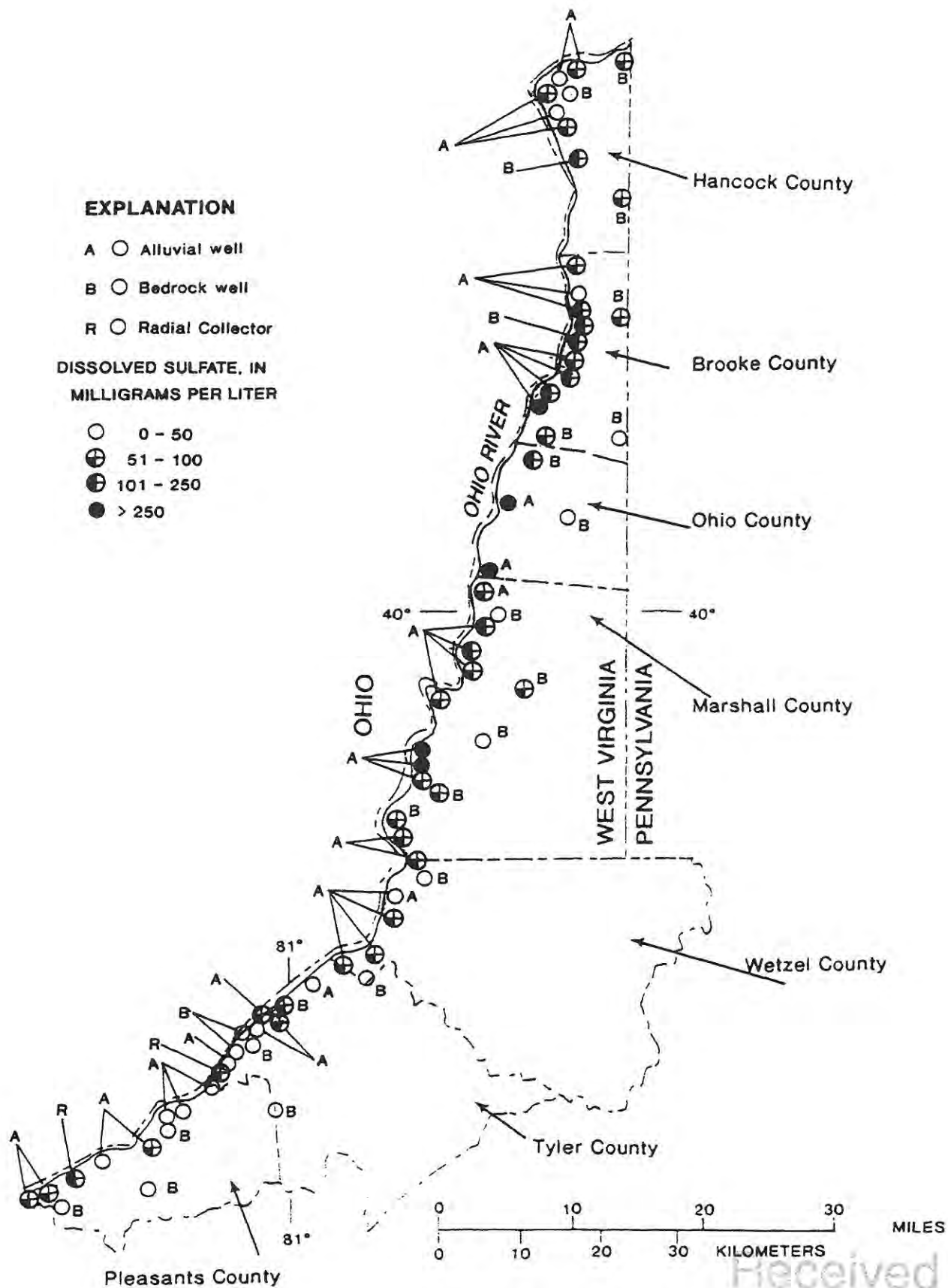


Figure 4.3.4-1. -- Areal distribution of dissolved sulfate.

4.0 WATER QUALITY--Continued

4.3 Chemical Constituents--Continued

4.3.5 Contaminants

CONTAMINANTS EXCEEDED STATE DRINKING-WATER LIMITS IN SOME WELLS

Arsenic, barium, mercury, or phenol concentrations exceeded State drinking-water limits in 7 of 50 ground-water samples.

Drinking-water limits, as established by the West Virginia State Board of Health (1981) for contaminants, were exceeded in 7 of 50 ground-water samples (fig. 4.3.5-1). Contaminant limits were exceeded as follows: arsenic, one well; barium, three wells; mercury, two wells; and phenols, three wells. Contaminants analyzed that did not exceed drinking-water limits in any well were cadmium, copper, lead, nitrate, selenium, silver, and zinc.

Concentration of arsenic ranged from 1 to 110 $\mu\text{g/L}$. Arsenic is reportedly not harmful in concentrations up to 1,000 $\mu\text{g/L}$ in drinking water for short-term use; but concentrations as low as 210 $\mu\text{g/L}$ have been reported as poisonous after long-term use (Hem, 1970).

Concentration of barium ranged from 20 to 11,000 $\mu\text{g/L}$; mercury ranged from less than 0.1 to 4.2 $\mu\text{g/L}$; and phenol ranged from less than 1 to 87 $\mu\text{g/L}$. Median concentration for barium in public-water supplies was reported to be 43 $\mu\text{g/L}$ (Durfor and Becker, 1964). Higher concentration of barium is associated with brines or water that has an elevated chloride concentration (Hem, 1959). The occurrence of detectable mercury in ground water is usually associated with industrial or mining waste. Likewise, phenols in water are the result of industrial pollution. Both mercury and phenols are toxic (Doll and others, 1963).

Received

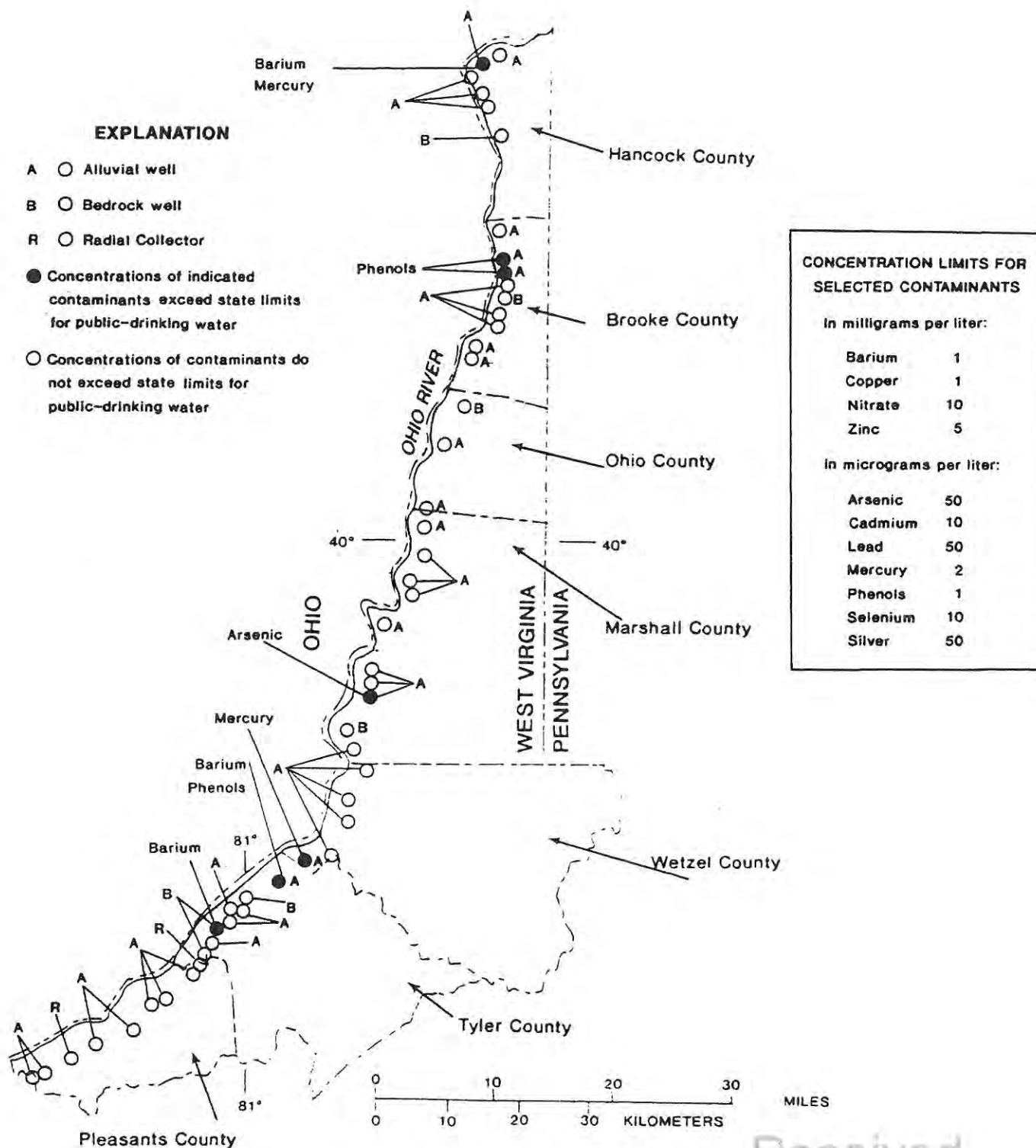


Figure 4.3.5-1. -- Areas where selected contaminant concentration exceeds established State limits (West Virginia State Board of Health, 1981).

4.0 WATER QUALITY--Continued

4.4 Relation to Ground-Water Movement

CHEMICAL QUALITY OF GROUND WATER PROVIDES INFORMATION ON GROUND-WATER MOVEMENT AND RECHARGE

Results of water-quality analyses indicate that (1) ground water flows from the adjacent hills toward the Ohio River; (2) a hydraulic connection exists between the alluvium and bedrock; and (3) precipitation is the major source of recharge to the alluvium.

Ground water flows from the adjacent hills toward the Ohio River. This is supported by changes in the chemical composition of ground water along the flow paths. The mean hardness of ground water from wells drilled into bedrock is as follows: bedrock underlying hilltops--280 mg/L, bedrock underlying hillsides--240 mg/L, bedrock underlying tributary valleys--140 mg/L, and bedrock underlying the Ohio River flood plain--280 mg/L. The decrease in ground-water hardness from hilltop to tributary-valley wells is probably due in part to sodium-calcium exchange. As water moves toward the valleys, it comes into contact with minerals having exchangeable sodium. Sodium has a higher exchange rate than calcium; thus, calcium ions in the ground water are exchanged for sodium ions. The higher ground-water hardness in wells that tap the bedrock underlying the Ohio River valley alluvium is probably due to induced mixing with the harder alluvial water. Ground water from wells open only to the alluvium has a mean hardness of 320 mg/L. When a well that is open to the underlying bedrock is pumped, water in the vicinity of the well may move downward from the alluvium into the bedrock. When this water mixes with water in the bedrock fractures, it causes an increase in hardness of the ground water in the bedrock. The amount of mixing depends on well depth, pumping rate, well efficiency, and local geology.

The trilinear water-analysis diagram in figure 4.4-1 shows the general chemical character of the water from the bedrock, alluvium, and Ohio River. On the central part of the diagram, some of the samples from alluvium and bedrock wells overlap, indicating that mixing of ground water from the two sources has been occurring. In order for the mixing of ground water from alluvium and bedrock to take place, there must be a hydraulic connection. However, only two ground-water samples overlap the group of Ohio River sample.

Received

Office of Oil and Gas
WV Dept. of Environmental Protection

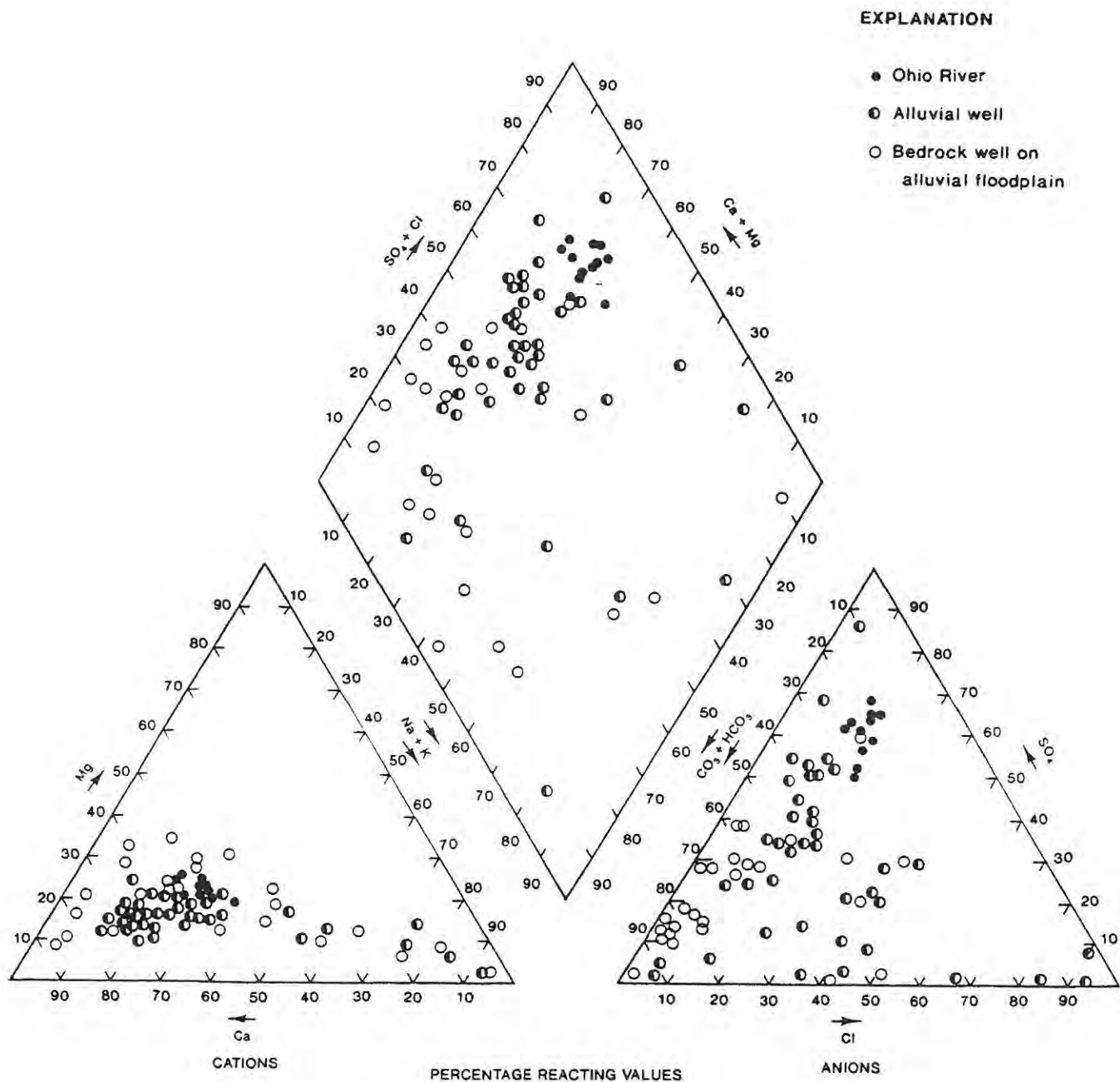


Figure 4.4-1. - - Trilinear water-analysis diagram of water samples from the alluvium, bedrock, and Ohio River.

Received

4.0 WATER QUALITY--Continued

4.4 Relation to Ground-Water Movement--Continued

Sulfate concentration also indicates a hydraulic connection between the alluvium and bedrock. The mean sulfate concentration of ground water from bedrock wells in the hills and tributary valleys was only 48 mg/L, while the mean sulfate concentration for wells open to the bedrock underlying the Ohio River valley alluvium was 100 mg/L. This increase in sulfate concentration may be caused by the mixing of ground water in the bedrock with ground water from the overlying alluvium that has a greater sulfate concentration. One probable source of the higher sulfate concentration in the alluvium is the fill material composed of industrial and mining waste that covers much of the alluvium (see section 4.3.4). Coal piles at coal-fired generating plants and at other industrial sites could be another source of the relatively high sulfate concentration in the alluvium. If sulfate leached from fill and from coal piles is reaching the ground water in the alluvium, precipitation must be an important source of recharge to the alluvium.

Received

5.0 SUMMARY

Ground-water reserves in West Virginia are contained in two aquifer systems. The largest is the system of fractures in the consolidated rock that underlies the State, and the other is the narrow band of alluvium that borders the Ohio and Kanawha Rivers. Ground-water use in Hancock, Brooke, Ohio, Marshall, Wetzel, Tyler, and Pleasants Counties was at least 6.3 billion gallons in 1980 for public supply, mining, and domestic purposes.

The consolidated rock that crops out in the study area is of Pennsylvanian or Permian age and includes the Allegheny Formation, Conemaugh Group, Monongahela Group, and Dunkard Group. Ground-water yields from these rock units are typically low for most wells in the study area. The only major geologic structure is the north-trending Burning Springs anticline in western Pleasants County. The alluvial deposits of Quaternary age are limited mostly to the flood plain of the Ohio River, but are the most productive aquifer system in the area. The lower part of the alluvial deposits consists of sand and gravel of glacial outwash origin and is overlain by clay and silt interspersed with sand stringers. In some areas, the tributary streams have deposited gravel deltas where they enter the valley of the Ohio River. In places, the alluvium has been covered or filled with industrial waste.

Ground water flows from the adjacent hills toward the river. As ground water from the hills enters bedrock underlying the flood plain, it mixes with the ground water percolating through the alluvium. Water-level measurements and water quality indicate that the alluvium and underlying bedrock are hydraulically connected and that the saturated zone is continuous in both rock units.

The alluvium is recharged by the following sources: (1) precipitation on the flood plain, (2) inflow from fractures and bedding-plane partings in the bedrock beneath and adjacent to the alluvium, (3) inflow from tributary streams through gravel deltas, and (4) induced inflow from the river. Precipitation is more likely to recharge the alluvial and bedrock aquifers during the months of November through April.

Drinking-water limits recommended by the West Virginia State Board of Health were exceeded in places by concentrations of iron, manganese, sulfate, arsenic, barium, mercury, and phenols. Hardness exceeded 120 mg/L in 91 percent of the samples. Chemical quality can help explain ground-water movement and recharge. Hardness decreases as the ground water moves through the bedrock from hills to valleys and then increases when it reaches the bedrock beneath the alluvial flood plain. Sulfate leached from fill in the alluvium appears in alluvial wells on the flood plain, indicating that precipitation is a significant source of recharge to the alluvium. Sulfate concentration was higher in bedrock underlying the alluvium than in bedrock underlying adjacent hills. This indicates that a good hydraulic connection exists between bedrock and alluvium. A trilinear water-analysis diagram shows that mixing of ground water from the bedrock and alluvium is occurring.

Received

6.0 DEFINITION OF TERMS

Confined ground water.--Confined ground water is under pressure significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs (Lohman and others, 1972).

Hydraulic conductivity.--A medium has a hydraulic conductivity of unit length per unit time if it will transmit in unit time a unit volume of ground water at the prevailing viscosity through a cross section of unit area, measured at right angles to the direction of flow, under a hydraulic gradient of unit change in head through unit length of flow (Lohman, 1972).

Hydraulic gradient.--The hydraulic gradient is the change in static head per unit of distance in a given direction (Lohman and others, 1972).

Porosity.--The porosity of a rock or a soil is its property of containing interstices or voids and may be expressed quantitatively as the ratio of the volume of its interstices to its total volume (Lohman and others, 1972).

Semiconfinement.--The distinction between confined and unconfined water is entirely gradational. The term semiconfined is used for the intermediate conditions. The material overlying an aquifer may be semipermeable so that water is only semiconfined (Davis and DeWiest, 1966).

Specific capacity.--The specific capacity of a well is the rate of discharge of water from the well divided by the drawdown of water level within the well (Lohman and others, 1972).

Specific discharge.--The specific discharge, or specific flux, for ground water is the rate of discharge of ground water per unit area measured at right angles to the direction of flow (Lohman and others, 1972).

Specific retention.--The specific retention of a rock or soil is the ratio of the volume of water, which the rock or soil, after being saturated, will retain against the pull of gravity to the volume of the rock or soil (Lohman and others, 1972).

Specific yield.--The specific yield of a rock or soil is the ratio of the volume of water which the rock or soil, after being saturated, will yield by gravity to the volume of the rock or soil (Lohman and others, 1972).

Storage coefficient.--The storage coefficient is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head (Lohman and others, 1972).

Transmissivity.--Transmissivity is the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient (Lohman and others, 1972).

Unconfined ground water.--Unconfined ground water is water in an aquifer that has a water table (Lohman and others, 1972).

Received

7.0 SELECTED REFERENCES

- American Public Health Association, Inc., 1960, Standard methods for the examination of water and wastewater (11th edition): New York, 626 p.
- Bader, J.S., 1984, Ground-water hydrology of the Guyandotte River basin, West Virginia: West Virginia Department of Natural Resources, Map report, scale 1:250,000, 1 sheet.
- _____, 1984, Ground-water hydrology of the Tug Fork and Twelvepole Creek basins, West Virginia: West Virginia Department of Natural Resources, Map report, scale 1:250,000, 1 sheet.
- Bader, J.S., Chisholm, J.L., Bragg, R.L., and Downs, S.C., 1980, Water resources of the Guyandotte River basin, West Virginia: West Virginia Geological and Economic Survey River Basin Bulletin 7, 201 p. (In press.)
- Bader, J.S., Mathes, M.V., and Runner, G.S., 1982, Water resources of Tug Fork of Big Sandy River basin, West Virginia, Kentucky, and Virginia, and Twelvepole Creek basin, West Virginia: West Virginia Geological and Economic Survey River Basin Bulletin 8. (In press.)
- Bader, J.S., and others, compilers, 1973, Selected references, ground-water contamination, the United States of America and Puerto Rico: U.S. Geological Survey Open-File Report 74-225, 103 p.
- Bain, G.L., and Friel, E.A., 1972, Water resources of the Little Kanawha River basin, West Virginia: West Virginia Geological and Economic Survey River Basin Bulletin 2, 122 p.
- Bentall, Ray, comp., 1963, Methods of determining permeability, transmissibility and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p. 243-341.
- Cardwell, D.H., 1978, Oil and gas report and map of Marshall, Wetzel, and Tyler Counties, West Virginia: West Virginia Geological and Economic Survey Bulletin 12A, 39 p.
- Cardwell, D.H., Erwin, R.B., and Woodward, H.P., Compilers, 1968, 1968 Geologic map of West Virginia: West Virginia Geological and Economic Survey Map, scale 1:250,000.
- Carlston, C.W., and Graeff, G.D., Jr., 1955, Ground-water resources of the Ohio River valley in West Virginia, pt. III, of Geology and economic resources of the Ohio River valley in West Virginia: West Virginia Geological Survey Volume XXII, p. 1-131.
- Chang, Mingteh; Lee, Richard; and Dickerson, W.H., 1976, Adequacy of hydrologic data for application in West Virginia: West Virginia University Water Research Institute Bulletin 7, series 78, No. 8-3, 1978, p. 78 and 84.
- Clark, W.E., Chisholm, J.L., and Frye, P.M., 1976, Water resources of the Upper New River basin, West Virginia: West Virginia Geological and Economic Survey River Basin Bulletin 4, 87 p.
- Crain, L.J., 1966, Ground-water resources of the Jamestown area, New York, with emphasis on the hydrology of the major stream valleys: New York Conservation Department, Water Resources Commission, Bulletin 58, 167 p.

Received

SEP

11

Office of Oil and Gas
WV Dept. of Environmental Protection

- Cross, A.T., and Schemel, M.P., 1956, Geology of the Ohio River valley in West Virginia, pt. I of Geology and economic resources of the Ohio River valley in West Virginia, 1956: West Virginia Geological and Economic Survey v. XXII, p. 1-149.
- Davis, S.N., and DeWiest, R.J.M., 1966, Hydrogeology: New York, John Wiley and Sons, Inc., 463 p.
- Davis, R.W., and Matthews, E.W., 1983, Chloroform contamination in part of the alluvial aquifer, southwest Louisville, Kentucky: U.S. Geological Survey Water-Supply Paper 2202, 25 p.
- Deutsch, Morris; Dove, G.D.; Jordan, P.R.; and Wallace, J.C., 1966, Ground-water distribution and potential in the Ohio River basin, in the Ohio River basin comprehensive survey, v. VI, Appendix E, Ground water: Corps of Engineers, U.S. Army Engineer Division, Ohio River, Cincinnati, Ohio, report, 197, p., 32 plates.
- Doll, W.L., Meyer, Gerald, and Archer, R.J., 1963, Water resources of West Virginia: West Virginia Department of Natural Resources, Division of Water Resources Report, 134 p.
- Durfor, C.N., and Becker, Edith, 1964, Public water supplies of the 100 largest cities in the United States, 1962: U.S. Geological Survey Water-Supply Paper 1812, 364 p.
- Fenneman, N.M., and Johnson, D.W., 1964, Physical divisions of the United States: U.S. Geological Survey Map prepared in cooperation with Physiographic Commission, U.S. Geological Survey, scale 1:7,000,000.
- Foster, J.B., 1980, Fresh and saline ground-water map of West Virginia: West Virginia Geological Survey Map WV-12, scale 1:250,000, 4 plates.
- Gallaher, J.T., and Price, W.E., Jr., 1966, Hydrology of the alluvial deposits in the Ohio River Valley in Kentucky: U.S. Geological Survey Water-Supply Paper 1818, 80 p.
- Grimsley, G.P., 1907, [Detailed geologic report of] Ohio, Brooke, and Hancock Counties: West Virginia Geological Survey County Report, 378 p., 16 plates.
- _____, 1910, [Detailed geologic report of] Pleasants, Wood, and Ritchie Counties: West Virginia Geological Survey County Report, 352 p., 21 plates.
- Grubb, H.F., 1975, Simulated drawdown for selected well fields in the Ohio River alluvial aquifer: U.S. Geological Survey Water-Resources Investigations 2-74, 38 p.
- Grubb, H.F., and Zehner, H.H., 1973, Aquifer diffusivity of the Ohio River alluvial aquifer by the flood-wave response method: U.S. Geological Survey Journal of Research, v. 1, no. 5, September-October 1973, p. 597-601.
- Haught, O.L., 1955a, Oil and gas report and map of Pleasants, Wood, and Ritchie Counties, West Virginia: West Virginia Geological and Economic Survey Bulletin 11, 21 p.
- _____, 1955b, Oil and gas report and map of Marshall, Wetzel, and Tyler Counties, West Virginia: West Virginia Geological and Economic Survey Bulletin 12, 49 p.
- Heath, R.C., 1983, Basic ground-water hydrology: U.S. Geological Survey Water-Supply Paper 2220, 84 p.
- Hem, J.D., 1959, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 1473, 269 p.
- _____, 1960a, Some chemical relationships among sulfur species and dissolved ferrous iron: U.S. Geological Survey Water-Supply Paper 1459-C, 73 p.

Received

SEP

1955

- _____. 1960b, Restraints on dissolved ferrous iron imposed by bicarbonate, redox potential, and pH: U.S. Geological Survey Water-Supply Paper 1459-B, 55 p.
- _____. 1963, Chemical equilibria and rates of manganese oxidation: U.S. Geological Survey Water-Supply Paper 1667-A, 64 p.
- _____. 1964, Deposition and solution of manganese oxides: U.S. Geological Survey Water-Supply Paper 1667-B, 42 p.
- _____. 1970, Study and interpretation of the chemical characteristics of natural water (2d ed.): U.S. Geological Survey Water-Supply Paper 1473, 363 p.
- _____. 1972, Chemical factors that influence the availability of iron and manganese in aqueous systems: Geological Society of America Special Paper 140, p. 17-24.
- Hennen, R.V., 1909**, [Detailed geologic report of] Marshall, Wetzell, and Tyler Counties: West Virginia Geological Survey County Report, 654 p., 12 plates.
- Jeffords, R.M., 1945**, Ground-water conditions along the Ohio Valley at Parkersburg, West Virginia: West Virginia Geological Survey Bulletin 10, 57 p.
- Jordan, P.R., 1966**, Preliminary survey of ground-water distribution and potential in the Ohio River basin, sub-drainage area 3, Upper Ohio River drainage area (area draining to the Ohio River between Pittsburgh and Marietta), *in* Ohio River basin comprehensive survey, v. VI., Appendix E, Ground water: Corps of Engineers, U.S. Army Engineer Division, Ohio River, Cincinnati, Ohio, report, p. 3-1 to 3-13, 2 plates.
- Kernodle, J.M., 1977**, Theoretical drawdown due to simulated pumpage from the Ohio River alluvial aquifer near Siloam, Kentucky: U.S. Geological Survey Water-Resources Investigations 77-24, 39.
- Lohman, S.W., 1972**, Ground-water hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.
- Lohman, S.W., and others, 1972**, Definitions of selected ground-water terms--revisions and conceptual refinements: U.S. Geological Survey Water-Supply Paper 1988, 21 p.
- McCue, J.B., Lucke, J.B., and Woodward, H.P., 1939**, Limestones of West Virginia: West Virginia Geological Survey, v. XII, 560 p.
- Munson, W.C., 1966**, Estimating consumptive use, Munson, P.E., index method, *in* Methods for estimating evapotranspiration: American Society of Civil Engineers Irrigation and Drainage Speciality Conference, Las Vegas, Nevada, November 1966, p. 65-107.
- National Oceanic and Atmospheric Administration, October 1973-November 1983**, Climatological data, West Virginia: National Climatic Center, Asheville, North Carolina. (Issued monthly.)
- _____. 1977, Climate of West Virginia: Asheville, North Carolina, 19 p.
- _____. 1982, Monthly normals of temperature, precipitation, and heating and cooling degree days 1951-80, West Virginia: Asheville, North Carolina, 10 p.
- Norris, S.E., 1970**, The effect of stream discharge on streambed leakage to a glacial outwash aquifer: U.S. Geological Survey Professional Paper 700-D, p. 262-265.
- Norris, S.E., and Eagon, H.B., Jr., 1971**, Recharge characteristics of a watercourse aquifer system at Springfield, Ohio, *in* Ground Water: v. 9, no. 1, p. 30-41.
- Norris, S.E., and Fidler, R.E., 1969**, Hydrogeology of the Scioto River valley near Piketon, south-central Ohio: U.S. Geological Survey Water-Supply Paper 1872, 70 p.

Received

- Patchen, D.G., 1982, Oil and gas activity in West Virginia, 1970-1979: West Virginia Geological and Economic Survey Circular C-29, 187 p.
- Pettyjohn, W.A., 1971, Water pollution by oil-field brines and related industrial wastes in Ohio: Ohio Journal of Science; 71, no. 5, September, p. 257-269.
- Price, P.H., Hare, C.E., McCue, J.B., and Hoskins, H.A., 1937, Salt brines of West Virginia: West Virginia Geological Survey, v. VIII, 203 p.
- Robison, T.M., 1964, Occurrence and availability of ground water in Ohio County, West Virginia: West Virginia Geological and Economic Survey Bulletin 27, 57 p.
- Rorabaugh, M.I., 1946, Ground-water resources of the southwestern part of the Louisville area, Kentucky: U.S. Geological Survey Open-File Report, 39 p.
- _____, 1956, Ground water in northeastern Louisville, Kentucky: U.S. Geological Survey Water-Supply Paper 1360-B, 69 p.
- Shultz, R.A., 1984, Ground-water hydrology of the minor tributary basins of the Ohio River, West Virginia: West Virginia Department of Natural Resources, Map report, scale 1:250,000, 1 sheet.
- Smith, R.C., Doll, W.L., and Stratton, Garland, 1955, Water resources of the Wheeling-Steubenville area, West Virginia and Ohio: U.S. Geological Survey Circular 340, 31 p.
- Stevens, H.C., and Lessing, Peter, 1982, Water use in West Virginia for 1980: West Virginia Geological and Economic Survey Circular C-27, 31 p.
- West Virginia State Board of Health, 1981, Public water-supply regulations: 47 p.
- Whitesides, D.V., and Ryder, P.D., 1969, Effects of pumping from the Ohio River Valley alluvium between Carrolton and Ghent, Kentucky: Kentucky Geological Survey Information Circular 18, 20 p.
- Wyrick, G.G., and Borchers, J.W., 1981, Hydrologic effects of stress-relief fracturing in an Appalachian valley: U.S. Geological Survey Water-Supply Paper 2177, 51 p.

Received

55

Office of Oil and Gas
WV Dept. of Environmental Protection