



**Pritcher Road Environmental Assessment
Lithia, Hillsborough County, Florida
Preliminary Contamination Assessment Report**

Appendices

SIS Report Number 2011-2
Issued January 2011

Robert Cilek, P.G.

*Florida Department of Environmental Protection
Site Investigation Section
William A. Martin, Professional Geologist Administrator
2600 Blair Stone Road
Tallahassee, FL 32399-2400
(850) 245-8927*

Appendix A

Request for Assistance

**Site Investigation Section
Request for Assistance**



Bureau of Waste Cleanup
JAN 12 2007
Site Investigation Section

January 5, 2007

To: William Martin, P.G. Administrator
Site Investigation Section
(850) 245-8927, SC 205-8927
MS 4515, FDEP Twin Towers, Tallahassee

From: District Waste Management Program Director

WMA 1/8/07

Site Name: Pritcher Road Arsenic Plume/Steppin Stone School
Street Address: various (see attached list)
City/Zip: Lithia, FL 33547
County: Hillsborough
FDEP/EPA Facility ID#: WCU Project No. 302975

Please attach site map!

Description of Requested Assistance, including contaminant(s) of concern

Background

In March 2006 the SW District was notified that potable well sampling performed by the Hillsborough County Health Department (HCHD) identified several private potable wells in Lithia as being contaminated with arsenic above the drinking water standard and molybdenum at elevated concentrations. During three sampling rounds (one by a private contractor, two by HCHD) at Steppin Stone School in Lithia, exceedances for arsenic were received for water samples collected from both of the school's drinking water wells. An irrigation well on the school property was also sampled for primary metals, as were two private wells and a mobile home park well in the vicinity. The lab results showed levels of arsenic at the two school drinking water wells of 24 ppb and 160 ppb. The irrigation well at the school had no exceedances. The mobile home park well (Bryant Acres) had an arsenic level of 124 ppb. Higher than normal levels of molybdenum (up to 2,600 ppb) were found in the samples that had high levels of arsenic (the two school wells and the mobile home park well). HCHD has since sampled numerous additional

wells in the area specifically for arsenic and molybdenum and resampled the mobile home park well. A summary table of the results and maps are attached.

HCDH indicated that the residents have been provided with bottled water, and the school's water supply was to be hooked up to their uncontaminated irrigation well. However, the source of the contamination has not been identified. DEP has surveyed the area and reviewed our database records, but we have not been able to identify any specific source for these impacts to the private wells. We do not know of any potential source except phosphate mines/gyp stacks located a mile or more away in Polk County. The area is in the vicinity of the Alafia River.

Requested Assistance

The Department of Health has requested our assistance in identifying the possible source(s) for the contamination and investigation of the hydrology of the area. The SW District is requesting assistance from SIS with logging the existing potable wells to identify the depth of contamination and additional site investigation to identify the possible source(s) of the contamination.

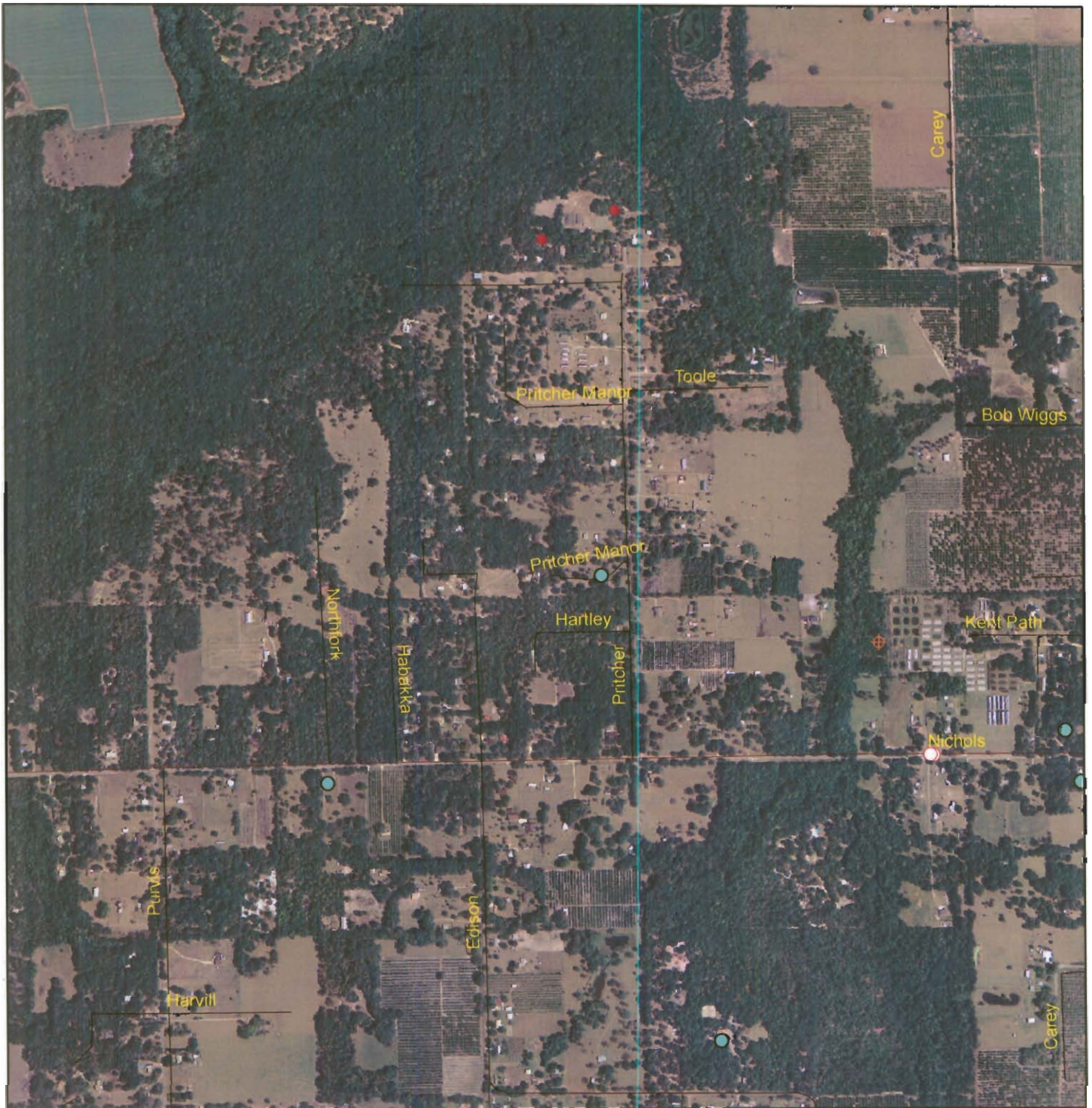
Priority

Emergency:	_____	Normal:	_____
High:	<u> X </u>	Low:	_____

District Contact Person: Nell Tyner, Manager, Waste Cleanup Section

Requested Scheduling Date: within the next few months if possible

Steppir. Stone Farm/Pritchard Road



0 0.1 0.2 0.4 0.6 Miles

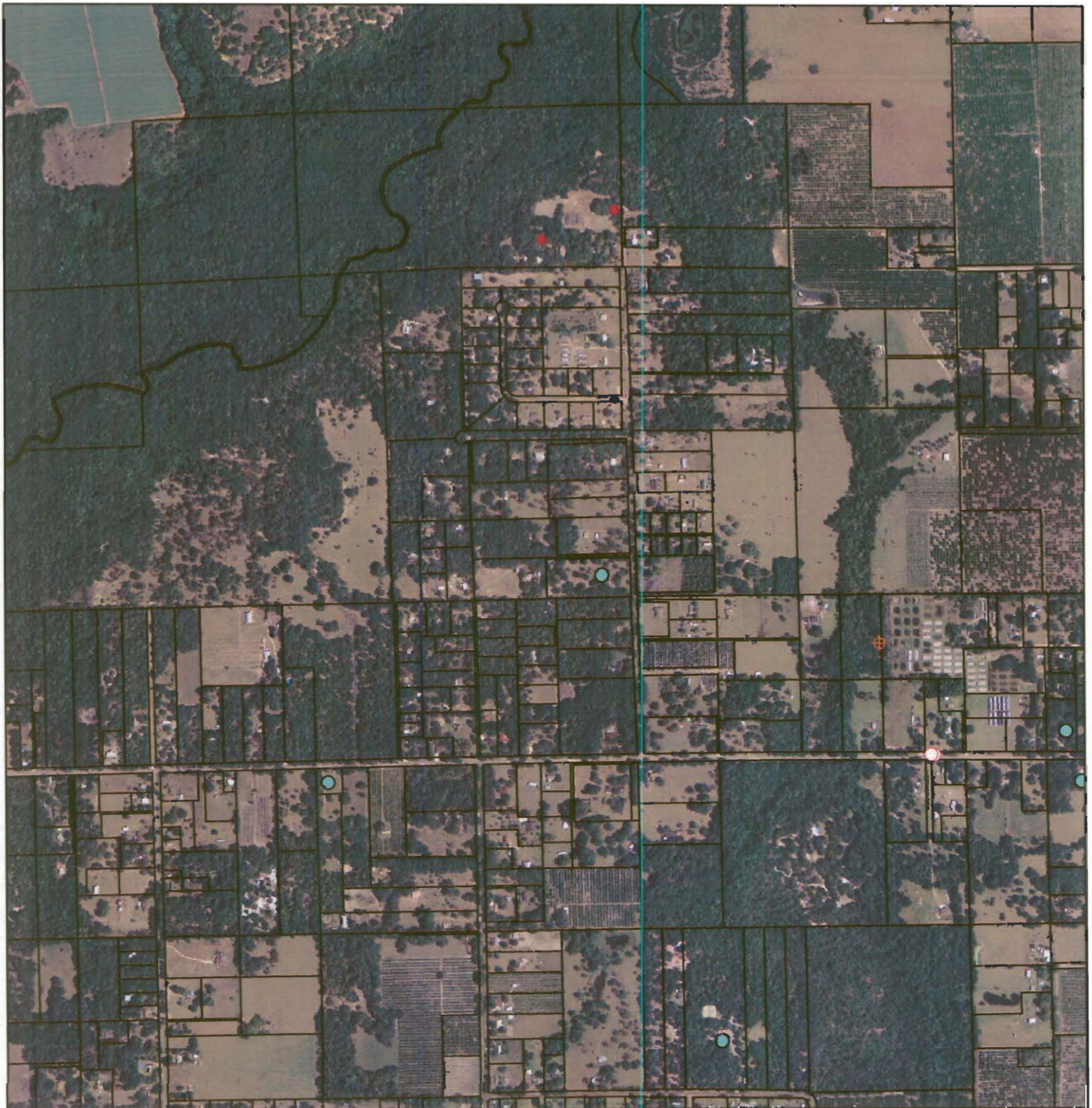


This map is for illustration only

Legend

-  COMET
-  Super Act Wells
-  Super Act Facilities
-  All Hits Exceeding Standards
-  Public Water Supply (PWS) Wells
-  Water Supply Restoration (WSRP) Wells

Steppin Stone Farm/Pritchard Road



0 0.1 0.2 0.4 0.6 Miles



This map is for illustration only

Legend

-  COMET
-  Super Act Wells
-  Super Act Facilities
-  All Hits Exceeding Standards
-  Public Water Supply (PWS) Wells
-  Water Supply Restoration (WSRP) Wells
-  Cadastral 2003 (Property Appraiser Parcels)

HCHD Sampled Wells in Pritcher Road Vicinity

Name	Address	Date Sampled	Well ID	Arsenic (ug/l)	Molybdenum (ug/l)
School – Tennis Court ✓	8421 Pritcher Rd	02/15/06	AAK5086	26.2	
School - Volleyball ✓	8421 Pritcher Rd	02/15/06	AAK5097	62.4	
School – Tennis Court ✓	8421 Pritcher Rd	02/23/06	AAK5086	23.7	1100
School - Volleyball ✓	8421 Pritcher Rd	02/23/06	AAK5097	160	2600
School - Irrigation ✓	8421 Pritcher Rd	02/23/06	AAK5087	0.166	12
Bryant MHP ✓	8601 Pritcher Rd	02/23/06	AAK5095	124	1300
Jenkins ✓	8520 Pritcher Rd.	02/23/06	AAK5096	0.10	7.1
Sarmiento ✓	8519 Pritcher Rd.	02/23/06	AAK5094	1.14	27
Lamar Maxwell ✓	2815 Hartley Lane	03/07/06	AAK5078	22.2	150
Bryant MHP	8601 Pritcher Road	03/07/06	AAK5095	134	1400
Roger Dapson ✓	8816 Pritcher Road	03/07/06	AAK5079	0.090	3.5
Scott Maxwell ✓	2821 Hartley Lane	03/07/06	AAK5077	3.16	97
Roger Dapson ✓	8836 Pritcher Road #2	03/07/06	AAK5080	0.090	28
Roger Dapson ✓	8836 Pritcher Road #1	03/07/06	AAK5081	0.090	35
James Toole ✓	3010 Toole Road	03/07/06	AAK5082	0.310	88
Tammy Smith	8611 County Line Rd	03/09/06	AAK5075	0.693	3.5
Judy Ottinger ✓	8709 Pritcher Road	03/09/06	AAK5076	0.986	2.7
Amanda Hamirck ✓	2741 Hartley Lane	04/03/06	AAK3696	3.70	210
Robert Webb	2915 Keysville Rd	04/03/06	AAK3692	0.090	2.7
Summer Rainard ✓	8906 Pritcher Rd	04/03/06	AAK3693	0.778	48
School - Irrigation	8421 Pritcher Rd	04/03/06	AAK5087	0.090	6.0
Michael Vaughn	2803 Pritchard Manor	04/03/06	AAK3694	0.090	77
Lamar Maxwell ✓	2815 Hartley Lane	04/03/06	AAK5078	57.6	310
Carroll Bennett ✓	2810 Hartley Lane	04/03/06	AAK3695	2.65	180
Steven Kittle ✓	2805 Hartley Lane	04/03/06	AAK3697	0.534	3.9
William Albritton	9513 Carey Road	04/03/06	AAK3698	1.24	4.6
Connie Cueto	9425 Carey Road	04/03/06	AAK3699	1.22	3.6
Rick Hoffman	2820 Hartley Lane	04/25/06	AAK5072	1.07	630
Jim Tozer ✓	2903 Pritcher Manor Ct	04/25/06	AAK5074	0.348	0.47
Robert Teta ✓	2901 Pritcher Manor Ct	04/25/06	AAK5073	0.765	0.60
Sue McClendan	8704 Pritcher Rd	05/09/06	AAK3678	49.1	1000
Susie Sisk	8716 Pritcher Rd	05/09/06	AAK3677	1.14	25
Lamar Maxwell ✓	2815 Hartley Lane	06/28/06	AAK5078	19.3	
Angela Miske	2902 Pritcher Manor Ct	08/07/06	AAK3615	42.3	810
James Toole ✓	3010 Toole Road	10/25/06	AAK5082	0.279	78
Amanda Hamirck ✓	2741 Hartley Lane	10/25/06	AAK3696	7.46	230
Scott Maxwell ✓	2821 Hartley Lane	10/25/06	AAK5077	17.1	180
Rick Hoffman	2820 Hartley Lane	10/25/06	AAK5072	1.14	
Carroll Bennett ✓	2810 Hartley Lane	10/25/06	AAK3695	3.10	160

Dept. of Environmental
Protection

DEC 26 2006

Southwest District



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ARSENIC

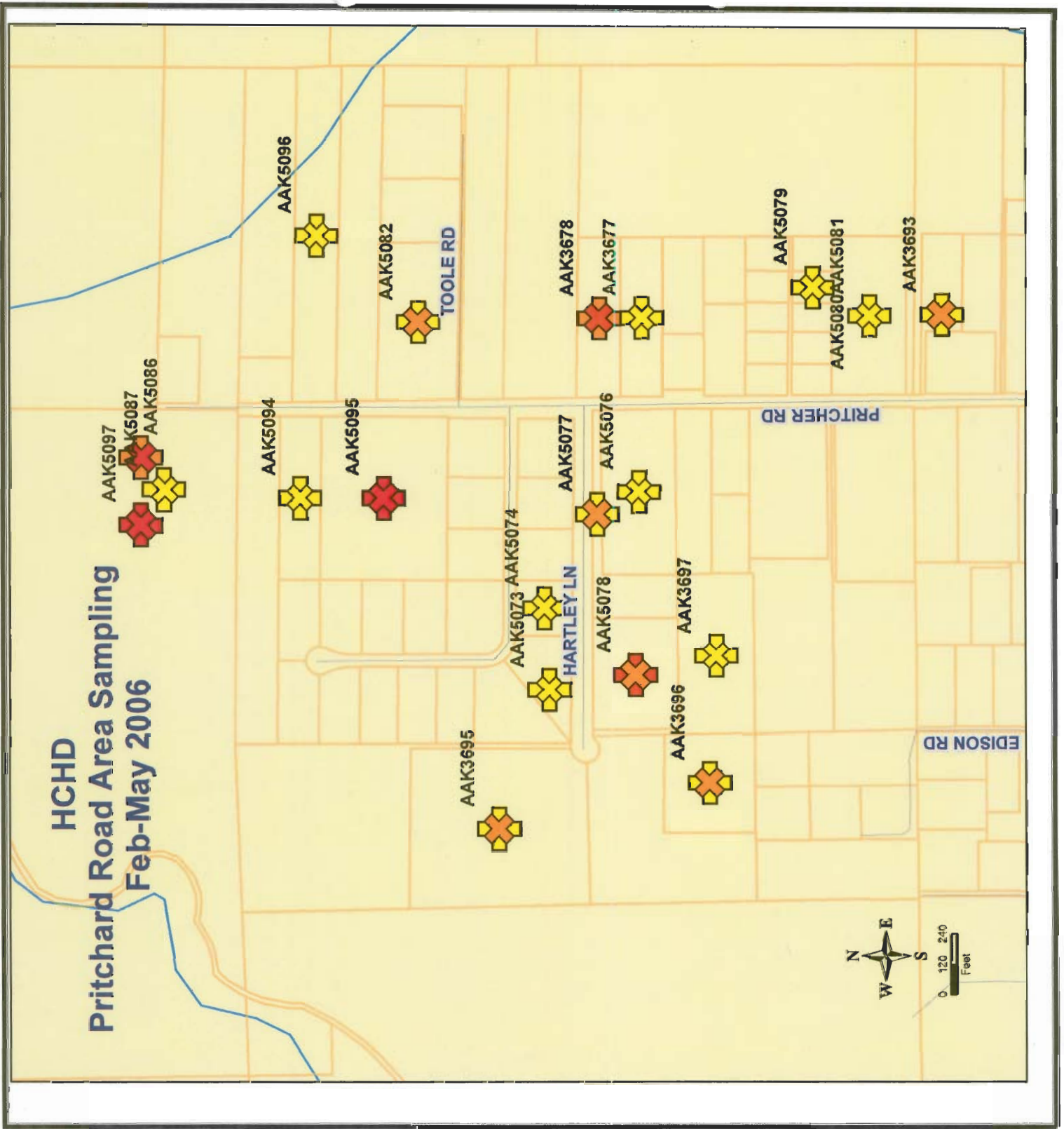
-  0 - 10
-  11 - 50
-  51 - 100
-  >100

MOLYBDENUM

-  0 - 35
-  36 - 500
-  501 - 1000
-  >1000

All Units are ug/l

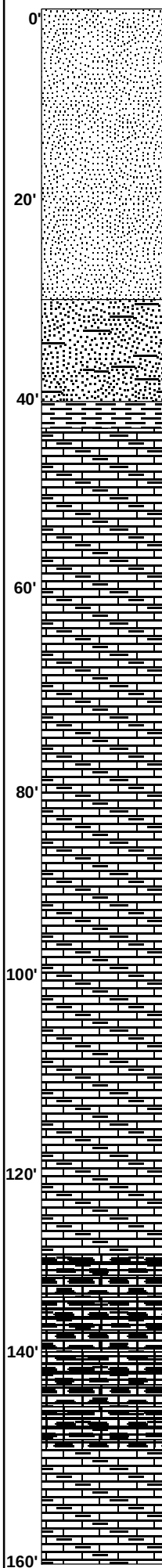
June 2006



Appendix B
Geologic Presentations

Part A Lithologic Profiles

Part B Pneumatic Slug Test Results



0-26' Light orange to dark brown quartz sand, fine to very fine grain with some silt, dry.



26-32' Medium grey fine grain sand with 5% phosphate sand, damp to wet.

32-36' Sand as above with clay content increasing with depth (10-30%), phosphatic sand is fine to coarse grain with subangular to rounded grains.

36-40' Sandy clay, light grey with 20% fine grain quartz sand, fine to coarse phosphate grains with some 5 to 20 millimeter size pebbles that are subangular to subround.

40-43' Light brown and grey "pipe" clay, damp, highly plastic. Less than 5% fine to medium grain phosphatic sands, no quartz sand.



43-46' Clay to limey clay matrix with limestone fragments (5-50 millimeters in size). Amount of limestone increases with depth.

46-55' Light brown to tan lime mud with 6 inch to 1 foot intervals of competent limestone that is fine grained with no secondary porosity. Mud displays little or no plasticity and has 5% phosphatic sand and pebbles and about 25% limestone fragments, damp to wet.

55-66' Medium to dark grey lime mud, with dark grey limestone pebble/cobble fragments throughout, little or no phosphate, dry to moist.



66-128' Dark to light grey lime mud with occasional limestone intervals of 1-6 inches in width with less than 3% phosphatic grains ranging in size from fine to coarse, most of the interval is dry with some damp zones.

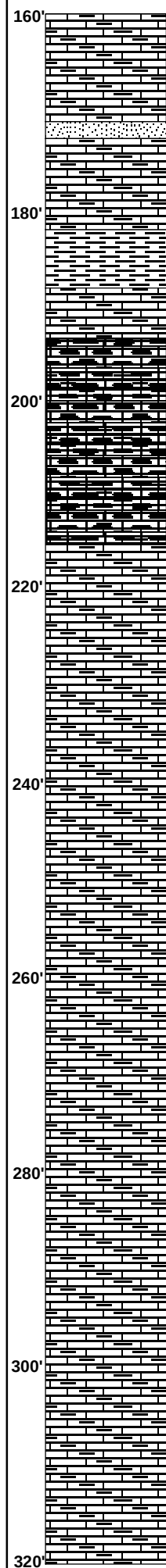


128-132' As above but with chert ranging in size from pebble to cobble size.

132-147' Broken and fractured chert fragments (80-90% of matrix) from 1 to 40 millimeters in size with angular breakage likely from drilling, chert content decreases with depth, some lime mud. Interval is wet.



147-169' Lime mud with some cemented lime mud rock fragments and 1-4 inch intervals of fossiliferous limestone (shell casts and impressions) with cavities and pore spaces. Interval is very wet.



169-172' Very fine to fine grain tan quartz sand.



172-176' Lime mud with 1-4 inch intervals of fossiliferous limestone (shell casts and impressions) with cavities and pore spaces. Interval is very wet.



176-189' Tan limestone fragments with shell cast impressions in the first 2 feet grading into an olive green clay, moderately plastic with some lime mud.



189-216' Tan lime mud with some cemented lime mud fragments. Chert fragments (5-10% of core matrix) present ranging from coarse grain to hand size. Intervals with chert and cemented fragments are damp; lime mud intervals are dry.



216-228' Tan lime and lime mudstone, damp to wet.



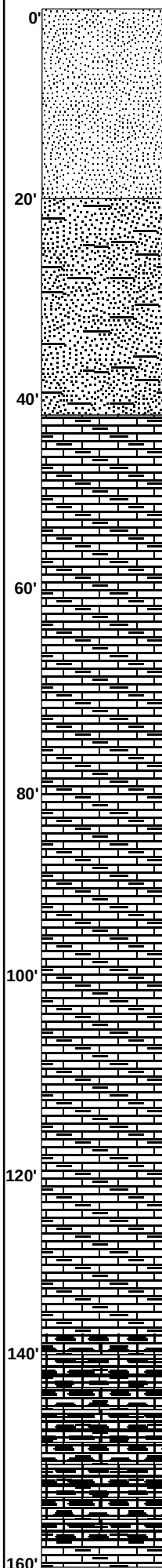
228-236' Fragmented limestone with shell fossils and casts, saturated.



236-276' Saturated lime mud, lime sands and limestone fragments. Light tan to cream with some cemented lime mud fragments. Limestone fragments from 5 millimeters to fist sized, fossiliferous (casts and impressions) with abundant pore spaces, saturated.

276-296' As above with coarse grain lime sand, saturated.

296-320' Predominantly lime sands with abundant fossiliferous limestone fragments. Sands are medium to coarse grain, saturated.



0-19' Light orange to dark brown quartz sand, fine to very fine grain with some silt, dry.



19-26' Light tan grey fine grain sand with 10-15% phosphate (coarse grain to small pebbles) grading into sandy clay with 5% phosphate, clay is moderately to highly plastic.



43-59' Medium to dark grey lime mud with occasional sand and a few phosphate pebbles.



59-91' Medium to light grey lime mud with some fine sand, medium to coarse phosphate grains (<3%), occasional lime mud blebs, dry to damp.

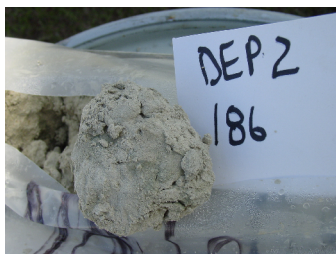
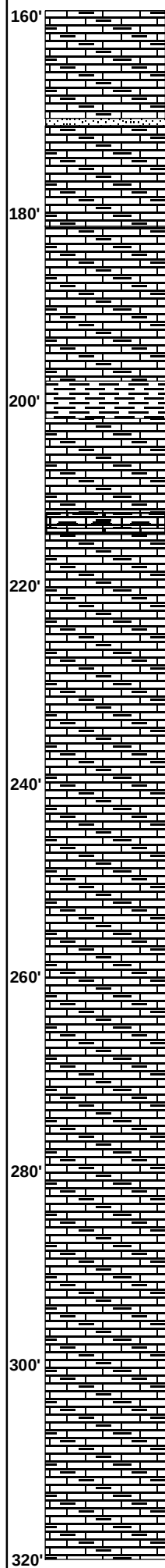


91-137' Tan lime mud with lime clay intervals, low to medium plasticity, occasional cemented mud rock fragments, few phosphate pebbles, generally dry.



137-160' As above but with chert (5-60%) ranging in size from pebble to cobble size, saturated. Some dark staining in lime mud.

DEP 2



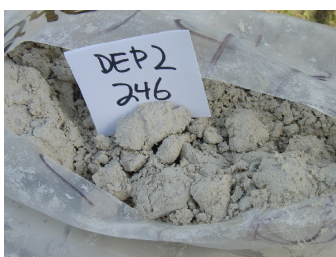
160-198' Wet tan lime mud with small cemented lime mud rock fragments, with thin intervals of very fine to fine grain quartz and lime sands. Interval from 176 to 186' very dry.



198-207' Tan lime mud grading into medium to dark grey green dense lime mud.



207-226' Tan lime mud with lime mud and chert fragments present from 213 to 217'. Lime mud becomes very dry and crumbly to 226' BLS.



226-246' Tan lime mud with lime sand and limerock rock fragments, saturated. Limestone at 236' is fossiliferous with shell casts and impressions.



246-275' Tan lime fine to medium grain sands and small pebbles, saturated.

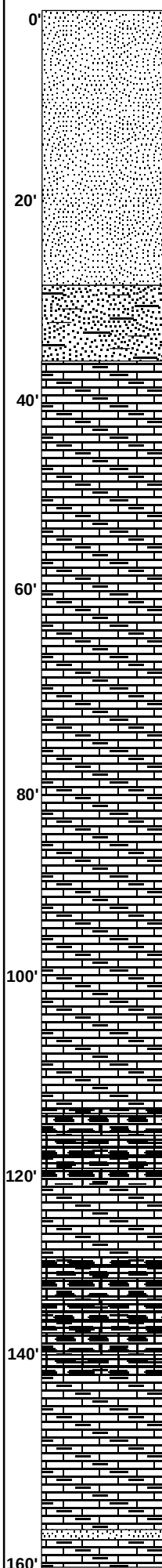


275-286' As above with abundant fossils, wet to saturated.



286-320' Tan lime sands and cemented lime sand fragments. Sands are fine to coarse grain. Black staining noted on tan lime sand from 310-315'.

DEP 3



0-28' Light orange to dark brown quartz sand, fine to very fine grain with some silt, dry.



28-36' Light grey fine grain sand with some clay, moderately plastic, wet to saturated.



36-66' Medium to dark grey lime mud with phosphatic sands (<5%).



66-86' Light to medium grey lime mud with some phosphatic sands and light brown pebbles, dry.



86-91' Medium to dark grey, green lime mud with some clay with low plasticity (5%) and some black staining, dry.



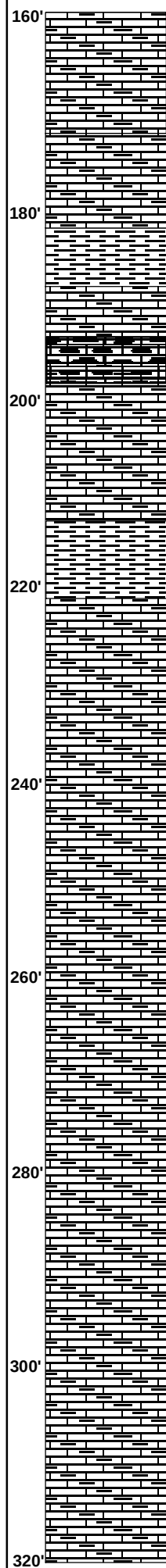
91-129' Light tan lime mud with mud rock fragments and some clay, predominantly dry. Chert interval from 117-121'.



129-145' Grey to tan lime mud with abundant large chert fragments, wet.

145-160' Lime sands and muds, light tan with 154-157' interval comprised of olive green very fine grain quartz sand.

DEP 3 (147-167)



160-182' Light tan lime mud with mud rock fragments, gravel and sand, wet.



182-187' Tan lime mud with 10% olive green clay in blebs. Clay is moderately to highly plastic, dry.



187-193' Dark olive green clay, moderately to highly plastic, damp, greasy with some lime mud.



193-209' Tan lime mud with some cemented lime mud fragments and moderate to large pieces of chert (197-198').



209-213' Tan lime, sands and gravels with mudstone fragments, fossiliferous with mollusks, saturated.

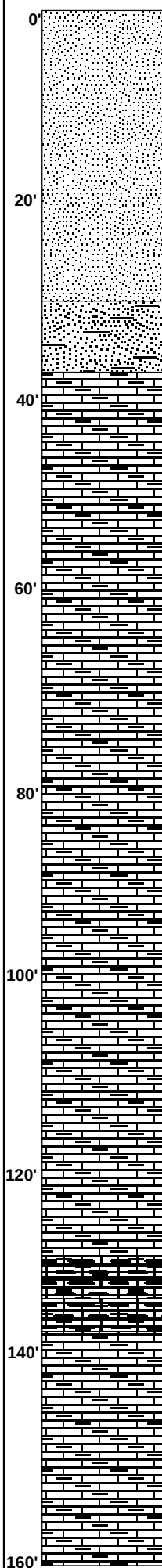


213-223' Medium olive green clay with some tan lime mud, low to moderate plasticity.



223-267' Saturated lime mud, lime sands and limestone fragments. Light tan to cream with some cemented lime mud fragments, saturated.

267-320' Light to medium tan, medium to coarse grain lime sands with abundant fossils and lime rock, saturated. Some black staining noted at 310 and 314' intervals.



0-27' Tan to gray, fine to very fine quartz sand, dry to 17'. Thin intervals of sand with clay (10%).



27-36' Light brown to dark grey fine grain sand with clay (20%) and black phosphatic sands (5-10%).



36-60' Dark grey lime mud with clay and trace of black phosphatic sand and pebbles. Large lime mud rock fragments from pebble to hand size (54-60').



60-85' Medium grey lime mud with lime mud rock fragments throughout. Possible wet zone at 66'. Some phosphatic sand and pebbles (less than 1%).



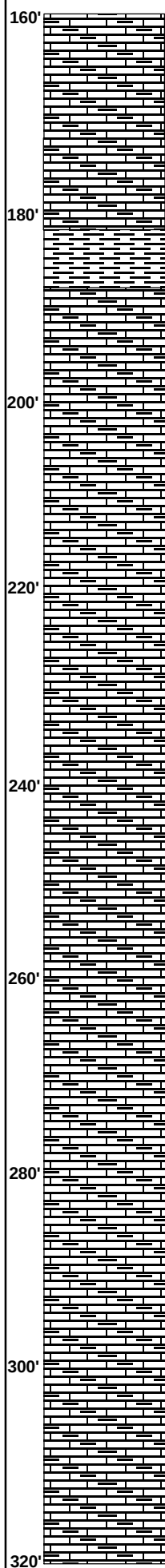
85-127' Grey green lime mud with occasional light tan lime muds with clay and lime mud rock fragments, very dry to wet.



127-136' Tan lime mud with abundant chert, medium grain to hand size fragments.

136-160' Light tan to very light tan lime sands, lime muds and rock (some with vuggy porosity), 5-10% containing shell molds.

DEP 4



160-182' Light tan lime mud with lime sand (15%) and consolidated limestone fragments (5%), damp to wet.

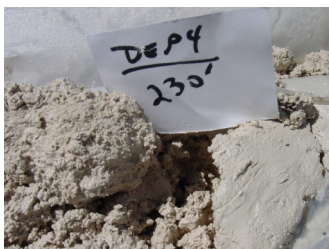
182-190' Dark to olive green stiff clay with some weathered limestone.



190-197' Tan lime mud with clay and limestone fragments, olive green clay from 195-197'.



197-227' Tan lime sand with lime mud and limestone fragments, saturated.



227-267' Light tan, poorly consolidated limestone with lime mud and lime sand, saturated.



267-287' Fragmented limestone with shell fossils and casts, saturated.



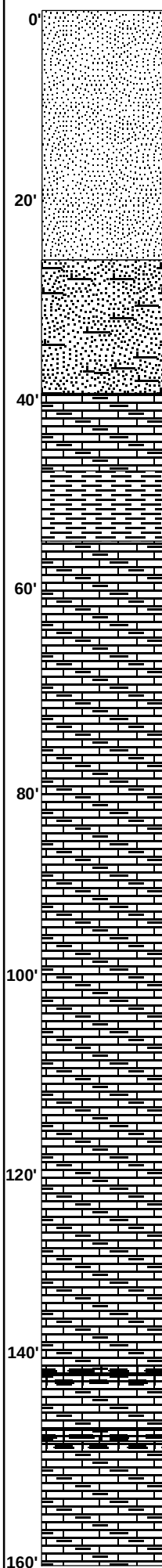
287-320' Poorly indurated tan limestone with shell and shell mold fossils, with lime sand and lime mud.



DEP 4 (208-228)

DEP 4 (255-275)

DEP 4 (300-320)



0-27' Light orange to dark brown quartz sand, fine to very fine grain with some silt, dry.



27-39' Tan brown lime mud with stringers of pure quartz sand, phosphatic sands and pebbles present, dry.



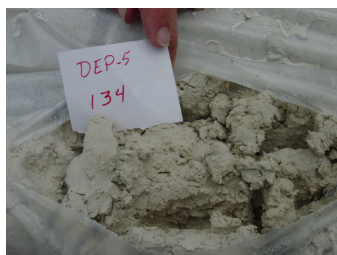
39-49' Dry stiff lime mud with grey green, marine clay with some quartz and phosphatic sand present.



49-55' Dark grey green marine clay with 10% phosphatic sand and pebbles present. Lime mud present increasing with respect to depth.



55-64' Lime mud with large phosphate pebbles present. Damp to wet at top with increasing dry/stiffness towards base of interval.



64-92' Lime mud, soft to very stiff with some phosphatic sand and pebbles (<10%).

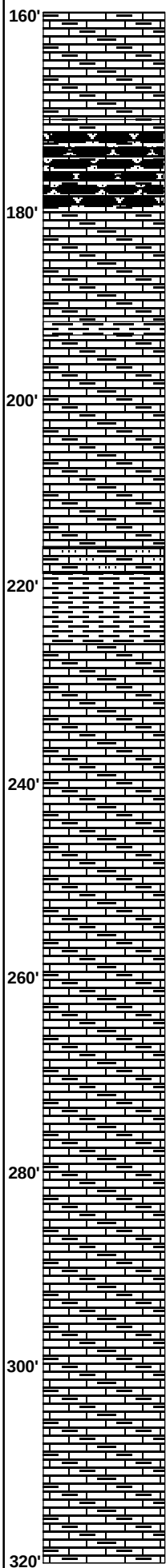


92-113' Dry lime mud with thin intervals of mottled green grey marine clay with small limestone fragments.

113-153' Lime mud with pieces of well indurated limestone present and quartz sand. Thin interval of chert from 146-147'.

153-160' Two foot chert interval at 153' intertwined with lime mud and sand, rest of interval is poorly indurated limestone, tan, wet.

DEP 5



DEP 5 (153-173)



160-167' Pure wet lime mud, dry.



167-181' Alternating limestone and chert layers with some lime mud, wet.

181-189' Tan lime mud, stiff, with limestone fragments, wet.

189-191' Green clay mottled with lime mud, very fine grain quartz sand present (30-40%), moist.



191-219' Tan lime mud with limestone fragments (50-50), some small phosphate pebbles with increasing amount of sand near base of interval (40%).

219-226' Dark green clay, stiff and dry, thin stringers of sand present.



226-247' Fossiliferous (molds and casts) well indurated, fractured limestone. Phosphate sand present (<10%).



DEP 5 (250-270)



247-320' Weathered limestone, coarse grained with occasional cemented pieces that are fossiliferous, wet.



DEP 5 (300-320)

Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: 8710 County Line Rd
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for a slug test. The diagram shows a vertical well casing with various dimensions and parameters labeled. A hand-drawn sketch of a well head is in the top right. The well casing is shown with a screen at the bottom. The diagram is divided into sections by horizontal lines. The top section shows the well head and casing. The middle section shows the well casing with a screen. The bottom section shows the well casing with a screen and an impermeable layer below. Dimensions and parameters are labeled in boxes: TD = 206, $r_t = 0.133$, $R_c = 2$, SWL = 46, $T_s = 15$, $L_w = 160$, $h =$, $L_c = 94$, $L_s = 94$, $R_b = 3$, $R_s = 2$, and $K = 2.647 \text{ Ft/Day}$. The impermeable layer is labeled at the bottom left.

Signature: _____ Date: _____

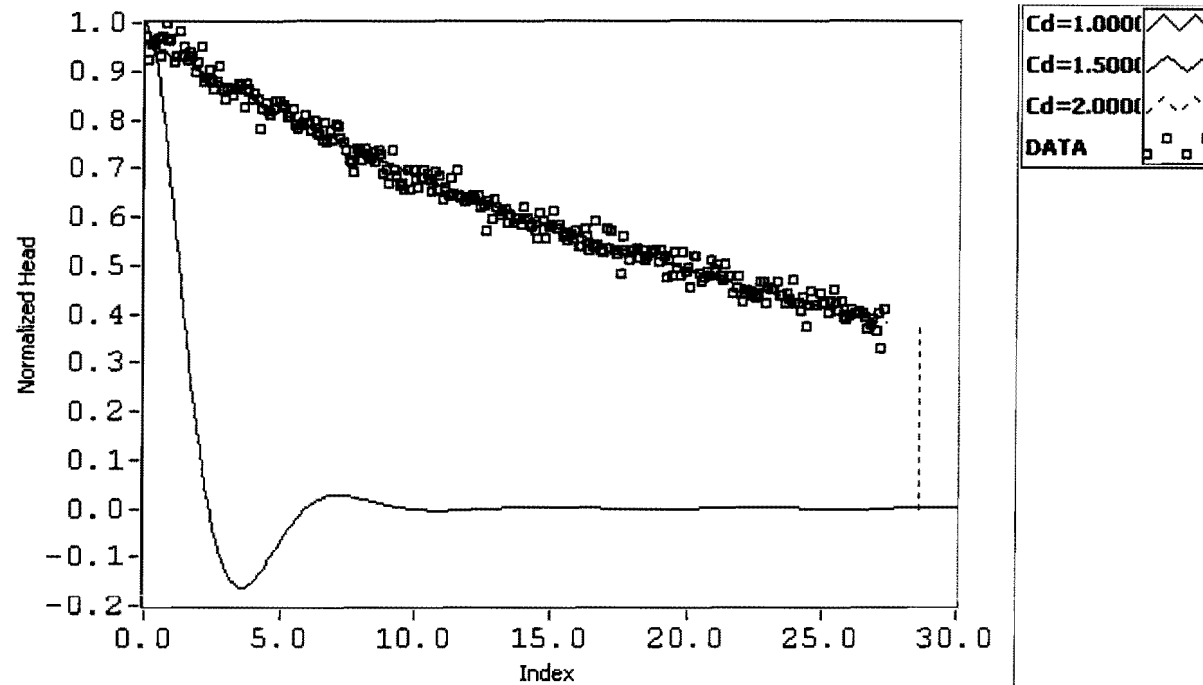
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 9.700 Sec to 234.400 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\8610-CL.dat

Printed: Monday, May 12, 2008 13:10:02



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pitcher Road
Well No: 7911 Carey Road
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The diagram shows a vertical well casing with a screen at the bottom. The parameters are defined as follows:

- r_t : Radius of the casing (0.133)
- R_c : Radius of the casing (2)
- SWL : Static Water Level (43.5)
- T_s : Screen length (4)
- L_w : Well length (90.5)
- L_e : Total length of the well (37)
- L_s : Screen length (37)
- R_b : Radius of the bottom of the screen (3)
- R_s : Radius of the screen (2)
- h : Height of the water column above the screen
- K : Permeability coefficient (35.964)
- Impermeable Layer**: The bottom boundary of the well.

Signature: _____ Date: _____

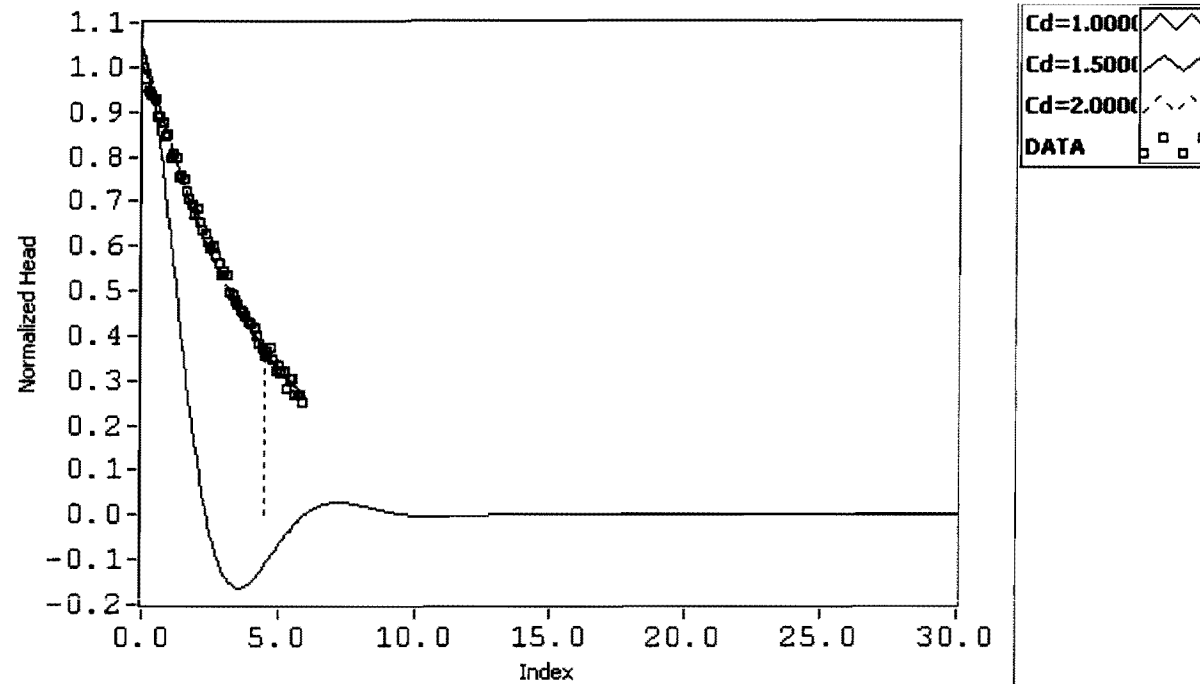
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 235.800 Sec to 293.800 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\7911-C.dat

Printed: Monday, May 12, 2008 13:33:00



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: 8506 Pritchard Road
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

TD = 187

$r_c = \underline{0.133}$

$R_c = \underline{2}$

SWL = 38.4

$T_s = \underline{9'}$

$L_w = \underline{148.6}$

$L_s = \underline{93.5}$

$R_b = \underline{3''}$

$R_s = \underline{2''}$

h = _____

Impermeable Layer

K: 21.14 ft/day

Signature: _____ Date: _____

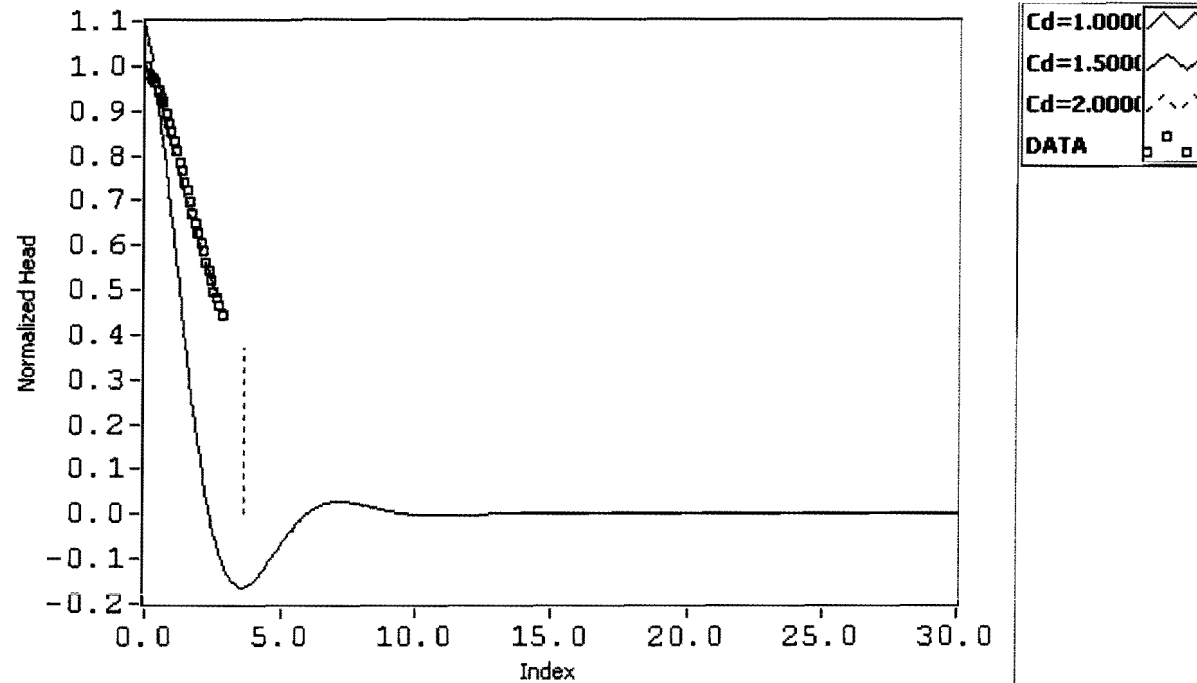
**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

Interval: 344.100 Sec to 477.300 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\8506-P.dat

Printed: Monday, May 12, 2008 13:03:58



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEPI-165
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

TD = 165'

$r_1 = \underline{0.133}$

$R_c = \underline{1"}$

SWL = 59.36

$T_s = \underline{14'}$

$L_w = \underline{105.64'}$

$h = \underline{\hspace{2cm}}$

$L_e = \underline{23'}$

$L_s = \underline{20'}$

$R_b = \underline{3"}$

$R_s = \underline{1"}$

Impermeable Layer

$K: \underline{4.247 \text{ Ft/Day}}$

Signature: _____ Date: _____

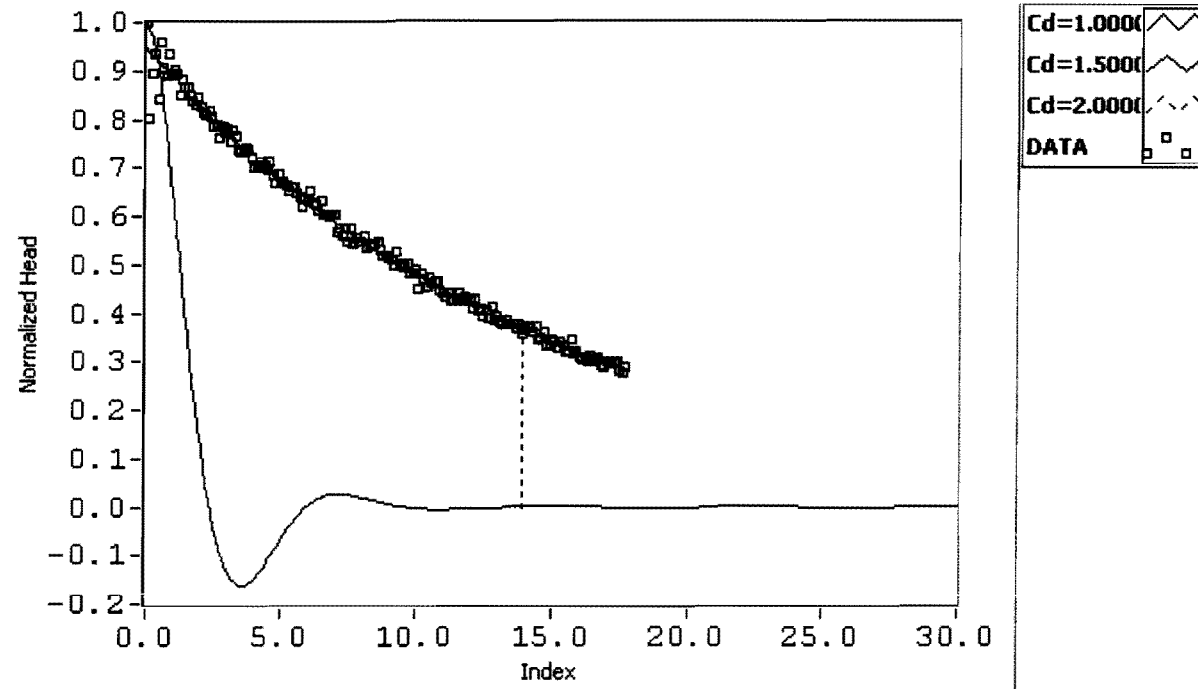
**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

Interval: 213.700 Sec to 299.300 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP1-165.dat

Printed: Monday, May 12, 2008 09:13:41



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pletcher Road
 Well No: DEP1-225'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown as a vertical cylinder with various layers and dimensions. The diagram includes labels for total depth (TD), casing radius (Rc), screen radius (Rs), and various lengths (Lw, Le, Ls, Ts). A dashed line indicates the water level (SWL). The bottom of the well is labeled as an impermeable layer with permeability K.

Key parameters and dimensions shown in the diagram:

- Site Name: Pletcher Road
- Well No: DEP1-225'
- Date: _____ Time: _____
- Operator: _____
- Proj. Name: _____
- TD = 225'
- $r_t = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 63.25'
- $T_s = \underline{10'}$
- $L_w = \underline{161.75'}$
- $L_e = \underline{23'}$
- $L_s = \underline{20'}$
- $R_b = \underline{3''}$
- $R_s = \underline{1''}$
- Impermeable Layer
- $K: \underline{41.216 \text{ Ft/Day}}$

Signature: _____ Date: _____

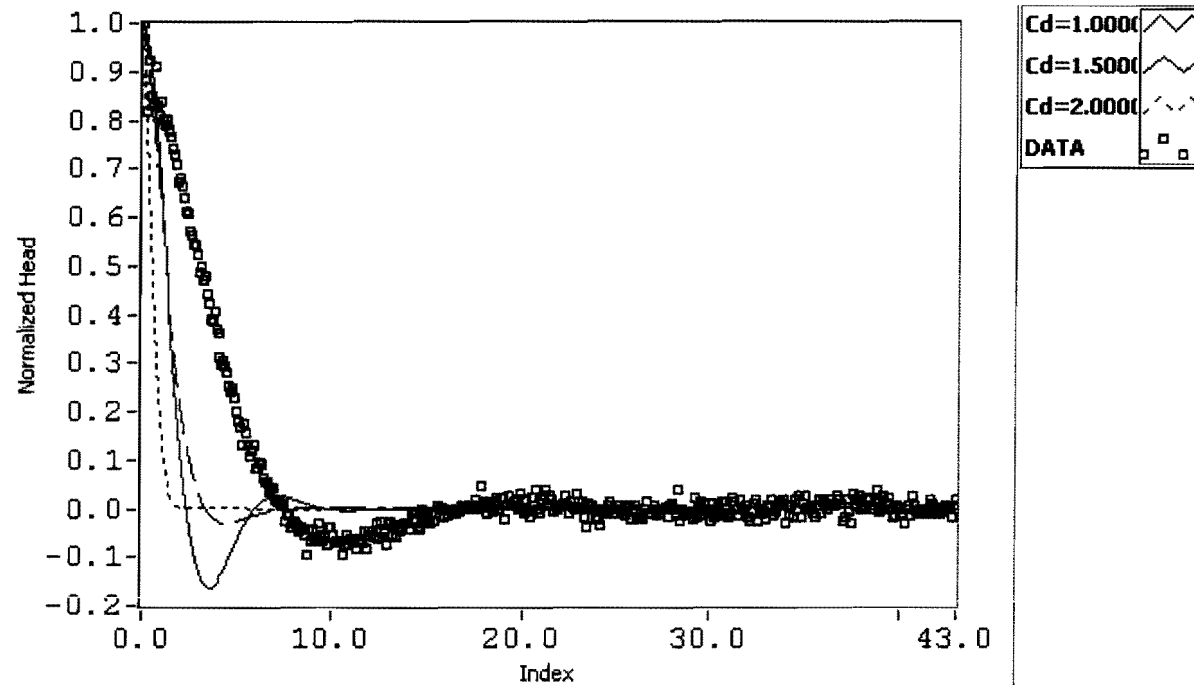
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 73.000 Sec to 116.200 Sec

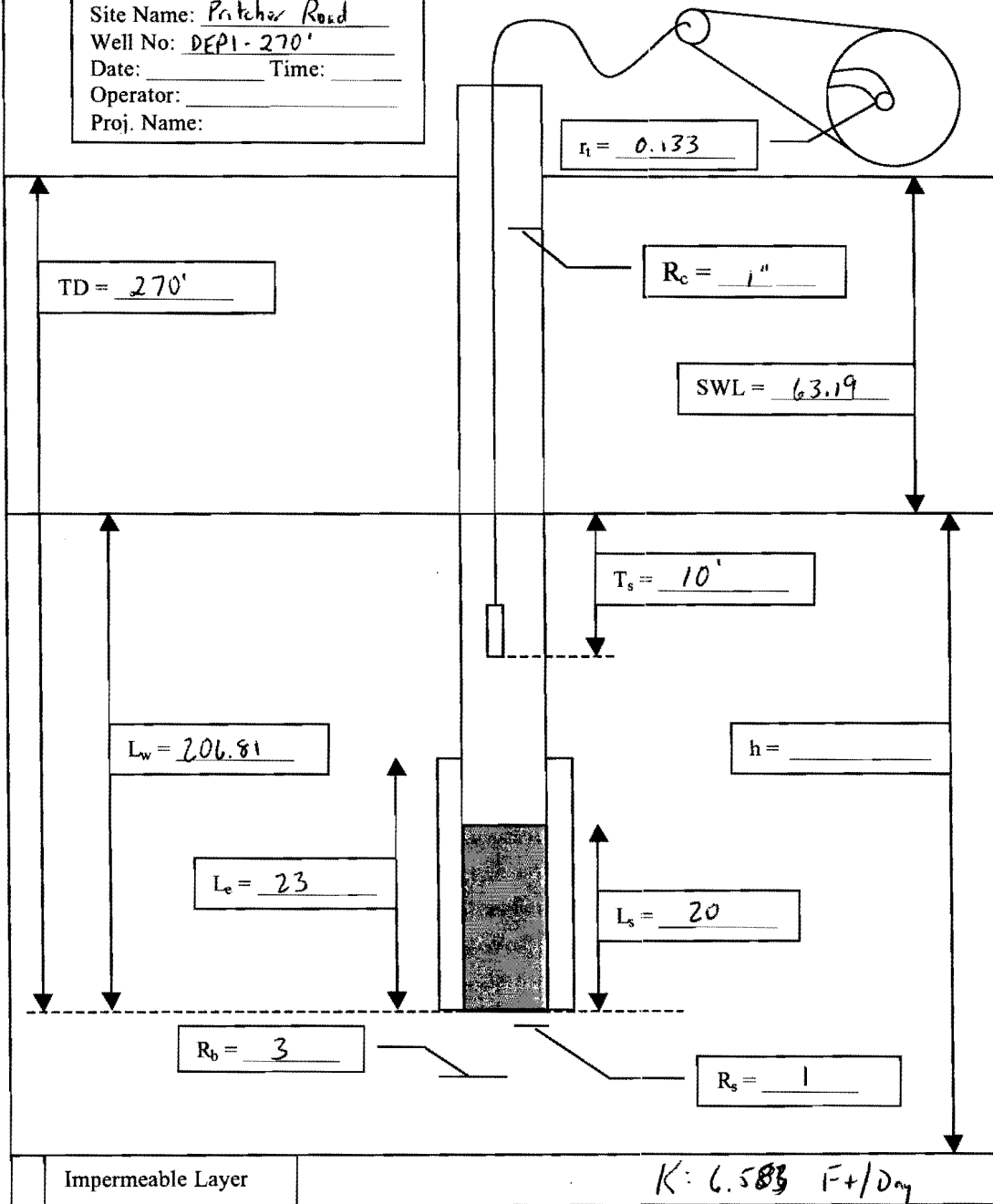
File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP1-225.dat

Printed: Monday, May 12, 2008 09:22:33



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP1-270'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____



Signature: _____ Date: _____

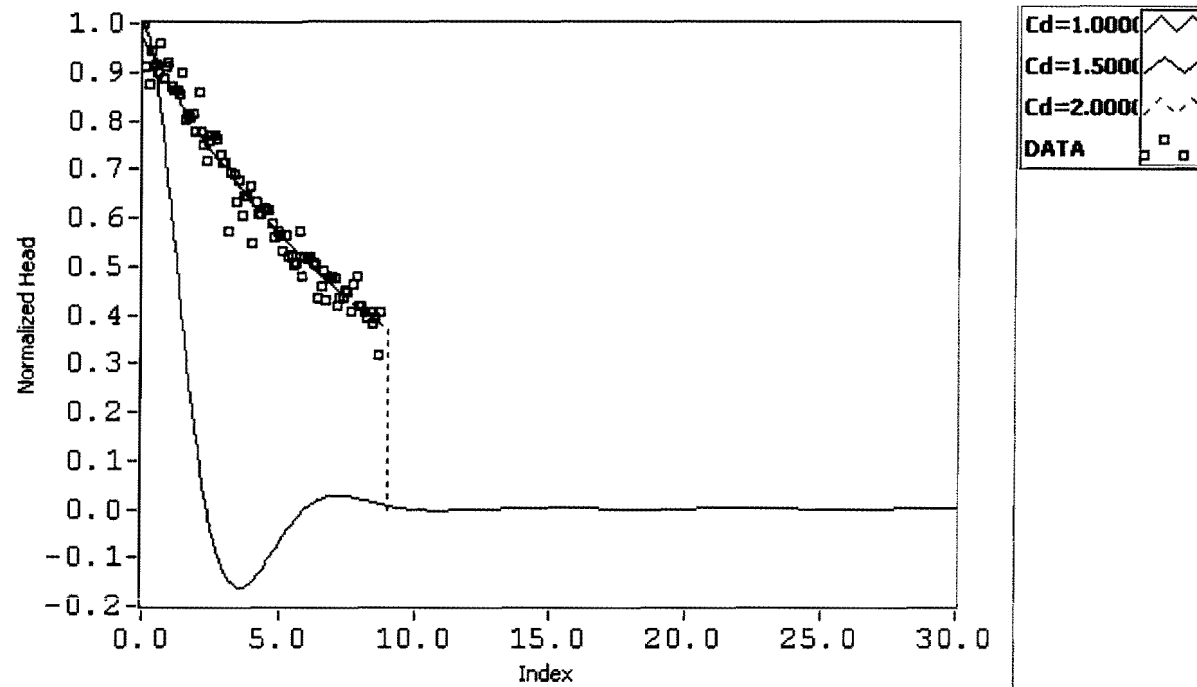
**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

Interval: 89.200 Sec to 178.900 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug Tests\DEP1-270.dat

Printed: Monday, May 12, 2008 09:28:12



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEPI-320'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for a slug test. The well is shown with various dimensions and parameters labeled:

- TD = 320'
- $r_t = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 63.32'
- $T_s = \underline{10'}$
- $L_w = \underline{251.68}$
- $h = \underline{\hspace{2cm}}$
- $L_c = \underline{23}$
- $L_s = \underline{20}$
- $R_b = \underline{3}$
- $R_s = \underline{1''}$
- Impermeable Layer
- $K: \underline{42.519 \text{ Ft/Day}}$

Signature: _____ Date: _____

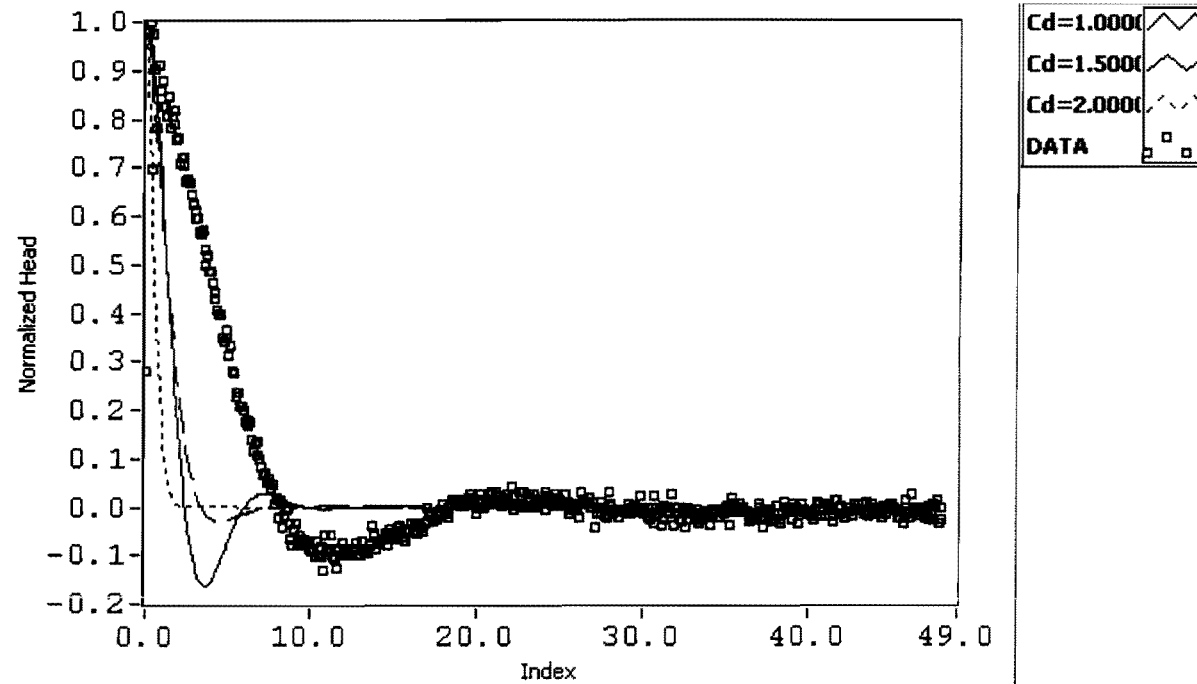
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 17.400 Sec to 65.700 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP1-320.dat

Printed: Monday, May 12, 2008 09:33:57



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEP2-163'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

$r_i = 0.133$

$R_c = 1''$

TD = 163'

SWL = 45.08

$T_s = 9.5'$

$L_w = 117.92$

$h =$ _____

$L_c = 23'$

$L_s = 20'$

$R_b = 3''$

$R_s = 1''$

Impermeable Layer

$K: 9.446 \text{ Ft/Day}$

Signature: _____ Date: _____

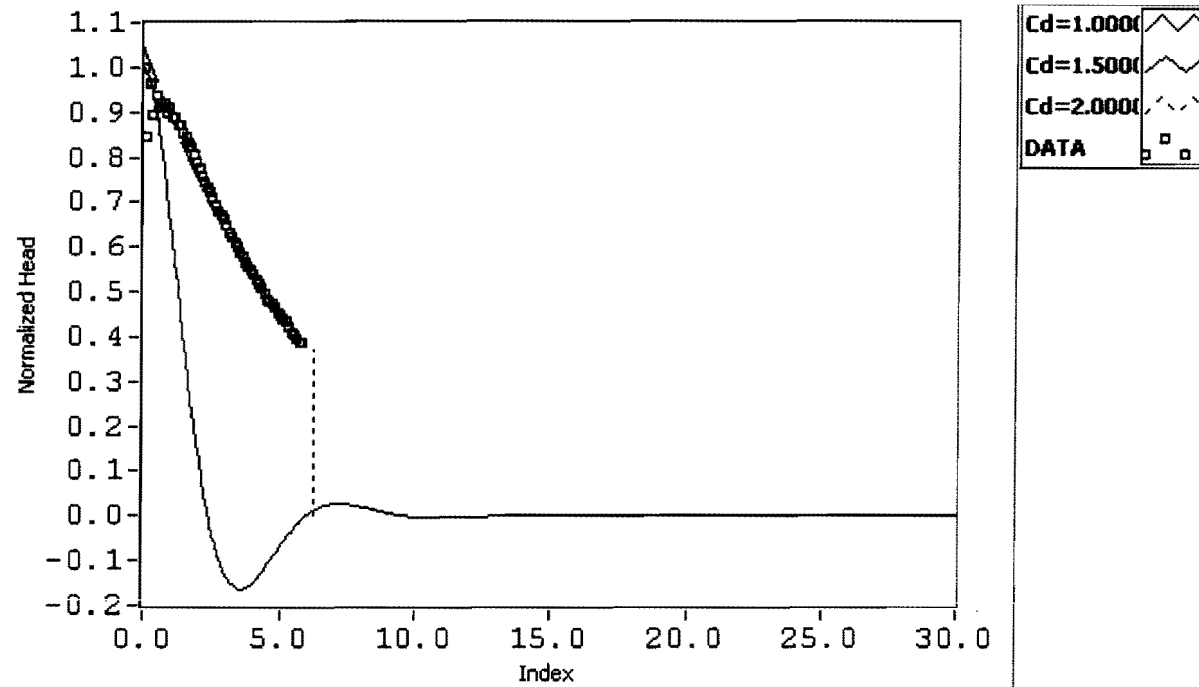
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 90.900 Sec to 136.100 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP2-163.dat

Printed: Friday, May 09, 2008 12:49:58



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritcher Road
 Well No: Rock N T Ranch
 Date: _____ Time: (8602)
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various layers and dimensions labeled.

Labels and values:

- TD = 119
- $r_t = \underline{0.133}$
- $R_c = \underline{2}$
- SWL = 38
- $T_s = \underline{9'}$
- $L_w = \underline{81}$
- $L_c = \underline{40}$
- $L_s = \underline{40}$
- $R_b = \underline{3}$
- $R_s = \underline{2}$
- h = _____
- Impermeable Layer
- K: 19.045 Ft/Day

Signature: _____ Date: _____

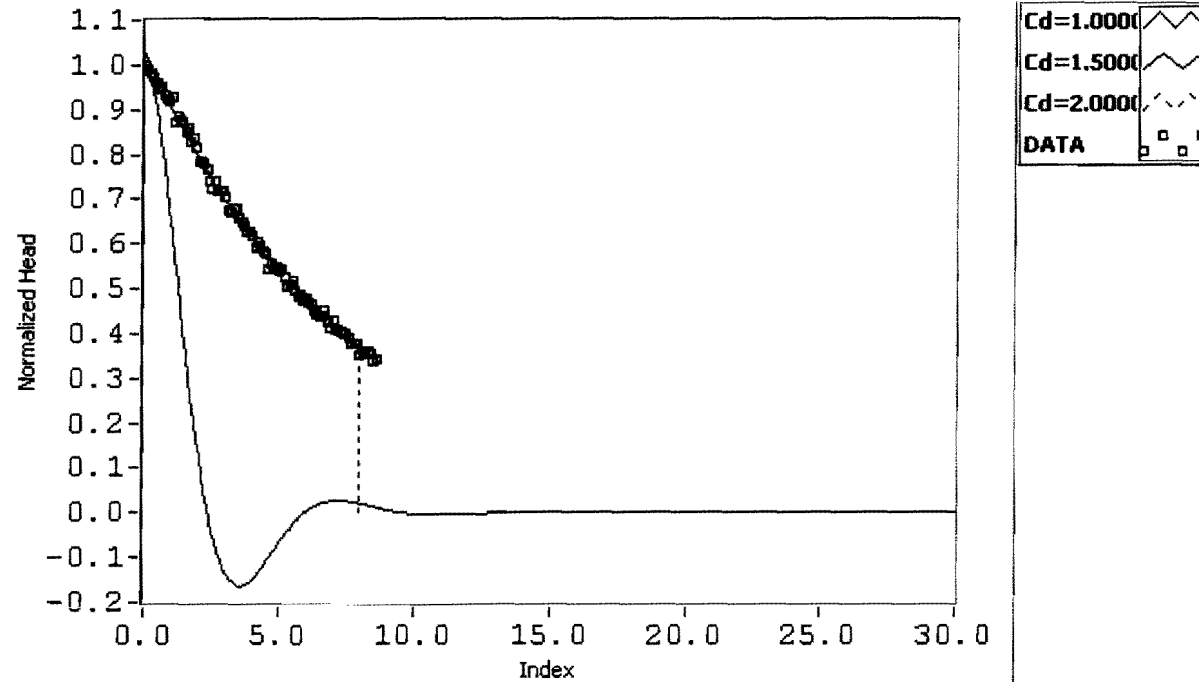
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 200.900 Sec to 372.200 Sec

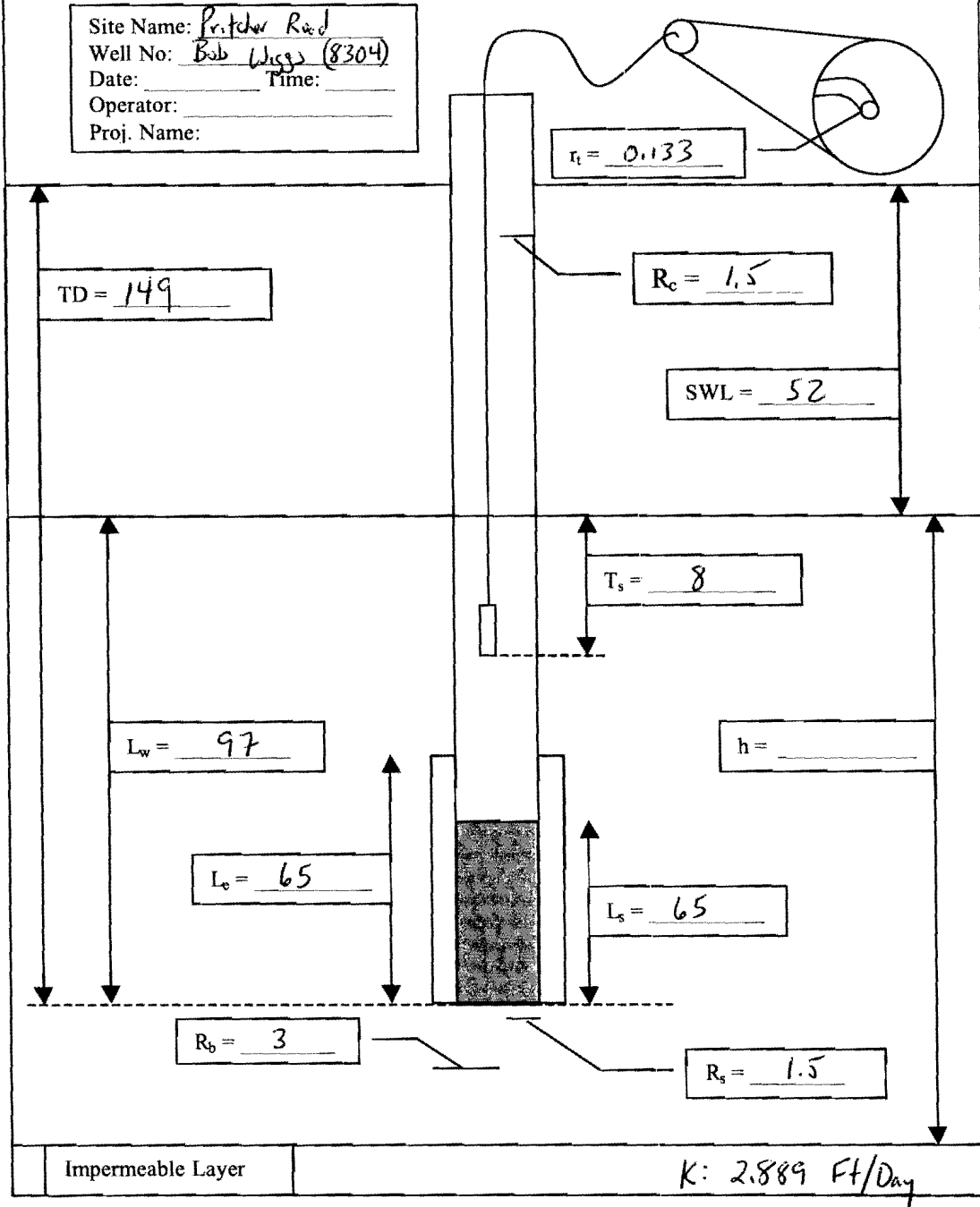
File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\RocnT.dat

Printed: Monday, May 12, 2008 13:13:38



Geoprobe® Slug Test Field Information Form for **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: Bob Wiggs (8304)
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____



Signature: _____ Date: _____

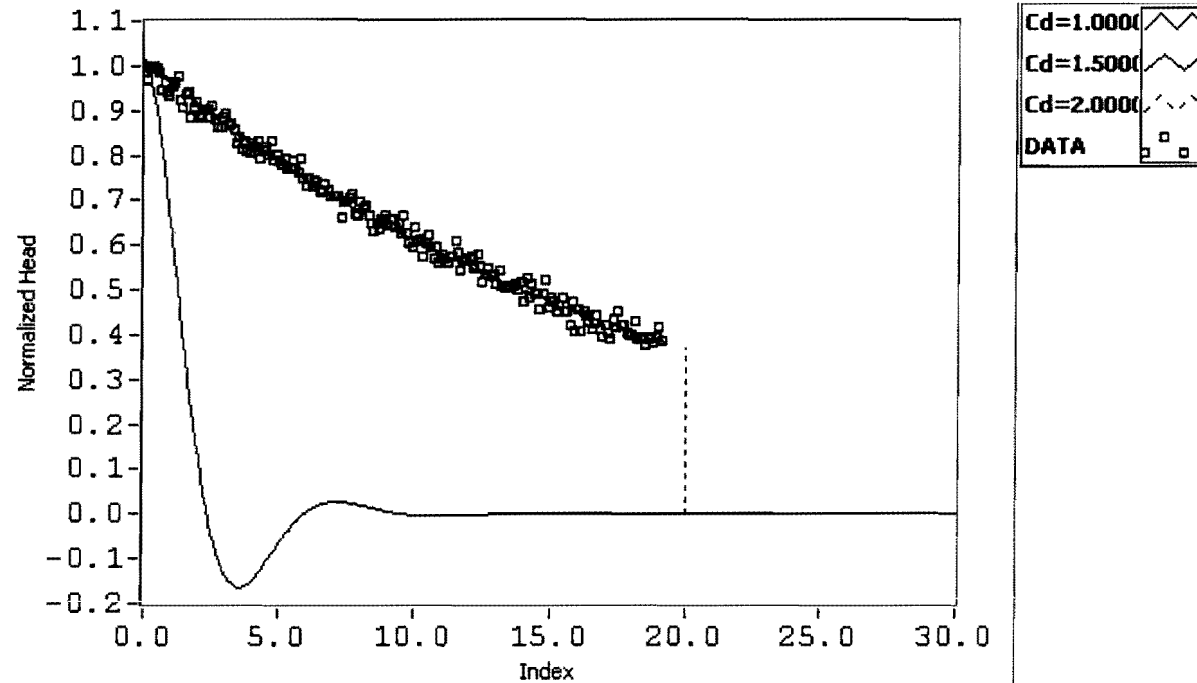
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 65.500 Sec to 214.900 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\Wiggs.dat

Printed: Monday, May 12, 2008 13:17:11



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: Bib U 455 (8304) #2
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The diagram shows a vertical well casing with a pump at the top. The well is divided into sections with various dimensions labeled in boxes. A dashed line at the bottom indicates an impermeable layer.

Parameters recorded on the form:

- Site Name: Pritchard Road
- Well No: Bib U 455 (8304) #2
- Date: _____ Time: _____
- Operator: _____
- Proj. Name: _____
- TD = 149
- $r_t = \underline{0.133}$
- $R_c = \underline{1.5}$
- SWL = 52
- $T_s = \underline{8}$
- $L_w = \underline{97}$
- $L_e = \underline{31}$
- $L_s = \underline{1}$
- $R_b = \underline{2''}$
- $R_s = \underline{1.5'}$
- Impermeable Layer
- K: 61.74 Ft/Day

Signature: _____ Date: _____

**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Site Name: Pritchard Road
Well No: DEP2-217
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Proj. Name:

$$R_s = \underline{\hspace{1cm}}$$

$K: 5.948 \text{ Ft/Day}$

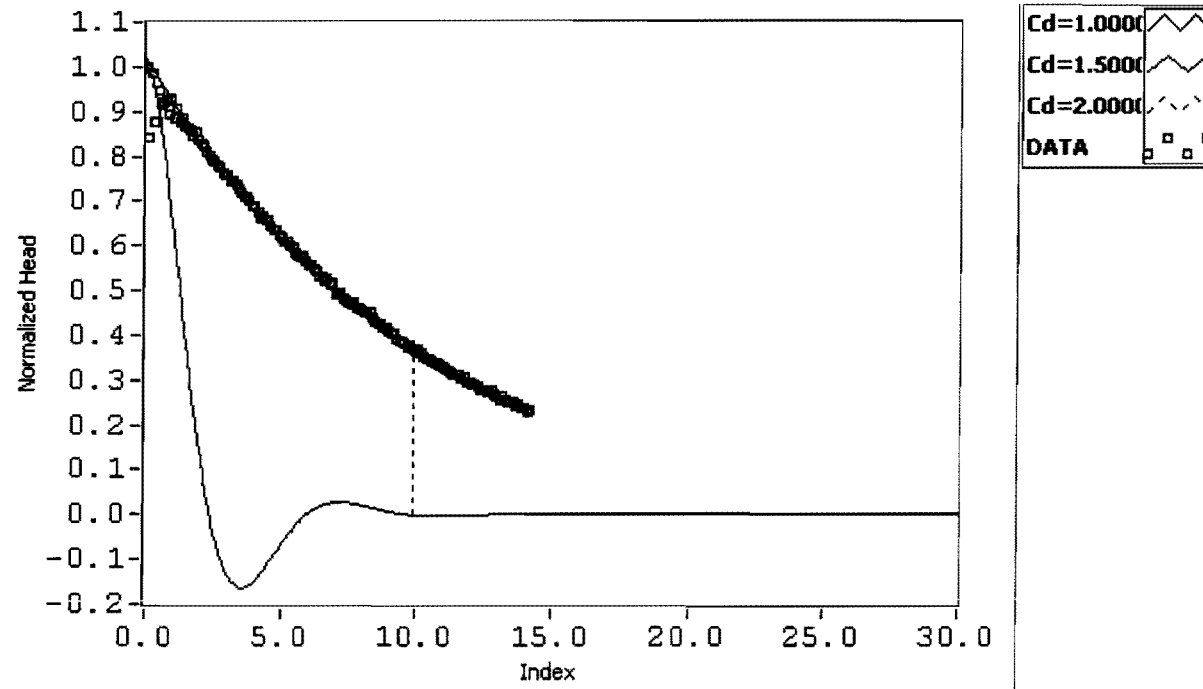
GW1600 Pneumatic Slug Test Kit

Interval Data Set

Interval: 171.200 Sec to 234.700 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP2-217.dat

Printed: Friday, May 09, 2008 12:55:03



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP2-276
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

TD = 276'

$r_t = 0.133$

$R_c = 1''$

SWL = 48.51

$T_s = 6.0$

$L_w = 23' \ 227.49$

$h =$ _____

$L_e = 23$

$L_s = 20'$

$R_b = 3''$

$R_s = 1''$

Impermeable Layer

$K = 3.329 \text{ FT/Day}$

Signature: _____ Date: _____

FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pitcher Road
 Well No: DEP 2 - 320'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and labels:

- TD = 320'
- $r_t = 0.133$
- $R_c = 1''$
- SWL = 52.05'
- $T_s = 16'$
- $L_w = 262.98$
- $L_e = 23$
- $L_s = 20'$
- $R_b = 3''$
- $R_s = 1'$
- h = _____
- Impermeable Layer
- $K = 3.085 \text{ ft/day}$

Signature: _____ Date: _____

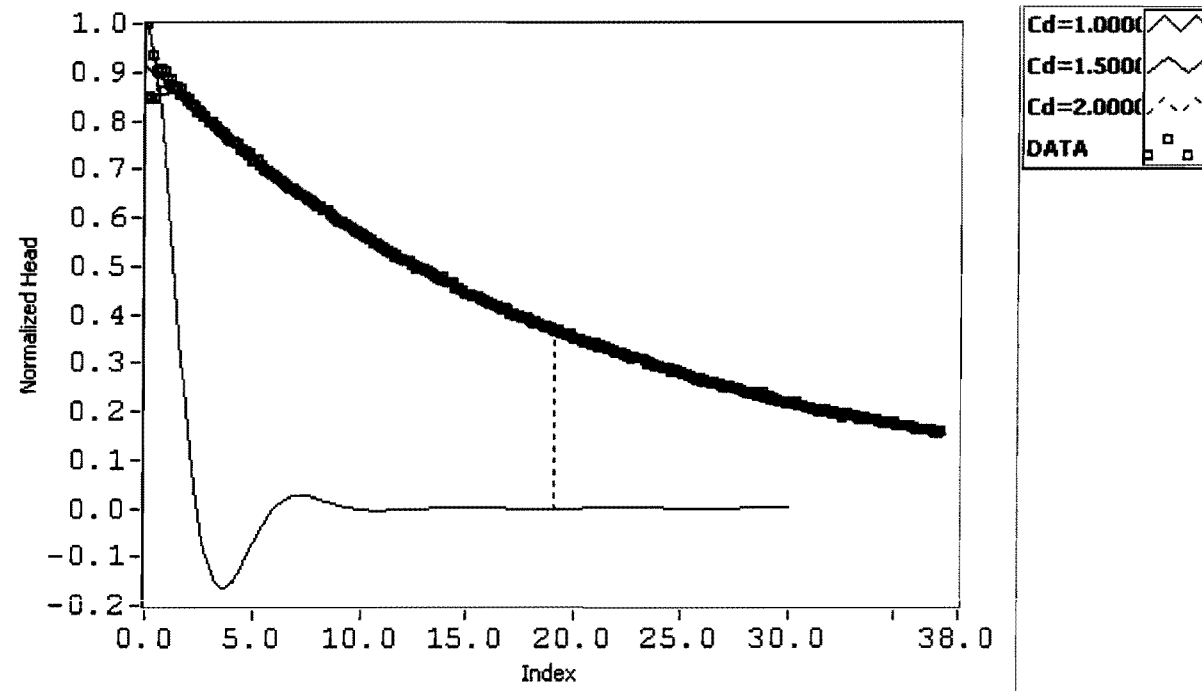
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 523.400 Sec to 642.000 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP2A320.dat

Printed: Friday, June 13, 2008 11:27:13



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEP3-167
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and parameters labeled:

- TD = 167
- $r_t = 0.133$
- $R_c = 1"$
- SWL = 38.59
- $T_s = 10'$
- $L_w = 128.41$
- $L_e = 23$
- $L_s = 20'$
- $R_b = 3"$
- $R_s = 1"$
- h = _____
- Impermeable Layer
- K: 2.694 Ft/Day

Signature: _____ Date: _____

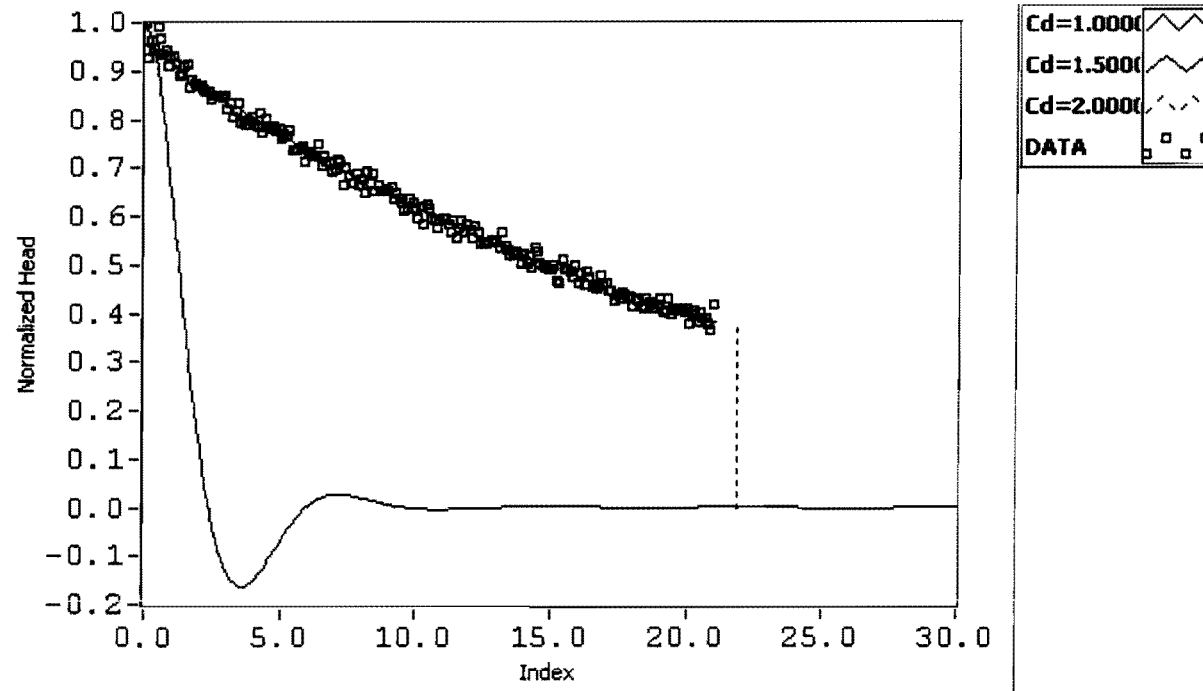
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 5.100 Sec to 142.400 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP3-167.dat

Printed: Friday, May 09, 2008 12:30:01



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritcher Road
 Well No: DEP3-215'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and labels:

- TD = 215'
- $r_t = 0.133$
- $R_c = 1''$
- SWL = 41.32'
- $T_s = 6.8'$
- $L_w = 173.68$
- $h =$ _____
- $L_e = 23'$
- $L_s = 20'$
- $R_b = 3''$
- $R_s = 1''$
- Impermeable Layer
- K: 41.376 Ft/Day

Signature: _____ Date: _____

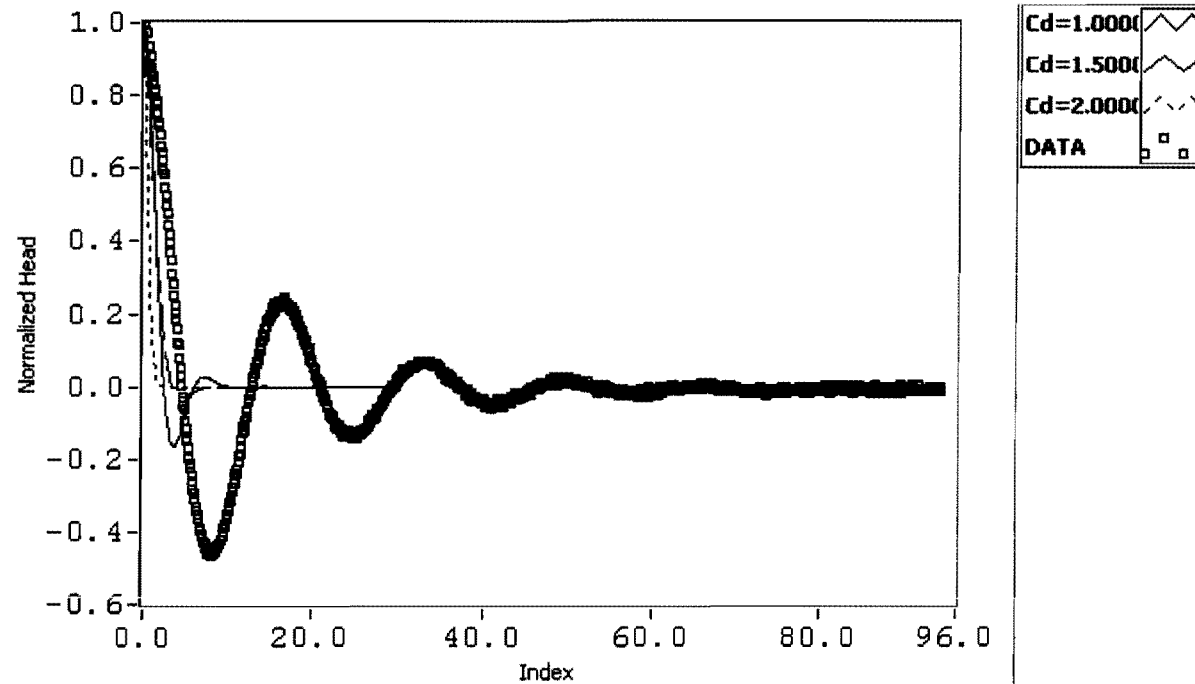
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 361.600 Sec to 456.000 Sec

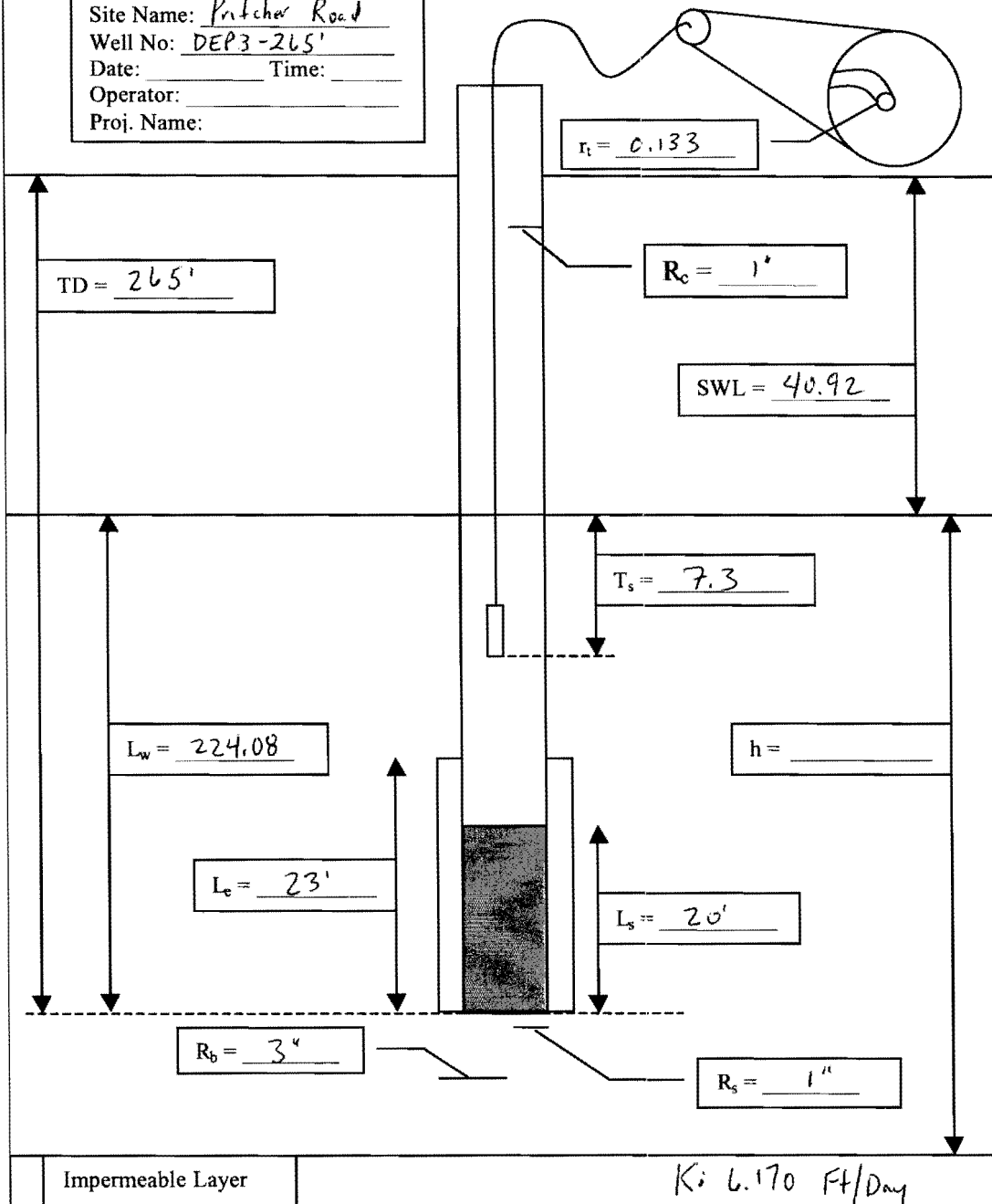
File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP3-215.dat

Printed: Friday, May 09, 2008 12:35:14



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP3-265'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____



Signature: _____ Date: _____

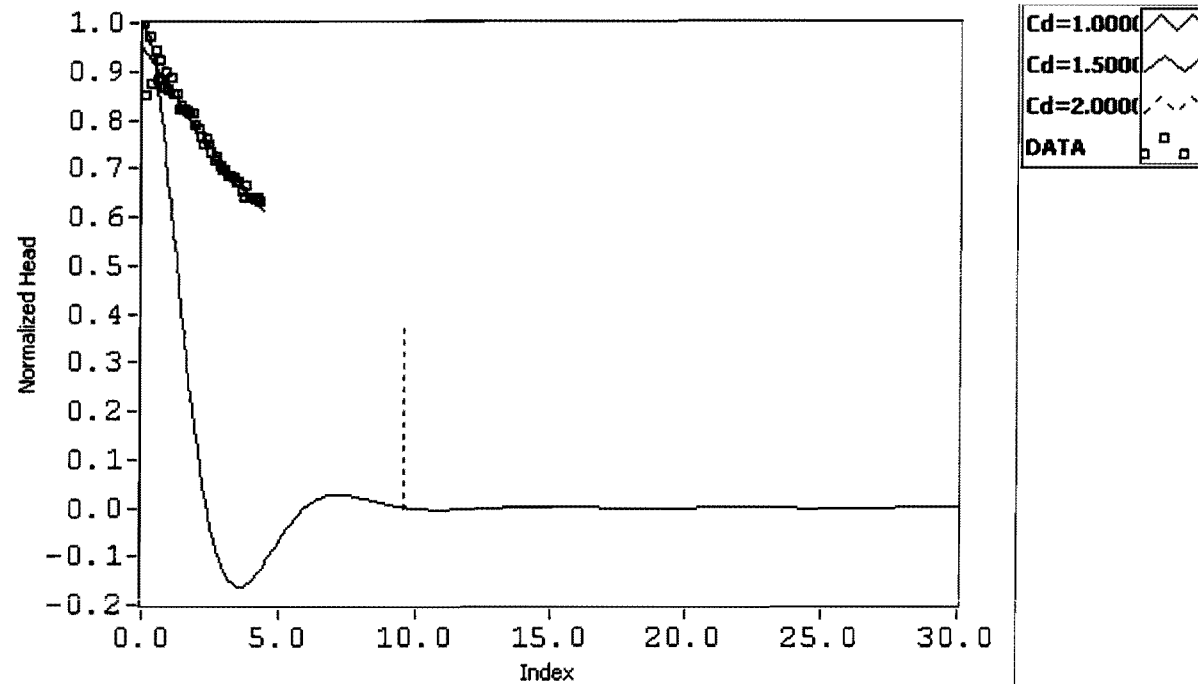
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 22.600 Sec to 204.200 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP3-265.dat

Printed: Friday, May 09, 2008 12:40:06



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP3-320
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and parameters labeled.

Parameters and Dimensions:

- TD = 320'
- $r_t = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 40.06
- $T_s = \underline{8'}$
- $L_w = \underline{279.94}$
- $h = \underline{\hspace{2cm}}$
- $L_e = \underline{23'}$
- $L_s = \underline{20'}$
- $R_b = \underline{3''}$
- $R_s = \underline{1''}$
- Impermeable Layer
- $K: \underline{1.386 \text{ Ft/Day}}$

Signature: _____ Date: _____

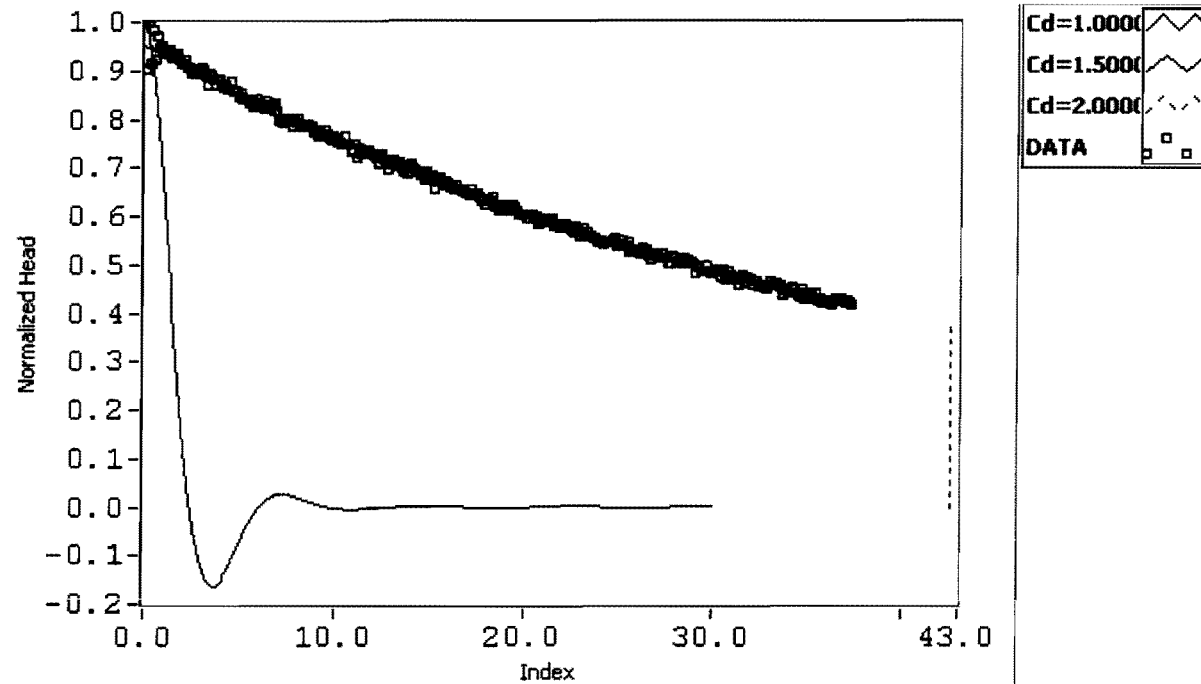
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 20.000 Sec to 269.700 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP3-320.dat

Printed: Friday, May 09, 2008 12:44:24



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEP4-163'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and parameters labeled:

- $r_s = 0.133$
- $R_c = 1"$
- $SWL = 45.21$
- $T_s = 16'$
- $L_w = 117.79$
- $h =$ _____
- $L_e = 23'$
- $L_s = 20$
- $R_b = 3'$
- $R_s = 1"$
- Impermeable Layer
- $K: 3.709 \text{ Ft/Day}$
- $TD = 163'$

Signature: _____ Date: _____

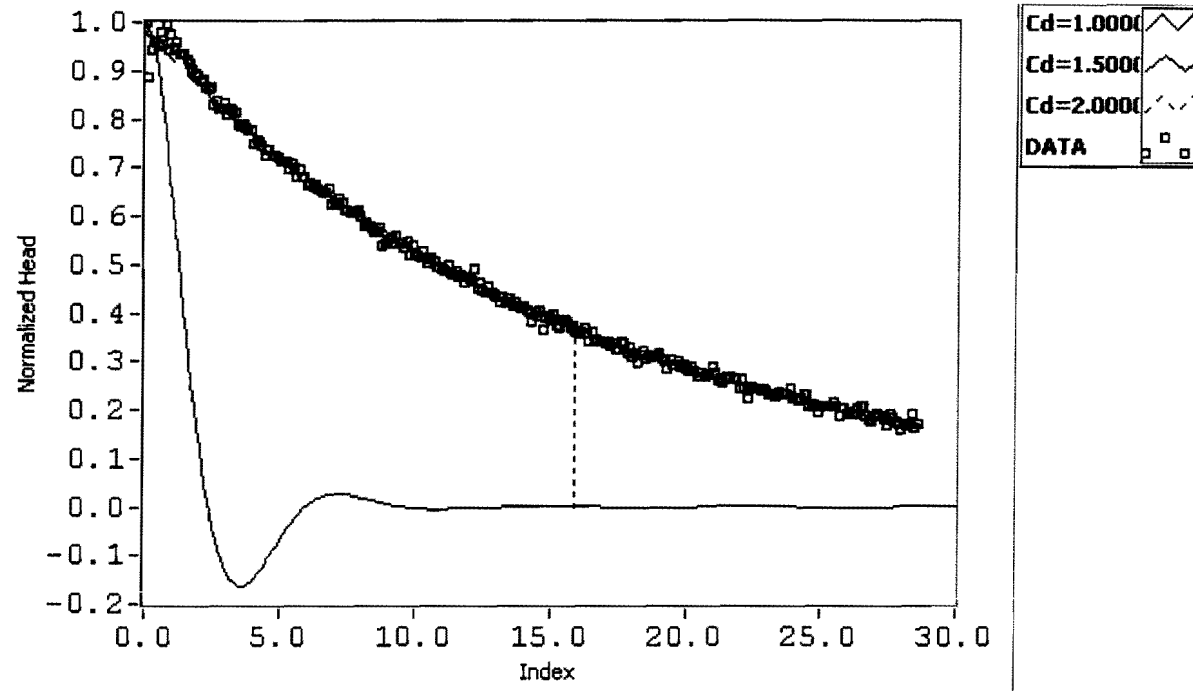
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 191.700 Sec to 303.400 Sec

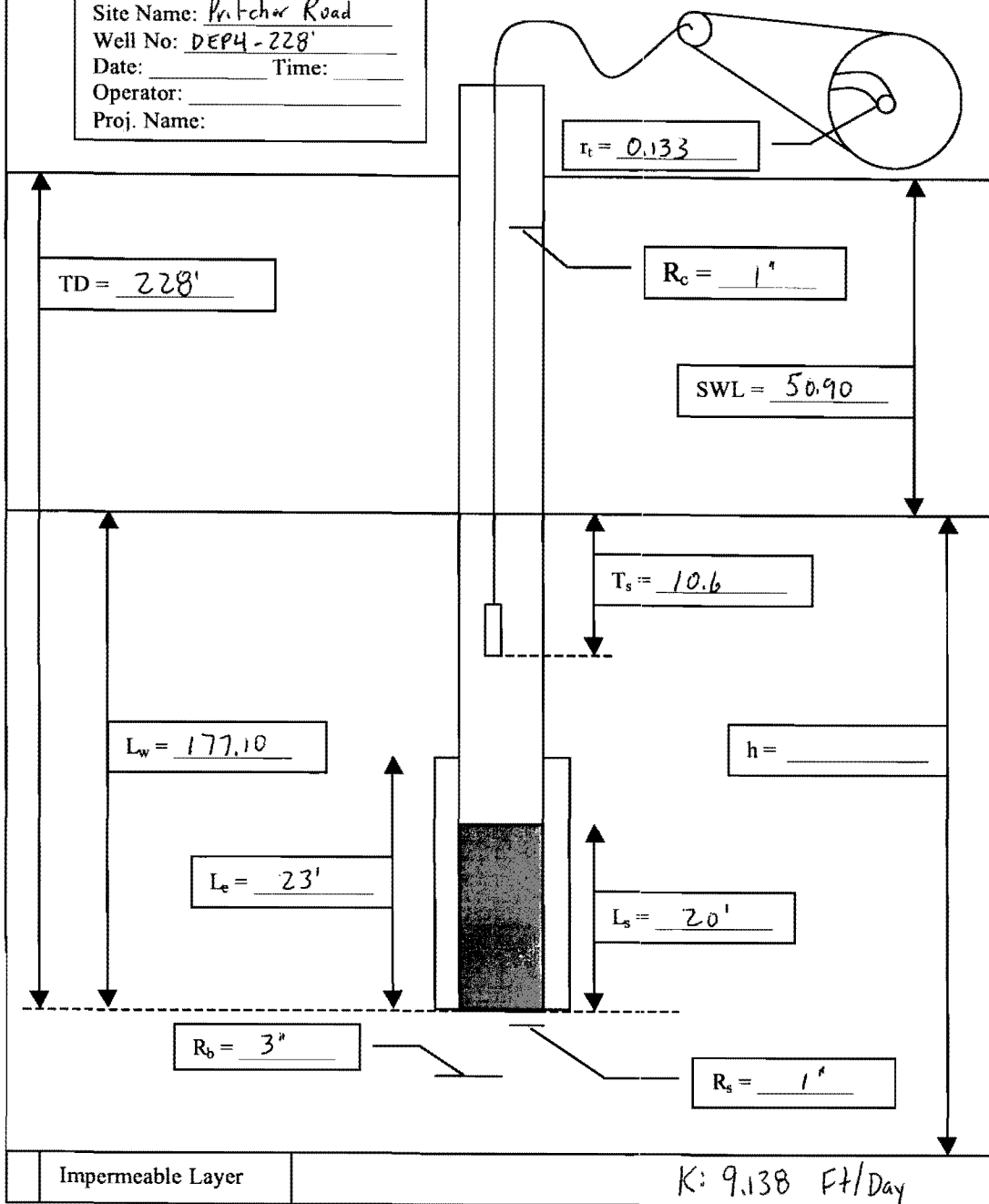
File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP4-163.dat

Printed: Friday, May 09, 2008 12:04:42



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEPH-228'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____



Signature: _____ Date: _____

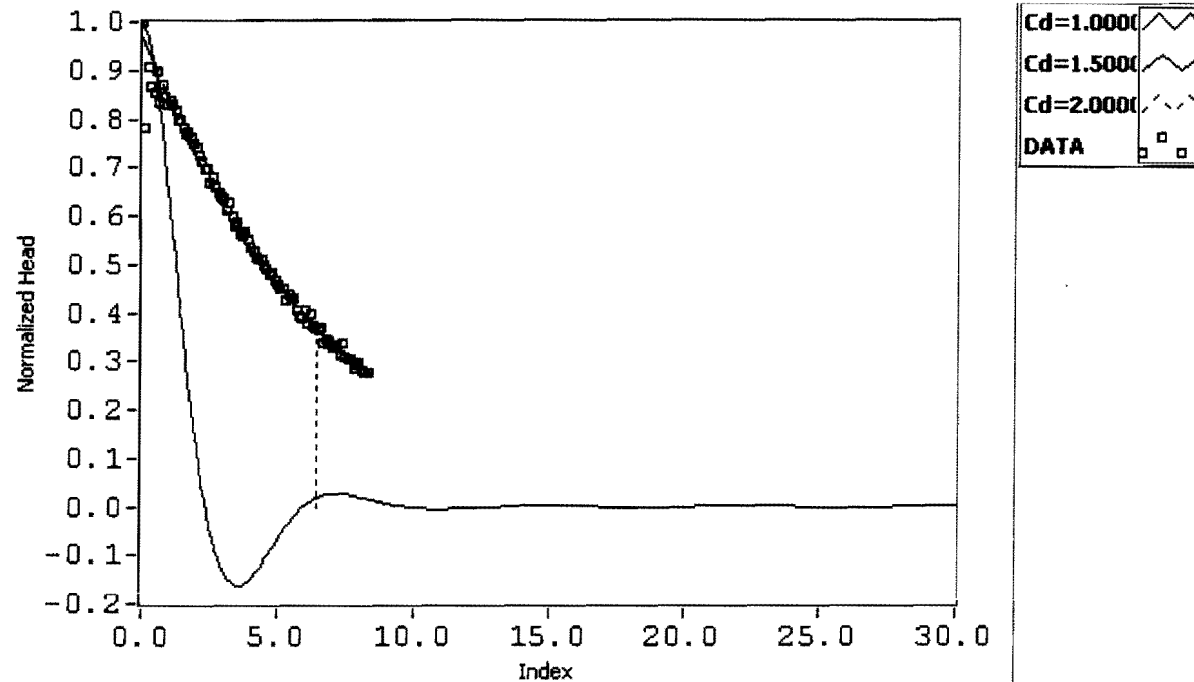
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 291.800 Sec to 405.100 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP4-228.dat

Printed: Friday, May 09, 2008 12:11:16



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEP4-275'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for a slug test. The well is shown with various dimensions and parameters labeled:

- TD = 275'
- $r_t = 0.133$
- $R_c = 1"$
- SWL = 50.88
- $T_s = 10.9$
- $L_w = 224.12$
- $L_e = 23'$
- $h =$ _____
- $L_s = 20'$
- $R_b = 3"$
- $R_s = 1"$
- Impermeable Layer
- $K = 9.419 \text{ Ft/Day}$

Signature: _____ Date: _____

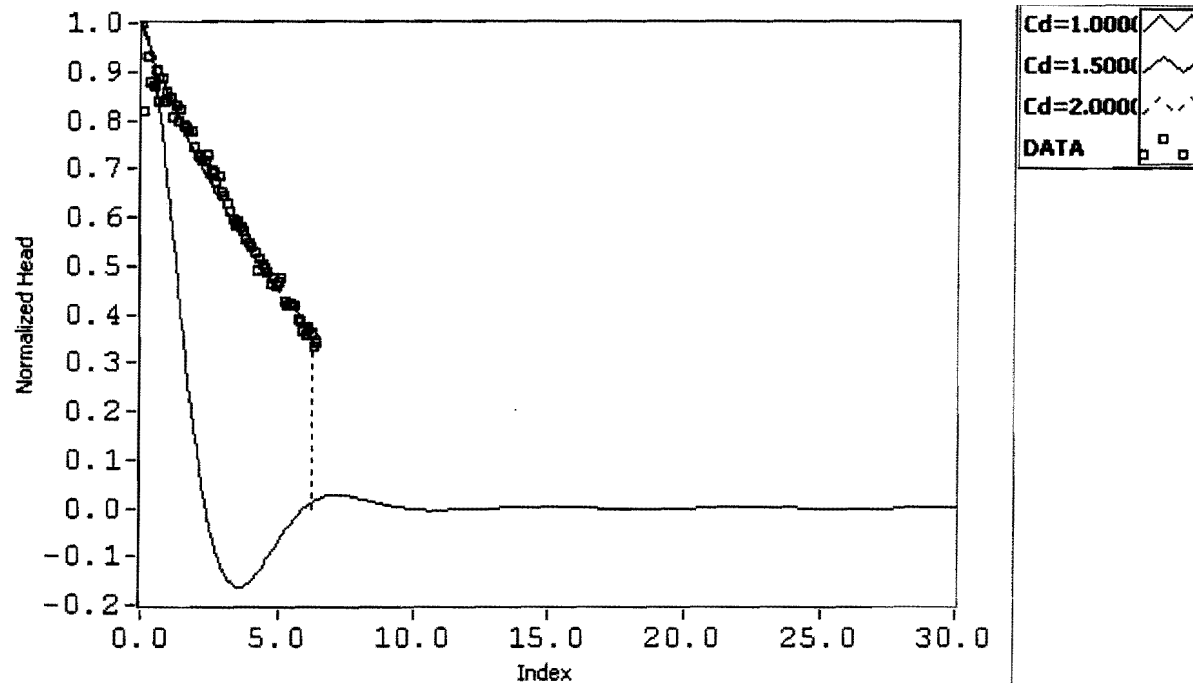
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 6.600 Sec to 153.900 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP4-275.dat

Printed: Friday, May 09, 2008 12:17:01



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP4-320'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and parameters labeled.

Parameters labeled in the diagram:

- TD = 320'
- $r_t = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 50.46
- $T_s = \underline{11'}$
- $L_w = \underline{269.54}$
- $h = \underline{\hspace{2cm}}$
- $L_e = \underline{23}$
- $L_s = \underline{20}$
- $R_b = \underline{3}$
- $R_s = \underline{1''}$
- Impermeable Layer
- $K: \underline{5.008 \text{ Ft/Day}}$

Signature: _____ Date: _____

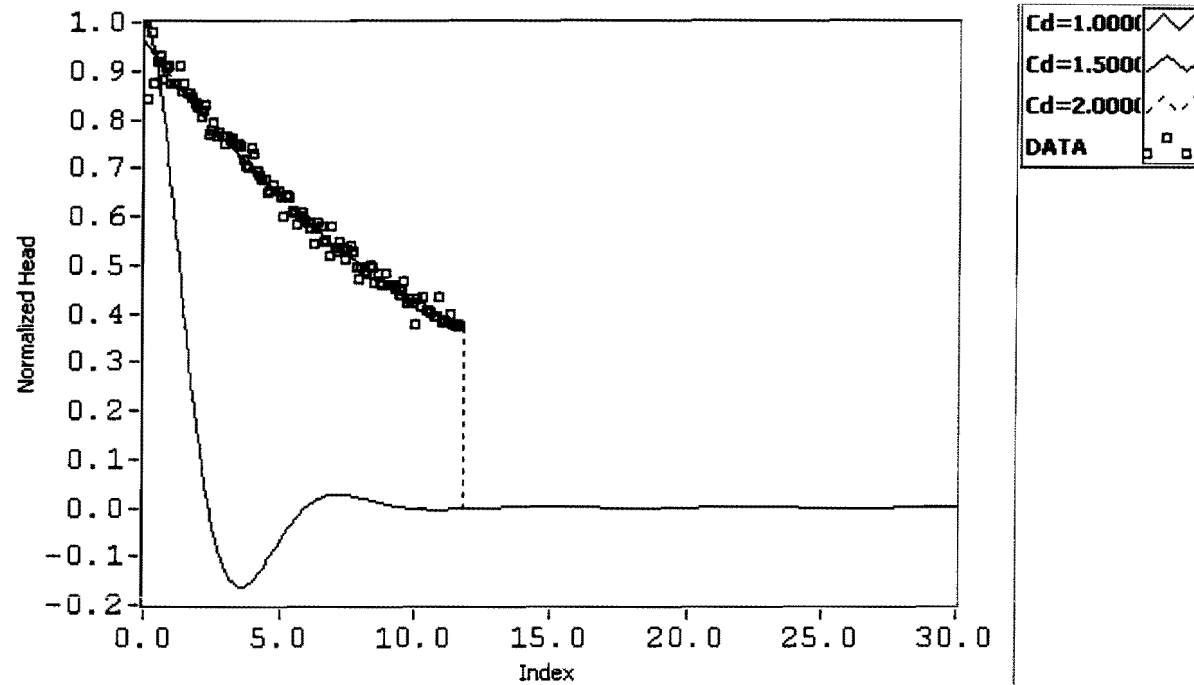
**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

Interval: 537.200 Sec to 621.200 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP4-320.dat

Printed: Friday, May 09, 2008 12:22:15



Geoprobe® Slug Test Field Information Form for **Well Construction / Water Sampler Installation**

Site Name: Pitcher Road
Well No: DEP5-173
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with a casing and a screen. The total depth (TD) is 173'. The casing radius (R_c) is 1. The static water level (SWL) is 44.48. The screen length (T_s) is 7.7'. The well length (L_w) is 128.52. The effective length (L_e) is 23'. The screen length (L_s) is 20'. The borehole radius (R_b) is 3". The screen radius (R_s) is 1". The permeability coefficient (K) is 4.175 Ft/Day. The bottom of the well is labeled as an Impermeable Layer.

Signature: _____ Date: _____

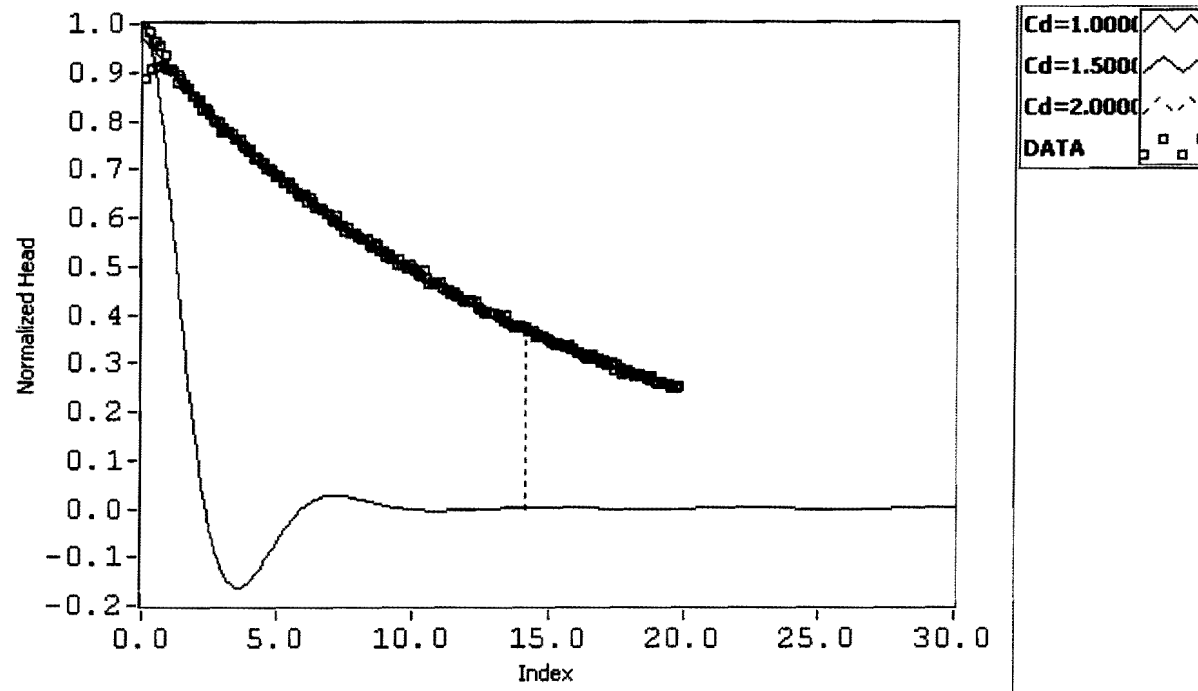
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 590.700 Sec to 667.000 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP5-173.dat

Printed: Friday, May 09, 2008 11:39:15



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Fletcher Road
Well No: DEPS-220'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and components labeled.

Parameters and Dimensions:

- TD = 220'
- $r_t = \underline{0.133}$
- $R_c = \underline{1}$
- SWL = 44.78
- $T_s = \underline{7.4}$
- $L_w = \underline{175.22}$
- $L_e = \underline{23'}$
- $L_s = \underline{20'}$
- $R_b = \underline{3}$
- $R_s = \underline{1}$
- Impermeable Layer
- $K: \underline{1.595 \text{ Ft/Day}}$
- $h = \underline{\hspace{2cm}}$

Signature: _____ Date: _____

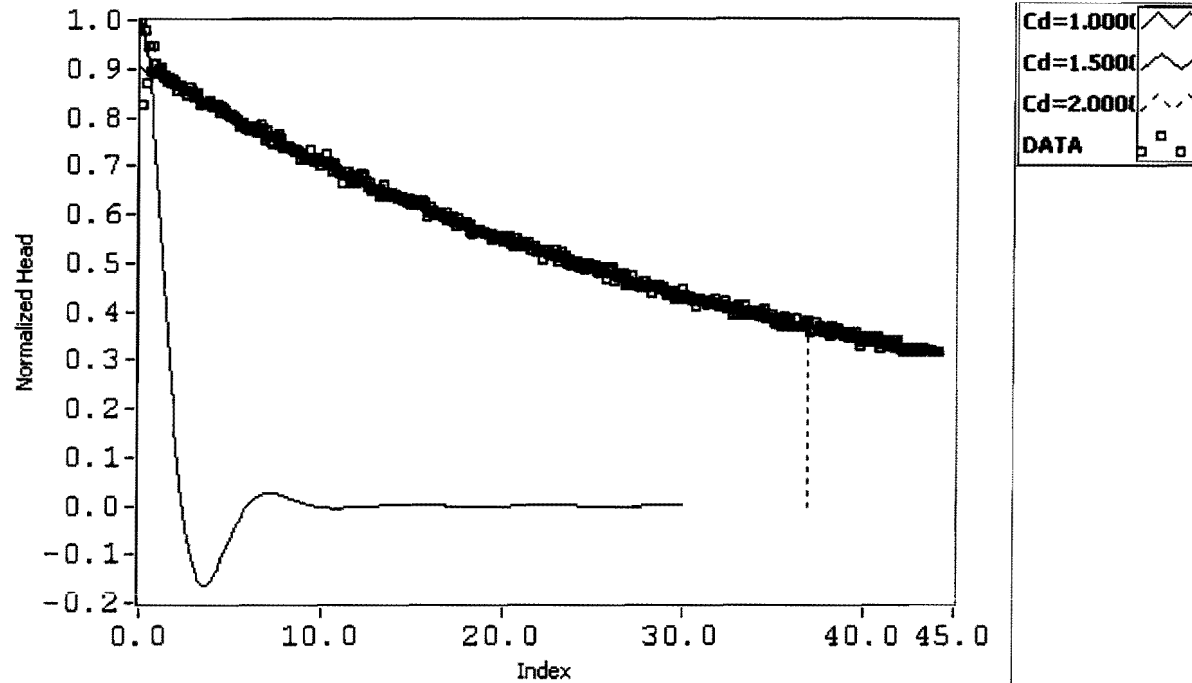
**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

Interval: 716.000 Sec to 992.600 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP5-220.dat

Printed: Friday, May 09, 2008 11:46:09



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEPS-270'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The diagram shows a vertical well casing with various dimensions and parameters labeled.

Parameters and Dimensions:

- TD = 270'
- $r_t = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 46.10
- $T_s = \underline{6.2}$
- $L_w = \underline{223.9}$
- $h = \underline{\hspace{2cm}}$
- $L_e = \underline{23'}$
- $L_s = \underline{20'}$
- $R_b = \underline{3''}$
- $R_s = \underline{1''}$
- Impermeable Layer
- $K = \underline{7.227 \text{ Ft/Day}}$

Signature: _____ Date: _____

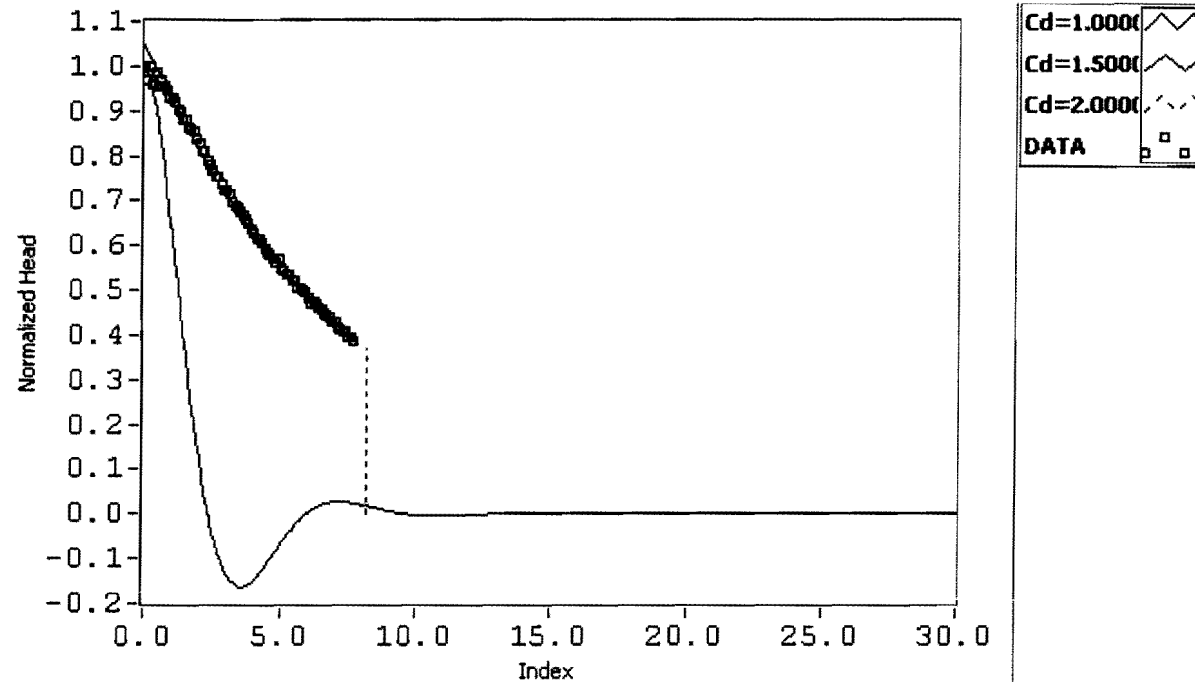
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 153.400 Sec to 220.200 Sec

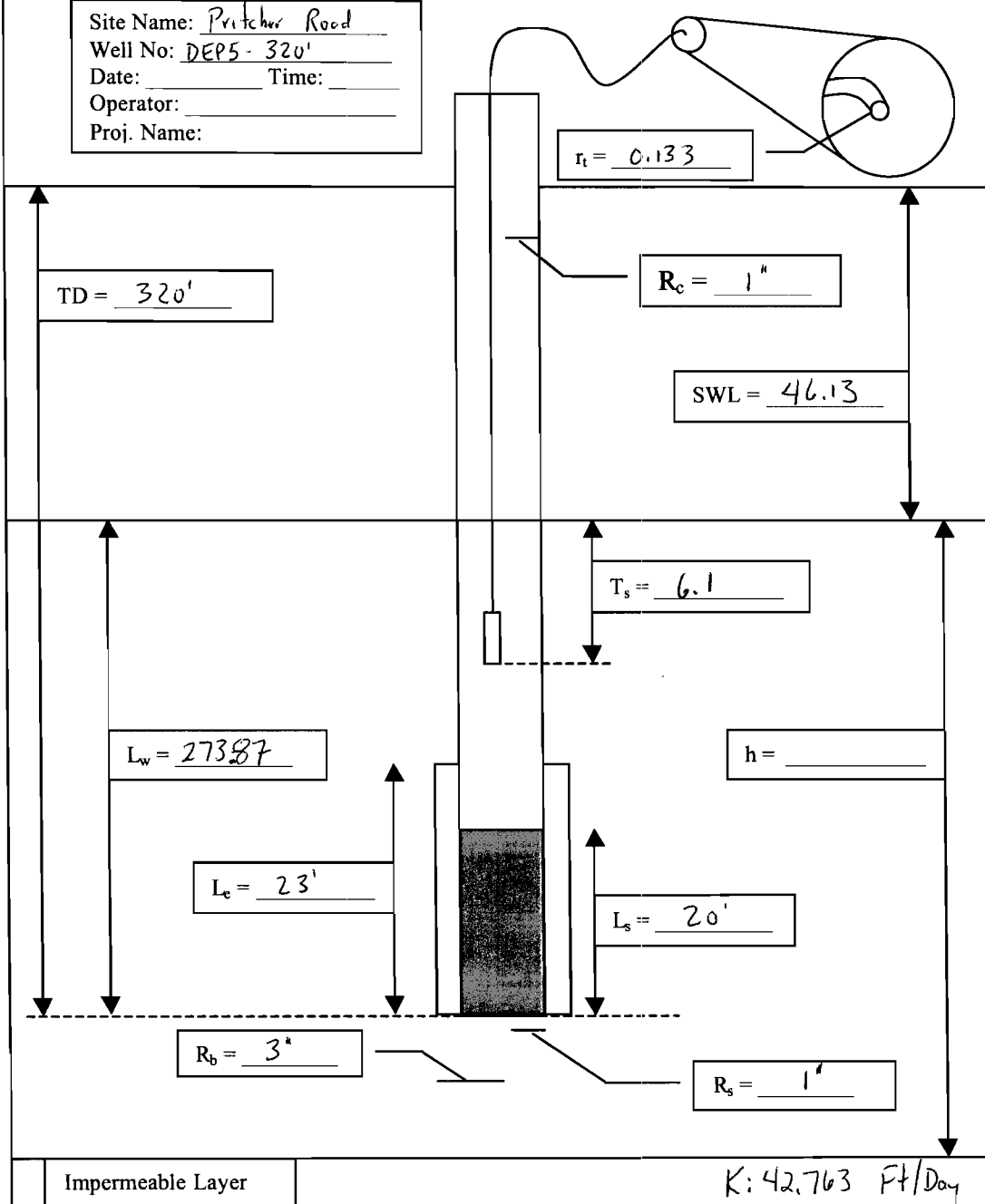
File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP5-270.dat

Printed: Friday, May 09, 2008 11:51:43



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEP5-320'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____



Signature: _____ Date: _____

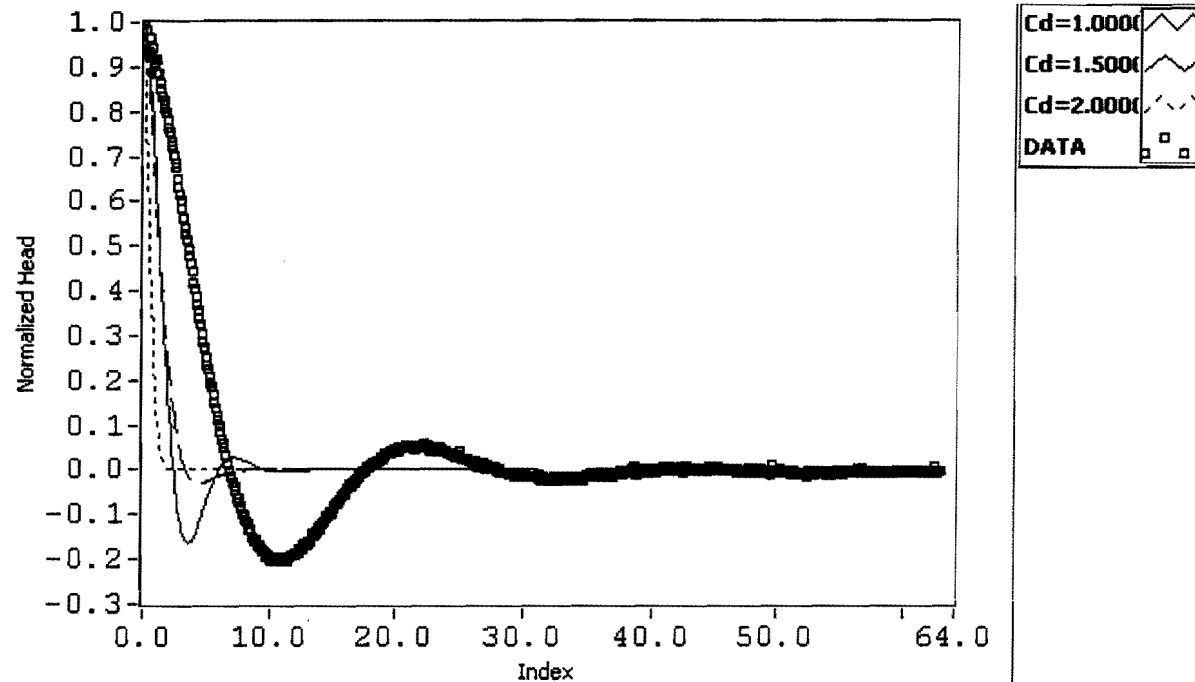
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 213.800 Sec to 276.900 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP5-320.dat

Printed: Friday, May 09, 2008 11:55:35



Appendix C
Geochemical Reports

**Part A Final Report, Evaluating Elevated Arsenic and Molybdenum Concentrations
at the Pritcher Road Site, Lithia, Central Florida, by Dr. Thomas Pichler**

**Part B General Conceptual Model for Arsenic and Molybdenum in Groundwater in
Lithia, Florida, Memorandum, by Dr. Carol Stein**

Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: 8710 County Line Rd
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for a slug test. The well is shown with various dimensions and parameters labeled:

- TD = 206
- $r_t = 0.133$
- $R_c = 2$
- SWL = 46
- $T_s = 15$
- $L_w = 160$
- $h =$ _____
- $L_c = 94$
- $L_s = 94$
- $R_b = 3$
- $R_s = 2$
- Impermeable Layer
- $K = 2.647 \text{ Ft/Day}$

Signature: _____ Date: _____

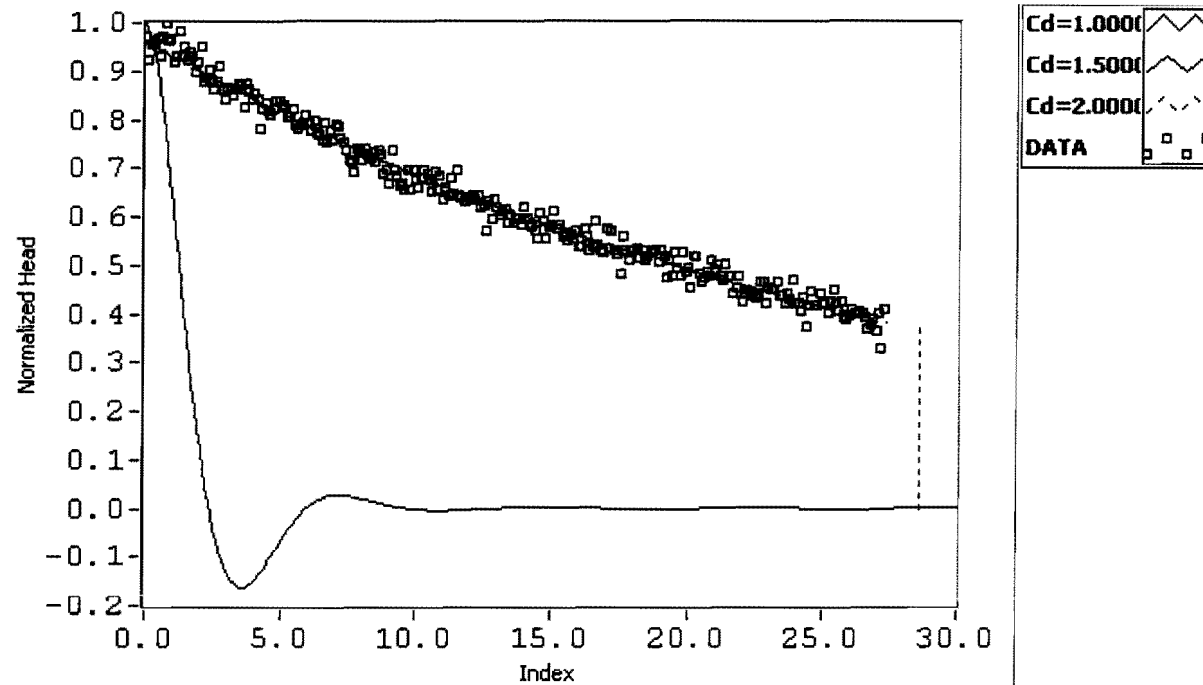
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 9.700 Sec to 234.400 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\8610-CL.dat

Printed: Monday, May 12, 2008 13:10:02



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pitcher Road
Well No: 7911 Carey Road
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown as a vertical cylinder with various parameters labeled. The total depth (TD) is 134. The casing radius (r_c) is 0.133. The casing length (L_c) is 37. The screen length (L_s) is 37. The screen radius (R_s) is 2. The bottom radius (R_b) is 3. The water level (SWL) is 43.5. The water level height (h) is blank. The water level height (T_s) is 4. The water level height (L_w) is 90.5. The well is installed in a permeable layer with a permeability coefficient (K) of 35.964. The bottom of the well is labeled 'Impermeable Layer'.

Signature: _____ Date: _____

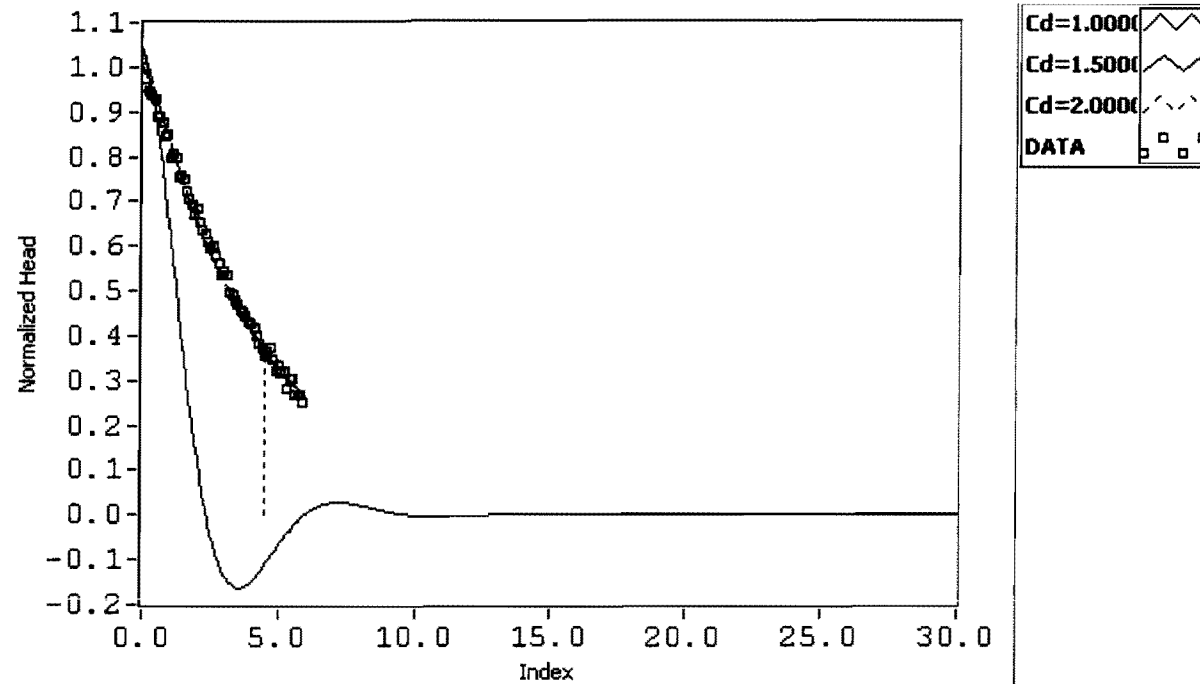
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 235.800 Sec to 293.800 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\7911-C.dat

Printed: Monday, May 12, 2008 13:33:00



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: 8506 Pritchard Road
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

TD = 187

$r_t = 0.133$

$R_c = 2$

SWL = 38.4

$T_s = 9'$

$L_w = 148.6$

$L_o = 93.5$

$L_s = 93.5$

$R_b = 3''$

$R_s = 2''$

h = _____

Impermeable Layer

K: 21.14 ft/day

Signature: _____ Date: _____

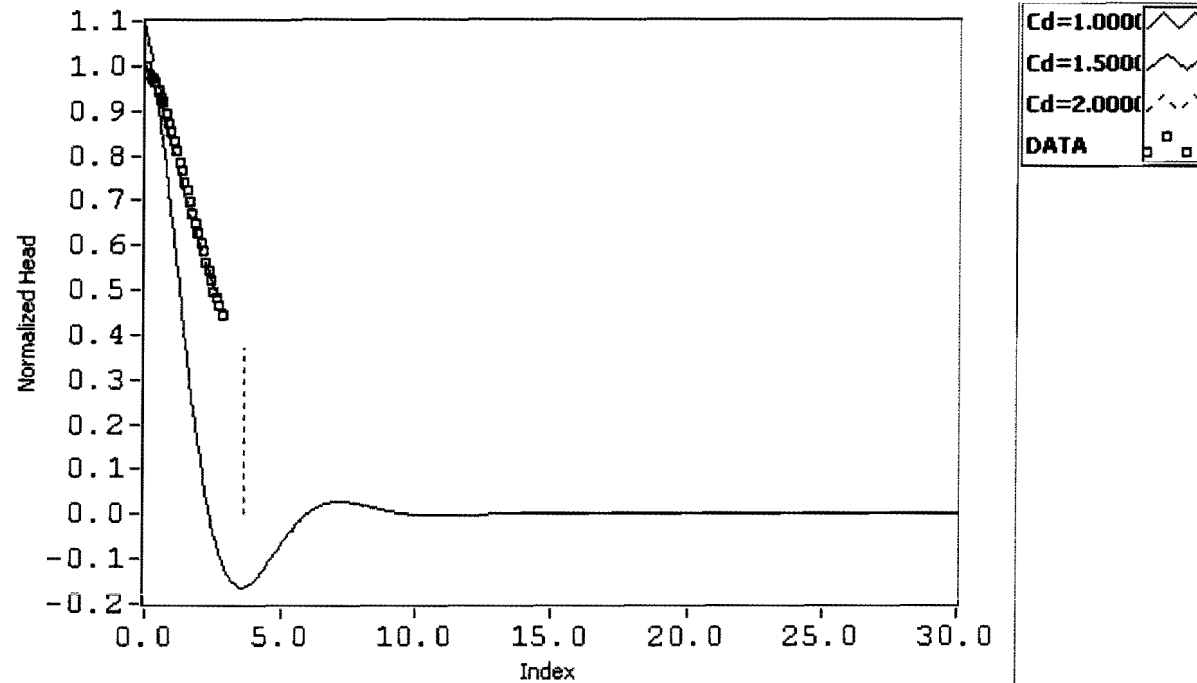
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 344.100 Sec to 477.300 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\8506-P.dat

Printed: Monday, May 12, 2008 13:03:58



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEPI-165
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

TD = 165'

$r_1 = \underline{0.133}$

$R_c = \underline{1"}$

SWL = 59.36

$T_s = \underline{14'}$

$L_w = \underline{105.64'}$

$h = \underline{\hspace{2cm}}$

$L_e = \underline{23'}$

$L_s = \underline{20'}$

$R_b = \underline{3"}$

$R_s = \underline{1"}$

Impermeable Layer

$K: \underline{4.247 \text{ Ft/Day}}$

Signature: _____ Date: _____

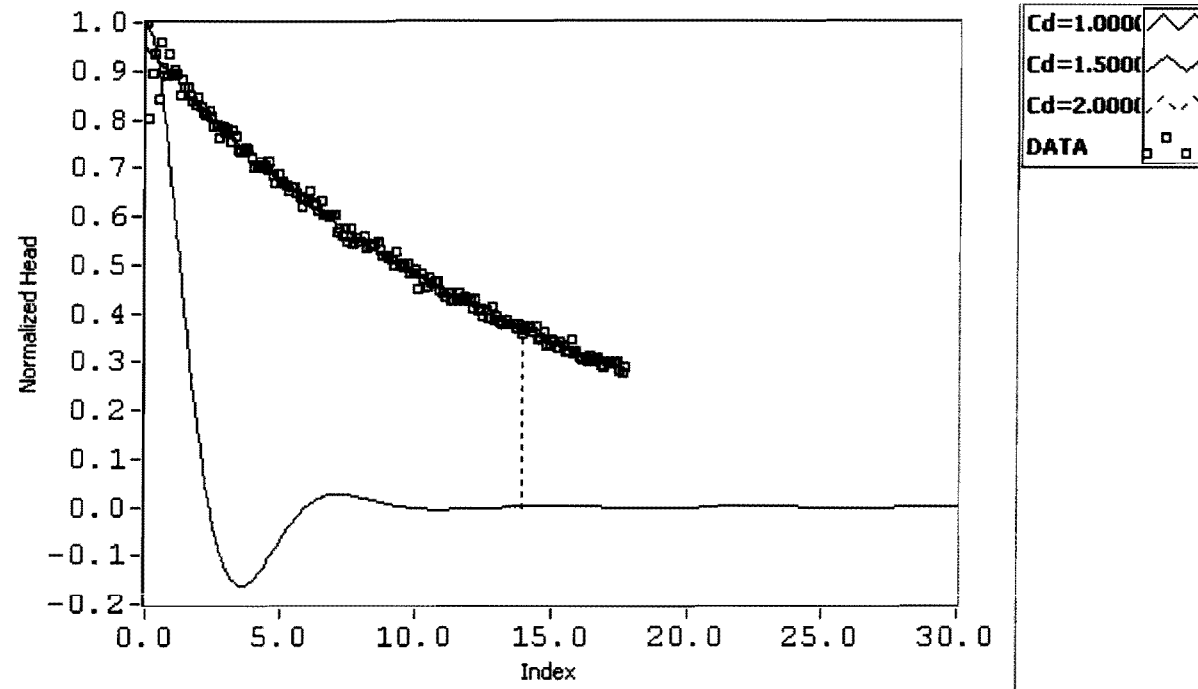
**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

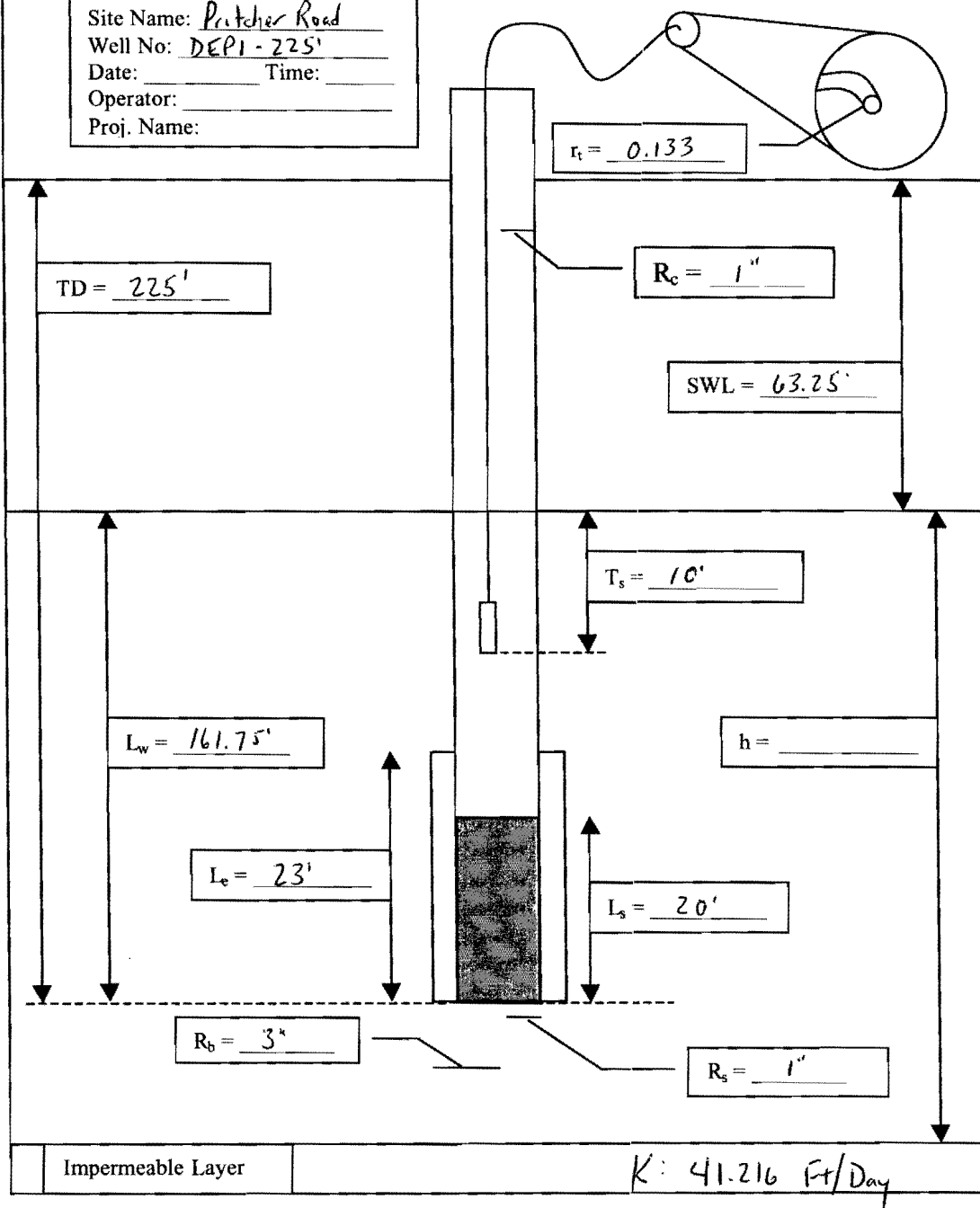
Interval: 213.700 Sec to 299.300 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP1-165.dat

Printed: Monday, May 12, 2008 09:13:41



Site Name: Pitcher Road
Well No: DEP1 - 225'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____



Signature: _____ Date: _____

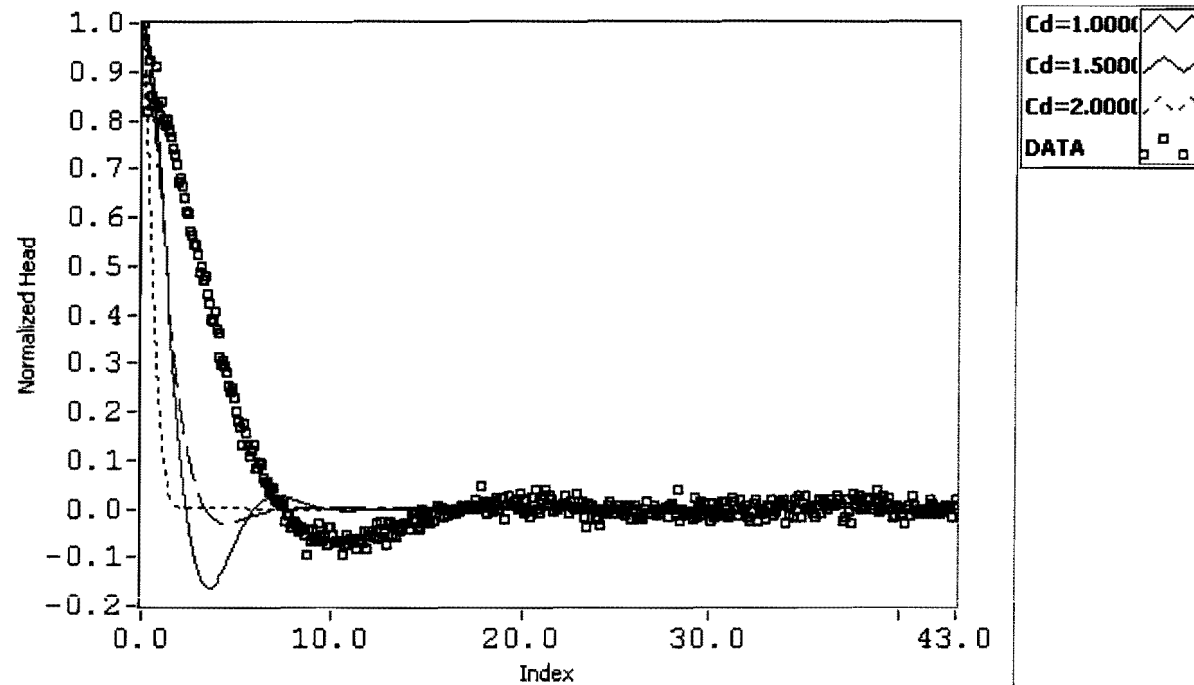
GW1600 Pneumatic Slug Test Kit

Interval Data Set

Interval: 73.000 Sec to 116.200 Sec

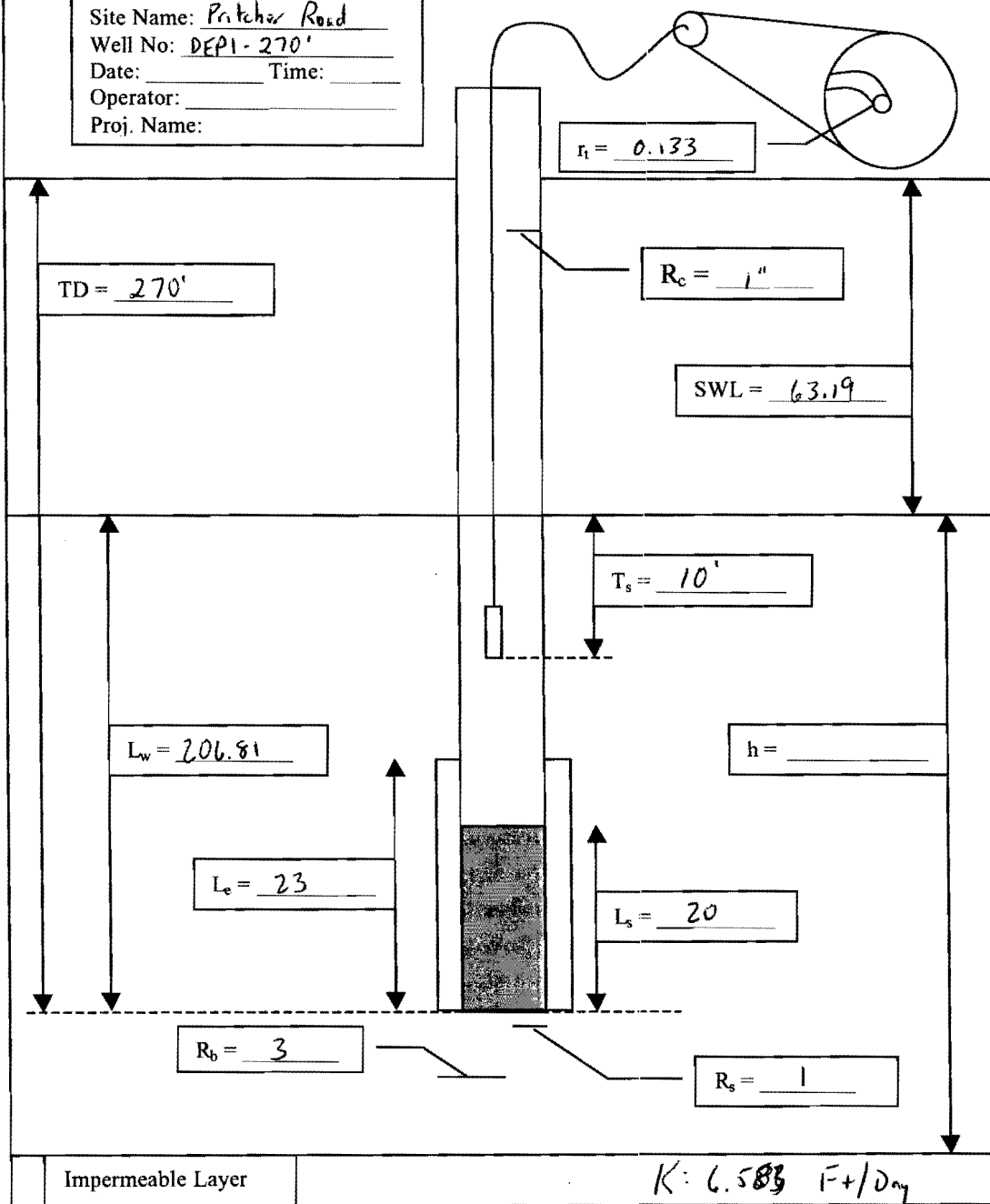
File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP1-225.dat

Printed: Monday, May 12, 2008 09:22:33



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEP1-270'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____



Signature: _____ Date: _____

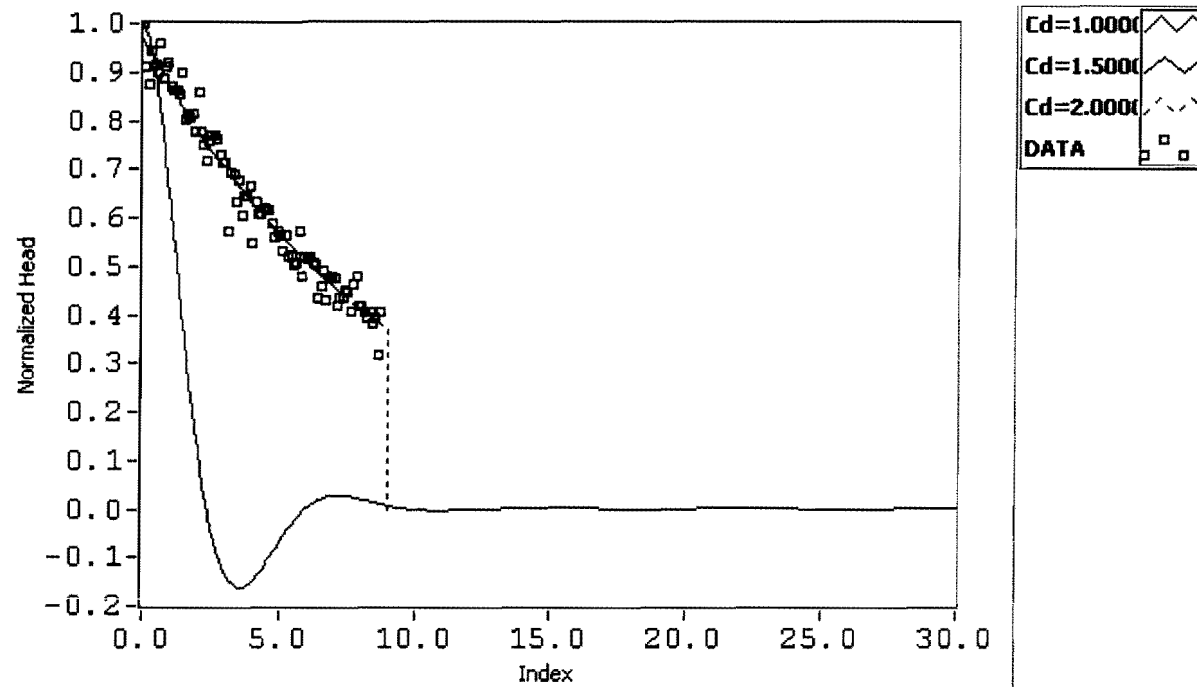
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 89.200 Sec to 178.900 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP1-270.dat

Printed: Monday, May 12, 2008 09:28:12



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEPI-320'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for a slug test. The well is shown as a vertical cylinder with various dimensions and parameters labeled.

Parameters and Dimensions:

- TD = 320'
- $r_t = \underline{0.133}$
- $R_c = \underline{1'}$
- SWL = 63.32'
- $T_s = \underline{10'}$
- $L_w = \underline{251.68}$
- $L_c = \underline{23}$
- $L_s = \underline{20}$
- $R_b = \underline{3}$
- $R_s = \underline{1'}$
- Impermeable Layer
- $K: \underline{42.519 \text{ Ft/Day}}$
- $h = \underline{\hspace{2cm}}$

Signature: _____ Date: _____

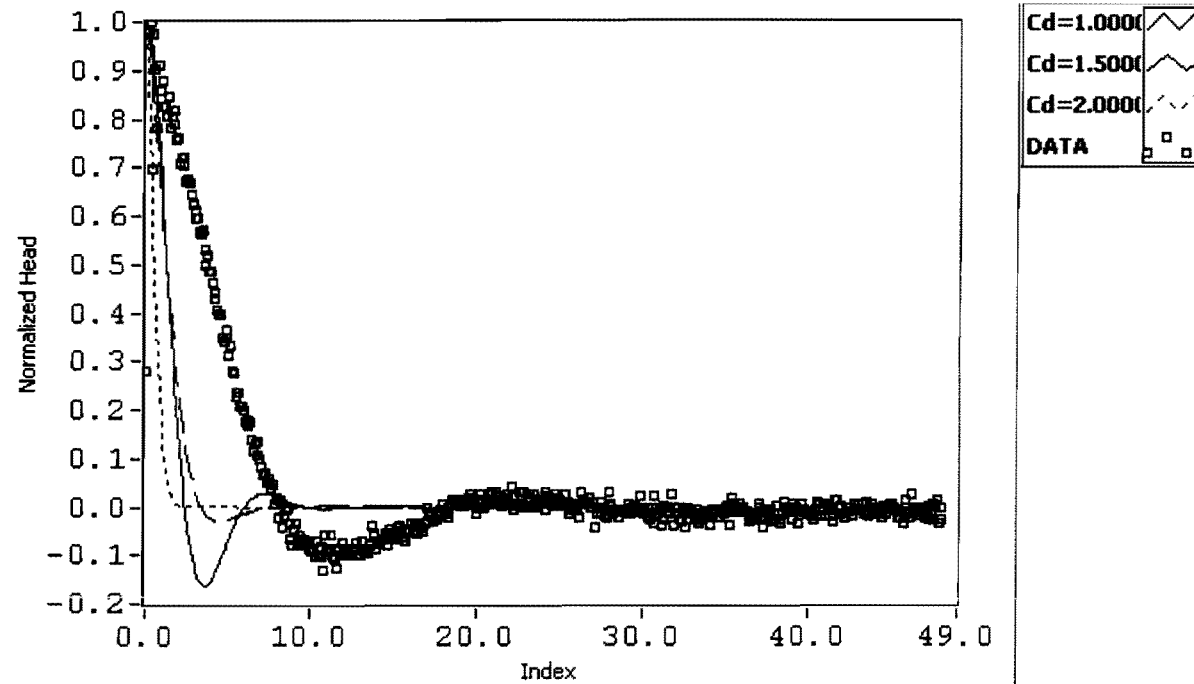
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 17.400 Sec to 65.700 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP1-320.dat

Printed: Monday, May 12, 2008 09:33:57



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEP2-163'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The diagram shows a well casing with a pump at the surface. Key parameters are labeled with boxes and arrows indicating their positions relative to the well and the ground surface.

Parameters shown in the diagram:

- TD = 163'
- $r_i = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 45.08
- $T_s = \underline{9.5'}$
- $L_w = \underline{117.92}$
- $h = \underline{\hspace{2cm}}$
- $L_c = \underline{23'}$
- $L_s = \underline{20'}$
- $R_b = \underline{3''}$
- $R_s = \underline{1''}$
- Impermeable Layer
- $K: \underline{9.446 \text{ Ft/Day}}$

Signature: _____ Date: _____

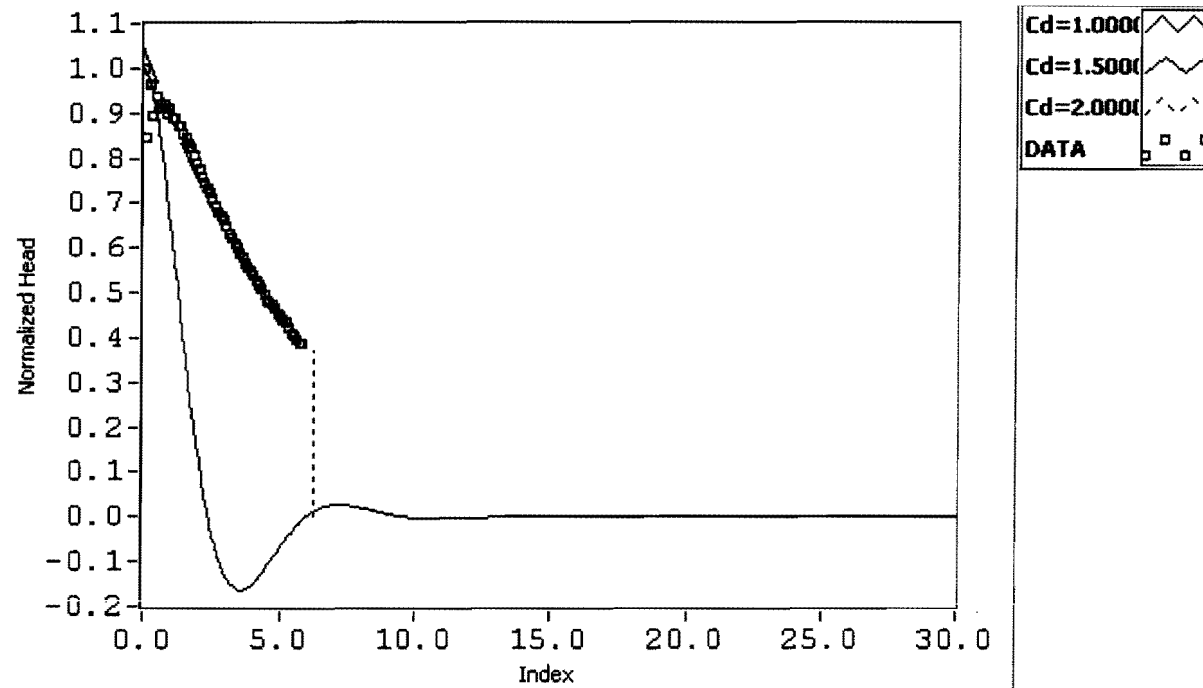
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 90.900 Sec to 136.100 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP2-163.dat

Printed: Friday, May 09, 2008 12:49:58



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritcher Road
 Well No: Rock N T Ranch
 Date: _____ Time: (8602)
 Operator: _____
 Proj. Name: _____

TD = 119

$r_c = 0.133$

$R_c = 2$

SWL = 38

$T_s = 9'$

$L_w = 81$

$L_c = 40$

$L_s = 40$

$R_b = 3$

$R_s = 2$

h = _____

Impermeable Layer

K: 19.045 Ft/Day

Signature: _____ Date: _____

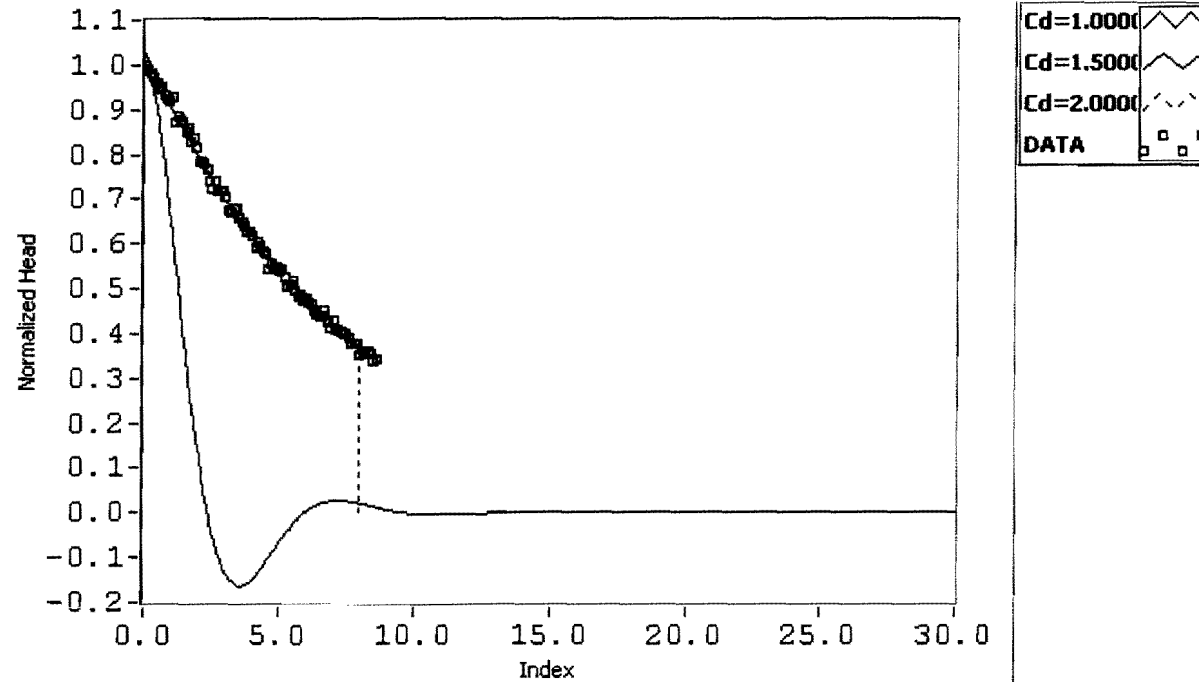
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 200.900 Sec to 372.200 Sec

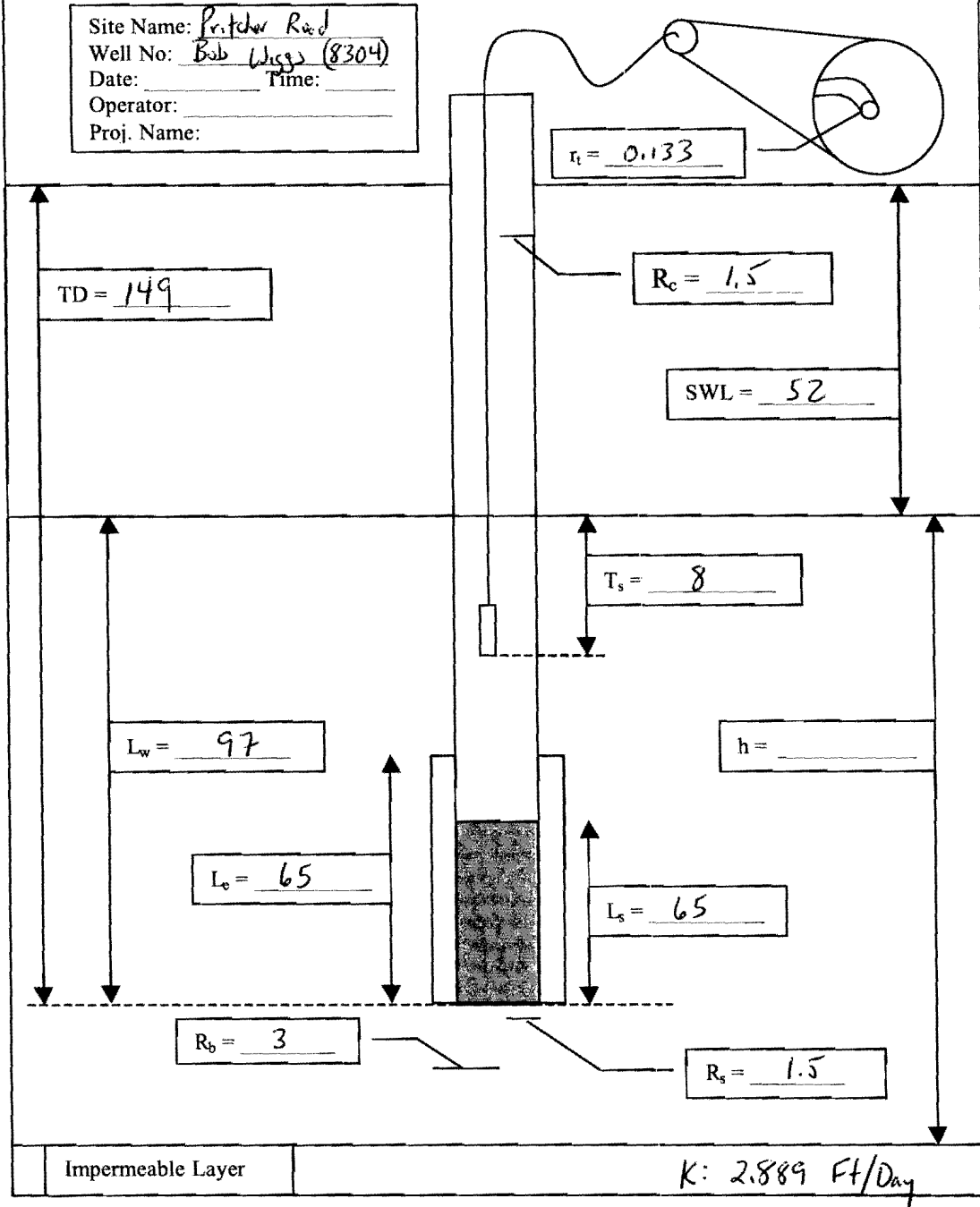
File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\RocnT.dat

Printed: Monday, May 12, 2008 13:13:38



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: Bob Wiggs (8304)
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____



Signature: _____ Date: _____

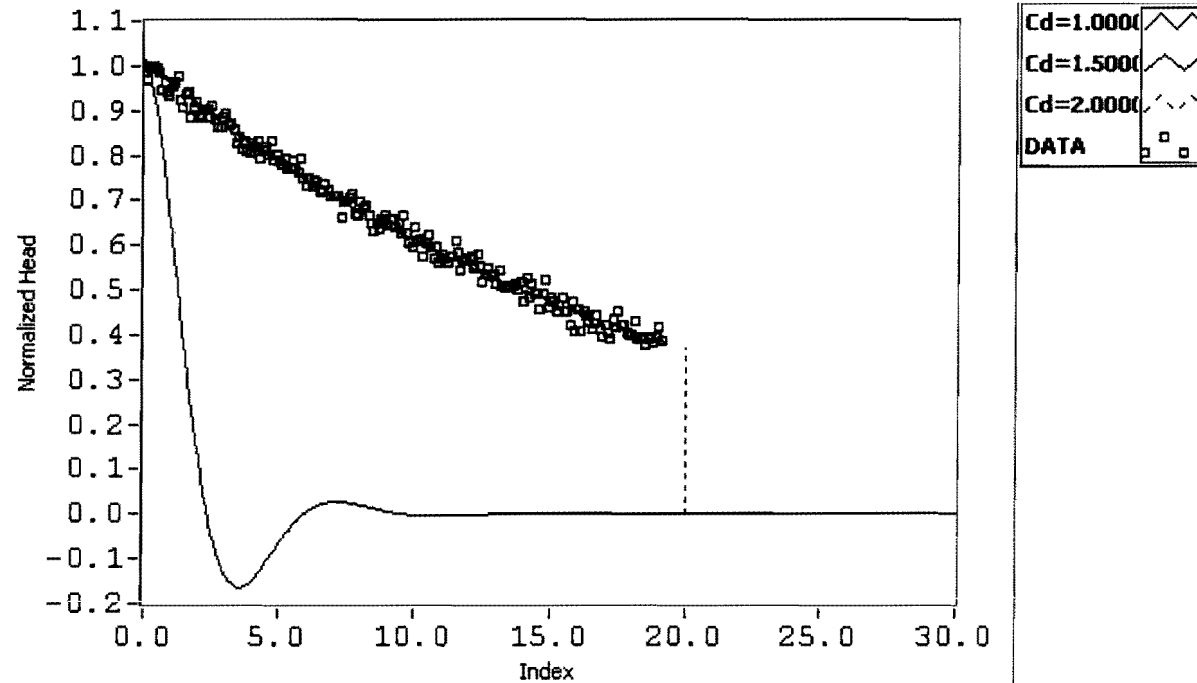
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 65.500 Sec to 214.900 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\Wiggs.dat

Printed: Monday, May 12, 2008 13:17:11



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: Bib U 455 (8304) #2
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The diagram shows a vertical well casing with a pump at the top. The well is divided into sections with various dimensions labeled in boxes. The bottom of the well is labeled 'Impermeable Layer'.

Parameters recorded on the form:

- TD = 149
- $r_t = \underline{0.133}$
- $R_c = \underline{1.5}$
- SWL = 52
- $T_s = \underline{8}$
- $L_w = \underline{97}$
- $L_e = \underline{31}$
- $L_s = \underline{1}$
- $h = \underline{\hspace{2cm}}$
- $R_b = \underline{2''}$
- $R_s = \underline{1.5'}$
- Impermeable Layer
- K: 61.74 Ft/Day

Signature: _____ Date: _____

**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Site Name: Pritchard Road
Well No: DEP2-217
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Proj. Name:

$$R_s = \underline{\hspace{1cm}}$$

$K: 5.948 \text{ Ft/Day}$

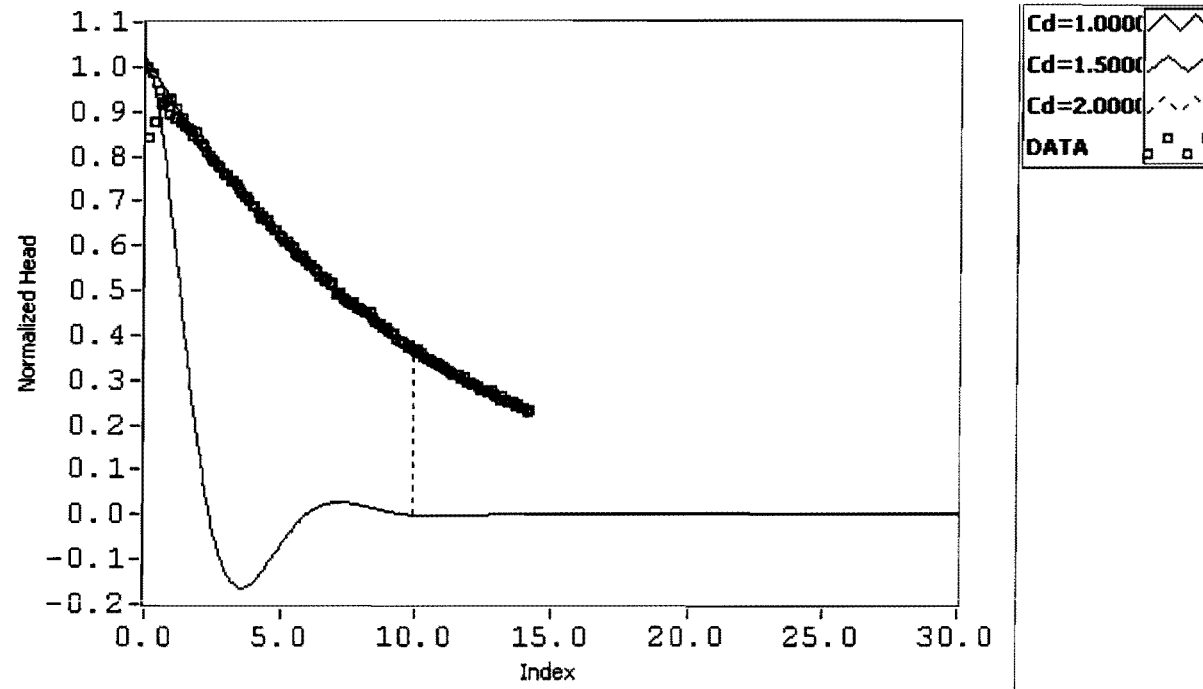
GW1600 Pneumatic Slug Test Kit

Interval Data Set

Interval: 171.200 Sec to 234.700 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP2-217.dat

Printed: Friday, May 09, 2008 12:55:03



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP 2-276
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

TD = 276'

$r_t = \underline{0.133}$

$R_c = \underline{1''}$

SWL = 48.51

$T_s = \underline{6.0}$

$L_w = \underline{23' 227.49}$

$h = \underline{\hspace{2cm}}$

$L_e = \underline{23}$

$L_s = \underline{20'}$

$R_b = \underline{3''}$

$R_s = \underline{1''}$

Impermeable Layer

$K = \underline{3.329 \text{ FT/Day}}$

Signature: _____ Date: _____

FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pitcher Road
 Well No: DEP 2 - 320'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and labels:

- TD = 320'
- $r_t = 0.133$
- $R_c = 1''$
- SWL = 52.05'
- $T_s = 16'$
- $L_w = 262.98$
- $h = \text{_____}$
- $L_e = 23$
- $L_s = 20'$
- $R_b = 3''$
- $R_s = 1'$
- Impermeable Layer
- $K = 3.085 \text{ ft/day}$

Signature: _____ Date: _____

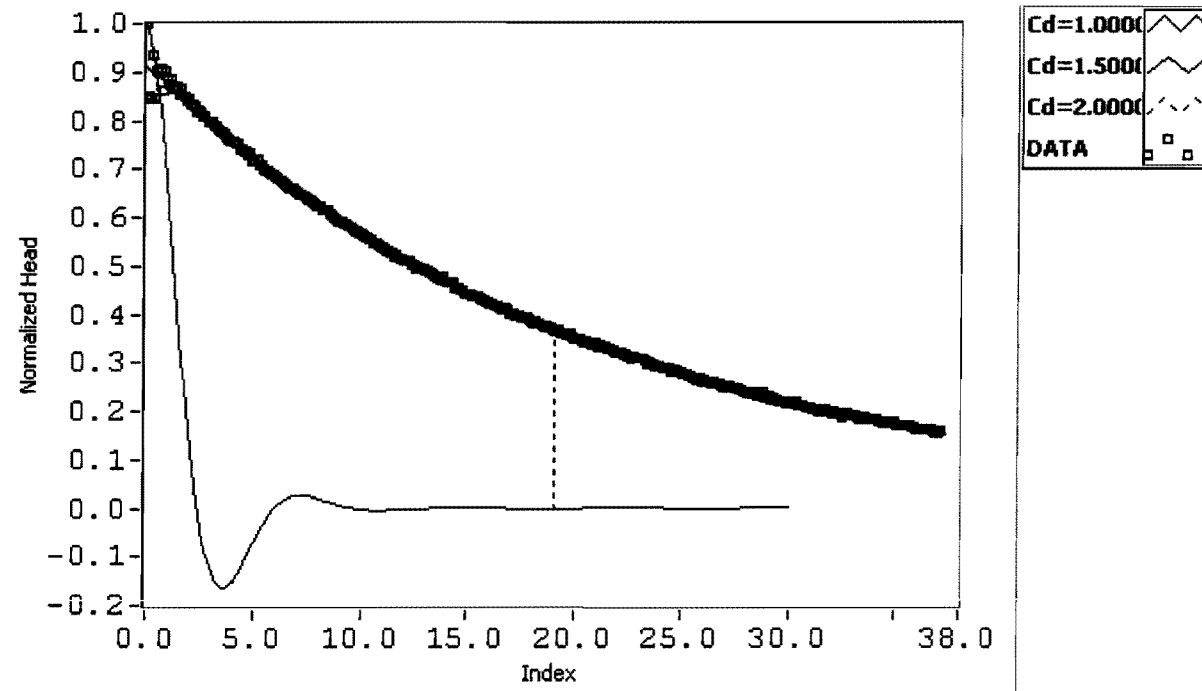
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 523.400 Sec to 642.000 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP2A320.dat

Printed: Friday, June 13, 2008 11:27:13



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEP3-167
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with a casing and a screen. The total depth (TD) is 167 feet. The casing radius (Rc) is 1 inch. The static water level (SWL) is 38.59 feet. The screen length (Lw) is 128.41 feet. The screen radius (Rb) is 3 inches. The screen length (Ls) is 20 feet. The casing radius at the screen (Rs) is 1 inch. The permeable layer is indicated at the bottom. The hydraulic conductivity (K) is 2.694 ft/day.

Parameters recorded on the form:

- TD = 167
- $r_t = 0.133$
- $R_c = 1''$
- SWL = 38.59
- $T_s = 10'$
- $L_w = 128.41$
- $L_e = 23$
- $L_s = 20'$
- $R_b = 3''$
- $R_s = 1''$
- h = _____
- Impermeable Layer
- K: 2.694 Ft/Day

Signature: _____ Date: _____

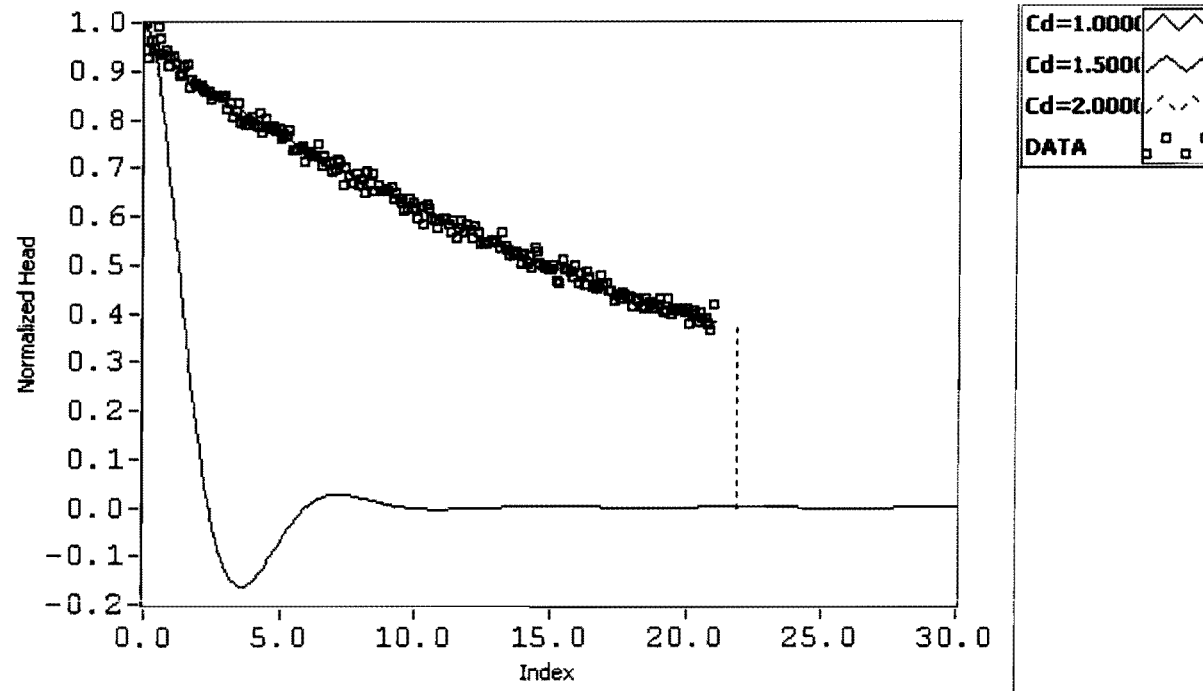
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 5.100 Sec to 142.400 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP3-167.dat

Printed: Friday, May 09, 2008 12:30:01



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritcher Road
Well No: DEP3-215'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and labels:

- TD = 215'
- $R_t = 0.133$
- $R_c = 1''$
- SWL = 41.32'
- $T_s = 6.8'$
- $L_w = 173.68$
- $h =$ _____
- $L_e = 23'$
- $L_s = 20'$
- $R_b = 3''$
- $R_s = 1''$
- Impermeable Layer
- K: 41.376 Ft/Day

Signature: _____ Date: _____

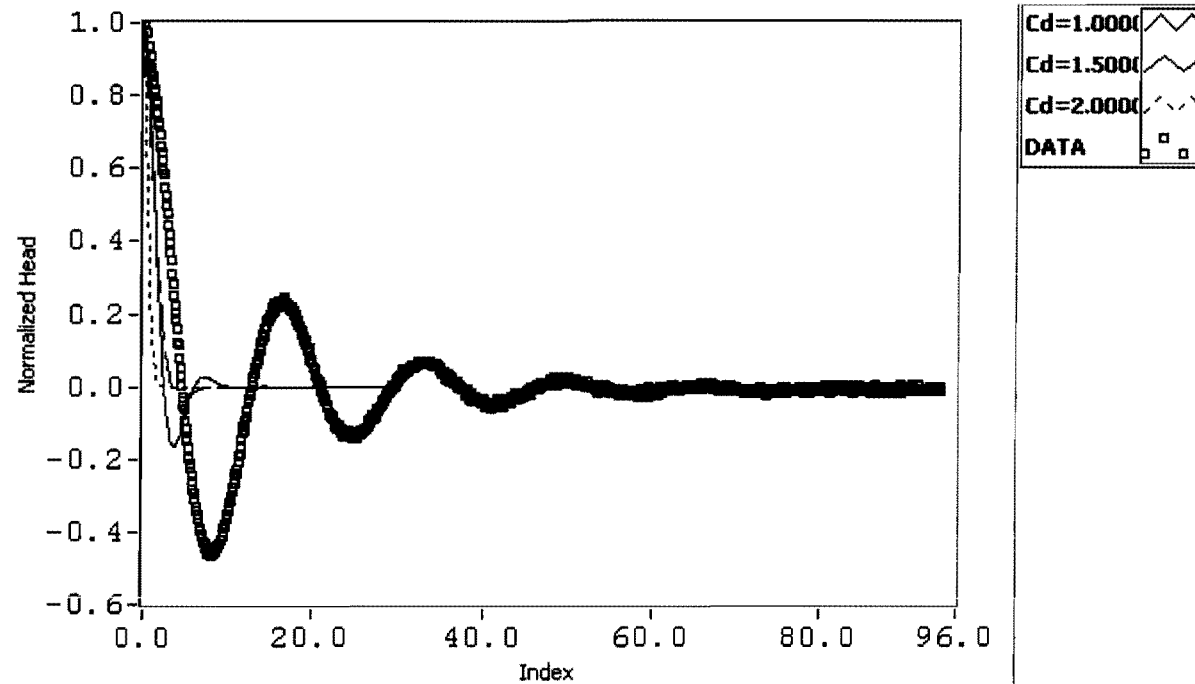
**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

Interval: 361.600 Sec to 456.000 Sec

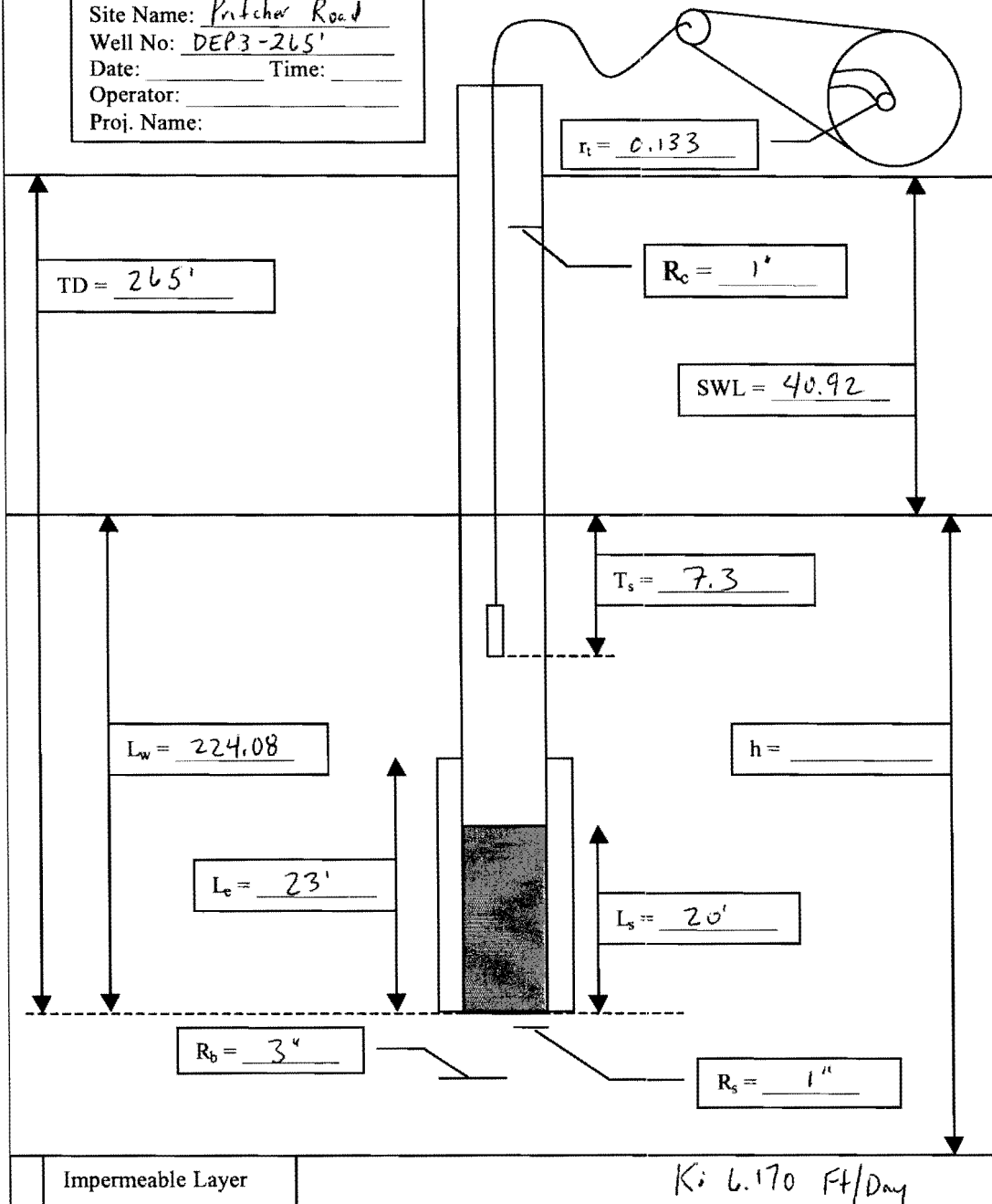
File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP3-215.dat

Printed: Friday, May 09, 2008 12:35:14



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP3-265'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____



Signature: _____ Date: _____

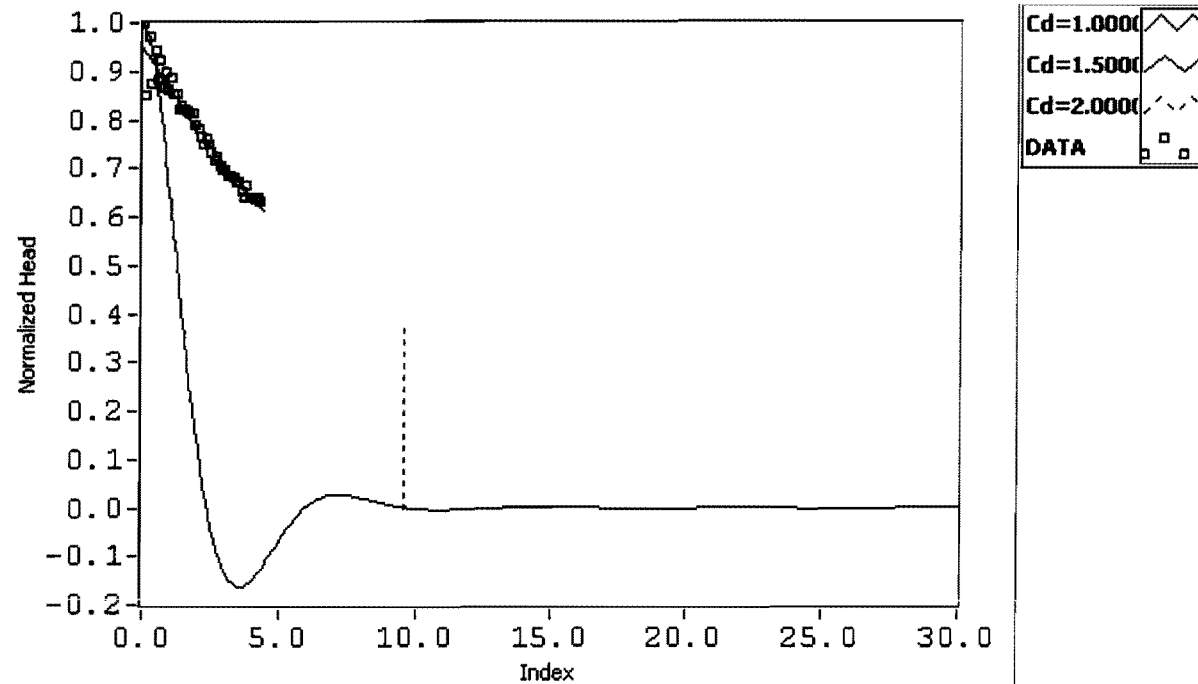
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 22.600 Sec to 204.200 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP3-265.dat

Printed: Friday, May 09, 2008 12:40:06



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP3-320
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

TD = 320'

$r_t = \underline{0.133}$

$R_c = \underline{1''}$

SWL = 40.06

$T_s = \underline{8'}$

$L_w = \underline{279.94}$

$h = \underline{\hspace{2cm}}$

$L_e = \underline{23'}$

$L_s = \underline{20'}$

$R_b = \underline{3''}$

$R_s = \underline{1''}$

Impermeable Layer

K: 1.386 Ft/Day

Signature: _____ Date: _____

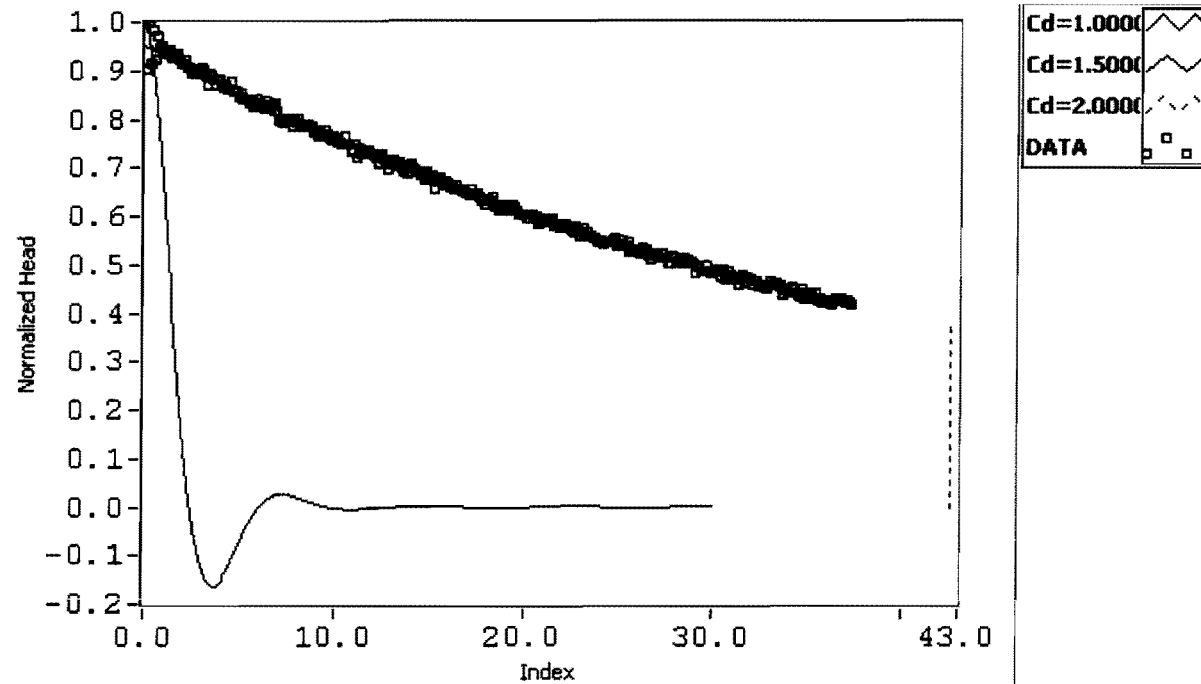
**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

Interval: 20.000 Sec to 269.700 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP3-320.dat

Printed: Friday, May 09, 2008 12:44:24



Geoprobe® Slug Test Field Information Form for **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP4-163'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and labels:

- $r_1 = 0.133$
- $R_c = 1"$
- SWL = 45.21
- $T_s = 16'$
- $h =$
- $L_w = 117.79$
- $L_e = 23'$
- $L_s = 20$
- $R_b = 3'$
- $R_s = 1"$
- Impermeable Layer
- $K: 3.709 \text{ Ft/Day}$

Signature: _____ Date: _____

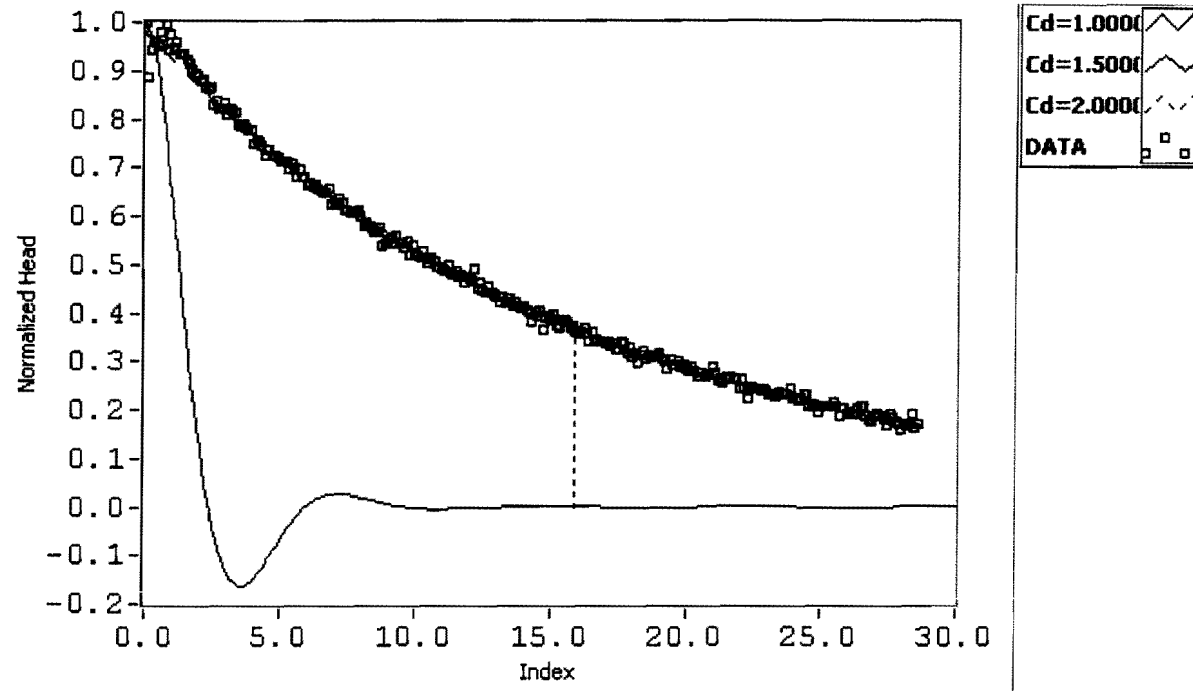
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 191.700 Sec to 303.400 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP4-163.dat

Printed: Friday, May 09, 2008 12:04:42



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
 Well No: DEP4-228'
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with a casing and a screen. The total depth (TD) is 228'. The casing radius (Rc) is 1'. The static water level (SWL) is 50.90'. The screen length (Lw) is 177.10'. The screen radius (Rb) is 3". The screen length (Ls) is 20'. The casing radius (Rs) is 1'. The permeable layer is indicated at the bottom. The hydraulic conductivity (K) is 9.138 Ft/Day.

Parameters recorded on the form:

- Site Name: Pritchard Road
- Well No: DEP4-228'
- Date: _____ Time: _____
- Operator: _____
- Proj. Name: _____
- TD = 228'
- $r_t = \underline{0.133}$
- $R_c = \underline{1'}$
- SWL = 50.90
- $T_s = \underline{10.6}$
- $L_w = \underline{177.10}$
- $h = \underline{\hspace{2cm}}$
- $L_e = \underline{23'}$
- $L_s = \underline{20'}$
- $R_b = \underline{3''}$
- $R_s = \underline{1'}$
- Impermeable Layer
- $K: \underline{9.138 \text{ Ft/Day}}$

Signature: _____ Date: _____

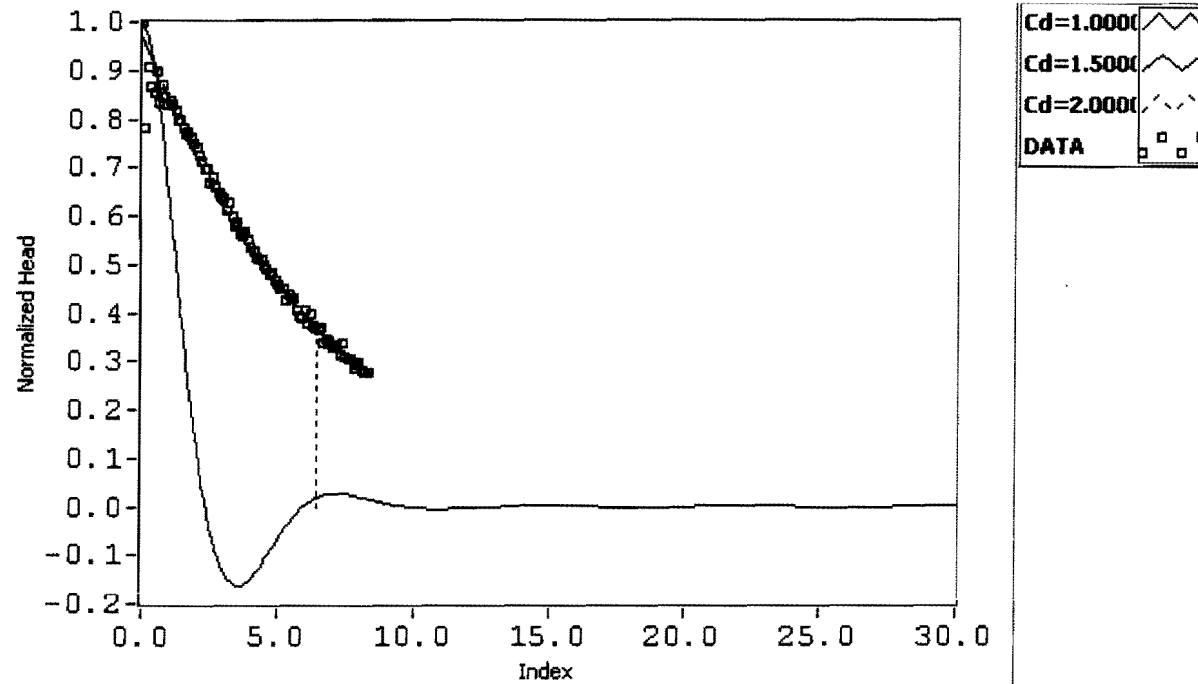
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 291.800 Sec to 405.100 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP4-228.dat

Printed: Friday, May 09, 2008 12:11:16



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP4-275'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for a slug test. The diagram shows a vertical well casing with various dimensions and parameters labeled.

Parameters and Dimensions:

- TD = 275'
- $r_t = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 50.88
- $T_s = \underline{10.9}$
- $L_w = \underline{224.12}$
- $L_c = \underline{23'}$
- $L_s = \underline{20'}$
- $R_b = \underline{3''}$
- $R_s = \underline{1''}$
- $h = \underline{\hspace{2cm}}$
- Impermeable Layer
- $K: \underline{9.419 \text{ Ft/Day}}$

Signature: _____ Date: _____

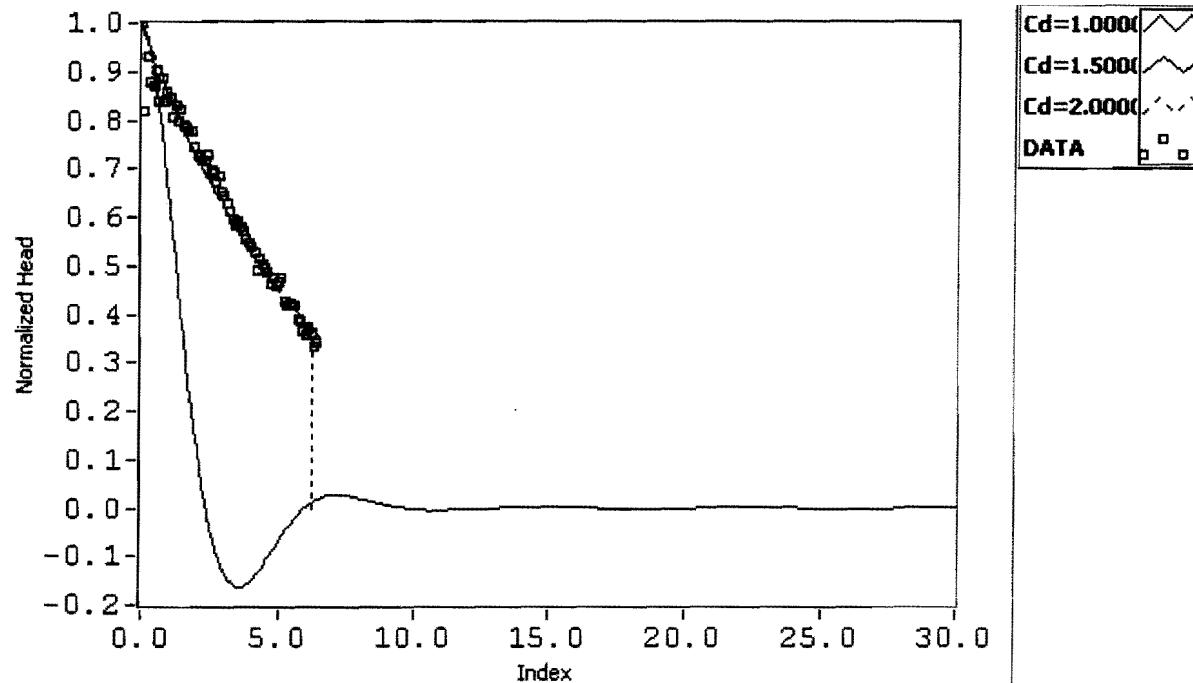
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 6.600 Sec to 153.900 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP4-275.dat

Printed: Friday, May 09, 2008 12:17:01



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP4-320'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with various dimensions and parameters labeled.

Parameters labeled in the diagram:

- TD = 320'
- $r_t = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 50.46
- $T_s = \underline{11'}$
- $L_w = \underline{269.54}$
- $L_e = \underline{23}$
- $L_s = \underline{20}$
- $R_b = \underline{3}$
- $R_s = \underline{1''}$
- h = _____
- Impermeable Layer
- K: 5.008 Ft/Day

Signature: _____ Date: _____

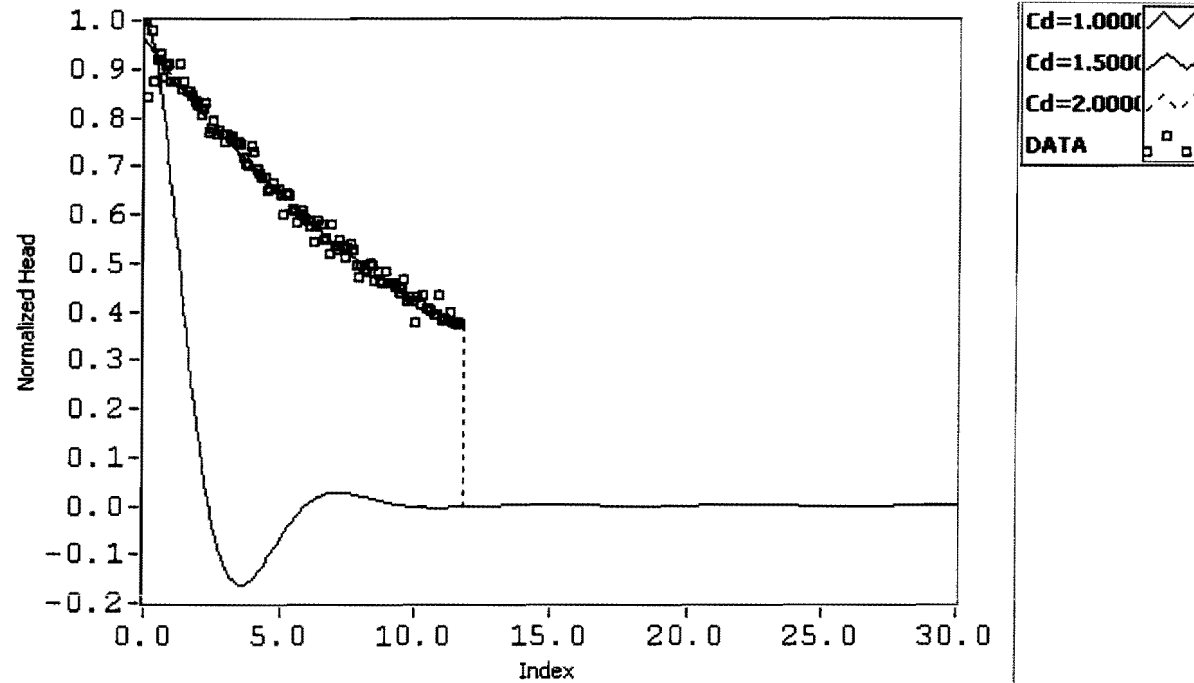
**FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

Interval: 537.200 Sec to 621.200 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP4-320.dat

Printed: Friday, May 09, 2008 12:22:15



Geoprobe® Slug Test Field Information Form **for** **Well Construction / Water Sampler Installation**

Site Name: Pitcher Road
 Well No: DEP5-173
 Date: _____ Time: _____
 Operator: _____
 Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with a casing and a screen. The total depth (TD) is 173'. The casing radius (R_c) is 1. The static water level (SWL) is 44.48. The screen length (T_s) is 7.7'. The well length (L_w) is 128.52. The casing length (L_c) is 23'. The screen length (L_s) is 20'. The borehole radius (R_b) is 3". The screen radius (R_s) is 1". The permeability coefficient (K) is 4.175 Ft/Day. The bottom of the well is labeled as the Impermeable Layer.

Signature: _____ Date: _____

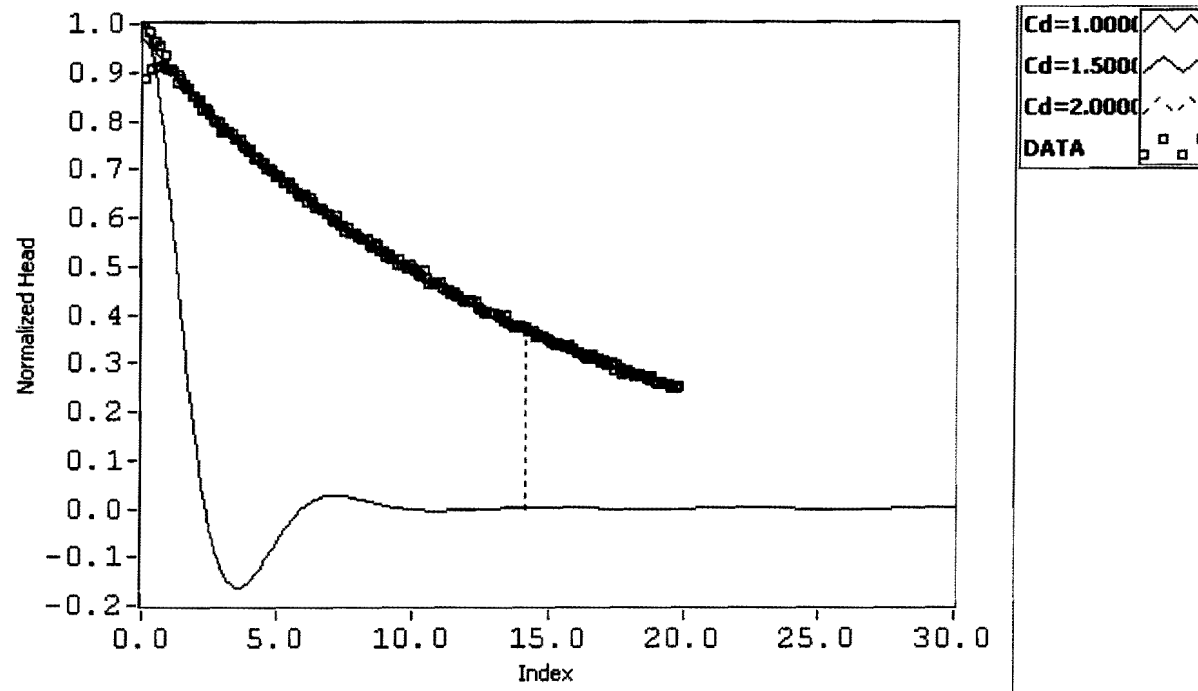
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 590.700 Sec to 667.000 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP5-173.dat

Printed: Friday, May 09, 2008 11:39:15



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Fletcher Road
Well No: DEPS-220'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

TD = 220'

$r_t = \underline{0.133}$

$R_c = \underline{1}$

SWL = 44.78

$T_s = \underline{7.4}$

$L_w = \underline{175.22}$

$L_e = \underline{23'}$

$L_s = \underline{20'}$

$R_b = \underline{3}$

$R_s = \underline{1}$

Impermeable Layer

$K: \underline{1.595 \text{ Ft/Day}}$

$h = \underline{\hspace{2cm}}$

Signature: _____ Date: _____

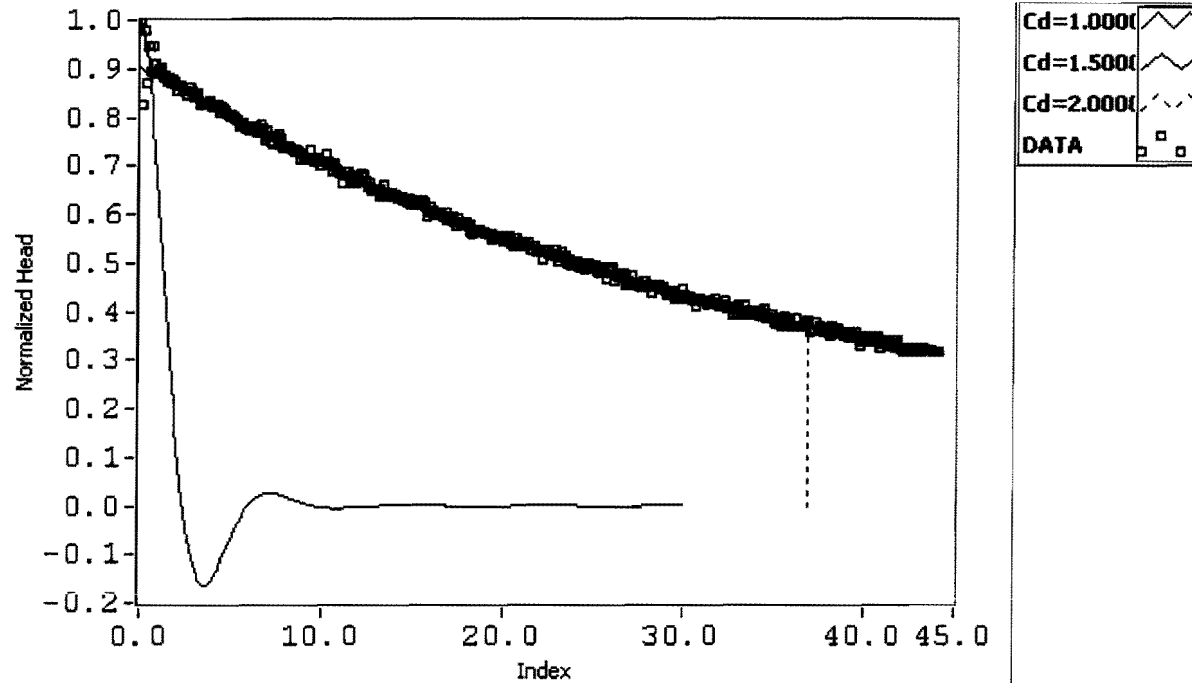
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 716.000 Sec to 992.600 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP5-220.dat

Printed: Friday, May 09, 2008 11:46:09



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEPS-270'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The diagram shows a vertical well casing with various dimensions and parameters labeled.

Parameters and Dimensions:

- TD = 270'
- $r_t = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 46.10
- $T_s = \underline{6.2}$
- $L_w = \underline{223.9}$
- $L_e = \underline{23'}$
- $L_s = \underline{20'}$
- $R_b = \underline{3''}$
- $R_s = \underline{1''}$
- $h = \underline{\hspace{2cm}}$
- Impermeable Layer
- $K: \underline{7.227 \text{ Ft/Day}}$

Signature: _____ Date: _____

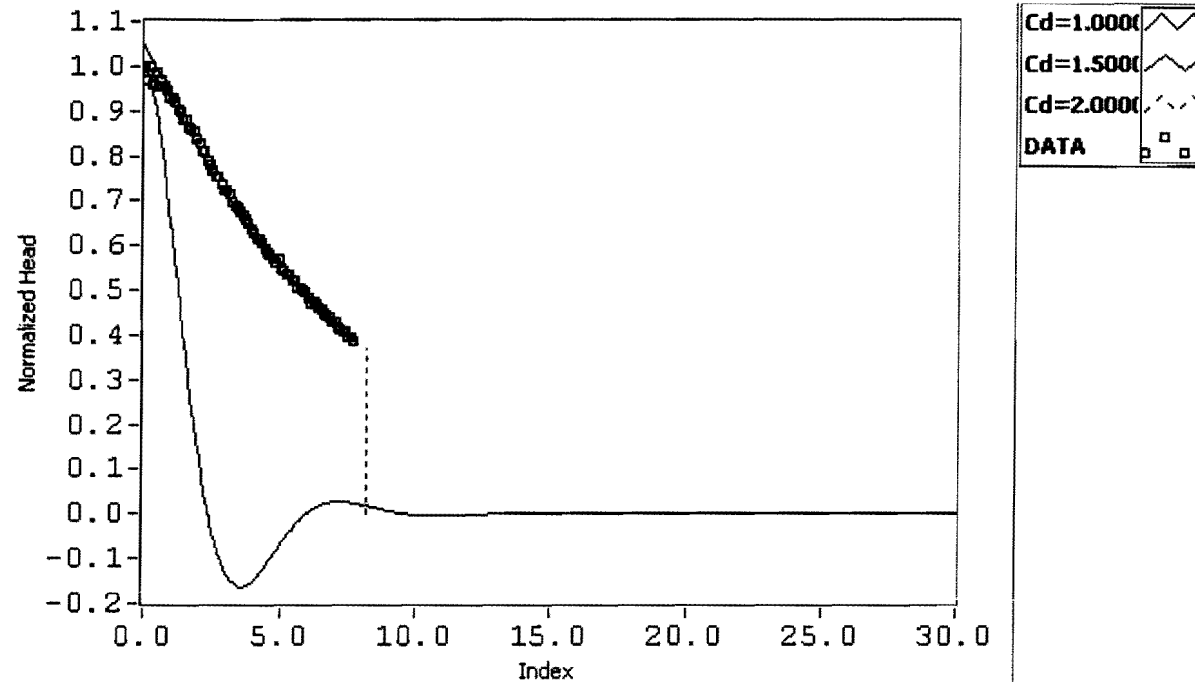
FIGURE 6.1:
**Copy and use this form in the field to record
construction and installation parameters for slug testing**

Interval Data Set

Interval: 153.400 Sec to 220.200 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP5-270.dat

Printed: Friday, May 09, 2008 11:51:43



**Geoprobe® Slug Test Field Information Form
for
Well Construction / Water Sampler Installation**

Site Name: Pritchard Road
Well No: DEP5-320'
Date: _____ Time: _____
Operator: _____
Proj. Name: _____

Diagram illustrating the well construction and installation parameters for slug testing. The well is shown with a pump and a cable. The parameters are as follows:

- TD = 320'
- $r_t = \underline{0.133}$
- $R_c = \underline{1''}$
- SWL = 46.13
- $T_s = \underline{6.1}$
- $L_w = \underline{273.87}$
- $h = \underline{\hspace{2cm}}$
- $L_c = \underline{23'}$
- $L_s = \underline{20'}$
- $R_b = \underline{3''}$
- $R_s = \underline{1''}$
- Impermeable Layer
- $K: \underline{42.763 \text{ Ft/Day}}$

Signature: _____ Date: _____

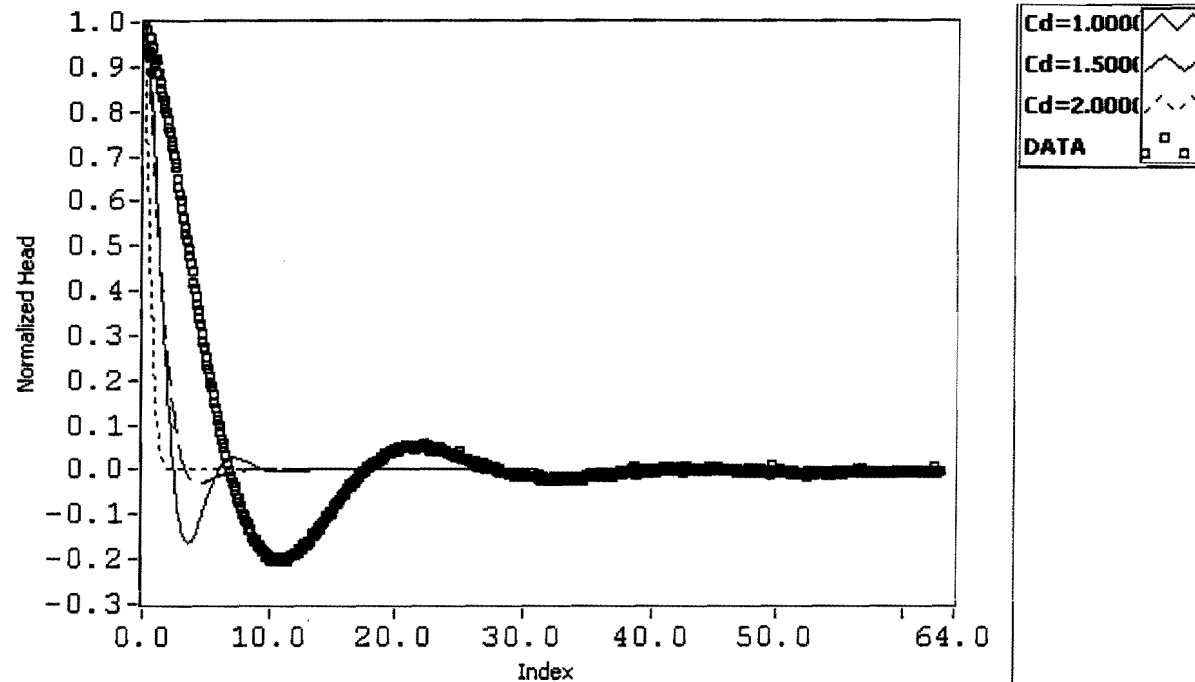
FIGURE 6.1:
Copy and use this form in the field to record
construction and installation parameters for slug testing

Interval Data Set

Interval: 213.800 Sec to 276.900 Sec

File Name: Log Name: Z:_COMMON_Sites\500-599\572 Pritcher Road\Geophysical & Soil Boring Logs\Slug
Tests\DEP5-320.dat

Printed: Friday, May 09, 2008 11:55:35



Appendix C
Geochemical Reports

**Part A Final Report, Evaluating Elevated Arsenic and Molybdenum Concentrations
at the Pritcher Road Site, Lithia, Central Florida, by Dr. Thomas Pichler**

**Part B General Conceptual Model for Arsenic and Molybdenum in Groundwater in
Lithia, Florida, Memorandum, by Dr. Carol Stein**

Final Report

Evaluating Elevated Arsenic and Molybdenum Concentrations at the Pritcher Road Site, Lithia, Central Florida

Prepared for Florida Department of Environmental Protection, Site
Investigation Section

By Dr. Thomas Pichler

April 2010

Executive Summary

Following the discovery of more than 300 µg/L As in a newly installed irrigation well near the village of Lithia in central Florida FDEP SIS sampled and analyzed approximately 100 private supply wells. Of these, 19 showed arsenic concentrations above the current drinking water standard of 10 µg/L. The highest value was 344 µg/L As. In addition many wells had molybdenum (Mo) concentrations above 40 µg/L (the US EPA recommended value). Besides As and Mo, all other parameters were as expected for central Floridan groundwater.

With no obvious anthropogenic or agricultural sources present, the As and Mo are likely of natural (geogenic) origin and released from the aquifer matrix due to a change in physicochemical conditions, such as the rapid infiltration of oxygen-rich surface water into the aquifer. To test this hypothesis 5 multi-level monitoring well clusters were installed in the Lithia are. The cores from 3 wells were logged and sampled for chemical and mineralogical analyses. The monitoring wells and a subset of 40 private supply wells were selected for a comprehensive chemical study, including As speciation, stable isotope analyses and tritium-helium dating.

The chemical study of the water revealed that most groundwater parameters in the monitoring wells and the private supply wells were as expected for central Florida. Only As and Mo showed a distinct pattern of (a) decreasing concentrations with depth and (b) a geographical distribution, with highest values in the center of the study area. A similar pattern could also be observed for $\delta^{18}\text{O}$ and δD , where lighter values were generally found at shallow depth. Isotope values for those private wells with elevated As and Mo fall into the same range as the shallow monitoring wells. Age dates for shallow groundwater samples were younger. Rapid infiltration is likely since the ages between waters collected from very shallow wells (approximately 30 ft) is basically are same ages as those for samples collected from at depth around 150 ft to 170 ft, while samples from just 30 ft deeper are much older. This separation in age also correlates to a separation based on groundwater levels, which decrease with depth.

In the 3 cores Mo and As varied significantly with depth and values were often significantly above the crustal average for As and Mo. Values were highest between approximately 130 and 250 ft, which is the interval that roughly corresponds to the Hawthorn and Tampa. Below 250 ft, which corresponds to the Suwannee Limestone values returned “normal”, i.e., expected values for crustal carbonate rocks. The mineral pyrite, which was identified in all cores, contained significant amounts of As and was thus identified as a potential source of As. In the core DEP-1 the calcium molybdate, powellite (CaMoO_4), was identified as a source of Mo and as a source of As, because powellite contained up to 18000 mg/kg As. In the subsurface As is elevated at three different depths and at each

of these depths it is associated with different elements. At 30 ft only As and Fe were elevated, while at 150 ft only As and Mo were elevated and at 200 ft only As, Fe and S were elevated. From this it is possible to deduce the mineralogical association of As. In the shallow subsurface where the conditions are still more oxygenated As is likely bound to hydrous ferric oxide (HFO). At the intermediate level off around 150 ft As seems to be more or less exclusively associated with powellite and at 200 ft where Fe and S were elevated, the source of As is likely As-rich pyrite. The inferred As mineralogy in the subsurface in the Lithia area follows an expected redox gradient for groundwater from oxygenated near the surface to more and more reducing conditions at depth.

There is no indication that Mo and As are of anthropogenic origin and thus they should be of geogenic origin and that a change in physicochemical conditions in the aquifer causes their release. However, what causes exactly this change in physicochemical conditions is still unclear. In summary, the combination of massive groundwater pumping to the west of Lithia combined with many private supply wells, which are open to several groundwater horizons in a karstic aquifer create an environment conducive to As and Mo release from the aquifer matrix.

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1. Introduction

During the past 20 to 30 years numerous occurrences of elevated arsenic (As) concentrations in groundwater were reported. With a few exceptions the source of As is geogenic, i.e., naturally occurring in the aquifer matrix. The release of As from the aquifer matrix, however, is generally caused by anthropogenic perturbations of the physicochemical conditions in the aquifer, such as a redox change. There are a multitude of scientific publications addressing the issue, including several excellent reviews (e.g., Amini et al., 2008; Ferguson and Gavis, 1972; Korte and Fernando, 1991; McNeill et al., 2002; Smedley and Kinniburgh, 2002). This type of As contamination is a public health issue world-wide. In particular the catastrophic problems in Bangladesh and West Bengal have been front-page stories in newspapers and scientific journals (e.g., Ahmed et al., 2006). Despite more than 20 years of ongoing research into the As problem in Bangladesh there is no consensus about the geochemical mechanisms of As mobilization. The dissolution of hydrous ferric oxide (HFO) is called upon, as well as the oxidation of pyrite (e.g., Polizzotto et al., 2005; Swartz et al., 2004; van Geen et al., 2008). Nevertheless, it is becoming clear that the problem of As release is a complex problem of agriculture, hydrogeology, microbiology and inorganic geochemical processes, which reaches far beyond the simple approach of oxic vs. anoxic (Dhar et al., 2008; Stute et al., 2007; Zheng et al., 2005).

Similar to the problem outlined for Bangladesh, there are many other locations where similar geogenic As contamination exist; independent of the aquifer matrix, whether fluvial sediments, marine shale or carbonate rocks. Surprisingly little is known about geogenic As contamination in limestone/carbonate aquifers. A thorough literature search provided only 5 references in addition to our own work (Armienta and Segovia, 2008; Gbadebo, 2005; Romero et al., 2004; Simsek et al., 2008; Vesper and White, 2003). Limestones, although excellent aquifers, are problematic because due to karstification contaminants can be easily transported over large distances, posing a threat to public and private water supplies (e.g., Ducci et al., 2008; Katz, 2004;

Kovacova and Malik, 2007; McMahon et al., 2008; Obeidat et al., 2008; Zhou and Beck, 2008). Groundwater can flow through conduits so that there is little opportunity for filtration or sorption of contaminants onto aquifer material. Thus it is important to assess and understand geogenic As contamination in limestone aquifers, where anthropogenic perturbations could cause the release of As from the limestone matrix at a large distance from the area where eventually elevated As values occur.

The Pritcher Road site near the village of Lithia in central Florida affords an exceptional field site to study the contamination of groundwater with geogenic As in a limestone aquifer. There, approximately 100 private supply wells were sampled for As, after the discovery of more than 300 µg/L As in a newly installed irrigation well. Similarly high As concentrations were detected in many of the private supply wells. Surprisingly there was no pattern recognizable and wells with low concentrations were adjacent to wells with extremely high concentrations (Fig. 1). Plots of As distribution in private supply wells in Bangladesh show the same enigma and thus new insights from this study may further progress unraveling the As disaster there. In particular, if excessive groundwater withdrawal from select aquifers may cause a sufficient change in physicochemical conditions across the system to cause the release of As (e.g., Ahmed et al., 2006).

Of the approximately 100 private supply wells, 19 wells showed arsenic concentrations above the current drinking water standard of 10 µg/L. The highest value was 344 µg/L. Several wells were also high in molybdenum (Mo), although of lesser concern because Mo is not regulated by the US EPA. Nevertheless there exists a recommended value of 40 µg/L. Besides As and Mo, all other parameters were as expected for central Floridan groundwater.

1.1. Working Hypothesis

With no obvious anthropogenic or agricultural sources present, the arsenic is likely of natural (geogenic) origin, i.e., present in the mineral pyrite, which is part of the aquifer matrix, but released into groundwater due to a change in

physicochemical conditions. The assumption that pyrite is the likely source of As to groundwater was based on detailed investigations about the mineralogical associations of As in the Intermediate Floridan Aquifer (IFA) and Upper Floridan Aquifer (UFA) (Lazareva, 2004; Lazareva and Pichler, 2007; Price, 2003; Price and Pichler, 2002, 2006). The key findings of those studies were that (1) As was only very slightly elevated in the aquifer matrix (3.5 mg/kg vs. 2.6 mg/kg world average in limestone) and (2) As was mostly associated with pyrite as a substitute element for sulfur in the FeS_2 structure. These studies in conjunction with geochemical modeling and observations from aquifer storage and recovery operation (ASR) provided insight into the question whether the interaction (reaction) of water with an aquifer matrix of normal As concentration that can generate high-As groundwater (Pichler and Jones, 2006). A change in physicochemical conditions that selectively affects the stability of pyrite is sufficient to increase As concentrations by several orders of magnitude (Jones and Pichler, 2007).

Assuming that pyrite is the source of arsenic, 4 scenarios (A-D) were considered to explain the high concentrations of arsenic. Each of these scenarios involves a change of hydraulic conditions in the Lithia area, causing the rapid introduction of oxygenated groundwater into the Upper Floridan aquifer where most of the supply wells are screened.

(A) The removal of clays during the phosphate mining process east of the Lithia area, which is hydraulically upgradient of the site, has allowed water with different geochemical characteristics from the surface/surficial aquifer to penetrate into the Suwannee Limestone.

(B) Water from a gypsum stack associated with the former phosphate plant is drained into a creek that straddles the up gradient extent of the site. This creek may be a surface reflection of a fracture that allows the drainage water with different characteristics to migrate quickly into the Suwannee Limestone.

(C) The extensive pumping from the well field located on the western portion of the site has significantly altered the difference in hydraulic head between the

surficial/Intermediate aquifer and the underlying Floridan providing more potential for waters from shallow intervals to migrate into the Suwannee Limestone.

(D) Combination of one or more of the scenarios from above.

2. Work Plan and Methods

To test these hypotheses, 40 private supply wells were selected for further study. Selection was based on the premise of geographical coverage, high As and low As concentrations. These wells were sampled a second time and in addition to the parameters of the previous sampling (turbidity, pH, conductivity, dissolved oxygen, oxygen reduction potential, alkalinity, Al, Sb, As, Br, Cd, Ca, Cl, Cr, Cu, F, Fe, Kie-N, Pb, Mg, Mn, Mo, Ni, N, K, Se, Si, Na, Sr, SO₄, S, P, V, Zn) the following were added: (1) As was speciated (As³⁺, As⁵⁺, DMA and MMA), (2) sulfide was determined in the field and (3) oxygen and hydrogen isotopes ($\delta^{18}\text{O}$ and δD). Those elements of particular interest, such as, sulfide, As, Sb and Mo were analyzed by the FDEP laboratory and also by EnChem for the purpose of quality control. The private supply wells provided only poor information about well depth and screened interval. Thus, FDEP installed 5 monitoring well clusters, each cluster consisting of four screened sampling intervals of 20 ft length at a depth of approximately 150 ft, 200 ft, 260 ft and 300 ft below surface. The cluster locations were chosen in order to represent geographical coverage, as well as high and low As areas (Fig. 2). The cluster DEP-5 was installed away from the area of high As to serve as a reference site. Subsequently the monitoring well clusters were sampled in May, June, October of 2008 and April 2009. The reason for the multiple sample collection was to establish a time series, allowing to observe a potential variation of groundwater chemistry based on: (1) well installation or (2) pumping in the well field to the west of the Pritcher Road site.

In order to test if infiltration of water from the phosphate mine to the east of the Pritcher Road site or infiltration of shallow groundwater (< 30 ft) is a source of As 8 shallow groundwater samples were collected by Geoprobe during the April 2009 sampling event (Fig. 3).

In addition 3 of the 5 geologic cores were described and sampled in detail to delineate the presence of arsenic in the aquifer matrix. This included: (1) the chemical analyses of at least 20 samples per core for As, Sb, Al, Si, Fe, Mg, Ca, P, Sr, S, Mo, and Mn content and (b) preparation of at least 10 thin sections per core for electron microprobe analyses of mineral phases to determine arsenic and antimony concentrations. Sampling consisted of a two-step process, where samples were collected randomly and from areas potentially higher in arsenic, such as fracture zones, framboidal pyrite, iron-oxyhydroxide coatings on limestone/dolostone grains, and high porosity zones containing molds, fractures and various other dissolution features. This sampling approach was successfully applied by Lazareva and Pichler (2007) and Price and Pichler (2006) to assess the importance of pyrite as the source of As in the Upper Floridan Aquifer.

Based on data collected until October 2008, 20 private supply wells and the FDEP monitoring wells were selected and sampled in April 2009 for groundwater dating using the tritium-helium method (T-He) to better assess key questions such as:

- ∞ Is there a correlation of age with predicted flow direction?
- ∞ Is there an increase of ages with depths in the deep aquifer?
- ∞ Is there a correlation of age with Arsenic concentration?
- ∞ Is there young water in deeper aquifer?
- ∞ Where are the pathways from upper to lower aquifer?

2.1. Analytical Methods: Water Chemistry

The FDEP staff and laboratories carried out the bulk of the field measurements and chemical analyses. Exceptions were As-speciation, total As, Sb, Mo, stable isotope and field-based sulfide analyses, which were provided by EnChem and by the University of California at Davis Stable Isotope Facility. The stable oxygen and hydrogen isotopes were determined by simultaneous analysis of $^{18}\text{O}/^{16}\text{O}$ and D/H isotope ratios in liquid water samples using an LGR DLT-100 instrument (Los Gatos Research, Inc., Mountain View, CA, USA). Each sample was injected 6 times, the first 3 injections are discarded to eliminate memory effects, and the

average of injections 4, 5 and 6 was used for isotope ratio calculations. Working standard waters calibrated against NIST standard reference materials (VSMOW, GISP, SLAP), were inserted in the sample sequence (usually before and after each group of 6 unknowns). Sample isotope ratios are adjusted to working reference waters. Results are given in delta notation ($\delta^{18}\text{O}$ and δD) relative to Vienna Standard Mean Ocean Water (VSMOW). Precision was better than 0.3 ‰ and 0.8 ‰ for $\delta^{18}\text{O}$ and δD , respectively.

Total As and Sb concentrations were analyzed by hydride generation-atomic fluorescence spectrometry (HG-AFS) on a PSA Millenium instrument following procedures by (Price and Pichler, 2005, 2006). A 2% solution of potassium iodide was used to reduce As(V) to As(III) prior to hydride generation. The 4 arsenic species, As(III), DMA, MMA and As(V) were separated in a Hamilton PRP-X100 column using a potassium phosphate buffer prior to HG-AFS analysis. The quality of the speciation data was confirmed by comparing total As to the sum of As species. Molybdenum (Mo) was determined on a Perkin Elmer Optima 2000 DV inductively coupled plasma – optical emission spectrometer (ICP-OES). The accuracy and precision of the measurements were verified through the use of internal and external standards.

Sulfide was determined in the field by photo spectrometry using a HACH DR 2400 Portable Spectrophotometer following the USEPA approved Methylene Blue method.

2.2. Analytical Methods: Rock/Sediment Mineralogy and Chemistry

The cores from the well clusters DEP-1, DEP-2 and DEP-5 were described in hand sample, using hand lens and stereo-microscope. A total of 219 samples were selected for further chemical and mineralogical analyses: DEP-1 (56), DEP-2 (88) and DEP-5 (75). Those samples for chemical analyses were dried at room temperature and subsequently powdered by hand with an agate mortar and pestle, which was cleaned with pure quartz sand and rinsed with distilled water between samples to prevent cross contamination. Approximately $0.5 \text{ g} \pm .005 \text{ g}$ of powdered sample was weighed into vials for digestion with aqua

regia, a 3:1 mixture of HCl and HNO₃. The samples were capped with a ribbed plastic watch glass to prevent the escape of arsine gas and placed on a hot block for 30 minutes at 80 °C. The glasses were then removed and the condensation rinsed from each lid with DI. For each digestion batch, 54 samples, 2 internal standards (homogenous local limestone), 1 external standard (JLS-1), 2 spiked samples, and a blank were included for quality control. Once cooled the digestates were diluted to 50 mL with DI water and allowed to settle for at least 24 hours before being passed through a 2.0 µm Teflon. Two mL of the filtered samples were diluted with 8 mL of DI for the determination of on the Perkin Elmer Optima 2000 DV inductively coupled plasma – optical emission spectrometer (ICP-OES) for Al, Si, Fe, Mg, Ca, P, Sr, S, Mo, and Mn following procedures by (Price and Pichler, 2006).

A second aliquot of each sample was prepared for As and Sb analysis using hydride generation-atomic fluorescence spectrometry (HG-AFS) on a PSA 10.055 Millennium Excalibur instrument following procedures by (Price and Pichler, 2006). Ten (10) mL of digested sample were transferred to a new Teflon vial. Then 15 mL trace metal grade HCl and 1 mL saturated KI solution were added to reduce the As to As³⁺. Each aliquot was finally diluted to 50 mL with DI water.

To assure quality control duplicate samples were randomly selected for approximately 10% of the samples and had a reproducibility of ≥ 95% on the ICP-OES and ≥ 90% on the HG-AFS. Sample blanks, which were added every 5 to 10 samples did not show detectable concentrations of As or Sb. To test for recovery, 2 samples from each batch were spiked with 25 mg/kg As before digestion. Recovery of As was always between 90 % and 110 %.

Polished thin sections were made for 20 samples high in As and Mo for further analyses of discrete mineral phases by transmitted and reflective light microscopy as well as electron microprobe analysis (EMPA). The thin sections were analyzed with a Nikon Eclipse LV100 POL petrographic microscope to determine the presence and mineral associations of pyrite and to delineate targets for EMPA. The individual pyrites and other targets were then analyzed for

As, Mo, Ca, Zn, Fe, S, and Sb with a JEOL JXA-8900R instrument. Reference materials consisted of natural and synthetic sulfide, sulfate, silicate, and oxide. Calcium was analyzed as an excitation-volume monitor during sulfide analysis as some samples were small, irregular, and thin. The analyses were corrected for electron beam and matrix effects, and instrumental drift and dead time using a Phi-Rho-Z algorithm supplied with the JEOL WDS electron microprobe (Armstrong, 1995). Relative accuracy of the analyses, based upon comparison between measured and published compositions of standard reference materials, is ~1-2 % for concentrations >1 wt. % and ~5-10% for concentrations <1 wt.%. Analyzed elements and oxides and their detection limits (wt.%) at 3 sigma (background) are as follows: Sb (0.02), As (0.05), Fe (0.03), S (0.03), Zn (0.07), Mo (0.08), FeO (0.05), SrO (0.09), MnO (0.04), BaO (0.04), CaO (0.04), As₂O₅ (0.09), MgO (0.03), SO₄ (0.08).

2.3. Analytical Methods: Tritium-Helium Dating

To avoid atmospheric contamination the samples were taken after excessive well purging. Conductivity, temperature, pH and oxygen content were monitored and sampling took place only once values were stable. The samples to be used for helium and neon analyses, and determination of the ³He/⁴He isotope ratio ($\delta^3\text{He}$) of dissolved helium were collected (in duplicate) into specially prepared copper sample tubes. The copper tubes were flushed for 5 minutes prior to capping. During sampling, the copper tubes were attached with clear Tygon[®] tubing to visually observe whether air bubbles are present in the water line. The sample fraction to be used for tritium determination by helium ingrowth was collected in duplicate into Safety-coated 500 mL glass bottles with polycone seals.

Analysis of ³H, He isotopes and Ne for ³H-³He dating was conducted at the noble gas laboratory of the Institute of Environmental Physics, University of Bremen. For the He and Ne isotope analysis all gases were extracted from water. He and Ne were separated from other gases with a cryo system kept at 25 K and 14 K and ⁴He, ²⁰Ne and ²²Ne were measured with a quadrupole mass spectrometer. The helium isotopes were analyzed with a high-resolution sector

field mass spectrometer (MAP 215-50). The system was calibrated with atmospheric air and controlled for stable conditions for the He and Ne concentrations and the $^3\text{He}/^4\text{He}$ ratio. For groundwater samples, the precision of the He and Ne concentrations was better than 1 % and for the $^3\text{He}/^4\text{He}$ ratio better than 0.5 %.

Tritium (^3H) was analyzed with the ^3He -ingrowth method (Clarke et al. 1976). Samples of 500 g of water were degassed and stored to allow for the accumulation of the ^3He the ^3H decay product in dedicated He-free glass bulbs. After a period of 6 months ^3He was analyzed using the MAP 215-50 instrument. This method achieves a detection limit of 0.01 TU, which allowed the detection of the residue of pre-bomb ^3H . The uncertainty was typically less than 3 % for samples of > 1 TU and 0.01 TU for very low concentrations. For ideal samples, analytical conditions allow a time resolution of about 3 months for apparent ages of less than 10 years. Unknown hydrogeological conditions affecting gas exchange, as for example inaccurate temperatures assumed for gas exchange with the atmosphere (Solomon and Cook, 2000) lead to a time resolution of about 0.5 to 1.0 year (Kipfer et al., 2002). More details of the sampling, analysis and data evaluation of the method are given in (Sültenfuß et al., 2009).

3. Results and Discussion

3.1. Water Chemistry

The analytical quality of the data was very good. There is excellent agreement for As data between the EnChem and the FLDEP laboratories. This provides the necessary confidence for data interpretation, since the distribution of As, Sb and Mo did not show any logical pattern.

Sample duplicates and field blanks demonstrated good reproducibility and the absence of sampling related contamination. Major and trace elements and hydrogen and oxygen isotopes stayed well within their analytical uncertainty of around 3 to 5 %. With the exception of samples from well DEP-1-165 charge balances were better than 5 %. This well showed some grout problems, as indicated by low Mg values, high pH and high K values. However once OH^- was

added to the charge balance the error also dropped below 10 %. Based on the analyses of sample duplicates As speciation data was deemed reliable (better than 10 % deviation) for samples with total As concentrations of > 10 µg/L.

3.1.1. Monitoring Well Clusters DEP-1 to DEP-5

Following installation, the monitoring well clusters DEP-1, DEP-2, DEP-3, DEP-4 and DEP-5 were sampled in May, June, October of 2008 and April 2009. The water was of the HCO₃-Ca type and most monitored elements showed little variation (Fig. 4 and Table 1). Water Type and distribution in the Piper diagram were as expected for Floridan groundwater (compare to Fig. 10 in Sacks, 1996). Only those elements sensitive to changes in redox conditions, such as, sulfide, oxygen, iron and arsenic showed larger variations.

Field Measurements: Those measurements done in the field by electrode, such as, oxygen (DO), ORP and turbidity showed a somewhat erratic data distribution. Changing oxygen values, for example were not recorded in ORP and vice versa. Turbidity was low but also showed unexpected variation with time. One would have expected turbidity values to constantly drop with time. Only pH and conductivity showed stable readings.

Sulfide: There was excellent agreement between those sulfide measurements made in the field and those in the laboratory ($r^2=0.89$). This indicates that sulfide did not oxidize to sulfate from the time of sampling until its analysis in the laboratory. For all subsequent calculations the laboratory values will be used. All wells showed the same pattern of increasing sulfide concentrations with depth (Fig. 5). In wells DEP-1 and DEP-2, there was only very little variation with time, whereas the other three wells showed increasing or decreasing values of sulfide with time. This would indicate that the groundwater conditions were disturbed during well installation, but are slowly returning to pre-installation conditions. This is particularly evident in well DEP-4 and to a lesser degree in DEP-5 where sulfide and As are inversely correlated. This is an argument to use the data from the most recent sampling for further discussion of the site.

Vanadium (V): Vanadium concentrations remained below the detection limit of 5 µg/L, except for the shallow interval in DEP-1 and DEP-2, where values were approximately 25 and 10 µg/L, respectively. However, only the value in DEP-1 could be verified by a second sampling.

Nickel (Ni): Nickel concentrations weakly correlated with those of Mo. Whenever Mo was substantially elevated above the assumed background concentration of approximately 0.5 µg/L Ni was detected at concentration above the detection limit of 0.25 µg/L. Values were never above a level considered detrimental to drinking water quality. It is likely that Ni is a minor element in the mineral powellite (CaMoO_4) and released during powellite dissolution.

Arsenic (As): Arsenic values were generated by two laboratories, the FDEP laboratory and the USF Center for Water Analyses. There was good agreement between the two data sets ($r^2=0.989$). Arsenic showed a most erratic behavior and without confirmation by two independent laboratories there would have been doubt about the data quality. Generally those wells with high values had relatively stable As concentrations, some times they displayed a slight increase with time. Those samples with lower As concentrations often showed decreasing trends with time (see sulfide above). This trend was particularly strong for six monitoring intervals, DEP-1-270, DEP-2-276, DEP-4-228, DEP-4-275, DEP-5-173 and DEP-5-270 (Fig. 6). In this set of samples an even more pronounced trend of decreasing values could be observed for Mo (Fig. 6). With the exception of DEP-5-173 these observations are confined to the deeper intervals. The reason for the declining values could be that during well installation oxygenated surface water was introduced into the deeper aquifer where due to the associated change in groundwater conditions, powellite and pyrite became instable and released As and Mo. Once well installation was completed the groundwater conditions slowly returned to pre-installation, “normal” conditions. Hence, the observed decline in As and Mo concentrations.

There was no statistically significant linear correlation between sulfide and As, although those wells with high As concentrations (DEP-1, DEP-2 and DEP-3) showed a clear pattern of low sulfide and high As (Fig. 5). In well DEP-4 this

pattern is much less developed and it is absent in well DEP-5 (Fig. 5). Arsenic speciation data confirmed the presence of arsenate (As^{5+}) in the those samples collected from the shallow wells (Fig. 7), which would indicate either a redox disequilibrium with respect to $\text{As}^{3+}/\text{As}^{5+}$, but more likely that As was released under more oxygenated conditions as one would expect for groundwater from a depth of more than 150 ft. The deeper groundwater samples show virtually no As^{3+} . These observations correlate well with the results for sulfide concentrations and the sulfate to sulfide ($\text{SO}_4^{2-}/\text{S}^{2-}$) ratio (Fig.8).

In summary, most groundwater parameters compared to those of the private supply wells and were as expected for central Florida (Sacks, 1996; Sacks et al., 1995; Sacks and Tihansky, 1996). Only As and Mo showed a distinct pattern of (a) decreasing concentrations with depth (Fig. 9) and (b) a geographical distribution, with highest values in the center of the study area (Fig. 1).

A similar pattern could also be observed for $\delta^{18}\text{O}$ and δD , where lighter values were generally found at shallow depth; thus low $\delta^{18}\text{O}$ and δD did correlate to some degree with As and Mo. This becomes particularly evident in a comparison of monitoring and private wells, where most of the elevated As and Mo values fall into the isotopic range of the shallow monitoring wells (Fig. 10). This indicates that those supply wells with high As and Mo concentrations are likely screened shallower than those wells with lower to “normal” concentrations.

The observed separation (based on As, Mo and isotope values) between the shallow sampling depth of approximately 145-165 ft and the deeper intervals was also observed in the height of the groundwater table. In all monitoring well clusters (DEP-1 to DEP-5, Fig. 2) the water level in the shallow interval was consistently 3 to 6 ft higher than in the deeper intervals, indicating two different aquifers (APPENDIX: Water Levels).

3.1.2. Surficial Monitoring Wells

The chemical composition for the surficial wells MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-7 and MW-8 was as expected for water in the Surficial

Floridan Aquifer, where water composition is much more variable than in the confined Upper Floridan Aquifer (Table 2 and Fig. 4). The overall quality of the chemical analyses was excellent; all calculated charge balances were better than $\pm 5\%$. Particularly the two wells, MW-2 and MW-3, which were located on the Mosaic Phosphates Company property showed extreme values for $\delta^{18}\text{O}$, δD , SO_4 and Fe (Table 2). These values are due to extreme evaporation in the clay settling area of the Mosaic property. The well MW-6, which is located in an agricultural area between the well clusters DEP-2 and DEP-1 (Fig. 2), showed the highest N and Cl concentrations. These concentrations are likely the result of fertilizer use. After exclusion of these three wells the remaining 5 wells are of a comparable water type to the DEP well clusters (Fig. 4). The surficial wells, with the exception of MW-2 and MW-3 show the lowest δD and $\delta^{18}\text{O}$ values. This fits well with the observed values for the DEP monitoring wells, where the shallow intervals had lower isotope values (Table 1).

In all MW samples As and Mo were below their recommended abundance of less than 10 $\mu\text{g/L}$ and 40 $\mu\text{g/L}$, respectively. Thus infiltration of As or Mo from the Surficial into Upper Floridan Aquifer seems not to be a mechanism responsible for the elevated concentrations seen in the private supply wells in the Lithia area and in the monitoring well clusters, DEP-1 to DEP-5.

3.1.3. Private Supply Wells

Private supply wells were sampled up to two times (Table 3). Most measured parameters remained stable within their analytical uncertainty. Arsenic and Mo values varied more than other elements, but did not show a predictable pattern, values increased in some wells while they decreased in others. Some high values of Zn and V are likely a result of plumbing. Of real concern is the water quality at 8710 COUNTY LINE ROAD, where As is low, however, many other heavy metals were elevated. The second analyses of the subset of 40 private supply wells in December 2007 confirmed the values of the initial sampling in May 2007. Arsenic ranged from 0.1 to 350 $\mu\text{g/L}$ and the correlation of the values between the two laboratories was excellent ($r^2 = 0.998$). The As speciation data was inconclusive; in some samples As^{3+} was the dominating species, while in

other As^{5+} . There was no correlation between As speciation and those of other redox indicators, such as ORP, DO, S^{2-} or the sulfide to sulfate ratio. This should indicate that the water samples, as collected, are out of redox equilibrium, which may be a result of sampling or alternatively that different water mix in the well itself during extraction (see the different water types determined in the DEP monitoring wells and the surficial wells). However, to some degree, total As concentration showed a positive correlation with total SO_4^{2-} and $\text{SO}_4^{2-}/\text{S}^{2-}$ ratio (Fig. 11), indicating both the release of SO_4^{2-} from the aquifer matrix and potentially slightly oxygenated conditions, because under reducing conditions S released from the aquifer matrix would be present as S^{2-} . No reliable data for the screened interval was available for the private supply wells, this it is concluded that data from these wells is not beneficial to the interpretation of groundwater processes in the Lithia area.

Oxygen and hydrogen isotope data from the public supply wells, as well as the 5 monitoring well clusters indicate that the bulk of the contamination is confined to the shallow aquifer between 140 and 170 ft. Thus we can assume that those private supply wells high in As and Mo are open to that depth. Furthermore the final concentration of Mo and As in each well may be a result of what percentage of the total screen is between 140 and 170 ft

3.2. Rock/Sediment Chemistry and Mineralogy

After the petrographic examination of cores from wells DEP-1 and DEP-2 the lithological boundaries in the study area were determined as follows: Surficial Sediments 0 to 55 ft, Hawthorn Group 55 to 200 ft, Tampa 200 to 230 ft and Suwannee Limestone below 230 ft (down to the maximum well depths of approximately 350 ft). A detailed description is attached as APPENDIX (Core Description). With exception of the uppermost sediments, calcium carbonates were the main lithology. Occasionally dolomite and clay minerals were present.

This lithology was also observed in the bulk sediment chemical composition, where Ca was generally above 300 000 mg/kg. A detailed chemical composition is presented as an APPENDIX (Core Chemistry). Molybdenum and

As varied significantly with depth (Fig. 12) and values were significantly above the crustal average for Mo of approximately 1.1 mg/kg (Li, 2000). Values were highest between approximately 130 and 250 ft, which is the interval that roughly corresponds to the Hawthorn and Tampa. Below 250 ft, which corresponds to the Suwannee Limestone values returned “normal”, i.e., expected values for crustal carbonate rocks. DEP-5, which was the reference core outside of the immediate area of contamination did not differ from DEP-1 and DEP-2. Surprisingly DEP-5 had higher Mo and As values than DEP-2, which is the core from the monitoring well cluster with much higher Mo and As values. However it is not advisable to compare the abundance of Mo and As in the aquifer matrix directly to those in the groundwater. It has been shown that even small amounts in the aquifer matrix can cause high values in groundwater, if the physicochemical conditions are changed (Pichler and Jones, 2006).

The high concentrations of Mo and As were also confirmed during the mineralogical analysis of the core material from DEP-1 and DEP-2. During the description of hand specimens, pyrite was identified in both cores and later verified by reflected light microscopy. Pyrite was present in euhedral, massive and framboidal forms (Fig. 13 B-D). Electron microprobe analyses revealed variable concentrations of As in pyrite ranging from approximately 200 to 9 000 mg/kg (Table 5). These values are in the same range as those previously reported for the Hawthorn Group (Lazareva and Pichler, 2007) and Suwannee Limestone (Price and Pichler, 2006). Thus oxidation of pyrite has the potential to release large amounts of As to the groundwater in the Lithia area. The bulk concentration of Fe and S in the three cores correlated well and plotted along the “pyrite” line (Fig. 14), indicating that pyrite is ubiquitous in the aquifer matrix.

The calcium molybdate powellite (CaMoO_4) was identified in DEP-1. It occurred as very small grains of approximately 20 μm diameter (Fig. 13A). Identification was made using EDX spectra obtained in the EMPA (Fig. 15). This is the first description of powellite in Florida and should be closely linked to the high Mo concentrations found in the monitoring and private supply wells. Powellite contained up to 18 000 mg/kg As (Table 5), which would explain the correlation

between Mo and As in the monitoring well water samples ($r^2 = 0.91$, Fig. 16), assuming that the dissolution of powellite is a possible source for elevated As and Mo in the private supply wells and the DEP monitoring wells. (Note: although powellite was only observed in the core from DEP-1 it is very likely that this mineral is present in all other cores where Mo concentrations are high.)

Taking a closer look at core DEP-2 (Fig. 12) it becomes evident that arsenic is elevated at three different depths, at around 30 ft (bls), at around 150 ft (bls) and at around 200 ft (bls). Surprisingly, at each of these depths arsenic is associated with different elements. At 30 ft only As and Fe were elevated, while at 150 ft only As and Mo were elevated and at 200 ft only As, Fe and S were elevated. From this it is possible to deduce the mineralogical association of As. In the shallow subsurface where the conditions are still more oxygenated As is likely bound to hydrous ferric oxide, which is common (Raven et al., 1998). At the intermediate level off around 150 ft As seems to be more or less exclusively associated with powellite and at 200 ft where Fe and S were elevated, the source of As is likely As-rich pyrite. Unfortunately the shallow sections were not analyzed in the cores from wells DEP-1 and DEP-5 and thus the presence of hydrous ferric oxide was not confirmed. Nevertheless, these two cores showed the same correlation of As and Mo at a depth of around 150 ft and Fe, S and As at a depth of approximately 200 ft. Interestingly the inferred As mineralogy in the subsurface in the Lithia area follows an expected redox gradient for groundwater from oxygenated near the surface to more and more reducing conditions at depth. Hydrous ferric oxides are generally stable under oxygen-rich conditions (Jambor and Dutrizac, 1998), while powellite is stable in intermediate conditions and pyrite under reducing conditions (Rickard, 1968).

In summary, stereo microscope and reflected light microscope analyses showed that pyrite was present in most samples, which were selected for microprobe analysis. The average concentration of As in approximately 90 pyrite crystals from all samples was more than 2000 mg/kg, which is more than sufficient As to account for the high As values seen in groundwater in the Lithia area. Those pyrites higher in the stratigraphy had generally higher As

concentrations. As part of this investigation the mineral powellite (CaMoO_4) was encountered in one core DEP-1. This mineral was not previously described in Florida. Although one of the more common molybdates, this is a relatively rare mineral. Its presence explains the extremely high Mo concentrations seen in the groundwater in the Lithia area, as well as the correlation between As and Mo for those samples high in the two elements. Arsenic concentrations in powellite were as high as 18,000 mg/kg. The occurrence of powellite correlated well with those sampling intervals highest in Mo in the monitoring wells and more importantly the ratios of As and Mo were similar in groundwater (18 to 25) and mineral (23). This indicates the likely dissolution of powellite as the source of Mo and As seen in those samples. The reverse that the high Mo values in groundwater cause the precipitation of powellite cannot be immediately ruled out, since evidently powellite is a very late phase (Fig. 15). However, unpublished data from a recent study of the Avon Park Formation showed the presence of powellite at a depth of more than 700 ft (bls). At this depth and location anthropogenic interference can be ruled out, therefore demonstrating the “natural” occurrence of powellite in the Floridan subsurface.

3.3. T-He Dating

The results of the Tritium-He dating should elucidate whether these changes in physicochemical conditions are caused by (a) forced lateral movement due to pumping or (b) forced vertical flow and the associated input of younger, potentially oxygen-rich water into the shallow aquifer.

In total 48 samples were analyzed for tritium (^3H) and for 39 samples Ne and He isotope data could be obtained. Most samples were analyzed twice and showed high reproducibility. Therefore the data was judged as very reliable. The focus was to use ^3H as a tracer for young water and the by alpha decay produced ^4He or so called radiogenic ^4He , as a tracer for old water. The achieved detection limit for ^3H was 0.025 TU (tritium units) and allowed to detect natural ^3H from before 1950. The precision for ^3He , ^4He and Ne was 1%. The resulting error for ^3He from ^3H decay (tritogenic ^3He) was 0.5 to 1 TU. The uncertainty for the

calculated ^3H - ^3He age resulting from analytical conditions was therefore about 1 to 2 years.

In general the calculated ages correlated with depth. All surficial wells, MW-1 to MW-8, displayed water ages of about 20 to 30 years (Table 6). The sum of ^3H (Fig. 17, red bars) and tritiogenic ^3He (blue bars) of the samples add up to the ^3H concentration in precipitation at the calculated infiltration time period. Thus a ^3H free component (older than 1950) can be ruled out.

The waters collected from the shallow interval in monitoring wells DEP-1, DEP-2, DEP-3 and DEP-5 were younger water in the range of about 30 to 40 years (Table 6). Nevertheless, those samples also contain an older ^3H -free water component. Decay corrected ^3H concentration in precipitation in Florida always exceeds 2 TU. Hence all samples with ^3H less than 2 TU contain older, ^3H -free waters. The ^3H concentrations of the deeper samples were below 1% of the concentration of ^3H in precipitation of the last decades, thus excluding an addition of younger water to those depths. Hence all samples with ^3H less than 2 TU contain older, ^3H -free waters. Because of the relatively short screen length that has was not expected for the shallow depths.

All surficial wells are free of radiogenic ^4He . From this we deduce a maximum ^4He accumulation rate $3\text{E-}8$ ccSTP/kg/yr. Hence the high radiogenic concentration in the private wells must point to very old water (> 1000 yrs). The predominant set of samples (Fig. 18, black diamonds) contained only atmospheric ^4He and Ne. Four samples displayed a significant concentration of radiogenic ^4He (Fig 14, no.: 39, 24, 27 & 21). Values of ^4He are used as an indicator for old water and typical ages derived from such ^4He values are some hundreds to some thousands years in age. Those 4 samples were all from private supply wells, which also contained significant concentrations of ^3H (0.65 – 1.63 TU). The presence of both, significant ^3H and ^4He , in those wells can only be explained by mixing between very old and younger waters in the well itself, i.e., a long filter screen. On the other hand several samples had low ^4He concentration, but did not contain significant ^3H .

Only one of the private wells was virtually ^3H -free (< 0.025 TU), whereas all samples from DEP wells with depths below 215 ft were free of ^3H . The same deep DEP monitoring well samples also contained As below $0.5\ \mu\text{g/L}$.

3.4. Groundwater levels

The groundwater level measurements for the surficial monitoring wells and the DEP monitoring wells show a decrease of water level with depth, indicating three potential aquifers and a potential downward movement of groundwater (Appendix: Water Levels). Differences in water level between the surficial wells and the DEP wells are up to 30 ft, while the differences between the shallow and deep intervals in the DEP wells are only between 3 and 6 ft (Fig. 19). The well DEP-5 did not show the same separation. In DEP-5 the first two intervals showed more or less identical water levels, which were separated from the two deeper intervals by only 1 ft to 1.5 ft (Fig. 19). Despite this separation all DEP wells underwent the same water level fluctuation with time of up to 15 ft (Fig. 20), indicating that they are hydraulically connected. If the surficial wells undergo the same water level fluctuations remains unknown, because they were only measured once in April 2009. A natural process which would cause these large fluctuations is hard to imagine, particularly in the Lithia area, which is topographically flat and removed from the ocean by more than 30 miles. Thus pumping in the well field to the west of the study area should be the cause.

4. Conclusions

The large fluctuations in groundwater level, which are up to 15 ft, may be a potential trigger of As release in the unconfined surficial aquifer: (1) during the drop in water level, conditions in the upper part of the aquifer may change from saturated to vadose, (2) pyrite oxidizes and As is being released, (3) ferrous iron (FeII), which is also released oxidizes to ferric iron (FeIII) and hydrous ferric oxide (HFO) precipitates, (4) As is adsorbed to the HFO, (5) HFO remains stable as long as conditions are of a vadose nature, (6) pumping stops/shifts and the conditions slowly change to saturated again, (7) in the absence of oxygen HFO becomes unstable and As is being released, (8) this time As remains in solution

because the formation of pyrite, which could immobilize As, is much slower than the precipitation of HFO. Those private supply wells, which are open to the surficial aquifer may tap into this As reservoir. While the DEP wells undergo the same fluctuations, it is not likely that the aquifer changes from saturated to vadose.

Based on the interpretation of available data it becomes evident that despite its relatively small area, the geochemical and hydrogeological setting in Lithia is very complex. The combination of extensive cyclical pumping in the well field to the east cause large fluctuations in groundwater levels and may activate fracture flow, thus (1) facilitating the rapid recharge of surface water into the aquifer or (2) causing the upward movement of deeper groundwater into the shallow regions of the aquifer. During both processes the result is a change in redox conditions, which affects the stability of minerals present in the aquifer matrix. The exchange between different groundwater bodies, i.e., deep and shallow, is potentially enhanced due to the installation of more than 100 private supply wells in the Lithia area. Most of these wells have large open screened intervals, which allow water movement between the different water bodies. With respect to arsenic (As), the already complex situation is further complicated by its mineralogical association in the aquifer matrix. In the shallow aquifer As is mainly bound to hydrous ferric oxides (HFO), while in the intermediate aquifer it is bound to the mineral powellite (CaMoO_4) and in the deeper portions of the aquifer it is bound to pyrite. Of these minerals particularly HFO and pyrite are greatly affected by a change in redox conditions, such as the movement of reducing groundwater into the shallow aquifer or movement of oxygenated groundwater into the deeper aquifer. The calcium molybdate, powellite, likely form under somewhat oxygenated conditions, because under reducing conditions the molybdenum sulfide, molybdenite (MoS_2) would form. However after precipitation, the stability of powellite is not as readily affected by a change in redox anymore. Its stability is now more or less controlled by the ion activity product (IAP) of Ca and Mo. Thus groundwater movement and mixing of different groundwaters are likely the largest impact on its stability. The large fluctuations in

groundwater level in combination with a karsitic aquifer and more than 100 private supply wells are thus the four processes noted above which cause the release of As from the aquifer matrix.

- 1) Movement of reducing water into the shallow aquifer causes the dissolution of HFO due to the reduction of ferric to ferrous iron. The As which was adsorbed to the surface of the HFO is released to the groundwater. Should the condition remain reducing and sulfide be present, then pyrite can form and scavenge As from the groundwater. While this reduces the As loading of the groundwater under reducing conditions it will oxidize and release the As once conditions change back to oxygenated.
- 2) Movement of oxygenated water into the deeper aquifer causes the dissolution of pyrite due to oxidation of ferrous to ferric iron. The As, which is present in the pyrite structure is released to the groundwater. Should conditions remain oxygenated, then HFO can form and scavenge As from the groundwater. While this reduces the As loading of the groundwater under oxygenated conditions it will oxidize and release the As once conditions change back to reducing.
- 3) Due to water movement, either up or down, powellite can become instable. With time the system will equilibrate with respect to powellite, meaning that neither powellite precipitation nor dissolution takes place. Under these conditions As is likely bound in the powellite structure. However, if the equilibrated water is removed and replaced with groundwater, which is undersaturated with respect to powellite, dissolution takes place and causes the release of As until equilibrium is attained once more.
- 4) Undersaturation or over saturation of powellite can also be caused by simple mixing of groundwaters with a different chemical composition. For example groundwater A contains elevated Ca^{2+} , but no MoO_4^{2-} and groundwater B contains elevated MoO_4^{2-} , but only little Ca^{2+} . Mixing of

these two waters can increase the IAP to the degree of powellite precipitation.

Arsenic levels in many of the private supply wells are much higher than those found in the DEP monitoring wells, while Mo value are more or less comparable. This could indicate the above-mentioned addition of As which was released in the surficial aquifer. There the aquifer matrix is relatively low in Mo (Fig. 12) and As is thought to be bound to HFO.

The true enigma, however is that DEP-4 and DEP-5, which are geographically removed from the Pritcher Road area where As levels are highest, undergo the same water level fluctuations, but show much lower Mo and As values. Arsenic and Mo values in core samples from DEP-5 did not differ from those in DEP-1 and DEP-2, although water samples from the DEP-5 cluster did not show any As values above 3 µg/L and only one sample had Mo above 40 µg/L. Considering that DEP-5 undergoes the same water level fluctuations as the other 4 wells it becomes evident that in the Pritcher Road area restricted geological, hydrological and physicochemical conditions occur, which promote the release of Mo and As. At this time it seems that the only difference is the amount of private supply wells, which is much higher in the area where As and Mo contamination is highest. Since these wells are likely open to all three groundwater horizons, vertical water movement is facilitated. The mixing of waters from different water horizons in the private supply wells is indicated by their position in the $\delta^{18}\text{O}$ - δD plot (Fig. 10) and in the $\delta^{18}\text{O}$ -TU plot (Fig. 21), where they plot intermediate between the shallow and deep samples.

There is no indication that Mo and As are of anthropogenic origin and thus they should be of geogenic origin and that a change in physicochemical conditions in the aquifer causes their release. However, what causes exactly this change in physicochemical conditions is still unclear.

In summary, the combination of massive groundwater pumping to the west of Lithia combined with many private supply wells, which are open to several

groundwater horizons in a karstic aquifer create an environment conducive to As and Mo release from the aquifer matrix.

5. Outlook and Recommendations

Installation of water level monitors in each of the DEP wells to investigate the hydraulic conductivity between the upper and lower aquifer. Expansion of a local groundwater model, which should include the data from the 5 monitoring well clusters.

A potential remedy for the As and Mo problem in the Lithia area may be to install wells with discrete screens in the Suwannee Limestone or deeper.

This study at the Pritcher Road site turned out to be more difficult than expected, BUT therein lies a great opportunity to further both, our practical and our scientific understanding of geogenic contamination scenarios. Eventually results from this study should be made available to a broader audience to aid such investigations across Florida, across the US and across the world. Thus I recommend FDEP to keep this site as a priority.

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7. Figures

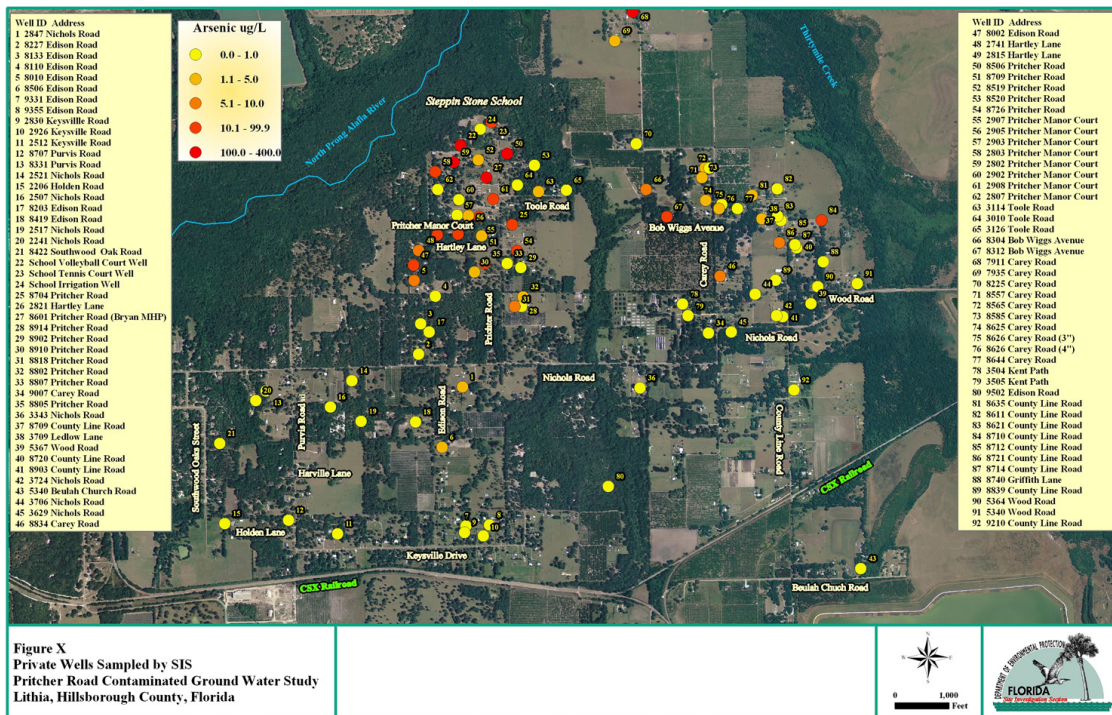


Fig.1 Location and distribution of private supply wells in the Lithia area, which were sampled in May 2007 by the Florida Department of Environmental Protection.

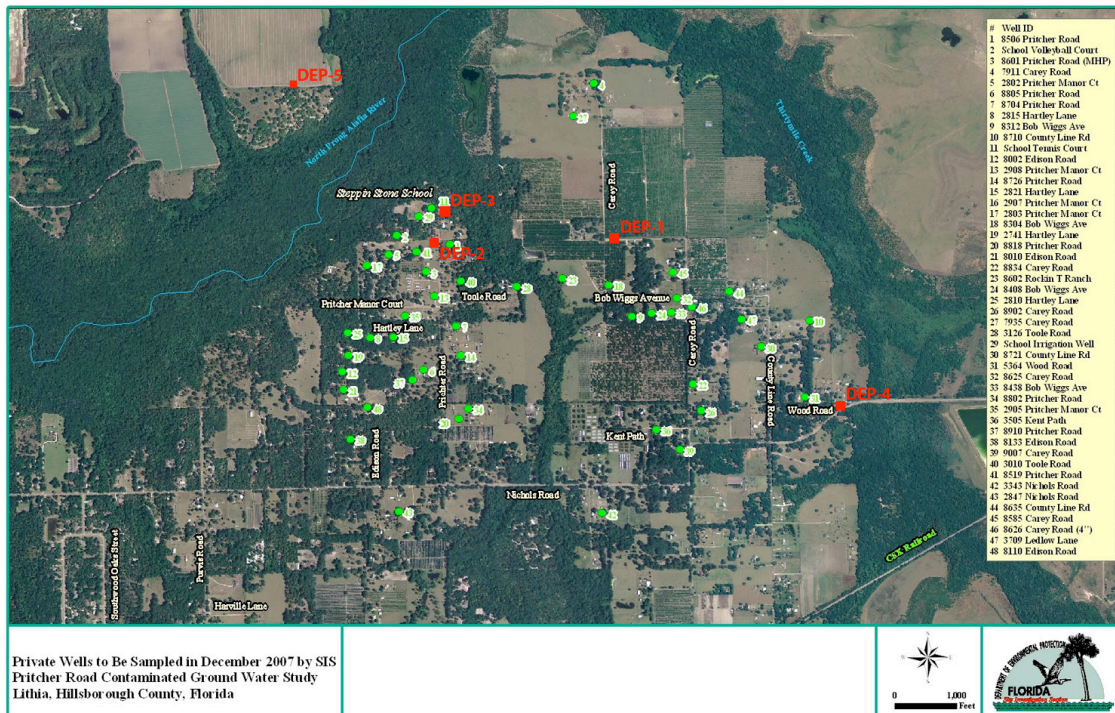


Fig.2 Location and distribution of those private supply wells, which were chosen for the second round of sampling, as well as the locations of the 5 monitoring well clusters DEP-1 to DEP-5.

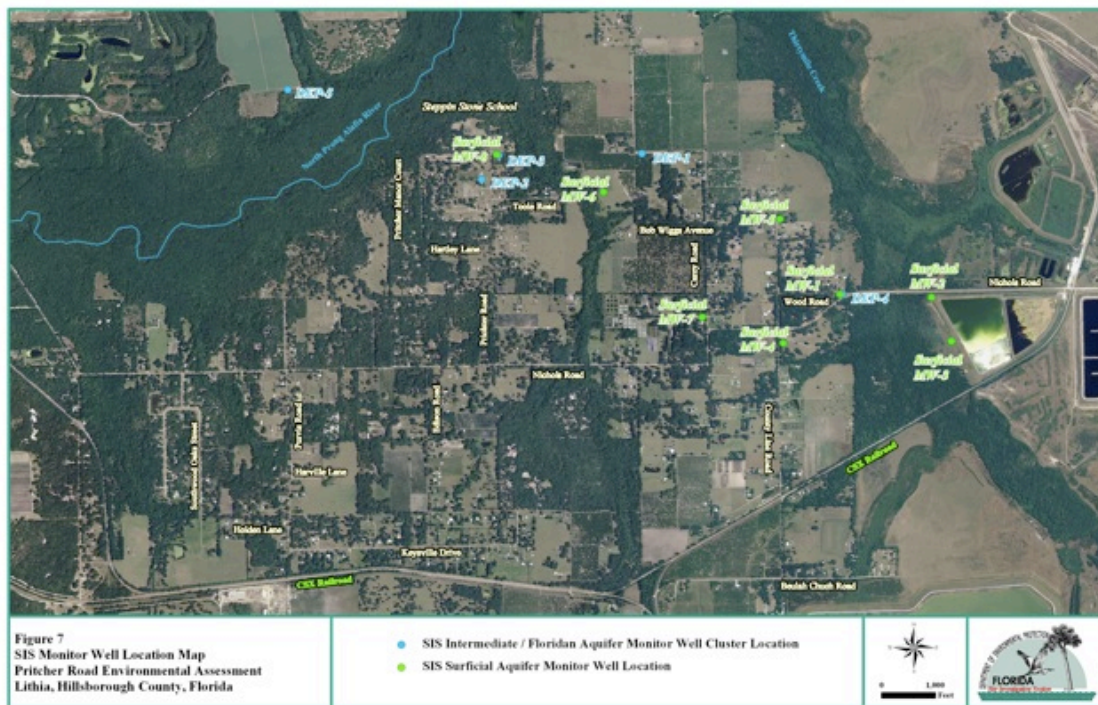


Fig.3 Location and distribution of the Surficial Aquifer Monitoring wells SW-1 to SW-5

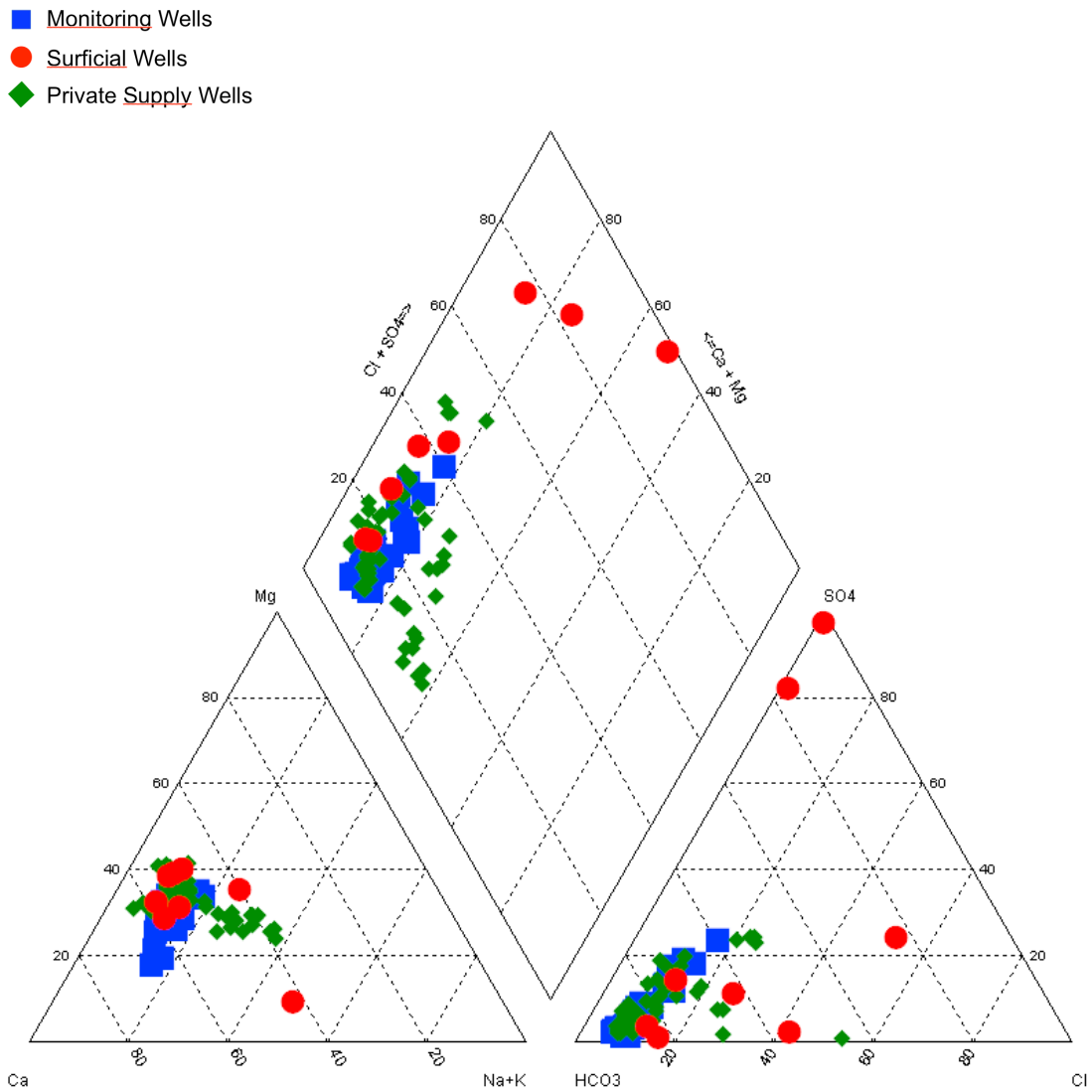


Fig. 4 Piper diagram of all water samples collected in from December 2007 until April 2009 from the DEP monitoring wells, private supply wells and shallow monitoring wells in the Lithia area.

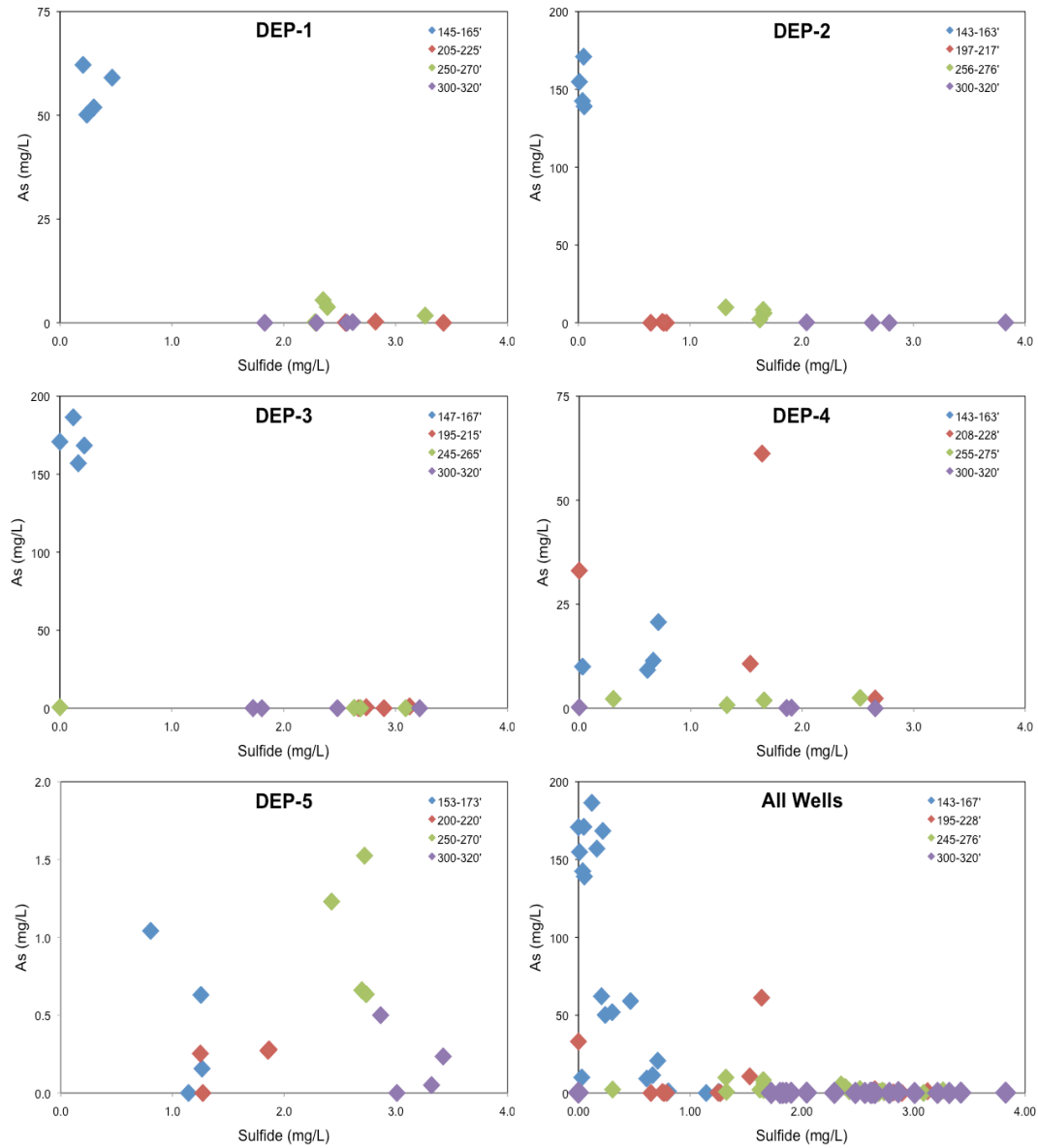


Fig. 5 Arsenic and sulfide concentrations for the 5 monitoring well clusters individually and for the whole data set.

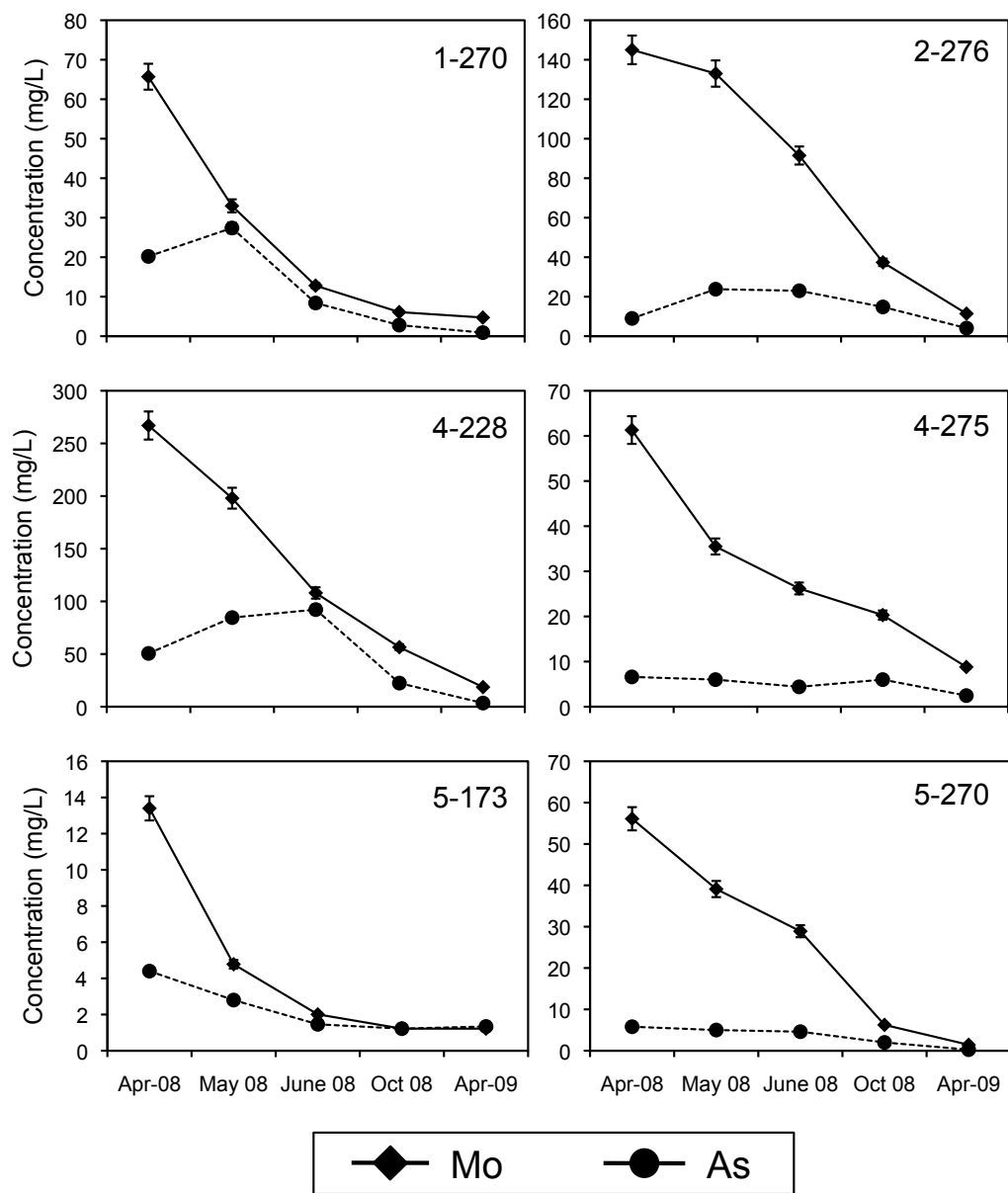


Fig. 6 Arsenic and Mo trends for selected DEP monitoring well intervals.

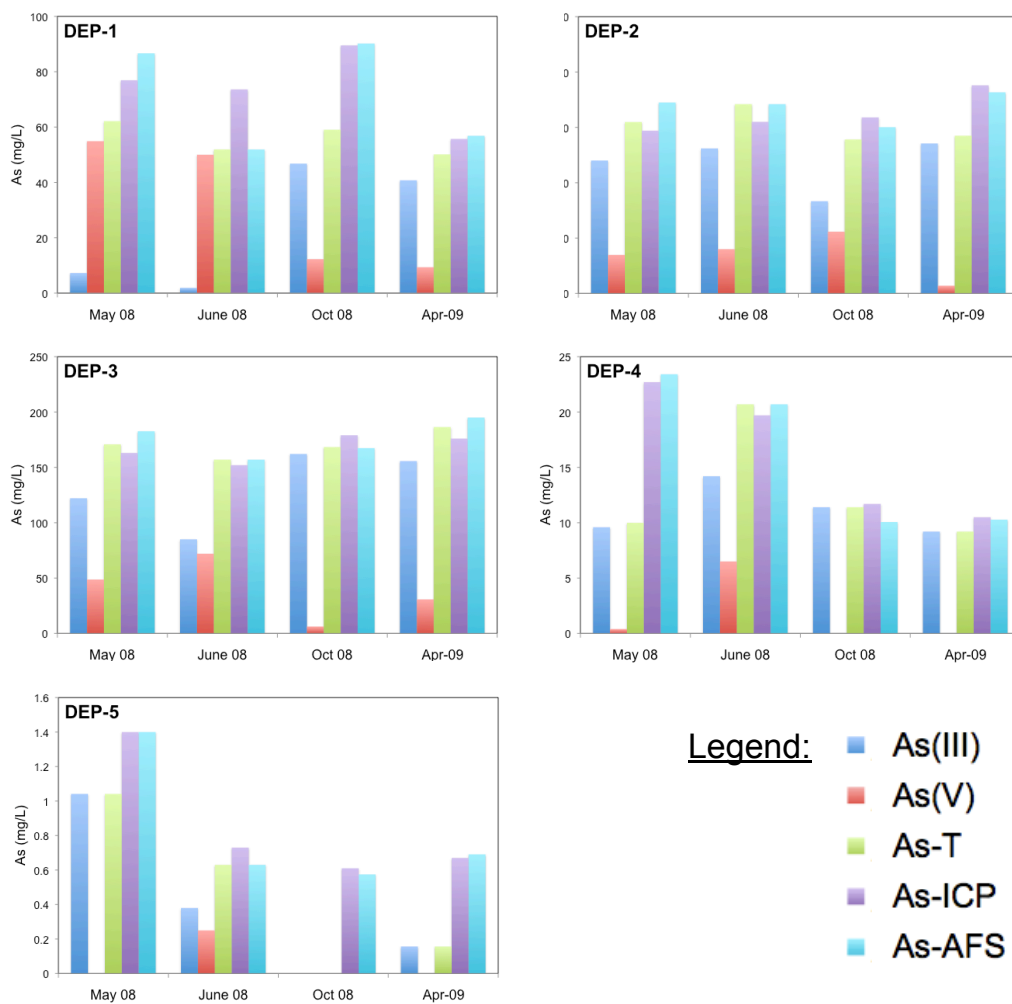


Fig. 7 Arsenic speciation results for As^{3+} and As^{5+} . Results are also compared to total As concentration determined by ICP and AFS

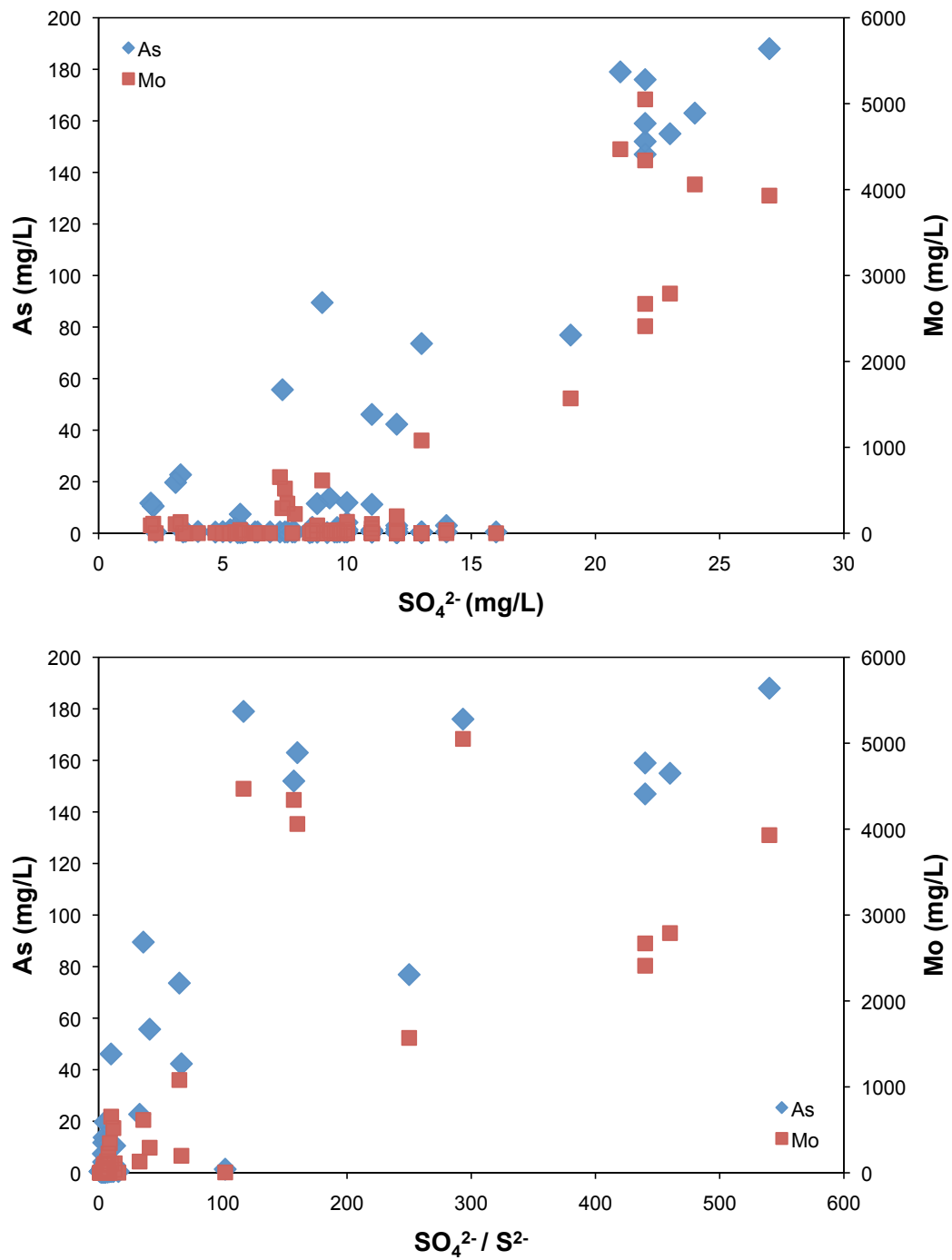


Fig. 8 Total sulfate and sulfate/sulfide ratios compared to As and Mo data in the DEP monitoring well clusters.

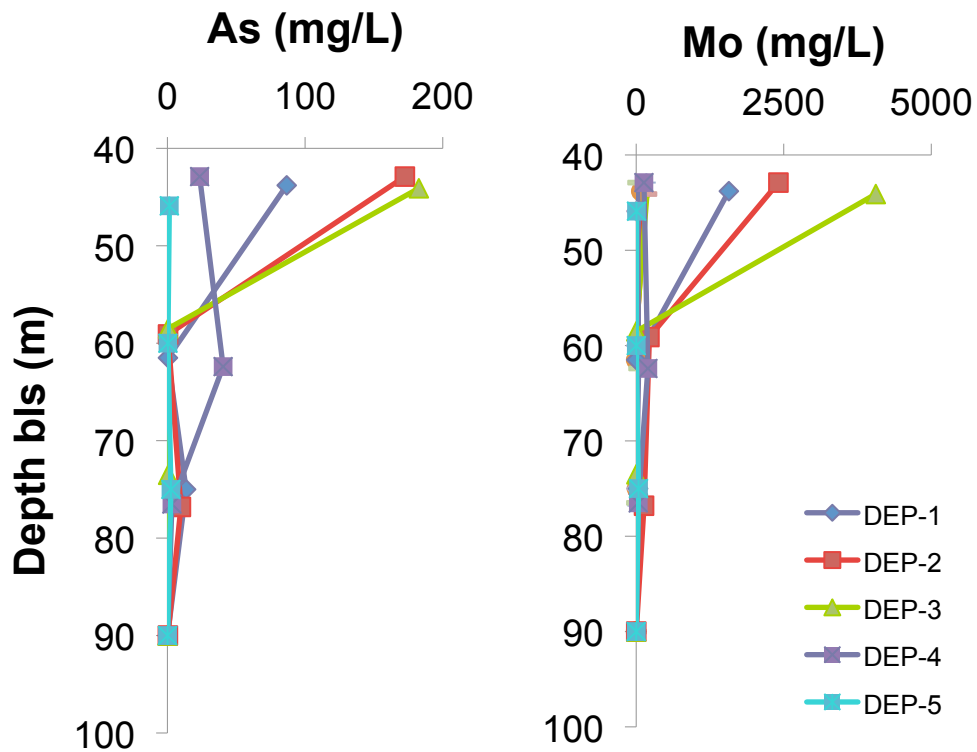


Fig. 9 As and Mo profiles with depth in the 5 monitoring well clusters in Lithia, Central Florida

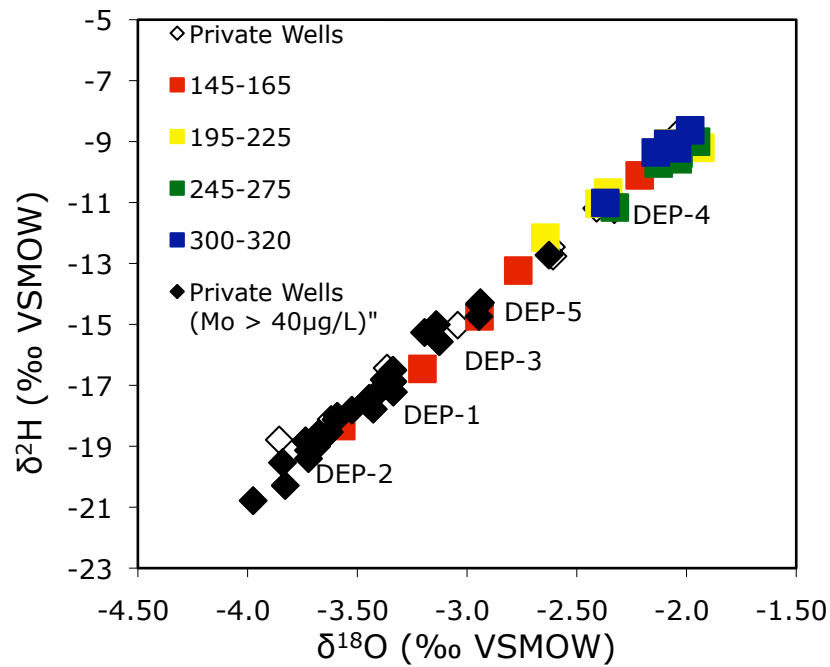
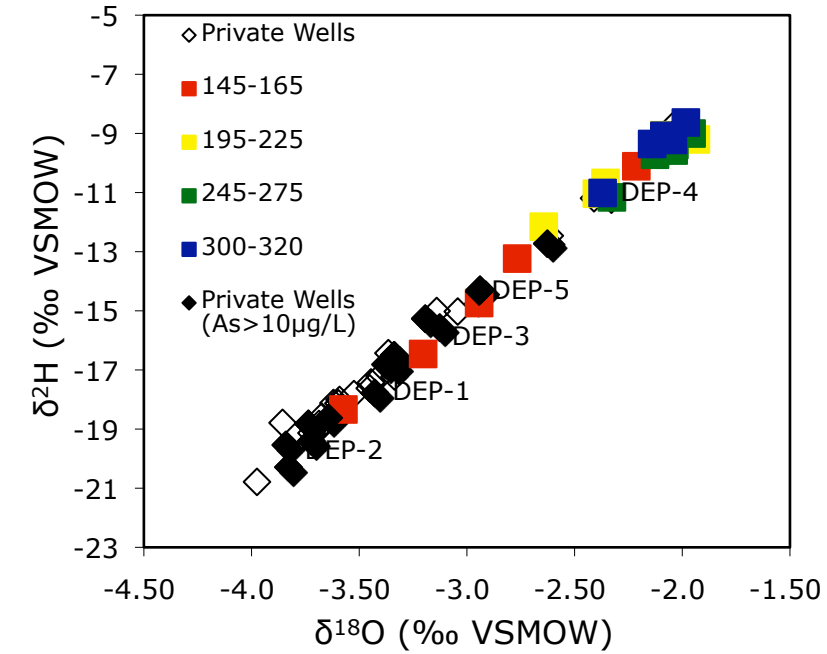


Fig. 10 Plot of $\delta^{18}\text{O}$ and δD for the 5 monitoring well clusters and 40 private supply wells in the Lithia area. The monitoring wells are color coded with depth. The private wells which show As values above the current drinking water standard are solid black. Most solid black diamonds fall within the range of the shallow interval in the monitoring wells (red color). Note: Well depths are in feet (ft).

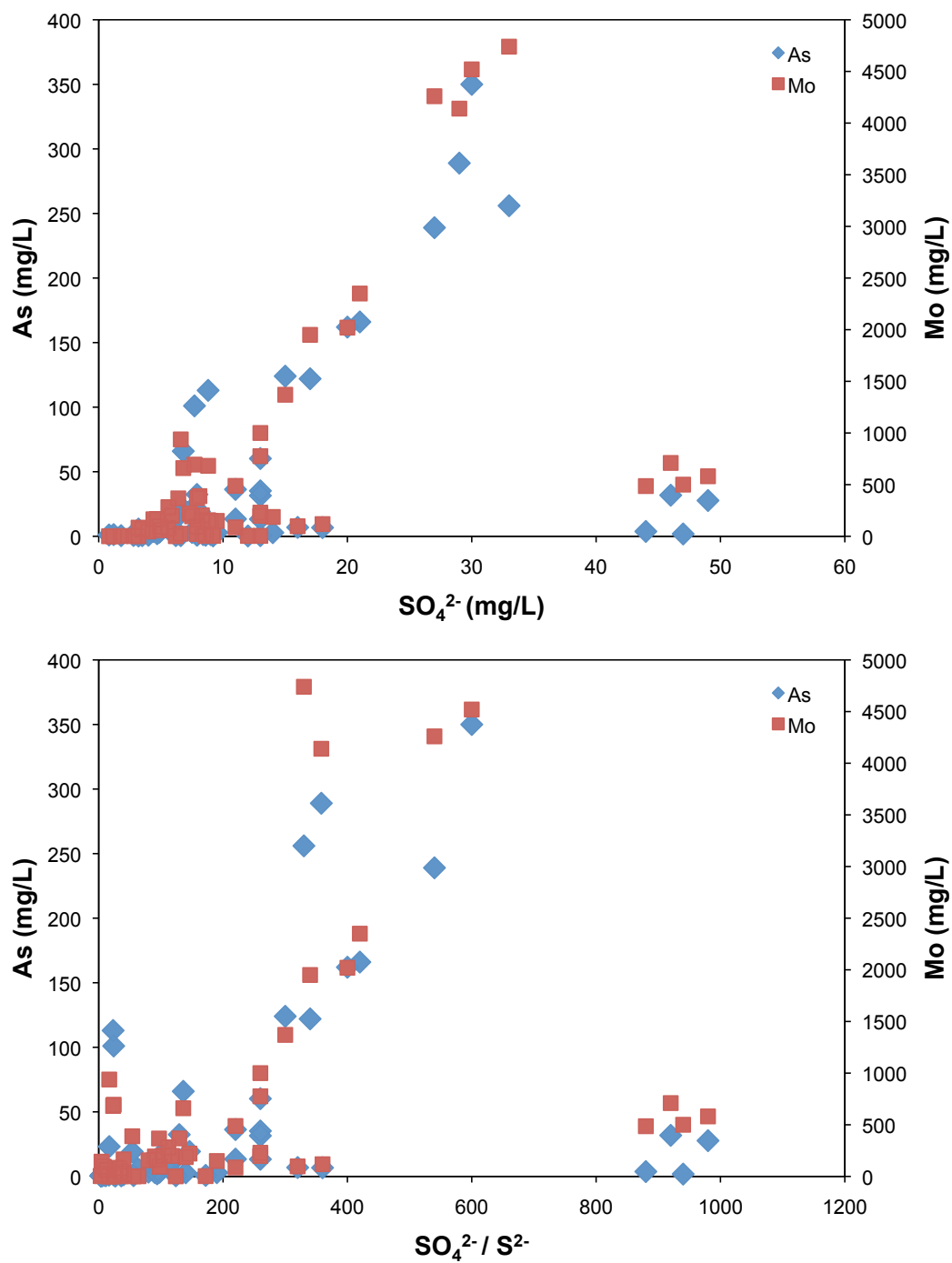


Fig. 11 Total sulfate and sulfate/sulfide ratios compared to As and Mo data in the private supply wells

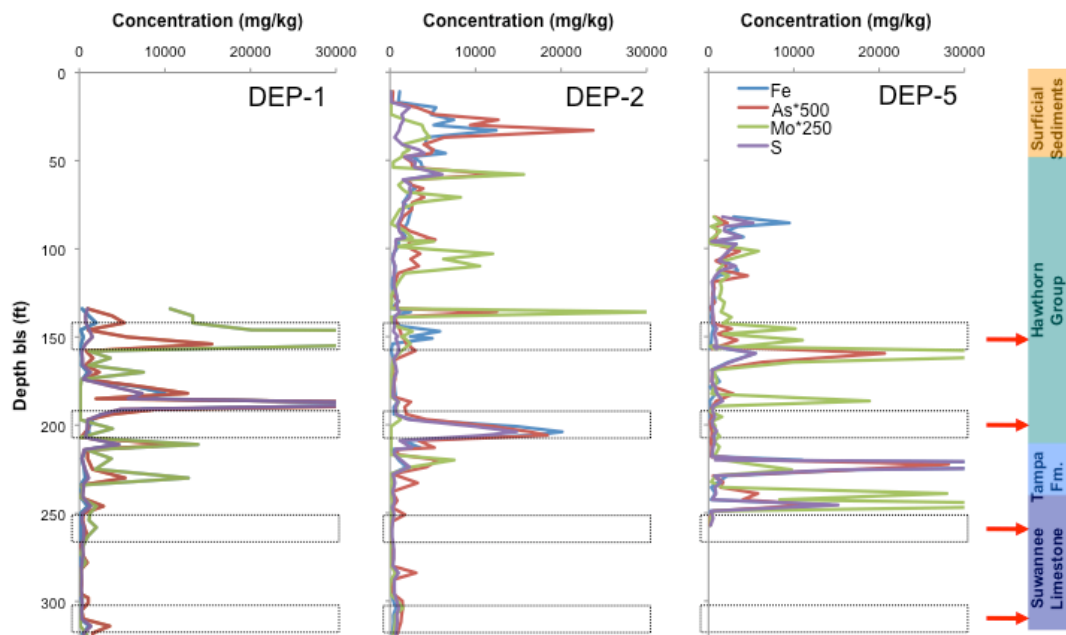


Fig. 12 Distribution of Mo and As with depth below surface (bls) for well clusters DEP-1, DEP-2 and DEP-5. The screened intervals are indicated by dashed boxes.

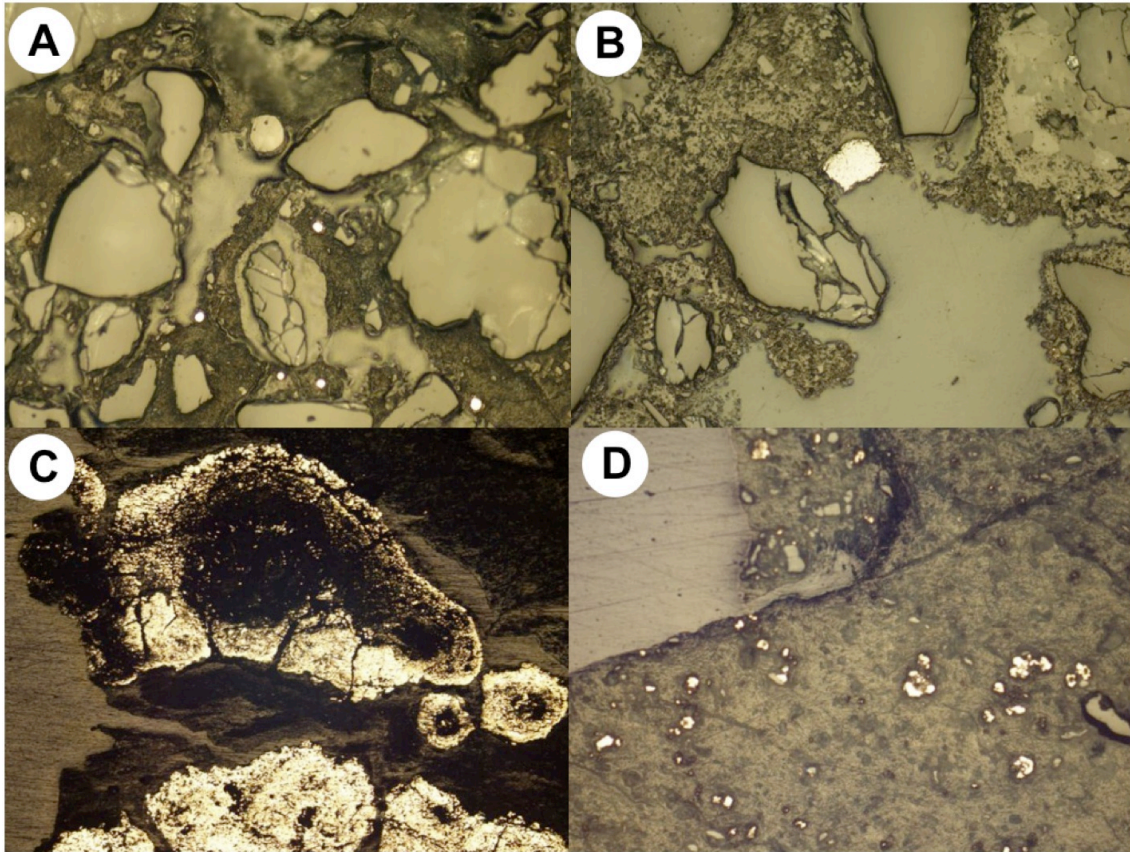


Fig. 13 Reflected light microscope images: (A) Small powellite crystals in a carbonate and clay matrix in core DEP-1 at 152 ft (20x magnification), (B) Larger euhedral pyrite in a carbonate and clay matrix in core DEP-1 at 156 ft (20x magnification), (C) Massive pyrite in core DEP-1 at 190 ft (2x magnification) and (D) Small framboidal pyrites in a carbonate matrix in core DEP-2 (20x magnification)

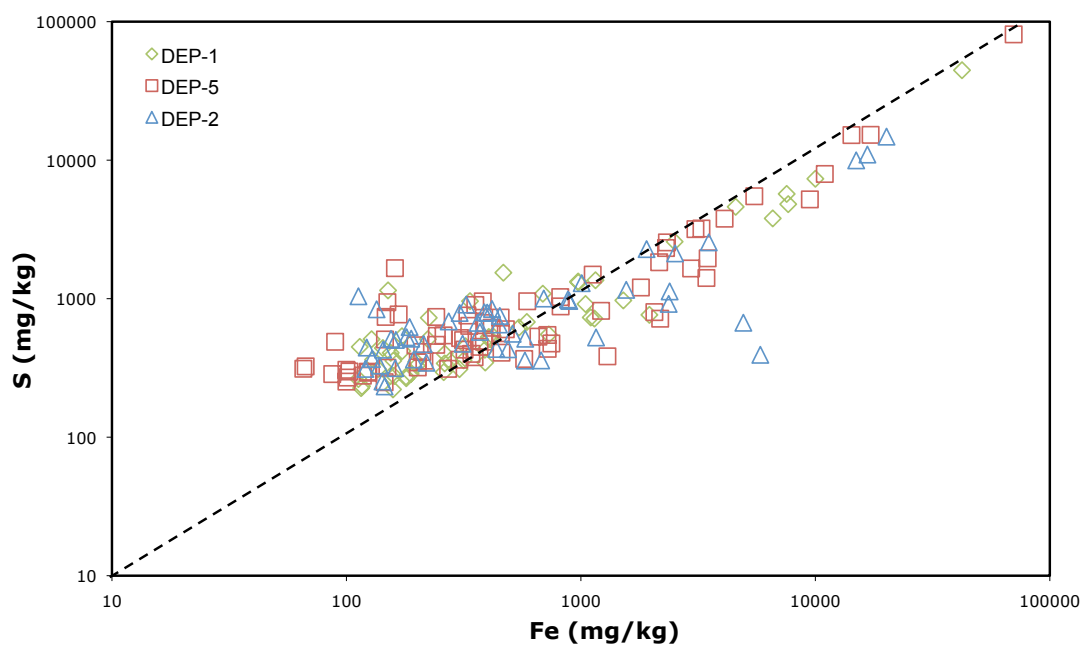


Fig. 14 Plot of Fe vs. S for the three monitoring well clusters DEP-1, DEP-2 and DEP-5. The dashed line represents the “pyrite line”, i.e., if pyrite would be the single source of Fe and S in a sample then all analyses would plot on this line.

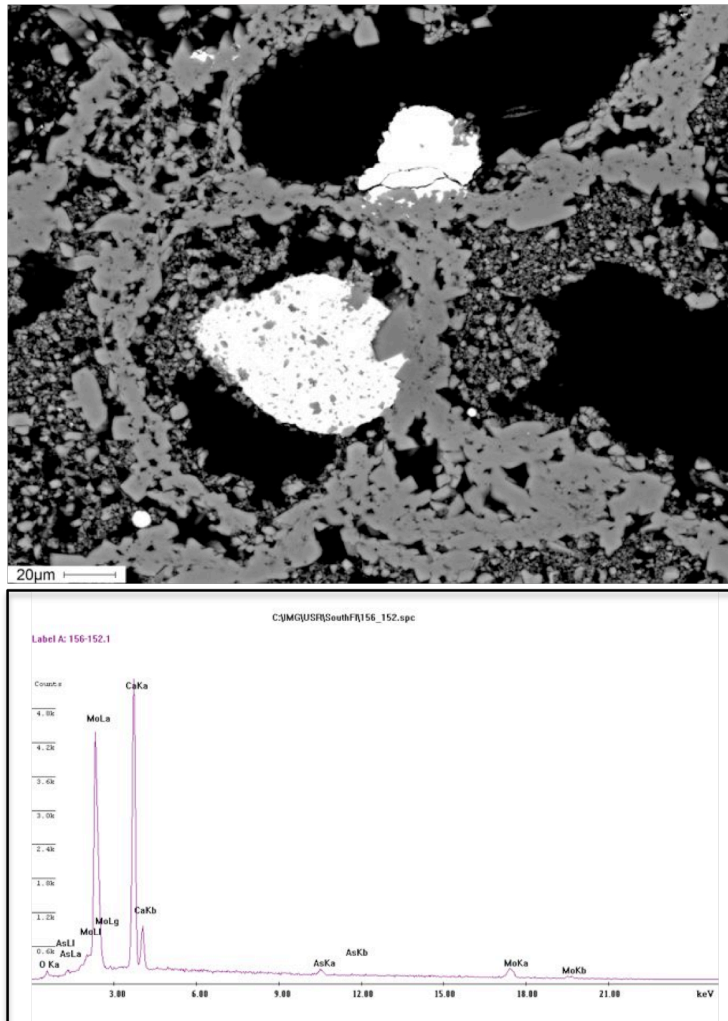


Fig. 15 Back scatter electron image from core DEP-1 (152 ft depth) of powellite in a clay/carbonate matrix. This type of image is based on density, the heavier a mineral phase the brighter it is displayed. Powellite is the latest stage of crystallization, not developing its own crystal shape, but filling pore space. The EDX spectra below was taken at a 5 μm-sized spot on the upper of the two powellites.

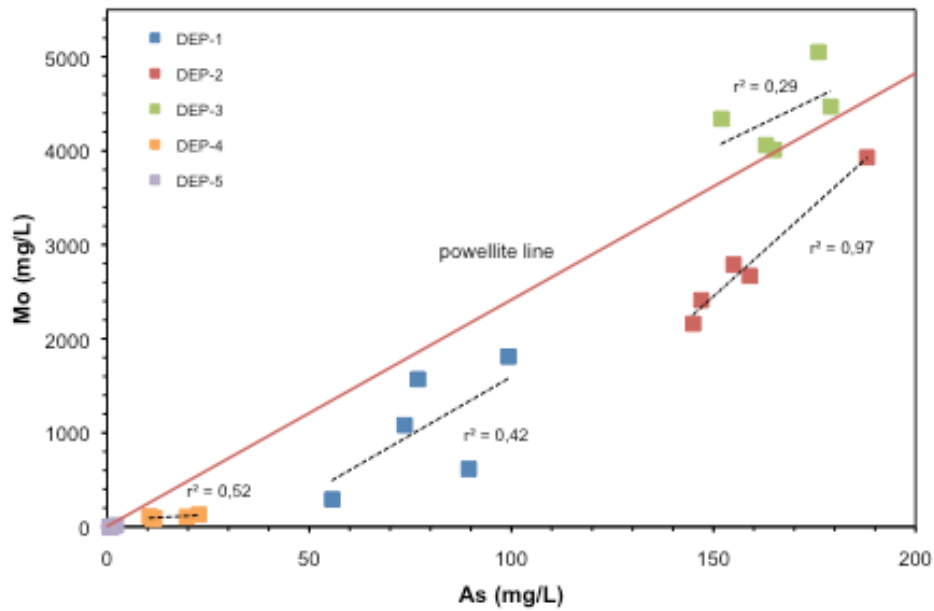
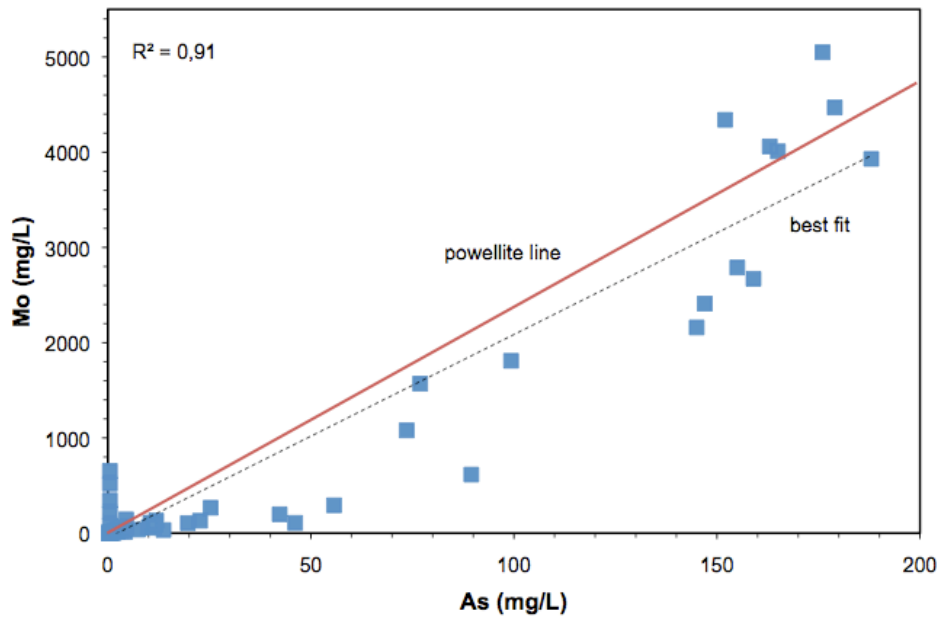


Fig. 16 Plot of As vs Mo for all FDEP monitoring well clusters. Above for the whole data set and below for the 5 well clusters individually. The powellite line was calculated based on the relative concentrations of Mo and As, which were determined by electron microprobe analysis (Table 5).

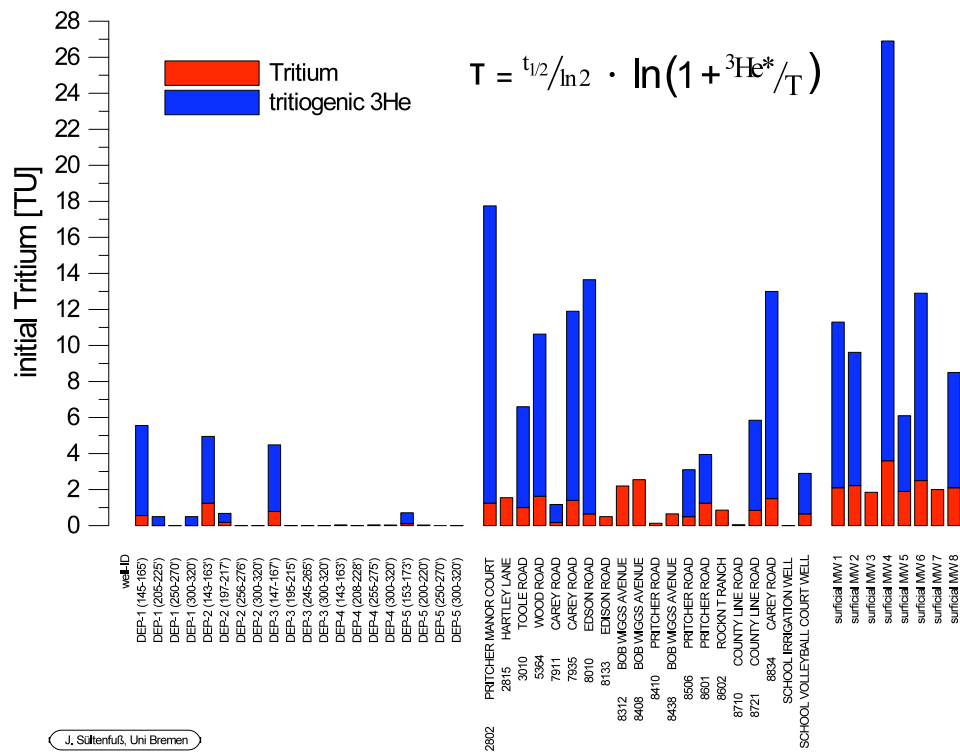


Fig. 17 Results of the tritium analyses and the calculated tritogenic ^3He for all samples. He isotopes were analyzed for samples where the blue bar on top of the red bar is missing.

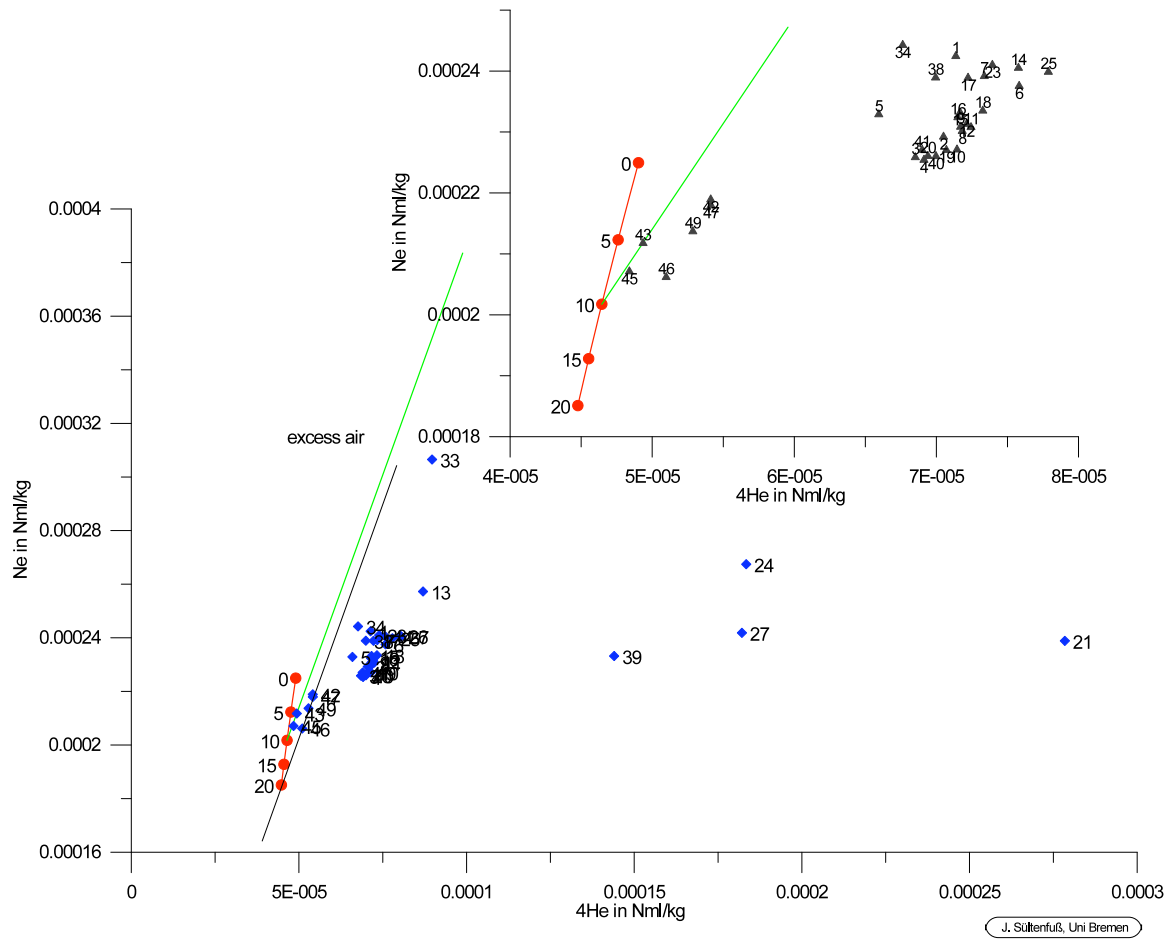


Fig. 18 Ne concentration vs. ⁴He concentration. The upper right figure is an enlargement. Red line indicates solubility equilibrium concentration for different temperatures. Green line represents the addition of atmospheric air to a sample equilibrated at 10°C.

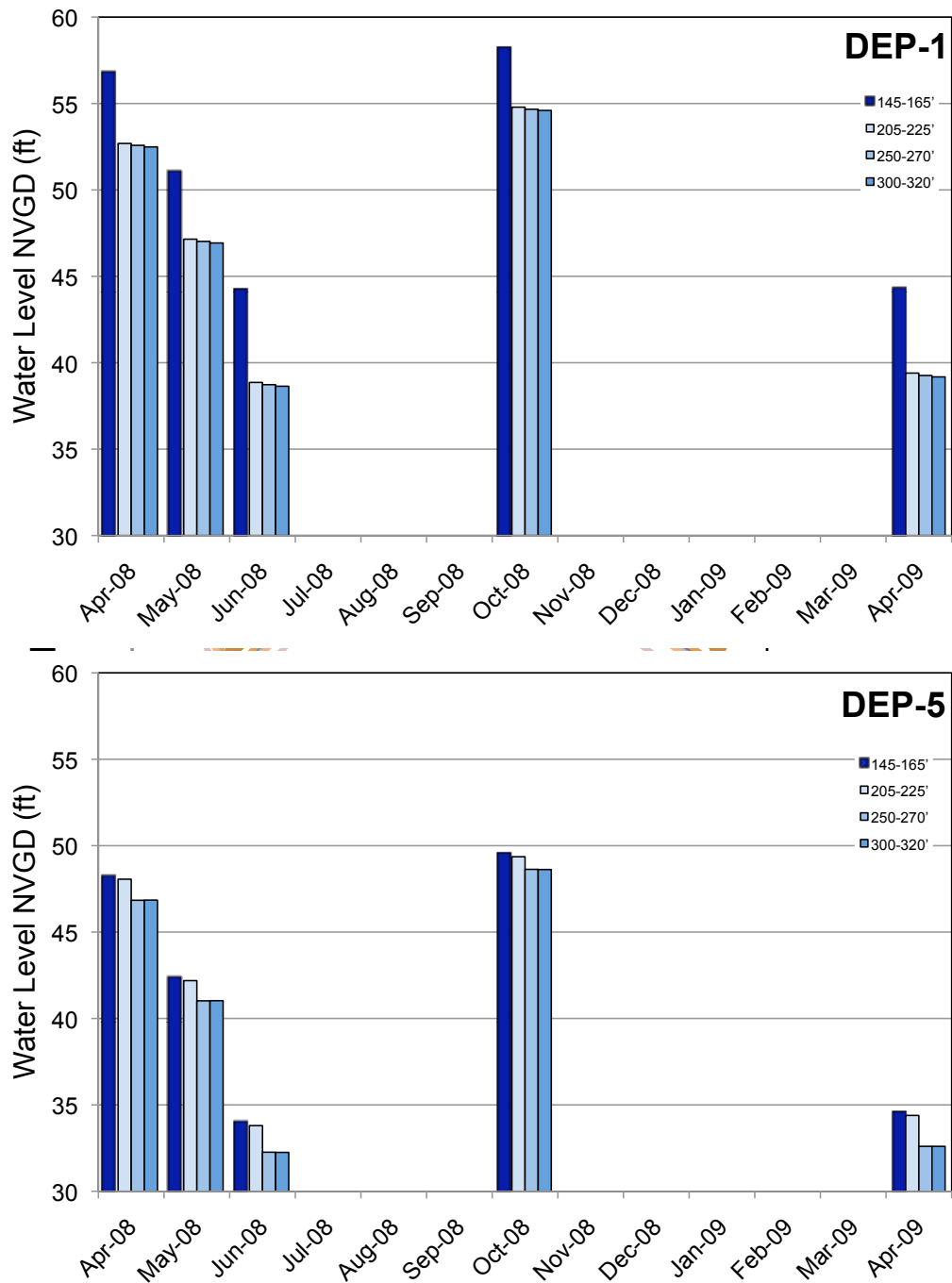


Fig. 19 Water level fluctuations with time in monitoring wells DEP-1 and DEP-5

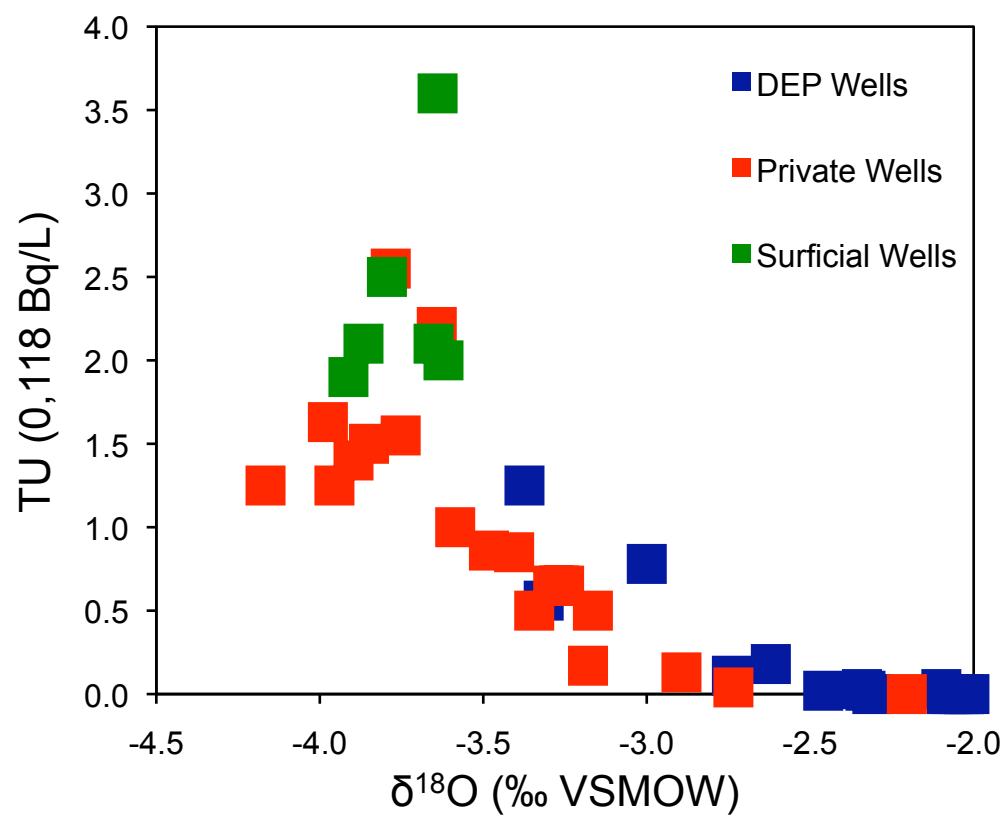


Fig. 21 $\delta^{18}\text{O}$ vs TU plot of private supply wells, DEP monitoring wells and surficial monitoring wells.

8. Tables

Table 1 Field and laboratory measurements of groundwater samples collected from the 5 DEP monitoring well clusters in the Lithia area, Central Florida

[illegible]

Table 2 Field and laboratory measurements of groundwater samples collected from the 8 shallow observation wells installed in April 2009 in the Lithia area, Central Florida

Field ID	Sample ID	Date	Turbidity	pH	Conductivity	DO	ORP	S	HCO ₃	Al	Si	As	Ca	Co	Cr	Cu	F	Fe	K	N	Pb	Mg	Mn	Mo	Ni	N	K	Se	Sr	SO ₄	S	P	V	Zn	A ¹⁰	BO	As ¹⁰	As ¹⁰	Y	As	As (AFS)	SS (AFS)		
					µS/cm	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
SURFICIAL MW-1	MW-1	Apr-09	2.0	7.1	209	10.6	0.9	192	24	106	60	0.25	1.5	1	26	12	0.3	0.5	0.3	440	0.08	0.2	16.1	17.2	2.8	0.3	0.2	0.4	3.76	14	4.9	26.9	0.1	0.05	0.18	19	5	3.7	20.9	1.6	0.5	2.3	1.5	2.9
SURFICIAL MW-2	MW-2	Apr-09	1.1	6.5	1625	15.3	1.3	159	7	189	60	0.25	1.4	1	153	12	0.3	0.5	0.3	7680	0.31	0.2	81.6	614	3.3	13.9	0.0	2.4	0.2	27.8	108	157	750	0.05	0.27	2	5	0.6	54	0.0	0.1	0.5	1.7	2.6
SURFICIAL MW-3	MW-3	Apr-09	8.4	6.4	3405	12.5	1.0	2	20	38	60	0.25	0.4	1	339	22	0.8	0.7	0.4	79100	0.74	0.2	44.8	530	0.3	32.8	0.0	1.7	0.3	21.4	442	381	2020	0.05	2.5	2	66	2.2	10.9	0.0	0.0	0.6	1.6	2.5
SURFICIAL MW-4	MW-4	Apr-09	10.6	6.8	235	8.0	0.7	98	65	105	480	0.25	0.3	1	28	11	2.1	0.5	0.4	1350	0.08	0.3	11.3	36	3.7	1.0	0.0	0.5	0.2	16	4.6	51.2	16	0.05	0.89	2	5	3.6	21.3	0.0	2.0	2.0	0.4	3.0
SURFICIAL MW-5	MW-5	Apr-09	7.6	6.6	163	60.9	5.1	9.5	13	39	110	0.25	0.5	1	16	17	0.8	0.5	0.4	71	0.08	0.2	5.6	44.9	4.6	3.6	3.6	0.4	9.82	14.6	4.8	31.3	1.2	0.05	1.1	4.5	9	3.9	23.5	0.0	0.0	0.0	0.9	2.8
SURFICIAL MW-6	MW-6	Apr-09	7.4	6.3	346	86.7	7.2	72	33	24	220	0.25	1.3	1	36	32	1.3	0.5	0.3	81	0.16	0.4	10.6	17.9	3.9	5.5	17.0	2.6	0.58	17.2	7.5	43.6	20	0.05	0.76	12	5	3.8	23.1	0.2	0.0	0.3	1.2	2.7
SURFICIAL MW-7	MW-7	Apr-09	5.4	6.6	231	14.7	1.2	144	83	78	160	0.25	0.3	1	25	19	1.3	0.5	0.8	3300	0.13	0.2	8.3	63.7	1.2	0.5	0.0	0.7	0.2	14.2	4.1	33	11	0.12	1.6	2.2	5	3.6	22.1	0.0	0.0	0.3	0.2	2.4
SURFICIAL MW-8	MW-8	Apr-09	2.8	7.1	157	69.0	5.7	17.0	11	79	60	0.25	1.0	1	17	7	0.9	3.0	0.3	66	0.08	0.2	7.8	29	4.1	1.0	0.7	0.4	0.46	10.9	3.3	36.2	2.6	0.11	0.12	3.8	5	3.8	23.6	4.0	0.0	4.0	6.5	3.8

State	City	Year	Latitude	Longitude	DO	SO	GO	HO	CO	AO	IO	PO	QO	RO	TO	VO	WO	XO	YO	ZO	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB	EC	ED	EE	EF	EG	EH	EI	EJ	EK	EL	EM	EN	EO	EP	EQ	ER	ES	ET	EU	EV	EW	EX	EY	EZ	FA	FB	FC	FD	FE	FF	FG	FH	FI	FJ	FK	FL	FM	FN	FO	FP	FQ	FR	FS	FT	FU	FV	FW	FX	FY	FZ	GA	GB	GC	GD	GE	GF	GG	GH	GI	GJ	GK	GL	GM	GN	GO	GP	GQ	GR	GS	GT	GU	GV	GW	GX	GY	GZ	HA	HB	HC	HD	HE	HF	HG	HH	HI	HJ	HK	HL	HM	HN	HO	HP	HQ	HR	HS	HT	HU	HV	HW	HX	HY	HZ	IA	IB	IC	ID	IE	IF	IG	IH	II	IJ	IK	IL	IM	IN	IO	IP	IQ	IR	IS	IT	IU	IV	IW	IX	IY	IZ	JA	JB	JC	JD	JE	JF	JG	JH	JI	JJ	JK	JL	JM	JN	JO	JP	JQ	JR	JS	JT	JU	JV	JW	JX	JY	JZ	KA	KB	KC	KD	KE	KF	KG	KH	KI	KJ	KK	KL	KM	KN	KO	KP	KQ	KR	KS	KT	KU	KV	KW	KX	KY	KZ	LA	LB	LC	LD	LE	LF	LG	LH	LI	LJ	LK	LL	LM	LN	LO	LP	LQ	LR	LS	LT	LU	LV	LW	LX	LY	LZ	MA	MB	MC	MD	ME	MF	MG	MH	MI	MJ	MK	ML	MM	MN	MO	MP	MQ	MR	MS	MT	MU	MV	MW	MX	MY	MZ	NA	NB	NC	ND	NE	NF	NG	NH	NI	NJ	NK	NL	NM	NO	NP	NQ	NR	NS	NT	NU	NV	NW	NX	NY	NZ	OA	OB	OC	OD	OE	OF	OG	OH	OI	OJ	OK	OL	OM	ON	OO	OP	OQ	OR	OS	OT	OU	OV	OW	OX	OY	OZ	PA	PB	PC	PD	PE	PF	PG	PH	PI	PJ	PK	PL	PM	PN	PO	PP	PQ	PR	PS	PT	PU	PV	PW	PX	PY	PZ	QA	QB	QC	QD	QE	QF	QG	QH	QI	QJ	QK	QL	QM	QN	QO	QP	QQ	QR	QS	QT	QU	QV	QW	QX	QY	QZ	RA	RB	RC	RD	RE	RF	RG	RH	RI	RJ	RK	RL	RM	RN	RO	RP	RQ	RR	RS	RT	RU	RV	RW	RX	RY	RZ	SA	SB	SC	SD	SE	SF	SG	SH	SI	SJ	SK	SL	SM	SN	SO	SP	SQ	SR	SS	ST	SU	SV	SW	SX	SY	SZ	TA	TB	TC	TD	TE	TF	TG	TH	TI	TJ	TK	TL	TM	TN	TO	TP	TQ	TR	TS	TT	TU	TV	TW	TX	TY	TZ	UA	UB	UC	UD	UE	UF	UG	UH	UI	UJ	UK	UL	UM	UN	UO	UP	UQ	UR	US	UT	UU	UV	UW	UX	UY	UZ	VA	VB	VC	VD	VE	VF	VG	VH	VI	VJ	VK	VL	VM	VN	VO	VP	VQ	VR	VS	VT	VU	VV	VW	VX	VY	VZ	WA	WB	WC	WD	WE	WF	WG	WH	WI	WJ	WK	WL	WM	WN	WO	WP	WQ	WR	WS	WT	WU	WV	WX	WY	WZ	XA	XB	XC	XD	XE	XF	YG	YH	YI	YJ	YK	YL	YM	YN	YO	YP	YQ	YR	YS	YT	YU	YV	YW	YX	YY	YZ	ZA	ZB	ZC	ZD	ZE	ZF	ZG	ZH	ZI	ZJ	ZK	ZL	ZM	ZN	ZO	ZP	ZQ	ZR	ZS	ZT	ZU	ZV	ZW	ZX	ZY	ZZ
1998	ALABAMA	Montgomery	32.36	-86.3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

Table 4 Average chemical compositions of pyrite in thin sections from cores DEP-1 and DEP-2

Mineral	Sample	Core	Fe wt %	S wt %	As ppm	Sb ppm	Zn ppm	Mo ppm	Ca wt%	Total wt %
pyrite	152-149	DEP-1	42	52	8788	730	320	0	0,19	95
pyrite	152-149b	DEP-1	47	52	2113	0	48	0	0,53	99
pyrite	190-187	DEP-1	47	52	1281	18	40	0	0,04	99
pyrite	190-187	DEP-1	48	53	360	0	15	0	0,03	101
pyrite	213-209b	DEP-1	47	53	451	9	68	0	0,15	100
pyrite	213-209	DEP-1	46	52	1412	16	54	0	0,24	98
pyrite	60-57a	DEP-2	47	53	794	9	59	0	0,22	99
pyrite	60-57b	DEP-2	46	52	1164	11	806	0	0,39	98
pyrite	137-136	DEP-2	38	51	6597	57	19	0	0,52	90
pyrite	206-203d	DEP-2	47	53	1846	32	28	0	0,03	100
pyrite	207-206b	DEP-2	47	52	1713	25	98	0	0,11	99
pyrite	222-219	DEP-2	46	54	681	66	21	0	0,76	101
pyrite	226-222	DEP-2	48	53	285	13	6	0	0,06	101

Table 5 Average chemical compositions of powellite in thin sections from core DEP-1

Mineral	Sample	Core	Fe ppm	S ppm	As ppm	Sb ppm	Zn ppm	Mo wt%	Ca wt%	Total wt %
powellite	152-149	DEP-1	5935	4690	15050	0	755	23	15	41
powellite	156-152	DEP-1	472	3216	17640	34	1312	42	21	66

Dr. Pichler reported that during the analysis of pyrite crystals found in cores DEP-1 and 2, the MDL for molybdenum was 30 ppm.

Table 6 Tritium (^3H) and Helium (^3He) Ages

Field ID	^3H [TU]	^3H - ^3He [TU]	Alter [Jahre]
DEP-1 (145-165')	0.56	5	40
DEP-1 (205-225')	0	0.5	>50
DEP-1 (250-270')	0	0	>50
DEP-1 (300-320')	0	0.5	>50
DEP-2 (143-163')	1.25	3.7	30
DEP-2 (197-217')	0.18	0.5	20
DEP-2 (256-276')	0	0	>50
DEP-2 (300-320')	0	0	>50
DEP-3 (147-167')	0.78	3.7	30
DEP-3 (195-215')	0	0	>50
DEP-3 (245-265')	0	0	>50
DEP-3 (300-320')	0	0	>50
DEP-4 (143-163')	0.03	0	>50
DEP-4 (208-228')	0	0	>50
DEP-4 (255-275')	0.03	0	>50
DEP-4 (300-320')	0.02	0	>50
DEP-5 (153-173')	0.11	0.6	32
DEP-5 (200-220')	0.02	0	>50
DEP-5 (250-270')	0	0	>50
DEP-5 (300-320')	0	0	>50
2802 PRITCHER MANOR COURT	1.25	16.5	46
2815 HARTLEY LANE	1.55		
3010 TOOLE ROAD	1	5.6	33
5364 WOOD ROAD	1.63	9	33
7911 CAREY ROAD	0.17	1	32
7935 CAREY ROAD	1.4	10.5	38
8010 EDSON ROAD	0.65	13	54
8133 EDISON ROAD	0.5		
8312 BOB WIGGS AVENUE	2.2		
8408 BOB WIGGS AVENUE	2.55		
8410 PRITCHER ROAD	0.13		
8438 BOB WIGGS AVENUE	0.65		
8506 PRITCHER ROAD	0.5	2.6	30
8601 PRITCHER ROAD	1.25	2.7	20
8602 ROCKN T RANCH	0.86		
8710 COUNTY LINE ROAD	0.04	0	
8721 COUNTY LINE ROAD	0.85	5	35
8834 CAREY ROAD	1.5	11.5	38
SCHOOL IRRIGATION WELL	0	0	>50
SCHOOL VOLLEYBALL COURT	0.65	2.25	27
SURFICIAL MW-1	2.1	9.2	30
SURFICIAL MW-2	2.22	7.4	26
SURFICIAL MW-3	1.85		
SURFICIAL MW-4	3.6	23.3	38
SURFICIAL MW-5	1.9	4.2	21
SURFICIAL MW-6	2.5	10.4	30
SURFICIAL MW-7	2		
SURFICIAL MW-8	2.1	6.4	25

Appendix: Enchem Tasks

To date EnChem Consulting has performed the following tasks:

December 2007

We analyzed 40 supply well samples for total arsenic and antimony as well as arsenic speciation (arsenite and arsenate) and field measurements for sulfide (HS^-). Compilation and interpretation of oxygen and hydrogen isotope data.

February 2008

Carried out a detailed stratigraphic description of two cores (DEP-1 and DEP-2) to delineate the presence of arsenic in the aquifer matrix, which included (a) the chemical analyses of 144 core samples (arsenic, antimony, iron, sulfur, silica, calcium, magnesium, strontium, molybdenum and phosphorous).

April 2008

Completed the detailed description of samples taken from cores DEP-1 and DEP-2 by stereo microscope. Preparation of 18 thin sections for electron microprobe analyses of mineral phases to determine arsenic, antimony, calcium, molybdenum, zinc and sulfur concentrations. These samples were chosen based on their bulk chemical composition. Electron microprobe analyses of those samples.

May 2008

We analyzed 20 samples from well clusters DEP-1, DEP-2, DEP-3, DEP-4, and DEP-5 (4 per cluster) for total arsenic, arsenic speciation (arsenite and arsenate), antimony and molybdenum.

June 2008

We analyzed 20 samples from well clusters DEP-1, DEP-2, DEP-3, DEP-4, and DEP-5 (4 per cluster) for total arsenic, arsenic speciation (arsenite and arsenate), antimony and molybdenum.

October 2008

We analyzed 20 samples from well clusters DEP-1, DEP-2, DEP-3, DEP-4, and DEP-5 (4 per cluster) for total arsenic, arsenic speciation (arsenite and arsenate), antimony and molybdenum.

April 2009

We analyzed 40 samples from well clusters DEP-1, DEP-2, DEP-3, DEP-4, and DEP-5 (4 per cluster), as well as 20 samples from private supply wells which were chosen based on As and Mo concentrations for total arsenic, arsenic speciation (arsenite and arsenate), antimony and molybdenum.

These 40 wells were also sampled for groundwater dating using the tritium-helium method (T-He). Data for the T-He samples will be available late 2009 or early 2010 since this type of analysis takes about 6 months to complete. Oxygen and hydrogen isotopes for these 40 samples are also in the process of being analyzed.

Appendix: Water Levels in DEP-1 to DEP-5

Well I.D.	Top-of-Casing Elevation (NGVD) ¹	Date	Time	Water Level Below Top-of-Casing	Water Level (NGVD)
DEP-1 (145-165')	110.35	04/18/08	923	53.65	56.70
		05.05.08	1544	59.36	50.99
		06.09.08	1419	66.13	44.22
		10/13/08	1714	52.25	58.10
		04/22/09	1029	66.07	44.28
DEP-1 (205-225')	110.40	04/18/08	921	57.71	52.69
		05.05.08	1541	63.25	47.15
		06.09.08	1417	71.54	38.86
		10/13/08	1716	55.61	54.79
		04/22/09	1027	71.00	39.40
DEP-1 (250-270')	110.21	04/18/08	920	57.63	52.58
		05.05.08	1539	63.19	47.02
		06.09.08	1416	71.48	38.73
		10/13/08	1718	55.54	54.67
		04/22/09	1023	70.95	39.26
DEP-1 (300-320')	110.25	04/18/08	918	57.76	52.49
		05.05.08	1537	63.32	46.93
		06.09.08	1415	71.61	38.64
		10/13/08	1719	55.65	54.60
		04/22/09	1020	71.07	39.18
DEP-2 (143-163')	91.11	04/18/08	853	38.73	52.38
		05.05.08	1524	45.08	46.03
		06.09.08	1436	51.66	39.45
		10/13/08	1645	37.15	53.96
		04/22/09	1013	51.47	39.64
DEP-2 (197-217')	92.33	04/18/08	849	42.21	50.12
		05.05.08	1526	48.05	44.28
		06.09.08	1435	56.37	35.96
		10/13/08	1648	40.24	52.09
		04/22/09	1009	55.43	36.90
DEP-2 (256-276')	91.43	04/18/08	846	42.73	48.70
		05.05.08	1528	48.51	42.92
		06.09.08	1433	56.98	34.45
		10/13/08	1643	40.70	50.73
		04/22/09	1005	56.50	34.93
DEP-2 (300-320')	91.48	04/18/08	844	42.77	48.71
		05.05.08	1529	48.51	42.97
		06.09.08	1431	57.02	34.46
		10/13/08	1647	40.75	50.73
		04/22/09	1007	56.52	34.96
DEP-3 (147-167')	84.45	04/18/08	907	32.40	52.05

		05.05.08	1517	38.59	45.86
		06.09.08	1447	45.55	38.90
		10/13/08	1703	30.63	53.82
		04/22/09	929	45.00	39.45
DEP-3 (195-215')	84.42	04/18/08	905	35.57	48.85
		05.05.08	1516	41.32	43.10
		06.09.08	1446	49.78	34.64
		10/13/08	1701	33.58	50.84
		04/22/09	934	49.21	35.21
DEP-3 (245-265')	84.08	04/18/08	902	35.17	48.91
		05.05.08	1514	40.92	43.16
		06.09.08	1445	49.36	34.72
		10/13/08	1659	33.17	50.91
		04/22/09	937	48.80	35.28
DEP-3 (300-320')	83.25	04/18/08	859	34.31	48.94
		05.05.08	1510	40.06	43.19
		06.09.08	1444	48.49	34.76
		10/13/08	1658	32.36	50.89
		04/22/09	944	47.97	35.28
DEP-4 (143-163')	99.82	04/18/08	939	40.89	58.93
		05.05.08	1559	45.21	54.61
		06.09.08	1402	52.96	46.86
		10/13/08	1729	38.41	61.41
		04/22/09	1037	53.02	46.80
DEP-4 (208-228')	99.53	04/18/08	938	45.57	53.96
		05.05.08	1557	50.90	48.63
		06.09.08	1401	59.21	40.32
		10/13/08	1731	42.68	56.85
		04/22/09	1035	58.85	40.68
DEP-4 (255-275')	99.51	04/18/08	941	45.55	53.96
		05.05.08	1556	50.88	48.63
		06.09.08	1400	59.19	40.32
		10/13/08	1733	42.66	56.85
		04/22/09	1032	58.93	40.58
DEP-4 (300-320')	99.11	04/18/08	934	45.13	53.98
		05.05.08	1550	50.46	48.65
		06.09.08	1359	58.76	40.35
		10/13/08	1735	42.25	56.86
		04/22/09	1030	58.37	40.74
DEP-5 (153-173')	86.87	04/18/08	1051	38.67	48.20
		05.05.08	1449	44.48	42.39
		06.09.08	1326	52.83	34.04
		10/13/08	1604	37.36	49.51
		04/22/09	1236	52.27	34.60
DEP-5 (200-220')	86.97	04/18/08	1050	38.91	48.06
		05.05.08	1447	44.78	42.19
		06.09.08	1325	53.17	33.80

		10/13/08	1606	37.61	49.36
		04/22/09	1233	52.58	34.39
DEP-5 (250-270')	87.12	04/18/08	1047	40.28	46.84
		05.05.08	1446	46.10	41.02
		06.09.08	1323	54.86	32.26
		10/13/08	1607	38.49	48.63
		04/22/09	1228	54.52	32.60
DEP-5 (300-320')	87.16	04/18/08	1045	40.31	46.85
		05.05.08	1445	46.13	41.03
		06.09.08	1320	54.91	32.25
		10/13/08	1609	38.54	48.62
		04/22/09	1225	54.56	32.60

Appendix: Core Description DEP-1

Row	Category	Sub-Category	Item	Material	Quantity	Unit	Value	Notes
1	A	1	1	1	1	1	1	1
2			2	2	2	2	2	2
3			3	3	3	3	3	3
4			4	4	4	4	4	4
5			5	5	5	5	5	5
6			6	6	6	6	6	6
7			7	7	7	7	7	7
8			8	8	8	8	8	8
9			9	9	9	9	9	9
10			10	10	10	10	10	10
11	B	2	11	11	11	11	11	11
12			12	12	12	12	12	12
13			13	13	13	13	13	13
14			14	14	14	14	14	14
15			15	15	15	15	15	15
16			16	16	16	16	16	16
17			17	17	17	17	17	17
18			18	18	18	18	18	18
19			19	19	19	19	19	19
20			20	20	20	20	20	20
21	C	3	21	21	21	21	21	21
22			22	22	22	22	22	22
23			23	23	23	23	23	23
24			24	24	24	24	24	24
25			25	25	25	25	25	25
26			26	26	26	26	26	26
27			27	27	27	27	27	27
28			28	28	28	28	28	28
29			29	29	29	29	29	29
30			30	30	30	30	30	30
31	D	4	31	31	31	31	31	31
32			32	32	32	32	32	32
33			33	33	33	33	33	33
34			34	34	34	34	34	34
35			35	35	35	35	35	35
36			36	36	36	36	36	36
37			37	37	37	37	37	37
38			38	38	38	38	38	38
39			39	39	39	39	39	39
40			40	40	40	40	40	40
41	E	5	41	41	41	41	41	41
42			42	42	42	42	42	42
43			43	43	43	43	43	43
44			44	44	44	44	44	44
45			45	45	45	45	45	45
46			46	46	46	46	46	46
47			47	47	47	47	47	47
48			48	48	48	48	48	48
49			49	49	49	49	49	49
50			50	50	50	50	50	50
51	F	6	51	51	51	51	51	51
52			52	52	52	52	52	52
53			53	53	53	53	53	53
54			54	54	54	54	54	54
55			55	55	55	55	55	55
56			56	56	56	56	56	56
57			57	57	57	57	57	57
58			58	58	58	58	58	58
59			59	59	59	59	59	59
60			60	60	60	60	60	60
61	G	7	61	61	61	61	61	61
62			62	62	62	62	62	62
63			63	63	63	63	63	63
64			64	64	64	64	64	64
65			65	65	65	65	65	65
66			66	66	66	66	66	66
67			67	67	67	67	67	67
68			68	68	68	68	68	68
69			69	69	69	69	69	69
70			70	70	70	70	70	70
71	H	8	71	71	71	71	71	71
72			72	72	72	72	72	72
73			73	73	73	73	73	73
74			74	74	74	74	74	74
75			75	75	75	75	75	75
76			76	76	76	76	76	76
77			77	77	77	77	77	77
78			78	78	78	78	78	78
79			79	79	79	79	79	79
80			80	80	80	80	80	80
81	I	9	81	81	81	81	81	81
82			82	82	82	82	82	82
83			83	83	83	83	83	83
84			84	84	84	84	84	84
85			85	85	85	85	85	85
86			86	86	86	86	86	86
87			87	87	87	87	87	87
88			88	88	88	88	88	88
89			89	89	89	89	89	89
90			90	90	90	90	90	90
91	J	10	91	91	91	91	91	91
92			92	92	92	92	92	92
93			93	93	93	93	93	93
94			94	94	94	94	94	94
95			95	95	95	95	95	95
96			96	96	96	96	96	96
97			97	97	97	97	97	97
98			98	98	98	98	98	98
99			99	99	99	99	99	99
100			100	100	100	100	100	100

Appendix: Core Description DEP-2

[illegible]

DEP2 302 298	299	gransone	coarse-grained	minor quartz sand				very minor	moderate - almost twice
DEP2 302 298	300	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	301	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	302	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	303	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	304	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	305	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	306	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	307	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	308	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	309	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	310	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	311	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	312	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	313	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	314	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	315	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	316	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	317	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	318	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	319	fine-grained	fine-grained					moderate	moderate - almost twice
DEP2 302 298	320	fine-grained	fine-grained					moderate	moderate - almost twice

Appendix: Core Chemistry DEP-1

Sample ID	Sample Interval	Sample Depth (ft)	Al ICP* mg/kg	Si ICP mg/kg	Fe ICP mg/kg	Mg ICP mg/kg	Ca ICP mg/kg	P ICP mg/kg	Sr ICP mg/kg	S ICP mg/kg	Mo ICP mg/kg	As AFS* mg/kg	Sb AFS mg/kg	Stratigraphy
DEP-1-136-132	136-132	134	575	357	337	4482	402709	85	1516	959	43	2.0	3.14	Hawthorn
DEP-1-141-136	141-136	138	489	316	1102	3276	317728	113	664	732	53	7.7	9.50	
DEP-1-144-141	144-141	142	173	294	1960	1620	119487	3215	304	764	53	10.5	0.81	
DEP-1-149-144	149-144	146	-14	174	151	2202	413831	73	919	1147	81	2.1	9.54	
DEP-1-152-149	152-149	150	1235	1028	467	1423	215257	775	423	1540	880	11.1	5.23	
DEP-1-156-152	156-152	154	168	434	225	1319	316397	63	478	728	158	31.0	9.32	
DEP-1-160-156	160-156	158	297	402	160	1280	300095	63	356	277	5	1.6	0.06	
DEP-1-164-160	164-160	162	574	507	316	1876	302281	109	408	359	15	3.2	0.13	
DEP-1-168-164	168-164	166	618	501	263	1664	259601	1199	377	401	5	1.5	0.06	
DEP-1-172-168	172-168	170	408	464	976	1220	255371	802	302	1310	30	4.7	0.34	
DEP-1-176-172	176-172	174	616	500	390	1601	213118	1502	427	428	1	1.2	0.05	
DEP-1-180-176	180-176	178	7040	1052	6580	9405	227519	4709	617	3798	<0.5	14.1	0.23	
DEP-1-184-180	184-180	182	7490	841	10000	8285	46863	3967	176	7339	<0.5	25.3	0.20	
DEP-1-187-184	187-184	185	6940	886	7545	7695	23284	3903	156	5705	<0.5	3.9	0.12	
DEP-1-190-187	190-187	188	5460	759	42210	6185	118489	3069	238	44609	<0.5	101.9	0.33	
DEP-1-193-190	193-190	191	7345	836	7660	6900	172719	5140	498	4813	<0.5	18.2	8.22	
DEP-1-196-193	196-193	194	2236	848	2511	3956	281702	217	508	2580	<0.5	7.3	0.32	
DEP-1-199-196	199-196	197	3274	834	1517	6505	289829	132	845	972	<0.5	2.1	0.09	
DEP-1-205-199	205-199	202	1982	723	1047	7285	290922	69	639	915	16	2.1	0.05	
DEP-1-209-205	209-205	207	1002	933	1143	7325	282129	47	1025	719	<0.5	0.4	0.03	
DEP-1-213-209	213-209	211	4038	955	4573	26055	264306	94	827	4605	56	22.7	1.06	
DEP-1-216-213	216-213	214	409	548	730	3460	295437	24	716	551	4	1.9	3.84	
DEP-1-222-216	222-216	219	239	420	304	2292	405086	26	902	310	15	1.9	0.23	
DEP-1-228-222	228-222	225	283	386	588	2121	398479	39	592	679	8	3.1	0.21	
DEP-1-232-228	232-228	230	886	736	688	3123	377804	223	1253	1086	51	10.7	1.40	
DEP-1-236-232	236-232	234	45	239	155	2853	409886	34	768	407	1	0.6	0.07	
DEP-1-236-232SP	236-232	235	41	190	223	2668	391207	36	775	510	1	0.9	8.59	
DEP-1-238-236	238-236	237	133	378	143	2555	417490	30	704	440	2	0.8	0.08	
DEP-1-244-238	244-238	241	103	318	173	2422	377567	43	660	419	<0.5	0.4	0.03	
DEP-1-248-244	248-244	246	647	630	974	2380	338118	34	626	1330	8	5.6	6.27	
DEP-1-253-248	253-248	250	33	199	159	2807	414211	41	807	357	5	0.9	0.09	
DEP-1-256-253	256-253	254	10	149	137	2687	397291	42	651	310	5	0.8	0.08	
DEP-1-261-256	261-256	258	33	187	173	2357	401521	51	523	536	8	1.2	0.20	
DEP-1-266-261	266-261	263	-2	123	128	2316	400713	54	500	510	4	1.9	5.26	
DEP-1-271-266	271-266	268	-10	119	130	2686	419534	41	474	363	2	0.3	0.01	
DEP-1-276-271	276-271	273	2	42	114	2199	394011	63	528	449	1	0.6	0.02	
DEP-1-280-276	280-276	278	58	130	200	2494	413165	70	581	328	3	1.9	2.60	
DEP-1-284-280	284-280	282	9	134	116	1954	386312	102	574	226	<0.5	0.3	0.01	
DEP-1-288-284	288-284	286	10	156	113	2095	383935	91	488	263	1	0.3	9.42	
DEP-1-292-288	292-288	290	-5	124	117	2136	376046	90	583	233	1	0.5	0.04	
DEP-1-296-292	296-292	294	13	123	158	2194	407985	100	620	221	<0.5	0.3	0.03	
DEP-1-297-296	297-296	296	-10	107	154	2292	414163	116	674	276	<0.5	0.5	0.01	
DEP-1-300-297	300-297	298	5	148	180	2139	396055	197	636	267	2	2.1	3.12	
DEP-1-303-300	303-300	301	116	307	277	2732	419677	116	628	356	1	2.1	2.49	
DEP-1-308-303	308-303	305	121	355	180	2682	405513	125	534	273	1	0.5	0.07	
DEP-1-312-308	312-308	310	62	253	188	2735	404943	181	572	286	1	0.9	0.13	
DEP-1-316-312	316-312	314	48	208	1154	2377	370913	155	568	1358	<0.5	7.1	0.18	
DEP-1-321-316	321-316	318	49	246	405	2389	368203	150	654	529	3	3.1	0.18	
DEP-1-321-316SP	321-316	319	46	206	421	2525	366920	150	629	537	4	3.2	8.45	
DEP-1-326-321	326-321	323	100	306	545	2147	383650	107	617	619	3	2.9	0.06	
DEP-1-332-326	332-326	329	42	215	322	2659	402899	119	526	454	3	1.0	7.53	
DEP-1-336-332	336-332	334	185	220	406	2696	391160	202	525	510	2	1.2	0.05	
DEP-1-339-336	339-336	337	111	204	391	2321	402139	83	557	346	4	1.6	0.06	
DEP-1-343-339	343-339	341	-38	47	199	2676	402662	68	627	351	1	1.0	0.04	
DEP-1-346-343	346-343	344	-31	66	263	2508	422861	75	866	341	3	1.3	0.07	
DEP-1-351-346	351-346	348	-17	96	260	2524	422766	104	528	295	<0.5	1.1	0.06	
Note: * ICP indicates elements analyzed by inductively coupled plasma-optical emission spectrometry and AFS indicates elements determined by atomic fluorescence spectrometry, yellow highlighted cell indicate the four depth intervals which are monitored														

Appendix: Core Chemistry DEP-2

Sample ID	Sample Interval	Sample Depth (ft)	Al	Si	Fe	Mg	Ca	P	Sr	S	Mo	As	Sb	Stratigraphy
			ICP* mg/kg	ICP mg/kg	ICP mg/kg	ICP mg/kg	ICP mg/kg	ICP mg/kg	ICP mg/kg	ICP mg/kg	ICP mg/kg	ICP mg/kg	AFS* mg/kg	
DEP-2-16-6	16-6	11	4906	331	1131	-384	3554	2878	126	104	<0.5	0.7	0.03	Surficial
DEP-2-19-16	19-16	17	9965	766	973	1726	18902	13105	644	155	<0.5	0.5	0.07	
DEP-2-22-19	22-19	20	7390	4680	5370	693	195817	70600	788	2281	<0.5	6.2	0.83	
DEP-2-26-22	26-22	24	7590	3125	4803	3054	140589	51000	319	1376	<0.5	10.6	0.90	
DEP-2-29-26	29-26	27	4711	1770	7450	63500	196530	29810	425	1579	7	25.3	0.93	
DEP-2-32-29	32-29	30	3653	1570	5115	71100	190779	23520	357	1235	15	18.8	0.66	
DEP-2-35-32	35-32	33	9030	1468	12410	62450	161407	22775	330	1069	16	47.5	2.06	
DEP-2-39-35	39-35	37	3239	1247	4241	68650	150285	9040	198	554	19	12.7	0.50	
DEP-2-43-39	43-39	41	2607	1537	4179	87950	193584	8840	273	1413	6	7.9	0.41	
DEP-2-46-43	46-43	44	4627	1458	4828	78550	167823	12340	261	3373	9	10.1	0.43	
DEP-2-47-46	47-46	46	6970	1290	6490	45050	123574	19815	319	4006	6	9.6	0.36	
DEP-2-50-47	50-47	48	2510	891	2555	96150	187643	3621	214	1722	6	3.2	0.20	
DEP-2-53-50	53-50	51	6145	1339	3597	21605	65637	17380	225	2953	2	5.0	0.35	
DEP-2-56-53	56-53	54	7165	1317	3780	27570	89924	17755	263	2854	2	5.3	0.82	
DEP-2-60-57	60-57	58	5360	1655	5535	73200	212405	32360	469	6100	63	25.5	1.61	Hawthorn
DEP-2-63-60	63-60	61	2280	1363	1865	108450	210171	8045	200	1520	7	4.2	0.29	
DEP-2-66-63	66-63	64	4662	1097	2520	85700	205656	24845	376	2413	4	5.0	0.19	
DEP-2-67-66	67-66	66	3988	1641	2952	99050	210551	15560	294	2297	6	7.7	0.35	
DEP-2-70-67	70-67	68	3118	1408	2237	88750	235504	25275	442	2406	8	6.1	0.55	
DEP-2-73-70	73-70	71	2735	1413	1982	98050	226854	18415	352	2296	33	7.9	0.87	
DEP-2-76-73	76-73	74	2843	1172	1525	98850	209553	9745	269	1617	13	5.2	0.57	
DEP-2-80-76	80-76	78	3443	1410	2448	92700	200856	15265	303	1523	5	5.1	0.73	
DEP-2-84-80	84-80	82	2638	1325	2258	94200	189544	9595	215	1304	3	3.1	0.29	
DEP-2-88-84	88-84	86	3376	1192	2003	83550	164591	7630	172	913	<0.5	2.2	0.20	
DEP-2-92-88	92-88	90	2533	909	1453	85550	173432	7235	170	1065	7	4.5	0.36	
DEP-2-96-92	96-92	94	2132	1216	1873	4275	182510	4144	93	1689	11	9.1	1.03	
DEP-2-97-96SP	97-96	95	1864	578	910	4198	327804	1246	320	699	4	10.6	1.55	
DEP-2-97-96	97-96	96	2354	1321	1009	3315	146483	1193	102	674	21	4.7	0.63	
DEP-2-101-97	101-97	99	1884	228	952	3556	312120	760	353	690	3	4.1	0.31	
DEP-2-105-101	105-101	103	794	837	387	3201	271483	931	323	463	48	7.0	0.85	
DEP-2-108-105	108-105	106	724	794	305	1662	192205	649	240	307	25	4.8	0.50	
DEP-2-112-108	112-108	110	1624	289	527	2567	329468	991	314	607	42	6.7	0.92	
DEP-2-116-112	116-112	114	2154	129	608	3218	279563	611	490	451	7	2.0	0.09	
DEP-2-118-116	118-116	117	832	579	315	2777	303755	550	811	491	5	1.5	0.06	
DEP-2-125-118	125-118	121	970	165	268	2979	349002	289	612	444	3	1.3	0.06	
DEP-2-129-125	129-125	127	801	241	429	2492	364829	358	739	820	<0.5	1.1	0.01	
DEP-2-132-129	132-129	130	899	434	1018	4801	379800	87	1086	836	1	1.9	0.05	
DEP-2-136-132	136-132	134	292	152	135	3846	401141	79	1371	838	0	1.0	0.00	
DEP-2-137-136	137-136	136	4564	189	2391	12280	251141	317	1167	1128	123	25.0	1.65	
DEP-2-142-137	142-137	139	158	81	155	898	223241	252	529	513	0	1.0	0.01	
DEP-2-146-142	146-142	144	391	567	1161	2323	226378	1249	533	525	3	1.9	0.04	
DEP-2-148-146	148-146	147	55	600	5825	686	100285	65	249	393	11	2.5	0.14	
DEP-2-152-148	152-148	150	98	565	2368	2620	325048	90	909	917	6	2.7	0.10	
DEP-2-152-148SP	152-148	151	267	603	4931	2403	254515	92	684	670	7	3.2	0.04	
DEP-2-156-152	156-152	154	384	232	325	4072	418061	63	1276	907	10	3.8	0.05	
DEP-2-161-156	161-156	158	-1	172	113	1214	392871	25	795	1041	6	5.9	0.06	
DEP-2-165-161	165-161	163	856	154	436	713	40504	14	53	433	2	1.2	0.03	
DEP-2-169-165	169-165	167	1022	386	363	1384	176996	51	296	669	1	0.8	0.02	
DEP-2-172-169	172-169	170	313	729	304	959	243061	50	387	789	1	0.8	0.01	
DEP-2-176-172	176-172	174	320	282	214	1072	224572	52	496	470	1	1.2	0.05	
DEP-2-179-176	179-176	177	1313	365	489	3470	276046	1298	927	431	<0.5	0.9	0.02	
DEP-2-183-179	183-179	181	1521	349	577	3694	256179	466	614	357	<0.5	0.9	0.01	
DEP-2-186-183	186-183	184	1683	286	677	3378	229468	825	618	358	<0.5	0.6	0.02	
DEP-2-188-186	188-186	187	988	120	892	1745	213783	388	283	963	4	4.8	0.21	
DEP-2-193-188	193-188	190	990	426	447	1960	243489	2608	637	651	3	3.4	0.13	
DEP-2-196-193	196-193	194	674	149	451	1630	256654	1271	359	751	3	3.8	0.22	
DEP-2-199-196	199-196	197	2322	1196	2523	5520	234743	2331	415	2123	5	8.4	0.17	
DEP-2-203-199	203-199	201	13640	325	14935	13345	168631	6135	429	9970	<0.5	24.2	0.58	
DEP-2-206-203	206-203	204	14680	723	20115	14070	30770	5235	197	14791	<0.5	32.7	0.67	
DEP-2-207-206	207-206	206	12430	368	16670	12135	30917	5445	213	10978	<0.5	36.8	0.62	
DEP-2-211-207	211-207	209	647	526	1561	4435	209553	24	452	1159	1	6.7	0.13	
DEP-2-215-211	215-211	213	3402	575	3511	4925	320010	1299	662	2550	<0.5	10.4	0.30	
DEP-2-215-211	215-211	214	89	158	186	3366	400523	30	1223	624	<0.5	1.5	0.01	
DEP-2-219-215	219-215	217	399	186	579	4337	365589	27	1036	514	0	2.0	0.09	
DEP-2-222-219	222-219	220	1097	440	1008	2699	362262	38	702	1295	30	11.2	1.19	
DEP-2-226-222	226-222	224	1325	1348	1906	3991	299762	308	532	2280	10	8.5	0.52	
DEP-2-231-226	231-226	228	181	283	194	2529	391778	33	613	364	0	0.7	0.02	
DEP-2-236-231	236-231	233	279	234	371	1791	386074	15	515	576	1	6.4	0.44	
DEP-2-241-236	241-236	238	2	160	139	2251	406749	24	564	329	0	0.5	0.07	
DEP-2-246-241	246-241	243	145	335	512	1421	395247	88	453	558	1	1.7	0.14	
DEP-2-249-246	249-246	247	43	188	121	2601	407082	37	490	311	1	0.5	0.06	
DEP-2-253-249	253-249	251	610	299	313	2302	380323	55	478	473	1	3.5	0.12	
DEP-2-257-253	257-253	255	-25	93	162	2432	406084	27	549	315	1	0.4	0.04	
DEP-2-262-257	262-257	259	-10	130	146	2293	414734	61	502	233	<0.5	0.3	0.01	
DEP-2-266-262	266-262	264	1	135	143	2406	400238	63	469	253	<0.5	0.1	0.02	
DEP-2-269-266	269-266	267	44	208	129	3839	407985	119	492	367	1	0.4	0.02	
DEP-2-274-269	274-269	271	25	176	122	3931	394297	161	467	444	0	0.7	0.03	
DEP-2-278-274	278-274	276	62	196	144	4185	396625	148	562	428	0	0.8	0.04	
DEP-2-282-278	282-278	280	26	170	220	3001	397576	206	448	345	<0.5	0.4	0.01	
DEP-2-286-282	286-282	284	80	222	881	2877	396958	119	713	987	3	6.1	0.11	
DEP-2-290-286	290-286	288	102	19										

Appendix: Core Chemistry DEP-5

Sample ID	Al ICP mg/kg	Si ICP mg/kg	Fe ICP mg/kg	Mg ICP mg/kg	Ca ICP mg/kg	P ICP mg/kg	Sr ICP mg/kg	S ICP mg/kg	Mo ICP mg/kg	As ICP mg/kg	As AFS mg/kg
84-80	4317	394	2953	95250	204950	13120	297	1653	-1	-2	1,52
87-84	10910	946	9475	30520	156200	53900	651	5210	-4	-10	4,43
88-87	5915	580	3473	60650	164700	22995	366	1956	-2	-3	1,38
92-88	3987	777	2157	45365	131450	18930	262	1833	3	-1	2,17
95-92	2687	310	4100	2171	13685	2878	65	3781	-2	-3	1,79
97-95	2242	313	573	2327	83000	1964	96	367	-1	-1	0,60
98-97	3307	529	3268	2639	18415	5870	99	3210	-2	-4	1,50
105-98A	2713	467	2308	2573	20730	3673	93	2321	22	14	7,32
109-105	1936	482	1803	2329	143100	3030	123	1205	6	1	1,73
111-109	2612	478	3080	2135	42360	5935	106	3178	3	2	4,27
114-111	7655	501	3431	6715	41350	14395	191	1411	0	-6	3,60
117-114	2861	246	1220	4953	224250	1244	466	817	9	17	9,17
121-117	1642	205	459	2907	188650	1067	372	408	5	2	1,04
124-121	1967	267	659	4536	321500	1567	926	532	4	2	1,37
127-124	1213	171	479	4076	357550	606	975	602	4	3	1,05
129-127	2130	169	749	5645	296400	316	677	475	5	0	0,90
132-129	2397	181	722	6030	254150	354	796	435	6	2	1,43
135-132	629	131	197	2619	309000	377	859	461	5	4	0,51
137-135	1206	81	386	3824	254250	552	610	490	6	2	0,91
141-137	1117	140	306	3475	273100	702	384	520	10	5	1,08
144-141A	1374	158	417	3923	320900	450	455	617	7	3	1,03
147-144	976	188	591	3103	318550	680	548	958	44	16	5,38
150-147	539	48	387	4496	284850	146	895	667	7	4	2,25
154-150	716	76	355	5580	293850	88	794	901	31	15	6,74
157	-1	-36	150	3174	410150	56	1195	944	-1	5	0,89
157-154	97	14	334	2213	325550	53	1035	637	2	4	0,84
162-157A	4624	364	5490	20205	196050	238	835	5490	225	77	41,29
167-162	1933	151	2328	10280	304600	130	994	2549	32	22	12,62
171-167	-28	190	370	1683	282500	26	946	449	1	4	0,91
177-174	132	207	1298	256	65700	88	264	384	3	3	0,77
180-177	84	-5	167	4208	388250	103	1707	770	2	7	1,25
185-180	1964	675	817	8795	143200	152	768	1027	94	10	5,81
188-185	200	76	161	4246	372900	89	1405	1661	4	5	1,86
191-188	639	46	243	1219	182550	51	294	539	3	3	0,97
194-191	356	270	146	3001	339200	388	585	508	0	3	0,44
197-194	268	212	147	2068	369500	100	554	739	6	3	0,92
199-197	377	146	211	2258	323500	132	486	412	4	5	0,35
202-199A	482	148	315	2486	327850	130	497	502	3	4	0,49
205-202	642	192	382	3430	340100	152	572	957	2	1	0,83
208-205	1567	159	720	6025	150150	831	423	547	4	-1	0,74
211-208A	415	71	242	2045	328350	377	438	738	2	4	0,56
214-211	1048	85	456	2469	210250	1438	329	563	4	2	0,78
219-217	865	185	342	3270	159000	1952	237	400	2	3	0,70
221-219 A	10455	383	10970	11650	113400	7085	271	7950	3	1	13,32
221-219 B	2544	285	2058	4025	149200	1379	298	800	4	-1	12,69
224-221	8910	411	70100	10185	42605	5555	216	80950	-56	-4	56,24
227-224A	10035	297	17200	10040	53650	6730	236	15235	20	37	33,85
231-227	1668	220	2179	1158	85350	2252	405	717	1	-4	1,10
234-231A	363	156	1123	2269	390600	58	708	1493	-1	8	3,40
237-234	368	226	328	2725	396600	53	1015	756	8	7	2,85
241-237	3234	278	820	5445	290650	31	563	880	111	19	11,58
244-241	947	429	319	1577	294200	23	296	429	32	18	8,06
247-244	3899	329	14255	3886	40375	11	114	15175	224	31	24,41
251-247	666	311	202	2405	375900	28	490	319	2	4	1,16
255-251	54	-44	260	2665	410100	34	506	543	3	2	0,08
259-255	296	299	146	1918	389450	56	325	250	-1	2	0,28
263-259A	-29	-119	101	3245	433950	18	523	270	5	3	0,08
269-263	79	139	150	2220	419700	27	471	318	-1	5	0,25
270-267	-27	-122	67	2004	406150	39	440	325	0	4	0,12
275-270	-32	-119	100	2118	418500	39	393	307	1	5	0,12
278-275	-35	-131	90	2363	417750	39	467	489	-1	4	0,13
281-278	17	-68	103	2622	415150	46	437	298	-1	3	0,14
284-281	2	-97	66	2206	408300	83	405	312	-1	1	0,09
287-284	-12	-96	100	2111	413950	75	410	252	-1	2	0,09
289-287	19	-44	118	2364	410350	105	403	278	1	2	0,12
291-289	14	-41	87	2451	397800	91	406	286	0	2	0,14
295-291	25	-60	242	2789	414950	105	404	465	7	5	0,32
299-295	4	-91	124	2369	407150	159	409	297	-1	3	0,21
303-299	41	-24	124	2336	421950	106	464	292	0	3	0,13
307-303	7	-47	202	2493	430500	122	530	347	0	4	0,28
309-307	37	-47	303	2493	404550	186	496	363	-1	3	3,66
312-309	23	-14	352	2378	400100	461	531	378	5	6	0,75
315-312	63	44	272	2669	415700	110	522	312	0	4	0,28
317-315	82	108	215	2427	393800	134	413	357	-1	5	0,42
320-317	79	123	455	3156	369250	165	408	731	-1	3	0,70

To: George Wiegand and Bob Cilek, Florida Department of Environmental Protection, Site Investigation Section
From: Carol Stein, Gannett Fleming
Date: 29 July 2010
Subject: General Conceptual Model for Arsenic and Molybdenum in Groundwater in Lithia, FL

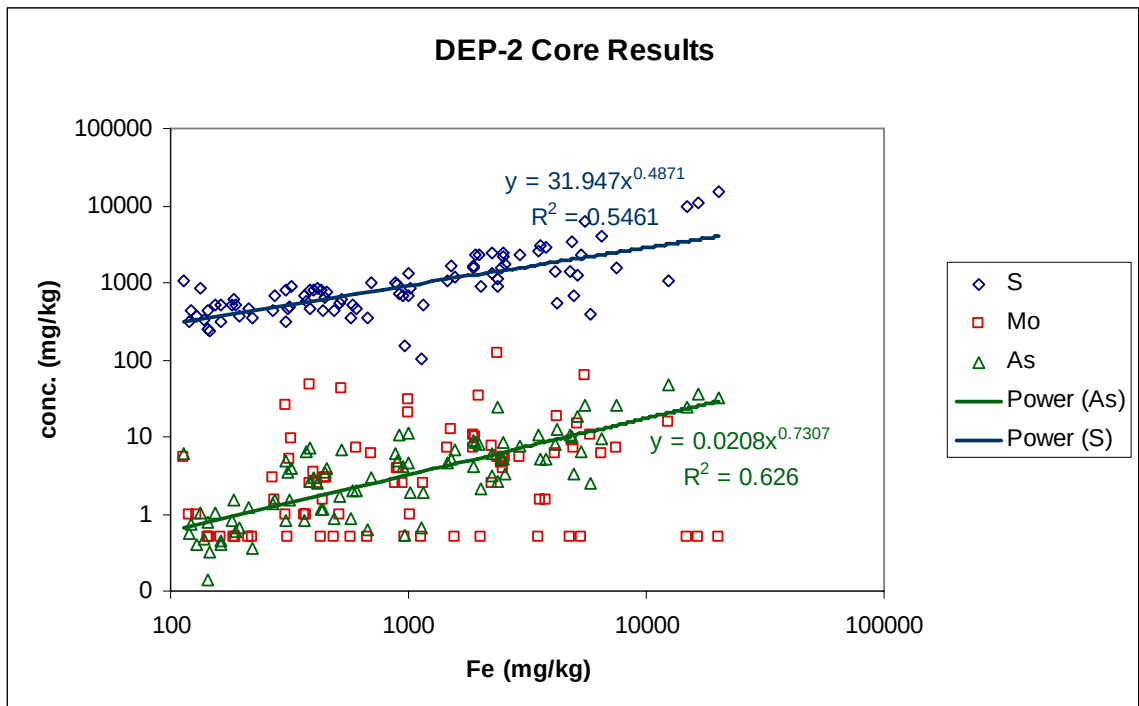
Presented here is an informal list of possible elements of a conceptual model that explains the elevated concentrations of arsenic and molybdenum in Lithia groundwater. Each element is summarized in a few words, and supporting evidence for each is provided. Note that nothing discussed here specifically conflicts with anything in the Pritcher Road site report (Pichler, 2010); however, these notes represent an attempt to use the data to support various conclusions in a logical and self-consistent manner. This is not necessarily a complete or detailed conceptual model, nor should it be considered definitive. Nevertheless, the regulatory decision process would benefit from an explicit statement in the report regarding the manner in which the data do, or do not, support a clearly defined conceptual model. Gannett Fleming (GF) suggests that the report be revised in response to previous comments on the need for a well-defined conceptual model that is consistent with the data.

1. The ultimate source of As and Mo is likely in the sulfides found in the carbonate bedrock units.

Supporting information: Fischler and Arthur (2008) analyzed pyrites from the Avon Park Formation, the Ocala Limestone, the Suwannee Limestone, and the Arcadia Formation. They report high As and Mo concentrations in pyrite in the Avon Park Formation and in the Ocala Limestone (the document found on-line does not have the appendices with complete geochemical data), and it is not clear what was found in pyrite in the Suwannee or the Arcadia lithologies. Also, this was not a final copy of this report but possibly FDEP has a copy. According to Table 4 in the Pichler report, no Mo was found in any of the pyrites in the Lithia cores DEP-1 and DEP-2. It seems strange that all of the values are reported as “0 ppm” (what was the detection limit for those analyses?) when others, e.g., Fischler and Arthur, found Mo in pyrites in Hawthorn Group carbonates at levels up to 0.57% using an electron microprobe.

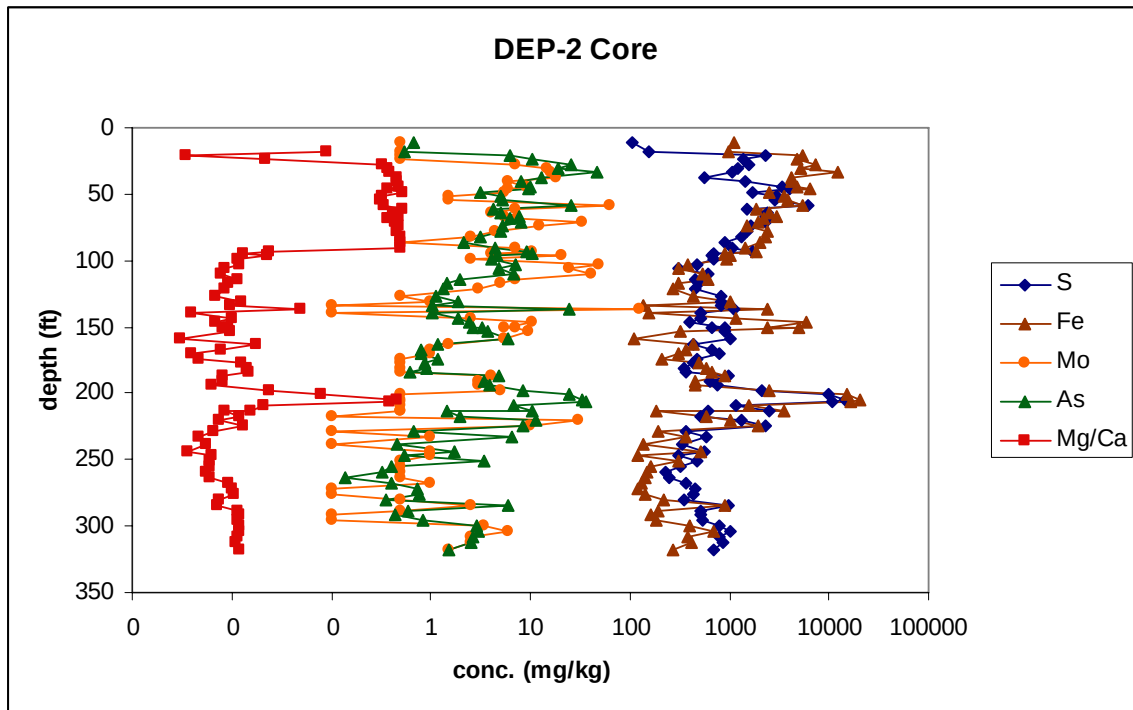
2. Overall, the bulk of the solid-phase arsenic appears to be associated with Fe, either in pyrite or sorbed onto hydrous ferric oxides (HFO). While it is apparent that the powellite (CaMoO_4) also contains arsenic in significant concentrations, it is likely that this phase represents a fraction of the total arsenic that is small compared to the mass of arsenian pyrite that is present.

Supporting information: data from the DEP-2 core show a good correlation of both As and S with Fe. Despite the presence of As and S in powellite (Table 5 in Pichler, 2010), the correlation of solid-phase As with Mo over the length of the core is not good. This observation suggests that most of the As in this core is associated with pyrite and HFO but not with powellite. Please note that this observation is qualified by the data from the middle ~100 ft of the core, where As is somewhat correlated with Mo. It is plausible that this is due to the coincident occurrence of arsenian pyrite and powellite in this portion of the core, and not because the As and Mo are derived from powellite alone. However, insufficient information is available to make this distinction.

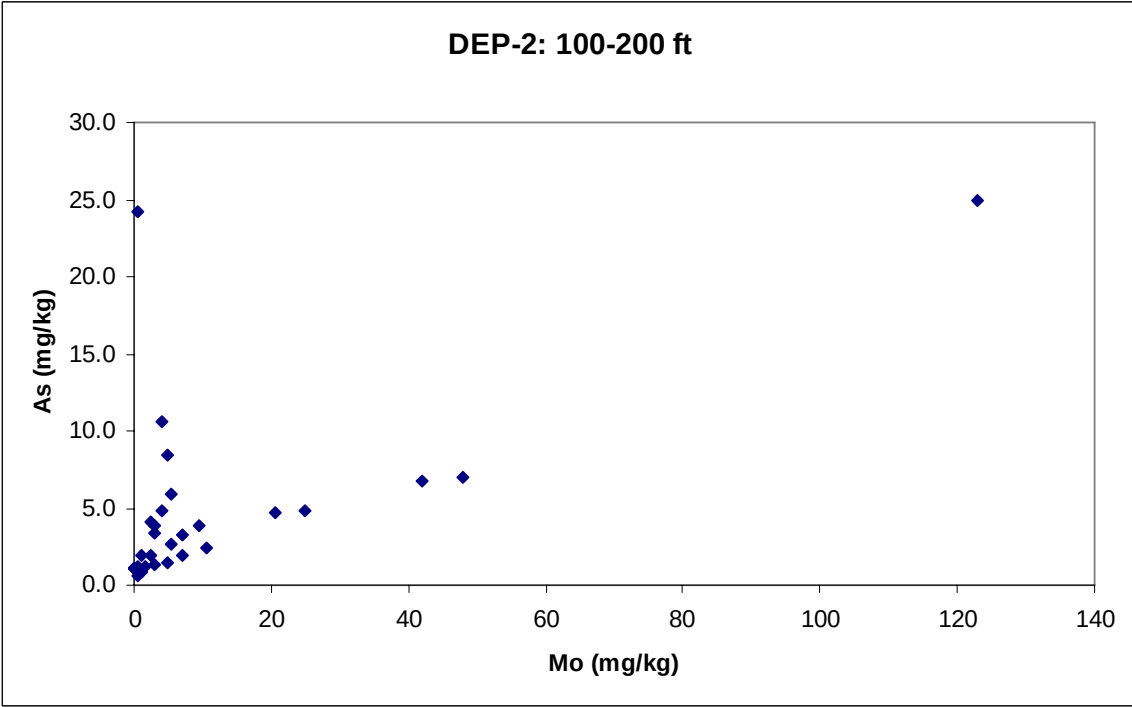
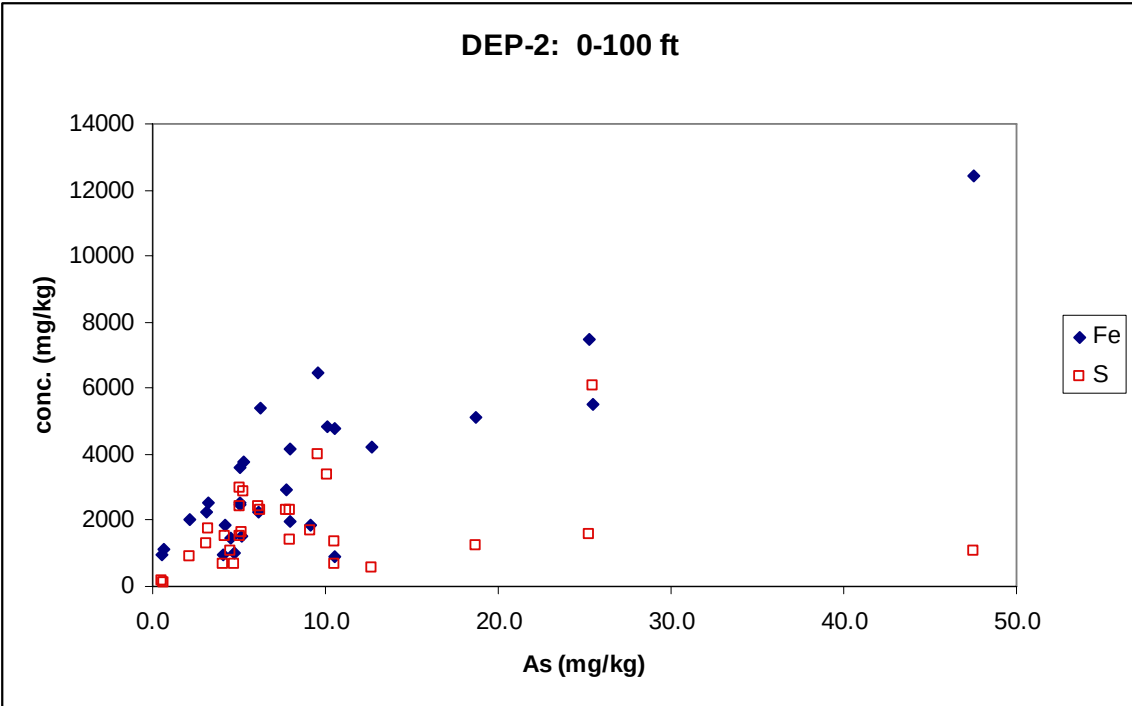


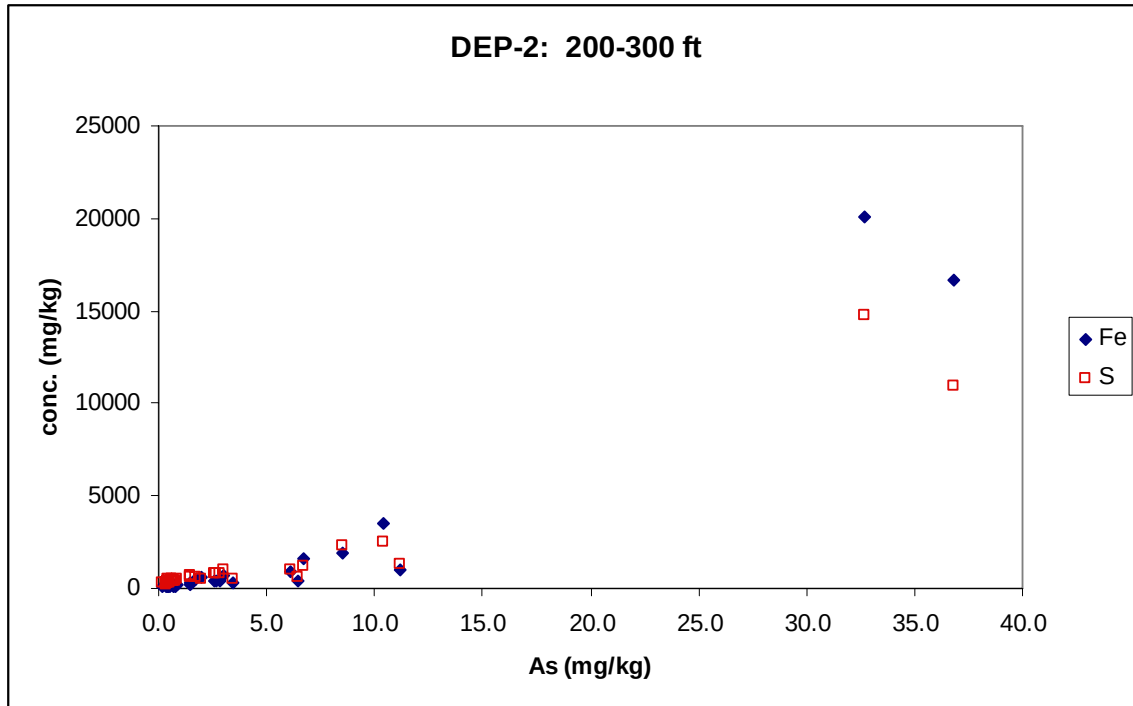
3. The upper part of the Hawthorn Group appears to be dolomitic (based on data from DEP-2). This is not noted on the DEP-2 core log, as that portion is described primarily as a 'calcareous sandstone.' However, the data appear to show consistent enrichment of Mg relative to Ca over the upper ~90 feet, and sporadically at depths (around 135 ft and 200 ft). The core description of the upper ~90 feet indicates the presence of pyrite in that interval as "minor" to "none" but Fe oxide is present throughout this zone. However, immediately below 90 feet, to ~125 feet, pyrite occurs in amounts ranging from "minor" to "much." Arsenic appears to be associated with Fe (presumably, primarily as HFO but also possibly some in pyrite) in the first ~100 ft, then with Mo in the middle part of the core, and with Fe and S in the last 100 feet. This is consistent with the Pichler report.

Supporting information:



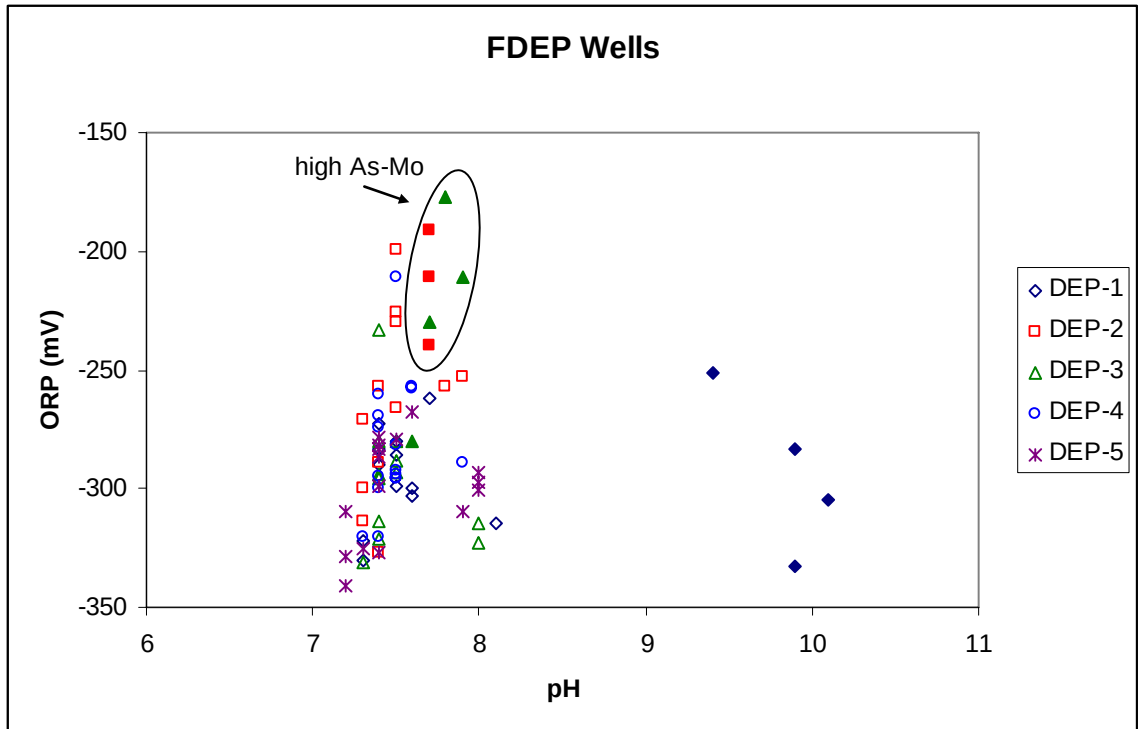
The associations of As with Fe, Mo, and Fe + S in different parts of the core are better seen in the plots below. For these plots, the core was divided arbitrarily into 3 equal segments, but in general As is correlated with Fe in the upper part ($R^2 = 0.75$; to a lesser extent with S); with Mo and Sb in the middle portion ($R^2 = 0.86$ and 0.79 , respectively) and to a lesser extent, S; and with Fe and S in the lower part (it is noted that pyrite is described in the report as 'ubiquitous' in the cores). It is interesting to note that Mo and Sb are strongly correlated in the middle 100 feet of the DEP-2 core ($R^2 = 0.94$) but the probe data in Table 5 (Pichler, 2010) show only two analyses of powellite and Sb is reported at concentrations of 0 and 34 ppm. Nevertheless, from these associations one may infer that in the upper part of the core, As is sorbed onto hydrous ferric oxides and possibly occurs in pyrite to a lesser extent. In the middle part of the core, As is associated with powellite and possibly also pyrite, and is clearly associated with pyrite in the lowest third of the core. As noted above (Item 2, Supporting Information), insufficient information is available to confirm that these element correlations are consistent with the associated mineralogy.





4. According to the scenario proposed for the elevated As, younger, more oxygenated water is pulled into the deeper aquifer by groundwater extraction. Oxidation of arsenian pyrite is suggested as the mechanism that releases As to solution. This is plausible but should be supported by data (in addition to the isotopic results) and geochemical modeling.

Supporting information: On the plot below, groundwater from the FDEP wells with significantly elevated As and Mo are shown with filled symbols. Note that the samples from the shallowest intervals from FDEP-2 and FDEP-3, which are highest in As and Mo, do in fact have the highest ORP measurements. Other samples (e.g., from DEP-1 and DEP-2) with pH and ORPs that are in the same general range do not show elevated As and Mo because these are screened in horizons where the sources of As and Mo (i.e., arsenian pyrite and/or powellite) may be absent.



Note also that DEP-5, which appears to have mineralogy that is very similar to DEP-1 and DEP-2, reports ORP values that are considerably lower than the high-As/Mo well screens – so, although the mineralogy is right for DEP-5 to have elevated As and Mo in groundwater, the redox conditions are not. Apparently water in the shallowest DEP-5 screen is young, but it does not appear to be quite as oxidizing as water of the same age in the vicinity of DEP-1, -2, and -3. Possibly this part of the conceptual model could be refined with more information about the local and regional hydrology – including drawdown in the area with the high-As/Mo wells, either due to fluctuations caused by pumping of the individual residential wells or due to larger-scale perturbations resulting from groundwater extraction by the City of Tampa.

5. If drawdown of surficial water and mixing with deeper aquifer water is the proposed mechanism for the observed levels of As and Mo, a simple chemical mixing model should be consistent with this scenario.

Supporting information: The following notes describe a preliminary simulation of groundwater mixing for the Pritcher Road site.

In the recent report (Pichler, 2010), the high concentrations of As and Mo in groundwater in the vicinity of Lithia, FL, are explained by ‘physicochemical changes’ that cause the dissolution of As- and Mo-bearing minerals. Although the ‘physicochemical changes’ are not further identified in this document, they are attributed to mixing of shallow groundwater with water deeper in the aquifer.

This drawdown is thought to be the result of groundwater extraction by the City of Tampa, and possibly also by pumping of local, residential wells.

The geochemical program PHREEQC (Parkhurst and Appelo, 1999) was used in a preliminary attempt to explore mixing of shallow and deeper groundwater. Water from one of the surficial monitoring wells represented the composition of the surficial aquifer. For this end-member, MW-1 was selected. As noted in the report, MW-2 and MW-3 appear to be intercepting water affected by the local phosphate operation, and MW-6 is in an agricultural area. At this time, those wells will not be considered further for any geochemical modeling. Data from DEP2(300-320 ft) from the April 2009 sampling event were used for the deep-aquifer water.

Initially, water from MW-1 was assumed to be equilibrated with atmospheric CO₂, calcite, and dolomite. The assumption of dolomite is based on the apparent enrichment of Mg relative to Ca in the upper part of core DEP-2.

The resulting solution was then mixed in equal proportions with water from DEP2(300-320 ft). A 50:50 ratio was chosen as an initial guess because chloride (generally considered to behave conservatively) is present at nearly the same concentration in each of the end-members (12 mg/L in MW-1, 13 mg/L in DEP2). (Other ratios were tried but the results are very sensitive to anything much different from 50:50). Redox was calculated by correcting the measured ORPs for the difference between a Pt electrode and the hydrogen half-cell. This is not wholly satisfactory, but it is unlikely that the As(V)/As(III) couple is at thermodynamic equilibrium, and also it represents only one of a number of couples that determine redox conditions at the time of sampling. Temperature was assumed to be 20°C. This mixture was then equilibrated with calcite, dolomite, and powellite.

Computed concentrations from the PHREEQC output for this equilibrated solution are tabulated below:

ELEMENT	PHREEQC OUTPUT (MG/L)	MEAS. IN DEP2(143-163) APRIL 2009
Ca	31.3	34.4
Cl	12.5	13
K	0.7	0.8
Mg	16.3	13
Na	7.5	8
SO ₄	6.4	27
Si (as Si(OH) ₄)	29.6	21
Mo	2610	3930

Overall, the agreement between the computed solution composition, based on mixing of the two end members as described above, and the data from the uppermost well screen in DEP2 is not bad. There is considerable discrepancy between the sulfate results, and although the Mo results are qualitatively comparable (same order of magnitude), the difference is significant.

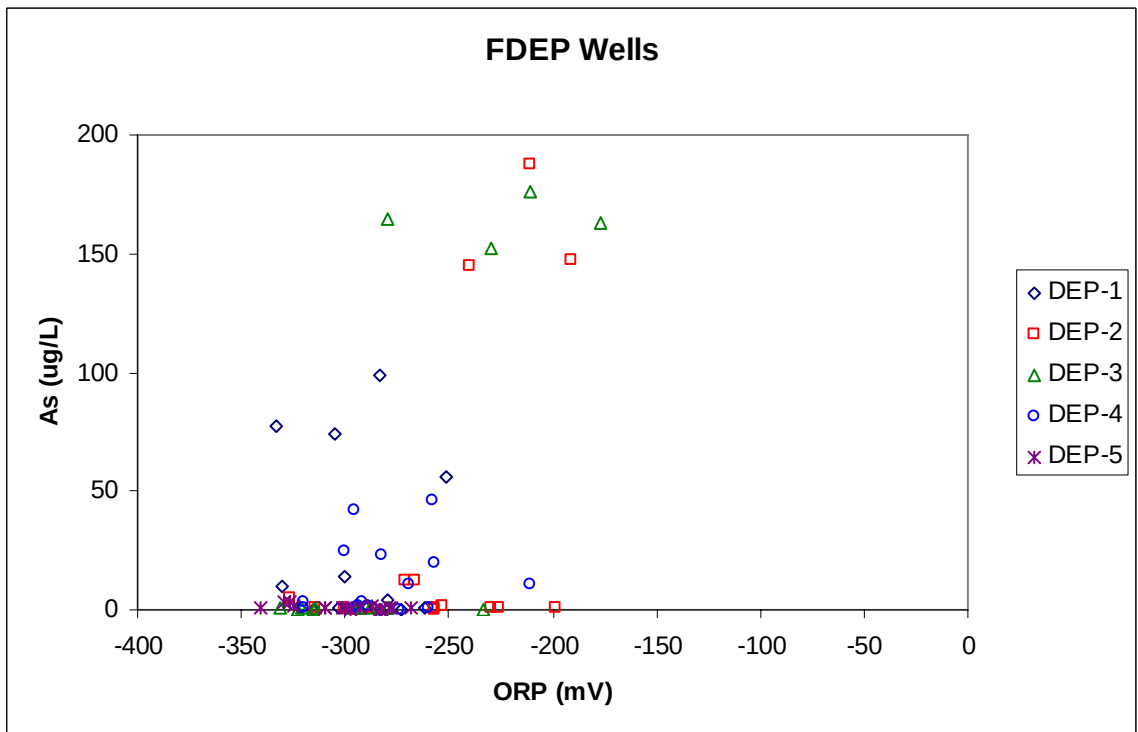
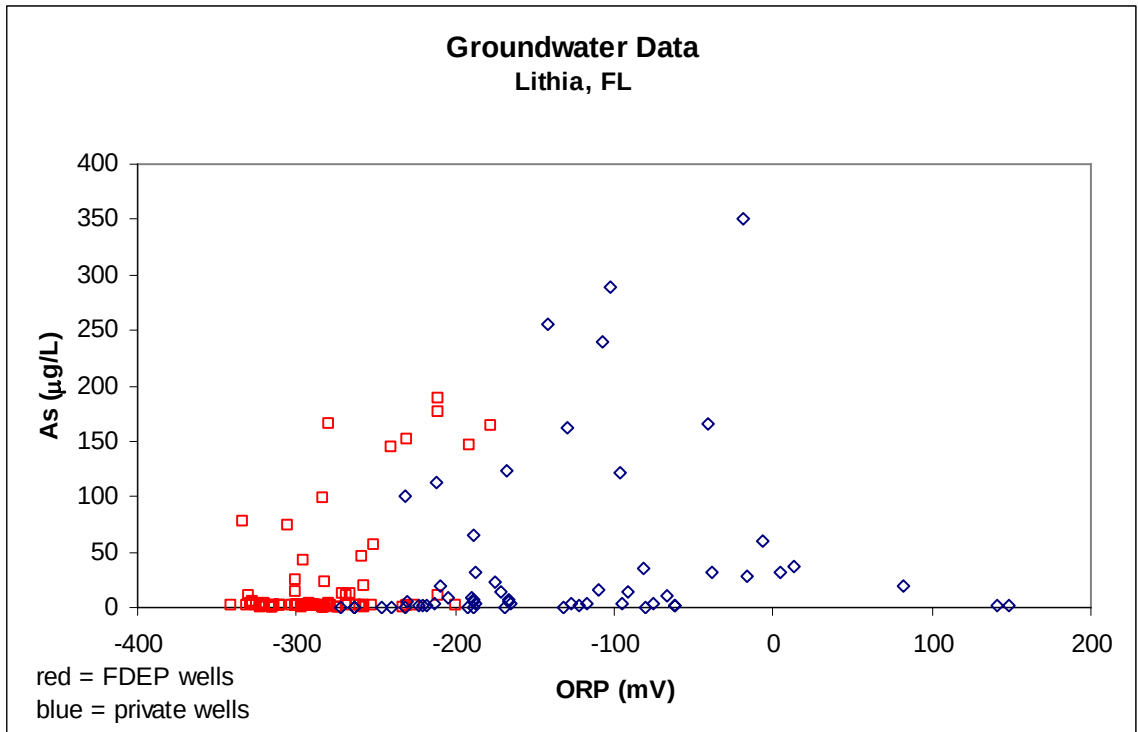
It must be noted that neither arsenic nor iron is represented in the example described above. An additional effort was made to ‘titrate’ the system with oxygen in order to simulate the oxidation of pyrite, which will increase the computed sulfate concentration and also allow for an estimate of the theoretical dissolved As (based on the As content of the pyrites reported in Table 4, Pichler 2010). However, in order to reproduce the sulfate concentration reported from FDEP-2(143-163), oxygen concentrations close to saturation were required. This result is in conflict with the measured DO for the end-member compositions, which were low: 0.89 mg/L for MW-1 and 0.1-0.6 mg/L for DEP-2(300-320).

This approach should be explored further, but these preliminary results suggest that the groundwater data may be used to support the scenario that was proposed in the Pichler report.

6. Additional support for pyrite oxidation as the mechanism for arsenic mobilization may be found in GF’s work on As behavior in sulfidic environments (e.g., Stein et al., 2005). Where conditions are oxidizing (ORPs generally $> +100$ mV) and Fe is present as hydrous ferric oxide (HFO), aqueous As concentrations are low due to sorption of arsenate and/or arsenite onto the HFO surface. At extremely low redox conditions (ORPs $< \sim -300$ mV) and in the presence of HS^- , aqueous As concentrations are low due to the formation of sulfides. The details of the mechanisms of As uptake remain speculative at this time, but may include sorption onto the surface of Fe-sulfide phases, co-precipitation with Fe-sulfides, and/or formation of discrete As-sulfides or Fe-As-sulfides such as orpiment, realgar, or arsenopyrite. In between these two redox extremes, around ORP = -150 to -200 mV, neither HFO nor sulfides are stable, and aqueous As concentrations are elevated. [We refer informally to this behavior as the ‘Bermuda Triangle’ because at sites where these mechanisms control groundwater arsenic concentrations, the data often display a triangular pattern, with the apex generally in the vicinity of -150 to -200 mV.] This scenario is supported by geochemical modeling (using PHREEQC), results from which show the stability of Fe-oxide phases at the high-ORP end, and the stability of various sulfides at the very-low-ORP end, and undersaturation with respect to all of these phases in the intermediate range.

Supporting information: It can be seen from these two plots that the FDEP wells highest in As plot toward the apex of the ‘triangle’ as do the highest-As residential wells. FDEP-5, which apparently intercepts the same lithology as

FDEP-1, 2, and 3, appears to have lower ORP, which favors the stability of sulfides.



7. The presence of Mo is due to the relatively high solubility of powellite. Estimates of the solubility constant vary but are generally around $\log k = -7.93$ (Felmy et al., 1992), which is similar to calcite ($\log k \sim -8.4$) but much larger than for pyrite ($\log k \sim -18.5$; Vminteq.v4 database). The correlation of As and Mo in groundwater at the Lithia site appears to be due to integration of the water chemistry in the aquifer, and not necessarily because they have a common source (i.e., a single solid phase).

Supporting information: please see previous comments about the association of As with HFO and pyrite; also, the powellite appears to be a late-stage diagenetic mineral (from what I can see in the SEM photos in Pichler, 2010). It is plausible that the As and Mo both originated in pyrite (see Comment 1, above), and subsequent diagenetic reactions – including pyrite oxidation – resulted in As-rich pyrite, As sorbed onto HFO, and Mo (with some As) in powellite due to the abundance of available Ca and the relatively high solubility product of CaMoO_4 . Results from geochemical modeling (using PHREEQC) are consistent with this scenario. The report should be revised to include all data pertaining to powellite that was not included in this draft.

Additional Recommendations for Florida DEP

1. Gannett Fleming suggests that FDEP consider undertaking a more comprehensive study of the local and regional hydrology in the Lithia area. In particular, GF suggests installing some continuously recording pressure transducers in the FDEP wells and in selected (high As, Mo) residential wells so that both short- and long-term fluctuations in the water table can be monitored in the area. [We use Solinst Leveloggers (both the Gold and Junior models) but there are a number of other manufacturers.]
2. Examine any existing regional flow models, if any are available. Did the City of Tampa water department develop any models (particle track or otherwise) for a Zone II assessment? Were pump tests conducted? Are withdrawal records available? If so, all of that information should be considered along with any hydraulic measurements from the Pritcher Road area. [A cautionary note – please be aware that most flow models are generally two-dimensional; vertical discretization is often minimal and will depend on how many layers are used to construct the model. Since our preliminary conclusion is that the As-Mo problem in the Pritcher Road area is caused by vertical mixing, this may be difficult to represent in the third dimension without a substantial, focused effort and collection of additional data.]
3. Additional examination of the cores is warranted; as other reviewers have pointed out, the occurrence of powellite has raised some questions. Is it a product of early- or late-stage diagenesis? Is it an artifact of coring? Why is its presence

apparently so sparse (occurring in only two samples)? The low probe totals for the two powellite samples are also questionable, as is the absence of Mo in any of the pyrites.

4. Depending on resources available, FDEP may also wish to consider batch or column experiments with core material containing powellite and/or pyrite. These experiments would entail flushing core samples with oxygenated groundwater and analyzing the effluent for As, Mo, etc.

References

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