A MEMBER OF THE TAIYUAN HEAVY MACHINERY GROUP (太重集团)

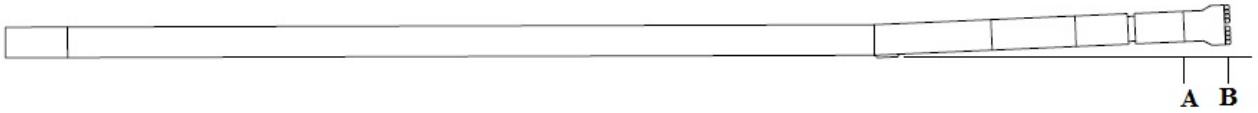
UNIVERSITY OF WOLLONGONG

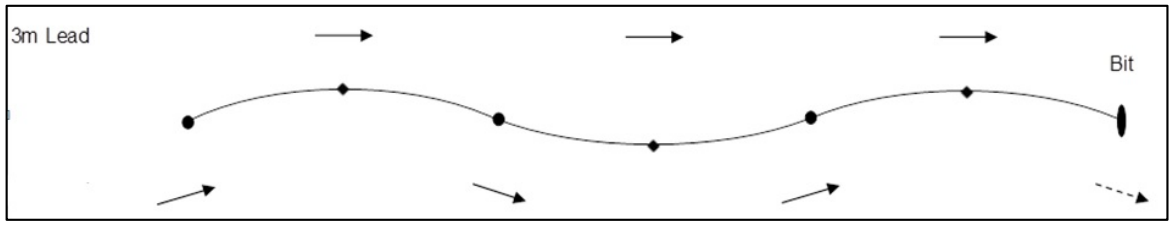
INSEAM BOREHOLES TO AND BEYOND 2000 M WITH A COMBINATION OF SLIDE AND ROTARY DRILLING

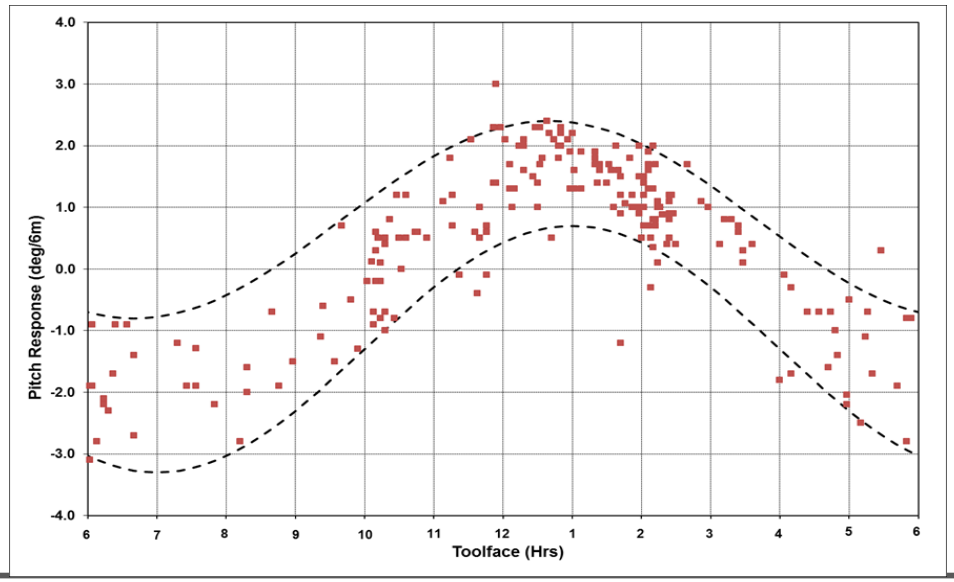
F Hungerford

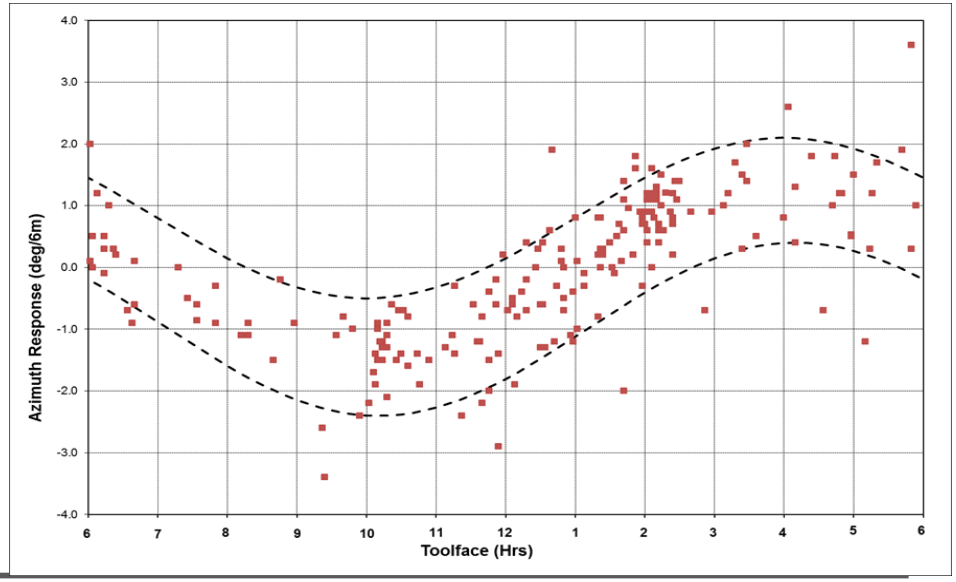
Half Day Seminar,
Gas and Coal Outburst Committee,
June 2016

- **Deflection of DHM used for steering**
- **Flip-flopping slide drilling**
- **In-hole friction causing surging, slower feed and eventual termination**
- **Increased bit diameter to 96mm, increased bend to 1.25 deg, Asahi 4/5 DHM**



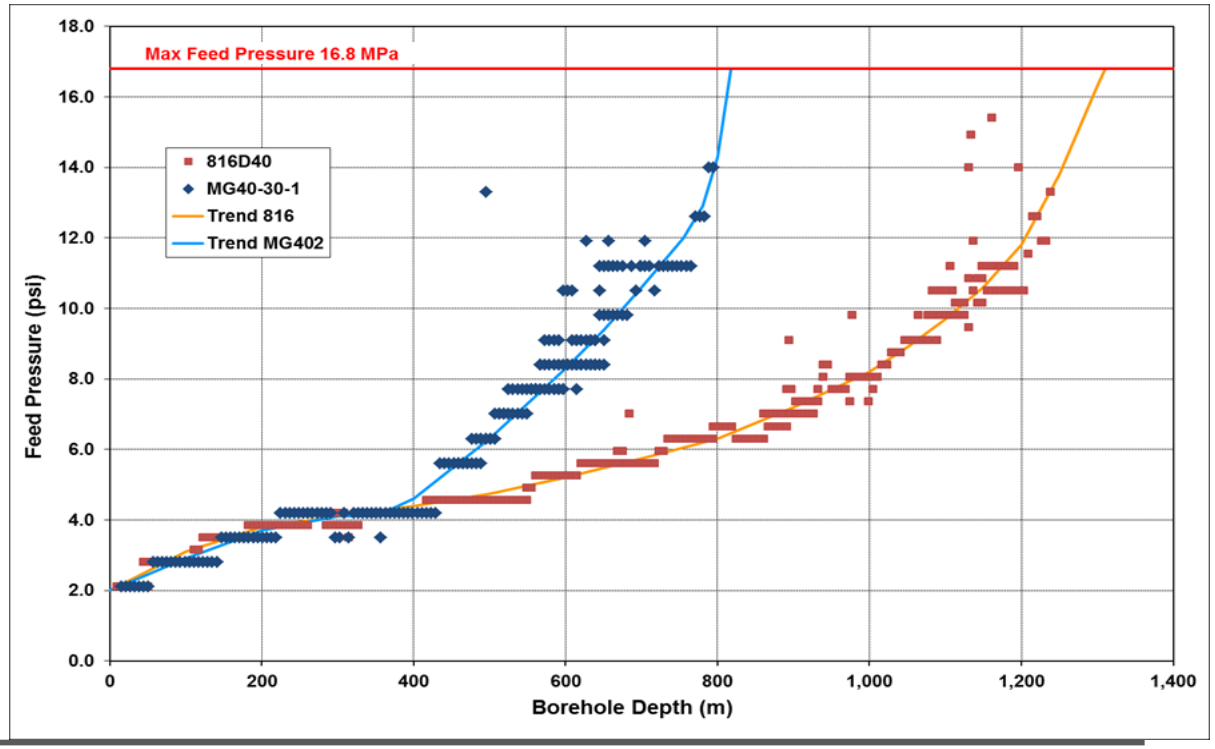






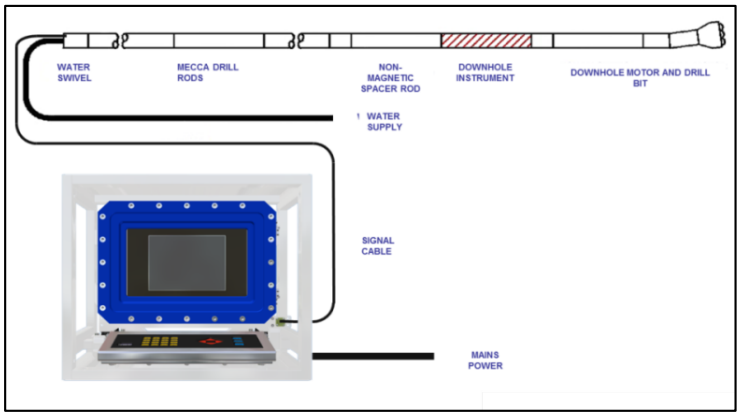
Thrust Limitations

- **Depth capacity increased to 1500m but variable**
- **Record in-seam depth of 1763m set at Newlands in 2001**
- **Rotary/slide limited in use U/G**
  - **Appin in 1986 – dived into floor**
  - **Appin along block - 1000m**
  - **China “slide one/rotate one”**



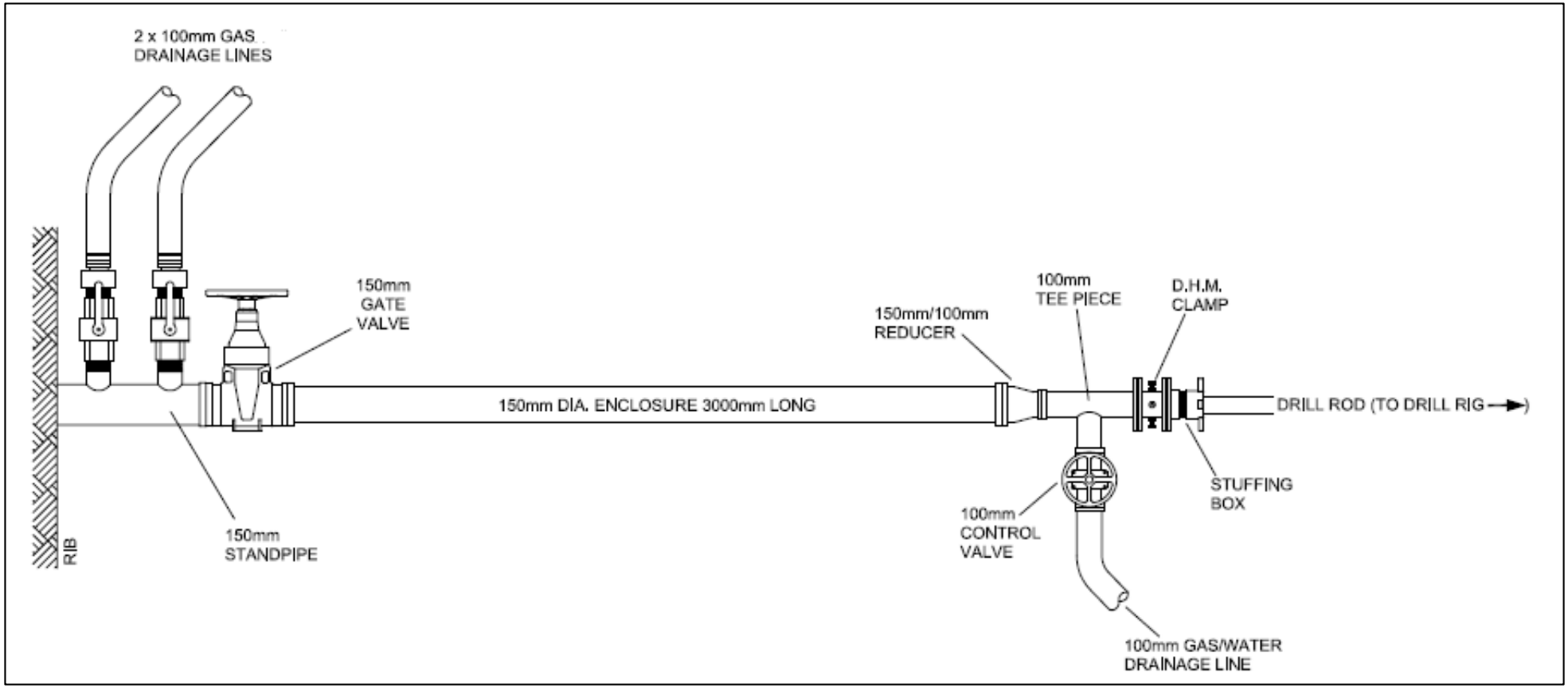
Longhole Drilling Challenge

- Developing into a new longwall domain in the Bulli Seam with no access for lateral drainage drilling
- Staged drainage and development would suffer delays
- Longwall block 2000m long with access from the southern end
- 2000m had never been drilled before
- AMT DGS survey instrument upgraded but never assessed for depth limit – DDM-MECCA previously preferred
- Drill Rod capacity – CHD preferred
- Water pump capacity
- Asahi PCD Bit and Accu-drill 4/5 DHM
- Alternate drilling method required



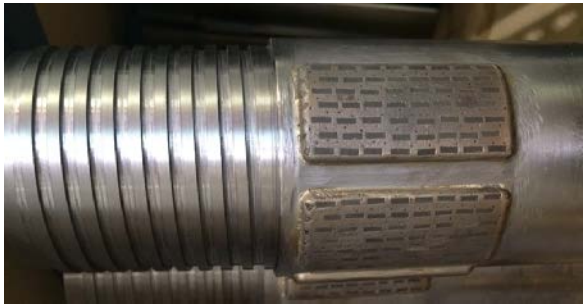
Standpipe Connections

- **High gas flows expected**
- **Standpipe extension attached to manage removal of DHM**



Defined Drilling Method

Drilling method:



- **1.125 deg bend with 1mm thick wear pad (Equivalent to 1.23 deg)**
- **96mm bit increased to 99mm after first hole**
- **Rotary drill whenever possible and borehole is controlled in-seam**
- **Limit rotational speed to 40-60 rpm**
- **Define seam profile with regular intersections in first borehole – gas content core as required**
- **Record:**
  - **Drilling mode**
  - **Feed pressure and hold-back pressure**
  - **Water idle and drilling pressure**
  - **Main pump pressure when rotary drilling**
  - **Intermediate “check-shot” survey**
  - **Assessment of rotational speed**

Drilling Record

VLI DRILLING PTY LTD

DHM-DDM DRILLING LOG

SHEET No: 05612

MINE: Metro	RIG: VLI 20	MINE DECLINATION: -11.1	
HOLE No: 0406 08120708	DRILLER(S): Tim | Woods4	ENTRY HDG ENTERED: 26.8	
LOCATION: 30021	DATE: 11-12-15	DESIRED HDG ENTERED: 18.8	18

Rod No	Depth (m) From	Depth (m) To	Notes	Feed Press	Water Idle	Water Drill	Water Flow	Comments	Survey Depth	Direct	Dip	Orient	D/Track	L/R	U/D
				1600/400	440	540	190			17.7	-2.5	126			
387	1156	1161	2, 2	1600/400	440	520	190	BLACK	BLACK 1158	17.7	-2.5	47	1150.6	50.4	-7.7
				1600/1200	440	620	190	BLACK		17.5	-2.3	342			
389	1161	1167	R, R	1600/1200	420	620	190	BLACK	BLACK 1164	18.2	-2.4	274	1156.6	50.3	-7.9
				1600/1200	420	620	190	MP. 1500PSI		18.6	-2.2	233			
391	1167	1173	R, R	1600/1200	420	620	190	BLACK	BLACK 1170	18.3	-1.7	75	1162.6	50.2	-8.2
				1600/1300	420	560	190			18.3	-2.0	135			
393	1173	1179	R, R	1600/1300	440	580	190	BLACK	BLACK 1176	17.3	-1.8	67	1168.6	50.1	-8.3
				1600/1300	440	620	190	MP. 1500		17.4	-1.8	126			
395	1179	1185	R, R	1600/1200	440	640	190	BLACK	BLACK 1182	17.5	-1.4	119	1174.5	50.0	-8.5
				1600/1200	440	640	190			17.6	-1.4	267			
397	1185	1191	R, 3	1600/400	440	520	190	BLACK	BLACK 1188	17.8	-0.9	130	1180.5	49.9	-8.6
				1600/400	440	560	190	MP. 400		17.4	-0.9	65			
399	1191	1197	2, 2	1600/400	460	560	190	BLACK PAY @ 1193m	BLACK 1194	17.5	-0.7	42	1186.5	49.8	-8.7
				1600/400	460	540	190			18.3	-0.4	92			
401	1197	1203	2, 2	1600/400	460	540	190	BLACK	BLACK 1200	19.2	0.0	117	1192.5	49.7	-8.8
				1600/400	440	540	190			19.7	-0.5	127			
403	1203	1209	3, R	1600/1300	440	600	190	BLACK	BLACK 1206	19.9	-1.0	61	1198.5	49.8	-8.8
				1600/1200	440	580	190			20.5	-1.0	114			
405	1209	1215	R, R	1600/1300	440	560	190	BLACK	BLACK 1212	20.0	-0.7	25	1204.5	49.9	-8.9
				1600/1200	460	620	190			20.7	-0.8	259			
407	1215	1221	R, R	1600/1200	460	620	190	BLACK	BLACK 1218	21.0	-0.6	148	1210.5	50.1	-9.0
				1600/400	460	540	190			20.3	0.0	358			
409	1221	1227	12, 11	1600/300	460	540	190	BLACK	BLACK 1224	20.2	0.8	340	1216.5	50.3	-9.0
				1600/300	440	580	190	PAY @ 1222m		20.3	1.4	303			

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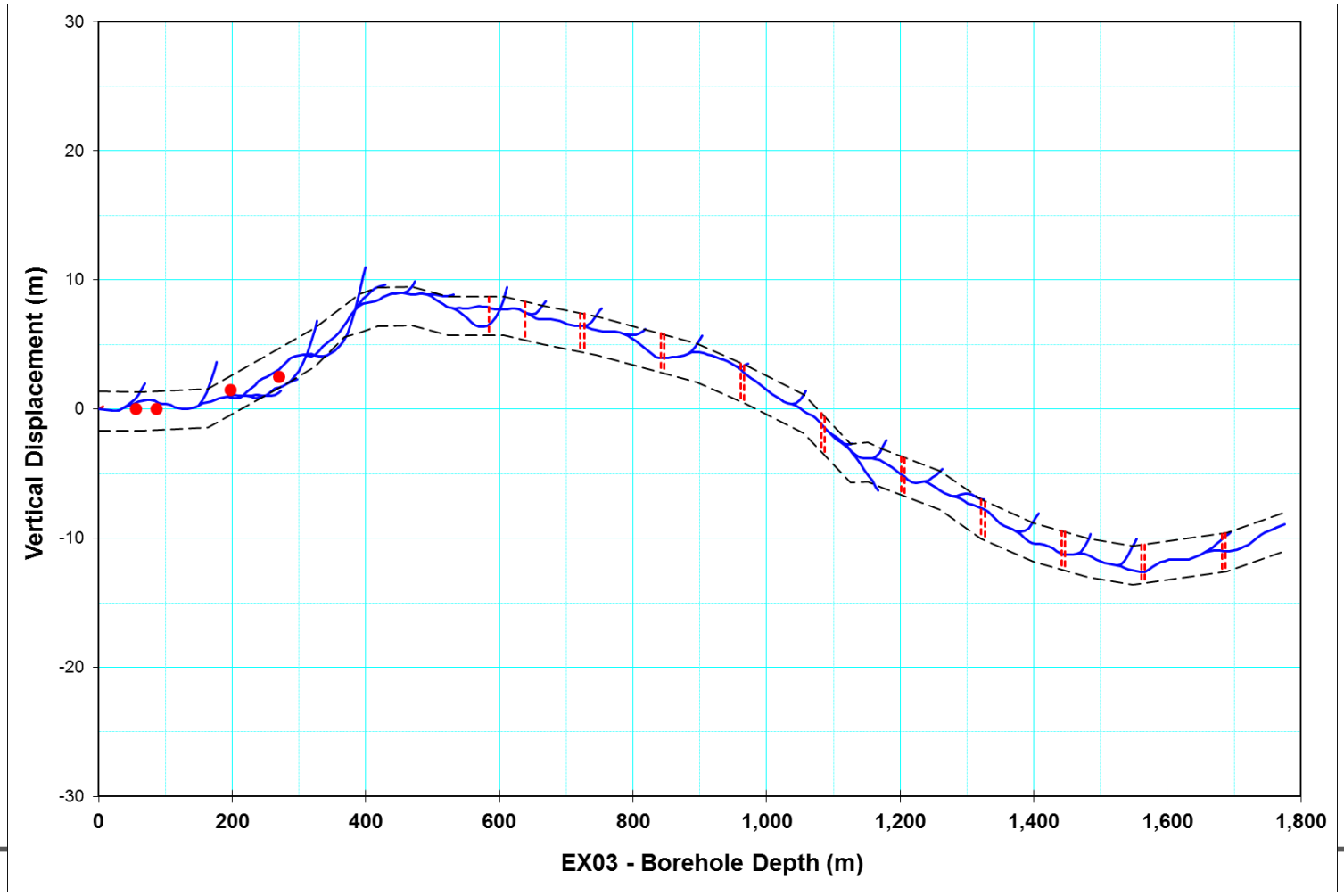
First longhole – EX03 – to 1771m

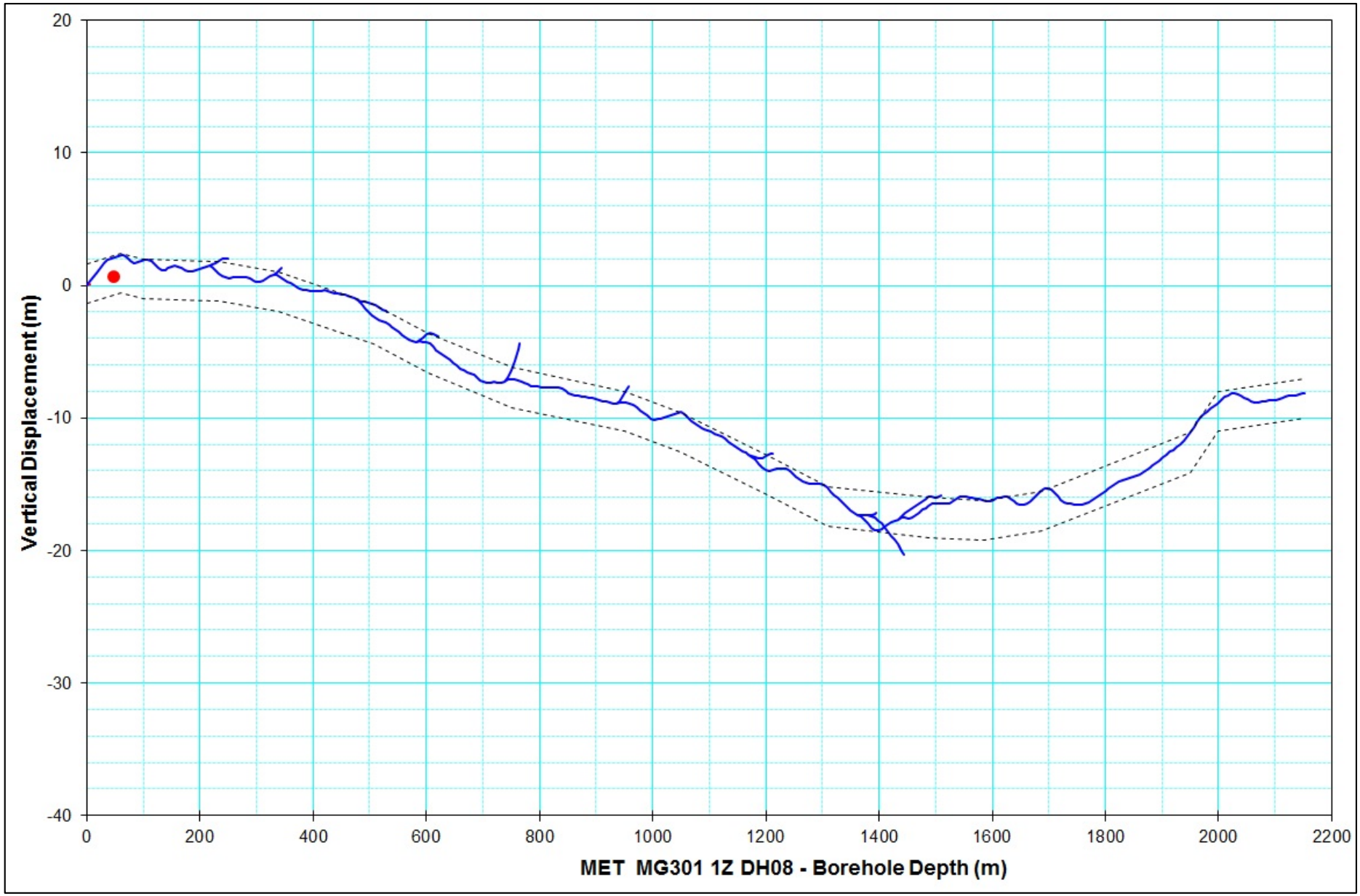
- **Regular roof intersections**
- **Borehole and future cut-through crossings indicated**
- **New world record**



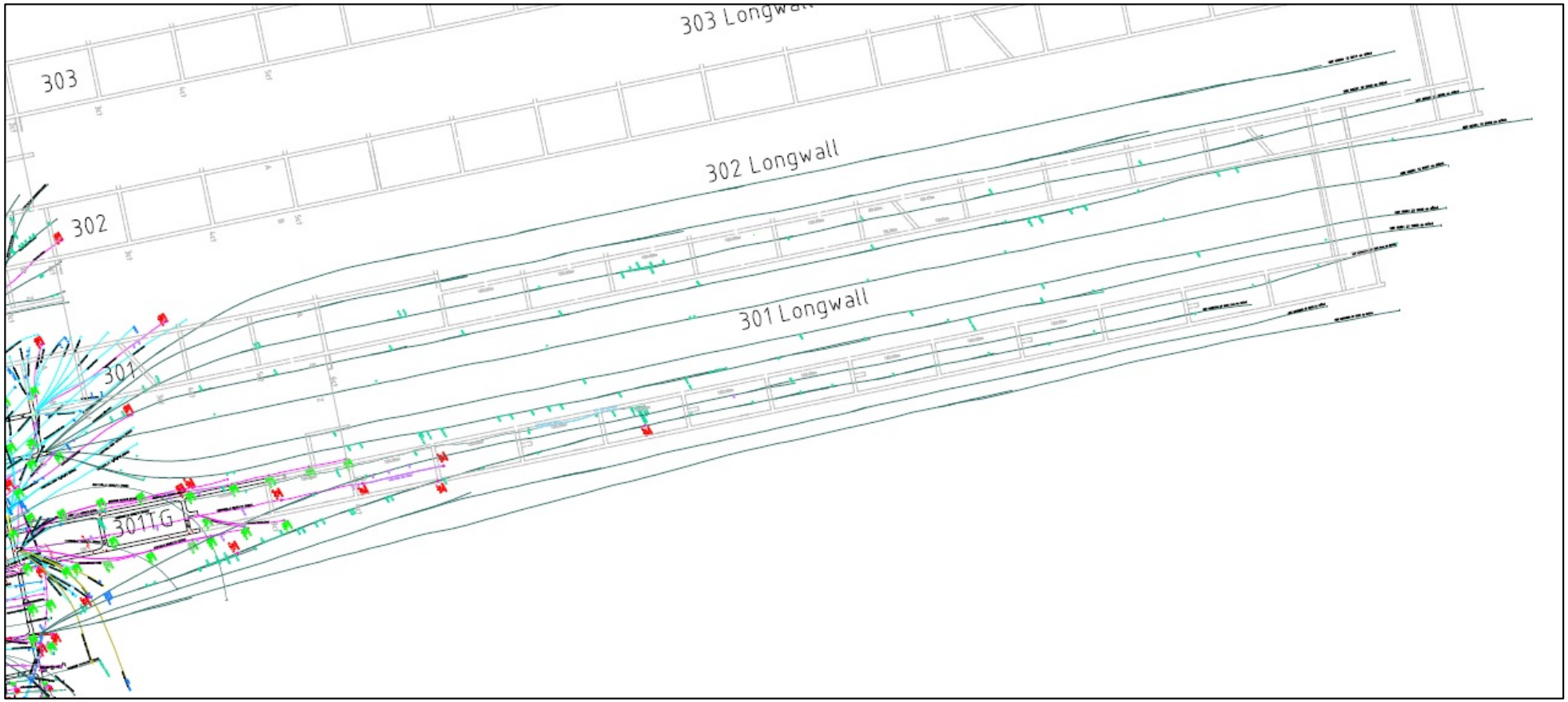
Borehole Depth Summary

Borehole	Date	Depth (m)	Slide to (m)	Lat Dev (m)	Terminated
EX03	15/06/2015	1779	1746	116 L	No signal
EX02	19/07/2015	1875	1851	58 L	Floor
DH01	28/07/2015	1971	1803	31 L	Floor
DH04	9/08/2015	2001	1821	129 L	Roof
DH05	31/08/2015	2007	1653	78 R	To design
DH08	23/09/2015	2151	1743	40 L	No rods
DH09	7/10/2015	2103	1761	83 L	No rods
DH10	27/10/2015	2007	1761	121 L	To design
DH11	17/11/2015	2016	1920	166 L	No rods
DH06	8/12/2015	2007	1923	145 R	No rods
DH07	22/12/2015	2013	1884	0 L/R	No rods

Borehole Profile – DH08 – 2151m



Final Borehole Layout

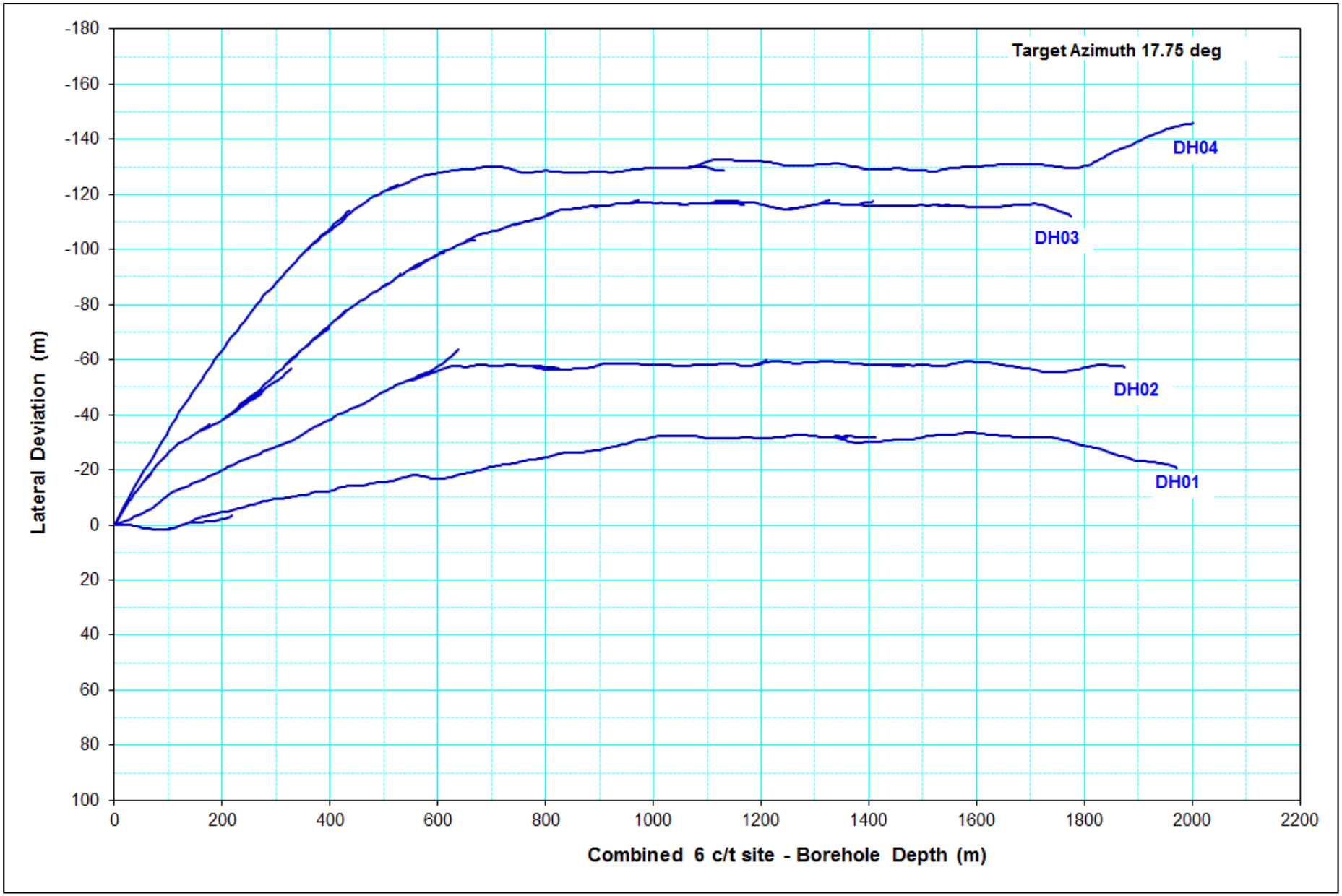


Drilling capacities

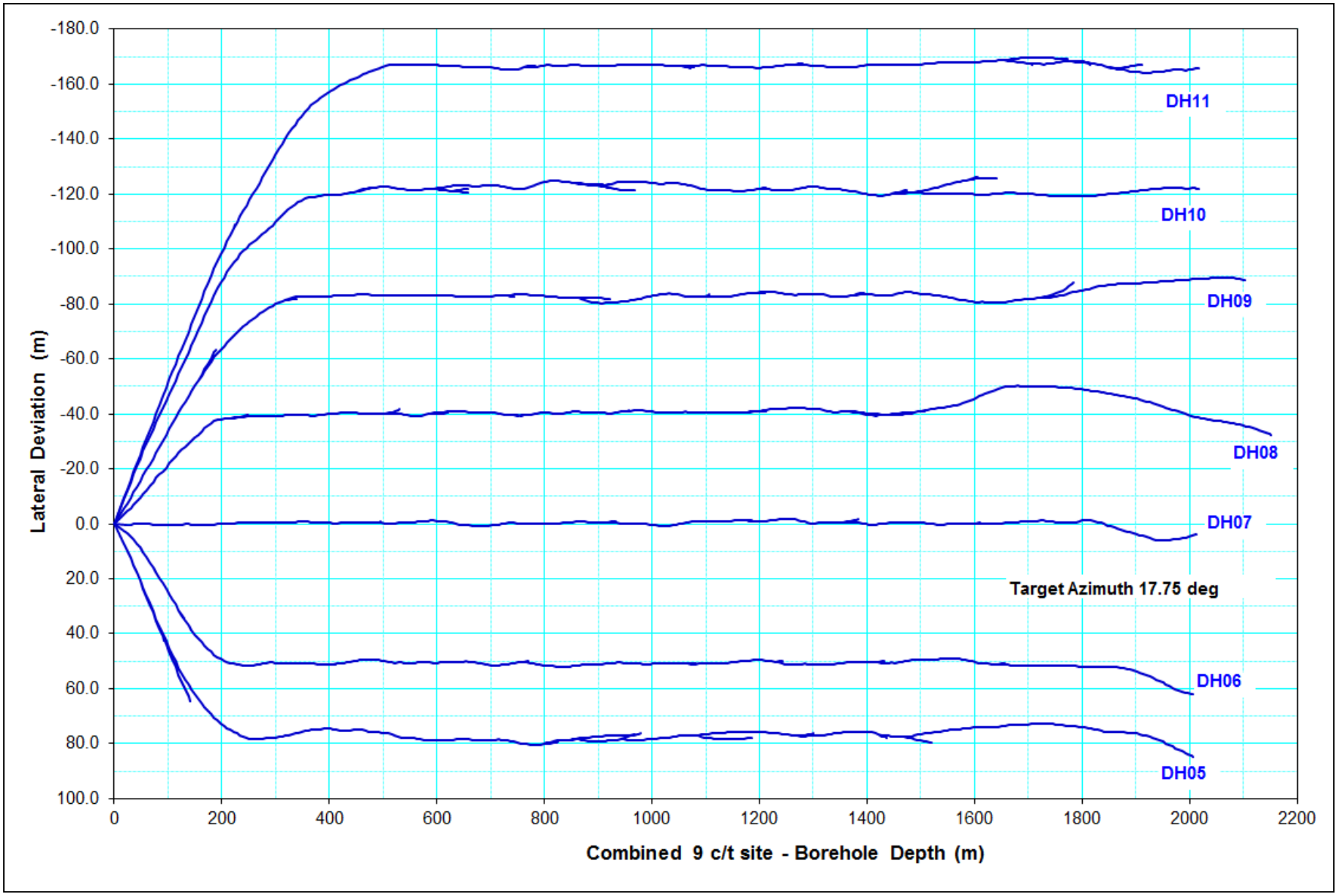
Drilling method:

- **Modular Series 1000 with 104 kN thrust capacity used on first 8 holes**
- **Track-mounted Series 1000 with 140 kN thrust capacity used on last 3 holes**
- **Slide capacity increased to 1900m achieved by increase in thrust capacity**
- **Thrust capacity reached as “no more feed capacity” rather than “surging and stalling”**
- **Drillers initially had no control with rotary drilling beyond end of slide**
- **Drillers experimented with rotary drilling control techniques (varied feed and rotation speed – to 180 rpm) with good results**

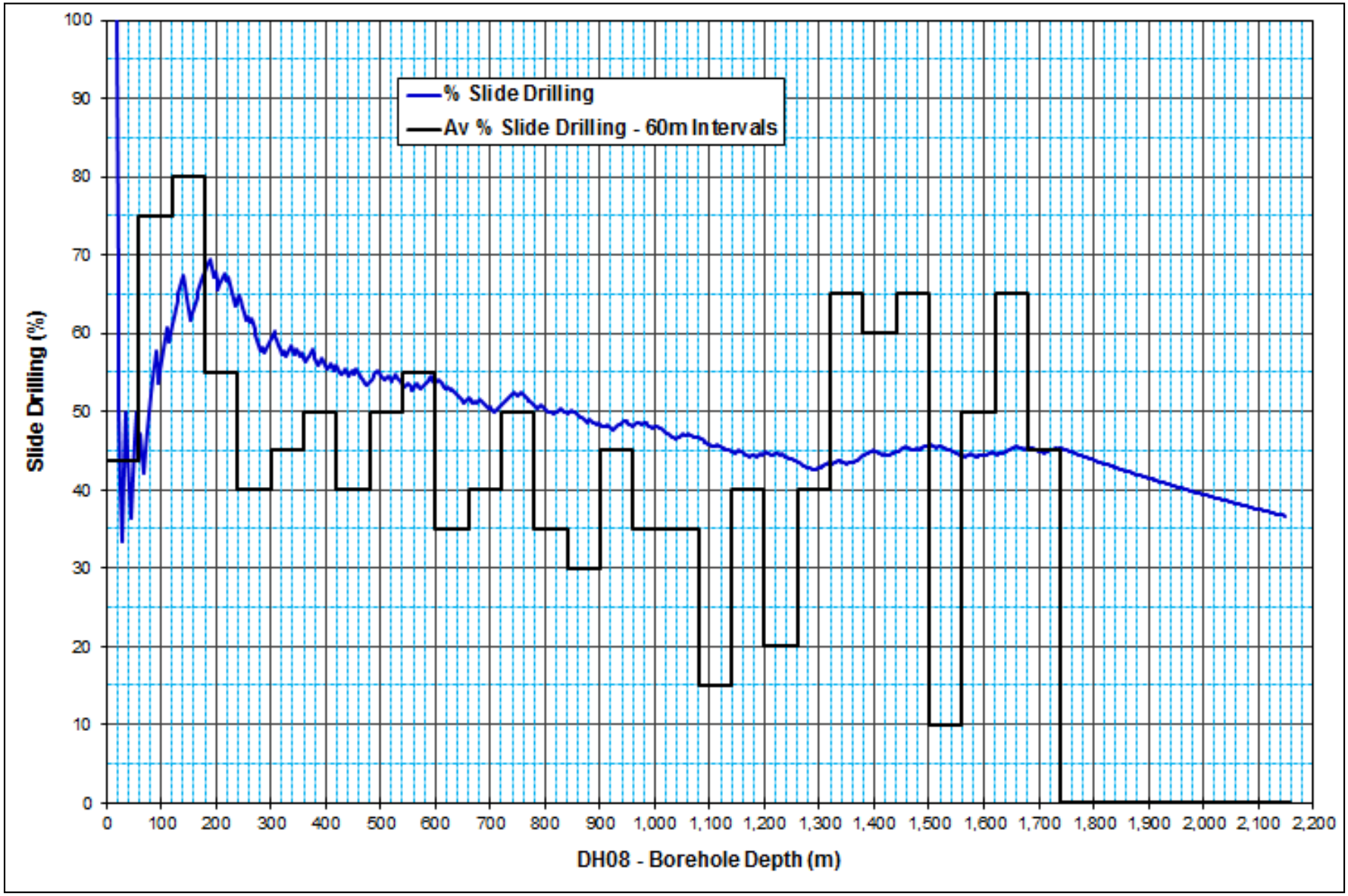
Lateral Deviation – first site



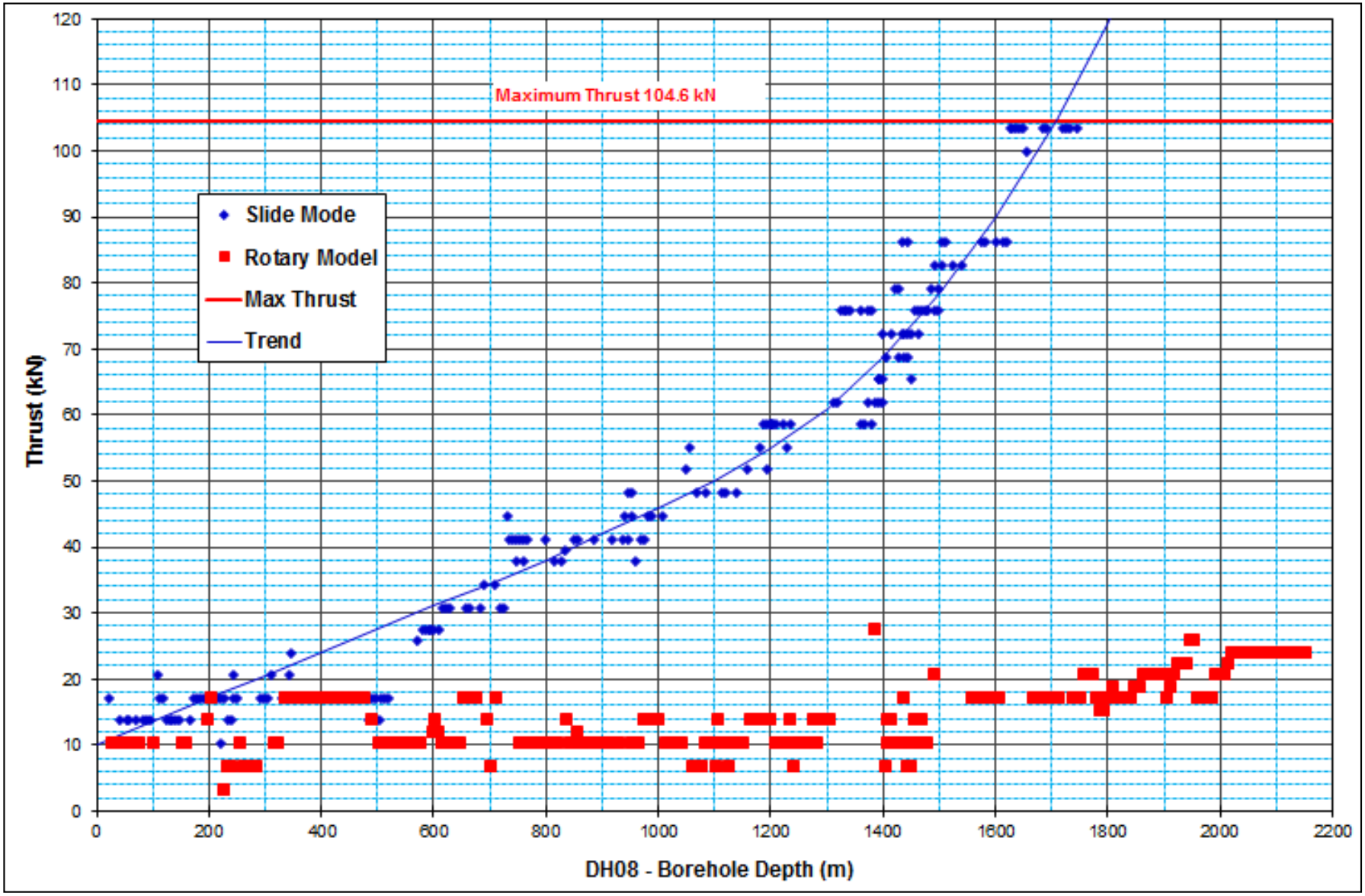
Lateral Deviation – second site



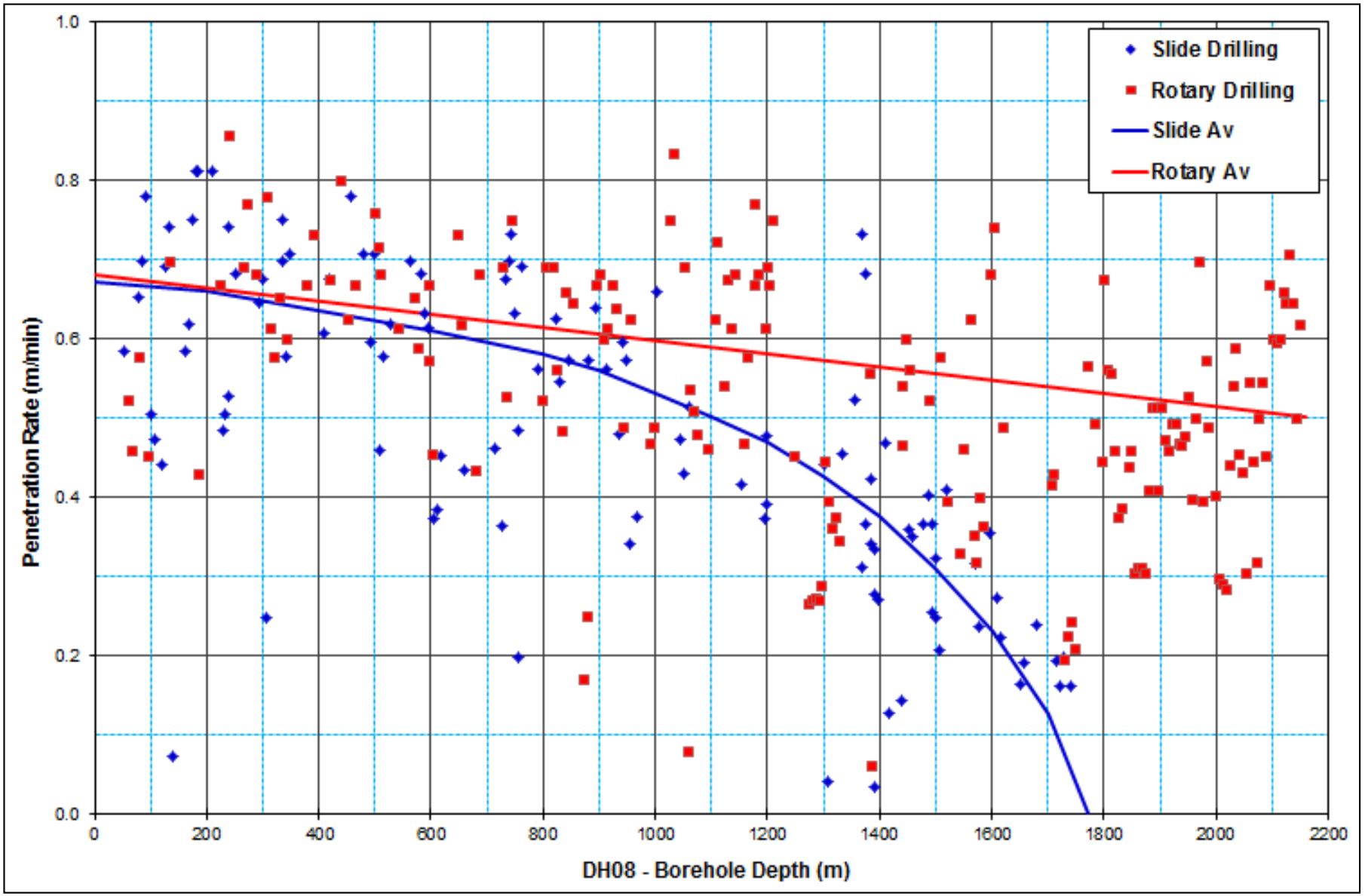
Drilling Mode



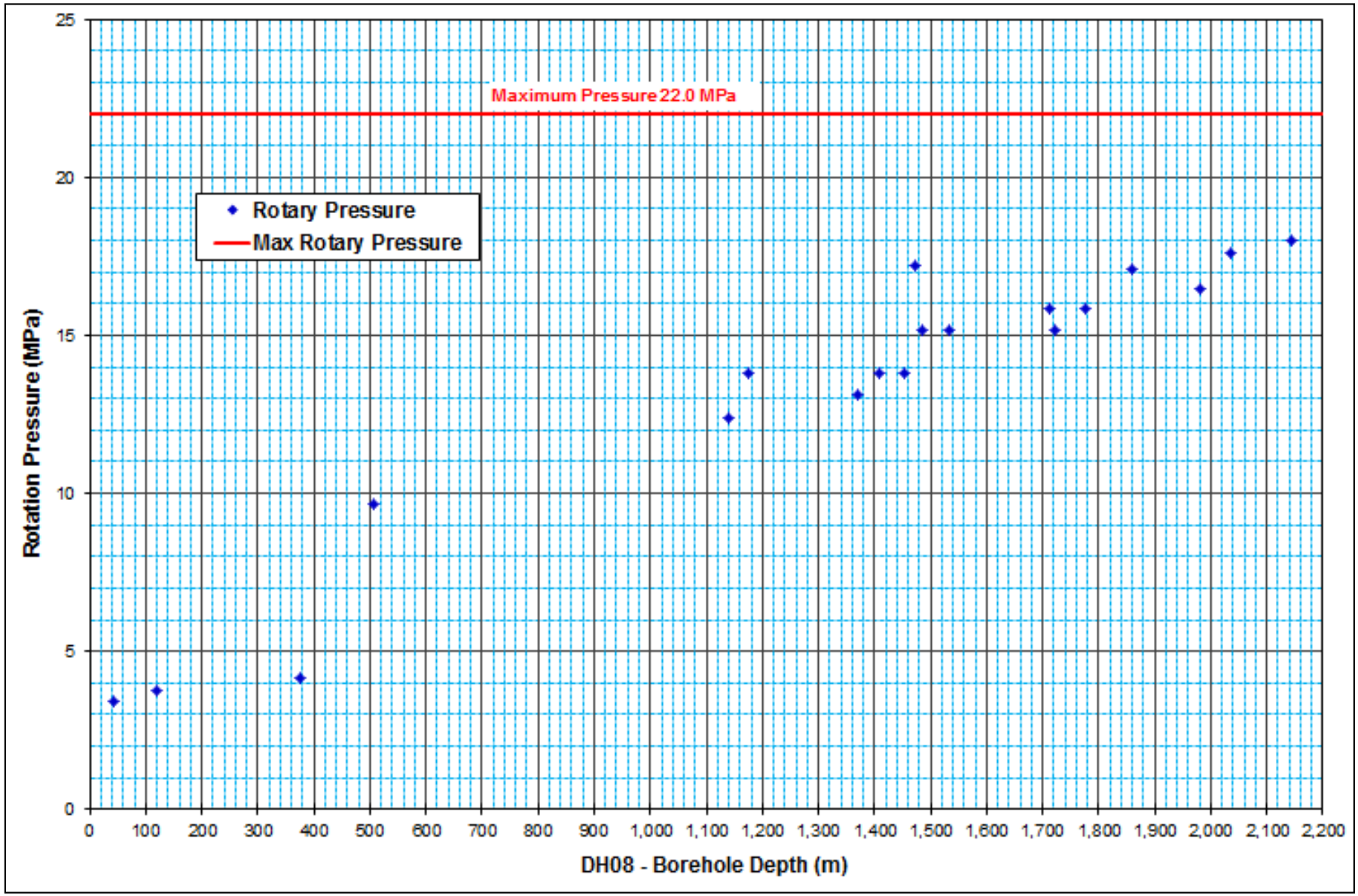
Thrust


Maximum Thrust 104.6 kN
Slide Mode
Rotary Model
Max Thrust
Trend
Thrust (kN)
DH08 - Borehole Depth (m)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

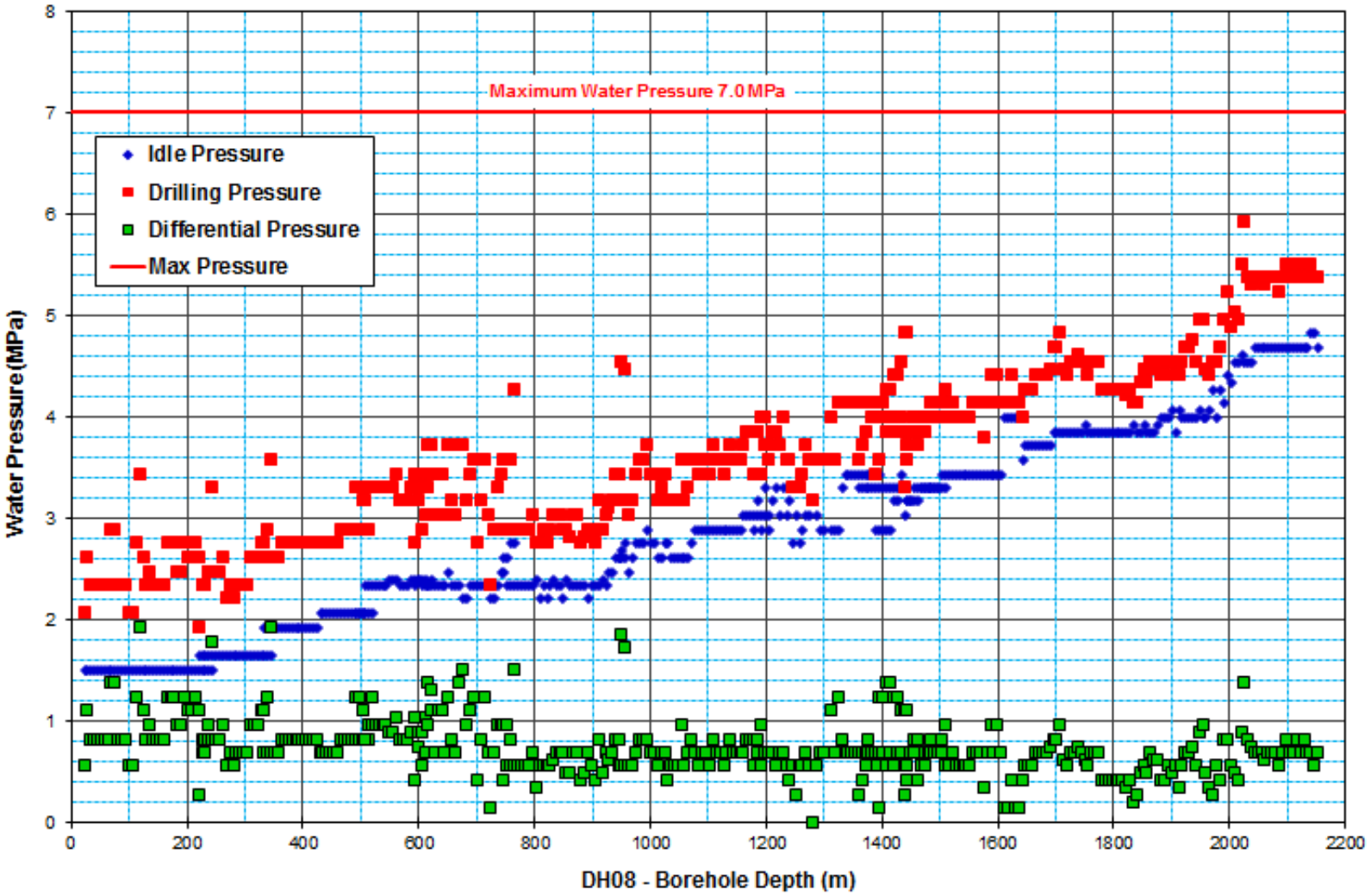
Penetration Rate



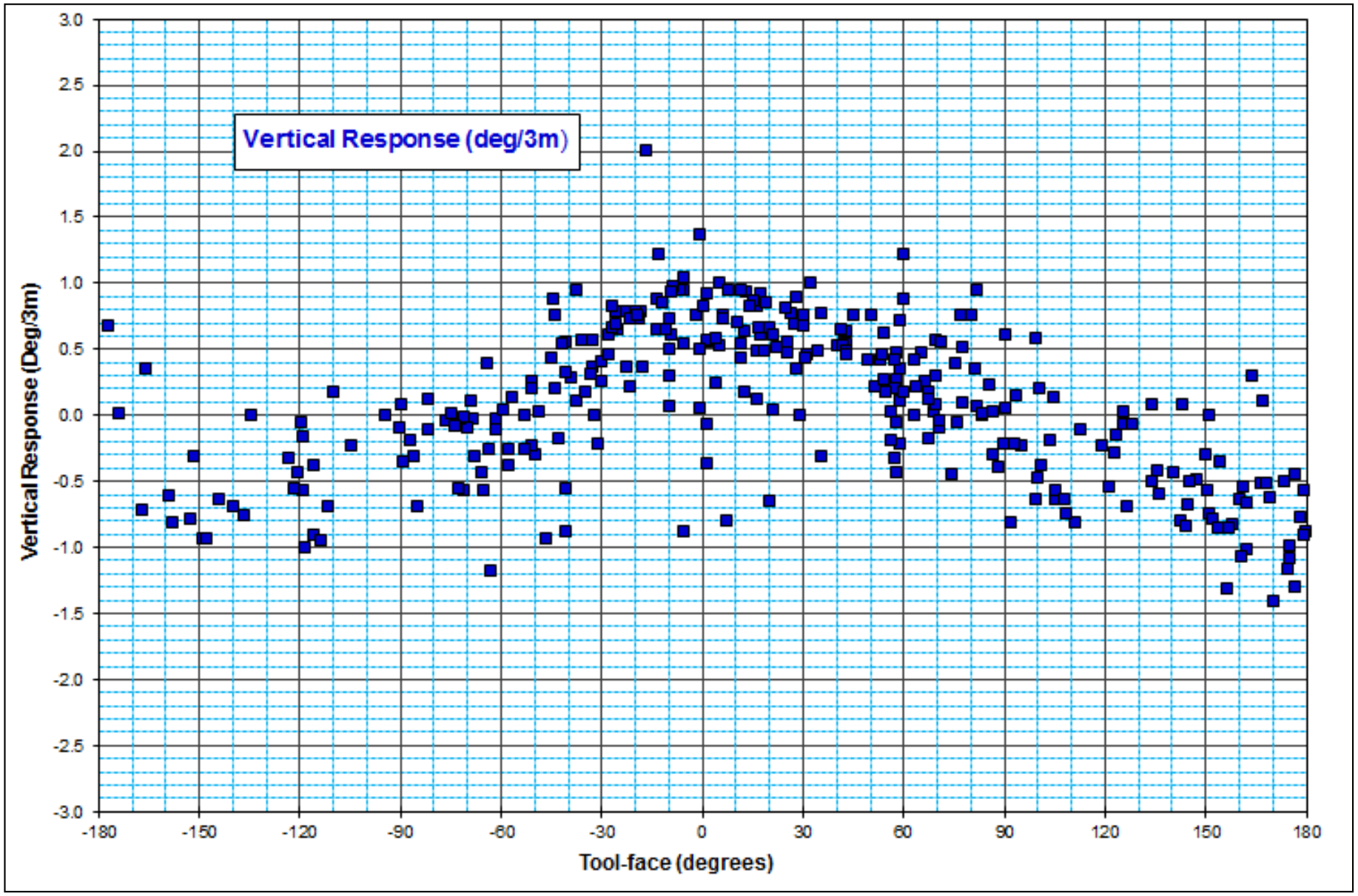
Rotation Pressure



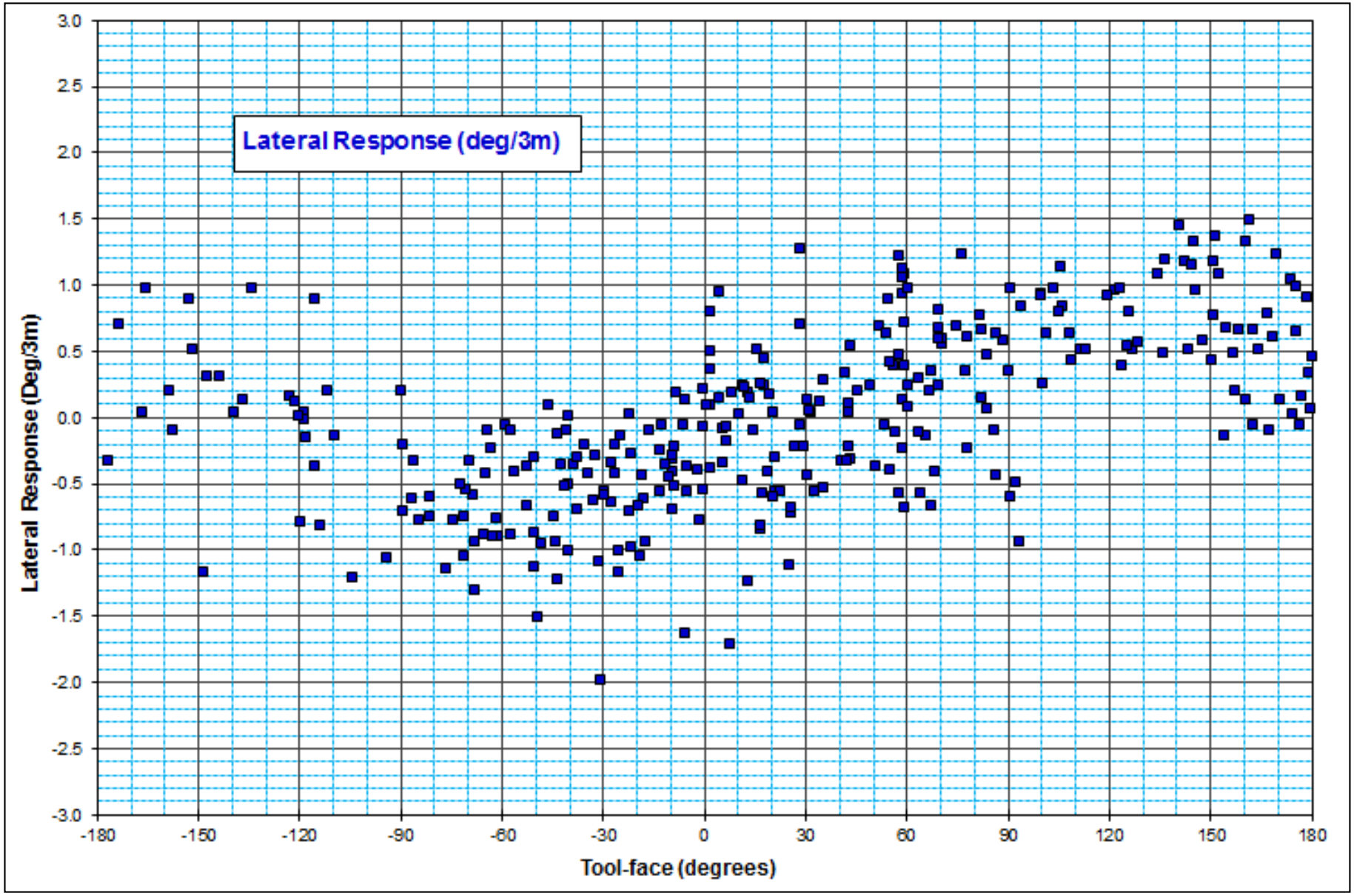
Water Pressure



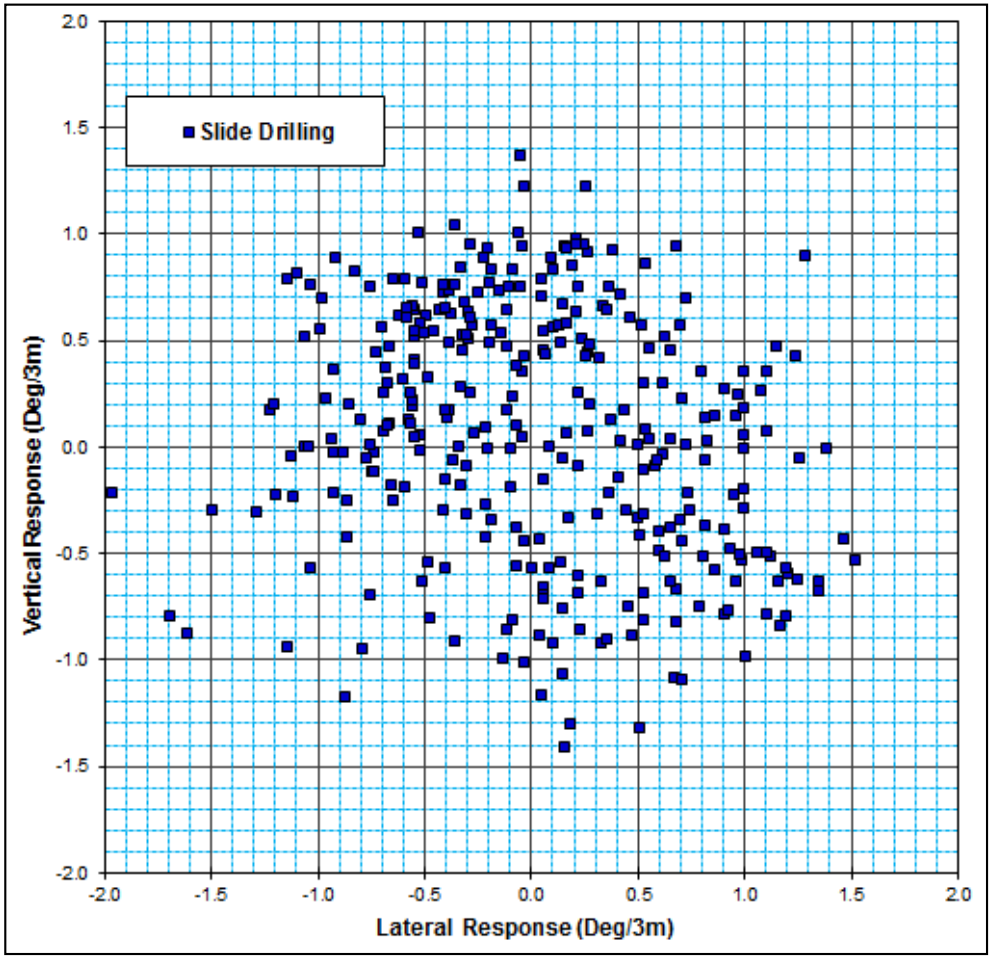
Vertical Response

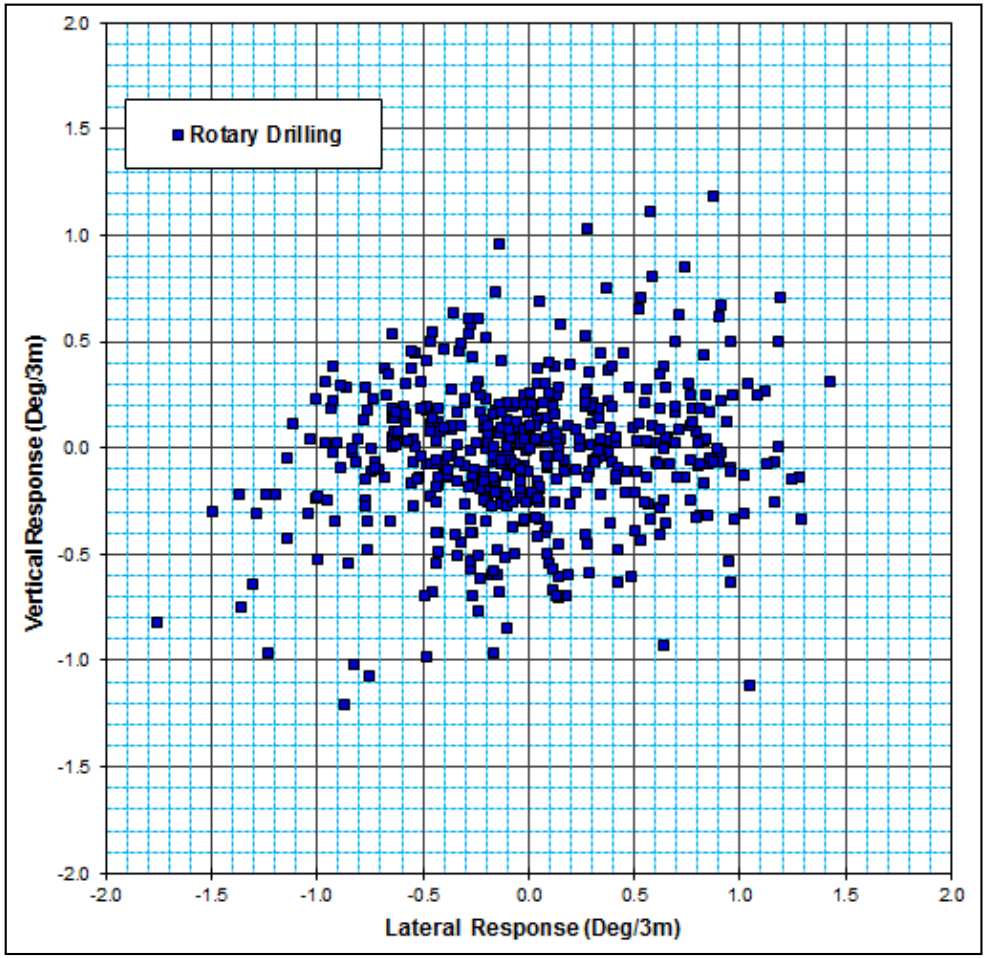


Lateral Response

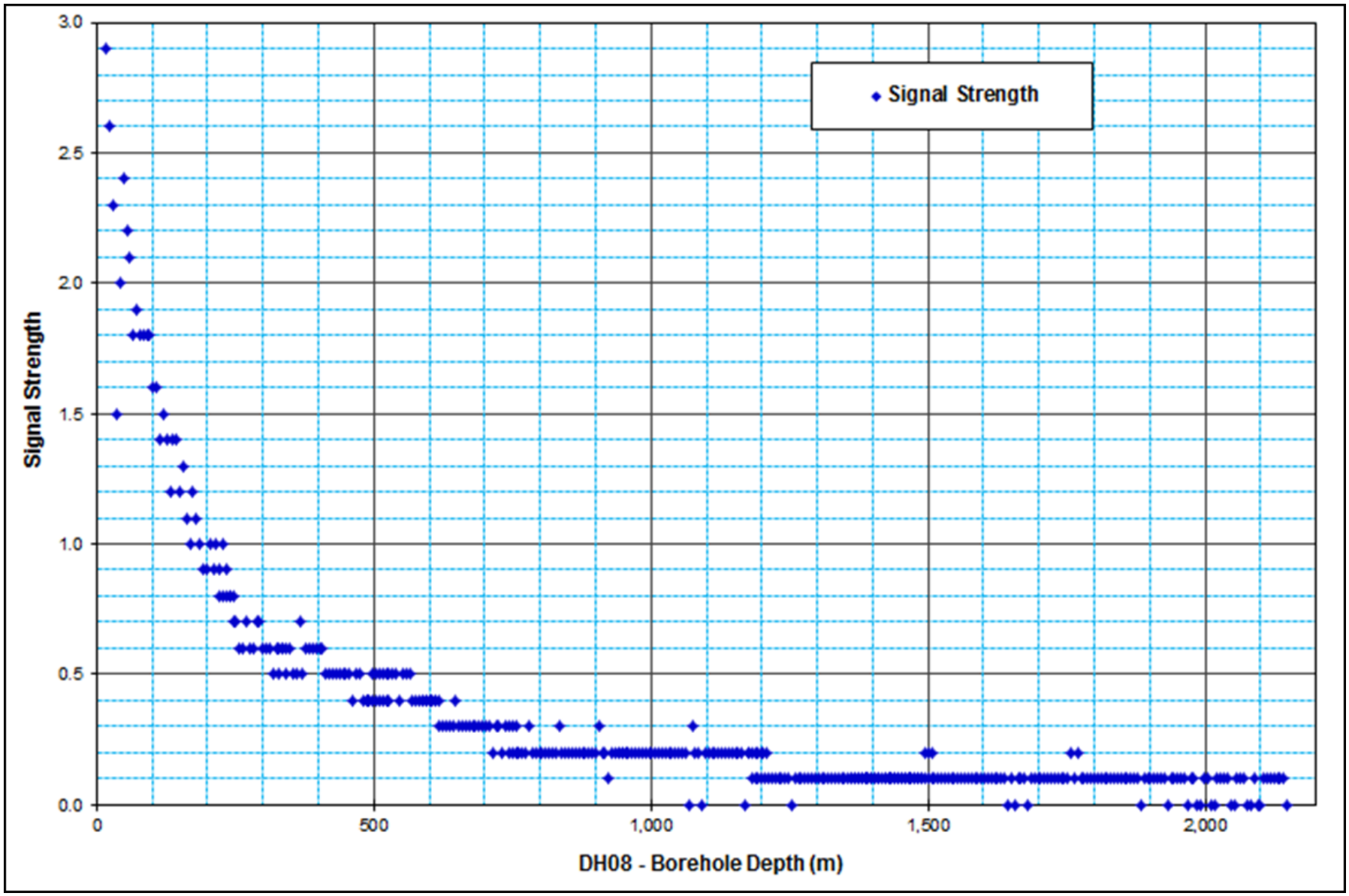


Borehole Deviation over 3m intervals





Signal Strength



DISCUSSION/CONCLUSIONS

- Bulli seam drilling conditions were very good with no instability experienced
- Use of rotary drilling was not regimented
- More work required to assess “control” of the rotary drilling section
- New underground in-seam drilling records
    - Slide at 1923m
    - Combination rotary/slide to 2151m
- 2000m long longwall block covered by in-seam drainage boreholes from remote access

- Is the gas flow sufficient to provide adequate drainage on schedule?
    - Considering seam gas is CO_2 and gas flow is restricted by borehole length
- What will be the gas flows when the boreholes are intersected and what mining procedures are required?
- Borehole locations to be adjusted with each intersection