SOLUTIONS FOR *SMART* FLOOD CONTROL

# 2012.09.05.6 IJKDIJK AIO-SVT GEOTECHNICAL ANALYSIS

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# INFO

**Title**
2012.09.05.6 IJkdijk All-in-one Sensor Validation Test – Geotechnical Analysis

**Commissioned by**
Stichting Flood Control

**Number of pages**
29

**Status**
Final

| Version | Date | Author | Signature | Reviewer | Signature |
|---|---|---|---|---|---|
| 1 | 2012-12-28 | A.R. Koelewijn | | M.T. van der Meer | |

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# MANAGEMENT SUMMARY

## THE ALL-IN-ONE SENSOR VALIDATION TEST OF THE IJKDIJK

The IJkdijk (‘calibration levee’) is a Dutch research program with the two-fold aim to test any kind of sensors for the monitoring of levees under field conditions and to increase the knowledge on levee failure mechanisms. Since 2007, several purpose-built levees have been brought to failure at the IJkdijk test site at Booneschans, in the North-East of the Netherlands. Meanwhile, several regular levees have been instrumented or put under advanced surveillance by validated sensor equipment under the name of Livedijk. In 2011 the Dutch Department of Economic Affairs, Agriculture and Innovation has granted a three million Euro subsidy to the IJkdijk foundation for a liquefaction test and a test including several different failure mechanisms together, the so-called ‘all-in-one’ test or Sensor Validation Test (AIO-SVT). The liquefaction test will be carried out in 2013, while the AIO-SVT has been carried out in August and September 2012.

The main purpose of the AIO-SVT was to test the predictive power of full-service levee sensor systems, i.e. sensors in and on levees combined with data processing and an information system producing a timely, reliable warning in case failure may occur. The application of such systems into practice will be a major improvement to the current state-of-the-art of levee management. Another reason to carry out this test, in accordance with the two-fold aim of the IJkdijk, is to learn more on levee failure mechanisms, including failure prevention methods. This report is focused on the geotechnical aspects of the test.

The AIO-SVT was carried out on three separate test dikes, referred to by their relative location on the test site as West dike, East dike and South dike.

## WEST DIKE

The West dike was a 3.5m high, 15m long and 15m wide test dike on top of a 3m sand layer, enclosing a reservoir with embankments 3.7m high on all other sides with a total volume of approx. 2000m$^3$. It is composed of a 60-70 cm thick compacted clay layer with a 1.7m high clay dike on top on the upstream side, backed up with a sand core and overlain by organic clay up to the crest level. Right behind the smaller clay dike, in the sand core, a controllable drainage tube has been placed. Such a tube has also been placed in the sand layer, close to the top, running parallel to the downstream toe at a distance of 3.7m to this toe. By design, failure was considered to be possible by piping (backward seepage erosion through the sand layer), by micro-instability (instability of the sand core caused by liquefaction), and from overtopping and subsequent erosion of the crest and downstream slope.

The test on the West dike in the All-in-One Sensor Validation Test of the IJkdijk started on Tuesday, August 21$^{st}$, 2012, at 4:30 pm (local time). Failure by micro-instability of the sand core occurred on the sixth day of the test, on Sunday, August 26$^{th}$, at 8:24 am, after 111.9 hrs. This was one of the three failure mechanisms indicated as desired before the start of the test. Other mechanisms which played a role in this test are compaction of the dike at first filling and piping (backward seepage erosion) through the sand layer underneath the dike. The reference monitoring data was sufficient to get a detailed view on the course of the test.

The aim of the test was met, as the failure was primarily caused by micro-instability of the sand core. The compaction on first fill was not foreseen, but that did not lead to failure. The preventive measures against piping and instability of the sand core – the controllable drainage tubes – appeared to be very effective.

## EAST DIKE

The East dike was nearly identical to the West dike, but without the controllable drainage tubes and with a box of coarse sand of 0.5m wide and 0.5m high instead of finer sand running parallel to the downstream toe at a distance of 3.5m to this toe. This sand filter was meant to prevent piping. According to the design, also for this dike failure was considered to be possible by piping (backward seepage erosion through the sand layer), instability of the sand core from liquefaction, and from overtopping and subsequent erosion of the crest and downstream slope.

The test on the East dike in the All-in-One Sensor Validation Test of the IJkdijk started on Tuesday, August 21st, 2012, at 3:20 pm (local time). Failure by micro-instability of the sand core occurred on the seventh day of the test, on Monday, August 27th, at 10:18 am, after 138.9 hrs. This was one of the three failure mechanisms indicated as desired before the start of the test. Other mechanisms which played a role in this test are compaction of the dike at first filling and piping (backward seepage erosion) through the sand layer underneath the dike. The reference monitoring data was sufficient to get a detailed view on the course of this test, which is in many ways comparable to the test on the West dike.

The aim of the test was met, as the failure was primarily caused by micro-instability of the sand core. The compaction on first fill was not foreseen, but that did not lead to failure. The preventive measure against piping – the coarse sand filter – appeared to be effective.

## SOUTH DIKE

The South dike was quite different from the other test dikes. After construction, it was 4m high, 50m long at crest level, with a crest width of 3m and side slopes of 1:1.5 (V:H). It was constructed on a 4.5m thick composition of soft peat and clay. The core was made of sand, overlain by a 0.5m thick clay layer. Failure of the South dike was considered to be possible either from rupture of the clay layer by high pore pressures inside the sand core resulting from saturating this core with water, or by slope stability involving a deep sliding plane through the original subsoil, with a minimum deformation of at least 20 cm.

The test on the South dike in the All-in-One Sensor Validation Test of the IJkdijk started on Monday, September 3rd, 2012, at 12:12 pm (local time). Failure by slope instability with a deep sliding plane took place on the sixth day of the test, on Saturday, September 8th, at 2:27 pm, after 122.26 hrs. This was one of the two failure mechanisms indicated as desired before the start of the test. Actually, according to the measurements of the inclinometer in the central section just in front of the toe, the deformation criterion was met already on Saturday, September 8th, at 2:13 pm. The reference monitoring data is sufficient to get a detailed view on the course of the test.

# TABLE OF CONTENTS

# 1 INTRODUCTION

## 1.1 IJKDIJK RESEARCH PROGRAM

The IJkdijk ('calibration levee') is a Dutch research program with the two-fold aim to test any kind of sensors for the monitoring of levees under field conditions and to increase the knowledge on levee failure mechanisms.

Since 2007, several purpose-built levees have been brought to failure at the IJkdijk test site at Booneschans, in the North-East of the Netherlands. Meanwhile, several regular levees have been instrumented or put under advanced surveillance by validated sensor equipment under the name of Livedijk.

In 2011 the Dutch Department of Economic Affairs, Agriculture and Innovation has granted a three million Euro subsidy to the IJkdijk foundation for a liquefaction test and a test including several different failure mechanisms together, the so-called 'all-in-one' test or Sensor Validation Test (AIO-SVT). The liquefaction test will be carried out in 2013, while the AIO-SVT has been carried out in August and September 2012.

## 1.2 ALL-IN-ONE SENSOR VALIDATION TEST

The main purpose of the AIO-SVT was to test the predictive power of full-service levee sensor systems, i.e. sensors in and on levees combined with data processing and an information system producing a timely, reliable warning in case failure may occur. The application of such systems into practice will be a major improvement to the current state-of-the-art of levee management. Another reason to carry out this test, in accordance with the two-fold aim of the IJkdijk, is to learn more on levee failure mechanisms, including failure prevention methods. This report is focused on the geotechnical aspects of the test, giving a detailed description of what happened and an in-depth analysis of the failure mechanism that dominated the last test..

The AIO-SVT was carried out on three separate test dikes, referred to by their relative location on the test site as West dike, East dike and South dike. The design of these dikes is described in [Koelewijn & Peters, 2012]. All data from soil investigations are available through [Koelewijn & Bennett, 2012].

### 1.2.1 West dike

The West dike was a 3.5m high, 15m long and 15m wide test dike on top of a 3m sand layer, enclosing a reservoir with embankments 3.7m high on all other sides with a total volume of approx. 2000m$^3$. It is composed of a 60-70 cm thick compacted clay layer with a 1.7m high clay dike on top on the upstream side, backed up with a sand core and overlain by organic clay up to the crest level. Right behind the smaller clay dike, in the sand core, a controllable drainage tube has been placed. Such a tube has also been placed in the sand layer, close to the top, running parallel to the downstream toe at a distance of 3.7m to this toe.

By design, failure was considered to be possible by piping (backward seepage erosion through the sand layer), micro-instability (instability of the sand core caused by liquefaction), and from overtopping and subsequent erosion of the crest and downstream slope.

### 1.2.2 East dike

The East dike was nearly identical to the West dike, but without the controllable drainage tubes and with a box of coarse sand of 0.5m wide and 0.5m high instead of finer sand running parallel to the downstream toe at a distance of 3.5m to this toe. This sand filter was meant to prevent piping.

According to the design, also for this dike failure was considered to be possible by piping (backward seepage erosion through the sand layer), instability of the sand core from liquefaction, and from overtopping and subsequent erosion of the crest and downstream slope.

### 1.2.3 South dike

The South dike was quite different from the other test dikes. After construction, it was 4m high, 50m long at crest level, with a crest width of 3m and side slopes of 1:1.5 (V:H). It was constructed on a 4.5m thick composition of soft peat and clay. The core was made of sand, overlain by a 0.5m thick clay layer.

Failure of the South dike was considered to be possible either from rupture of the clay layer by high pore pressures inside the sand core resulting from saturating this core with water, or by slope stability involving a deep sliding plane through the original subsoil, with a minimum deformation of at least 20 cm.

## 1.3 ABOUT THIS REPORT

In this report geotechnical analyses of the failures of each test dike in the AIO-SVT are given in chronological order of the failures, i.e. first the West dike (Chapter 2), then the East dike (Chapter 3) and then the South dike (Chapter 4). References are given in Chapter 5. The most important supporting data of each test is reproduced from the factual report of each test in Appendices 1, 3 and 5, respectively, while additional data and rearrangements of data are given in Appendices 2, 4 and 6, respectively. Appendix 7 contains a short Dutch-English dictionary to facilitate the understanding of the copies from the factual reports.

# 2 WEST DIKE

## 2.1 SUMMARY

The test on the West dike in the All-in-One Sensor Validation Test of the IJkdijk started on Tuesday, August 21st, 2012, at 4:30 pm (local time). This moment is defined as t=0. Failure by micro-instability of the sand core occurred on the sixth day of the test, on Sunday, August 26th, at 8:24 am (t=111.9 hrs). This was one of the three failure mechanisms indicated as desired before the start of the test. Other mechanisms which played a role in this test are compaction of the dike at first filling and piping (backward seepage erosion) through the sand layer underneath the dike. The reference monitoring data [Koelewijn et al., 2012a] suffices to get a detailed view on the course of the test.

## 2.2 CONSTRUCTION OF THE DIKE

The dike has been constructed in the west part of the IJkdijk facility already built in 2009 [van Beek, 2009], cf. Appendix A, page A-1. In May and June of 2012 this has been rehabilitated and the new test dike has been built, mainly in accordance with the design as reported in [Koelewijn & Peters, 2012] and with some minor modifications as detailed in [Koelewijn et al., 2012a]. The upper 40 to 60 cm of the test sand has been removed and replaced by similar sand. Compaction has taken place to arrive at a relative density of about 65 to 75 percent. After saturation using about 50% vacuum pressure, instruments have been placed on the sand/clay interface and the test dike has been built. The layer of clay dividing the subsoil suspectible to piping from the upper part of the dike vulnerable to micro-instability and erosion from overtopping has been compacted very well, while the higher parts of the dike (sand core, small clay dike at the upstream side and the cover layer) were hardly compacted at all. Some of the instrumentation has been added in July, and some right before the start of the test.

## 2.3 RELIABILITY AND ACCURACY OF INSTRUMENTS

### 2.3.1 Levels of upstream and downstream basins

In the weeks before the test started, both basins were nearly level. The day before it started the levels were equal, as checked by DGPS (TopCon) measurements. On the morning of the day the test started, all levels were checked by DGPS and traditional leveling, as reported in Appendix A, page C-6. These values all seem to be reliable with an accuracy of 1 cm, yet often the upstream level is measured slightly higher from the gauge than by the pore pressure meter, as shown in Appendix A, page D-6.

### 2.3.2 Discharge

For the downstream discharge, the malfunctioning automatic discharge meter should not be trusted. The measurements using a 12.5 litre bucket and a timer are supposed to be reliable within 10%. For a detailed analysis it may be required to take account of the slow rise of the downstream basin until t=65 hours and the variation thereafter. A more detailed analysis may also include a break-down of the inflow from the upstream discharge as given in Appendix A, pages C-4 and C-5 and rainfall, into storage in both basins, the test dike and outflow from the usual exit pipe and from both controllable drainage tubes. Note that the upstream discharge has not been checked yet against the upstream level, discharge through the test dike and storage in the test dike. Also note the influence of rain showers: the influence of the thundershower around t=5 hours bringing a total rainfall of 13.8mm is well visible in the measurements of both basins, see Appendix A, page D-6.

### 2.3.3 Pore pressure meters at the sand/clay interface underneath the test dike

Pore pressure meters O109 (Appendix A, page D-17) and O203 (Appendix A, page D-28) show a deviating behaviour already well before any signs of wells have been sighted, cf. Appendix A, pages D-1 and D-2: the values of these two instruments tend to be significantly lower. Looking at the overall behavior, which is otherwise well comparable with the other instruments here, an explanation could be that these two instruments have been dislocated downstream after installation, e.g. during the placement of the lower part of the clay – see Appendix A, pages F-6 and F-7. When comparing the gradients for rows x07 through x14 (see Appendix B, pages 1-4), calculated using the exact locations of the instruments as measured directly after installation as given in Appendix A, pages B-1 to B-3, one of the most striking differences is the high level of the gradient between instruments O109 and O 209 – in the graph showing row x09, the red line is higher than in any of the other gradient graphs. By assuming a more downstream position of instrument O109, this would be corrected. More in general, this shows some of the limitations to the absolute accuracy of the measurements.

The behaviour of all other instruments is in agreement with the other observations made during the test, although sometimes peculiar small drops or rises of up to 0.5 kPa occurred, for example a single drop in O212 at t=50 hrs (see Appendix B, page 12) and repeated drops around t=20 hrs in O409 and O410 (see Appendix B, page 24). This behaviour is always limited to either one rise or one drop compared to the initial reading. Similar behaviour was observed with the same type of instruments used three years before, during the first four piping tests at the IJkdijk [van Beek et al., 2009; Knoeff & De Bruijn, 2009; Koelewijn et al., 2009ab]. Consultation of an instrumentation specialist did not resolve this issue [van Waardenberg, 2012]. Apart from these clearly detectable measurement errors, the relative accuracy of the instruments appears to be better than 0.1 kPa and enough for their main purpose: detection of piping.

### 2.3.4 Pore pressure meters in the sand core

All these instruments show a behaviour that can be typified as reasonable. The accuracy seems comparable to the accuracy of the pore pressure meters at the sand/clay interface.

## 2.4 COMPACTION AT FIRST FILLING

Cracks appeared on the crest and on both slopes already at a water level in the upstream basin that was much lower than the top of the small clay dike that is part of the upstream side of the test dike, see. Appendix A, page A-2: this is about 2.4m above the top of the lower sand layer. The first cracks on the crest were discovered on August 22, early in the morning at t=13.9 hrs (see Appendix A, page F-9), while the upstream level was only about 1.2m above the top of the lower sand layer. At the end of the morning (t=20 hrs), a large crack was discovered on the upstream slope, in the middle of the dike just above the water level, cf. Appendix B, page 5. The cracks increased in size over time. From t=21 hrs the pore pressures in the sand core close to the upstream side, just behind the small clay dike on top of the well-compacted clay layer, started to rise. First this happened only in the middle and on the east side, at t=24 hrs also on the west side, see Appendix B, page 6. This delayed reaction on the west side cannot be explained from a difference in installation level (see Appendix A, page B-2), but that part of the sand core was simply reached later. An important notion is the development of a height difference at the two sides of the cracks on the crest: the upstream side got lower in course of time.

An explanation for these observations is that the water from the upstream basin could easily flow through the slightly compacted clay of the small clay dike, which was placed on top of the well compacted clay layer separating this small clay dike and the sand core from the lower sand layer. Through this slightly compacted clay, and probably even through concentrated flow at the interface between well compacted clay and slightly compacted clay, the sand core got wet, causing (limited) compaction of the most upstream part of the sand core and also some compaction of the wet part of the small clay dike. This compaction caused deformations, leading to the observed cracks and uneven settlements. In turn, these cracks may have accelerated the wetting and compaction of the sand core. This is reflected by the quick reaction of pore pressure meters A03-A06-A09, right behind the small clay dike, to the water level rise in the upstream basin at t=42 hrs and t=50 hrs. This was accompanied by a further increase of the size of the cracks. This explanation that the cracks occurring during the first days of the test were related to the poor compaction of the sand core and the small clay dike is supported by the observations made during the removal of the (identical) east dike, where a sharp contrast was found between the well-compacted clay layer which was still strong, and the nearly liquefied clay of the small clay dike.

It is noted that it took quite a while before the more downstream instruments in the sand core showed any reaction: instruments A02-A05-A08 at 1.8m downstream of the small clay dike to only at t=38 hrs and instruments A04-A07 (6.0m downstream of the small clay dike and 1.4m upstream of the downstream slope) at t=76 hrs, instrument A01 at t=98 hrs. At t=63.3 hrs the upper controllable drainage tube was opened, which must have slowed down the filling of the sand core. Internal overtopping of the small clay dike did not occur until t=86 hrs.

## 2.5 MICRO-INSTABILITY OF THE SAND CORE

The failure mechanism called 'micro-instability' is described well by De Groot et al. [2011]. Application of the formula given in that article to this test dike, to be precise: to the situation with a 1:2 inner slope made of sand with only a thin cover of soft material yields that the situation is unstable as soon as the sand gets saturated – which may take quite some time. The cover will only cause a limited delay of the failure process, which is altogether described by De Groot et al. [2011] as 'rather slow'.

Right after closure of the upper controllable drainage tube, the pore pressures in the sand core started to rise sharp at t=94 hrs. At t=97.6 hrs, the higher pore pressures in the wet part of the sand core led to partial loss of the shear strength, causing some sliding of the downstream slope. At this point, most of the sand core below the crest may have been filled with water. This sliding may have caused further cracking of the sand core, thereby also the last pore pressure meter there (A01) was reached by the rising water inside the core (at t=98 hrs). During the following night, the deformations continued while the water level in the upstream basin receded, but only slowly. The deformations concentrated at the east side of the dike, cf. Appendix A, pages F-32 to F-35. This was preceded by outflow of sand and clay with water on the slope, as shown in Appendix A, page F-31. The next morning, at t=111.0 hrs the upstream basin was refilled. The pore pressures in the sand core quickly responded to that. Before the level of 3.43 metres above the lower sand level was reached again, at t=111.9 hrs the continued and increased deformation of the downstream slope and the crest lead to so much subsidence of the crest that overtopping at a reservoir level of 3.38 metres above the sand level occurred a few metres west of the east side of the dike, as shown in Appendix A, page F-36.This happened on Sunday, August 26th, at 8:24 am. Breaching occurred and as a result, the reservoir emptied within 10 minutes (Appendix A, page D-6). It seems impractical to make a detailed analysis of this failure with the available knowledge, as time-dependency seems to be of significant importance, while a time-dependent analysis is yet impossible.

It is hard to tell why the failure occurred at that location, apart from coincidence. Probably it was in part related to the concentration of flow down at the toe, caused by the vicinity of the dike wrapped in foil separating the West and the East test dikes, which made this location slightly more vulnerable than the middle part of the dike. This however equally applies to the west side, where even less compaction of the sand core had occurred during construction, as this was carried out from the central part of the piping facility. It should be noted here that in order to avoid failure right at any of the ends of the West and East test dikes, an extra lump of clay was placed near the sides, see Appendix B, page 7, showing the west side of the East dike during construction.

## 2.6 PIPING

The first signs of sand transport induced from seepage flow were recorded already at a hydraulic head over the test dike of 1.15m, as indicated in Appendix B, page 8 (this is identical to Appendix A, page E-1, but with an indication of the nearest pore pressure meters added in the heading). Yet, between t=21.5 hrs and t=42.7 hrs, only traces of sand were seen, cf. Appendix A, page F-11. Soon after raising the head to 1.56m, the first proper well was discovered, both in the field at t=45.1 hrs, see Appendix A, page F-13, and from the pore pressure measurements at instruments O113 and O114, see Appendix B, page 9 or page 11. This first line of instruments was located about 0.9m from the downstream toe.

Later on, after raising the upstream basin further to a head of 1.79m, at t=51 hrs, increased well activity at well #1 and pore pressure meters O113 and O114 could be seen, shortly after followed by a drop in pore pressure meter O110 (well #4, also visible in Appendix A, page F-15) and drops in O107, O108 and O109 upstream of wells #2 and #3. A temporary drop is seen in O105 and O106, which may be attributed to drainage of that area to supply discharge for the wells.

Upstream of well #1, O113 and O114 dropped first, later on followed by a clear drop of O214 between t=55.5 hrs and t=57 hrs indicating the passage of a piping channel. This second line of instruments was located about 2.5m from the downstream toe. At t=57.5 hrs, a tiny drop in instrument O312 (in the third line of instruments, at 4.3m from the downstream toe and upstream of the controllable drainage tube which was located at 3.7m from the downstream toe) can be discerned in Appendix B, page 13, but that is not very convincing. In instrument line 4xx, located at 11.2m upstream from the downstream toe, nothing special can be seen, see Appendix B, page 14.

Upstream of wells #2 and #3, drops of O107, O108 and O109 between t=51.5 hrs and t=53.5 hrs and also the turbulence between t=60 hrs and t=64 hrs may be attributed to the observed well activity (see Appendix B, page 10 or page 11). This also roughly applies to O207, O208 and O209, except that at O209 the pressure starts to build up again from t=61 hrs. In lines 3xx and 4xx nothing special can be seen.

Well #4 is between the previous wells and may be connected to pore pressure meter O110, notably between t=51.5 hrs and t=53.5 hrs and also very distinct between t=62.5 hrs and t=63.5 hrs.

Well #5 can be traced in O101 and O102 around t=57-58 hrs. No more wells have been detected.

On the West side, the pore pressures tend to decrease more after t=64 hrs than on the East side, see Appendix B, page 11.

The opening of the lower controllable drainage tube to various degrees, starting at t=66.7 hrs, had a clear effect on the pore pressures under the test dike. This is shown for the row in the middle, x09, in Appendix B, page 15. This had an almost immediate effect on the well activity: no sand was produced anymore. An alternative presentation of the various stages of the piping process during the test is given in Appendix B, page 16. At t=89.6 hrs it was decided for safety reasons that the wells should no longer be inspected from nearby. After closing the controllable drainage tube around t=94 hrs, the pore pressures were restored again and the piping erosion process restarted, as e.g. shown by the new well in Appendix A, page F-33, which has been observed from a distance. However, the pore pressure measurements and the available pictures and videos clearly show that the breaching of the dike was not caused by piping.

One remarkable measurement can be seen for instrument O102 between t=103 hrs and t=107 hrs, see Appendix B, page 17. This is during the night while the sliding of the downstream slope at the east side of the dike continues. The other instruments are hardly affected, see also Appendix B, pages 18 to 20.

Regarding the first 40 hours a general remark can be made that during that period the pressures are slightly higher and more homogeneous on the west side than on the east side, see Appendix B, pages 21 to 24.

When comparing the measurements close to the east and west boundaries (x02 and x16, respectively) to the measurements in the middle (x09), no clear boundary effect can be seen (cf. Appendix B, pages 25 and 26) when the graph for O109 is adjusted for the presumed change in its location.

Finally, the apparently required gradient for the production of sand from a well is illustrated in different ways both in Appendix B, pages 1 to 4 and by two graphs showing the pore pressure against distance for rows x07 and x13, see Appendix B, pages 27 and 28. In the latter two, at 15m along the horizontal axis the upstream water level is plotted. This isn't necessarily the pressure in the sand under the upstream toe of the dike.

## 2.7 DISCUSSION: FULFILLING THE AIM OF THE TEST

The aim of the test, as formulated before the construction of the dikes, was that it should fail by (at least) one of the failure mechanisms piping, micro-instability of the sand core and overtopping/erosion. This aim was met, as the failure was primarily caused by micro-instability of the sand core.

The compaction on first fill was not foreseen, but that did not lead to failure.

The preventive measures against piping and instability of the sand core – the controllable drainage tubes – appeared to be very effective.

# 3 EAST DIKE

## 3.1 SUMMARY

The test on the East dike in the All-in-One Sensor Validation Test of the IJkdijk started on Tuesday, August 21st, 2012, at 3:20 pm (local time / t=-3.37 hrs[1]). Failure by micro-instability of the sand core occurred on the seventh day of the test, on Monday, August 27th, at 10:18 am (t=135.5 hrs, i.e. 138.9 hrs after the start of the test). This was one of the three failure mechanisms indicated as desired before the start of the test. Other mechanisms which played a role in this test are compaction of the dike at first filling and piping (backward seepage erosion) through the sand layer underneath the dike. The reference monitoring data [Koelewijn et al., 2012b] suffices to get a detailed view on the course of the test, which is in many ways comparable to the test on the West dike.

## 3.2 CONSTRUCTION OF THE DIKE

The dike has been constructed in the east part of the IJkdijk facility already built in 2009 [Koelewijn et al., 2009a], cf. Appendix A, page A-1. In May and June of 2012 this has been rehabilitated and the new test dike has been built, mainly in accordance with the design as reported in [Koelewijn & Peters, 2012] and with some minor modifications as detailed in [Koelewijn et al., 2012b]. The upper 40 to 60 cm of the test sand has been removed and replaced by similar sand. Compaction has taken place to arrive at a relative density of about 65 to 75 percent. After saturation using about 50% vacuum pressure, instruments have been placed on the sand/clay interface and the test dike has been built. The layer of clay dividing the subsoil suspectible to piping from the upper part of the dike vulnerable to micro-instability and erosion from overtopping has been compacted very well, while the higher parts of the dike (sand core, small clay dike at the upstream side and the cover layer) were hardly compacted at all. Some of the instrumentation has been added in July, and some right before the start of the test.

## 3.3 RELIABILITY AND ACCURACY OF INSTRUMENTS

### 3.3.1 Levels of upstream and downstream basins

In the weeks before the test started, both basins were nearly level. The day before it started the levels were equal, as checked by DGPS (TopCon) measurements. On the morning of the day the test started, all levels were checked by DGPS and traditional leveling, as reported in Appendix C, page C-6. These values all seem to be reliable with an accuracy of 1 cm, although the lower measurement frequency of the manual measurements during the test causes some differences in the graph, as shown in Appendix C, page D-9. A more important remark to be made is that at t=65.18 hrs a difference of 14 cm between the reference levels of the upstream and the downstream basins is discovered. The earlier logs in the factual report have not been corrected for this error.

### 3.3.2 Discharge

For the downstream discharge, the malfunctioning automatic discharge meter should not be trusted. The measurements using a 12.5 litre bucket and a timer are supposed to be reliable within 10%. For a detailed analysis it may be required to take account of the disturbance of the downstream basin at t=109.7 hrs by the failure of the West dike and the variation thereafter. A more detailed analysis may also include a break-down of the inflow from the upstream discharge as given in Appendix C, pages C-4 and C-5 and rainfall, into storage in both basins, the test dike and outflow from the usual exit pipe and from both controllable drainage tubes. Note that the upstream discharge has not been checked yet against the upstream level, discharge through the test dike and storage in the test dike. Also note the influence of rain showers: the influence of the thundershower around t=3 hours bringing a total rainfall of 13.8mm is well visible in the measurements of both basins, see Appendix C, page D-9.

[1] A reset of the read-out unit of the pore pressure measurements appeared to be necessary a few hours after the start of the test, at 6:42 pm. That moment therefore is reported at t=0 hrs, resulting in a negative starting time.

### 3.3.3 Pore pressure meters at the sand/clay interface underneath the test dike

Pore pressure meters O215 (Appendix C, page D-4), O404 and O412 (Appendix C, page D-7) show a delayed reaction and appeared not to be in equilibrium yet when all instruments were set to zero right before the start of the test. This is likely to be caused by clay in, or in front of, the filter of the instrument.

The behaviour of all other instruments is in agreement with the other observations made during the test, although sometimes peculiar small drops or rises of up to 0.5 kPa occurred, for example between t=21 hrs and t=30 hrs in O307 (see Appendix D, page 3), but at several other instruments too (see Appendix D, pages 1 to 16). This behaviour is always limited to either one rise or one drop compared to the initial reading. Similar behaviour was observed with the same type of instruments used three years before, during the first four piping tests at the IJkdijk [van Beek et al., 2009; Knoeff & De Bruijn, 2009; Koelewijn et al., 2009ab]. Consultation of an instrumentation specialist did not resolve this issue [van Waardenberg, 2012]. Apart from these clearly detectable measurement errors, the relative accuracy of the instruments appears to be better than 0.1 kPa and enough for their main purpose: detection of piping.

### 3.3.4 Pore pressure meters in the sand core

All these instruments show a behaviour that can be typified as reasonable, except for the peculiar small drops or rises, for example between t=60 hrs and t=70 hrs in A04 (see Appendix C, page D-8). The accuracy seems comparable to the accuracy of the pore pressure meters at the sand/clay interface.

## 3.4 COMPACTION AT FIRST FILLING

Cracks appeared on the crest and on both slopes already at a water level in the upstream basin that was much lower than the top of the small clay dike that is part of the upstream side of the test dike, see. Appendix A, page A-2: this is about 2.4m above the top of the lower sand layer. The first cracks on the crest were discovered on August 22, early in the morning at t=11.3 hrs (see Appendix C, pages F-10 and F-11), while the upstream level was only about 1.2m above the top of the lower sand layer. The cracks increased in size over time. From t=18 hrs the pore pressures in the sand core close to the upstream side, just behind the small clay dike on top of the well-compacted clay layer, started to rise. First this happened only in the middle, after t=20 hrs also on the sides, see Appendix C, page D-8. An important notion is the development of a height difference at the two sides of the cracks on the crest: the upstream side got lower in course of time.

An explanation for these observations is that the water from the upstream basin could easily flow through the slightly compacted clay of the small clay dike, which was placed on top of the well compacted clay layer separating this small clay dike and the sand core from the lower sand layer. Through this slightly compacted clay, and probably even through concentrated flow at the interface between well compacted clay and slightly compacted clay, the sand core got wet, causing (limited) compaction of the most upstream part of the sand core and also some compaction of the wet part of the small clay dike. This compaction caused deformations, leading to the observed cracks and uneven settlements. In turn, these cracks may have accelerated the wetting and compaction of the sand core. This was accompanied by a further increase of the size of the cracks. This explanation that the cracks occurring during the first days of the test were related to the poor compaction of the sand core and the small clay dike is supported by the observations made during the removal of the (identical) east dike, where a sharp contrast was found between the well-compacted clay layer which was still strong, and the nearly liquefied clay of the small clay dike.

## 3.5 MICRO-INSTABILITY OF THE SAND CORE

The failure mechanism called ‘micro-instability’ is described well by De Groot et al. [2011]. Application of the formula given in that article to this test dike, to be precise: to the situation with a 1:2 inner slope made of sand with only a thin cover of soft material yields that the situation is unstable as soon as the sand gets saturated – which may take quite some time. The cover will only cause a limited delay of the failure process, which is altogether described by De Groot et al. [2011] as ‘rather slow’.

The pore pressures in the sand core gradually increased, but during the first three days of the test this did not lead to a significant settlement of the dike or outflow of water. At t=73,4 hrs seepage at the west side of the dike, at the foil, was seen. During the next 36 hours hardly anything changed, only after the failure of the West dike (t=109.7 hrs) major changes to the downstream slope were seen: cracks at the west side of the dike.

At t=116.6 hrs water started to flow from the slope above the well-compacted clay layer and the downstream slope started to give way.

At t=132.8 hrs, on Monday, August 27th at 7:30 am the head drop was about 3.3m. During the night before, hardly anything had happened. It was decided to increase the head drop to nearly 3.5m. This was reached at 9:10 am (t=134.28 hrs). At 9:30 (t=134.80 hrs) settlements of the crest near the east side were visible and water started to flow through the cracks, collected on the settled crest and streamed along the downstream slope (see Appendix C, page F-24). At 10:18 (t=135.50 hrs) the settlement of the crest was such that water started to overflow the upper crest line (see Appendix C, page F-25). The downstream slope was already in bad shape by then. At 10:24 (t=135.60 hrs) the water was flowing through two large scour holes (see Appendix C, page F-26) and at 10:28 (t=135.73 hrs) a clear breach had formed (see Appendix C, page F-26), which widened and deepened until the upstream reservoir was nearly empty. It seems impractical to make a detailed analysis of this failure with the available knowledge, as time-dependency seems to be of significant importance, while a time-dependent analysis is yet impossible. Comparison with the failure of the West indicates much similarity, but this failure occurred slower.

It is hard to tell why the failure occurred at that location, apart from coincidence. Probably it was in part related to the concentration of flow down at the toe, caused by the vicinity of the dike wrapped in foil separating the West and the East test dikes, which made this location slightly more vulnerable than the middle part of the dike. This however equally applies to the west side, where even less compaction of the sand core had occurred during construction, as this was carried out from the central part of the piping facility. It should be noted here that in order to avoid failure right at any of the ends of the West and East test dikes, an extra lump of clay was placed near the sides, see Appendix B, page 7, showing the west side of the East dike during construction.

## 3.6 PIPING

The first well was discovered after a little less than two days (t=16.6 hrs) at the downstream toe, with a head drop of 1.60m. Only more than one day later (t=46.4 hrs), with a head drop of 2.02m, this well transformed from producing water only into a sand producing well, implying piping. By then, five other wells had started too. Until the end of the regular inspections at t=107.6 hrs, close before the failure of the West dike, a total of seven wells occurred, three of which produced sand. After the failure of the West dike, observations were hindered by the sand from the West dike deposited at the west side of the downstream basin of this test (see Appendix C, page F-18). Because of safety reasons, at t=113.2 hrs it was decided to stop the detailed inspections altogether. An overview of the well activity in combination with the head drop is given in Appendix D, page D-17.

Piping can be found in the measurements of both the first and the second line of pore pressure meters, at 0.9m and 2.5m from the downstream toe, respectively. Both lines are downstream of the piping prevention measure applied in this test dike: a coarse sand filter with a particle size between 1 and 2 mm, with proper filter properties to interrupt the erosion process) on 3.2 to 3.7 metres from the downstream toe, with a depth of 0.5m (see Appendix C, page F-2). Upstream of this filter, in the pore pressure meters at 4.0m and 11.3m upstream from the downstream toe, no sign of piping could be discerned (cf. Appendix D, pages D-1 to D-16). In addition to the other observations, this clearly proves that failure was not caused by piping.

## 3.7 DISCUSSION: FULFILLING THE AIM OF THE TEST

The aim of the test, as formulated before the construction of the dikes, was that it should fail by (at least) one of the failure mechanisms piping, micro-instability of the sand core and overtopping/erosion. This aim was met, as the failure was primarily caused by micro-instability of the sand core.

The compaction on first fill was not foreseen, but that did not lead to failure.

The preventive measure against piping – the coarse sand filter – appeared to be effective.

# 4 SOUTH DIKE

## 4.1 SUMMARY

The test on the South dike in the All-in-One Sensor Validation Test of the IJkdijk started on Monday, September 3rd, 2012, at 12:12 pm (local time). This moment is defined as t=0. Failure by slope instability with a deep sliding plane took place on the sixth day of the test, on Saturday, September 8th, at 2:27 pm (t=122.26 hrs). This was one of the two failure mechanisms indicated as desired before the start of the test. The reference monitoring data [de Vries et al., 2012] suffices to get a detailed view on the course of the test. Initially, the test has been executed more or less according to the detailed scenario as described in [de Vries, 2012], which is slightly different from the earlier design report [Koelewijn & Peters, 2012], but later on several amendments had to be made.

## 4.2 CONSTRUCTION OF THE DIKE AND CONSOLIDATION PERIOD

The test dike has been constructed from 13 until 26 June 2012 at the IJkdijk test site in Booneschans, Netherlands. The length at the crest was 50 metres and the height above the ground surface was 4.0m at the end of construction. This dike has been constructed South of the earlier test locations, on clay and peat layers with a total thickness of about 4.5m. At the start of the test, on Monday, September 3rd, a settlement had occurred of 0.85m in the East section and 0.99m in the West section (see Appendix 6, pages F-1 and F-2). This was slightly less than the 1.0 to 1.2 metres as anticipated by settlement calculations using the geometry as designed (see Appendix 6, page F-3). The as-built geometry and the fitted settlements for the West section are shown in Appendix 6, pages F-4 and F-5. The time-settlement curves already show that the excess pore pressures had more or less dissipated at the start of the test, but that can also be concluded from the measured pore pressures (see Appendix 5, pages E-A3a, E-A3b, E-A4a and E-A4b – note that these measurements have not been corrected for settlement of the instruments).

A little more than a week before this test started, the whole test area up to the instrumented toe of the South dike was flooded as a result of the failure of the West dike. This failure, on August 26th, can be traced in the measurements of most of the upper pore pressure meters (see Appendix 5, pages E-A3a, E-A3b, E-A4a and E-A4b).

## 4.3 RELIABILITY OF THE INSTRUMENTS

For a detailed registration of the construction of the dike, the consolidation period and the test itself a total number of 26 pore pressure meters and two inclinometers have been installed at the start of the construction. Until the end of August, another 8 pore pressure meters and four inclinometers have been added. All these instruments have performed well, except one inclinometer which failed just before the start of the test. This analysis is based upon this reference monitoring. In addition, Deltares has deployed the following instrumentation to use in case of loss of instrumentation or in case unfavourable conditions, like loss of power supply, would occur:

> a webcam;
> an HD optical camera, taking one frame every five seconds;
> six cheap floating devices, one for each container on top of the embankment, for visual control of complete filling;
> traditional surveying of the settlements of each of the six containers.

As the main instrumentation functioned well (except for one inclinometer) and no unfavourable conditions occurred, this additional instrumentation has not been used for this analysis. By the companies participating in this test, a large variety of instruments has been deployed. The data obtained by these companies is mainly in agreement with the reference monitoring data, but was not required for this analysis, except the data from the weather station.

## 4.4 COURSE OF THE TEST BEFORE FAILURE

The test started on Monday, September 3rd at 12:12 pm. In accordance with the plan, it started by saturating the sand core of the dike by slowly infiltrating water until a phreatic level inside the dike of 0.5m above the level of the (Northern) toe would be reached (stage 1). Starting with a phreatic level of NAP -1.40m and a toe level of NAP -1.15m, the goal was a level of NAP -0.65m. However, at t=12.60 hrs the infiltration has been aborted at a level of NAP -1.10m, because of serious wetting of the area around the toe of the dike. That leakage could occur rather easy is easy to understand regarding the reaction of most of the upper pore pressure meters to the high water level outside the dike earlier.

Filling the basin at the South side of the dike (stage 2) has been carried out from t=1.90 hrs until t=9.55 hrs. To maintain the level, this basin has been refilled several times after (see Appendix 5, page E-B8).

On the second day of the test a ditch has been excavated in front of the dike on the North side (stage 3). This ditch started at 1.5 metres from the toe (0.5m more because of the erroneous placement of a part of a measurement system by one of the participating companies), with a slope of 1:1 at the side of the dike and 1:1.5 at the other side. The excavation has been carried out in three steps, first a depth of 0.5m and a bottom width of 2m (t=23.17 hrs to t=24.05 hrs), then a depth of 1.0m and a bottom width of again 2m (t=24.88 hrs to t=26.30 hrs) and finally a widening to a bottom width of 4m at a depth of 1.0m (t=26.80 hrs to t=28.30 hrs).

On the third day of the test, the deformation rates were such small that the option of waiting (stage 4 of the initial plan) seemed unnecessary. Therefore a further excavation was carried out (stage 5). First, a further excavation by 0.5m to a total depth of 1.5m was carried out, with a bottom width of 4m and side slopes of 1:1 at the dike and 1:2 at the other side (t=45.80 hrs to t=47.30 hrs). Next, the ditch was excavated to a depth of 2m below ground surface (i.e. a ditch bottom at NAP -3.15m) with a bottom width of 4m and the same side slopes as before (t=49.80 hrs to t=52.55 hrs). In the plan, in this stage a further widening of the ditch to a bottom width of 6m was foreseen, but this has not been carried out because of signals of hydraulic fracturing of the ditch bottom (cracks in the bottom and an increase of the inflow of water).

Applying the current pore pressures in the lower sand and considering vertical equilibrium only, at the moment the excavation was carried out the safety factor against uplift was only 0.73, i.e. an unsafe situation. Theoretically, equilibrium would just be achieved with an excavation down to NAP -2.31m only, i.e. an excavation depth of 1.16m. However, because of both arching and limited inflow from beneath a deeper excavation is possible at this site, as was already known from earlier experience. Therefore the maximum excavation depth could not be determined from a simple theoretical calculation, but much closer to reality from practical experience. See Section 4.6 for the impact of the size of the ditch on the stability of the dike.

Water has been infiltrated into the sand core of the dike again on the fourth day of the test, starting at t=67.63 hrs. Probably not only water but also air (from within the pipe) has been pumped into the dike then, because of the quite significant pressure rise. About fifteen minutes later, when less than 1500 litres had been infiltrated, the settlements increased, as well as the horizontal deformations. As soon as this was observed, the infiltration was stopped, this happened at t=67.97 hrs. On hindsight, a few minutes earlier the dike had more or less stopped moving already, depending on the position (or: the instrument) between t=67.88 hrs and t=67.93 hrs.

Infiltration was resumed at t=69.83 hrs. From then on, a limited amount of water was discharged from the sand core through a controllable drainage tube buried close to the Northern toe of the dike. The influence of this drainage can not be found clearly in the measurements, perhaps because the test leaders demanded a too limited outflow discharge.

From t=76.85 hrs on also the tanks on top of the dike were filled with water. The initial filling was with about 0.25m, completed within half an hour. After this, on average every seven hours another filling took place until a level of about 1.75m was reached at t=117.65 hrs, except in both outer tanks as these were less high. The water levels in the tanks (numbered as 1 to 6 from East to West) are shown in Appendix 5, page E-B9.

From t=99.30 hrs the discharge of the controllable drainage tube has been increased, as shown by the measurements (see Appendix 5, pages E-B2a and E-B2b). At t=102.80 hrs this tube has been closed.

On the sixth day of the test, Saturday September 8, the infiltration rate of the sand core is increased by maintaining the level in the intermediate water tank at a constant, high level (instead of intermittently filling this tank). Also, the water was pumped out of the ditch. This went rather slow – based upon the pump discharge, the lowering of the water level in the ditch should have been at least twice as fast, but apparently the seepage flow into the ditch increased as the level dropped. This process went in a non-linear manner (see Appendix 5, page E-B7).

The horizontal deformations accelerated at every increase of the load, just to slow then again later on.

## 4.5 FAILURE OF THE DIKE

As the infiltration of the sand core gradually slowed down because of the decreasing head and the lowering of the water level in the ditch went rather slow too, it was decided to increase the infiltration rate by connecting the pump directly to the infiltration pipe, i.e. bypassing the intermediate tank used to limit the infiltration pressures. This was realised at t=121.69 hrs. While changing the configuration, care was taken to ensure that no air got into the infiltration pipe. Again, this led to an increase of the deformation rate.

At t=122.00 hrs the maximum pressure in the sand core was reached and the deformations continued to increase, most in the middle, slightly less at the East section and even more less at the West section. At t=122.18 hrs the deformations became visible for the human eye, from the bulking of the slope of the ditch, which at t=122.25 hrs concentrated in a zone slightly West to the middle. Within a minute, at t=122.26 hrs (Saturday at 2:27 pm), this slope broke into pieces, after which a slightly more superficial sliding plane occurred and the pore pressures in the sand core decreased quickly. A few minutes later the failure seemed to have stopped, although the measurements show an increase of the deformations up to half an hour later. Plan and side views of the situation after failure are presented in Appendix 6, page F-6. Cross-sections of the post-failure situation are presented in Appendix 6, pages F-7 and F-8.

A forensic investigation was carried out two days after the failure. Several trenches were cut in the area where most of the deformation had taken place. Pictures taken at different depths are shown in Appendix 6, page F-9. In Appendix 6, page F-10, a cross-section is shown indicating several shear planes as found in this investigation, as well as the location of a skewed peat layer closer to the surface, which presumably got there only after the slope of the ditch broke into pieces. Inflow of water and failure of the sides prevented detailed analysis at greater depth.

It does not seem likely that the leakage of water out of the containers (initially mainly at the East side, mostly from container #2, later mainly at the location of the final failure, from containers #4 and #5 – see Appendix 5, page D-31) has contributed much to the failure. The leakage appeared to be significant, but the total volume of water was limited. No influence can be found either in the pore pressure readings which did react to the breach of the West dike and, earlier, to rain (e.g. on August 6-7 a total of 6.6 mm in several showers and on the evening of August 21 a total of 13.8mm within an hour).

## 4.6 STABILITY ANALYSIS

After the failure, an analysis has been made of the slope stability at several important instances during the lifetime of the dike. To this end, all relevant soil investigations carried out from 2006 until 2012 at this site have been used [Koelewijn & Bennett, 2012]. The analytical slope stability models by Bishop [1955] and Van [2001], as implemented into the software package ‘D-Geo Stability’ (version 10.1, build 2.2), have been used to calculate the factor of safety against failure, using average (or ‘best guess’) values for the strength parameters, unit weight and geometry, and measured values for the pore pressures assuming no vertical movements since the start of the test. With respect to the settlements from primary consolidation and creep, this assumption seems fully justified, while for the last phase of the test this assumption may lead to a limited error.

The results of the calculations are presented in Table 4.1. In addition to several situations as they have occurred in reality, a few hypothetical situations have been calculated too, viz. ‘What if a wider ditch would have been excavated?’ and ‘What if no water tanks would have been put on top?’

The first calculated situation is right after completion of the embankment on June 26$^{th}$, as shown in Appendix 6, page F-11 (cf. Appendix 5, page D-31). The excess pore pressures lead to decreased stability with a minimum safety factor of 1.46 according to Van’s model employing a similar model factor of 1.00 as applied for Bishop’s model, because the sliding planes are of similar size and shape. At the start of the test, dissipation of excess pore pressures has led to an increase of the calculated safety factor to 1.74. Right before the last excavation step, the safety factor was reduced already to 1.24. This excavation led to a further reduction to 1.05. A wider ditch bottom would have led to a safety factor of 0.98, implying failure conditions. Just before the infiltration was started, redistribution of pore pressures (a lower phreatic surface inside the sand core, a higher water level in the ditch) had led to an increase again of the safety factor to 1.08. When the test leaders got alarmed by the increased rate of deformation, the calculated safety factor seemed to be as low as 1.01. When the final infiltration step started, on Saturday afternoon, the safety factor was again at 1.01 according to Van's model. For the moment when the maximum pore pressures were reached, a safety factor of 0.92 is calculated, implying failure – which was indeed occurring at that moment. Given the results of the forensic investigation, alternative calculations were made forcing the sliding plane at a higher level. This only resulted in a higher calculated safety factor of 0.97 at the same moment. For the hypothetical situation of not applying water tanks on top of the dike, a safety factor of 0.93 is calculated, i.e. only marginally higher. When the final failure occurred, the measured pore pressures were already lower, resulting in a calculated safety factor of 0.94. Plots of all calculated situations are given in Appendix 6, pages F-12 to F-23.

**Table 4.1 Results for slope stability calculations**

| Situation | Date and time | t (hrs) | SF Van | SF Bishop |
|---|---|---|---|---|
| 1. Embankment completed | 2012.06.26 17:00 | - | 1.46 | 1.50 |
| 2. Start of test | 2012.09.03 12:12 | 0.00 | 1.74 | 1.82 |
| 3. Before last excavation | 2012.09.05 09:00 | 44.80 | 1.24 | 1.38 |
| 4a. After last excavation | 2012.09.05 17:00 | 52.80 | 1.05 | 1.08 |
| 4b. - with ditch bottom width of 6m | hypothetical | 52.80 | 0.98 | 1.01 |
| 5a. Restart of infiltration | 2012.09.06 07:50 | 67.63 | 1.08 | 1.12 |
| 5b. Alarming movements | 08:07 | 67.92 | 1.01 | 1.05 |
| 6a. Start of last infiltration | 2012.09.08 13:53 | 121.69 | 1.01 | 1.05 |
| 6b. Maximum pore pressures | 14:13 | 122.02 | 0.92 | 0.95 |
| 6c. – higher level of sliding plane | 14:13 | 122.02 | 0.97 | - |
| 6d. – without tanks on top | hypothetical | 122.02 | 0.93 | 0.96 |
| 6e. Final failure | 2012.09.08 14:27 | 122.26 | 0.94 | 0.98 |

Because Van's method is based upon Bishop's model, basically with a more flexible shape of the sliding plane, it is logical that $SF_{Bishop} > SF_{Van}$. Usually, the differences are rather small – compare for instance the results for the situation with the lowest safety factor, situation 6b. The location and shape of the sliding plane are nearly the same (Appendix 6, pages F-20 and F-24). The largest difference is found for situation 3, see Appendix 6, pages F-14 and F-25.

The results are almost suspiciously good: a safety factor above 1 for conditions not quickly leading to failure, and below 1 for failure conditions. Note that in this case most input for the calculations was available with a higher accuracy or density than usual. All input has been collected before a calculation was done, i.e. no unethical attempts have been made to arrive at convenient answers. Reference is also made to Spencer [1967] for the accuracy of Bishop's model in practical situations.

No attempt has been made to use the finite element method for this analysis, because of the limited availability of stiffness parameters. In such a case, the advantage of a finite element analysis over analytical methods for slope stability is limited – except that other failure modes may be captured better. However, this does not hold for fracturing from uplift, which seems to be the main 'other failure mode' in this case, as this is very difficult to calculate with most geotechnical finite element software packages because of the zero effective stress in the most important zone.

Although in this analysis the emphasis is put on the pore pressures and the resulting safety factors, the deformations measured by the inclinometers also provide valuable information. Table 4.2 provides some deformation data for two situations: the failure on Saturday and the restart of the infiltration on Thursday, when the decision was made to proceed with more caution. The data given for the failure clearly shows the progressive nature of this failure. The tabulated data for Thursday morning shows a much smaller deformation rate, which appears to be the largest on the East side. Graphical data for both situations is presented in Appendix 6, pages F-26 to F-35 for the failure on Saturday and pages F-36 to F-40 for the restart of the infiltration.

**Table 4.2 Horizontal deformations measured by the inclinometers**

| Situation | East in toe | Middle under crest | Middle in front of toe | West in front of toe | West in toe |
|---|---|---|---|---|---|
| **Failure Saturday** | | | | | |
| 1:53 pm | 115mm | 145mm | 160mm | 140mm | 135mm |
| 2:13 pm | 145mm | 190mm | 200mm | 175mm | 155mm |
| 2:27 pm | 180mm | 430mm | 470mm | 310mm | 320mm |
| 2:30 pm | 225mm | 1450mm | 1650mm | 900mm | 830mm |
| **Infiltration Thursday** | | | | | |
| 7:50 am | 43mm | 37mm | 49mm | 56mm | 44mm |
| just after 8 am | 52mm | 43mm | 56mm | 60mm | 52mm |
| (time of maximum) | (8:08 am) | (8:07 am) | (8:07 am) | (8:06 am) | (8:08 am) |

## 4.7 DISCUSSION: FULFILLING THE AIM OF THE TEST

According to the design report, this test would be a success if the dike would fail either by rupture of the clay layer covering the sand core, or by a deep sliding plane with a minimum deformation of 20 cm along the desired slip plane. The latter occurred. According to the measurements of the inclinometer in the central section just in front of the toe, the deformation criterion was met on Saturday, September 8th, at 2:13 pm (t=122.02 hrs).

# 5 REFERENCES


[van Beek et al., 2009]
V.M. van Beek, H.T.J. De Bruijn & J.G. Knoeff, 'SBW Piping: Hervalidatie Piping, HP5.4b Full-scale proeven (factual report proef 2)', Deltares rapport 1200690-005-GEO-0005, Deltares, Delft November 2009.

[Bishop, 1955]
A.W. Bishop, *The use of the slip circle in the stability analysis of slopes,* Géotechnique 5(1):7-17, 1955.

[de Groot et al., 2011]
Maarten de Groot, Dick Mastbergen, Adam Bezuijen & Theo Stoutjesdijk, 'Micro-instability at dike inner slopes' in: *A feeling for soil and water. A tribute to prof. Frans Barends,* Meindert Van, Evert den Haan & Jurjen van Deen (editors), Deltares Select Series 07/2011, Deltares, Delft, 2011, 65-74

[Knoeff & De Bruijn, 2009]
J.G. Knoeff & H.T.J. De Bruijn, 'SBW Piping: Hervalidatie Piping, HP5.4b Full-scale proeven (factual report proef 3)', Deltares rapport 1200690.005-GEO-0005, Deltares, Delft November 2009.

[Koelewijn et al., 2009a]
A.R. Koelewijn, H.T.J. De Bruijn & V.M. van Beek, 'SBW Piping: Hervalidatie Piping, HP5.4b Full-scale proeven (factual report proef 1)', Deltares rapport 1200690-000-GEO-0023, Deltares, Delft November 2009.

[Koelewijn et al., 2009b]
A.R. Koelewijn, V.M. van Beek & H.T.J. De Bruijn, 'IJkdijk Full Scale Pipingproeven najaar 2009, Factual report proef 4', Deltares rapport 1200375-002-GEO-001, Deltares, Delft December 2009.

[Koelewijn & Bennett, 2012]
A.R. Koelewijn & V.G. Bennett, *Levee failure prediction competition 2012,* ijkdijk.rpi.edu, last visited 20 December 2012.

[Koelewijn & Peters, 2012]
A.R. Koelewijn & D.J. Peters, *Design of IJkdijk All-in-One/Sensor Validation Test,* Report 1206242-000-GEO-0002, version 5, 7 May 2012. Delft: Deltares.

[Koelewijn et al., 2012a]
Andre Koelewijn, Dennis Peters, Goaitske de Vries, Jacoline van Loon & Silvia Bersan, *All in One-Sensor Validatie Test, Factual report Westdijk – proefverloop en referentiemonitoring,* Report 1206242-006-GEO-0001, 3 November 2012. Delft: Deltares.

[Koelewijn et al., 2012b]
Andre Koelewijn, Dennis Peters, Goaitske de Vries, Jacoline van Loon & Silvia Bersan, *All in One-Sensor Validatie Test, Factual report Eastdijk – proefverloop en referentiemonitoring,* Report 1206242-006-GEO-0002, 5 November 2012. Delft: Deltares.

[Kruse, 2012]
Gerard Kruse, *Inspectie van vervorming in de grond van de afschuiving van de IJKDIJK stabiliteitsproef, zuiddijk, van september 2012,* Report 1206015-007, September 2012. Delft: Deltares.

[Spencer, 1967]
E. Spencer, *A method of analysis of the stability of embankments assuming parallel inter-slice forces,* Géotechnique 17(1):11-26, 1967.

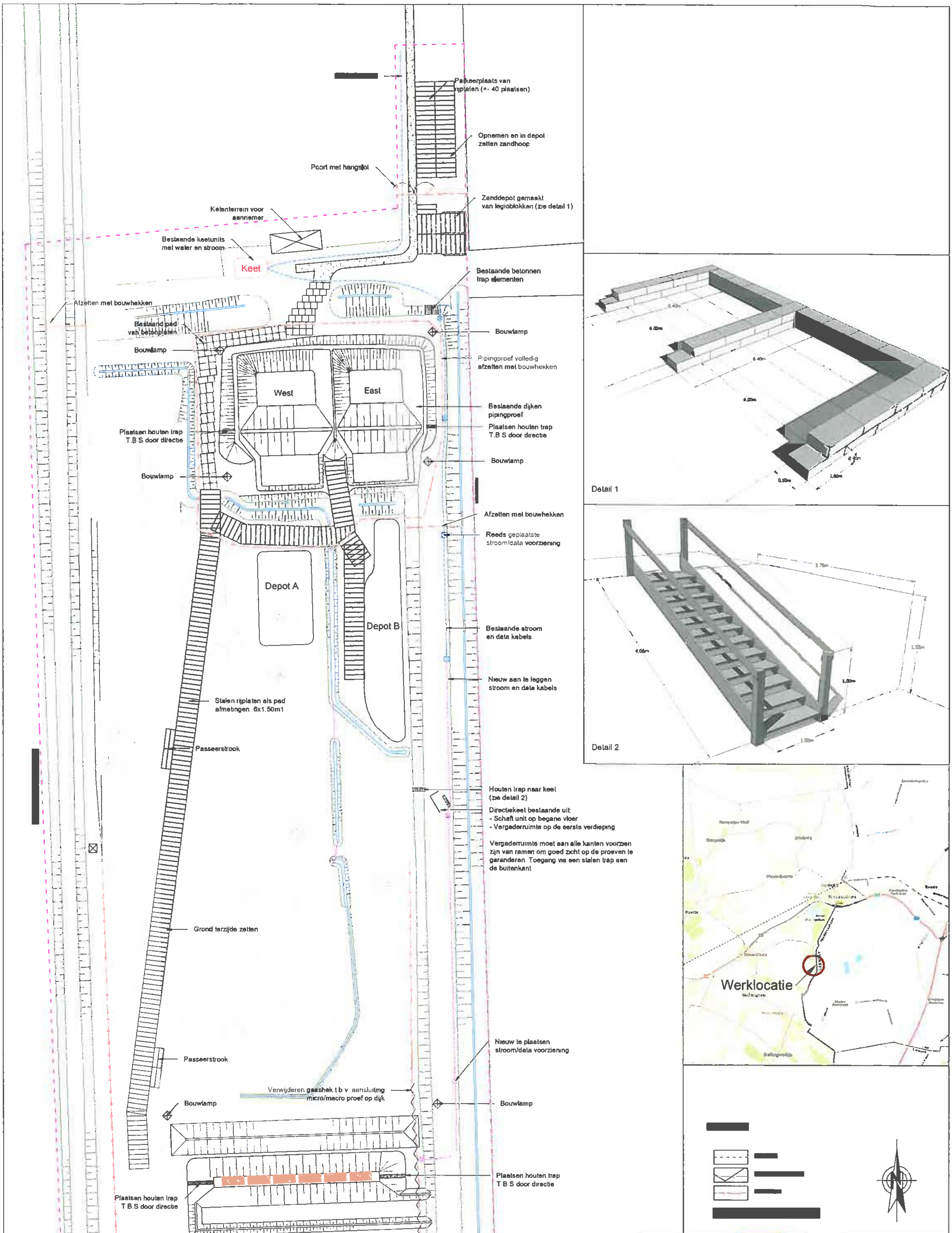
[Van, 2001]
M.A. Van, *New approach for uplift induced slope failure,* Proceedings XVth International Conference on Soil Mechanics and Geotechnical Engineering, Istanbul, September 2001, 2285-2288.

[de Vries, 2012]
G. de Vries, *Draaiboek All in One Sensor Validatie Test (AIO SVT),* Report 1206242-001-GEO-0013, versie 2, 2 August 2012. Delft: Deltares.

[de Vries et al., 2012]
G. de Vries, H.T.J. de Bruijn, D.J. Peters, J. van Loon & A.R. Koelewijn, *All in One-Sensor Validatie Test, Factual report Zuiddijk – proefverloop en referentiemonitoring,* Report 1206242-006-GEO-0005, 12 November 2012. Delft: Deltares.

[van Waardenberg, 2012]
E.H. van Waardenberg, personal communication, Delft, October 2012.

# APPENDIX 1 : WEST DIKE – COPIES FROM FACTUAL REPORT




bovisie projectbureau

[redacted] BO 2012 11 1203

[redacted] All In One experiment

[redacted] Bad Nieuweschans

[redacted] Terreininrichting

[redacted]

[redacted] Definitief

A1

[redacted] 12-04-2012

1:500

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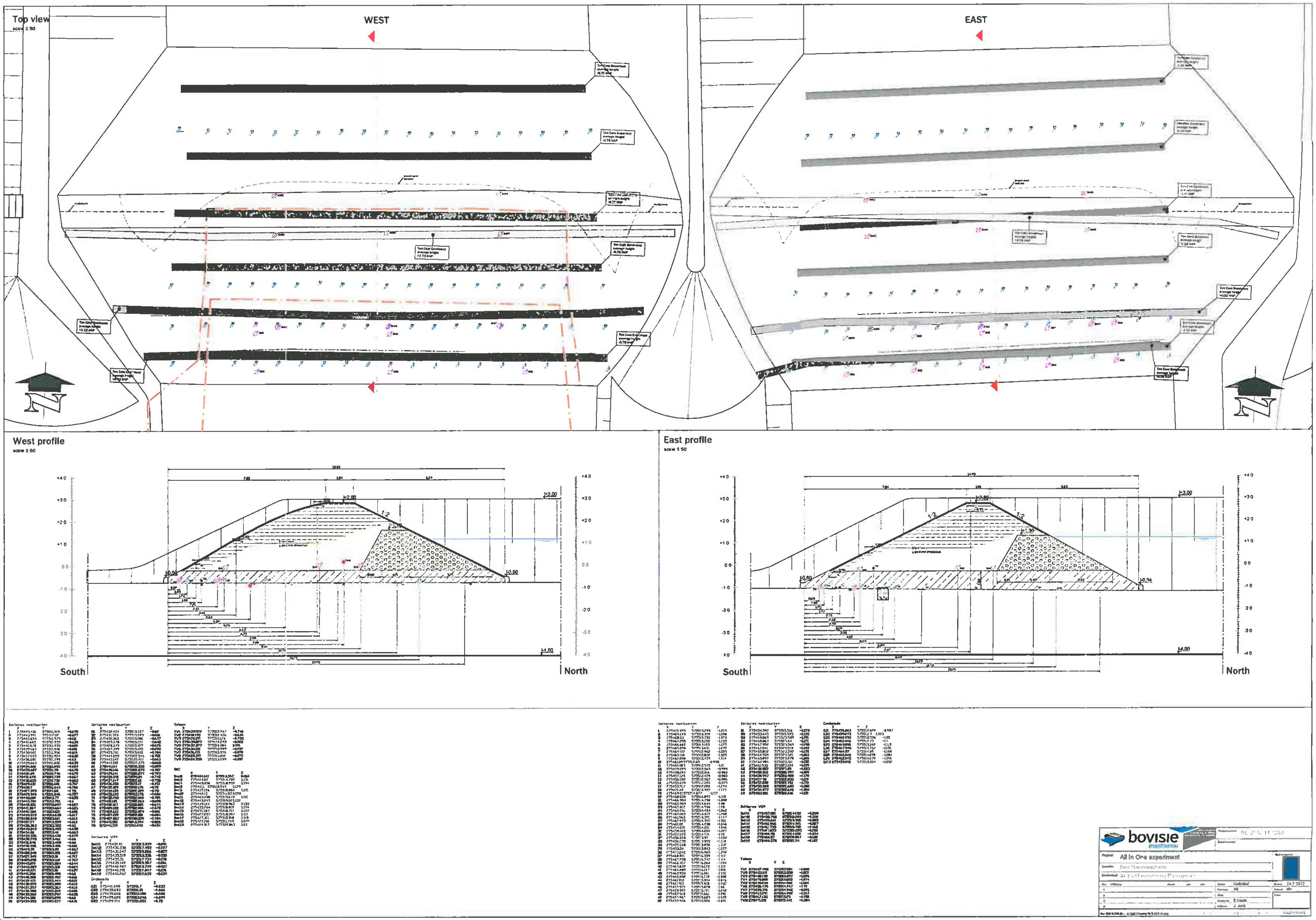
[redacted] E Loots

J. Jonk

www.bovisie.nl

A-1



Top view
scale 1:50
WEST
EAST
West profile
scale 1:50
East profile
scale 1:50
South
North
1:2
+2.80
+3.00
-4.00
+4.0
+3.0
+2.0
+1.0
0.0
-1.0
-2.0
-3.0
-4.0
bovisie
All In One experiment
Bad Nieuweschans


A-2

| | | | | | | |
|---|---|---|---|---|---|---|
| **Hoekpunten proefdijk** | | | | | | |
| zuidwest | 275425.9 | 575510.8 | -0.758 | | 2012-06-27 | 13:58:29 |
| zuidoost | 275445.4 | 575511.2 | -0.706 | | 2012-06-27 | 13:58:55 |
| noordwest | 275426 | 575525.7 | -0.792 | | 2012-06-27 | 14:38:46 |
| noordoost | 275443.7 | 575526 | -0.808 | | 2012-06-27 | 14:40:09 |
| | | | | | | |
| **Meetraai 1** | | | | | | |
| oostzijde | 275445.4 | 575511.9 | -0.695 | | 2012-06-27 | 11:50:24 |
| 101 | 275444 | 575512 | -0.627 | | 2012-06-27 | 11:50:56 |
| 102 | 275442.7 | 575512 | -0.62 | | 2012-06-27 | 11:51:40 |
| 103 | 275441.7 | 575511.9 | -0.635 | | 2012-06-27 | 11:52:15 |
| 104 | 275440.7 | 575511.9 | -0.609 | | 2012-06-27 | 11:52:39 |
| 105 | 275439.7 | 575511.9 | -0.601 | | 2012-06-27 | 11:53:00 |
| 106 | 275438.7 | 575511.9 | -0.616 | | 2012-06-27 | 11:53:21 |
| 107 | 275437.7 | 575511.8 | -0.632 | | 2012-06-27 | 11:53:39 |
| 108 | 275436.7 | 575511.8 | -0.63 | | 2012-06-27 | 11:54:01 |
| 109 | 275435.7 | 575511.8 | -0.639 | | 2012-06-27 | 11:54:21 |
| 110 | 275434.7 | 575511.8 | -0.664 | | 2012-06-27 | 11:54:52 |
| 111 | 275433.7 | 575511.8 | -0.678 | | 2012-06-27 | 11:55:21 |
| 112 | 275432.7 | 575511.7 | -0.678 | | 2012-06-27 | 11:56:27 |
| 113 | 275431.7 | 575511.7 | -0.667 | | 2012-06-27 | 11:56:59 |
| 114 | 275430.7 | 575511.7 | -0.663 | | 2012-06-27 | 11:57:21 |
| 115 | 275429.7 | 575511.7 | -0.707 | | 2012-06-27 | 11:57:44 |
| 116 | 275428.7 | 575511.6 | -0.708 | | 2012-06-27 | 11:58:02 |
| 117 | 275427.4 | 575511.6 | -0.72 | | 2012-06-27 | 11:58:23 |
| westzijde | 275425.9 | 575511.5 | -0.787 | | 2012-06-27 | 11:59:05 |
| | | | | | | |
| **Meetraai 2** | | | | | | |
| oostzijde | 275445.2 | 575513.8 | -0.655 | | 2012-06-27 | 12:00:06 |
| 201 | 275443.7 | 575513.7 | -0.6 | | 2012-06-27 | 12:00:41 |
| 202 | 275442.5 | 575513.7 | -0.627 | | 2012-06-27 | 12:01:02 |
| 203 | 275441.6 | 575513.7 | -0.623 | | 2012-06-27 | 12:01:22 |
| 204 | 275440.6 | 575513.7 | -0.606 | | 2012-06-27 | 12:01:39 |
| 205 | 275439.6 | 575513.6 | -0.617 | | 2012-06-27 | 12:01:55 |
| 206 | 275438.5 | 575513.6 | -0.613 | | 2012-06-27 | 12:02:11 |
| 207 | 275437.6 | 575513.5 | -0.613 | | 2012-06-27 | 12:02:26 |
| 208 | 275436.6 | 575513.5 | -0.65 | | 2012-06-27 | 12:02:44 |
| 209 | 275435.5 | 575513.5 | -0.658 | | 2012-06-27 | 12:03:04 |
| 210 | 275434.6 | 575513.5 | -0.663 | | 2012-06-27 | 12:03:19 |
| 211 | 275433.5 | 575513.4 | -0.679 | | 2012-06-27 | 12:03:39 |
| 212 | 275432.6 | 575513.5 | -0.66 | | 2012-06-27 | 12:03:57 |
| 213 | 275431.5 | 575513.4 | -0.66 | | 2012-06-27 | 12:04:18 |
| 214 | 275430.6 | 575513.4 | -0.661 | | 2012-06-27 | 12:04:35 |
| 215 | 275429.6 | 575513.4 | -0.667 | | 2012-06-27 | 12:04:52 |
| 216 | 275428.5 | 575513.4 | -0.687 | | 2012-06-27 | 13:10:49 |
| 217 | 275427.3 | 575513.3 | -0.717 | | 2012-06-27 | 13:11:11 |
| westzijde | 275425.9 | 575513.2 | -0.767 | | 2012-06-27 | 13:11:30 |
| | | | | | | |
| **Meetraai 3** | | | | | | |
| oostzijde | 275445 | 575515.6 | -0.644 | | 2012-06-27 | 13:12:50 |
| 301 | 275443.4 | 575515.5 | -0.624 | | 2012-06-27 | 13:13:04 |
| 302 | 275442.4 | 575515.5 | -0.627 | | 2012-06-27 | 13:13:19 |
| 303 | 275441.4 | 575515.5 | -0.62 | | 2012-06-27 | 13:13:41 |
| 304 | 275440.4 | 575515.5 | -0.616 | | 2012-06-27 | 13:13:57 |
| 305 | 275439.4 | 575515.4 | -0.618 | | 2012-06-27 | 13:14:19 |
| 306 | 275438.4 | 575515.4 | -0.613 | | 2012-06-27 | 13:14:37 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 307 | 275437.4 | 575515.4 | -0.613 | | 2012-06-27 | 13:14:56 |
| 308 | 275436.4 | 575515.3 | -0.606 | | 2012-06-27 | 13:15:07 |
| 309 | 275435.4 | 575515.3 | -0.632 | | 2012-06-27 | 13:15:19 |
| 310 | 275434.4 | 575515.3 | -0.62 | | 2012-06-27 | 13:15:40 |
| 311 | 275433.4 | 575515.3 | -0.651 | | 2012-06-27 | 13:15:53 |
| 312 | 275432.4 | 575515.3 | -0.62 | | 2012-06-27 | 13:16:07 |
| 313 | 275431.4 | 575515.2 | -0.616 | | 2012-06-27 | 13:16:21 |
| 314 | 275430.4 | 575515.2 | -0.637 | | 2012-06-27 | 13:16:33 |
| 315 | 275429.4 | 575515.2 | -0.642 | | 2012-06-27 | 13:16:46 |
| 316 | 275428.4 | 575515.1 | -0.676 | | 2012-06-27 | 13:17:01 |
| 317 | 275427.4 | 575515.1 | -0.692 | | 2012-06-27 | 13:17:17 |
| westzijde | 275425.8 | 575515 | -0.784 | | 2012-06-27 | 13:17:36 |
| | | | | | | |
| **Meetraai 4** | | | | | | |
| oostzijde | 275444.2 | 575522.5 | -0.705 | | 2012-06-27 | 13:23:15 |
| 401 | 275443.1 | 575522.4 | -0.663 | | 2012-06-27 | 13:23:33 |
| 402 | 275442.1 | 575522.4 | -0.665 | | 2012-06-27 | 13:23:54 |
| 403 | 275441.1 | 575522.3 | -0.689 | | 2012-06-27 | 13:24:08 |
| 404 | 275440.1 | 575522.3 | -0.707 | | 2012-06-27 | 13:24:24 |
| 405 | 275439.1 | 575522.3 | -0.723 | | 2012-06-27 | 13:26:34 |
| 406 | 275438.1 | 575522.2 | -0.742 | | 2012-06-27 | 13:40:48 |
| 407 | 275437.1 | 575522.2 | -0.736 | | 2012-06-27 | 13:41:18 |
| 408 | 275436.2 | 575522.2 | -0.713 | | 2012-06-27 | 13:41:45 |
| 409 | 275435.1 | 575522.2 | -0.72 | | 2012-06-27 | 13:42:03 |
| 410 | 275434.1 | 575522.2 | -0.711 | | 2012-06-27 | 13:42:18 |
| 411 | 275433.1 | 575522.2 | -0.684 | | 2012-06-27 | 13:42:35 |
| 412 | 275432.1 | 575522.1 | -0.709 | | 2012-06-27 | 13:42:51 |
| 413 | 275431.1 | 575522.1 | -0.692 | | 2012-06-27 | 13:43:10 |
| 414 | 275430.2 | 575522 | -0.674 | | 2012-06-27 | 13:43:28 |
| 415 | 275429.1 | 575522 | -0.675 | | 2012-06-27 | 13:44:42 |
| 416 | 275428.1 | 575522 | -0.661 | | 2012-06-27 | 13:54:09 |
| 417 | 275427.2 | 575522 | -0.684 | | 2012-06-27 | 13:54:16 |
| westzijde | 275425.9 | 575522.1 | -0.784 | | 2012-06-27 | 13:54:23 |
| | | | | | | |
| **Bovenstrooms bassin** | | | | | | |
| baak | 275441.6 | 575513.4 | -0.626 | | 2012-06-27 | 13:56:23 |
| peilmeter | 275441.7 | 575511.7 | -0.654 | | 2012-06-27 | 13:56:35 |
| | | | | | | |
| **Waterspanningsmeters in de zandkern - A01 t/m A09** | | | | | | |
| 1 | 275440.5 | 575513.7 | -0.037 | | 2012-07-02 | 16:38:41 |
| 2 | 275440.4 | 575517.8 | -0.051 | | 2012-07-02 | 16:38:51 |
| 3 | 275440.3 | 575519.6 | -0.039 | | 2012-07-02 | 16:39:00 |
| 4 | 275435.5 | 575513.5 | -0.058 | | 2012-07-02 | 16:39:15 |
| 5 | 275435.3 | 575517.7 | -0.008 | | 2012-07-02 | 16:39:24 |
| 6 | 275435.1 | 575519.6 | -0.016 | | 2012-07-02 | 16:39:32 |
| 7 | 275430.6 | 575513.3 | -0.091 | | 2012-07-02 | 16:39:43 |
| 8 | 275430.3 | 575517.5 | -0.027 | | 2012-07-02 | 16:39:55 |
| 9 | 275430.2 | 575519.3 | -0.023 | | 2012-07-02 | 16:40:05 |
| | | | | | | |
| **Kleidijk - diverse punten** | | | | | | |
| Kleidijk | 275425 | 575516.6 | -0.089 | | 2012-07-02 | 16:50:35 |
| Kleidijk1 | 275426.2 | 575517.9 | -0.116 | | 2012-07-02 | 16:50:53 |
| Kleidijk2 | 275427.2 | 575518.7 | -0.087 | | 2012-07-02 | 16:51:00 |
| Kleidijk3 | 275428.7 | 575519.8 | -0.024 | | 2012-07-02 | 16:51:09 |
| Kleidijk4 | 275432.4 | 575520 | -0.031 | | 2012-07-02 | 16:51:17 |
| Kleidijk5 | 275435.2 | 575520 | -0.042 | | 2012-07-02 | 16:51:25 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Kleidijk6 | 275438 | 575520 | -0.047 | | 2012-07-02 | 16:51:32 |
| Kleidijk7 | 275440.4 | 575520 | -0.03 | | 2012-07-02 | 16:51:40 |
| Kleidijk8 | 275443.1 | 575519.1 | -0.057 | | 2012-07-02 | 16:51:50 |
| Kleidijk9 | 275444.5 | 575517.6 | -0.006 | | 2012-07-02 | 16:51:58 |
| Kleidijk10 | 275445.6 | 575516.3 | -0.007 | | 2012-07-02 | 16:52:05 |
| Kleidijk11 | 275446 | 575517.6 | 0.434 | | 2012-07-02 | 16:52:11 |
| Kleidijk12 | 275446.7 | 575519.2 | 1.304 | | 2012-07-02 | 16:52:30 |
| Kleidijk13 | 275447.1 | 575520.4 | 1.638 | | 2012-07-02 | 16:52:37 |
| Kleidijk14 | 275447.1 | 575522.2 | 1.736 | | 2012-07-02 | 16:53:02 |
| Kleidijk15 | 275445.5 | 575522.5 | 1.752 | | 2012-07-02 | 16:53:15 |
| Kleidijk16 | 275442.9 | 575522.6 | 1.728 | | 2012-07-02 | 16:53:31 |
| Kleidijk17 | 275439.8 | 575522.7 | 1.763 | | 2012-07-02 | 16:53:49 |
| Kleidijk18 | 275434.4 | 575522.5 | 1.722 | | 2012-07-02 | 16:54:00 |
| Kleidijk19 | 275430.4 | 575522.2 | 1.722 | | 2012-07-02 | 16:54:09 |
| Kleidijk20 | 275426.9 | 575521.9 | 1.725 | | 2012-07-02 | 16:54:19 |
| Kleidijk21 | 275423.9 | 575521.5 | 1.723 | | 2012-07-02 | 16:54:30 |
| Kleidijk22 | 275422.3 | 575521.1 | 1.717 | | 2012-07-02 | 16:54:41 |
| Kleidijk23 | 275422.3 | 575520.2 | 1.718 | | 2012-07-02 | 16:54:48 |
| Kleidijk24 | 275425.1 | 575520.4 | 1.638 | | 2012-07-02 | 16:54:57 |
| Kleidijk25 | 275428.6 | 575520.8 | 1.727 | | 2012-07-02 | 16:55:07 |
| Kleidijk26 | 275433 | 575520.9 | 1.751 | | 2012-07-02 | 16:55:21 |
| Kleidijk27 | 275437.1 | 575520.9 | 1.774 | | 2012-07-02 | 16:55:33 |
| Kleidijk28 | 275441.8 | 575520.8 | 1.716 | | 2012-07-02 | 16:55:47 |
| Kleidijk29 | 275444.4 | 575520.7 | 1.709 | | 2012-07-02 | 16:55:58 |
| Kleidijk30 | 275423.3 | 575519.1 | 1.004 | | 2012-07-02 | 16:56:23 |
| Kleidijk31 | 275423.6 | 575518 | 0.695 | | 2012-07-02 | 16:56:32 |
| Kleidijk32 | 275424.9 | 575516.7 | -0.136 | | 2012-07-02 | 16:56:43 |
| | | | | | | |
| **Zandlaag - diverse punten** | | | | | | |
| zand | 275447.4 | 575521.1 | 1.989 | | 2012-07-03 | 11:56:34 |
| zand1 | 275444.8 | 575522 | 2.067 | | 2012-07-03 | 11:56:44 |
| zand2 | 275443.1 | 575521.8 | 2.106 | | 2012-07-03 | 11:56:52 |
| zand3 | 275437.3 | 575521.9 | 2.126 | | 2012-07-03 | 11:57:03 |
| zand4 | 275433 | 575521.7 | 2.08 | | 2012-07-03 | 11:57:15 |
| zand5 | 275426.6 | 575521.4 | 1.936 | | 2012-07-03 | 11:57:29 |
| zand6 | 275422 | 575520.5 | 1.952 | | 2012-07-03 | 11:57:49 |
| zand7 | 275422.2 | 575520.1 | 1.845 | | 2012-07-03 | 13:38:05 |
| zand8 | 275425.5 | 575520.6 | 1.934 | | 2012-07-03 | 13:38:13 |
| zand9 | 275430.7 | 575520.2 | 2.008 | | 2012-07-03 | 13:38:25 |
| zand10 | 275436 | 575520.3 | 2.059 | | 2012-07-03 | 13:38:37 |
| zand11 | 275439.9 | 575520.3 | 2.201 | | 2012-07-03 | 13:38:52 |
| zand12 | 275443.7 | 575520.6 | 1.981 | | 2012-07-03 | 13:39:02 |
| zand13 | 275444.3 | 575518.3 | 1.157 | | 2012-07-03 | 13:39:34 |
| zand14 | 275439.8 | 575518 | 1.047 | | 2012-07-03 | 13:39:44 |
| zand15 | 275435.9 | 575518 | 1.074 | | 2012-07-03 | 13:39:53 |
| zand16 | 275430.6 | 575518.1 | 1.126 | | 2012-07-03 | 13:40:05 |
| zand17 | 275427.3 | 575518.3 | 1.076 | | 2012-07-03 | 13:40:14 |
| zand18 | 275426 | 575519.6 | 1.394 | | 2012-07-03 | 13:40:26 |

**Debieten bovenstrooms en verval**

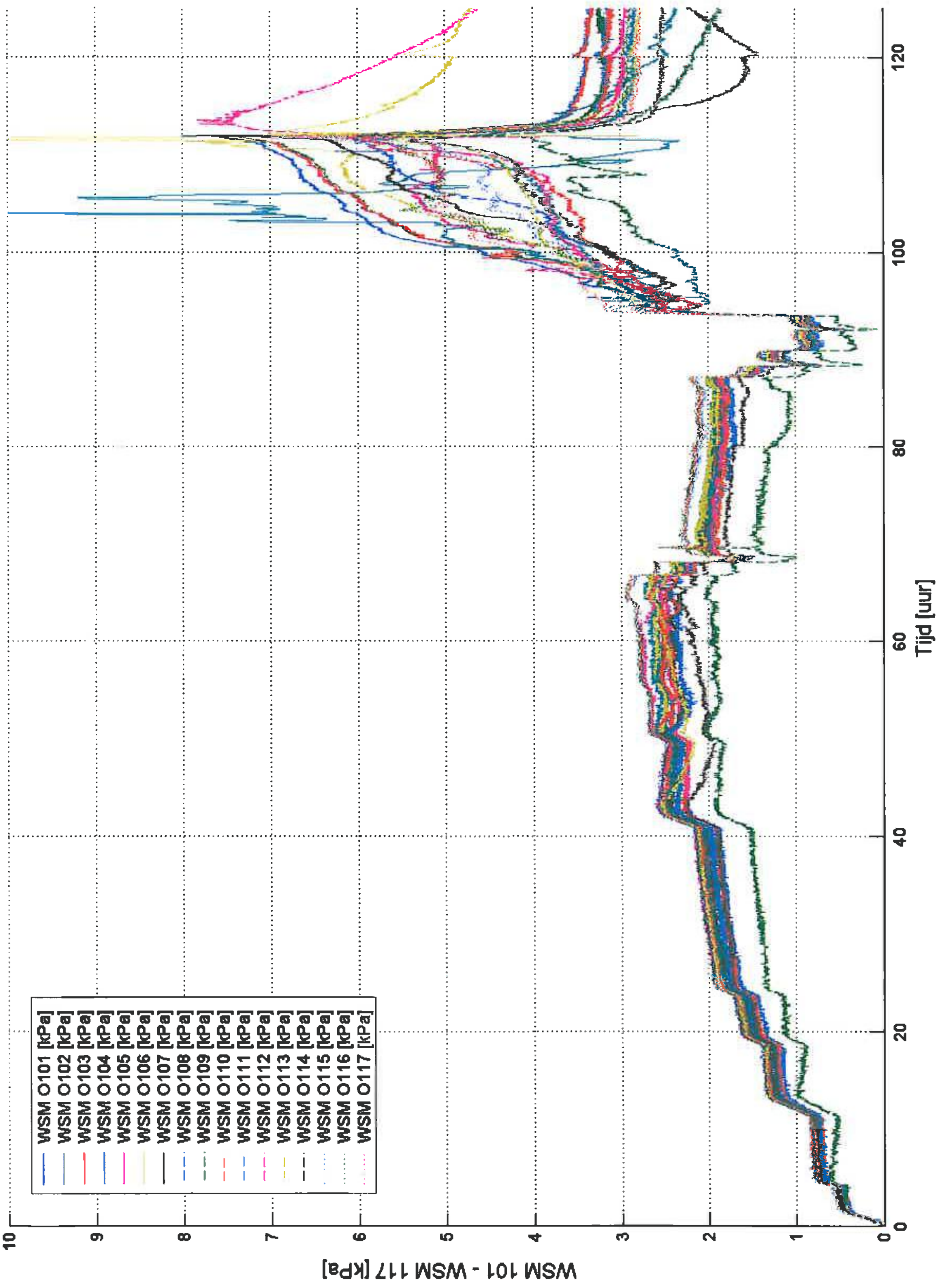
| datum | tijd | debietmeterstand | | waterstand | | verval |
|---|---|---|---|---|---|---|
| | | (west *10 voor m3) | m3 | benedenstr, | bovenstr. | |
| 21-8-2012 | 10:50 | 18672 | | 0.11 | 0.1 | -0.01 |
| 21-8-2012 | 18:00 | 18683 | 110 | 0.11 | 0.61 | 0.5 |
| 21-8-2012 | 21:25 | | | 0.13 | 0.64 | 0.51 |
| 21-8-2012 | 21:44 | | | 0.13 | 0.62 | 0.49 |
| 21-8-2012 | 23:43 | | | 0.13 | 0.62 | 0.49 |
| 22-8-2012 | 01:16 | | | 0.14 | 0.62 | 0.48 |
| 22-8-2012 | 03:34 | 18683 | 0 | | 0.62 | |
| 22-8-2012 | 05:29 | 18696.56 | 135.6 | 0.14 | 1.12 | 0.98 |
| 22-8-2012 | 06:20 | | | 0.145 | 1.12 | 0.975 |
| 22-8-2012 | 07:59 | 18696.56 | 0 | 0.145 | 1.12 | 0.975 |
| 22-8-2012 | 13:32 | 18703.45 | 68.9 | 0.16 | 1.31 | 1.15 |
| 22-8-2012 | 17:40 | 18710.5 | 70.5 | 0.16 | 1.5 | 1.34 |
| 22-8-2012 | 21:51 | | | 0.175 | 1.48 | 1.305 |
| 22-8-2012 | 23:31 | | | 0.18 | 1.46 | 1.28 |
| 23-8-2012 | 01:40 | | | 0.18 | 1.45 | 1.27 |
| 23-8-2012 | 06:00 | | | 0.19 | 1.42 | 1.23 |
| 23-8-2012 | 07:28 | 18710.5 | 0 | 0.195 | 1.41 | 1.215 |
| 23-8-2012 | 10:44 | 18723 | 125 | 0.2 | 1.76 | 1.56 |
| 23-8-2012 | 13:12 | 18723 | 0 | 0.25 | 1.735 | 1.485 |
| 23-8-2012 | 14:18 | 18724 | 10 | | | |
| 23-8-2012 | 16:01 | 18724 | 0 | 0.2 | 1.75 | 1.55 |
| 23-8-2012 | 18:53 | 18734.225 | 102.25 | | | |
| 23-8-2012 | 19.40 | 18734.225 | 0 | 0.2 | 1.99 | 1.79 |
| 23-8-2012 | 22.30 | 18734.235 | 0.1 | | | |
| 23-8-2012 | 22.50 | 18736.748 | 25.13 | | | |
| 23-8-2012 | 23.06 | 18736.748 | 0 | | | |
| 24-8-2012 | 2.19 | | | 0.21 | 2.08 | 1.87 |
| 24-8-2012 | 5.14 | 18740.016 | 32.68 | 0.22 | 2.05 | 1.83 |
| 24-8-2012 | 5.46 | 18742.968 | 29.52 | | | |
| 24-8-2012 | 07:48 | 18743 | 0.32 | 0.215 | 2.08 | 1.865 |
| 24-8-2012 | 08:48 | 18748 | 50 | | 2.215 | |
| 24-8-2012 | 09:58 | | | | 2.2 | |
| 24-8-2012 | 10:08 | 18750.518 | 25.18 | 0.225 | 2.24 | 2.015 |
| 24-8-2012 | 11:11 | 18750.518 | 0 | 0.23 | 2.23 | 2 |
| 24-8-2012 | 13:38 | 18751 | 4.82 | 0.22 | 2.23 | 2.01 |
| 24-8-2012 | 17:23 | 18756 | 50 | | 2.31 | 2.1 |
| 24-8-2012 | 18:42 | 18757 | 10 | 0.21 | 2.32 | 2.11 |
| 24-8-2012 | 20.25 | 18757.87 | 8.7 | 0.21 | 2.3 | 2.09 |
| 24-8-2012 | 20.35 | 18758.864 | 9.94 | | 2.325 | 2.12 |
| 24-8-2012 | 23.18 | 18758.864 | 0 | 0.21 | 2.3 | 2.09 |
| 24-8-2012 | 23.28 | 18759.49 | 6.26 | | 2.33 | 2.13 |
| 25-8-2012 | 1.05 | | | 0.2 | 2.315 | 2.115 |
| 25-8-2012 | 2.47 | | | | 2.3 | 2.1 |
| 25-8-2012 | 2.57 | 18761.857 | 23.67 | | 2.33 | 2.13 |
| 25-8-2012 | 4.45 | | | 0.2 | 2.315 | 2.115 |
| 25-8-2012 | 5.44 | | | | 2.305 | 2.11 |
| 25-8-2012 | 5.53 | 18762 | 1.43 | | 2.33 | 2.13 |
| 25-8-2012 | 06:48 | 18767 | 50 | | | |

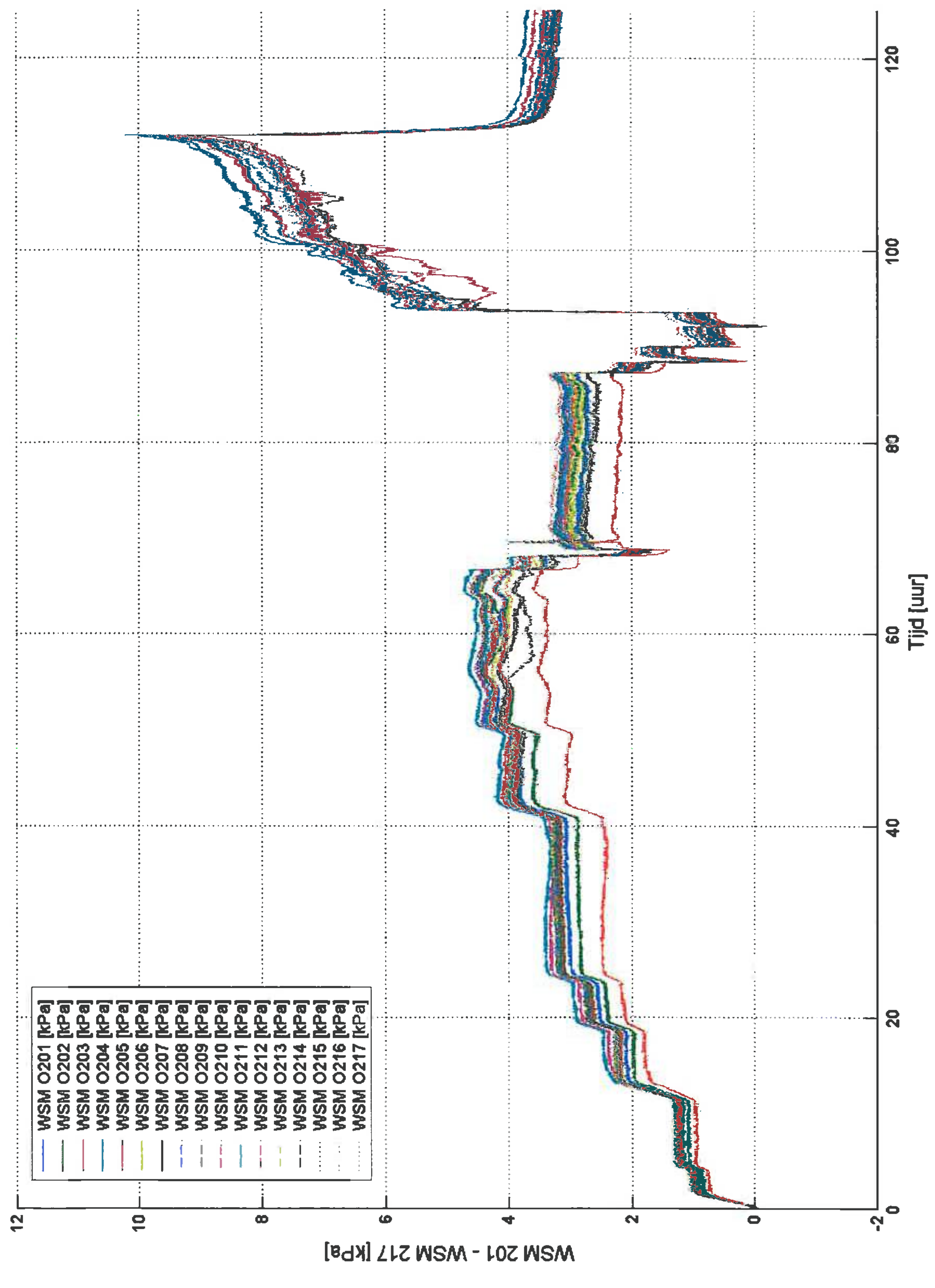
| | | | | | | |
|---|---|---|---|---|---|---|
| 25-8-2012 | 07:34 | 18767 | 0 | 0.2 | 2.42 | 2.22 |
| 25-8-2012 | 09:35 | 18771 | 40 | 0.185 | 2.49 | 2.305 |
| 25-8-2012 | 10:38 | | | | 2.7 | 2.53 |
| 25-8-2012 | 13:15 | 18792.425 | 214.25 | 0.165 | 2.9 | 2.735 |
| 25-8-2012 | 14:37 | | | | 3.1 | 2.91 |
| 25-8-2012 | 18:07 | | | | 3.44 | 3.23 |
| 25-8-2012 | 19.10 | 18825.094 | 326.69 | 0.24 | 3.42 | 3.18 |
| 25-8-2012 | 20.09 | | | 0.25 | 3.41 | 3.16 |
| 25-8-2012 | 22.05 | | | | 3.385 | |
| 25-8-2012 | 22.36 | | | 0.3 | 3.38 | 3.08 |
| 26-8-2012 | 2.11 | | | | 3.335 | |
| 26-8-2012 | 4.00 | | | | 3.31 | |
| 26-8-2012 | 6.00 | | | | 3.29 | |
| 26-8-2012 | 09:07 | 18833.461 | 83.67 | | | |
| 24-8-2012 | 0.17 | 18740.016 | -934.45 | | 2.1 | |

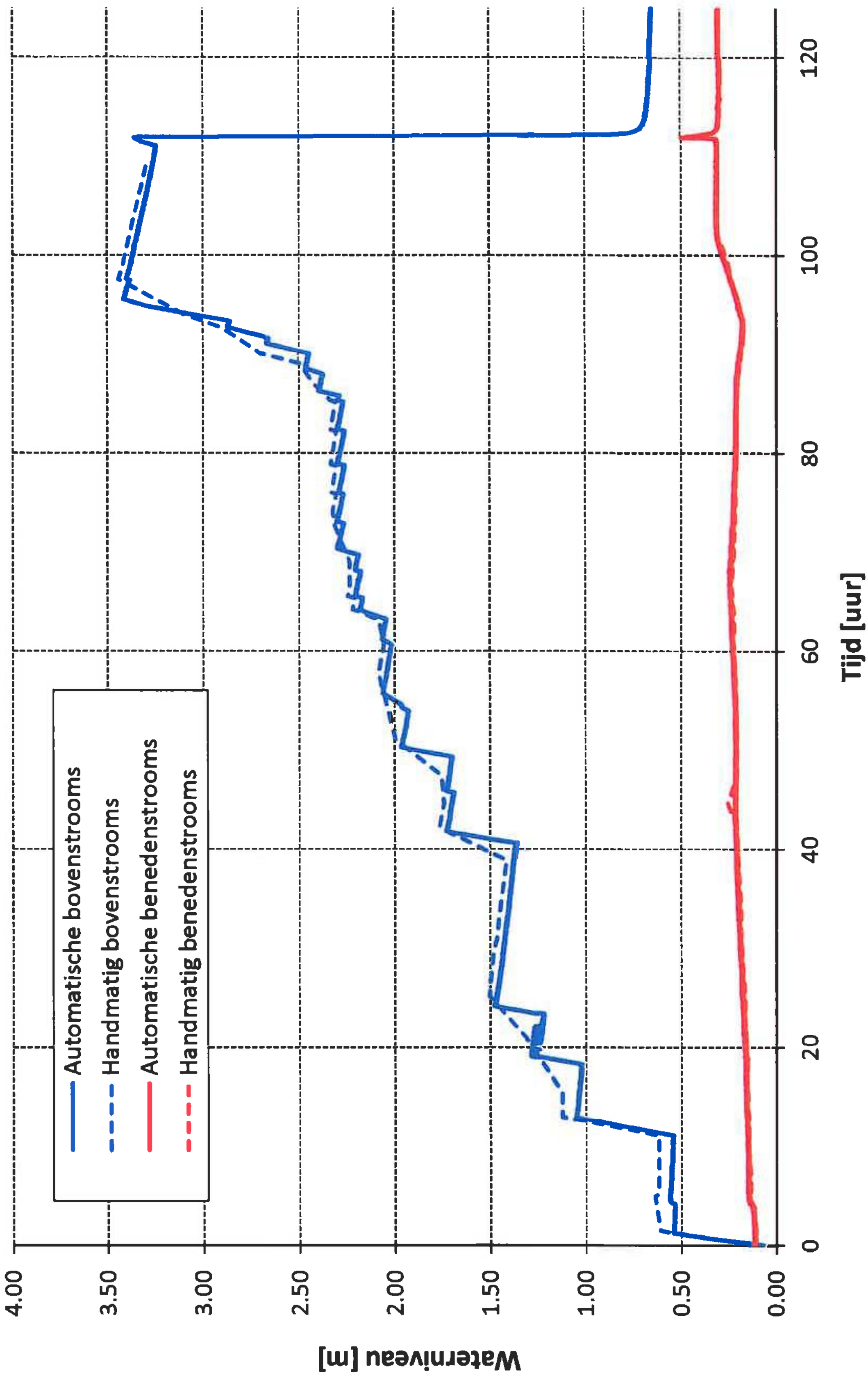
| WEST LAAG | |
|---|---|
| bovenkant zand | = -0.78 NAP |
| nulpunt baak | = -0.78 NAP |
| sensorniveau | = -0.74 NAP |
| waterstand | = -0.67 NAP |

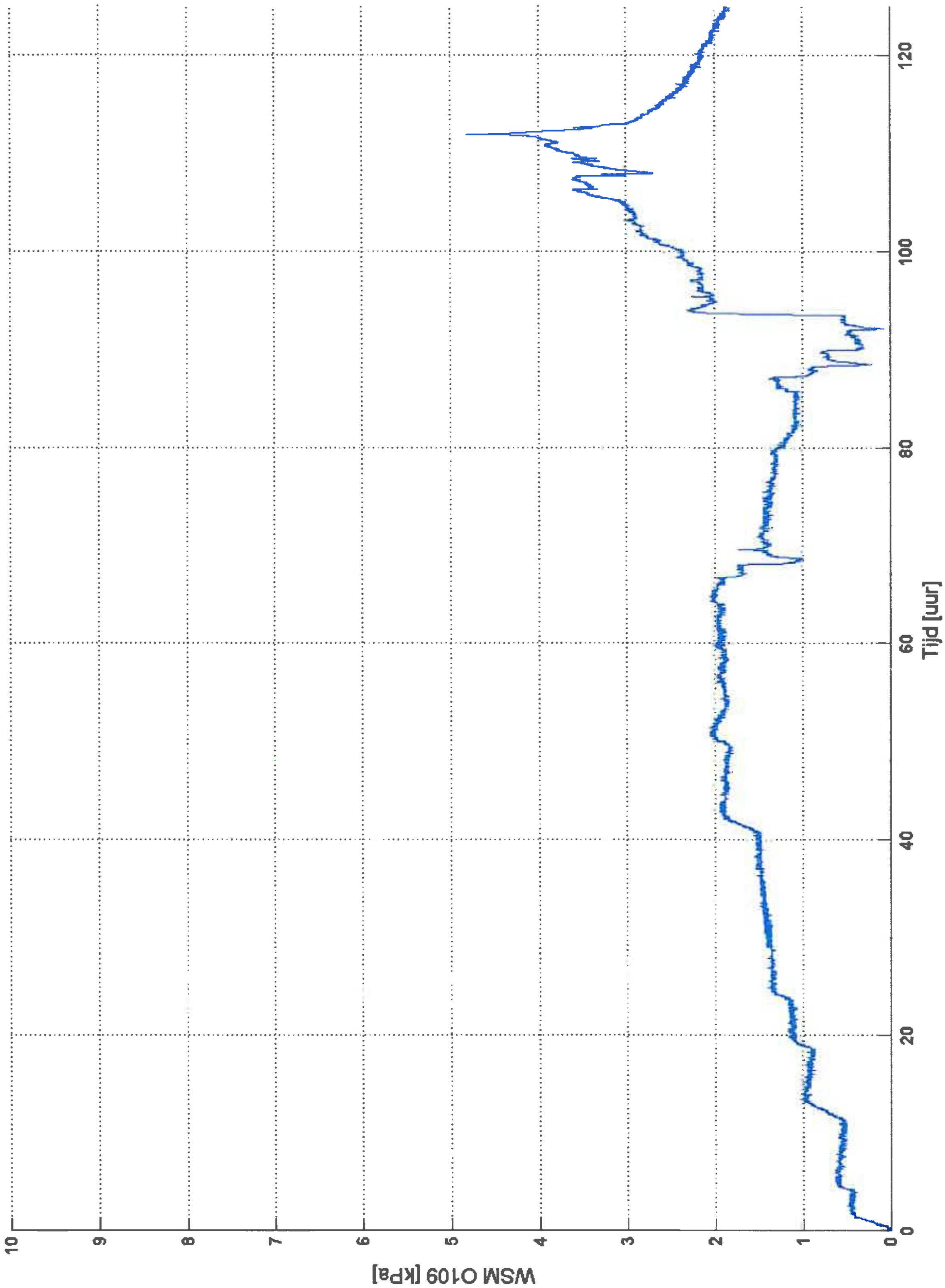
| WEST HOOG | |
|---|---|
| bovenkant zand | = -0.79 NAP |
| nulpunt baak | = -0.79 NAP |
| sensorniveau | = -0.82 NAP |
| waterstand | = -0.63 NAP |

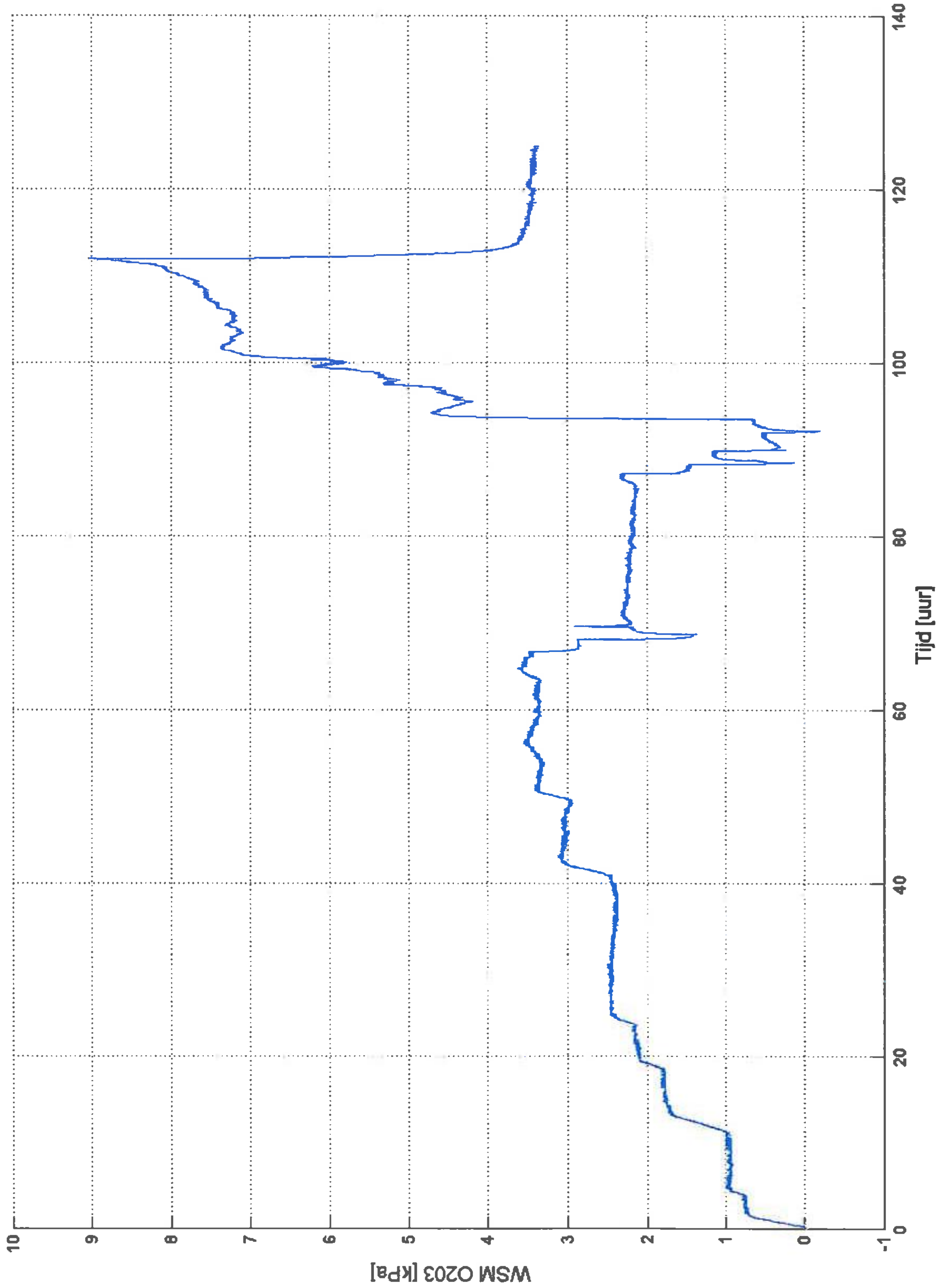
Bij gelijke waterstand is de
aflezing op de baak in het hoge bassin 0.01 m hoger
Voor de sensor is dat 0.08 m


WSM 101 - WSM 117 [kPa]
Tijd [uur]
0
1
2
3
4
5
6
7
8
9
10
0
20
40
60
80
100
120
WSM O101 [kPa]
WSM O102 [kPa]
WSM O103 [kPa]
WSM O104 [kPa]
WSM O105 [kPa]
WSM O106 [kPa]
WSM O107 [kPa]
WSM O108 [kPa]
WSM O109 [kPa]
WSM O110 [kPa]
WSM O111 [kPa]
WSM O112 [kPa]
WSM O113 [kPa]
WSM O114 [kPa]
WSM O115 [kPa]
WSM O116 [kPa]
WSM O117 [kPa]


WSM 201 - WSM 217 [kPa]
Tijd [uur]
WSM O201 [kPa]
WSM O202 [kPa]
WSM O203 [kPa]
WSM O204 [kPa]
WSM O205 [kPa]
WSM O206 [kPa]
WSM O207 [kPa]
WSM O208 [kPa]
WSM O209 [kPa]
WSM O210 [kPa]
WSM O211 [kPa]
WSM O212 [kPa]
WSM O213 [kPa]
WSM O214 [kPa]
WSM O215 [kPa]
WSM O216 [kPa]
WSM O217 [kPa]


Automatische bovenstrooms
Handmatig bovenstrooms
Automatische benedenstrooms
Handmatig benedenstrooms
Waterniveau [m]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Tijd [uur]
0
20
40
60
80
100
120


WSM O109 [kPa]
Tijd [uur]
0
1
2
3
4
5
6
7
8
9
10
0
20
40
60
80
100
120


WSM O203 [kPa]
Tijd [uur]
-1
0
1
2
3
4
5
6
7
8
9
10
0
20
40
60
80
100
120
140

**Overzicht wellen en kraters IJkdijk AIO-SVT West**

| | | |
|---|---|---|
| Legenda: | 0 | Stilgevallen/bedolven |
| | 1 | Zandspoor, geen zichtbaar koken van zand of zandtransport, geen verandering in grootte, geen stofwolk |
| | 2a | Zandspoor, geen zichtbaar koken van zand of zandtransport, wel geleidelijke groei |
| | 2b | Zandspoor, geen zichtbaar koken van zand of zandtransport, wel een stofwolk zichtbaar |
| | 3a | Watervoerende wel, maar geen kokend zand |
| | 3b | Watervoerende wel; kokend zand, niet zandmeevoerend |
| | 4 | zandmeevoerende wel (ZMV) |
| | x | afscheppen zonder volume-indicatie |
| | - | niet goed te zien |
| | .. | aangenomen gelijk te zijn aan laatste vermelding |

NB: Debietwaarden zijn betrekkelijk **onzeker**, overgenomen uit logboek (*niet* van meetwaarden)

| | | | | welnummer en positie (in meters vanaf westelijke rand bak) | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| datum | tijd | verval | debiet | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 2012 | hh:mm | m | l/min | 5.2 | 11.7 | 11.2 | 8.7 | 17.4 | 7.0 | | | | 3.0 | 4.0 | 5.8 | 6.5 | 10.3 | 17.3 | | | | | |
| 22-Aug | 14:01 | 1.15 | | | | | | | | | | | | | 2b | | | | | | | | |
| 22-Aug | 14:54 | | | | | | | | | | | | | | | 2b | | | | | | | |
| 22-Aug | 17:37 | 1.34 | | | | | | | | | | | | | 2b | 2b | | | | | | | |
| 22-Aug | 19:30 | | | | | | | | | | | | | | | | | 2b | | | | | |
| 22-Aug | 21:50 | 1.31 | 8.0 | | | | | | | | | | | | | | | 2b | | | | | |
| 23-Aug | 01:40 | 1.27 | | | | | | | | | | | | | | | | 2b | | | | | |
| 23-Aug | 06:00 | 1.23 | 20.6 | | | | | | | | | | | | | | | 2b | | | | | |
| 23-Aug | 11:00 | 1.56 | 28.0 | | | | | | | | | | | | | | 2a | | | | | | |
| 23-Aug | 11:01 | 1.56 | | | | | | | | | | | | | | | 2b | | | | | | |
| 23-Aug | 11:04 | 1.56 | | | | | | | | | | | 2b | | | | | | | | | | |
| 23-Aug | 11:06 | 1.56 | | | | | | | | | | | | | 2a | | | | | | | | |
| 23-Aug | 11:09 | 1.56 | | | | 2a | | | | | | | | | | | | | | | | | |
| 23-Aug | 13:41 | 1.49 | 52.0 | 3 | | | | | | | | | | | | | | | | | | | |
| 23-Aug | 15:46 | 1.55 | 54.0 | 3 | | | | | | | | | | | | | | | | | | | |
| 23-Aug | 20:05 | 1.79 | | 3 | | | | | | | | | | 2b | | | | | | | | | |
| 23-Aug | 23:40 | | | | 3 | | | | | | | | | | | | | | | | | | |
| 23-Aug | 23:41 | | | | | 3 | | | | | | | | | | | | | | | | | |
| 23-Aug | 23:45 | | | | | | 3 | | | | | | | | | | | | | | | | |
| 23-Aug | 23:47 | | | 4 | | | | | | | | | | | | | | | | | | | |
| 24-Aug | 2.28 | 1.87 | | 4 | | | | | | | | | | | | | | | | | | | |
| 24-Aug | 2.30 | 1.87 | | | | | 3 | | | | | | | | | | | | | | | | |
| 24-Aug | 2.35 | 1.87 | | | | 3 | | | | | | | | | | | | | | | | | |
| 24-Aug | 2.39 | 1.87 | | | 4 | | | | | | | | | | | | | | | | | | |
| 24-Aug | 05:23 | 1.83 | | | | | | 3 | | | | | | | | | | | | | | | |
| 24-Aug | 05:28 | 1.83 | | | 4 | | | | | | | | | | | | | | | | | | |
| 24-Aug | 05:34 | 1.83 | | | | 3 | | | | | | | | | | | | | | | | | |
| 24-Aug | 05:37 | 1.83 | | | | | 3 | | | | | | | | | | | | | | | | |
| 24-Aug | 09:15 | 2.02 | 54.0 | | 4 | | | | | | | | | | | | | | | | | | |
| 24-Aug | 09:19 | 2.02 | | | | 4 | | | | | | | | | | | | | | | | | |
| 24-Aug | 09:23 | 2.02 | | | | | 4 | | | | | | | | | | | | | | | | |
| 24-Aug | 09:25 | 2.02 | | 4 | | | | | | | | | | | | | | | | | | | |
| 24-Aug | 09:31 | 2.02 | | | | | | | 3 | | | | | | | | | | | | | | |
| 24-Aug | 13:52 | 2.01 | 54.0 | | | | | 3 | | | | | | | | | | | | | | | |
| 24-Aug | 13:54 | 2.01 | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug | 20:58 | 2.09 | | 3 | | | | | | | | | | | | | | | | | | | |
| 24-Aug | 21:02 | 2.12 | | | | | | | 0 | | | | | | | | | | | | | | |
| 24-Aug | 21:04 | 2.12 | | | | | 3 | | | | | | | | | | | | | | | | |
| 24-Aug | 21:10 | 2.12 | | | | 3 | | | | | | | | | | | | | | | | | |
| 24-Aug | 21:12 | 2.12 | | | 3 | | | - | | | | | | | | | | | | | | | |
| 25-Aug | 00:30 | 2.12 | | | | 3 | 3 | | | | | | | | | | | | | | | | |
| 25-Aug | 00:30 | 2.12 | | | | | | | | | | | | | | | | | | | | | |
| 25-Aug | 00:35 | 2.12 | | | | | | | 3 | | | | | | | | | | | | | | |
| 25-Aug | 00:36 | 2.12 | | 3 | | | | | | | | | | | | | | | | | | | |
| 25-Aug | 00:37 | 2.12 | | | 3 | | | - | | | | | | | | | | | | | | | |
| 25-Aug | 05:29 | 2.12 | | | | 3 | | | | | | | | | | | | | | | | | |
| 25-Aug | 05:37 | 2.12 | | | | | 3 | | | | | | | | | | | | | | | | |
| 25-Aug | 05:38 | 2.12 | | | | | | | 3 | | | | | | | | | | | | | | |
| 25-Aug | 05:40 | 2.12 | | 3 | | | | | | | | | | | | | | | | | | | |
| 25-Aug | 08:45 | 2.30 | | 4 | 3x | 3x | | | | | | | | | | | | | | | | | |


Foto 168 – Het plaatsen van de waterspanningsmeters.


Foto 172 – Overzichtsfoto van de aangebrachte waterspanningsmeters.


Foto 198 – Start van de dijkopbouw.


Foto 206 – Verdichten van de onderste kleilaag van de dijk.

Foto 1283 – Participant (Empec) met meetapparatuur op de dijk.

Foto 1292 – Scheuren in de dijk.

Foto 1306 – Overzichtfoto van het talud.

Foto 1308 – Wel 13 en zandwolken.


Foto 1320 – Participant (Metasensing) plaatst reflectoren op de dijk.


Foto 1337 – Wel 1

Foto 1352 – Wel 4

Foto 1353 – Wel 1, zandmeevoerend.

Foto 1469 – Water loopt over het talud en neemt materiaal mee.

Foto 1472 – Afschuiving aan oostkant van de dijk.

Foto 1473 – Overzichtfoto afschuiving.

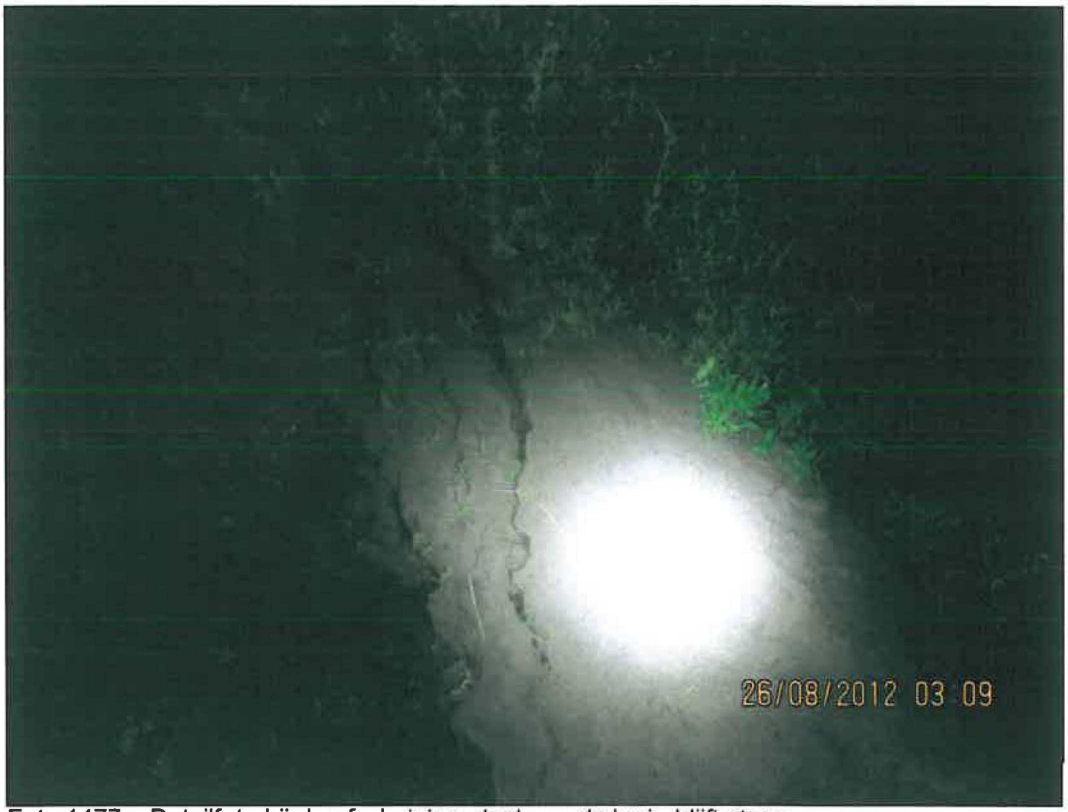


Foto 1477 – Detailfoto bij de afschuiving, deel van de kruin blijft staan.

Foto 1479 – Zijaanzicht afschuiving.

Foto 1480 – Nieuwe wel.

Foto 1484 – Afschuiving zakt verder uit.

Foto 1487 – Uitbuiking groeit.


Foto 1488 – Zijaanzicht verschuiving en uitbuiking.

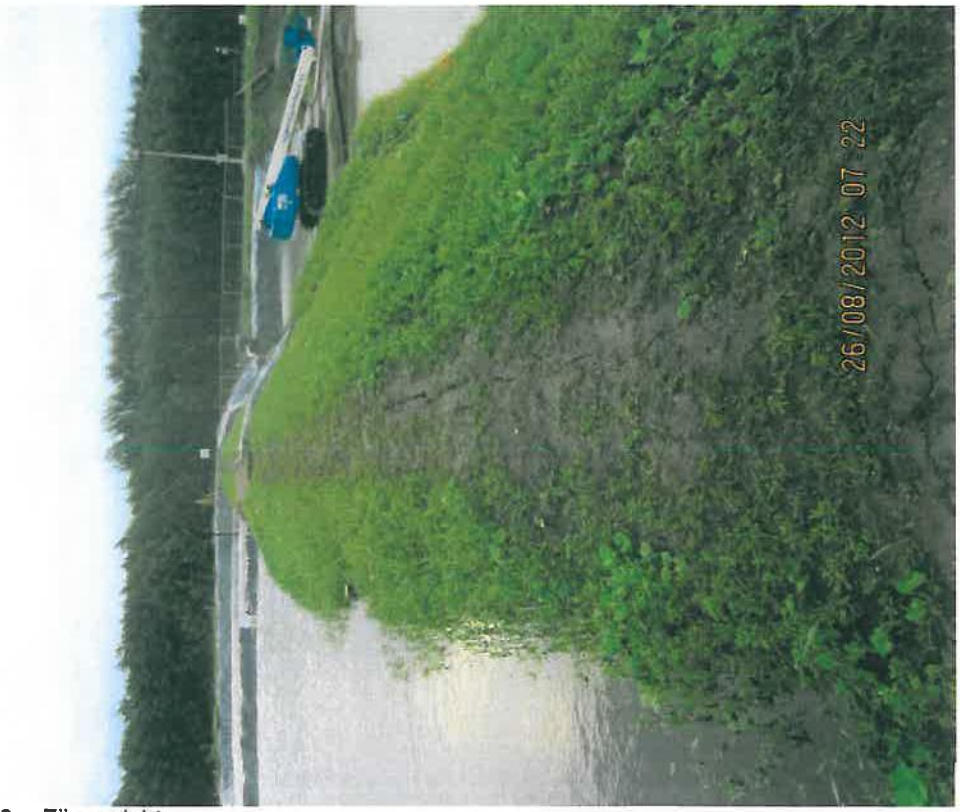
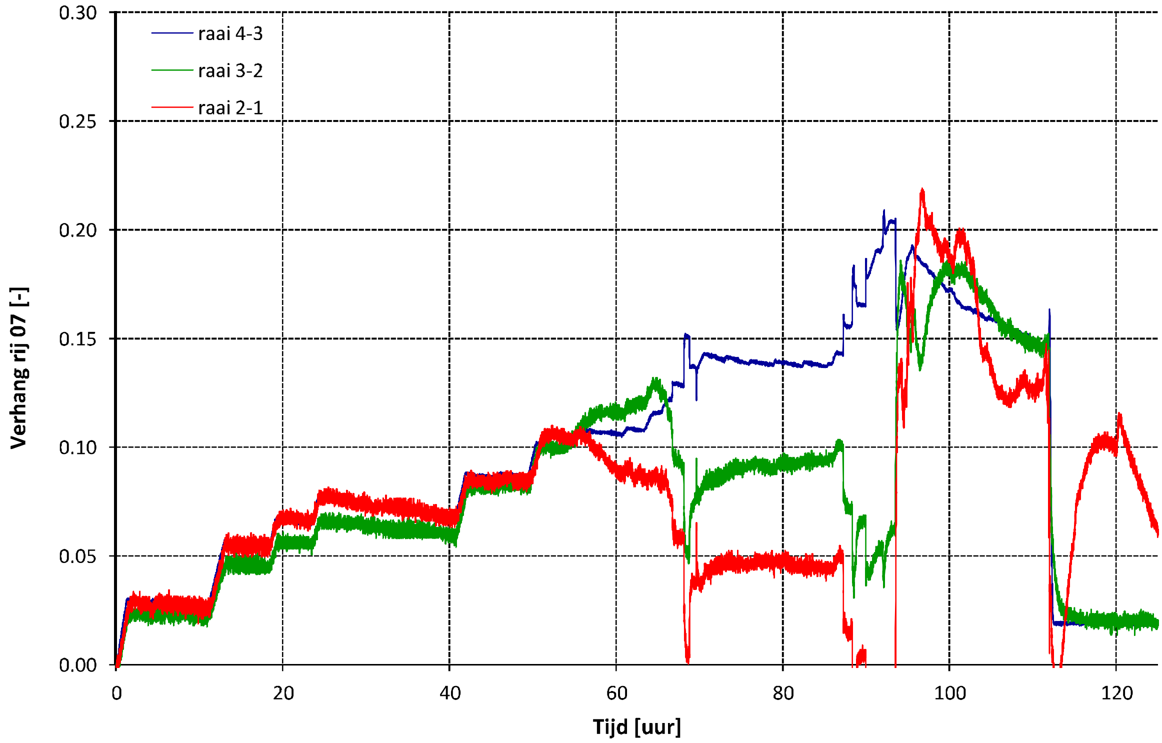


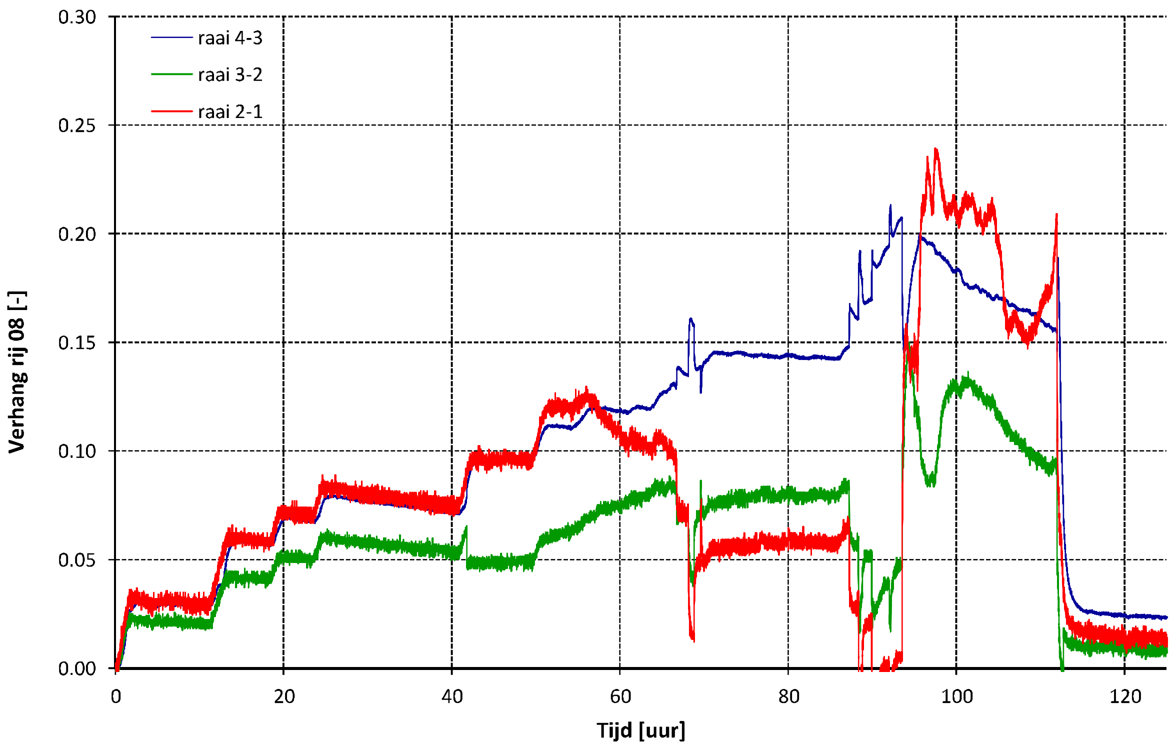

Foto 1490 – Zijaanzicht.

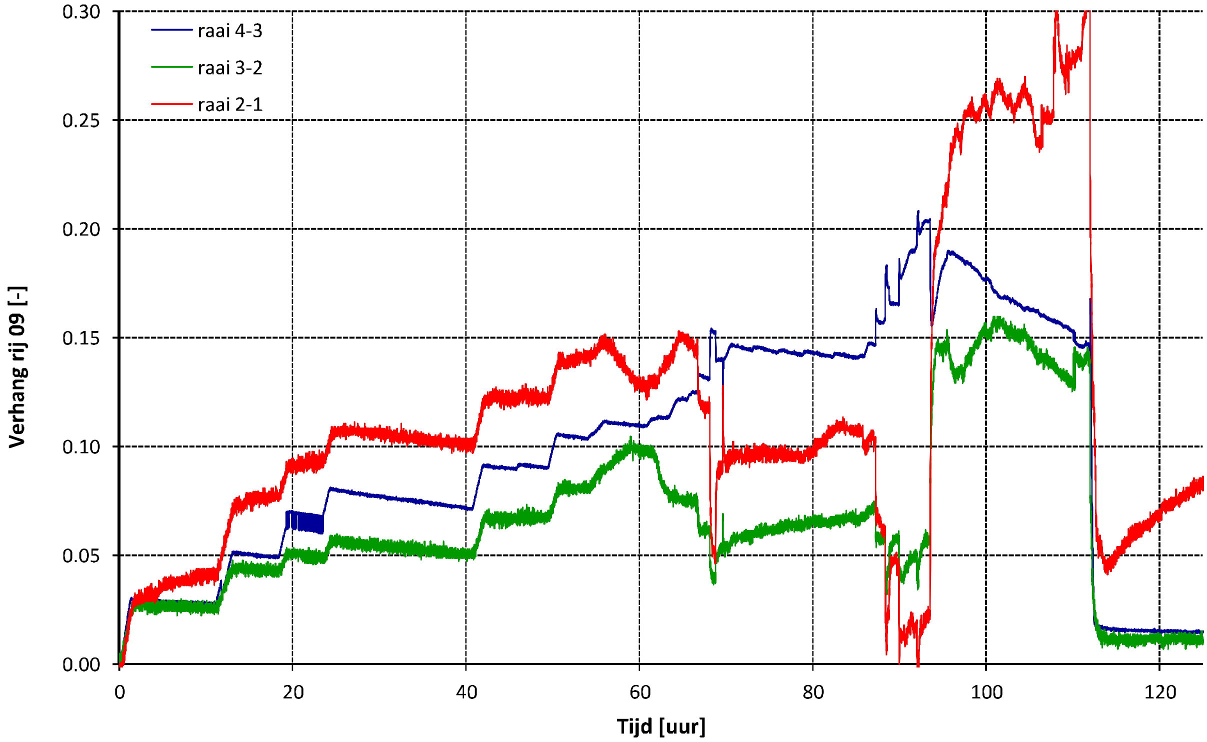
Foto 1491 – Doorbraak.

Foto 1499 – Meetapparatuur spoelt mee.

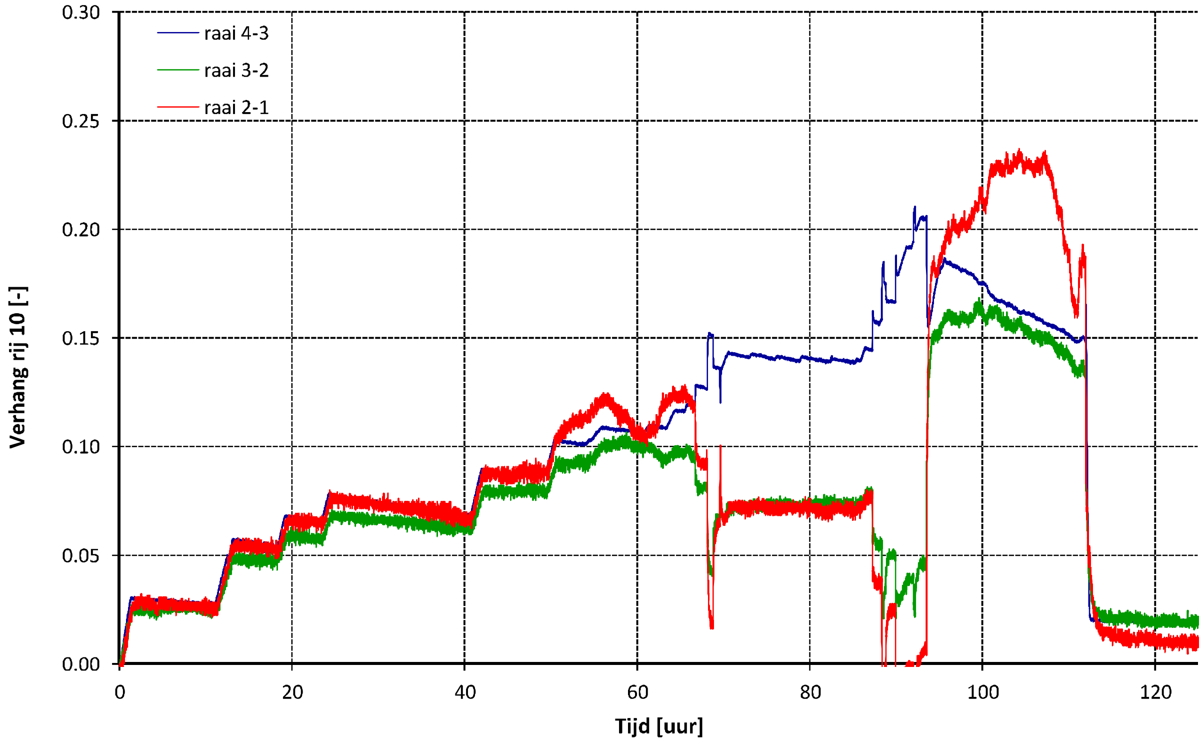
# APPENDIX 2 : WEST DIKE – ADDITIONAL GRAPHS


0.30
0.25
0.20
0.15
0.10
0.05
0.00
raai 4-3
raai 3-2
raai 2-1
0
20
40
60
80
100
120
Tijd [uur]
Verhang rij 07 [-]

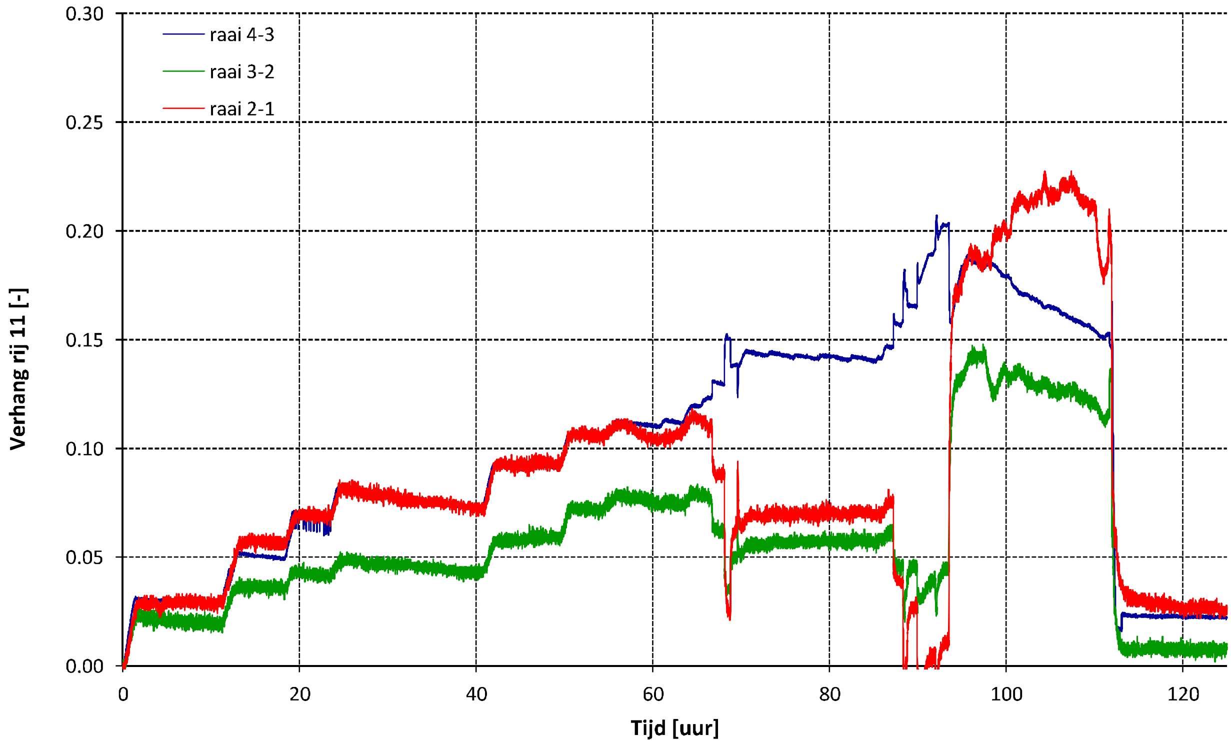

0.30
0.25
0.20
0.15
0.10
0.05
0.00
raai 4-3
raai 3-2
raai 2-1
0
20
40
60
80
100
120
Tijd [uur]
Verhang rij 08 [-]

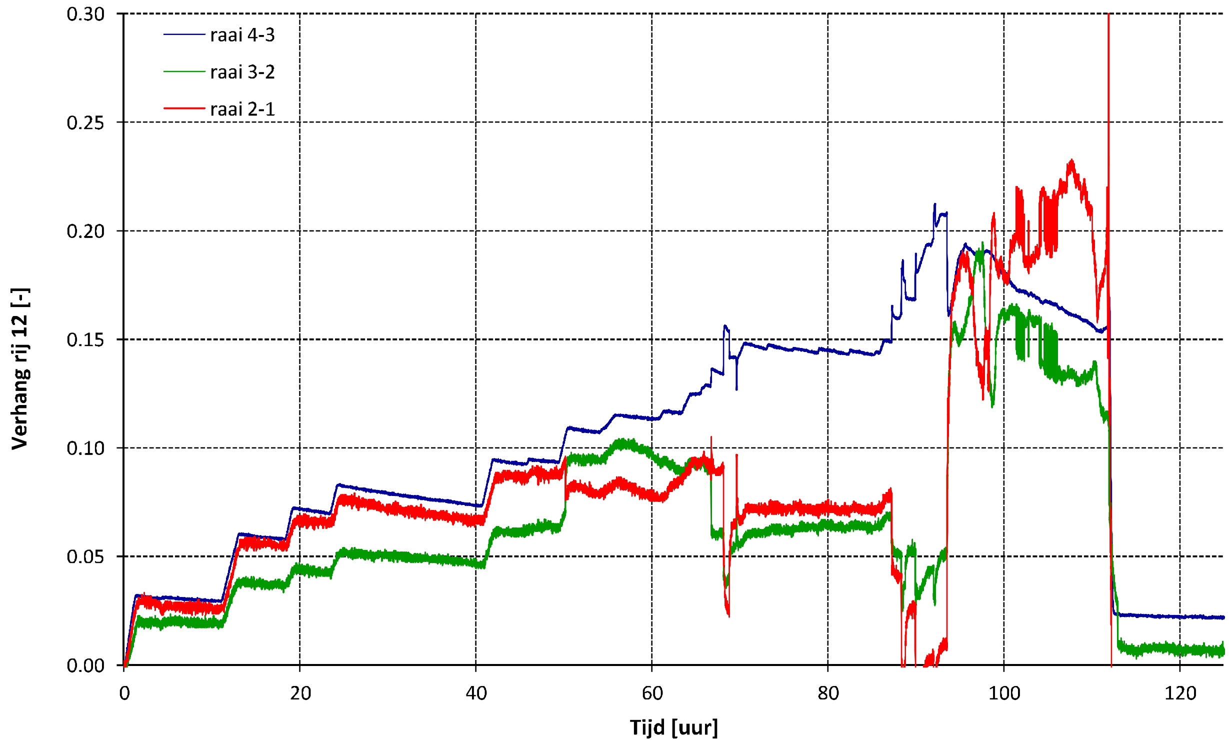


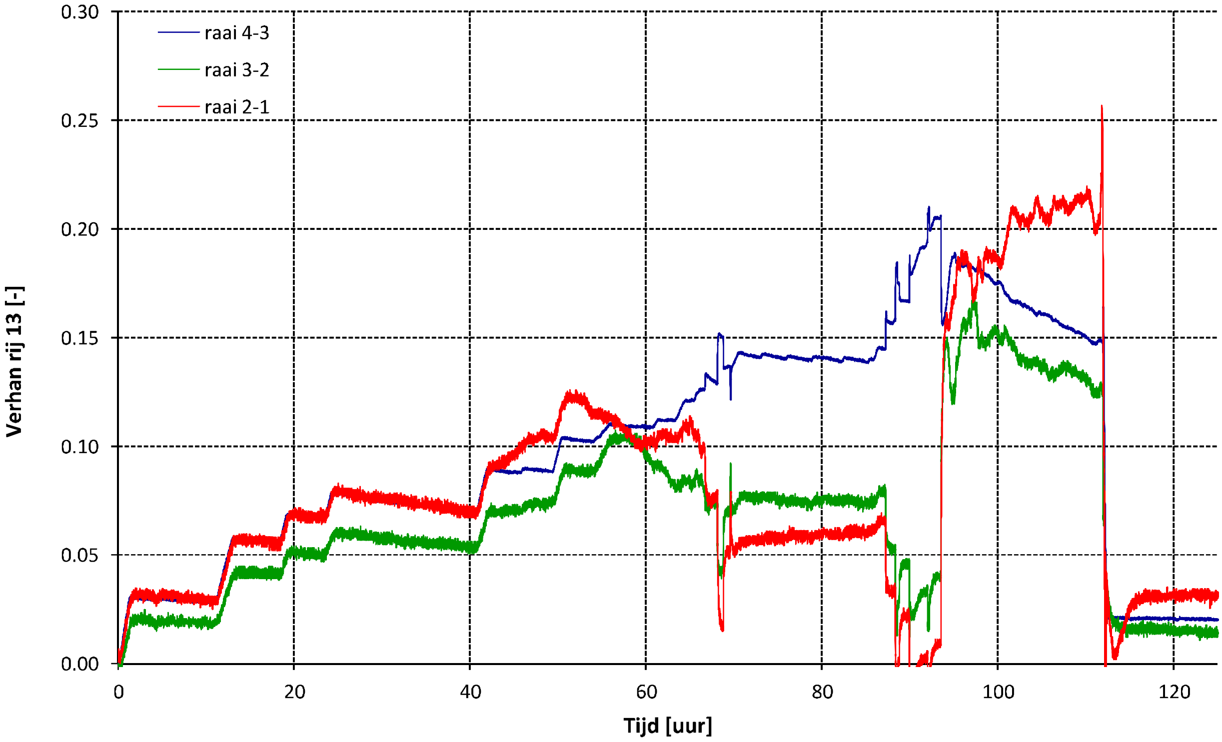
0.30
0.25
0.20
0.15
0.10
0.05
0.00
raai 4-3
raai 3-2
raai 2-1
Verhang rij 09 [-]
0
20
40
60
80
100
120
Tijd [uur]

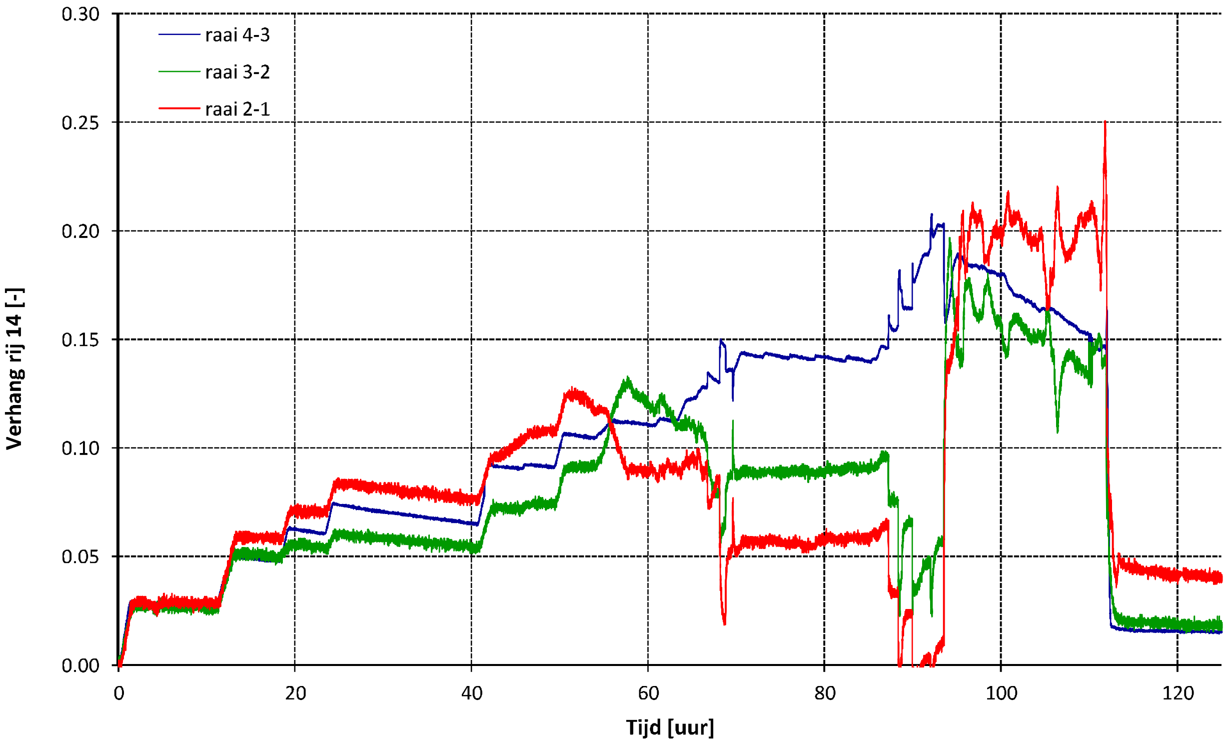



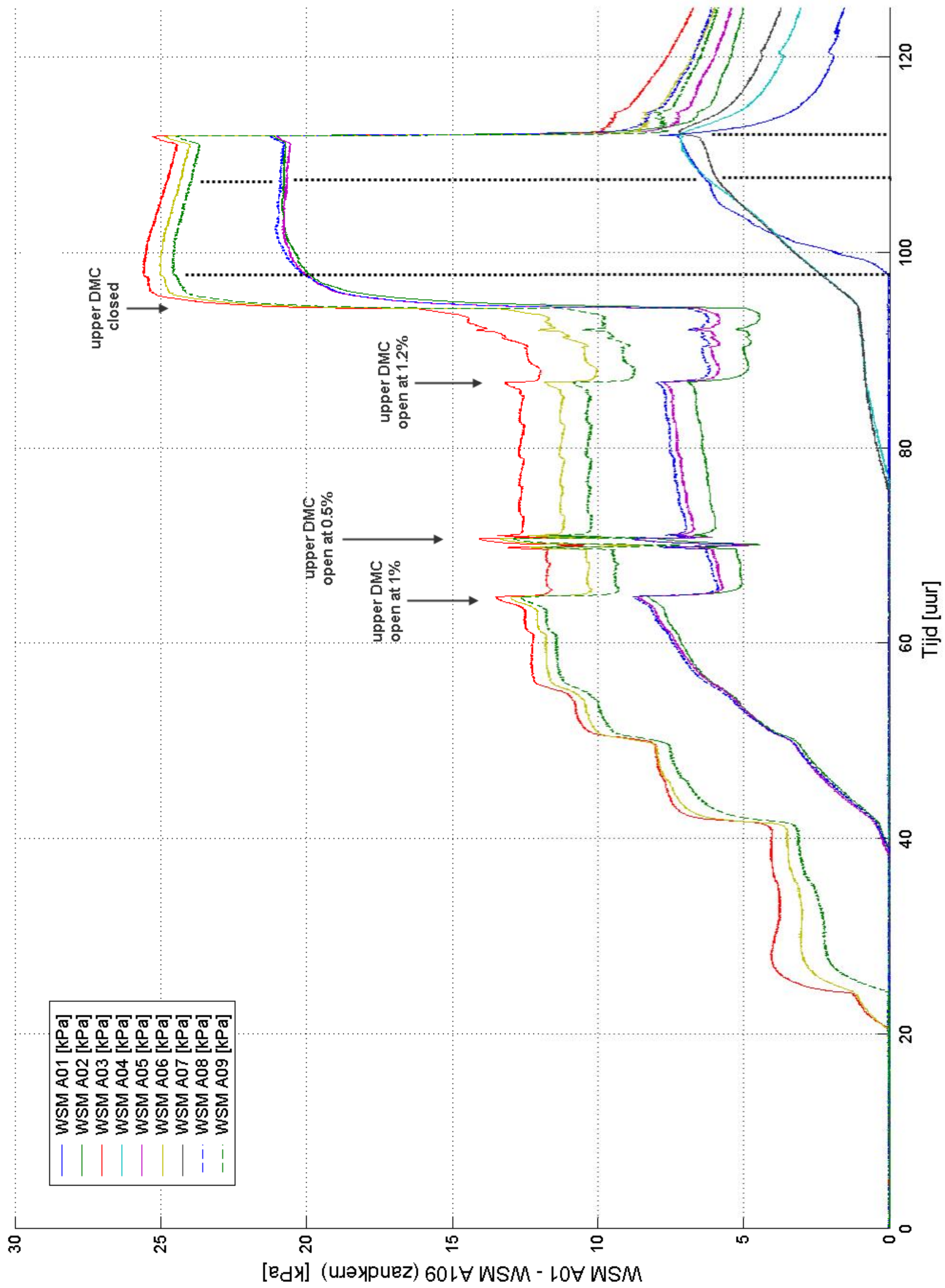
0.30
0.25
0.20
0.15
0.10
0.05
0.00
raai 4-3
raai 3-2
raai 2-1
Verhang rij 10 [-]
0
20
40
60
80
100
120
Tijd [uur]


0.30
0.25
0.20
0.15
0.10
0.05
0.00
raai 4-3
raai 3-2
raai 2-1
Verhang rij 11 [-]
0
20
40
60
80
100
120
Tijd [uur]


0.30
0.25
0.20
0.15
0.10
0.05
0.00
raai 4-3
raai 3-2
raai 2-1
Verhang rij 12 [-]
0
20
40
60
80
100
120
Tijd [uur]


raai 4-3
raai 3-2
raai 2-1
Verhan rij 13 [-]
Tijd [uur]


raai 4-3
raai 3-2
raai 2-1
Verhang rij 14 [-]
Tijd [uur]

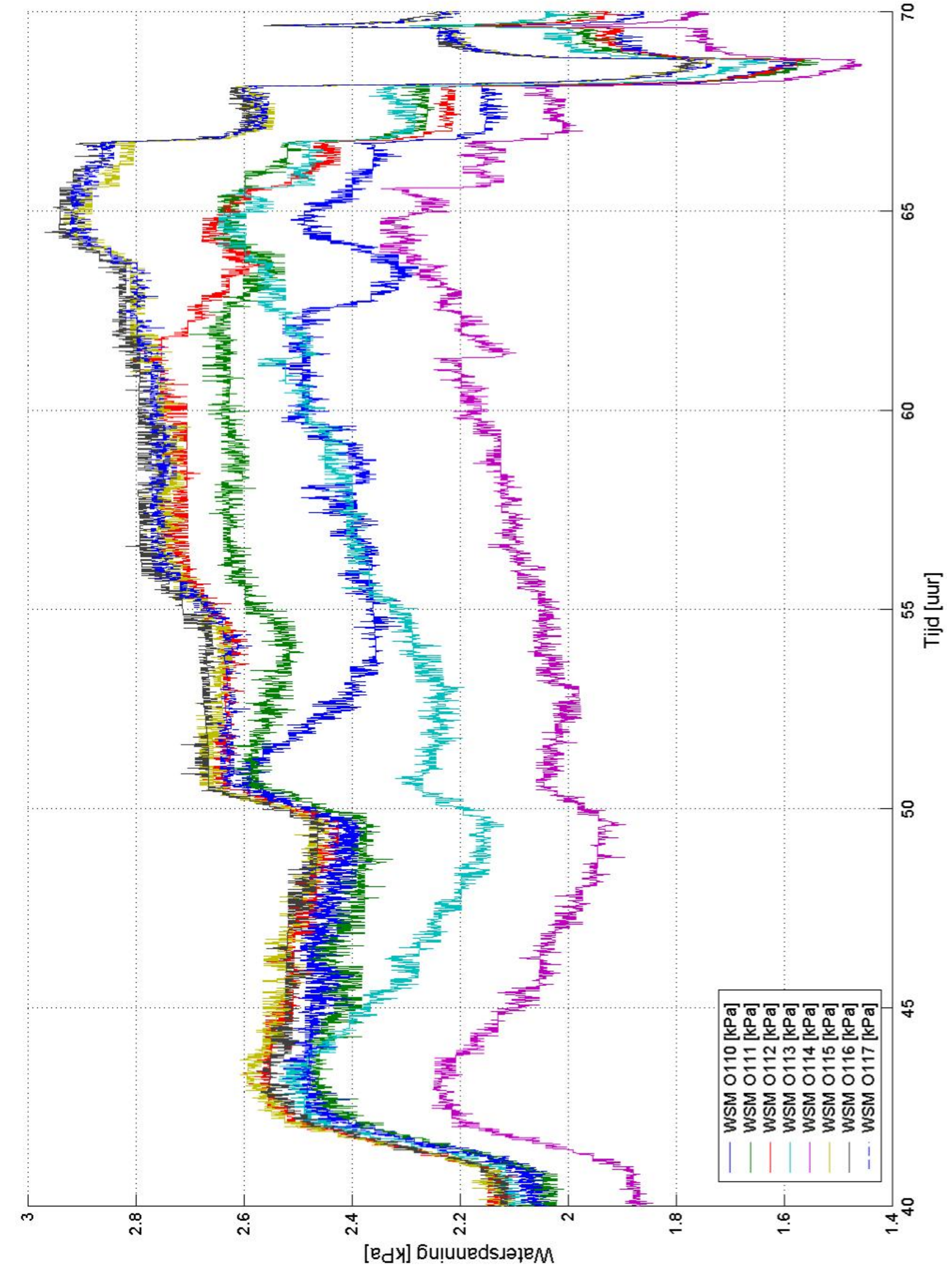


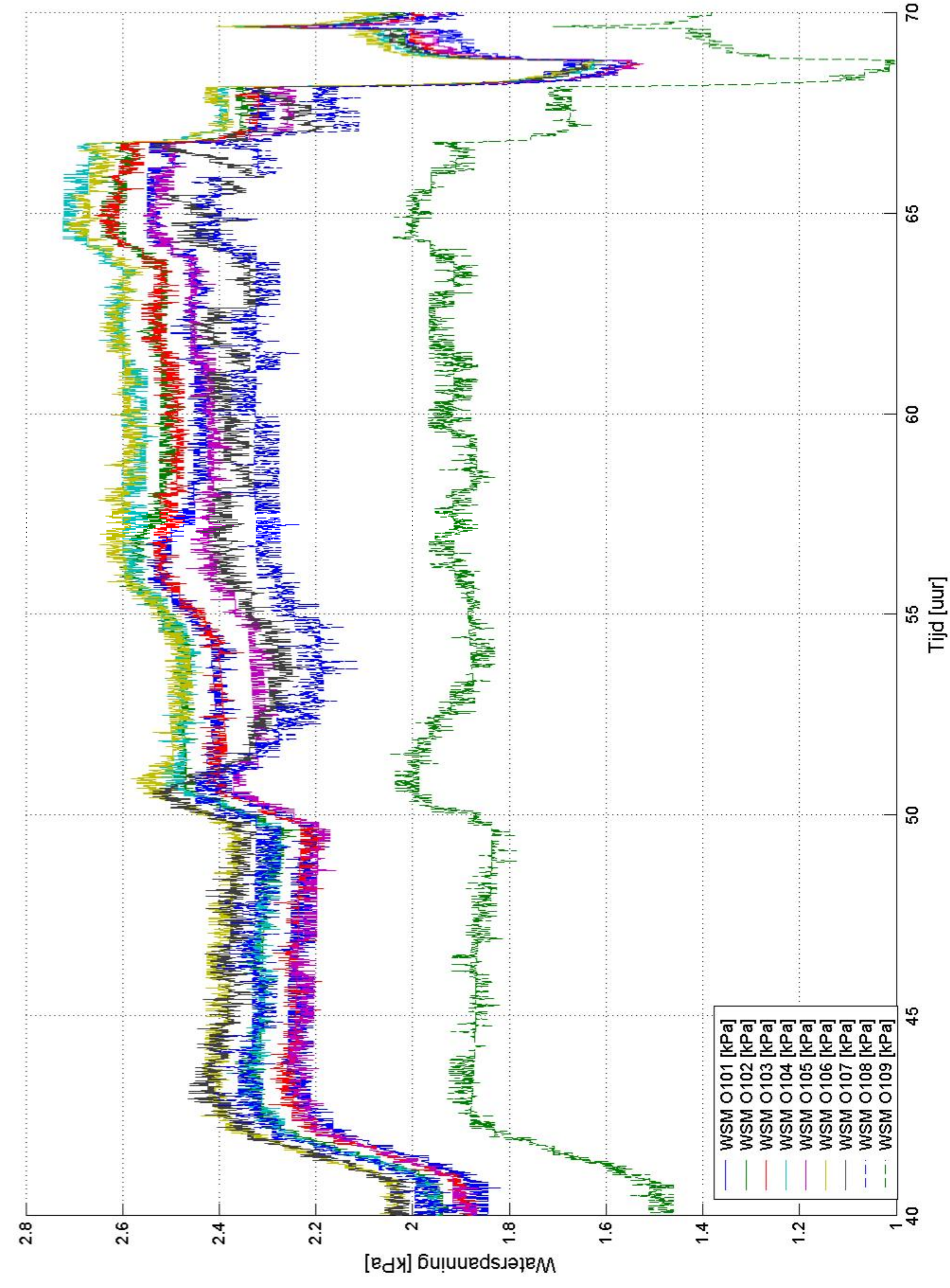
WSM A01 [kPa]
WSM A02 [kPa]
WSM A03 [kPa]
WSM A04 [kPa]
WSM A05 [kPa]
WSM A06 [kPa]
WSM A07 [kPa]
WSM A08 [kPa]
WSM A09 [kPa]
upper DMC closed
upper DMC open at 1.2%
upper DMC open at 0.5%
upper DMC open at 1%
Tijd [uur]
WSM A01 - WSM A109 (zandkern) [kPa]
0
20
40
60
80
100
120
0
5
10
15
20
25
30

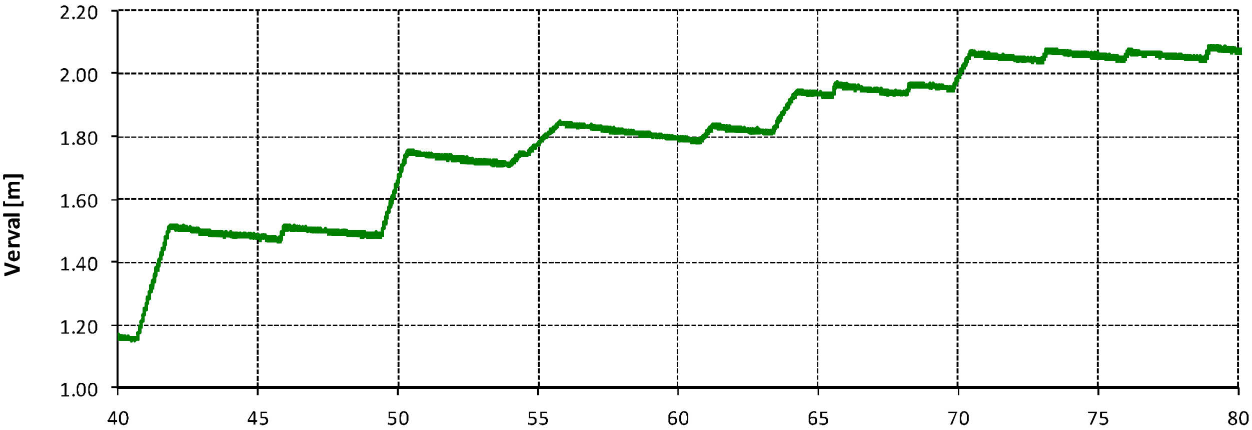
Legend:

| | |
|---|---|
| 0 | Stopped / buried |
| 1 | Trace of sand, no visible boiling of sand or transport of sand, no change in size, no dust cloud |
| 2a | Trace of sand, no visible boiling of sand or transport of sand, yet steady growth, no dust cloud |
| 2b | Trace of sand, no visible boiling of sand or transport of sand, dust cloud (from fine sand) visible |
| 3a | Well producing water only, no sand boil |
| 3b | Well producing water only, with sand boil, but no sand production |
| 4 | Sand producing well |
| x | Removal of sand |
| - | Not accessible |
| .. | Assumed to be equal to the previous reading |

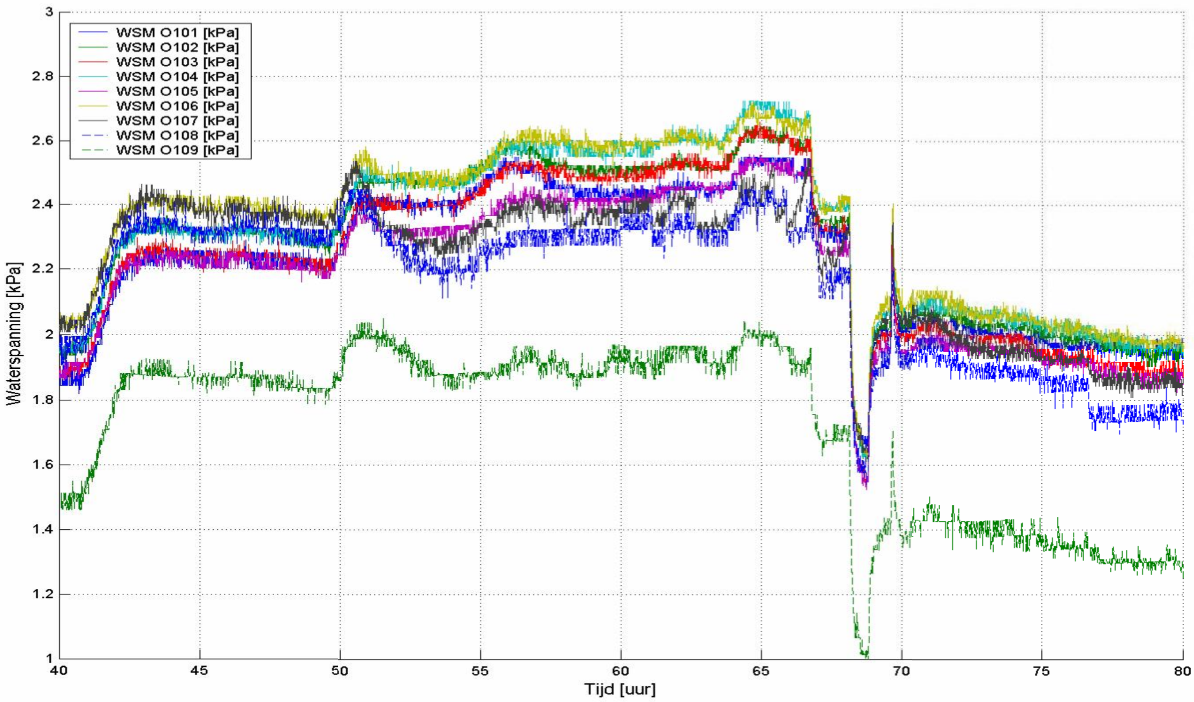
| | | | | well number / position (in metres from the west side) / closest pore pressure meters | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | | | | 5.2 | 11.7 | 11.2 | 8.7 | 17.4 | 7.0 | | | | 3.0 | 4.0 | 5.8 | 6.5 | 10.3 | 17.3 | | | | | |
| **date** | **time** | **total time** | **head** | 113 | 107 | 107 | 110 | 101 | 112 | | | | 115 | 114 | 113 | 112 | 108 | 101 | | | | | |
| **2012** | **hh.mm** | **hh.mm** | **m** | 114 | | 108 | | 102 | | | | | 116 | 115 | | | 109 | 102 | | | | | |
| 22/08 | 14.01 | 21.31 | 1.15 | | | | | | | | | | | | 2b | | | | | | | | |
| 22-08 | 14.54 | 22.24 | | | | | | | | | | | | | | 2b | | | | | | | |
| 22-08 | 17.37 | 25.07 | 1.34 | | | | | | | | | | | | 2b | 2b | | | | | | | |
| 22-08 | 19.30 | 27.00 | | | | | | | | | | | | | | | | 2b | | | | | |
| 22-08 | 21.50 | 29.20 | 1.31 | | | | | | | | | | | | | | | 2b | | | | | |
| 23-08 | 1.40 | 33.10 | 1.27 | | | | | | | | | | | | | | | 2b | | | | | |
| 23-08 | 6.00 | 37.30 | 1.23 | | | | | | | | | | | | | | | 2b | | | | | |
| 23-08 | 11.00 | 42.30 | 1.56 | | | | | | | | | | | | | | 2a | | | | | | |
| 23-08 | 11.01 | 42.31 | 1.56 | | | | | | | | | | | | | | 2b | | | | | | |
| 23-08 | 11.04 | 42.34 | 1.56 | | | | | | | | | | 2b | | | | | | | | | | |
| 23-08 | 11.06 | 42.36 | 1.56 | | | | | | | | | | | | 2a | | | | | | | | |
| 23-08 | 11.09 | 42.39 | 1.56 | | | 2a | | | | | | | | | | | | | | | | | |
| 23-08 | 13.41 | 45.11 | 1.49 | 3 | | | | | | | | | | | | | | | | | | | |
| 23-08 | 15.46 | 47.16 | 1.55 | 3 | | | | | | | | | | | | | | | | | | | |
| 23-08 | 20.05 | 51.35 | 1.79 | 3 | | | | | | | | | | 2b | | | | | | | | | |
| 23-08 | 23.40 | 55.10 | | | 3 | | | | | | | | | | | | | | | | | | |
| 23-08 | 23.41 | 55.11 | | | | 3 | | | | | | | | | | | | | | | | | |
| 23-08 | 23.45 | 55.15 | | | | | 3 | | | | | | | | | | | | | | | | |
| 23-08 | 23.47 | 55.17 | | 4 | | | | | | | | | | | | | | | | | | | |
| 24-08 | 2.28 | 57.58 | 1.87 | 4 | | | | | | | | | | | | | | | | | | | |
| 24-08 | 2.30 | 58.00 | 1.87 | | | | 3 | | | | | | | | | | | | | | | | |
| 24-08 | 2.35 | 58.05 | 1.87 | | | 3 | | | | | | | | | | | | | | | | | |
| 24-08 | 2.39 | 58.09 | 1.87 | | 4 | | | | | | | | | | | | | | | | | | |
| 24-08 | 5.23 | 60.53 | 1.83 | | | | | 3 | | | | | | | | | | | | | | | |
| 24-08 | 5.28 | 60.58 | 1.83 | | 4 | | | | | | | | | | | | | | | | | | |
| 24-08 | 5.34 | 61.04 | 1.83 | | | 3 | | | | | | | | | | | | | | | | | |
| 24-08 | 5.37 | 61.07 | 1.83 | | | | 3 | | | | | | | | | | | | | | | | |
| 24-08 | 9.15 | 64.45 | 2.02 | | 4 | | | | | | | | | | | | | | | | | | |
| 24-08 | 9.19 | 64.49 | 2.02 | | | 4 | | | | | | | | | | | | | | | | | |
| 24-08 | 9.23 | 64.53 | 2.02 | | | | 4 | | | | | | | | | | | | | | | | |
| 24-08 | 9.25 | 64.55 | 2.02 | 4 | | | | | | | | | | | | | | | | | | | |
| 24-08 | 9.31 | 65.01 | 2.02 | | | | | | 3 | | | | | | | | | | | | | | |
| 24-08 | 13.52 | 69.22 | 2.01 | | | | | 3 | | | | | | | | | | | | | | | |
| 24-08 | 13.54 | 69.24 | 2.01 | | | | | | | | | | | | | | | | | | | | |
| 24-08 | 20.58 | 76.28 | 2.09 | 3 | | | | | | | | | | | | | | | | | | | |
| 24-08 | 21.02 | 76.32 | 2.12 | | | | | | 0 | | | | | | | | | | | | | | |
| 24-08 | 21.04 | 76.34 | 2.12 | | | | 3 | | | | | | | | | | | | | | | | |
| 24-08 | 21.10 | 76.40 | 2.12 | | | 3 | | | | | | | | | | | | | | | | | |
| 24-08 | 21.12 | 76.42 | 2.12 | | 3 | | | - | | | | | | | | | | | | | | | |
| 25-08 | 0.30 | 80.00 | 2.12 | | | 3 | 3 | | | | | | | | | | | | | | | | |
| 25-08 | 0.30 | 80.00 | 2.12 | | | | | | | | | | | | | | | | | | | | |
| 25-08 | 0.35 | 80.05 | 2.12 | | | | | | 3 | | | | | | | | | | | | | | |
| 25-08 | 0.36 | 80.06 | 2.12 | 3 | | | | | | | | | | | | | | | | | | | |
| 25-08 | 0.37 | 80.07 | 2.12 | | 3 | | | - | | | | | | | | | | | | | | | |
| 25-08 | 5.29 | 84.59 | 2.12 | | | 3 | | | | | | | | | | | | | | | | | |
| 25-08 | 5.37 | 85.07 | 2.12 | | | | 3 | | | | | | | | | | | | | | | | |
| 25-08 | 5.38 | 85.08 | 2.12 | | | | | | 3 | | | | | | | | | | | | | | |
| 25-08 | 5.40 | 85.10 | 2.12 | 3 | | | | | | | | | | | | | | | | | | | |
| 25-08 | 8.45 | 88.15 | 2.30 | 4 | 3x | 3x | | | | | | | | | | | | | | | | | |


Waterspanning [kPa]
Tijd [uur]
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
40
45
50
55
60
65
70
WSM O110 [kPa]
WSM O111 [kPa]
WSM O112 [kPa]
WSM O113 [kPa]
WSM O114 [kPa]
WSM O115 [kPa]
WSM O116 [kPa]
WSM O117 [kPa]

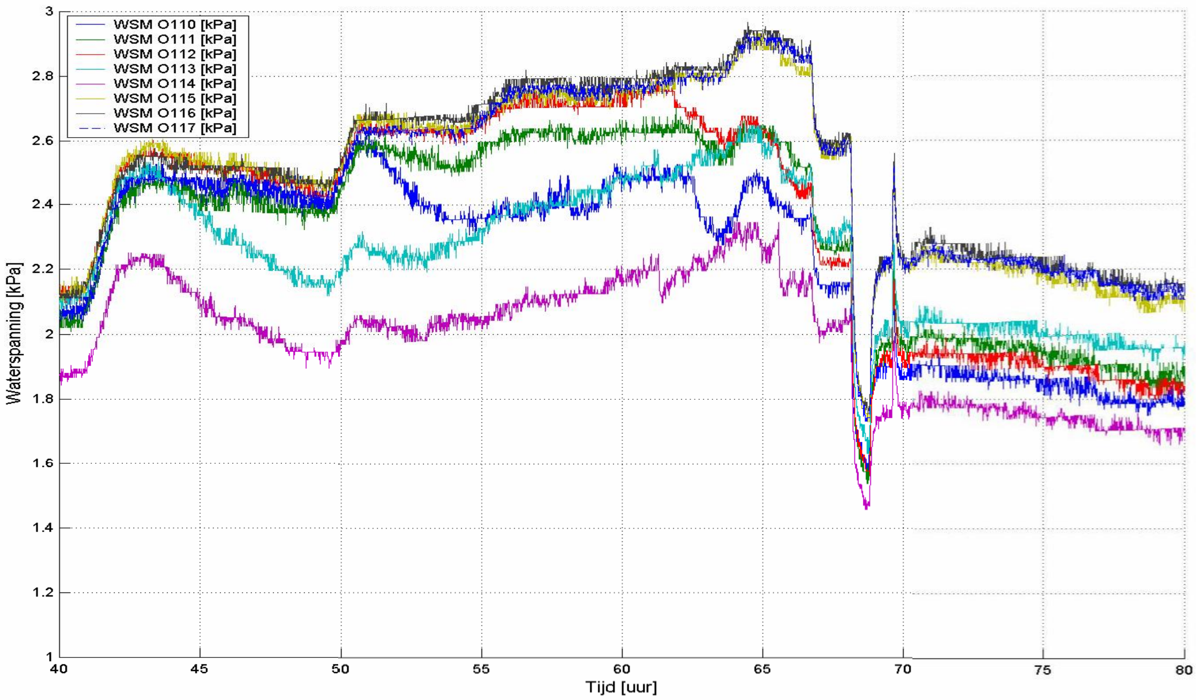

Waterspanning [kPa]
Tijd [uur]
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
40
45
50
55
60
65
70
WSM O101 [kPa]
WSM O102 [kPa]
WSM O103 [kPa]
WSM O104 [kPa]
WSM O105 [kPa]
WSM O106 [kPa]
WSM O107 [kPa]
WSM O108 [kPa]
WSM O109 [kPa]



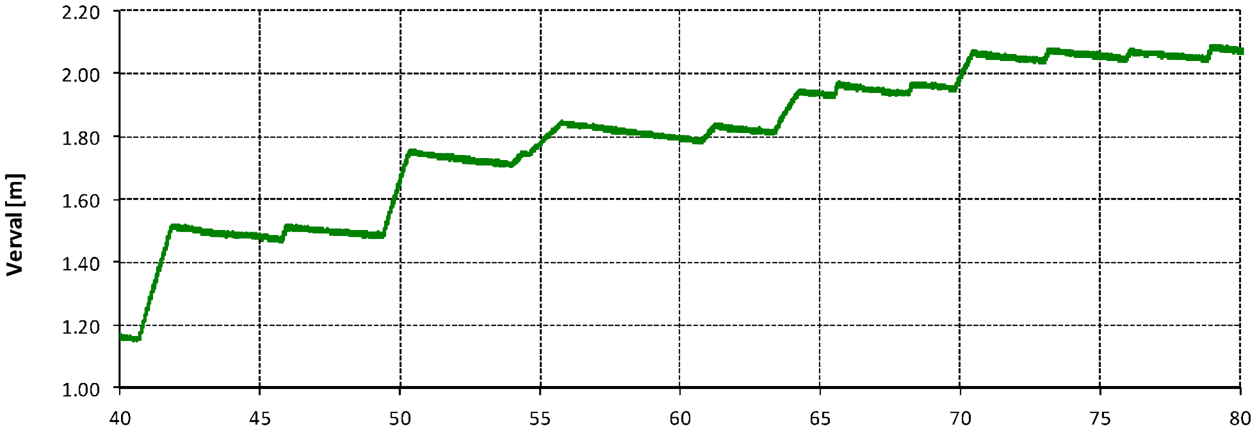
Verval [m]
2.20
2.00
1.80
1.60
1.40
1.20
1.00
40
45
50
55
60
65
70
75
80

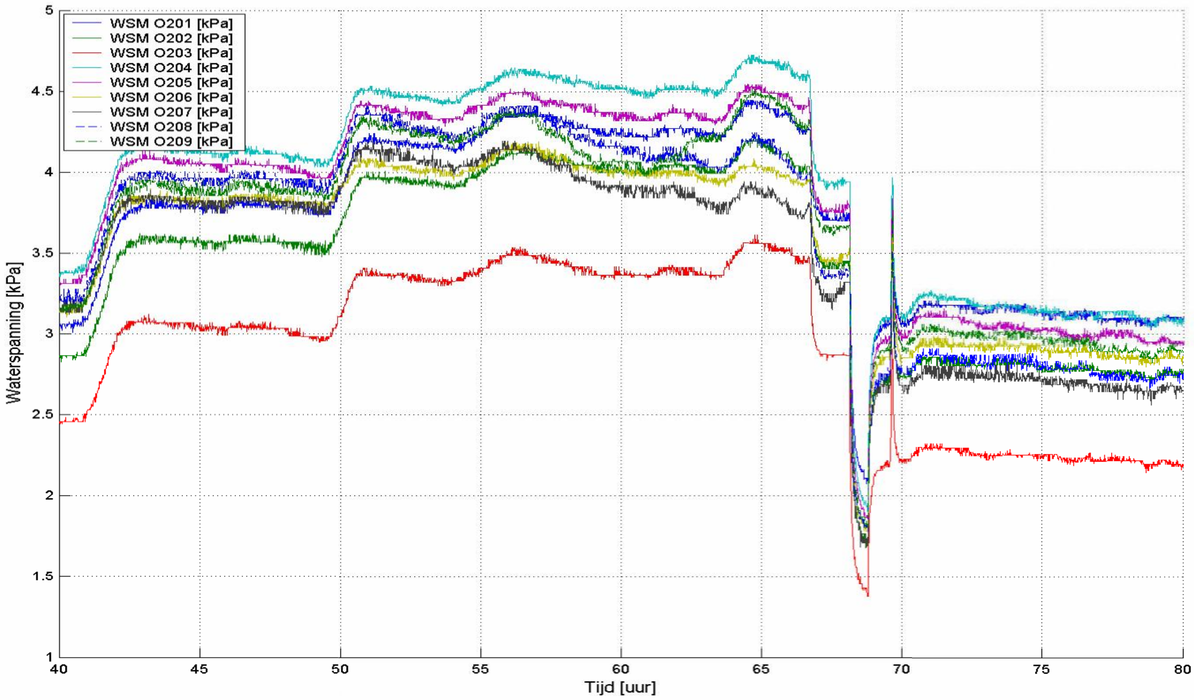
WSM O101 [kPa]
WSM O102 [kPa]
WSM O103 [kPa]
WSM O104 [kPa]
WSM O105 [kPa]
WSM O106 [kPa]
WSM O107 [kPa]
WSM O108 [kPa]
WSM O109 [kPa]
Waterspanning [kPa]
Tijd [uur]

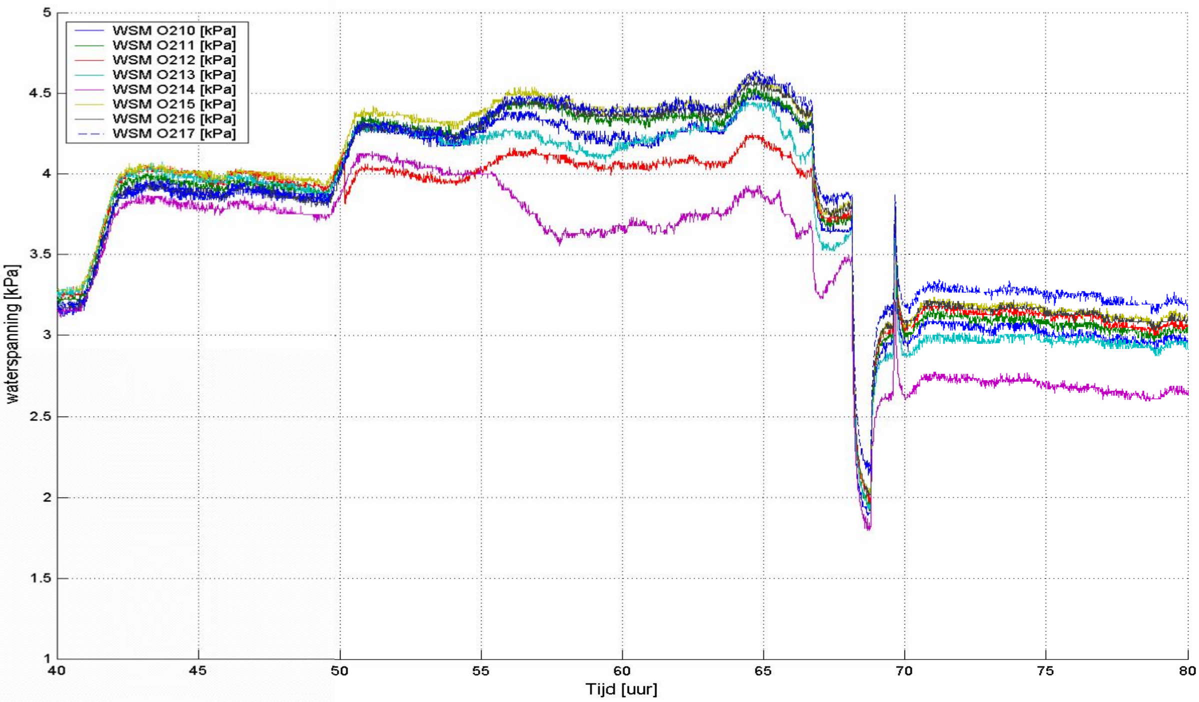
WSM O110 [kPa]
WSM O111 [kPa]
WSM O112 [kPa]
WSM O113 [kPa]
WSM O114 [kPa]
WSM O115 [kPa]
WSM O116 [kPa]
WSM O117 [kPa]
Waterspanning [kPa]
Tijd [uur]



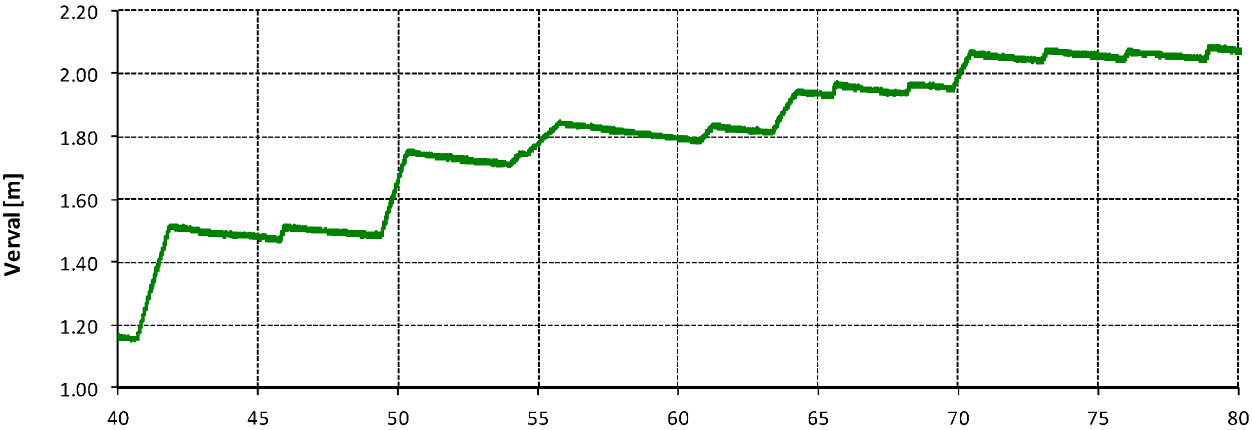
Verval [m]
2.20
2.00
1.80
1.60
1.40
1.20
1.00
40
45
50
55
60
65
70
75
80

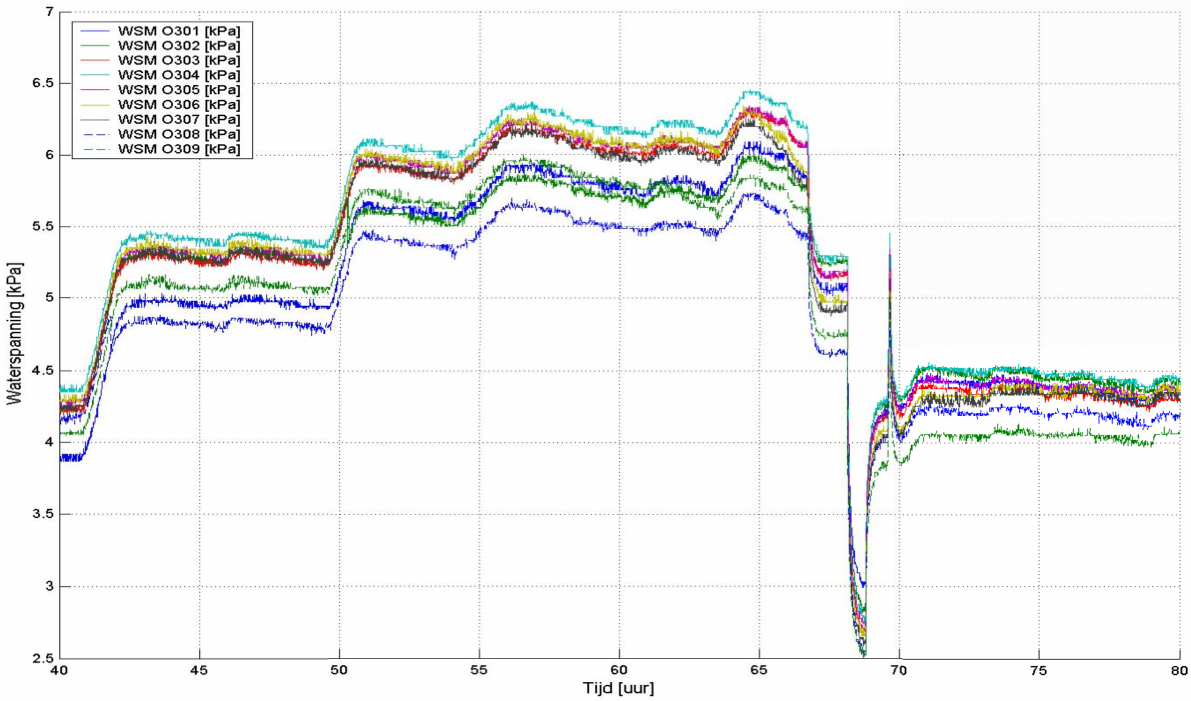



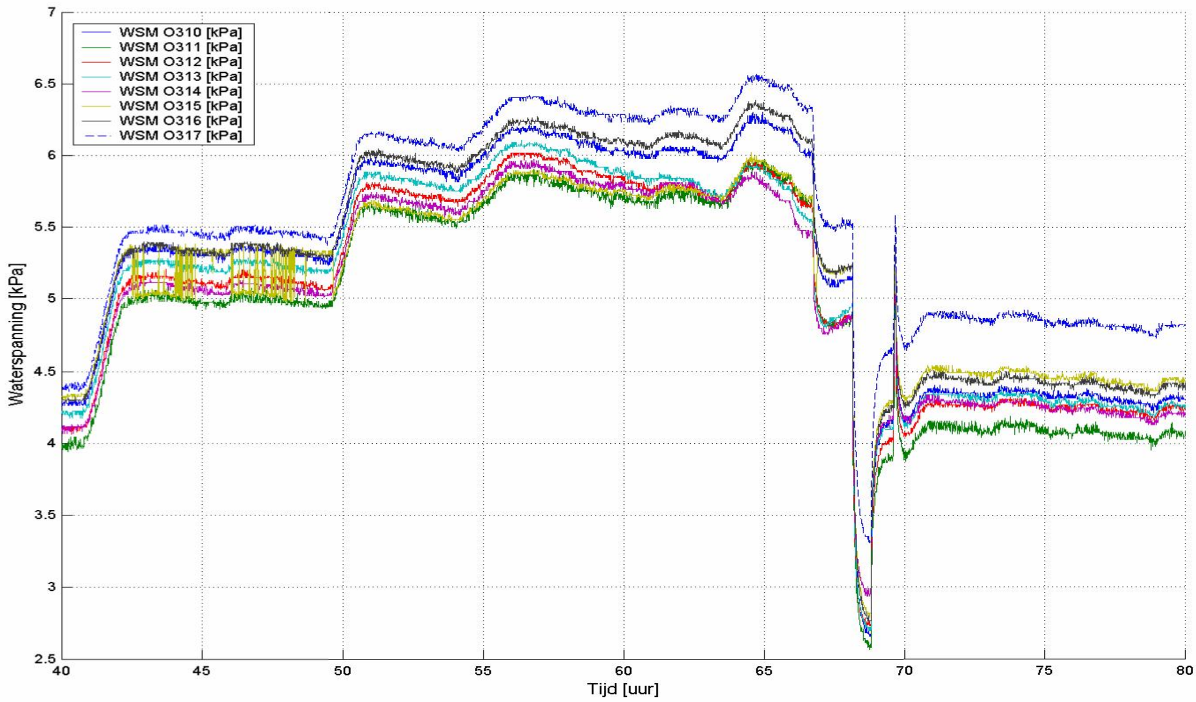
WSM O201 [kPa]
WSM O202 [kPa]
WSM O203 [kPa]
WSM O204 [kPa]
WSM O205 [kPa]
WSM O206 [kPa]
WSM O207 [kPa]
WSM O208 [kPa]
WSM O209 [kPa]
Waterspanning [kPa]
Tijd [uur]

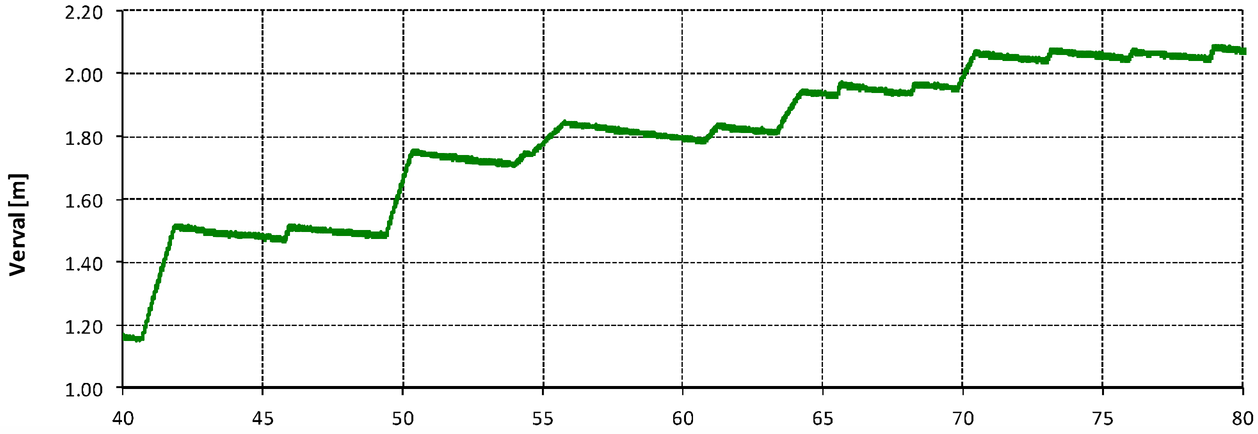



WSM O210 [kPa]
WSM O211 [kPa]
WSM O212 [kPa]
WSM O213 [kPa]
WSM O214 [kPa]
WSM O215 [kPa]
WSM O216 [kPa]
WSM O217 [kPa]
waterspanning [kPa]
Tijd [uur]

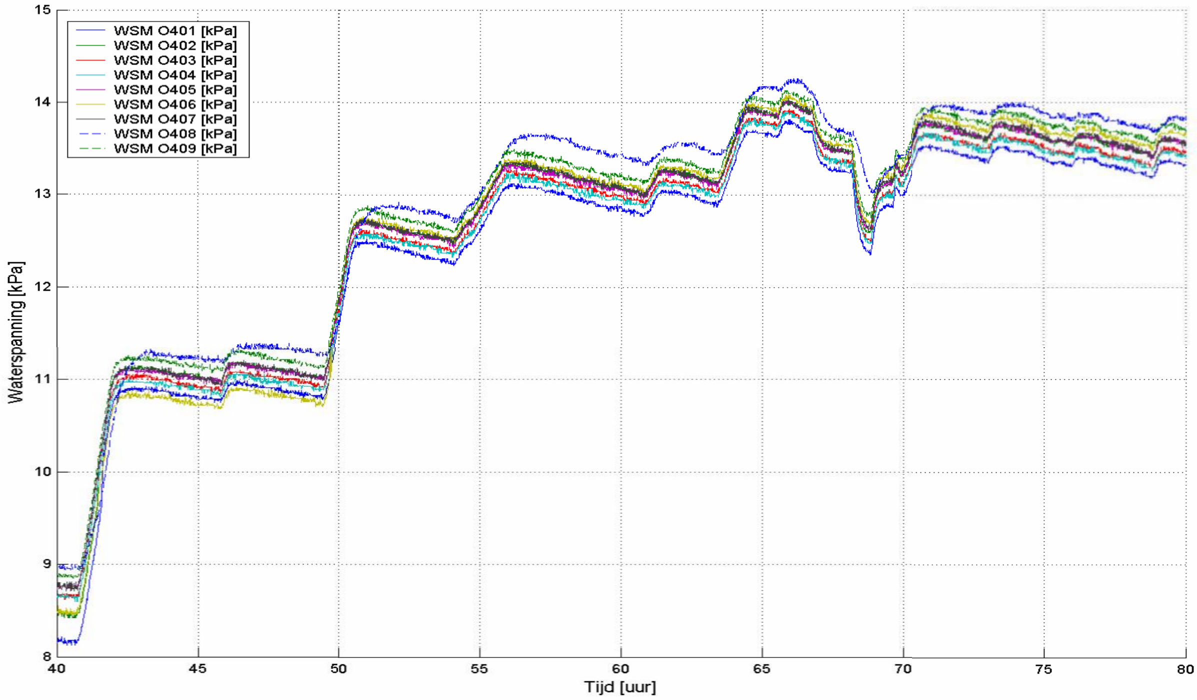

Verval [m]
2.20
2.00
1.80
1.60
1.40
1.20
1.00
40
45
50
55
60
65
70
75
80


WSM O301 [kPa]
WSM O302 [kPa]
WSM O303 [kPa]
WSM O304 [kPa]
WSM O305 [kPa]
WSM O306 [kPa]
WSM O307 [kPa]
WSM O308 [kPa]
WSM O309 [kPa]
Waterspanning [kPa]
Tijd [uur]

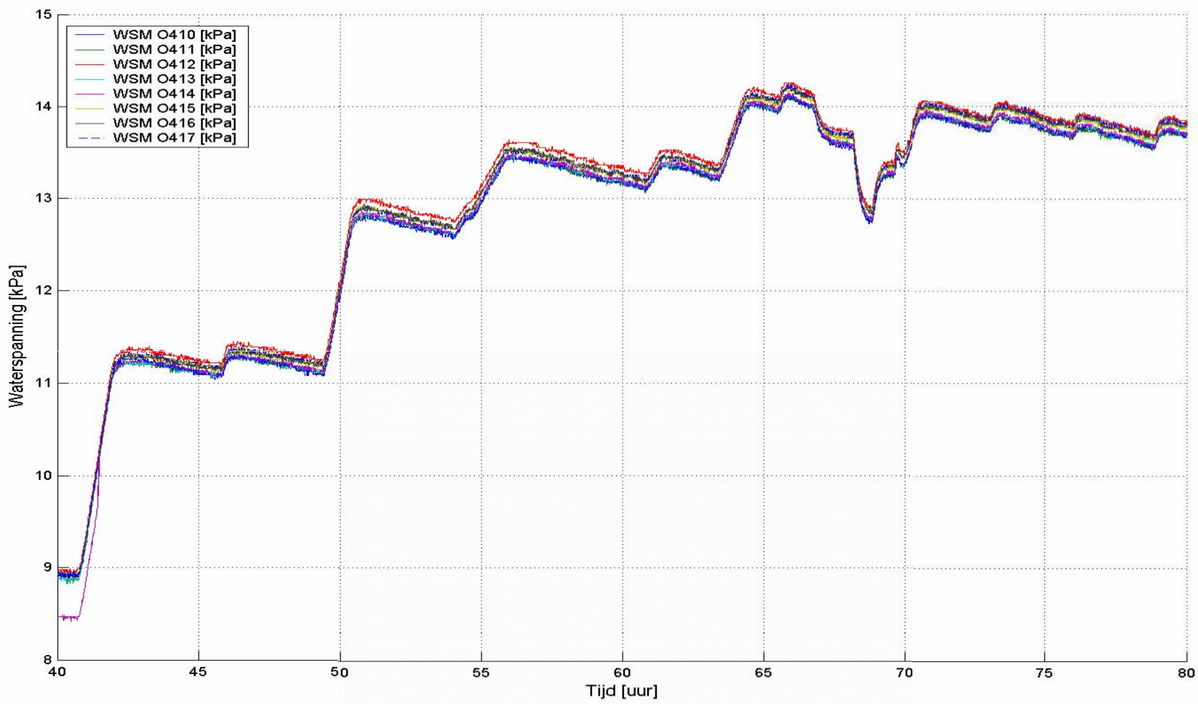

WSM O310 [kPa]
WSM O311 [kPa]
WSM O312 [kPa]
WSM O313 [kPa]
WSM O314 [kPa]
WSM O315 [kPa]
WSM O316 [kPa]
WSM O317 [kPa]
Waterspanning [kPa]
Tijd [uur]



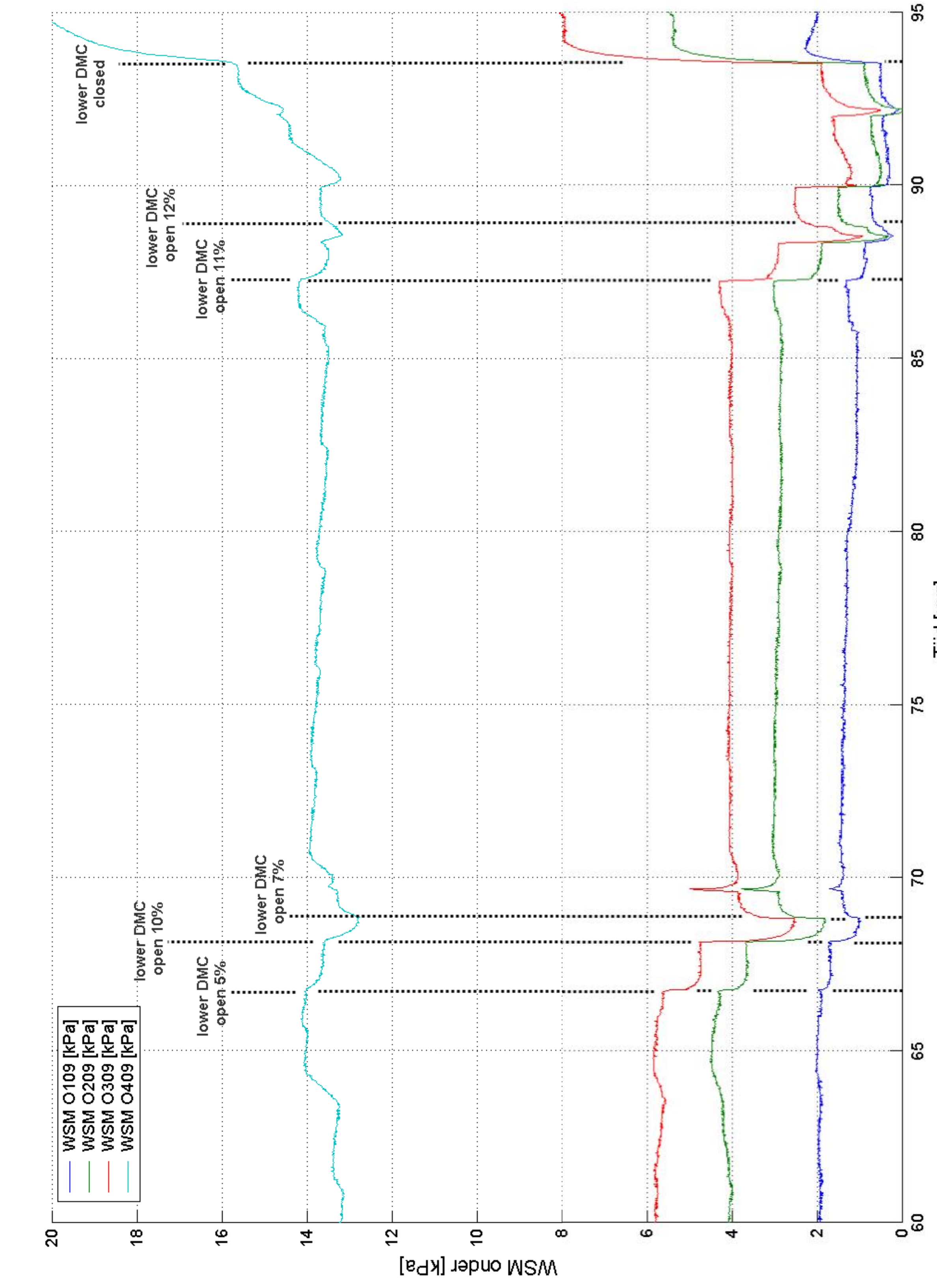
Verval [m]
2.20
2.00
1.80
1.60
1.40
1.20
1.00
40
45
50
55
60
65
70
75
80

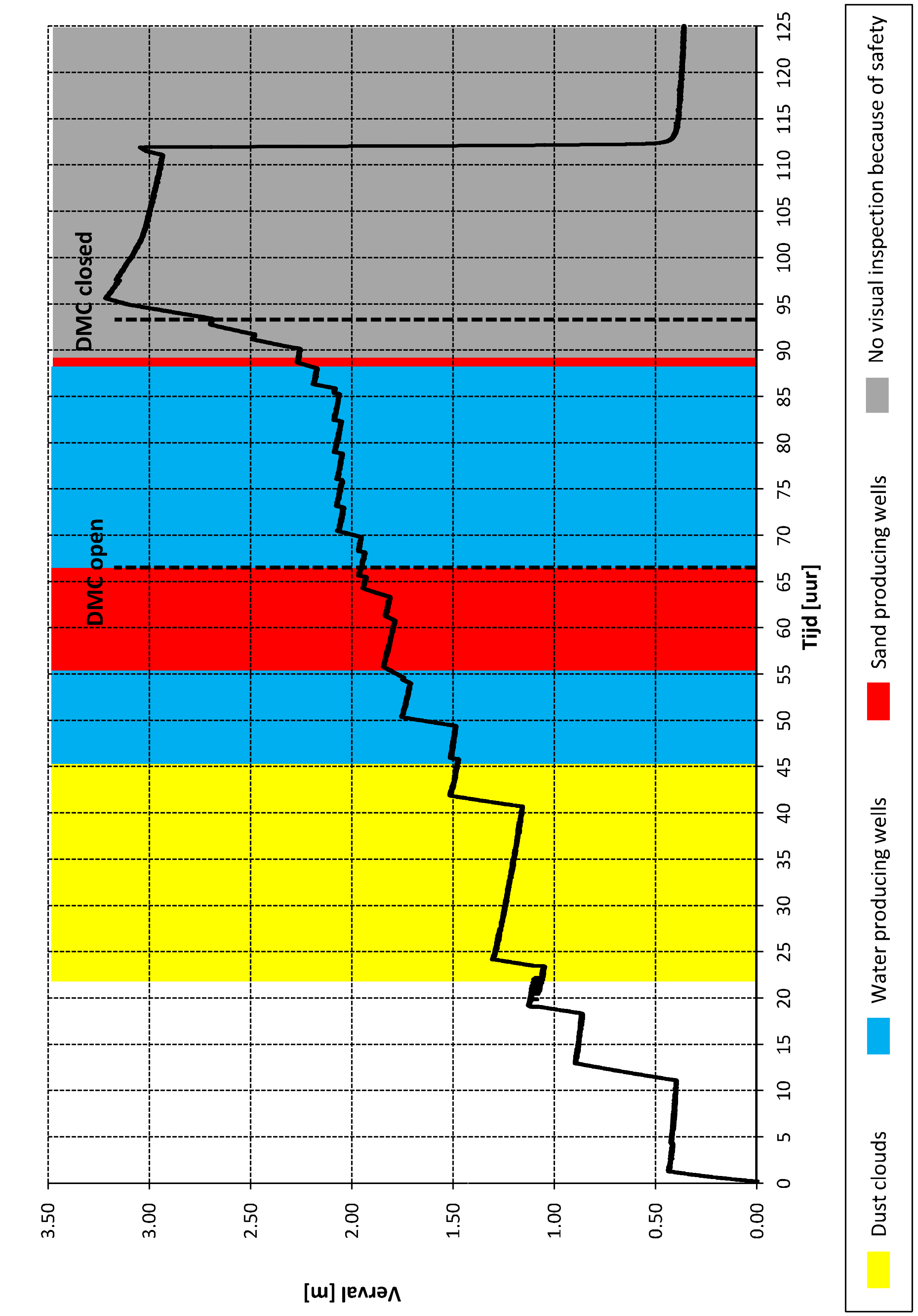
WSM O401 [kPa]
WSM O402 [kPa]
WSM O403 [kPa]
WSM O404 [kPa]
WSM O405 [kPa]
WSM O406 [kPa]
WSM O407 [kPa]
WSM O408 [kPa]
WSM O409 [kPa]
Waterspanning [kPa]
Tijd [uur]

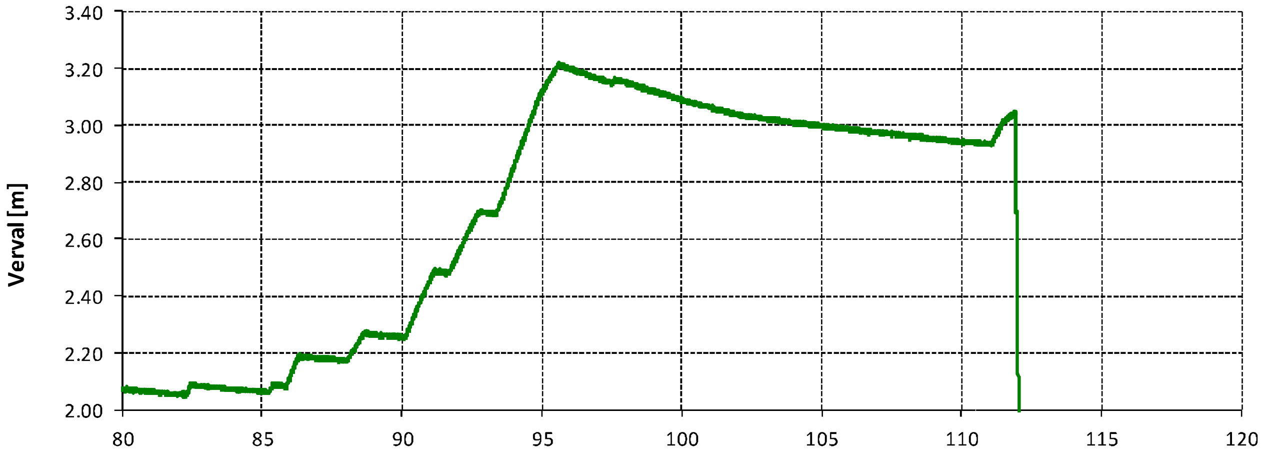
WSM O410 [kPa]
WSM O411 [kPa]
WSM O412 [kPa]
WSM O413 [kPa]
WSM O414 [kPa]
WSM O415 [kPa]
WSM O416 [kPa]
WSM O417 [kPa]
Waterspanning [kPa]
Tijd [uur]



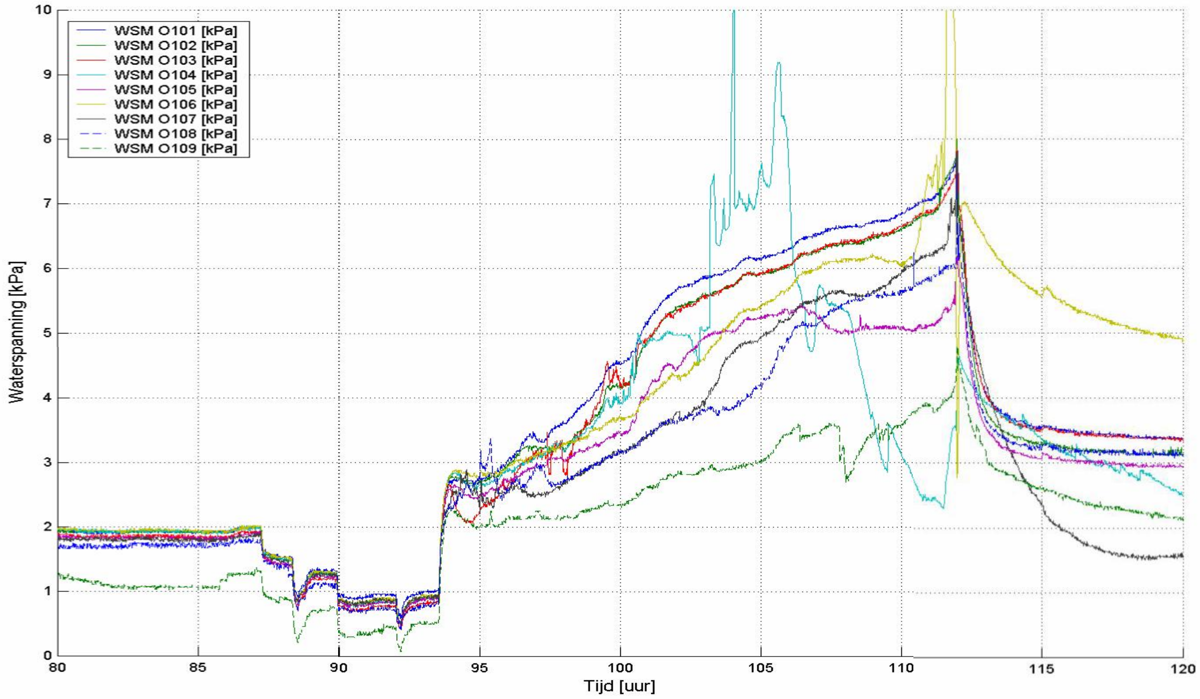
WSM O109 [kPa]
WSM O209 [kPa]
WSM O309 [kPa]
WSM O409 [kPa]
lower DMC open 5%
lower DMC open 10%
lower DMC open 7%
lower DMC open 11%
lower DMC open 12%
lower DMC closed
WSM onder [kPa]
Tijd [uur]



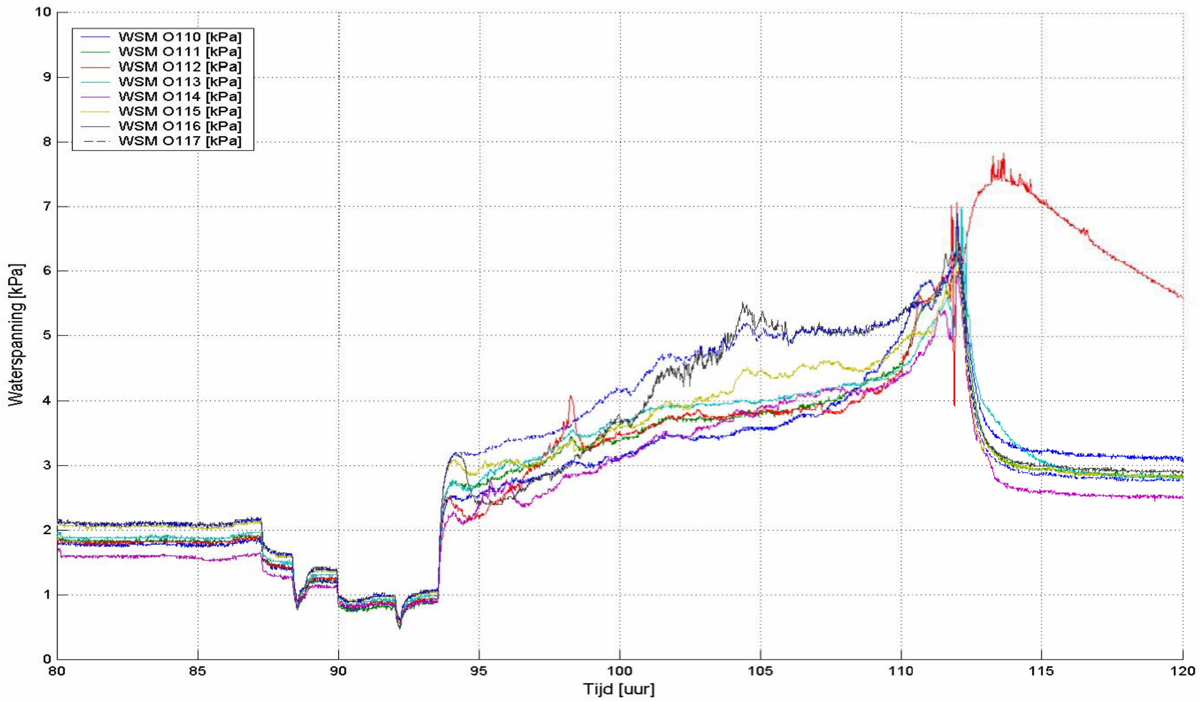
Verval [m]
Tijd [uur]
DMC open
DMC closed
Dust clouds
Water producing wells
Sand producing wells
No visual inspection because of safety



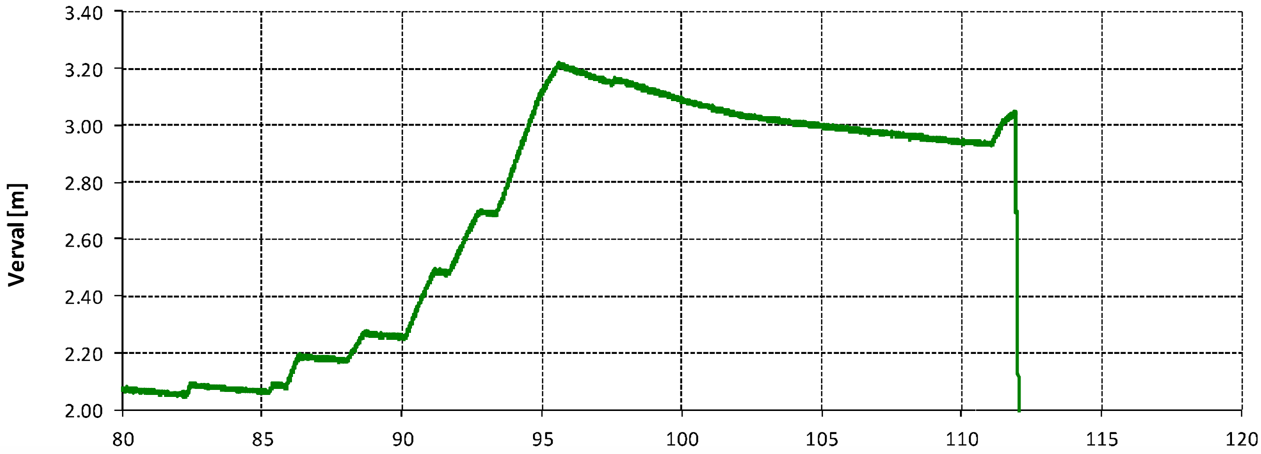
Verval [m]
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
80
85
90
95
100
105
110
115
120

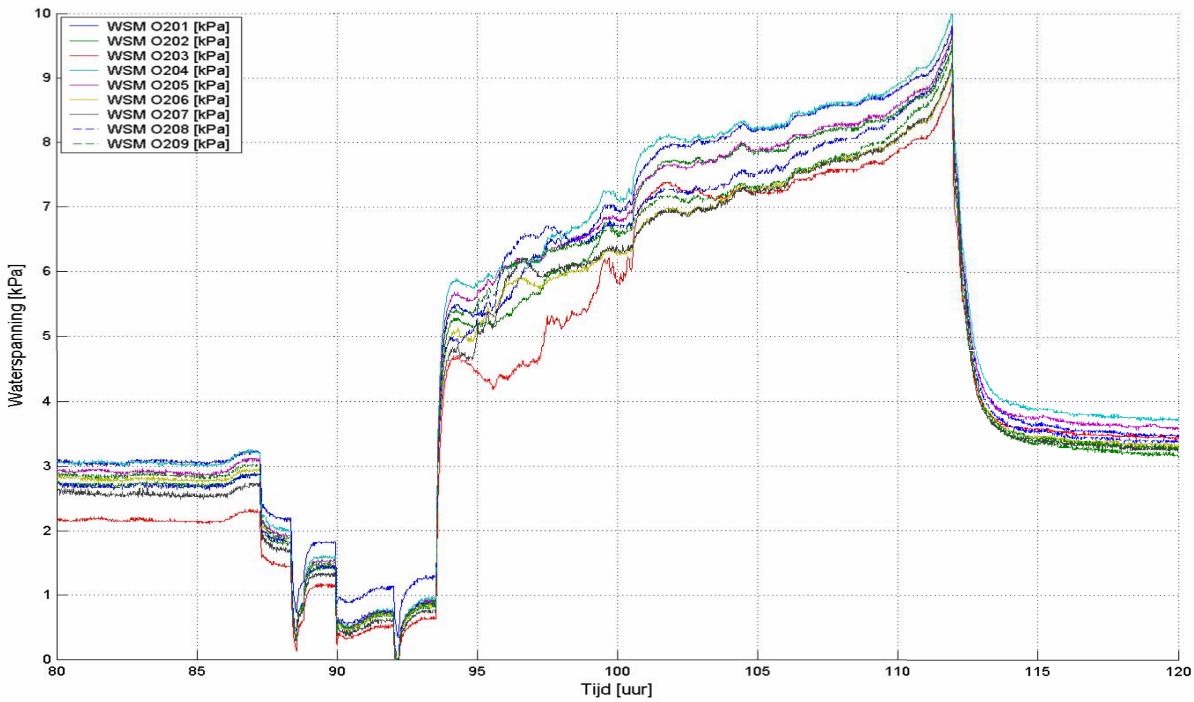



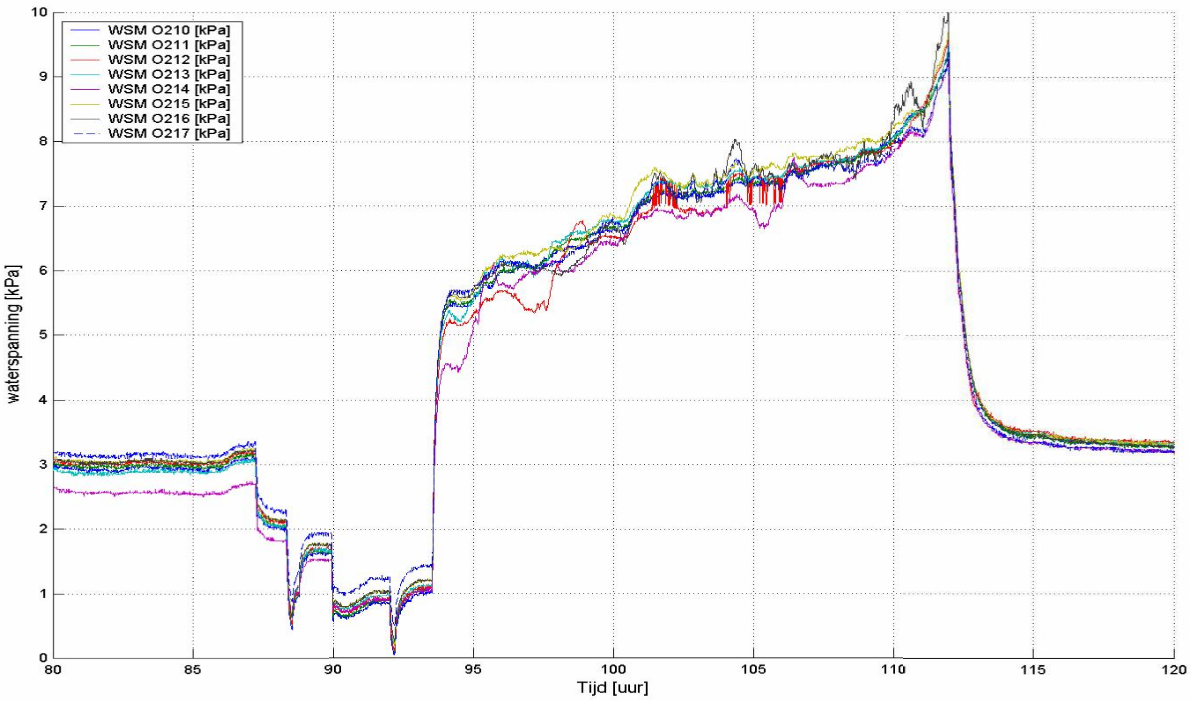
WSM O101 [kPa]
WSM O102 [kPa]
WSM O103 [kPa]
WSM O104 [kPa]
WSM O105 [kPa]
WSM O106 [kPa]
WSM O107 [kPa]
WSM O108 [kPa]
WSM O109 [kPa]
Waterspanning [kPa]
Tijd [uur]

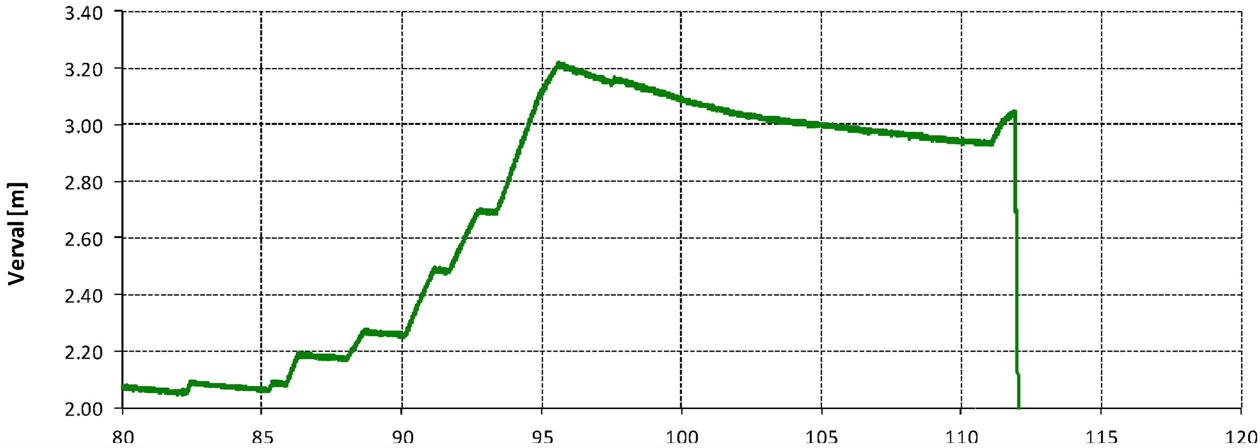



WSM O110 [kPa]
WSM O111 [kPa]
WSM O112 [kPa]
WSM O113 [kPa]
WSM O114 [kPa]
WSM O115 [kPa]
WSM O116 [kPa]
WSM O117 [kPa]
Waterspanning [kPa]
Tijd [uur]

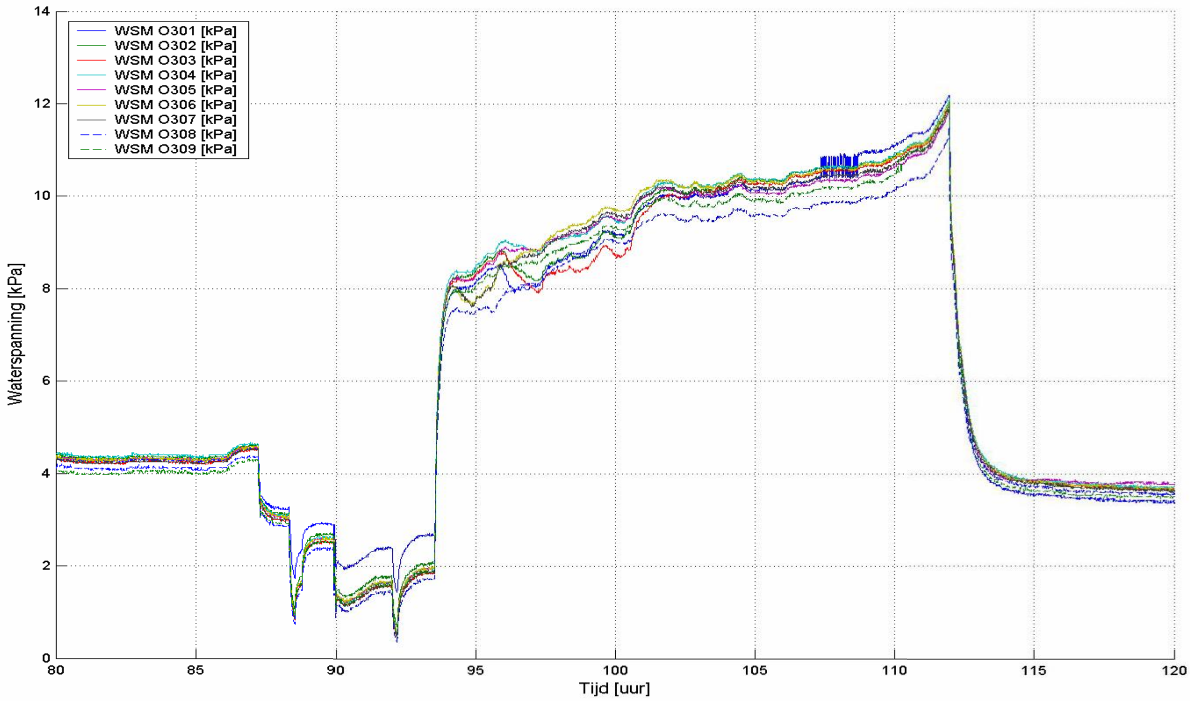

Verval [m]


WSM O201 [kPa]
WSM O202 [kPa]
WSM O203 [kPa]
WSM O204 [kPa]
WSM O205 [kPa]
WSM O206 [kPa]
WSM O207 [kPa]
WSM O208 [kPa]
WSM O209 [kPa]
Waterspanning [kPa]
Tijd [uur]

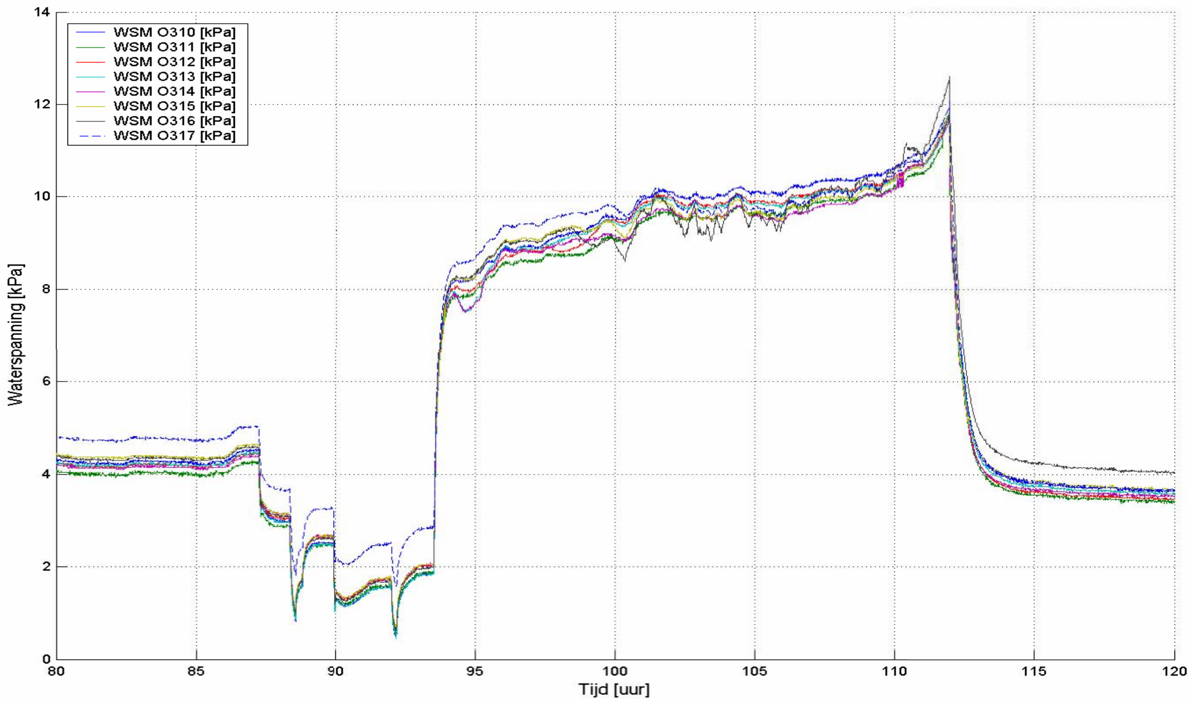

WSM O210 [kPa]
WSM O211 [kPa]
WSM O212 [kPa]
WSM O213 [kPa]
WSM O214 [kPa]
WSM O215 [kPa]
WSM O216 [kPa]
WSM O217 [kPa]
waterspanning [kPa]
Tijd [uur]



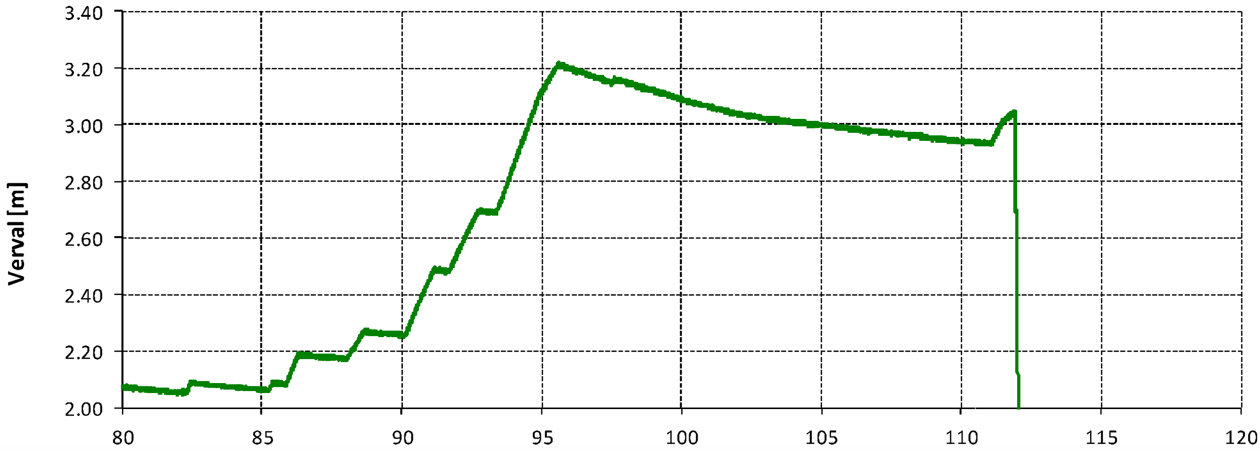
Verval [m]
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
80
85
90
95
100
105
110
115
120

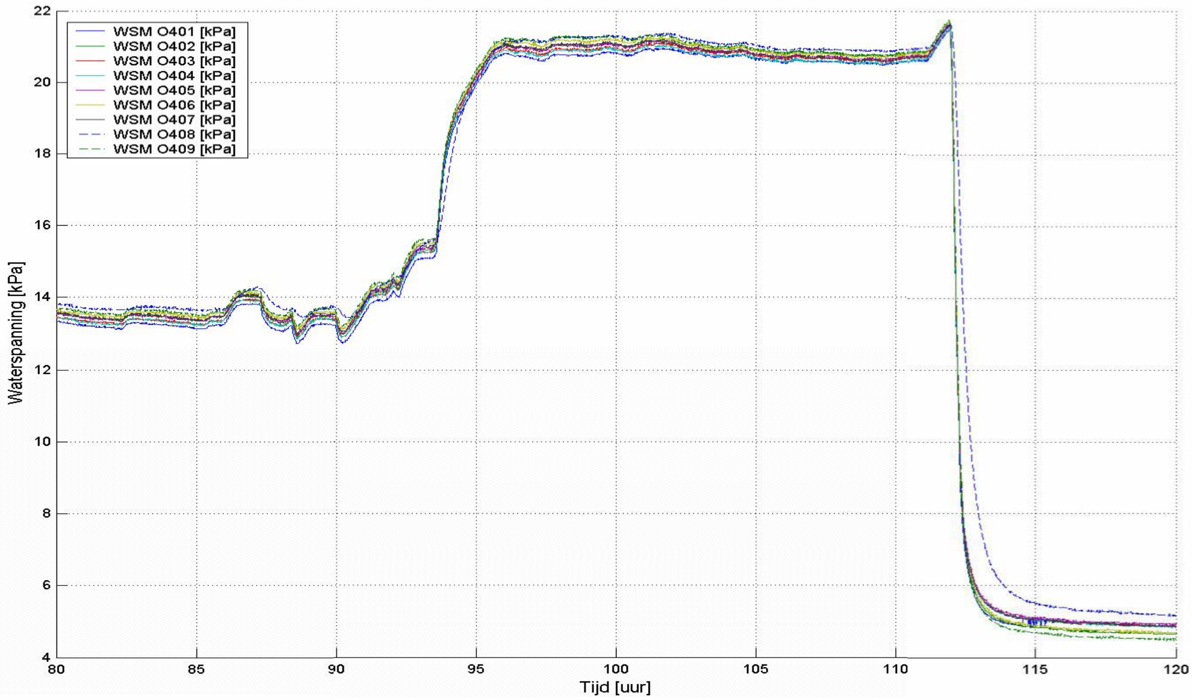
WSM O301 [kPa]
WSM O302 [kPa]
WSM O303 [kPa]
WSM O304 [kPa]
WSM O305 [kPa]
WSM O306 [kPa]
WSM O307 [kPa]
WSM O308 [kPa]
WSM O309 [kPa]
Waterspanning [kPa]
Tijd [uur]

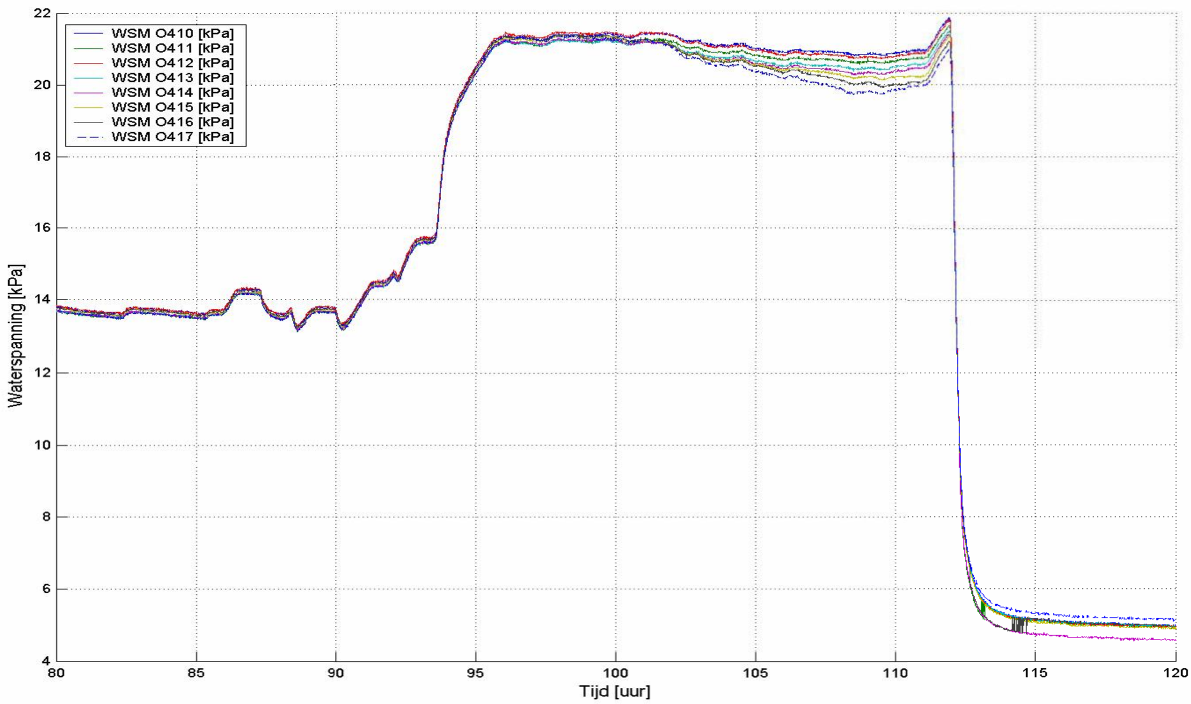
WSM O310 [kPa]
WSM O311 [kPa]
WSM O312 [kPa]
WSM O313 [kPa]
WSM O314 [kPa]
WSM O315 [kPa]
WSM O316 [kPa]
WSM O317 [kPa]
Waterspanning [kPa]
Tijd [uur]



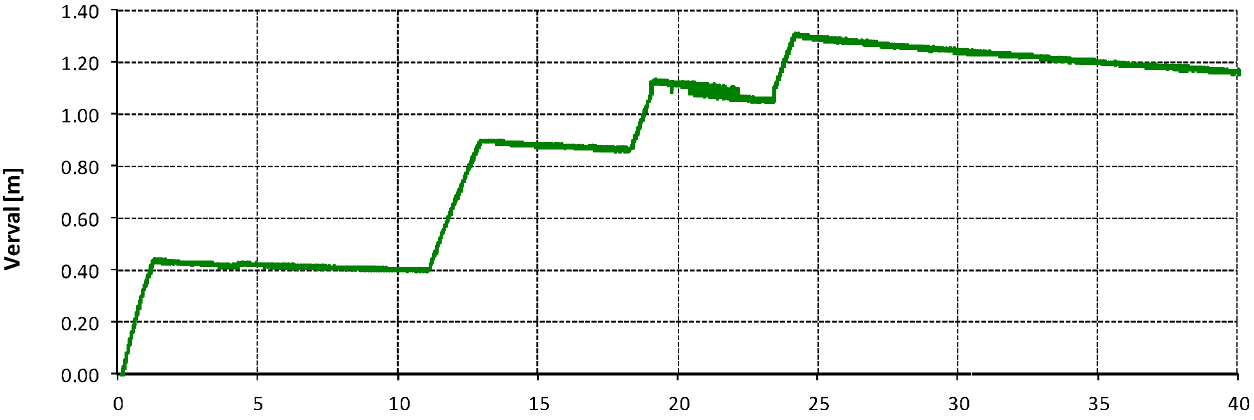
Verval [m]
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
80
85
90
95
100
105
110
115
120

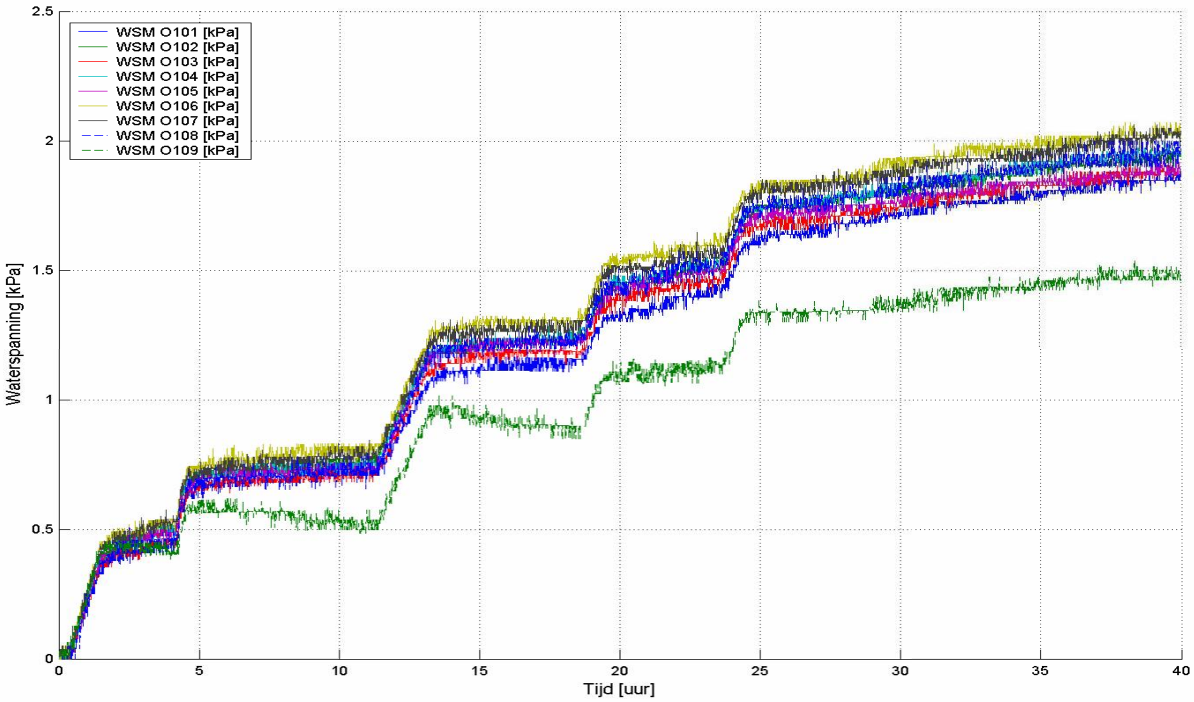



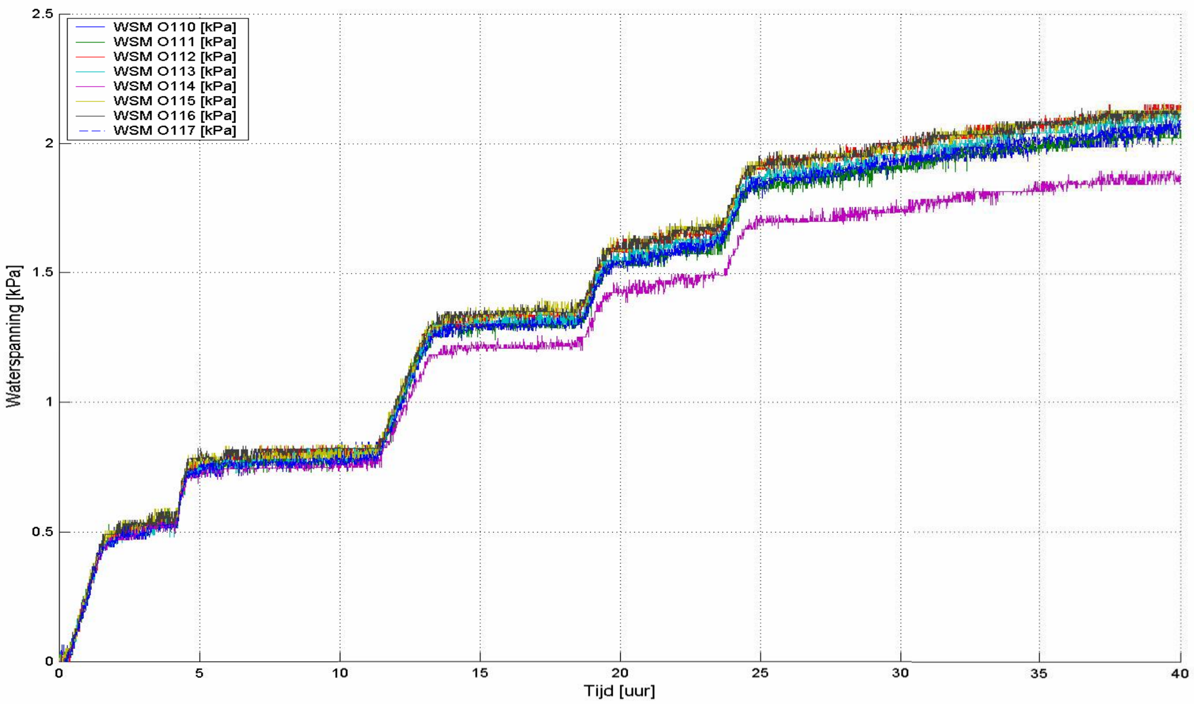
WSM O401 [kPa]
WSM O402 [kPa]
WSM O403 [kPa]
WSM O404 [kPa]
WSM O405 [kPa]
WSM O406 [kPa]
WSM O407 [kPa]
WSM O408 [kPa]
WSM O409 [kPa]
Waterspanning [kPa]
Tijd [uur]

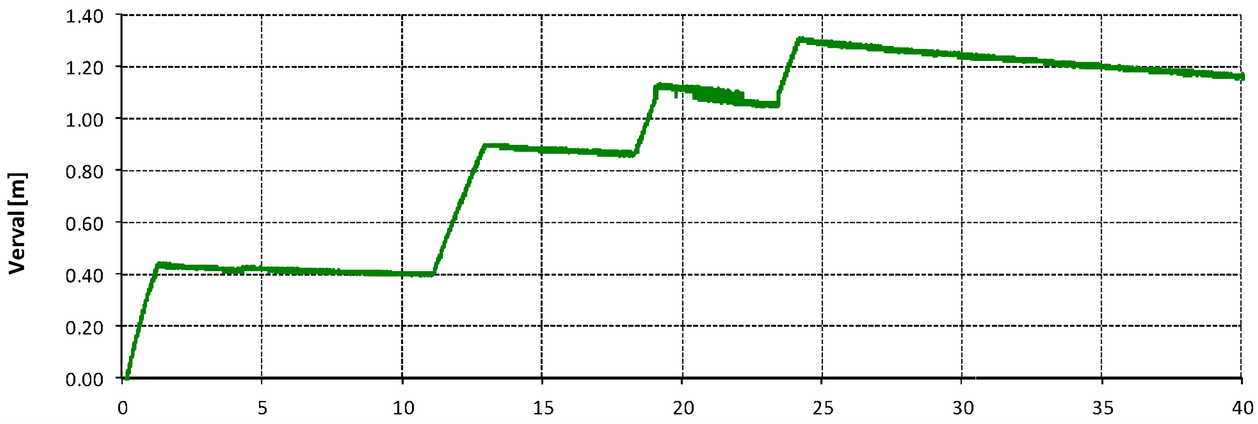



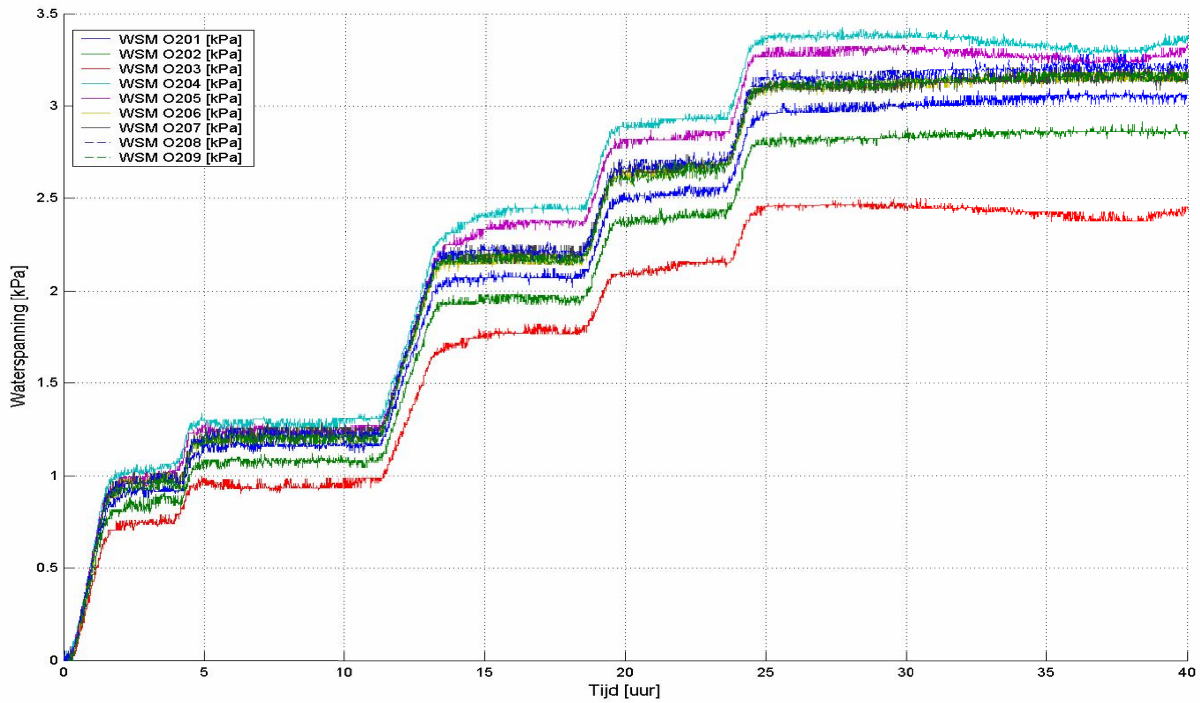
WSM O410 [kPa]
WSM O411 [kPa]
WSM O412 [kPa]
WSM O413 [kPa]
WSM O414 [kPa]
WSM O415 [kPa]
WSM O416 [kPa]
WSM O417 [kPa]
Waterspanning [kPa]
Tijd [uur]

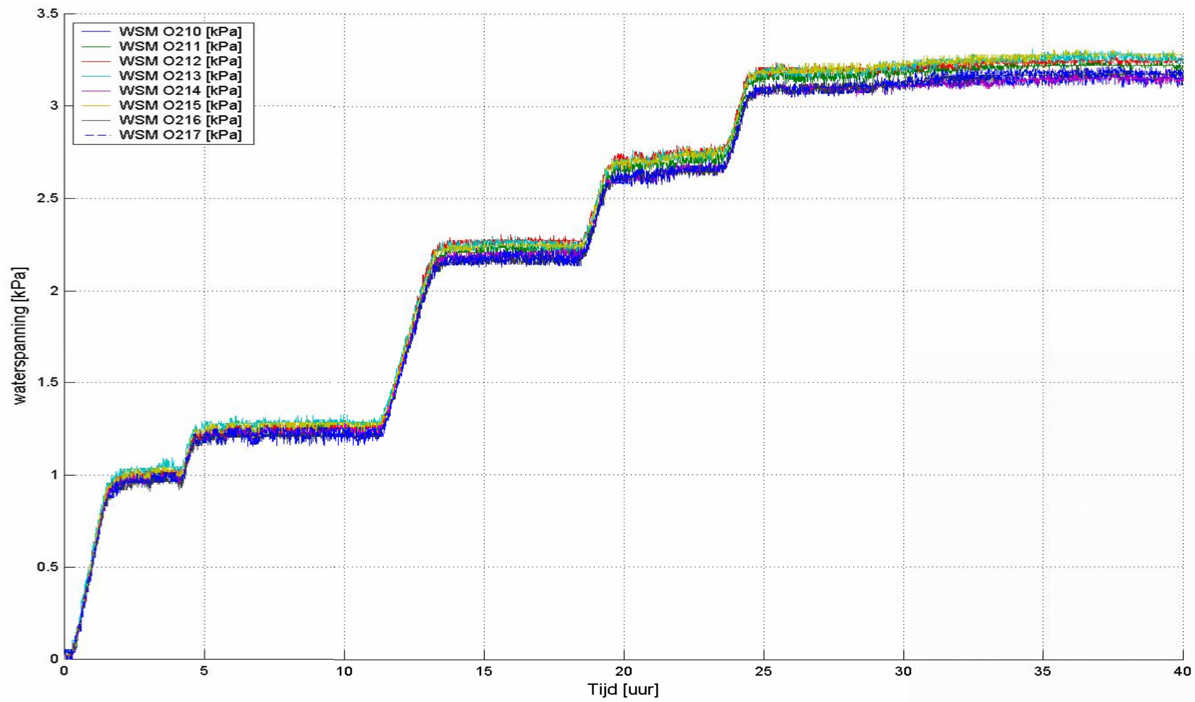

Verval [m]
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
5
10
15
20
25
30
35
40

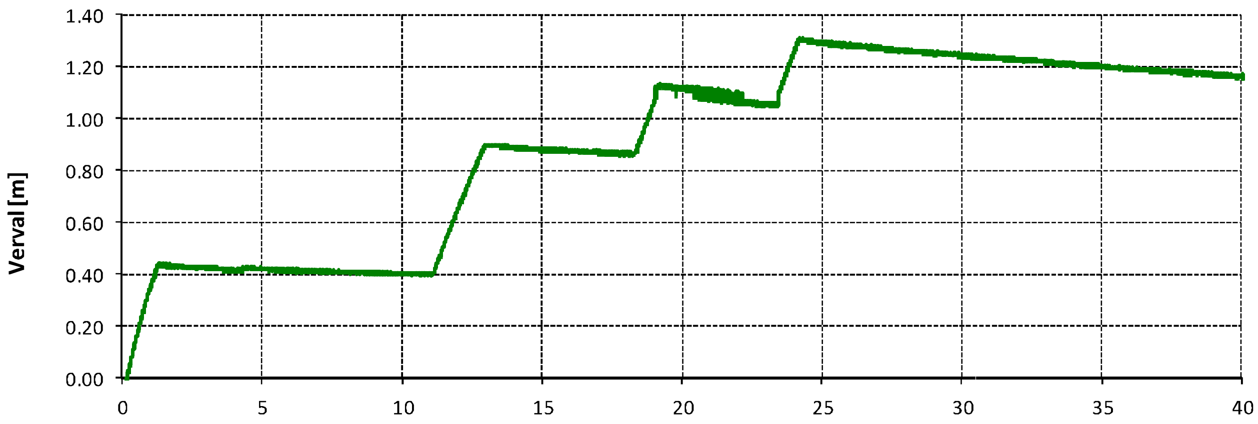

WSM O101 [kPa]
WSM O102 [kPa]
WSM O103 [kPa]
WSM O104 [kPa]
WSM O105 [kPa]
WSM O106 [kPa]
WSM O107 [kPa]
WSM O108 [kPa]
WSM O109 [kPa]
Waterspanning [kPa]
Tijd [uur]


WSM O110 [kPa]
WSM O111 [kPa]
WSM O112 [kPa]
WSM O113 [kPa]
WSM O114 [kPa]
WSM O115 [kPa]
WSM O116 [kPa]
WSM O117 [kPa]
Waterspanning [kPa]
Tijd [uur]

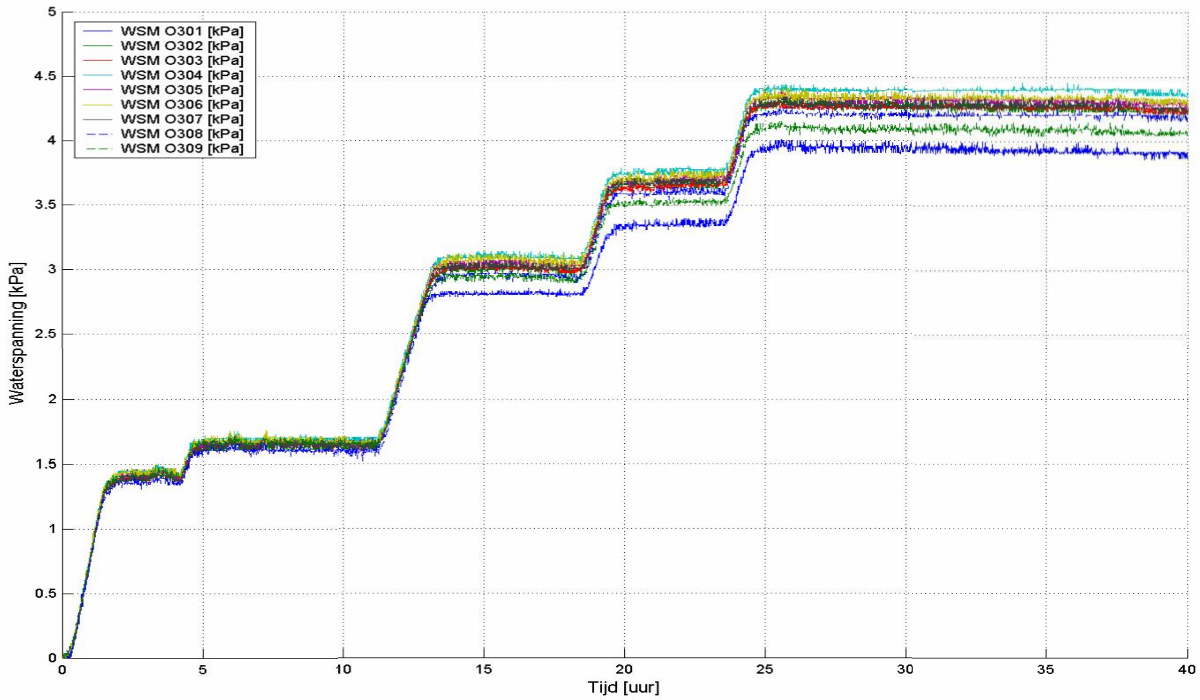

Verval [m]
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
5
10
15
20
25
30
35
40


WSM O201 [kPa]
WSM O202 [kPa]
WSM O203 [kPa]
WSM O204 [kPa]
WSM O205 [kPa]
WSM O206 [kPa]
WSM O207 [kPa]
WSM O208 [kPa]
WSM O209 [kPa]
Waterspanning [kPa]
Tijd [uur]

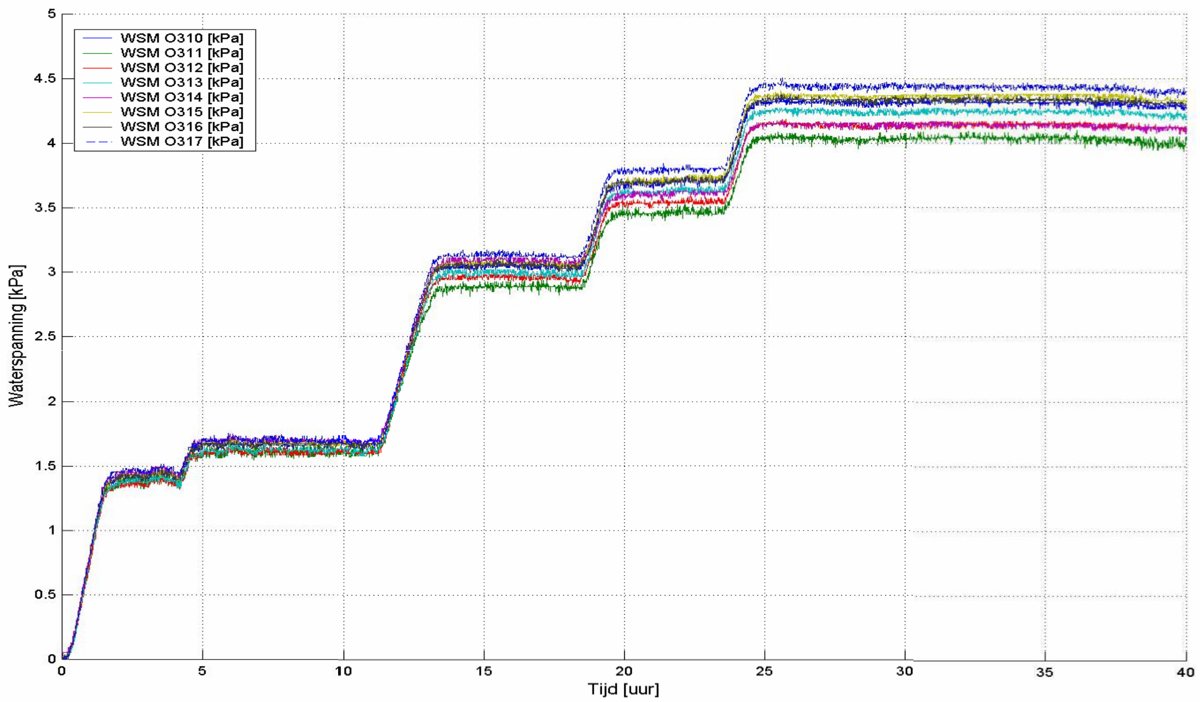

WSM O210 [kPa]
WSM O211 [kPa]
WSM O212 [kPa]
WSM O213 [kPa]
WSM O214 [kPa]
WSM O215 [kPa]
WSM O216 [kPa]
WSM O217 [kPa]
waterspanning [kPa]
Tijd [uur]



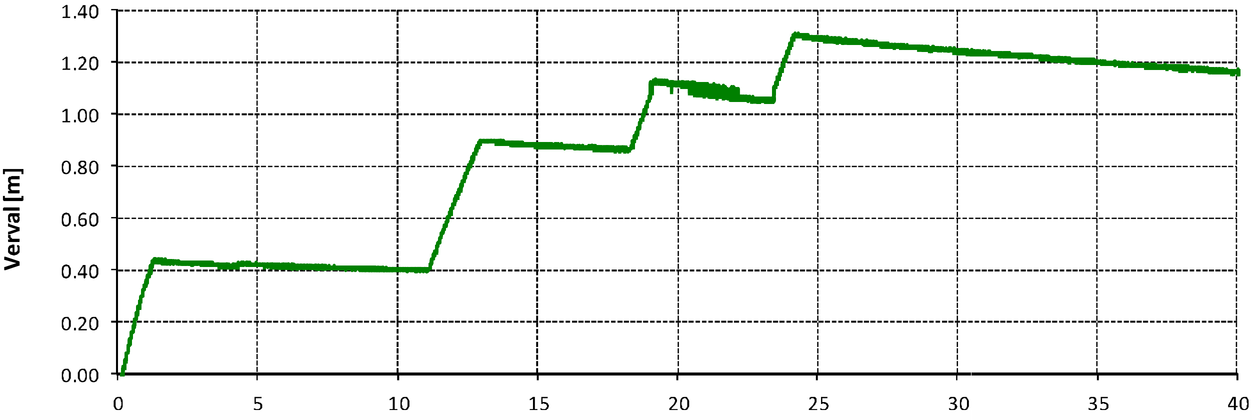
Verval [m]
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
5
10
15
20
25
30
35
40

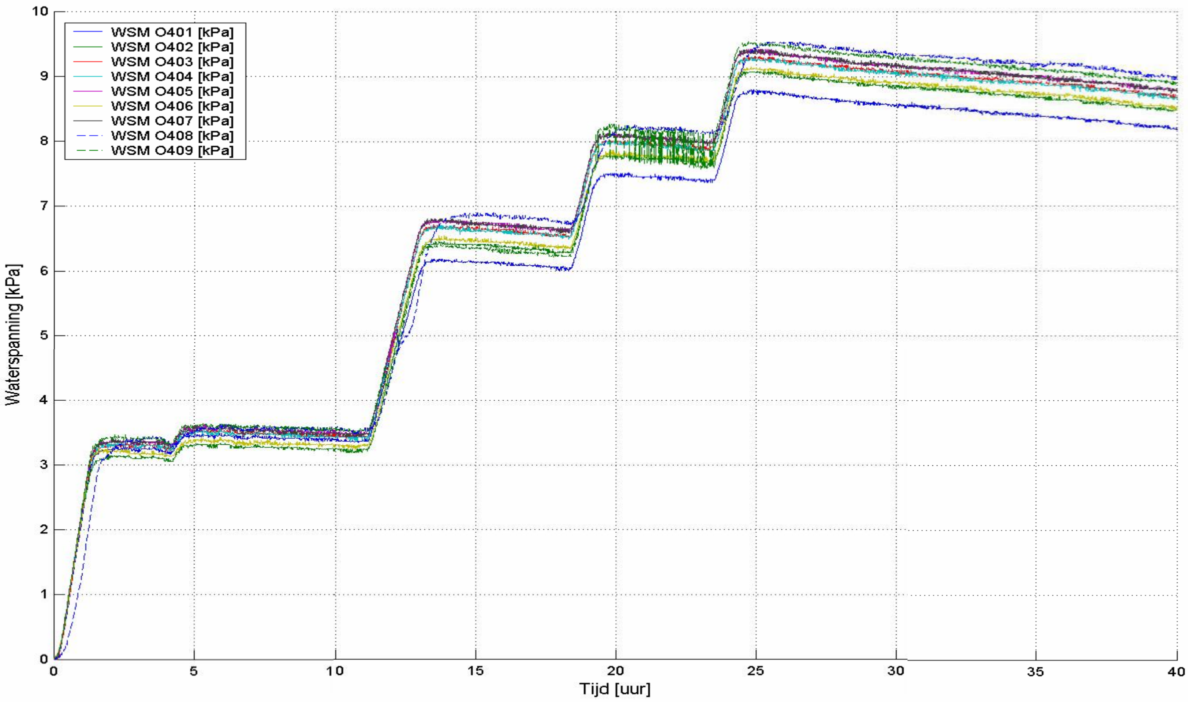
WSM O301 [kPa]
WSM O302 [kPa]
WSM O303 [kPa]
WSM O304 [kPa]
WSM O305 [kPa]
WSM O306 [kPa]
WSM O307 [kPa]
WSM O308 [kPa]
WSM O309 [kPa]
Waterspanning [kPa]
Tijd [uur]

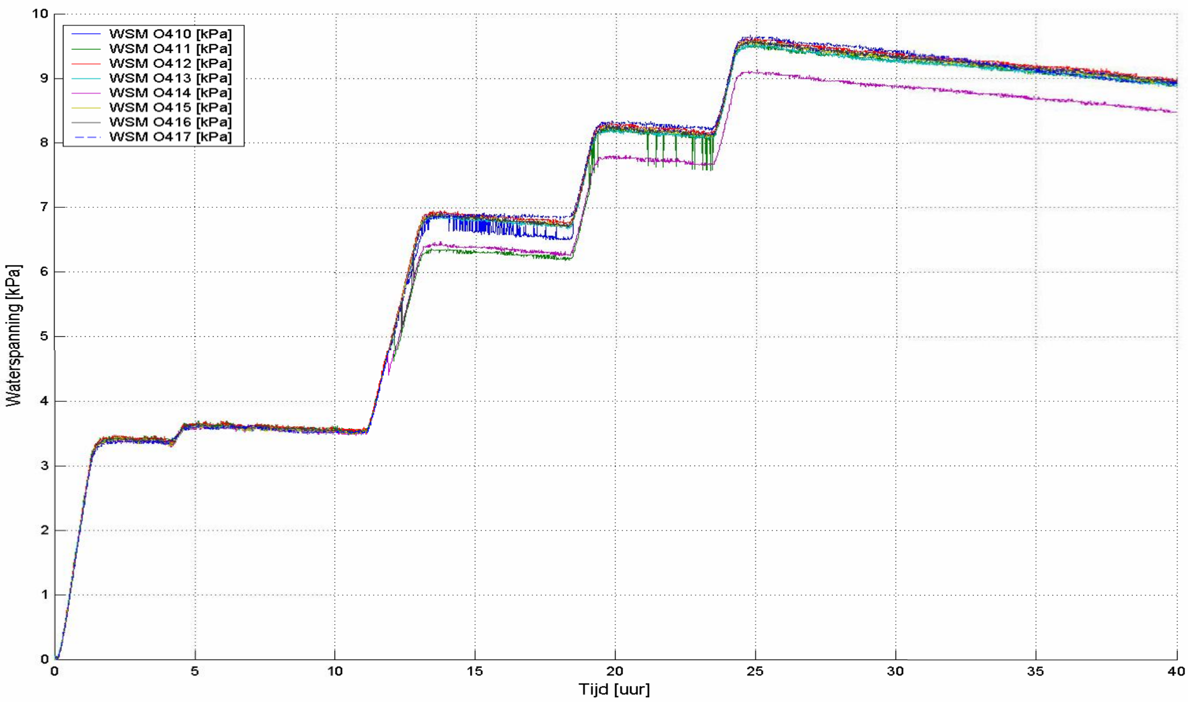
WSM O310 [kPa]
WSM O311 [kPa]
WSM O312 [kPa]
WSM O313 [kPa]
WSM O314 [kPa]
WSM O315 [kPa]
WSM O316 [kPa]
WSM O317 [kPa]
Waterspanning [kPa]
Tijd [uur]



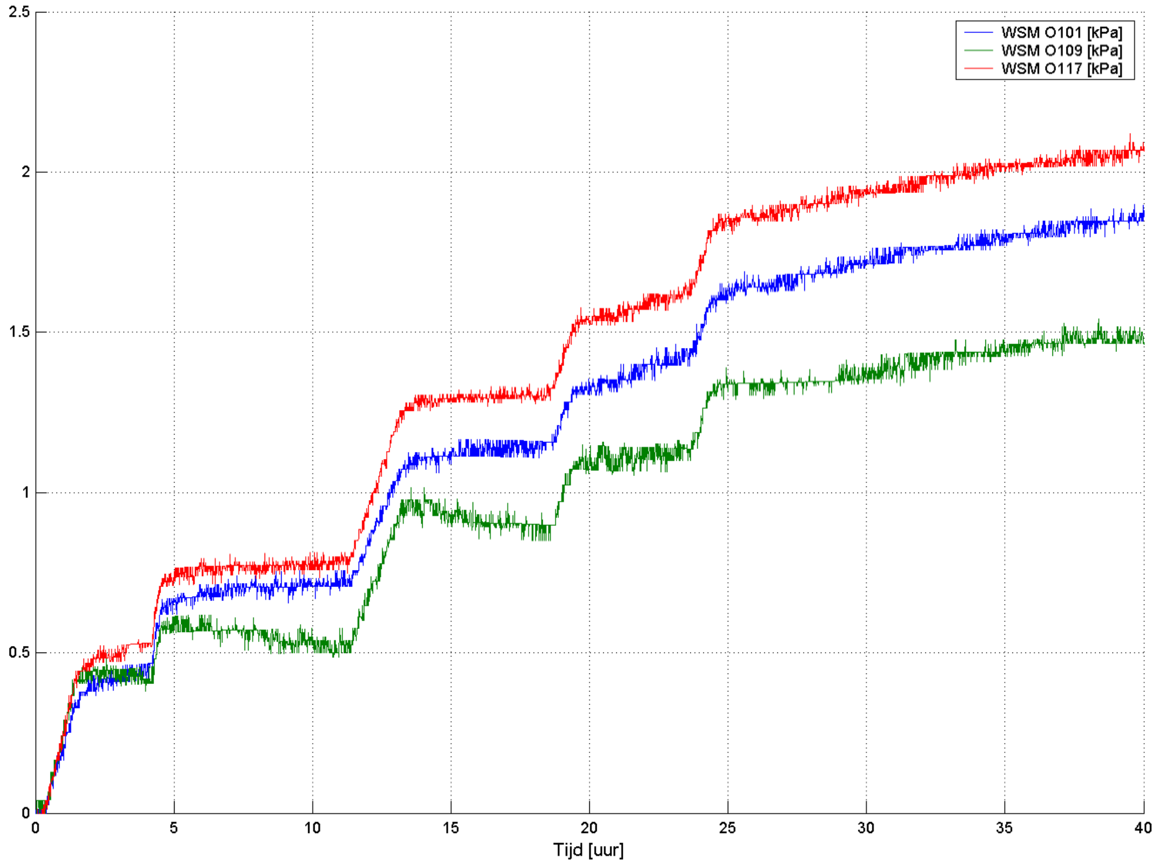
Verval [m]
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
5
10
15
20
25
30
35
40

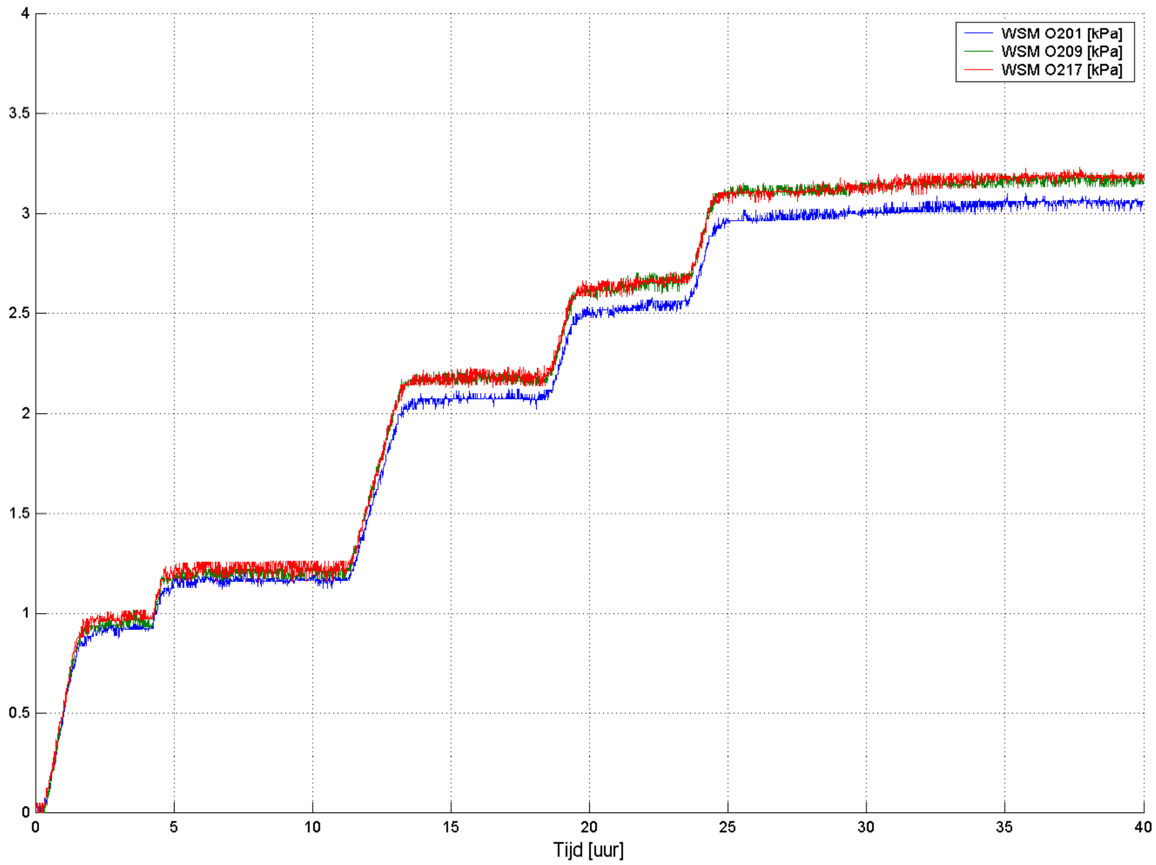
WSM O401 [kPa]
WSM O402 [kPa]
WSM O403 [kPa]
WSM O404 [kPa]
WSM O405 [kPa]
WSM O406 [kPa]
WSM O407 [kPa]
WSM O408 [kPa]
WSM O409 [kPa]
Waterspanning [kPa]
Tijd [uur]

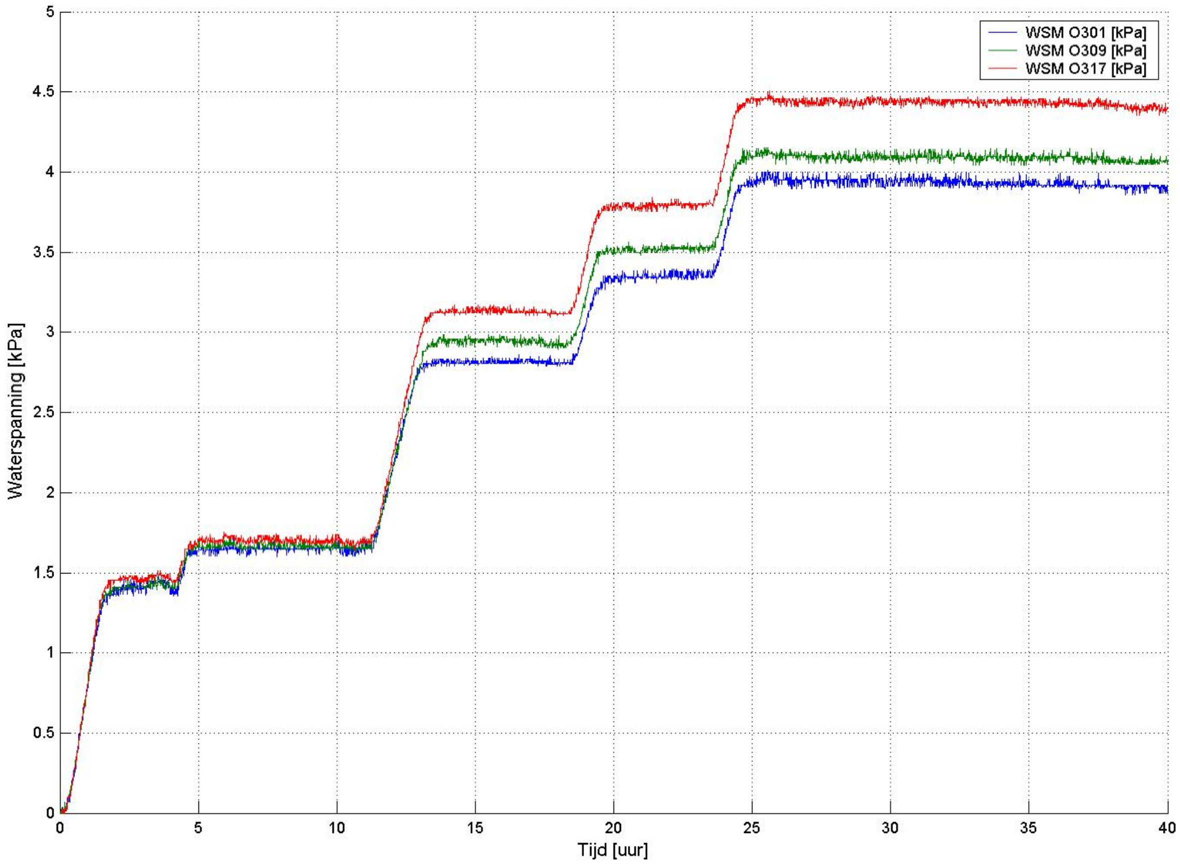
WSM O410 [kPa]
WSM O411 [kPa]
WSM O412 [kPa]
WSM O413 [kPa]
WSM O414 [kPa]
WSM O415 [kPa]
WSM O416 [kPa]
WSM O417 [kPa]
Waterspanning [kPa]
Tijd [uur]

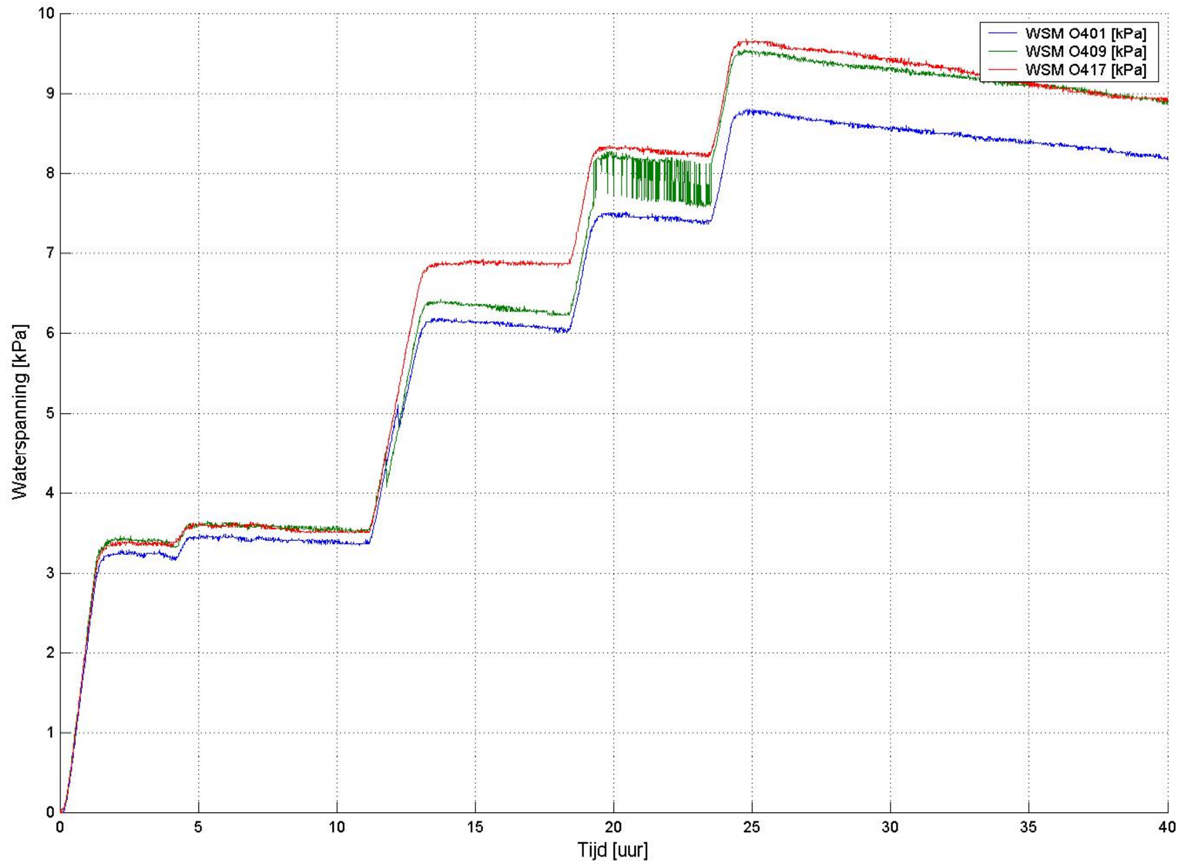


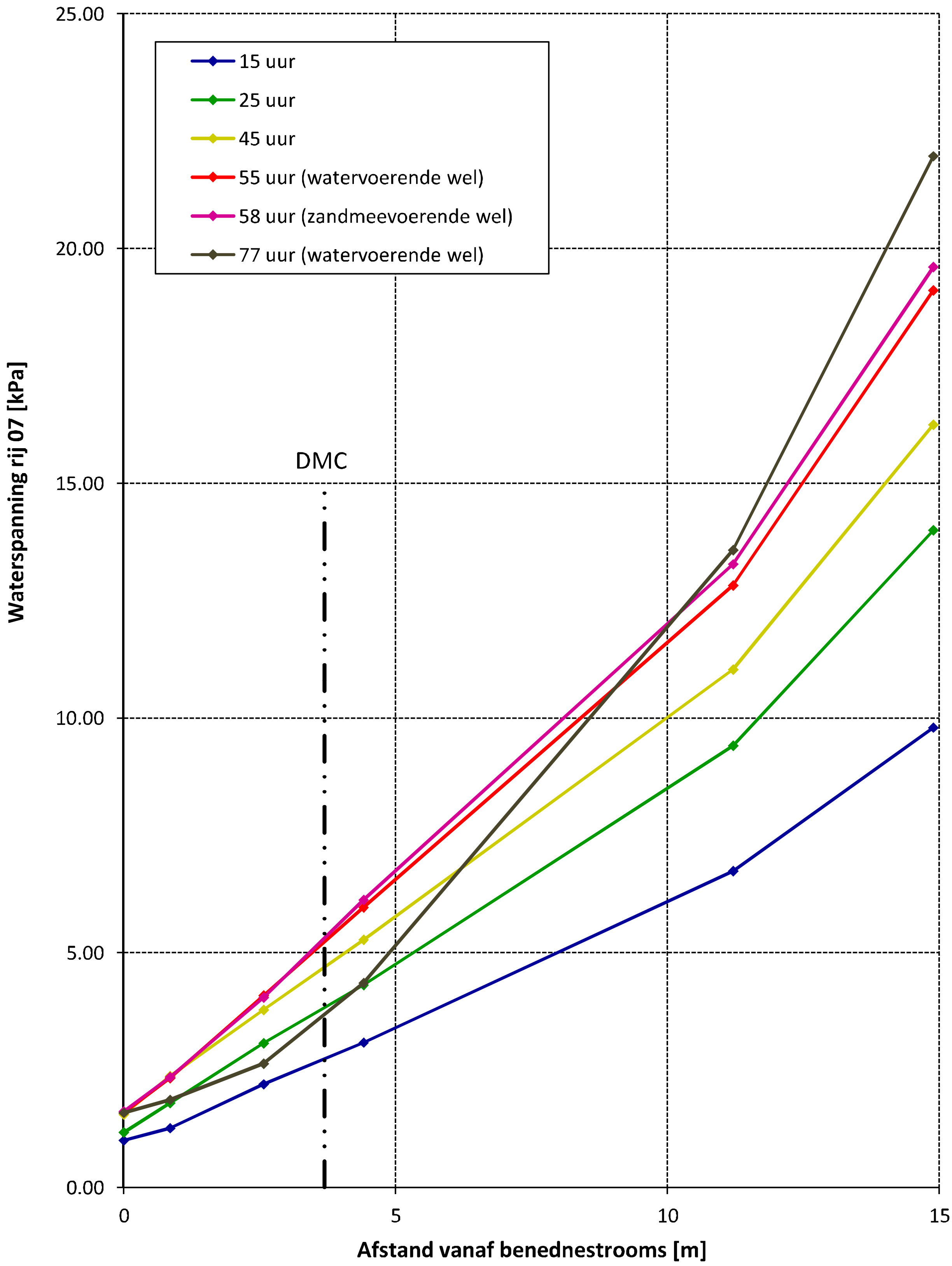
WSM O101 [kPa]
WSM O109 [kPa]
WSM O117 [kPa]
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
40
Tijd [uur]

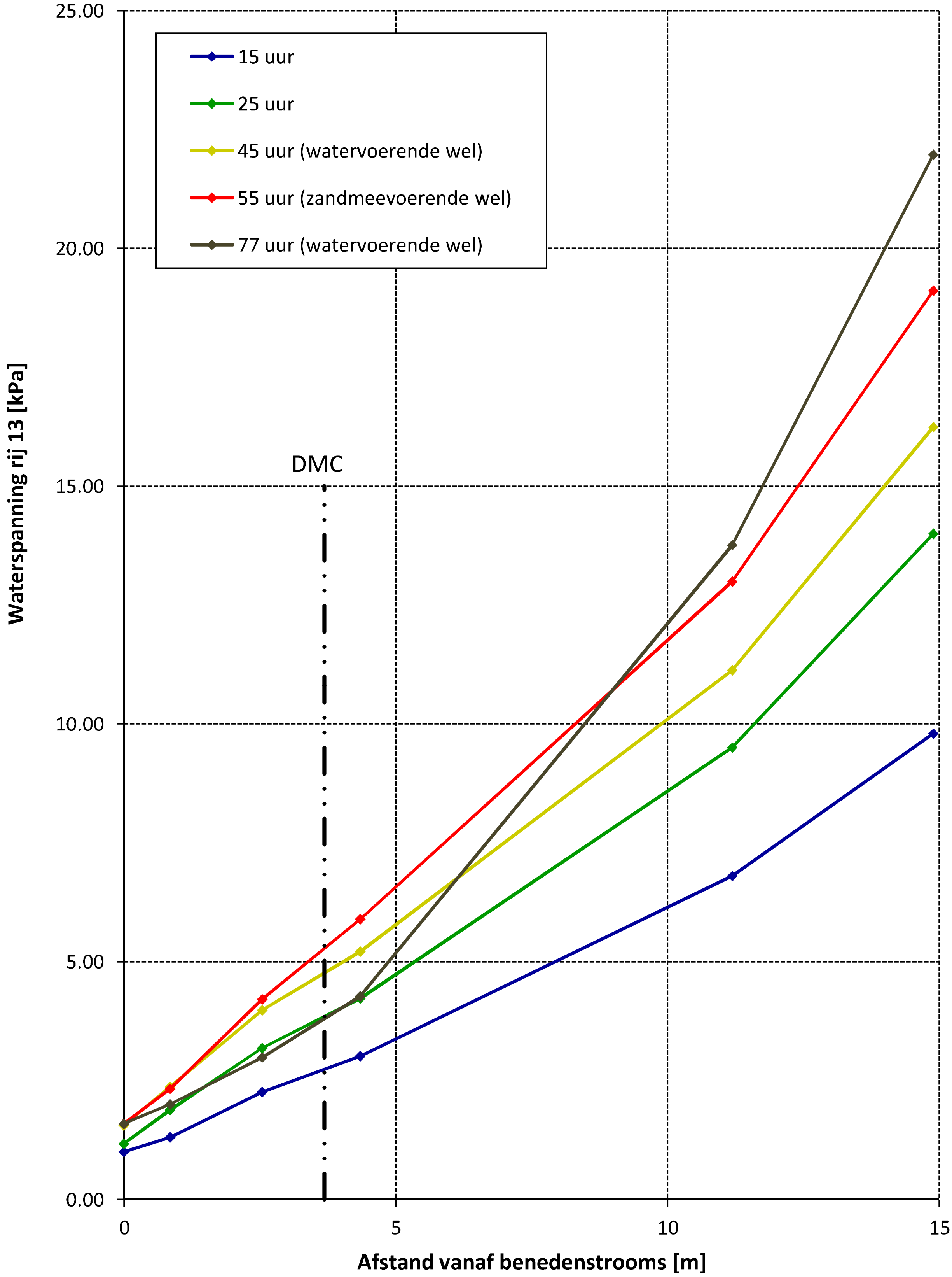
WSM O201 [kPa]
WSM O209 [kPa]
WSM O217 [kPa]
4
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
40
Tijd [uur]


WSM O301 [kPa]
WSM O309 [kPa]
WSM O317 [kPa]
Waterspanning [kPa]
Tijd [uur]
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
5
10
15
20
25
30
35
40


WSM O401 [kPa]
WSM O409 [kPa]
WSM O417 [kPa]
Waterspanning [kPa]
Tijd [uur]
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
35
40



25.00
20.00
15.00
10.00
5.00
0.00
0
5
10
15
15 uur
25 uur
45 uur
55 uur (watervoerende wel)
58 uur (zandmeevoerende wel)
77 uur (watervoerende wel)
DMC
Waterspanning rij 07 [kPa]
Afstand vanaf benednestrooms [m]


25.00
20.00
15.00
10.00
5.00
0.00
Waterspanning rij 13 [kPa]
15 uur
25 uur
45 uur (watervoerende wel)
55 uur (zandmeevoerende wel)
77 uur (watervoerende wel)
DMC
0
5
10
15
Afstand vanaf benedenstrooms [m]

# APPENDIX 3 : EAST DIKE – COPIES FROM FACTUAL REPORT

**Debieten bovenstrooms en verval**

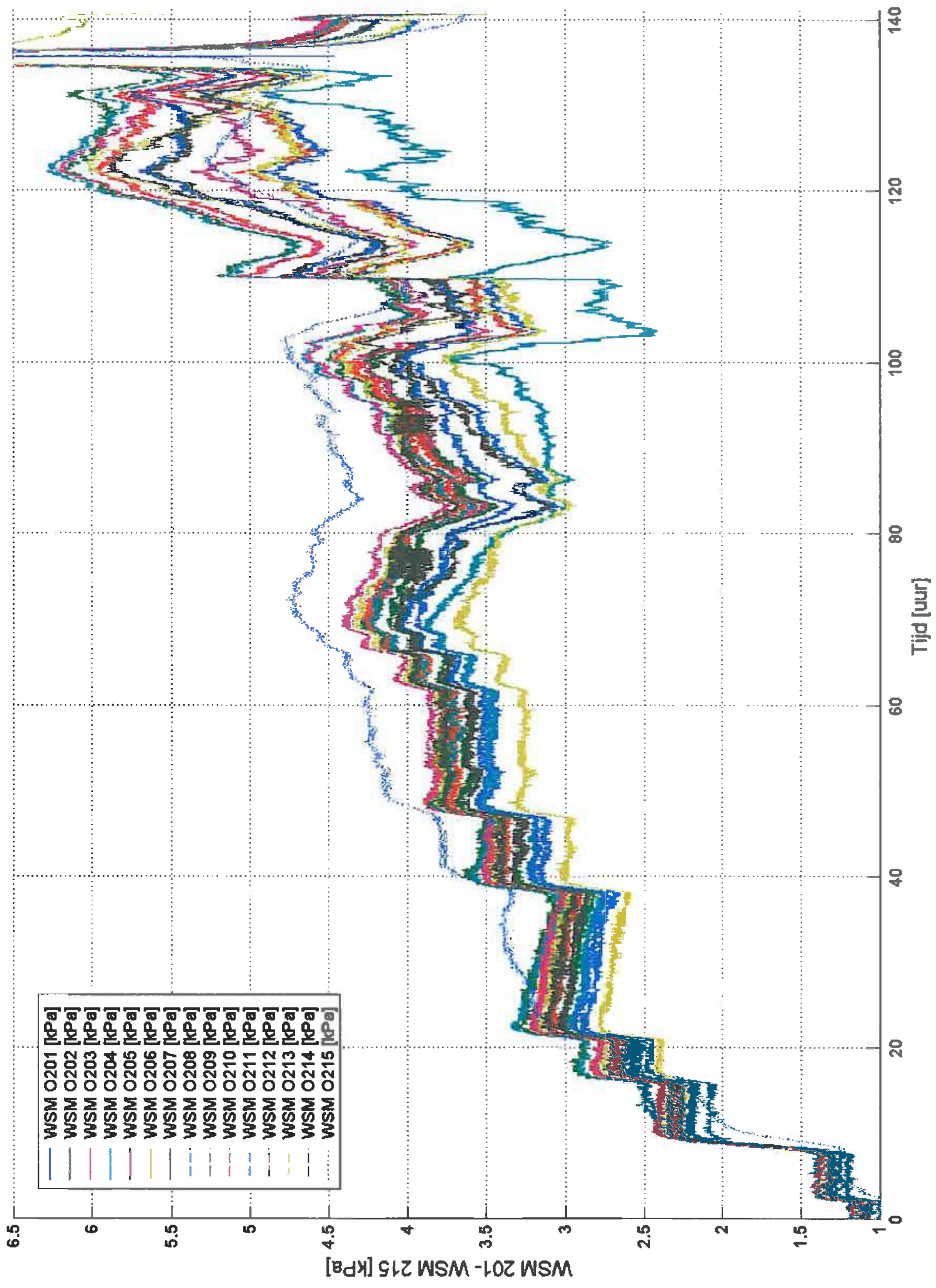
| Datum | Tijd | debietmeterstand | | waterniveau | | verval |
|---|---|---|---|---|---|---|
| | | | verschil | benedenstr, | bovenstr, | |
| 21-8-2012 | 10:50 | 19524 | | 0.18 | 0.16 | -0.02 |
| 21-8-2012 | 16:55 | 19636 | 112 | 0.17 | 0.71 | 0.54 |
| 21-8-2012 | 21:25 | | | 0.2 | 0.73 | 0.53 |
| 21-8-2012 | 23:30 | | | 0.2 | 0.73 | 0.53 |
| 22-8-2012 | 01:11 | | | 0.2 | 0.73 | 0.53 |
| 22-8-2012 | 02:04 | 19636 | 0 | | | 0 |
| 22-8-2012 | 03:34 | 19766 | 130 | 0.2 | 1.23 | 1.03 |
| 22-8-2012 | 04:45 | | | 0.2 | 1.23 | 1.03 |
| 22-8-2012 | 06:17 | | | 0.2 | 1.23 | 1.03 |
| 22-8-2012 | 07:56 | 19766 | 0 | 0.2 | 1.225 | 1.025 |
| 22-8-2012 | 13:36 | 19827 | 61 | 0.2 | 1.42 | 1.22 |
| 22-8-2012 | 17:44 | 19896 | 69 | 0.21 | 1.62 | 1.41 |
| 22-8-2012 | 21:15 | | | 0.21 | 1.615 | 1.405 |
| 22-8-2012 | 23:31 | | | 0.2 | 1.595 | 1.395 |
| 23-8-2012 | 01:30 | | | 0.2 | 1.59 | 1.39 |
| 23-8-2012 | 06:00 | | | 0.2 | 1.57 | 1.37 |
| 23-8-2012 | 07:26 | 19896 | 0 | 0.2 | 1.565 | 1.365 |
| 23-8-2012 | 10:41 | 19973 | 77 | 0.2 | 1.795 | 1.595 |
| 23-8-2012 | 13:06 | 19973 | 0 | 0.2 | 1.78 | 1.58 |
| 23-8-2012 | 14:12 | 19982 | 9 | | | |
| 23-8-2012 | 16:03 | 19982 | 0 | 0.2 | 1.8 | 1.6 |
| 23-8-2012 | 18:55 | 20054 | 72 | | | |
| 23-8-2012 | 19:34 | 20054 | 0 | 0.205 | 1.99 | 1.785 |
| 23-8-2012 | 22:55 | 20054 | 0 | | | |
| 23-8-2012 | 23:06 | 20063 | 9 | | 2 | |
| 24-8-2012 | 02:03 | | | 0.21 | 1.99 | 1.78 |
| 24-8-2012 | 05:08 | | | 0.21 | 1.975 | 1.765 |
| 24-8-2012 | 05:46 | 20063 | 0 | | | |
| 24-8-2012 | 06:00 | 20072 | 9 | | 2 | |
| 24-8-2012 | 07:46 | 20072 | 0 | 0.21 | 1.99 | 1.78 |
| 24-8-2012 | 10:11 | 20072 | 0 | 0.215 | 2.105 | 1.89 |
| 24-8-2012 | 11:08 | 20120 | 48 | 0.215 | 2.1 | 1.885 |
| 24-8-2012 | 13:36 | 20175 | 55 | 0.22 | 2.24 | 2.02 |
| 24-8-2012 | 17:24 | 20214 | 39 | | 2.32 | |
| 24-8-2012 | 18:40 | 20225 | 11 | 0.21 | 2.34 | 2.13 |
| 24-8-2012 | 20:20 | 20225.76 | 0.76 | 0.21 | 2.34 | 2.13 |
| 24-8-2012 | 23:28 | 20225.718 | -0.042 | 0.21 | 2.31 | 2.1 |
| 24-8-2012 | 23:45 | 20237.87 | 12.152 | | 2.345 | |
| 25-8-2012 | 01:05 | | | 0.21 | | |
| 25-8-2012 | 02:47 | | | | 2.33 | |
| 25-8-2012 | 06:22 | | | | 2.45 | |
| 25-8-2012 | 07:30 | 20289 | 51.13 | 0.215 | 2.44 | 2.225 |
| 25-8-2012 | 09:41 | 20339 | 50 | 0.215 | 2.55 | 2.335 |
| 25-8-2012 | 13:20 | | | 0.21 | 2.54 | 2.33 |
| 25-8-2012 | 18:01 | 20395 | 56 | | 2.655 | |
| 25-8-2012 | 19:08 | 20395.01 | 0.01 | 0.22 | 2.65 | 2.43 |
| 25-8-2012 | 22:00 | 20438.22 | 43.21 | 0.22 | 2.74 | 2.52 |
| 25-8-2012 | 22:33 | 20489.18 | 50.96 | | 2.85 | |
| 25-8-2012 | 23:55 | 20489.18 | 0 | 0.22 | 2.84 | 2.62 |
| 26-8-2012 | 00:33 | 20538.4 | 49.22 | | 2.95 | |
| 26-8-2012 | 02:07 | | | | 2.94 | |
| 26-8-2012 | 02:11 | 20591.62 | 53.22 | | 3.05 | |
| 26-8-2012 | 04:00 | | | | 3.04 | |

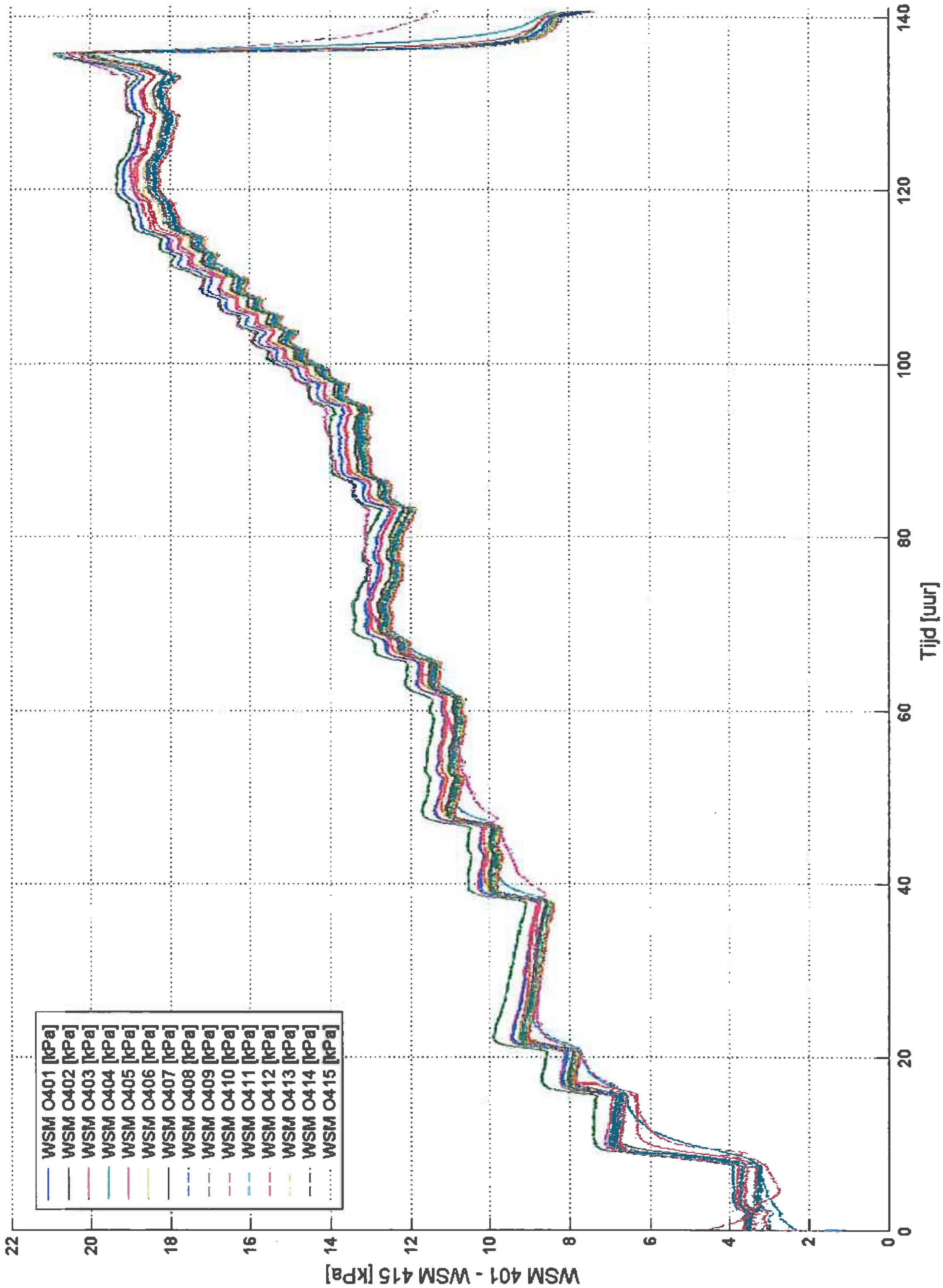
| | | | | | | |
|---|---|---|---|---|---|---|
| 26-8-2012 | 04:30 | 20645.1 | 53.48 | 0.23 | 3.15 | 2.92 |
| 26-8-2012 | 06:00 | | | 0.23 | 3.14 | 2.91 |
| 26-8-2012 | 06:30 | 20700.91 | 55.81 | | 3.25 | 3.25 |
| 26-8-2012 | 09:09 | 20701 | 0.09 | | | |
| 26-8-2012 | 09:40 | 20763 | 62 | | 3.35 | 3.35 |
| 26-8-2012 | 10:54 | | | 0.28 | | |
| 26-8-2012 | 11:35 | 20819 | 56 | 0.26 | 3.45 | 3.19 |
| 26-8-2012 | 13:40 | | | 0.26 | 3.55 | 3.29 |
| 26-8-2012 | 15:40 | 20893.9 | 74.9 | 0.26 | 3.55 | 3.29 |
| 26-8-2012 | 19:52 | | | | 3.54 | |
| 26-8-2012 | 23:00 | | | 0.32 | 3.52 | 3.2 |
| 27-8-2012 | 01:15 | | | 0.31 | 3.5 | 3.19 |
| 27-8-2012 | 03:00 | 20905 | 313.38 | 0.31 | 3.49 | 3.18 |
| 27-8-2012 | 03:55 | 20935 | 30 | | 3.55 | |
| 27-8-2012 | 06:00 | | | 0.23 | 3.535 | 3.305 |
| 27-8-2012 | 07:30 | 20941 | 47.1 | | 3.52 | |
| 27-8-2012 | 09:10 | 21059 | 118 | | 3.72 | |

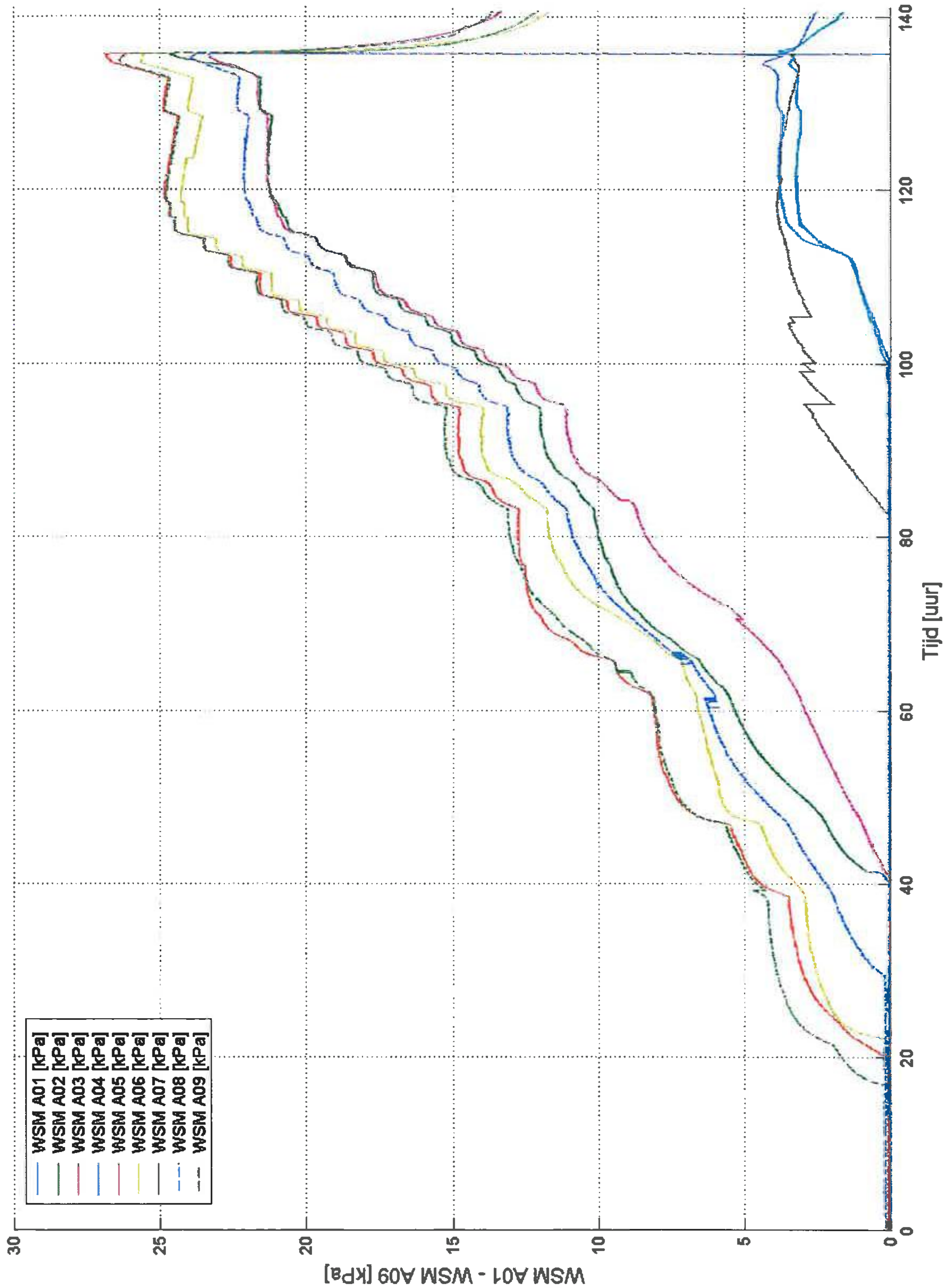
| OOST LAAG | |
|---|---|
| bovenkant zand | = -1.05 NAP |
| nulpunt baak | = -1.06 NAP |
| sensorniveau | = -1.00 NAP |
| waterstand | = -0.89 NAP |

| OOST HOOG | |
|---|---|
| bovenkant zand | = -1.18 NAP |
| nulpunt baak | = -1.20 NAP |
| sensorniveau | = -1.13 NAP |
| waterstand | = -1.04 NAP |

Bij gelijke waterstand is de
aflezing op de baak in het hoge bassin 0.14 m hoger
Voor de sensor is dat 0.13 m


WSM O201 [kPa]
WSM O202 [kPa]
WSM O203 [kPa]
WSM O204 [kPa]
WSM O205 [kPa]
WSM O206 [kPa]
WSM O207 [kPa]
WSM O208 [kPa]
WSM O209 [kPa]
WSM O210 [kPa]
WSM O211 [kPa]
WSM O212 [kPa]
WSM O213 [kPa]
WSM O214 [kPa]
WSM O215 [kPa]
WSM 201- WSM 215 [kPa]
Tijd [uur]
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
0
20
40
60
80
100
120
140


WSM O401 [kPa]
WSM O402 [kPa]
WSM O403 [kPa]
WSM O404 [kPa]
WSM O405 [kPa]
WSM O406 [kPa]
WSM O407 [kPa]
WSM O408 [kPa]
WSM O409 [kPa]
WSM O410 [kPa]
WSM O411 [kPa]
WSM O412 [kPa]
WSM O413 [kPa]
WSM O414 [kPa]
WSM O415 [kPa]
WSM 401 - WSM 415 [kPa]
Tijd [uur]
0
2
4
6
8
10
12
14
16
18
20
22
0
20
40
60
80
100
120
140


WSM A01 [kPa]
WSM A02 [kPa]
WSM A03 [kPa]
WSM A04 [kPa]
WSM A05 [kPa]
WSM A06 [kPa]
WSM A07 [kPa]
WSM A08 [kPa]
WSM A09 [kPa]
WSM A01 - WSM A09 [kPa]
Tijd [uur]
0
5
10
15
20
25
30
0
20
40
60
80
100
120
140

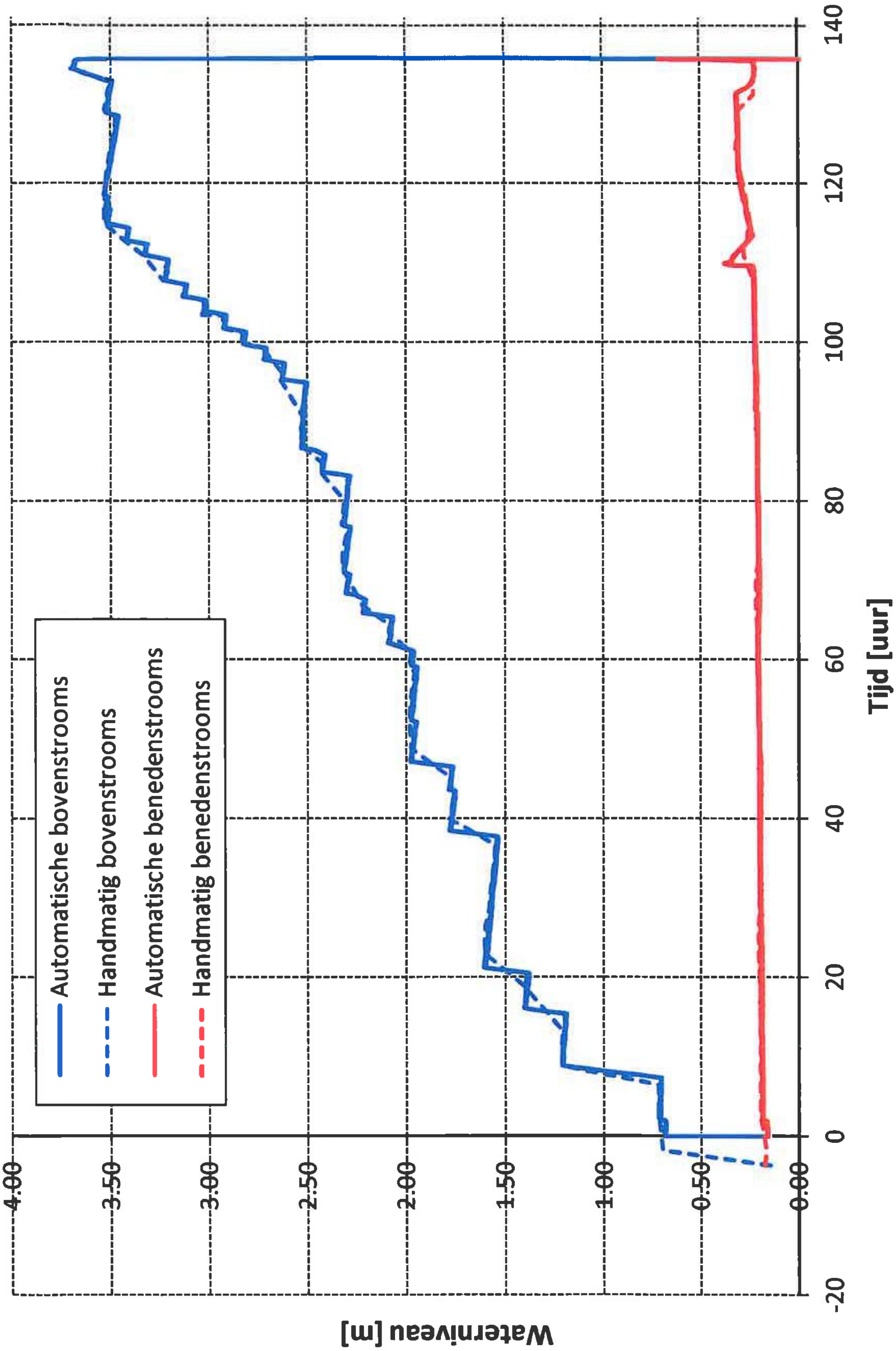

Automatische bovenstrooms
Handmatig bovenstrooms
Automatische benedenstrooms
Handmatig benedenstrooms
Waterniveau [m]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Tijd [uur]
-20
0
20
40
60
80
100
120
140

Foto 53 – Overzichtsfoto van de grof-zand-koffer.

Foto 55 – Het leggen van het folie.



Foto 1303 – Scheuren in de dijk ingespoten met oranje verf.



Foto 1305 – Overzichtsfoto van het talud.

Foto 1318 – Overzichtsfoto scheuren in de dijk.

Foto 1340 - Wel 1

Foto 1475 – Water komt uit het talud, vlak bij de teen.

Foto 1542 – Zandplaat ontstaan door overstroming van de westdijk.

Foto 1591 – Close-up verzakking. Water vult de scheuren.

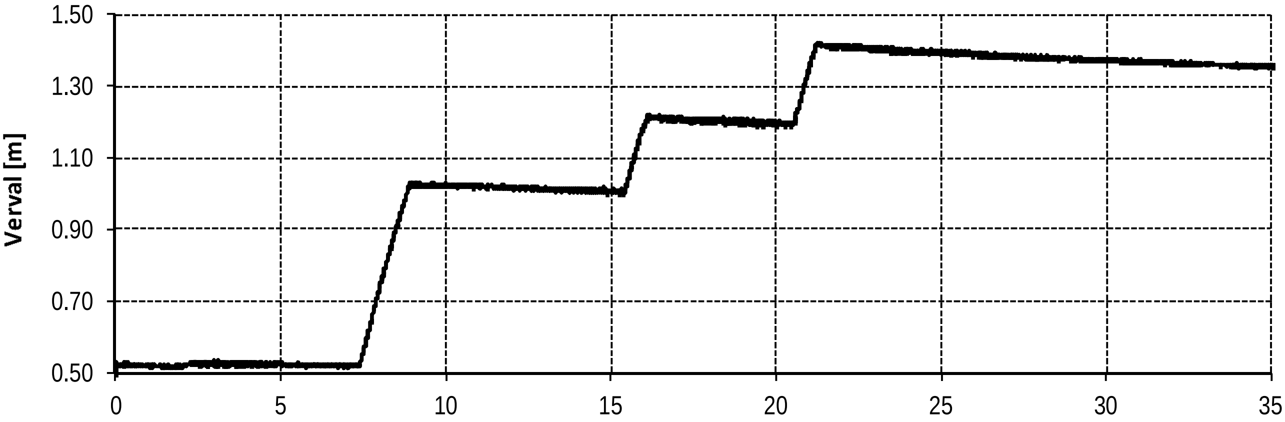
Foto 070 (PF) 27-08-2012 10:18 – Water loopt door de scheuren heen naar beneden.

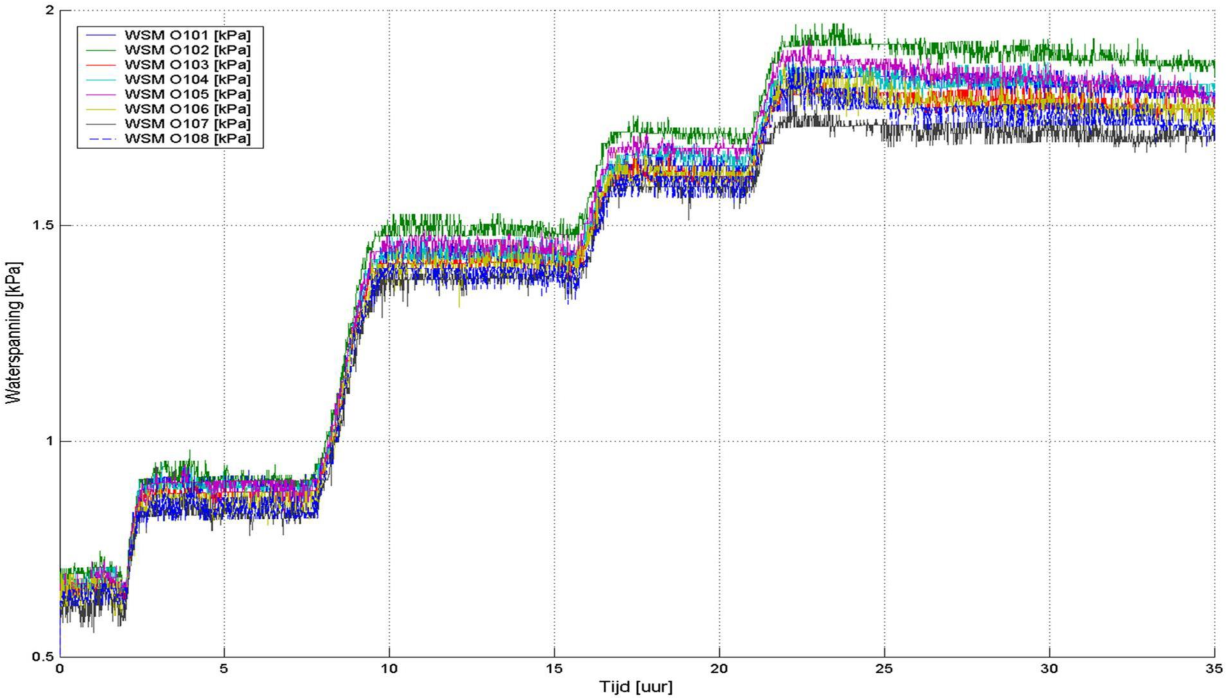
Foto 071 (PF) 27-08-2012 10:19 – Water spoelt de toplaag aan de onderkant van de dijk weg.

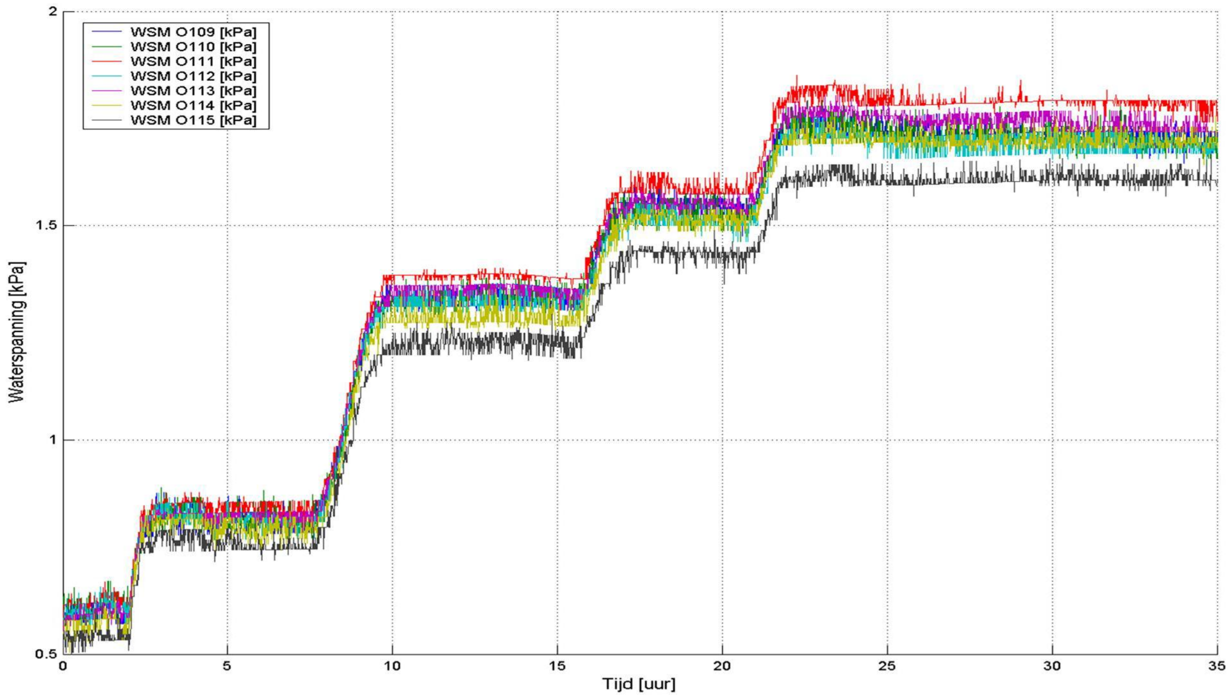
Foto 078 (PF) 27-08-2012 10:24 – Water spoelt door 2 grote scheuren heen en spoelt de toplaag weg.

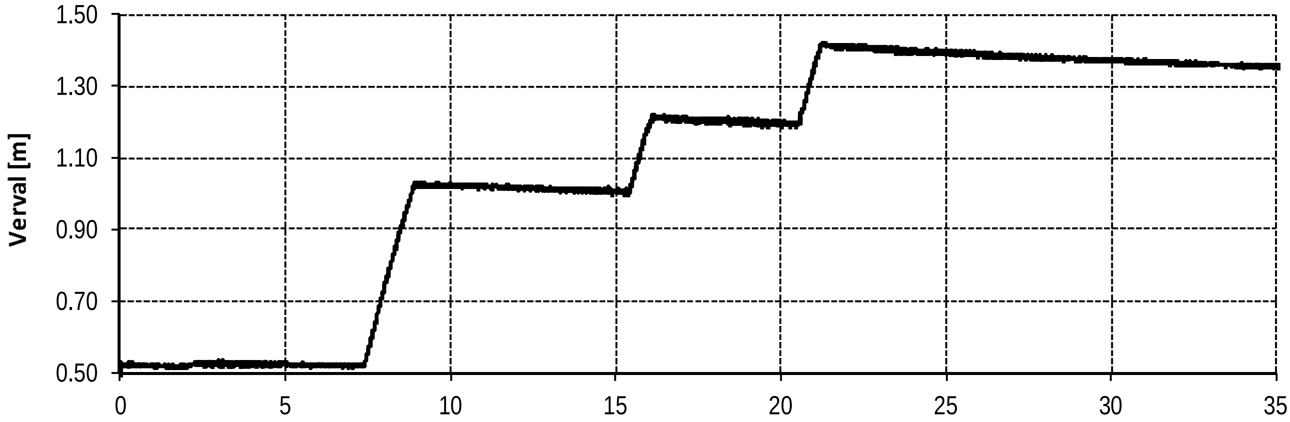
Foto 091 (PF) 27-08-2012 10:28 – Water spoelt de dijk weg.

# APPENDIX 4 : EAST DIKE – ADDITIONAL GRAPHS

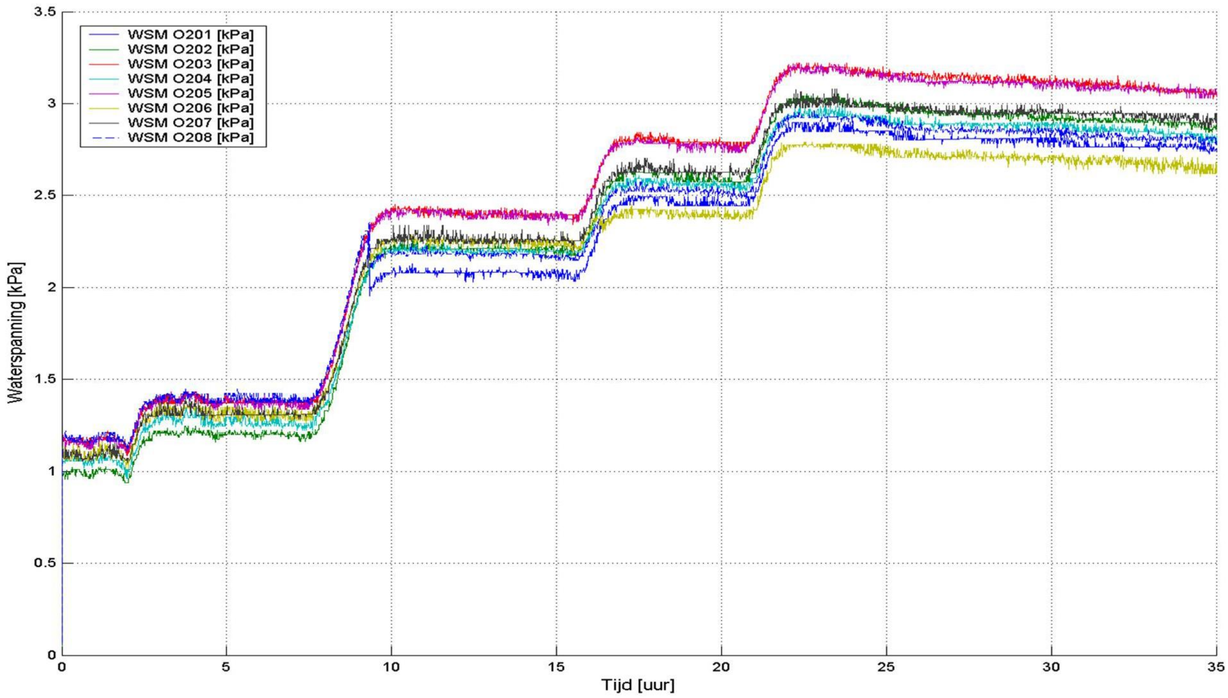

Verval [m]
1.50
1.30
1.10
0.90
0.70
0.50
0
5
10
15
20
25
30
35


WSM O101 [kPa]
WSM O102 [kPa]
WSM O103 [kPa]
WSM O104 [kPa]
WSM O105 [kPa]
WSM O106 [kPa]
WSM O107 [kPa]
WSM O108 [kPa]
Waterspanning [kPa]
Tijd [uur]

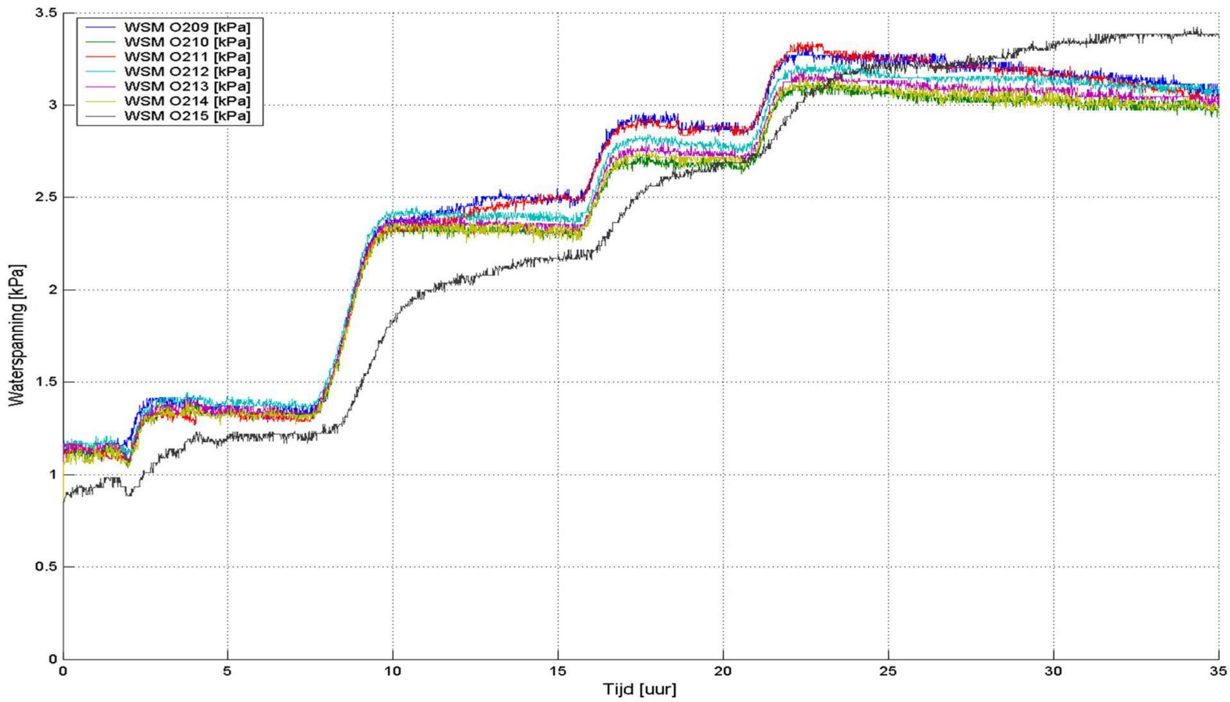

WSM O109 [kPa]
WSM O110 [kPa]
WSM O111 [kPa]
WSM O112 [kPa]
WSM O113 [kPa]
WSM O114 [kPa]
WSM O115 [kPa]
Waterspanning [kPa]
Tijd [uur]



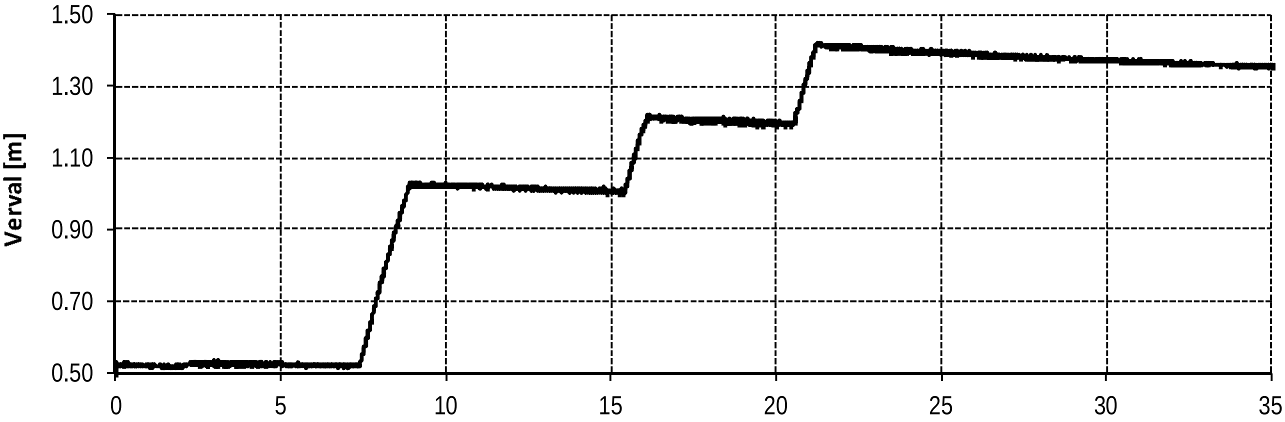
Verval [m]
1.50
1.30
1.10
0.90
0.70
0.50
0
5
10
15
20
25
30
35

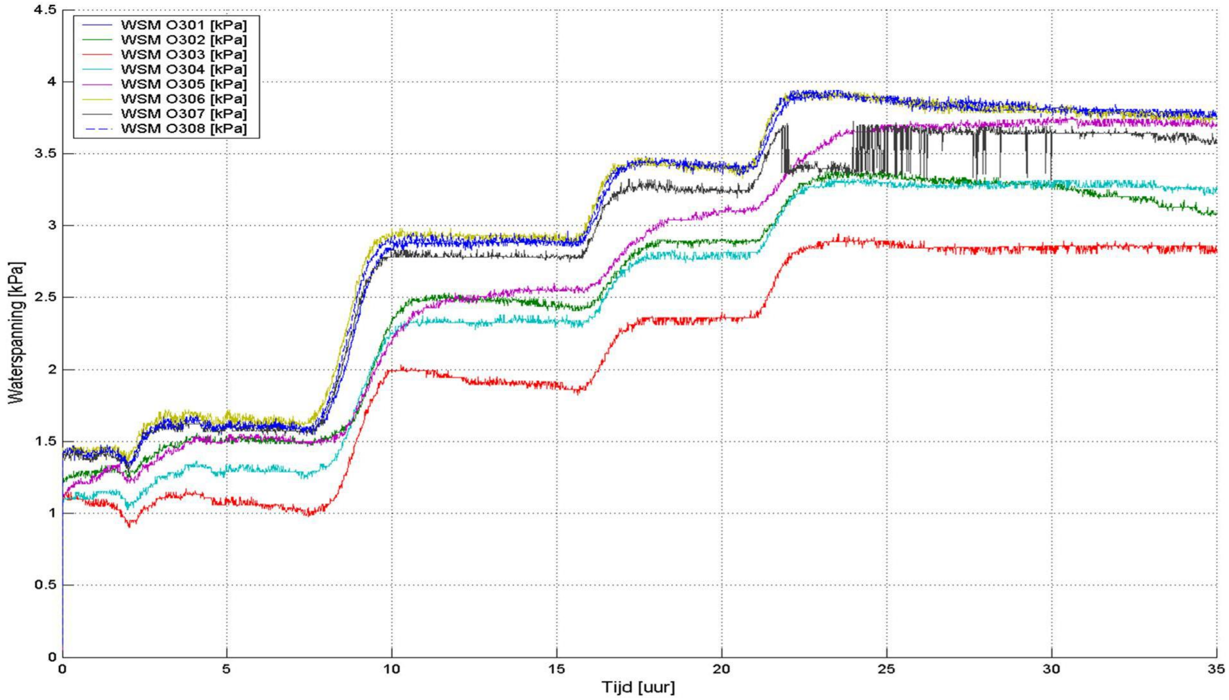
WSM O201 [kPa]
WSM O202 [kPa]
WSM O203 [kPa]
WSM O204 [kPa]
WSM O205 [kPa]
WSM O206 [kPa]
WSM O207 [kPa]
WSM O208 [kPa]
Waterspanning [kPa]
Tijd [uur]

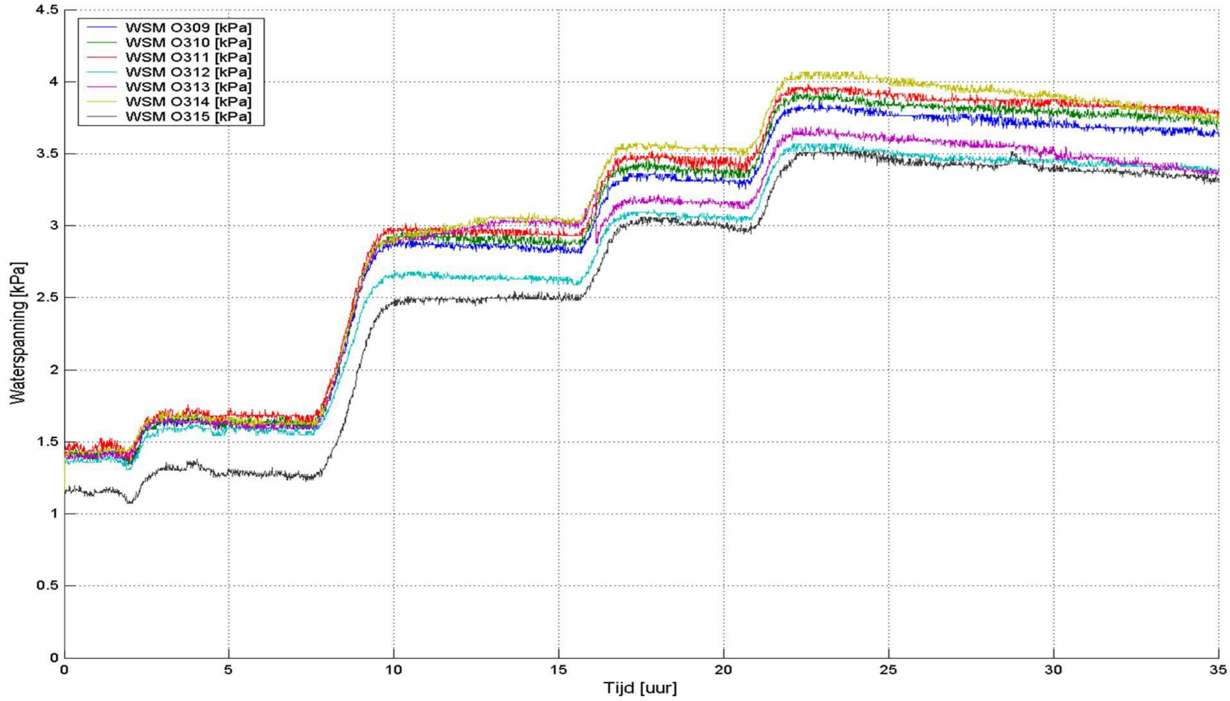
WSM O209 [kPa]
WSM O210 [kPa]
WSM O211 [kPa]
WSM O212 [kPa]
WSM O213 [kPa]
WSM O214 [kPa]
WSM O215 [kPa]
Waterspanning [kPa]
Tijd [uur]



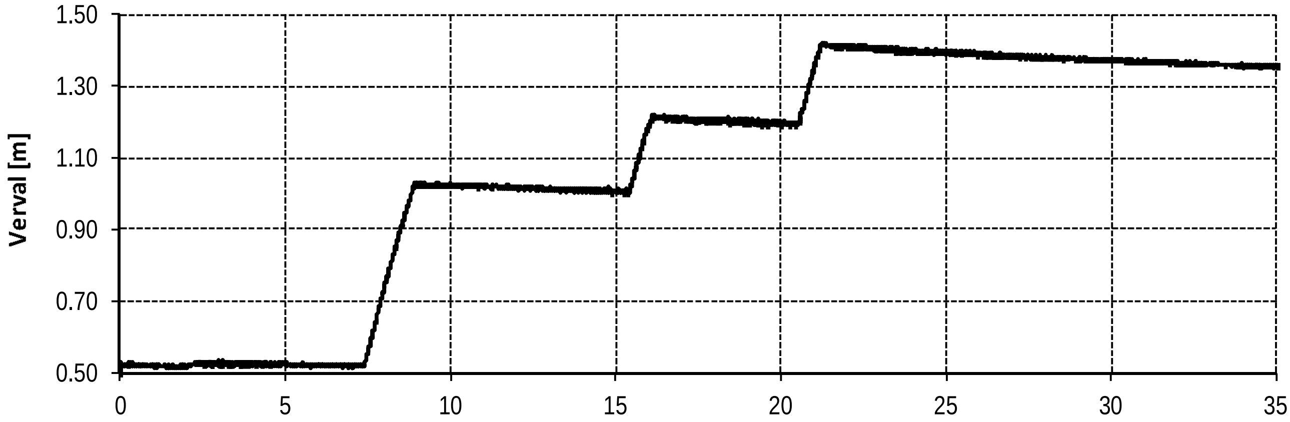
Verval [m]
1.50
1.30
1.10
0.90
0.70
0.50
0
5
10
15
20
25
30
35

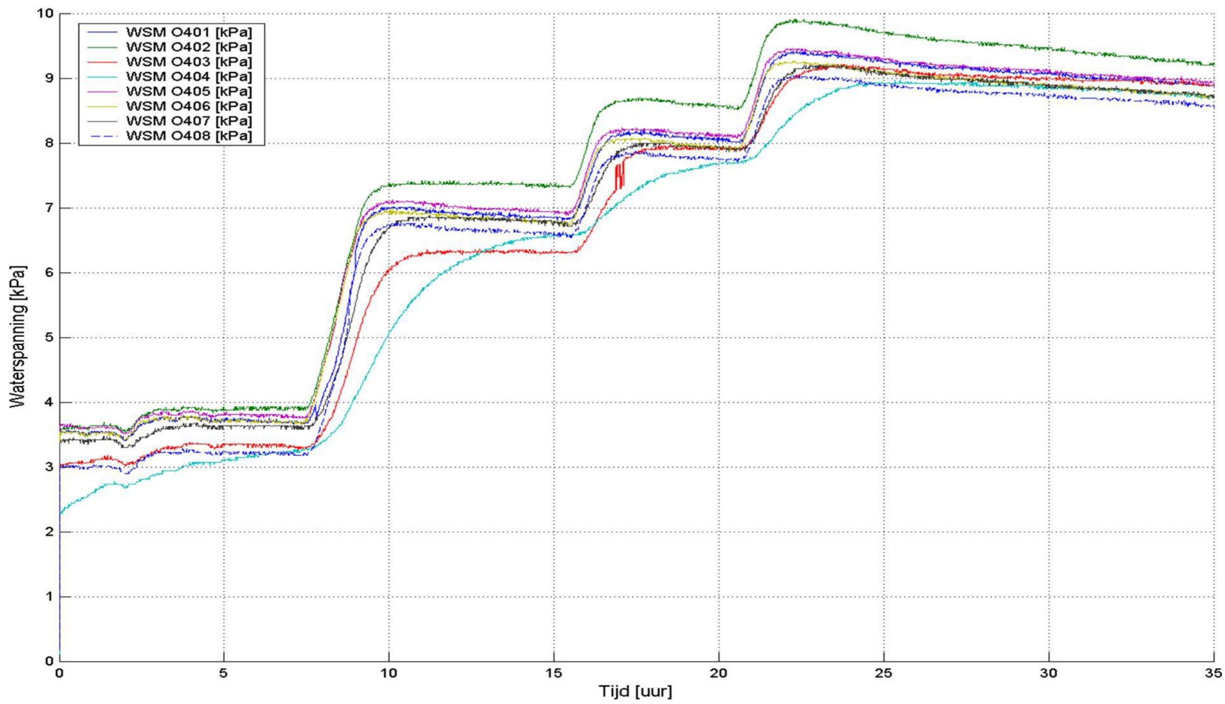



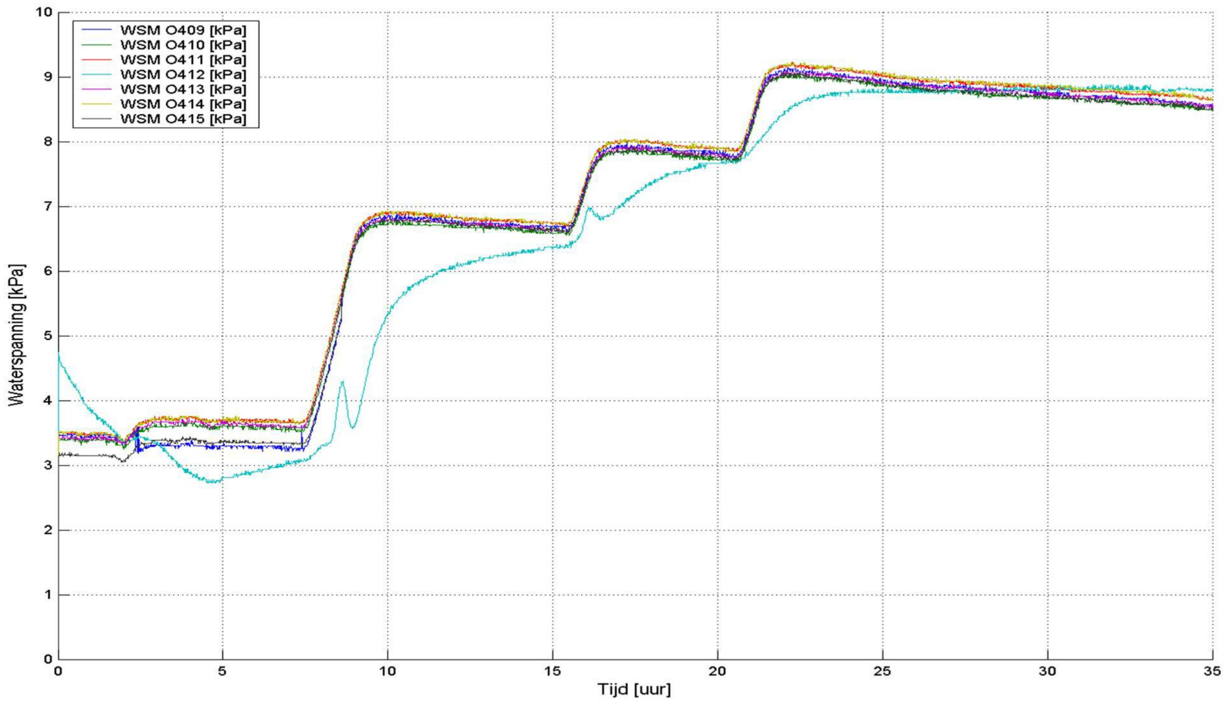
WSM O301 [kPa]
WSM O302 [kPa]
WSM O303 [kPa]
WSM O304 [kPa]
WSM O305 [kPa]
WSM O306 [kPa]
WSM O307 [kPa]
WSM O308 [kPa]
Waterspanning [kPa]
Tijd [uur]

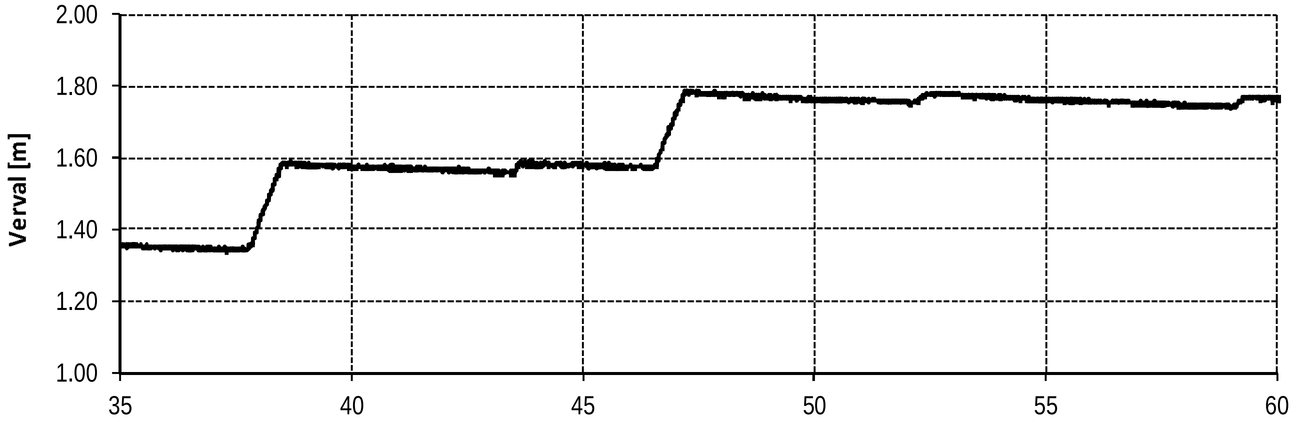



WSM O309 [kPa]
WSM O310 [kPa]
WSM O311 [kPa]
WSM O312 [kPa]
WSM O313 [kPa]
WSM O314 [kPa]
WSM O315 [kPa]
Waterspanning [kPa]
Tijd [uur]

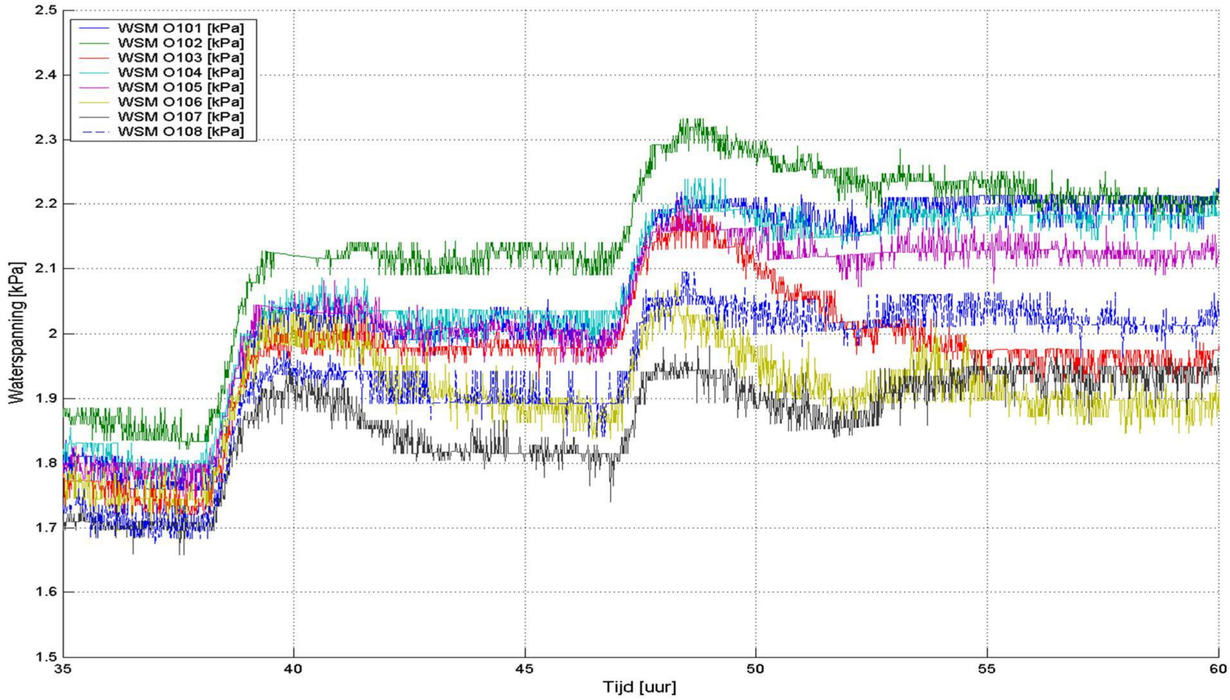

Verval [m]
1.50
1.30
1.10
0.90
0.70
0.50
0
5
10
15
20
25
30
35


WSM O401 [kPa]
WSM O402 [kPa]
WSM O403 [kPa]
WSM O404 [kPa]
WSM O405 [kPa]
WSM O406 [kPa]
WSM O407 [kPa]
WSM O408 [kPa]
Waterspanning [kPa]
Tijd [uur]

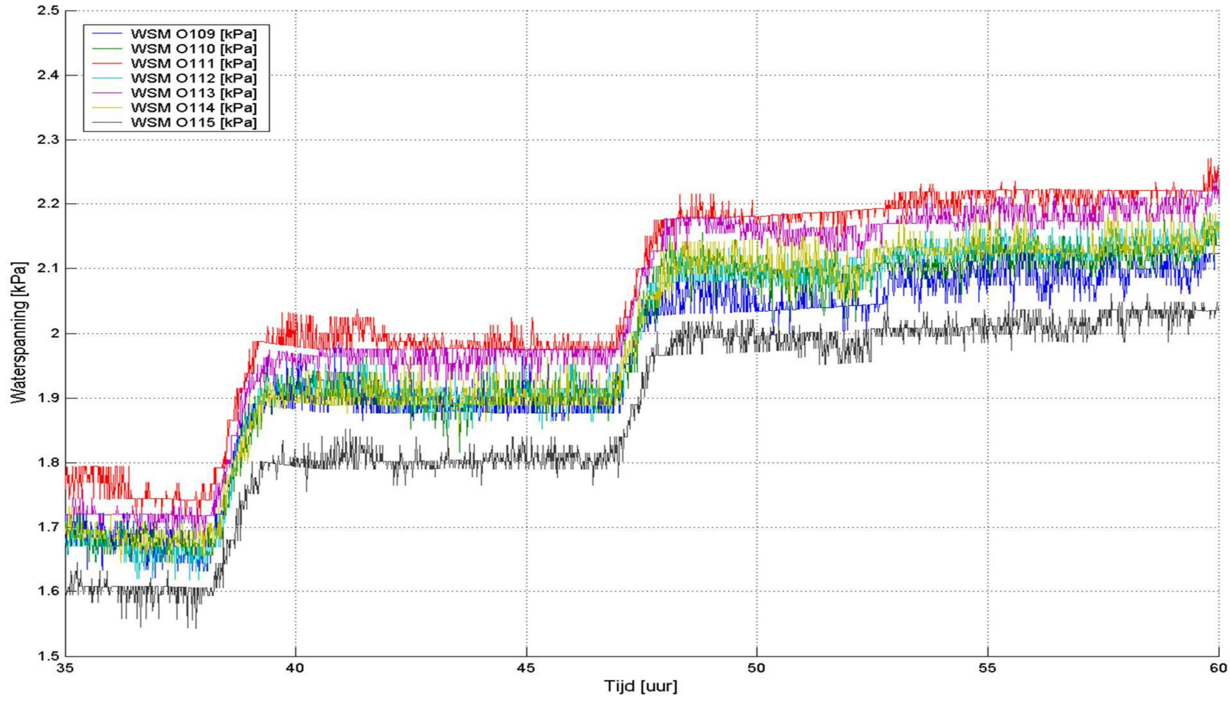

WSM O409 [kPa]
WSM O410 [kPa]
WSM O411 [kPa]
WSM O412 [kPa]
WSM O413 [kPa]
WSM O414 [kPa]
WSM O415 [kPa]
Waterspanning [kPa]
Tijd [uur]



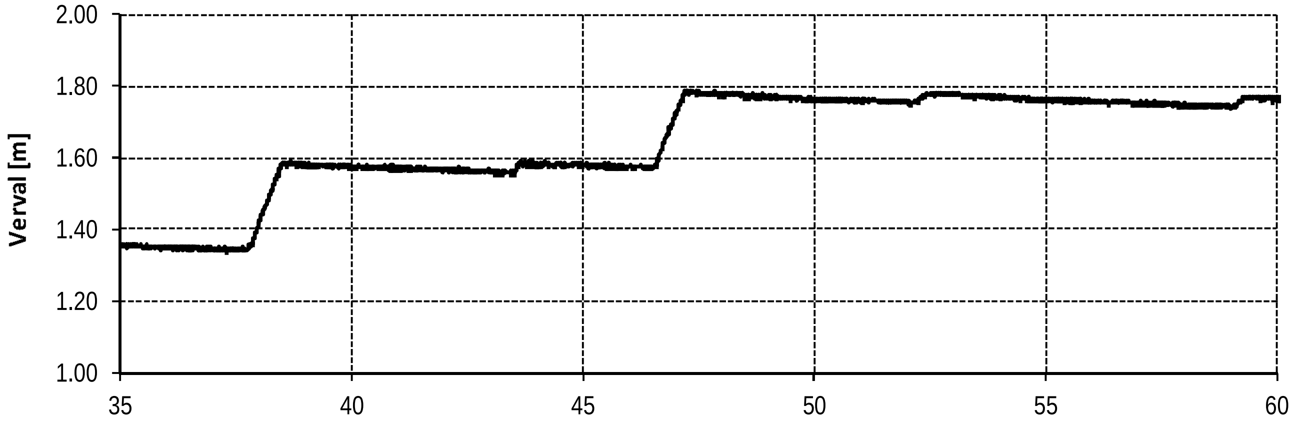
Verval [m]
2.00
1.80
1.60
1.40
1.20
1.00
35
40
45
50
55
60

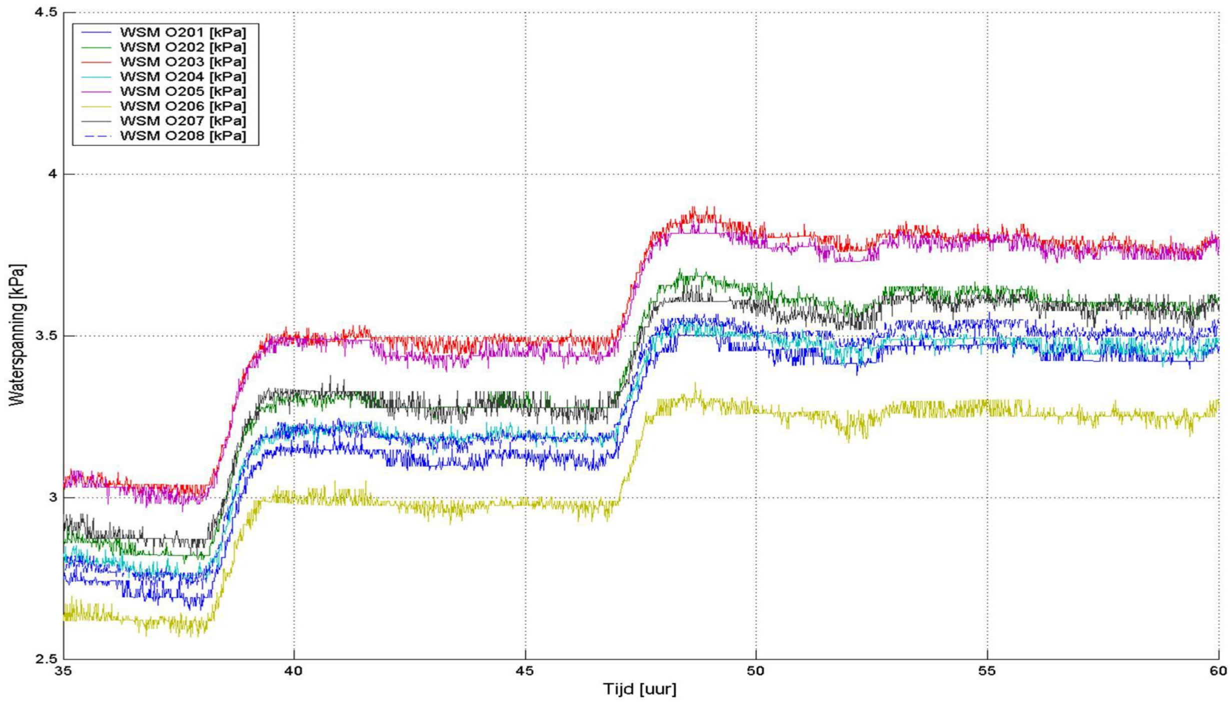
WSM O101 [kPa]
WSM O102 [kPa]
WSM O103 [kPa]
WSM O104 [kPa]
WSM O105 [kPa]
WSM O106 [kPa]
WSM O107 [kPa]
WSM O108 [kPa]
Waterspanning [kPa]
Tijd [uur]

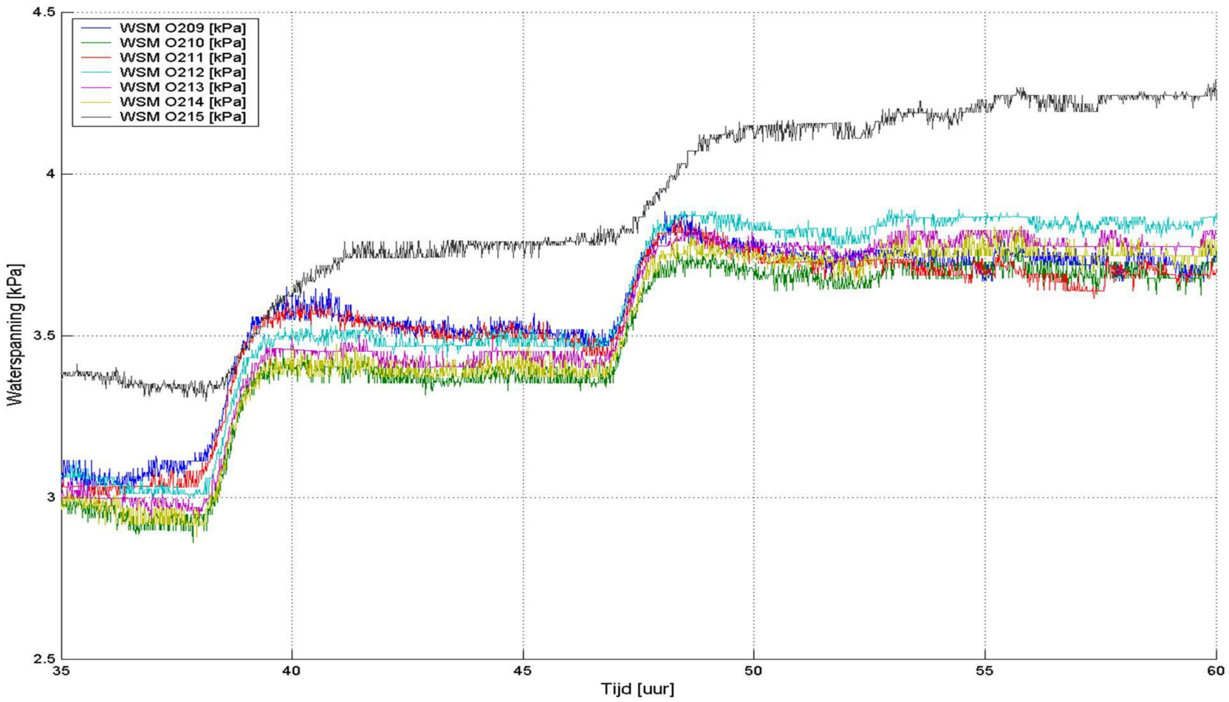
WSM O109 [kPa]
WSM O110 [kPa]
WSM O111 [kPa]
WSM O112 [kPa]
WSM O113 [kPa]
WSM O114 [kPa]
WSM O115 [kPa]
Waterspanning [kPa]
Tijd [uur]



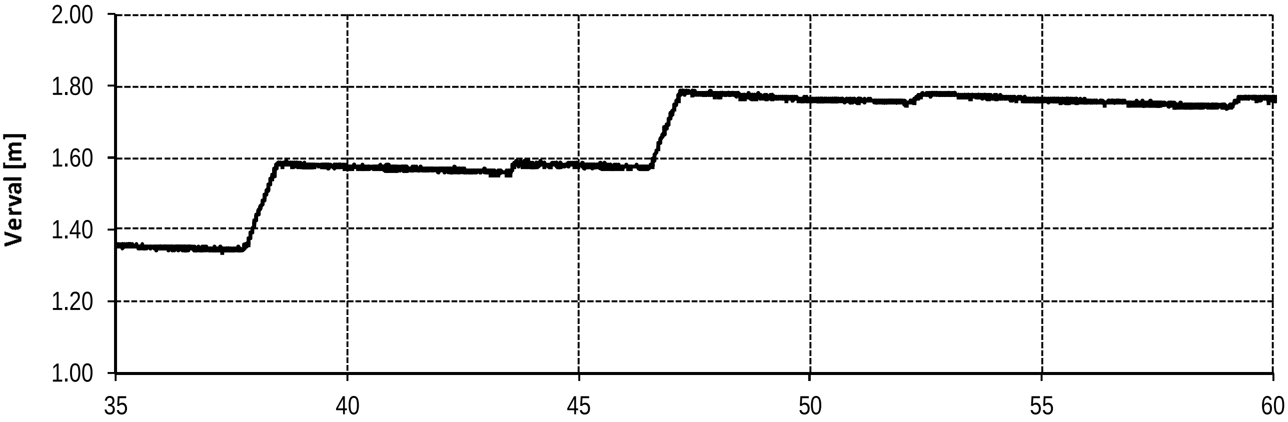
Verval [m]
2.00
1.80
1.60
1.40
1.20
1.00
35
40
45
50
55
60

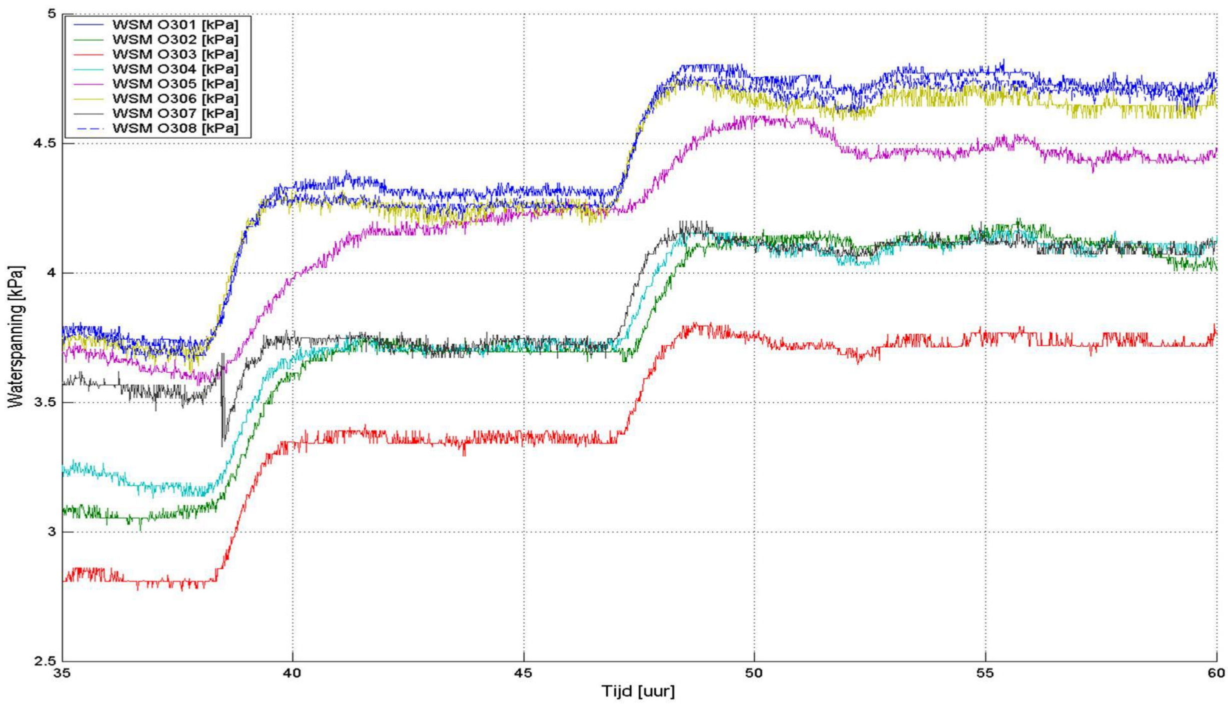



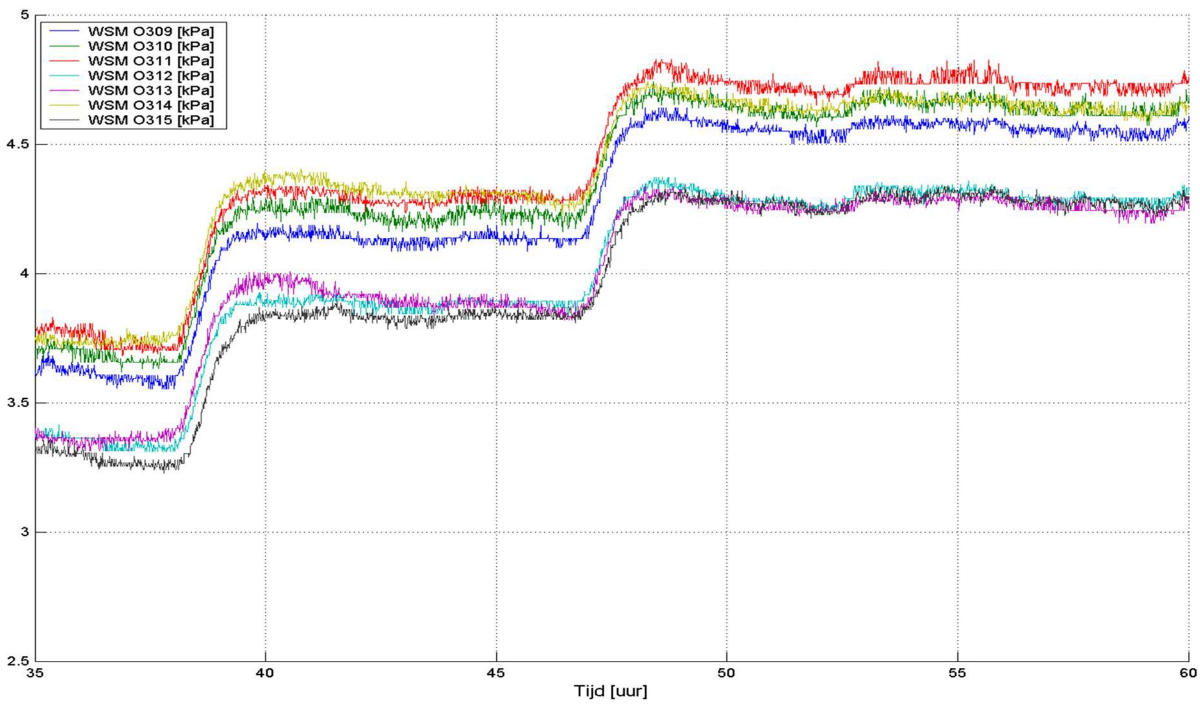
WSM O201 [kPa]
WSM O202 [kPa]
WSM O203 [kPa]
WSM O204 [kPa]
WSM O205 [kPa]
WSM O206 [kPa]
WSM O207 [kPa]
WSM O208 [kPa]
Waterspanning [kPa]
Tijd [uur]
4.5
4
3.5
3
2.5
35
40
45
50
55
60

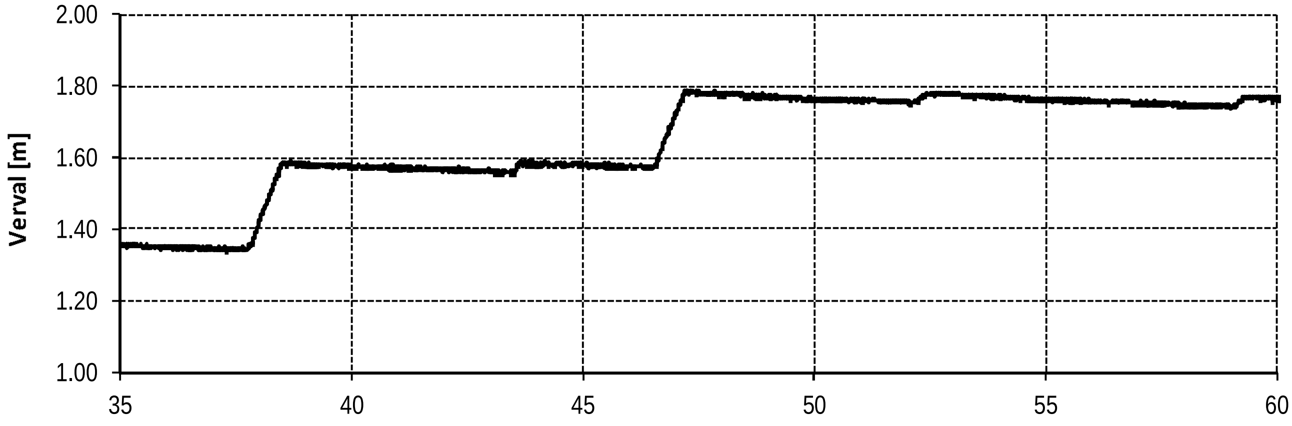



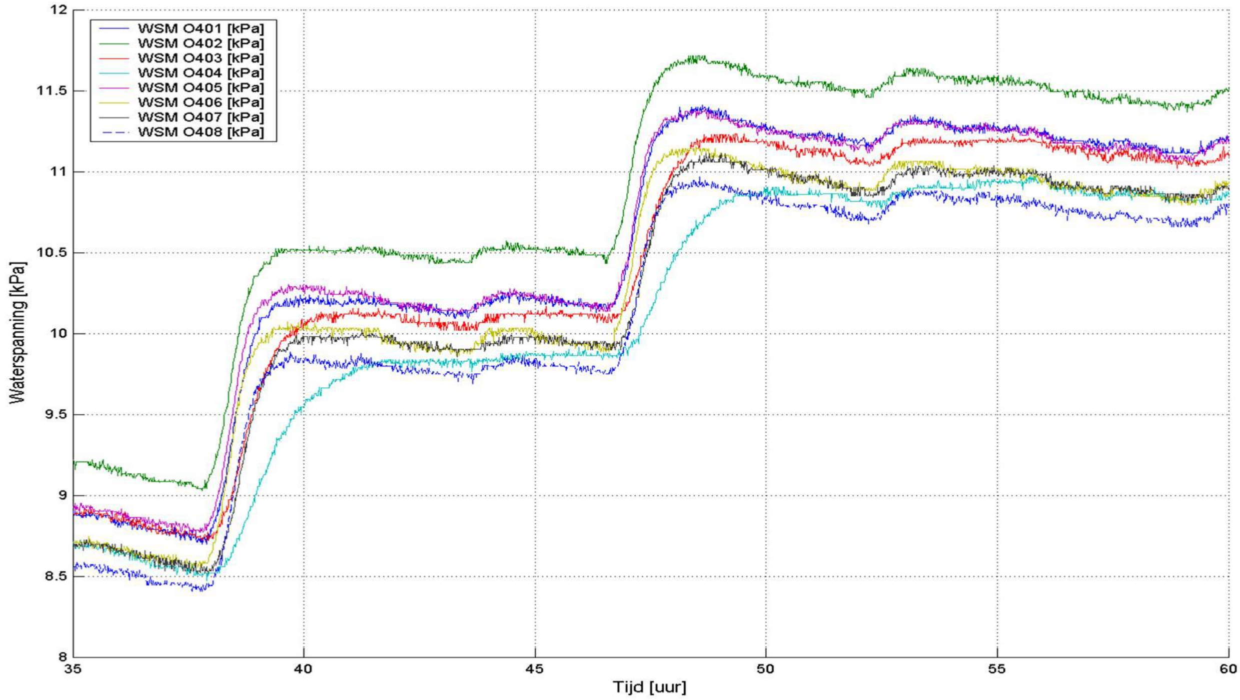
WSM O209 [kPa]
WSM O210 [kPa]
WSM O211 [kPa]
WSM O212 [kPa]
WSM O213 [kPa]
WSM O214 [kPa]
WSM O215 [kPa]
Waterspanning [kPa]
Tijd [uur]
4.5
4
3.5
3
2.5
35
40
45
50
55
60

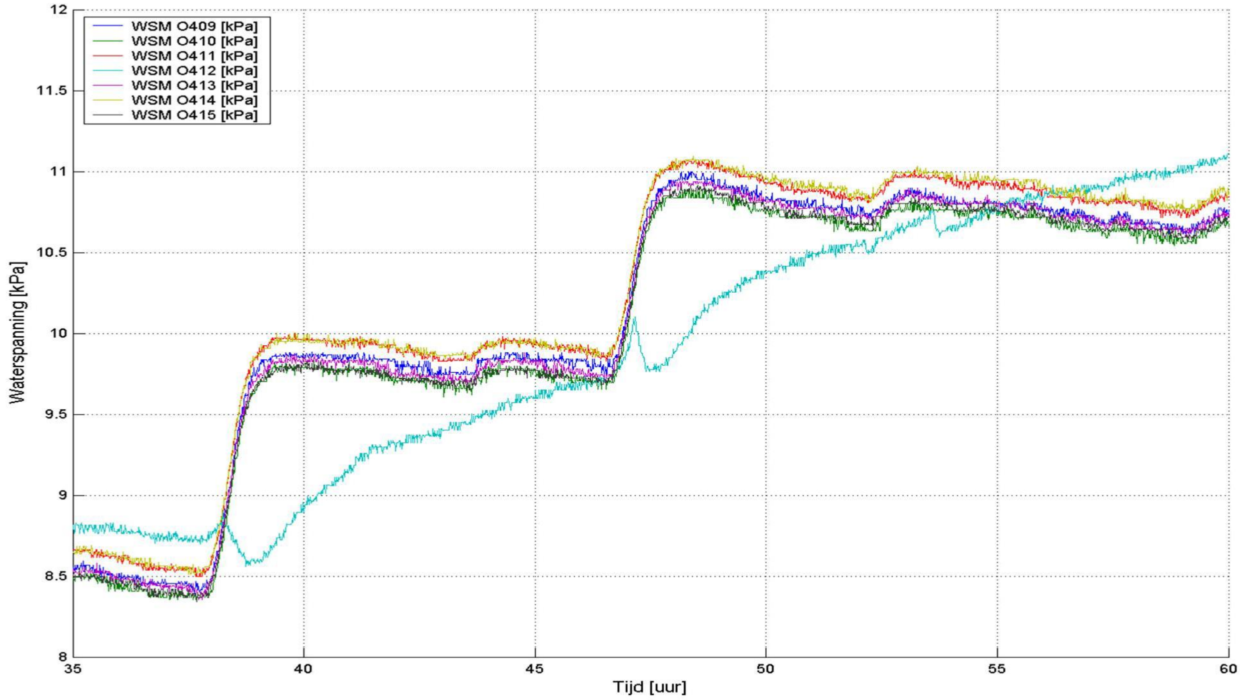

Verval [m]
2.00
1.80
1.60
1.40
1.20
1.00
35
40
45
50
55
60

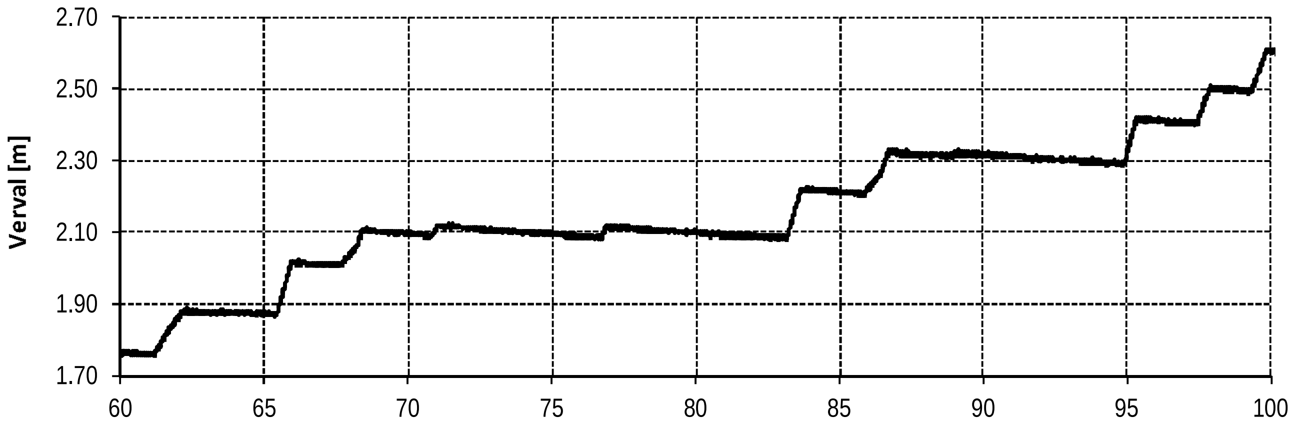

WSM O301 [kPa]
WSM O302 [kPa]
WSM O303 [kPa]
WSM O304 [kPa]
WSM O305 [kPa]
WSM O306 [kPa]
WSM O307 [kPa]
WSM O308 [kPa]
Waterspanning [kPa]
Tijd [uur]

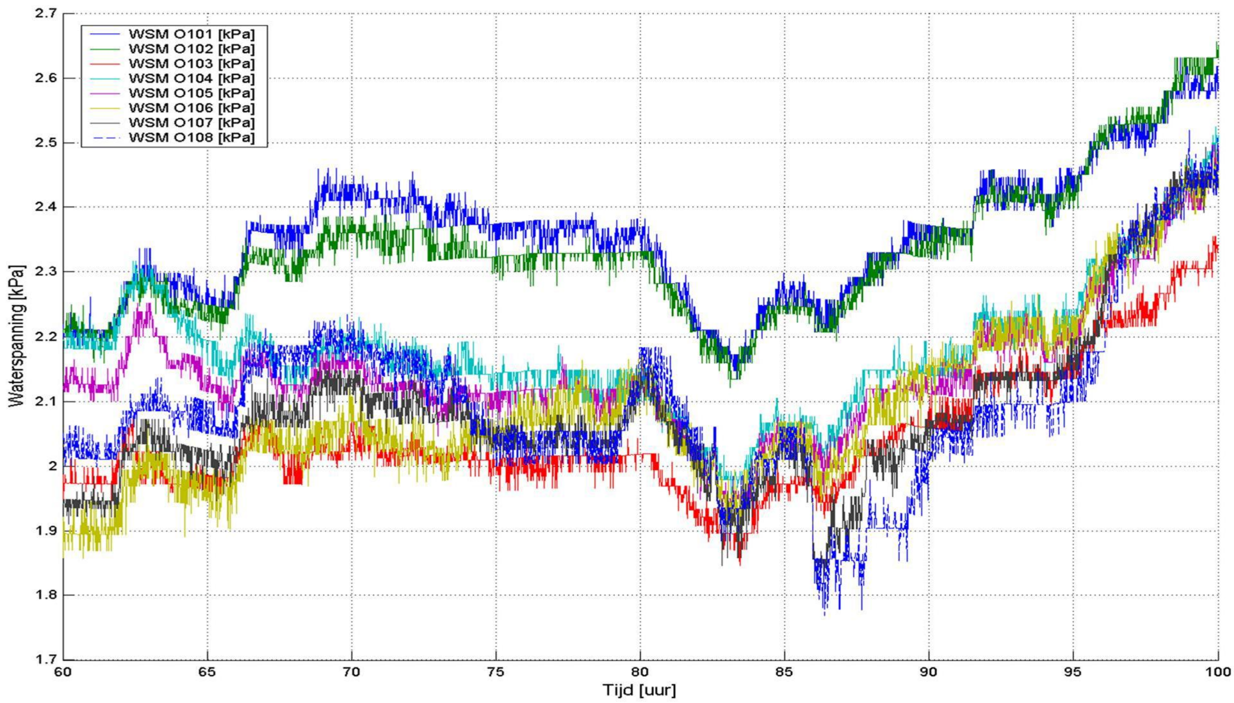

WSM O309 [kPa]
WSM O310 [kPa]
WSM O311 [kPa]
WSM O312 [kPa]
WSM O313 [kPa]
WSM O314 [kPa]
WSM O315 [kPa]
Tijd [uur]

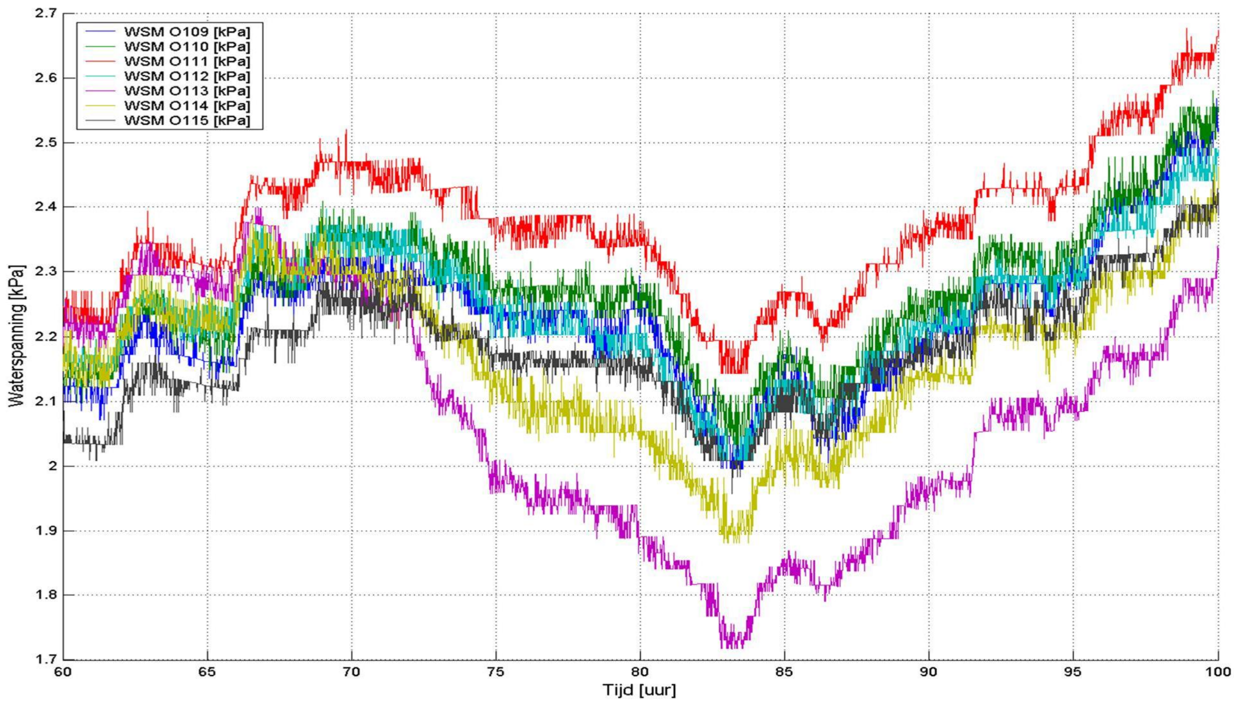

Verval [m]
2.00
1.80
1.60
1.40
1.20
1.00
35
40
45
50
55
60

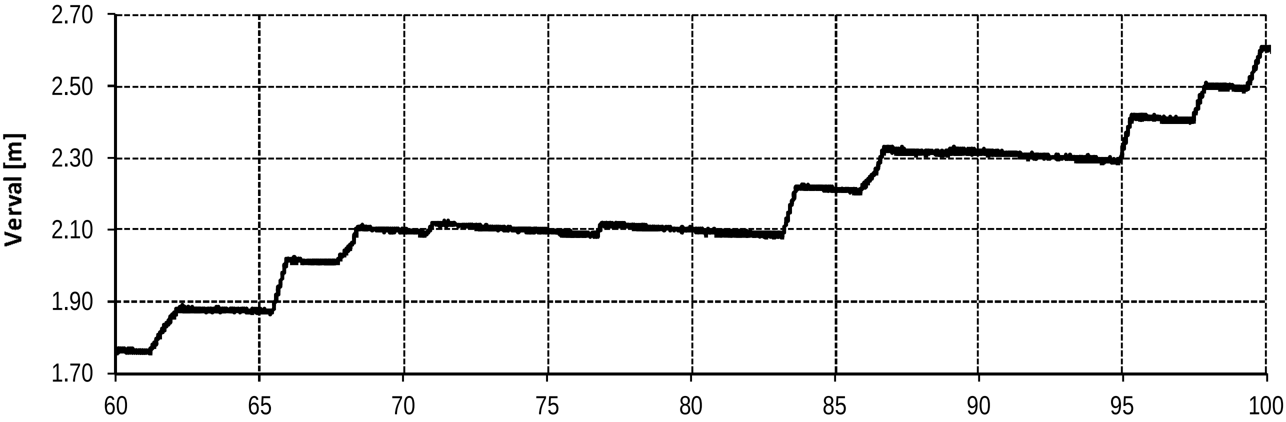

WSM O401 [kPa]
WSM O402 [kPa]
WSM O403 [kPa]
WSM O404 [kPa]
WSM O405 [kPa]
WSM O406 [kPa]
WSM O407 [kPa]
WSM O408 [kPa]
Waterspanning [kPa]
Tijd [uur]


WSM O409 [kPa]
WSM O410 [kPa]
WSM O411 [kPa]
WSM O412 [kPa]
WSM O413 [kPa]
WSM O414 [kPa]
WSM O415 [kPa]
Waterspanning [kPa]
Tijd [uur]

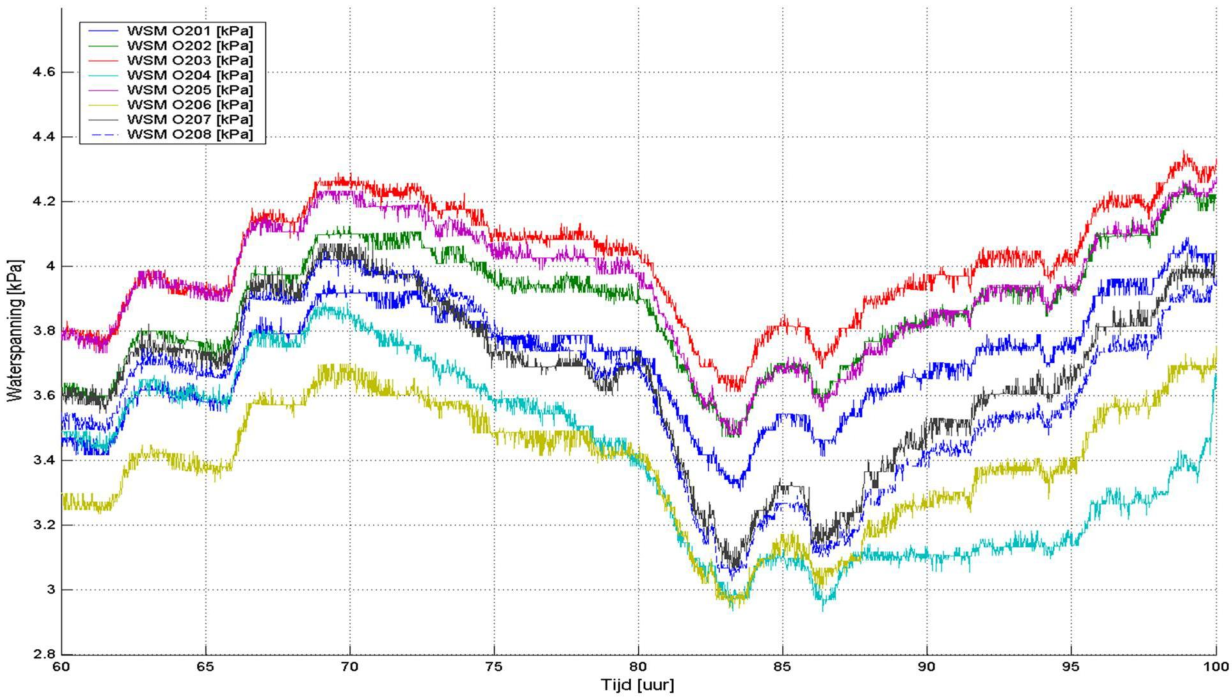

Verval [m]
2.70
2.50
2.30
2.10
1.90
1.70
60
65
70
75
80
85
90
95
100


WSM O101 [kPa]
WSM O102 [kPa]
WSM O103 [kPa]
WSM O104 [kPa]
WSM O105 [kPa]
WSM O106 [kPa]
WSM O107 [kPa]
WSM O108 [kPa]
Waterspanning [kPa]
Tijd [uur]

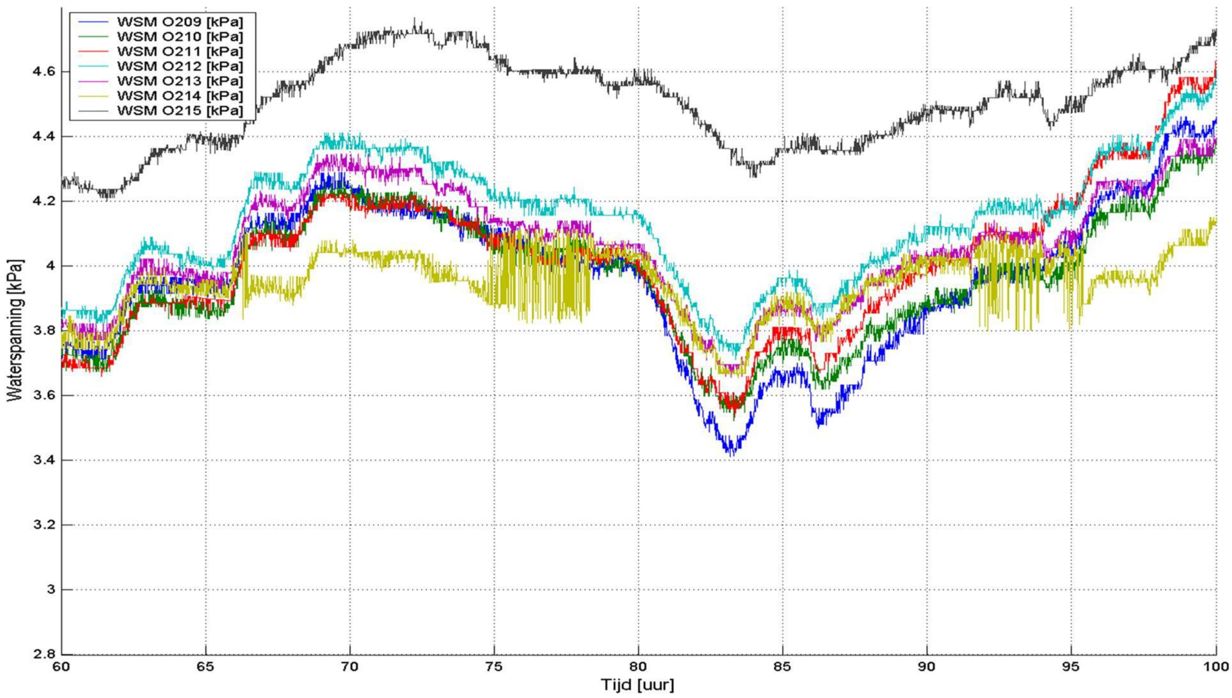

WSM O109 [kPa]
WSM O110 [kPa]
WSM O111 [kPa]
WSM O112 [kPa]
WSM O113 [kPa]
WSM O114 [kPa]
WSM O115 [kPa]
Waterspanning [kPa]
Tijd [uur]



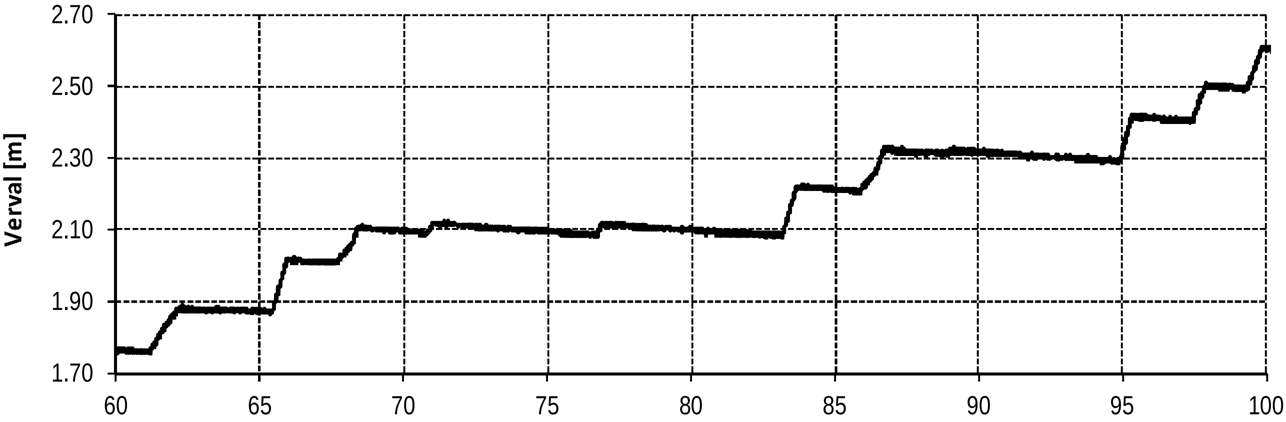
2.70
2.50
2.30
2.10
1.90
1.70
Verval [m]
60
65
70
75
80
85
90
95
100

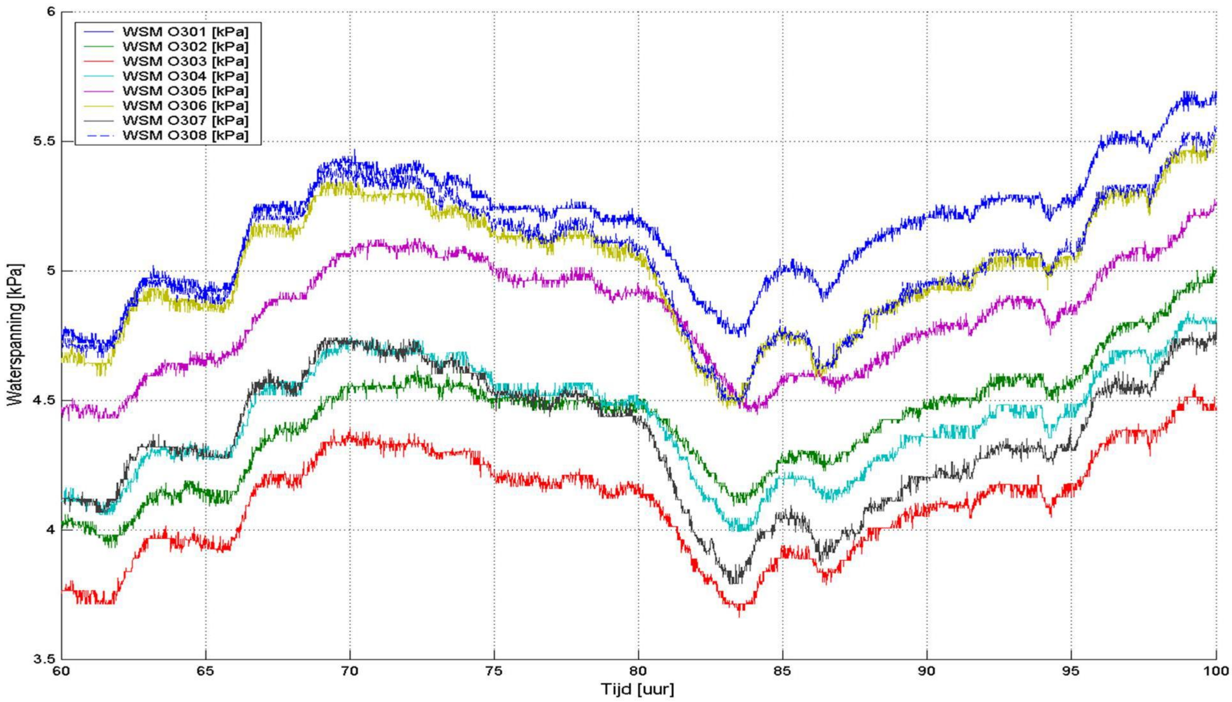



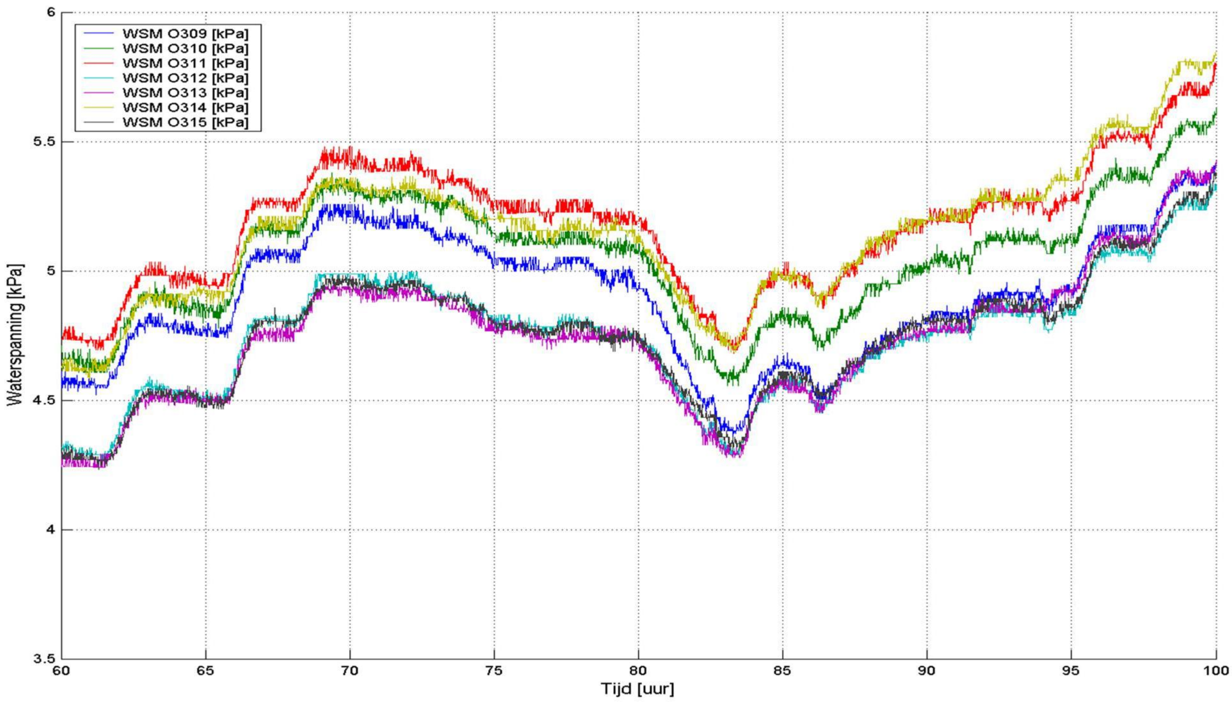
WSM O201 [kPa]
WSM O202 [kPa]
WSM O203 [kPa]
WSM O204 [kPa]
WSM O205 [kPa]
WSM O206 [kPa]
WSM O207 [kPa]
WSM O208 [kPa]
Waterspanning [kPa]
Tijd [uur]

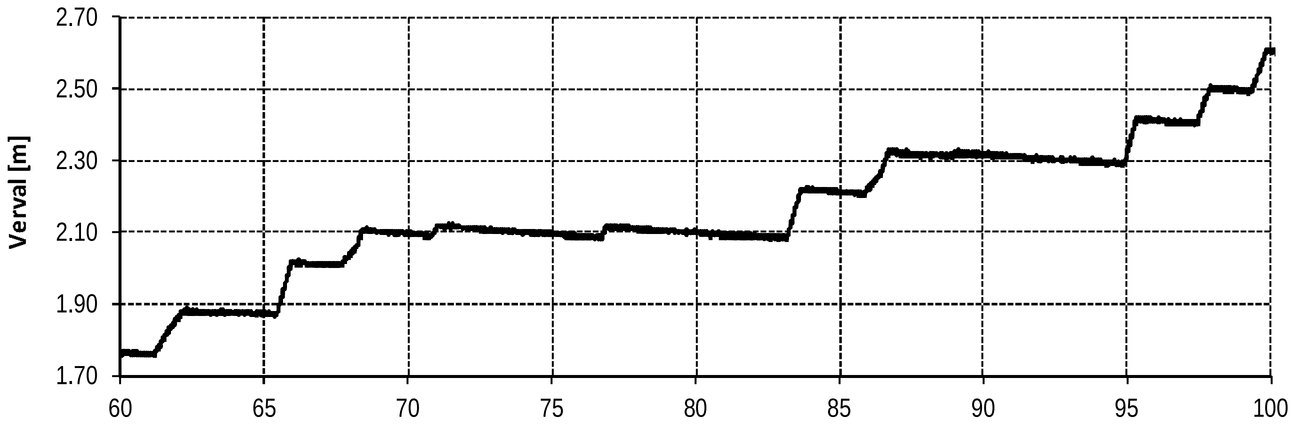



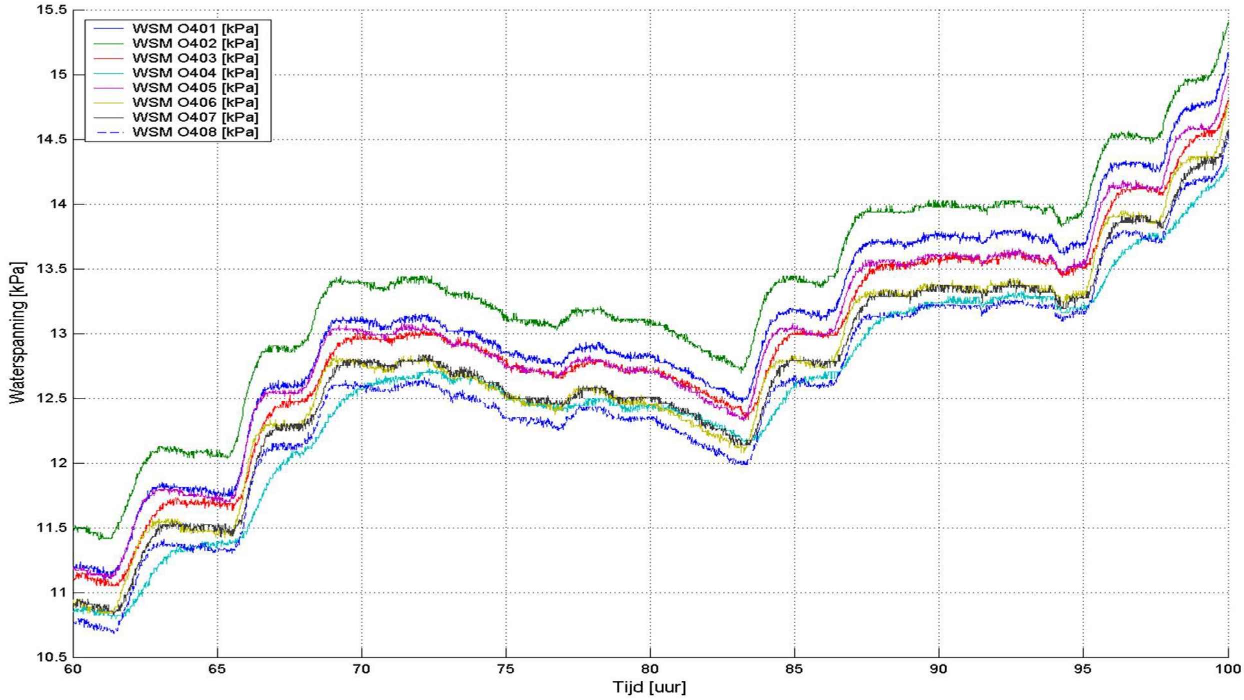
WSM O209 [kPa]
WSM O210 [kPa]
WSM O211 [kPa]
WSM O212 [kPa]
WSM O213 [kPa]
WSM O214 [kPa]
WSM O215 [kPa]
Waterspanning [kPa]
Tijd [uur]

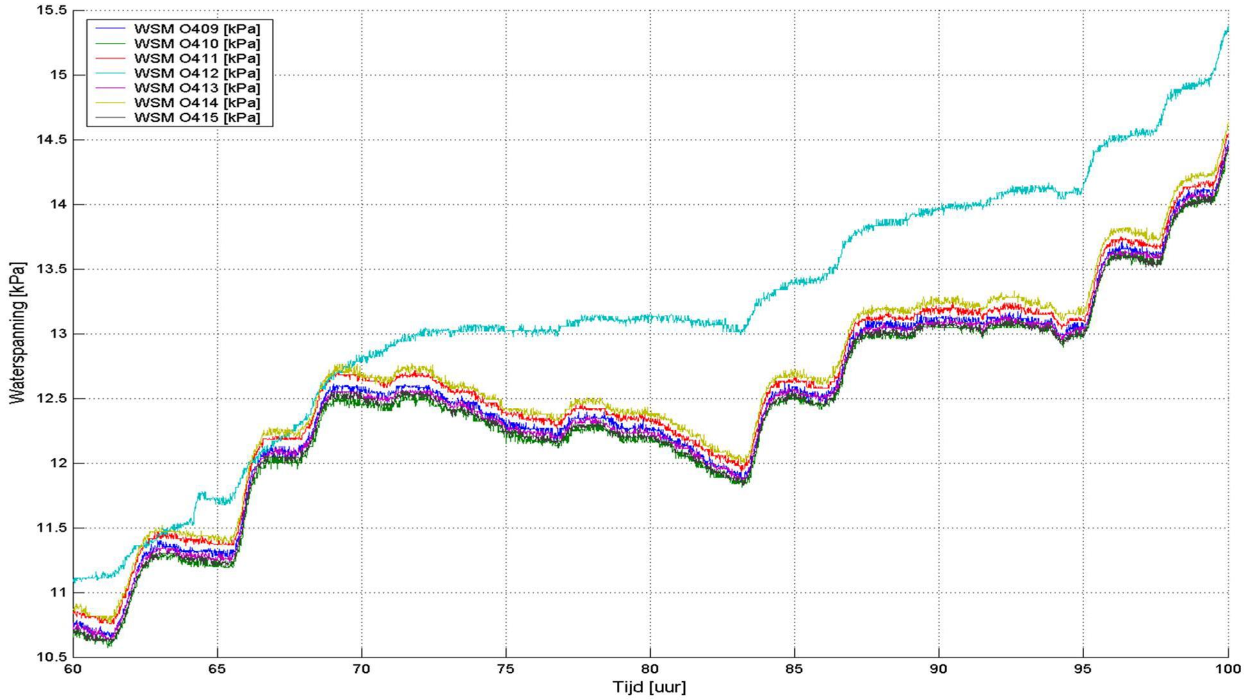

Verval [m]
2.70
2.50
2.30
2.10
1.90
1.70
60
65
70
75
80
85
90
95
100

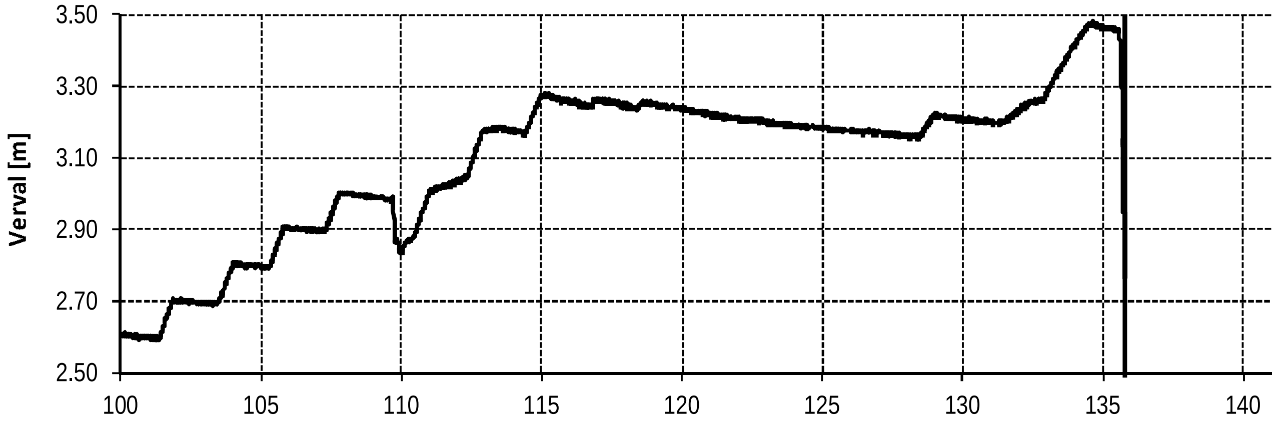

WSM O301 [kPa]
WSM O302 [kPa]
WSM O303 [kPa]
WSM O304 [kPa]
WSM O305 [kPa]
WSM O306 [kPa]
WSM O307 [kPa]
WSM O308 [kPa]
Waterspanning [kPa]
Tijd [uur]


WSM O309 [kPa]
WSM O310 [kPa]
WSM O311 [kPa]
WSM O312 [kPa]
WSM O313 [kPa]
WSM O314 [kPa]
WSM O315 [kPa]
Waterspanning [kPa]
Tijd [uur]

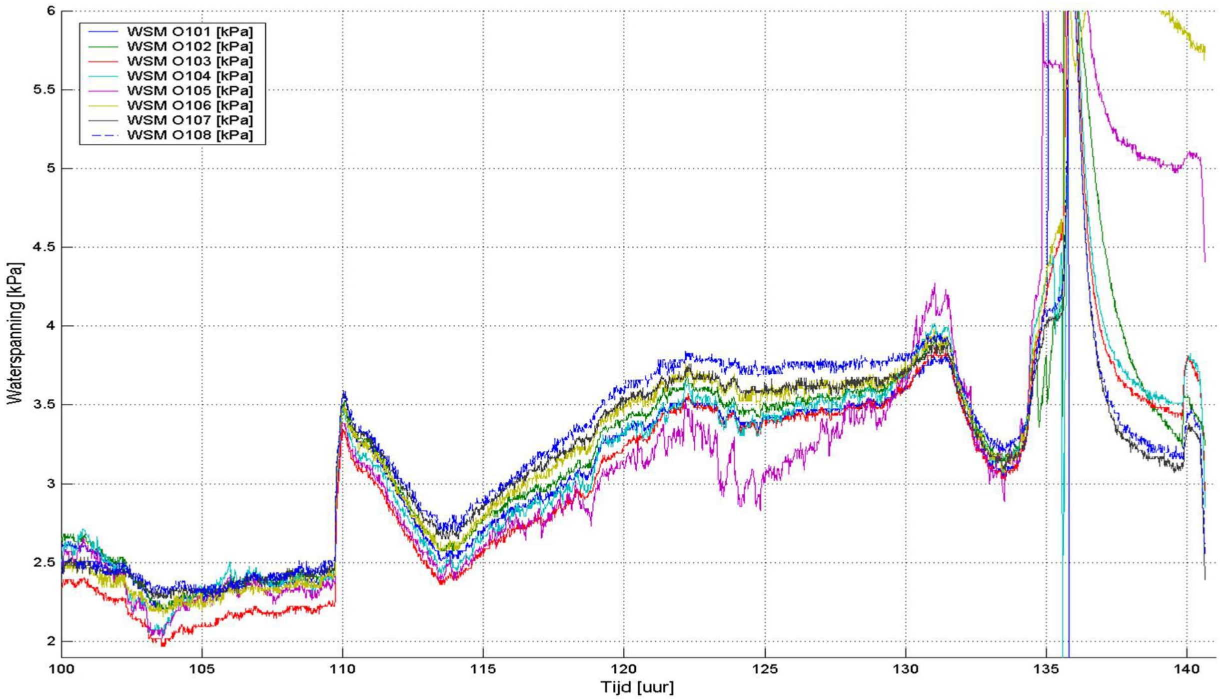

Verval [m]
2.70
2.50
2.30
2.10
1.90
1.70
60
65
70
75
80
85
90
95
100


WSM O401 [kPa]
WSM O402 [kPa]
WSM O403 [kPa]
WSM O404 [kPa]
WSM O405 [kPa]
WSM O406 [kPa]
WSM O407 [kPa]
WSM O408 [kPa]
Waterspanning [kPa]
Tijd [uur]

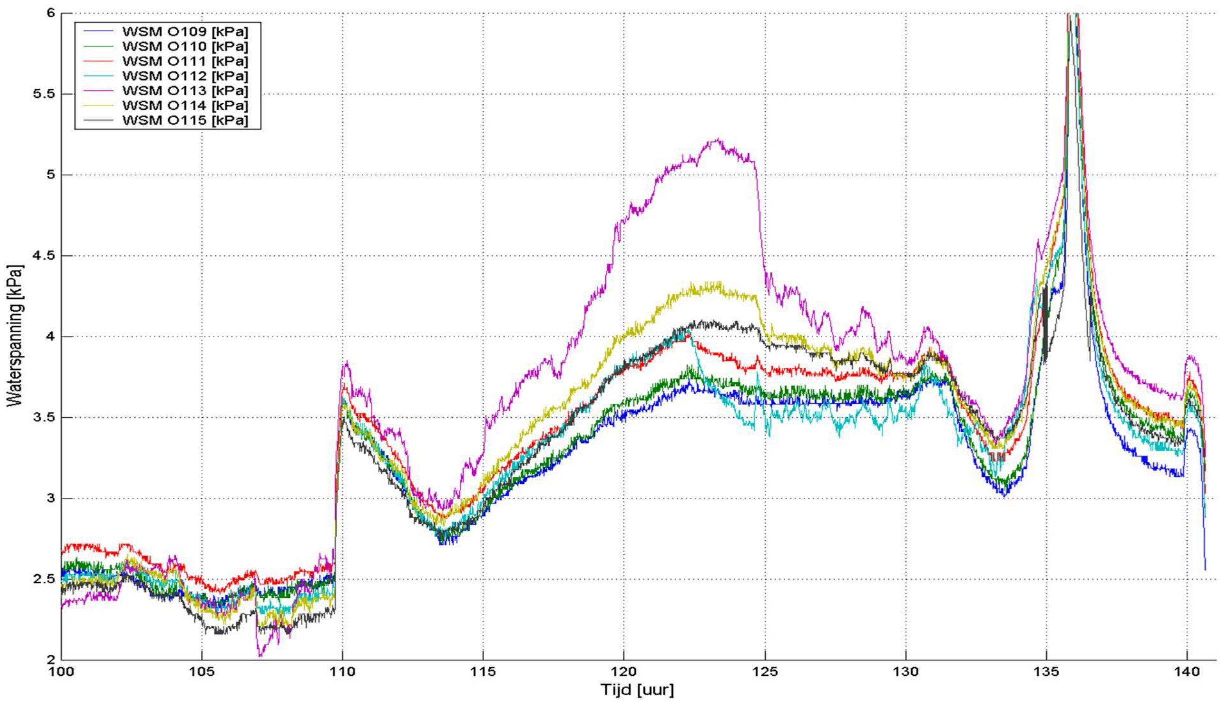

WSM O409 [kPa]
WSM O410 [kPa]
WSM O411 [kPa]
WSM O412 [kPa]
WSM O413 [kPa]
WSM O414 [kPa]
WSM O415 [kPa]
Waterspanning [kPa]
Tijd [uur]



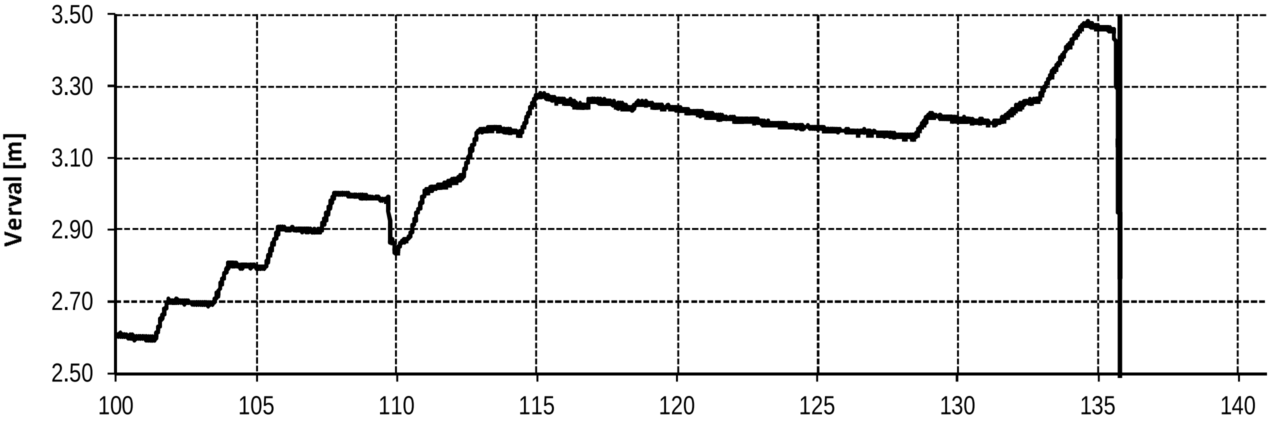
Verval [m]
3.50
3.30
3.10
2.90
2.70
2.50
100
105
110
115
120
125
130
135
140

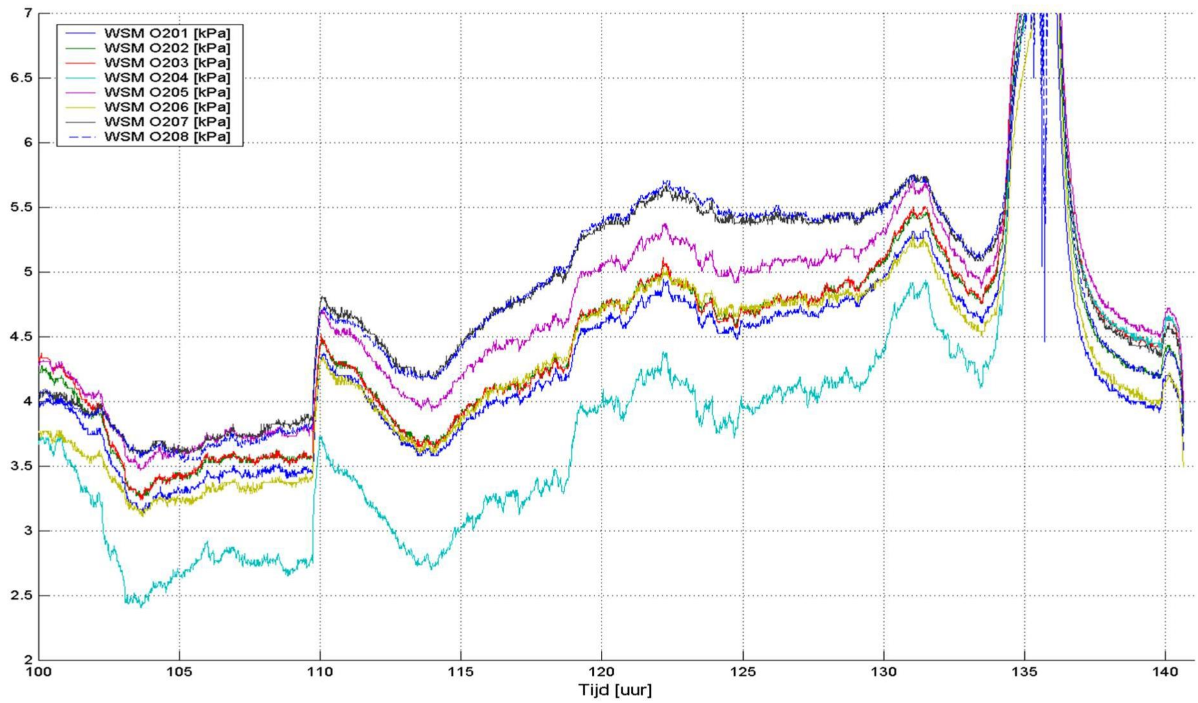



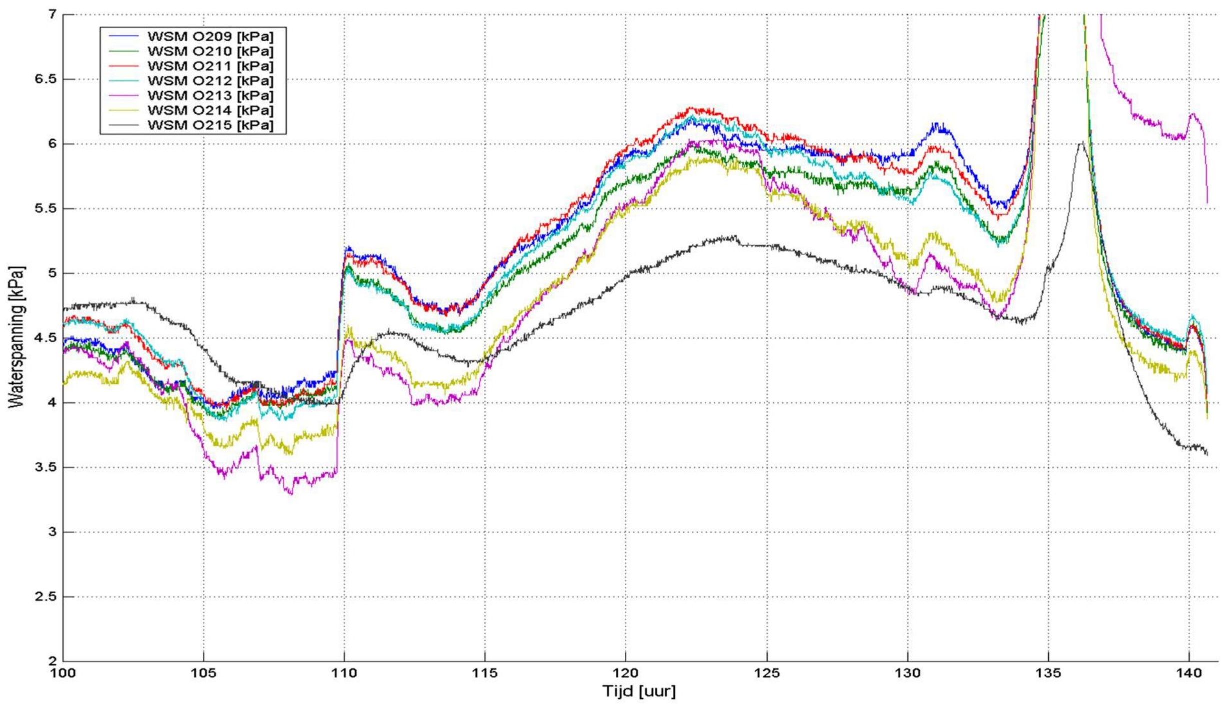
WSM O101 [kPa]
WSM O102 [kPa]
WSM O103 [kPa]
WSM O104 [kPa]
WSM O105 [kPa]
WSM O106 [kPa]
WSM O107 [kPa]
WSM O108 [kPa]
Waterspanning [kPa]
Tijd [uur]

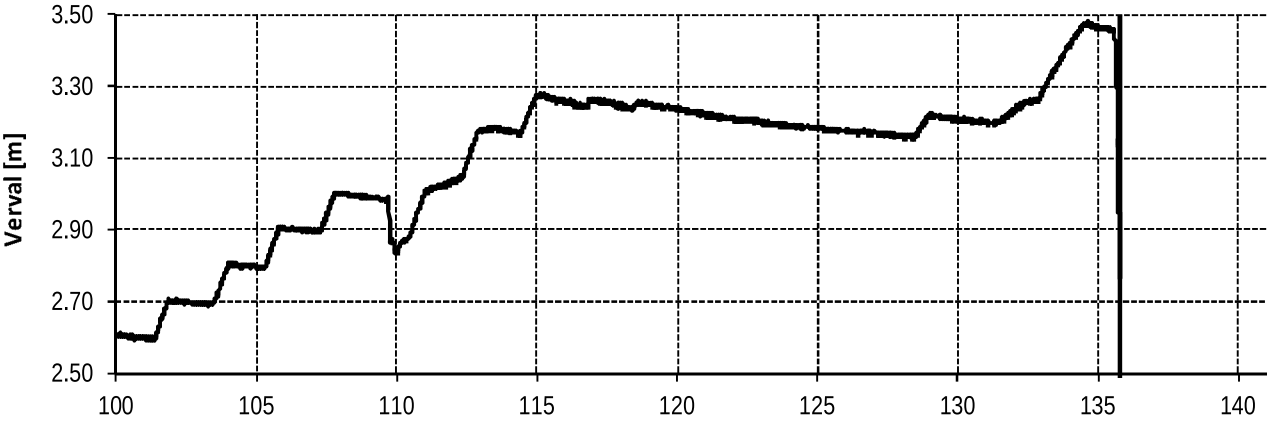



WSM O109 [kPa]
WSM O110 [kPa]
WSM O111 [kPa]
WSM O112 [kPa]
WSM O113 [kPa]
WSM O114 [kPa]
WSM O115 [kPa]
Waterspanning [kPa]
Tijd [uur]

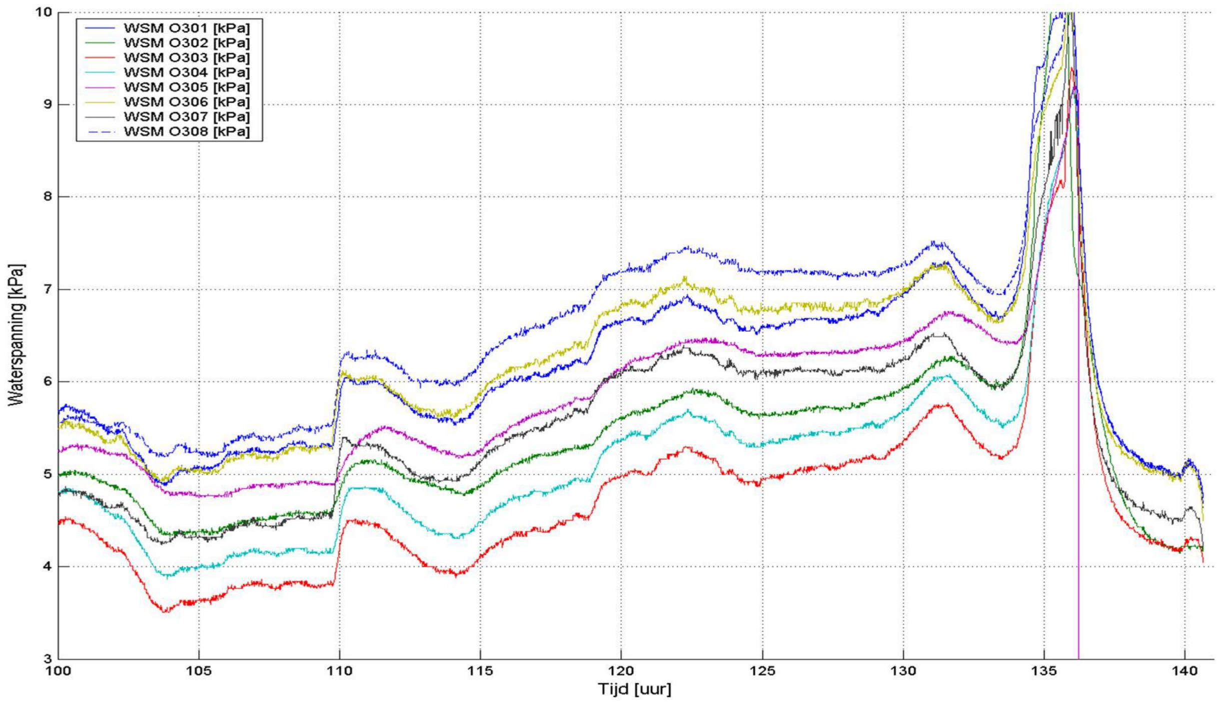

Verval [m]
3.50
3.30
3.10
2.90
2.70
2.50
100
105
110
115
120
125
130
135
140


WSM O201 [kPa]
WSM O202 [kPa]
WSM O203 [kPa]
WSM O204 [kPa]
WSM O205 [kPa]
WSM O206 [kPa]
WSM O207 [kPa]
WSM O208 [kPa]
Tijd [uur]

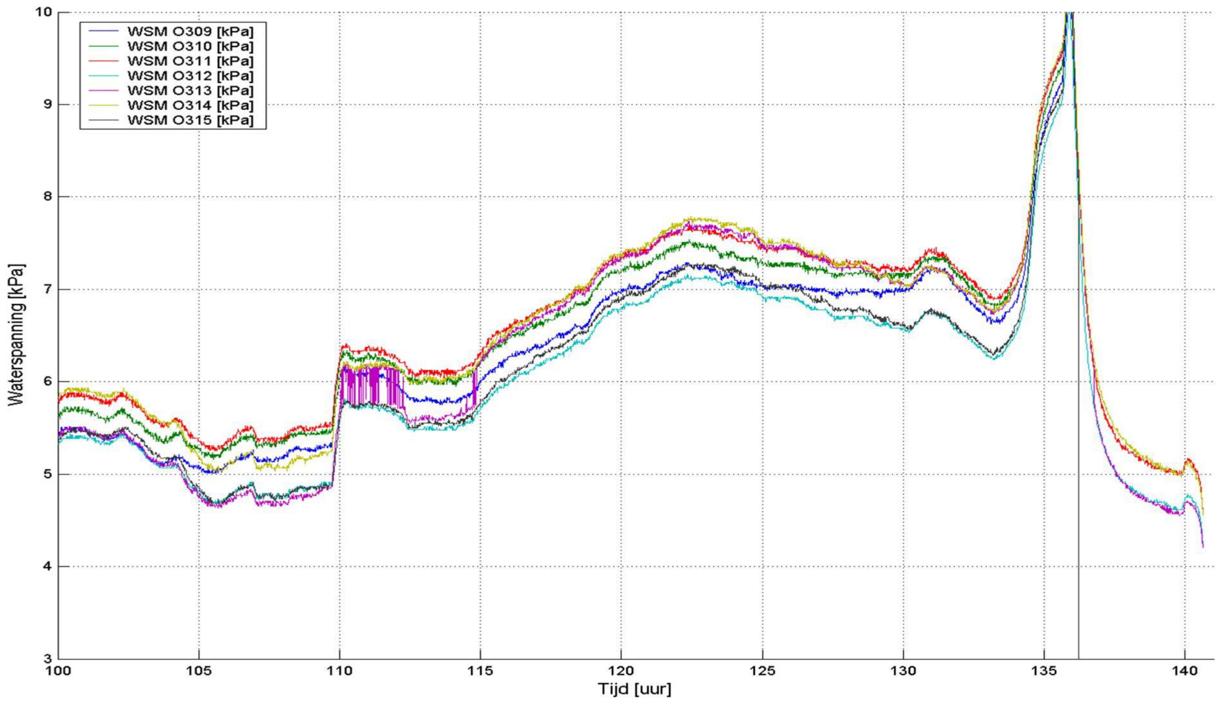

WSM O209 [kPa]
WSM O210 [kPa]
WSM O211 [kPa]
WSM O212 [kPa]
WSM O213 [kPa]
WSM O214 [kPa]
WSM O215 [kPa]
Waterspanning [kPa]
Tijd [uur]



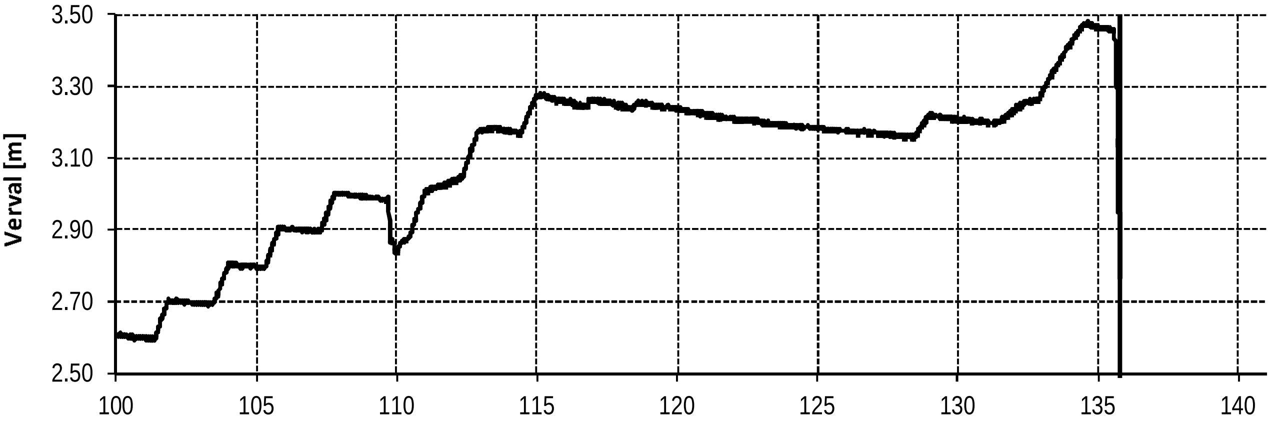
Verval [m]
3.50
3.30
3.10
2.90
2.70
2.50
100
105
110
115
120
125
130
135
140

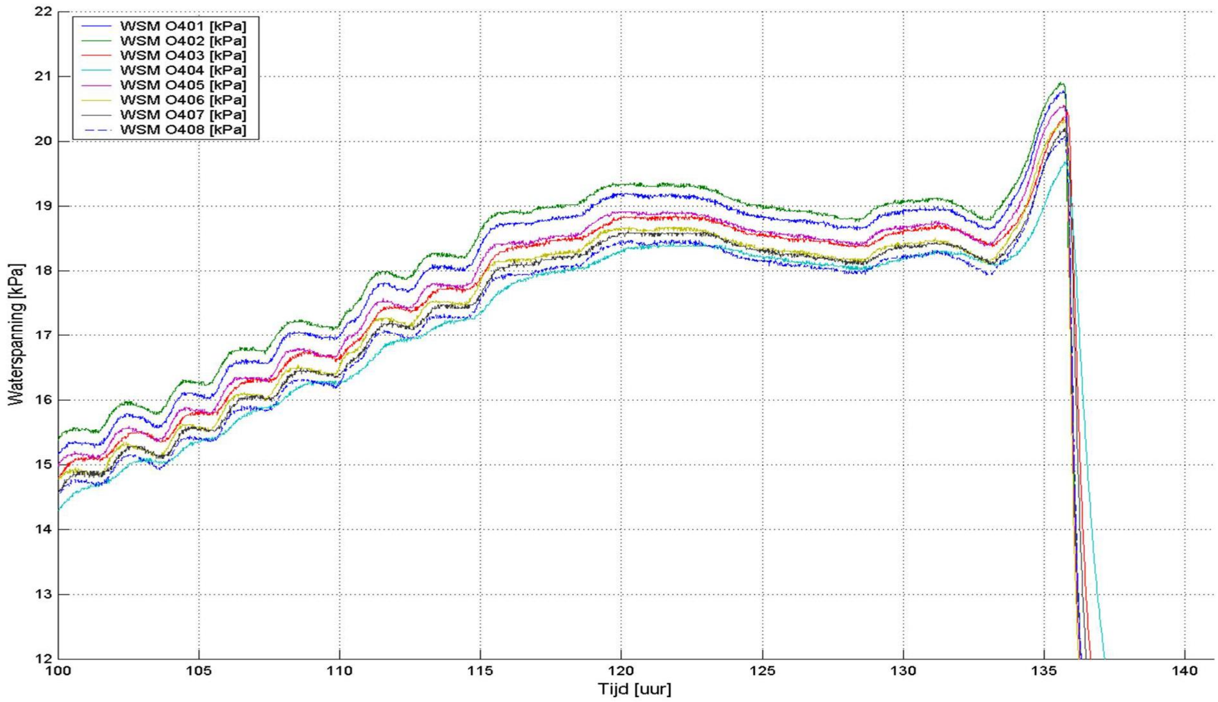
WSM O301 [kPa]
WSM O302 [kPa]
WSM O303 [kPa]
WSM O304 [kPa]
WSM O305 [kPa]
WSM O306 [kPa]
WSM O307 [kPa]
WSM O308 [kPa]
Waterspanning [kPa]
Tijd [uur]

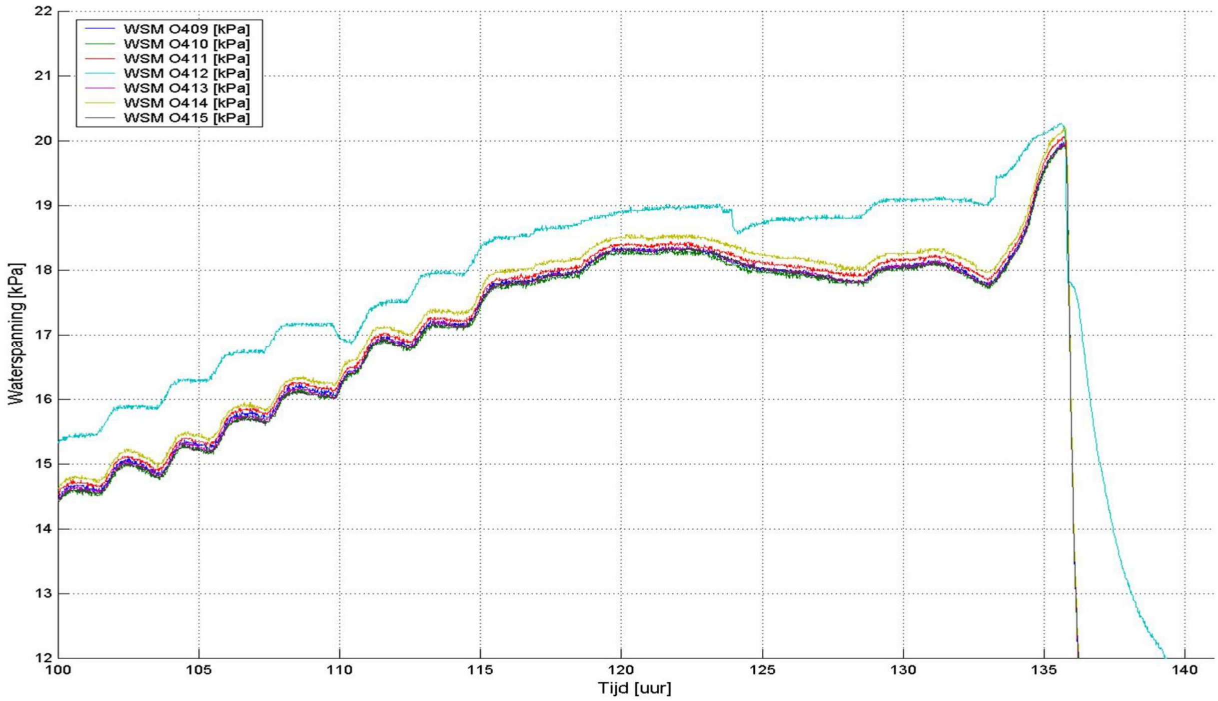
WSM O309 [kPa]
WSM O310 [kPa]
WSM O311 [kPa]
WSM O312 [kPa]
WSM O313 [kPa]
WSM O314 [kPa]
WSM O315 [kPa]
Waterspanning [kPa]
Tijd [uur]



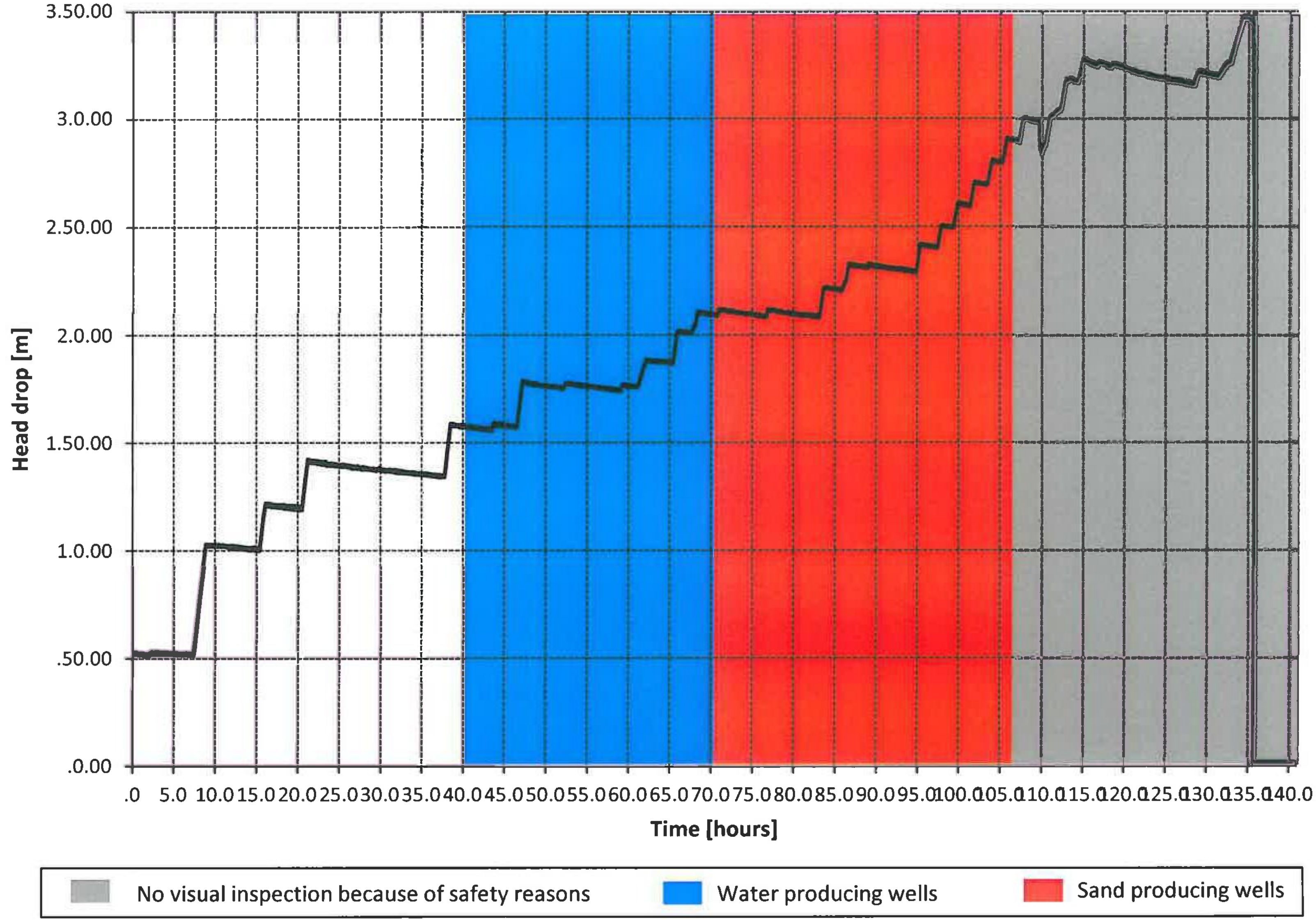
Verval [m]
3.50
3.30
3.10
2.90
2.70
2.50
100
105
110
115
120
125
130
135
140

WSM O401 [kPa]
WSM O402 [kPa]
WSM O403 [kPa]
WSM O404 [kPa]
WSM O405 [kPa]
WSM O406 [kPa]
WSM O407 [kPa]
WSM O408 [kPa]
Waterspanning [kPa]
Tijd [uur]

WSM O409 [kPa]
WSM O410 [kPa]
WSM O411 [kPa]
WSM O412 [kPa]
WSM O413 [kPa]
WSM O414 [kPa]
WSM O415 [kPa]
Waterspanning [kPa]
Tijd [uur]



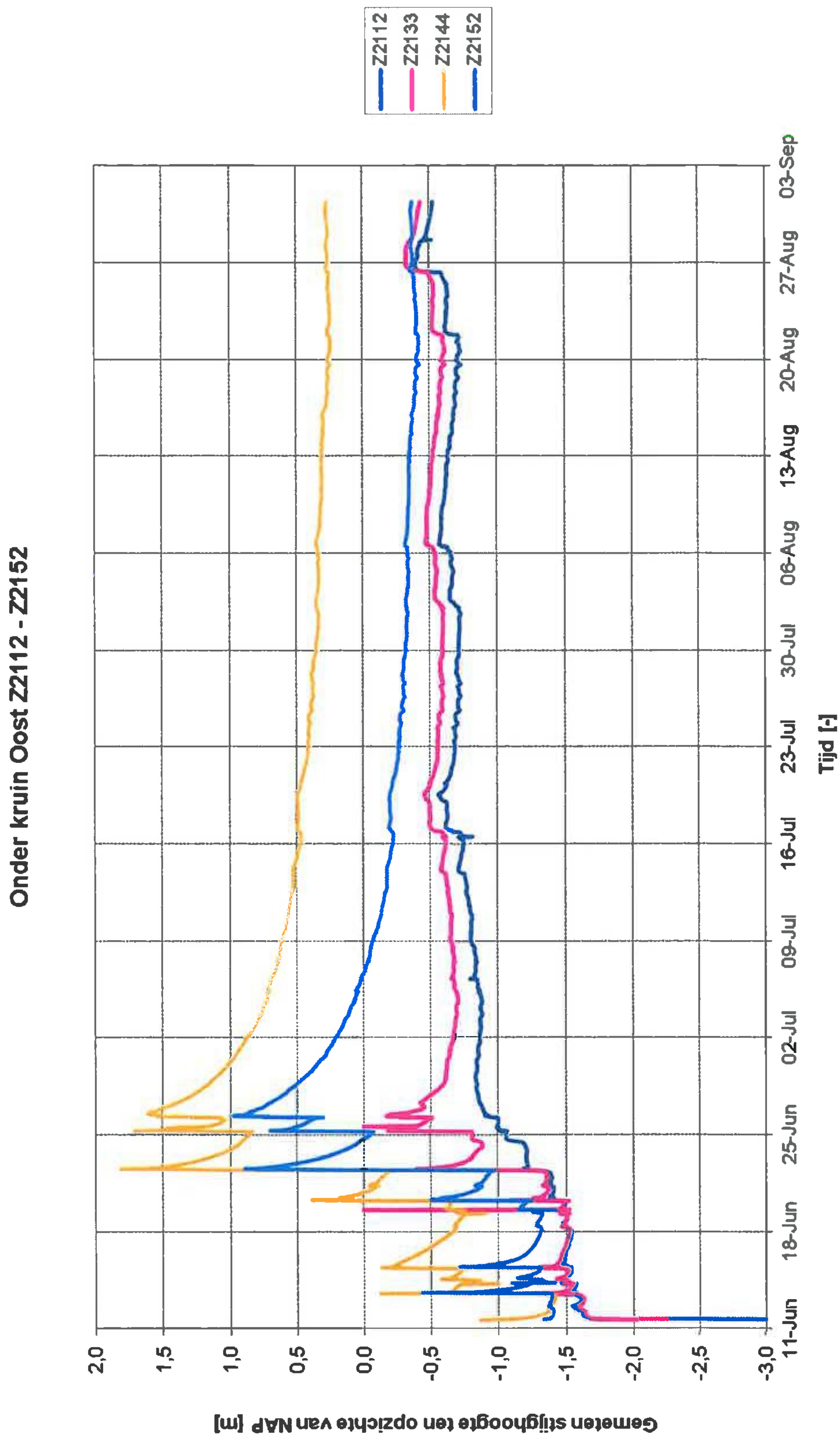
3.50.00
3.0.00
2.50.00
2.0.00
1.50.00
1.0.00
.50.00
.00
Head drop [m]
.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
75.0
80.0
85.0
90.0
95.0
100.0
105.0
110.0
115.0
120.0
125.0
130.0
135.0
140.0
Time [hours]
No visual inspection because of safety reasons
Water producing wells
Sand producing wells


D-17

# APPENDIX 5 : SOUTH DIKE – COPIES FROM FACTUAL REPORT

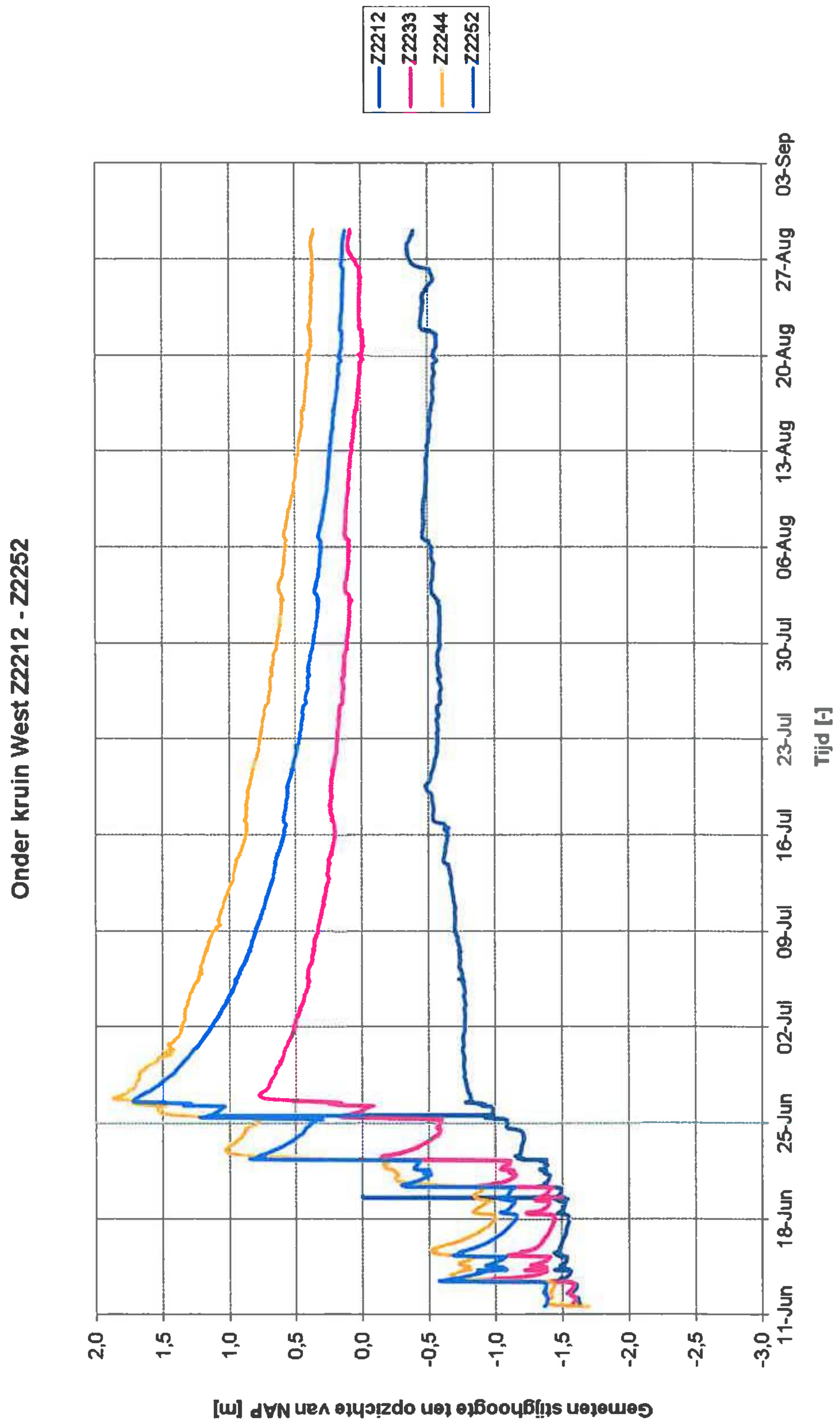
Foto 1873 – Openbarsten en verplaatsen van de slootkant. Inzakking van de dijk.

Foto 1879 – Openbarsten en verplaatsen van de slootkant. Inzakking van de dijk.



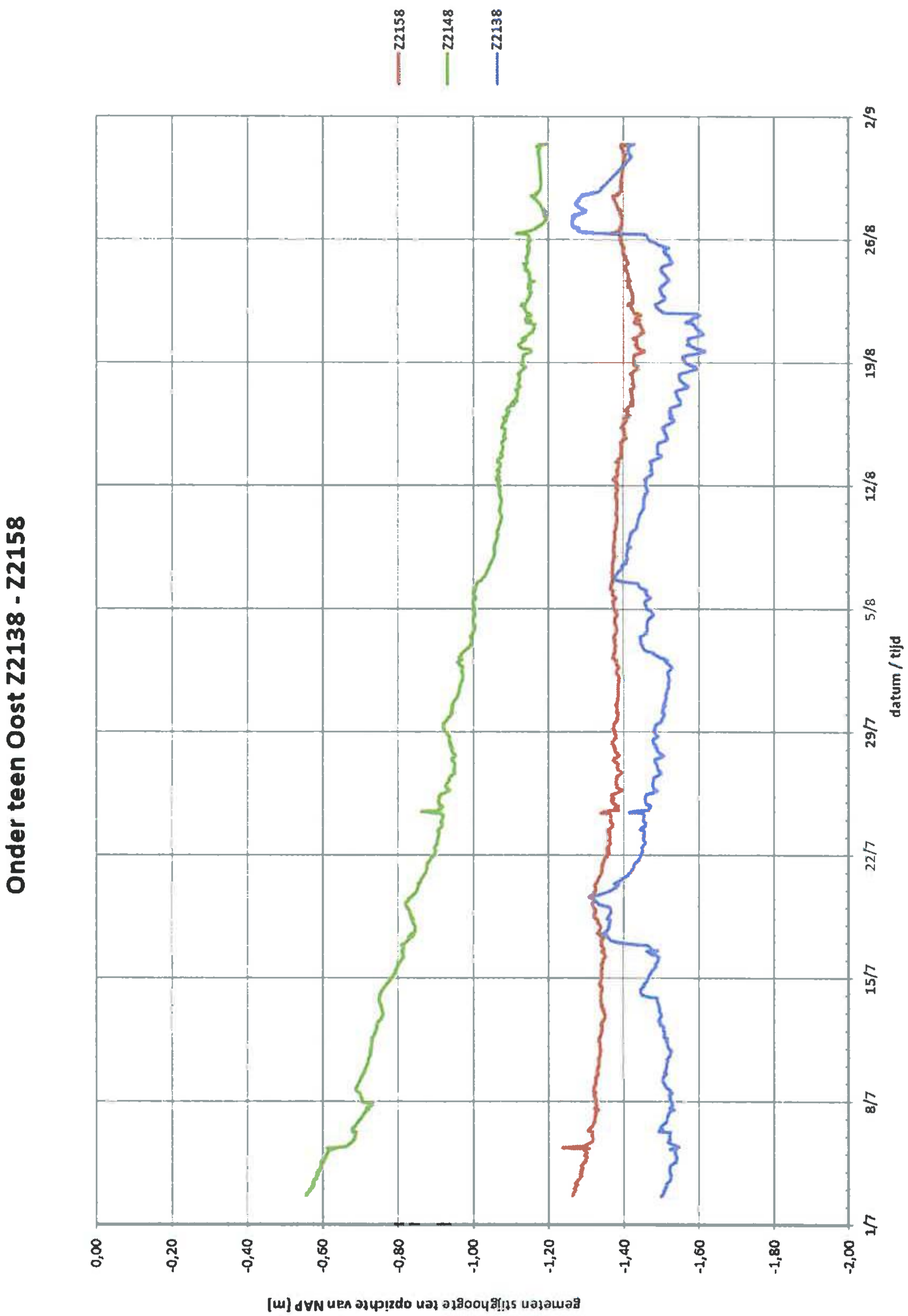

A3a: Waterspanningsmetingen onder de kruin oost

E-A3a



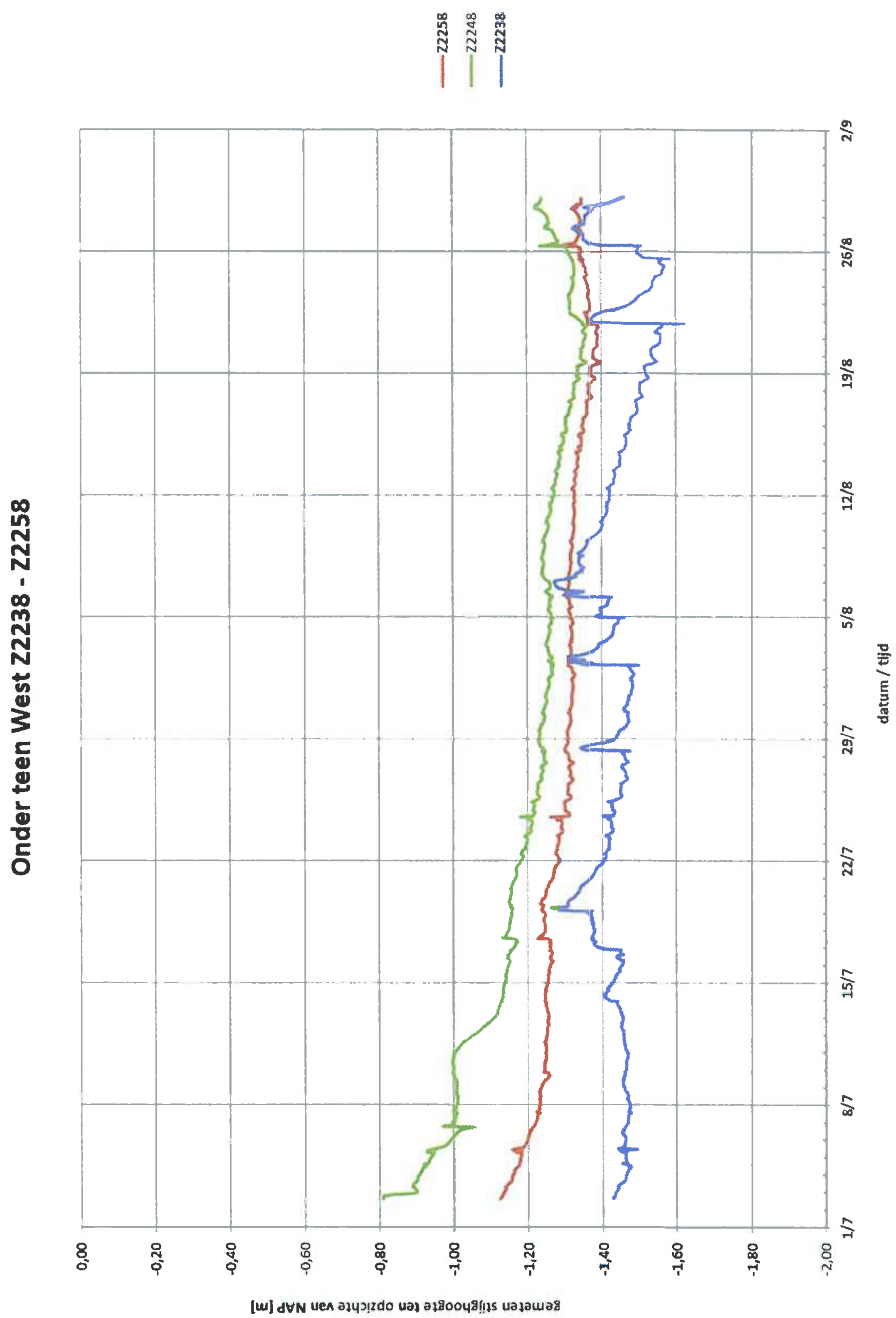

A3b: Waterspanningsmetingen onder de kruin west

E-A3b



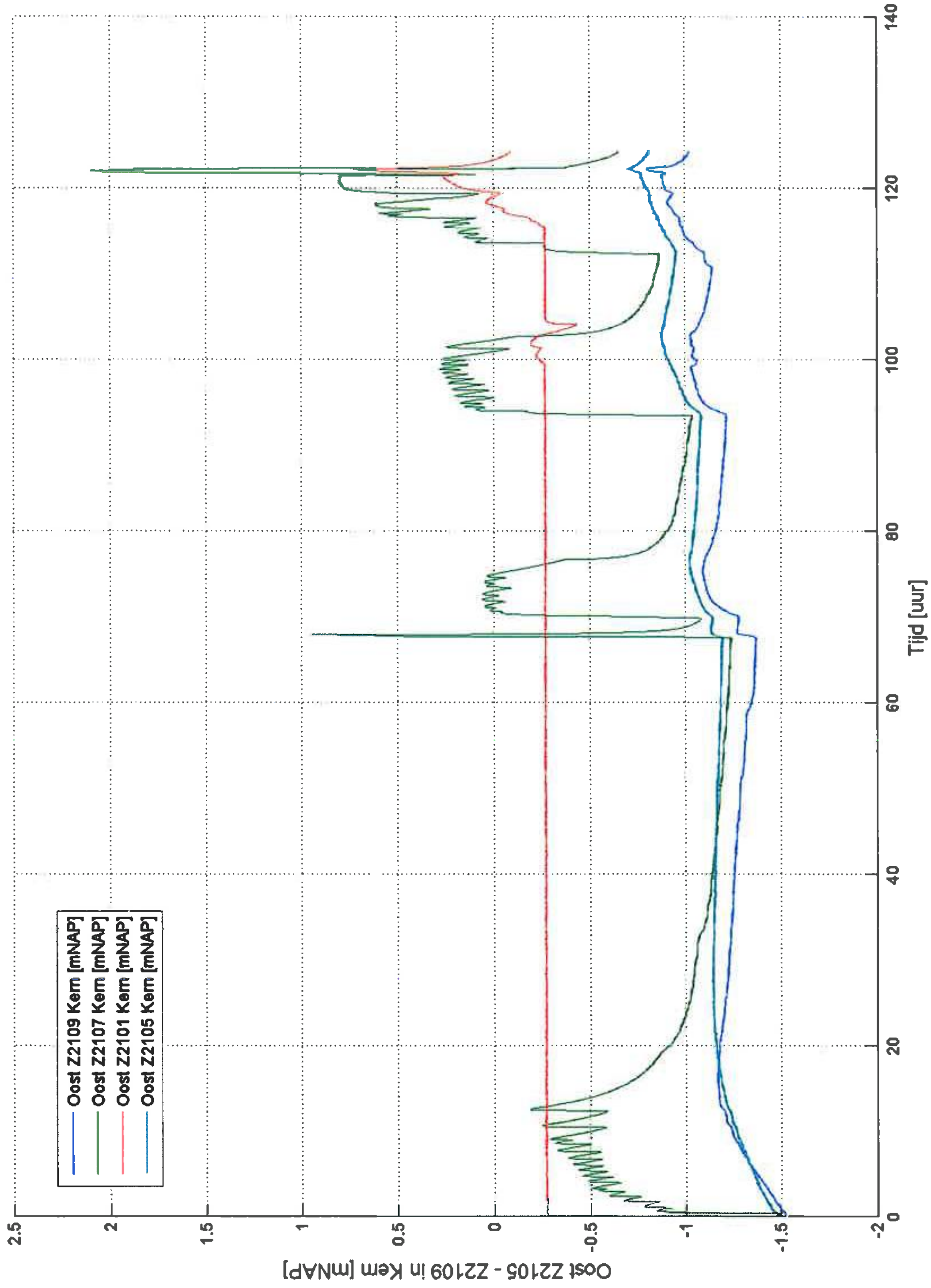

A4a: Waterspanningsmetingen onder de teen oost

E-A4a



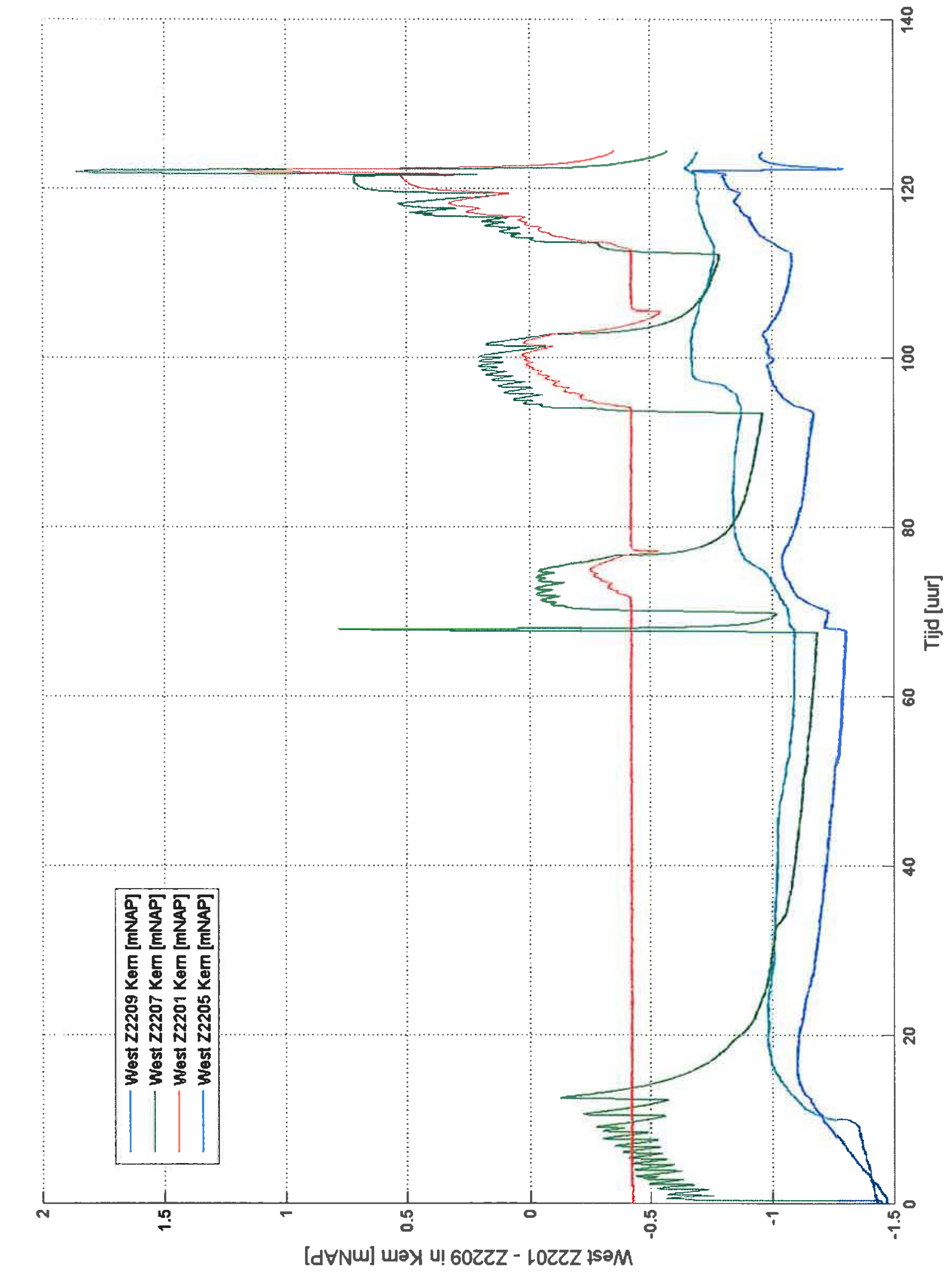

A4b: Waterspanningsmetingen onder de teen west

E-A4l



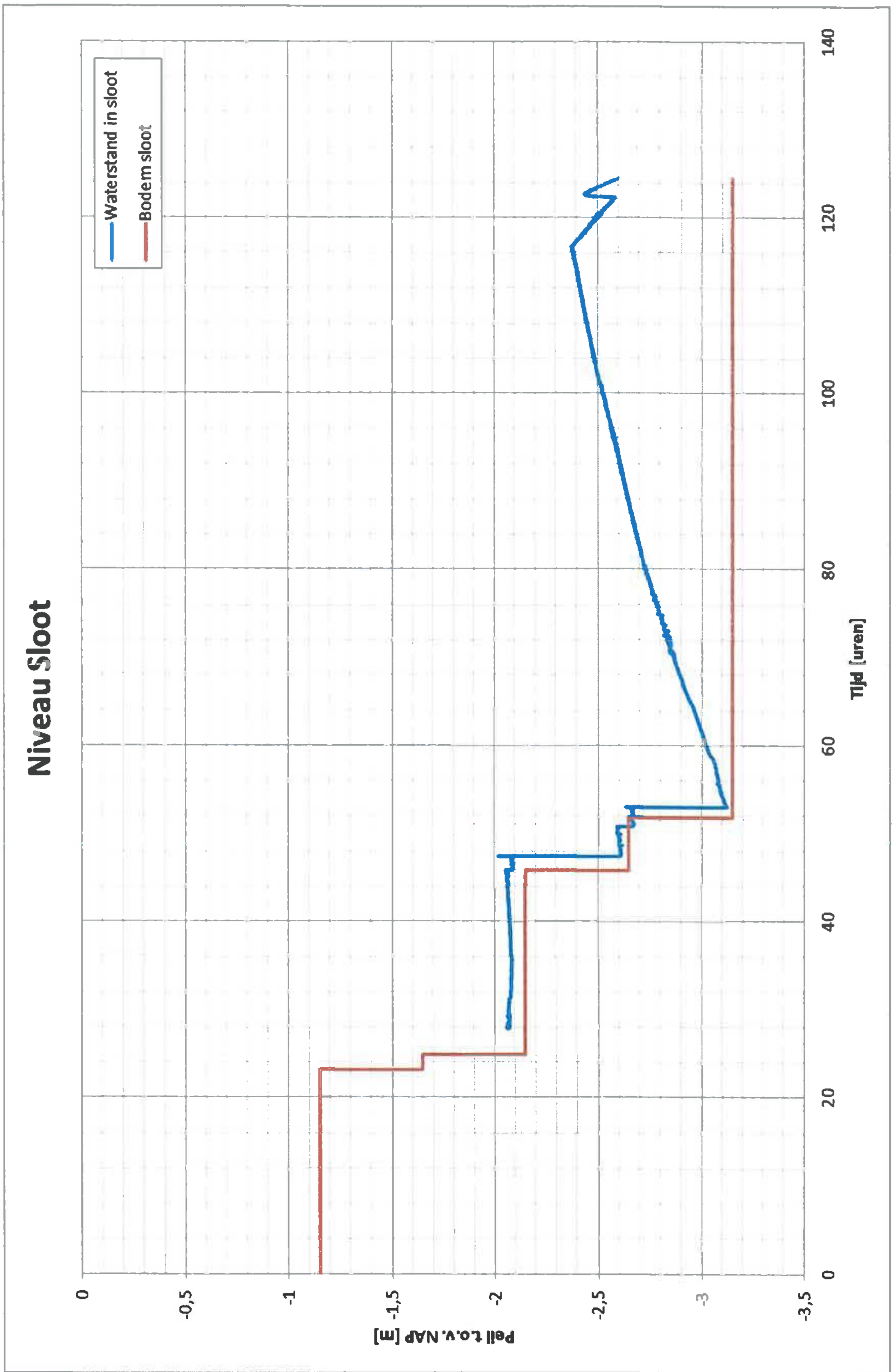

B2a: Waterspanningsmetingen in de zandkern oost

E-B2a



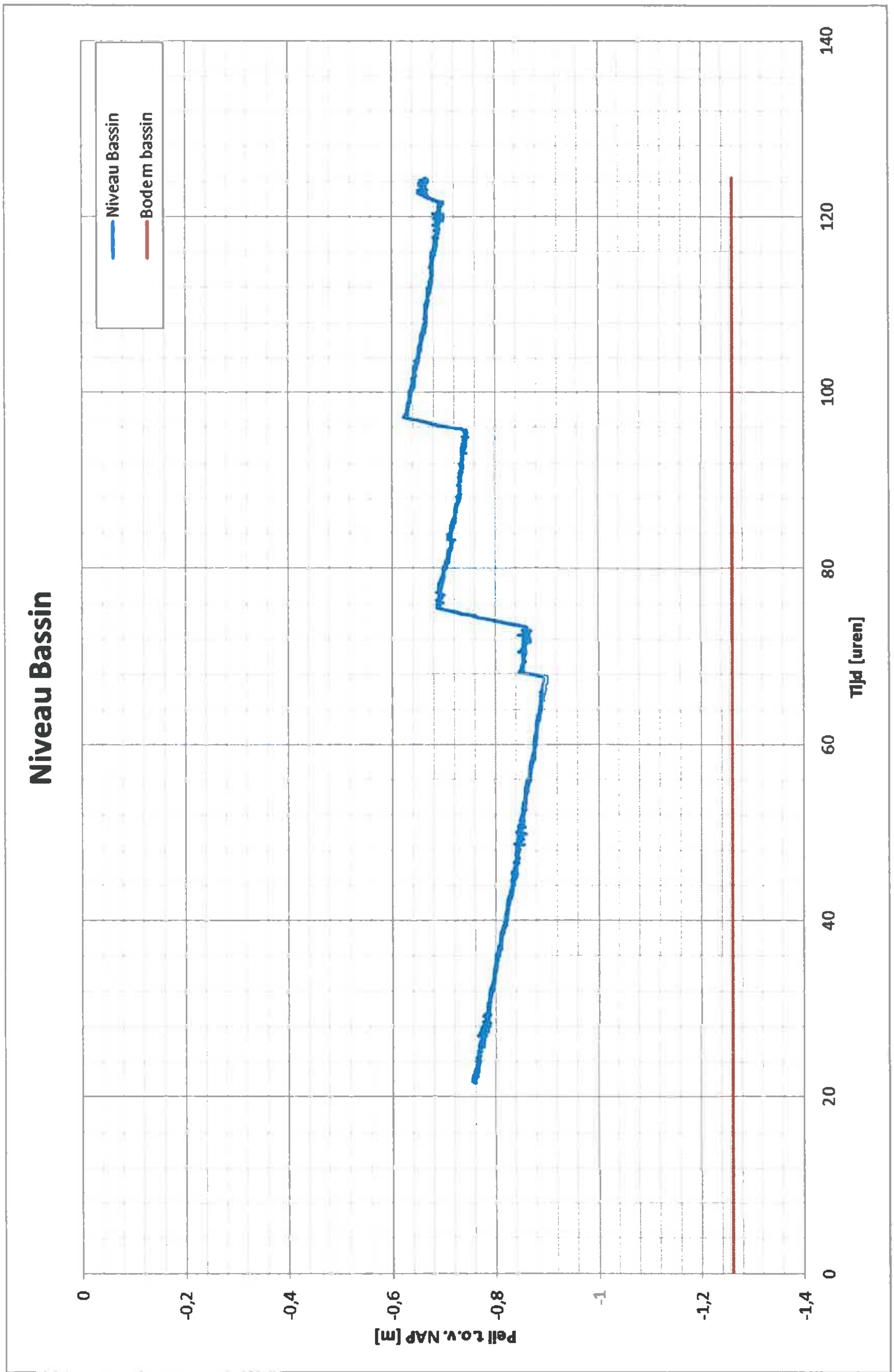

B2b: Waterspanningsmetingen in de zandkern west

E-B2b



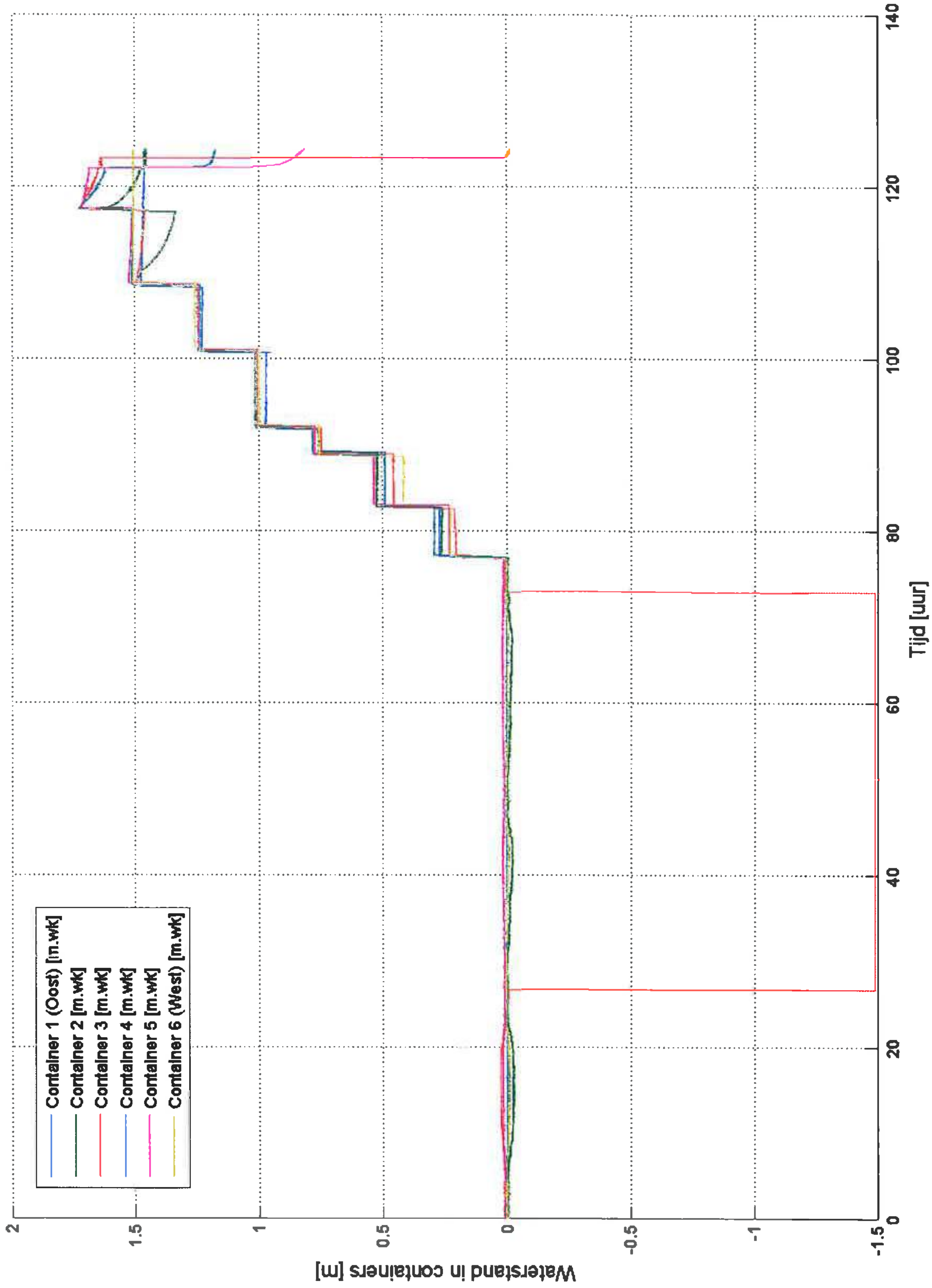

B7: Niveau sloot

E-B7




B8: Niveau zuidelijk basin

E-B8

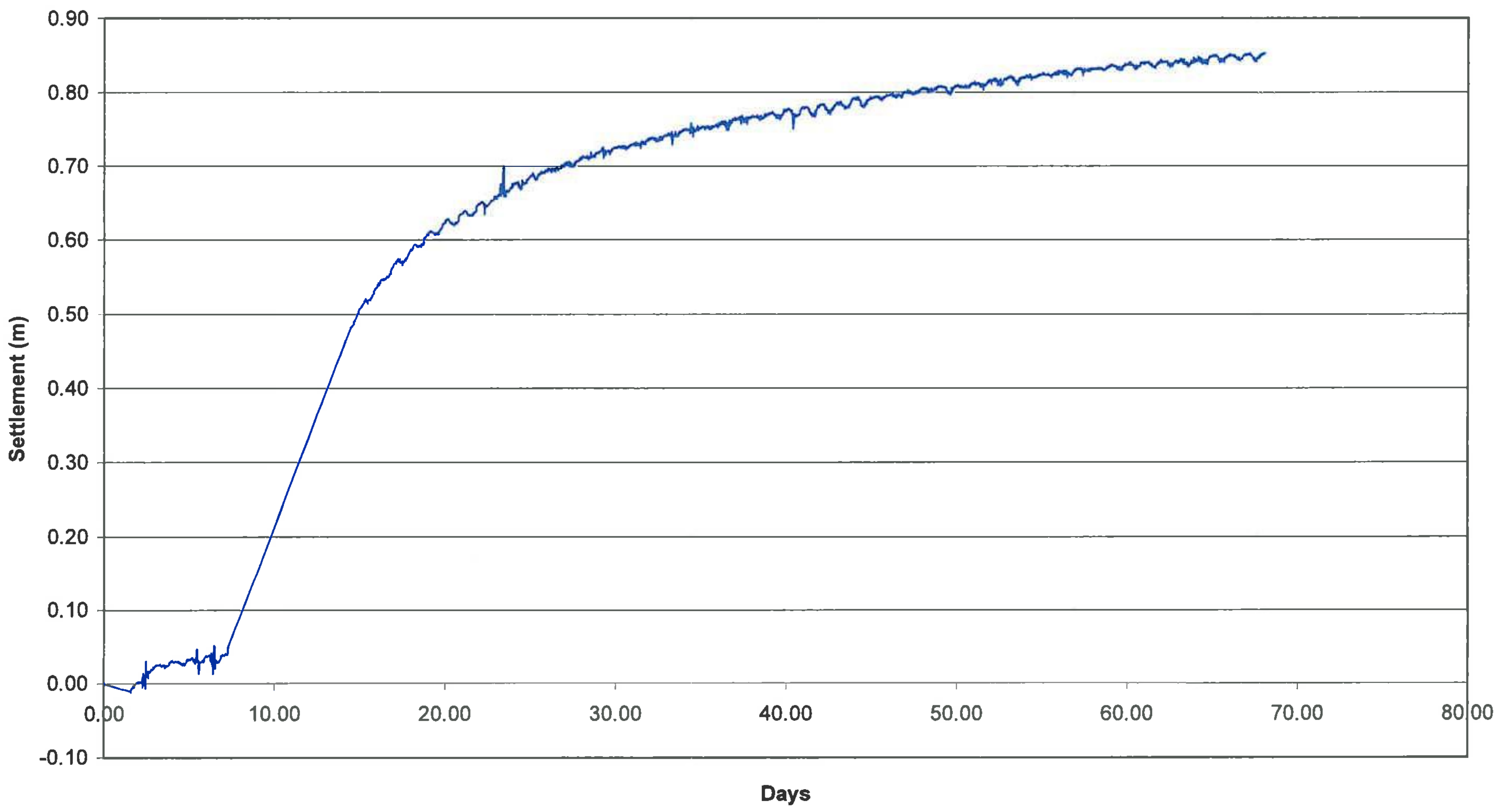



B9: Water nievau's in containers

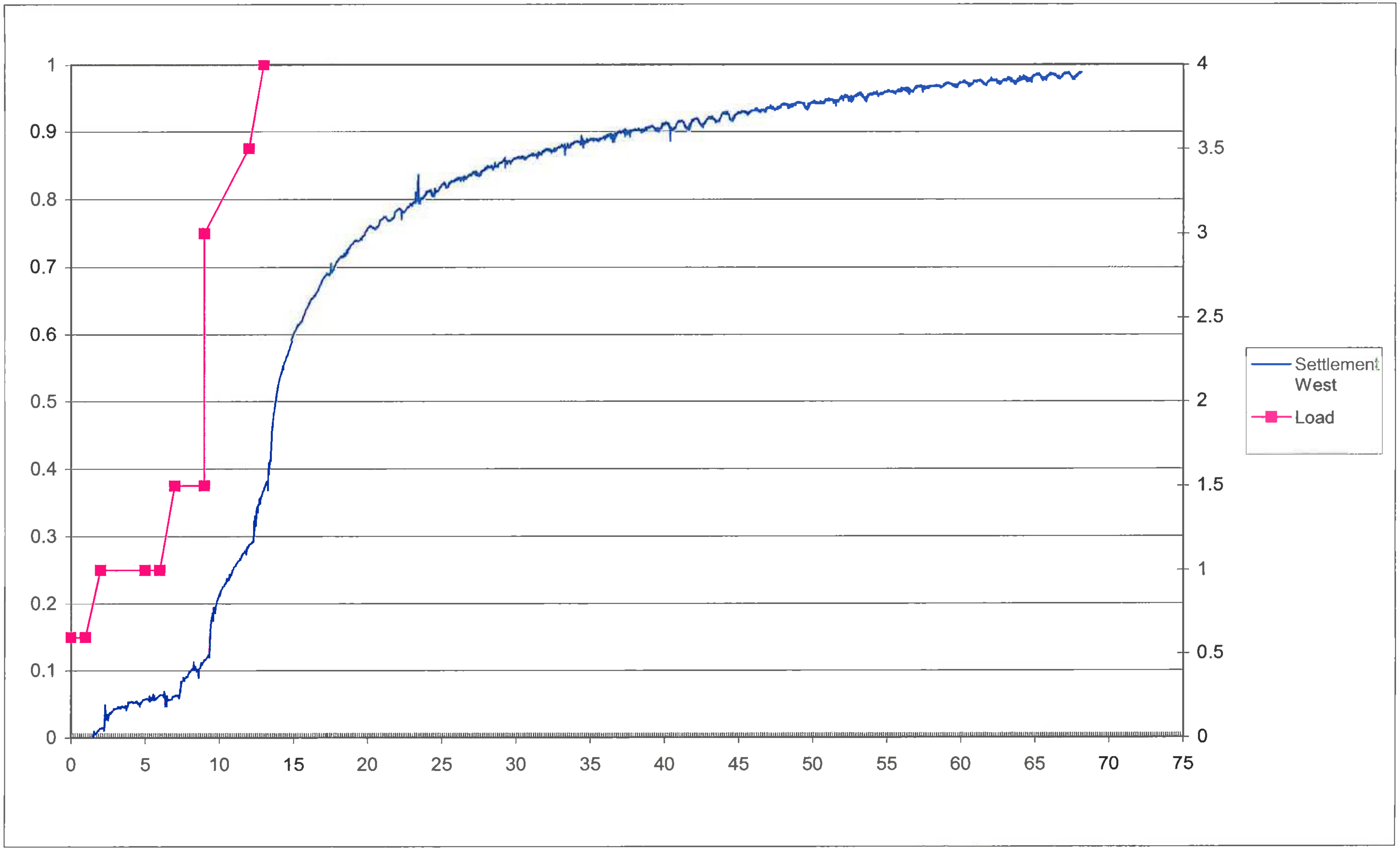
E. B9

# APPENDIX 6 : SOUTH DIKE – ADDITIONAL GRAPHS

## Settlement East side



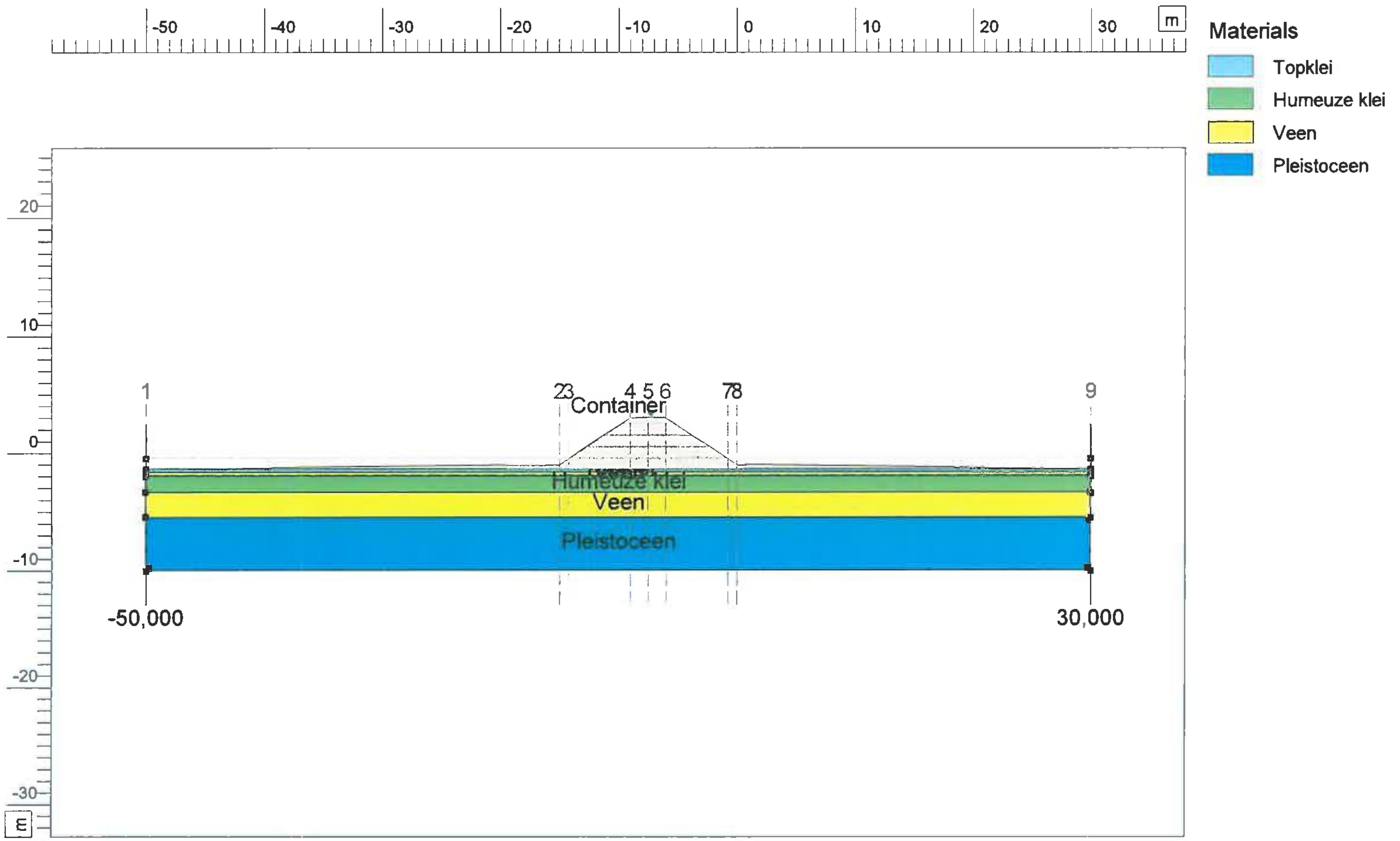

F-1



1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
Settlement West
Load


F-2

# Input View




D-Settlement 9.2 : **Ijkdijk basis B44 sli**

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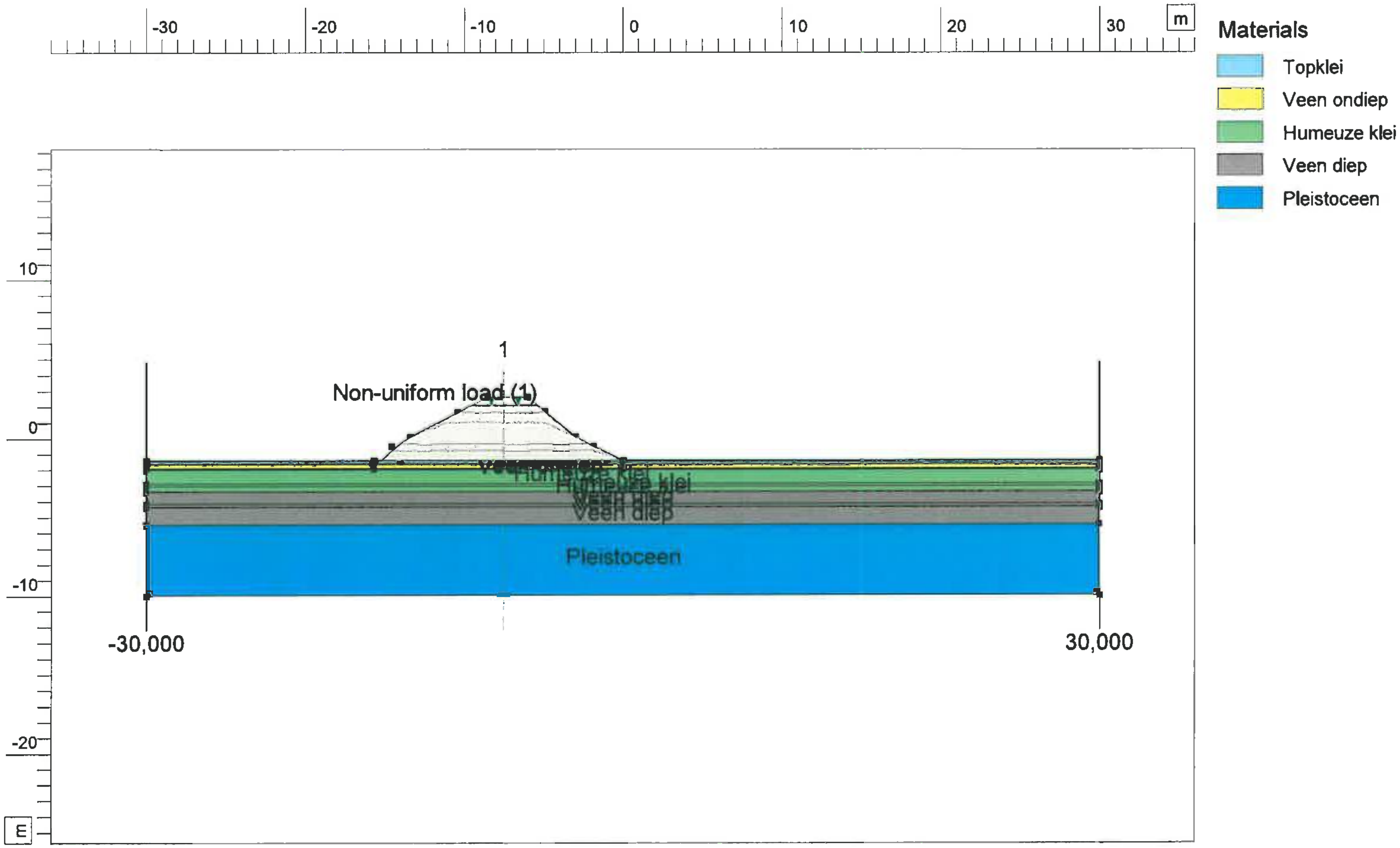
| Phone<br>Fax | date<br>2-1-2013 |
| | |
| | Annex F-3 |

# Input View




D-Settlement 9.2 : ijkdijk zetting fit 20-8-12 sli

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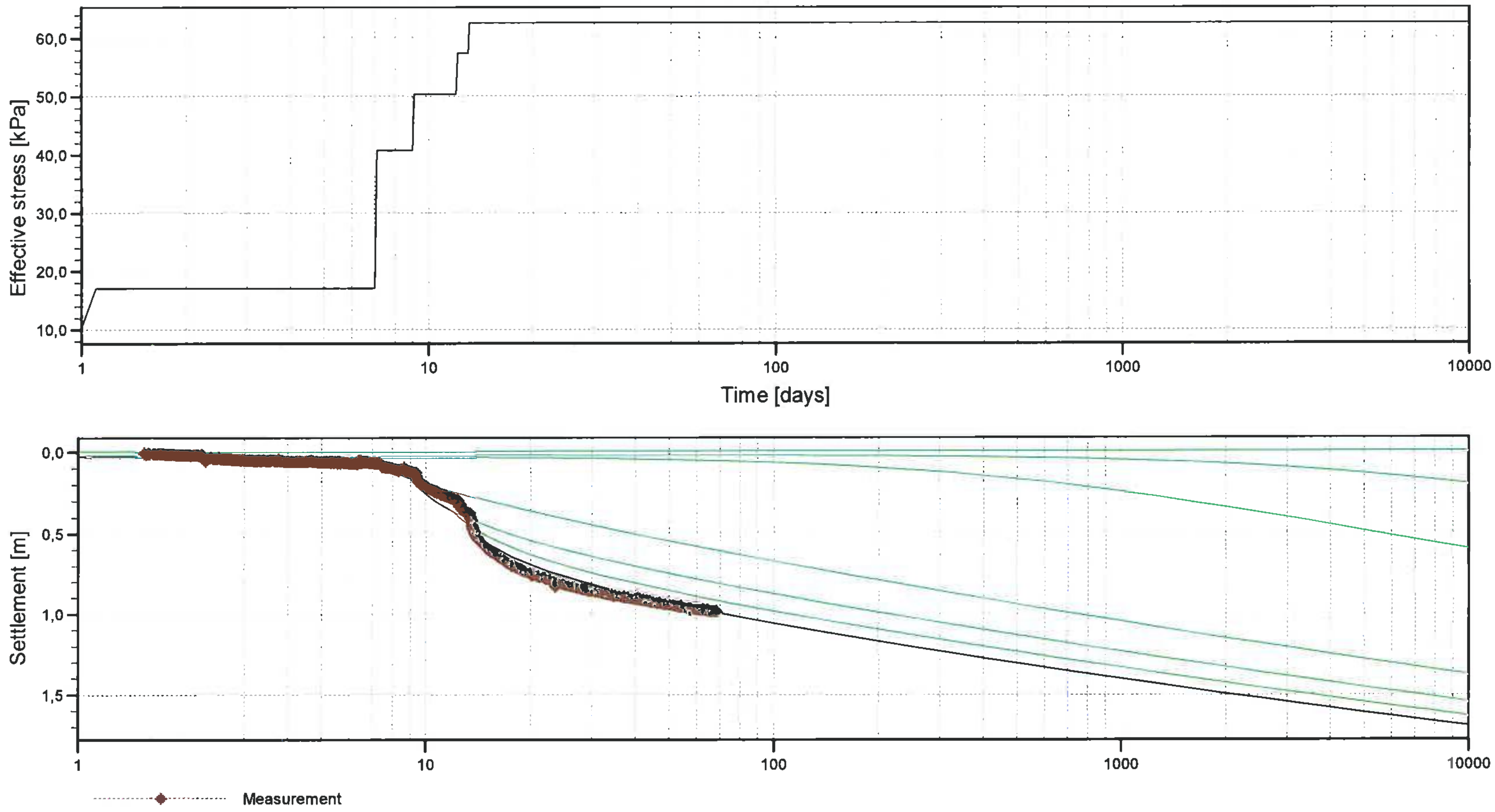
Fax

date
2-1-2013

Annex F-4

# Time-History (Fit)




Vertical 1 (X = -7,500 m; Z = 0,000 m)
Method = Isotache with Darcy (Natural strain)

Fit factors used
Coefficient of determination = 0,990

Depth = 1,400 (-) [m]
Settlement after 10000 days = 1,692 [m]

D-Settlement 9.2 : Ijkdijk zetting fit 20-8-12.sli

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| Phone<br>Fax | date<br>2-1-2013 |
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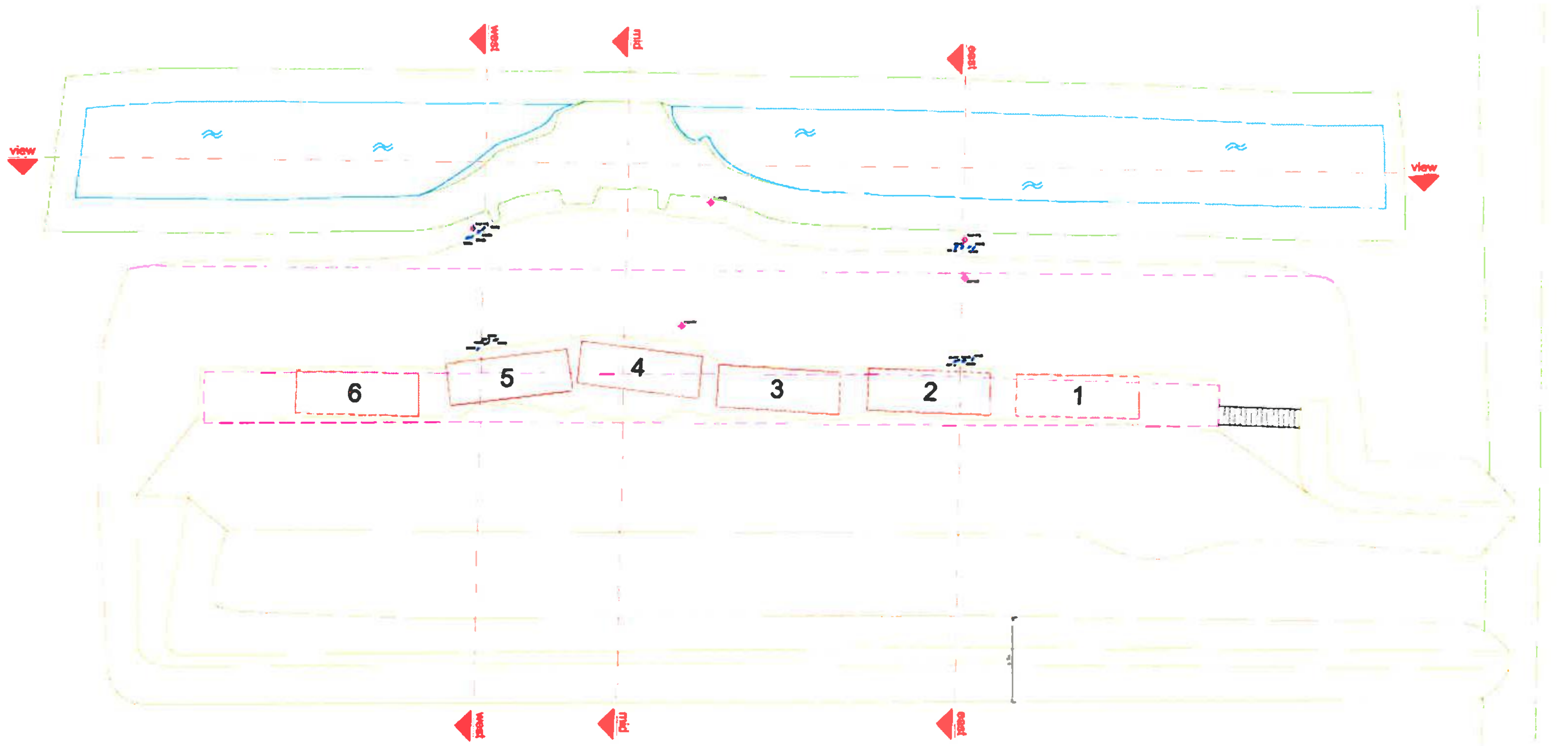
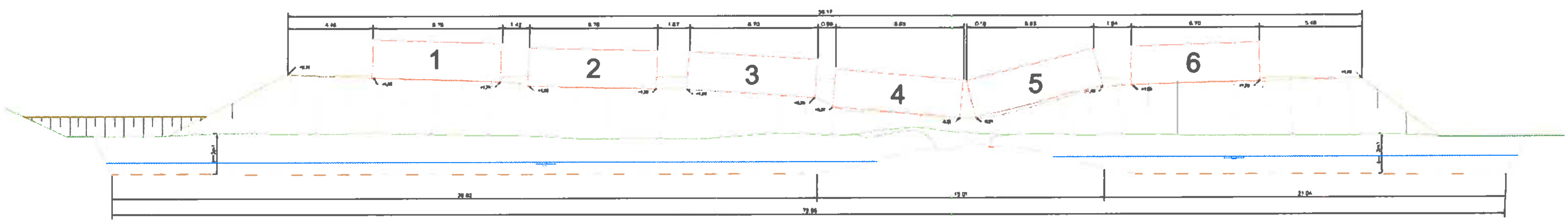
| | Annex F-5 |

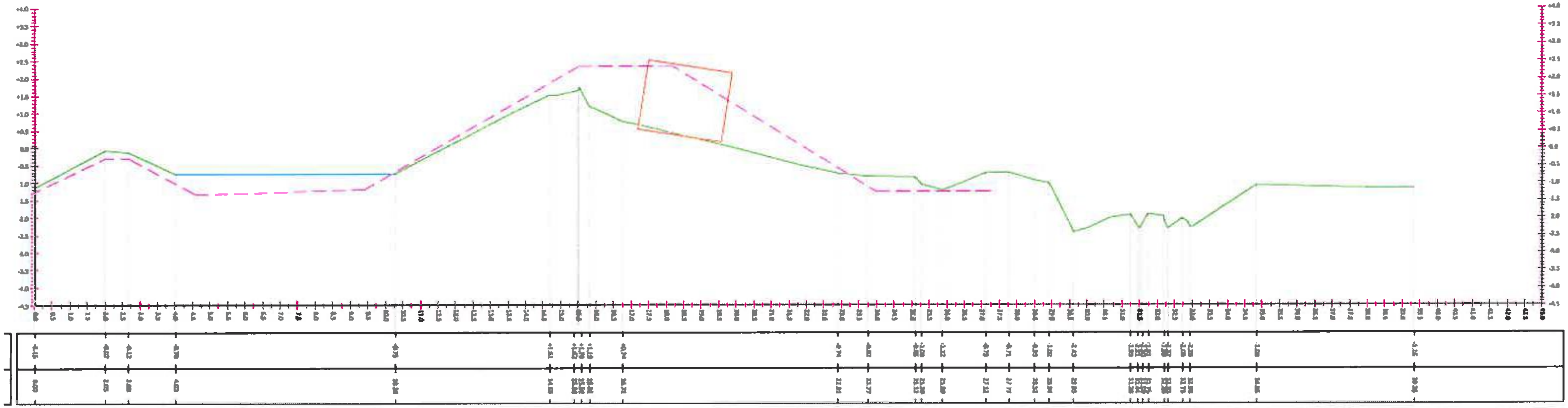



Top View after failure

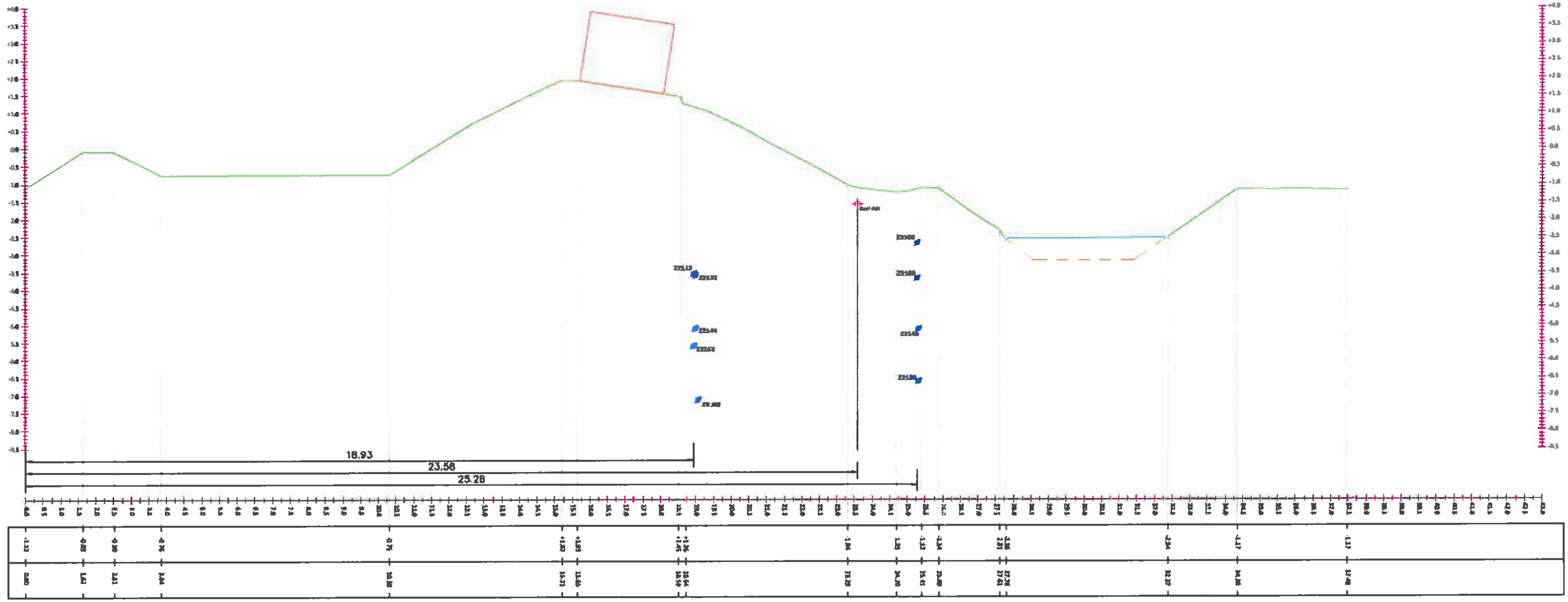



Side view after failure

F-6


Cross-section ‘mid’ (see top view for location)

F-7



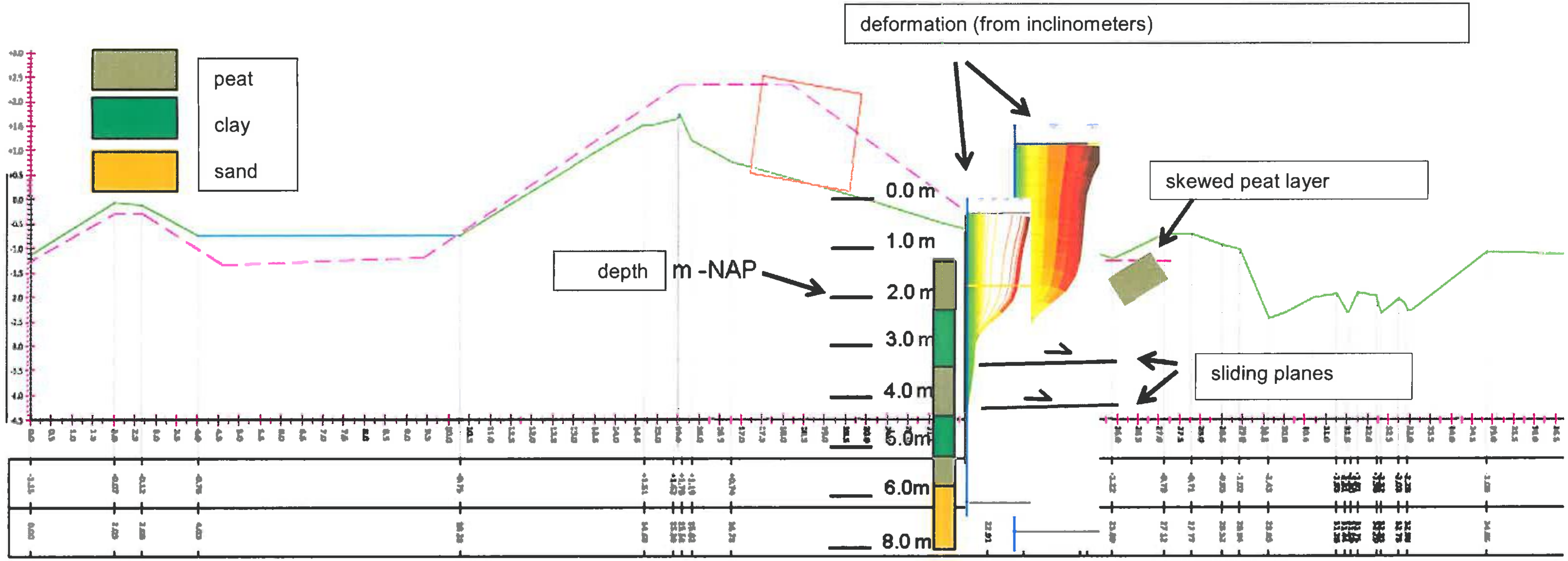
Cross-section ‘west’ (see top view for location)

F-8


Skewed peat layer


Failure plane at about NAP -2.5m, showing transitions of peat into clay layer


Peat layer around NAP -4m with many weak zones through normally coherent parts, indicating fracturing

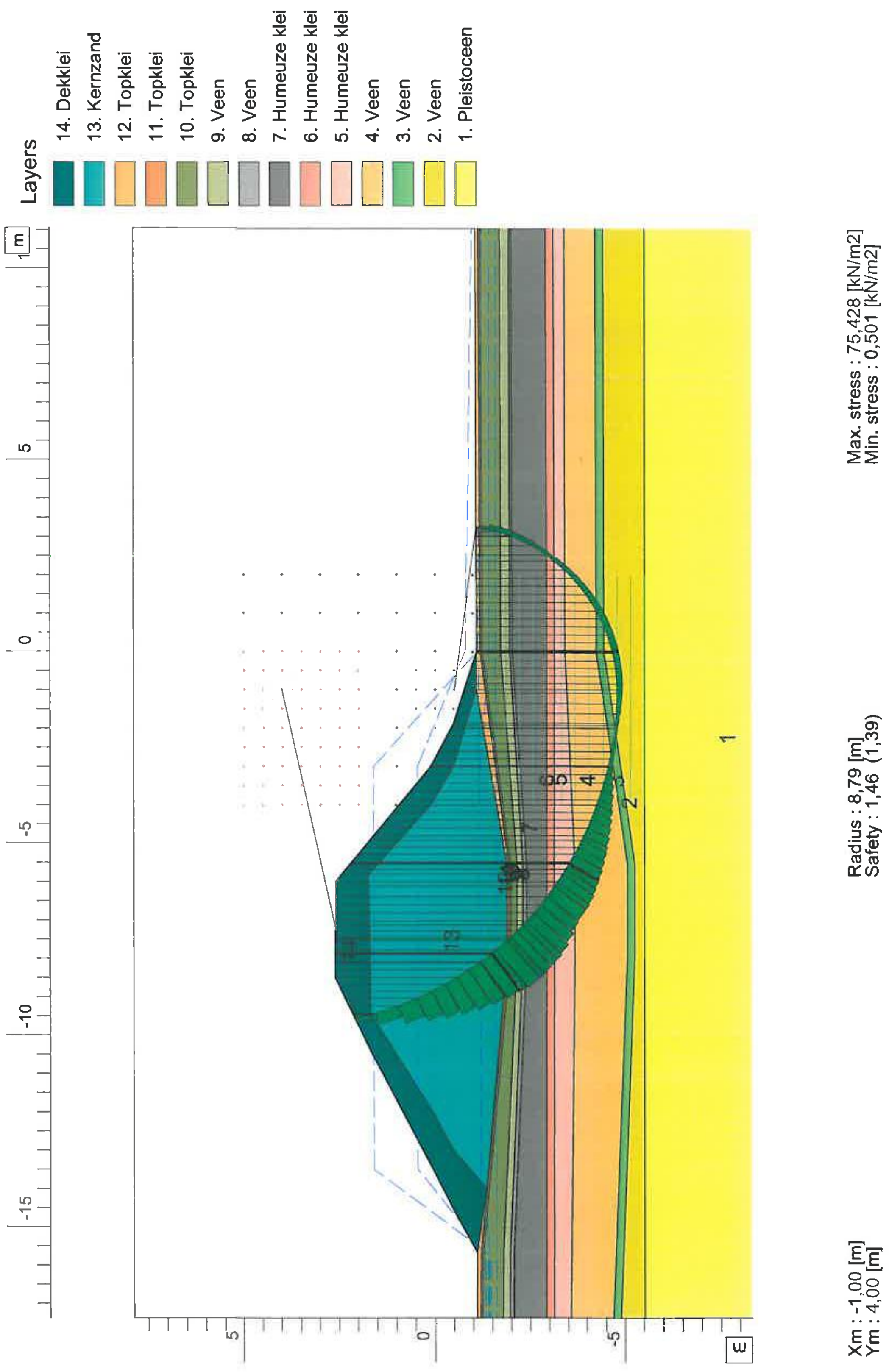



Indication of failure after forensic investigation

F-10

F-11

# Effective Stress Uplift Van




D-Geo Stability 10.1 : Zuid 120626 1700 voltooide dijk B44 Van.sti

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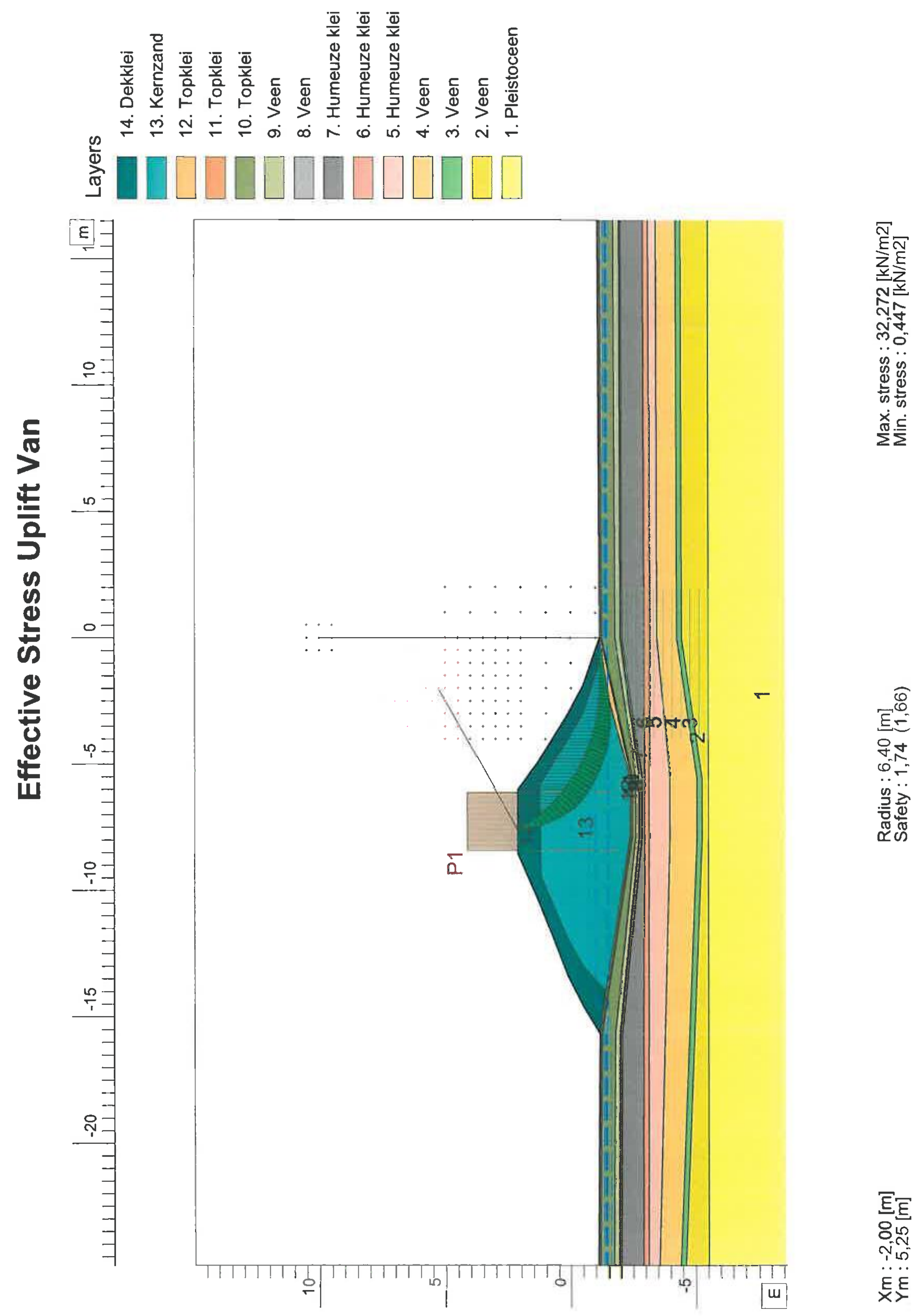
| | | | | Annex F-12 |




D-Geo Stability 10.1 : Zuid 120903-1212 start proef B44 Van.sti

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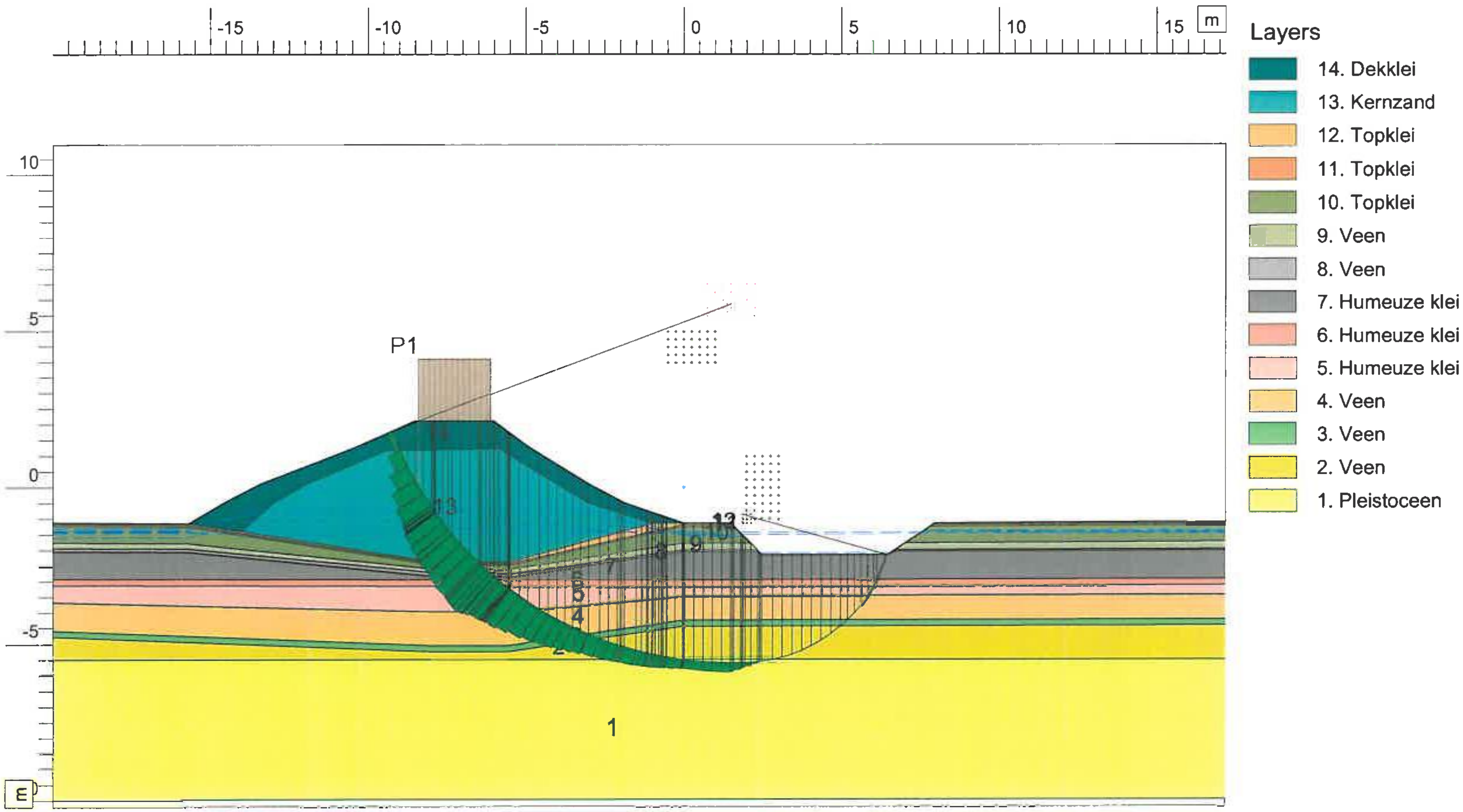
| | | | | Annex F13 |

# Effective Stress Uplift Van




Xm : 1,50 [m]
Ym : 5,88 [m]

Radius : 11,49 [m]
Safety : 1,24 (1,18)

Max. stress : 72,877 [kN/m2]
Min. stress : 0,000 [kN/m2]

D-Geo Stability 10.1 : Zuid 120905-0800 voor laatste ontgravingsslap B44 Van detailglijvlak.sti

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Fax <Not Registered>

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2013-01-03

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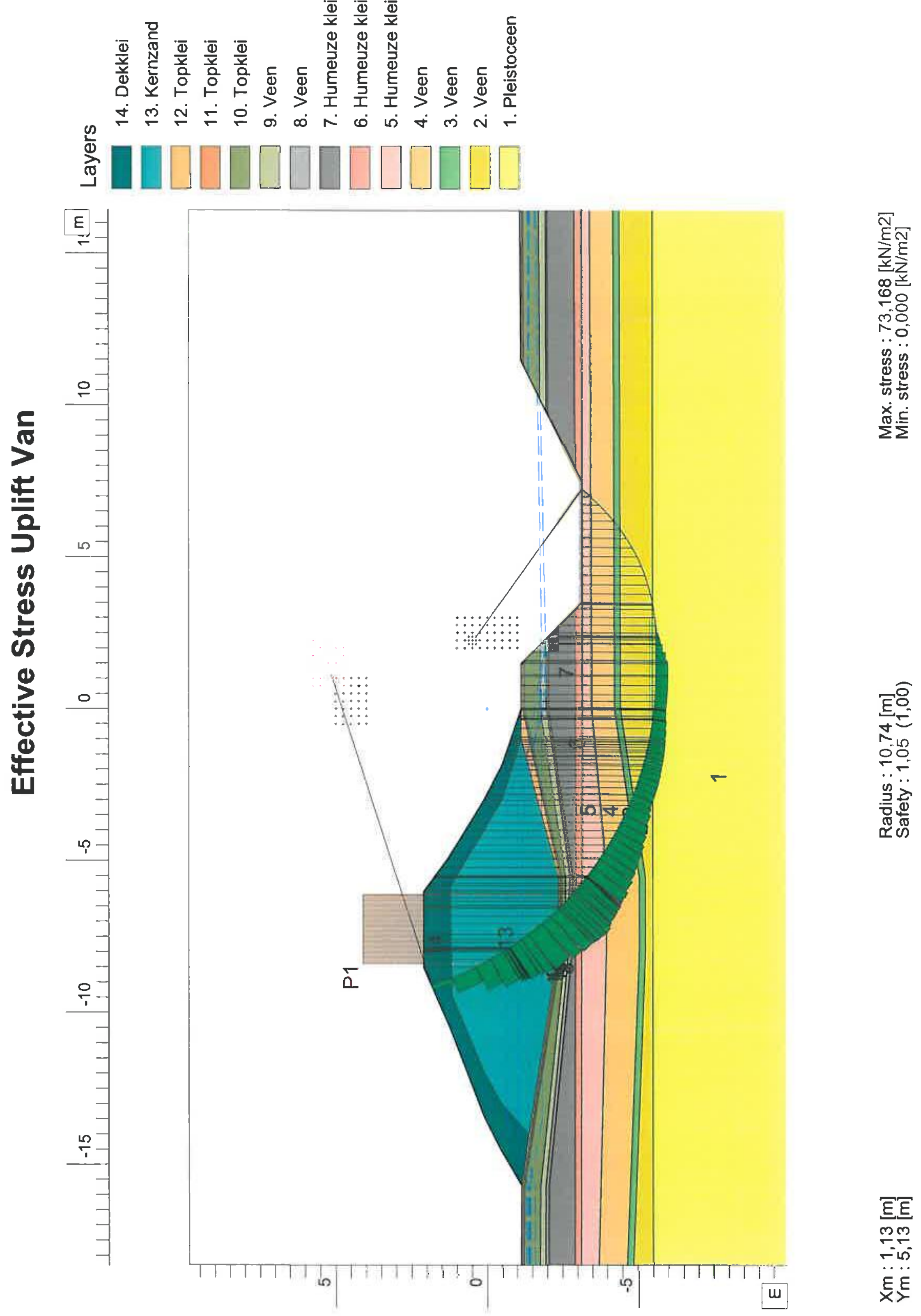
Annex F-14




D-Geo Stability 10.1 : Zuid 120905-1700 Na ontgraven B44 Van detailglijvlak.sti

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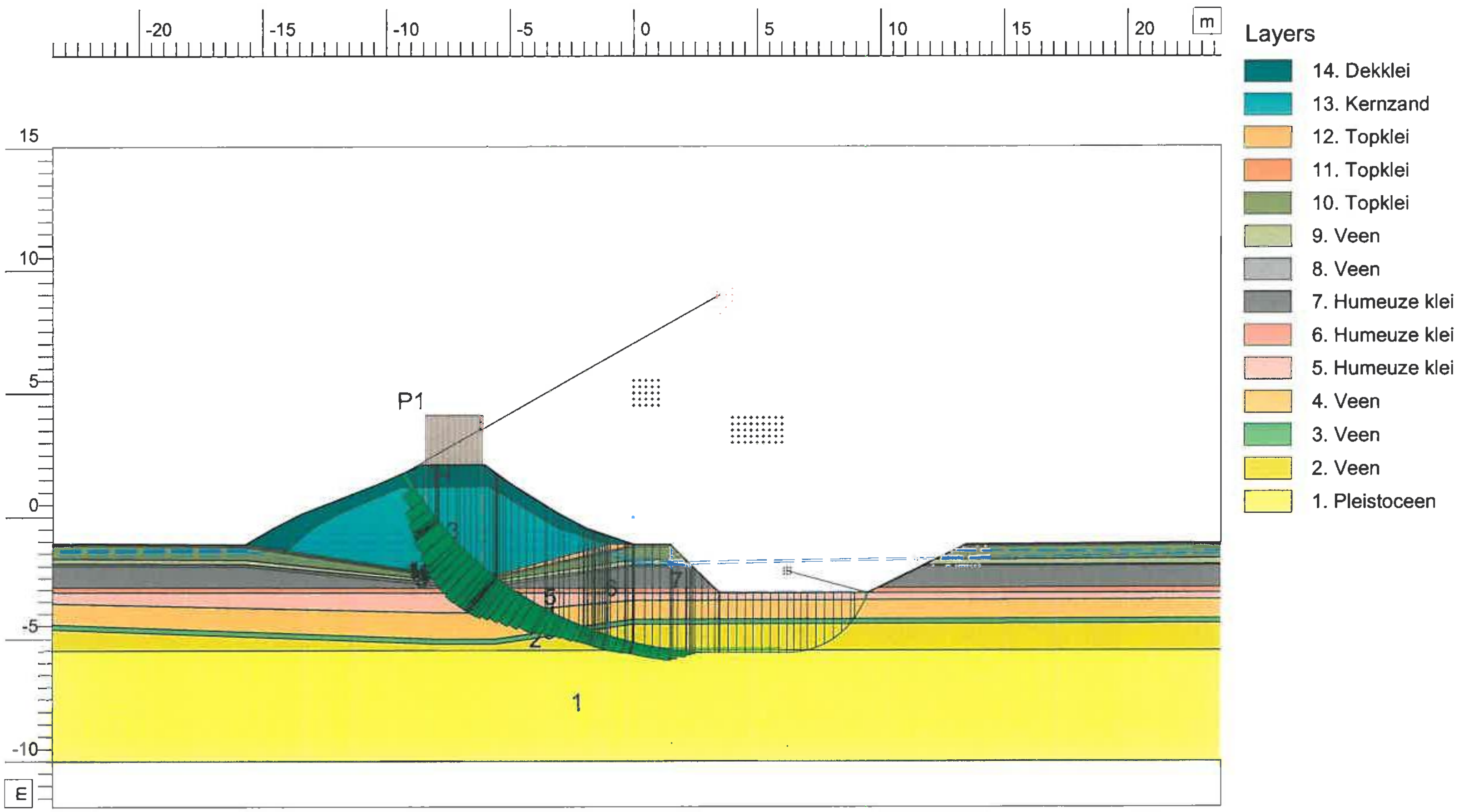
| | | | | 4a |
| | | | | Annex F-15 |

# Effective Stress Uplift Van




Xm : 3,50 [m]
Ym : 9,00 [m]

Radius : 14,62 [m]
Safety : 0,98 (0,94)

Max. stress : 65,953 [kN/m2]
Min. stress : 0,000 [kN/m2]

D-Geo Stability 10.1 : Zuid hypothetisch 120905-1700 Na ontgraven EN VERBREDEN B44 Van verfijnd grid.sti

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2013-01-04

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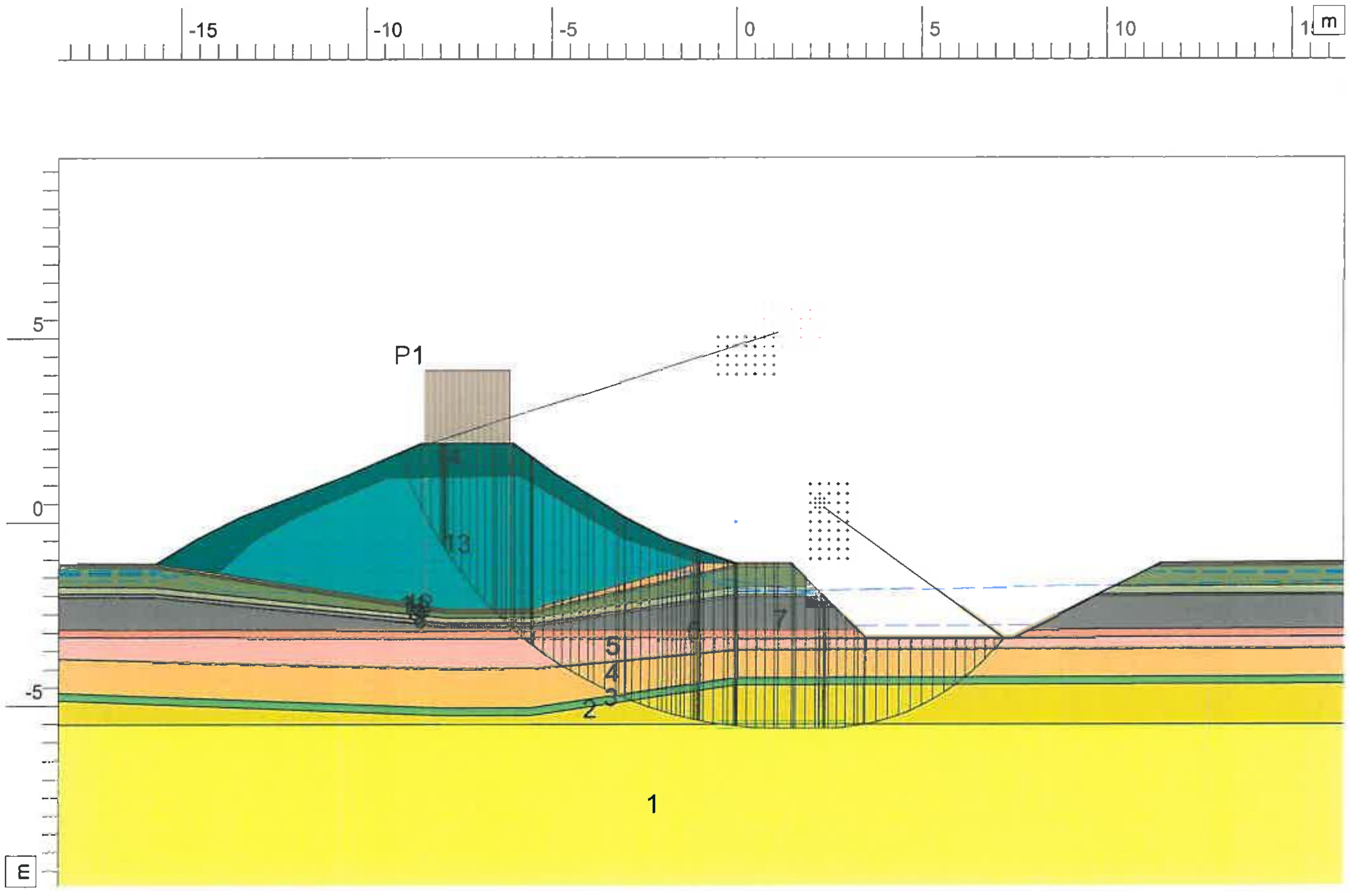
Annex F-16

# Slip Plane Uplift Van




Layers

- 14. Dekklei
- 13. Kernzand
- 12. Topklei
- 11. Topklei
- 10. Topklei
- 9. Veen
- 8. Veen
- 7. Humeuze klei
- 6. Humeuze klei
- 5. Humeuze klei
- 4. Veen
- 3. Veen
- 2. Veen
- 1. Pleistoceen

Xm : 1,13 [m]
Ym : 5,13 [m]

Radius : 10,74 [m]
Safety : 1,08 (1,03)

D-Geo Stability 10.1 : Zuid 120906-0750 voor hervatten vullen B44 Van detailglijvlak.sti

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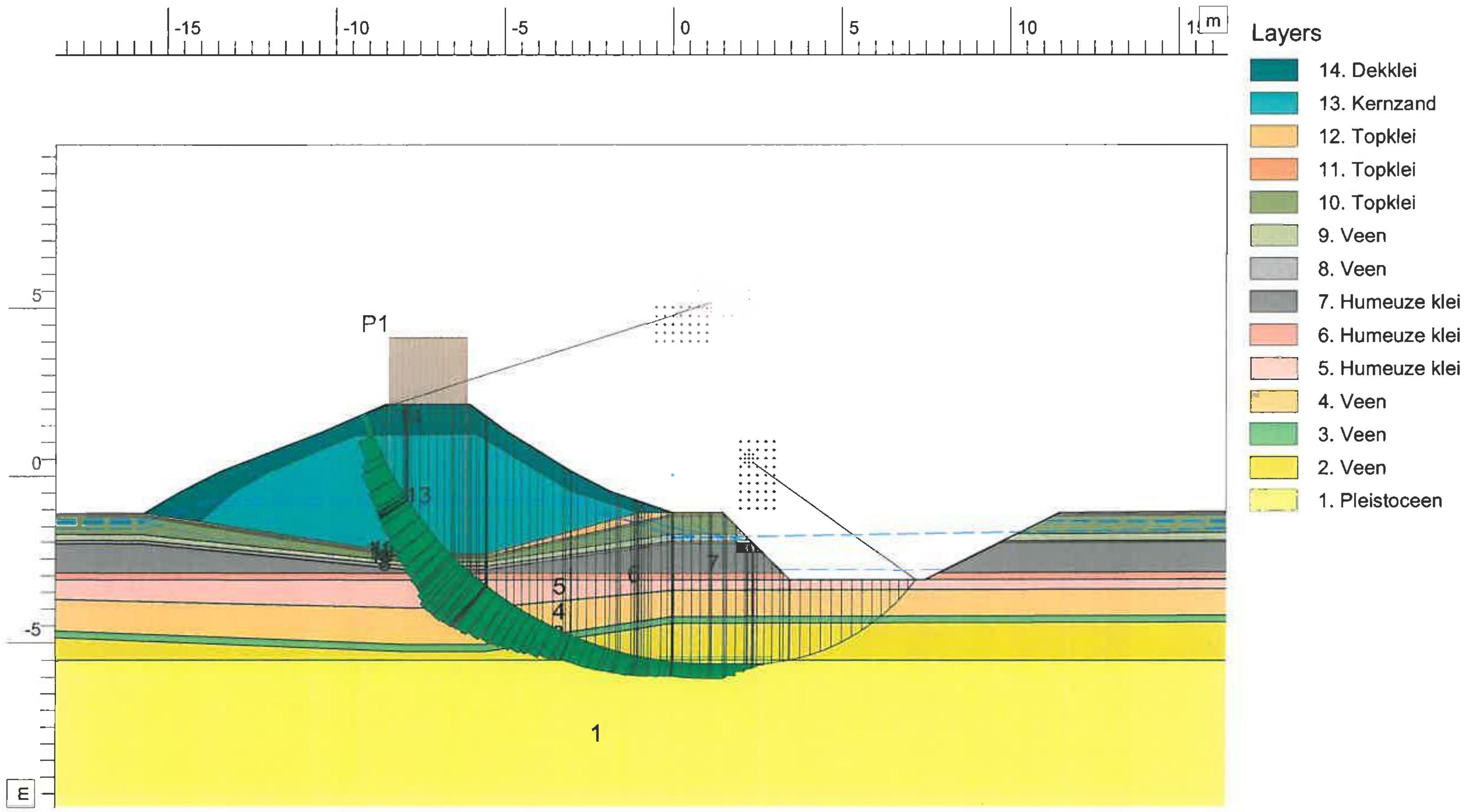
Annex F-17

# Effective Stress Uplift Van




Xm : 1,13 [m]
Ym : 5,13 [m]

Radius : 10,74 [m]
Safety : 1,01 (0,96)

Max. stress : 68,886 [kN/m2]
Min. stress : 0,000 [kN/m2]

D-Geo Stability 10.1 : Zuid 120606-0807 net na hervatten vullen B44 Van detailglijvlak.sti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Fax <Not Registered>


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2013-01-03

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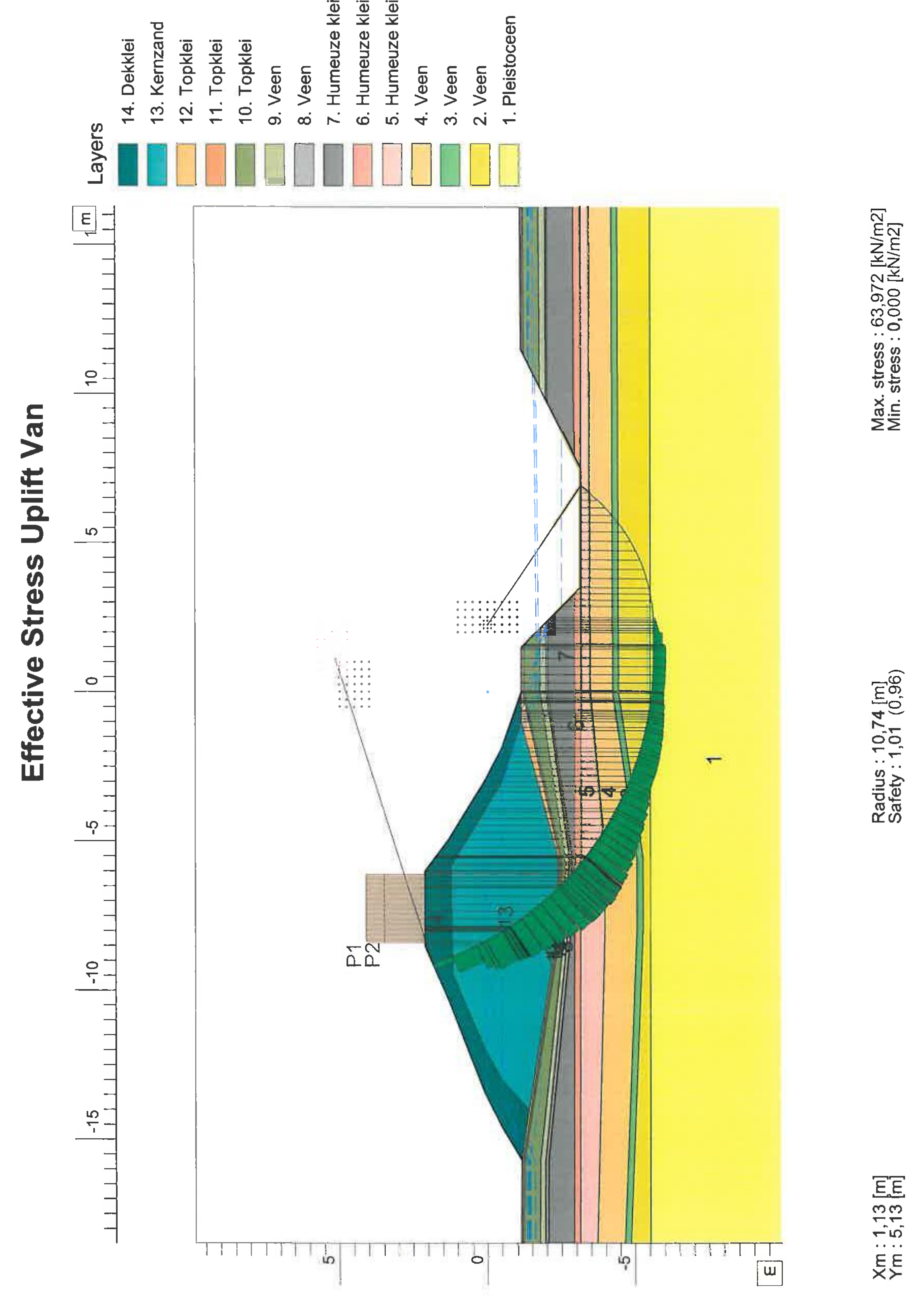
Annex F-18




D-Geo Stability 10.1 : Zuid 120908-1353 voor laatste keer vullen B44 Van detailglijvlak.sti

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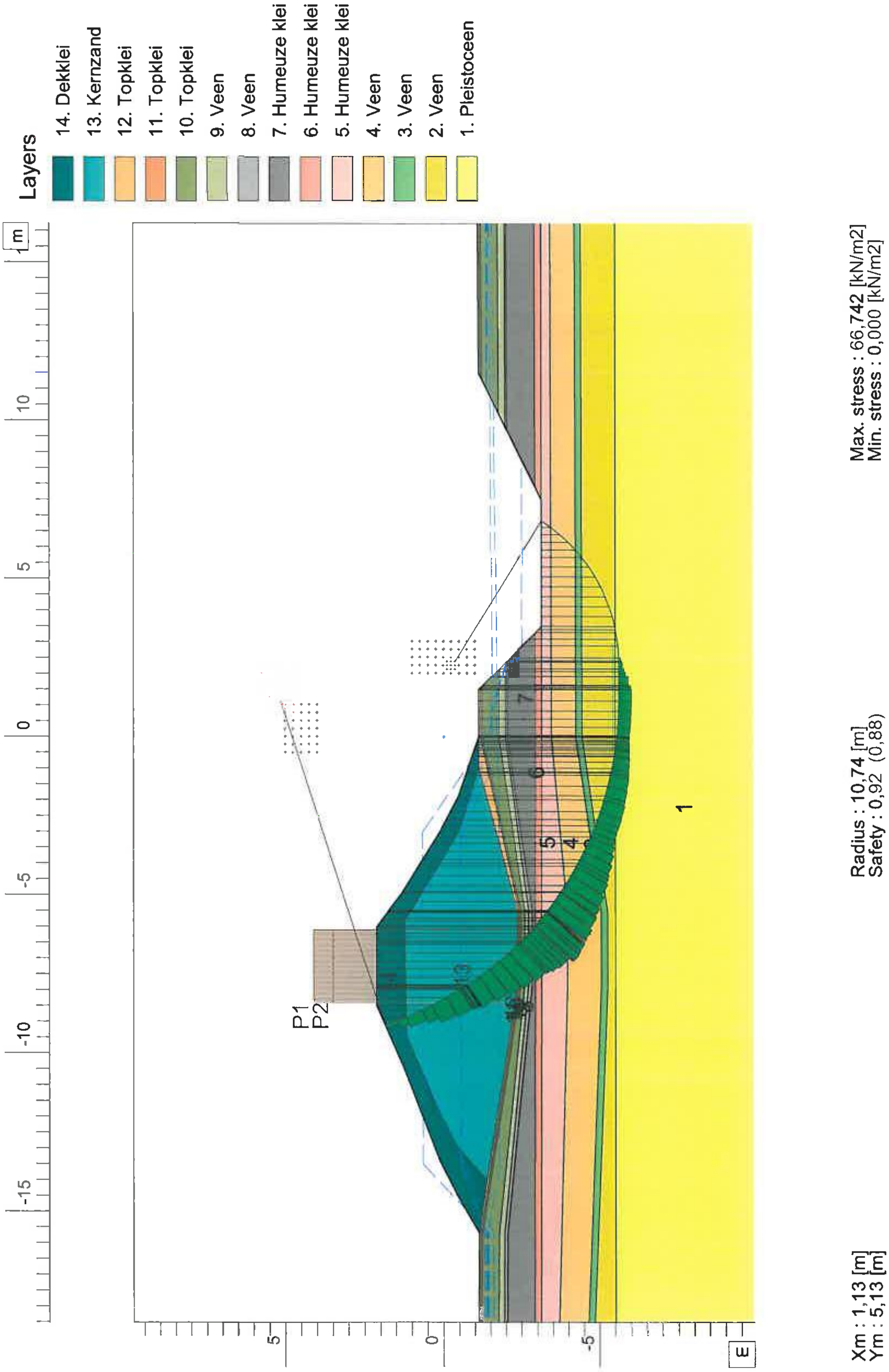
| | | | | Annex F-10 |

# Effective Stress Uplift Van




D-Geo **Stability** 10.1 : Zuid 120908-1413 maximale belasting B44 Van detailglijvlak.sti

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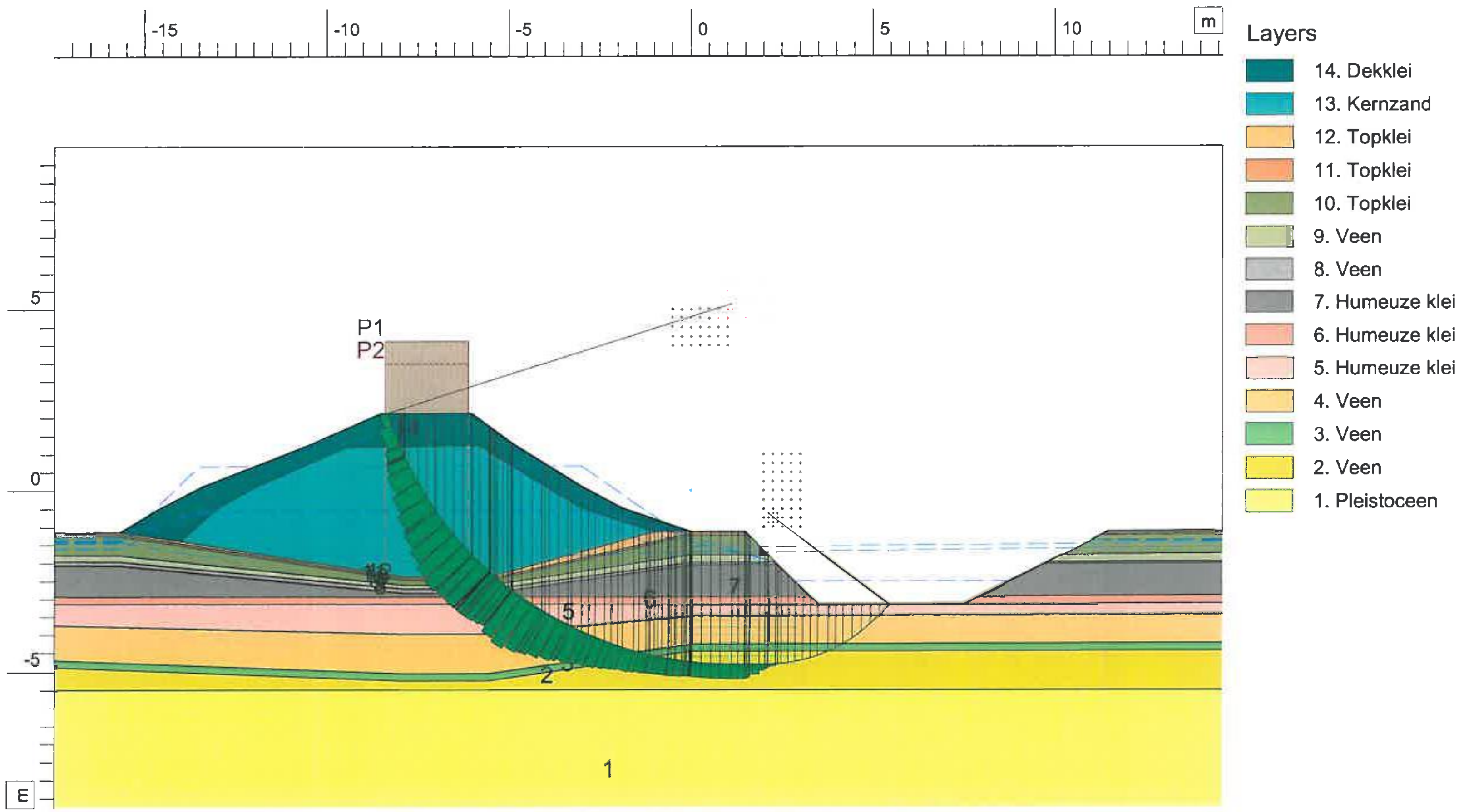
| | | | | Annex F20 |

# Effective Stress Uplift Van




Xm : 1,13 [m]
Ym : 5,13 [m]

Radius : 9,93 [m]
Safety : 0,97 (0,92)

Max. stress : 47,449 [kN/m2]
Min. stress : 0,000 [kN/m2]

D-Geo Stability 10.1 : Zuid 120908-1413 maximale belasting B44 Van hoger detailglijvlak.sti

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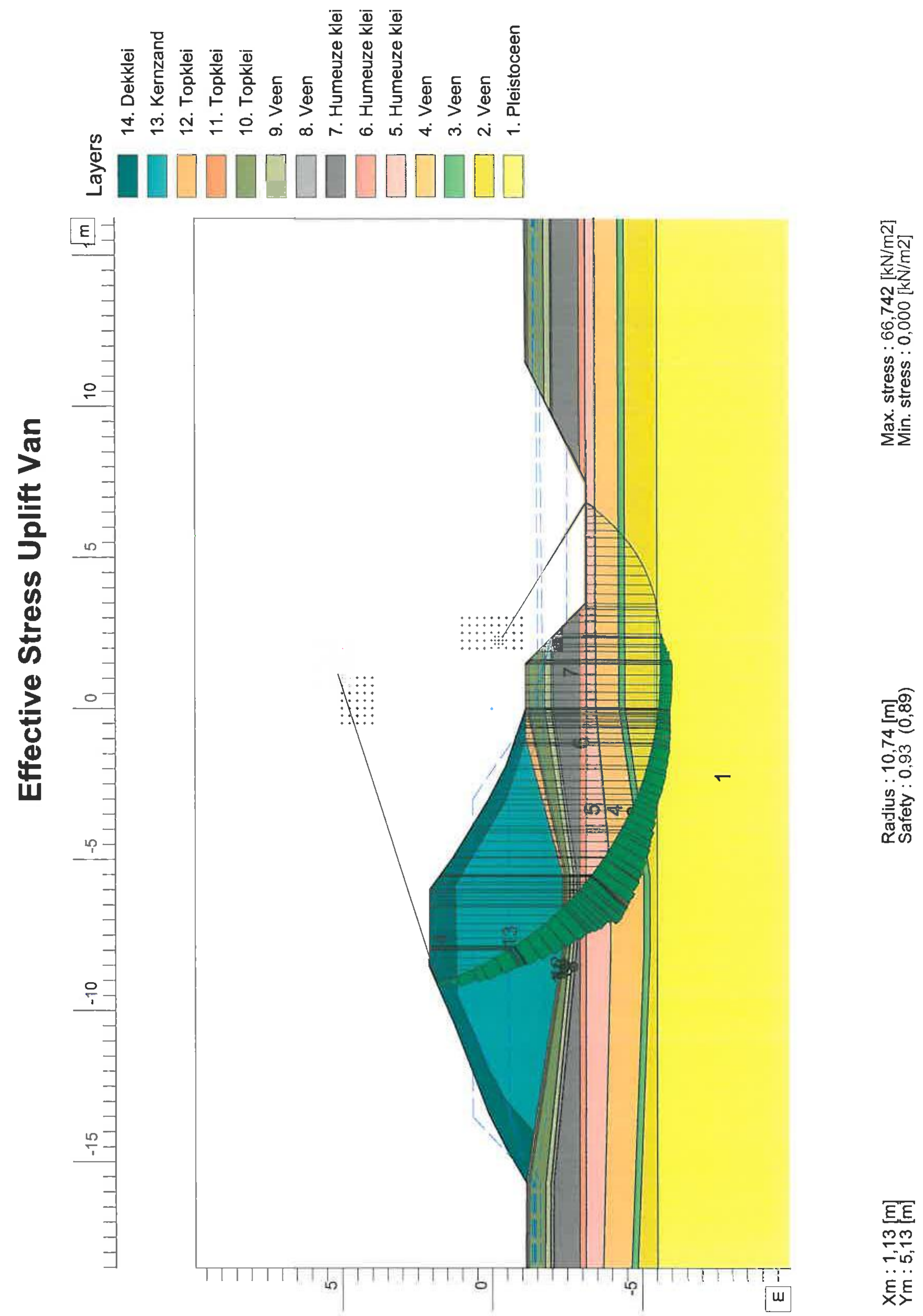
| | | | | 6c |
| | | | | Annex F-21 |




D-Geo Stability 10.1 : Zuid hypothetisch 120908-1413 maximale belasting ZONDER CONTAINERS B44 Van detailglijvlak.sti

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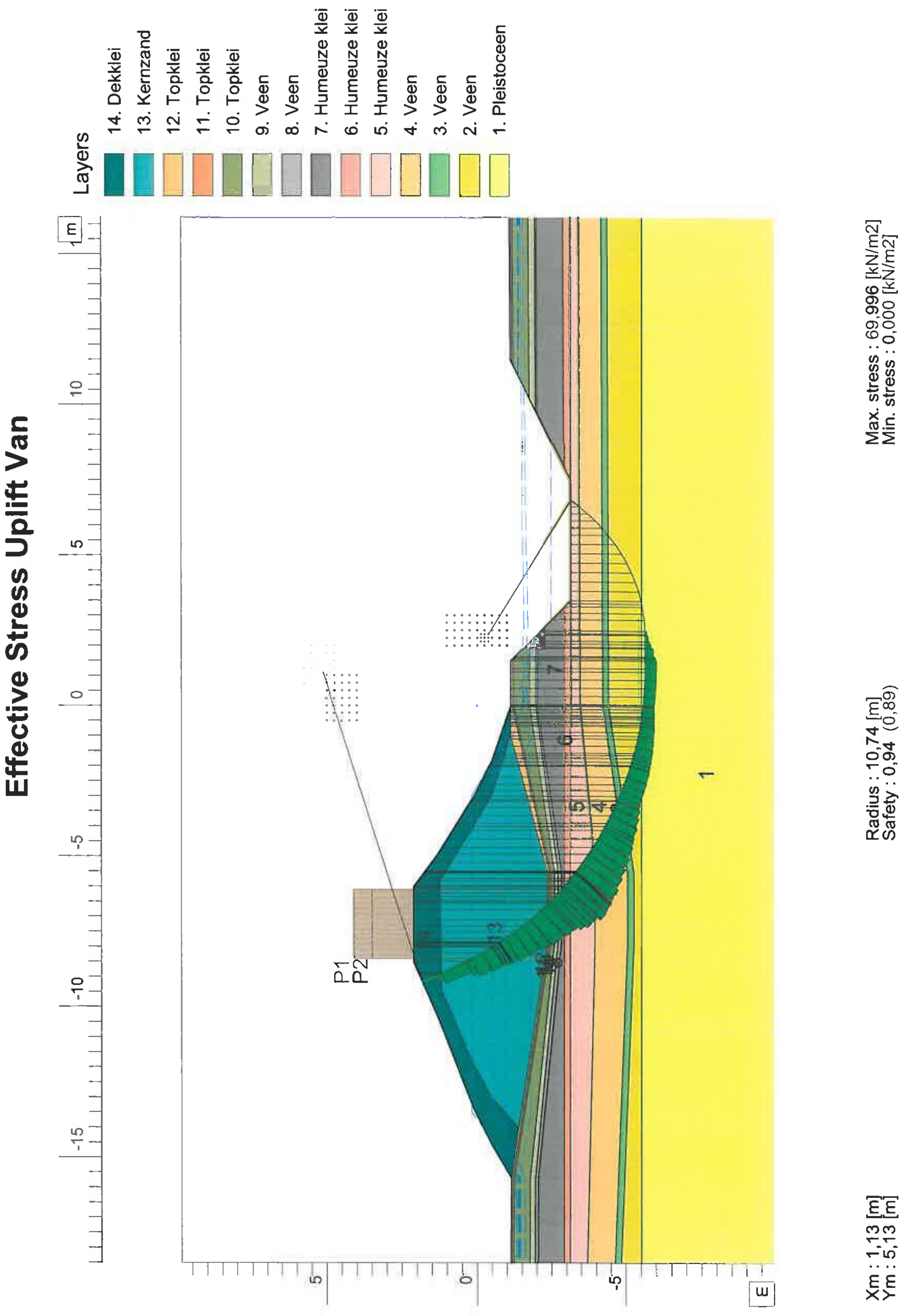
| | | | | 6d |
| | | | | Annex F22 |




D-Geo Stability 10.1 : Zuid 120908-1427 bezwijken B44 Van detailglijvlak.sli

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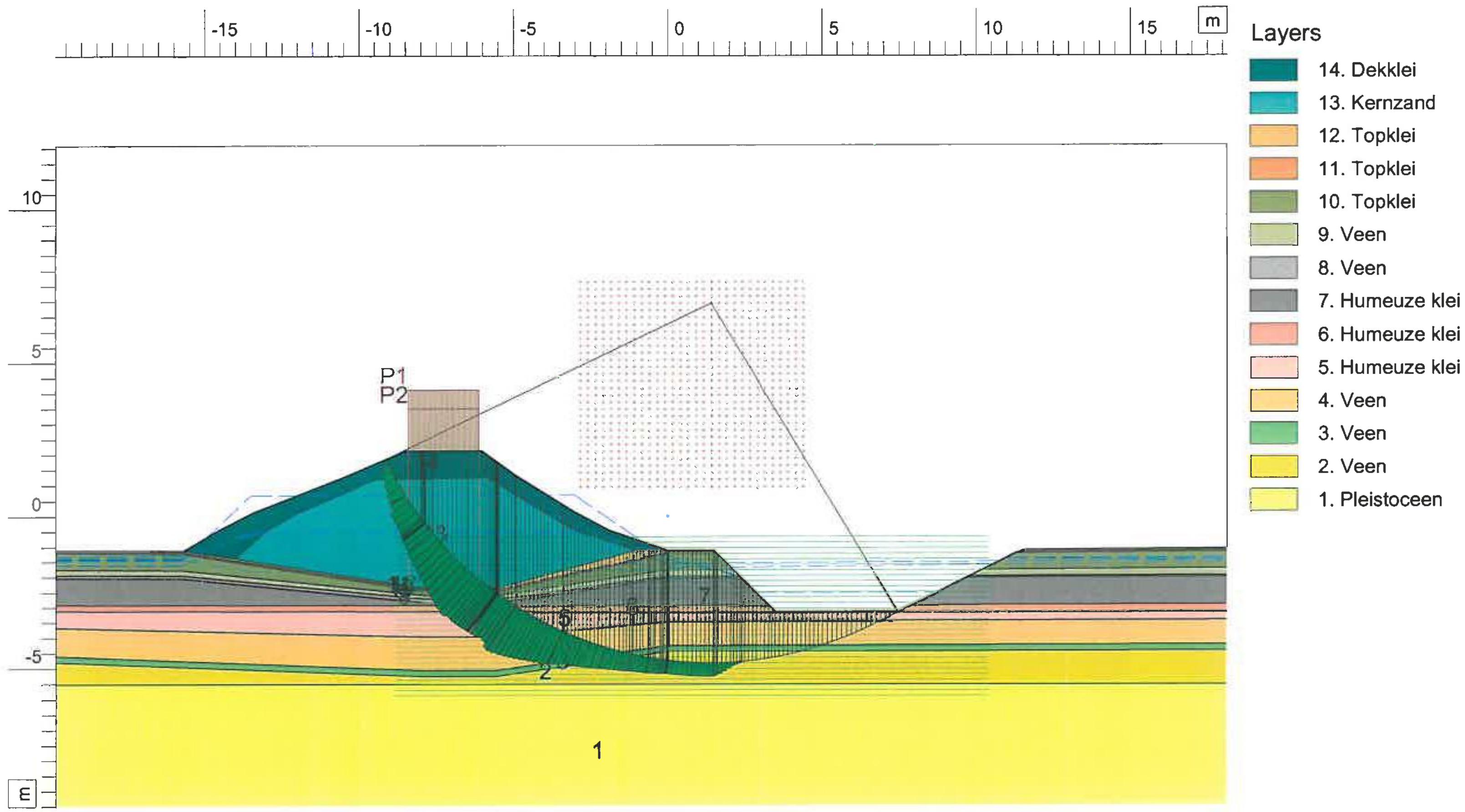
| | | | | 6e |
| | | | | Annex F-23 |

# Effective Stress Bishop




Xm : 1,43 [m]
Ym : 6,92 [m]

Radius : 11,74 [m]
Safety : 0,95

Max. stress : 52,695 [kN/m2]
Min. stress : 0,000 [kN/m2]

D-Geo Stability 10.1 : Zuid 120908-1413 maximale belasting B44 Bishop detailglijvlak.sli

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Phone <Not Registered>
Fax <Not Registered>

date
2013-01-03

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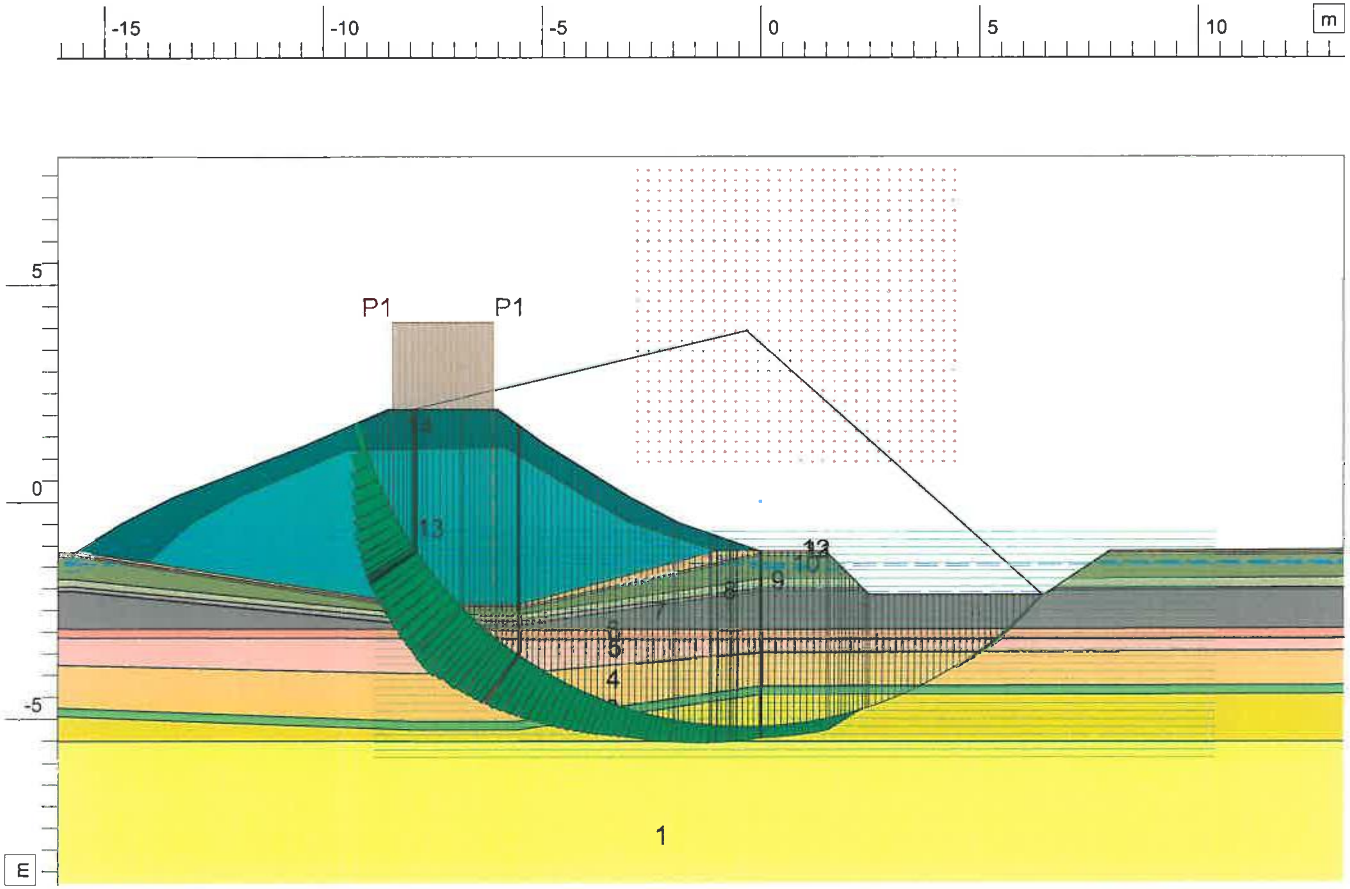
Annex F-24

# Effective Stress Bishop




Layers

- 14. Dekklei
- 13. Kernzand
- 12. Topklei
- 11. Topklei
- 10. Topklei
- 9. Veen
- 8. Veen
- 7. Humeuze klei
- 6. Humeuze klei
- 5. Humeuze klei
- 4. Veen
- 3. Veen
- 2. Veen
- 1. Pleistoceen

Xm : -0,32 [m]
Ym : 3,92 [m]

Radius : 9,10 [m]
Safety : 1,38

Max. stress : 72,972 [kN/m2]
Min. stress : 0,000 [kN/m2]

D-Geo Stability 10.1 : Zuid 120905-0900 voor laatste ontgravingsslap B44 Bishop fijn grid.sti

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Fax <Not Registered>

date
2013-01-03

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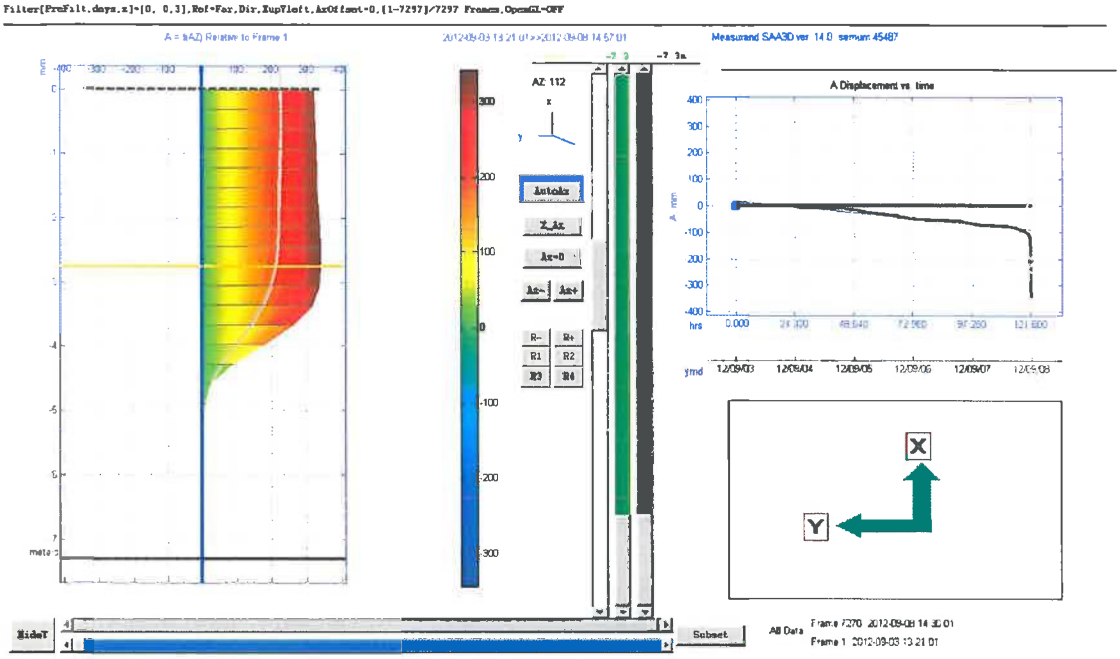
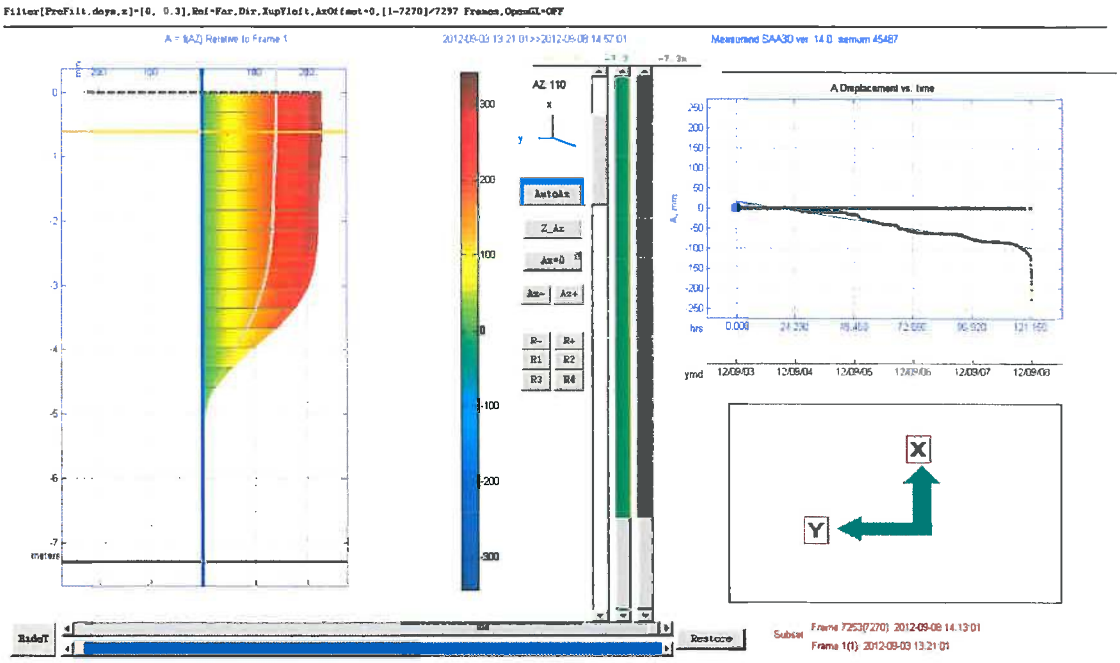
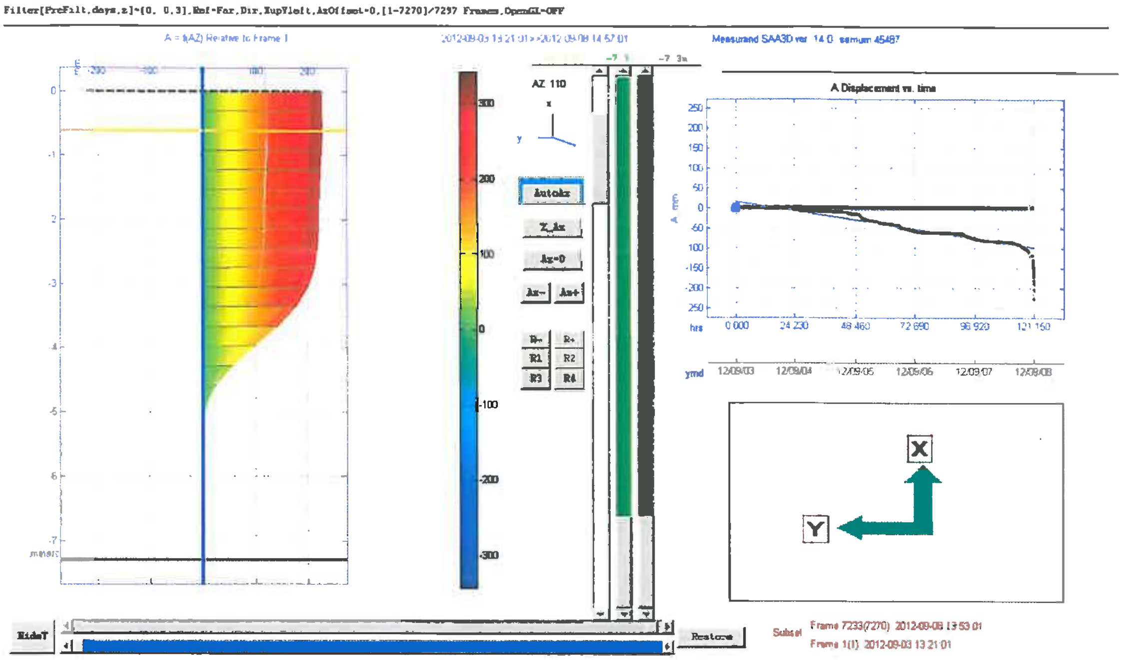
Annex F-25



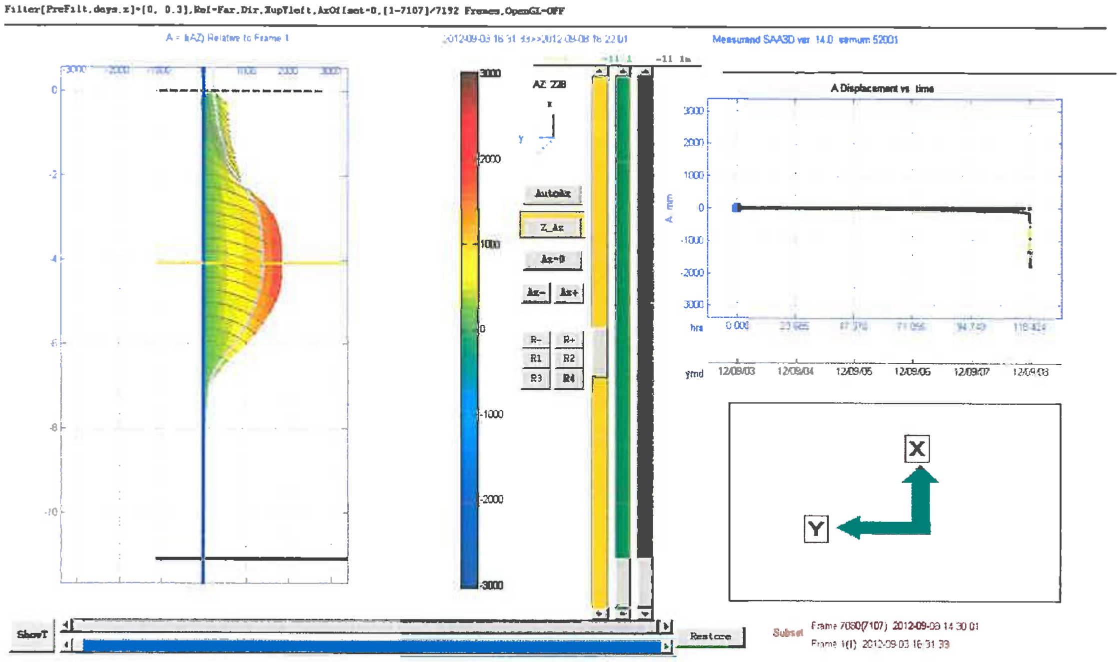

SAAF in East toe total deformation until t=122.75hrs, gray line until t=122.30 hrs



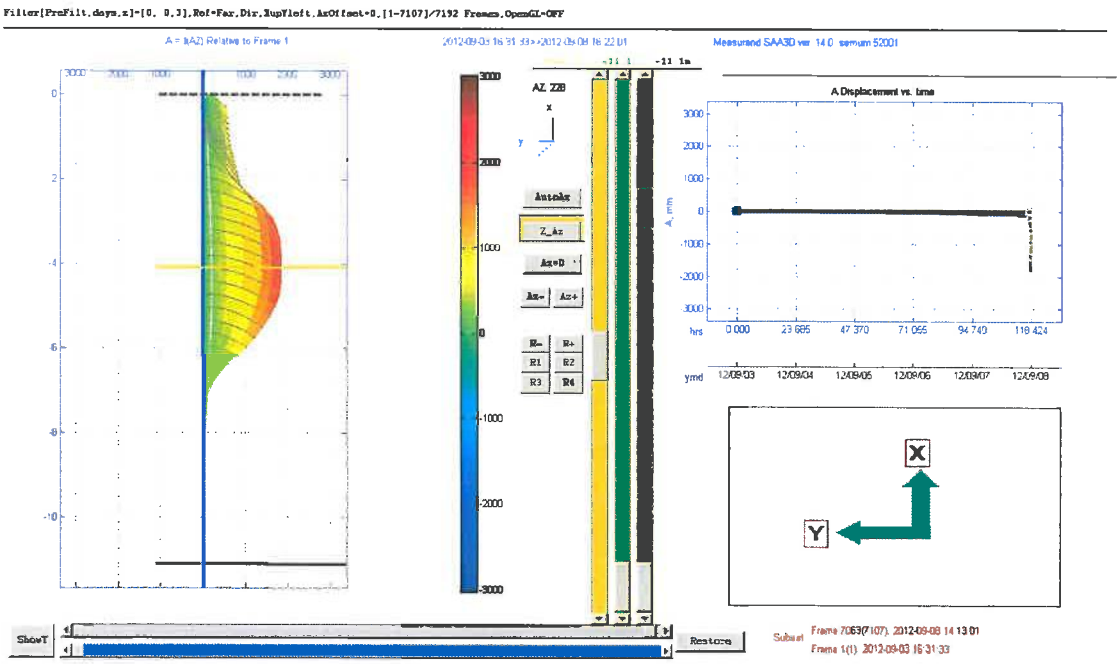

SAAF in East toe total deformation until t=122.30 hrs, gray line until t=122.02 hrs (maximum pore pressure)



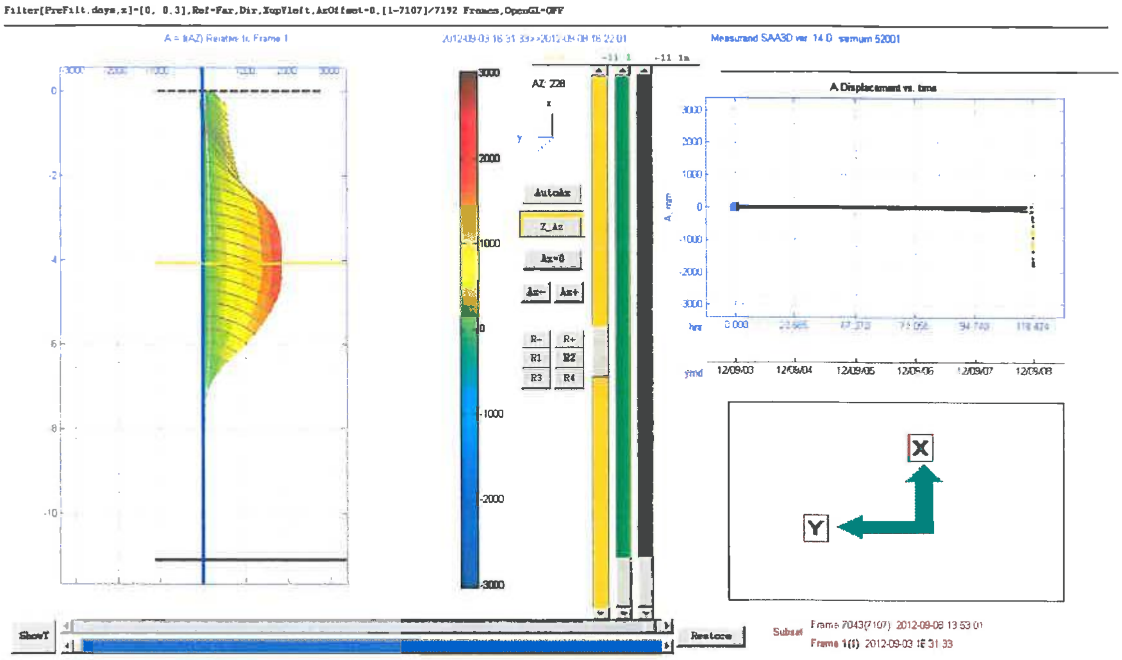

SAAF in East toe total deformation until t=122.30 hrs, gray line until t=121.69 hrs



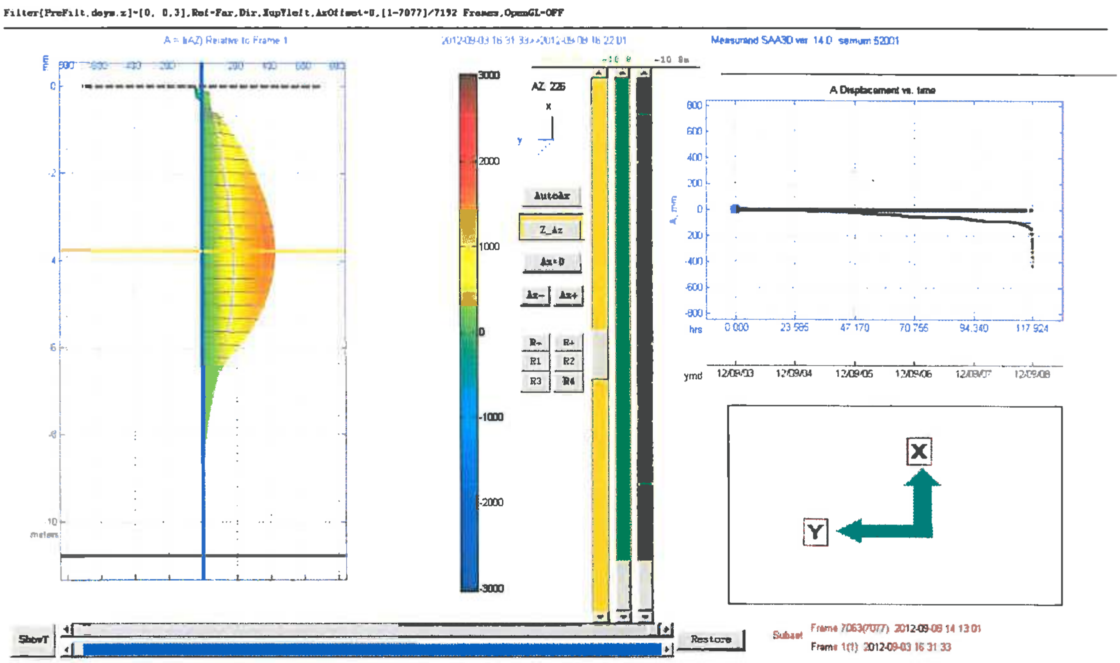
SAAF at middle under crest total deformation until t=122.75hrs, gray line until t=122.30 hrs



SAAF at middle under crest total deformation until t=122.30 hrs, gray line until t=122.02 hrs (maximum pore pressure)

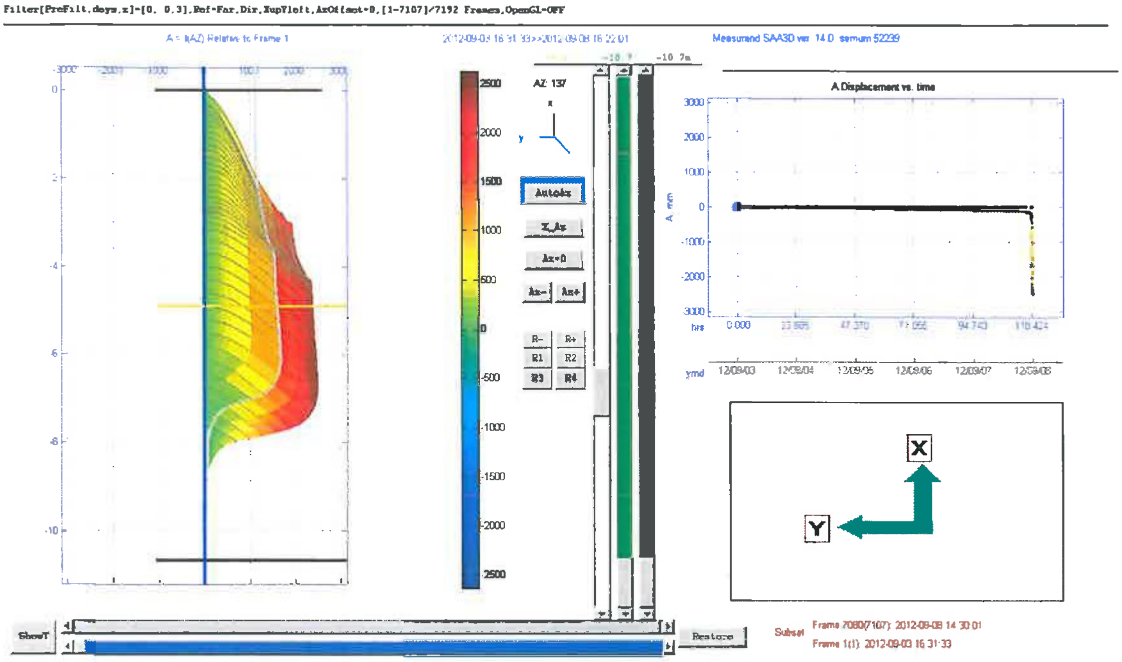



SAAF at middle under crest total deformation until t=122.30 hrs, gray line until t=121.69 hrs

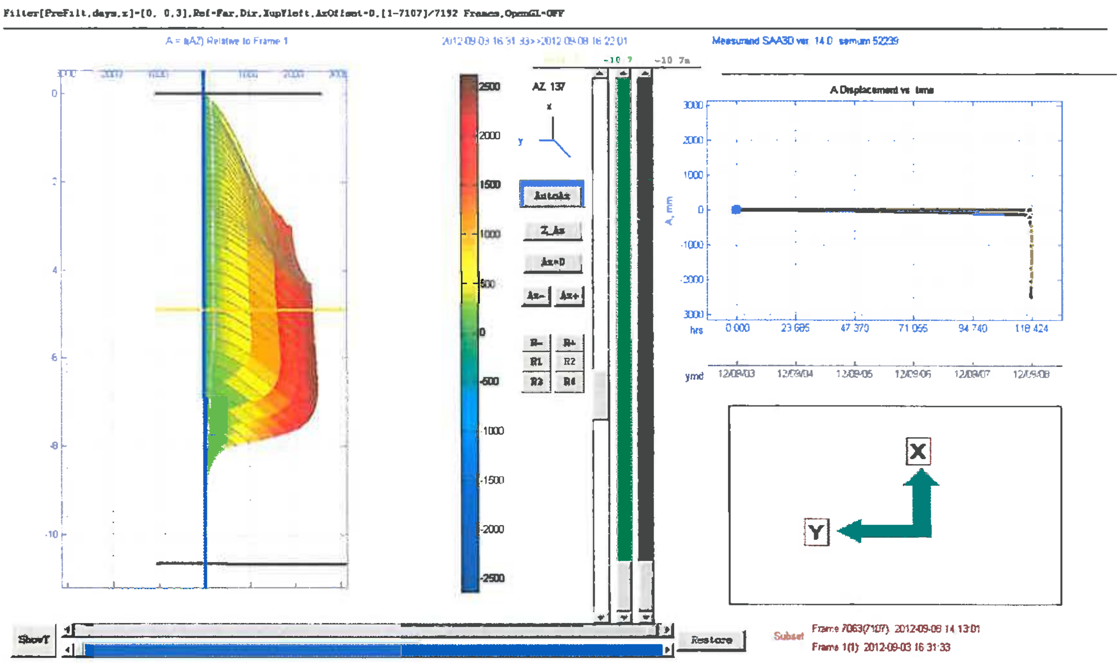



SAAF at middle under crest total deformation until t=122.02 hrs, gray line until t=121.69 hrs

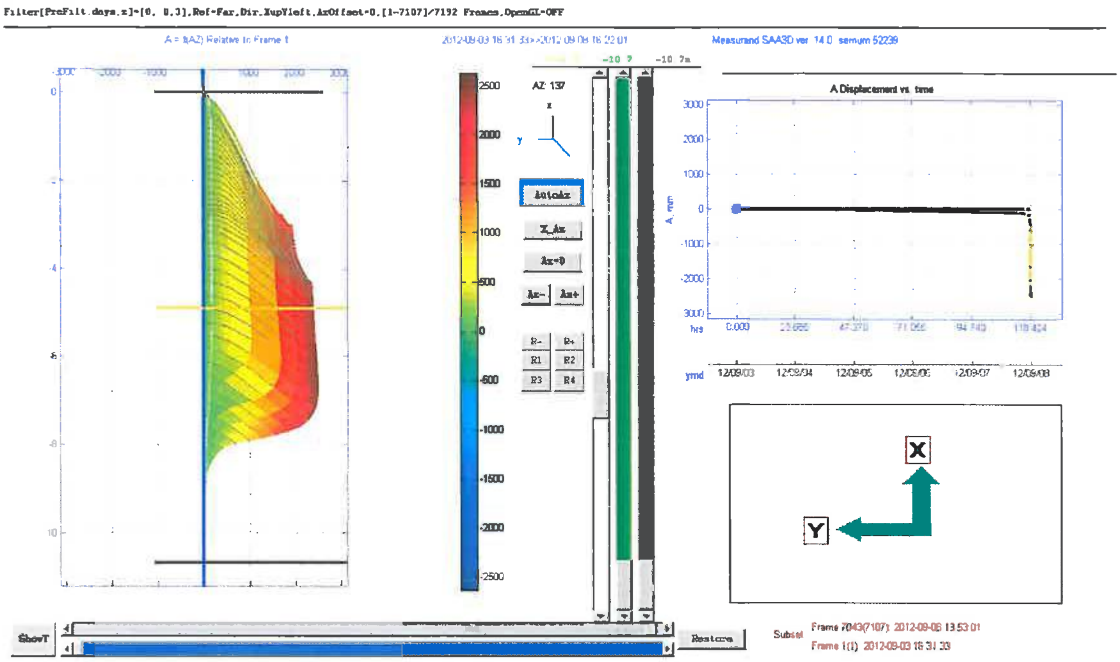
F-29



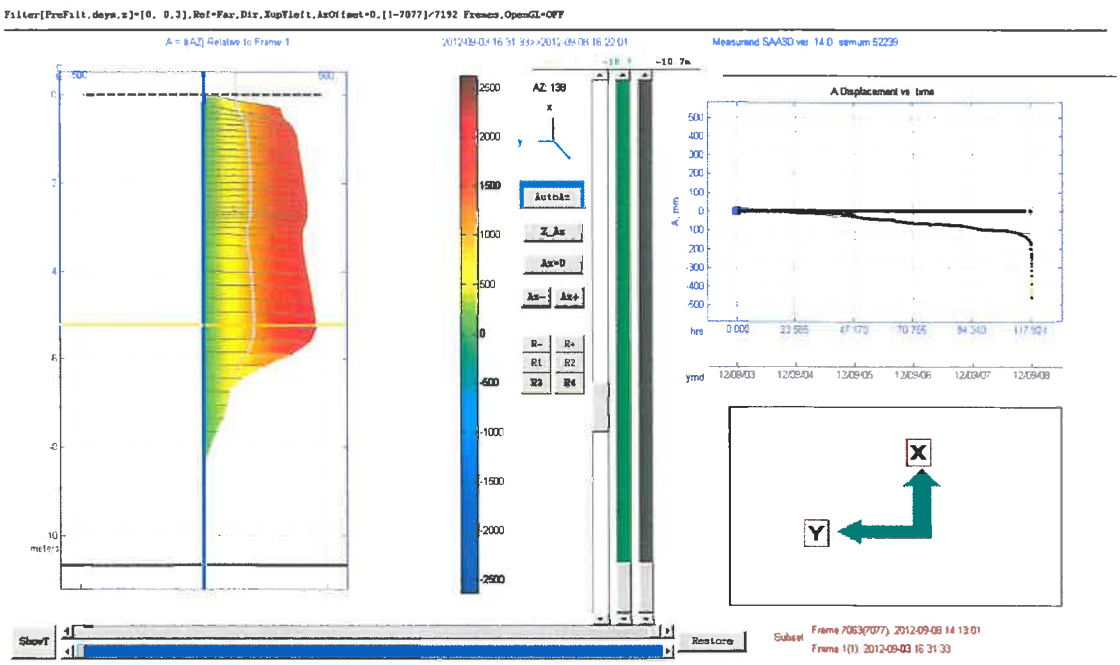
SAAF in front of toe at middle total deformation until t=122.75hrs, gray line until t=122.30 hrs



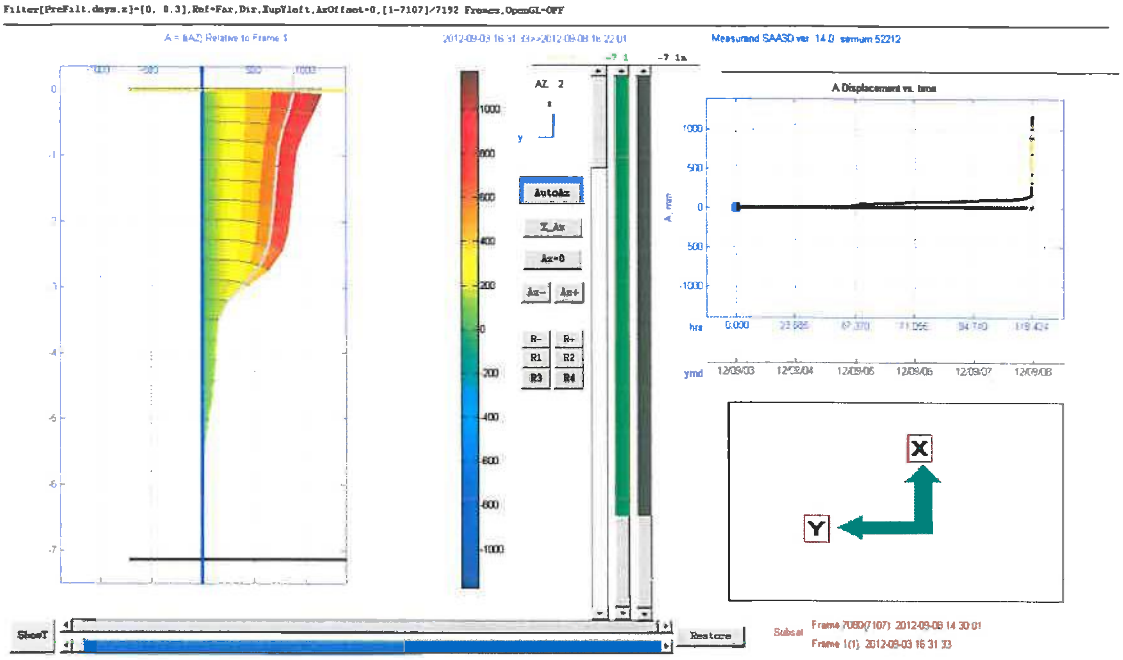
SAAF in front of toe at middle total deformation until t=122.30 hrs, gray line until t=122.02 hrs (maximum pore pressure)



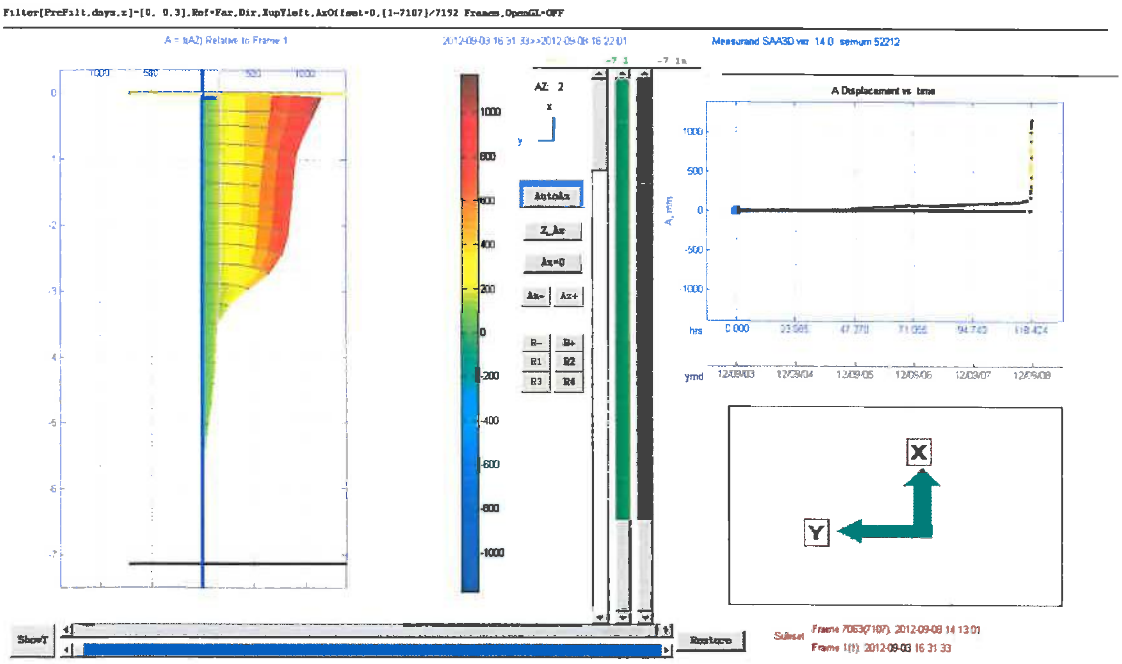

SAAF in front of toe at middle total deformation until t=122.30 hrs, gray line until t=121.69 hrs



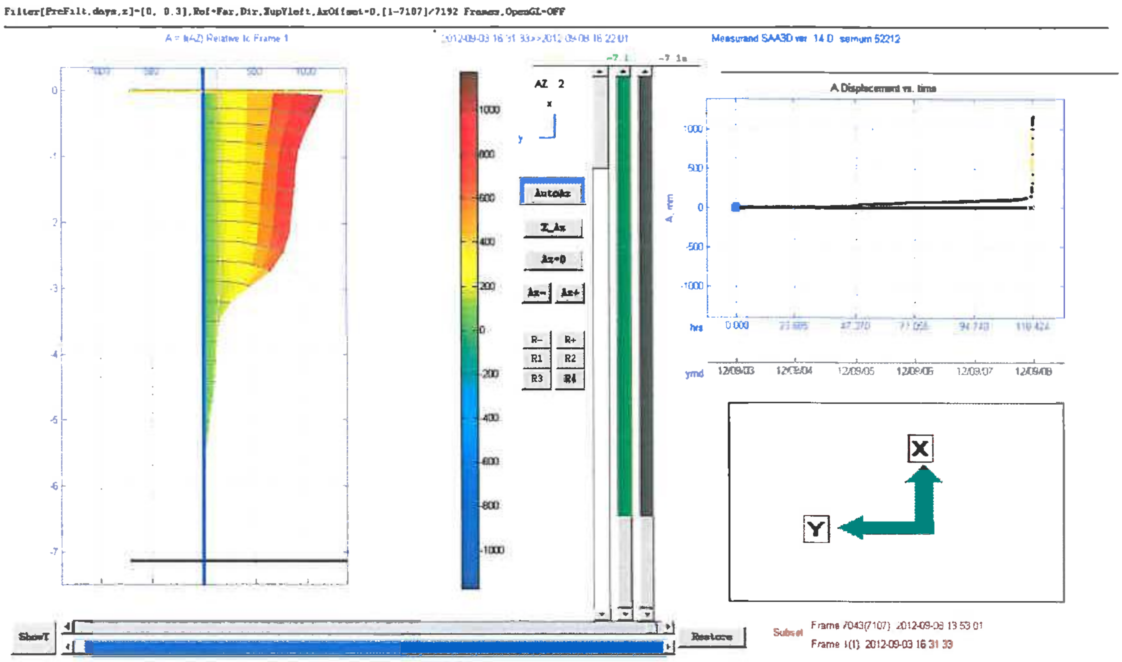

SAAF in front of toe at middle total deformation until t=122.02 hrs, gray line until t=121.69 hrs



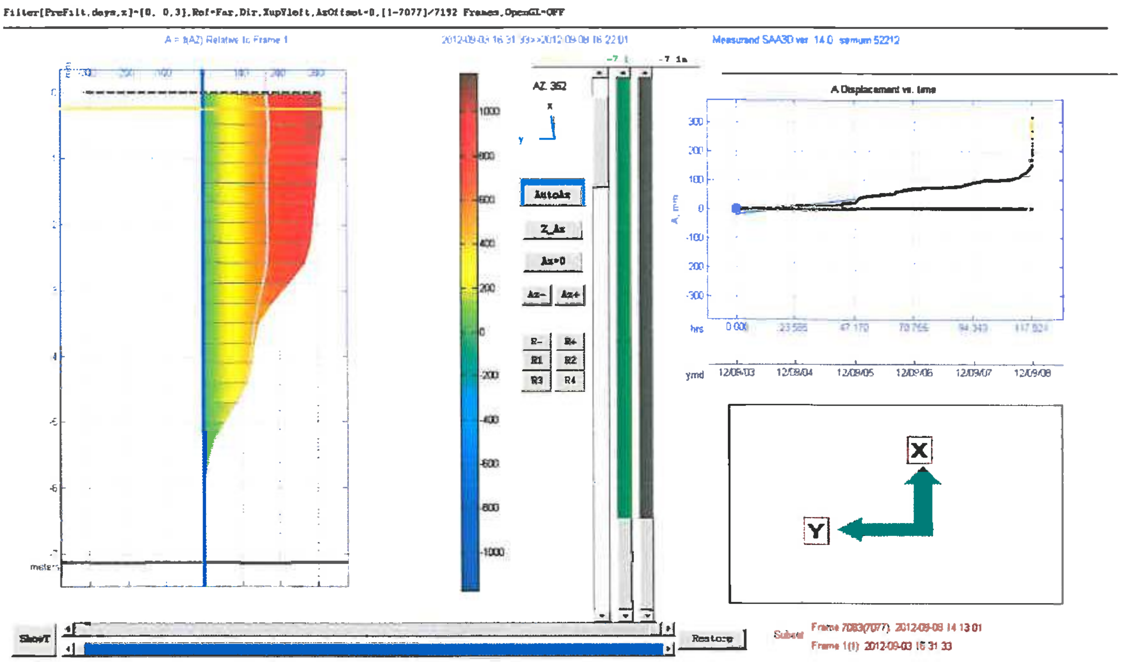

SAAF in front of West toe total deformation until t=122.75hrs, gray line until t=122.30 hrs




SAAF in front of West toe total deformation until t=122.30 hrs, gray line until t=122.02 hrs (maximum pore pressure)

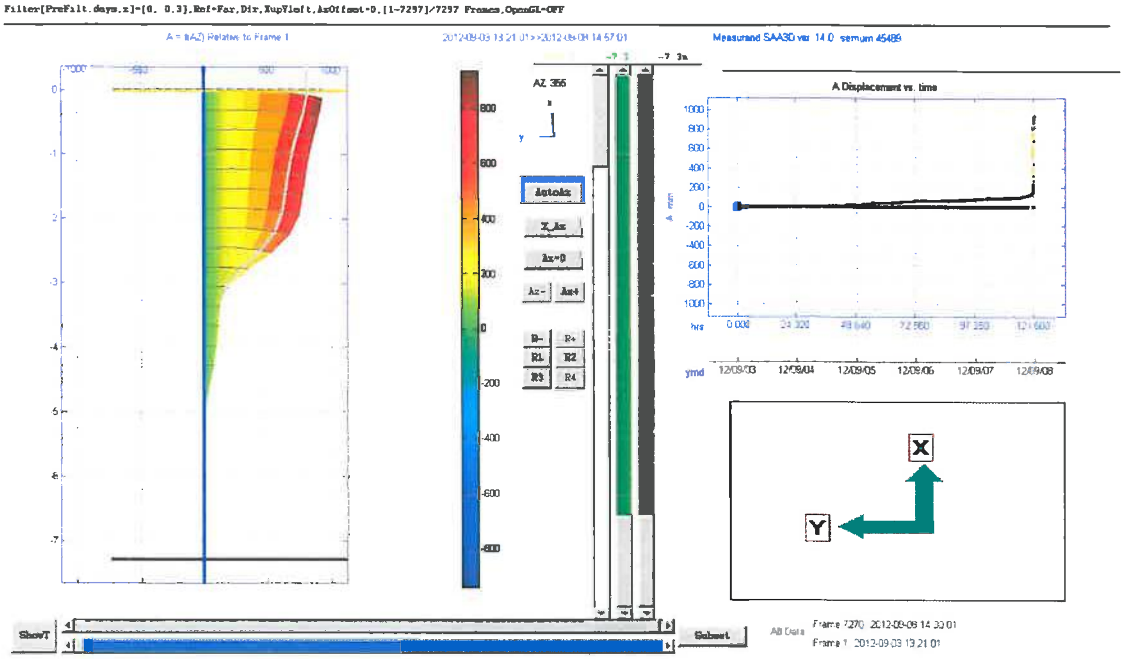


SAAF in front of West toe total deformation until t=122.30 hrs, gray line until t=121.69 hrs

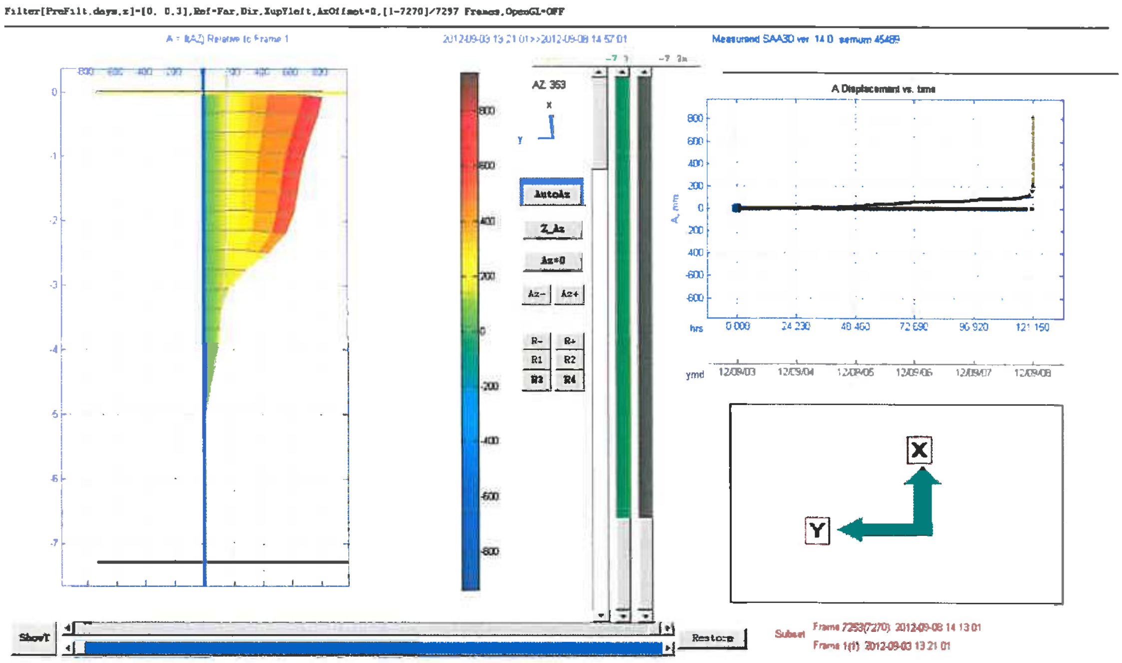


SAAF in front of West toe total deformation until t=122.02 hrs, gray line until t=121.69 hrs

F-33

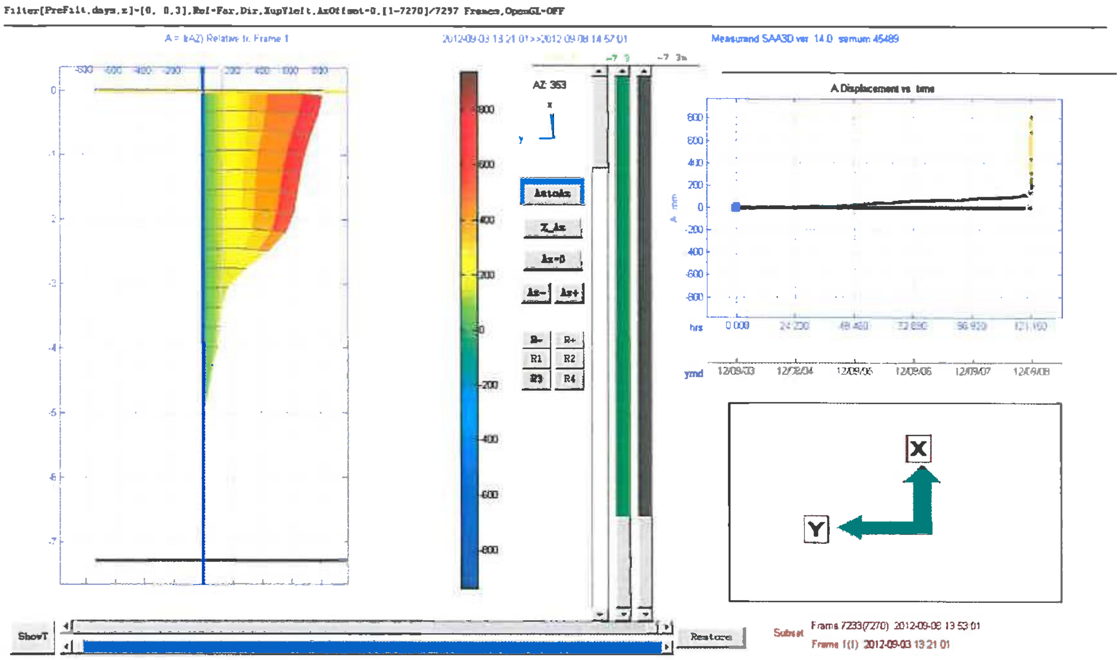



SAAF in West toe total deformation until t=122.75hrs, gray line until t=122.30 hrs

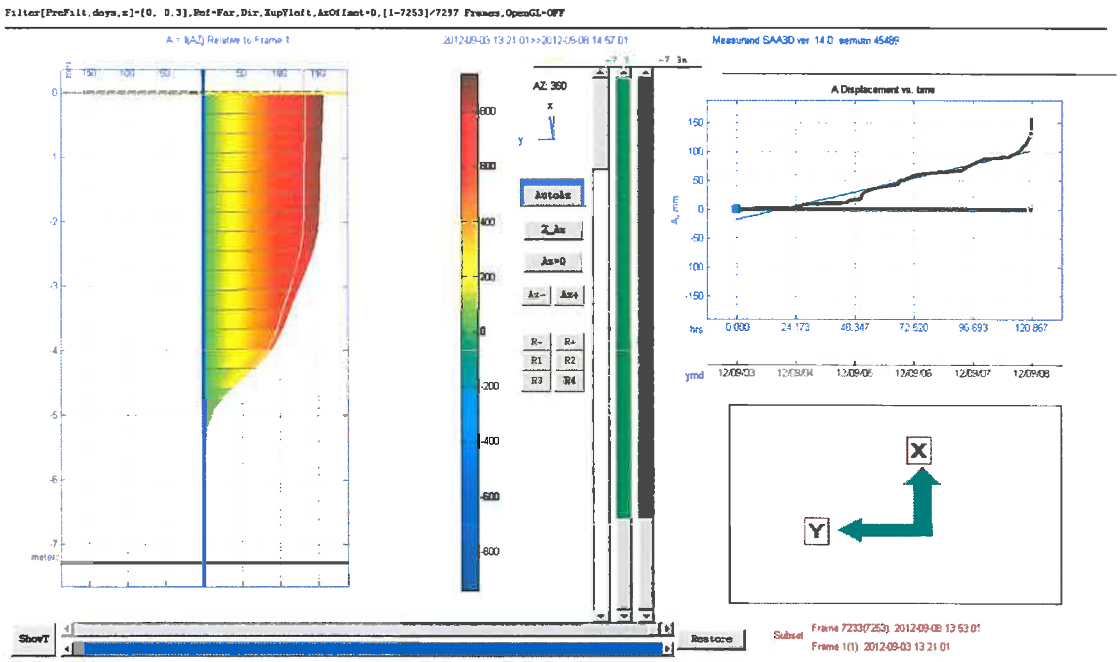



SAAF in West toe total deformation until t=122.30 hrs, gray line until t=122.02 hrs (maximum pore pressure)

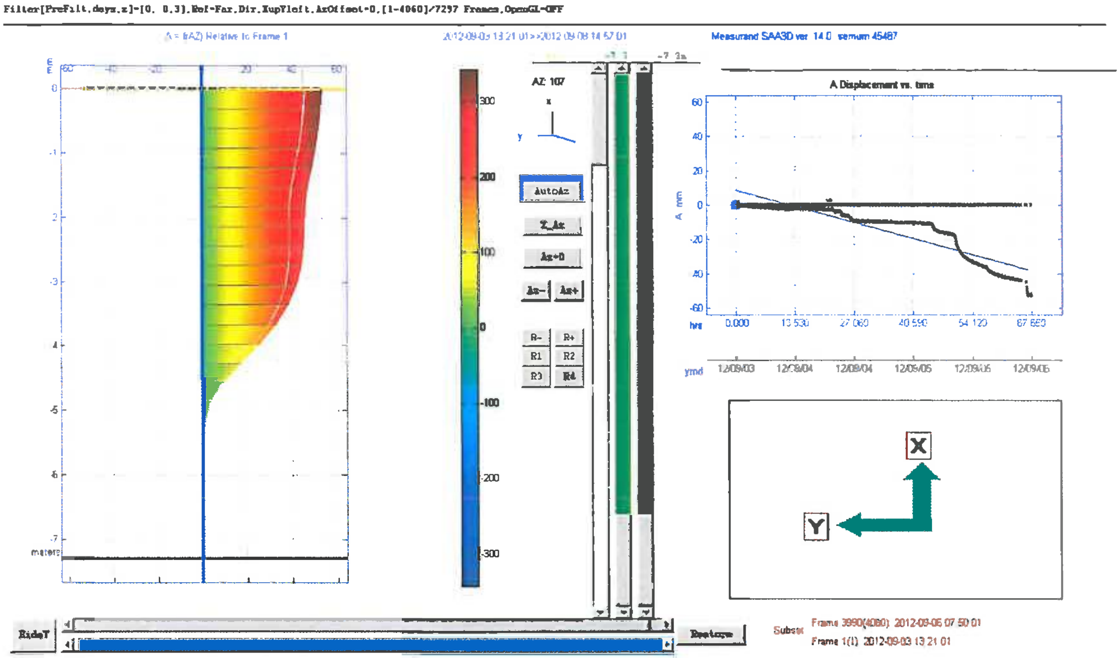
F-34



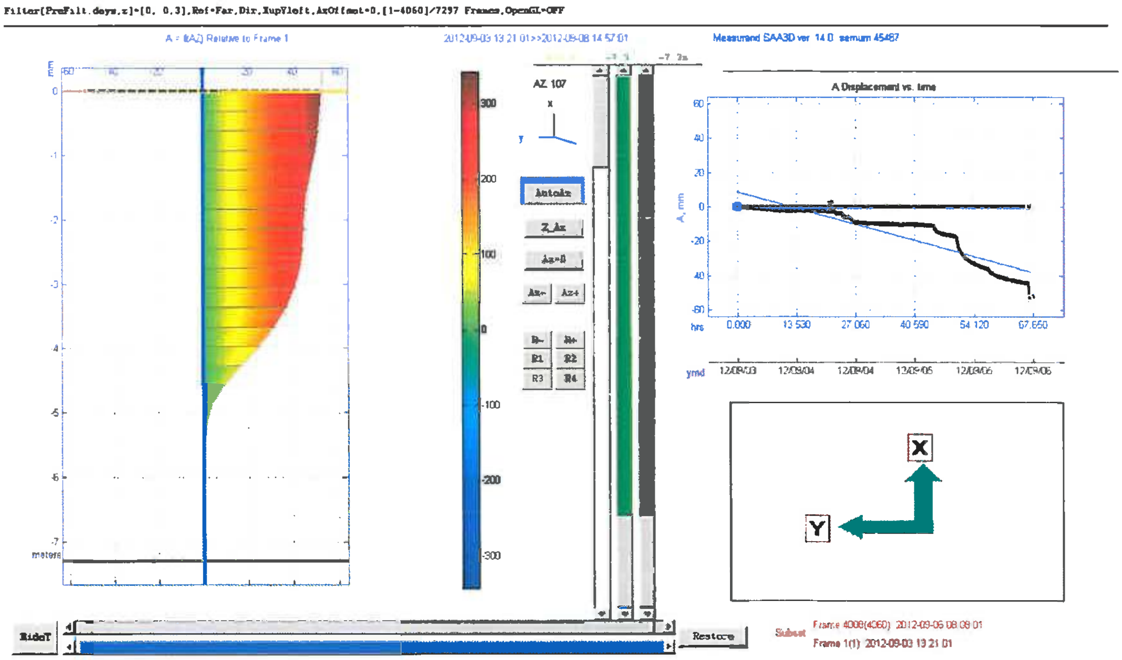
SAAF in West toe total deformation until t=122.30 hrs, gray line until t=121.69 hrs



SAAF in West toe total deformation until t=122.02 hrs, gray line until t=121.69 hrs

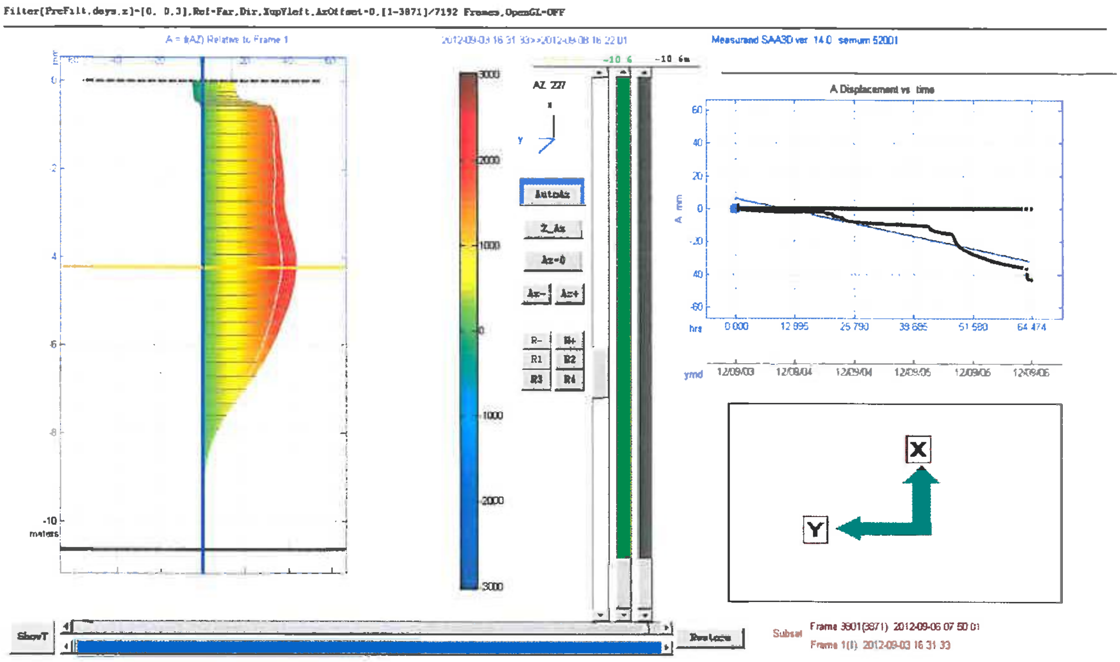



SAAF in East toe total deformation until t=68.80 hrs, gray line until t=67.63 hrs

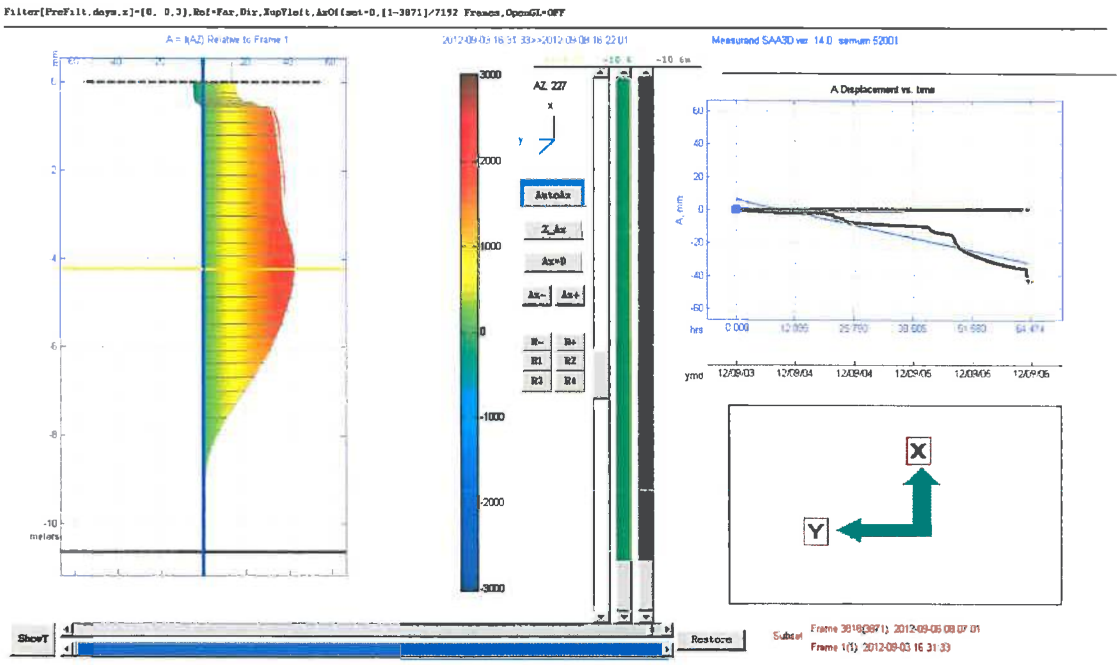



SAAF in East toe total deformation until t=68.80 hrs, gray line until t=67.93 hrs

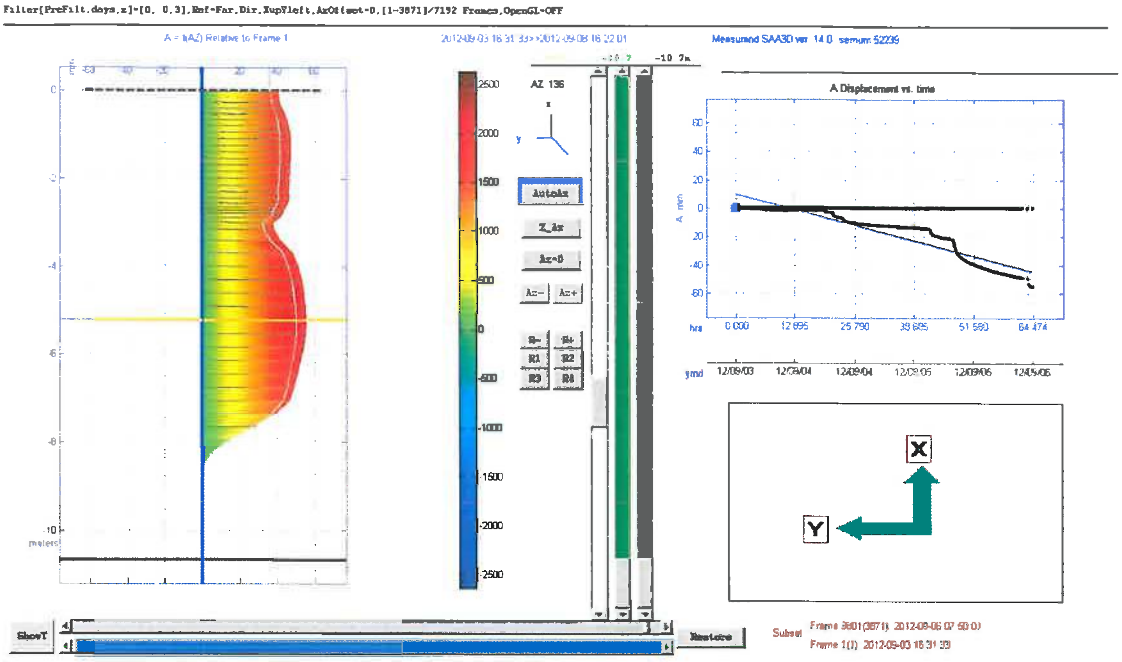
F-36



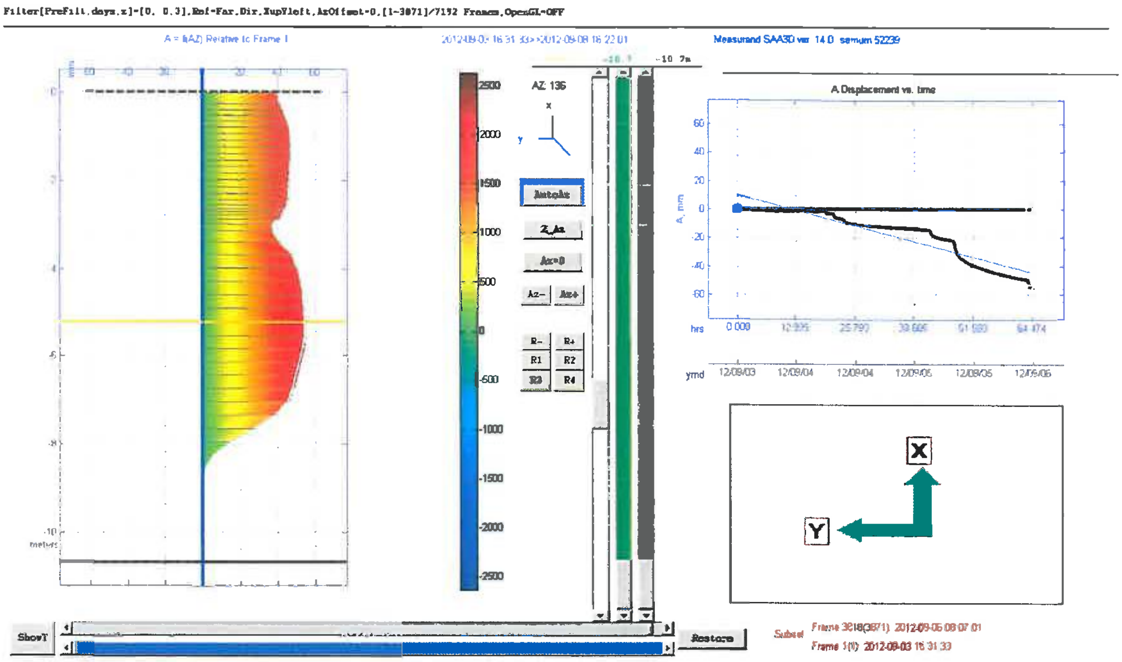
SAAF at middle under crest total deformation until t=68.80 hrs, gray line until t=67.63 hrs



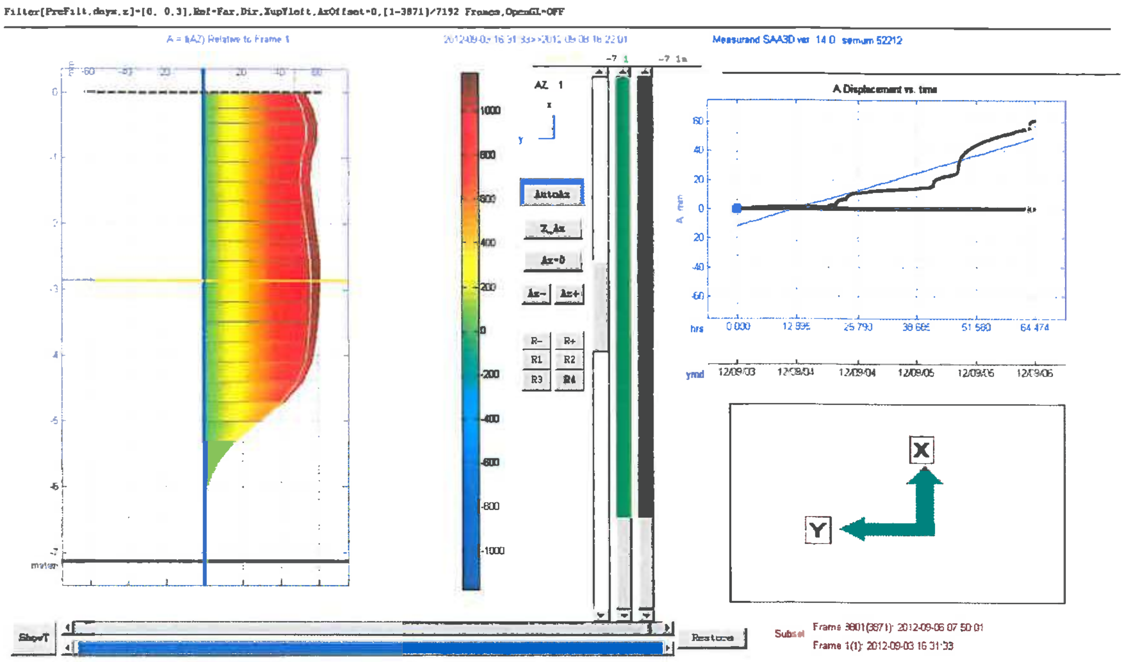
SAAF at middle under crest total deformation until t=68.80 hrs, gray line until t=67.92 hrs



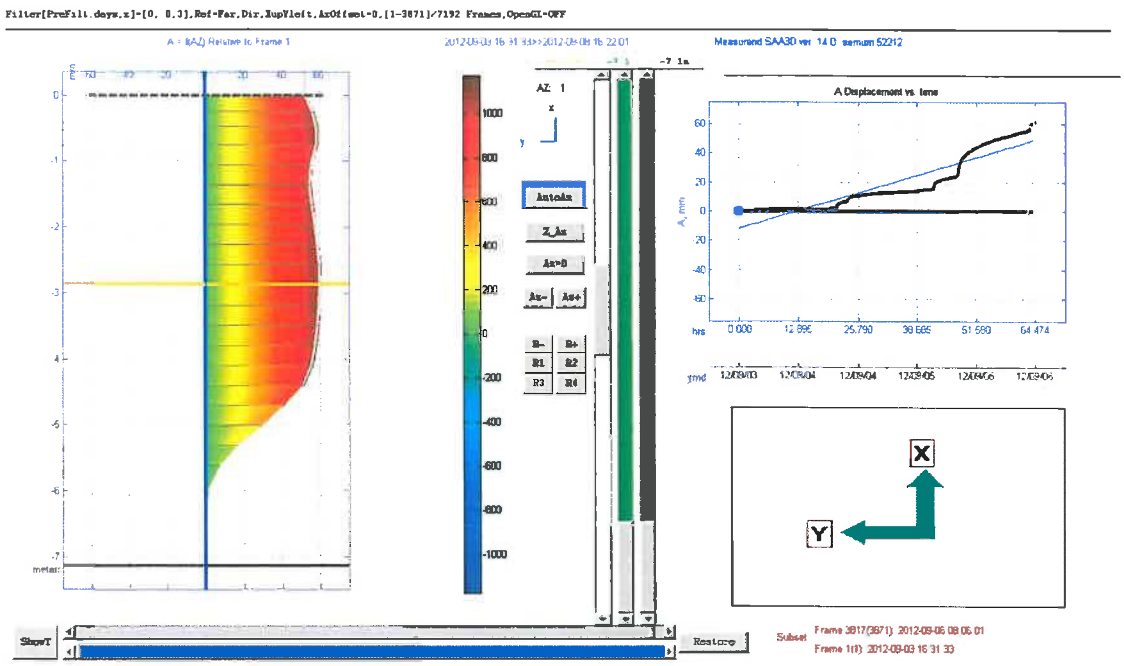

SAAF in front of toe at middle total deformation until t=68.80 hrs, gray line until t=67.63 hrs




SAAF in front of toe at middle total deformation until t=68.80 hrs, gray line until t=67.92 hrs

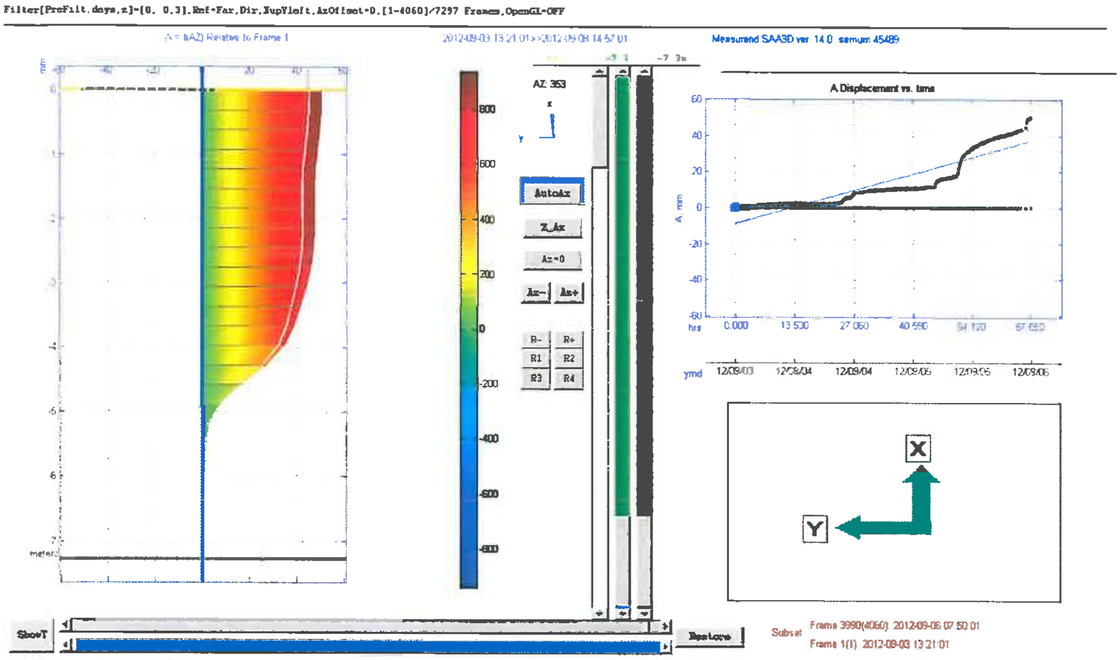


SAAF in front of West toe total deformation until t=68.80 hrs, gray line until t=67.63 hrs

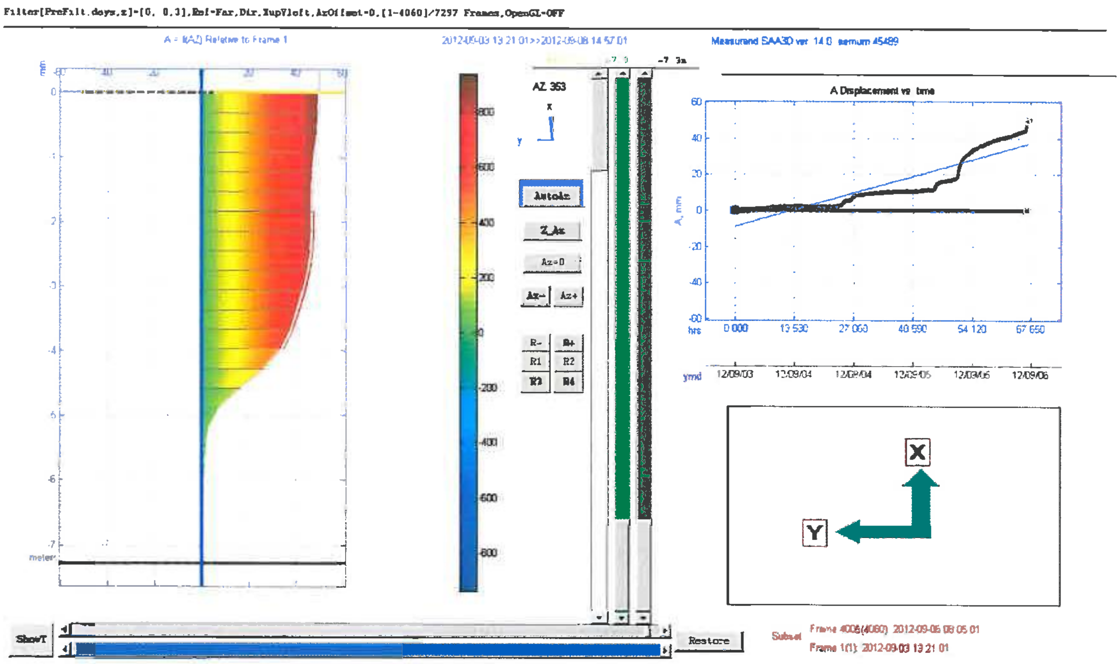


SAAF in front of West toe total deformation until t=68.80 hrs, gray line until t=67.90 hrs

F-39



SAAF in West toe total deformation until t=68.80 hrs, gray line until t=67.63 hrs



SAAF in West toe total deformation until t=68.80 hrs, gray line until t=67.88 hrs

# APPENDIX 7 : SHORT DICTIONARY

**Dutch to English vocabulary**
Note: only valid within the context of this report.

| | |
|---|---|
| afstand (vanaf) | distance (from) |
| automatische meting | automatic measurement |
| benedenstrooms | downstream |
| bovenstrooms | upstream |
| debiet | discharge, flow |
| handmatige meting | manual measurement |
| kruin | crest |
| niveau | level |
| raai | row |
| rij | line |
| sloot | ditch |
| teen | toe |
| tijd | time |
| uur | hour |
| verhang | gradient |
| verval | head, head drop |
| waterniveau | water level |
| waterspanning | pore pressure |
| waterspanningsmeter (wsm) | pre pressure meter |
| wel | well |
| stilgevallen - | stopped |
| watervoerende - | carrying water |
| zandmeevoerende - | carrying sand |
| zand | sand |
| zandkern | sand core |