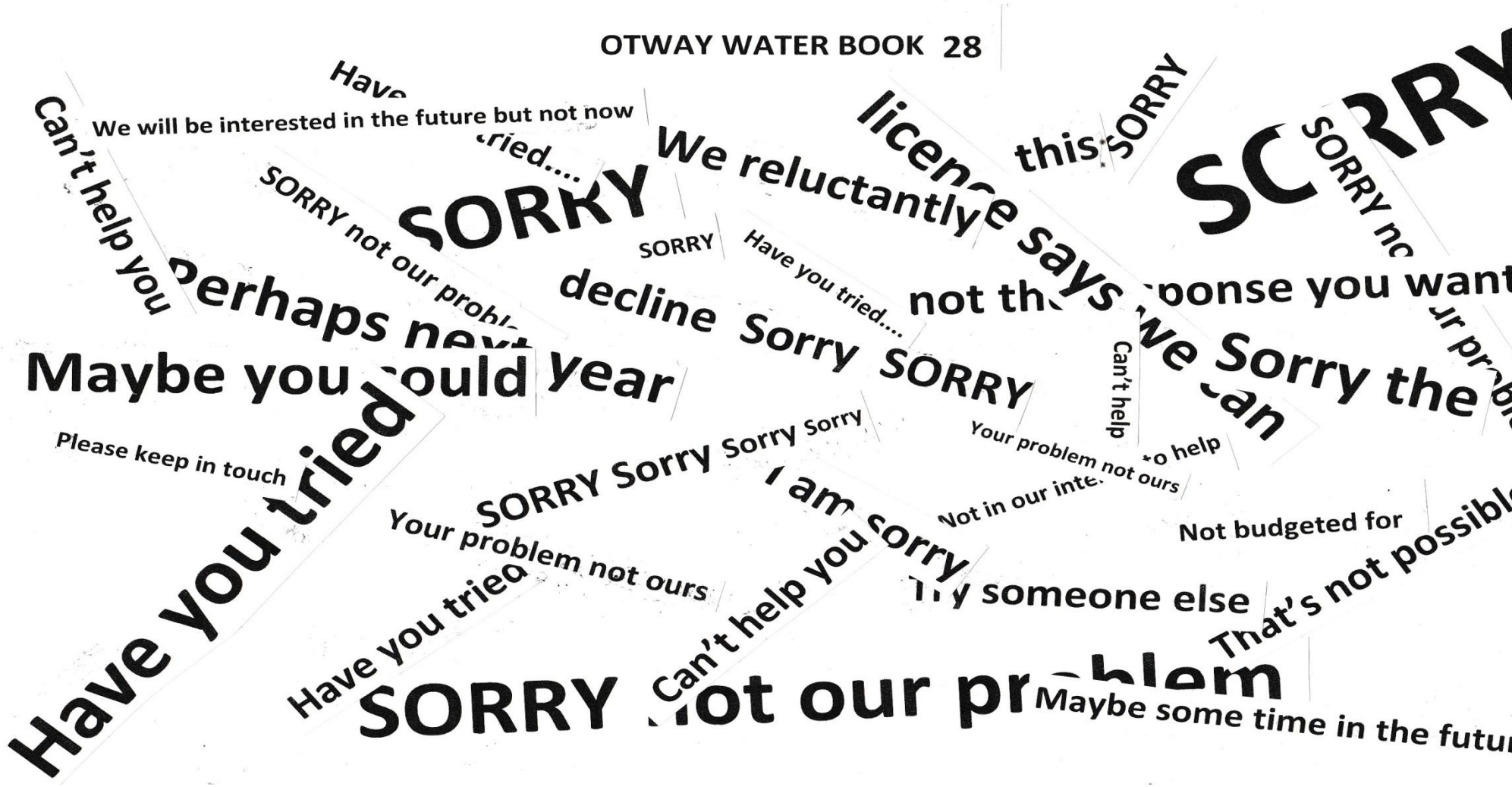
The Western Front - Ten Mile/Loves Creek Catchment



"The darkest places in hell are reserved for those who maintain their neutrality in times of moral crisis."

Dante Alighiles.

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September 2015

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INTRODUCTION

A 'war' of sorts has been raging in the Otway Ranges for 35 years between landholders, environmentalists and authorities who have been extracting huge volumes of groundwater for urban use. Government authorities call one of the "battles" taking place, the "Western Flank." This line of demarcation or "front," is located in the areas to the west and south west of the impact area created by groundwater extraction from the Barwon Downs Borefield. However, this Western Flank would be more aptly described as the "Western Front." The First World War analogy fits well. Problems have been recognised for decades; failure to move forward has reached a stalemate; the local community is caught up in a protracted situation not of its making and the State Government authorities who should be able to resolve the matter are locked into entrenched attitudes and management practices.

As drawdown impacts from groundwater extraction at the Barwon Downs Borefield spreads further and further out, streams found in the Gellibrand River Catchment to the west and the south west extremities of the Borefield have experienced decreasing natural stream baseflows. Landholders in this catchment fear that the Gellibrand River system will suffer the same disastrous outcomes as experienced along Boundary Creek in the Barwon River system.[61(66)]

This book attempts to draw together and make some sense of the many pieces of the jigsaw puzzle including studies that have attempted to clarify the Barwon Downs Borefield groundwater extraction impacts on the upper reaches of the Gellibrand River Catchment, especially along the Western Aquifer Flank Flowpath.

The Big Picture

Data on its own or if dealt with in isolation is often of limited use. Hydrogeologists refer to the "big picture" of a groundwater system and how it behaves, as a "conceptual model."[44] There are various tools used by hydrogeologists when drawing up a conceptual model, simple groundwater flow equations to very complex numerical models.[44] However, there is always the danger of not encompassing all the various aspects that should be included when attempting to gain a comprehensive "big picture."

To narrow down uncertainties and inaccuracies regarding how a groundwater system is behaving, any conceptual model or big picture must include as much data and information as possible. Numerical modelling often doesn't do this. The big picture should include...

1. Observation bore information, data, hydrographs and behaviour.
2. Observable data and behaviour of groundwater receptors such as vegetation, springs, wetlands, streams and rivers. This observable data should be sourced from both scientifically accepted data collecting processes and local experience and knowledge.
3. Rainfall history and patterns.
4. Infiltration rates.
5. Stream flow gauging station records.
6. Land use change.

In regard to groundwater flowpaths to the west and south-west originating in the Barongarook High (see page 8, 24 & 64-69), drawing all of this information together has never been done let alone attempted. As has often been stated in the Otway Water books it is extremely difficult for the State Government authorities to adequately manage the water resources of the Barwon River and Gellibrand Catchments of the Otway Ranges when this has never been done. Mistakes and poor decisions will result when relying on assumptions and working from a narrow and limited knowledge base. Perhaps this book will go some way to broadening this knowledge base.

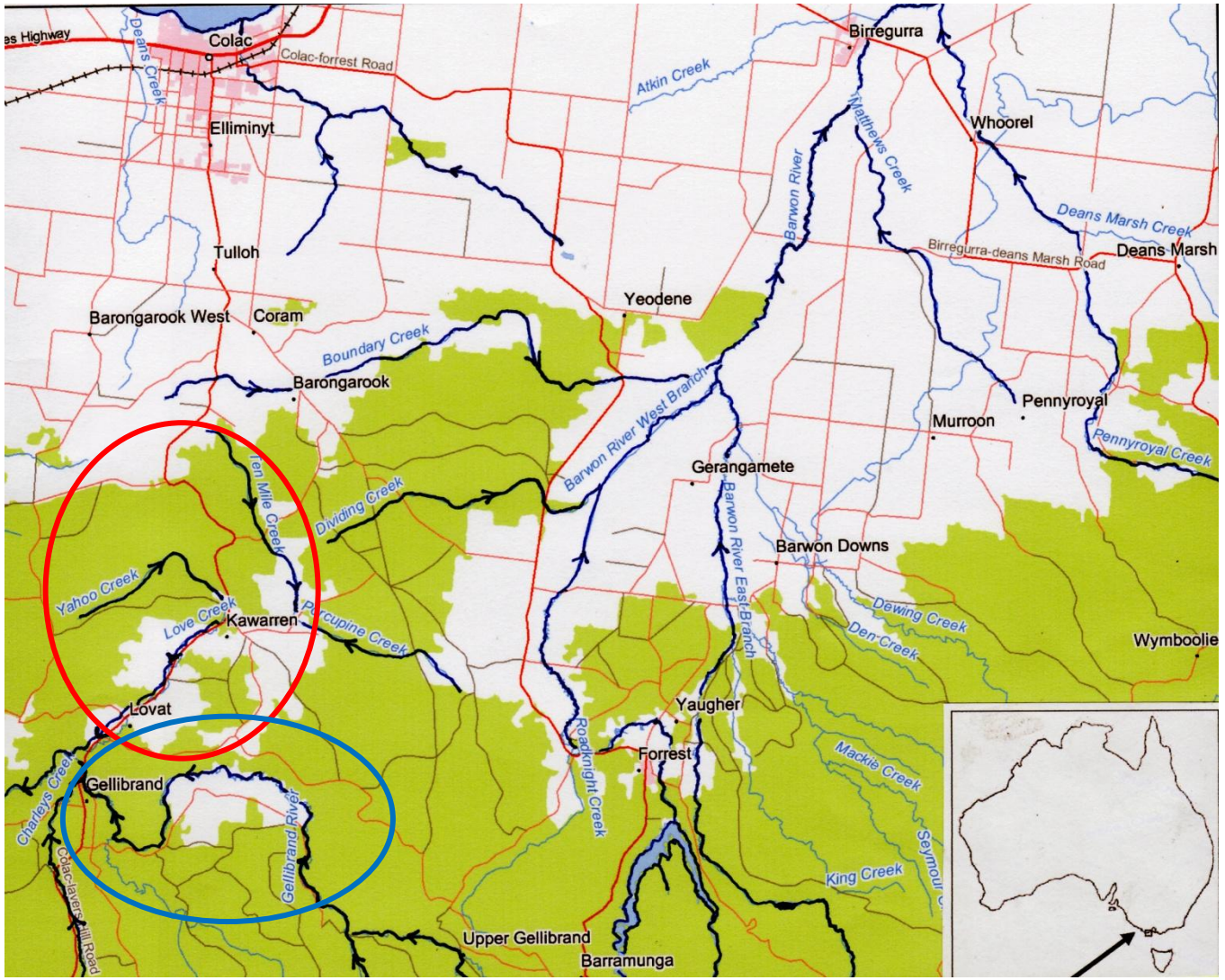
What is the Concern?

Over the last few decades locals have noticed a dramatic decline in the surface water flows in the Loves Creek ⬭ and Upper Gellibrand River ⬭ catchments.

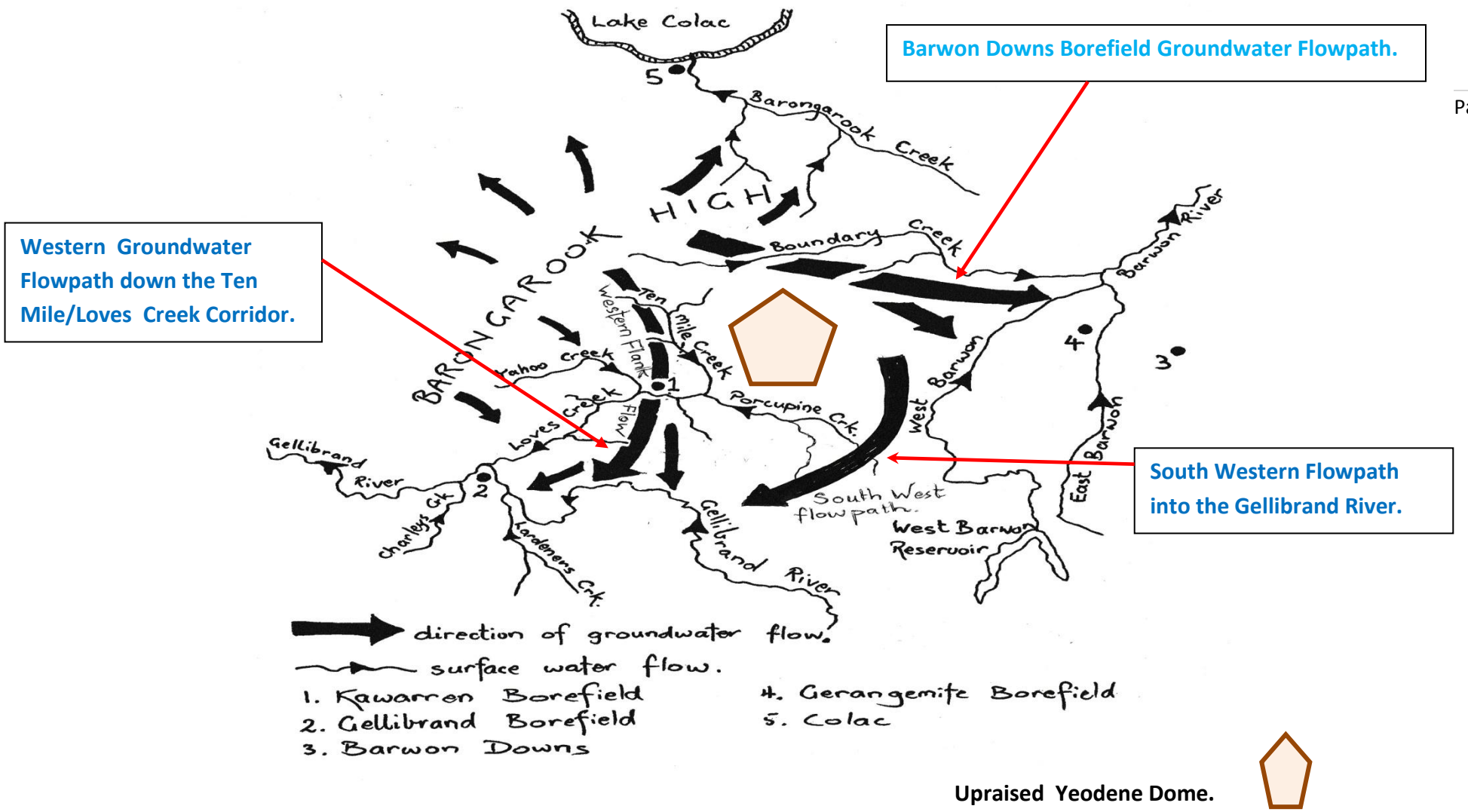
There is also a fear that springs, soaks and small streams are also suffering a similar fate.

The majority of summer flows discharging into these systems is groundwater overflowing from the Eastern View Formation (EVF).

The EVF is principally recharged from rain falling on the porous soils throughout the Barongarook High region. This rainwater seeping into the EVF is then dispersed in several directions.



Map 1.



Map 2 - Location and Flowpaths Map adapted from Leonard[(John)]

Local Knowledge.

Eamus et al.[45] states that estimations of water regimes are developed through strategic scientific research including the application of local knowledge based on many years of observation. MacKay[99] writes in a similar fashion stating cutting edge science needs to recognise that the lay person can identify simple but precise indicators of the status of groundwater-dependent ecosystems. The summer baseflows of the Loves Creek and Upper Gellibrand River come out of the Eastern View Formation. This groundwater supports and maintains the ecosystems that have evolved and prevailed since time began. When developing a conceptual or big picture model local knowledge should be taken into account. In fact the reason why an examination of water resource management in the Otways has come under any scrutiny is based on the observations and concerns expressed by local community members. If local knowledge had not identified indicators of detrimental impact, the unsustainable management of water resources by deskbound State Government authorities would have continued unanimously. A Google search of the word unanimously defines it as synonymous to *"... without opposition, with one accord, with one mind, to a man, as one, one and all, each and every one, bar none, without exception."* Unfortunately the one and all and bar none in the management process has too often ignored those people at the pointy end of any ramifications from bad management decisions, the local community.

In an effort to record local knowledge in regard to the stream and river baseflows, local community members of long standing, were approached to express their observations. These recordings are found in Appendix 10. To summarise these is somewhat presumptuous but one or two things are common throughout...

- Each person approached has demonstrated concern that the low flows in the creek or river they have been intimately connected to for a considerable time, have fallen away.
- Associated ecosystems have undergone detrimental change.

Some locals have been able to identify specific signs pointing to reduced groundwater levels and health.

It will be pointed out in the following pages that these observations and concerns are well founded.

AQUIFER FLOWPATHS of Interest.

The groundwater flowpaths of the Eastern View Formation (EVF) that are of particular interest are;

1. the one that flows down the Boundary Creek Catchment corridor towards the Barwon Downs Borefield,
2. the one flowing east and then to the south west around the upraised Yeodene Dome discharging into the Gellibrand River, and
3. the flowpath, called the Western Flank Flowpath, through the Ten Mile Creek corridor of the Loves Creek Catchment that also discharges into the Gellibrand Township valley.

(See conceptual model of these flowpaths on page 8)

The Barwon Downs Borefield Groundwater Flowpath.

Since the drought of 1982-1983 Barwon Water has extracted over 130 000 ML of water from the Barwon Downs Borefield. In the 1990s a 4,000 ML/year limit was set as the Permissible Annual Volume. It was determined that 1,500 ML/year extraction would have little impact. At 4,000 ML/year surface impacts would be detectable. If more than 4,000 ML/year is extracted, an aquifer storage and recovery programme should be implemented. The 12,600 ML/year licence of 1995 was extended to a 20,000 ML/year licence in 2004. During the last years of the latest drought, over 11,000 ML were extracted each year. No aquifer storage recovery program has been implemented.

The environmental consequences from this pumping regime have been profound. Landholders' permanent water resources have been lost and, after 5 years since pumping ceased, the aquifer is still struggling to recover. The Barwon Downs Borefield Aquifer Flowpath will take some considerable years to recharge to such an extent that Boundary Creek returns to being a permanent creek with usable stock and domestic standard water.

Impacts from groundwater extraction on the Barwon Downs Groundwater Flowpath were predictable; they have occurred and are both measurable and observable.

The Big Swamp in 2011.

Chart 1.

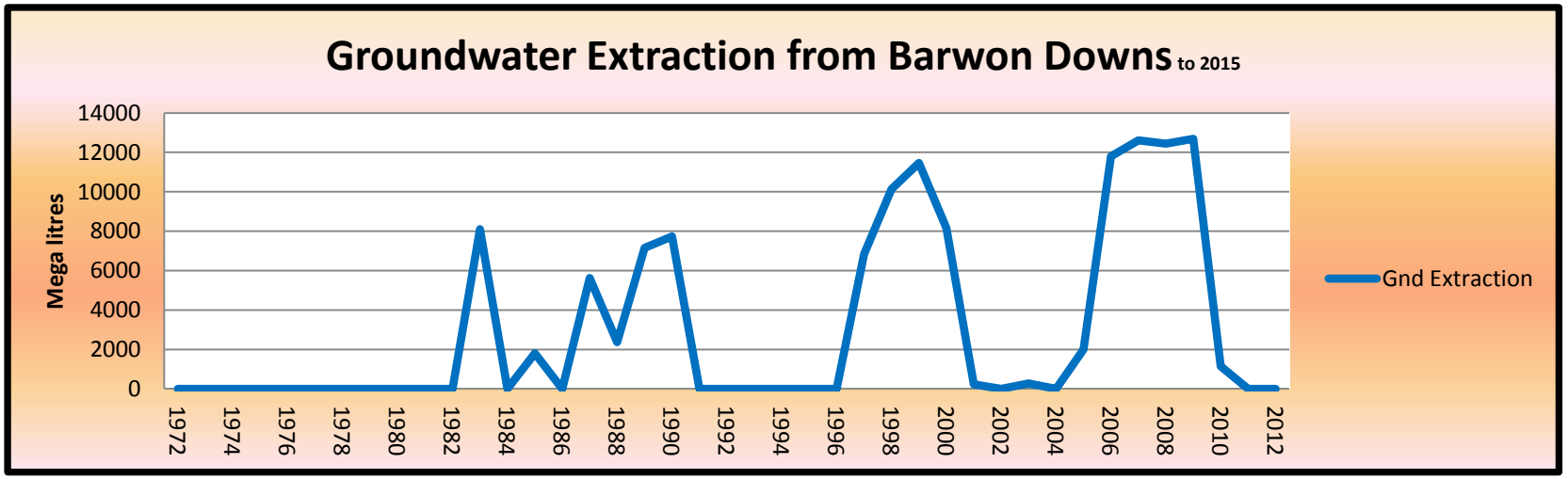
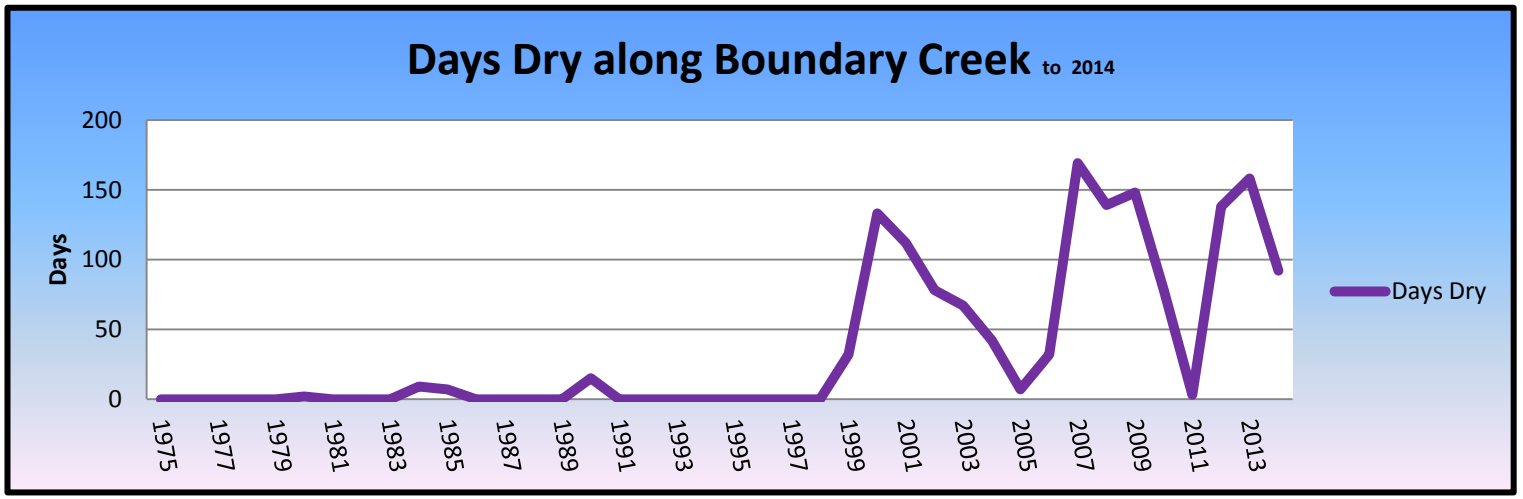
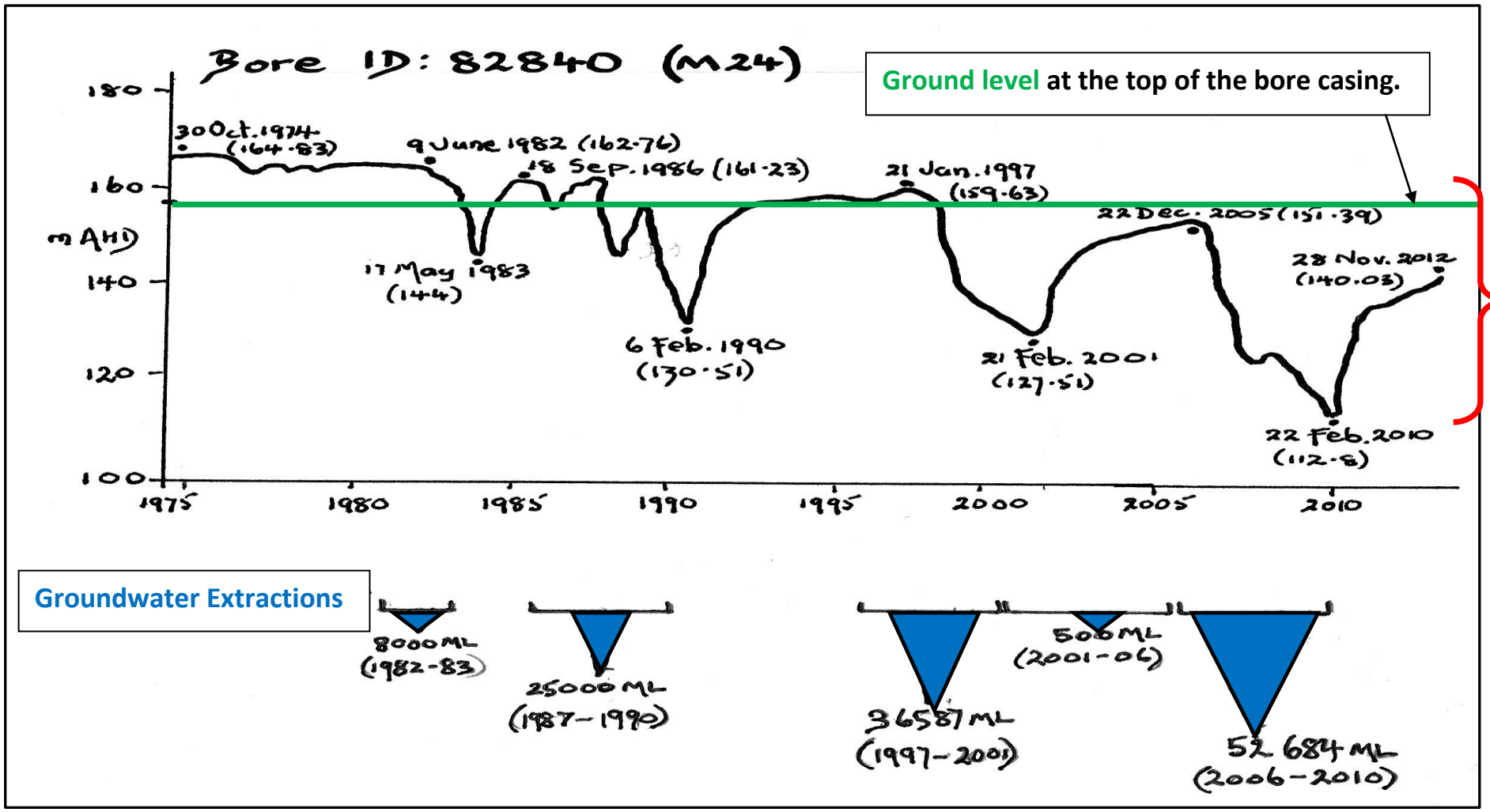


Chart 2.



After groundwater extractions at the Barwon Downs Borefield the days of decreased flows in Boundary Creek increase, followed by days of no flow. Groundwater extraction stopped in August 2010 but five years on and the impact from pumping is still felt with many months each year of no flows in Boundary Creek.

Hydrograph 1. Information Sourced from Southern Rural Water Website.



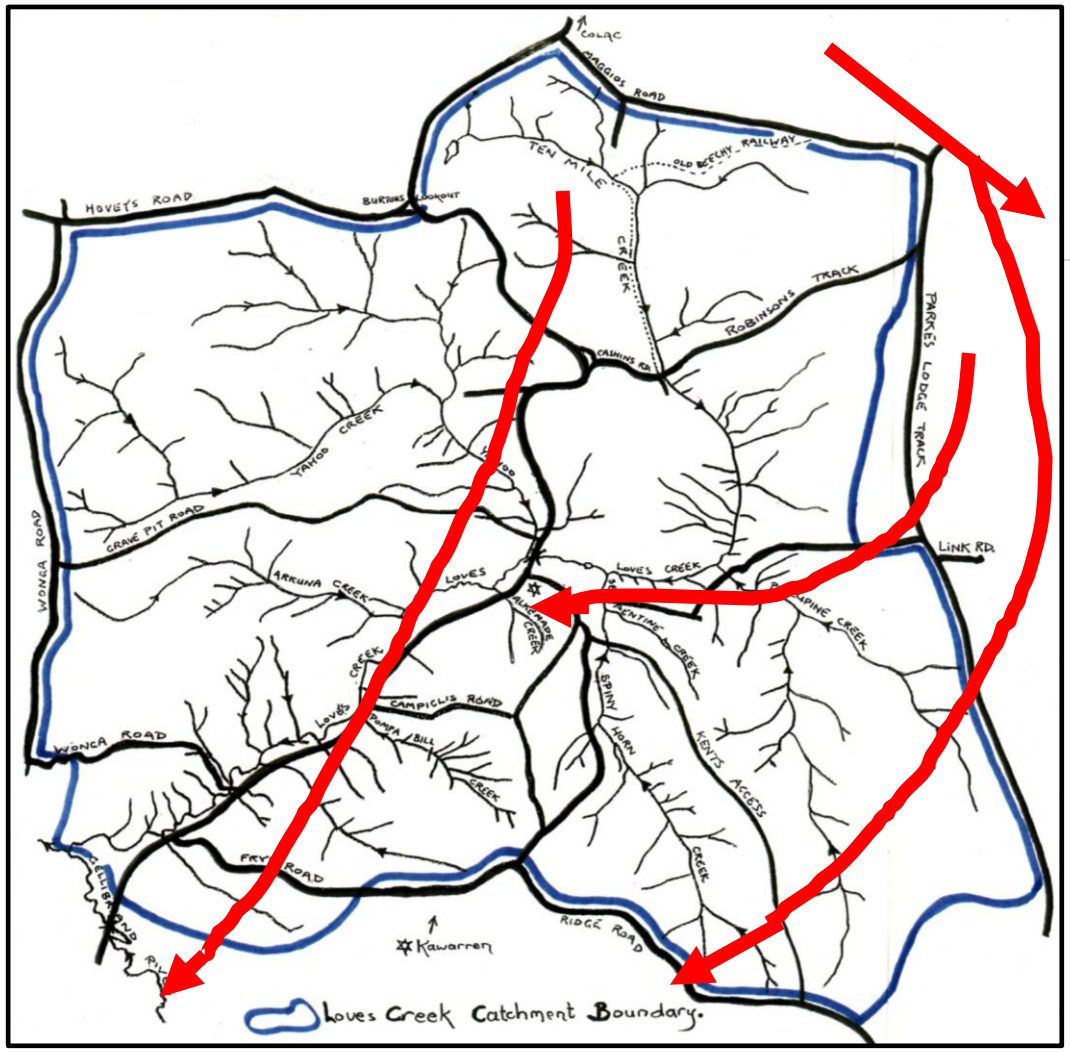
Every time there is a groundwater extraction the hydrographs down the Boundary Creek corridor drop in response.

Boundary Creek pollution resulting from Actual Acid Sulfate Soil problems as a result of the water table being lowered below the Big Swamp peat wetland.

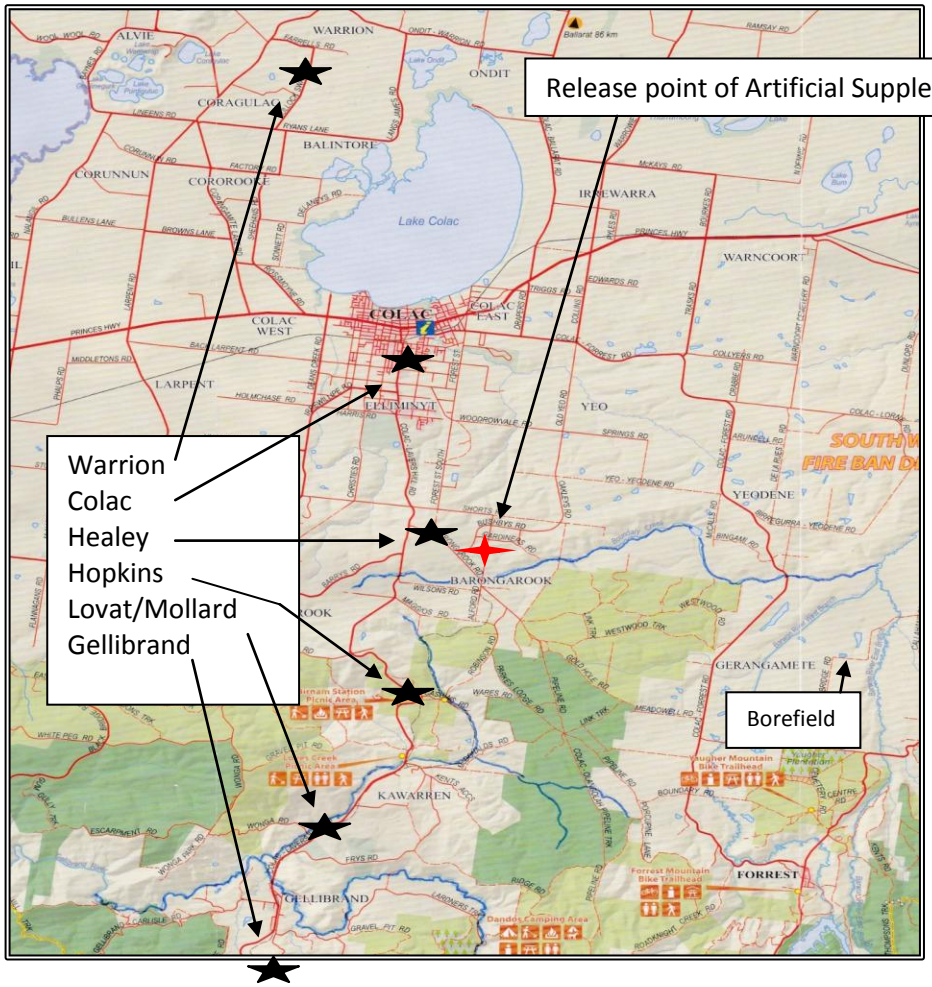
A Possible Fourth Aquifer Flowpath.

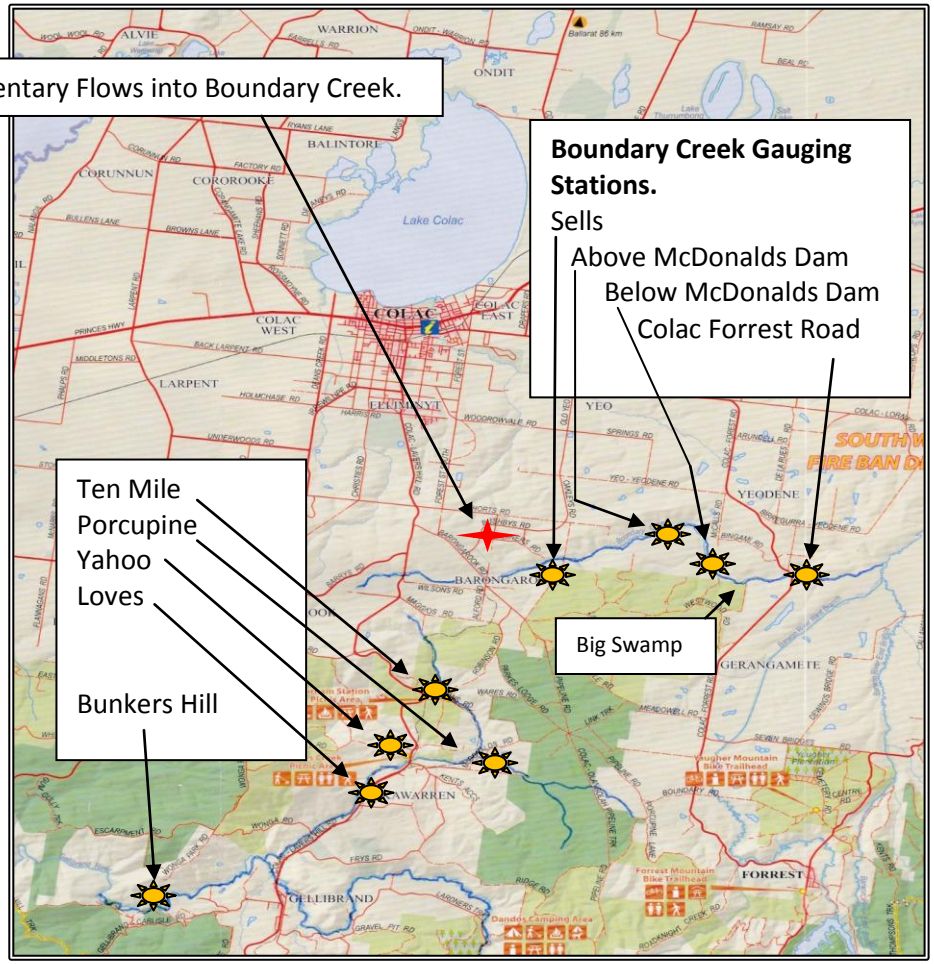
As part of Jacobs work for Barwon Water a request was made to me for information regarding where groundwater was being extracted in the Kawarren region. That there was any noticeable groundwater extraction taking place that would cause a cone of depression, was of some surprise. The only extraction in the area has been an extremely small amount pumped from a private bore some considerable distance from the "hot spot" of enquiry. The water from this bore is used for stock and domestic purposes only. The small amount extracted could not be the cause of the drawdown outlined by Jacobs.

Despite this local knowledge being made known to Jacobs, Jacobs in a 2015 report[91] made this recommendation... "***The cause(s) of drawdown in the bores around Kawarren should be investigated further, including estimating the likely magnitude of groundwater pumping in the area***."
Perhaps this recommendation has been made in the vain hope that the water that has "gone missing" can be blamed on some other factor than the groundwater extraction at the Barwon Downs Borefield.



It is possible there is a fourth narrow aquifer flowpath that flows just south of and around the Yeo Dome into the Kawarren valley, a distinctly different flowpath to the South West Flowpath. With Jacobs's unexplained drawdown in this area, it is quite conceivable that there is another direct flowpath connection with the cone of depression that is still levelling out and sucking water towards the Barwon Downs Borefield. If this is the case water usually flowing into and under the Kawarren area is also being drawn back towards the Barwon Downs Borefield.





Location of Rainfall Gauging Stations. ★

Warrion No. 090080	Colac
Healey	Hopkins
Lovat/Mollard	Gellibrand Forestry No. 090134

Location of Stream Flow Gauging Stations. ☀

Ten Mile No. 235239.	Porcupine No. 235241.
Yahoo No. 235240.	Loves No. 235234.
Bunkers Hill No.	Colac Forrest Rd Bridge No.233228

Observation Bore Hydrographs showing water levels – Hydrograph Charts 1H(page 21), 2A to 2F(pp 23-30) and 3A to 3F(pp32-39).

When these hydrograph charts are set out as depicted in Diagram One some very interesting observations can be made. Chart 1H clearly shows drawdown as a result of groundwater extraction taking place and shows why Boundary Creek ceases to flow. As the observation bores in the 2A-2F series of charts gets closer to the borefield the bigger and more protracted the impact. However, there does seem to be an artificial buffering effect around those bores closest to the Artificial Supplementary Flow release point shown on page 28. Some of these bores are located in the aquifer divide.

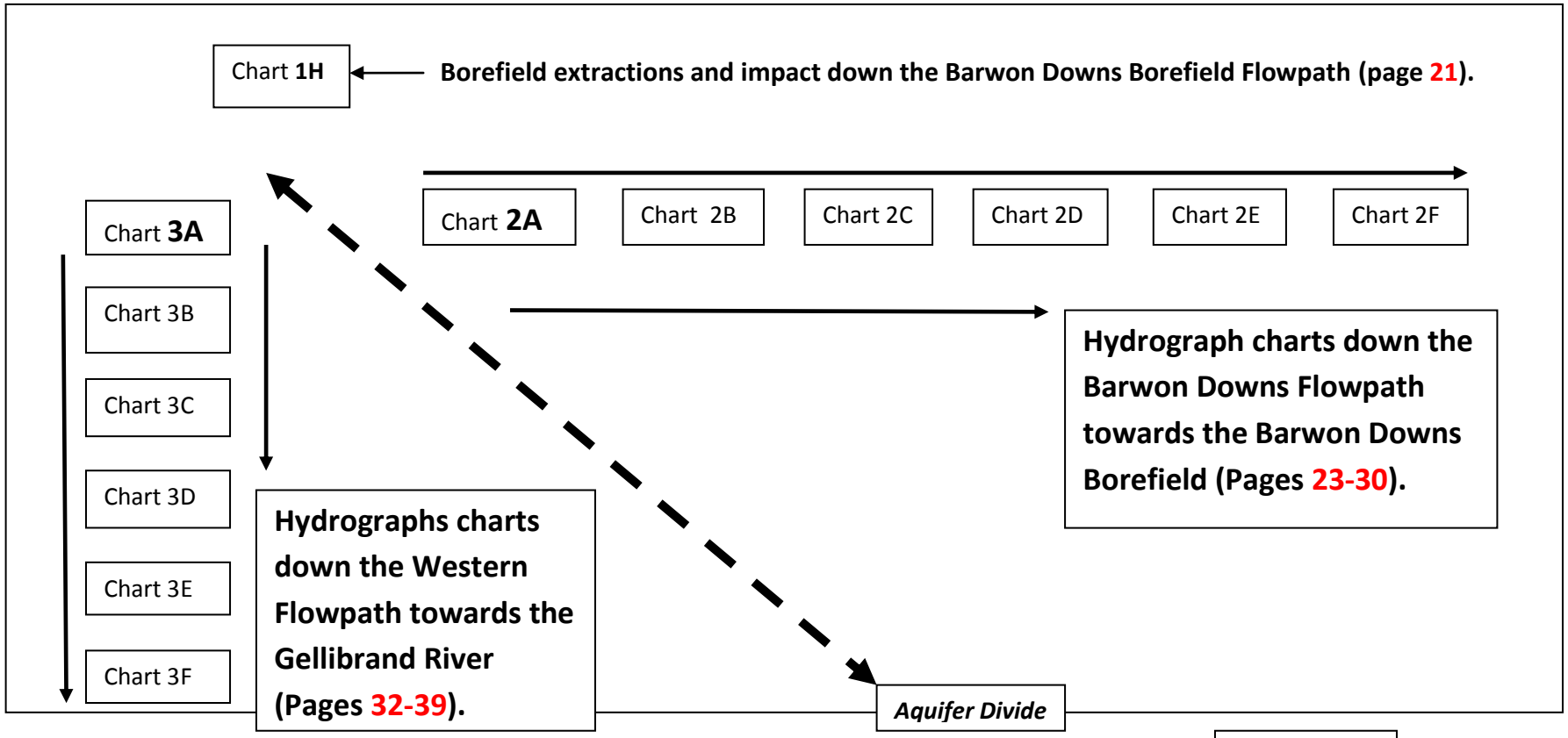
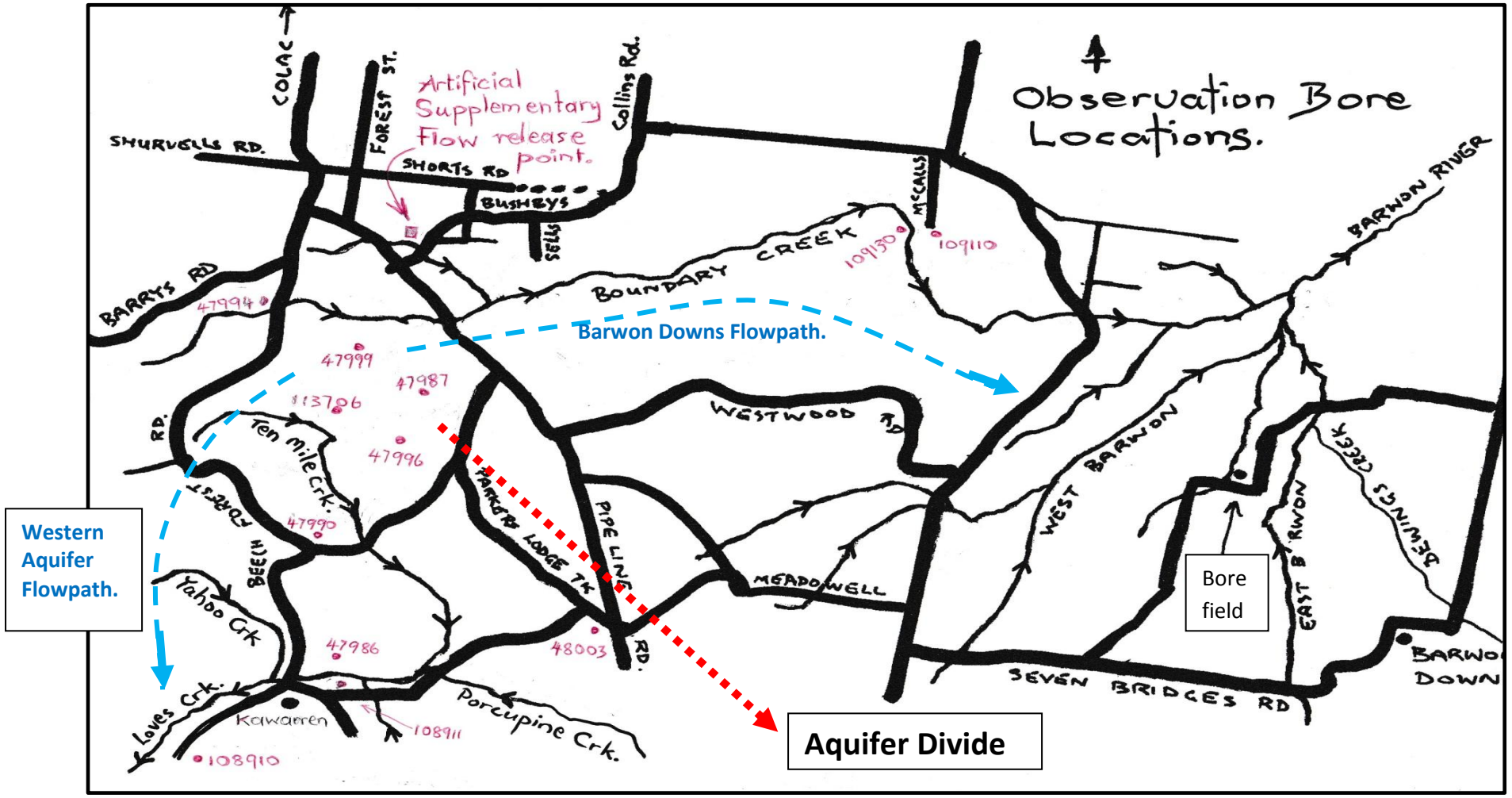


Diagram One.

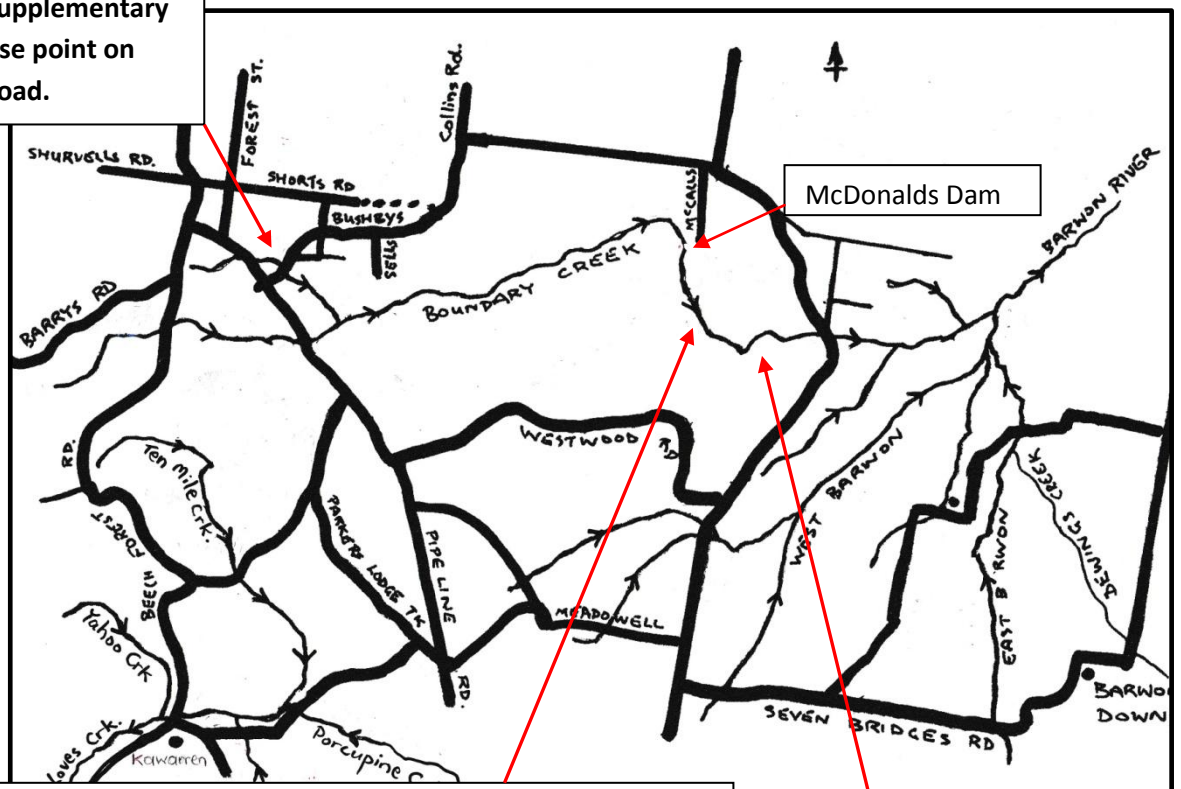
The 3A-3F series of charts clearly show a gradual AND continually drawdown impact long after the drought has broken.



Map showing observation bore locations.

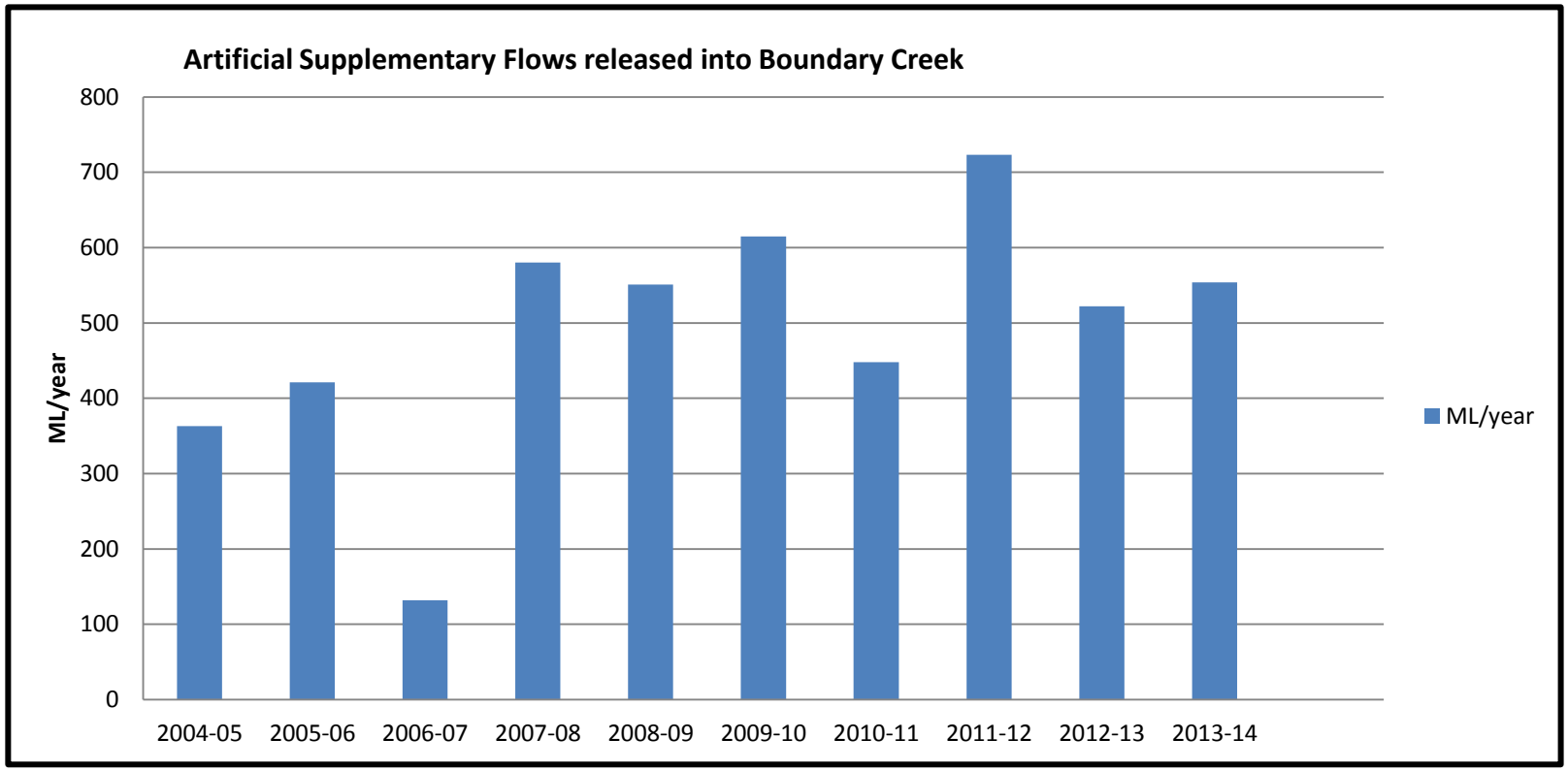
Artificial Supplementary Flows in Boundary Creek.

Artificial Supplementary Flow release point on Bushbys Road.



After the drought broke in 2010 the Artificial Supplementary Flows released into a tributary of Boundary Creek disappeared into the ground further and further upstream. By 2013 during the drier months the flows disappeared 800 metres below McDonalds Dam, some considerable distance above the Big Swamp (M.Buttegieg - pers. com.). This can be regarded as a form of artificial recharge rather than the intended surface water flow for downstream landholders.

During the 2000s drought and up to the 2010 fires, the Artificial Supplementary Flows would completely disappear approximately halfway through the Big Swamp zone.



This water is released out of the Otway to Colac Pipeline at Bushbys Road (see page 16 & 18). The water flows down Sandy Creek, a tributary of Boundary Creek and during non rainfall periods disappears into the depleted Eastern View Formation well above where Boundary Creek joins the Barwon River. These releases started in 2004. See page 12 for the graph showing the number of no flow days in Boundary Creek at the Stream flow Gauging Station on the Colac/Forrest road bridge.

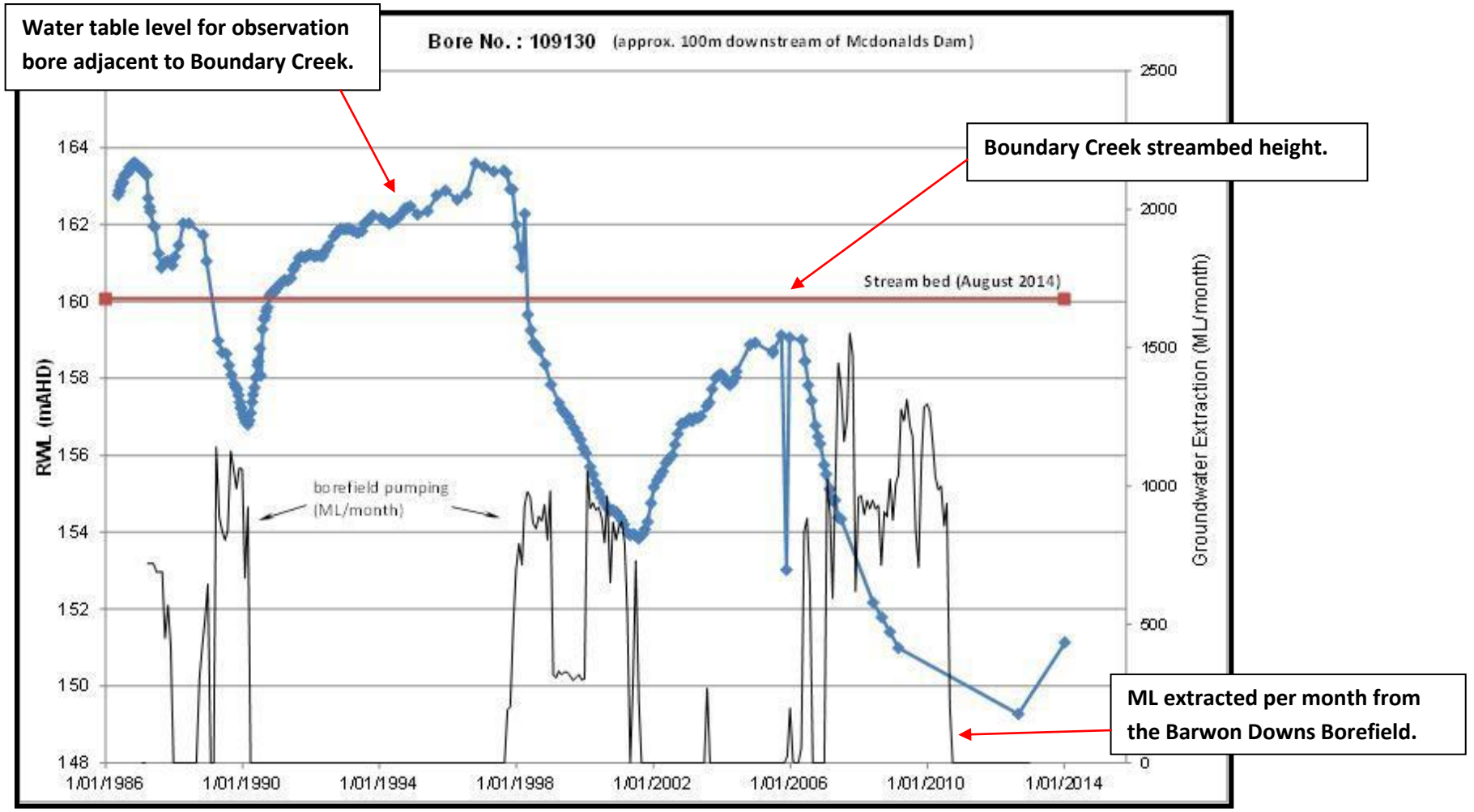
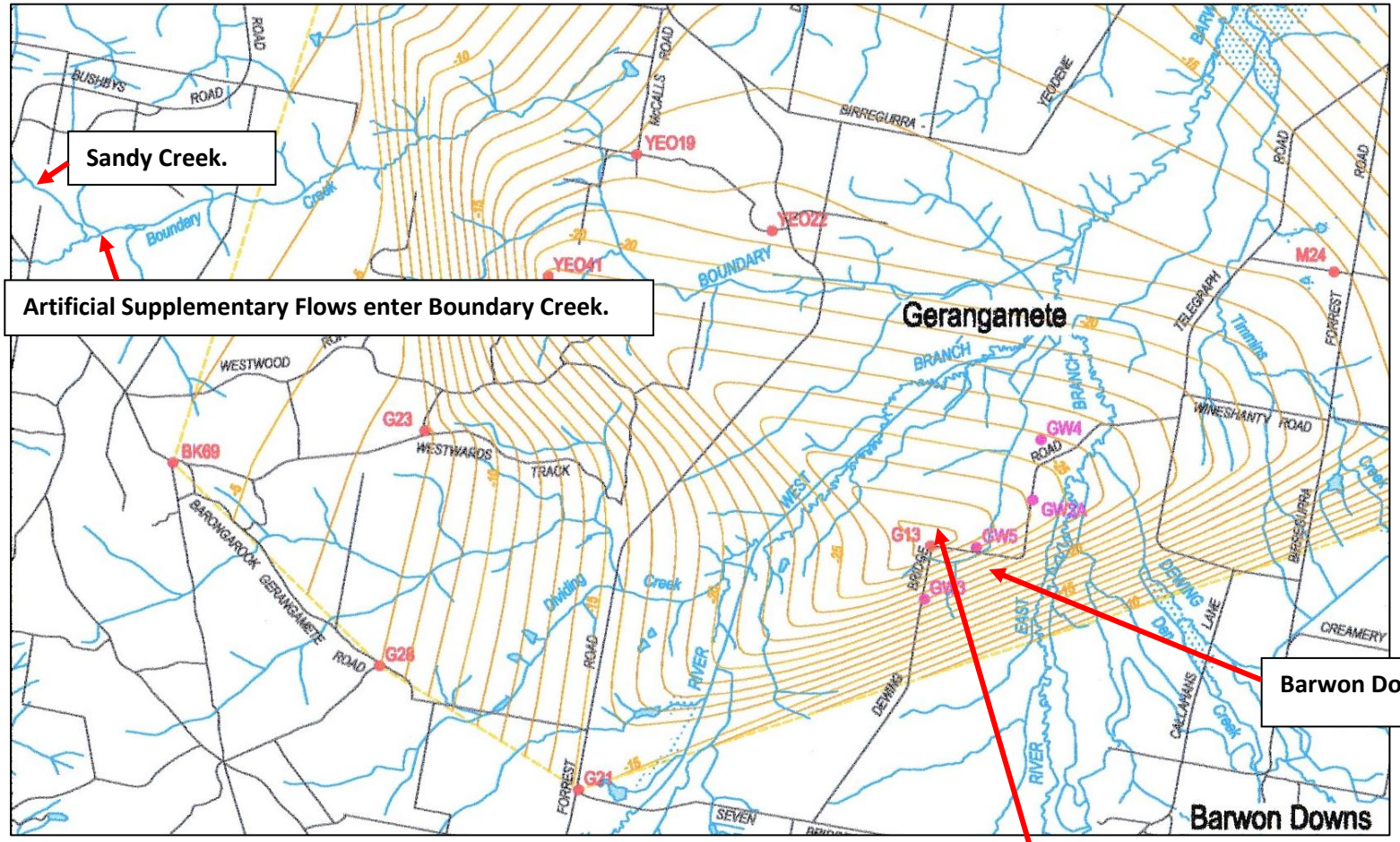


Chart 1H. Source. R. Evans presentation to Barwon Downs Groundwater Community Reference Group 2015.

Soon after groundwaer extraction commences at the Barwon Downs Borefield the observation bore water levels react in a similiar fashion as depicted in Chart 1H above. After pumping ceases the impact continues before recovery begins. During these non pumping episodes watertable levels have not been able to fully recover. In fact one of the aquifers that groundwater is being extracted from, the Pebble Point Aquifer, still had residual drawdown levels of 28 metres in 2014. This was four years after groundwater extraction ceased (see residual drawdown map below).



RESIDUAL DRAWDOWN MAP SOURCE: Barwon Water Licence no. BEEO32496 2013-2014 Report to Southern Rural Water.

The brown lines(contours) show the drawdown gradients.

Barwon Downs Aquifer Flowpath Charts.

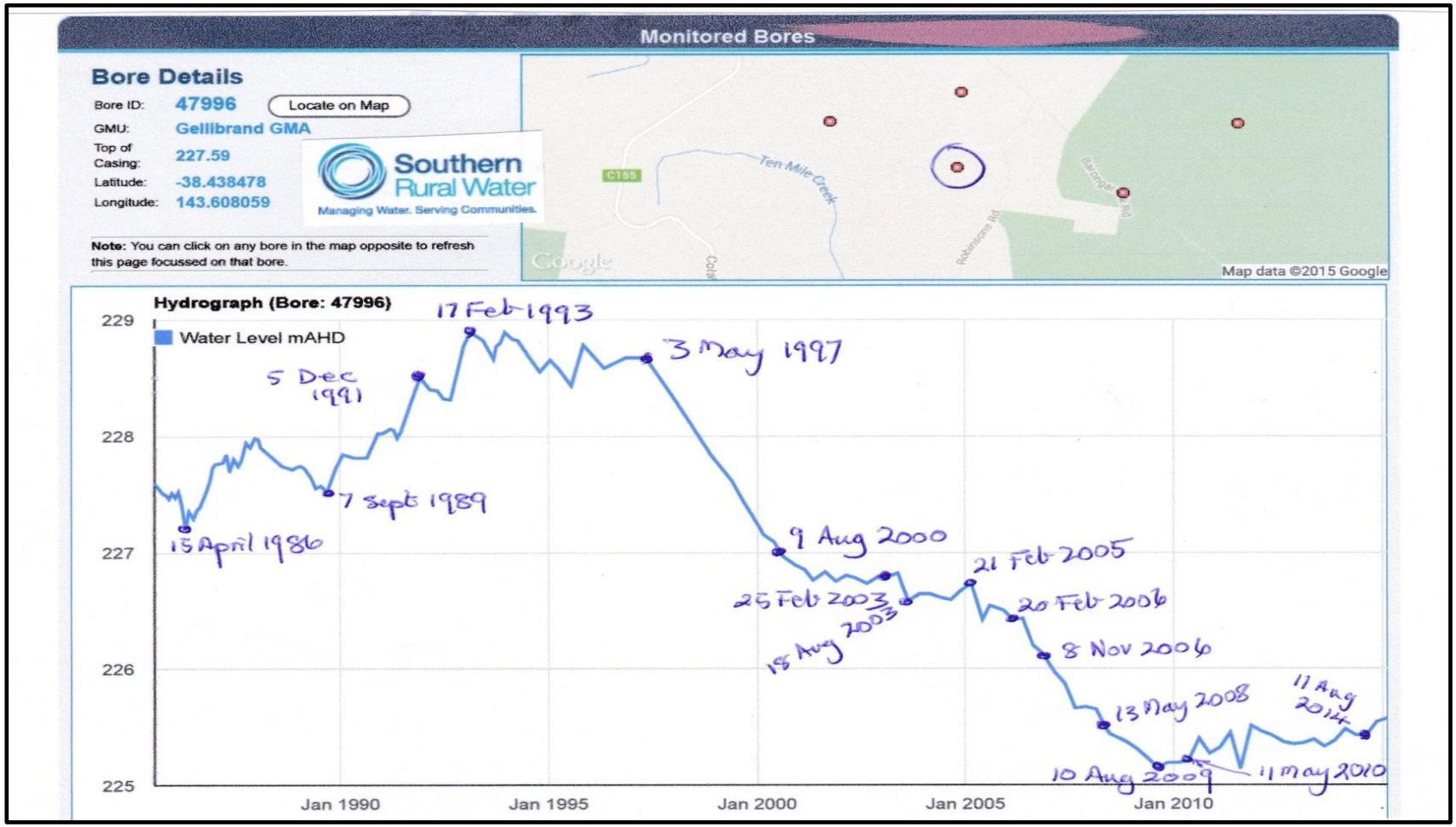
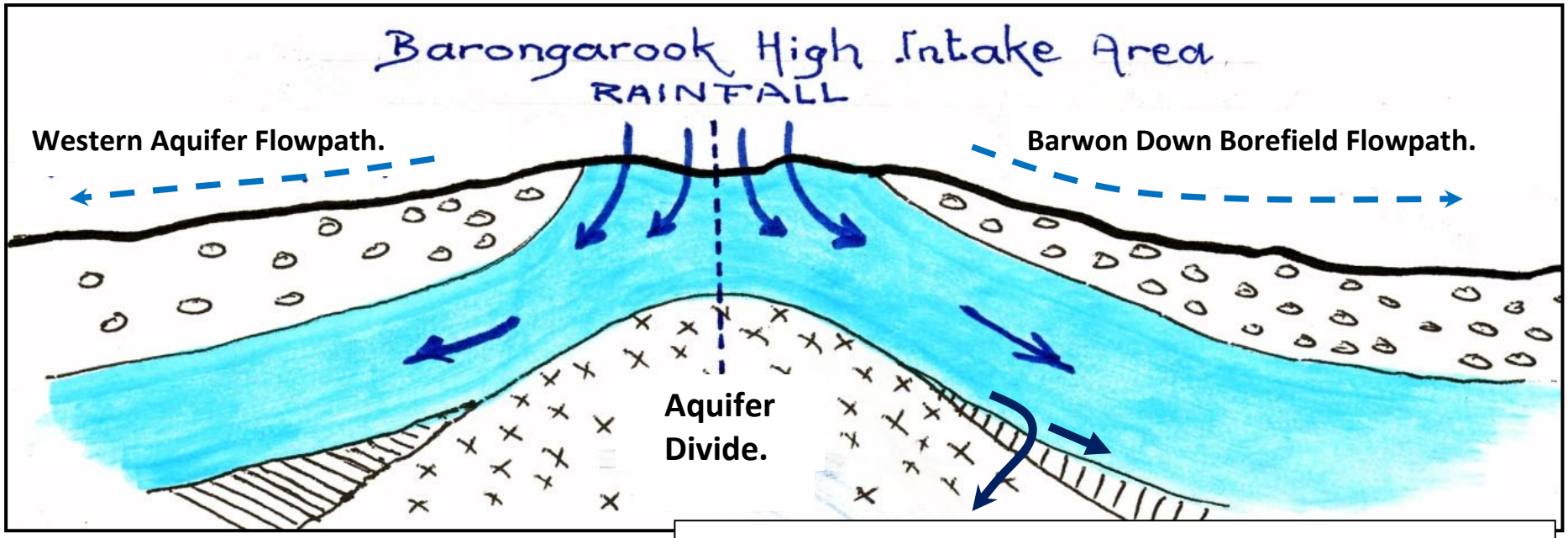


Chart 2A.

This bore sits very close to the shoulder of the aquifer divide between the Western and Barwon Downs Aquifer Flowpaths.



Conceptual Diagram.

This diagram represents how the rain that falls onto the sands and gravels of the exposed Eastern View Formation flow underground through the aquifer flowpaths.

The Western Aquifer Flowpath moves down the Loves Creek Catchment towards Kawarren and rises in the valley flats and stream bed of the Gellibrand River in the region of the Gellibrand township.

The Barwon Downs Borefield Aquifer Flowpath splits into two branches one swinging to the south west to flow into the Gellibrand River valley and the other continues on to the Barwon Downs Borefield region.

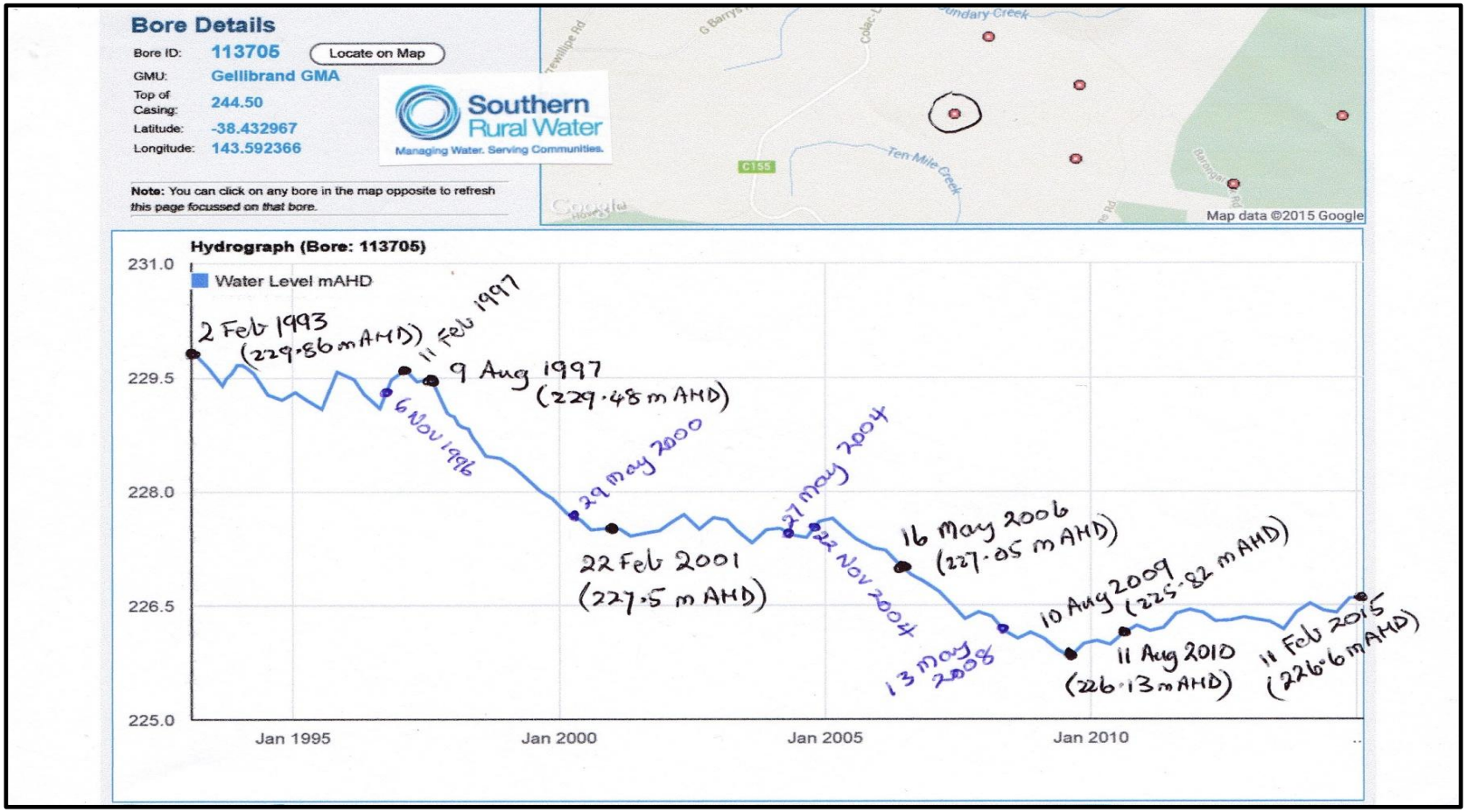


Chart 2B

This observation bore is also located in the vicinity of the aquifer divide.

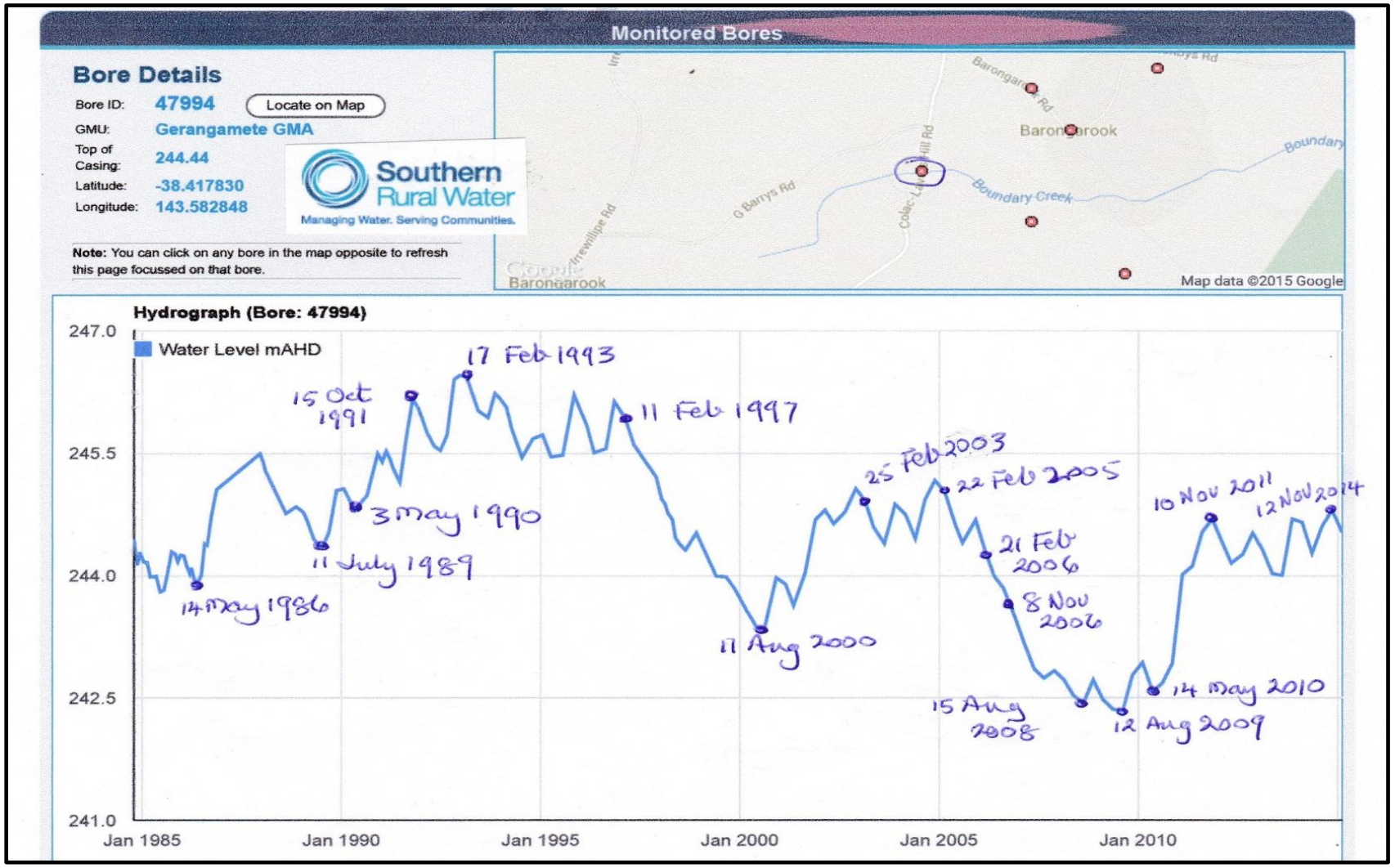


Chart 2C.

Note the high rainfall period that is reflected in the hydrograph levels on all of these charts for the early to mid 1990s,.

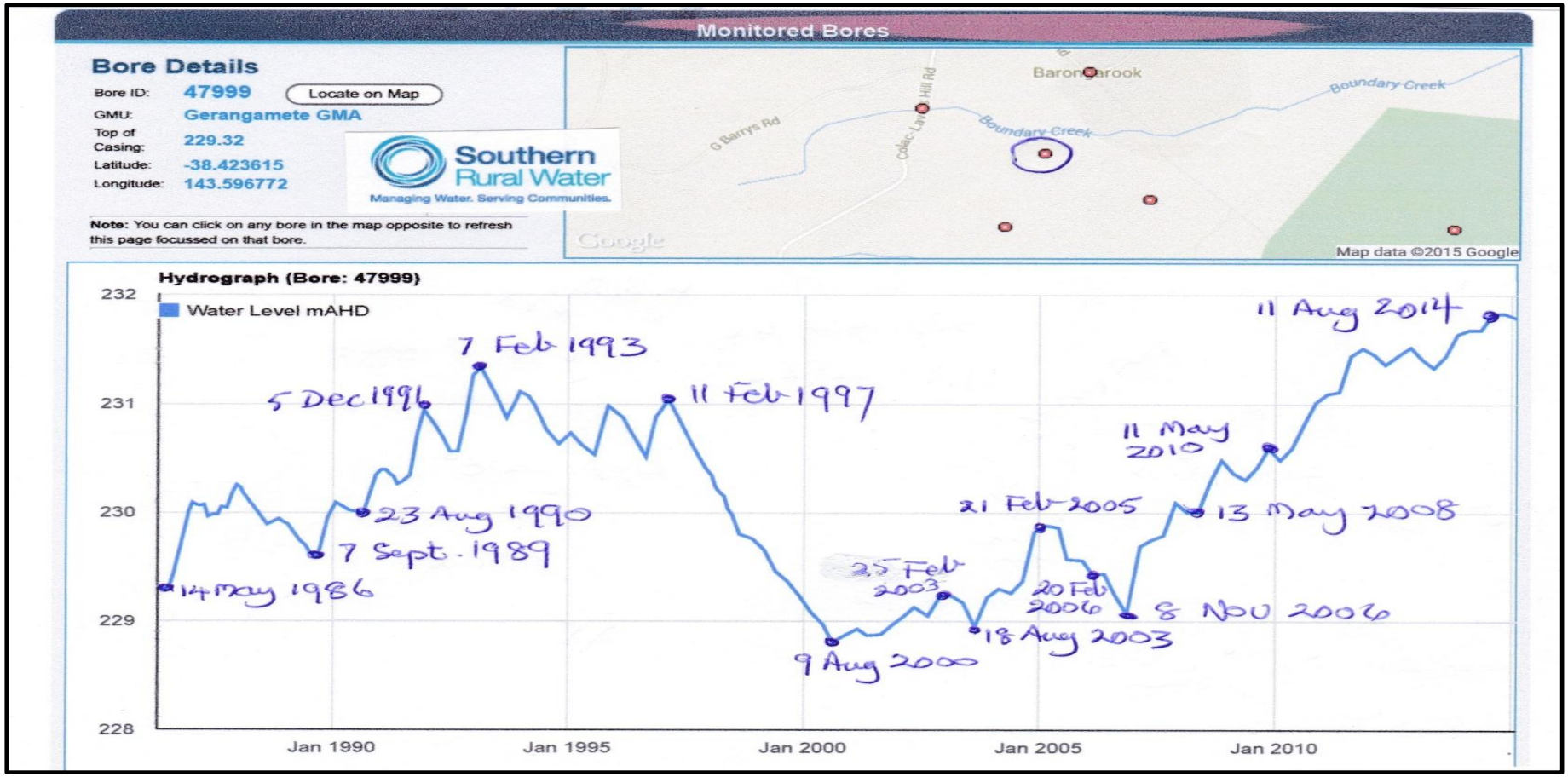
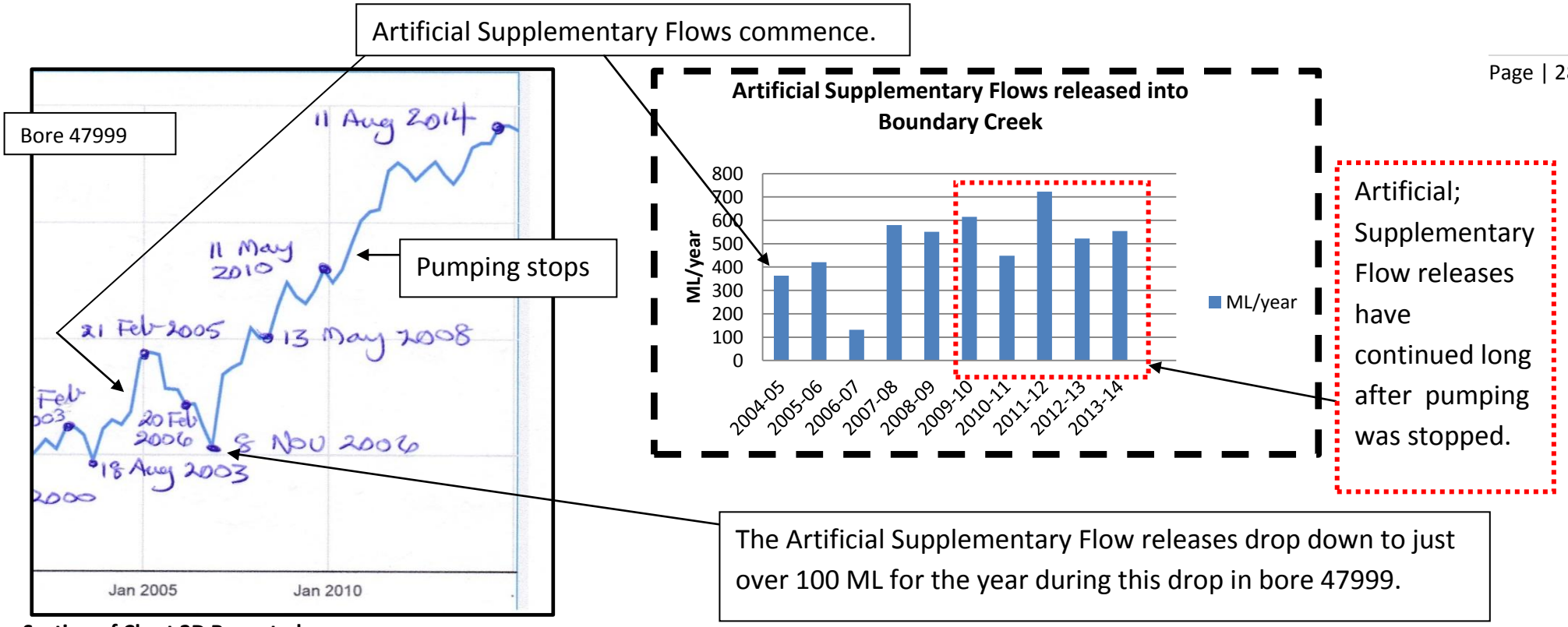


Chart 2D.

This bore's hydrograph goes against the downward trend during the 2000s drought, stabilising and actually rising. There appears to be a close relationship between this and the commencement of the Artificial Supplementary Flows.



Section of Chart 2D Repeated.

Four years after pumping has stopped (August 2010) this bore has recovered to such an extent it is well above those levels recorded in that very wet period of the early 1990s. Interestingly the Artificial Supplementary Flow releases have been maintained through the intervening five years since pumping extraction ceased. These releases have to be maintained because Boundary Creek still does not flow at the Colac/Forrest Road bridge during the drier months of the year.

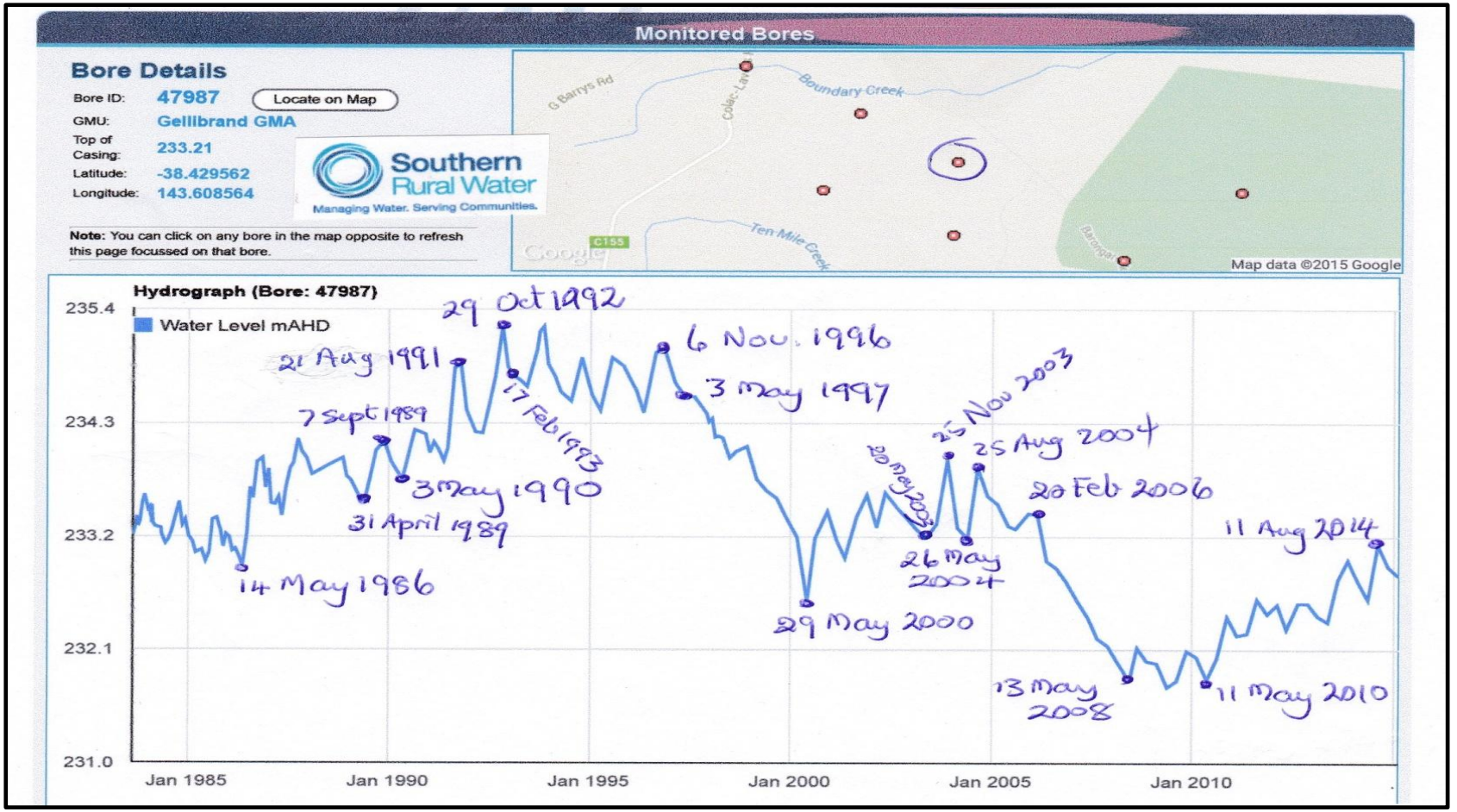


Chart 2E

This hydrograph appears to show a similar relationship as the one in Chart 2D. There is a definite upward trend in this hydrograph once the release of the Artificial Supplementary Flows start. However, the releases during 2006 were markedly reduced from 400 ML to 100 ML and this is also reflected in this hydrograph.

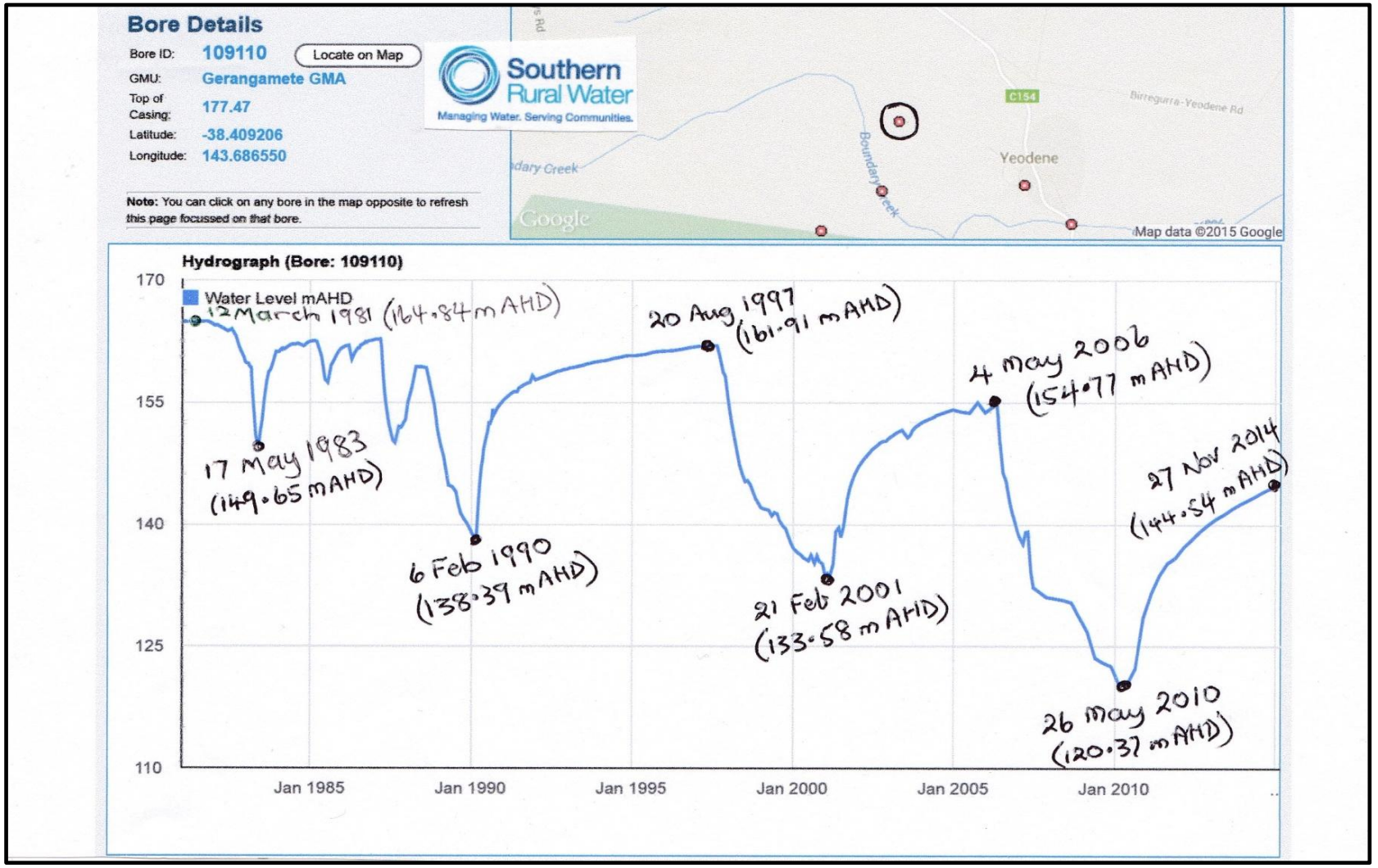


Chart 2F.

Drawdowns from pumping in this observation bore have been as much 32 metres, with recovery of 20 metres since pumping ceased in August 2010. It must be borne in mind that this bore is many kilometres from the borefield. The closer to the borefield the bigger the drawdown.

As far back as 1982 it was predicted that extensive groundwater extraction for urban use in Geelong could have profound surface water impacts throughout the Otway Ranges region..

In 1984 Leonard[97] had this to say, "***Creation of a cone of depression in the potentiometric surface in the Gerangamete area will distort the present flow pattern and absorb the northeasterly and southwesterly components of recharge from the Yeodene recharge avenue***." In other words the aquifer flowpath down the Western Flank into the Kawarren/Gellibrand region will be impacted.

Leonard also stated that, "***Underflow via the Barwon Downs Graben to the Gellibrand River catchment will cease; gradient reversal will result in components of recharge being drawn away in the northeast and southwest and from any as yet undelineated recharge zone along the Bambra fault.***"[97] The words "cease," "gradient reversal," and "drawn away" are quite precise and contain a powerful meaning.

Are these predictions actually taking place? It would appear so.

It was not until 2000[8] that any attempt to study the impact from the Barwon Downs Borefield upon the Western Flank and the South West Flowpaths was first mooted. Even after assurances made by Barwon Water to do this work, it was not done.

In January 2015 a draft conceptualisation of possible impacts was prepared but is still not available for public scrutiny or comment.

What can be said about this whole issue is that any genuine attempt by a Government authority to ascertain exactly what is happening down the Western and South Western Aquifer Flowpaths, is a very low priority.

Western Flank Flowpath Charts down the Loves Creek Catchment through Kawarren.

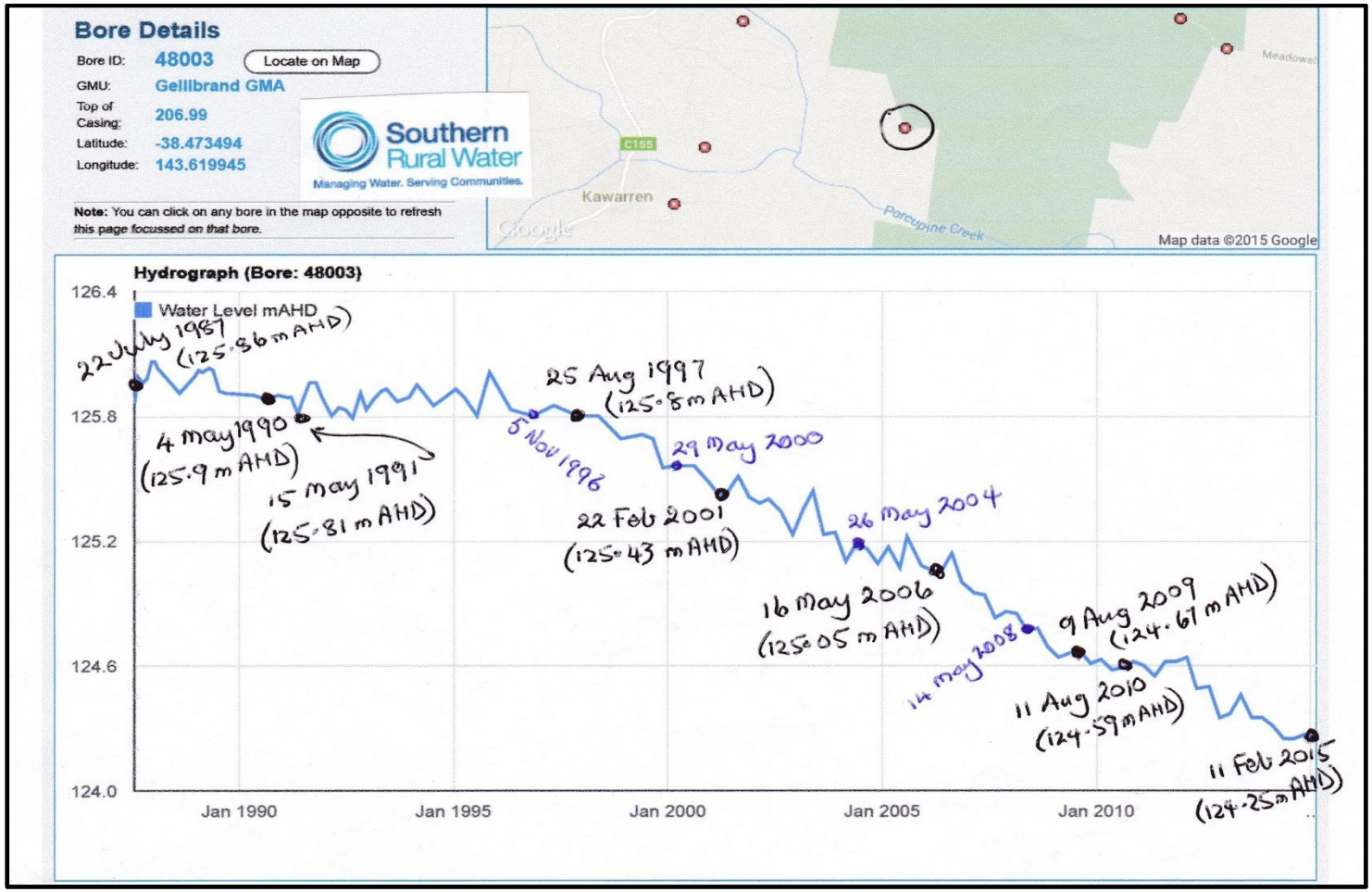
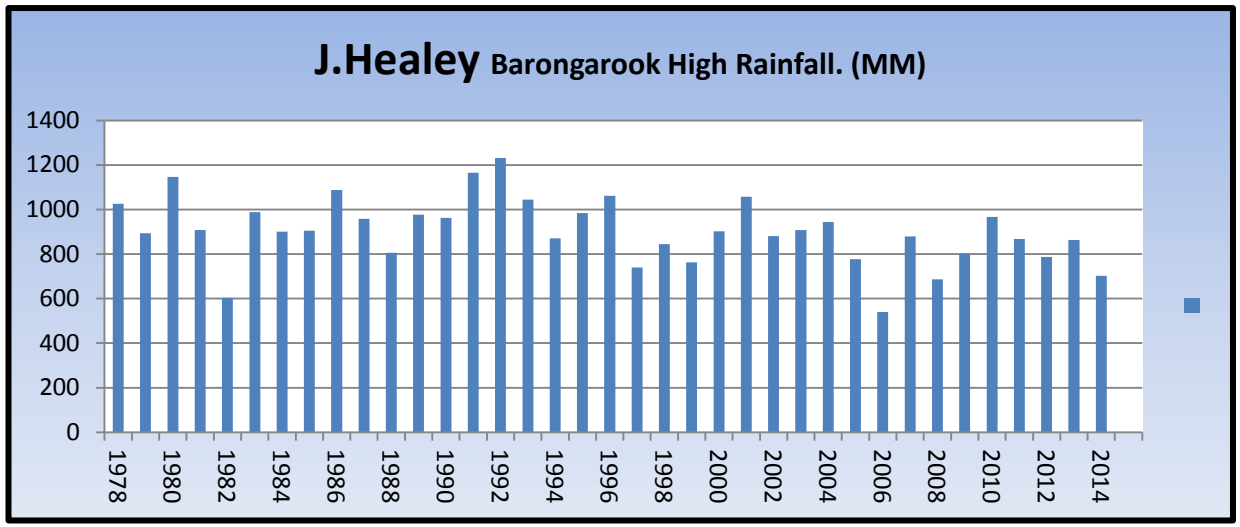


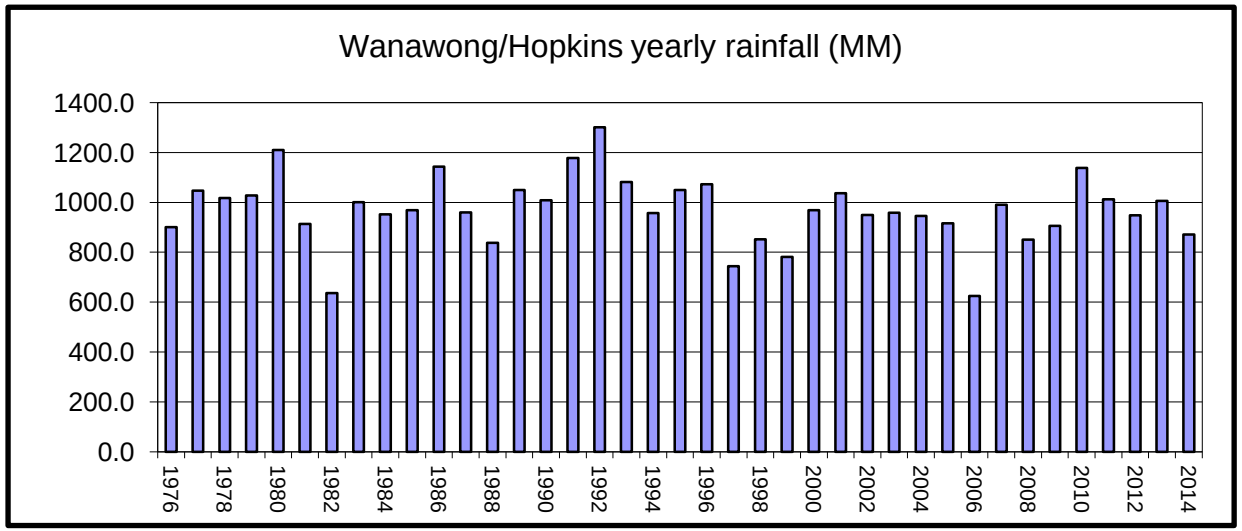
Chart 3A.

On the western side of the aquifer divide the hydrographs display a continual and gradual decline since the very wet years of the 1990s, despite pumping having ceased in August 2010.



As shown on page 16 Jan Healey's rainfall station is located in the Eastern View Formation recharge area of the Barongarook High

The Wanawong (Hopkins) rainfall station is run by David Hopkins at Burtons Lookout and the chart follows a very similar pattern to Jan's rainfall chart.



These charts indicate that since the drought there should have been reasonable recharge taking place that should be reflected in the observation bore network down the Western Flank Flowpath corridor. This is not the case.

The Healey and Hopkins rainfall data has been analysed on pages 40-50.

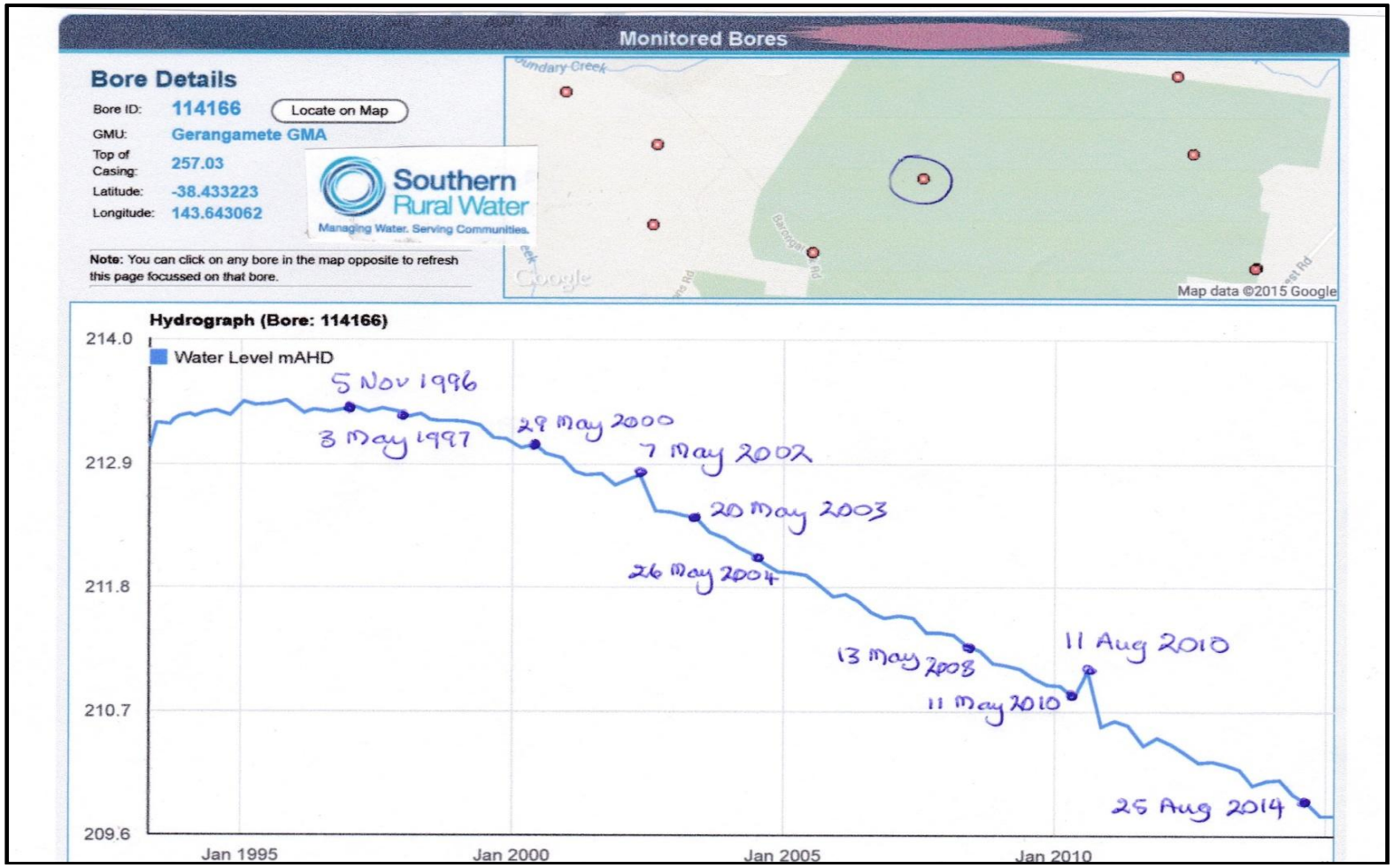


Chart 3B.

The observation bore hydrographs down the Western Flank Flowpath show a gradual decline in the order of 4-5 metres as opposed to up to 60 metres in the vicinity of the Barwon Downs Borefield. There has been no noticeable recovery period down the Western Flank Flowpath whereas bores in the Barwon Downs Flowpath have had massive recoveries, some as much as 30 metres. Also, there has been very little response to the wet years since2010 in the Western Flank graphs.

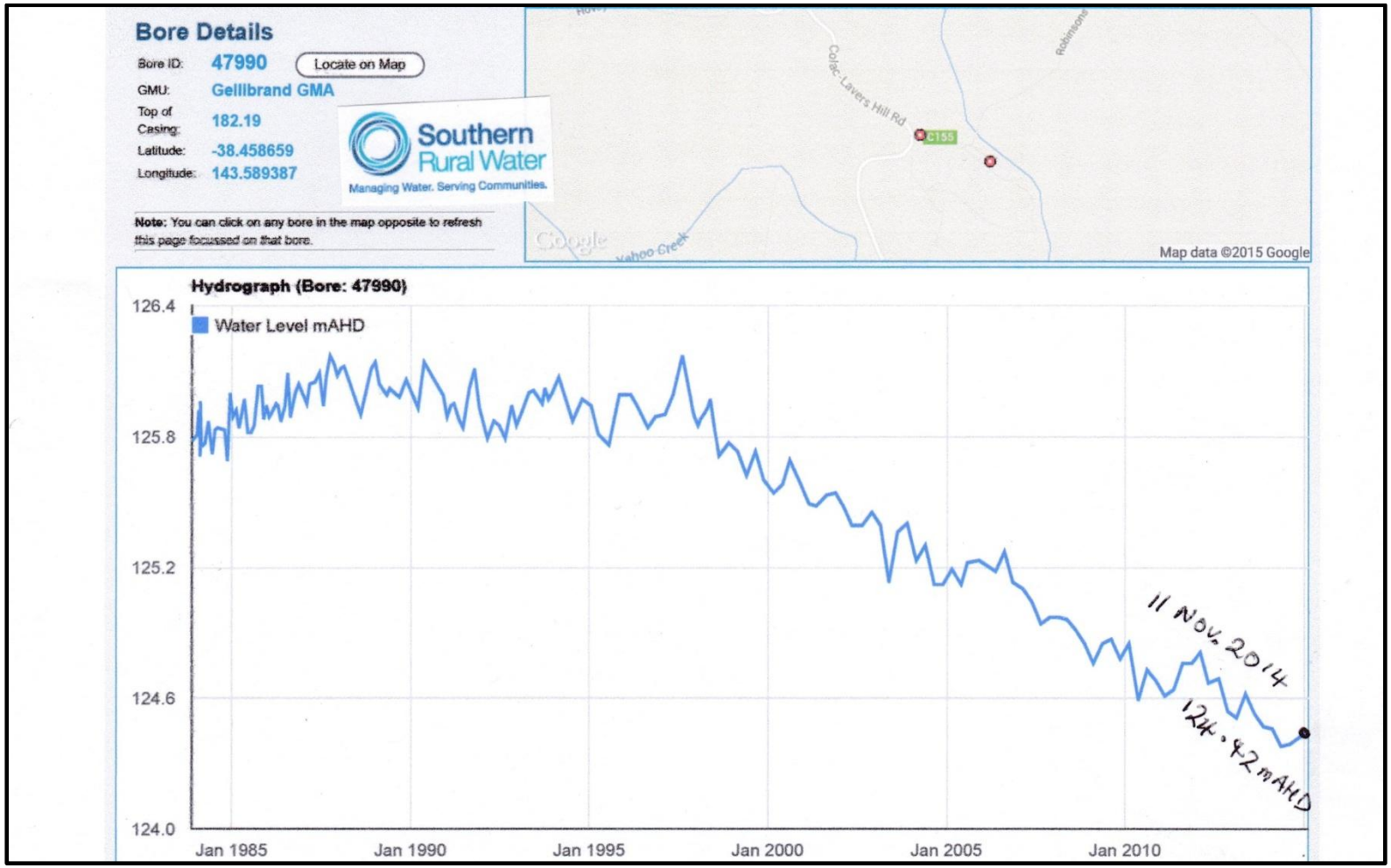

Bore Details
Bore ID: 47990
Locate on Map
GMU: Gellibrand GMA
Top of Casing: 182.19
Latitude: -38.458659
Longitude: 143.589387
Southern Rural Water
Managing Water. Serving Communities.
Note: You can click on any bore in the map opposite to refresh this page focussed on that bore.
Colac Lavers Hill Rd
C155
Robinsons
Yahoo Creek
Map data ©2015 Google
Hydrograph (Bore: 47990)
Water Level mAHD
126.4
125.8
125.2
124.6
124.0
Jan 1985
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
11 Nov. 2014
124.42 mAHD

Chart 3C.

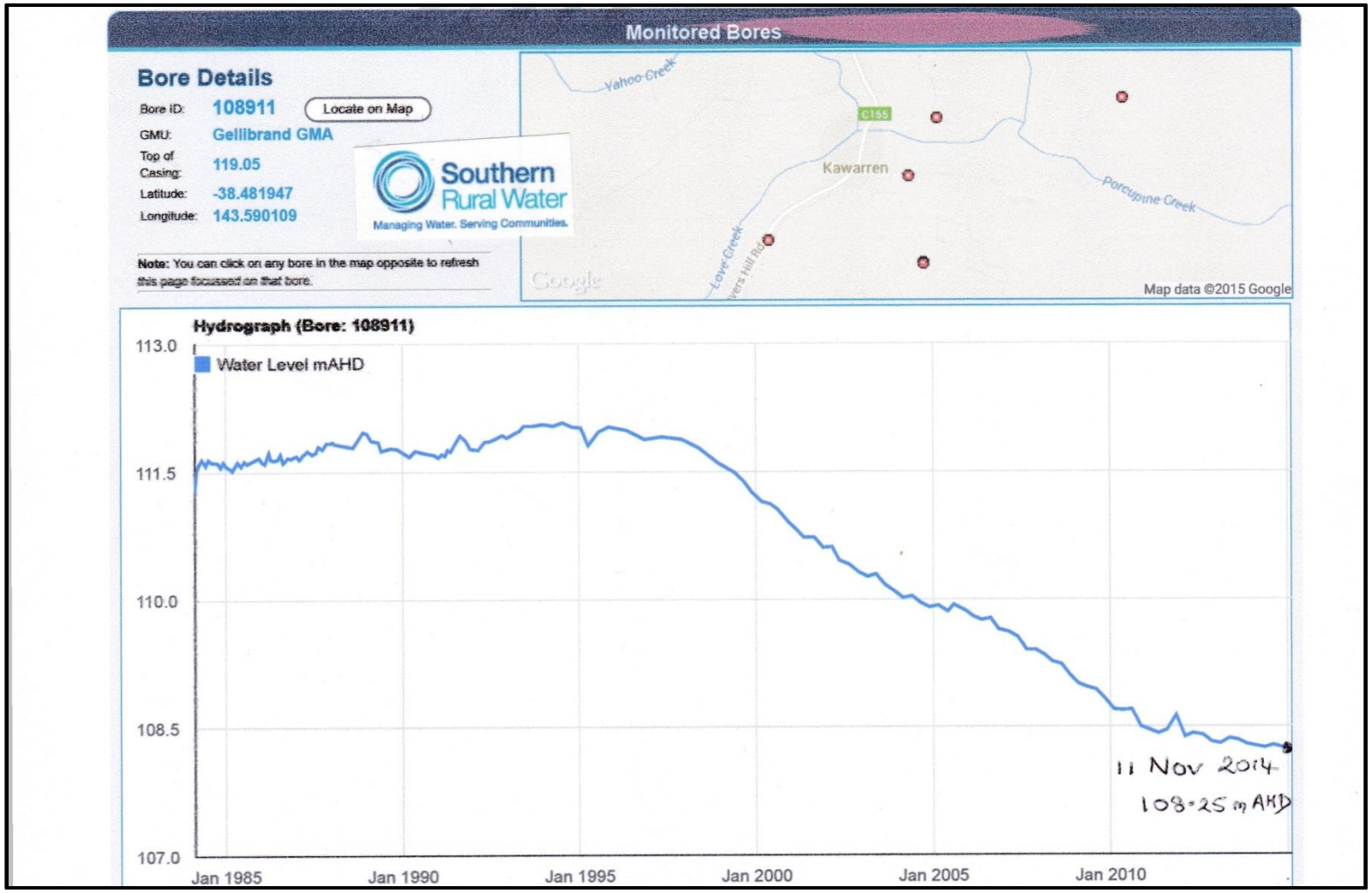

Monitored Bores
Bore Details
Bore ID: 108911
Locate on Map
GMU: Gellibrand GMA
Top of Casing: 119.05
Latitude: -38.481947
Longitude: 143.590109
Southern Rural Water
Managing Water. Serving Communities.
Note: You can click on any bore in the map opposite to refresh this page focussed on that bore.
Yahoo Creek
C155
Kawarren
Porcupine Creek
Love Creek
Google
Map data ©2015 Google
Hydrograph (Bore: 108911)
Water Level mAHD
113.0
111.5
110.0
108.5
107.0
Jan 1985
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
11 Nov 2014
108.25 m AHD

Chart 3D.

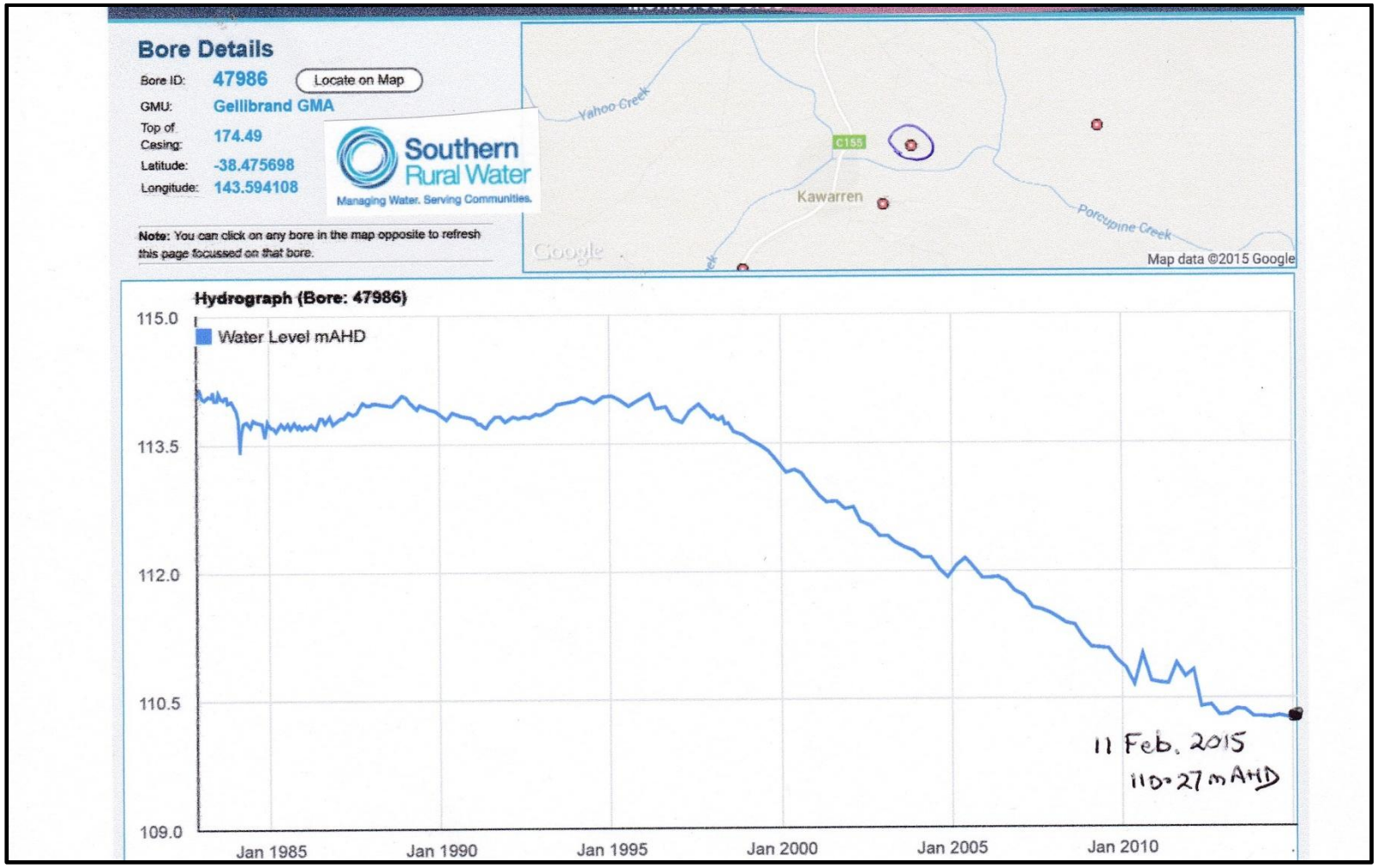

Bore Details
Bore ID: 47986
Locate on Map
GMU: Gellibrand GMA
Top of Casing: 174.49
Latitude: -38.475698
Longitude: 143.594108
Southern Rural Water
Managing Water. Serving Communities.
Note: You can click on any bore in the map opposite to refresh this page focussed on that bore.
Yahoo Creek
C155
Kawarren
Porcupine Creek
Google
Map data ©2015 Google
Hydrograph (Bore: 47986)
Water Level mAHD
115.0
113.5
112.0
110.5
109.0
Jan 1985
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
11 Feb. 2015
110.27 mAHD

Chart 3E.

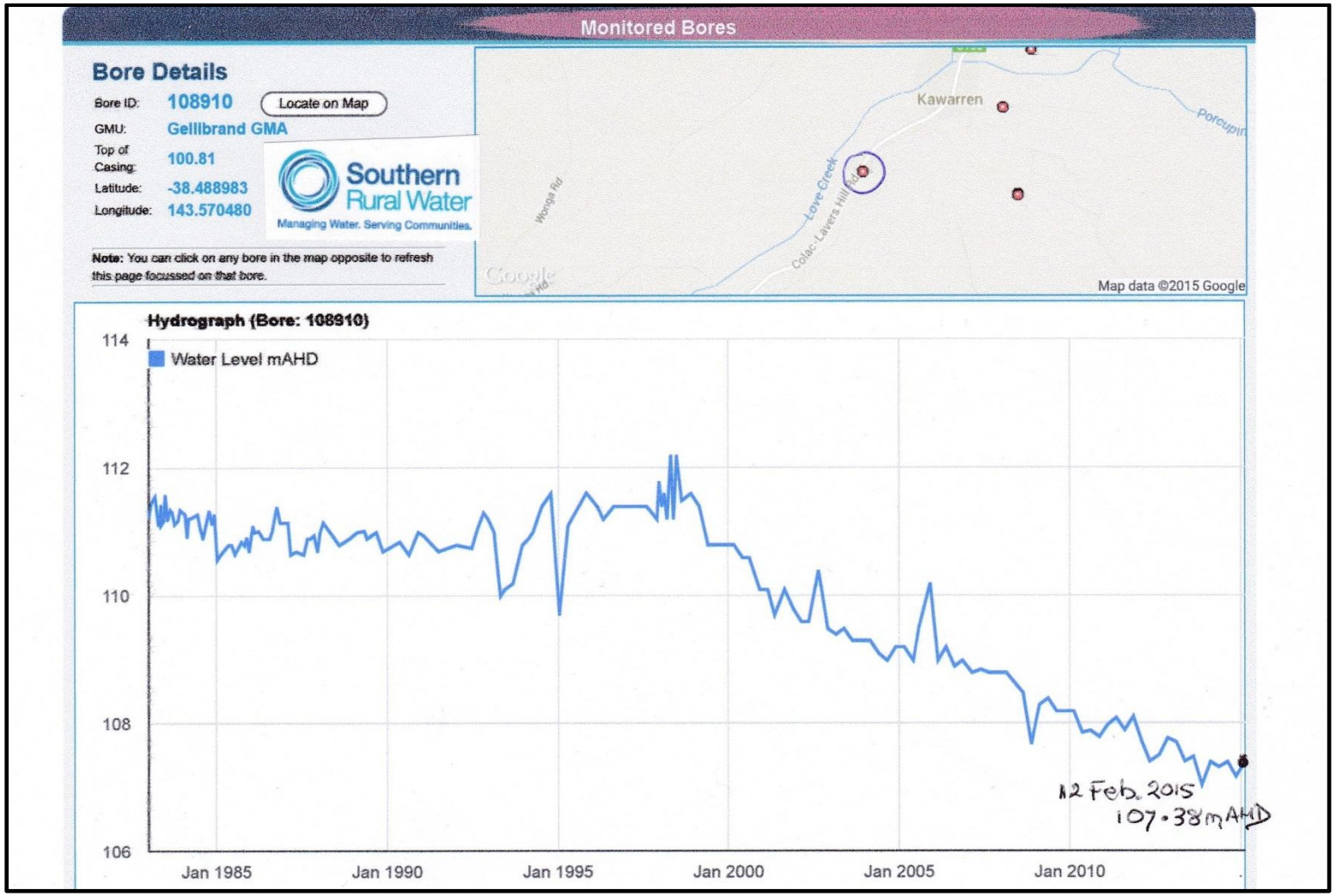
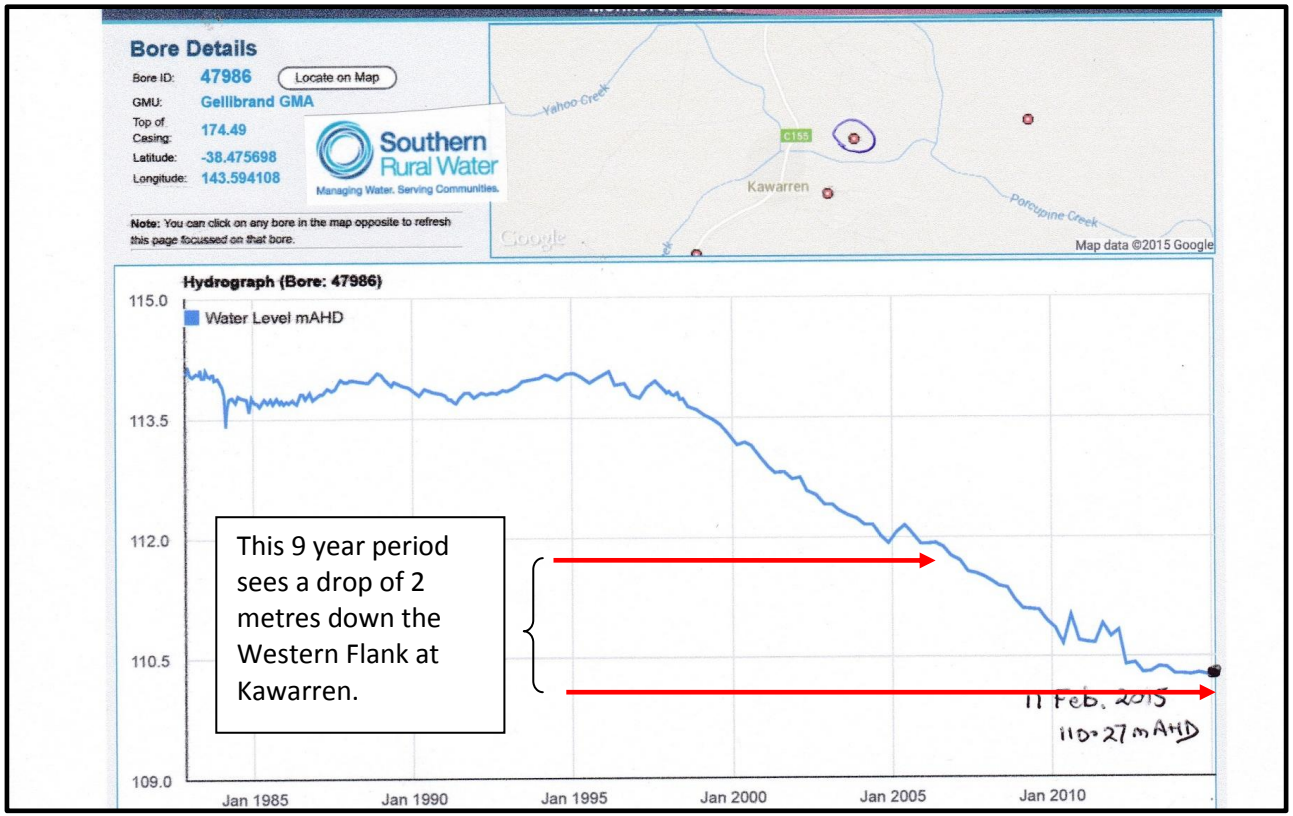


Chart 3F.

It would appear there may be a levelling out of the hydrographs in the 2015 period.

Government Research.

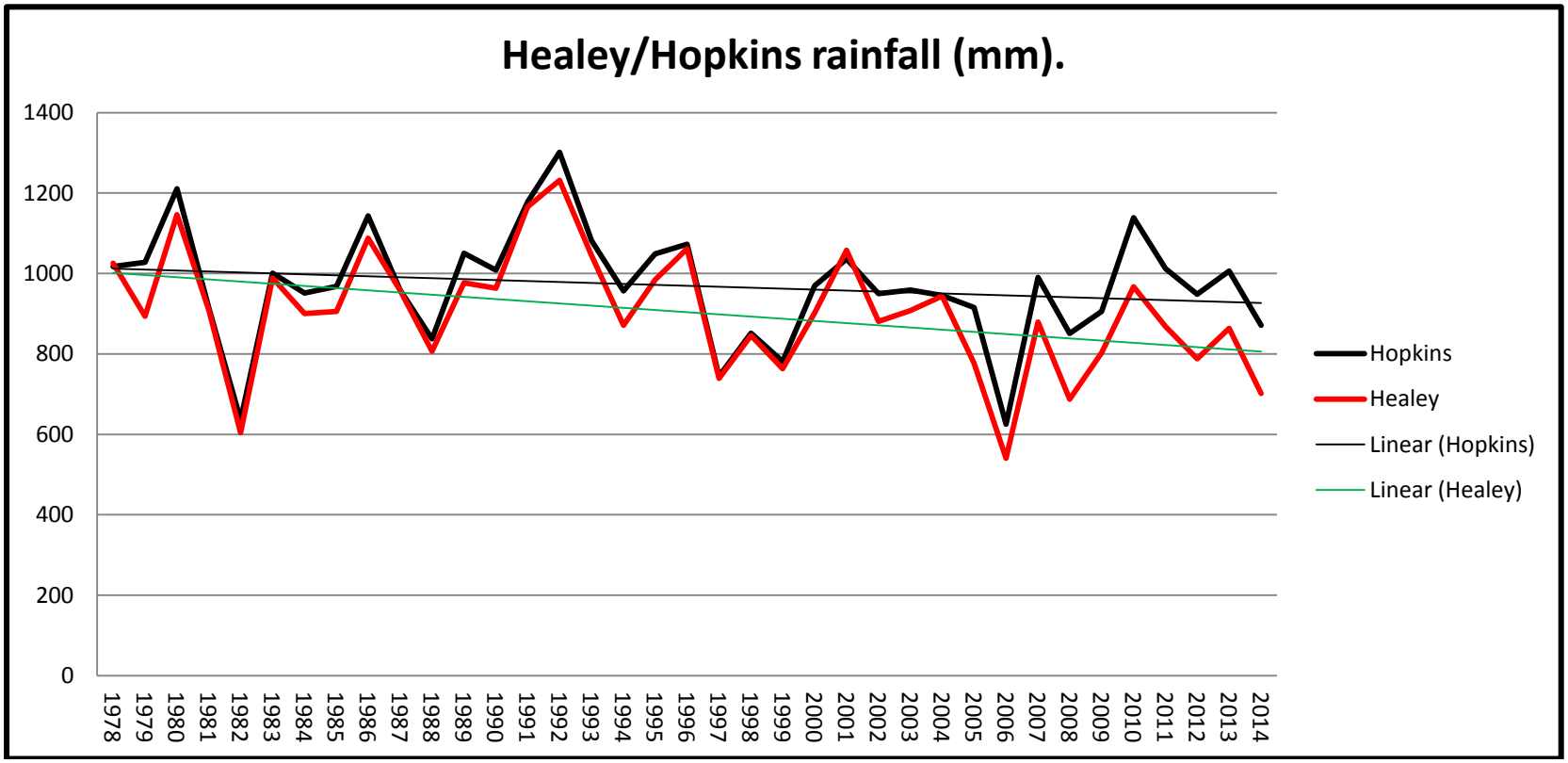
In December 2006 the Department of Sustainability & Environment (DSE) tabled a report "*Regional Groundwater Monitoring Network Review for the Deep Water Aquifer System in South West Victoria*."[37] This report states that groundwater is declining generally at rates less than 10 centimetres a year. This report goes on to say that at the current rate of decline watertables will drop in the order of one metre in ten years. This was taking into account climate change and present groundwater extraction in the South West. Strangely, this study did not included the Barwon Downs borefield area of influence. A similar study for this area has never been done.



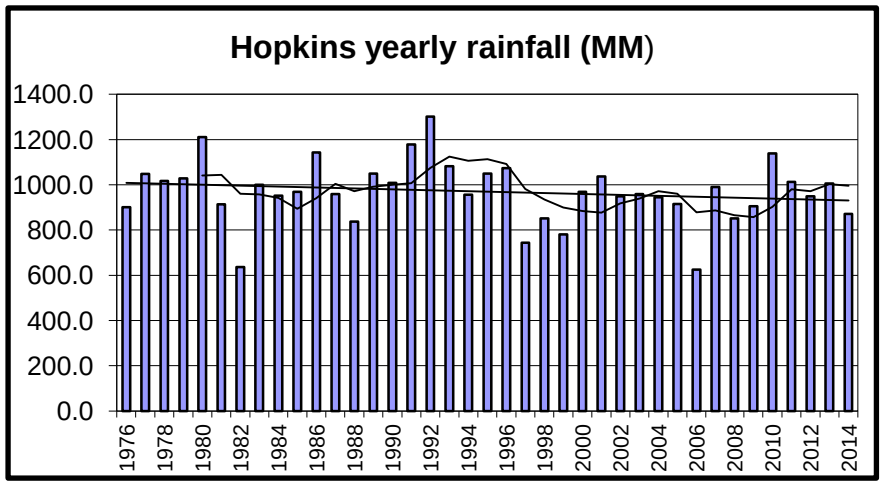
The observation bore in the graph above shows a 2 metre dropat Kawarren over a 9 year period since 2006 **AND** this has occurred over 5 wet winters. This is at least double the drop that the Government report predicted. In contrast the Warrion Aquifer during the same time period has risen significantly. A metre rise during 2013 (see pages 49 -50).

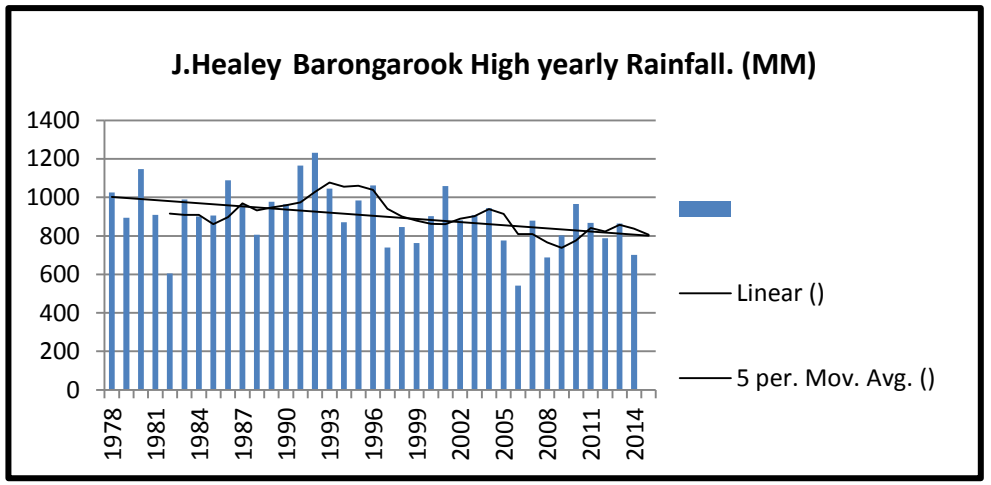
PRECIPITATION/RAINFALL.

Over the years Lakey,[96] Leonard,[97] Stanley,[135] Witebsky[167] and SKM[124][125][128] have determined that the major recharge zone for the Western Flank Flowpath, the Barwon Downs Borefield Flowpath and the South Western Aquifer Flowpath is the outcropping Eastern View Formation on the Barongarook High. The Healey rainfall collection point is situated in this recharge area and provides excellent rainfall data for this region. The Hopkins data collection point is a little further south into the Otway Ranges and is also in the Barongarook High area. As expected the Hopkins data set follows a very similar pattern but with a higher level of rainfall (see page 16 for weather station locations).

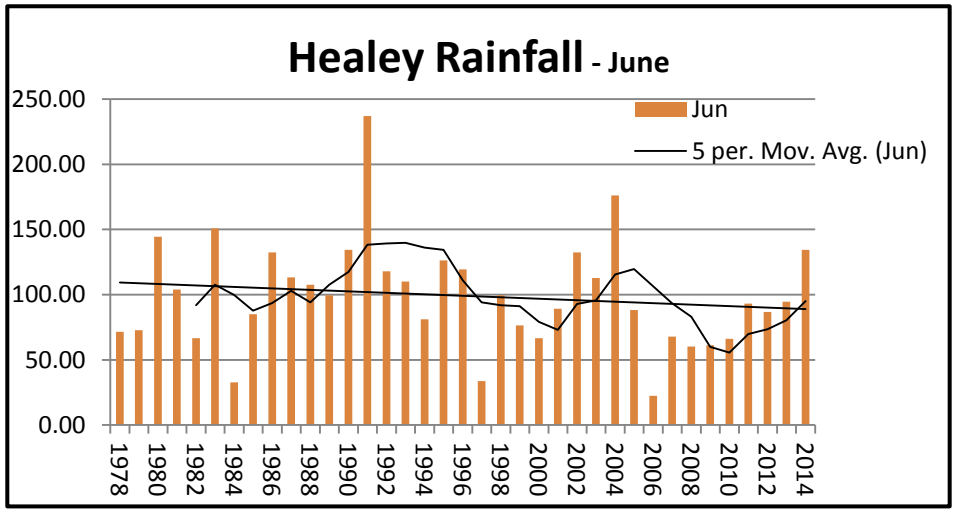


The Healey rainfall linear trend over the 1978 – 2014 period drops approximately 200mm. The Hopkins trend for this same period is less than a 100mm drop. The Hopkins 5 year moving average is on the rise whereas the Healey one is stabilising.



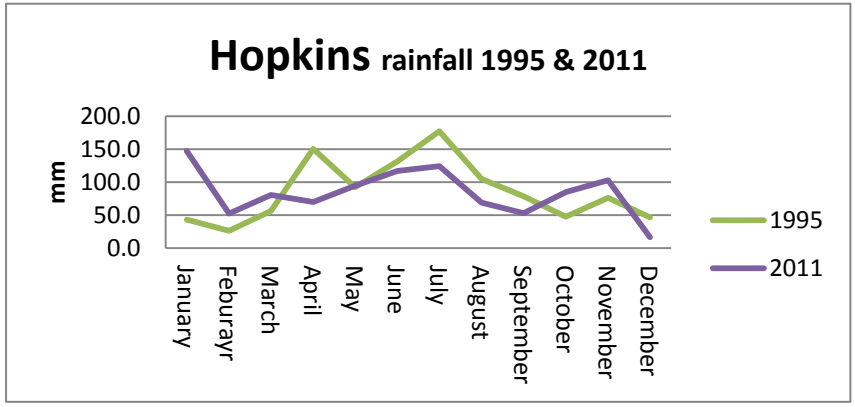


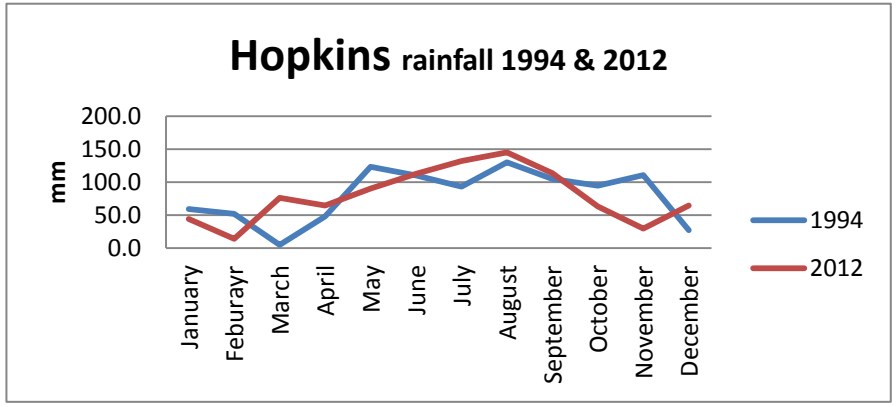
The Healey monthly charts over the 1978-2014 period found in Appendix Three show a stable or upward linear trend in the months of January (+2mm), February (+5), March (+5) and August (+5mm). The other months have a downward linear trend, April (-40mm), May (-30), June (-15), July (-10), September (-35), October (-40), November (-10) and December (-20mm). However, the five year moving average across the months has in most months, stabilised or increased, June being the most notable.



Appendix One compares two similar rainfall years, 1994

and 2012, using the Hopkins data. Appendix Two compares the years 1995 and 2011. These years have been chosen for comparison because the rainfall patterns in these years are very similar. It must also be noted the early to mid 1990s recorded very high rainfall.





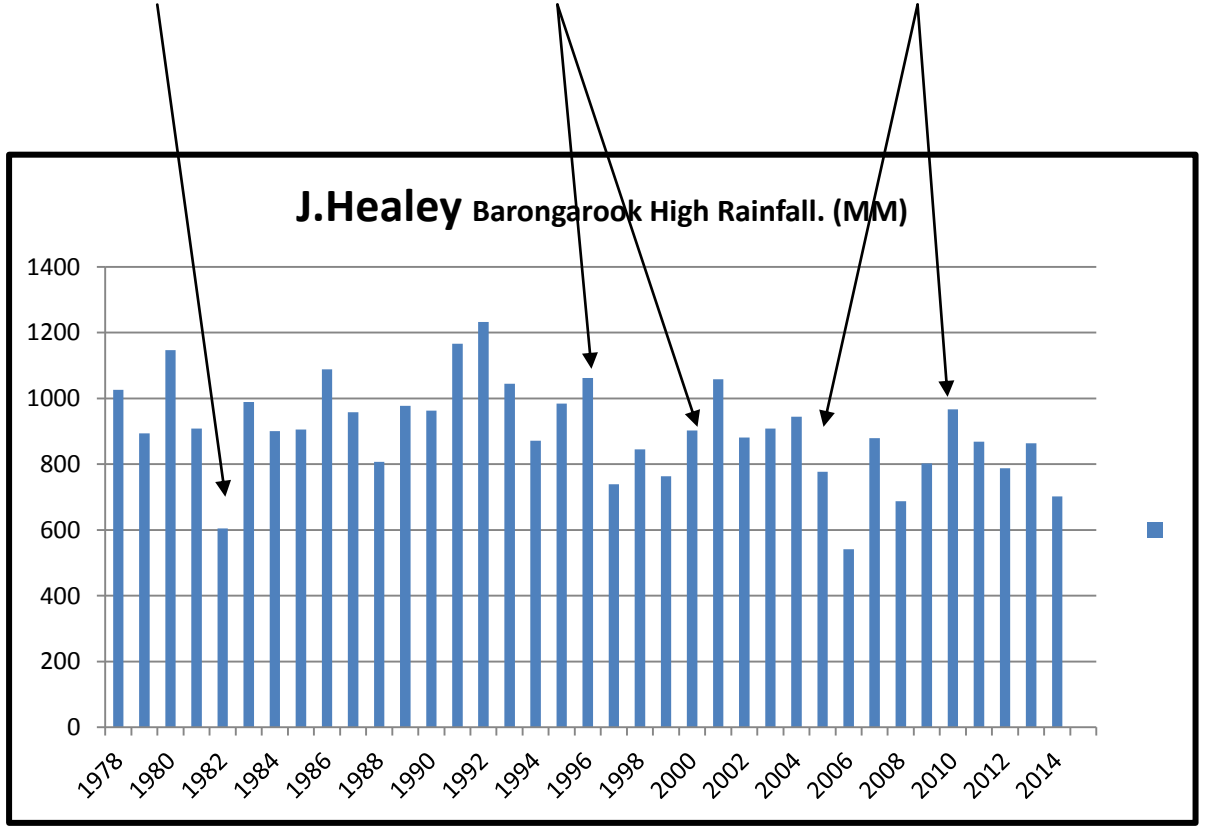
These graphs indicate that recharge to the Eastern View Formation aquifers outcropping in the Barongarook High region should have, since the end of the 2010 drought, returned close to normal. It would also be expected that the events of "normal" rainfall would be reflected in the observation bore network down the Western Flank Flowpath through the Ten Mile/Loves Creek Catchment. This has not been the case (see pages 32-39).

Recent Droughts.

Either side of and even during the drought periods, the Healey and Hopkins charts indicate appreciable rainfalls (see page 41). At first glance these charts indicate the drought period in the Otway Ranges to have had mild impact. This would appear to have been the case. Over much of Victoria, especially in regions of low annual average rainfall, a mild drop in precipitation can be critical. This is not the case in the Otway Ranges. The further into the Otway Ranges the wetter it becomes. In fact the Ridge along the Otway Ranges has the highest rainfall in Victoria. A large portion of this rain flushes from the area as runoff having little to no impact on recharge and infiltration. When regions to the north of Colac have a

critically dry period the Otway Ranges has a “bumper” season, and in most cases this is not regarded as a drought but a “lovely” mild winter. 200mm less rain in the Otway Ranges is not as critical as it would be north of the Princess Highway. A 200mm loss of precipitation in the Barongarook High would only have a mild impact on aquifer recharge and is discussed in the next section, “Infiltration and Recharge.”

Drought Periods. 1982-83 1996-2000 2005-2010



Infiltration and Recharge.

During precipitation the first rain to fall easily infiltrates into the soils of the Barongarook High. As the pores of soil saturate the rate of infiltration slows. During high rainfall events not all of the water is able to infiltrate and puddles form. Eventually the rain will run off as overland flow. Overland flow happens when the volume of precipitation exceeds the soil's ability to absorb and transfer the water.

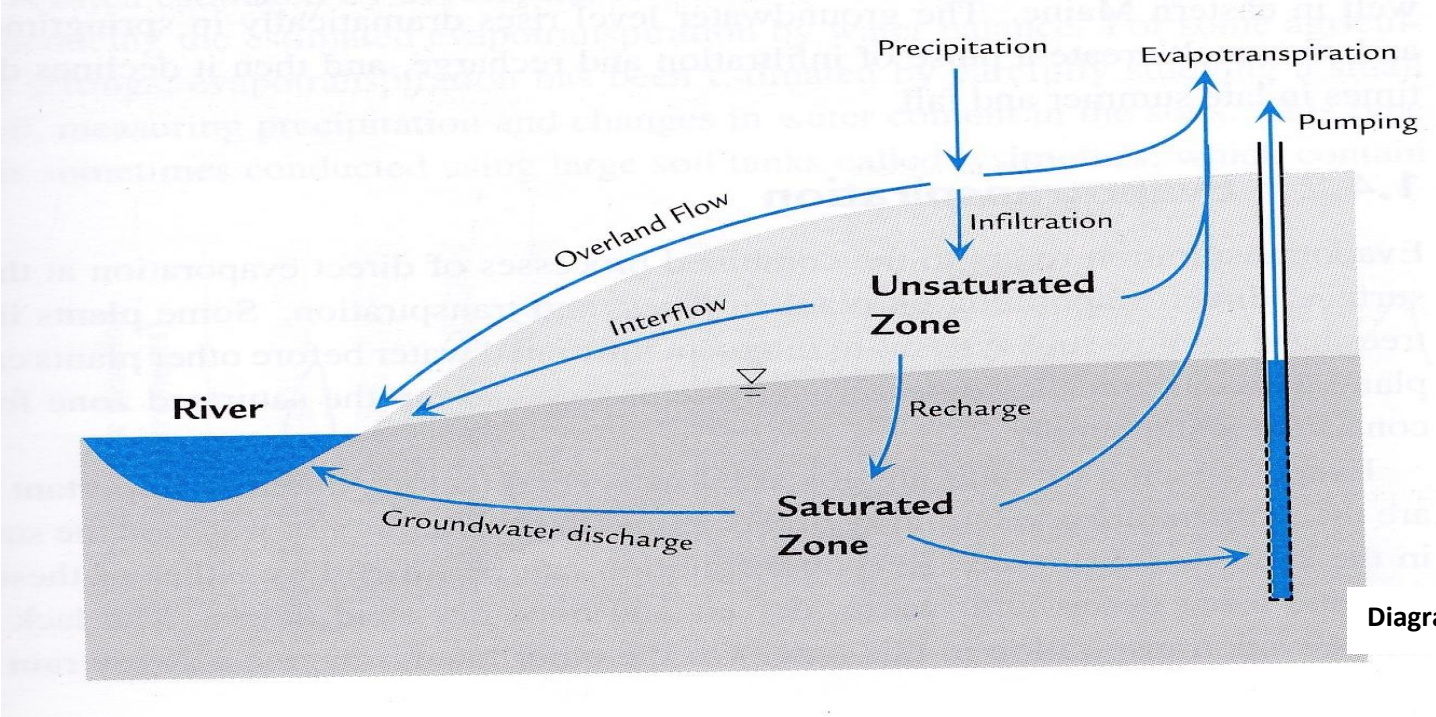
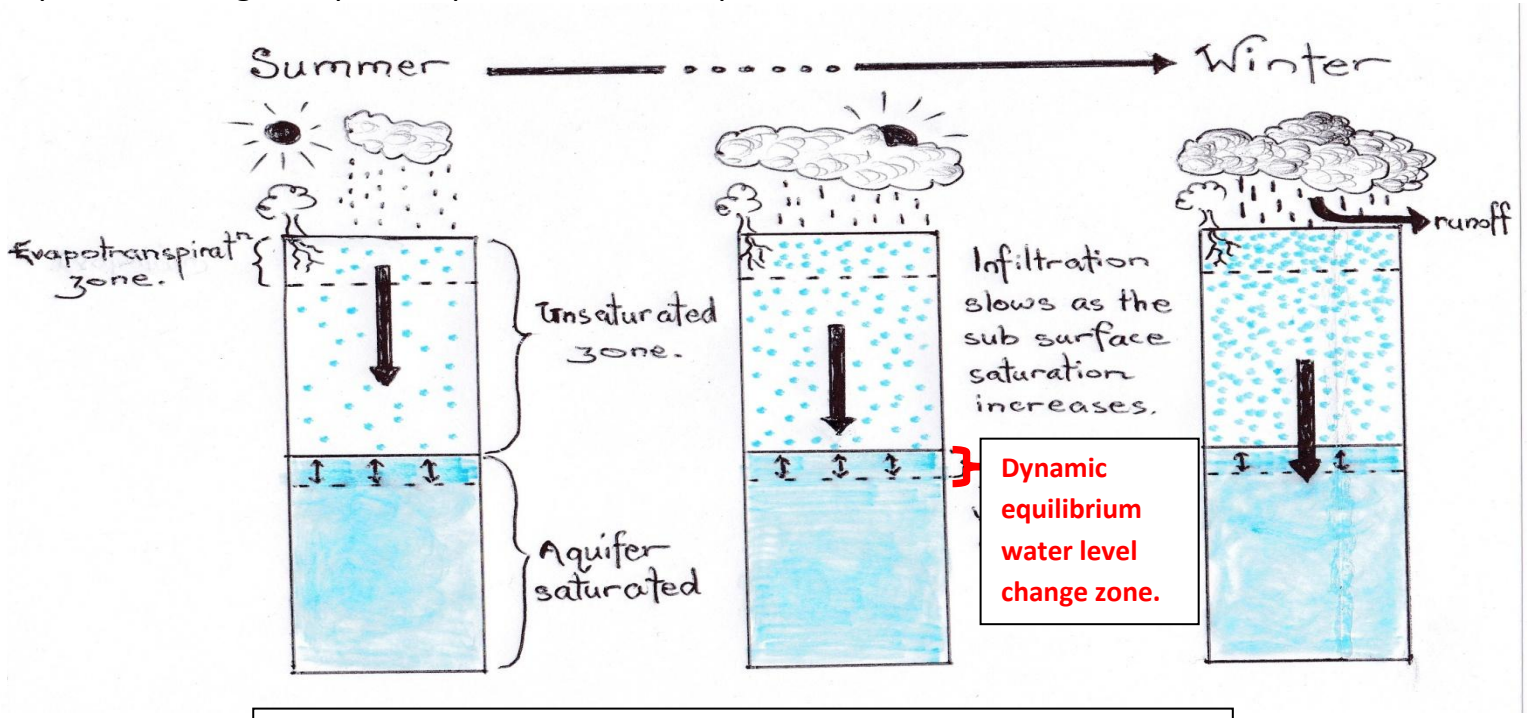


Diagram Source: Fitts(000)

Interflow is the horizontal movement of water caused by low permeability layers in the unsaturated zone. However, the exposed Eastern View Formation has limited areas of low permeable soils and therefore there would be little interflow in this recharge area. The majority of the precipitation would travel downwards.

The more porous the unsaturated zone, such as on the Barongarook High, the higher the amount of water that can be drawn down by gravity towards, and eventually recharging, the saturated zone. The amount of recharge in the Barongarook High area has been estimated to be between 23 and 28% of precipitation.[6] Fitts[51] states the rate of recharge can be as much as 50% in a porous structure such as the structure of the Eastern View Formation. The other 50% of the precipitation is dispersed through evapotranspiration and or replenishment in the unsaturated zone.

Eastern View Formation outcropping on the Barongarook High– An extremely porous soil structure.

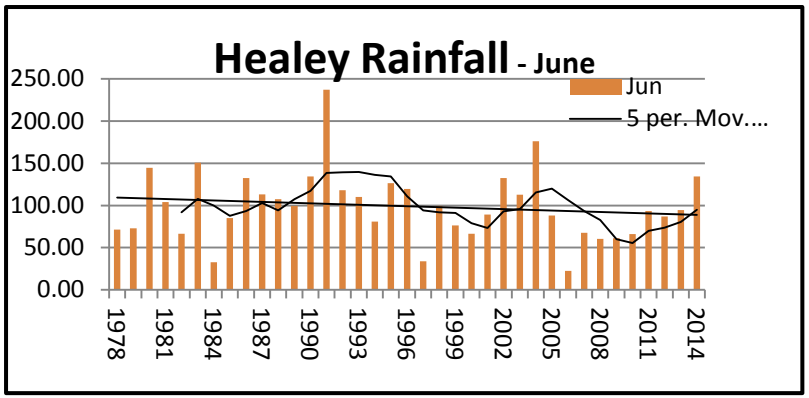


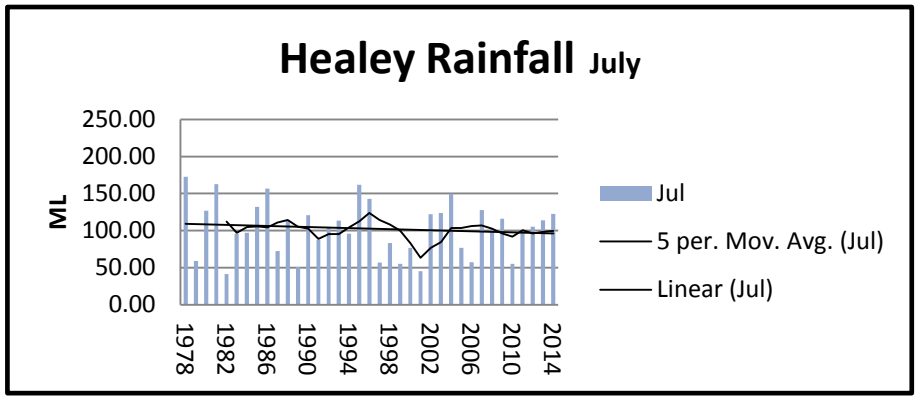
Conceptual model showing the infiltration process.

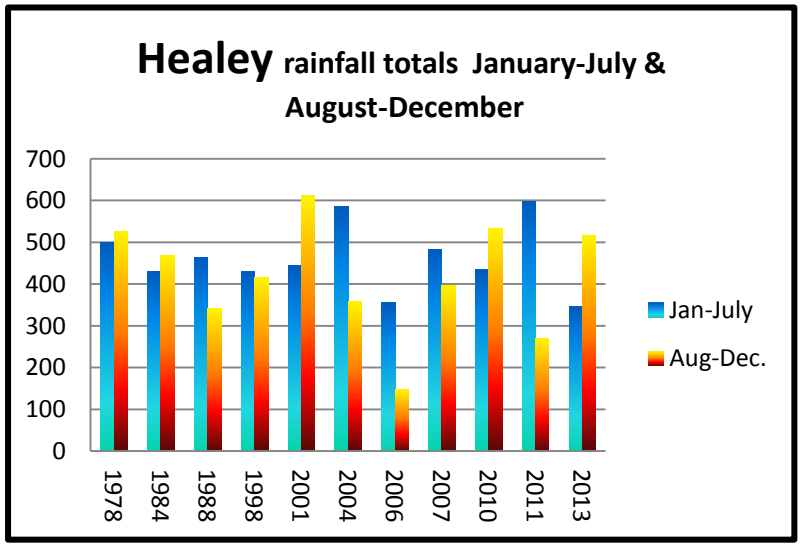
The dynamic equilibrium water level change zone oscillates up and down through wet and dry periods, including drought.

Unless there is a significant rainfall event, runoff or overland flow in the region of the Healey rainfall station does not usually happen until well into the winter month of August (Jan & Barry Healey pers. com.). Up to this stage all precipitation

is used up through evapotranspiration; dispersal into the unsaturated zone and or topping up or recharging that section of the Eastern View Formation that may have dropped in the dynamic equilibrium water level change zone.







Up to August when runoff normally occurs, there are significant amounts of infiltration (for more graphs see Appendix Three).

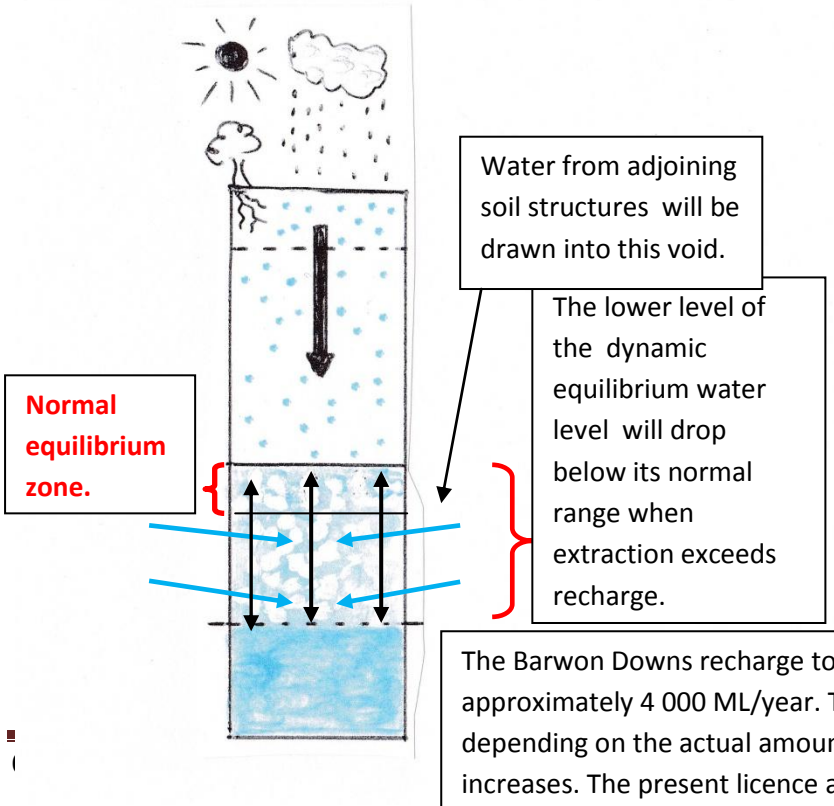
Eleven representative years between 1978 & 2013 were chosen to gain some understanding of how much rain falls in the months of January to July compared to the August to December period. Approximately half of the yearly rain falls in the high infiltration period before runoff occurs in August.

	Jan-July	Aug-Dec.	Total
1978	499.25	526.25	1025.25
1984	430.75	469.75	900.5
1988	464.5	342	806.5
1998	429.75	415.5	845.25
2001	445	612.75	1057.75
2004	587	358.75	945.75
2006	355.75	149	540.75
2007	482.75	396.5	879.25
2010	434.25	532	966.25
2011	597	270.75	867.75
2013	346.25	517.25	863.5

As the temperatures decrease in the colder and wetter autumn and winter months so does the amount of evapotranspiration.

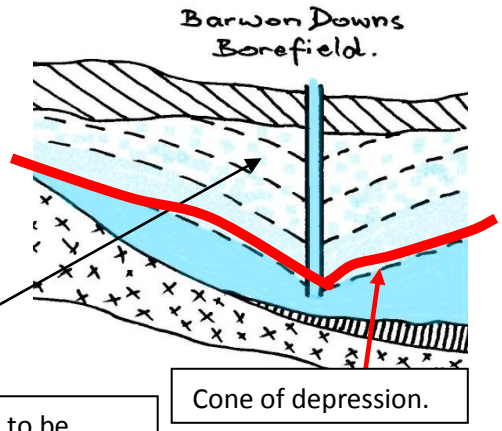
Theoretically infiltration would continue until all of the unsaturated zone becomes saturated. However, this is not the case in the Barongarook High area as the normal overflow out of the Eastern View Formation aquifers is through springs, wetlands and streams. With these natural overflow release points the higher section of the unsaturated Eastern View Formation will never become saturated. Infiltration to the degree where the headwater springs and streams are flowing occurs when the dynamic equilibrium zone returns back to its highest point. Appendixes One, Two and Three rainfall charts indicate that there has been ample rainfall either side of the drought episodes for this to happen.

The watertable or water level in the dynamic equilibrium zone, between the unsaturated and saturated zones, will vary naturally according to the amount of precipitation. This dynamic equilibrium zone will increase whenever groundwater is extracted faster than nature can replace it. Extraction of water at the Barwon Downs Borefield is an example of this.



Increase this dynamic equilibrium zone enough and the water level in groundwater fed wetlands, springs and streams will begin to dry up; observation bore water levels will fall and water from adjoining soil structures will be drawn towards the expanded equilibrium zone in an effort to restore this zone to a natural variable level.

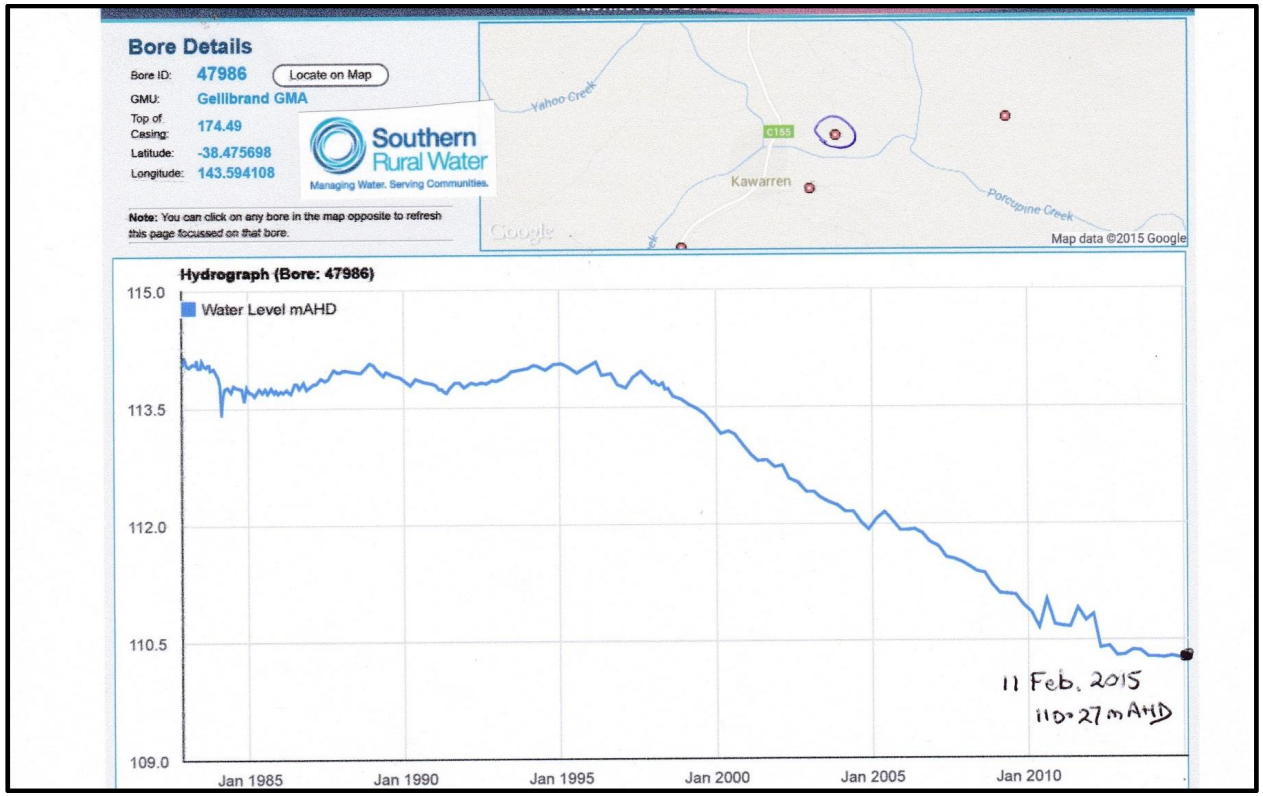
Until the cone of depression created by groundwater extraction from a borefield returns to a natural pre-pumping dynamic equilibrium level, water from precipitation and the adjoining soil structures will be drawn down and sucked into this depleted zone.



The Barwon Downs recharge to the Eastern View Formation has been calculated to be approximately 4 000 ML/year. The dynamic equilibrium zone would oscillate up and down depending on the actual amount. When water extraction exceeds this, the equilibrium zone increases. The present licence allows extraction of 20 000 ML/year. For the last few years of the 2005-10 drought over 11 000 ML/year was extracted.

The natural overflow from the Eastern View Formation aquifers into wetlands, springs and streams will not occur until the dynamic equilibrium zone returns to its usual fluctuating pattern.

Purely from a precipitation consideration, there is a strong and convincing case to support the notion that the observation bores in the Western Flank Flowpath of the Eastern View Formation should reflect a reasonably full aquifer system if it had not been for significant groundwater extraction . The observation bores down the Western Flank Flowpath should have maintained a reasonable level; not have drawn down by 4-5 metres. The watertable levels in the Western Flank Flowpath observation bores display a gradual and continual decline. None have reflected an upward trend.



In August 2010 the drought in the Western District was over with massive rainfall events.
By 2011...

Warrnambool Standard 26 -02-2011.

"Wettest Ever." "Rainfall records have been smashed with the south-west experiencing its wettest summer ever."

Geelong Advertiser 26-02-2011.

"Geelong, like much of Victoria, has received rain, wind and clouds almost all season."

This return to rainfall events should have signalled the upturn and return of the Western Flank hydrographs tracking back to "normal."

Reservoir overflowing after rain

by Jennifer Chiu

A Colac district reservoir overflowed in November for the first time in more than a decade.

The West Barwon Reservoir, Barwon Water's water storage at Forrest, has been spilling for about a week after three months of above-average rain.

Water started flowing over the reservoir spillway at a rate of 450 million litres a day from November 24, after the reservoir received more than 22 millimetres of rain in the previous four days.

Mount Sabine, near Lorne, received 88 millimetres in the same period, adding to the water storage and sparking the spill.

Barwon Water infrastructure systems general manager Paul Northey said it was unusual for the reservoir to spill in late spring.

"The last time West Barwon spilled in November was 2001," Mr Northey said.

"Good, consistent rainfall since August has seen West Barwon remain at a high level, even with a large volume of water sent to Wurdee Boluc Reservoir, which is also currently at capacity," he said.

Mr Northey said the West Barwon Reservoir overflowed "several times" between July and October 2012, and in July 2002.

WET: The West Barwon Reservoir is overflowing afterthree months of above-average rain

Rainfall patterns returned to some form of normality but the opposite has happened in the recovery of aquifers in the area. Or have they?

Aquifer level increases

by Kate Deppeler

A wet spring has helped increase the water level at a Colac district aquifer.

The Warrion aquifer in farmland north of Colac, has risen a metre in a year.

The rain gauge at Colac Otway Shire Council's office has recorded 192.2 millimetres of rain for spring so far.

Southern Rural Water's groundwater and rivers general manager Craig Parker said the aquifer's levels were about a metre higher than the same time last year.

"Levels vary across the aquifer, but they are currently about one metre higher than they were this time last year, and in most areas are well above the levels seen during the drought," Mr Parker said. "Levels usually increase over winter and spring in response to higher rainfall and little, if any, pumping," he said.

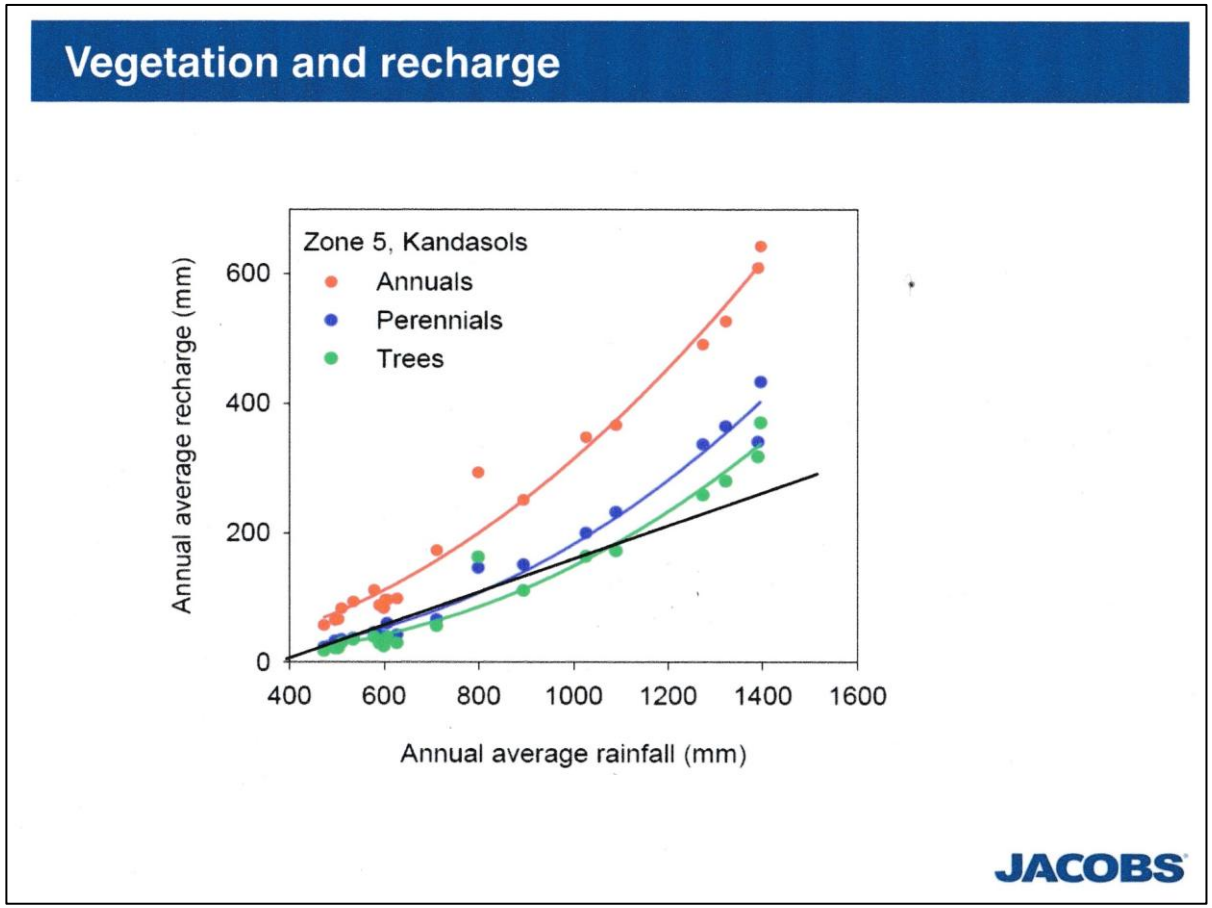
Mr Parker said people could look online to see level movement in the groundwater.

"Members of the public can see changing groundwater levels on hydrographs for State Observation Bores across the region, via the "groundwater levels" handylink on the front of Southern Rural Water's web page," he said.

The information in this clipping, Colac Herald 2 Dec. 2013, indicating a positive one metre rise in the Warrion aquifer, is the response expected in the Western Flank Aquifer. The exact opposite is the case. These hydrographs tracked down in 2013.

Evapotranspiration & Recharge.

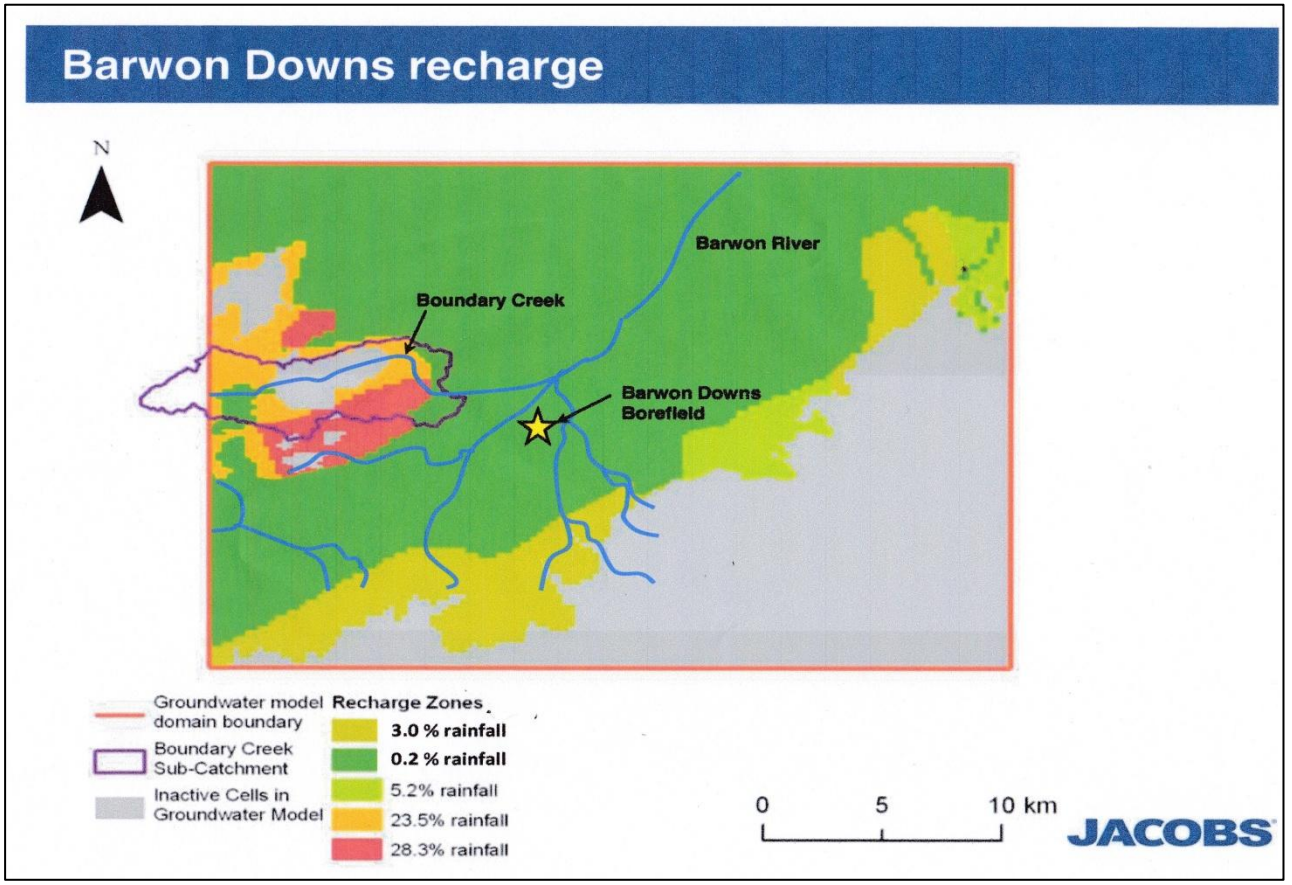
Vegetation in the Barongarook High area is primarily perennials and trees. This Jacobs chart[91] opposite indicates that vegetation water needs in the recharge area would work out to be around the 100 mm/year mark.



However, referring to the Bureau of Meteorology website the areal evapotranspiration in the Barongarook High Region is somewhere between 500 and 600 mm/year. Using the middle reading of 550 mm and deducting this from the Healey rainfall records, the recharge and runoff for the Barongarook High has been in the order of 300-400 mm/year since the drought broke.

The Barongarook recharge area covers 28 square kilometres.[88] Sixteen km^2 recharges the Barwon Downs corridor and twelve square kilometres is credited with recharging the Western Flank Aquifer Flowpath.[88] Using the lower 300 mm figure, the recharge to the Barwon Downs Borefield and South West Flowpaths would be in the order of 4800 ML/year and 3600 ML/year recharging the Western Flank Flowpath.

However, if calculations use the figure of 23% of rainfall going to recharge as outlined in this map by Jacobs, with the Healey rainfall records of the last few years, the following calculations show a different rate of recharge (see Appendix Eleven).



Recharge to the Barwon Downs and South West Aquifer Flowpaths...
16 square kilometres times 800mm, multiplied by 23% would give a recharge value of 2944 ML/year.

The recharge to the Western Flank Aquifer Flowpath would calculate to be 2208 ML/year.

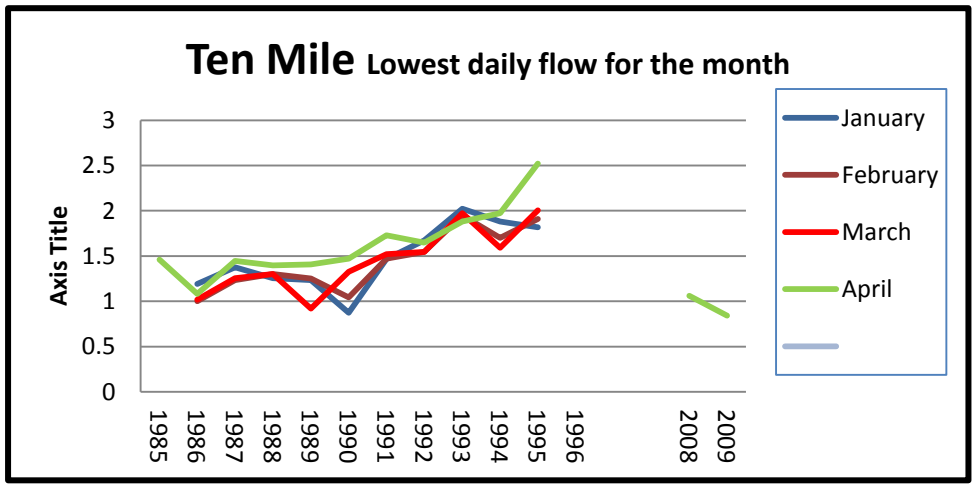
If earlier studies[88][90][97][124][125][135] are close to accurate, the recharge falls somewhere in between these two sets of calculations. There seems little doubt that a return to pre-drought recharge has been taking place but is not reflected in the observation bore network down the Western Flank Aquifer Flowpath. Where is this recharge going?

Stream Flow

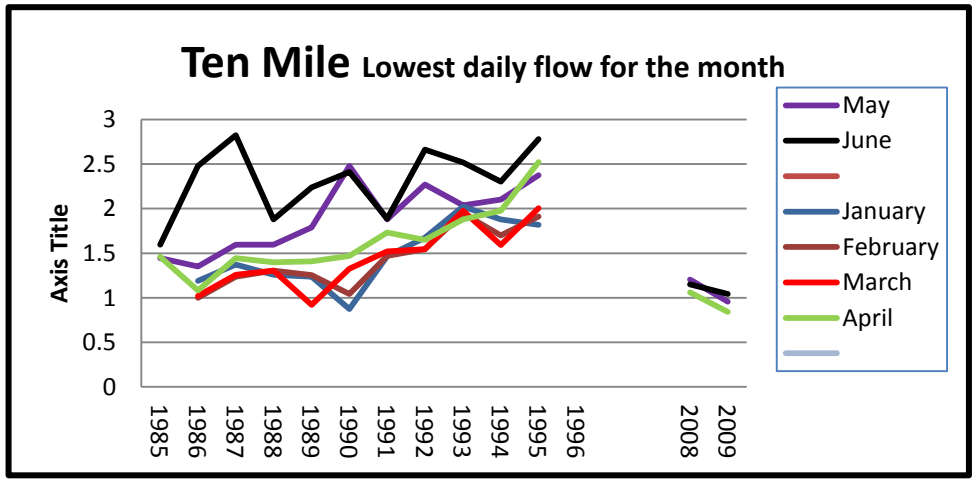
All of the stream flow charts in this discussion, deal with the lowest daily flow recorded in each month.

Ten Mile Creek(Ten Mile Creek charts can be seen in Appendix Seven)

This stream flow gauging station was first set up in 1985 and was decommissioned in 1995 once it was decided there would be no groundwater extraction taking place at the Kawarren or Gellibrand Borefields. When it was decided to investigate the extraction of 16 GL from the Kawarren Borefield in 2007 this stream flow gauging station was reinstated in April 2008. Once this project was abandoned in 2009 the station was once again shut down.



C

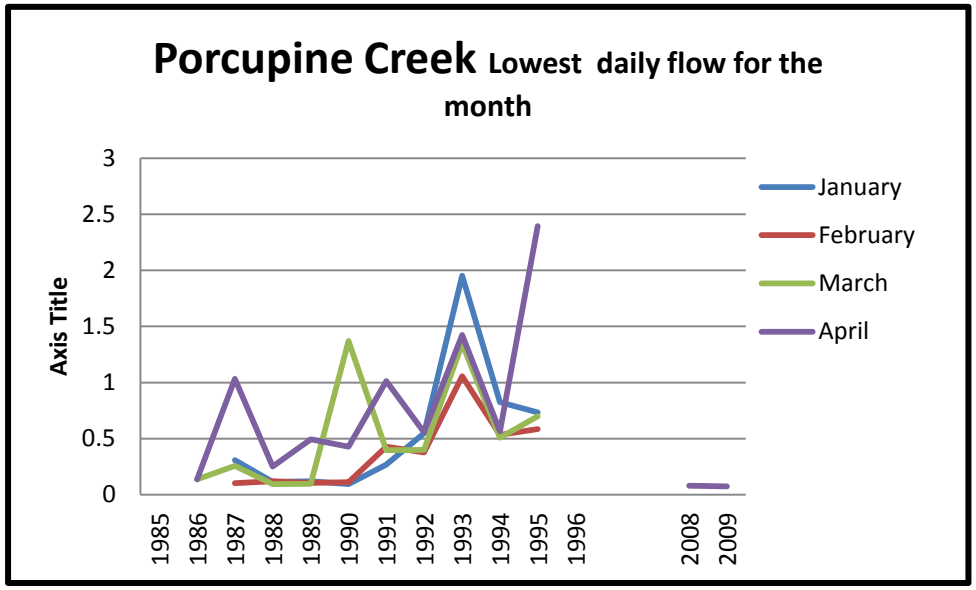


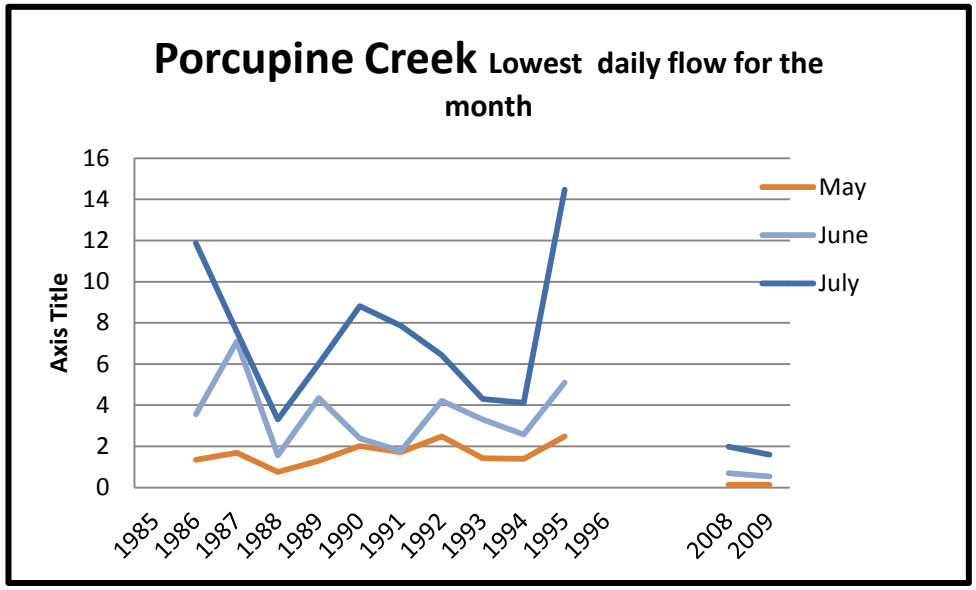
With such a small data set it is difficult to draw many conclusions. However, in a larger context the following is worthy of note. A 25 000 ML extraction was conducted from the Barwon Downs Borefield between 1986 and 1990. The flows during the drier months for this period of extraction show a distinct decline. This should not have happened as the Healey rainfall for this same period was over 800 mm each year; a very wet period.

When the Stream Flow Gauging Station was reinstated the low flow for that short period in 2008-09 should not have been this low. The Healey rainfall for 2008 & 2009 shows rainfall being over 650 mm/yr.

Porcupine Creek(Porcupine Creek charts can be seen in Appendix Eight)

This stream flow gauging station was set up and has the same history as does the Ten Mile Creek gauge. The Porcupine Creek Catchment is located mainly above the South Western Aqifer Flowpath.

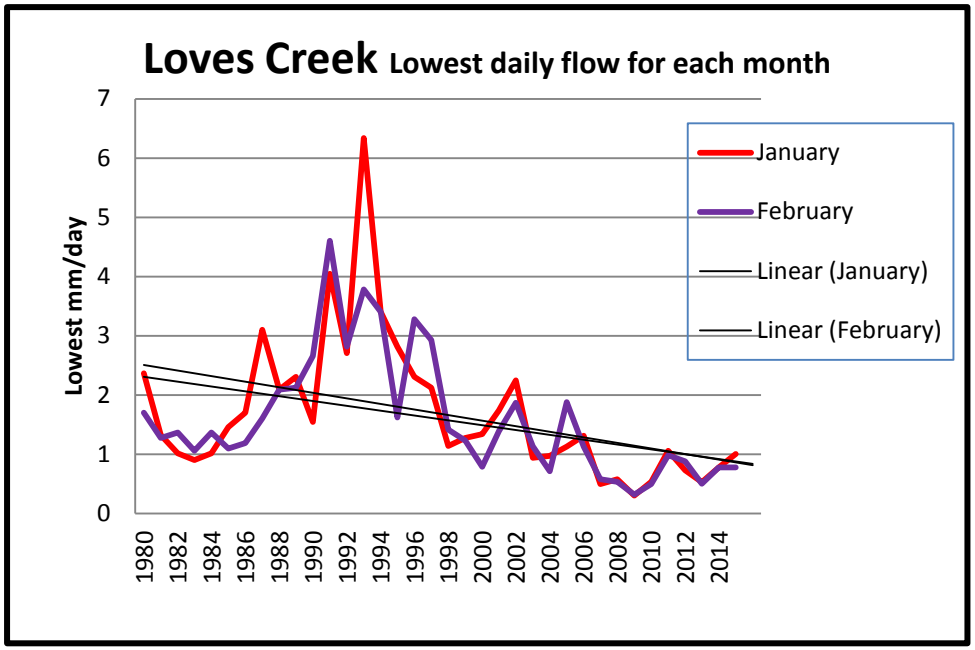


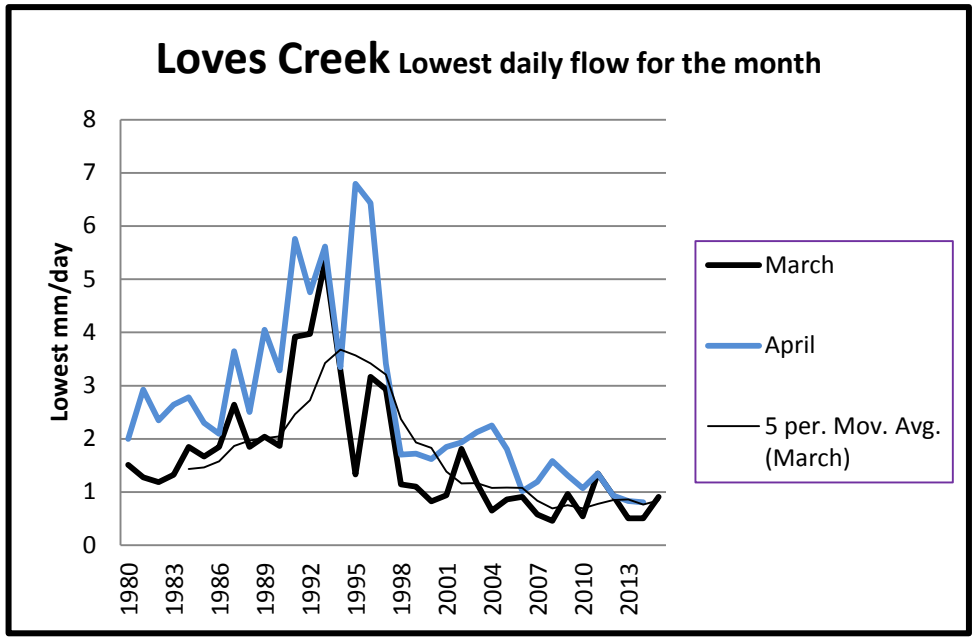


The data, though very limited, for both the Ten Mile and Porcupine Creeks indicate the lowest daily flows during the drier months is trending downwards and is reflective of a lower baseflow component. There also appears to be a downward trend during the 1986-1991 stress test pump that was conducted at the Barwon Downs Borefield. These years were reasonably wet years.

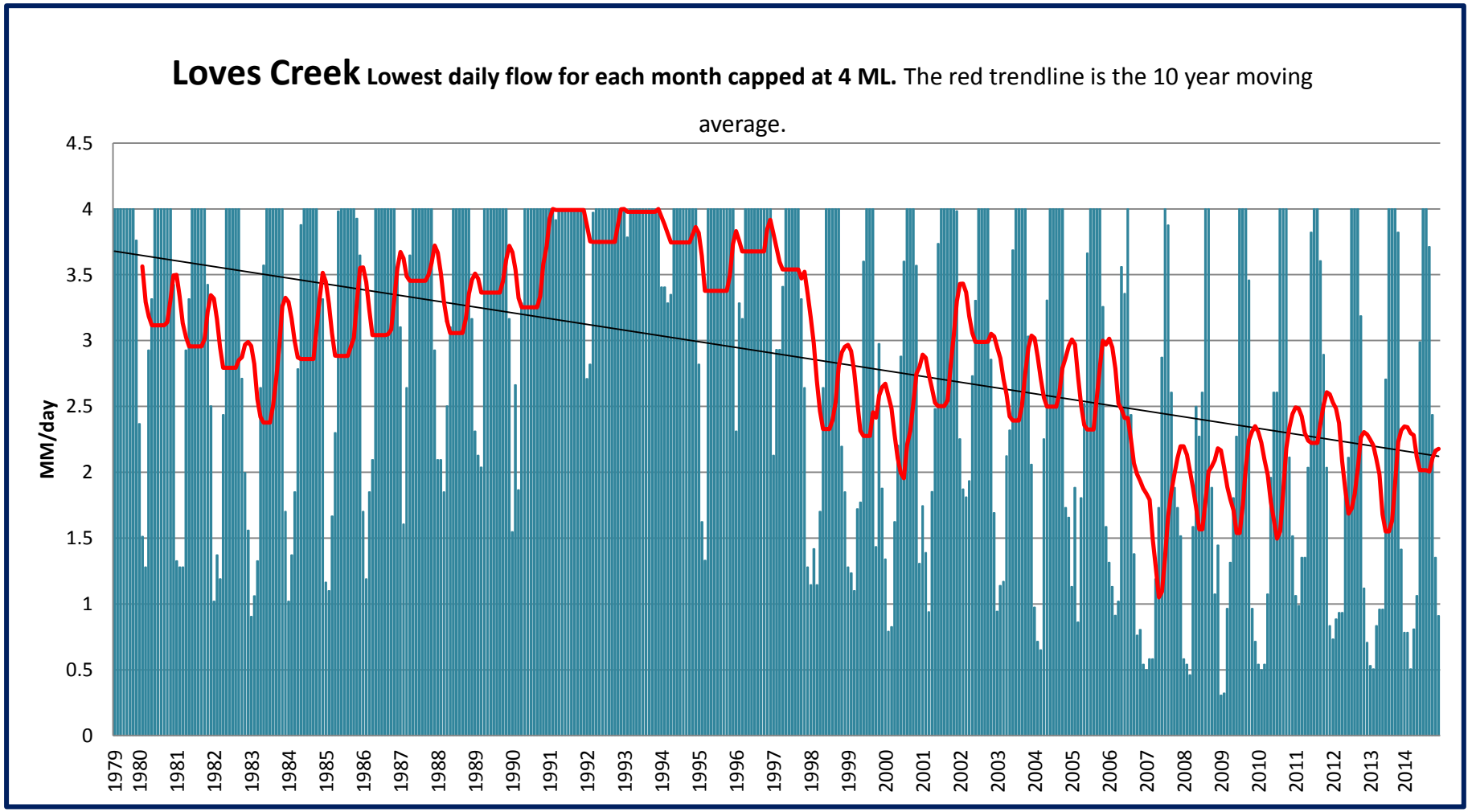
Loves Creek(Loves Creek charts can be seen in Appendix Five)

This stream flow gauging station has been in continuous operation since 1979. Except for rainfall events the lowest daily flow for each month during the drier summer months mainly comprises of baseflow emanating from the Eastern View Formation overflow.

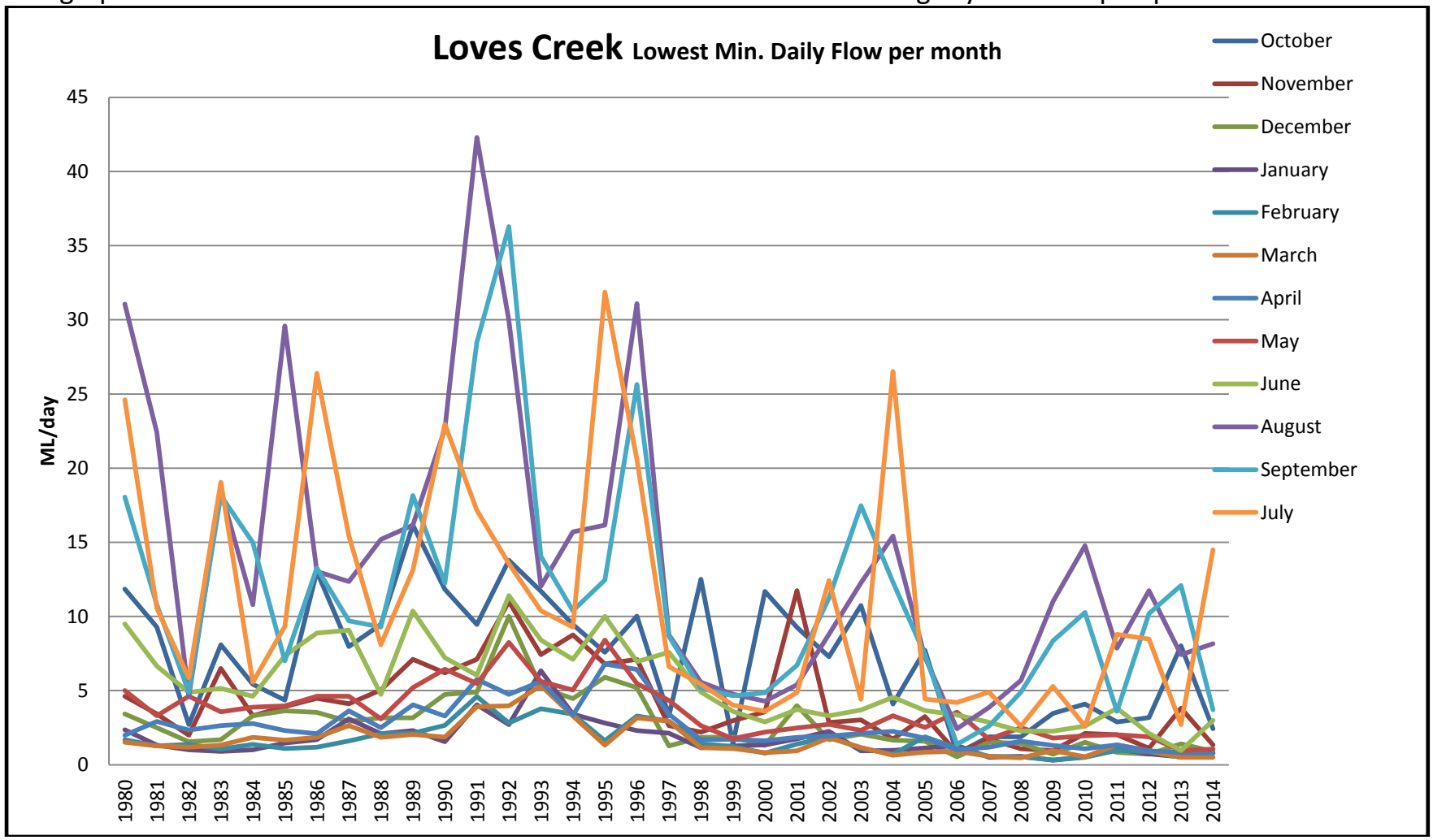




The Healey and Hopkins rainfall charts show sufficient infiltration to maintain the water table in the dynamic equilibrium zone within the usual variation. The Western Flank observation bores do not reflect this. Neither do the baseflows recorded at the Loves Creek Stream Flow Gauging Station. This miss-match indicates the groundwater normally discharging into streams, and the recharge that maintains water table levels, is being drawn away in another direction; most likely into the Barwon Downs Borefield cone of depression.


Loves Creek Lowest daily flow for each month capped at 4 ML. The red trendline is the 10 year moving average.
MM/day
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

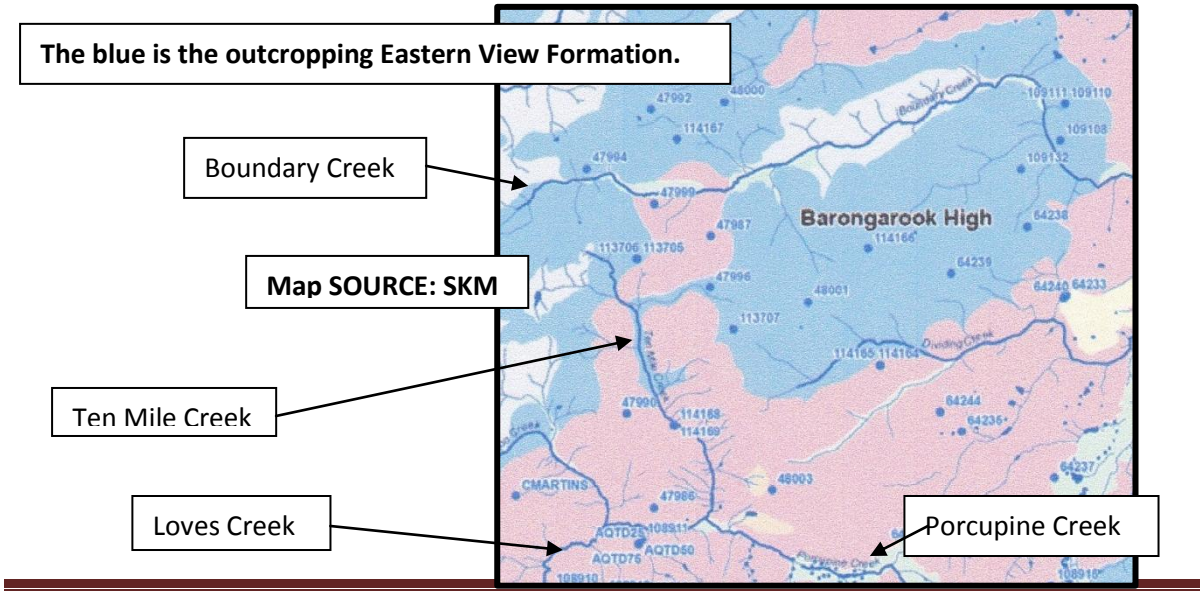
This graph shows this downward trend in Loves Creek baseflows from a slightly different perspective.



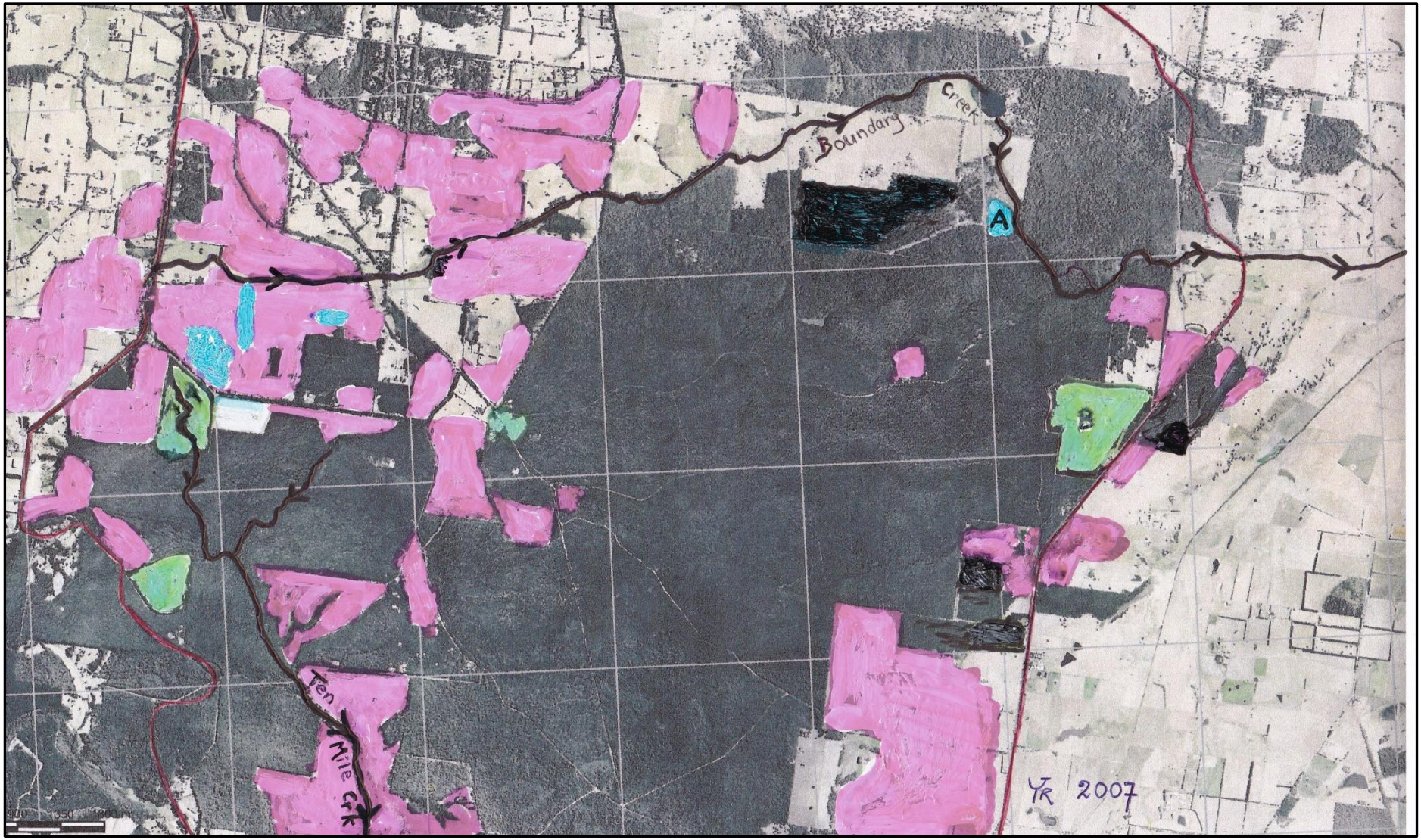
Land Use Change,

In 2012 Barwon Water had SKM prepare a new monitoring program to be implemented in the lead up to the potential renewal of the Barwon Downs Borefield groundwater extraction licence in 2019. The program centres around the Boundary Creek Catchment area. As part of this program any adverse impacts with wetland, spring and stream baseflow decline is being attributed to three variables. These are groundwater extraction, climate change and land use change. The study will use modelling scenarios in an attempt to determine the groundwater extraction impact. A similar calculation is attempted for climate change. Once this has been done all other observable impact will be attributed to land use change. No investigation regarding land use change is contemplated. It has been regarded as too costly and time consuming. In an effort to gain some insight into the impact of land use change, the following discussion makes a start in this direction.

The most obvious starting point is to determine exactly where the Eastern View Formation outcrops so that land use change in this area can be investigated. As previously discussed it has been determined that this is in the Barongarook High region and has been determined to be the major source of recharge to the aquifers in the Eastern View Formation.



This SKM map clearly shows the outcropping Eastern View Formation – shown in blue. Rain falling on this outcropping formation readily infiltrates into the porous surface and subsurface structures. This outcropping area has undergone very small change for some considerable time. The satellite photo on the next page demonstrates this.



Map 55

The **PINK** areas marked on Map 59 show those areas cleared of trees between 1947 and 1977.
The **BLUE** areas have been cleared between 1977 and 2007. The blue area marked with an A indicates the mineral earth clearing applied to the area surrounding the 2006 peat fire.
Three **GREEN** areas have been planted out in pine and blue gum forestry operations. The smallest and fourth green area has been allowed to naturally regenerate.

There has been very little land use change in the last 50 years. The construction of McDonalds Dam on Boundary Creek in the early 1980s would be the most significant change. However, this should not have any significant impact on infiltration into the Eastern View Formation down the aquifer flowpaths. Any water entering the damn during dry periods must be released from the dam allowing the water to flow on down Boundary Creek, mimicking natural flow. Under pre-pumping conditions this water would then flow into the Barwon River. However, as discussed earlier, since groundwater extraction, this water now disappears into the depleted aquifer in the Big Swamp region during non rainfall periods..

Land regarded as productive farmland was cleared very early in European occupation with the remainder being left relatively untouched. Drainage of swampy land that could be drained was done pre 1947 and attempts to drain other areas has been largely unsuccessful. Areas of the pre 1947 cleared land have been broken up into smaller holdings. Water harvesting of rainfall has increased for domestic use as a result, but this is minimal when compared with the thousands of megalitres extracted for urban use in Geelong and district.

The majority of the land in the Barongarook High area is Forest Park or National Park. The biggest potential influence upon water infiltration in these forests may be fuel reduction burns. Occurrences of planned burns and bushfire has varied very little over the decades.

It could be argued that the building of farm dams has a substantial impact. This is probably true of surface flow runoff into streams. However, runoff does not occur until infiltration has reached a saturation point or when there is a large amount

of rainfall in a short period. Farm dams modify flushes down drainage corridors rather than having a significant impact on infiltration rates.

In general terms land use change in the Barongarook High region has been minimal for many decades.

These photographs are typical of the extensive state owned land in the recharge forested area.

Area of Influence created by the Barwon Downs Borefield.

The Barwon Downs Borefield extracts water from the three aquifers in the Eastern View Formation, the Mepunga, the Dilwyn and the Pebble Point. The extraction bores are screened in all three aquifers.

When preparing residual drawdown maps a separate map should be done for each aquifer. These maps will show the amount of residual drawdown in each aquifer as a cone of depression. Each aquifer should, in all probability, have a different cone of depression.

The extraction bores at the Barwon Downs borefield are pumping water from between 400 and 600 metres below groundlevel.

In the 1990s the Permissible Annual Volume (PAV) was set at 4 000 ML/year but was later changed to a Permissible Consumptive Volume allowing large yearly extractions to be averaged out over a longer time period. The PCV was set in 2004 at 20 000 ML/year. Five times the PAV.

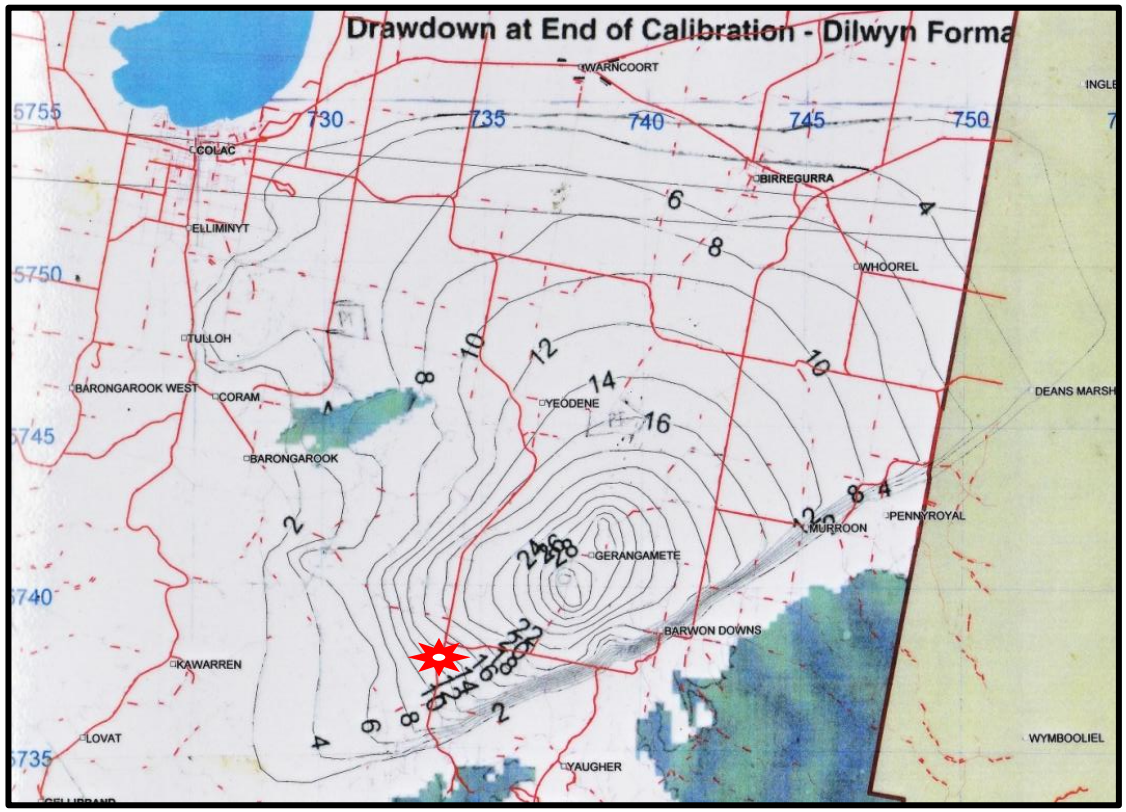
Groundwater extraction ceased in 2010 at the end of the drought. However, even by 2014 the Pebble Point aquifer, still had a 28 metre cone of depression at the borefield.

Eastern View Formation.

Geologic unit		Type
SKY		
Quanternary		Aquifer
Gelli Marl		Aquitard
CLifton		Aquifer
Narrawaturk		Aquitard
Mepunga		Aquifer
Dilwyn		Aquifer
Pember		Aquitard
Pebb lepoint		Aquifer
Bedrock		Aquitard

Since 2002, obtaining residual drawdown maps for the Mepunga and Dilwyn aquifers has not been possible. Barwon Water will not produce them. Also, Barwon Water maintains that producing residual drawdown maps out to the point of zero Influence do not have to be provided.

As part of the 2002 renewal of the groundwater extraction licence the following two residual drawdown maps were presented to the community reference panel. On exactly what date these maps were prepared is not known other than to say it was pre the granting of the 2004 licence.



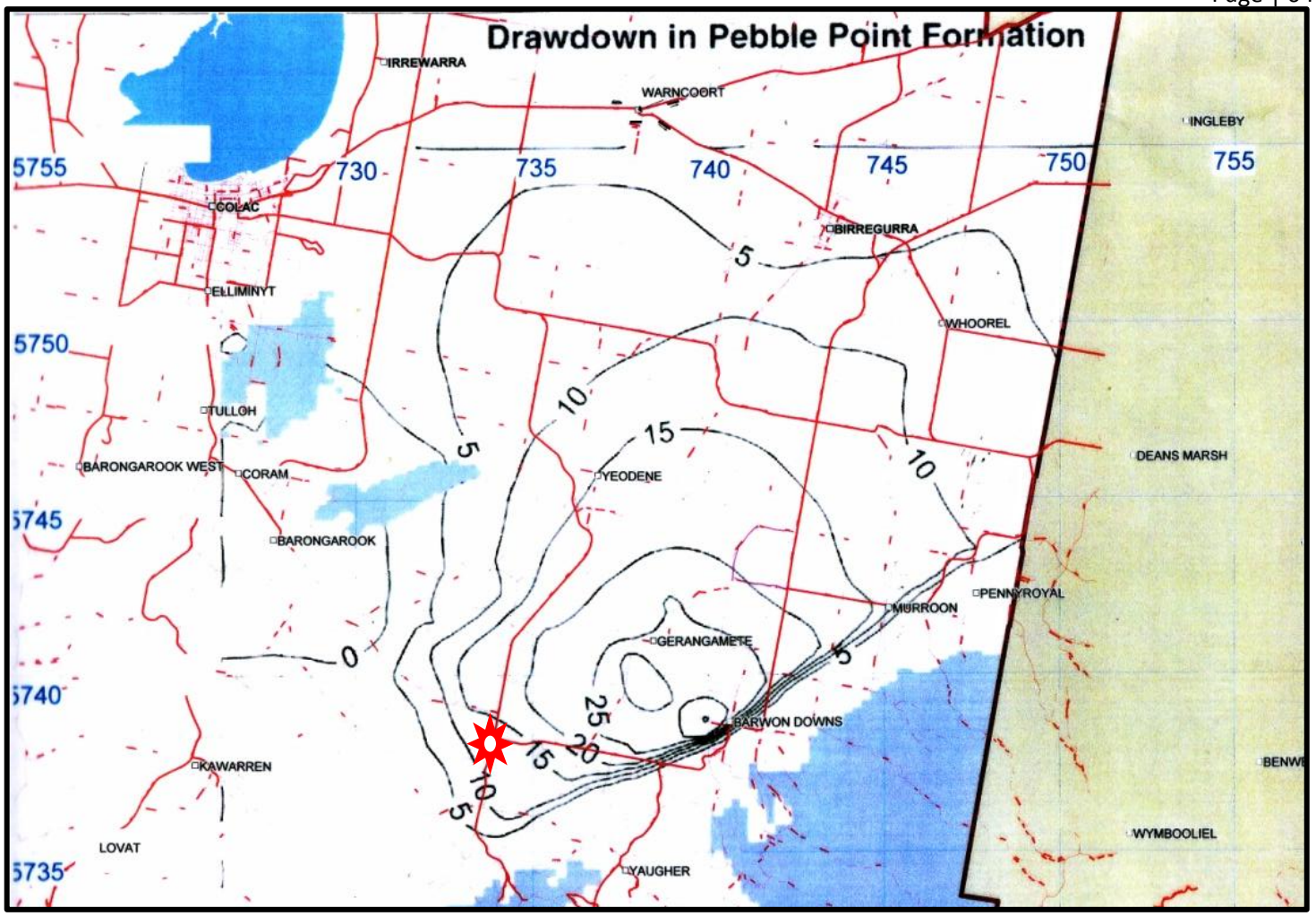
This map shows the residual drawdown created in the Dilwyn aquifer. The 2 metre drawdown contour extends down the Western Flank Flowpath into the Kawarren region. The cone of depression at its deepest being around 30 metres at the borefield.

By 2005 some of the observation bores indicated extraction drawdown of 60 metres.

This star designates a reference point on the these residual drawdown maps.

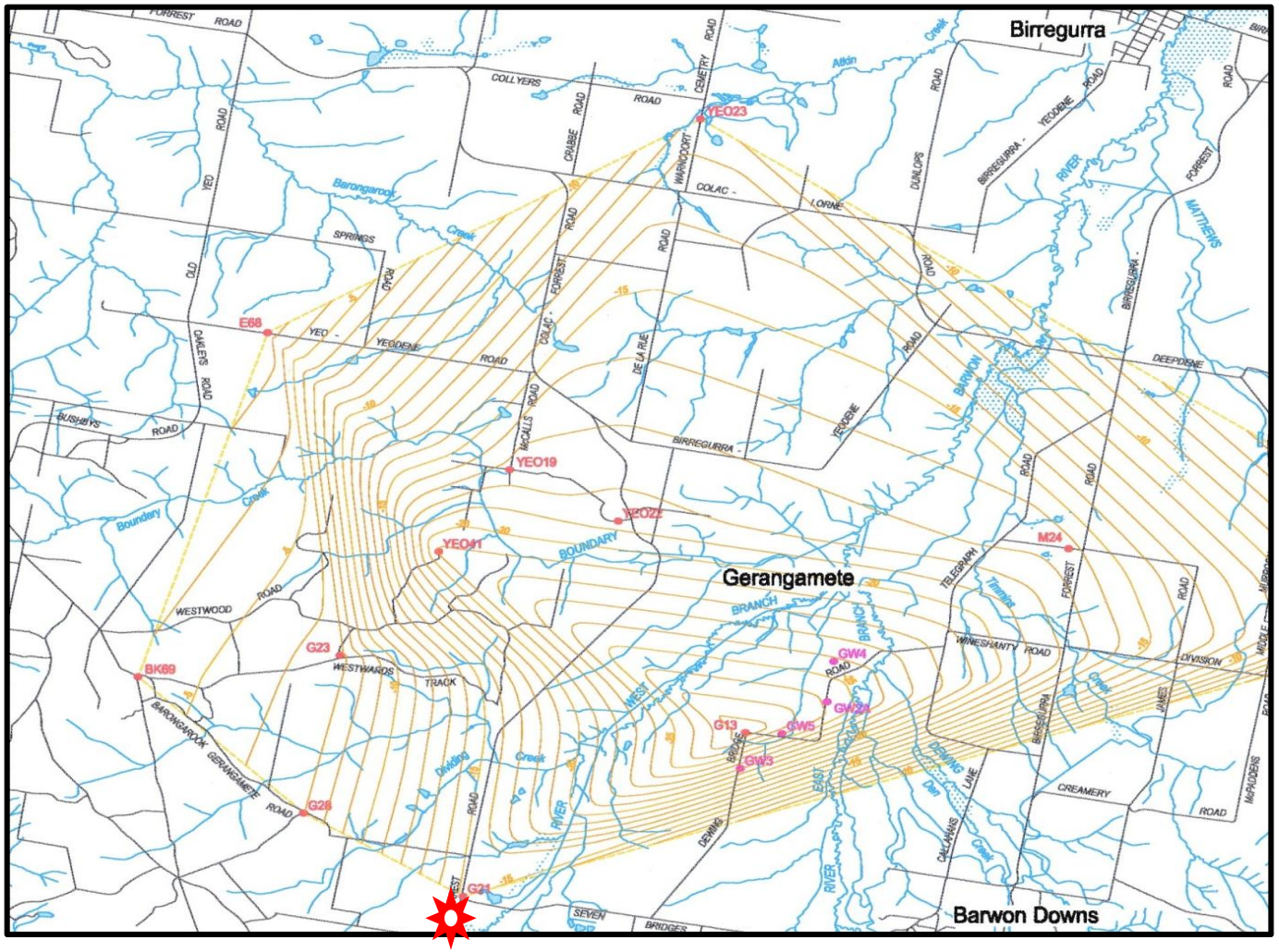
In 2002 the Pebble Point aquifer displayed a different impact to the one for the Dilwyn aquifer. The Dilwyn aquifer appears to have a wider and more pronounced impact.

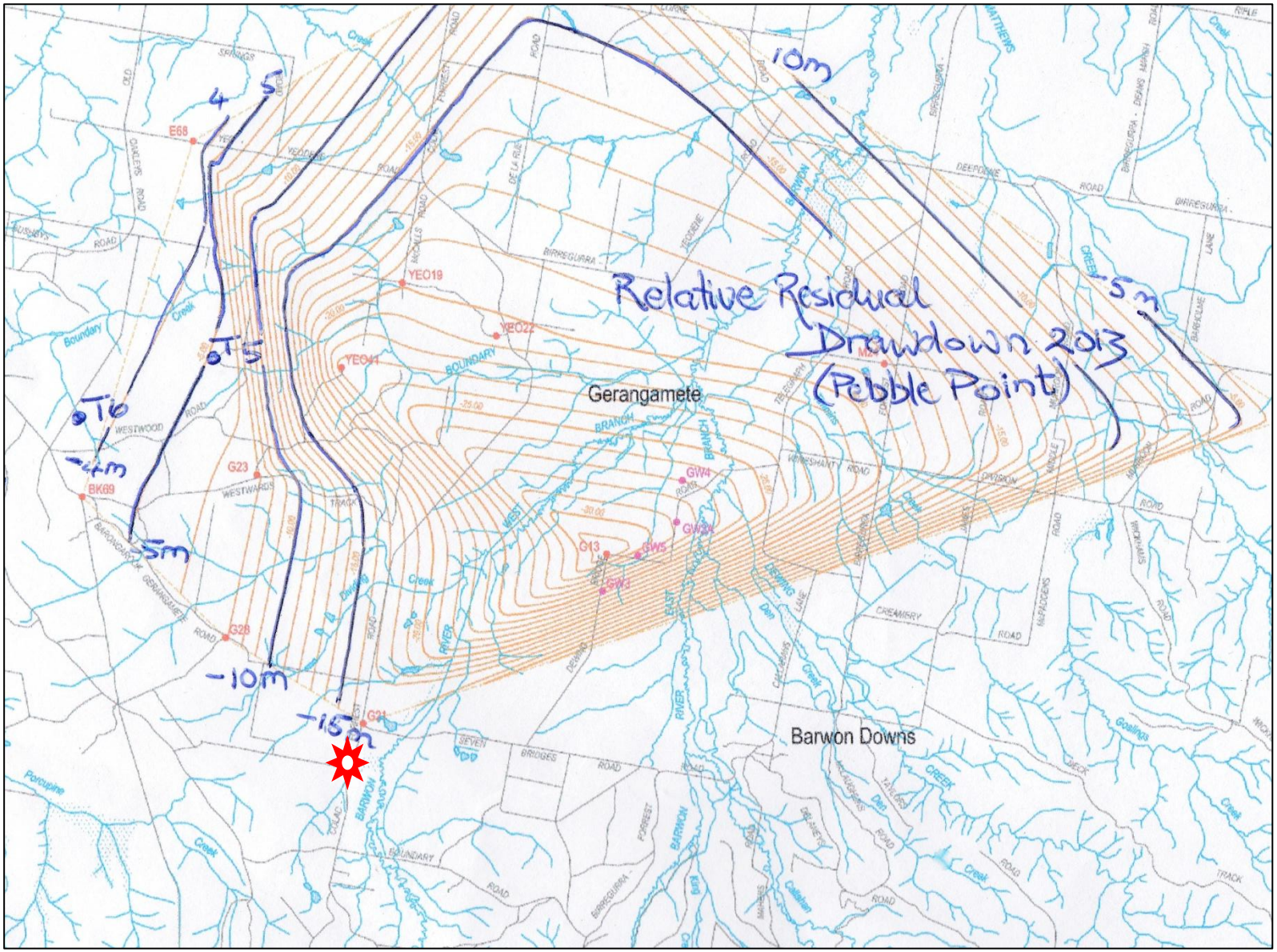
This is expected as the Dilwyn Aquifer is higher up the profile. The Mepunga would be expected to be different again, being even higher and the first to be influenced. Originally the extraction pumps were between 400 and 500 metres below the surface. These have been lowered to 500-600 metres.



This 2014 residual map for the Pebble Point aquifer still shows a 28 metre drawdown at the borefield 4 years after pumping has ceased. Also, the residual drawdown contours cease at the boundaries that Barwon Water states were set down by the 2004 licence agreement. No reference in the licence can be found to back this assertion.

These three residual drawdown maps clearly indicate that the residual drawdown area of influence extends some considerable distance down the Western Flank Flowpath. Determining exactly where and how far is not accepted by Barwon Water as being a task that must be undertaken as part of the licence conditions. Perhaps when the conditions were being drawn up it was not anticipated that the influence would extend as far as it appears is has.




Relative Residual
Drawdown 2013
(Pebble Point)
Gerangamete
Barwon Downs
10m
-5m
-10m
-15m
T5
T6
-4m
-5m
4
5
E68
YEO19
YEO22
YEO41
G23
BK69
G28
G21
GW4
GW24
GW5
G13
GW3
M24

The following three conceptualisation diagrams show the residual drawdown from a different perspective.

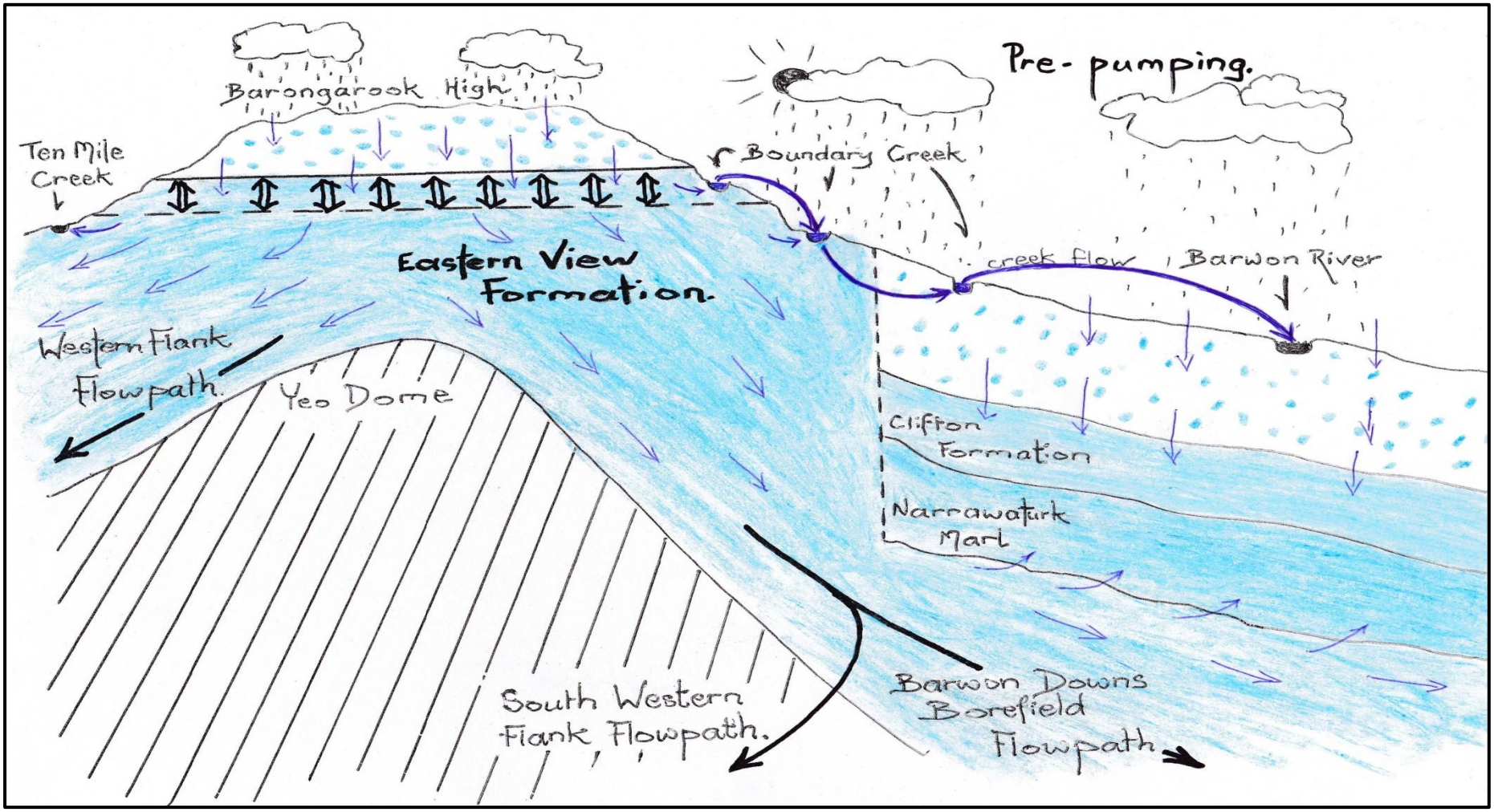


Figure 67.

The **Figure 67** (page 67) cross section shows the Eastern View Formation aquifers under natural conditions pre groundwater extraction. During normal weather patterns, the dynamic equilibrium water table level would oscillate up and down within a range whereby the top end of Boundary Creek would dry up in most summers. However, the lower reaches of Boundary Creek would continue to flow all year, every year. These lower reaches being below the oscillating dynamic equilibrium water table level, receiving continual discharge from the Eastern View Formation.

During dry periods the dynamic equilibrium water table level would drop and then rise during recharge events. The Western, South Western and Barwon Downs Borefield flowpaths would maintain a reasonably consistent level. Baseflow waters discharging into the Ten Mile/Loves Creek Catchment and the Gellibrand River would show little variation.

The Narawaturk Marl would have water driven up into it from the pressurised Eastern View Formation. In turn water would be forced up into the bottom of the Clifton aquifer formation. Infiltration across the system would come from above.

The functioning of this system would have evolved over eons of time and ecosystems would have adapted accordingly, reaching a relatively stable equilibrium where discharge from the system equalled recharge into the system. However, if water extraction from the Eastern View Formation aquifers was greater than the recharging capacity of the system then changes would take place. The greater the difference between recharge and extraction the greater the changes the impact would be.

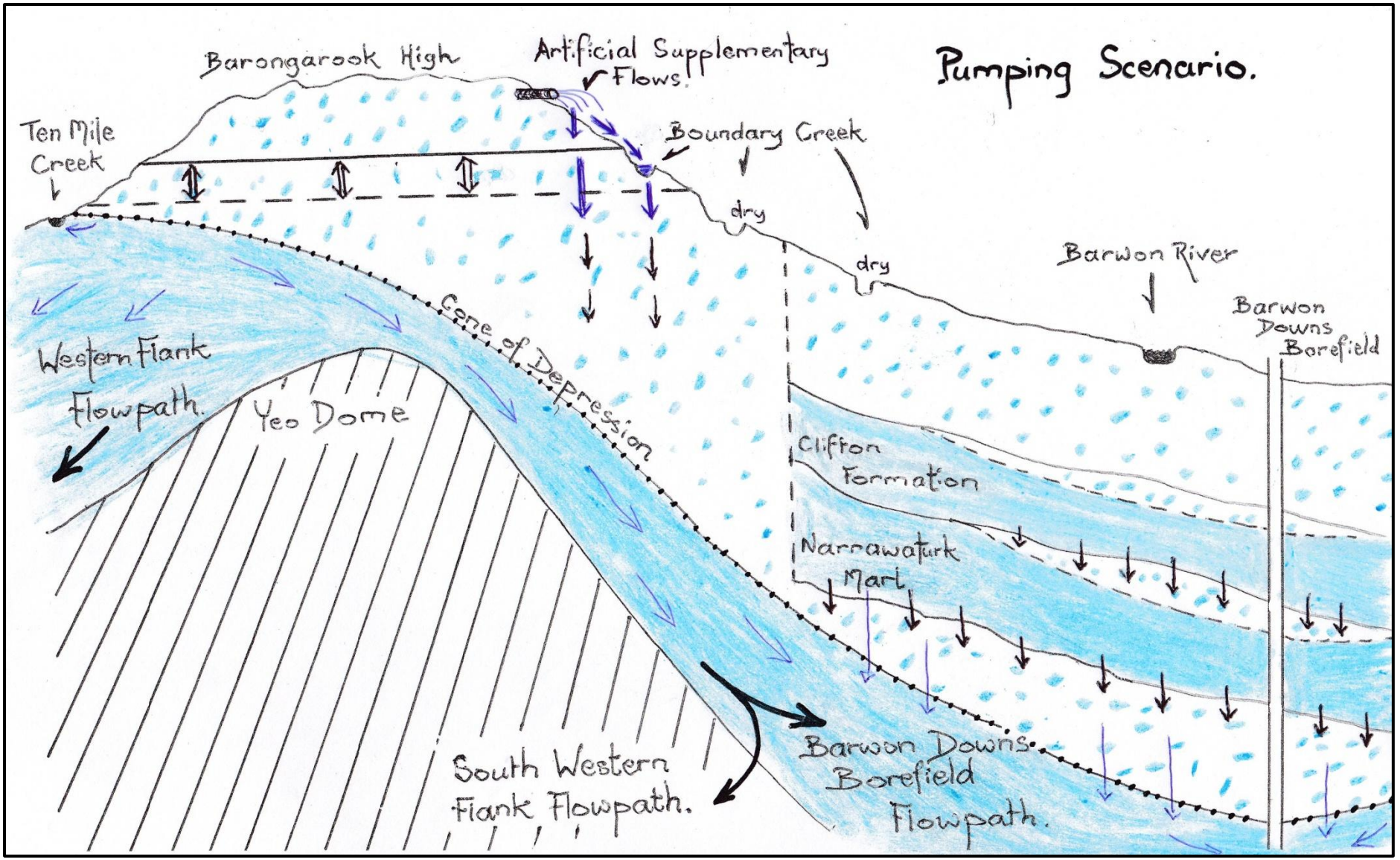

Pumping Scenario.
Barongarook High
Artificial Supplementary Flows.
Ten Mile Creek
Boundary Creek
dry
dry
Barwon River
Barwon Downs Borefield
Western Flank Flowpath.
Yeo Dome
Cone of Depression
Clifton Formation
Narrawaturk Marl
South Western Flank Flowpath.
Barwon Downs Borefield Flowpath.

Figure 69.

The **Figure 69** (page 69) cross section highlights some of the changes that take place when an aquifer system is drawdown faster than the natural processes can recharge this system.

Groundwater extraction causes the water table level to fall way below the dynamic equilibrium zone; Boundary Creek stops running; water from the Narawaturk Marl begins to leak downwards to fill the dewatered space and the Clifton Formation aquifer begins to leak downwards to fill the leaking Narawaturk Marl.

As the cone of depression spreads, water from further and further out is sucked into the void that is left from the groundwater extraction. This influence begins to impact on other seemingly independently functioning systems. Quantities of water that normally flow down the West and South West flowpaths are drawn off to the east. The process of the Eastern View Formation returning to its former equilibrium state is still taking place years after pumping has stopped. The impact on adjoining systems will also continue until the state of natural dynamic equilibrium is achieved.

The Artificial Supplementary Water being released into the Barongarook High area out of the Otway to Colac Pipeline, fails to maintain flows in Boundary Creek. Water released disappears into the dewatered Eastern View Formation, going no further than the Big Swamp. However, it appears that these releases have a mild buffering affect on the impact being felt in the upper reaches in the Boundary Creek area.

The Ten Mile/Loves Creek Catchment Western Flowpath is being impacted (see page 28). The Gellibrand River is also being impacted from a decreased flow of water through the South Western Flowpath. This impact is reflected in the stream flow gauging station records.

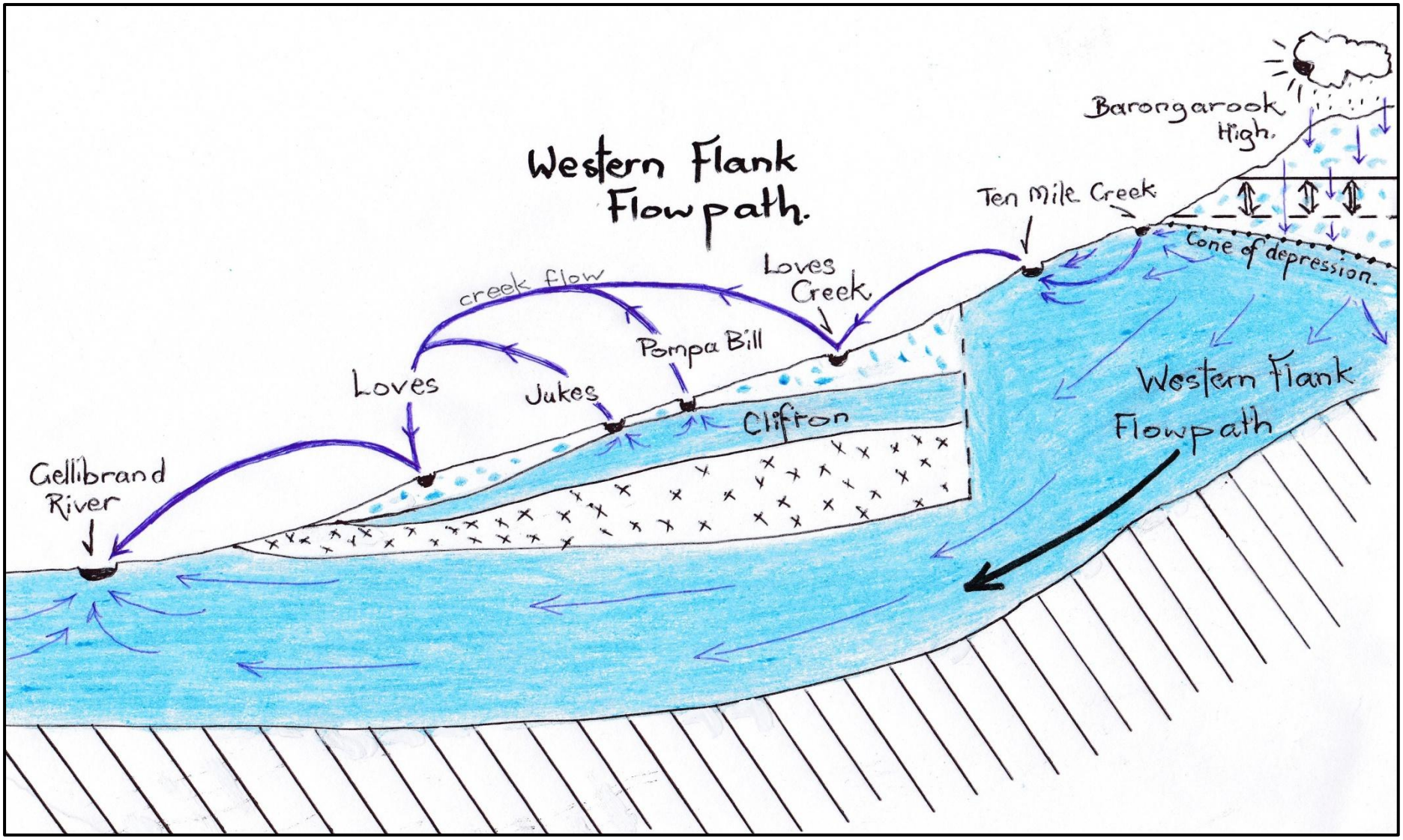
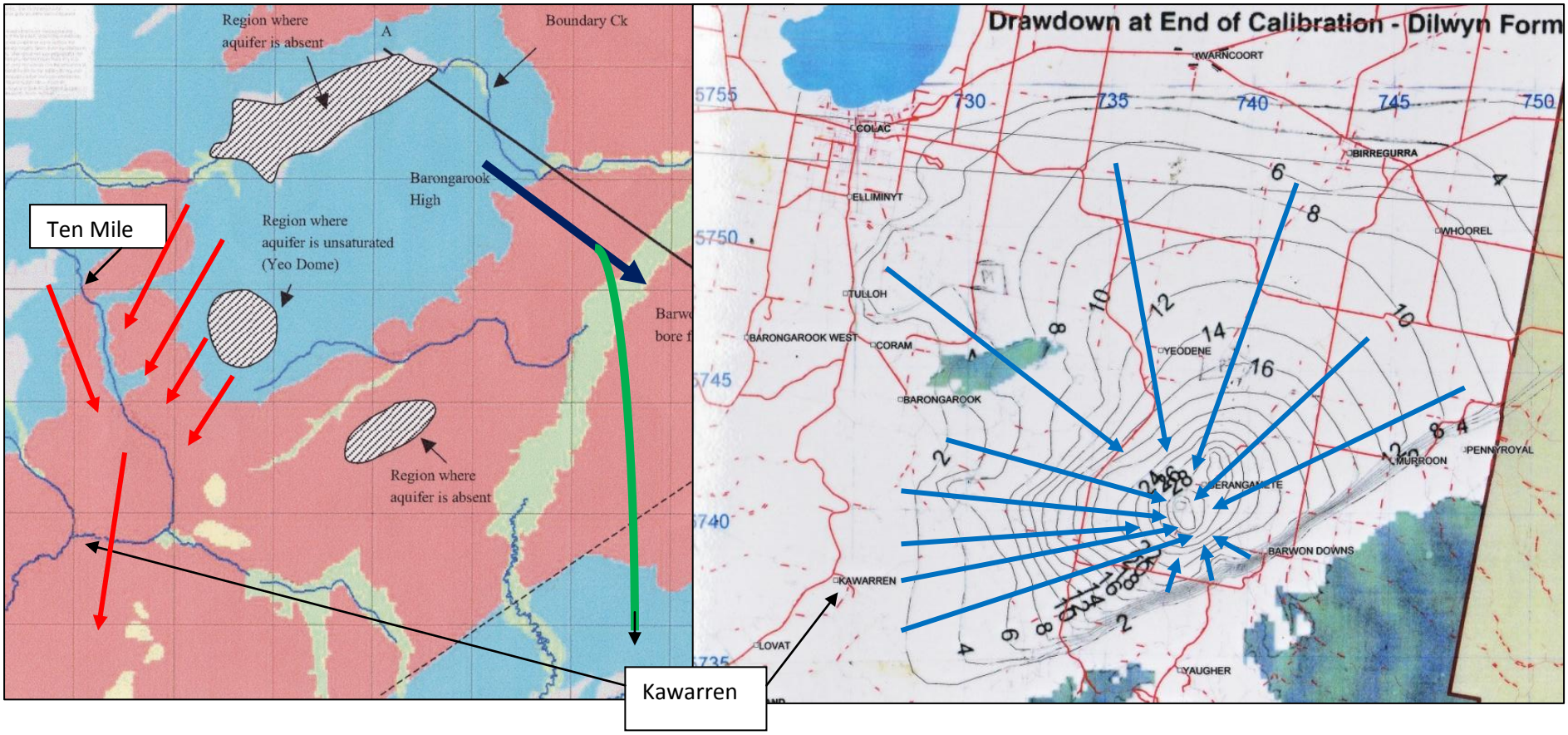

Western Flank
Flowpath.
Barongarook
High.
Ten Mile Creek
Cone of depression.
creek flow
Loves
Creek
Pompa Bill
Loves
Jukes
Clifton
Gellibrand
River
Western Flank
Flowpath

Figure 71.

The **Figure 71** (see page 71) map demonstrates how the surface flows in the Ten Mile/Loves Creek Catchment will be impacted as the cone of depression spreads out.



This cone of depression is influencing and affects the headwaters of the Ten Mile Creek.
The maps above demonstrate additional pressure placed on the surface flows and also demonstrate one reason why the observation bore water levels are continuing to fall along the Western Flank Flowpath. The map on the left shows the

recharging outcropping Eastern View Formation in blue; the Western Flank Aquifer Flowpath in red and the Barwon Downs Borefield and South Western Flowpaths in dark blue and green. The map on the right demonstrates how water is drawn in from all directions filling the void left when groundwater extraction exceeds the ability of the system to recharge as fast as water is extracted. This would explain the continuing drawdown observed in the bores down the Western Flank Aquifer Flowpath. The recharge water normally flowing past these bores is being drawn into the depleted Eastern View Formation created by the extraction of groundwater from the Barwon Downs Borefield.

The time it will take the Eastern View Formation to recover is unknown. What is known is that the drawdown cone, large distances from the Borefield, continues to expand.[(44)] Since pumping in the 1990s the Eastern View has never been given the time to recover to a pre groundwater extraction level before the next period of pumping has begun. How far out and for how long the cone of depression will influence adjoining springs, wetlands and streams is also another unknown. However, there does appear to be substantial data available to indicate that this influence is real and will continue for some considerable time.

CONCLUSION.

The connection between the aquifers and the baseflows in creeks in the Loves Creek Catchment and the Upper Gellibrand Catchment is extremely strong. The baseflow that maintains these creeks during the drier months of the year is water from the full and overflowing Eastern View Formation aquifers. Under normal conditions, including droughts, these creeks continue to flow throughout the years. However, extract more groundwater than the system is able to naturally recharge, the water table drops, and, out of the ordinary impacts are set in motion.

Observations made by landholders along the Gellibrand River and the Loves Creek catchments indicate something unusual has indeed been set in motion. Concern is being expressed as it appears baseflows in streams during dry periods have not recovered since the drought of five years earlier. Rainfall records indicate that the surface stream baseflows and groundwater water tables should have begun to recover from any downturn experienced during this drought. However this is not happening.

On examination of many of the factors that go into “painting” the big picture, it becomes apparent that groundwater extractions at the Barwon Downs Borefield are the major cause of these occurrences. There has been ample rainfall since the drought to have had a significant upward trending influence on the recharge and infiltration to the Eastern View Formation aquifers. An upward trend in the observation bores along the Western Flank Aquifer Flowpath has not taken place. The exact opposite has happened.

Also, base stream flow data indicates a similar downward trend. Even though post drought rainfall in the Barongarook High region has not fully recovered to pre drought falls, this slightly lower rainfall has the biggest impact on runoff not on infiltration. Examination of the rainfall data from the Healey and Hopkins weather stations reveals that taking the evapotranspiration losses from the total rainfall still leaves ample rainfall recharging the aquifers. Also, comparing years of similar rainfall periods before and after the drought indicate that the hydrographs down the Western Flank Aquifer Flowpath should have recovered by this stage. Consequently, surface baseflows should have returned to normal.

In general, evapotranspiration takes the first amount of rainfall, then recharge, and lastly any water not used in these ways becomes runoff or overland flow. The small drop in yearly rainfall since the drought broke, is reflected in dams being slower to fill and flushes down creeks being less regular. However, there has been sufficient rainfall to recharge the Eastern View Formation.

Amazingly, the hydrograph falls in the observation bores down the Western Flank Aquifer Flowpath have significantly fallen below the predictions made by a State Government project. These predictions made in the middle of the drought (2006), estimated aquifer water table falls in the south west of Victoria to be in the order of 10 cm a year. The falls in the observation bores down the Western Flank have been double this prediction. Not only that, water tables have continued to free fall when aquifers outside the influence of the Barwon Downs Borefield have significantly risen.

Land use change has been ruled out as having no more than a mild impact on aquifer recharge in the Barongarook High region.

Residual drawdown maps show that the cone of depression from the Barwon Downs Borefield extends a considerable distance into the Kawarren and Gellibrand regions. The recharge that normally flows down the Western Flank Aquifer Flowpath is now being sucked away to the east towards the void created at the Barwon Downs Borefield.

It would appear that the Artificial Supplementary Flows being released into Boundary Creek are masking and having a buffering effect at the top end of the Boundary Creek and Ten Mile Creek catchments. These releases disappear into the exposed Eastern View Formation and act as a form of Artificial Recharge into this depleted aquifer formation.

Also, prior to the commencement of the Artificial Supplementary Flow Releases a stress test pump was conducted at the Barwon Downs Borefield and there is every indication streams down the Western Flank were affected by this extraction.

The amount of data continues to amass indicating that the Barwon Downs Borefield extractions not only affect the Boundary Creek Catchment, but also has a significant impact on the Ten Mile/Loves Creek and Upper Gellibrand River catchments.

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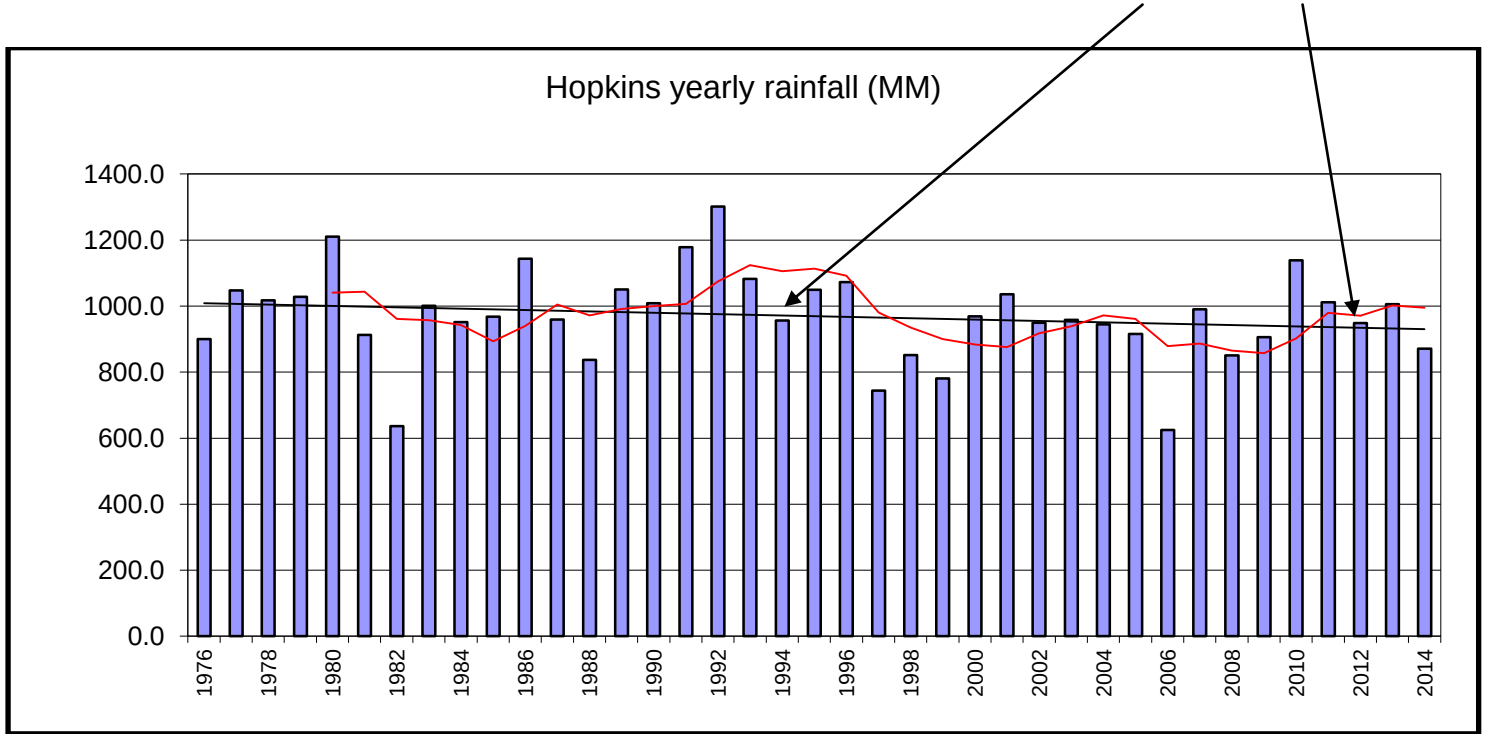
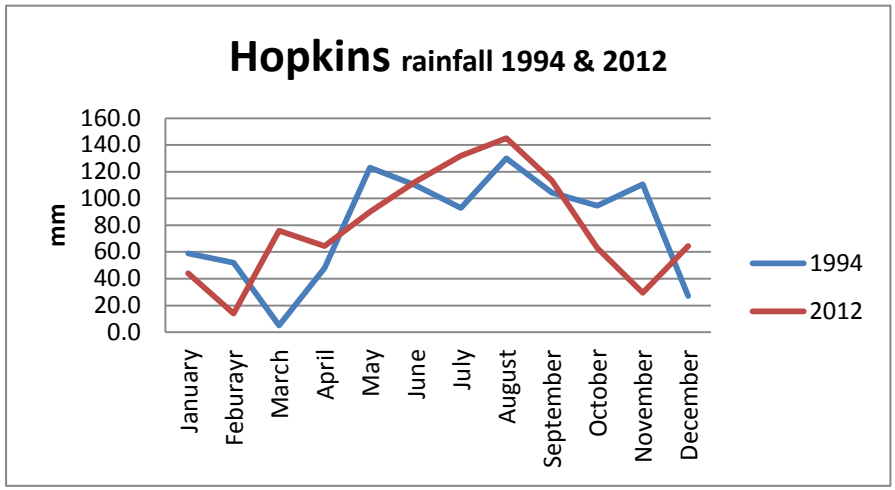
APPENDIX ONE

The rainfall charts in Appendix One have been capped at 30mm.
There are two months of records on each chart. They cover the two years 1994 and 2012.

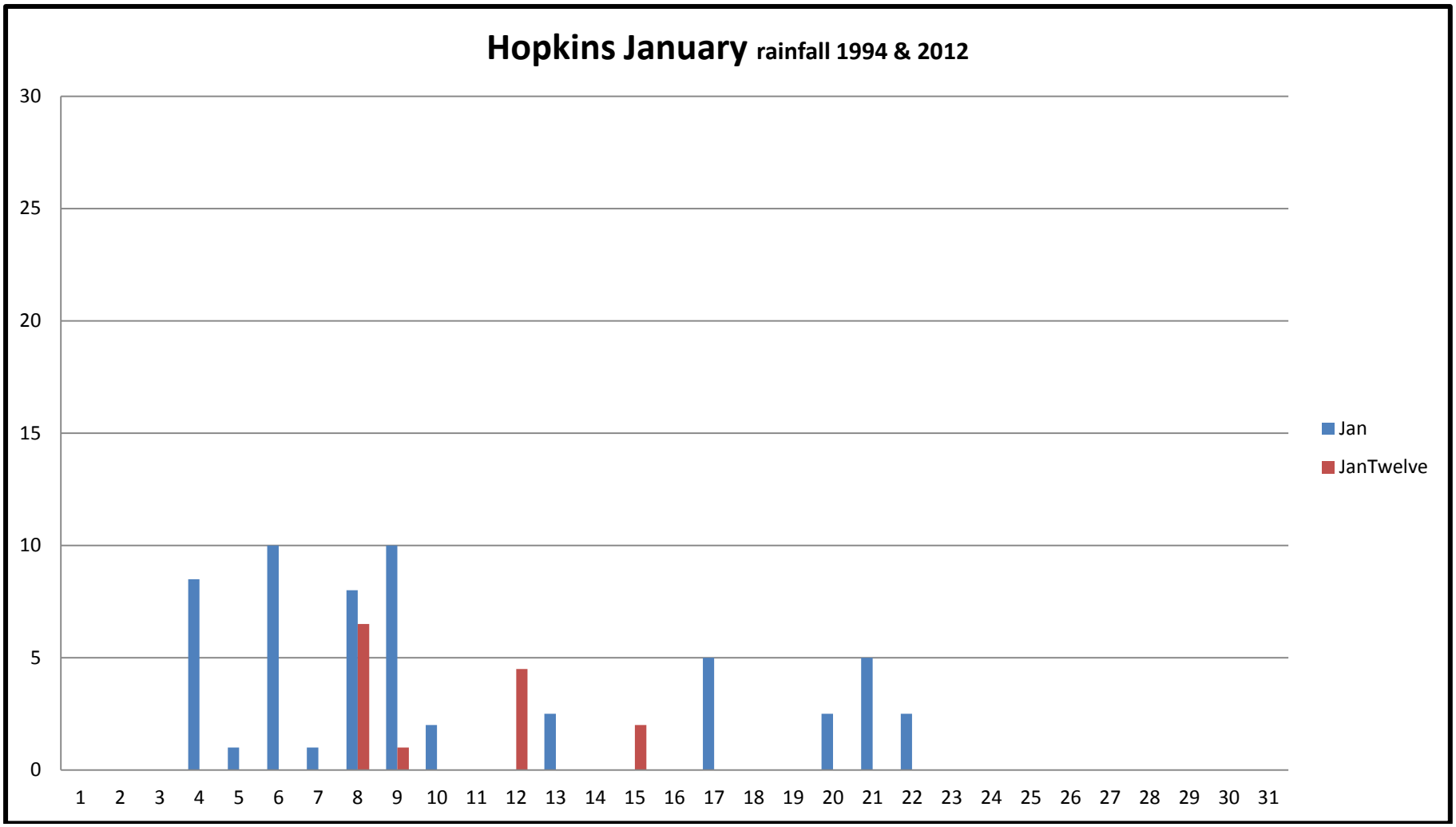


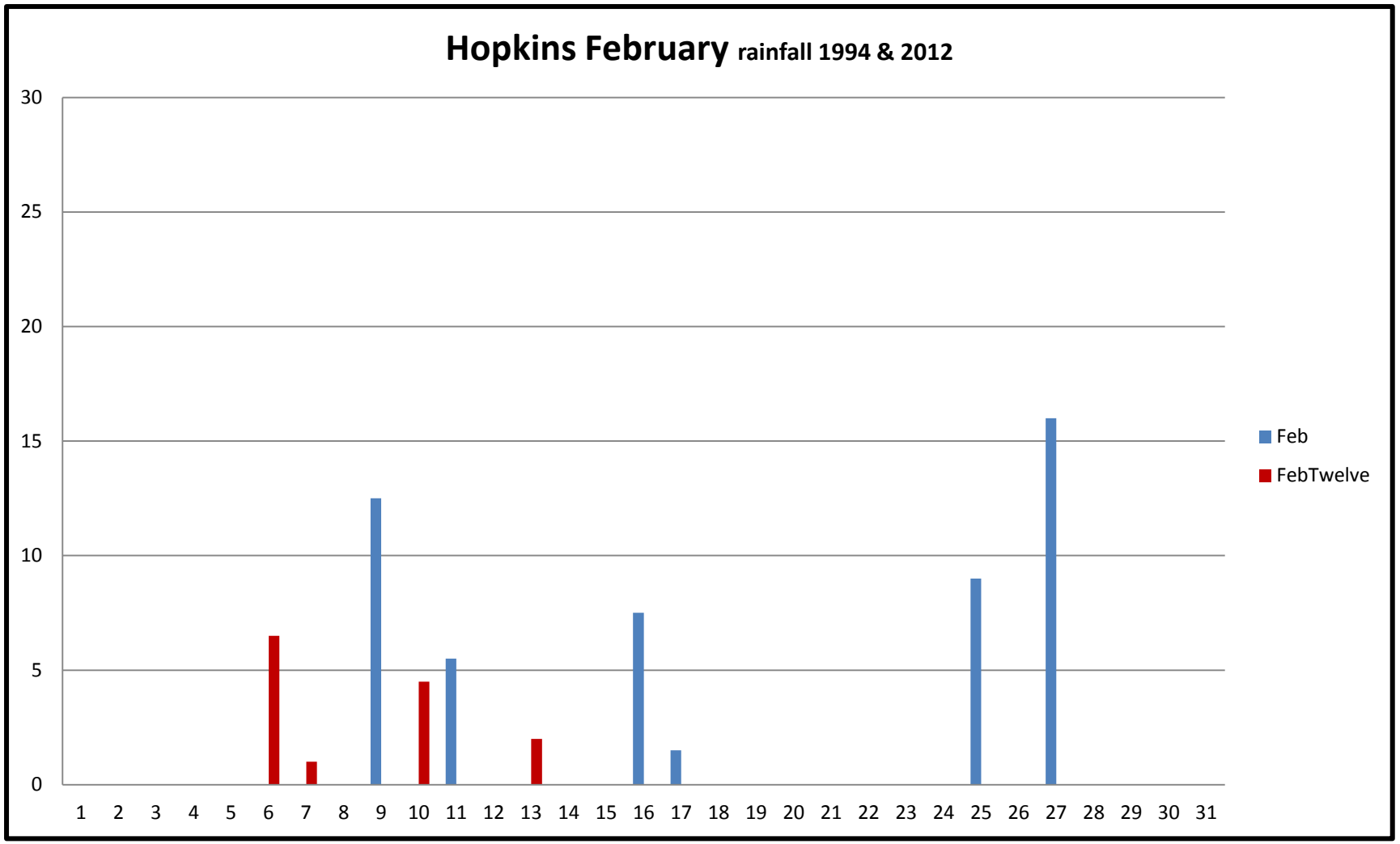


The following table has the total for each month during the 1994 and 2012 months.

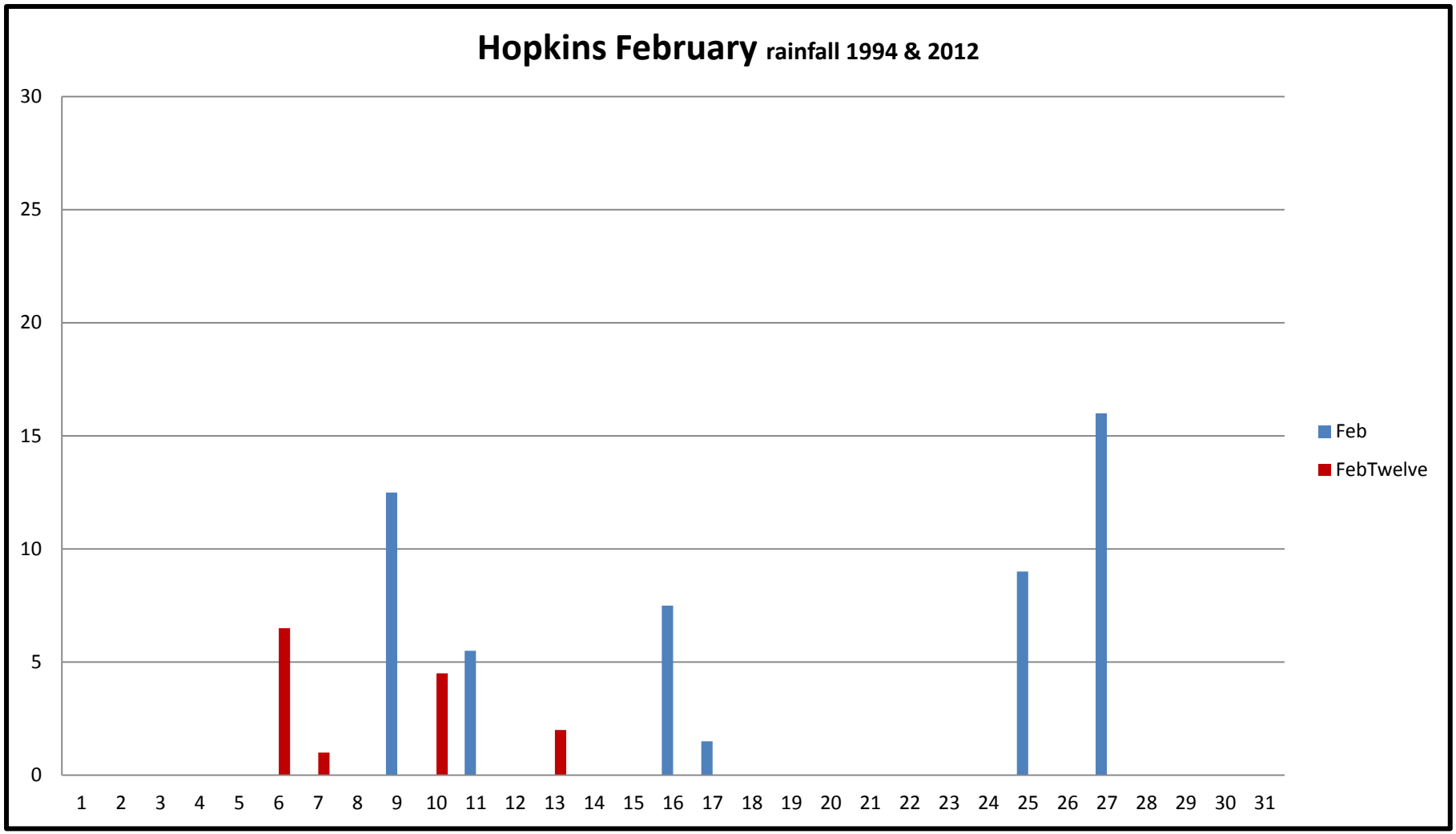
Month	1994	2012
January	59	44
February	52	14
March	5	76
April	48	64.5
May	123	90
June	110	112.5
July	93	132
August	130	145
September	104.5	113.5
October	94.5	63
November	110.5	29.5
December	27	64.5

.


Hopkins January rainfall 1994 & 2012
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan
JanTwelve

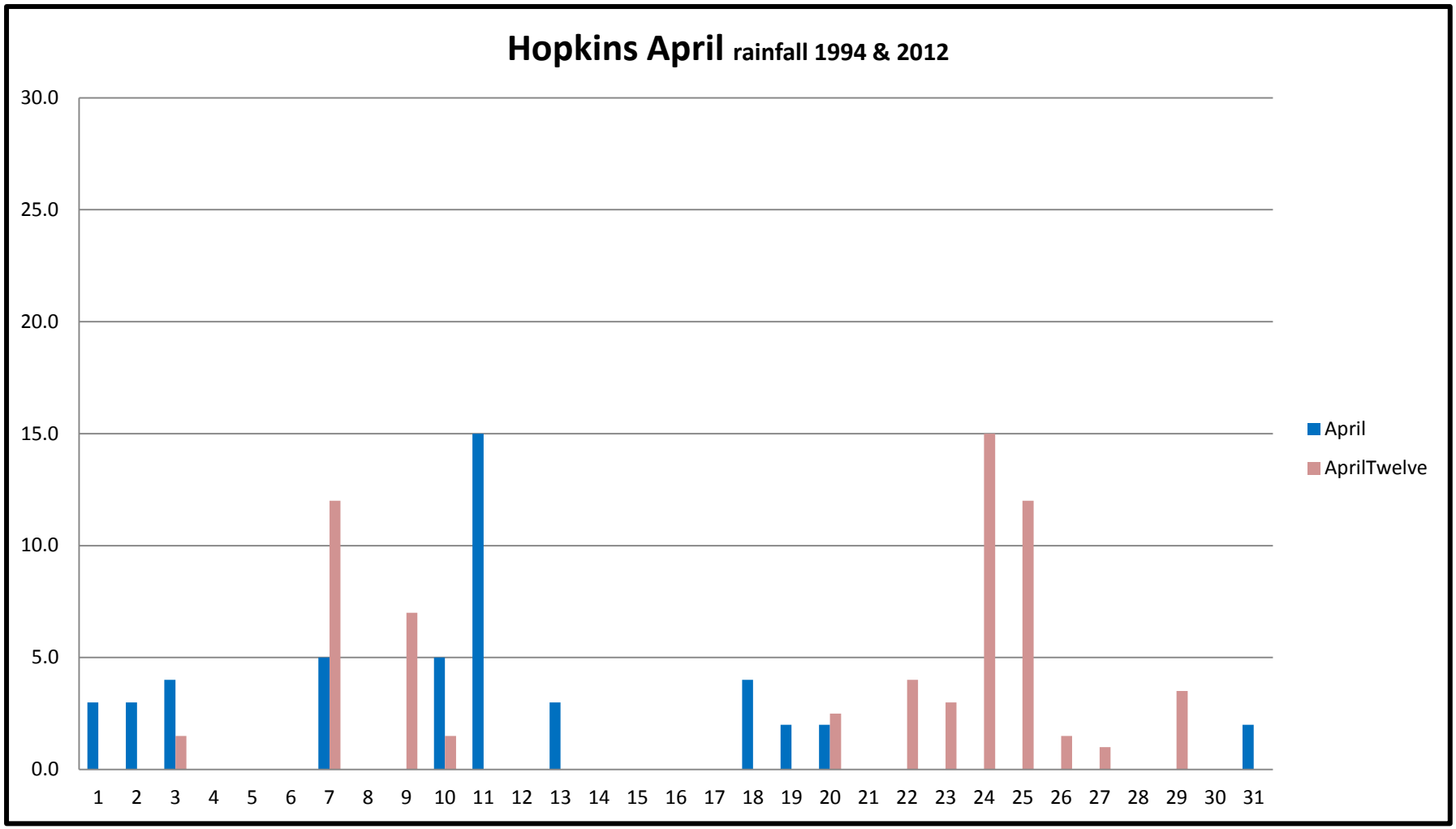

Hopkins February rainfall 1994 & 2012
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Feb
FebTwelve

D

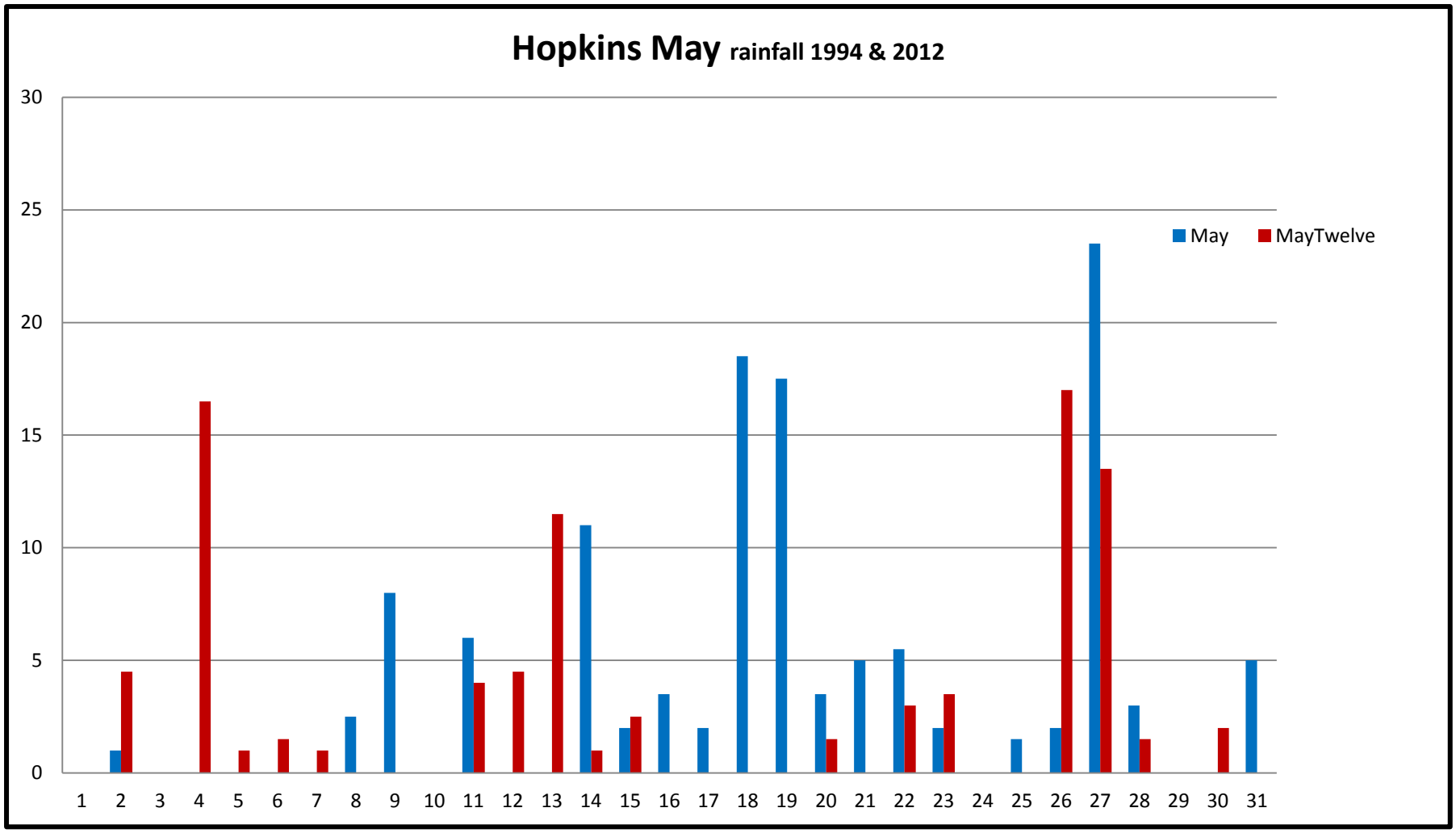

Hopkins February rainfall 1994 & 2012
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Feb
FebTwelve

D

D

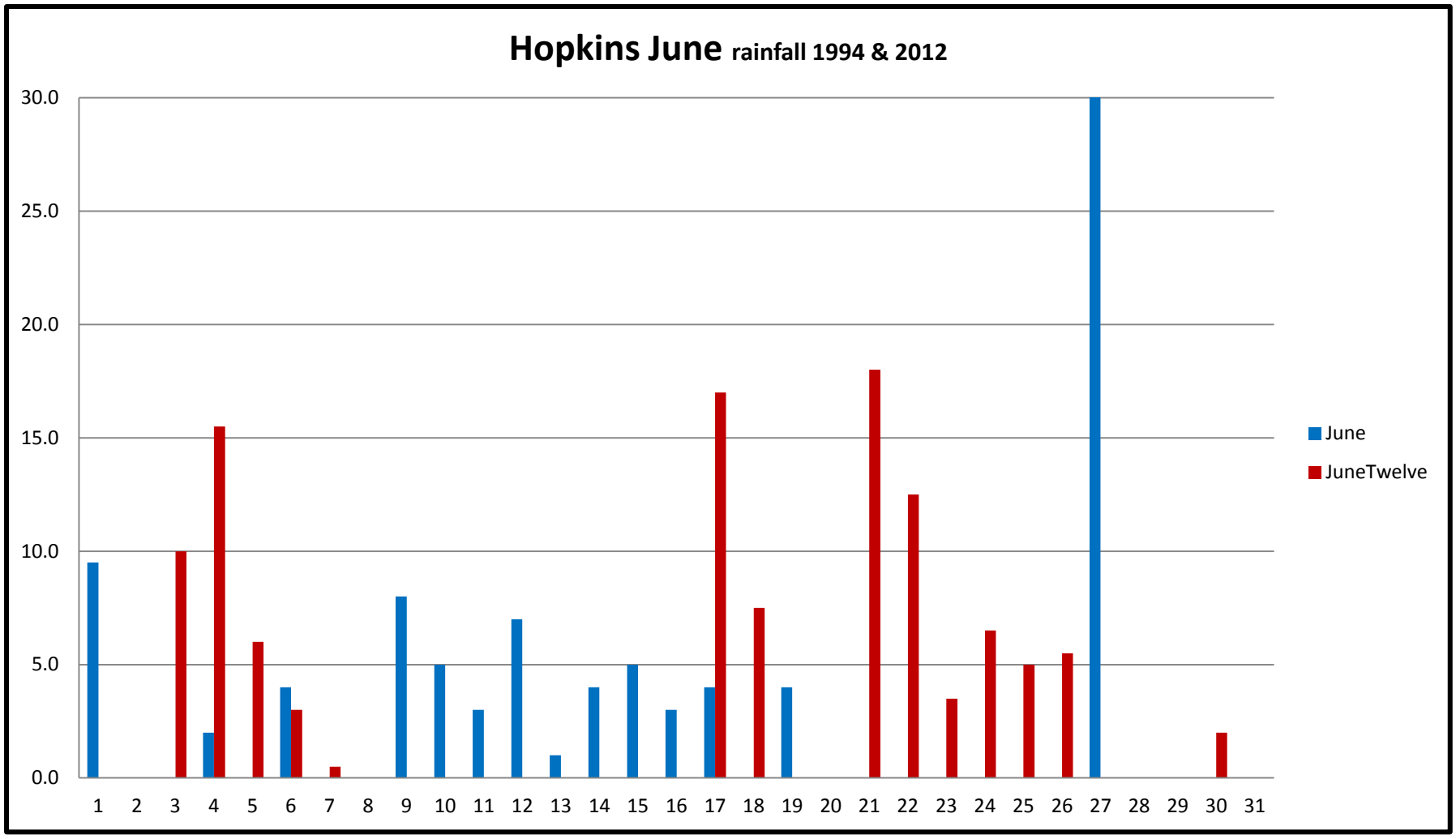

Hopkins April rainfall 1994 & 2012
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
April
AprilTwelve

D

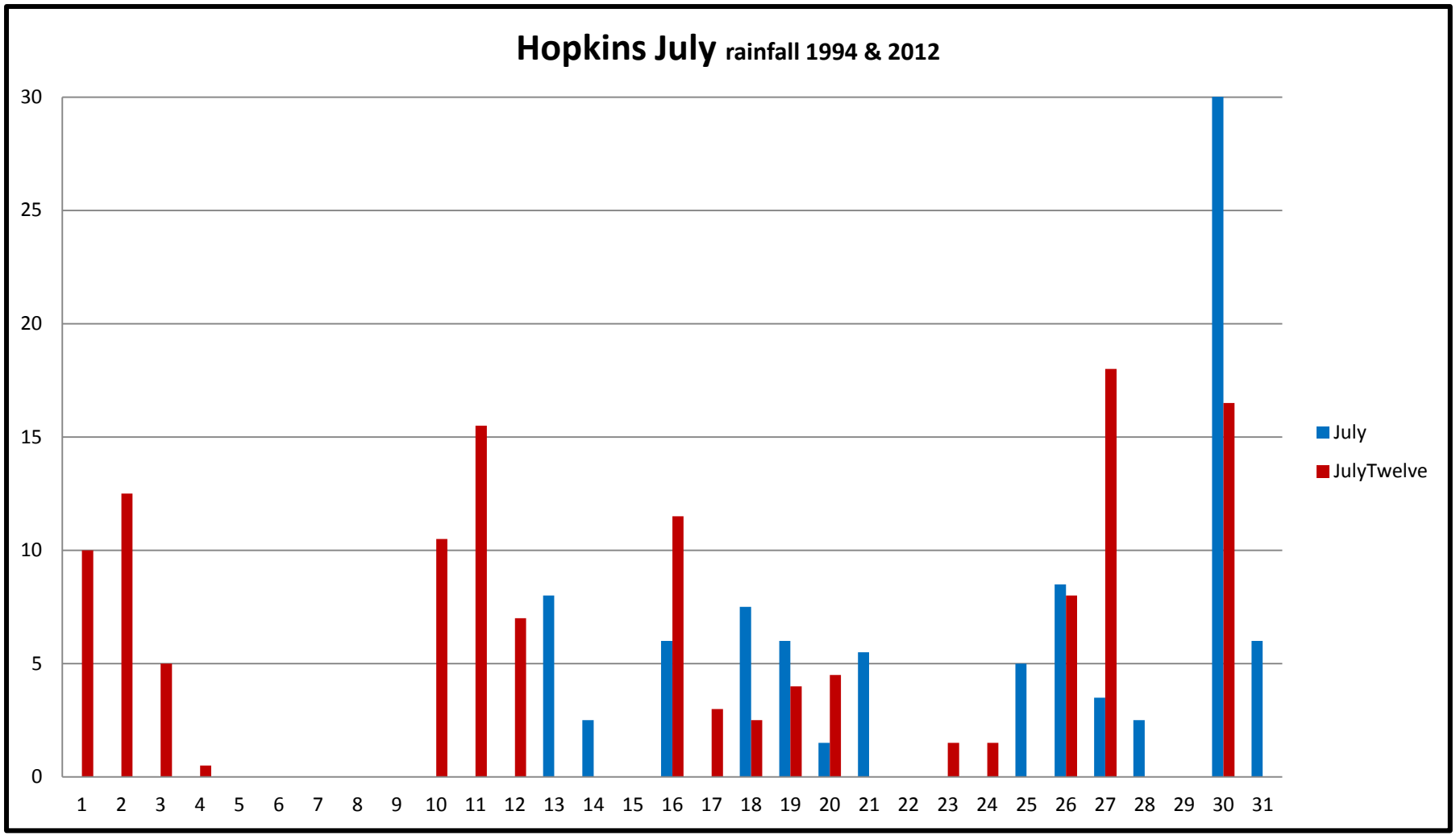

Hopkins May rainfall 1994 & 2012
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
May
MayTwelve

D

D

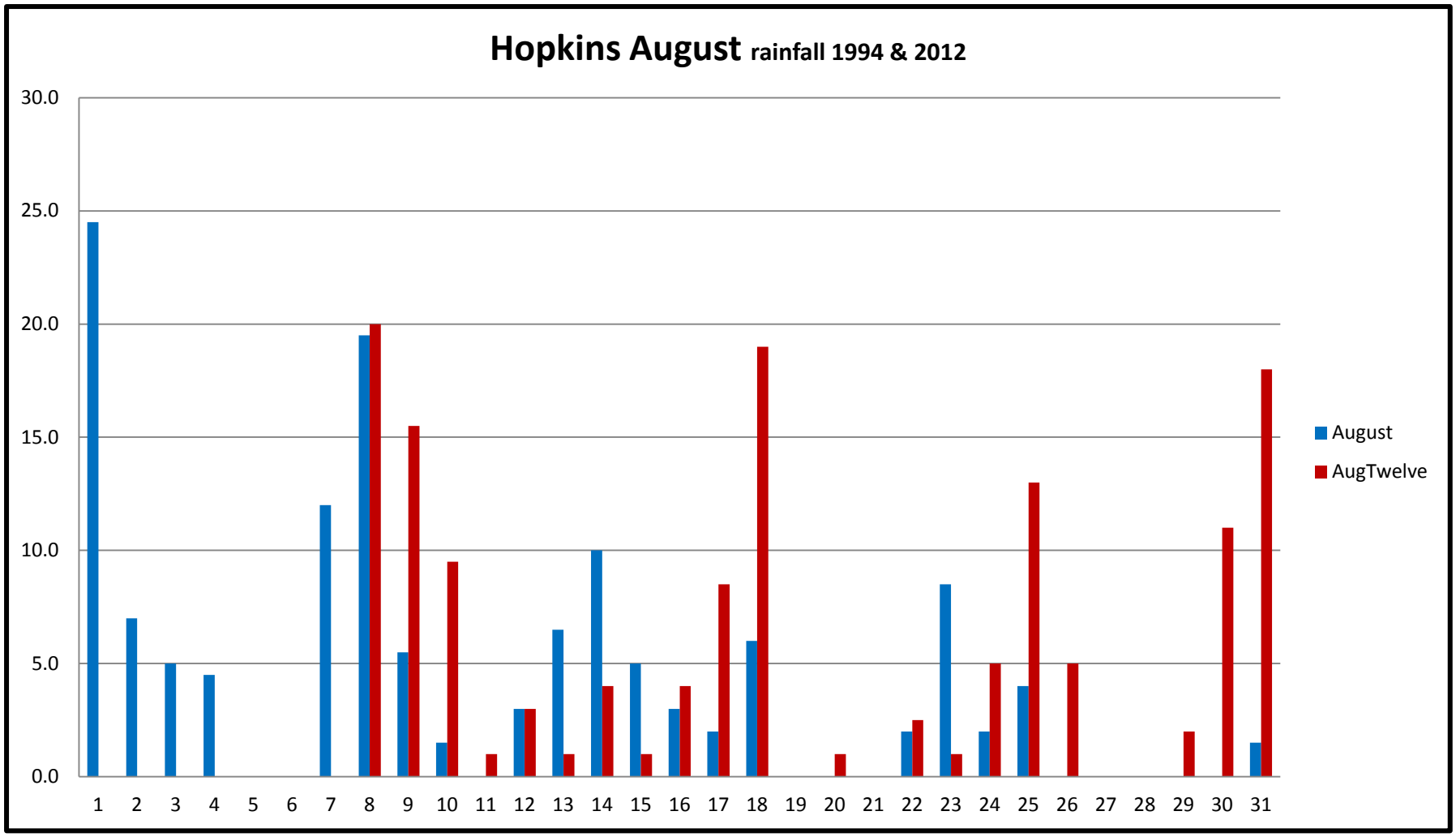

Hopkins June rainfall 1994 & 2012
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
June
JuneTwelve

D
D


Hopkins July rainfall 1994 & 2012
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
July
JulyTwelve

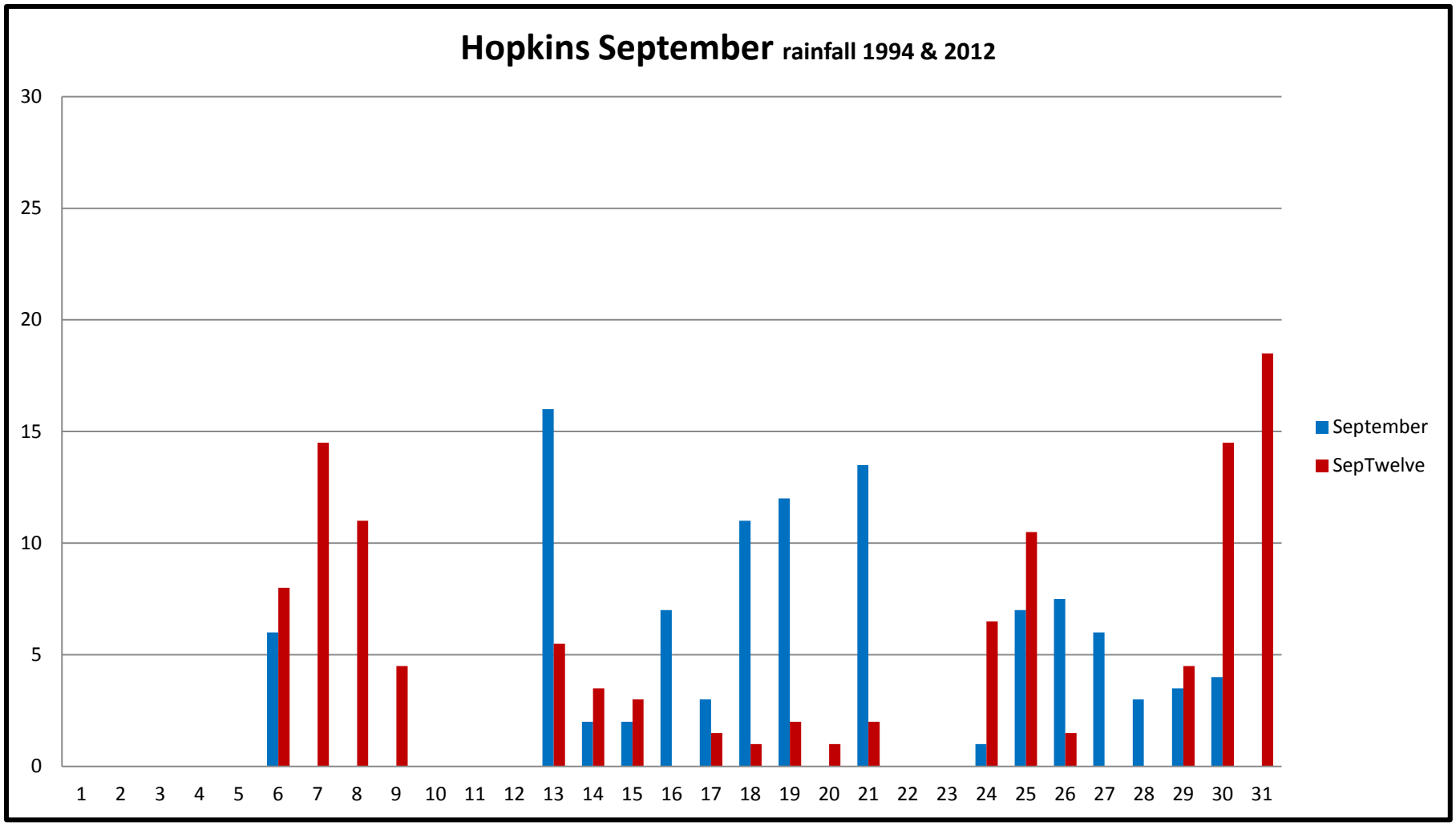
D

D

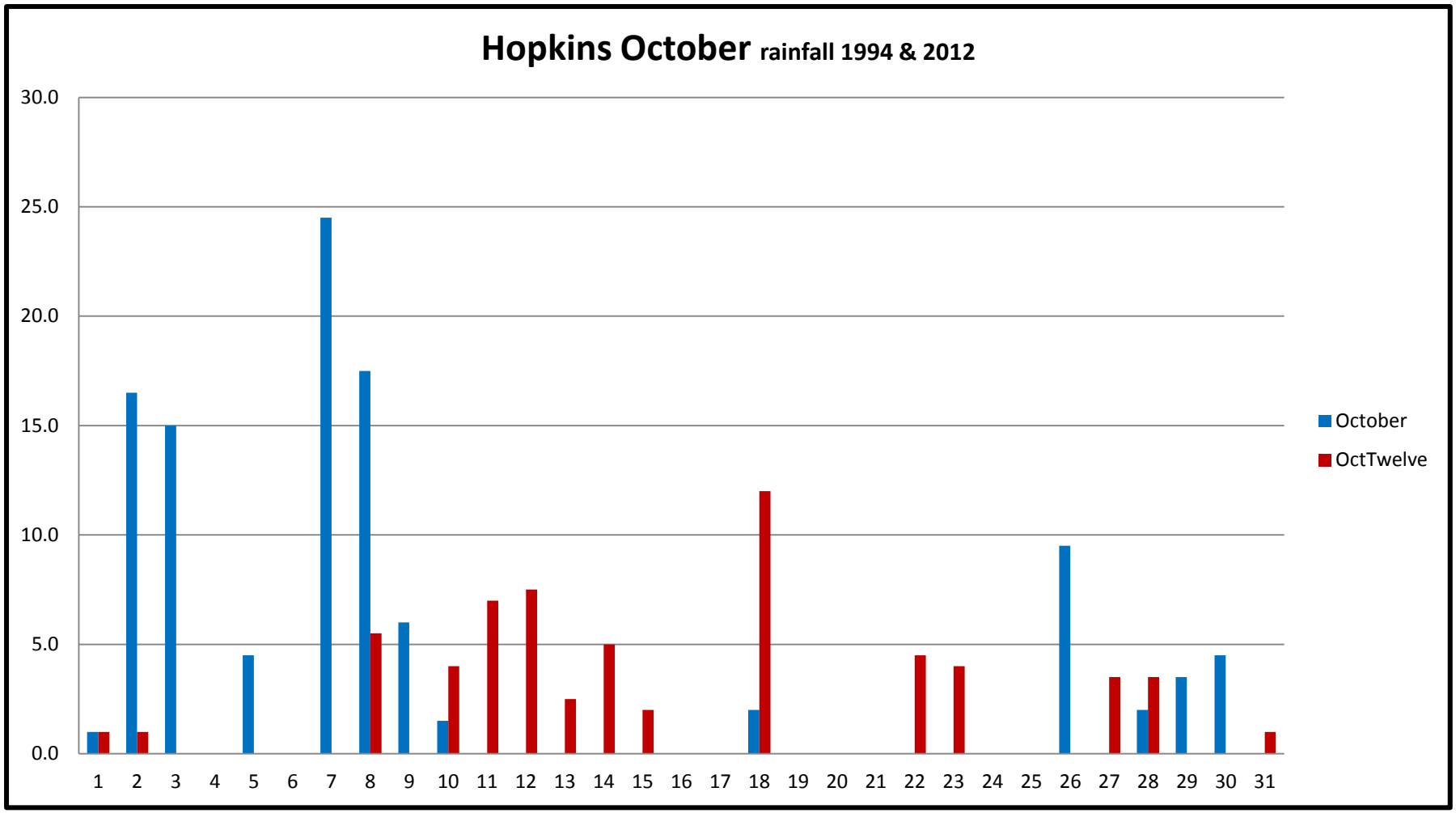

Hopkins August rainfall 1994 & 2012
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
August
AugTwelve

D

D

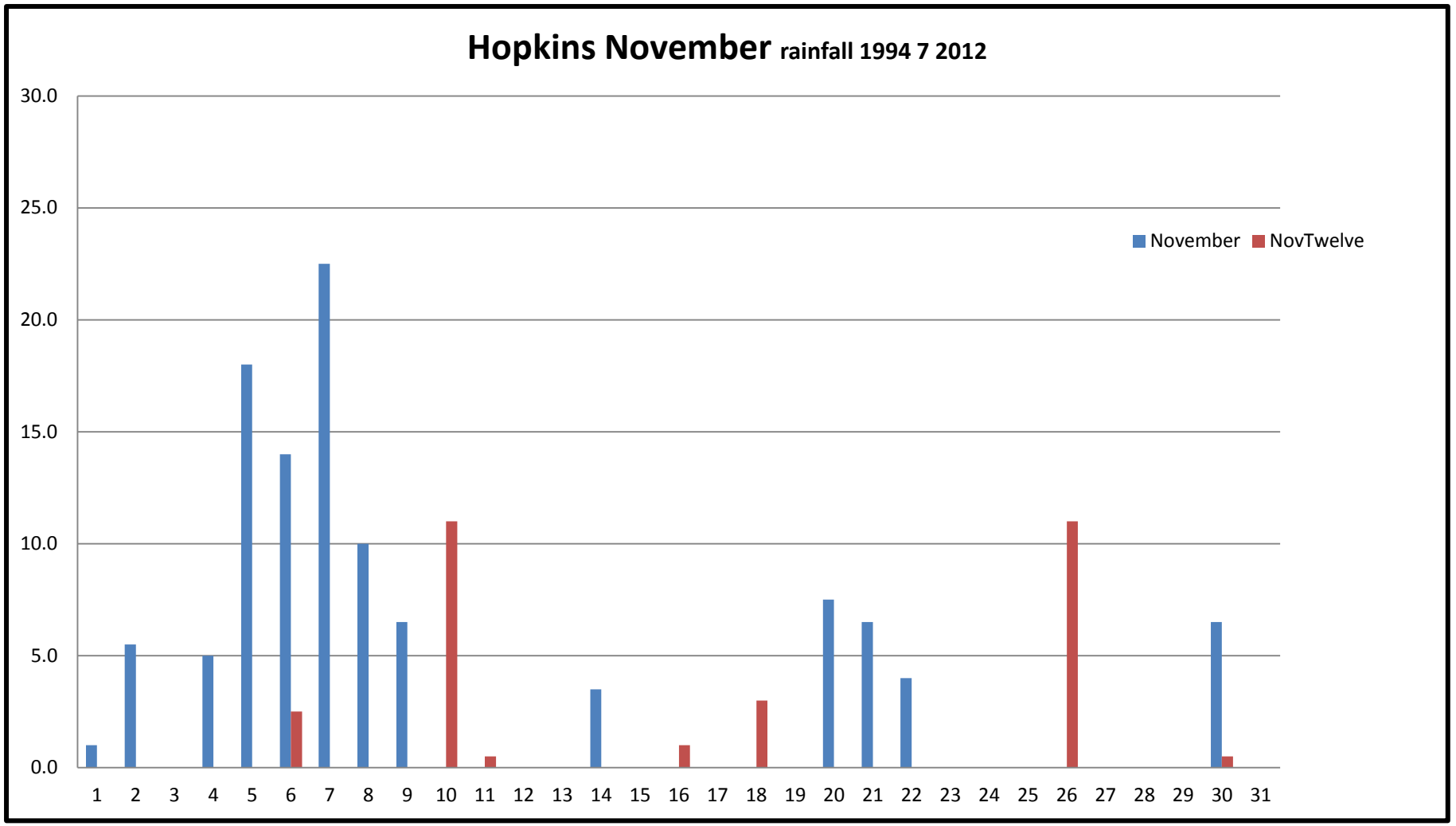

Hopkins September rainfall 1994 & 2012
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
September
SepTwelve

D
D


Hopkins October rainfall 1994 & 2012
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
October
OctTwelve

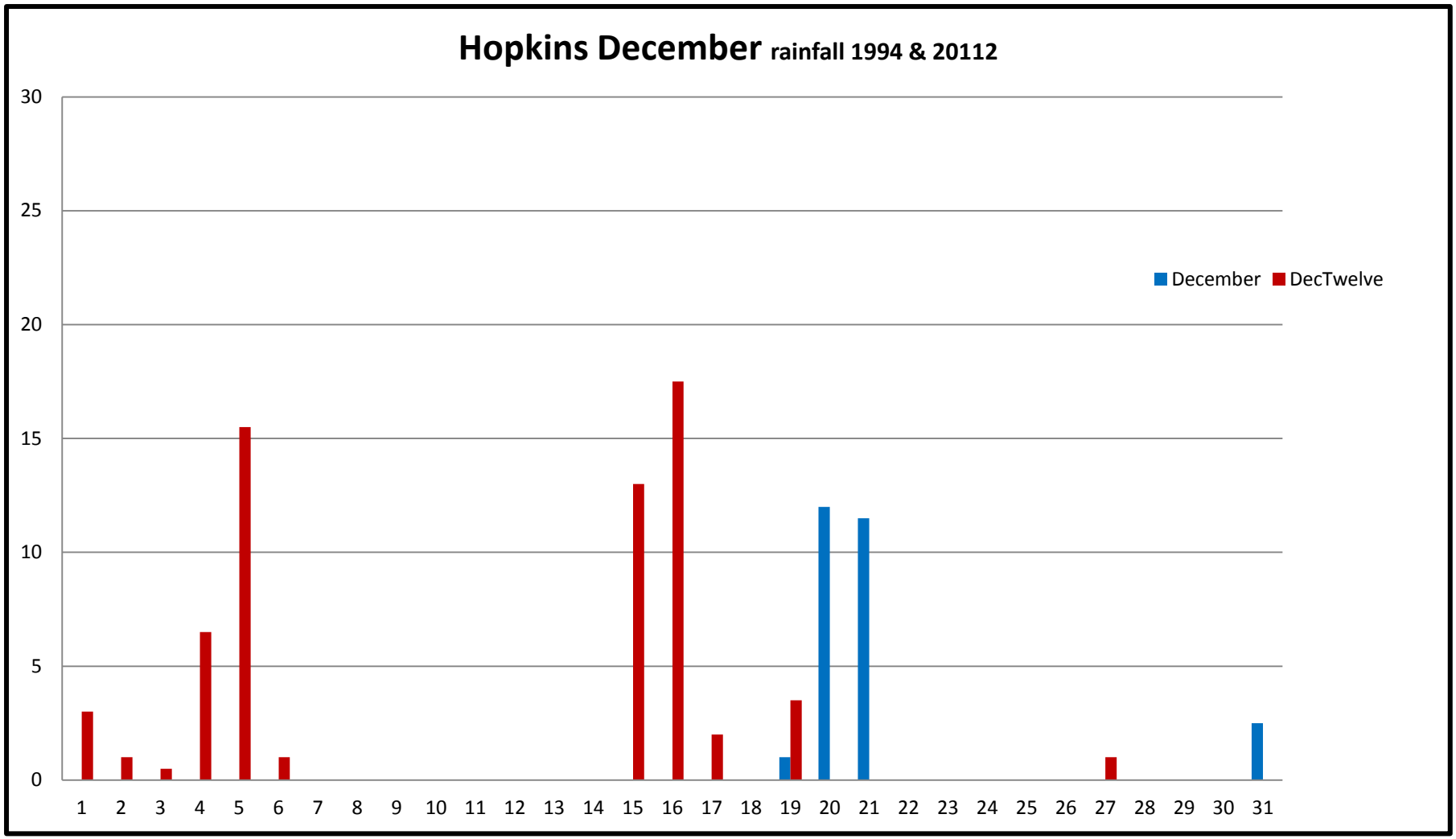
D

D


Hopkins November rainfall 1994 7 2012
30.0
25.0
20.0
15.0
10.0
5.0
0.0
November
NovTwelve
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

D

D

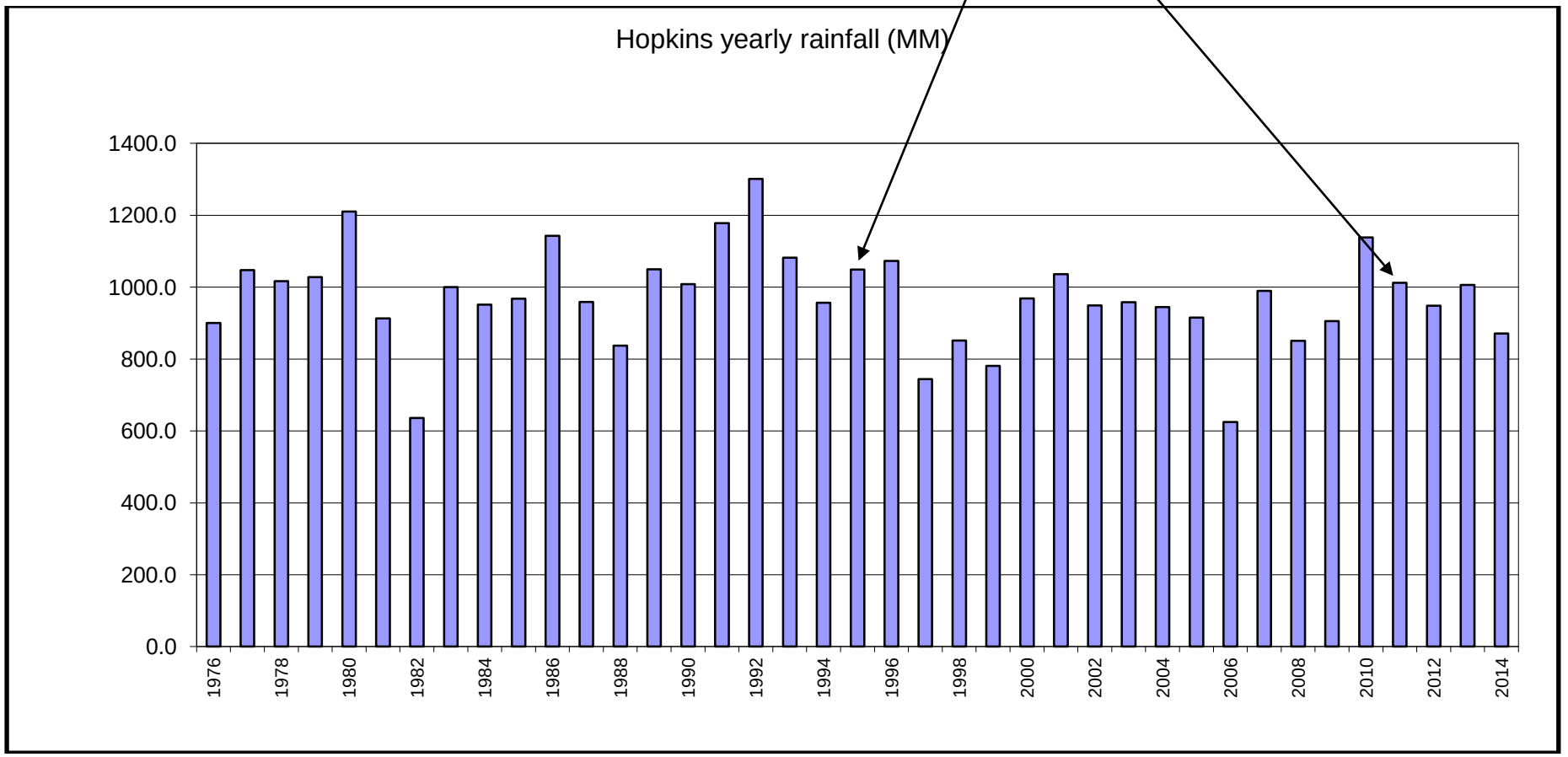

Hopkins December rainfall 1994 & 20112
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
December
DecTwelve

D
D

APPENDIX TWO

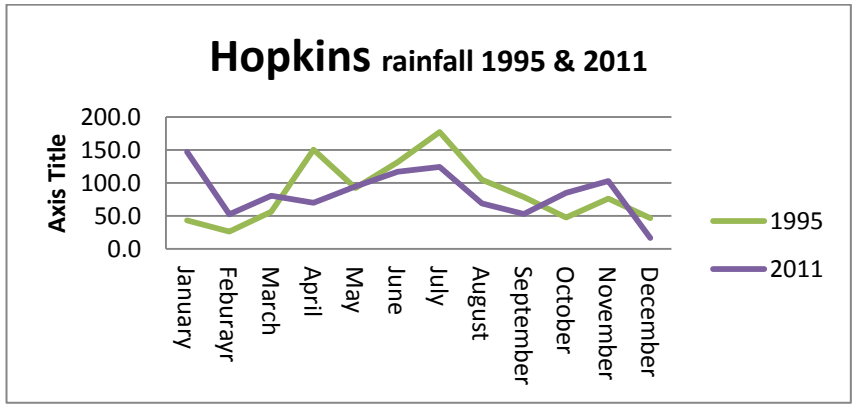
The rainfall charts in Appendix Two have also been capped at 30mm.

There are two months of records on each chart. They cover the two years 1995 and 2011.

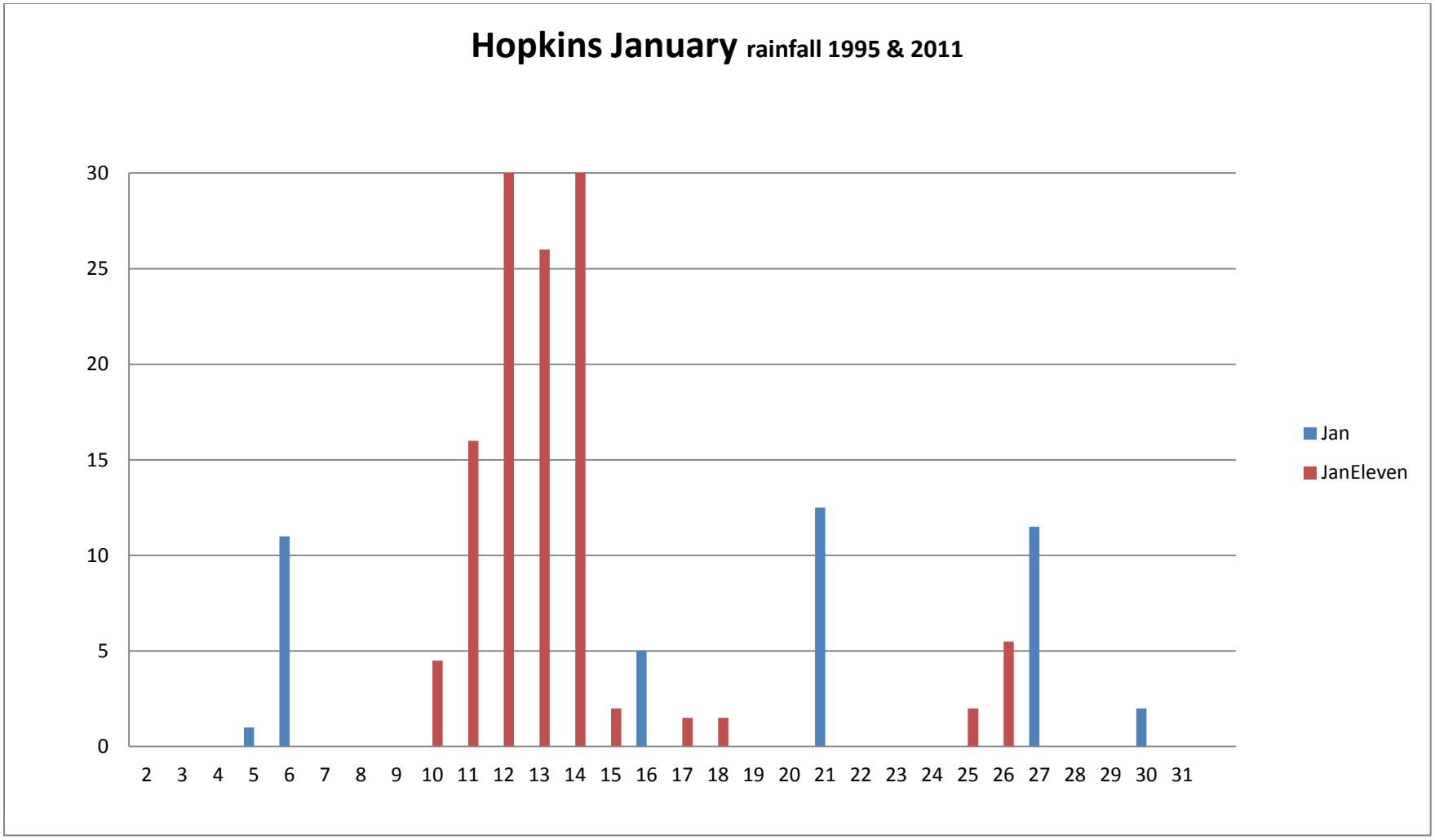


D

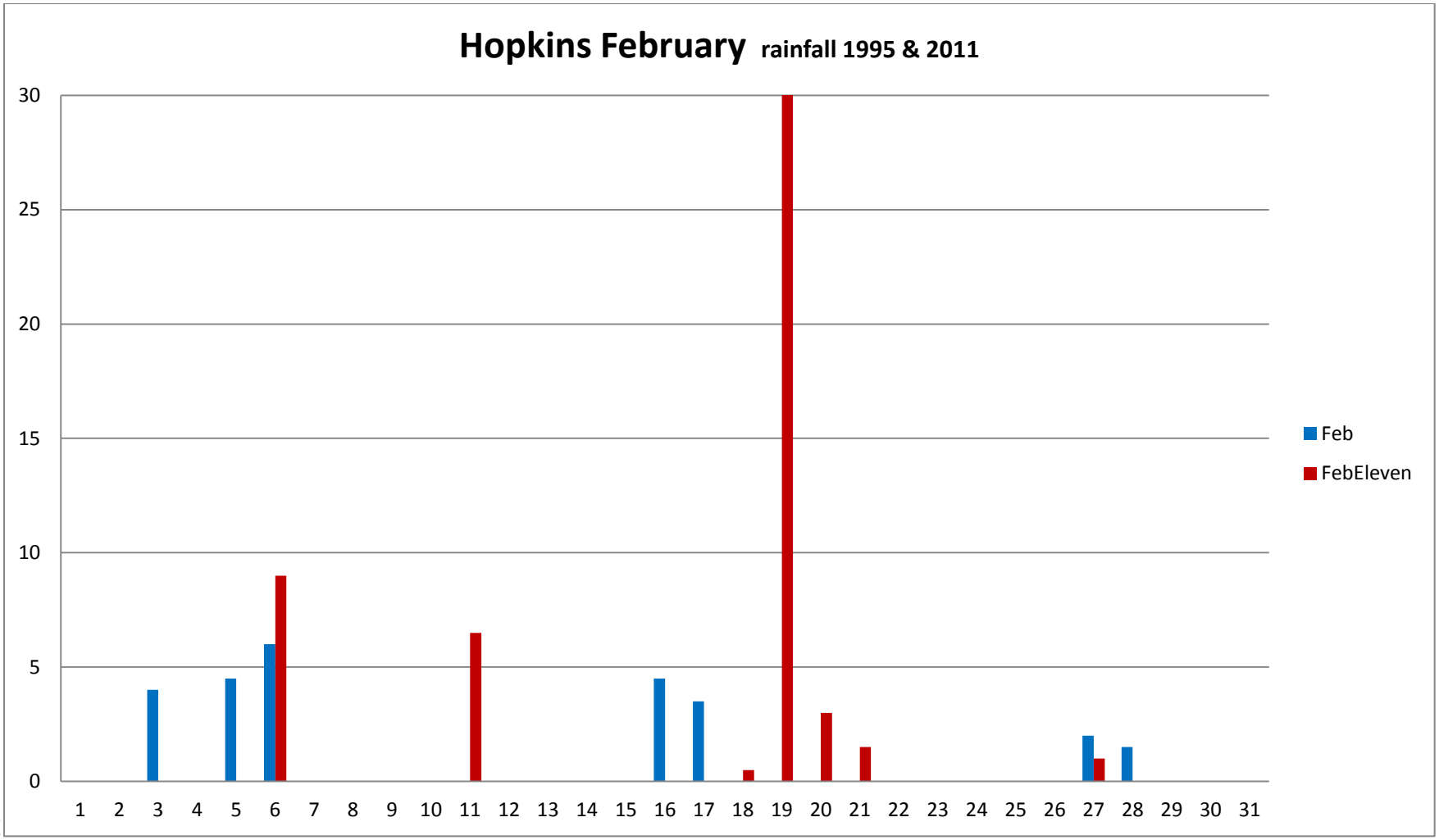
Month	1995	2011
January	43	147
February	26	52.5
March	56	80.5
April	150.5	70
May	92	94.5
June	131.5	117
July	177	124
August	104.5	69
September	78.5	53
October	47.5	85
November	76	103
December	46.5	16.5



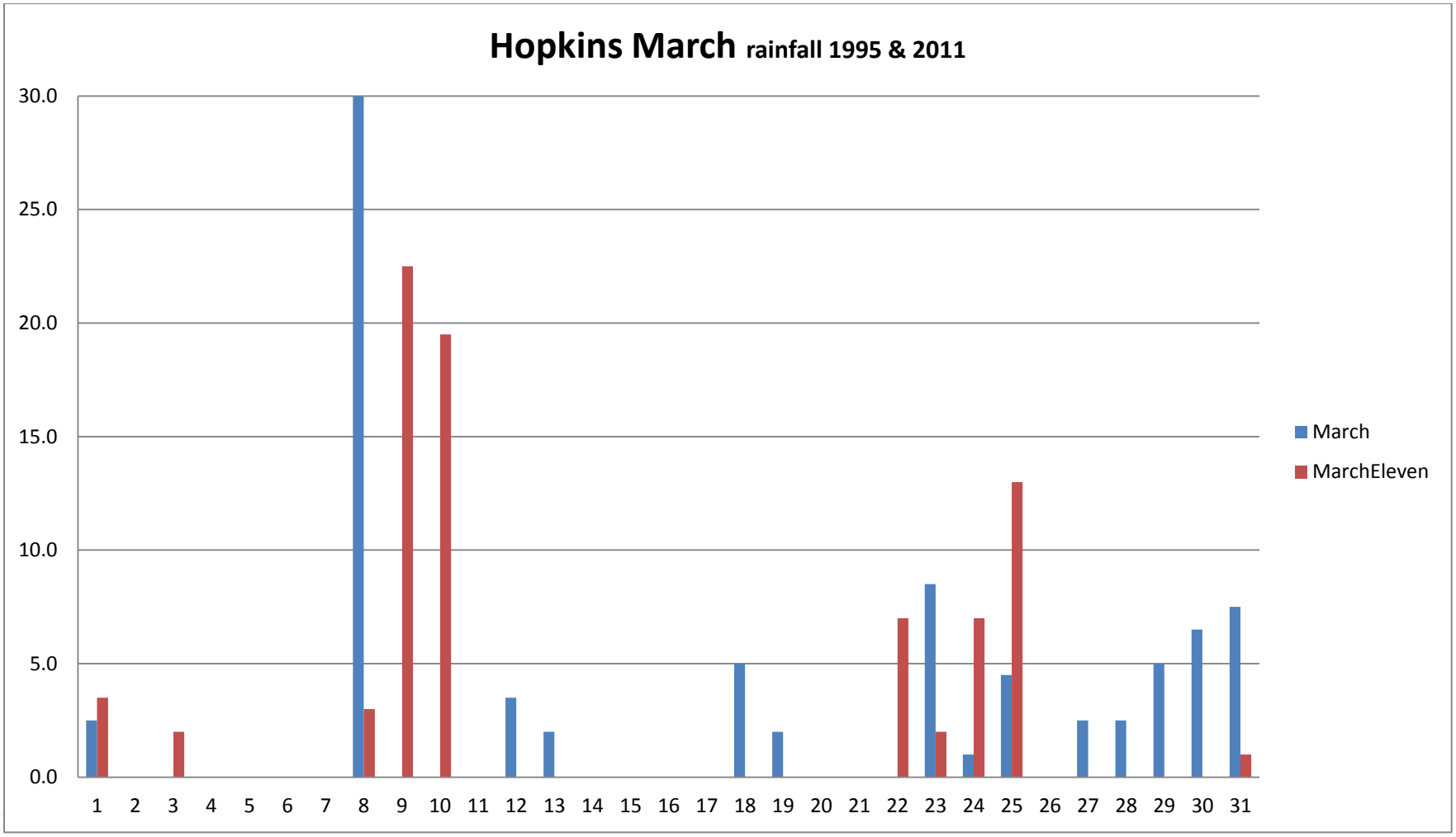
.


Hopkins January rainfall 1995 & 2011
30
25
20
15
10
5
0
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan
JanEleven

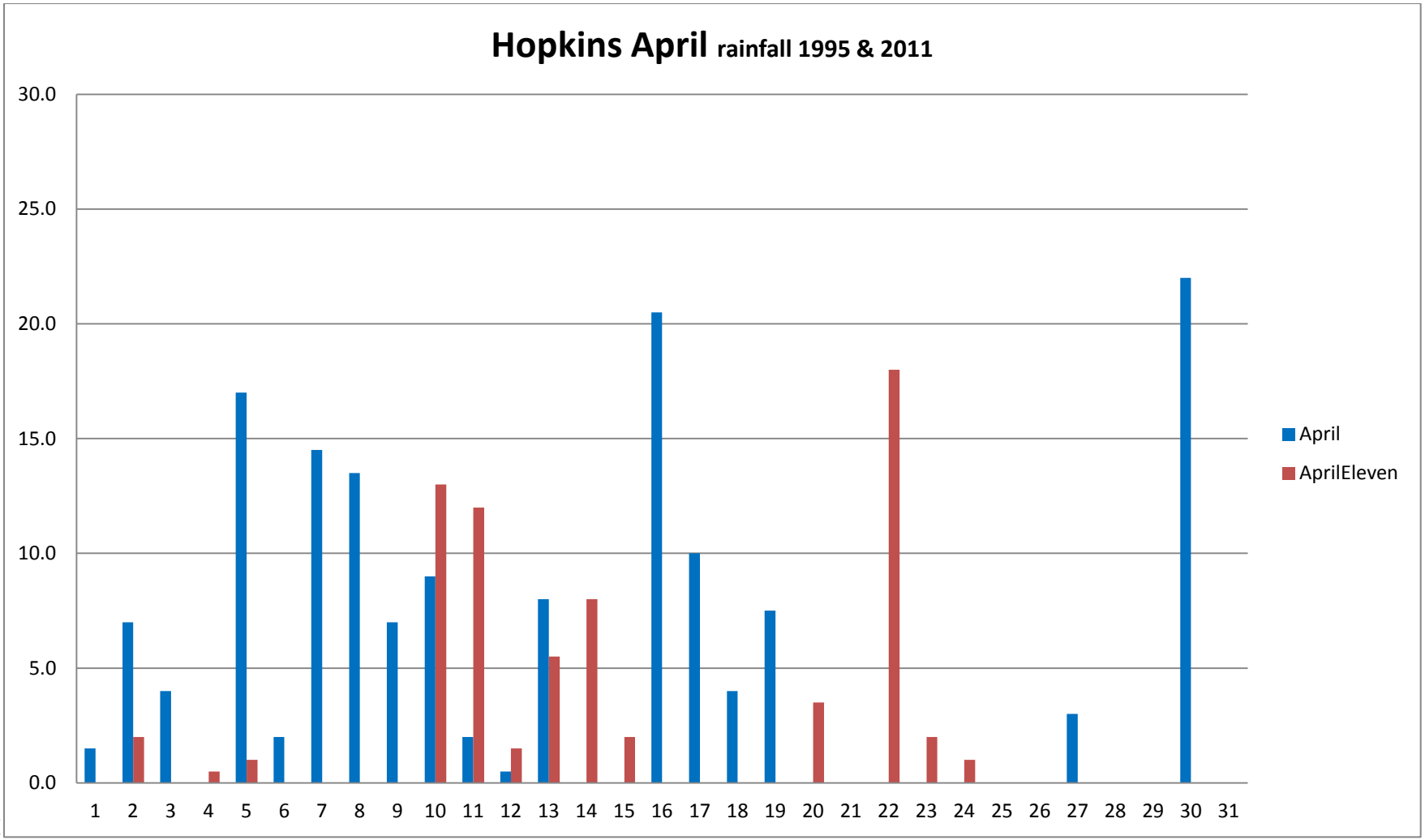
C


Hopkins February rainfall 1995 & 2011
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Feb
FebEleven

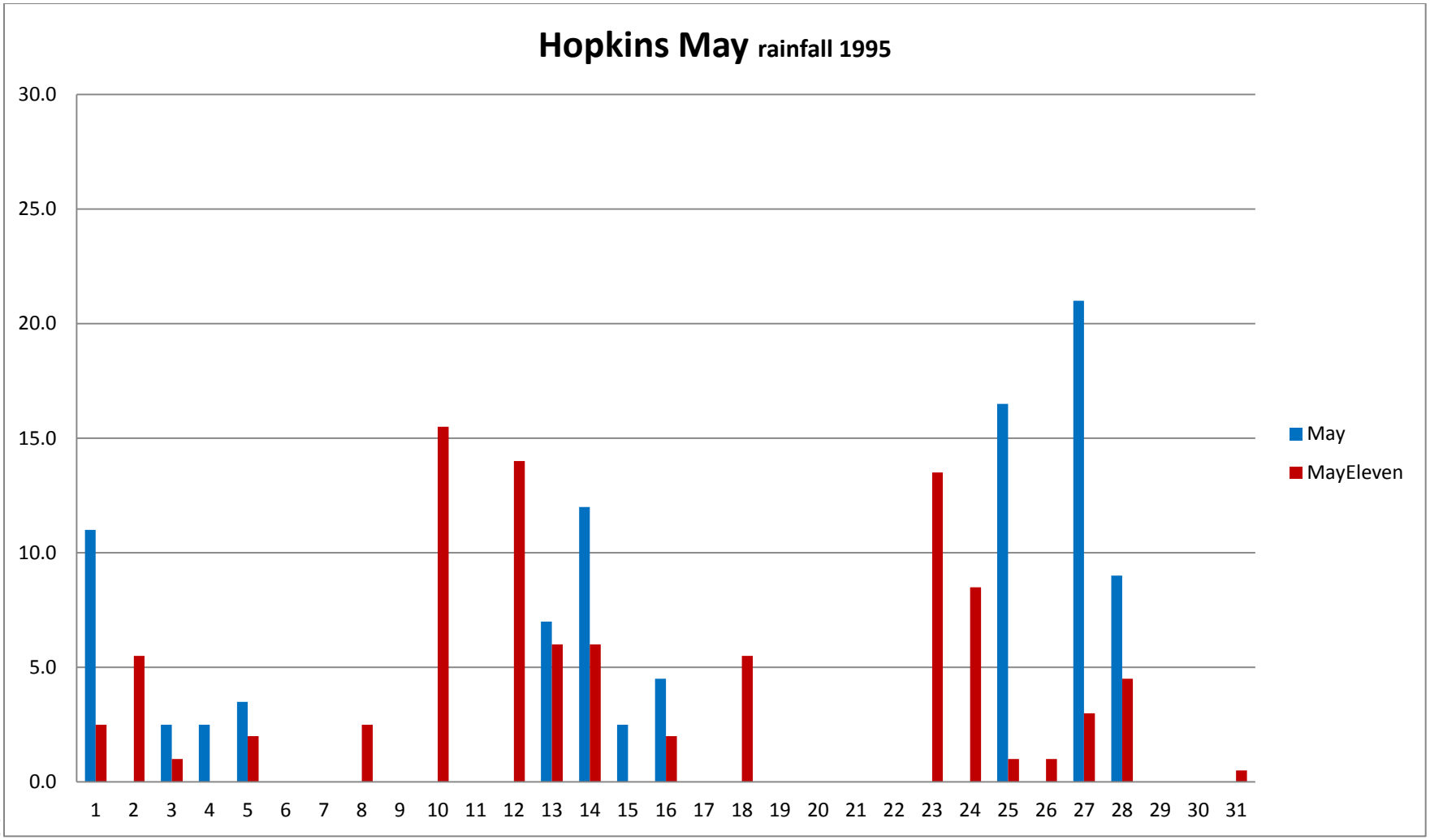
C


Hopkins March rainfall 1995 & 2011
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
March
MarchEleven

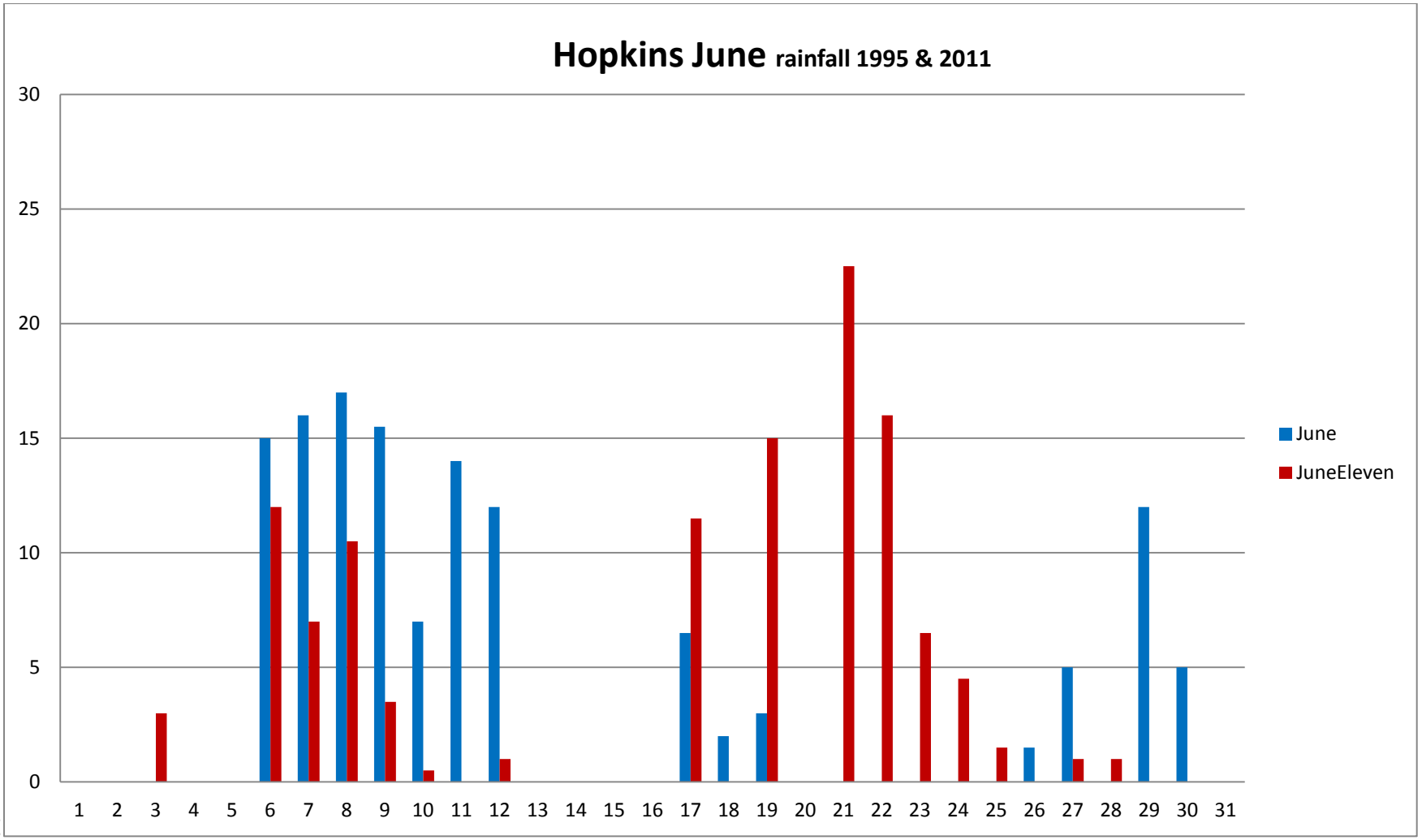
C


Hopkins April rainfall 1995 & 2011
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
April
AprilEleven

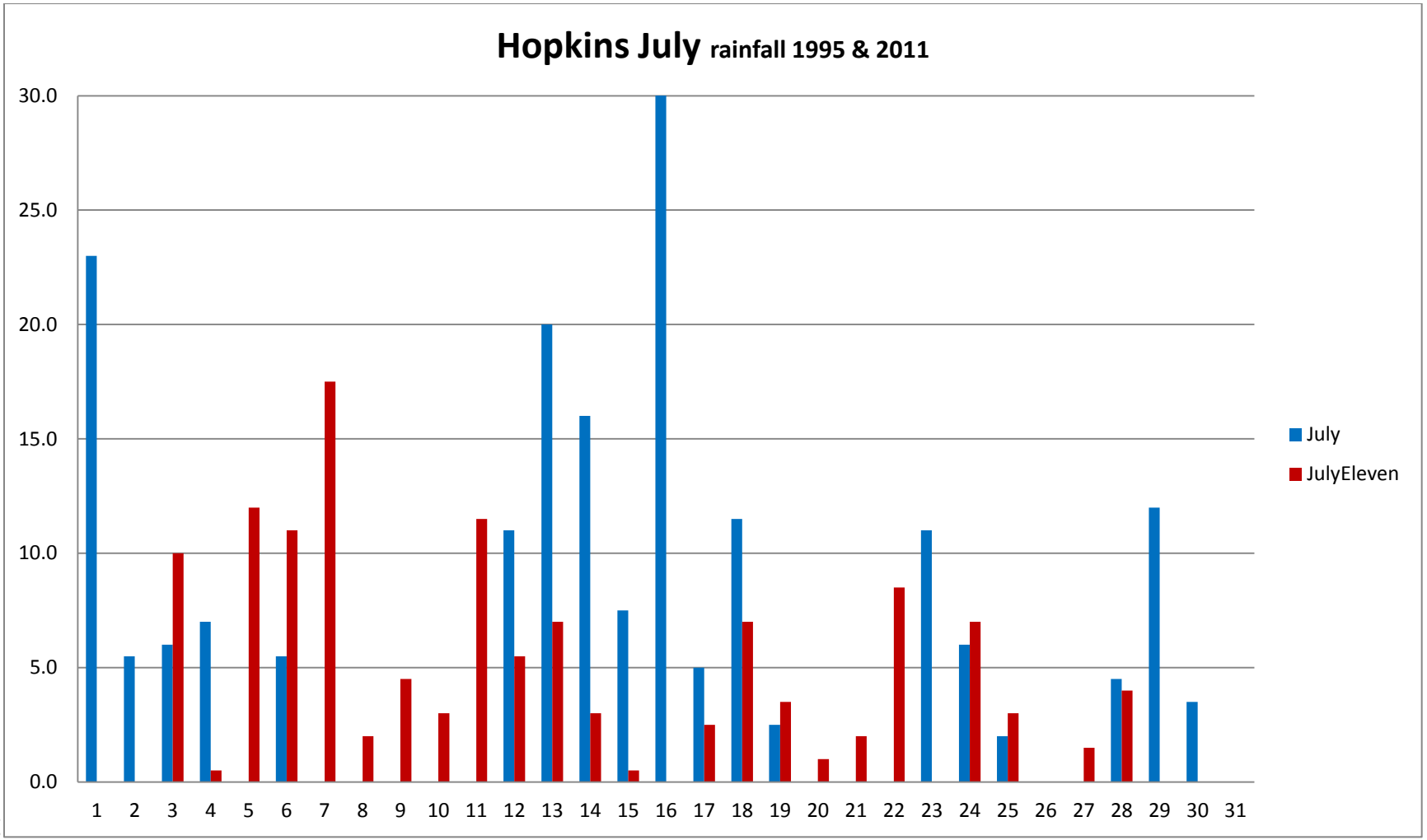
C


Hopkins May rainfall 1995
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
May
MayEleven

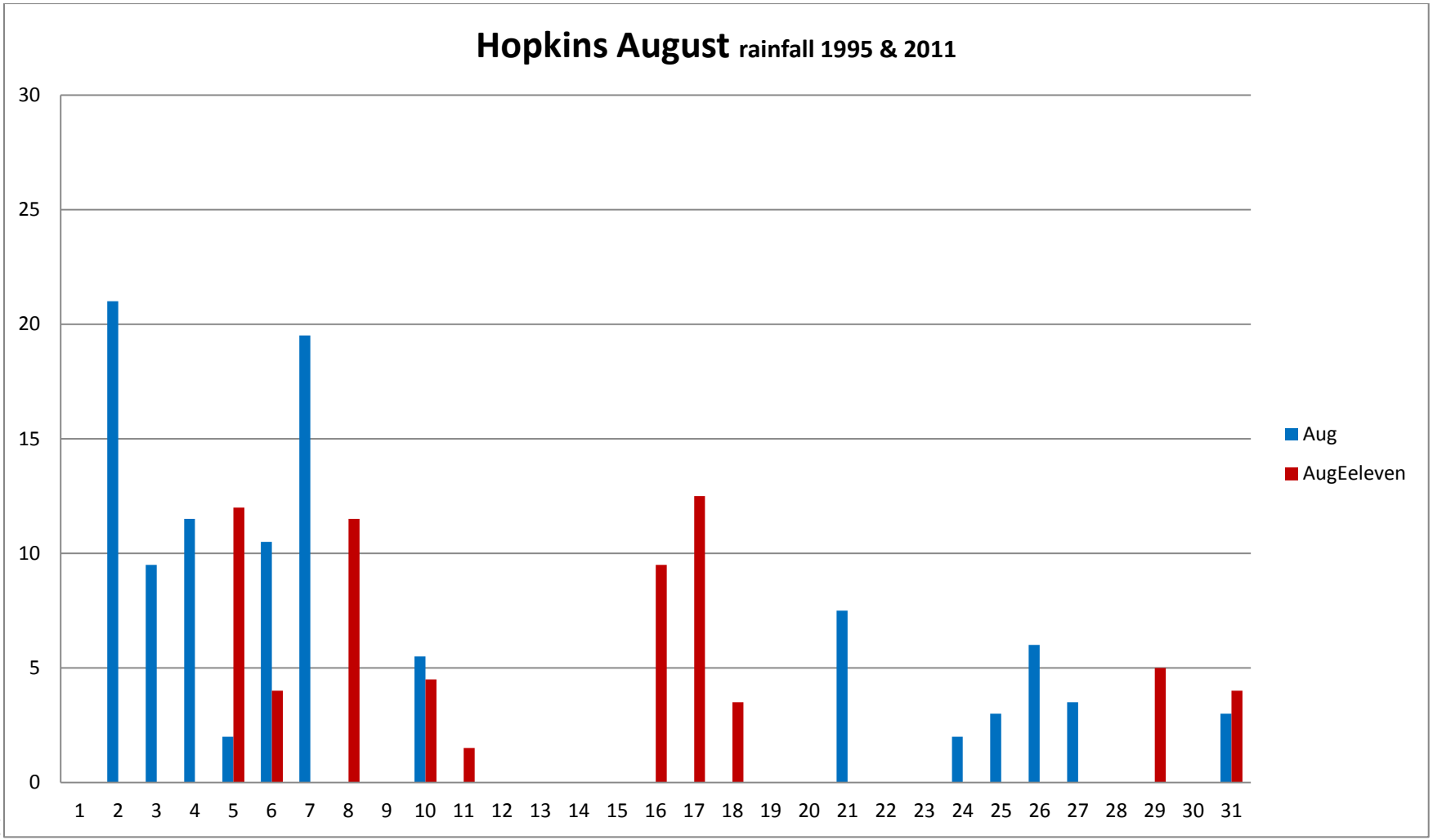
C


Hopkins June rainfall 1995 & 2011
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
June
JuneEleven

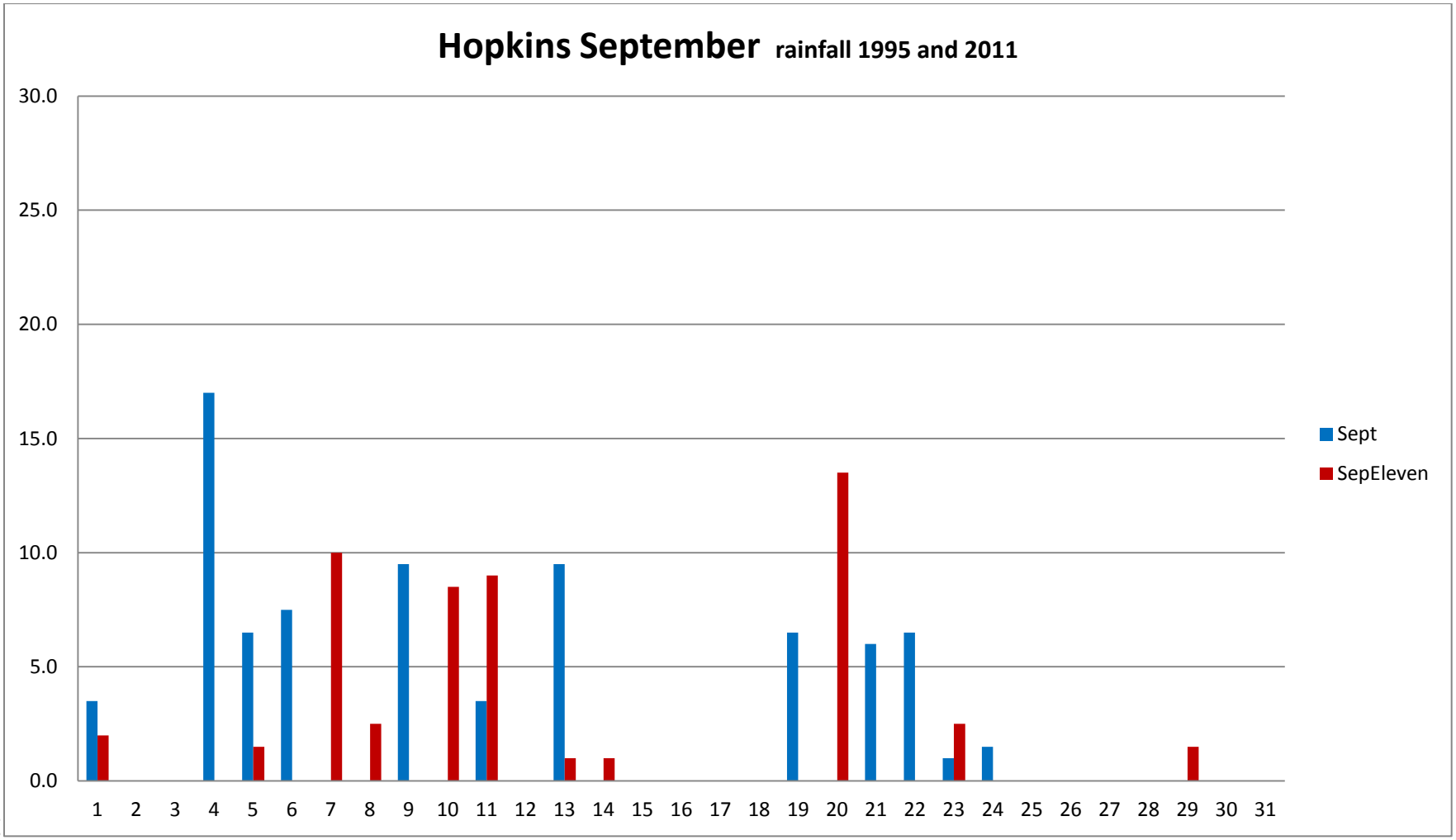
C


Hopkins July rainfall 1995 & 2011
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
July
JulyEleven

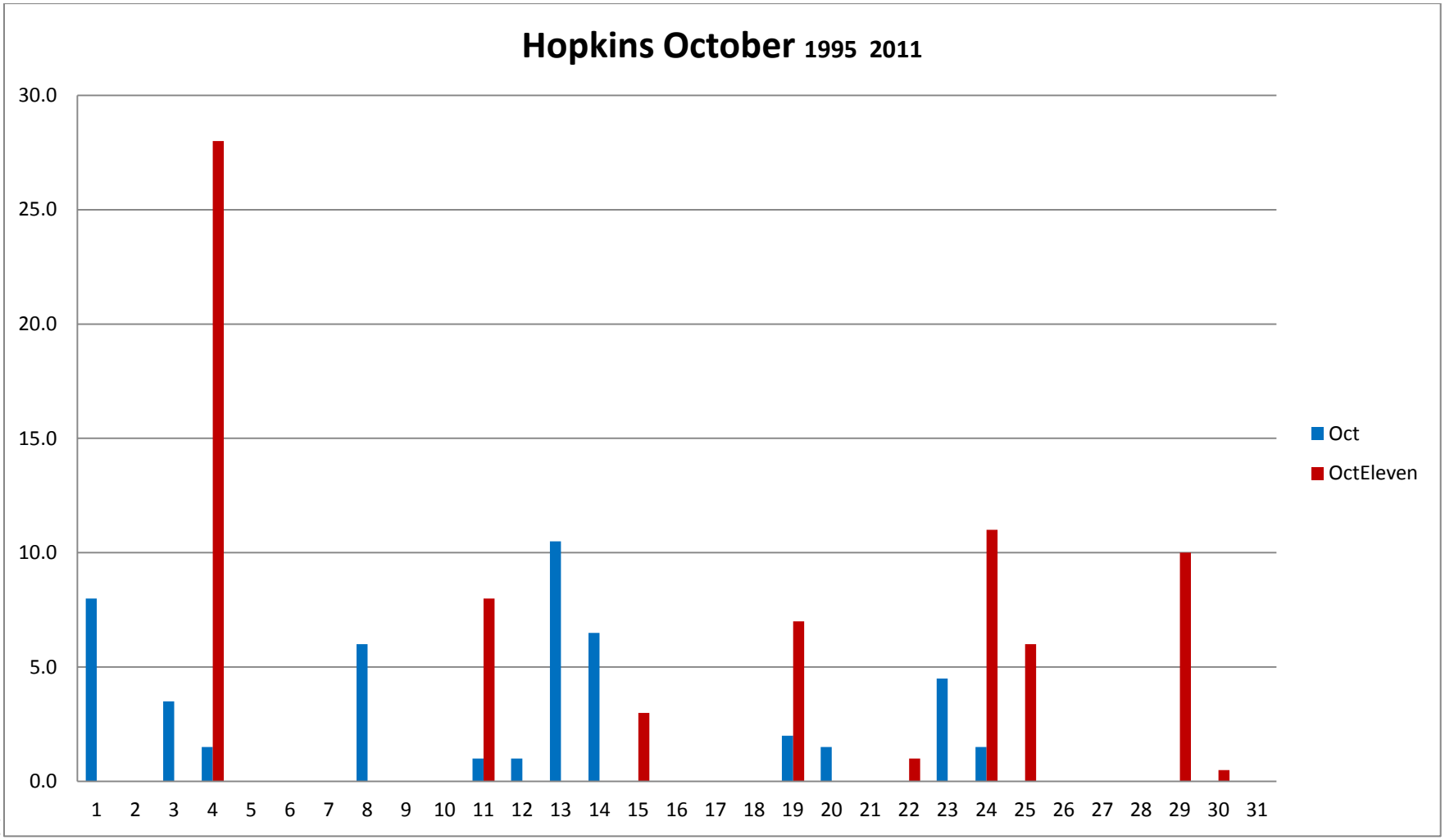
C


Hopkins August rainfall 1995 & 2011
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Aug
AugEeleven

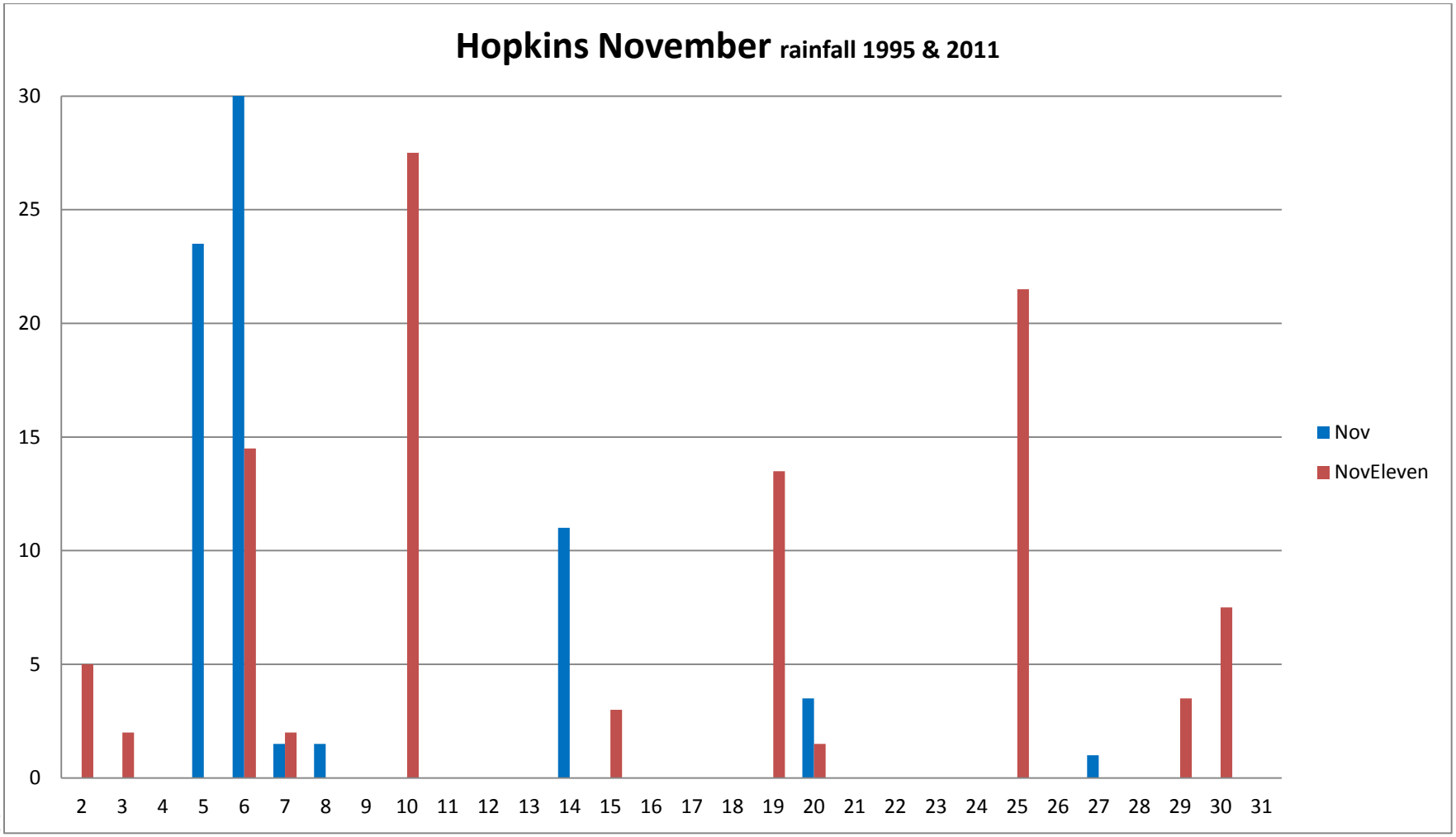
C


Hopkins September rainfall 1995 and 2011
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Sept
SepEleven

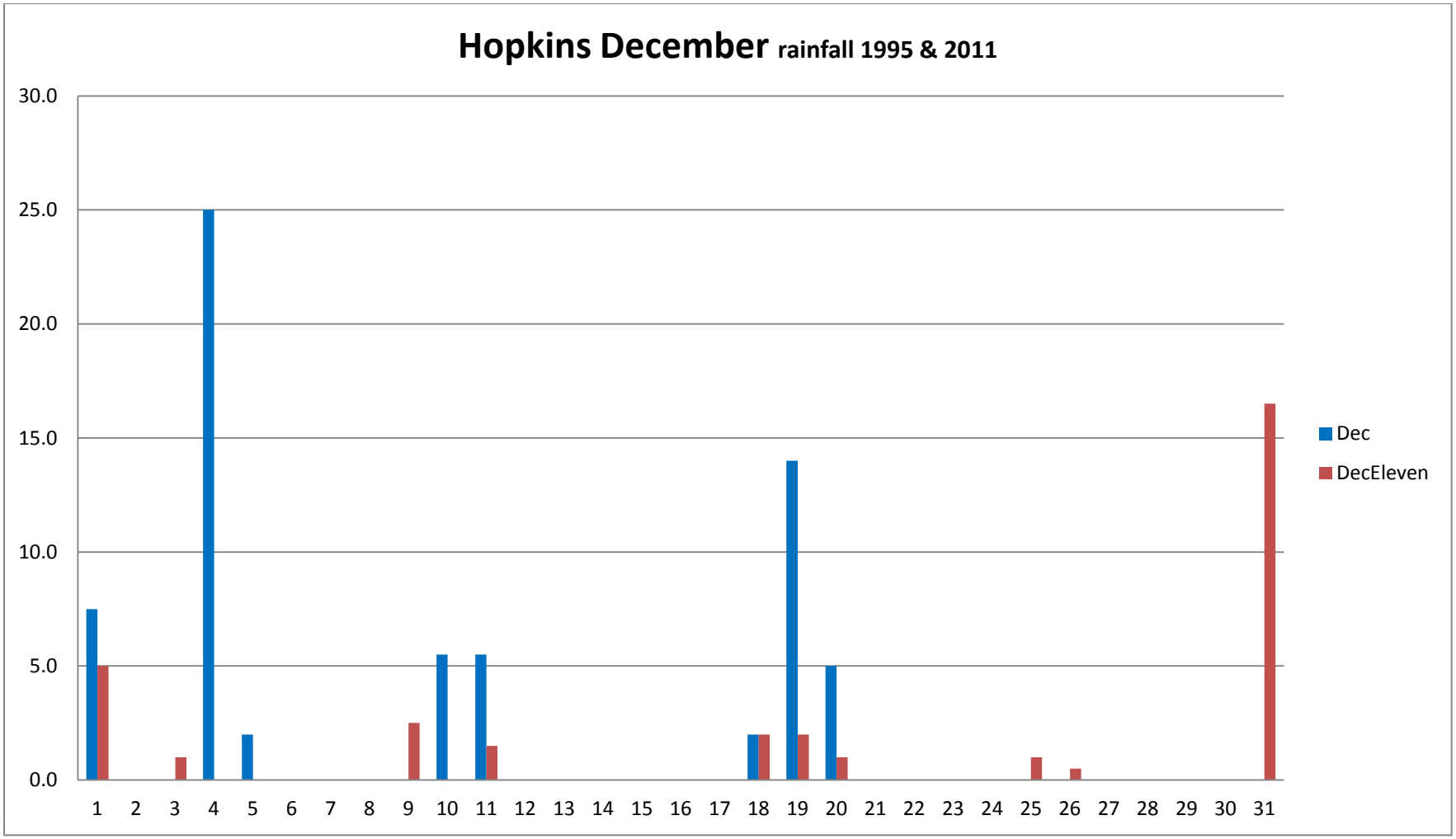
C


Hopkins October 1995 2011
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Oct
OctEleven

C


Hopkins November rainfall 1995 & 2011
30
25
20
15
10
5
0
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Nov
NovEleven

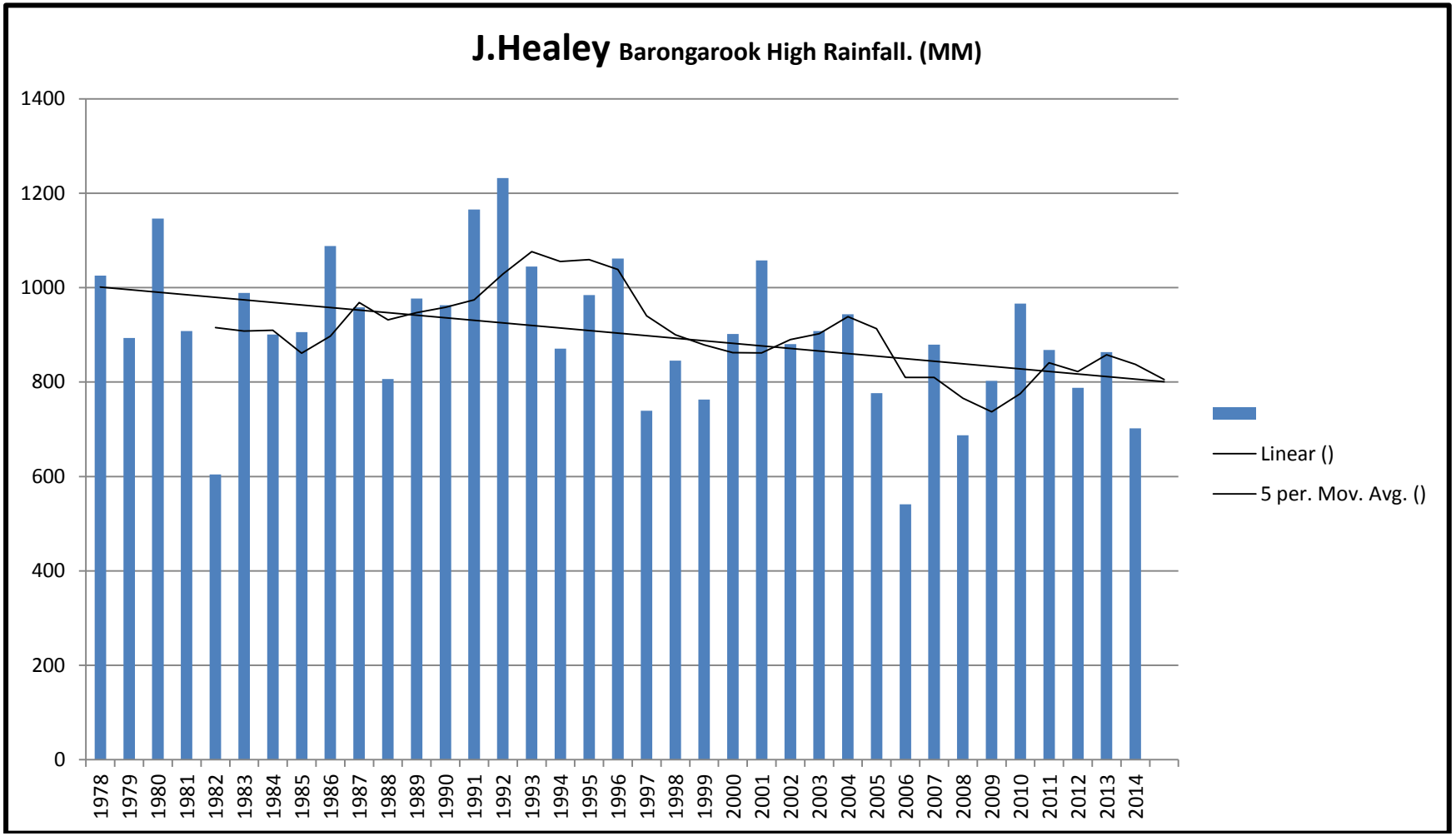
C


Hopkins December rainfall 1995 & 2011
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Dec
DecEleven

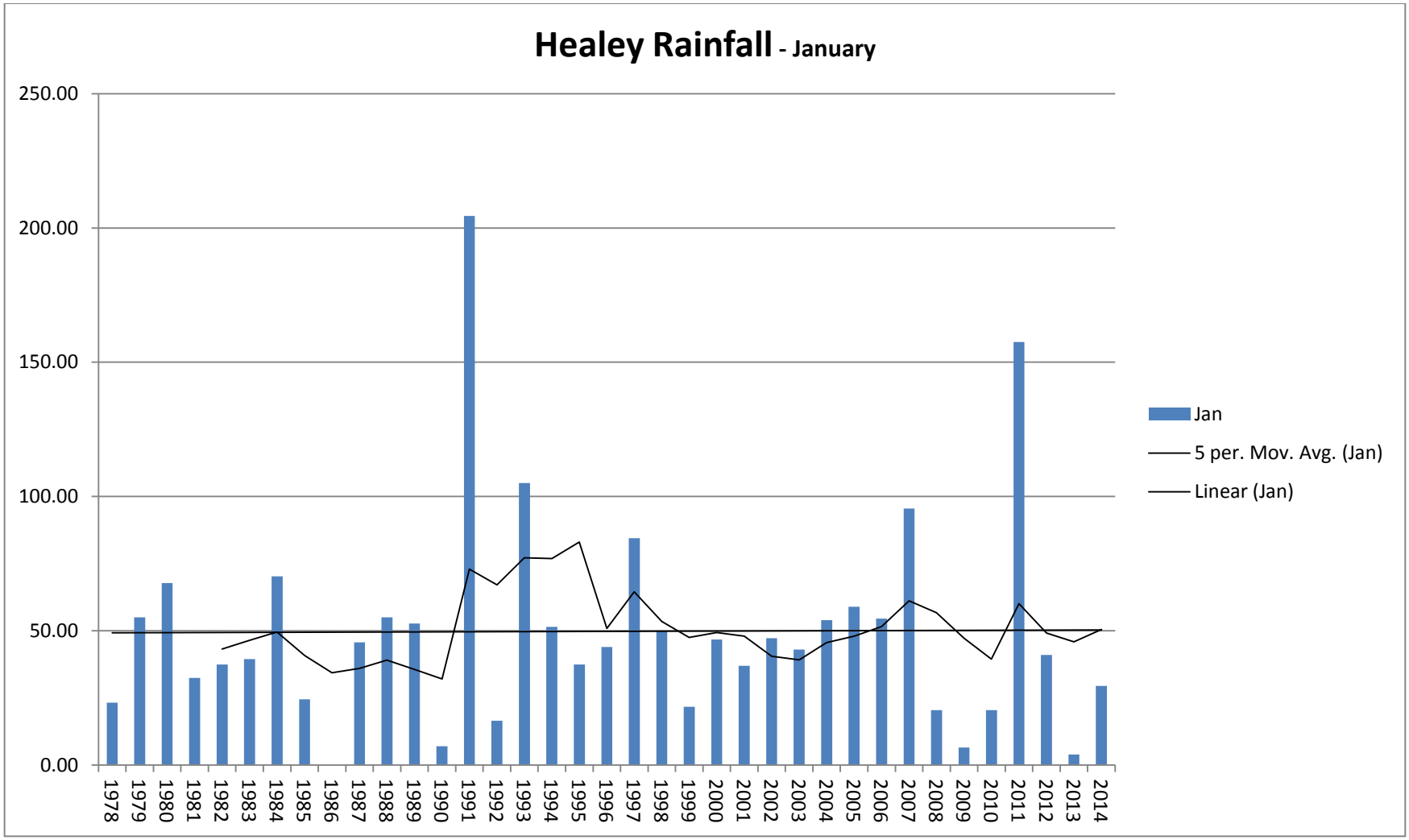
C
C
C
C

APPENDIX THREE

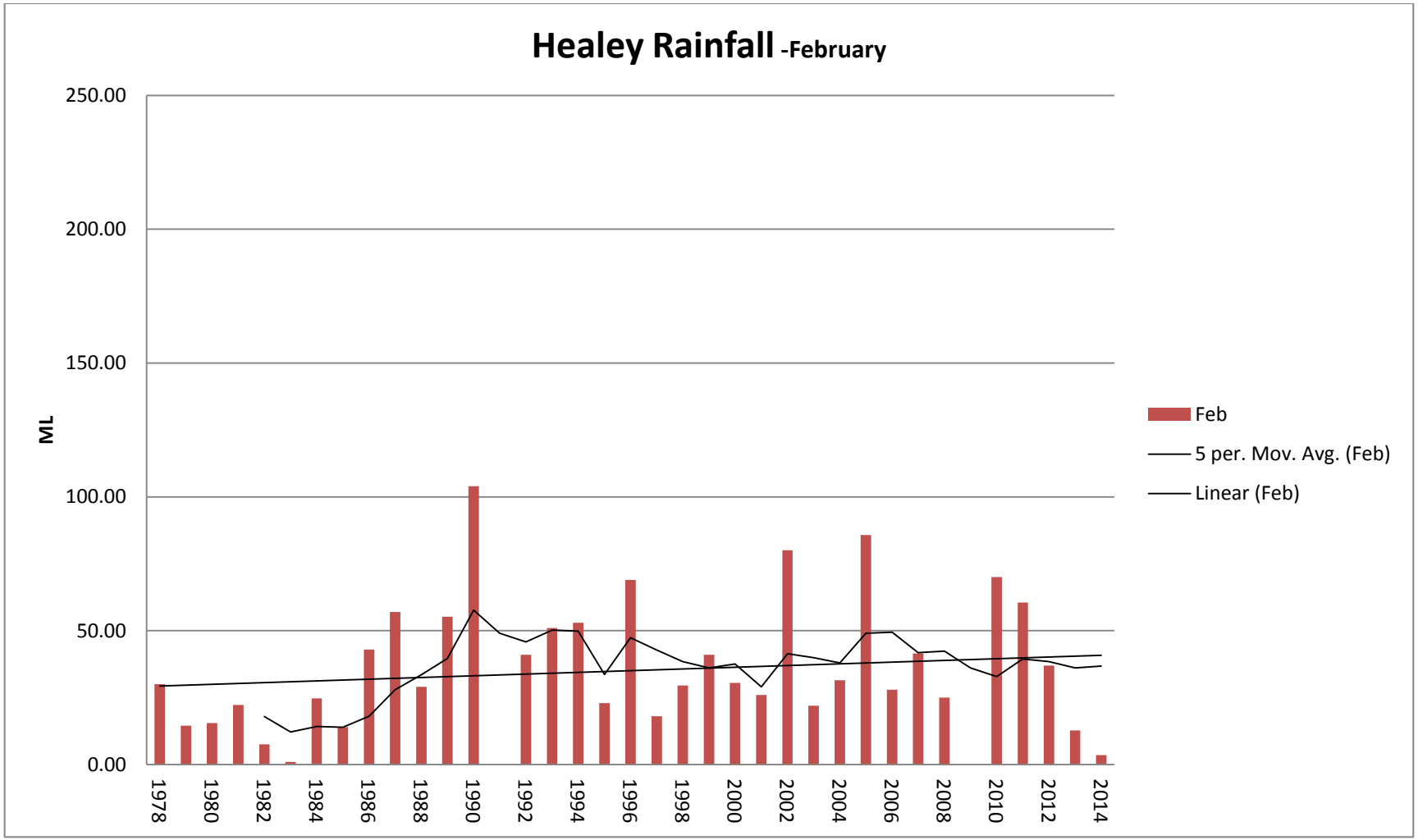
The following charts are taken from the Healey rainfall data.



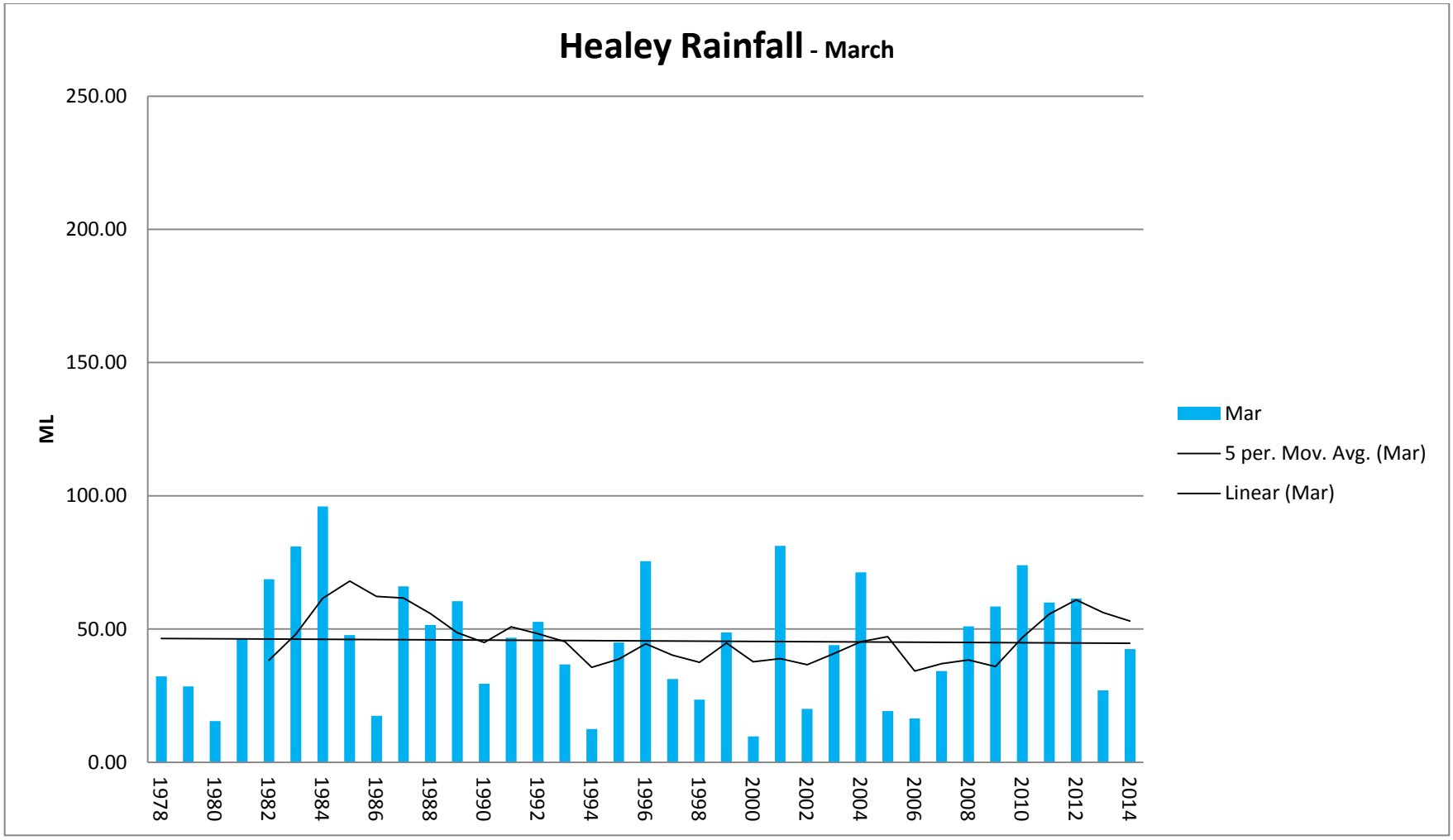
C


Healey Rainfall - January
250.00
200.00
150.00
100.00
50.00
0.00
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Jan
5 per. Mov. Avg. (Jan)
Linear (Jan)

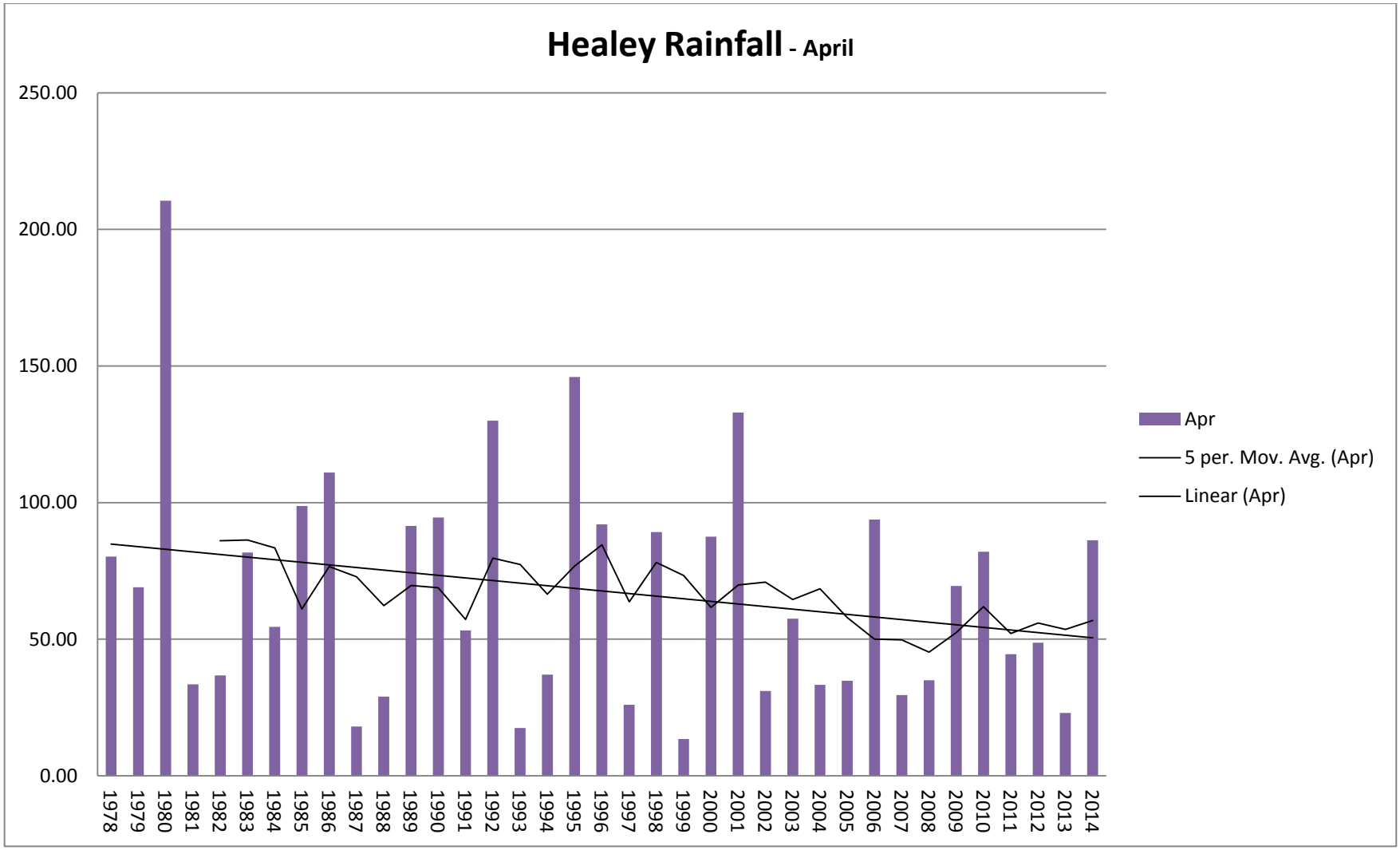
C


Healey Rainfall -February
250.00
200.00
150.00
100.00
50.00
0.00
ML
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Feb
5 per. Mov. Avg. (Feb)
Linear (Feb)

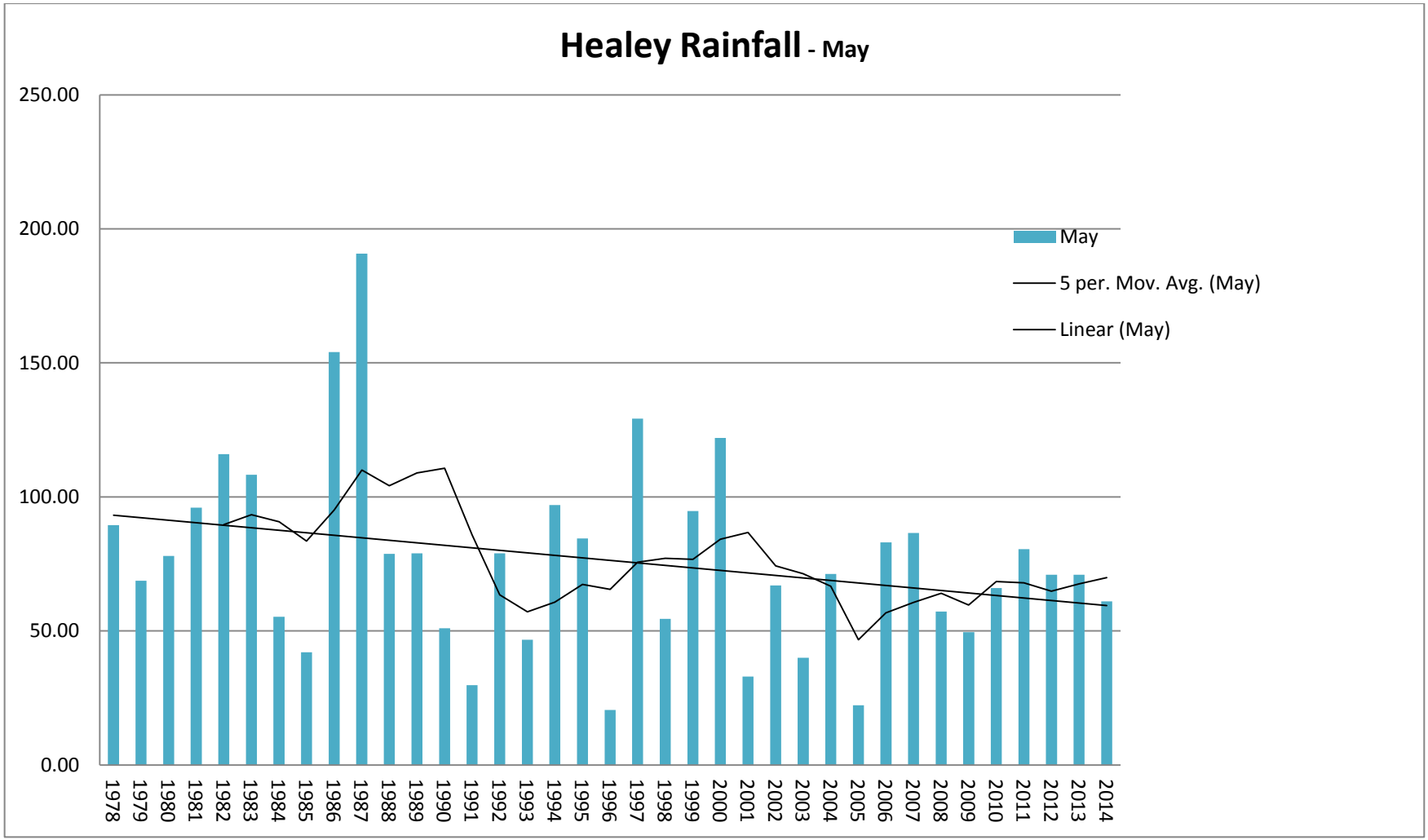
C


Healey Rainfall - March
250.00
200.00
150.00
100.00
50.00
0.00
ML
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Mar
5 per. Mov. Avg. (Mar)
Linear (Mar)

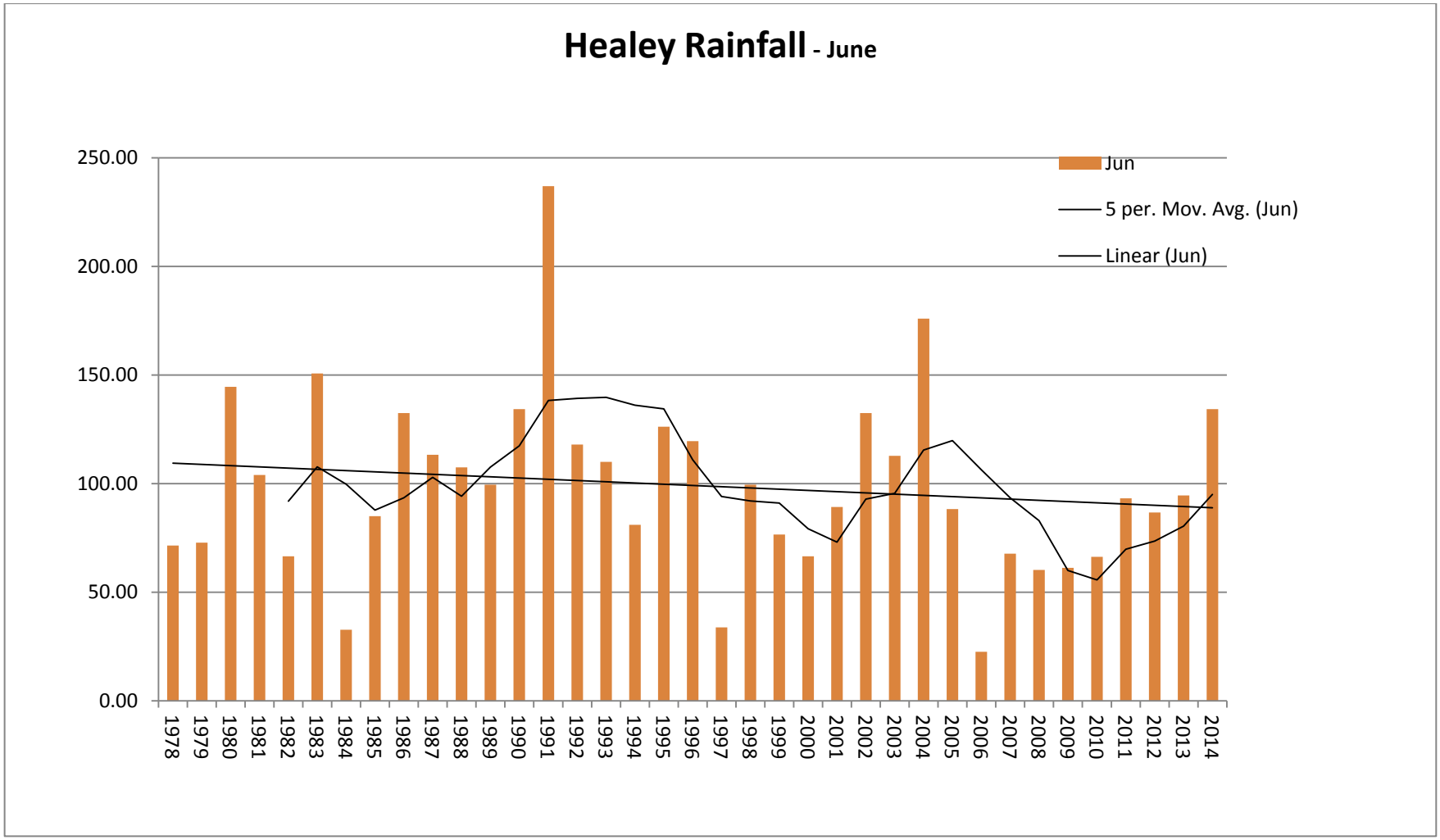
C


Healey Rainfall - April
250.00
200.00
150.00
100.00
50.00
0.00
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Apr
5 per. Mov. Avg. (Apr)
Linear (Apr)

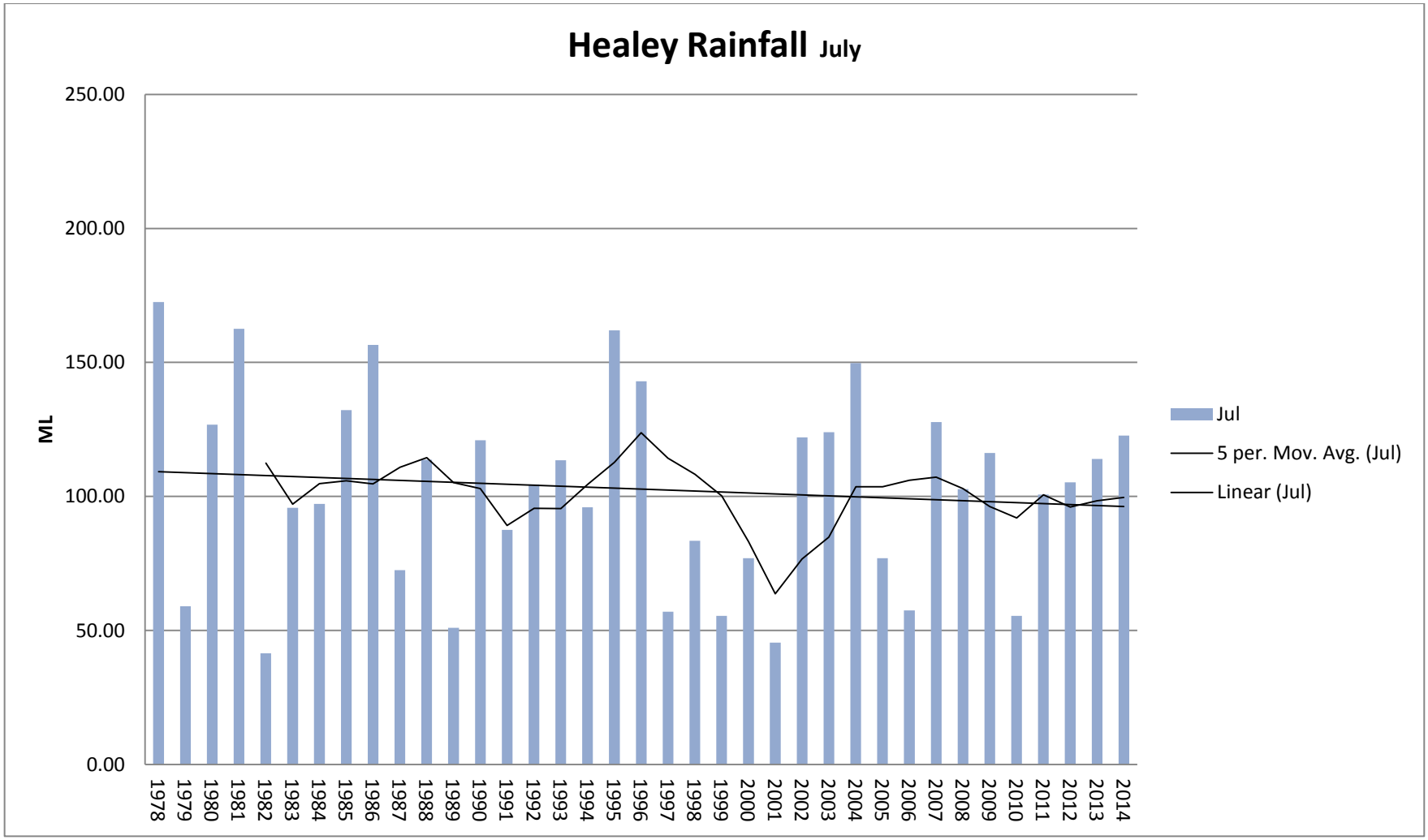
C


Healey Rainfall - May
250.00
200.00
150.00
100.00
50.00
0.00
May
5 per. Mov. Avg. (May)
Linear (May)
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

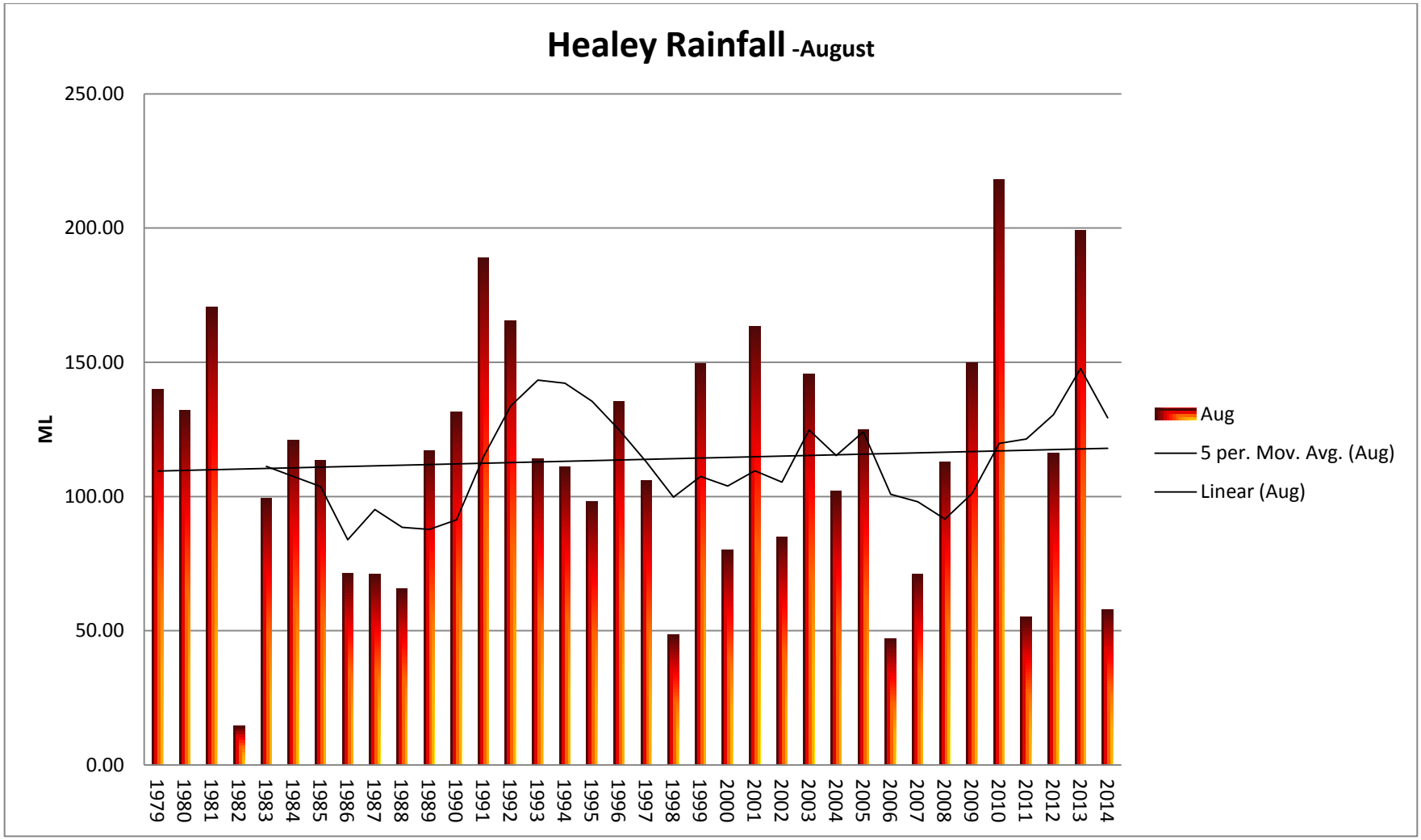
C


Healey Rainfall - June
250.00
200.00
150.00
100.00
50.00
0.00
Jun
5 per. Mov. Avg. (Jun)
Linear (Jun)
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

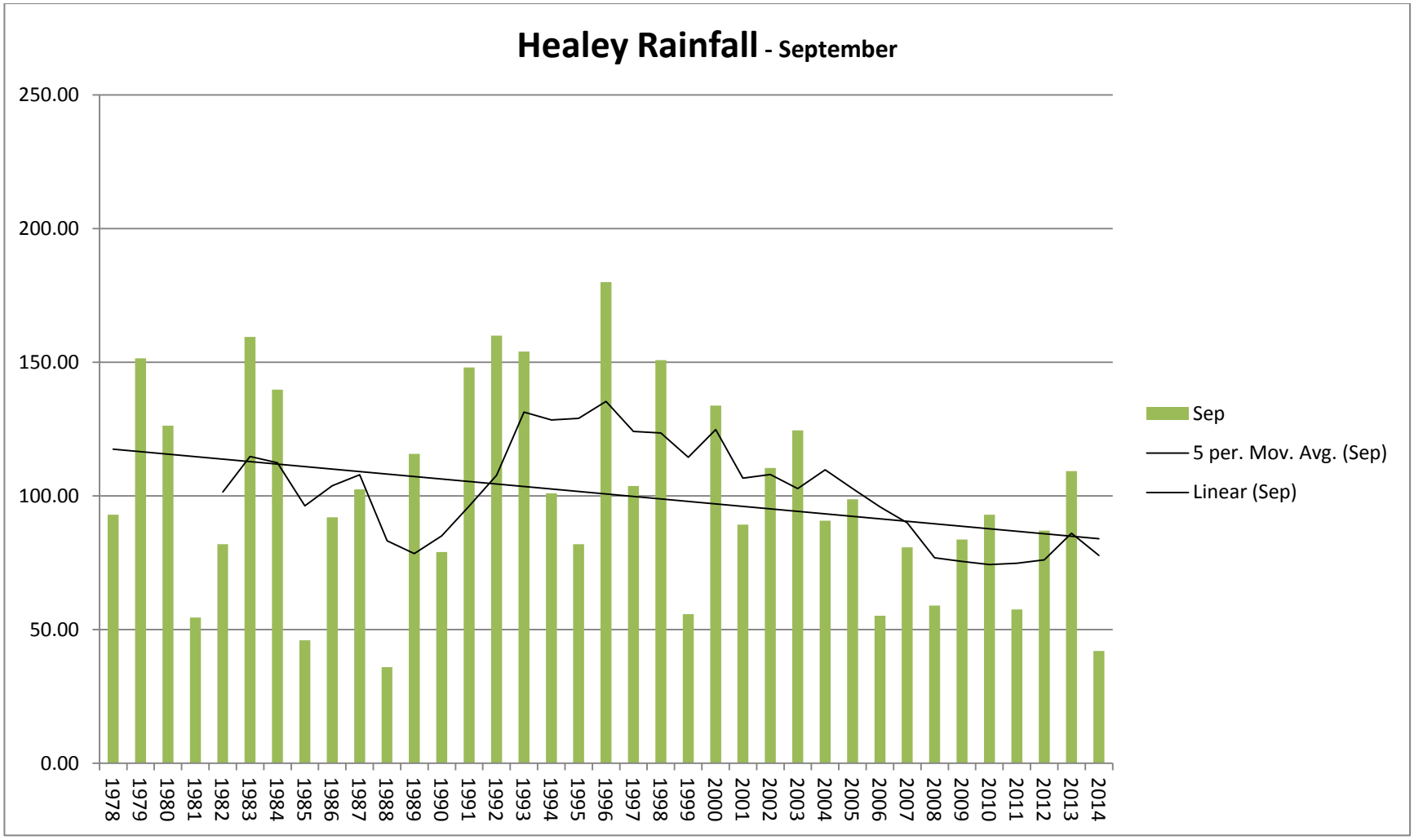
C


Healey Rainfall July
250.00
200.00
150.00
100.00
50.00
0.00
ML
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Jul
5 per. Mov. Avg. (Jul)
Linear (Jul)

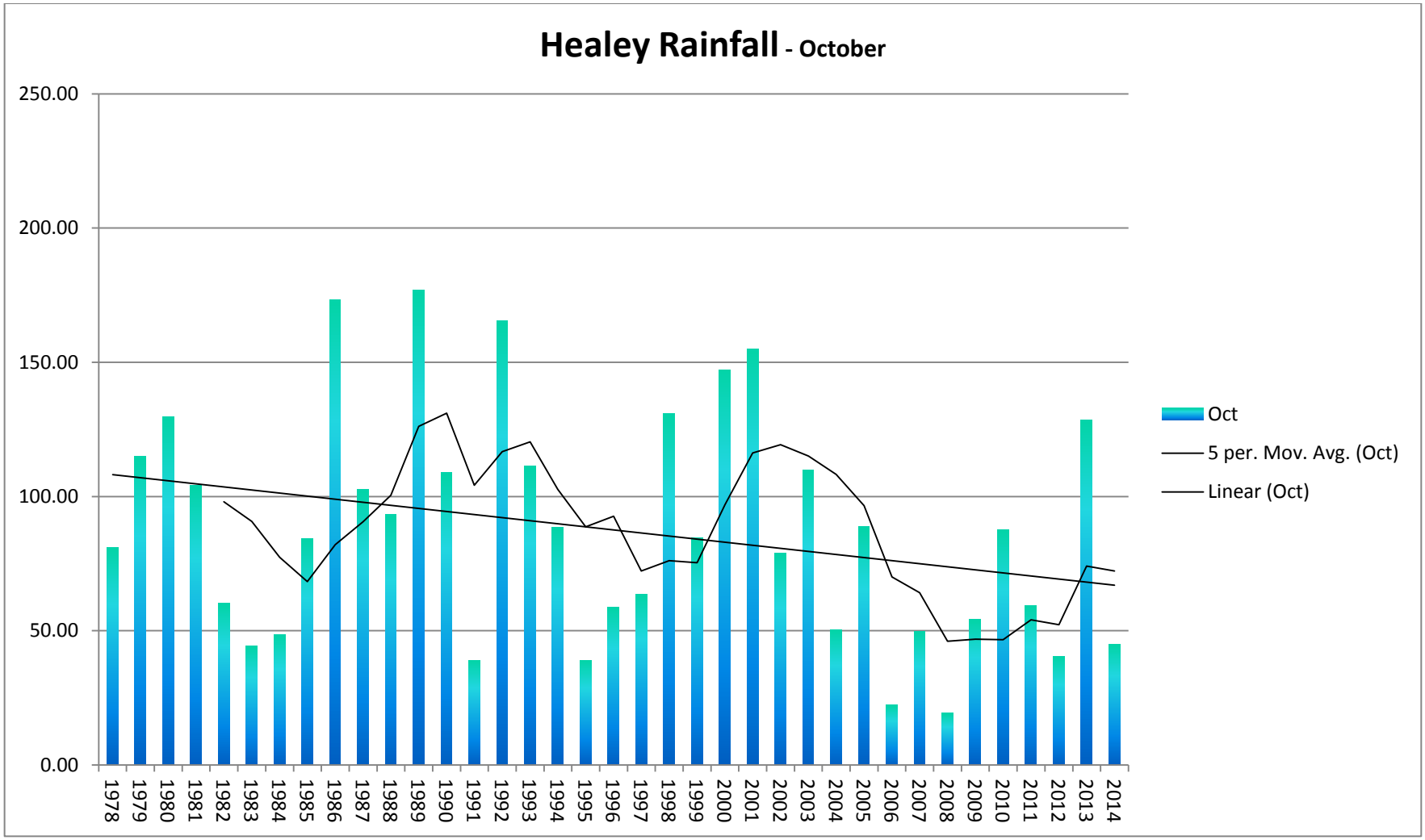
C


Healey Rainfall -August
250.00
200.00
150.00
100.00
50.00
0.00
ML
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Aug
5 per. Mov. Avg. (Aug)
Linear (Aug)

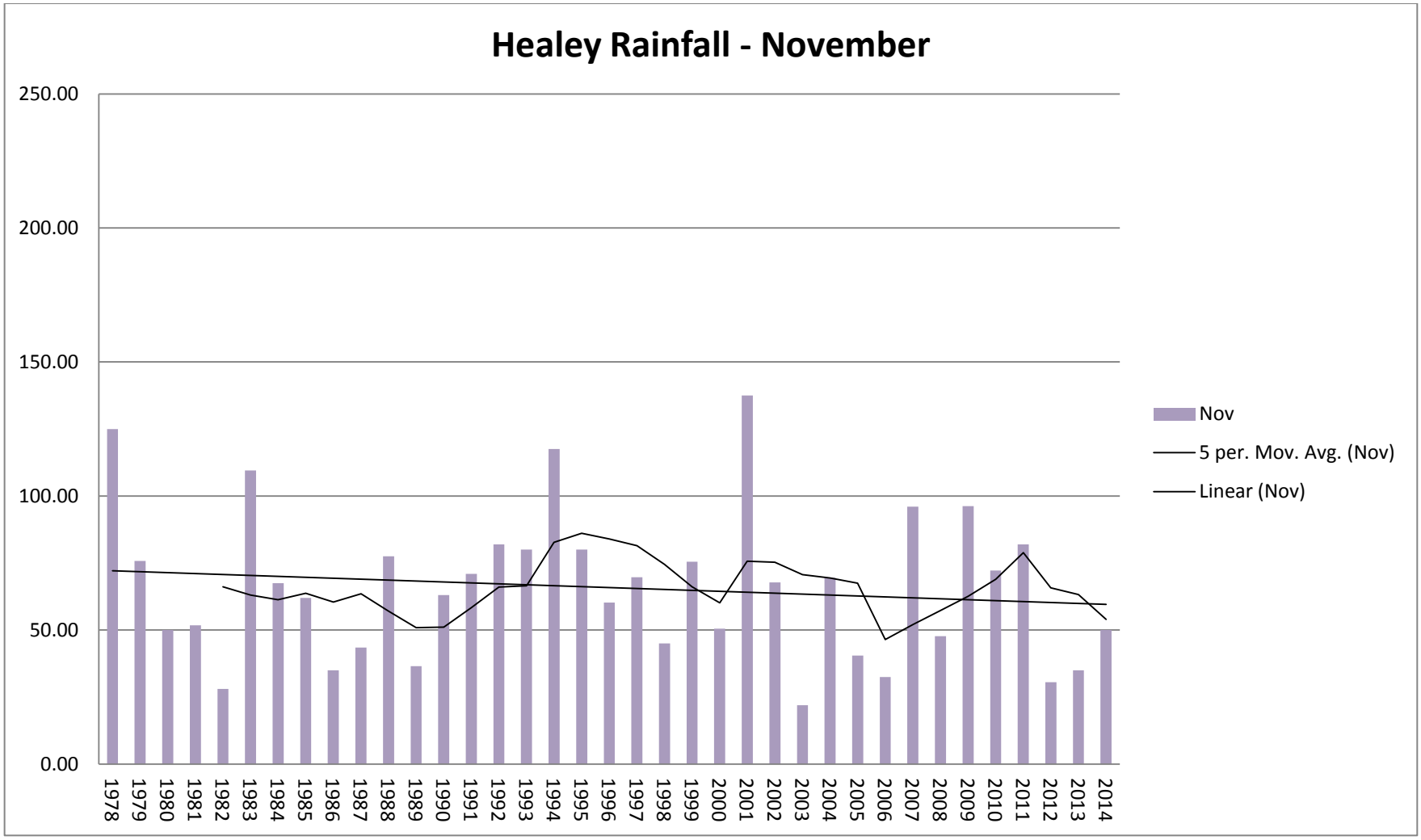
C


Healey Rainfall - September
250.00
200.00
150.00
100.00
50.00
0.00
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Sep
5 per. Mov. Avg. (Sep)
Linear (Sep)

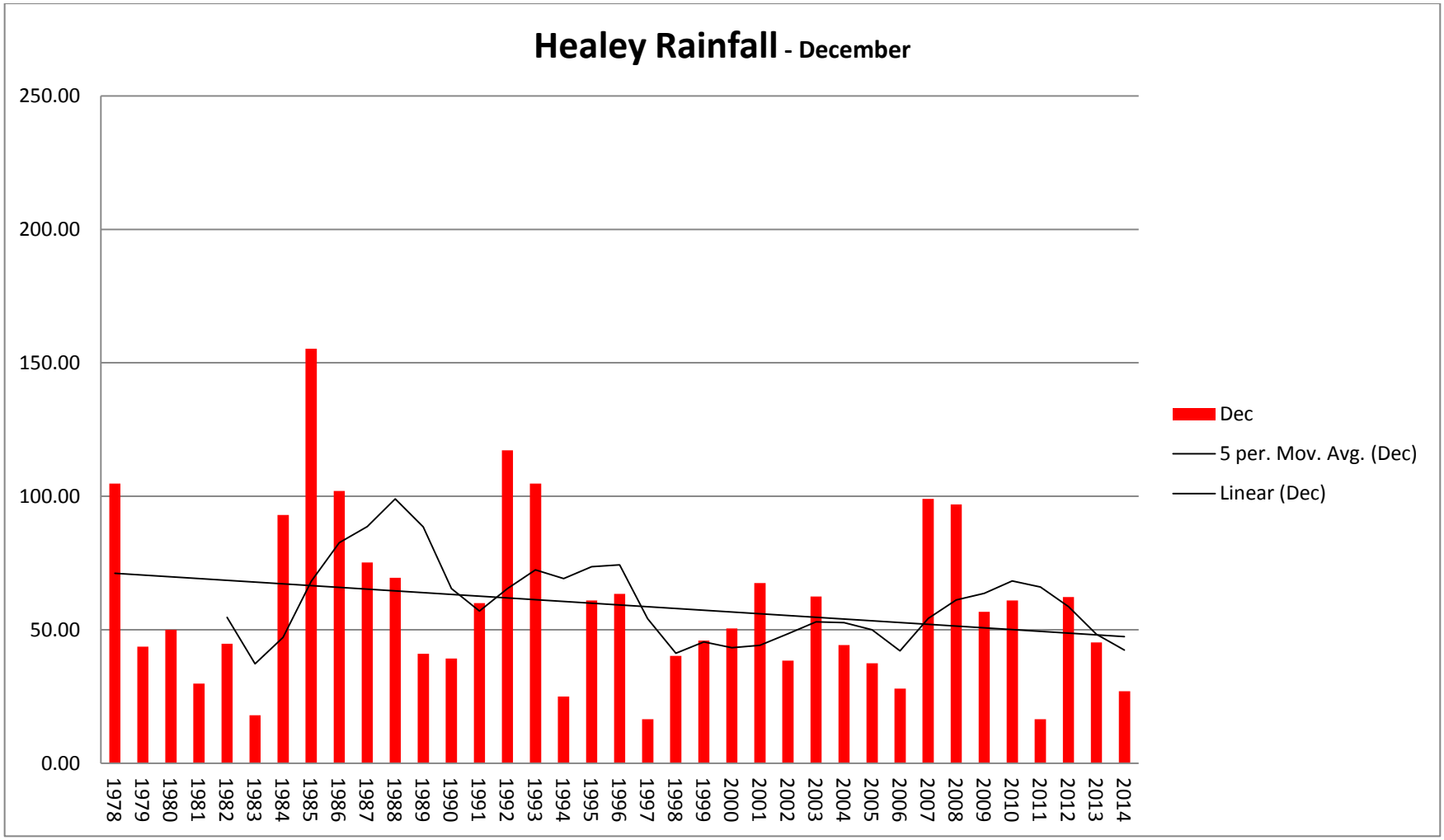
Cc


Healey Rainfall - October
250.00
200.00
150.00
100.00
50.00
0.00
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Oct
5 per. Mov. Avg. (Oct)
Linear (Oct)

C


Healey Rainfall - November
250.00
200.00
150.00
100.00
50.00
0.00
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Nov
5 per. Mov. Avg. (Nov)
Linear (Nov)

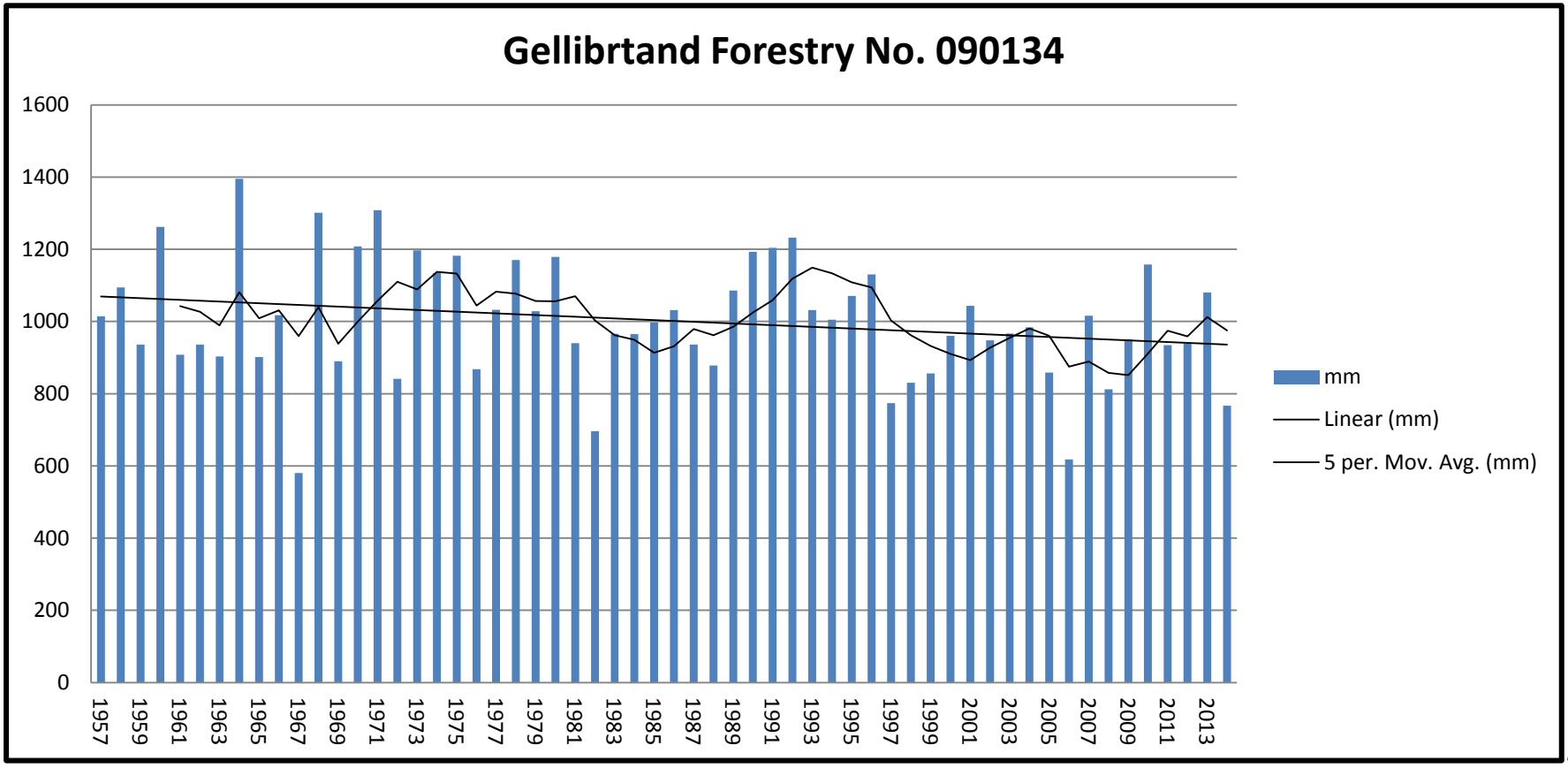
C


Healey Rainfall - December
250.00
200.00
150.00
100.00
50.00
0.00
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Dec
5 per. Mov. Avg. (Dec)
Linear (Dec)

C
C
c
C

APPENDIX FOUR

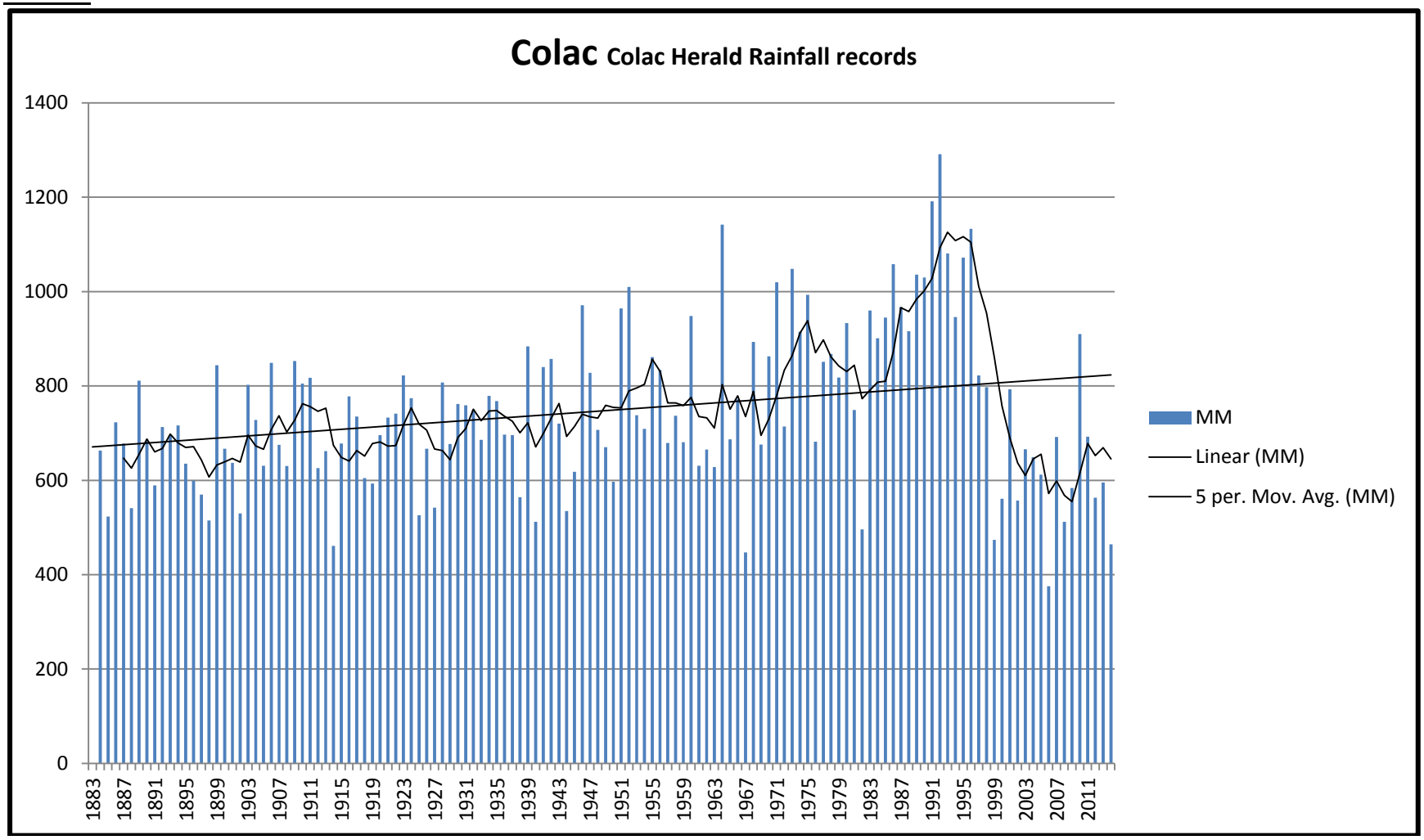
Other rainfall charts in the district (see location map, page ****).



.

C
C
C

Source: Colac Herald Office records.



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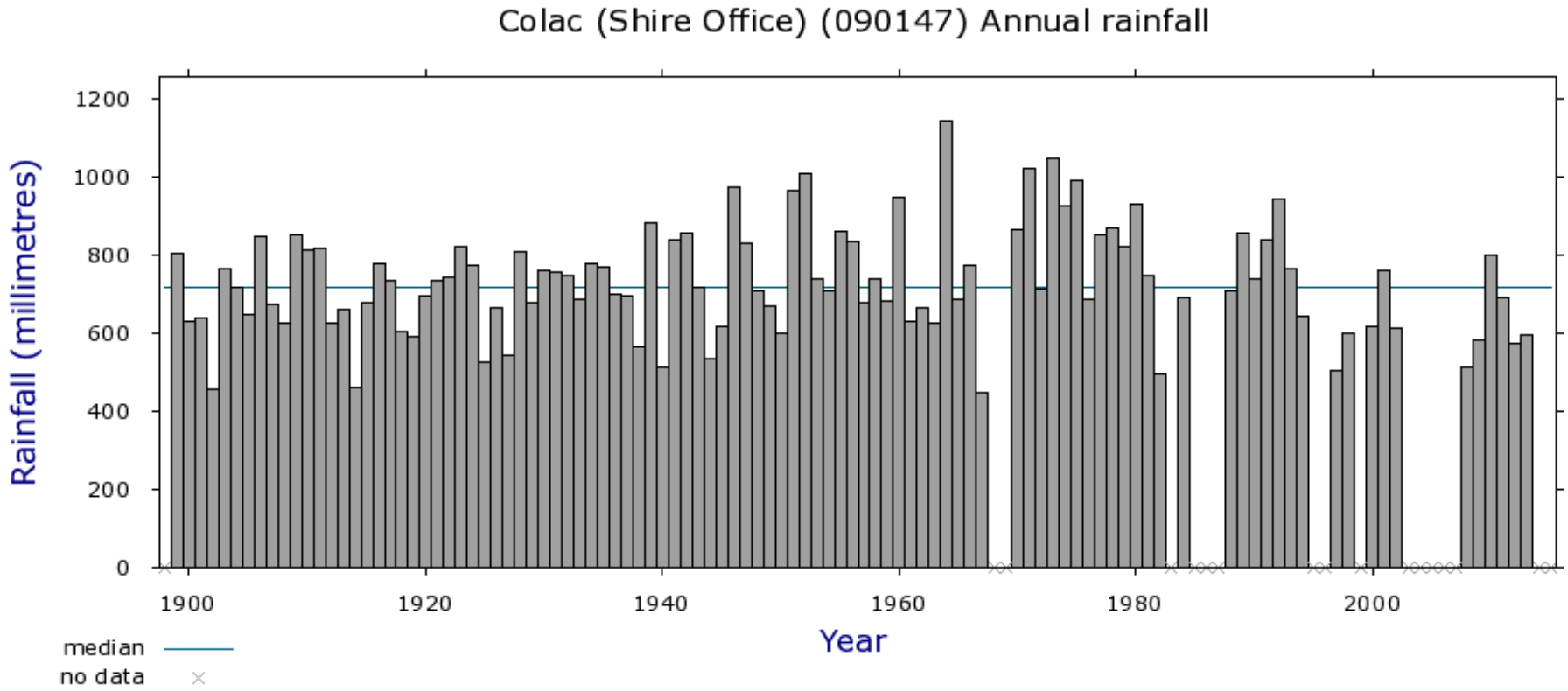

Climate Data Online, Bureau of Meteorology
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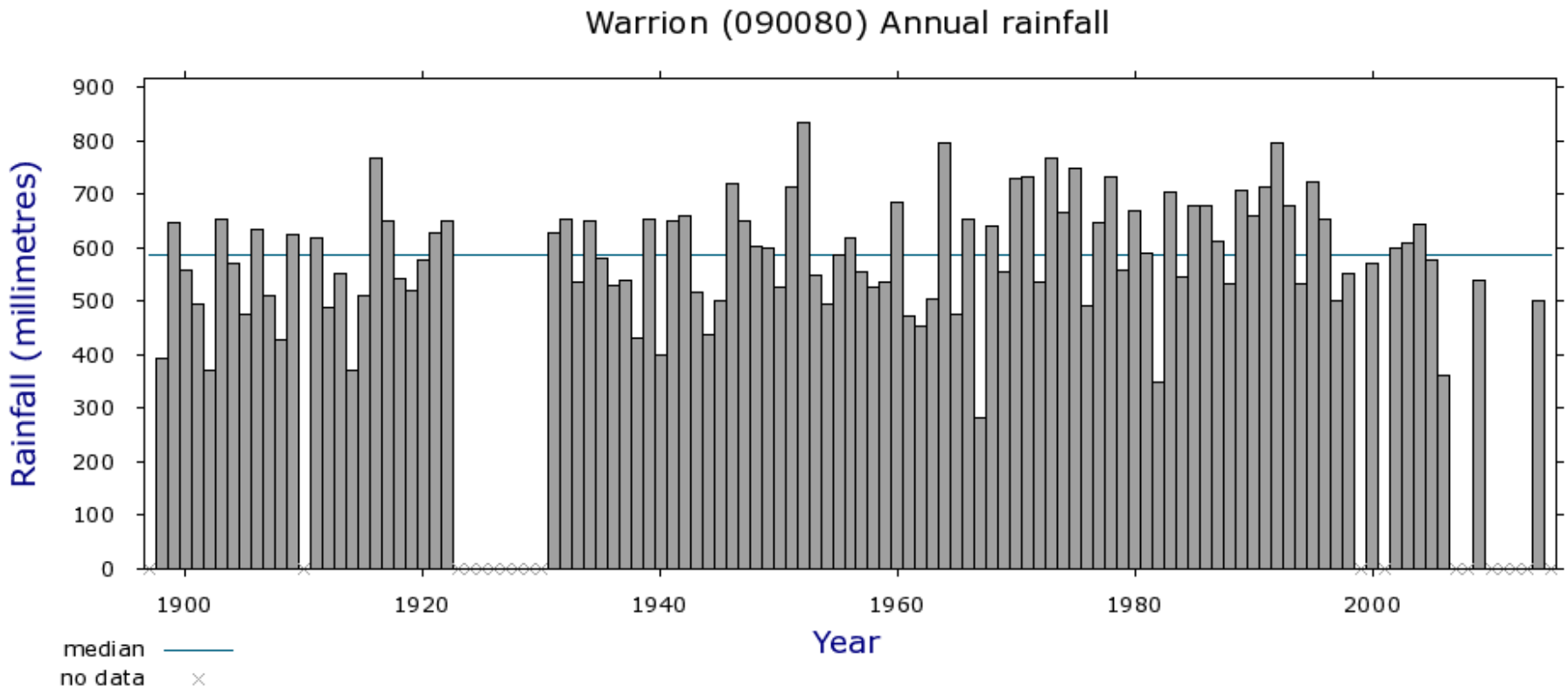
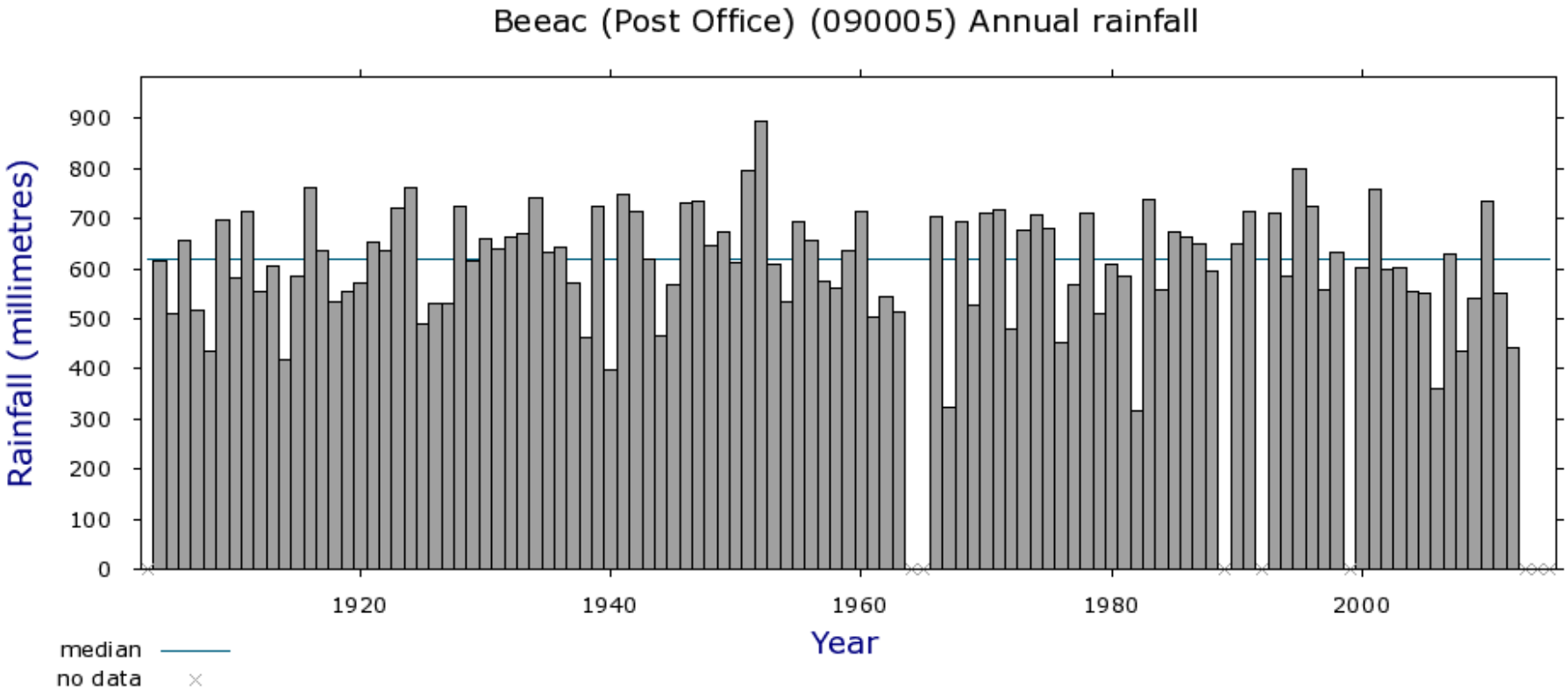
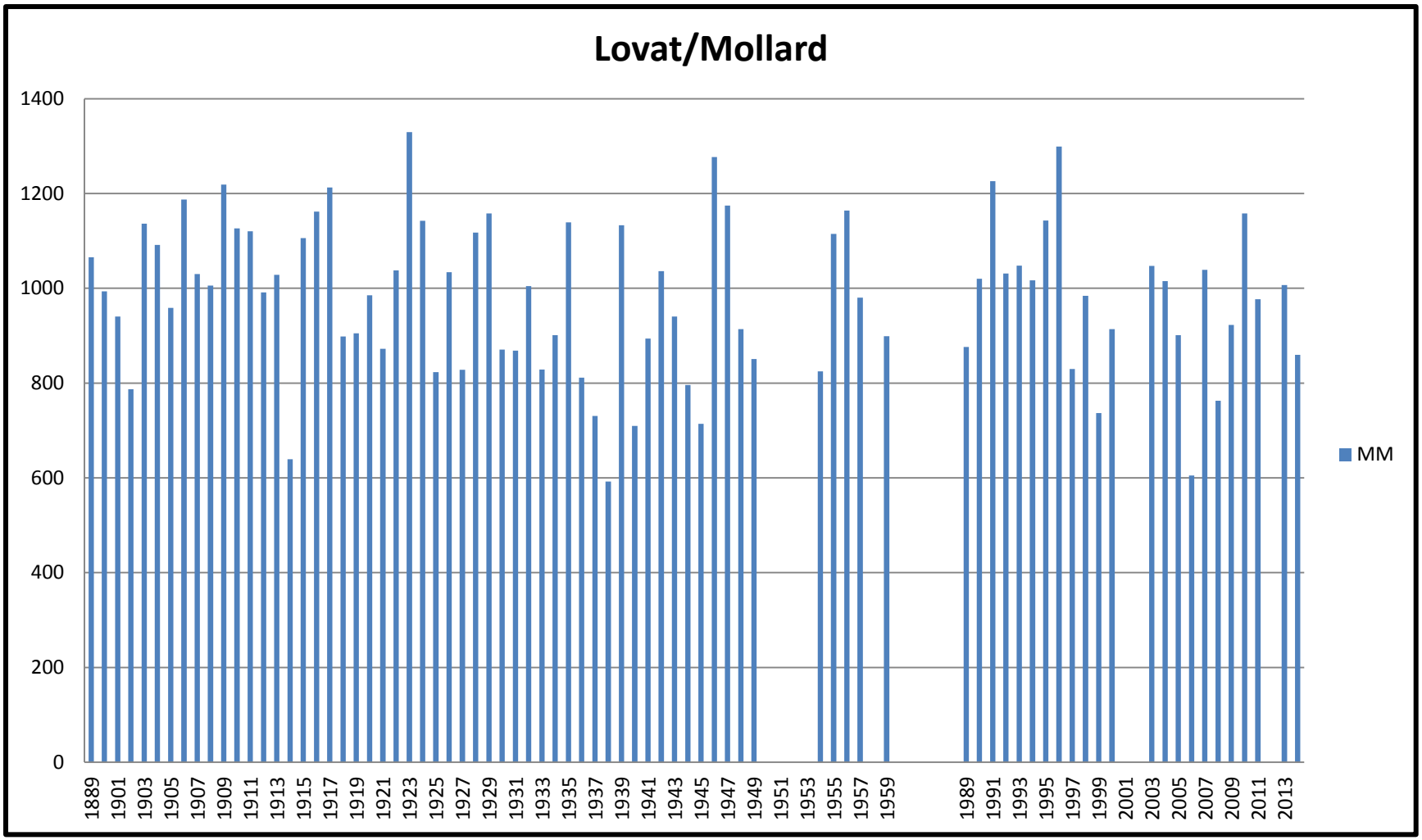


Climate Data Online, Bureau of Meteorology
Copyright Commonwealth of Australia, 2015

B

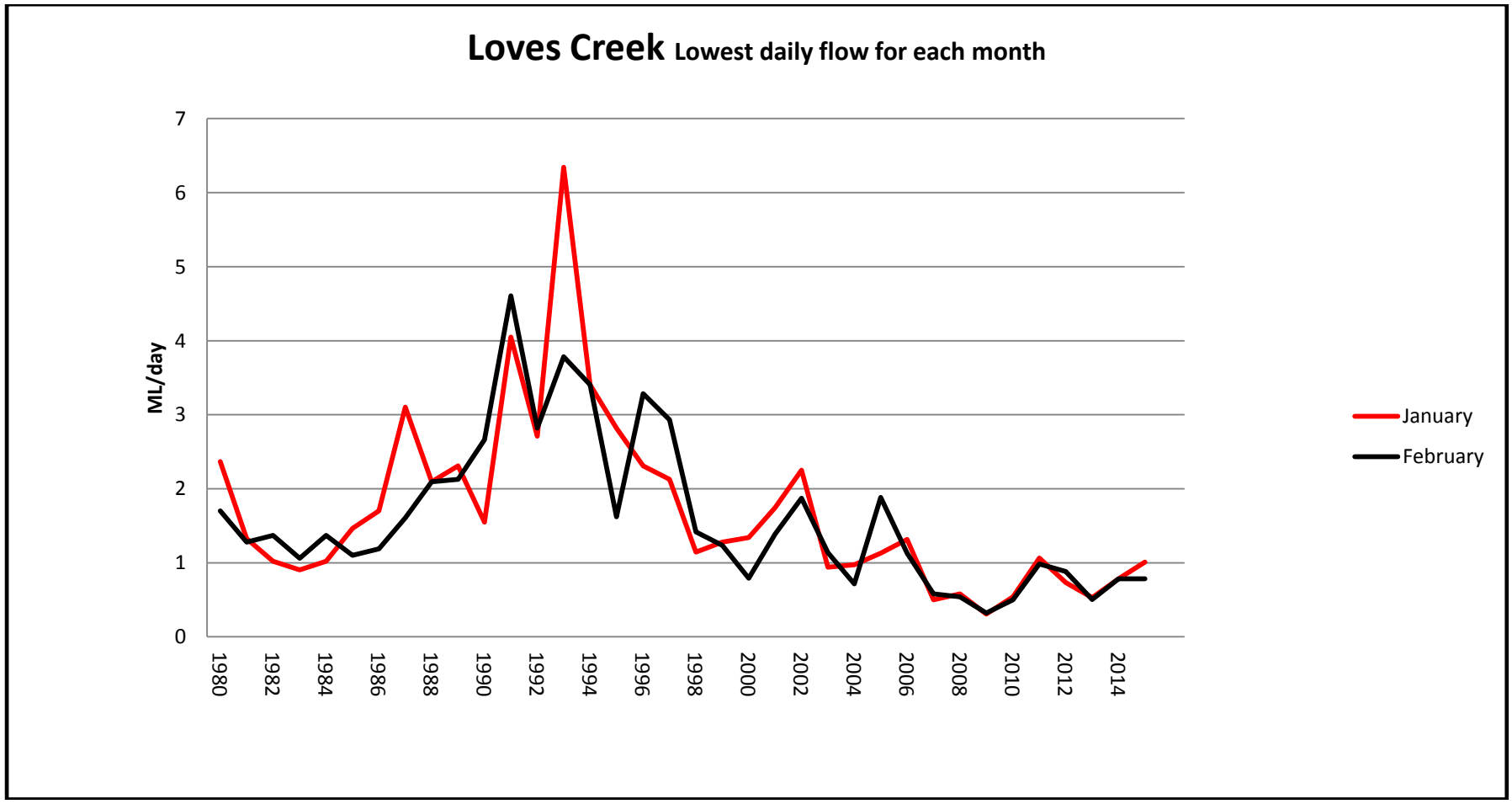


Climate Data Online, Bureau of Meteorology
Copyright Commonwealth of Australia, 2015


Lovat/Mollard
1400
1200
1000
800
600
400
200
0
1889
1901
1903
1905
1907
1909
1911
1913
1915
1917
1919
1921
1923
1925
1927
1929
1931
1933
1935
1937
1939
1941
1943
1945
1947
1949
1951
1953
1955
1957
1959
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
MM

B
B
B

APPENDIX FIVE



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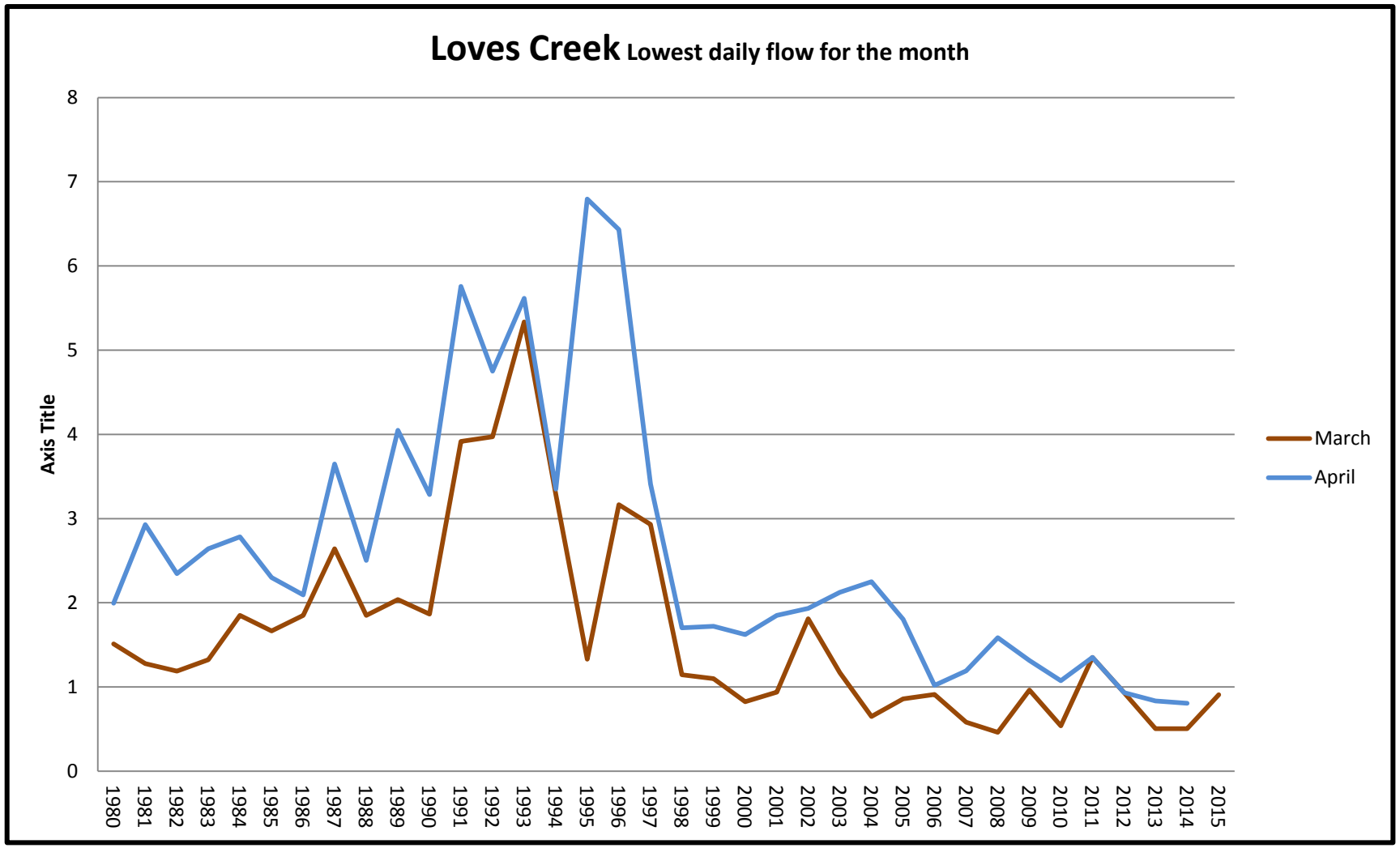
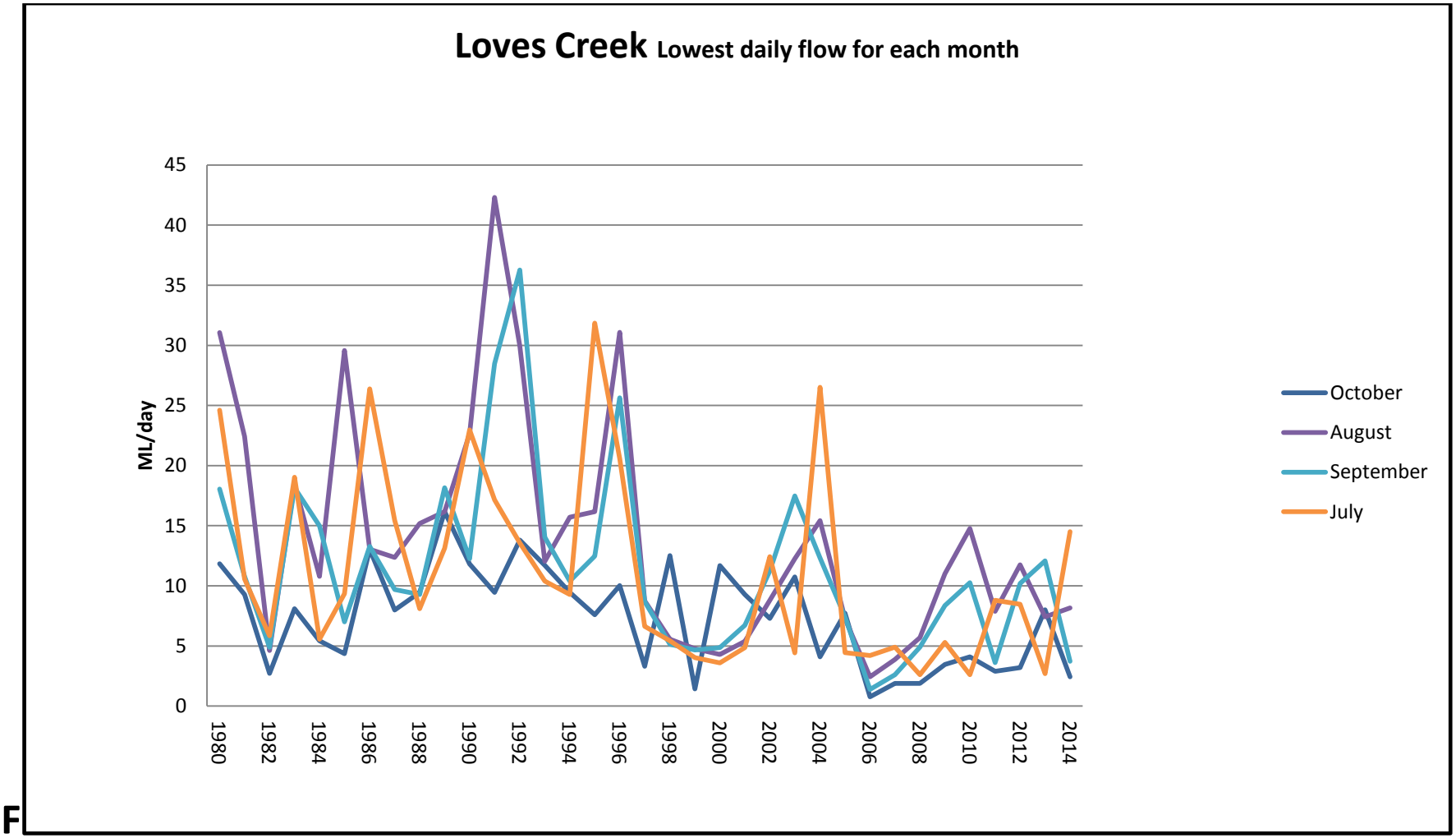
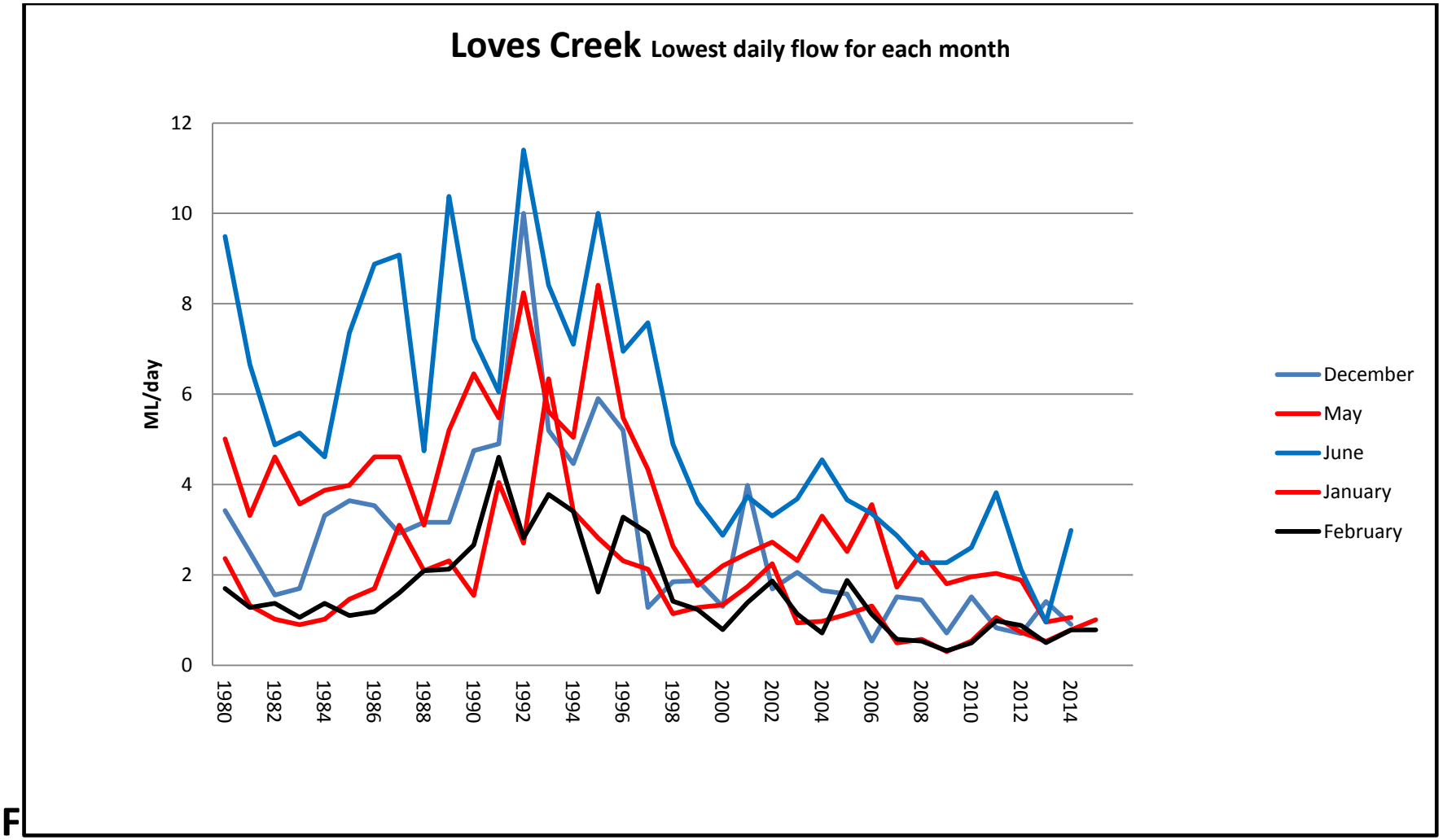

Loves Creek Lowest daily flow for the month
Axis Title
0
1
2
3
4
5
6
7
8
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
March
April

k


Loves Creek Lowest daily flow for each month
ML/day
45
40
35
30
25
20
15
10
5
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
October
August
September
July

F

F

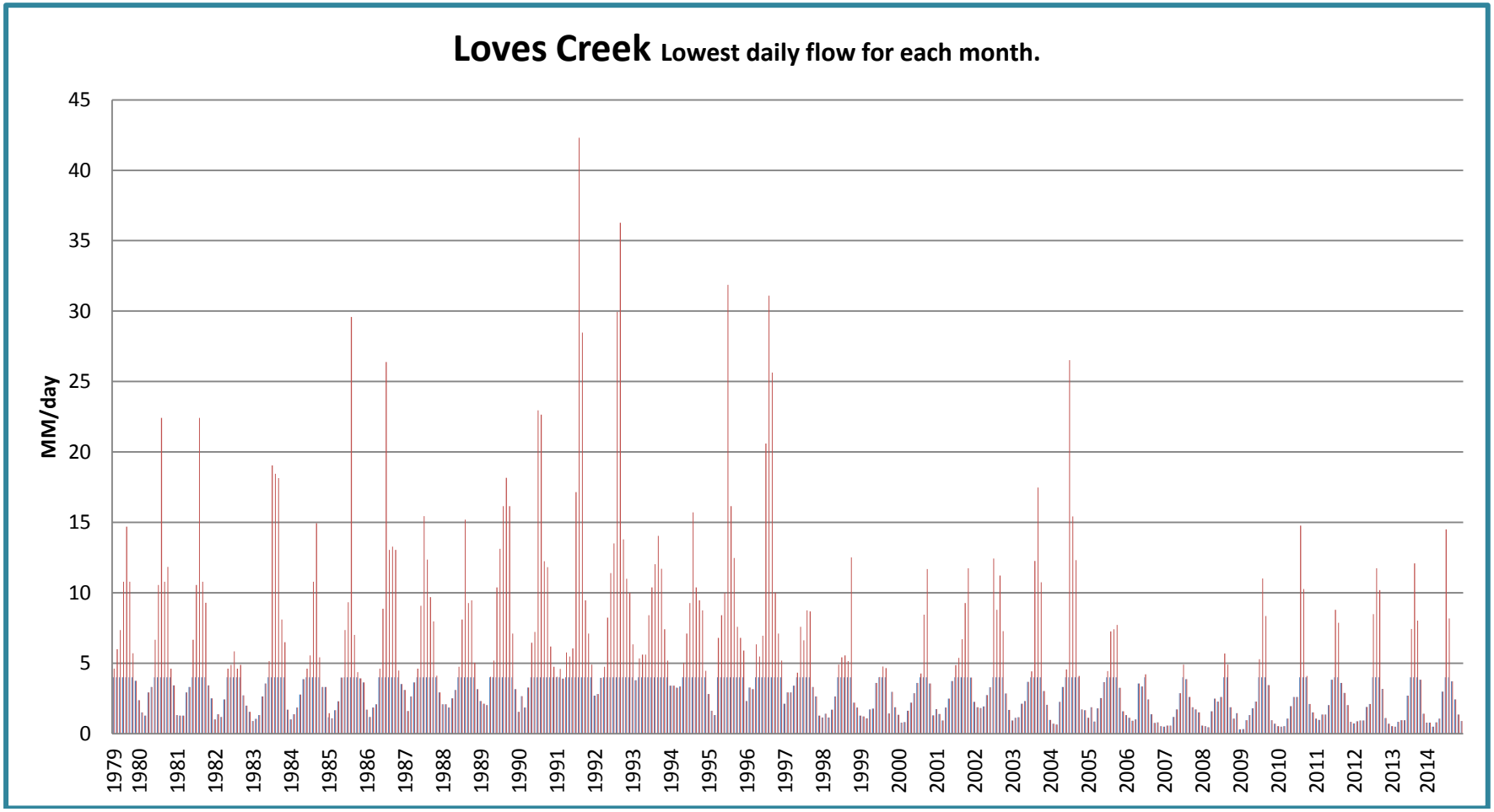

Loves Creek Lowest daily flow for each month
ML/day
0
2
4
6
8
10
12
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
December
May
June
January
February

F

F

F

APPENDIX SIX



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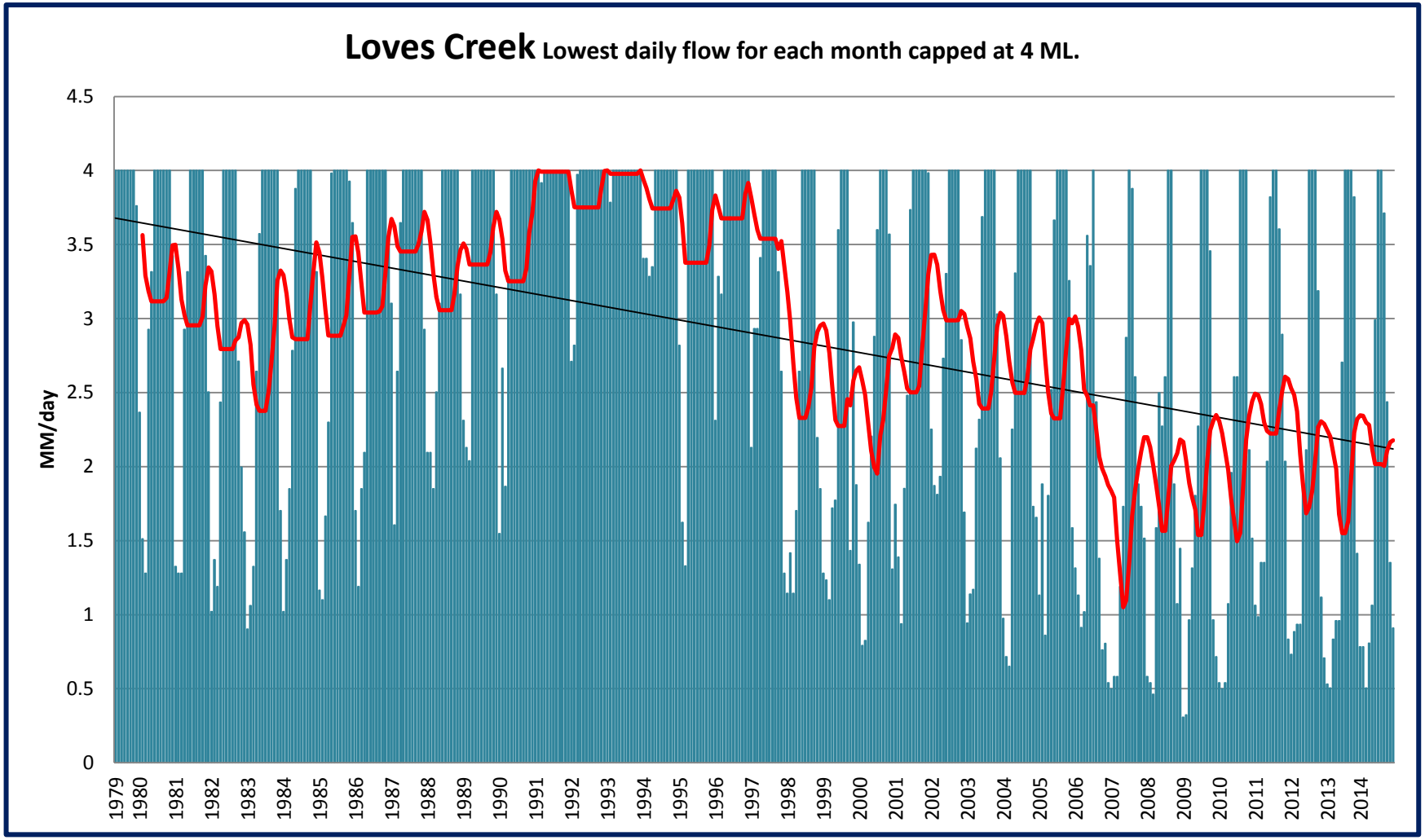
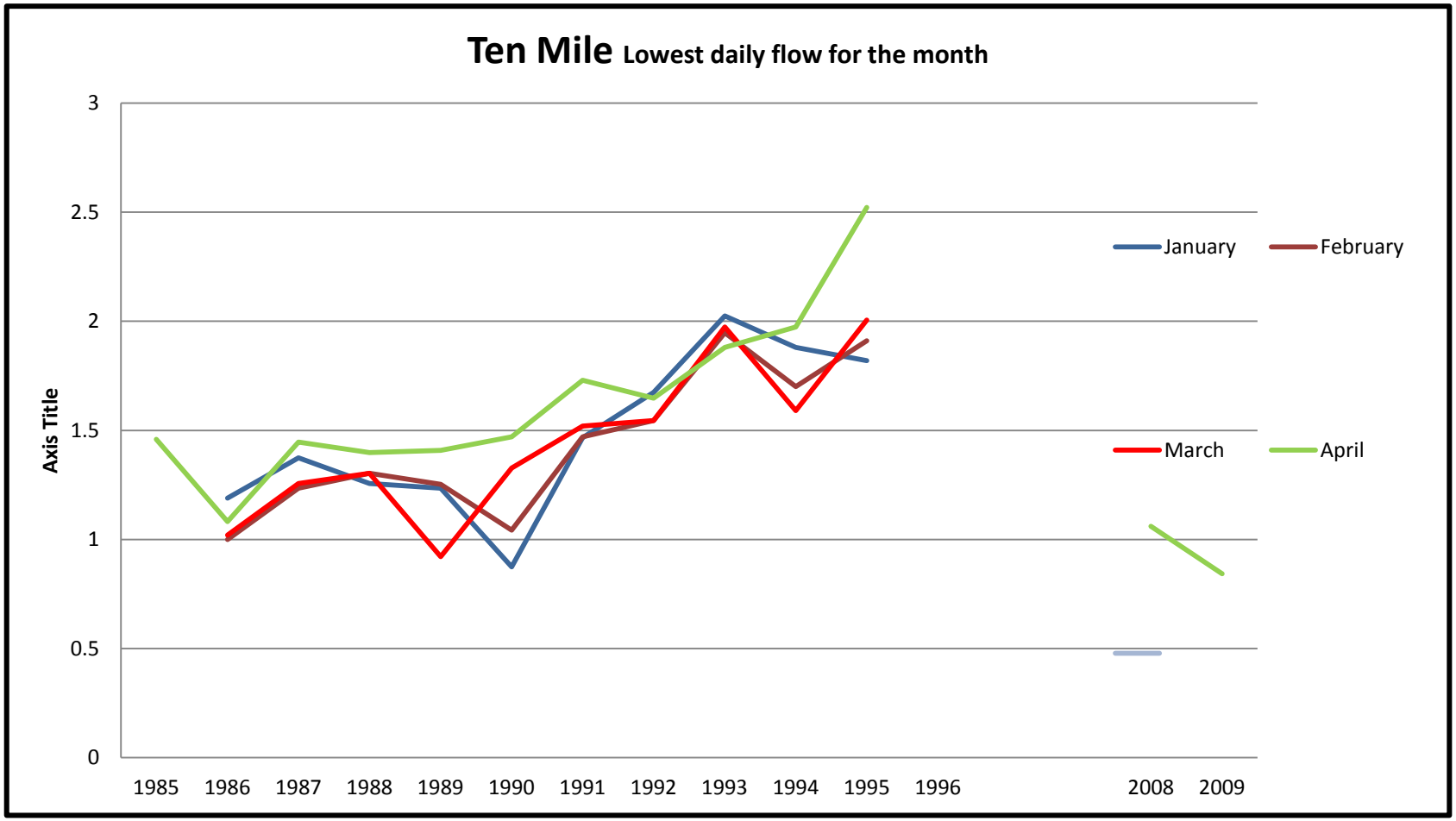

Loves Creek Lowest daily flow for each month capped at 4 ML.
MM/day
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

F

F

F

APPENDIX SEVEN



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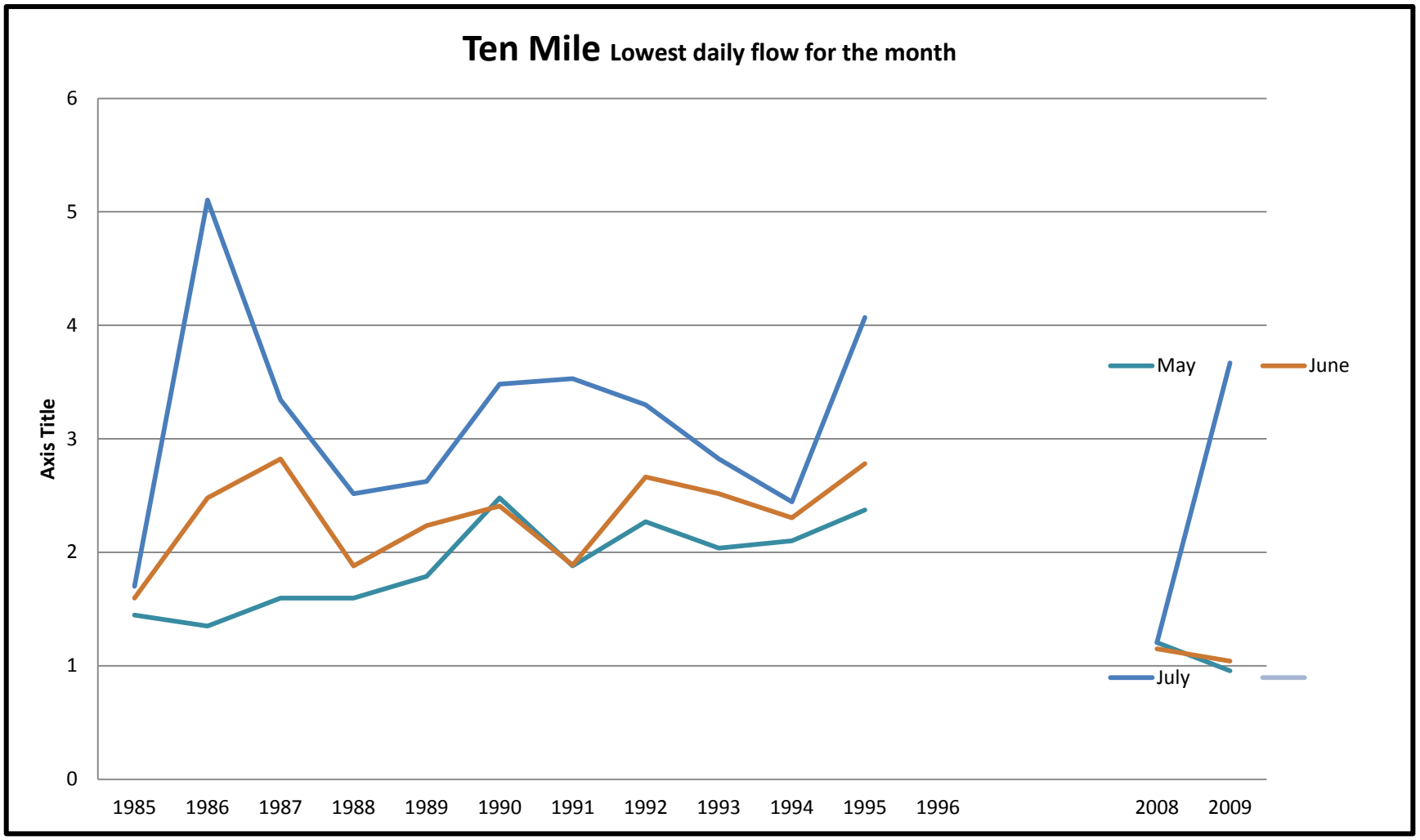
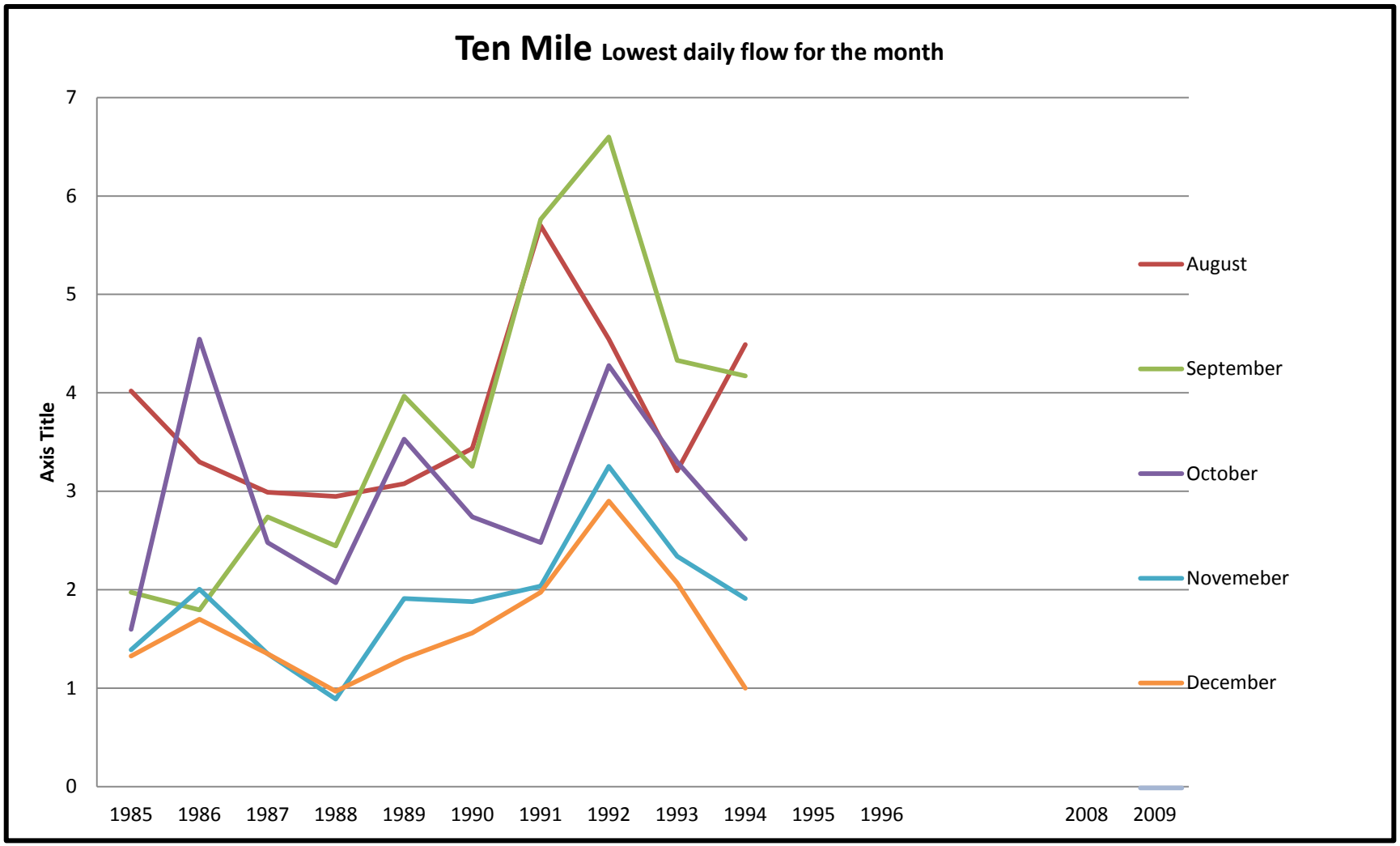

Ten Mile Lowest daily flow for the month
Axis Title
6
5
4
3
2
1
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
2008
2009
May
June
July

D

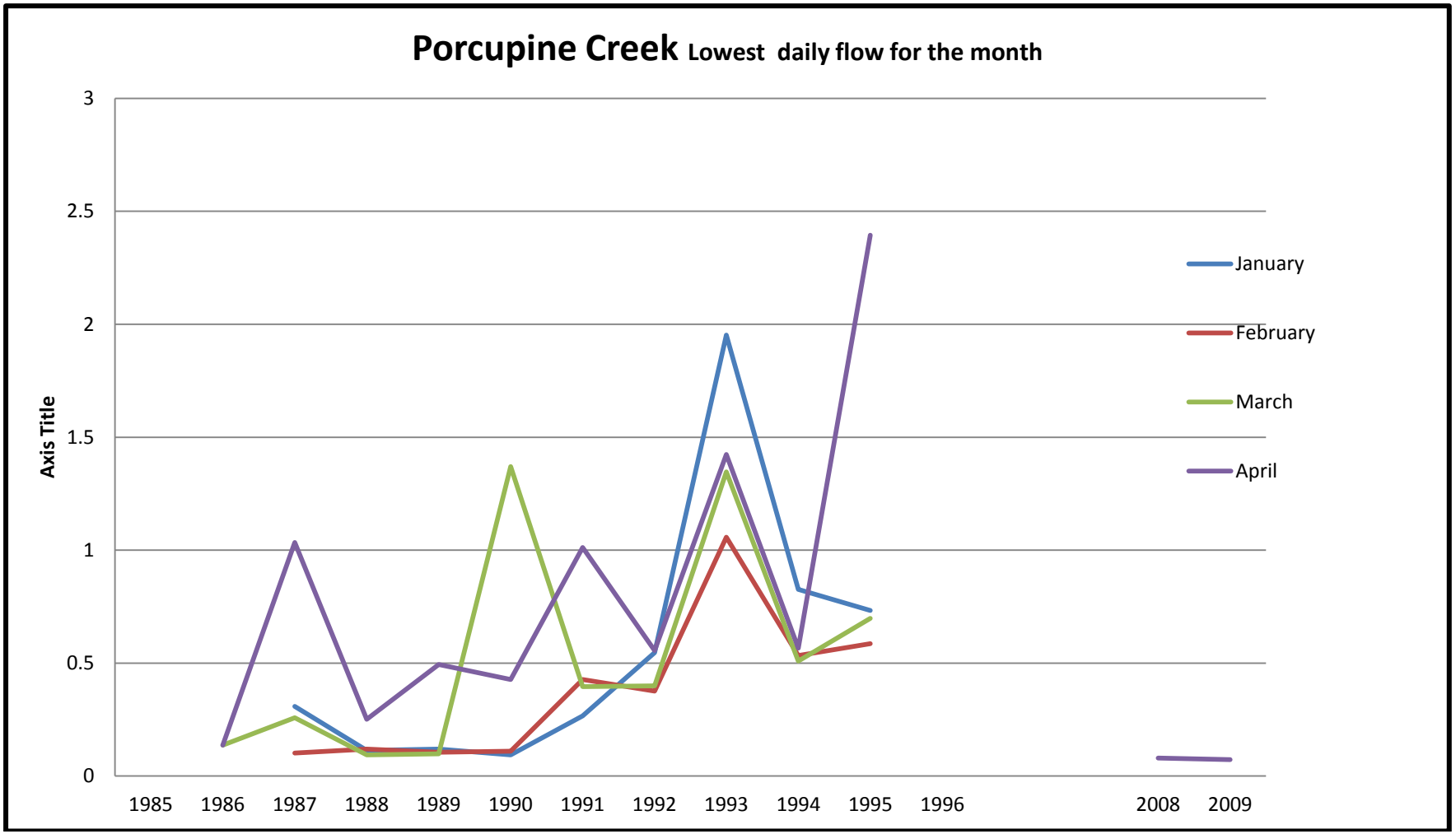
D


Ten Mile Lowest daily flow for the month
Axis Title
0
1
2
3
4
5
6
7
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
2008
2009
August
September
October
Novemeber
December

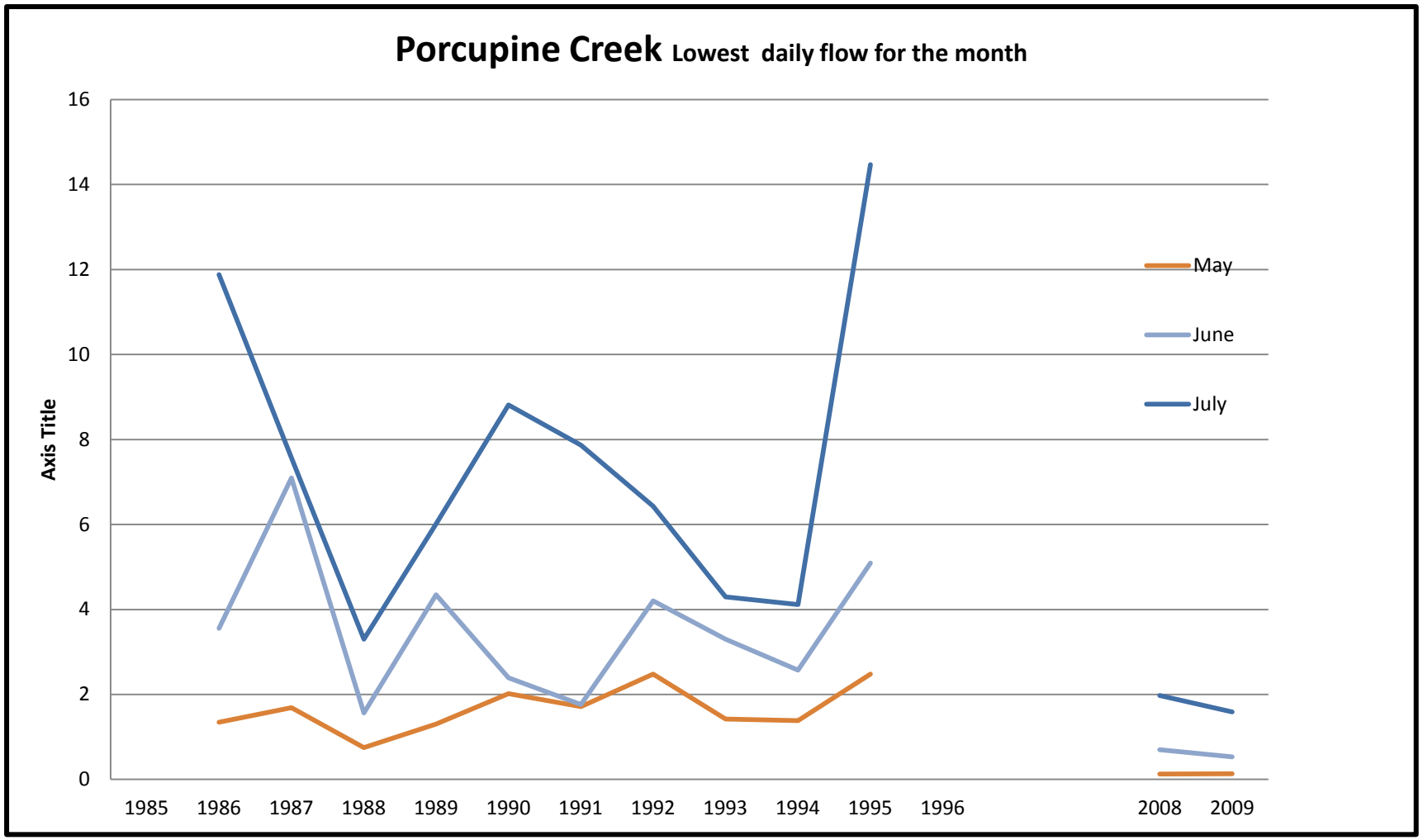
D

D

APPENDIX EIGHT

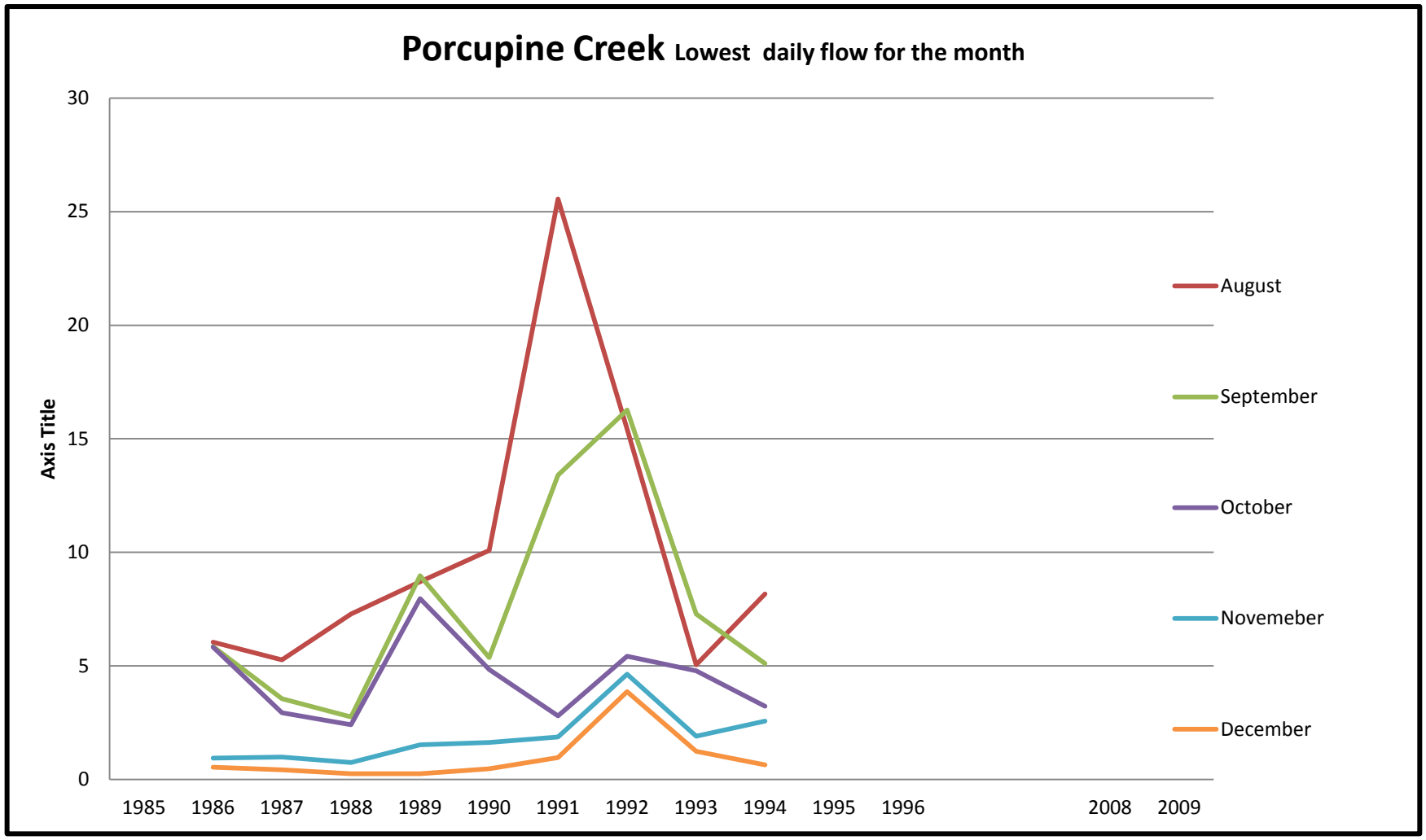


D


Porcupine Creek Lowest daily flow for the month
Axis Title
16
14
12
10
8
6
4
2
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
2008
2009
May
June
July

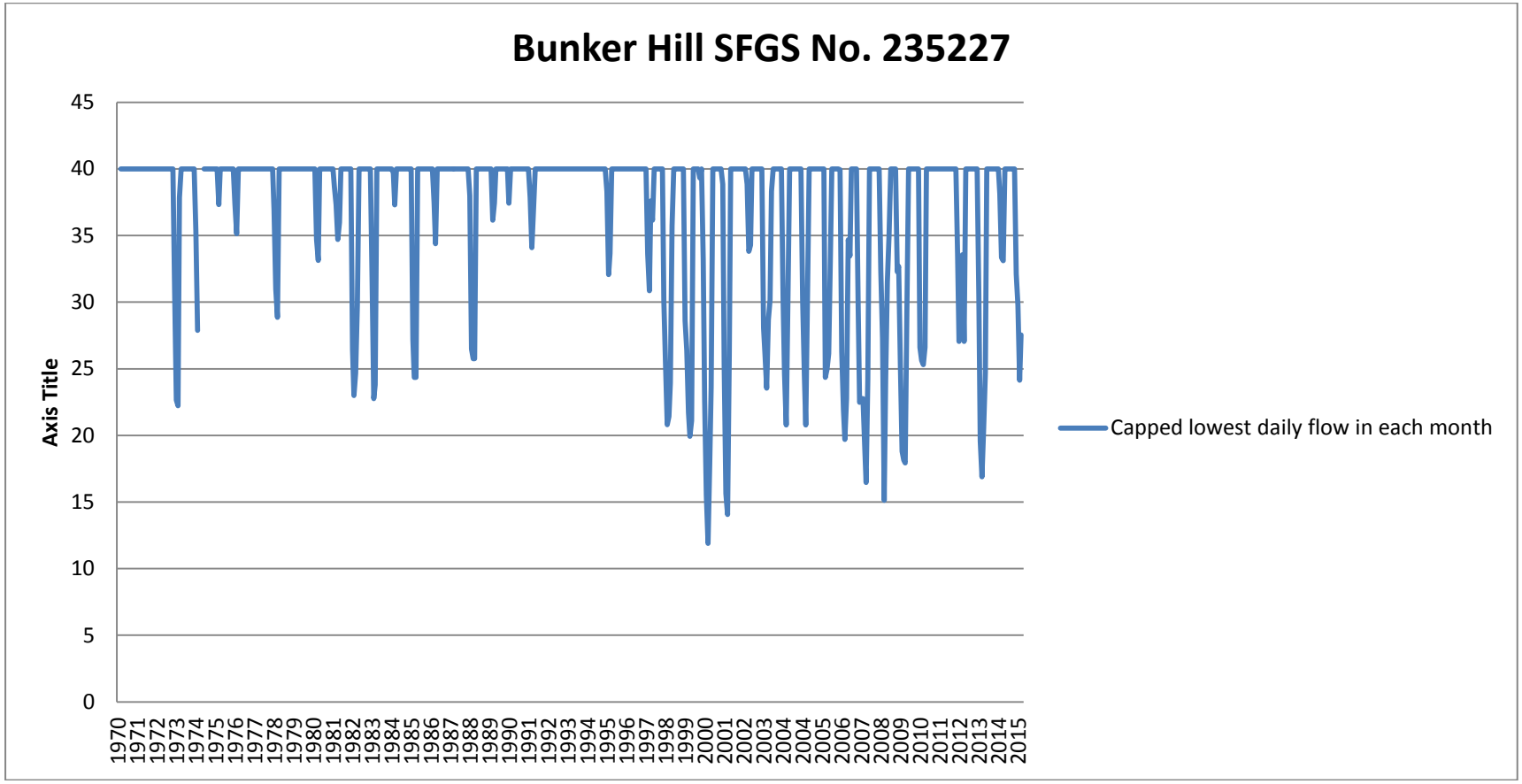
D

D


Porcupine Creek Lowest daily flow for the month
Axis Title
30
25
20
15
10
5
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
2008
2009
August
September
October
Novemeber
December

G
G

APPENDIX NINE



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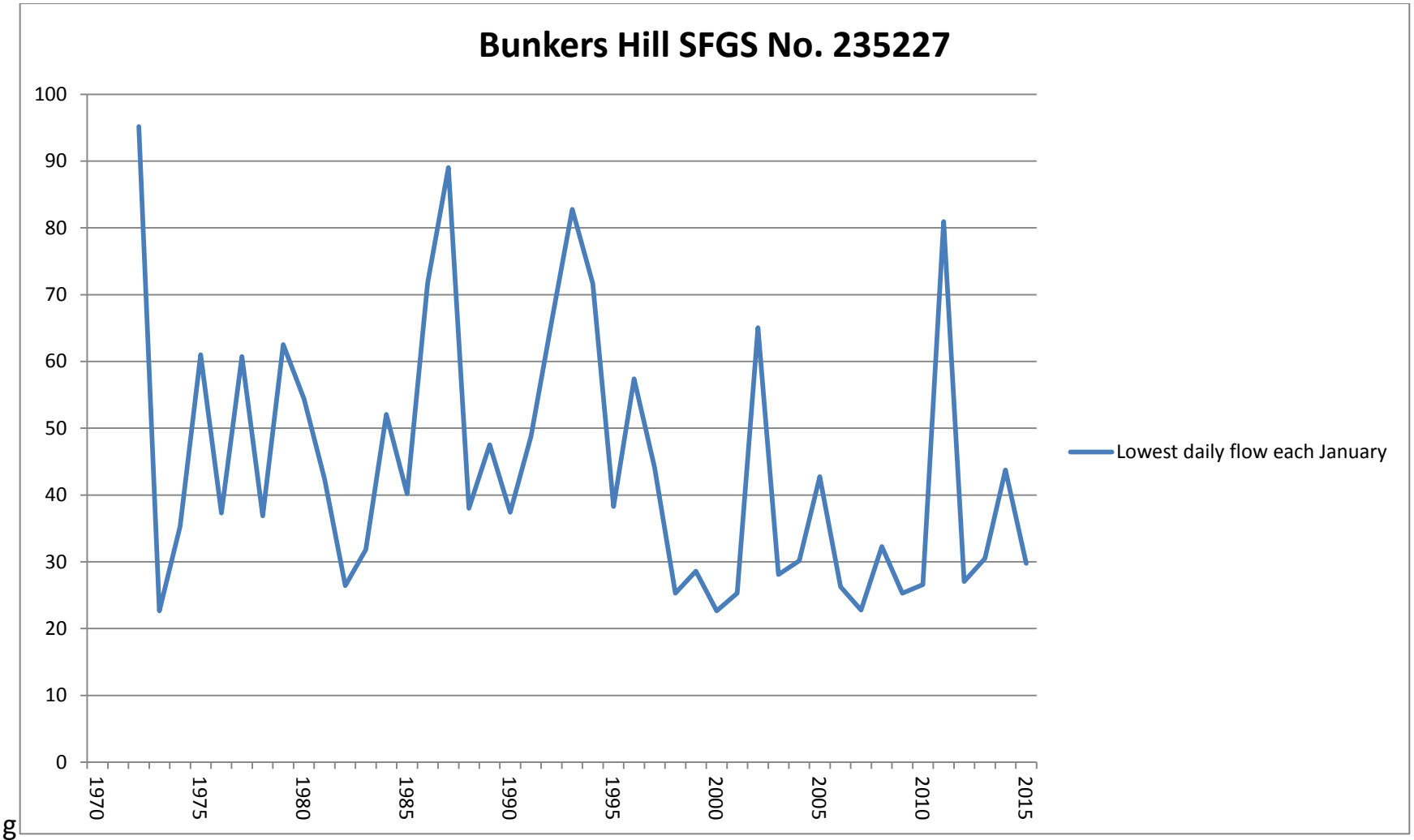
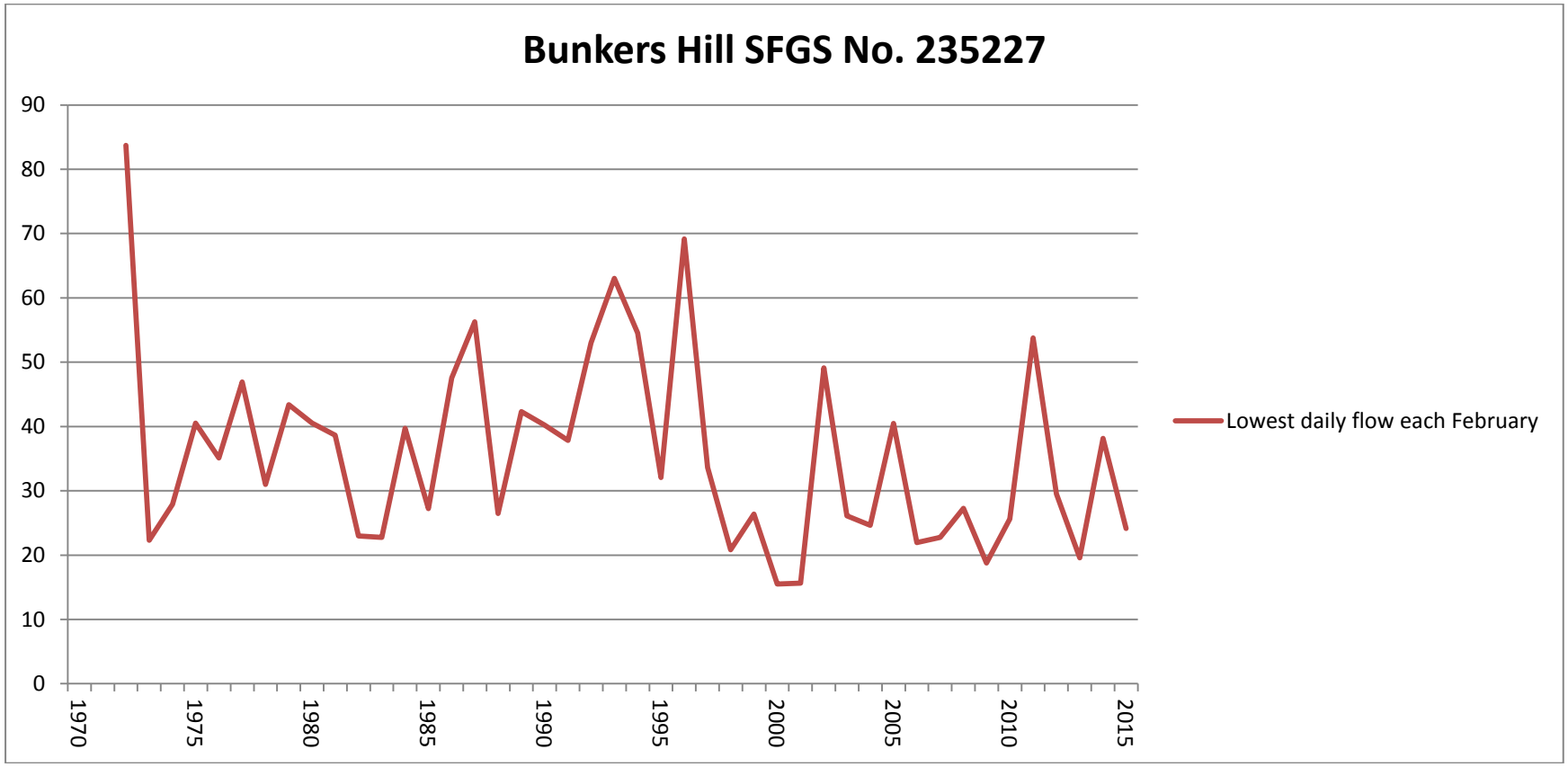
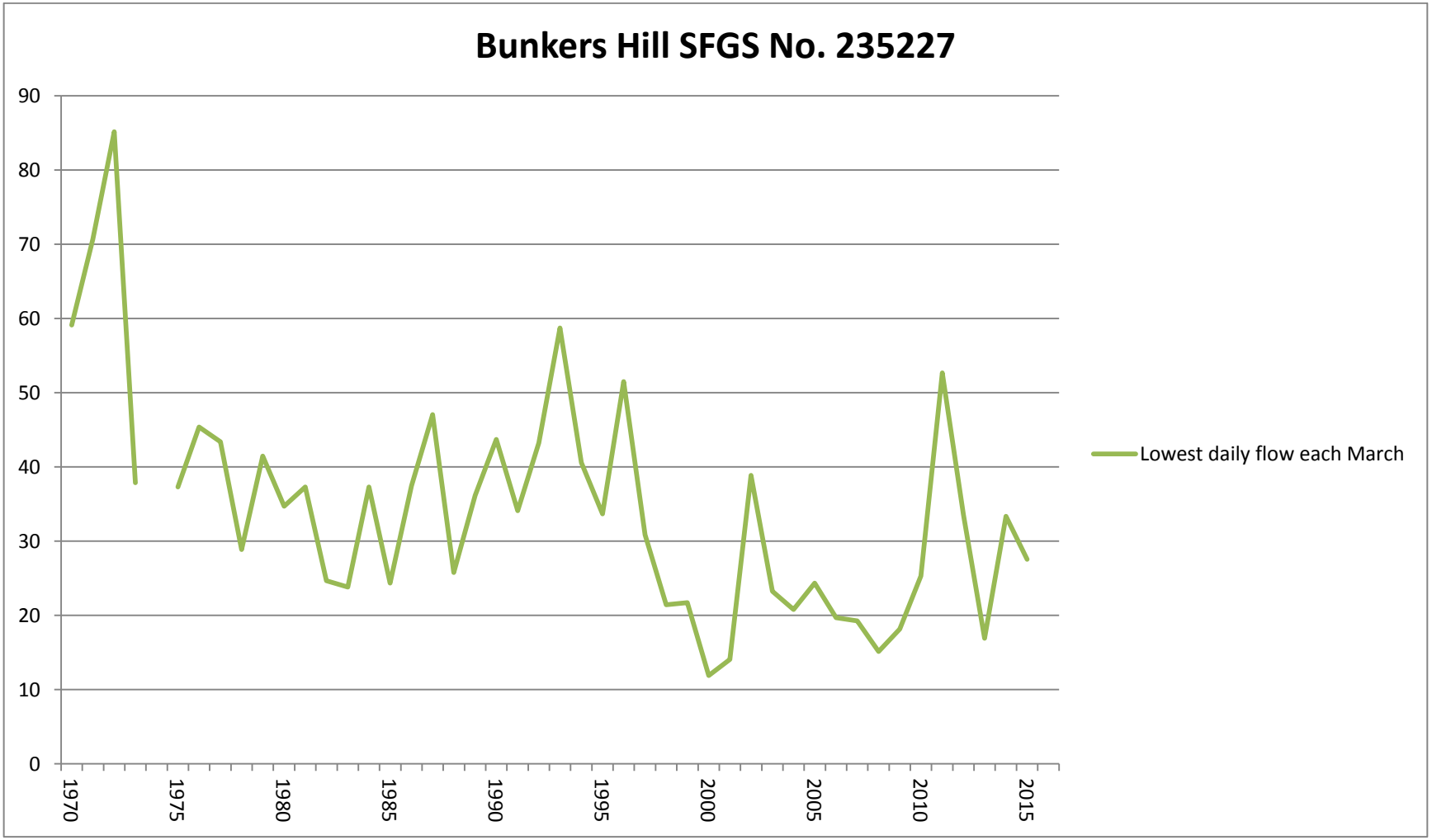

Bunkers Hill SFGS No. 235227
100
90
80
70
60
50
40
30
20
10
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Lowest daily flow each January

g
G


Bunkers Hill SFGS No. 235227
90
80
70
60
50
40
30
20
10
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Lowest daily flow each February


Bunkers Hill SFGS No. 235227
90
80
70
60
50
40
30
20
10
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Lowest daily flow each March

G

G

APPENDIX TEN

State of Victoria

Statutory Declaration

I, Marina Josephine Lewis

of 25 Raffertys Road, Gellibrand River, Victoria, 3239

Researcher, do solemnly and sincerely declare that:-

I HAVE LIVED IN THE SAME LOCATION BESIDE THE GELLIBRAND RIVER FOR AT LEAST 18 YEARS. I CHECK THE WATER LEVELS AND THE PRESENCE OR ABSENCE OF PLATYPUS ON A DAILY BASIS. I HAVE NOTICED IN THE LAST FIVE YEARS THAT SUMMER FLOWS SEEM TO BE DECREASING. I HAVE ALSO NOTICED THAT THE WATER TABLE MAY BE FALLING, AS EVIDENCED BY THE TOWERS OF BURROWING CRAYFISH RETREATING ON THE RIVER FLATS. THEY APPEAR TO LIVE IN SATURATED ZONES AND THEIR NUMBERS HAVE DECREASED IN THE LAST FIVE YEARS

I acknowledge that this declaration is true and correct, and I make it with the understanding and belief that a person who makes a false declaration is liable to the penalties of perjury.

Declared at Gellibrand River

this 12 day of September 2015

M J. Lewis
.....
Signature of person making this declaration
[to be signed in front of an authorised witness]

Before me,

.....
Signature of Authorised Witness

NEIL L LONGMORE
25 Rafferty Road, Gellibrand River 3239
An Australian Legal Practitioner within the meaning of the Legal Profession Act 2004

The authorised witness must print or stamp his or her name, address and title under section 107A of the *Evidence (Miscellaneous Provisions) Act 1958* (as of 1 January 2010), (previously *Evidence Act 1958*), (eg. Justice of the Peace, Pharmacist, Police Officer, Court Registrar, Bank Manager, Medical Practitioner, Dentist)

State of Victoria

Statutory Declaration

I, Neil Leonard Longmore

of 25 Raffertys Road, Gellibrand River, Victoria, 3239

Lawyer, do solemnly and sincerely declare that:-

I have been a resident at the above address for 35 years. I have monitored river levels almost every day, in the last five years there has been a marked decrease in summer flows in the river. Our farm is located on Eastern View formation sands that become saturated in winter, but they appear to dry out much more quickly in recent times i.e the last 5-10 years. Winter rainfall usually runs off the sands, or through them and fills the billabongs on the river flats, but it appears to be mostly soaking into the ground these days. There are not the numbers of high flows in the river either. Signs of water table levels being near the surface such as Otway Burrowing Crayfish towers are becoming less common.

I acknowledge that this declaration is true and correct, and I make it with the understanding and belief that a person who makes a false declaration is liable to the penalties of perjury.

Declared at GELLIBRAND RIVER

this 12 day of SEPTEMBER 2015

.....
Signature of person making this declaration
[to be signed in front of an authorised witness]

Before me,

.....
Signature of Authorised Witness

MARINA J. LEWIS
25 Rafferty Road, Gellibrand River 3239
Law Clerk

The authorised witness must print or stamp his or her name, address and title under section 107A of the *Evidence (Miscellaneous Provisions) Act 1958* (as of 1 January 2010), (previously *Evidence Act 1958*), (eg. Justice of the Peace, Pharmacist, Police Officer, Court Registrar, Bank Manager, Medical Practitioner, Dentist)

APPENDIX ELEVEN

1 mm of rain falling on 1 square metre yields 1 litre of water.

1 mm falling on 1 square kilometre yields 1 ML of water.

16 km^2 multiplied by 800 mm (Healey rainfall), multiplied by 23%, will see a value of 2944 ML/year recharge.

12 km^2 multiplied by 800 mm, multiplied by 23%, will give a value of 2208 ML/year .