Appendix 4
2004 Offsite Analytical Data Laboratory Packages

GENERAL ENGINEERING LABORATORIES, LLC
a Member of THE GEL GROUP, INC.
Meeting Today's Needs with a Vision for Tomorrow

September 10, 2004

Mr. Dave Keefer
CYAPCo
Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424

RE: Quarterly Groundwater PO# 002337
Work Order: 120208
SDG: MSR#04-2742

Dear Mr. Keefer:
General Engineering Laboratories, LLC (GEL) appreciates the opportunity to provide the following analytical results for the sample(s) we received on August 27, 2004. Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time.
This data report has been prepared and reviewed in accordance with GEL's standard operating procedures. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4243.
Sincerely,

Cheryl Jones
Project Manager

Purchase Order: 002337
Enclosures

CONNECTICUT YANKEE

RE: Quarterly Groundwater

PO# 002337

Work Order: 120208

SDG: MSR# 04-2742

120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5

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CASE NARRATIVE

CASE NARRATIVE
For
CONNECTICUT YANKEE
RE: Quarterly Groundwater
PO# 002337
Work Order: 120208
SDG: MSR# 04-2742

September 10, 2004

Laboratory Identification:
General Engineering Laboratories, LLC

Mailing Address:
P.O. Box 30712
Charleston, South Carolina 29417

Express Mail Delivery and Shipping Address:
2040 Savage Road
Charleston, South Carolina 29407

Telephone Number:
(843) 556-8171

Summary:

Sample receipt

The groundwater samples for SDG# MSR# 04-2742 arrived at General Engineering Laboratories, LLC, (GEL) in Charleston, South Carolina on August 27, 2004. All sample containers arrived without any visible signs of tampering or breakage. The chain of custody contained the proper documentation and signatures.

The laboratory prepared the following samples:

Sample ID	Client Sample ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5

Items of Note:

There are no items to note.

Case Narrative:

Sample analyses were conducted using methodology as outlined in General Engineering Laboratories (GEL) Standard Operating Procedures. Any technical or administrative problems during analysis, data review, and reduction are listed below by analytical parameter.

Analytical Request:

Three groundwater samples were analyzed for ALL.

Internal Chain of Custody:

Custody was maintained for all of these samples.

Data Package:

The enclosed data package contains the following sections: Case Narrative, Chain of Custody, Cooler Receipt Checklist, Laboratory Certifications, and all Analytical Fractions.

I certify that this data package is in compliance with the SOW, both technically and for completeness, for other than the conditions detailed above. Release of the data contained in this hard copy data package has been authorized by the Laboratory Manager or a designee, as verified by the following signature.

Cheryl Jones
Project Manager

CHAIN OF CUSTODY

Chain of Custody Form

No. 2004-00175

Connecticut Yankee Atomic Power Company
362 Injun Hollow Road, East Hampton, CT 06424
860-267-2556

1202089.

Project Name: Haddam Neck Decommissioning

Contact Name & Phone:
David Keefer 860-267-2556 (x3085)

Analytical Lab (Name, City, State):
General Engineering Lab (GEL), 2040 Savage Rd, Charleston, SC 29407, 843.556.8171 (Sarah Kozlik)

Priority: ☐ 45 D. ☐ 30 D. ☒ 14 D. ☐ 7 D.
Other:

Sample Designation	Date	Time	Media Code	Sample Type Code	Container Size- &Type Code	Analyses Requested: ALL						Lab Use Only: Comment, Preservation	Lab Use Only: Lab Sample ID
S153-176-2,3,4,5	08/13/04	15:00	WG	G	4-LP (3) 1-LP (1)	X						20-ml Nitric (4L 3ea.), None (1-L 1ea.)	

NOTES: PO #: 002337 MSR #: 04-2742 ☐ LTP QA ☐ Radwaste QA ☒ Non QA

Sample should be analyzed for ALL suite of analyses to typical groundwater program MDC's.

1) Relinquished By:	Date/Time	2) Received By	Date/Time
Matt Darois	8/26/04 0940		8/27/04 0915
3) Relinquished By	Date/Time	4) Received By	Date/Time
5) Relinquished By	Date/Time	6) Received By	Date/Time

Samples Shipped Via:
☒ Fed Ex
☐ UPS
☐ Hand
☐ Other ~~29107~~ MED

Bill of Lading #
7913 2910 2943

Internal Container Temp.: ___ Deg. C

Custody Sealed?
Y ☐ N ☐

Custody Seal Intact?
Y ☐ N ☐

Chain of Custody Form

No. 2004-00176

Connecticut Yankee Atomic Power Company
362 Injun Hollow Road, East Hampton, CT 06424
860-267-2556

Project Name: Haddam Neck Decommissioning

Contact Name & Phone:
David Keefer 860-267-2556 (x3085)

Analytical Lab (Name, City, State):
General Engineering Lab (GEL), 2040 Savage Rd, Charleston, SC 29407, 843.556.8171 (Sarah Kozlik)

Priority: ☐ 45 D. ☐ 30 D. ☒ 14 D. ☐ 7 D.
Other:

Sample Designation	Date	Time	Media Code	Sample Type Code	Container Size- &Type Code	Analyses Requested: ALL	Lab Use Only: Comment, Preservation	Lab Use Only: Lab Sample ID
S152-157-2,3,4,5	06/10/04	10:40	WG	G	4-LP (3) 1-LP (1)	X	20-ml Nitric (4L 3ea.), None (1-L 1ea.)	

NOTES: PO #: 002337 MSR #: 04-2742 ☐ LTP QA ☐ Radwaste QA ☒ Non QA

Sample should be analyzed for ALL suite of analyses to typical groundwater program MDC's.

Samples Shipped Via:
☒ Fed Ex
☐ UPS
☐ Hand
☐ Other ____

Internal Container Temp.: ____ Deg. C

Custody Sealed? Y ☐ N ☐

Custody Seal Intact? Y ☐ N ☐

1) Relinquished By: MED Matt Davis	Date/Time ~~8/25/04~~	2) Received By MED	Date/Time
3) Relinquished By Matt Davis	Date/Time 8/26/04 0942	4) Received By	Date/Time 8/27/04 0915
5) Relinquished By	Date/Time	6) Received By	Date/Time

7902 5277 0109
Bill of Lading #

Chain of Custody Form

No. 2004-00174

Connecticut Yankee Atomic Power Company
362 Injun Hollow Road, East Hampton, CT 06424
860-267-2556

Project Name: Haddam Neck Decommissioning

Contact Name & Phone:
David Keefer 860-267-2556 (x3085)

Analytical Lab (Name, City, State):
General Engineering Lab (GEL), 2040 Savage Rd, Charleston, SC 29407, 843.556.8171 (Sarah Kozlik)

Priority: ☐ 45 D. ☐ 30 D. ☒ 14 D. ☐ 7 D.
Other:

Sample Designation	Date	Time	Media Code	Sample Type Code	Container Size- &Type Code	Analyses Requested: ALL						Lab Use Only: Comment, Preservation	Lab Use Only: Lab Sample ID
S103-108-2,3,4,5	07/01/04	10:05	WG	G	4-LP (3) 1-LP (1)	X						20-ml Nitric (4L 3ea.), None (1-L 1ea.)	

NOTES: PO #: 002337 MSR #: 04-2742 ☐ LTP QA ☐ Radwaste QA ☒ Non QA

Sample should be analyzed for ALL suite of analyses to typical groundwater program MDC's.

1) Relinquished By	Date/Time	2) Received By	Date/Time
Matt Durors	8/26/04 0936		8/27/04 0915
3) Relinquished By	Date/Time	4) Received By	Date/Time
5) Relinquished By	Date/Time	6) Received By	Date/Time

Samples Shipped Via:
☒ Fed Ex
☐ UPS
☐ Hand
☐ Other ____

7920 7579 7114
Bill of Lading #
MSR# 04-2742

Internal Container Temp.: ____ Deg. C

Custody Sealed?
Y ☐ N ☐

Custody Seal Intact?
Y ☐ N ☐

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COOLER RECEIPT CHECKLIST

Figure 1. Sample Check-in List

Date/Time Received: 8/27/2004 - 0915

SDG#: MSR#04-2742

Work Order Number: 120208

Shipping Container ID: _____ Chain of Custody # 2004-00174

1. Custody Seals on shipping container intact? Yes [✓] No [ ]
2. Custody Seals dated and signed? Yes [✓] No [ ]
3. Chain-of-Custody record present? Yes [✓] No [ ]
4. Cooler temperature 18.0°C
5. Vermiculite/packing materials is: ~~N/A~~ Wet [ ] Dry [✓]
6. Number of samples in shipping container: 4
7. Sample holding times exceeded? Yes [ ] No [✓]

8. Samples have:
   - ✓ tape
   - ✓ hazard labels
   - ✓ custody seals
   - ✓ appropriate sample labels

9. Samples are:
   - ✓ in good condition
   - ____ leaking
   - ____ broken
   - ____ have air bubbles

10. Were any anomalies identified in sample receipt? Yes [ ] No [✓]
11. Description of anomalies (include sample numbers): _____

RAD SCREEN = 30 CPM

Sample Custodian/Laboratory: NCW Date: 8-27-04

Telephoned to: _____ On _____ By _____

Figure 1. Sample Check-in List

Date/Time Received: 8/27/04 - 0915

SDG#: MSR# 04-2742

Work Order Number: 120208

Shipping Container ID: _____ Chain of Custody # 2004-00175

1. Custody Seals on shipping container intact? Yes [✓] No [ ]
2. Custody Seals dated and signed? Yes [✓] No [ ]
3. Chain-of-Custody record present? Yes [✓] No [ ]
4. Cooler temperature 18.0° C
5. Vermiculite/packing materials is: Wet [ ] Dry [✓]
6. Number of samples in shipping container: 4
7. Sample holding times exceeded? Yes [ ] No [✓]

8. Samples have:
   - ✓ tape
   - ✓ hazard labels
   - ✓ custody seals
   - ✓ appropriate sample labels

9. Samples are:
   - ✓ in good condition
   - ____ leaking
   - ____ broken
   - ____ have air bubbles

10. Were any anomalies identified in sample receipt? Yes [ ] No [✓]
11. Description of anomalies (include sample numbers): LAB SCREEN = 30 cpm

Sample Custodian/Laboratory: M. Cahill Date: 8/27/04

Telephoned to: _____ On _____ By _____

Figure 1. Sample Check-in List

Date/Time Received: 8/27/04 0915

SDG#: MSR # 04-2742

Work Order Number: 120208

Shipping Container ID: _____ Chain of Custody # 2004-00176

1. Custody Seals on shipping container intact? Yes [✓] No [ ]
2. Custody Seals dated and signed? Yes [✓] No [ ]
3. Chain-of-Custody record present? Yes [✓] No [ ]
4. Cooler temperature 18.0 °C
5. Vermiculite/packing materials is: Wet [ ] Dry [✓]
6. Number of samples in shipping container: 4
7. Sample holding times exceeded? Yes [ ] No [✓]

8. Samples have:

✓ tape	✓ hazard labels
✓ custody seals	✓ appropriate sample labels

9. Samples are:

✓ in good condition	___ leaking
___ broken	___ have air bubbles

10. Were any anomalies identified in sample receipt? Yes [ ] No [✓]
11. Description of anomalies (include sample numbers): _____

RAD SCREEN = 30 cpm

Sample Custodian/Laboratory: [signature] Date: 8/27/04

Telephoned to: _____ On _____ By _____

INORGANIC ANALYSIS

Metals Fractional Narrative
Connecticut Yankee Atomic Power Co. (YANK)
SDG MSR#04-2742

Method/Analysis Information

Analytical Batch:	363906
Prep Batch :	363905
Standard Operating Procedures:	GL-MA-E-014 REV# 9, GL-MA-E-006 REV# 9
Analytical Method:	SW846 6020
Prep Method :	SW846 3005A

Sample Analysis

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200698170	Method Blank (MB)
1200698171	Laboratory Control Sample (LCS)
1200698174	120208001(S153-176-2,3,4,5L) Serial Dilution (SD)
1200698172	120208001(S153-176-2,3,4,5D) Sample Duplicate (DUP)
1200698173	120208001(S153-176-2,3,4,5S) Matrix Spike (MS)

Preparation/Analytical Method Verification

The SOP stated above has been prepared based on technical research and testing conducted by General Engineering Laboratories, LLC. and with guidance from the regulatory documents listed in this "Method/Analysis Information" section.

System Configuration

The ICP-MS analysis was performed on a Perkin Elmer ICP-MS ELAN 9000. The instrument is equipped with a cross-flow nebulizer, quadrupole mass spectrometer, and dual mode electron multiplier detector. Internal standards of scandium, germanium, indium, and tantalum were utilized to cover the mass spectrum. Operating conditions are set at 1400W power and combined argon pressures of 360+/-7 kPa for the plasma and auxiliary gases, and 0.85 L/min carrier gas flow, and an initial lens voltage of 5.2.

Calibration Information

Instrument Calibration
All initial calibration requirements have been met for this sample delivery group (SDG).

CRDL Requirements
All CRDL standard(s) met the referenced advisory control limits.

ICSA/ICSAB statement
All interference check samples (ICSA and ICSAB) associated with this SDG met the established acceptance criteria.

Continuing Calibration Blank (CCB) Requirements
All continuing calibration blanks (CCB) bracketing this batch met the established acceptance criteria.

Continuing Calibration Verification (CCV) Requirements
All continuing calibration verifications (CCV) bracketing this SDG met the acceptance criteria.

Quality Control (QC) Information

Method Blank (MB) Statement
The MB analyzed with this SDG met the acceptance criteria.

Laboratory Control Sample (LCS) Recovery
The LCS spike recoveries met the acceptance limits.

Quality Control (QC) Sample Statement
Sample 120208001 (S153-176-2,3,4 and 5) was selected as the quality control (QC) sample for this SDG.

Matrix Spike (MS) Recovery Statement
The percent recoveries (%R) obtained from the MS analyses are evaluated when the sample concentration is less than four times (4X) the spike concentration added. All applicable elements met the acceptance criteria.

Duplicate Relative Percent Difference (RPD) Statement
The RPD obtained from the designated sample duplicate (DUP) is evaluated based on acceptance criteria of 20% when the sample is 5X the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control of +/-RL is used to evaluate the DUP results. All applicable analytes met these requirements.

Serial Dilution % Difference Statement
The SDILT failed for B. All-ICP-MS.
The serial dilution is used to assess matrix suppression or enhancement. Raw element concentrations 25x the IDL for CVAA, 50X the IDL for ICP and 100X the IDL for ICP-MS analyses are applicable for serial dilution assessment. All applicable analytes did not meet the established criteria of less than 10% difference (%D). All-ICP-MS.

Technical Information

Holding Time Specifications
GEL assigns holding times based on the associated methodology, which assigns the date and time from sample collection of sample receipt. Those holding times expressed in hours are calculated in the AlphaLIMS system. Those holding times expressed as days expire at midnight on the day of expiration. All samples in this SDG met the specified holding time.

Preparation/Analytical Method Verification
All procedures were performed as stated in the SOP.

Sample Dilutions
Dilutions are performed to minimize matrix interferences resulting from elevated mineral element concentrations present in soil samples and/or to bring over range target analyte concentrations into the linear calibration range of the instrument. The samples in this SDG did not require dilutions.

Preparation Information
The samples in this SDG were prepared exactly according to the cited SOP.

Miscellaneous Information

Nonconformance Documentation
Nonconformance reports (NCRs) are generated to document procedural anomalies that may deviate from referenced SOP or contractual documents. A NCR was not required for this SDG.

Additional Comments
Additional comments were not required for this SDG.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: _____ **Date:** 9/14

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 14, 2004

Client Sample ID: S153-176-2,3,4,5
Sample ID: 120208001
Matrix: Ground Water
Collect Date: 13-AUG-04 15:00
Receive Date: 27-AUG-04
Collector: Client

Project: YANK00304
Client ID: YANK001

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Metals Analysis-ICP-MS											
3005/6020 Boron-ALL,STND,MIX											
Boron		189	0.540	16.0	ug/L	1	BAJ	09/12/04	1820	363906	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
V846 3005A	ICP-MS 3005 PREP	CQH1	09/08/04	2109	363905

The following Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 14, 2004

Client Sample ID: S152-157-2,3,4,5
Sample ID: 120208002
Matrix: Ground Water
Collect Date: 10-JUN-04 10:40
Receive Date: 27-AUG-04
Collector: Client

Project: YANK00304
Client ID: YANK001

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Metals Analysis-ICP-MS											
3005/6020 Boron-ALL,STND,MIX											
Boron		214	0.540	16.0	ug/L	1	BAJ	09/12/04	1841	363906	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	CQH1	09/08/04	2109	363905

The following Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 14, 2004

Client Sample ID: S103-108-2,3,4,5
Sample ID: 120208003
Matrix: Ground Water
Collect Date: 01-JUL-04 10:05
Receive Date: 27-AUG-04
Collector: Client

Project: YANK00304
Client ID: YANK001

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Metals Analysis-ICP-MS											
3005/6020 Boron-ALL,STND,MIX											
Boron		45.2	0.540	16.0	ug/L	1	BAJ	09/12/04	1846	363906	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	CQH1	09/08/04	2109	363905

The following Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: September 14, 2004

Client: CYAPCo
Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut
Contact: Mr. Dave Keefer

Workorder: 120208

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Metals Analysis - ICPMS										
Batch 363906										
QC1200698172 120208001 DUP										
Boron		189		199	ug/L	5		(0%-20%)	BAJ	09/12/04 18:25
QC1200698171 LCS										
Boron	100			112	ug/L		112	(80%-120%)		09/12/04 18:15
QC1200698170 MB										
Boron			U	ND	ug/L					09/12/04 18:10
QC1200698173 120208001 MS										
Boron	100	189		312	ug/L		123	(75%-125%)		09/12/04 18:31
QC1200698174 120208001 SDILT										
Boron		189		51.2	ug/L	35.4				09/12/04 18:36

Notes:
The Qualifiers in this report are defined as follows:

- B Target analyte was detected in the sample as well as the associated blank.
- BD Flag for results below the MDC or a flag for low tracer recovery.
- E Concentration of the target analyte exceeds the instrument calibration range.
- H Analytical holding time exceeded.
- J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
- U Indicates the target analyte was analyzed for but not detected above the detection limit.
- UI Uncertain identification for gamma spectroscopy.
- X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
- h Sample preparation or preservation holding time exceeded.

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

RADIOLOGICAL ANALYSIS

Radiochemistry Case Narrative
Connecticut Yankee Atomic Power Co. (YANK)
SDG MSR#04-2742

Method/Analysis Information

Product:	**Am241,Cm, Liquid-ALL**
Analytical Method:	DOE EML HASL-300, Am-05-RC Modified
Analytical Batch Number:	361741

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200692804	Method Blank (MB)
1200692807	Laboratory Control Sample (LCS)
1200692805	120208001(S153-176-2,3,4,5) Sample Duplicate (DUP)
1200692806	120208001(S153-176-2,3,4,5) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-011 REV# 13.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208001 (S153-176-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis

None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Manual Integration
No manual integrations were performed on data in this batch.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Alphaspec Pu, Liquid-ALL**
Analytical Method:	DOE EML HASL-300, Pu-11-RC Modified
Analytical Batch Number:	361744

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200692814	Method Blank (MB)
1200692817	Laboratory Control Sample (LCS)
1200692815	120208001(S153-176-2,3,4,5) Sample Duplicate (DUP)
1200692816	120208001(S153-176-2,3,4,5) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-011 REV# 13.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208001 (S153-176-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Manual Integration
No manual integrations were performed on data in this batch.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint Pu241, Liquid-ALL**
Analytical Method:	DOE EML HASL-300, Pu-11-RC Modified
Analytical Batch Number:	361746

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200692820	Method Blank (MB)
1200692823	Laboratory Control Sample (LCS)
1200692821	120208001(S153-176-2,3,4,5) Sample Duplicate (DUP)
1200692822	120208001(S153-176-2,3,4,5) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-035 REV# 5.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208001 (S153-176-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Manual Integration
No manual integrations were performed on data in this batch.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF**
Analytical Method:	EPA 901.1
Analytical Batch Number:	362473

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200694603	Method Blank (MB)
1200694606	Laboratory Control Sample (LCS)
1200694604	120208001(S153-176-2,3,4,5) Sample Duplicate (DUP)
1200694605	120208001(S153-176-2,3,4,5) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-013 REV# 10.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208001 (S153-176-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information

Qualifier	Reason	Analyte	Sample
UI	Data rejected due to low abundance.	Bismuth-214	1200694604
		Lead-212	1200694604
UI	Data rejected due to no valid peak.	Lead-214	1200694604
		Thorium-230	1200694604

Method/Analysis Information

Product:	**Gross A/B, liquid-ALL,STND,MIX,PENN,LF**
Analytical Method:	EPA 900.0
Analytical Batch Number:	361900

Sample ID	Client ID
120208001	S153-176-2,3,4,5

120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200693212	Method Blank (MB)
1200693216	Laboratory Control Sample (LCS)
1200693213	120208002(S152-157-2,3,4,5) Sample Duplicate (DUP)
1200693214	120208002(S152-157-2,3,4,5) Matrix Spike (MS)
1200693215	120208002(S152-157-2,3,4,5) Matrix Spike Duplicate (MSD)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-001 REV# 8.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208002 (S152-157-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
Samples 1200693213 (S152-157-2,3,4,5), 120208002 (S152-157-2,3,4 and 5) were recounted due to high relative percent difference/relative error ratio.

Chemical Recoveries
All chemical recoveries meet the required acceptance limits for this sample set.

Gross Alpha/Beta Preparation Information
High hygroscopic salt content in evaporated samples can cause the sample mass to fluctuate due to moisture absorption. To minimize this interference, the salts are converted to oxides by heating the sample under a flame until a dull red color is obtained. The conversion to oxides stabilizes the sample weight and ensures that proper alpha/beta efficiencies are assigned for each sample. Volatile radioisotopes of carbon, hydrogen, technetium, polonium and cesium may be lost during sample heating.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Additional Comments
The alpha relative percent difference failed high. However, when a relative error ratio is calculated, it falls inside 1.0 with a value of .5930.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**GFPC, Sr90, liquid-ALL,MIX**
Analytical Method:	EPA 905.0 Modified
Analytical Batch Number:	361520

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200692415	Method Blank (MB)
1200692418	Laboratory Control Sample (LCS)
1200692416	120208001(S153-176-2,3,4,5) Sample Duplicate (DUP)
1200692417	120208001(S153-176-2,3,4,5) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-004 REV# 8.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208001 (S153-176-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Chemical Recoveries
All chemical recoveries meet the required acceptance limits for this sample set.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint Tc99, Liquid-ALL**
Analytical Method:	DOE EML HASL-300, Tc-02-RC Modified
Analytical Batch Number:	361583

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200692487	Method Blank (MB)
1200692490	Laboratory Control Sample (LCS)
1200692488	120208003(S103-108-2,3,4,5) Sample Duplicate (DUP)
1200692489	120208003(S103-108-2,3,4,5) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-005 REV# 11.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208003 (S103-108-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
Sample 120208003 (S103-108-2,3,4 and 5) was recounted due to a negative result greater than three times the error.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint Fe55, Liquid-ALL**
Analytical Method:	DOE RESL Fe-1, Modified
Analytical Batch Number:	361838

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200693073	Method Blank (MB)
1200693076	Laboratory Control Sample (LCS)
1200693074	120208003(S103-108-2,3,4,5) Sample Duplicate (DUP)
1200693075	120208003(S103-108-2,3,4,5) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-040 REV# 2.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208003 (S103-108-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint Ni63, Liquid-ALL**
Analytical Method:	DOE RESL Ni-1, Modified
Analytical Batch Number:	361840

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200693077	Method Blank (MB)
1200693080	Laboratory Control Sample (LCS)
1200693078	120208003(S103-108-2,3,4,5) Sample Duplicate (DUP)
1200693079	120208003(S103-108-2,3,4,5) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering

Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-022 REV# 6.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208003 (S103-108-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier Information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN**
Analytical Method:	EPA 906.0 Modified
Analytical Batch Number:	361585

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5

1200692491	Method Blank (MB)
1200692494	Laboratory Control Sample (LCS)
1200692492	119484006(18541-006) Sample Duplicate (DUP)
1200692493	119484006(18541-006) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-002 REV# 9.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 119484006 (18541-006).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint C14, Liquid-ALL**
Analytical Method:	EPA EERF C-01 Modified

Analytical Batch Number: 361546

Sample ID	Client ID
120208001	S153-176-2,3,4,5
120208002	S152-157-2,3,4,5
120208003	S103-108-2,3,4,5
1200692447	Method Blank (MB)
1200692450	Laboratory Control Sample (LCS)
1200692448	120208001(S153-176-2,3,4,5) Sample Duplicate (DUP)
1200692449	120208001(S153-176-2,3,4,5) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-003 REV# 7.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 120208001 (S153-176-2,3,4 and 5).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information
Manual qualifiers were not required.

Certification Statement
Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:
GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.
The following data validator verified the information presented in this case narrative:

Reviewer: Elizabeth Cicak 9/10/04

SAMPLE DATA SUMMARY

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 10, 2004

Client Sample ID: S153-176-2.3.4.5
Sample ID: 120208001
Matrix: Ground Water
Collect Date: 13-AUG-04
Receive Date: 27-AUG-04
Collector: Client

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Alpha Spec Analysis													
Alphaspec Pu, Liquid-ALL													
Plutonium-238	U	-0.051	+/-0.0779	0.117	+/-0.0781	0.319	pCi/L		JAS1	09/03/04	0833	361744	1
Plutonium-239/240	U	-0.0597	+/-0.0736	0.100	+/-0.0737	0.284	pCi/L						
Am241,Cm, Liquid-ALL													
Americium-241	U	-0.0132	+/-0.068	0.0835	+/-0.068	0.248	pCi/L		JAS1	09/03/04	0833	361741	2
Curium-242	U	0.00	+/-0.0642	0.00	+/-0.0642	0.0887	pCi/L						
Curium-243/244	U	0.00359	+/-0.113	0.118	+/-0.113	0.317	pCi/L						
quid Scint Pu241, Liquid-ALL													
Plutonium-241	U	1.08	+/-7.42	6.20	+/-7.42	12.8	pCi/L		JAS1	09/05/04	0615	361746	3
Rad Gamma Spec Analysis													
Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF													
Americium-241	U	3.25	+/-8.84	6.72	+/-8.66	13.8	pCi/L		AKB	09/02/04	2102	362473	4
Cesium-134	U	-0.0124	+/-1.35	1.12	+/-1.33	2.39	pCi/L						
Cesium-137	U	1.67	+/-1.33	1.20	+/-1.30	2.55	pCi/L						
Cobalt-60	U	0.0755	+/-1.32	1.10	+/-1.29	2.42	pCi/L						
Europium-152	U	3.25	+/-3.91	3.36	+/-3.84	7.00	pCi/L						
Europium-154	U	-0.977	+/-3.82	3.09	+/-3.74	6.75	pCi/L						
Europium-155	U	-1.37	+/-5.34	4.32	+/-5.24	8.88	pCi/L						
Manganese-54	U	0.117	+/-1.37	1.13	+/-1.34	2.41	pCi/L						
Niobium-94	U	-0.957	+/-1.18	0.922	+/-1.16	1.97	pCi/L						
Silver-108m	U	-0.355	+/-1.34	1.07	+/-1.31	2.25	pCi/L						
Rad Gas Flow Proportional Counting													
GFPC, Sr90, liquid-ALL,MIX													
Strontium-90	U	0.368	+/-0.312	0.252	+/-0.329	0.518	pCi/L		HOB1	09/03/04	2308	361520	5
Gross A/B, liquid-ALL,STND,MIX,PENN,LF													
Alpha		129	+/-7.61	0.607	+/-12.0	1.53	pCi/L		LCW1	09/01/04	1358	361900	6
Beta		35.0	+/-3.24	1.53	+/-3.50	3.22	pCi/L						
Rad Liquid Scintillation Analysis													
LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN													
Tritium		8170	+/-381	167	+/-403	333	pCi/L		LAG1	08/30/04	2313	361585	7
Liquid Scint C14, Liquid-ALL													
Carbon-14	U	4.39	+/-31.6	26.4	+/-31.6	54.2	pCi/L		LAG1	09/01/04	2000	361546	8
Liquid Scint Fe55, Liquid-ALL													
Iron-55	U	-19.8	+/-13.0	9.17	+/-13.0	18.5	pCi/L		JLB1	09/04/04	0456	361838	9
Liquid Scint Ni63, Liquid-ALL													

GENERAL ENGINEERING LABORATORIES, LLC
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Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 10, 2004

Client Sample ID: S153-176-2.3.4.5
Sample ID: 120208001

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Liquid Scintillation Analysis													
Liquid Scint Ni63, Liquid-ALL													
Nickel-63	U	10.2	+/-7.40	5.91	+/-7.40	12.2	pCi/L		JLB1	09/03/04	1956	361840	10
Liquid Scint Tc99, Liquid-ALL													
Technetium-99	U	-2.14	+/-4.62	3.94	+/-4.62	8.09	pCi/L		DAJ1	09/06/04	1637	361583	11

The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, Pu-11-RC Modified
	DOE EML HASL-300, Am-05-RC Modified
	DOE EML HASL-300, Pu-11-RC Modified
4	EPA 901.1
5	EPA 905.0 Modified
6	EPA 900.0
7	EPA 906.0 Modified
8	EPA EERF C-01 Modified
9	DOE RESL Fe-1, Modified
10	DOE RESL Ni-1, Modified
11	DOE EML HASL-300, Tc-02-RC Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Plutonium-242	Alphaspec Pu, Liquid-ALL	99	(15%-125%)
Americium-243	Am241,Cm, Liquid-ALL	90	(25%-125%)
Carrier/Tracer Recovery	Liquid Scint Pu241, Liquid-ALL	99	
Carrier/Tracer Recovery	GFPC, Sr90, liquid-ALL,MIX	80	
Carrier/Tracer Recovery	Liquid Scint Fe55, Liquid-ALL	78	
Carrier/Tracer Recovery	Liquid Scint Ni63, Liquid-ALL	88	
Carrier/Tracer Recovery	Liquid Scint Tc99, Liquid-ALL	102	

Notes:
The Qualifiers in this report are defined as follows:

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.

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Certificate of Analysis

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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 10, 2004

Client Sample ID: S153-176-2,3,4,5
Sample ID: 120208001

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch Mtd.

J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Heather D Cecil

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 10, 2004

Client Sample ID: S152-157-2,3,4,5
Sample ID: 120208002
Matrix: Ground Water
Collect Date: 10-JUN-04
Receive Date: 27-AUG-04
Collector: Client

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch	Mtd.
Rad Alpha Spec Analysis												
Alphaspec Pu, Liquid-ALL												
Plutonium-238	U	0.0489	+/-0.134	0.112	+/-0.134	0.324	pCi/L		JAS1 09/03/04	0833	361744	1
Plutonium-239/240	U	0.0755	+/-0.130	0.0844	+/-0.131	0.269	pCi/L					
Am241,Cm, Liquid-ALL												
Americium-241	U	0.089	+/-0.122	0.0569	+/-0.123	0.210	pCi/L		JAS1 09/03/04	0833	361741	2
Curium-242	U	0.0386	+/-0.102	0.0579	+/-0.102	0.253	pCi/L					
Curium-243/244	U	-0.0328	+/-0.0844	0.115	+/-0.0845	0.326	pCi/L					
uid Scint Pu241, Liquid-ALL												
itonium-241	U	8.81	+/-7.67	6.18	+/-7.70	12.7	pCi/L		JAS1 09/05/04	0646	361746	3
Rad Gamma Spec Analysis												
Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF												
Americium-241	U	-0.847	+/-9.18	6.55	+/-8.99	13.6	pCi/L		AKB 09/02/04	2103	362473	4
Cesium-134	U	-0.98	+/-1.58	1.18	+/-1.55	2.56	pCi/L					
Cesium-137	U	-0.375	+/-1.39	1.10	+/-1.36	2.36	pCi/L					
Cobalt-60	U	1.45	+/-1.55	1.37	+/-1.52	2.98	pCi/L					
Europium-152	U	-2.54	+/-3.86	2.90	+/-3.78	6.11	pCi/L					
Europium-154	U	-1.16	+/-3.61	2.81	+/-3.54	6.28	pCi/L					
Europium-155	U	-1.78	+/-4.66	3.88	+/-4.57	8.02	pCi/L					
Manganese-54	U	-0.196	+/-1.60	1.26	+/-1.57	2.71	pCi/L					
Niobium-94	U	-0.469	+/-1.29	1.01	+/-1.26	2.15	pCi/L					
Silver-108m	U	0.586	+/-1.30	1.11	+/-1.27	2.34	pCi/L					
Rad Gas Flow Proportional Counting												
GFPC, Sr90, liquid-ALL,MIX												
Strontium-90	U	-0.161	+/-0.279	0.238	+/-0.283	0.490	pCi/L		HOB1 09/03/04	2356	361520	5
Gross A/B, liquid-ALL,STND,MIX,PENN,LF												
Alpha		26.4	+/-4.80	0.815	+/-5.17	2.23	pCi/L		LCW1 09/01/04	1825	361900	6
Beta		21.4	+/-3.69	2.13	+/-3.77	4.58	pCi/L					
Rad Liquid Scintillation Analysis												
LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN												
Tritium		2430	+/-253	156	+/-256	312	pCi/L		LAG1 08/31/04	0015	361585	7
Liquid Scint C14, Liquid-ALL												
Carbon-14	U	45.4	+/-36.2	29.3	+/-37.4	60.0	pCi/L		LAG1 09/01/04	2032	361546	8
Liquid Scint Fe55, Liquid-ALL												
Iron-55	U	-16.9	+/-13.5	9.48	+/-13.5	19.2	pCi/L		JLB1 09/04/04	0700	361838	9
Liquid Scint Ni63, Liquid-ALL												

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Company: CYAPCo
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East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 10, 2004

Client Sample ID: S152-157-2.3.4.5
Sample ID: 120208002

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Liquid Scintillation Analysis													
Liquid Scint Ni63, Liquid-ALL													
Nickel-63	U	2.56	+/-7.48	6.20	+/-7.48	12.8	pCi/L		JLB1	09/03/04	2027	361840	10
Liquid Scint Tc99, Liquid-ALL													
Technetium-99	U	-2.42	+/-4.65	3.97	+/-4.65	8.17	pCi/L		DAJ1	09/06/04	1709	361583	11

The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, Pu-11-RC Modified
2	DOE EML HASL-300, Am-05-RC Modified
3	DOE EML HASL-300, Pu-11-RC Modified
4	EPA 901.1
5	EPA 905.0 Modified
6	EPA 900.0
7	EPA 906.0 Modified
8	EPA EERF C-01 Modified
9	DOE RESL Fe-1, Modified
10	DOE RESL Ni-1, Modified
11	DOE EML HASL-300, Tc-02-RC Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Plutonium-242	Alphaspec Pu, Liquid-ALL	87	(15%-125%)
Americium-243	Am241,Cm, Liquid-ALL	96	(25%-125%)
Carrier/Tracer Recovery	Liquid Scint Pu241, Liquid-ALL	99	
Carrier/Tracer Recovery	GFPC, Sr90, liquid-ALL,MIX	78	
Carrier/Tracer Recovery	Liquid Scint Fe55, Liquid-ALL	80	
Carrier/Tracer Recovery	Liquid Scint Ni63, Liquid-ALL	83	
Carrier/Tracer Recovery	Liquid Scint Tc99, Liquid-ALL	101	

Notes:
The Qualifiers in this report are defined as follows:

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.

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Report Date: September 10, 2004

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Sample ID: 120208002

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch	Mtd.

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UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
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East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 10, 2004

Client Sample ID: S103-108-2.3.4.5
Sample ID: 120208003
Matrix: Ground Water
Collect Date: 01-JUL-04
Receive Date: 27-AUG-04
Collector: Client

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Alpha Spec Analysis													
Alphaspec Pu, Liquid-ALL													
Plutonium-238	U	0.00864	+/-0.0655	0.0609	+/-0.0655	0.205	pCi/L		JAS1	09/03/04	0833	361744	1
Plutonium-239/240	U	0.0234	+/-0.0621	0.0351	+/-0.0622	0.154	pCi/L						
Am241,Cm, Liquid-ALL													
Americium-241	U	0.00942	+/-0.0714	0.0664	+/-0.0714	0.224	pCi/L		JAS1	09/03/04	0833	361741	2
Curium-242	U	0.00	+/-0.0867	0.00	+/-0.0867	0.120	pCi/L						
Curium-243/244	U	0.0338	+/-0.0663	0.00	+/-0.0665	0.0917	pCi/L						
liquid Scint Pu241, Liquid-ALL													
Plutonium-241	U	1.49	+/-8.11	6.76	+/-8.11	13.9	pCi/L		JAS1	09/05/04	0718	361746	3
Rad Gamma Spec Analysis													
Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF													
Americium-241	U	3.70	+/-7.09	6.14	+/-6.94	12.7	pCi/L		AKB	09/02/04	2108	362473	4
Cesium-134	U	1.15	+/-1.39	1.21	+/-1.36	2.60	pCi/L						
Cesium-137	U	0.792	+/-1.38	1.17	+/-1.35	2.49	pCi/L						
Cobalt-60	U	0.314	+/-1.41	1.18	+/-1.38	2.59	pCi/L						
Europium-152	U	2.56	+/-4.30	2.97	+/-4.21	6.25	pCi/L						
Europium-154	U	-0.771	+/-3.97	3.16	+/-3.89	6.96	pCi/L						
Europium-155	U	-1.7	+/-4.96	4.07	+/-4.86	8.40	pCi/L						
Manganese-54	U	-1.14	+/-1.28	0.987	+/-1.26	2.15	pCi/L						
Niobium-94	U	1.13	+/-1.18	1.03	+/-1.15	2.19	pCi/L						
Silver-108m	U	-0.57	+/-1.28	1.03	+/-1.25	2.18	pCi/L						
Rad Gas Flow Proportional Counting													
GFPC, Sr90, liquid-ALL,MIX													
Strontium-90	U	-0.00757	+/-0.332	0.279	+/-0.332	0.574	pCi/L		HOB1	09/04/04	0004	361520	5
Gross A/B, liquid-ALL,STND,MIX,PENN,LF													
Alpha		11.9	+/-2.36	0.692	+/-2.61	1.68	pCi/L		LCW1	09/01/04	1358	361900	6
Beta		12.4	+/-2.20	1.46	+/-2.30	3.09	pCi/L						
Rad Liquid Scintillation Analysis													
LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN													
Tritium		1290	+/-240	169	+/-241	338	pCi/L		LAG1	08/31/04	0118	361585	7
Liquid Scint C14, Liquid-ALL													
Carbon-14	U	-0.434	+/-31.1	26.1	+/-31.1	53.5	pCi/L		LAG1	09/01/04	2104	361546	8
Liquid Scint Fe55, Liquid-ALL													
Iron-55	U	-12.3	+/-13.6	9.51	+/-13.6	19.2	pCi/L		JLB1	09/04/04	0904	361838	9
Liquid Scint Ni63, Liquid-ALL													

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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: September 10, 2004

Client Sample ID: S103-108-2.3.4.5
Sample ID: 120208003

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Liquid Scintillation Analysis													
Liquid Scint Ni63, Liquid-ALL													
Nickel-63	U	1.91	+/-7.45	6.20	+/-7.45	12.8	pCi/L		JLB1	09/03/04	2059	361840	10
Liquid Scint Tc99, Liquid-ALL													
Technetium-99	U	-6.04	+/-4.50	3.95	+/-4.50	8.13	pCi/L		DAJ1	09/08/04	1015	361583	11

The following Analytical Methods were performed

Method	Description
	DOE EML HASL-300, Pu-11-RC Modified
	DOE EML HASL-300, Am-05-RC Modified
3	DOE EML HASL-300, Pu-11-RC Modified
4	EPA 901.1
5	EPA 905.0 Modified
6	EPA 900.0
7	EPA 906.0 Modified
8	EPA EERF C-01 Modified
9	DOE RESL Fe-1, Modified
10	DOE RESL Ni-1, Modified
11	DOE EML HASL-300, Tc-02-RC Modified

Surrogate/Tracer recovery	Test	Recovery %	Acceptable Limits
Plutonium-242	Alphaspec Pu, Liquid-ALL	90	(15%-125%)
Americium-243	Am241,Cm, Liquid-ALL	88	(25%-125%)
Carrier/Tracer Recovery	Liquid Scint Pu241, Liquid-ALL	91	
Carrier/Tracer Recovery	GFPC, Sr90, liquid-ALL,MIX	62	
Carrier/Tracer Recovery	Liquid Scint Fe55, Liquid-ALL	80	
Carrier/Tracer Recovery	Liquid Scint Ni63, Liquid-ALL	81	
Carrier/Tracer Recovery	Liquid Scint Tc99, Liquid-ALL	101	

Notes:
The Qualifiers in this report are defined as follows :

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BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.

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Report Date: September 10, 2004

Client Sample ID: S103-108-2.3.4.5
Sample ID: 120208003

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch	Mtd.

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QUALITY CONTROL DATA

GENERAL ENGINEERING LABORATORIES, LLC
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QC Summary

Report Date: September 10, 2004

Client: CYAPCo
Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut
Contact: Mr. Dave Keefer

Workorder: 120208

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time
Rad Alpha Spec											
Batch 361741											
QC1200692805 120208001 DUP											
Americium-241	U	-0.0132	U	0.0551	pCi/L	N/A		(0% - 100%)	JAS1	09/02/04	14:32
	Uncert:	+/-0.068		+/-0.109							
	TPU:	+/-0.068		+/-0.109							
Curium-242	U	0.00	U	-0.016	pCi/L	N/A		(0% - 100%)			
	Uncert:	+/-0.0642		+/-0.0691							
	TPU:	+/-0.0642		+/-0.0692							
Curium-243/244	U	0.00359	U	-0.0135	pCi/L	N/A		(0% - 100%)			
	Uncert:	+/-0.113		+/-0.0697							
	TPU:	+/-0.113		+/-0.0697							
QC1200692807 LCS											
Americium-241	13.4			13.8	pCi/L		103	(75%-125%)			
	Uncert:			+/-1.25							
	TPU:			+/-2.06							
n-242			U	-0.0143	pCi/L						
	Uncert:			+/-0.0615							
	TPU:			+/-0.0616							
Curium-243/244	17.1			16.0	pCi/L		94				
	Uncert:			+/-1.35							
	TPU:			+/-2.32							
QC1200692804 MB											
Americium-241			U	0.0231	pCi/L					09/02/04	14:32
	Uncert:			+/-0.0613							
	TPU:			+/-0.0614							
Curium-242			U	0.00	pCi/L						
	Uncert:			+/-0.0603							
	TPU:			+/-0.0603							
Curium-243/244			U	0.0158	pCi/L						
	Uncert:			+/-0.063							
	TPU:			+/-0.063							
QC1200692806 120208001 MS											
Americium-241	13.4 U	-0.0132		12.9	pCi/L		96	(75%-125%)		09/02/04	14:32
	Uncert:	+/-0.068		+/-1.19							
	TPU:	+/-0.068		+/-1.93							
Curium-242	U	0.00	U	0.0628	pCi/L						
	Uncert:	+/-0.0642		+/-0.087							
	TPU:	+/-0.0642		+/-0.0874							
Curium-243/244	17.2 U	0.00359		14.8	pCi/L		86				
	Uncert:	+/-0.113		+/-1.28							
	TPU:	+/-0.113		+/-2.15							
Batch 361744											
QC1200692815 120208001 DUP											
Plutonium-238	U	-0.051	U	0.0215	pCi/L	N/A		(0% - 100%)	JAS1	09/03/04	08:33

QC Summary

Workorder: 120208

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Alpha Spec										
Batch 361744										
	Uncert:	+/-0.0779		+/-0.057						
	TPU:	+/-0.0781		+/-0.057						
Plutonium-239/240	U	-0.0597	U	0.0215	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-0.0736		+/-0.057						
	TPU:	+/-0.0737		+/-0.057						
QC1200692817 LCS										
Plutonium-238			U	-0.0327	pCi/L			(75%-125%)		09/03/04 08:33
	Uncert:			+/-0.151						
	TPU:			+/-0.151						
Plutonium-239/240	12.0			13.9	pCi/L		116	(75%-125%)		
	Uncert:			+/-1.44						
	TPU:			+/-2.23						
QC1200692814 MB										
Plutonium-238			U	-0.0239	pCi/L					
	Uncert:			+/-0.0271						
	TPU:			+/-0.0272						
Plutonium-239/240			U	0.0173	pCi/L					
	Uncert:			+/-0.0688						
	TPU:			+/-0.0689						
C1200692816 120208001 MS										
nium-238	U	-0.051	U	0.0736	pCi/L			(75%-125%)		09/03/04 08:33
	Uncert:	+/-0.0779		+/-0.107						
	TPU:	+/-0.0781		+/-0.107						
Plutonium-239/240	12.0 U	-0.0597		12.7	pCi/L		106	(75%-125%)		
	Uncert:	+/-0.0736		+/-1.13						
	TPU:	+/-0.0737		+/-1.63						
Batch 361746										
QC1200692821 120208001 DUP										
Plutonium-241	U	1.08	U	2.86	pCi/L	0		(0% - 100%)	JAS1	09/05/04 08:21
	Uncert:	+/-7.42		+/-8.33						
	TPU:	+/-7.42		+/-8.33						
QC1200692823 LCS										
Plutonium-241	176			146	pCi/L		83	(75%-125%)		09/05/04 09:24
	Uncert:			+/-11.9						
	TPU:			+/-17.3						
QC1200692820 MB										
Plutonium-241			U	-6.01	pCi/L					09/05/04 07:49
	Uncert:			+/-8.10						
	TPU:			+/-8.12						
QC1200692822 120208001 MS										
Plutonium-241	176 U	1.08		182	pCi/L		102			09/05/04 08:53
	Uncert:	+/-7.42		+/-14.1						
	TPU:	+/-7.42		+/-22.9						
Rad Gamma Spec										
Batch 362473										
QC1200694604 120208001 DUP										
Americium-241	U	3.25	U	-0.986	pCi/L	N/A			AKB	09/03/04 15:04
	Uncert:	+/-8.84		+/-11.3						
				+/-11.0						

QC Summary

Workorder: 120208

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gamma Spec										
Batch 362473										
	TPU:	+/-8.66								
Cesium-134	U	-0.0124	U	0.112	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-1.35		+/-2.01						
	TPU:	+/-1.33		+/-1.97						
Cesium-137	U	1.67	U	2.01	pCi/L	18		(0% - 100%)		
	Uncert:	+/-1.33		+/-2.09						
	TPU:	+/-1.30		+/-2.04						
Cobalt-60	U	0.0755	U	2.69	pCi/L	189		(0% - 100%)		
	Uncert:	+/-1.32		+/-3.74						
	TPU:	+/-1.29		+/-3.67						
Europium-152	U	3.25	U	-1.92	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-3.91		+/-5.68						
	TPU:	+/-3.84		+/-5.57						
Europium-154	U	-0.977	U	-2.14	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-3.82		+/-5.47						
	TPU:	+/-3.74		+/-5.36						
Europium-155	U	-1.37	U	-1.89	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-5.34		+/-7.72						
	TPU:	+/-5.24		+/-7.57						
anese-54	U	0.117	U	-1.71	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-1.37		+/-2.24						
	TPU:	+/-1.34		+/-2.20						
Niobium-94	U	-0.957	U	0.406	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-1.18		+/-1.77						
	TPU:	+/-1.16		+/-1.74						
Silver-108m	U	-0.355	U	0.976	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-1.34		+/-1.91						
	TPU:	+/-1.31		+/-1.87						
QC1200694606 LCS										
Americium-241	1170			1150	pCi/L		99	(75%-125%)		09/03/04 15:05
	Uncert:			+/-179						
	TPU:			+/-175						
Cesium-134			U	3.82	pCi/L					
	Uncert:			+/-10.7						
	TPU:			+/-10.5						
Cesium-137	460			456	pCi/L		99	(75%-125%)		
	Uncert:			+/-32.7						
	TPU:			+/-32.0						
Cobalt-60	696			685	pCi/L		98	(75%-125%)		
	Uncert:			+/-47.7						
	TPU:			+/-46.8						
Europium-152			U	12.1	pCi/L					
	Uncert:			+/-27.9						
	TPU:			+/-27.4						
Europium-154			U	5.25	pCi/L					
	Uncert:			+/-22.2						
	TPU:			+/-21.8						
Europium-155			U	-7.15	pCi/L					

QC Summary

Workorder: 120208

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gamma Spec										
Batch 362473										
	Uncert:			+/-38.6						
	TPU:			+/-37.8						
Manganese-54			U	-5.29	pCi/L					
	Uncert:			+/-10.7						
	TPU:			+/-10.5						
Niobium-94			U	-0.811	pCi/L					
	Uncert:			+/-8.97						
	TPU:			+/-8.79						
Silver-108m			U	4.00	pCi/L					
	Uncert:			+/-9.17						
	TPU:			+/-8.99						
QC1200694603 MB										
Americium-241			U	0.973	pCi/L					09/02/04 21:13
	Uncert:			+/-2.06						
	TPU:			+/-2.01						
Cesium-134			U	1.92	pCi/L					
	Uncert:			+/-1.78						
	TPU:			+/-1.75						
Cesium-137			U	0.192	pCi/L					
	Uncert:			+/-1.64						
	TPU:			+/-1.60						
Cobalt-60			U	0.0944	pCi/L					
	Uncert:			+/-1.79						
	TPU:			+/-1.76						
Europium-152			U	2.90	pCi/L					
	Uncert:			+/-3.66						
	TPU:			+/-3.59						
Europium-154			U	-0.0192	pCi/L					
	Uncert:			+/-4.56						
	TPU:			+/-4.47						
Europium-155			U	-0.801	pCi/L					
	Uncert:			+/-3.36						
	TPU:			+/-3.29						
Manganese-54			U	0.835	pCi/L					
	Uncert:			+/-1.42						
	TPU:			+/-1.39						
Niobium-94			U	0.702	pCi/L					
	Uncert:			+/-1.63						
	TPU:			+/-1.59						
Silver-108m			U	-1.27	pCi/L					
	Uncert:			+/-1.38						
	TPU:			+/-1.36						
QC1200694605 120208001 MS										
Americium-241	9360 U	3.25		9660	pCi/L		103			09/02/04 21:11
	Uncert:	+/-8.84		+/-1080						
	TPU:	+/-8.66		+/-30300						
Cesium-134	U	-0.0124	U	29.4	pCi/L					
	Uncert:	+/-1.35		+/-69.2						
	TPU:	+/-1.33		+/-114						

QC Summary

Workorder: 120208

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gamma Spec										
Batch 362473										
Cesium-137	3680 U	1.67		3840	pCi/L		104			
	Uncert:	+/-1.33		+/-453						
	TPU:	+/-1.30		+/-12000						
Cobalt-60	5610 U	0.0755		5920	pCi/L		106			
	Uncert:	+/-1.32		+/-423						
	TPU:	+/-1.29		+/-18600						
Europium-152	U	3.25	U	-70.1	pCi/L					
	Uncert:	+/-3.91		+/-147						
	TPU:	+/-3.84		+/-263						
Europium-154	U	-0.977	U	169	pCi/L					
	Uncert:	+/-3.82		+/-147						
	TPU:	+/-3.74		+/-549						
Europium-155	U	-1.37	U	-21.5	pCi/L					
	Uncert:	+/-5.34		+/-177						
	TPU:	+/-5.24		+/-186						
Manganese-54	U	0.117	U	-16.6	pCi/L					
	Uncert:	+/-1.37		+/-61.5						
	TPU:	+/-1.34		+/-79.7						
Niobium-94	U	-0.957	U	19.0	pCi/L					
	Uncert:	+/-1.18		+/-55.8						
	TPU:	+/-1.16		+/-80.8						
Silver-108m	U	-0.355	U	1.03	pCi/L					
	Uncert:	+/-1.34		+/-54.3						
	TPU:	+/-1.31		+/-53.3						
Rad Gas Flow										
Batch 361520										
QC1200692416 120208001 DUP										
Strontium-90	U	0.368	U	0.781	pCi/L	0		(0% - 100%)	HOB1	09/04/04 00:04
	Uncert:	+/-0.312		+/-0.562						
	TPU:	+/-0.329		+/-0.703						
QC1200692418 LCS										
Strontium-90	36.6			34.3	pCi/L		94	(75%-125%)		09/07/04 10:14
	Uncert:			+/-1.77						
	TPU:			+/-9.76						
QC1200692415 MB										
Strontium-90			U	0.0585	pCi/L					09/04/04 00:04
	Uncert:			+/-0.274						
	TPU:			+/-0.275						
QC1200692417 120208001 MS										
Strontium-90	73.2 U	0.368		67.5	pCi/L		92	(75%-125%)		
	Uncert:	+/-0.312		+/-1.94						
	TPU:	+/-0.329		+/-24.6						
Batch 361900										
QC1200693213 120208002 DUP										
Alpha		26.4		33.1	pCi/L	22*		(0% - 20%)	CW1	09/01/04 18:25
	Uncert:	+/-4.80		+/-5.53						
	TPU:	+/-5.17		+/-6.07						
P--		21.4		23.2	pCi/L	8		(0% - 20%)		

QC Summary

Workorder: 120208

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gas Flow										
Batch 361900										
	Uncert:	+/-3.69		+/-3.74						
	TPU:	+/-3.77		+/-3.85						
QC1200693216 LCS										
Alpha	71.9			73.1	pCi/L		102	(75%-125%)		09/01/04 13:59
	Uncert:			+/-5.16						
	TPU:			+/-10.1						
Beta	244			246	pCi/L		101	(75%-125%)		
	Uncert:			+/-7.30						
	TPU:			+/-28.0						
QC1200693212 MB										
Alpha			U	0.843	pCi/L					09/01/04 13:58
	Uncert:			+/-0.757						
	TPU:			+/-0.760						
Beta			U	2.55	pCi/L					
	Uncert:			+/-1.46						
	TPU:			+/-1.46						
QC1200693214 120208002 MS										
Alpha	71.9	26.4		100	pCi/L		102	(75%-125%)		09/01/04 13:59
	Uncert:	+/-4.80		+/-6.35						
	TPU:	+/-5.17		+/-10.9						
	245	21.4		265	pCi/L		100	(75%-125%)		
	Uncert:	+/-3.69		+/-7.73						
	TPU:	+/-3.77		+/-17.6						
QC1200693215 120208002 MSD										
Alpha	71.9	26.4		101	pCi/L	1*	104	(75%-125%)		
	Uncert:	+/-4.80		+/-6.41						
	TPU:	+/-5.17		+/-17.3						
Beta	245	21.4		282	pCi/L	6*	106	(75%-125%)		
	Uncert:	+/-3.69		+/-7.95						
	TPU:	+/-3.77		+/-40.8						
Rad Liquid Scintillation										
Batch 361546										
QC1200692448 120208001 DUP										
Carbon-14	U	4.39	U	17.5	pCi/L	0		(0% - 100%)	LAG1	09/01/04 22:09
	Uncert:	+/-31.6		+/-32.8						
	TPU:	+/-31.6		+/-32.9						
QC1200692450 LCS										
Carbon-14	1310			1320	pCi/L		101	(75%-125%)		09/01/04 23:14
	Uncert:			+/-59.2						
	TPU:			+/-270						
QC1200692447 MB										
Carbon-14			U	-14.8	pCi/L					09/01/04 21:37
	Uncert:			+/-31.4						
	TPU:			+/-31.5						
QC1200692449 120208001 MS										
Carbon-14	1310 U	4.39		1310	pCi/L		100	(75%-125%)		09/01/04 22:42
	Uncert:	+/-31.6		+/-58.6						
	TPU:	+/-31.6		+/-268						
361583										

QC Summary

Workorder: 120208

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Liquid Scintillation										
Batch 361583										
QC1200692488 120208003 DUP										
Technetium-99	U	-6.04	U	-5.77	pCi/L	N/A		(0% - 100%)	DAJ1	09/06/04 18:45
	Uncert:	+/-4.50		+/-4.52						
	TPU:	+/-4.50		+/-4.52						
QC1200692490 LCS										
Technetium-99	470			496	pCi/L		106	(75%-125%)		09/06/04 19:49
	Uncert:			+/-13.6						
	TPU:			+/-17.5						
QC1200692487 MB										
Technetium-99			U	-3.83	pCi/L					09/06/04 18:13
	Uncert:			+/-4.58						
	TPU:			+/-4.58						
QC1200692489 120208003 MS										
Technetium-99	470 U	-6.04		485	pCi/L		103	(75%-125%)		09/06/04 19:17
	Uncert:	+/-4.50		+/-13.3						
	TPU:	+/-4.50		+/-17.2						
Batch 361585										
QC1200692492 119484006 DUP										
Tritium	U	-137	U	-52.3	pCi/L	N/A		(0% - 100%)	LAG1	08/31/04 03:23
	Uncert:	+/-193		+/-203						
	TPU:	+/-193		+/-203						
QC1200692494 LCS										
Tritium	3220			2610	pCi/L		81	(75%-125%)		08/31/04 05:28
	Uncert:			+/-274						
	TPU:			+/-277						
QC1200692491 MB										
Tritium			U	-137	pCi/L					08/31/04 02:20
	Uncert:			+/-201						
	TPU:			+/-201						
QC1200692493 119484006 MS										
Tritium	3230 U	-137		3000	pCi/L		93	(75%-125%)		08/31/04 04:25
	Uncert:	+/-193		+/-283						
	TPU:	+/-193		+/-287						
Batch 361838										
QC1200693074 120208003 DUP										
Iron-55	U	-12.3	U	-9.2	pCi/L	N/A		(0% - 100%)	JLB1	09/04/04 13:12
	Uncert:	+/-13.6		+/-13.0						
	TPU:	+/-13.6		+/-13.0						
QC1200693076 LCS										
Iron-55	287			291	pCi/L		101*	(0%-%)		09/04/04 17:20
	Uncert:			+/-21.3						
	TPU:			+/-24.6						
QC1200693073 MB										
Iron-55			U	-17.9	pCi/L					09/04/04 11:08
	Uncert:			+/-13.4						
	TPU:			+/-13.4						
QC1200693075 120208003 MS										
Iron-55	300 U	-12.3		287	pCi/L		96*	(0%-%)		09/04/04 15:16
	Uncert:	+/-13.6		+/-15.2						

QC Summary

Workorder: 120208

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Liquid Scintillation										
Batch 361838										
	TPU:	+/-13.6		+/-19.1						
Batch 361840										
QC1200693078 120208003 DUP										
Nickel-63	U	1.91	U	-2.43	pCi/L	N/A		(0% - 100%)	JLB1	09/03/04 22:03
	Uncert:	+/-7.45		+/-7.28						
	TPU:	+/-7.45		+/-7.28						
QC1200693080 LCS										
Nickel-63	342			325	pCi/L		95	(75%-125%)		09/03/04 23:07
	Uncert:			+/-15.1						
	TPU:			+/-16.4						
QC1200693077 MB										
Nickel-63			U	-2.16	pCi/L					09/03/04 21:31
	Uncert:			+/-7.32						
	TPU:			+/-7.32						
QC1200693079 120208003 MS										
Nickel-63	343 U	1.91		353	pCi/L		103	(75%-125%)		09/03/04 22:35
	Uncert:	+/-7.45		+/-15.7						
	TPU:	+/-7.45		+/-17.1						

s:
The Qualifiers in this report are defined as follows:

- B Target analyte was detected in the sample as well as the associated blank.
- BD Flag for results below the MDC or a flag for low tracer recovery.
- E Concentration of the target analyte exceeds the instrument calibration range.
- H Analytical holding time exceeded.
- J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
- U Indicates the target analyte was analyzed for but not detected above the detection limit.
- UI Uncertain identification for gamma spectroscopy.
- X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
- h Sample preparation or preservation holding time exceeded.

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more.
** Indicates analyte is a surrogate compound.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptence criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

GENERAL ENGINEERING LABORATORIES, LLC
a Member of THE GEL GROUP, INC.
Meeting Today's Needs with a Vision for Tomorrow

June 25, 2004

Mr. Dave Keefer
CYAPCo
Haddam Neck Plant 362 Injun Hollow Road
East Hampton, Connecticut 06424

RE: Quarterly Groundwater PO# 002337
Work Order: 113759
SDG: MSR#04-1662

Dear Mr. Keefer:

General Engineering Laboratories, LLC (GEL) appreciates the opportunity to provide the following analytical results for the sample(s) we received on May 27, 2004. Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time.

This data report has been prepared and reviewed in accordance with GEL's standard operating procedures. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4475.

Sincerely,

Sarah Kozlik
Project Manager

Purchase Order: 002337
Chain of Custody: 2004-00086, 2004-00087 and 2004-00088
Enclosures

P.O. Box 30712 • Charleston, SC 29417 • 2040 Savage Road (29407)
Phone (843) 556-8171 • Fax (843) 766-1178 • www.gel.com

CONNECTICUT YANKEE

RE: Quarterly Groundwater
PO# 002337
Work Order: 113759
SDG: MSR#04-1662

113759001	317-322-2	113759011	178-183-4
113759002	178-183-2	113759012	317-322-4
113759003	S-2	113759013	S-14
113759004	S-7	113759014	S-4
113759005	S-12	113759015	S-9
113759006	178-183-3	113759016	178-183-5
113759007	317-322-3	113759017	317-322-5
113759008	S-13	113759018	S-15
113759009	S-3	113759019	S-5
113759010	S-8	113759020	S-10

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CASE NARRATIVE

CASE NARRATIVE
For
CONNECTICUT YANKEE
RE: Quarterly Groundwater
PO# 002337
Work Order: 113759
SDG: MSR#04-1662

June 25, 2004

Laboratory Identification:
General Engineering Laboratories, LLC

Mailing Address:
P.O. Box 30712
Charleston, South Carolina 29417

Express Mail Delivery and Shipping Address:
2040 Savage Road
Charleston, South Carolina 29407

Telephone Number:
(843) 556-8171

Summary:

Sample receipt

The samples for the Quarterly Groundwater Project for work order 113759 arrived at General Engineering Laboratories, LLC, (GEL) in Charleston, South Carolina May 27, 2004 for environmental analysis. All sample containers arrived without any visible signs of tampering or breakage. The chain of custody contained the proper documentation and signatures.

The laboratory received the following groundwater samples:

113759001	317-322-2	113759011	178-183-4
113759002	178-183-2	113759012	317-322-4
113759003	S-2	113759013	S-14
113759004	S-7	113759014	S-4
113759005	S-12	113759015	S-9
113759006	178-183-3	113759016	178-183-5
113759007	317-322-3	113759017	317-322-5
113759008	S-13	113759018	S-15
113759009	S-3	113759019	S-5
113759010	S-8	113759020	S-10

Items of Note:

There are no items to note.

Case Narrative:

Sample analyses were conducted using methodology as outlined in General Engineering Laboratories (GEL) Standard Operating Procedures. Any technical or administrative problems during analysis, data review, and reduction are listed below by analytical parameter.

Analytical Request:

Five groundwater samples were analyzed for Tritium and H-3. Five samples were analyzed for Gross A/B and y-isotopic. Five samples were analyzed for a-isotopic, Pu-241, Fe-55, Ni-63, and Tc-99. Five samples were analyzed for Sr-90 and Boron.

Internal Chain of Custody:

Custody was maintained for all of these samples.

Data Package:

The enclosed data package contains the following sections: Case Narrative, Chain of Custody, Cooler Receipt Checklist, Laboratory Certifications, and Radiochemistry.

I certify that this data package is in compliance with the SOW, both technically and for completeness, for other than the conditions detailed above. Release of the data contained in this hard copy data package has been authorized by the Laboratory Manager or a designee, as verified by the following signature.

Sarah Kozlik
Project Manager

CHAIN OF CUSTODY

Connecticut Yankee Atomic Power Company

362 Injun Hollow Road, East Hampton, CT 06424
860-267-2556

Chain of Custody Form

No. 2004-00088

Project Name: Haddam Neck Decommissioning

Contact Name & Phone:
Dave Keefer 860-267-2556 (x3085)

Analytical Lab (Name, City, State):
General Engineering Lab (GEL), 2040 Savage Rd, Charleston, SC 29407, 843.556.8171 (Sarah Kozlik)

Priority: ☐ 45 D. ☒ 30 D. ☐ 14 D. ☐ 7 D.
Other:

Lab Use Only: 113759

Sample Designation	Date	Time	Media Code	Sample Type Code	Container Size- &Type Code	Analyses Requested: Tritium, C-14	Gross α/β, γ-isotopic	α-isotopic*, Pu-241, Fe-55, Ni-63, Tc-99	Sr-90, Boron			Comment, Preservation	Lab Sample ID
317-322-2	04/23/04	11:29	WG	G	1LP	X						None	
178-183-2	05/19/04	08:50	WG	G	1LP	X						None	
178-183-3	05/19/04	08:50	WG	G	4LP		X					20 ml. Nitric	
178-183-4	05/19/04	08:50	WG	G	4LP			X				20 ml. Nitric	
178-183-5	05/19/04	08:50	WG	G	4LP				X			20 ml. Nitric	
S-2	03/09/04	15:15	WG	G	1LP	X						None	
S-7	03/10/04	09:11	WG	G	1LP	X						None	
S-12	03/15/04	16:06	WG	G	1LP	X						None	

NOTES: PO #: 002337 MSR #: 04-1662 ☐ LTP QA ☐ Radwaste QA ☒ Non QA

*α-isotopic to include Pu & Am/Cm.

Samples Shipped Via:
☒ Fed Ex
☐ UPS
☐ Hand
☐ Other ____
Bill of Lading #

Internal Container Temp.: 2.3 Deg. C
Custody Sealed? Y ☑ N ☐
Custody Seal Intact? Y ☑ N ☐

1) Relinquished By:	Date/Time	2) Received By	Date/Time
Matt Davis	5/25/04 1545	N. Mitchell	5-27-04 10:15
3) Relinquished By	Date/Time	4) Received By	Date/Time
5) Relinquished By	Date/Time	6) Received By	Date/Time

Connecticut Yankee Atomic Power Company

362 Injun Hollow Road, East Hampton, CT 06424
860-267-2556

Chain of Custody Form

No. 2004-00086

Project Name: Haddam Neck Decommissioning

Contact Name & Phone:
Dave Keefer 860-267-2556 (x3085)

Analytical Lab (Name, City, State):
General Engineering Lab (GEL), 2040 Savage Rd, Charleston, SC 29407, 843.556.8171 (Sarah Kozlik)

Priority: ☐ 45 D. ☒ 30 D. ☐ 14 D. ☐ 7 D.
Other:

Lab Use Only: 113759

Sample Designation	Date	Time	Media Code	Sample Type Code	Container Size- &Type Code	Analyses Requested: Tritium	Gross α/β, γ-isotopic	A-isotopic*, Pu-241, Fe-55, Ni-63, Tc-99	Sr-90, Boron			Comment, Preservation	Lab Sample ID
317-322-3	04/23/04	11:48	WG	G	4LP		X					20 ml. Nitric	
317-322-4	04/23/04	11:58	WG	G	4LP			X				20 ml. Nitric	
317-322-5	04/23/04	11:38	WG	G	4LP				X			20 ml. Nitric	
S-13	03/15/04	16:26	WG	G	4LP		X					20 ml. Nitric	
S-14	03/15/04	16:31	WG	G	4LP			X				20 ml. Nitric	
S-15	03/15/04	16:35	WG	G	4LP				X			20 ml. Nitric	

NOTES: PO #: 002337 MSR #: 04-1662 ☐ LTP QA ☐ Radwaste QA ☒ Non QA

*α-isotopic to include Pu & Am/Cm.

Samples Shipped Via:
☒ Fed Ex
☐ UPS
☐ Hand
☐ Other ____
Bill of Lading #

Internal Container Temp.: 1.7 Deg. C
Custody Sealed? Y ☒ N ☐
Custody Seal Intact? Y ☒ N ☐

1) Relinquished By	Date/Time	2) Received By	Date/Time
Matt Davis	5/25/04 1545	M. Mitchell	5-27-04 10:15
3) Relinquished By	Date/Time	4) Received By	Date/Time
5) Relinquished By	Date/Time	6) Received By	Date/Time

Connecticut Yankee Atomic Power Company

362 Injun Hollow Road, East Hampton, CT 06424
860-267-2556

Chain of Custody Form

No. 2004-00087

Project Name: Haddam Neck Decommissioning

Contact Name & Phone:
Dave Keefer 860-267-2556 (x3085)

Analytical Lab (Name, City, State):
General Engineering Lab (GEL), 2040 Savage Rd, Charleston, SC 29407, 843.556.8171 (Sarah Kozlik)

Priority: ☐ 45 D. ☒ 30 D. ☐ 14 D. ☐ 7 D.
Other:

Lab Use Only: 113759

Sample Designation	Date	Time	Media Code	Sample Type Code	Container Size- &Type Code	Analyses Requested: Tritium, C-14	Gross α/β, γ-isotopic	α-isotopic*, Pu-241, Fe-55, Ni-63, Tc-99	Sr-90, Boron			Comment, Preservation	Lab Sample ID
S-3	03/09/04	15:17	WG	G	4LP		X					20 ml. Nitric	
S-4	03/09/04	15:21	WG	G	4LP			X				20 ml. Nitric	
S-5	03/09/04	15:23	WG	G	4LP				X			20 ml. Nitric	
S-8	03/10/04	09:49	WG	G	4LP		X					20 ml. Nitric	
S-9	03/10/04	09:56	WG	G	4LP			X				20 ml. Nitric	
S-10	03/10/04	09:54	WG	G	4LP				X			20 ml. Nitric	

NOTES: PO #: 002337 MSR #: 04-1662 ☐ LTP QA ☐ Radwaste QA ☒ Non QA

*α-isotopic to include Pu & Am/Cm.

Samples Shipped Via:
☒ Fed Ex
☐ UPS
☐ Hand
☐ Other ____
Bill of Lading #

Internal Container Temp.: 23.3 Deg. C
Custody Sealed? Y ☐ N ☐
Custody Seal Intact? Y ☐ N ☐

1) Relinquished By:	Date/Time	2) Received By	Date/Time
Matt Darois	5/25/04 1545	M. Mitchell	52704 10:15
3) Relinquished By	Date/Time	4) Received By	Date/Time
5) Relinquished By	Date/Time	6) Received By	Date/Time

COOLER RECEIPT CHECKLIST

Figure 1. Sample Check-in List

Date/Time Received: 5-27-04 10:15

SDG#: MSR#04-1662

Work Order Number: 113759

Shipping Container ID: 7920 0724 0780 0764 0806 Chain of Custody # 2004-00086, 00087, 00088

1. Custody Seals on shipping container intact? Yes [✓] No [ ]
2. Custody Seals dated and signed? Yes [✓] No [ ]
3. Chain-of-Custody record present? Yes [✓] No [ ]
4. Cooler temperature 22.3° 21.7° 23.3°
5. Vermiculite/packing materials is: Wet [ ] Dry [✓]
6. Number of samples in shipping container: 20
7. Sample holding times exceeded? Yes [ ] No [ ]

8. Samples have:

____tape	____hazard labels
✓ custody seals	____appropriate sample labels

9. Samples are:

✓ in good condition	____leaking
____broken	____have air bubbles

10. Were any anomalies identified in sample receipt? Yes [ ] No [✓]
11. Description of anomalies (include sample numbers): _____

Sample Custodian/Laboratory: M Mitchell Date: 5-27-04 10:15

Telephoned to: _____ On _____ By _____

SAMPLE RECEIPT & REVIEW FORM

GENERAL ENGINEERING LABORATORIES, LLC

PM use only

Client: Yankee	SDG/ARCOC/Work Order:
Date Received: 5-27-04	PM(A) Review (ensure non-conforming items are resolved prior to signing):
Received By: UM	

	Sample Receipt Criteria	Conforming	NA	Non-Conforming	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?				Circle Applicable: seals broken damaged container leaking container other (describe)
2	Samples requiring cold preservation within (4 +/- 2 C)? Record preservation method.				ice bags blue ice dry ice none other(describe)
3	Chain of custody documents included with shipment?				
4	Sample containers intact and sealed?				Circle Applicable: seals broken damaged container leaking container other (describe)
5	Samples requiring chemical preservation at proper pH?				Sample ID's, containers affected and observed pH:
6	VOA vials free of headspace (defined as < 6mm bubble)?				Sample ID's and containers affected:
7	Samples received within holding time?				Id's and tests affected:
8	Sample ID's on COC match ID's on bottles?				Sample ID's and containers affected:
9	Date & time on COC match date & time on bottles?				Sample ID's affected:
10	Number of containers received match number indicated on COC?				Sample ID's affected:
11	COC form is properly signed in relinquished/received sections?				
12	Air Bill & Tracking #'s				

Radiological Information	Non-RAD	RAD	RAD Counter
What is the radiological classification of the samples?			
Radioactivity Screening Results (maximum observed CPM)			

RSO RAD Receipt #:

Comments:

*If > 2 x area background is observed on a non-radioactive sample, contact the RSO to investigate.

INORGANIC ANALYSIS

Metals Fractional Narrative
Connecticut Yankee Atomic Power Co. (YANK)
SDG MSR#04-1662

Method/Analysis Information

Analytical Batch:	337363
Prep Batch:	337362
Standard Operating Procedures:	GL-MA-E-014 REV# 8, GL-MA-E-006 REV# 9
Analytical Method:	SW846 6020
Prep Method:	SW846 3005A

Sample Analysis

Sample ID	Client ID
113759016	178-183-5
113759017	317-322-5
113759018	S-15
113759019	S-5
113759020	S-10
1200634917	Method Blank (MB) ICP-MS
1200634918	Laboratory Control Sample (LCS)
1200634921	113889001(LeachateL) Serial Dilution (SD)
1200634919	113889001(LeachateD) Sample Duplicate (DUP)
1200634920	113889001(LeachateS) Matrix Spike (MS)

Preparation/Analytical Method Verification

The SOP stated above has been prepared based on technical research and testing conducted by General Engineering Laboratories, LLC. and with guidance from the regulatory documents listed in this "Method/Analysis Information" section.

System Configuration

The ICP-MS analysis was performed on a Perkin Elmer Elan 6100E inductively coupled plasma mass spectrometer (ICP-MS). The instrument is equipped with a cross-flow

nebulizer, quadrupole mass spectrometer, and dual mode electron multiplier detector. Internal standards of scandium, germanium, indium, and tantalum were utilized to cover the mass spectrum. Operating conditions are set at 1400W power and combined argon pressures of 3607 kPa for the plasma and auxiliary gases, and 0.85 L/min carrier gas flow, and an initial lens voltage of 5.2.

Calibration Information

Instrument Calibration
All initial calibration requirements have been met for this SDG.

CRDL Requirements
All CRDL standard(s) met the referenced advisory control limits.

ICSA/ICSAB statement
All interference check samples (ICSA and ICSAB) associated with this SDG met the established acceptance criteria.

Continuing Calibration Blank (CCB) Requirements
All continuing calibration blanks (CCB) bracketing this batch met the established acceptance criteria.

Continuing Calibration Verification (CCV) Requirements
All continuing calibration verifications (CCV) bracketing this SDG met the acceptance criteria.

Quality Control (QC) Information

Method Blank (MB) Statement
The MB analyzed with this SDG met the acceptance criteria.

Laboratory Control Sample (LCS) Recovery
The LCS spike recoveries met the acceptance limits.

Quality Control (QC) Sample Statement
The following sample was selected as the quality control (QC) sample for this batch: 113889001 (Leachate).

Matrix Spike (MS) Recovery Statement
The percent recoveries (%R) obtained from the MS analyses are evaluated when the sample concentration is less than four times (4X) the spike concentration added. All applicable elements met the acceptance criteria.

Duplicate Relative Percent Difference (RPD) Statement
The relative percent difference (RPD) obtained from the designated sample duplicate (DUP) is evaluated based on acceptance criteria of 20% when the sample is >5X the

contract required detection limit (RL). In cases were either the sample or duplicate value is less than 5X the contract required detection limit (RL), a control of RL is used to evaluate the DUP results. All applicable analytes met these requirements.

Serial Dilution % Difference Statement
The serial dilution is used to assess matrix suppression or enhancement. Raw element concentrations 25x the IDL for CVAA, 50X the IDL for ICP and 100X the IDL for ICP-MS analyses are applicable for serial dilution assessment. All applicable analytes met the established criteria of less than 10% difference (%D).

Technical Information

Holding Time Specifications
GEL assigns holding times based on the associated methodology, which assigns the date and time from sample collection of sample receipt. Those holding times expressed in hours are calculated in the AlphaLIMS system. Those holding times expressed as days expire at midnight on the day of expiration. All samples in this SDG met the specified holding time.

Preparation/Analytical Method Verification
All procedures were performed as stated in the SOP.

Sample Dilutions
Dilutions are performed to minimize matrix interferences resulting from elevated mineral element concentrations present in soil samples and/or to bring over range target analyte concentrations into the linear calibration range of the instrument. The samples in this SDG did not require dilutions.

Preparation Information
The samples in this SDG were prepared exactly according to the cited SOP.

Miscellaneous Information

Nonconformance Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. No NCR was generated with this SDG.

Additional Comments
Additional comments were not required for this SDG.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: _____ **Date:** 6/21/04

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: June 21, 2004

Client Sample ID: 178-183-5
Sample ID: 113759016
Matrix: Ground Water
Collect Date: 19-MAY-04 08:50
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Metals Analysis-ICP-MS											
3005/6020 Boron-ALL,STND,MIX											
Boron		215	0.540	16.0	ug/L	1	PRB	06/04/04	1736	337363	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
6 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

6/21/04

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: **Quarterly Groundwater PO# 002337**

Report Date: June 21, 2004

Client Sample ID: 317-322-5
Sample ID: 113759017
Matrix: Ground Water
Collect Date: 23-APR-04 11:38
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Metals Analysis-ICP-MS											
3005/6020 Boron-ALL,STND,MIX											
Boron		338	0.540	16.0	ug/L	1	PRB	06/04/04	1742	337363	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Allison M. 6/21/04
Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Report Date: June 21, 2004
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Client Sample ID: S-15
Sample ID: 113759018
Matrix: Ground Water
Collect Date: 15-MAR-04 16:35
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Metals Analysis-ICP-MS											
3005/6020 Boron-ALL,STND,MIX											
Boron	J	12.9	0.540	16.0	ug/L	1	PRB	06/04/04	1747	337363	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Allison M. Cumbie 6/21/04
Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: June 21, 2004

Client Sample ID: S-5
Sample ID: 113759019
Matrix: Ground Water
Collect Date: 09-MAR-04 15:23
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001

Parameter	Qualifier	Result	DL	RL	Units	DF	AnalystDate	Time	Batch	Method
Metals Analysis-ICP-MS										
3005/6020 Boron-ALL,STND,MIX										
Boron	J	5.42	0.540	16.0	ug/L	1	PRB 06/04/04	1752	337363	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

6/21/04
Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Report Date: June 21, 2004
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Client Sample ID: S-10
Sample ID: 113759020
Matrix: Ground Water
Collect Date: 10-MAR-04 09:54
Receive Date: 27-MAY-04
Collector: Client
Project: YANK00304
Client ID: YANK001

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Metals Analysis-ICP-MS											
3005/6020 Boron-ALL,STND,MIX											
Boron	J	2.34	0.540	16.0	ug/L	1	PRB	06/04/04	1758	337363	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
[illegible]46 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

[signature] 6/21/04
Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: June 21, 2004

Client : CYAPCo
Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut
Contact: Mr. Dave Keefer

Workorder: 113759

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time
Metals Analysis - ICPMS											
Batch 337363											
QC1200634919 113889001 DUP											
Boron		9660		10000	ug/L	4		(0%-20%)	BAJ	06/07/04	16:38
QC1200634918 LCS											
Boron	100			112	ug/L		112	(80%-120%)	PRB	06/04/04	17:31
QC1200634917 MB											
Boron			U	ND	ug/L					06/04/04	17:26
QC1200634920 113889001 MS											
Boron	100	9660		9860	ug/L		N/A	(75%-125%)	BAJ	06/07/04	16:41
QC1200634921 113889001 SDILT											
Boron		96.6		19.4	ug/L	.109				06/07/04	16:44

Notes:
The Qualifiers in this report are defined as follows:

- B Target analyte was detected in the sample as well as the associated blank.
- BD Flag for results below the MDC or a flag for low tracer recovery.
- E Concentration of the target analyte exceeds the instrument calibration range.
- H Analytical holding time exceeded.
- J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
- U Indicates the target analyte was analyzed for but not detected above the detection limit.
- UI Uncertain identification for gamma spectroscopy.
- X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
- h Sample preparation or preservation holding time exceeded.

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

RADIOLOGICAL ANALYSIS

Radiochemistry Case Narrative
Connecticut Yankee Atomic Power Co. (YANK)
SDG MSR#04-1662

Method/Analysis Information

Product:	**Am241,Cm, Liquid-ALL**
Analytical Method:	DOE EML HASL-300, Am-05-RC Modified
Analytical Batch Number:	341329

Sample ID	Client ID
113759011	178-183-4
113759012	317-322-4
113759013	S-14
113759014	S-4
113759015	S-9
1200644403	Method Blank (MB)
1200644406	Laboratory Control Sample (LCS)
1200644404	113759011(178-183-4) Sample Duplicate (DUP)
1200644405	113759011(178-183-4) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-011 REV# 13.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 113759011 (178-183-4).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Manual Integration
No manual integrations were performed on data in this batch.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Alphaspec Pu, Liquid-ALL**
Analytical Method:	DOE EML HASL-300, Pu-11-RC Modified
Analytical Batch Number:	341332

Sample ID	Client ID
113759011	178-183-4
113759012	317-322-4
113759013	S-14
113759014	S-4
113759015	S-9
1200644411	Method Blank (MB)
1200644414	Laboratory Control Sample (LCS)
1200644412	113759011(178-183-4) Sample Duplicate (DUP)
1200644413	113759011(178-183-4) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-011 REV# 13.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC

The following sample was used for QC: 113759011 (178-183-4).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Manual Integration
No manual integrations were performed on data in this batch.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF**
Analytical Method:	EPA 901.1
Analytical Batch Number:	337182

Sample ID	Client ID
113759006	178-183-3
113759007	317-322-3
113759008	S-13
113759009	S-3
113759010	S-8
1200634477	Method Blank (MB)
1200634480	Laboratory Control Sample (LCS)
1200634478	113759006(178-183-3) Sample Duplicate (DUP)
1200634479	113759006(178-183-3) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-013 REV# 10.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 113759006 (178-183-3).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information

Qualifier	Reason	Analyte	Sample
UI	Data rejected due to low abundance.	Cesium-137	113759008

Method/Analysis Information

Product:	**GFPC, Sr90, liquid-ALL,MIX**
Analytical Method:	EPA 905.0 Modified
Analytical Batch Number:	340973

Sample ID	Client ID
113759016	178-183-5
113759017	317-322-5
113759018	S-15
113759019	S-5
113759020	S-10
1200643662	Method Blank (MB)
1200643665	Laboratory Control Sample (LCS)
1200643663	113759018(S-15) Sample Duplicate (DUP)

1200643664 113759018(S-15) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-004 REV# 8.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 113759018 (S-15).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
Sample 113759016 (178-183-5) was recounted to verify sample result. Second count being reported.

Chemical Recoveries
All chemical recoveries meet the required acceptance limits for this sample set.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier Information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint Tc99, Liquid-ALL**
Analytical Method:	DOE EML HASL-300, Tc-02-RC Modified

Analytical Batch Number: 340926

Sample ID	Client ID
113759011	178-183-4
113759012	317-322-4
113759013	S-14
113759014	S-4
113759015	S-9
1200643522	Method Blank (MB)
1200643525	Laboratory Control Sample (LCS)
1200644474	113759011(178-183-4) Sample Duplicate (DUP)
1200644475	113759011(178-183-4) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-005 REV# 11.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 113759011 (178-183-4).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced

SOP or contractual documents. An NCR was not generated for this SDG.

Additional Comments
Samples 113759011 (178-183-4), 113759012 (317-322-4), 113759013 (S-14), 113759014 (S-4), 113759015 (S-9), 1200643522 (MB), 1200643525 (LCS), 1200644474 (178-183-4) and 1200644475 (178-183-4) were preserved with nitric prior to analysis.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint Fe55, Liquid-ALL**
Analytical Method:	DOE RESL Fe-1, Modified
Analytical Batch Number:	340950

Sample ID	Client ID
113759011	178-183-4
113759012	317-322-4
113759013	S-14
113759014	S-4
113759015	S-9
1200643608	Method Blank (MB)
1200643611	Laboratory Control Sample (LCS)
1200643609	113759015(S-9) Sample Duplicate (DUP)
1200643610	113759015(S-9) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-040 REV# 2.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 113759015 (S-9).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Additional Comments
Absolute value of the sample results for samples 113759012 (317-322-4), 113759014 (S-4) and 1200643609 (S-9) is greater than 3* 1 sigma tpu due to crosstalk factor and large concentration of Fe-59 tracer. Sample spectrums verifies there is no Fe-55 in the samples, however the results may be biased low due to the crosstalk from tracer.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint Ni63, Liquid-ALL**
Analytical Method:	DOE RESL Ni-1, Modified
Analytical Batch Number:	340951

Sample ID	Client ID
113759011	178-183-4
113759012	317-322-4
113759013	S-14
113759014	S-4
113759015	S-9
1200643612	Method Blank (MB)
1200643615	Laboratory Control Sample (LCS)
1200643613	113759015(S-9) Sample Duplicate (DUP)
1200643614	113759015(S-9) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-022 REV# 6.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry

All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 113759015 (S-9).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN**
Analytical Method:	EPA 906.0 Modified
Analytical Batch Number:	340954

Sample ID	Client ID
113759001	317-322-2
113759002	178-183-2
113759003	S-2
113759004	S-7
113759005	S-12
1200643624	Method Blank (MB)
1200643627	Laboratory Control Sample (LCS)
1200643625	113759005(S-12) Sample Duplicate (DUP)
1200643626	113759005(S-12) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-002 REV# 9.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: *113759005* (S-12).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint C14, Liquid-ALL**
Analytical Method:	EPA EERF C-01 Modified
Analytical Batch Number:	341392

Sample ID	Client ID
113759001	317-322-2
113759002	178-183-2
113759003	S-2
113759004	S-7
113759005	S-12
1200644561	Method Blank (MB)

1200644564	Laboratory Control Sample (LCS)
1200644562	113960002(FBI 17D) Sample Duplicate (DUP)
1200644563	113960002(FBI 17D) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-003 REV# 7.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 113960002 (FBI 17D).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Gross A/B, liquid-ALL,STND,MIX,PENN,LF**
Analytical Method:	EPA 900.0
Analytical Batch Number:	341271

Sample ID	Client ID
113759006	178-183-3
113759007	317-322-3
113759008	S-13
113759009	S-3
113759010	S-8
1200644273	Method Blank (MB)
1200644277	Laboratory Control Sample (LCS)
1200644274	113759009(S-3) Sample Duplicate (DUP)
1200644275	113759009(S-3) Matrix Spike (MS)
1200644276	113759009(S-3) Matrix Spike Duplicate (MSD)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-001 REV# 8.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 113759009 (S-3).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
None of the samples in this sample set required reprep or reanalysis.

Chemical Recoveries
All chemical recoveries meet the required acceptance limits for this sample set.

Gross Alpha/Beta Preparation Information

High hygroscopic salt content in evaporated samples can cause the sample mass to fluctuate due to moisture absorption. To minimize this interference, the salts are converted to oxides by heating the sample under a flame until a dull red color is obtained. The conversion to oxides stabilizes the sample weight and ensures that proper alpha/beta efficiencies are assigned for each sample. Volatile radioisotopes of carbon, hydrogen, technetium, polonium and cesium may be lost during sample heating.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. An NCR was not generated for this SDG.

Qualifier information
Manual qualifiers were not required.

Method/Analysis Information

Product:	**Liquid Scint Pu241, Liquid-ALL**
Analytical Method:	DOE EML HASL-300, Pu-11-RC Modified
Analytical Batch Number:	344849

Sample ID	Client ID
113759011	178-183-4
113759012	317-322-4
113759013	S-14
113759014	S-4
113759015	S-9
1200652998	Method Blank (MB)
1200653001	Laboratory Control Sample (LCS)
1200652999	113759013(S-14) Sample Duplicate (DUP)
1200653000	113759013(S-14) Matrix Spike (MS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-RAD-A-035 REV# 5.

Calibration Information:

Calibration Information
All initial and continuing calibration requirements have been met.

Standards Information
Standard solution(s) for these analyses are NIST traceable and used before the expiration date(s).

Sample Geometry
All counting sources were prepared in the same geometry as the calibration standards.

Quality Control (QC) Information:

Blank Information
The blank volume is representative of the sample volume in this batch.

Designated QC
The following sample was used for QC: 113759013 (S-14).

QC Information
All of the QC samples met the required acceptance limits.

Technical Information:

Holding Time
All sample procedures for this sample set were performed within the required holding time.

Preparation Information
All preparation criteria have been met for these analyses.

Sample Re-prep/Re-analysis
Samples were reprepped due to low/high carrier/tracer yield.
Samples were reprepped due to low/high recovery.

Miscellaneous Information:

NCR Documentation
Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. The following NCR was generated for this SDG:
NCR 123785 was generated due to RDL less than MDA. 1. Samples 113759011 and 113759015 did not meet the client required detection limit. The samples were prepared three times due to matrix problems encounted during analytical preparation. The final preparation did not meet the required detection limit due to limited remaining sample volumes.

Manual Integration
Manual intergration of alpha spectroscopy spectra 1200652998 (MB) was performed to fully separate counts in Regions of Interest which would have been biased.

Qualifier information
Manual qualifiers were not required.

Certification Statement
Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:
GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.
The following data validator verified the information presented in this case narrative:

A Kellen Chou 7/1/04

Reviewer: _____

NCR Report No.: 123785
Revision No.:

COMPANY - WIDE NONCONFORMANCE REPORT

Mo.Day Yr.	Division:		Type:
01-JUL-04	Radiochemistry		Process
Instrument Type:	**Quality Criteria:**		**Client Code:**
LSC	Specifications		YANK
Test / Method:	**Matrix Type:**	**Batch ID:**	**Sample Numbers:**
DOE EML HASL-300, Pu-11-RC Modified	Liquid	344849	See Below

Potentially affected work order(s)(SDG): 113759(MSR#04-1662)

Application Issues:

RDL less than MDA

Specification and Requirements Nonconformance Description:	NRG Disposition:
1. Samples 113759011 and 113759015 did not meet the client required detection limit. The samples were prepared three times due to matrix problems encounted during analytical preparation. The final preparation did not meet the required detection limit due to limited remaining sample volumes.	1. Reporting results.

Originator's Name:
Melanie Aycock 01-JUL-04

Data Validator/Group Leader:
Scott Baskett 01-JUL-04

Quality Review:

Corrective Action:

Director:

Corrective Action ID and Complete Date:

SAMPLE DATA SUMMARY

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: 317-322-2
Sample ID: 113759001
Matrix: Ground Water
Collect Date: 23-APR-04
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Liquid Scintillation Analysis													
LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN													
Tritium		496	+/-137	105	+/-137	210	pCi/L		JLB1	06/18/04	1752	340954	1
Liquid Scint C14, Liquid-ALL													
Carbon-14	U	-38.5	+/-49.4	52.3	+/-51.7	107	pCi/L		MWX1	06/19/04	1504	341392	2

The following Analytical Methods were performed

Method	Description
1	EPA 906.0 Modified
2	EPA EERF C-01 Modified

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	178-183-2	Project:	YANK00304
Sample ID:	113759002	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	19-MAY-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Liquid Scintillation Analysis													
LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN													
Tritium		6060	+/-231	108	+/-250	216	pCi/L		JLB1	06/18/04	1956	340954	1
Liquid Scint C14, Liquid-ALL													
Carbon-14	U	-11.2	+/-50.8	52.7	+/-51.0	108	pCi/L		MWX1	06/19/04	1536	341392	2

The following Analytical Methods were performed

Method	Description
1	EPA 906.0 Modified
2	EPA EERF C-01 Modified

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.
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Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	S-2	Project:	YANK00304
Sample ID:	113759003	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	09-MAR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Liquid Scintillation Analysis													
LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN													
Tritium		329	+/-130	103	+/-130	206	pCi/L		JLB1	06/18/04	2200	340954	1
Liquid Scint C14, Liquid-ALL													
Carbon-14	U	18.3	+/-54.5	55.3	+/-55.0	113	pCi/L		MWX1	06/19/04	1608	341392	2

The following Analytical Methods were performed

Method	Description
1	EPA 906.0 Modified
2	EPA EERF C-01 Modified

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

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Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: S-7
Sample ID: 113759004
Matrix: Ground Water
Collect Date: 10-MAR-04
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Liquid Scintillation Analysis													
LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN													
Tritium		338	+/-137	108	+/-137	216	pCi/L		JLB1	06/19/04	0003	340954	1
Liquid Scint C14, Liquid-ALL													
Carbon-14	U	15.9	+/-50.8	51.6	+/-51.2	106	pCi/L		MWX1	06/19/04	1640	341392	2

The following Analytical Methods were performed

Method	Description
1	EPA 906.0 Modified
2	EPA EERF C-01 Modified

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: S-12
Sample ID: 113759005
Matrix: Ground Water
Collect Date: 15-MAR-04
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch	Mtd.
Rad Liquid Scintillation Analysis												
LSC, Tritium Dist, Liquid-ALL,STND,MIX,PENN												
Tritium		325	+/-140	111	+/-140	222	pCi/L		JLB1 06/19/04	0207	340954	1
Liquid Scint C14, Liquid-ALL												
Carbon-14	U	-8.24	+/-50.7	52.4	+/-50.8	107	pCi/L		MWX 06/19/04	1712	341392	2 1

The following Analytical Methods were performed

Method	Description
1	EPA 906.0 Modified
2	EPA EERF C-01 Modified

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Heather G Wood
Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	178-183-3	Project:	YANK00304
Sample ID:	113759006	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	19-MAY-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Gamma Spec Analysis													
Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF													
Americium-241	U	-6.32	+/-10.5	8.00	+/-10.3	16.6	pCi/L		SRB	06/10/04	2243	337182	1
Cesium-134	U	-1.38	+/-1.34	0.961	+/-1.31	2.10	pCi/L						
Cesium-137	U	-0.0136	+/-1.26	1.04	+/-1.24	2.23	pCi/L						
Cobalt-60	U	-1.4	+/-1.39	0.995	+/-1.36	2.23	pCi/L						
Europium-152	U	2.61	+/-4.38	3.21	+/-4.30	6.74	pCi/L						
Europium-154	U	-3.17	+/-3.51	2.53	+/-3.44	5.70	pCi/L						
Europium-155	U	-4.25	+/-4.96	4.09	+/-4.86	8.46	pCi/L						
Manganese-54	U	-0.766	+/-1.27	0.968	+/-1.25	2.10	pCi/L						
Niobium-94	U	-0.136	+/-1.14	0.924	+/-1.11	1.98	pCi/L						
Silver-108m	U	0.168	+/-1.20	1.03	+/-1.18	2.18	pCi/L						
Rad Gas Flow Proportional Counting													
Gross A/B, liquid-ALL,STND,MIX,PENN,LF													
Alpha		12.9	+/-2.07	0.389	+/-2.27	1.00	pCi/L		ATH1	06/25/04	0802	341271	2
Beta		9.25	+/-1.92	1.46	+/-1.95	3.04	pCi/L						

The following Analytical Methods were performed

Method	Description
1	EPA 901.1
2	EPA 900.0

Notes:
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H Analytical holding time exceeded.
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UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: 178-183-3
Sample ID: 113759006

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch	Mtd.

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362 Injun Hollow Road
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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: 317-322-3
Sample ID: 113759007
Matrix: Ground Water
Collect Date: 23-APR-04
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Gamma Spec Analysis													
Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF													
Americium-241	U	-8.83	+/-12.2	8.51	+/-11.9	17.5	pCi/L		SRB	06/10/04	2244	337182	1
Cesium-134	U	-0.581	+/-1.84	1.46	+/-1.80	3.12	pCi/L						
Cesium-137	U	-0.148	+/-1.45	1.19	+/-1.42	2.54	pCi/L						
Cobalt-60	U	-0.0272	+/-1.41	1.16	+/-1.38	2.58	pCi/L						
Europium-152	U	0.188	+/-4.94	3.99	+/-4.84	8.29	pCi/L						
Europium-154	U	-0.429	+/-4.48	3.70	+/-4.39	8.06	pCi/L						
Europium-155	U	-0.555	+/-6.91	5.90	+/-6.77	12.1	pCi/L						
Manganese-54	U	-0.572	+/-1.54	1.21	+/-1.51	2.60	pCi/L						
Niobium-94	U	0.643	+/-1.39	1.18	+/-1.36	2.51	pCi/L						
Silver-108m	U	-0.935	+/-1.66	1.26	+/-1.62	2.65	pCi/L						
Rad Gas Flow Proportional Counting													
Gross A/B, liquid-ALL,STND,MIX,PENN,LF													
Alpha	U	1.90	+/-1.50	1.06	+/-1.50	2.35	pCi/L		ATH1	06/25/04	1536	341271	2
Beta	U	1.18	+/-2.09	1.72	+/-2.09	3.53	pCi/L						

The following Analytical Methods were performed

Method	Description
1	EPA 901.1
2	EPA 900.0

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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: 317-322-3
Sample ID: 113759007

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.

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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	S-13	Project:	YANK00304
Sample ID:	113759008	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	13-MAR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd
Rad Gamma Spec Analysis													
Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF													
Americium-241	U	-8.94	+/-9.08	6.28	+/-8.90	12.9	pCi/L		SRB	06/10/04	2250	337182	1
Cesium-134	U	0.245	+/-2.11	1.79	+/-2.07	3.82	pCi/L						
Cesium-137	U UI	0.00	+/-3.27	2.86	+/-3.21	5.92	pCi/L						
Cobalt-60	U	0.995	+/-2.22	1.68	+/-2.18	3.65	pCi/L						
Europium-152	U	3.88	+/-4.24	4.44	+/-4.16	9.24	pCi/L						
Europium-154	U	1.28	+/-4.97	4.18	+/-4.87	9.17	pCi/L						
Europium-155	U	-7.0	+/-6.78	5.24	+/-6.64	10.8	pCi/L						
Manganese-54	U	0.632	+/-1.81	1.56	+/-1.78	3.37	pCi/L						
Niobium-94	U	0.707	+/-1.76	1.45	+/-1.73	3.08	pCi/L						
Silver-108m	U	-1.28	+/-1.78	1.39	+/-1.74	2.92	pCi/L						
Rad Gas Flow Proportional Counting													
Gross A/B, liquid-ALL,STND,MIX,PENN,LF													
Alpha	U	-0.136	+/-0.653	0.723	+/-0.653	1.68	pCi/L		ATH1	06/25/04	1338	341271	2
Beta	U	0.356	+/-1.68	1.76	+/-1.68	3.67	pCi/L						

The following Analytical Methods were performed

Method	Description
1	EPA 901.1
2	EPA 900.0

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Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: S-13
Sample ID: 113759008

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.

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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	S-3	Project:	YANK00304
Sample ID:	113759009	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	09-MAR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Gamma Spec Analysis													
Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF													
Americium-241	U	0.942	+/-10.4	8.79	+/-10.2	18.2	pCi/L		SRB	06/10/04	2251	337182	1
Cesium-134	U	-0.291	+/-1.46	1.15	+/-1.43	2.48	pCi/L						
Cesium-137	U	0.594	+/-1.36	1.15	+/-1.33	2.43	pCi/L						
Cobalt-60	U	1.54	+/-1.59	1.43	+/-1.56	3.09	pCi/L						
Europium-152	U	1.74	+/-3.73	3.22	+/-3.65	6.74	pCi/L						
Europium-154	U	0.243	+/-3.14	2.62	+/-3.08	5.85	pCi/L						
Europium-155	U	1.64	+/-5.29	4.43	+/-5.19	9.13	pCi/L						
Manganese-54	U	0.077	+/-1.41	1.14	+/-1.39	2.46	pCi/L						
Niobium-94	U	-0.383	+/-1.20	0.949	+/-1.18	2.03	pCi/L						
Silver-108m	U	0.250	+/-1.23	1.04	+/-1.20	2.19	pCi/L						
Rad Gas Flow Proportional Counting													
Gross A/B, liquid-ALL,STND,MIX,PENN,LF													
Alpha	U	0.0983	+/-0.385	0.339	+/-0.385	0.861	pCi/L		ATH1	06/25/04	0802	341271	2
Beta	U	-1.71	+/-1.48	1.64	+/-1.48	3.39	pCi/L						

The following Analytical Methods were performed

Method	Description
1	EPA 901.1
2	EPA 900.0

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Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: S-3
Sample ID: 113759009

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch	Mtd.

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362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	S-8	Project:	YANK00304
Sample ID:	113759010	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	10-MAR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Gamma Spec Analysis													
Gammaspec, Gamma,Liquid-ALL,GAM2,STND,MIX,PENN,LF													
Americium-241	U	-3.8	+/-9.36	6.55	+/-9.18	13.6	pCi/L		SRB	06/10/04	2252	337182	1
Cesium-134	U	-0.12	+/-1.52	1.20	+/-1.49	2.60	pCi/L						
Cesium-137	U	-0.225	+/-1.40	1.12	+/-1.37	2.40	pCi/L						
Cobalt-60	U	0.410	+/-1.37	1.16	+/-1.35	2.57	pCi/L						
Europium-152	U	3.23	+/-4.01	3.33	+/-3.93	6.97	pCi/L						
Europium-154	U	1.03	+/-4.02	3.38	+/-3.94	7.42	pCi/L						
Europium-155	U	-0.249	+/-4.73	3.99	+/-4.64	8.25	pCi/L						
Manganese-54	U	1.04	+/-1.71	1.44	+/-1.67	3.07	pCi/L						
Niobium-94	U	0.164	+/-1.33	1.08	+/-1.30	2.30	pCi/L						
Silver-108m	U	-0.514	+/-1.27	1.03	+/-1.24	2.18	pCi/L						
Rad Gas Flow Proportional Counting													
Gross A/B, liquid-ALL,STND,MIX,PENN,LF													
Alpha	U	0.268	+/-0.462	0.388	+/-0.462	0.951	pCi/L		ATH1	06/25/04	0801	341271	2
Beta	U	0.643	+/-1.09	1.08	+/-1.09	2.27	pCi/L						

The following Analytical Methods were performed

Method	Description
1	EPA 901.1
2	EPA 900.0

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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: S-8
Sample ID: 113759010

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.

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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: 178-183-4
Sample ID: 113759011
Matrix: Ground Water
Collect Date: 19-MAY-04
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Alpha Spec Analysis													
Alphaspec Pu, Liquid-ALL													
Plutonium-238	U	-0.0844	+/-0.0585	0.142	+/-0.0591	0.402	pCi/L		BJB1	06/20/04	1300	341332	1
Plutonium-239/240	U	0.0246	+/-0.132	0.123	+/-0.132	0.364	pCi/L						
Am241,Cm, Liquid-ALL													
Americium-241	U	-0.0118	+/-0.0991	0.056	+/-0.0992	0.245	pCi/L		BJB1	06/21/04	1153	341329	2
Curium-242	U	0.00	+/-0.111	0.00	+/-0.111	0.154	pCi/L						
Curium-243/244	U	0.00	+/-0.0966	0.00	+/-0.0966	0.134	pCi/L						
Liquid Scint Pu241, Liquid-ALL													
Plutonium-241	U	-2.43	+/-16.6	14.0	+/-16.6	28.7	pCi/L		BJB1	06/30/04	0934	344849	3
Rad Liquid Scintillation Analysis													
Liquid Scint Fe55, Liquid-ALL													
Iron-55	U	-11.3	+/-11.8	4.41	+/-11.8	9.12	pCi/L		JLB1	06/20/04	2314	340950	6
Liquid Scint Ni63, Liquid-ALL													
Nickel-63	U	-0.0908	+/-5.48	4.60	+/-5.48	9.47	pCi/L		JLB1	06/20/04	0720	340951	7
Liquid Scint Tc99, Liquid-ALL													
Technetium-99	U	-3.36	+/-4.12	3.55	+/-4.15	7.30	pCi/L		DAJ1	06/21/04	0125	340926	8

The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, Pu-11-RC Modified
2	DOE EML HASL-300, Am-05-RC Modified
3	DOE EML HASL-300, Pu-11-RC Modified
4	DOE EML HASL-300, Pu-11-RC Modified
5	DOE EML HASL-300, Pu-11-RC Modified
6	DOE RESL Fe-1, Modified
7	DOE RESL Ni-1, Modified
8	DOE EML HASL-300, Tc-02-RC Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Plutonium-242	Alphaspec Pu, Liquid-ALL	92	(15%-125%)
Americium-243	Am241,Cm, Liquid-ALL	85	(25%-125%)
Carrier/Tracer Recovery	Liquid Scint Pu241, Liquid-ALL	78	
Carrier/Tracer Recovery	Liquid Scint Fe55, Liquid-ALL	83	

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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: 178-183-4
Sample ID: 113759011

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Carrier/Tracer Recovery		Liquid Scint Ni63, Liquid-ALL			82								
Carrier/Tracer Recovery		Liquid Scint Tc99, Liquid-ALL			101								

Notes:
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Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	317-322-4	Project:	YANK00304
Sample ID:	113759012	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	23-APR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Alpha Spec Analysis													
Alphaspec Pu, Liquid-ALL													
Plutonium-238	U	0.00173	+/-0.0938	0.0984	+/-0.0938	0.314	pCi/L		BJB1	06/20/04	1300	341332	1
Plutonium-239/240	U	-0.0414	+/-0.0406	0.0983	+/-0.0408	0.313	pCi/L						
Am241,Cm, Liquid-ALL													
Americium-241	U	-0.00807	+/-0.0897	0.103	+/-0.0897	0.315	pCi/L		BJB1	06/21/04	1153	341329	2
Curium-242	U	0.027	+/-0.107	0.0837	+/-0.108	0.308	pCi/L						
Curium-243/244	U	-0.00973	+/-0.0817	0.0462	+/-0.0818	0.202	pCi/L						
Liquid Scint Pu241, Liquid-ALL													
Plutonium-241	U	8.92	+/-8.24	6.71	+/-8.28	13.7	pCi/L		BJB1	06/30/04	1036	344849	3
Rad Liquid Scintillation Analysis													
Liquid Scint Fe55, Liquid-ALL													
Iron-55	U	-23.1	+/-12.5	5.05	+/-12.6	10.4	pCi/L		JLB1	06/21/04	0017	340950	6
Liquid Scint Ni63, Liquid-ALL													
Nickel-63	U	0.674	+/-6.12	5.12	+/-6.12	10.5	pCi/L		JLB1	06/20/04	0751	340951	7
Liquid Scint Tc99, Liquid-ALL													
Technetium-99	U	-1.15	+/-4.16	3.53	+/-4.17	7.25	pCi/L		DAJ1	06/21/04	0157	340926	8

The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, Pu-11-RC Modified
2	DOE EML HASL-300, Am-05-RC Modified
3	DOE EML HASL-300, Pu-11-RC Modified
4	DOE EML HASL-300, Pu-11-RC Modified
5	DOE EML HASL-300, Pu-11-RC Modified
6	DOE RESL Fe-1, Modified
7	DOE RESL Ni-1, Modified
8	DOE EML HASL-300, Tc-02-RC Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Plutonium-242	Alphaspec Pu, Liquid-ALL	98	(15%-125%)
Americium-243	Am241,Cm, Liquid-ALL	94	(25%-125%)
Carrier/Tracer Recovery	Liquid Scint Pu241, Liquid-ALL	85	
Carrier/Tracer Recovery	Liquid Scint Fe55, Liquid-ALL	73	

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Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: 317-322-4
Sample ID: 113759012

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch Mtd.
Carrier/Tracer Recovery		Liquid Scint Ni63, Liquid-ALL			73						
Carrier/Tracer Recovery		Liquid Scint Tc99, Liquid-ALL			103						

Notes:
The Qualifiers in this report are defined as follows :

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BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.

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Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	S-14	Project:	YANK00304
Sample ID:	113759013	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	15-MAR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Alpha Spec Analysis													
Alphaspec Pu, Liquid-ALL													
Plutonium-238	U	0.0128	+/-0.0967	0.0899	+/-0.0967	0.303	pCi/L		BJB1	06/20/04	1300	341332	1
Plutonium-239/240	U	-0.0218	+/-0.0302	0.0733	+/-0.0303	0.270	pCi/L						
Am241,Cm, Liquid-ALL													
Americium-241	U	-0.0182	+/-0.0783	0.061	+/-0.0784	0.224	pCi/L		BJB1	06/21/04	1153	341329	2
Curium-242	U	0.00	+/-0.113	0.00	+/-0.113	0.156	pCi/L						
Curium-243/244	U	0.00	+/-0.0749	0.00	+/-0.0749	0.104	pCi/L						
Liquid Scint Pu241, Liquid-ALL													
Plutonium-241	U	4.72	+/-8.34	6.89	+/-8.35	14.1	pCi/L		BJB1	06/30/04	1137	344849	3
Rad Liquid Scintillation Analysis													
Liquid Scint Fe55, Liquid-ALL													
Iron-55	U	-7.76	+/-12.6	4.81	+/-12.6	9.94	pCi/L		JLB1	06/21/04	0119	340950	6
Liquid Scint Ni63, Liquid-ALL													
Nickel-63	U	4.80	+/-6.51	5.32	+/-6.51	11.0	pCi/L		JLB1	06/20/04	0823	340951	7
Liquid Scint Tc99, Liquid-ALL													
Technetium-99	U	-1.32	+/-4.21	3.57	+/-4.22	7.34	pCi/L		DAJ1	06/21/04	0230	340926	8

The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, Pu-11-RC Modified
2	DOE EML HASL-300, Am-05-RC Modified
3	DOE EML HASL-300, Pu-11-RC Modified
4	DOE EML HASL-300, Pu-11-RC Modified
5	DOE EML HASL-300, Pu-11-RC Modified
6	DOE RESL Fe-1, Modified
7	DOE RESL Ni-1, Modified
8	DOE EML HASL-300, Tc-02-RC Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Plutonium-242	Alphaspec Pu, Liquid-ALL	85	(15%-125%)
Americium-243	Am241,Cm, Liquid-ALL	100	(25%-125%)
Carrier/Tracer Recovery	Liquid Scint Pu241, Liquid-ALL	85	
Carrier/Tracer Recovery	Liquid Scint Fe55, Liquid-ALL	79	

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Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: S-14
Sample ID: 113759013

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Carrier/Tracer Recovery		Liquid Scint Ni63, Liquid-ALL			68								
Carrier/Tracer Recovery		Liquid Scint Tc99, Liquid-ALL			101								

Notes:
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B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
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UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.
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Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	S-4	Project:	YANK00304
Sample ID:	113759014	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	09-MAR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Alpha Spec Analysis													
Alphaspec Pu, Liquid-ALL													
Plutonium-238	U	0.0351	+/-0.154	0.143	+/-0.154	0.399	pCi/L		BJB1	06/20/04	1300	341332	1
Plutonium-239/240	U	-0.03	+/-0.034	0.0823	+/-0.0341	0.278	pCi/L						
Am241,Cm, Liquid-ALL													
Americium-241	U	0.0748	+/-0.148	0.106	+/-0.148	0.324	pCi/L		BJB1	06/21/04	1153	341329	2
Curium-242	U	-0.0156	+/-0.131	0.0739	+/-0.131	0.323	pCi/L						
Curium-243/244	U	-0.0101	+/-0.0846	0.0478	+/-0.0847	0.209	pCi/L						
Liquid Scint Pu241, Liquid-ALL													
Plutonium-241	U	1.27	+/-8.27	6.91	+/-8.27	14.1	pCi/L		BJB1	06/30/04	1239	344849	3
Rad Liquid Scintillation Analysis													
Liquid Scint Fe55, Liquid-ALL													
Iron-55	U	-29.6	+/-11.6	4.75	+/-11.7	9.81	pCi/L		JLB1	06/21/04	0222	340950	6
Liquid Scint Ni63, Liquid-ALL													
Nickel-63	U	0.580	+/-6.20	5.19	+/-6.20	10.7	pCi/L		JLB1	06/20/04	0854	340951	7
Liquid Scint Tc99, Liquid-ALL													
Technetium-99	U	-3.11	+/-4.19	3.60	+/-4.21	7.40	pCi/L		DAJ1	06/21/04	0302	340926	8

The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, Pu-11-RC Modified
2	DOE EML HASL-300, Am-05-RC Modified
3	DOE EML HASL-300, Pu-11-RC Modified
4	DOE EML HASL-300, Pu-11-RC Modified
5	DOE EML HASL-300, Pu-11-RC Modified
6	DOE RESL Fe-1, Modified
7	DOE RESL Ni-1, Modified
8	DOE EML HASL-300, Tc-02-RC Modified

Surrogate/Tracer recovery	Test	Recovery %	Acceptable Limits
Plutonium-242	Alphaspec Pu, Liquid-ALL	85	(15%-125%)
Americium-243	Am241,Cm, Liquid-ALL	91	(25%-125%)
Carrier/Tracer Recovery	Liquid Scint Pu241, Liquid-ALL	84	
Carrier/Tracer Recovery	Liquid Scint Fe55, Liquid-ALL	75	

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Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: S-4
Sample ID: 113759014

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch	Mtd.
Carrier/Tracer Recovery		Liquid Scint Ni63, Liquid-ALL			70							
Carrier/Tracer Recovery		Liquid Scint Tc99, Liquid-ALL			101							

Notes:
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UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
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Certificate of Analysis

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362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	S-9	Project:	YANK00304
Sample ID:	113759015	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	10-MAR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Alpha Spec Analysis													
Alphaspec Pu, Liquid-ALL													
Plutonium-238	U	0.0723	+/-0.166	0.129	+/-0.166	0.384	pCi/L		BJB1	06/20/04	1300	341332	1
Plutonium-239/240	U	0.00185	+/-0.101	0.105	+/-0.101	0.336	pCi/L						
Am241,Cm, Liquid-ALL													
Americium-241	U	0.0635	+/-0.119	0.0673	+/-0.119	0.248	pCi/L		BJB1	06/21/04	1153	341329	2
Curium-242	U	0.0337	+/-0.134	0.105	+/-0.134	0.385	pCi/L						
Curium-243/244	U	0.032	+/-0.085	0.0481	+/-0.0851	0.210	pCi/L						
Liquid Scint Pu241, Liquid-ALL													
Plutonium-241	U	6.10	+/-16.7	13.9	+/-16.7	28.4	pCi/L		BJB1	06/30/04	1340	344849	3
Rad Liquid Scintillation Analysis													
Liquid Scint Fe55, Liquid-ALL													
Iron-55	U	-17.7	+/-12.8	4.87	+/-12.8	10.1	pCi/L		JLB1	06/21/04	0324	340950	6
Liquid Scint Ni63, Liquid-ALL													
Nickel-63	U	1.50	+/-6.36	5.30	+/-6.37	10.9	pCi/L		JLB1	06/20/04	0926	340951	7
Liquid Scint Tc99, Liquid-ALL													
Technetium-99	U	-1.93	+/-4.07	3.47	+/-4.08	7.12	pCi/L		DAJ1	06/21/04	0334	340926	8

The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, Pu-11-RC Modified
2	DOE EML HASL-300, Am-05-RC Modified
3	DOE EML HASL-300, Pu-11-RC Modified
4	DOE EML HASL-300, Pu-11-RC Modified
5	DOE EML HASL-300, Pu-11-RC Modified
6	DOE RESL Fe-1, Modified
7	DOE RESL Ni-1, Modified
8	DOE EML HASL-300, Tc-02-RC Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Plutonium-242	Alphaspec Pu, Liquid-ALL	88	(15%-125%)
Americium-243	Am241,Cm, Liquid-ALL	93	(25%-125%)
Carrier/Tracer Recovery	Liquid Scint Pu241, Liquid-ALL	83	
Carrier/Tracer Recovery	Liquid Scint Fe55, Liquid-ALL	80	

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Certificate of Analysis

Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: S-9
Sample ID: 113759015

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Carrier/Tracer Recovery		Liquid Scint Ni63, Liquid-ALL			70								
Carrier/Tracer Recovery		Liquid Scint Tc99, Liquid-ALL			104								

Notes:
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E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
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U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
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Certificate of Analysis

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362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	178-183-5	Project:	YANK00304
Sample ID:	113759016	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	19-MAY-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch	Mtd.
Rad Gas Flow Proportional Counting												
GFPC, Sr90, liquid-ALL,MIX												
Strontium-90	U	0.209	+/-0.418	0.439	+/-0.421	0.949	pCi/L		HOB1 06/22/04	0923	340973	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description
1	EPA 905.0 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Sr90, liquid-ALL,MIX	90	

Notes:
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E Concentration of the target analyte exceeds the instrument calibration range.
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U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
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362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	317-322-5	Project:	YANK00304
Sample ID:	113759017	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	23-APR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Gas Flow Proportional Counting													
GFPC, Sr90, liquid-ALL,MIX													
Strontium-90	U	0.507	+/-0.510	0.500	+/-0.525	1.06	pCi/L		HOB1	06/17/04	2146	340973	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description
1	EPA 905.0 Modified

Surrogate/Tracer recovery	Test	Recovery %	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Sr90, liquid-ALL,MIX	92	

Notes:
The Qualifiers in this report are defined as follows:

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.
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Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	S-15	Project:	YANK00304
Sample ID:	113759018	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	15-MAR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Gas Flow Proportional Counting													
GFPC, Sr90, liquid-ALL,MIX													
Strontium-90	U	0.289	+/-0.506	0.512	+/-0.511	1.08	pCi/L		HOB1	06/17/04	2146	340973	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description
1	EPA 905.0 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Sr90, liquid-ALL,MIX	84	

Notes:
The Qualifiers in this report are defined as follows:

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
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UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
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Company: CYAPCo
Address: Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID: S-5
Sample ID: 113759019
Matrix: Ground Water
Collect Date: 09-MAR-04
Receive Date: 27-MAY-04
Collector: Client

Project: YANK00304
Client ID: YANK001
Vol. Recv.:

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	Analyst	Date	Time	Batch	Mtd.
Rad Gas Flow Proportional Counting													
GFPC, Sr90, liquid-ALL,MIX													
Strontium-90	U	0.0754	+/-0.480	0.515	+/-0.481	1.11	pCi/L		HOB1	06/18/04	1207	340973	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description
1	EPA 905.0 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Sr90, liquid-ALL,MIX	88	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
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U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Sarah Kozlik.

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : CYAPCo
Address : Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut 06424
Contact: Mr. Dave Keefer
Project: Quarterly Groundwater PO# 002337

Report Date: July 1, 2004

Client Sample ID:	S-10	Project:	YANK00304
Sample ID:	113759020	Client ID:	YANK001
Matrix:	Ground Water	Vol. Recv.:	
Collect Date:	10-MAR-04		
Receive Date:	27-MAY-04		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	LC	TPU	MDA	Units	DF	AnalystDate	Time	Batch	Mtd.
Rad Gas Flow Proportional Counting												
GFPC, Sr90, liquid-ALL,MIX												
Strontium-90	U	0.573	+/-0.631	0.619	+/-0.655	1.33	pCi/L		HOB1 06/18/04	1207	340973	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	06/04/04	0800	337362

The following Analytical Methods were performed

Method	Description
1	EPA 905.0 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Sr90, liquid-ALL,MIX	73	

Notes:
The Qualifiers in this report are defined as follows :

B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

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Reviewed by

QUALITY CONTROL DATA

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: July 1, 2004

Client: CYAPCo
Haddam Neck Plant
362 Injun Hollow Road
East Hampton, Connecticut
Contact: Mr. Dave Keefer

Workorder: 113759

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time
Rad Alpha Spec											
Batch 341329											
QC1200644404 113759011 DUP											
Americium-241	U	-0.0118	U	0.00356	pCi/L	N/A		(0% - 100%)	BJB1	06/21/04	11:53
Uncert:		+/-0.0991		+/-0.137							
TPU:		+/-0.0992		+/-0.137							
Curium-242	U	0.00	U	-0.0247	pCi/L	N/A		(0% - 100%)			
Uncert:		+/-0.111		+/-0.0342							
TPU:		+/-0.111		+/-0.0343							
Curium-243/244	U	0.00	U	-0.0536	pCi/L	N/A		(0% - 100%)			
Uncert:		+/-0.0966		+/-0.047							
TPU:		+/-0.0966		+/-0.0476							
QC1200644406 LCS											
Americium-241	17.9			16.4	pCi/L		92	(75%-125%)			
Uncert:				+/-1.52							
TPU:				+/-2.63							
Curium-242			U	0.00	pCi/L						
Uncert:				+/-0.0732							
TPU:				+/-0.0732							
Curium-243/244	23.1			23.8	pCi/L		103				
Uncert:				+/-1.83							
TPU:				+/-3.62							
QC1200644403 MB											
Americium-241			U	-0.0088	pCi/L						
Uncert:				+/-0.0979							
TPU:				+/-0.0979							
Curium-242			U	-0.0215	pCi/L						
Uncert:				+/-0.0298							
TPU:				+/-0.030							
Curium-243/244			U	0.0458	pCi/L						
Uncert:				+/-0.129							
TPU:				+/-0.129							
QC1200644405 113759011 MS											
Americium-241	17.9 U	-0.0118		15.7	pCi/L		88	(75%-125%)			
Uncert:		+/-0.0991		+/-1.54							
TPU:		+/-0.0992		+/-2.60							
Curium-242	U	0.00	U	0.0448	pCi/L						
Uncert:		+/-0.111		+/-0.0879							
TPU:		+/-0.111		+/-0.0881							
Curium-243/244	23.1 U	0.00		22.4	pCi/L		97				
Uncert:		+/-0.0966		+/-1.83							
TPU:		+/-0.0966		+/-3.49							
Batch 341332											
QC1200644412 113759011 DUP											
Curium-238	U	-0.0844	U	-0.0392	pCi/L	N/A		(0% - 100%)	BJB1	06/20/04	13:00

QC Summary

Workorder: 113759

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Alpha Spec										
Batch 341332										
	Uncert:	+/-0.0585		+/-0.0888						
	TPU:	+/-0.0591		+/-0.0888						
Plutonium-239/240	U	0.0246	U	0.0424	pCi/L	53		(0% - 100%)		
	Uncert:	+/-0.132		+/-0.119						
	TPU:	+/-0.132		+/-0.120						
QC1200644414 LCS										
Plutonium-238			U	-0.0187	pCi/L			(75%-125%)		
	Uncert:			+/-0.0966						
	TPU:			+/-0.0966						
Plutonium-239/240	15.9			16.0	pCi/L		101	(75%-125%)		
	Uncert:			+/-1.62						
	TPU:			+/-2.26						
QC1200644411 MB										
Plutonium-238			U	-0.0342	pCi/L					
	Uncert:			+/-0.117						
	TPU:			+/-0.117						
Plutonium-239/240			U	-0.0603	pCi/L					
	Uncert:			+/-0.0528						
	TPU:			+/-0.0532						
QC1200644413 113759011 MS										
Plutonium-238	U	-0.0844	U	0.00397	pCi/L			(75%-125%)		
	Uncert:	+/-0.0585		+/-0.152						
	TPU:	+/-0.0591		+/-0.152						
Plutonium-239/240	15.9 U	0.0246		17.6	pCi/L		111	(75%-125%)		
	Uncert:	+/-0.132		+/-1.83						
	TPU:	+/-0.132		+/-2.59						
Batch 344849										
QC1200652999 113759013 DUP										
Plutonium-241	U	4.72	U	4.29	pCi/L	10		(0% - 100%)	BJB1	06/30/04 15:44
	Uncert:	+/-8.34		+/-7.26						
	TPU:	+/-8.35		+/-7.27						
QC1200653001 LCS										
Plutonium-241	177			172	pCi/L		97	(75%-125%)		06/30/04 17:46
	Uncert:			+/-11.6						
	TPU:			+/-18.7						
QC1200652998 MB										
Plutonium-241			U	0.814	pCi/L					06/30/04 14:42
	Uncert:			+/-7.32						
	TPU:			+/-7.32						
QC1200653000 113759013 MS										
Plutonium-241	180 U	4.72		156	pCi/L		84	(75%-125%)		06/30/04 16:45
	Uncert:	+/-8.34		+/-10.2						
	TPU:	+/-8.35		+/-16.7						
Rad Gamma Spec										
Batch 337182										
QC1200634478 113759006 DUP										
Americium-241	U	-6.32	U	0.705	pCi/L	N/A		(0% - 100%)	SRB	06/13/04 13:09
	Uncert:	+/-10.5		+/-6.88						
				+/-6.75						

QC Summary

Workorder: 113759

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gamma Spec										
Batch 337182										
	TPU:	+/-10.3								
Cesium-134	U	-1.38	U	0.873	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-1.34		+/-1.29						
	TPU:	+/-1.31		+/-1.27						
Cesium-137	U	-0.0136	U	0.800	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-1.26		+/-1.07						
	TPU:	+/-1.24		+/-1.04						
Cobalt-60	U	-1.4	U	1.25	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-1.39		+/-1.51						
	TPU:	+/-1.36		+/-1.48						
Europium-152	U	2.61	U	0.638	pCi/L	121		(0% - 100%)		
	Uncert:	+/-4.38		+/-3.33						
	TPU:	+/-4.30		+/-3.26						
Europium-154	U	-3.17	U	2.24	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-3.51		+/-2.91						
	TPU:	+/-3.44		+/-2.86						
Europium-155	U	-4.25	U	1.76	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-4.96		+/-4.12						
	TPU:	+/-4.86		+/-4.03						
ganese-54	U	-0.766	U	-0.153	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-1.27		+/-1.01						
	TPU:	+/-1.25		+/-0.989						
Niobium-94	U	-0.136	U	-0.416	pCi/L	N/A		(0% - 100%)		
	Uncert:	+/-1.14		+/-0.917						
	TPU:	+/-1.11		+/-0.899						
Silver-108m	U	0.168	U	0.464	pCi/L	94		(0% - 100%)		
	Uncert:	+/-1.20		+/-1.09						
	TPU:	+/-1.18		+/-1.07						
QC1200634480 LCS										
Americium-241	1170			1210	pCi/L		103	(75%-125%)		06/14/04 09:01
	Uncert:			+/-188						
	TPU:			+/-185						
Cesium-134			U	0.938	pCi/L					
	Uncert:			+/-10.9						
	TPU:			+/-10.6						
Cesium-137	462			485	pCi/L		105	(75%-125%)		
	Uncert:			+/-45.6						
	TPU:			+/-44.7						
Cobalt-60	718			743	pCi/L		103	(75%-125%)		
	Uncert:			+/-64.4						
	TPU:			+/-63.1						
Europium-152			U	2.11	pCi/L					
	Uncert:			+/-26.6						
	TPU:			+/-26.0						
Europium-154			U	-0.82	pCi/L					
	Uncert:			+/-24.3						
	TPU:			+/-23.8						
ium-155			U	4.56	pCi/L					

QC Summary

Workorder: 113759

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gamma Spec										
Batch 337182										
	Uncert:			+/-43.2						
	TPU:			+/-42.3						
Manganese-54			U	-10	pCi/L					
	Uncert:			+/-10.3						
	TPU:			+/-10.1						
Niobium-94			U	-3.86	pCi/L					
	Uncert:			+/-10.2						
	TPU:			+/-10.0						
Silver-108m			U	-6.59	pCi/L					
	Uncert:			+/-8.78						
	TPU:			+/-8.60						
QC1200634477 MB										
Americium-241			U	-0.409	pCi/L					06/10/04 22:52
	Uncert:			+/-2.15						
	TPU:			+/-2.10						
Cesium-134			U	-0.996	pCi/L					
	Uncert:			+/-1.72						
	TPU:			+/-1.68						
C[illegible]m-137			U	-0.352	pCi/L					
	Uncert:			+/-1.75						
	TPU:			+/-1.72						
Cobalt-60			U	-0.115	pCi/L					
	Uncert:			+/-1.94						
	TPU:			+/-1.90						
Europium-152			U	2.24	pCi/L					
	Uncert:			+/-4.24						
	TPU:			+/-4.16						
Europium-154			U	1.90	pCi/L					
	Uncert:			+/-4.85						
	TPU:			+/-4.75						
Europium-155			U	1.17	pCi/L					
	Uncert:			+/-3.31						
	TPU:			+/-3.24						
Manganese-54			U	0.230	pCi/L					
	Uncert:			+/-1.55						
	TPU:			+/-1.52						
Niobium-94			U	-0.846	pCi/L					
	Uncert:			+/-1.49						
	TPU:			+/-1.46						
Silver-108m			U	0.358	pCi/L					
	Uncert:			+/-1.41						
	TPU:			+/-1.39						
QC1200634479 113759006 MS										
Americium-241	9370	U		10400	pCi/L		111			06/14/04 09:00
	Uncert:	+/-10.5		+/-1620						
	TPU:	+/-10.3		+/-32600						
Cesium-134	U	-1.38	U	-51.7	pCi/L					
	Uncert:	+/-1.34		+/-161						
	TPU:	+/-1.31		+/-227						

QC Summary

Workorder: 113759

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gamma Spec										
Batch 337182										
Cesium-137	3700 U	-0.0136		3810	pCi/L		103			
	Uncert:	+/-1.26		+/-516						
	TPU:	+/-1.24		+/-12000						
Cobalt-60	5790 U	-1.4		6450	pCi/L		112			
	Uncert:	+/-1.39		+/-778						
	TPU:	+/-1.36		+/-20200						
Europium-152	U	2.61	U	26.0	pCi/L					
	Uncert:	+/-4.38		+/-346						
	TPU:	+/-4.30		+/-348						
Europium-154	U	-3.17	U	-153	pCi/L					
	Uncert:	+/-3.51		+/-327						
	TPU:	+/-3.44		+/-577						
Europium-155	U	-4.25	U	183	pCi/L					
	Uncert:	+/-4.96		+/-413						
	TPU:	+/-4.86		+/-702						
Manganese-54	U	-0.766	U	39.7	pCi/L					
	Uncert:	+/-1.27		+/-152						
	TPU:	+/-1.25		+/-194						
um-94	U	-0.136	U	-4.36	pCi/L					
	Uncert:	+/-1.14		+/-128						
	TPU:	+/-1.11		+/-126						
Silver-108m	U	0.168	U	-66.6	pCi/L					
	Uncert:	+/-1.20		+/-132						
	TPU:	+/-1.18		+/-246						
Rad Gas Flow										
Batch 340973										
QC1200643663 113759018 DUP										
Strontium-90	U	0.289	U	0.112	pCi/L	89		(0% - 100%)	HOB1	06/18/04 13:40
	Uncert:	+/-0.506		+/-0.515						
	TPU:	+/-0.511		+/-0.516						
QC1200643665 LCS										
Strontium-90	45.9			48.2	pCi/L		105	(75%-125%)		
	Uncert:			+/-2.50						
	TPU:			+/-14.2						
QC1200643662 MB										
Strontium-90			U	0.670	pCi/L					
	Uncert:			+/-0.618						
	TPU:			+/-0.646						
QC1200643664 113759018 MS										
Strontium-90	92.4 U	0.289		89.7	pCi/L		97	(75%-125%)		
	Uncert:	+/-0.506		+/-4.54						
	TPU:	+/-0.511		+/-24.0						
Batch 341271										
QC1200644274 113759009 DUP										
Alpha	U	0.0983	U	0.122	pCi/L	0		(0% - 100%)	ATH1	06/25/04 08:01
	Uncert:	+/-0.385		+/-0.595						
	TPU:	+/-0.385		+/-0.596						
	U	-1.71	U	-0.581	pCi/L	N/A		(0% - 100%)		

QC Summary

Workorder: 113759

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gas Flow										
Batch 341271										
	Uncert:	+/-1.48		+/-1.08						
	TPU:	+/-1.48		+/-1.09						
QC1200644277 LCS										
Alpha	69.8			64.6	pCi/L		93	(75%-125%)		06/25/04 07:47
	Uncert:			+/-6.86						
	TPU:			+/-19.7						
Beta	245			229	pCi/L		94	(75%-125%)		
	Uncert:			+/-10.4						
	TPU:			+/-25.0						
QC1200644273 MB										
Alpha			U	-0.111	pCi/L					06/25/04 08:01
	Uncert:			+/-0.339						
	TPU:			+/-0.339						
Beta				2.55	pCi/L					
	Uncert:			+/-1.15						
	TPU:			+/-1.16						
QC1200644275 113759009 MS										
Alpha	69.8 U	0.0983		68.9	pCi/L		99	(75%-125%)		
	Uncert:	+/-0.385		+/-4.23						
	TPU:	+/-0.385		+/-9.26						
Beta	247 U	-1.71		252	pCi/L		102	(75%-125%)		
	Uncert:	+/-1.48		+/-6.54						
	TPU:	+/-1.48		+/-28.5						
QC1200644276 113759009 MSD										
Alpha	69.8 U	0.0983		70.9	pCi/L	3*	101	(75%-125%)		06/25/04 07:47
	Uncert:	+/-0.385		+/-7.00						
	TPU:	+/-0.385		+/-9.51						
Beta	247 U	-1.71		255	pCi/L	1*	104	(75%-125%)		
	Uncert:	+/-1.48		+/-10.7						
	TPU:	+/-1.48		+/-15.3						
Rad Liquid Scintillation										
Batch 340926										
QC1200644474 113759011 DUP										
Technetium-99	U	-3.36	U	-1.44	pCi/L	N/A		(0% - 100%)	DAJ1	06/21/04 04:38
	Uncert:	+/-4.12		+/-4.15						
	TPU:	+/-4.15		+/-4.16						
QC1200643525 LCS										
Technetium-99	392			392	pCi/L		100	(75%-125%)		06/21/04 05:42
	Uncert:			+/-11.4						
	TPU:			+/-61.2						
QC1200643522 MB										
Technetium-99			U	-1.03	pCi/L					06/21/04 04:06
	Uncert:			+/-4.30						
	TPU:			+/-4.30						
QC1200644475 113759011 MS										
Technetium-99	392 U	-3.36		416	pCi/L		106	(75%-125%)		06/21/04 05:10
	Uncert:	+/-4.12		+/-11.6						
	TPU:	+/-4.15		+/-64.8						
1 340950										

QC Summary

Workorder: 113759

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Liquid Scintillation										
Batch 340950										
QC1200643609 113759015 DUP										
Iron-55	U	-17.7	U	-27.2	pCi/L	N/A		(0% - 100%)	JLB1	06/21/04 05:30
	Uncert:	+/-12.8		+/-11.9						
	TPU:	+/-12.8		+/-12.0						
QC1200643611 LCS										
Iron-55	55.1			51.7	pCi/L		94*	(0%-%)		06/21/04 07:35
	Uncert:			+/-11.9						
	TPU:			+/-12.1						
QC1200643608 MB										
Iron-55			U	-14	pCi/L					06/21/04 04:27
	Uncert:			+/-11.2						
	TPU:			+/-11.2						
QC1200643610 113759015 MS										
Iron-55	59.0 U	-17.7		45.4	pCi/L		77*	(0%-%)		06/21/04 06:32
	Uncert:	+/-12.8		+/-13.5						
	TPU:	+/-12.8		+/-13.6						
Batch 340951										
QC1200643613 113759015 DUP										
Nickel-63	U	1.50	U	3.48	pCi/L	0		(0% - 100%)	JLB1	06/20/04 10:28
	Uncert:	+/-6.36		+/-6.43						
	TPU:	+/-6.37		+/-6.43						
QC1200643615 LCS										
Nickel-63	249			214	pCi/L		86	(75%-125%)		06/20/04 11:31
	Uncert:			+/-9.99						
	TPU:			+/-10.8						
QC1200643612 MB										
Nickel-63			U	-0.198	pCi/L					06/20/04 09:57
	Uncert:			+/-5.11						
	TPU:			+/-5.11						
QC1200643614 113759015 MS										
Nickel-63	250 U	1.50		203	pCi/L		81	(75%-125%)		06/20/04 11:00
	Uncert:	+/-6.36		+/-9.37						
	TPU:	+/-6.37		+/-10.2						
Batch 340954										
QC1200643625 113759005 DUP										
Tritium		325		323	pCi/L	1		(0% - 100%)	JLB1	06/19/04 06:14
	Uncert:	+/-140		+/-138						
	TPU:	+/-140		+/-138						
QC1200643627 LCS										
Tritium	3240			3110	pCi/L		96	(75%-125%)		06/19/04 08:46
	Uncert:			+/-258						
	TPU:			+/-263						
QC1200643624 MB										
Tritium			U	-8.7	pCi/L					06/19/04 04:11
	Uncert:			+/-117						
	TPU:			+/-117						
QC1200643626 113759005 MS										
Tritium	3280	325		3440	pCi/L		95	(75%-125%)		06/19/04 07:46
	Uncert:	+/-140		+/-223						

QC Summary

Workorder: 113759

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Liquid Scintillation										
Batch 340954										
	TPU:	+/-140		+/-230						
Batch 341392										
QC1200644562 113960002 DUP										
Carbon-14		41.8		42.1	pCi/L	1		(0% - 100%)	MWX	06/19/04 20:24
	Uncert:	+/-5.25		+/-5.18						
	TPU:	+/-5.42		+/-5.35						
QC1200644564 LCS										
Carbon-14	202			213	pCi/L		105	(75%-125%)		06/19/04 21:28
	Uncert:			+/-8.66						
	TPU:			+/-11.0						
QC1200644561 MB										
Carbon-14			U	1.25	pCi/L					06/19/04 19:52
	Uncert:			+/-3.97						
	TPU:			+/-3.97						
QC1200644563 113960002 MS										
Carbon-14	202	41.8		255	pCi/L		106	(75%-125%)		06/19/04 20:56
	Uncert:	+/-5.25		+/-9.29						
	TPU:	+/-5.42		+/-12.3						

Notes:
The Qualifiers in this report are defined as follows:

- B Target analyte was detected in the sample as well as the associated blank.
- BD Flag for results below the MDC or a flag for low tracer recovery.
- E Concentration of the target analyte exceeds the instrument calibration range.
- H Analytical holding time exceeded.
- J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
- U Indicates the target analyte was analyzed for but not detected above the detection limit.
- UI Uncertain identification for gamma spectroscopy.
- X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
- h Sample preparation or preservation holding time exceeded.

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more.
** Indicates analyte is a surrogate compound.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptence criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Appendix 5
COLOG Borehole Geophysics Report, Hydrophysical Sampling Data Quality Assessment

Data Quality Assessment of Hydrophysical Sampling Results Collected in Summer of 2004

CH2M HILL has performed a data quality assessment (DQA) of the results of borehole sampling conducted during hydrophysical™ logging at the Connecticut Yankee Atomic Power Company (CYAPCo) Haddam Neck Plant (HNP). Discrete point samples were collected using a downhole sampling device just above each identified water-producing zone identified by the fluid electrical conductivity profiles and temperature changes recorded by the hydrophysical™ logging technique. The fluid samples were procured just above each identified flow zone to insure complete mixing of the inflowing formation waters fluid moving up to the pump placed inside the surface casing in order to obtain a sample representative of each discrete depth point.

The purpose of collecting and analyzing discrete point samples at the HNP was to provide screening of the bedrock interval for the vertical distribution of tritium, confirm the analytical results and overall characterization of the boreholes obtained from previous packer testing, and determine potential screen intervals for water quality monitoring.

The DQA was performed as outlined below. The data set generated from the borehole sampling was evaluated against criteria for measurement precision, accuracy, representativeness, completeness, and comparability to determine data validity and usability. The following summarizes the results of the DQA.

Summary of Data Collection Activities

Fluid replacement and fluid-column conductivity logging, or hydrophysical™ logging, involves electrical conductivity logging of the fluid column over time after the borehole fluid has been diluted or replaced with de-ionized water. Periodic electrical conductivity logs show formation fluids and possible contamination reentering the borehole as a function of the hydraulic conductivity of the surrounding rocks. Hydrophysical logging is used to determine flow magnitude and direction under both ambient and pumping conditions to identify hydraulically conductive intervals to within one wellbore diameter. The data can be analyzed with a multi-parameter, finite difference model to produce hydraulic conductivity measurements that compare well with hydraulic conductivity values calculated from packer tests (Keys, 1997). The hydrophysical™ logs were used to measure the magnitude and direction of flow, identify possible fluid entry and exit points in the boreholes to complete the bedrock characterization effort, providing confirmation or alternative interpretations of flow conditions measured by the heat-pulse flowmeter surveys and indications of water-bearing fractures by the conventional geophysical logs. Other specific applications of hydrophysical™ logging for this characterization effort included assessment of possible fracture interconnection within and between boreholes, providing flow measurements to calculate the hydraulic conductivity and transmissivity of specific fractures or intervals, and targeting discrete point sample locations. Discrete point samples are procured via a

downhole sampling device just above each identified water-producing zone identified by flow logging. These fluid samples collected provide an indication of the presence and vertical extent of substances of concern in a borehole.

During the second phase of the geophysical logging program at the HNP, data were collected to confirm the location of water-bearing fractures, refine the understanding of the flow regime in the boreholes, assess fracture interconnection, generate hydraulic conductivity values for specific fractures and intervals, and collect discrete point samples to screen the bedrock interval for the vertical distribution of tritium. The optical camera logging was completed in each borehole prior to the hydrophysical logging™ to confirm the location and apparent aperture of possible fracture features. Hydrophysical logging™ was conducted to provide an overall assessment of hydrogeologic conditions and refine previous interpretations of groundwater flow at the facility. The hydrophysical logging™ technique was conducted in three sequential logging steps:

(1) ambient logging runs prior to de-ionized (DI) emplacement,

(2) logging runs immediately after DI water was emplaced in the borehole, and

(3) logging runs conducted after DI water was emplaced during low-rate pumping.

The ambient water quality logs are conducted to provide baseline values for undisturbed borehole fluid conditions prior to testing. Multiple logging runs were conducted during each step to provide repeatable profiles of the fluid electrical conductivity and temperature changes in the borehole caused by electrically contrasting water being drawn into the borehole by pumping or native formation pressures.

Based on the water-producing zones identified by the fluid electrical conductivity profiles and temperature changes recorded, discrete point sample locations were then selected to confirm the vertical distribution of tritium in the bedrock interval at the Industrial Area of the HNP. The CYAPCo laboratory at the HNP analyzed these samples. COLOG then calculated interval specific pore water tritium concentrations using a mass-balance equation with the HNP laboratory results and interval specific flow rates from the hydraulically conductiver interval directly below the sample collection depth. These analytical results comprise the hydrophysical sampling conducted during the summer of 2004 and are the focus of this DQA.

The computer programs FLOWCALC and/or BORE II (COLOG, 2004) were utilized to evaluate the inflow quantities of the formation water for each specific inflow location. FLOWCALC is used to estimate the interval-specific flow rates for the production test results based on "hand-picked" values of fluid electrical conductivity and depth. The values are determined from the "Pumping" and "Pumping during DI Injection logs." Numerical modeling of the reported data is performed using code BORE II. These methods accurately reflect the flow quantities for the identified water bearing intervals (COLOG, 2004).

For interval-specific permeability estimations, COLOG utilizes Hvorslev's 1951 porosity equation in conjunction with the hydrophysical™ logging results. Several assumptions are made for estimating the permeability of secondary porosity. First, the type of production test COLOG performs in the field may significantly affect the accuracy of the transmissivity estimation. The permeability equation is relatively sensitive to overall observed drawdown.

For a high yield borehole, drawdown will usually stabilize and an accurate observed drawdown can be estimated. However, for a low yield borehole, drawdown usually does not stabilize but instead, water level continues to drop until it reaches the pump inlet and the test is complete. In this case COLOG utilizes the maximum observed drawdown. The inaccuracy arises in the fact that overall observed drawdown does not stabilize and therefore is more an arbitrary value dependent on the placement of the pump downhole. Secondly, in an environment where flow originates from secondary porosity the length of thickness of the fracture network producing water. This assumption of a fracture network producing water versus a porous media is not how the permeability equation was designed to be used. In lieu of a more appropriate equation unknown to COLOG at this time, COLOG utilizes Hvorslev's 1951 porosity equation based on its sensitivity to interval-specific flow which can be measured accurately, drawdown which can be measured accurately in the case of a high yield borehole and its insensitivity to effective radius. The insensitivity to effective radius is critical when an observation well is not available to measure drawdown at a known distance from the subject borehole (COLOG, 2004).

Summary of Data Collected

The borehole samples collected were analyzed for tritium by using liquid scintillation counting (the recommended counting method). Two different preparation methods were used: distillation and resin adsorption separation. Of the samples collected, 20 percent were analyzed by the distillation method, 80 percent by the resin adsorption separation method, and four samples were analyzed by both distillation and resin adsorbtion.

Discrete point sampling was conducted at depth in borehole 118A during development pumping at a time-averaged pumping rate of 4.81 gpm after production testing was completed. Eight at-depth samples and one wellhead sample were collected. Samples collected from 40.28, 53.4, 67.5 feet bgs contained the highest concentrations of tritium, while samples collected from 72, 108, and 124.7 feet bgs detected tritium at lower concentrations. The HNP laboratory results and the pore water contaminant concentrations derived by COLOG using a mass balance equation are presented in Table 3-1. Discrete point sampling was conducted at depth in borehole 119 during development pumping at a time-averaged rate of 1.41 gpm after production testing was completed. Eight at-depth samples and one wellhead sample were collected. Samples collected from 44, 70, and 82 feet bgs contained the highest concentrations of tritium, while lower values were detected from samples collected from 143, 156, 298, and 453.5 feet bgs. The derived pore water contaminant concentrations were significantly elevated compared to the HNP laboratory for the 156, 298, and 453.5 feet bgs samples as noted in Table 3-2. It was determined the lower concentrations reported by the HNP laboratory at 298 and 453.5 feet bgs are more representative of site conditions. The rationale for this assessment of representative analytical results for the lower depths is discussed in detail in provided in the Results of Data Quality Assessment section below.

Discrete point samples were collected at depth in borehole 120 during development pumping at a time-averaged rate of 1.80 gpm after production testing was completed. Seven at-depth samples and one wellhead sample were collected. The sample collected from 77

feet bgs contained the highest concentrations of tritium with much lower levels detected at 85.3 and 99.7 feet bgs (See Table 3-3).

Discrete point samples were collected at depth in borehole 121A during development pumping at a time-averaged rate of 6.75 gpm after production testing was completed. Eight at-depth samples were collected. In summary, samples collected from depths 163 and 173 feet bgs detected tritium at elevated t concentrations. All other samples analyzed were non-detect as shown in Table 3-4 .

Results of Data Quality Assessment

The Phase II Hydrogeologic Characterization Work Plan (Malcom-Pirnie, 2002) data quality objectives specify goals of "determining the cause, location, nature and condition of release areas and their associated SOCs" and "determining the degree and extent of the resulting plumes". Even though the samples were collected for screening purposes, the data were assessed for precision, accuracy, representativeness, completeness, and comparability. The individual assessment parameters are discussed in the following subsections.

Precision

Precision is the measurement of the repeatability of a measurement or measurement technique. Precision is evaluated through analysis of multiple duplicate samples. The following types of duplicate samples are typically assessed:

- Field duplicate, or split, samples that are collected in the field and submitted to the laboratory as blind samples (i.e., not identifiable to the laboratory as duplicates); and
- Laboratory duplicate, or replicate, samples that are prepared by the laboratory and analyzed by the laboratory to assess internal method precision.

Since the objective of the discrete point sample collection was to screen the bedrock interval for tritium, duplicate and/or field samples were not collected for tritium analysis during the hydrophysical™ sampling. As part of regularly-scheduled groundwater monitoring activities in future bedrock wells, field and laboratory duplicates will be collected, to assess measurement precision.

Accuracy

Accuracy is typically assessed through analysis of known standards and through the analysis of blanks and/or matrix spike samples. No blank and/or matrix spike information was provided by the onsite laboratory to assess accuracy. Measurement calibration is performed in accordance with laboratory procedures.

Representativeness

Representativeness refers to the degree to which a data set is actually a sample of a population. In this case representativeness refers to the degree to which the information presented by the data set can be extrapolated to describe the overall site.

Discrete point sample collection during hydrophysical logging is intended to collect samples from specific transmissive intervals in the geologic formation. In zones where the formation

is sufficiently productive to allow complete development of the borehole, consistent with the protocols employed by COLOG, samples of borehole water at identified intervals are considered to be representative of formation water from the identified zones. In some zones, the production of water from the formation under the test conditions is insufficient to fully develop the water within the borehole. In this case, the sample of water collected from the borehole corresponding to that zone is not considered to be representative of formation water. This situation was encountered in the following depth intervals in borehole 119 during hydrophysical testing at HNP (See Table 3-2):

- 254-ft bgs (interval 253- to 254.5-ft bgs),
- 298-ft bgs (interval 297.2- to 299.3-ft bgs), and
- 453.5-ft bgs (interval 456.4- to 456.7-ft bgs).

COLOG uses an arithmetic dilution algorithm to derive an estimated concentration of constituents of interest for zones that are not fully developed. The actual representativeness of these samples, and the concentrations derived from laboratory measurements of those samples is not quantifiable and the derived tritium values should not be compared to other measurements. These values should not be used to represent the formation water quality at those intervals and should rather be used only as indication of the presence or absence of tritium in the borehole at those elevations.

This uncertainty regarding representativeness of samples from zones that did not develop fully is generally confined to zones at substantial depth in the bedrock formation. Those zones exhibiting a low degree of development during hydrophysical testing may be exhibiting other features such as temporary storage of small quantities of borehole water in discontinuous, or "blind" fractures into which tritium-bearing borehole water was forced due to previous placement of the flexible borehole liners. The resulting inability to quantitatively assess the presence or absence of tritium in these poorly developed zones demonstrates the need to establish monitoring capability in those zones to confirm conditions.

In another instance, the pore water tritium concentration calculated from an interval is significantly less than the laboratory analytical results because of a low specific interval flow detected at that depth. The sample procured at 144 feet bgs in BH-121A detected 6,250 pCi/L of tritium by the HNP laboratory, while the resulting pore water tritium estimation using the Mass-Balance equation was "No Detect" (ND) as shown in Table 3-4. This ND calculation is derived because the sample just below 144 feet procured at 163 feet contained 7,230 pCi/L of tritium with 6.47 gpm (aggregate flow below 163 feet) of flow associated with this sample, which comprises approximately 94 percent of the flow measured in the borehole. The sample procured at 144 feet had only an additional 0.18 gpm of flow associated with it. The difference in observed concentrations between the sample at 163 feet and 144 feet, as far as estimations made using the Mass-Balance equation are concerned, is solely the result of the introduction of a certain concentration of tritium into the borehole at 0.18 gpm. The water coming into the borehole must be relatively low in tritium compared to the borehole fluids and steady-state conditions are present at and below this depth, resulting in the ND value for the corresponding water-bearing flow feature. In this case, the

ND pore water tritium concentration is considered representative of the groundwater at depth interval 160.4-160.5.Completeness
Completeness refers to the ability of the data set to encompass the entirety of the target system. The data should be sufficient to answer the questions that prompted the data collection in the first place. As stated above, the data collected as part of this characterization effort met the hydrophysical/geophysical logging program objectives of screening the bedrock interval for vertical distribution of tritium, providing necessary information to refine the hydrogeologic conceptual site model, assist with the design of the bedrock groundwater monitoring network, and calibrate the upcoming numerical groundwater modeling for the facility.

Eight discrete point samples were collected in each borehole as planned: seven samples collected from water-producing intervals and one wellhead sample per borehole. Valid analytical results from the HNP onsite laboratory were obtained for each sample collected.

Comparability

Comparability refers to the degree to which a data set, or single datum can be compared to another measurement for the purposes of assessing change over time or space. Collected samples were analyzed for tritium by using liquid scintillation counting (the recommended counting method) using two different preparation methods: distillation and resin adsorption separation. Twenty percent of the samples were analyzed by the distillation method, 80 percent by the resin adsorption separation method, and four samples were analyzed by both methods. To assess comparabilty, relative percent difference was calculated for each sample for which both preparation methods were used. If the two sample preparation methods are indeed comparable, then the results should compare well when evaluated as duplicate analyses of the same sample.

Seven laboratory duplicates were identified in the data set provided for this sampling campaign. The Relative Percent Difference (RPD) for the laboratory duplicates are summarized in Table 1.

Table 1. Comparison of Distilled and Resin Results

Borehole	Sample depth (ft bgs)	Distilled Result (Pci/L)	Resin Result (Pci/L)	RPD (%)
118	109	3,390	3,390	0%
120	76.6	1,810	1,730	4.5%
120	85.3	1,310	1,390	3%
121A	326.3	<1,290	<1,250	--
121A	463.7	<1,290	<1,270	--

Notes:

-- = RPD could not be calculated because the actual value unknown. The result was reported as "less than" a certain number.

RPD was calculated as:

$$RPD = \frac{|S1-S2|}{(S1+S2)/2} \times 100$$

Where: RPD = Relative Percent Difference reported as a %
S1 = First measurement
S2 = Second measurement
|S1-S2| = Absolute value of the difference between the two measurements
(S1+S2)/2 = Average of the two measurements

The calculated RPD for the two zones indicates that the two methods of analyzing tritium are comparable.

Upon review, the discrete point sample analytical results generated by the CYAPCo HNP laboratory were generally similar to but lower than the pore water contaminant concentrations estimated by COLOG using the mass balance equation. Both sets of concentrations were generally lower than the 2003 and the 2004 packer sampling results. A direct comparison of the discrete point sample results and both rounds of packer sampling results, however, is difficult for some intervals because some packer samples came from 23-ft intervals and some intervals were not sampled by packers because of insufficient seal developed in the borehole; discrete point samples were collected without these limitations. However, the results from both sampling methodologies are similar, especially between the 2004 packer sampling results in borehole 121A and the discrete point sample results obtained from the same borehole. With the exception of results for the two lower depths sampled in borehole 119, the pore water tritium concentrations estimated by COLOG using the mass-balance equation could be considered representative of the bedrock intervals sampled. Because the flow zones sampled in borehole 119 were not fully developed and the sample dilution corrections made by COLOG for these depths are as described above, the HNP laboratory results for 298 and 453,5feet bgs in this borehole are determined to be more representative of actual concentrations from these discrete bedrock intervals than those derived by COLOG's methodology.

DQA Summary

The primary goal of re-sampling boreholes 118A, 119, 120 and 121A was to further characterize the tritium plume at depth and determine potential depth intervals for the bedrock groundwater quality monitoring network.

The data set generated from the 2004 hydrophysical™ sampling was evaluated against criteria for measurement precision, accuracy, representativeness, completeness, and comparability to determine data validity and usability. Several observations were made concerning the representativeness of pore water tritium concentrations calculated using the mass-balance equation versus the laboratory analytical results in certain flow conditions:

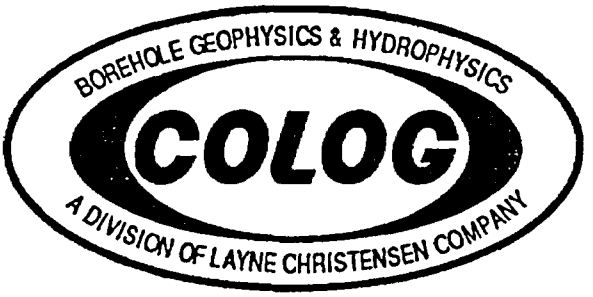
- Discrete point samples collected and analyzed from zones that did not fully develop under the hydrophysical™ testing conditions should not be considered representative for assessment of the presence, absence, or relative concentration of tritium.
- Discrete point samples collected from low flow zones directly above high flow zones may not yield analytical results representative of those intervals.

The following data deficiencies were noted by the DQA:

- No field duplicate samples were collected to measure precision.

- No blank and/or matrix spike information was provided by the onsite laboratory to assess accuracy (e.g., blanks, spikes, and standards).

The data collected as part of this characterization effort met the hydrophysical/geophysical logging program objectives and provided necessary information to refine the hydrogeologic conceptual site model, assist with the design of the bedrock groundwater monitoring network, and calibrate the upcoming numerical groundwater modeling for the facility.



HydroPhysical™ Logging Results
CYAPCO
Haddam Neck, Connecticut

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November 8, 2004

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CYAPCO; Haddam Neck, Connecticut

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List of Acronyms

gpm – gallons per minute
FEC – Fluid Electrical Conductivity
ft – feet
min. – minute
cm – centimeters
s – second
µS – micro Seimens
HpL™ - HydroPhysical™ Logging
DI – De-ionized, e.g., DI water
ftbgs – feet below ground surface
TD – total depth
CYAPCO – Connecticut Yankee Atomic Power Company

HydroPhysical™ Logging Results
CYAPCO; Haddam Neck, Connecticut

I. Executive Summary

The results of the HydroPhysical™ logging performed in four boreholes at the CYAPCO identified repeatable fracture and flow patterns in throughout each of the four boreholes. Ambient horizontal flow was identified in each of the four boreholes while no vertical flow in the bores under ambient conditions was identified. The ambient horizontal flow rates identified on site ranged from 0.0002 to 0.012 gpm. Under pumping conditions each borehole exhibited a similar flow pattern consisting of the dominant water-bearing fractures or features originating in the upper portions of the wellbore – no deeper than 167 feet in three of the four boreholes. In all four boreholes little to no flow was identified below 243 feet. Under pumping conditions the lower portions of the boreholes proved to be of little to no water-bearing capacity. Interval specific transmissivity estimates of the dominant flow features ranged from 0.488 to 30.7 square feet per day. Interval specific transmissivity and FEC estimates are observed to not differ significantly among dominant water-bearing features suggesting an inter-connected network of fractures and features comprising the dominant flow features in these four boreholes.

In three of the four boreholes, the highest concentrations of tritium are observed between the intervals of 45.9 to 88.8 feet.

Please refer to the well tables in each section for each borehole for a complete summary of the HydroPhysical™ logging results. All depths reported herein are referenced to ground surface.

II. Introduction

In accordance with COLOG's proposal dated July 13, 2004, COLOG has applied HydroPhysical™ (HpL™) logging methods along with downhole sampling and downhole video to characterize the formation waters of four boreholes at the CYAPCO in Haddam Neck, Connecticut. The objectives of the investigation were to:

1) Evaluate temperature and fluid electrical conductivity under pre-testing conditions.
2) Identify and characterize water-bearing fractures and features intersecting the borehole.
3) Characterize and quantify flow in the borehole under both non-stressed (ambient) and stressed (pumping) conditions.
4) Evaluate the vertical distribution of flow and interval-specific permeability for all identified water-producing fractures or intervals.
5) Evaluate the vertical distribution of tritium utilizing downhole sampling.

The four bores hydrophysically logged are: BBH-118A, BH-119, BH-120 and BH-121A. The boreholes ranged in total depth from 552 to 621 feet. All open boreholes were approximately 6.1 inches in diameter and all had 6-inch surface steel casing installed to bedrock ranging in depth from 17.8 to 98.4 feet. The wellbores were tested under both non-stressed, or ambient, conditions and stressed, or pumping, conditions to fully evaluate the water-bearing intervals intersecting the borehole.

COLOG's logging of the four boreholes was performed over the period of July 19 through August 5, 2004.

Methodology

A. HydroPhysical™ Logging (HpL™)

The HydroPhysical™ logging technique involves pumping the borehole and then pumping while injecting into the borehole with deionized water (DI). During this process, profiles of the changes in fluid electrical conductivity of the fluid column are recorded. These changes occur when electrically contrasting formation water is drawn back into the borehole by pumping or by native formation pressures (for ambient flow characterization). A downhole wireline HydroPhysical™ tool, which simultaneously measures fluid electrical conductivity (FEC) and temperature is employed to log the physical/chemical changes of the emplaced fluid.

The computer programs FLOWCALC and/or BORE II (Hale and Tsang, 1988 and (Daughtery and Tsang, 2000) can be utilized to evaluate the inflow quantities of the formation water for each specific inflow location. FLOWCALC is used to estimate the interval-specific flow rates for the production test results based on "hand-picked" values of FEC and depth. The values are determined from the "Pumping" and "Pumping During DI Injection logs". Numerical modeling of the reported data is performed using code BORE II. These methods accurately reflect the flow quantities for the identified water bearing intervals.

In addition to conducting HydroPhysical™ logging for identification of the hydraulically conductive intervals and quantification of the interval specific flow rates, additional logging runs are also typically performed. Prior to emplacement of DI, ambient fluid electrical conductivity and temperature (FEC/T) logs are acquired to assess the ambient fluid conditions within the borehole. During these runs, no pumping or DI emplacement is performed, and precautions are taken to preserve the existing ambient geohydrological and geochemical regime. These ambient water quality logs are performed to provide baseline values for the undisturbed borehole fluid conditions prior to testing.

For interval-specific permeability estimations, COLOG utilizes Hvorslev's 1951 porosity equation in conjunction with the HpL™ results. Several assumptions are made for estimating the permeability of secondary porosity. First, the type of production test COLOG performs in the field may significantly affect the accuracy of the transmissivity estimation. The permeability equation is relatively sensitive to overall observed drawdown. For a high yield borehole, drawdown will usually stabilize and an accurate observed drawdown can be estimated. However, for a low yield borehole, drawdown usually does not stabilize but instead, water level continues to drop until it reaches the pump inlet and the test is complete. In this case COLOG utilizes the maximum observed drawdown. The inaccuracy arises in the fact that overall observed drawdown does not stabilize and therefore is more an arbitrary value dependent on the placement of the pump downhole. Secondly, in an environment where flow originates from secondary porosity the length of the interval is derived from the either the thickness of the fracture down to 0.1 feet or the thickness of the fracture network producing water. This assumption of a fracture network producing water versus a porous media is not how the permeability equation was designed to be used. In lieu of a more appropriate equation unknown to COLOG at this time, COLOG utilizes Hvorslev's 1951 porosity equation based on its sensitivity to interval-specific flow which can be measured accurately, drawdown which can be measured accurately in the case of a high yield borehole and its insensitivity to effective radius. The insensitivity to effective radius is critical when an observation well is not available to measure drawdown at a known distance from the subject borehole.

How to Interpret HydroPhysical™ Logs

Figure HpL:1 below is an example data set. The data represents HpL™ logs acquired immediately after deionized (DI) water emplacement for ambient flow evaluation. For ambient flow evaluation the wellbore fluids are first replaced with DI water (termed "emplacement"), then a series of fluid electrical conductivity (FEC) logs are acquired over a period of a time to monitor ground water entering the wellbore under natural pressures and migrating either vertically or horizontally through the wellbore. The borehole fluids are replaced with DI water without disturbing the ambient free-water level by injecting DI water at the bottom of the borehole and extracting borehole water at exactly the same rate at the free-water surface. However, at the beginning of the DI water emplacement, a slightly depressed free-water level (approximately one tenth of a foot below ambient free water-level) is achieved and maintained throughout the test. This procedure is implemented to ensure that little to no DI water is able to enter the surrounding formation during DI water emplacement. By acquiring FEC logs during the emplacement of DI water and by continuously measuring water level with a downhole pressure transducer the emplacement can be properly monitored and controlled to minimize the disturbance of the recorded ambient water. After the borehole fluids are replaced with DI water, the injection and extraction pumps are turned off and in most cases the downhole plumbing is removed from the borehole. A check valve is installed in the pump standpipe to ensure water in the standpipe does not drain back into the borehole. While the plumbing is removed from the borehole DI water is injected from the top of the borehole to maintain ambient water level. Often a baseline FEC log is acquired during the final stages of the emplacement of DI water to provide baseline conditions just before the ceasing of pumping. Figure HpL:1 illustrates ambient flow entering the borehole at depths of 150.0 to 152.7, 138.8 to 139.0, 132.7 to 133.4, 122.3 to 123.1 and 118.0 to 118.1 feet. The location of these intervals is illustrated by the sharp increases or "spikes" in FEC. The increase in FEC over time at these four intervals is characteristic of ambient inflow. The upward vertical trend in this inflow is also apparent from the FEC logs. For example, the dominant inflowing zone at 138.8 to 139.0 feet illustrates a major growth in FEC above the inflow "spike", and little growth below the "spike." The zone at 118.0 to 118.1 feet is the termination of all inflow into the well. The sum of the four inflow zones make up the outflow of this zone, and this value, along with the value of the four inflow zones is computed using code BORE II.

COLOG uses three types of tests to identify the water-bearing intervals in a borehole under stressed conditions. In the lowest yield environment (less than 0.7 gpm) a slug test approach is utilized. In a relatively low-yield borehole environment, 1-2 gpm, a pump after emplacement (PAE) test is conducted, and in a relatively medium to high-yield environment a pump and inject (PNI) test is conducted. The decision on the type of test to perform on a specific borehole is made in the field based on the ability of the borehole to recover to ambient free-water level when a disturbance in water level is introduced into the well, i.e. inserting tools and/or pluming into the well.

In a low-yield borehole environment a slug or PAE test is utilized to identify the water-bearing intervals under stressed conditions. These tests are similar in protocol and involve first a replacement of borehole fluids with DI water in a manner identical to that of the emplacement during an ambient flow evaluation. Often a baseline FEC log is acquired during the final stages of the emplacement of DI water to provide baseline conditions just before the ceasing of injection pumping. Following the cessation of injection pumping, the extraction pump is left used to either pull an instantaneous slug (slug test) or is used to pump at a relatively steady low rate of flow in the borehole (approximately 1-2 gpm). During this time numerous FEC logs are acquired over time. The location of water-bearing intervals is apparent by the sharp increases or "spikes" in

FEC over time. The rate at which these intervals inflow is calculated using BORE II and is based on the rate of increase of mass (area under the curve using the FEC log as the curve). Flow direction is easily determined by tracking the center of mass of the area under the curve. In most cases, if pumping is being conducted flow is traveling up the borehole towards the pump which is situated inside casing.

Figure HpL:2 is an example data set. The data represents HpL™ logs acquired during a PNI test. The set of FEC logs on the right of this figure (FEC1303, FEC1310, FEC1320, and FEC1329) illustrate the condition of the borehole during development pumping. In the case of this example, the wellbore was stressed at a rate of approximately 10 gpm until a relatively steady-state condition was achieved in the borehole. A steady-state condition is apparent when the FEC logs begin to repeat as they do in figure HPL:2. Repeatable FEC logs indicate that the hydrochemistry of the water inflowing to the borehole is not changing over time (steady-state) and that the flow rates of all inflow zones is also not changing over time. Additionally, the drawdown is monitored continuously to observe a "slowing down" in the rate of increase of drawdown. When drawdown (water level) is stable, the inflow rates of the various inflow zones are assumed to be steady. By contrast, if DI water injection is begun in the early stages of pumping when drawdown is still increasing, i.e. water level is dropping rapidly, the inflow rates of the various inflow zones would increase with time as less wellbore storage is used to maintain a particular pumping rate. The remaining FEC logs (FEC1435, FEC1450, FEC1503, and FEC1516) illustrate the conditions in the borehole during pumping and injection procedures. Fluid was extracted from the borehole at a rate of approximately twelve gpm while DI water was simultaneously injected at the bottom of the borehole at a rate of approximately two gpm, until a relatively steady-state condition existed in the well. Water-bearing intervals in the borehole are identified by changes or "steps" in FEC throughout the FEC logs. The flow rate of these intervals is computed using BORE II and/or Flowcalc software. Every location that the FEC increases in these logs is a zone of inflow. Similarly, where the logs decrease in FEC indicates a zone of inflow with water lower in FEC than the water in the borehole. A zone exhibiting a decrease in FEC on the injection logs should also decrease at the same depth on the development (pre-DI water injection) logs. Please refer to Appendix B for a complete discussion of the BORE II modeling software.

Sensitivity of Transmissivity to Effective Radius

An estimation of transmissivity (T) has be made for all identified water-bearing intervals using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w} \ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated using HpL™ results (or "Delta Flow" from the table which equals "Interval-Specific Flow Rate During Pumping Conditions" minus "Ambient Flow Rate" if any), r_w is the borehole radius, r_e is the effective pumping radius, Δh_w is the observed maximum drawdown and L is the thickness of the zone through which flow occurs. For this example, the data is taken from a test borehole in fractured limestone in Birmingham, Alabama is used. The thickness, or length of the interval is calculated using a combination of both the HpL™ data and the OBI optical data. L can usually be estimated with a high degree of confidence based on both of those data sets. Q_i, or Delta Flow, can also be estimated accurately using code BORE II (see appendix B) for the HpL™ data sets. Δh_w is estimated with a high degree of confidence using Cologs' downhole pressure transducer and a laptop to record water-level data every 10 seconds. Additionally, the borehole radius is confirmed quite readily from the caliper data. For this example, r_w equals 0.25 feet, r_e of 50, 100 and 300 feet are used and the observed maximum drawdown was estimated at 11.64 feet. By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific transmissivity can be calculated for each identified water-producing interval.

Colog utilizes Hvorslevs' 1951 equation when an observation well a known distance away with measurable drawdown is not available. Essentially, Hvorslevs' 1951 equation is similar to the prevalent Theis equation minus the observation well drawdown information. In replace of the observation well drawdown data Hvorslevs' equation uses an assumed "effective radius" divided by the borehole radius. One benefit to using Hvorslevs' 1951 equation when observation well data is unavailable is the insensitivity of the equation to the assumed effective radius as this is the only "unknown" variable in the equation. All other variables are known or calculated with a high degree of confidence. Only the effective radius is unproven, or unsupported, but its value can be estimated with some degree of accuracy.

The following example will illustrate the insensitivity of Hvorslevs' 1951 equation in relation to the assumed effective radius of an aquifer. The greatest magnitude of change in this example between r_e of 50 feet and r_e of 300 feet is 73 feet^2/day transmissivity.

Interval (feet)	Length of Interval (feet)	Q_i - Delta Flow (gpm)	Borehole Radius (feet)	Transmissivity Using r_e of 50 Feet	Transmissivity Using r_e of 100 Feet	Transmissivity Using r_e of 300 Feet
122.4 – 123.7	1.3	15.400	0.25	$2.15 \times E^{02}$	$2.43 \times E^{02}$	$2.88 \times E^{02}$
127.2 – 127.3	0.1	0.645	0.25	$9.00 \times E^{00}$	$1.02 \times E^{01}$	$1.20 \times E^{01}$
139.4 – 139.7	0.3	0.497	0.25	$6.87 \times E^{00}$	$7.76 \times E^{00}$	$9.19 \times E^{00}$
185.2 – 185.6	0.4	0.058	0.25	$8.09 \times E^{-01}$	$9.15 \times E^{-01}$	$1.08 \times E^{00}$

B. Downhole Fluid Sampling

COLOG utilizes a 1.5-inch diameter downhole discrete-point fluid sampler manufactured by MLS. After flow zones have been identified by flow logging (HydroPhysics™, Heat Pulse or Spinner Flow Meter tests) discrete-point sampling is conducted at selected intervals. The samples are procured just above each identified producing zone to insure complete mixing of the inflowing formation waters fluid moving up the fluid column towards the pump (pump is typically placed inside blank casing). The samples are procured by sending the closed, sealed sampler down to a given depth. By sending a specific voltage down the wireline the sampler ports open up and expose a 1 or 2 liter barrel to the wellbore fluids. Once the sample barrel is filled, the ports are closed and the sealed sample barrel is brought to the surface for decanting. Between each procured sample, the sampler tool is thoroughly cleaned with a solution of deionized water and Alconox or Liquinox soap and rinsed with deionized water. The disassembled sampler is then left to air dry or swab-dried before being reassembled.

Using the results from laboratory analysis of each sample procured in the field, the pore water or actual contaminant concentration may be estimated for each sampled inflow point using the mass-balance equation where:

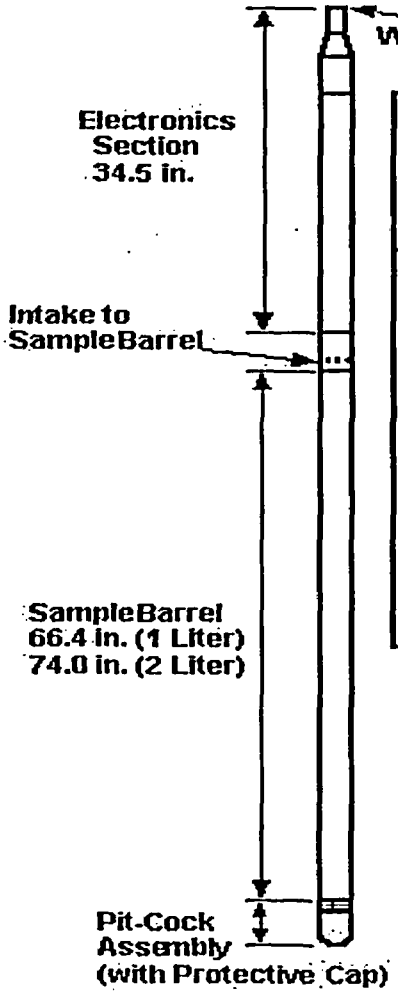
$$C_o = \frac{\sum q_i C_{i\,actual}}{\sum q_i}$$

C_o = Contaminant concentration of procured sample at a given depth as reported by laboratory analysis.

q_i = Interval specific inflow rate for each hydraulically conductive interval beneath the sample location as determined by code BORE.

$C_{i\,actual}$ = Estimated actual contaminant concentration associated with the sampled interval(s).

The accuracy of the results obtained using the Mass-Balance equation is affected by the inputs into the equation and their variability. For example, "error bars" or a range of estimations from the laboratory analysis of the samples or q_i estimations would be magnified in their magnitude as a result of the Mass-Balance equation.



Layne Christensen/COLOG Downhole Discrete-Point Fluid Sampler

1. Lower sampler to specific depth in wellbore
2. Open sample barrel intake electronically
3. Close sample barrel intake when filled
4. Bring sampler to the surface for a depth-specific sample of the wellbore fluids.

BH-118A Logging Results

1.0 HydroPhysical™ Logging

1.1 Ambient Fluid Electrical Conductivity and Temperature Log: BH-118A

At 1043 hours on August 2, 2004, after a calibration check of the fluid electrical conductivity (FEC) and temperature logging tool, the fluid column was logged for FEC and temperature profiles with COLOG's 1.5-inch diameter HpL™ tool. These logs were performed prior to the installation of any pumping equipment. Please refer to Figure BH-118A:1. The ambient FEC/temperature profiles indicate inflections at approximately 63 feet. These inflections in temperature and FEC correspond well with an identified interval of ambient horizontal flow. The ambient temperature log recorded a gradual increase in temperature with depth to approximately 100 feet, below which occurs a gradual decrease in temperature. The ambient FEC log exhibits a similar trend. An increase in FEC to a depth of approximately 77 feet is observed, below this depth a gradual decrease in FEC is observed. Near the bottom of the ambient FEC log, an increase in FEC is observed. This inflection does not correspond with any interval of flow identified during testing and is most likely the result of sediment or fill in the bottom of the borehole.

1.2 Ambient Flow Characterization: BH-118A

On August 2, 2004, an ambient flow characterization was conducted in boring BH-118A. For ambient flow assessment, the fluid column in the borehole was replaced with de-ionized water (DI) and the boring left in an undisturbed state to allow any natural flow to occur. The pump was removed from the boring to insure that water in the pump standpipe would not drain back into the boring. Prior to this period and throughout all HpL™ testing, water levels and flow rates were monitored and recorded digitally every second. Ambient flow evaluation is reported for the period after the water surface returned to near pre-DI water emplacement levels. A series of FEC and temperature logs were then conducted over the duration of testing to identify changes in the fluid column associated with ambient flow. Ambient flow characterization is conducted to evaluate the presence of both vertical and horizontal ambient flow.

On August 2, 2004, at 1410 hours (t=0 minutes, elapsed time of test), dilution of the fluid column was complete. Minimal to no DI water was lost to the formation due to the slightly depressed head maintained during DI water emplacement procedures. During the 18.4 hours following the emplacement of DI water, multiple logs were conducted. Of these logs, 5 are presented in Figure BH-118A:2. The designation of each logging with the FEC tool is indicated in the figure legend by the time of logging (e.g., log FEC1412 was begun at 1412 hours versus a subsequent logging at FEC1448). The progressing of curves to the right in this figure represents changes in FEC over the total logging period. The last four digits of each log ID corresponds to the time at which that particular log was started. Only logs acquired during logging in the downward direction are presented as the design of the FEC/temperature probe allows for the most accurate data to be collected in the downward direction. The logs acquired in the upward logging direction are not representative of downhole conditions and are therefore omitted. These logs illustrate changes at several intervals throughout the upper portion of the borehole. These changes in the FEC profiles with respect to time are associated with ambient horizontal flow occurring within these intervals.

Formation water migration caused by horizontal flow within the fluid column is indicated by the increase in FEC over time in Figure BH-118A:2 for the intervals at 45.9 to 46.1, 63.9 to 65.0, 113.9 to 114.5, 127.8 to 128.0 and 219.8 to 219.9 feet. Numeric modeling of the reported field data for these intervals suggests horizontal flow is occurring at rates of 0.0008, 0.002, 0.002, 0.003, and 0.001 gpm, respectively. These flow rates are based on the rate of increase of mass at these intervals. Correcting for convergence of flow at the wellbore and factoring the length of the interval, these flow rates equate to a Darcy velocity, or specific discharge of groundwater in the aquifer of 0.61, 0.28, 0.50, 2.27 and 1.51 ft/day, respectively. Please refer to Table BH-118A:1 and SUMMARY:1 for a complete summary of the HydroPhysical™ logging results. Please refer to Appendix B for a discussion of the methodology and code used to calculate these values. The ambient depth to water at the time of testing was 19.42 ftbgs.

1.3 Flow Characterization During 5 GPM Production Test: BH-118A

Low-rate pumping of wellbore fluids after DI water emplacement was conducted at one pumping rate to establish the inflow locations and evaluate the interval-specific inflow rates. For DI water emplacement, DI water is injected at the bottom of the wellbore while simultaneous extraction pumping is conducted near water surface at the same rate. Water levels and flow rates are monitored and recorded digitally continuously to ensure minimal to no DI water is lost to the formation. This is achieved by maintaining water level at or below the recorded ambient level. After DI water emplacement is complete low-rate pumping is conducted to stress the aquifer(s) and draw groundwater into the wellbore where it is contrasted by the DI water in the wellbore. Continuous FEC profiling over time yields the depth and rate of influx of groundwater during pumping. These procedures were conducted at a time-averaged pumping rate of 4.81 gpm.

On August 3, 2004 at 0821 hours (t = 0 minutes elapsed time of testing), pumping was initiated at approximately 5 gpm. Prior to initiating pumping, the ambient depth to water was recorded at 19.31 ftbgs. Time dependent depth to water, pumping totals and flow rate information were recorded and are presented in Figure BH-118A:3. Low-rate pumping was maintained at a time-averaged rate of 4.81 gpm until 1746 hours (t = 565 minutes, elapsed time of testing). During this period drawdown was observed to stabilize at approximately 4.8 feet. A maximum drawdown of 4.81 feet was observed. During the period of testing, multiple loggings were conducted. Of these logs, thirteen FEC traces are presented in Figures BH-118A:4A and 4B. These logs clearly illustrate specific intervals of dramatic increase in FEC with respect to time. The depth at which the peak value for a given interval occurs is indicative of a water-bearing interval. The data presented in Figures BH-118A:4A and 4B suggests the presence of 13 hydraulically conductive intervals, with the dominant water-bearing interval at 29.8 to 30.2 feet. Numerical modeling of the reported field data was performed using code BOREII (Hale and Tsang, 1988, Tsang et.al. 1990, Daughtery and Tsang, 2000). This modeling was performed to estimate the rate of inflow and FEC for each identified hydraulically conductive interval during pumping. The results of the modeling and analysis are presented in Table BH-118A:1. In summary, the interval 29.8 to 30.2 feet dominated inflow producing 3.81 gpm, or 79.2 percent of the total inflow during production testing. Please refer to Table BH-118A:1 for a complete listing of the depths of water-bearing zones and their interval-specific inflow rates during testing.

At the conclusion of the test, the extraction pump inlet was lowered to approximately 110 feet below ground surface per the request of CH2M Hill. The extraction rate was increased to approximately 30 gpm (max rate) in order to induce more drawdown and evaluate the presence, or lack of, any water-bearing intervals in the lower portion of the wellbore under increased stressed conditions. This increase in extraction rate identified one additional minor flow interval

at approximately 430 feet. The estimated flow rate of this interval is approximately less than 0.05 gpm, or less than 0.2 percent of the total extraction rate during the increased development pumping.

1.4 Downhole Sampling

Eight downhole samples and one wellhead sample were procured from wellbore BH-118A on August 3, 2004. Downhole samples were procured from depths of 25.5, 40.3, 53.4, 67.5, 72, 97, 109 and 124.7 feet. The wellhead sample was taken from the discharge outlet of the downhole pump. The downhole pump was set at 28 feet. Downhole sampling was conducted during development pumping at a time-averaged rate of 4.89 gpm after production testing was completed. The laboratory analyses of the procured samples are incorporated with the hydrophysical flow data to obtain actual, or "pore" water, contaminant concentrations for each sampled interval using the mass-balance equation. In summary, the highest concentrations of contaminants were found in the samples taken from 40 and 68 feet. The actual contaminant concentrations of these samples are 13911 and 13,046 pCi/L. Please refer to Table BH-118A:2 for a complete listing of sample locations and actual contaminant concentrations. The sample taken at 26 feet did not correspond with any interval of identified flow, therefore, this sample has not been included in Table BH-118A:2

The sample locations were identified by on-site interpretation of the FEC/Temperature logs acquired during pumping. Between procurement of samples, the downhole sampler was cleaned with an alconox and DI water solution and rinsed with DI water.

1.5 Estimation of Interval Specific Transmissivity: BH-118A

An estimation of transmissivity (T) can be made using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w} \ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated by HpL™ results, r_w is the borehole radius (0.25 ft), r_e is the effective pumping radius, Δh_w is the observed maximum drawdown (4.81 feet) and L is the thickness of the zone through which flow occurs. For our calculations, COLOG used r_e of 100 feet (assumed). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific hydraulic conductivity can be calculated for each identified water producing interval. The calculations made at each identified interval are presented in Table BH-118A:1. In summary, the interval at 29.8 to 30.2 feet registered the highest transmissivity at 145 feet^2/day.

2.0 Data Summary

Processing and interpretation of the HydroPhysical™ logs in BH-118A suggest the presence of 13 producing intervals for this borehole. Numerical modeling of the reported HydroPhysical™ field data was performed to estimate the rate of inflow for each identified hydraulically conductive borehole interval during DI injection procedures. The results of these analyses are presented in

Table BH-118A:1. These identified producing intervals correlate well with water-bearing zones identified during ambient testing. In summary, the interval 29.8 to 30.2 feet dominated inflow during the production test, producing 3.81 gpm, or 79.2 percent of the total flow during the production test.

During ambient testing, boring BH-118A exhibited a horizontal flow regime. Five water-bearing zones were identified under ambient conditions exhibiting horizontal flow. No vertical pressure gradient was observed under ambient conditions. The five water-bearing zones at 45.9 to 46.1, 63.9 to 65.0, 113.9 to 114.5, 127.8 to 128.0 and 219.8 to 219.5 feet contributed water to the borehole at estimated flow rates of 0.0008, 0.002, 0.002, 0.003, and 0.001 gpm, respectively. Correcting for convergence of flow at the wellbore and factoring the length of the interval, these flow rates equate to a Darcy velocity, or specific discharge of groundwater in the aquifer of 0.61, 0.28, 0.50, 2.27 and 1.51 ft/day, respectively.

The ambient fluid temperature log (Figure BH-118A:1) acquired on August 2, 2004 indicates an increase in temperature with depth to approximately 100 feet. Below this depth, the log indicates a decrease in temperature with depth. The ambient FEC profile indicates an increase in fluid conductivity with depth to approximately 77 feet. Below this depth, the log indicates a decrease in FEC with depth. Both the temperature and FEC log exhibit inflections at approximately 63 feet. This depth corresponds well with an ambient horizontal flow location. The FEC log indicates an increase in FEC near the bottom of the well. As no flow is identified at this depth under ambient or pumping conditions, this inflection is most likely the result of sediment or fill in the bottom of the borehole.

Interval-specific FEC did not differ significantly with the sole exception of the uppermost flow zone at 29.8 – 30.2 feet registering 857 µS/cm.

The 13 interval-specific estimated transmissivities in BH-118A ranged from 0.076 to 145 square feet per day with the interval of 29.8 to 30.2 feet registering the highest transmissivity. The 13 interval-specific transmissivity estimates differ significantly with respect to each other, however, for the intervals producing the appreciable amounts of flow during testing (the major flow zones) the interval-specific transmissivity estimates do not differ significantly.

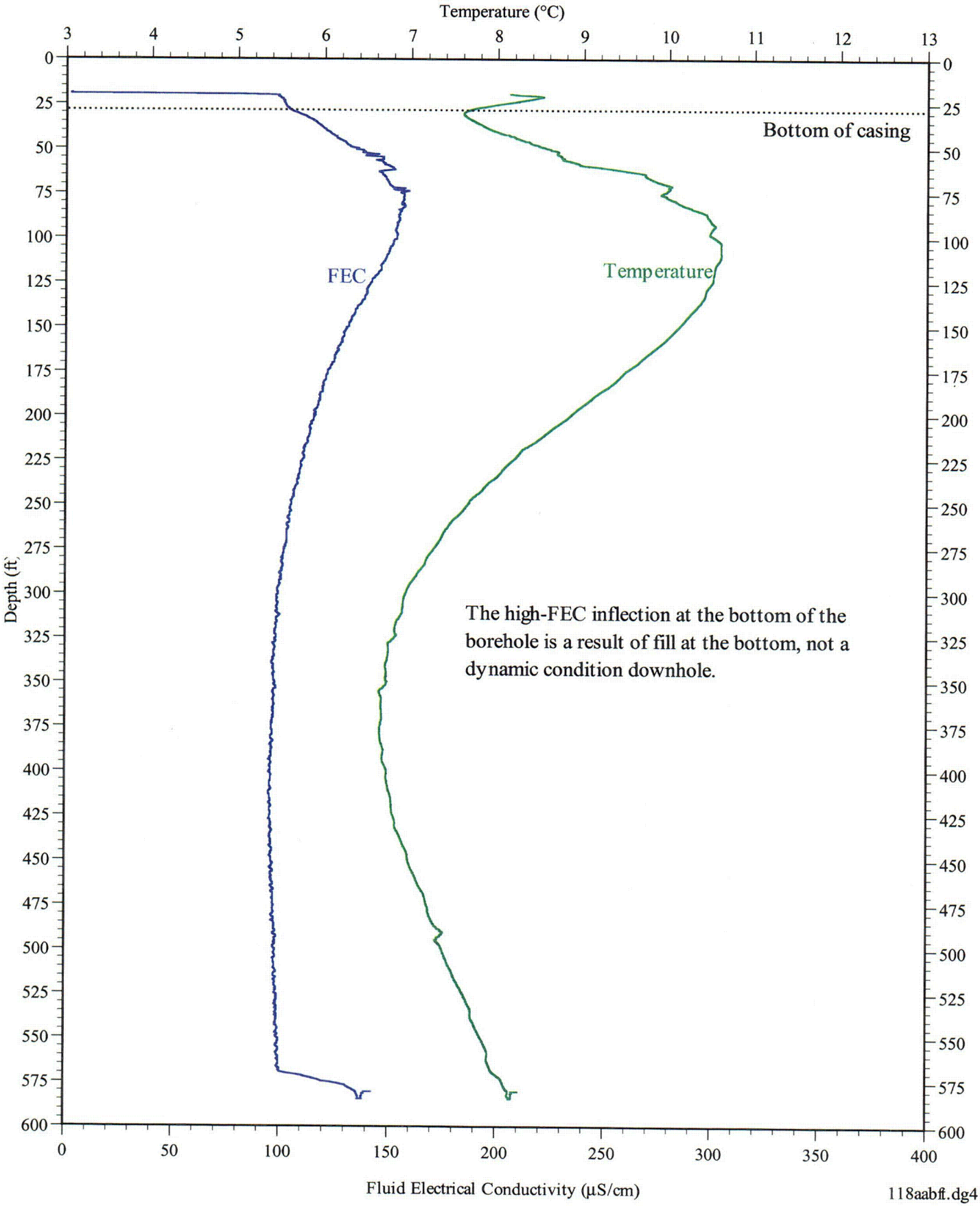
Downhole sampling was conducted in wellbore BH-118A during development pumping at a time-averaged rate of 4.89 gpm after production testing was completed. Eight downhole samples and one wellhead sample were procured from wellbore BH-118A. The samples procured from 40 and 68 feet contained the highest levels of contaminant concentration.

Fracture inter-connectiveness in the immediate vicinity of a wellbore can be inferred by the similarity, or lack there of, of parameters such as interval-specific transmissivity estimates and interval-specific FEC, along with the presence of pressure differentials within the borehole. Similar transmissivity and FEC estimates would suggest an inter-connected network of fractures or aquifers in the immediate vicinity of the wellbore. Although a pressure differential present in the wellbore would suggest the driving force for vertical communication is present, in a vertically inter-connected network of fractures the aquifer pressures tend to equilibrate.

The data acquired in BH-118A exhibited similar interval-specific transmissivity and similar FEC estimates among the dominant water-bearing zones suggesting an inter-connected network of fractures near the surface. No vertical gradient is observed in the wellbore suggesting the dominant water-bearing intervals are inter-connected thereby negating any pressure differentials.

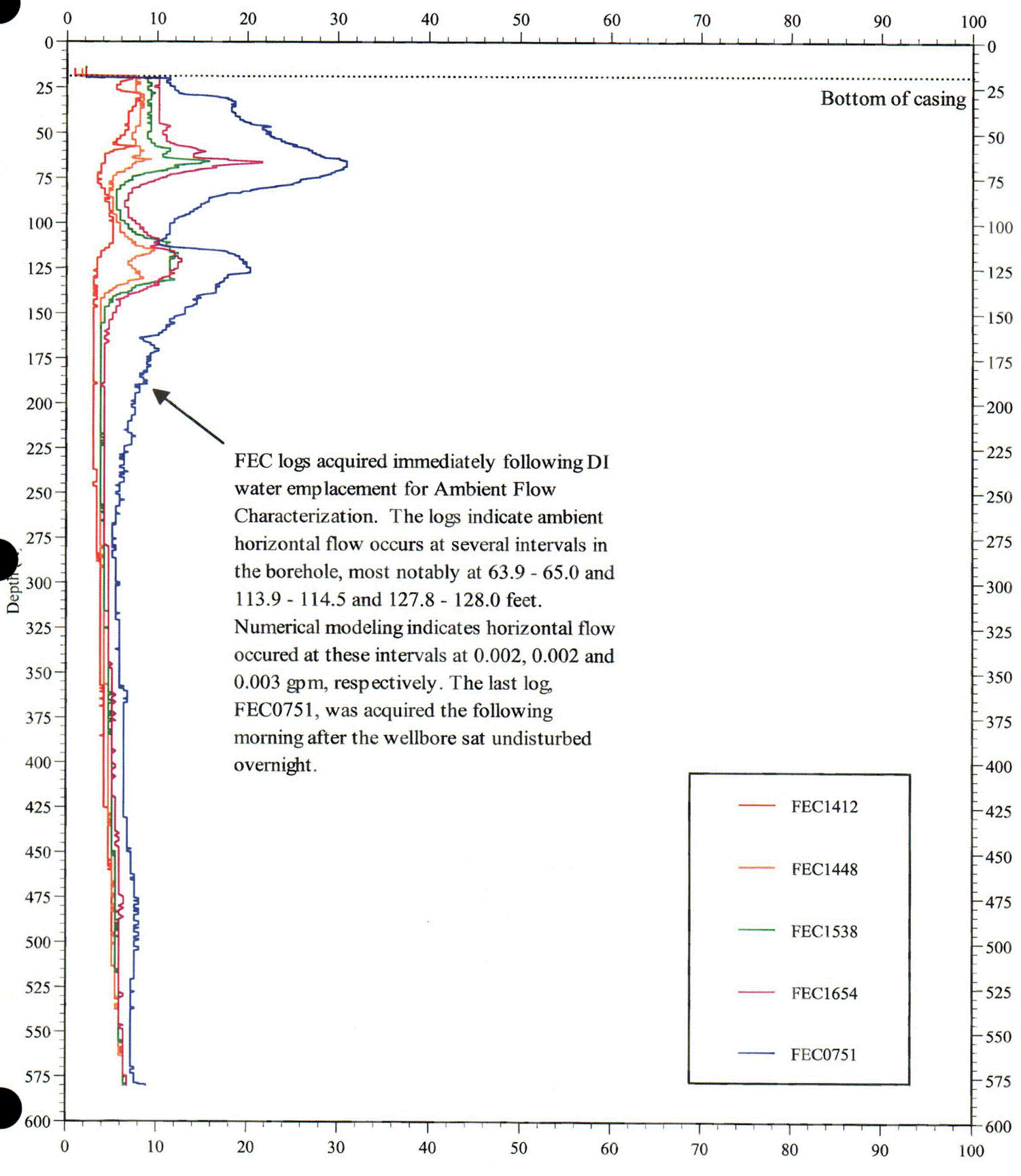
The data suggest the fractures intersecting the wellbore may be inter-connected in the immediate vicinity of the wellbore. Please see Tables BH-118A:1 and SUMMARY:1 for a summary that includes the locations, flow rates and hydraulic conductivity estimates assessed by COLOG.

FIGURE BH-118A:1. AMBIENT TEMPERATURE AND FLUID ELECTRICAL CONDUCTIVITY; CH2M HILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-118A.



C71

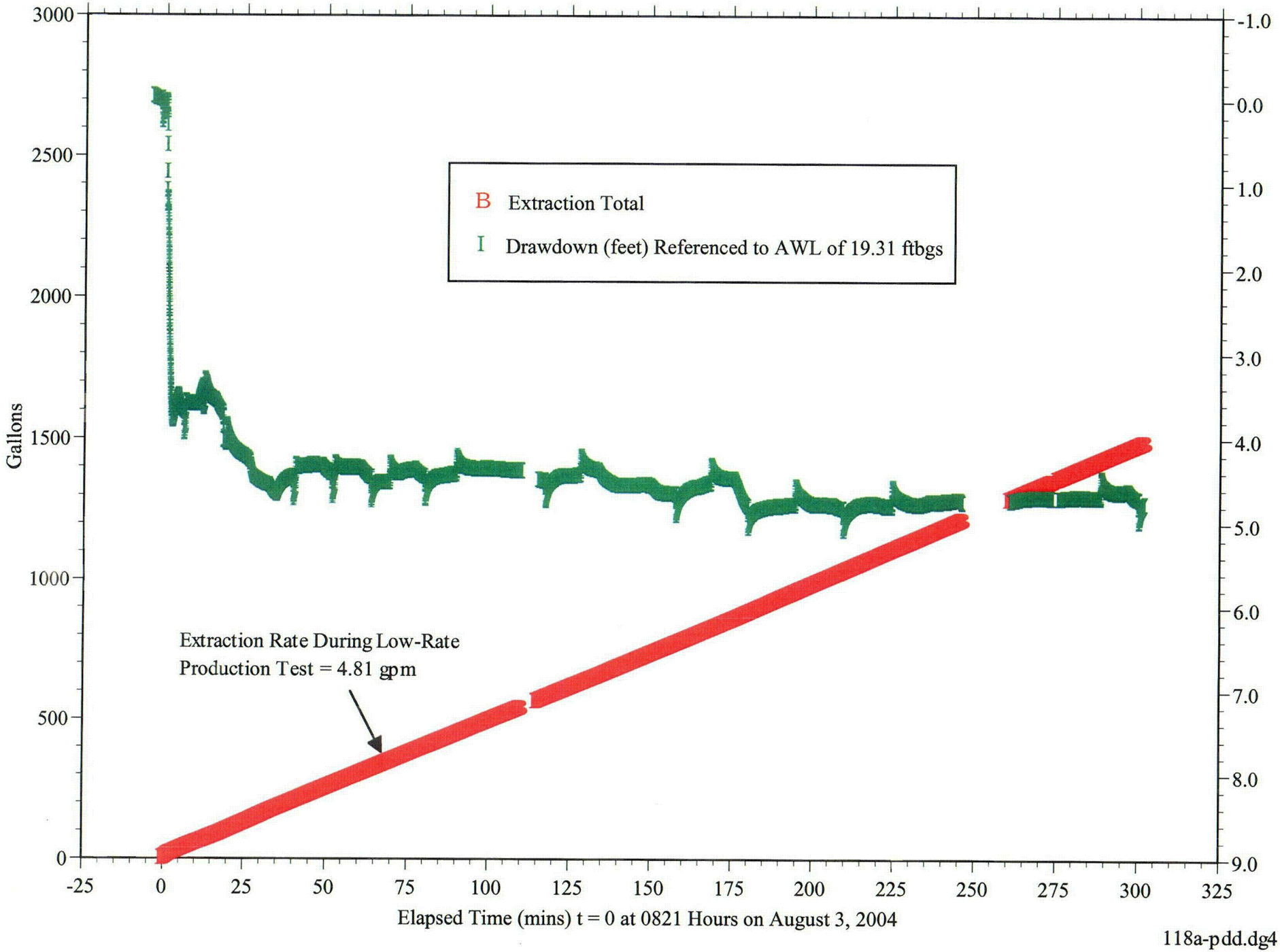
FIGURE BH-118A:2 SUMMARY OF HYDROPHYSICAL LOGS DURING AMBIENT FLOW CHARACTERIZATION; CH2M HILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-118A.



118a-afc.dg4

CT2

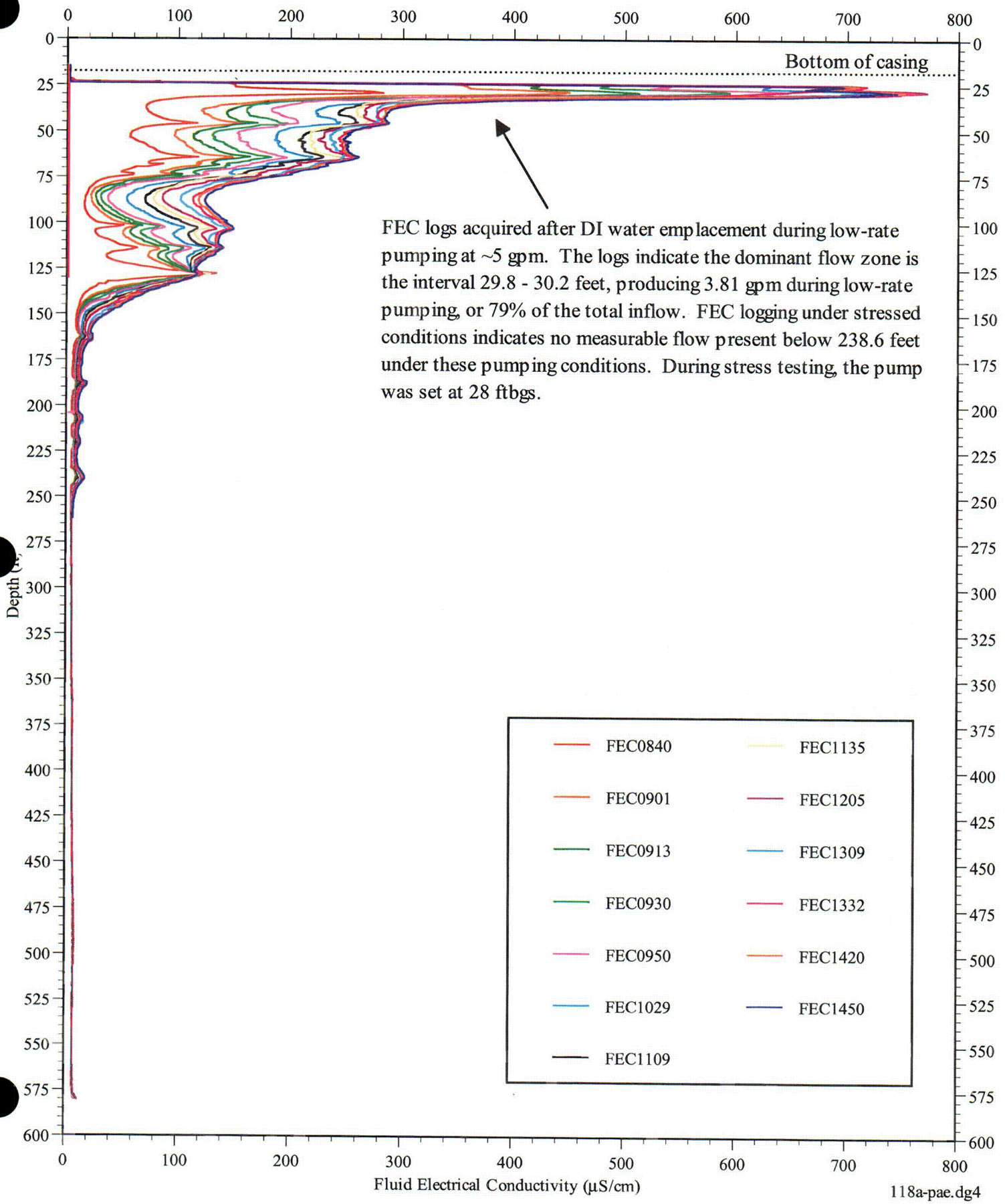
FIGURE BH-1118A:3. PUMPING AND DRAWDOWN DATA DURING LOW-RATE PRODUCTION TEST AT 5 GPM; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-118A.



118a-pdd.dg4

C73

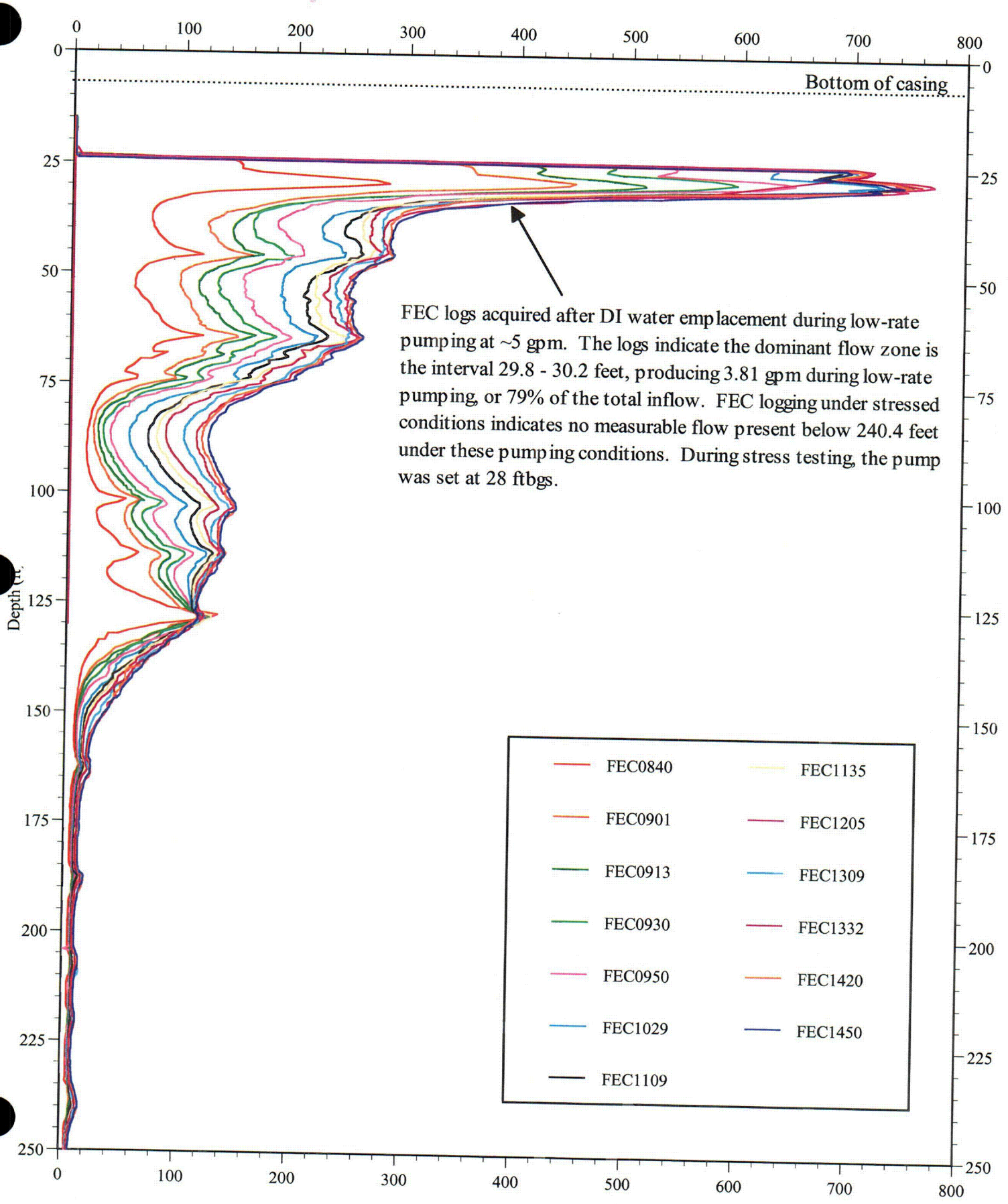
FIGURE BH-118A:4A. SUMMARY OF HYDROPHYSICAL LOGS DURING LOW-RATE PUMPING AT 5 GPM; CH2M HILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-118A.



118a-pae.dg4

CTY

FIGURE BH-118A:4B. SUMMARY OF HYDROPHYSICAL LOGS DURING LOW-RATE PUMPING AT 5 GPM - 0 TO 250 FEET; CH2M HILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-118A.



118apae2.dg4

C75

TABLE BH-118A:1. SUMMARY OF HYDROPHYSICALTM LOGGING RESULTS WITH HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY ESTIMATIONS; CH2MHILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-118A.

Project and Borehole Name	CYAPCO: BH-118A
AWL Prior to Pumping (ftbgs)	19.31
Diameter of Borehole (ft)	0.51
Observed Drawdown (ft)	4.81
Effective Radius (ft)	100

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Thickness of Interval (ft)	Ambient Flow[1] (gpm)	Darcy Velocity in Aquifer[2] (Specific Discharge) (ft/day)	Interval Specific Flow Rate During Pumping (gpm)	Delta Flow[3] (gpm)	Delta Flow (ft^3/min.)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft^2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)	Sample Depth (feet)	HNP Onsite Lab Result (pCi/L)	Interval Specific Pore water Concentration of Tritium (pCi/L)
1	29.8	30.2	0.4	0.000	NA	3.81	3.810	0.509	3.63E+02	1.45E+02	857	28	1850	ND
2	45.9	46.1	0.2	0.001	0.61	0.185	0.184	0.025	3.51E+01	7.01E+00	398	40	8550	13911
3	63.9	65.0	1.1	0.002	0.28	0.238	0.236	0.032	8.17E+00	8.99E+00	382	53.4	7330	9818
4	68.3	68.4	0.1	0.000	NA	0.132	0.132	0.018	5.03E+01	5.03E+00	303	67.5	6300	13046
5	73.9	74.0	0.1	0.000	NA	0.211	0.211	0.028	8.03E+01	8.03E+00	252	72	4290	5939
6	101.8	101.9	0.1	0.000	NA	0.048	0.048	0.006	1.83E+01	1.83E+00	185	97	2790	ND
7	113.9	114.5	0.6	0.002	0.50	0.053	0.051	0.007	3.24E+00	1.94E+00	183	109	3390	5466
8	127.8	128.0	0.2	0.003	2.27	0.106	0.103	0.014	1.96E+01	3.92E+00	166	124.7	2550	2550
9	161.7	161.8	0.1	0.000	NA	0.008	0.008	0.001	3.05E+00	3.05E-01	126	NS	NS	NS
10	187.2	187.3	0.1	0.000	NA	0.005	0.005	0.001	1.90E+00	1.90E-01	118	NS	NS	NS
11	206.0	206.1	0.1	0.000	NA	0.004	0.004	0.001	1.52E+00	1.52E-01	113	NS	NS	NS
12	219.8	219.9	0.1	0.001	1.51	0.003	0.002	0.000	7.62E-01	7.62E-02	111	NS	NS	NS
13	238.5	238.6	0.1	0.000	NA	0.005	0.005	0.001	1.90E+00	1.90E-01	107	NS	NS	NS

[1] All ambient flow identified for this borehole is horizontal ambient flow.

[2] Darcy Velocity is calculated using the observed volumetric flow rate, the cross-sectional area of the flow interval in the borehole and a borehole convergence factor of 2.5 (Drost, 1968). The Darcy Velocity is only applicable to ambient horizontal flow.

[3] Delta Flow is the difference between Interval-Specific Flow Rate (during pumping) and Ambient Flow Rate.

[4] Hydraulic conductivity and transmissivity estimates are based on single well drawdown data, a porus-medium equivilent model and Hvorslev's 1951 porosity equation.

AWL = Ambient Water Level
NA = Not Applicable
ND = No Detect/Below Detection Limit for that SampleNot Applicable
NS = Not Sampled

BH-119 Logging Results

1.0 HydroPhysical™ Logging

1.1 Ambient Fluid Electrical Conductivity and Temperature Log: BH-119

At 1049 hours on July 22, 2004, after a calibration check of the fluid electrical conductivity (FEC) and temperature logging tool, the fluid column was logged for FEC and temperature profiles with COLOG's 1.5-inch diameter HpL™ tool. These logs were performed prior to the installation of any pumping equipment. Please refer to Figure BH-119:1. The ambient FEC/temperature profiles indicate inflections at approximately 47 feet. These inflections in temperature and FEC correspond well with an identified interval of ambient horizontal flow. The ambient temperature log recorded a gradual increase in temperature with depth to approximately 88 feet, below this depth the log indicates a gradual decrease in temperature to approximately 300 feet. Below this depth the log indicates a gradual increase in temperature with depth. The ambient FEC log is relatively featureless below the inflection at approximately 47 feet.

1.2 Ambient Flow Characterization: BH-119

On July 22, 2004, an ambient flow characterization was conducted in boring BH-119. For ambient flow assessment, the fluid column in the borehole was replaced with de-ionized water (DI) and the boring left in an undisturbed state to allow any natural flow to occur. The pump was removed from the boring to insure that water in the pump standpipe would not drain back into the boring. Prior to this period and throughout all HpL™ testing, water levels and flow rates were monitored and recorded digitally every ten seconds. Ambient flow evaluation is reported for the period after the water surface returned to near pre-DI water emplacement levels. A series of FEC and temperature logs were then conducted over the duration of testing to identify changes in the fluid column associated with ambient flow. Ambient flow characterization is conducted to evaluate the presence of both vertical and horizontal ambient flow.

On July 22, 2004, at 1502 hours (t=0 minutes, elapsed time of test), dilution of the fluid column was complete. Minimal to no DI water was lost to the formation due to the slightly depressed head maintained during DI water emplacement procedures. During the 17.3 hours following the emplacement of DI water, multiple logs were conducted. Of these logs, 3 are presented in Figure BH-119:2. The designation of each logging with the FEC tool is indicated in the figure legend by the time of logging (e.g., FEC1521 versus a subsequent logging at FEC1622), thus the progressing of curves to the right in this figure represents changes in FEC over the total logging period. The last four digits of each log ID corresponds to the time at which that particular log was started. Only logs acquired during logging in the downward direction are presented as the design of the FEC/temperature probe allows for the most accurate data to be collected in the downward direction. The logs acquired in the upward logging direction are not representative of downhole conditions and are therefore omitted. These logs illustrate changes in FEC at several intervals throughout the upper portion of the borehole. These changes in the FEC profiles with respect to time are associated with ambient horizontal flow occurring within these intervals.

Formation water migration caused by horizontal flow within the fluid column is indicated by the increase in FEC over time in Figure BH-119:2 for the intervals at 47.3 to 47.4, 85.2 to 88.8, 160.0 to 160.3, 253.0 – 254.5 and 262.2 to 263.8 feet. Numeric modeling of the reported field data for

these intervals suggests horizontal flow is occurring at rates of 0.003, 0.001, 0.001, 0.0002, and 0.0002 gpm, respectively. These flow rates are based on the rate of increase of mass at these intervals. Correcting for convergence of flow at the wellbore and factoring the length of the interval, these flow rates equate to a Darcy velocity, or specific discharge of groundwater in the aquifer 4.54, 0.04, 0.50, 0.02 and 0.02 ft/day, respectively. Please refer to Table BH-119:1 and SUMMARY:1 for a complete summary of the HydroPhysical™ logging results. Please refer to Appendix B for a discussion of the methodology and code used to calculate these values. The ambient depth to water at the time of testing was 18.91 ftbgs.

1.3 Flow Characterization During 1.4 GPM Production Test: BH-119

Low-rate pumping of wellbore fluids after DI water emplacement was conducted at one pumping rate to establish the inflow locations and evaluate the interval-specific inflow rates. Low-rate pumping at a given rate after DI water emplacement is conducted when the subject wellbore cannot sustain more than approximately 2-3 gpm yield. For DI water emplacement, DI water is injected at the bottom of the wellbore while simultaneous extraction pumping is conducted near water surface at the same rate. Water levels and flow rates are monitored and recorded digitally continuously to ensure minimal to no DI water is lost to the formation. This is achieved by maintaining water level at or below the recorded ambient level. After DI water emplacement is complete low-rate pumping is conducted to stress the aquifer(s) and draw groundwater into the wellbore where it is contrasted by the DI water in the wellbore. Continuous FEC profiling over time yields the depth and rate of influx of groundwater during pumping. These procedures were conducted at a time-averaged pumping rate of 1.40 gpm.

On July 23, 2004 at 0925 hours (t = 0 minutes elapsed time of testing), pumping was initiated at approximately 1.4 gpm. Prior to initiating pumping, the ambient depth to water was recorded at 18.28 ftbgs. Time dependent depth to water, totals and flow rate information were recorded and are presented in Figure BH-119:3. Low-rate pumping was maintained at a time-averaged rate of 1.40 gpm until 1521 hours (t = 356 minutes, elapsed time of testing). During this period drawdown was observed to stabilize at approximately 20 feet. In the case of a low-yield well such as BH-119, drawdown may take some time to reach equilibrium. While drawdown is stabilizing, wellbore storage contributes to the total extraction rate. The volume of borehole fluid that is removed from the well during extraction pumping is calculated and incorporated in the numerical modeling of the field data. Wellbore storage contributed 0.044 gpm during the late-time testing. A maximum drawdown of 20.75 feet was observed. During the period of testing, multiple loggings were conducted. Of these logs eight FEC traces are presented in Figure BH-119:4. These logs clearly illustrate specific intervals of dramatic increase in FEC with respect to time. The depth at which the peak value for a given interval occurs is indicative of a water-bearing interval. The data presented in Figure BH-119:4 suggests the presence of 18 hydraulically conductive intervals, with the dominant water-bearing interval at 85.2 to 88.8 feet. Numerical modeling of the reported field data was performed using code BOREII (Hale and Tsang, 1988, Tsang et.al. 1990, Daughtery and Tsang, 2000). This modeling was performed to estimate the rate of inflow and FEC for each identified hydraulically conductive interval during the pumping. The results of the modeling and analysis are presented in Table BH-119:1. In summary, the interval of 85.2 to 88.8 feet dominated inflow producing 0.438 gpm, or 32.4 percent of the total inflow during production testing. Please refer to Table BH-119:1 for a complete listing of the depths of water-bearing zones and their interval-specific inflow rate during testing.

1.4 Downhole Sampling

Eight downhole samples and one wellhead sample were procured from wellbore BH-119 on July 26, 2004. Downhole samples were procured from depths of 44, 70, 82, 143, 156, 254, 298 and 454 feet. Downhole sampling was conducted during development pumping at a time-averaged rate of 1.41 gpm after production testing was completed. The laboratory analyses of the procured samples are incorporated with the hydrophysical flow data to obtain actual, or "pore" water, contaminant concentrations for each sampled interval using the mass-balance equation.

Wellbore BH-119 exhibited relatively minor flow rates in the lower portion of the wellbore. Complete development of flow intervals exhibiting such small flow rates may take days. For this reason, samples collected at 254, 298 and 454 feet do not represent fully developed flow intervals. A ratio of borehole fluid dilution at the time of sampling was calculated by comparing FEC of the developing interval at the time of testing (sampling) and actual the FEC of the interval estimated through numerical modeling or observed in the ambient FEC log. This ratio was applied to the laboratory results to estimate actual contamination levels of the lowermost three sampled intervals. These intervals had not completely developed; therefore, the mixing of these lowermost intervals may be better estimated using laboratory concentrations. As opposed to the standard procedure of sampling above a developed producing zone, these zones were sampled with the sampler intake ports at precisely the depth of the interval due to their lack of development. These samples, along with the subsequent estimation of the dilution factor, may not be representative of actual contaminant concentrations. Because these intervals are not well developed and the mixing of the water in the borehole at these intervals can not be determined, the HNP laboratory results should be considered likely more representative estimates of tritium concentrations at these depths.

In summary the intervals 47.3 to 47.4, 74.4 to 74.5 and 85.2 to 88.8 feet registered the highest pore water concentrations of tritium at 9,148, 18,346 and 10,107 pCi/L, respectively. Please refer to Table BH-119:2 for a listing of sample depths and actual contamination concentrations.

The sample locations were identified by on-site interpretation of the FEC/Temperature logs acquired during pumping. Between procurement of samples, the downhole sampler was cleaned with an alconox and DI water solution and rinsed with DI water.

1.5 Estimation of Interval Specific Transmissivity: BH-119

An estimation of transmissivity (T) can be made using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w} \ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated by HpL™ results, r_w is the borehole radius (0.25 ft), r_e is the effective pumping radius , Δh_w is the observed maximum drawdown (20.75 feet) and L is the thickness of the zone through which flow occurs. For our calculations, COLOG used r_e of 100 feet (assumed). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific hydraulic conductivity can be calculated for each identified water producing interval. These calculations were made at each

identified interval and are presented in Table BH-119:1. In summary, the interval 85.2 to 88.8 feet registered the highest transmissivity at 3.86 feet^2/day.

2.0 Data Summary

Processing and interpretation of the HydroPhysical™ logs in BH-119 suggest the presence of 18 producing intervals for this borehole. Numerical modeling of the reported HydroPhysical™ field data was performed using the computer program BOREII. These analyses were performed to estimate the rate of inflow for each identified hydraulically conductive borehole interval during DI injection procedures. The results of these analyses are presented in Table BH-119:1. These identified producing intervals correlate well with water-bearing zones identified during ambient testing. In summary, the interval 85.2 to 88.8 feet dominated inflow during the production test, producing 0.438 gpm, or 32.4 percent of the total flow during the production test.

During ambient testing, boring BH-119 exhibited a horizontal flow regime. Five water-bearing zones were identified under ambient conditions exhibiting horizontal flow. No vertical pressure gradient was observed under ambient conditions. The five water-bearing zones at 47.3 to 47.4, 85.2 to 88.8, 160.0 to 160.3, 241.2 to 241.4 and 262.2 to 263.8 feet contributed water to the borehole at estimated flow rates of 0.003, 0.001, 0.001, 0.0002, and 0.0002 gpm, respectively. Correcting for convergence of flow at the wellbore and factoring the length of the interval, these flow rates equate to a Darcy velocity, or specific discharge of groundwater in the aquifer of 4.54, 0.04, 0.50, 0.02 and 0.02 ft/day, respectively.

The ambient fluid temperature log (Figure BH-119:1) acquired on July 22, 2004 indicates an increase in temperature with depth to approximately 88 feet. Below this depth the log indicates a decrease in temperature with depth to approximately 300 feet. Below this depth the temperature log indicates an increase in temperature with depth. Both the temperature and FEC log exhibit inflections at approximately 47 feet. This depth corresponds well with an ambient horizontal flow location. The ambient FEC profile is relatively featureless with the exception of the infection at approximately 47 feet.

The 18 interval-specific estimated transmissivities in BH-119 ranged from 0.003 to 3.86 square feet per day with the interval of 85.2 to 88.8 feet registering the highest transmissivity. The 18 interval-specific transmissivity estimates differ significantly with respect to each other, however, regarding just the dominant water producing zones interval-specific transmissivity did not differ significantly.

Downhole sampling was conducted in wellbore BH-119 on July 26, 2004 at a time-averaged rate of 1.41 gpm after production testing was completed. Eight downhole samples and one wellhead sample were procured from wellbore BH-119. The samples procured from 44 and 82 feet contained the highest levels of contaminant concentration.

Fracture inter-connectiveness in the immediate vicinity of a wellbore can be inferred by the similarity, or lack there of, of parameters such as interval-specific transmissivity estimates and interval-specific FEC, along with the presence of pressure differentials within the borehole. Similar transmissivity and FEC estimates would suggest an inter-connected network of fractures or aquifers in the immediate vicinity of the wellbore. Although a pressure differential present in the wellbore would suggest the driving force for vertical communication is present, in a vertically inter-connected network of fractures the aquifer pressures tend to equilibrate.

The data acquired in BH-119 exhibited similar interval-specific transmissivity estimates among dominant water producing intervals and similar FEC estimates. No vertical gradient is observed in the wellbore. The data suggest the fractures intersecting the wellbore may be inter-connected in the immediate vicinity of the wellbore. Please see Tables BH-119:1 and SUMMARY:1 for a summary which includes the locations, flow rates and hydraulic conductivity estimates assessed by COLOG.

FIGURE BH-119:1. AMBIENT TEMPERATURE AND FLUID ELECTRICAL CONDUCTIVITY; CH2M HILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-119.

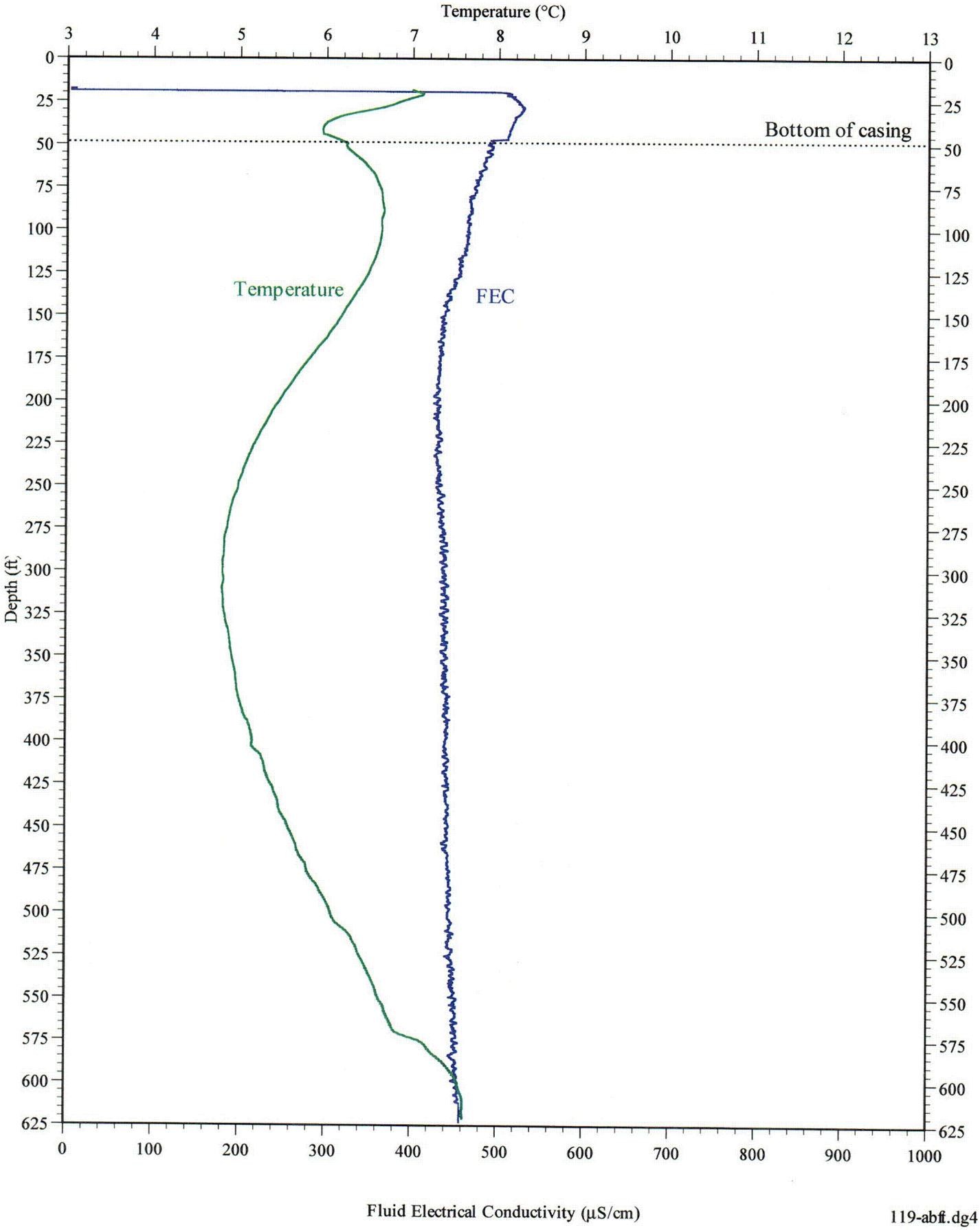


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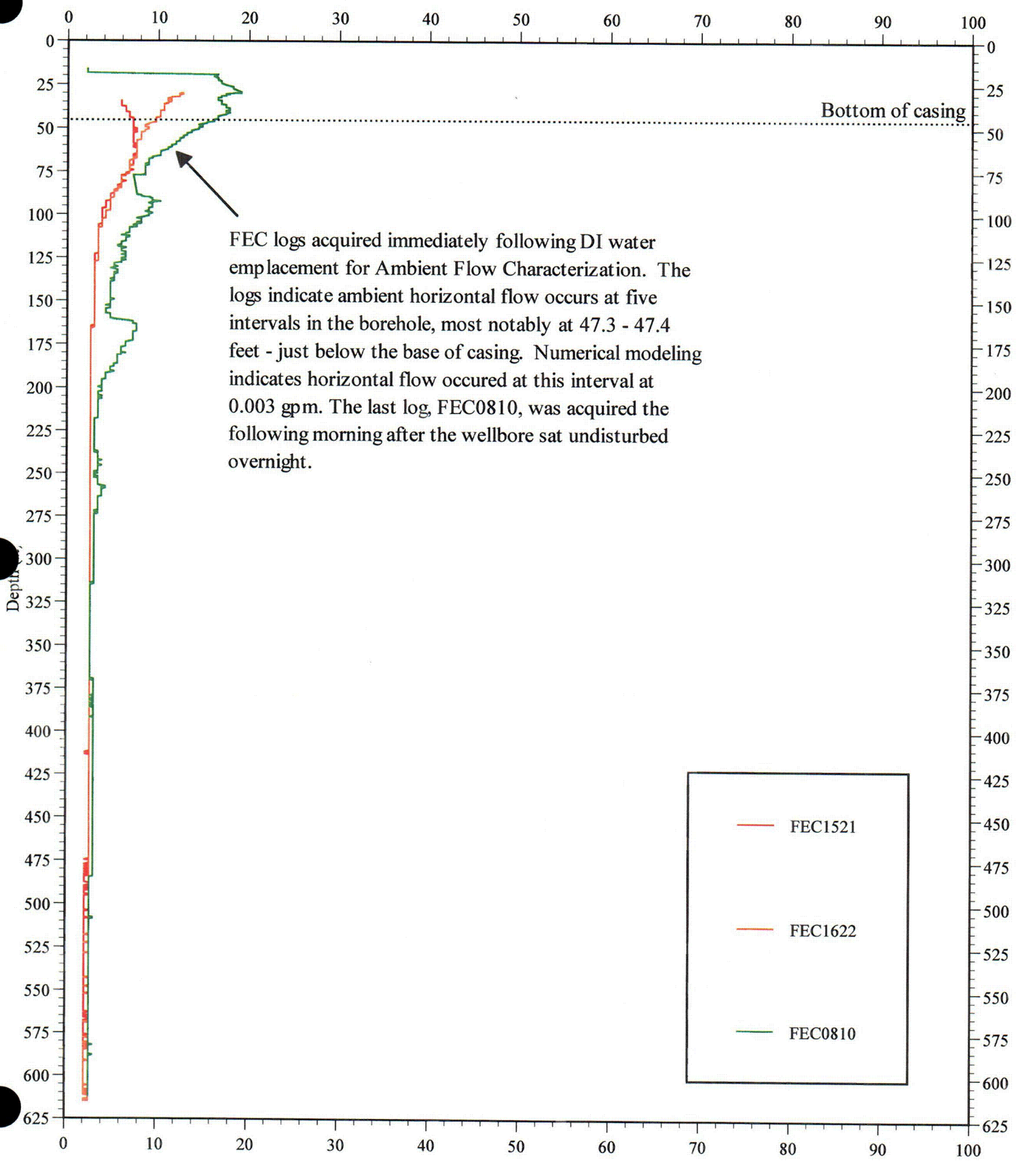
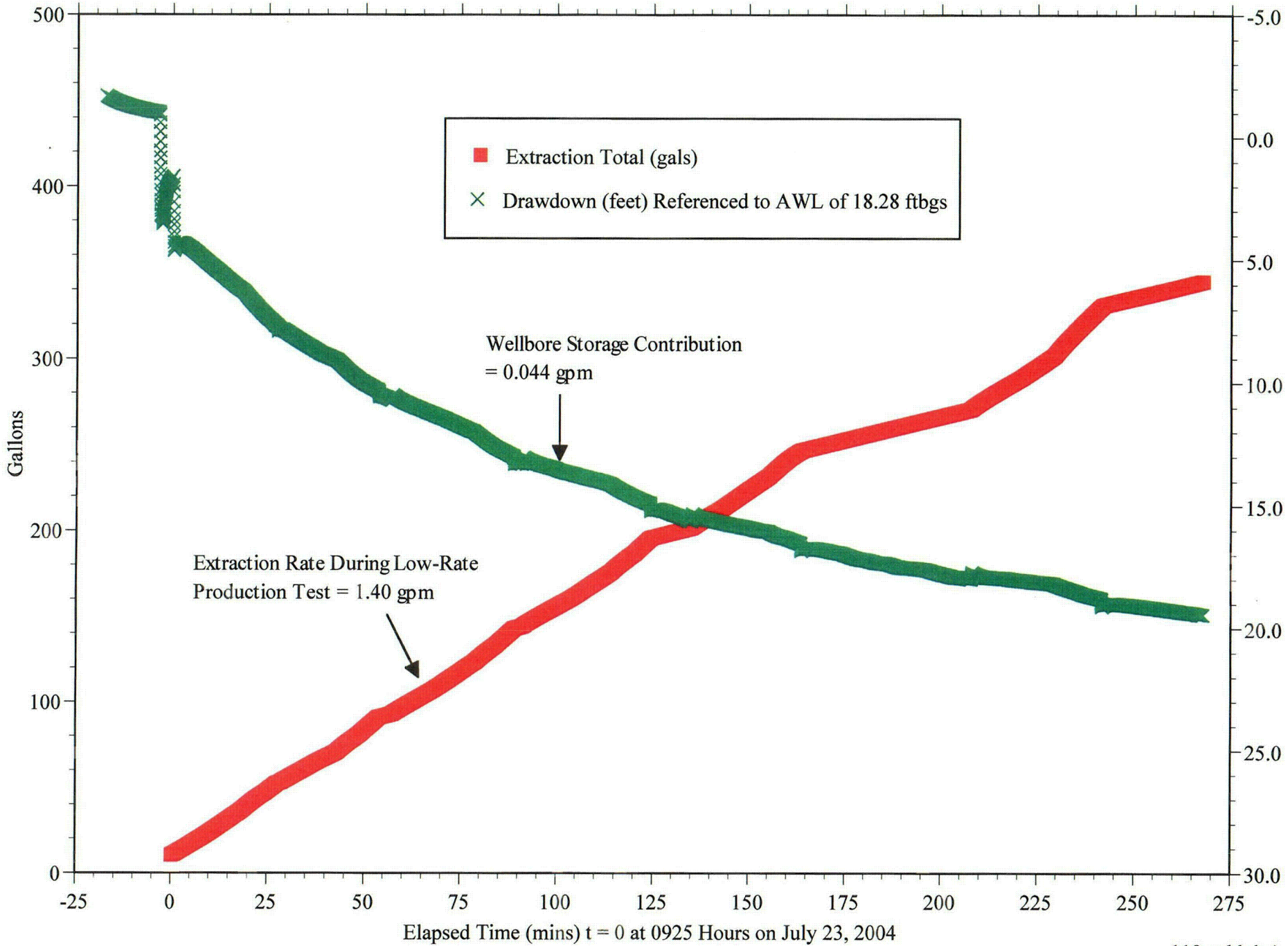
FIGURE BH-119:2 SUMMARY OF HYDROPHYSICAL LOGS DURING AMBIENT FLOW CHARACTERIZATION; CH2M HILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-119.



119-afc.dg4

C77

FIGURE BH-119:3. PUMPING AND DRAWDOWN DATA DURING LOW-RATE PRODUCTION TEST AT 1 GPM; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-119.



C78

FIGURE BH-119:4. SUMMARY OF HYDROPHYSICAL LOGS DURING LOW-RATE PUMPING AT 1 GPM; CH2M HILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-119.

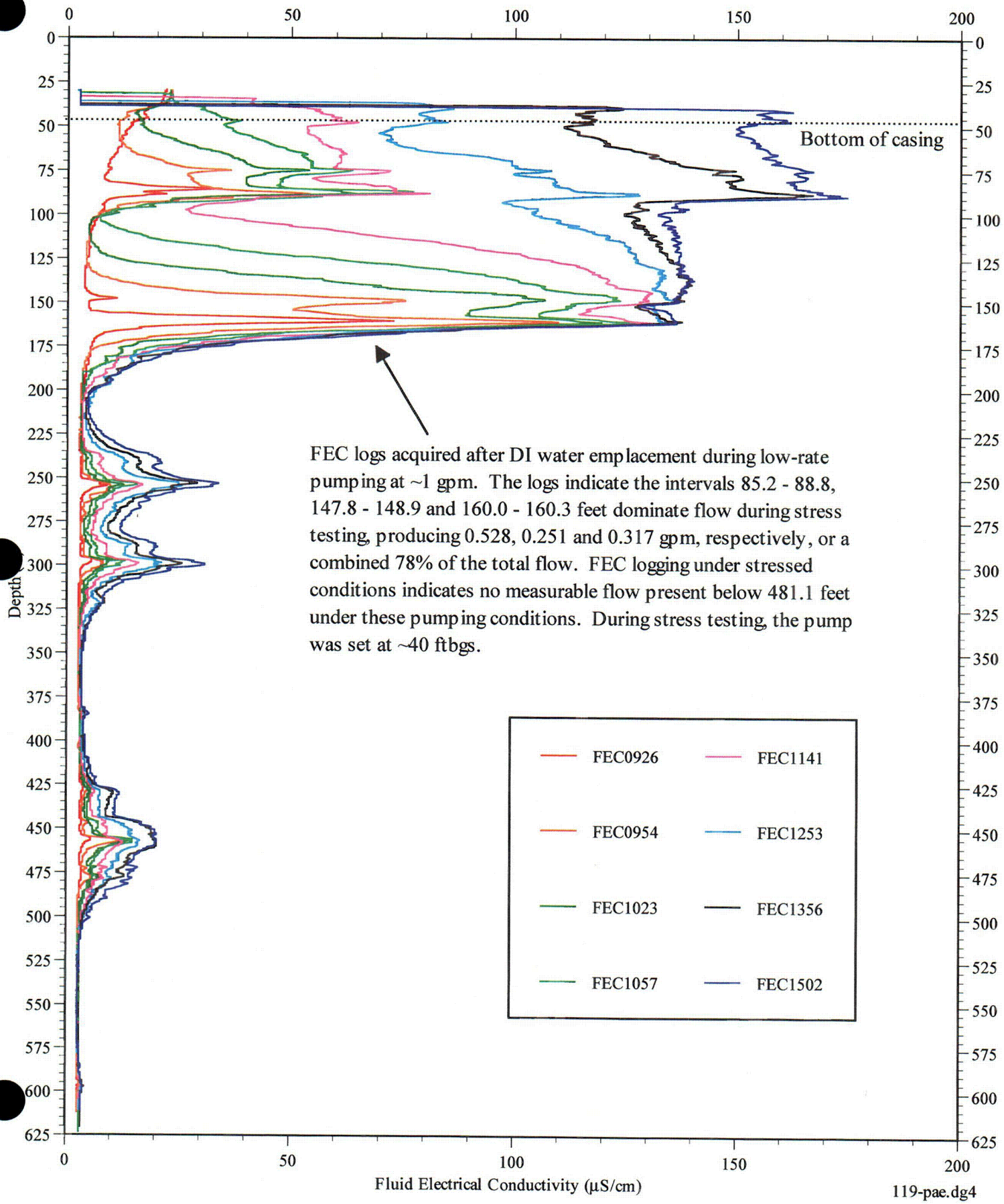


TABLE BH-119:1. SUMMARY OF HYDROPHYSICALTM LOGGING RESULTS WITH HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY ESTIMATIONS; CH2MHILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-119.

Project and Borehole Name	CYAPCO: BH-119
AWL Prior to Pumping (ftbgs)	18.28
Diameter of Borehole (ft)	0.51
Observed Drawdown (ft)	20.75
Effective Radius (ft)	100

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Thickness of Interval (ft)	Ambient Flow[1] (gpm)	Darcy Velocity in Aquifer[2] (Specific Discharge) (ft/day)	Interval Specific Flow Rate During Pumping (gpm)	Delta Flow[3] (gpm)	Delta Flow (ft^3/min.)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft^2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)	Sample Depth (feet)	HNP Onsite Lab Result (pCi/L)	Interval Specific Pore water Concentration of Tritium (pCi/L)
1	47.3	47.4	0.1	0.003	4.54	0.158	0.155	0.021	1.37E+01	1.37E+00	201	44	7550	9148
2	74.4	74.5	0.1	0.000	NA	0.169	0.169	0.023	1.49E+01	1.49E+00	185	70	7340	18346
3	85.2	88.8	3.6	0.001	0.04	0.438	0.437	0.058	1.07E+00	3.86E+00	183	82	5540	10107
4	147.8	148.9	1.1	0.000	NA	0.251	0.251	0.034	2.01E+00	2.22E+00	151	143	2180	3085
5	160.0	160.3	0.3	0.001	0.50	0.273	0.272	0.036	8.00E+00	2.40E+00	168	156	1520	1604
6	178.4	184.0	5.6	0.000	NA	0.008	0.008	0.001	1.26E-02	7.06E-02	167	NS	NS	NS
7	236.0	236.1	0.1	0.000	NA	0.002	0.002	0.000	1.77E-01	1.77E-02	166	NS	NS	NS
8	241.2	241.4	0.2	0.000	NA	0.003	0.003	0.000	1.32E-01	2.65E-02	167	NS	NS	NS
9	253.0	254.5	1.5	0.0002	0.02	0.013	0.013	0.002	7.53E-02	1.13E-01	167	254	<1110	<1110
10	262.2	263.8	1.6	0.0002	0.02	0.004	0.004	0.001	2.10E-02	3.35E-02	168	NS	NS	NS
11	288.1	288.3	0.2	0.000	NA	0.002	0.002	0.000	8.83E-02	1.77E-02	169	NS	NS	NS
12	297.2	299.3	2.1	0.000	NA	0.015	0.015	0.002	6.31E-02	1.32E-01	169	298	1170	6744
13	318.7	321.5	2.8	0.000	NA	0.002	0.002	0.000	6.31E-03	1.77E-02	169	NS	NS	NS
14	384.2	385.5	1.3	0.000	NA	0.001	0.001	0.000	6.79E-03	8.83E-03	170	NS	NS	NS
15	426.7	430.9	4.2	0.000	NA	0.003	0.003	0.000	6.31E-03	2.65E-02	171	NS	NS	NS
16	446.5	452.8	6.3	0.000	NA	0.0003	0.000	0.000	4.20E-04	2.65E-03	171	NS	NS	NS
17	456.4	456.7	0.3	0.000	NA	0.012	0.012	0.002	3.53E-01	1.06E-01	172	453.5	1570	10801
18	472.0	481.1	9.1	0.000	NA	0.004	0.004	0.001	3.88E-03	3.53E-02	173	NS	NS	NS

[1] All ambient flow identified for this borehole is horizontal ambient flow.

[2] Darcy Velocity is calculated using the observed volumetric flow rate, the cross-sectional area of the flow interval in the borehole and a borehole convergence factor of 2.5 (Drost, 1968). The Darcy Velocity is only applicable to ambient horizontal flow.

[3] Delta Flow is the difference between Interval-Specific Flow Rate (during pumping) and Ambient Flow Rate.

[4] Hydraulic conductivity and transmissivity estimates are based on single well drawdown data, a porus-medium equivilent model and Hvorslev's 1951 porosity equation.

[5] The samples at 298 and 453 had a dilution factor applied to them to derive the actual contaminant concentration.

AWL = Ambient Water Level
NA = Not Applicable
ND = No Detect/Below Detection Limit for that SampleNot Applicable
NS = Not Sampled

BH-120 Logging Results

1.0 HydroPhysical™ Logging

1.1 Ambient Fluid Electrical Conductivity and Temperature Log: BH-120

At 1059 hours on August 4, 2004, after a calibration check of the fluid electrical conductivity (FEC) and temperature logging tool, the fluid column was logged for FEC and temperature profiles with COLOG's 1.5-inch diameter HpL™ tool. These logs were performed prior to the installation of any pumping equipment. Please refer to Figure BH-120:1. The ambient FEC profile indicates an inflection at approximately 142 feet. This inflection in FEC corresponds well with an identified interval of ambient horizontal flow. The remainder of the FEC log was relatively featureless. The ambient temperature log recorded a gradual decrease in temperature with depth to approximately 313 feet, below this depth the log indicates a gradual increase in temperature to approximately wellbore TD (550.9 ft).

1.2 Ambient Flow Characterization: BH-120

On August 4, 2004, an ambient flow characterization was conducted in boring BH-120. For ambient flow assessment, the fluid column in the borehole was replaced with de-ionized water (DI) and the boring left in an undisturbed state to allow any natural flow to occur. The pump was removed from the boring to insure that water in the pump standpipe would not drain back into the boring. Prior to this period and throughout all HpL™ testing, water levels and flow rates were monitored and recorded digitally every ten seconds. Ambient flow evaluation is reported for the period after the water surface returned to near pre-DI water emplacement levels. A series of FEC and temperature logs were then conducted over the duration of testing to identify changes in the fluid column associated with ambient flow. Ambient flow characterization is conducted to evaluate the presence of both vertical and horizontal ambient flow.

On August 4, 2004, at 1427 hours (t=0 minutes, elapsed time of test), dilution of the fluid column was complete. Minimal to no DI water was lost to the formation due to the slightly depressed head maintained during DI water emplacement procedures. During the 17.6 hours following the emplacement of DI water, multiple logs were conducted. Of these logs, 4 are presented in Figure BH-120:2. The designation of each logging with the FEC tool is indicated in the figure legend by the time of logging (e.g., FEC1443 versus a subsequent logging at FEC1558), thus the progressing of curves to the right in this figure represents changes in FEC over the total logging period. The last four digits of each log ID corresponds to the time at which that particular log was started. Only logs acquired during logging in the downward direction are presented as the design of the FEC/temperature probe allows for the most accurate data to be collected in the downward direction. The logs acquired in the upward logging direction are not representative of downhole conditions and are therefore omitted. These logs illustrate changes at several intervals throughout the upper portion of the borehole. These changes in the FEC profiles with respect to time are associated with ambient horizontal flow occurring within these intervals.

Formation water migration caused by horizontal flow within the fluid column is indicated by the increase in FEC over time in Figure BH-120:2 for the intervals at 105.6 to 106.0, 153.2 to 153.3 and 211.0 to 211.3 feet. Numeric modeling of the reported field data for these intervals suggests horizontal flow is occurring at rates of 0.004, 0.008 and 0.002 gpm, respectively. These flow

rates are based on the rate of increase of mass at these intervals. Correcting for convergence of flow at the wellbore and factoring the length of the interval, these flow rates equate to a Darcy velocity, or specific discharge of groundwater in the aquifer 1.51, 12.1 and 1.01 ft/day, respectively. Please refer to Table BH-120:1 and SUMMARY:1 for a complete summary of the HydroPhysical™ logging results. Please refer to Appendix B for a discussion of the methodology and code used to calculate these values. The ambient depth to water at the time of testing was 18.23 ftbgs.

1.3 Flow Characterization During 1.9 GPM Production Test: BH-120

Low-rate pumping of wellbore fluids after DI water emplacement was conducted at one pumping rate to establish the inflow locations and evaluate the interval-specific inflow rates. Low-rate pumping at a given rate after DI water emplacement is conducted when the subject wellbore cannot sustain more than approximately 2-3 gpm yield. For DI water emplacement, DI water is injected at the bottom of the wellbore while simultaneous extraction pumping is conducted near water surface at the same rate. Water levels and flow rates are monitored and recorded digitally continuously to ensure minimal to no DI water is lost to the formation. This is achieved by maintaining water level at or below the recorded ambient level. After DI water emplacement is complete low-rate pumping is conducted to stress the aquifer(s) and draw groundwater into the wellbore where it is contrasted by the DI water in the wellbore. Continuous FEC profiling over time yields the depth and rate of influx of groundwater during pumping. These procedures were conducted at a time-averaged pumping rate of 1.85 gpm.

On August 5, 2004 at 0826 hours (t = 0 minutes elapsed time of testing), pumping was initiated at approximately 1.9 gpm. Prior to initiating pumping, the ambient depth to water was recorded at 17.96 ftbgs. Time dependent depth to water, totals and flow rate information were recorded and are presented in Figure BH-120:3. Low-rate pumping was maintained at a time-averaged rate of 1.85 gpm until 1612 hours (t = 466 minutes, elapsed time of testing). During this period drawdown was observed to stabilize at approximately 16.9 feet. In the case of a low-yield well such as BH-120, drawdown may take some time to reach equilibrium. While drawdown is stabilizing, wellbore storage contributes to the total extraction rate. The volume of borehole fluid that is removed from the well during extraction pumping is calculated and included in the numerical modeling of the field data. A maximum drawdown of 16.90 feet was observed. During the period of testing, multiple loggings were conducted. Of these logs twelve FEC traces are presented in Figure BH-120:4. These logs clearly illustrate specific intervals of dramatic increase in FEC with respect to time. The depth at which the peak value for a given interval occurs is indicative of a water-bearing interval. The data presented in Figure BH-120:4 suggests the presence of 11 hydraulically conductive intervals, with the dominant water-bearing interval at 105.6 to 106.0 feet. Numerical modeling of the reported field data was performed using code BOREII (Hale and Tsang, 1988, Tsang et.al. 1990, Daughtery and Tsang, 2000). This modeling was performed to estimate the rate of inflow and FEC for each identified hydraulically conductive interval during the pumping. The results of the modeling and analysis are presented in Table BH-120:1. In summary, the interval of 105.6 to 106.0 feet dominated inflow producing 0.778 gpm, or 41 percent of the total inflow during production testing. Please refer to Table BH-120:1 for a complete listing of the depths of water-bearing zones and their interval-specific inflow rate during testing.

1.4 Downhole Sampling

Seven downhole samples and one wellhead sample were procured from wellbore BH-120 on August 5, 2004. Downhole samples were procured from depths 77, 85, 100, 124, 136, 208 and 231 feet. The wellhead sample was taken from the discharge outlet of the downhole pump. The downhole pump was set at 35 feet. Downhole sampling was conducted during development pumping at a time-averaged rate of 1.80 gpm after production testing was completed. The laboratory analyses of the procured samples are incorporated with the hydrophysical flow data to obtain actual, or "pore" water, contaminant concentrations for each sampled interval using the mass-balance equation. In summary, the interval 83.5 to 83.6 registered the highest concentration of tritium at 15,413 pCi/L. Please refer to Table BH-120:2 for a complete listing of sample locations and actual contaminant concentrations. The sample taken at 35 feet (wellhead) did not correspond with any interval of identified flow, therefore, this sample has not been included in Table BH-120:2

The sample locations were identified by on-site interpretation of the FEC/Temperature logs acquired during pumping. Between procurement of samples, the downhole sampler was cleaned with an alconox and DI water solution and rinsed with DI water.

1.5 Estimation of Interval Specific Transmissivity: BH-120

An estimation of transmissivity (T) can be made using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w} \ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated by HpL™ results, r_w is the borehole radius (0.25 ft), r_e is the effective pumping radius , Δh_w is the observed maximum drawdown (16.90 feet) and L is the thickness of the zone through which flow occurs. For our calculations, COLOG used r_e of 100 feet (assumed). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific hydraulic conductivity can be calculated for each identified water producing interval. These calculations were made at each identified interval and are presented in Table BH-120:1. In summary, the interval 105.6 to 106.0 feet registered the highest transmissivity at 8.39 feet^2/day.

2.0 Data Summary

Processing and interpretation of the HydroPhysical™ logs in BH-120 suggest the presence of 11 producing intervals for this borehole. Numerical modeling of the reported HydroPhysical™ field data was performed using the computer program BOREII. These analyses were performed to estimate the rate of inflow for each identified hydraulically conductive borehole interval during DI injection procedures. The results of these analyses are presented in Table BH-120:1. These identified producing intervals correlate well with water-bearing zones identified during ambient testing. In summary, the interval 105.6 to 106.0 feet dominated inflow during the production test, producing 0.778 gpm, or 41 percent of the total flow during the production test.

During ambient testing, boring BH-120 exhibited a horizontal flow regime. Four water-bearing zones were identified under ambient conditions exhibiting horizontal flow. No vertical pressure

gradient was observed under ambient conditions. The four water-bearing zones at 105.6 to 106.0, 153.2 to 153.3 and 211.0 to 211.3 feet contributed water to the borehole at estimated flow rates of 0.004, 0.008 and 0.002 gpm, respectively. Correcting for convergence of flow at the wellbore and factoring the length of the interval, these flow rates equate to a Darcy velocity, or specific discharge of groundwater in the aquifer of aquifer 1.51, 12.1 and 1.01 ft/day, respectively.

The ambient fluid temperature log (Figure BH-120:1) acquired on August 4, 2004 indicates a decrease in temperature with depth to approximately 313 feet. Below this depth the log indicates an increase in temperature with depth to TD (550.9 ft). The ambient FEC profile exhibits an inflection at approximately 142 feet. This depth corresponds well with an identified ambient horizontal flow location. The ambient FEC profile is relatively featureless with the exception of the infection at approximately 142 feet.

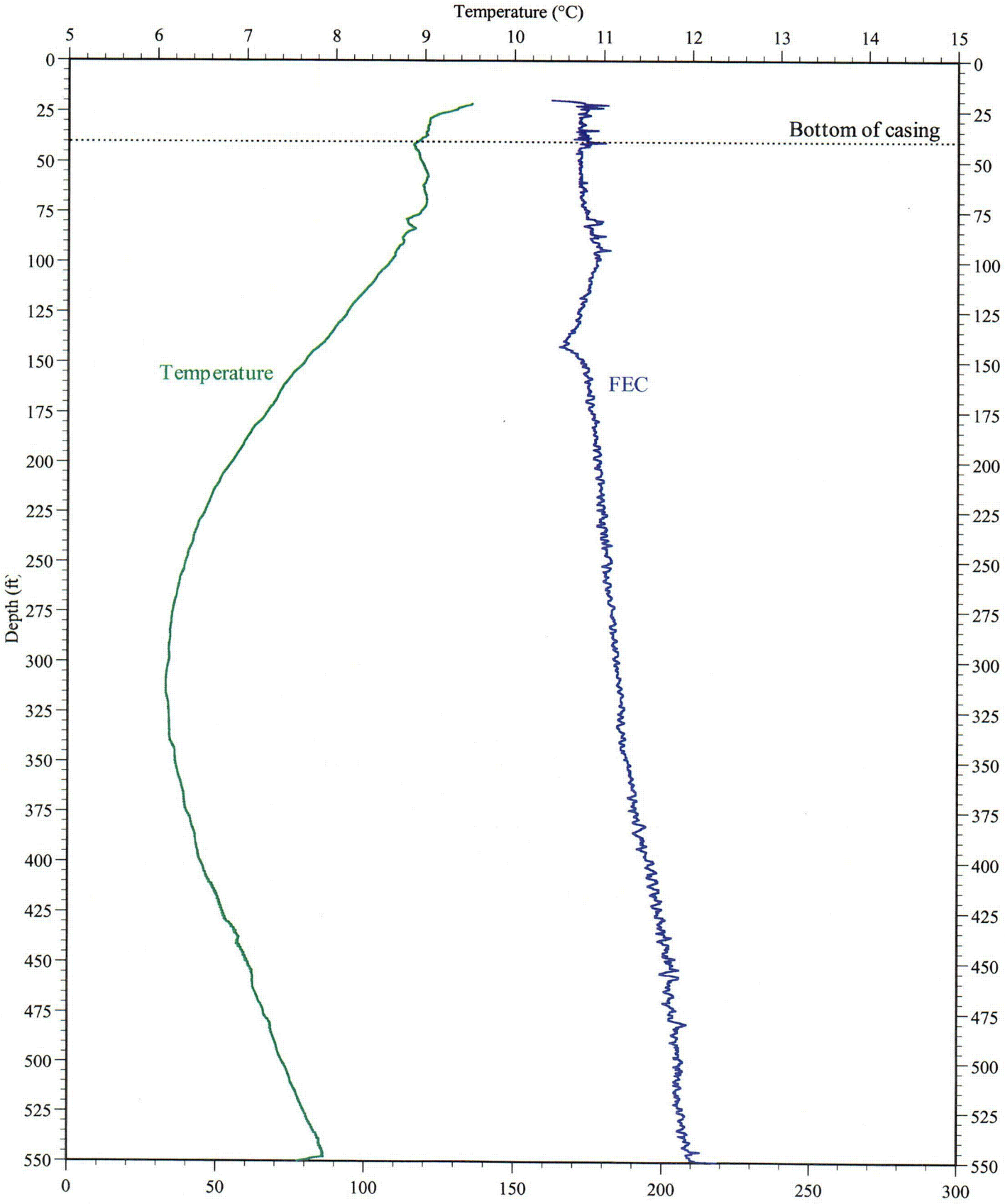
The 11 interval-specific estimated transmissivities in BH-120 ranged from 0.043 to 8.93 square feet per day with the interval of 105.6 to 106.0 feet registering the highest transmissivity. Among dominant water producing intervals the interval-specific transmissivity estimates do not differ significantly with respect to each other.

Downhole sampling was conducted in wellbore BH-120 during development pumping at a time-averaged rate of 1.80 gpm after production testing was completed. Seven downhole samples and one wellhead sample were procured from wellbore BH-120. The sample procured from 77 feet contained the highest levels of contaminant concentration.

Fracture inter-connectiveness in the immediate vicinity of a wellbore can be inferred by the similarity, or lack there of, of parameters such as interval-specific transmissivity estimates and interval-specific FEC, along with the presence of pressure differentials within the borehole. Similar transmissivity and FEC estimates would suggest an inter-connected network of fractures or aquifers in the immediate vicinity of the wellbore. Although a pressure differential present in the wellbore would suggest the driving force for vertical communication is present, in a vertically inter-connected network of fractures the aquifer pressures tend to equilibrate.

The data acquired in BH-120 exhibited similar interval-specific transmissivity estimates among dominant water producing intervals and somewhat similar FEC estimates suggesting an inter-connected network of fractures in the immediate vicinity of the wellbore. No vertical gradient is observed in the wellbore. The data suggest the fractures intersecting the wellbore may be vertically interconnected in the immediate vicinity of the wellbore. Please see Tables BH-120:1 and SUMMARY:1 for a summary which includes the locations, flow rates and hydraulic conductivity estimates assessed by COLOG.

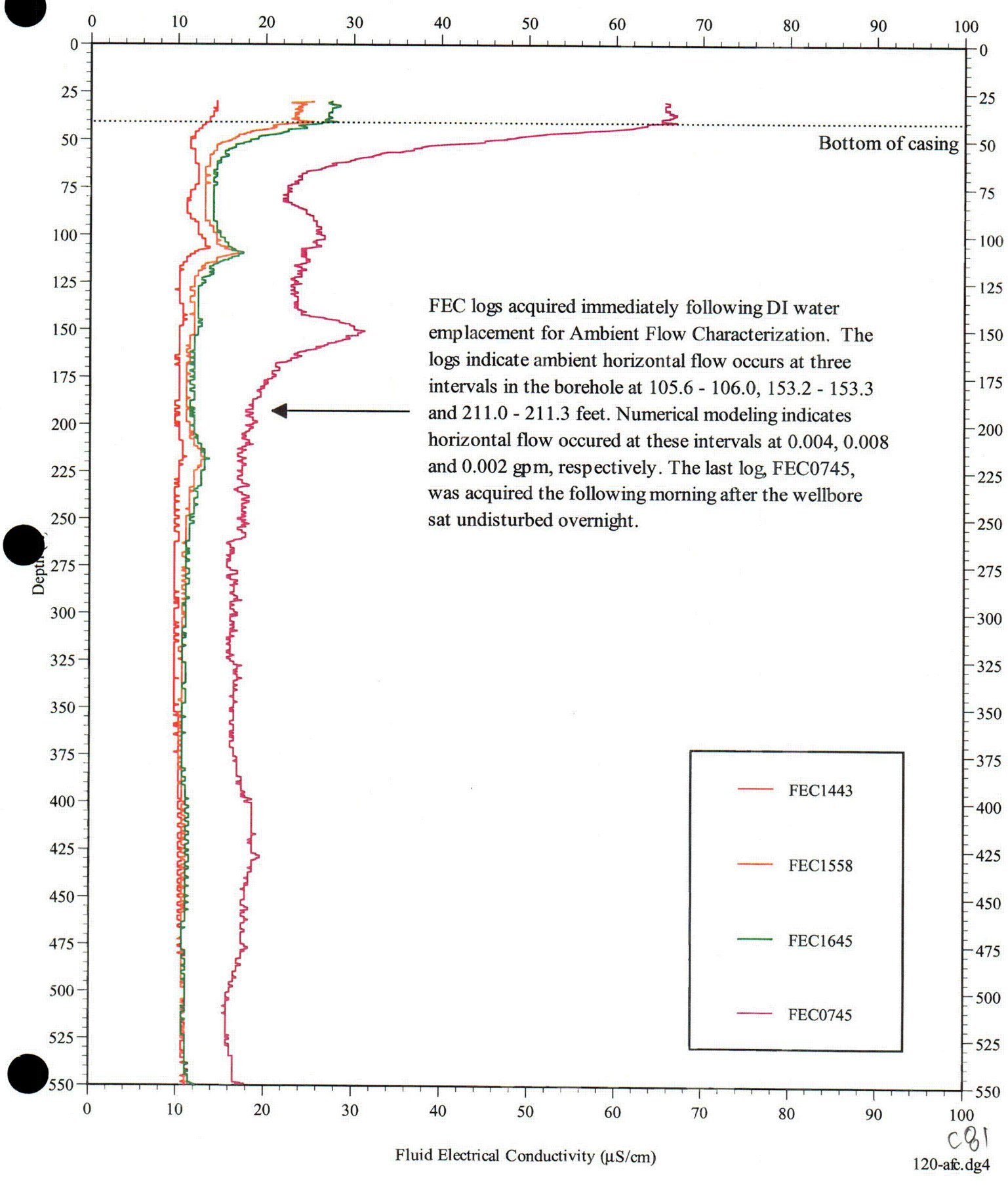
FIGURE BH-120:1. AMBIENT TEMPERATURE AND FLUID ELECTRICAL CONDUCTIVITY; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-120.



120-abft.dg4

C80

FIGURE BH-120:2 SUMMARY OF HYDROPHYSICAL LOGS DURING AMBIENT FLOW CHARACTERIZATION; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-120.



C81

120-afc.dg4

FIGURE BH-120:3. PUMPING AND DRAWDOWN DATA DURING LOW-RATE PRODUCTION TEST AT 2 GPM; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-120.

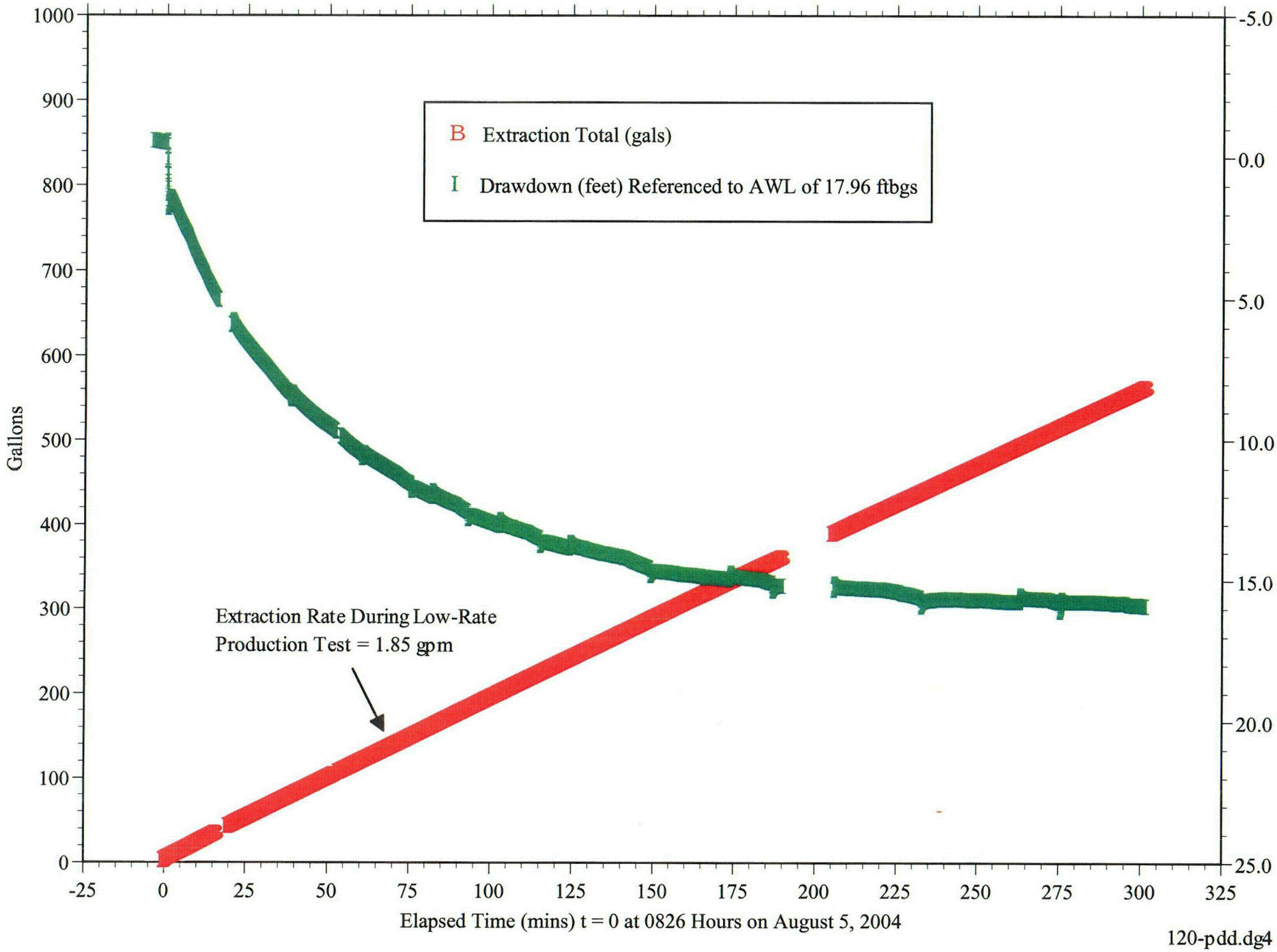
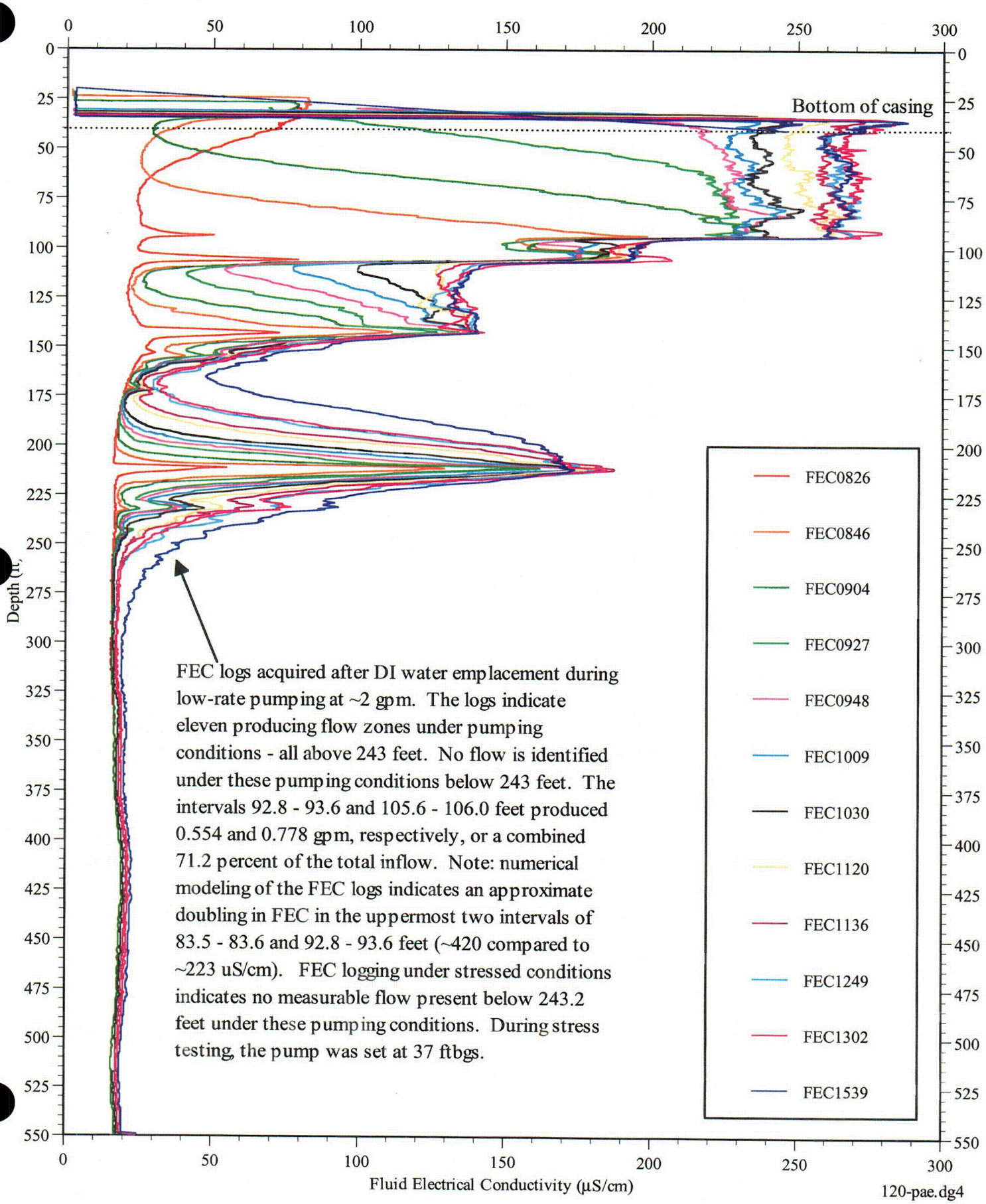


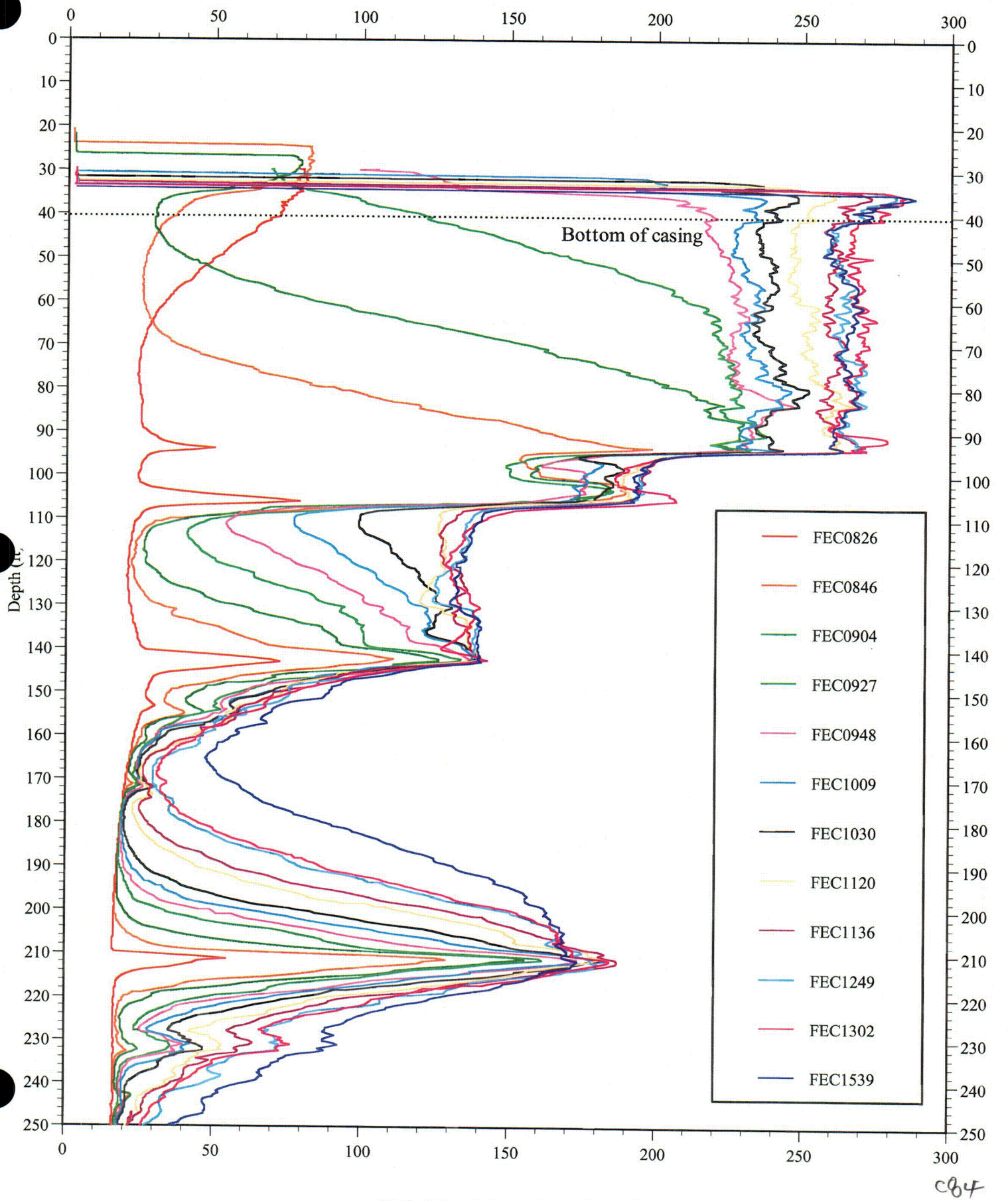
FIGURE BH-120:4A. SUMMARY OF HYDROPHYSICAL LOGS DURING LOW-RATE PUMPING AT 2 GPM; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-120.



120-pae.dg4

C03

FIGURE BH-120:4B. SUMMARY OF HYDROPHYSICAL LOGS DURING LOW-RATE PUMPING AT 2 GPM - 0 TO 250 FEET; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-120.



C84

120-pae2.dg4

TABLE BH-120:1. SUMMARY OF HYDROPHYSICALTM LOGGING RESULTS WITH HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY ESTIMATIONS; CH2MHILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-120.

Project and Borehole Name	CYAPCO: BH-120
AWL Prior to Pumping (ftbgs)	17.96
Diameter of Borehole (ft)	0.51
Observed Drawdown (ft)	16.90
Effective Radius (ft)	100

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Thickness of Interval (ft)	Ambient Flow[1] (gpm)	Darcy Velocity in Aquifer[2] (Specific Discharge) (ft/day)	Interval Specific Flow Rate During Pumping (gpm)	Delta Flow[3] (gpm)	Delta Flow (ft^3/min.)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft^2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)	Sample Depth (feet)	HNP Onsite Lab Result (pCi/L)	Interval Specific Pore water Concentration of Tritium (pCi/L)
1	83.5	83.6	0.1	0.000	NA	0.045	0.045	0.00602	4.88E+00	4.88E-01	421	76.6	1730	15413
2	92.8	93.6	0.8	0.000	NA	0.554	0.554	0.07406	7.51E+00	6.00E+00	414	85.3	1390	1458
3	105.6	106.0	0.4	0.004	1.51	0.778	0.774	0.10348	2.10E+01	8.39E+00	223	99.7	1360	1459
4	130.1	130.4	0.3	0.000	NA	0.079	0.079	0.01056	2.85E+00	8.56E-01	172	124.8	<1200	<1200
5	142.4	142.9	0.5	0.000	NA	0.264	0.264	0.03529	5.72E+00	2.86E+00	184	136.2	<1200	<1200
6	153.2	153.3	0.1	0.008	12.1	0.026	0.018	0.00241	1.95E+00	1.95E-01	175			
7	171.1	171.2	0.1	0.000	NA	0.008	0.008	0.00107	8.67E-01	8.67E-02	176			
8	211.0	211.3	0.3	0.002	1.01	0.074	0.072	0.00963	2.60E+00	7.80E-01	297	208	<833	<833
9	228.9	232.8	3.9	0.000	NA	0.016	0.016	0.00214	4.45E-02	1.73E-01	180	230.8	<1200	<1200
10	238.1	238.2	0.1	0.000	NA	0.008	0.008	0.00107	8.67E-01	8.67E-02	179	NS	NS	NS
11	242.3	243.2	0.9	0.000	NA	0.004	0.004	0.00053	4.82E-02	4.34E-02	181	NS	NS	NS

[1] All ambient flow identified for this borehole is horizontal ambient flow.

[2] Darcy Velocity is calculated using the observed volumetric flow rate, the cross-sectional area of the flow interval in the borehole and a borehole convergence factor of 2.5 (Drost, 1968). The Darcy Velocity is only applicable to ambient horizontal flow.

[3] Delta Flow is the difference between Interval-Specific Flow Rate (during pumping) and Ambient Flow Rate.

[4] Hydraulic conductivity and transmissivity estimates are based on single well drawdown data, a porus-medium equivilent model and Hvorslev's 1951 porosity equation.

AWL = Ambient Water Level
NA = Not Applicable
ND = No Detect/Below Detection Limit for that Sample
NS = Not Sampled

BH-121A Logging Results

1.0 HydroPhysical™ Logging

1.1 Ambient Fluid Electrical Conductivity and Temperature Log: BH-121A

At 0817 hours on July 28, 2004, after a calibration check of the fluid electrical conductivity (FEC) and temperature logging tool, the fluid column was logged for FEC and temperature profiles with COLOG's 1.5-inch diameter HpL™ tool. These logs were performed prior to the installation of any pumping equipment. Please refer to Figure BH-121A:1. The ambient FEC profile indicates notable inflections at approximately 98, 126, 160, 277, 217 and 455 feet. The inflection in FEC at approximately 98 feet corresponds with the base of casing. The inflection in FEC at approximately 277 feet corresponds relatively well with an interval of identified ambient horizontal flow. The inflection at approximately 455 feet corresponds relatively well with a water bearing zone identified during development pumping. The FEC log indicated a general increase in FEC with depth. The ambient temperature log recorded notable inflections at approximately 98, 277 and 405 feet. The infection at approximately 98 feet corresponds relatively well with the base of casing. The inflection at approximately 277 feet corresponds relatively well with an interval of identified ambient horizontal flow. The temperature log indicates a general decrease in temperature with depth to approximately 277 feet. Below this depth the temperature log indicates a general increase in temperature with depth, with the exception of the infection at approximately 405 feet.

1.2 Ambient Flow Characterization: BH-121A

On July 28, 2004, an ambient flow characterization was conducted in boring BH-121A. For ambient flow assessment, the fluid column in the borehole was replaced with de-ionized water (DI) and the boring left in an undisturbed state to allow any natural flow to occur. The pump was removed from the boring to insure that water in the pump standpipe would not drain back into the boring. Prior to this period and throughout all HpL™ testing, water levels and flow rates were monitored and recorded digitally every ten seconds. Ambient flow evaluation is reported for the period after the water surface returned to near pre-DI water emplacement levels. A series of FEC and temperature logs were then conducted over the duration of testing to identify changes in the fluid column associated with ambient flow. Ambient flow characterization is conducted to evaluate the presence of both vertical and horizontal ambient flow.

On July 28, 2004, at 1733 hours (t=0 minutes, elapsed time of test), dilution of the fluid column was complete. Minimal to no DI water was lost to the formation due to the slightly depressed head maintained during DI water emplacement procedures. During the 15.7 hours following the emplacement of DI water, multiple logs were conducted. Of these logs, 5 are presented in Figure BH-121A:2. The designation of each logging with the FEC tool is indicated in the figure legend by the time of logging (e.g., FEC1736 versus a subsequent logging at FEC1803), thus the progressing of curves to the right in this figure represents changes in FEC over the total logging period. The last four digits of each log ID corresponds to the time at which that particular log was started. Only logs acquired during logging in the downward direction are presented as the design of the FEC/temperature probe allows for the most accurate data to be collected in the downward direction. The logs acquired in the upward logging direction are not representative of downhole conditions and are therefore omitted. These logs illustrate changes at several intervals

throughout the upper portion of the borehole. These changes in the FEC profiles with respect to time are associated with ambient horizontal flow occurring within these intervals.

Formation water migration caused by horizontal flow within the fluid column is indicated by the increase in FEC over time in Figure BH-121A:2 for the intervals at 165.9 to 166.8, 278.0 to 278.8 and 460.7 to 465.1 feet. Numeric modeling of the reported field data for these intervals suggests that horizontal flow is occurring at rates of 0.012, 0.0008 and 0.0004 gpm, respectively. These flow rates are based on the rate of increase of mass at these intervals. Correcting for convergence of flow at the wellbore and factoring the length of the interval, these flow rates equate to a Darcy velocity, or specific discharge of groundwater in the aquifer 2.02, 0.15 and 0.01 ft/day, respectively. Please refer to Table BH-121A:1 and SUMMARY:1 for a complete summary of the HydroPhysical™ logging results. Please refer to Appendix B for a discussion of the methodology and code used to calculate these values. The ambient depth to water at the time of testing was 17.19 ftbgs.

1.3 Flow Characterization During 7 GPM Production Test: BH-121A

Low-rate pumping of wellbore fluids after DI water emplacement was conducted at one pumping rate to establish the inflow locations and evaluate the interval-specific inflow rates. Water levels and flow rates are monitored and recorded digitally continuously to ensure minimal to no DI water is lost to the formation. This is achieved by maintaining water level at or below the recorded ambient level. After DI water emplacement is complete low-rate pumping is conducted to stress the aquifer(s) and draw groundwater into the wellbore where it is contrasted by the DI water in the wellbore. Continuous FEC profiling over time yields the depth and rate of influx of groundwater during pumping. These procedures were conducted at a time-averaged pumping rate of 6.69 gpm.

On July 29, 2004 at 1047 hours (t = 0 minutes elapsed time of testing), pumping was initiated at approximately 7 gpm. Before initiating pumping, the ambient depth to water was recorded at 17.35 ftbgs. Time dependent depth to water, totals and flow rate information were recorded and are presented in Figure BH-121A:3. Low-rate pumping was maintained at a time-averaged rate of 6.69 gpm until 1557 hours (t = 310 minutes, elapsed time of testing). During this period drawdown was observed to stabilize at approximately 37 feet. During development pumping drawdown may take some time to reach equilibrium. While drawdown is stabilizing, wellbore storage contributes to the total extraction rate. The volume of borehole fluid that is removed from the well during extraction pumping is calculated and included in the numerical modeling of the field data. A maximum drawdown of 37.3 feet was observed. During the period of testing, multiple loggings were conducted. Of these logs eight FEC traces are presented in Figure BH-121A:4. These logs clearly illustrate specific intervals of dramatic increase in FEC with respect to time. The depth at which the peak value for a given interval occurs is indicative of a water-bearing interval. The data presented in Figure BH-121A:4 suggests the presence of 13 hydraulically conductive intervals, with the dominant water-bearing interval at 165.9 to 166.8 feet. Numerical modeling of the reported field data was performed using code BOREII (Hale and Tsang, 1988, Tsang et.al. 1990, Daughtery and Tsang, 2000). This modeling was performed to estimate the rate of inflow and FEC for each identified hydraulically conductive interval during the pumping. The results of the modeling and analysis are presented in Table BH-121A:1. In summary, the interval of 165.9 to 166.8 feet dominated inflow producing 6.26 gpm, or 93.6 percent of the total inflow during production testing. Please refer to Table BH-121A:1 for a complete listing of the depths of water-bearing zones and their interval-specific inflow rate during testing.

1.4 Downhole Sampling

Eight downhole samples were procured from wellbore BH-121A on July 30, 2004. Downhole samples were procured from depths 83, 144, 163, 173, 279, 309, 326 and 464 feet. Downhole sampling was conducted while wellbore BH-121A was being developed at a time-averaged rate of 6.75 gpm. The laboratory analyses of the procured samples are incorporated with the hydrophysical flow data to obtain actual, or "pore" water, contaminant concentrations for each sampled interval using the mass-balance equation. In summary, the intervals 165.9 to 166.8 and 177.6 to 177.7 feet registered the highest concentrations of tritium at 7,322 and 8,645 pCi/L, respectively. It is worth noting that the sample procured at 144 feet registering 6,250 pCi/L tritium and the resulting pore water tritium estimation using the Mass-Balance equation of "No Detect" (ND). This is because the sample just below 144 feet procured at 163 feet contained 7,230 pCi/L of tritium with 6.47 gpm (aggregate flow below 163 feet) of flow associated with this sample, which comprises approximately 94 percent of the flow measured in the borehole. The sample procured at 144 feet had only an additional 0.18 gpm of flow associated with it. In other words, the difference in observed concentrations between the sample at 163 feet and 144 feet, as far as estimations made using the Mass-Balance equation are concerned, is solely the result of the introduction of a certain concentration of tritium into the borehole at 0.18 gpm, meaning the water coming into the borehole must be relatively low in tritium compared to the borehole fluids and steady-state conditions are present at and below this depth, hence the ND. Please refer to Table BH-121A:2 for a complete listing of sample locations and actual contaminant concentrations. The sample taken at 83 feet did not correspond with any interval of identified flow, therefore, this sample has not been included in Table BH-121A:2

The sample locations were identified by on-site interpretation of the FEC/Temperature logs acquired during pumping. Between procurement of samples, the downhole sampler was cleaned with an alconox and DI water solution and rinsed with DI water.

1.5 Estimation of Interval Specific Transmissivity: BH-121A

An estimation of transmissivity (T) can be made using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w} \ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated by HpL™ results, r_w is the borehole radius (0.25 ft), r_e is the effective pumping radius , Δh_w is the observed maximum drawdown (37.3 feet) and L is the thickness of the zone through which flow occurs. For our calculations, COLOG used r_e of 100 feet (assumed). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific hydraulic conductivity can be calculated for each identified water producing interval. These calculations were made at each identified interval and are presented in Table BH-121A:1. In summary, the interval 165.9 to 166.8 feet registered the highest transmissivity at 30.7 $feet^2$/day.

2.0 Data Summary

Processing and interpretation of the HydroPhysical™ logs in BH-121A suggest the presence of 13 producing intervals for this borehole. Numerical modeling of the reported HydroPhysical™ field data was performed using the computer program BOREII. These analyses were performed to estimate the rate of inflow for each identified hydraulically conductive borehole interval during DI injection procedures. The results of these analyses are presented in Table BH-121A:1. These identified producing intervals correlate well with water-bearing zones identified during ambient testing. In summary, the interval 165.9 to 166.8 feet dominated inflow during the production test, producing 6.26 gpm, or 93.6 percent of the total flow during the production test.

During ambient testing, boring BH-121A exhibited a horizontal flow regime. Three water-bearing zones were identified under ambient conditions exhibiting horizontal flow. No vertical pressure gradient was observed under ambient conditions. The three water-bearing zones at 165.9 to 166.8, 278.0 to 278.8 and 467.9 to 469.5 feet contributed water to the borehole at estimated flow rates of 0.012, 0.0008 and 0.0004 gpm, respectively. Correcting for convergence of flow at the wellbore and factoring the length of the interval, these flow rates equate to a Darcy velocity, or specific discharge of groundwater in the 2.02, 0.15 and 0.01 ft/day, respectively.

The ambient fluid temperature log (Figure BH-121A:1) acquired on July 28, 2004 indicates a general decrease in temperature with depth to approximately 277 feet. At approximately 277 feet there is an inflection in temperature that corresponds well with an identified horizontal flow interval. Below this depth the log indicates a general increase in temperature with depth. The ambient FEC profile exhibits a general increase in FEC with depth. Numerous inflections can be observed in the log. The infection in FEC at approximately 277 feet corresponds well with an interval of identified horizontal ambient flow.

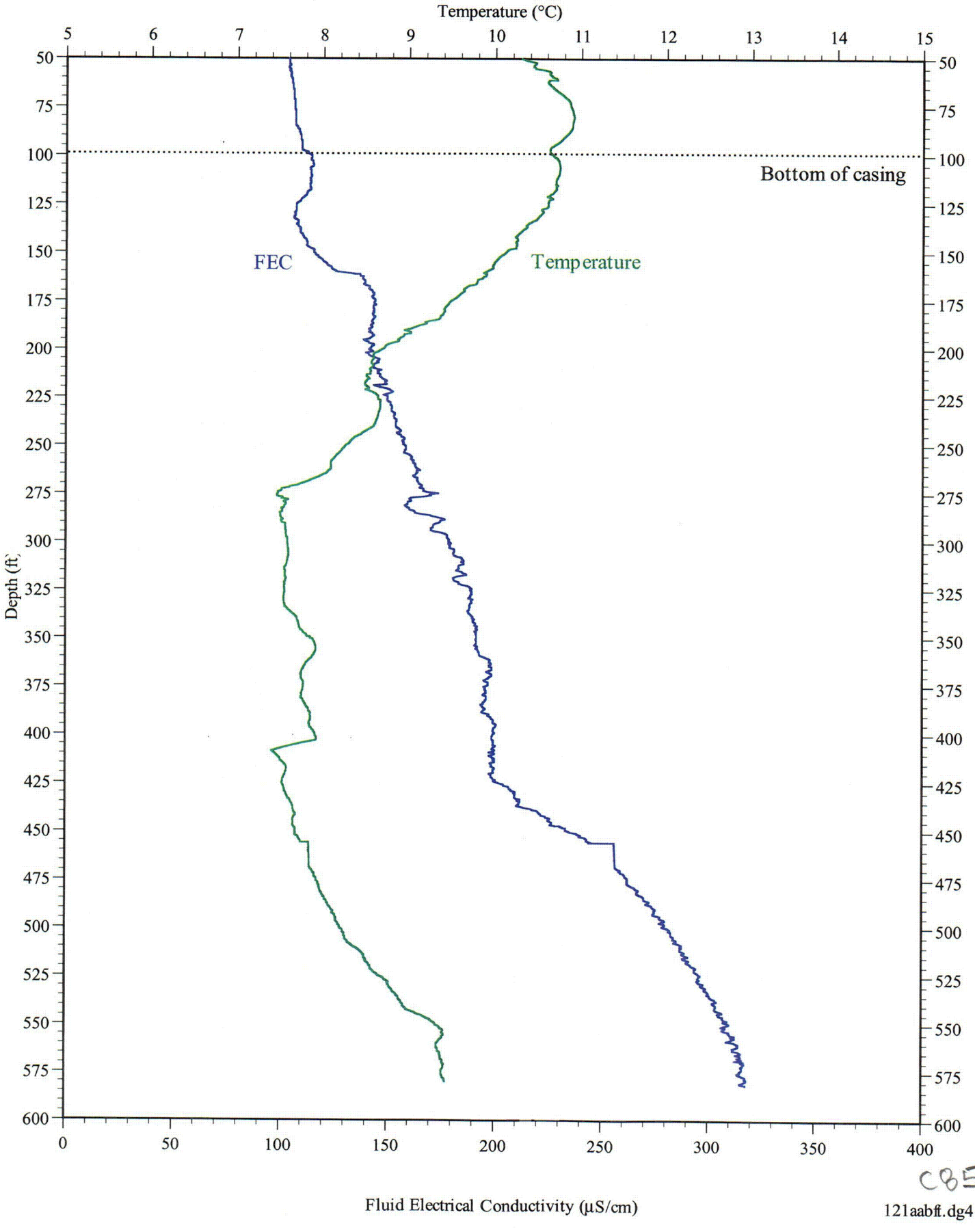
The 13 interval-specific estimated transmissivities in BH-121A ranged from 0.004 to 30.7 square feet per day with the interval of 165.9 to 166.8 feet registering the highest transmissivity. The 13 interval-specific transmissivity estimates do not differ significantly with respect to each other with the sole exception of the dominant producing zone at 165.9 to 166.8 feet.

Downhole sampling was conducted in wellbore BH-121A during development pumping at a time-averaged rate of 6.75 gpm after production testing was completed. Eight downhole samples were procured from wellbore BH-121A. In summary, the intervals 165.9 to 166.8 and 177.6 to 177.7 feet registered the highest concentrations of tritium at 7,322 and 8,645 pCi/L, respectively.

Fracture inter-connectiveness in the immediate vicinity of a wellbore can be inferred by the similarity, or lack there of, of parameters such as interval-specific transmissivity estimates and interval-specific FEC, along with the presence of pressure differentials within the borehole. Similar transmissivity and FEC estimates would suggest an inter-connected network of fractures or aquifers in the immediate vicinity of the wellbore. Although a pressure differential present in the wellbore would suggest the driving force for vertical communication is present, in a vertically inter-connected network of fractures the aquifer pressures tend to equilibrate.

The data acquired in BH-121A exhibited similar interval-specific transmissivity and similar FEC estimates suggesting an inter-connected network of fractures in the immediate vicinity of the wellbore. No vertical gradient is observed in the wellbore. The data suggest the fractures intersecting the wellbore may be inter-connected in the immediate vicinity of the wellbore. Please see Tables BH-121A:1 and SUMMARY:1 for a summary which includes the locations, flow rates and hydraulic conductivity estimates assessed by COLOG.

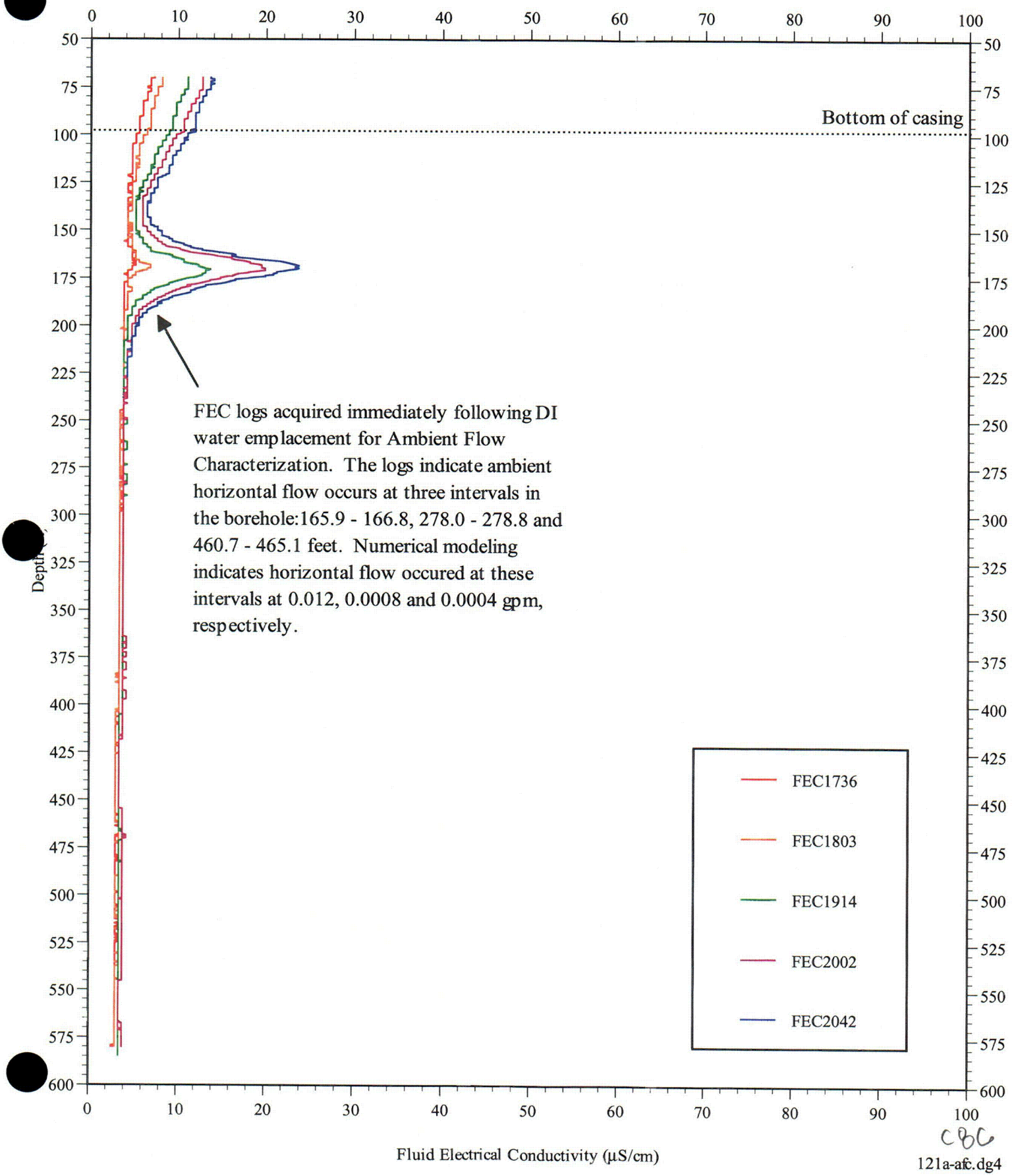
FIGURE BH-121A:1. AMBIENT TEMPERATURE AND FLUID ELECTRICAL CONDUCTIVITY; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-121A.



C85

121aabft.dg4

FIGURE BH-121A:2 SUMMARY OF HYDROPHYSICAL LOGS DURING AMBIENT FLOW CHARACTERIZATION; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-121A.



CBC

121a-afc.dg4

FIGURE BH-121A:3. PUMPING AND DRAWDOWN DATA DURING LOW-RATE PRODUCTION TEST AT 7 GPM; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-121A.

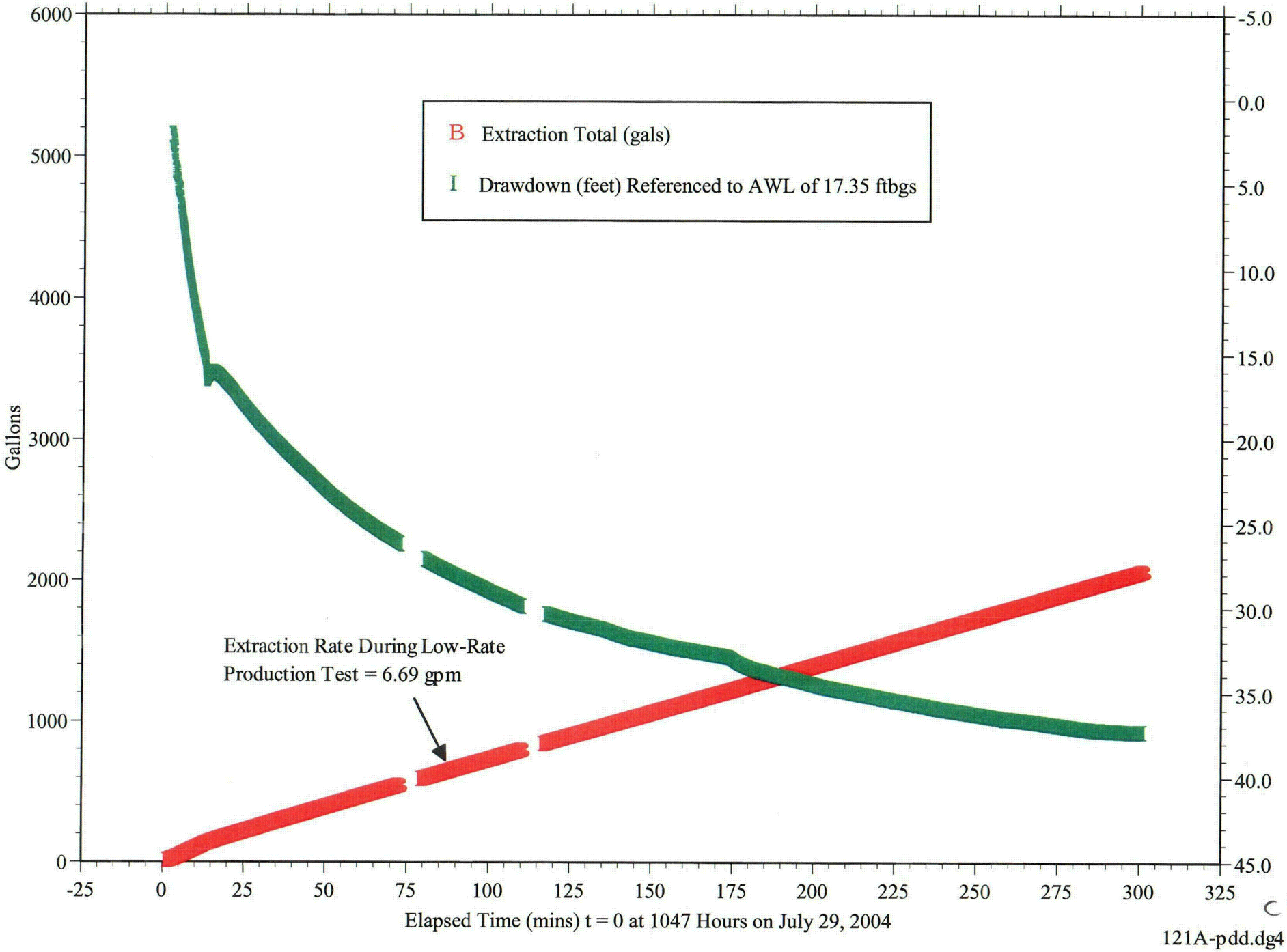
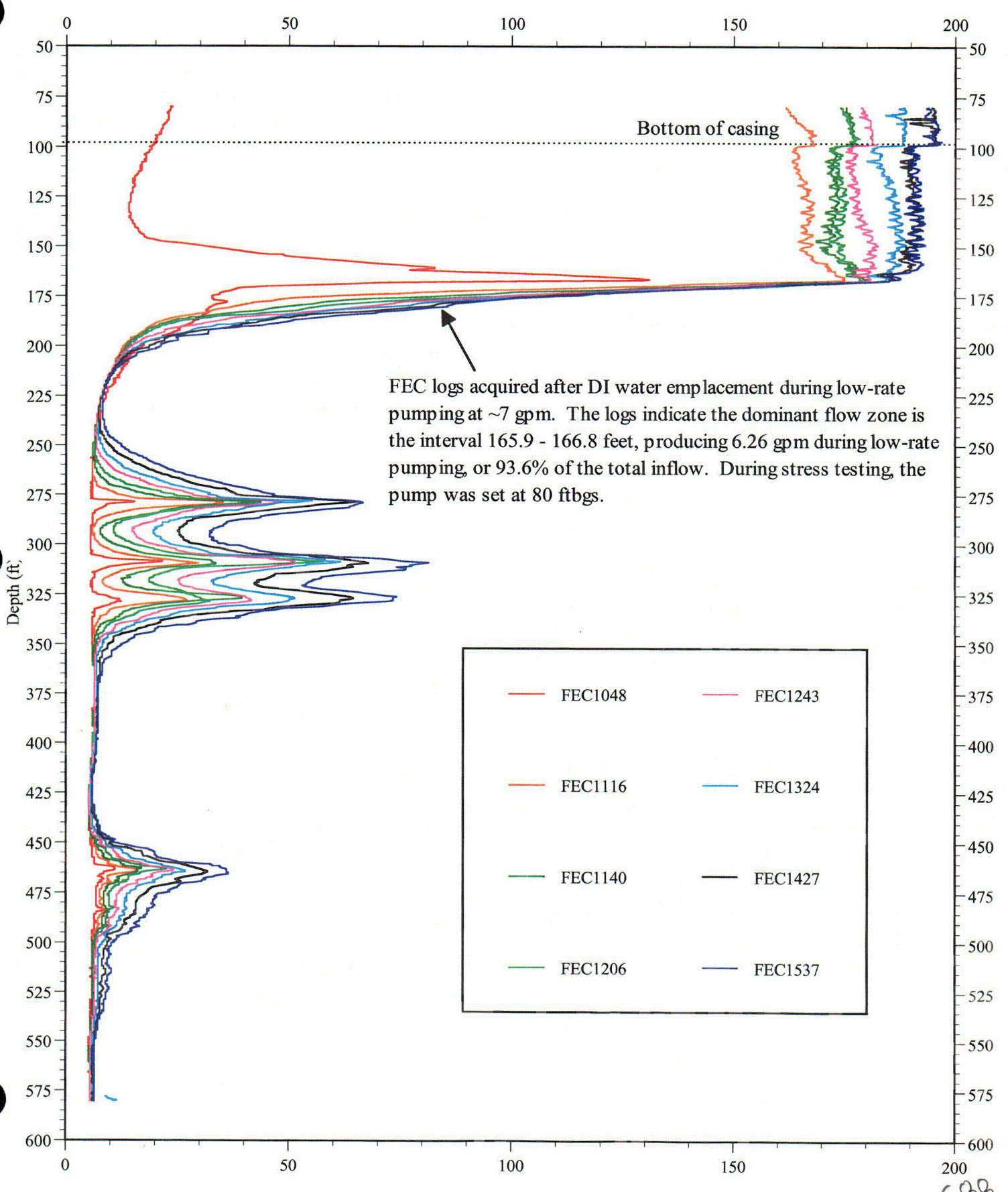


FIGURE BH-121A:4A. SUMMARY OF HYDROPHYSICAL LOGS DURING LOW-RATE PUMPING AT 7 GPM; CH2M HILL; CYAPCO; HADDAM NECK, CT; WELLBORE: BH-121A.



C88

121apae1.dg4

TABLE BH-121A:1. SUMMARY OF HYDROPHYSICALTM LOGGING RESULTS WITH HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY ESTIMATIONS; CH2MHILL; CYACO; HADDAM NECK, CT; WELLBORE: BH-121A.

Project and Borehole Name	CYAPCO: BH-121A
AWL Prior to Pumping (ftbgs)	17.35
Diameter of Borehole (ft)	0.51
Observed Drawdown (ft)	37.33
Effective Radius (ft)	100

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Thickness of Interval (ft)	Ambient Flow[1] (gpm)	Darcy Velocity in Aquifer[2] (Specific Discharge) (ft/day)	Interval Specific Flow Rate During Pumping (gpm)	Delta Flow[3] (gpm)	Delta Flow (ft^3/min.)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft^2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)	Sample Depth (feet)	HNP Onsite Lab Result (pCi/L)	Interval Specific Pore Water Concentration of Tritium (pCi/L)
1	160.4	160.5	0.1	0.000	NA	0.180	0.180	0.02406	8.83E+00	8.83E-01	194	144	6250	ND
2	165.9	166.8	0.9	0.012	2.02	6.26	6.248	0.83529	3.41E+01	3.07E+01	194	163	7230	7322
2	177.6	177.7	0.1	0.0000	NA	0.090	0.090	0.01203	4.42E+00	4.42E-01	194	173	4460	8645
3	278.0	278.8	0.8	0.0008	0.15	0.029	0.028	0.00377	1.73E-01	1.38E-01	203	278.5	<1260	<1260
4	308.4	309.0	0.6	0.000	NA	0.032	0.032	0.00428	2.62E-01	1.57E-01	221	309	<1270	<1270
5	326.1	328.5	2.4	0.000	NA	0.037	0.037	0.00495	7.56E-02	1.82E-01	188	326.3	<1250	NS
6	446.8	449.1	2.3	0.000	NA	0.001	0.001	0.00013	2.13E-03	4.91E-03	238	NS	NS	NS
7	454.2	456.4	2.2	0.000	NA	0.001	0.001	0.00013	2.23E-03	4.91E-03	256	NS	NS	NS
8	460.7	465.1	4.4	0.0004	0.01	0.008	0.008	0.00102	8.47E-03	3.73E-02	256	463.7	<1270	<1270
9	467.9	469.5	1.6	0.000	NA	0.003	0.003	0.00040	9.20E-03	1.47E-02	257	NS	NS	NS
10	483.1	483.2	0.1	0.000	NA	0.003	0.003	0.00040	1.47E-01	1.47E-02	269	NS	NS	NS
11	491.7	491.8	0.1	0.000	NA	0.002	0.002	0.00027	9.81E-02	9.81E-03	274	NS	NS	NS
12	506.0	506.1	0.1	0.000	NA	0.0009	0.001	0.00012	4.42E-02	4.42E-03	285	NS	NS	NS
13	515.1	515.2	0.1	0.000	NA	0.0008	0.001	0.00011	3.93E-02	3.93E-03	291	NS	NS	NS

[1] All ambient flow identified for this borehole is horizontal ambient flow.

[2] Darcy Velocity is calculated using the observed volumetric flow rate, the cross-sectional area of the flow interval in the borehole and a borehole convergence factor of 2.5 (Drost, 1968). The Darcy Velocity is only applicable to ambient horizontal flow.

[3] Delta Flow is the difference between Interval-Specific Flow Rate (during pumping) and Ambient Flow Rate.

[4] Hydraulic conductivity and transmissivity estimates are based on single well drawdown data, a porus-medium equivilent model and Hvorslev's 1951 porosity equatio

AWL = Ambient water Level
NA = Not Applicable
ND = No Detect/Below Detection Limit for that Sample
NS = Not Sampled

APPENDIX A

STANDARD OPERATING PROCEDURES
FOR
HYDROPHYSICAL LOGGING

Standard Operating Procedures
HydroPhysical™ Logging for Aquifer Characterization

By

COLOG Division of Layne Christensen Co.

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1. Purpose

Application of the HydroPhysical™ (HpL™) logging method to analyze and determine:

- The location of hydraulically conductive intervals within a wellbore
- The interval specific rate of inflow during well production, in conjunction with the drawdown data, can be used to estimate interval specific hydraulic conductivity or transmissivity
- Ambient (non-pumping) flow conditions (inflow and outflow rates, and locations)
- The hydrochemistry (fluid electrical conductivity (FEC) and temperature) of the associated formation waters

In addition, when downhole, discrete point fluid sampling is coupled with the HydroPhysical™ Logging technique, analysis of the actual contaminant concentrations associated with each identified conductive interval is accomplished for any aqueous phase contaminant.

2. Equipment and Materials

This SOP specifically applies to application of the technique using COLOG's HydroPhysical™ Logging Truck 16, which has been specially configured to handle those field conditions associated with small diameter, low-moderate yield wells The maximum capability of the van is to a total depth of 700 ft and 350 ft total drawdown (maximum depth to water) . In the event of high yield wells, the wireline capability of any COLOG truck can be used to accompany fluid management equipment.

- HydroPhysical™ logging truck field equipment includes:

- Fluid management system
  - Back Pressure Regulator or orifices
  - Rubber hose (0.75-inch i.d.) for injection
  - Submersible Pump
  - Evacuation Line
  - Storage tanks (as required) with inlet/outlet valves
  - Surface Pump
  - Fluid management manifold/Monitoring Panel
  - Data Acquisition System (for recording volumes, flow rates, time)
  - Wireline System
  - Wireline winch unit
  - Depth encoder

- Water level indicator
- Computer System
  - HydroPhysical™ Logging tool
  - Downhole Fluid Sampler
- Deionizing Units
- Deionized water (prepared with wellbore fluids or transported on-site)
- Standard Reference Solutions - Electrical conductivity reference solutions (set of 3 solutions).

3. Procedures

1.) Review well construction details and complete general well information sheet. The HydroPhysical™ logging technique involves dilution of the wellbore fluids with DI water and profiling of the wellbore dynamics using a HydroPhysical™ logging tool. Significant aberrations or reductions in the borehole diameter should be identified as the downhole equipment can become lodged in the borehole. Additionally, application of the technique requires certain wellbore conditions:

- In open bedrock boreholes, casing must be installed through the overburden and grouted at the rock/alluvium interface to inhibit water leakage into the borehole from the saturated alluvium. For cased boreholes, the well should be fully cased and gravel packed with single or multiple screened intervals;
- The diameter of the borehole must be approximately 4 inches or greater for application with the slim-tool (1.5-inch o.d.). Two inch i.d. boreholes may be tested using the slug test approach described in Section 5.
- For newly drilled wells, cuttings and drill fluids must be removed from the affected fractures by standard well development procedures.

2.) Review and record additional wellbore construction/site details and fill out the general well information form which includes the following information:

- Ambient depth-to-water
- Depth of casing
- Total depth of well
- Lithology (if available)
- Estimated well yield and any available drawdown data
- Type and concentration of contamination

3.) Prepare the deionized (DI) water. Consult with DI water tank firm for assistance if necessary. If DI water has not been transported to the site, surface or groundwater may be used if it is of suitable quality Generally source water containing less than 1000 micro Siemens per centimeter (µS/cm) and less then 200 ppb VOCs will not significantly affect the deionizing units, but this should be confirmed with DI water firm. If the groundwater from the well under construction cannot be used for DI water generation, then DI water must be transported to the site and containerized at the wellhead.

Depending on the amount of HydroPhysical™ testing to be performed (ambient and/or during production) the typical volume of DI water required for each borehole is approximately three times the volume of the standing column of formation water in the wellbore per type of HydroPhysical™ characterization.

If preparation takes place on site, pump the source water through a pre-filter, to the deionizing units, and into the storage tanks.

Monitor the FEC of the DI water in-line to verify homogeneity; the target value is 5 to 25 µS/cm.

4.) Calibrate the HydroPhysical™ logging tool using standard solutions prepared and certified by a qualified chemical supply manufacturer. Fill out tool calibration form following the steps defined in the software program, "tools" under the directory, calibration. Also use a separate field temperature / FEC / pH meter to support calibration data. Record the results of the tool calibrations, specifically noting any problems on the tool calibration form. Also record the certification number of the standard solutions.

5.) Set datum on the depth encoder with the FEC sensor on the tool as 0 depth at the top of casing. If inadequate space is available at the wellhead, measure 10 feet from the FEC sensor up the cable (using measuring tape) and reference with a wrap of electrical tape. Lower the tool down the hole to the point where the tape equals the elevation at the top of the casing and reference that as 10 feet depth on the depth encoder.

6.) Place the top of the tool approximately 3 feet below the free-water surface to allow it to achieve thermal equilibrium. Monitor the temperature output until thermal stabilization is observed at approximately $\pm$ .02 °C.

7.) After thermal stabilization of the logging tool is observed, log the ambient conditions of the wellbore (temperature and FEC). Fill out the water quality log form. During the logging run, the data are plotted in real time in log format on the computer screen and, the data string is simultaneously recorded on the hard drive.

Log the ambient fluid conditions in both directions (i.e. record down and up). The ideal logging speed is 5 feet per minute (fpm). For deeper wells the logging speed can be adjusted higher, but the fpm should not exceed 20.

At completion of the ambient log, place the tool approximately 10 feet below the free water surface. The tool will remain there during equipment set up as long as borehole conditions permit. Establish and record ambient depth to water using top of protective casing as datum.

8.) Attach back pressure regulator or orifice, if used, and weighted boot, to end of emplacement line and secure. Insure that the injection line is of adequate length to reach the bottom of the wellbore.

9.) Lower the flexible emplacement line to the bottom of the well allowing one foot of clearance from the well bottom to the outlet of the injection line.

10.) Lower tool about 10 feet below the water surface. The tool will be stationed beneath the submersible pump during non-logging times.

11.) Lower submersible pump in the well to a depth just above the logging tool. Record approximate depth of the pump location.

12.) Record all initial readings of gauges at elapsed time 0.0 minutes. Fill out well testing data form.

13.) Mark hoses with a round of electrical tape for reference. In addition, establish datum for tool depth to the nearest foot and mark on wire with wrap of tape. Reset datum on optical encoder for this depth.

14.) When ambient flow characterization is to be conducted, it should be done now, before disturbing the aquifer (i.e. by pumping). Fill out ambient flow characterization (AFC) form. Skip to Section 17 for procedures.

15.) After AFC, if performed, conduct a controlled, short term well production test (pump test) to characterize the overall hydraulics of the wellbore (drawdown at given pumping rate provides total well transmissivity or yield) and to make an initial assessment of formation water hydrochemistry. Begin pumping at a total extraction flow rate appropriate for wellbore under investigation (see Section 4 Special Notes). During this period, record elapsed time of pumping, depth to water, total gallons extracted, and extraction flow rate at approximately one minute intervals.

During extraction, log the fluid column continuously until at least three wellbore volumes have been extracted from the wellbore, or a stabilized water level elevation is obtained.

Review fluid logging results to verify that true formation water is present within the affected borehole interval and that the vertical distribution of water quality parameters within this interval is stable.

16.) Review data obtained during the pumping test to determine DI water emplacement and pumping/logging procedures. Extraction procedures for detection and characterization of hydraulically conductive intervals and the formation water hydrochemistry are determined based on the pumping test information. The emplacement, testing and pumping procedures will differ depending upon well yield and determined lengths of intervals of interest. In wellbore situations where intervals of interest are small (less than 30 feet) and hydraulic characteristics observed during borehole advancement and preliminary hydraulic testing indicate hydraulically conductive intervals with extremely low flow rates (i.e. <0.10 gpm/foot of drawdown), a slug testing procedure can be employed. In wellbore cases where the preliminary

hydraulic testing indicates low to moderate total yield (i.e. $0.10 < Q < 4$ gpm/foot of drawdown), constant low flow rate pumping after DI water emplacement procedures can be employed. In wellbore situations where intervals of interest are large, and high total yield (i.e. > 4 gpm/foot of drawdown) is observed, constant pumping during DI water injection procedures will be employed.

17.) When the fluid column is to be replaced with DI water, (vertical flow characterization, slug testing, logging during pumping after DI water emplacement) the following emplacement procedures apply:

Pump the DI water to the bottom of the wellbore using the surface pump and the injection riser. Simultaneously use the submersible pump to maintain a stable, elevated total head by extracting groundwater from near the free-water surface. When groundwater from the subject well is used for DI water generation, generate DI water from the extracted formation water and re-circulated to the well bottom via the solid riser.

Use the water level meter to observe the elevated total head during emplacement. If borehole conditions permit (i.e. the absence of constricted borehole intervals), the logging tool is used to monitor the advancement of the fluid up the borehole as it displaces the standing formation water. Draw the logging tool up the wellbore in successive increments as the DI water is emplaced. Monitor the electrical conductivity of the fluid expelled from the evacuation pump during emplacement procedures. When FEC values are representative of the DI water, or sufficiently diluted formation water, terminate emplacement procedures.

Emplacement is complete when DI water, or sufficiently diluted formation water, is observed from the evacuation pump or when logging tool stationed near the pump indicates DI water or sufficiently diluted formation water.

Upon completion, turn off the evacuation pump. Then turn off the injection line.

18.) Record volumes of extracted and injected fluids on the well testing data form. Calculate the volume of DI water lost to the formation.

19.) Take initial background HydroPhysical™ log, or begin continuous logging depending upon extraction method (i.e. slug vs. continuous).

20.) Pumping and testing procedures vary depending upon wellbore hydraulics and construction detail.

21.) Continuous logging is conducted until stabilized and consistent diluted FEC logs are observed. If inflow characterization at a second pumping rate is desired, increase extraction rate and assure the proper DI water injection rate. Perform continuous logging until stabilized and consistent FEC logs are observed and all diluted formation water is re-saturated with formation water.

22.) After stabilized and consistent FEC traces are observed, terminate DI water injection. Reduce the total extraction flow rate to the net formation rate and conduct continuous logging. Conduct logging until stable and consistent FEC values are observed.

23.) Conduct depth specific sampling at this time.

24.) At the conclusion of the above procedures, assess the wellbore fluid conditions and compare them with those observed during the original pumping (Step 14).

25.) Turn all pumps off. First remove the extraction pump from the borehole. During removal, thoroughly clean the evacuation line (2-inch o.d.) with a brush and alconox and rinse DI water. Also clean the outside of the pump. Place the pump in a drum of DI water and flush DI water through the system.

Remove the tool. Clean the wireline for the tool in a similar manner during its withdrawal from the borehole.

Remove the injection line from the well. Follow the same procedures when cleaning the injection line as for the evacuation line.

Store the pumps and logging tools properly for transport.

Place cover on well and lock (if available).

4. Special Notes

On-site pre-treatment of groundwater using activated carbon, can be conducted prior to DI water generation, if there is a contaminated groundwater source. In addition, on-site treatment can also be considered to handle extracted fluids that would require containerization and treatment prior to disposal.

The rate(s) of pumping are determined by drawdown information previously obtained or at rate(s) appropriate for the wellbore diameter and saturated interval thickness. The appropriate extraction rate is a function of length of saturated interval, borehole diameter, and previous well yield knowledge. The appropriate pumping procedures to be employed are also dictated by the length of the exposed rock interval. In general, the extraction flow rate should be sufficient to induce adequate inflow from the producing intervals. The concern is that the extraction flow rate does not cause extreme drawdown within the well i.e. lowering the free water surface to within the interval of investigation.

5. Discussion

LOW YIELD: Extraction Slug Test After DI water Emplacement

In wells with very low total flow capability (i.e. < 0.10 gpm/foot of drawdown), perform a slug test in accordance with procedures developed by Hvorslev (1951). Rapidly extract a small volume of water from near the free water surface using the extraction riser and pump. A drop in piezometric head of about 2 feet should be adequate for the initial test. Record the rise in the free water surface with time and develop a conventional time-lag plot.

When the free water surface has recovered to a satisfactory elevation, log the wellbore fluid conditions. Repeat the procedures described above with successive increases in the drop of piezometric head (or volume extracted). Let the wellbore recover and record the rise in the free water surface. Repeat logging of the wellbore fluid after the free water surface has recovered to a satisfactory elevation. The number of slug tests performed is determined in the field after review of previous logging results.

MODERATE YIELD: Time Series HydroPhysical™ Logging During Continuous Pumping After DI water Emplacement

In the case of moderate yield wells (i.e. 0.10 < Y < 4 gpm/foot of drawdown), maintain a constant flow rate from the evacuation pump and record the total volume of groundwater evacuated from the wellbore. Employ a continuous reading pressure transducer (or equivalent device) to monitor the depressed total head during pumping, along with the associated pumping rate.

Hold the flow rate from the evacuation pump constant at a rate determined for the specific borehole. Drawdown of the free water surface produced during pumping should not overlap any identified water producing interval. Conduct hydrophysical logging continuously. The time interval is a function of flow rate and is specific to each well. The number of logging runs and the length of time required to conduct all loggings is a function of the particular hydraulic conditions. Logging and pumping is continued until the fluid column is re-saturated with formation water (i.e. all DI water is removed from the borehole).

HIGH YIELD: Time Series Wellbore Fluid Logging During Continuous Pumping and Simultaneous DI Water Injection

When wells exhibit high yield (> 4 gpm/foot of drawdown), as determined by a review of the interval of interest, the borehole diameter and the results obtained from previous information and preliminary hydraulic testing, the appropriateness of time series fluid logging during continuous pumping and simultaneous DI water injection is determined.

In this case, maintain a constant flow rate from the evacuation pump and record this rate and the associated drawdown. During this period, conduct hydrophysical logging until reasonably similar HydroPhysical™ logs are observed and stabilized drawdown is achieved. After reasonably similar downhole fluid conditions are observed and simultaneous with extraction pumping, inject DI water at the bottom of the well at a constant rate of 10 to 20% of that employed for extraction. Increase the total rate of

extraction to maintain total formation production reasonably similar to that prior to DI water injection (i.e. increase the total extraction by amount equal to the DI water injection rate).

Periodically record the total volume and flow rate of well fluids evacuated and the total volume and flow rate of DI water injected. Use a continuous reading pressure transducer or similar device to monitor the depressed total head during pumping. Record the depressed total head (piezometric surface) periodically, with the associated pumping and injection data.

The evacuation and DI water injection flow rates are held constant at a rate determined for the specific wellbore. Drawdown of the free water surface during pumping must not overlap any identified water producing intervals. HydroPhysical™ Logging is conducted continuously. The number of logging runs and the length of time required to conduct all loggings is a function of the particular hydraulic conditions exhibited by the well under investigation.

APPENDIX B

BORE II MODELING SOFTWARE

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BORE II – A Code to Compute Dynamic Wellbore Electrical Conductivity Logs with Multiple Inflow/Outflow Points Including the Effects of Horizontal Flow across the Well

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Abstract

Dynamic wellbore electrical conductivity logs provide a valuable means to determine the flow characteristics of fractures intersecting a wellbore, in order to study the hydrologic behavior of fractured rocks. To expedite the analysis of log data, a computer program called BORE II has been developed that considers multiple inflow or outflow points along the wellbore, including the case of horizontal flow across the wellbore. BORE II calculates the evolution of fluid electrical conductivity (FEC) profiles in a wellbore or wellbore section, which may be pumped at a low rate, and compares model results to log data in a variety of ways. FEC variations may arise from inflow under natural-state conditions or due to tracer injected in a neighboring well (interference tests). BORE II has an interactive, graphical user interface and runs on a personal computer under the Windows operating system. BORE II is a modification and extension of an older code called BORE, which considered inflow points only and did not provide an interactive comparison to field data. In this report, we describe BORE II capabilities, provide a detailed user's guide, and show a series of example applications.

1. Introduction

The variation of formation permeability surrounding a wellbore is useful information not only for identifying hydraulically conducting fractures or other high-conductivity features intercepted by the well, but also for quantifying the heterogeneity of the medium. These are essential data in the evaluation of in-situ flow and transport characteristics at a given site.

Methods to evaluate permeability values along the depth of a well include the packer method, in which constant pressure, constant flow, or pulse tests are conducted in packed-off intervals in a wellbore, and various downhole flow meters. The packer method has the disadvantage that it is very time consuming and costly, and the vertical resolution is limited by the interval between the two packers that can be set in the well. Flow meter methods such as spinners and heat pulse flow meters generally allow better vertical resolution than the packer method, but they are not as accurate in determining permeability, because they mostly measure the wellbore fluid velocity, which is very sensitive to variations in the wellbore radius.

In 1990, Tsang et al. (1990) proposed a method using logs of fluid electric conductivity (FEC) at successive times under constant-pumping conditions to obtain inflow from the formation into the well as a function of depth in the well. In this method, the wellbore is first filled by de-ionized water or water of a constant salinity (i.e., ion concentration) distinct from that of the formation water. This is usually done by passing the de-ionized water down a tube to the bottom of the wellbore at a given rate while simultaneously pumping at the top of the well at the same rate. After this is done, the well is pumped at a constant flow rate, which can be adjusted to optimize wellbore flow conditions. An electric resistivity probe is lowered into the wellbore to scan FEC as a function of depth along the wellbore. This is what is called fluid conductivity logging. A series of five or six such logs are obtained at time intervals over a one- or two-day period. At the depth levels where water enters the wellbore, the conductivity log displays peaks, which grow with time and become skewed in the direction of water flow. By analyzing these logs, it is possible to obtain the permeability and salinity of each hydrologic layer transmitting water. The method has been very successful, being much more accurate than flow meters and much more efficient (much cheaper) than packer tests (Tsang et al. 1990), particularly in low permeability formations. A typical 1000-m section in a deep hole can be tested in two or three days at a spatial resolution of ~0.10 m all along the length of the wellbore

section. The method is now being widely used in Europe and the U.S. (Marschall and Vomvoris, 1995; Pedler et al., 1992; Bauer and LoCoco, 1996), both under natural-state flow conditions and while tracer is injected in a neighboring well (i.e., interference tests).

Along with the method, a code was developed called BORE (Hale and Tsang, 1988), which performed the forward calculation to produce wellbore FEC profiles given different inflow positions, rates, and concentrations. The code has been well used over the last decade. However, it appears now that there is a need to revise the code to make it more suitable for current computer environments and to add new capabilities. Thus, the code has been updated to run under current operating systems, provide interactive modification of model parameters, and produce graphical comparisons between model and field data. More importantly, the revised code allows the possible inclusion of both flows into and out of the well at various depths, a feature that has been observed in real field conditions when different layers penetrated by the well have different hydraulic heads. Furthermore, the new code allows the calculation of the case with equal inflow and outflow at the same depth level, which is effectively the special case of horizontal flow across the wellbore. Drost (1968) proposed a measurement of solute dilution in the wellbore to evaluate ambient horizontal flow velocity in the formation and it has become a well-accepted method. The new code provides the opportunity to analyze such cases and to identify the depth interval of horizontal flow to within ~0.1 m as well as to estimate the flow rate. Moreover, one can analyze the combination of horizontal flow across the wellbore and vertical diffusion or dispersion along the length of the wellbore, which is not possible with Drost's solution.

The report is organized as follows. In Section 2, the basic capabilities of the revised code, called BORE II, are described, and the key parameters associated with BORE II are defined. Details of the mathematical background and numerical approach are described in Appendix 1, which is adapted from Hale and Tsang (1988). A user's guide is presented in Section 3, which includes a description of BORE II's interactive user interface, required input items, and options available when running BORE II. Four example applications are given in Section 4 to conclude the report.

We are still open to further improvements of BORE II; any suggestions and comments are invited and should be addressed to the authors.

2. BORE II Capabilities

BORE II calculates FEC as a function of space and time in a wellbore containing multiple feed points given the pumping rate of the well, the inflow or outflow rate of each feed point, its location and starting time, and, for inflow points, its ion concentration. A simple polynomial correlation between ion concentration, C, and FEC is assumed. Ion transport occurs by advection and diffusion along the wellbore, with instantaneous mixing of feed-point fluid throughout the wellbore cross-section. These assumptions allow use of a one-dimensional model. BORE II divides the wellbore section under study into equal height cells and solves the advection/diffusion equation using the finite difference method. Further details of the mathematical and numerical approach are given in Appendix 1.

Inflow and Outflow Feed Points

The original BORE code (Hale and Tsang, 1988) considered inflow points only, so flow through the wellbore was upward at all depths. BORE II allows both inflow and outflow points, so flow in the wellbore can be upward, downward, or horizontal at different depths and flow at either end of the wellbore section being studied can be into or out of the wellbore section or be zero. By convention, upward flow in the wellbore is positive and flow into the wellbore is positive.

Steady and Varying Fluid Flow

The original BORE code considered steady fluid flow, so feed points had constant flow rates. They also had constant concentrations, but delayed starting times for feed-point concentration to enter the wellbore were allowed. BORE II permits both steady and varying fluid flow. For the steady-flow case, the user specifies flow rate, concentration, and concentration start time for each feed point, but for outflow points (those with negative flow rates) the concentration and concentration start time are not used. Variable flow rate or concentration can be specified for feed points by interpolating from a table of time, flow rate, and concentration. If a table includes both positive and negative flow rates (i.e., a feed point alternates between inflow and outflow), the concentration for the positive flow rate is used when interpolating between positive and negative flow rates.

Concentration Boundary Conditions

If the flow at the top of the wellbore section under study is into the wellbore, the initial concentration for the uppermost cell in the wellbore is used as the inflow concentration. Analogously, if flow at the bottom of the wellbore section is a flow up from greater depths, the initial concentration for the lowermost cell in the wellbore is used as the inflow concentration. Furthermore, for inflow points with a concentration start time greater than zero, the initial concentration of the wellbore is used as the inflow concentration for times less than concentration start time.

Horizontal Flow

The special case of horizontal flow through the wellbore, as described by Drost (1968), can also be considered, by locating an inflow point and an outflow point with equal magnitude flow rates at the same depth. The flow rates may be specified as either (1) the Darcy velocity through the aquifer or (2) the volumetric flow rate into/out of the wellbore. BORE II multiplies Darcy velocity by the cross-sectional area of the feed point (wellbore diameter times cell height) and Drost's α_h convergence factor to convert it to a volumetric flow rate. The value of α_h can range from 1 (no convergence) to 4 (maximum possible convergence, which occurs for the case of a thick, highly-permeable well screen). Drost suggested that for a uniform aquifer with no well screen, $\alpha_h = 2$, and that for typical applications, a good choice for α_h is 2.5. Horizontal flow feed points may have time-varying flow rates, but for Darcy-velocity calculations to make sense, the inflow and outflow rates must be equal and opposite at any time. Thus, if a feed point location changes from a horizontal flow point to a non-horizontal flow point with time, volumetric flow rates must be specified rather than Darcy velocities.

BORE II Parameters

The key parameters associated with BORE II are defined below.

Parameter	I/O units*	Description
C	g/L	Ion concentration in the wellbore; converted to FEC using FEC = $\gamma + \beta C + \alpha C^2$, where α, β, and γ are user-specified constants (default values are provided in the code, see Section 3)
C_i	g/L	Ion concentration of ith feed point
C_0	g/L	Initial ion concentration in wellbore
D_0	m^2/s	Diffusion coefficient (may include dispersive effects as well molecular diffusion)
d_w	cm	Wellbore diameter (assumed constant)
FEC	µS/cm	Fluid electrical conductivity
q	L/min	Fluid flow rate in wellbore (upward flow is positive)
q_i	L/min	Fluid flow rate of ith feed point; positive for inflow and negative for outflow
q_w	L/min	Fluid flow rate in wellbore at x_{max}, specified by the user
q_0	L/min	Fluid flow rate in wellbore at x_{min} (or any depth of interest), calculated internally
T or TEMP	°C	Temperature (assumed constant)
t	hr	Time
t_{max}	hr	Maximum simulation time
t_{0i}	hr	Concentration start time of ith feed point
v_d	m/day	Darcy velocity through aquifer for horizontal flow ($q_i = v_d \alpha_h \Delta x d_w$)
x	m	Depth (positive, increases down the wellbore)
x_{min}, x_{max}	m	Top and bottom, respectively, of wellbore interval being studied
Δx	m	Cell height for wellbore discretization
α_h	–	Drost (1968) convergence factor for horizontal flow

*I/O units are chosen for convenience; all quantities are converted to SI units before BORE II calculations.

3. BORE II User's Guide

Operating System

BORE II may be run under Windows 95, 98, or 2000 by double-clicking the executable icon (BOREII.EXE) in Windows Explorer, by double-clicking on a desktop shortcut key to BOREII.EXE, or by typing BOREII in the Run command in the Start Menu or in a DOS-prompt window. BORE II will not run in stand-alone DOS or in the DOS-mode of Windows. BORE II was compiled using Microsoft Fortran PowerStation™ Version 4.0, but this software is not necessary to run the program.

BORE II Graphical Output

The primary user interface with BORE II is interactive, with the user responding to on-screen prompts to modify model parameters and choose options (described below) for the real-time graphical display of model results and data. The basic BORE II output screen consists of three windows.

- The borehole profile window shows FEC profiles as a function of depth and time. Simulation time t is shown in the upper left corner. Fluid flow rate at a user-specified depth in the wellbore, q_0, is shown in the middle of the top line (the depth at which q_0 is calculated is set by option P). The depth of a C-t plot is also shown.

- The inflow parameters window shows the feed-point characteristics for the model that can be modified with option M (location, flow rate, and concentration). Often there are more feed points than can be displayed at once on the screen. BORE II starts out showing the first few (deepest) feed points, then shows the feed points in the neighborhood of any point that is being modified.

- The dialog window allows the user to select options (described below) when running BORE II.

On computers with small screens, it may be desirable to run BORE II in full-screen mode, so that the entire BORE II screen can be seen at once without scrolling. Full-screen mode is entered by pressing Alt-VF (or on some computers by pressing Alt-Enter). Pressing Esc (or

Alt-Enter) terminates full-screen mode. There are three potential problems associated with the use of full-screen mode.

(1) The status line describing what BORE II is doing (e.g., running, waiting for input) is not visible.

(2) Drawing an *x-t* plot (options X, S, D, F, and I), which creates a new window, may be very slow and the graphics quality poor.

(3) On some computers, text is difficult to read after closing the *x-t* plot window.

To address the latter two problems, one may terminate full-screen mode before using options X, S, D, F, and I. The new window will be small, but after drawing is complete it may be expanded by pressing Alt-VF to enter full-screen mode. Full-screen mode should be terminated before the new window is closed to avoid the final problem.

To print an image of the screen, press Alt-PrintScreen to copy the screen image into the clipboard. Then open a program such as Microsoft Paint and paste in the image. It can be manipulated, saved in a variety of graphics formats, or printed from Paint. The image can also be pasted directly into another Windows application such as MS Word.

Input/Output File Overview

Running BORE II requires one or two external files: a file with an initial set of model input parameters (mandatory, known as the input file) and a file with observed data (optional, known as the data file). These files are plain ASCII text, and must reside in the same folder as the BORE II executable. The input file contains model parameters such as the depth interval being studied, feed point characteristics, problem simulation time, and *C*-to-FEC conversion factors. The data file contains observed values of FEC and temperature, and optionally contains other fluid properties such as pH. Detailed instructions for preparing an input file and a data file are given below.

BORE II always creates a temporary file, called BOREII.TMP (see options C and R), and optionally creates a new input file (see option V), which is useful if model parameters have been changed during the BORE II run.

Line-by-line Instructions for Input File

After starting BORE II, the user is prompted to choose the input file from the list of files residing in the folder where the BORE II executable is. Input file names with more than 8 characters before a period or blanks will appear in the list of files in an abbreviated form. File names can be at most 20 characters long.

A sample input file is provided that can be modified as needed using a text editor such as Notepad or a word processor such as MS Word. If a word processor is used to create or modify an input file, be sure that the file is saved as plain ASCII text.

The input file is designed to be self-documenting, with header lines preceding data lines. These header lines must be present, but BORE II does not use the text on them. Data entries are read in free format, with individual entries on a given line separated by blanks, tabs, or commas. This means that entries cannot be left blank, even if they are not being used (e.g., concentration for an outflow point). Unused entries may be set to zero or any convenient value. Comments may be added on data lines, after the requisite number of entries. In the sample input file, comments begin with an exclamation point.

Item	Computer Variables	Unit	Description
1.	TITLE	–	A description of the problem, 80 characters maximum
2 header for wellbore geometry			
2.	RXMIN	m	Top of study area, x_{min}
	RXMAX	m	Bottom of study area, x_{max}
	RDIAM	cm	Wellbore diameter, d_w
3 header for flow parameters			
3.	RQW	L/min	Flow into (positive) or out of (negative) the bottom of the study area, q_w
	HALPHA	–	Factor to account for convergence of horizontal flow lines toward the wellbore, α_h (Drost, 1968) Range: 1.0 – 4.0; default value: 2.5 Only used for horizontal flow

4 header for feed points			
4.	IINFN	–	Number of feed points (maximum 180)
	IQFLAG	–	Variable flow-rate flag – a 3 digit integer used to identify feed points with variable flow (suggested value 999)
5 header for constant-flow-rate feed points			
5. Repeat IINFN times	RINFX	m	Location of feed point, x_i * For horizontal flow put two feed points at the same location, with equal magnitude, opposite sign flow rates
	RINFQ	L/min (m/day if IINFV=1)	Constant inflow rate (positive) or outflow rate (negative) of feed point, q_i For a variable flow rate, set RINFQ = IIIJJ, where III = IQFLAG, and JJ is a two digit integer giving the number of times in the variable-flow-rate table, which follows in 5a For horizontal flow, v_d replaces q_i if IINFV = 1
	RINFC	g/L	Constant feed point concentration, C_i - only used for inflow points For a variable concentration, set RINFQ = IIIJJ, where III = IQFLAG, and JJ is a two digit integer giving the number of times in the variable-flow-rate table, which follows in 5a
	RINFT	hr	Start time for constant feed point concentration, t_{0i} - only used for inflow points Feed point concentration is C_0 of cell containing feed point for $t < t_{0i}$
	IINFV	–	Horizontal flow Darcy-velocity flag (must be zero for non-horizontal flow case): = 0: RINFQ is flow rate q_i into/out of the wellbore in L/min = 1: RINFQ is +/–Darcy velocity v_d through the aquifer in m/day

5a header for variable-flow-rate table (only when RINFQ = IQFLAGJJ)			
5a. Repeat JJ times when RINFQ = IQFLAGJJ	RINFQT	hr	Time t_j (set $t_1 = 0$, set $t_{JJ} > t_{max}$)
	RINFQQ	L/min (m/day if IINFV=1)	Volumetric flow rate q_j at time t_j For horizontal flow, v_d replaces q_j if IINFV = 1
	RINFCC	g/L	Concentration C_j at t_j
6 header for misc. parameters			
6.	TMAX	hr	Maximum simulation time, t_{max}
	DPYMAX	µS/cm	Maximum FEC for plots
	RK	m^2/s	Diffusion coefficient, D_0
7 header for C-to-FEC conversion			
7.	RGAMMA	µS/cm	Conversion from C in g/L to FEC in µS/cm: $FEC = \gamma + \beta C + \alpha C^2$ Default values (for 20°C): $\gamma = 0$, $\beta = 1870$, $\alpha = -40$ Set $\gamma = 0$, $\beta = 1$, $\alpha \approx$ 1.e-8 for $FEC \approx C$
	RBETA	[µS/cm]/[g/L]	
	RALPHA	[µS/cm]/$[g/L]^2$	
8 header for initial conditions			
8.	IC0FLAG	–	Initial concentration flag: = 0: $C_0 = 0$, no further input for item 8 < 0: read uniform non-zero C_0 in 8a > 0: read IC0FLAG $(x, C_0(x))$ pairs in 8b to describe variable initial concentration
8a header for uniform initial conditions (only when IC0FLAG < 0)			
8a. when IC0FLAG<0	RC0	g/L	Uniform non-zero C_0
8b header for non-uniform initial conditions (only when IC0FLAG > 0)			
8b. repeat IC0FLAG times when IC0FLAG>0	RX	m	x value*
	RC0	g/L	$C_0(x)$
9 header for data file name			
9.	CFDATA	–	Name of data file, 20 characters maximum; 'NONE' if there is no data file

*see Appendix 1, Section A1.5, for additional information on locating feed points and specifying non-uniform initial conditions

Sample Input File

An input file illustrating many of these options is shown below. Text or numbers following an exclamation point (!) are comments, and are not used by BORE II.

```
TITLE: Sample Input File with flow from below, horizontal flow, variable flow
XMIN(m)      XMAX(m)      DIAM(cm)
.0000        60.00        7.600
QW(L/min)    HALPHA       !QW=flow from below; HALPHA=hor. flow constriction
 0.50        0.           !default value of HALPHA will be used
#FEED_PTS    VARIABLE_FLOWRATE_IDENTIFIER
   4              999
DEPTH(m)     Q (L/min)    C(g/L)       T0(hr)       Q/V_FLAG
 25.         +1.          6.0          .0000        1 !1st 2 feed pts-hor. flow
 25.         -1.          6.0          .0000        1 !C & T0 not used (outflow)
 30.         99905.       6.0          .0000        0 !C & T0 not used (table)
     T(hr)        Q(L/min)     C(g/L)       !#entries is two digits after  999 .
      .0000        .0000        6.          !first time in table is zero
      .3000        .2800E-01    5.
      .5000        .3200        4.
      1.000        .4600        3.
      1.500        .4600        2.          !last time in table is > tmax
 35.         .5           4.0          .2000        0 !final feed pt
TMAX(hr)     FECMAX       DIFFUSION_COEF.(m2/s)
 1.000       5000.        .7500E-09
RGAMMA       RBETA        RALPHA       !FEC = RGAMMA + C*RBETA + C*C*RALPHA
0.           0.           0.           !default values will be used
ICOFLAG      !If 0, C0=0; If <0, read one C0; If >0,read ICOFLAG (X,C0) pairs
    1
X(m)         C0(g/L)              !#entries is ICOFLAG
60.          2.                   !Concentration associated with Qw
DATA_FILE    !'NONE' if there is no data file
NONE
```

The first two feed points represent constant horizontal flow, and since the Q/V flag (IINFV) is one, flow rate is given as Darcy velocity through the aquifer in m/day. The third feed point has variable flow rate and concentration, with a five-entry table specifying the variation with time. The fourth feed point is an inflow point with constant flow rate and concentration and a non-zero concentration start time.

Note that the flow from below, q_w, is positive (into the wellbore section), so the corresponding concentration is specified as the initial condition of the lowermost cell in the wellbore (at $x = x_{min}$) by using ICOFLAG = 1. If ICOFLAG = 0, the concentration associated with q_w would be zero, and if ICOFLAG = -1, the concentration associated with q_w would be the uniform non-zero initial concentration in the wellbore.

When BORE II writes an input file (option V), it changes several things to the file form shown above. Comments found in the original input file are not reproduced, but two comments are added. First, the cell height and the equation used to calculate it are shown on the line with x_{min}, x_{max}, and d_w. Second, if feed points represent horizontal flow, then the flag IINVF is set to 0, flow rate is given in L/min, and the corresponding Darcy velocity through the aquifer in m/day is added as a comment. Finally, if IC0FLAG > 0, BORE II sets IC0FLAG to the number of wellbore cells, and explicitly shows every $(x, C_0(x))$ pair. This option is useful for identifying the x values of various cells, which may expedite assignment of feed point locations or initial conditions. Part of the input file created by BORE II for the above sample is shown below.

```
TITLE: Sample Input File with flow from below, horizontal flow, variable flow
XMIN(m)      XMAX(m)      DIAM(cm)     !DX(m) = MAX(|XMIN - XMAX|/180, DIAM/100)
 .0000        60.00        7.600       ! .3333
QW(L/min)    HALPHA       !QW=flow from below; HALPHA=hor. flow constriction
 .5000        2.500
#FEED_PTS    VARIABLE_FLOWRATE_IDENTIFIER
    4              999
DEPTH(m)     Q(L/min)     C(g/L)       T0(hr)       Q/V_FLAG     !Vd(m/day)
 35.00        .5000        4.000        .2000         0
 30.00       99905.        6.000        .0000         0
     T(hr)        Q(L/min)     C(g/L)       !#entries is two digits after  999
      .0000        .0000        6.000
      .3000        .2800E-01    5.000
      .5000        .3200        4.000
      1.000        .4600        3.000
      1.500        .4600        2.000
 25.00        .4398E-01    6.000        .0000         0          ! 1.000
 25.00       -.4398E-01    6.000        .0000         0          !-1.000
TMAX(hr)     FECMAX       DIFFUSION_COEF.(m2/s)
 1.000        5000.        .7500E-09
RGAMMA       RBETA        RALPHA       !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000        1870.       -40.00
IC0FLAG      !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0) pairs
  179
X(m)         C0(g/L)              !#entries is IC0FLAG
 59.83        2.000
 59.50        .0000
 59.17        .0000
 58.83        .0000
…(169 entries with C0=0 not shown)…
 2.167        .0000
 1.833        .0000
 1.500        .0000
 1.167        .0000
 .8333        .0000
 .5000        .0000
DATA_FILE    !'NONE' if there is no data file
NONE
```

Line by Line Instructions for Data File

The data file is read in the fixed format shown below. If data are available in a different format, an auxiliary program should be used to convert it to this form (a simple preprocessor called PREBORE, described in Appendix 2, converts the data file format used by BORE to the new format shown below). Note that because a fixed format is used, blank entries are allowed; they are interpreted as zero.

Lines 1-8 are header lines, not used by BORE II.

Each line of the remainder of the file contains:

Variable	x	FEC	TEMP	DAT3	DAT4	DAT5	HR	MIN	SEC
Units	m	μS/cm	°C				–	–	–
Format	F10.3	F10.3	F10.3	E10.3	E10.3	E10.3	I3	I2	I2
Columns	1-10	11-20	21-30	31-40	41-50	51-60	62-64	66-67	69-70

The entries DAT3, DAT4, and DAT5 represent optional data types that may be collected with certain logging tools, such as pH and dissolved oxygen (see options A and Y for ways to display this data). Note that there is one blank column before each of the HR, MIN, and SEC entries, to make the data file more readable. The first time entry corresponds to $t = 0$ for the model.

BORE II Options

The following options are available on the BORE II main menu. Either uppercase or lowercase letters may be used, and should be followed by pressing ENTER.

C – (C)-x plot – Displays FEC versus depth for data and/or model continuously in time (an animation); stores [x (m), t (sec), data FEC (μS/cm), model FEC (μS/cm)] in file BOREII.TMP for later use by option R or post-processing.

T – c-(T) plot – Displays FEC versus time for data and model for a chosen depth.

R – d/m cu(R)ve – Displays FEC versus depth plots for data and model at a series of times (snapshots of the option C display); uses results of most recent option C, read from BOREII.TMP. Does not work if there is no data file or if there are only data at one depth in data file.

N – i(N)flow-c – Displays inflow FEC for a chosen feed point as a function of time.

A – p(A)ram display – Displays all data profiles (FEC, TEMP, DAT3, DAT4, DAT5) simultaneously, using user-specified plot limits (selections 3-6). For selection 1, all points are connected on one continuous curve; for selection 2, points that are beyond depth or time limits start new curve segments.

X – (X)-t plot – Displays a color-coded plot of model FEC versus depth and time in a new window, then repeats the plot in the borehole profile window.

S – tool (S)tudy x-t plot – Same as X, but limits display to what would be obtained with a tool whose parameters (number of probes, gap between probes, and tool velocity) are specified by the user.

D – (D)ata x-t – Displays a color-coded plot of data traces versus depth and time in a new window, then repeats the plot in the borehole profile window (data type specified by option Y, default is FEC).

F – (F)ill data x-t – Same as D, except that data traces are interpolated to fill the *x-t* plane.

I – d/m d(I)ff x-t – Displays a color-coded plot of the difference between model and data FEC versus depth and time in a new window, then repeats the plot in the borehole profile window. User selects whether to show data traces (mode 1) or filled data (mode 2).

M – (M)odify inp– Opens interactive session for modifying location, flow rate, and concentration of feed points, or adding new feed points. User is prompted to enter feed point number and given the chance to modify or maintain current parameters. To add a new feed point, specify a feed point number greater than that for any existing feed point. If horizontal flow is implemented using option M, flow rate must be specified as volumetric flow rate through the wellbore in L/min.

P – (P)lot adjust – Sets new values of parameter minimum and maximum; t_{max}; difference range for option I; and depth for which wellbore flow rate q_0 is displayed in borehole profile window (default depth is x_{min}).

G – (G)rid – Sets grid spacing for new window showing *x-t* plots.

Y – data t(Y)pe – Chooses data type (FEC, TEMP, DAT3, DAT4, DAT5) to display in options C, T, D, and F. Model results always show FEC, so option C and T plots, which show both model and data, must be read carefully. Note that options R and I are not affected by the choice of data type, but always compare model and data FEC.

Z – print – Displays instructions for printing a screen image.

V – sa(V)e – Creates a new input file with current model parameters. User is prompted for new file name.

Q – (Q)uit – Terminates BORE II program.

4. Example Applications

Five example applications are presented to illustrate the capabilities of BORE II. Although BORE II simulates the forward problem (it produces wellbore FEC profiles given different inflow positions, rates, and concentrations), it is most commonly used in an inverse mode, in which inflow positions, rates and concentrations are varied by trial and error until the model matches observed values of wellbore FEC profiles. Initial guesses for the trial and error process may be obtained using direct integral methods (Tsang and Hale, 1989; Tsang et al., 1990) or other means (see example 2 below). Example applications 3, 4, and 5 demonstrate such comparisons to real data provided to us as typical field data sets by G. Bauer (private communication, 2000). The results of these example applications do not necessarily provide physically realistic flow rates and inflow concentrations, because they employ the artificial equality FEC = C. Furthermore, rough matches to real data, as are obtained here, can often be obtained equally well with a variety of different parameters (i.e., the solution of the inverse problem is non-unique). The input files for the example applications are shown in Appendix 3.

	Problem	Data File	Input File	Features
1	Up flow	up_num.dbt (numerically simulated)	up_num.inp	Advection and dilution, diffusion/dispersion minor
2	Horizontal flow	hor_an.dbt (analytical solution)	hor_an.inp	Dilution only, no advection or diffusion/dispersion One pair inflow/outflow points
3	Horizontal flow	hor_real.dbt (real data)	hor_real.inp	Dilution and diffusion/dispersion Multiple pairs inflow/outflow points Initial time added to data
4	Down flow	down_c.dbt (real data)	down_c.inp	Advection, dilution, and diffusion/dispersion Variable inflow concentration
5	Combination flow	comb_ic.dbt (real data)	comb_ic.inp	Advection, dilution, and diffusion/dispersion Non-uniform initial conditions

1. Up Flow – Numerically Simulated Data

Perhaps the most common application of BORE II is to the case of up flow - when one pumps from the top of the wellbore section, and fluid enters the wellbore at one or more feed points. Figure 1 shows C versus x for several times for a typical up flow case (obtained with BORE II option R). Each feed point has the same inflow rate and the same concentration, and there is also up flow from below. At early times, the feed points show up as individual FEC peaks, but as time passes, the deeper peaks merge with those above them, creating a step-like structure. The data set for this example is not real, but the results of a numerical simulation using the flow and transport simulator TOUGH2 (Pruess, 1987; 1991; 1995; 1998). TOUGH2 has been verified and validated against analytical solutions, other numerical models, and laboratory and field data. The TOUGH2 simulation uses a one-dimensional model with the same cell spacing as BORE II and constant mass sources located at the BORE II feed points. Thus, BORE II and TOUGH2 are solving the same problems, and comparing the results for wellbore FEC profiles verifies that the BORE II calculations are done correctly.

2. Horizontal Flow – Analytical Solution and Numerically Simulated Data

For horizontal flow in the absence of diffusion/dispersion along the wellbore, an analytical solution for the concentration observed in the wellbore as a function of time, $C(t)$, is given by (Drost, 1968):

$$C(t) = C_i - [C_i - C(0)]\exp\left(\frac{-2tv_d\alpha_h}{\pi r_w}\right), \qquad (1)$$

where C_i is the formation (inflow) concentration, t is time (s), v_d is the Darcy velocity through the aquifer (m/s), α_h is the aquifer-to-wellbore convergence factor, and r_w is the wellbore radius (m). Figure 2 shows the analytical solution and the BORE II results for this problem, obtained using option T. The agreement is excellent. Note that for small values of v_d, if C(0) = 0, the analytical solution becomes approximately

$$C(t) = C_i\left[1 - \exp\left(\frac{-2tv_d\alpha_h}{\pi r_w}\right)\right] \approx C_i\left[1 - \left(1 - \frac{2tv_d\alpha_h}{\pi r_w}\right)\right] = \frac{C_i 2tv_d\alpha_h}{\pi r_w}. \qquad (2)$$

Thus, any combination of C_i and v_d whose product is a constant gives the same value of C. This condition corresponds to the early-time straight-line portion of Figure 2. The analytical solution may be implemented in a spreadsheet to expedite the choice of BORE II parameters, by examining the solution for various values of v_d and C_i. Note that care must be taken to use a consistent set of units for t, v_d, and r_w in Equations (1) and (2). For example, when time is in seconds, BORE II input parameters v_d in m/day and r_w in cm must be converted to m/s and m, respectively.

Figure 2 also shows the evolution of concentration at and near a horizontal flow layer when diffusion/dispersion along the wellbore is significant ($D_0 = 10^{-5}$ m^2/s). For this case, the analytical solution is not applicable, but BORE II results compare very well to numerically simulated data obtained using TOUGH2. When dispersion is significant, use of the Drost solution generally results in an underestimation of C_i and an overestimation of v_d. These errors do not arise when using BORE II, since diffusion/dispersion can be explicitly included.

3. Horizontal Flow – Real Data

As indicated in Figure 2, the addition of diffusion or dispersion modifies the depth-FEC profile arising from a thin layer of horizontal flow, by widening the base of the FEC peak. A thick layer of horizontal flow produces a distinct signature, with an FEC response that has a wide peak as well as a wide base. To model a thick layer of horizontal flow, one may use several adjacent inflow/outflow point pairs in the model. Figure 3 compares model and data profiles (G. Bauer, private communication, 2000) of C versus x for several times, using option R. Seven pairs of inflow/outflow points are used, assigned to seven adjacent cells. By multiplying the number of inflow/outflow pairs by cell thickness, one may estimate the thickness of the layer of horizontal flow, in this case 2.3 m. See Appendix 1, Section A1.5, for additional information about assigning feed points to specific cells.

For this particular data set, the earliest observations show a variable FEC profile. One possible way to address this is to specify a non-uniform initial concentration distribution in the wellbore. An alternative approach (used here) is to add a dummy entry to the data file, specifying a time prior to the first real data time, at which the FCE distribution in the wellbore is assumed to be uniform. In general, it is not possible to determine when, if ever, the FEC distribution in the wellbore is uniform, but the approach can work quite well, as shown in Figure

4, which shows C versus t at the center of the horizontal flow zone (option T). The data zero time taken from the header of the data file, where the date and time of the logging run are specified.

4. Down Flow – Real Data

Figure 5 compares model and data profiles (G. Bauer, private communication, 2000) of C versus x for several times (option R) for a case with primarily down flow. A uniform non-zero initial concentration is used (IC0FLAG < 0) to approximate the low, slightly variable initial concentration. Two shallow inflow points have variable concentrations that increase in time, which suggests that de-ionized water penetrated into the fractures when it was introduced into the wellbore to establish low-concentration initial conditions for logging. A low-concentration feed point at $x = 158.5$ m creates up flow above it, but the remainder of the wellbore section shows down flow.

5. Combination Flow – Real Data

Figure 6 compares model and data profiles (G. Bauer, private communication, 2000) of C versus x for several times (option R) for a case with combination flow. A non-uniform initial condition has been used, which is extracted from the data file using the preprocessor PREBORE (see Appendix 2). Note that there are more entries in the initial condition specification (232) than there are cells in the model (179). Thus, some cells are assigned more than one initial condition. For cells where this occurs, only the final initial condition assigned is used. See Appendix 1, Section A1.5, for additional information on specifying non-uniform conditions. Figure 7 shows the same information as Figure 6, but plotted in a different way, with the difference between data and model FEC plotted as an x-t plot (option I). The blue and orange diagonal features indicate that the largest discrepancy between model and data gradually deepens with time.

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Appendix 1: Mathematical Background and Numerical Approach

The principal equation governing wellbore FEC variation is the equation for the transport of mass (or ion concentration) in the wellbore. However, additional consideration must be given to the determination of FEC as a function of ion concentration and the temperature dependence of FEC.

A1.1 FEC as a Function of Concentration

The relationship between ion concentration and FEC is reviewed, for example, by Shedlovsky and Shedlovsky (1971), who give graphs and tables relating these two quantities. Hale and Tsang (1988) made a sample fit for the case of NaCl solution at low concentrations and obtained

$$\mathrm{FEC} = 1{,}870\, C - 40\, C^2, \qquad \text{(A.1)}$$

where C is ion concentration in kg/m^3 ($\approx$ g/L) and FEC is in $\mu S/cm$ at 20°C. The expression is accurate for a range of C up to $\approx 6\ kg/m^3$ and FEC up to 11,000 $\mu S/cm$. The quadratic term can be dropped if one is interested only in values of C up to $\approx 4\ kg/m^3$ and FEC up to 7,000 $\mu S/cm$, in which case the error will be less than 10%.

Fracture fluids typically contain a variety of ions, the most common being Na^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, and HCO_3^-. If a hydrochemical analysis has been completed, various methods are available for computing an equivalent NaCl concentration for other ions. Schlumberger (1984) presents charts of multiplicative factors that convert various solutes to equivalent NaCl concentrations with respect to their effect on electric conductivity.

A1.2 Temperature Dependence of FEC

BORE II calculations are made assuming a uniform temperature throughout the wellbore. Actual wellbore temperatures generally vary with depth, so temperature corrections must be applied to field FEC data to permit direct comparison with model output.

The effect of temperature T on FEC can be estimated using the following equation (Schlumberger, 1984)

$$\mathrm{FEC}(20^\circ\mathrm{C}) = \frac{\mathrm{FEC(T)}}{1 + \mathrm{S(T} - 20^\circ\mathrm{C})}, \tag{A.2}$$

where $S = 0.024$.

Generally, temperature increases with depth below the land surface. If full temperature logs are available, these data can be used to correct the corresponding FEC values. However, if no complete logs are available, a simplifying assumption may be made that the temperature variation in the wellbore is linear and can be modeled by:

$$T = Ax + B, \tag{A.3}$$

where A and B are parameters determined by fitting any available temperature versus depth data. If the fit is unsatisfactory, other relationships with higher order terms must be used.

A1.3 Governing Equation

The differential equation for mass or solute transport in a wellbore is:

$$\frac{\partial}{\partial x}\left(D_o \frac{\partial C}{\partial x}\right) - \frac{\partial}{\partial x}(Cv) + S = \frac{\partial C}{\partial t}, \tag{A.4}$$

where x is depth, t is time, and C is ion concentration. The first term is the diffusion term, with D_0 the diffusion/dispersion coefficient in m^2/s, the second term is the advective term, with v the fluid velocity in m/s, and S is the source term in kg/m^3s. This one-dimensional partial differential equation is solved numerically using the finite difference method, with upstream weighting used in the advective term. The following initial and boundary conditions are specified:

$$C(x,0) = C_0(x), \tag{A.5}$$

$C(x_{min},t) = C_0(x_{min})$ for flow into the wellbore from above,

$C(x_{max},t) = C_0(x_{max})$ for flow into the wellbore from below,

$D_0 = 0$ for $x < x_{min}$ and $x > x_{max}$.

The first condition allows for the specification of initial ion concentrations in the wellbore. The second and third conditions allow for advective flow of ions into the wellbore interval from above and below. The final condition indicates that diffusion and dispersion do not take place across the boundaries of the wellbore interval. In general, advection will be the dominant

process at the boundaries. If diffusion or dispersion is dominant for a particular problem, the boundaries should be extended in order to prevent improper trapping of electrolyte.

A1.4 Discretization in Time

Time stepping is explicit, with the time step Δt determined by stability constraints for advection

$$\Delta t \leq \frac{\pi d_w^2 \Delta x}{8 q_{max}}, \tag{A.6}$$

and diffusion

$$\Delta t \leq \frac{\Delta x^2}{4 D_0}, \tag{A.7}$$

where q_{max} (m^3/s) is the maximum fluid flow rate anywhere in the wellbore. BORE II starts its calculation at $t = 0$. The first time in the data file is also identified with $t = 0$. If it is apparent that model and data times are not synchronized, then one may insert an additional line into the data file after the header lines, with an earlier time than the first real data time, in order to reset the data zero time. On the inserted line, FEC, x, and other data entries may be left blank or copied from the first real data line.

A1.5 Discretization in Space

The wellbore interval between x_{min} and x_{max} is uniformly divided into N cells and it is assumed that the wellbore has uniform diameter, d_w. Cell height Δx is determined as the larger of $(x_{max} - x_{min})/180$ and d_w. Position values indicate depth in the wellbore and thus x is zero at the surface and increases downward. The cell index increases upward, with cells 1 and N located at the bottom and top, respectively, of the wellbore interval. In general, the ith node (the center of the ith cell) is located at

$$x_i = x_{max} - (i\text{-}1/2)\Delta x, \tag{A.8}$$

with the ith cell extending from $x_{max} - (i - 1)\Delta x$ to $x_{max} - i\Delta x$.

BORE II assigns feed points and initial concentrations to cell i if the location of the feed point or $C_0(x)$ value lies within the boundaries of the ith cell. If multiple feed points are assigned to the same cell, they will all be accounted for, but if multiple initial conditions are assigned to the same cell, only the final one assigned will be used. By definition, the lower boundary of cell

1 is at x_{max}, but due to round-off errors, the upper boundary of cell N may not be at x_{min}. Hence, it is often useful to know the x coordinates of each node. These are displayed in the input file written by BORE II (option V) when IC0FLAG > 0. Thus, if the user sets IC0FLAG = 1, inputs one (x, $C_0(x)$) pair, and uses option V, then a new input file will be created with IC0FLAG = N and a complete list of the x coordinates for all nodes, with $C_0 = 0$ for all cells except the one identified in the original input file. Alternatively, if the initial conditions are taken from the data file with PREBORE (or taken from any source that is independent of the nodal coordinates), then using option V will create an input file that shows the actual initial conditions assigned to each cell.

The list of nodal x coordinates may be useful when modeling a thick fracture zone or aquifer, in order to place one feed point in each cell over a given depth range. Similarly, when using IC0FLAG > 0 to specify non-uniform initial concentrations, one must assign a C_0 value to each cell in the interval of interest in order to obtain a continuous C profile, because no interpolation is done between scattered initial concentrations. Finally, knowing the coordinate of the top cell in the model is useful for assigning the initial concentration that serves as the boundary condition for inflow into the wellbore interval from above. For inflow from below, either $x = x_1$ or $x = x_{max}$ may be used.

A1.6 Calculation of Flow Rates

Feed point flow rates may be constant in time, in which case a steady-state flow field is assumed in the wellbore, or variable, with feed point flow rates determined by linear interpolation between tabulated values. Although feed point flow rate may vary, true transient wellbore flow including fluid compressibility effects is not considered. Rather, the wellbore fluid flow field is assumed to change instantly from one steady-state flow field to another. In other words, the flow rate out of cell i is always the sum of the flow rates from all feed point locations within the boundaries of cell i plus the flow rate out of cell i-1.

Appendix 2: The Preprocessor PREBORE

PREBORE is a simple Fortran program that does preprocessing for BORE II. It runs under either Windows or DOS. PREBORE converts the old BORE data file format into the new BORE II data file format. Depth is converted from feet to meters, and other data columns are realigned. PREBORE can also create a file with (x,C_0) pairs to be added to the BORE II input file as initial conditions (this option requires that x values steadily increase or steadily decrease in each profile).

If data file conversion is being done, the user is prompted to enter the old and new data file names.

If a file with initial conditions is being created, the user is prompted for the following information: the name of the BORE II data file; a name for the initial condition file; which profile in the data file to use; the direction of logging (downward assumes x values increase in the data file, upward assumes they decrease, and both assumes the profiles alternately increase and decrease in x); and the conversion factors (γ, β, α) between FEC and C (default values 0, 1870, -40). In addition to creating an ASCII text file with (x,C_0) pairs, which may be added to the BORE II input file using a text editor or word processor, PREBORE prints out the number of pairs on the screen, which should be used for IC0FLAG. Note that IC0FLAG may be greater than the number of cells in the model (usually about 180), but that in this case not all the C_0 values will be used (see Appendix 1, Section A1.5).

Data file conversion and initial condition creation can be done in the same PREBORE run. In this case the user must specify both old and new data file names in addition to the parameters describing the creation of initial conditions.

Appendix 3: Input Files for Example Applications

A2.1 Example Application 1 – Up Flow – up_num.inp

```
TITLE: up flow with flow from below, compare to synthetic data
XMIN(m)      XMAX(m)      DIAM(cm)     !DX(m) = MAX(|XMIN - XMAX|/180, DIAM/100)
 .0000        180.0        14.00       ! 1.000
QW(L/min)    HALPHA       !QW=flow from below; HALPHA=hor. flow constriction
 .7500        2.500
#FEED_PTS    VARIABLE_FLOWRATE_IDENTIFIER
    3              999
DEPTH(m)     Q(L/min)     C(g/L)       T0(hr)       Q/V_FLAG     !Vd(m/day)
 160.5        .7500        100.0        .0000          0
 130.5        .7500        100.0        .0000          0
 50.50        .7500        100.0        .0000          0
TMAX(hr)     FECMAX       DIFFUSION_COEF.(m2/s)
 24.00        100.0        .7500E-09
RGAMMA       RBETA        RALPHA       !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000        1.000        .1000E-07
ICOFLAG      !If 0, C0=0; If <0, read one C0; If >0,read ICOFLAG (X,C0) pairs
    0
DATA_FILE    !'NONE' if there is no data file
up_num.dbt
```

A2.2 Example Application 2 – Horizontal Flow Analytical Solution – hor_an.inp

```
TITLE: Horizontal Flow - Compare to Analytical Solution
XMIN(m)      XMAX(m)      DIAM(cm)
0.000        50.000       7.600
QW(L/min)    HALPHA
0.           2.850000
#FEED_PTS    VARIABLE_FLOWRATE_IDENTIFIER
       2     999
DEPTH(m)     Vd(m/d)      C(g/L)       T0(hr)       Q/V_FLAG
  25.0000      1.         1000.      .0000          1
  25.0000     -1.         1000.      .0000          1
TMAX(hr)     FECMAX       DIFFUSION_COEF.(m2/s)
3.0000       1000.        1.e-10
RGAMMA       RBETA        RALPHA
0.000000     1.000000     1.e-08
ICOFLAG
0
DATA_FILE
hor_an.dbt
```

The input file for the case with significant dispersion is identical, except that the diffusion coefficient is increased from 10^{-10} m^2/s to 10^{-5} m^2/s.

A2.3 Example Application 3 – Horizontal Flow - hor_real.inp

```
TITLE: Horizontal Flow Example
XMIN(m)      XMAX(m)      DIAM(cm)     !DX(m) = MAX(|XMIN - XMAX|/180, DIAM/100)
 .0000        60.00        7.600       ! .3333
QW(L/min)    HALPHA       !QW=flow from below; HALPHA=hor. flow constriction
 .0000        2.500
#FEED_PTS    VARIABLE_FLOWRATE_IDENTIFIER
   14              999
DEPTH(m)     Q(L/min)     C(g/L)       T0(hr)       Q/V_FLAG     !Vd(m/d)
 26.73        .5295E-02    730.0        .0000          0          ! .1204
 26.73       -.5295E-02    .0000        .0000          0          !-.1204
 26.39        .5295E-02    730.0        .0000          0          ! .1204
 26.39       -.5295E-02    .0000        .0000          0          !-.1204
 26.06        .5295E-02    730.0        .0000          0          ! .1204
 26.06       -.5295E-02    .0000        .0000          0          !-.1204
 25.73        .5295E-02    730.0        .0000          0          ! .1204
 25.73       -.5295E-02    .0000        .0000          0          !-.1204
 25.39        .5295E-02    730.0        .0000          0          ! .1204
 25.39       -.5295E-02    .0000        .0000          0          !-.1204
 25.06        .5295E-02    730.0        .0000          0          ! .1204
 25.06       -.5295E-02    .0000        .0000          0          !-.1204
 24.73        .5295E-02    730.0        .0000          0          ! .1204
 24.73       -.5295E-02    .0000        .0000          0          !-.1204
TMAX(hr)     FECMAX       DIFFUSION_COEF.(m2/s)
 4.000        400.0        .7500E-04
RGAMMA       RBETA        RALPHA       !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000        1.000        .1000E-07
IC0FLAG      !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0) pairs
    0
DATA_FILE    !'NONE' if there is no data file
hor_real.dbt
```

A2.4 Example Application 4 – Down Flow – down_c.inp

```
TITLE: downflow, variable source conc., uniform non-zero initial conc.
XMIN(m)      XMAX(m)      DIAM(cm)     !DX(m) = MAX(|XMIN - XMAX|/180, DIAM/100)
 140.0        240.0        7.600       ! .5556
QW(L/min)    HALPHA       !QW=flow from below; HALPHA=hor. flow constriction
 .0000        2.850
#FEED_PTS    VARIABLE_FLOWRATE_IDENTIFIER
   12              999
DEPTH(m)     Q(L/min)     C(g/L)       T0(hr)       Q/V_FLAG     !Vd(m/day)
 239.0       -.7000        .0000        .4000         0
 212.0       -1.000        .0000        .4000         0
 187.0        .7500        1800.        .4000         0
 183.0        .1900        1900.        .4000         0
 181.0        .1200        1900.        .4000         0
 178.0        .5000E-01    1900.        .4000         0
 176.0        .4000E-01    1900.        .4000         0
 174.0        .3000E-01    1900.        .4000         0
 171.0        .1000E-01    1900.        .4000         0
 164.4       99905.        1900.        .4000         0
     T(hr)        Q(L/min)     C(g/L)       !#entries is two digits after  999
      .0000        .4400        80.00
      .4000        .4400        100.0
      1.200        .4400        1100.
      1.900        .4400        1650.
      4.500        .4400        1950.
 162.0       99904.        1800.        .0000         0
     T(hr)        Q(L/min)     C(g/L)       !#entries is two digits after  999
      .0000        .6000E-01    80.00
      .4000        .6000E-01    200.0
      1.900        .6000E-01    1650.
      4.500        .6000E-01    1950.
 158.5        .1000        80.00        .0000         0
TMAX(hr)     FECMAX       DIFFUSION_COEF.(m2/s)
 4.400        1700.        .1000E-02
RGAMMA       RBETA        RALPHA       !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000        1.000        .1000E-07
ICOFLAG      !If 0, C0=0; If <0, read one C0; If >0,read ICOFLAG (X,C0) pairs
   -1
C0 (g/L)     !Uniform, non-zero C0
 80.00
DATA_FILE    !'NONE' if there is no data file
down_c.dbt
```

A2.5 Example Application 5 – Combination Flow – comb_ic.inp

```
TITLE: Combination flow example, non-uniform initial concentration
XMIN(m)      XMAX(m)      DIAM(cm)     !DX(m) = MAX(|XMIN - XMAX|/180, DIAM/100)
 .00000       50.000       7.6000      ! .2778
QW(L/min)    HALPHA       !QW=flow from below; HALPHA=hor. flow constriction
 .00000       2.8500
#FEED_PTS    VARIABLE_FLOWRATE_IDENTIFIER
   12              999
DEPTH(m)     Q(L/min)     C(g/L)       T0(hr)       Q/V_FLAG     !Vd(m/day)
 45.000      -.13000       .00000       .00000        0
 33.300       .11000       800.00       .15000        0
 33.300      -.31000       .00000       .00000        0
 27.500      -1.0500       .00000       .00000        0
 25.700       .30000       810.00       .15000        0
 25.400       .30000       810.00       .15000        0
 25.140       .30000       810.00       .15000        0
 24.900       .30000       810.00       .15000        0
 23.500       .12000       800.00       .15000        0
 21.500       .40000E-01   800.00       .15000        0
 14.000       .15000E-01   750.00       .15000        0
 12.200       .10000E-01   750.00       .15000        0
TMAX(hr)     FECMAX       DIFFUSION_COEF.(m2/s)
 1.0000       1000.0       .50000E-03
RGAMMA       RBETA        RALPHA       !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .00000       1.0000       .10000E-07
IC0FLAG      !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0) pairs
  232
X(m)         C0(g/L)              !#entries is IC0FLAG
1.524        2
1.615        2
1.707        3
1.829        3
1.951        3
2.073        3
2.225        3
2.377        3
2.53         3
2.713        3
2.865        3
3.018        3
3.353        589
3.536        597
3.719        588
3.871        583
4.054        584
…(208 entries not shown)…
43.282       2
43.8         2
43.983       2
44.166       1
44.318       1
44.501       1
44.684       1
DATA_FILE    !'NONE' if there is no data file
comb_ic.dbt
```

Figure 1. Concentration (=FEC) versus depth at a series of times for example application 1 - up flow. Data are numerically simulated using the TOUGH2 code. Figure is a BORE II screen-print after running option R.

C89

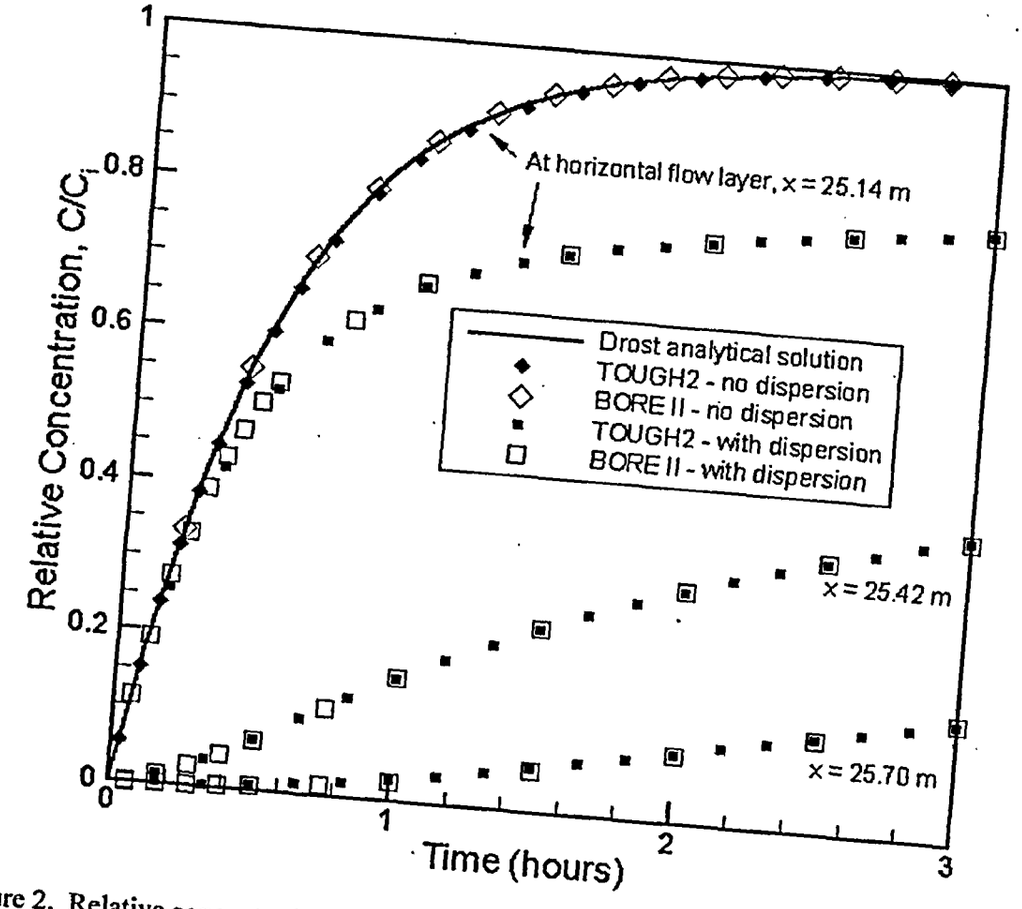

Figure 2. Relative concentration versus time for example application 2 – horizontal flow. When diffusion/dispersion is negligible, the concentration increase only occurs at the depth of the horizontal flow layer. The solid line shows the analytical solution as given by Drost (1968), Equation (1).

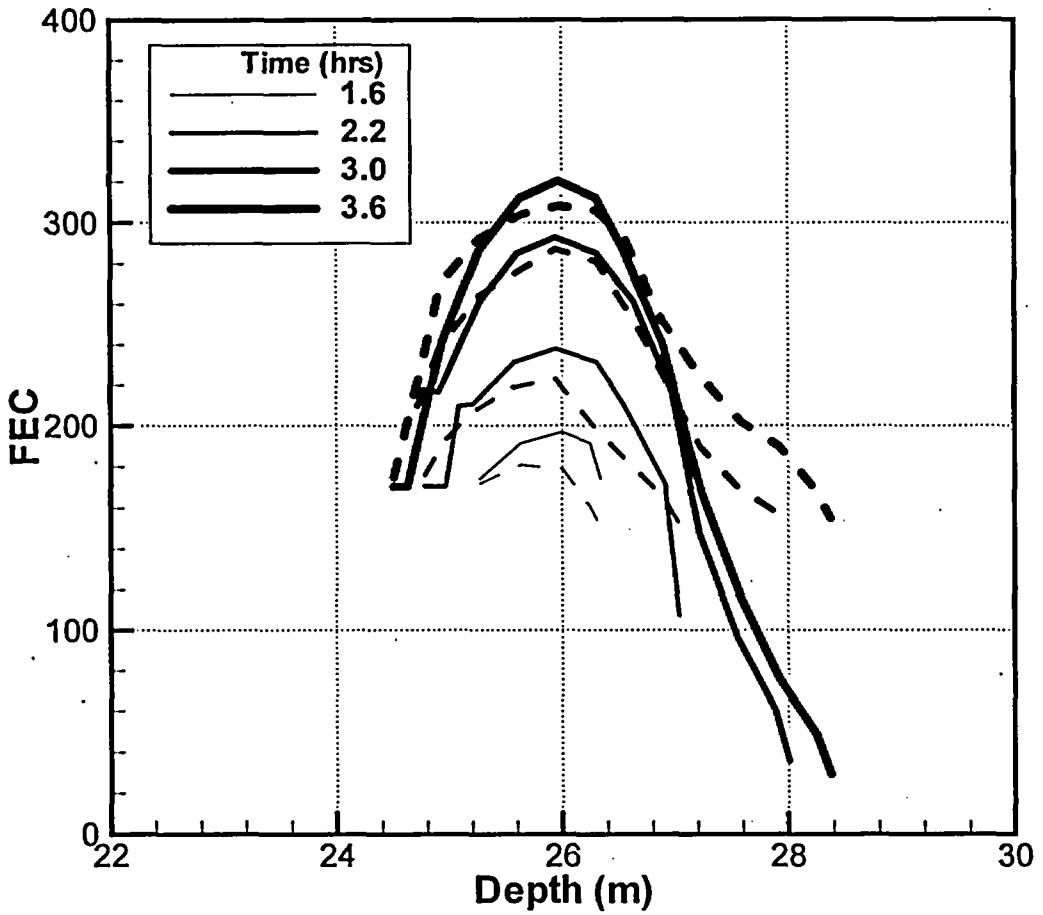

Figure 3. Concentration (= FEC) versus depth at a series of times for example application 3 – a thick layer of horizontal flow. Dashed lines represent field data, solid lines represent BORE II results. Diffusion/dispersion is significant.

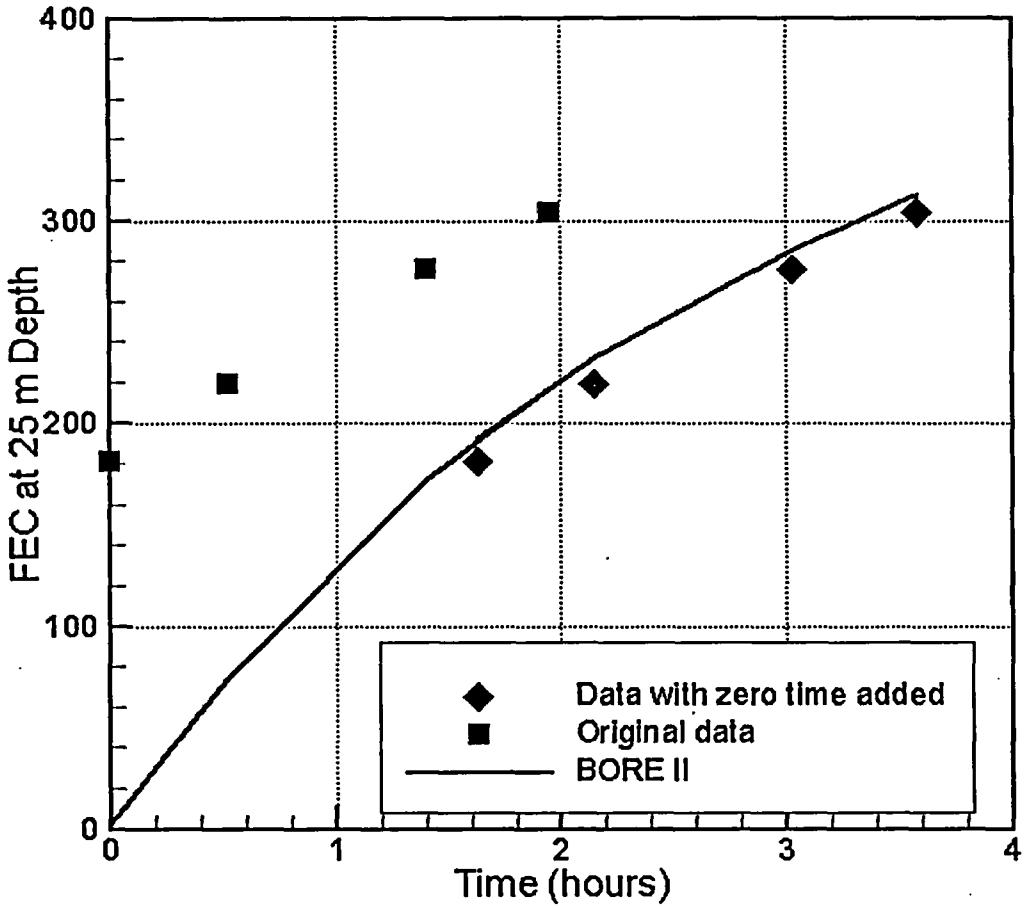

Figure 4. Concentration (= FEC) versus time at the center of the horizontal flow zone of example application 3, illustrating the addition of a data zero time.

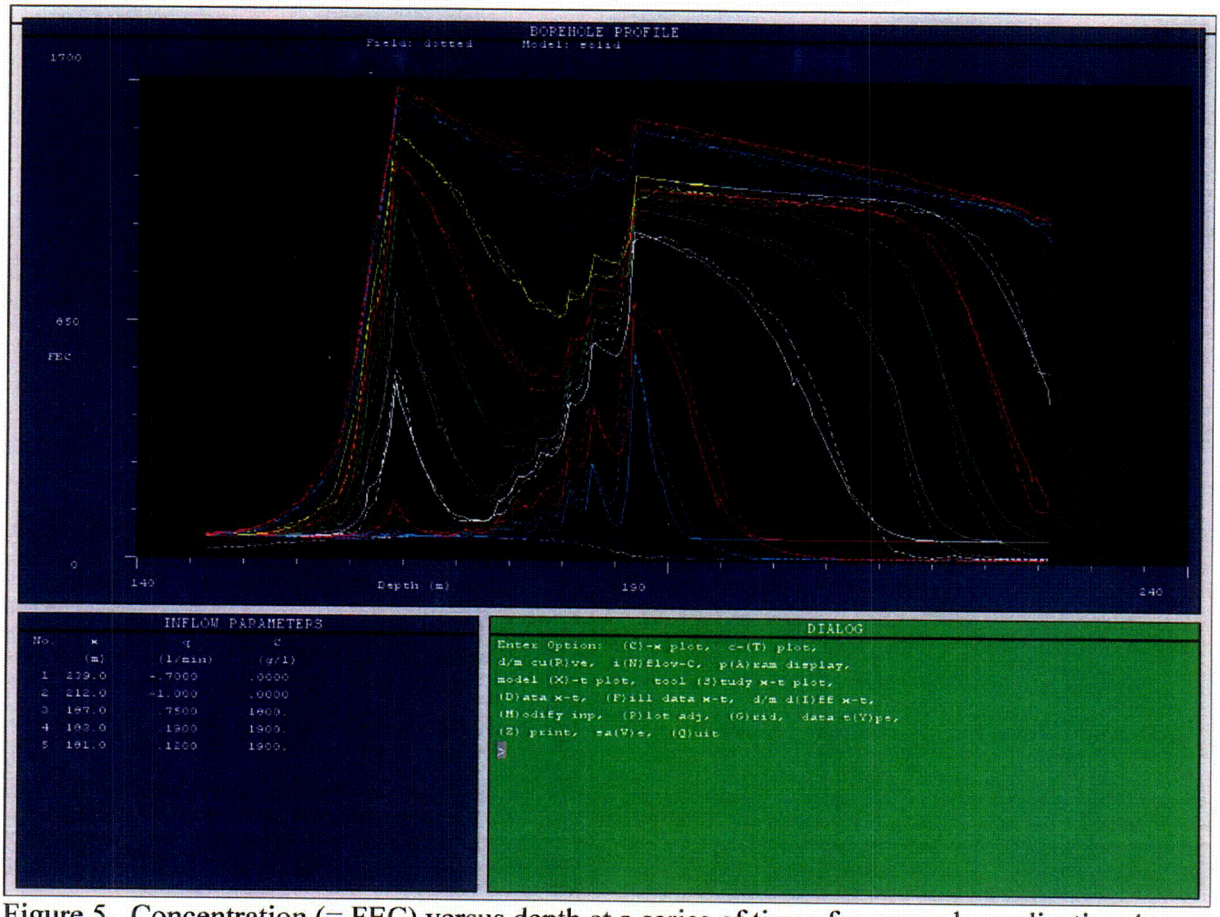

Figure 5. Concentration (= FEC) versus depth at a series of times for example application 4 – down flow. Figure is a BORE II screen-print after running option R.

C90

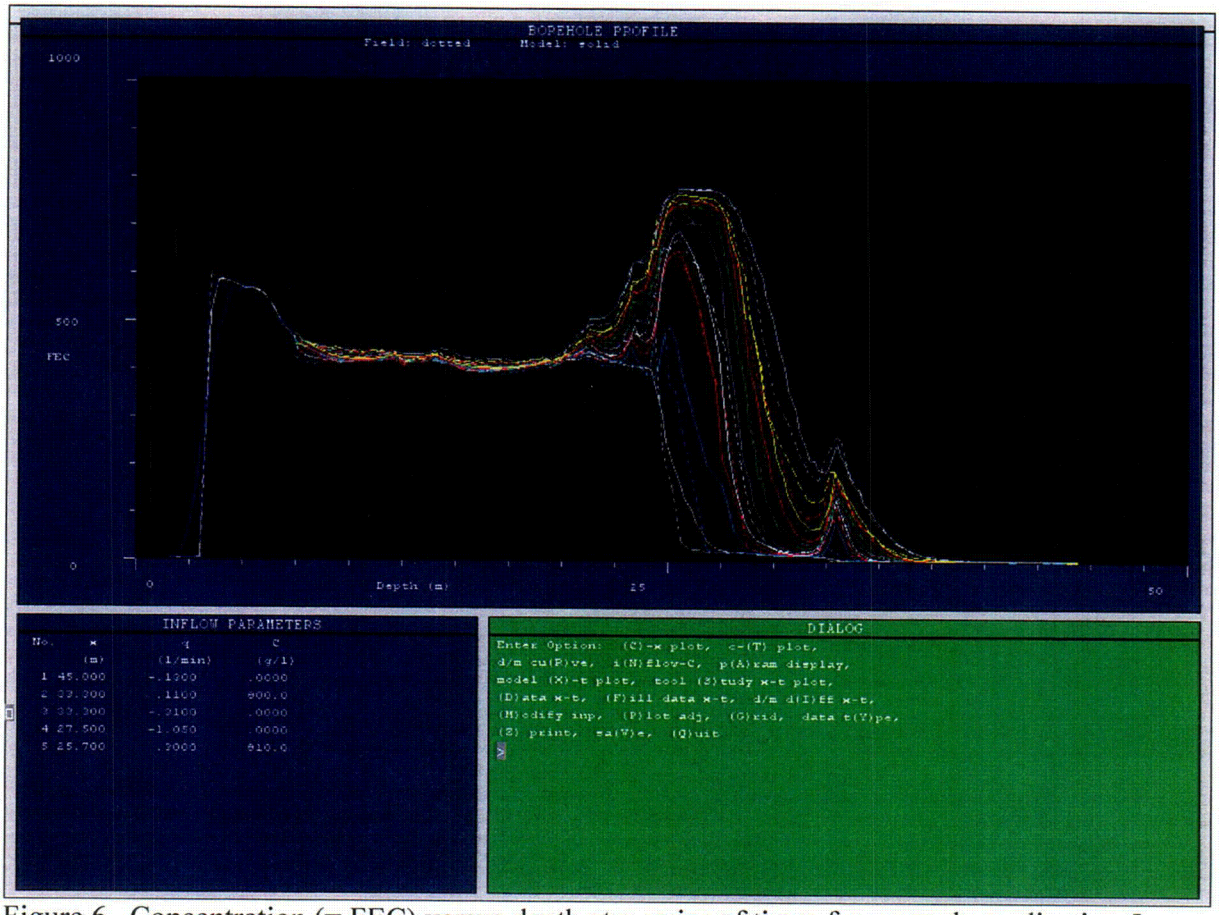

Figure 6. Concentration (= FEC) versus depth at a series of times for example application 5 – combination flow. Figure is a BORE II screen-print after option R.

C91

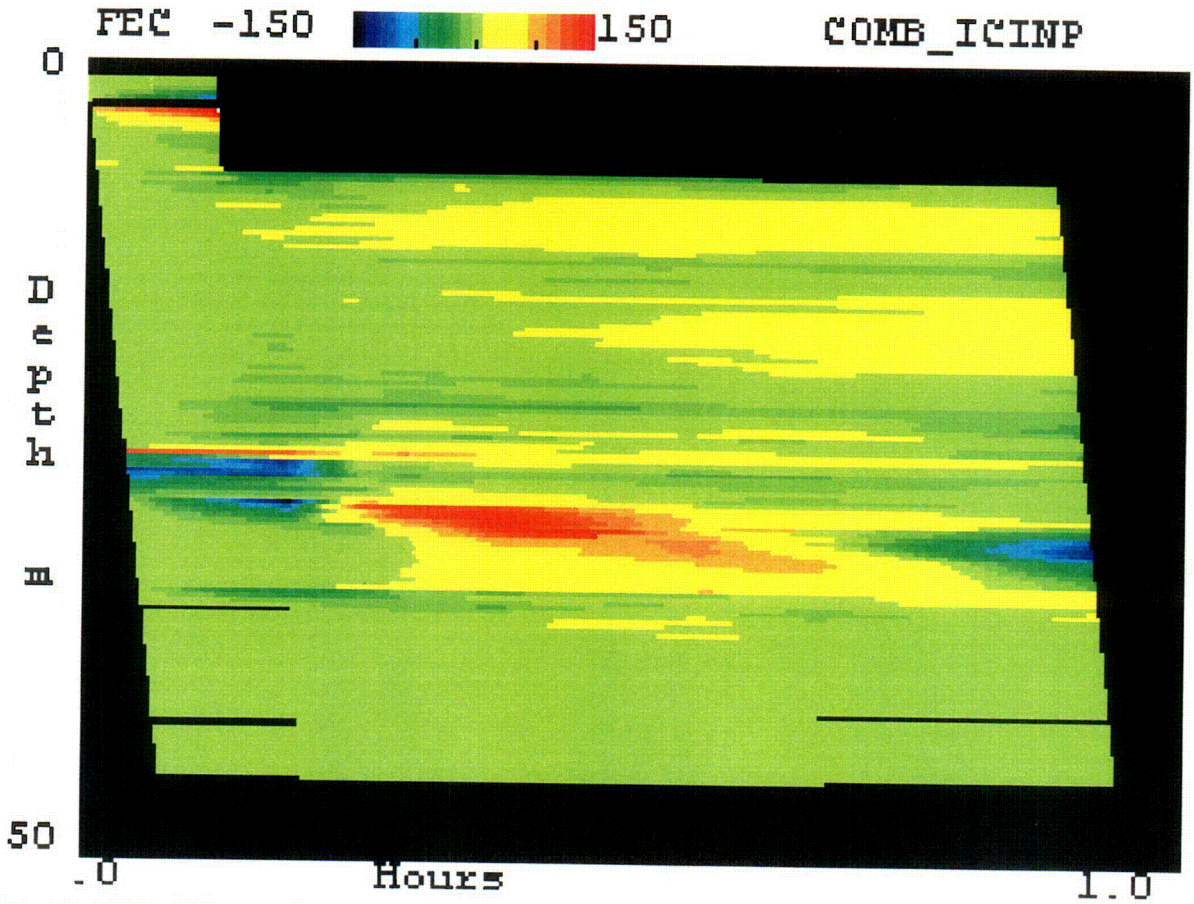

Figure 7. FEC difference between model and data as a function of depth and time (an *x-t* plot) for example application 5 – combination flow. Figure is a BORE II screen-print after option I, mode 2.

C92

APPENDIX C

LIMITATIONS

LIMITATIONS

COLOG's logging was performed in accordance with generally accepted industry practices. COLOG has observed that degree of care and skill generally exercised by others under similar circumstances and conditions. Interpretations of logs or interpretations of test or other data, and any recommendation or hydrogeologic description based upon such interpretations, are opinions based upon inferences from measurements, empirical relationships and assumptions. These inferences and assumptions require engineering judgment, and therefore, are not scientific certainties. As such, other professional engineers or analysts may differ as to their interpretation. Accordingly, COLOG cannot and does not warrant the accuracy, correctness or completeness of any such interpretation, recommendation or hydrogeologic description.

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