

# **Three Kings Quarry**

## **28 August 2017 – Site Liaison Group Meeting**

### **Site Monitoring Report**



# August 2017 Site Monitoring Report

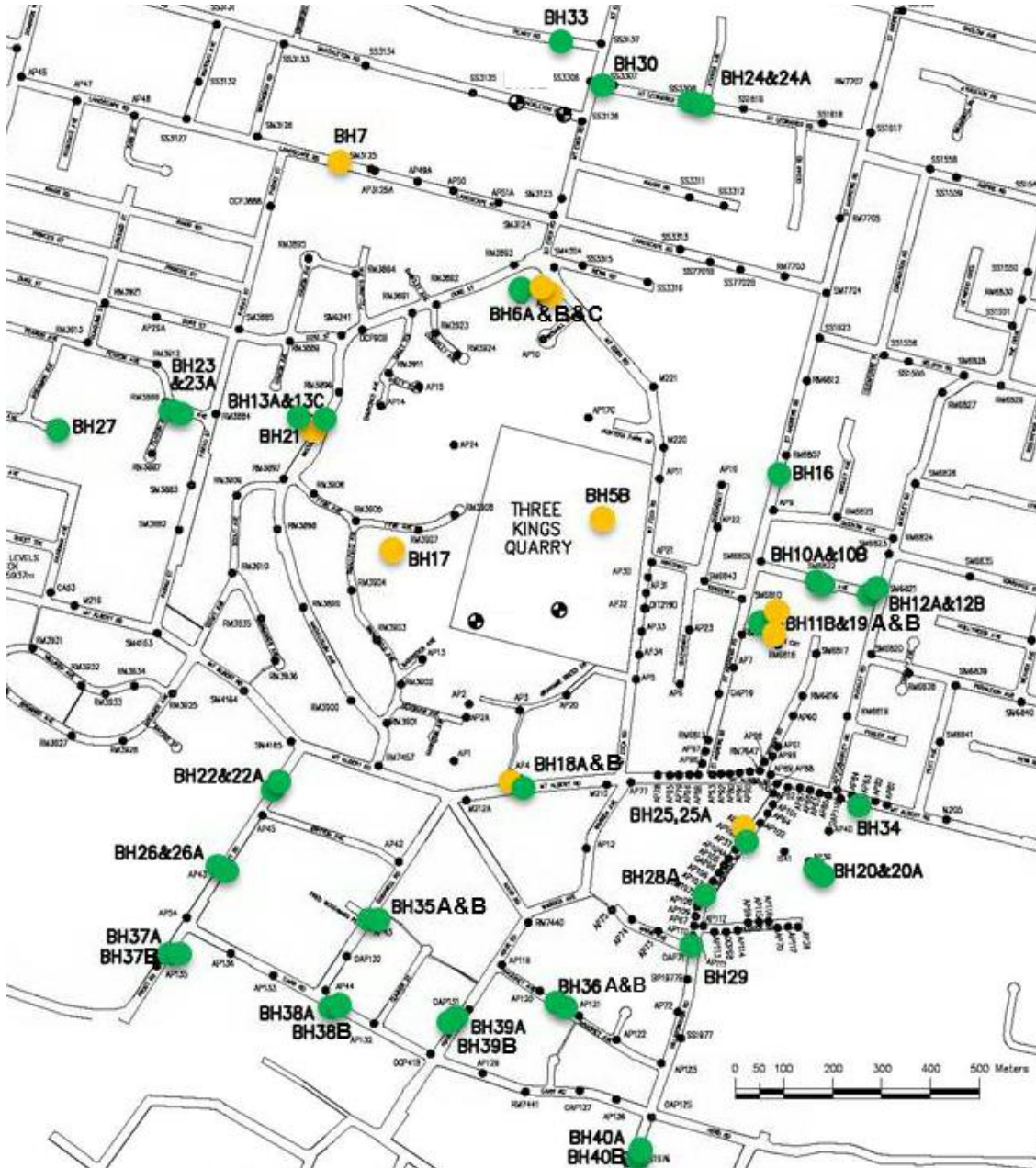
This Site Monitoring Report is a summary of environmental monitoring data collected since the last Site Liaison Group meeting and includes:

- Groundwater Level Monitoring Results
- Groundwater Chemistry Monitoring Results
  - Air Quality Monitoring Results
    - Noise Monitoring
  - Precise Level Survey

## Groundwater Level Monitoring

- Dewatering of Three Kings Quarry commenced in March 1999
- Groundwater levels within Three Kings Quarry have been held above RL34m since October 2002
- Groundwater levels are currently being measured monthly in 51 boreholes and piezometers located in and around Three Kings Quarry
- Groundwater levels are generally following seasonal trends

## Borehole Location Plan with July 2017 Groundwater Levels Included



## LEGEND

- 34 – 36 RL m
- 36 – 45 RL m
- >45 RL m

# Groundwater Chemistry Monitoring

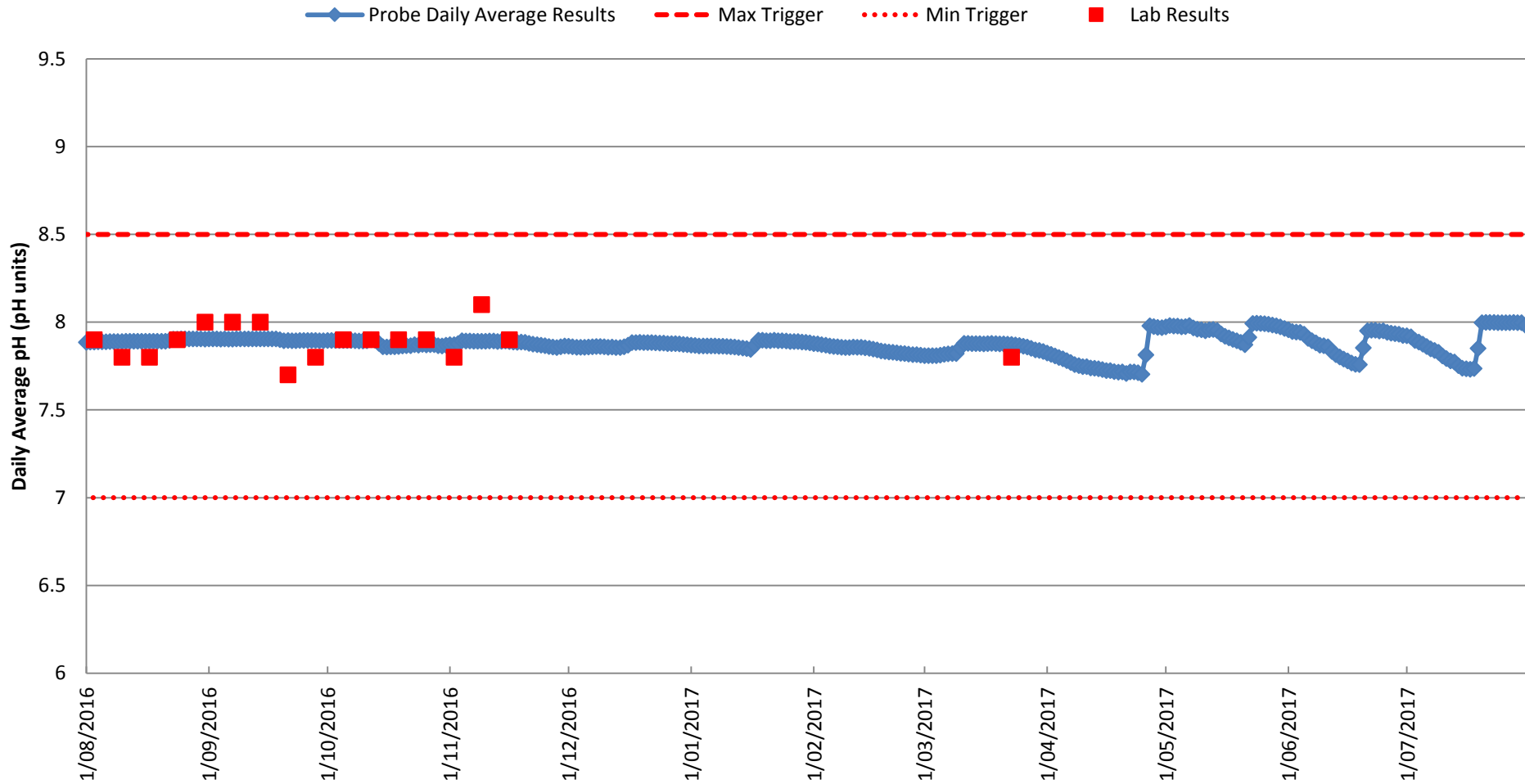
- Monitoring of Groundwater Chemistry commenced in December 2011 following the granting of Resource Consents to fill Three Kings Quarry.
- Samples were taken at three monthly intervals from the Pumping Bore within Three Kings Quarry and from BH 7 on Landscape Road for analysis of a suite of chemical parameters for the first 2 years of monitoring.
- Following 2 years of monitoring, samples for chemical analysis are required to be taken at 6 monthly intervals from the Pumping Bore within Three Kings Quarry and from BH 7 on Landscape Road (March and September).
- The next round of groundwater chemistry sampling is scheduled for September 2017.

# Continuous Groundwater Quality Monitoring

- Continuous monitoring of electrical conductivity (EC) and pH is required to be undertaken in the Three Kings Quarry pumping bore.
- New pH & EC probes were installed at the Three Kings Quarry pumping bore in August 2015.
- The pH & EC probes are calibrated quarterly by an external technician and the pH electrode has been replaced annually in July 2016 and July 2017.
- The downward spikes in the EC recorded in October 2016 and June/July 2017 were both investigated and found to be a result of too high a flow in the sampling vessel.

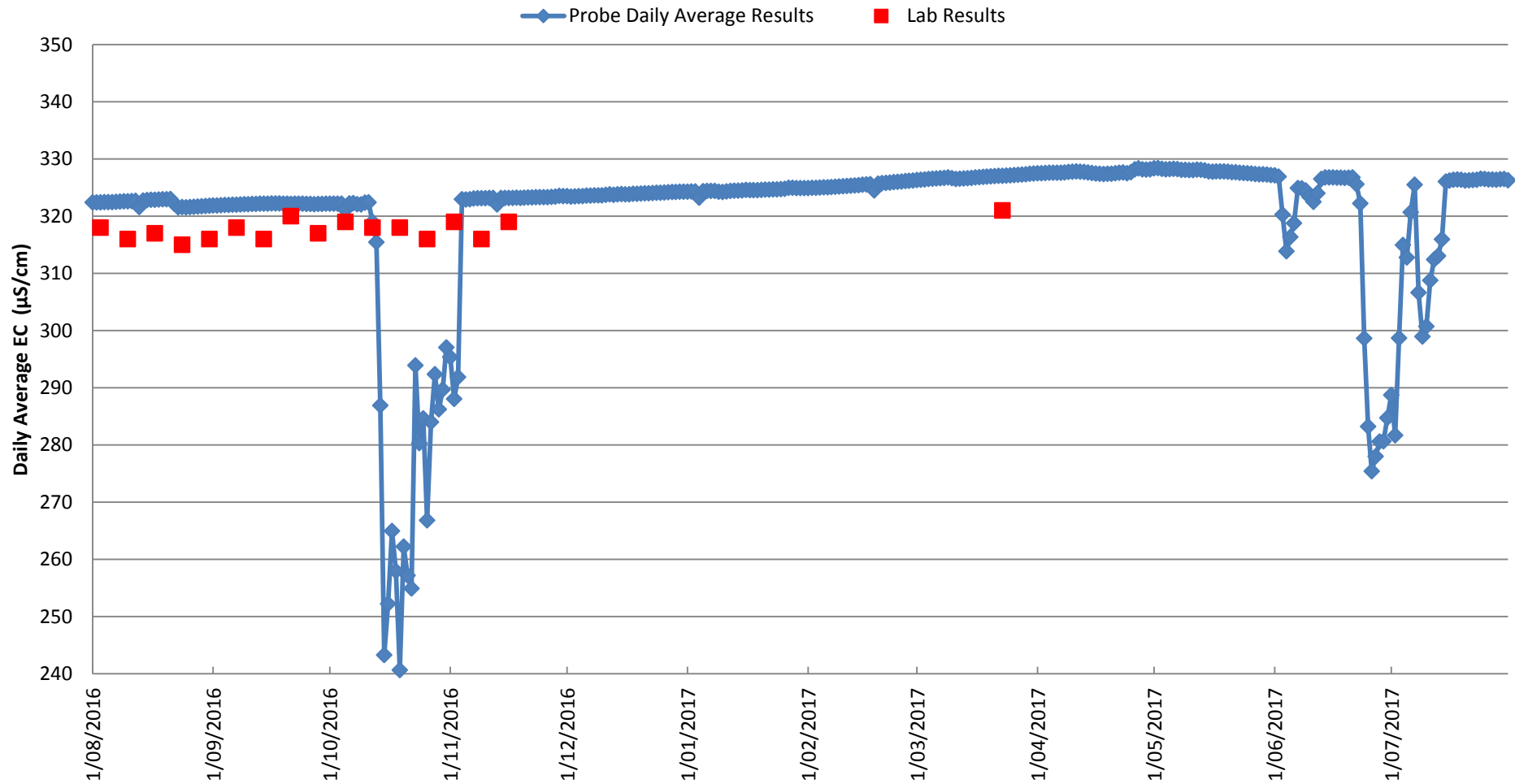
# Continuous Groundwater Quality Monitoring

## Average Daily pH Graph



# Continuous Groundwater Quality Monitoring

## Average Daily EC Graph

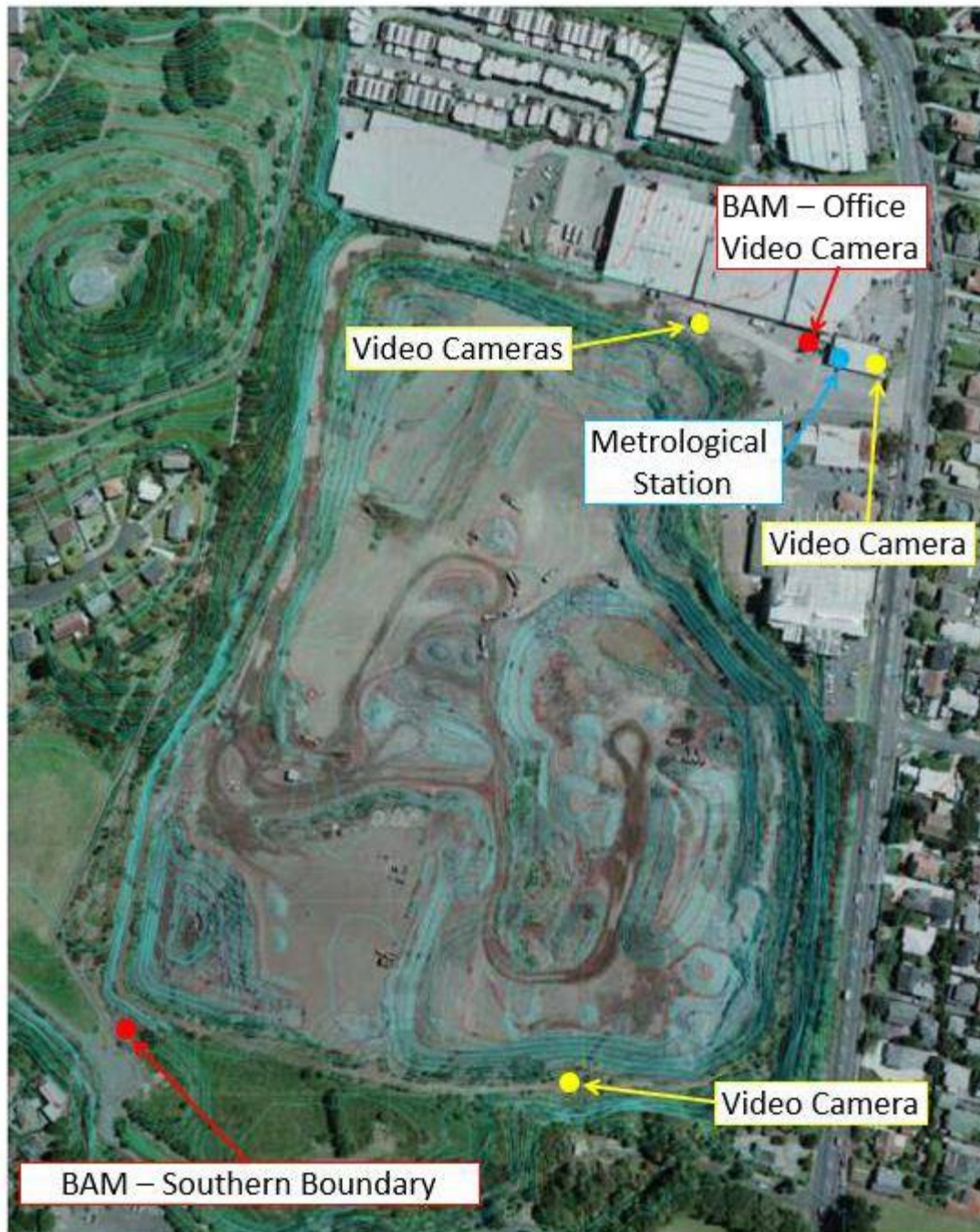




# Air Quality Monitoring

- Air Quality Monitoring equipment at Three Kings Quarry consists of two Continuous Real Time Beta Attenuation Monitors (BAM), time lapse video cameras and a metrological station
- The BAM monitor located on the roof of the site office has been operating since April 2008. A second BAM monitor was commissioned in April 2012 in the south-western corner of Three Kings Quarry
- The Air Discharge Consent for Three Kings Quarry was renewed in February 2015.
- The air quality trigger was changed from 80 micrograms per cubic metre as a 24hour average (all results) to 60 micrograms per cubic metre as a 24hour average as measured by the BAM units.

# Air Quality Monitoring Equipment



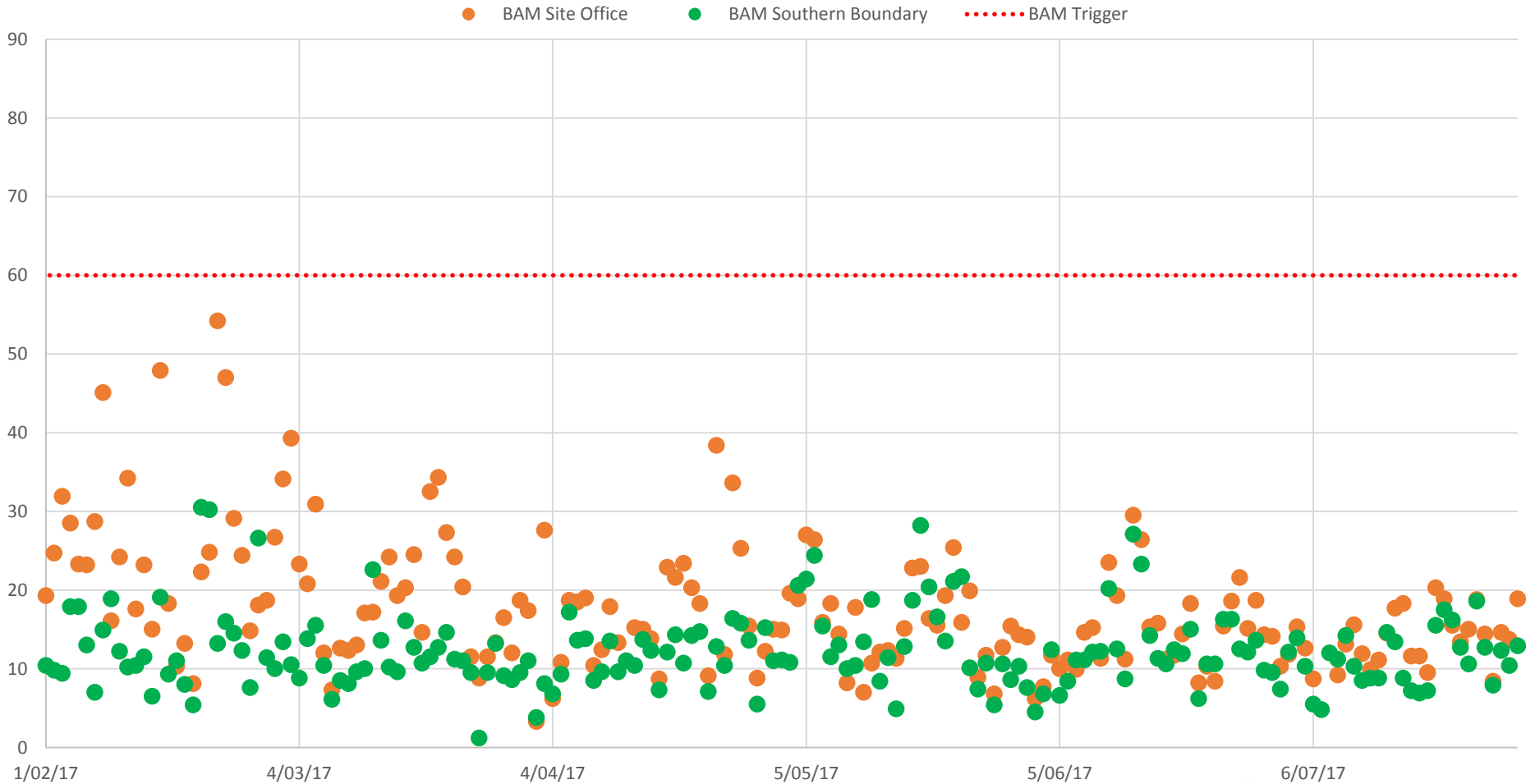
# Air Quality Monitoring Results

- Continuous air quality monitoring results recorded since the last SLG meeting have been less than 30 micrograms per cubic meter as a 24 hour average
- No air quality triggers have been recorded since the last SLG meeting.

# Air Quality Monitoring Results

The following figure shows air monitoring results from 1<sup>st</sup> February to 31<sup>st</sup> July 2017.

All results are in  $\mu\text{g}/\text{m}^3$ .



# Noise Monitoring

- To ensure that the noise performance standards set in the District Plan and consents authorising filling are met, monitoring on two representative occasions per year is undertaken.
- The District Plan requires that the noise from the quarry and fill operations shall not exceed  $L_{A10}55\text{dBA}$  at or within the boundary of any residential property
- Noise monitoring was undertaken on the 20<sup>th</sup> June 2017 by Marshall Day Acoustics Ltd.
- The cumulative acoustic emission from fill operations resulted in sound levels which complied with the relevant noise rules for quarry operations at both the Fyvie Avenue measurement position and the Grahame Breed Drive position.

# Precise Level Survey

- A precise level survey of survey marks surrounding Three King Quarry is undertaken annually.
- The 2017 precise level survey was undertaken in March-April 2017, results were received in May.
- The survey marks extend from Dominion Road to the Royal Oak roundabout, from Watling Street to Carr Road.
- 267 survey marks were surveyed in the 2017 survey.









# Precise Level Survey Results

- With the exception of one survey mark on Landscape Road, all survey marks were within 5mm of the 2016 annual survey.
- Survey mark SS3313 recorded a 6mm rise compared with the 2016 survey. Similar rises, and subsequent falls, have been recorded on this and adjacent marks previously. The rise is considered to be a result of survey accuracy.
- Differential Settlement Alarms continue to be recorded as follows:
  - AP92 and AP93, and AP92 and AP80 on Mt Albert Road,
  - AP62A and AP88A at the intersection of Mt Albert Road and Hillsborough Road,
  - AP110 and AP111 on Hillsborough Road,
  - AP112 and AP113, OCP68 and AP114, AP69 and AP114, AP115 and AP116, AP70 and AP117, and AP38 and AP117 on Budock Road,
  - AP74A and AP75 on Marie Avenue,
  - OCP90B and SM6241 on Duke Street,
  - RM3901 and RM3902 on Smallfield Avenue, and
  - RM3900 and RM3901 on McCullough Avenue/Smallfield Avenue.
- Differential Settlement Alarms were also recorded between:
  - AP71A and BP1977B on Hillsborough Road (previously recorded in 2014), and
  - RM3901 and RM7457 on McCullough Avenue.
- Intermediate Stage Control Triggers were recorded in Settlement Zones I, II, III and V.

# Precise Level Survey

## Recap of Differential Settlement Alarms

- Limits were set in the consent to dewater Three King Quarry as to the amount of differential settlement allowed between survey marks
- Differential settlement is a measure of the change in level between two adjacent survey marks
- The first trigger is set at 1 in 5000, the second trigger is 1 in 2000
- The maximum differential settlement allowed by the consent to dewater Three Kings Quarry is 1 in 1000
- Differential settlements greater than 1 in 500 are required before there is an appreciable risk of minor damage to property i.e. twice the limit imposed by resource consent conditions
- Differential settlements greater than 1 in 250 are required before there is potential for structure damage i.e. four times the limit imposed by resource consent conditions.

# Precise Level Survey

## Differential Settlement Alarms

- Differential settlements greater than 1 in 5000 (as a result of dewatering Three Kings Quarry) require:
  - ❖ the Auckland Council to be contacted
  - ❖ additional survey marks to be installed at 50 metre spacing
- Differential settlements greater than 1 in 2000 (as a result of dewatering Three Kings Quarry) require:
  - ❖ adjacent residents, Community Groups, Local Boards, and the Auckland Council to be contacted
  - ❖ additional survey marks to be installed at 25 metre spacing
  - ❖ an assessment of the impact of the settlement
  - ❖ a review of the groundwater model and settlement predictions
- Differential settlements greater than 1 in 1000 (as a result of dewatering Three Kings Quarry) require:
  - ❖ the pumping of groundwater to cease immediately
  - ❖ adjacent landowners, Community Groups, Locals Boards and the Auckland Council to be contacted
  - ❖ an assessment of the impact of the settlement
  - ❖ pumping can not recommence without the permission of the Auckland Council

# Differential Settlement Alarms

Marks	Location	April-17 Differential Settlement	Distance between Marks	Adjusted Difference in Levels between Marks
AP92 and AP93	Mt Albert Road	1 in 586	16.7m	28mm
AP92 and AP80	Mt Albert Road	1 in 590	17.7m	30mm
AP62A and AP88A	Mt Albert and Hillsborough	1 in 3002	24.1m	8mm
AP110 and AP111	Hillsborough Road	1 in 2920	17.7m	6mm
AP71A and BP1977B	Hillsborough Road	1 in 4991	53.0m	11mm
AP112 and AP113	Budock Road	1 in 3886	25.7m	7mm
OCP68 and AP114	Budock Road	1 in 1507	23.0m	15mm
AP69 and AP114	Budock Road	1 in 1865	26.4m	14mm
AP115 and AP116	Budock Road	1 in 3372	20.2m	6mm
AP70 and AP117	Budock Road	1 in 1420	21.5m	15mm
AP38 and AP117	Budock Road	1 in 1457	22.9m	16mm
AP74A and AP75	Marie Avenue	1 in 3930	52.8m	13mm
OCP90B and SM6241	Duke Street	1 in 4582	42.6m	9mm
RM3900 and RM3901	McCullough Avenue	1 in 3860	82.7m	21mm
RM3901 and RM3902	Smallfield Avenue	1 in 4157	82.6m	20mm
RM3901 and RM7457	McCullough Avenue	1 in 4668	96.0m	21mm

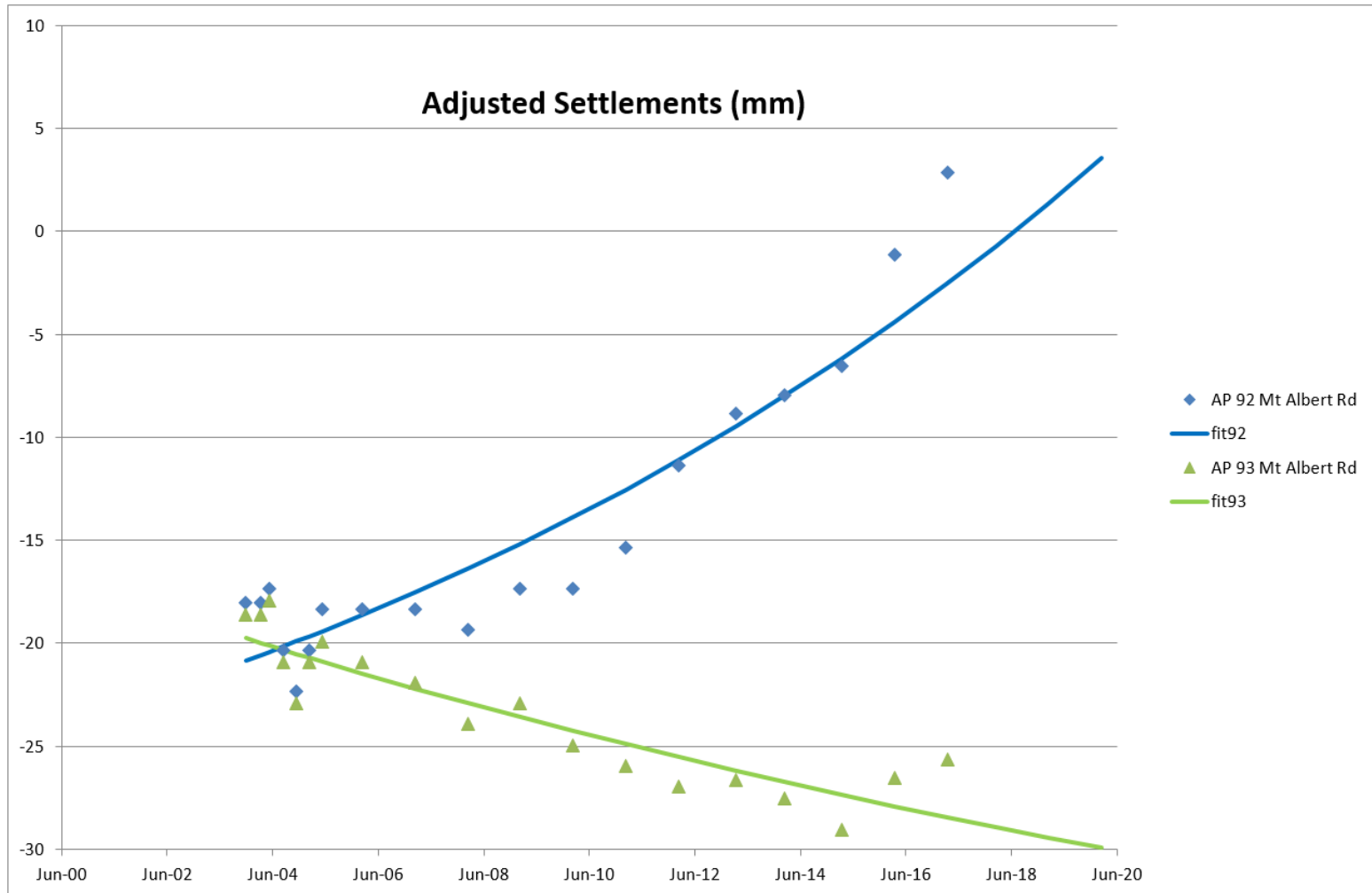
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# Mt Albert Road – AP80, AP92 and AP93

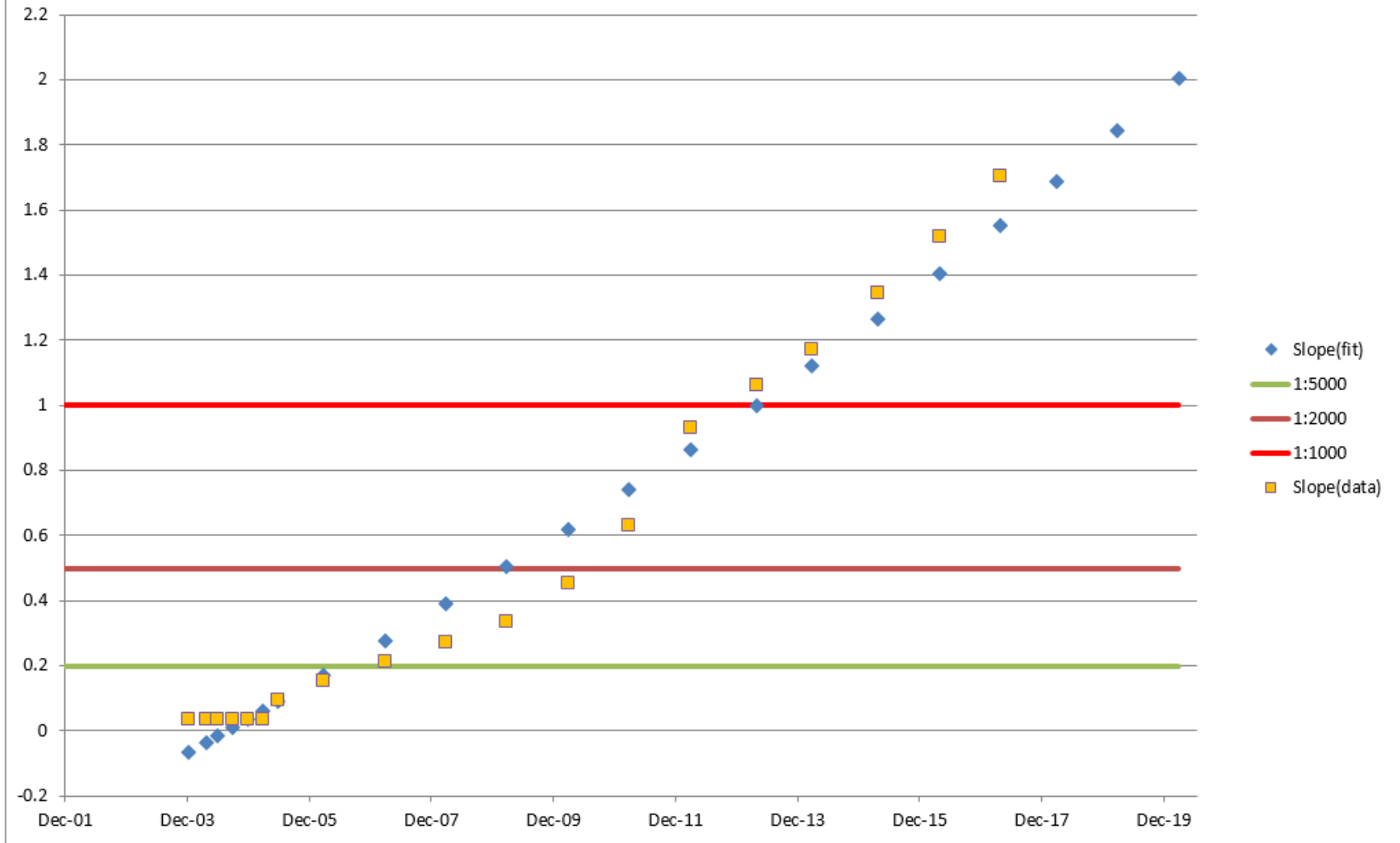


C SEE SHEET 1		NO	02/11	ISSUED	DATE	SIGNATURE	PLUT DATE	15/02/2011	 ASSOCIATION OF CONSULTING ENGINEERS NEW ZEALAND	120 9901 QUALITY ASSURED	 HARRISON GRIERSON  CONSULTING ENGINEERS SURVEYORS PLANNERS Level 5 Copia House, 20 Acheron Way Manukau City (Ph 09 966 1360 Fax 09 966 3390)	PROJECT:  WINSTONE AGGREGATES THREE KINGS QUARRY	TITLE:  SURVEY MONITORING LEVEL CONTROL POINTS	AUT DATE:  PROJECT NO: 11/20/00451 SCALE: A3 1:1500 A3 1:3000 A1 A3 REV  6451_102	C
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				APPROVED	DATE	SIGNATURE	SURVEY DATE:								
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2	AMENDMENT	BY	DATE												

## Settlement Trends – AP92 and AP93

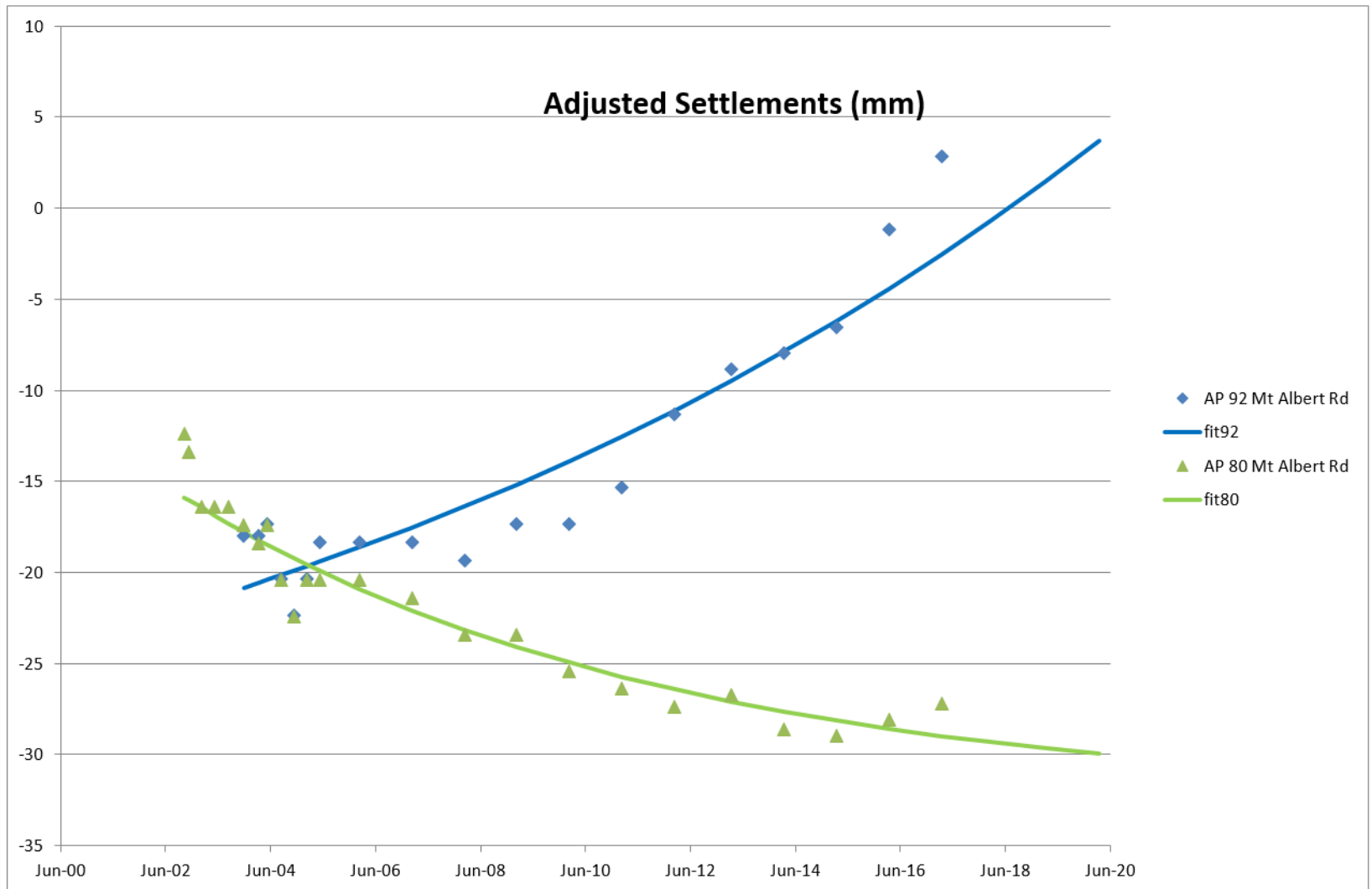


## Differential Settlement Trend Analysis - AP92 vs AP93

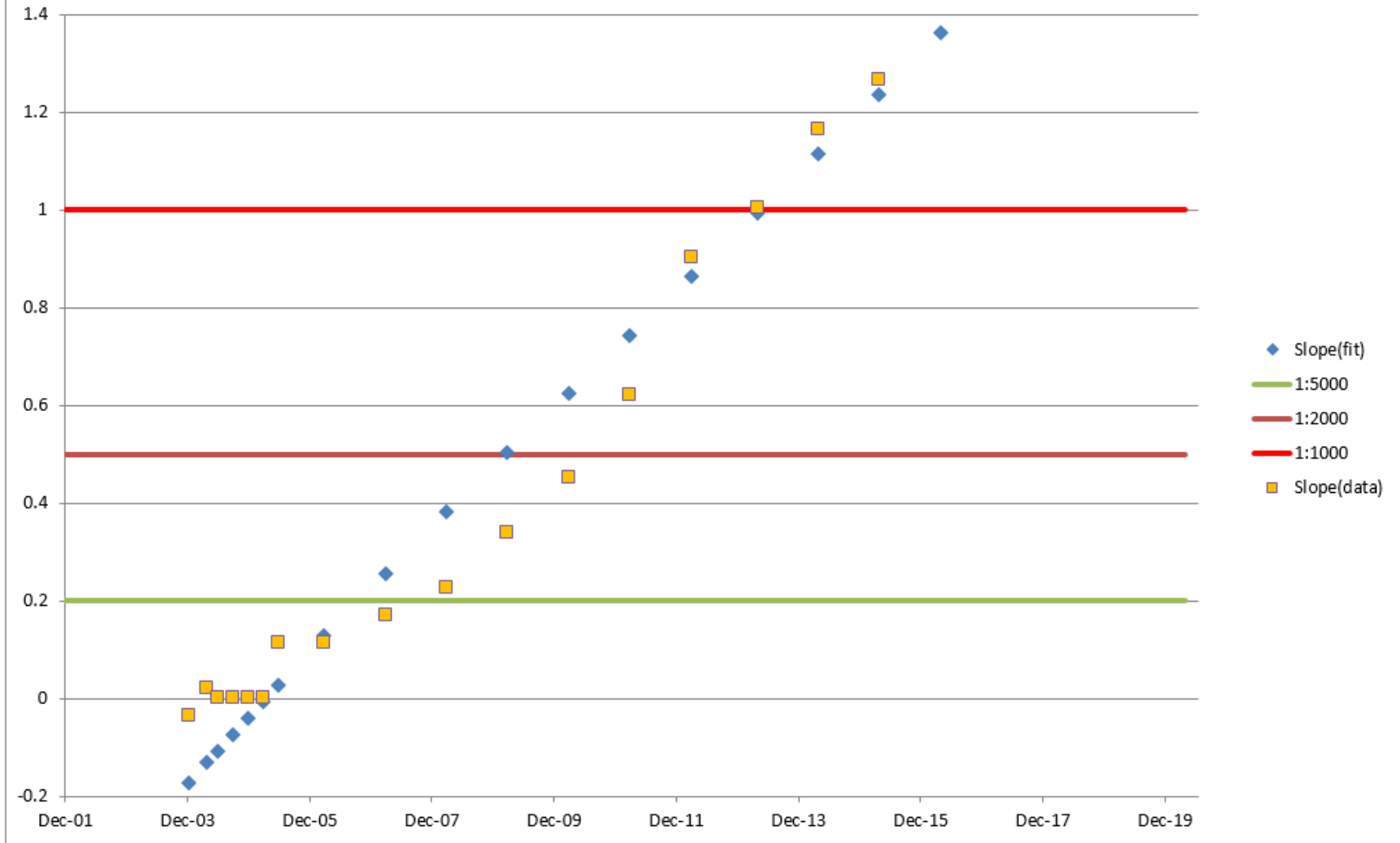




## Settlement Trends – AP92 and AP80



## Differential Settlement Trend Analysis - AP80 vs AP92



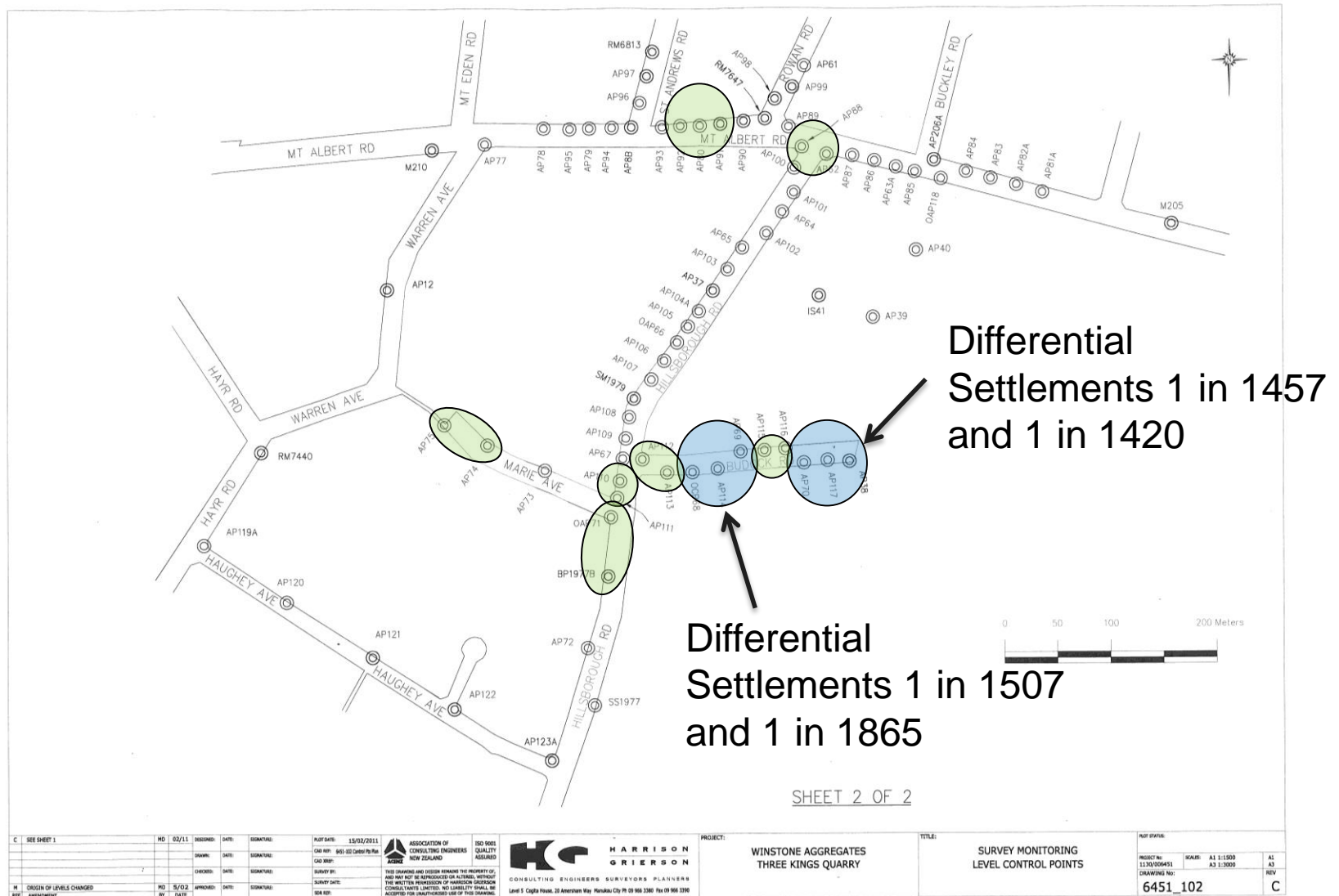
## **Mt Albert Road – AP80, AP92 and AP93**

- The Differential Settlement Alarms between AP80, AP92 and AP93 on Mt Albert Road adjacent to the St Andrews Reserve are not a result of dewatering Three Kings Quarry.
- AP80 and AP93 have recorded settlements consistent with other marks in this area, AP92 has risen since it was first surveyed;
- The results of the precise level survey show that the change in level of AP92 is anomalous and not consistent with the change in levels in the surrounding precise level survey marks.
- The relative rise in level of AP92 is not a result of dewatering Three Kings Quarry.

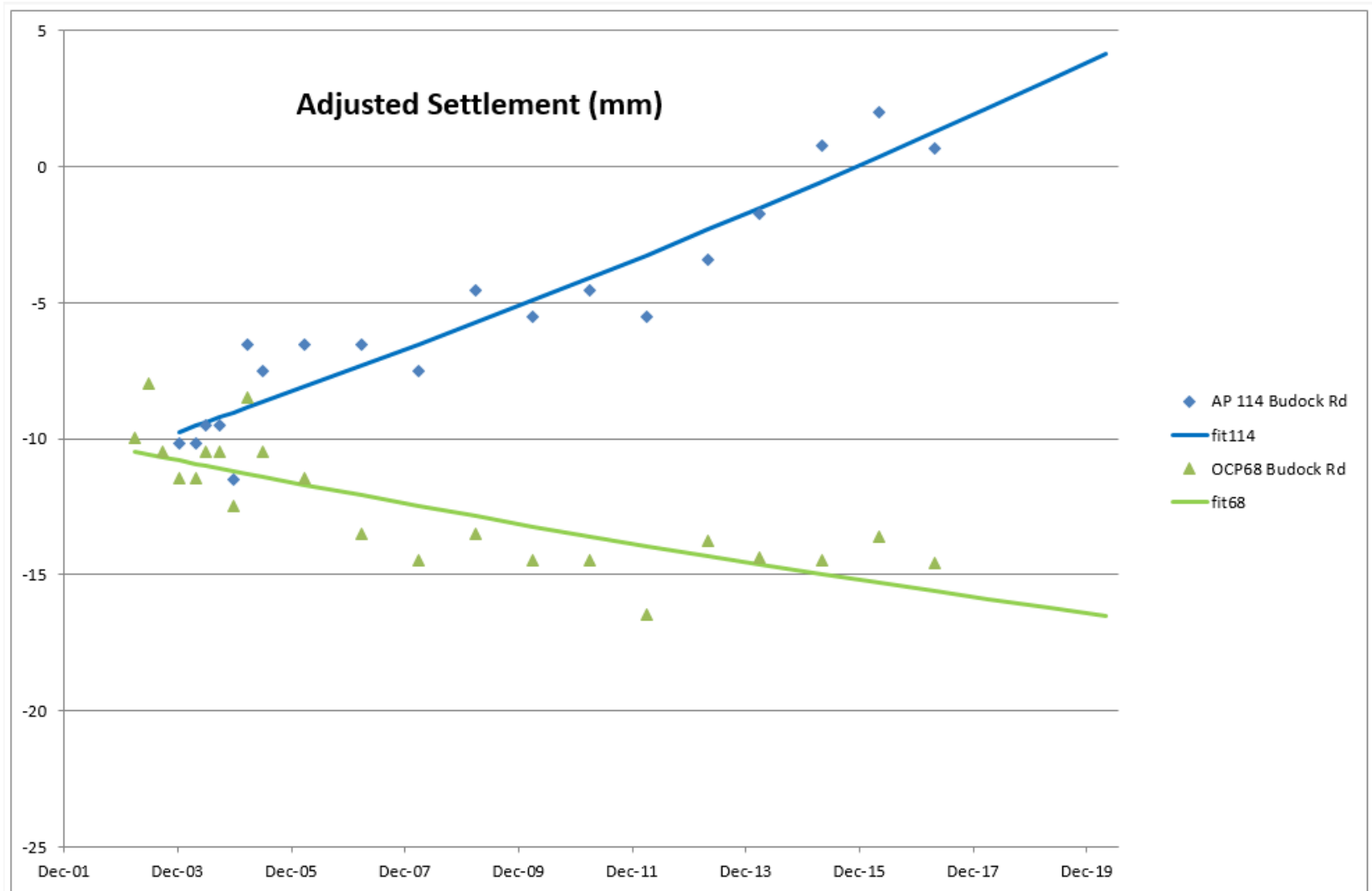
## Analysis of Precise Level Survey Marks Adjacent to AP80, AP92 and AP93

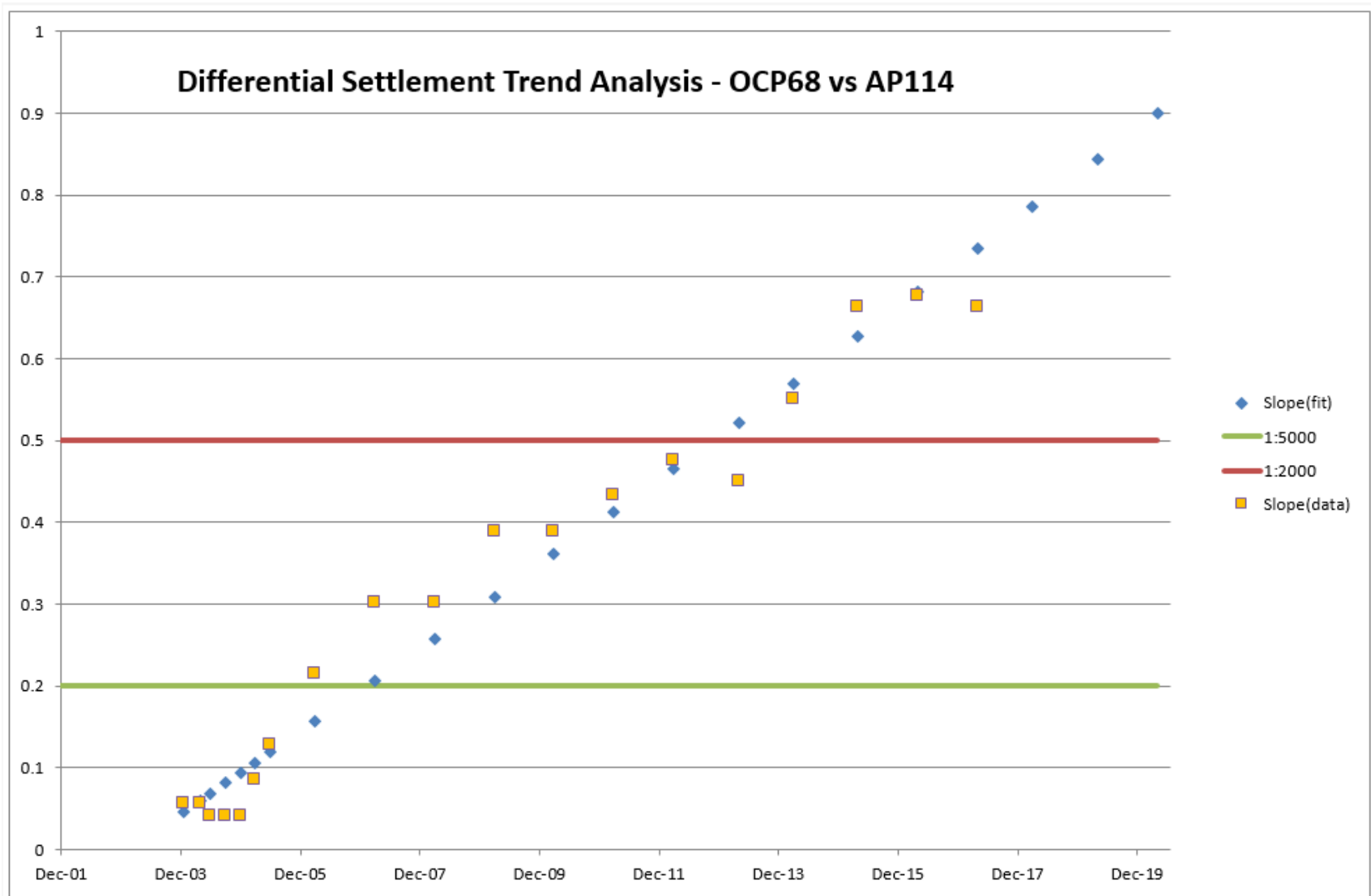
<i>Precise Level Mark</i>	<i>Change in Level since First Survey (mm)</i>	<i>Adjusted Change in Level (mm)</i>	<i>Precise Level Marks</i>	<i>Differential Settlement</i>	
				Spacing (metres)	Differential Settlement
RM 6813	-26.83	-26.83			
AP 97	-6.60	-25.26	RM6813-AP97	25.0	1 in 15876
AP 96	-5.50	-24.55	AP97-AP96	25.5	1 in 35941
AP 8B	-15.00	-27.43	AP96-AP8B	25.0	1 in 13298
AP 79	-7.10	-20.03			
AP 94	-5.07	-22.70	AP79-AP94	21.8	1 in 8171
AP 8B	-15.00	-26.43	AP94-AP8B	23.2	1 in 6208
AP 93	-7.03	-25.63	AP8B-AP93	23.7	1 in 29755
AP 92	+20.87	+2.85	AP93-AP92	16.7	1 in 586
AP 80	-13.13	-27.20	AP92-AP80	17.7	1 in 590
AP 91	-9.03	-26.85	AP80-AP91	20.9	1 in 59820
AP90	-9.20	-27.45	AP91-AP90	21.8	1 in 36546
RM 7647	-26.87	-26.87	AP90-RM7647	21.0	1 in 35919

Budock Road – AP38, AP70 and AP117, and OCP68, AP69 and AP114

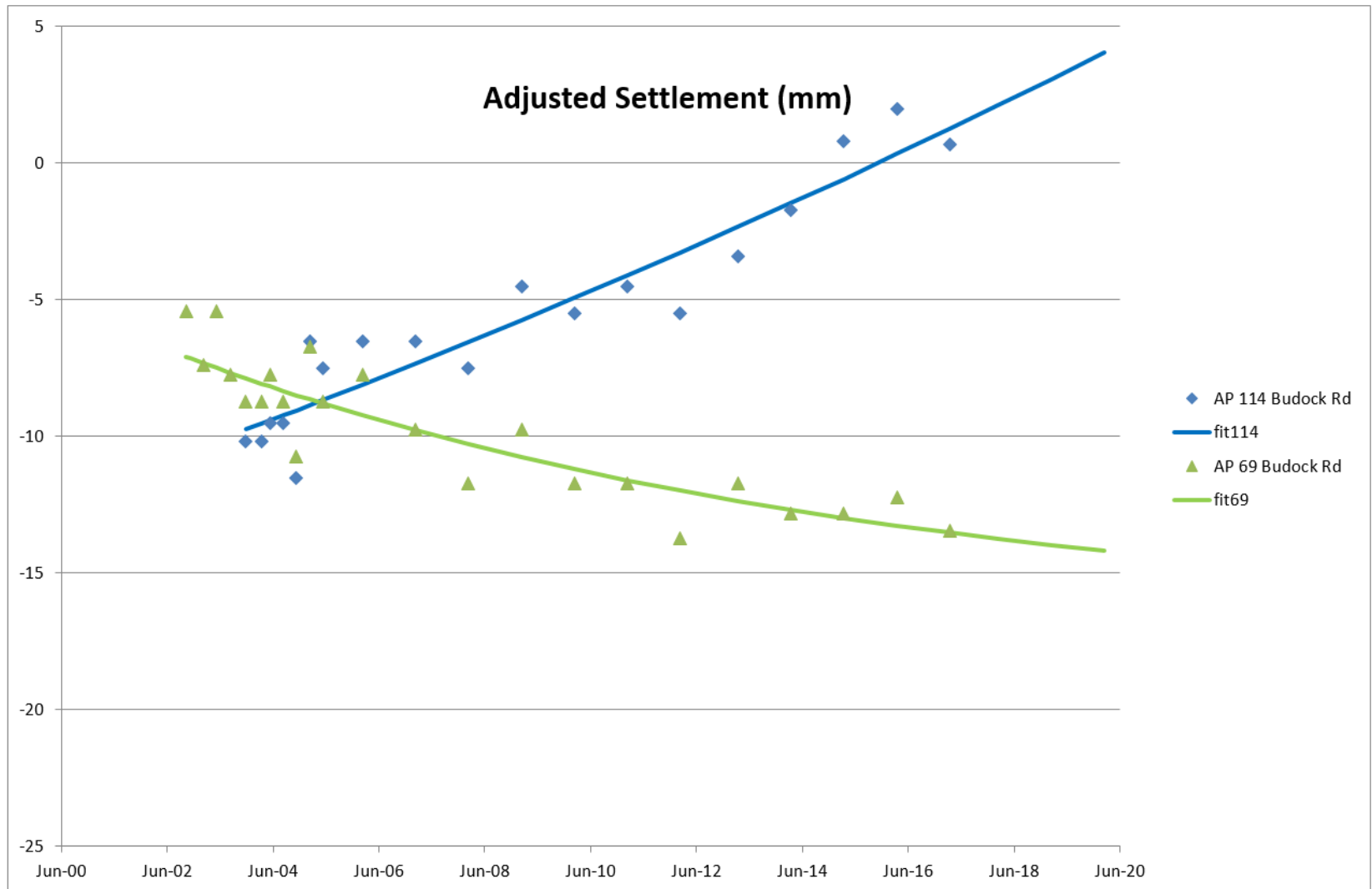


## Settlement Trends – OCP68 and AP114

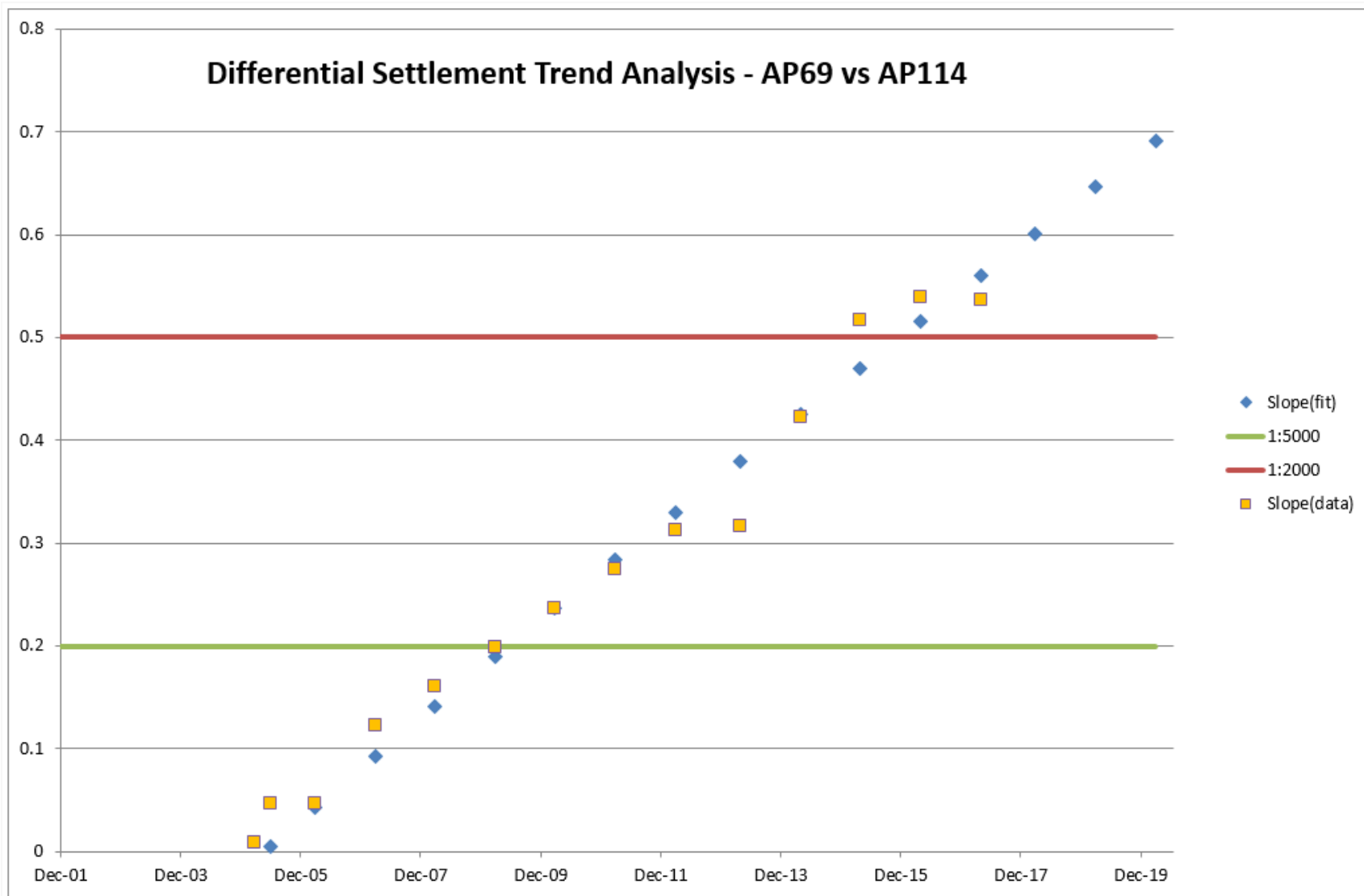




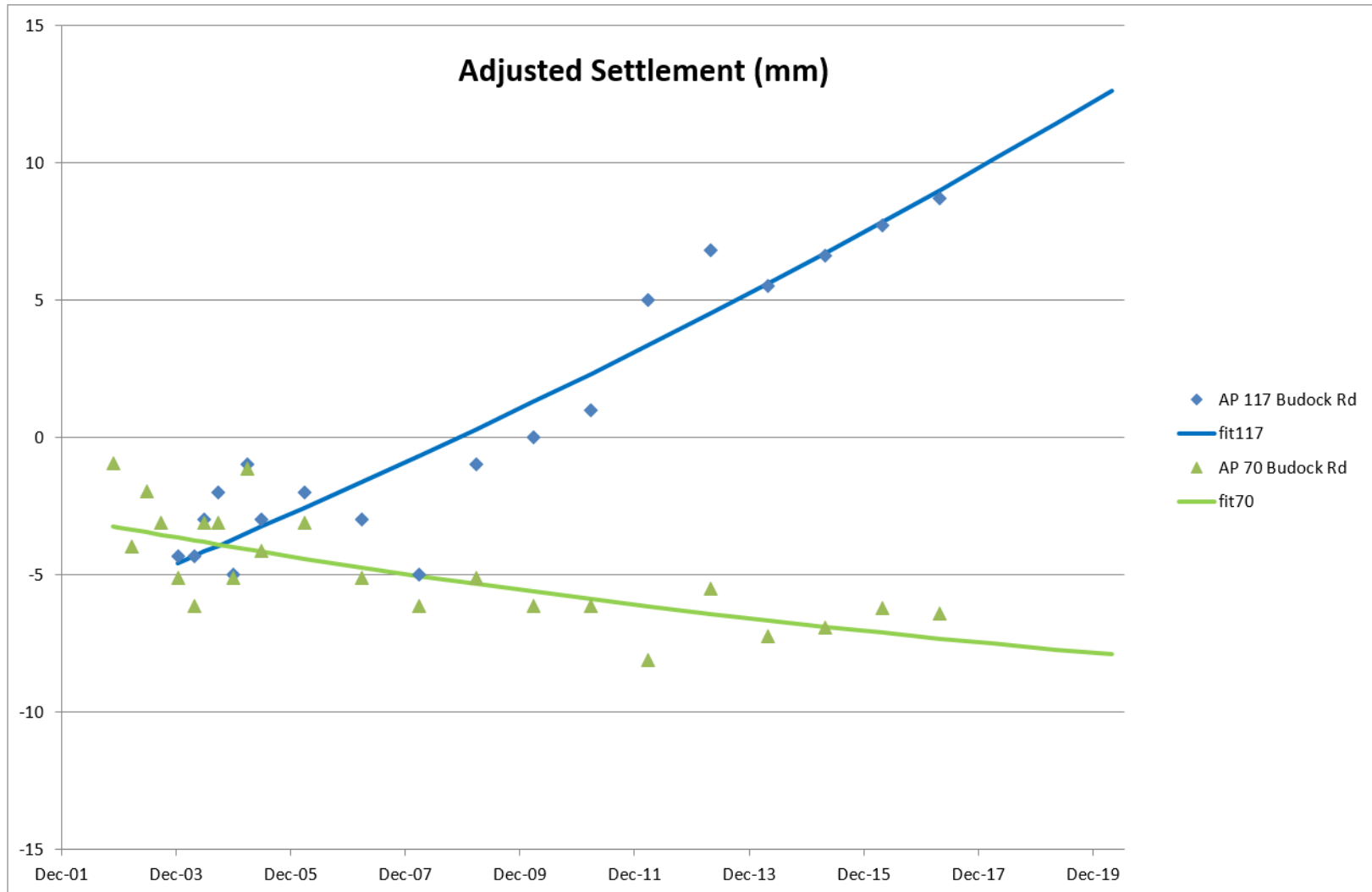
## Settlement Trends – AP69 and AP114



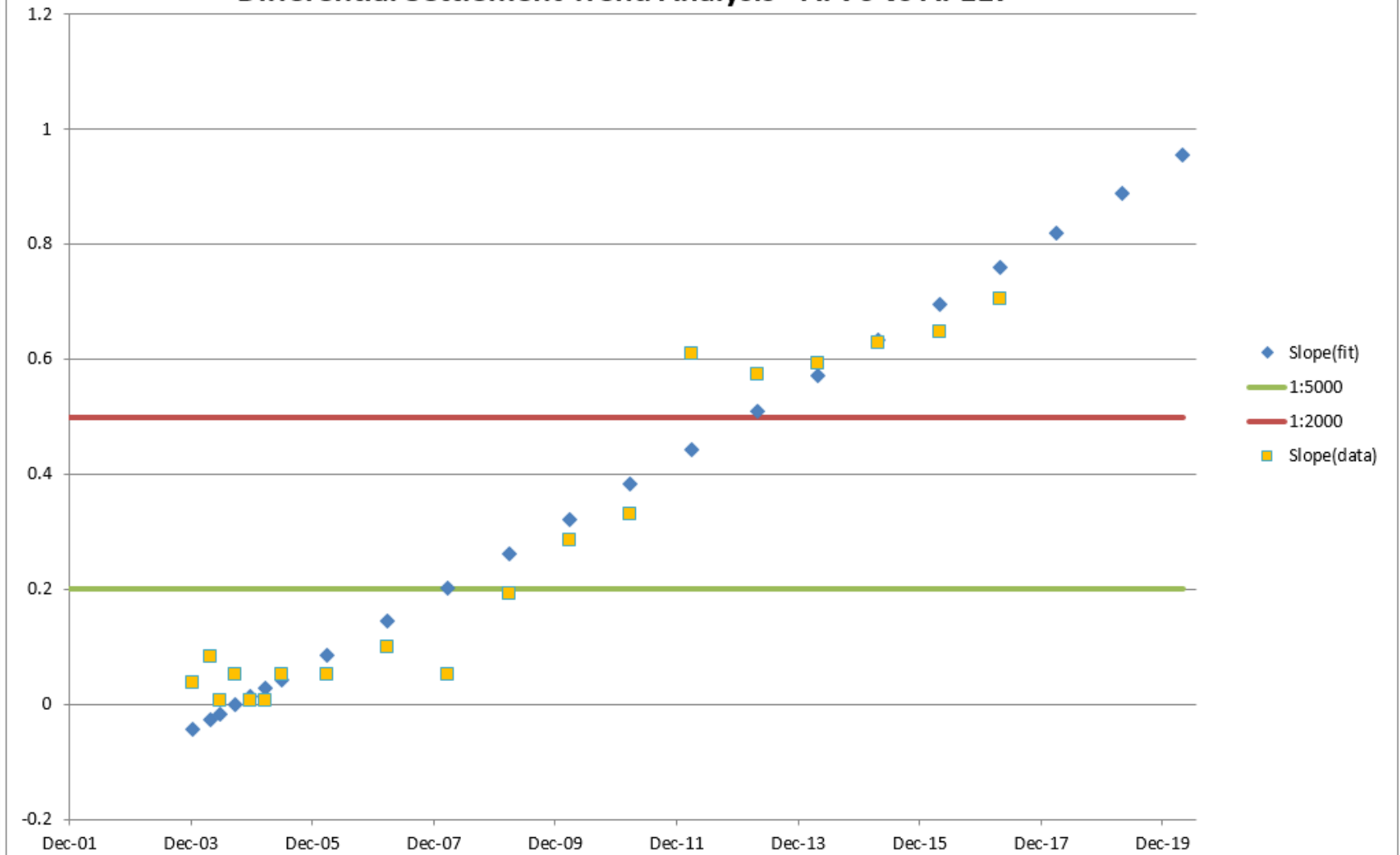




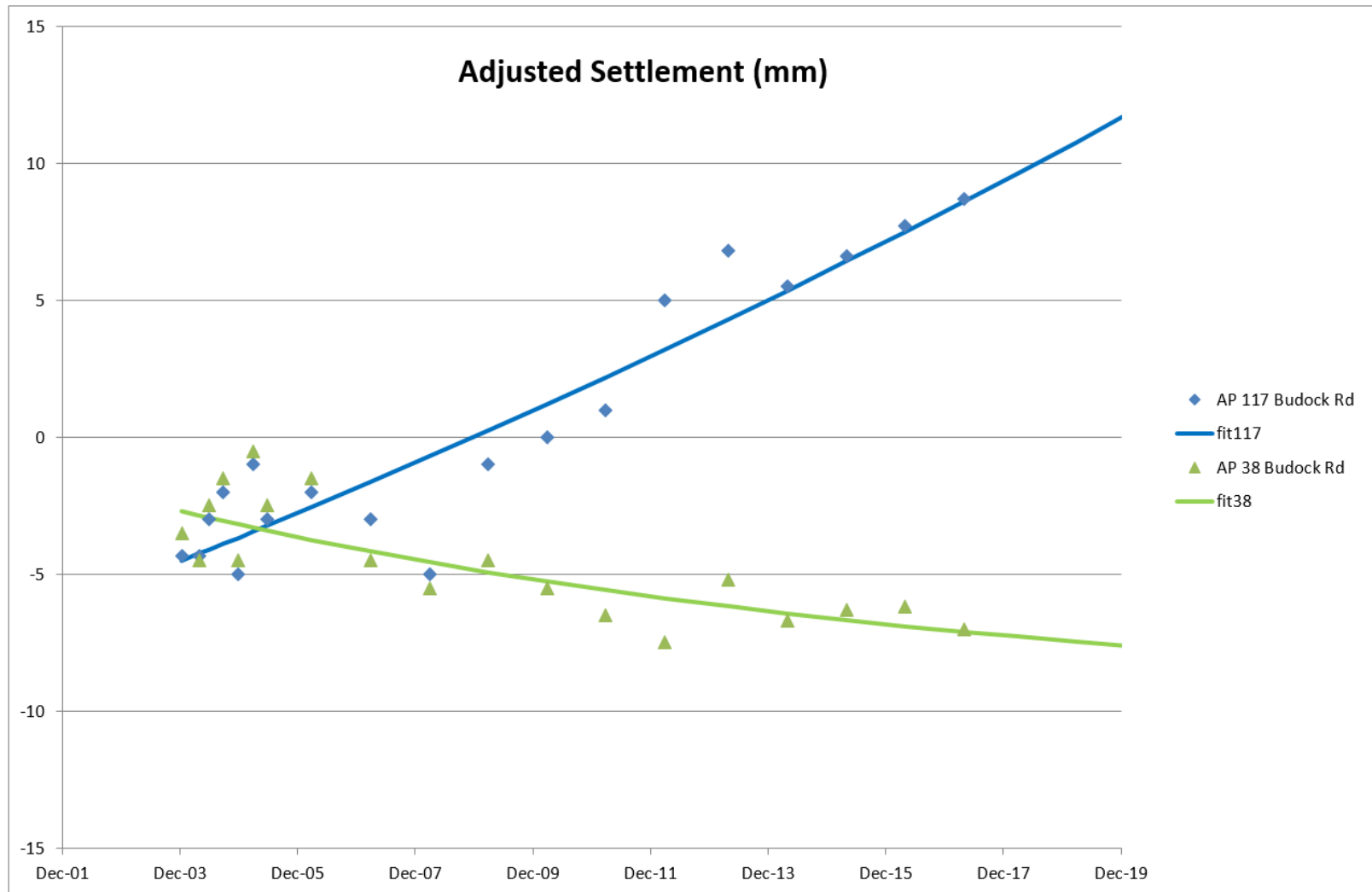
## Settlement Trends – AP70 and AP117

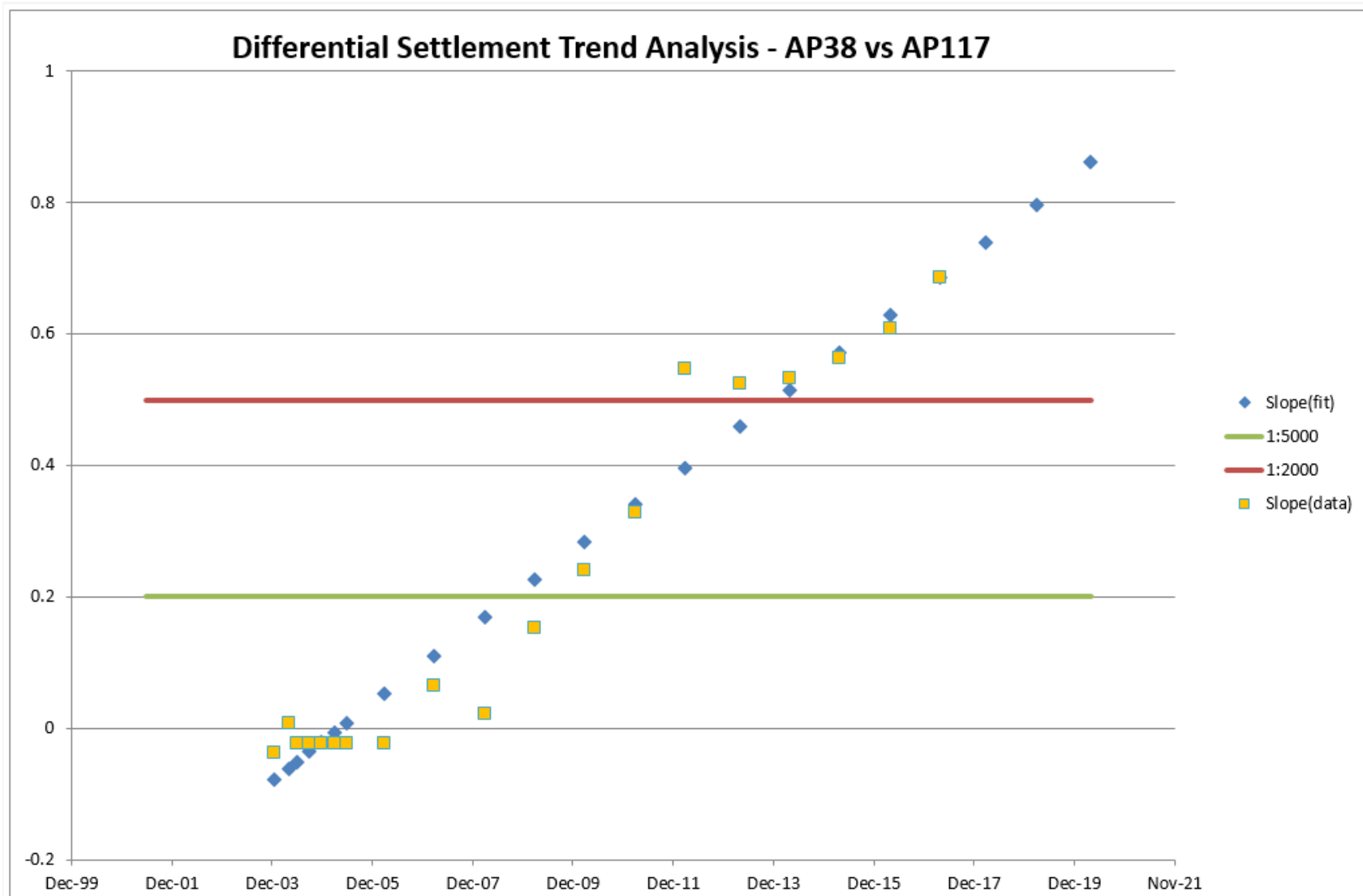


## Differential Settlement Trend Analysis - AP70 vs AP117



## Settlement Trends – AP38 and AP117





# **Budock Road – AP38, AP70 and AP117, and OCP68, AP69 and AP114**

The Differential Settlement Alarms between AP38, AP70 and AP117 , and OCP68, AP69 and AP114 on Budock Road are not a result of dewatering Three Kings Quarry.

- AP38, OCP68, AP69 and AP70 have recorded settlements consistent with other marks in this area
- AP114 and AP117 has risen since they were first surveyed

The results of the precise level surveys show that the change in level of AP114 and AP117 are anomalous and not consistent with the change in levels in the surrounding precise level survey marks.

The relative rise in level of AP114 and AP117 are not a result of dewatering Three Kings Quarry.

## Analysis of Precise Level Survey Marks on Budock Road

<i>Precise Level Mark</i>	<i>Change in Level since First Survey (mm)</i>	<i>Adjusted Change in Level (mm)</i>	<i>Precise Level Marks</i>	<i>Differential Settlement</i>	
				Spacing (metres)	Differential Settlement
AP 38	-7.00	-7.00			
AP 117	+13.03	+8.69	AP38-AP117	22.9	1 in 1457
AP 70	-3.97	-6.43	AP117-AP70	21.5	1 in 1420
AP 116	-1.87	-8.05	AP70-AP116	18.7	1 in 11569
AP 115	-6.63	-14.04	AP116-AP115	20.2	1 in 3372
AP 69	-7.03	-13.45	AP115-AP69	22.0	1 in 37285
AP 114	+10.87	+0.68	AP69-AP114	26.4	1 in 1865
OCP 68	-5.10	-14.57	AP114-OCP68	23.0	1 in 1507
AP 113	-1.23	-14.02	OCP68-AP113	22.1	1 in 40379
AP 112	-5.90	-20.63	AP113-AP112	25.7	1 in 3886
AP 67	-9.00	-22.71	AP112-AP67	17.6	1 in 8463

## Budock Road – AP115 and AP116

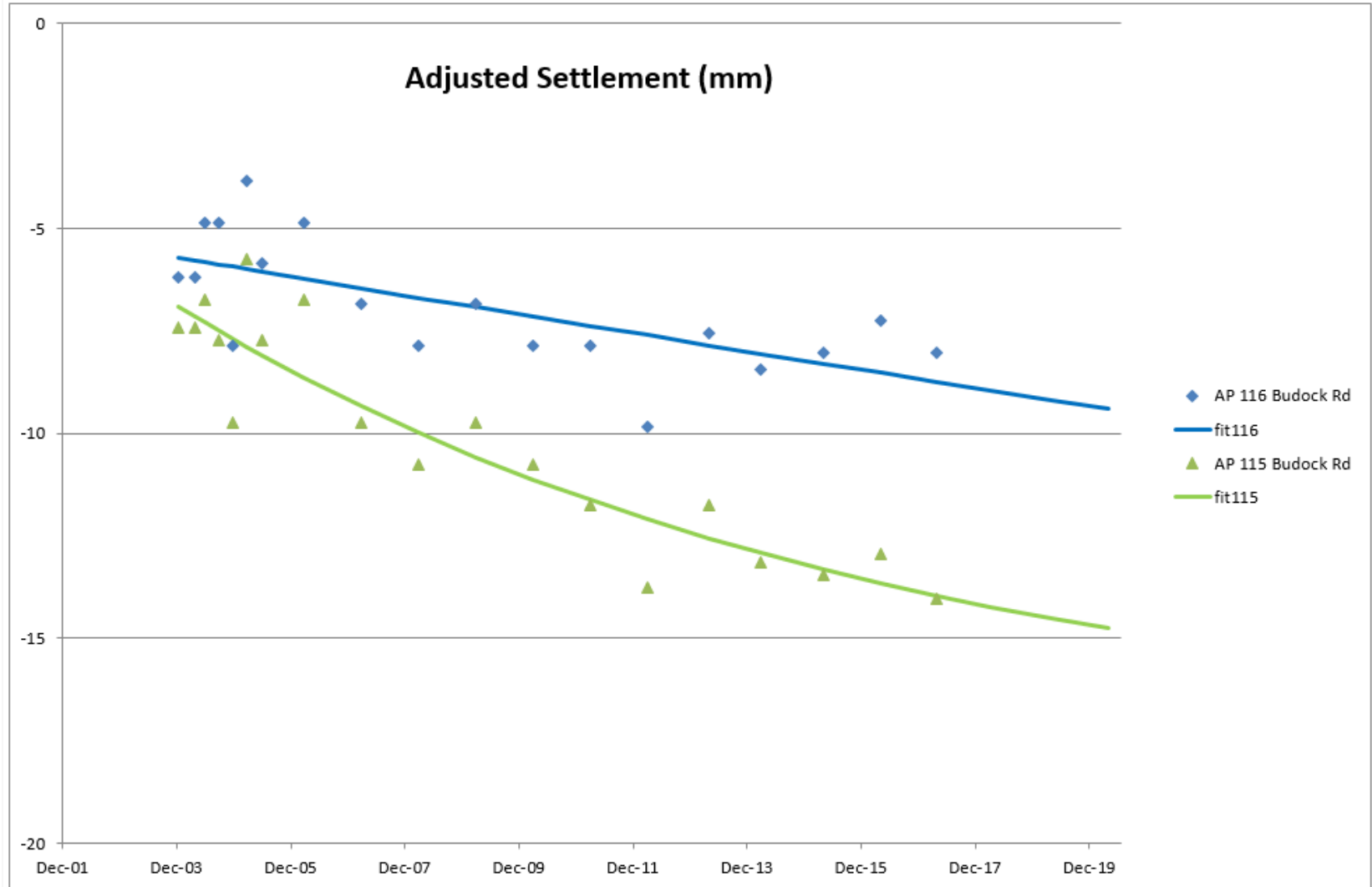


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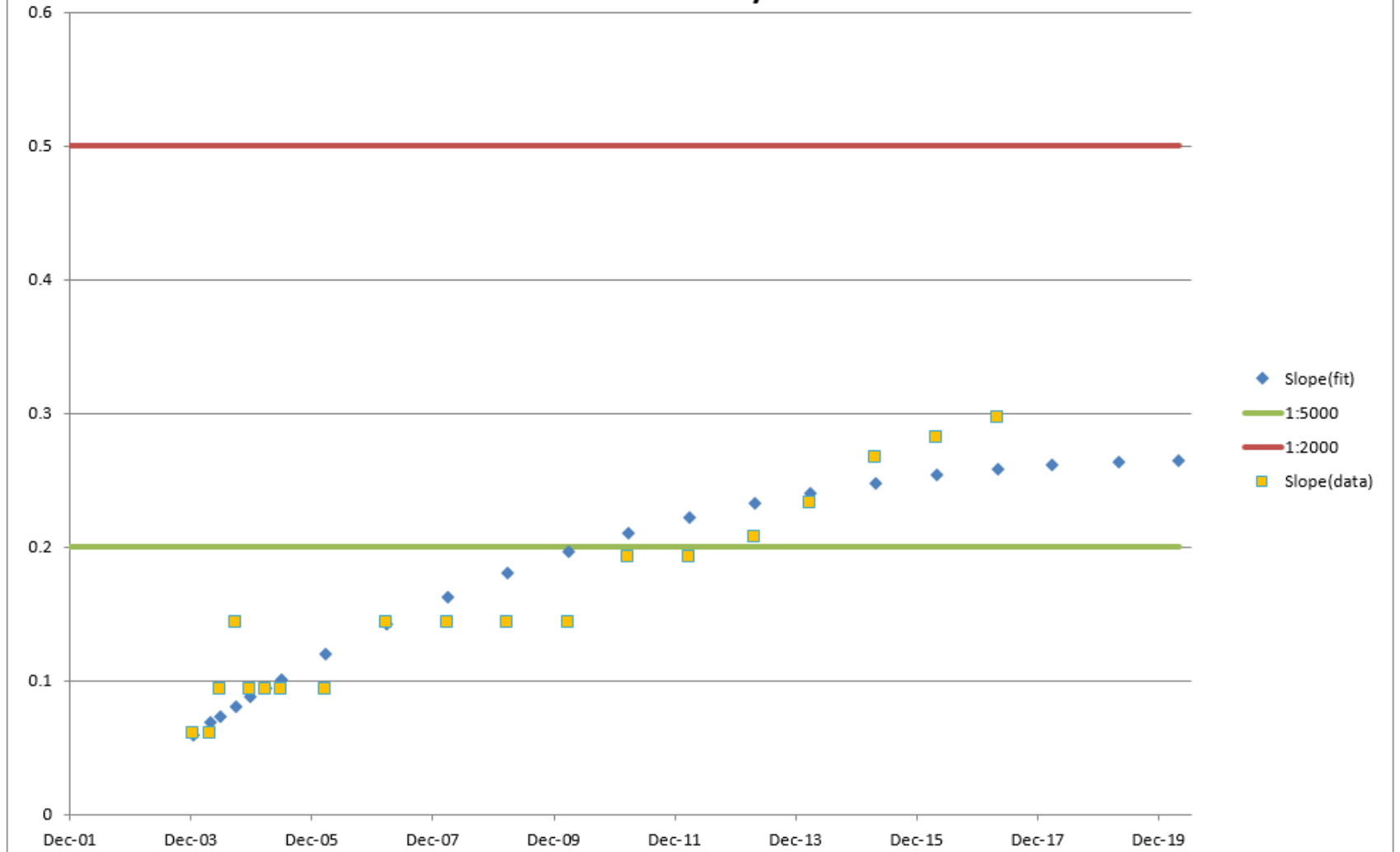
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## Settlement Trends – AP115 and AP116



### Differential Settlement Trend Analysis - AP115 vs AP116

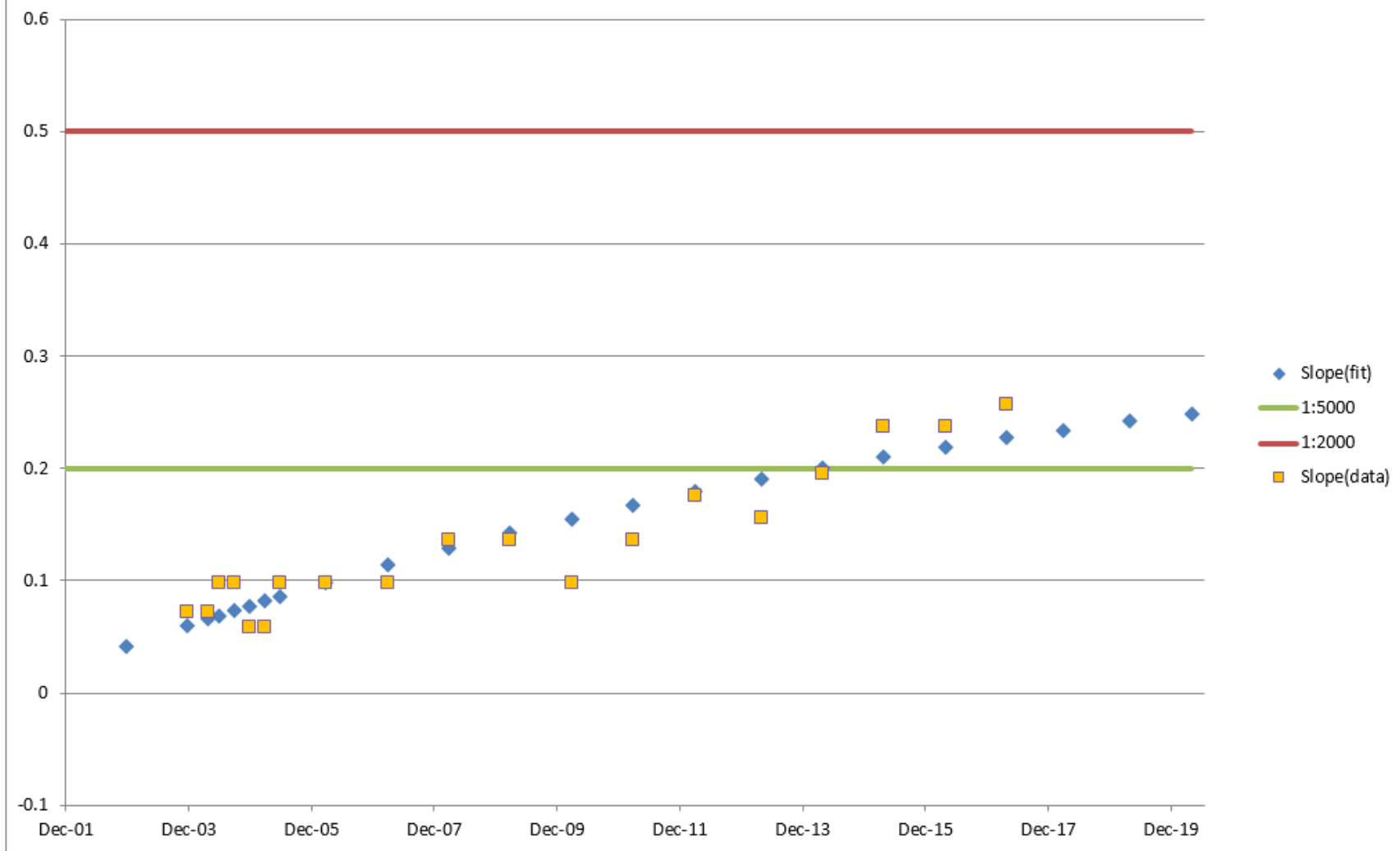




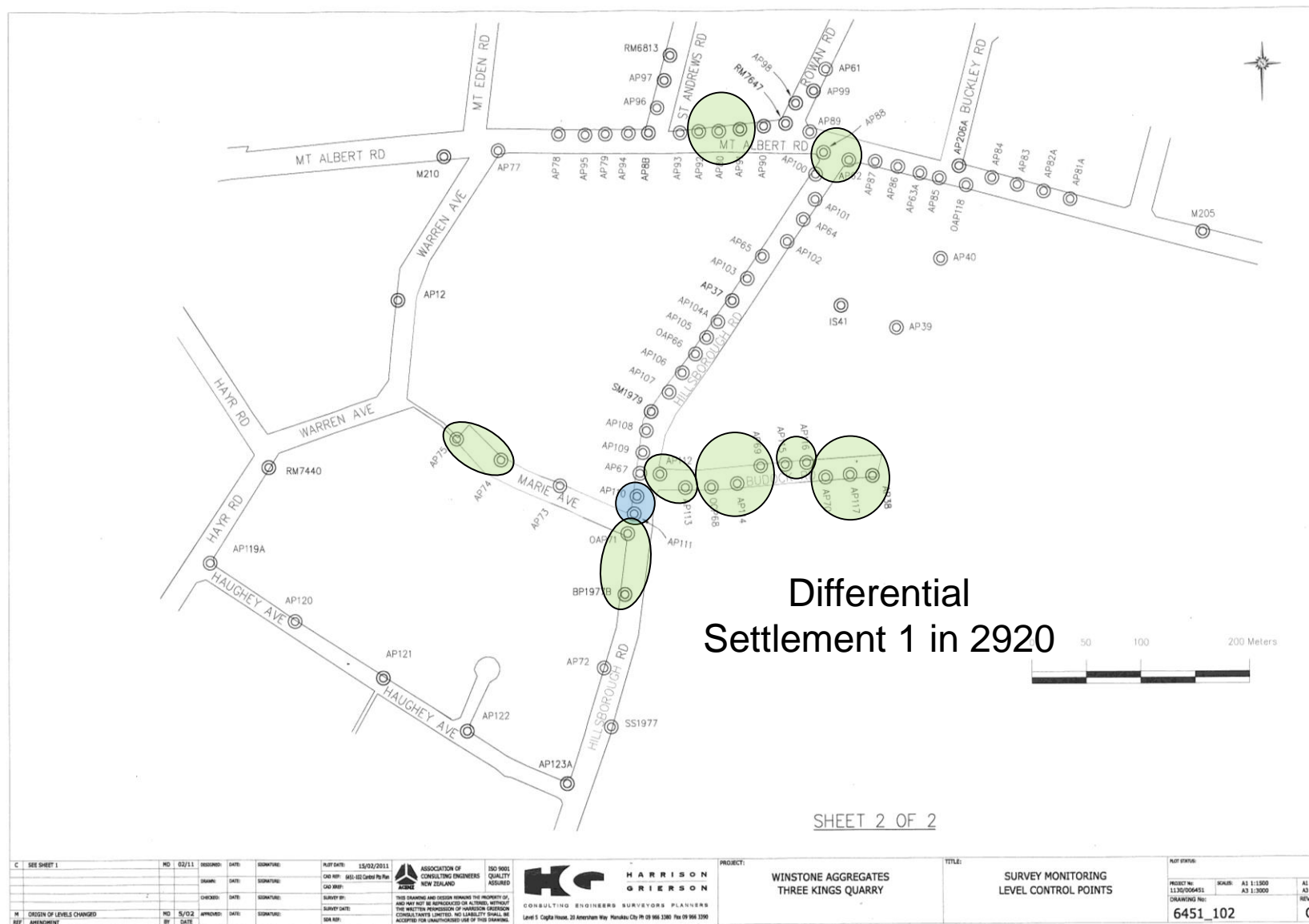
## Settlement Trends – AP112 and AP113



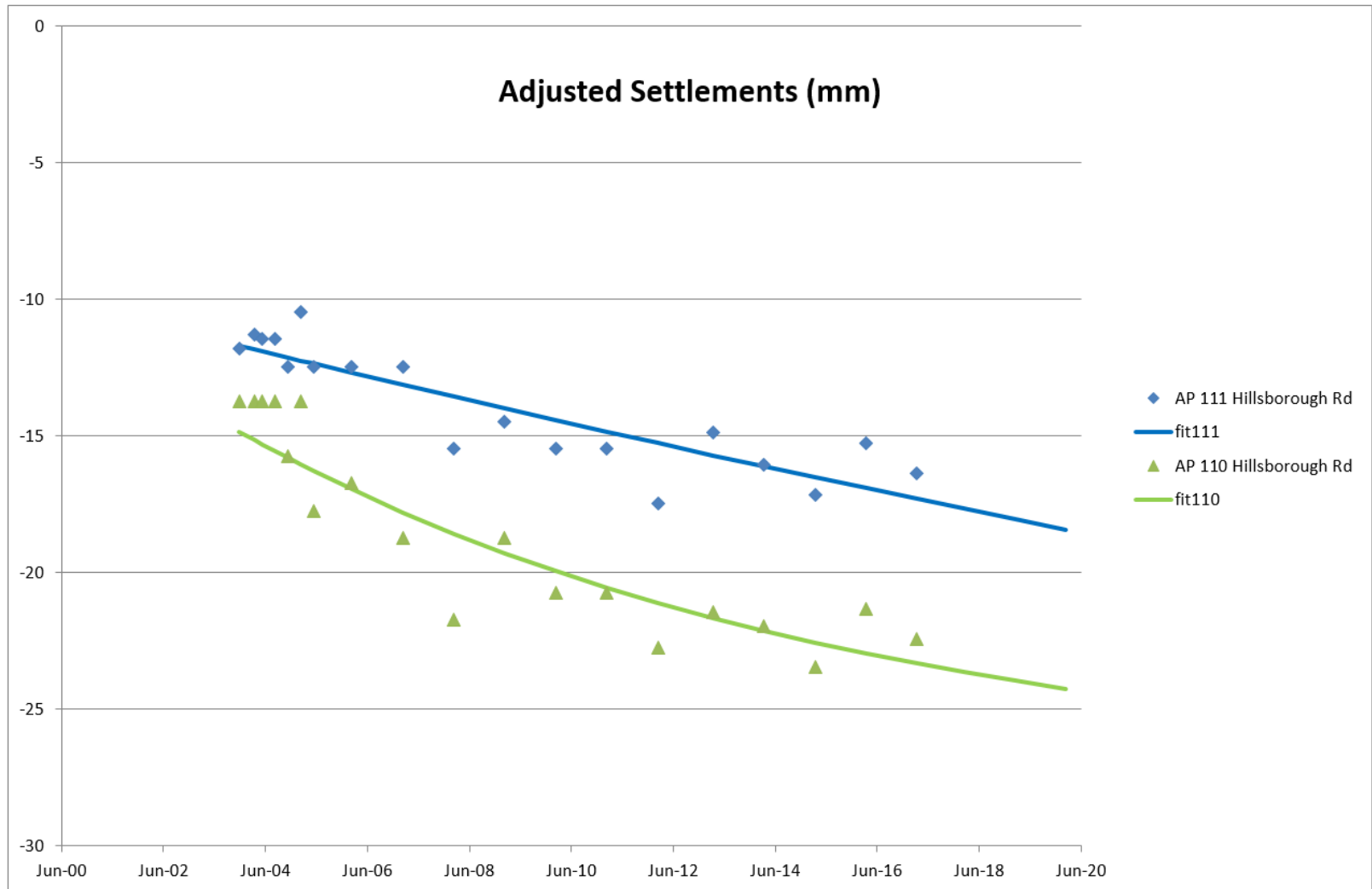
## Differential Settlement Trend Analysis - AP112 vs AP113

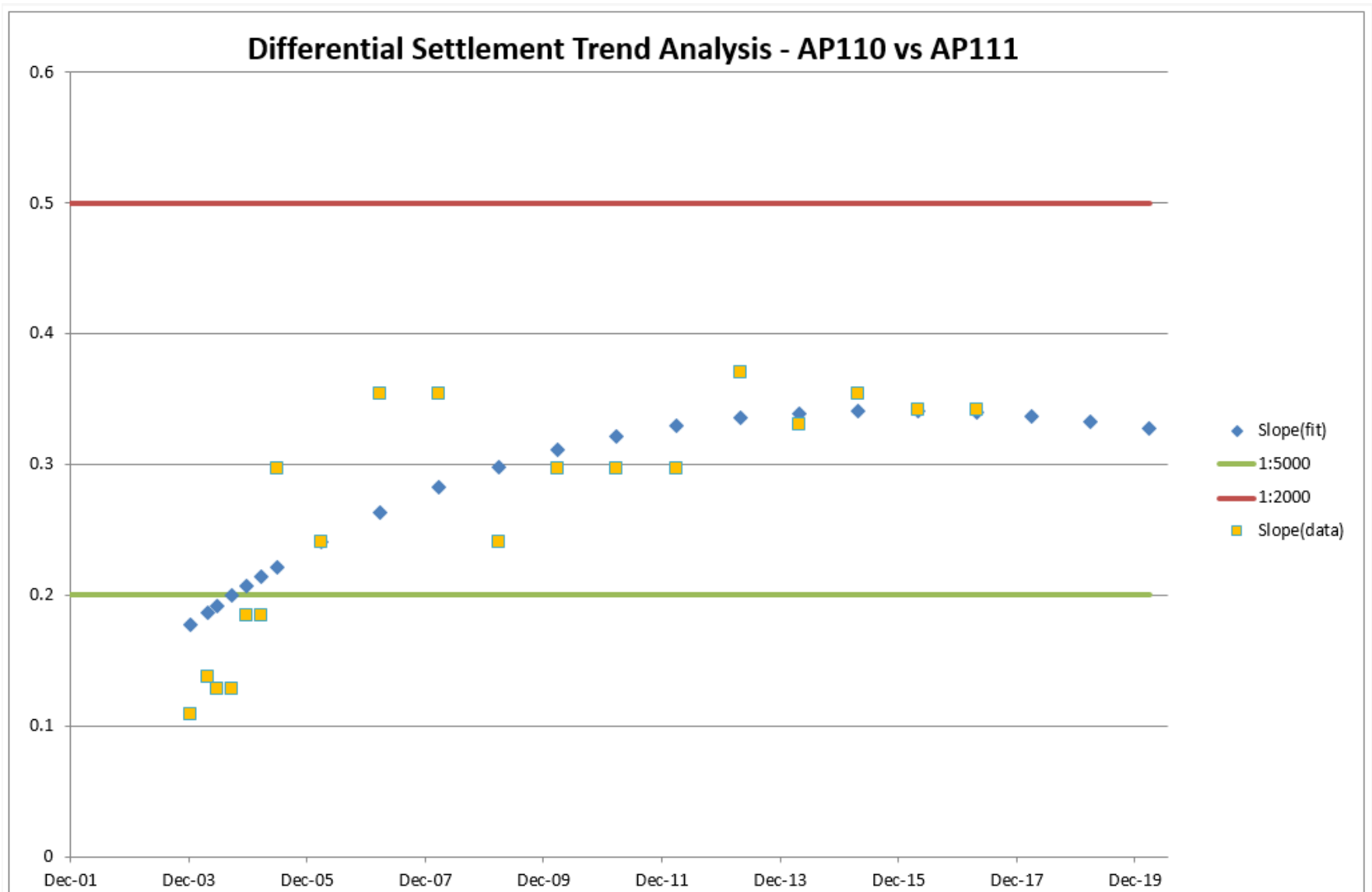


## Hillsborough Road – AP110 and AP111



## Settlement Trends – AP110 and AP111







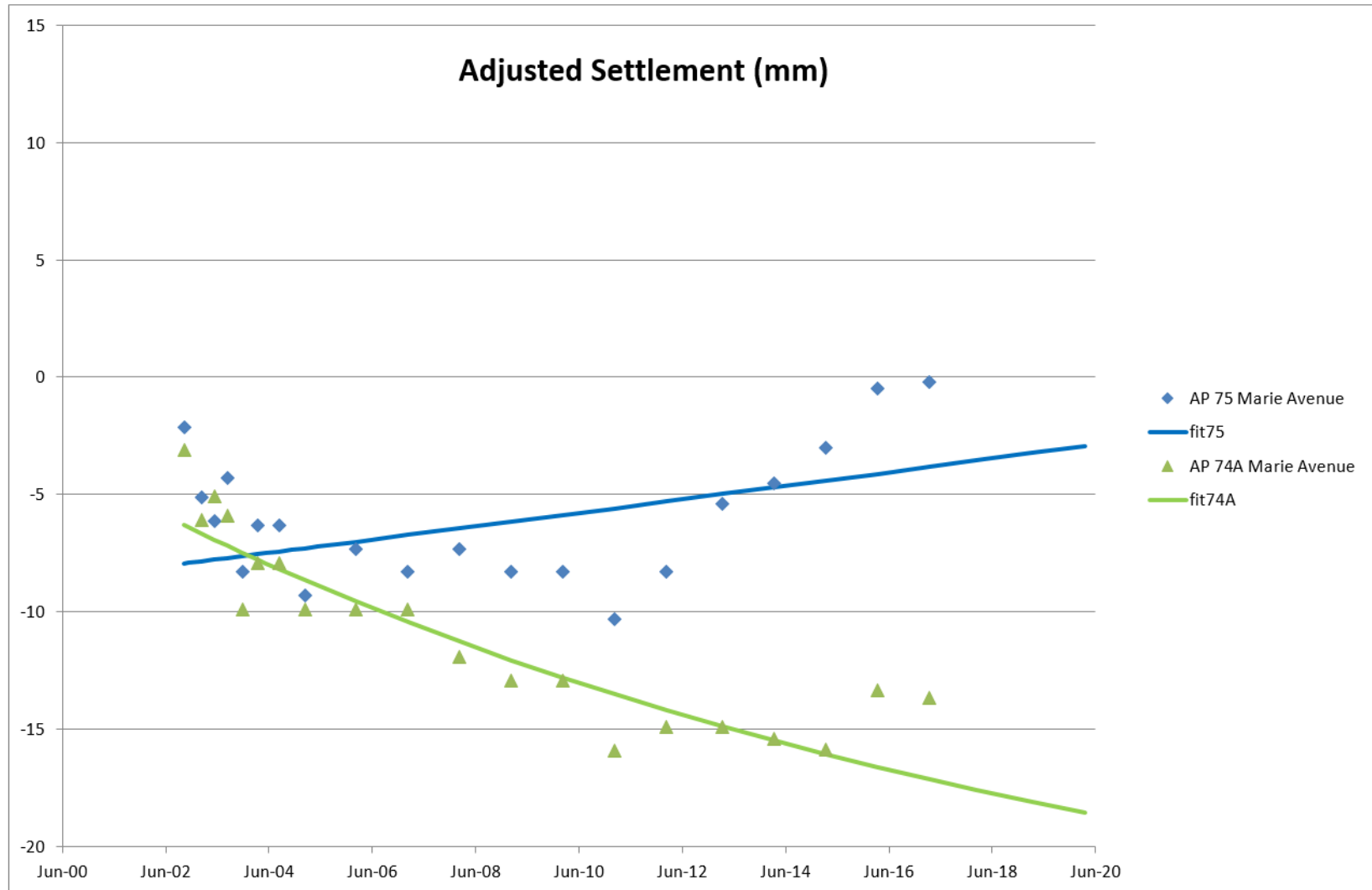
# Marie Avenue – AP74A and AP75

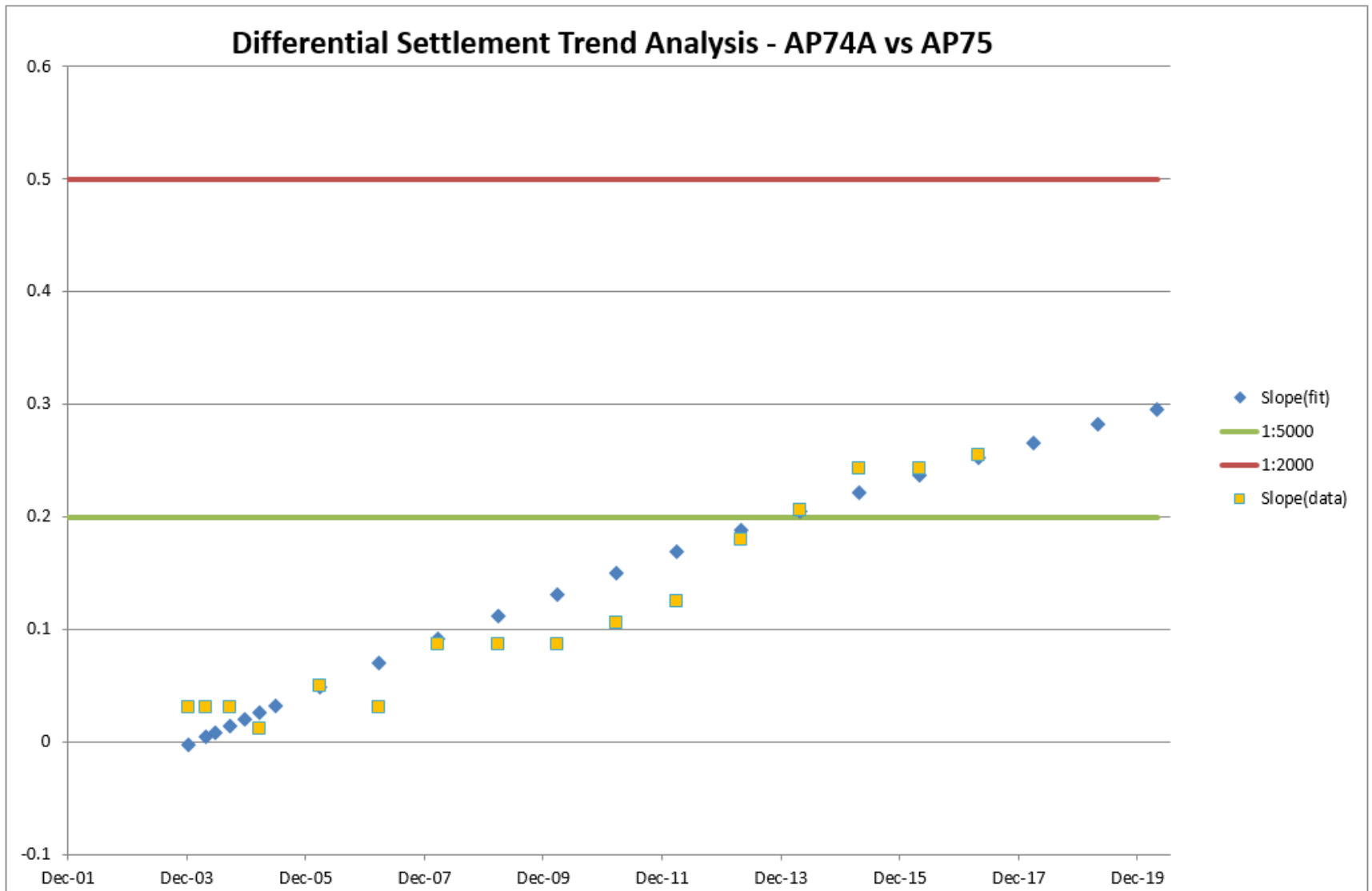
Differential  
Settlement 1 in 3930

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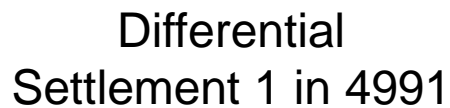
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REF AMENDMENT		BY	DATE				SURVEY DATE:							

## Settlement Trends – AP74A and AP75





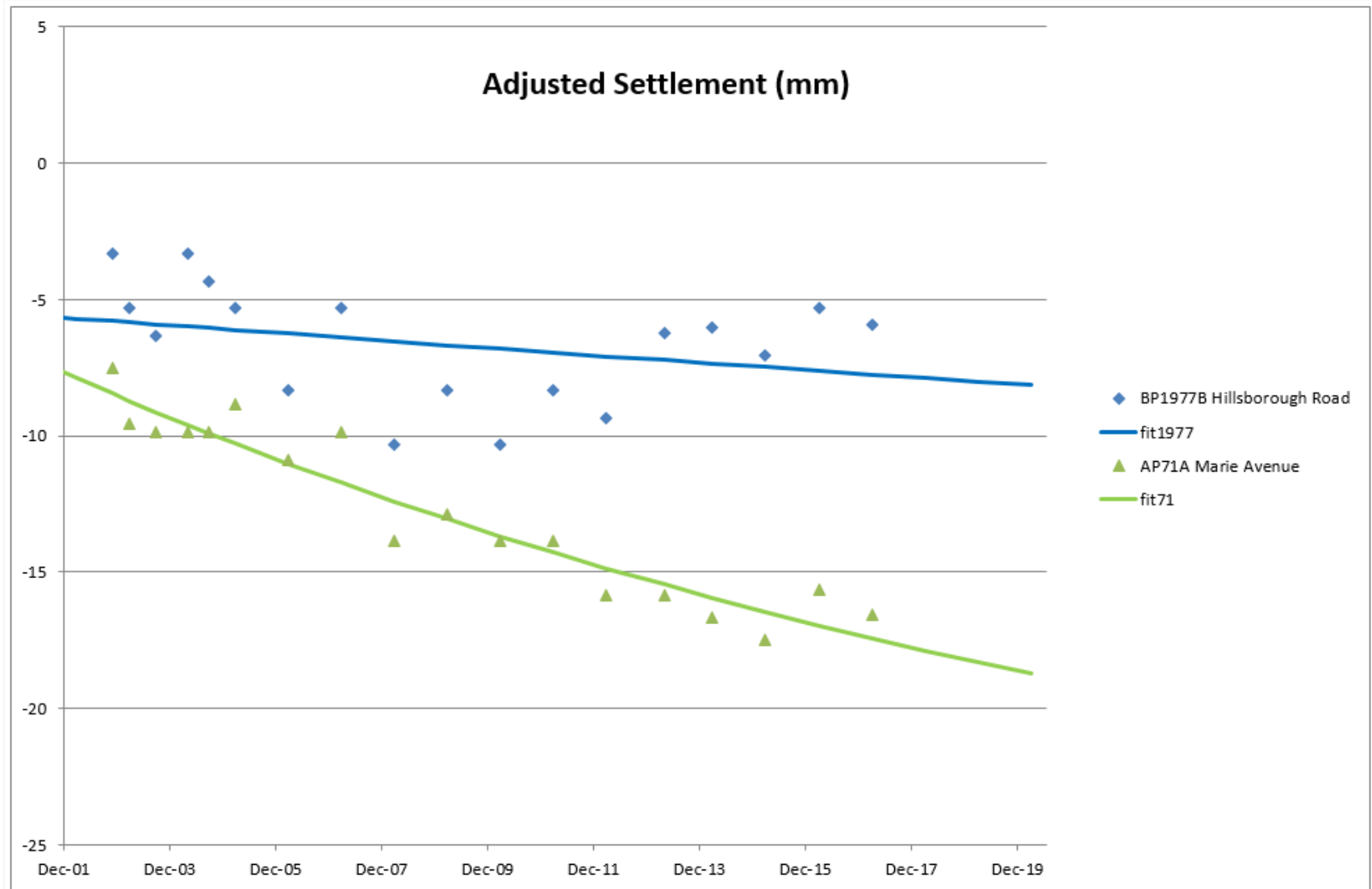
# Marie Avenue – BP1977B and AP71A



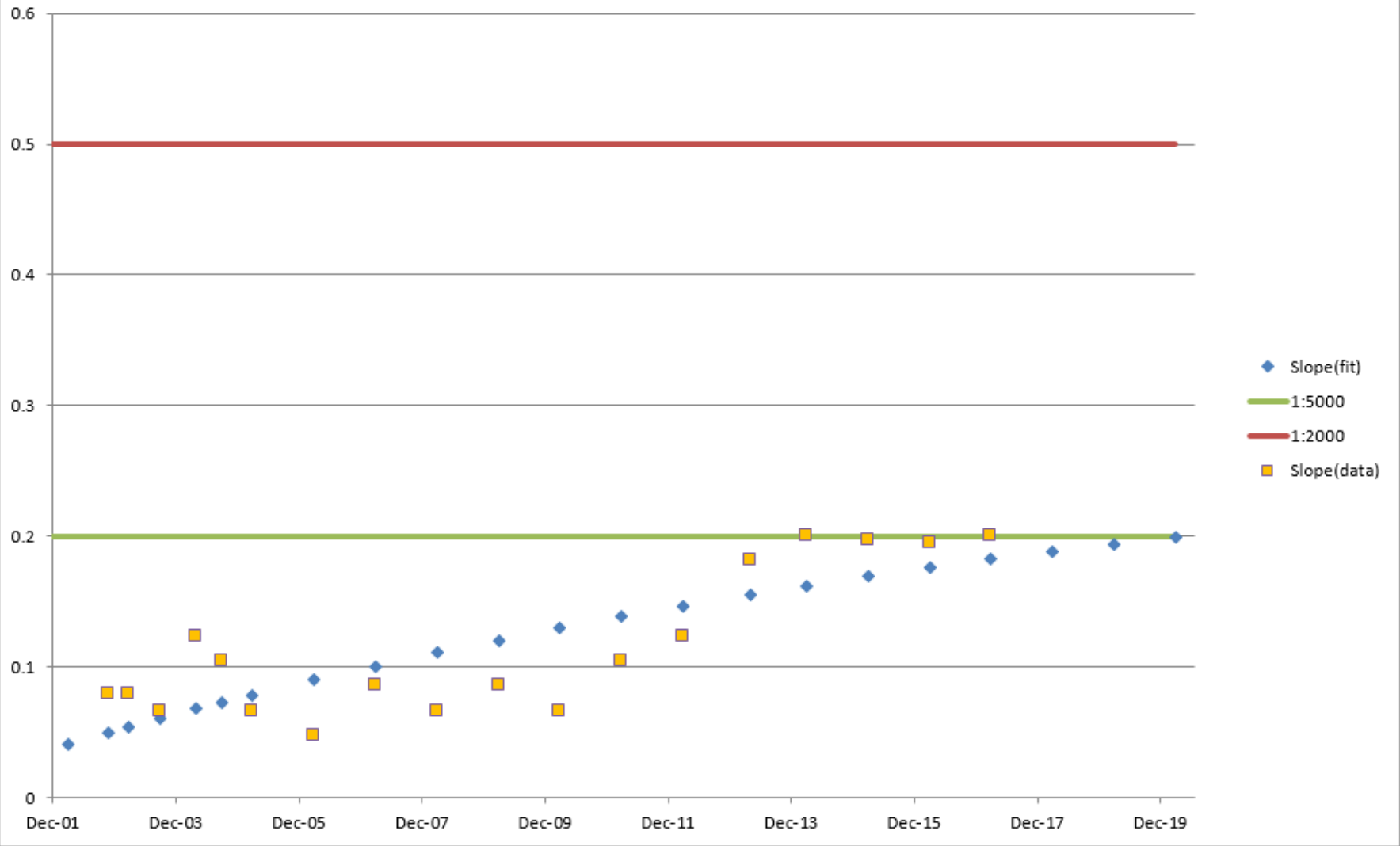
SHEET 2 OF 2

C. SEE SHEET 1		NO	02/11	ISSUED:	DATE:	01/03/2011	 ASSOCIATION OF REGISTERED ENGINEERS NEW ZEALAND <small>ISO 9001          QUALITY          ASSURED</small>	 HARRISON O'RIERSON CONSULTING ENGINEERS PLANNERS	PROJECT:	WINSTONE AGGREGATES THREE KINGS QUARRY	TITLE:	SURVEY MONITORING LEVEL CONTROL POINTS	AUST PARTIAL: PROJECT NO 11/03/2011 DRAWING NO: <b>6451_102</b>
		NO	02/11	ISSUED:	DATE:	01/03/2011	 ASSOCIATION OF REGISTERED ENGINEERS NEW ZEALAND <small>ISO 9001          QUALITY          ASSURED</small>	 HARRISON O'RIERSON CONSULTING ENGINEERS PLANNERS	PROJECT:	WINSTONE AGGREGATES THREE KINGS QUARRY	TITLE:	SURVEY MONITORING LEVEL CONTROL POINTS	AUST PARTIAL: PROJECT NO 11/03/2011 DRAWING NO: <b>6451_102</b>
N		ORIGIN OF LEVELS CHANGED	NO	05/02	DATE:	01/03/2011	 ASSOCIATION OF REGISTERED ENGINEERS NEW ZEALAND <small>ISO 9001          QUALITY          ASSURED</small>	 HARRISON O'RIERSON CONSULTING ENGINEERS PLANNERS	PROJECT:	WINSTONE AGGREGATES THREE KINGS QUARRY	TITLE:	SURVEY MONITORING LEVEL CONTROL POINTS	AUST PARTIAL: PROJECT NO 11/03/2011 DRAWING NO: <b>6451_102</b>

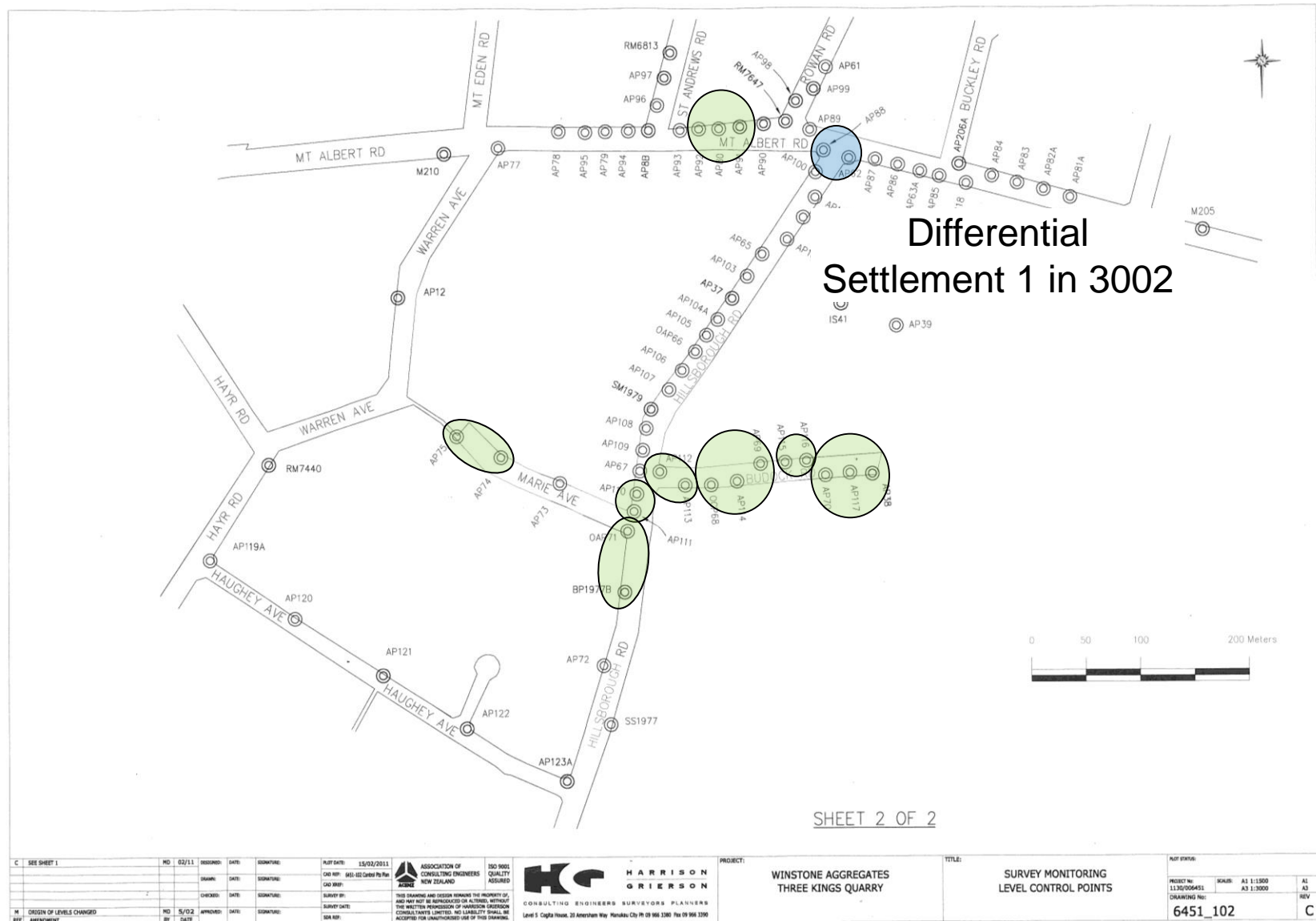
## Settlement Trends – BP1977B and AP71A



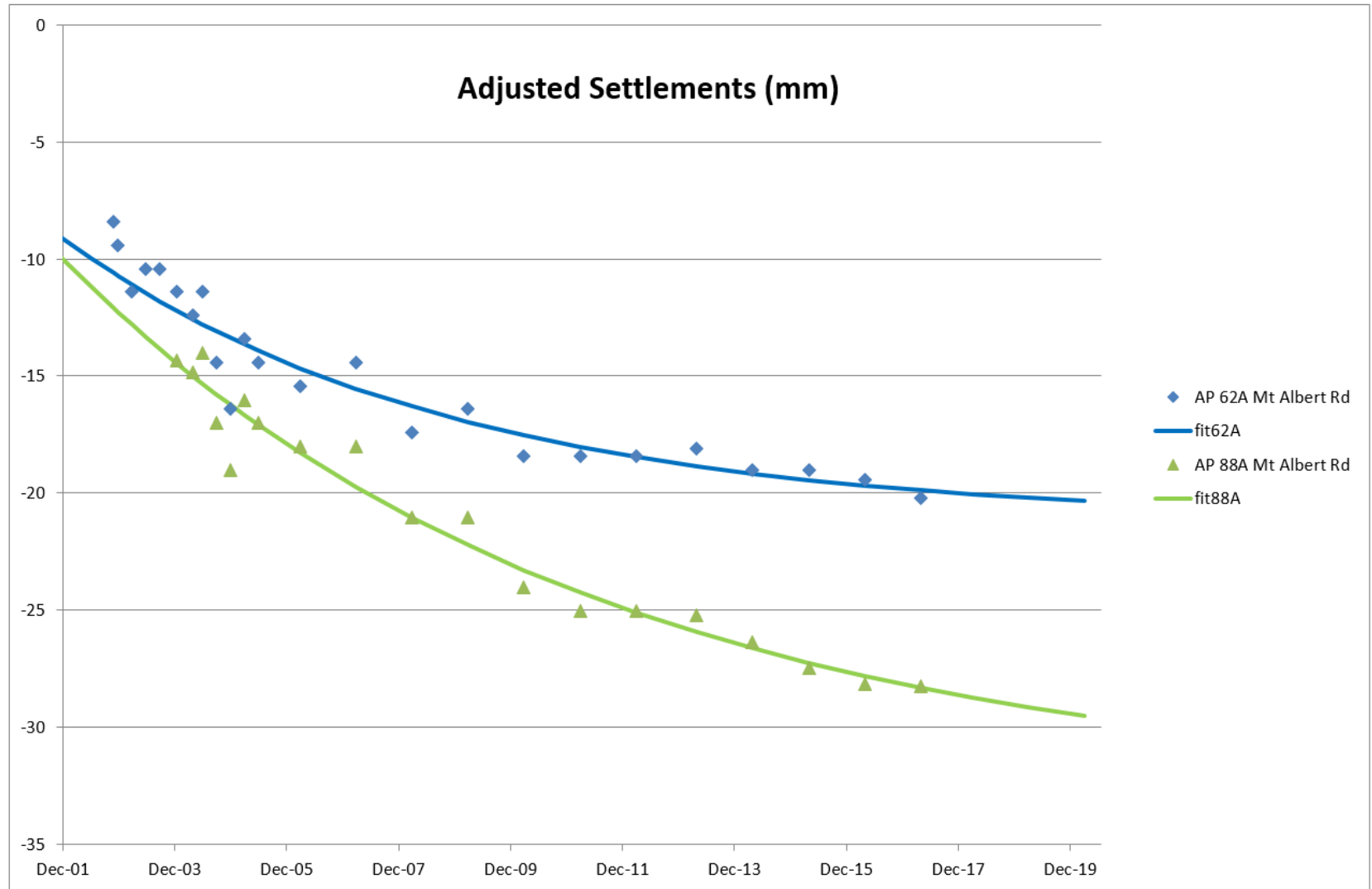
# Differential Settlement Trend Analysis - BP1977B vs AP71A



# Mt Albert Road - Hillsborough Road intersection – AP62A and AP88A

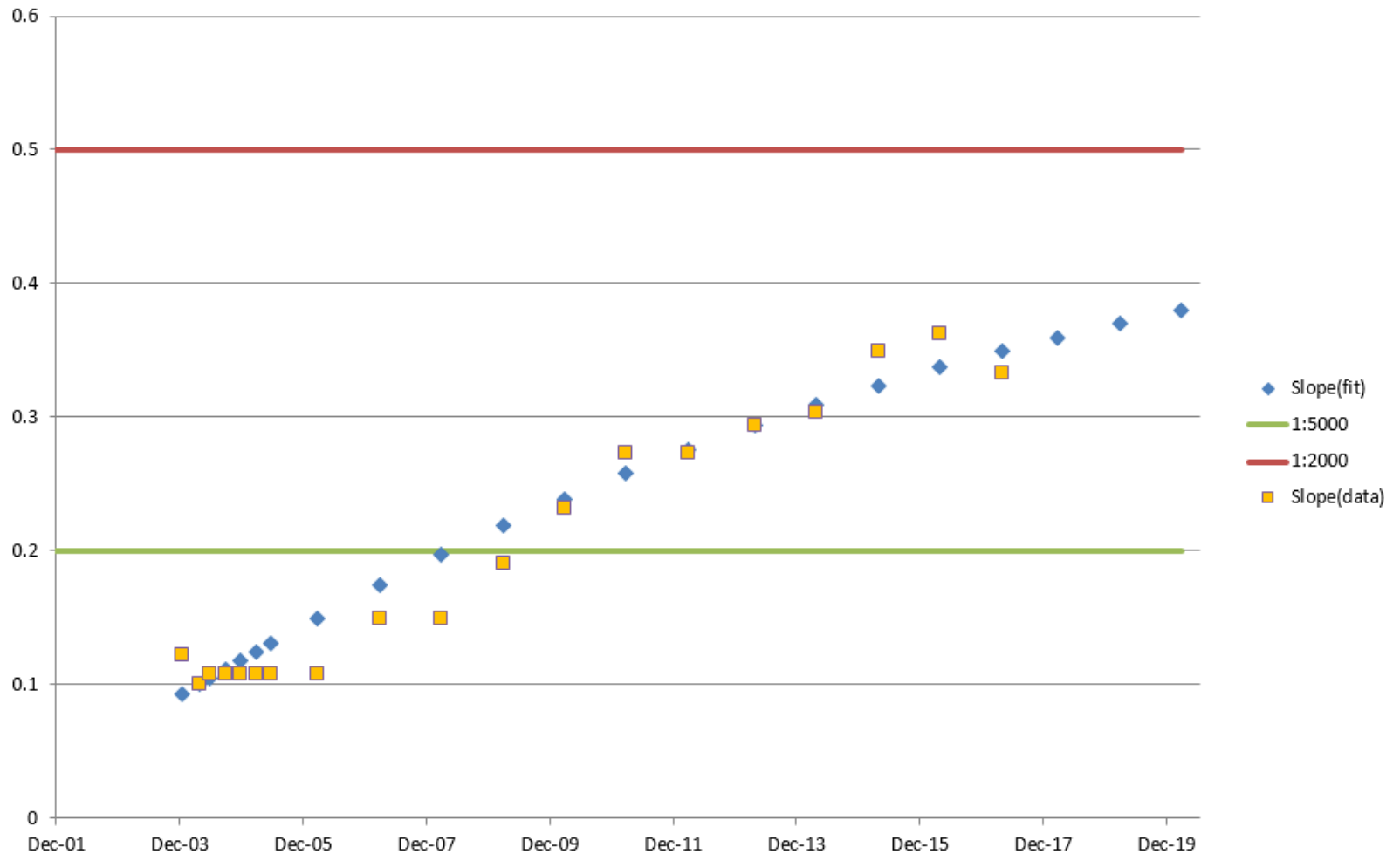


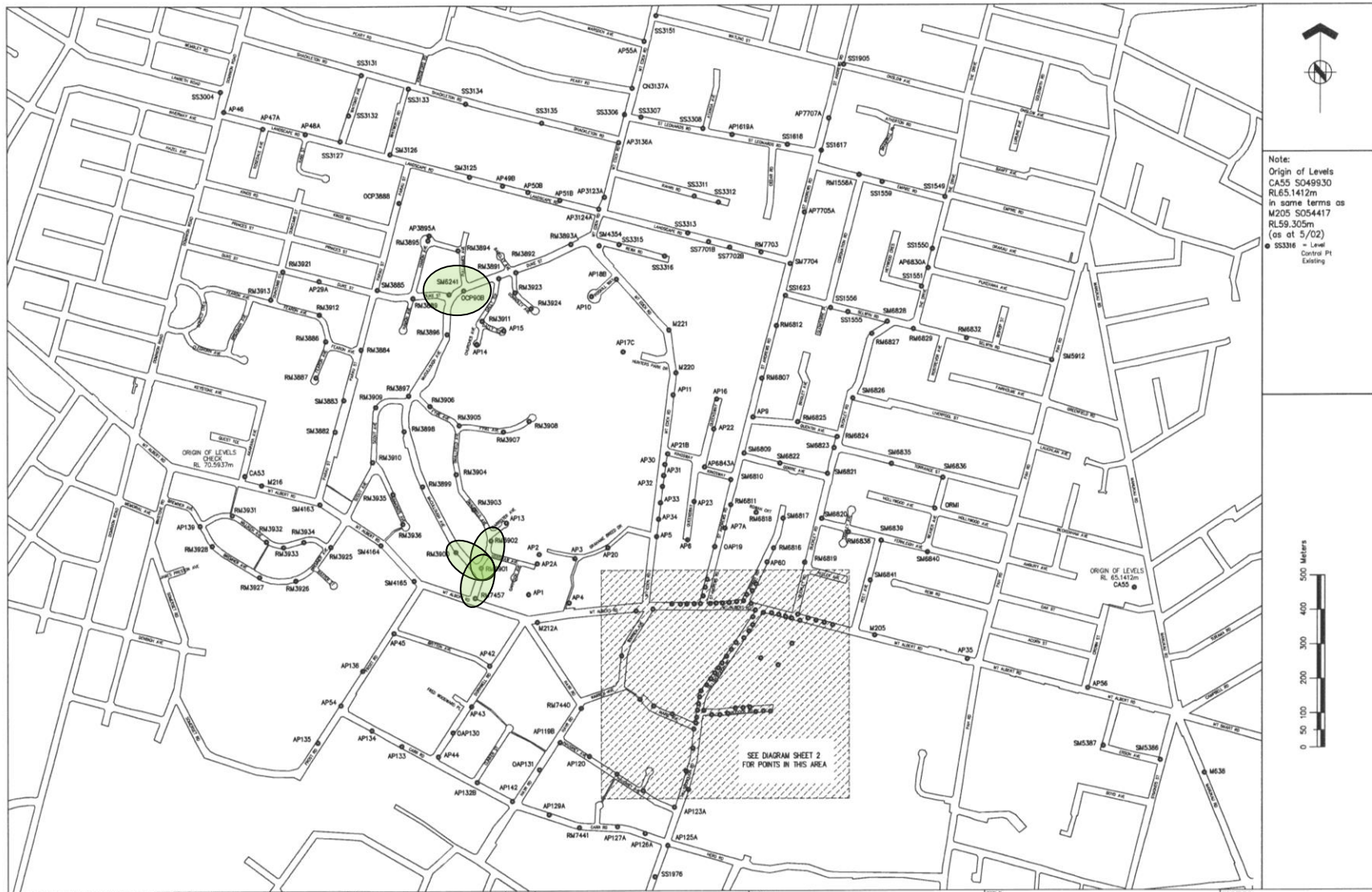
## Settlement Trends – AP62A and AP88A





## Differential Settlement Trend Analysis - AP62A vs AP88A

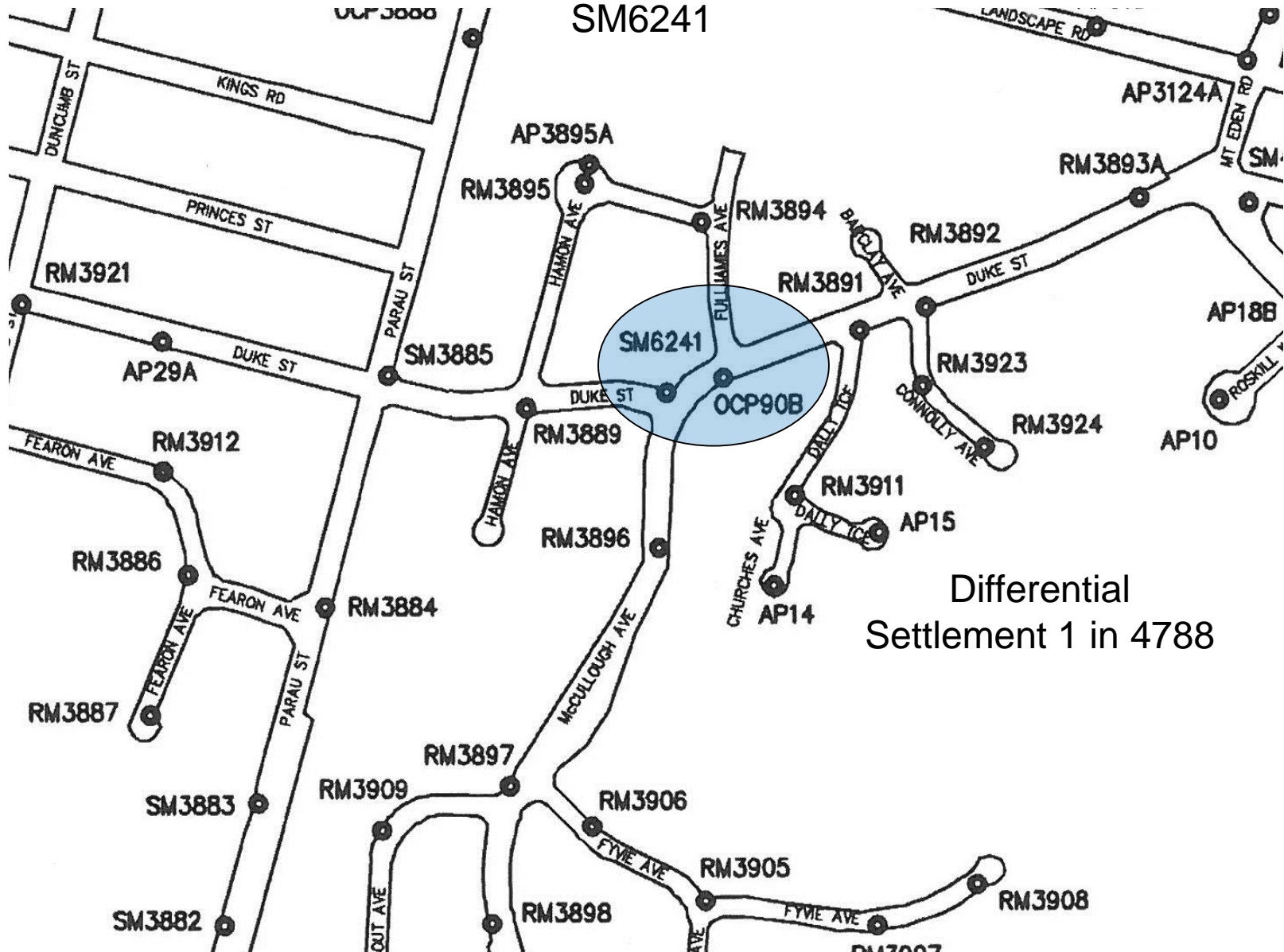




Note:  
Origin of Levels  
CA55 S049930  
RL65.1412m  
In some terms as  
M205 S054417  
RL59.305m  
(as at 5/02)  
● SS3316 = Level  
Control PH  
Existing

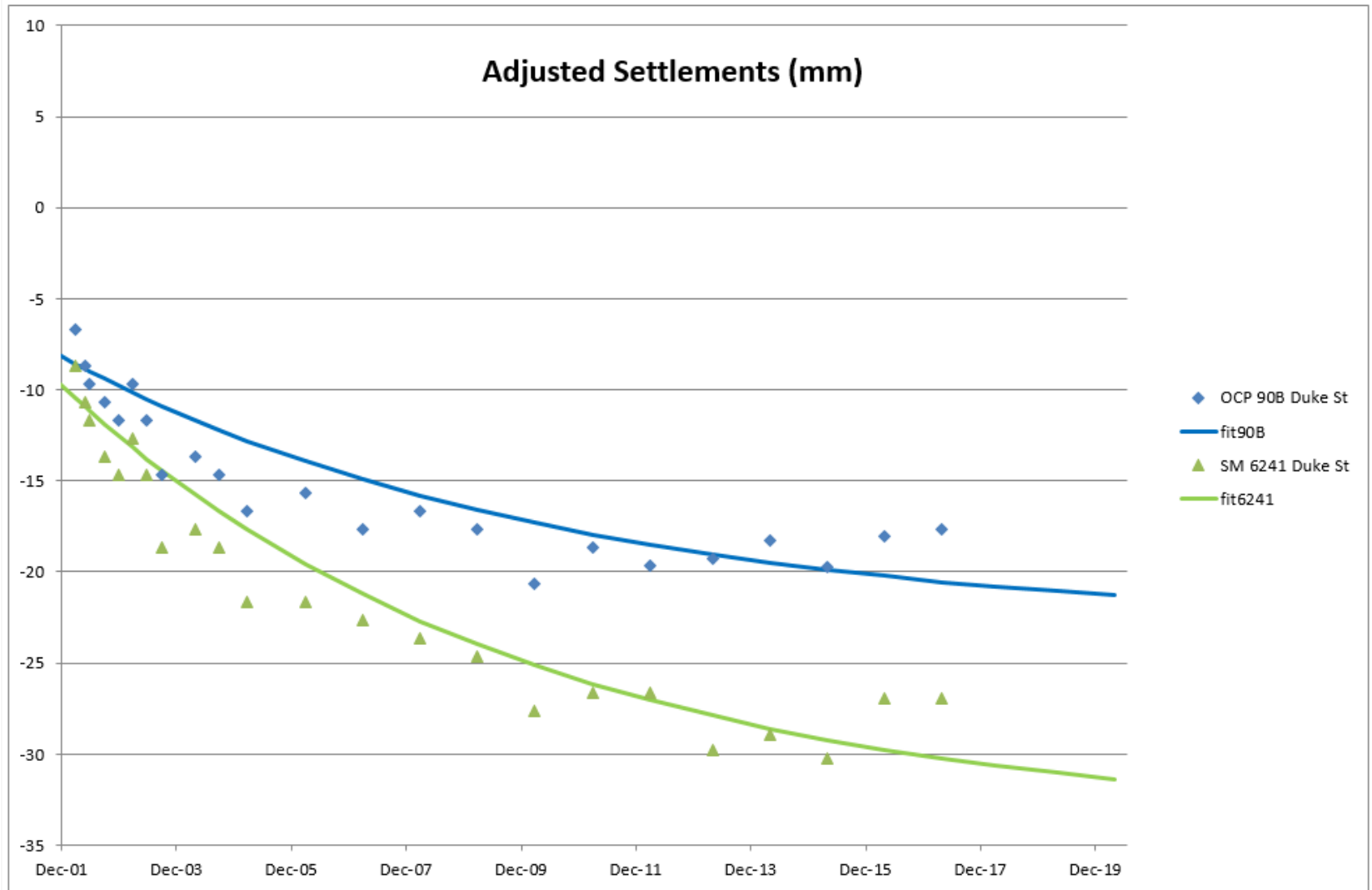
3		CNT136A, AP1123A, AP124A, AP136A, AP171A, AP174A		MED	10.04.13	PREPARED BY:	MED	10.04.13			ISO 9001 QUALITY ASSURED			Manukau Office Level 5 Epsom House 20 Arambour Way, Manukau 2104 P +64 9 966 3380 www.harrisonengr.com	PROJECT:	WINSTONE AGGREGATES THREE KINGS QUARRY	TITLE:	Differential Settlement Alarm Locations SHEET 1 OF 2	DRAWING NO:		PROJECT NO:	1130 006451 01	SCALE:	1:500	A1	REV
1		SS3136, SM1213, SM1214, AP15, CAP17, AP14				DRAWN BY:	MED	10.04.13																		
2		DELIVERED				CHECKED BY:	MED	11.04.13																		
4		ORIGIN OF LEVELS CHANGED		MED	25.02.02	APPROVED BY:																				
5		REVISIONS																								

# Duke Street – OCP90B and SM6241

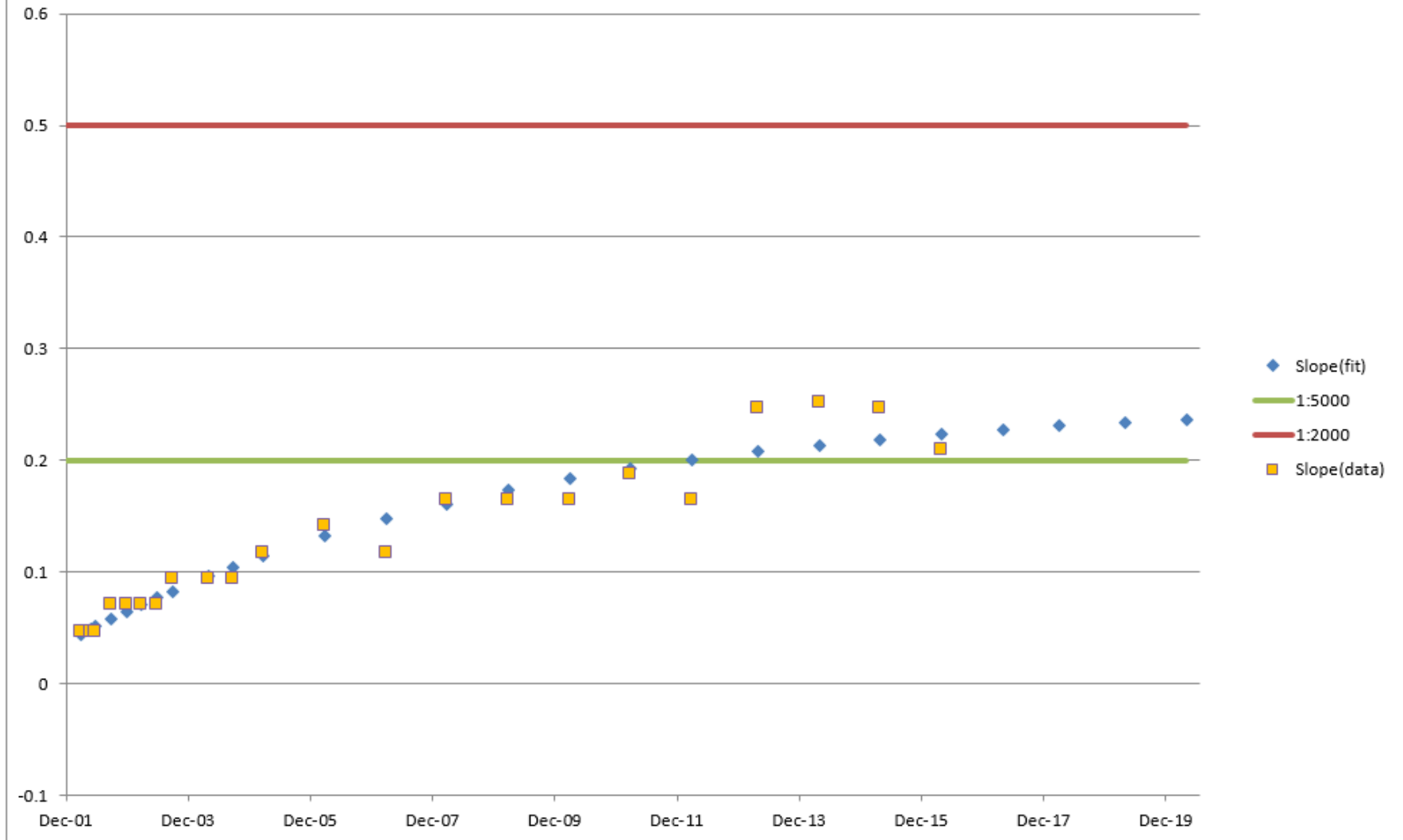


Differential  
Settlement 1 in 4788

## Settlement Trends – OCP90B and SM6241

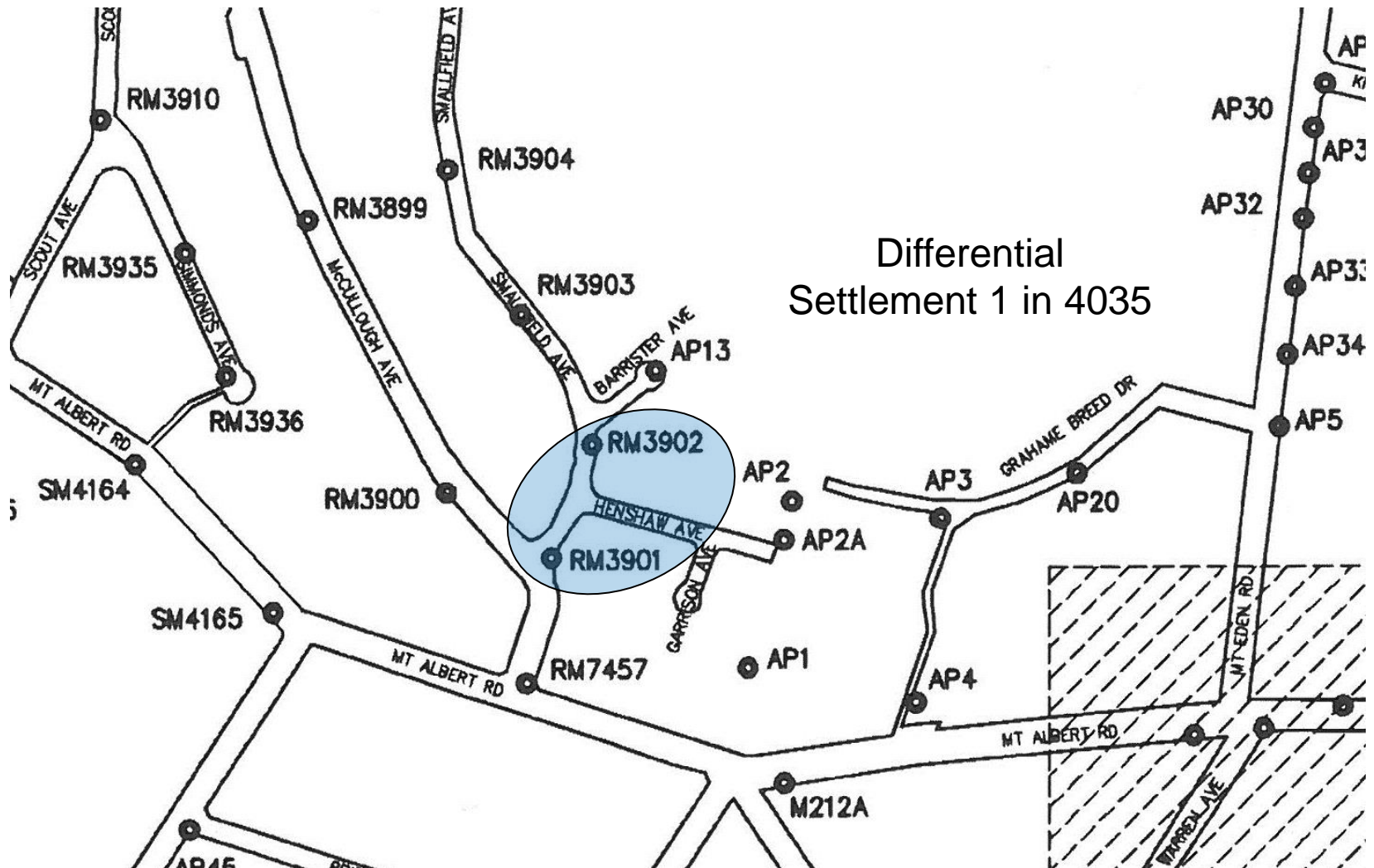


## Differential Settlement Trend Analysis - OCP90B vs SM6241

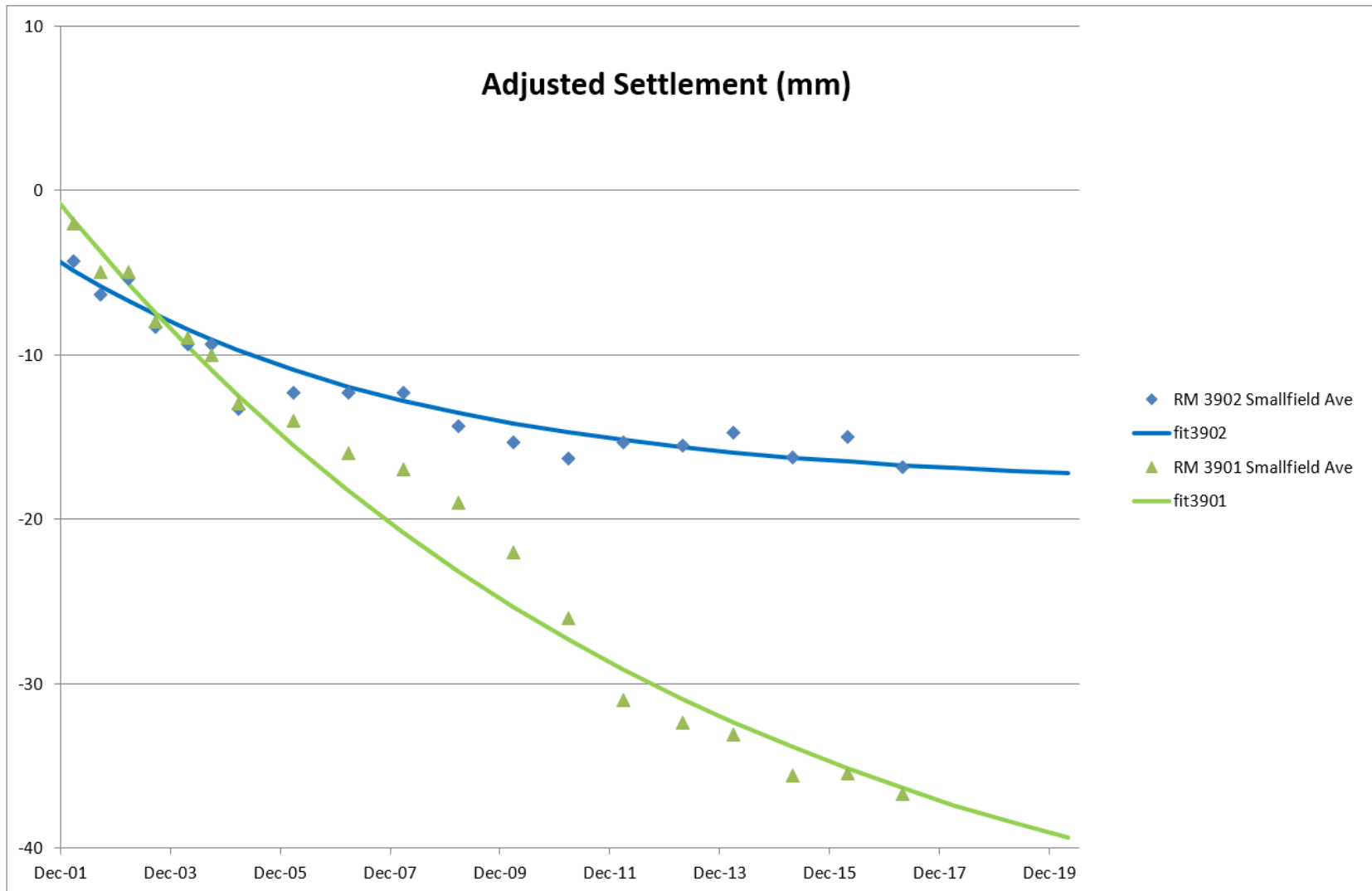




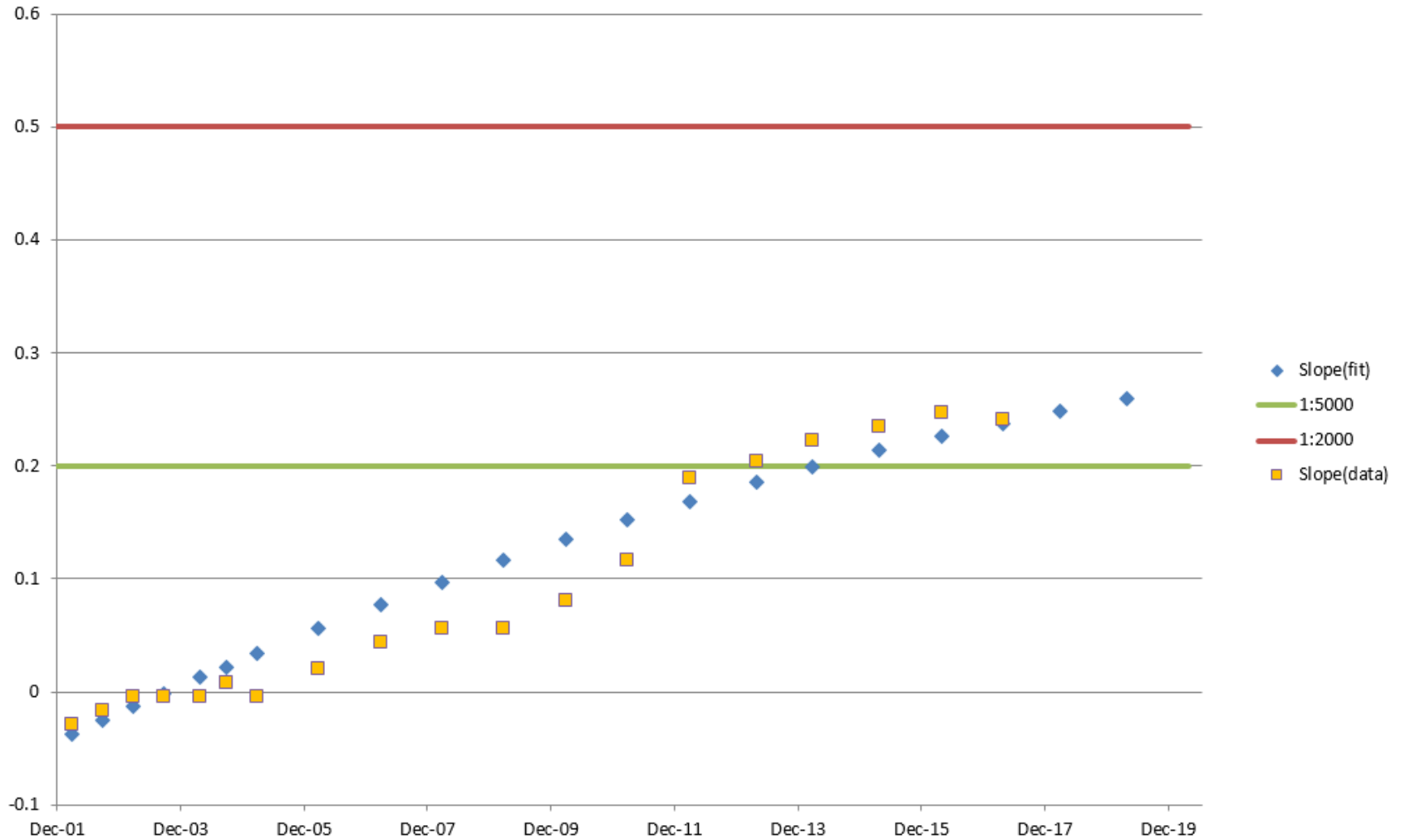
## Smallfield Avenue – RM3901 and RM3902



## Settlement Trends – RM3901 and RM3902

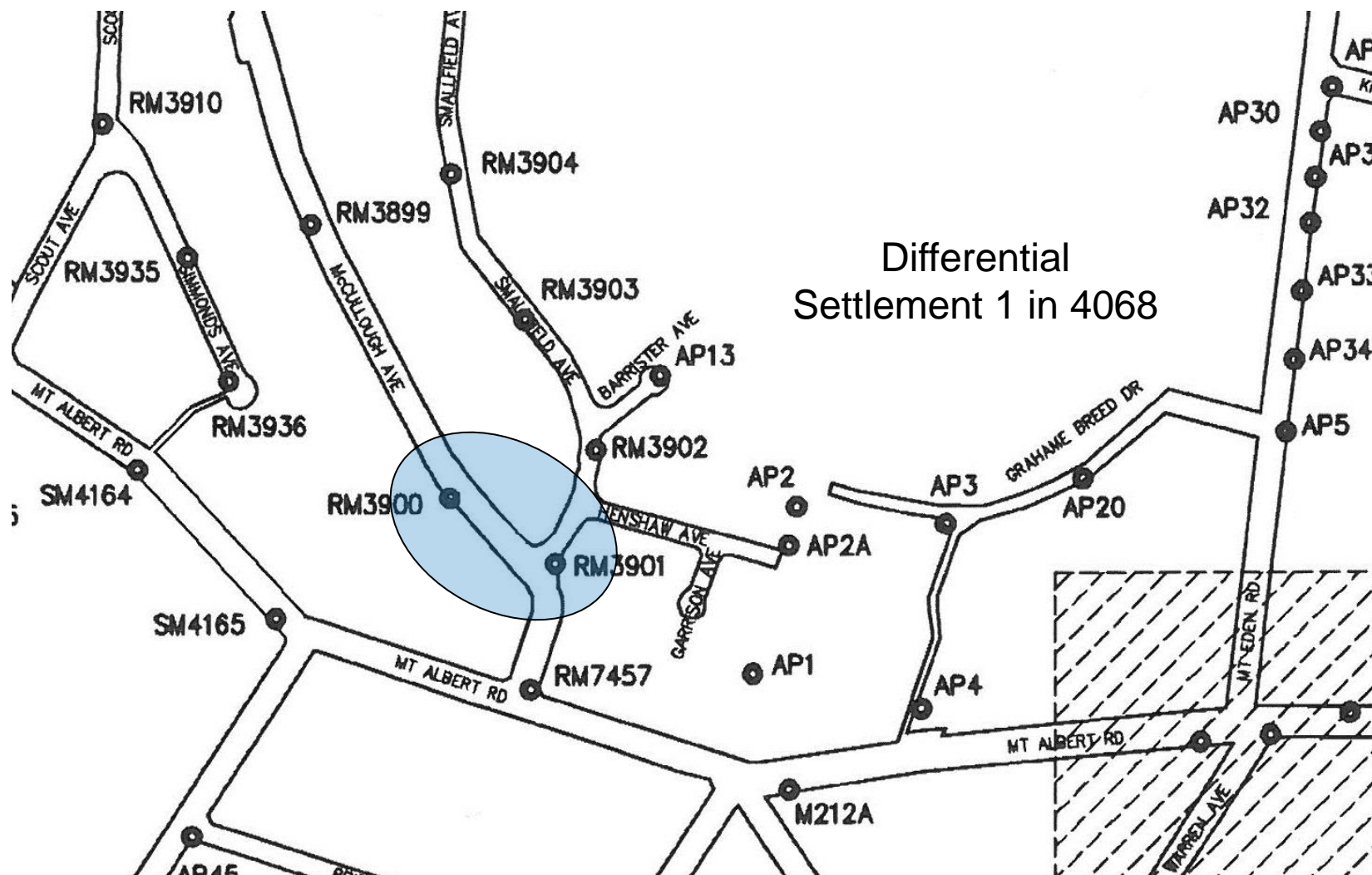


## Differential Settlement Trend Analysis - RM3901 vs RM3902

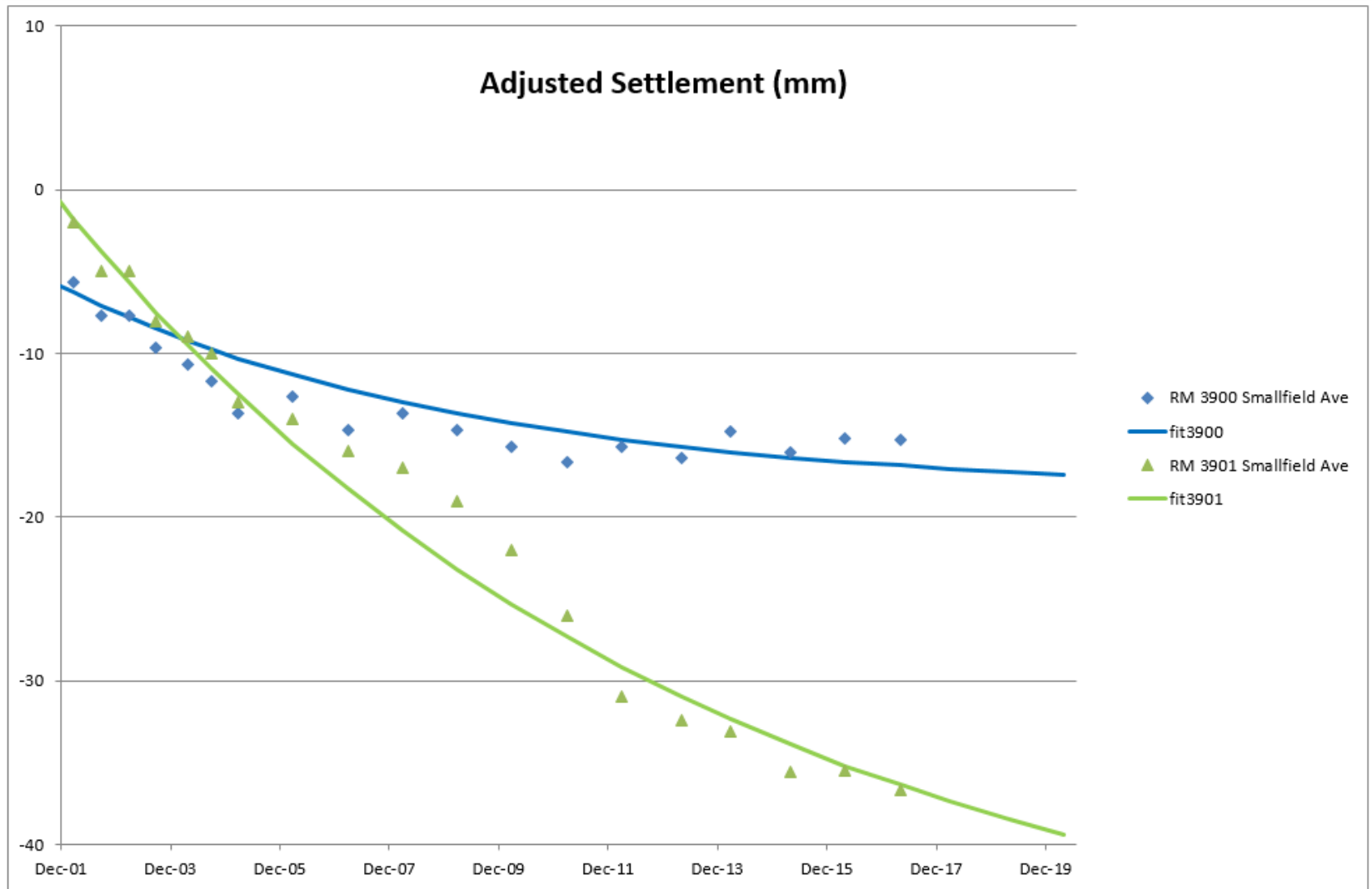




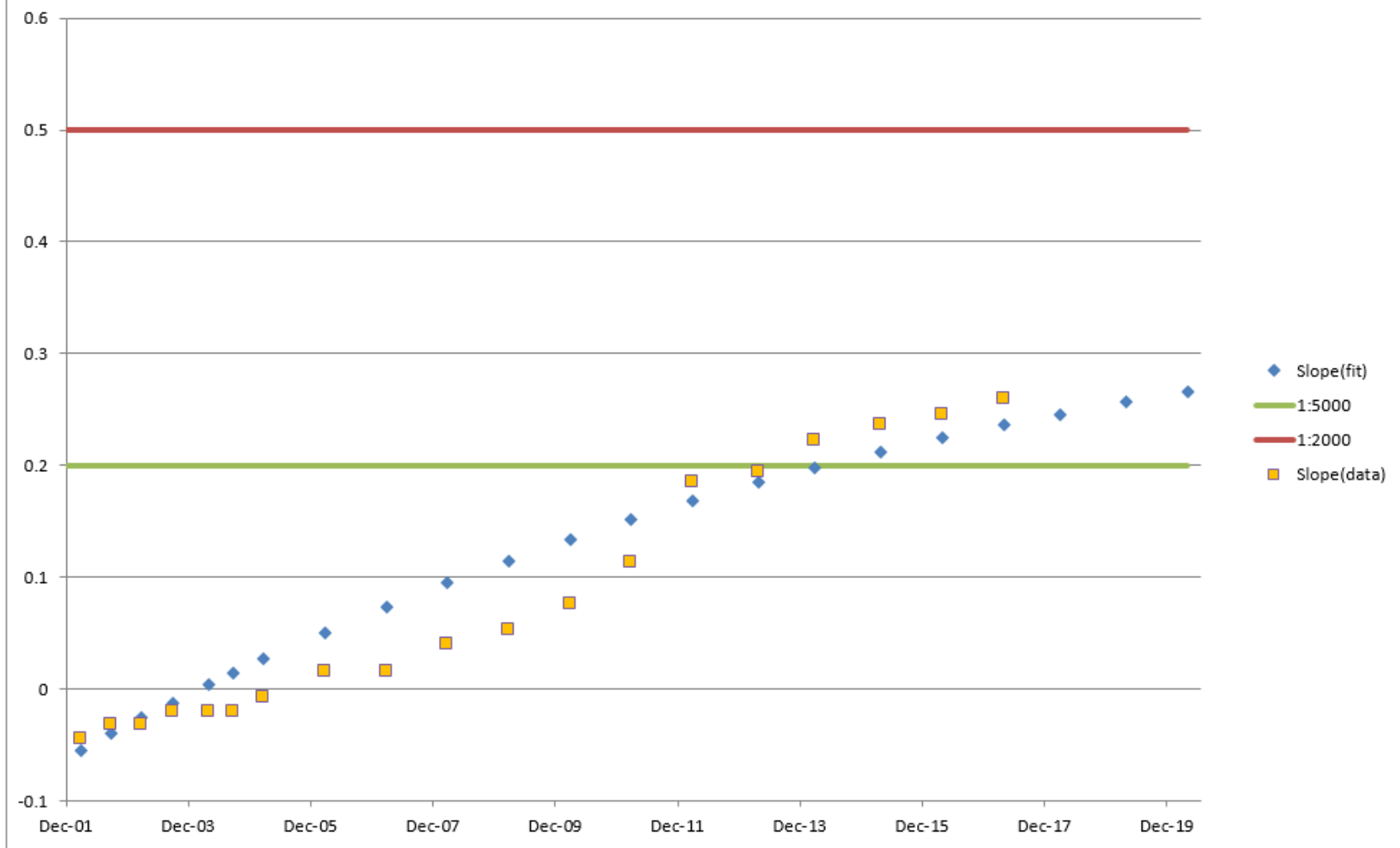
## Smallfield Avenue – RM3900 and RM3901



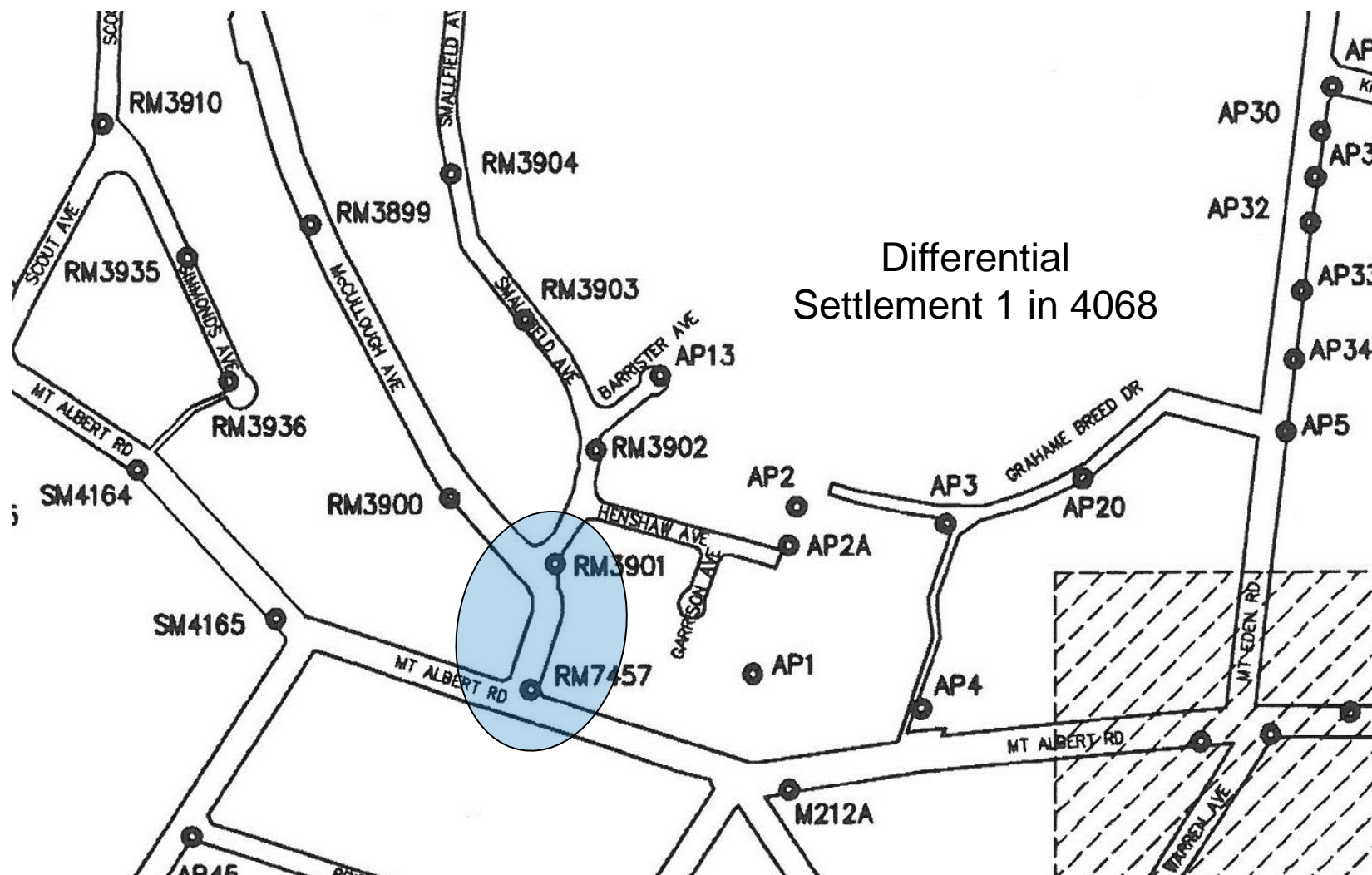
## Settlement Trends – RM3900 and RM3901



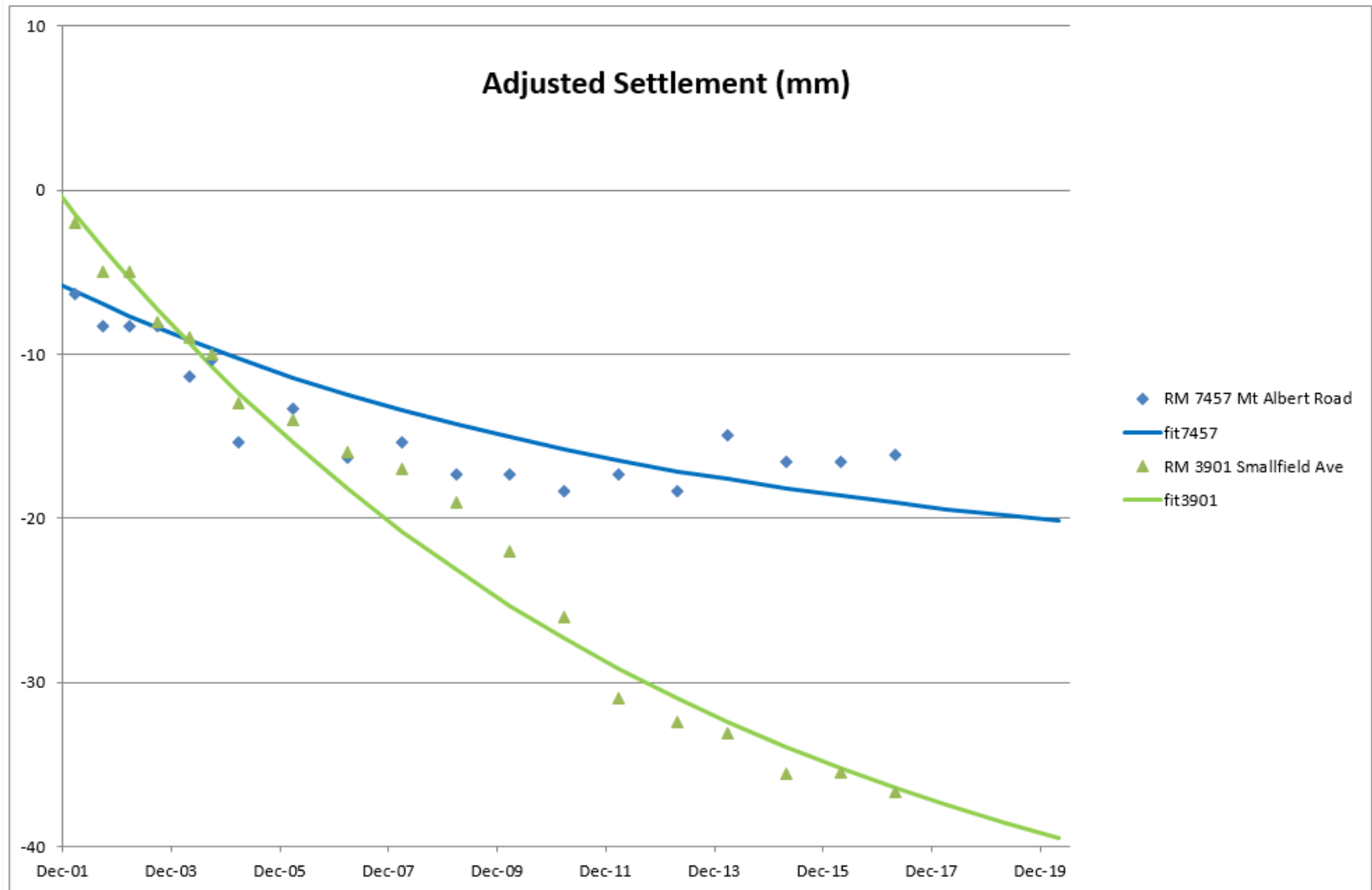
# Differential Settlement Trend Analysis - RM3900 vs RM3901



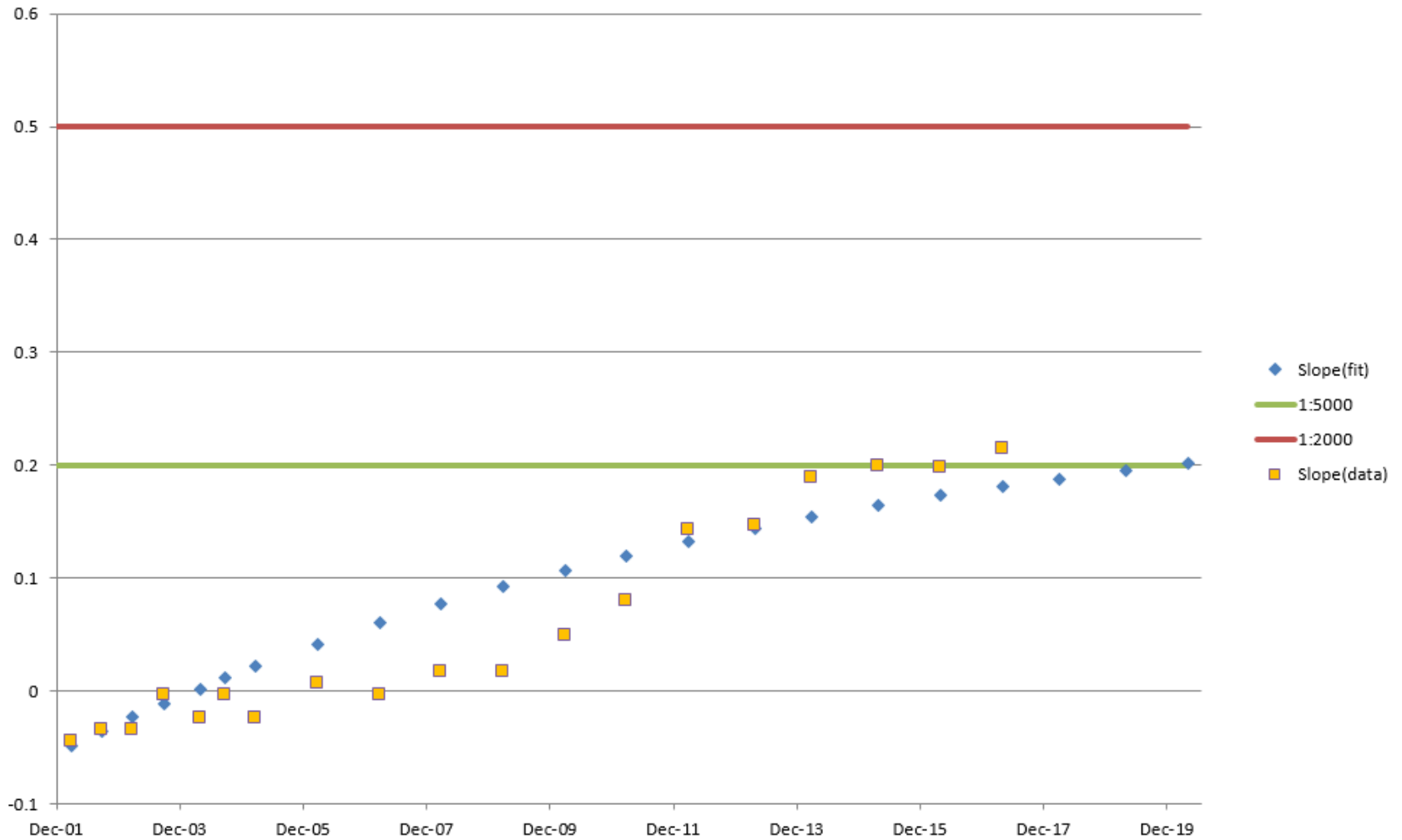
## Smallfield Avenue – RM3901 and RM7457



## Settlement Trends – RM3901 and RM7457



## Differential Settlement Trend Analysis - RM7457 vs RM3901



# Summary of Differential Settlement Triggers

Differential Settlement Triggers are very conservative to avoid the risk of property damage

Specific actions are defined and required to be undertaken should a trigger be recorded

Of the 16 Differential Settlement Triggers currently being recorded:

- Ten triggers are the result of survey marks being affected by factors other than dewatering
- The remaining six triggers are not showing significantly adverse trends and are generally consistent with the findings of the 2004 Dewatering Resource Consent Review

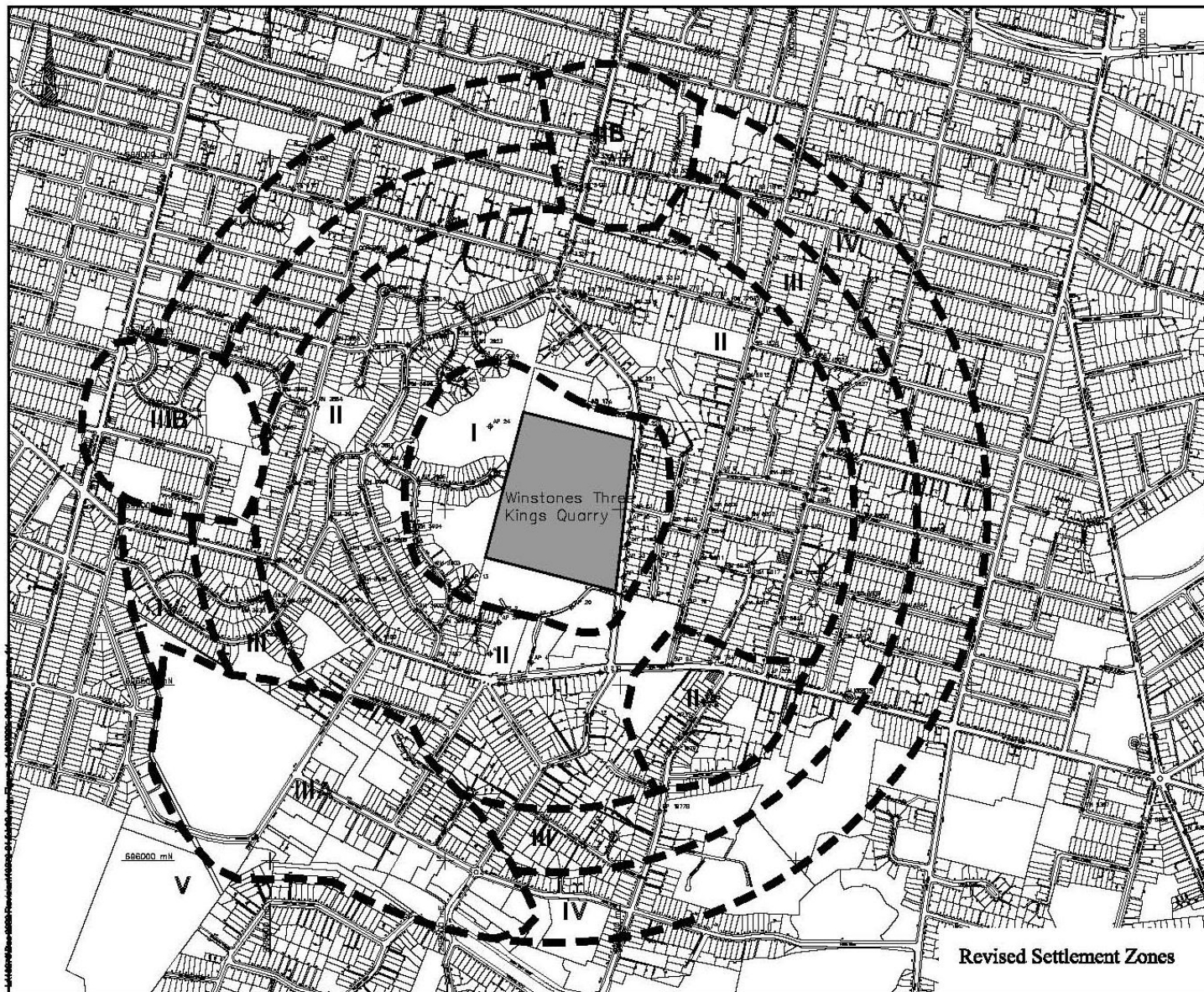
No further action is required.

# Stage Control Levels for Total Settlement

Stage Control Levels were calculated following the 2004 review of the consent to dewater Three Kings Quarry for various amount of drawdown of quarry groundwater levels.

Stage Control Levels for Total Settlement									
	Intermediate Trigger (mm) for Settlement Zones								
	I	II	IIA	IIB	III	IV	V	IIIA	IIIB
Quarry Drawdown to RL30m	10	20	45	15	10	10	5	25	20
Quarry Drawdown to RL15m	15	25	55	35	15	10	5	35	30
Quarry Drawdown to RL0m	20	30	65	45	20	15	5	45	40
Steady State Water Level (at RL0m)	20	35	75	50	25	20	5	65	60





**NOTES**  
1. All dimensions are in metres unless noted otherwise.

**LEGEND**  
Quarry

0 First Issue	BY	DATE
DESIGNED :		
DRAWN :	AMM	OCT 02
DESIGN CHECKED :		
DRAFTING CHECKED :		
REFERENCE :		

PROFILE : L:\18670\18670-01  
REVISED

**NOT FOR CONSTRUCTION**  
This drawing is not to be used for construction purposes unless signed as approved.  
COPYING OR THIS DRAWING IS PROHIBITED.

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Blackland - 18 Morgan St. - Newmarket  
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Dunedin : [ouck@tuckie.co.nz](mailto:ouck@tuckie.co.nz) Christchurch : [ouck@tuckie.co.nz](mailto:ouck@tuckie.co.nz)

**WINSTONE AGGREGATES LTD**

THREE KINGS QUARRY  
DEWATERING

REVIEW OF  
SETTLEMENT PREDICTIONS

**Figure 7**

SCALE : (6.33 x 9.25)  
1:10000  
DATE : 18670-04  
REV : 0

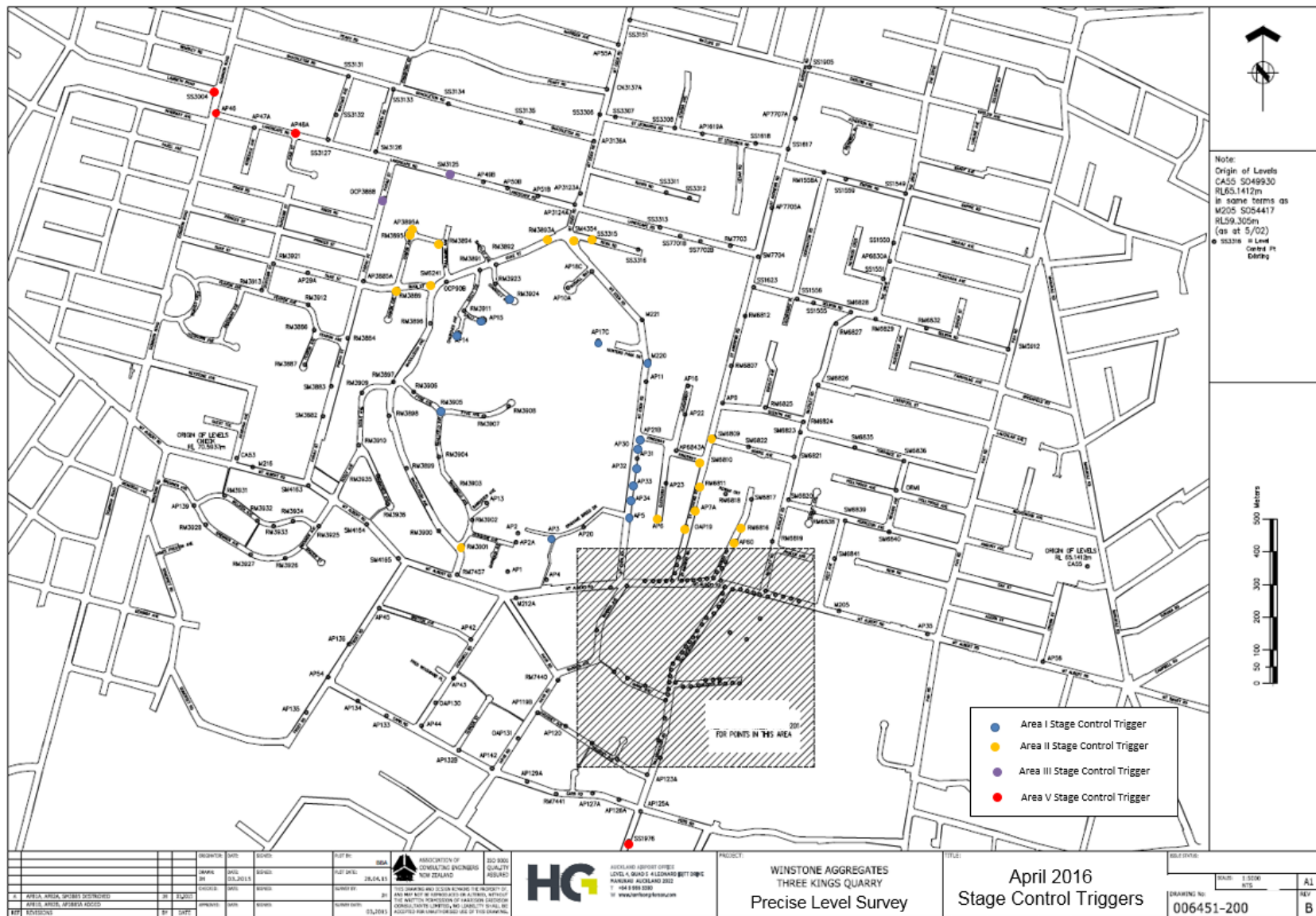
Revised Settlement Zones

## Stage Control Level Summary Table

Groundwater Level RL34m – April 2017 Precise Level Survey

Settlement Zone	Intermediate Trigger (mm)	Current Maximum Total Settlement (mm)
Zone 1	10	17 (35)
Zone II	20	27 (37)
Zone IIA	45	30
Zone IIB	15	15
Zone III	10	12
Zone IIIA	25	15
Zone IIIB	20	-
Zone IV	10	8
Zone V	5	6





# Review and Summary of Stage Control Levels

A review of the Stage Control Levels has been undertaken

Intermediate triggers were recorded for Total Settlement in Zones I, II, III and V.

The Monitoring and Contingency Plan requires that if a Stage Control Trigger is recorded:

- ❖ Dewatering is to cease.
- ❖ A review of groundwater levels and precise level survey data is to be undertaken, and
- ❖ The results of this review be forwarded to the Auckland Council prior to dewatering recommencing.

Although further dewatering is not being proposed, a review of groundwater levels and survey data has been undertaken.

The review noted that in accordance with controls and definitions within the consent to dewater Three Kings Quarry:

- ❖ Settlements greater than 10mm settlement per year have not been recorded
- ❖ Differential settlements greater than 1 in 2000 have not been recorded
- ❖ Total settlement limits of 100mm and 75mm are not going to be exceeded
- ❖ Cessation of settlement has been recorded since September 2005

**Thank you - that concludes the  
August 2017 Monitoring Report**