Ground Improvement Trials at Port of Brisbane

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&

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Acknowledgements:

This presentation on the Ground Improvement Trials at the Port of Brisbane (POB) is made with the approval of POB . From the POB side special thanks are due to

1. **Mr.Arie Geelhoed**
2. **Mr. Peter Boyle**

Coffey Geotechnics : Dr. Jayantha Ameratunga

Review Team Colleagues : Prof. Harry Poulos

Prof. Buddhima Indraratna

Introduction

Background

1. **Close to 300ha of tidal land will be reclaimed adjacent to the Port of Brisbane at the mouth of the Brisbane River, using channel maintenance dredging materials consisting of river mud capped with sand. Already 60ha or so of this area has been reclaimed. The soft compressible clay thickness is highly variable and is as deep as 30m and overlain by dredged materials with mud thicknesses varying up to 9m or so.**
2. **Ground improvement trials were carried out by three specialist contractors**
   (i) Austress Menard
   (ii) Boskalis and
   (iii) Van Oord
3. **Brief description of the trials is given and concentration will be more on the Austrss Menard Trials which include vacuum consolidation with cut off walls**

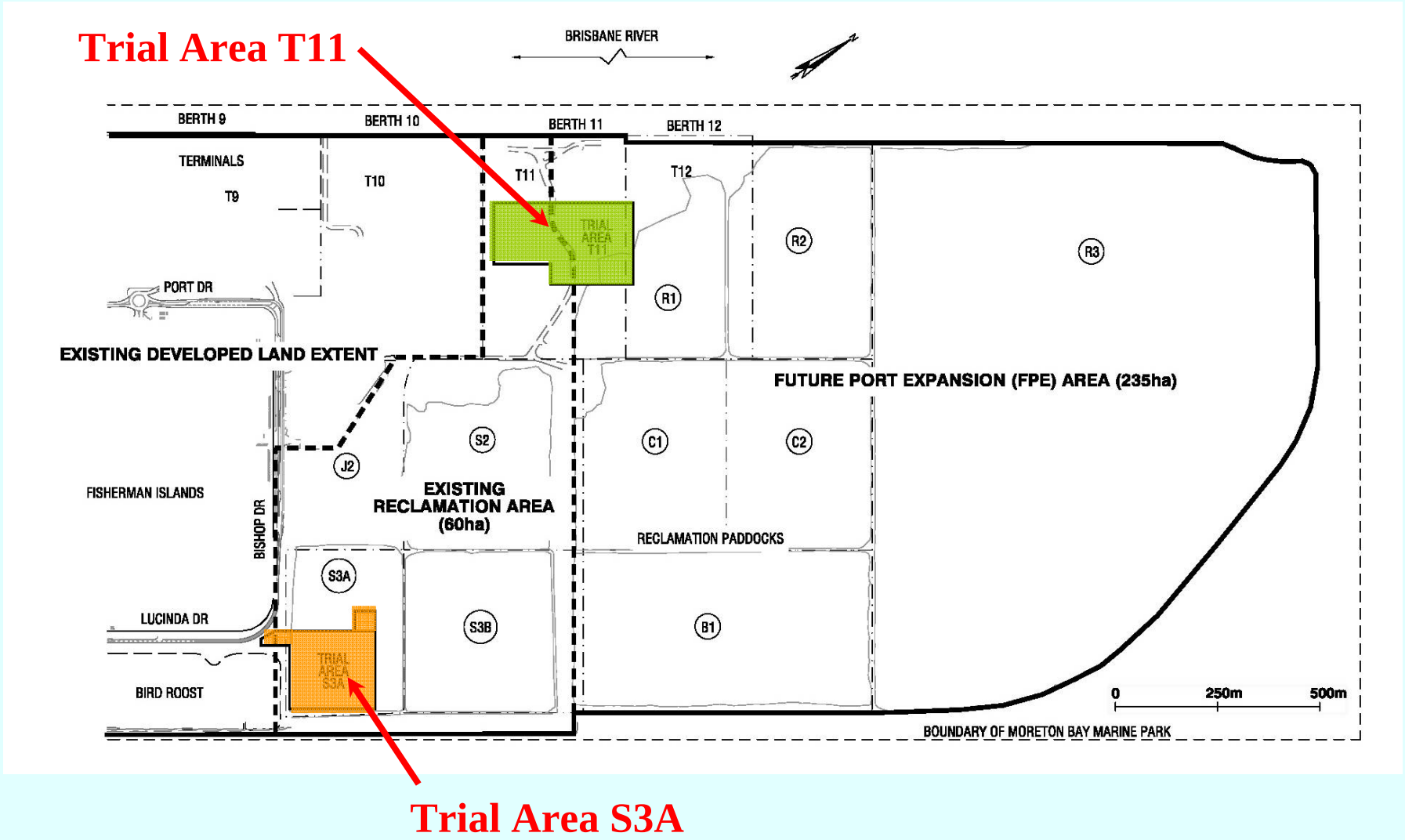
An overview of the PBC site

Austress Menard trial sections

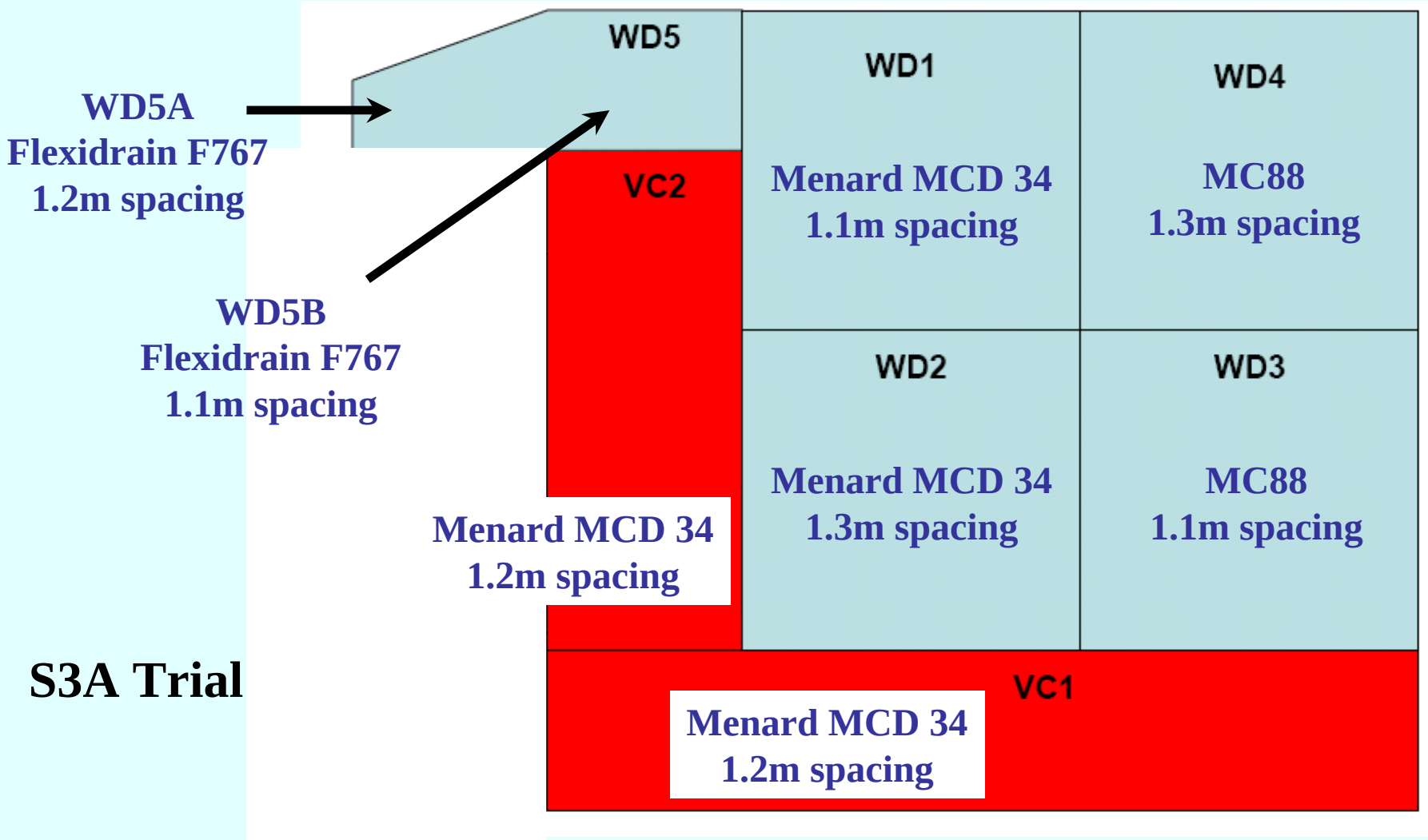
Details of trial sections by the three contractors

Menard (S3A)	Boskalis (T11)	Van Oord (T11)
• **WD Spacing (m): 1.1, 1.2 & 1.3** • **Wick (PVD) Types: MD88, FD767 & MCD34** • **Duration: 13 -16 months** • **Surcharge: 3m to 8m** • **Max. clay thickness 22.5** • **Max. dredged mud thickness 6m**	• WD Spacing (m): 1.25 • WD Types: MD7007, MD88HD, MD88H with variable filters • BeauDrain-S vacuum system • Duration: 12 months • Surcharge: 5m to 9m • Max. clay thickness 19.5 • Max. dredged mud thickness 4m	• WD Spacing (m): 1.0, 1.4 • Wick (PVD) Types: MD7007, MD88H • Duration: 6 and 12 months • Surcharge: from 7.5m to 10m • Max. clay thickness 20m • Max. dredged mud thickness 4.5m

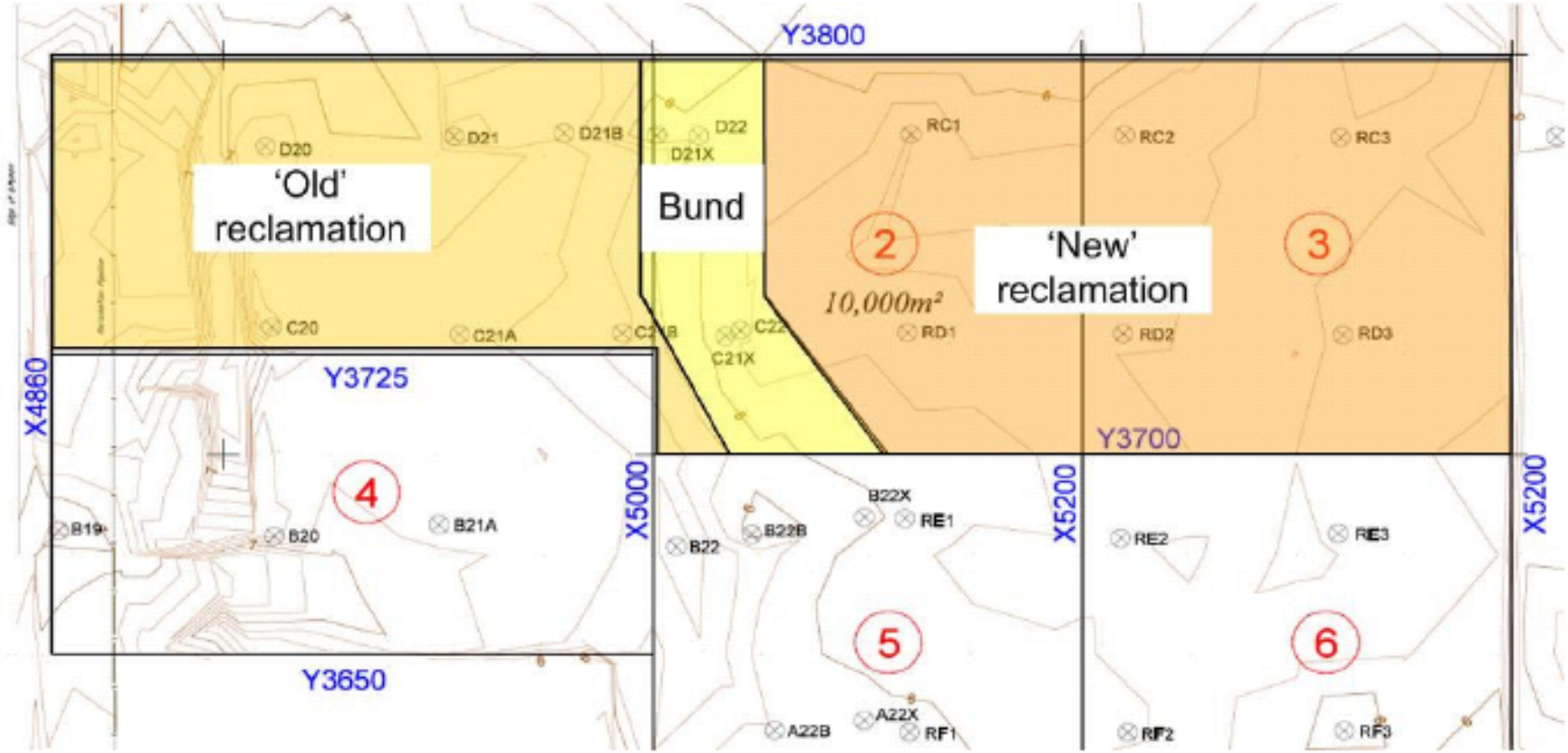
Trial Areas Locations



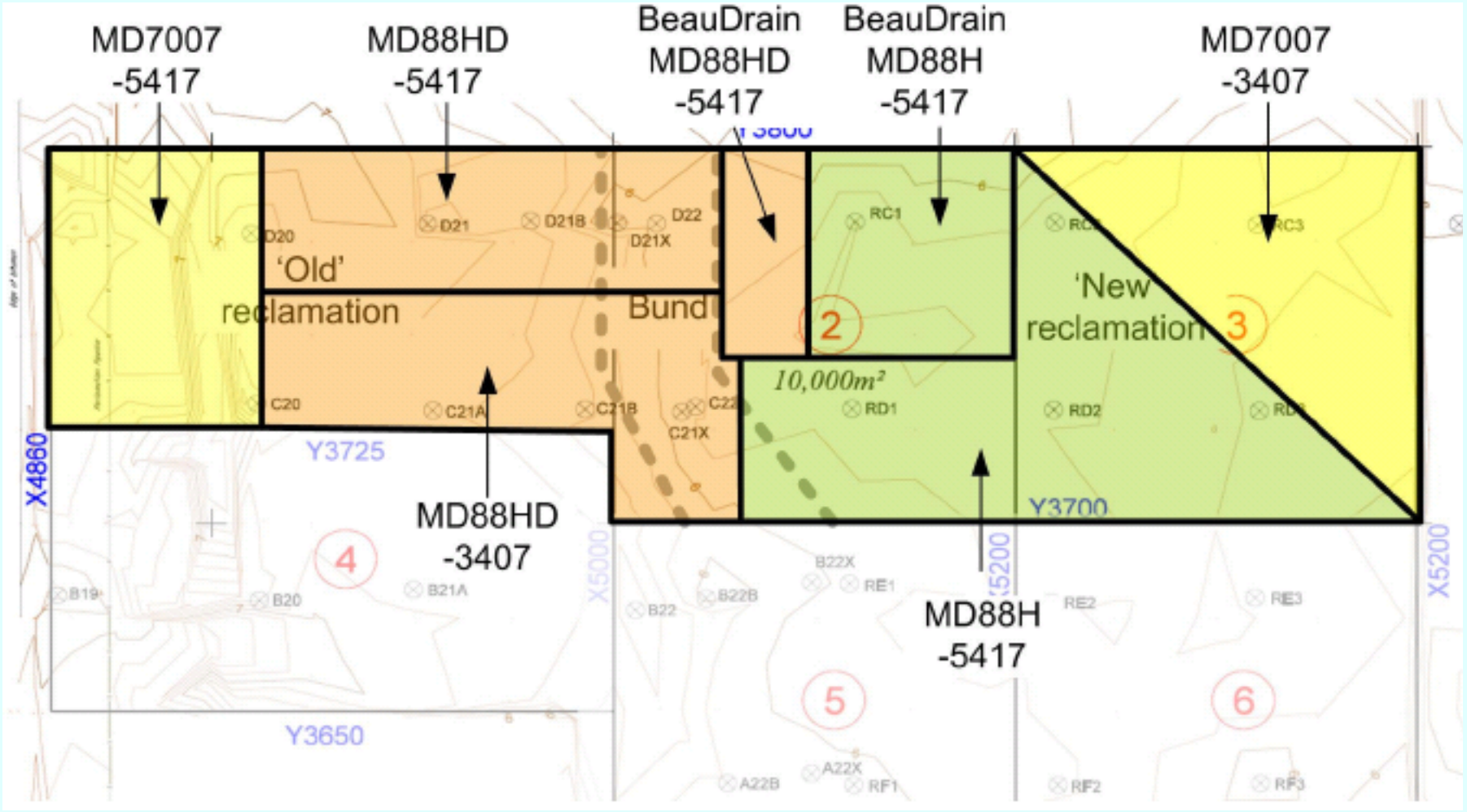
Austress Menard trial sections



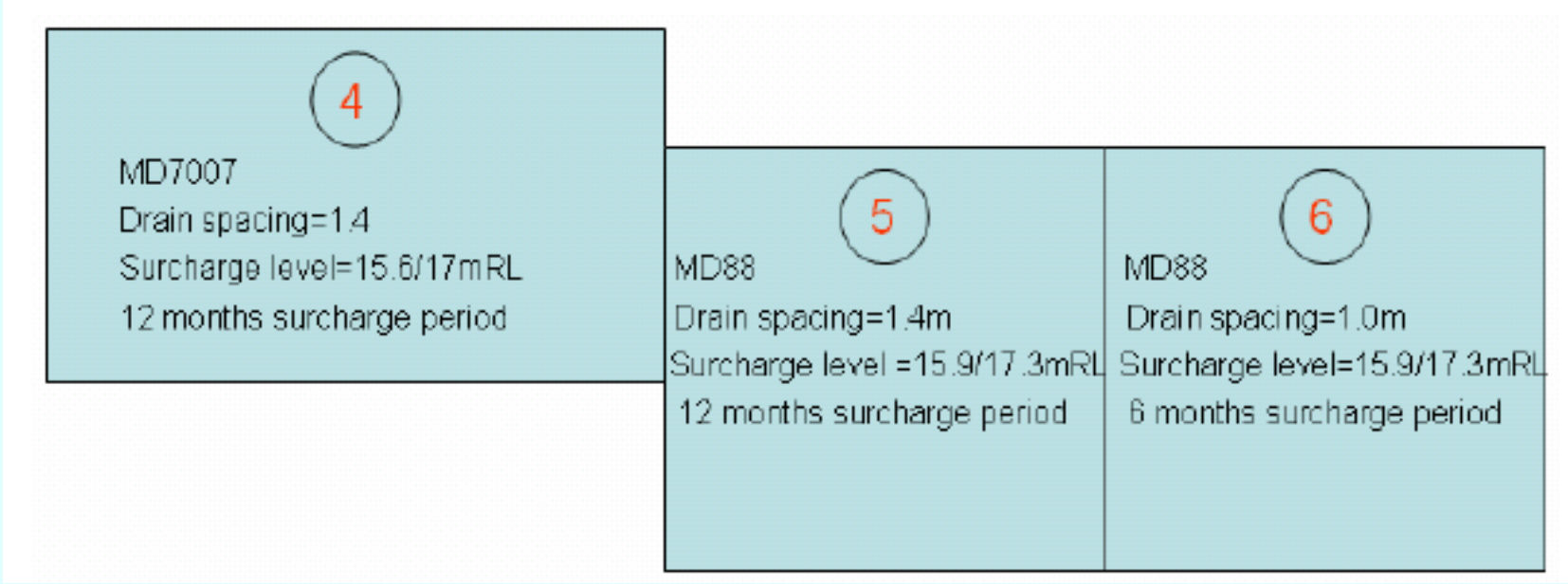
S3A Trial



Boskalis and Van Oord trial sections

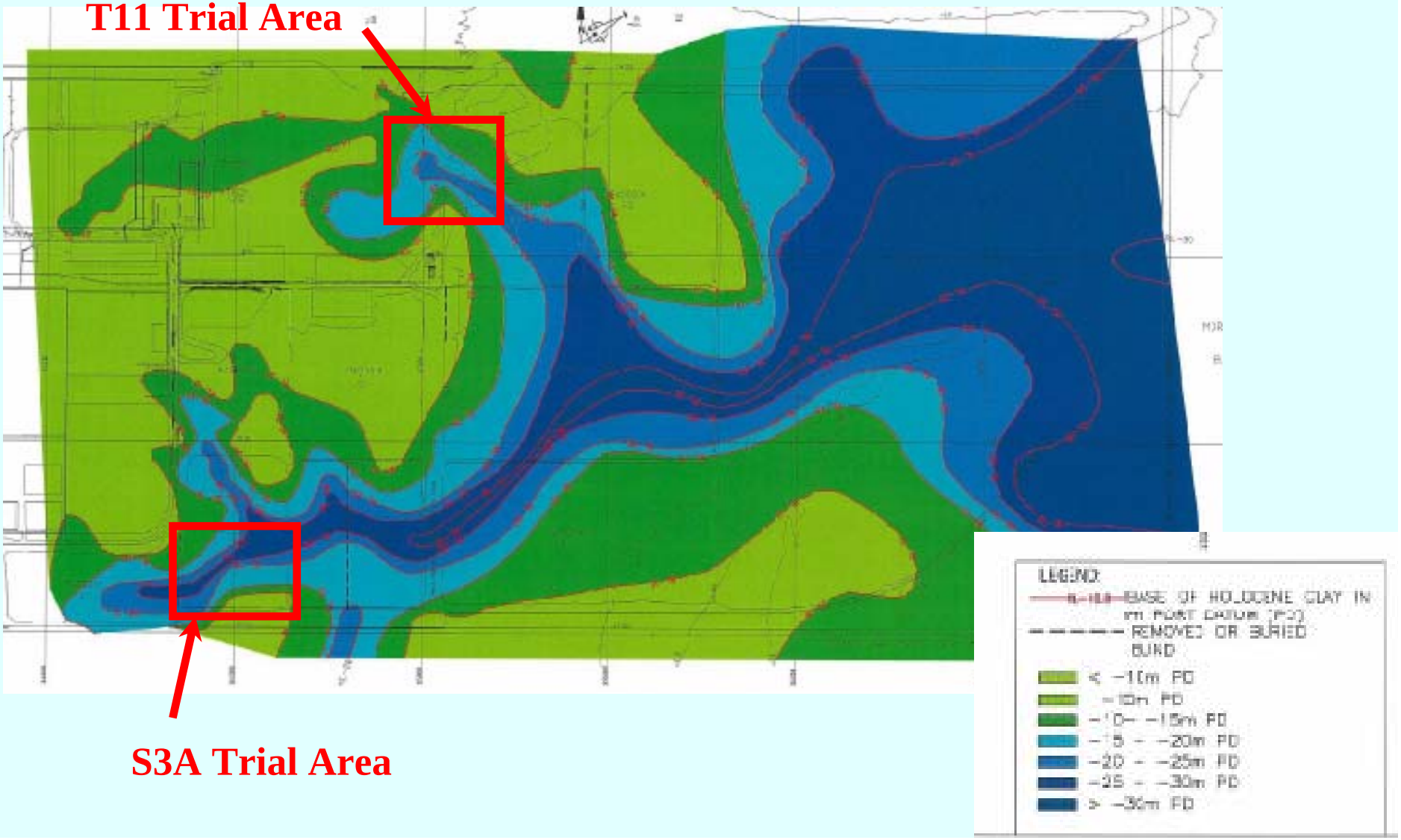


Details of Boskalis trial sections



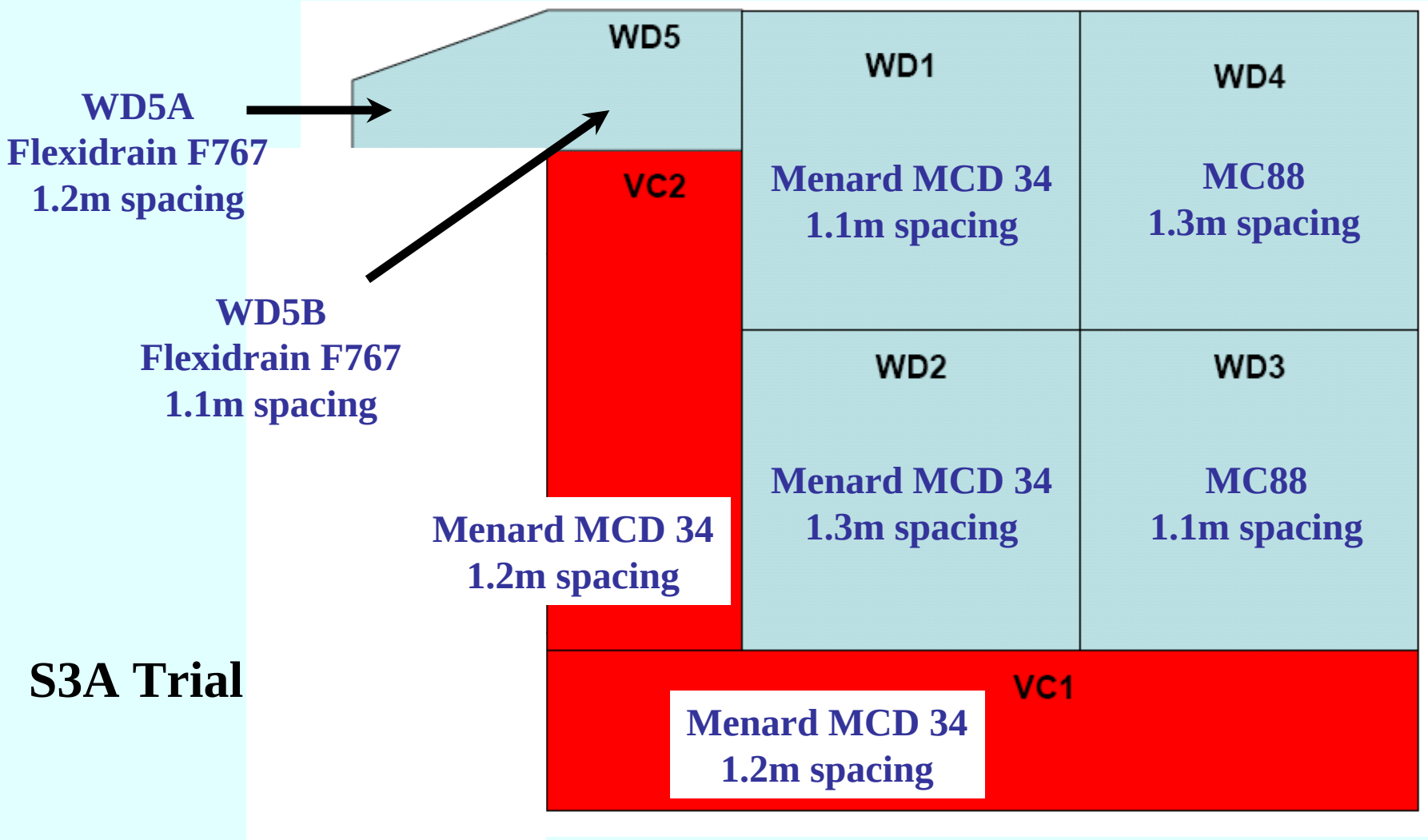
Details of Van Oord trial sections

Thickness of LHC & Trial Locations



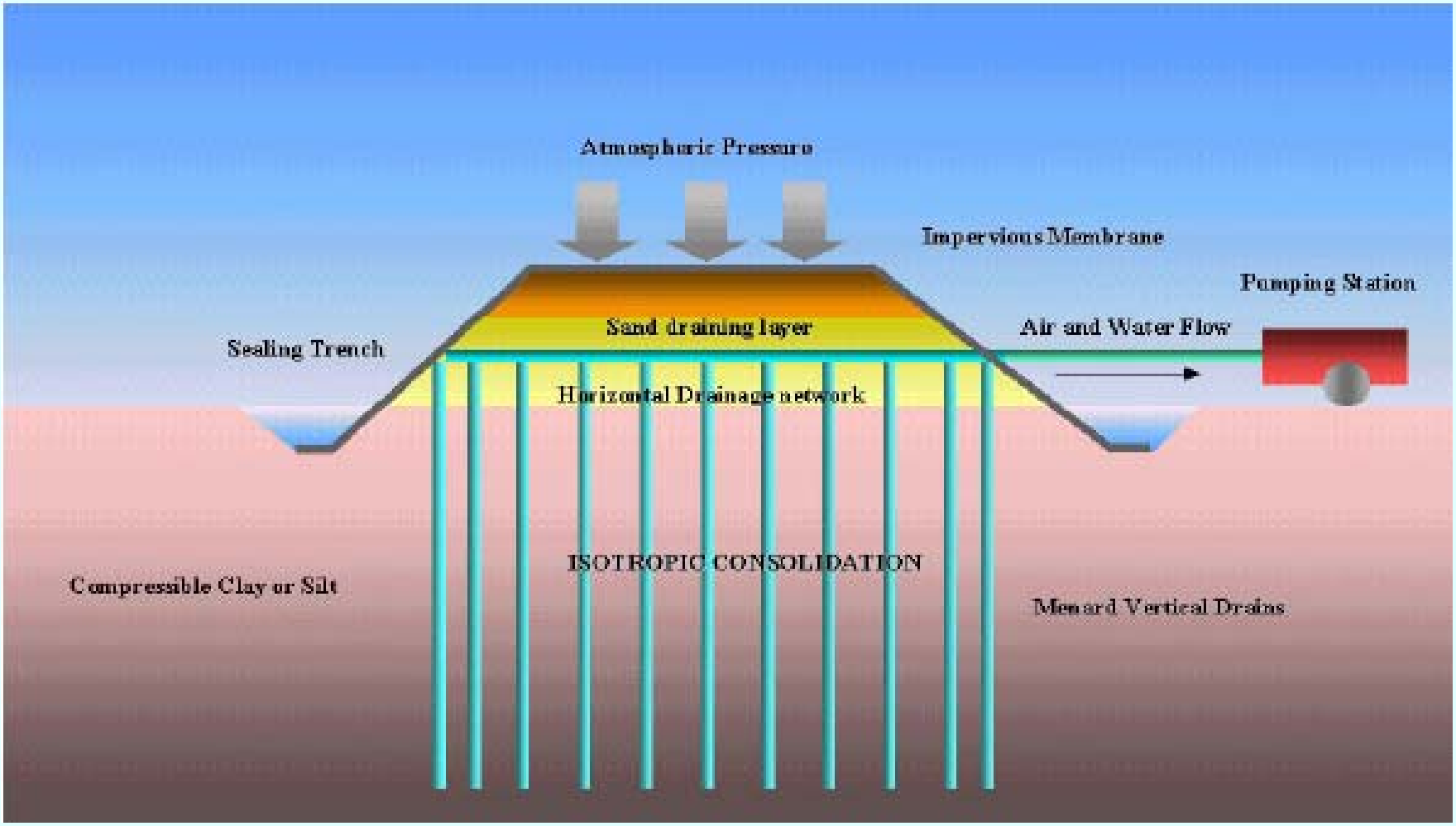
Austress Menard trials

Austress Menard trial sections



S3A Trial

Details of vacuum consolidation



Details of Menard vacuum consolidation

Placement of geotextile and sand capping

HDPE liner installation on inner face of cut-off wall

MCD 34 vertical drain installation

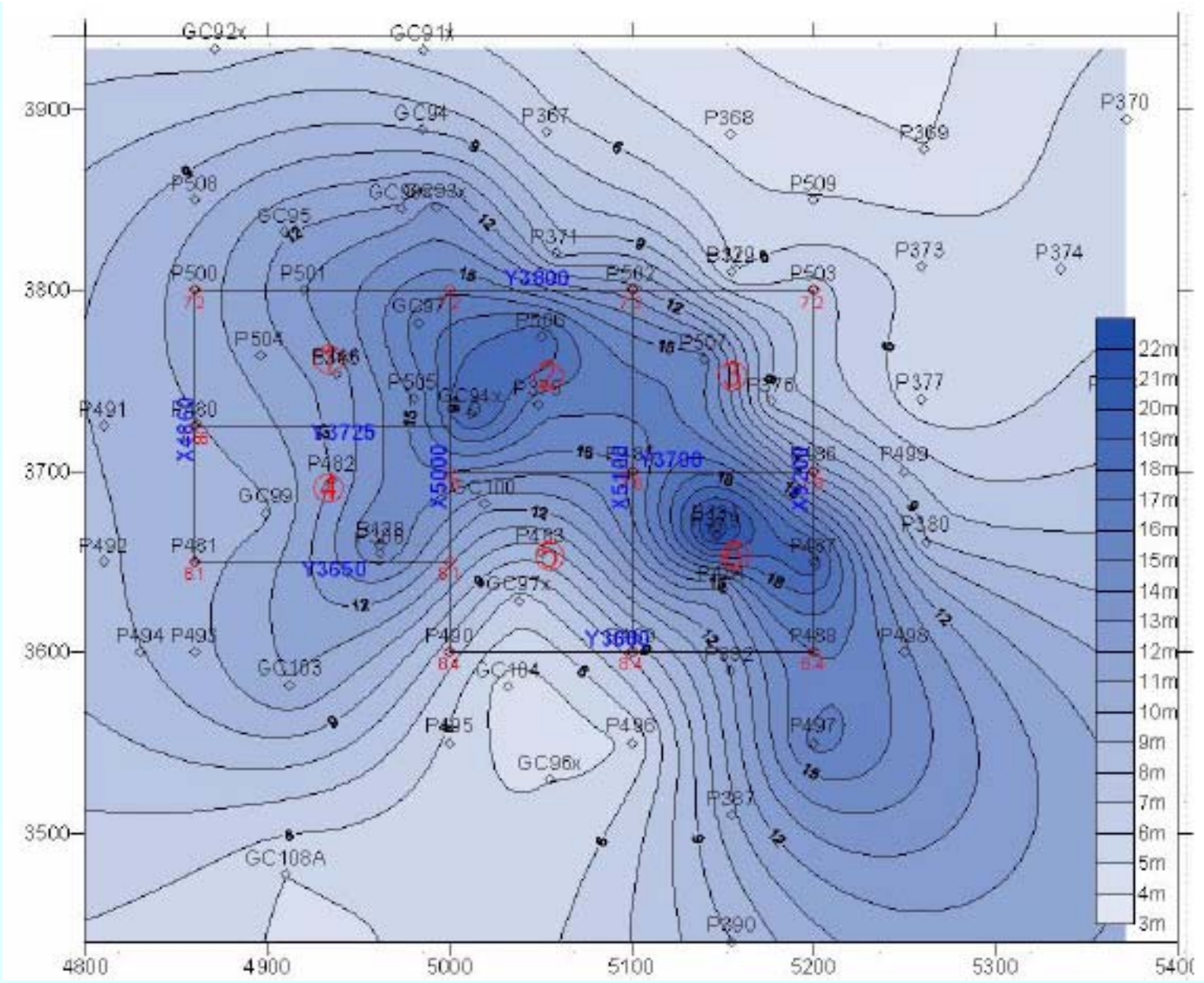
HDPE membrane installation

HDPE membrane installation

Menard vacuum pump setup

Photograph 15: Vacuum Pressure Monitoring setup

Details of soil profile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P502
P503
GC97x
P504
P506
P507
P505
GC94x
P376
P377
P491
P480
X4850
Y3725
P482
X5000
X5100
Y3700
X5200
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GC99
GC100
P180
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P481
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GC103
GC104
P485
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GC96x
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GC108A
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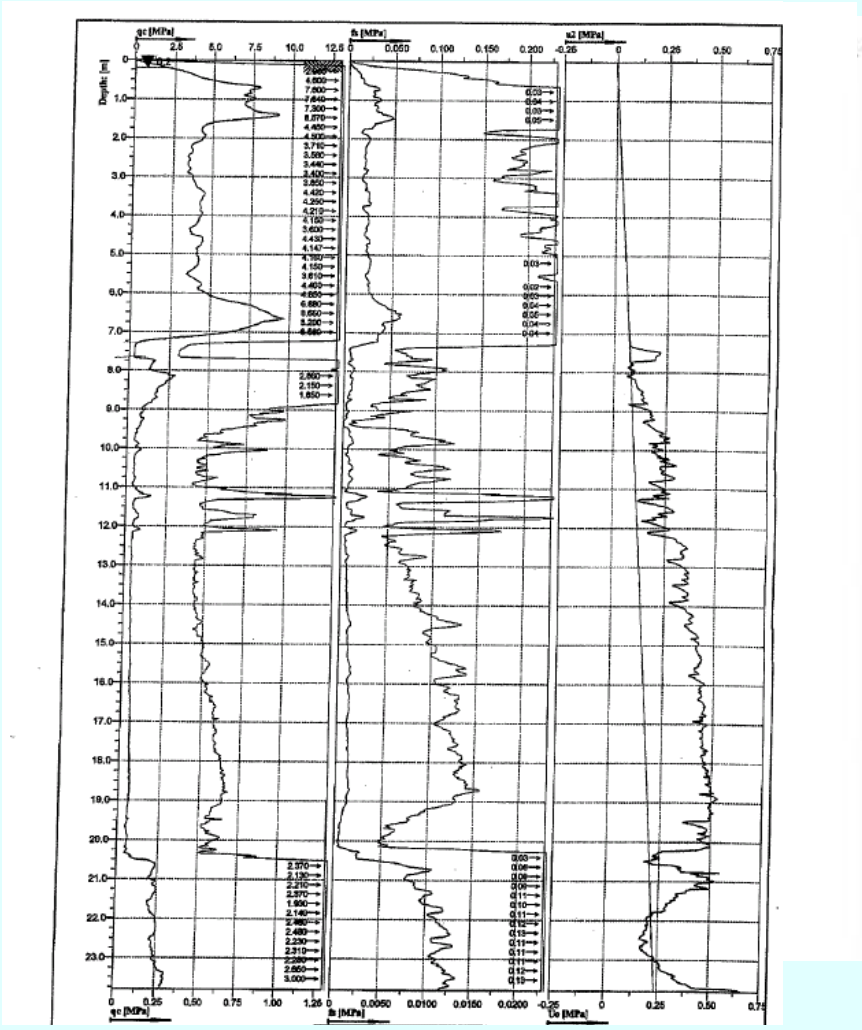
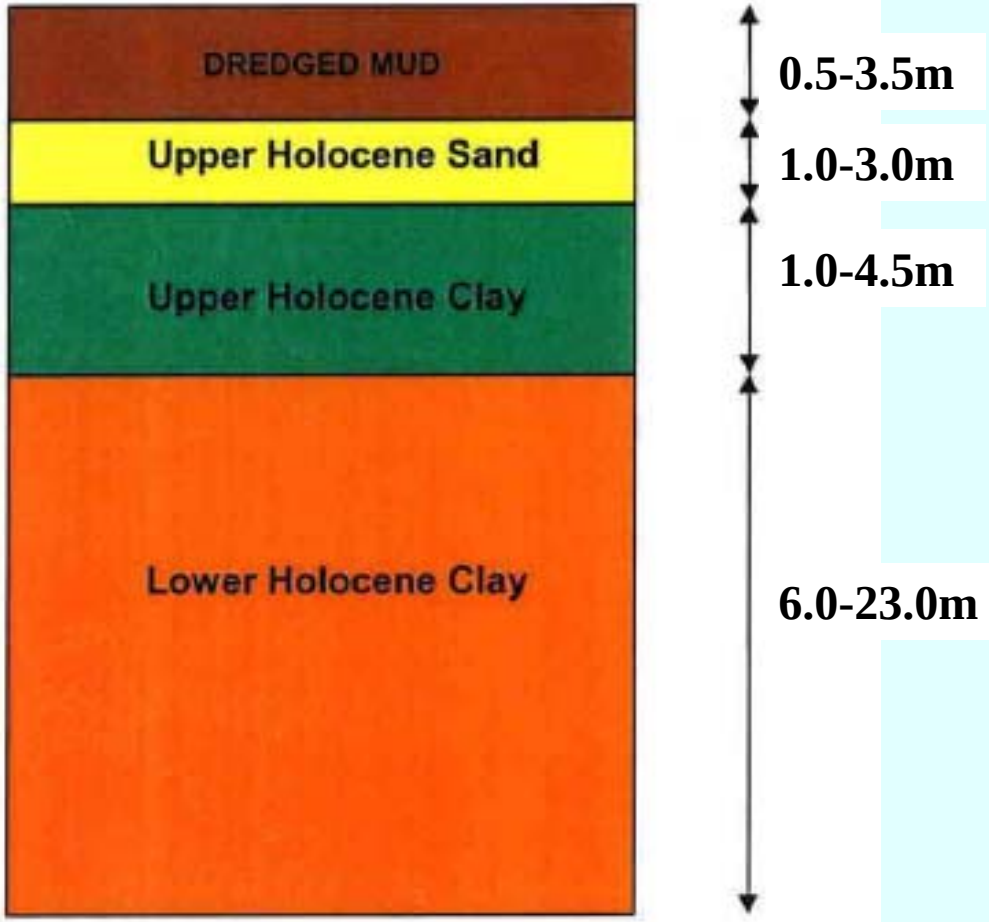
3m

Depth of LHC

Typical Soil Profile from CPTu

S3A Trial Area:





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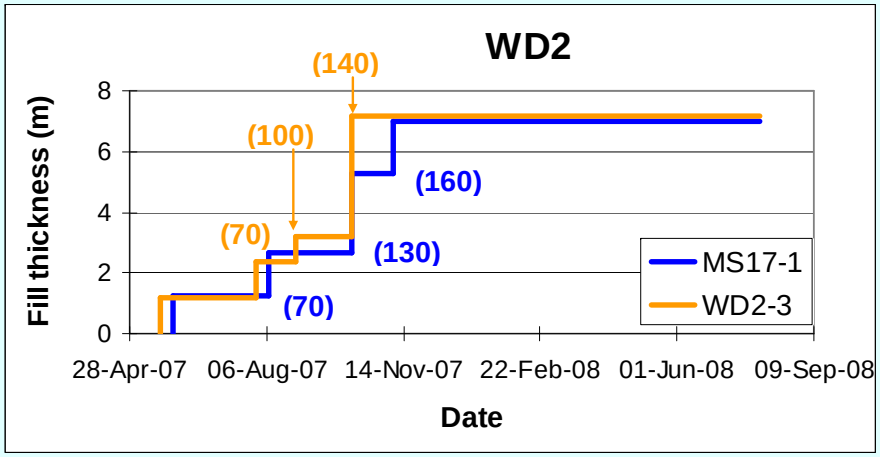
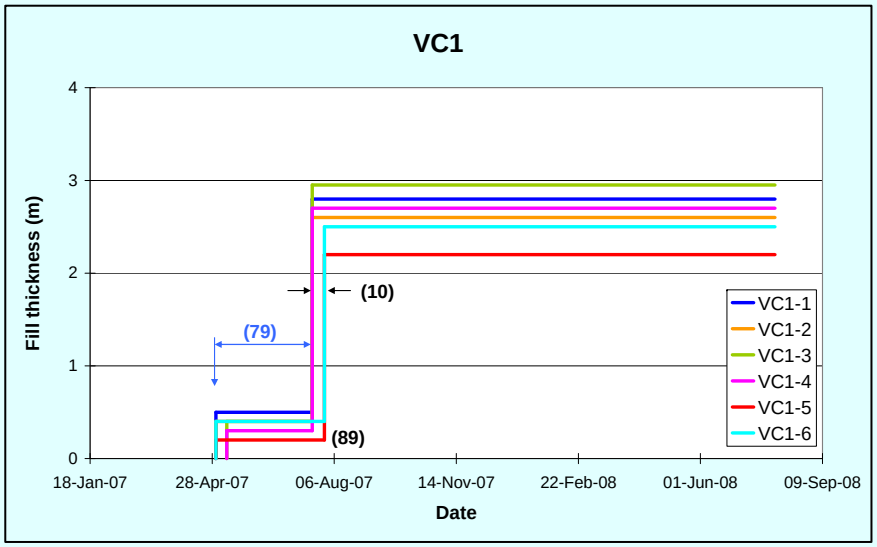
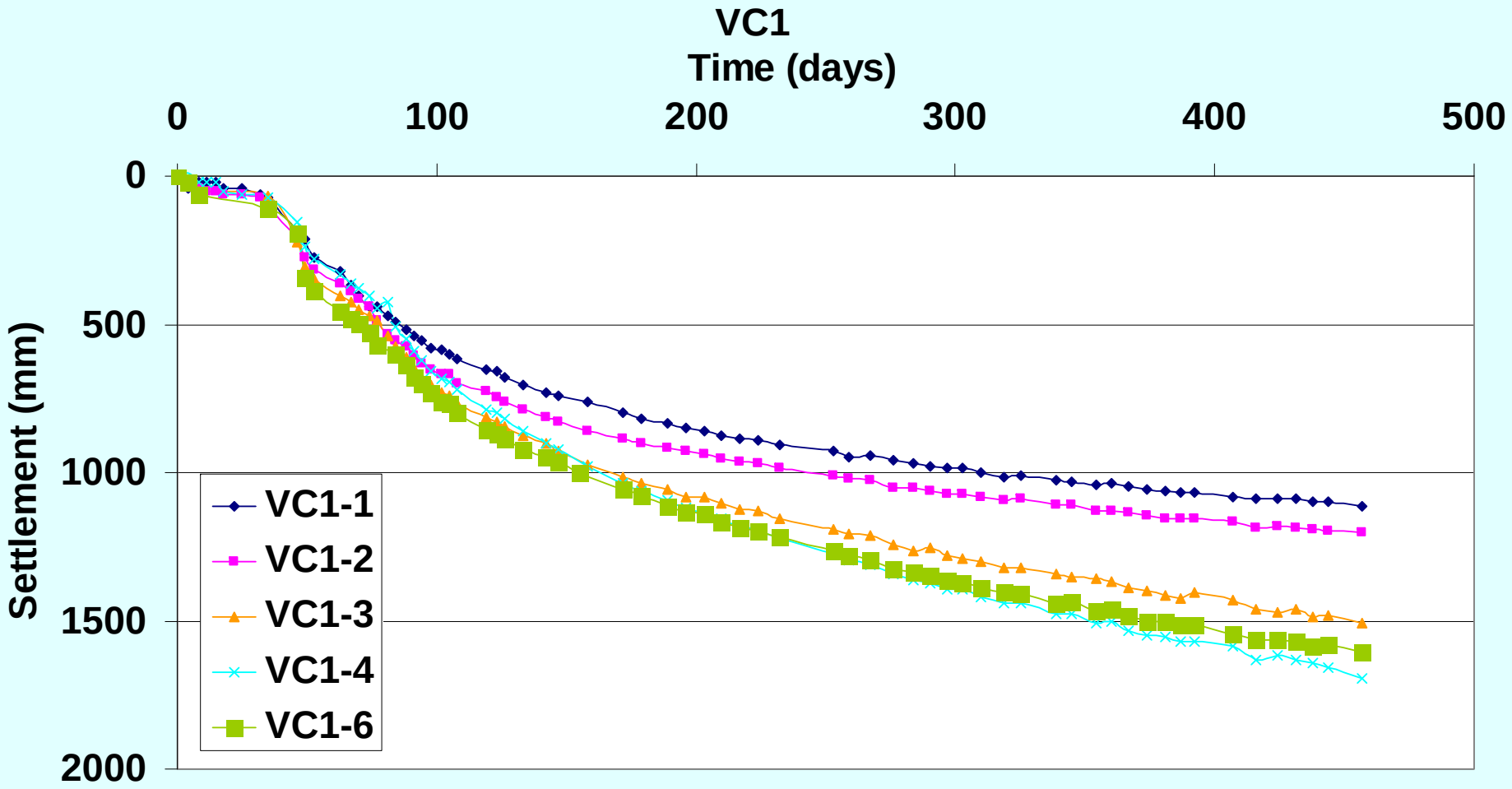
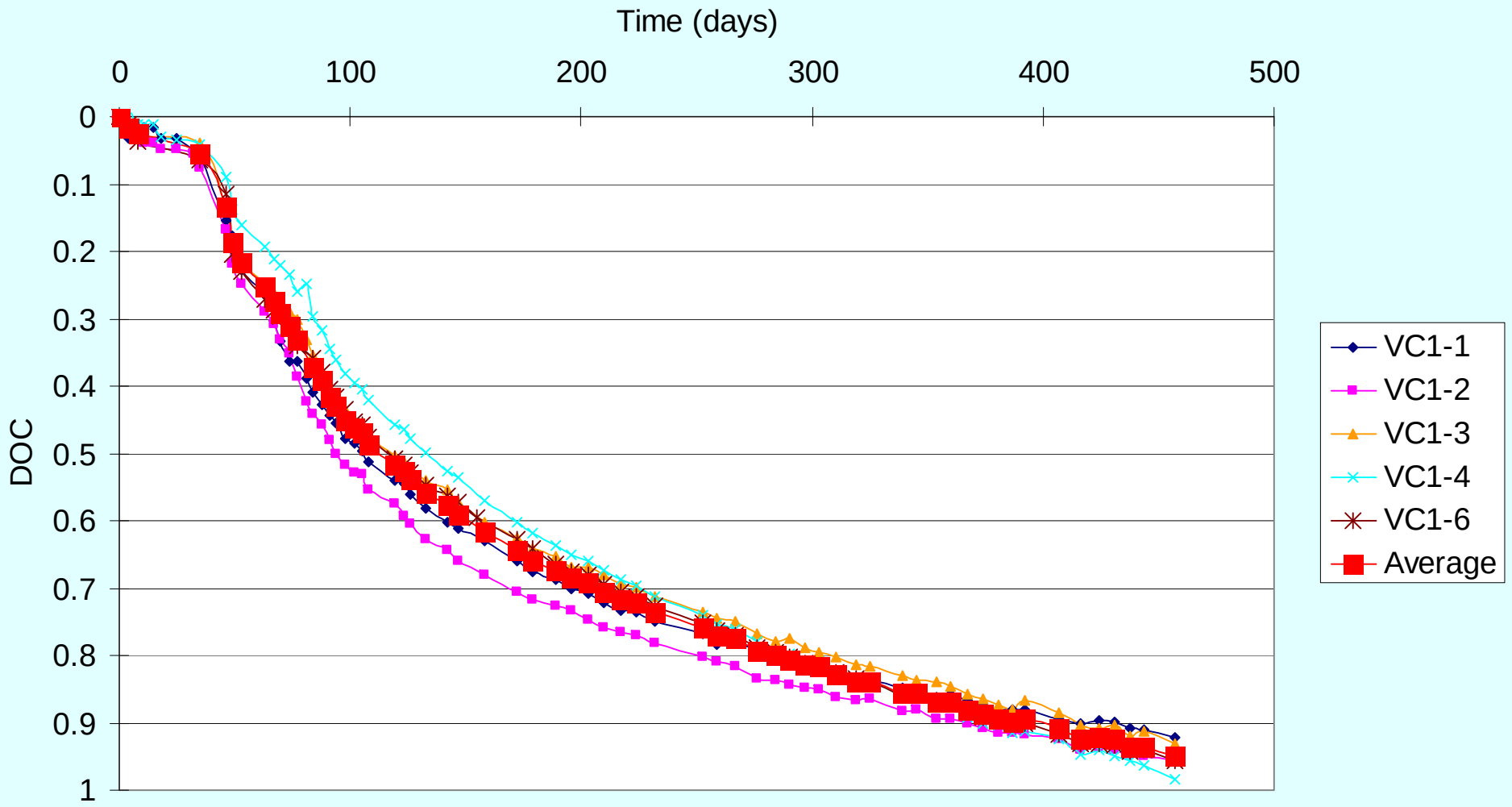




Settlement and DOC from surface settlement measurements

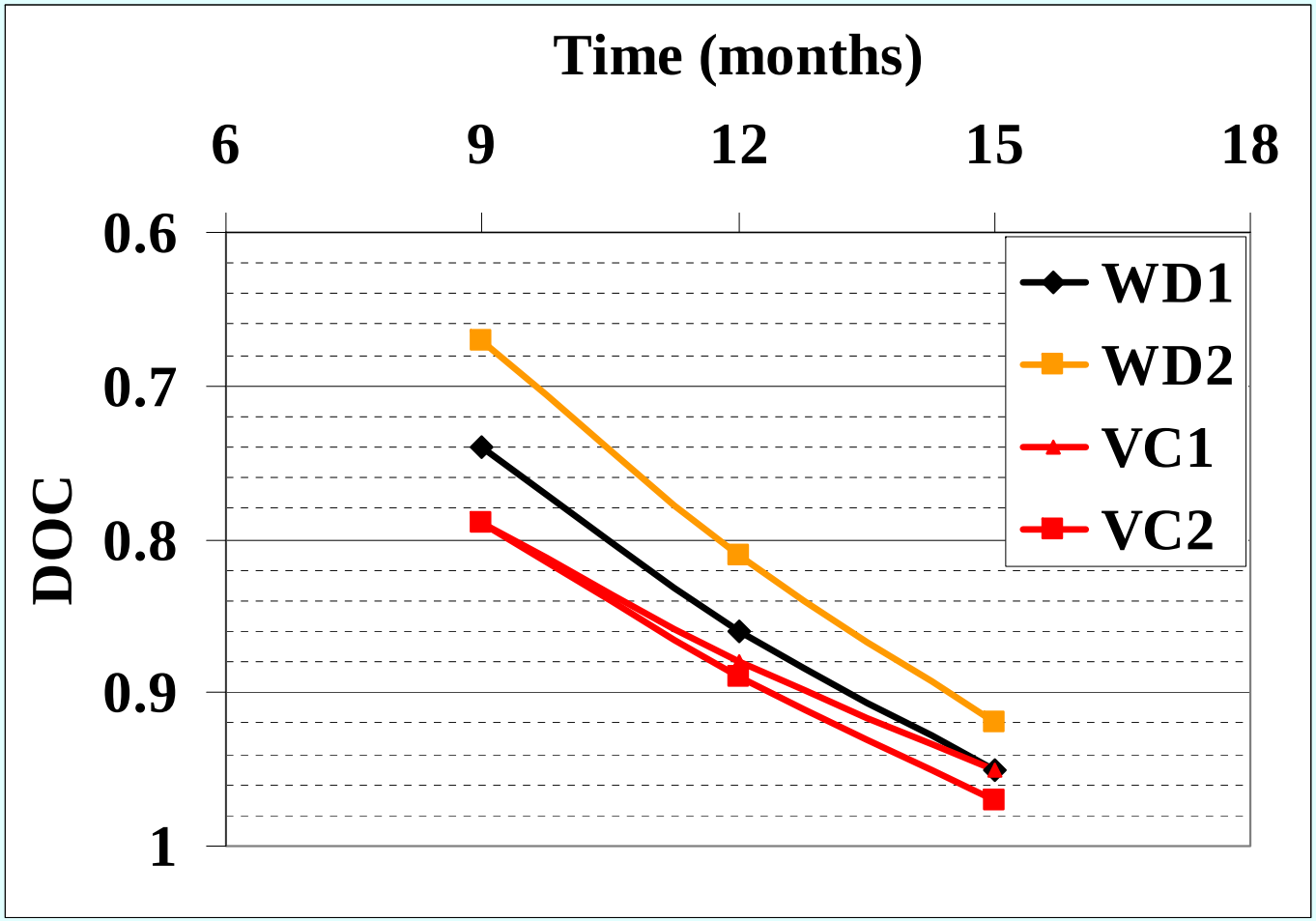


Settlement-time plots in VC section

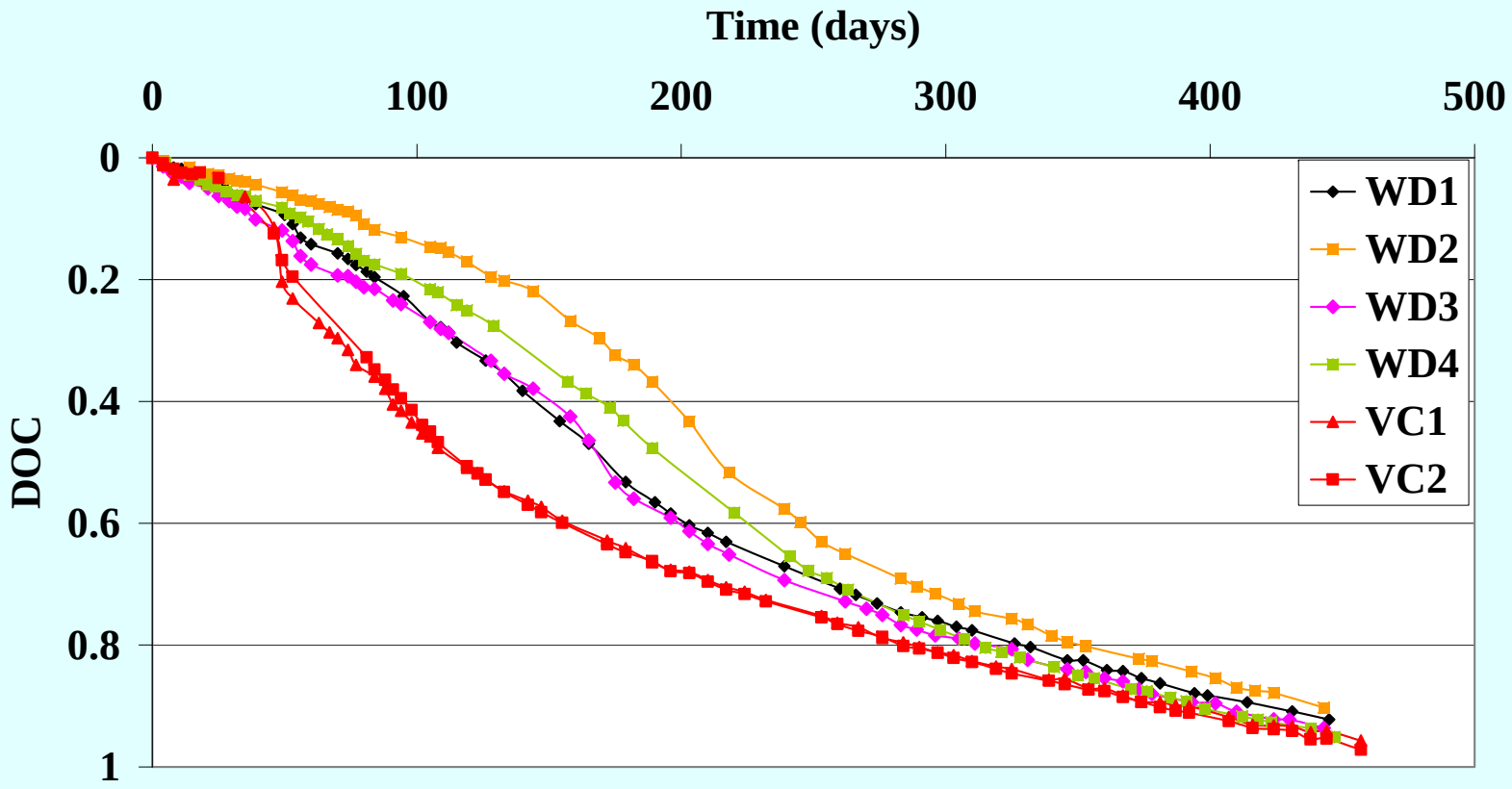


DOC-time plots in VC section

Comparison of DOC vs Time (Surface Settlement measurements)



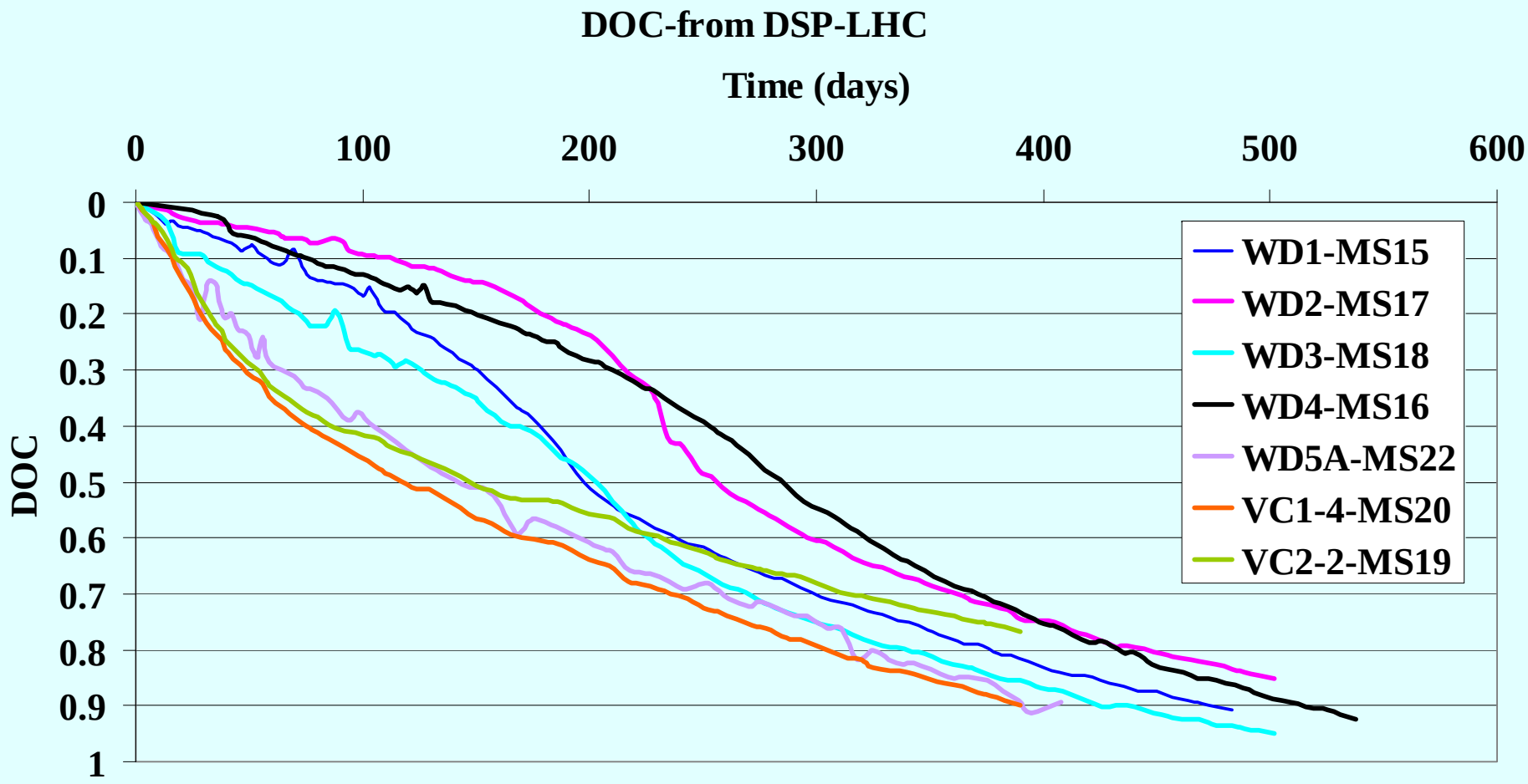
Average DOC: WD and VC Sections



Settlement and DOC from deep settlement measurements

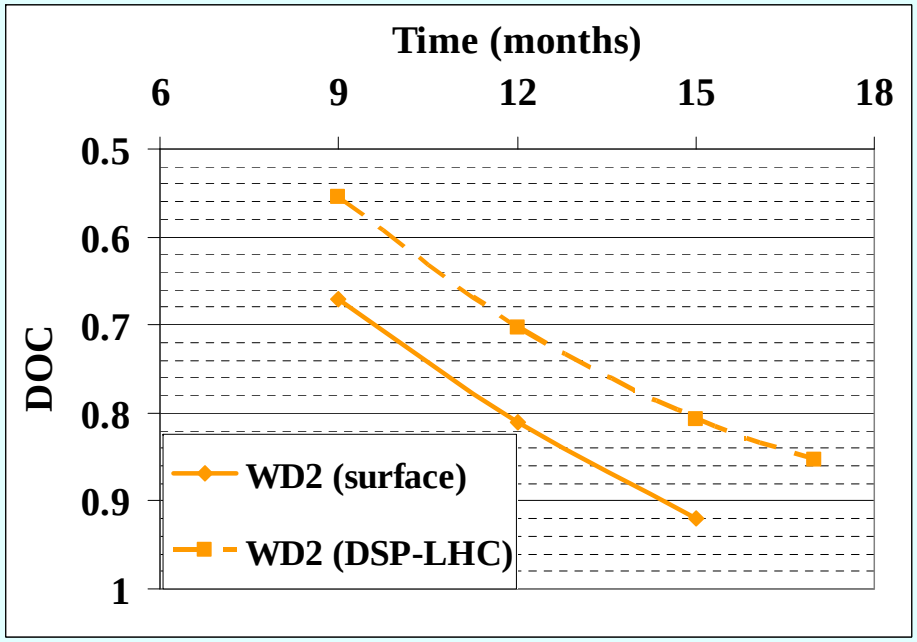
Locations of DSG

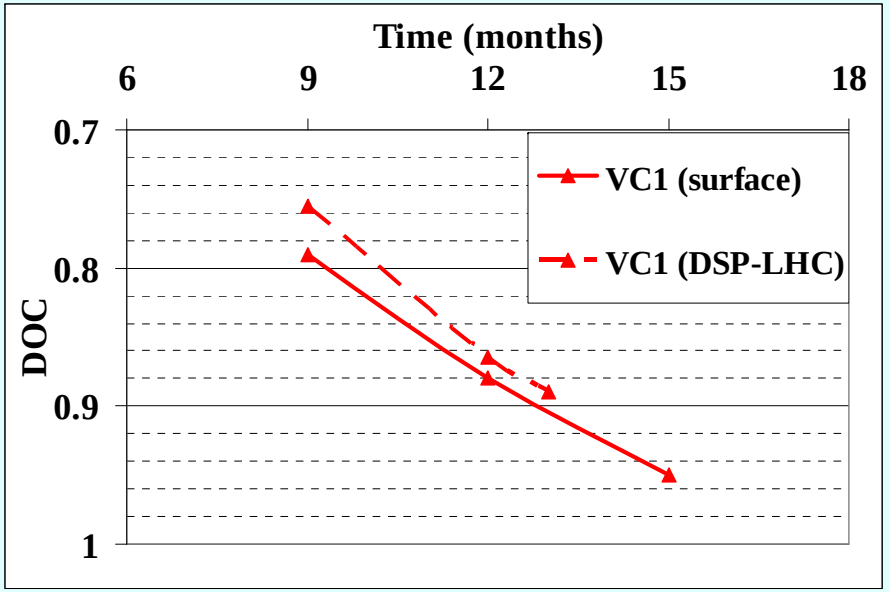
Sections	Deep settlement gauges (RL)	Locations
WD1- MS15	DSP2 (-0.2)	Top of Holocene sand
	DSP1 (-5.5)	Top of Lower Holocene clay
	DSP3 (-5.5)	Top of Lower Holocene clay
WD2-MS17	DSP2 (0.1)	Above Holocene sand
	DSP1 (-6.2)	Top of Lower Holocene clay
	DSP3 (-6.9)	Top of Lower Holocene clay
VC2-MS19	DSP2 (-0.9)	Top of Holocence sand
	DSP1 (-5.9)	Top of Lower Holocene clay



Comparison of DOC-time plots from DSP

Comparison of DOC from Surface Settlements and DSP in LHC



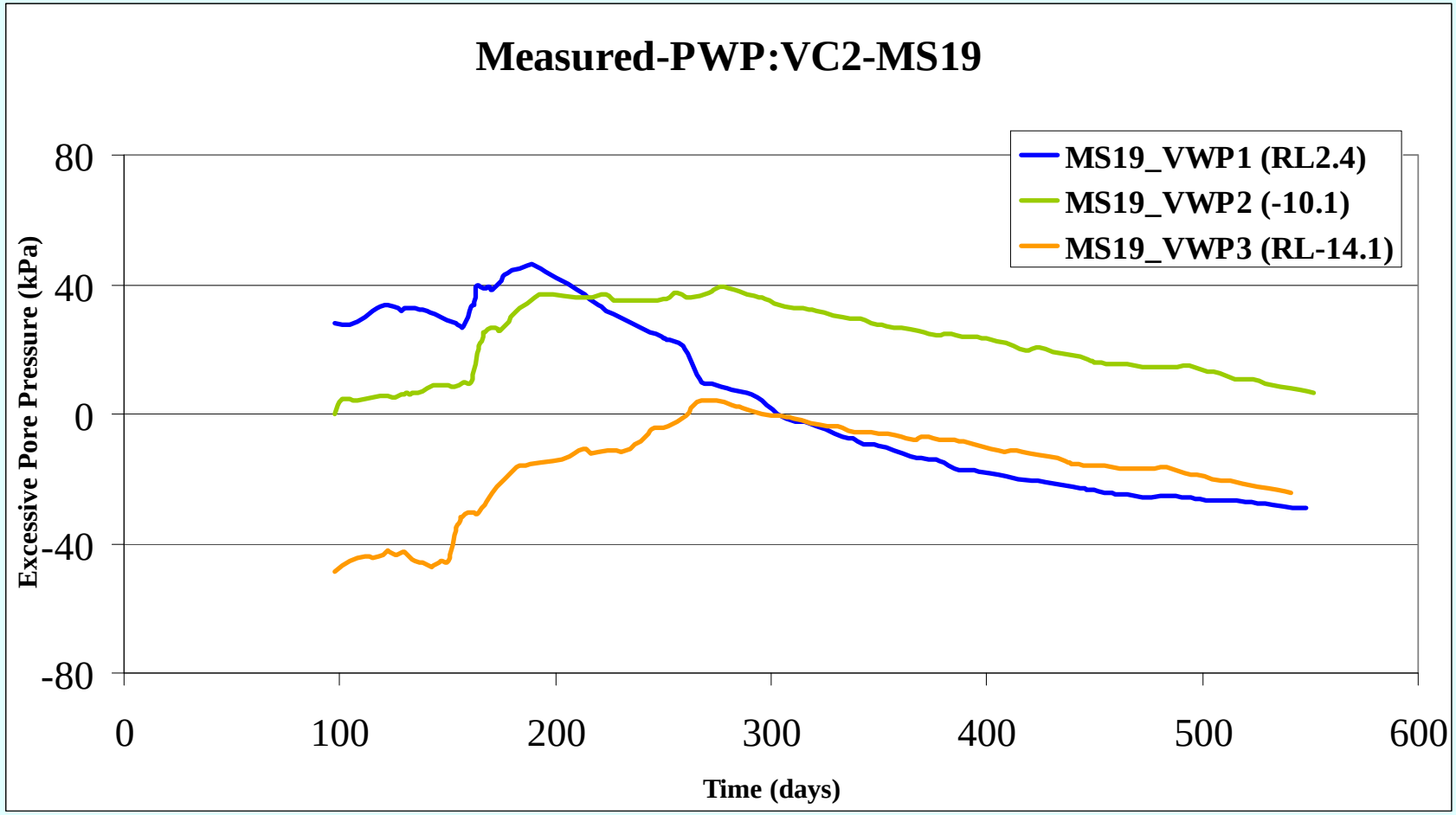


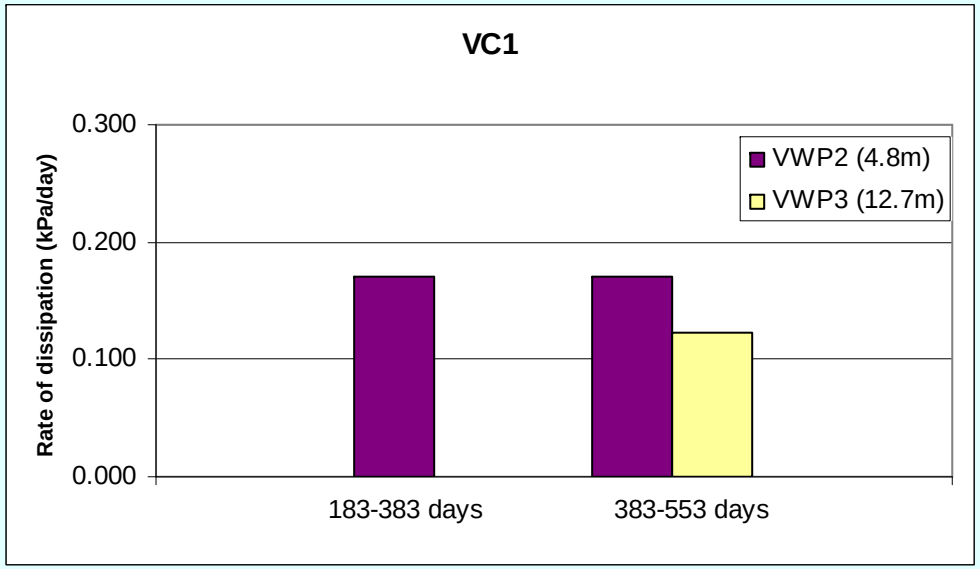
Pore pressure dissipation from piezometers

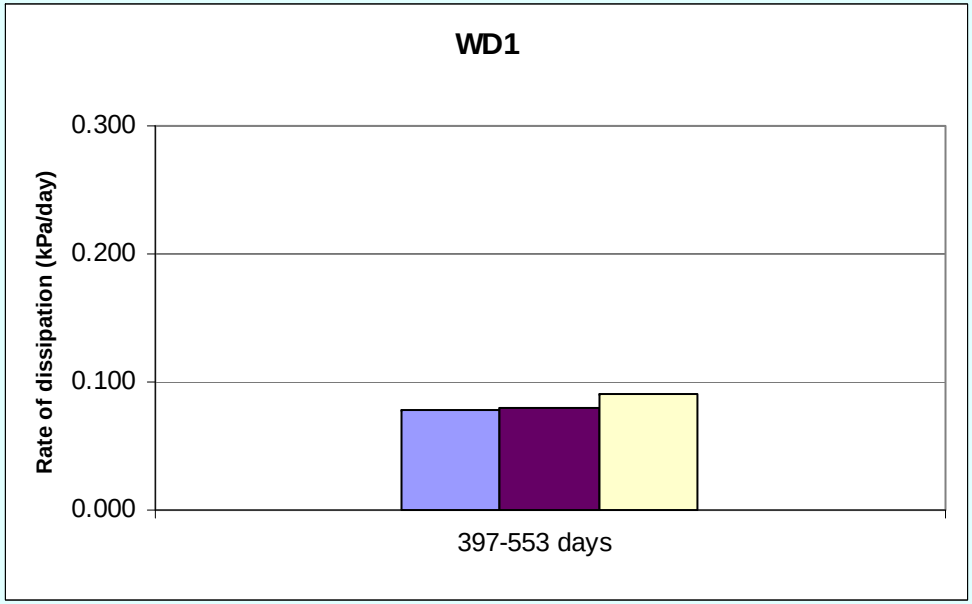
Locations of Piezometers

Sections		Piezometer (RL)	Locations
VC1	MS20	VWP1 (0.7)	Mud
		VWP2 (-10.1)	Lower Holocene Clay
		VWP3 (-13.8)	Lower Holocene Clay
		VWP4 (-18)	Lower Holocene Clay
	MS21	VWP1 (0.6)	Dredge sand
		VWP2 (-7.4)	Lower Holocene Clay
VC2-MS19		VWP1 (2.4)	Top of Mud
		VWP2 (-10.1)	Lower Holocene Clay
		VWP3 (-14.1)	Lower Holocene Clay

Measured Excess Pore Pressure







Comparison of Pore pressure dissipation rates

DOC and residual settlements

Residual Settlement criteria

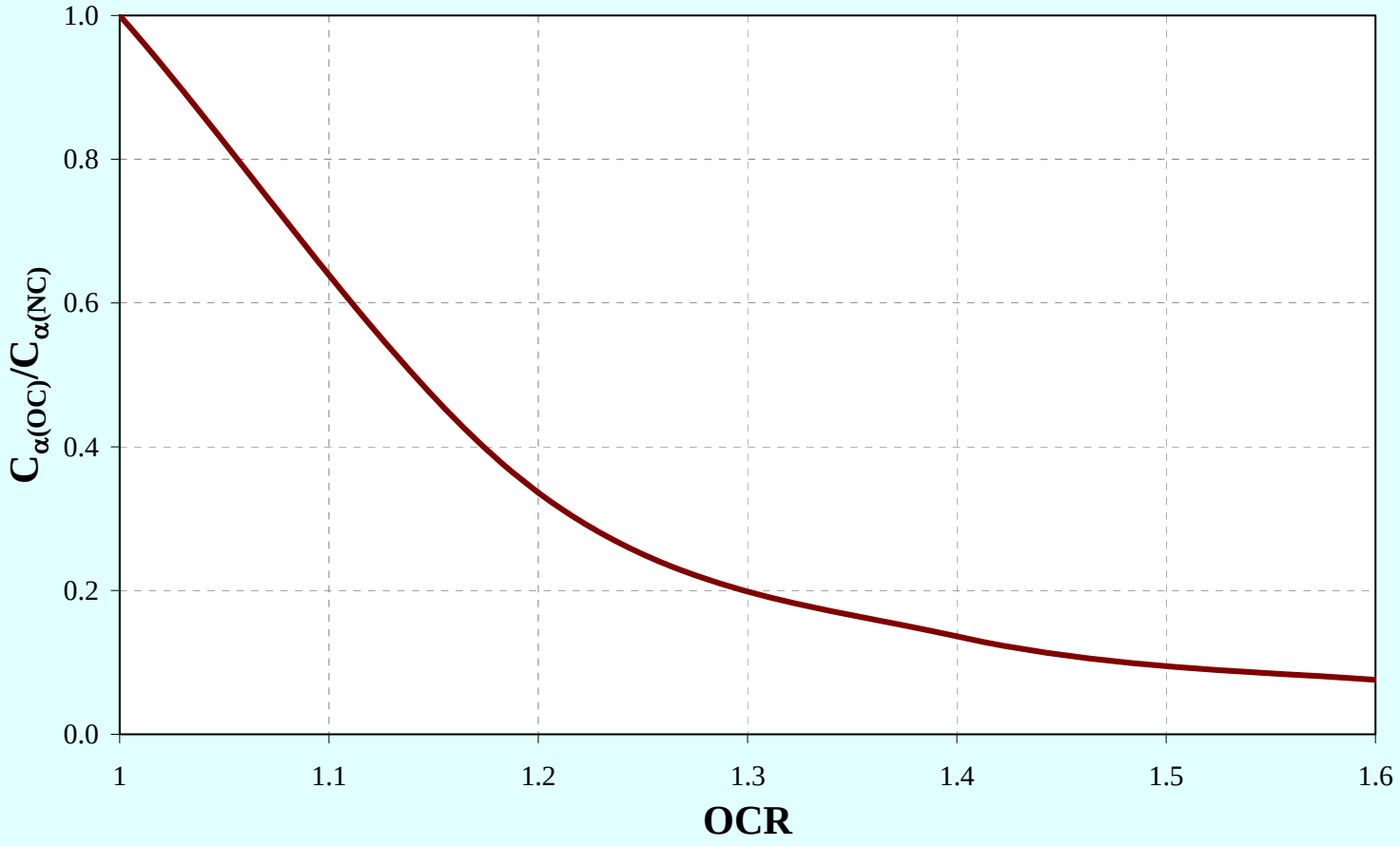
Three cases are considered for the residual settlements as follows:

- **Case 1: 150 mm settlement under 15 kPa service load in 20 year**
- **Case 2: 250 mm settlement under 25 kPa service load in 20 years**
- **Case 3: 150 mm settlement under 25 kPa service load in 20 years**

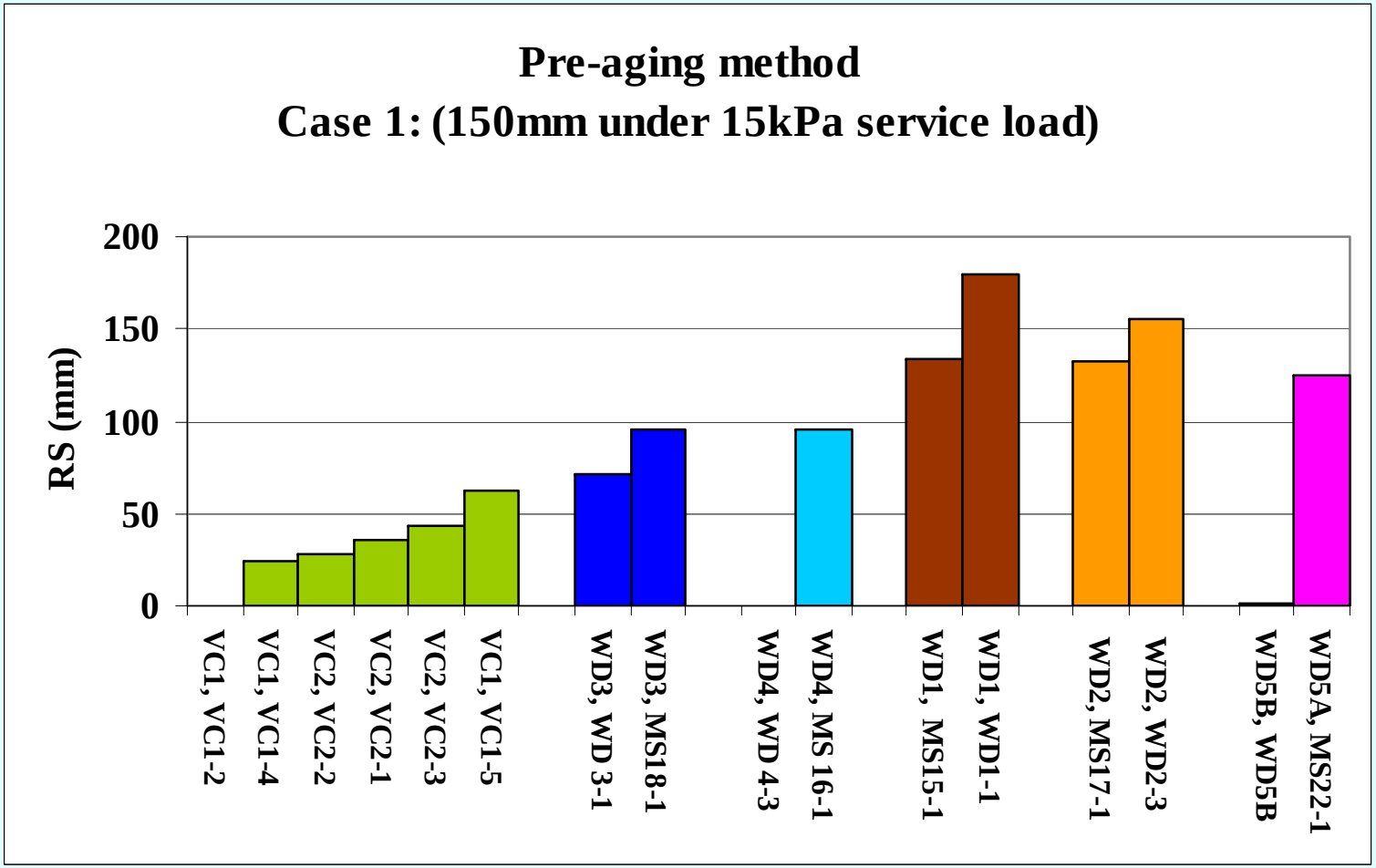
	Settlement plate	DOC at 1 year	DOC at removal time-15kPa (Case 1)	DOC at removal time-25kPa-250mm (Case 2)	DOC at removal time-25kPa-150mm (Case 3)	DOC at 18 months
WD1	MS15-1	0.88	0.97	0.94	0.97	0.96
	WD1-1	0.86	0.92	0.91	0.92	0.95
WD2	MS17-1	0.77	0.90	0.92	0.93	0.89
	WD2-3	0.77	0.85	0.85	0.88	0.89
WD3	MS18-1	0.90	0.94	0.94	0.94	0.97
	WD 3-1	0.89	0.94	0.96	0.98	0.97
WD4	MS 16-1	0.79	0.88	0.90	0.94	0.91
	WD 4-3	0.80	0.85	0.85	0.89	0.92
WD5A	MS22-1	0.90	0.93	0.93	0.93	0.97
WD5B	WD5B	0.91	0.94	0.94	0.94	0.97
VC1	VC1-2	0.88	0.92	0.92	0.92	0.95
	VC1-4	0.84	0.88	0.88	0.88	0.94
	VC1-5	0.83	0.88	0.88	0.96	0.93
VC2	VC2-1	0.82	0.87	0.87	0.87	0.93
	VC2-2	0.85	0.89	0.89	0.89	0.94
	VC2-3	0.85	0.89	0.89	0.89	0.94

DOC at different times

Cα(OC)/Cα(NC) – OCR Relationship



Residual Settlements: Case 1



Lateral movements

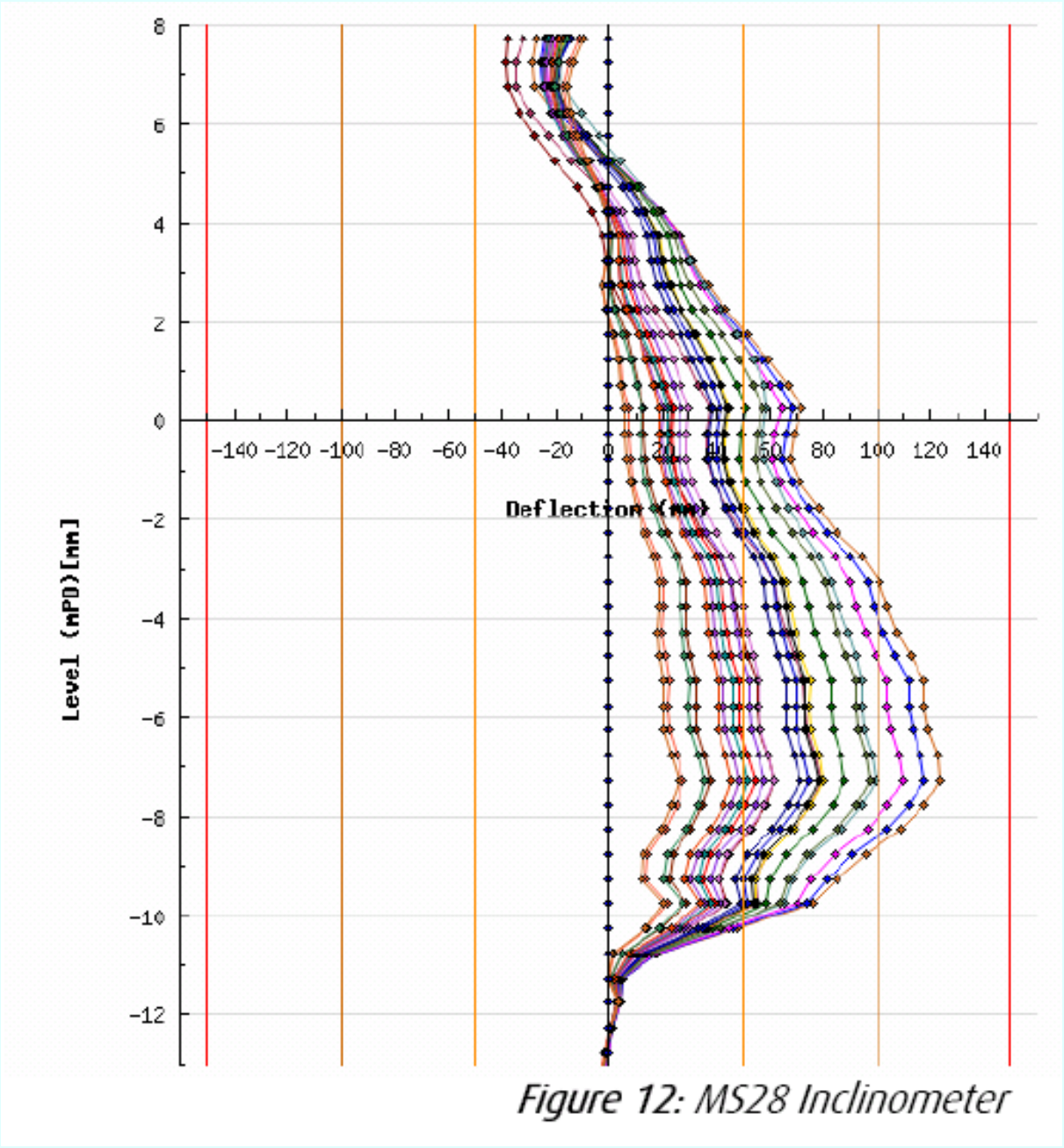
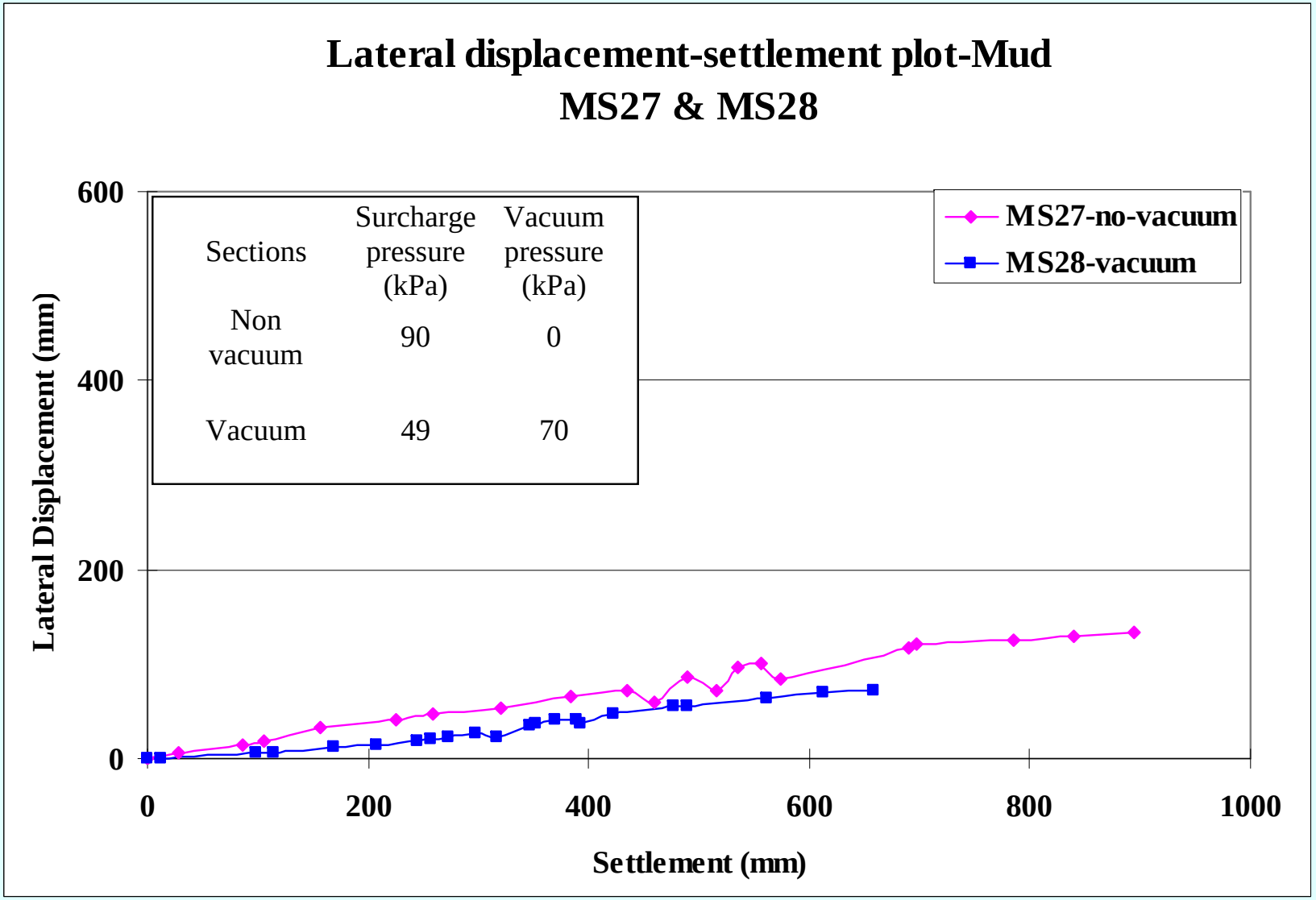


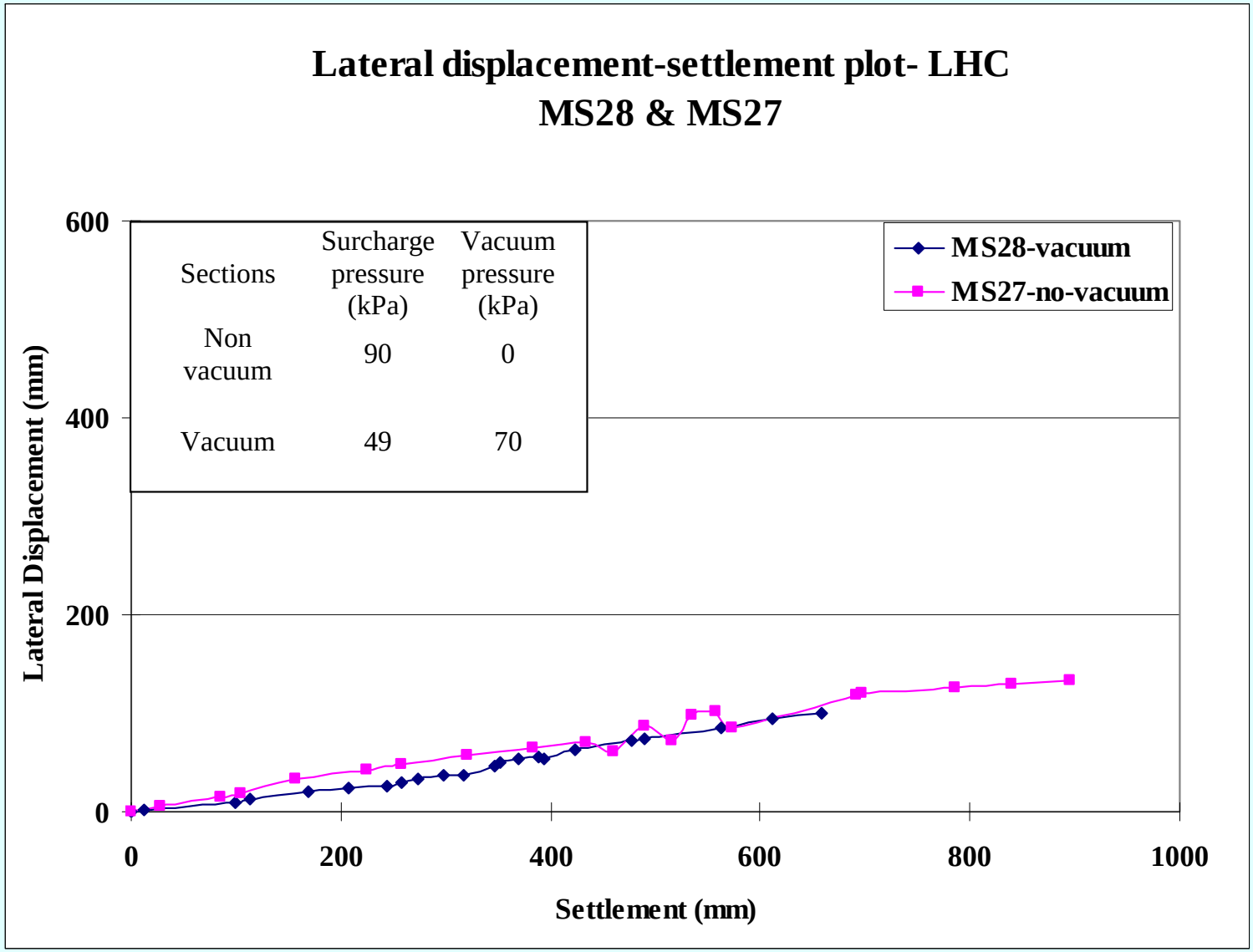
Figure 12: MS28 Inclinometer

Lateral movement profile with depth – VC section

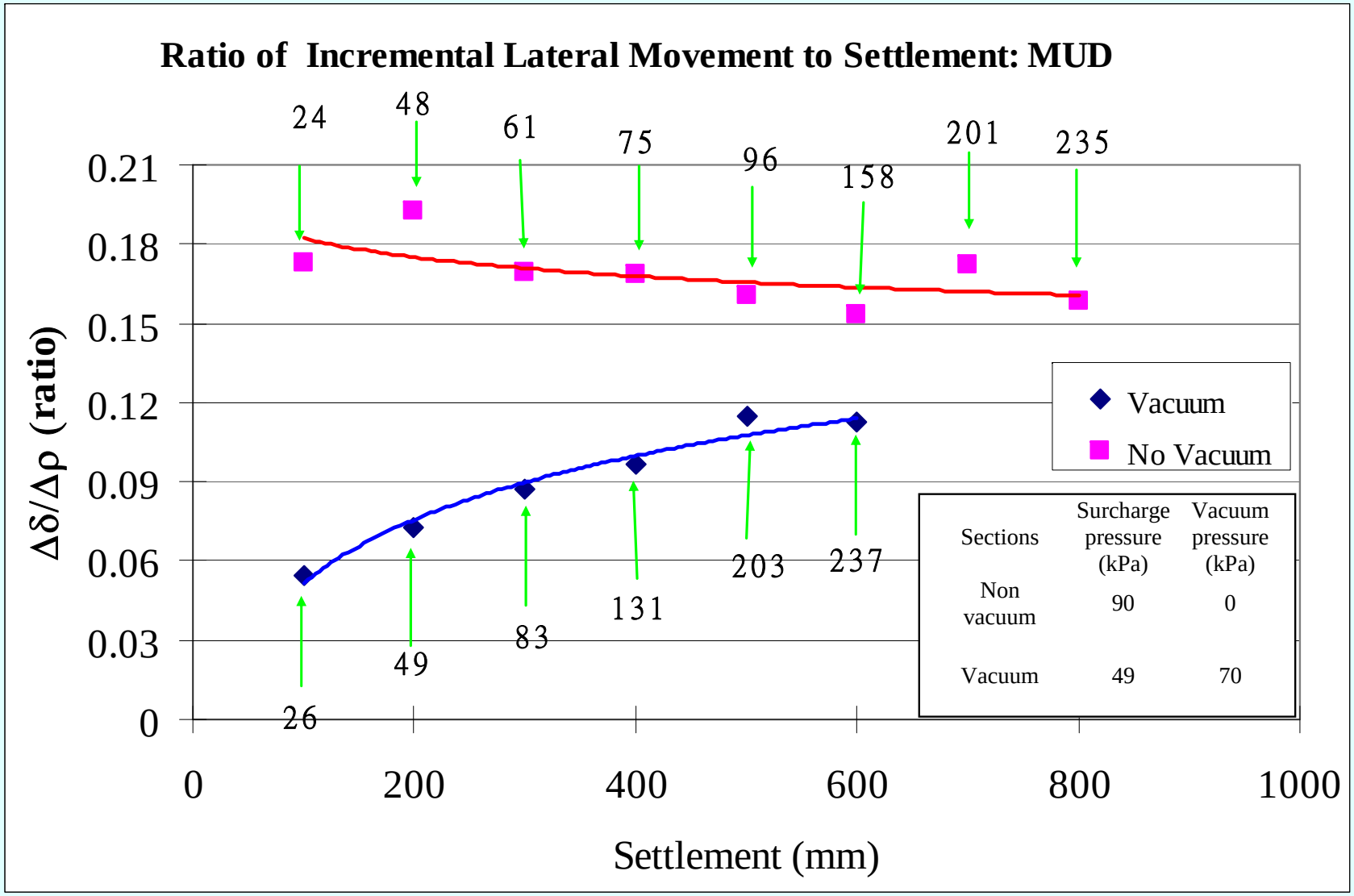
Comparison of lateral displacement-settlement plots (Mud)



Comparison of lateral displacement-settlement plots (LHC)



Ratio of incremental lateral movement to settlement (Mud)



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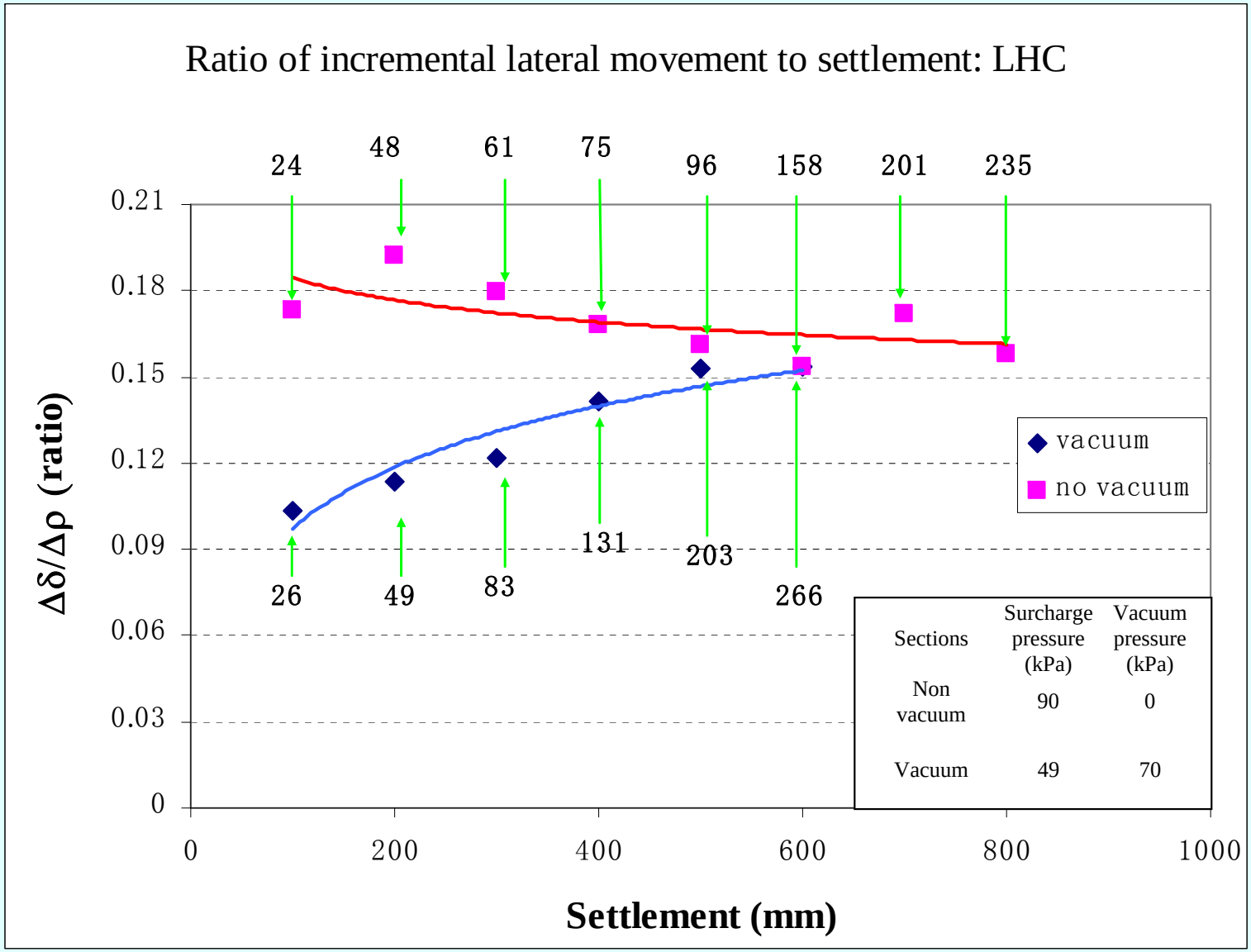
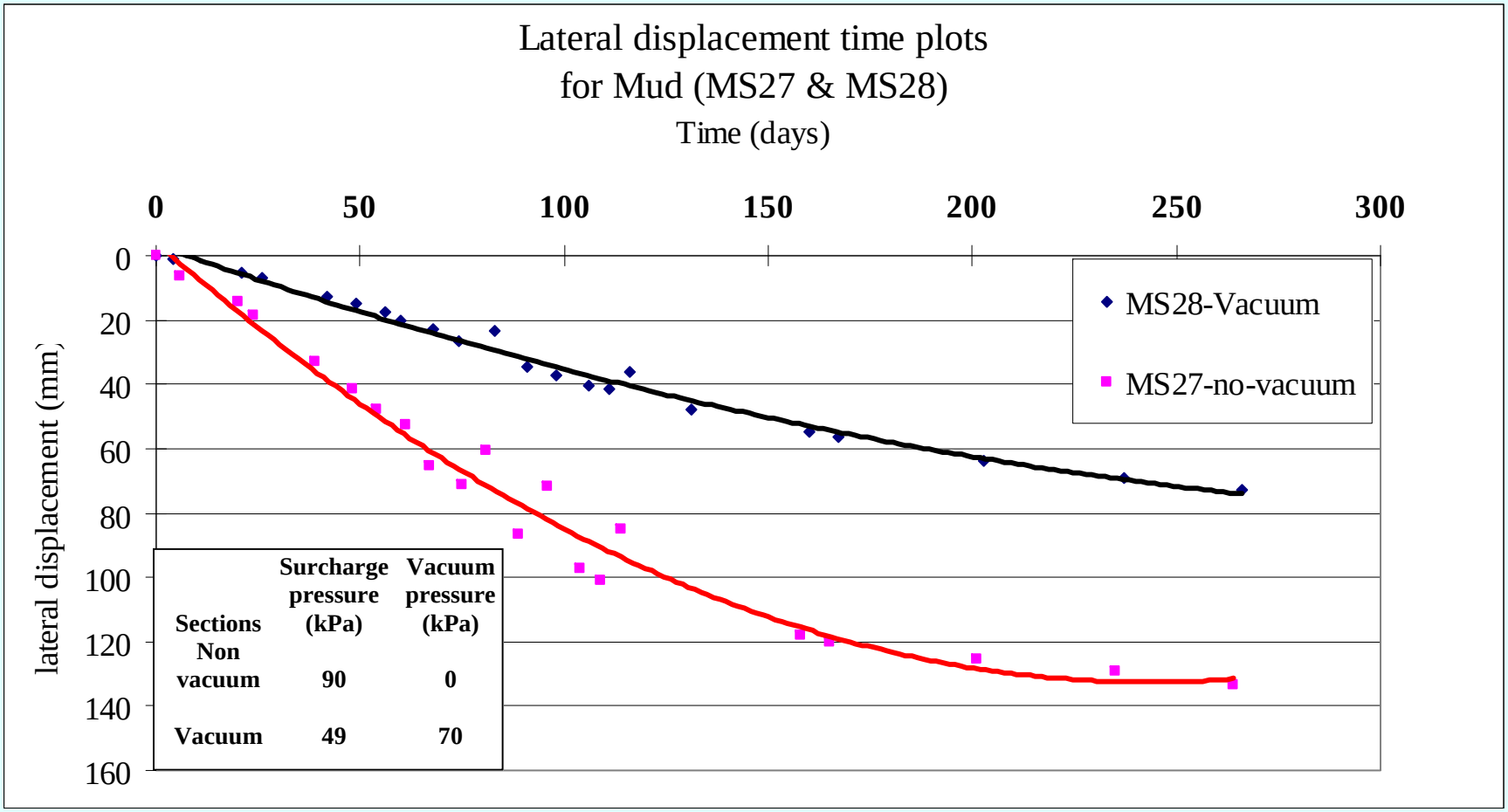
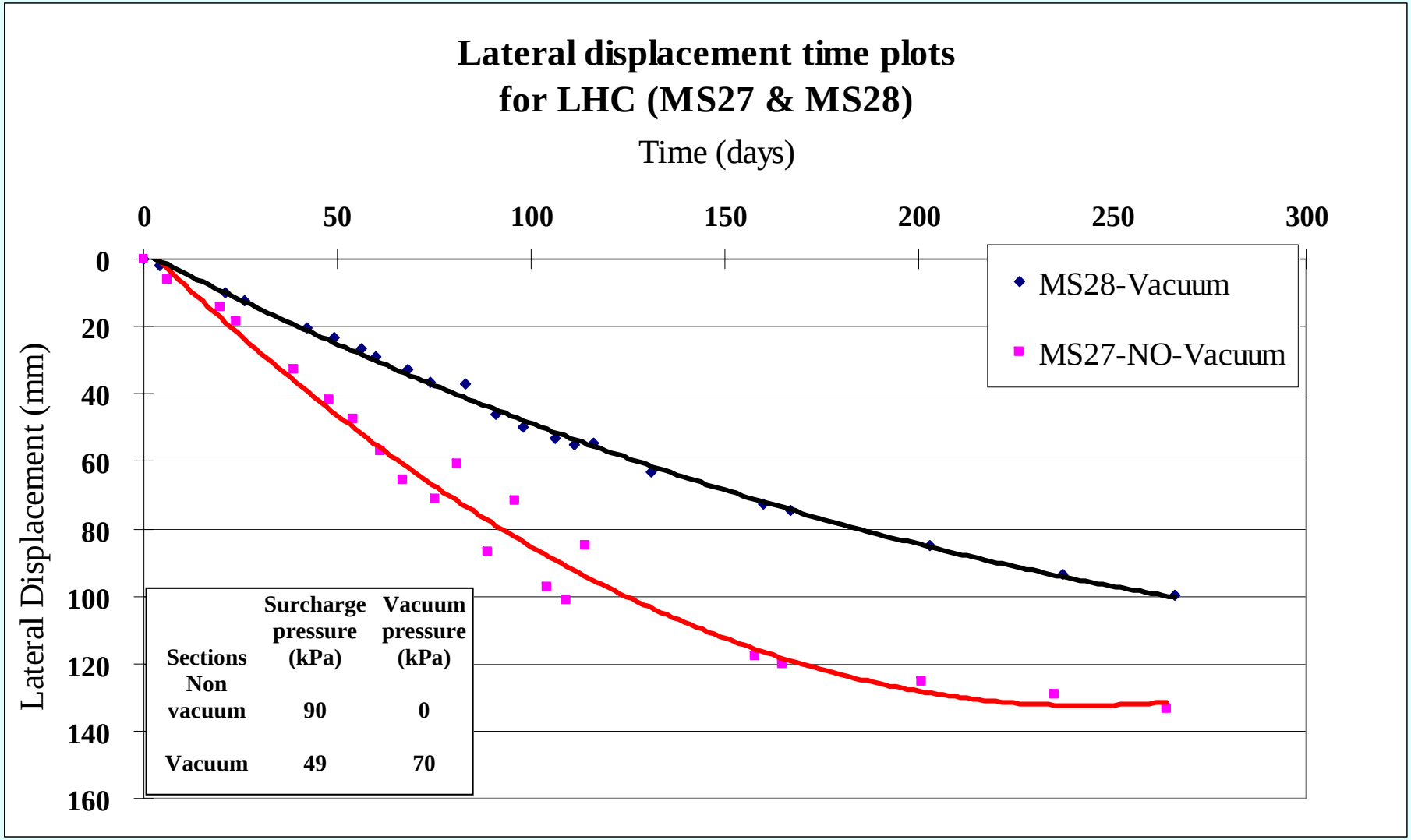


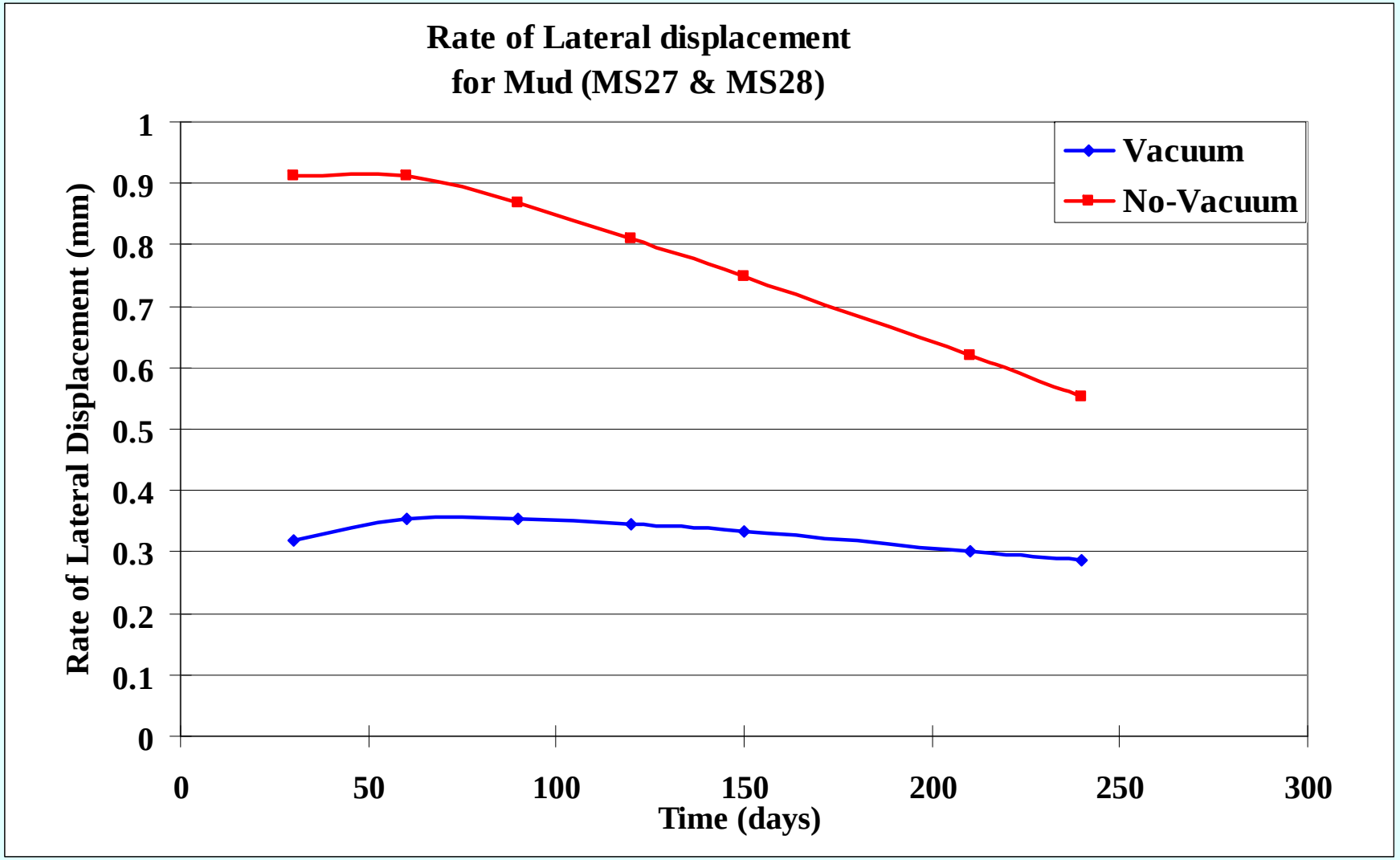
Lateral displacement time plots (Mud)



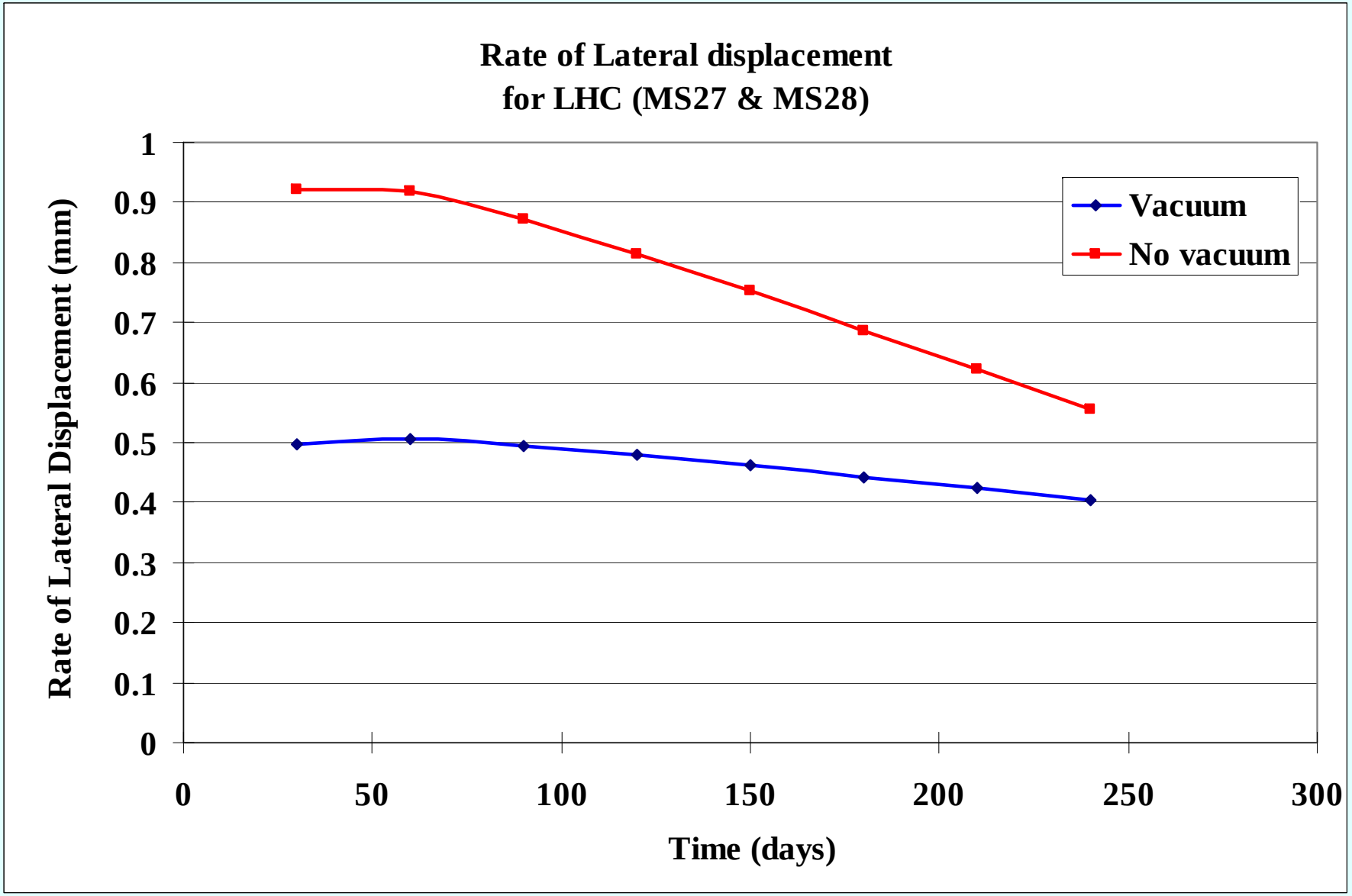
Lateral displacement time plots (LHC)



Comparison of rates of lateral displacement (Mud)

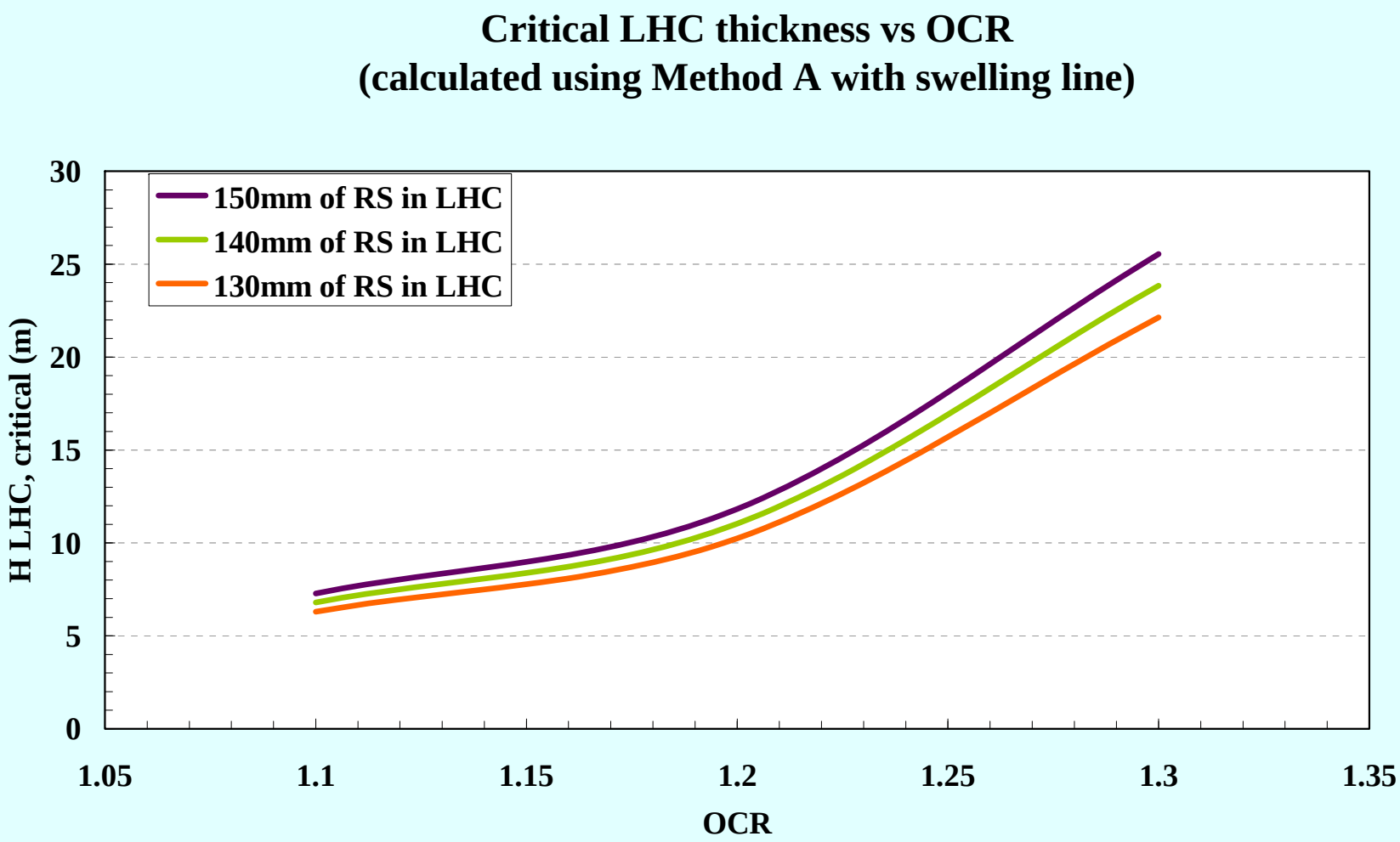


Comparison of rates of lateral displacement (LHC)



Limitation of residual settlement in LHC

Critical Thickness of LHC



Conclusions

Conclusions

- **From the interpretations of surface settlements, deep settlements, pore pressures and the lateral displacements, it can be concluded that:**
- **(1) The DOC is found to be successful in all ways to evaluate the relevant relative performances.**
- **(2) The VC sections performed better than the WD areas with no vacuum with respect to all the field measured parameters.**
- **(3) Clear evidences are there to demonstrate that the 1.1m drain spacing performs better than the 1.3 m drain spacing; with some anomaly.**