

Appendix J: Liquefaction Vulnerability Parameter Sensitivity Analyses

Table J1.1 – Classifications used for CPT and borehole log review

CPT Examples J1 – J11

This appendix presents examples of each of the classifications used for the review of CPT and boreholes during the Stage 2 ILV qualification process. The different classifications are presented in Table J1.1 followed by the examples.

Table J1.1: Classifications used for CPT and borehole review

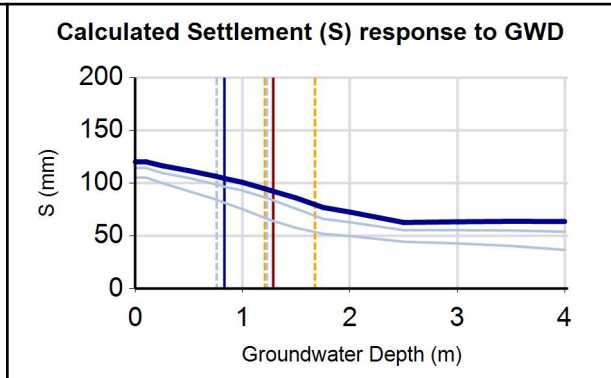
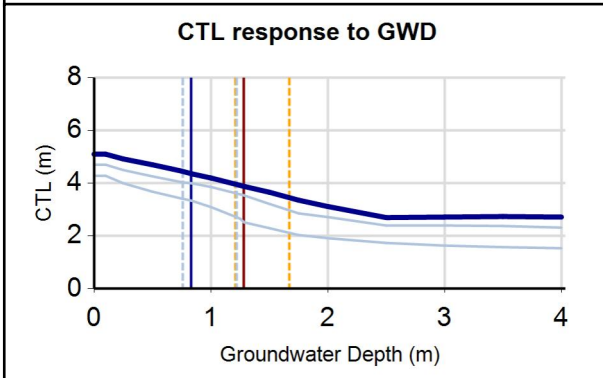
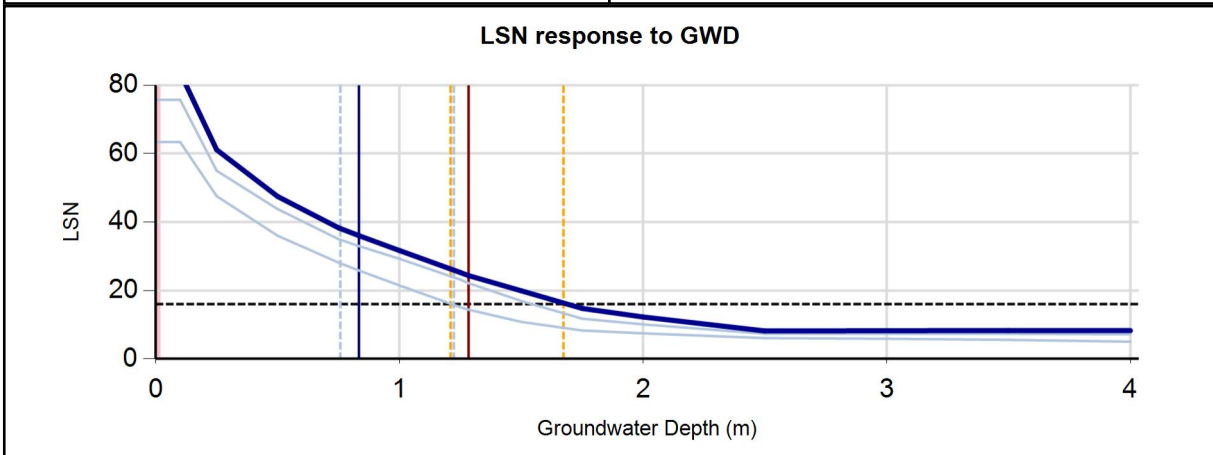
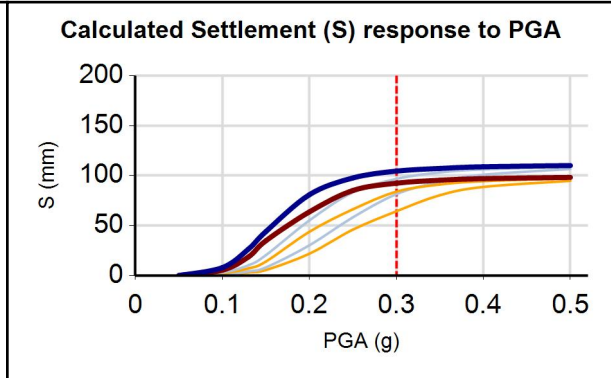
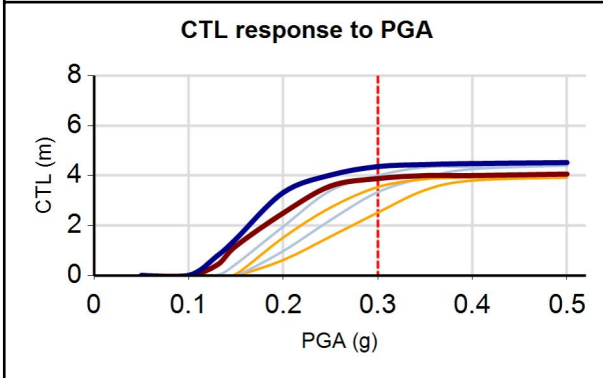
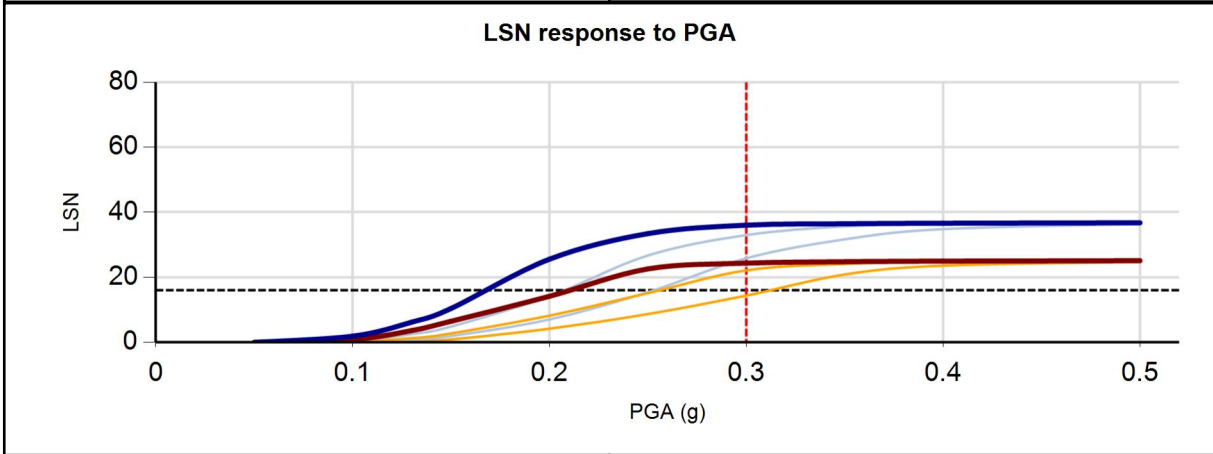
| Symbol | Description | Example |
|----------|---|--------------|
| ✓ | Post-CES median LSN at M6 0.3g greater than or equal to 16 and Δ LSN greater than or equal to 5 | J1 |
| ✘ | Post-CES median and mean LSN at M6 0.3g less than or equal to 14; or Post-CES median and mean LSN at M6 0.3g between 14 and 16 and Δ LSN less than 5. | J2 |
| Mean✓ | Post-CES mean LSN at M6 0.3g greater than or equal to 16 and mean Δ LSN greater than or equal to 5 | J3 |
| NC | Post-CES median and mean LSN at M6 0.3g greater than or equal to 16 and Δ LSN less than 4. | J4 |
| M | Post-CES LSN at M6 0.3g greater than or equal to 16 and Δ LSN between 4 and 5; or Post-CES median and mean LSN at M6 0.3g between 14 and 16 and Δ LSN greater than or equal to 5 | J5.1 J5.2 |
| PD | Pre-drill on CPT affects LSN result | J6 |
| ? | CPT data quality is questionable | J7 |
| SC | Stress Change – Δ LSN at M6 0.3g is less than 5; but Δ LSN is greater than or equal to 5 for any M6 PGA less than 0.3g where the corresponding post-CES LSN is greater than 16 | J8 |
| S | CPT depth is less than 5m | J9 |
| ✓h | LSN > 16 and Δ LSN > 5 at M6 0.3g but LSN is hypersensitive to very small changes in depth of groundwater (typically where groundwater is shallower than 0.5m) | J10 |
| GW issue | Significant difference between the mean and median groundwater levels noted | J11 |

J1

LSN > 16

Δ LSN > 5

| | | | |
|---|--|---|---------------------|
| CGD ID: 15566 | LSN Pre Sept = 24 | LSN Post Dec = 36 | Δ LSN = 11.7 |
| Key: ■ Pre Sept GWD 1.3m ■ Post Dec GWD 0.8m CFC = 0 | Predrill Depth = 0m CPT Depth = 10m Ic Limit = 2.6 | Investigation Date: 25/01/2013 Supervising Company: Tonkin & Taylor Ltd Drilling Company: RDCL CPT Rig: Geoprobe66 | |

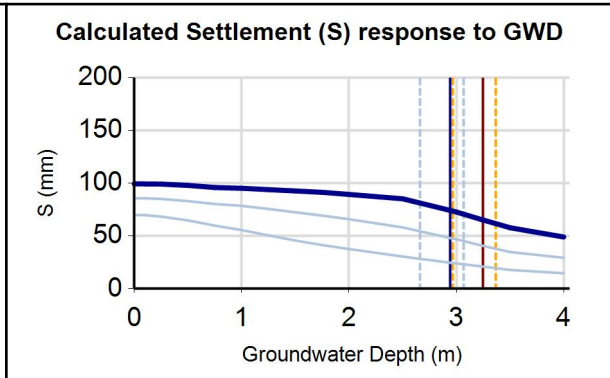
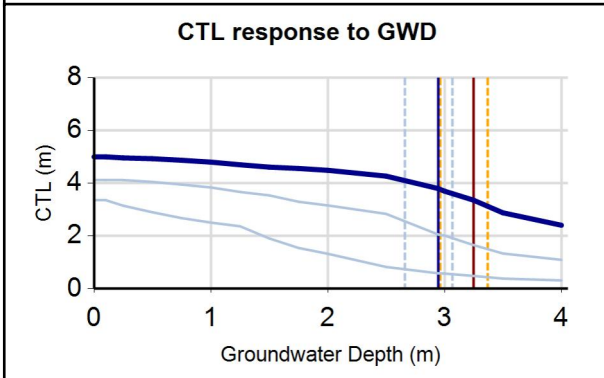
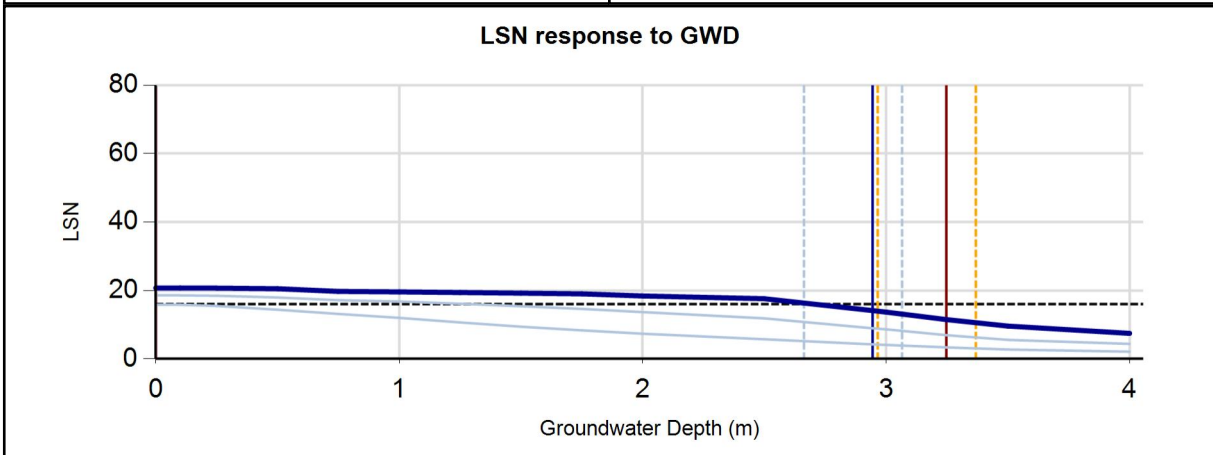
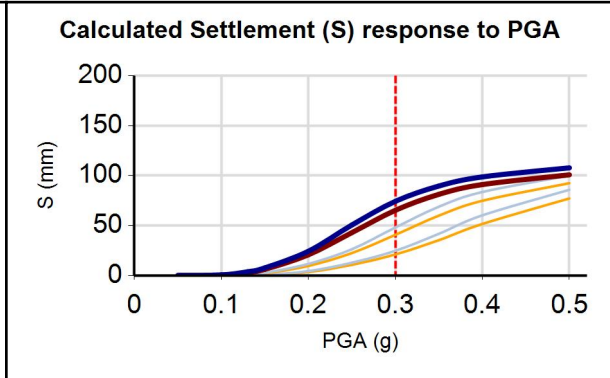
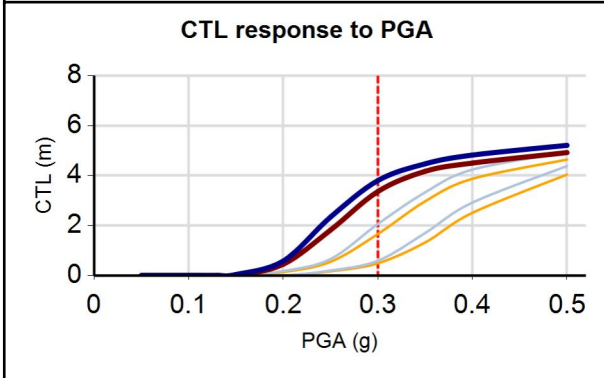
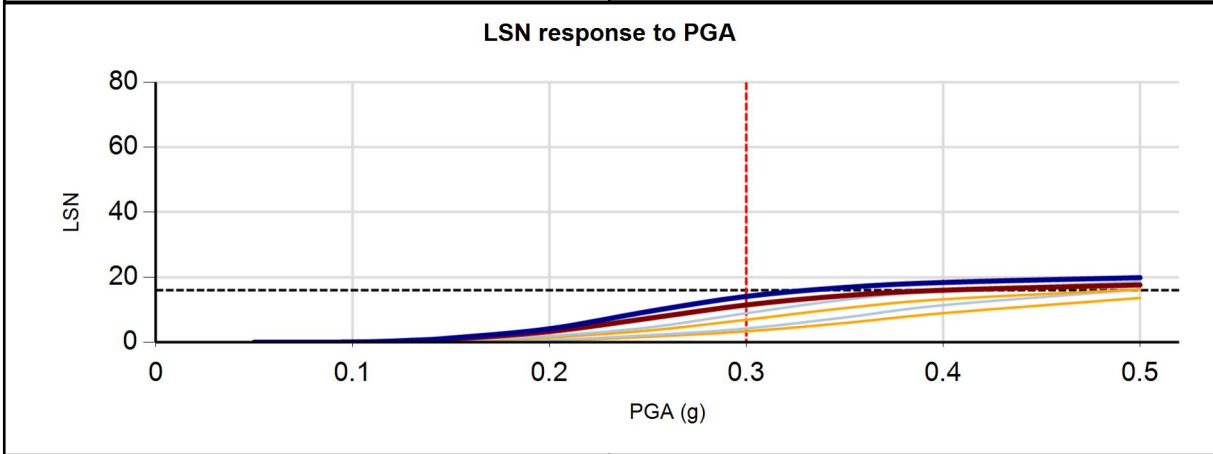


J2

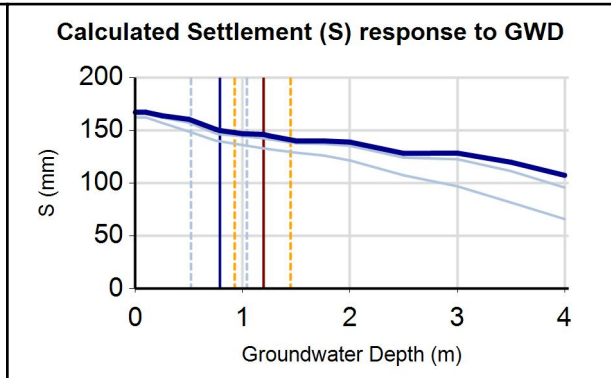
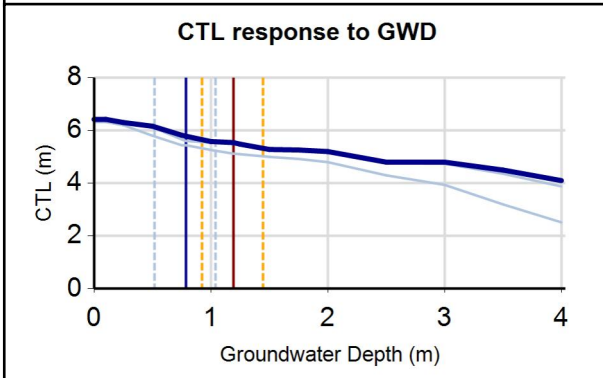
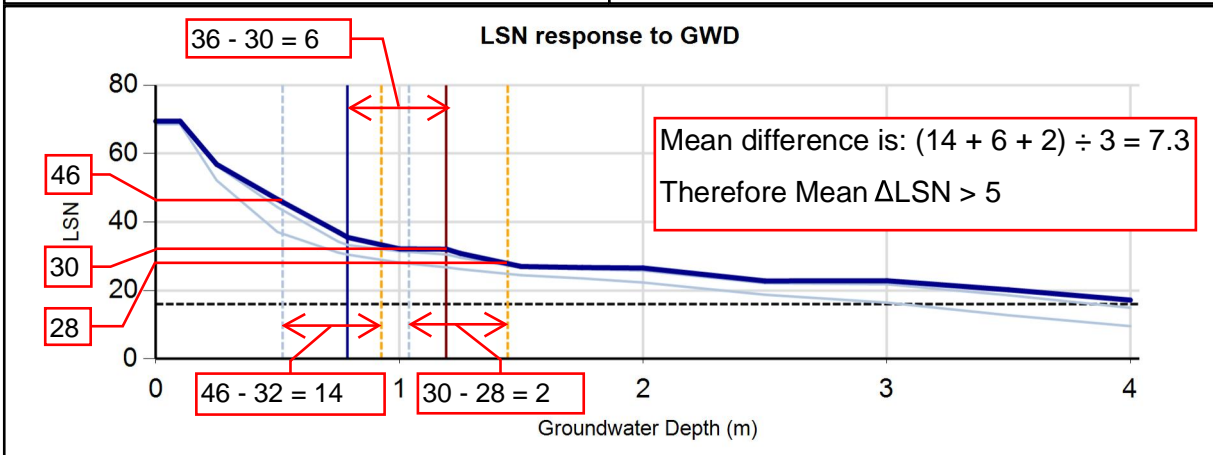
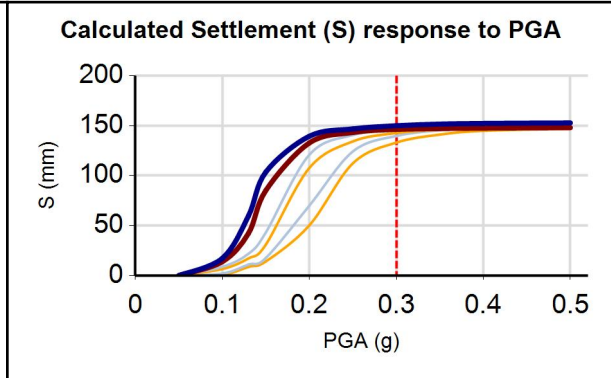
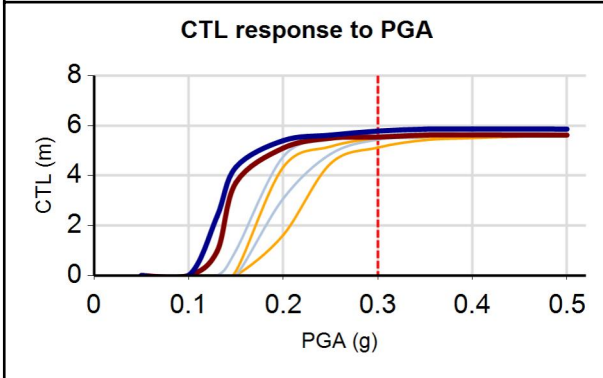
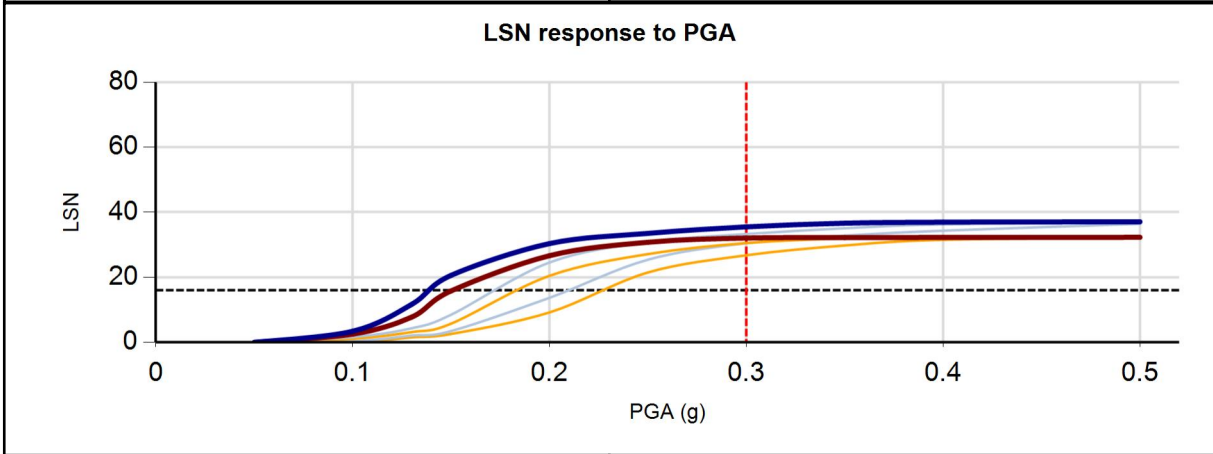
LSN < 16

Δ LSN < 5

| | | | |
|---|---|--|--------------------|
| CGD ID: 17155 | LSN Pre Sept = 12 | LSN Post Dec = 14 | Δ LSN = 2.6 |
| Key: ■ Pre Sept GWD 3.2m ■ Post Dec GWD 2.9m CFC = 0 | Predrill Depth = 0m CPT Depth = 19.92m Ic Limit = 2.6 | Investigation Date: 30/11/2012 Supervising Company: Coffeys Drilling Company: Coffey Information CPT Rig: PG200 | |



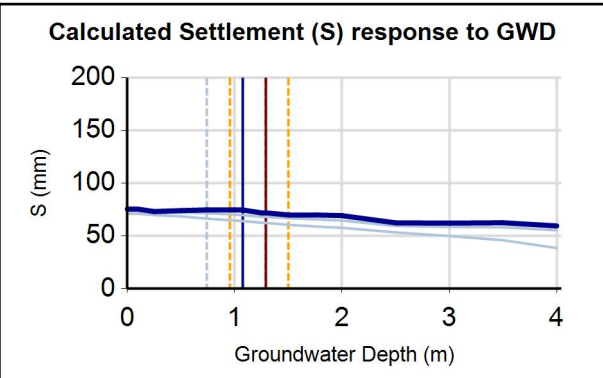
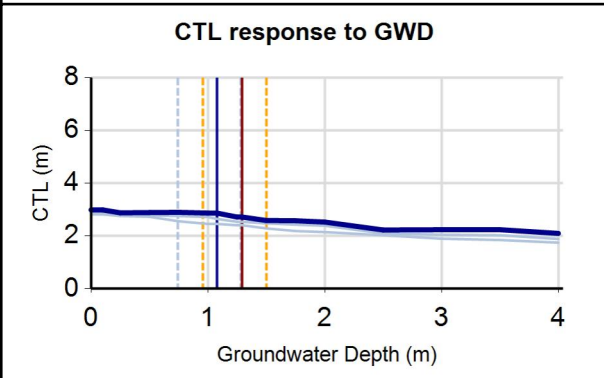
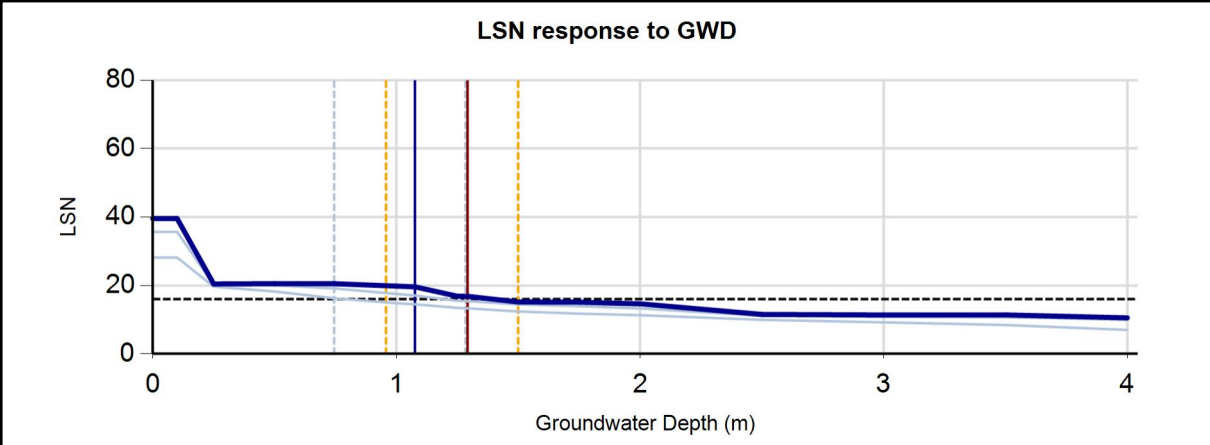
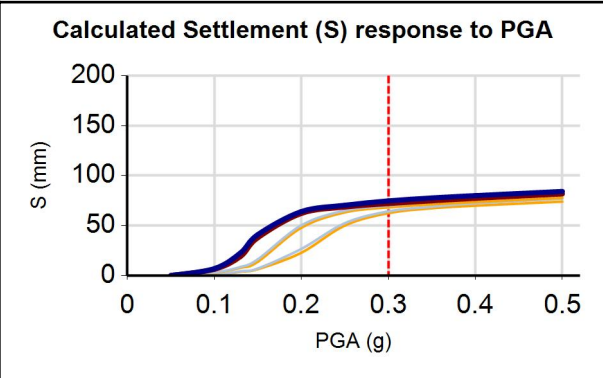
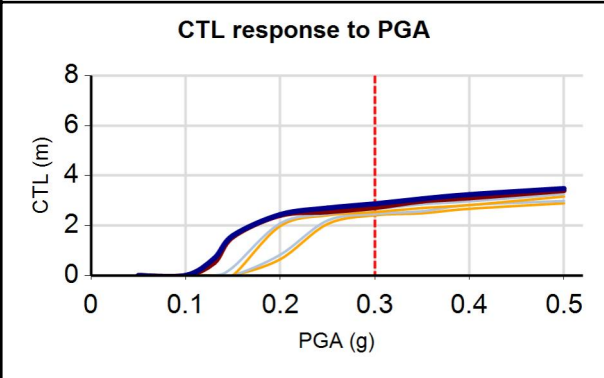
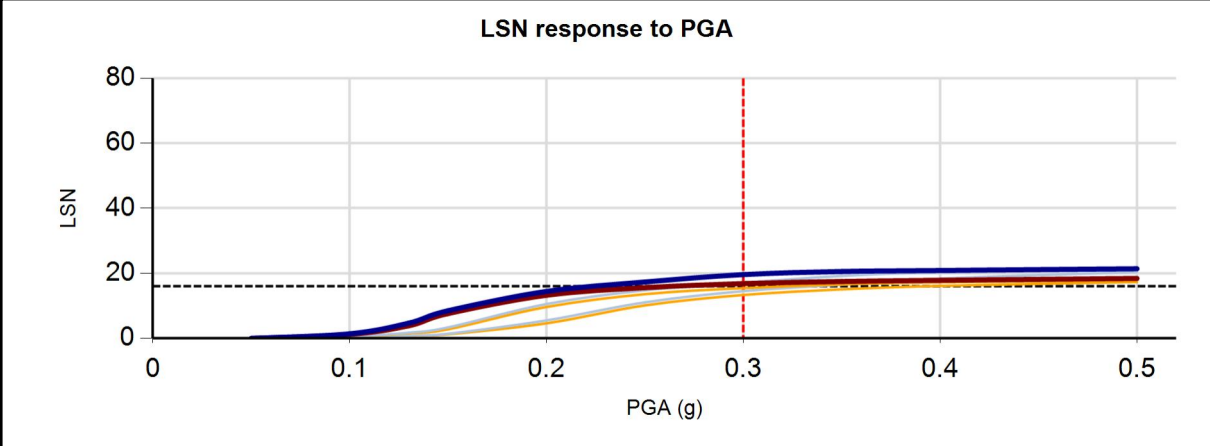
| | | | |
|---------------------|---------------------|----------------------|--------------------|
| CGD ID: 49423 | LSN Pre Sept = 32 | LSN Post Dec = 36 | Δ LSN = 3.4 |
| Key: | | Investigation Date: | 3/11/2014 |
| ■ Pre Sept GWD 1.2m | Predrill Depth = 0m | Supervising Company: | Geotechnics LTD |
| ■ Post Dec GWD 0.8m | CPT Depth = 9.64m | Drilling Company: | Geotechnics |
| CFC = 0 | Ic Limit = 2.6 | CPT Rig: | Georig220 |



LSN > 16

Δ LSN < 5

| | | | |
|---|-------------------|--|--------------------|
| CGD ID: 36085 | LSN Pre Sept = 17 | LSN Post Dec = 20 | Δ LSN = 2.8 |
| Key: ■ Pre Sept GWD 1.3m ■ Post Dec GWD 1.1m CFC = 0 | | Investigation Date: 5/10/2013 Supervising Company: Cook Costello Ltd Drilling Company: GEOCIVIL CPT Rig: Geomil LWC 200 | |
| Predrill Depth = 0m CPT Depth = 19.04m Ic Limit = 2.6 | | | |

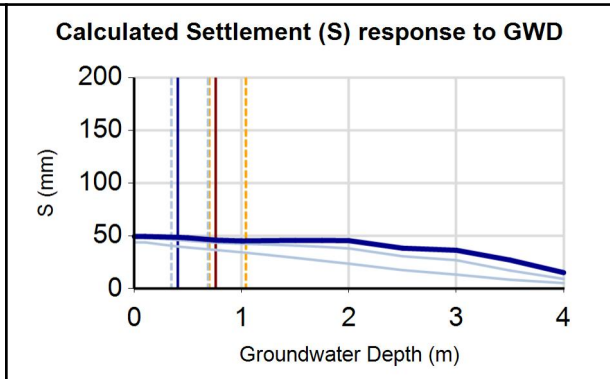
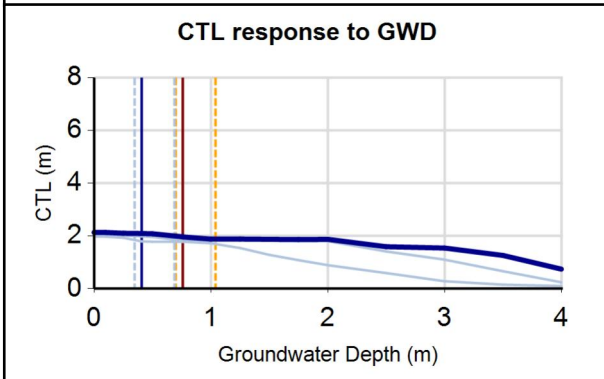
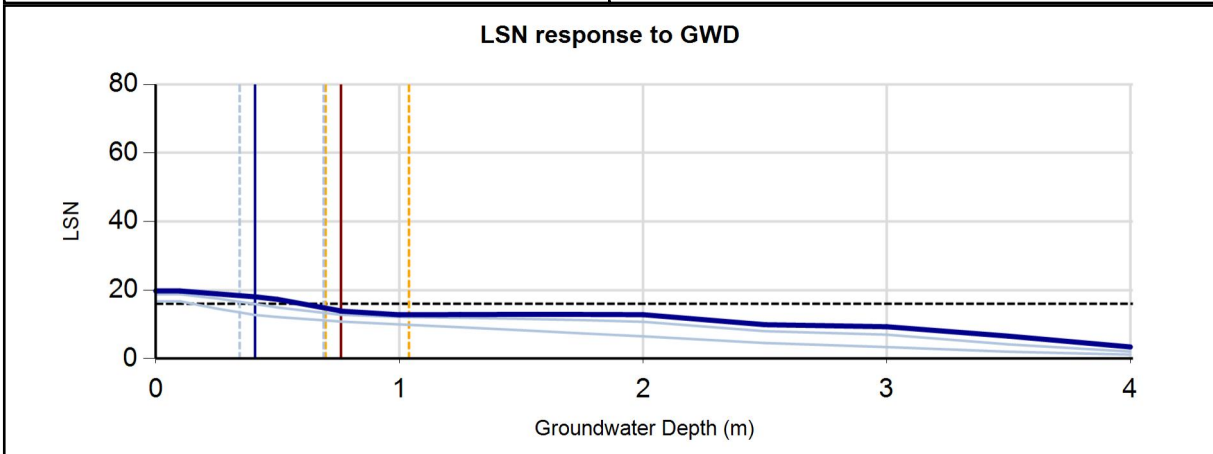
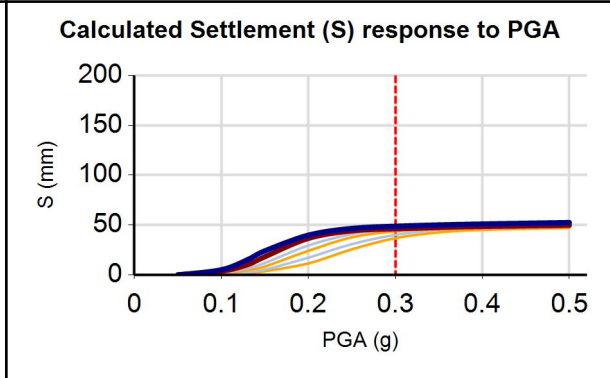
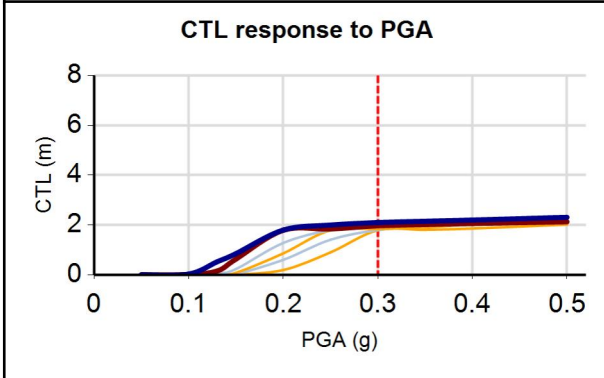
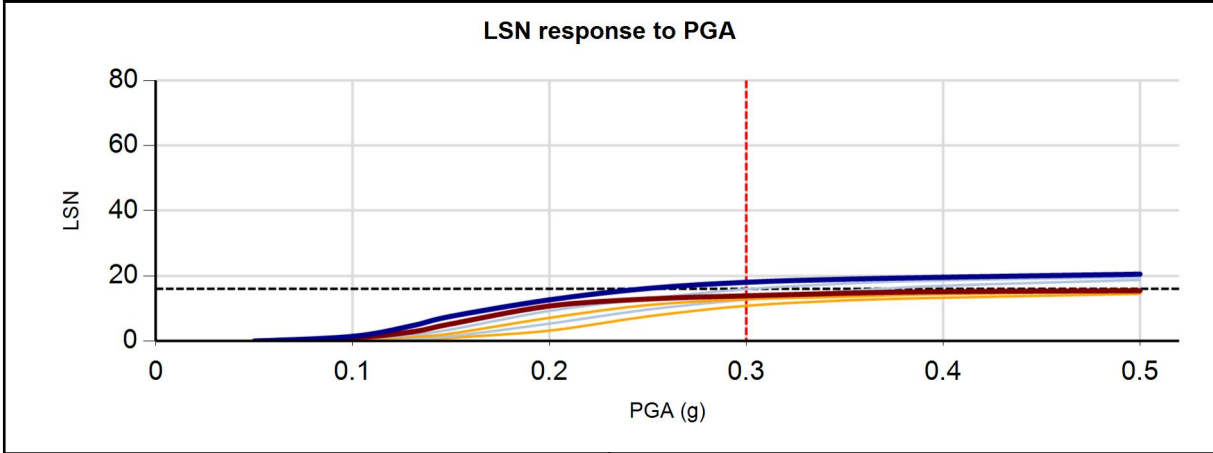


J5.1

LSN > 16

Δ LSN between 4 and 5

| | | | |
|--|-------------------|---|--------------------|
| CGD ID: 45578 | LSN Pre Sept = 14 | LSN Post Dec = 18 | Δ LSN = 4.2 |
| Key: ■ Pre Sept GWD 0.8m ■ Post Dec GWD 0.4m CFC = 0 | | Investigation Date: 25/07/2014 Supervising Company: Tonkin & Taylor Ltd Drilling Company: Lankelma CPT Rig: Lankelma Geomil 200kN (UK18) | |
| Predrill Depth = 0m CPT Depth = 10.23m Ic Limit = 2.6 | | | |

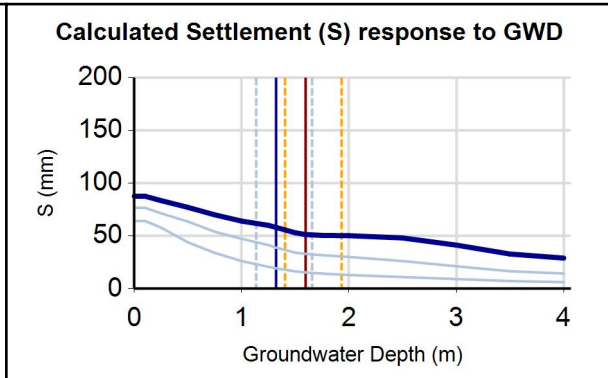
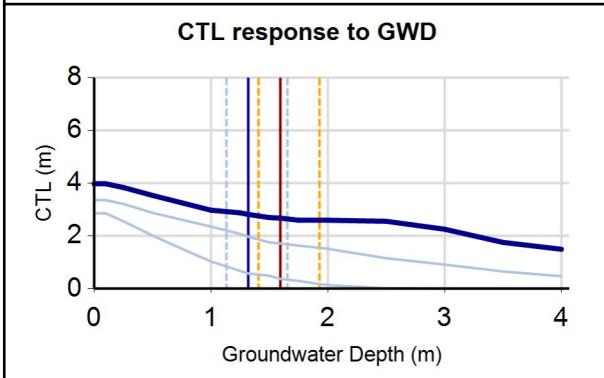
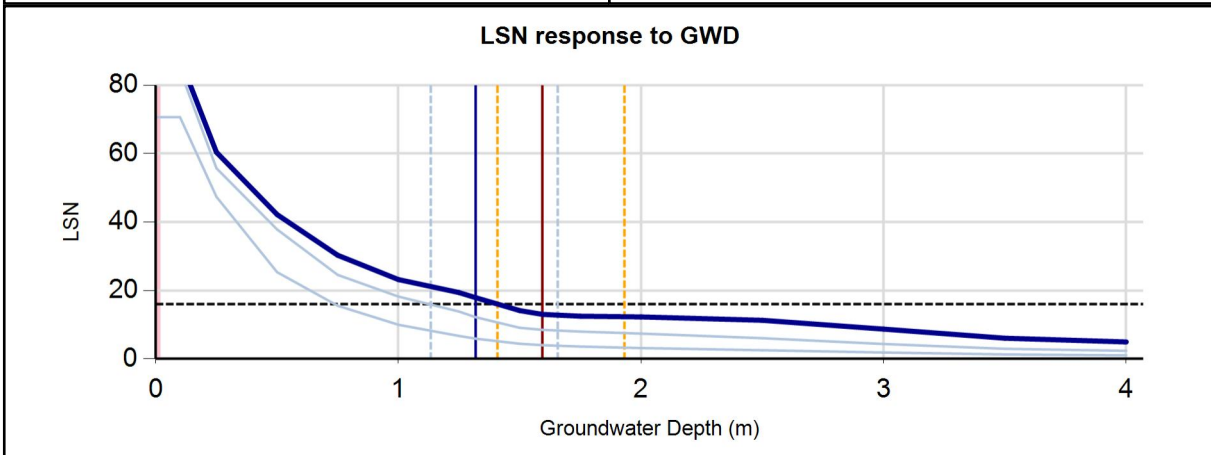
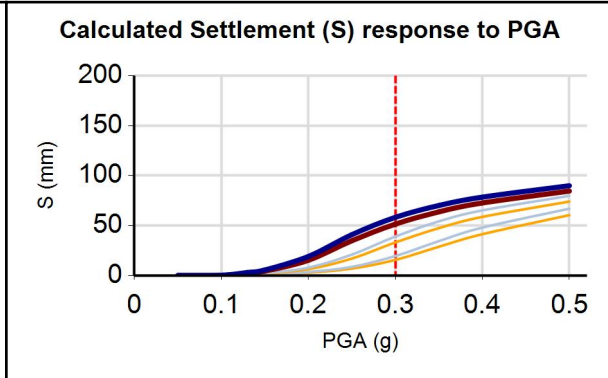
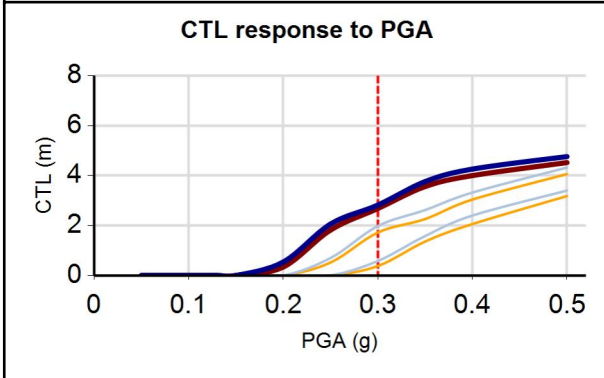
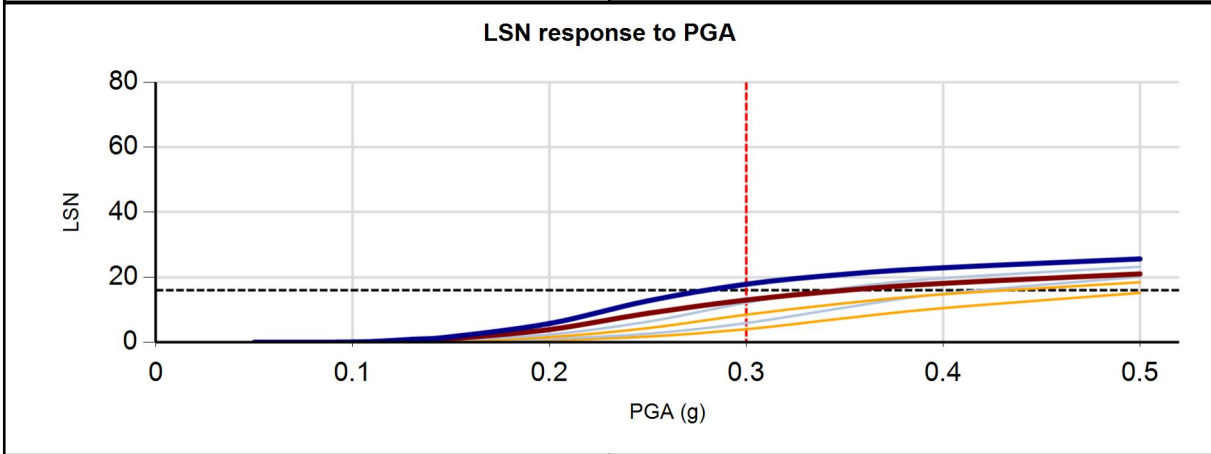


J5.2

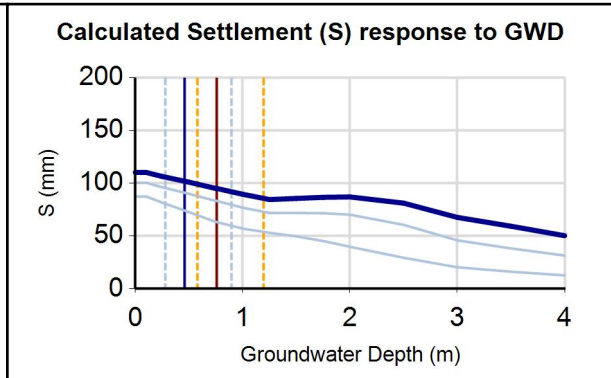
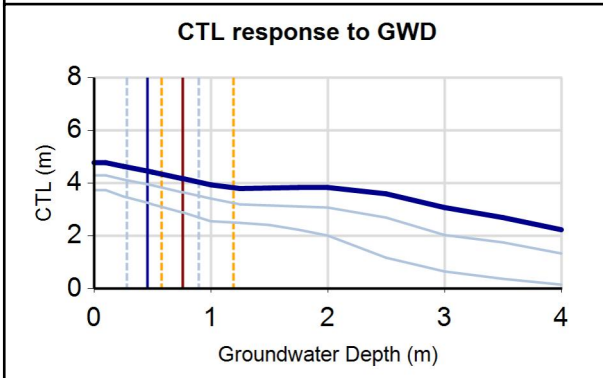
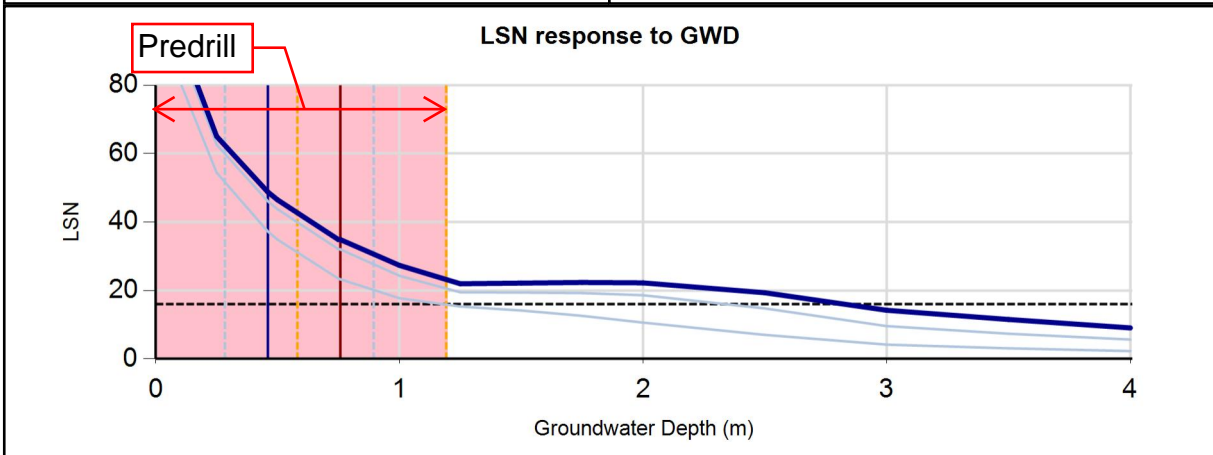
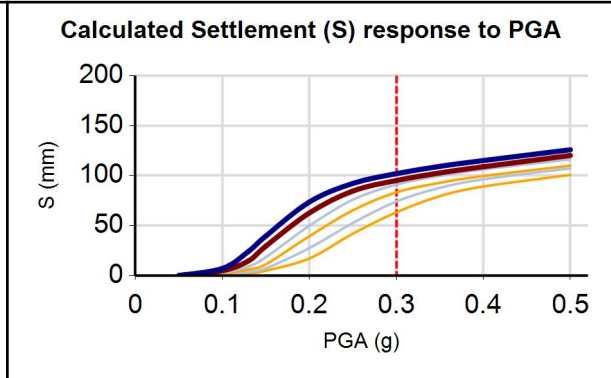
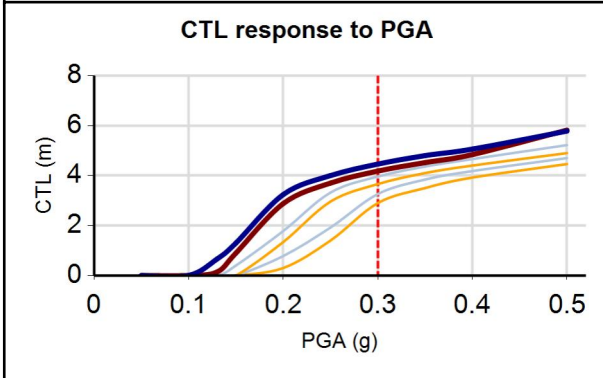
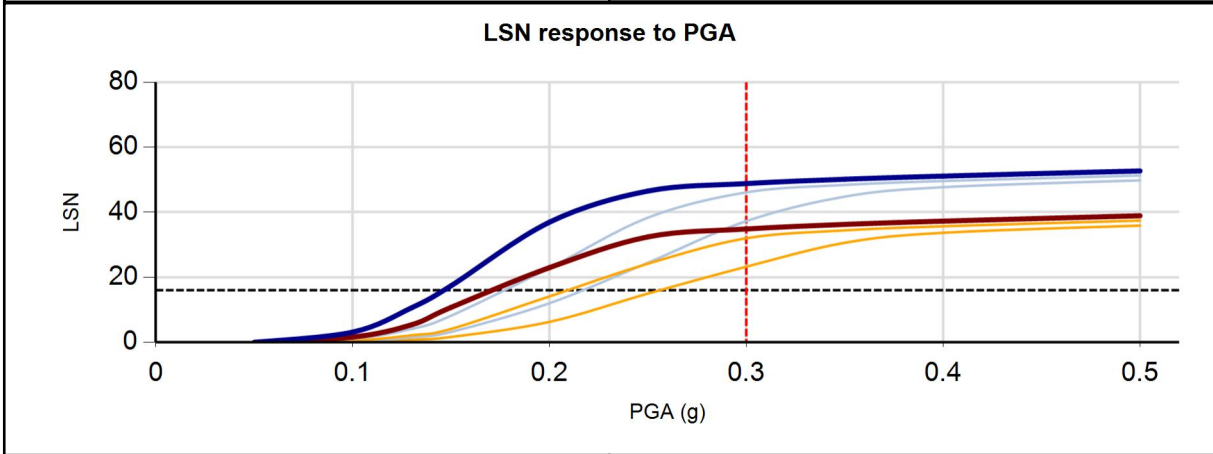
LSN > 16

Δ LSN between 4 and 5

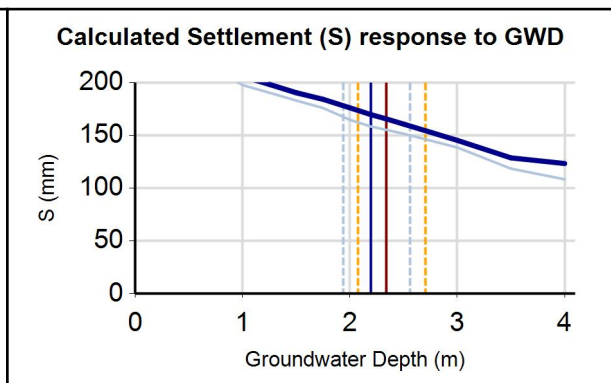
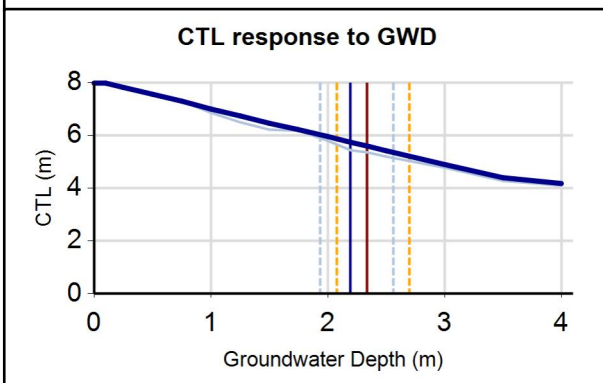
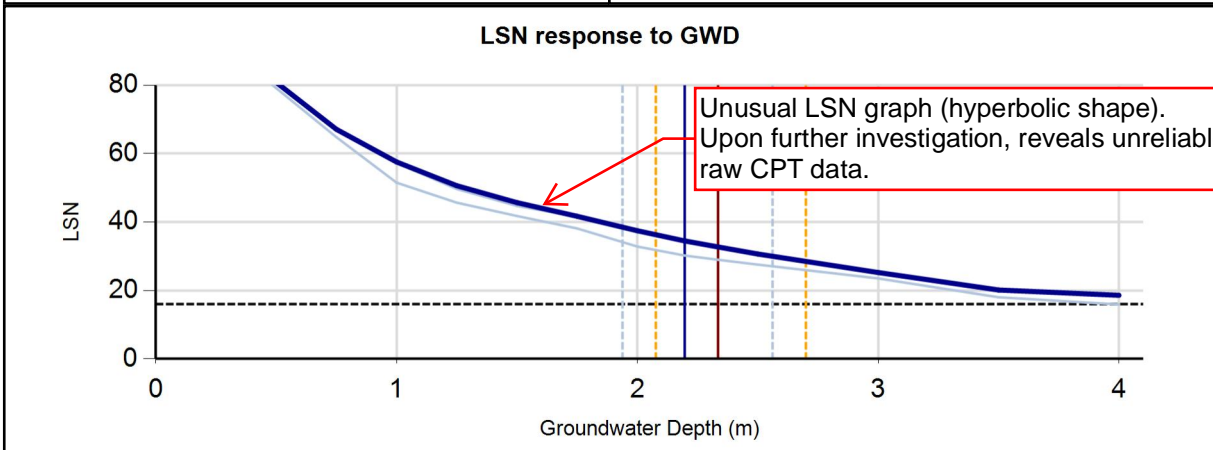
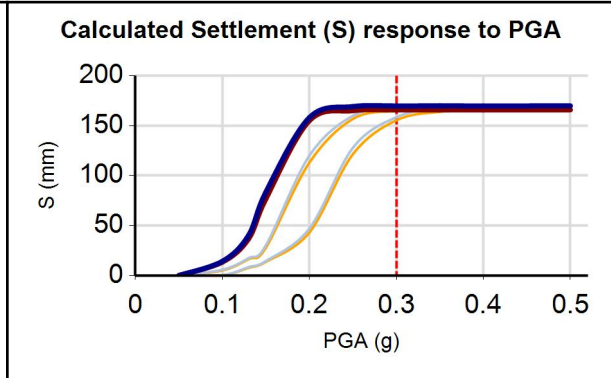
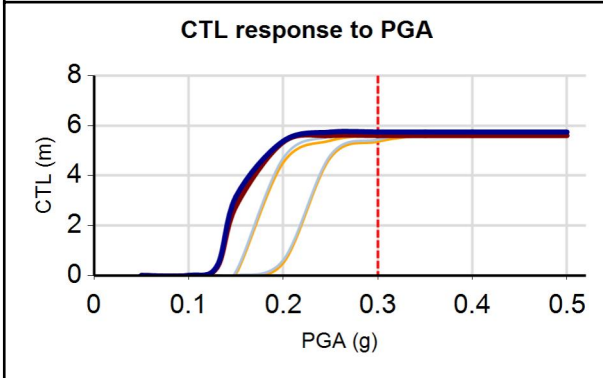
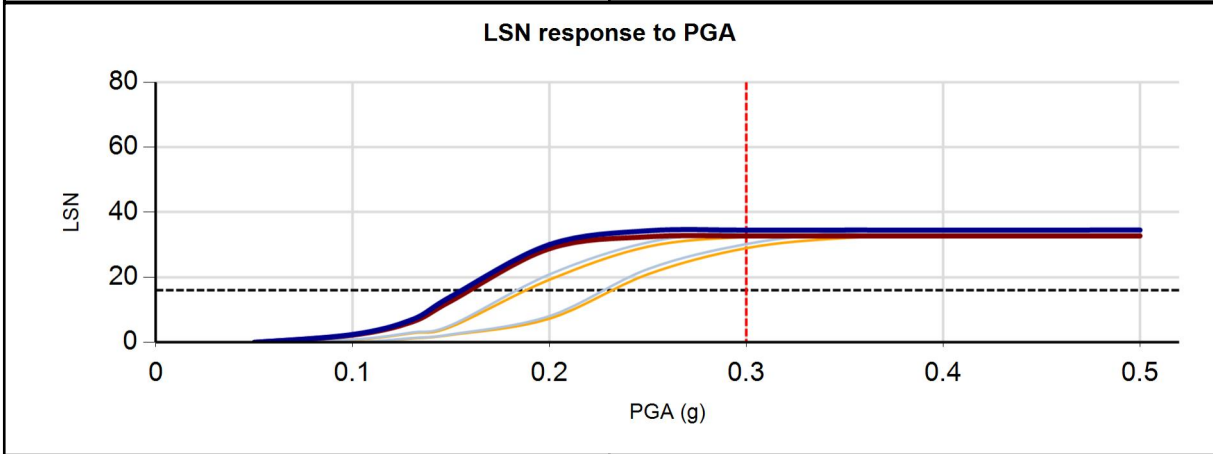
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|---|--|--|--------------------|
| CGD ID: 25870 | LSN Pre Sept = 13 | LSN Post Dec = 18 | Δ LSN = 4.9 |
| Key: ■ Pre Sept GWD 1.6m ■ Post Dec GWD 1.3m CFC = 0 | Predrill Depth = 0m CPT Depth = 20m Ic Limit = 2.6 | Investigation Date: 9/04/2013 Supervising Company: Golder Associates Drilling Company: GCL CPT Rig: Georig220 | |



| | | | |
|---------------------|-----------------------|----------------------|----------------------|
| CGD ID: 1428 | LSN Pre Sept = 35 | LSN Post Dec = 49 | Δ LSN = 14 |
| Key: | | Investigation Date: | 10/06/2011 |
| ■ Pre Sept GWD 0.8m | Predrill Depth = 1.2m | Supervising Company: | Tonkin & Taylor Ltd |
| ■ Post Dec GWD 0.5m | CPT Depth = 10.54m | Drilling Company: | Geotech Drilling Ltd |
| CFC = 0 | Ic Limit = 2.6 | CPT Rig: | N/A |



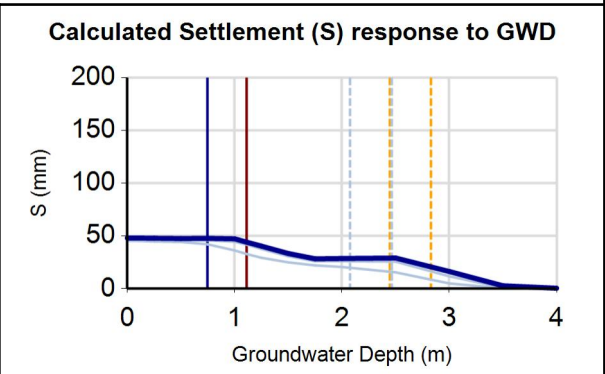
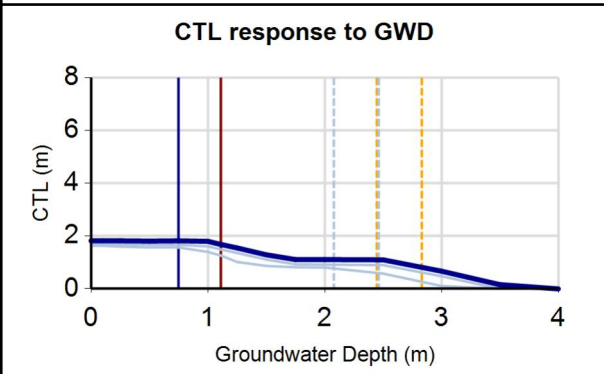
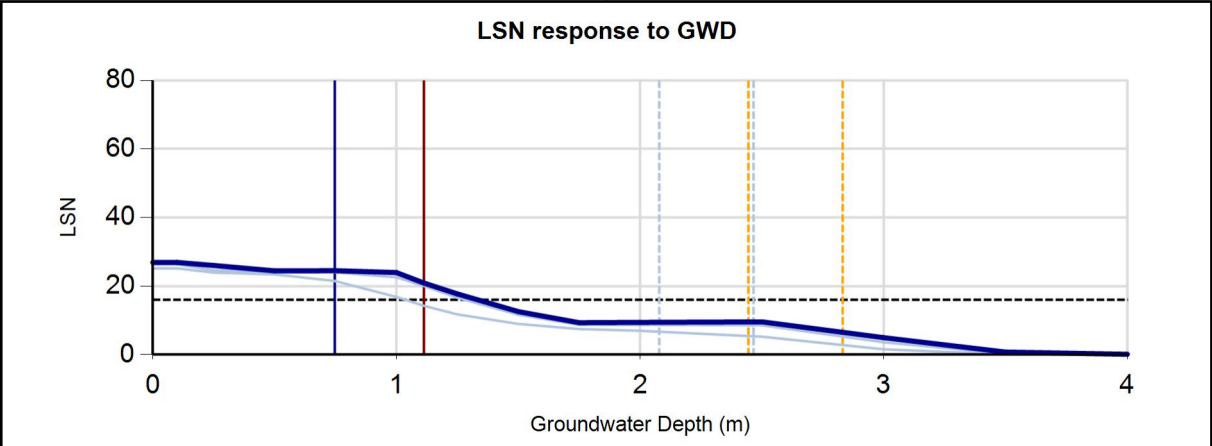
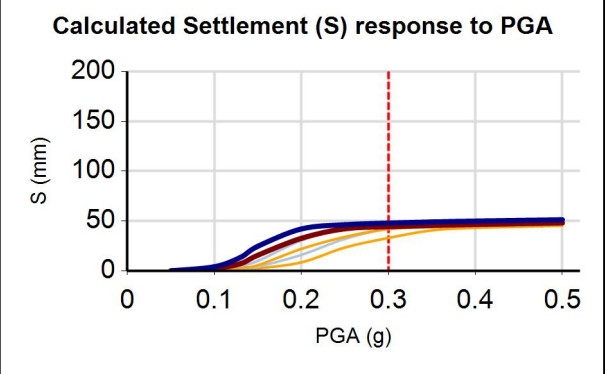
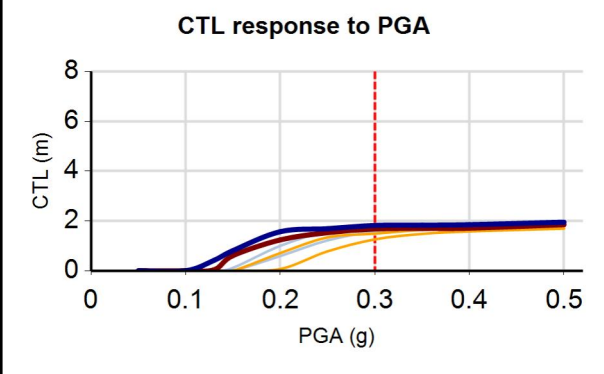
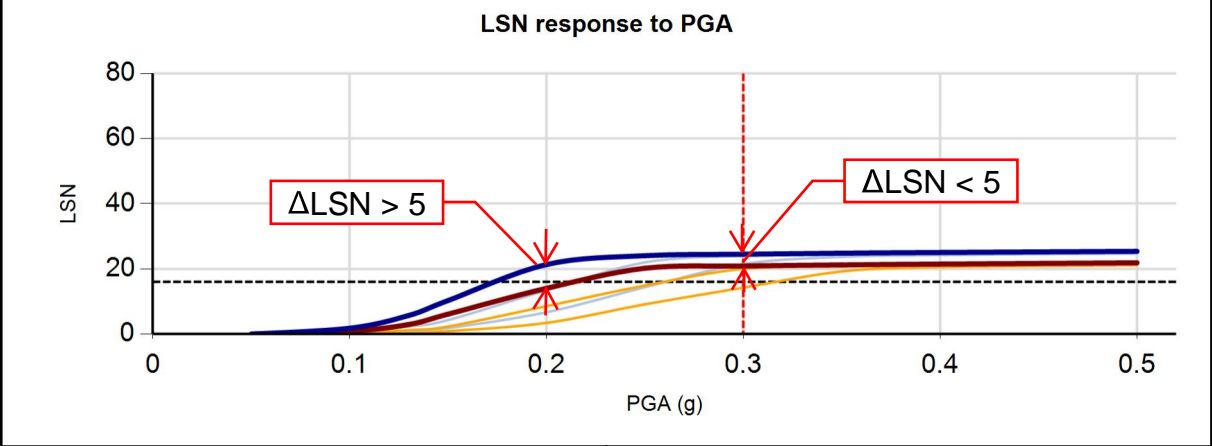
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|---------------------|---------------------|----------------------|---------------------|
| CGD ID: 5668 | LSN Pre Sept = 33 | LSN Post Dec = 35 | Δ LSN = 1.8 |
| Key: | | Investigation Date: | 10/09/2012 |
| ■ Pre Sept GWD 2.3m | Predrill Depth = 0m | Supervising Company: | Tonkin & Taylor Ltd |
| ■ Post Dec GWD 2.2m | CPT Depth = 15.62m | Drilling Company: | RDCL |
| CFC = 0 | Ic Limit = 2.6 | CPT Rig: | Geoprobe66 |



LSN > 16

Δ LSN < 5

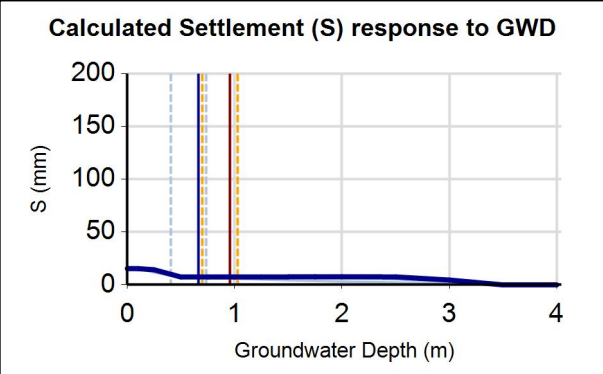
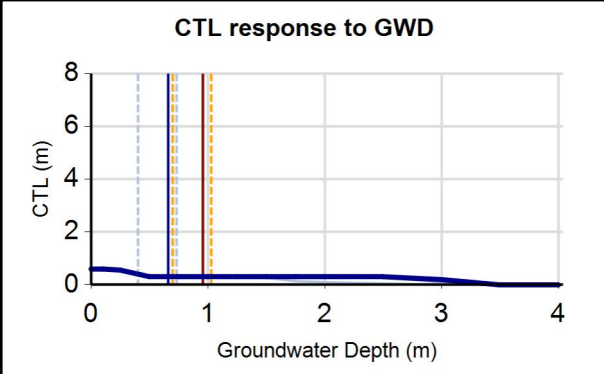
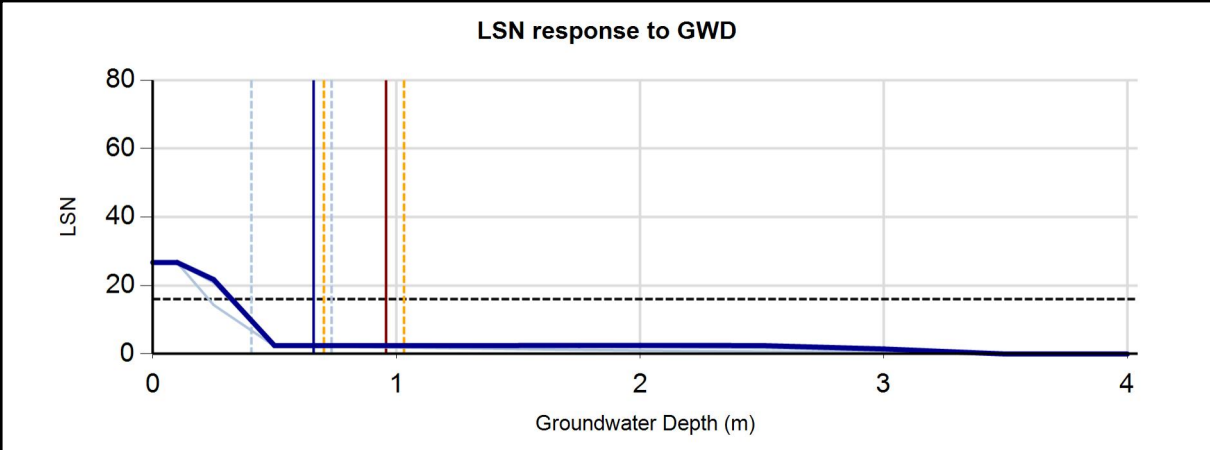
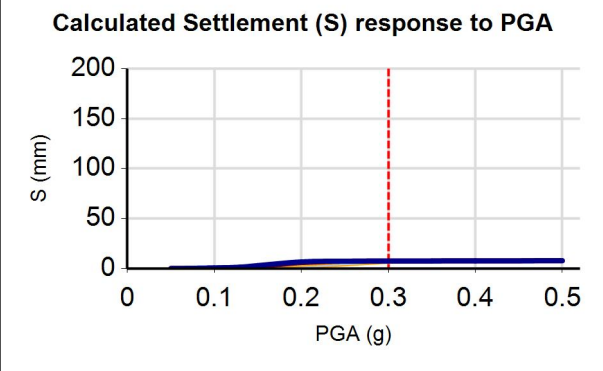
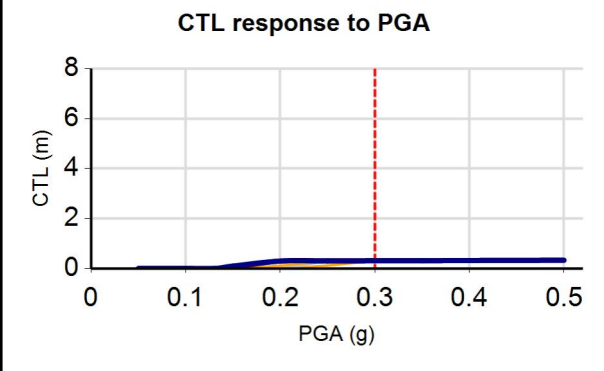
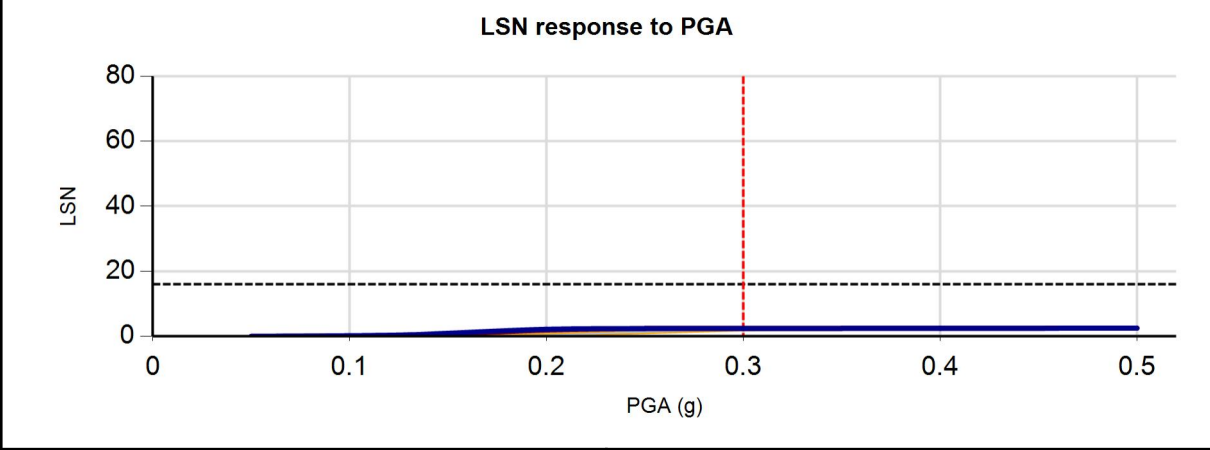
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|---------------------|---------------------|----------------------|--------------------------------|
| CGD ID: 31332 | LSN Pre Sept = 21 | LSN Post Dec = 25 | Δ LSN = 3.6 |
| Key: | | Investigation Date: | 15/10/2013 |
| ■ Pre Sept GWD 1.1m | Predrill Depth = 0m | Supervising Company: | KGA Geotechnical Investigators |
| ■ Post Dec GWD 0.7m | CPT Depth = 5.18m | Drilling Company: | Perry Drilling |
| CFC = 0 | Ic Limit = 2.6 | CPT Rig: | Geomill |



J9

Depth \leq 5m

| | | | |
|---|---|--|------------------|
| CGD ID: 45974 | LSN Pre Sept = 2 | LSN Post Dec = 2 | Δ LSN = 0 |
| Key: ■ Pre Sept GWD 1m ■ Post Dec GWD 0.7m CFC = 0 | Predrill Depth = 0m CPT Depth = 3.9m Ic Limit = 2.6 | Investigation Date: 3/05/2014 Supervising Company: Cook Costello Ltd Drilling Company: GEOCIVIL CPT Rig: Geomil LWC 200 | |



J10

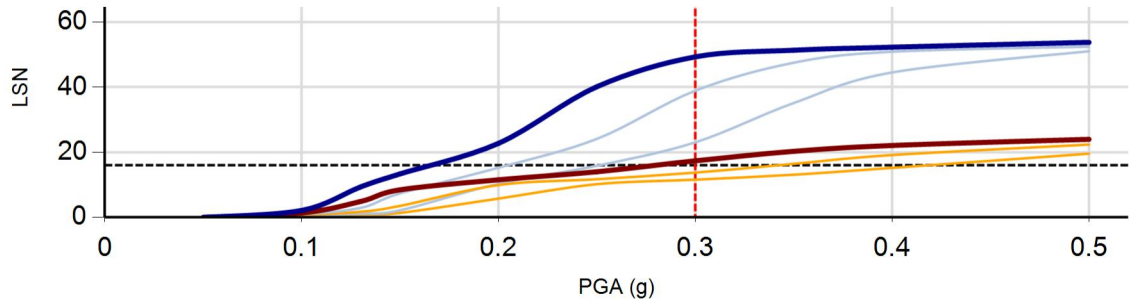
GWD is very shallow

$\Delta LSN \gg 5$

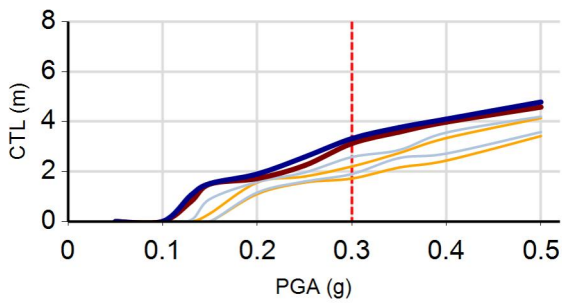
| | | | |
|---|--|--|-------------------|
| CGD ID: 37940 | LSN Pre Sept = 17 | LSN Post Dec = 49 | $\Delta LSN = 32$ |
| Key: ■ Pre Sept GWD 0.3m ■ Post Dec GWD 0.1m CFC = 0 | Predrill Depth = 0m CPT Depth = 20.2m Ic Limit = 2.6 | Investigation Date: 27/02/2014 Supervising Company: Davis Ogilvie Drilling Company: Fugro CPT Rig: 20 Tonne Fugro CPT truck | |

LSN response to PGA

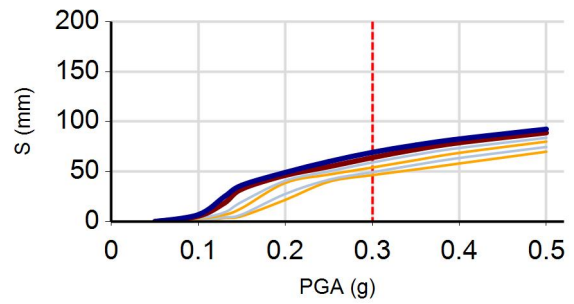
Example 10 - "Hypersensitive" CPT (ΔLSN is $\gg 5$ because DGW is very shallow)



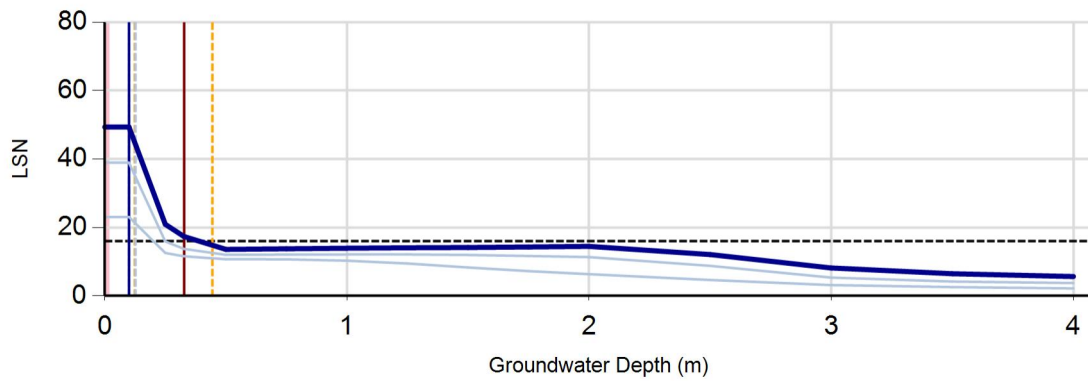
CTL response to PGA



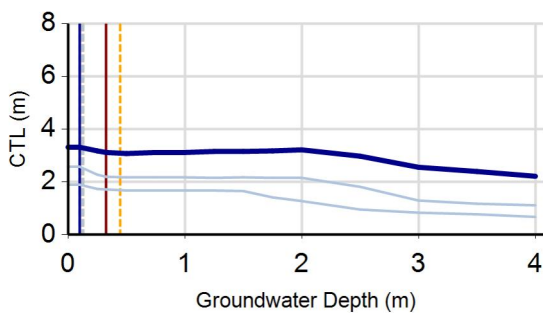
Calculated Settlement (S) response to PGA



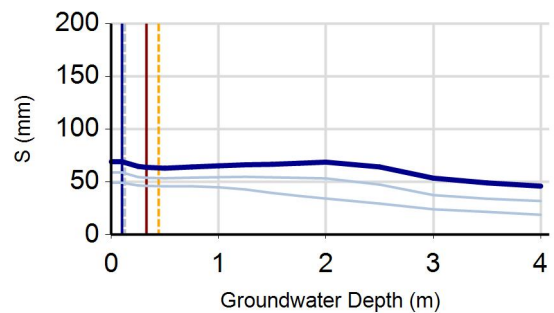
LSN response to GWD



CTL response to GWD



Calculated Settlement (S) response to GWD



| | | | |
|---------------------|---------------------|----------------------|---------------------|
| CGD ID: 37799 | LSN Pre Sept = 28 | LSN Post Dec = 41 | Δ LSN = 12.8 |
| Key: | | Investigation Date: | 8/05/2013 |
| ■ Pre Sept GWD 1.3m | Predrill Depth = 0m | Supervising Company: | Cook Costello Ltd |
| ■ Post Dec GWD 0.9m | CPT Depth = 20.12m | Drilling Company: | GEOCIVIL |
| CFC = 0 | Ic Limit = 2.6 | CPT Rig: | Geomil LWC 200 |

