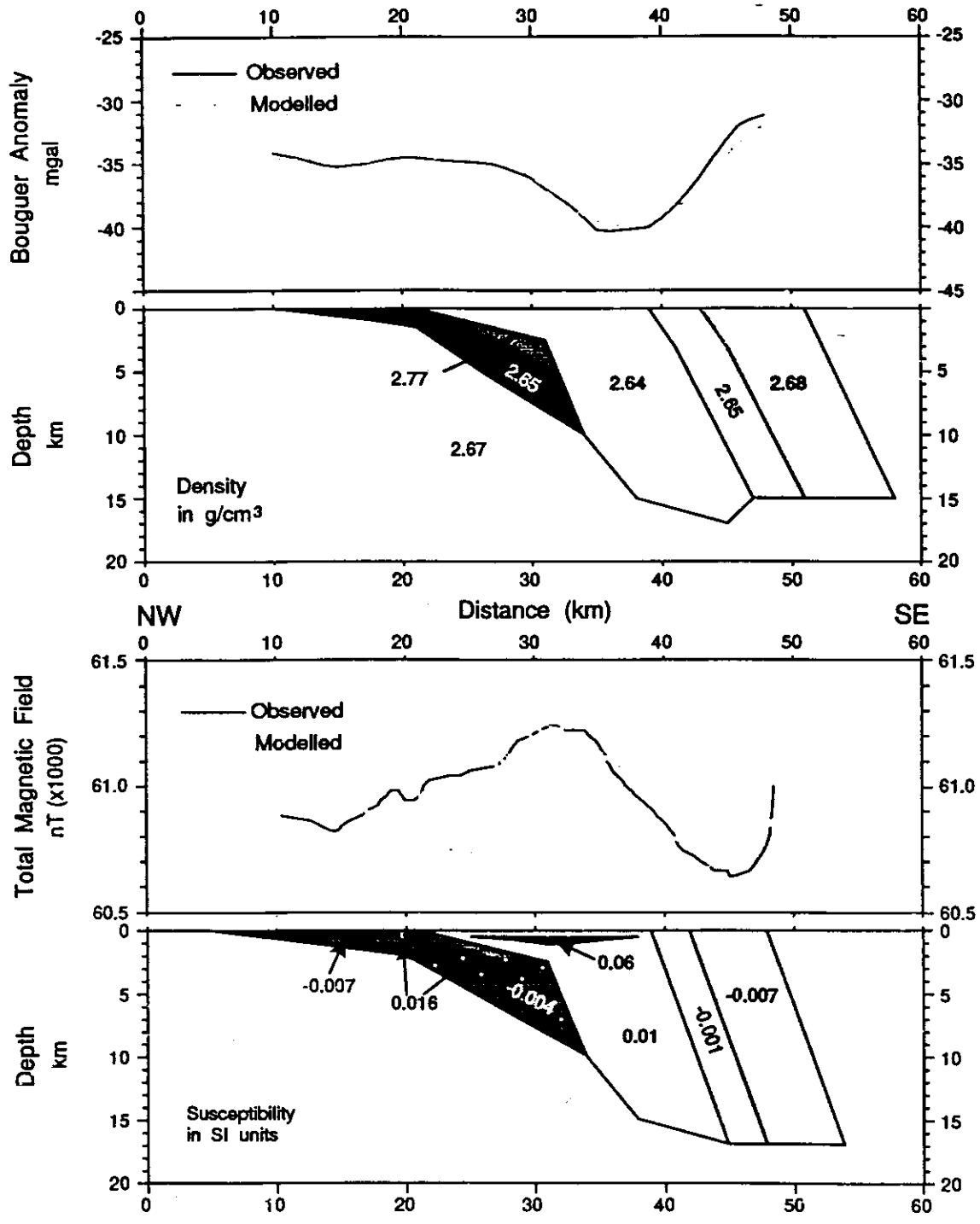
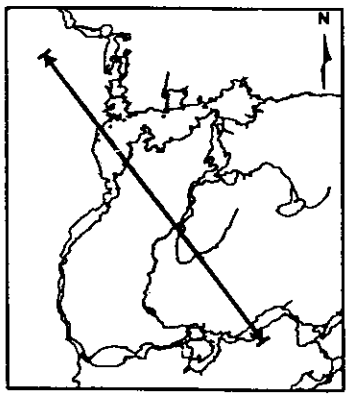


Legend

- Lac du Bonnet Batholith
- Granodiorite
- Xenolithic Granite
- Fine Grained Tonalite Gneisses
- Greenstone and Ultramafic Unit
- Tonalite / Diorite
- Undifferentiated Gneisses

Location of Modelled Profile



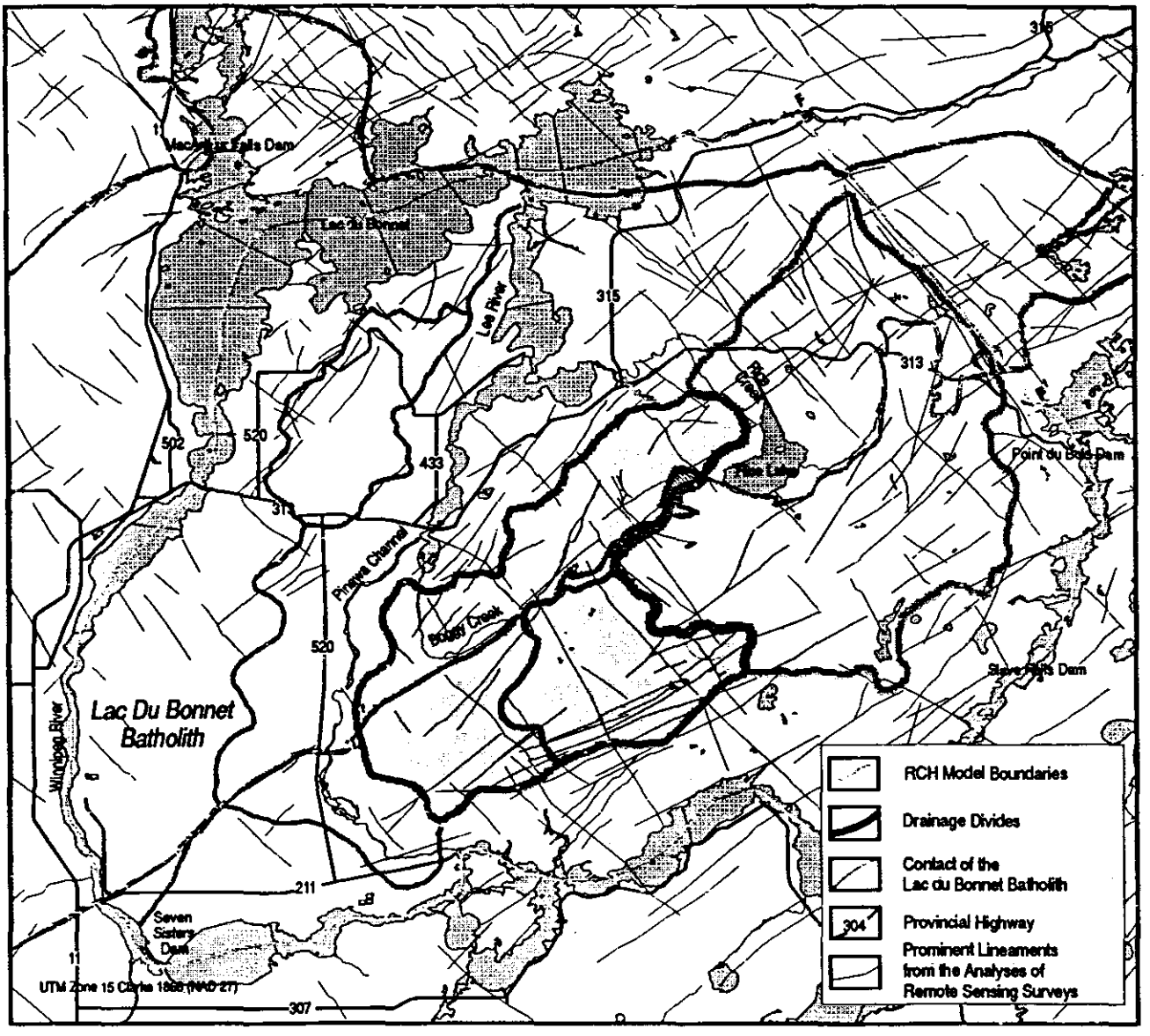


Figure 1: Boundaries of the revised conceptual hydrogeological (RCH) model, drainage catchments, the Lac du Bonnet batholith, and composite lineaments from remote sensing and geophysical surveys.

LOWER SECTION ATIKOKAN WATER CATCHMENT

NW ONTARIO

Legend

Recharge area

Discharge area

Recharge area

Discharge area

2 km

CANDIDATE AREA CHARACTERIZATION :

- *OPTIMIZING SITE CHARACTERIZATION COSTS*
- *REMOTE SENSING, AIRBORNE SURVEYS, AND RECONNAISSANCE MAPPING*
- ***BOREHOLE SITING, DRILLING AND LOGGING,AND TESTING***
- *PIEZOMETER CONSTRUCTION AND MONITORING*
- *GROUNDWATER SAMPLING*
- *DATA COLLECTION, ANALYSIS AND ARCHIVING*
- *CONCEPTUAL HYDROGEOLOGIC MODEL CONSTRUCTION*

BOREHOLE SITING, DRILLING AND LOGGING, AND TESTING

BOREHOLE SITING:

- *divide Candidate Area in separate structural domains, and locate a few boreholes in each domain to extend surface structural pattern to depth in stages: shallow depth (0 - 100 m); intermediate depth (100 -400 m); deep(400 -1000 m).*
- *orient shallow borehole(s) to intersect all shallow joint sets and fractures zones; log and instrument boreholes as drilled to observe hydraulic interference.*
- *locate and orient deeper boreholes to intersect major fracture zones at depth (case and cement off upper 100 m of deep holes).*

DRILLING AND LOGGING: (see next slide)

BOREHOLE SITING, DRILLING AND LOGGING, AND TESTING (cont'd)

DRILLING AND LOGGING:

- *core shallow boreholes (triple tube) and deeper boreholes below the 100 m level (drill with water and flush cuttings); identify and orientate permeable fractures / fracture zones / aquifers*
- *standard geophysical logs, TV / BATV, flow meter.*

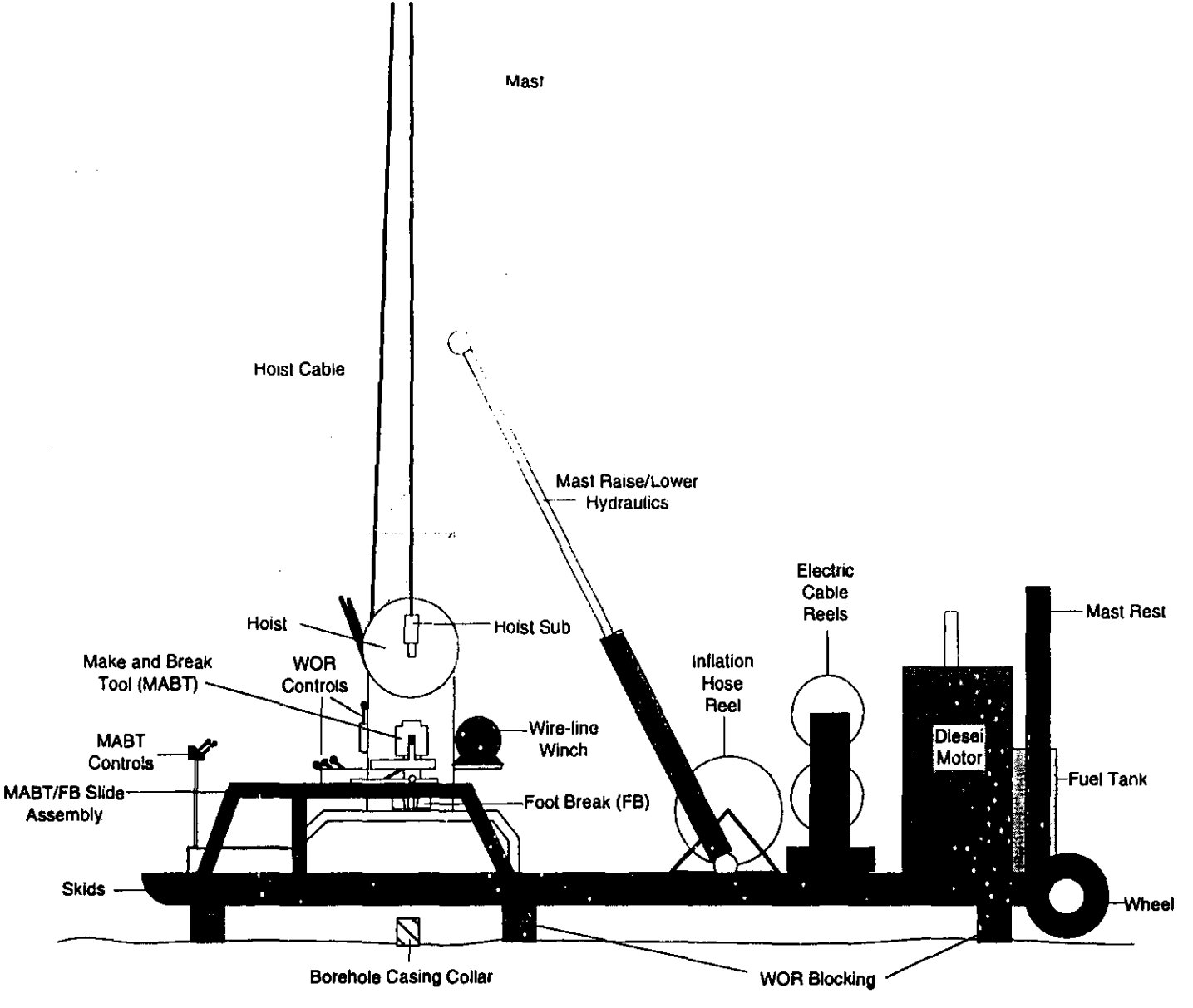
TESTING: *SINGLE BOREHOLE HYDRAULIC TESTING:*

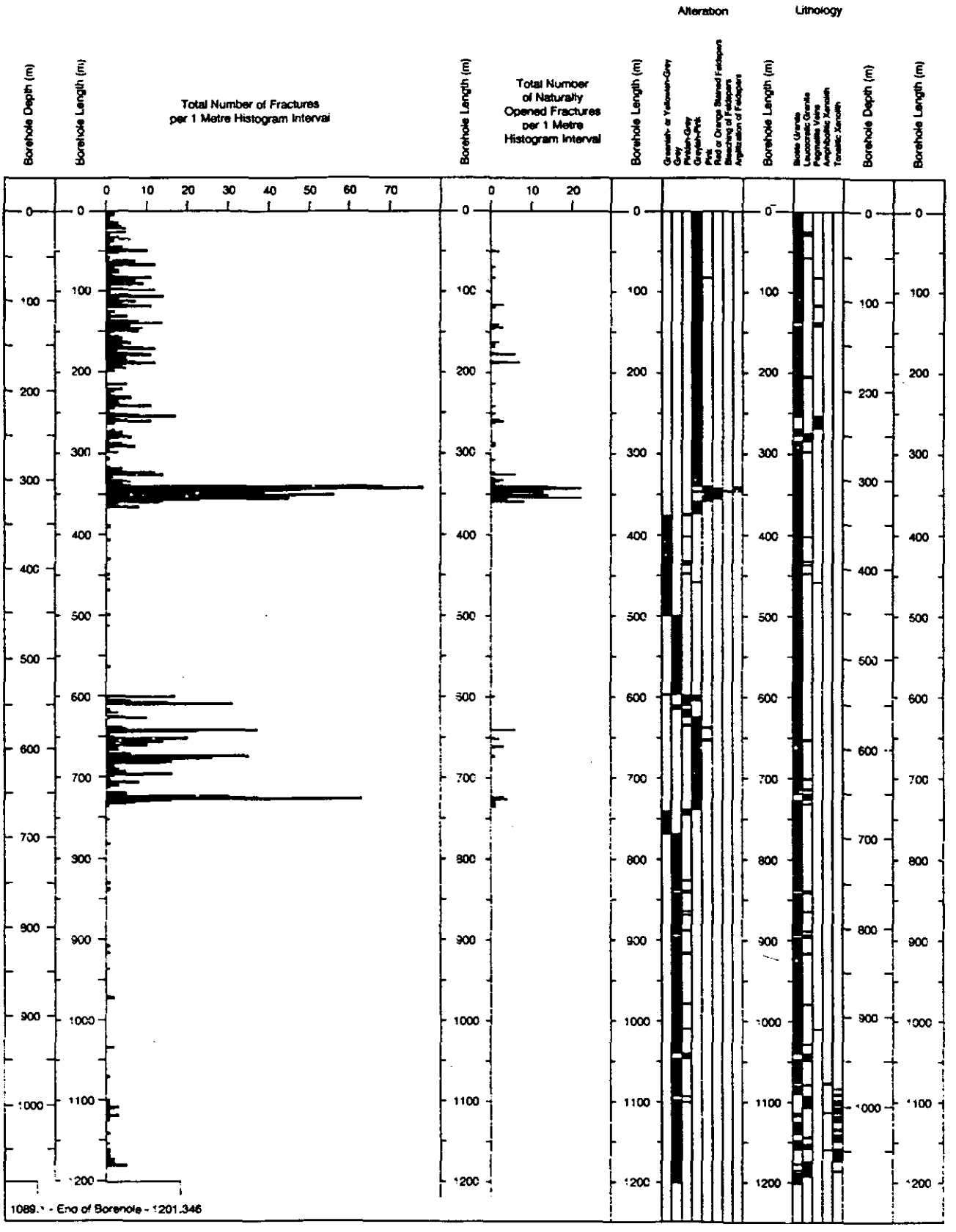
- *straddle packer:* closed system injection (Leugeon), *constant flow, constant head, pulse;* open system *constant flow, constant head, slug, rising head;* heat pulse.
- *multi-packer (piezometer) testing:* closed system *pressure falloff / buildup;* open system, *slug, rising head.*

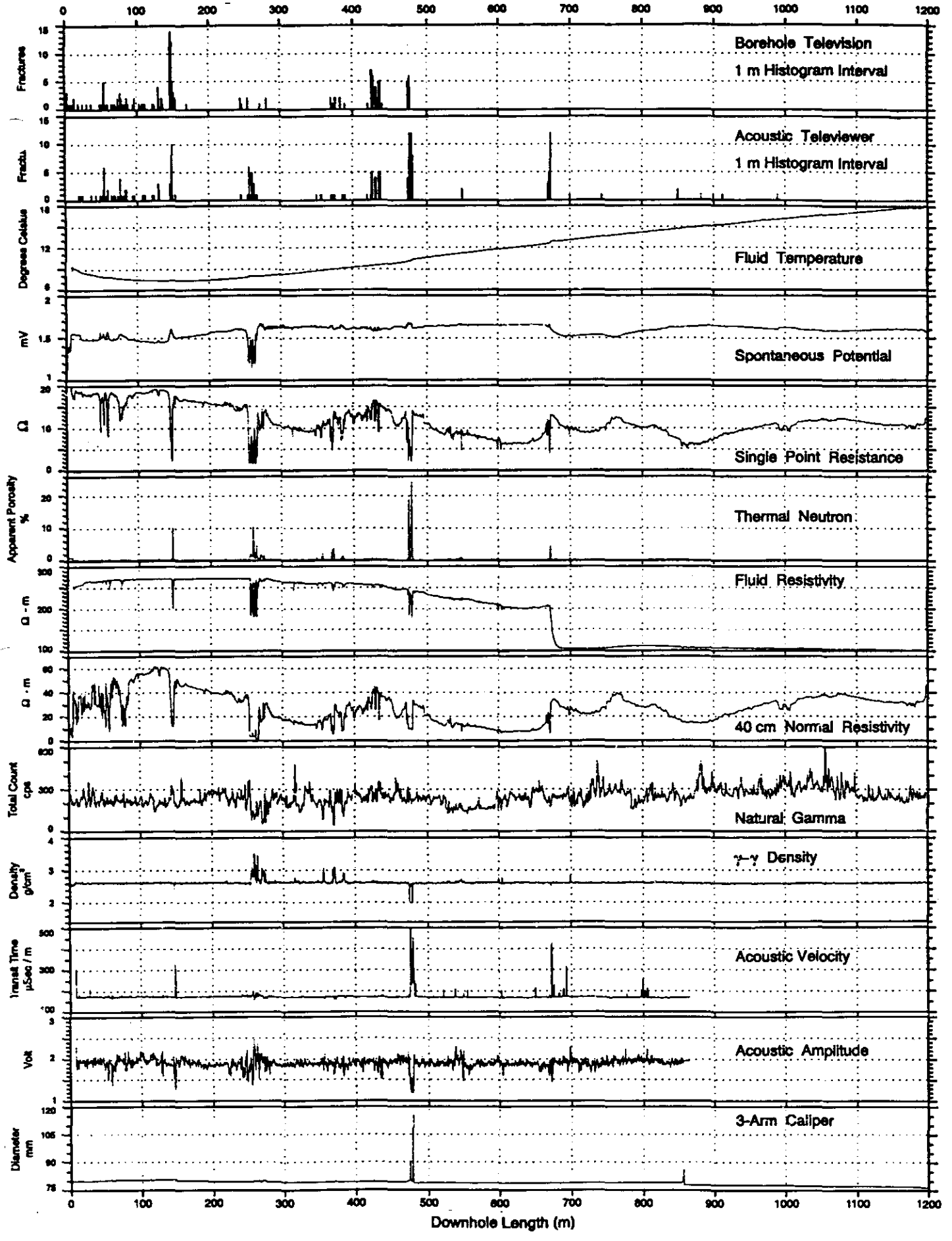
INTERFERENCE TESTING:

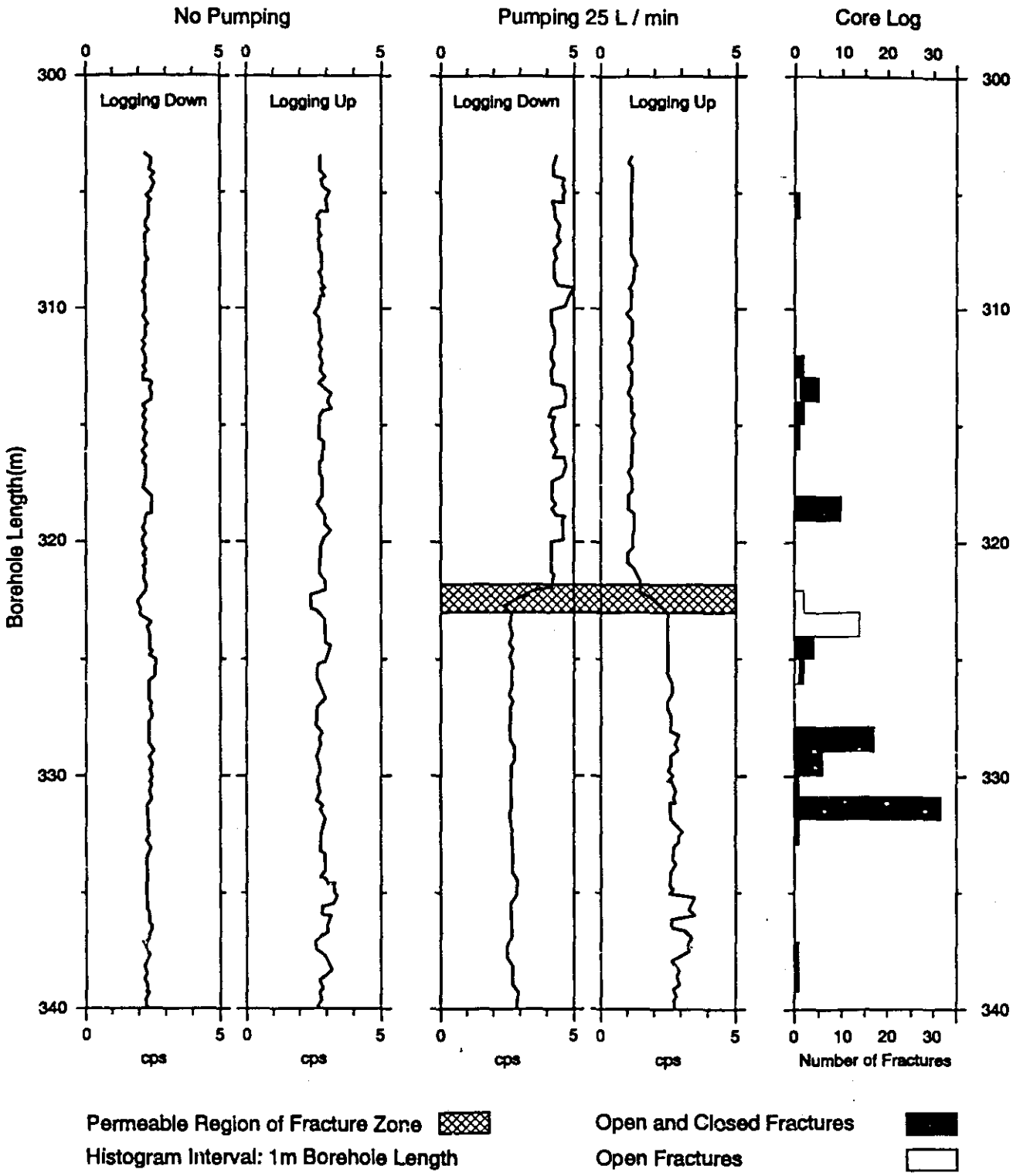
- *test well and observation well(s) / piezometer(s).*

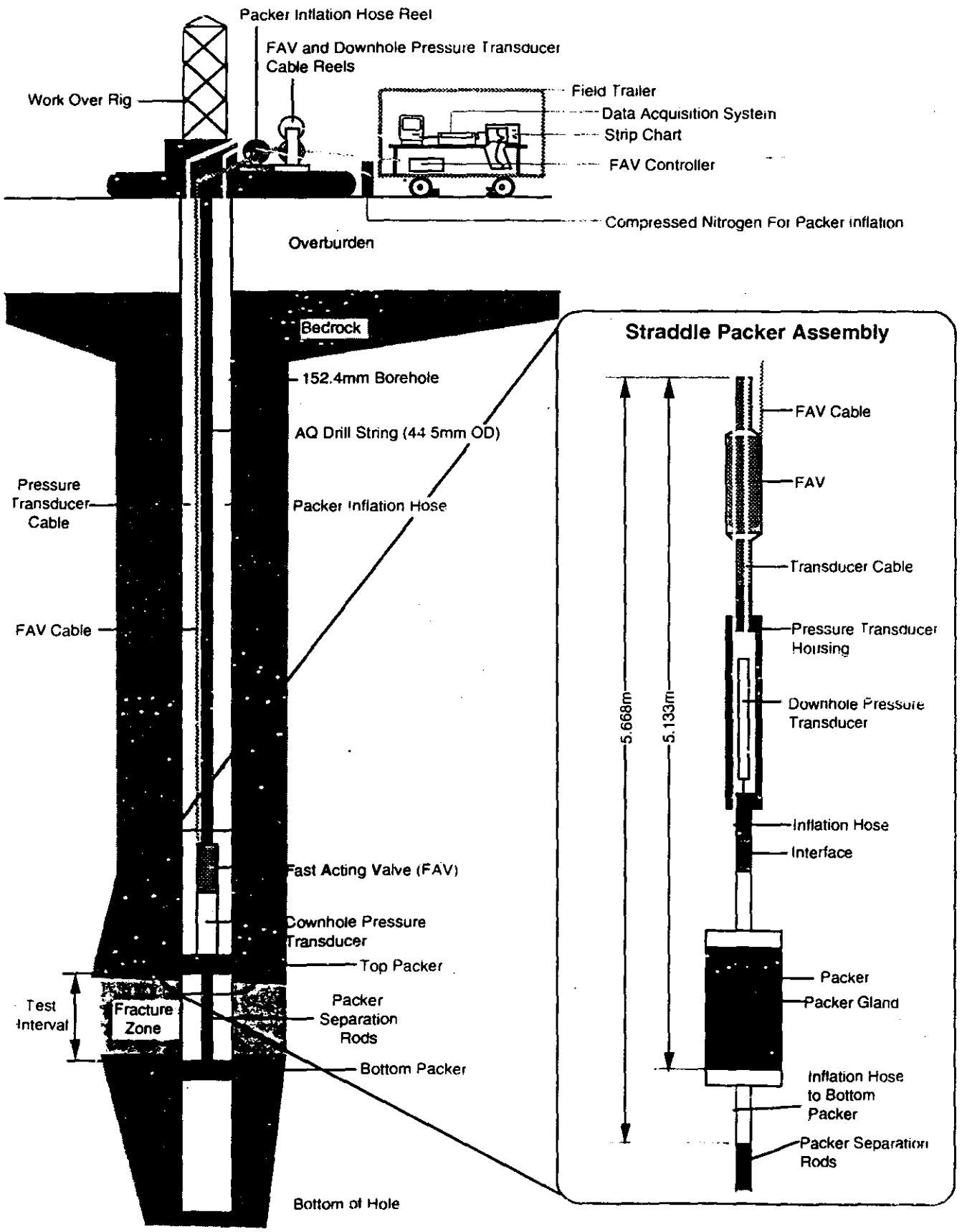
Work Over Rig




Alteration
Lithology
Borehole Depth (m)
Borehole Length (m)
Total Number of Fractures per 1 Metre Histogram Interval
Total Number of Naturally Opened Fractures per 1 Metre Histogram Interval
Greenish- or Yellowish-Grey
Grey
Pinkish-Grey
Greyish-Pink
Pink
Red or Orange Stained Feldspars
Bleaching of Feldspars
Argillization of Feldspars
Biotite Granite
Leucocratic Granite
Pegmatite Veins
Amphibolitic Xenolith
Tonalitic Xenolith
0 10 20 30 40 50 60 70
0 10 20
0 100 200 300 400 500 600 700 800 900 1000 1100 1200
1089.1 - End of Borehole - 1201.346


Borehole Television
1 m Histogram Interval
Fractures
Acoustic Televiewer
1 m Histogram Interval
Fractu
Fluid Temperature
Degrees Celsius
Spontaneous Potential
mV
Single Point Resistance
Ω
Thermal Neutron
Apparent Porosity
%
Fluid Resistivity
Ω - m
40 cm Normal Resistivity
Ω - m
Natural Gamma
Total Count
cps
γ–γ Density
Density
g/cm³
Acoustic Velocity
Transit Time
µSec / m
Acoustic Amplitude
Volt
3-Arm Caliper
Diameter
mm
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Downhole Length (m)


No Pumping
Pumping 25 L / min
Core Log
Logging Down
Logging Up
Logging Down
Logging Up
Borehole Length(m)
300
310
320
330
340
0
5
10
20
30
cps
cps
cps
cps
Number of Fractures
Permeable Region of Fracture Zone
Histogram Interval: 1m Borehole Length
Open and Closed Fractures
Open Fractures


Packer Inflation Hose Reel
FAV and Downhole Pressure Transducer Cable Reels
Work Over Rig
Field Trailer
Data Acquisition System
Strip Chart
FAV Controller
Compressed Nitrogen For Packer Inflation
Overburden
Bedrock
152.4mm Borehole
AQ Drill String (44.5mm OD)
Pressure Transducer Cable
Packer Inflation Hose
FAV Cable
Fast Acting Valve (FAV)
Downhole Pressure Transducer
Top Packer
Test Interval
Fracture Zone
Packer Separation Rods
Bottom Packer
Bottom of Hole
Straddle Packer Assembly
FAV Cable
FAV
Transducer Cable
Pressure Transducer Housing
Downhole Pressure Transducer
5.668m
5.133m
Inflation Hose
Interface
Packer
Packer Gland
Inflation Hose to Bottom Packer
Packer Separation Rods

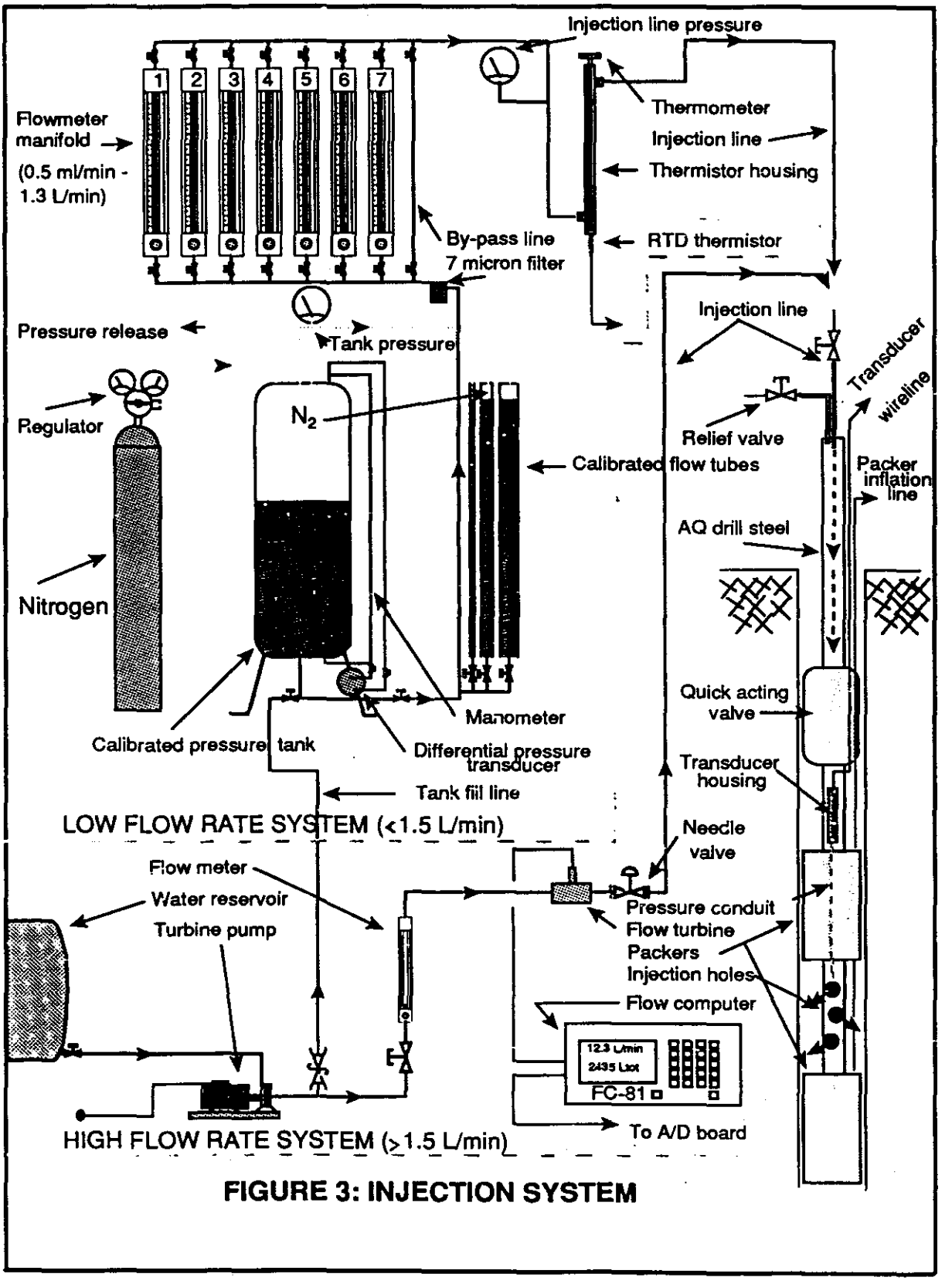


FIGURE 3: INJECTION SYSTEM

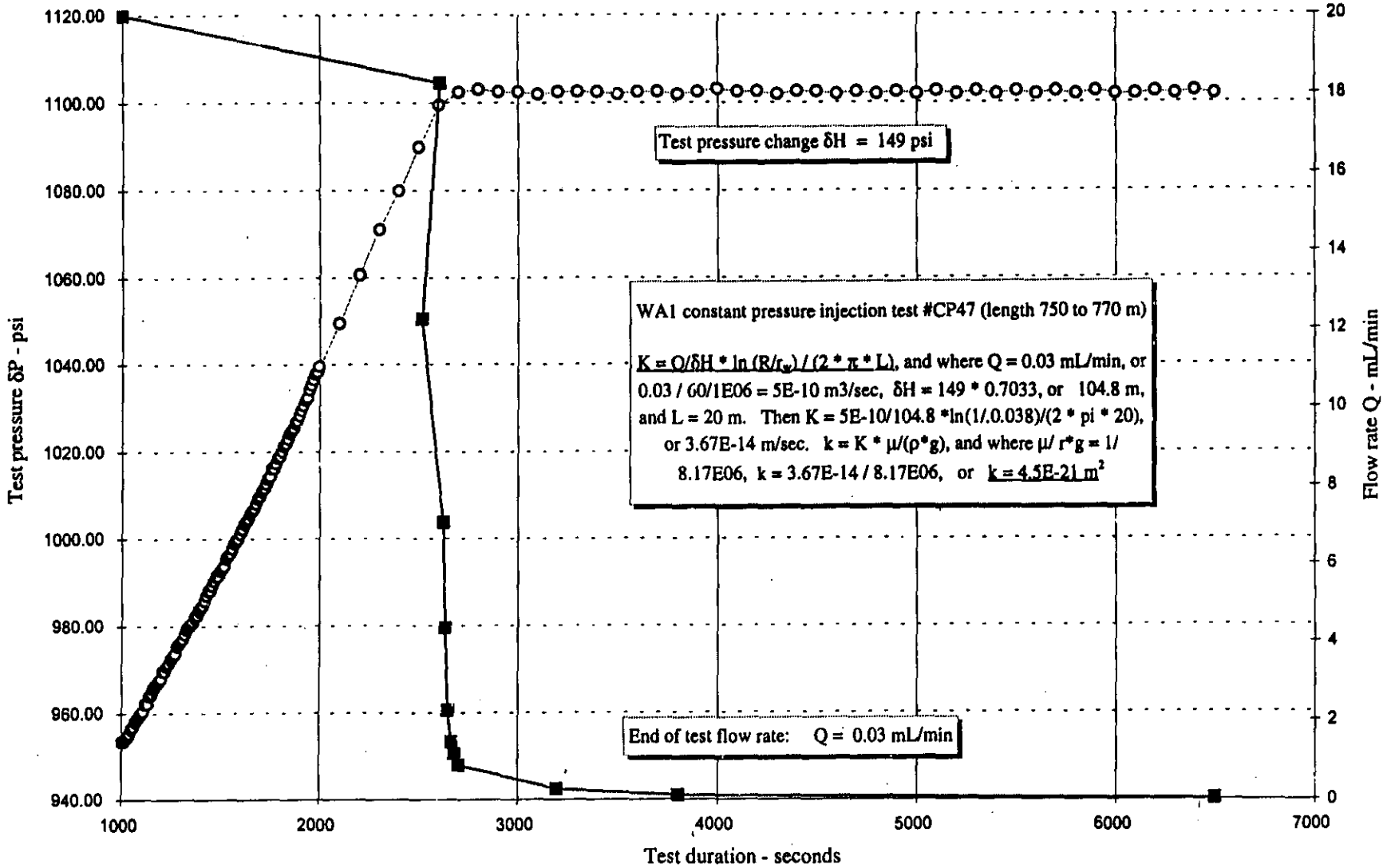


Figure 9: Plot of test interval pressure and injection rate versus test duration for hydraulic test #CP47 in borehole WA1.

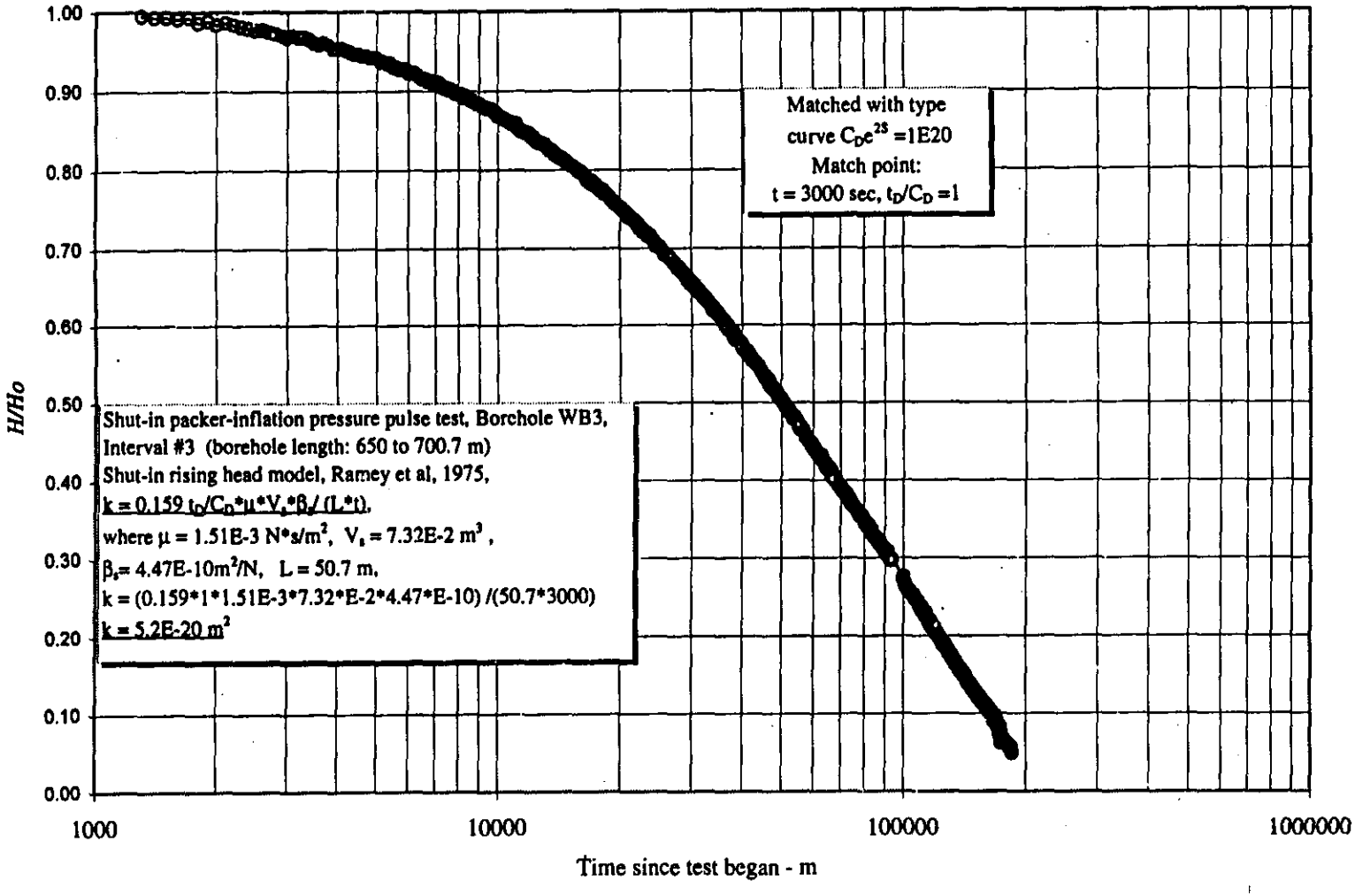


Figure 10: Plot of normalized shut-in interval pressure fall-off (due to packer-inflation pulse) versus test duration in borehole WB3

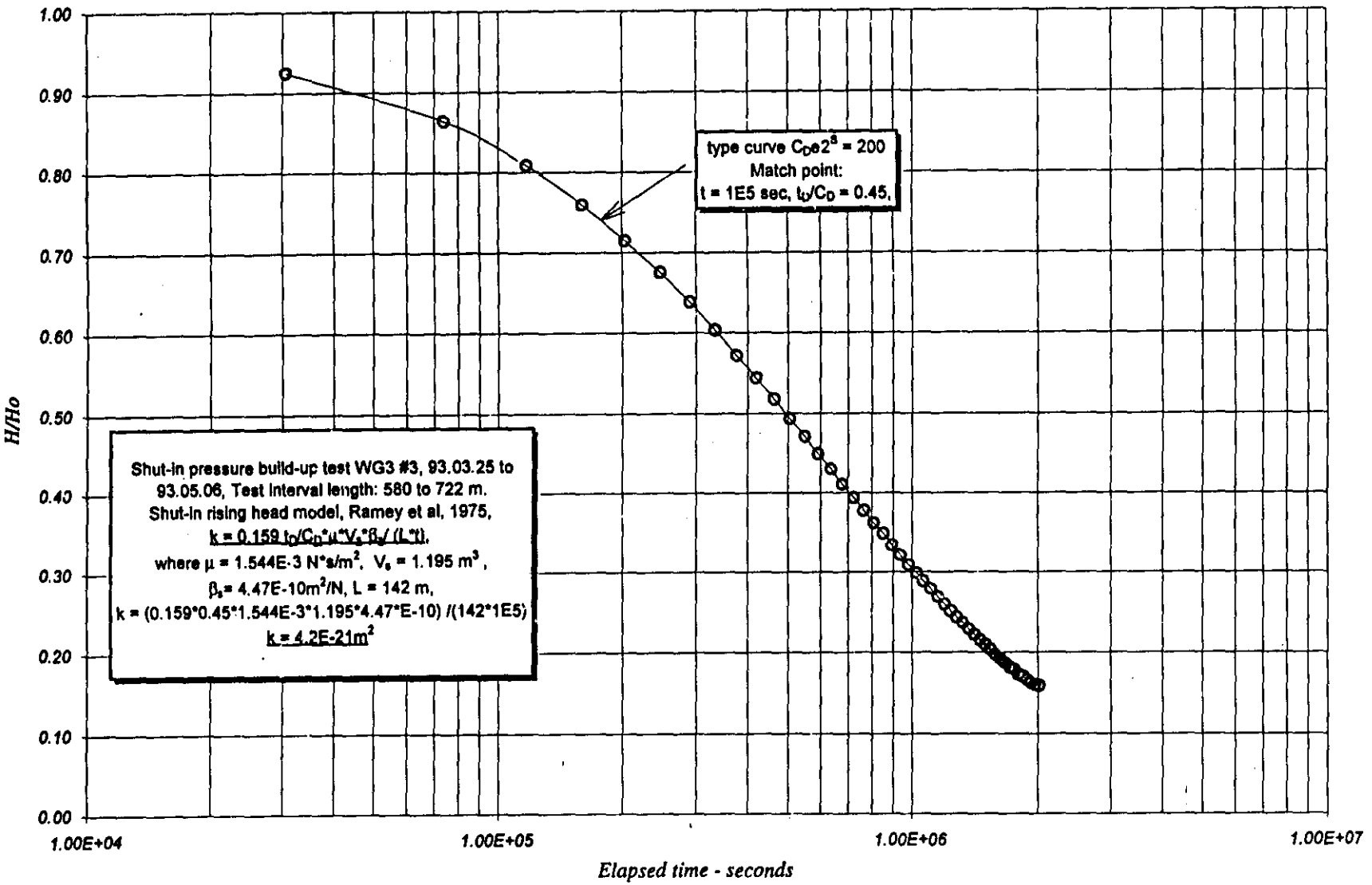
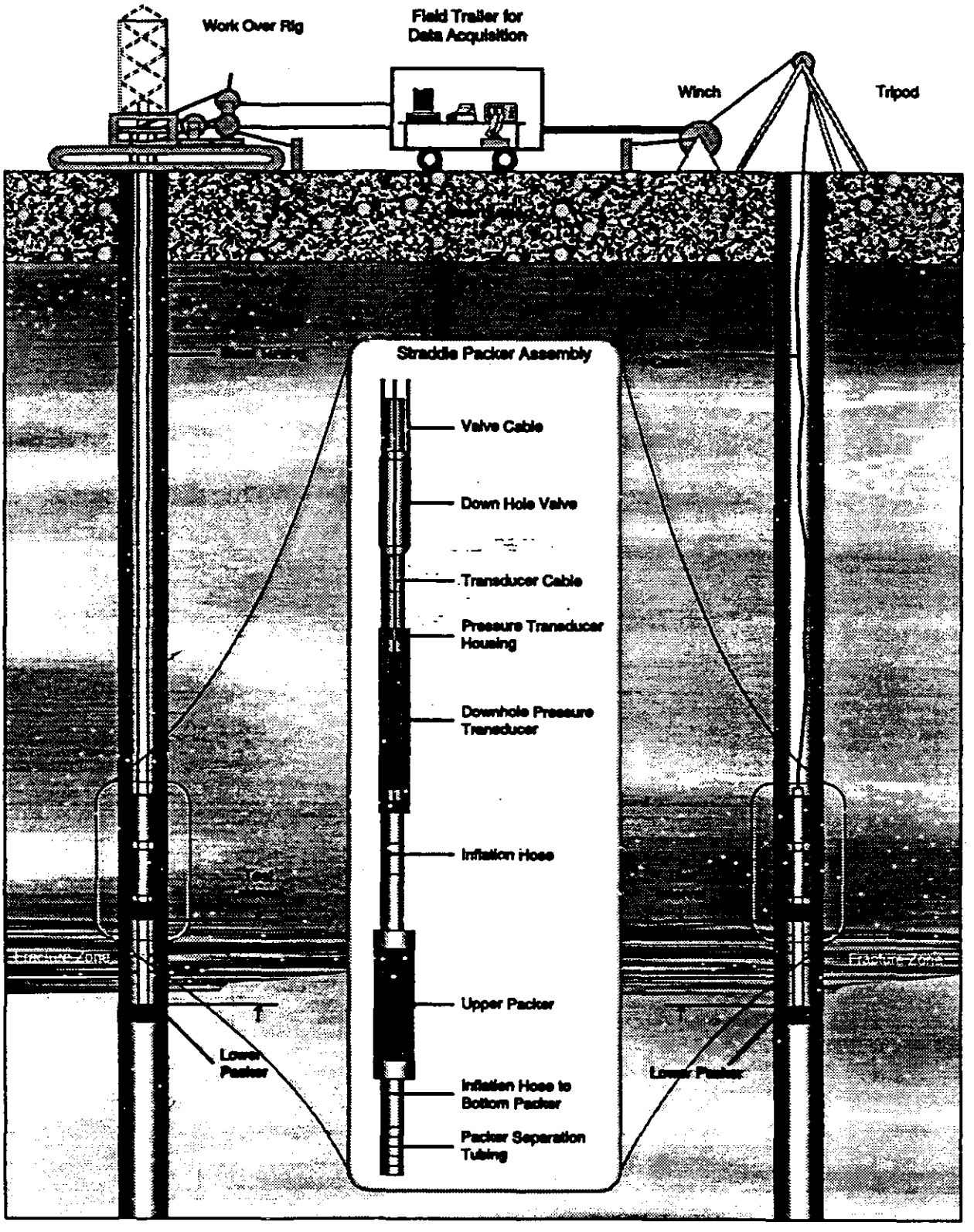


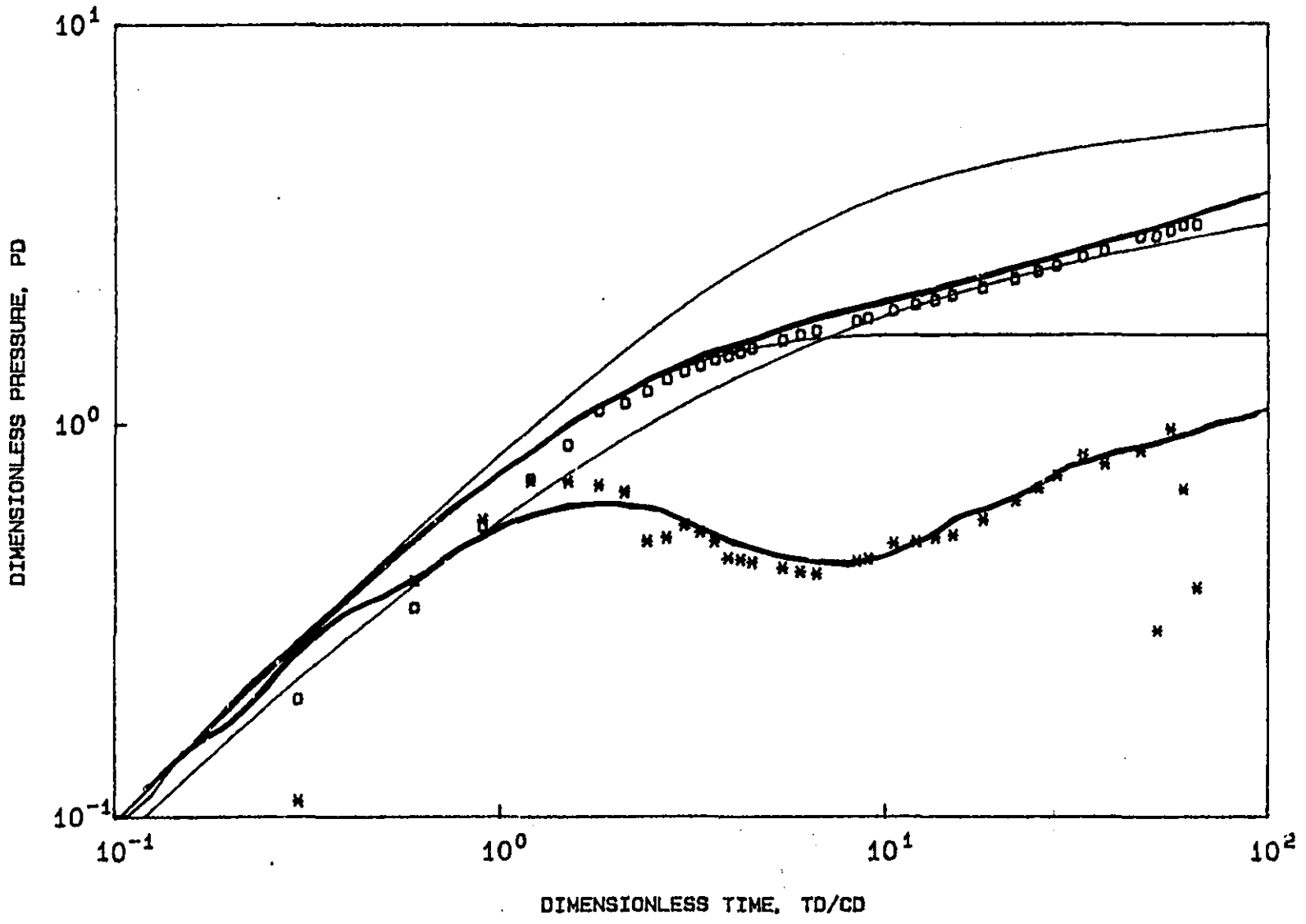
Figure 11: Plot of normalized shut-in pressure build-up versus test duration in a packer-isolated interval in the lower part of borehole WG3.

Borehole Name	Test interval length, (m)	Test interval mid-depth, (m)	Borehole hydraulic test method / permeability "k" - m^2					
			SPCPI*	SPP*	OSPRH*	SPPBU*	WBPBU*	OBHSp* k - m^2
URL15HT-4	4	51	2.23E-19					
WB1HT-34	2.26	72.5	4E-20					
WG1HT-D7	0.6	74.3	3.23E-18					
WB1WB-3	33.1	95.3					6.7E-18	
WG1HT-F1	48.84	122.6	5.76E-19					
WA1HT-4	2.19	124	2.7E-17					
M4B-2HT	51.6	126.13			4.2E-18			
URL1HT-3	7.1	166.6		1.3E-20				
URL15HT-4	4	195	7.89E-20					
WG1HT-F3	48.84	207.6	1.09E-19					
WA1HT-8	2.19	231	3.2E-18					
AC3	5.143	231						1.90E-21
AC15	4.075	231						1.10E-21
OC1/OC2	35.1	234						7.40E-21
RM13 EBH	1	233						1.40E-20
URLHG7-3	1.8	240		2E-20				
URL3HT-8	229.4	253.2		1.4E-19				
WG3SI-2	384.2	320.06				9.9E-21		
WG1HT-F6	48.84	333.1	1.61E-20					
WB3HT-4C	199.7	344.2	4.37E-18					
URL13-PZP9	63.6	372			3.9E-20			
WG1HT-F7	48.84	374.6	4.4E-20					
SM1	20.6	413						1.10E-21
WG1HT-F8	48.84	415.8	2.49E-20					
SM7	23.2	425						1.90E-21
GC1	20	426						4.70E-21
WA1HT-48	199.7	426	2.61E-19					
WG3SI-3	142.2	443.3				4.2E-21		
WG3OSP-4	122.2	448.64			2.7E-21			
WG1HT-F9	48.84	457	2.61E-20					
WB3HT-14	10.15	467.6	3.78E-21					
URL1HT-5	7.1	468.3		2.5E-22				
WG1HT-F10	48.84	498	2.28E-20					
WB3HT-5	199.73	512.7	2.29E-20					
WB3HT-8	50.38	533.9	3.42E-20					
WB1HT-29	7.3	571.3	4.6E-20					
WB3HT-9	50.38	574.6	1.6E-20					
WB3HT-3	50.7	586.3	4.5E-20			5.2E-20		
WN9-4	113.7	643.1			2.2E-20			
WG1HT-F13	48.84	620.7	2.88E-20					
WG1HT-F15	48.84	685.1	3.66E-21					
WA1HT-47	20	687.5	4.5E-21					
WJ1HT-14	20.3	567.9	7.7E-21					
URL2HT-13	399.8	857.6		1.1E-21				
WJ1HT-06	142.3	883.2	8.8E-21					

* SPCPI = straddle packer constant pressure injection; SPP = straddle packer pulse; OSPRH = open standpipe rising head; SPPBU = straddle packer pressure buildup; WBPBU = Westbay pressure buildup; OBHSp = open borehole seepage.

Table 1: Summary of permeability tests in sparsely fractured rock versus test interval mid-depth, Whiteshell Research Area.


Work Over Rig
Field Trailer for Data Acquisition
Winch
Tripod
Straddle Packer Assembly
Valve Cable
Down Hole Valve
Transducer Cable
Pressure Transducer Housing
Downhole Pressure Transducer
Inflation Hose
Upper Packer
Inflation Hose to Bottom Packer
Packer Separation Tubing
Lower Packer
Lower Packer



AUTOLOGLOG PLOT (Q2PPSWSI MODEL + TWO IMAGE WELLS) OF WN12QWPW DATA
WELL WITH WELLBORE STORAGE AND SKIN IN A RESERVOIR WITH 2-POROSITY BEHAVIOR
DRAWDOWN TYPE CURVE. [CDE(2S)]f+m= 2.50, [CDE(2S)]f= 374., LE(-2S)= 4.500E-02
FP01, BOUNDARY #1 AT 676 FT (206M), BOUNDARY #2 AT 1353 FT (412M)

WN12QWPW data (89.6.20-27 P.T.)

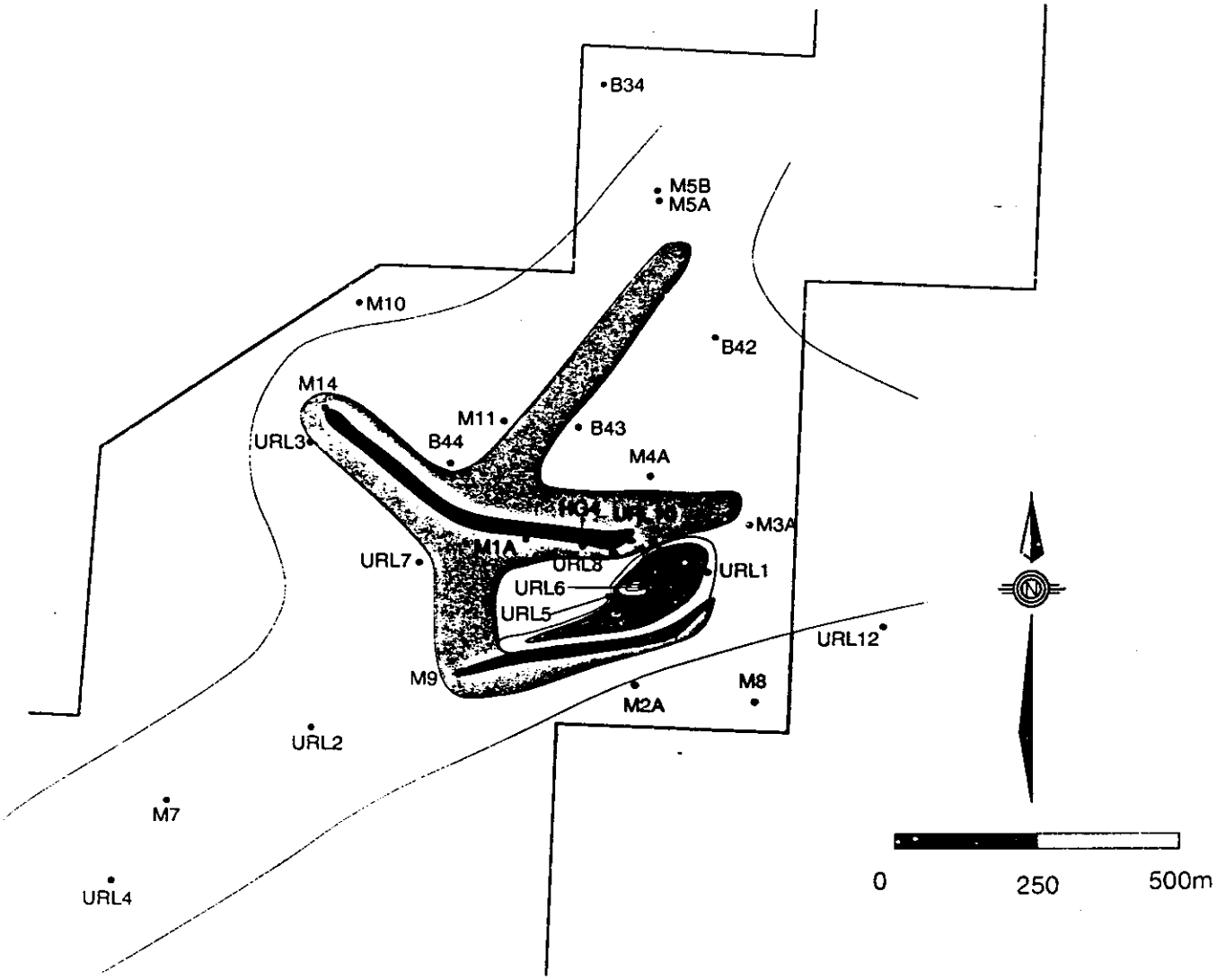
DERIVED FROM : AUTOLOGLOG
2PPS-WELL STORAGE-INF RES-FORMULA(OIL) (FQ2PPSWSIOP)

INPUT DATA :		
IATION VOLUME FACTOR		1.0000000
RIX POROSITY	-fraction	0.20000000
COSITY	-cP	1.3460000
AL COMPRESSIBILITY	-1/psi	0.53472002E-03
ERVOIR THICKNESS	-ft	1.6404001
L RADIUS	-ft	0.34999999
TA RATE QN-Q(N-1)	-bbl/D; Mscf/D	1358.5995
SSURE MATCH		1.1283822
E MATCH		18.000000
AL SYSTEM CURVE MATCH [CDE2S]F+M		2.5000000
H K MEDIUM CURVE MATCH [CDE2S]F		374.00000
NSITION CURVE MATCH (LE-2S)		0.45000002E-01
RESULTS :		
MEABILITY THICKNESS	-mD.ft	291370.59
MEABILITY	-mD	177621.67
LBORE STORAGE COEFFICIENT	-bbl/psi	3.5486567
ENSIONLESS WELLBORE STORAGE COEF.		146570.50
N FACTOR		-5.4894857
RATIVITY RATIO - OMEGA		0.66844919E-02
ERPOROSITY FLOW COEF. - LAMBDA		0.76754844E-06
ERPOSITION SLOPE	-psi/bbl/D	0.751E-03
F LENGTH OF FRACTURE	-ft	0.00000000E+00

177621.67 mD x 0.987E-15 = 1.75E-12 m

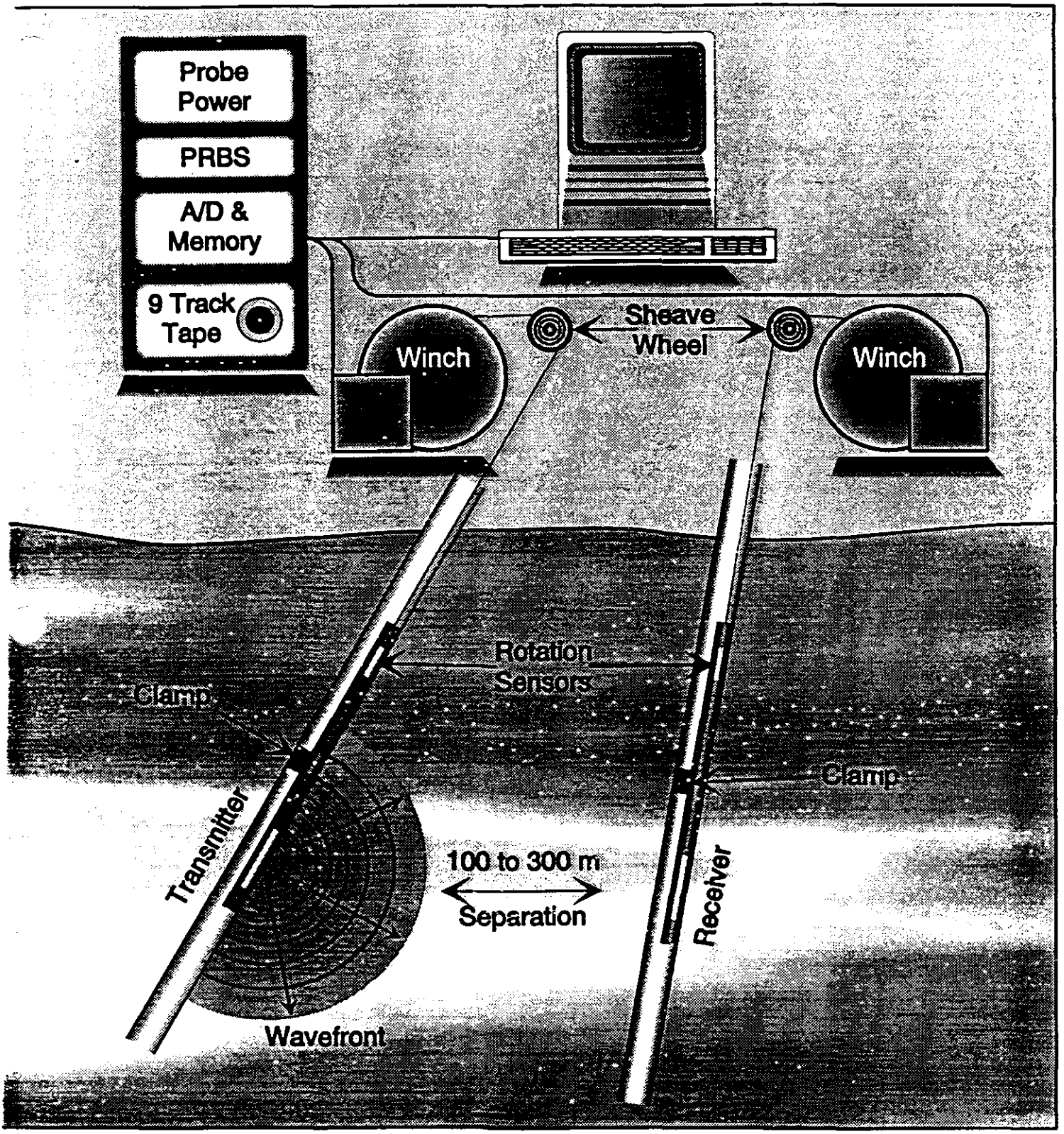
1.75E-12 m² x 0.66E7 = 1.16E-3 m/s

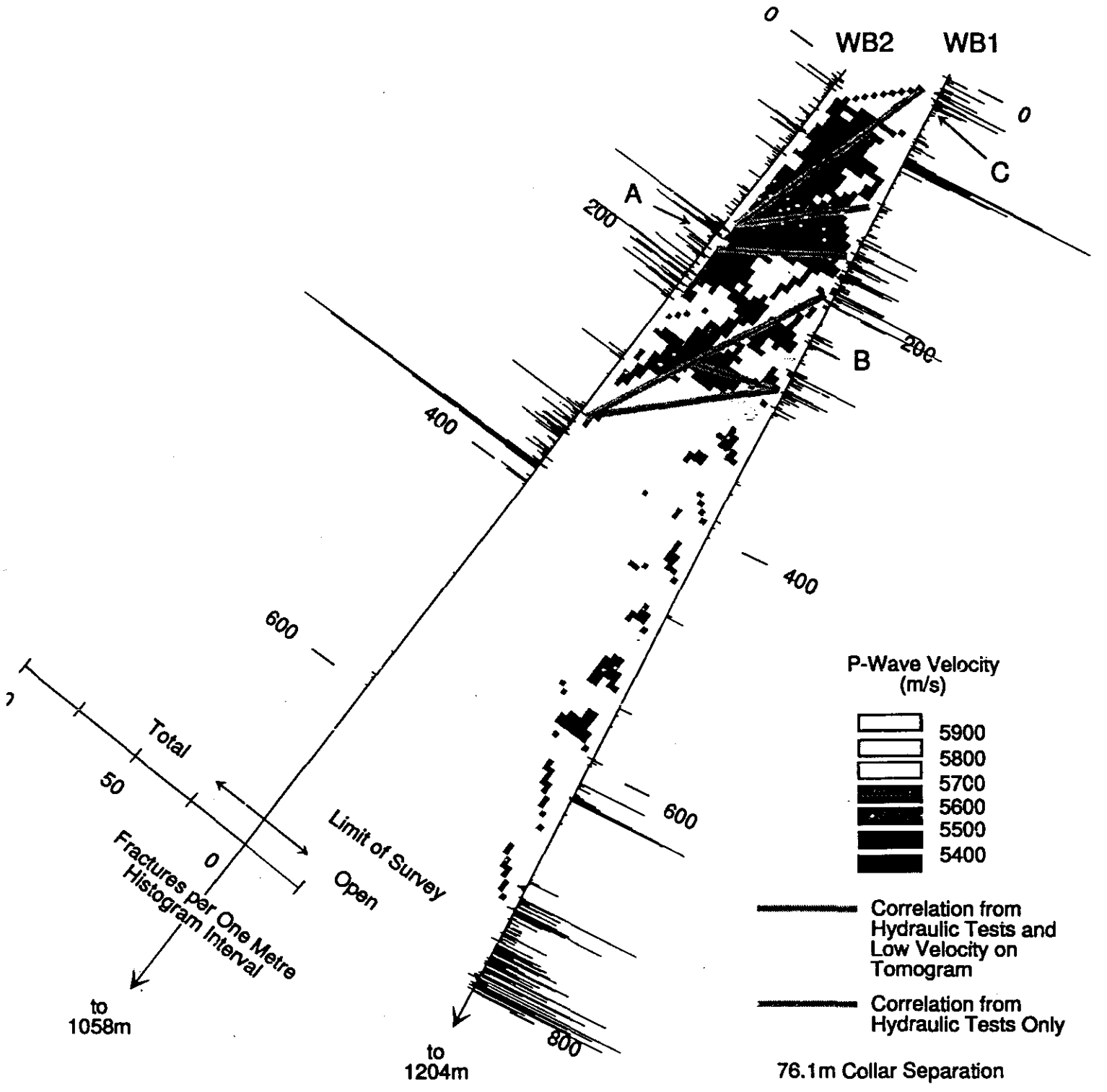
S = -5.5

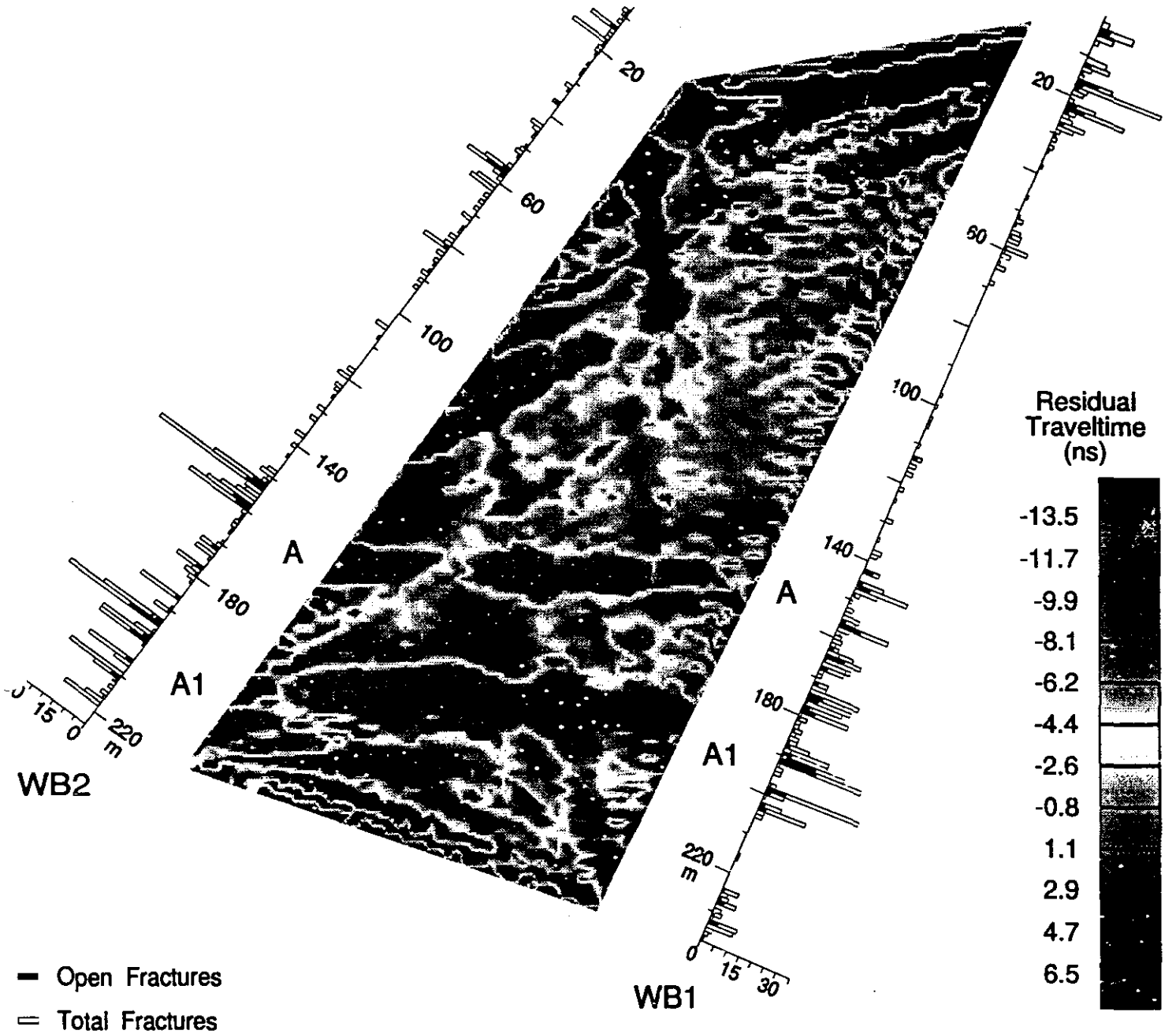


- Borehole Intersection with Fracture Zone 2

$T \geq 10^{-3}$ m^2/s	$T = 10^{-5}$ to 10^{-3} m^2/s
$T = 10^{-7}$ to 10^{-5} m^2/s	$T = 10^{-9}$ to 10^{-7} m^2/s
$T \leq 10^{-9}$ m^2/s	No Data


Probe Power
PRBS
A/D & Memory
9 Track Tape
Winch
Sheave Wheel
Winch
Rotation Sensors
Clamp
Clamp
Transmitter
100 to 300 m
Separation
Receiver
Wavefront


0
WB2
WB1
0
C
A
200
200
B
400
400
600
600
800
Total
50
0
Fractures per One Metre Histogram Interval
Limit of Survey
Open
to
1058m
to
1204m
P-Wave Velocity
(m/s)
5900
5800
5700
5600
5500
5400
Correlation from Hydraulic Tests and Low Velocity on Tomogram
Correlation from Hydraulic Tests Only
76.1m Collar Separation



Open Fractures

Total Fractures

One Metre Histogram Interval

76.1m Collar Separation

Total Number of Rays: 2605

Enhanced Residual Traveltime Backprojection

CANDIDATE AREA CHARACTERIZATION :

- *OPTIMIZING SITE CHARACTERIZATION COSTS*
- *REMOTE SENSING, AIRBORNE SURVEYS, AND RECONNAISSANCE MAPPING*
- *BOREHOLE SITING, DRILLING AND LOGGING,AND TESTING*
- ***PIEZOMETER CONSTRUCTION AND MONITORING***
- *GROUNDWATER SAMPLING*
- *DATA COLLECTION, ANALYSIS AND ARCHIVING*
- *CONCEPTUAL HYDROGEOLOGIC MODEL CONSTRUCTION*

PIEZOMETER CONSTRUCTION AND MONITORING

PIEZOMETER CONSTRUCTION:

MULTI-PACKER (MP) CASING SYSTEMS:

- Surface collared: *Westbay MP casing system;*
  AECL MP casing system
- Underground: AECL *MP casing system.*

PIEZOMETRIC LEVEL MONITORING:

- *WESTBAY CASING SYSTEMS*: *single probe, periodic pressure profile; single interval, continuous pressure profile (HDAS: surface collared); multi-probe, remote transmitted, continuous pressure profiles.*
- *AECL MP CASING SYSTEMS: multi - interval, continuous pressure profiles (UDAS: underground - collared);*

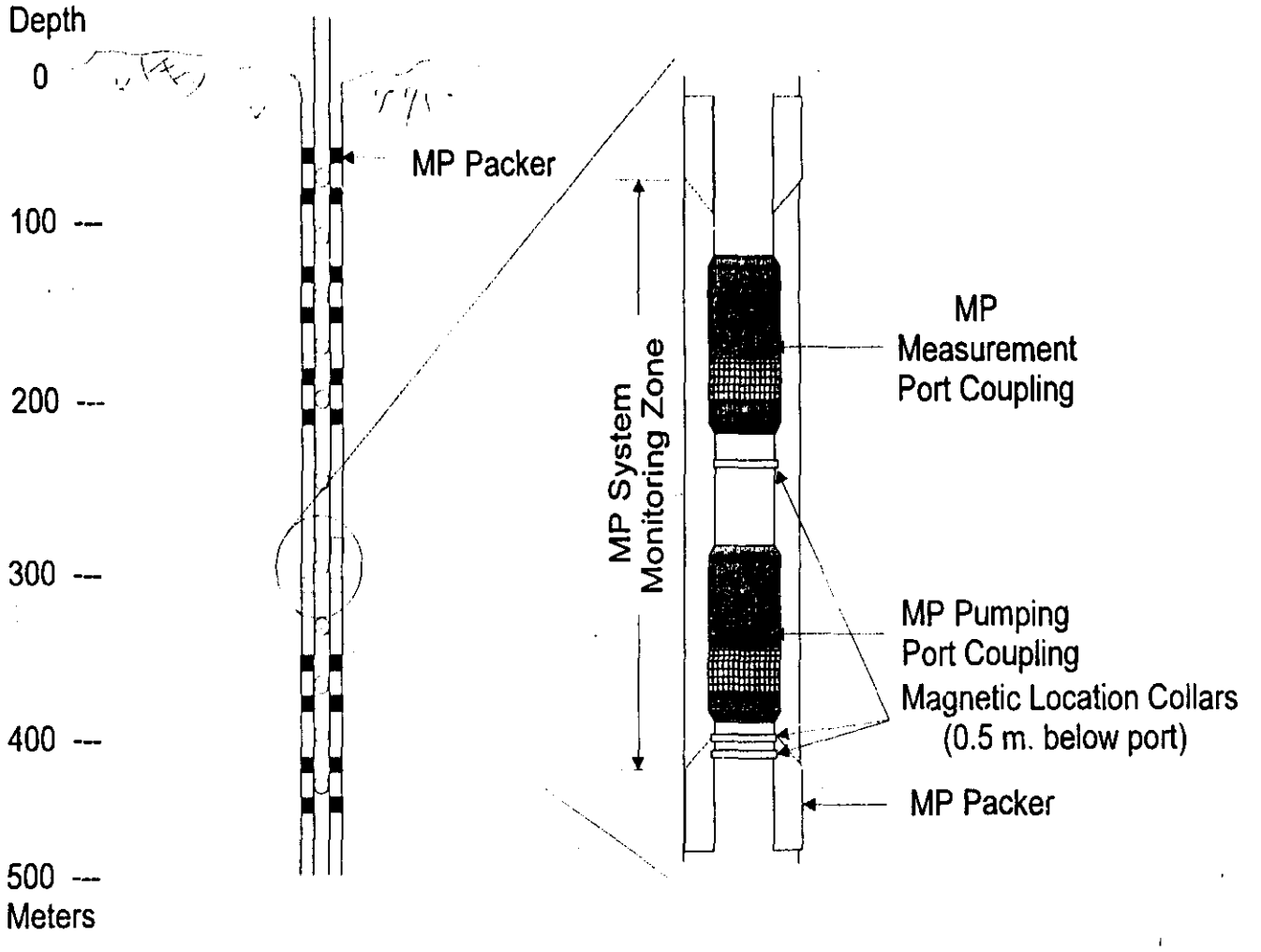
HYDRAULIC HEAD

COMPONENTS: *PRESSURE HEAD (m):* $\psi = P/\rho * g$, where P = gauge pressure, and ρ = pore fluid density (varies with temperature and dissolved ions).

ELEVATION HEAD (m): z, where *z* = measuring point elevation,

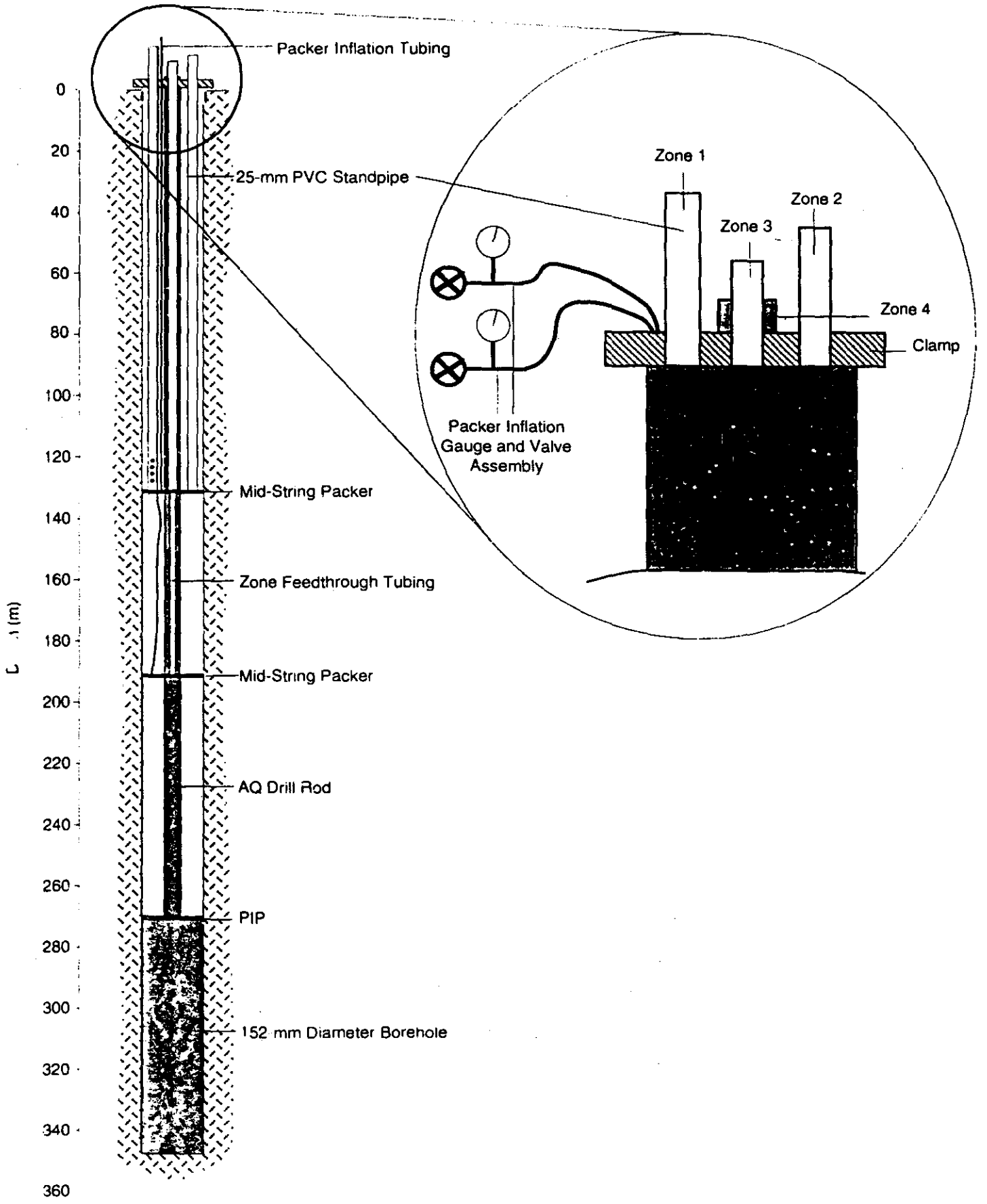
$\psi + z =$ *HYDRAULIC HEAD (h)*

RANGE: *between the highest and lowest elevations at the water table between the regional boundaries, and above the fresh water / salt water interface*



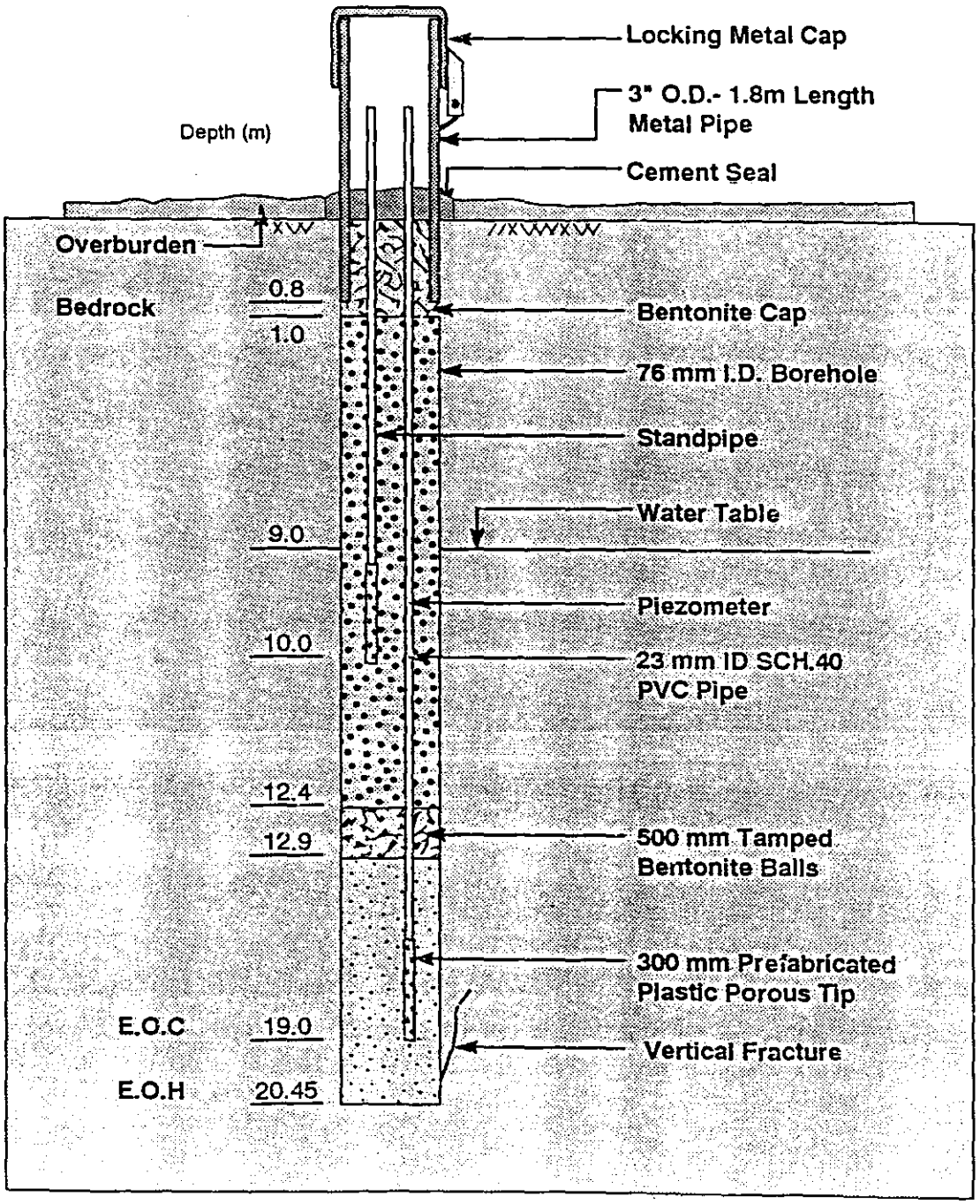
MP System installation with monitoring zones isolated by packers.

152mm Diameter Borehole Packer System



Water Table Instrument

FL 15

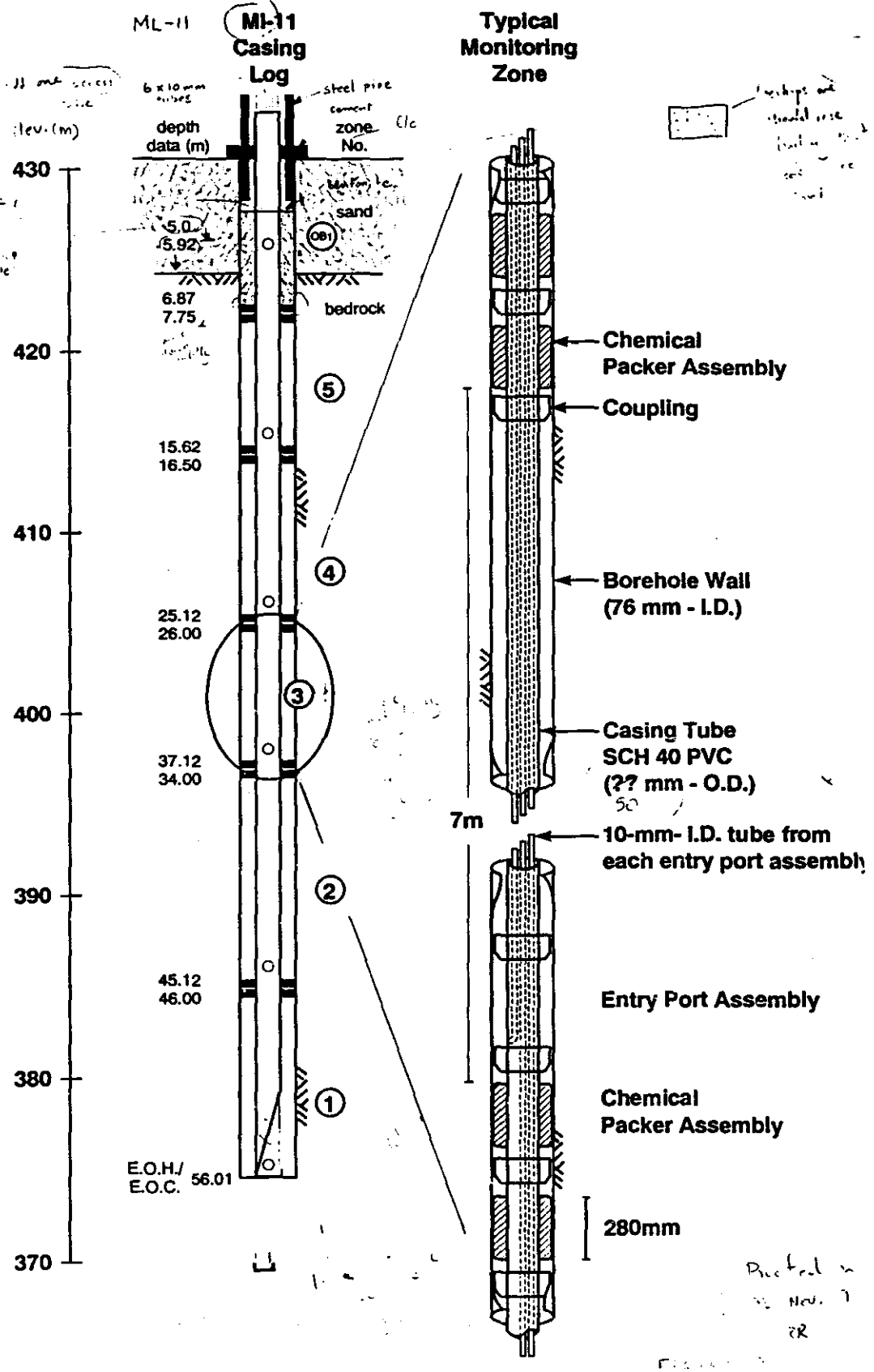


TIS 1171 W/T

Fig 10

NW. 17/93

Waterloo Monitoring Instrument



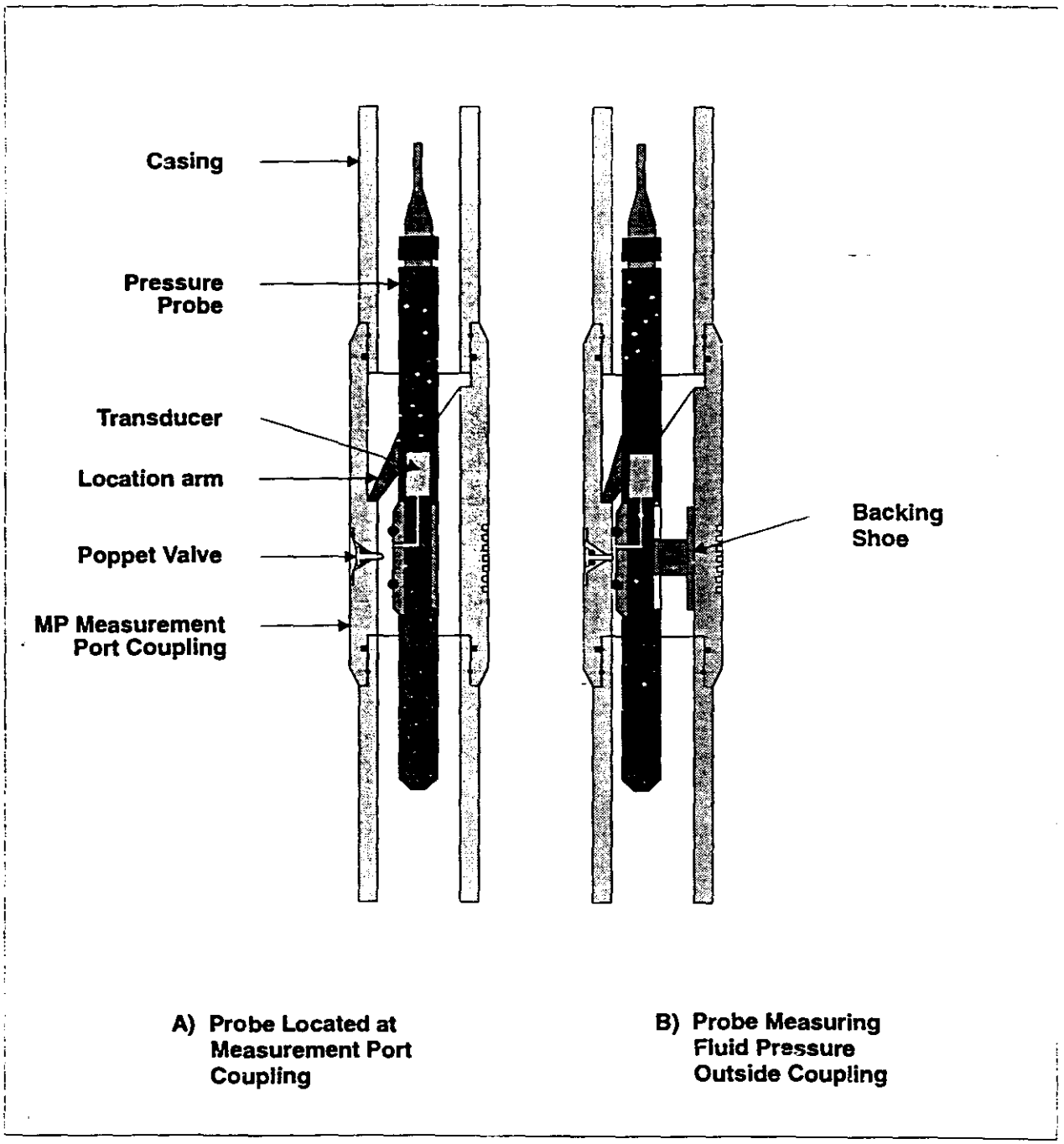
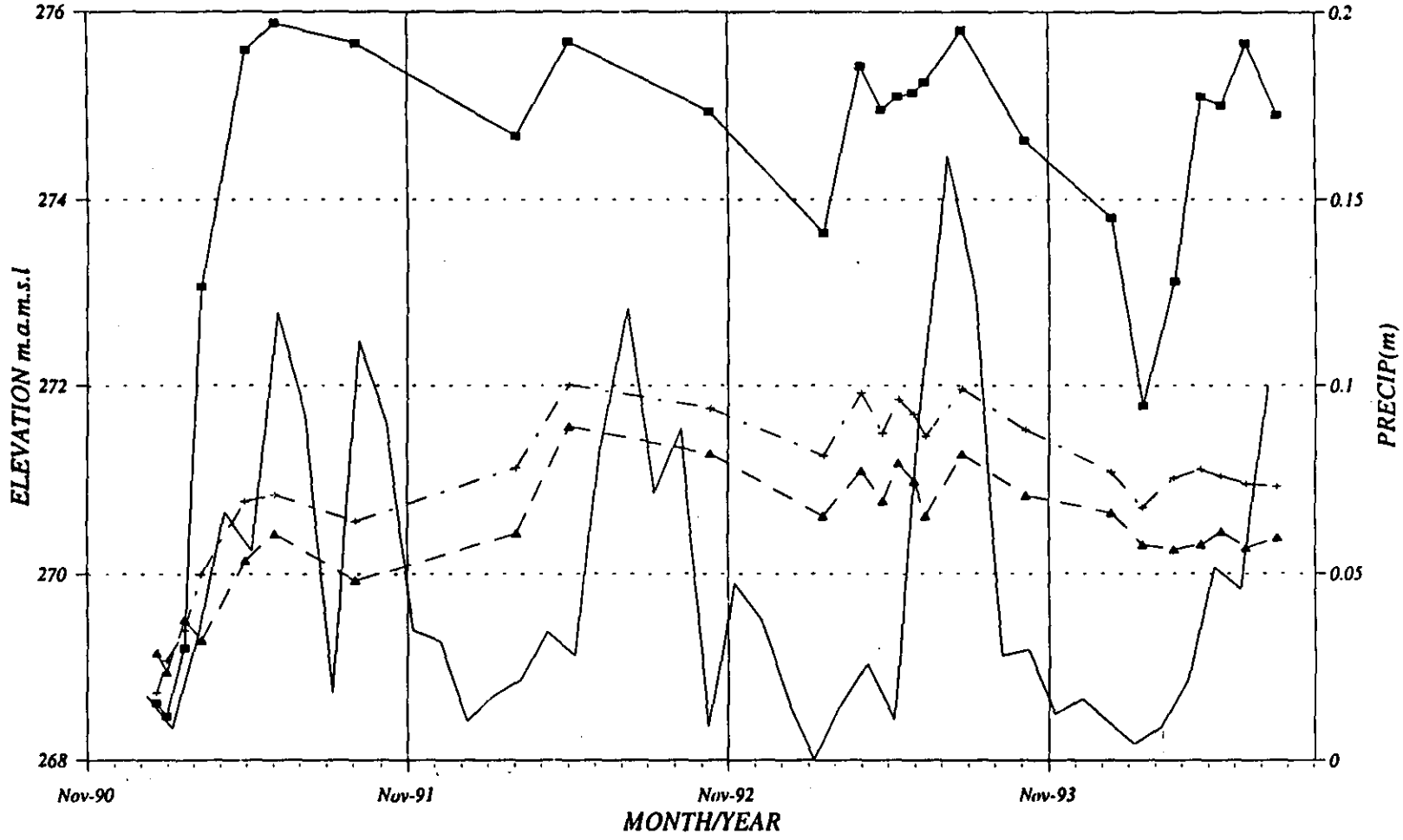


FIGURE 2: Operation of a Westbay Electric Pressure Probe

WG2

HYDRAULIC HEAD VS TIME



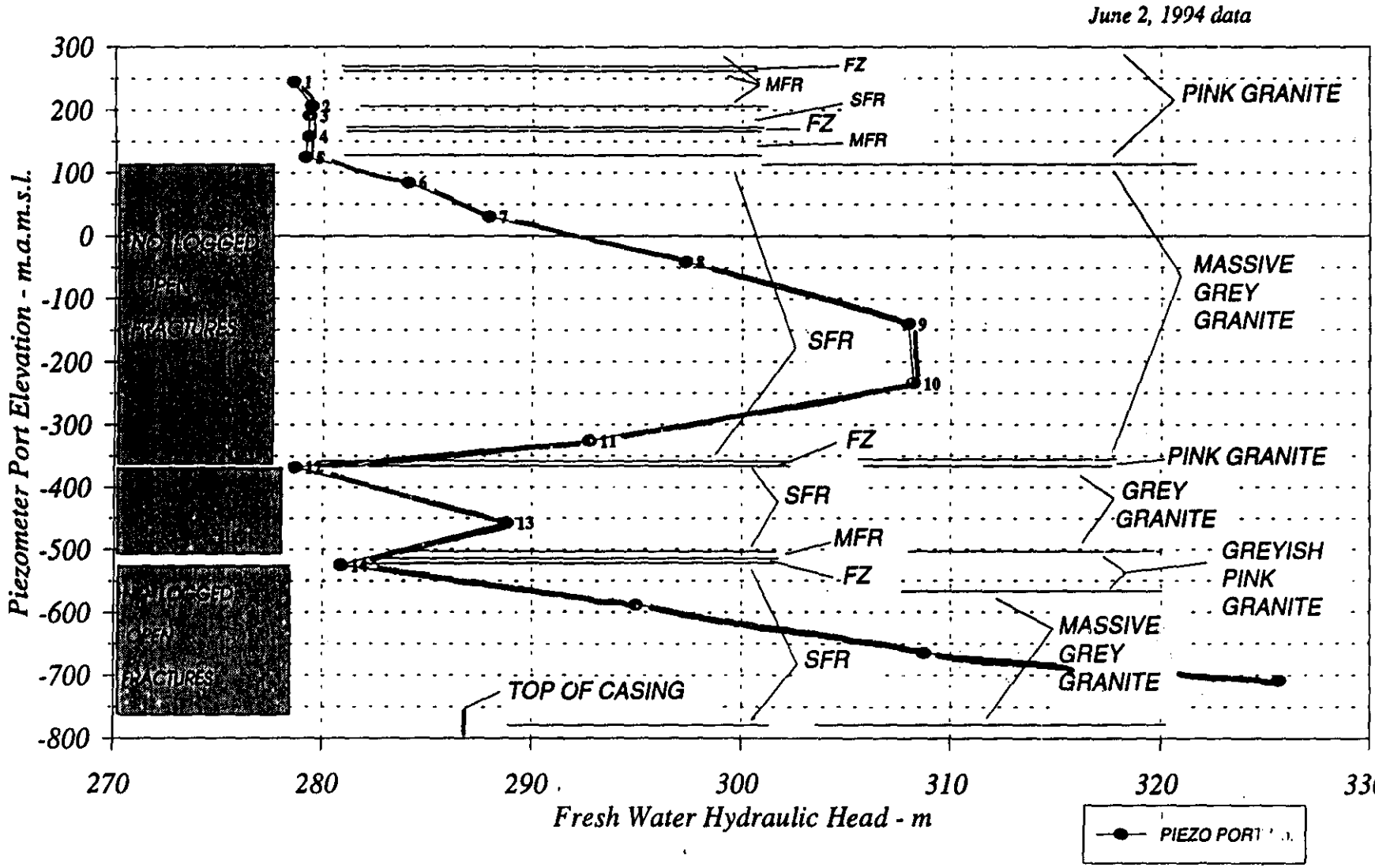


Figure : Borehole WD3 lithology, fractured rock domains, and equivalent fresh water hydraulic head versus piezometer port elevation

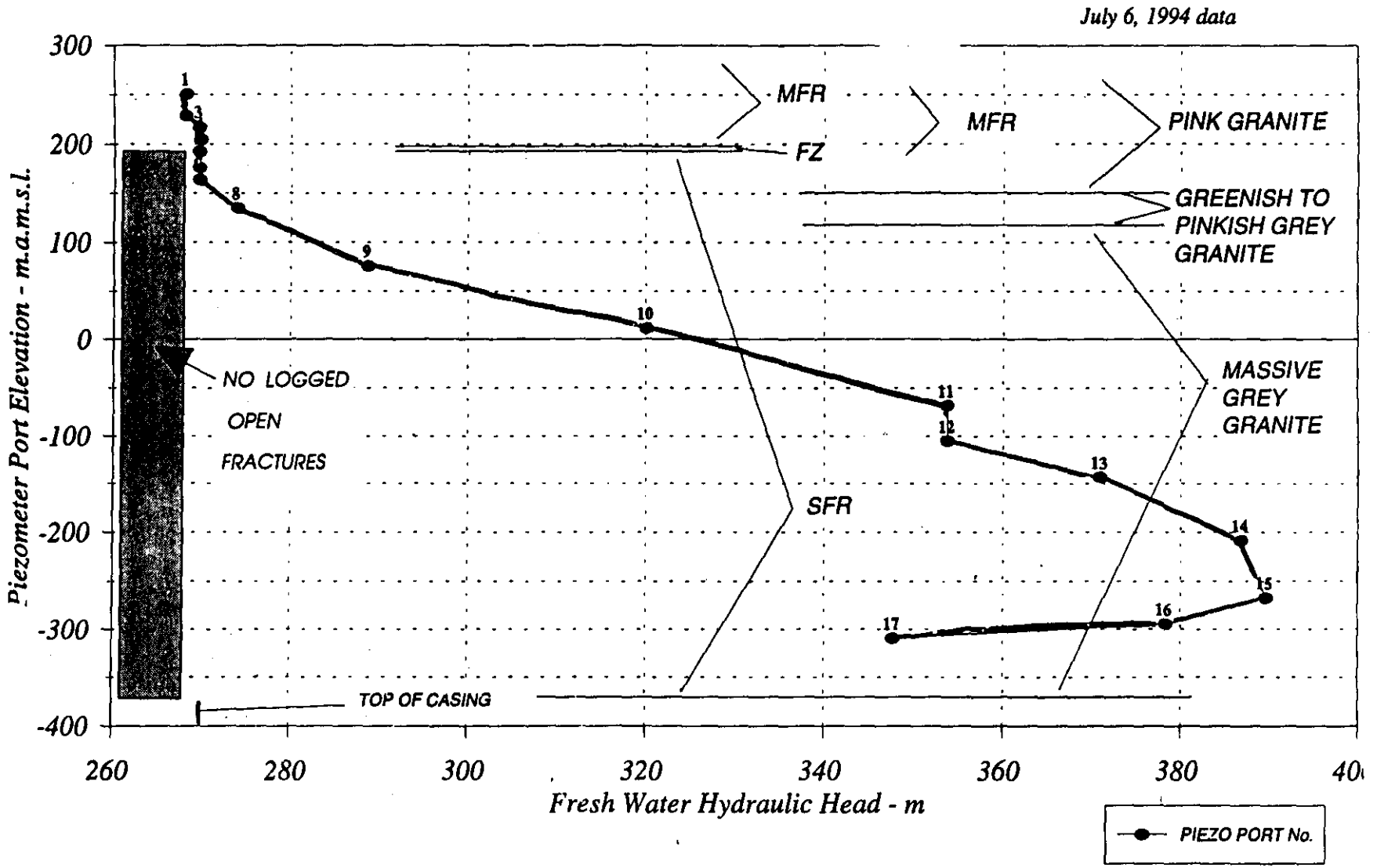


Figure 9a: Borehole WG4 lithology, fractured rock domains, and equivalent fresh water hydraulic head versus piezometer port elevation

CANDIDATE AREA CHARACTERIZATION :

- *OPTIMIZING SITE CHARACTERIZATION COSTS*
- *REMOTE SENSING, AIRBORNE SURVEYS, AND RECONNAISSANCE MAPPING*
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