ANNUAL ANNUAL GROUNDWATER MONITORING REPORT 2013

SPRINGVALE GROUNDWATER MONITORING PROGRAMME

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EXECUTIVE SUMMARY

Reporting Period

The analysis in this report therefore covers the eleven month period from January to December 2013.

During this period mining was carried out on Longwall 415 and Longwall 416.

Site Conceptual Hydrogeology

The series of aquifers and aquitards underlying the ground surface across the Springvale mining lease boundary can be grouped together to form three basic groundwater systems as follows:

- A perched groundwater system;
- A shallow regional groundwater system, ranging from unconfined to semi-confined; and
- A deep confined groundwater system which includes the Lithgow coal seam.

The aquifer units identified above are each separated by strata of lower permeability, which behave as aquitards.

Swamp Classification

For past assessments, the swamps in the monitoring programme have been divided into two basic types based on an interpretation of the dominant source of water within the swamp. This interpretation was undertaken based on the available monitoring results available at the time. The two basic types identified are:

- Type A: swamp water derived predominantly from rainfall infiltration (periodically waterlogged swamps).
- Type C: swamp water derived predominantly from groundwater discharge as well as rainfall contribution (permanently waterlogged swamps).

With ongoing monitoring it has become apparent that a rigid classification of swamps is not entirely correct. Within a swamp there may be a transition from rainfall to groundwater dependency along the range of the swamp, and the point of that transition will vary depending on the prevailing climatic conditions.

This observation has prompted a move away from applying the swamp classification until more definitive analysis of long term trends can be undertaken.

Rainfall

Apart from two peaks in February and June, both plateau and Lithgow rainfall levels for 2013 remained below the Lithgow long term average, and quite significantly so in the latter two thirds of the year. The peak recorded in February 2013 along with the February 2012 peak, is the highest since records began. On the whole, predominantly a very dry year reflected in the Autumn levels which were the lowest Autumnal levels since 2006.

Swamp Water Levels

The water level patterns recorded in swamps which have been undermined, and those which have not been undermined show similar trends. A characteristic Type A trend and a characteristic Type C trend is identifiable from the hydrographs. These two trends remain the same whether the swamp has been undermined or not.

As no mining influenced water level fluctuations can be identified in any of the monitored swamps (both undermined and baseline) it is accurate to say that mining at Springvale has not led to any identifiable water level impacts on the monitored swamps, and that all undermined swamps display water levels which can be likened to baseline behaviour.

Regional Shallow Aquifer Water Levels

On the whole, water levels in the standpipe piezometers which monitor water levels in the regional shallow aquifer display stable trends which fluctuate as normal and in the same manner as previous years. No identifiable mining impacts in the shallow aquifer have been recorded.

Surface Water Monitoring

Surface water flows are monitored at three discharge points at Springvale – Junction Swamp, Sunnyside Swamp and Carne west Pool. The data at these monitoring points is consistent with that observed in previous years monitoring showing no discernable effects from mining. Both peak flows and base flows appear unchanged from the previous reporting period.

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1. Introduction

As part of the environmental management plans for Springvale Colliery, an intensive monitoring programme has been implemented on the Newnes Plateau to detect any impacts from underground mining on the groundwater regime, and in particular the Newnes Plateau Shrub Swamps (NPSS). The greater monitoring programme incorporates NPSS and groundwater monitoring locations above both Springvale Colliery and the adjacent Angus Place Colliery, the monitoring locations within the Springvale mining lease boundary (Figure 1) include the following main aspects:

- Groundwater levels are monitored in 10 swamps, with a total of 24 swamp piezometers.
- Flow from Junction Swamp is monitored through a v-notch weir, and flows in Sunnyside Swamp and Carne West Swamp are indicated by pool depth monitors.
- The groundwater level in the regional shallow aquifer is measured in 22 piezometers, which have been installed on the ridges between the swamps.
- Hydrogeological conditions in the geological sequence above the working seam are monitored by multi-level piezometer arrays, installed in 11 boreholes across the entire spatial extent of mining lease boundary.
- A basic weather station provides climatic data on the plateau.
- Water quality data is recorded in 10 piezometers across 4 swamps

Data are recorded at various frequencies as follows:

- The swamp and aquifer piezometers, data are automatically recorded every three hours.
- Surface water level data in pools and weirs are automatically recorded every hour.
- Multilevel piezometers generally record data once per day.
- Dipped aquifer piezometers are measured at each data collection trip (monthly).
- Barometric data are recorded automatically every three hours for correction of piezometer data.
- Swamp water quality data are recorded monthly.

The locations of the monitoring points are shown on Figure 1.

During each monitoring round the condition of the instruments are checked, as well as the battery levels and the data quality. A full review of the current status of the monitoring instruments, and the monitoring network is being undertaken by RPS. Any maintenance or remedial requirements will be presented in a piezometer review report which will be produced in early 2014.

The following report presents the latest data downloaded from the installations, and also includes data from previous monitoring periods to aid in the identification of longer term trends. An interpretation of the data for 2013 is provided, which highlights any anomalies and any observed mining-induced impacts, interpreted from the data over the review period for swamps that are in the vicinity of active mining areas (for 2013 this is Longwall 415). Any observed impacts that exceed trigger levels set out in the Newnes Plateau Shrub Swamp Management Plan are also identified so that appropriate management or engineering solutions can be implemented.

1.1 Reporting period

The latest data from the monitoring installations were downloaded over the period 18 - 26 November 2013. The reporting period is marked on each data plot for reference, however as stated previously analysis has also been undertaken on data from previous monitoring periods to aid in the identification of longer term trends.

Over the last few review periods it has become apparent that a number of vibrating wire piezometer installations have begun providing erroneous readings. The reasons for this are currently subject to review and until the data can be either corrected or discounted it has not been included in this monitoring report.

Mining on Longwall Panel 415 began on 15th March 2012 and ceased on 16th September 2013. The planned full length of the panel was not reached on account of a major collapse at the coal face. The net result of this collapse was that the longwall mining machinery was unable to be restarted and management made the decision to move onto the next planned longwall while temporarily halting operation of LW 415. Mining on (LW416) started on 24th September 2013, and the current reporting period encompasses mining on LW415 and LW416.

2. Existing Environment

2.1 Hydrogeology

The groundwater regime underlying the Springvale mining lease boundary can be grouped together to form three basic groundwater systems as follows:

- A perched groundwater system;
- A shallow regional groundwater system, ranging from unconfined to semi-confined; and
- A deep confined groundwater system which includes the Lithgow coal seam.

The aquifer units identified above are each separated by strata of lower permeability, which behave as aquitards.

Perched Groundwater System – Burralow Formation

These systems comprise multiple, discontinuous, perched aquifer systems that are hydraulically independent of the underlying regional groundwater system. The perched groundwater is generally near surface geological horizons where the Burralow Formation is present. It is derived from excess rainfall which is largely prevented from infiltrating deeper down into the regional systems due to the presence of fine grained or less permeable claystone and siltstone horizons. The perched groundwater system produces seeps and discharge points at outcrop areas which are fundamental to the existence of the shrub swamp systems. At the base of the perched groundwater system, a regionally continuous aquitard unit (SP4) separates the perched groundwater system from the underlying shallow groundwater system

Shallow Groundwater System – Banks Wall Sandstone

This groundwater system is a regional system located in the Banks Wall Sandstone of the Narrabeen Group. This system generally extends to a depth of 200m below ground surface.

Most groundwater flow in this water bearing sequence is generally horizontal through more permeable formations and along bedding planes. Some vertical flow is likely to occur within the shallow groundwater system, such as the infiltration of rainfall in the upper part of the aquifer where it is exposed in gullies and limited vertical leakage from the perched groundwater system.

Bish (1999) identified that the general flow direction in the shallow groundwater system is towards the northeast, in the general formation dip direction. Recharge potentially occurs in areas of outcrop/sub-crop to the west and southwest of the study area. Discharge is inferred to occur to the northeast, where the units outcrop in the scarp of the plateau.

At the base of the shallow groundwater system is the Mount York Claystone (MYC) horizon. This horizon comprises a low permeability layer that restricts infiltration downwards from this system to the underlying deep groundwater system.

Deep Groundwater System

The deep groundwater system is located in the strata underlying the MYC, and includes the Illawarra Coal Measures in the lower half of the groundwater system. The deep groundwater system is around 200m thick and generally starts at a depth of more than 200m below ground surface, beneath the MYC. Most of the coal measures overlying the Lithgow seam in this groundwater system have low permeability characteristics. A small number of aquifer units in the system have a slightly higher permeability and represent the water bearing zones.

The few water bearing zones that do occur at depth in this groundwater system are typically fractured rock aquifers (with groundwater flow exploiting the secondary porosity, fracture-plane conduits). These include jointed or cleated coal seams and other localised jointed or fractured lithologies, often adjacent to faults.

2.2 Swamp Classification

For past assessments, the swamps in the monitoring programme have been divided into two basic types based on an interpretation of the dominant source of water within the swamp. This interpretation was undertaken based on the available monitoring results available at the time. The two basic types identified are:

- Type A: swamp water derived predominantly from rainfall infiltration (periodically waterlogged swamps).
- Type C: swamp water derived predominantly from groundwater discharge as well as rainfall contribution (permanently waterlogged swamps).

With ongoing monitoring it has become apparent that a rigid classification of swamps is not entirely correct. Within a swamp there may be a transition from rainfall to groundwater dependency along the range of the swamp, and the point of that transition will vary depending on the prevailing climatic conditions. Different swamps and even different areas of the same swamp can display varying lag times between predominantly wet or dry conditions and a corresponding fluctuation in water levels. This can be further compounded where a swamp may be in connection with multiple perched aquifers (groundwater discharge points) along its length.

Following a recent period of prevailing dry (below average rainfall) conditions a number of swamps that had previously been classified as Type C, are now displaying a tendency towards Type A characteristics.

This observation has prompted a move away from applying the swamp classification until more definitive analysis of long term trends can be undertaken.

2.3 Rainfall data

Monthly rainfall data are summarised in Table 2.1 and displayed in graphical form on Figure 2.

Newnes Plateau rainfall data is based on the Lithgow average rainfall x 1.18. This figure has been calculated using analysis of long term differences between Plateau rainfall values and Lithgow rainfall values.

Table 2.1: Average Rainfall Data

	Average rainfall	
	Newnes Plateau* (mm)	Lithgow (mm)
January 2013	142.8	121.0
February 2013	134.6	114.0
March 2013	121.4	102.9
April 2013	94.3	79.9
May 2013	95.9	81.3
June 2013	97.9	83.0
July 2013	80.6	68.3
August 2013	98.5	83.5
September 2013	80.1	67.9
October 2013	108.0	91.5
November 2013	105.0	89.0
December 2013	106.7	90.4
Annual Total	1265.9	1072.8

These values are calculated using the Lithgow average x 1.18 multiplier.

Apart from two peaks in February and June, both plateau and Lithgow rainfall levels for 2013 remained below the Lithgow long term average, and quite significantly so in the latter two thirds of the year.

Along with the February 2012 rainfall, the plateau rainfall in February 2013 is the highest recorded since monitoring began, while the corresponding rainfall at Lithgow during this rainfall event was the highest since June 2007.

The three month period between these peak rainfall events show rainfall levels well below the long term average, and along with the 2012 rainfall data for the same period are some of the lowest Autumnal levels since 2006.

From July to November rainfall levels dropped to their lowest recorded levels since approximately May 2008. Following the lowest recorded levels for 2013 in November, rainfall levels began to climb to long term average levels for that time of year, however they do not exceed this long term average.

On the whole, 2013 was a very dry year with rainfall levels remaining well below the long term average throughout the entire year apart from two peaks.

3. Swamp Water Level Monitoring

The swamp monitoring hydrographs are plotted on Figures 3 to 11, and the locations of all the monitoring boreholes are shown in Figure 1.

3.1 Monitoring Results

The following sections detail the salient points ascertained from the analysis of the swamp hydrographs. An interpretation summary is provided in Section 3.2.

Sunnyside West Swamp

There is one piezometer installed in Sunnyside West Swamp the details of which are shown in Table 3.1.

Table 3.1: Sunnyside West Swamp Piezometer Information

Piezometer	Mined Status	Swamp Type	Monitoring Commencement
SW1	LW413B & LW414	Type A	26/07/2007

The water levels at Sunnyside West show a strong response to rainfall and commenced the current review period at or below the logger, which is situated at 2.2mbgl. An immediate response is witnessed to the increased rainfall during the first quarter of 2013 and by March water levels reached a maximum of 0.5mbgl before declining and fluctuating between 1 and 1.75mbgl until September. Throughout September and October water levels dropped to the logger level or below and have remained there through to November.

The observed trend is similar to that observed during the previous review period and is consistent with generally below average rainfall with a small number of large rainfall events.

Sunnyside Swamp

There are four piezometers installed in Sunnyside swamp, the details of which are shown in Table 3.2.

Table 3.2: Sunnyside Swamp Piezometer Information

Piezometer	Mined Status	Swamp Type	Monitoring Commencement
SS1	Not Undermined	Type C	12/05/2005
SS2	Not Undermined	Type C	12/05/2005
SS3	Not Undermined	Type C	12/03/2010
SS4	Not Undermined	Type C	12/03/2010
SS5	Not Undermined	Type C	12/03/2010

SS1 has shown a relatively steady trend throughout the review period, which is consistent with previous years. Water levels were approximately 0.15mbgl in January 2013 and peaked at around ground level after the period of rainfall experienced from January to March 2013. Water levels then declined slightly and remained steady at around 0.15 to 0.22mbgl for the remainder of the review period. Sampling events are evident from the rapid drop and subsequent recovery in water levels and as such this data set should be interpreted through consideration of the upper water level trends.

SS2 has also shown relatively steady water levels throughout the current and previous review periods. Water levels were approximately 0.35mbgl in January 2013 and approached ground level following a period of rainfall from January to March 2013. Water levels subsequently show a gradual decline over remainder of the year. Sampling events are also evident in SS2 and rapid response to rainfall events can be seen.

SS3 commenced the review period with a significant decline in water levels that began to occur in November 2012 where water levels dropped from around ground level to 1.07mbgl. A drop of this magnitude is not consistent with the typical response to rainfall at this site as water levels have consistently remained at around ground level prior to November 2012, however 2012 was a particularly dry year and swamp water levels were generally low. Following the period of rainfall from January to March 2013 water levels returned to ground level before declining and remaining steady at approximately 0.1mbgl. The dry period during August and September 2013 led to a decline in water levels to 0.25mbgl and subsequent recovery due to a period of light rainfall. Water levels then declined rapidly in the same fashion as the beginning of the review period, again to 1.07mbgl in early November before responding a to a period of rainfall and increasing at the end of the data set.

SS4 has shown steady water levels throughout the current and previous review periods with a relatively subdued response to rainfall of the order 0.1 to 0.2m. The data set shows groundwater levels to be above ground; however this is likely due to a small discrepancy in the logger depth data used for calibration. The water levels at SS4 also show a rapid decline in December 2012 and January 2013, which is typical of the end of a long period of no rainfall and is reflected in SS3 and SS5 responses and shown in Figure 4. Water levels throughout the review period have consistently remained approximately at ground level.

SS5 water levels have shown a very similar pattern to those at SS4 with a greater response to rainfall. As with all Sunny Side piezometers, a significant reduction in water levels is evident at SS5 during the end of 2012 and into January 2013 where water levels dropped from approximately ground level to around 0.6mbgl. Water levels subsequently increased due to the period of rainfall during the first quarter of 2013 and fluctuated between ground level and 0.2mbgl before declining more significantly during October, which may be attributed to the dry period throughout September and October. The decline continues and increases in magnitude during November, when there was increased rainfall

Sunnyside East Swamp

Three piezometers are installed into Sunnyside East Swamp as shown in Table 3.3.

Table 3.3:Sunnyside East Swamp Piezometer Information

Piezometer	Mined Status	Swamp Type	Monitoring Commencement
SSE1	Not Undermined	Type A	12/03/2010
SSE2	Not Undermined	Type C	12/03/2010
SSE3	Not Undermined	Type C	12/03/2010

SSE1 is the deepest of the three piezometers installed at Sunny Side East and has shown water levels to typically be 0 to 0.1m above the logger throughout the review period. Historically this site has shown some strong responses to rainfall but only after prolonged rainfall and higher than average seasonal rainfall. Throughout the latter half of 2012 rainfall was below average and hence swamp water levels at SSE1 were low at the beginning of the review period. The rainfall experienced from the end of January 2013 through to the beginning of March 2013 did lead to a rise in water levels at SSE1 in early March, however water levels quickly declined back to approximately 2.1mbgl and continued to decline throughout 2013 to approximately 2.2mbgl, which is only a few centimetres above the logger.

SSE2 (Figure 5), showed a decline in water levels throughout the latter half of 2012 from approximately ground level down to approximately 0.8mbgl by the beginning of the current review, which is marginally above the logger depth. Water levels at this site showed a rapid response to rainfall events throughout the year and have been at or approaching ground level shortly after periods of rainfall before quickly declining to or approaching the logger depth.

SSE3 water levels have shown a very similar pattern to those in SSE2 with a decline from approximately ground level during the latter half of 2012 and commencing the current review period at around 0.8mbgl. During 2013 SSE3 showed a strong response to rainfall and following rainfall events water levels approached ground level before declining. Overall during 2013 water levels showed a general declining trend and since September 2013 have been around the logger depth or possibly below.

Carne West Swamp

Carne West swamp is situated approximately 300m east of the mid-point of LW415 (Figure 1).

There are four piezometers installed into Carne West Swamp as shown in Table 3.4 and the trends are presented in Figure 6.

Table 3.4: Carne West Piezometer Information

Piezometer	Mined status	Swamp Type	Monitoring Commencement
CW1	Not undermined	Type C	12/05/2005
CW2	Not undermined	Type C	12/05/2005
CW3	Not undermined	Type A	14/10/2011
CW4	Not undermined	Type A	14/10/2011

The most recent water levels recorded in all of the piezometers at the end of 2013 are comparable to those which were recorded at the end of 2012, with no significant net increase or decrease observed.

For the Type A section of Carne West (CW3 & CW4), the water level remains at the bottom of the piezometer for most of the year. This indicates that this is actually remnant water help within the base of the standpipe and is not representative of actual swamp water levels. From January to June 2013 some rapid increases and decreases in water level in CW3 & CW4 are observed. These increases and decreases correlate to increasing and decreasing rainfall events. The peak in rainfall recorded in early March corresponds with a peak water level in both CW3 & CW4 at this time period also. While periods of below average rainfall recorded throughout the rest of 2013 correspond with water levels in these piezometers falling to below the limit of monitoring as described above.

Overall, the water levels observed in CW1 & CW2 fluctuate as expected in comparison to previous years. The lowest water levels are observed in summer time around mid-January and November 2013. The lowest rainfall is also recorded in January. This shows that these water levels are somewhat responsive to rainfall patterns. Due to their more subdued fluctuation patterns however, it can be ascertained that rainfall inflows are a minor contribution to the swamp levels, with the predominant inflows coming from groundwater seeps and discharges.

Junction Swamp

There are three piezometers installed into Junction Swamp, as shown in Table 3.5.

Table 3.5: Junction Swamp Piezometer Information

Piezometer	Mined Status	Swamp Type	Monitoring Commencement
D1 / JS1	LW408 & LW409	Type A	10/05/2002
D2 / JS2	LW408 & LW409	Type A	10/05/2002
D3 / JS3	LW408 & LW409	Type A	10/05/2002

The water levels in all three piezometers commenced the current review in decline, following a recharge event in March 2012, with JS1 and JS2 reaching a low of 4.3mbgl by February 2013 before responding to rainfall and increasing to approximately 2.5mbgl by March. Water levels then began to decline and have done so for the remainder of the review period as presented in Figure 7.

The water levels in JS3 have shown a similar pattern to the other piezometers in Junction Swamp with water levels remaining slightly higher as the response to rainfall is slightly more subdued in this piezometer.

The water levels in Junction Swamp appear to respond to periods of sustained rainfall or seasonal rainfall showing only marginal fluctuations to individual rainfall events.

Gang Gang West Swamp

There are two piezometers installed into Gang Gang West Swamp, as shown in Table 3.6.

Table 3.6: Gang Gang West Swamp Piezometer Information

Piezometer	Mined Status	Swamp Type	Monitoring Commencement
GW1	Not Undermined	Type C	14/10/2011
GW2	Not Undermined	Type C	14/10/2011

The water levels measured at GW1 have consistently remained at approximately ground level throughout the current and previous review periods. Water levels reached their lowest level in January 2013 at 0.08mbgl before showing a rapid response to rainfall and increasing to around ground level for the remainder of the review period (Figure 8).

GW2 water levels have shown a very similar pattern to those at GW1 in that they have fluctuated very close to ground level, reaching a minimum in January 2013 of 0.12mbgl and showing a rapid response to rainfall events.

Gang Gang Swamp

There is one piezometer installed in Gang Gang Swamp, as shown in Table 3.7.

Table 3.7: Gang Gang Swamp Piezometer Information

Piezometer	Mined status	Swamp Type	Monitoring Commencement
GG1	Not Undermined	Type C	14/10/2011

The Gang Gang swamp piezometer shows water levels (Figure 9) to have been in steady decline throughout the latter half of 2012 and commenced the current review period at 0.25mbgl and continuing to decline during January to 0.56mbgl, which is the minimum since data collection began in October 2011. Water levels showed a response to the rainfall experienced in the first quarter of 2013 and increased to ground level by the end of February before declining and generally fluctuating between 0.05 and 0.15mbgl throughout most of the year. During October, water levels showed a rapid response to rainfall and increased to approximately ground level for the remainder of the dataset.

Carne Central Swamp

Water levels measured at the Carne Central piezometer (CC1) have shown a steady trend at around ground level since data collection commenced in 2011 (Figure 10). Sampling events are evident in the data set with sampling frequency increasing from June 2013, as such, interpretation of this data should be undertaken with consideration of monthly maximums. The groundwater level was relatively low (0.1mbgl) at the commencement of the current review period and increased back to ground level following rainfall during the first quarter. Water levels then fluctuated between ground level and 0.05mbgl for the remainder of the dataset.

The current intensity of water sampling appears to be impacting on the quality of data recorded and consideration should be given to reverting to the original monitoring frequency.

Table 3.8: Carne Central Swamp Piezometer Information

Piezometer	Mined Status	Swamp Type	Monitoring Commencement
CC1	Not undermined	Type C	04/11/2011

Bungleboori Swamp and Marangaroo Swamp

There are three piezometers installed in Bungleboori Swamp and one piezometer installed into Marrangaroo Swamp, as shown in Table 3.9.

Table 3.9: Bungleboori and Marangaroo Swamps Piezometer Information

Piezometer	Mined status	Swamp Type	Monitoring Commencement
BS1	Not undermined	Type C	14/10/2011
BS2	Not undermined	Type C	04/11/2011
BS3	Not undermined	Type C	04/11/2011
MS1	Not undermined	Type C	04/11/2011

The water levels measured at BS1 have consistently remained around ground level since data collection commenced in 2011. Sampling events are evident, as are short term fluctuations due to rainfall of the order of a few centimeters and seasonal fluctuations of around 0.05m (Figure 11)

The water levels at BS2 have shown an overall rising trend during the review period and have consistently remained around ground level. The response to rainfall is barely discernible in this hydrograph as it is of the order 0.01m.

The water levels at BS3 have remained steady at around 0.6mbgl throughout the review period. Small scale responses to rainfall are evident.

Water levels in Marrangaroo Swamp piezometer commenced the review period in decline, which began in mid-2012 and reached an all time low in January 2013 at 0.50mbgl. The rainfall in the first quarter of 2013 brought water levels to approaching ground level before declining and remaining steady at approximately 0.15mbgl. Water levels then began to decline through September and October to around 0.30mbgl before increasing in response to rainfall in November.

3.2 Swamp Groundwater Level Interpretation

As expected the groundwater level data from the Type C swamp areas at Springvale show a much more subdued pattern in response to rainfall events. This pattern which is observed in previous years data does not change for the 2013 reporting year. As these swamp types depend predominantly on aquifer recharge as major source of water to the swamps, the low rainfall through the latter two thirds of 2013 do not impact the water levels to a great extent.

The water level patterns recorded in swamps which have been undermined, and those which have not been undermined show similar trends. A characteristic Type A trend and a characteristic Type C trend is identifiable from the hydrographs. These two trends remain the same whether the swamp has been undermined or not.

Due to the groundwater discharge being the predominant source of water supplying the Type C swamps, it is fair to say that these swamp types are more likely to show mining induced water level impacts. However, no mining induced fluctuations can be observed in these swamps (or the Type A swamps).

As no mining influenced water level fluctuations can be identified in any of the monitored swamps (both undermined and baseline) it is accurate to say that mining at Springvale has not led to any identifiable water level impacts on the monitored swamps, and that all undermined swamps display water levels which can be likened to baseline behaviour.

4. Groundwater Monitoring

4.1 Standpipe Piezometers

A series of fourteen (14) ridge boreholes have been established to monitor the groundwater level in the near-surface unconfined aquifer in the Banks Wall Sandstone at Springvale (Figure 1). Three of these bores is monitored manually (RNW, REN and RSE, Figure 1) the rest are equipped with water level data loggers.

The hydrographs from the ridge boreholes that are manually dipped as well as data from open holes that have continuous water level loggers installed are shown in Figure 12.

4.1.1 Monitoring Results

Manually Monitored Standpipe Piezometers

The three manually dipped piezometers are shown in Table 4.1

Table 4.1: Manually Dipped Piezometers

Monitoring Point	Easting	Northing	Monitoring Frequency	Monitoring Commence Date	Monitoring Depth (mbgl)	Data recording method
RNW	235076	6304525	Every two months	20/12/2005	Unknown	Manual dip
REN	236122	6304315	Every two months	20/12/2005	Unknown	Manual dip
RSE	236840	6304191	Every two months	20/12/2005	Unknown	Manual dip

REN and RNW boreholes both showed spiked drops in September 2013. In the case of RNW the spike is to below the currently recorded base of casing, suggesting that the September reading may be erroneous. The bottom of hole at RNW has been tagged at a depth above previously recorded water levels suggesting that the bore has collapsed or been otherwise blocked (dry at 52.19m below top of casing).

Borehole REN has been dry for most of the monitoring history, but has recorded water levels above the base of bore since November 2011. Towards the last third of the reporting period (September 2013), REN was dry but muddy, and during the most recent monitoring (November 2013) the bore again showed a water level above base of casing. The reason for the fluctuations in water level is unclear, but could be related to rainfall infiltration following above average rainfall in 2011 and early 2012, or may be related to rainfall penetration directly into the hole.

The RSE standpipe piezometer is situated in the north west region of the site and is monitored by manual measurements approximately bi-monthly. Figure 12 shows that water levels in this piezometer respond to rainfall with fluctuations between 49 and 50.5mbgl and have not been affected by mining during the review period.

Mining impacts:

Both REN and RNW holes showed either declining water levels (RNW) or water levels below base of bore (REN) prior to being undermined in 2008/2009. There was no mining activity near any of the bores during the current period. The data show no impacts from mining over time and both bores have demonstrated a rise in water levels since mining took place.

Continuously Monitored Standpipe Piezometers

Standpipe piezometers equipped with water level pressure transducers and data loggers are installed over a large spatial extent of Springvale mining lease boundary. Some of the standpipe piezometers at Springvale are located next to multilevel vibrating wire piezometer installations, in areas that have not been mined, while several stand-alone standpipe piezometers have also now been installed (Figure 12).

Table 4.2:Continuously Monitored Piezometers

Monitoring Point	Easting	Northing	Monitoring Commence Date	Monitoring Depth (mbgl)	Data recording method
SPR1111	240404	6303692	14/12/2011	60	Pressure transducer
SPR1112	240852	6302995	15/12/2011	50.1	Pressure transducer
SPR1113	240625	6302160	13/02/2012	60	Pressure transducer
SPR1109	239186	6303314	14/12/2011	60	Pressure transducer
SPR1108	241045	6301305	04/11/2011	75	Pressure transducer
SPR1107	239739	6302330	04/11/2011	55	Pressure transducer
SPR1110	238699	6302635	14/12/2011	65	Pressure transducer
SPR1101	238484	6303627	14/11/2011	84.5	Pressure transducer
SPR1106	239980	6304227	15/12/2011	85	Pressure transducer
SPR1104	239746	6303184	04/11/2011	50	Pressure transducer
RSS	238072	6303500	01/12/2005 to 14/12/2011	Unknown	Manual Dip
			14/12/2011		Pressure transducer

In general, observed trends in previous years continued for 2013 in all but one monitoring point (SPR1110, discussed below), without any significant anomalies. An overall flat trend with occasional and minor steps in the water levels was observed in the following 6 piezometers:

- SPR1113, SPR1104, RSS, SPR1108, SPR1101 and SPR1106.

Two of these piezometers (SPR1112 and RSS) deviated from the overall flat trend which was maintained throughout the 2013 reporting period in all other piezometers. Both piezometers show a sharp rise in water levels between late February and mid-March 2013. RSS and SPR1112 are shown to rise by 4.41m and 0.95m respectively. Both of these sharp rises are followed by a similar sharp decline back to corresponding levels before the rise began. These rises can be attributed to a significant rainfall event which occurred at the same time that the water level rise was recorded (late February 2013).

A slight declining level is observed in the following piezometers:

- SPR1107 (1.67m), SPR1112 (2.55m), SPR1111 (0.4m) and SPR1109 (1.86m).

These slightly declining levels can be attributed to the very dry latter 2/3 of the year. Rainfall levels are below average and this is manifested in the shallow regional aquifer as slightly reduced water levels as recorded by these piezometers.

A more significant drop of 3.97m is observed in SPR1110. This declining trend begins in January 2013 and continues throughout the year to the most recent monitoring period in December 2013. The below average rainfall recorded throughout 2013 would certainly have contributed to the declining level in this piezometer. Although the design on the piezometer is not known, it is apparent that this piezometer is more responsive to declining rainfall levels. The declining level is not likely to be mining related as no responses are observed in any of the piezometers closer to the nearest active longwall, LW415 (SPR1101 and RSS).

4.2 Standpipe Water Level Interpretation

The three standpipe piezometers closest to LW415 which was mined during this review period are the following:

- RSS (directly overlying LW415);
- SPR1101 (directly to the east of LW415); and
- SPR1110 (directly to the east of LW415.

RSS is located directly overlying LW415. Apart from a sharp slight rise at the end of February, the water levels in this piezometer maintained a steady trend throughout 2013. This trend is comparable to the response observed in previous years. Similarly, a steady, unchanging trend is also observed in SPR1101 which is located approximately 300m to the east of LW415 panel.

While SPR1110 is also located in the vicinity of LW415 panel (approximately 400m to the east of the panel), a declining trend is observed in this piezometer. The declining rainfall from April – December 2013 and the fact that no water level changes are observed in piezometers situated closer to LW415 all indicate that this piezometer is more responsive to rainfall than other piezometers installed in the regional shallow aquifer across the site.

On the whole, water levels in the standpipe piezometers which monitor water levels in the regional shallow aquifer display stable trends which fluctuate as normal and in the same manner as previous years. No identifiable mining impacts in the shallow aquifer have been observed.

4.3 Vibrating Wire Piezometers

Multi-level vibrating wire piezometers (VWPs) have been installed in boreholes across the mining lease boundary area to monitor pore pressures at various levels in the overburden and coal measures lithologies. Most of the VWPs are located in the centre of the current workings at Springvale Colliery, in the area that is currently being mined, or will be mined over the next few years. The locations of the VWP monitoring points are shown on Figure 1.

The VWP hydrographs are presented on Figures 14 to 17. For the analysis and interpretation of groundwater levels in this report, only VWP monitoring points in the vicinity of active longwall extraction have been analysed, these being SPR48, SPR49, SPR66 and SPR67, as shown in Table 4.3.

Table 4.3: VWP Monitoring Details adjacent to LW415

Monitoring Point	Easting	Northing	Monitoring Frequency	Monitoring Commence Date	Number of Piezometers installed	VWP setting depth (mbgl)
SPR48	237217	6304198	Daily	28/11/2007	8	30, 50, 70, 90, 110, 140, 170, 200
SPR49	237245	6303199	Daily	09/06/2008	8	30, 50, 80, 110, 150, 200, 250, 295
SPR66	239824	6301994	Daily	30/09/2009	8	35, 80, 130, 180, 230, 290, 348, 372
SPR67	238709	6302283	Daily	28/09/2009	8	35, 50, 70, 90, 110, 160, 200, 260

SPR48 (Figure 14)

The multi-level VWP SPR48 comprises six piezometers and is situated within the chain pillar between LW412 and LW413. All five VWPs that are currently operational are installed at various depths in the Banks Wall Sandstone. As can be seen from Figure 14 all VWPs have shown a stable trend in piezometric heads throughout the review period. There have been very minor fluctuations in the water table VWP (Piezo-8) with no net variation in piezometric head during 2013. VWP 7 and VWP 6 have shown net increases in head of 0.4 and 0.7m respectively. VWP 5 and VWP 4 have shown net reduction is head of 0.9 and 0.4m respectively during the review period.

SPR49 & SPR66 (Figure 15 and 16)

The data from these piezometers is showing anomalous trends and therefore has not been included in the analysis.

SPR67 (Figure 17)

Figure 17 shows the hydrographs for the individual sensors installed within SPR67. The data for the two shallowest sensors, 7 and 8, appears to be erratic and is considered erroneous. These two sensors are installed in the Banks Wall Sandstone.

Sensors3 to 6 are also installed in the Banks Wall Sandstone and all began the year in decline, which commenced around June 2012. The decline has continued at sensors 4 and 5 for the duration of the data set and during 2013 with head reductions of 10m and 6m respectively. The decline at sensor 3 continued through to June 2013 before leveling out after a head reduction of approximately 6m.

Sensor 2 is installed in the Burra Moko Head Formation, which is separated from the Banks Wall Sandstone by the Mount York Claystone. Sensor 2 shows a very similar pattern to sensor 3 with a decline in piezometric head of over 20m from January to June 2013 before leveling out for the remainder of the year. It is possibly that this is a climatic response due to variations in rainfall at formation outcrop; however, if this was the case then it would be expected to be most pronounced in the shallowest sensors.

Sensor 1 is installed in the Caley Formation and also experienced a decline in piezometric head throughout the latter half of 2012 which began to level out at the commencement of 2013 before increasing by approximately 2m by May 2013. The head then declined by around 4m during the next three months before increasing by over 10m to the end of the data set. It is not clear what caused the fluctuation in this formation but it may be a response to the passing of LW415 during June 2013.

5. Surface Water Monitoring

5.1 Surface Water Levels

Surface water levels at Springvale are monitored at three separate locations as detailed below:

- Junction Swamp – flow is measured here through a V-notch weir;
- Sunnyside Swamp – flows are interpreted through pool depth monitors; and
- Carne West Swamp – flows are interpreted through pool depth monitors.

The locations of the surface water monitoring points are shown on Figure 13.

5.1.1 Monitoring Results

Carne West Pool

A pool depth monitor was installed at the bottom end of Carne West Swamp on 30 May 2012. Pool data depths show characteristic spikes which correspond to rainfall (Figure 18). Pool depths were generally low during the reporting period, and regularly dropped below the level of the gauge, consistent with below-average rainfall. Despite pool water level falling below the level of the sensor, there is still flow observed coming out of the lower end of Carne West Swamp.

It is noteworthy that spikes in pool depth do not always have a clear, immediate relationship to individual rainfall readings. Progressive increases in pool depth during periods of below average rainfall indicate that there is considerable storage retained in the swamp alluvium/peat, and a delayed release of this water to the stream is occurring. The lag appears to vary between a few days to a few weeks.

Mining impacts:

There are no mining impacts indicated by the monitoring results over the review period. Surface water flow behaviour has not changed when pre-mining and post mining behaviour are compared.

Junction Swamp

Throughout 2013 there was only one recorded flow event, in February 2013 (Figure 19). This flow event corresponds with a period of intensive rainfall at the same time. Discharge at Junction swamp occurs very infrequently and this has been the case since 2003. Flow events are only recorded during periods of high rainfall intensity.

Groundwater levels remain near historic highs and the behaviour continues to be typical for a periodically waterlogged swamp.

Mining impacts: There were no observed mining impacts indicated by the monitoring results over the reporting period.

Sunnyside Swamp

Pool depth data show characteristic peaks which correlate to rainfall intensity and downstream flow gauging, as would be expected (Figure 20). (Note that the absolute range of pool depth is generally of the order of 100 – 200mm. The data are scaled to make them visible on Figure 20. Early in 2013 maximum peaks were recorded around February when rainfall was also displaying above average levels.

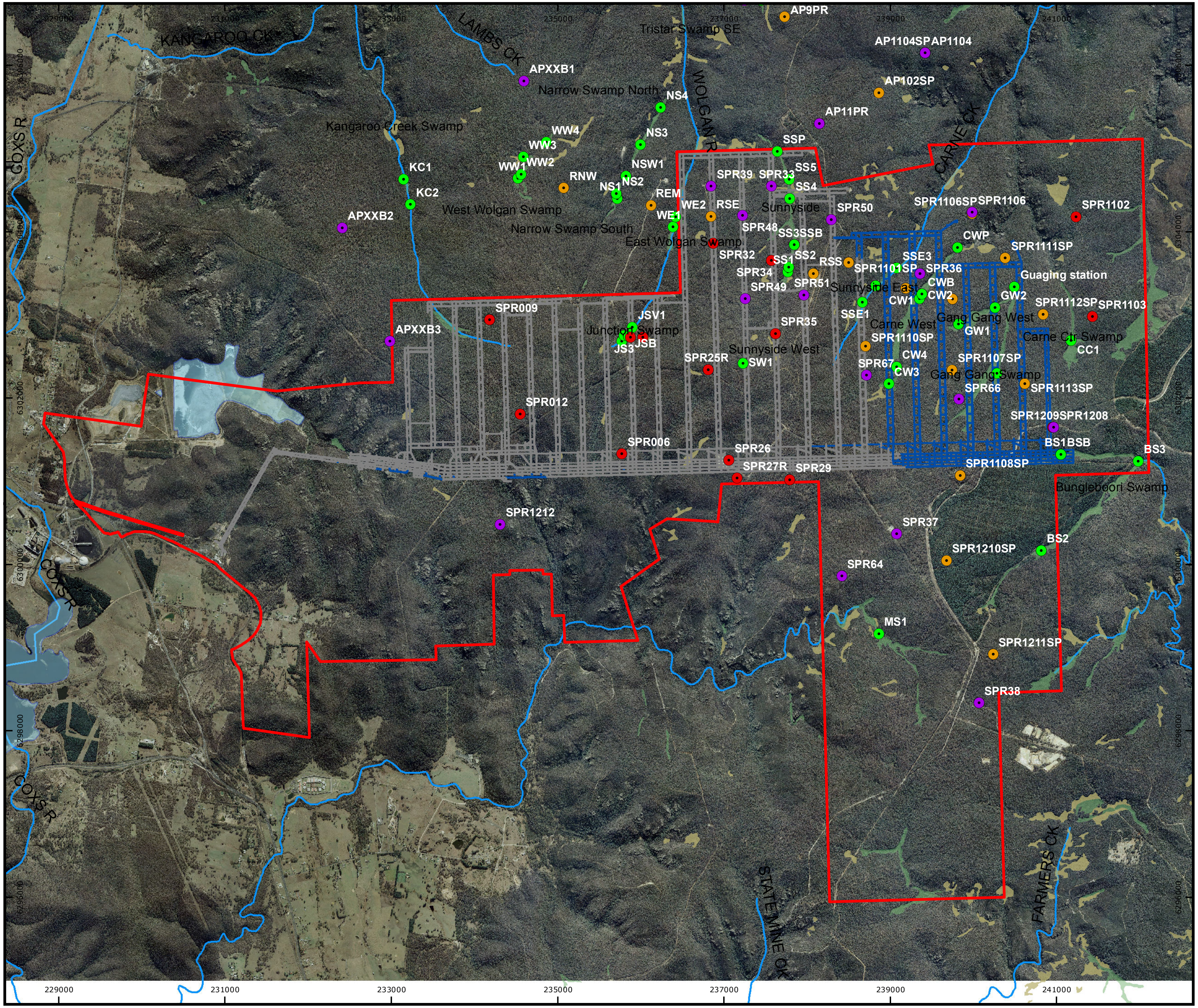
During the latter part of the current reporting period, baseline pool depth fell steadily due to below-average rainfall. During this period, intermittent small spikes in discharge volume are manifested in the data. These spikes also correspond directly to rainfall intensity.

The pattern of pool depth fluctuations correlates with the patterns observed from the v-notch data in previous years. This implies that there is no significant change in the behaviour of stream flows and that the fluctuations are behaving as normal. It is expected that pool depth will broadly relate to creek discharge, but the relationship between them has not been established at present.

Mining impacts:

LW413 lies approximately 300 m west of the weir. The stream record shows no impact of mining on flows. LW414 commenced approximately 100 m south of the upstream end of the swamp in February 2011 with no impacts evident on the flows. Longwall 415 commenced during early 2012, and extraction has now continued south to beyond the headwaters of Sunnyside Swamp. There has been no evidence of any mining impact from LW 415 during the reporting period. Peaks in water depth shows that the maximum water level in the pool is controlled by rainfall. Base level flows appear unchanged from the last reporting period.

FIGURES



LEGEND

Piezometer

- Standpipe
- Swamp
- Vibrating Wire
- Unknown
- Springvale Project Application Area
- Lakes or Dam
- Rivers
- Hanging Swamp
- Swamps

Springvale Workings

- Existing Workings
- Proposed Workings

500 0 500 1,000
Metres

APPROX SCALE 1:65,000 @ A4

GDA 1994 MGA Zone 56

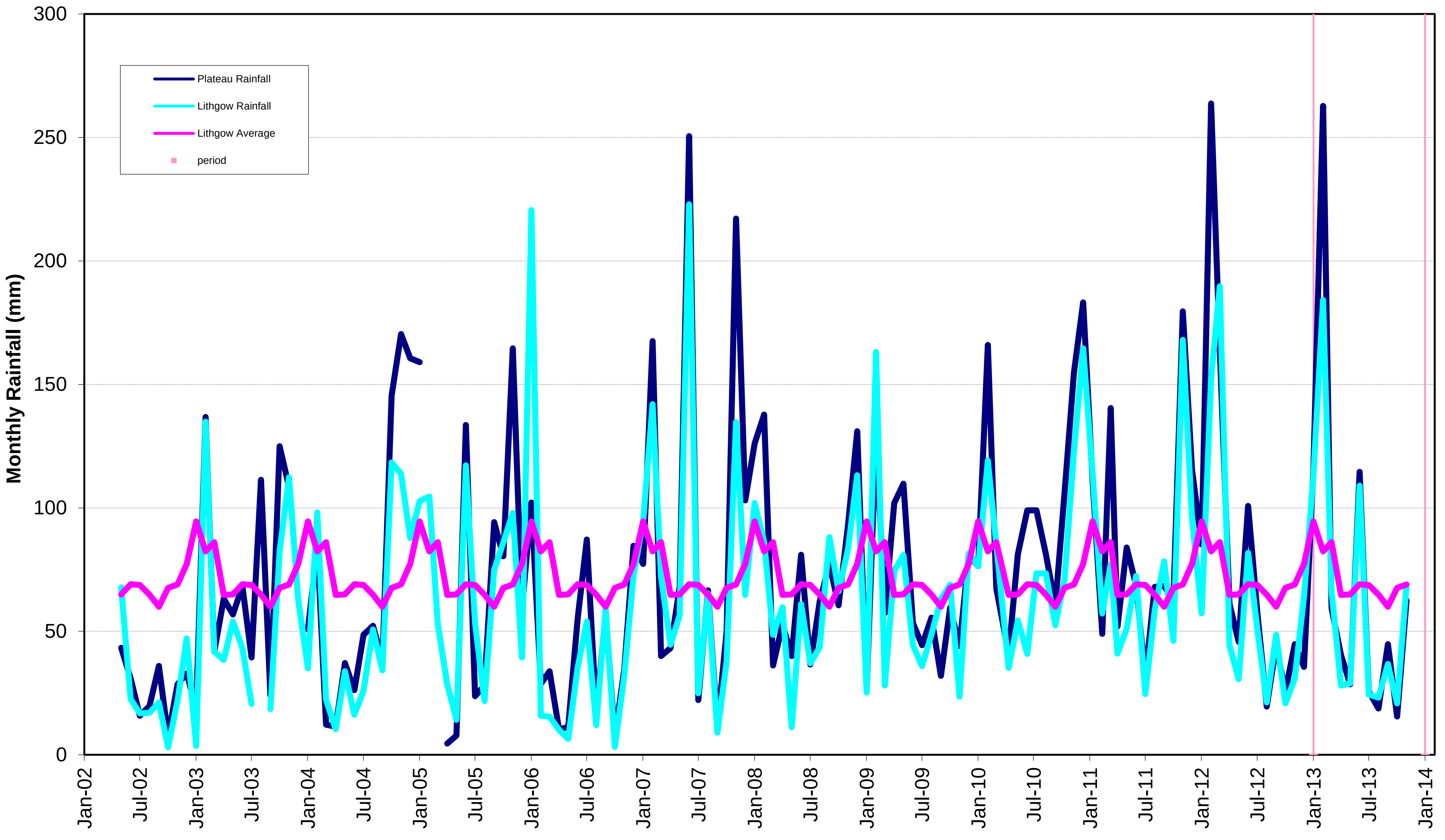
DATA SOURCES:
Centennial Coal
Australia/MapConnect
Land and Property Management Authority

RPS

FIGURE 1

Springvale Piezometer Monitoring Locations

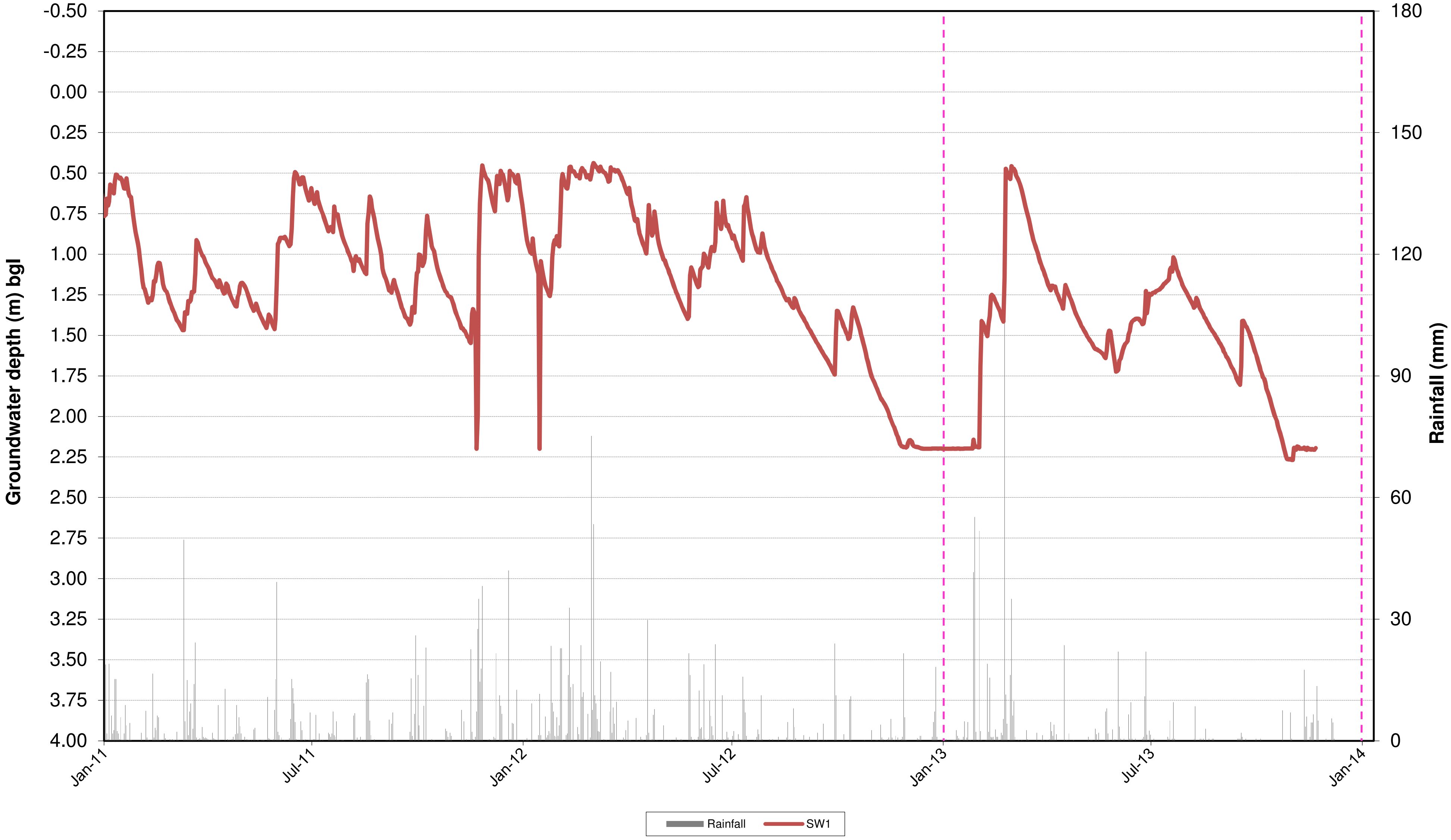
S202b_024a_DD04_Springvale_Monitoring_Piezometers.mxd Produced: JC Reviewed: JF Date: 16/01/2013



RPS

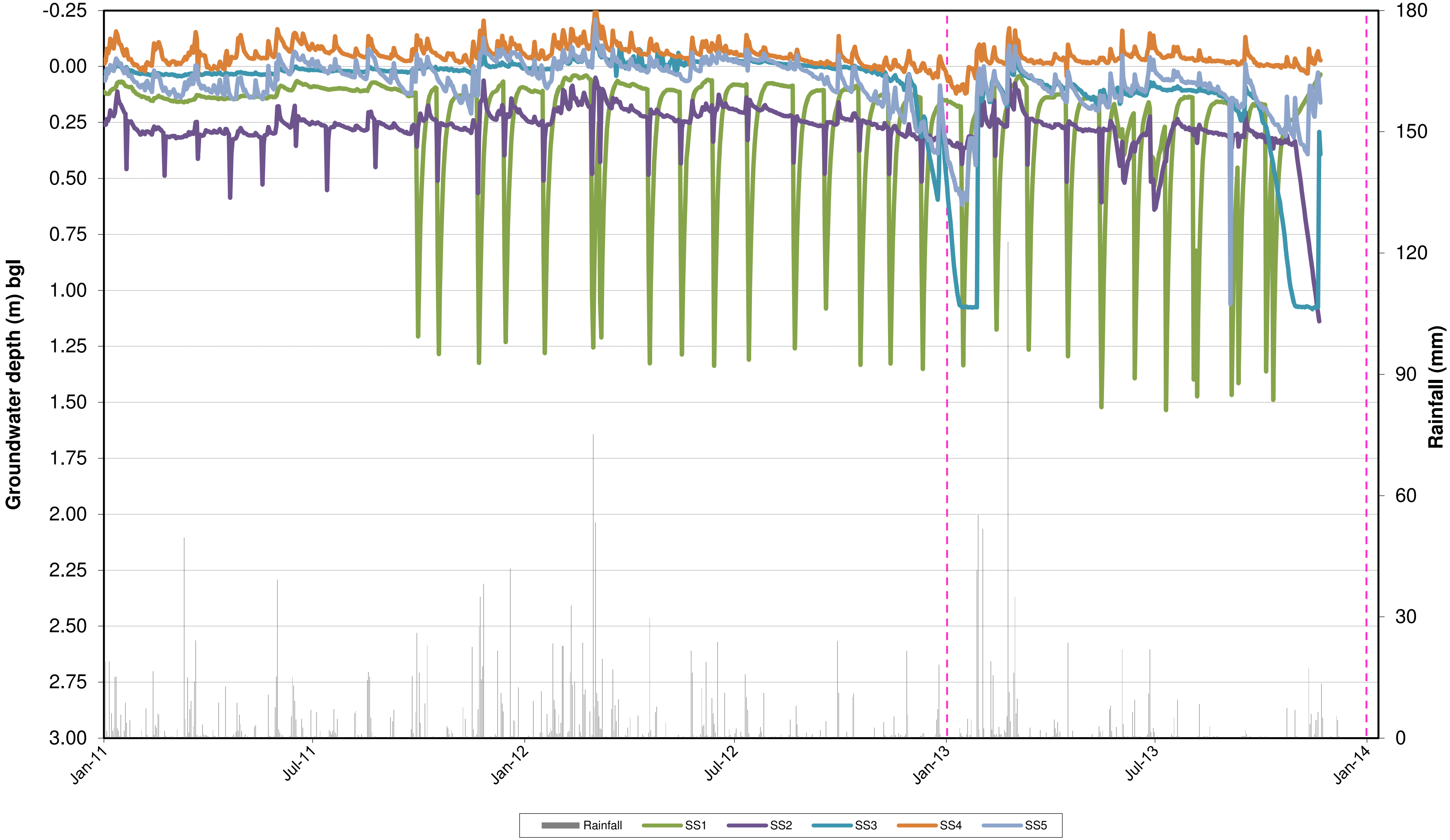
Monthly Rainfall - Figure 2

F:\Jobs\S202B\300\Excel\Projects\Angus Place\[JunctionData.xls]RPS Template Rainfall

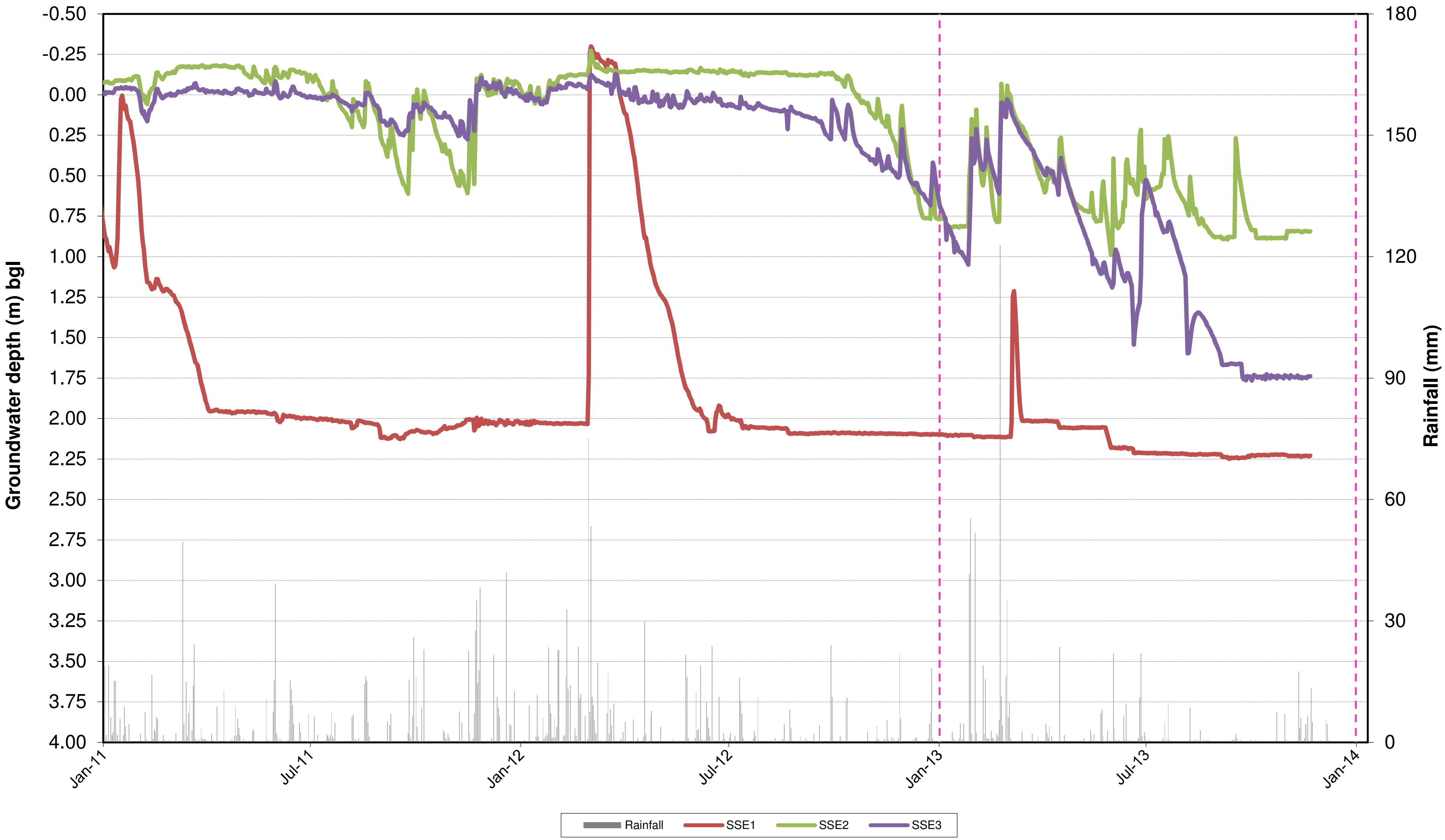


HYDROGRAPH - Sunnyside West Swamp Piezometer - Figure 3

\\syddc04\at1\Jobs\S202B\300\Excel\Projects\Angus Place\[020a_Peter_Corbett_SwampData_Case_Studies_Final.xlsx]SV-Figure 3 - SW

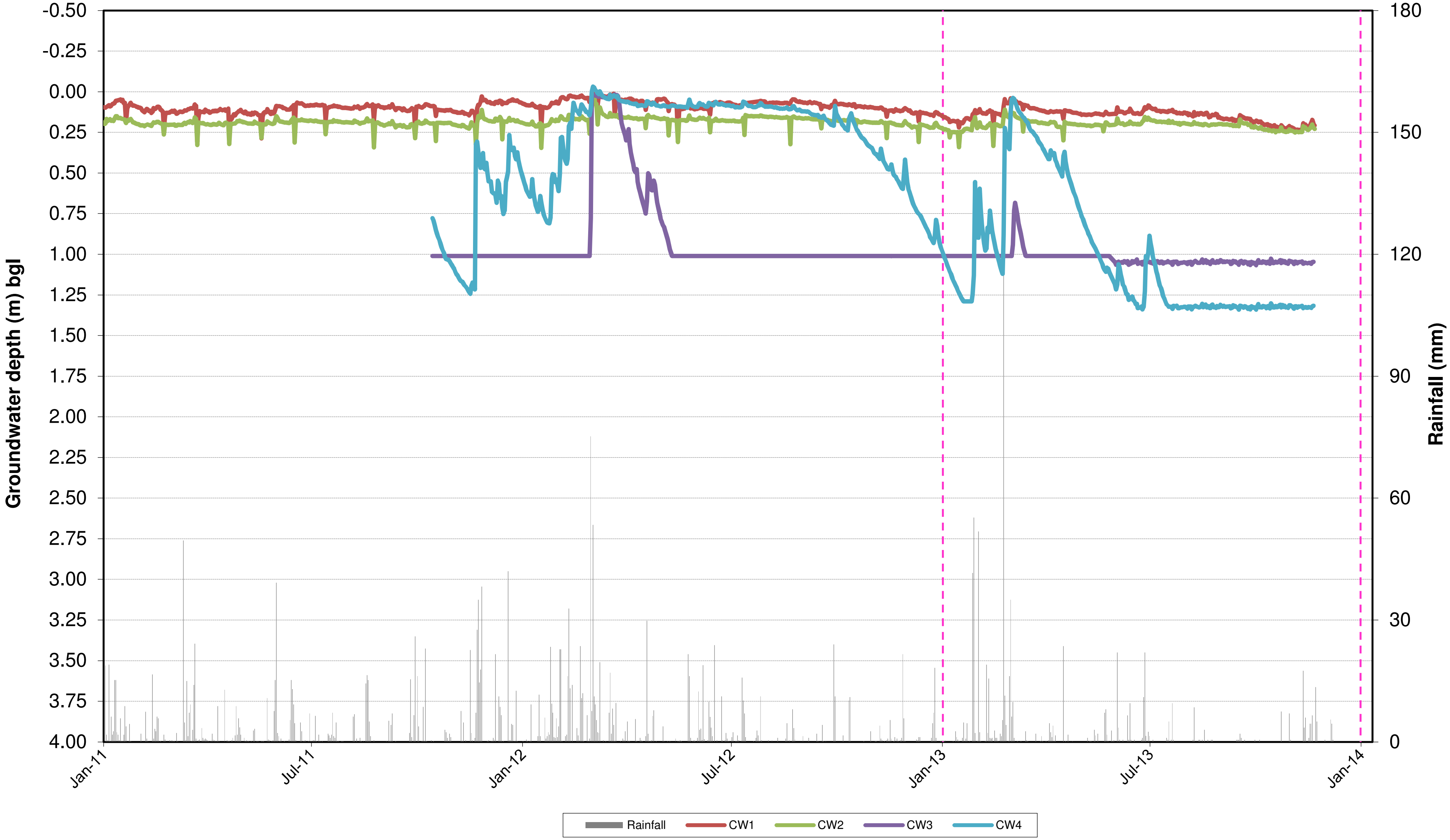


HYDROGRAPH - Sunnyside Swamp Piezometers - Figure 4



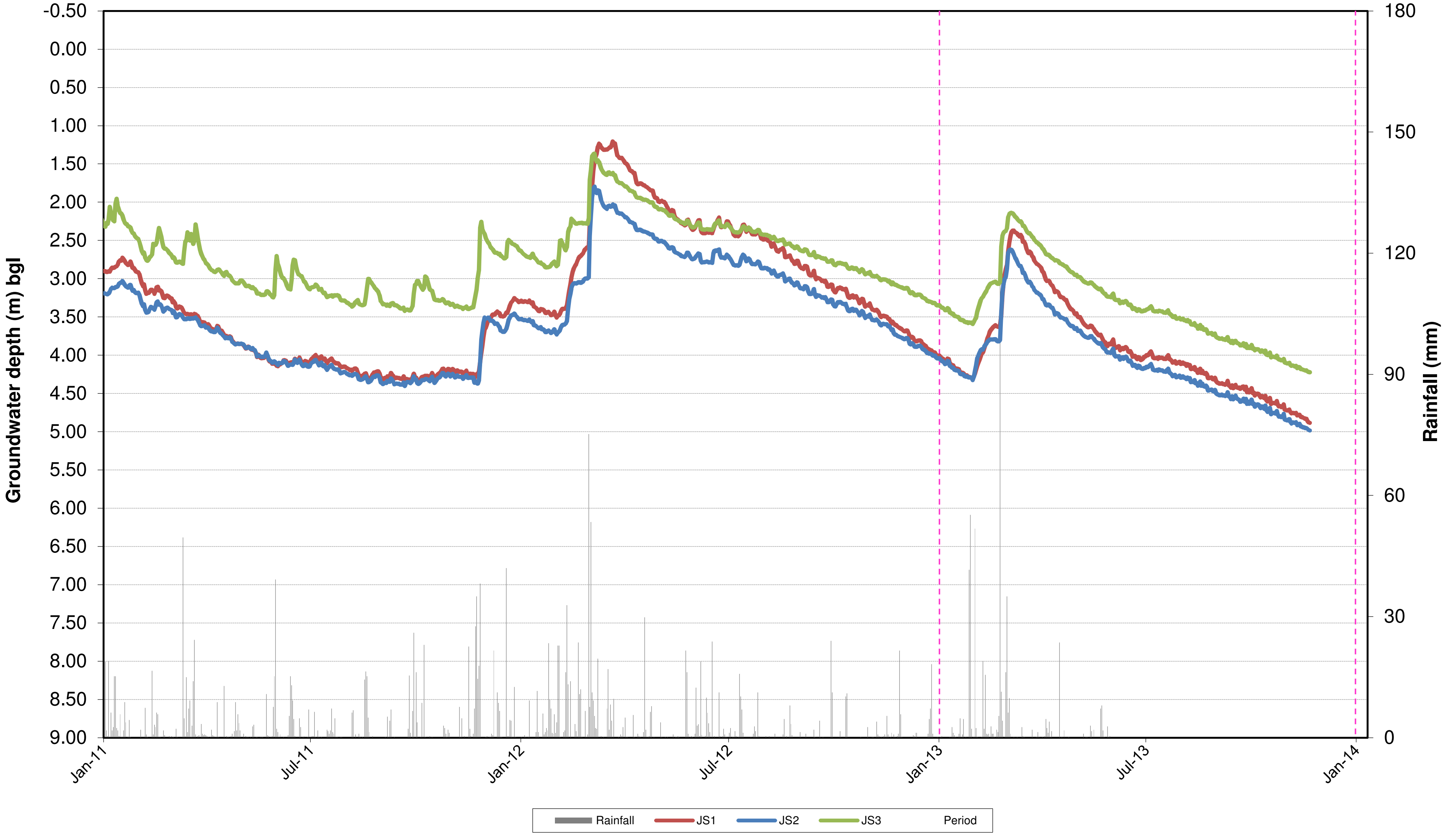
HYDROGRAPH - Sunnyside East Swamp Piezometers - Figure 5

\\syddc04\at1\Jobs\S202B\300\Excel\Projects\Angus Place\[020a_Peter_Corbett_SwampData_Case_Studies_Final.xlsx]SV-Figure 5 - SSE

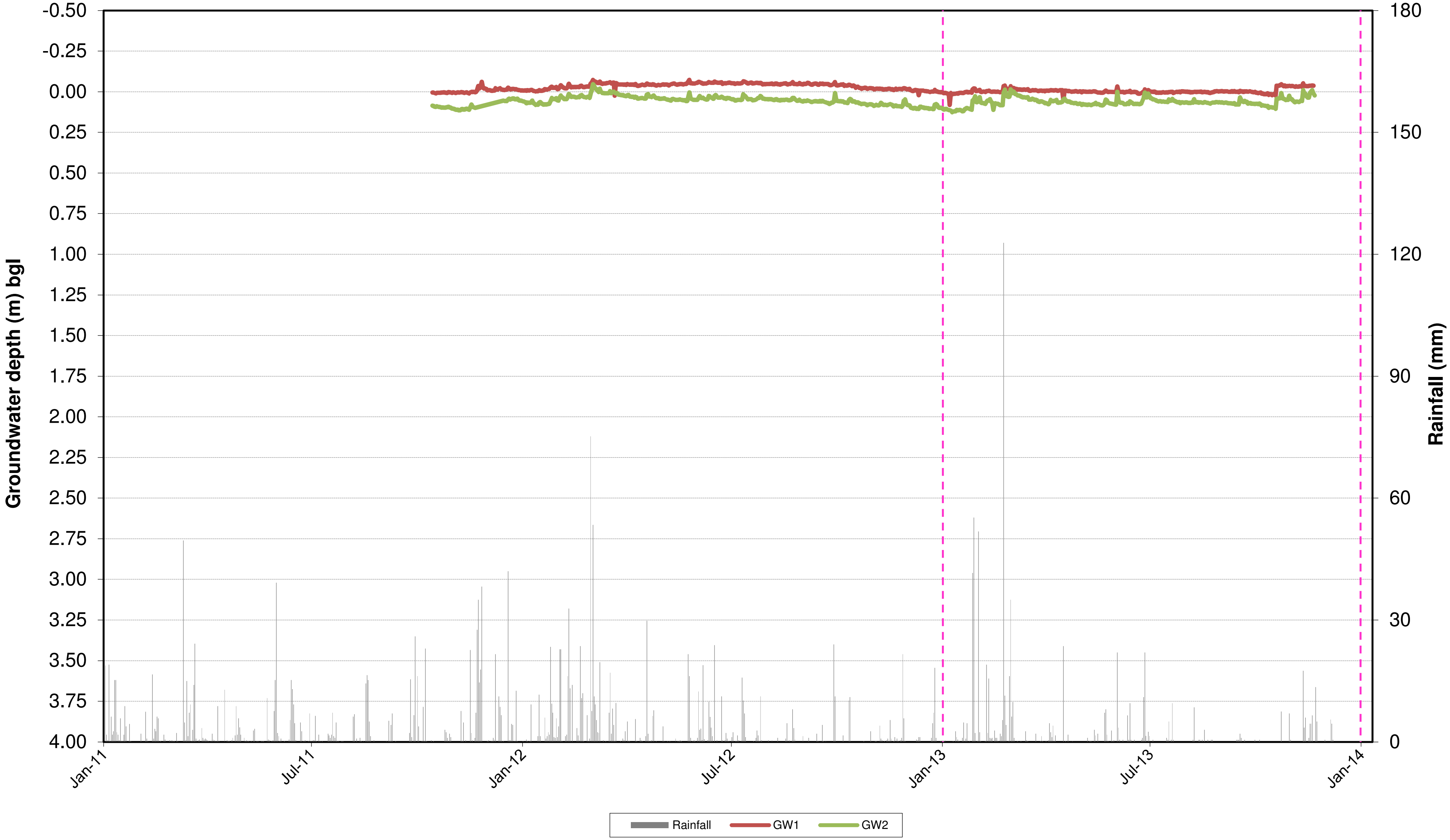


HYDROGRAPH - Carne West Swamp Piezometers - Figure 6

\\syddc04\at1\Jobs\S202B\300\Excel\Projects\Angus Place\[020a_Peter_Corbett_SwampData_Case_Studies_Final.xlsx]SV-Figure 6 - CW

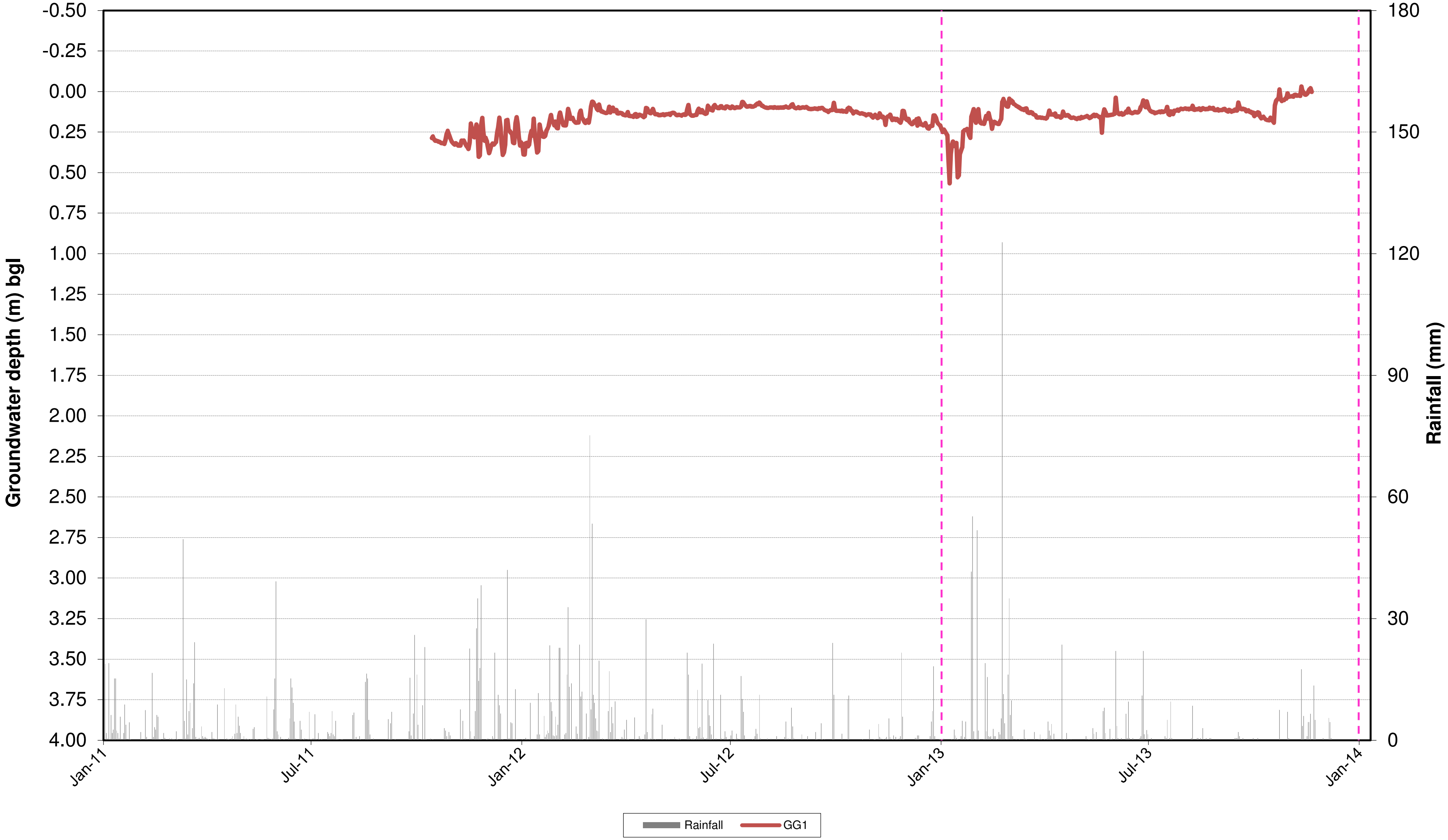


HYDROGRAPH - Junction Swamp Piezometer - Figure 7



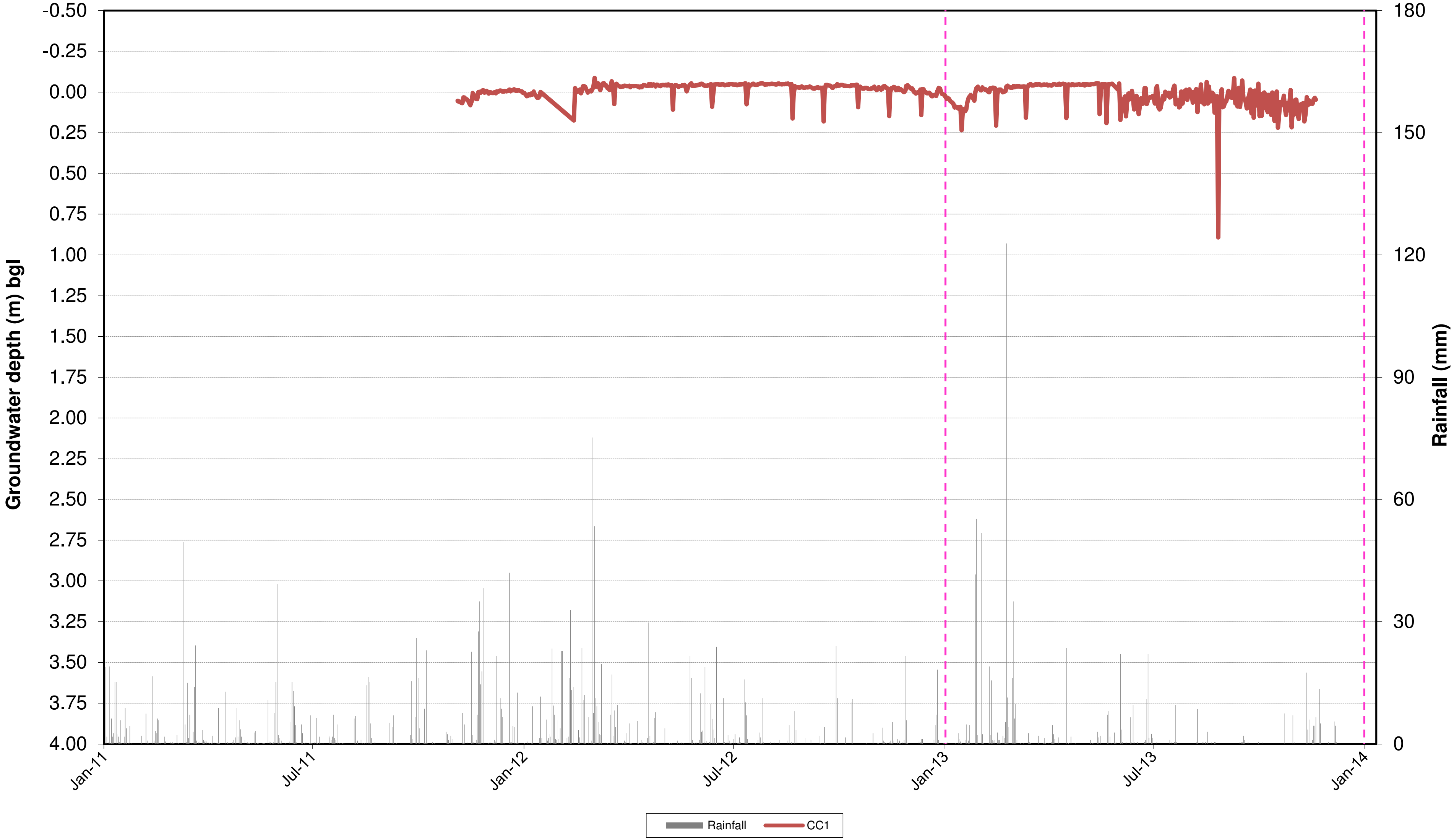
HYDROGRAPH - Gang Gang West Swamp Piezometers - Figure 8

\\syddc04\at1\Jobs\S202B\300\Excel\Projects\Angus Place\[020a_Peter_Corbett_SwampData_Case_Studies_Final.xlsx]SV-Figure 8 - GGW



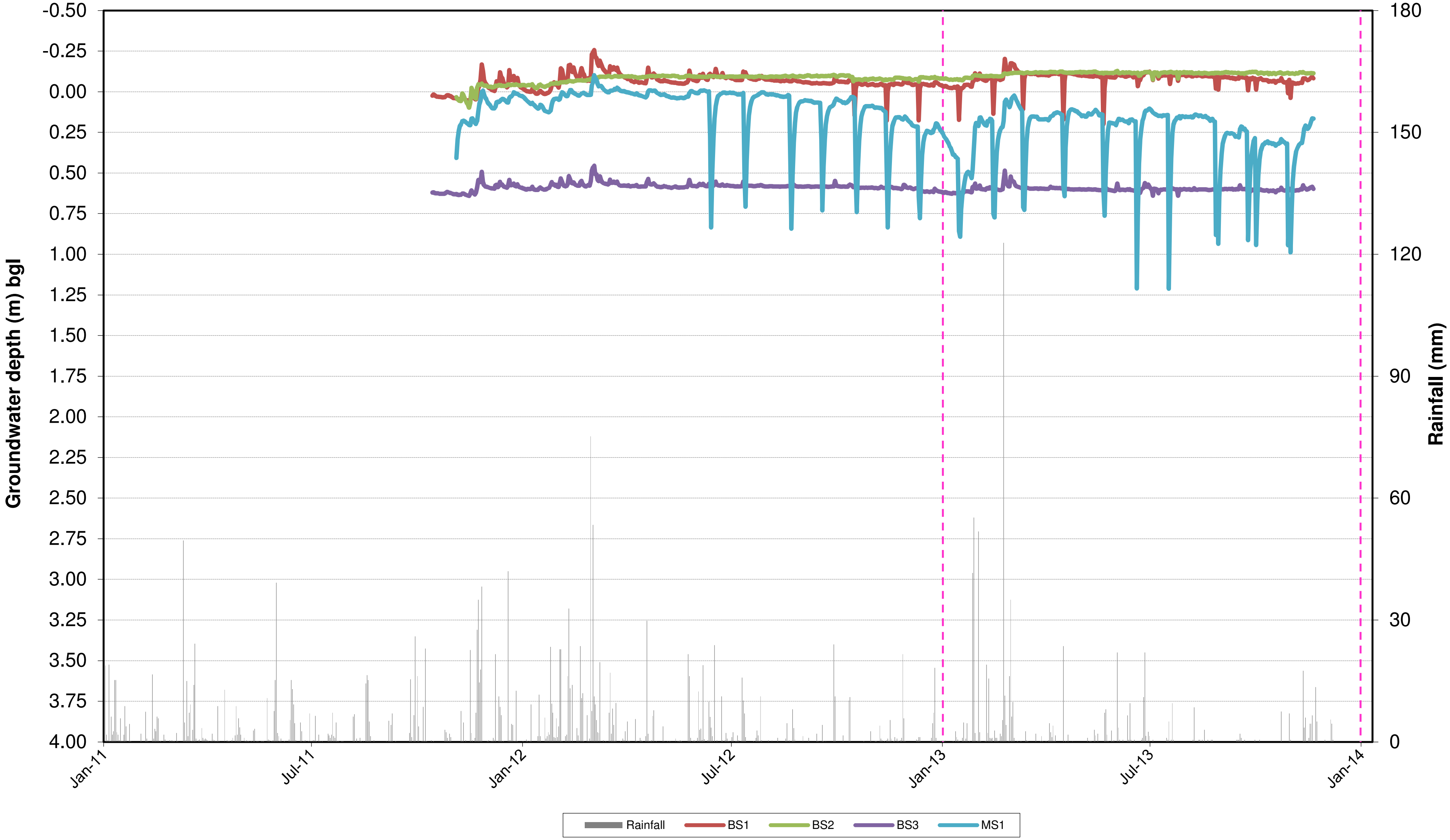
HYDROGRAPH - Gang Gang Swamp Piezometer - Figure 9

\\syddc04\at1\Jobs\S202B\300\Excel\Projects\Angus Place\[020a_Peter_Corbett_SwampData_Case_Studies_Final.xlsx]SV-Figure 9 - GG1



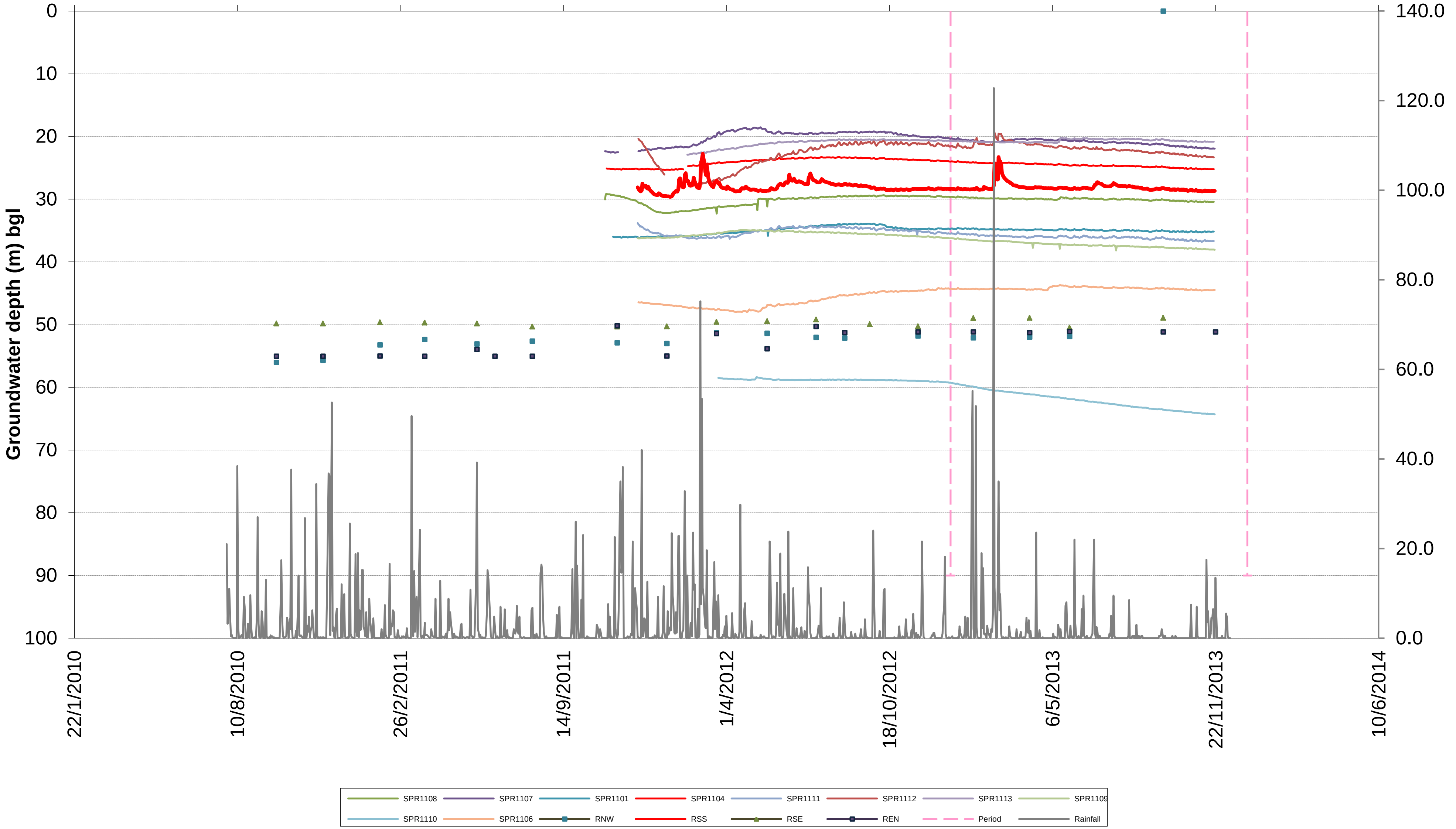
HYDROGRAPH - Carne Central Swamp Piezometer - Figure 10

\\syddc04\at1\Jobs\S202B\300\Excel\Projects\Angus Place\[020a_Peter_Corbett_SwampData_Case_Studies_Final.xlsx]SV-Figure 10 - CC1



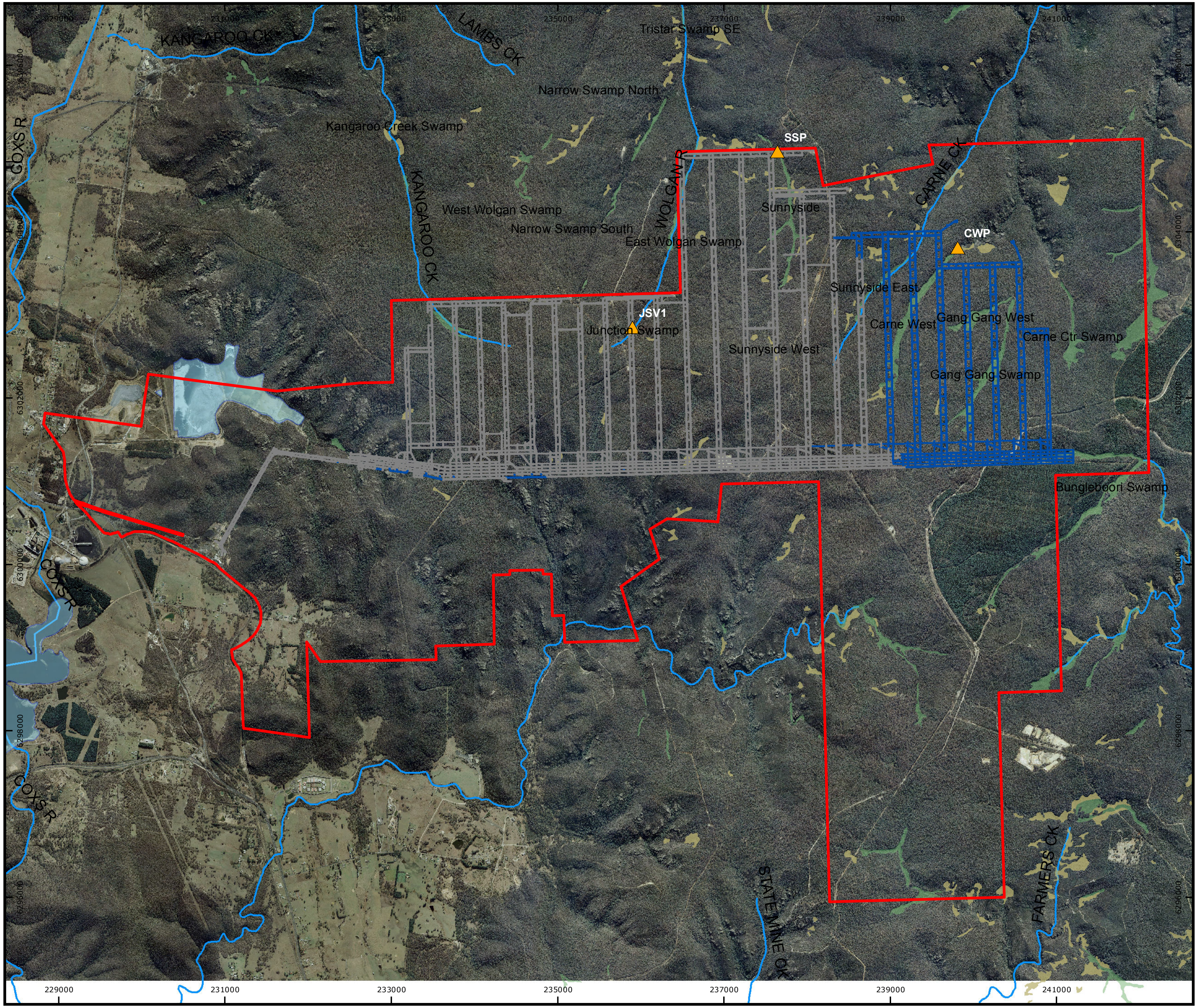
HYDROGRAPH - Bungleboori and Marrangaroo Swamp Piezometers - Figure 11

\\syddc04\at1\Jobs\S202B\300\Excel\Projects\Angus Place\[020a_Peter_Corbett_SwampData_Case_Studies_Final.xlsx]SV-Figure 11 - BB & MS



HYDROGRAPH - Ridge Piezometers - Figure 12

F:\Jobs\S202B\300\Excel\Projects\Angus Place\[Open Boreholes.xls]SV RPS Template



LEGEND

- Surface Water Monitoring Location
- Springvale Project Application Area
- Lakes or Dam
- Rivers
- Hanging Swamp
- Swamps

Springvale Workings

- Existing Workings
- Proposed Workings

N

500 0 500 1,000

Metres

APPROX SCALE 1:65,000 @ A4

GDA 1994 MGA Zone 56

DATA SOURCES:
Centennial Coal
Australia/MapConnect
Land and Property Management Authority

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

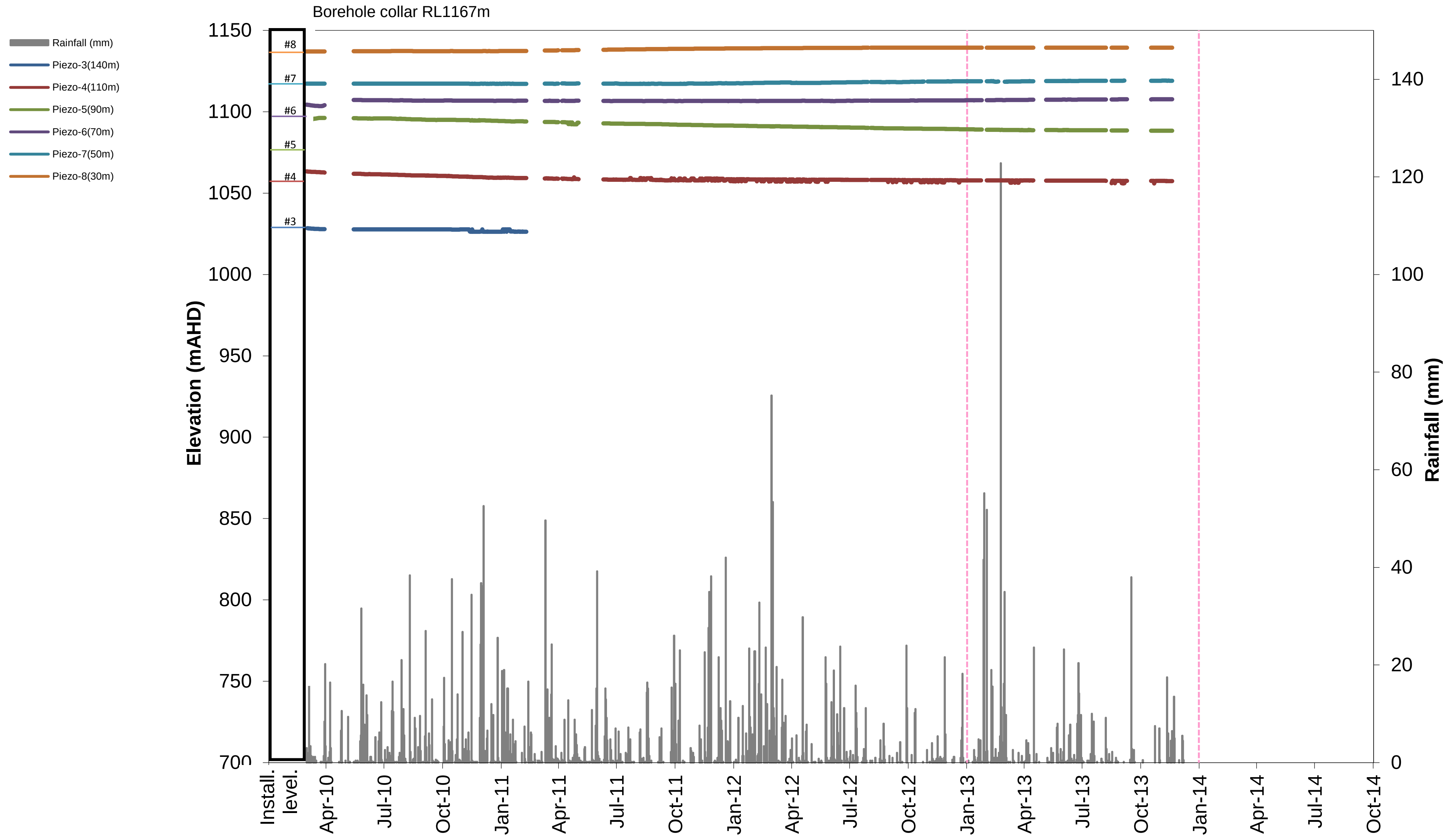
RPS

FIGURE 13

Springvale

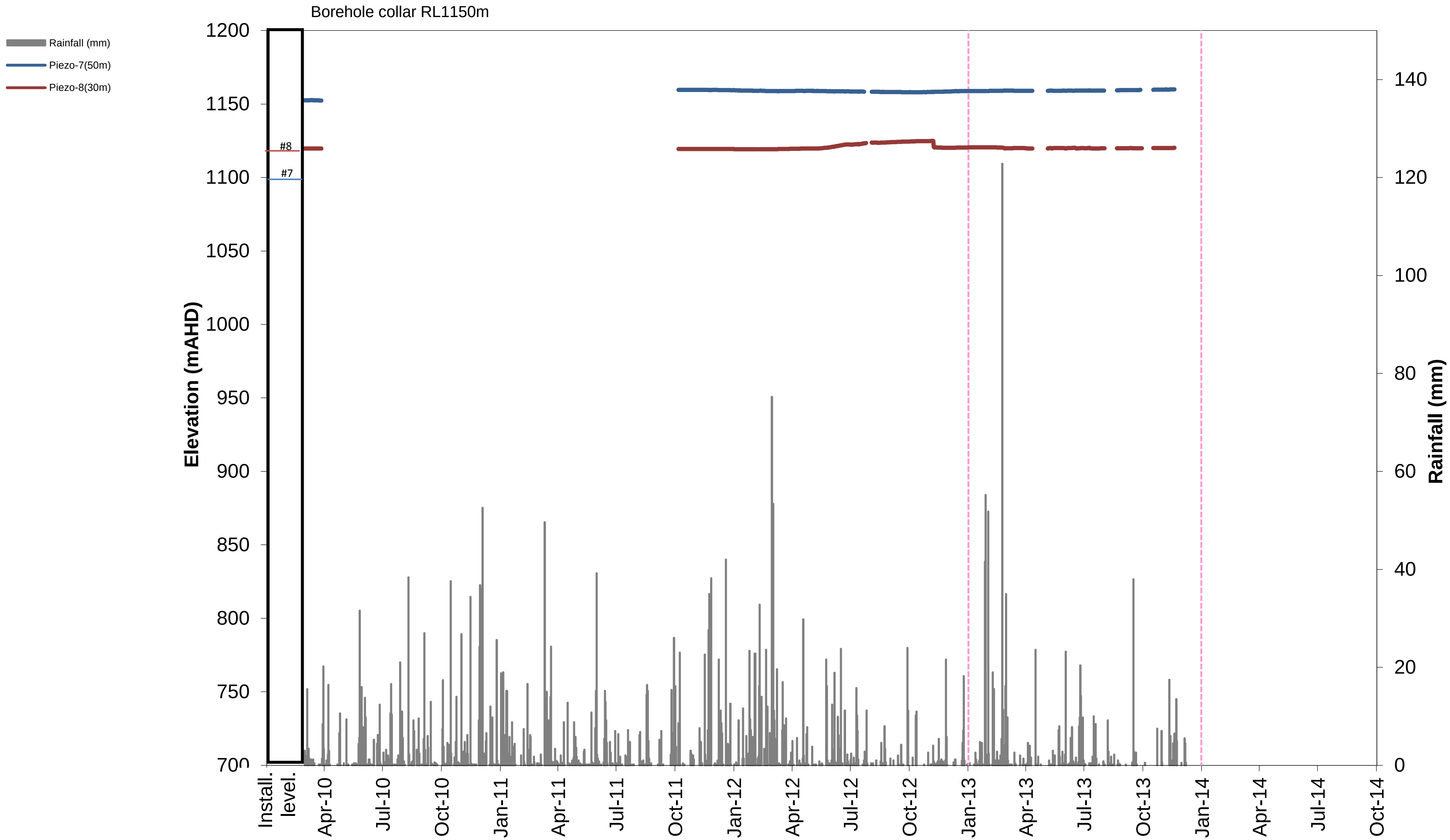
Surface Water Monitoring Locations

S202b_024a_DD05_Springvale_Surface_Water_Monitoring_Locations.mxd Produced: JC Reviewed: JF Date: 17/01/2013



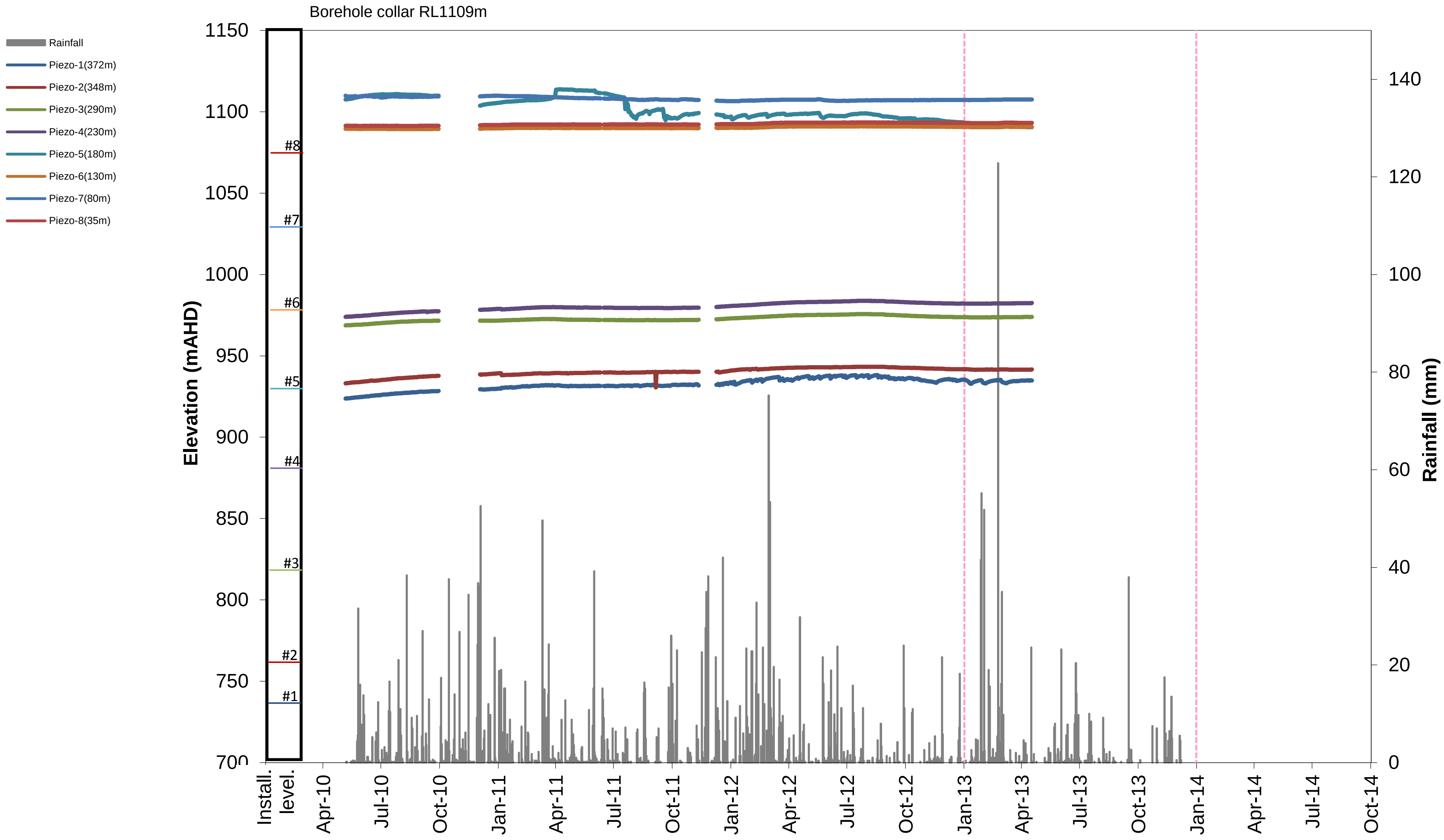
HYDROGRAPH - SPR48 Vibrating Wire Piezometer Data - Figure 14

F:\Jobs\S202B\300\Excel\Projects\Springvale\[SPR48.xls]Figure - SPR48



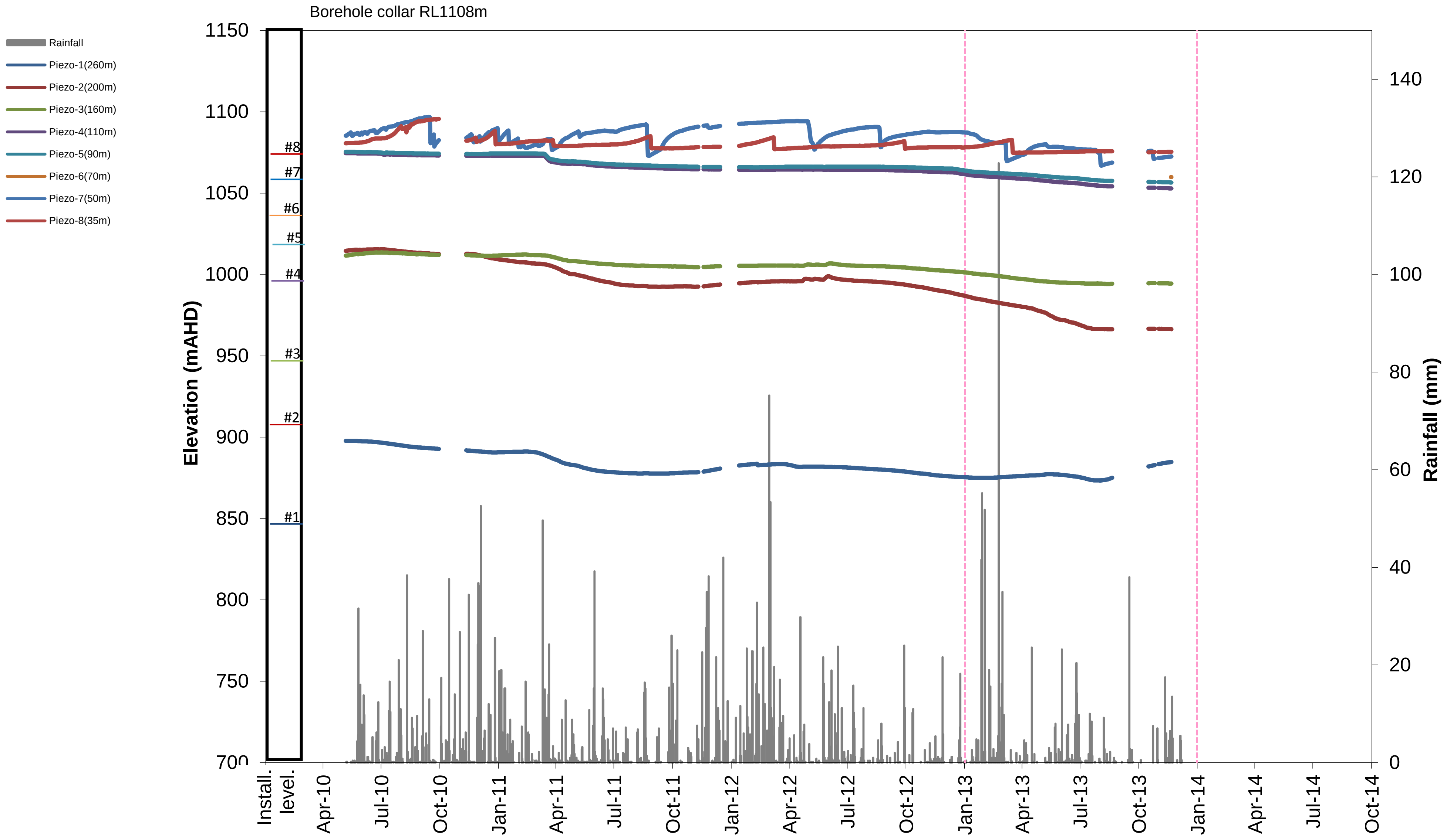
HYDROGRAPH - SPR49 Vibrating Wire Piezometer Data - Figure 15

F:\Jobs\S202B\300\Excel\Projects\Springvale\[SPR49.xls]Figure - SPR49



HYDROGRAPH - SPR66 Vibrating Wire Piezometer Data - Figure 16

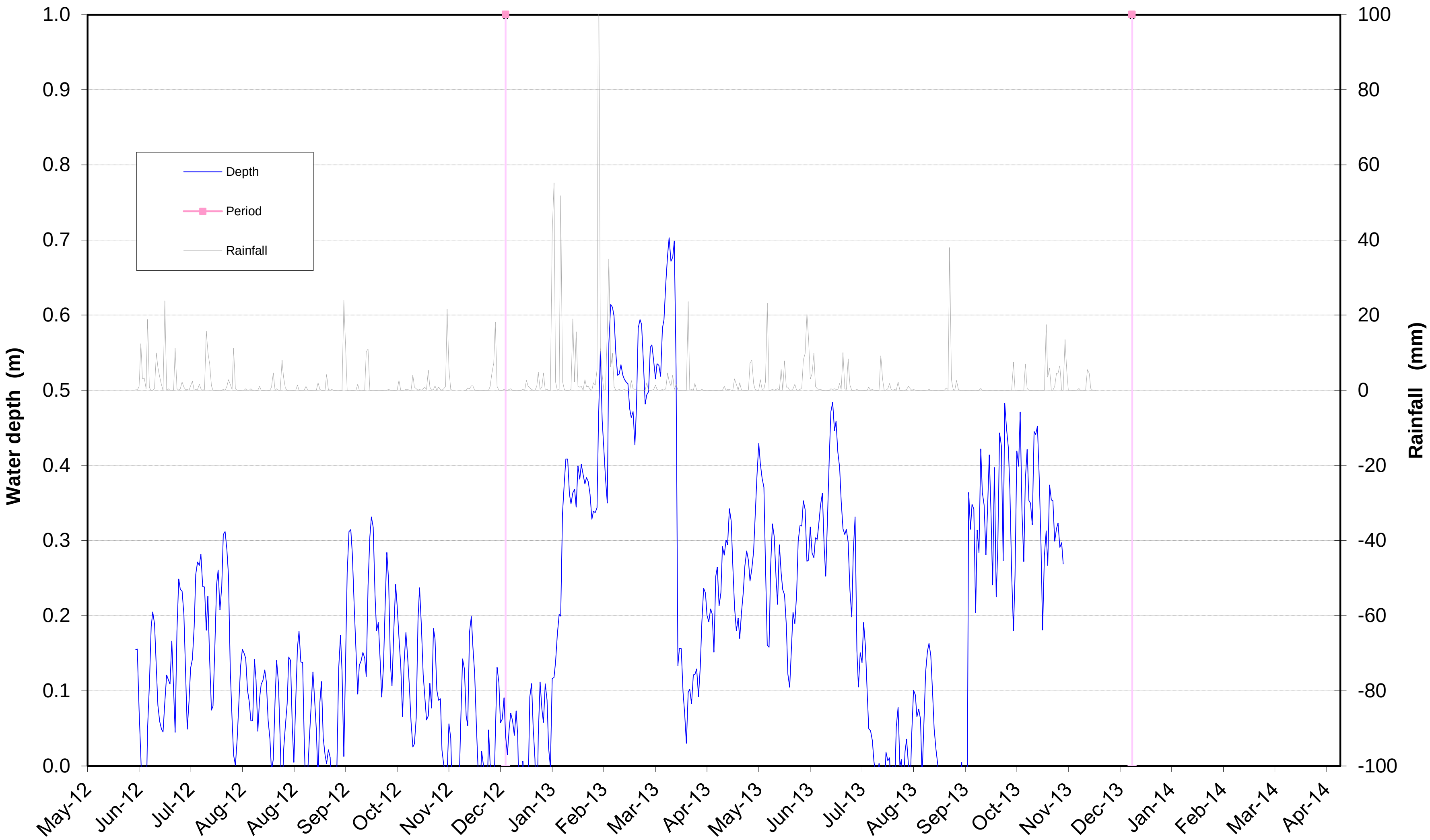
F:\Jobs\S202B\300\Excel\Projects\Springvale\[SPR66.xls]Figure - SPR66



RPS

HYDROGRAPH - SPR67 Vibrating Wire Piezometer Data - Figure 17

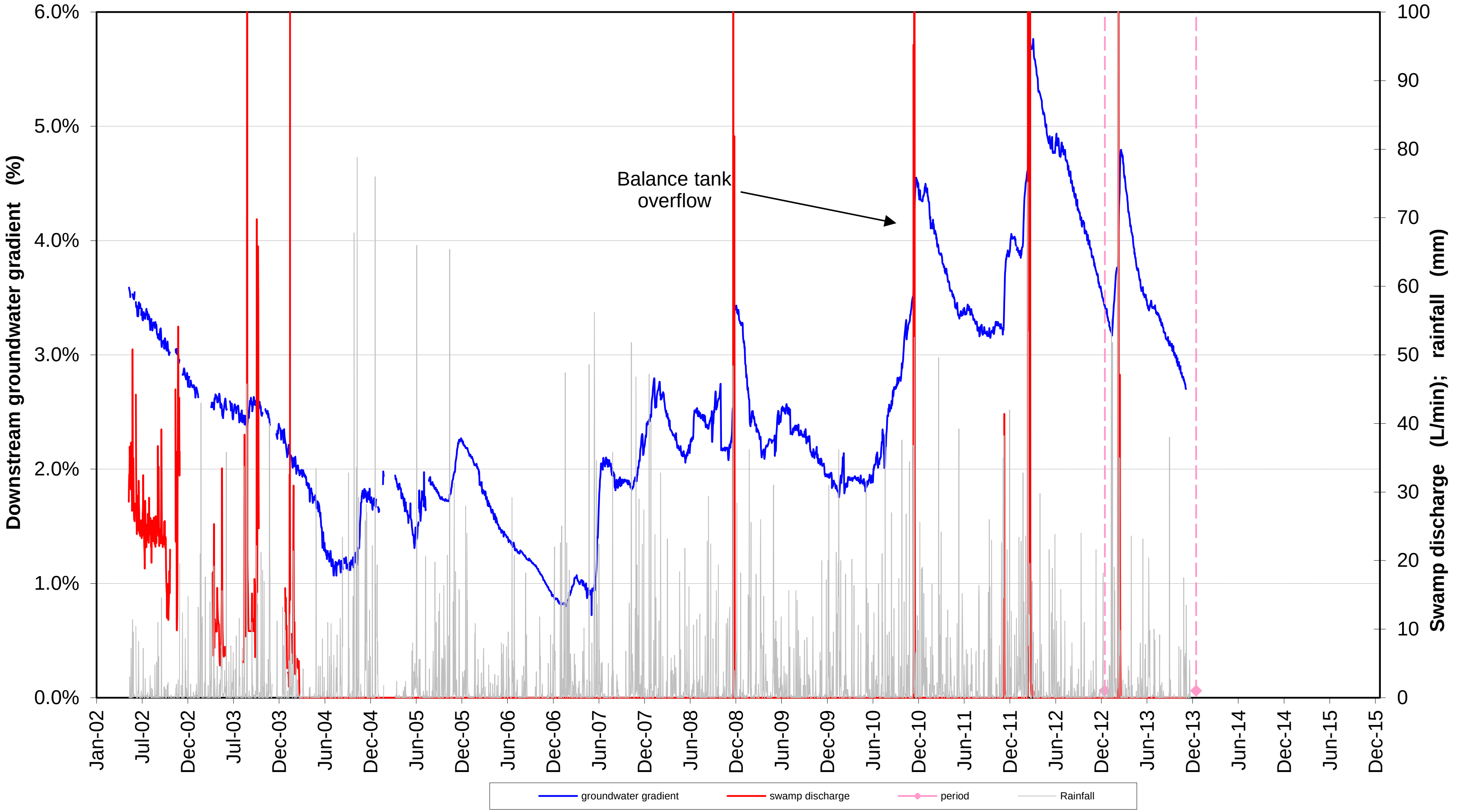
F:\Jobs\S202B\300\Excel\Projects\Springvale\[SPR67.xls]Figure - SPR67



RPS

CWP (Waterhole) - Figure 18

F:\Jobs\S202B\300\Excel\Projects\Springvale\[Carne West pool.xlsx]SSP RPS Template



Balance tank overflow
Downstream groundwater gradient (%)
Swamp discharge (L/min); rainfall (mm)
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
100
90
80
70
60
50
40
30
20
10
0
Jan-02
Jul-02
Dec-02
Jul-03
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08
Dec-08
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Dec-09
Jun-10
Dec-10
Jun-11
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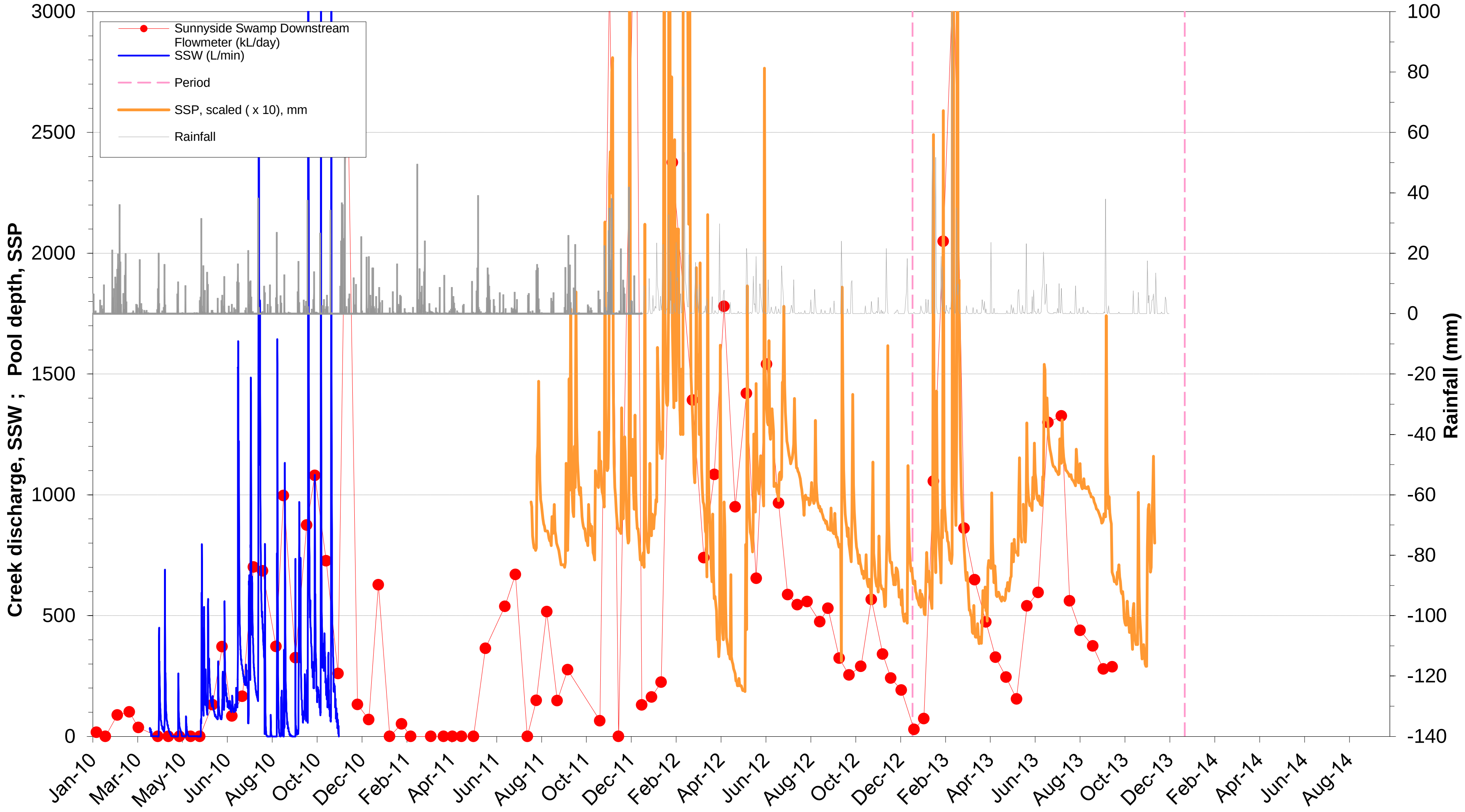
Dec-13
Jun-14
Dec-14
Jun-15
Dec-15
groundwater gradient
swamp discharge
period
Rainfall



Sunnyside Swamp Downstream Flowmeter (kL/day)
SSW (L/min)
Period
SSP, scaled (x 10), mm
Rainfall
Creek discharge, SSW ; Pool depth, SSP
Rainfall (mm)
3000
2500
2000
1500
1000
500
0
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
Jan-10
Mar-10
May-10
Jun-10
Aug-10
Oct-10
Dec-10
Feb-11
Apr-11
Jun-11
Aug-11
Oct-11
Dec-11
Feb-12
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Feb-14
Apr-14
Jun-14
Aug-14