CSIRO WATER FOR A HEALTHY COUNTRY FLAGSHIP
www.csiro.au

Trends in physical and chemical aspects of water quality in the Murray Darling Basin 1978-2012: APPENDICES

Prepared for:

Murray Darling Basin Authority

GPO Box 1801

Canberra City 2601

September 2013

Water for a Healthy Country Flagship Report series ISSN: 1835-095X

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills.

CSIRO initiated the National Research Flagships to address Australia's major research challenges and opportunities. They apply large scale, long term, multidisciplinary science and aim for widespread adoption of solutions. The Flagship Collaboration Fund supports the best and brightest researchers to address these complex challenges through partnerships between CSIRO, universities, research agencies and industry.

The Water for a Healthy Country Flagship aims to provide Australia with solutions for water resource management, creating economic gains of $3 billion per annum by 2030, while protecting or restoring our major water ecosystems.

For more information about Water for a Healthy Country Flagship or the National Research Flagship Initiative visit www.csiro.au/org/HealthyCountry.html

CSIRO Contact details:

Dr Brent Henderson

Research Group Leader - Environmetrics, Biometrics and Bioinformatics

CSIRO Computational Informatics

Phone: +61 2 6216 7095

Brent.Henderson@csiro.au

Postal Address: GPO Box 664 Canberra ACT 2601 Australia.

Citation

Henderson, B., Liu Y, and Baldwin D (2013) Trends in physical and chemical aspects of water quality in the Murray Darling Basin 1978-2012: APPENDICES. CSIRO Water for a Healthy Country Flagship, Australia.

Note: These appendices exist as separate report to the main report of the same name.

Acknowledgement:

This report into trends in physical and chemical aspects of water quality in the Murray-Darling Basin 1978-2012 was funded by the Murray-Darling Basin Authority. This report has been reviewed and approved by Tapas Biswas and Brian Lawrence of the MDBA.

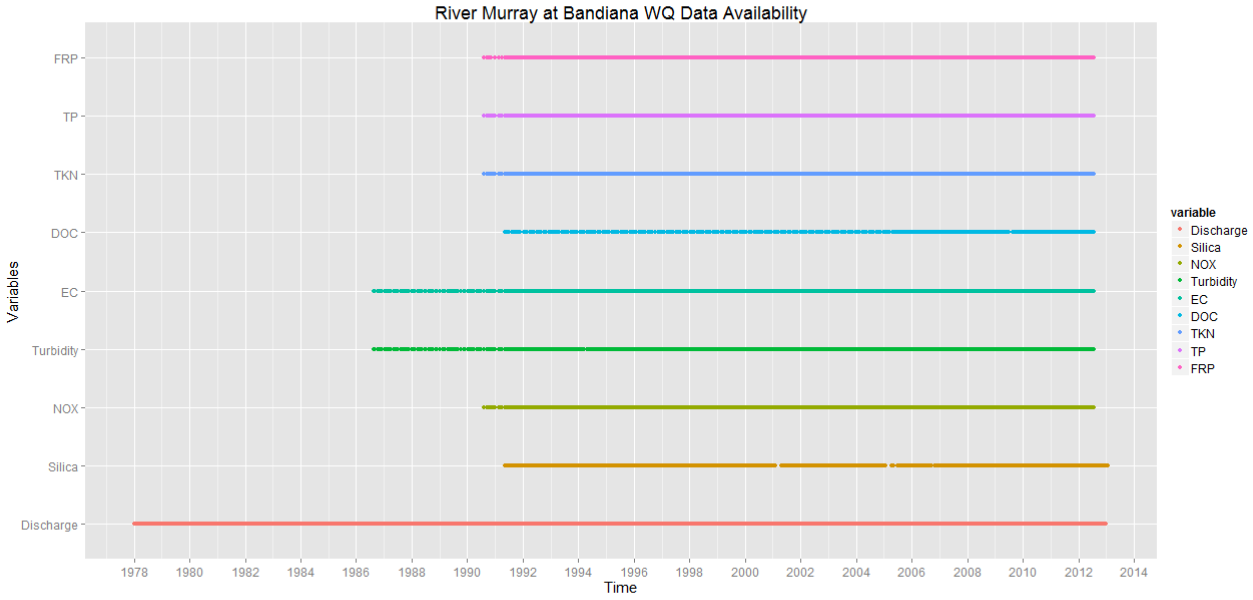
Copyright and disclaimer

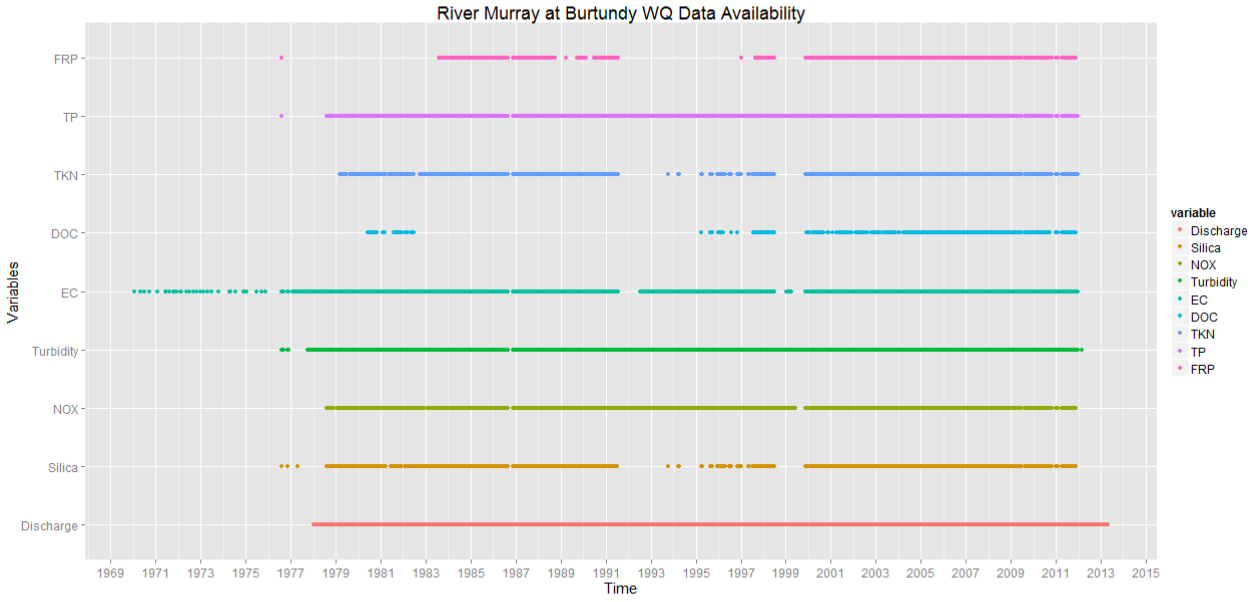
Important disclaimer

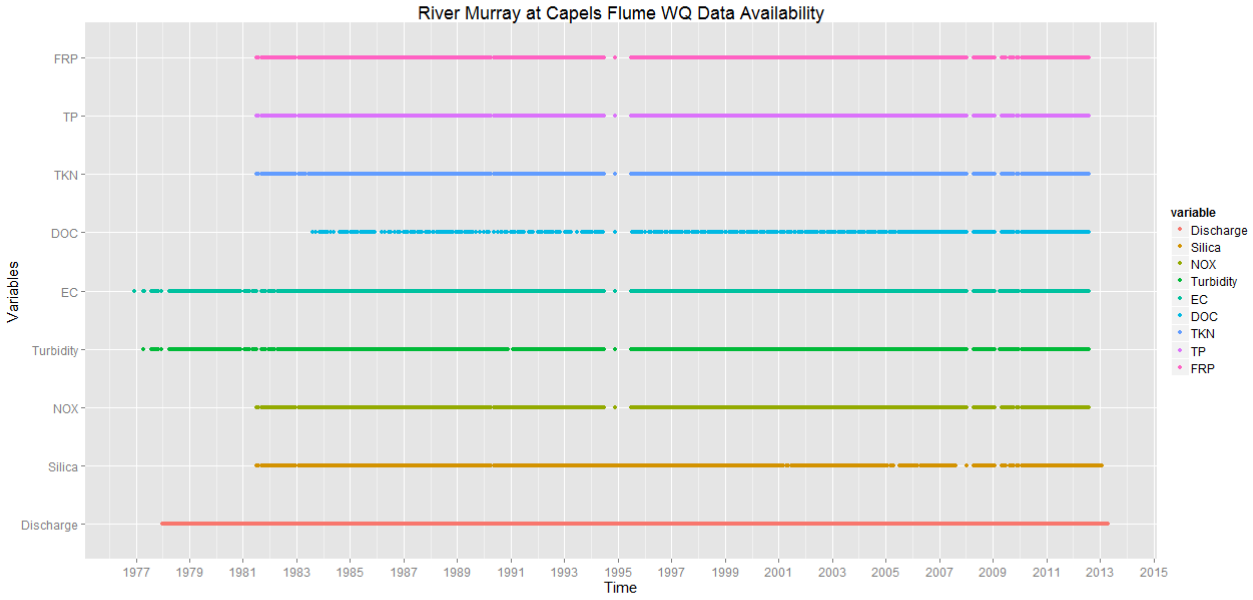
Contents

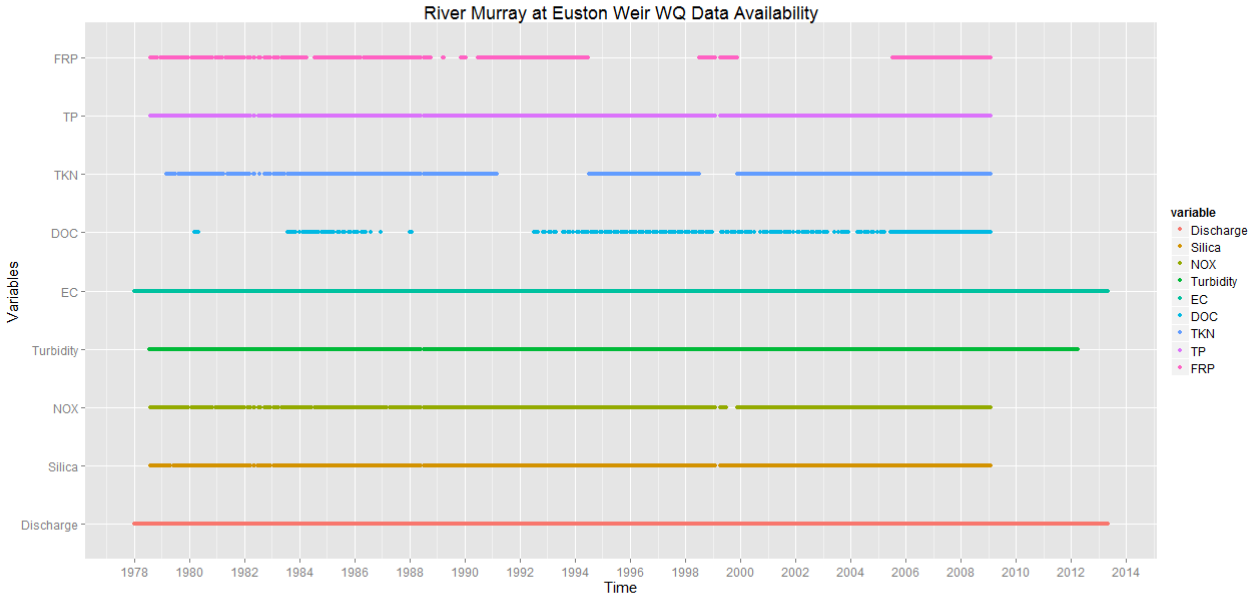
APPENDICES

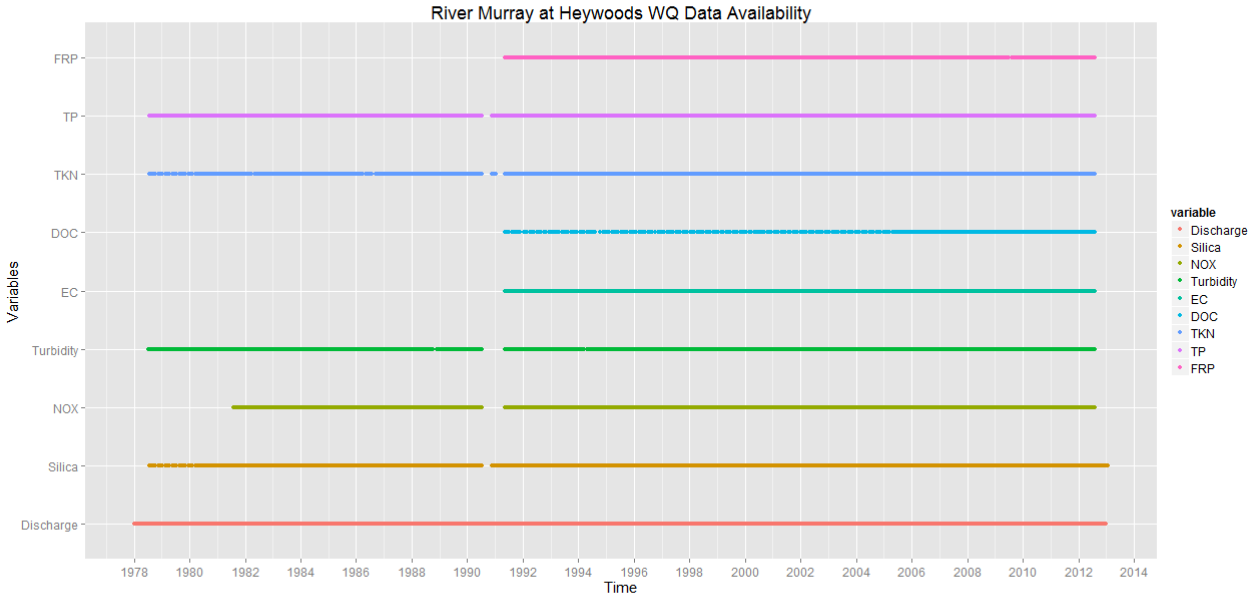
A: Data availability

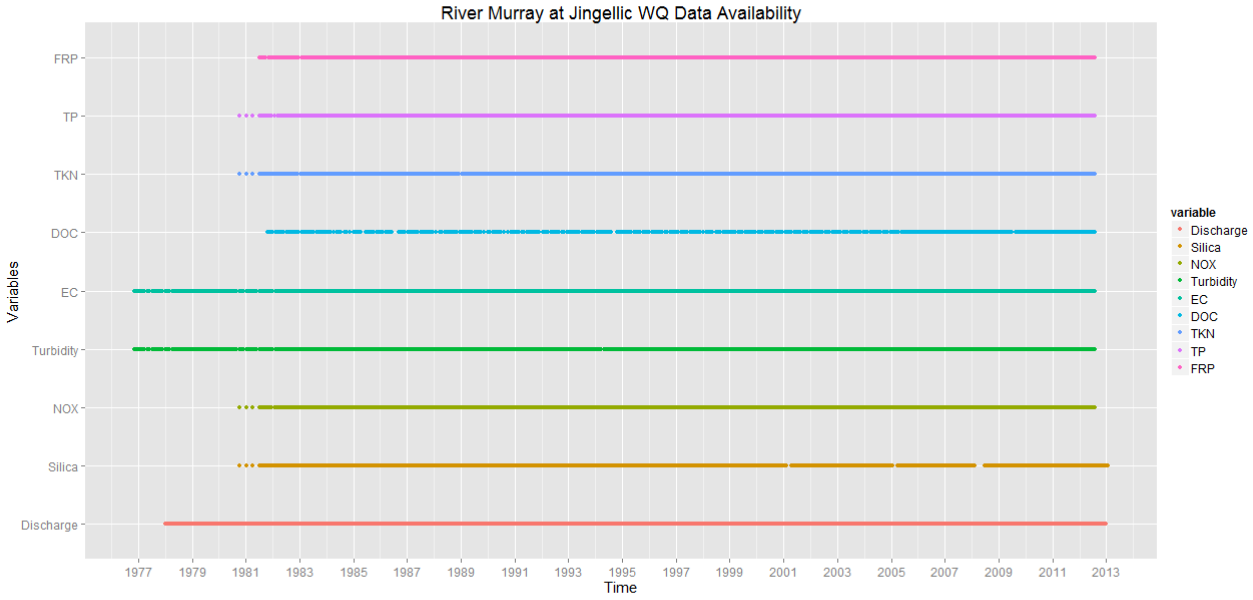


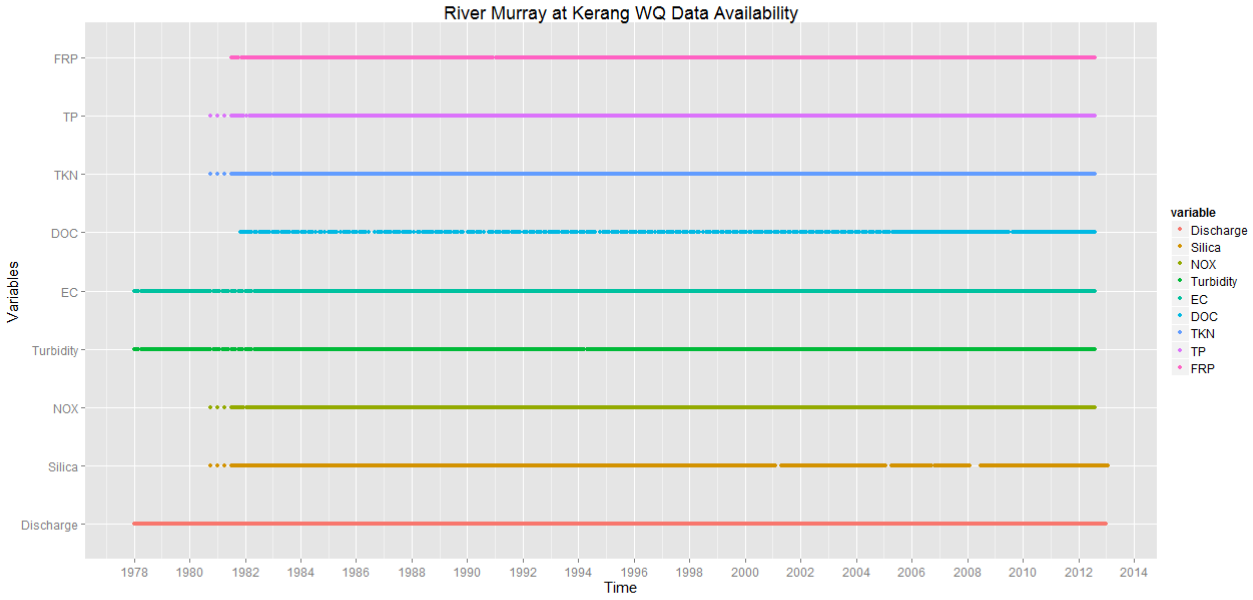


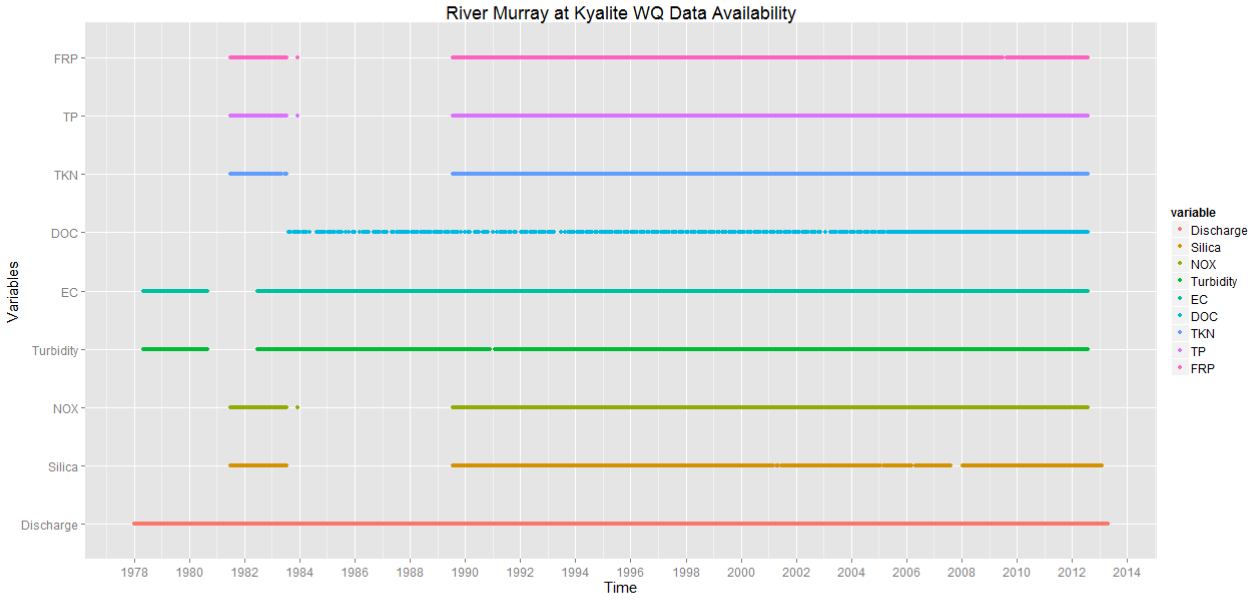

River Murray at Capels Flume WQ Data Availability
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
Variables
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

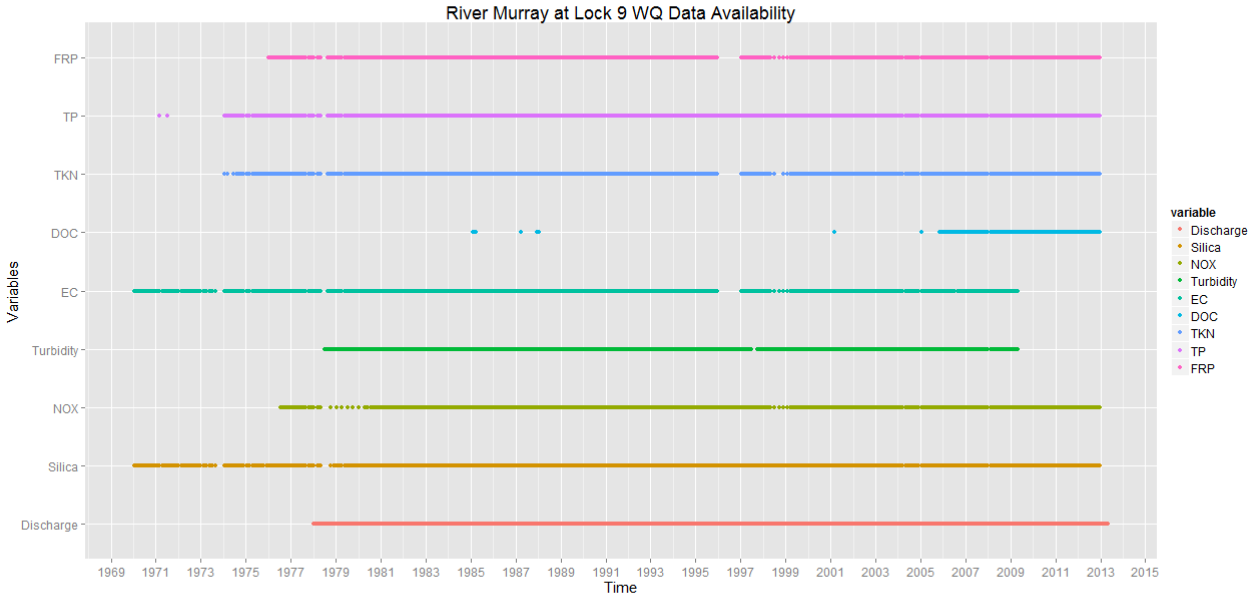

River Murray at Euston Weir WQ Data Availability
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
Variables
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

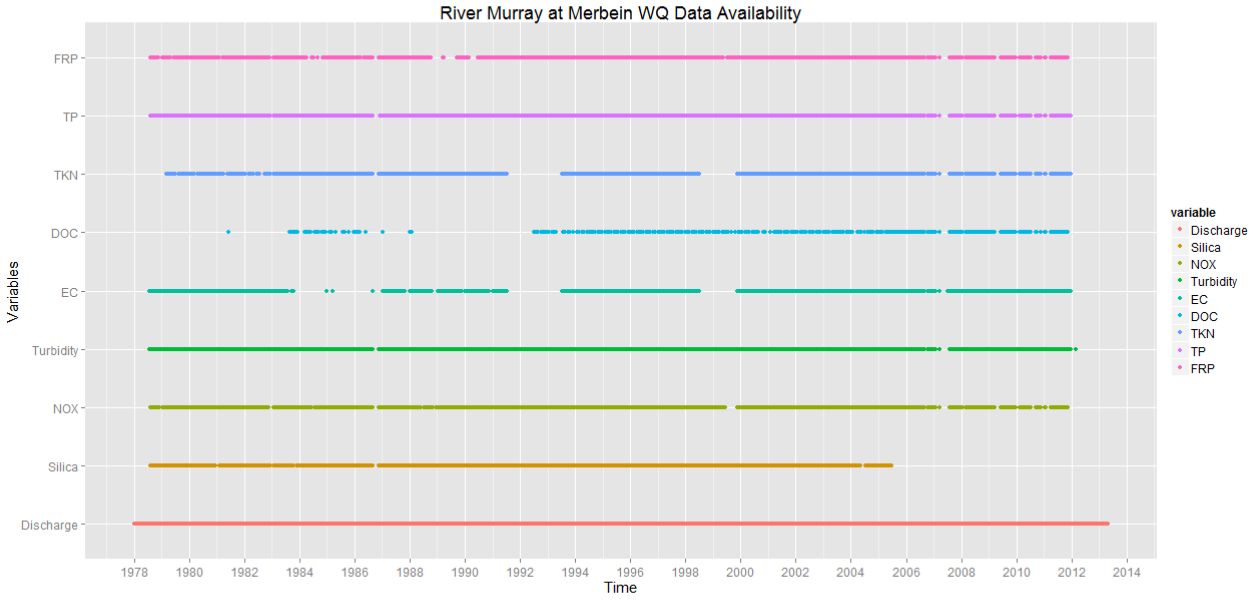

River Murray at Heywoods WQ Data Availability
Variables
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

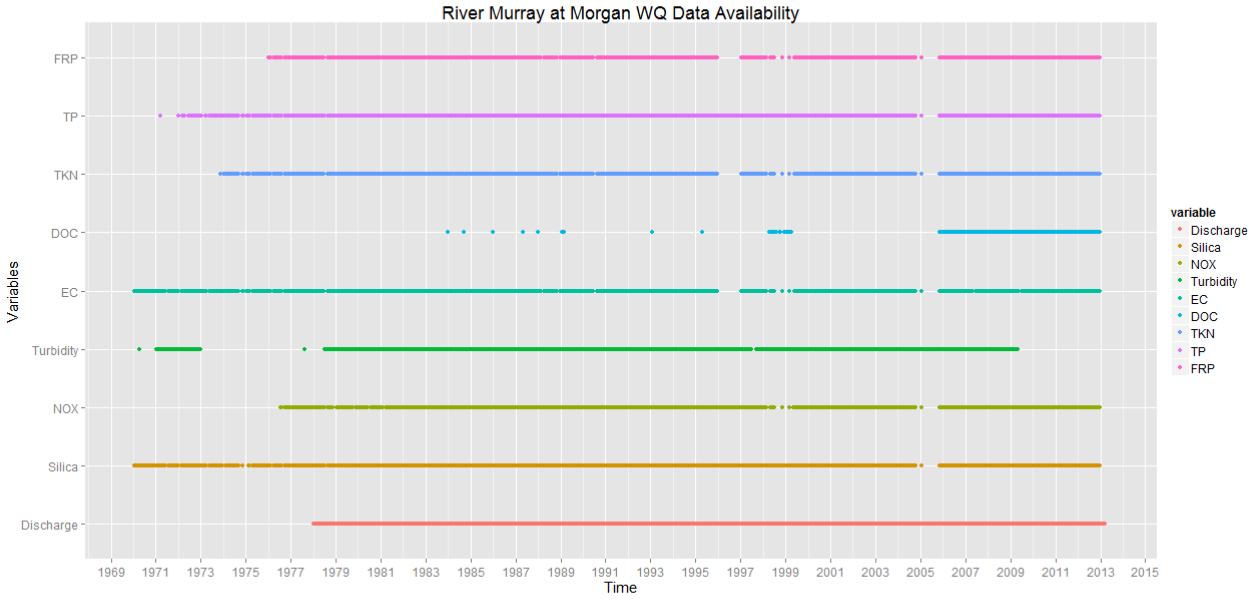

River Murray at Jingellic WQ Data Availability
Variables
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

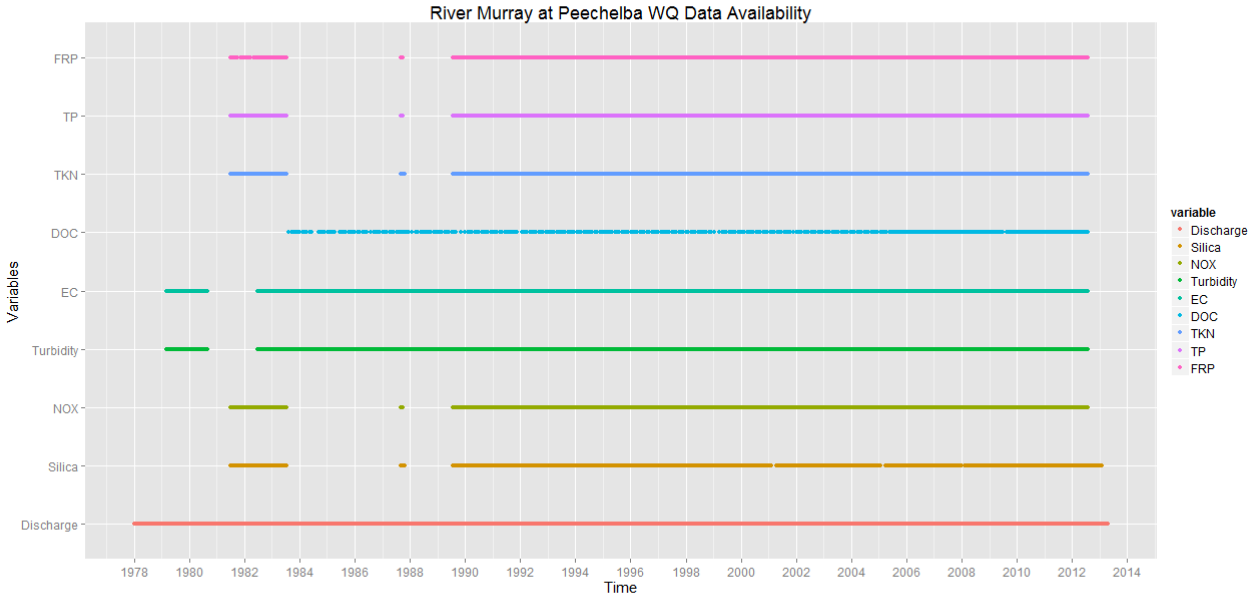

River Murray at Kerang WQ Data Availability
Variables
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

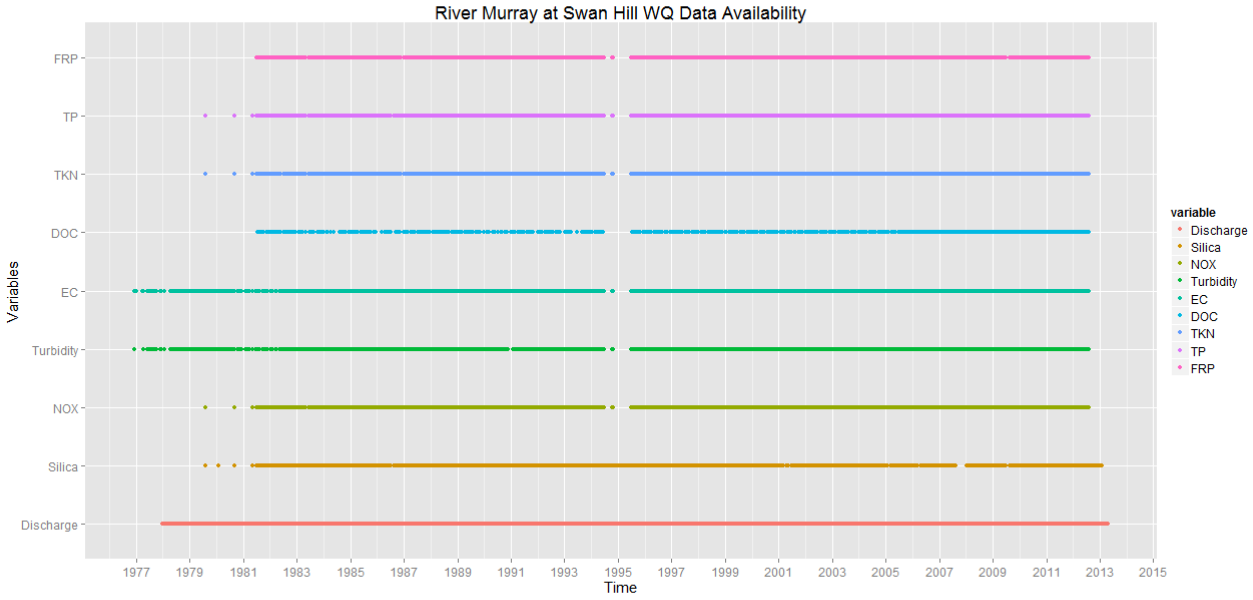

River Murray at Kyalite WQ Data Availability
Variables
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

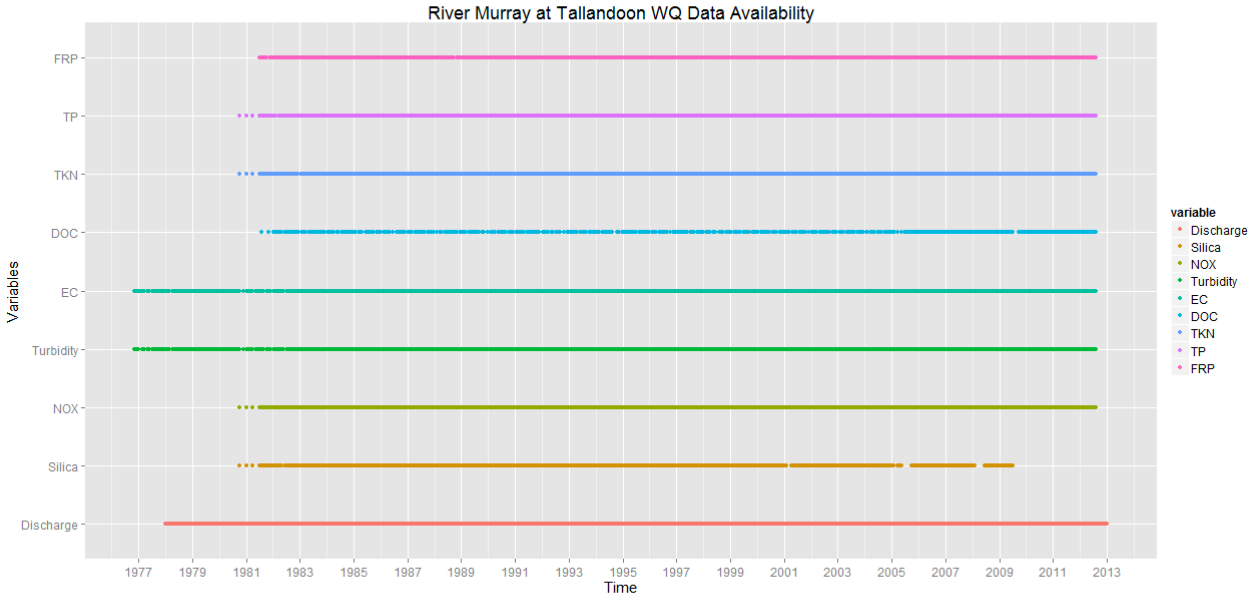

River Murray at Lock 9 WQ Data Availability
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
Variables
1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

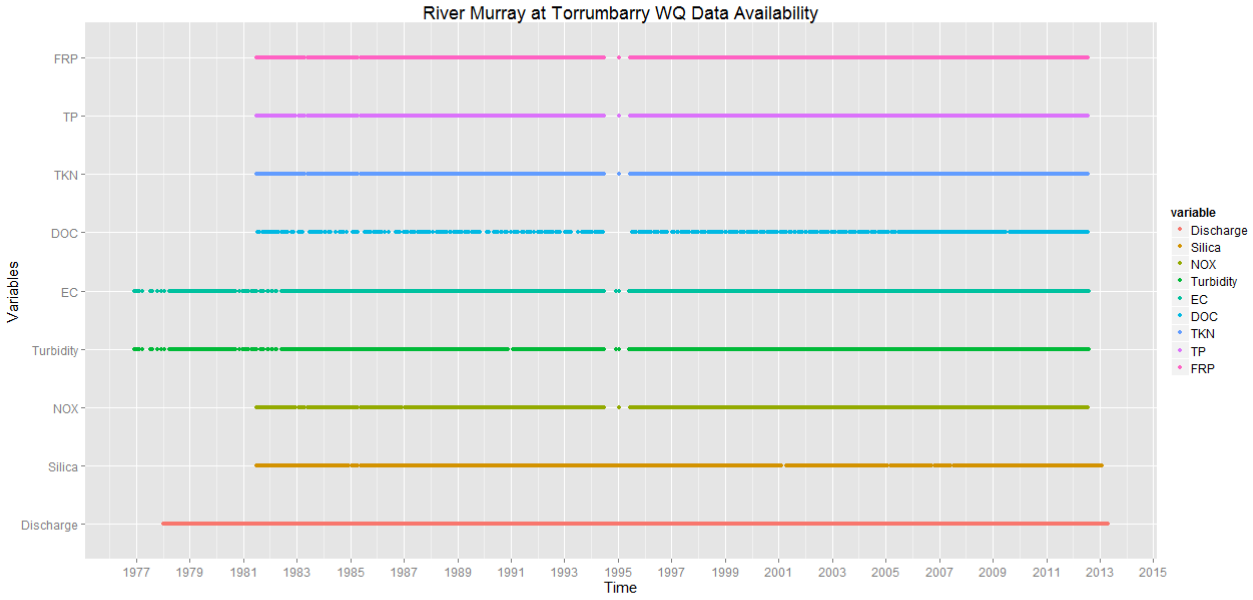

River Murray at Merbein WQ Data Availability
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
Variables
1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

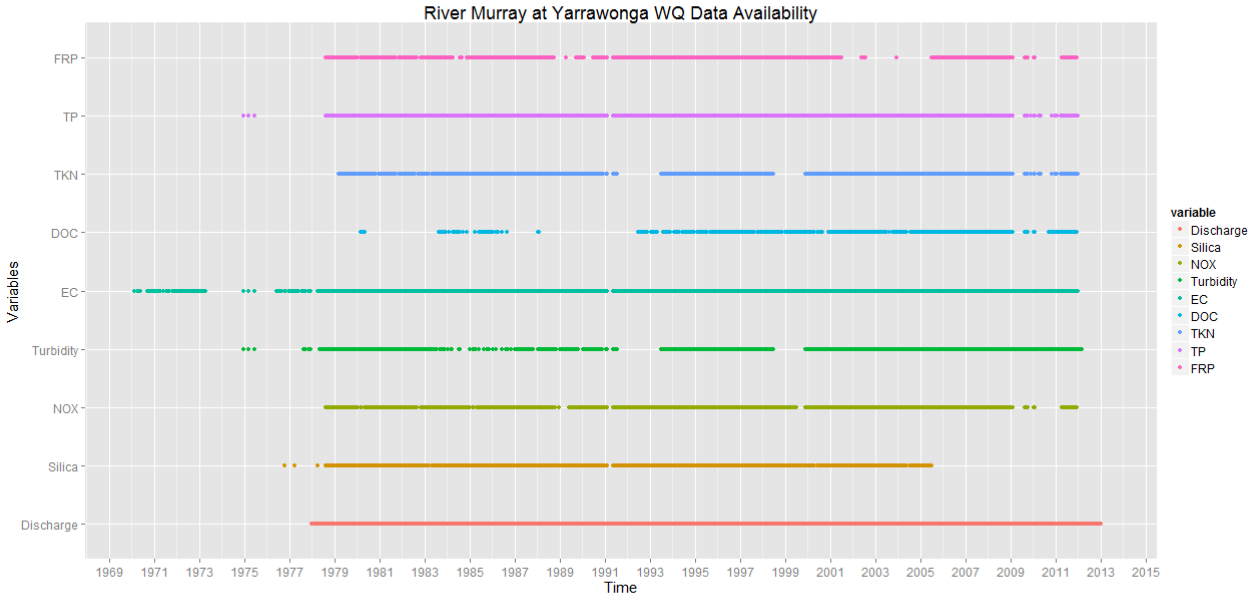

River Murray at Morgan WQ Data Availability
Variables
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP


River Murray at Peechelba WQ Data Availability
Variables
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

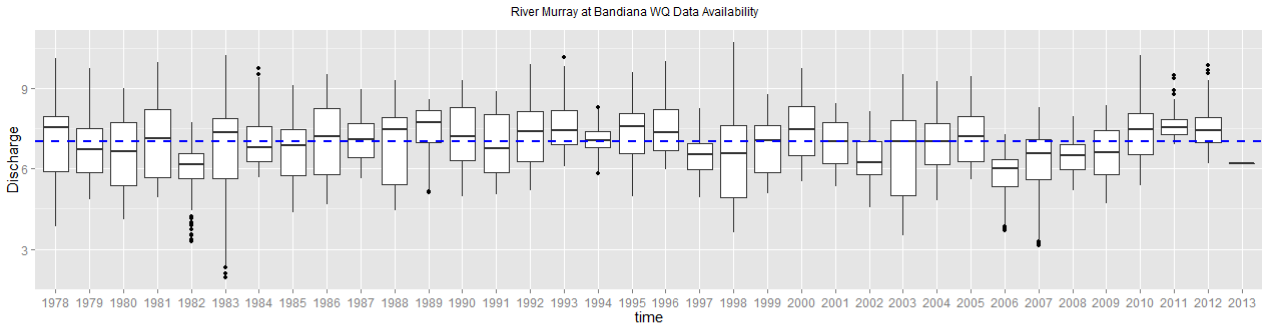

River Murray at Swan Hill WQ Data Availability
Variables
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

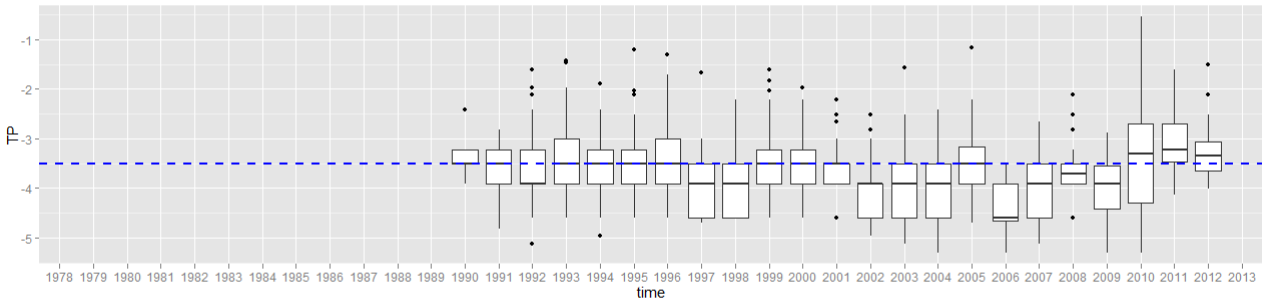

River Murray at Tallandoon WQ Data Availability
Variables
FRP
TP
TKN
DOC
EC
Turbidity
NOX
Silica
Discharge
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Time
variable
Discharge
Silica
NOX
Turbidity
EC
DOC
TKN
TP
FRP

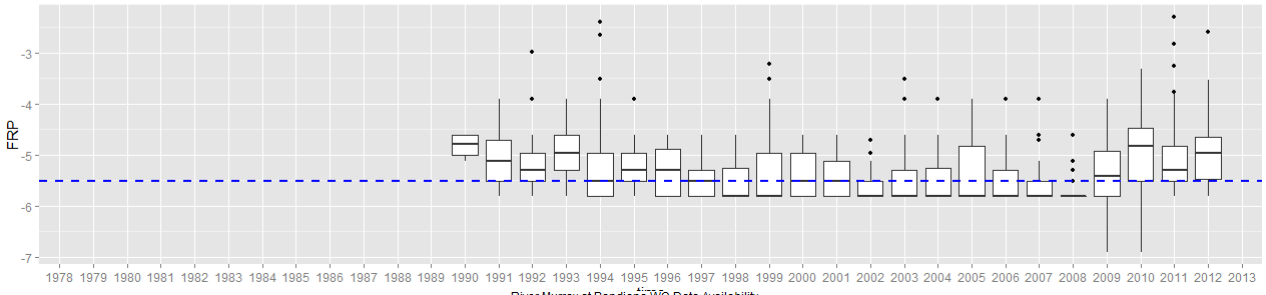


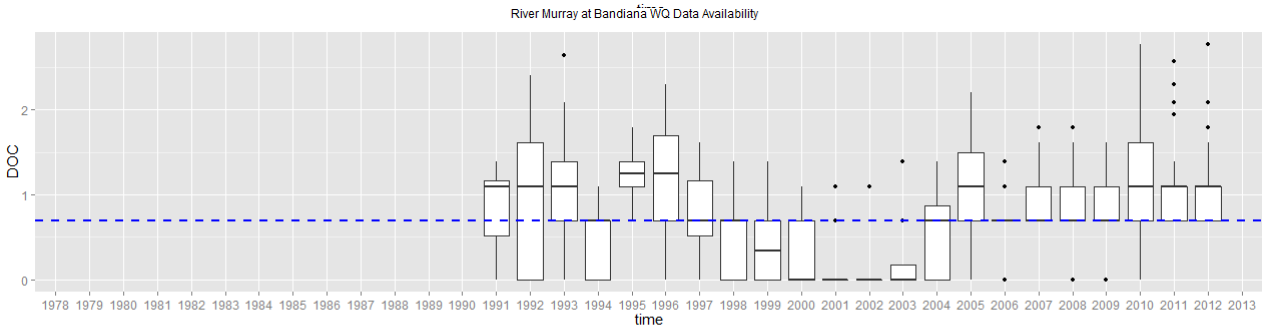


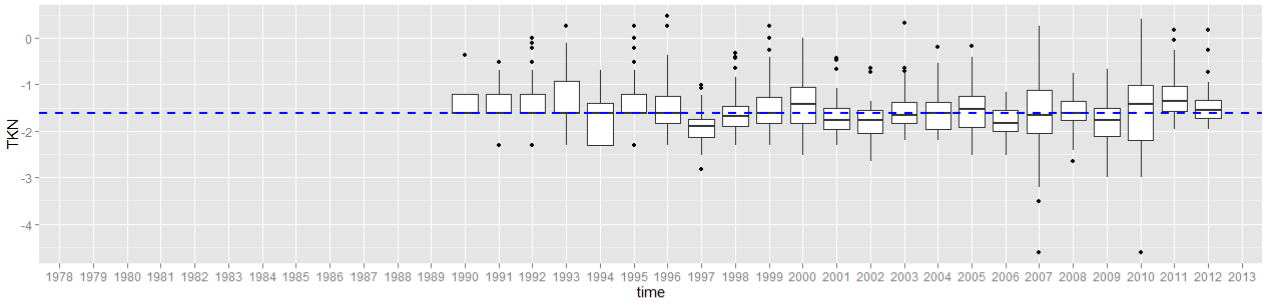
B: Water quality time series

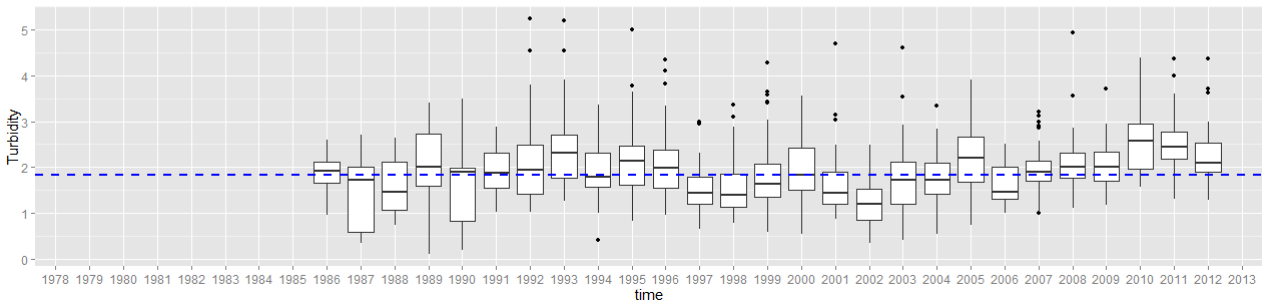

River Murray at Bandiana WQ Data Availability
Discharge
9
6
3
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

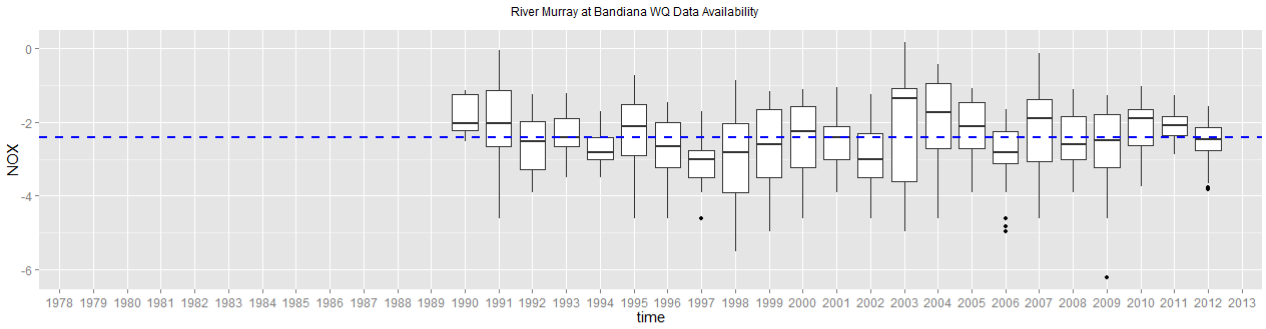

TP
-1
-2
-3
-4
-5
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

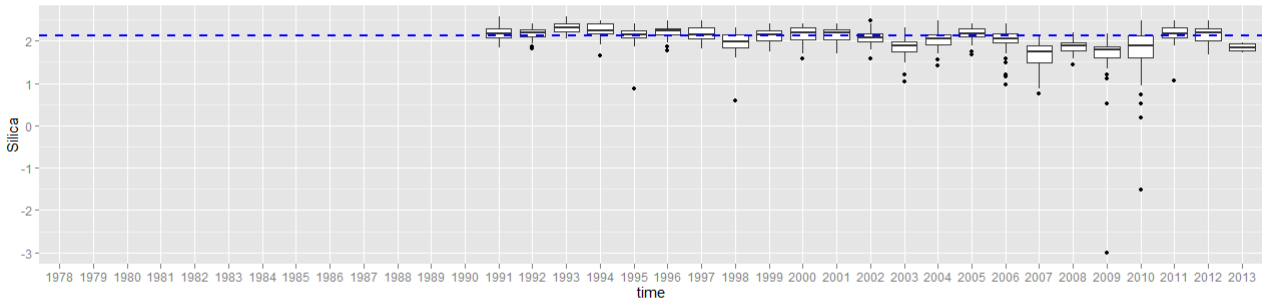

FRP
-3
-4
-5
-6
-7
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

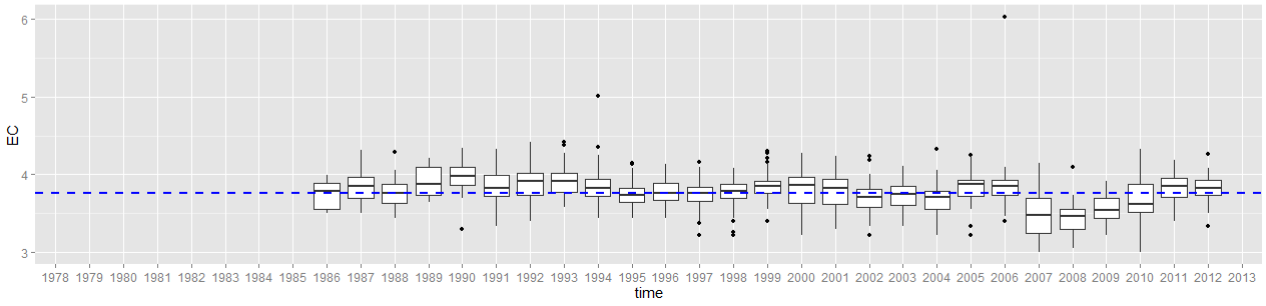

River Murray at Bandiana WQ Data Availability
DOC
2
1
0
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

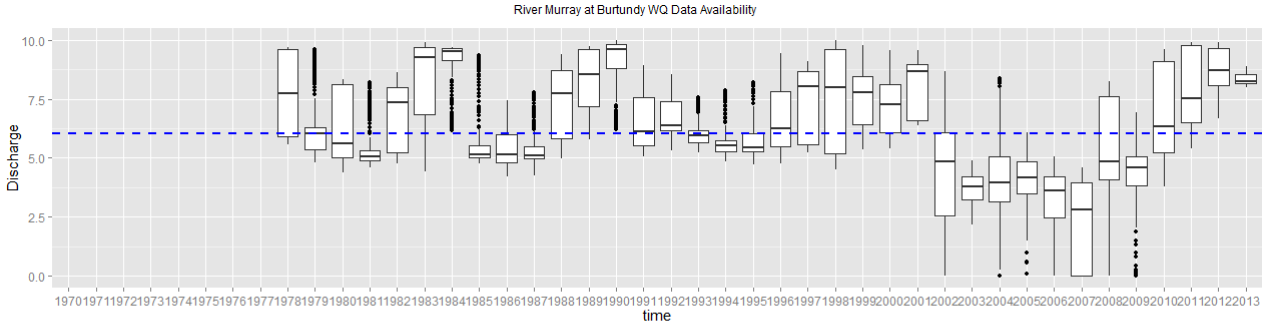

TKN
0
-1
-2
-3
-4
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

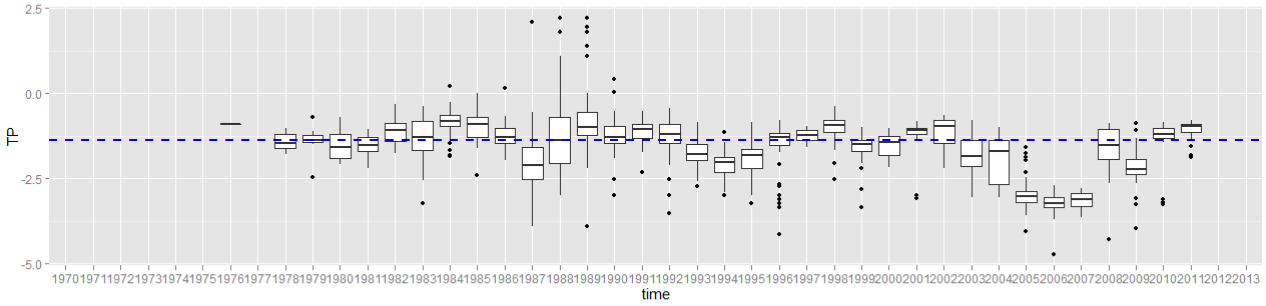

Turbidity
5
4
3
2
1
0
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

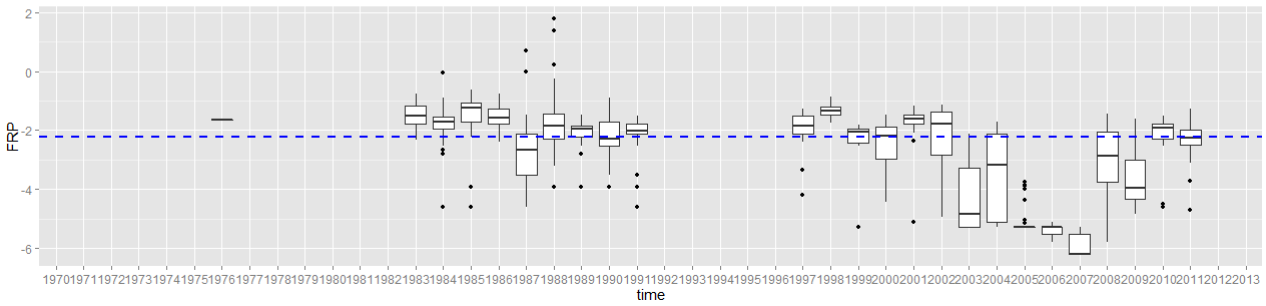

River Murray at Bandiana WQ Data Availability
NOX
time

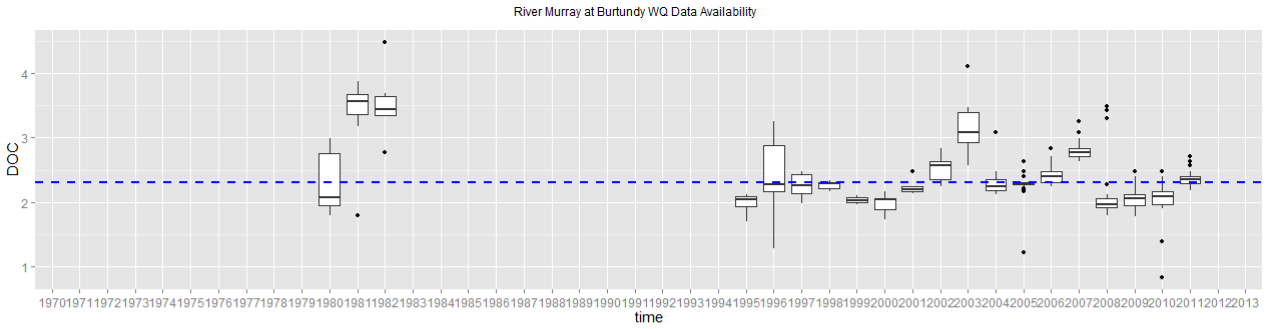

Silica
time

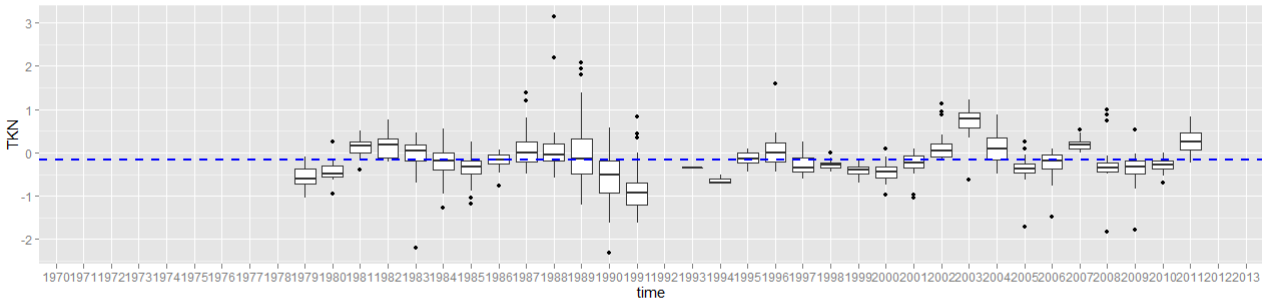

EC
time

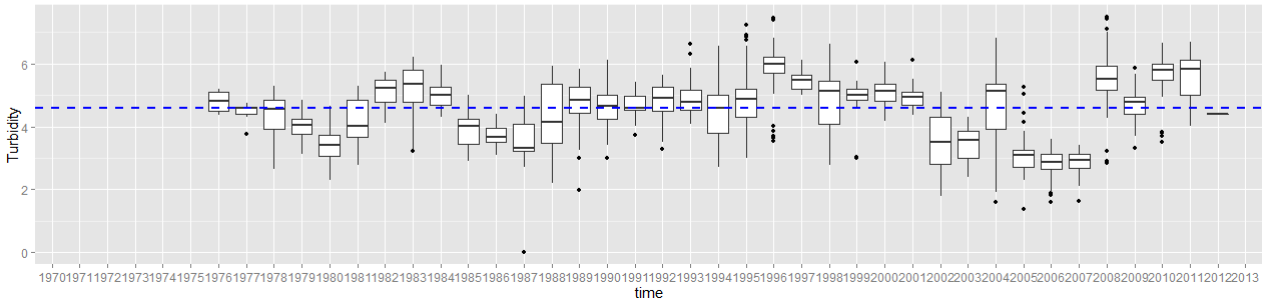

River Murray at Burtundy WQ Data Availability
Discharge
time

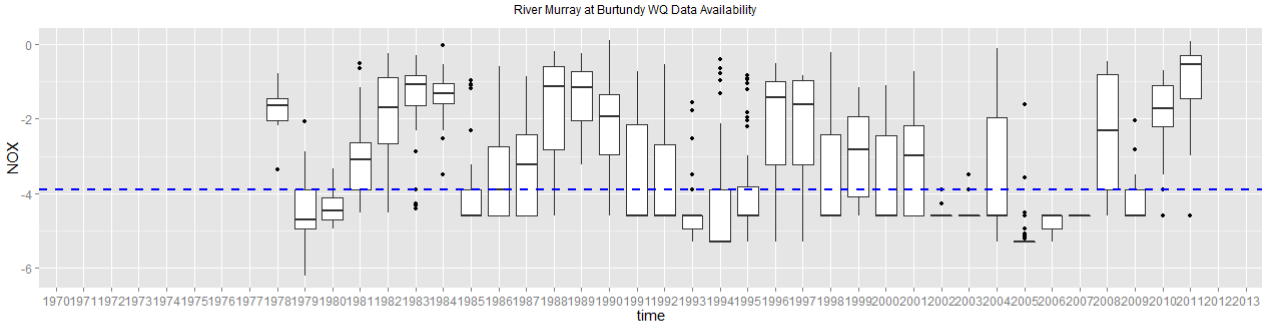

TP
time

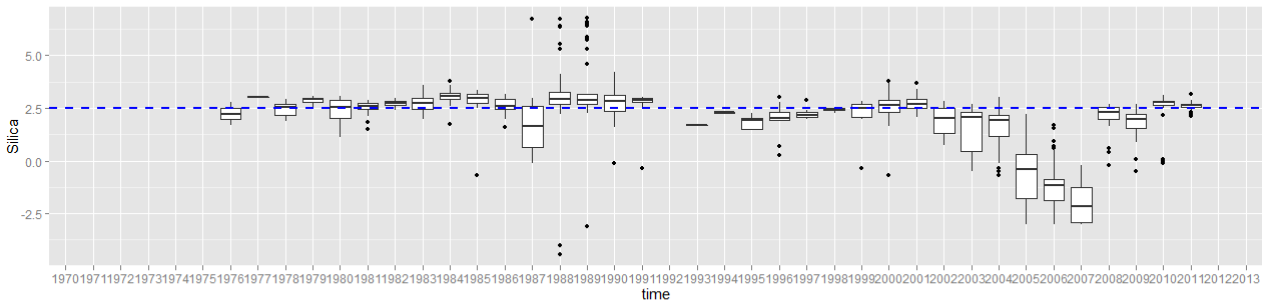

FRP
time

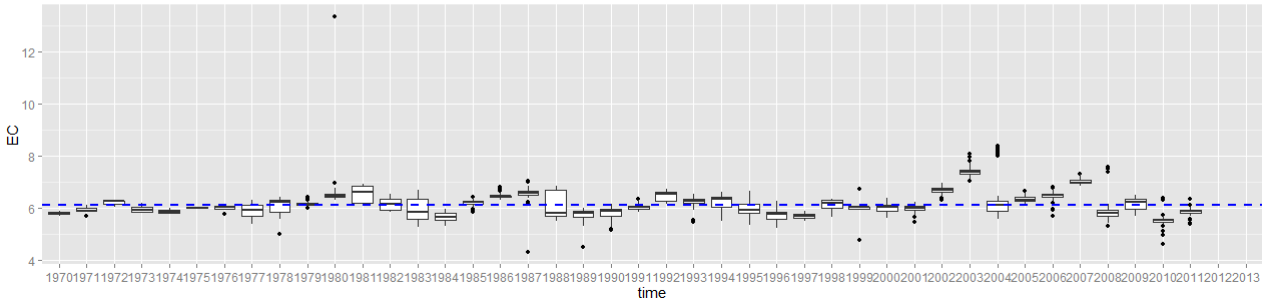

River Murray at Burtundy WQ Data Availability
DOC
time

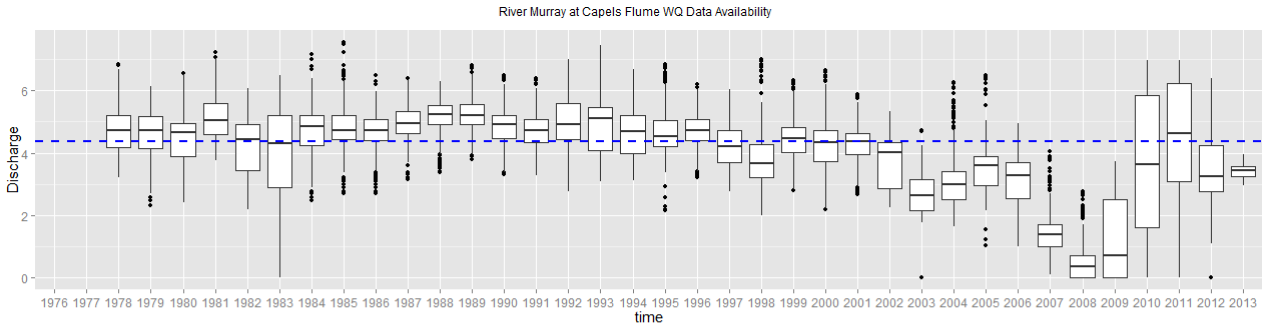

TKN
time

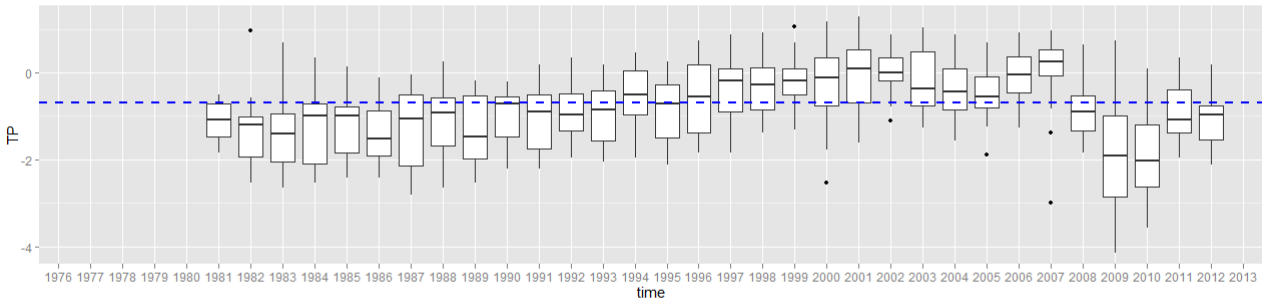

Turbidity
time

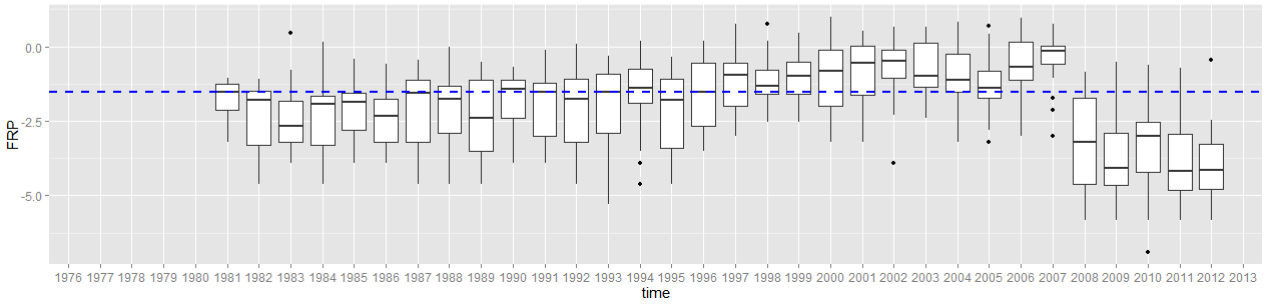

River Murray at Burtundy WQ Data Availability
NOX
time

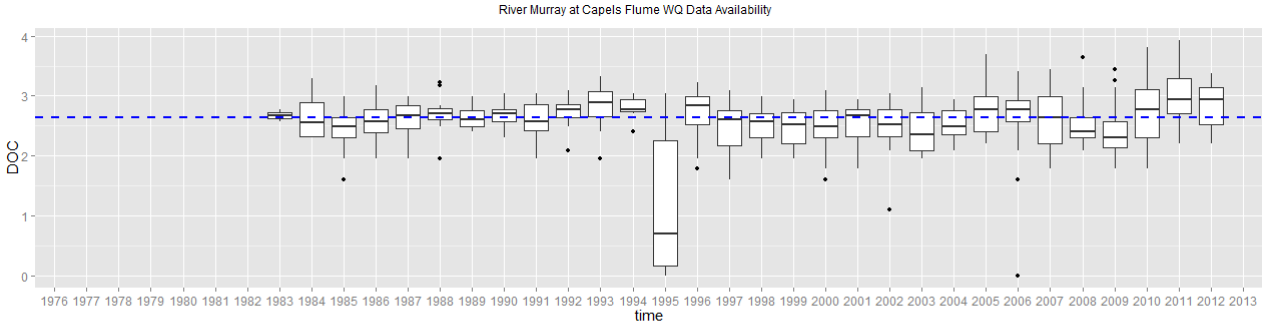

Silica
time

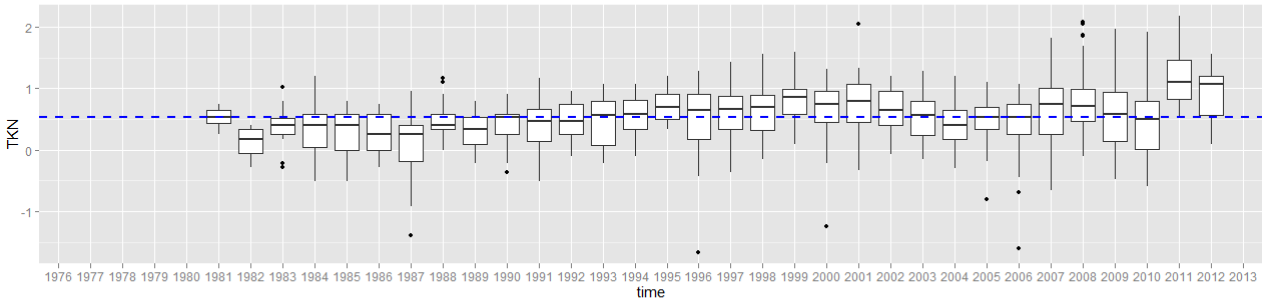

EC
time

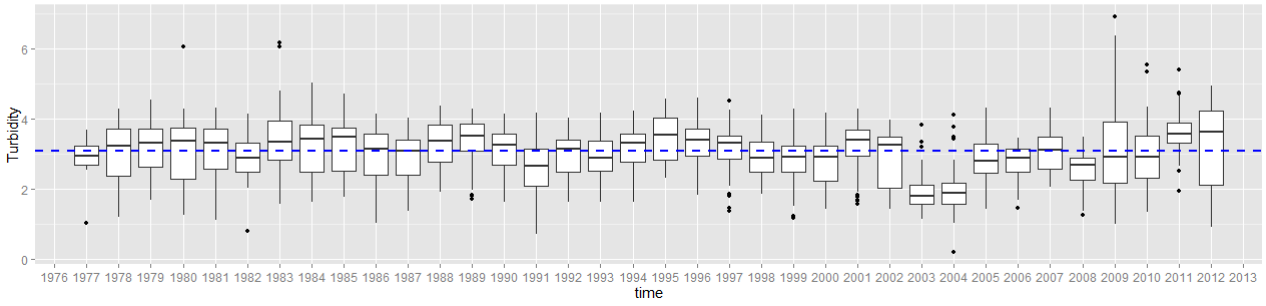

River Murray at Capels Flume WQ Data Availability
Discharge
time

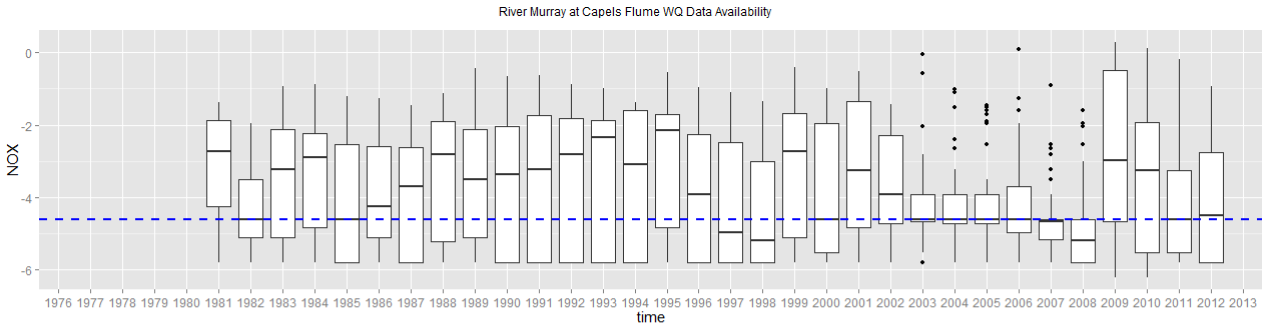

TP
time

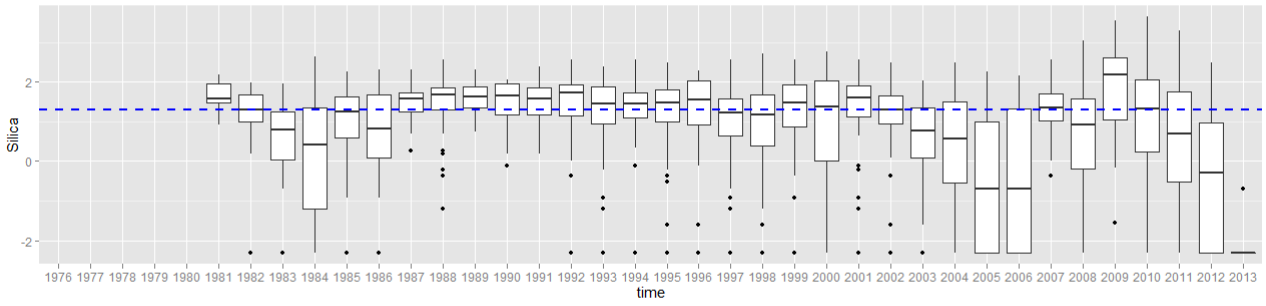

FRP
time

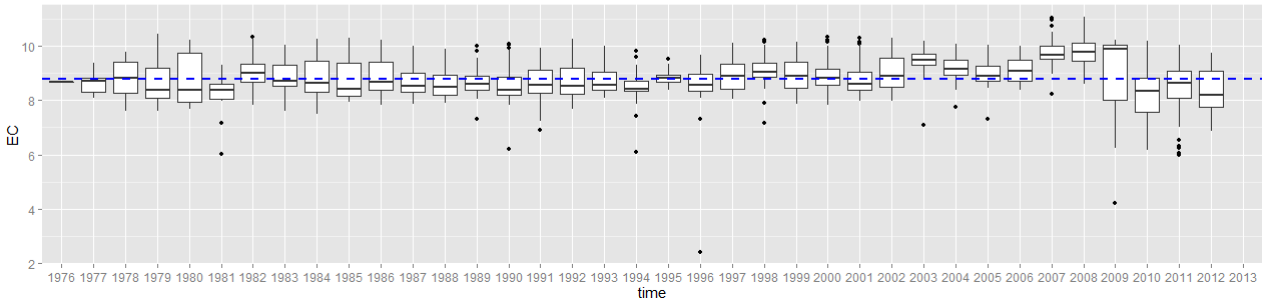

River Murray at Capels Flume WQ Data Availability
DOC
time

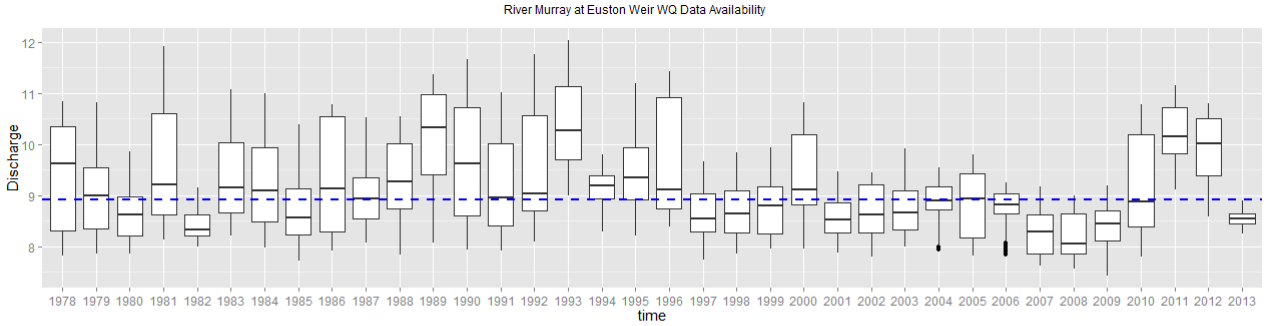

TKN
time

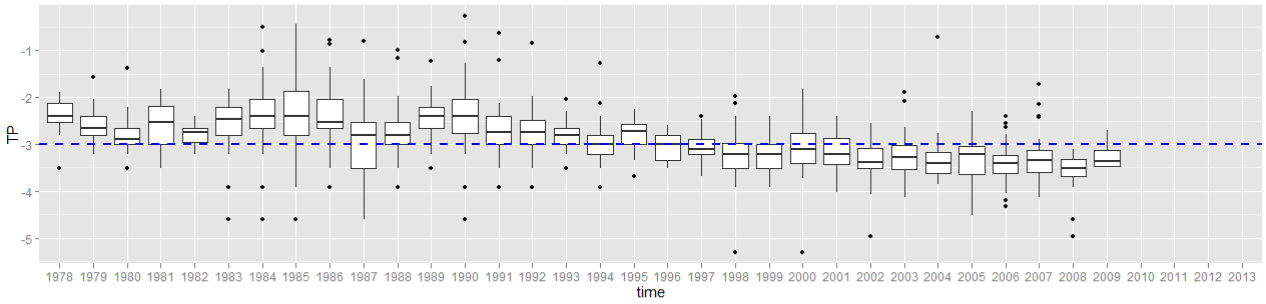

Turbidity
time

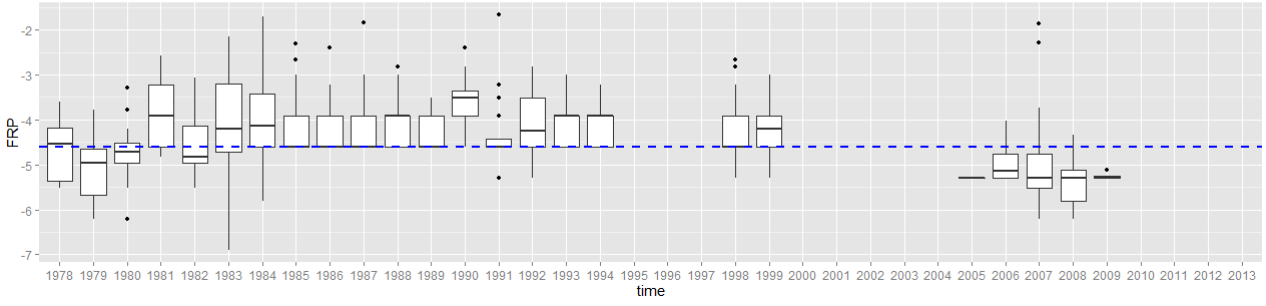

River Murray at Capels Flume WQ Data Availability
NOX
0
-2
-4
-6
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

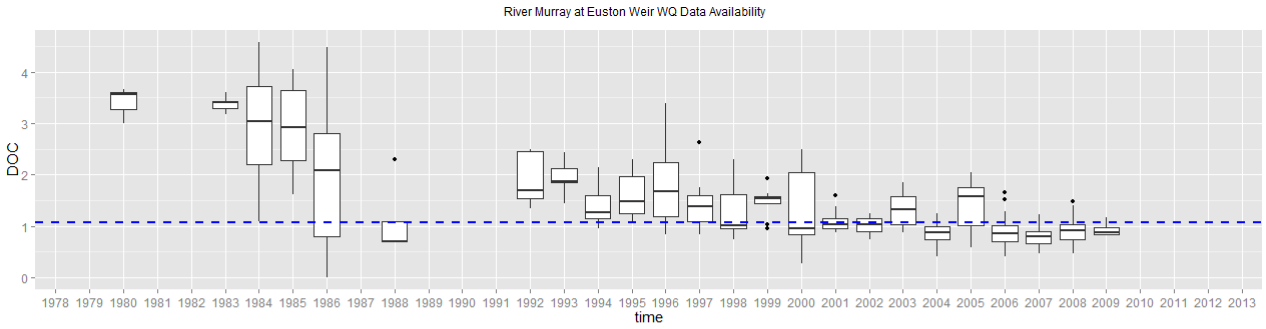

Silica
2
0
-2
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

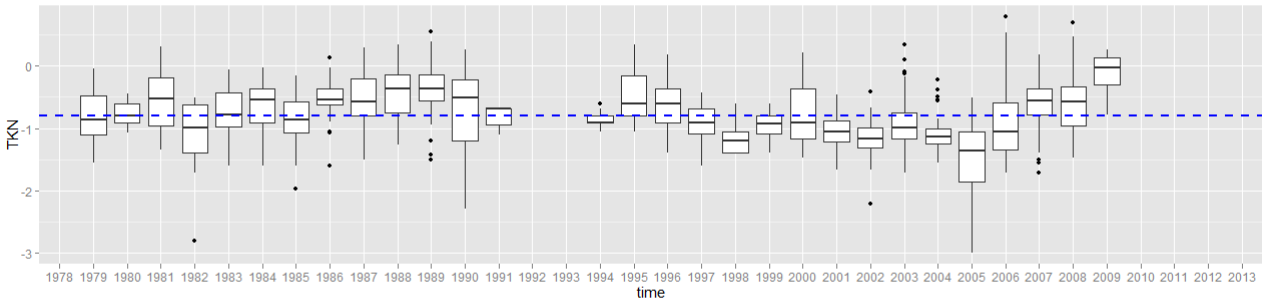

EC
10
8
6
4
2
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

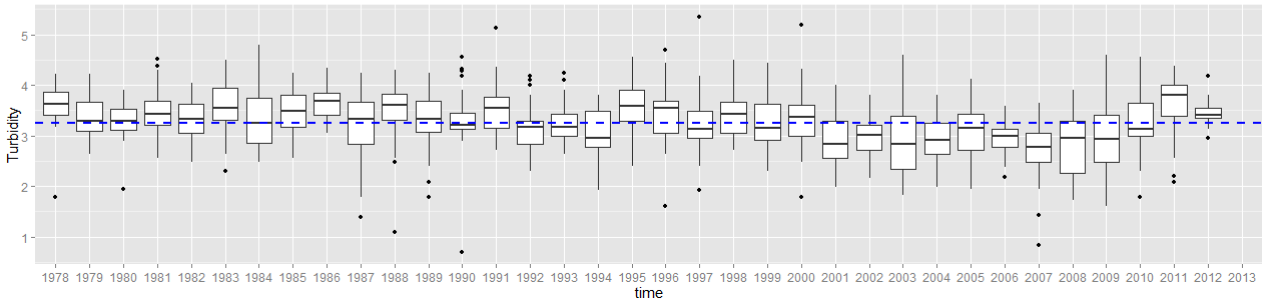

River Murray at Euston Weir WQ Data Availability
Discharge
12
11
10
9
8
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

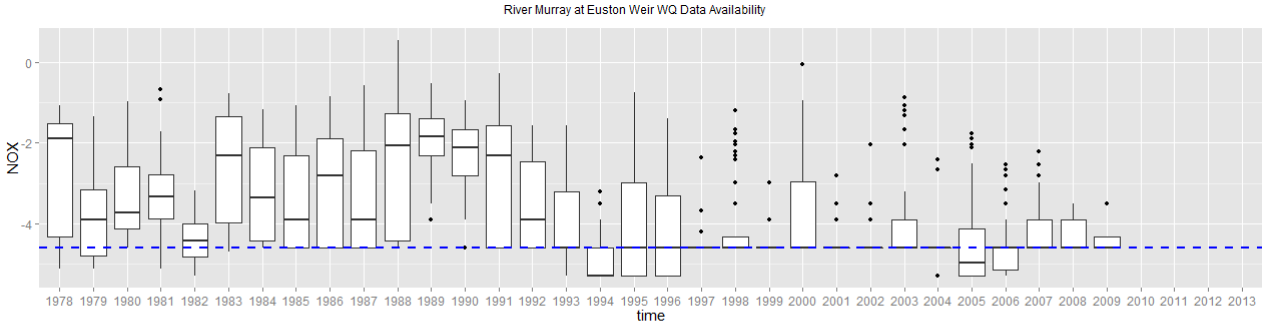

TP
-1
-2
-3
-4
-5
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

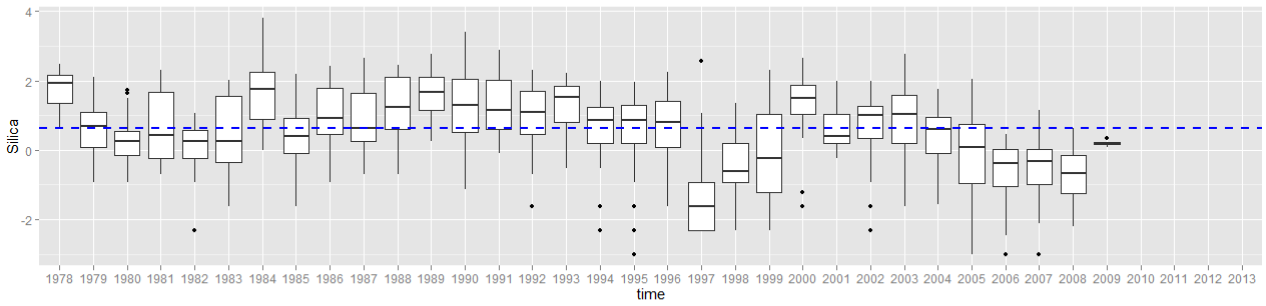

FRP
-2
-3
-4
-5
-6
-7
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

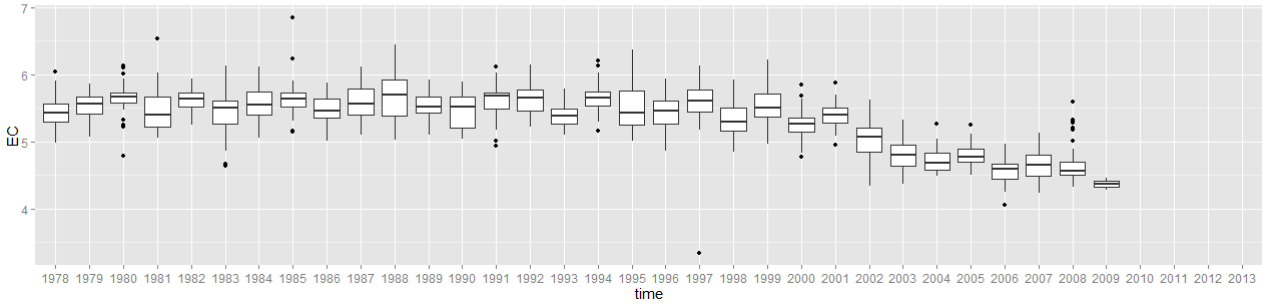

River Murray at Euston Weir WQ Data Availability
DOC
time

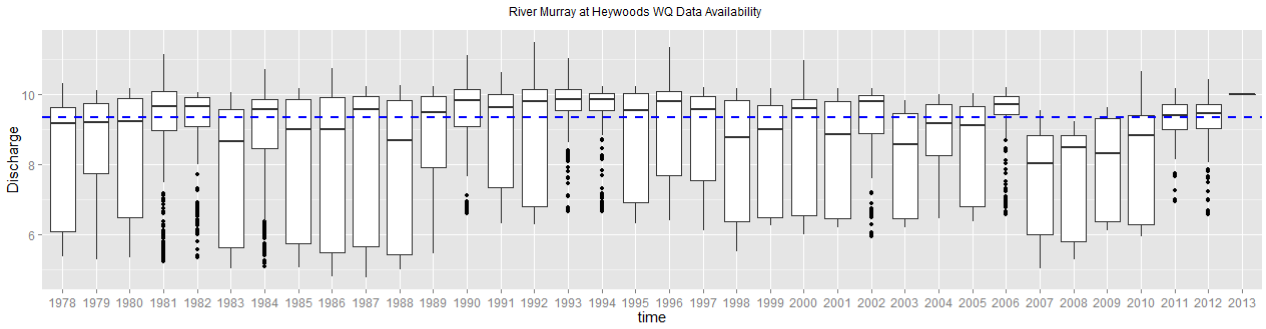

TKN
time

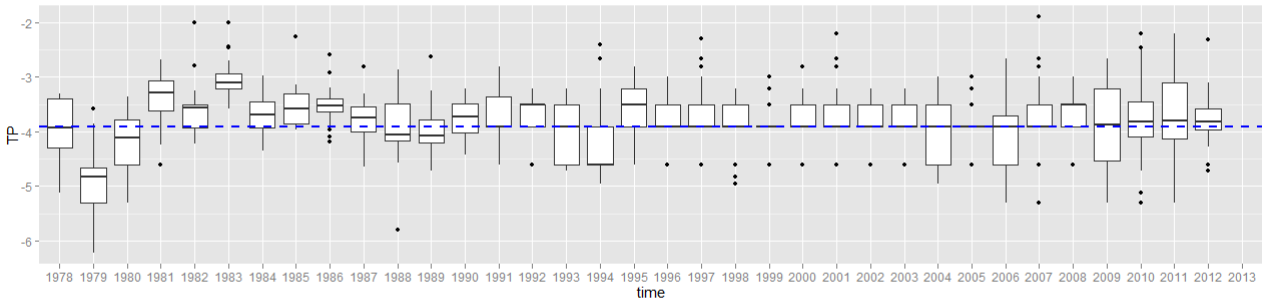

Turbidity
time

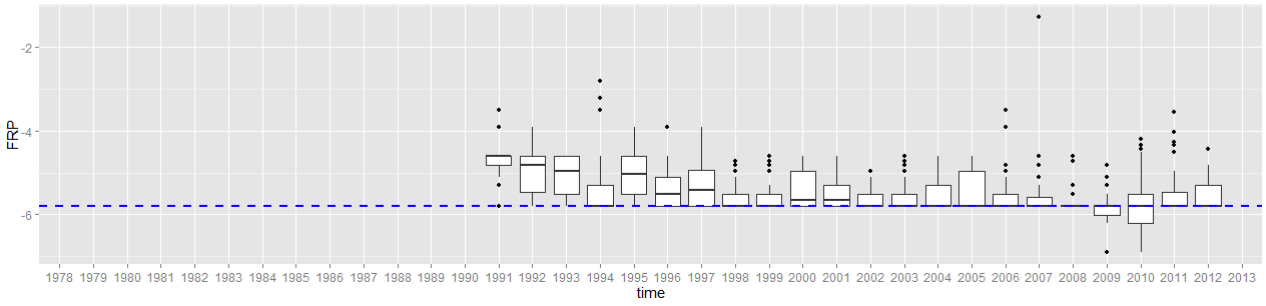

River Murray at Euston Weir WQ Data Availability
NOX
time

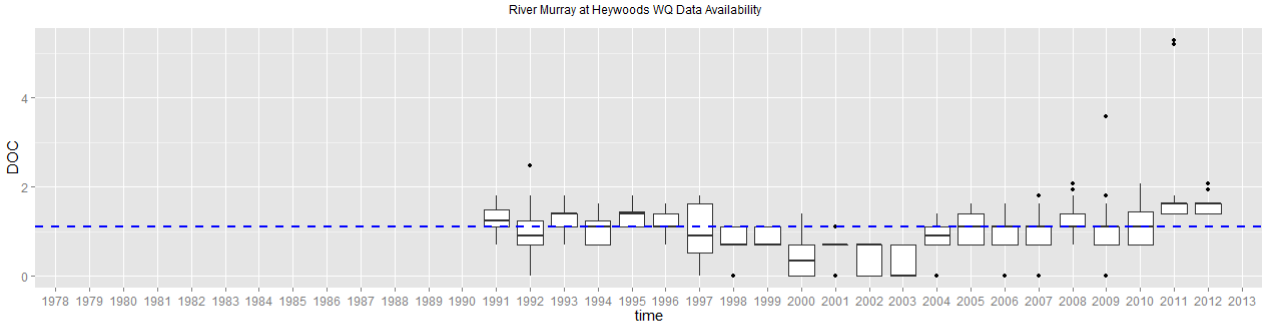

Silica
time

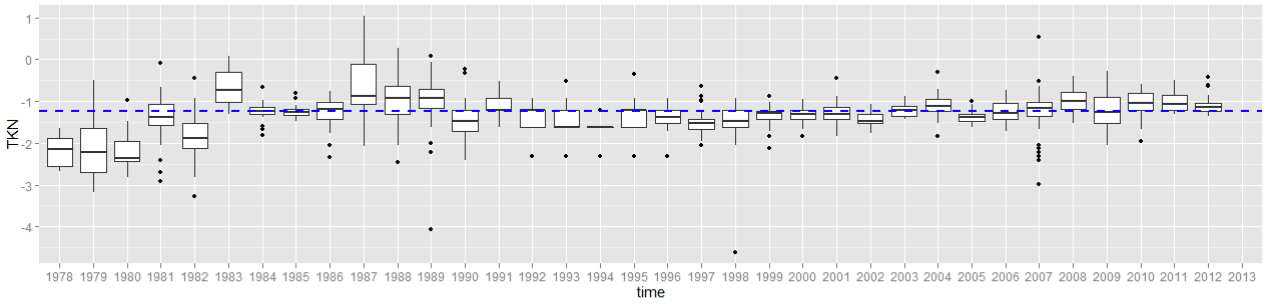

EC
time

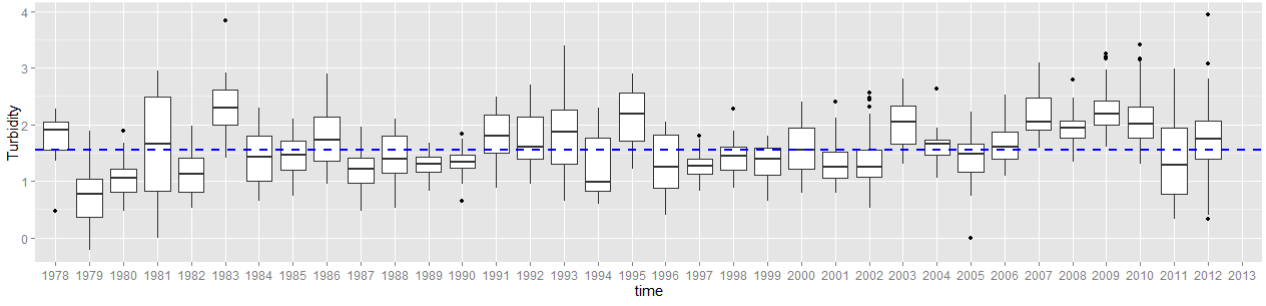

River Murray at Heywoods WQ Data Availability
Discharge
time

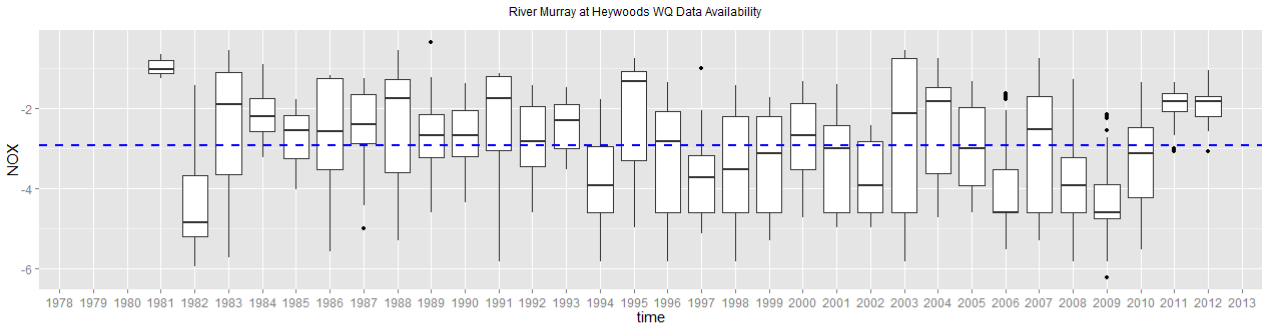

TP
time

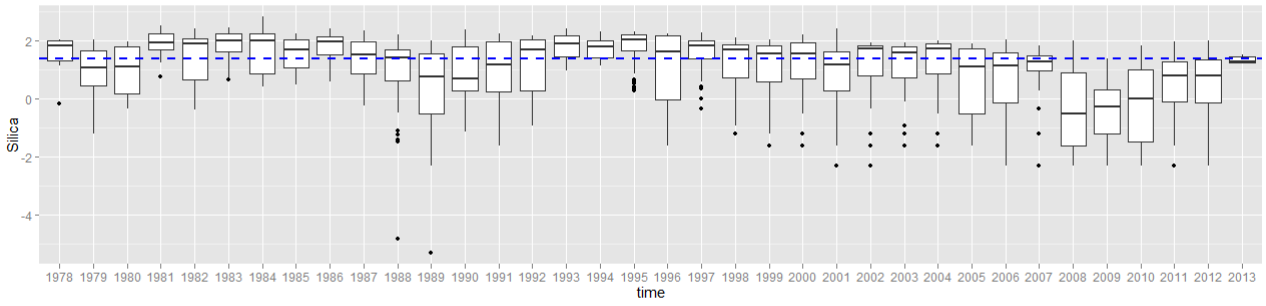

FRP
time

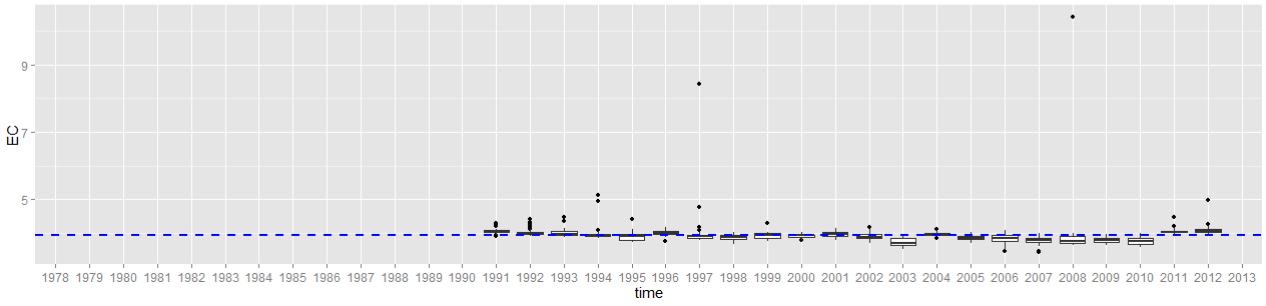

River Murray at Heywoods WQ Data Availability
DOC
time

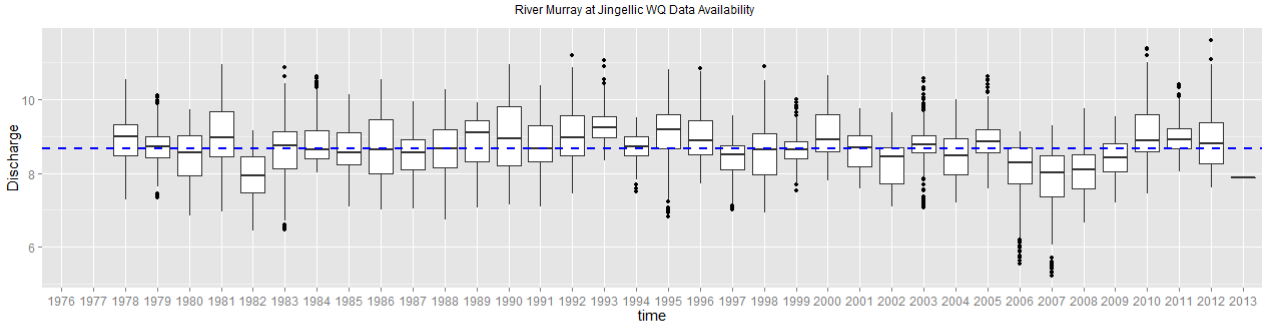

TKN
time

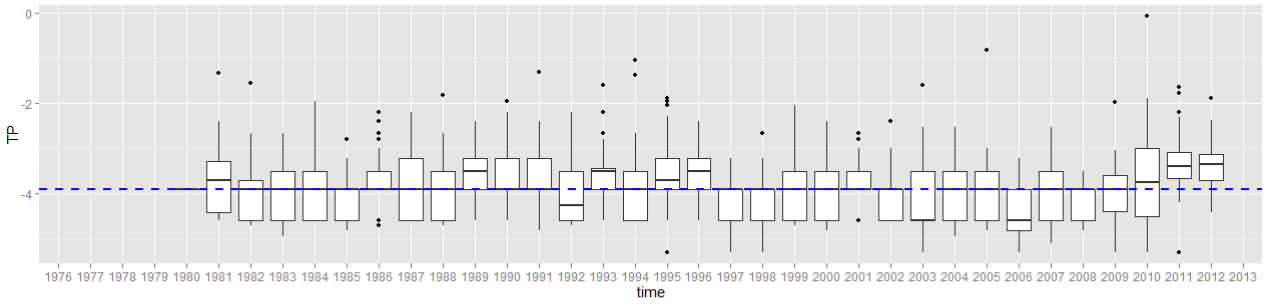

Turbidity
time

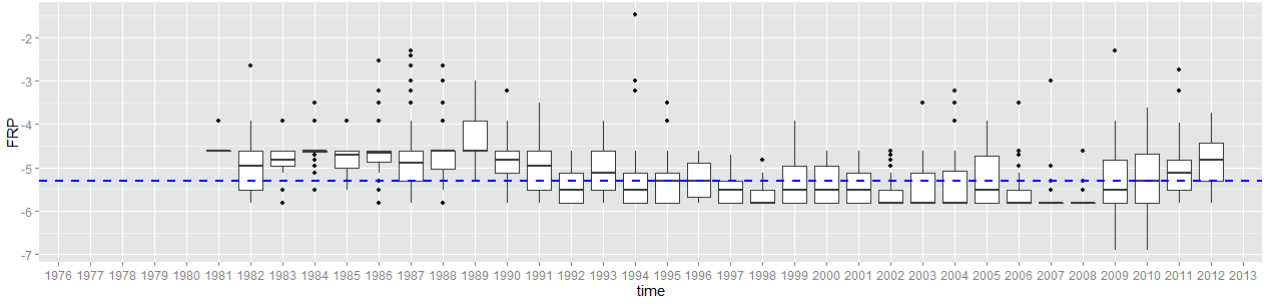

River Murray at Heywoods WQ Data Availability
NOX
-2
-4
-6
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

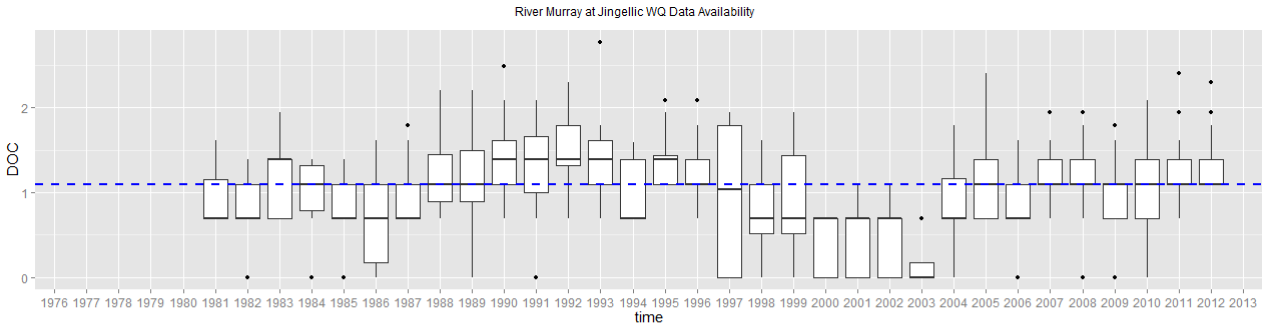

Silica
2
0
-2
-4
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

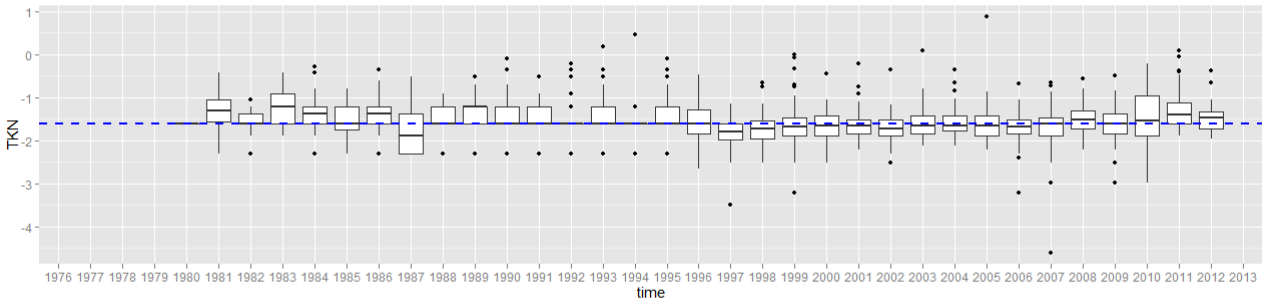

EC
9
7
5
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

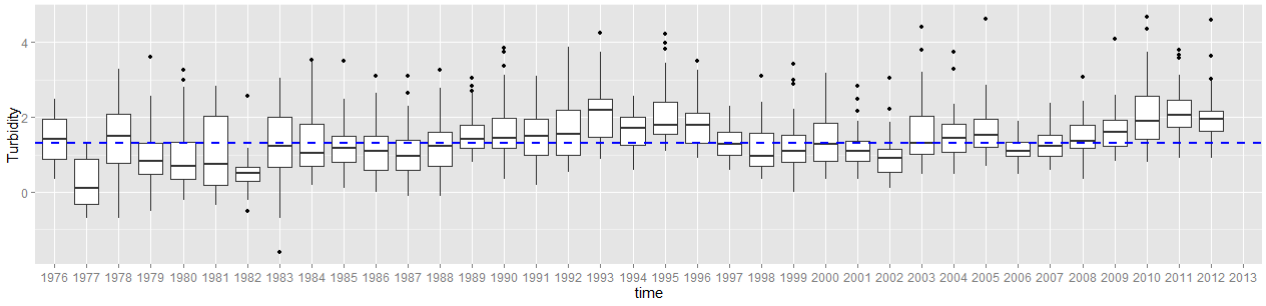

River Murray at Jingellic WQ Data Availability
Discharge
10
8
6
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

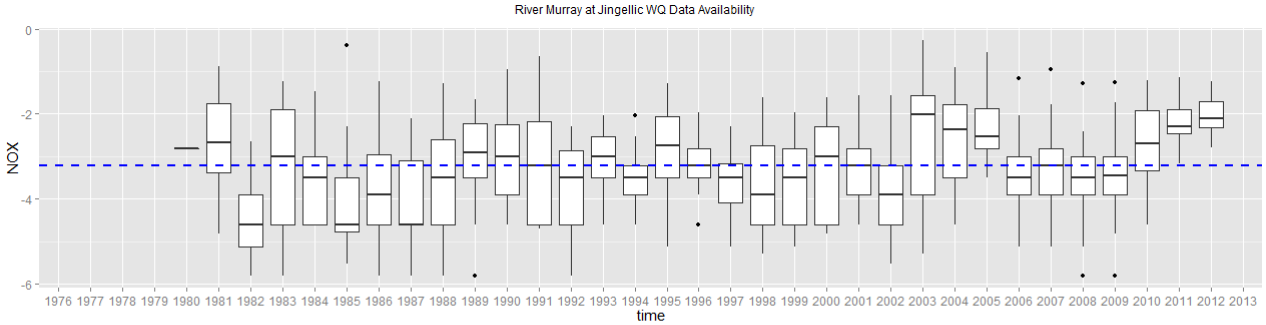

TP
0
-2
-4
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

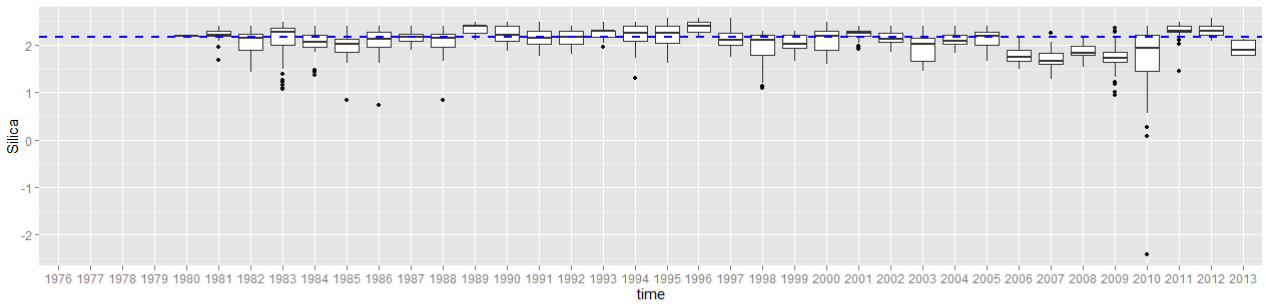

FRP
-2
-3
-4
-5
-6
-7
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

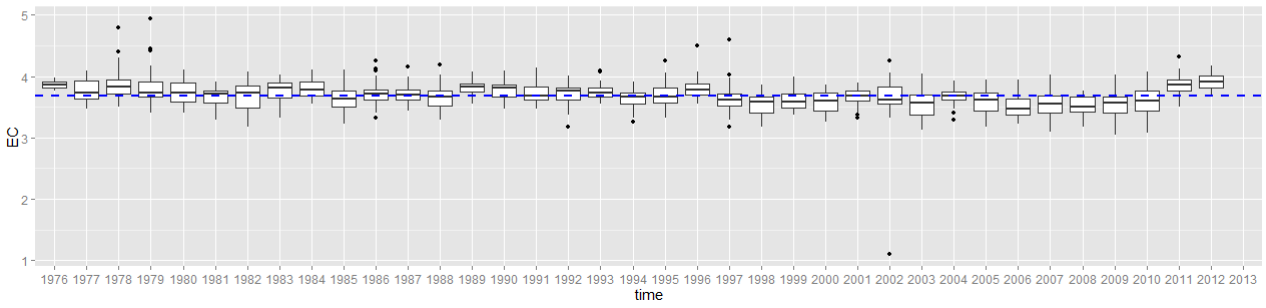

River Murray at Jingellic WQ Data Availability
DOC
time

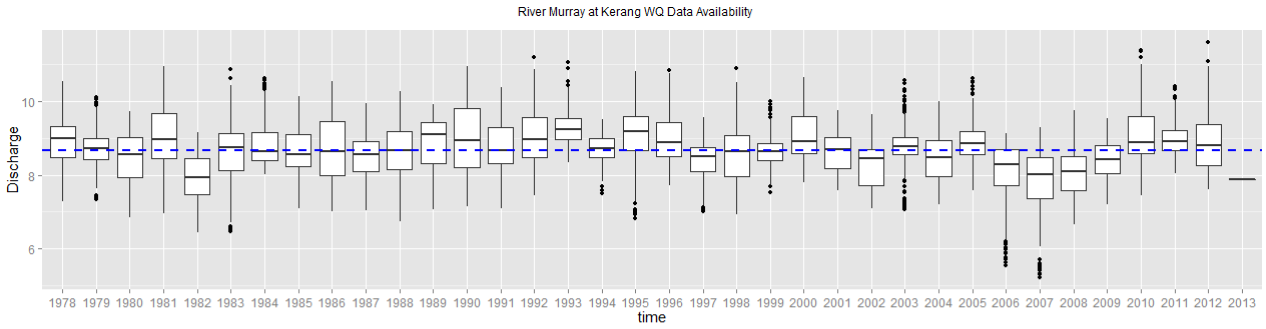

TKN
time

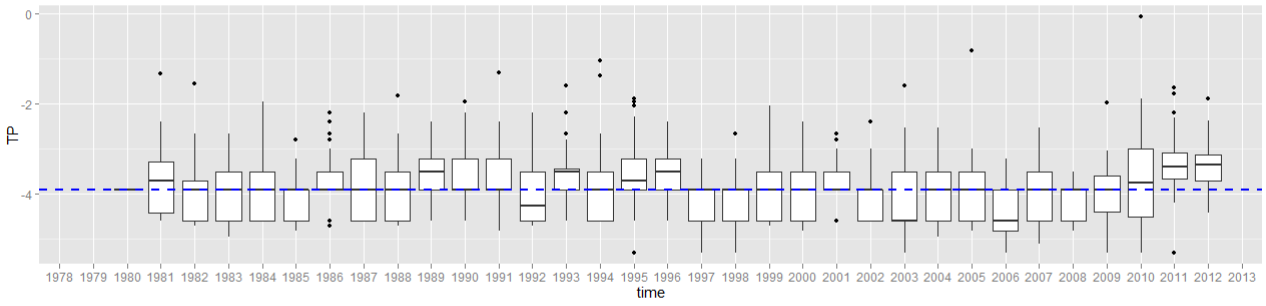

Turbidity
time

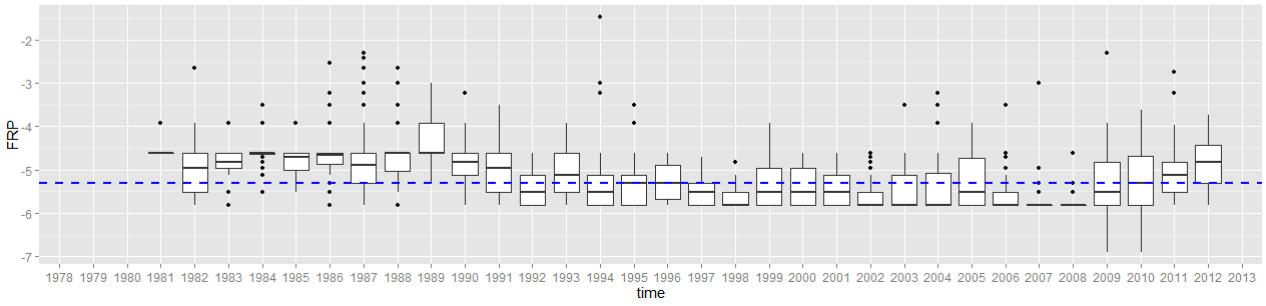

River Murray at Jingellic WQ Data Availability
NOX
time

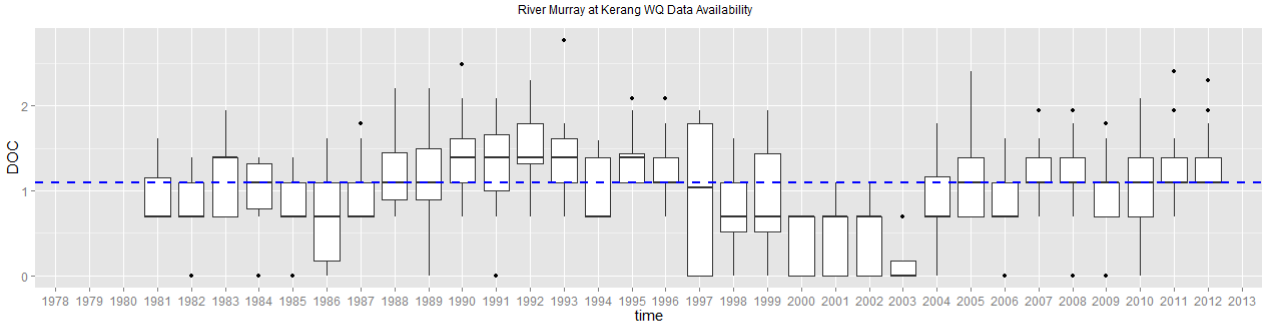

Silica
time

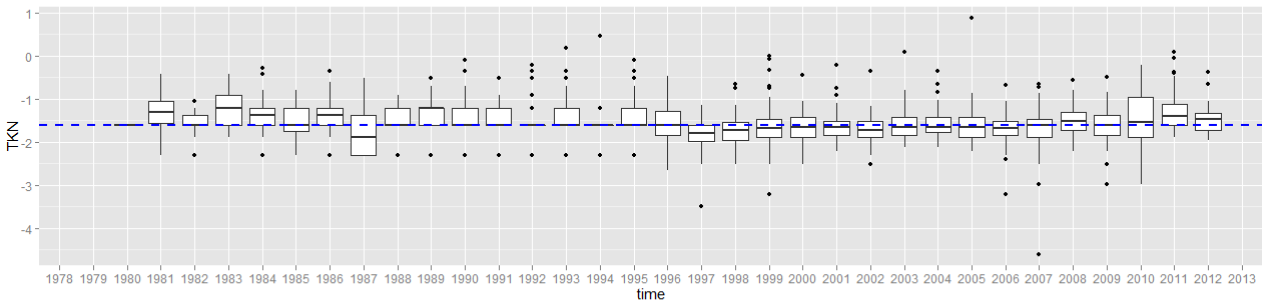

EC
time

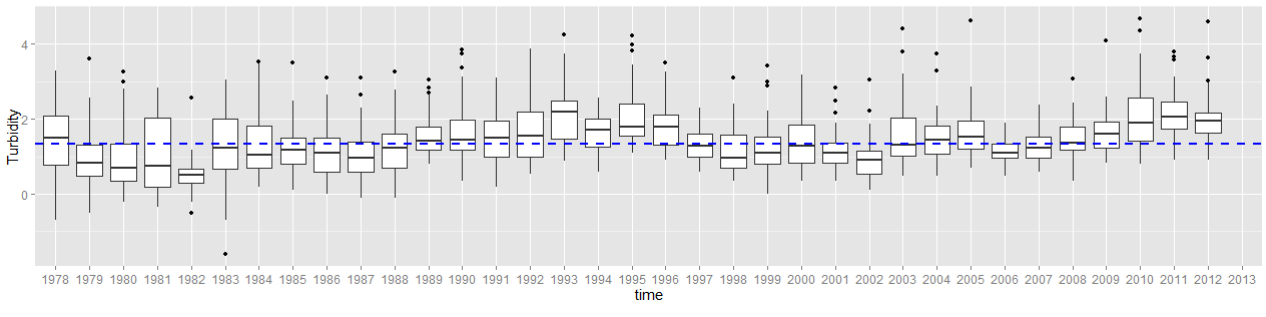

River Murray at Kerang WQ Data Availability
Discharge
time

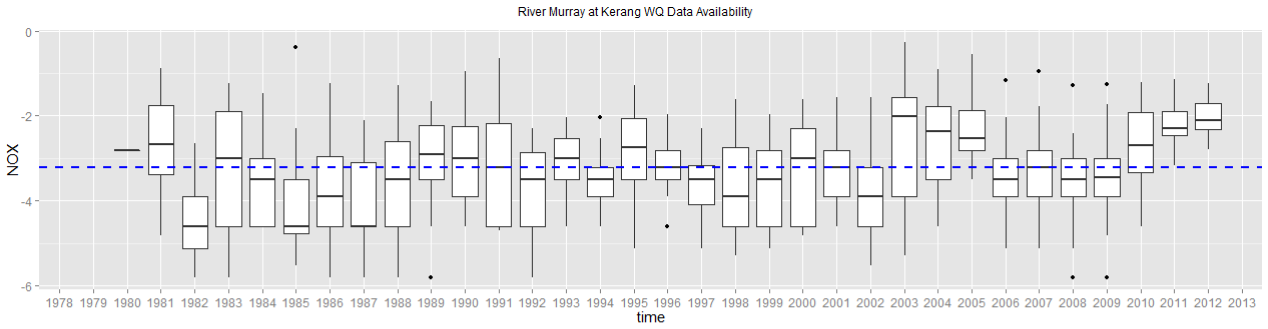

TP
time

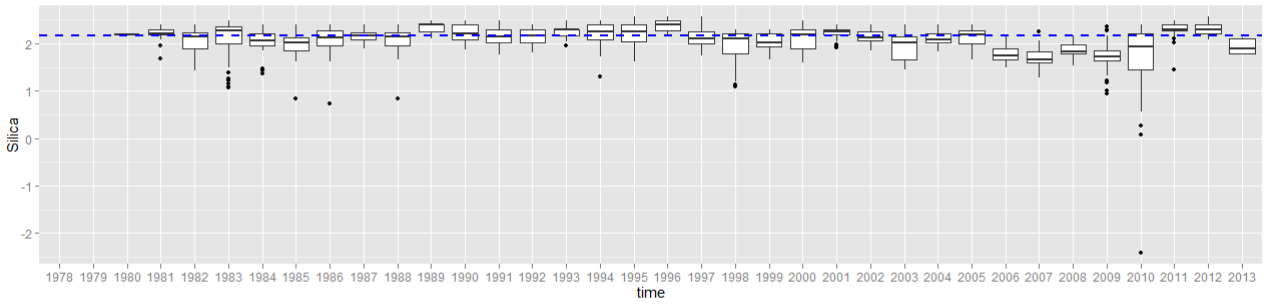

FRP
time

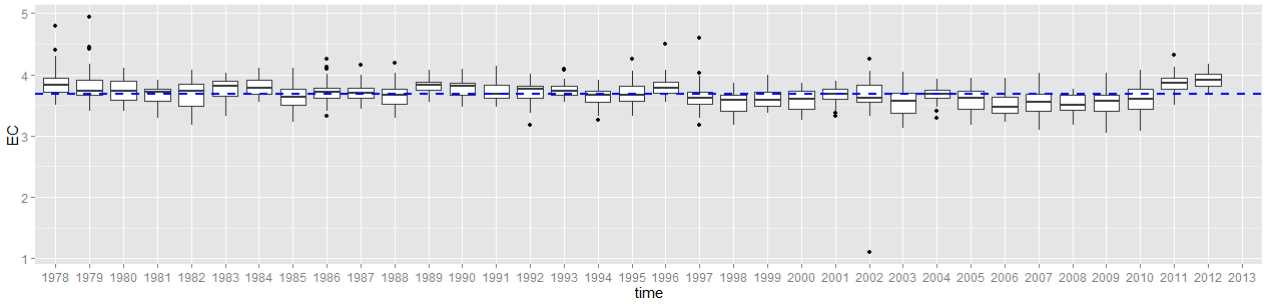

River Murray at Kerang WQ Data Availability
DOC
time


TKN
time

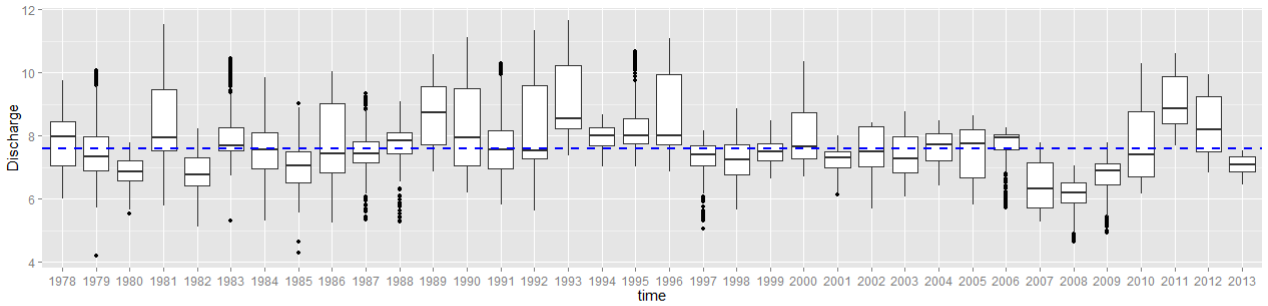

Turbidity
time

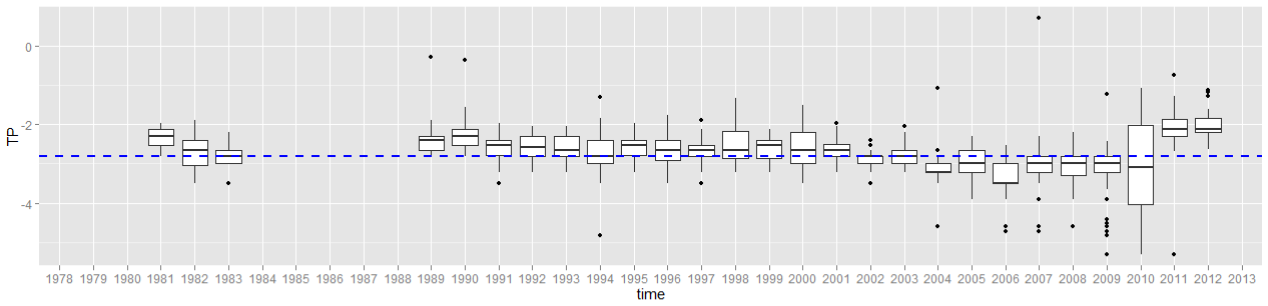


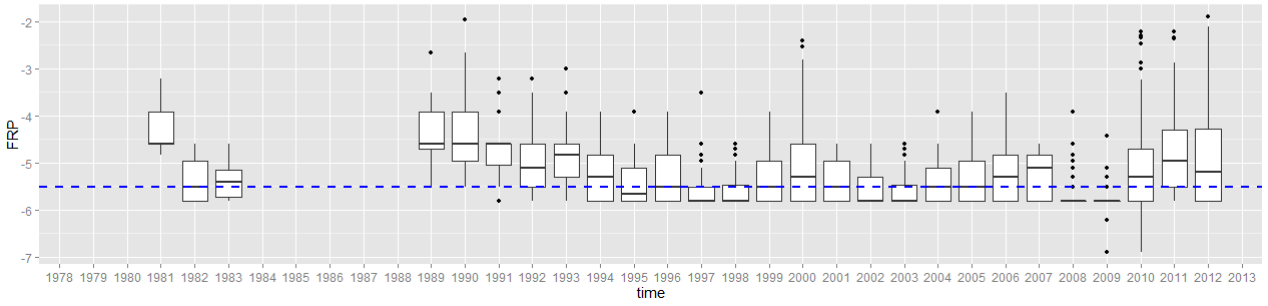


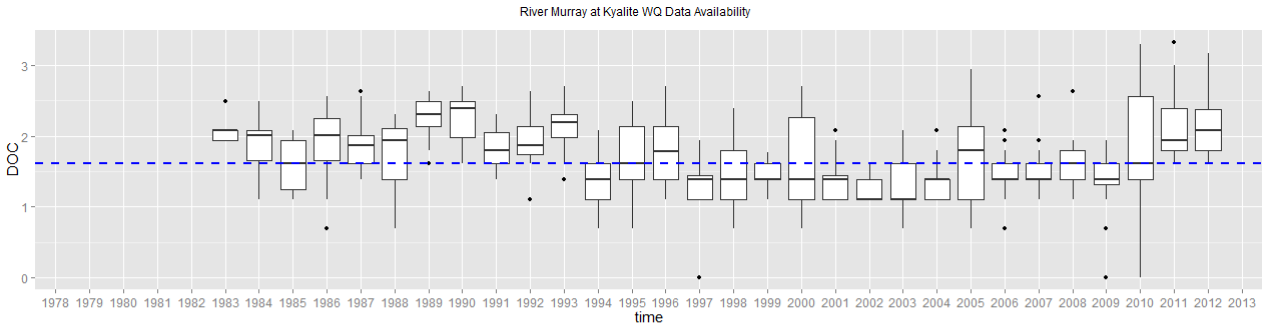


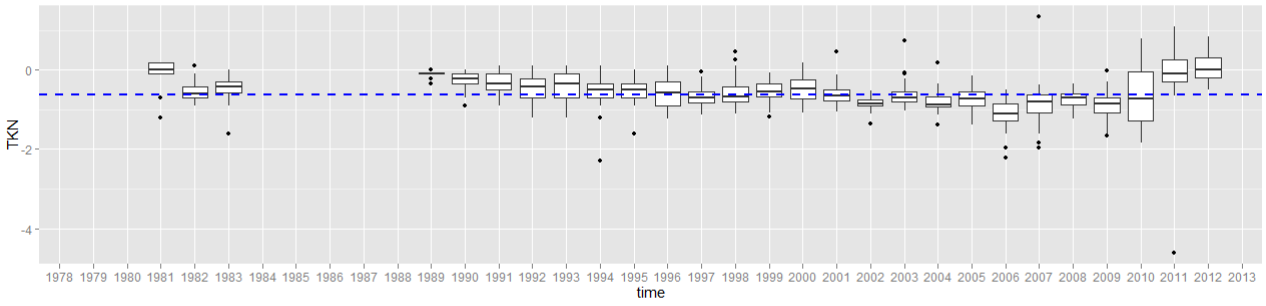
River Murray at Kyalite WQ Data Availability

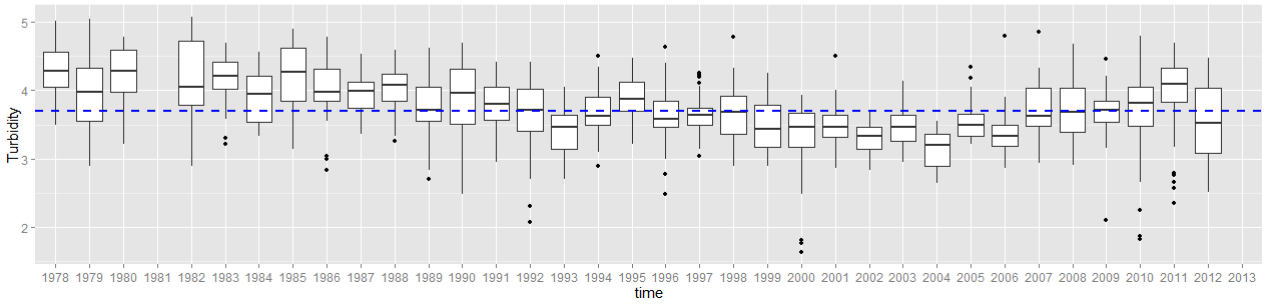


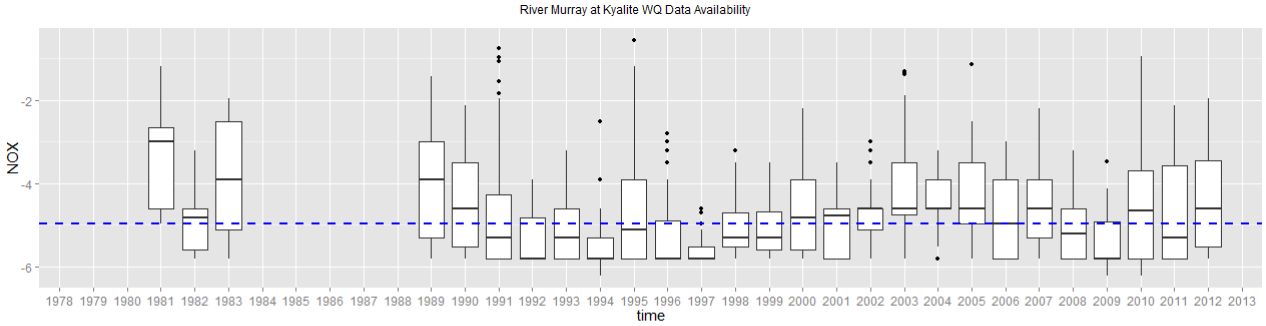


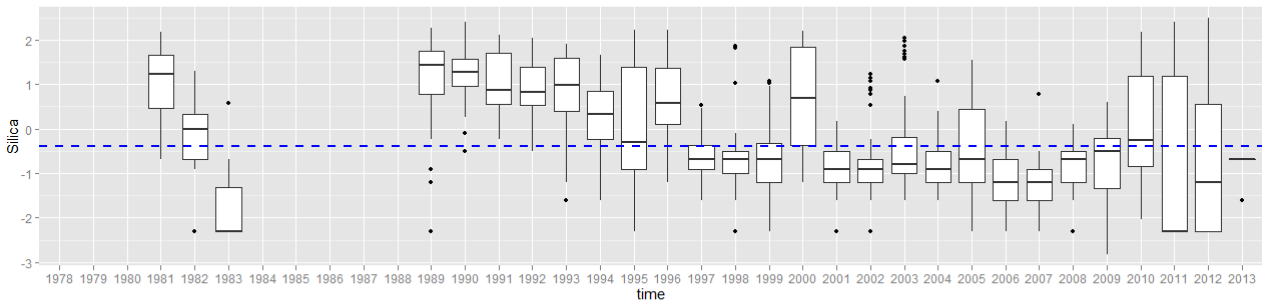


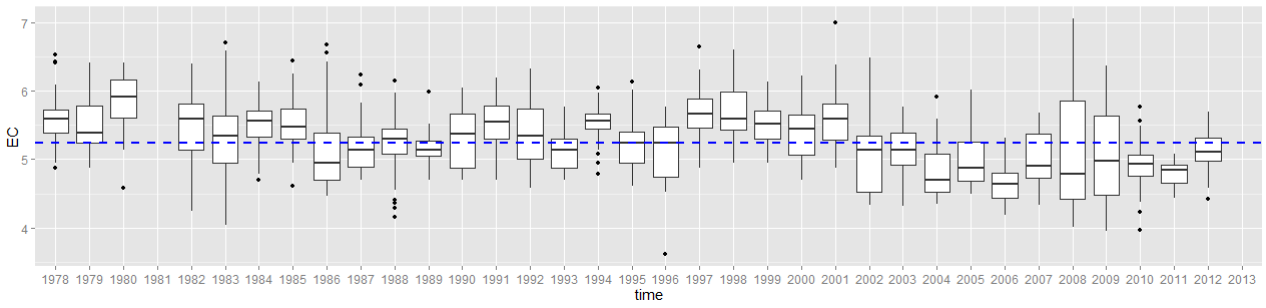

River Murray at Kyalite WQ Data Availability
DOC
time

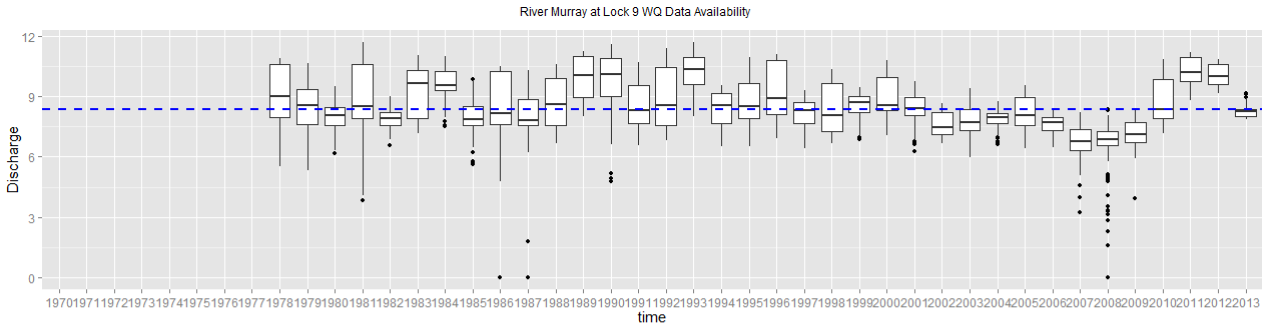

TKN
time

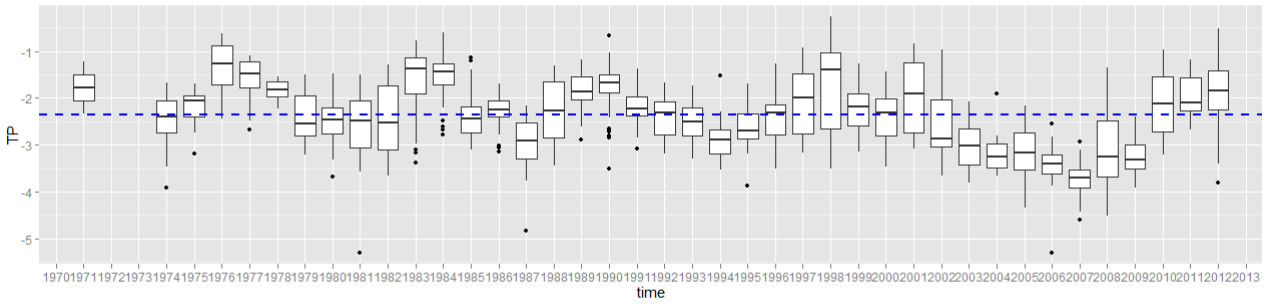

Turbidity
time

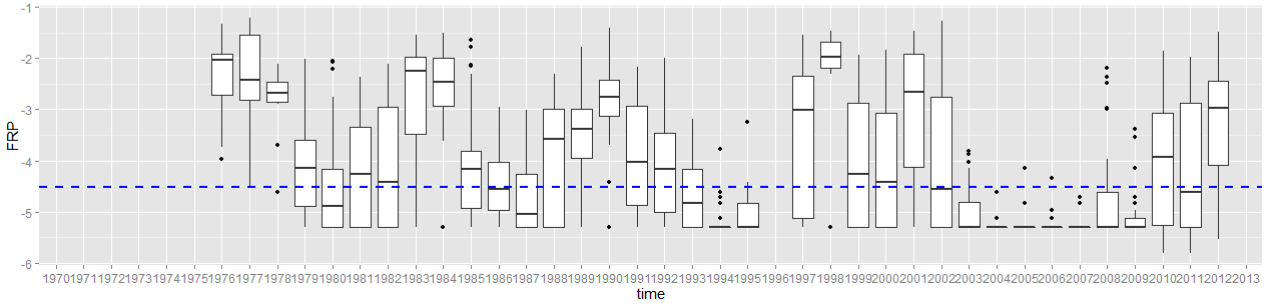

River Murray at Kyalite WQ Data Availability
NOX
time

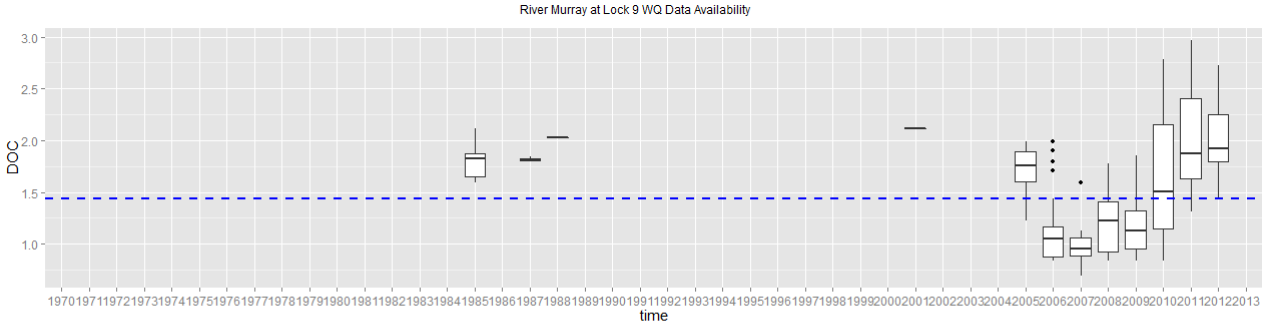

Silica
time

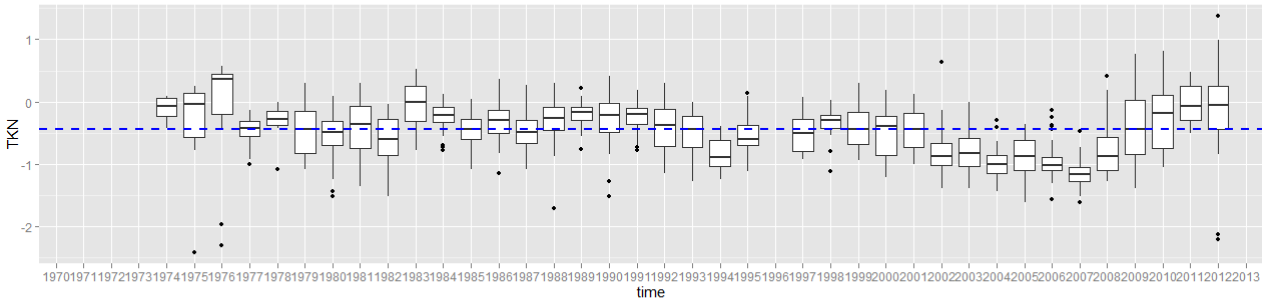

EC
time

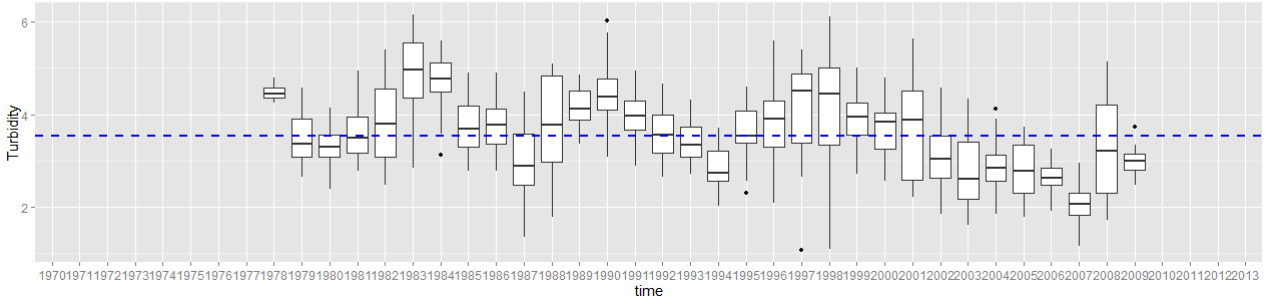

River Murray at Lock 9 WQ Data Availability
Discharge
time

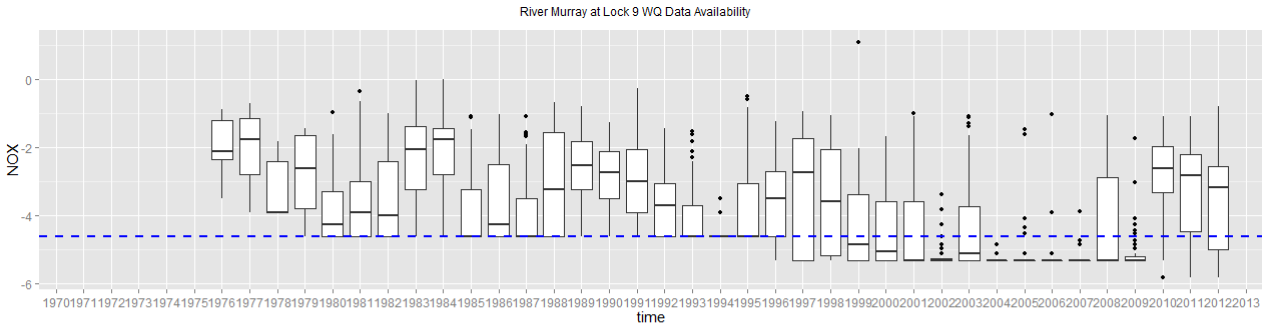

TP
time

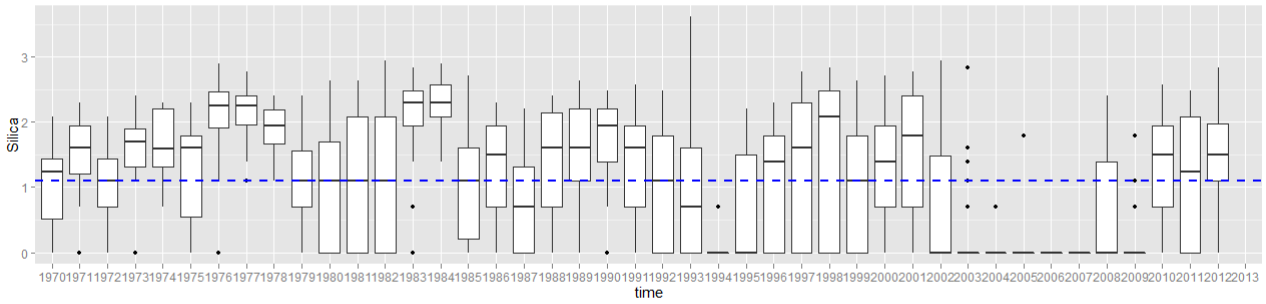

FRP
time

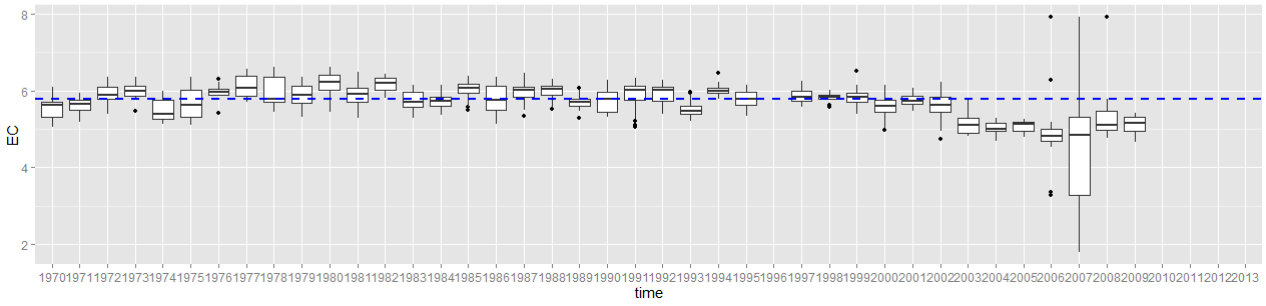

River Murray at Lock 9 WQ Data Availability
DOC
time

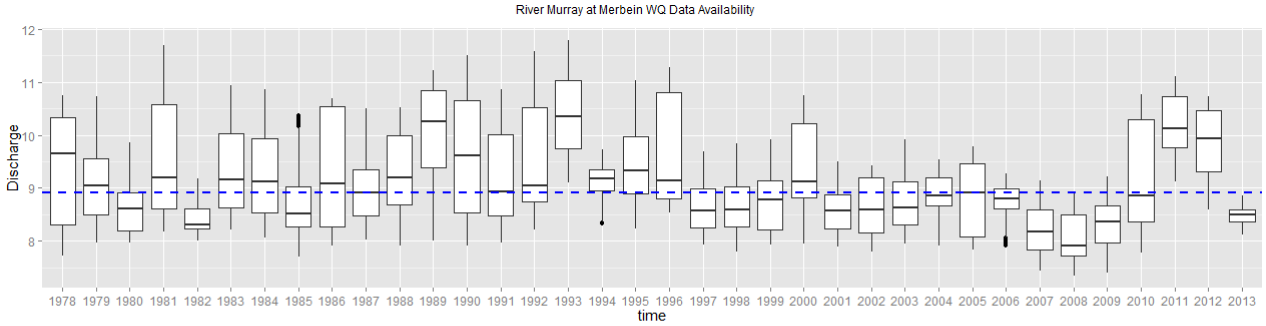

TKN
time

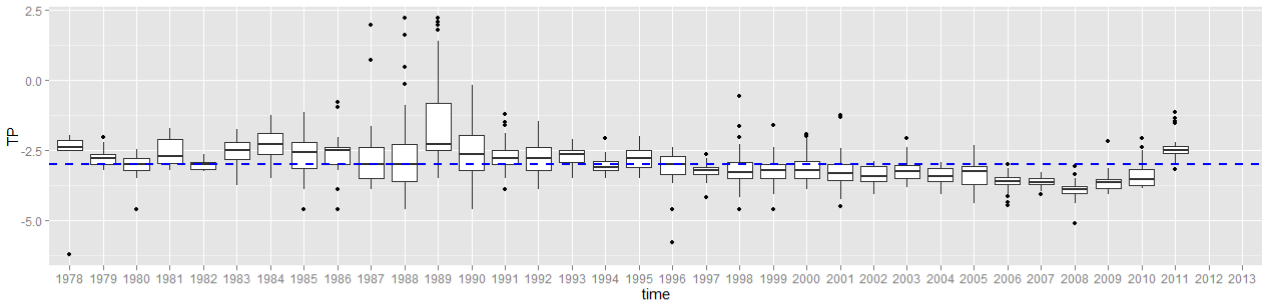

Turbidity
time

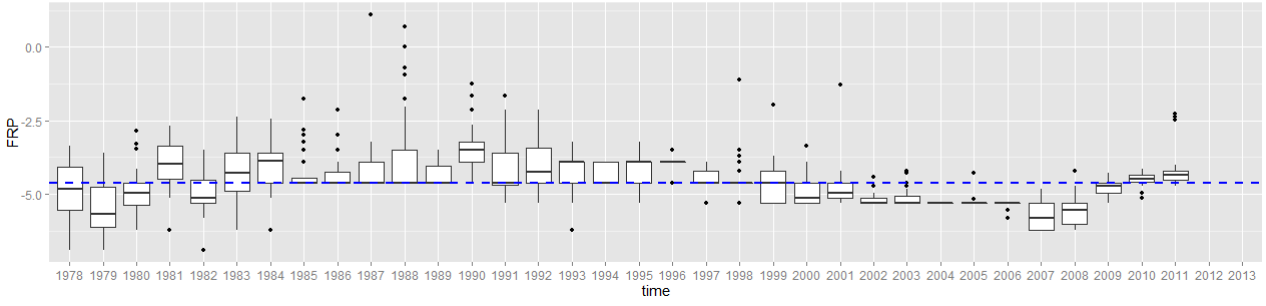

River Murray at Lock 9 WQ Data Availability
NOX
time

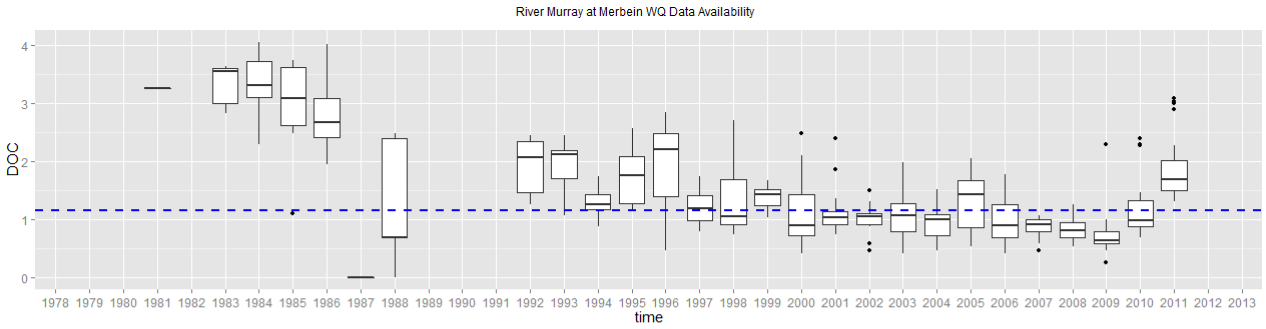

Silica
time

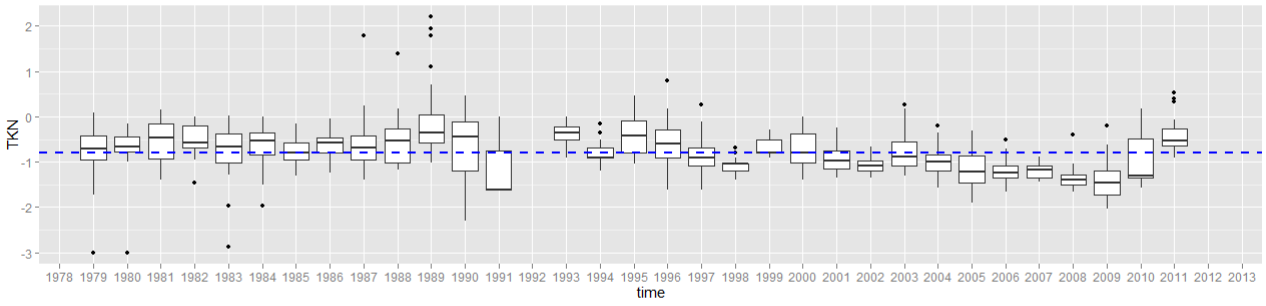

EC
time

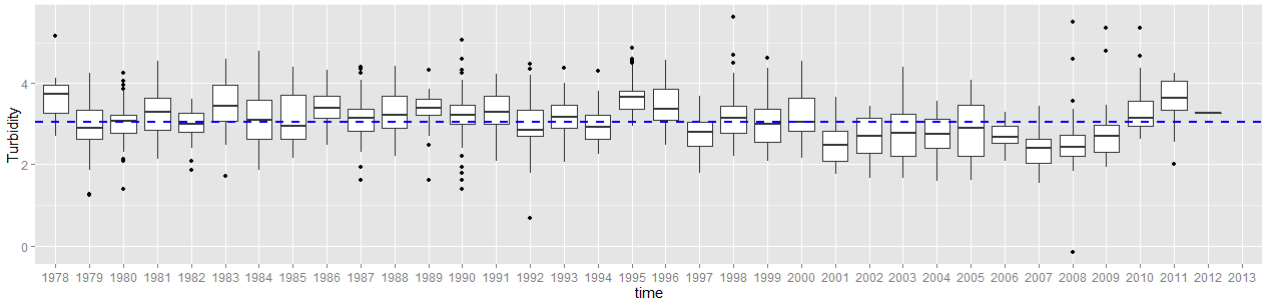

River Murray at Merbein WQ Data Availability
Discharge
time

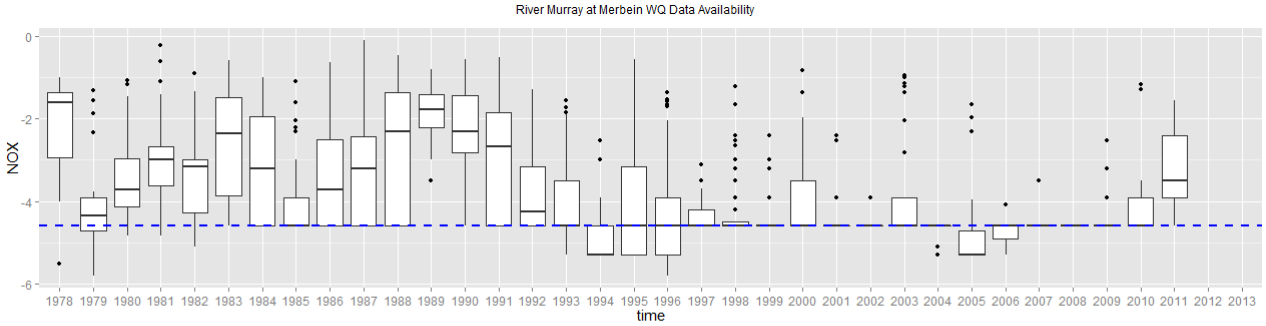

TP
time

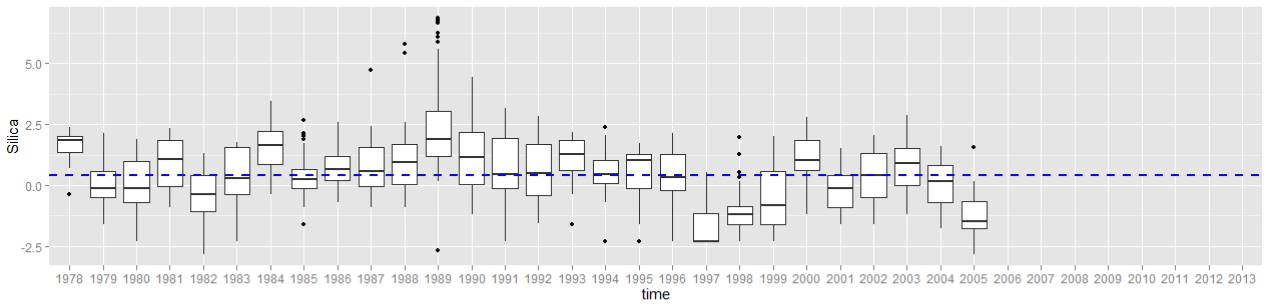

FRP
time

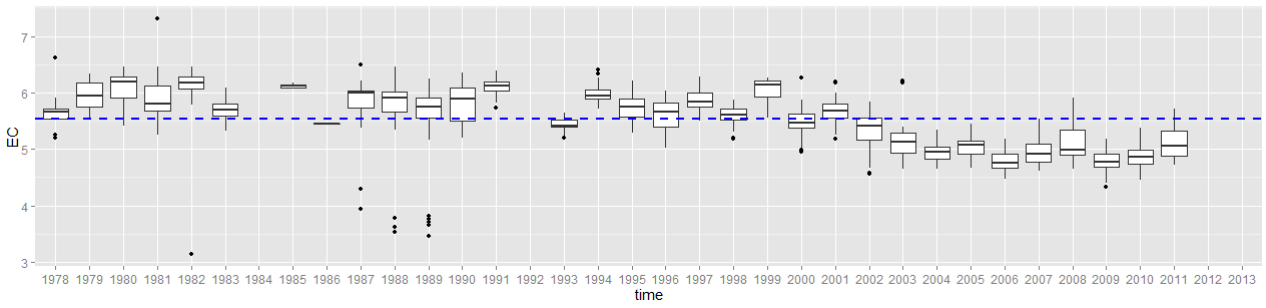

River Murray at Merbein WQ Data Availability
DOC
time

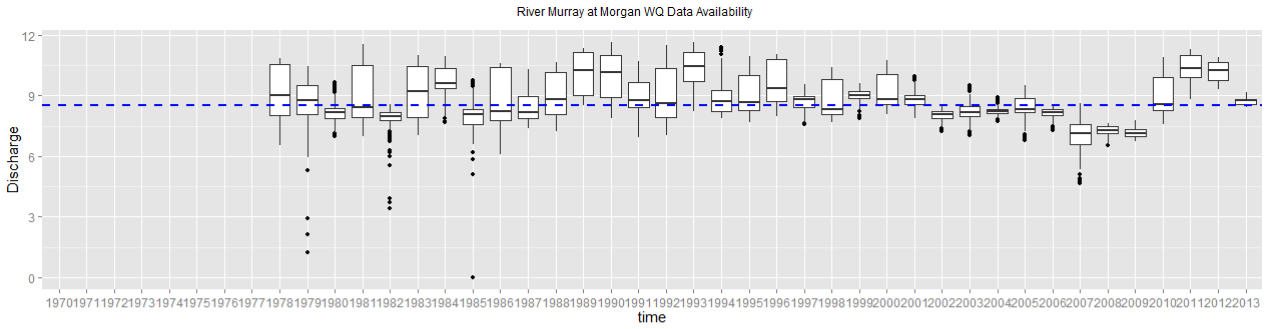

TKN
time

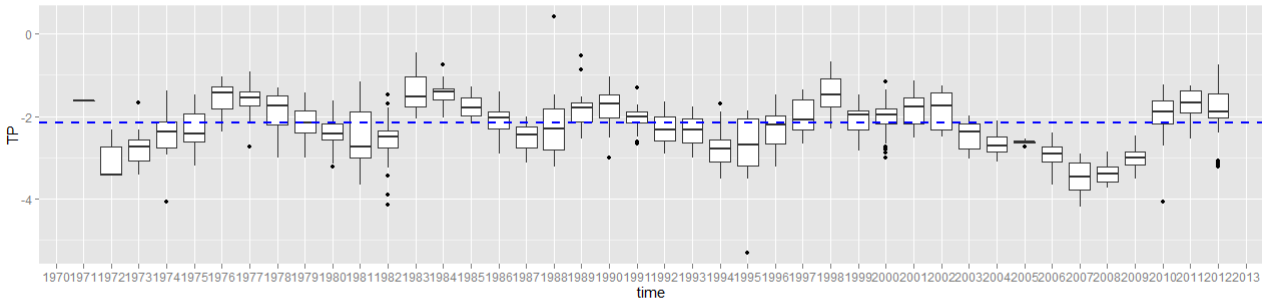

Turbidity
time

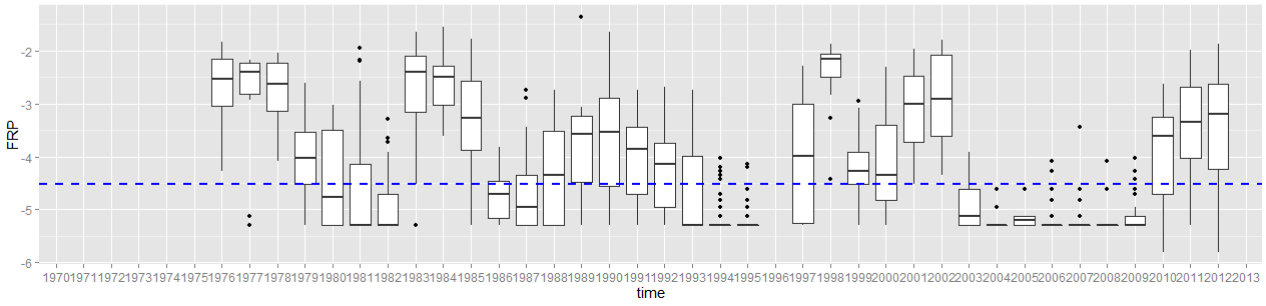

River Murray at Merbein WQ Data Availability
NOX
time

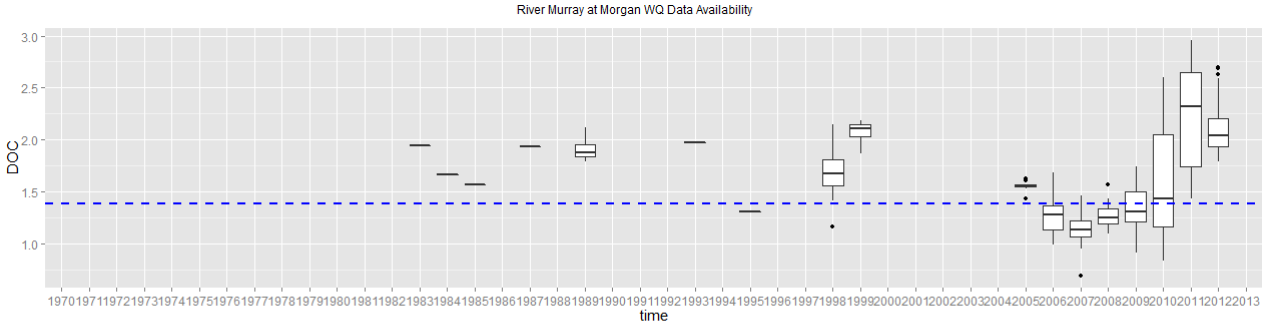

Silica
time

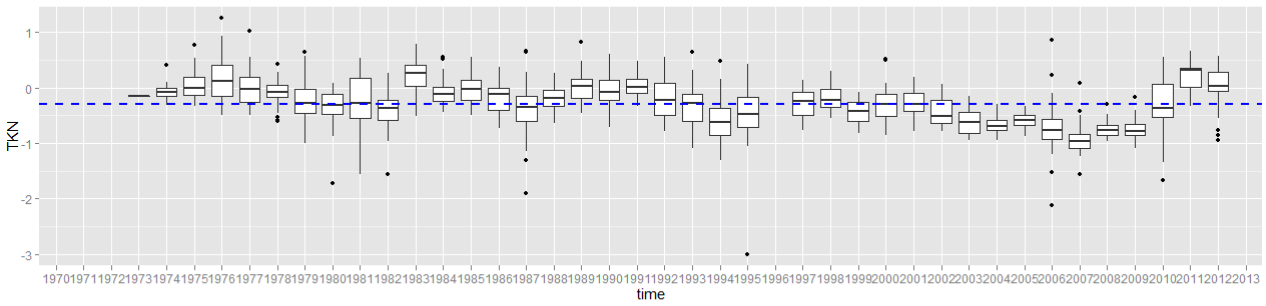

EC
time

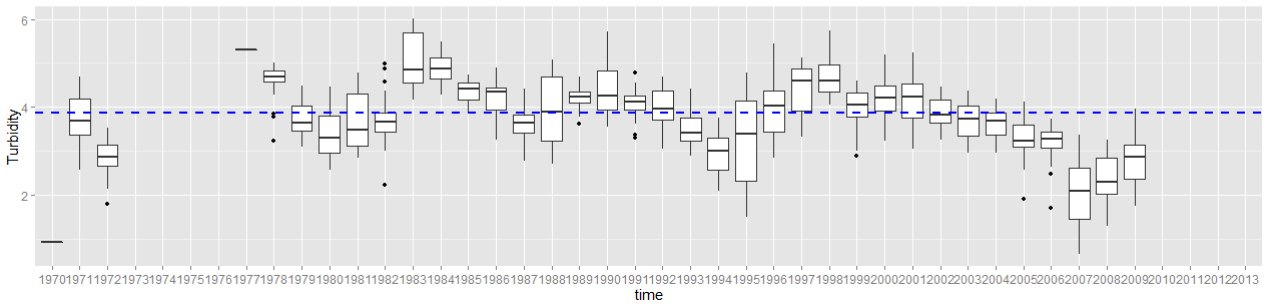

River Murray at Morgan WQ Data Availability
Discharge
time

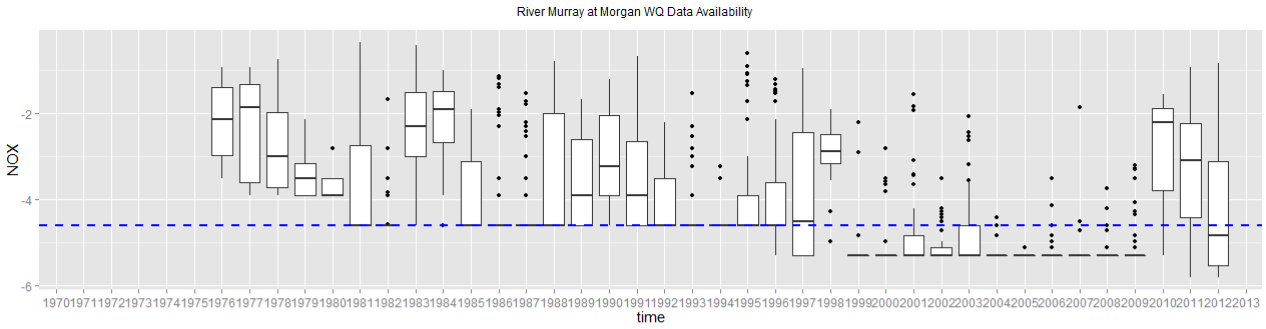

TP
time

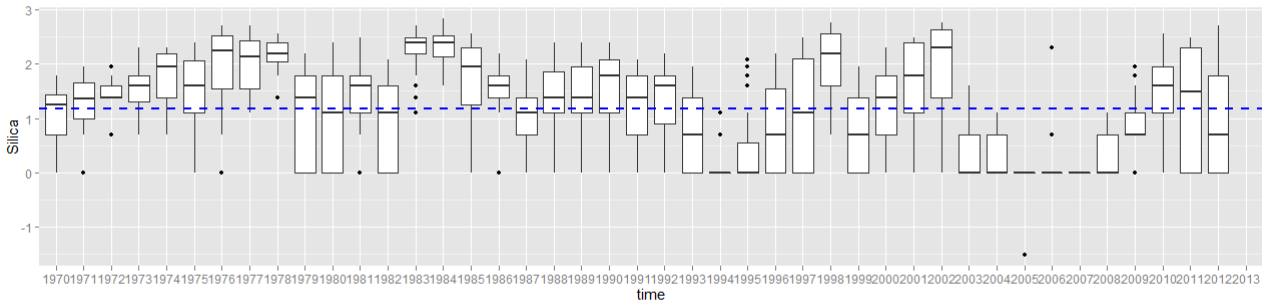

FRP
time

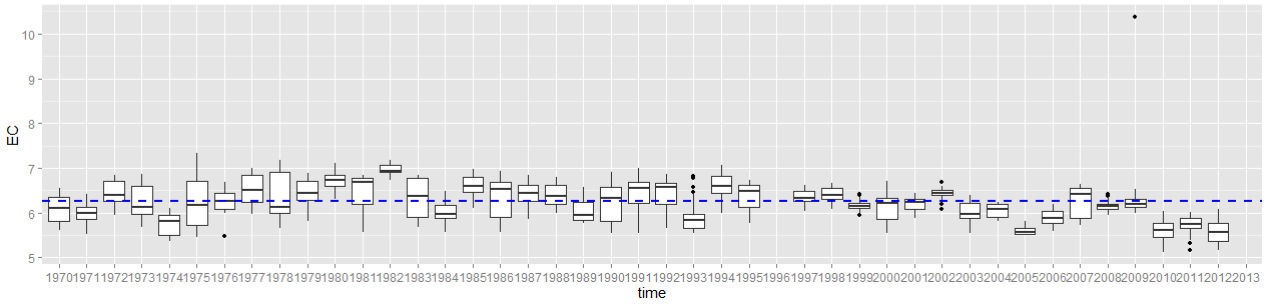

River Murray at Morgan WQ Data Availability
DOC
time

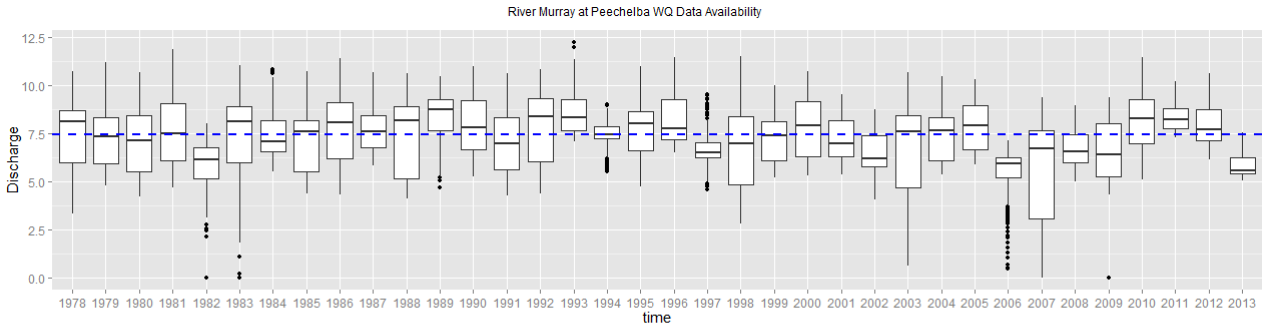

TKN
time

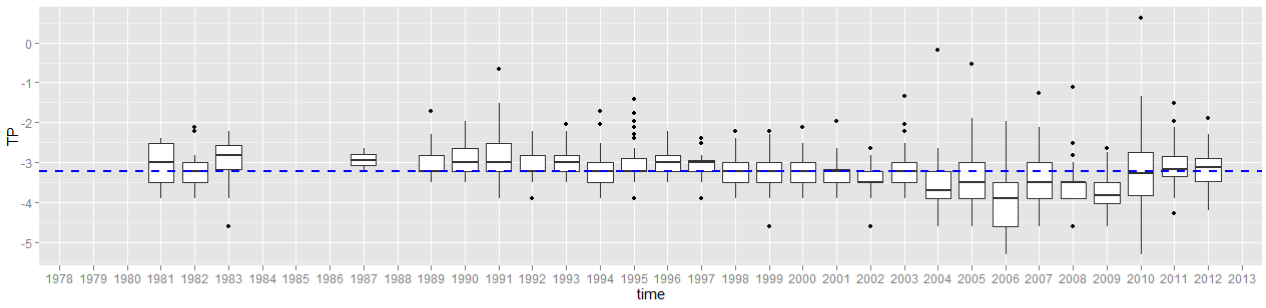

Turbidity
time

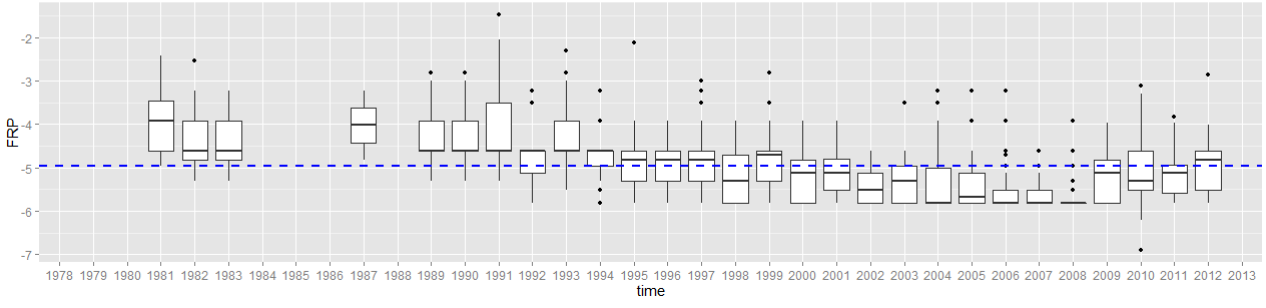

River Murray at Morgan WQ Data Availability
NOX
time

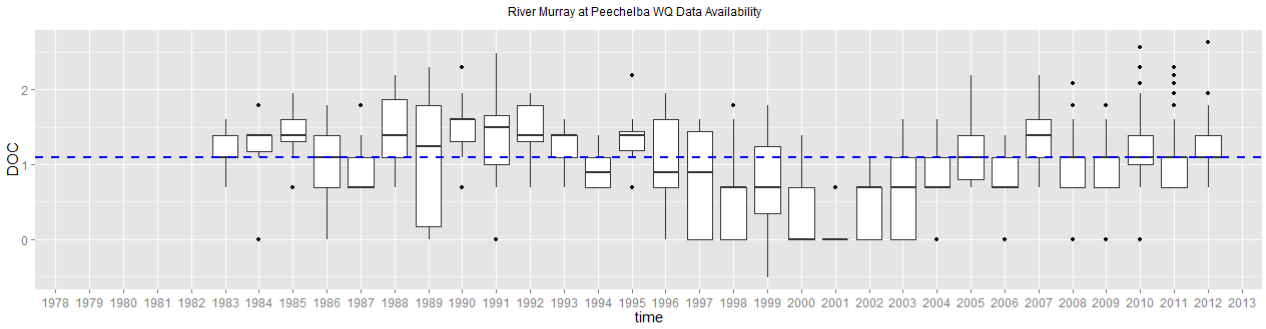

Silica
time

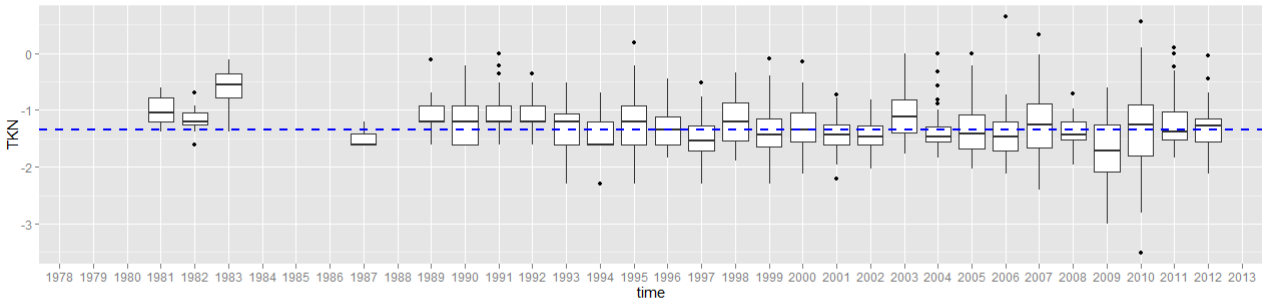

EC
time

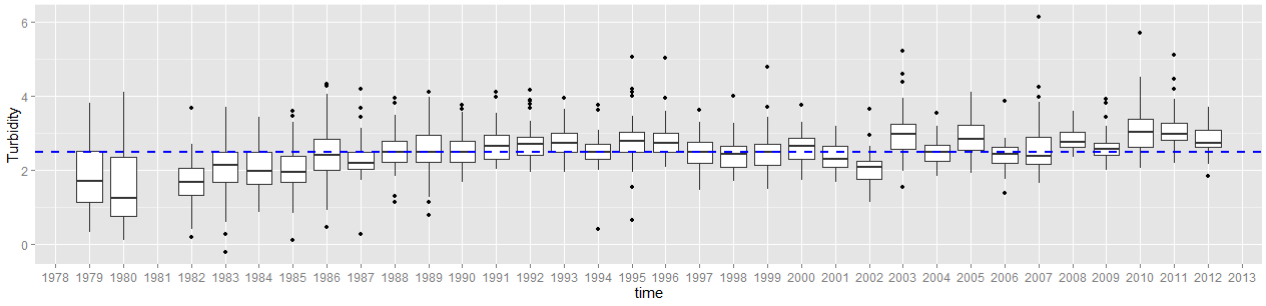

River Murray at Peechelba WQ Data Availability
Discharge
time

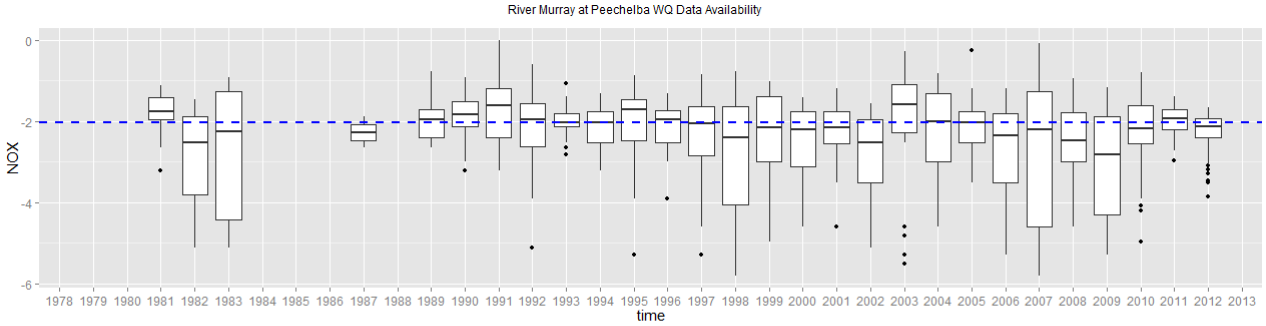

TP
time

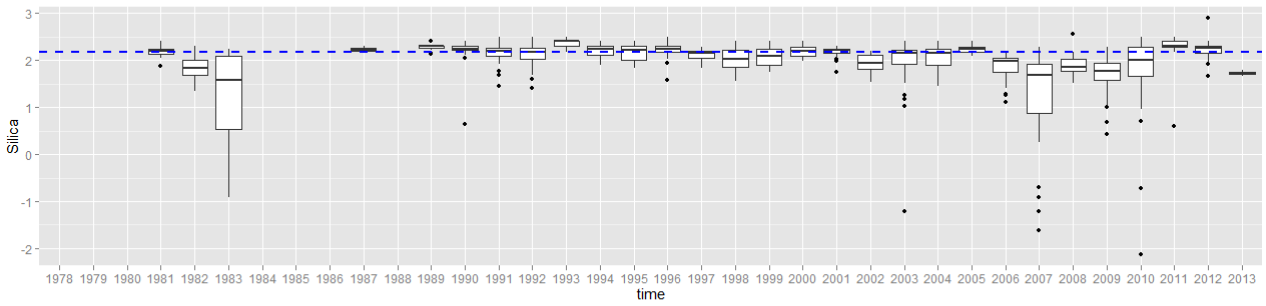

FRP
time

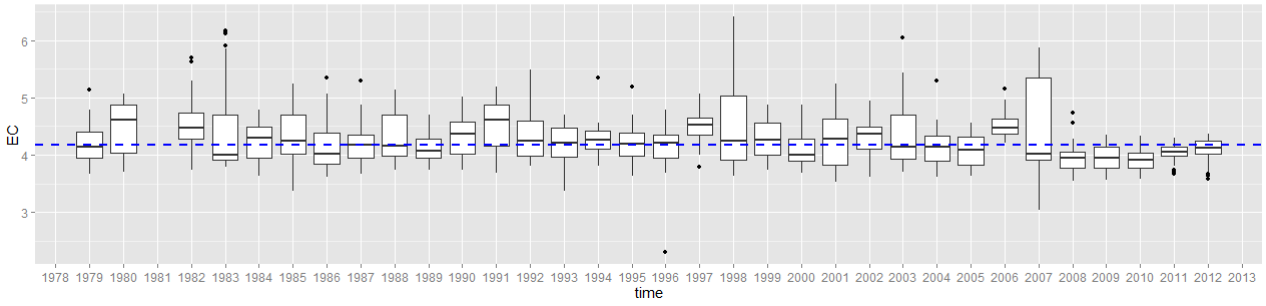

River Murray at Peechelba WQ Data Availability
DOC
time

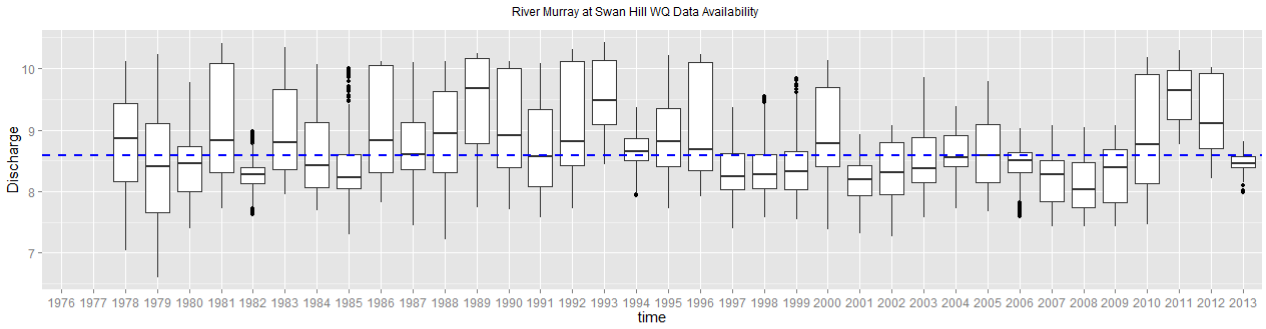

TKN
time

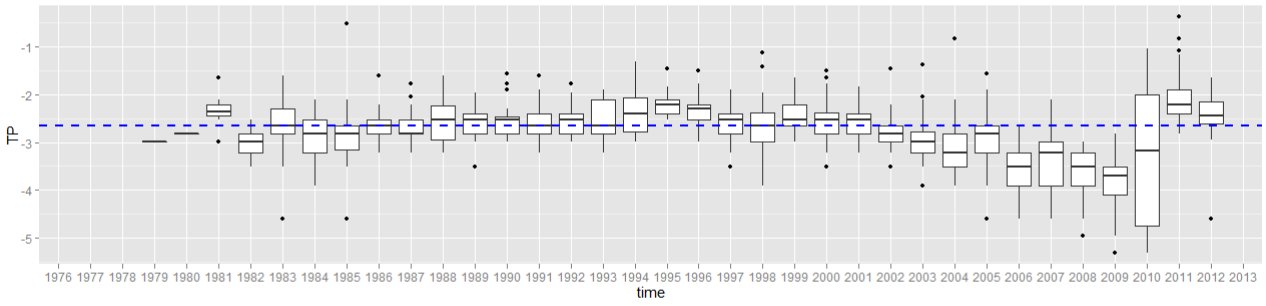

Turbidity
time

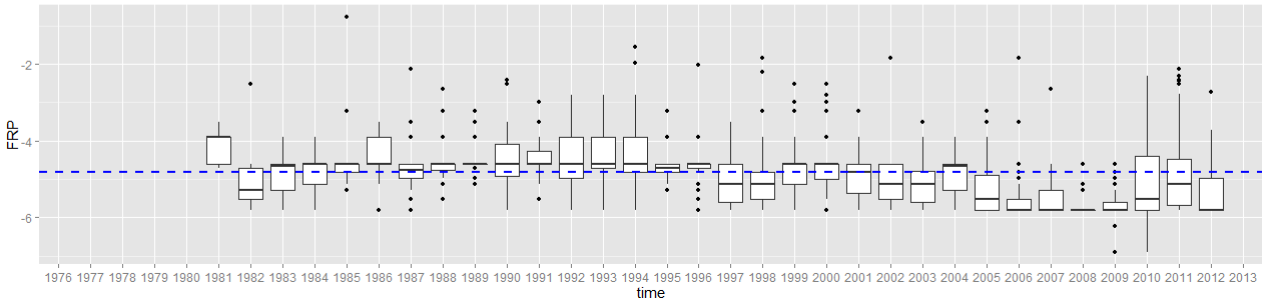

River Murray at Peechelba WQ Data Availability
NOX
time

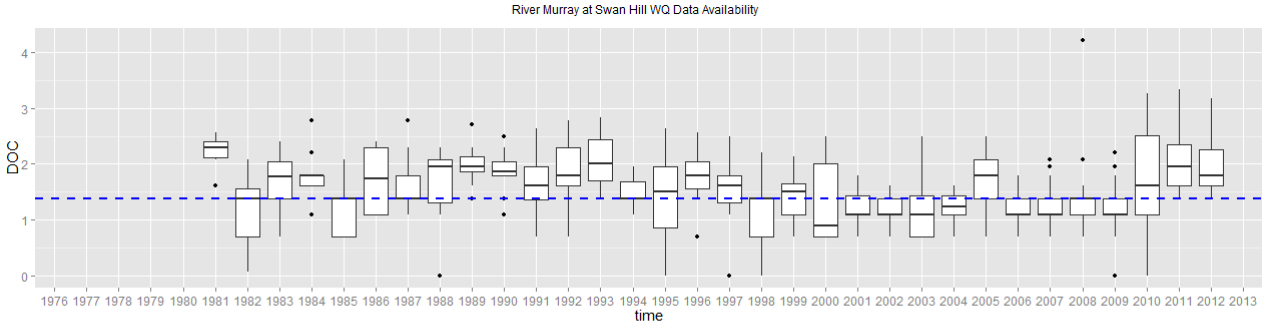

Silica
time

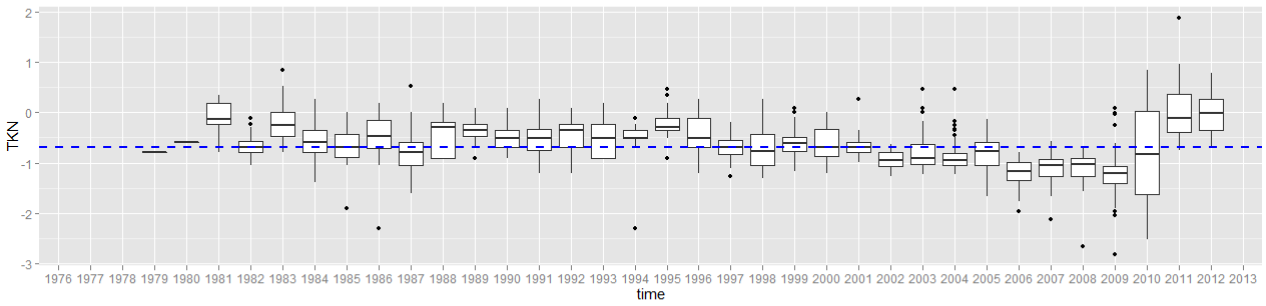

EC
time

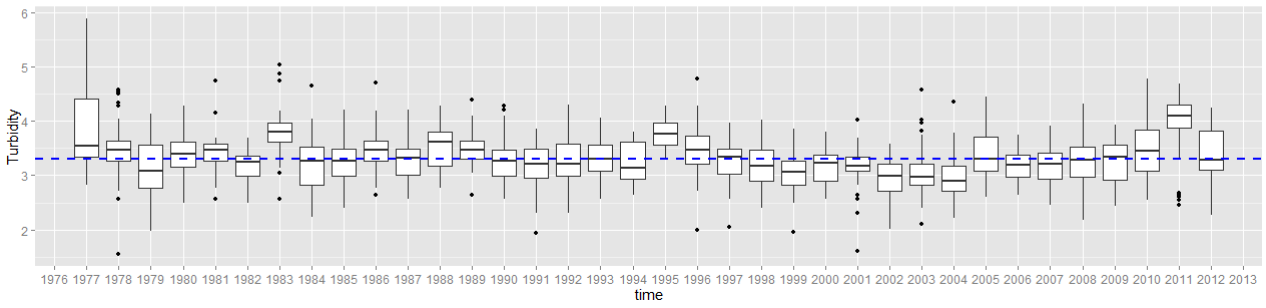

River Murray at Swan Hill WQ Data Availability
Discharge
time

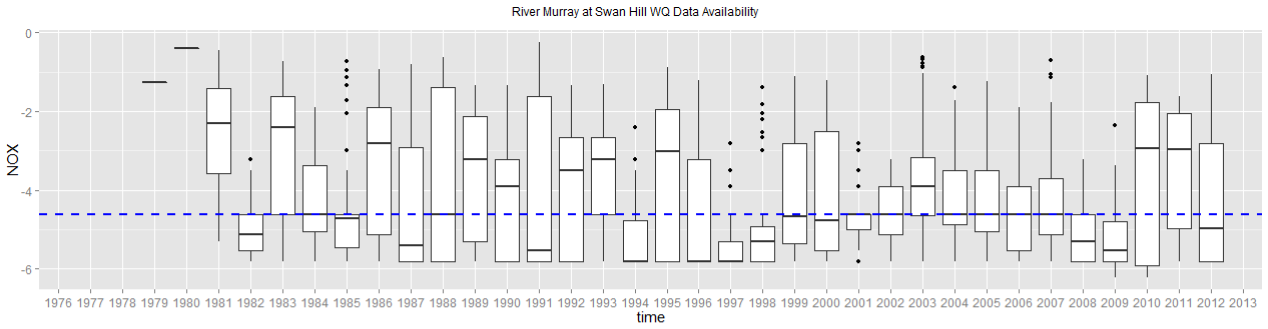

TP
time

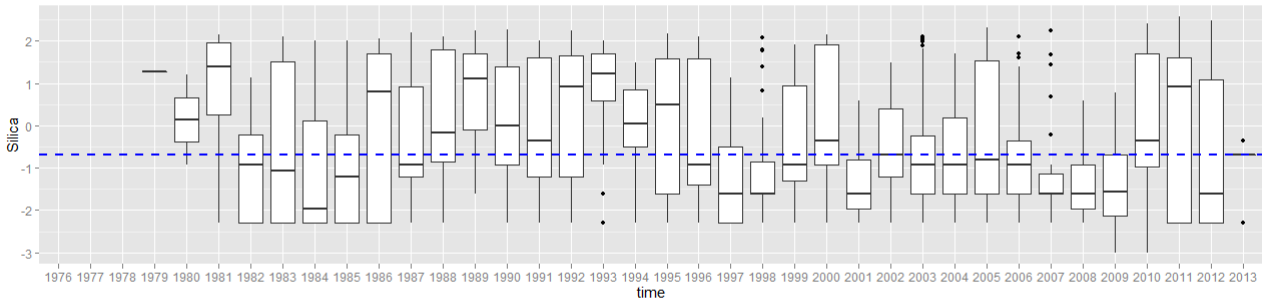

FRP
time

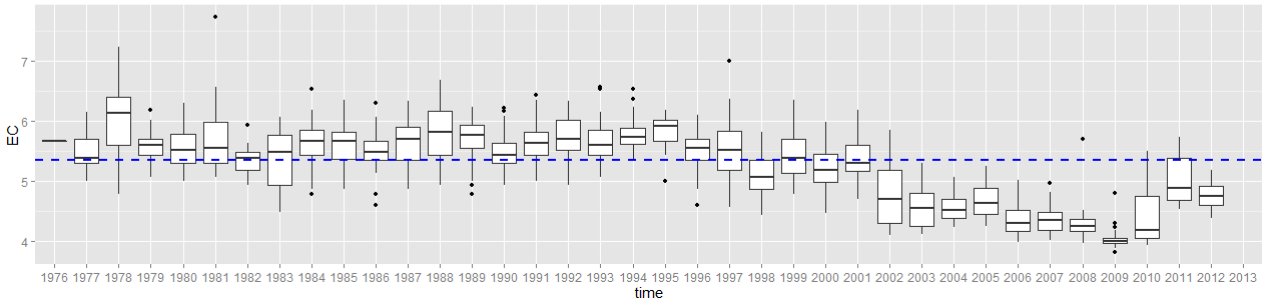

River Murray at Swan Hill WQ Data Availability
DOC
time

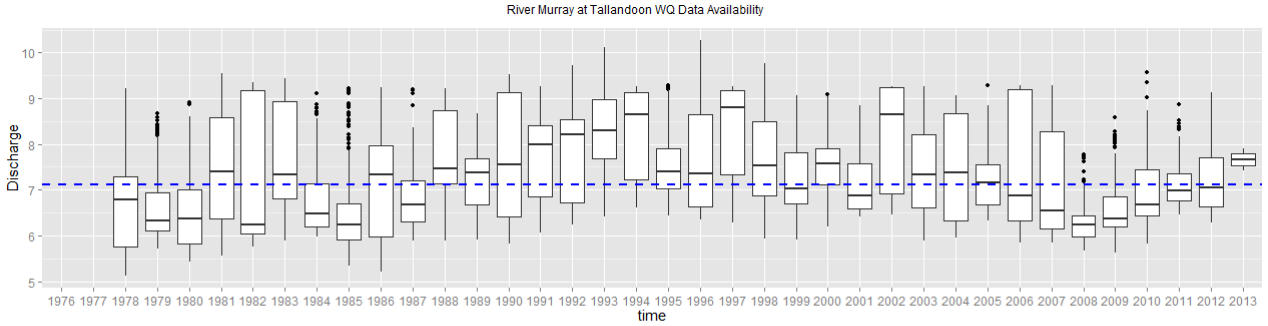

TKN
time

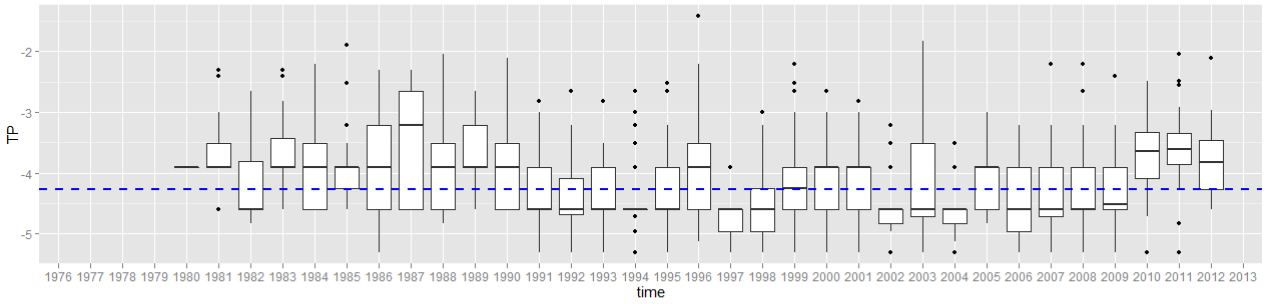

Turbidity
time

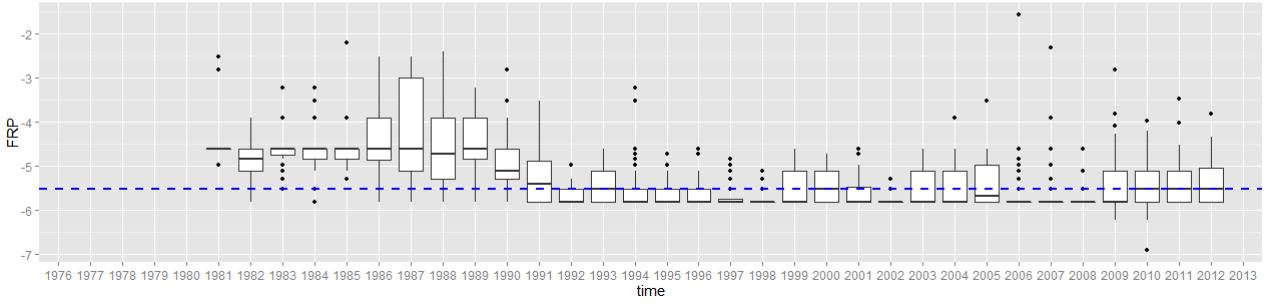

River Murray at Swan Hill WQ Data Availability
NOX
0
-2
-4
-6
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

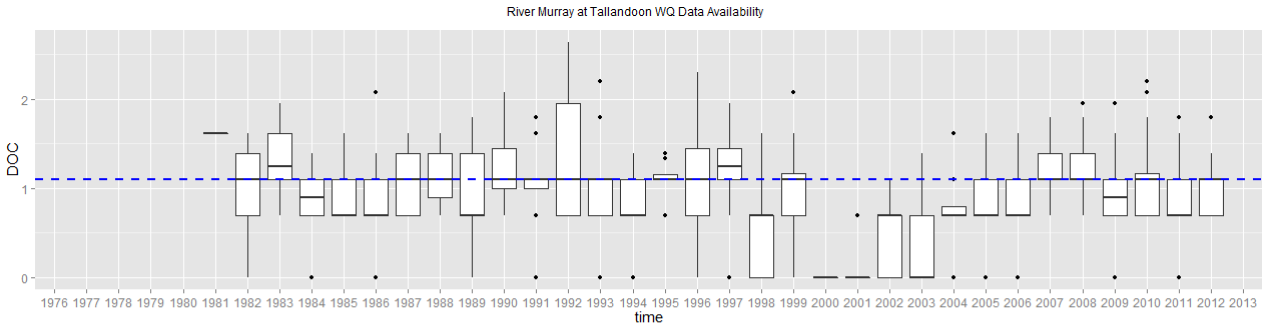

Silica
2
1
0
-1
-2
-3
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

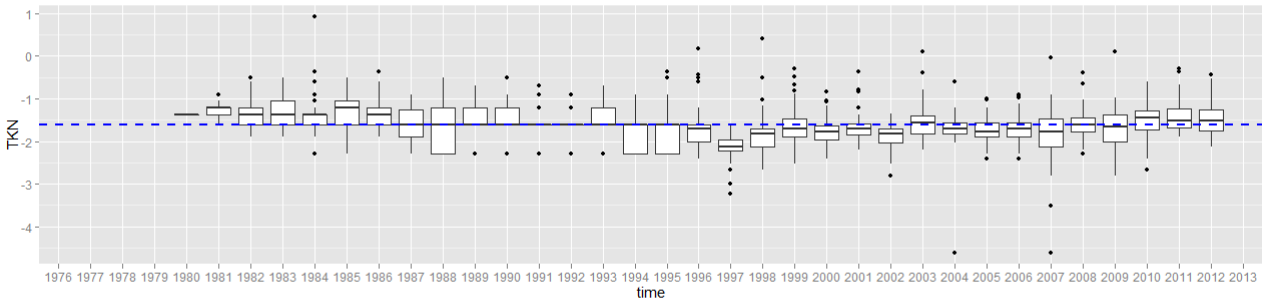

EC
7
6
5
4
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

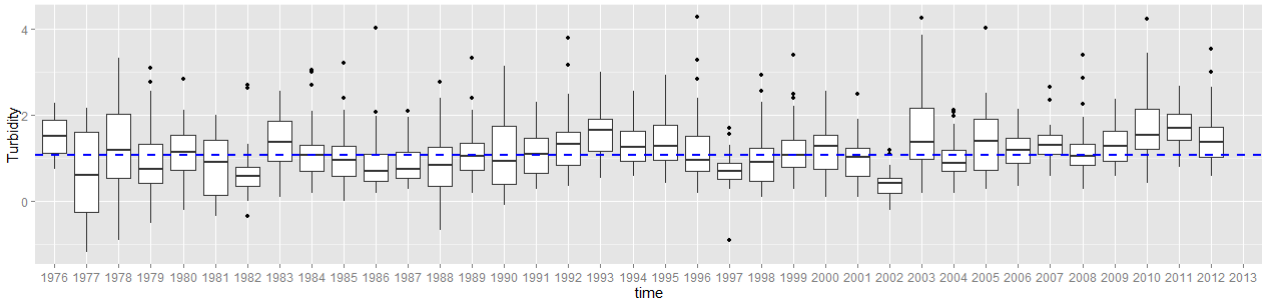

River Murray at Tallandoon WQ Data Availability
Discharge
10
9
8
7
6
5
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

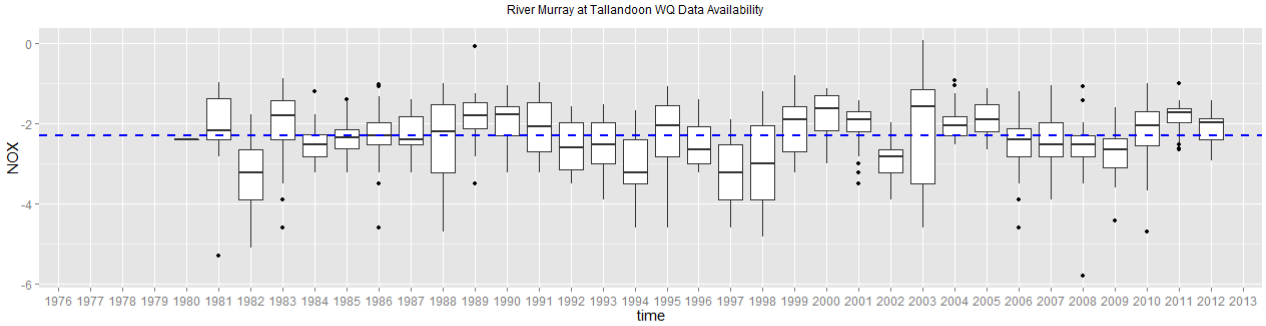

TP
-2
-3
-4
-5
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

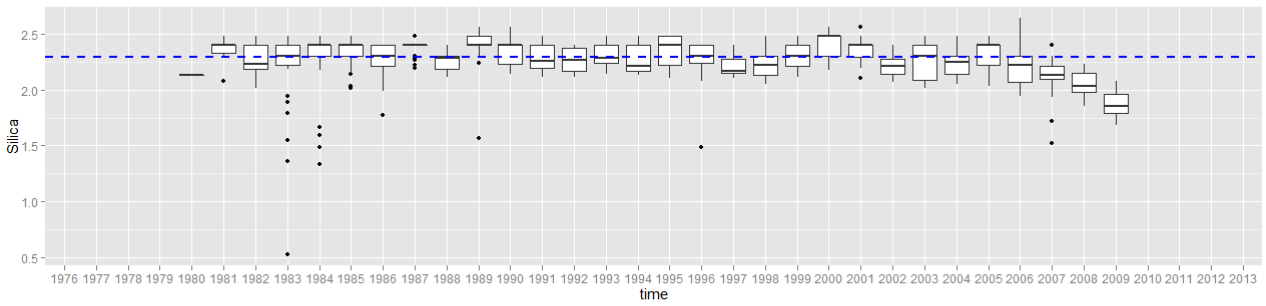

FRP
-2
-3
-4
-5
-6
-7
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
time

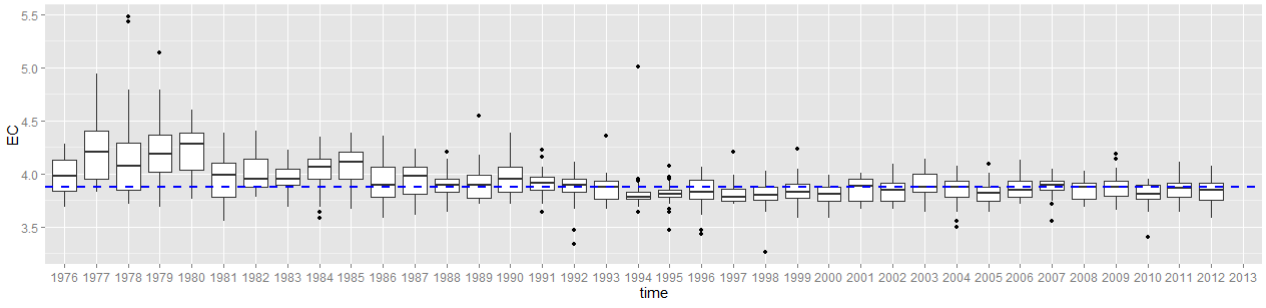

River Murray at Tallandoon WQ Data Availability
DOC
time

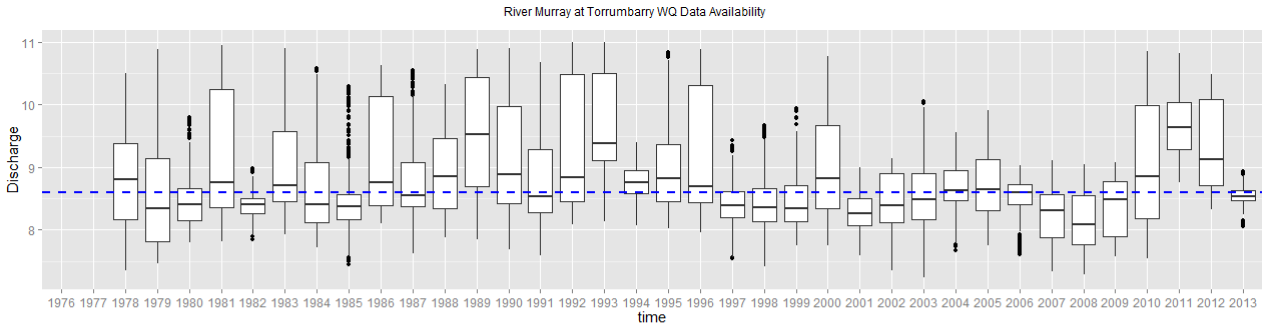

TKN
time

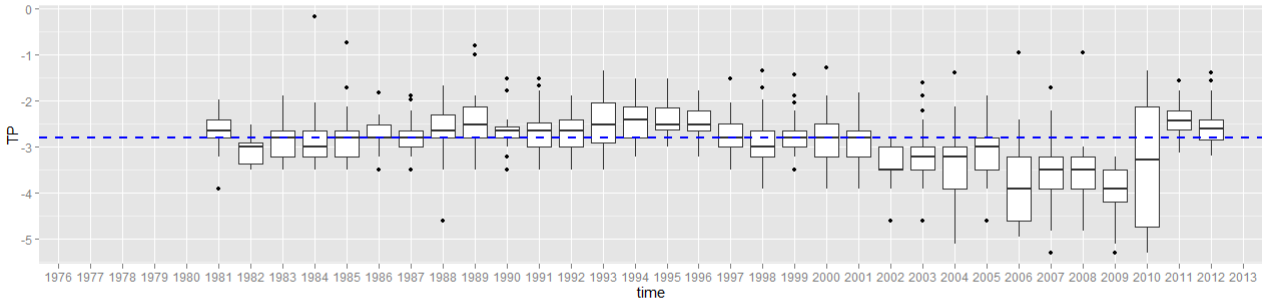

Turbidity
time

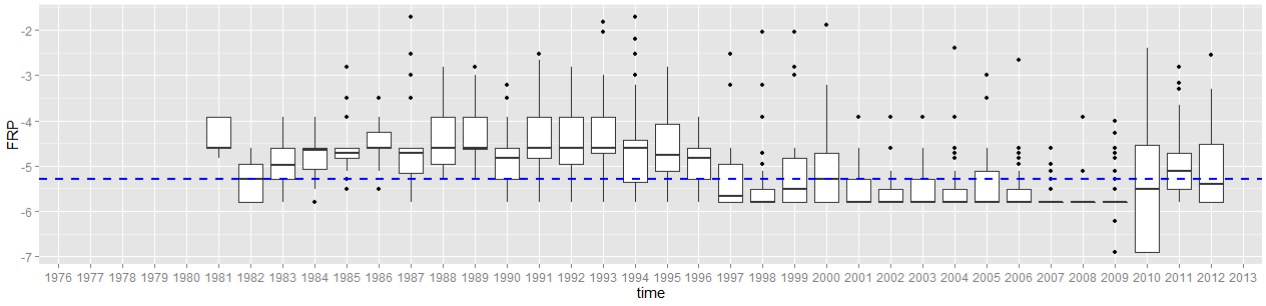

River Murray at Tallandoon WQ Data Availability
NOX
time

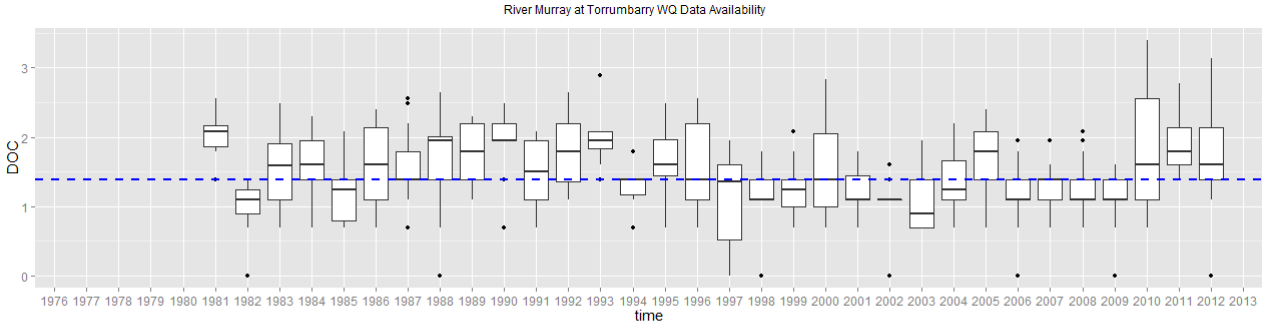

Silica
time

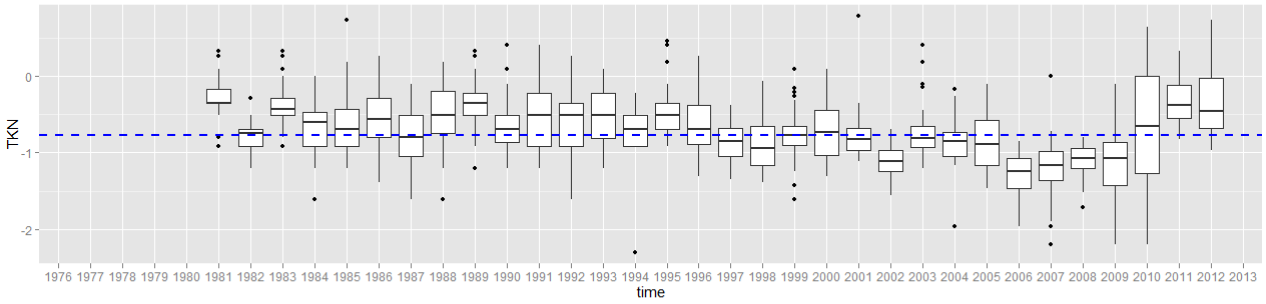

EC
time

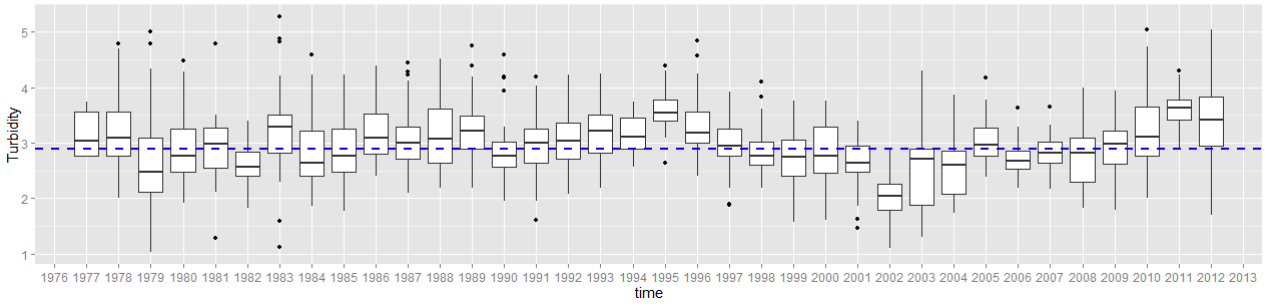

River Murray at Torrumbarry WQ Data Availability
Discharge
time

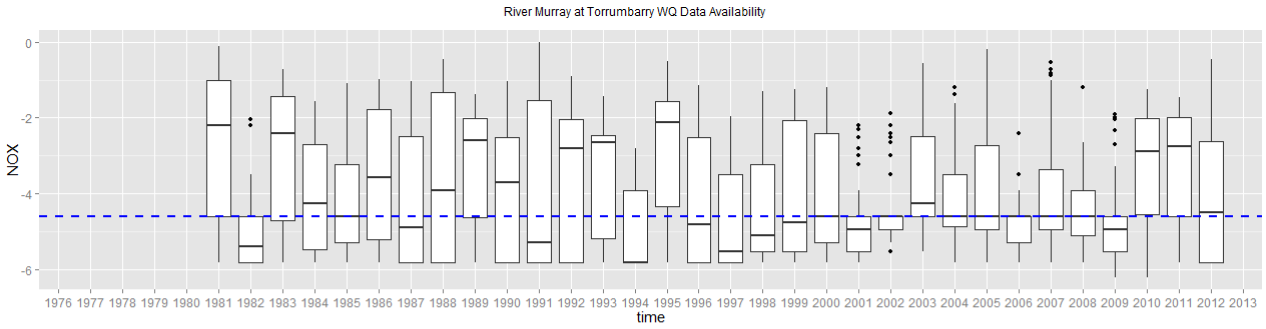

TP
time

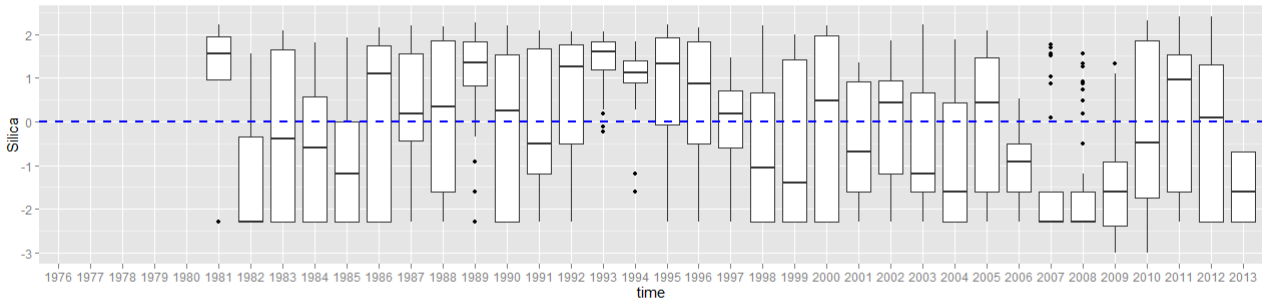

FRP
time

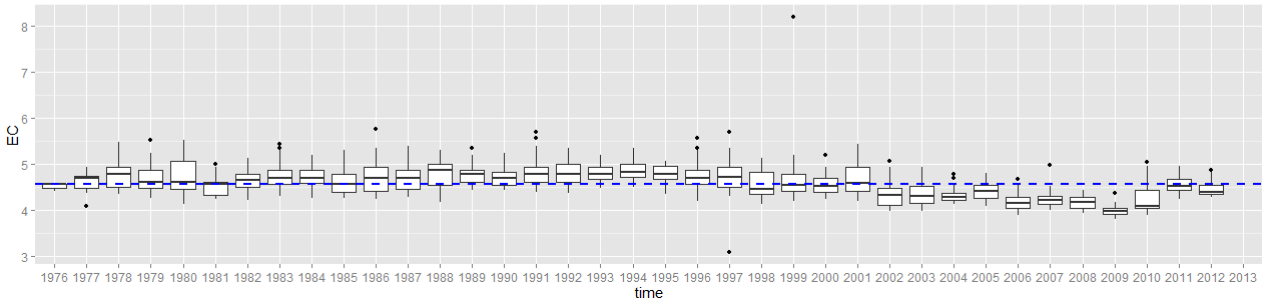

River Murray at Torrumbarry WQ Data Availability
DOC
time

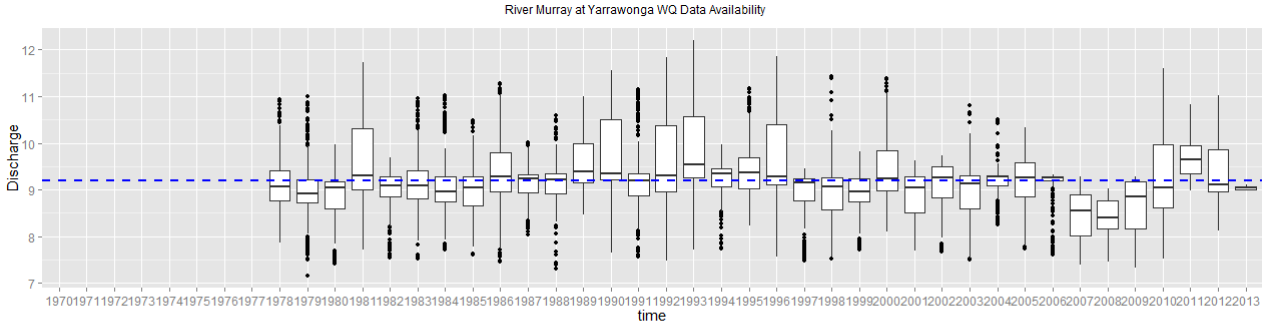

TKN
time

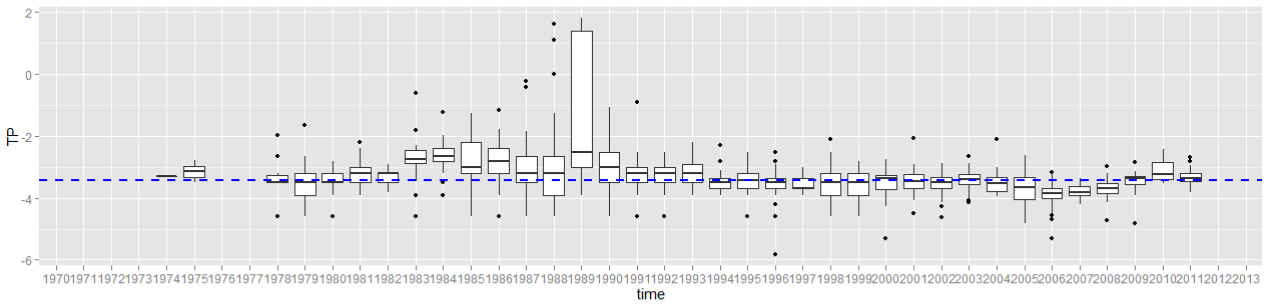

Turbidity
time

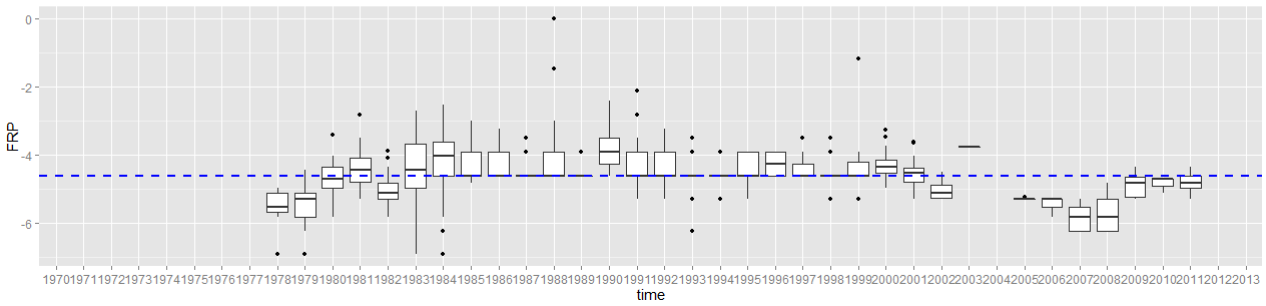

River Murray at Torrumbarry WQ Data Availability
NOX
time

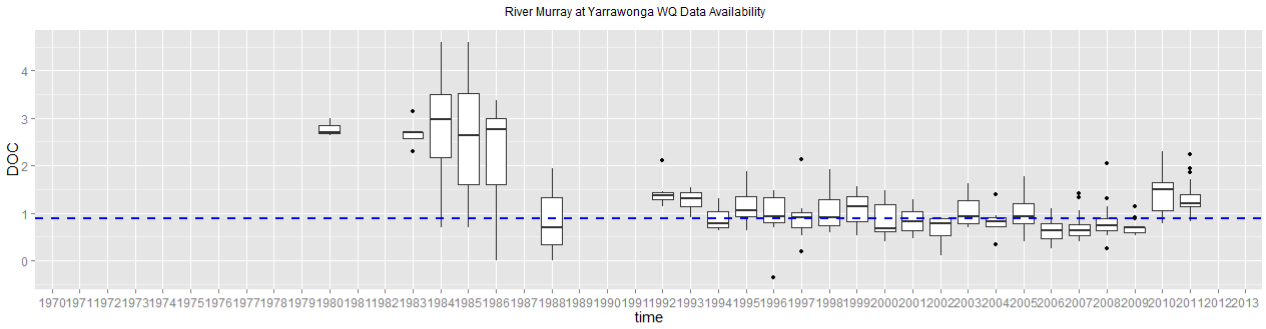

Silica
time

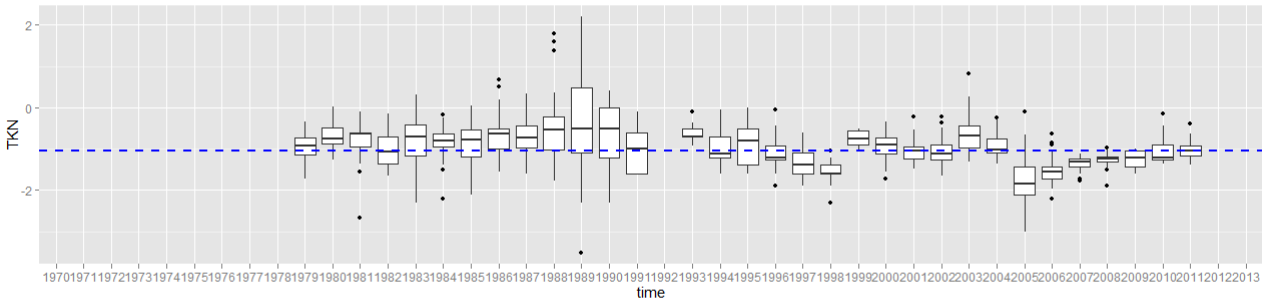

EC
time

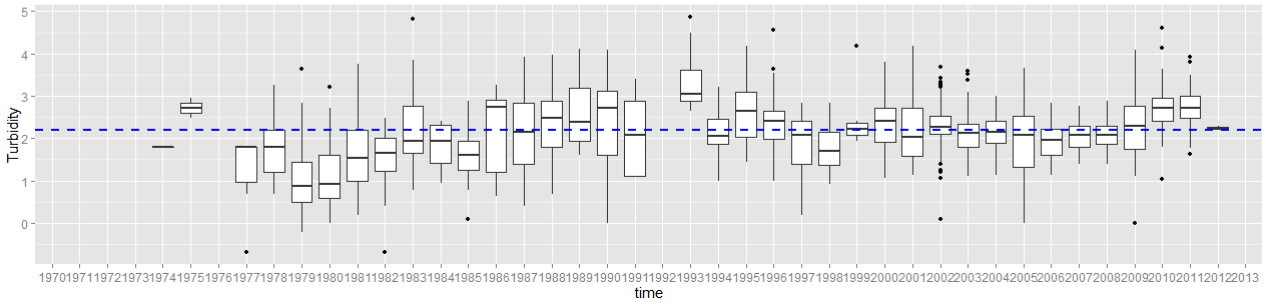

River Murray at Yarrawonga WQ Data Availability
Discharge
time

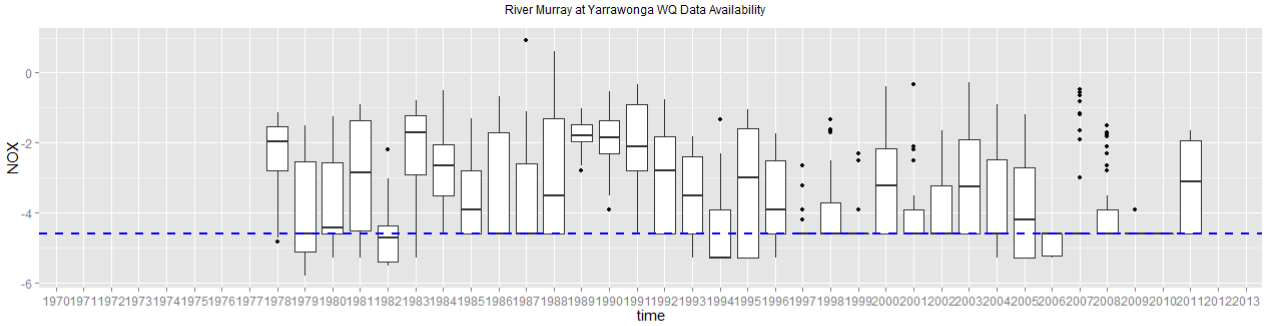

TP
time

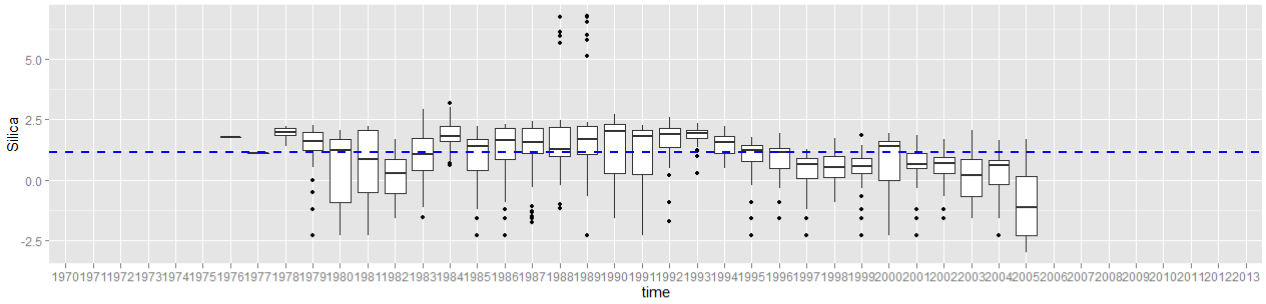

FRP
time

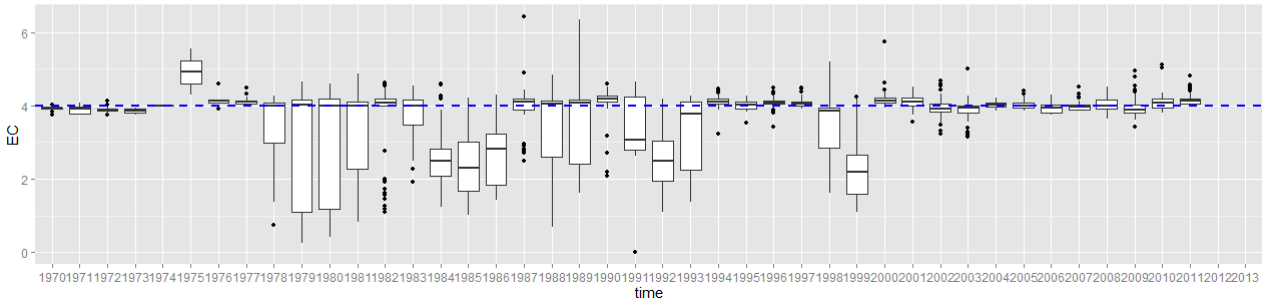

River Murray at Yarrawonga WQ Data Availability
DOC
time


TKN
time

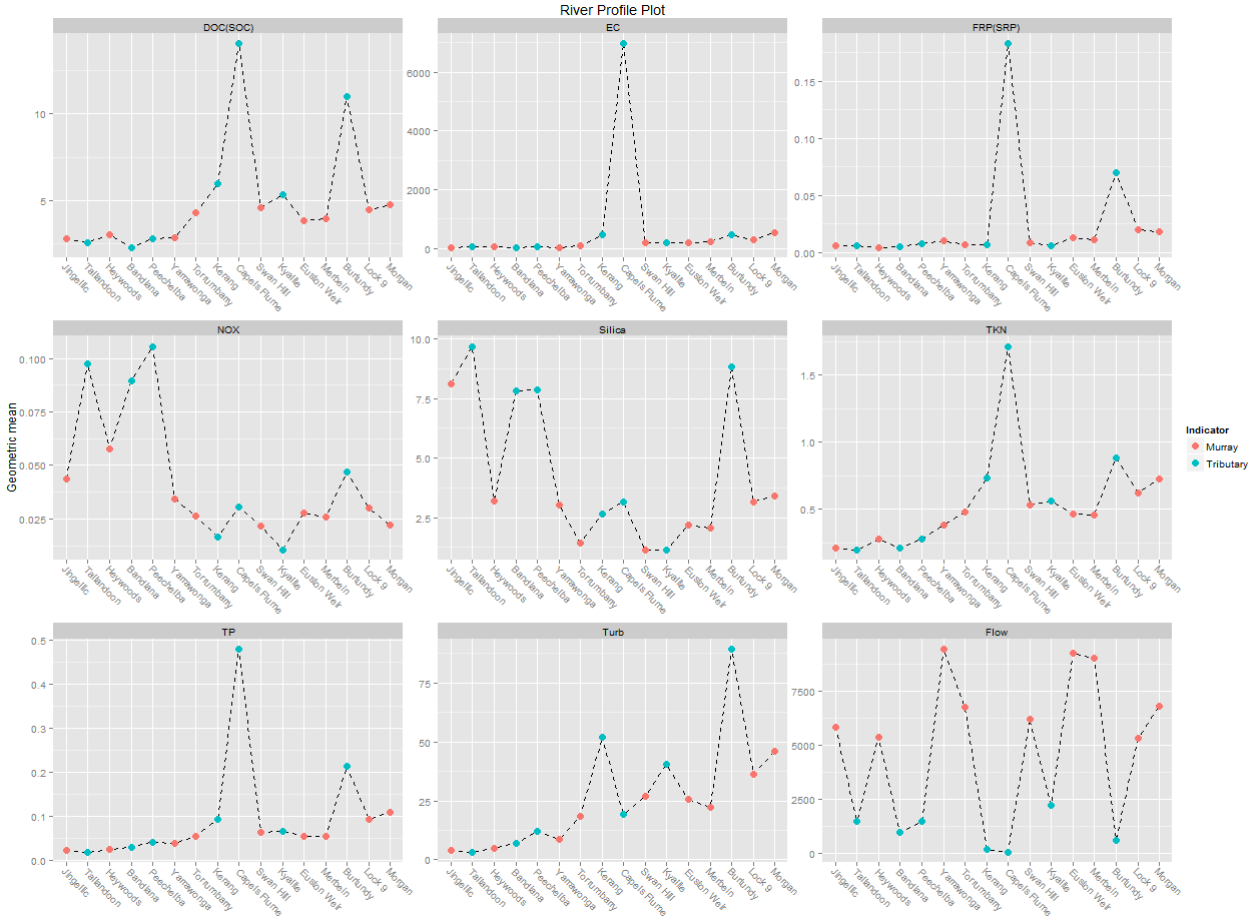

Turbidity
time


River Murray at Yarrawonga WQ Data Availability
NOX
time


Silica
time


EC
time

C: River profile plots: Geometric means



D: Generalized additive modelling trend analysis

Log transformations and geometric means

The response for each water quality variate was first log-transformed. This was performed because:

- the data were often strongly right-skewed, and taking logs helped make the data more Normally distributed.
- covariate effects are often found to be additive on the log-scale.
- where the data shows a variance that increases with the mean, a log-transformation tends to make the variance more nearly constant.
- estimating the trend over time as percent per annum using the log transformation conveniently translates the problem into estimating the slope of a straight line on the log-scale.

Note that natural logarithms (i.e. to base *e*) were used throughout. For some log transformations it was necessary to add a constant to accommodate a zero response, i.e. use log(response + *c*), where *c* is the constant used.

The geometric mean is used throughout this report because it is less sensitive to outliers than the arithmetic mean. The geometric mean for data $x_1, \ldots, x_n$ is equivalent to the exponential of the mean on the log scale, i.e.

$$gm = \left(\prod_{i=1}^{n} x_i \right)^{1/n} = \exp\left(\sum_{i=1}^{n} \log(x_i)/n \right). \quad (1)$$

Since all the trend analyses are conducted on the log transformed response, the mean of the variate becomes the geometric mean when transformed back to the original scale. This value is lower than the arithmetic mean. If the data on the original scale approximately follows a log-Normal distribution, the theoretical geometric mean is close to the median.

Generalized additive models

A Generalized Additive Model (GAM) (Hastie & Tibshirani, 1990; Wood 2006) is a regression model where one or more of the additive terms take the form of an arbitrary smooth function. This function is nonparametric in that it does not follow a prescribed parametric formula. The graphs in Sections 3 to 7 exhibit a wide range of shapes the trend curve can take. The property of smoothness enables its value at any point to be estimated from many observations locally in time. A GAM necessarily tends to smooth over rapid changes such as a sharp peak or trough or an abrupt change of level.

GAMs make the same assumptions as that used in ordinary regression and rely on independent residual errors which follow a Normal distribution with constant variance. Lack of Normality in the residuals does not invalidate the statistical inference. A lack of constancy of variance or statistical independence does not bias the estimated regression parameters, but can give seriously misleading standard errors, statistical significance and confidence intervals. This is however not a serious issue unless the variance changes dramatically. The main concern is the non-independence. This is addressed by combining time series errors with the GAM. Equal spacing of the time points is not a requirement of a GAM any more than it is for an ordinary linear regression model. However, unequal spacing or missing data can create additional difficulties when time series errors are used, whether the regression is a GAM or not.

In the analysis of the water quality variates, we represent flow effects and time trends by smoothing splines (Green & Silverman 1994). For a log-transformed variate *y*, the basic GAM model is

$$y = \beta_0 + \beta_1 \sin(2\pi t) + \beta_2 \cos(2\pi t) + s(x; df_x) + s(t; df_t) + \varepsilon \quad (2)$$

where s (z ; df) denotes a smoothing spline for variate z with degrees of freedom, df, sin and cos represent the seasonal effects linearly as a single annual cycle sinusoidal curve, and ε is the residual error. The unit of time t is taken to be one year.

Environmental covariates like flow often describe a significant amount of the natural variation in important water quality parameters. As our interest is typically in the underlying trend, and in particular the trend attributable to anthropogenic activities, it makes sense to adjust for such covariates in the estimation of the trends whenever the relationship between covariate and response may be adequately modelled. Esterby (1996) offers more discussion on the inclusion of covariates in trend analyses. In the analyses undertaken here the s (x; df) term is used to adjust for log flow x. The form of the flow effect is assumed to be very smooth, so we take $df = 2$.

As the trend in time t is expected to be less regular the choice of $df = 8$ is made to allow a non-linear curve of reasonable complexity. For shorter sequences of data it would sensible to make the degrees of freedom smaller. The linear component of each spline term is estimated and reported as a slope parameter with its associated standard error. The smooth terms in equation (2) are considered as being comprised of two components; a linear component and a term that captures the deviations from linearity. More specifically we consider

$$s(x; df_x) = \beta_3 x + \text{nonlinear component} \quad (3)$$

and

$$s(t; df_t) = \beta_4 t + \text{nonlinear component.} \quad (4)$$

The relationship between log response y and log flow x is principally evident from the sign and size of β_3. The coefficient β_4 is the overall linear trend per year over the period. Since y represents a log-transformed variate, the linear component can be expressed as an estimated increase of

$$100(\exp(\beta_4) - 1)\% \text{ p.a. compounded.} \quad (5)$$

This should be interpreted as implying that the mean level of the water quality variate of interest is on average increasing $100(\exp(\beta_4) - 1)\%$ per annum. It is important that this is interpreted in relation to the mean value. For instance, an α% increase in turbidity for a site with low turbidity corresponds to a much smaller absolute change than an α% increase in turbidity for a more degraded site with higher turbidity.

The raw trend (i.e. linear trend unadjusted for flow) may be of interest as this represents the change in quality to the user. It may also be important to see how much the adjustment has changed the trend at those sites where there has been large change in flow over the period. In this case the estimation of the trend and flow effects will be confounded (i.e. it is difficult to distinguish between them) and therefore the adjustment of the trend for flow could be unreliable. For any sites where the adjustment has been obtained from a relationship to flow that is unusual, a comparison with the raw trend should also be considered. The raw trend was obtained by fitting a GAM with only seasonal and time terms assuming correlated errors, i.e.

$$y = \beta_0 + \beta_1 \sin(2\pi t) + \beta_2 \cos(2\pi t) + s(t; df_t) + \varepsilon, \quad (6)$$

was fitted to allow comparisons.

Seasonal effects

The seasonal variation in the GAM trend models are captured by the sinusoidal terms in (2). These seasonal effects can also be represented in terms of an amplitude R and the phase ϕ. Here, the amplitude is half the seasonal range on the log-scale and the phase is the time in months from January 1 to the maximum. Thus, a phase of 7.5 means mid-August (i.e. 7.5 months after the start of the year). The minimum of the sinusoidal curve is six months earlier or later. Figure 1 provides a graphical depiction of the seasonal amplitude and phase. Insofar as the seasonal effects are not exactly fitted by a sinusoidal curve, the phase should be regarded as descriptive rather than estimating the time of the precise maximum and minimum. As can be seen in the graphs in Appendices A to D, there is generally substantial variation about the fitted curves, so that in any given year the observed maximum or minimum need not coincide with that predicted by the curve. The relationships between the amplitude R and phase ϕ and the seasonal parameters β_1, β_2 are

$$\beta_1 = R\sin(\pi\phi/12) \quad \text{and} \quad \beta_2 = R\cos(\pi\phi/12) \quad (7)$$

from which we obtain

$$R = \sqrt{\beta_1^{\,2} + \beta_2^{\,2}} \quad (8)$$

and

$$\phi = (6/\pi)\arccos(\beta_2 / R) \quad (9)$$

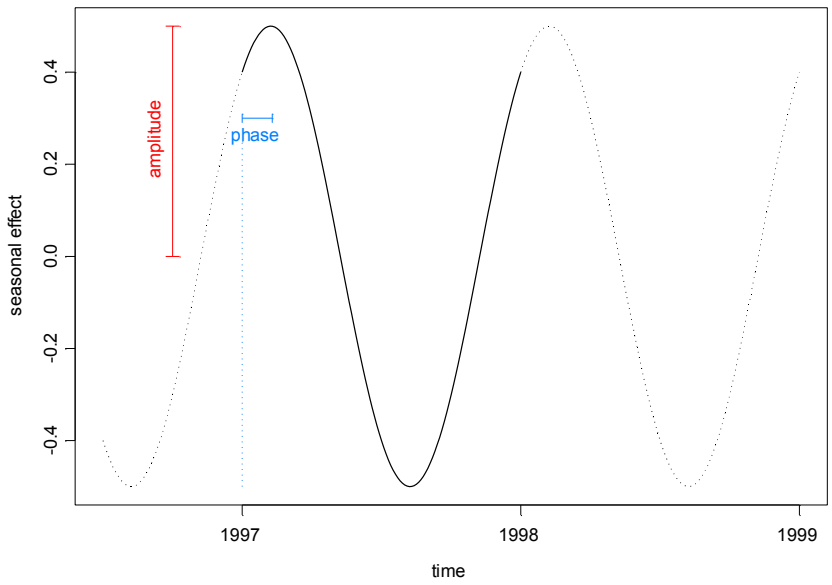


Figure 1. Graphical depiction of the seasonal amplitude and phase. The above is derived from β_1=0.3 (sine term) and β_2=0.4 (cosine term), which corresponds to an amplitude of 0.5 and a phase or seasonal peak of 1.24 months.

Diagnostics & outlying data

The GAM model and parameters $\beta_0, \beta_1, \ldots, \beta_4$ were first estimated by ordinary least squares (OLS) assuming the errors are uncorrelated. The residuals, which are the difference between the observed value and that predicted from the regression, were calculated and diagnostics based on them considered. An unusually large residual value indicates that the observation is an outlier for some reason. Residuals are standardised so that they have variance 1. In order to handle outliers in a systematic manner, observations where the standardised residual exceeded 3.5 in absolute value were excluded from the analysis. In some data sets several outliers were excluded on the basis that these should not be allowed to distort the analysis of the remaining data. The number of observations excluded was small – at most 2 observations were omitted from any analysis. Generally, the outliers had very little effect on the trend estimation, unless they occurred at either end of the period, where they would have high influence (leverage) and consequently high Cook's D statistic (Cook & Weisberg 1982). This is of particular concern for prediction if a single high outlier in 2005 could give a dramatic upsurge to the trend curve at the end. It is undesirable to let one observation give such an impression. Removal of the outliers with low Cook's D statistic can have a considerable effect on the estimate of residual variance and autocorrelation and is also a good reason for their exclusion.

Correlated Errors

It is very common that data observed sequentially in time is serially correlated. When observations are taken at regular intervals in time it is common to assume that the sequence of residuals ε is an autoregressive process of first order (AR1) with autocorrelation ρ, where the residual is related to the past only through the residual from the previous sample time. Second or higher order autoregressive processes have not been considered here as they would imply that the current error has a more complicated dependence on the past. The model for the errors is $\varepsilon_t = \rho\varepsilon_{t-1} + \nu_t$ where ν_t are assumed to be independent Normal random variables.

Positive autocorrelation has the effect of reducing the statistical significance of estimated time trends. An autocorrelation of $\rho > 0.5$ is sufficient to invalidate the standard errors and confidence intervals obtained using OLS estimation (Morton 1997). That is, the OLS estimates are generally good estimates, but the formal standard errors and confidence intervals can be misleadingly small. An approximation described in Morton (1997) gives an informal argument suggesting that the standard error for the linear trend component should be multiplied by the factor $\sqrt{(1+\rho)/(1-\rho)}$. Note that the trend estimates obtained from the OLS fit and the approach with correlated errors are usually in good agreement, but they can be substantially different in some cases when autocorrelation is over 0.5. In short, trend estimation in the presence of such high autocorrelation is unreliable if only OLS can be used.

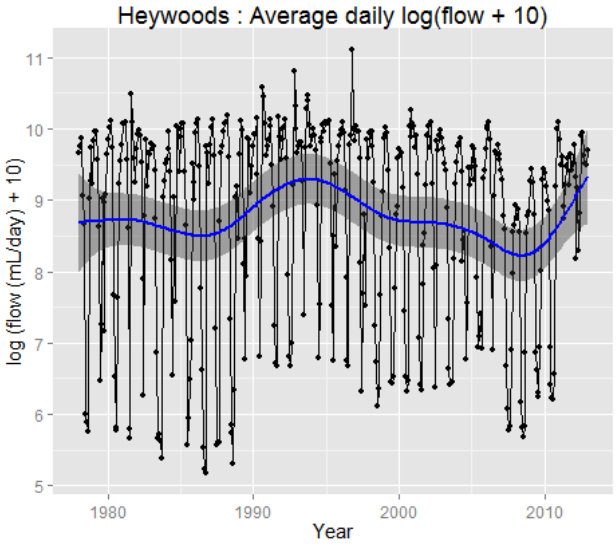
Following the identification and removal of any outliers, the GAM model and parameters $\beta_0, \beta_1, \ldots, \beta_4$ were estimated assuming the errors in (2) follow a first order autoregressive process (AR1). The same procedure is used for trend analyses unadjusted for flow.

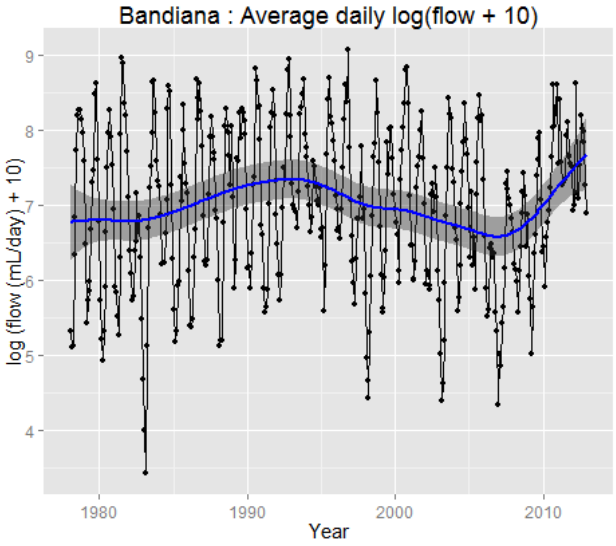
Nonparametric Linear Trend

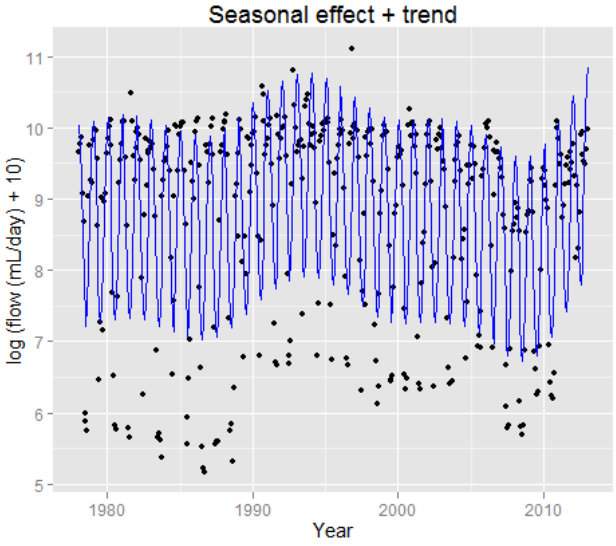
Non parametric methods for water quality trend analysis have been popular. The Mann-Kendall test and Kendall's tau are based on the sum of signed differences and are useful for detecting monotonic change. The Theil estimate (Theil, 1950) and Sen estimate (Sen, 1968) provide a measure of the slope of the linear trend. Extensions that account for seasonality are also available, e.g. the seasonal Kendall's tau (Hirsch *et al*. 1991). Non-parametric have derived popularity from their ability to implicitly downweight outliers and deal with non-normal data. They are however not as flexible as the GAM approach in either their ability to adjust for important covariates, confront non-linearity in the trend or handle auto-correlation. The non parametric estimate of trend (Theil slope estimate) is however reported as part of the analyses undertaken for comparison.

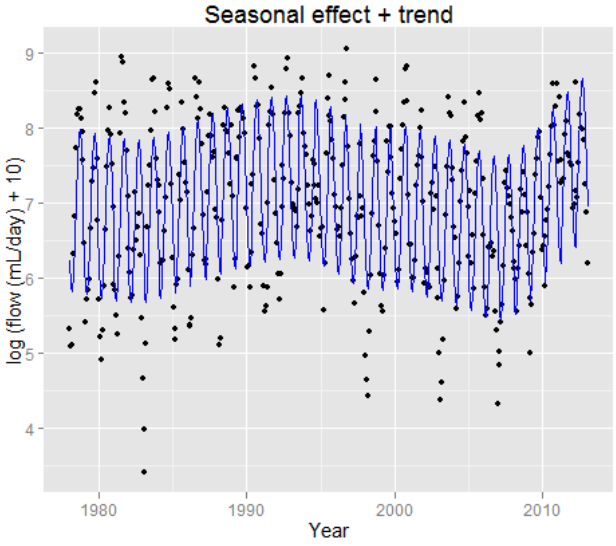
E: Streamflow

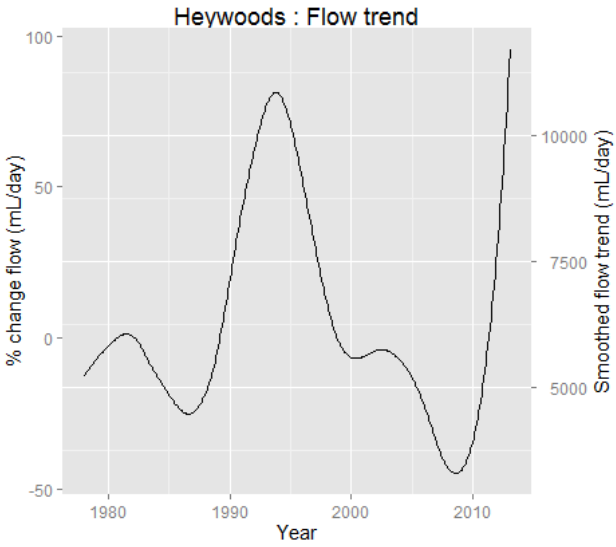
Monitoring Site	Geometric Mean	Amplitude	Seasonal Peak	Autocorrelation
Jingellic	5835.7558	80.2057	8.1533	0.5884
Tallandoon	1511.0522	76.1400	9.9263	0.6927
Heywoods	5400.9369	316.3904	0.3407	0.4948
Bandiana	996.2909	200.6503	8.2116	0.7326
Peechelba	1508.4015	365.5651	8.0821	0.7665
Yarrawonga	9455.7220	57.6696	9.9731	0.5592
Torrumbarry	6772.0896	68.6511	8.6525	0.6480
Kerang	203.5751	48.8013	7.7293	0.6760
Capels Flume	67.5855	13.6177	0.8876	0.6011
Swan Hill	6204.9598	66.0938	8.6093	0.6361
Kyalite	2227.1253	72.2237	9.4212	0.6967
Euston Weir	9241.2578	81.5339	8.8117	0.7070
Merbein	9013.1076	80.1555	8.8068	0.7092
Burtundy	610.7838	83.2004	0.9853	0.7514
Lock 9	5327.2240	85.6964	9.4346	0.7784
Morgan	6802.4485	76.0093	9.4549	0.8059

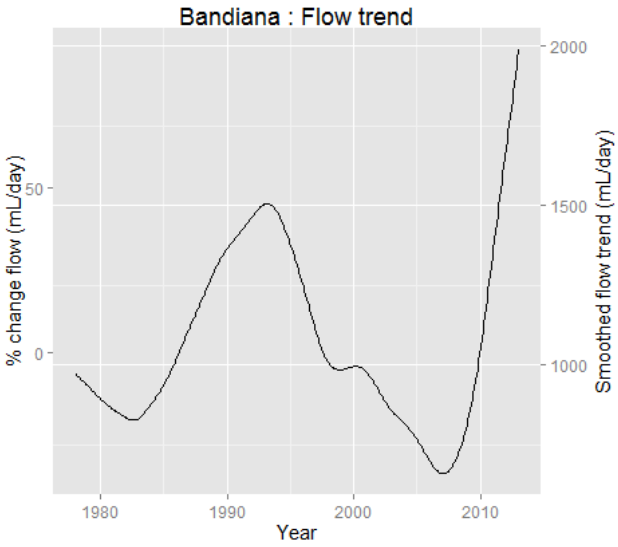

Heywoods : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

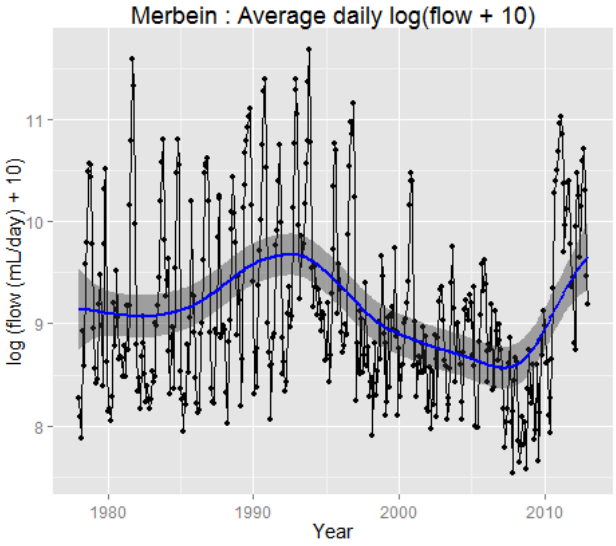

Bandiana : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

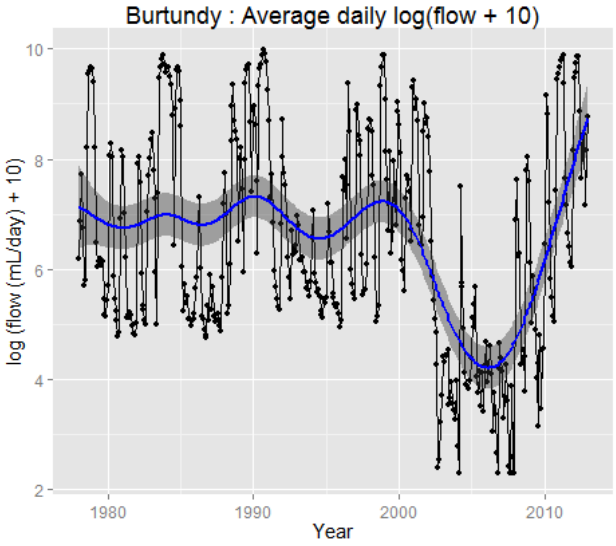

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

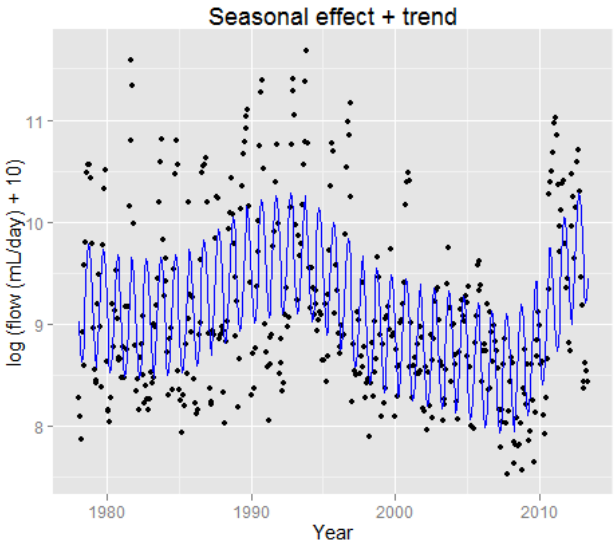

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

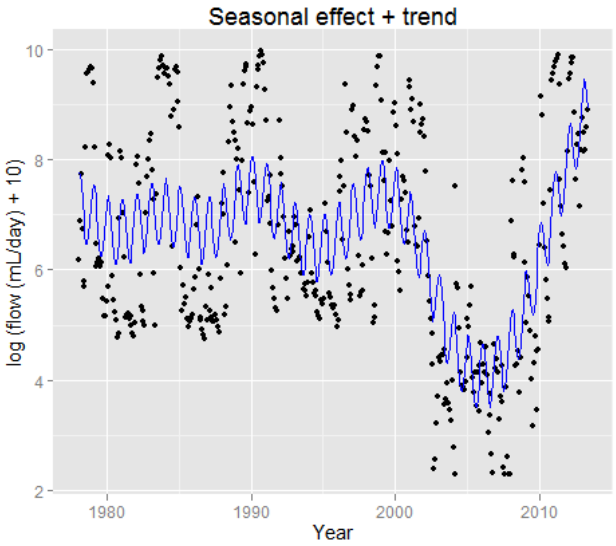

Heywoods : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

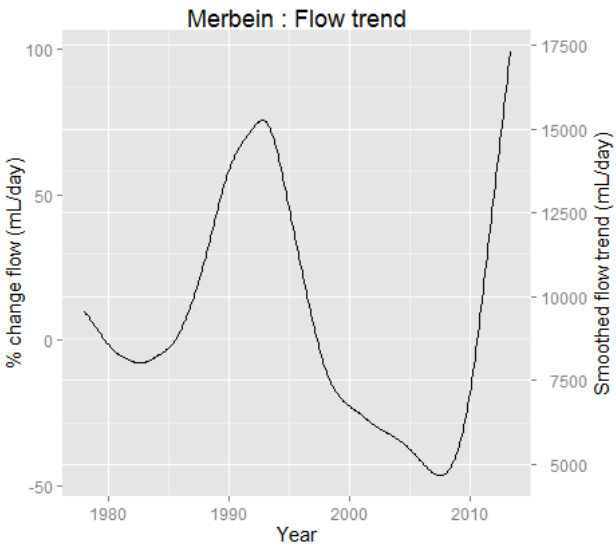

Bandiana : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

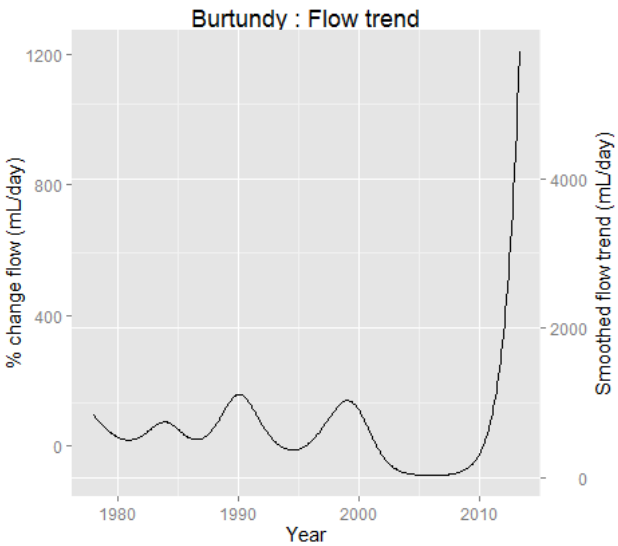

Merbein : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

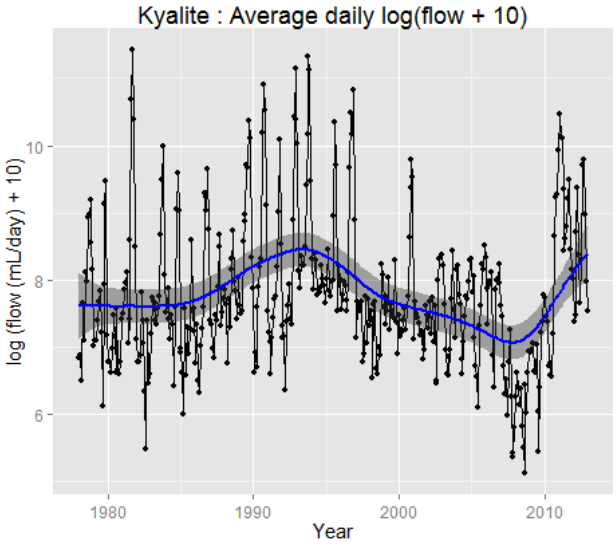

Burtundy : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

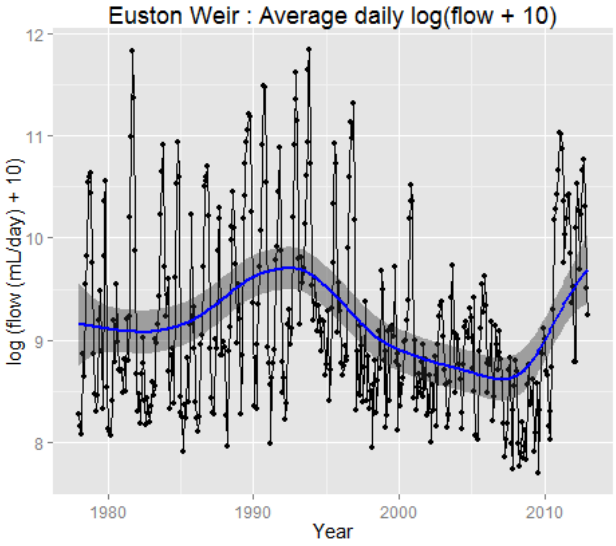

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

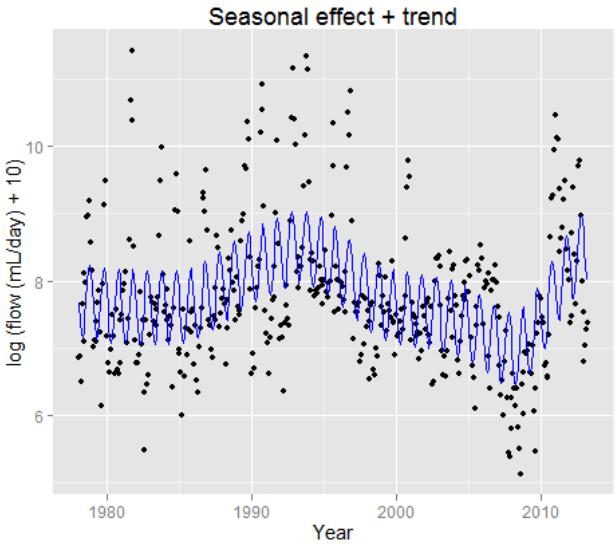

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

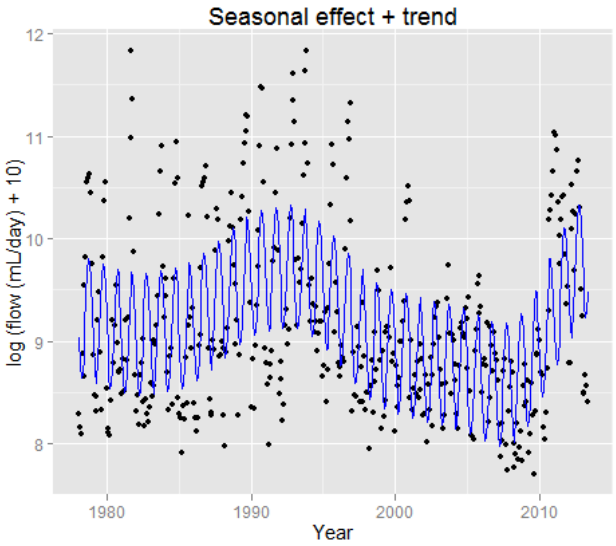

Merbein : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

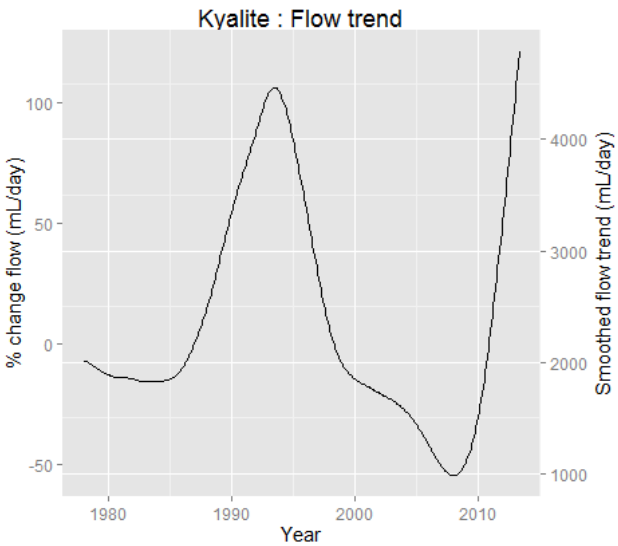

Burtundy : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

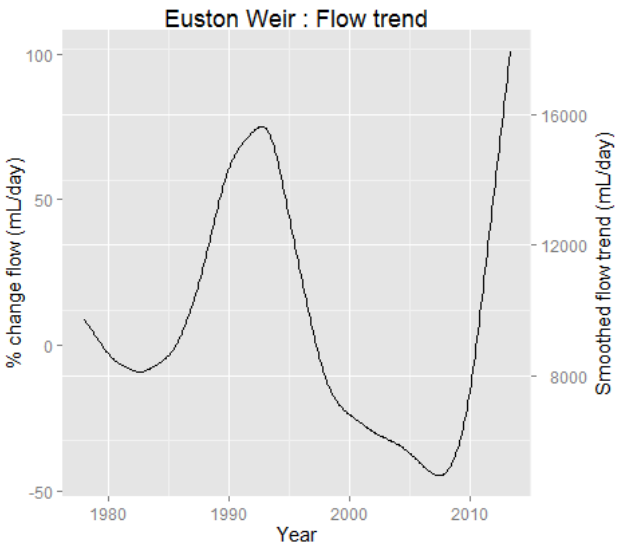

Kyalite : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

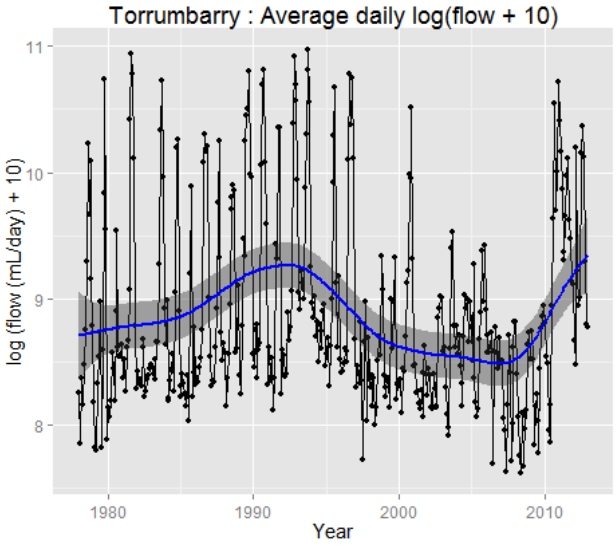

Euston Weir : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

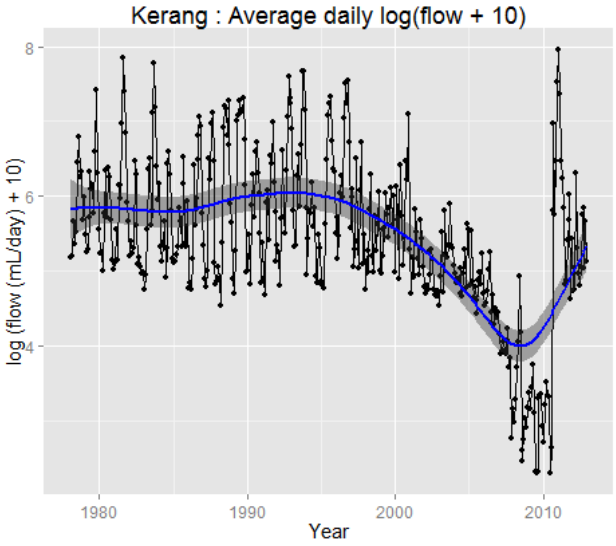

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

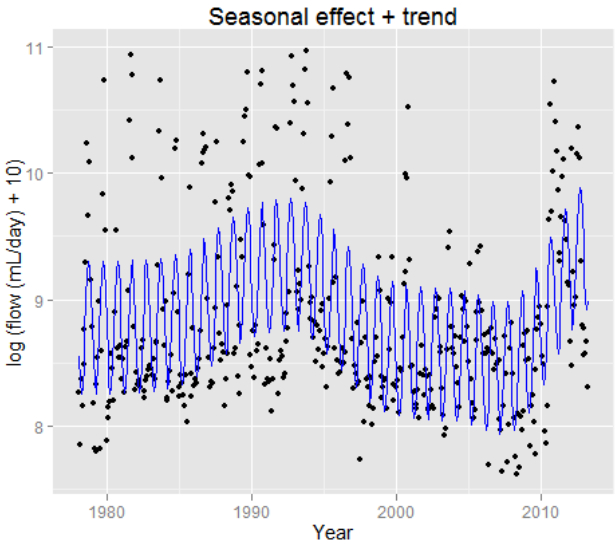

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

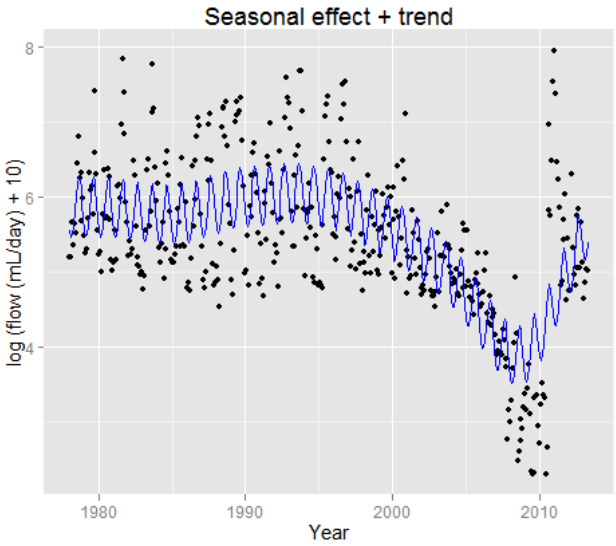

Kyalite : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

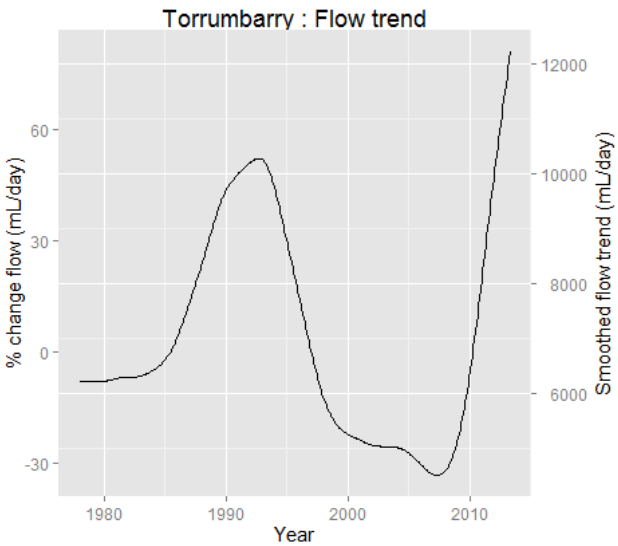

Euston Weir : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

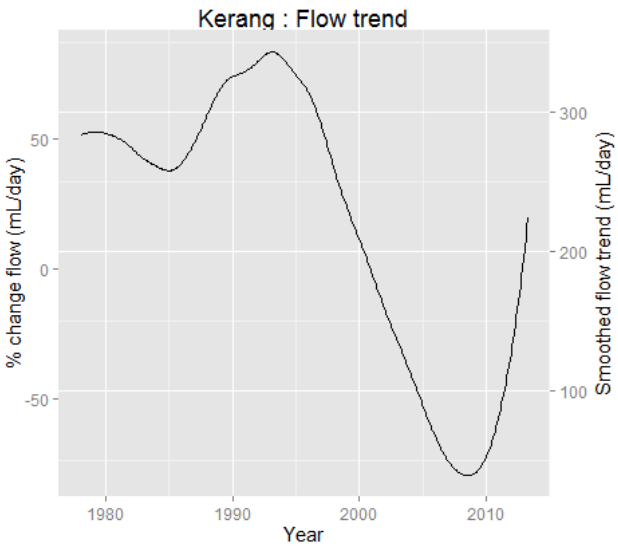

Torrumbarry : Average daily log(flow + 10)
log (flow (mL/day) + 10)
11
10
9
8
1980
1990
2000
2010
Year

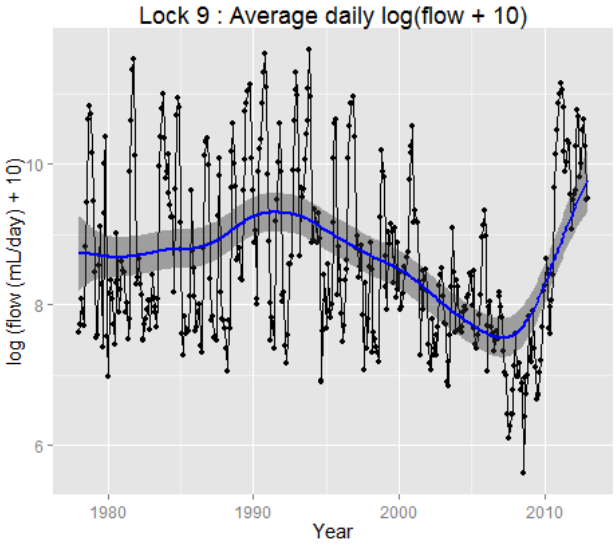

Kerang : Average daily log(flow + 10)
log (flow (mL/day) + 10)
8
6
4
1980
1990
2000
2010
Year

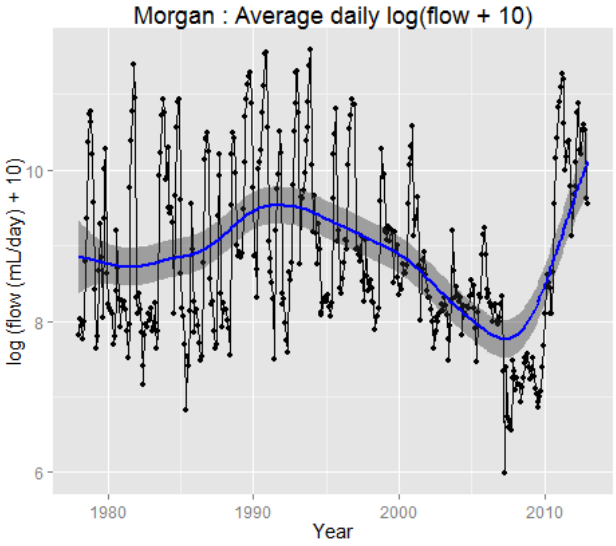

Seasonal effect + trend
log (flow (mL/day) + 10)
11
10
9
8
1980
1990
2000
2010
Year

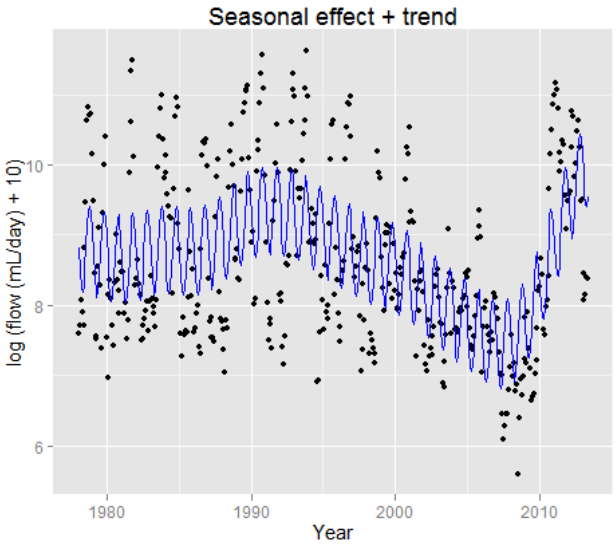

Seasonal effect + trend
log (flow (mL/day) + 10)
8
6
4
1980
1990
2000
2010
Year

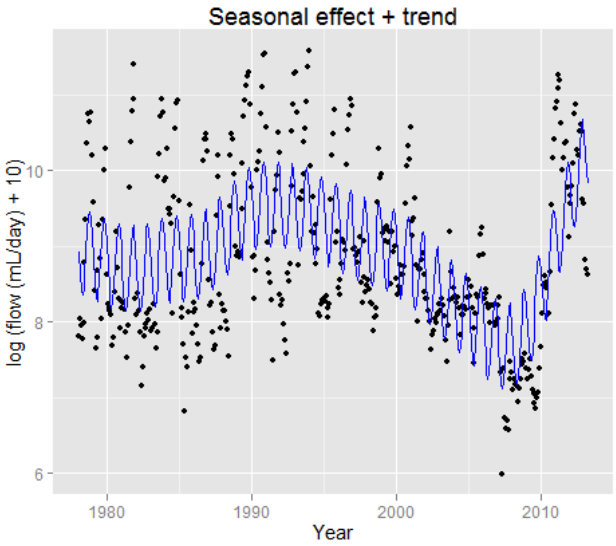

Torrumbarry : Flow trend
% change flow (mL/day)
60
30
0
-30
Smoothed flow trend (mL/day)
12000
10000
8000
6000
1980
1990
2000
2010
Year

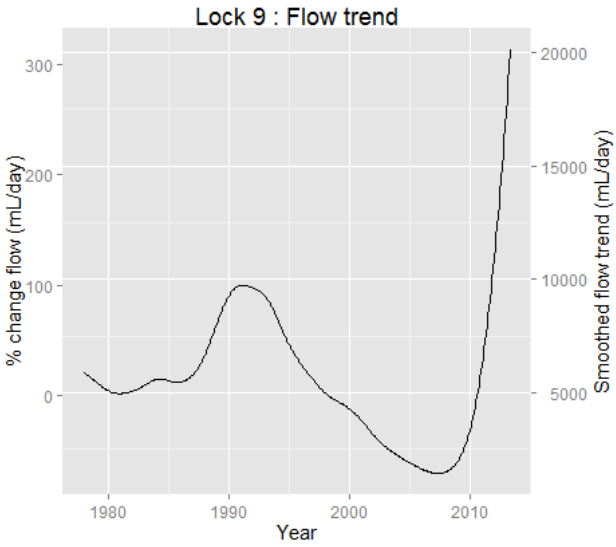

Kerang : Flow trend
% change flow (mL/day)
50
0
-50
Smoothed flow trend (mL/day)
300
200
100
1980
1990
2000
2010
Year

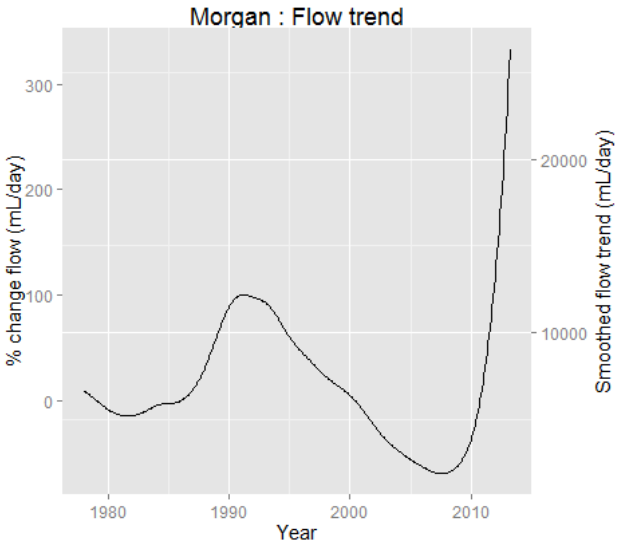

Lock 9 : Average daily log(flow + 10)
log (flow (mL/day) + 10)
10
8
6
1980
1990
2000
2010
Year

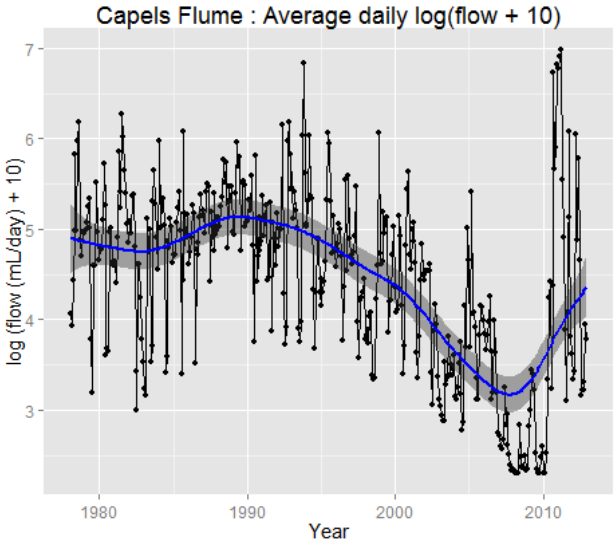

Morgan : Average daily log(flow + 10)
log (flow (mL/day) + 10)
10
8
6
1980
1990
2000
2010
Year

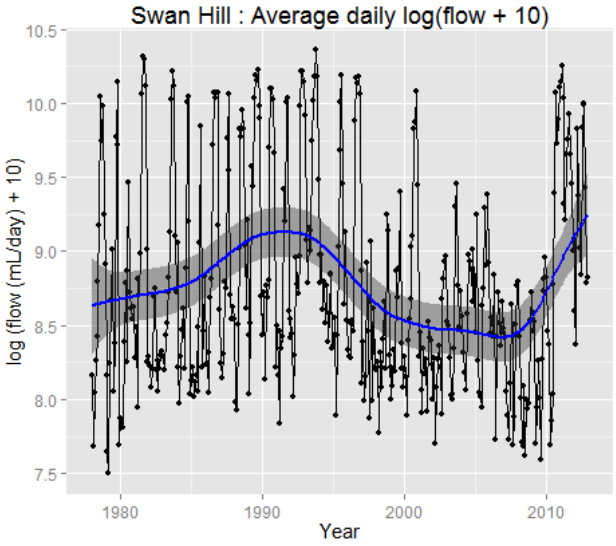

Seasonal effect + trend
log (flow (mL/day) + 10)
10
8
6
1980
1990
2000
2010
Year

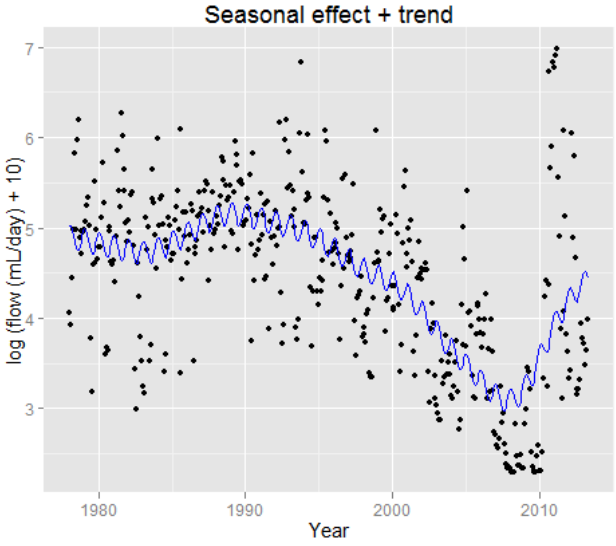

Seasonal effect + trend
log (flow (mL/day) + 10)
10
8
6
1980
1990
2000
2010
Year

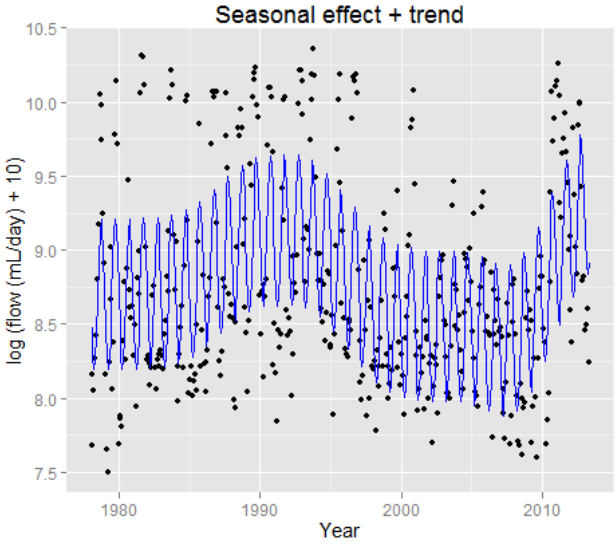

Lock 9 : Flow trend
% change flow (mL/day)
300
200
100
0
Smoothed flow trend (mL/day)
20000
15000
10000
5000
1980
1990
2000
2010
Year

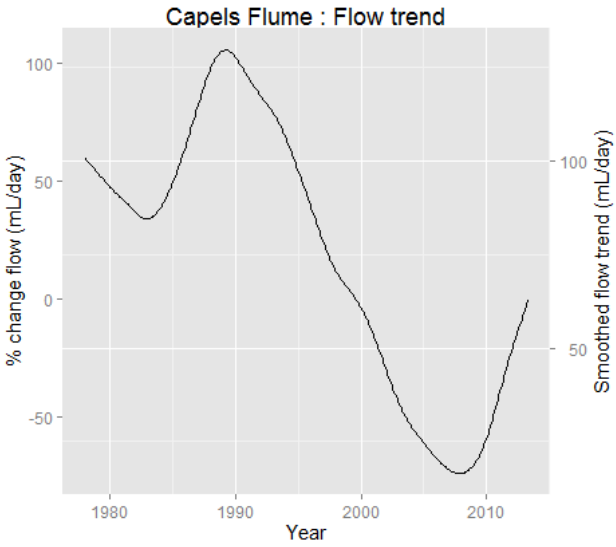

Morgan : Flow trend
% change flow (mL/day)
300
200
100
0
Smoothed flow trend (mL/day)
20000
10000
1980
1990
2000
2010
Year

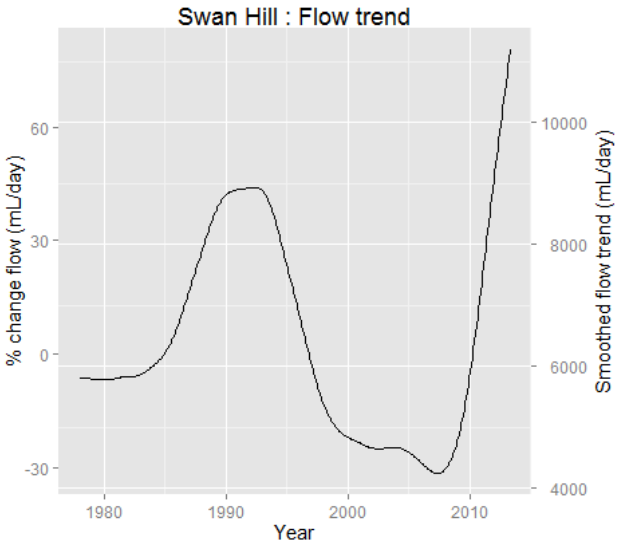

Capels Flume : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

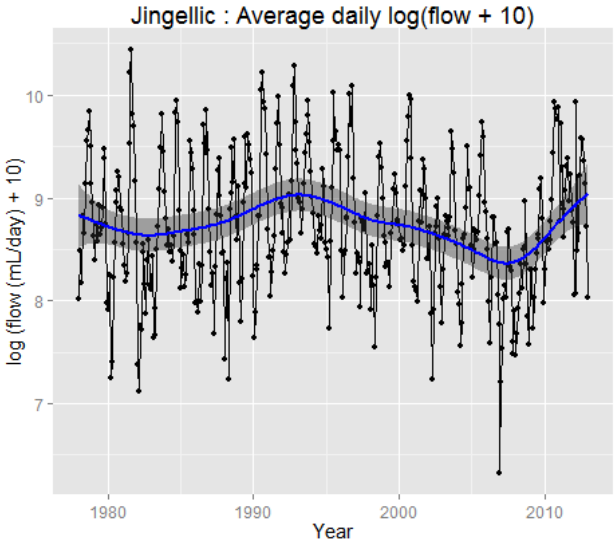

Swan Hill : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

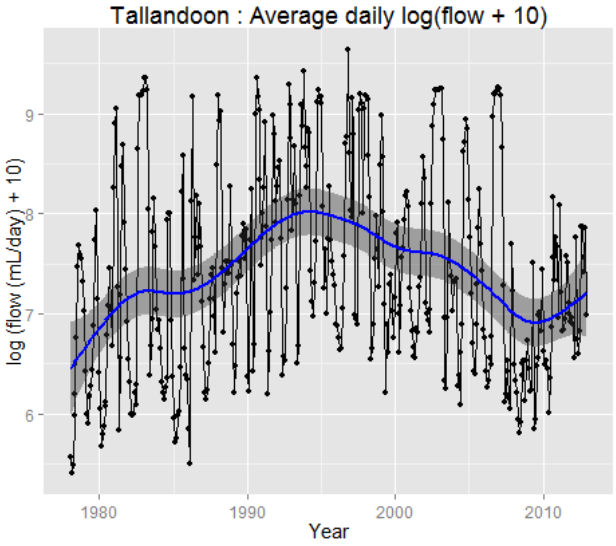

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

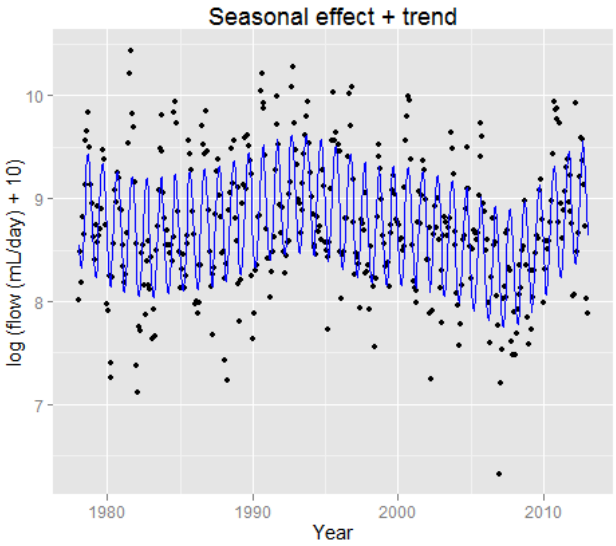

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

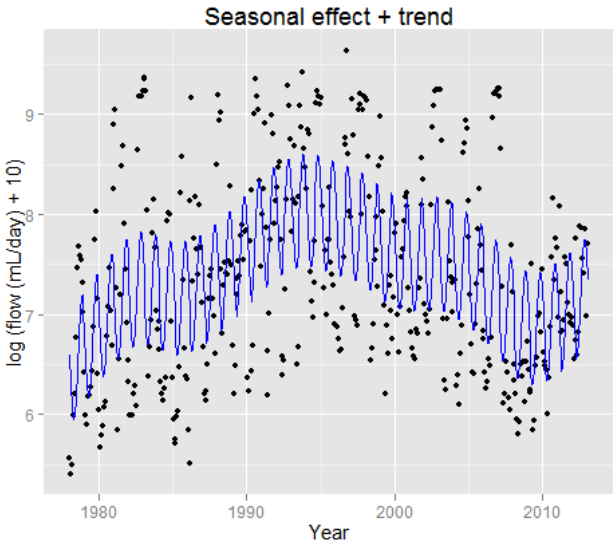

Capels Flume : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

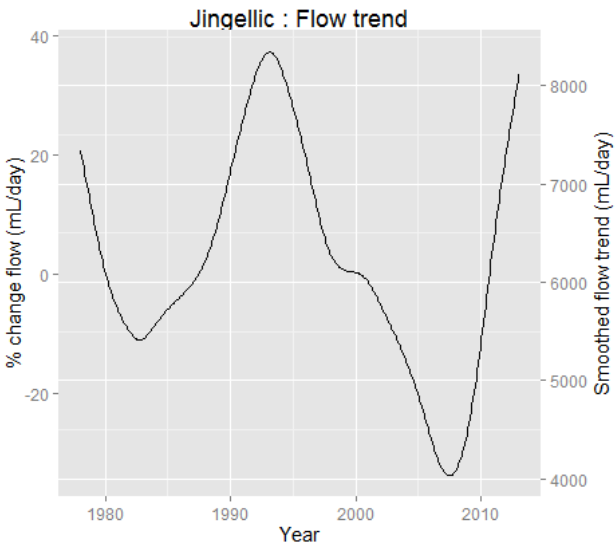

Swan Hill : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

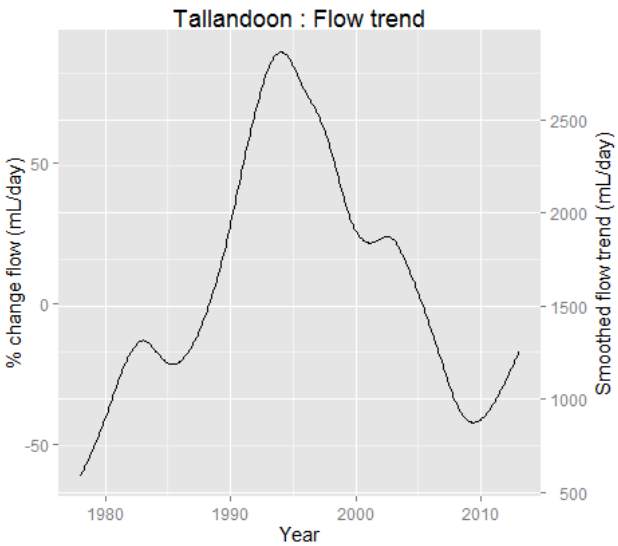

Jingellic : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

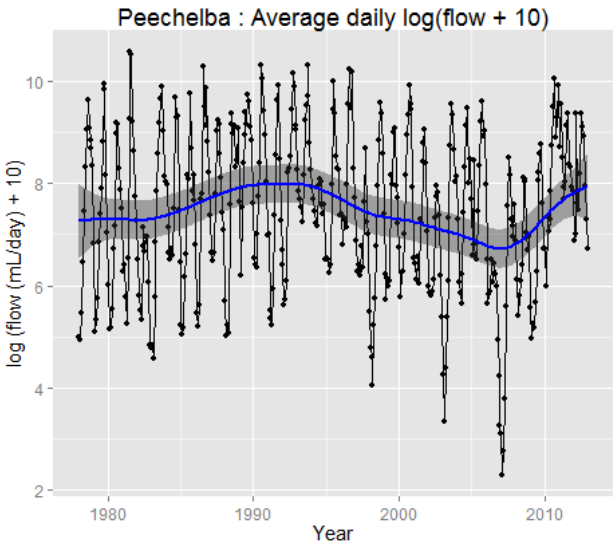

Tallandoon : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year

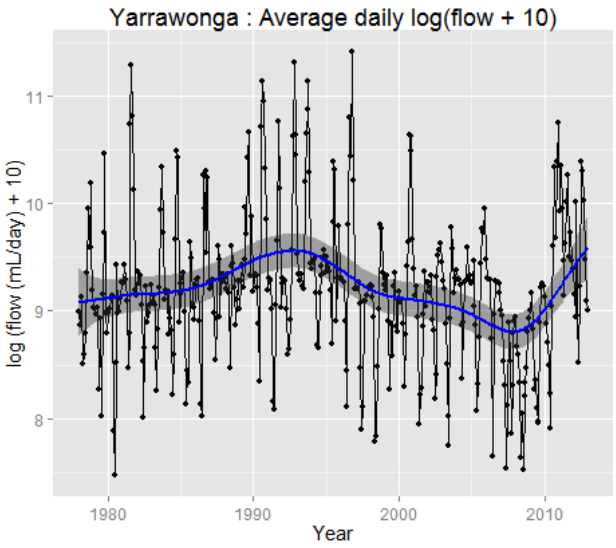

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

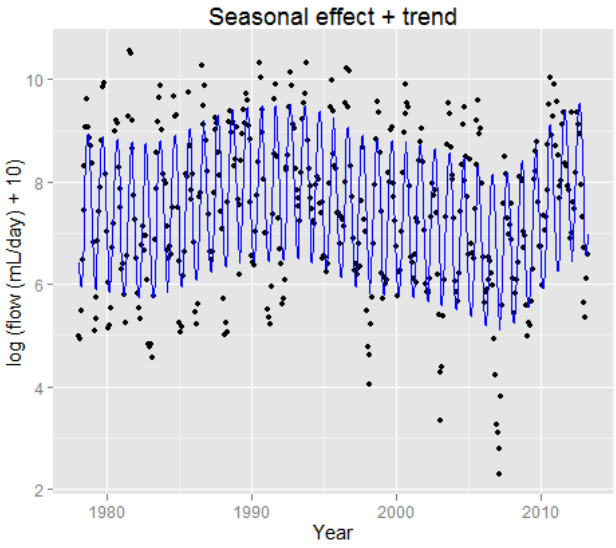

Seasonal effect + trend
log (flow (mL/day) + 10)
Year

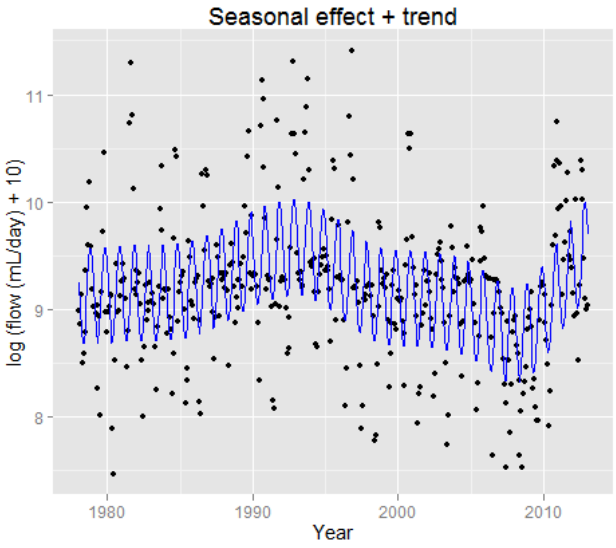

Jingellic : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

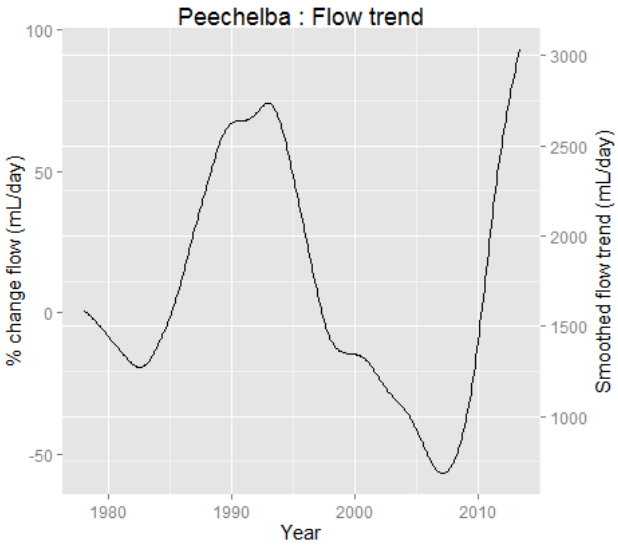

Tallandoon : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

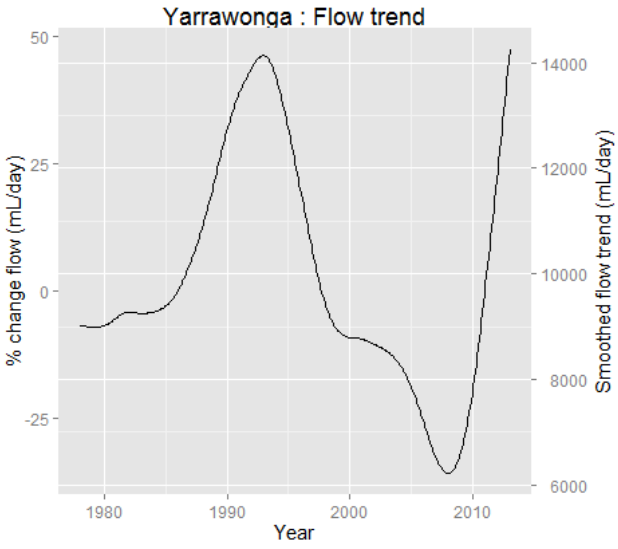

Peechelba : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year


Yarrawonga : Average daily log(flow + 10)
log (flow (mL/day) + 10)
Year


Seasonal effect + trend
log (flow (mL/day) + 10)
Year


Seasonal effect + trend
log (flow (mL/day) + 10)
Year

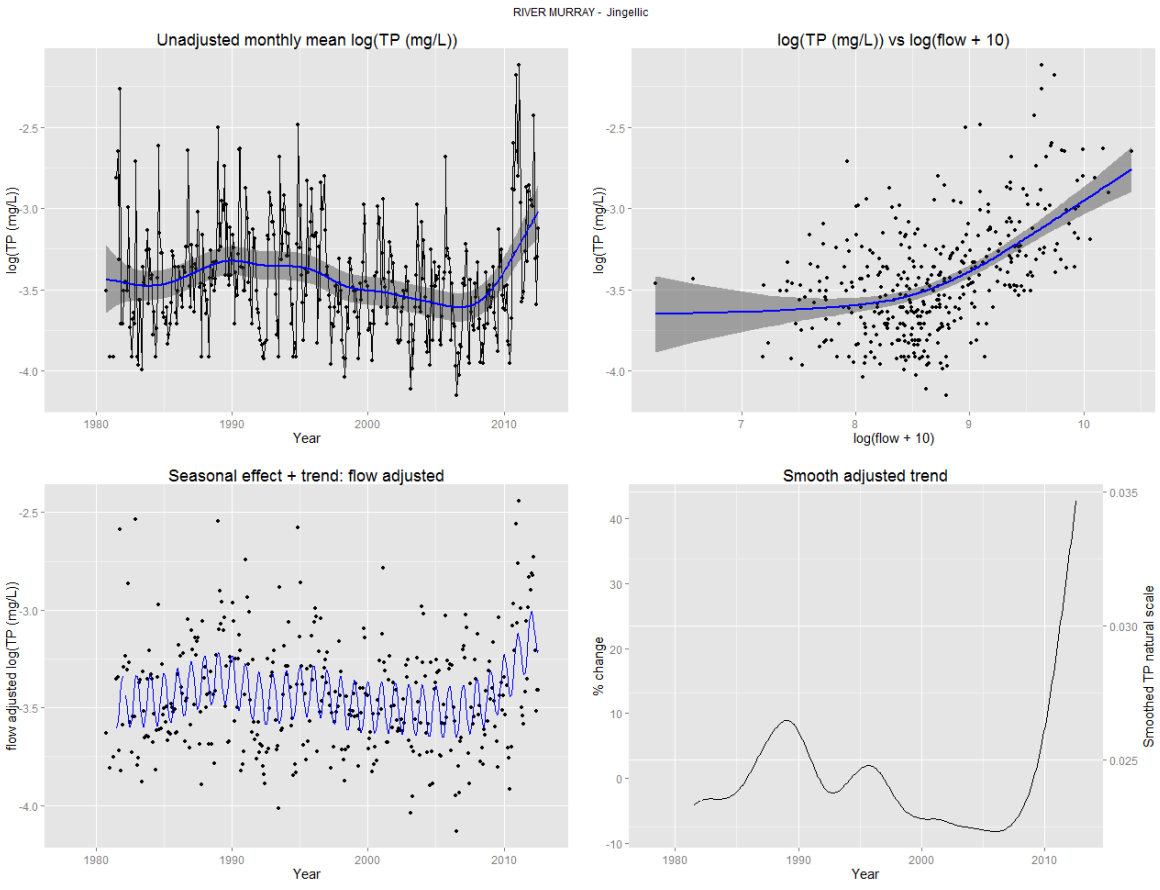

Peechelba : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year


Yarrawonga : Flow trend
% change flow (mL/day)
Smoothed flow trend (mL/day)
Year

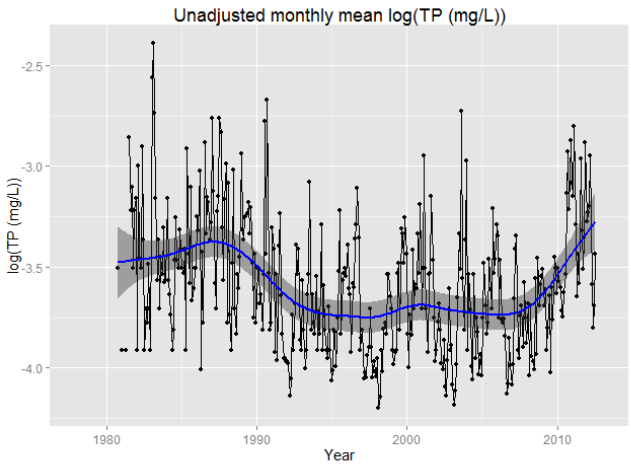
F: Total Phosphorus

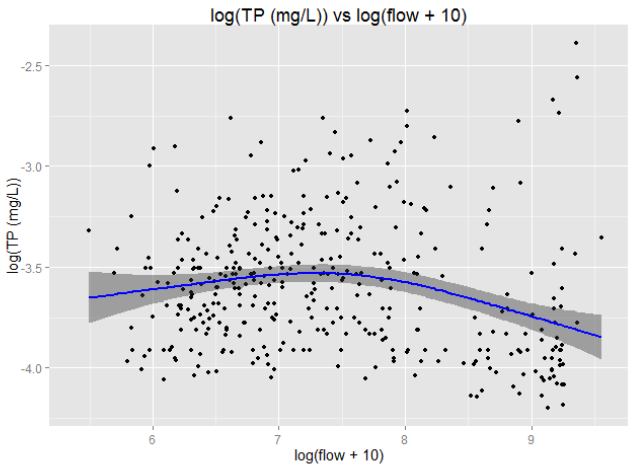
Monitoring Site	Geometric Mean	Linear Trend 1978-2012			Raw Trend 1978-2012			Linear Trend 2003-2012			Raw Trend 2003-2012		
Jingellic	0.0223	0.16		NL	-0.06		NL	**4.28**	**		**5.93**	**	NL
Tallandoon	0.0172	**-0.66**	**	NL	**-0.61**	**	NL	**3.98**	**	nl	**5.25**	**	NL
Heywoods	0.0231	0.02		NL	0.00		NL	1.87			1.43		
Bandiana	0.0275	0.33		nl	-0.26		NL	**2.64**	**		**6.29**	**	NL
Peechelba	0.0404	**-1.30**	**	NL	**-1.43**	**	NL	0.70		NL	2.10		NL
Yarrawonga	0.0374	**-1.48**	**	NL	**-1.58**	**	NL	1.56		NL	2.58	*	NL
Torrumbarry	0.0547	**-1.32**	**	NL	**-1.65**	**	NL	-0.07		NL	5.62	*	NL
Kerang	0.0919	**1.24**	**	NL	0.02		NL	**9.48**	**	nl	**8.97**	**	
Capels Flume	0.4799	**3.30**	**	NL	**2.73**	**	NL	**-16.51**	**	NL	**-14.99**	**	NL
Swan Hill	0.0633	**-0.95**	**	NL	**-1.15**	**	NL	0.20		NL	5.42		NL
Kyalite	0.0661	-0.77	*	NL	-0.80	*	NL	4.17	*	NL	7.38	*	nl
Euston Weir	0.0548	**-2.27**	**	NL	**-2.76**	**	NL	-1.78			-4.00	*	
Merbein	0.0542	**-1.65**	**	NL	**-2.21**	**	NL	-1.13		NL	3.62		NL
Burtundy	0.2130	**-1.42**	**	NL	**-2.65**	**	NL	0.29		NL	**11.59**	**	NL
Lock 9	0.0916	**-1.27**	**	NL	**-1.63**	**	NL	**6.94**	**	nl	**13.74**	**	NL
Morgan	0.1083	**-1.03**	**	NL	**-1.23**	**	NL	**6.63**	**	NL	**9.18**	**	NL

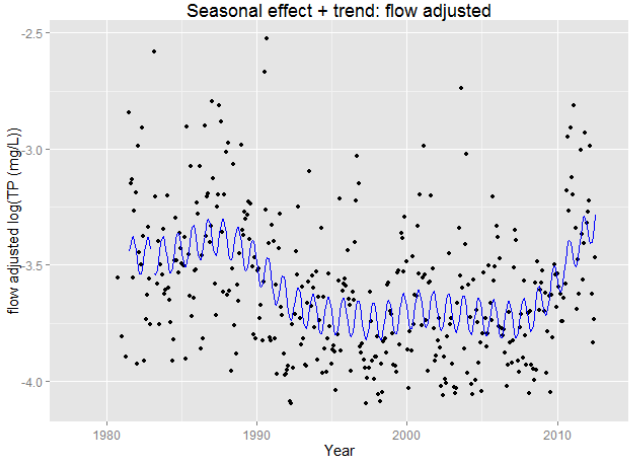
Monitoring Site	Geometric Mean	Relationship to Log flow	Significance	Amplitude(log scale)	Seasonal Peak	Autocorrelation
Jingellic	0.0223	+	**	0.1288	0.0938	0.2451
Tallandoon	0.0172	-		0.0645	8.9802	0.2868
Heywoods	0.0231	-	**	0.1006	0.7160	0.5884
Bandiana	0.0275	+	**	0.2257	1.2464	0.0973
Peechelba	0.0404	+	**	0.1592	1.4147	0.2000
Yarrawonga	0.0374	+	**	0.0574	9.6380	0.1141
Torrumbarry	0.0547	+	**	0.1553	0.5279	0.4452
Kerang	0.0919	+	**	0.4471	11.6069	0.4853
Capels Flume	0.4799	+	**	0.6600	0.2764	0.5470
Swan Hill	0.0633	+	**	0.1994	0.3527	0.5655
Kyalite	0.0661	+	*	0.2282	11.6091	0.5437
Euston Weir	0.0548	+	**	0.1429	11.4819	0.1764
Merbein	0.0542	+	**	0.0808	11.6600	0.0974
Burtundy	0.2130	+	**	0.0870	7.0804	0.5700
Lock 9	0.0916	+	**	0.2650	0.7785	0.5715
Morgan	0.1083	+	**	0.1196	1.4693	0.6685

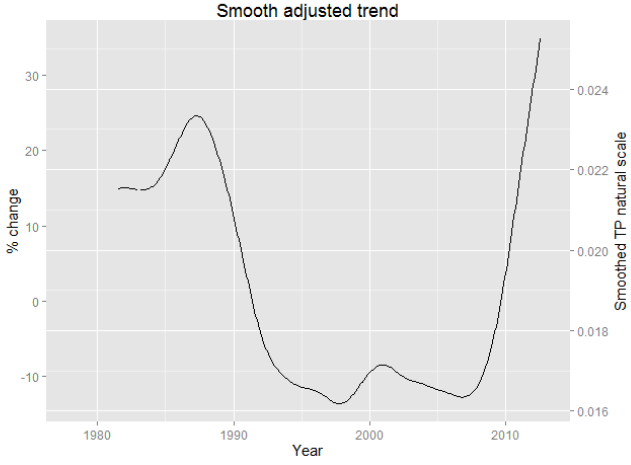


RIVER MURRAY - Tallandoon

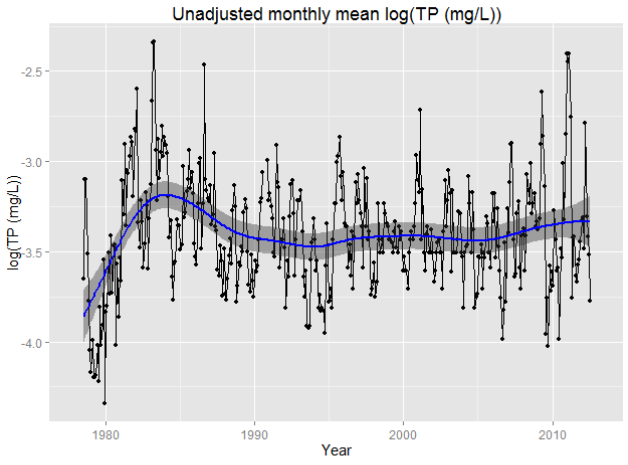


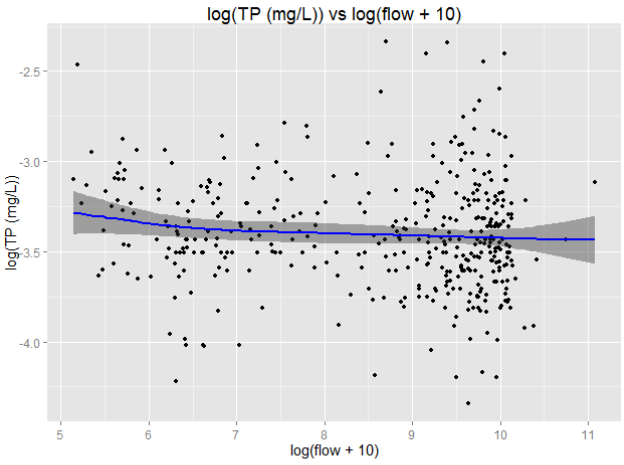


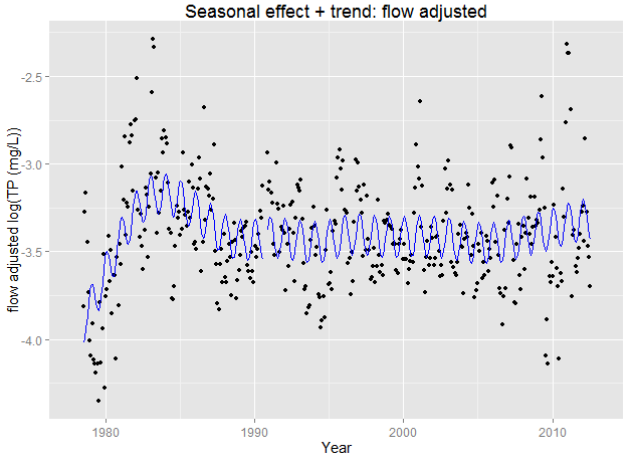


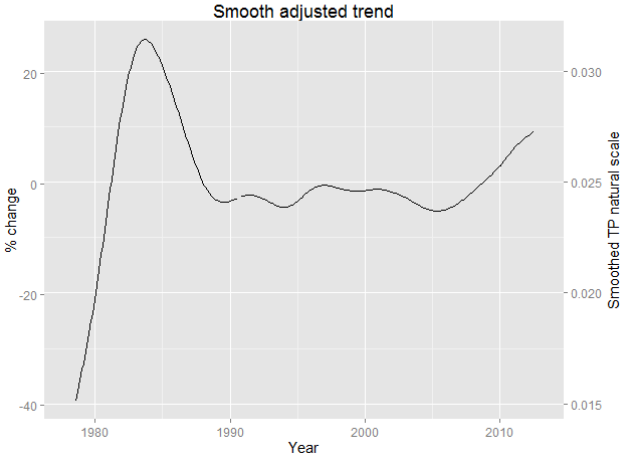


RIVER MURRAY - Heywoods

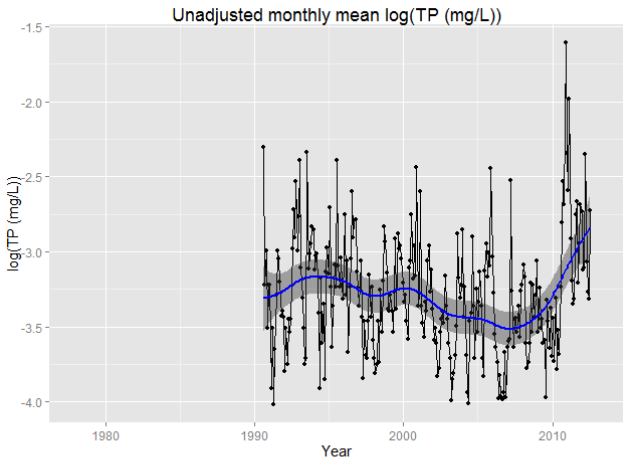


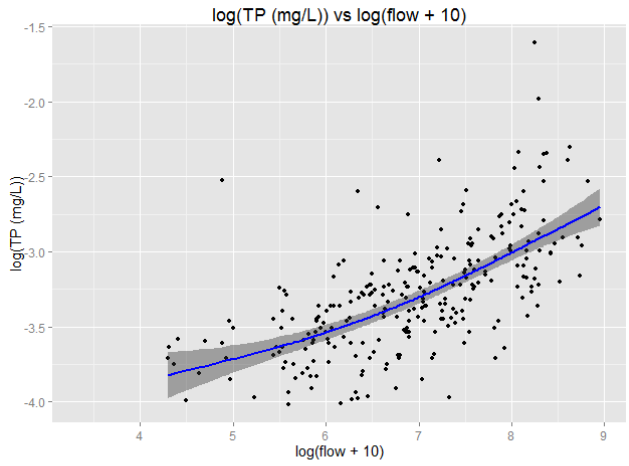


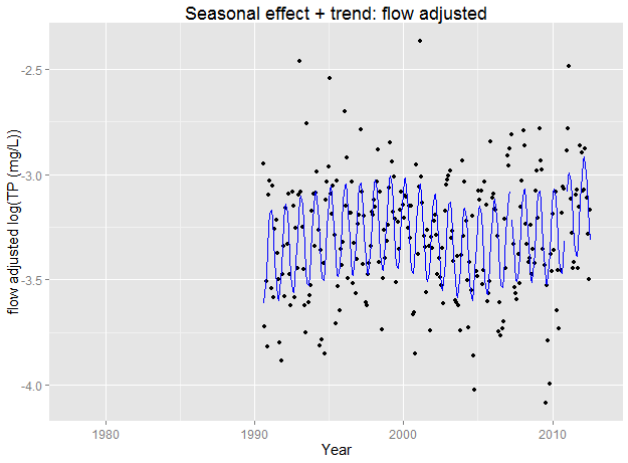


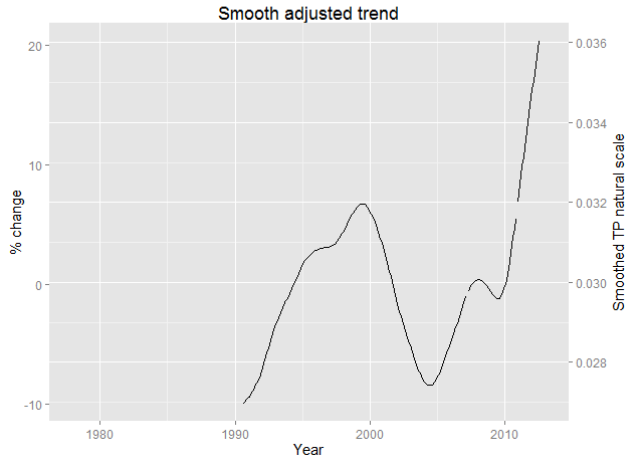


RIVER MURRAY - Bandiana

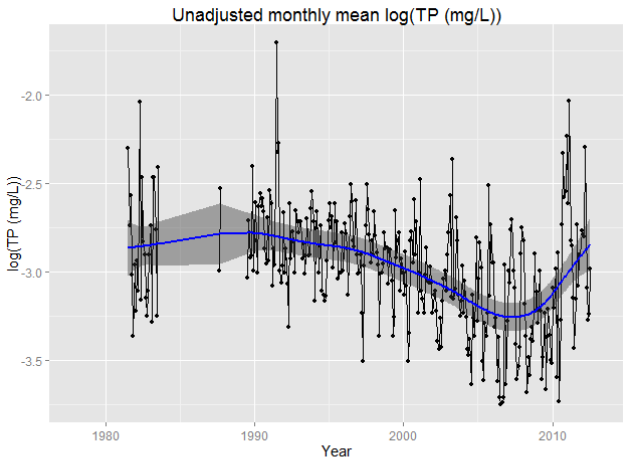


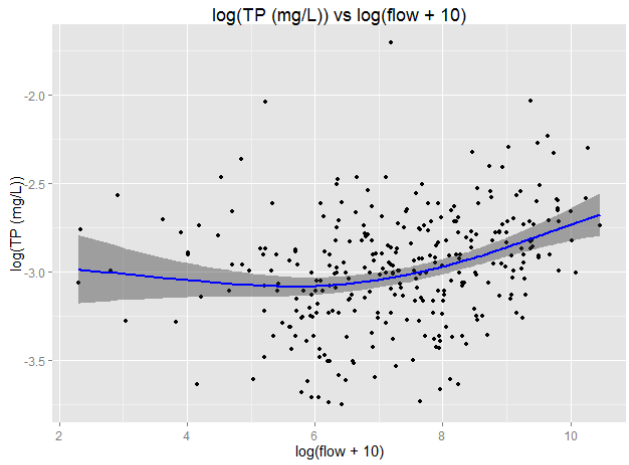


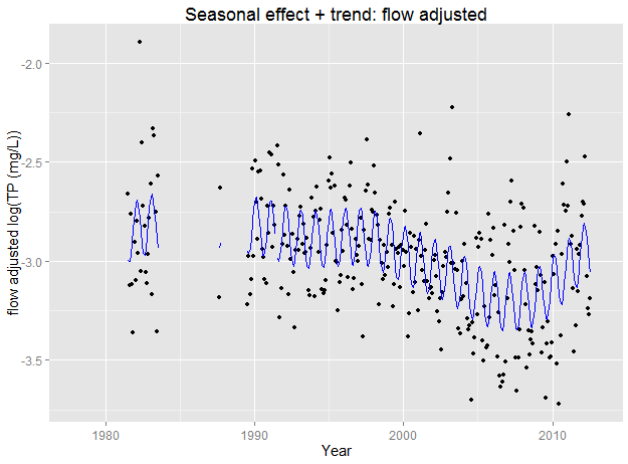


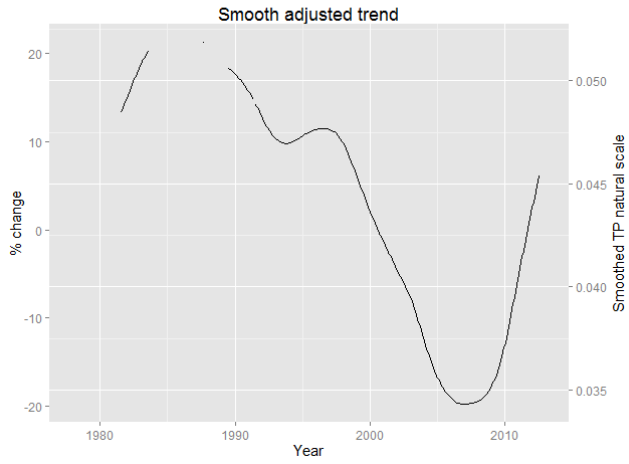


RIVER MURRAY - Peechelba

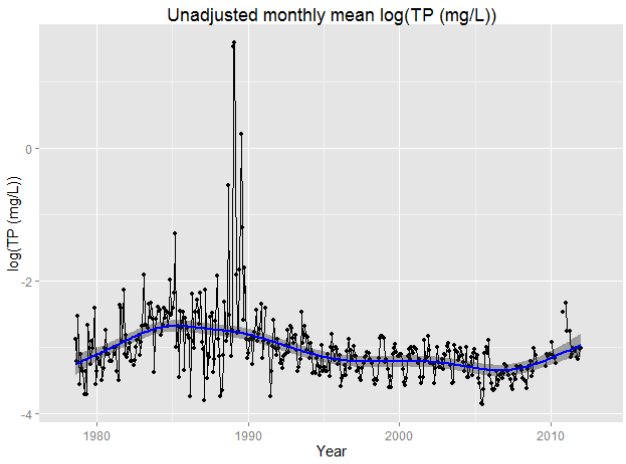


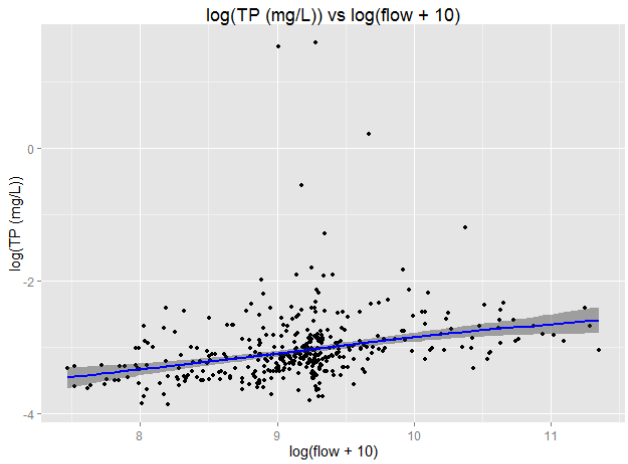


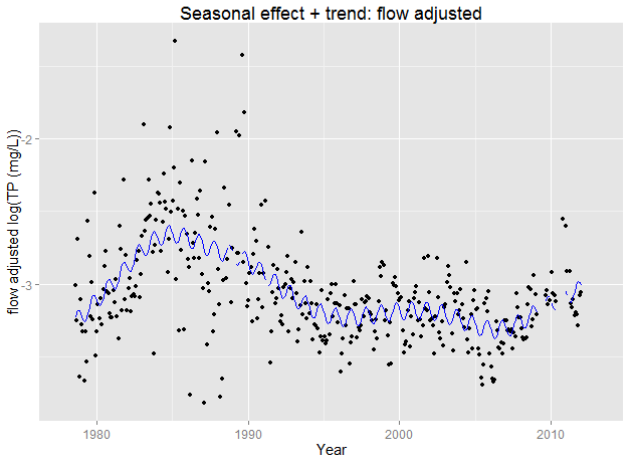


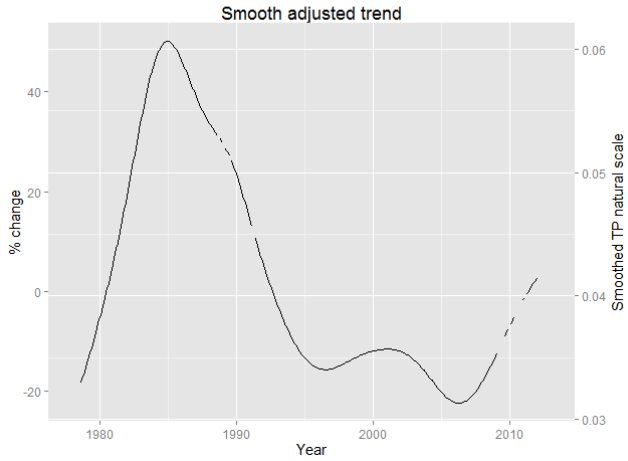


RIVER MURRAY - Yarrawonga

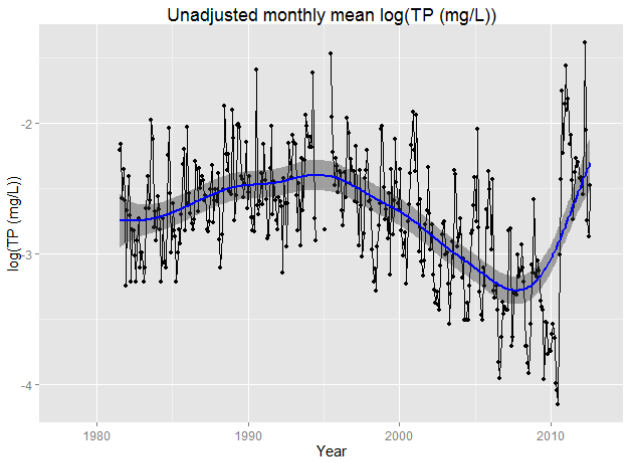


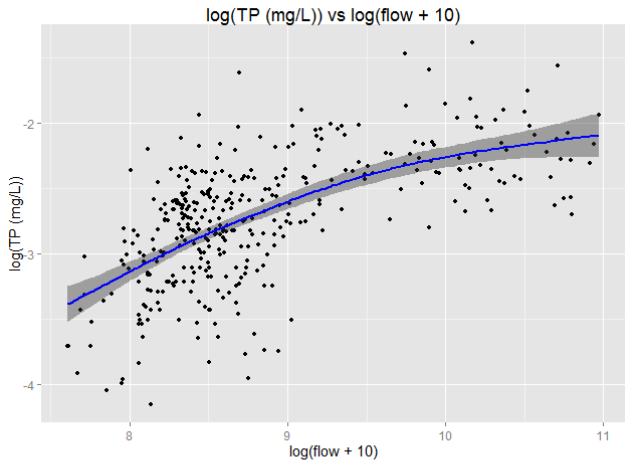


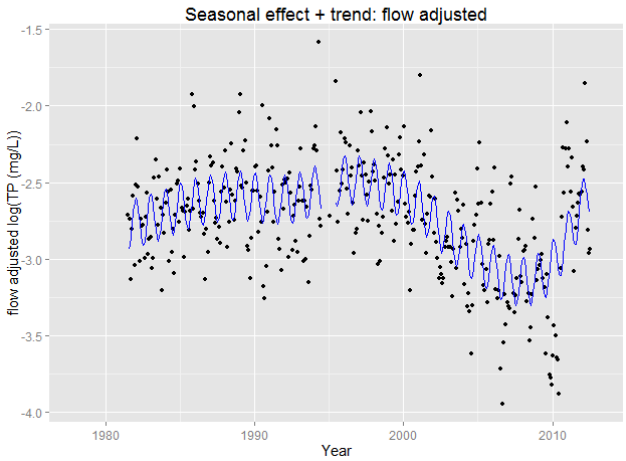


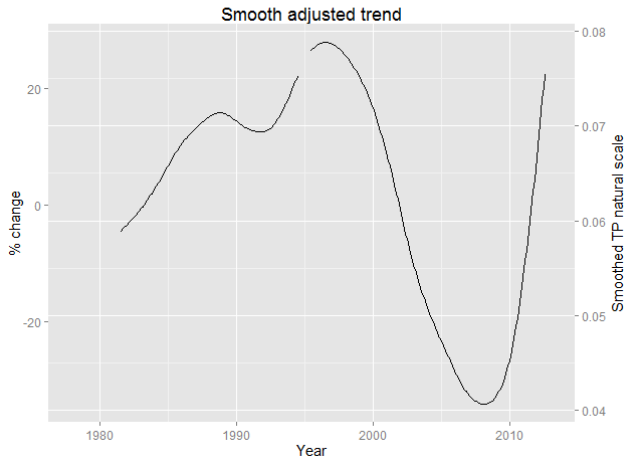


RIVER MURRAY - Torrumbarry

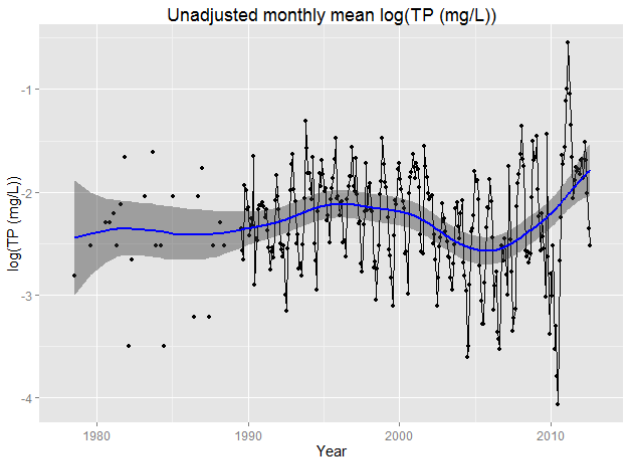


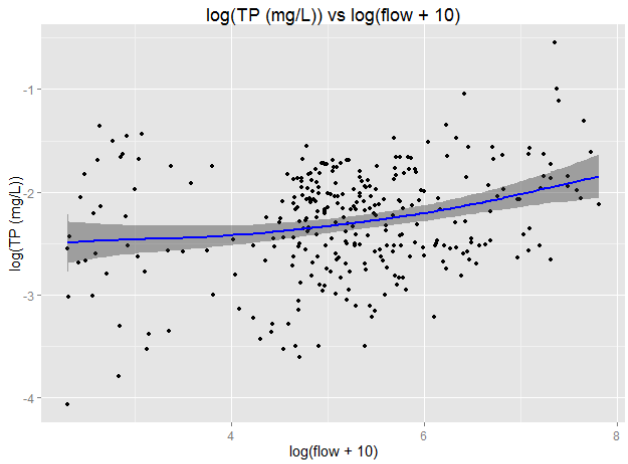


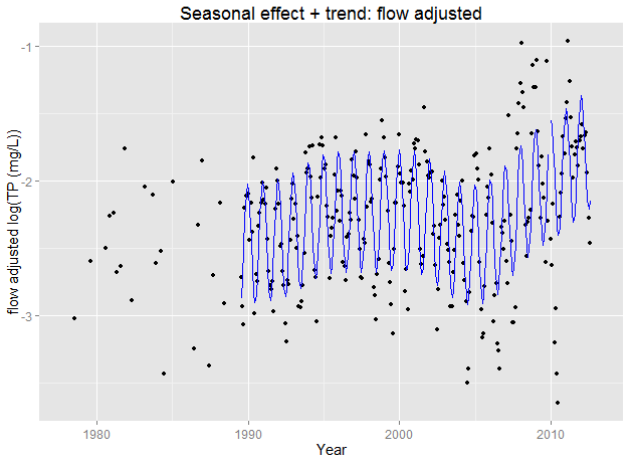


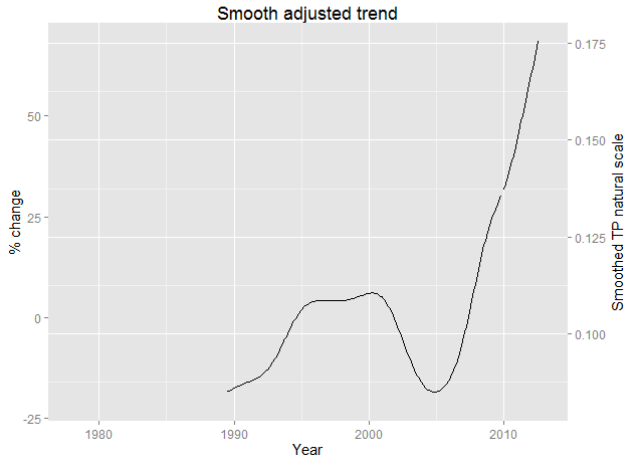


RIVER MURRAY - Kerang

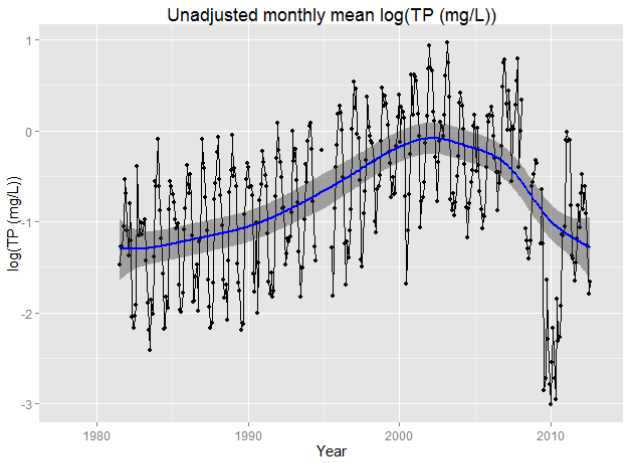


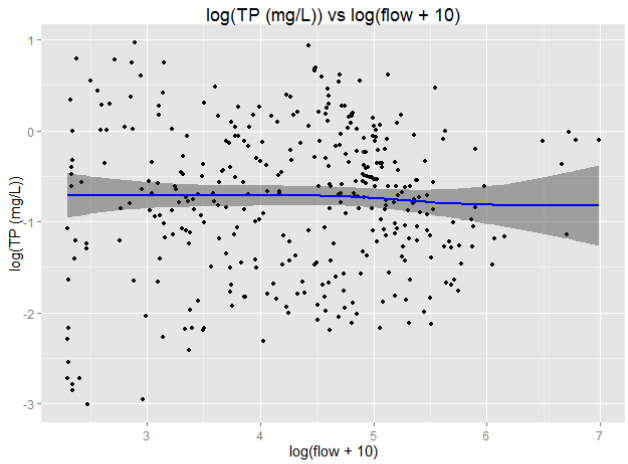


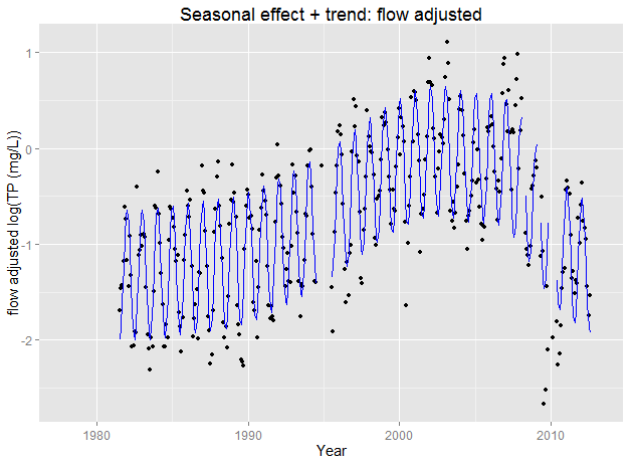


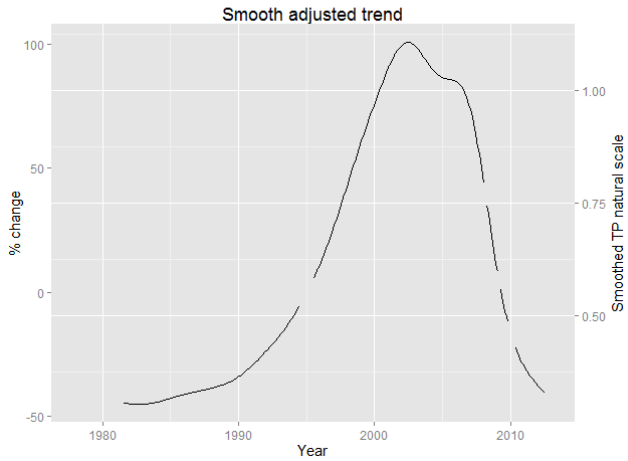


RIVER MURRAY - Capels Flume

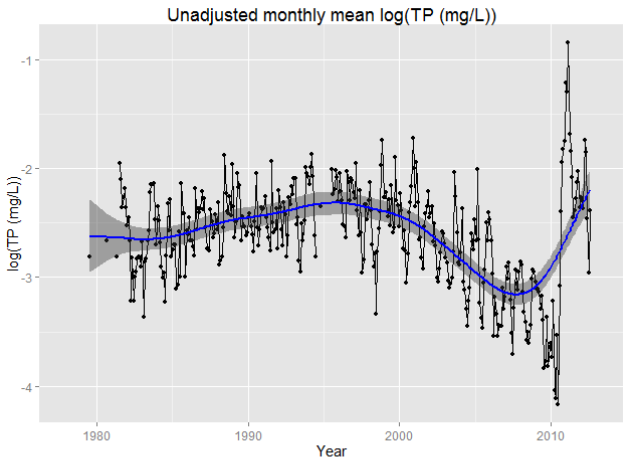


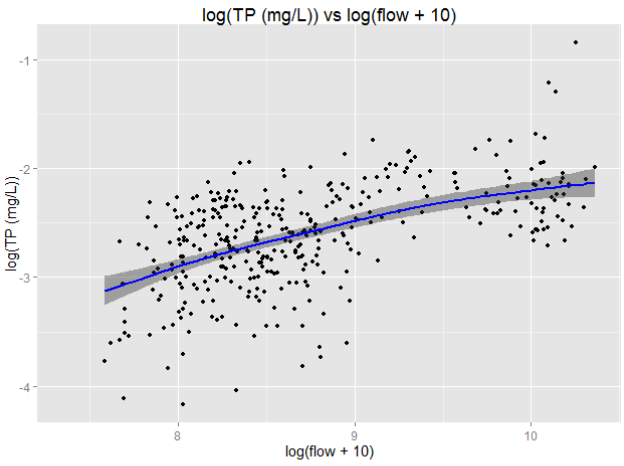


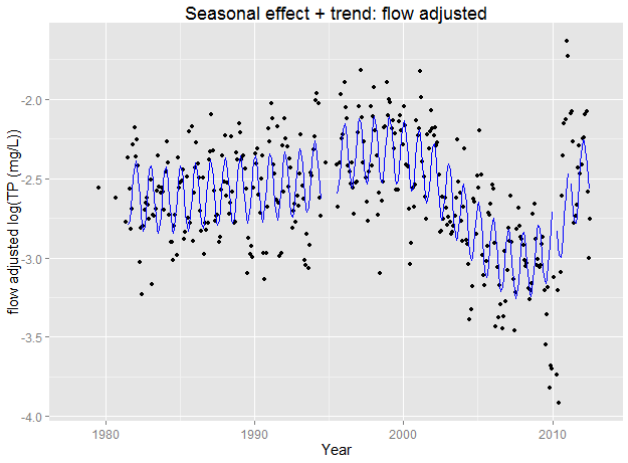


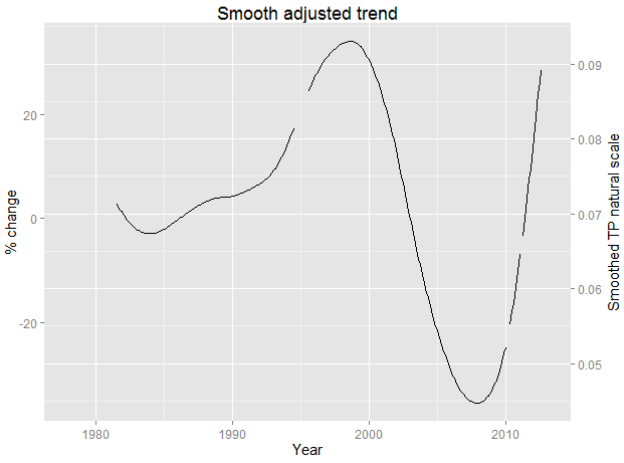


RIVER MURRAY - Swan Hill

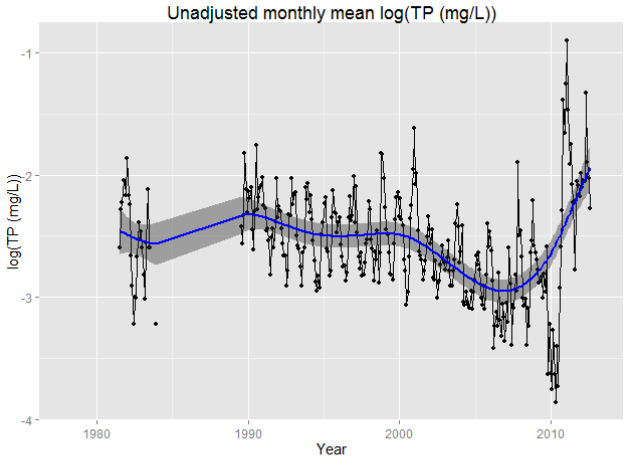


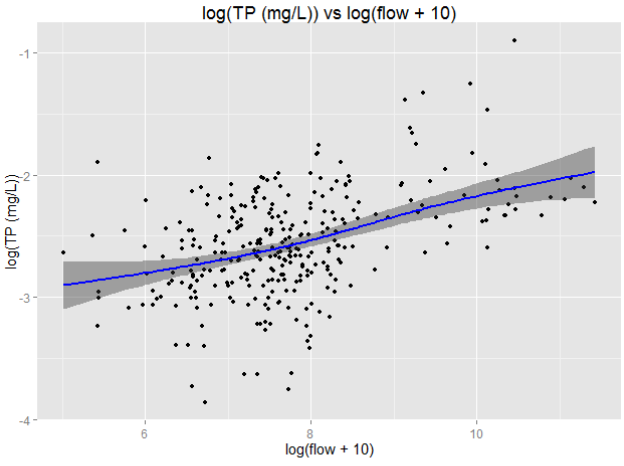


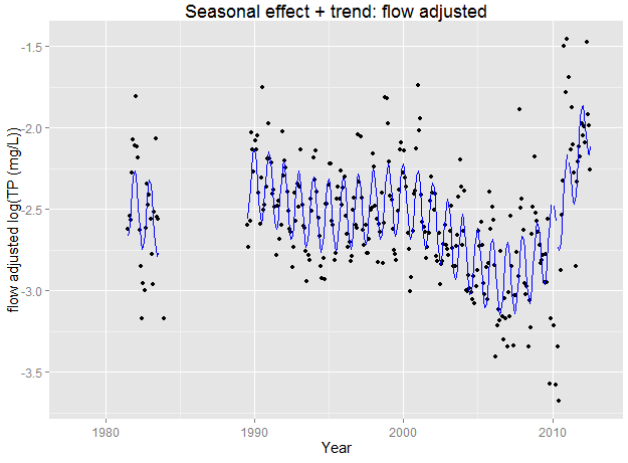


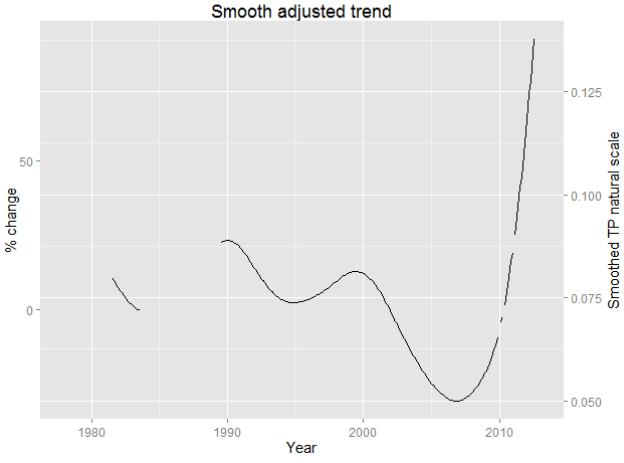


RIVER MURRAY - Kyalite

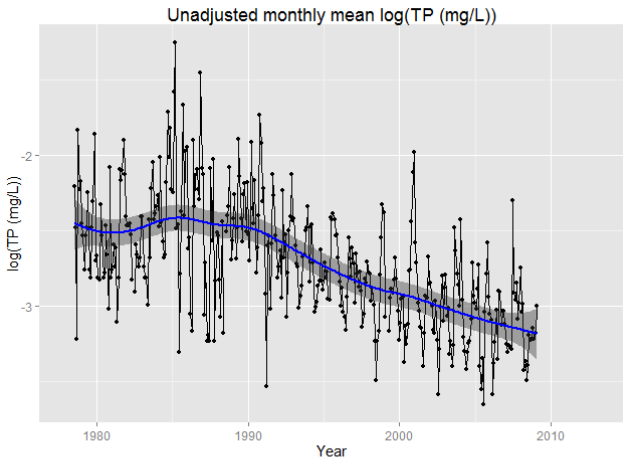


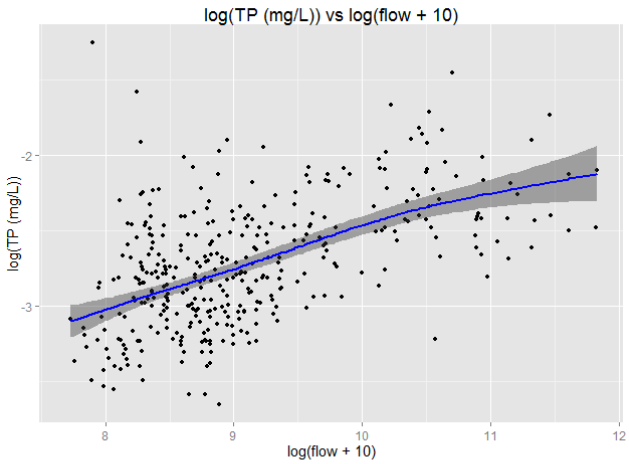


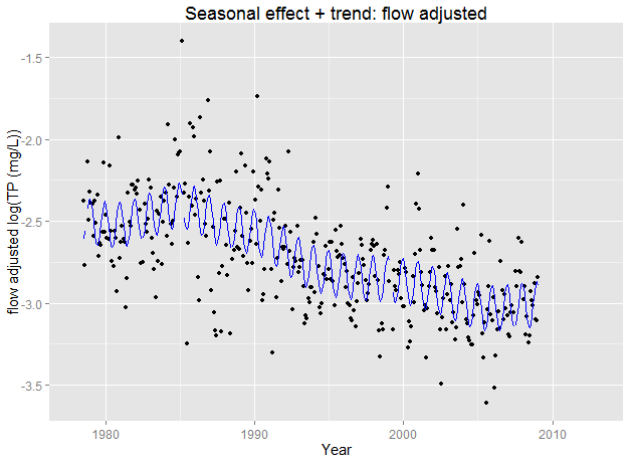


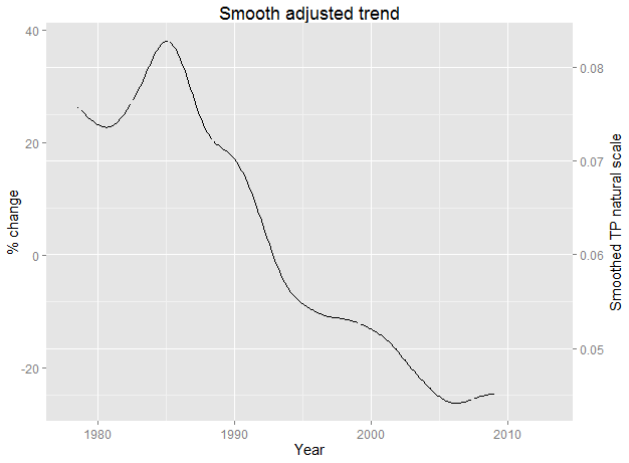


RIVER MURRAY - Euston Weir

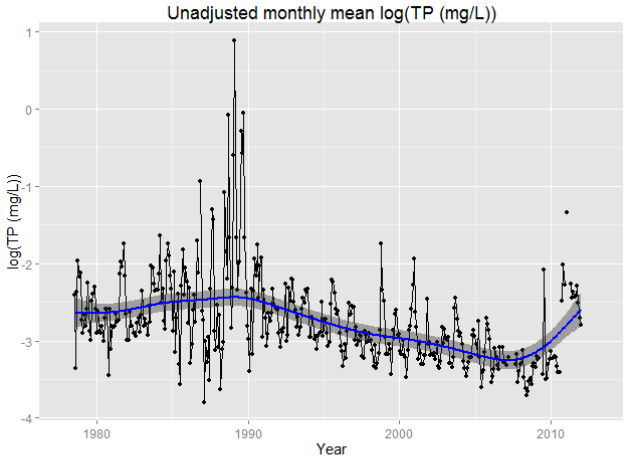


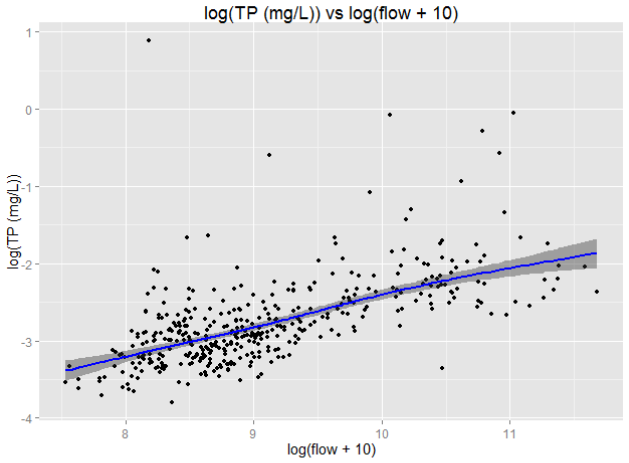


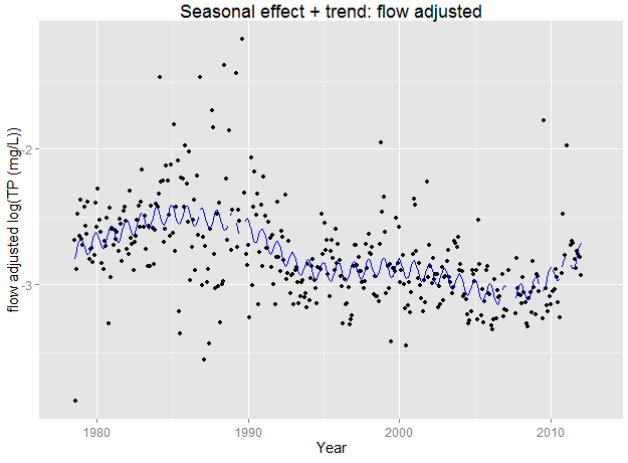


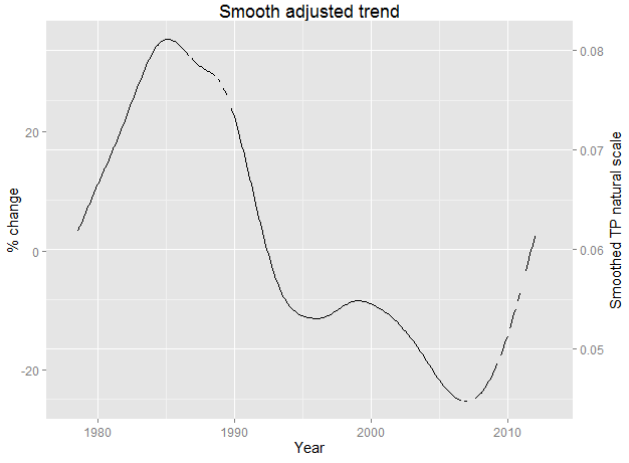


RIVER MURRAY - Merbein

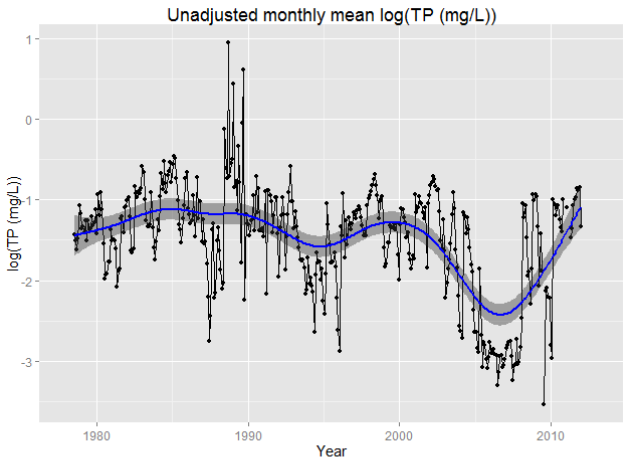


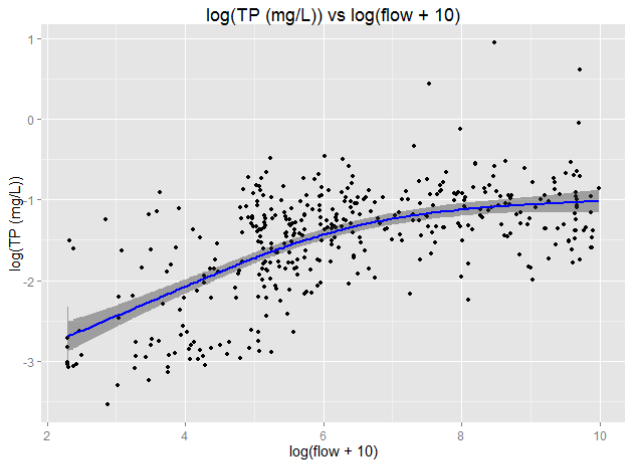


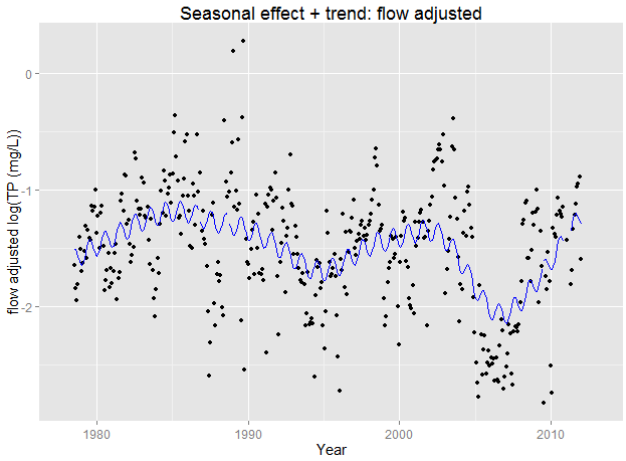


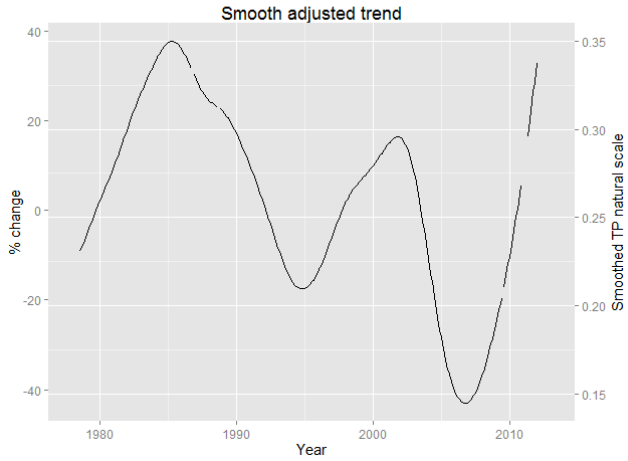


RIVER MURRAY - Burtundy

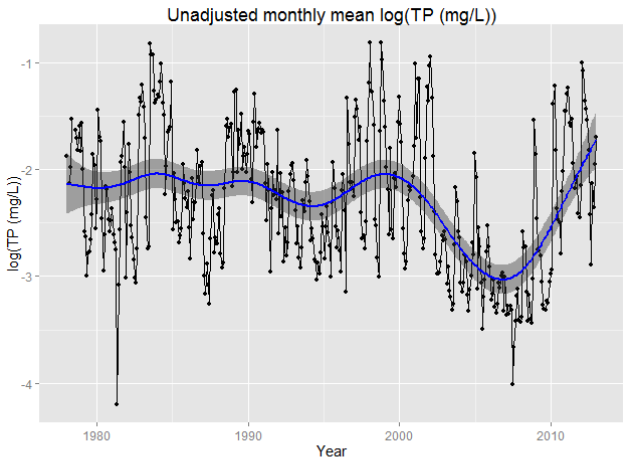


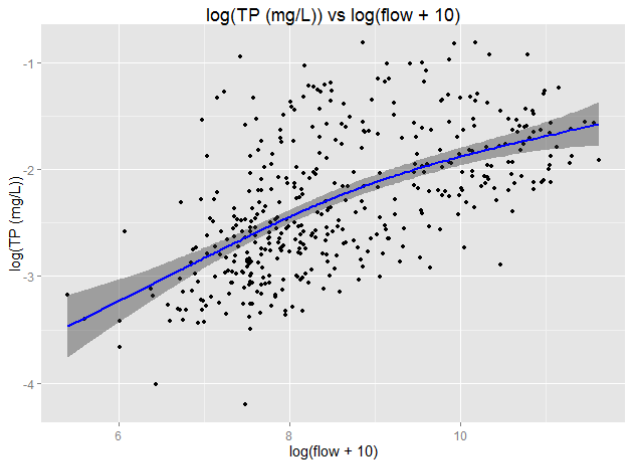


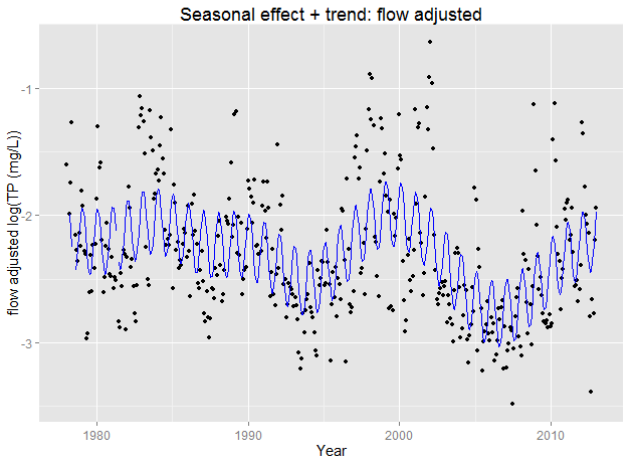


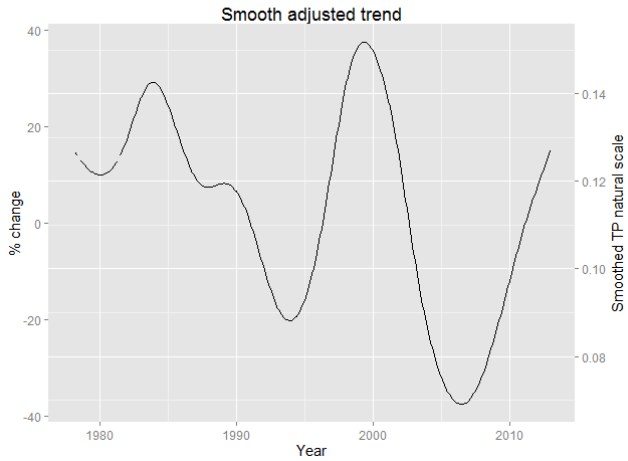


RIVER MURRAY - Lock 9

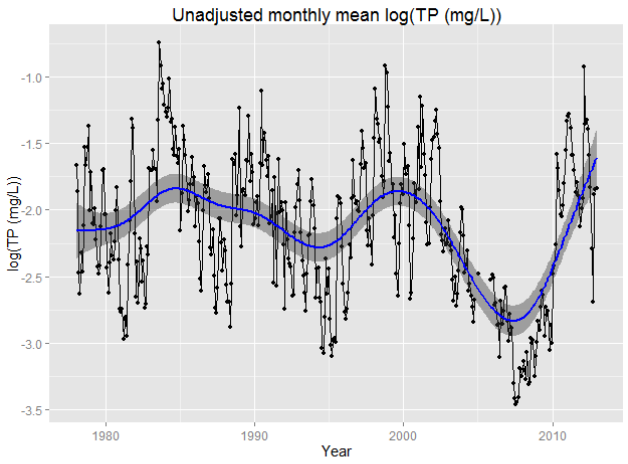


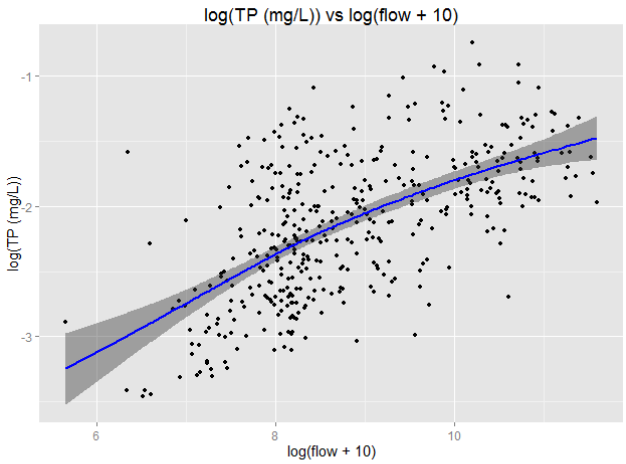


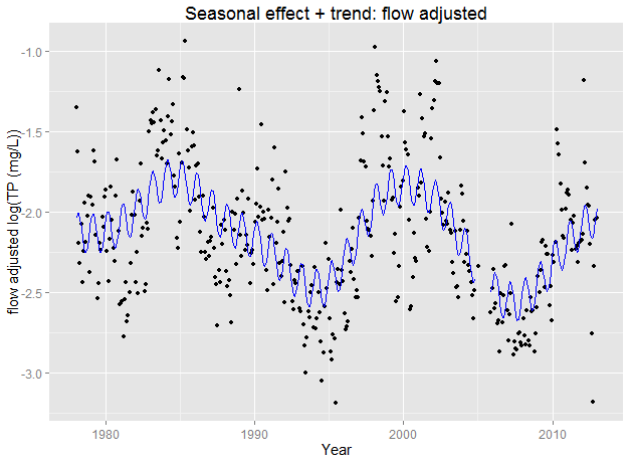


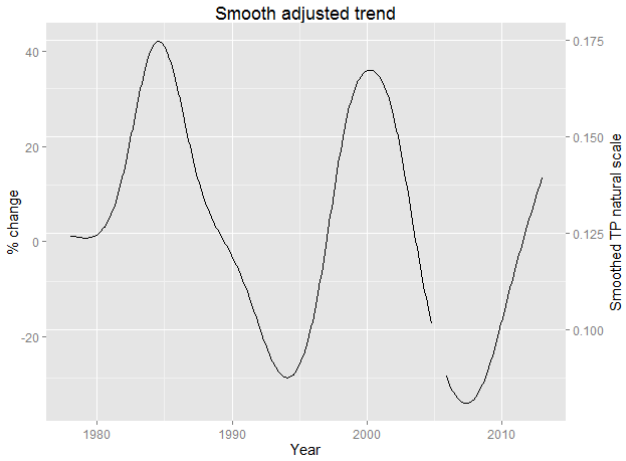


RIVER MURRAY - Morgan







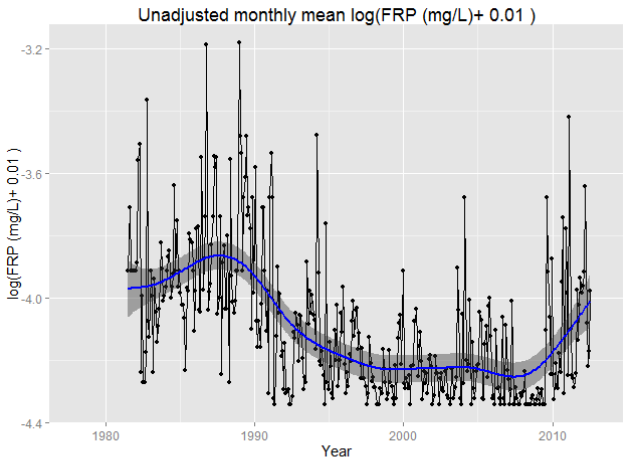


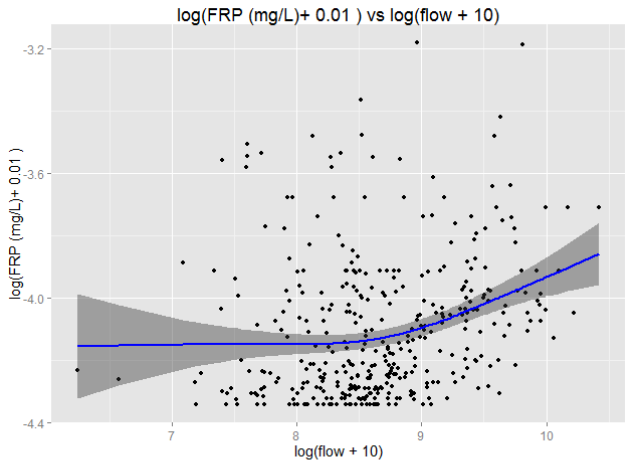
G: Filtered Reactive Phosphorus

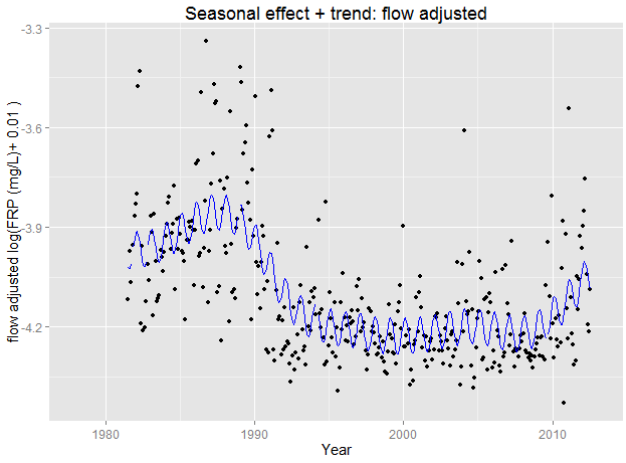
Monitoring Site	Geometric Mean	Linear Trend 1978-2012			Raw Trend 1978-2012			Linear Trend 2003-2012			Raw Trend 2003-2012		
Jingellic	0.0064	**-1.05**	**	NL	**-1.15**	**	NL	**1.28**	**	NL	**1.68**	**	NL
Tallandoon	0.0058	**-1.50**	**	NL	**-1.5**	**	NL	0.23			0.44		NL
Heywoods	0.0047	**-1.30**	**	NL	**-1.17**	**	NL	-0.26		NL	-0.33		NL
Bandiana	0.0053	-0.05		NL	-0.21		NL	**1.87**	**		**2.33**	**	NL
Peechelba	0.0078	**-2.00**	**	NL	**-1.98**	**	NL	0.77			1.37	*	NL
Yarrawonga	0.0102	**-0.56**	**	NL	**-0.63**	**	NL	**3.01**	**		**3.21**	**	NL
Torrumbarry	0.0074	**-1.13**	**	NL	**-1.28**	**	NL	-1.17			2.62	*	nl
Kerang	0.0072	0.32		NL	**-1.02**	**	NL	**2.29**	**		**3.95**	**	
Capels Flume	0.1825	**2.27**	**	NL	0.81		NL	**-32.25**	**	NL	**-29.46**	**	NL
Swan Hill	0.0086	**-0.85**	**	NL	**-1.14**	**	NL	**-3.38**	**		0.37		nl
Kyalite	0.0064	-0.32	*	NL	**-0.75**	**	NL	-0.21			2.82		
Euston Weir	0.0134	**-0.88**	**	NL	**-1.28**	**	NL	1.05		NL	-0.64		NL
Merbein	0.0113	**-0.90**	**	NL	**-1.15**	**	NL	**4.09**	**	NL	**4.44**	**	NL
Burtundy	0.0704	**-3.83**	**	NL	**-5.73**	**	NL	5.45		nl	**20.30**	**	NL
Lock 9	0.0202	-1.26	*	NL	-1.52	*	NL	**9.60**	**		**13.26**	**	
Morgan	0.0180	-1.02		NL	-1.18		NL	**9.02**	**		**11.92**	**	NL

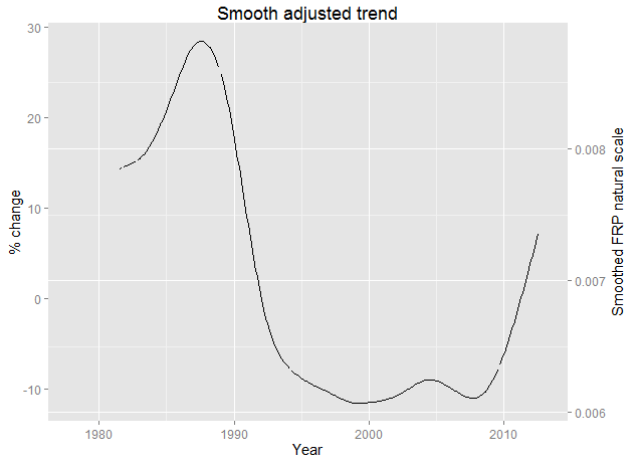
Monitoring Site	Geometric Mean	Relationship to Log flow	Significance	Amplitude(log scale)	Seasonal Peak	Autocorrelation
Jingellic	0.0064	+	**	0.0604	1.4528	0.1577
Tallandoon	0.0058	+		0.0048	4.4845	0.1820
Heywoods	0.0047	-	**	0.0856	11.6143	0.3541
Bandiana	0.0053	+	**	0.0460	1.3751	0.0609
Peechelba	0.0078	+	**	0.0151	3.0771	0.1033
Yarrawonga	0.0102	+	**	0.0163	9.7180	0.2516
Torrumbarry	0.0074	+	**	0.0817	2.0714	0.2222
Kerang	0.0072	+	**	0.1759	0.4669	0.1739
Capels Flume	0.1825	+	**	0.8766	0.3299	0.5602
Swan Hill	0.0086	+	**	0.1410	1.4032	0.2604
Kyalite	0.0064	+	**	0.0582	1.0643	0.2654
Euston Weir	0.0134	+	**	0.1165	0.6484	0.2654
Merbein	0.0113	+	**	0.0263	11.8577	0.2369
Burtundy	0.0704	+	**	0.1805	5.0355	0.2369
Lock 9	0.0202	+	**	0.4151	1.1247	0.6500
Morgan	0.0180	+	**	0.2214	2.5791	0.7557

RIVER MURRAY - Jingellic

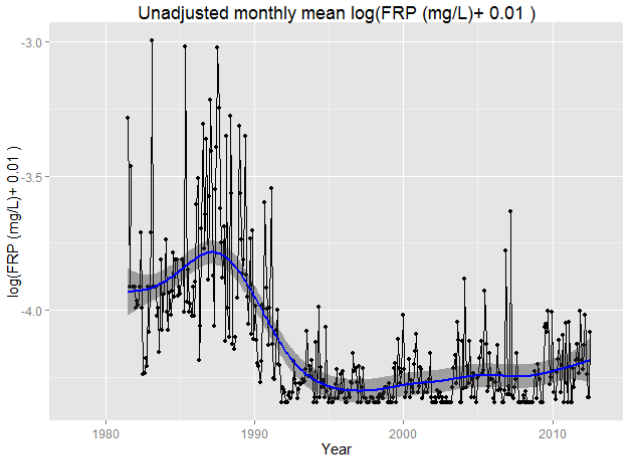


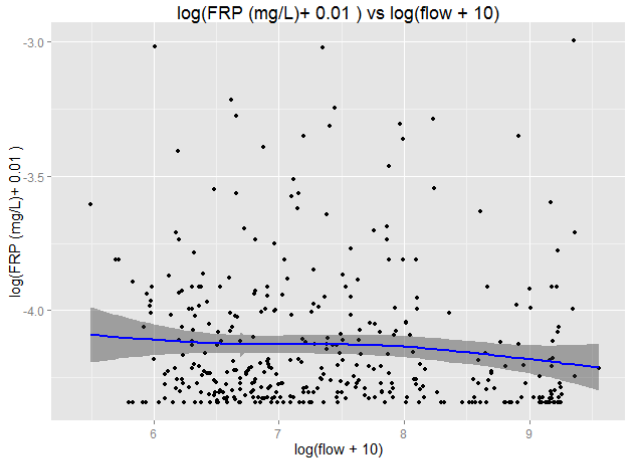


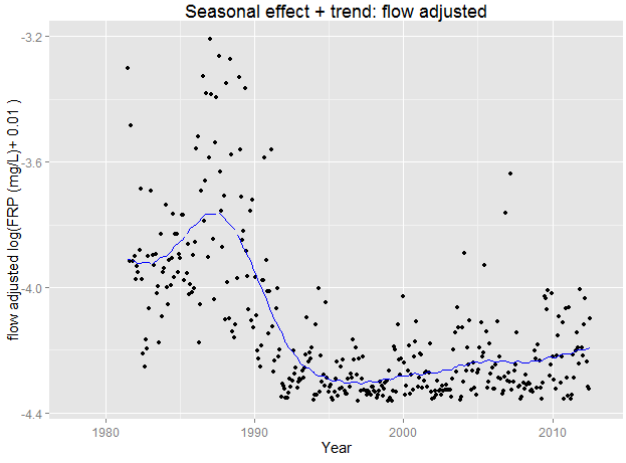


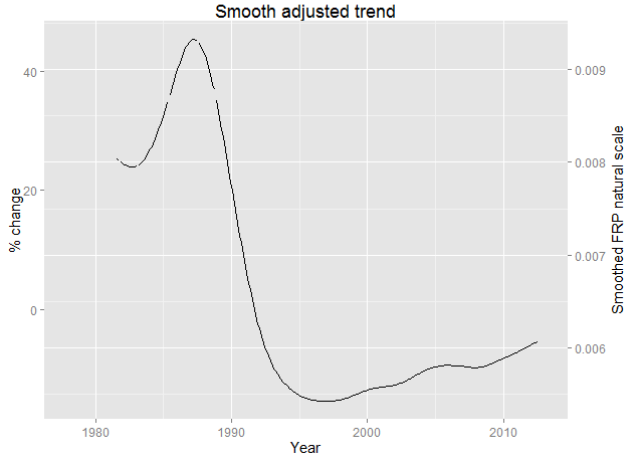


RIVER MURRAY - Tallandoon

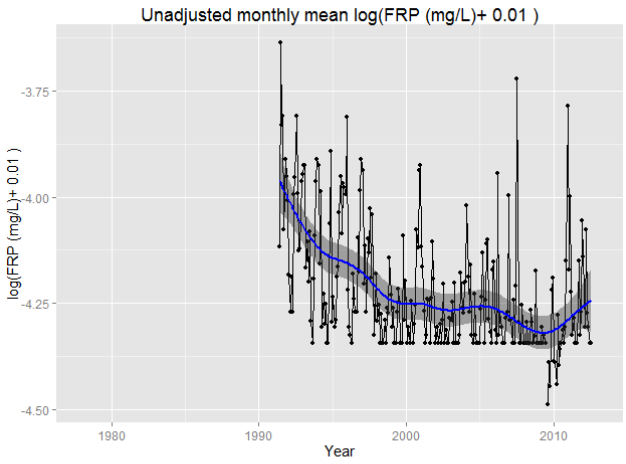


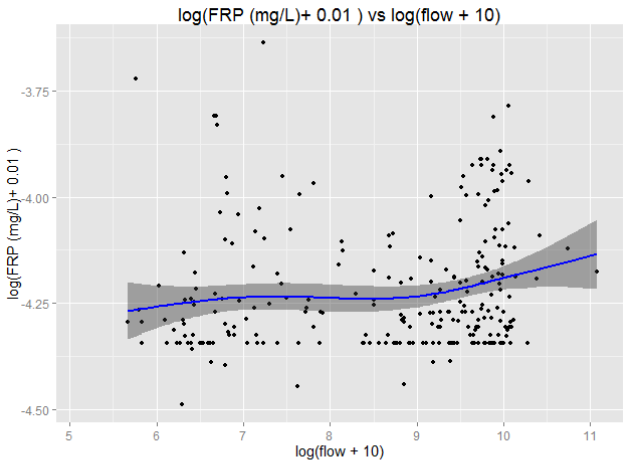


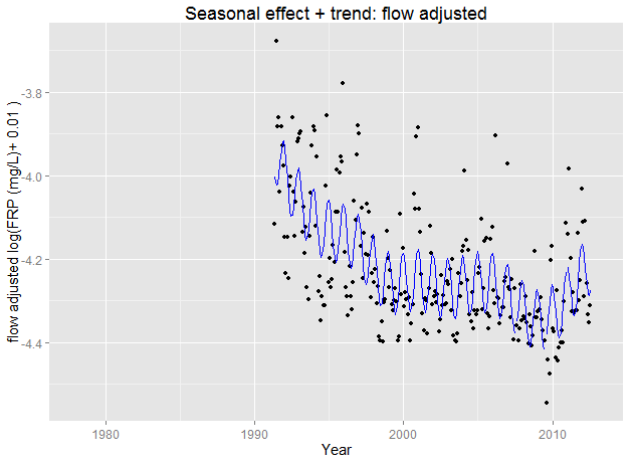


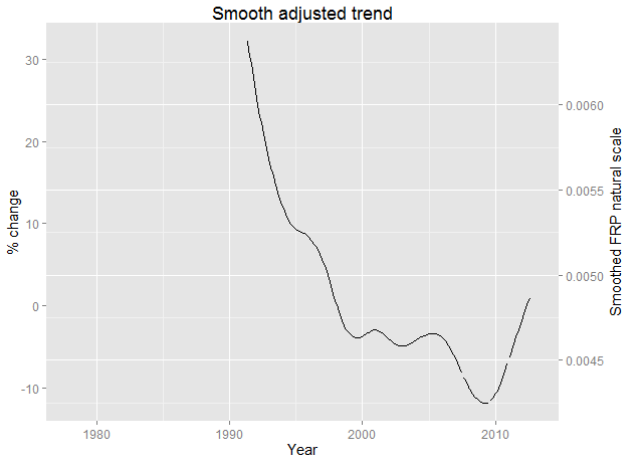


RIVER MURRAY - Heywoods

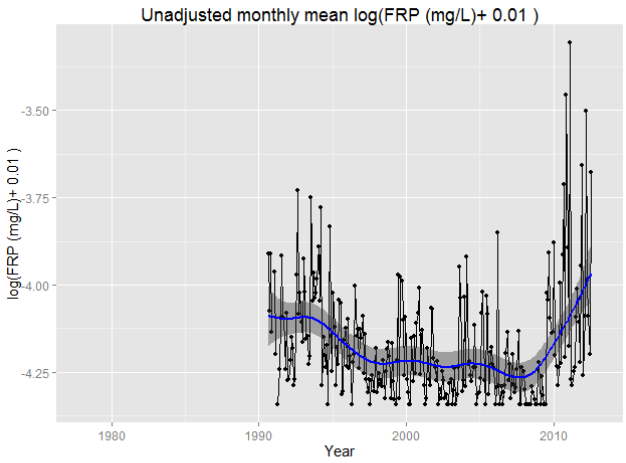


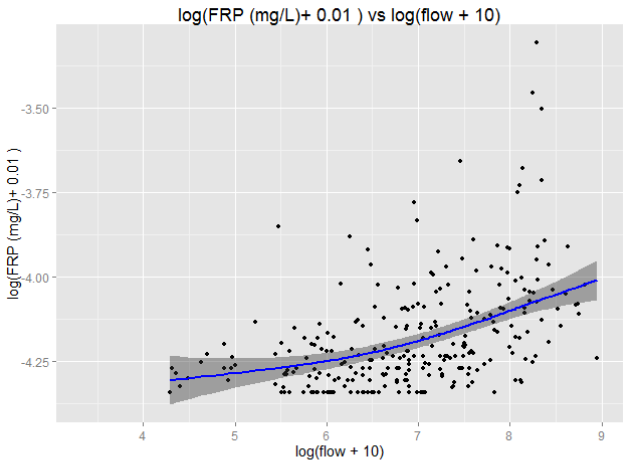


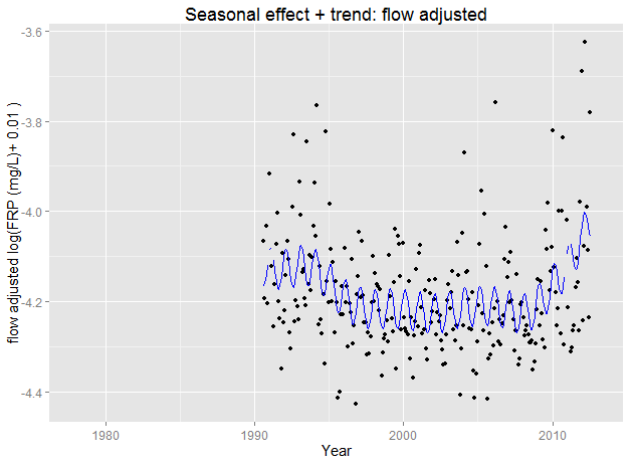


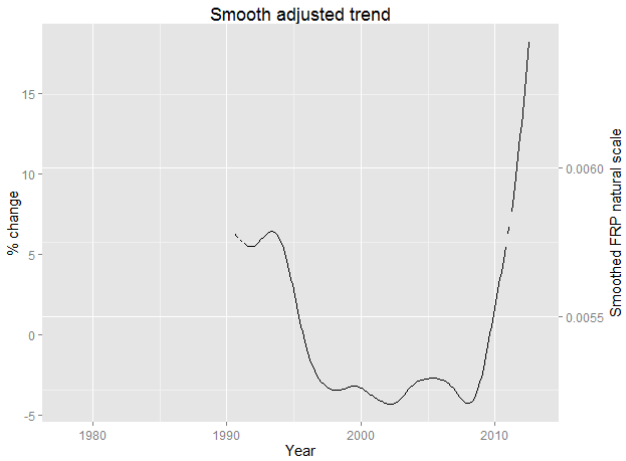


RIVER MURRAY - Bandiana

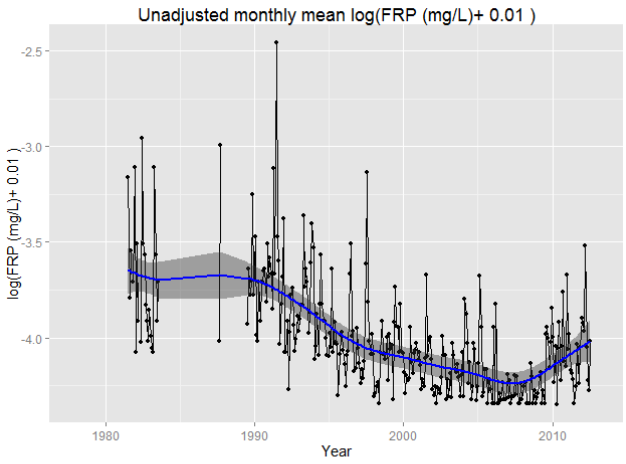


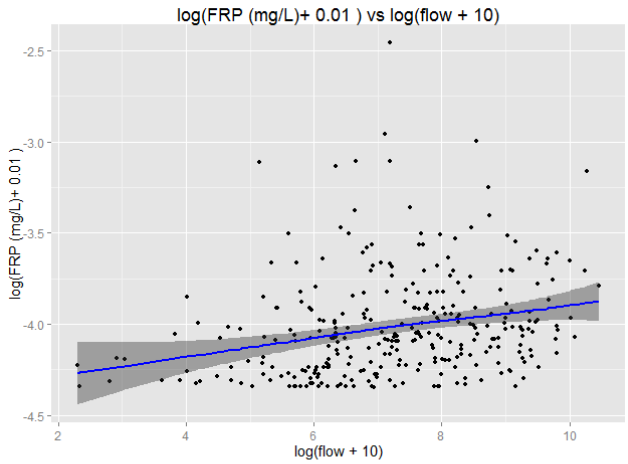


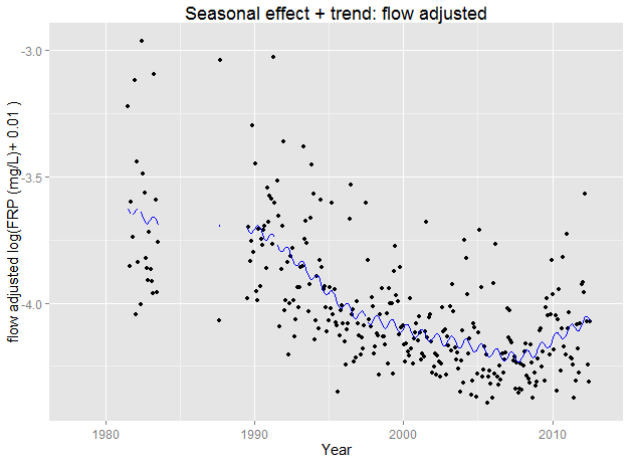


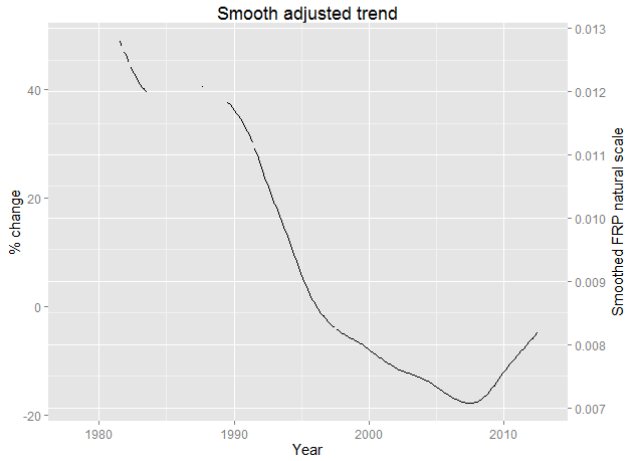


RIVER MURRAY - Peechelba

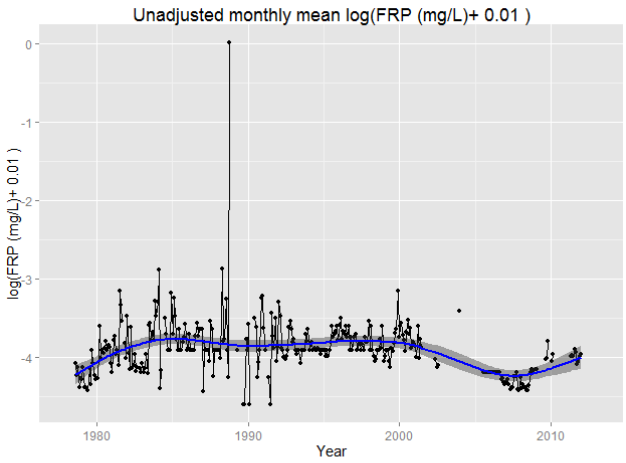


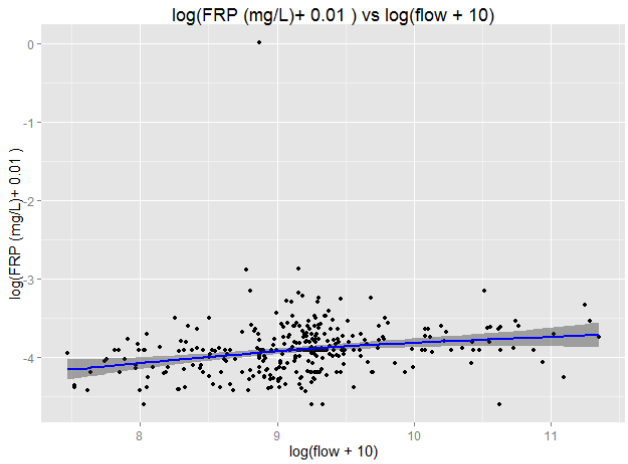


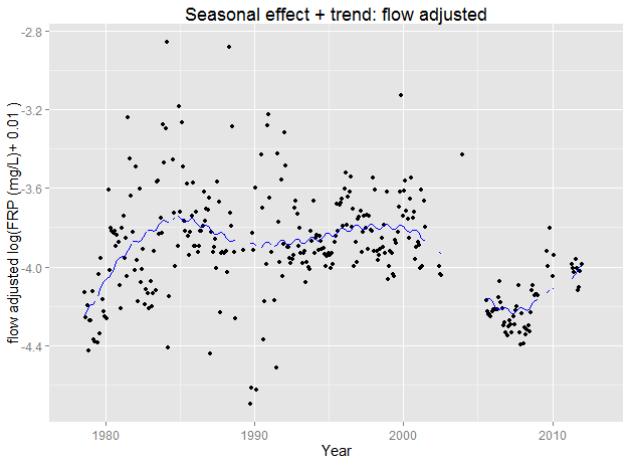


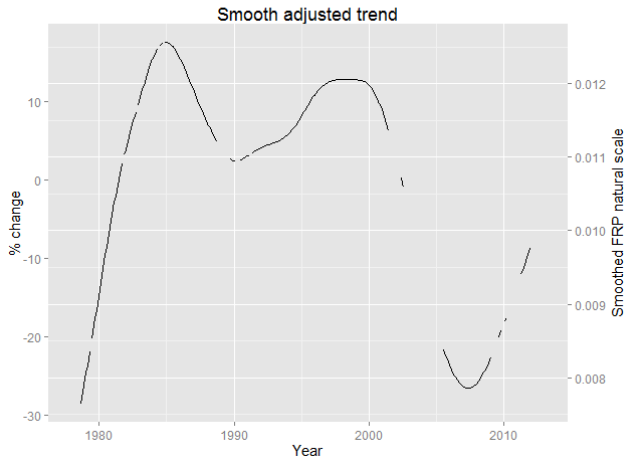


RIVER MURRAY - Yarrawonga

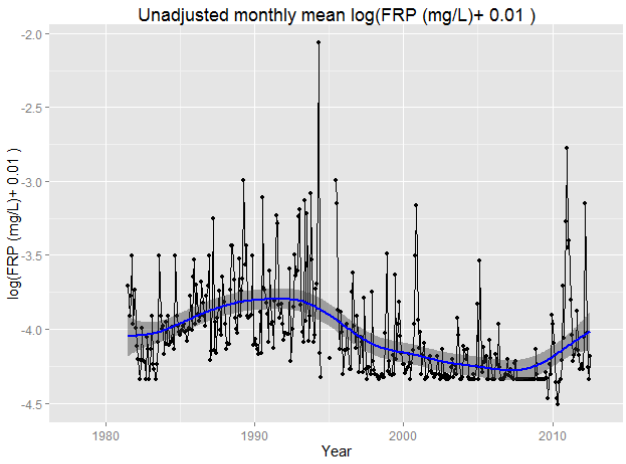


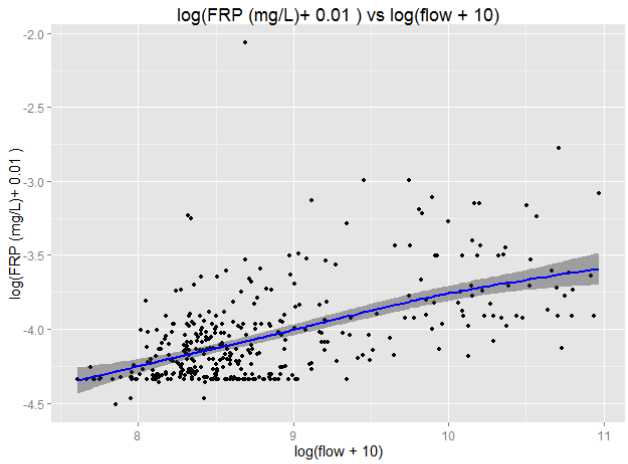


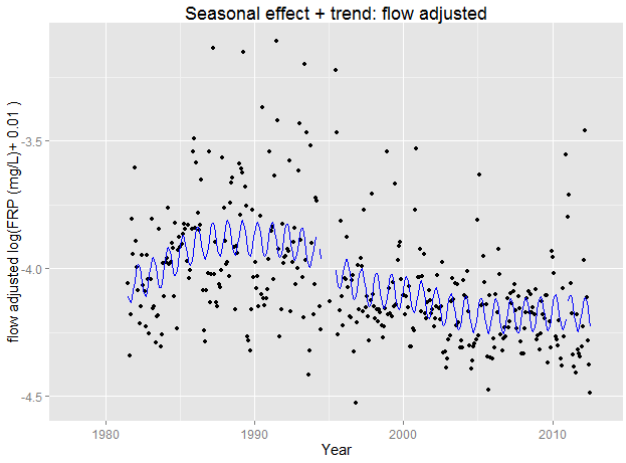


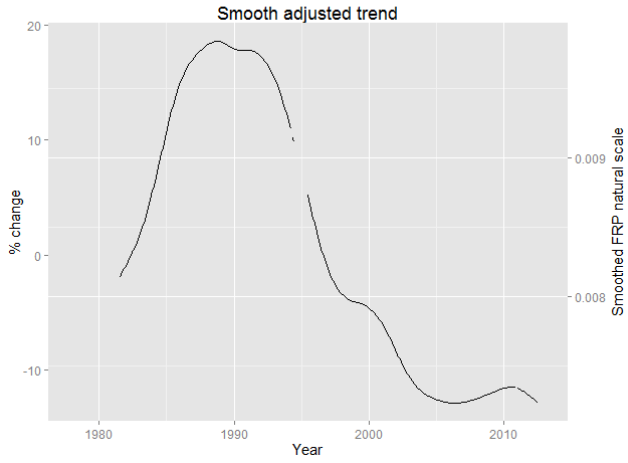


RIVER MURRAY - Torrumbarry

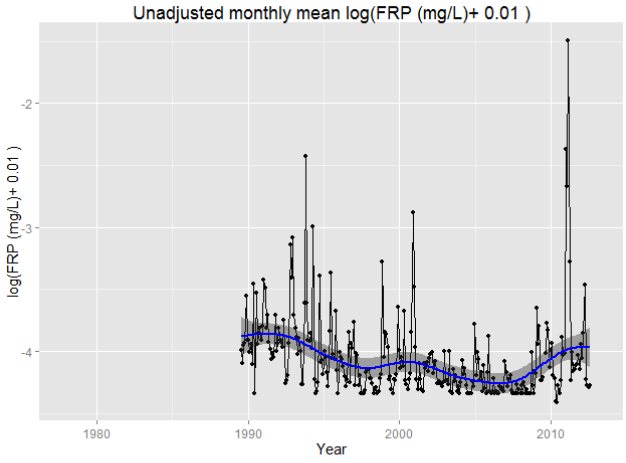


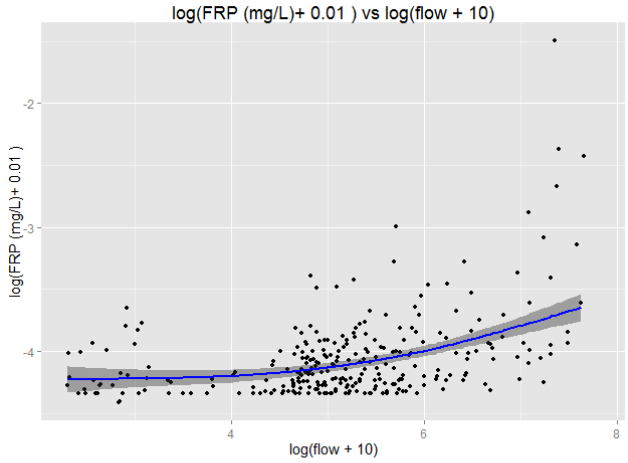


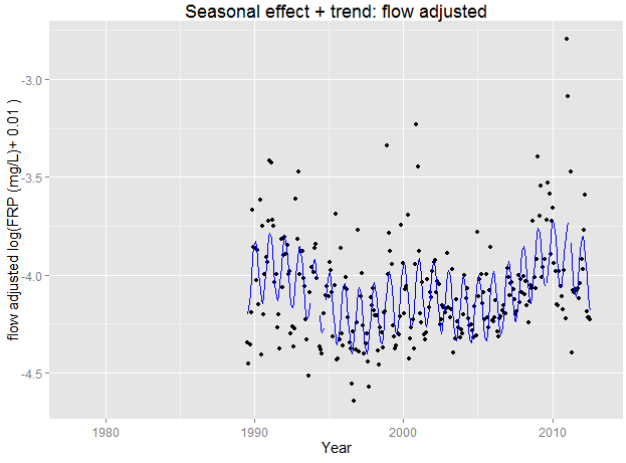


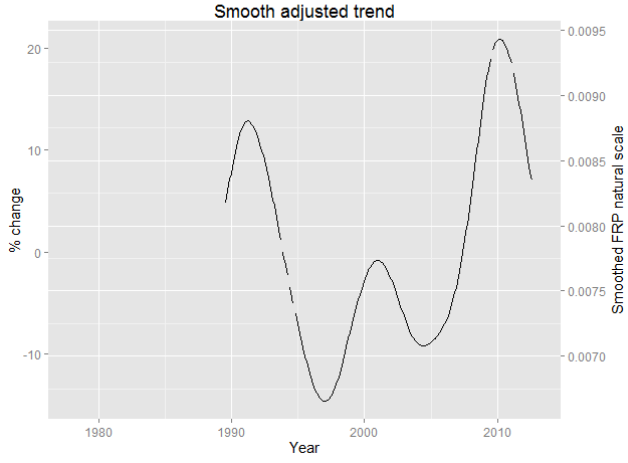


RIVER MURRAY - Kerang

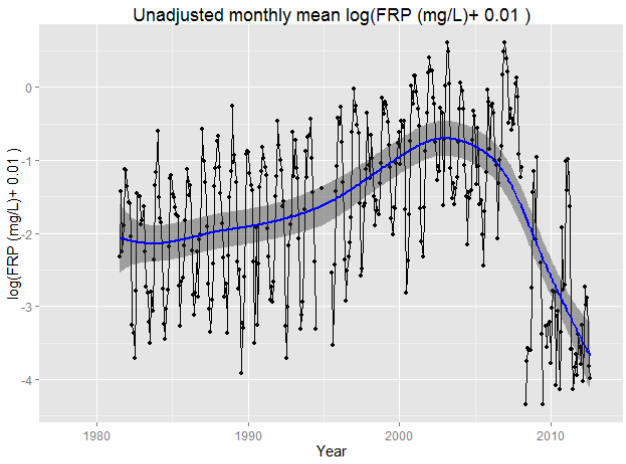


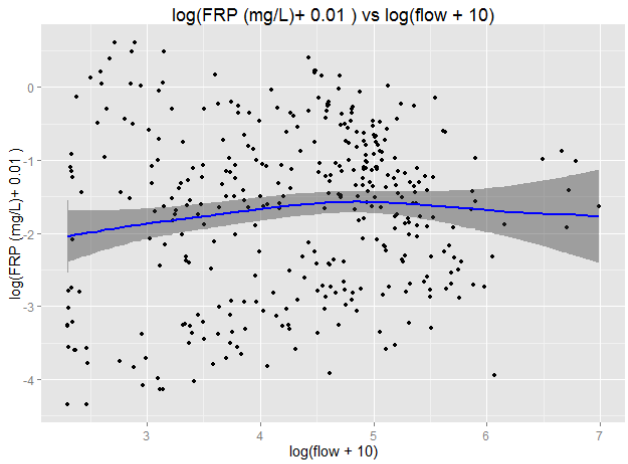


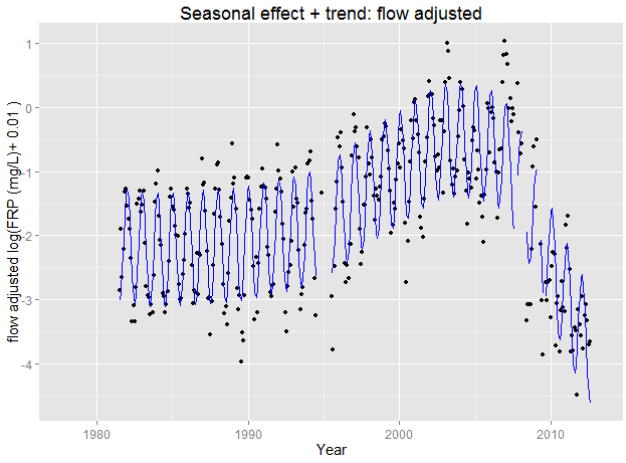


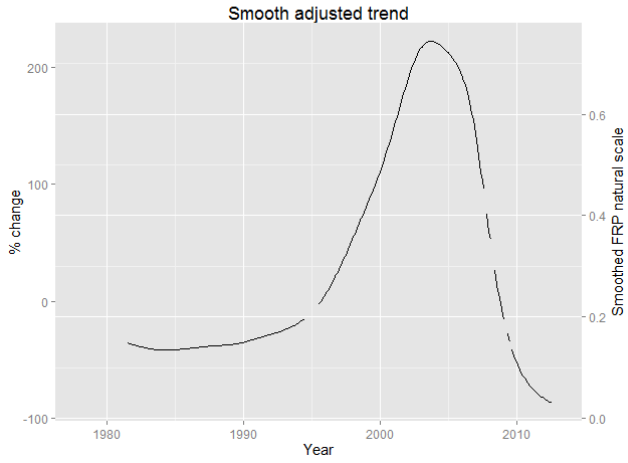


RIVER MURRAY - Capels Flume

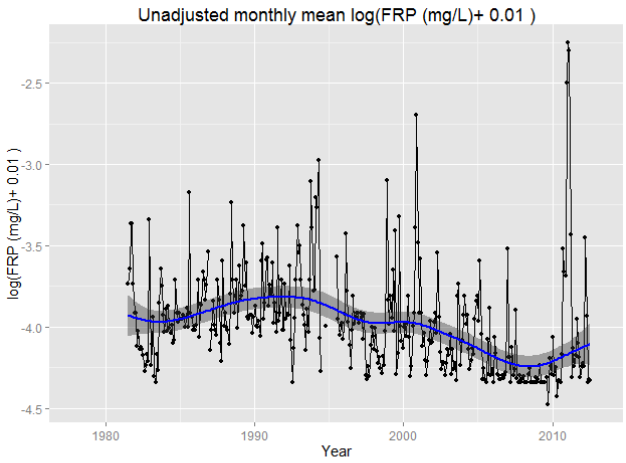


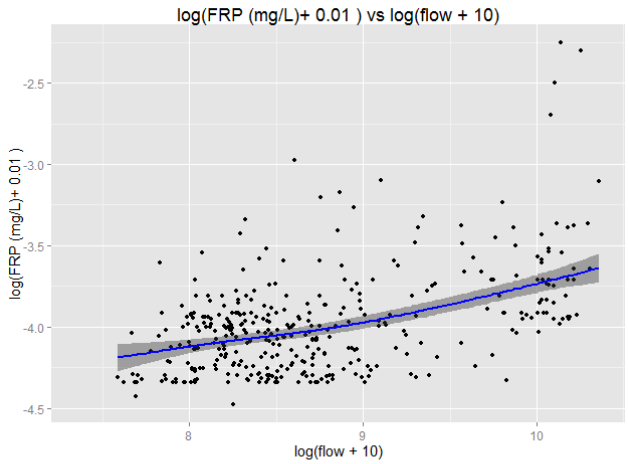


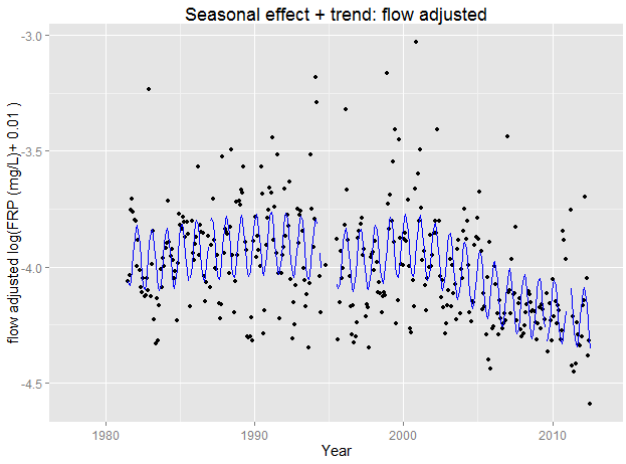


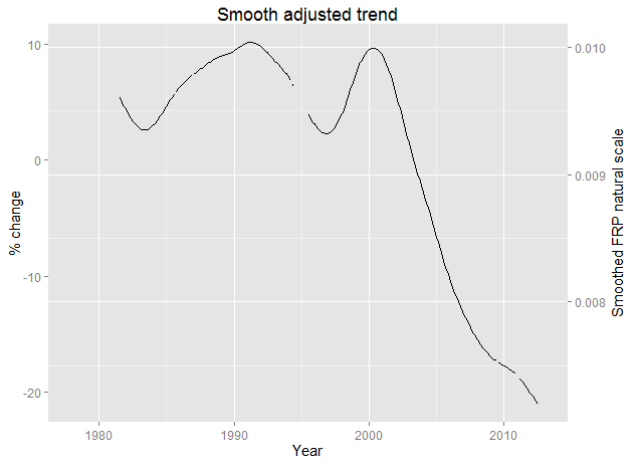


RIVER MURRAY - Swan Hill

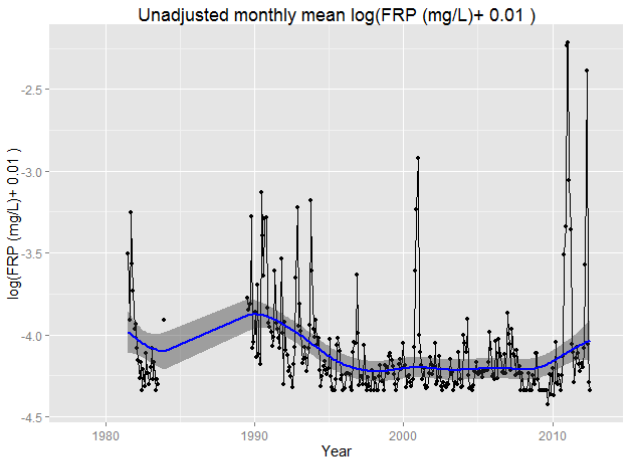


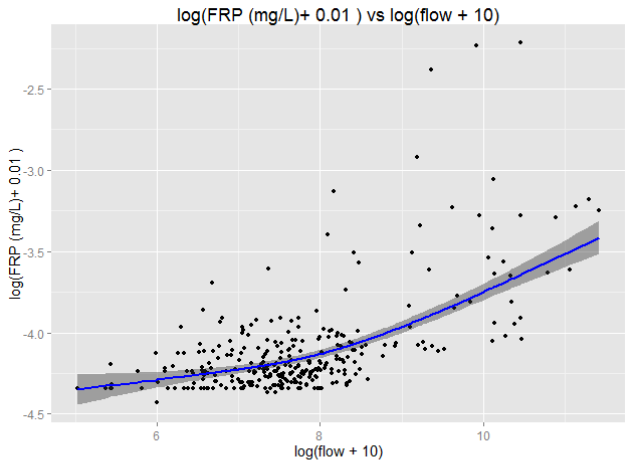


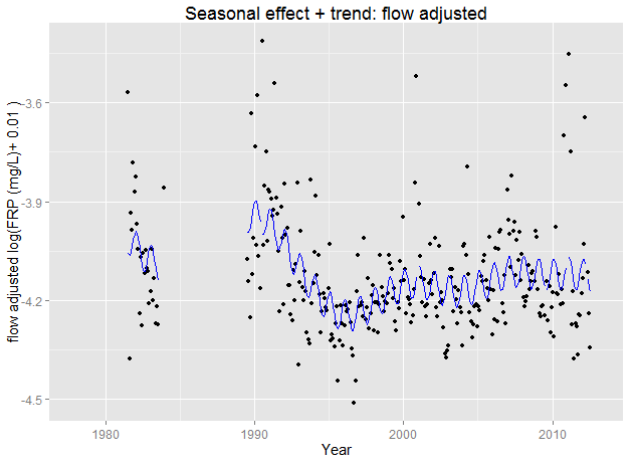


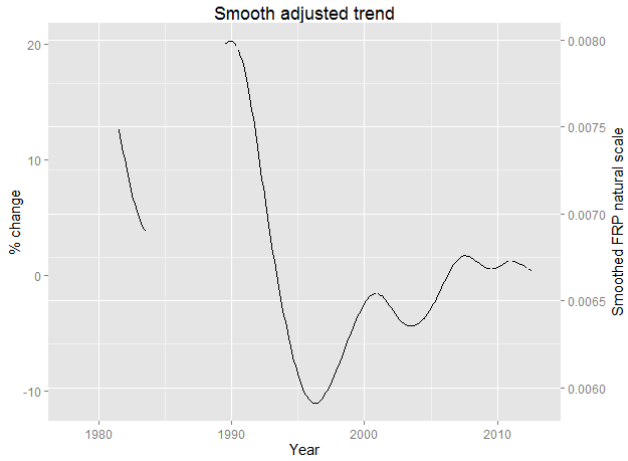


RIVER MURRAY - Kyalite

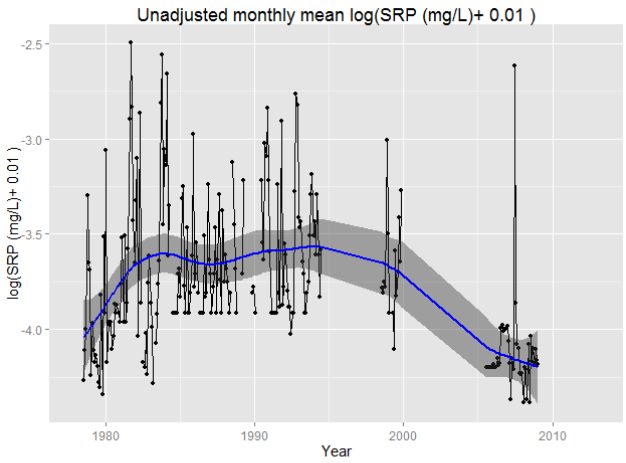


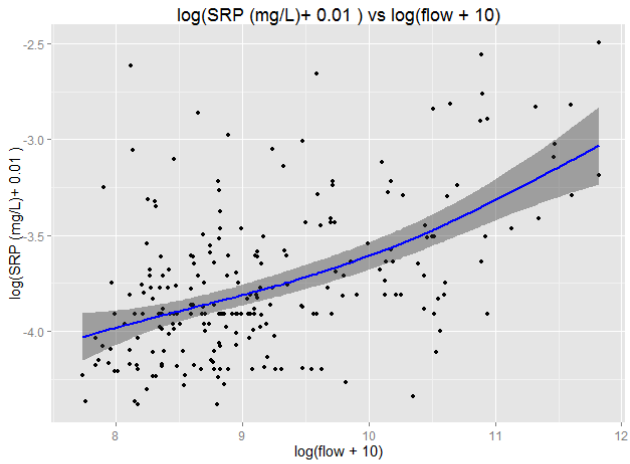


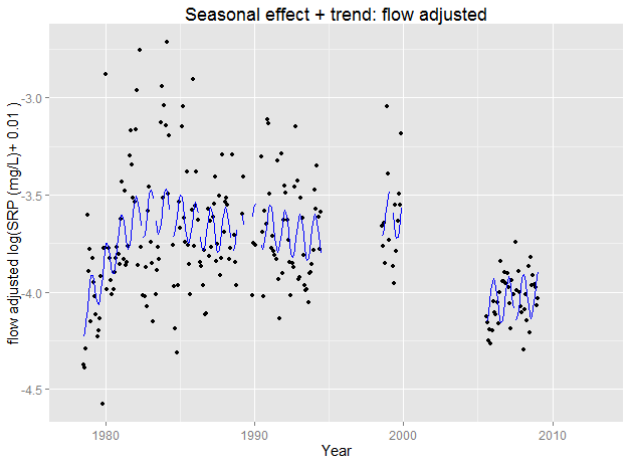


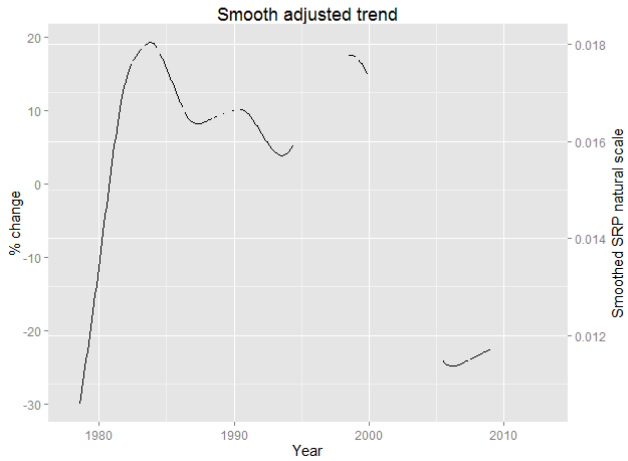


RIVER MURRAY - Euston Weir

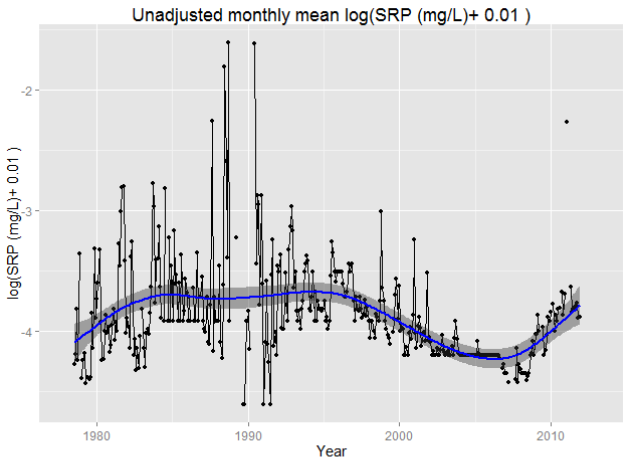


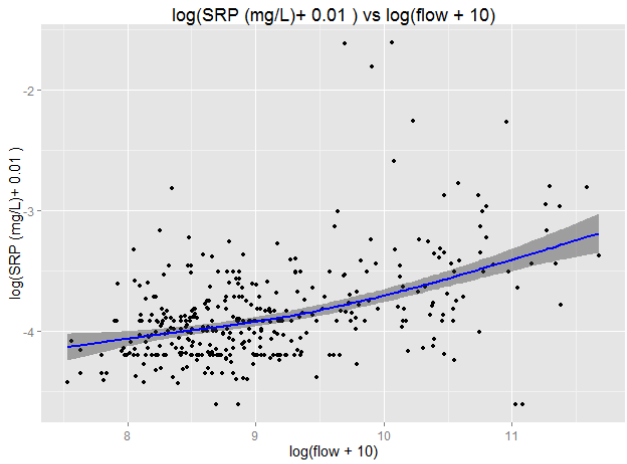


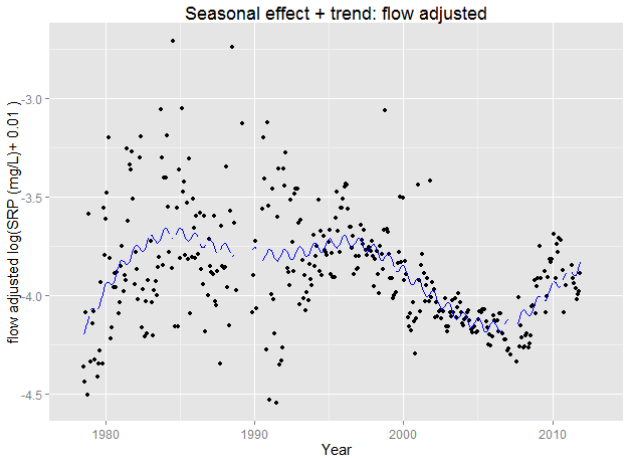


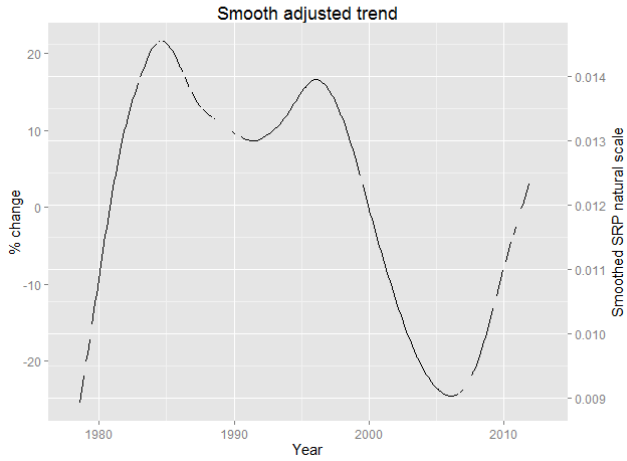


RIVER MURRAY - Merbein

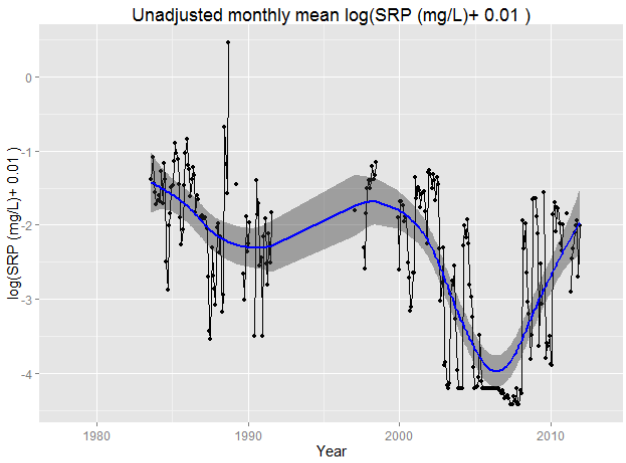


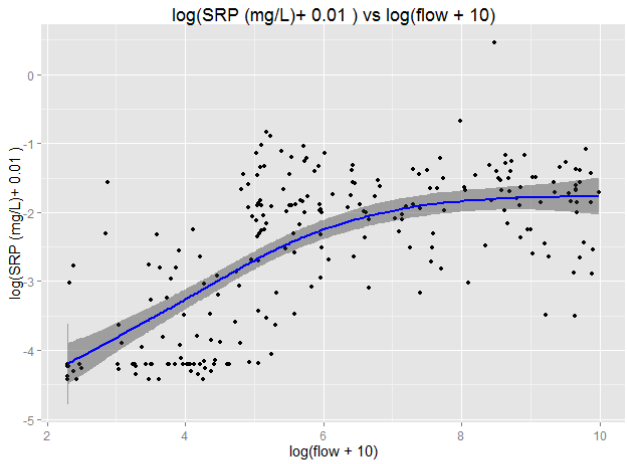


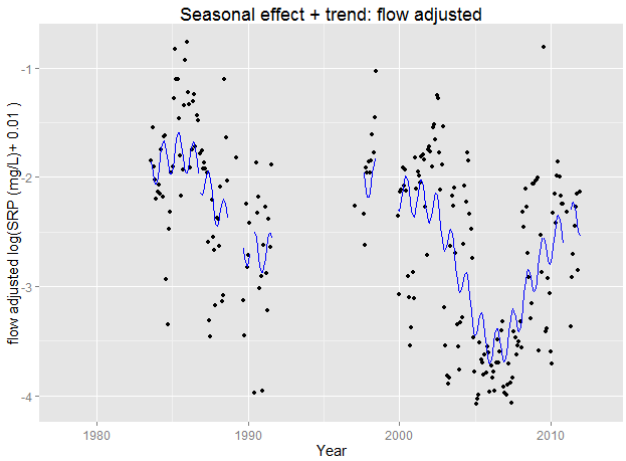


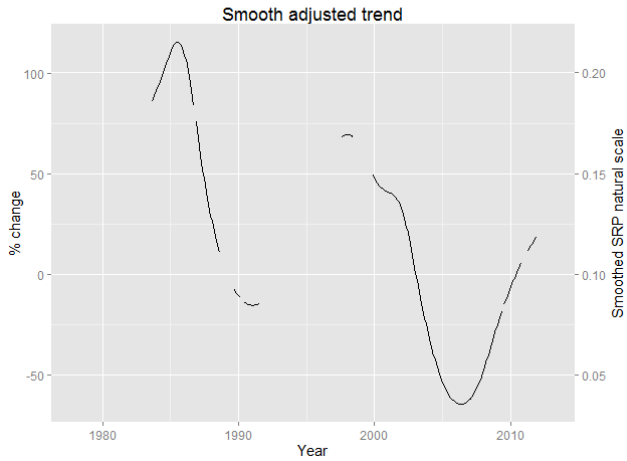


RIVER MURRAY - Burtundy

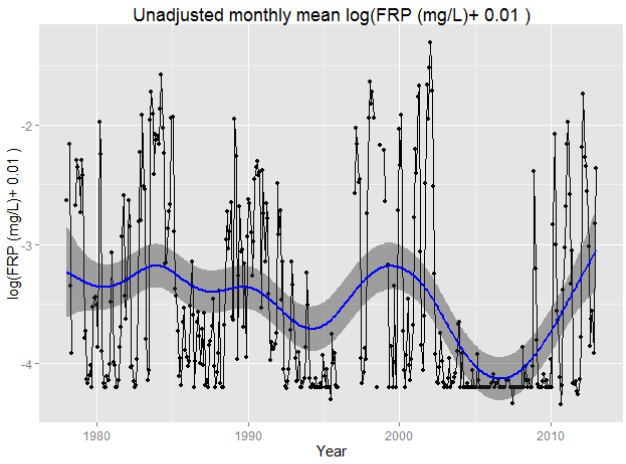


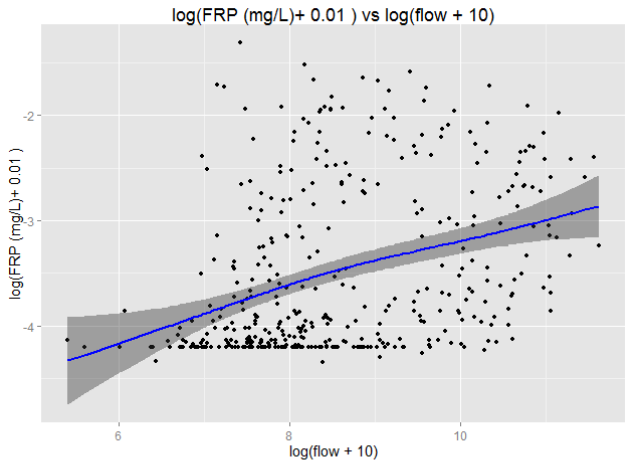


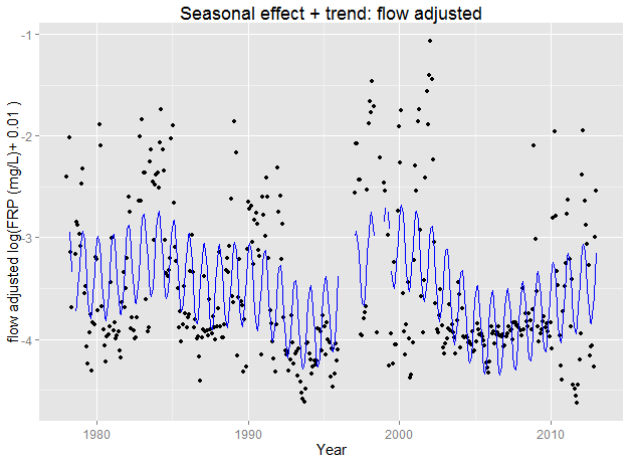


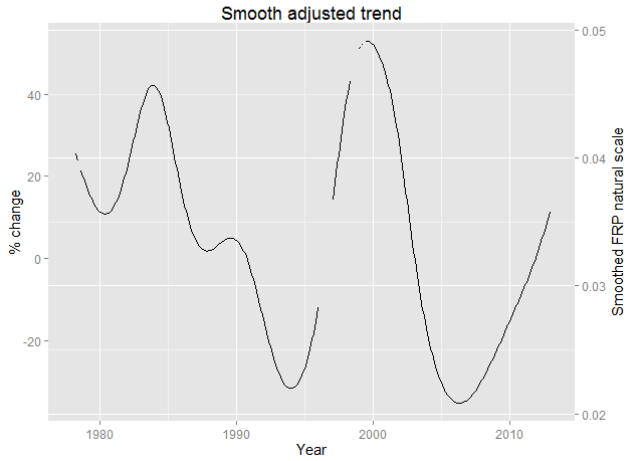


RIVER MURRAY - Lock 9

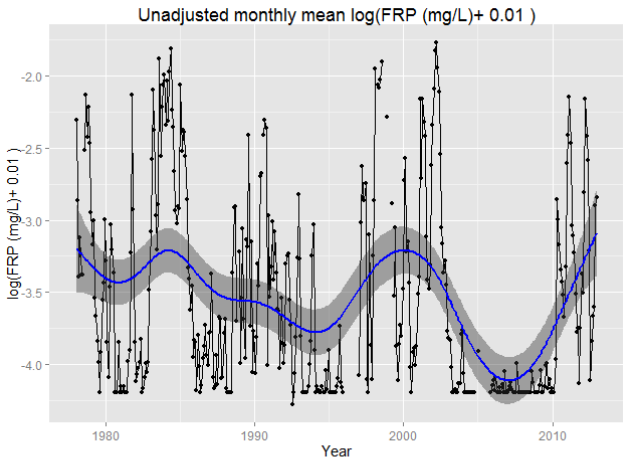


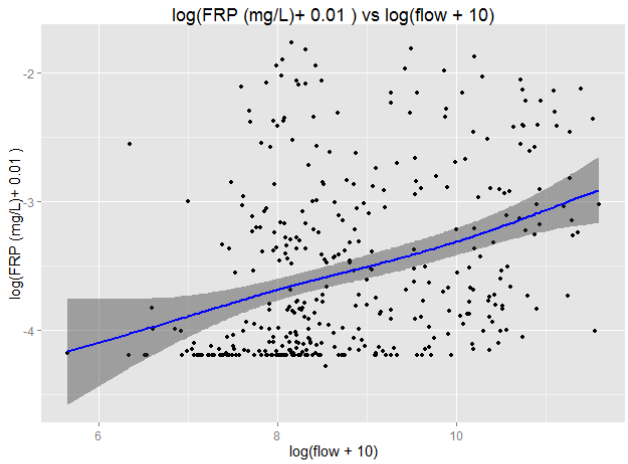


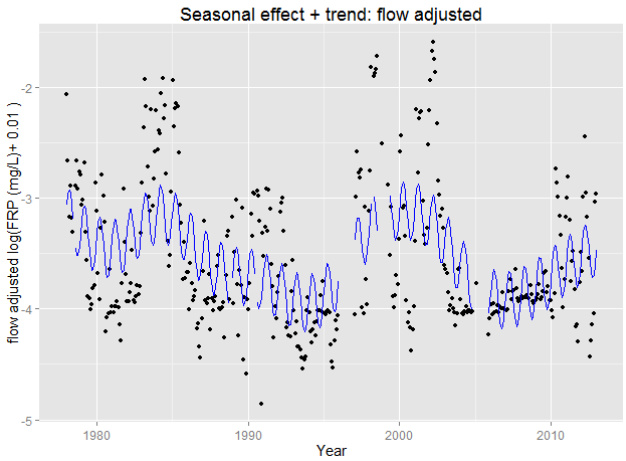


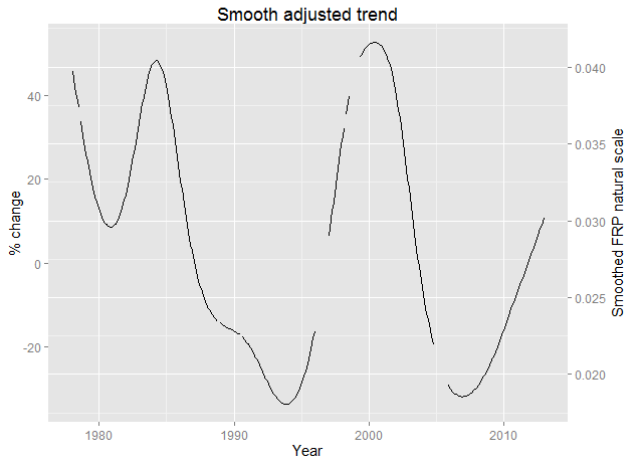


RIVER MURRAY - Morgan







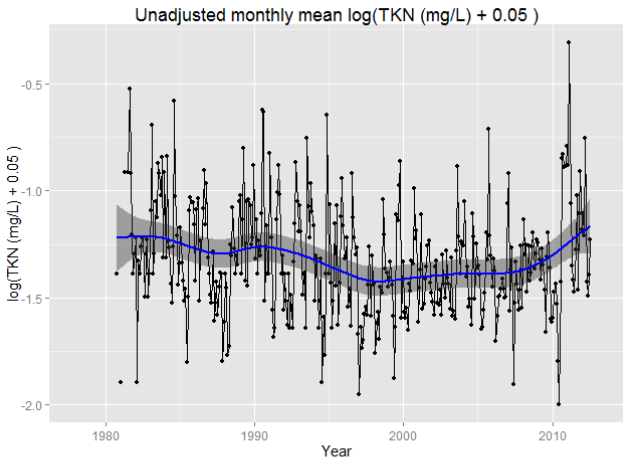


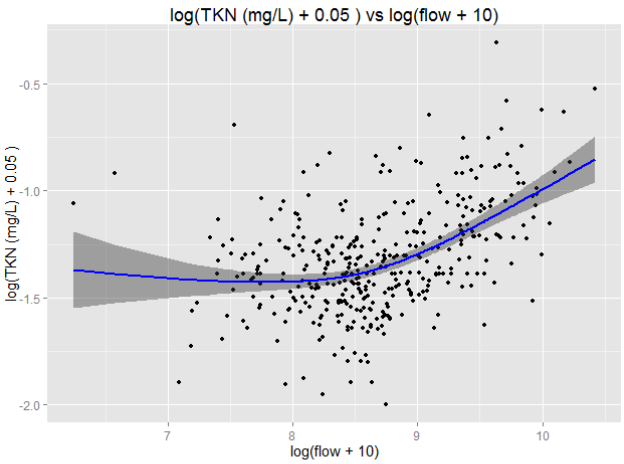
H: Total Kjeldahl Nitrogen (TKN)

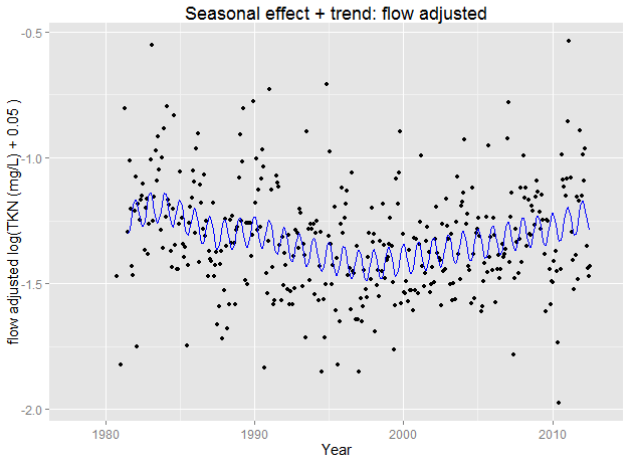
Monitoring Site	Geometric Mean	Linear Trend 1978-2012			Raw Trend 1978-2012			Linear Trend 2003-2012			Raw Trend 2003-2012		
Jingellic	0.2148	-0.16		NL	-0.33		NL	1.07			2.20	*	
Tallandoon	0.1983	**-0.84**	**	NL	**-0.78**	**	NL	**1.93**	**		**2.38**	**	nl
Heywoods	0.2811	**1.02**	**	NL	**1.01**	**	NL	2.12			2.15		
Bandiana	0.2131	0.27			-0.18		nl	-0.19			1.90		nl
Peechelba	0.2776	**-0.82**	**		**-0.99**	**		-1.30		nl	-1.04		nl
Yarrawonga	0.3810	**-1.46**	**	NL	**-1.50**	**	NL	-1.38		NL	-0.60		NL
Torrumbarry	0.4823	**-0.81**	**	NL	**-1.09**	**	NL	0.18		NL	**4.84**	**	NL
Kerang	0.7371	0.86	*	nl	-0.18		nl	**8.70**	**		8.78	*	
Capels Flume	1.7131	**2.17**	**	NL	**1.75**	**	NL	4.37		NL	**5.58**	**	nl
Swan Hill	0.5294	**-0.83**	**	NL	**-1.01**	**	NL	1.44		NL	**7.00**	**	NL
Kyalite	0.5657	**-0.87**	**	NL	**-1.06**	**	NL	**3.82**	**	NL	**6.75**	**	NL
Euston Weir	0.4639	-0.40		NL	-0.76	*	NL	**11.27**	**	NL	**9.90**	**	NL
Merbein	0.4612	**-1.11**	**	NL	**-1.40**	**	NL	-2.37		nl	2.32		NL
Burtundy	0.8833	0.29		NL	0.49		NL	-3.17		NL	-4.64	*	NL
Lock 9	0.6230	-0.35	*	NL	-0.59	*	NL	4.23	*	NL	**10.37**	**	NL
Morgan	0.7267	**-0.85**	**	NL	**-1.00**	**	NL	**3.50**	**	NL	**8.41**	**	NL

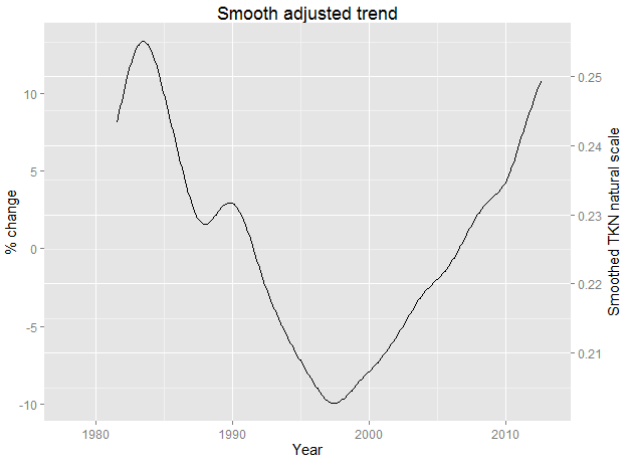
Monitoring Site	Geometric Mean	Relationship to Log flow	Significance	Amplitude(log scale)	Seasonal Peak	Autocorrelation
Jingellic	0.2148	+	**	0.0621	0.4425	0.2309
Tallandoon	0.1983	-	**	0.0455	9.6088	0.2026
Heywoods	0.2811	-		0.0278	3.8238	0.5455
Bandiana	0.2131	+	**	0.0945	1.4899	0.1741
Peechelba	0.2776	+	**	0.1274	1.6682	0.3566
Yarrawonga	0.3810	+	**	0.0754	11.2951	0.4755
Torrumbarry	0.4823	+	**	0.0530	0.2523	0.4179
Kerang	0.7371	+	**	0.2172	11.0204	0.6858
Capels Flume	1.7131	+	**	0.3085	11.9165	0.4391
Swan Hill	0.5294	+	**	0.0950	11.4914	0.3650
Kyalite	0.5657	+	**	0.1499	11.7509	0.5358
Euston Weir	0.4639	+	**	0.0985	11.0555	0.4126
Merbein	0.4612	+	**	0.1291	0.4679	0.2929
Burtundy	0.8833	-		0.0714	1.0053	0.6042
Lock 9	0.6230	+	**	0.1682	0.2797	0.3519
Morgan	0.7267	+	**	0.1448	0.8986	0.3579

RIVER MURRAY - Jingellic

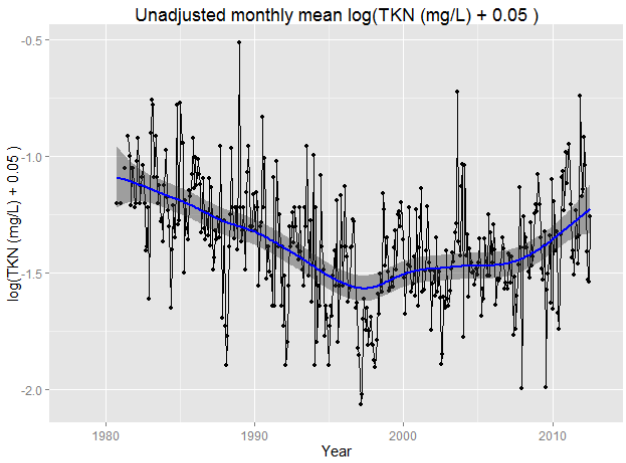


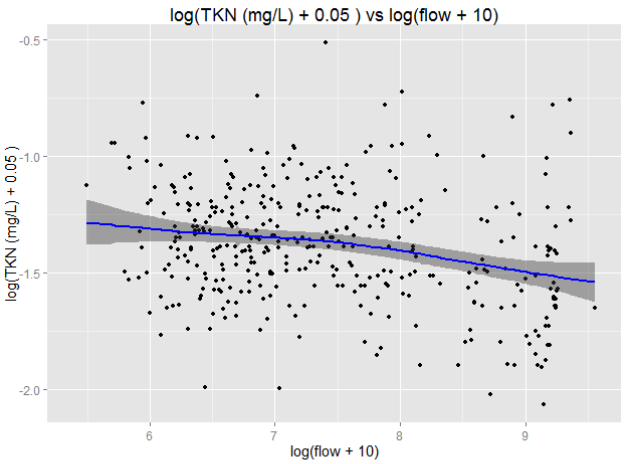


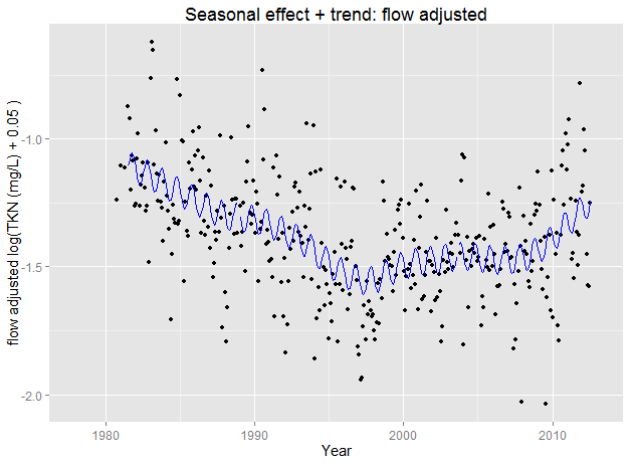


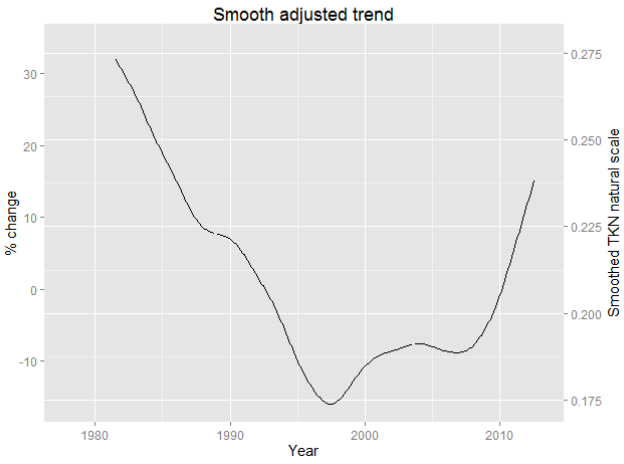


RIVER MURRAY - Tallandoon

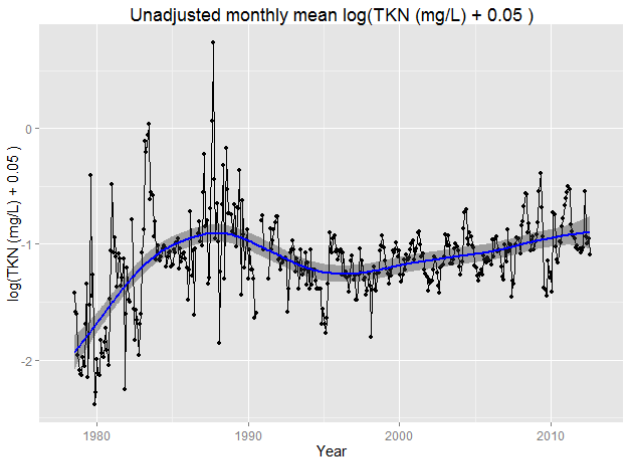


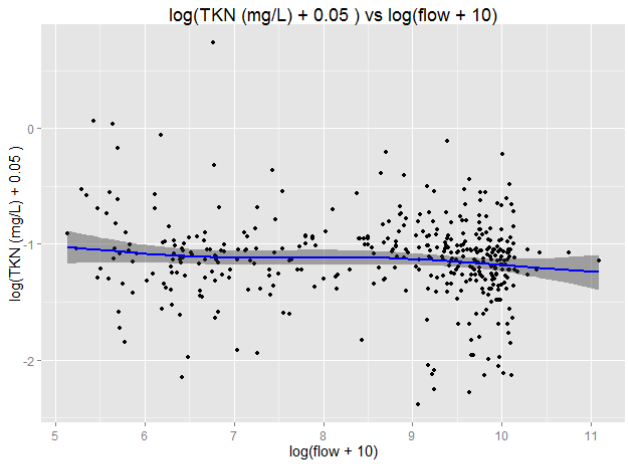


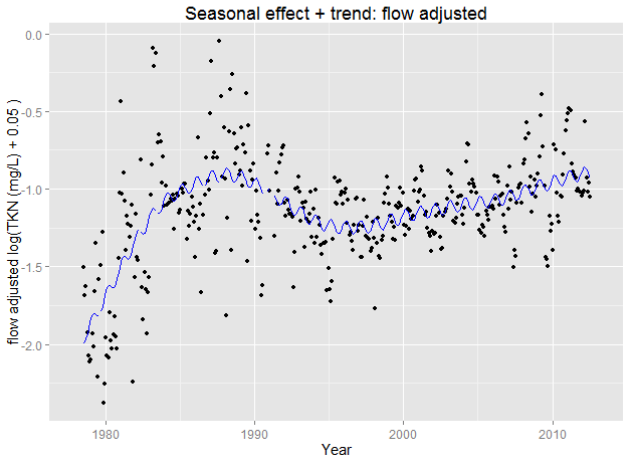


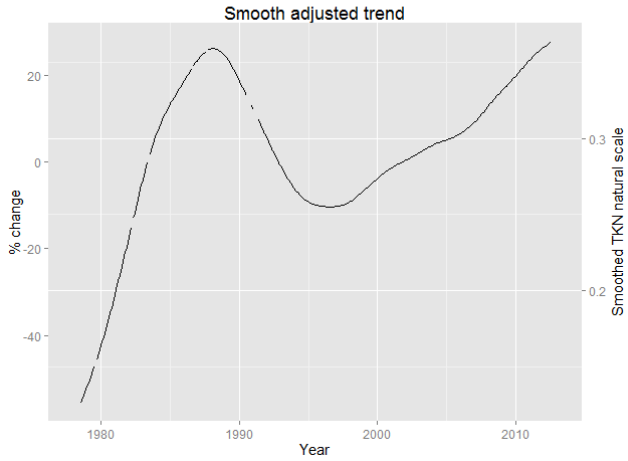


RIVER MURRAY - Heywoods

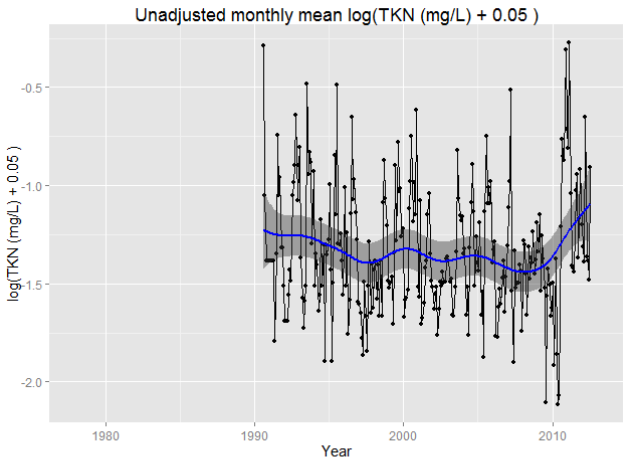


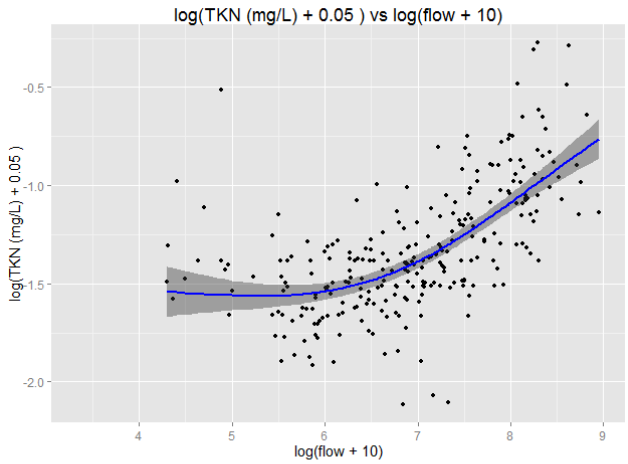


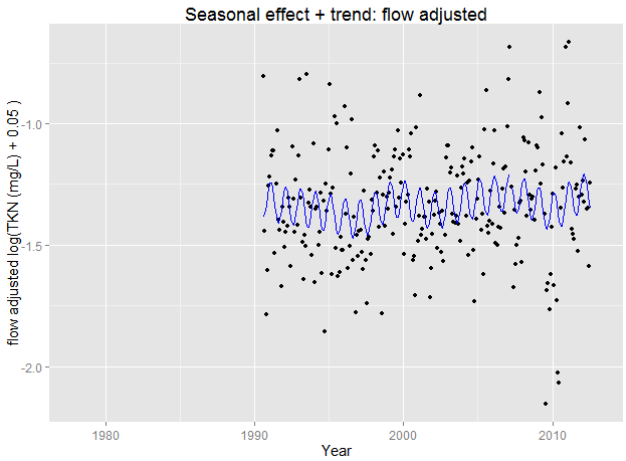


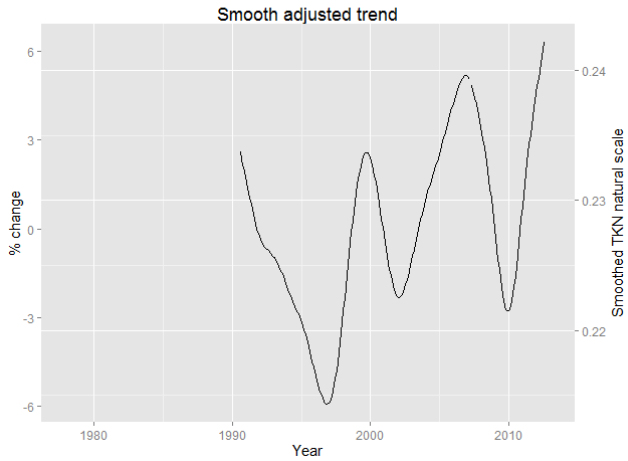


RIVER MURRAY - Bandiana

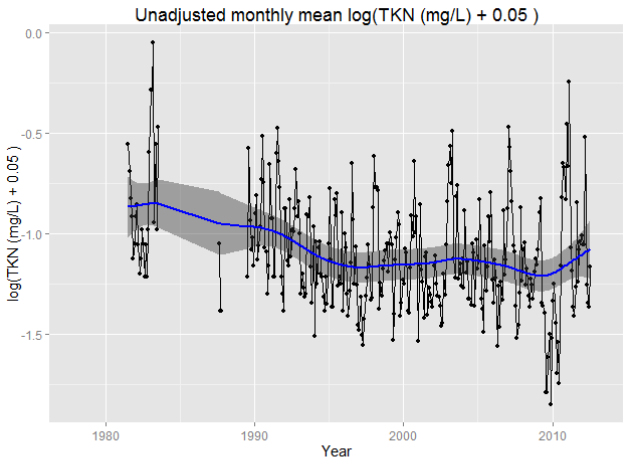


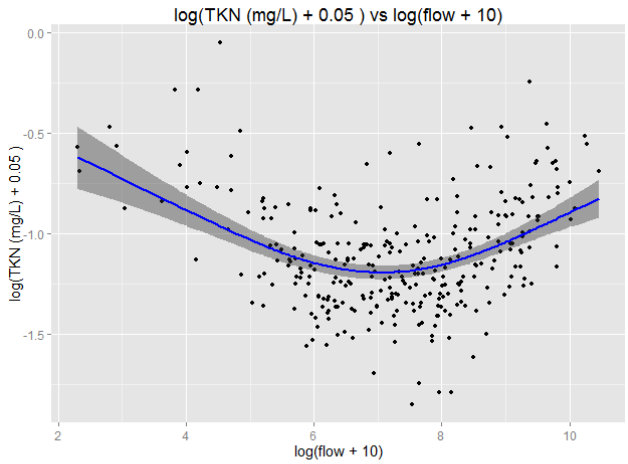


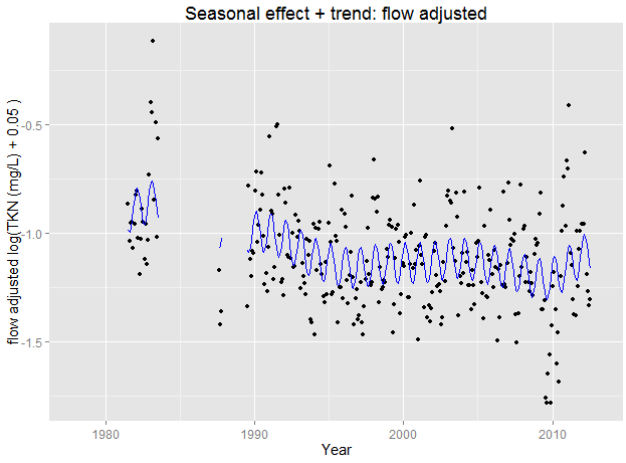


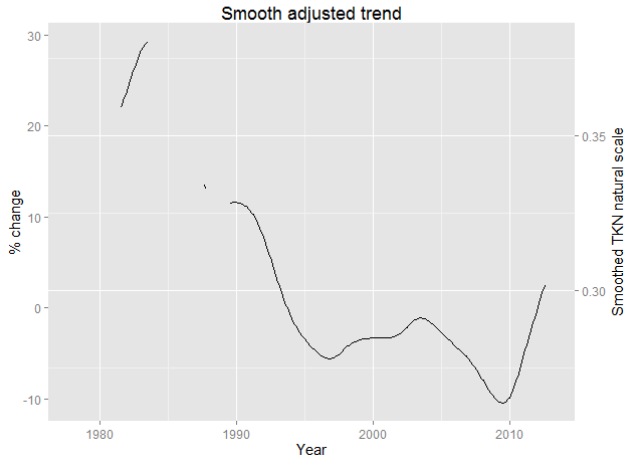


RIVER MURRAY - Peechelba

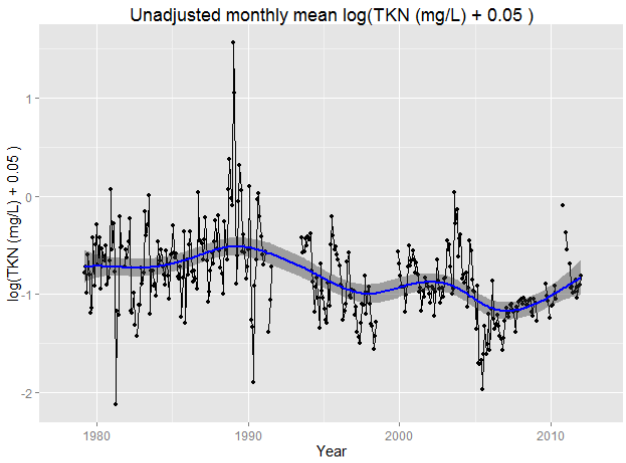


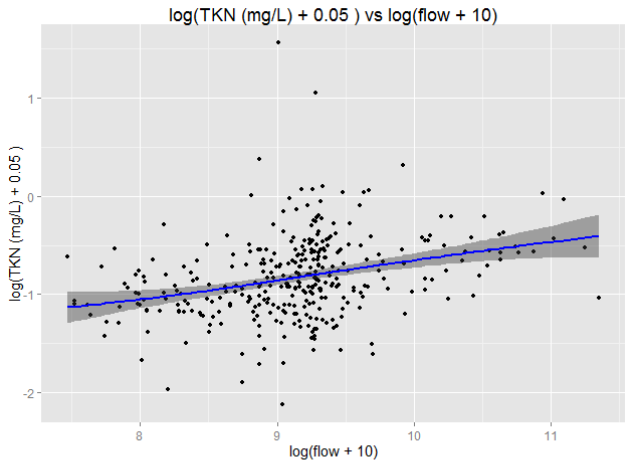


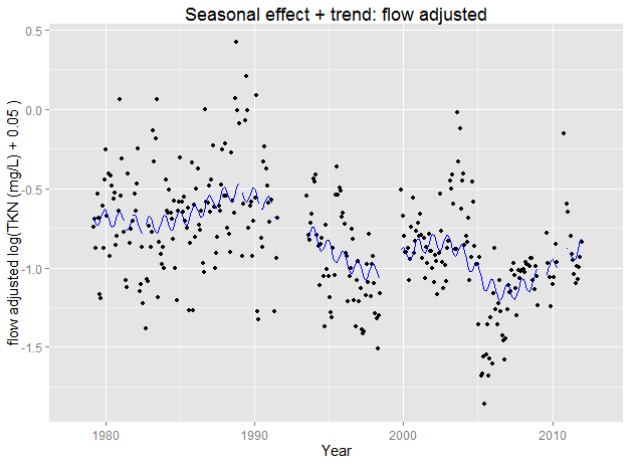


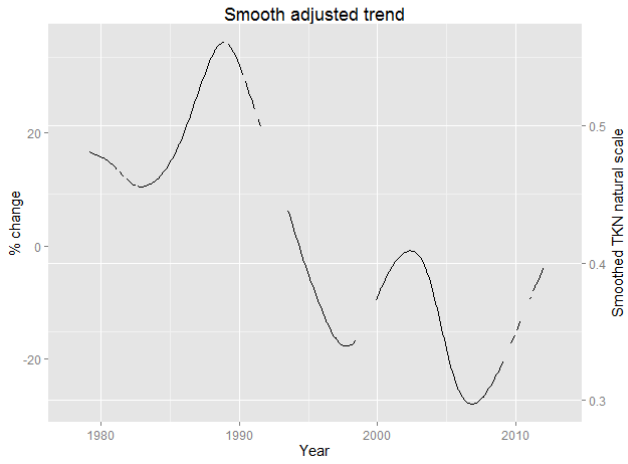


RIVER MURRAY - Yarrawonga

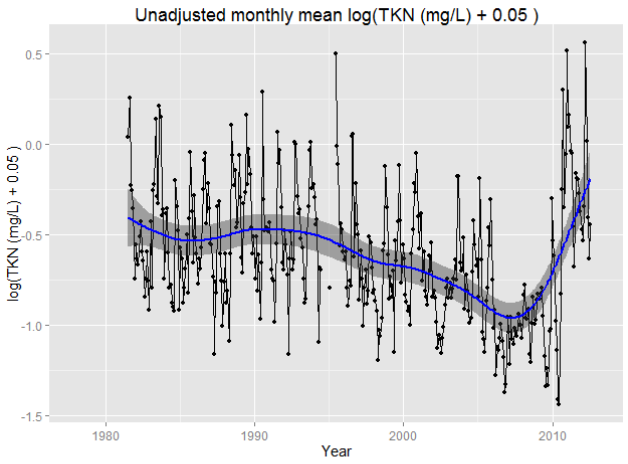


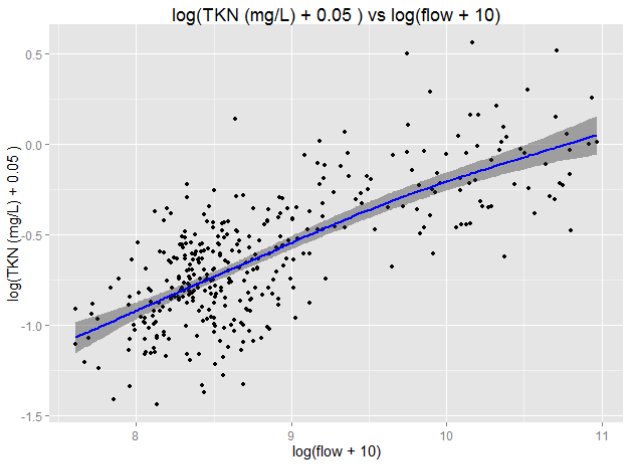


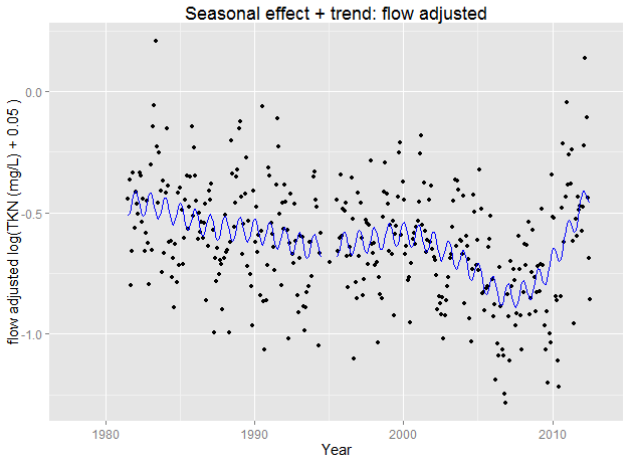


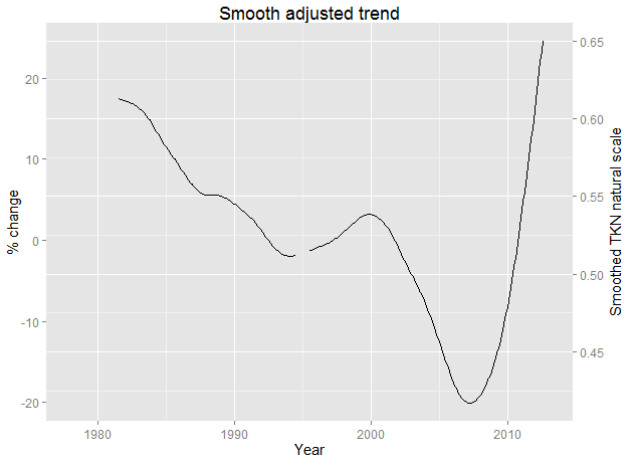


RIVER MURRAY - Torrumbarry

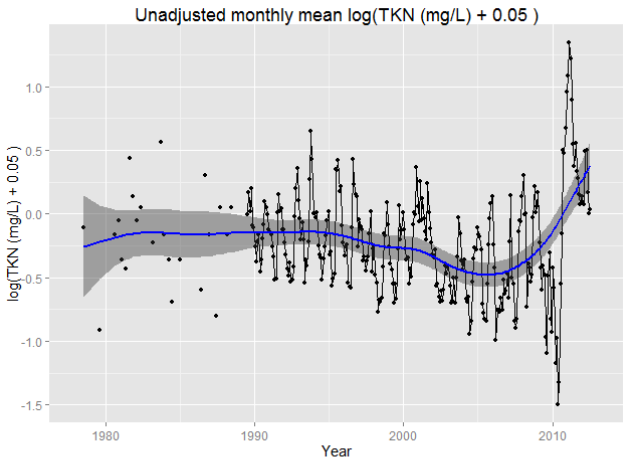


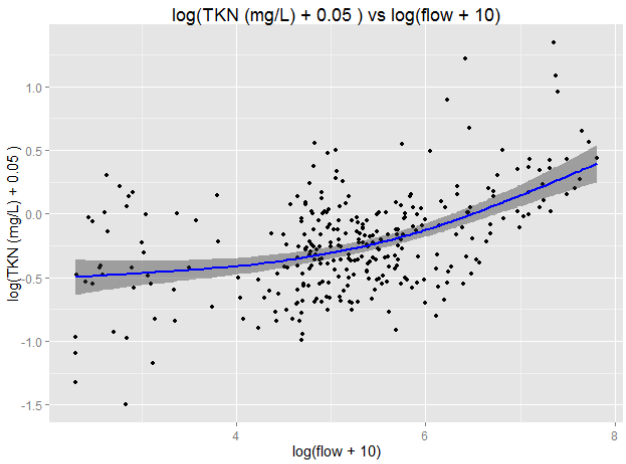


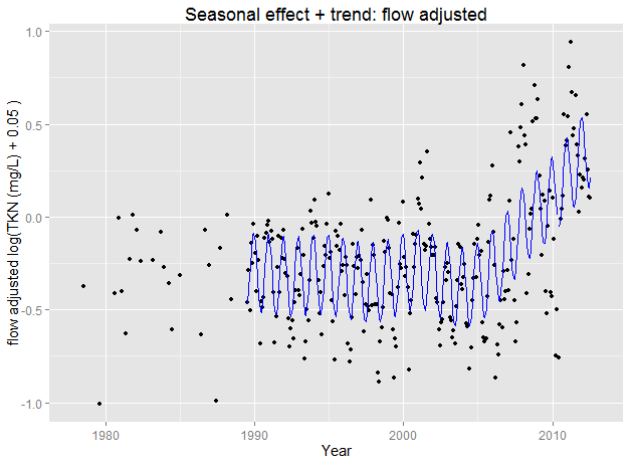


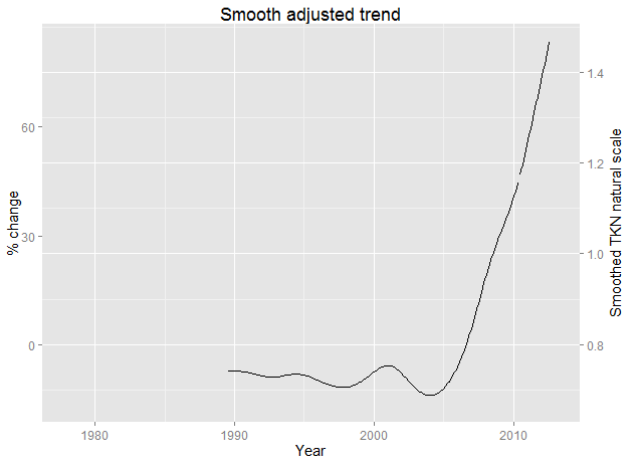


RIVER MURRAY - Kerang

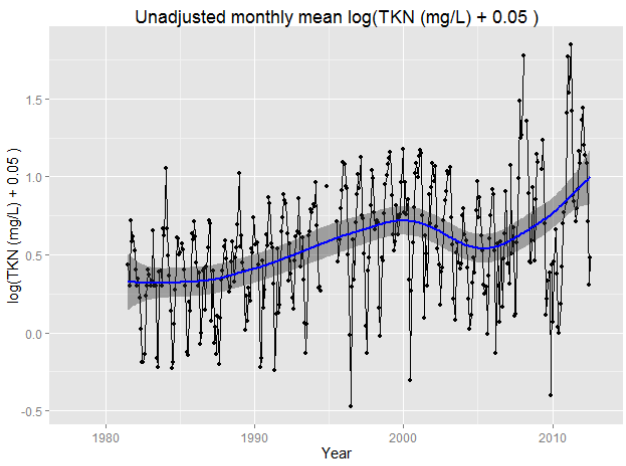


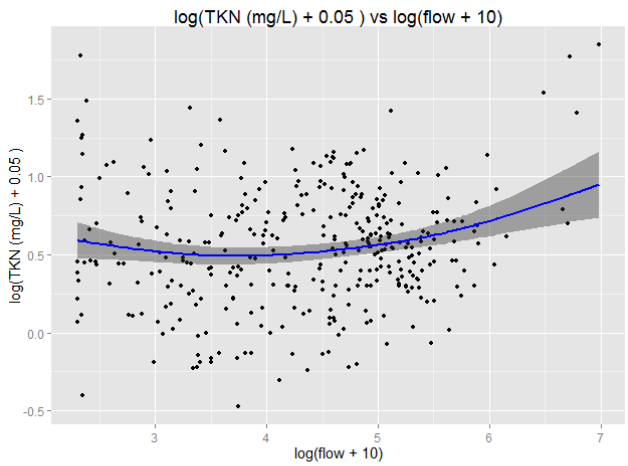


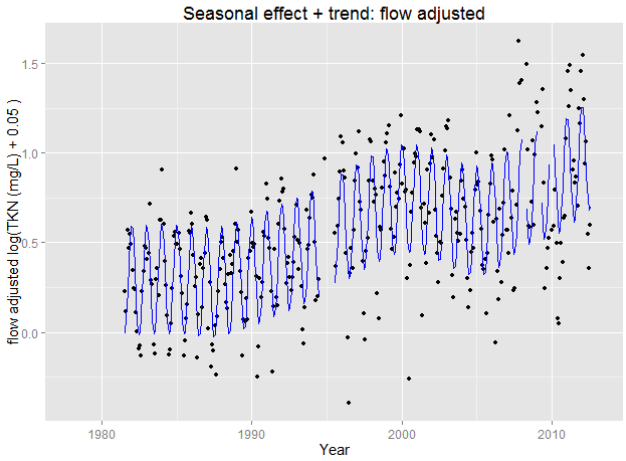


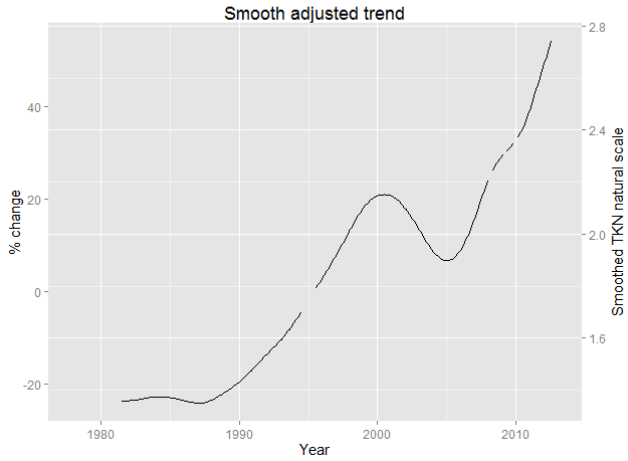


RIVER MURRAY - Capels Flume

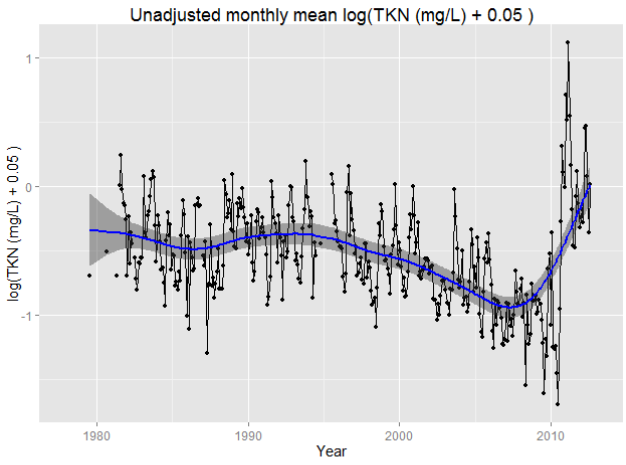


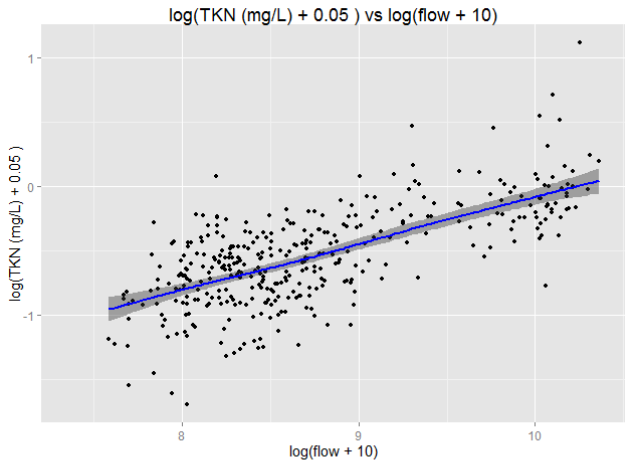


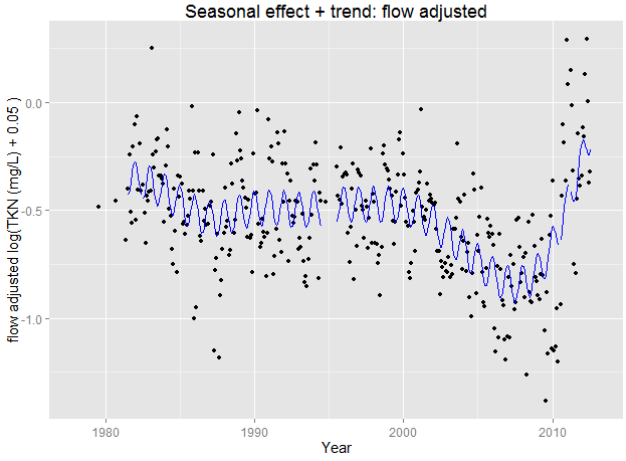


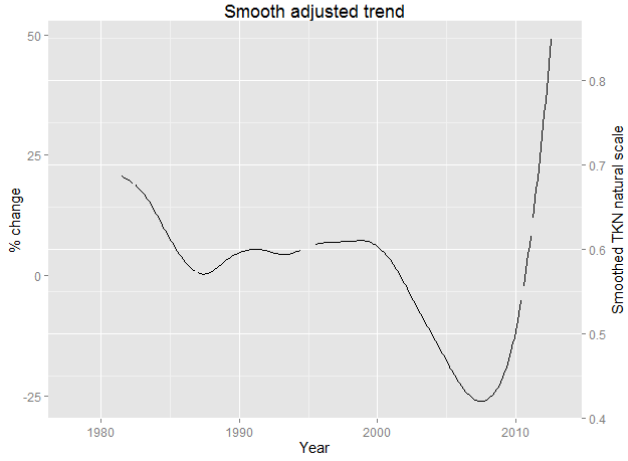


RIVER MURRAY - Swan Hill

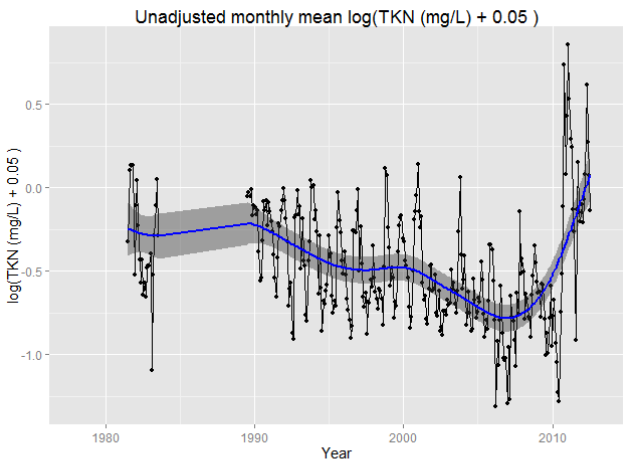


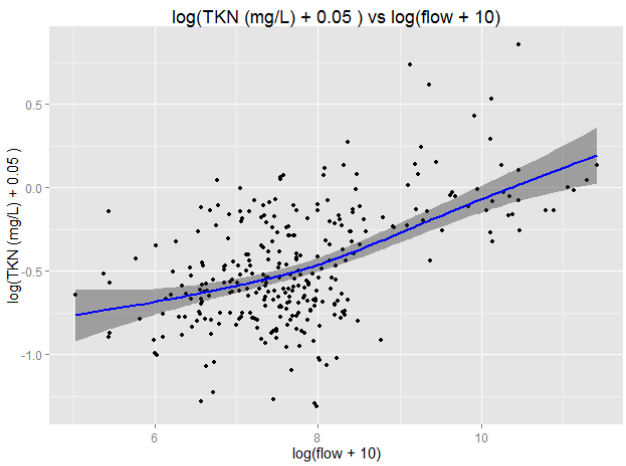


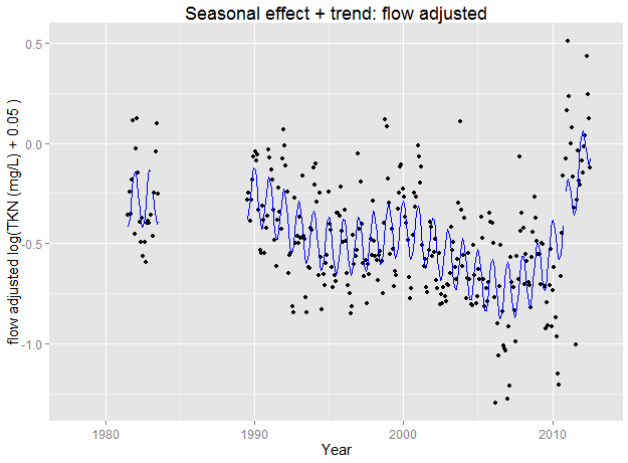


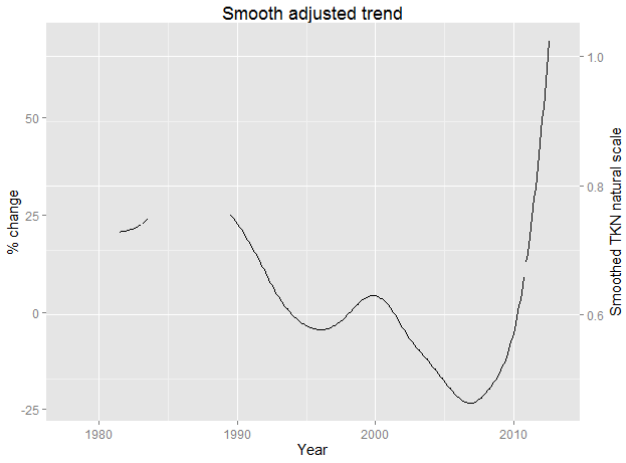


RIVER MURRAY - Kyalite

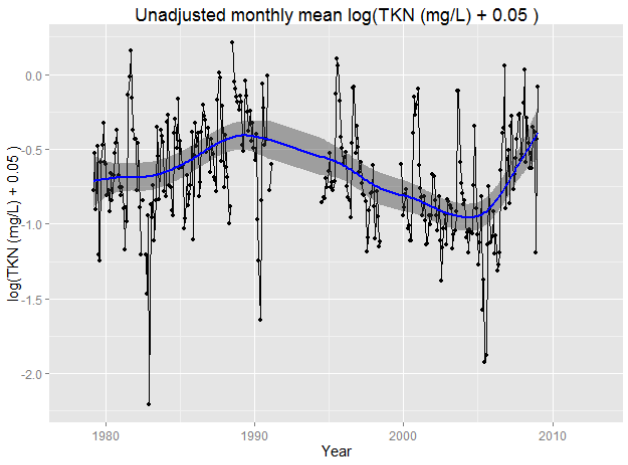


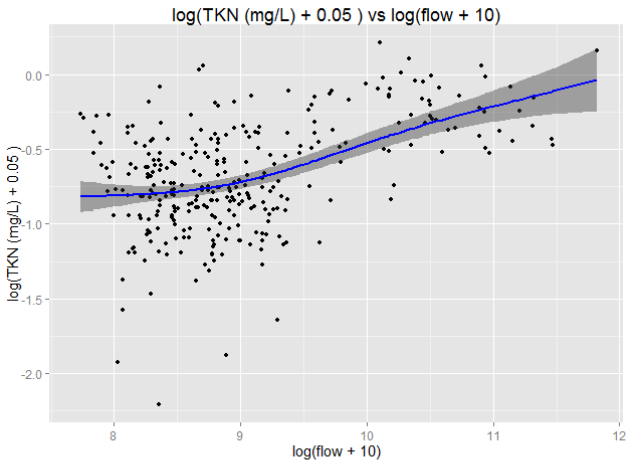


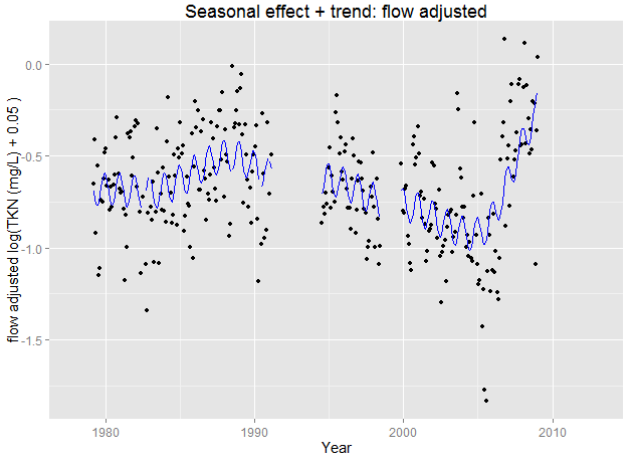


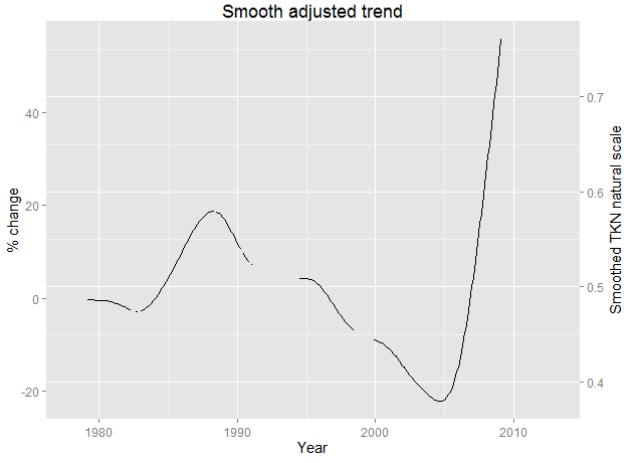


RIVER MURRAY - Euston Weir

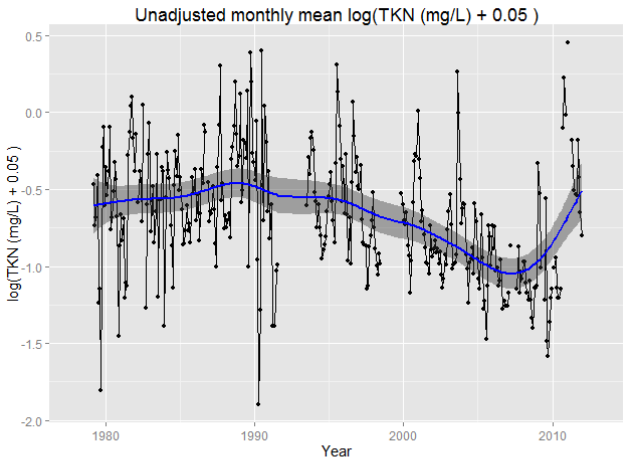


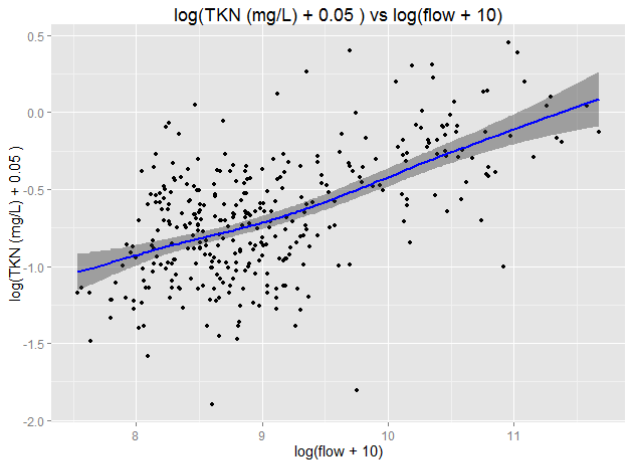


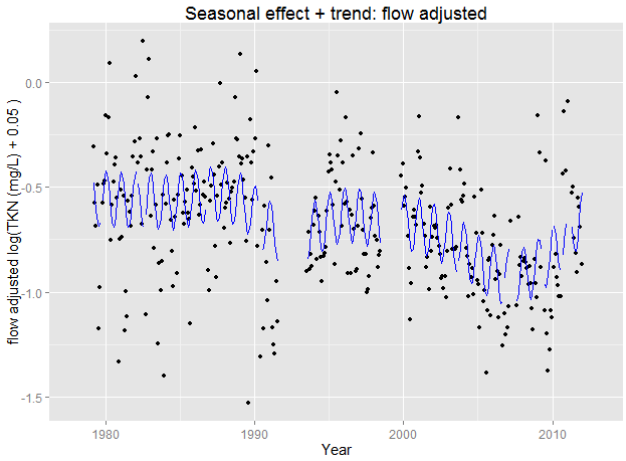


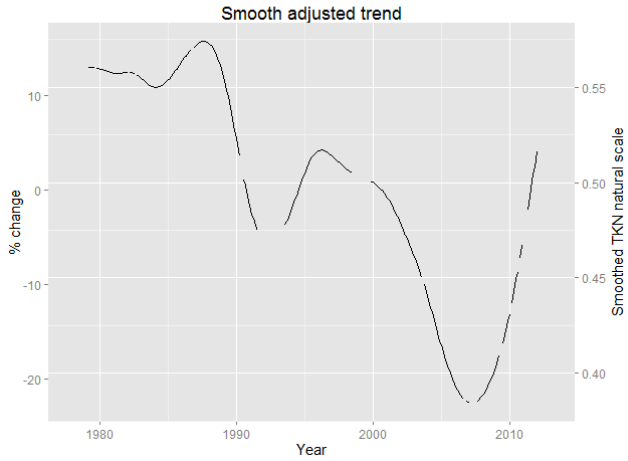


RIVER MURRAY - Merbein

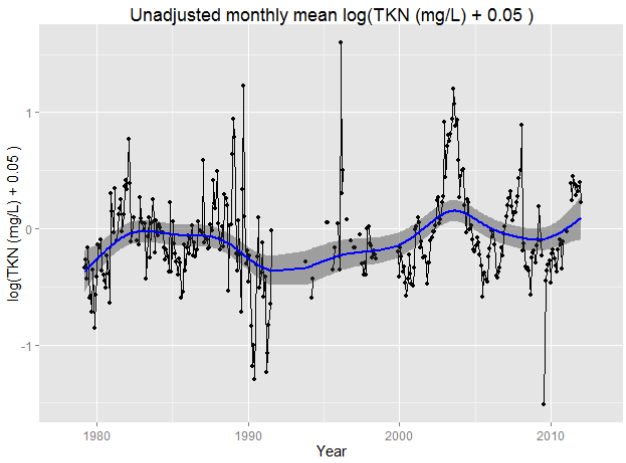


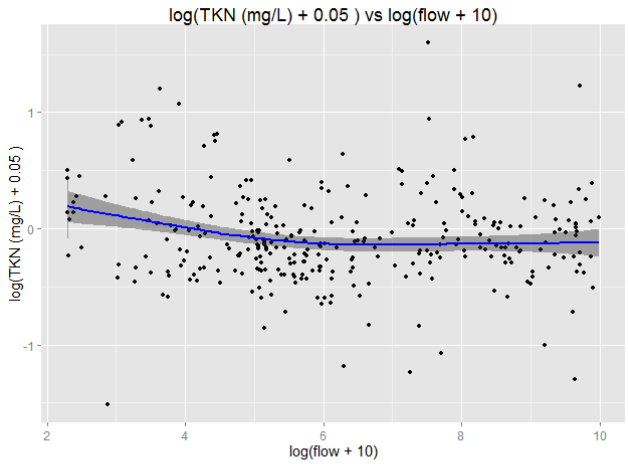


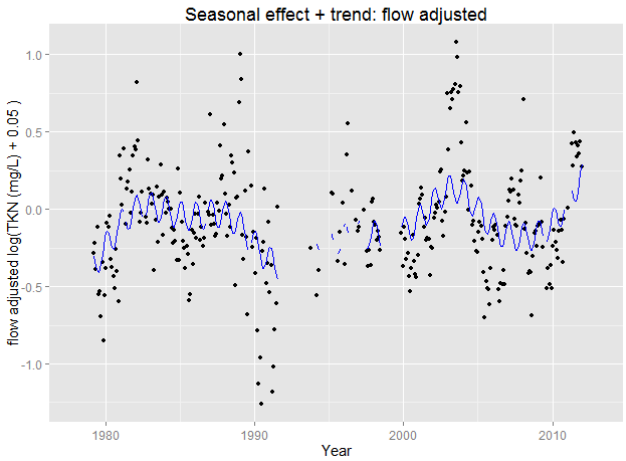


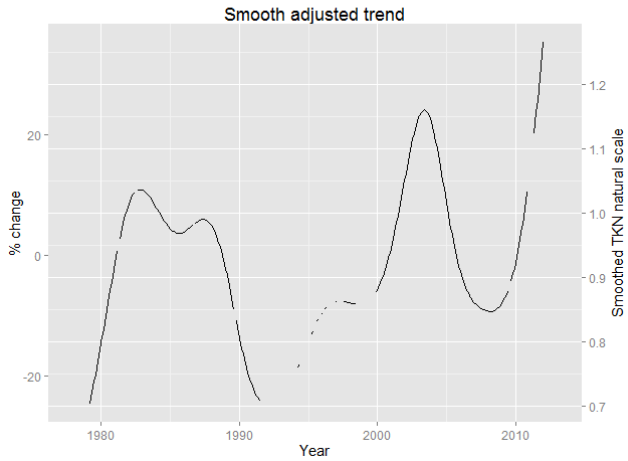


RIVER MURRAY - Burtundy

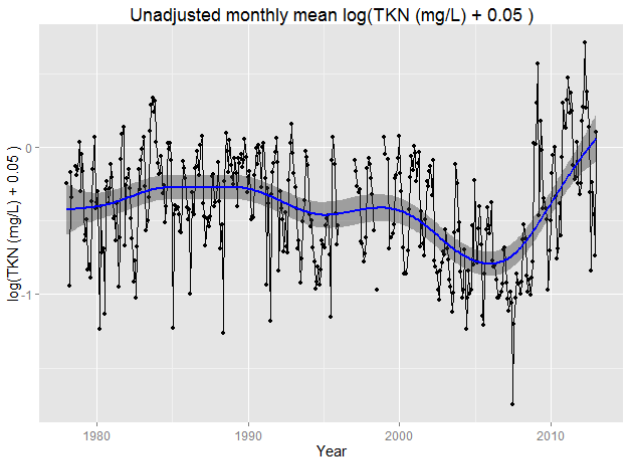


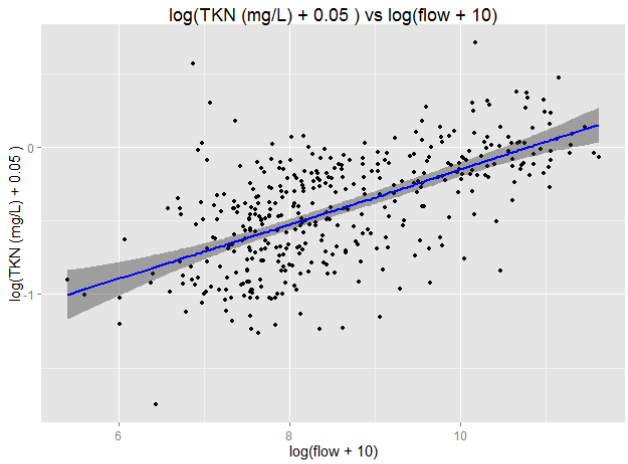


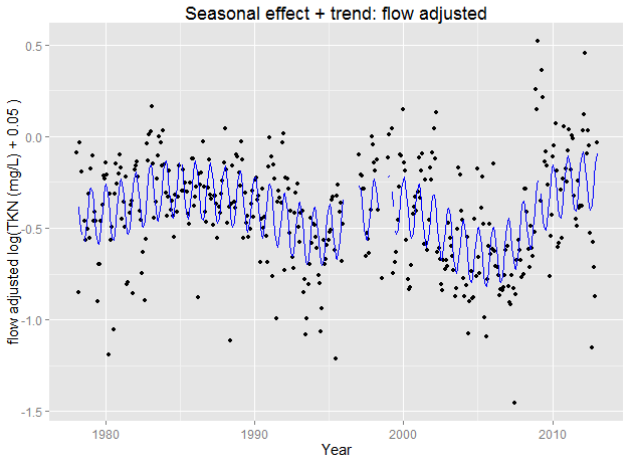


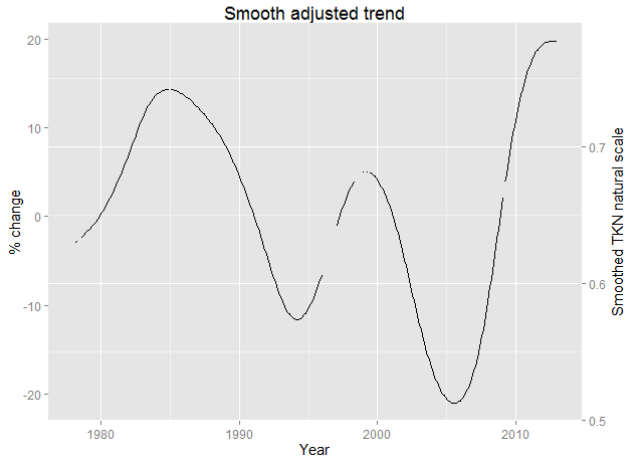


RIVER MURRAY - Lock 9

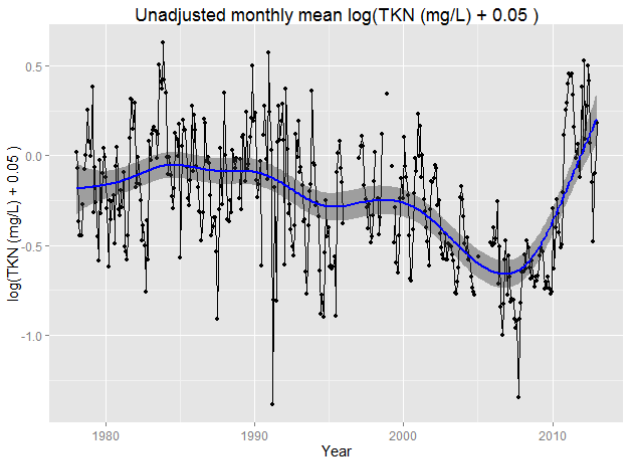


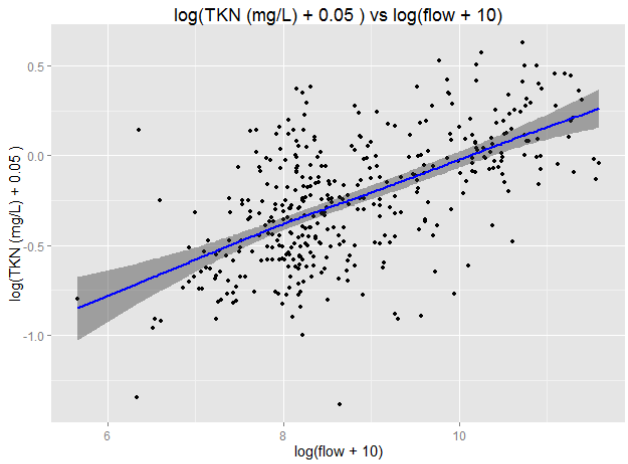


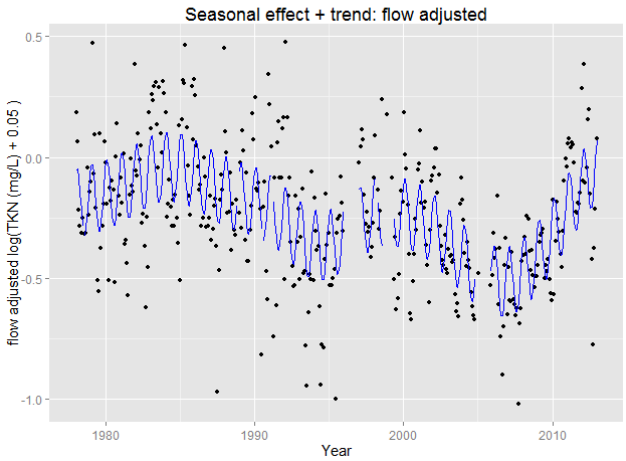


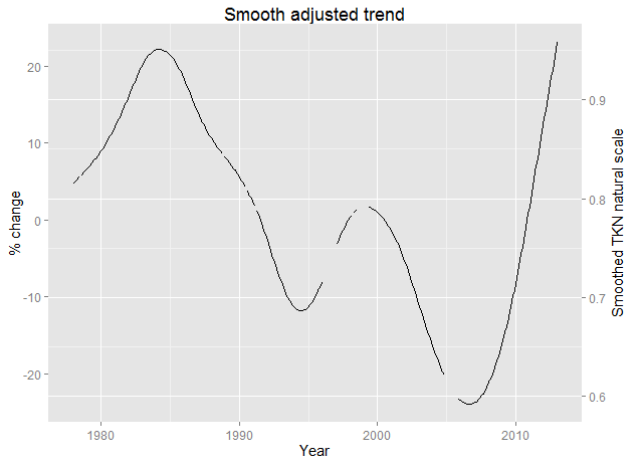


RIVER MURRAY - Morgan







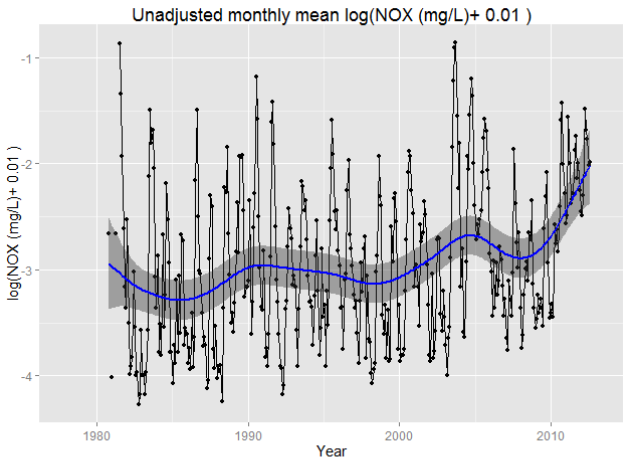


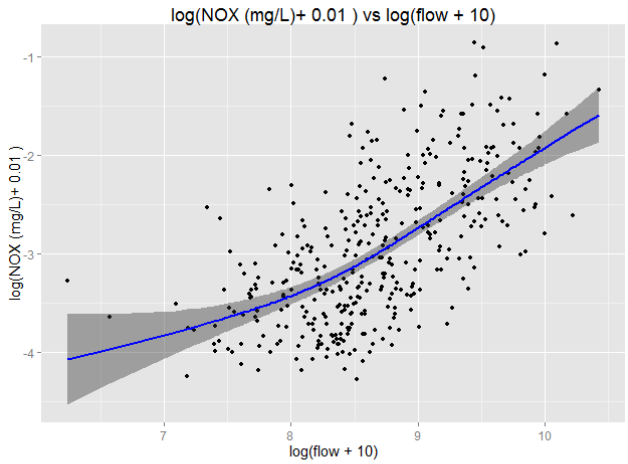
I: Oxides of nitrogen (NOx)

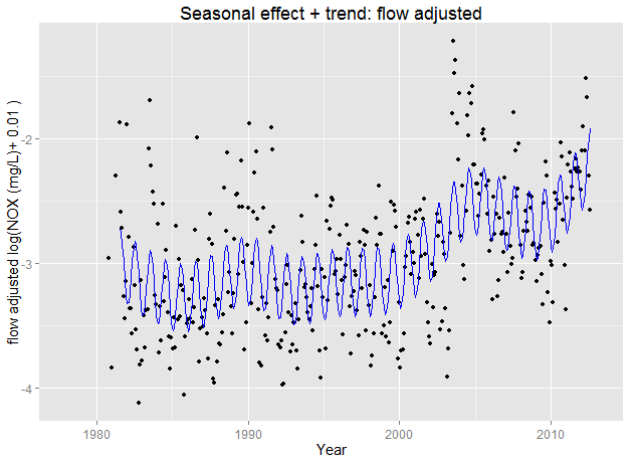
Monitoring Site	Geometric Mean	Linear Trend 1978-2012			Raw Trend 1978-2012			Linear Trend 2003-2012			Raw Trend 2003-2012		
Jingellic	0.0435	**2.57**	**	NL	**2.18**	**	NL	0.33		NL	1.91		NL
Tallandoon	0.0972	0.47		nl	0.62			-1.63		nl	0.19		nl
Heywoods	0.0577	-1.74			-1.92			3.06		nl	3.36		
Bandiana	0.0893	**1.91**	**	NL	1.37		NL	**-8.51**	**	nl	-1.66		nl
Peechelba	0.1055	-0.59		nl	-0.63			**-6.13**	**	NL	0.61		
Yarrawonga	0.0344	**-1.84**	**	NL	**-2.25**	**	NL	-6.62		nl	-6.92		
Torrumbarry	0.0266	-0.42			-1.07			-6.87	*		3.30		nl
Kerang	0.0166	**2.06**	**	NL	0.07		nl	-3.79		NL	-3.06		nl
Capels Flume	0.0305	**3.81**	**	NL	-1.25			6.92		NL	6.26		
Swan Hill	0.0216	-0.40		NL	-1.18			**-9.94**	**		1.95		NL
Kyalite	0.0106	-0.30		NL	-0.46		NL	**-4.76**	**		-1.95		nl
Euston Weir	0.0276	**-2.96**	**	NL	**-3.75**	**	NL	2.50		nl	-0.49		
Merbein	0.0261	**-3.25**	**	NL	**-3.74**	**	NL	1.57		nl	**5.14**	**	NL
Burtundy	0.0469	0.66		NL	-2.00		NL	7.86	*	NL	**31.83**	**	NL
Lock 9	0.0303	**-2.33**	**	NL	**-3.05**	**	NL	7.03		NL	**14.68**	**	NL
Morgan	0.0223	**-2.29**	**	NL	**-2.63**	**	NL	**11.50**	**	NL	**13.52**	**	NL

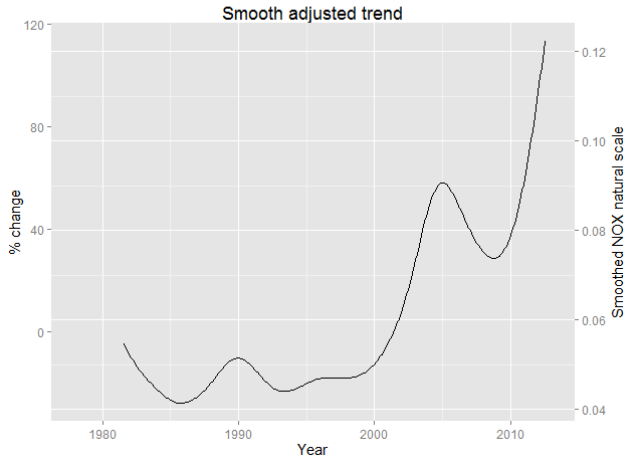
Monitoring Site	Geometric Mean	Relationship to Log flow	Significance	Amplitude(log scale)	Seasonal Peak	Autocorrelation
Jingellic	0.0435	+	**	0.3316	6.9245	0.4967
Tallandoon	0.0972	-	**	0.3948	7.3385	0.6870
Heywoods	0.0577	-	**	0.7649	10.5899	0.7998
Bandiana	0.0893	+	**	0.2772	7.6745	0.3336
Peechelba	0.1055	+	**	0.4213	7.0194	0.3889
Yarrawonga	0.0344	+	**	0.6729	7.4380	0.5098
Torrumbarry	0.0266	+	**	0.7084	6.5908	0.3750
Kerang	0.0166	+	**	0.0548	6.5096	0.4269
Capels Flume	0.0305	+	**	0.2240	6.5896	0.2686
Swan Hill	0.0216	+	**	0.3725	6.0901	0.3703
Kyalite	0.0106	+	**	0.1120	5.9053	0.3832
Euston Weir	0.0276	+	**	0.2382	7.0742	0.4190
Merbein	0.0261	+	**	0.1603	6.9699	0.4325
Burtundy	0.0469	+	**	0.2889	7.3148	0.5367
Lock 9	0.0303	+	**	0.0548	5.9551	0.3570
Morgan	0.0223	+	**	0.2000	5.4696	0.4789

RIVER MURRAY - Jingellic

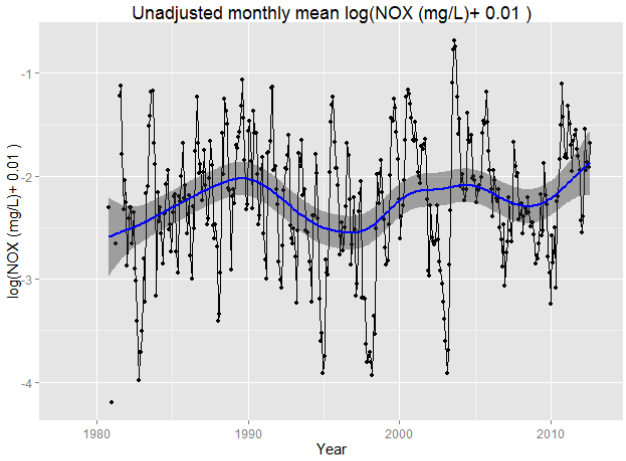


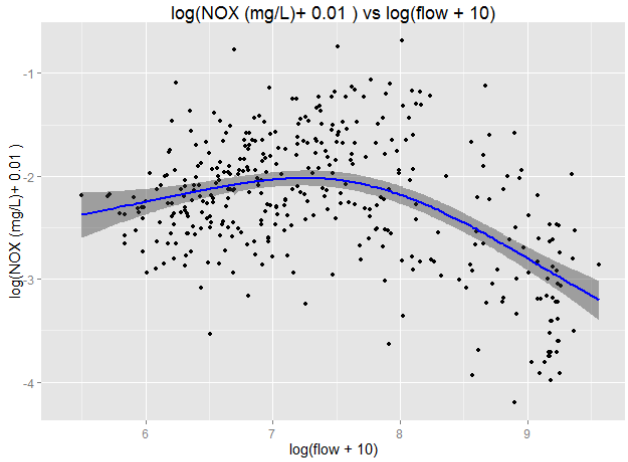


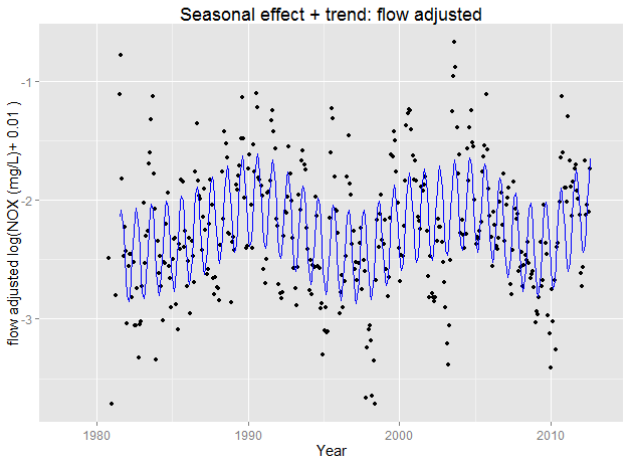


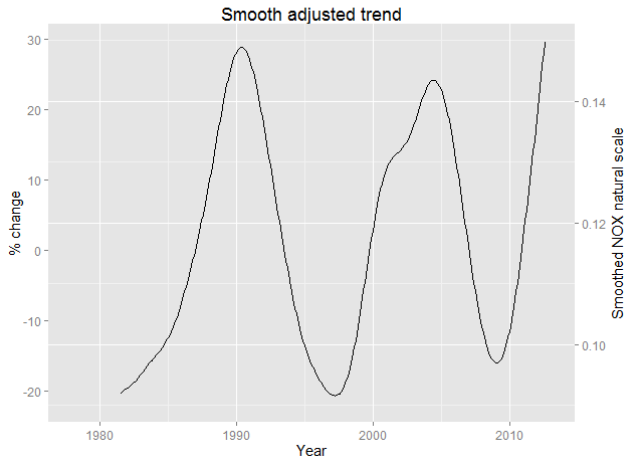


RIVER MURRAY - Tallandoon

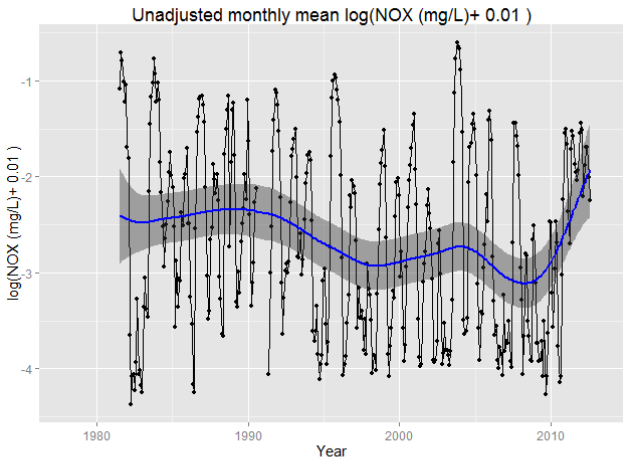


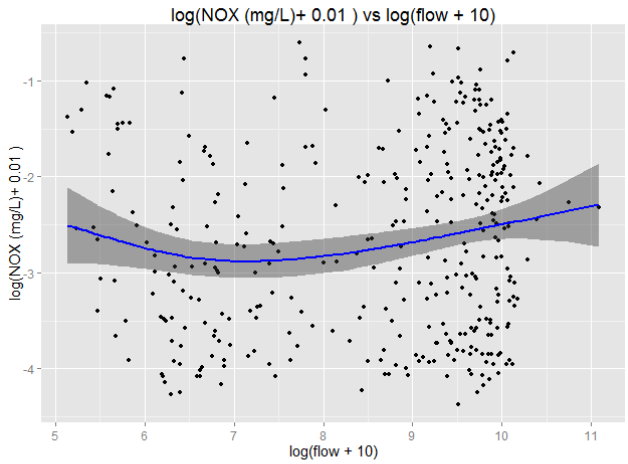


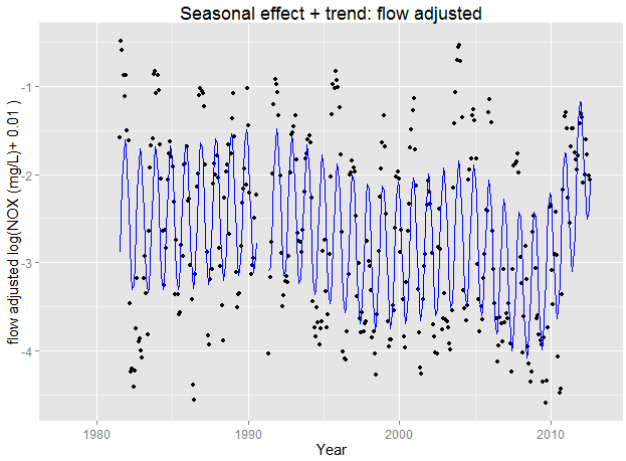


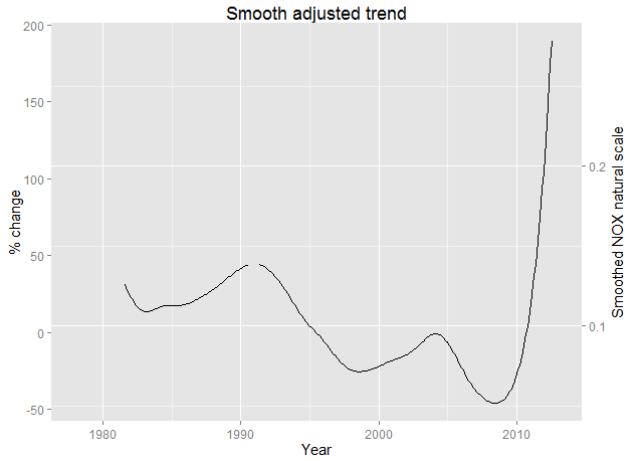


RIVER MURRAY - Heywoods

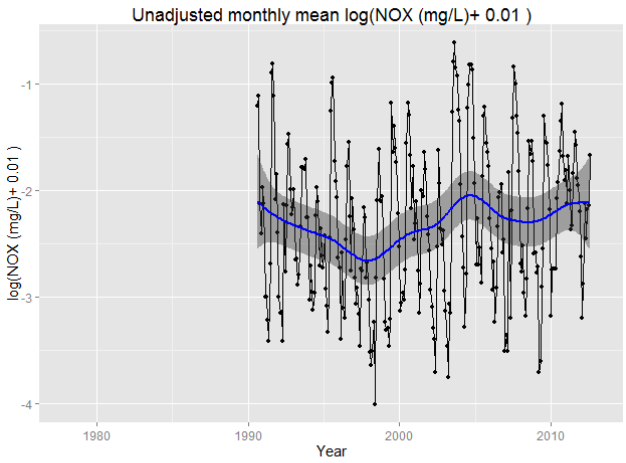


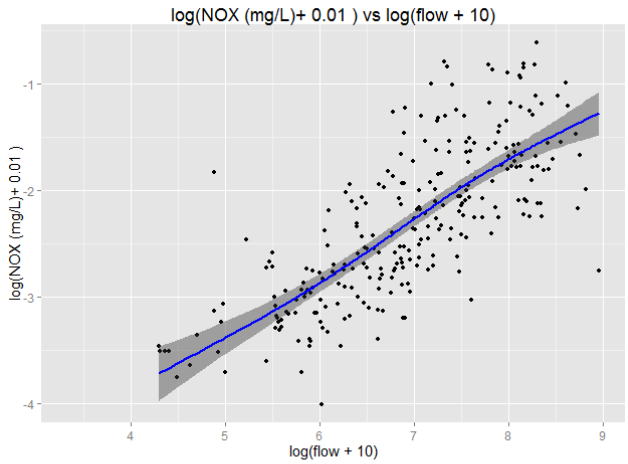


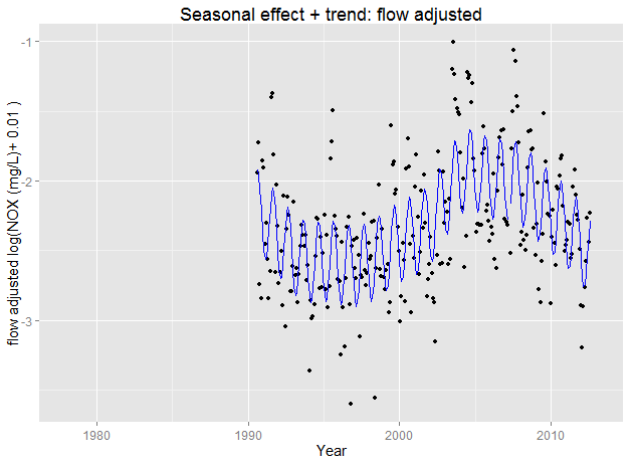


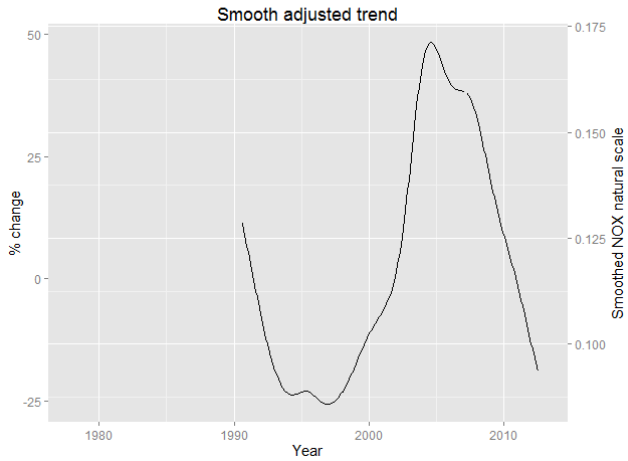


RIVER MURRAY - Bandiana

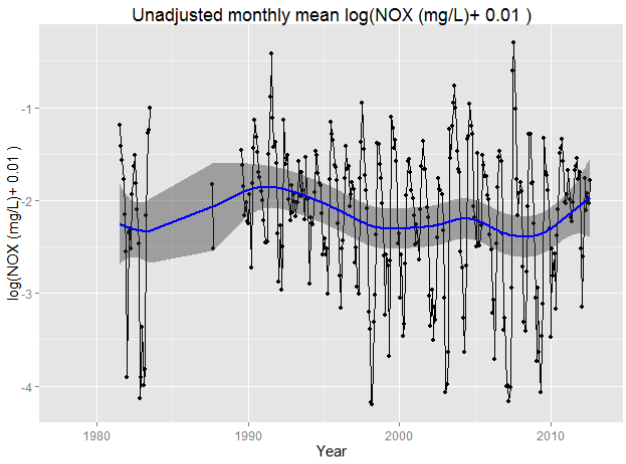


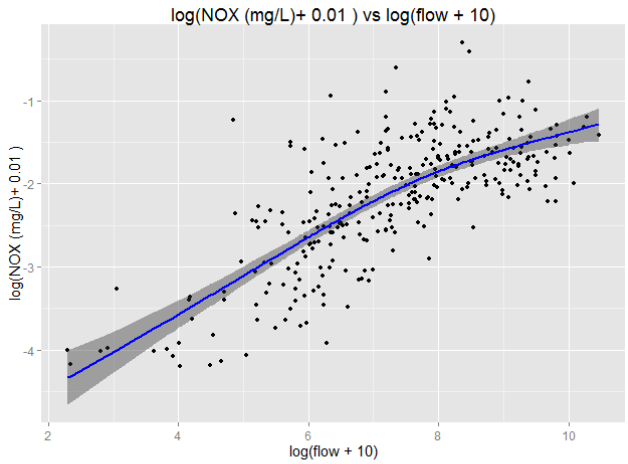


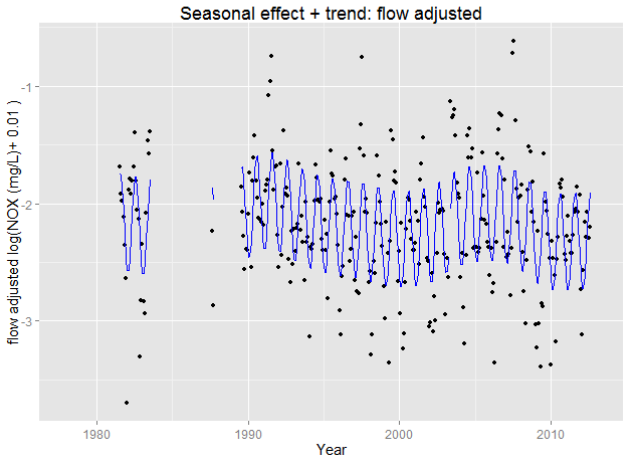


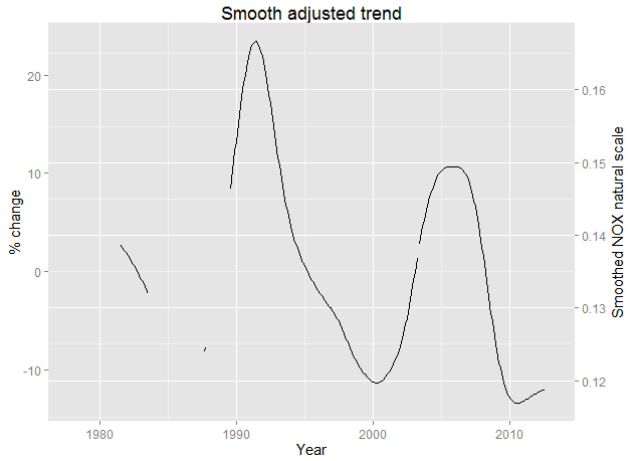


RIVER MURRAY - Peechelba

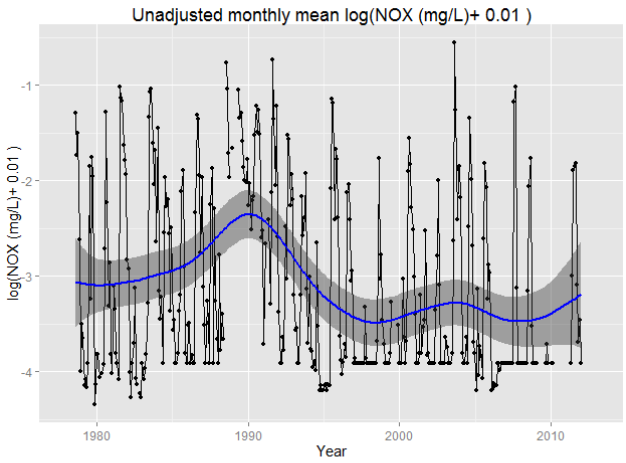


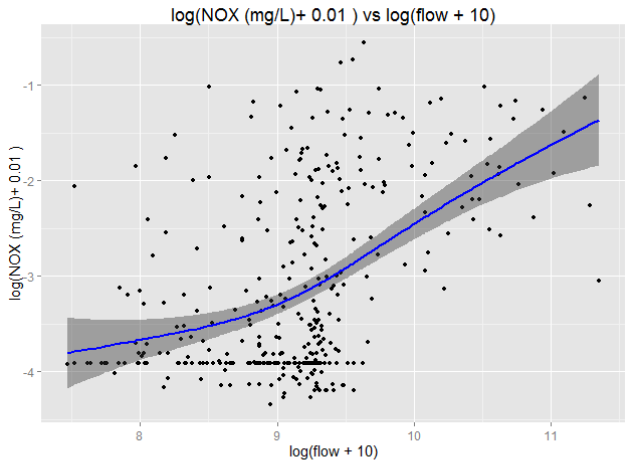


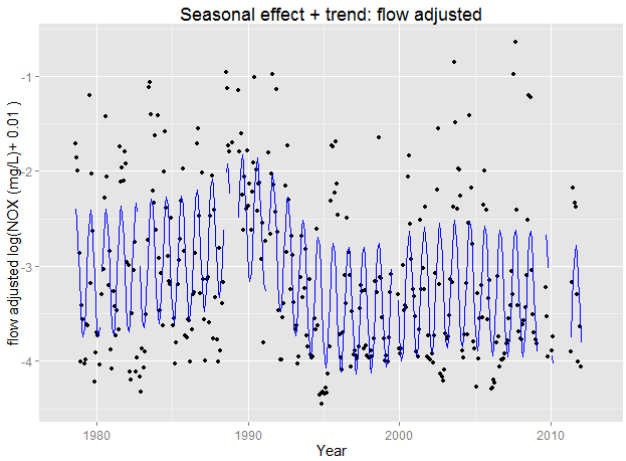


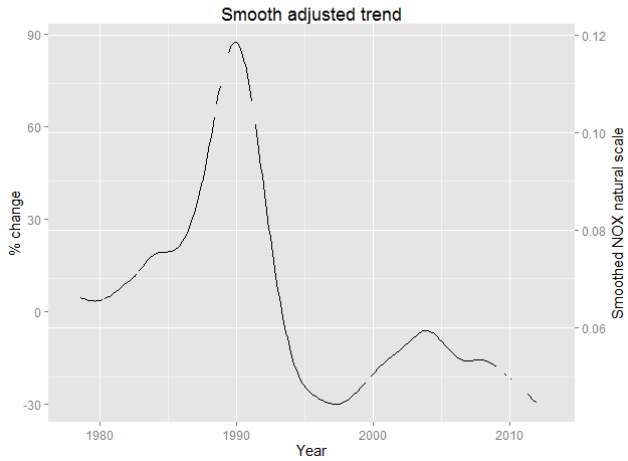


RIVER MURRAY - Yarrawonga

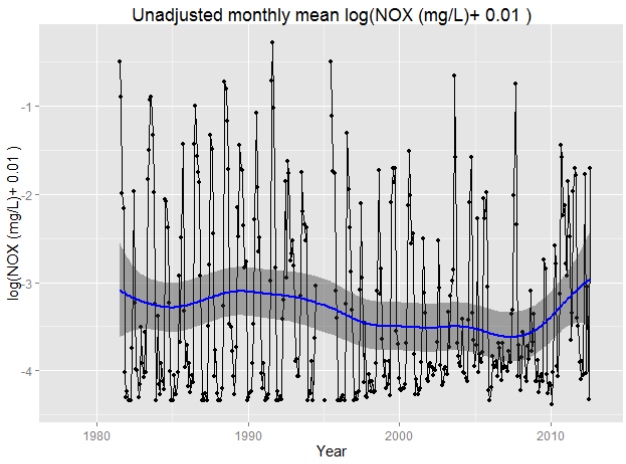


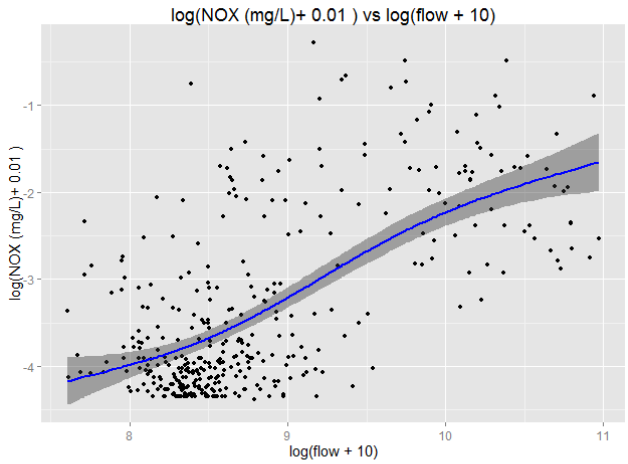


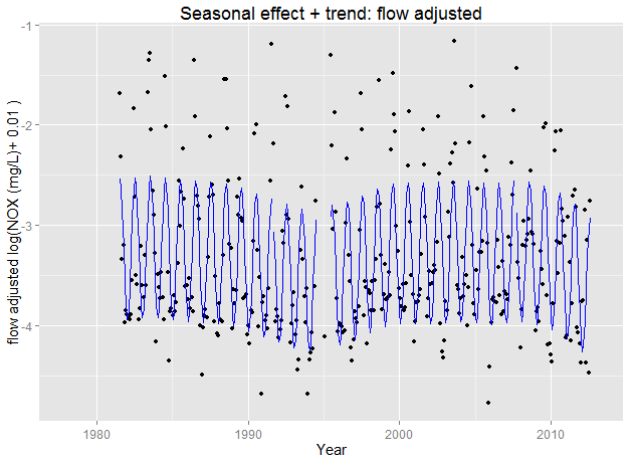


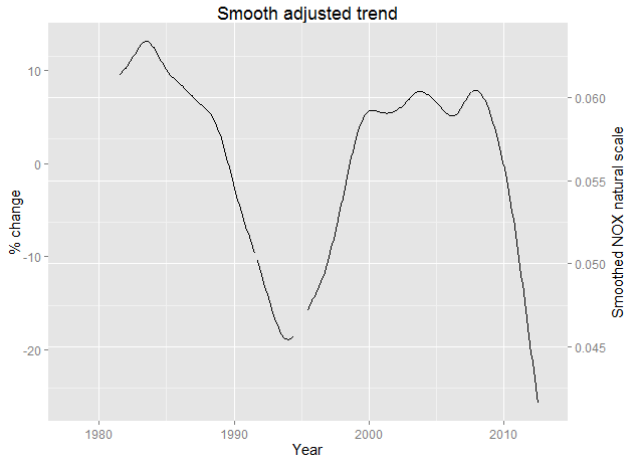


RIVER MURRAY - Torrumbarry

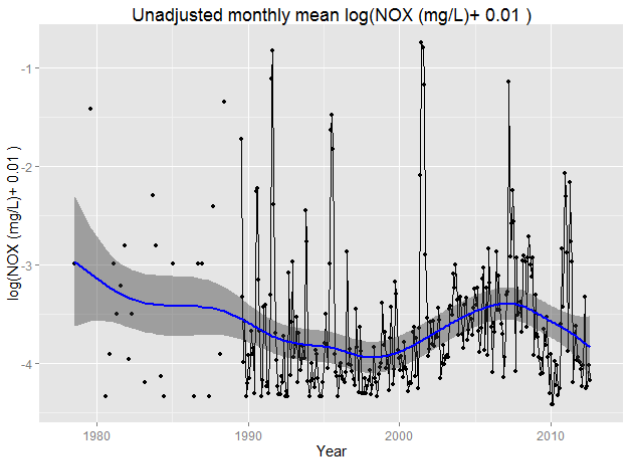


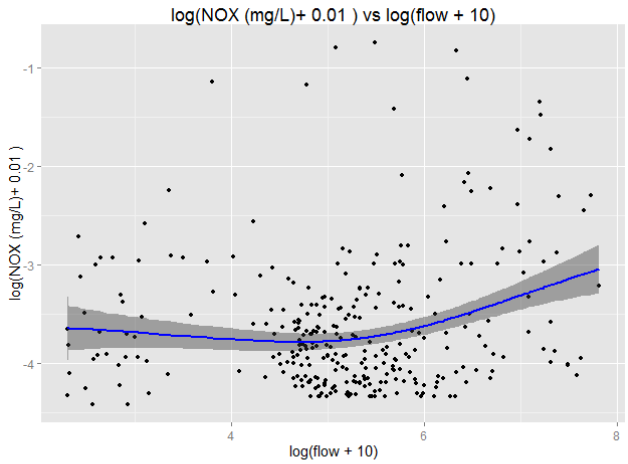


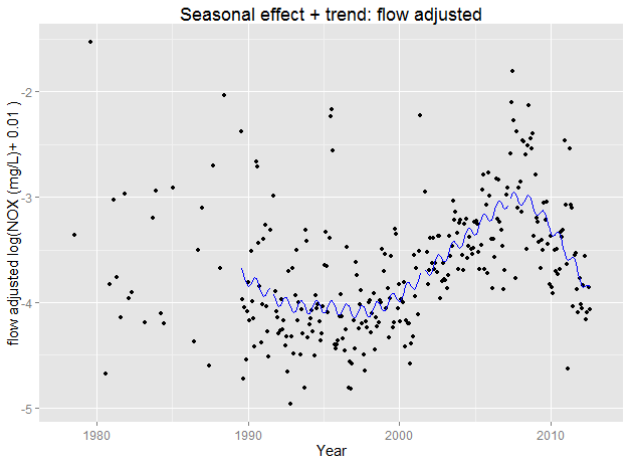


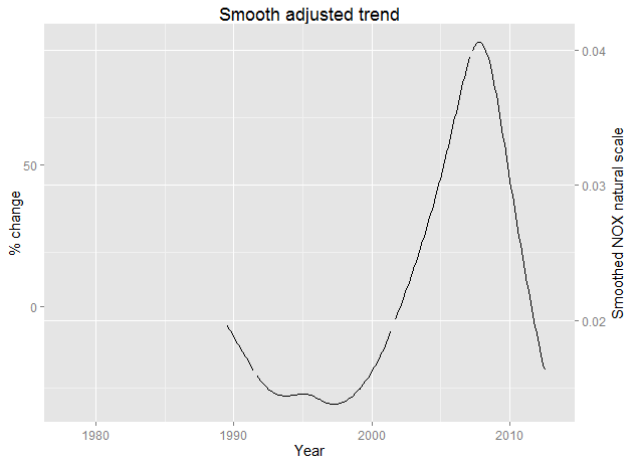


RIVER MURRAY - Kerang

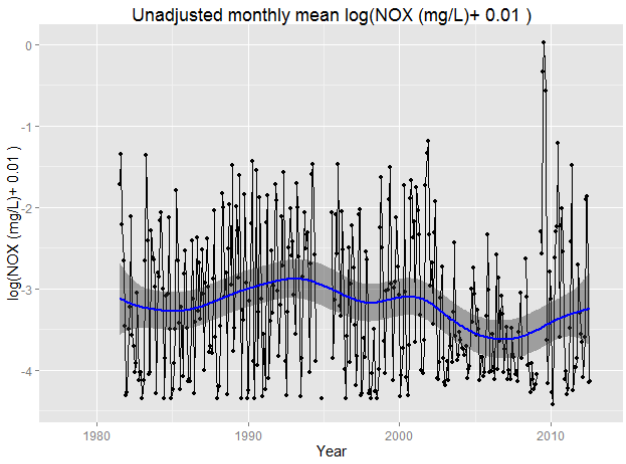


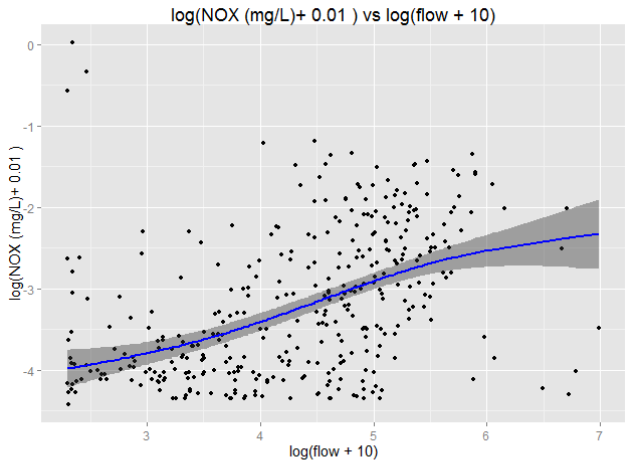


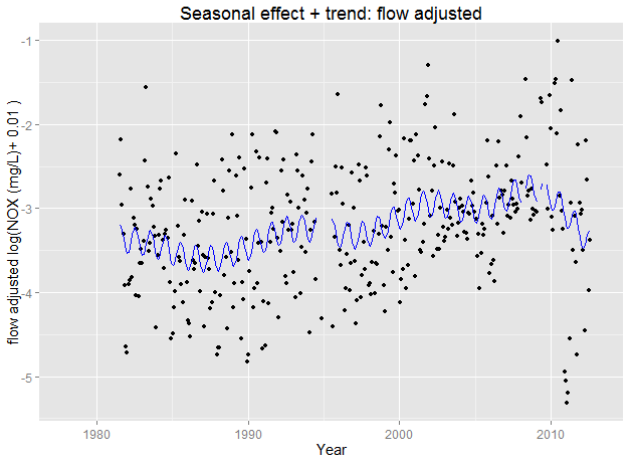


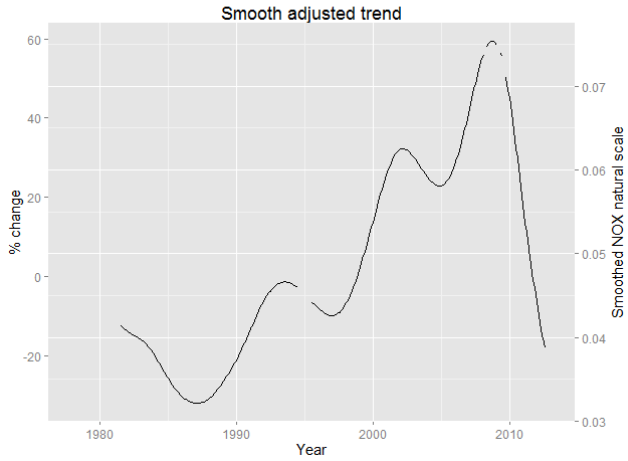


RIVER MURRAY - Capels Flume

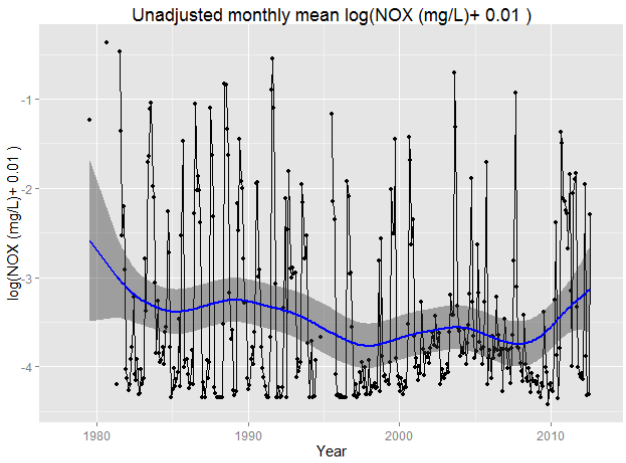


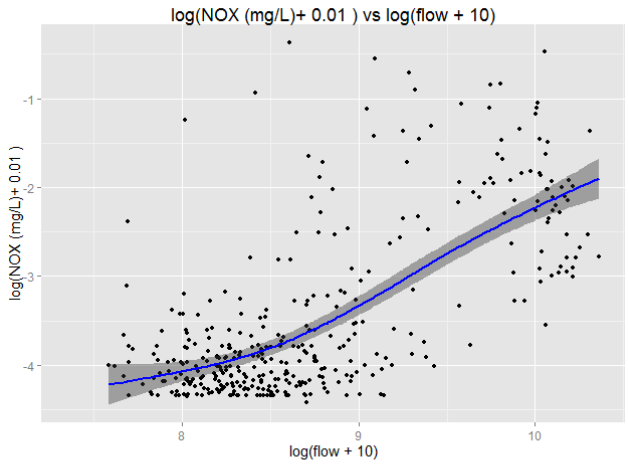


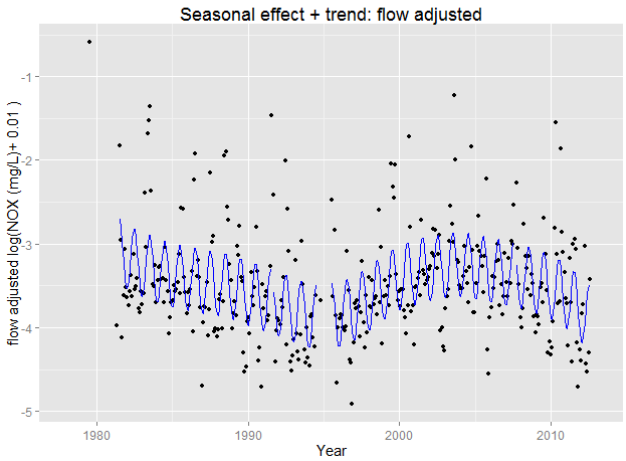


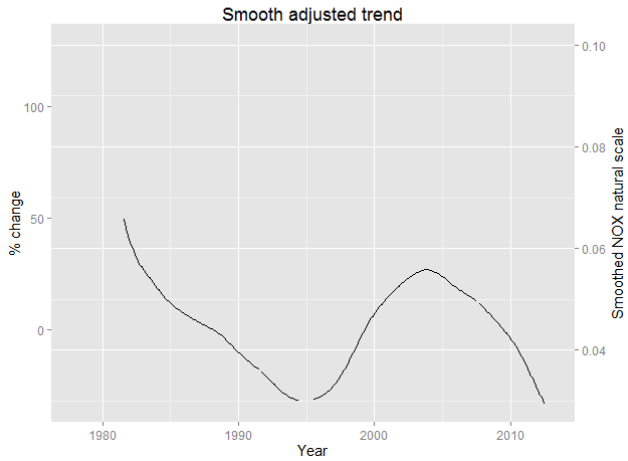


RIVER MURRAY - Swan Hill

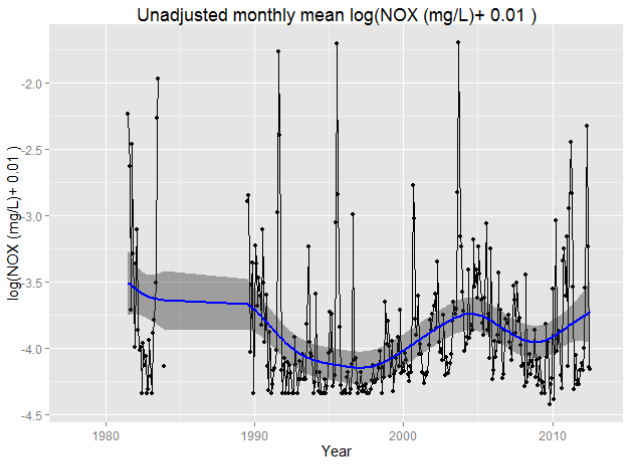


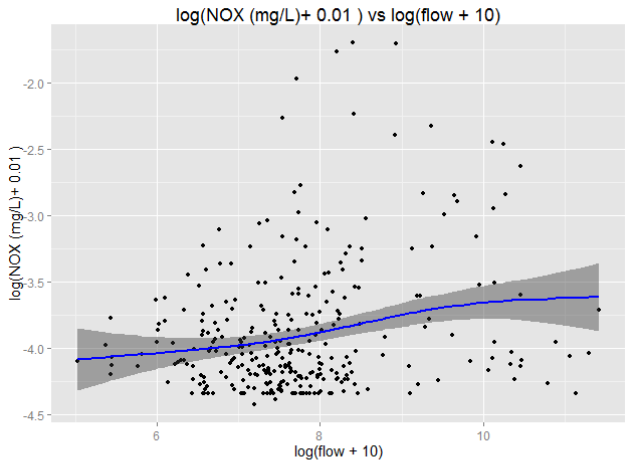


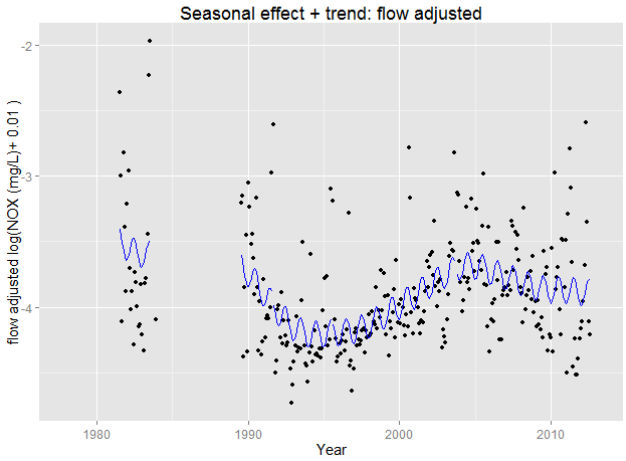


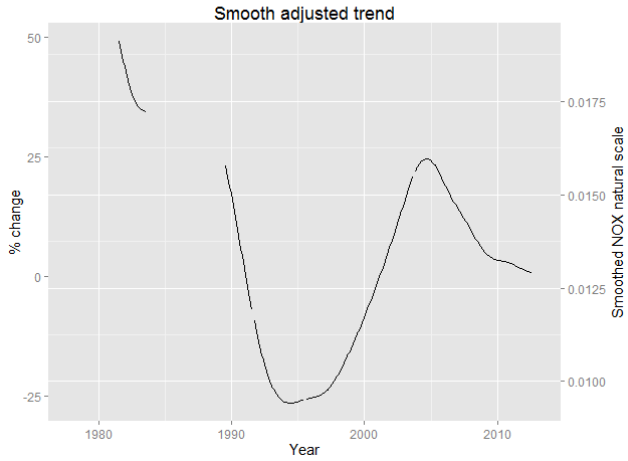


RIVER MURRAY - Kyalite

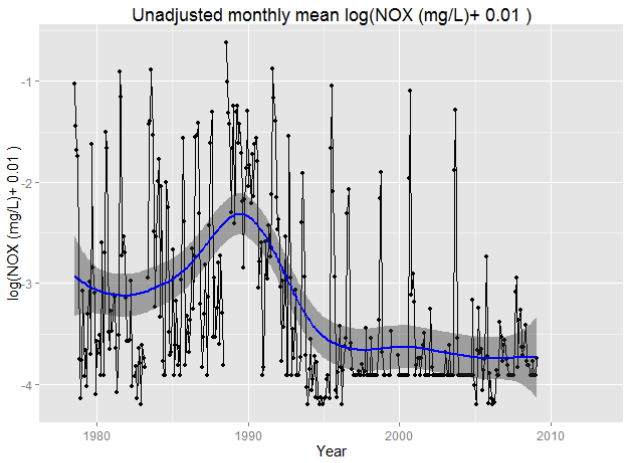


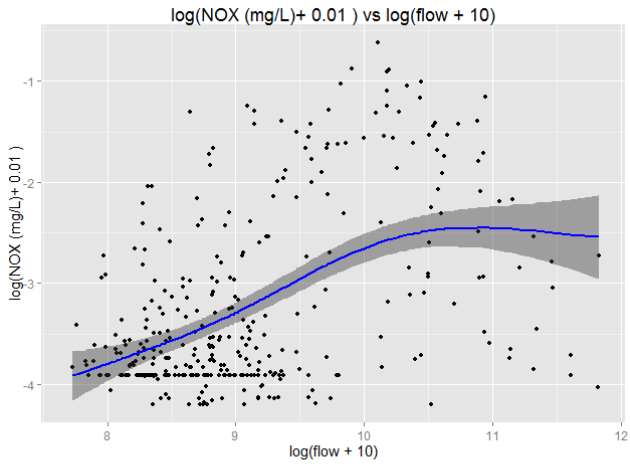


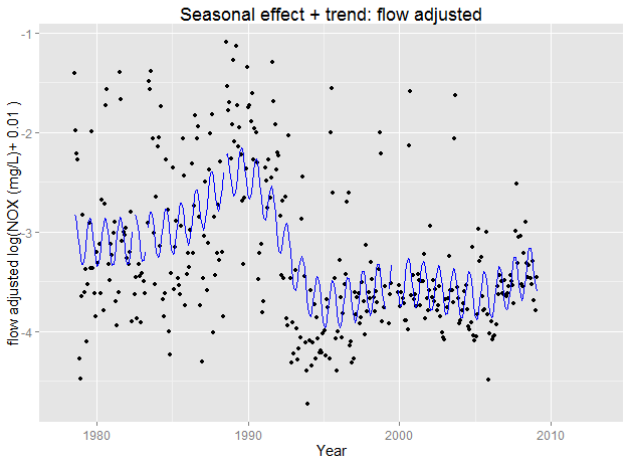


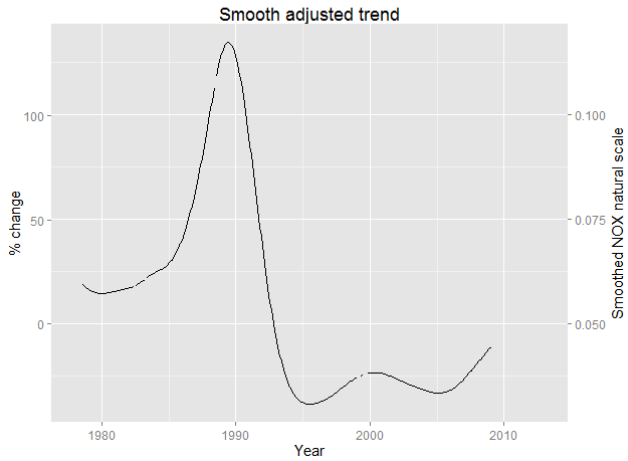


RIVER MURRAY - Euston Weir

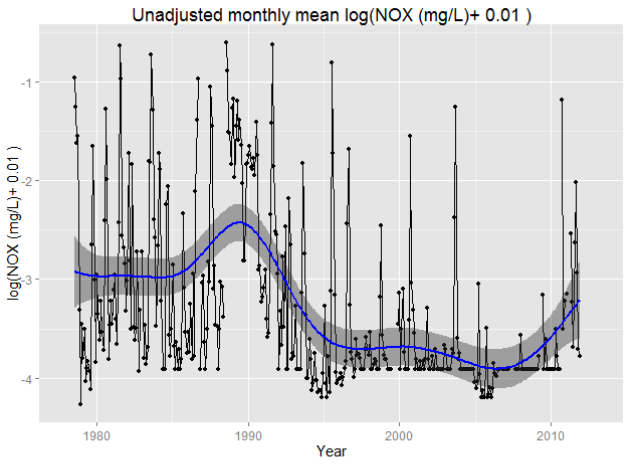


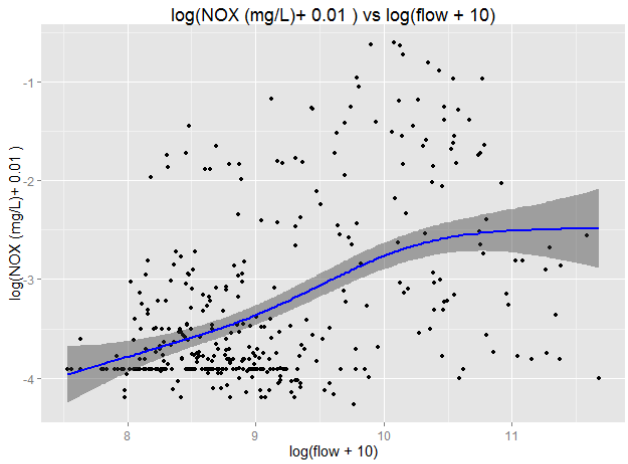


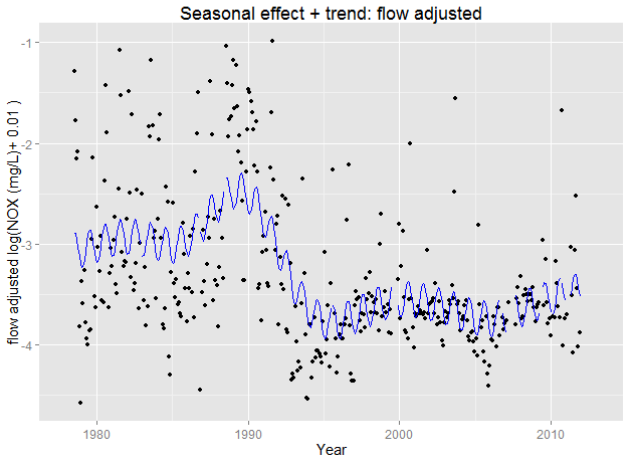


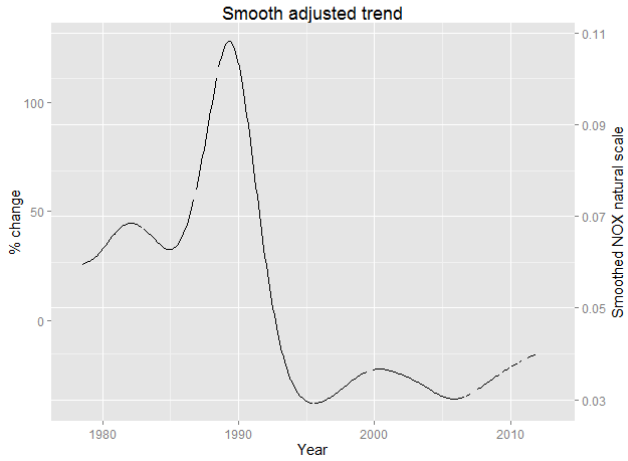


RIVER MURRAY - Merbein

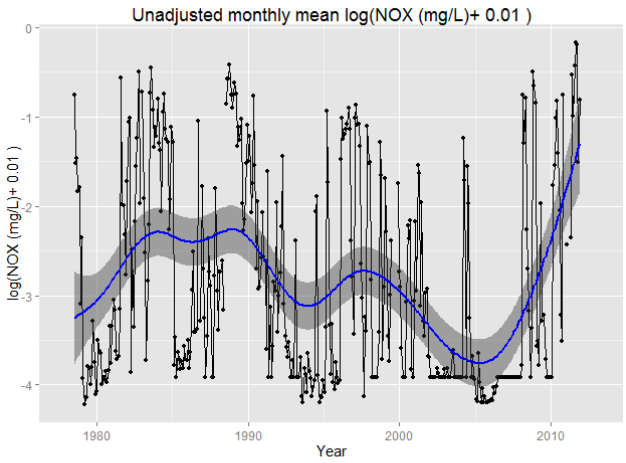


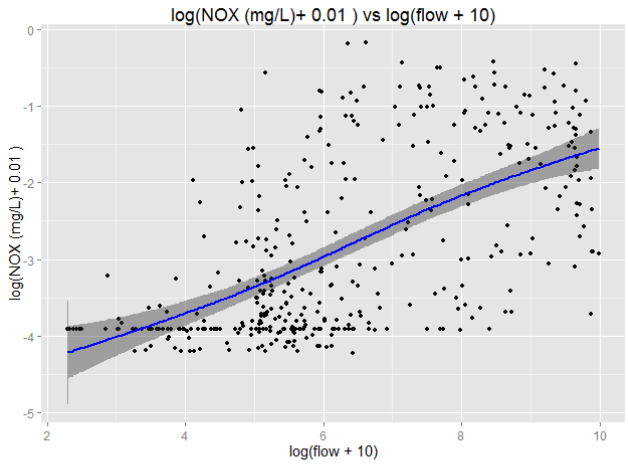


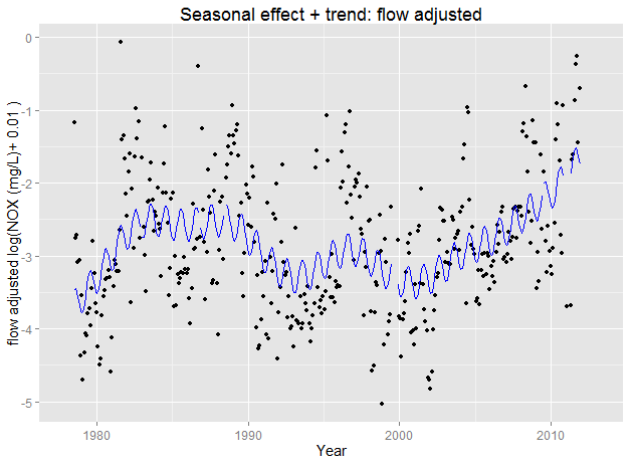


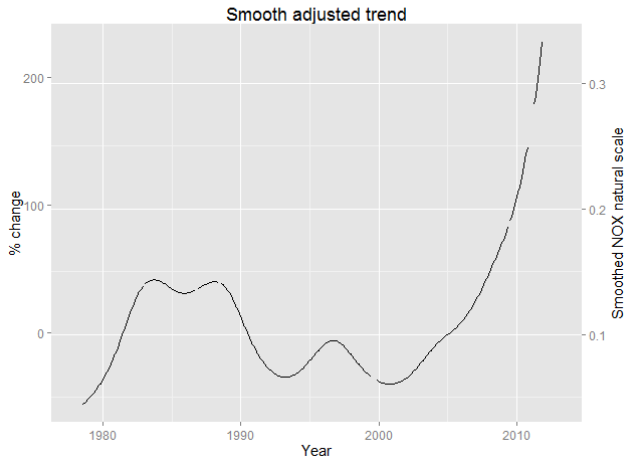


RIVER MURRAY - Burtundy

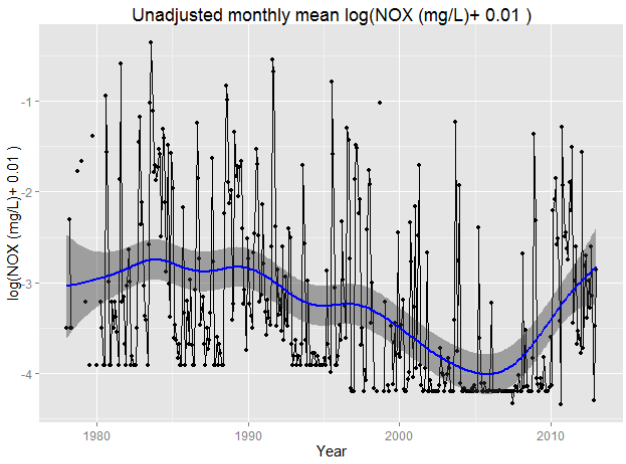


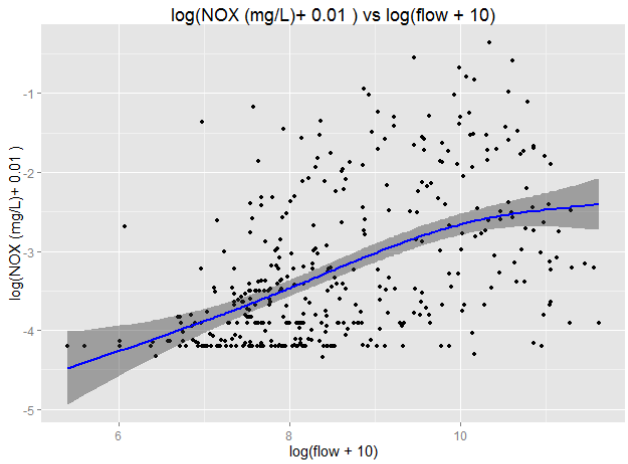


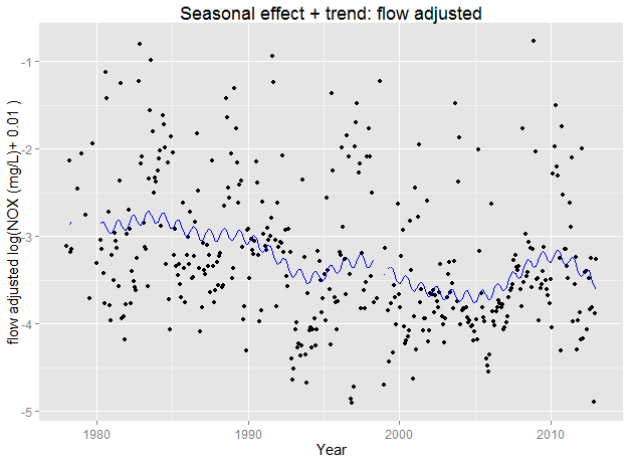


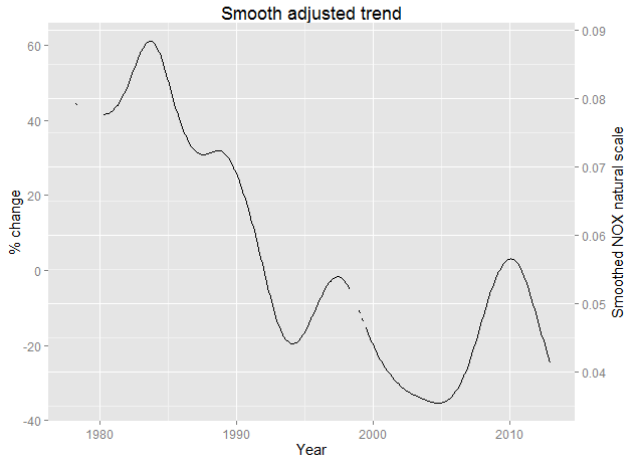


RIVER MURRAY - Lock 9

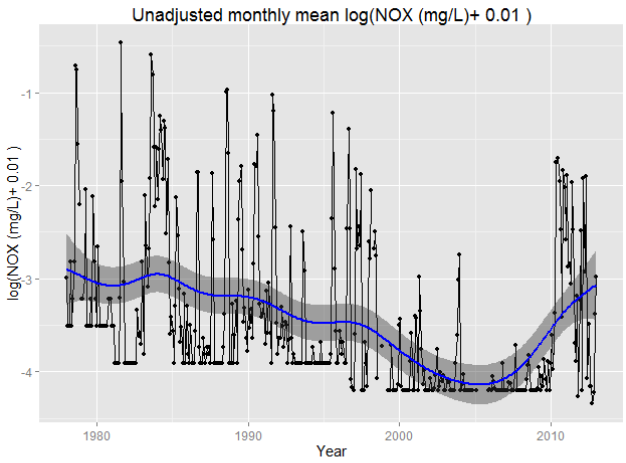


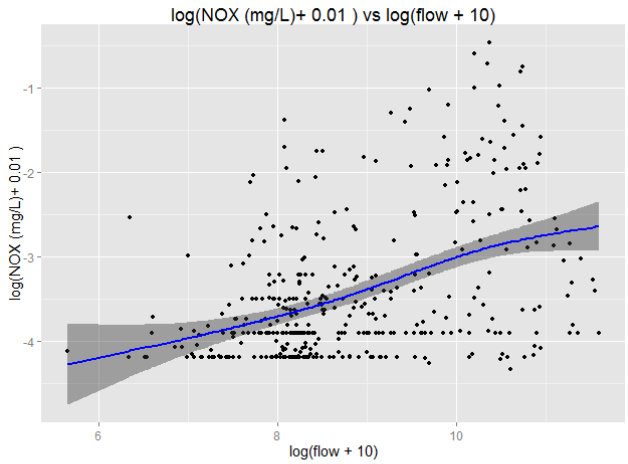


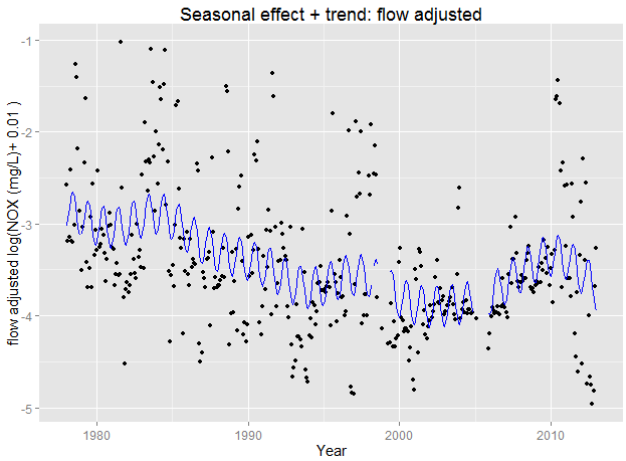


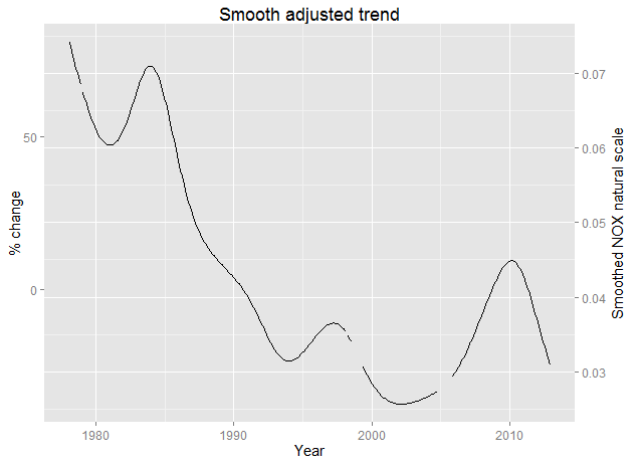


RIVER MURRAY - Morgan







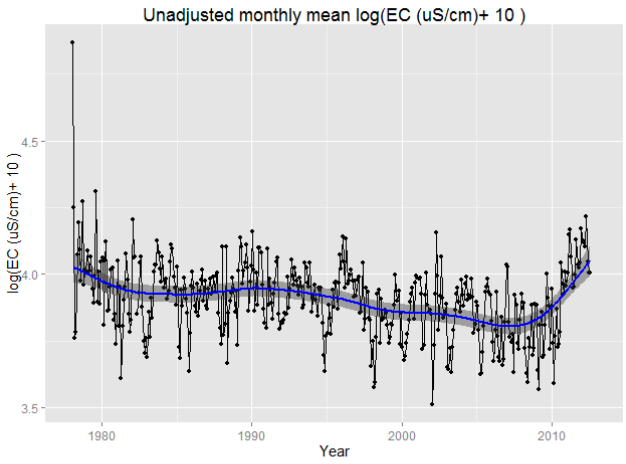


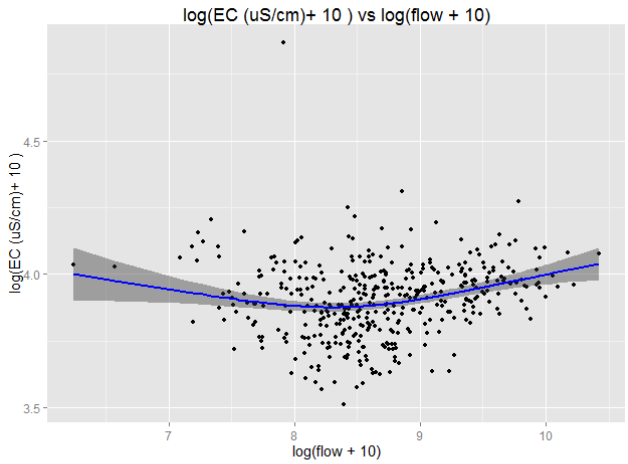
J: Salinity / Electrical Conductivity

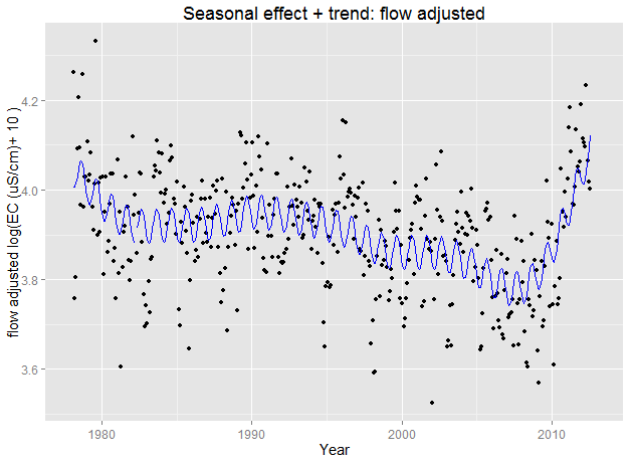
Monitoring Site	Geometric Mean	Linear Trend 1978-2012			Raw Trend 1978-2012			Linear Trend 2003-2012			Raw Trend 2003-2012		
Jingellic	39.7392	**-0.38**	**	NL	**-0.35**	**	NL	**2.18**	**	NL	**2.06**	**	NL
Tallandoon	49.9282	**-0.67**	**	NL	**-0.72**	**	NL	**-0.62**	**		-0.33		
Heywoods	50.8767	**-0.62**	**	NL	**-0.53**	**	NL	1.25		NL	1.22	*	NL
Bandiana	42.9172	**-0.84**	**	NL	**-0.82**	**	NL	0.39		NL	-0.26		NL
Peechelba	70.7703	**-0.93**	**	NL	**-0.78**	**		-1.30		NL	**-4.07**	**	NL
Yarrawonga	40.8800	**2.11**	**	NL	**2.06**	**	NL	1.41		NL	1.43	*	nl
Torrumbarry	98.0188	**-1.35**	**	NL	**-1.35**	**	NL	-0.90		NL	0.48		NL
Kerang	478.4481	-0.62		nl	**-2.01**	**	NL	-3.77		nl	-3.64		NL
Capels Flume	6959.2141	**-1.90**	**	NL	**1.23**	**	NL	**-8.10**	**	NL	**-10.52**	**	NL
Swan Hill	187.7514	**-3.80**	**	NL	**-3.83**	**	NL	-0.95		NL	1.05		NL
Kyalite	192.4274	**-1.86**	**	NL	**-1.81**	**	NL	0.35			0.03		
Euston Weir	205.3906	**-3.15**	**	NL	**-2.90**	**	NL	**-3.71**	**		-3.06	*	
Merbein	241.0862	**-3.66**	**	NL	**-3.37**	**	NL	-2.16		nl	-0.75		
Burtundy	483.9665	-0.52		NL	0.41		NL	-6.32	*	nl	**-13.90**	**	NL
Lock 9	303.0559	**-3.64**	**	NL	**-3.26**	**	NL	2.43			-0.32		
Morgan	522.1754	**-2.29**	**	NL	**-2.12**	**		-1.15			-3.56	*	NL

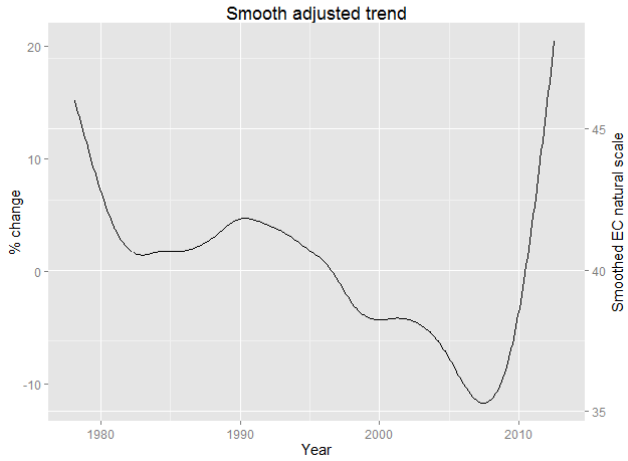
Monitoring Site	Geometric Mean	Relationship to Log flow	Significance	Amplitude(log scale)	Seasonal Peak	Autocorrelation
Jingellic	39.7392	-	**	0.0594	7.8539	0.4441
Tallandoon	49.9282	-	**	0.0473	2.1202	0.2741
Heywoods	50.8767	-	**	0.0285	0.7263	0.5690
Bandiana	42.9172	-	*	0.0405	5.3465	0.3116
Peechelba	70.7703	-	**	0.0374	2.2624	0.3375
Yarrawonga	40.8800	+	*	0.0993	5.4658	0.6919
Torrumbarry	98.0188	+		0.1537	6.7477	0.4613
Kerang	478.4481	+	**	0.7418	6.8365	0.3895
Capels Flume	6959.2141	-	**	0.3751	7.3727	0.1999
Swan Hill	187.7514	+		0.1712	6.6416	0.5328
Kyalite	192.4274	-	**	0.0879	5.6584	0.3242
Euston Weir	205.3906	-	**	0.1425	7.1434	0.4827
Merbein	241.0862	-	**	0.0305	6.8290	0.4963
Burtundy	483.9665	-	**	0.1778	1.1500	0.7686
Lock 9	303.0559	-	**	0.0473	1.1278	0.6128
Morgan	522.1754	-	**	0.0439	7.0281	0.6609

RIVER MURRAY - Jingellic

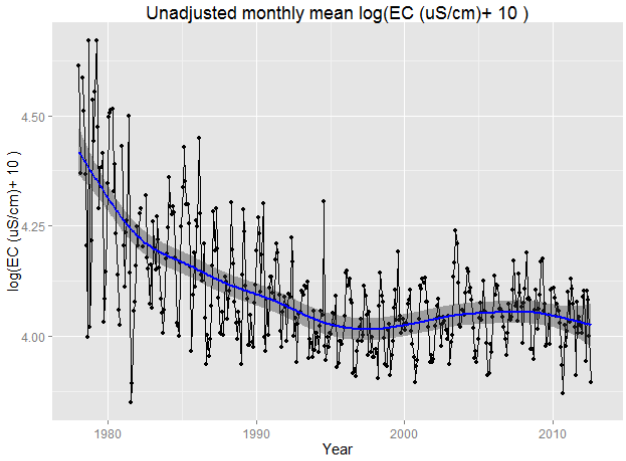


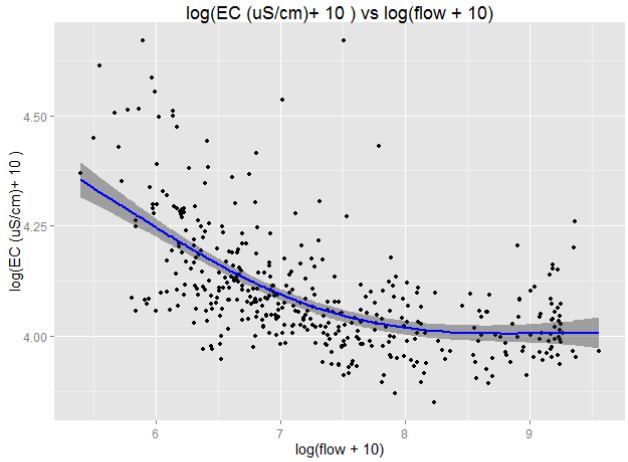


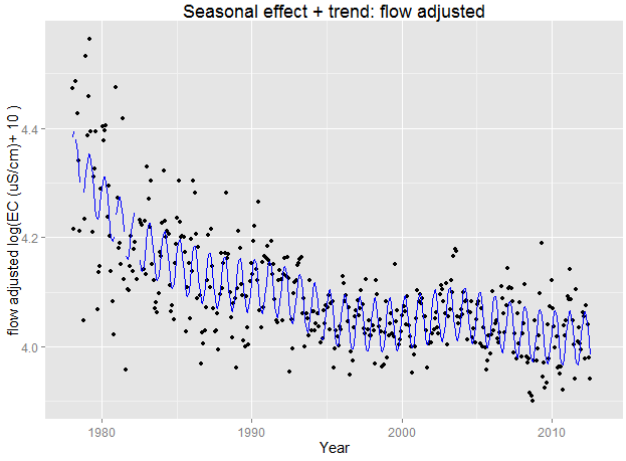


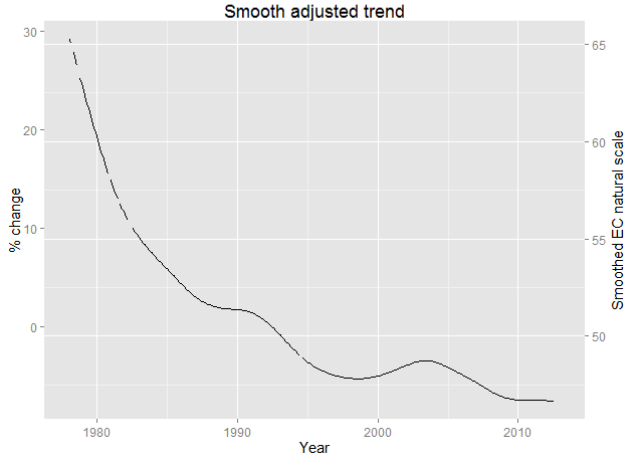


RIVER MURRAY - Tallandoon

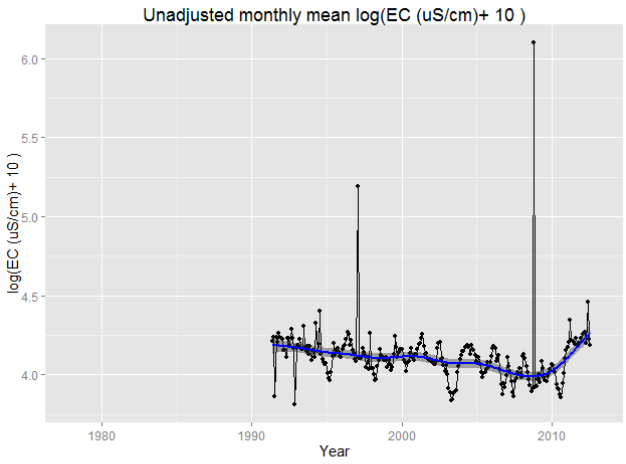


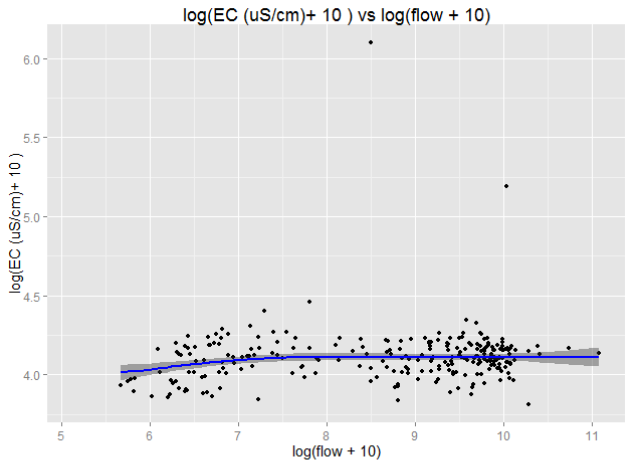


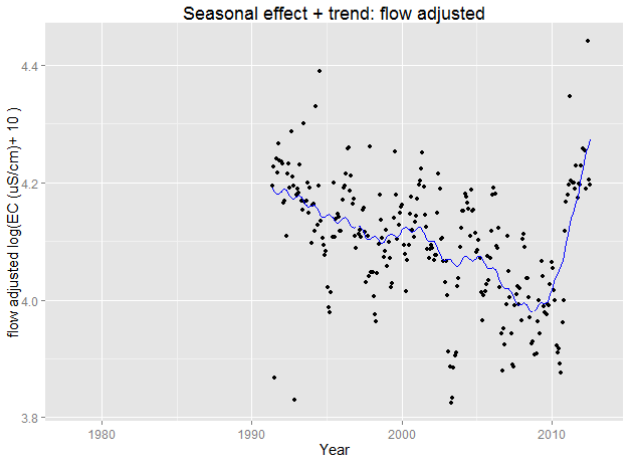


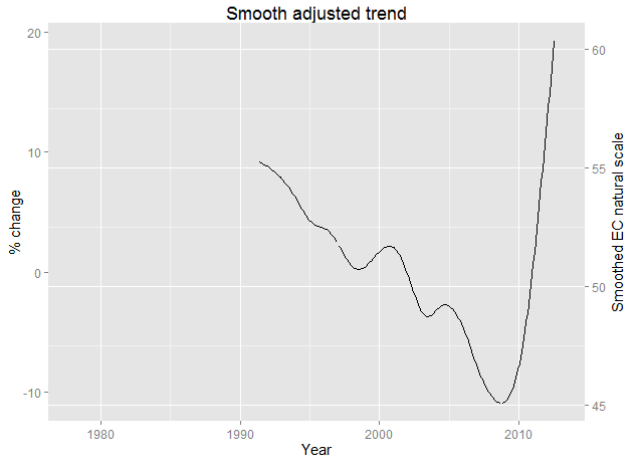


RIVER MURRAY - Heywoods

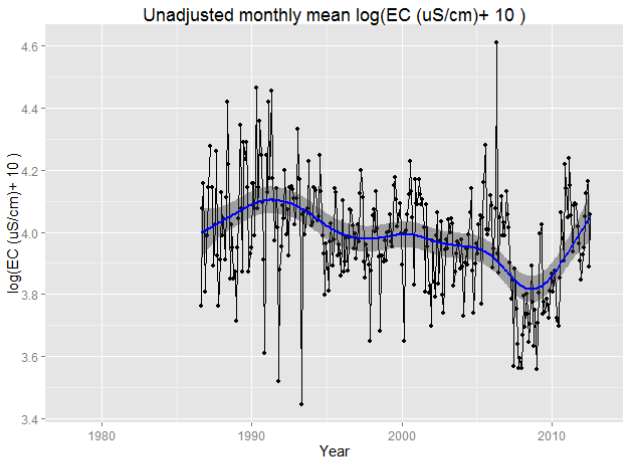


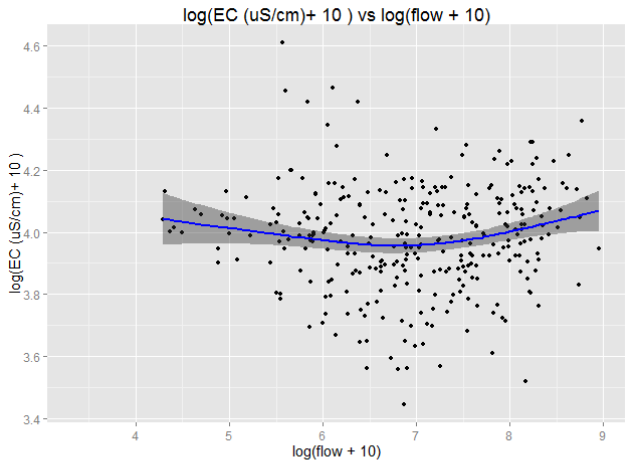


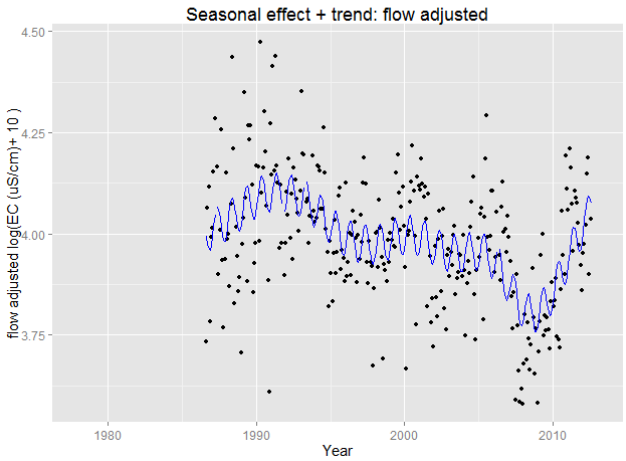


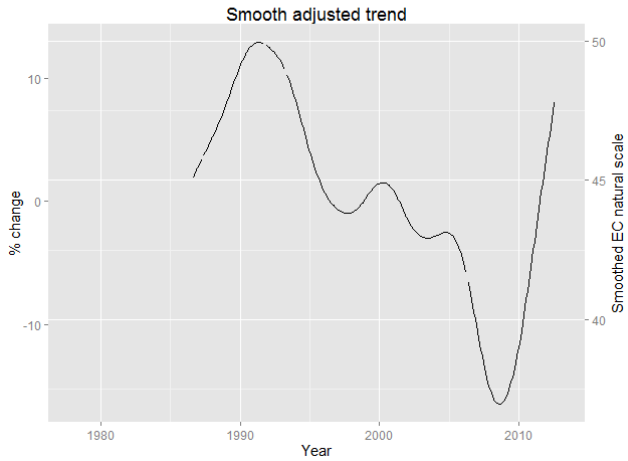


RIVER MURRAY - Bandiana

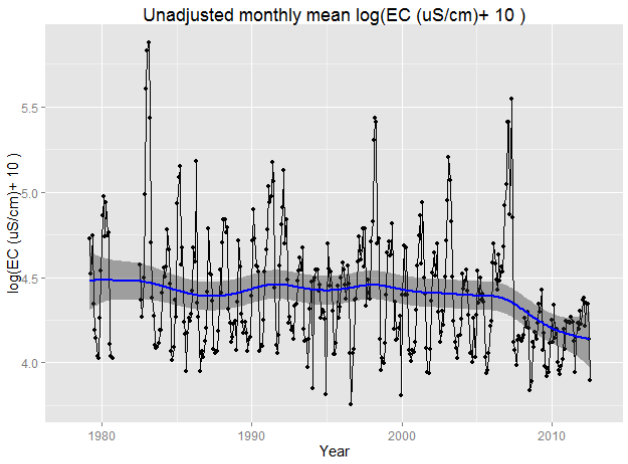


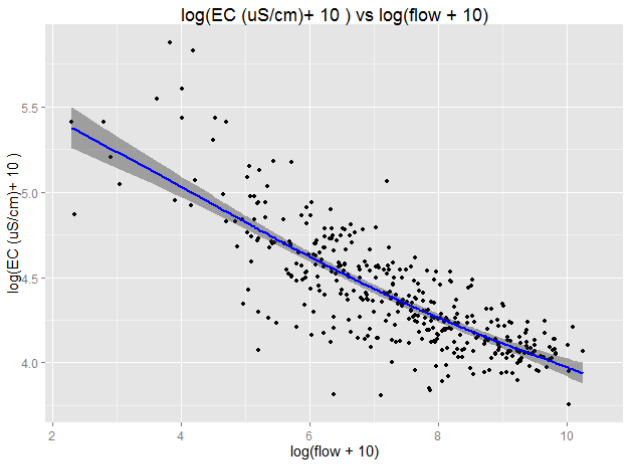


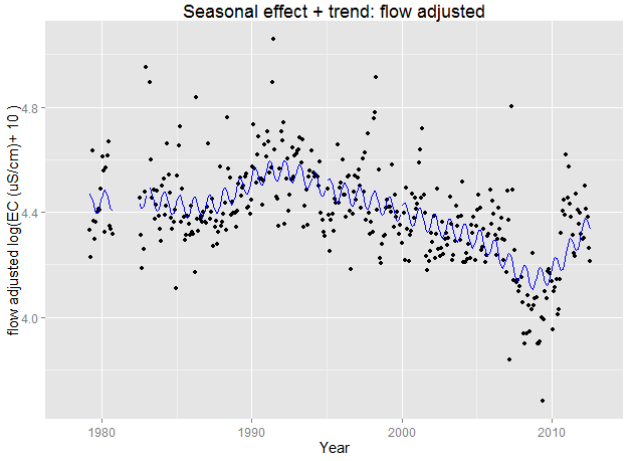


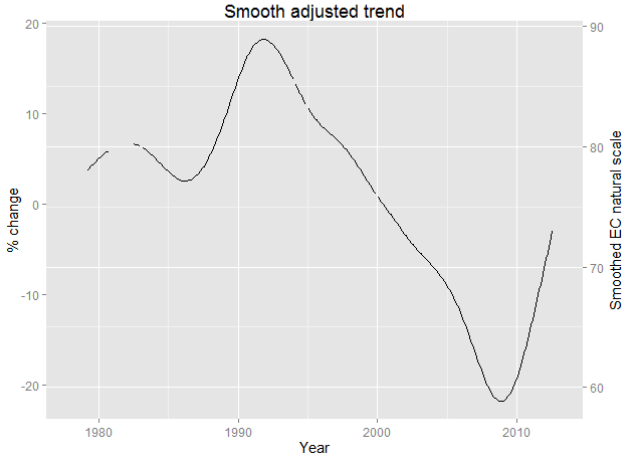


RIVER MURRAY - Peechelba

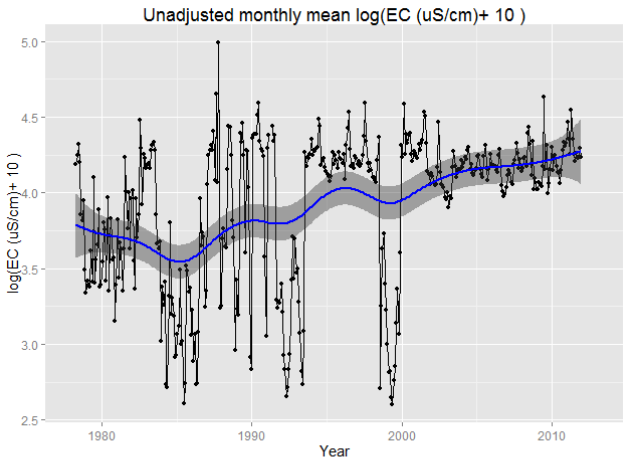


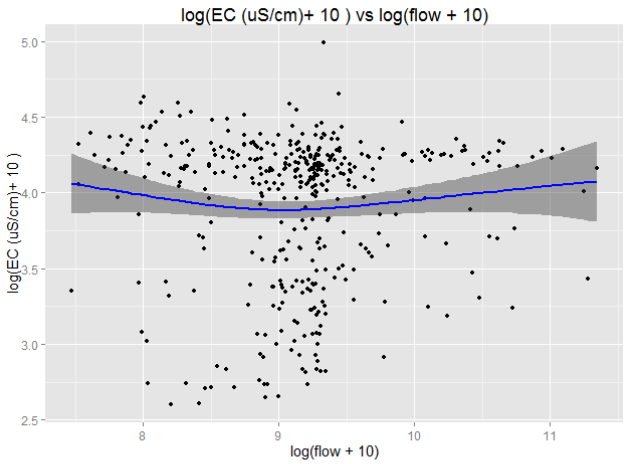


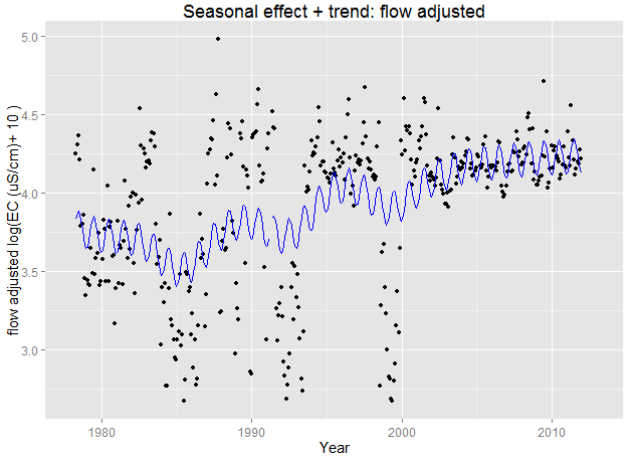


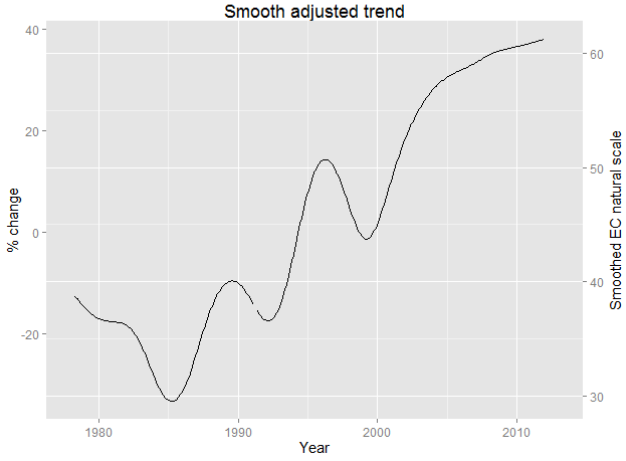


RIVER MURRAY - Yarrawonga

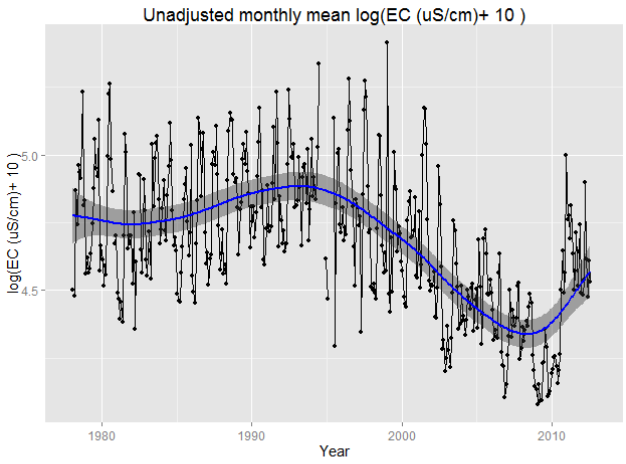


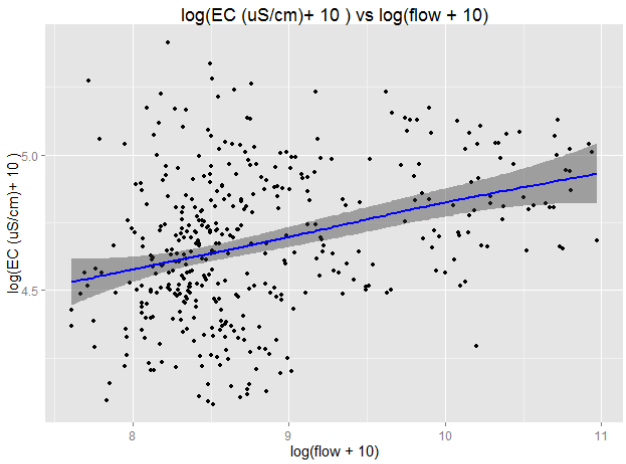


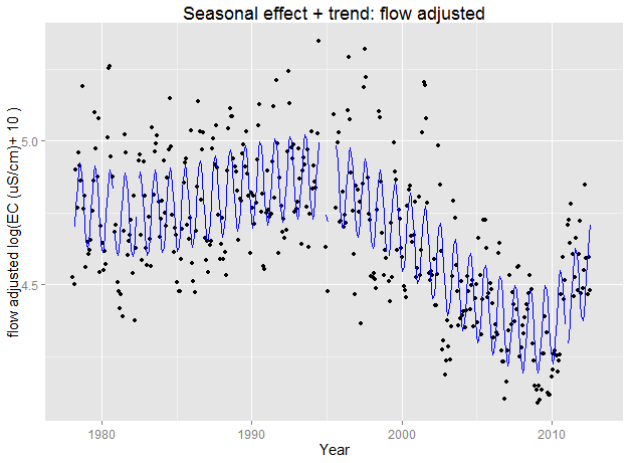


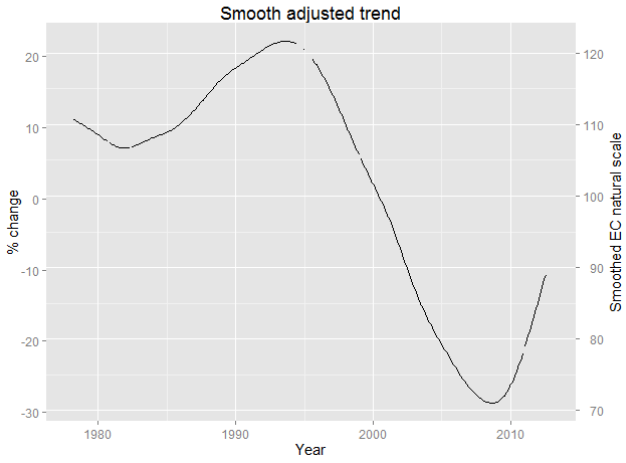


RIVER MURRAY - Torrumbarry

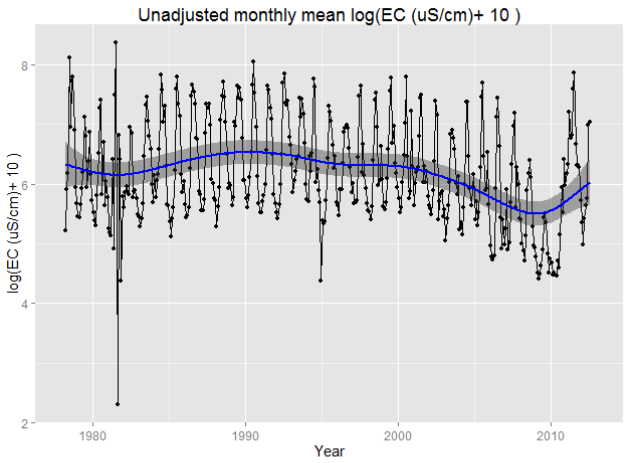


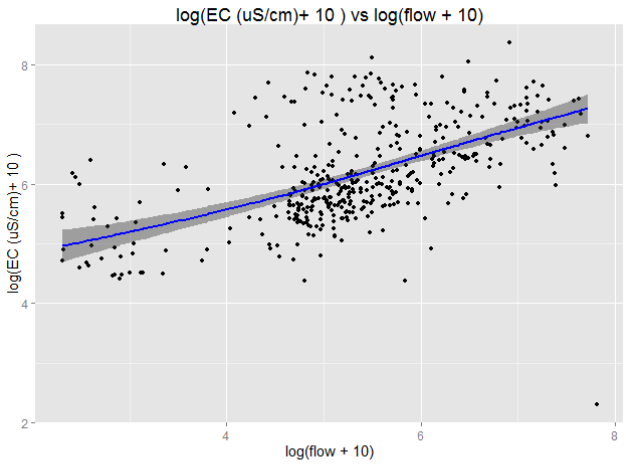


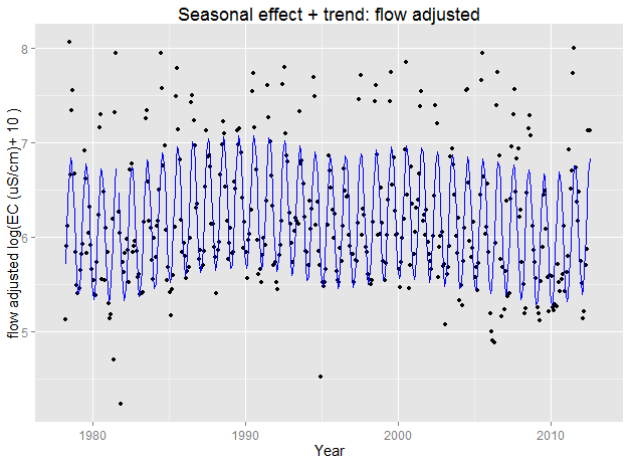


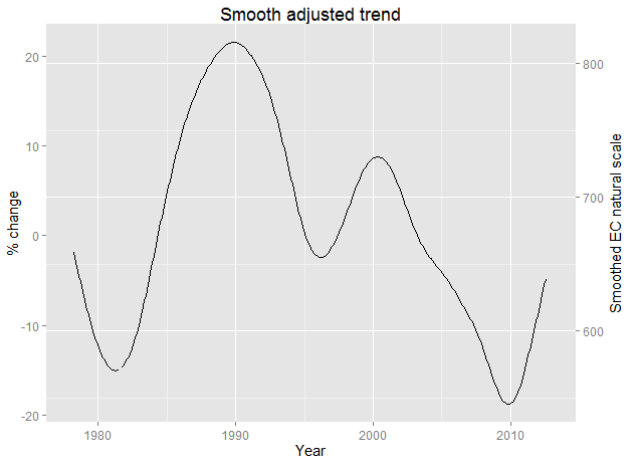


RIVER MURRAY - Kerang

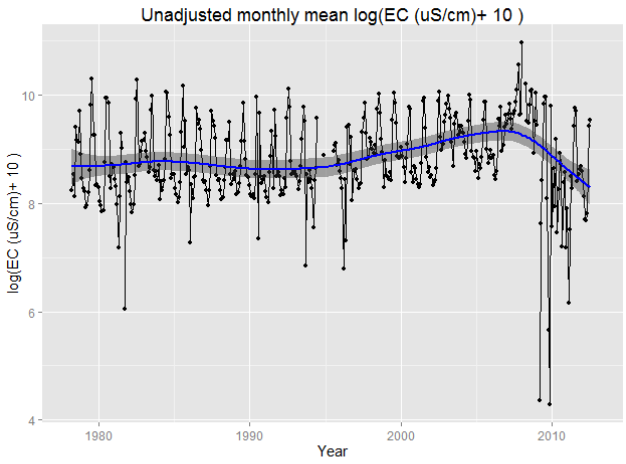


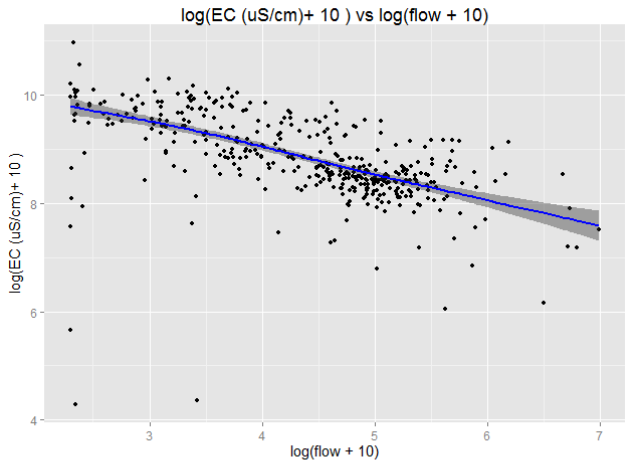


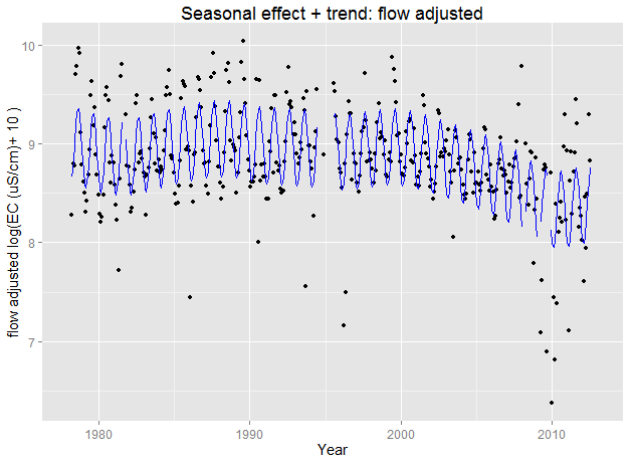


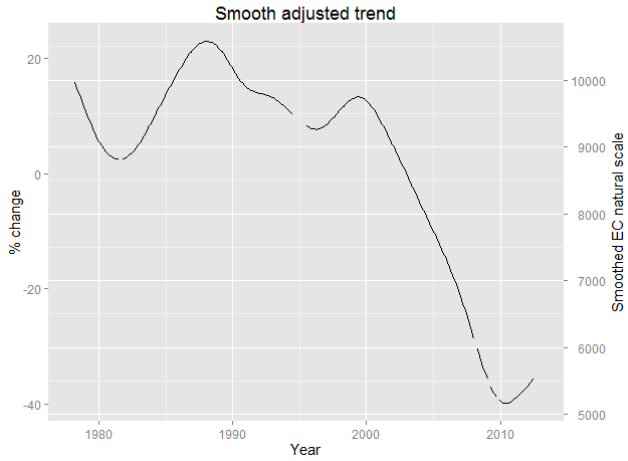


RIVER MURRAY - Capels Flume

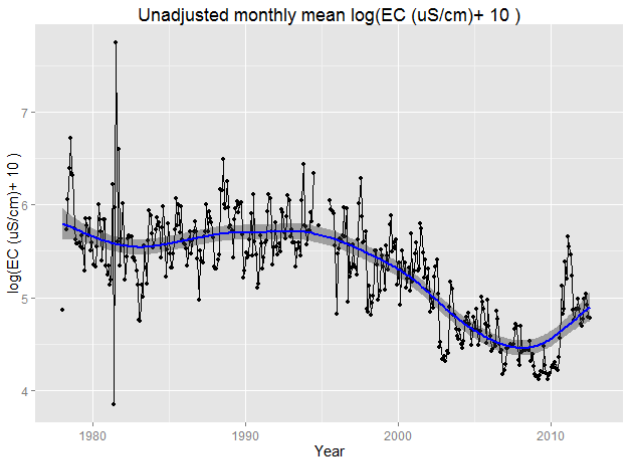


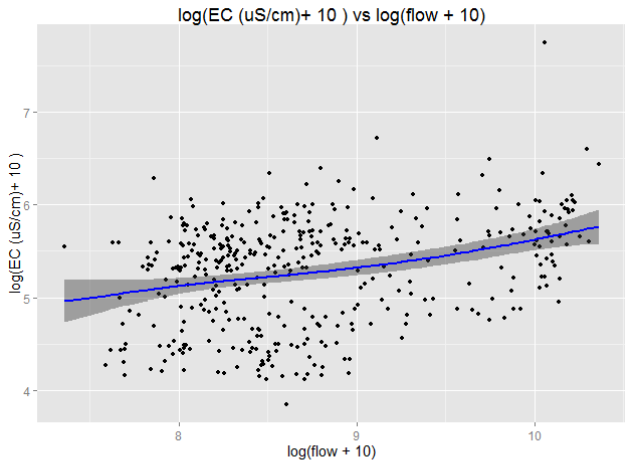


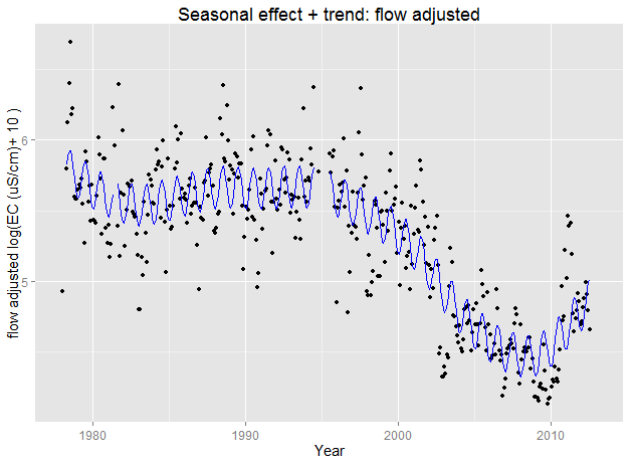


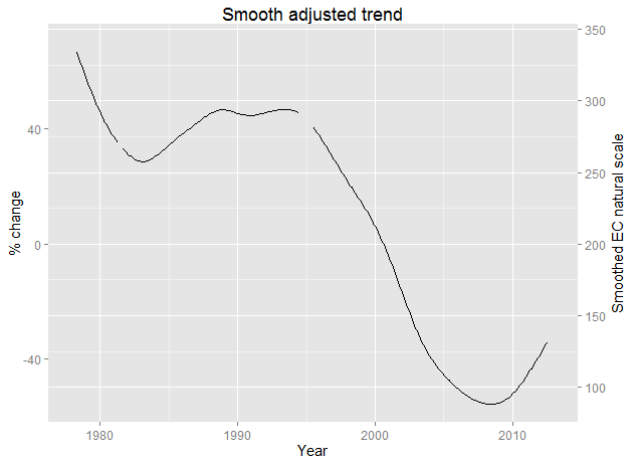


RIVER MURRAY - Swan Hill

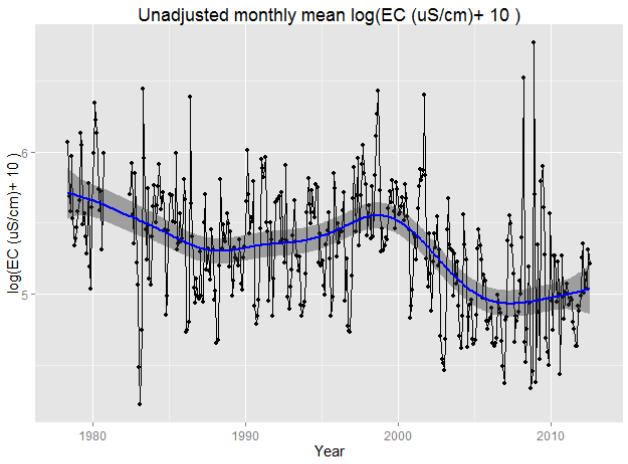


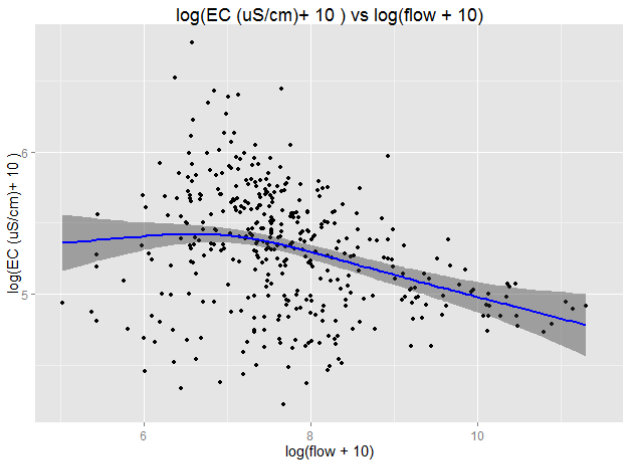


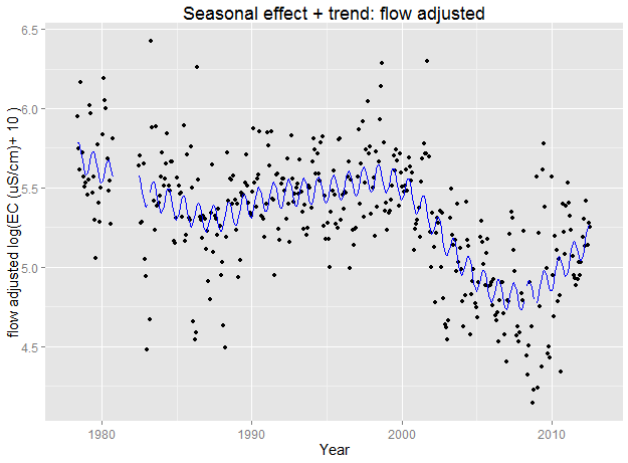


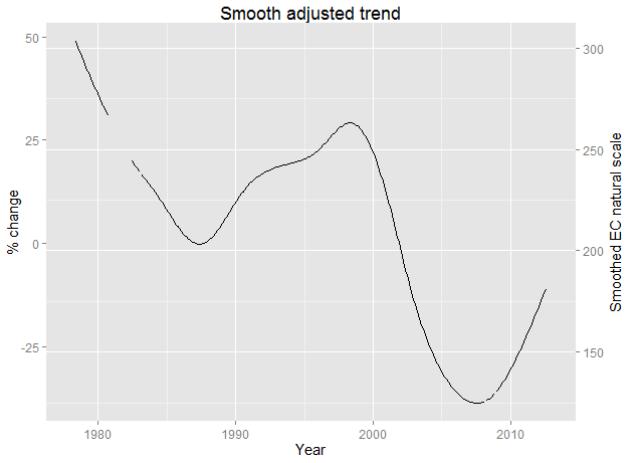


RIVER MURRAY - Kyalite

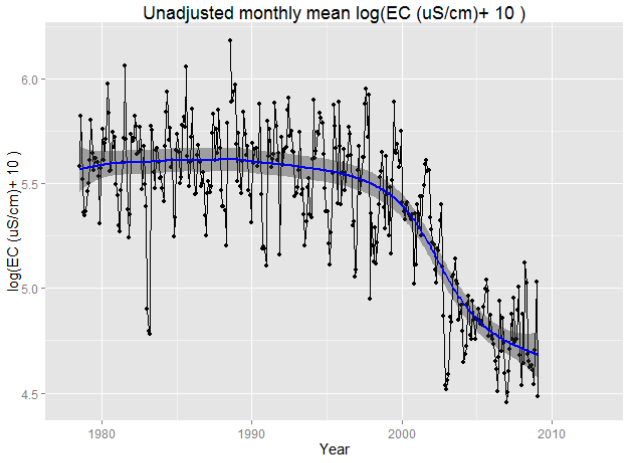


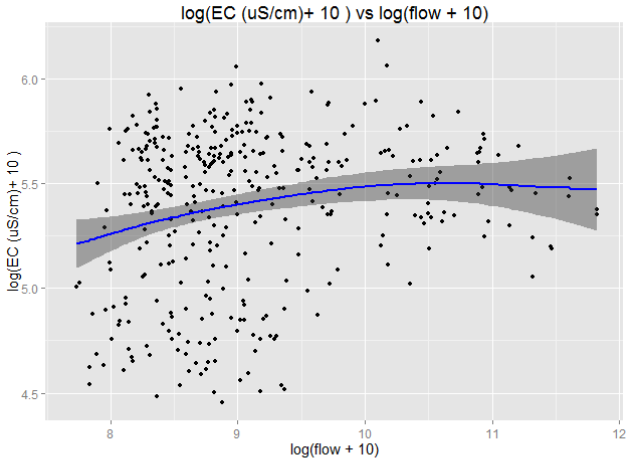


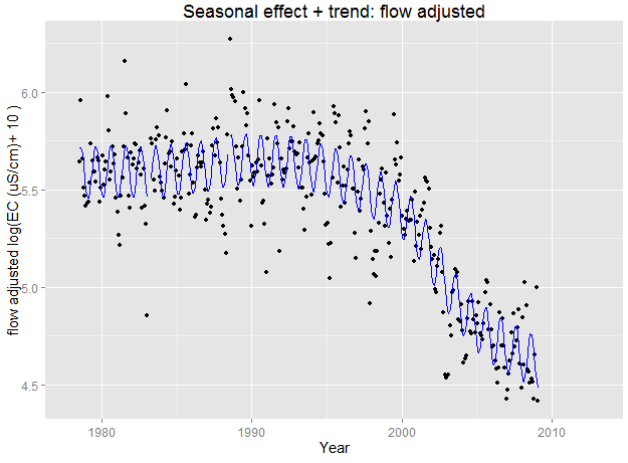


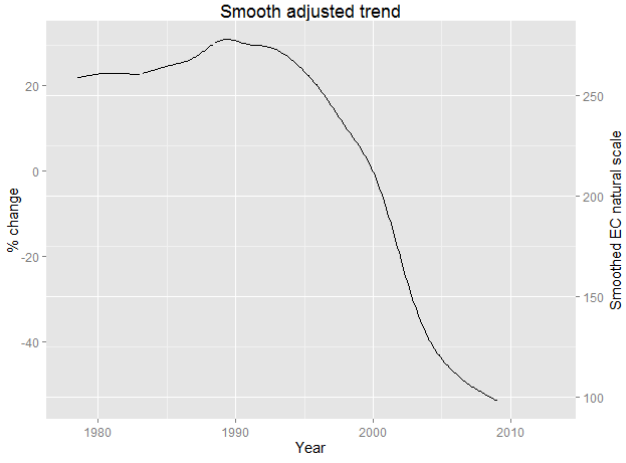


RIVER MURRAY - Euston Weir

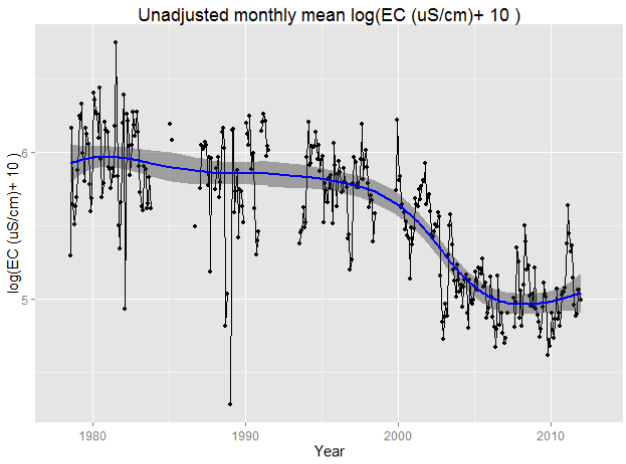


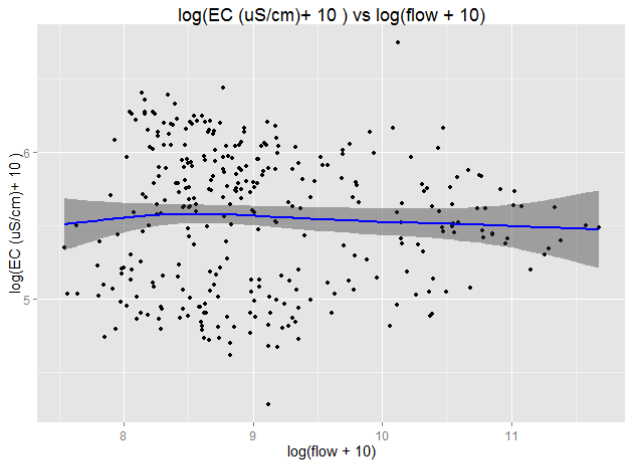


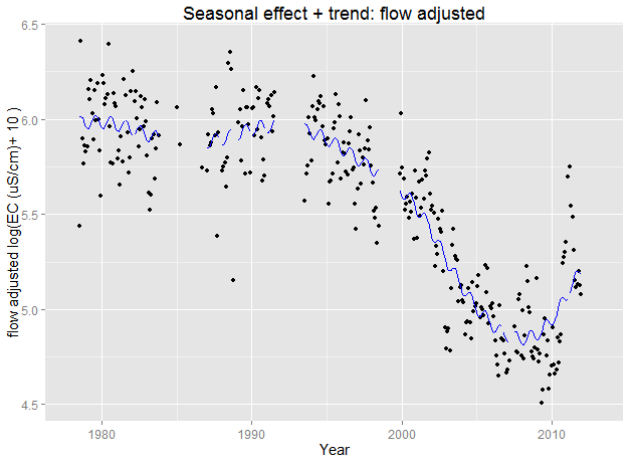


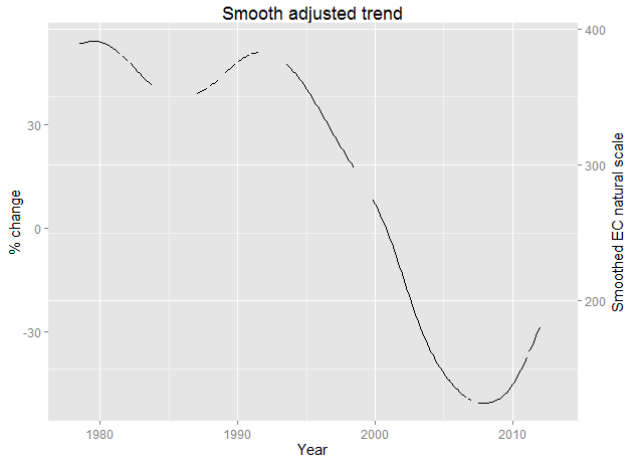


RIVER MURRAY - Merbein

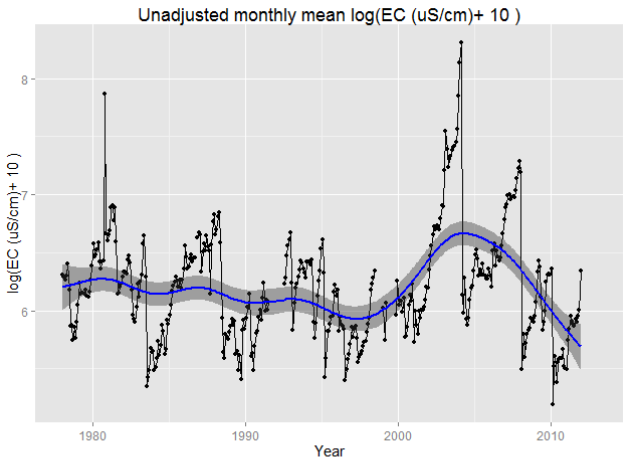


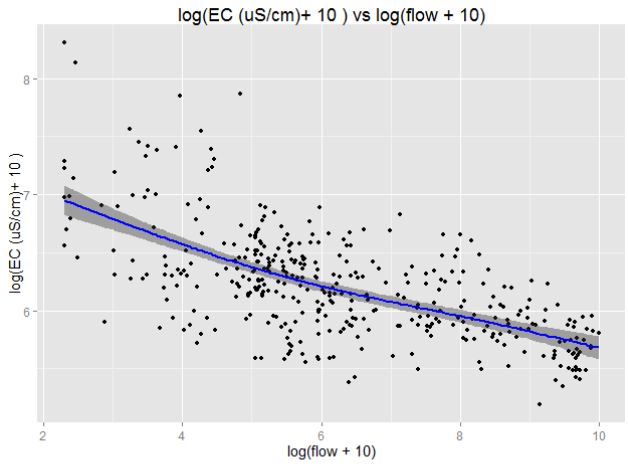


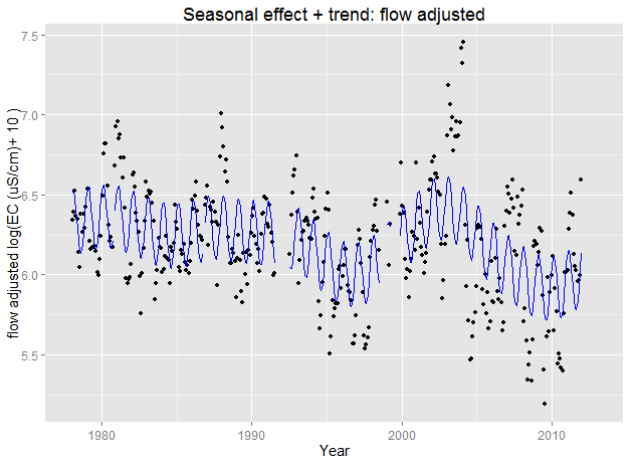


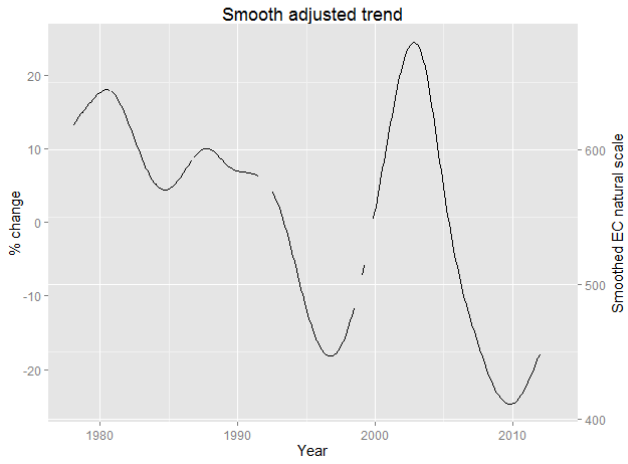


RIVER MURRAY - Burtundy

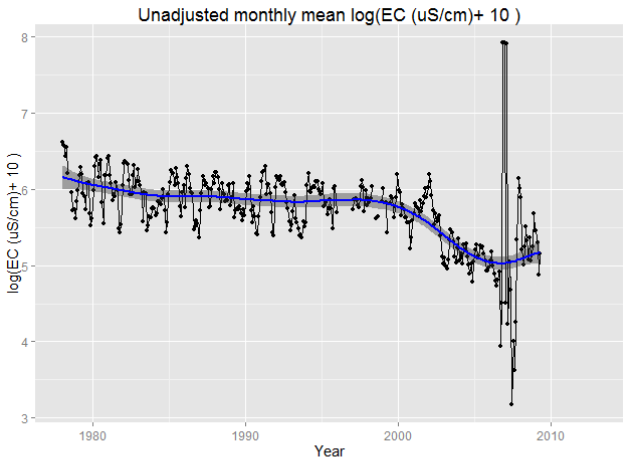


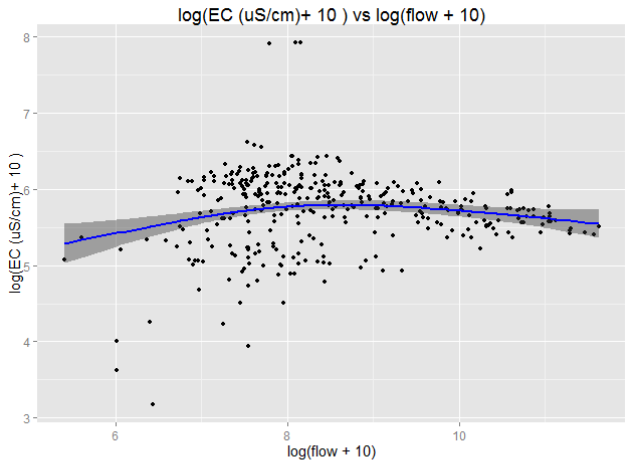


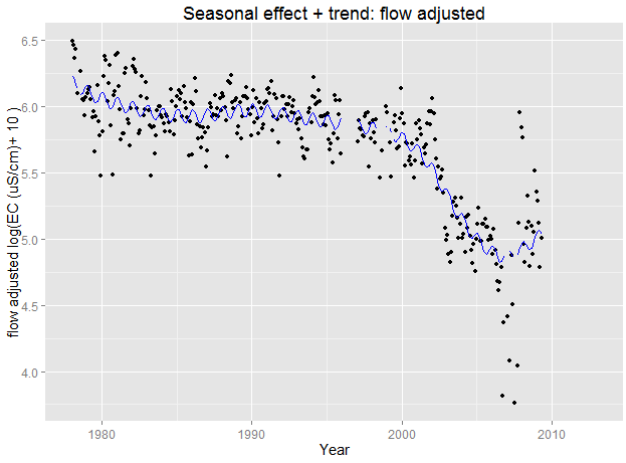


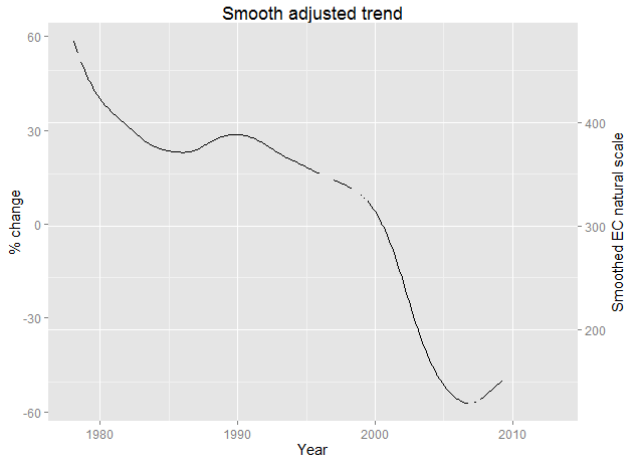


RIVER MURRAY - Lock 9

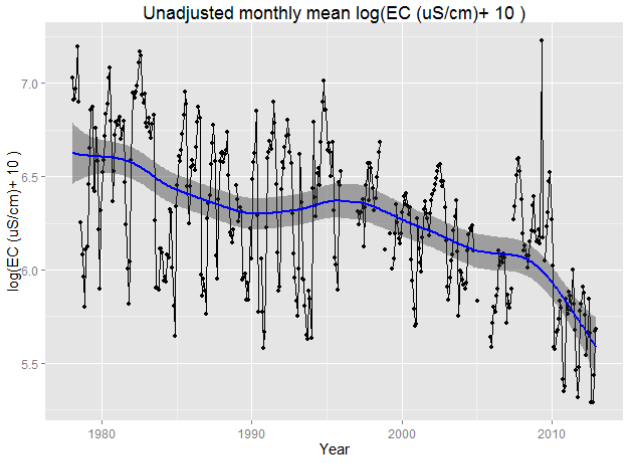


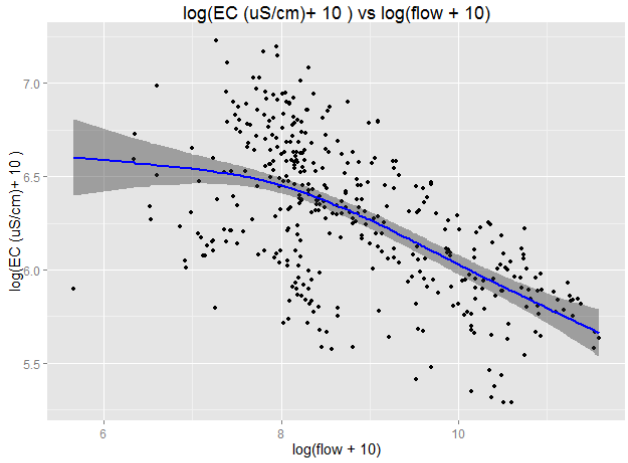


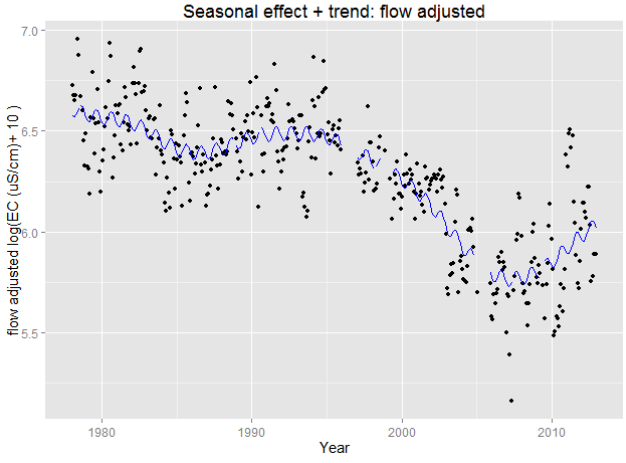


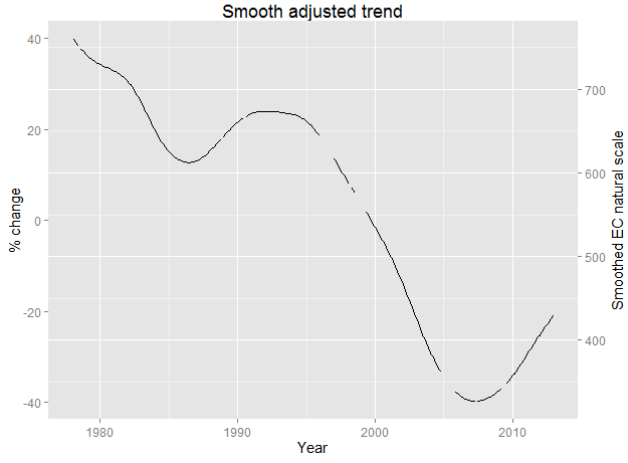


RIVER MURRAY - Morgan







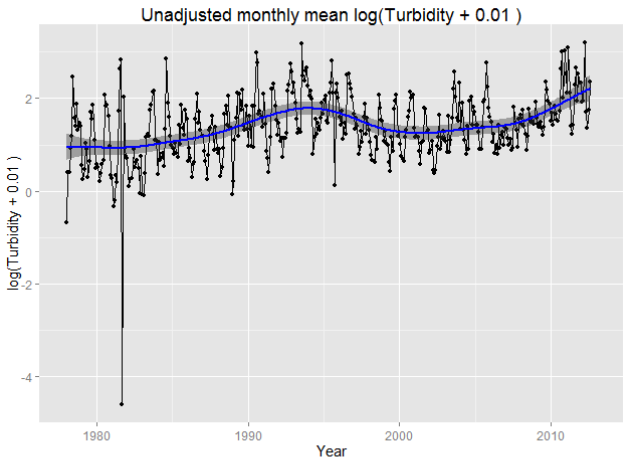


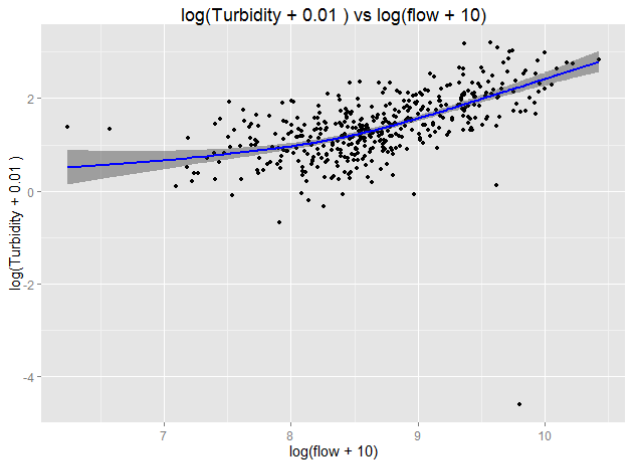
K: Turbidity

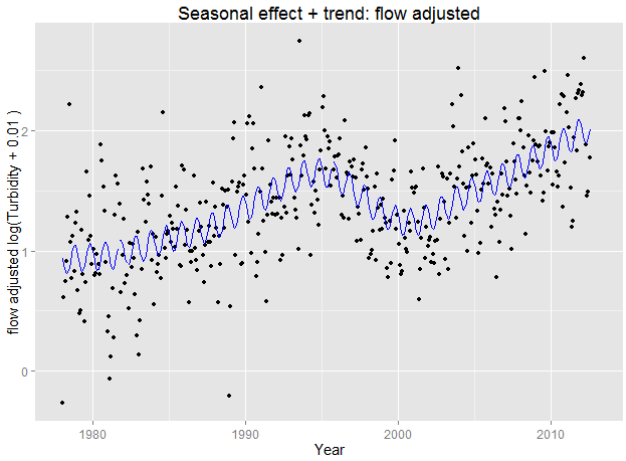
Monitoring Site	Geometric Mean	Linear Trend 1978-2012			Raw Trend 1978-2012			Linear Trend 2003-2012			Raw Trend 2003-2012		
Jingellic	4.0468	**2.50**	**	NL	**2.19**	**	NL	**6.02**	**	nl	**8.32**	**	NL
Tallandoon	3.1216	**1.21**	**	NL	**1.39**	**	NL	**4.21**	**		**5.22**	**	nl
Heywoods	4.7881	1.51	*		1.43	*		1.39		NL	0.56		NL
Bandiana	6.7841	**2.71**	**	NL	**1.84**	**	NL	**4.43**	**	NL	**9.57**	**	
Peechelba	12.2323	**3.02**	**	NL	**2.78**	**	NL	-0.25		NL	4.21		
Yarrawonga	8.7002	**2.50**	**	NL	**2.16**	**	NL	**6.43**	**	NL	**8.14**	**	NL
Torrumbarry	18.3801	0.11		NL	-0.09		NL	**7.94**	**		**11.34**	**	
Kerang	51.8389	**1.01**	**	NL	**1.68**	**	NL	**14.69**	**	NL	**11.51**	**	NL
Capels Flume	19.0898	0.44		NL	**-1.22**	**	NL	**15.63**	**	NL	**15.75**	**	nl
Swan Hill	26.7446	-0.18		nl	-0.31		NL	**5.66**	**		**7.52**	**	
Kyalite	40.5819	**-2.03**	**	NL	**-1.92**	**	NL	**8.74**	**		5.88	*	
Euston Weir	25.6991	**-1.06**	**	NL	**-1.29**	**	NL	**6.34**	**		6.25	*	nl
Merbein	22.0540	-0.62	*	NL	**-1.27**	**	NL	**7.51**	**		**7.81**	**	NL
Burtundy	89.4642	**2.63**	**	NL	0.42		NL	13.49		nl	**31.51**	**	nl
Lock 9	36.2455	**-2.60**	**	NL	**-3.88**	**	NL	1.82			-0.83		
Morgan	46.0714	**-2.29**	**	NL	**-3.16**	**	NL	**-17.01**	**	NL	**-24.20**	**	NL

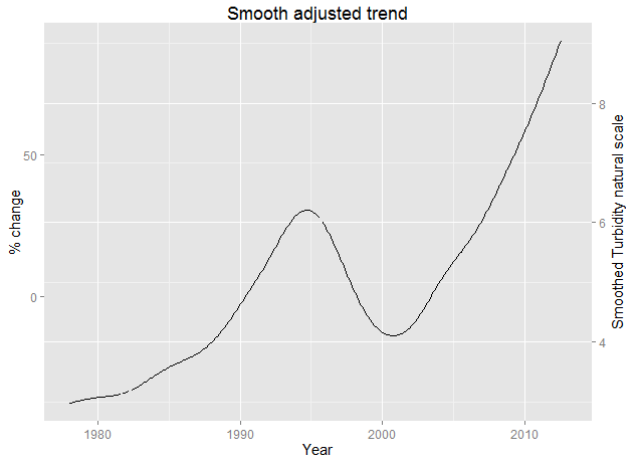
Monitoring Site	Geometric Mean	Relationship to Log flow	Significance	Amplitude(log scale)	Seasonal Peak	Autocorrelation
Jingellic	4.0468	+	**	0.1101	9.6303	0.2970
Tallandoon	3.1216	+	**	0.2479	7.7453	0.4665
Heywoods	4.7881	-	*	0.2183	10.4035	0.7372
Bandiana	6.7841	+	**	0.1422	1.6139	0.1770
Peechelba	12.2323	+	**	0.2161	2.0526	0.3553
Yarrawonga	8.7002	+	**	0.3024	8.1577	0.4196
Torrumbarry	18.3801	+	**	0.0790	11.0980	0.4023
Kerang	51.8389	-	**	0.5504	11.6231	0.2910
Capels Flume	19.0898	+	**	0.4597	0.6038	0.2819
Swan Hill	26.7446	+	**	0.1534	11.7899	0.4427
Kyalite	40.5819	-	**	0.1630	11.0012	0.5757
Euston Weir	25.6991	+	**	0.2169	10.9789	0.4373
Merbein	22.0540	+	**	0.1417	10.4942	0.4065
Burtundy	89.4642	+	**	0.2035	8.3337	0.6759
Lock 9	36.2455	+	**	0.2141	11.8124	0.5162
Morgan	46.0714	+	**	0.0526	0.3993	0.6804

RIVER MURRAY - Jingellic

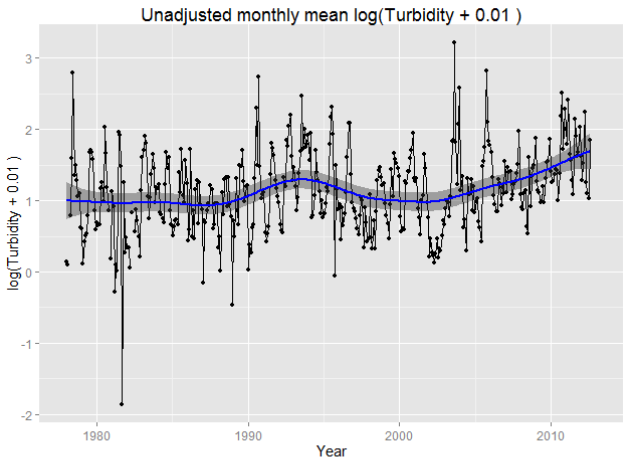


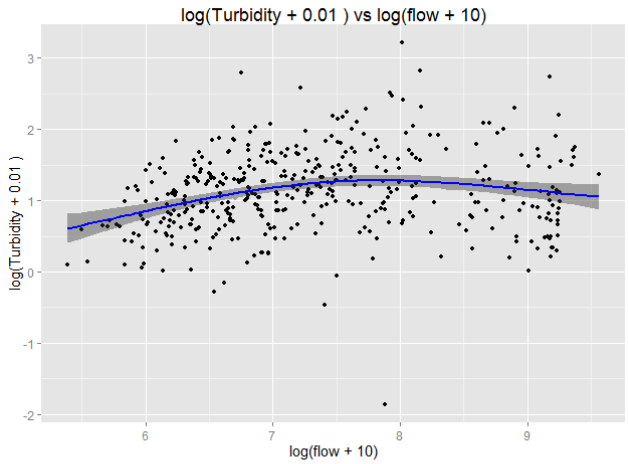


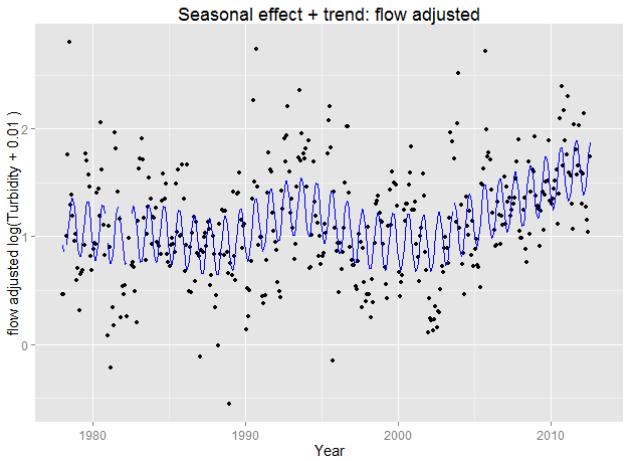


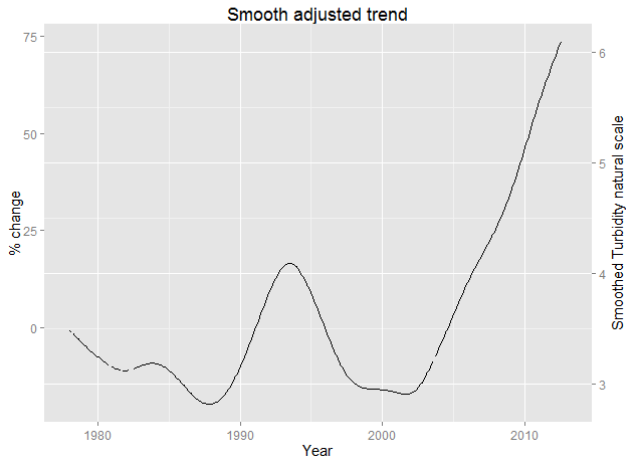


RIVER MURRAY - Tallandoon

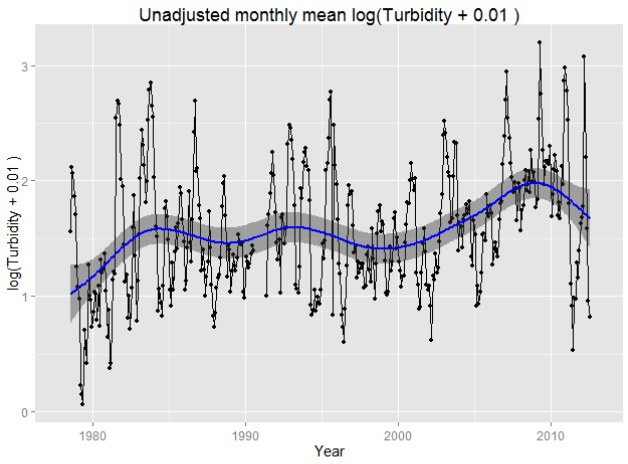


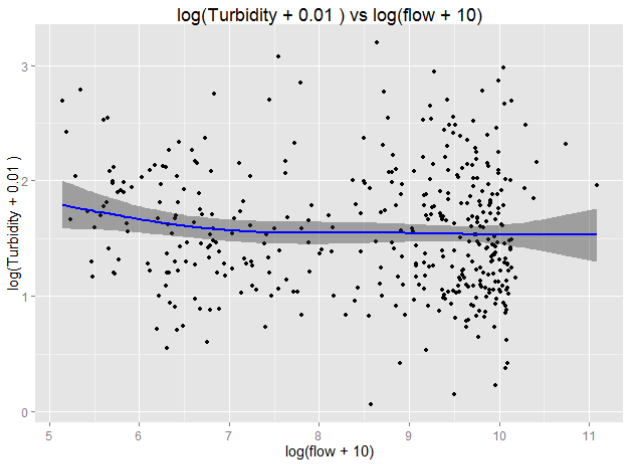


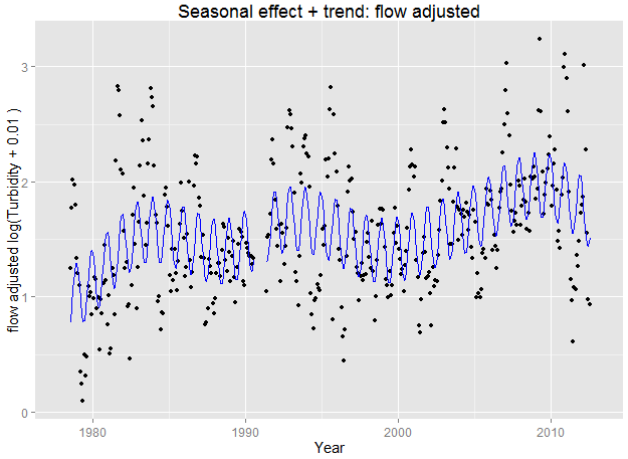


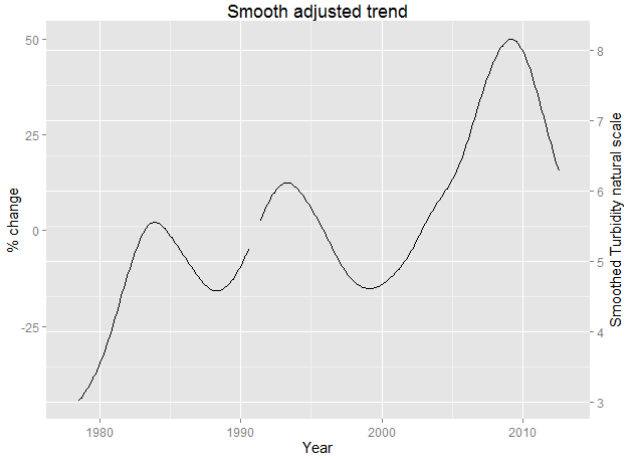


RIVER MURRAY - Heywoods

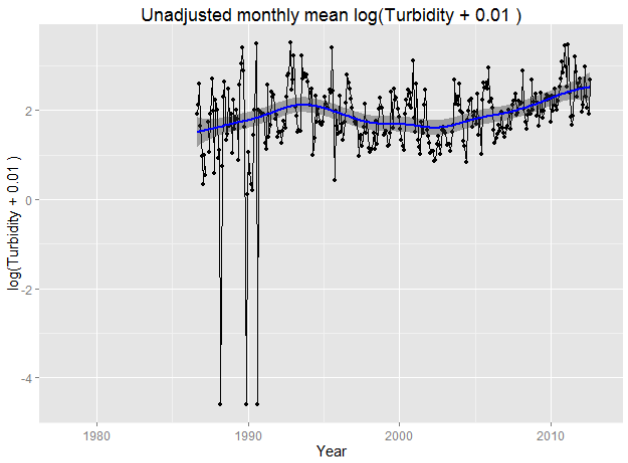


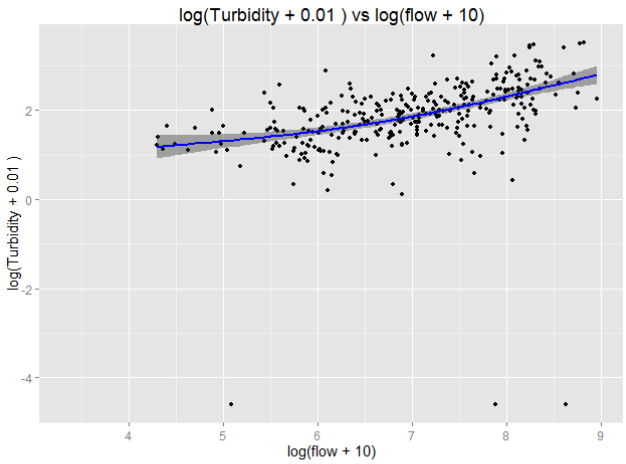


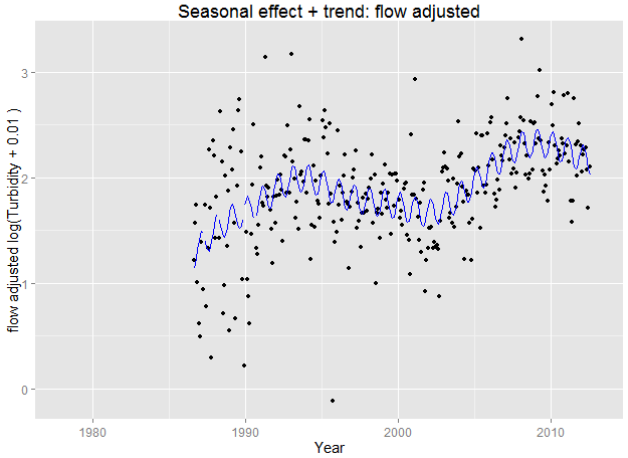


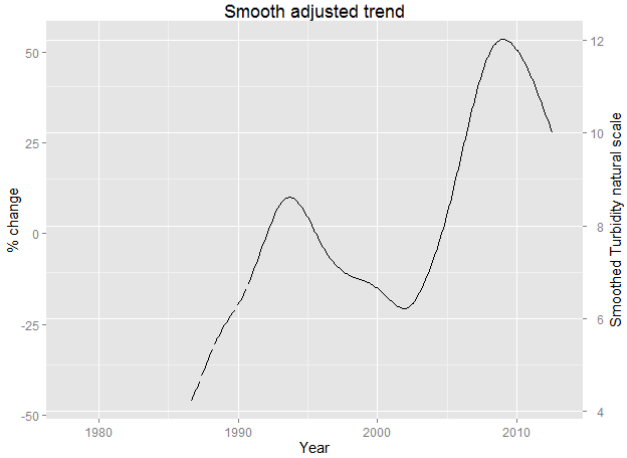


RIVER MURRAY - Bandiana

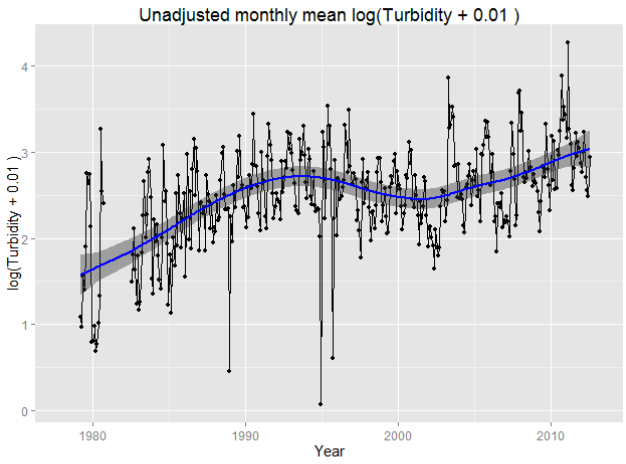


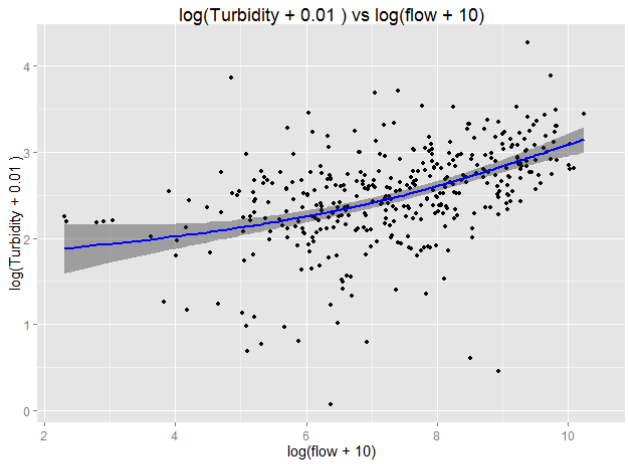


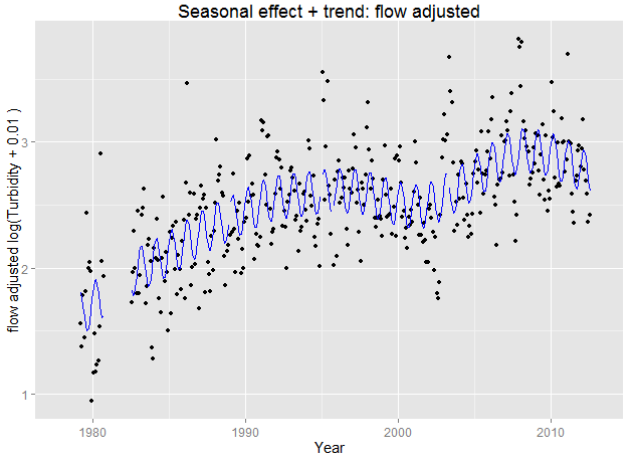


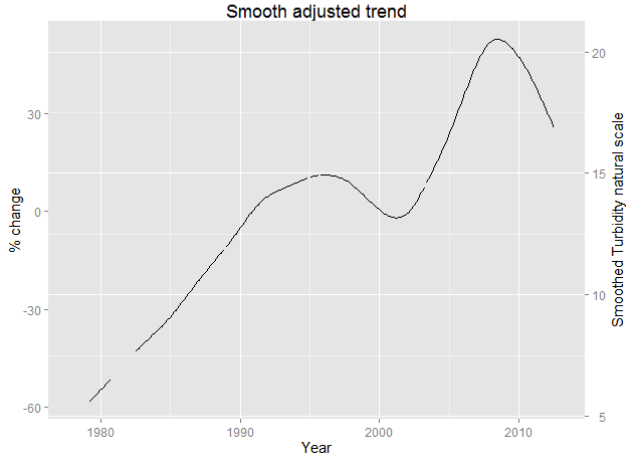


RIVER MURRAY - Peechelba

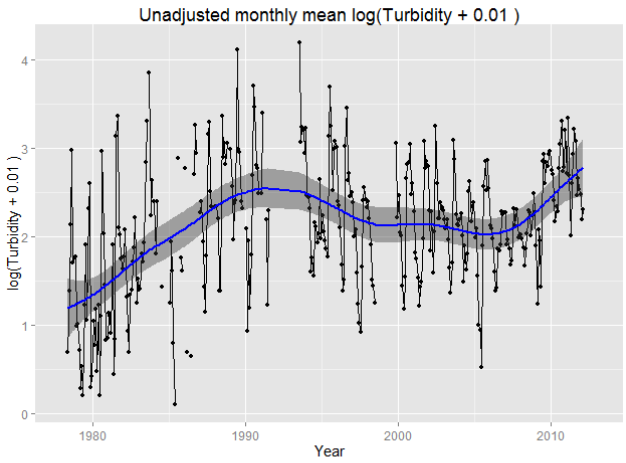


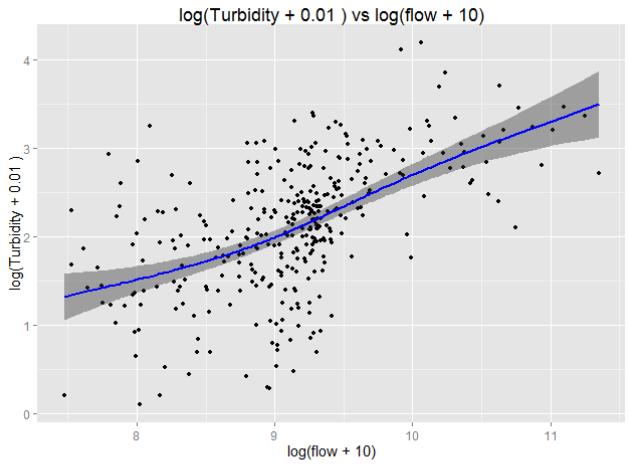


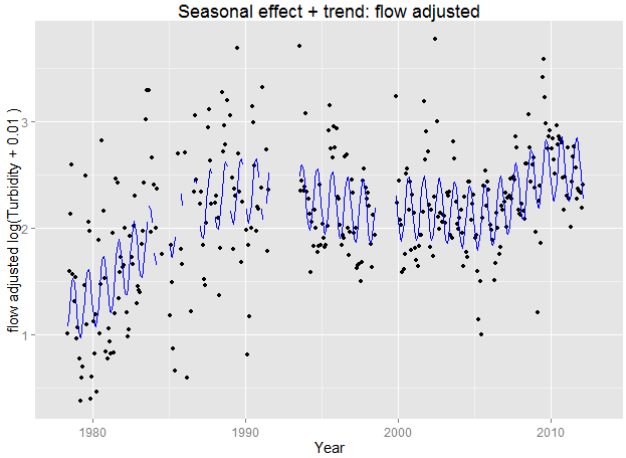


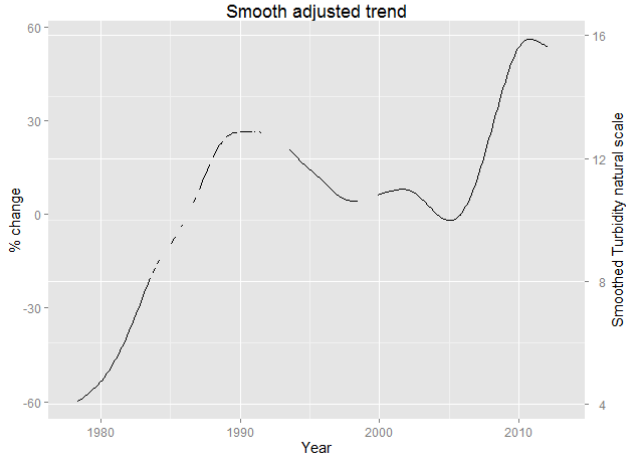


RIVER MURRAY - Yarrawonga

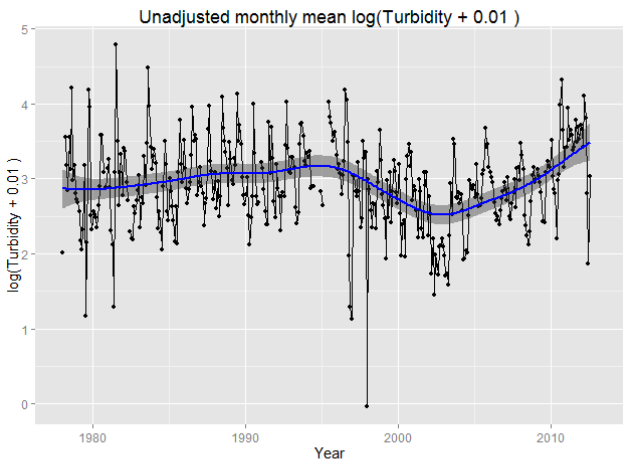


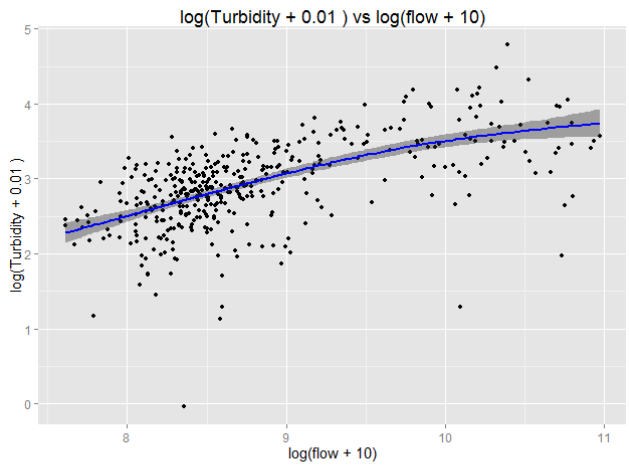


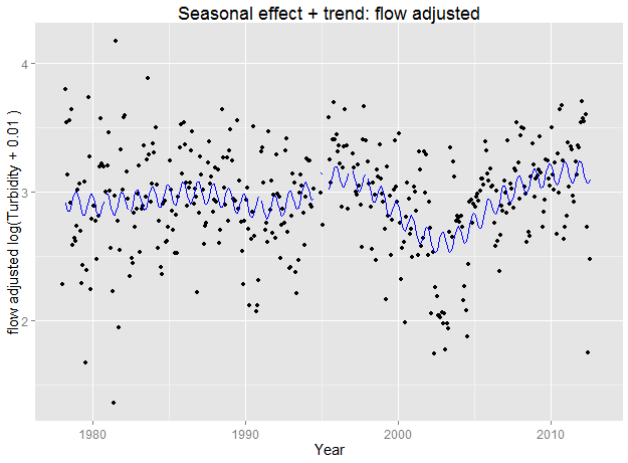


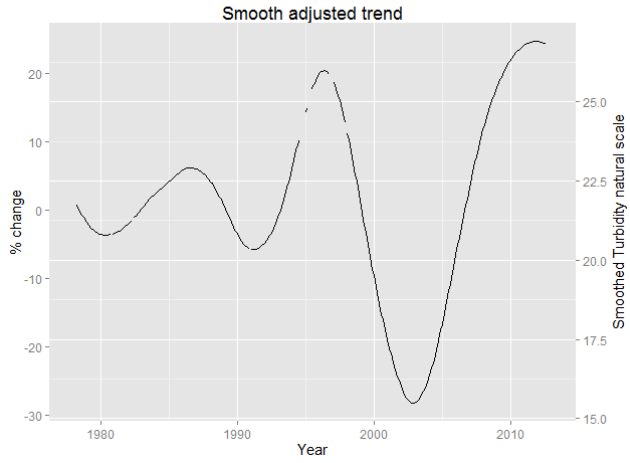


RIVER MURRAY - Torrumbarry

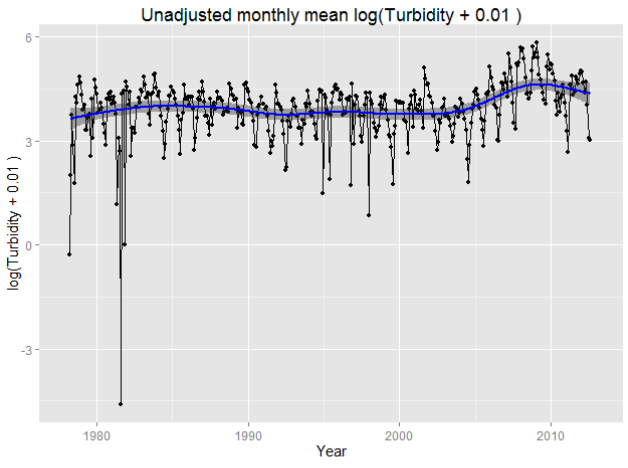


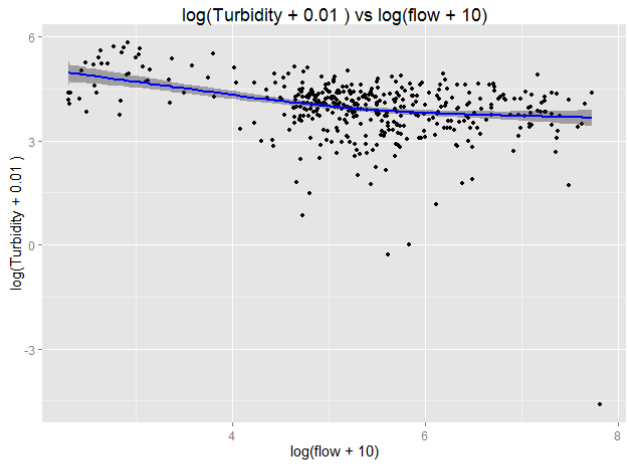


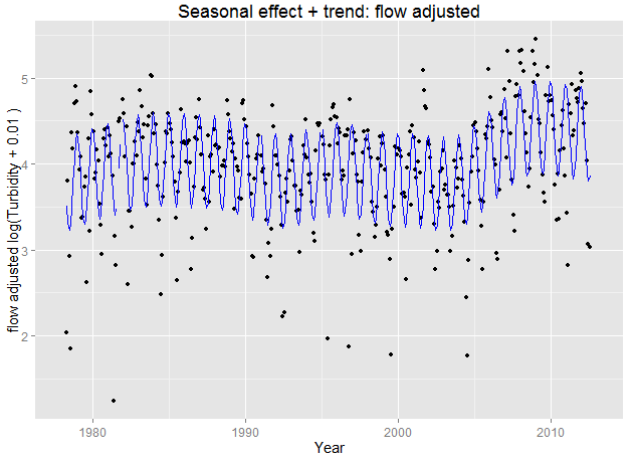


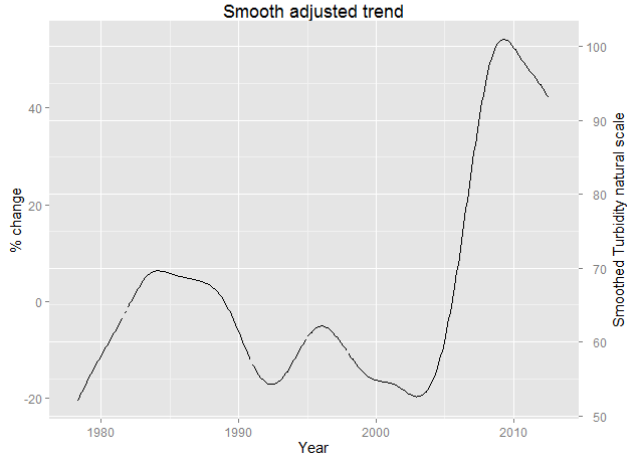


RIVER MURRAY - Kerang

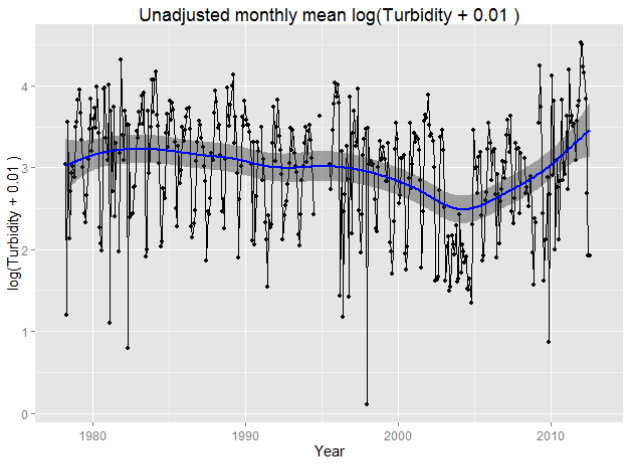


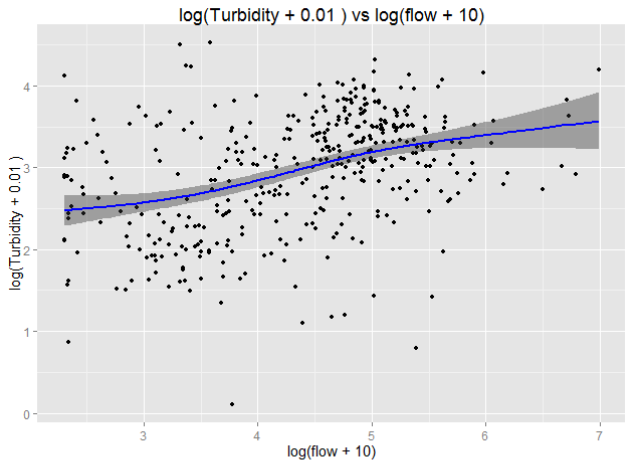


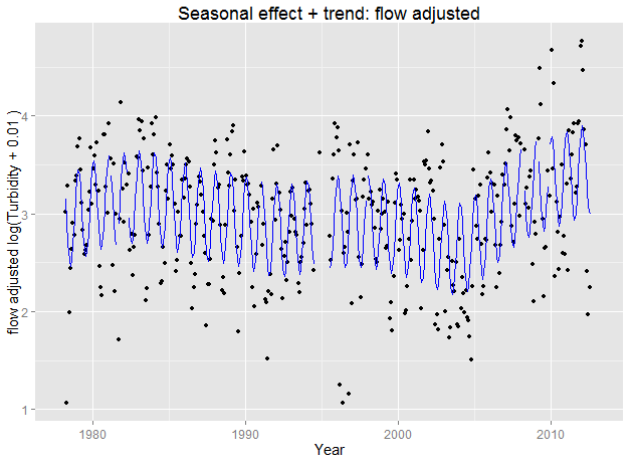


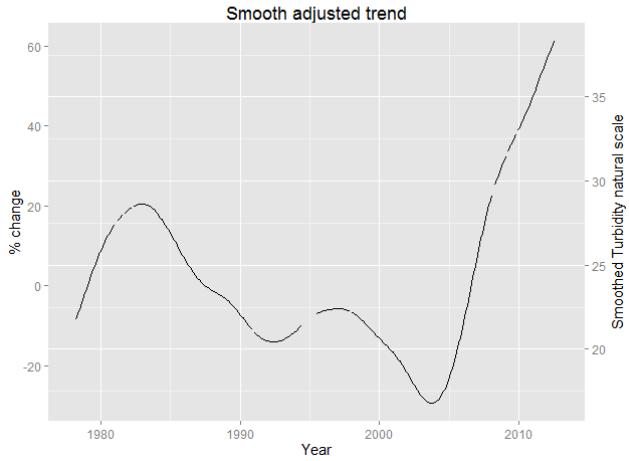


RIVER MURRAY - Capels Flume

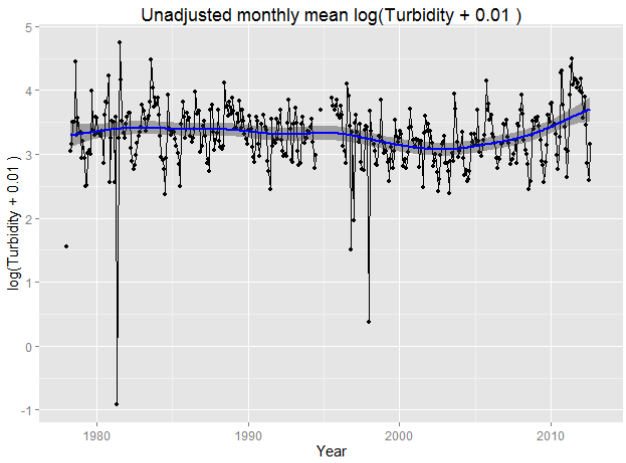


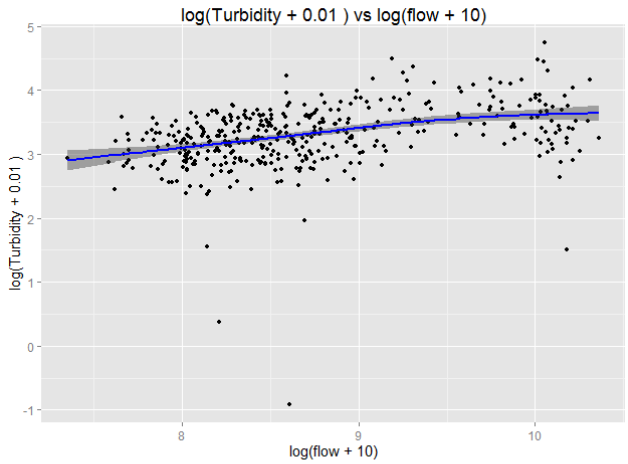


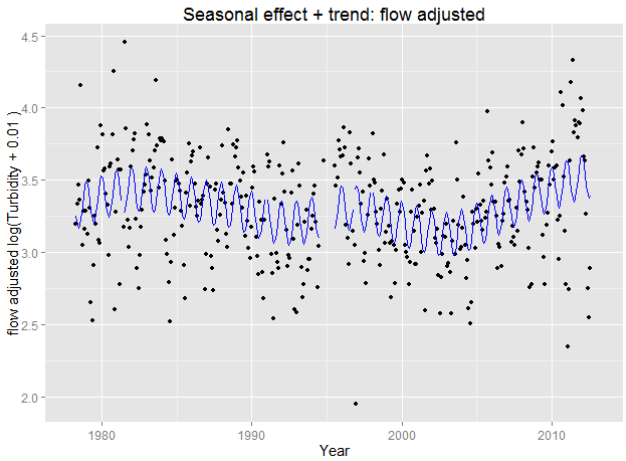


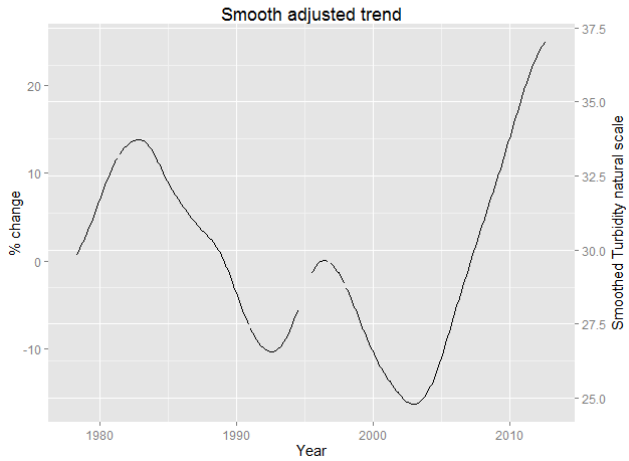


RIVER MURRAY - Swan Hill

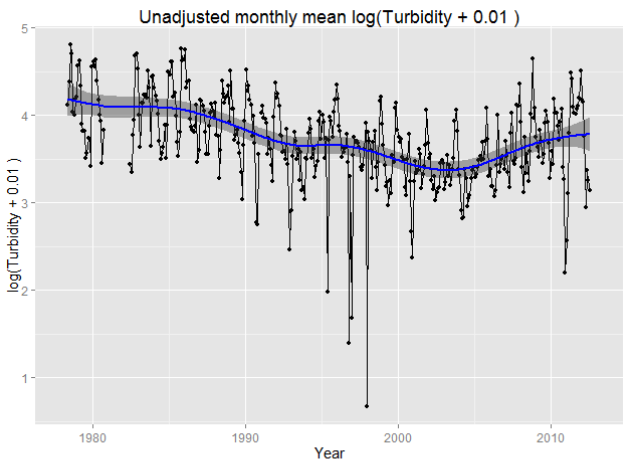


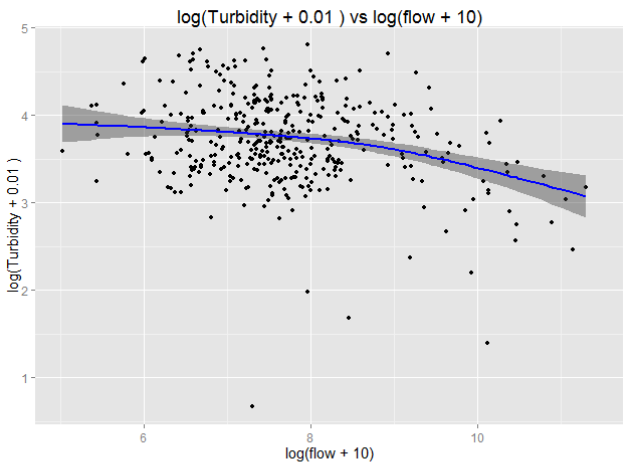


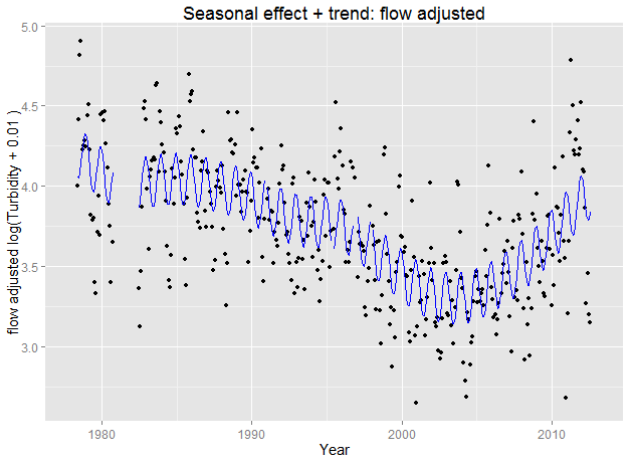


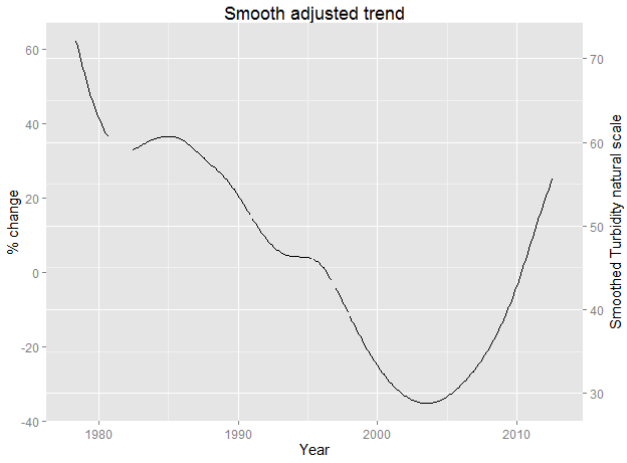


RIVER MURRAY - Kyalite

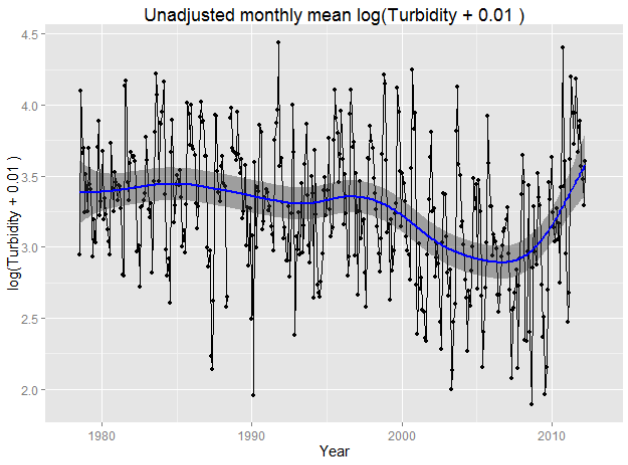


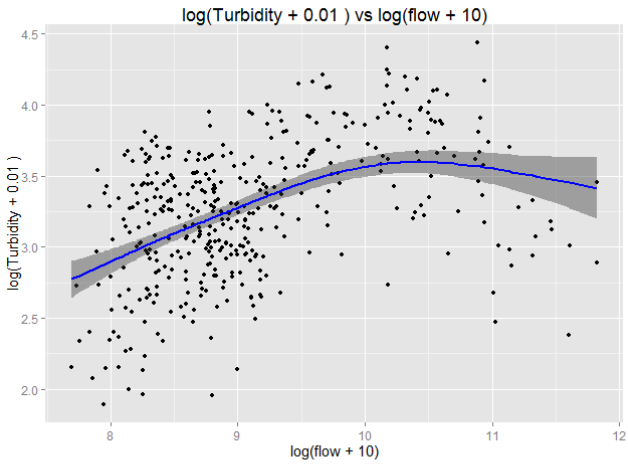


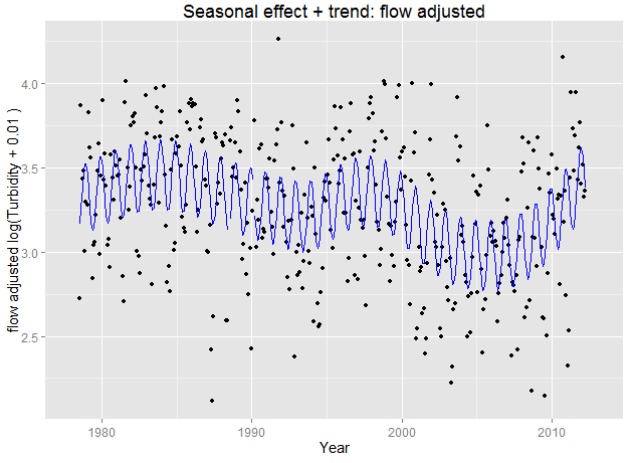


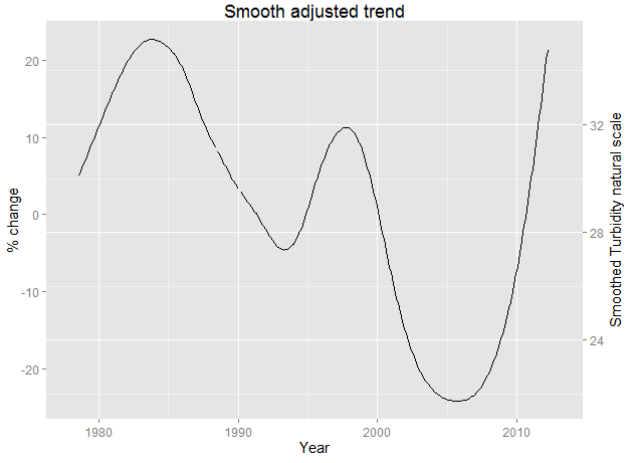


RIVER MURRAY - Euston Weir

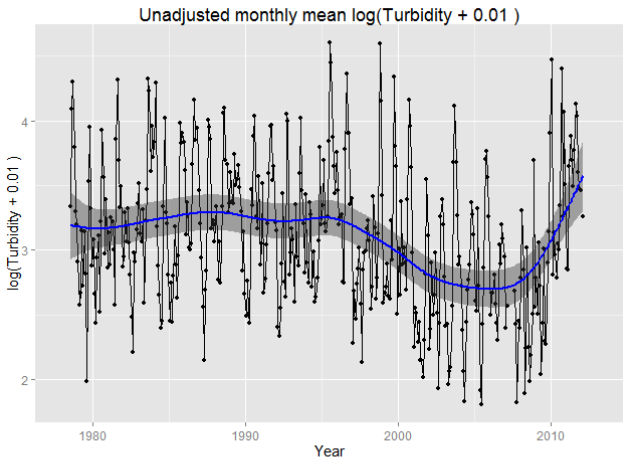


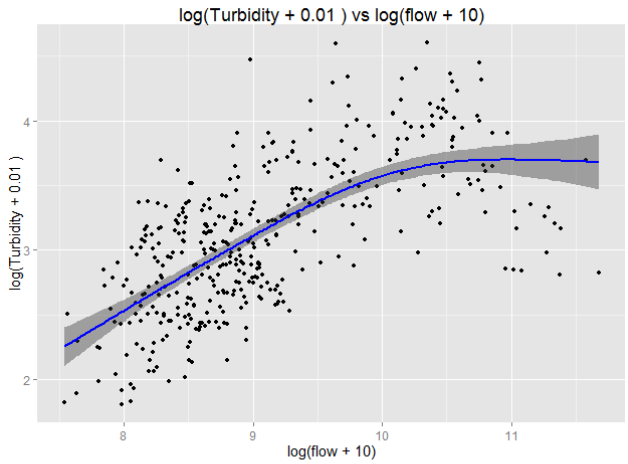


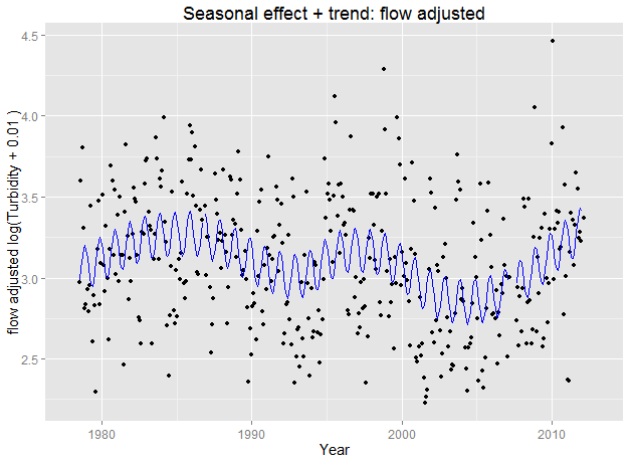


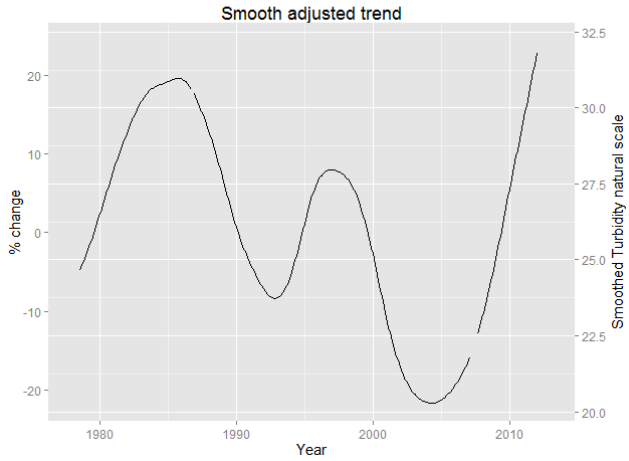


RIVER MURRAY - Merbein

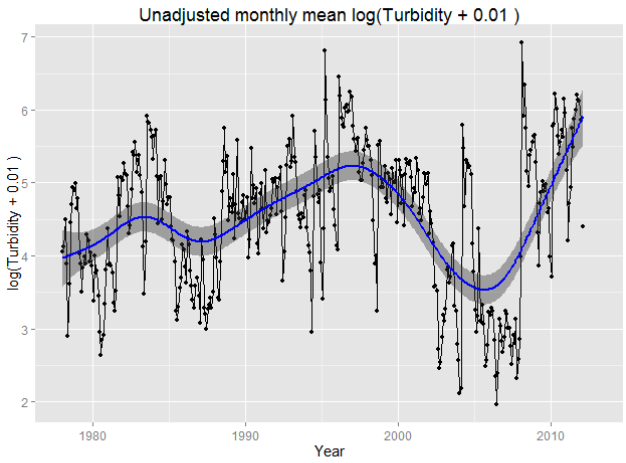


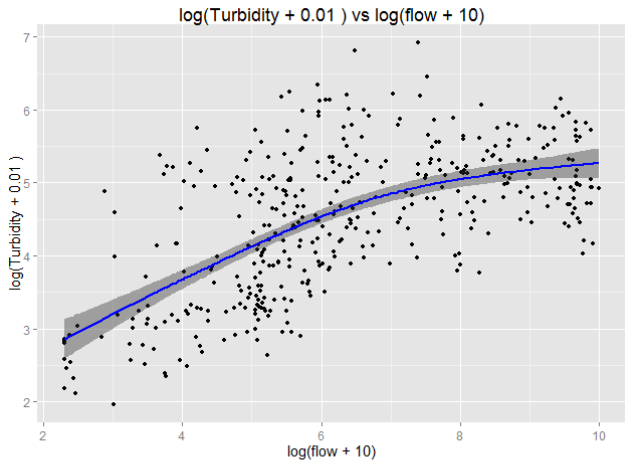


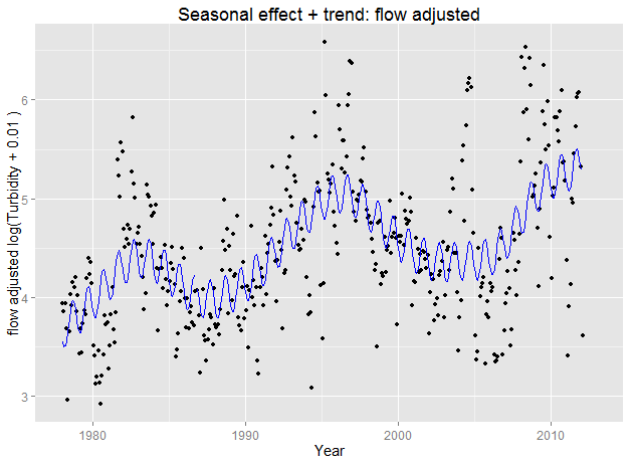


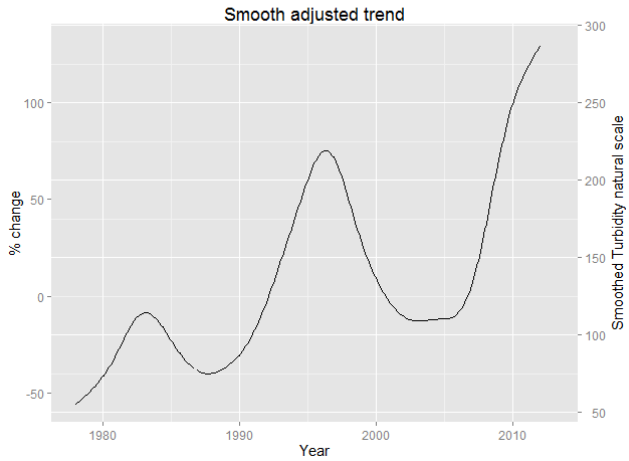


RIVER MURRAY - Burtundy

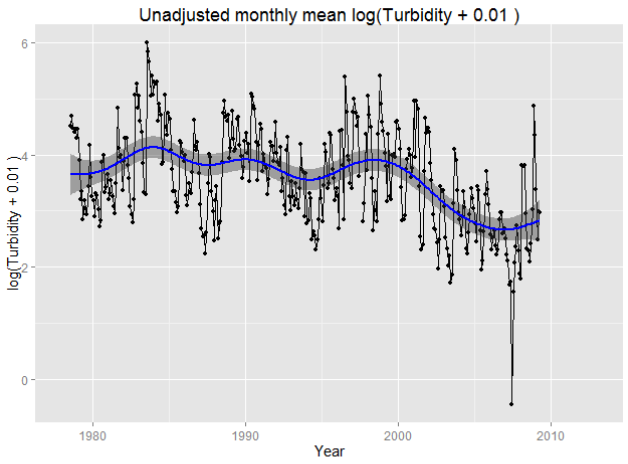


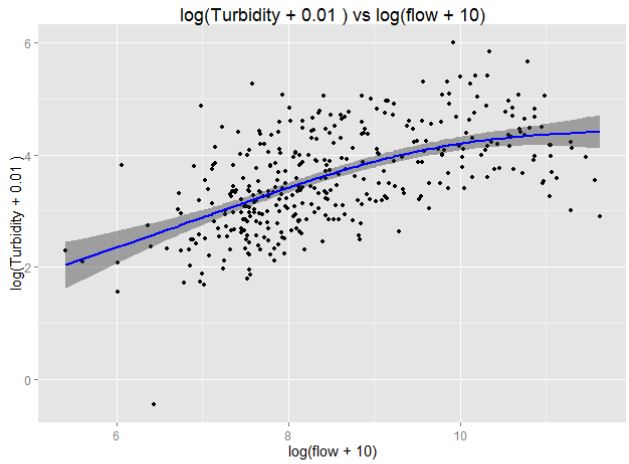


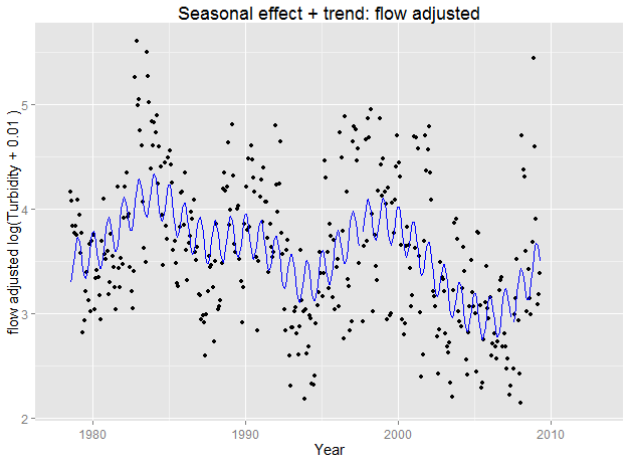


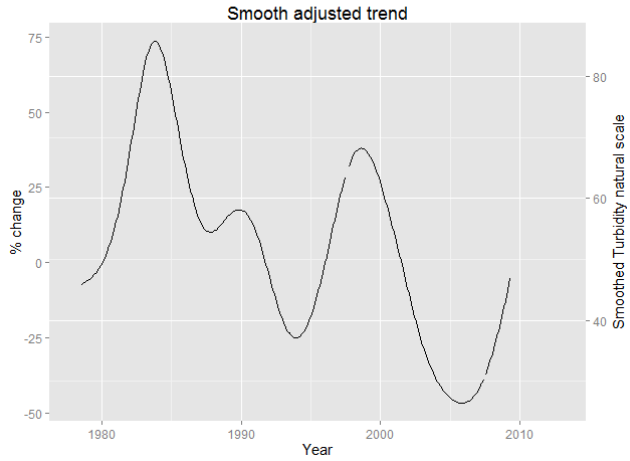


RIVER MURRAY - Lock 9

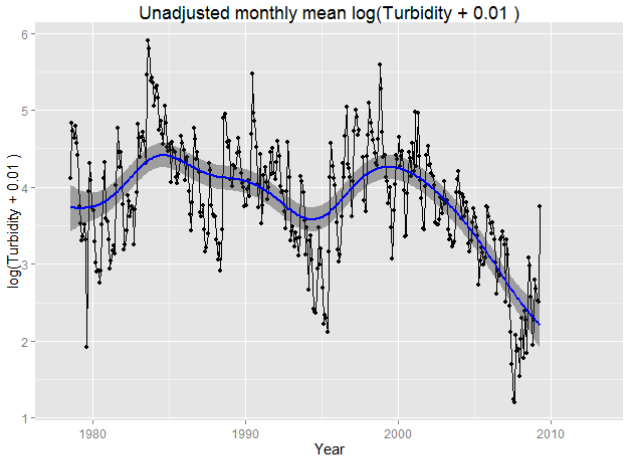


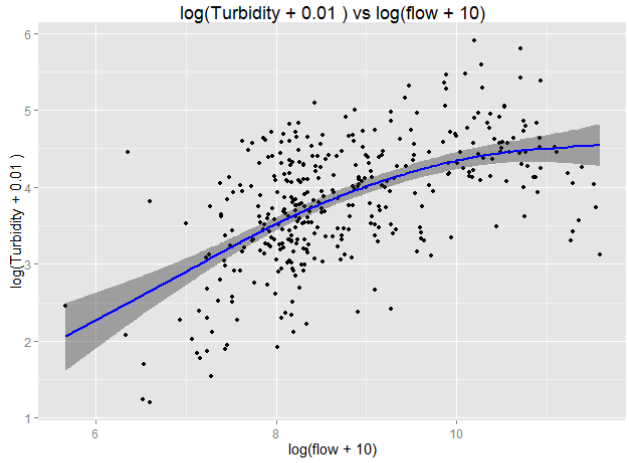


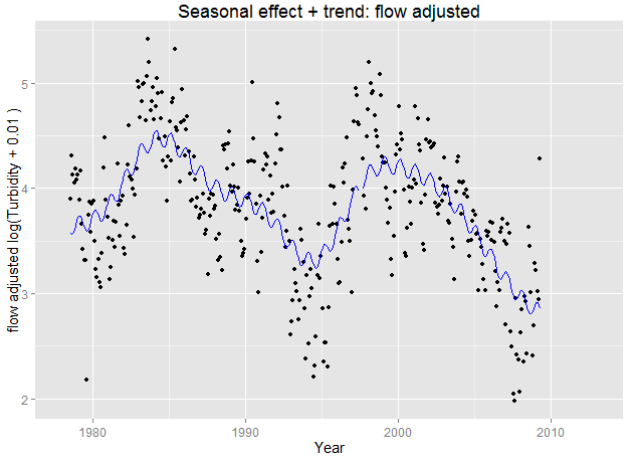


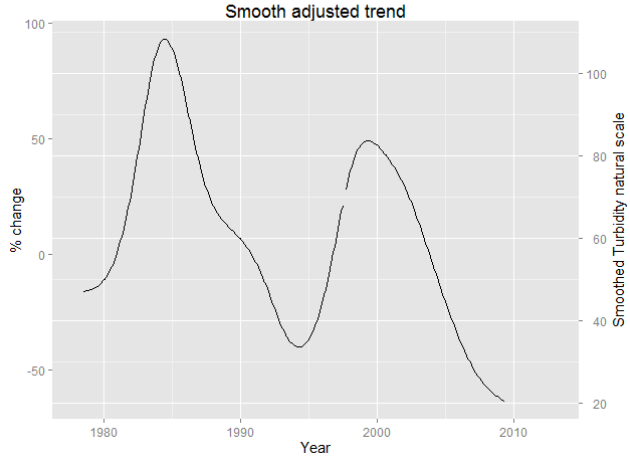


RIVER MURRAY - Morgan







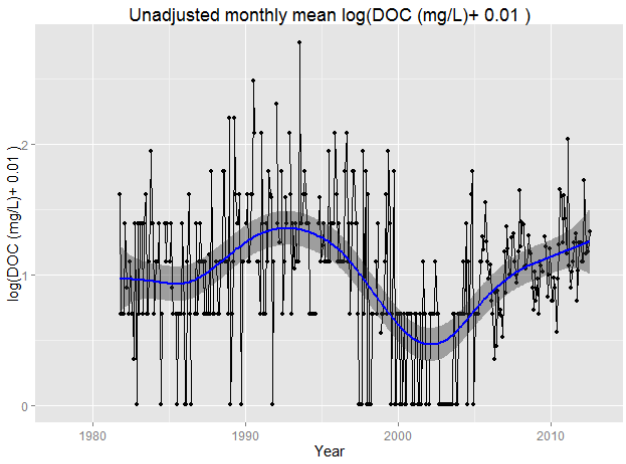


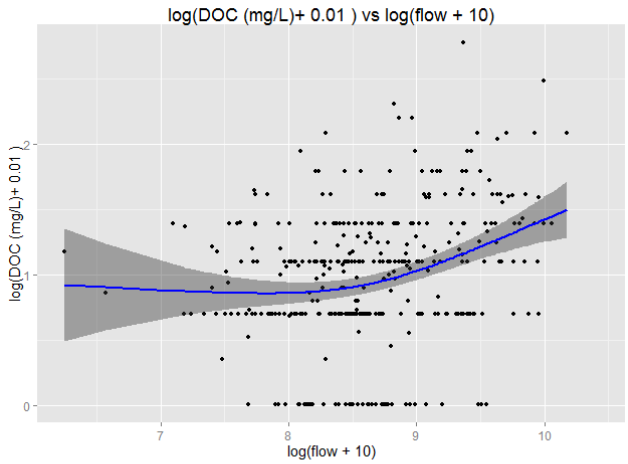
L: Dissolved organic carbon (soluble organic carbon)

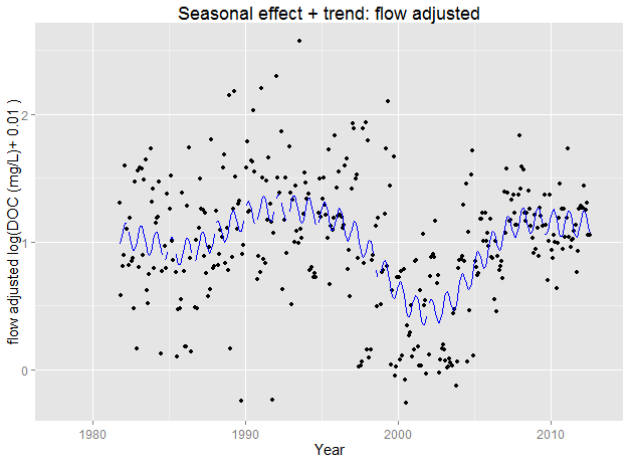
Monitoring Site	Geometric Mean	Linear Trend 1978-2012			Raw Trend 1978-2012			Linear Trend 2003-2012			Raw Trend 2003-2012		
Jingellic	2.7892	-0.41		NL	-0.54		NL	**7.42**	**	NL	**8.84**	**	NL
Tallandoon	2.5734	**-0.84**	**	NL	**-0.90**	**	NL	**6.02**	**	NL	**6.33**	**	NL
Heywoods	3.0143	0.92	*	NL	0.67		NL	**11.70**	**	NL	**11.88**	**	NL
Bandiana	2.3090	0.63		NL	0.18		NL	**5.04**	**	NL	**7.68**	**	NL
Peechelba	2.8291	**-0.98**	**	NL	**-1.23**	**	NL	**4.30**	**	NL	**5.69**	**	nl
Yarrawonga	2.8345	**-5.19**	**	NL	**-5.60**	**	NL	0.66		NL	**3.48**	**	NL
Torrumbarry	4.3122	0.00			**-0.40**		NL	0.42		nl	**7.40**	**	nl
Kerang	5.9550	**3.15**	**	NL	0.38		NL	**12.72**	**		**12.27**	**	
Capels Flume	14.0358	**1.49**	**	NL	0.37		NL	2.81		nl	**4.08**	**	nl
Swan Hill	4.5825	-0.42			-0.98	*	NL	1.13		nl	**8.52**	**	NL
Kyalite	5.3299	-0.80	*	NL	-1.11	*	NL	4.65	*		**8.88**	**	
Euston Weir	3.8471	**-7.15**	**	NL	**-8.32**	**	NL	-6.35		nl	-6.84	*	nl
Merbein	3.9884	**-5.76**	**	NL	**-6.32**	**	NL	0.00			5.63		NL
Burtundy	11.0262	**-3.30**	**	NL	**-2.97**	**	NL	-3.61		NL	**-7.43**	**	NL
Lock 9	4.4944	**-1.31**	**	NL	0.89	*	NL	6.44			**18.86**	**	nl
Morgan	4.7832	-0.49		NL	-0.06		NL	3.59			**16.33**	**	nl

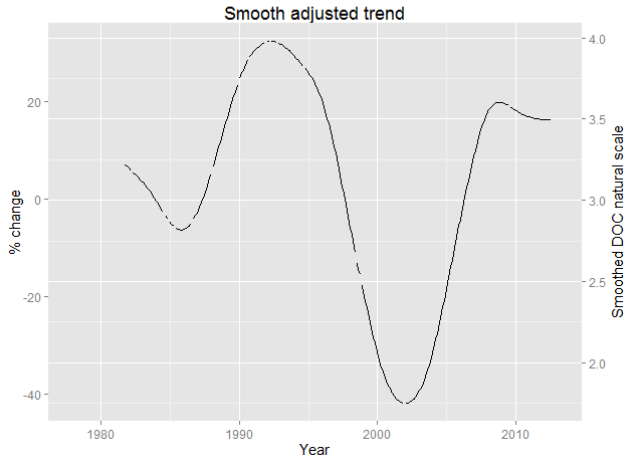
Monitoring Site	Geometric Mean	Relationship to Log flow	Significance	Amplitude(log scale)	Seasonal Peak	Autocorrelation
Jingellic	2.7892	+	**	0.1174	2.2202	0.1000
Tallandoon	2.5734	+	*	0.0581	6.1273	0.1540
Heywoods	3.0143	+		0.0779	11.3570	0.2247
Bandiana	2.3090	+	**	0.1368	2.0877	0.0496
Peechelba	2.8291	+	**	0.2116	2.0388	0.1166
Yarrawonga	2.8345	+	**	0.0320	4.1778	0.1166
Torrumbarry	4.3122	+	**	0.0868	11.6092	0.1747
Kerang	5.9550	+	**	0.2116	11.1221	0.2926
Capels Flume	14.0358	+	**	0.2784	0.1012	0.1235
Swan Hill	4.5825	+	**	0.1543	0.3267	0.1675
Kyalite	5.3299	+	**	0.1949	0.0904	0.3484
Euston Weir	3.8471	+	**	0.0689	10.8842	0.3484
Merbein	3.9884	+	**	0.1276	0.2862	0.3484
Burtundy	11.0262	+	**	0.0930	2.5659	0.3484
Lock 9	4.4944	+	**	0.1935	1.4017	0.3484
Morgan	4.7832	+	**	0.1352	2.5262	0.3484

RIVER MURRAY - Jingellic

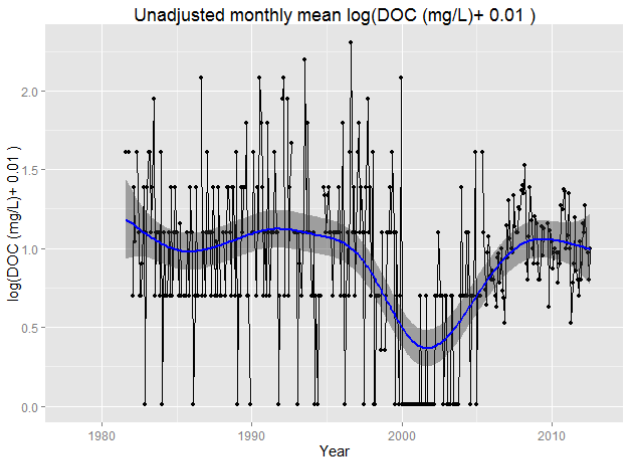


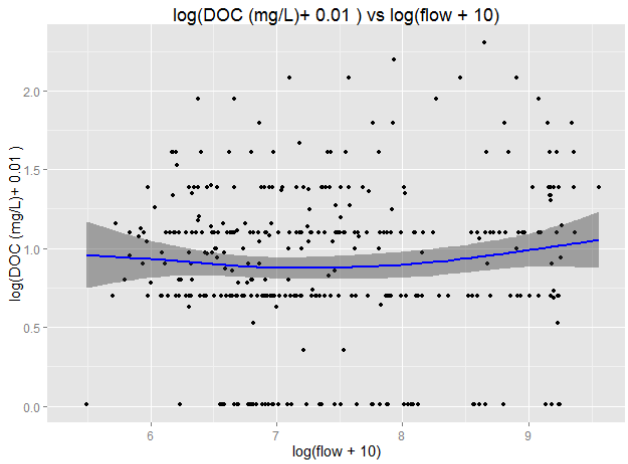


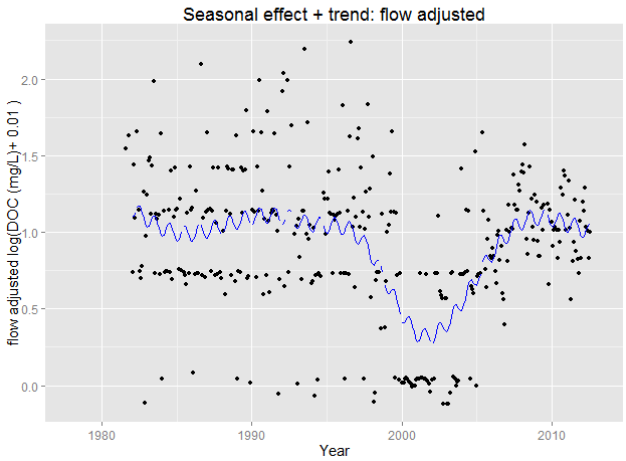


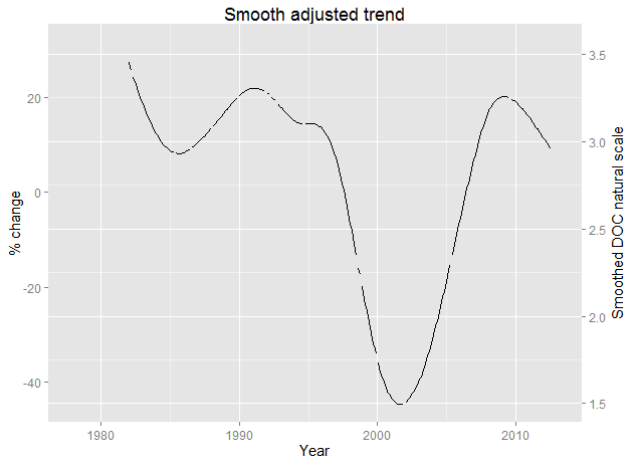


RIVER MURRAY - Tallandoon

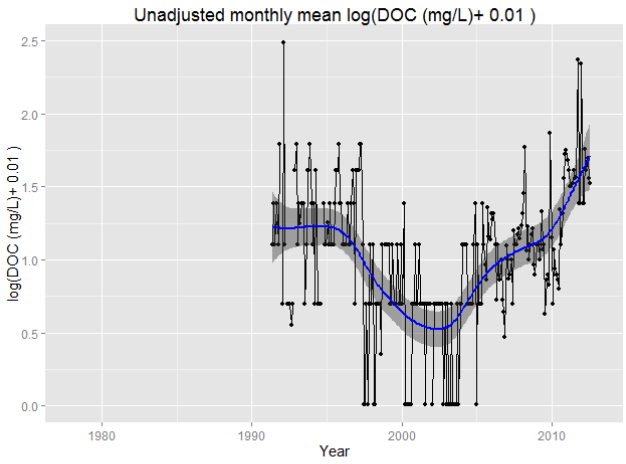


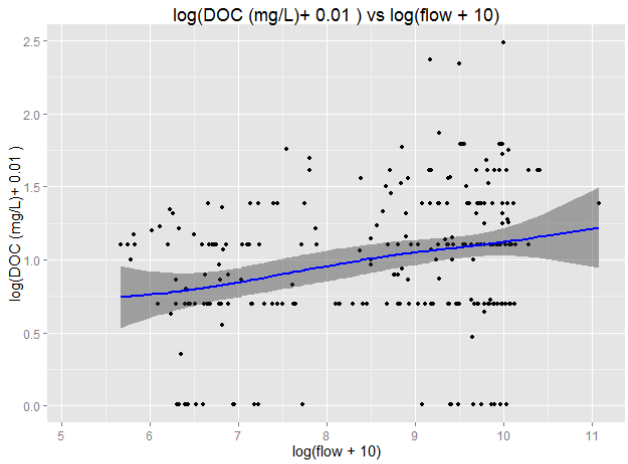


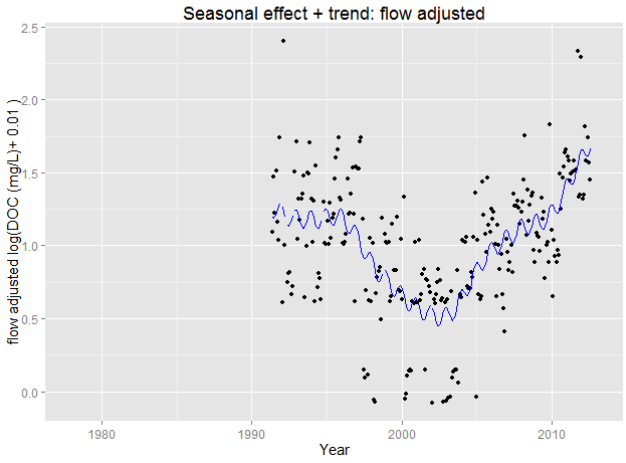


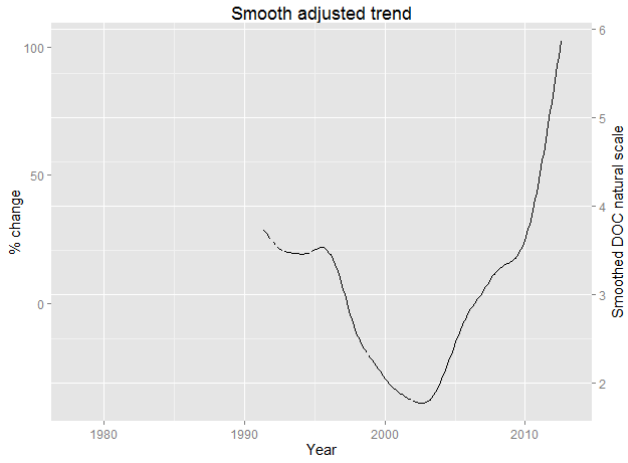


RIVER MURRAY - Heywoods

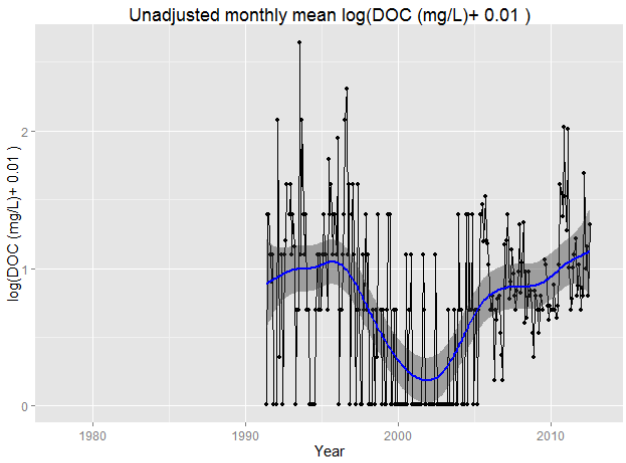


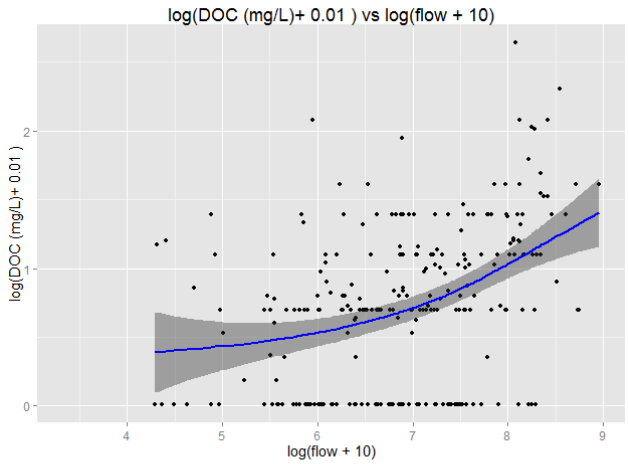


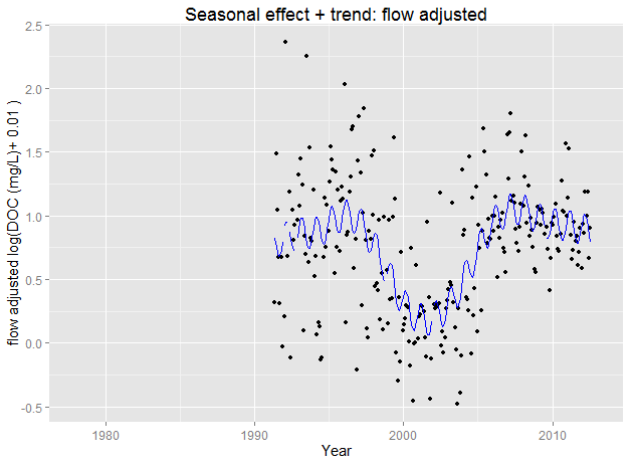


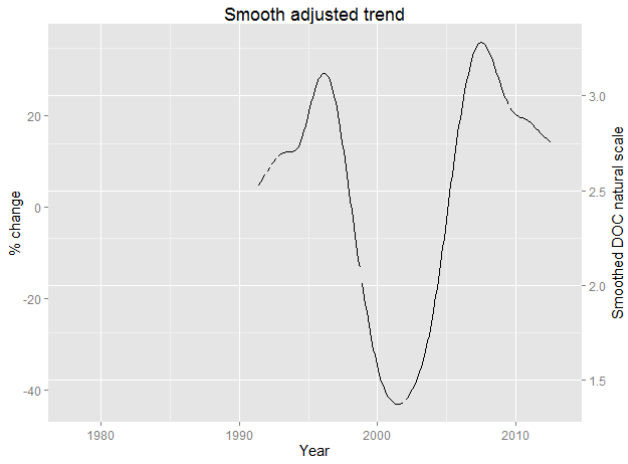


RIVER MURRAY - Bandiana

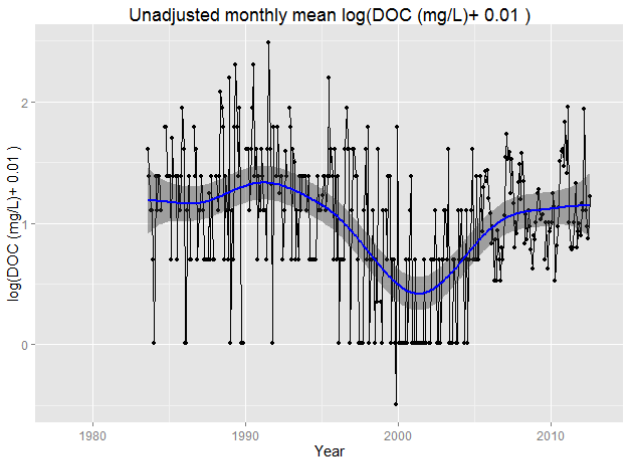


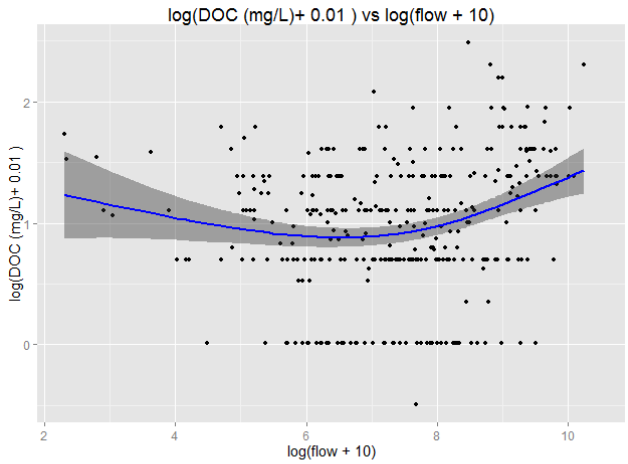


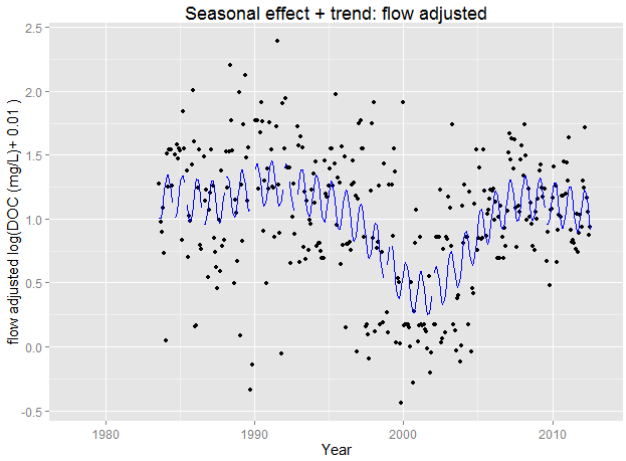


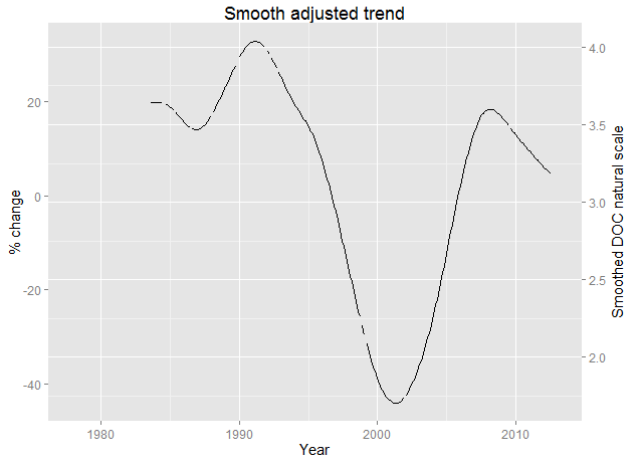


RIVER MURRAY - Peechelba

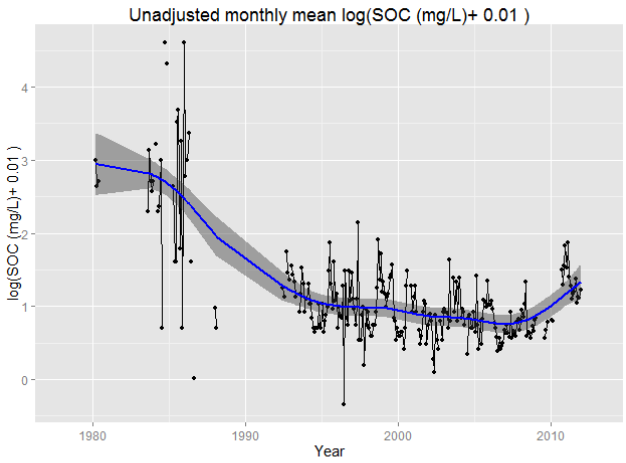


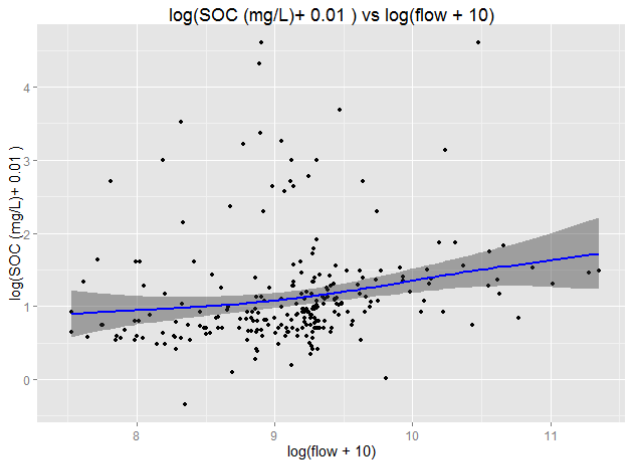


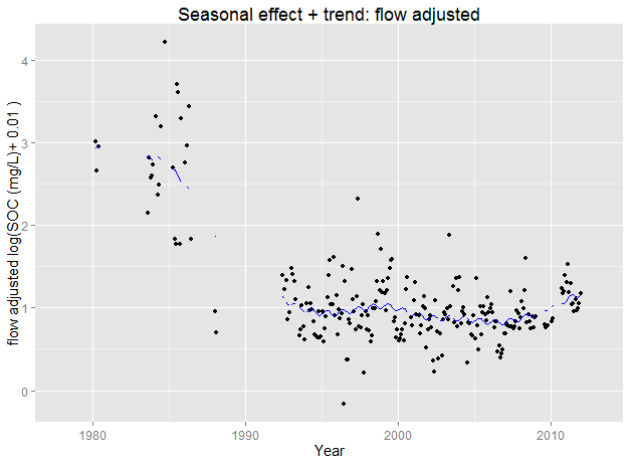


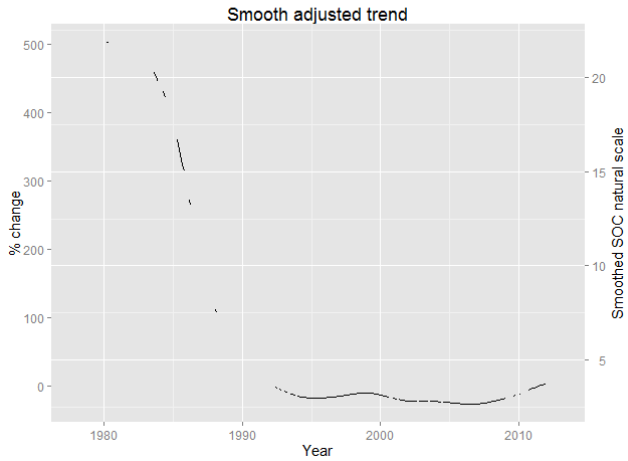


RIVER MURRAY - Yarrawonga

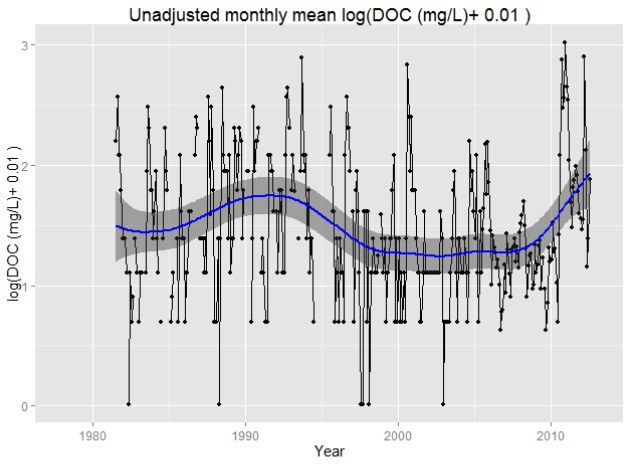


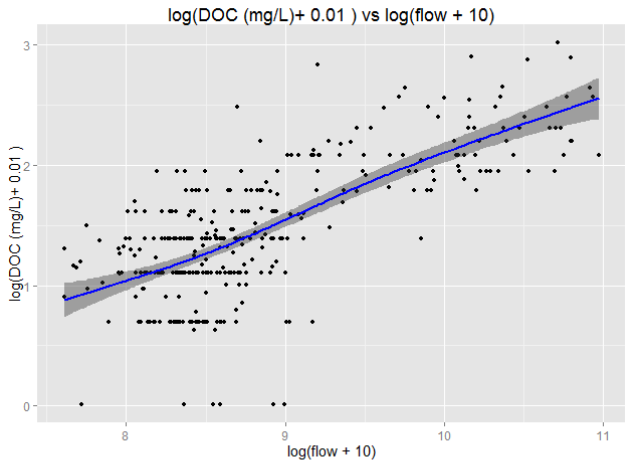


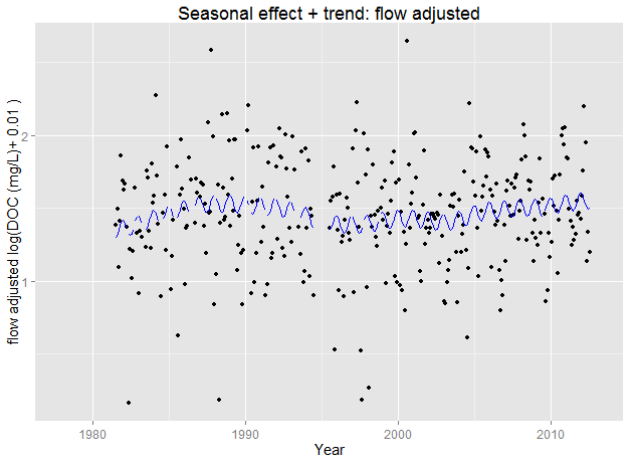


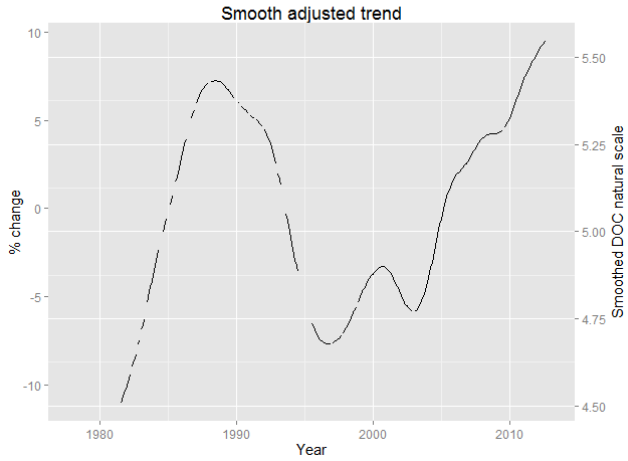


RIVER MURRAY - Torrumbarry

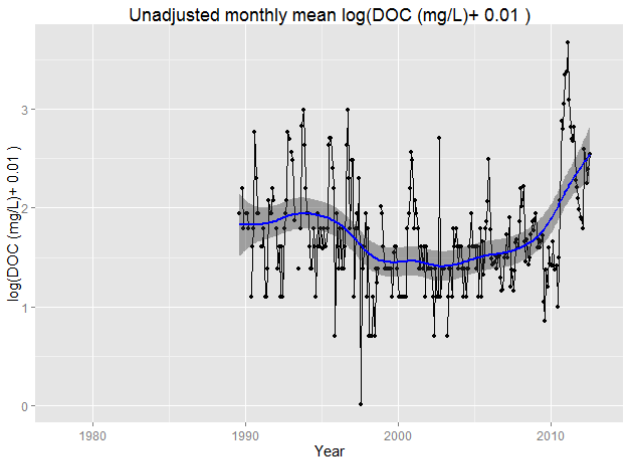


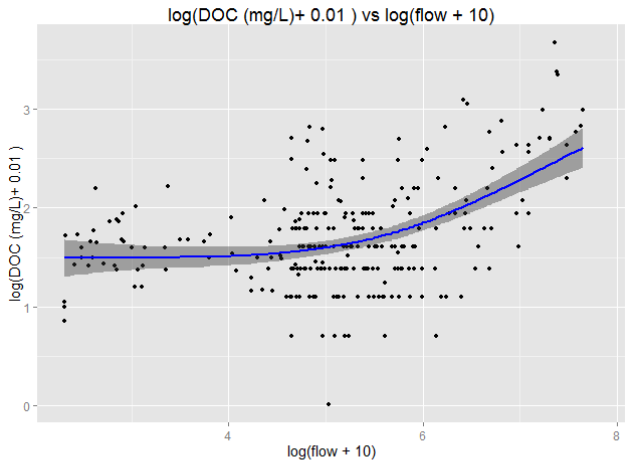


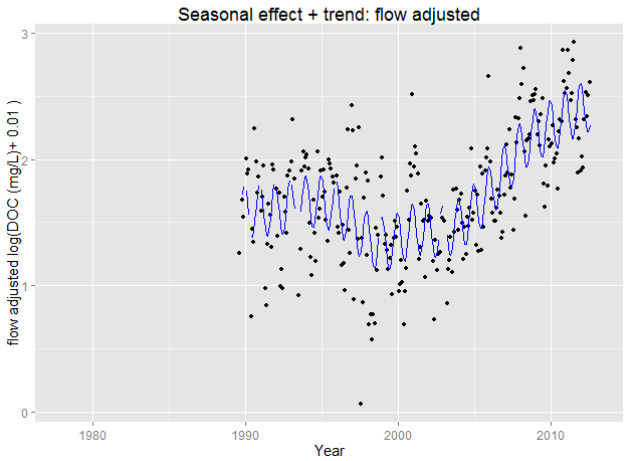


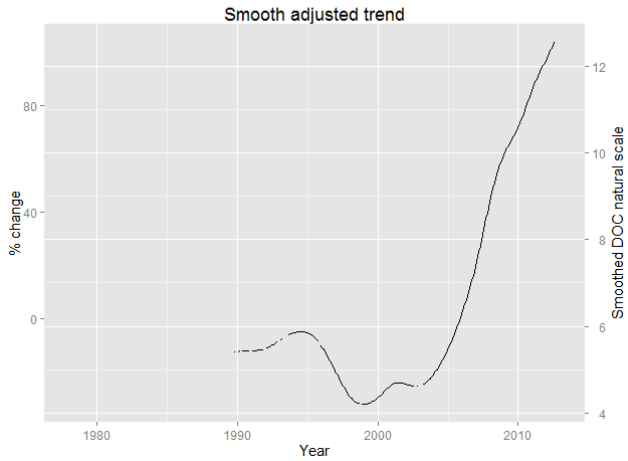


RIVER MURRAY - Kerang

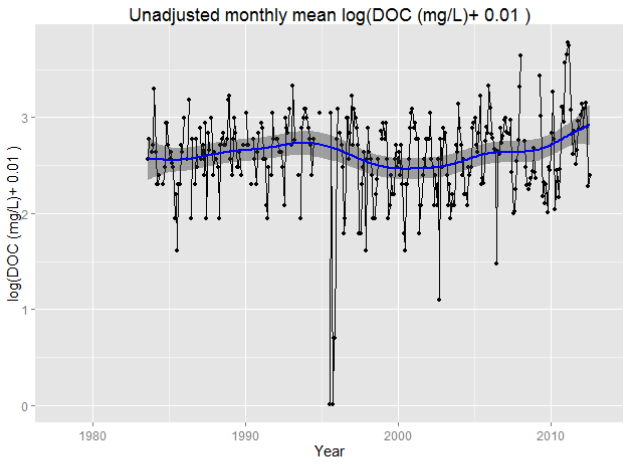


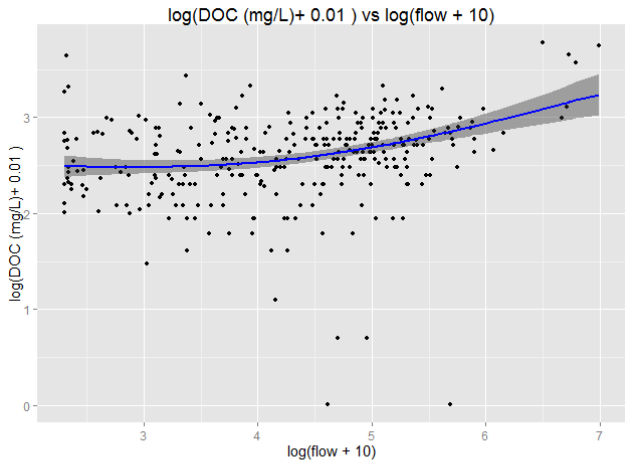


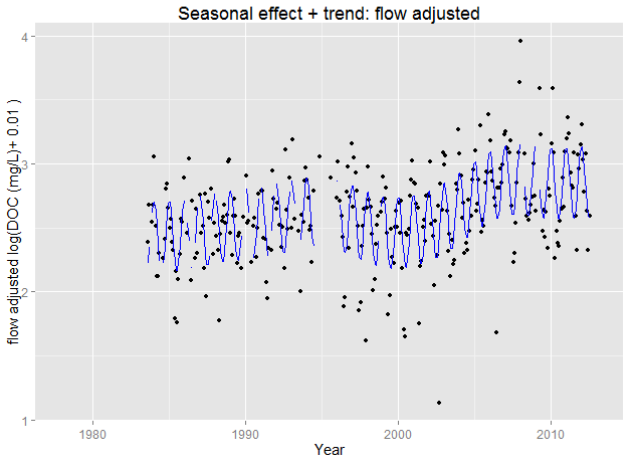


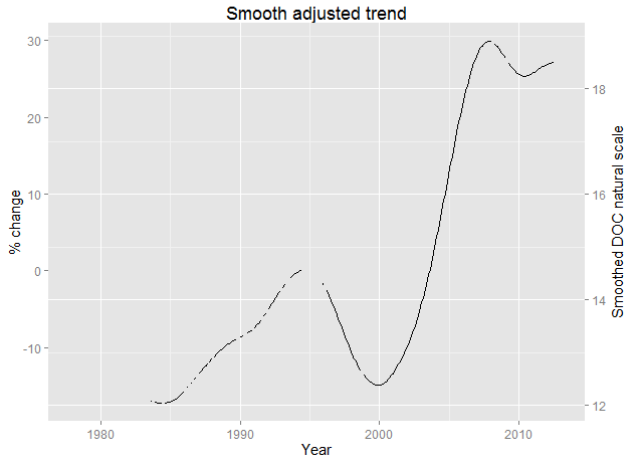


RIVER MURRAY - Capels Flume

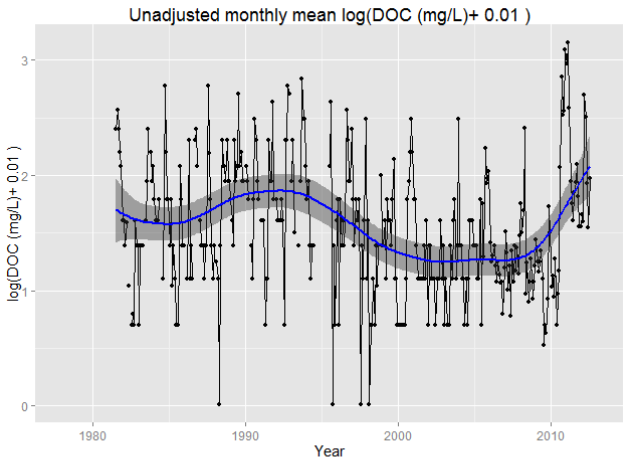


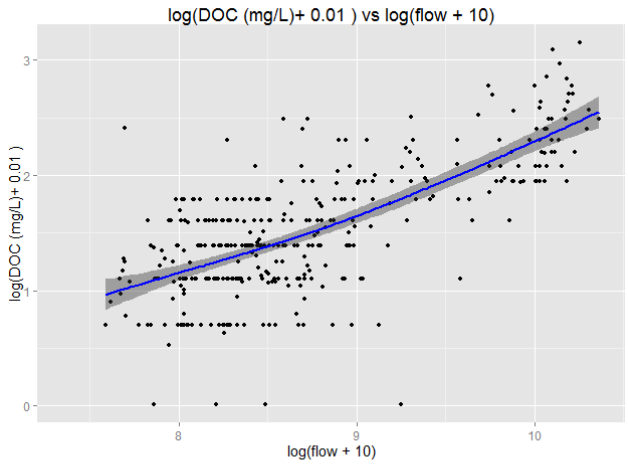


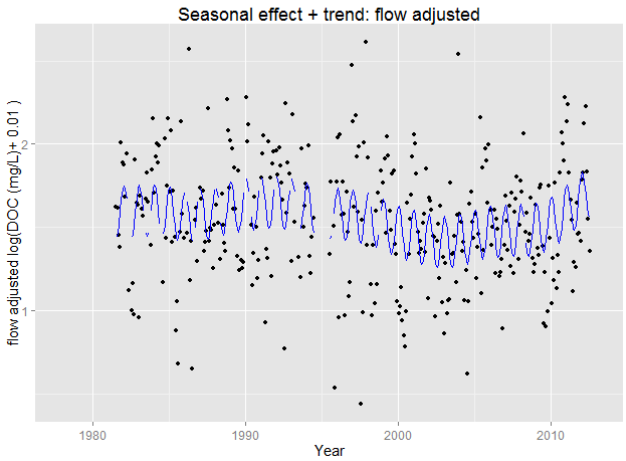


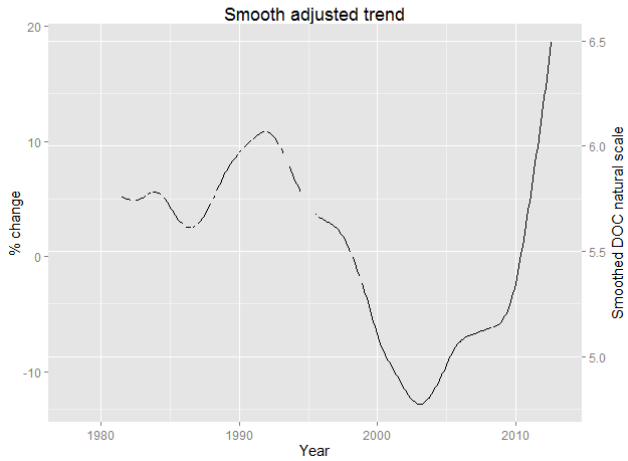


RIVER MURRAY - Swan Hill

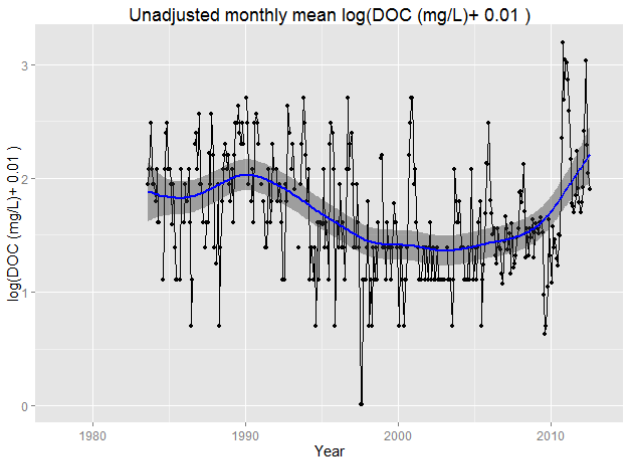


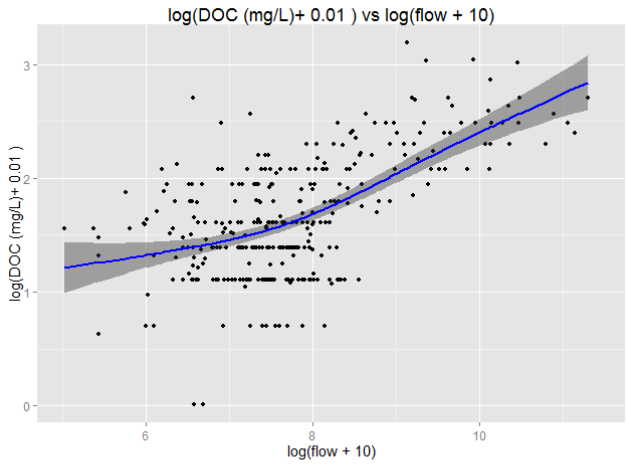


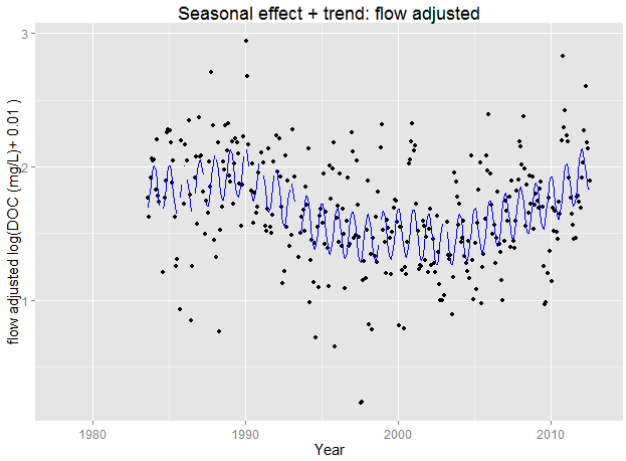


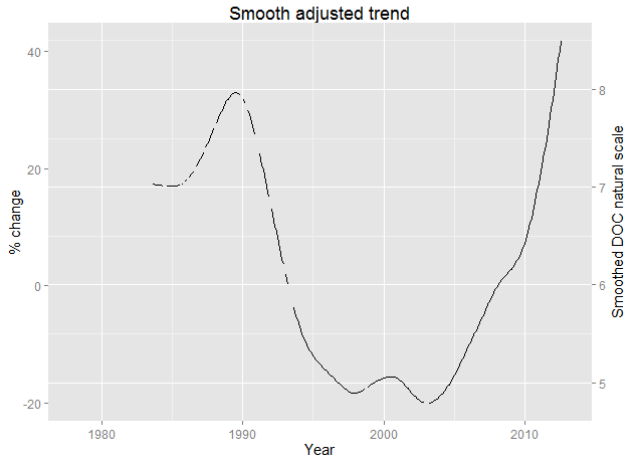


RIVER MURRAY - Kyalite

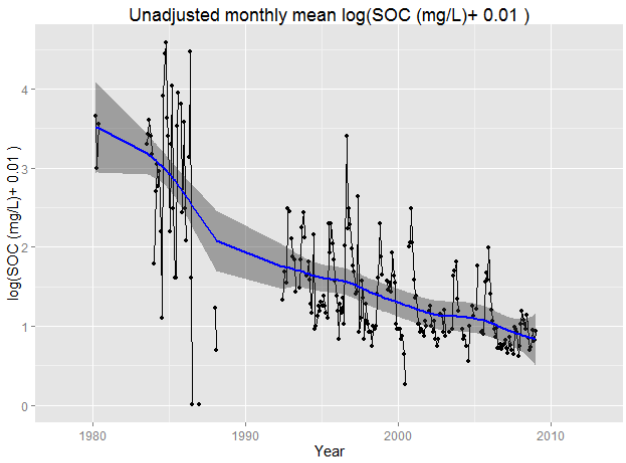


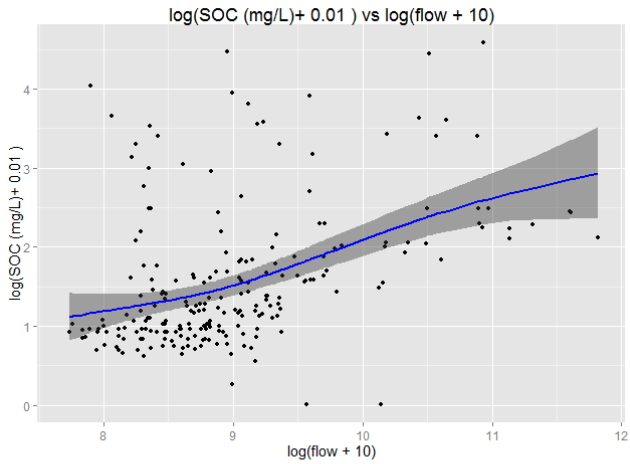


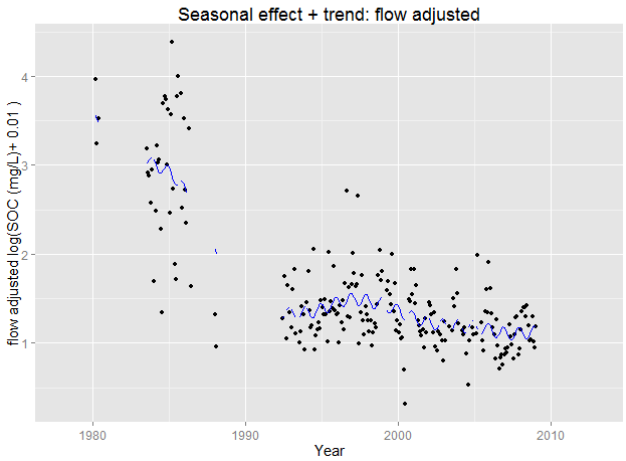


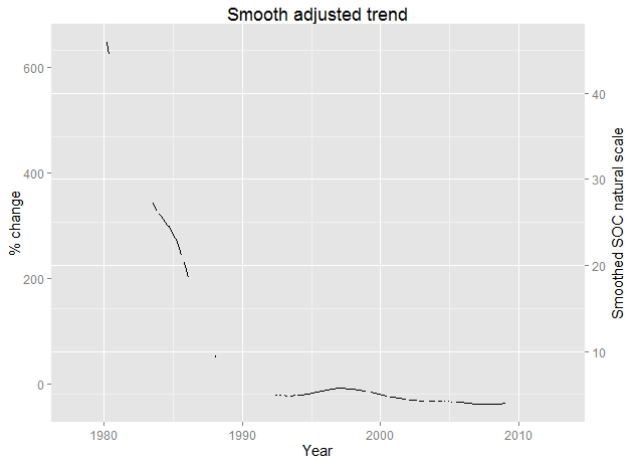


RIVER MURRAY - Euston Weir

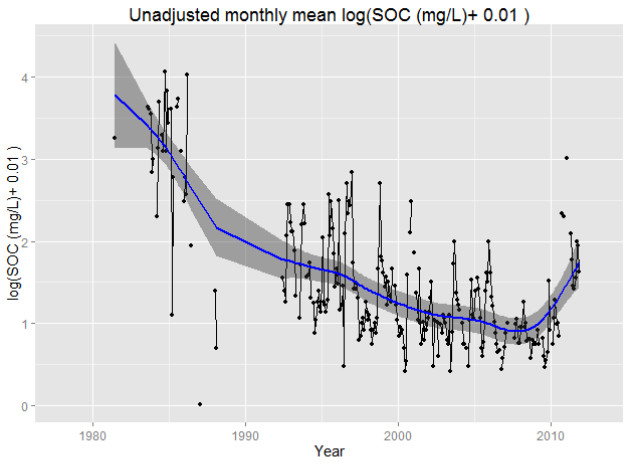


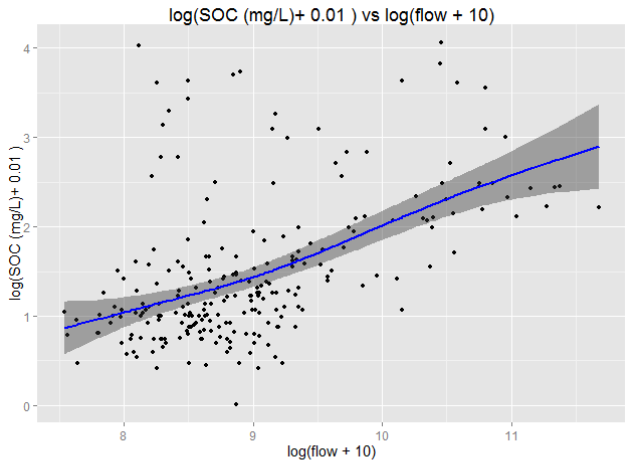


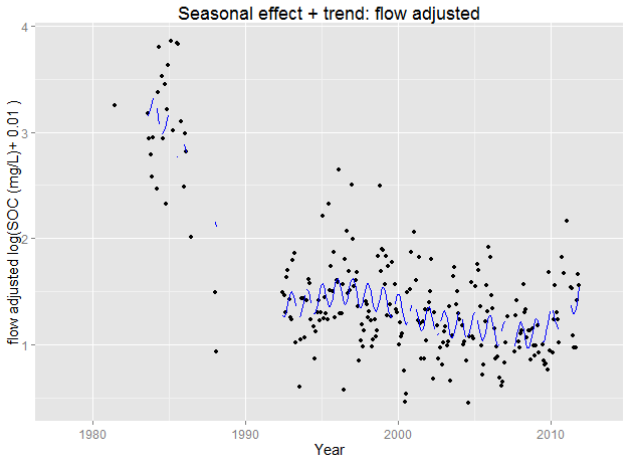


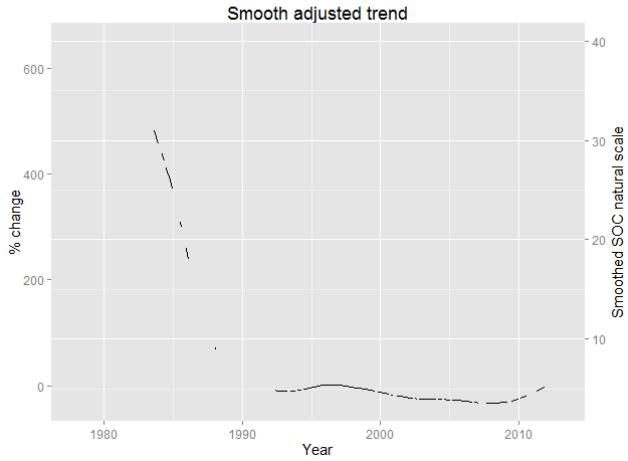


RIVER MURRAY - Merbein

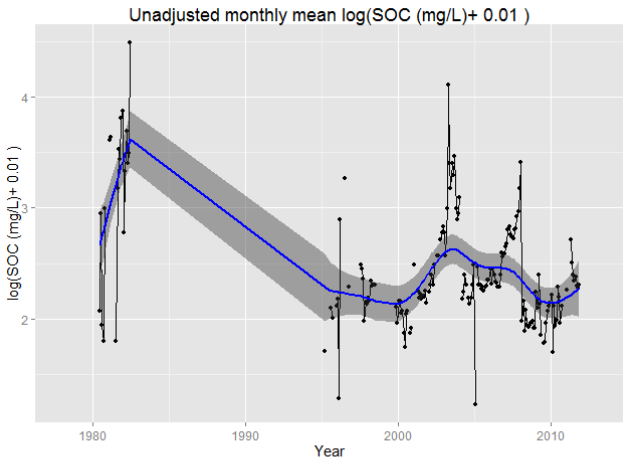


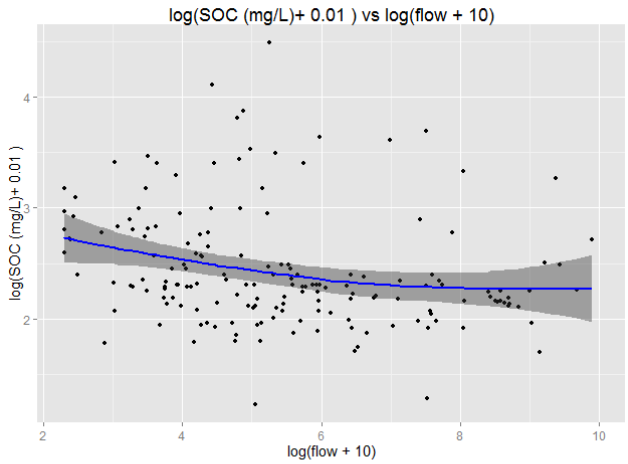


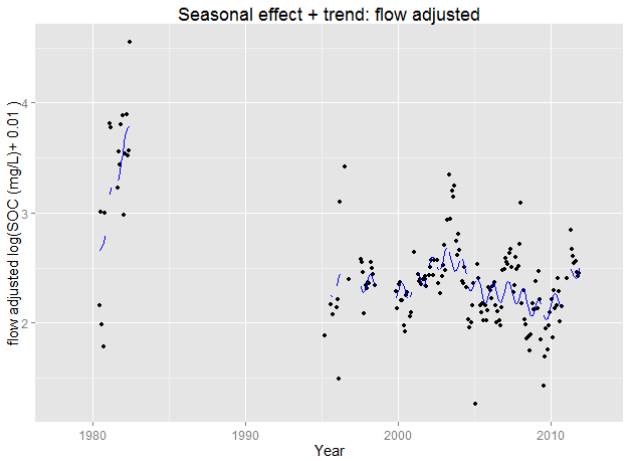


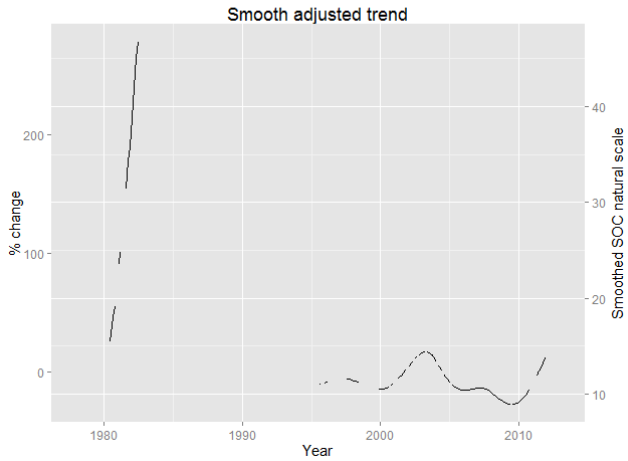


RIVER MURRAY - Burtundy

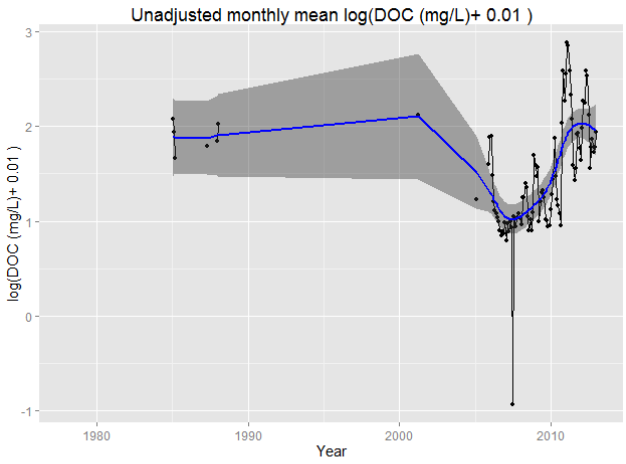


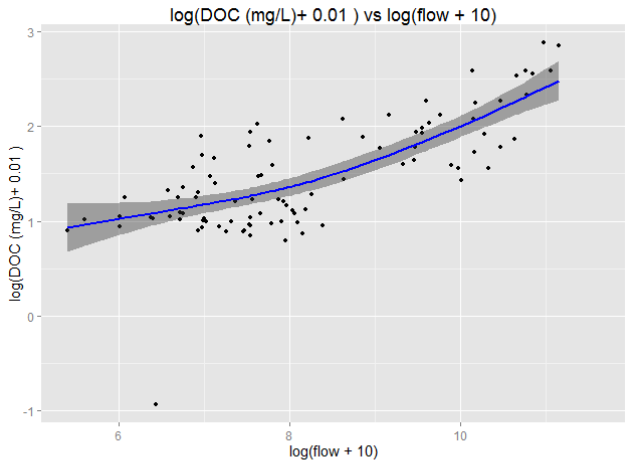


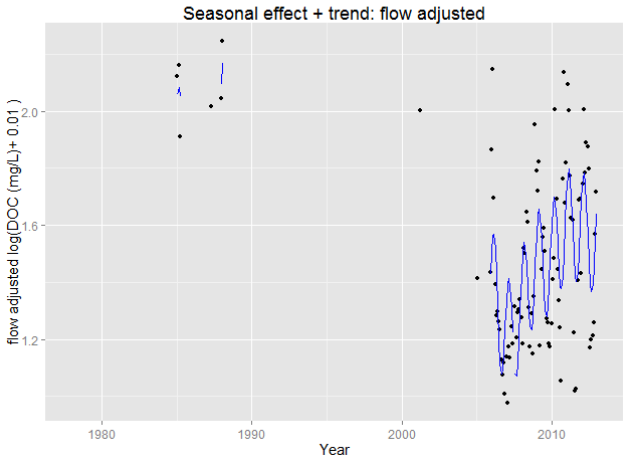


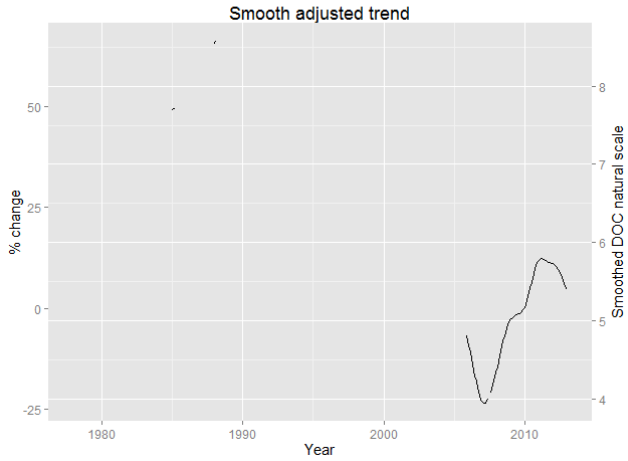


RIVER MURRAY - Lock 9

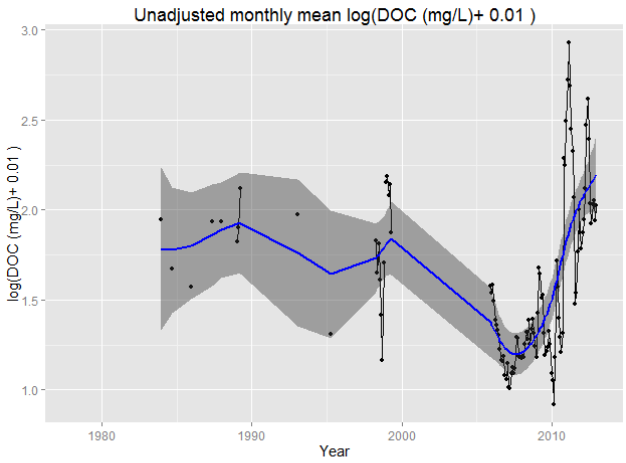


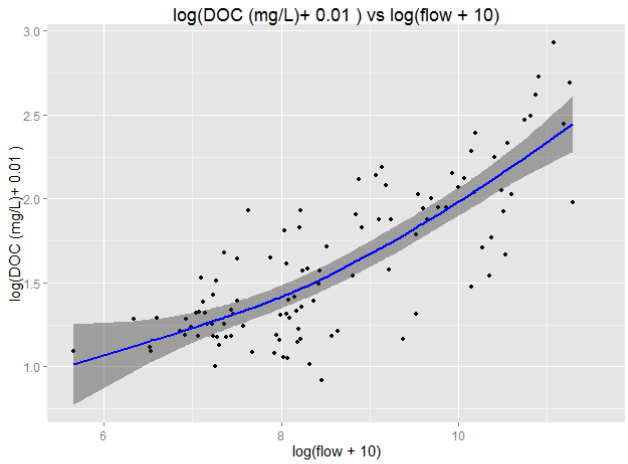


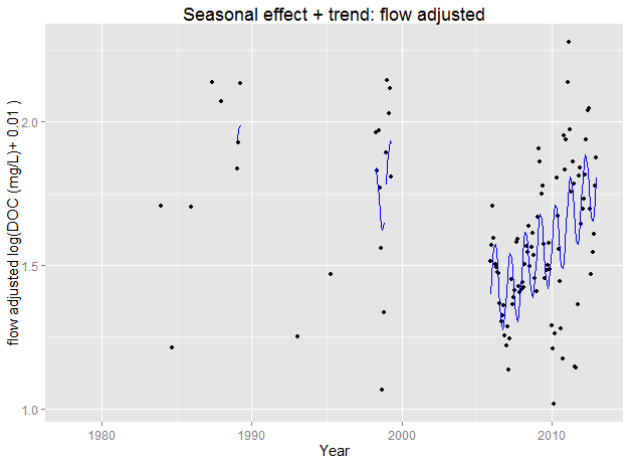


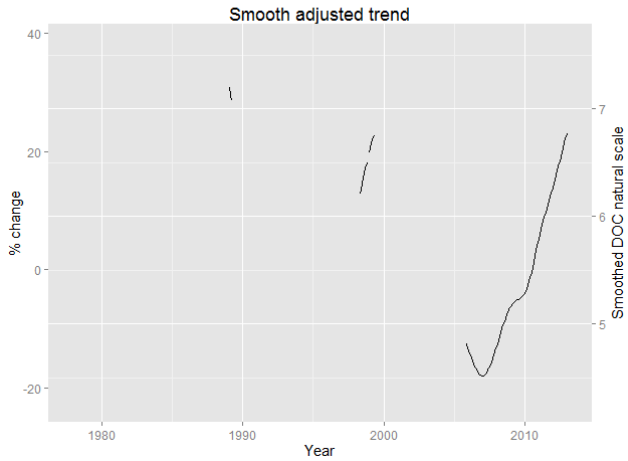


RIVER MURRAY - Morgan







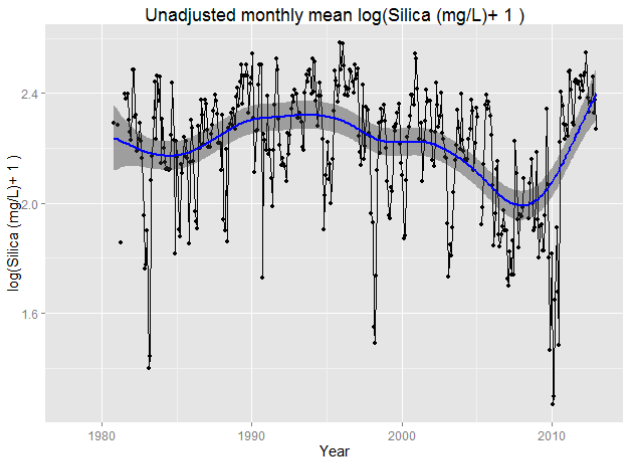


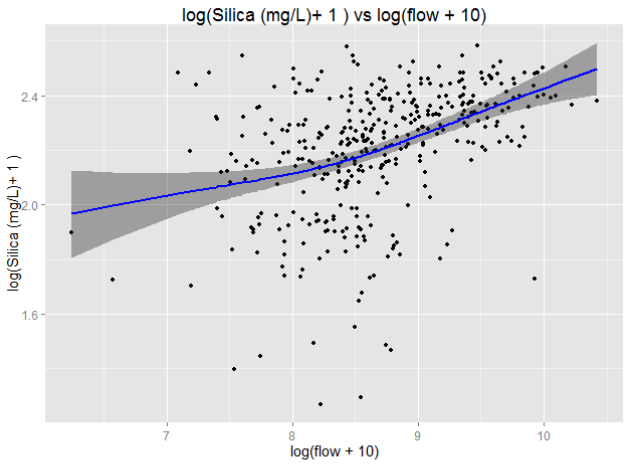
M: Silica

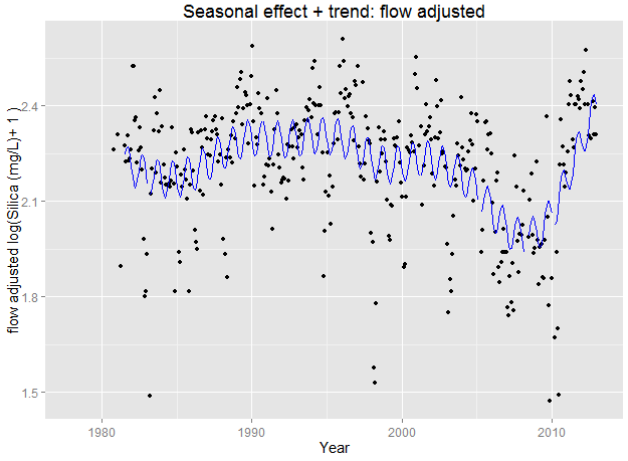
Monitoring Site	Geometric Mean	Linear Trend 1978-2012			Raw Trend 1978-2012			Linear Trend 2003-2012			Raw Trend 2003-2012		
Jingellic	8.1016	-0.44	*	NL	-0.40	*	NL	1.44		NL	1.51		NL
Tallandoon	9.6894	**-0.5**	**	NL	**-0.51**	**	NL	**-5.09**	**	NL	**-4.33**	**	nl
Heywoods	3.1974	**-2.2**	**	NL	**-2.28**	**	NL	-6.08		nl	-6.26	*	
Bandiana	7.8088	**-1.44**	**	NL	**-1.51**	**	NL	-0.46		NL	0.72		NL
Peechelba	7.8566	-0.28		NL	-0.42		NL	-1.15		NL	1.01		NL
Yarrawonga	3.0135	**-2.14**	**	NL	**-2.15**	**	NL	-4.29			-3.77		
Torrumbarry	1.4484	-0.47		NL	-0.98		NL	-3.94			3.59		nl
Kerang	2.6612	1.27	*		0.50		nl	1.15		NL	3.26		NL
Capels Flume	3.1467	-0.55		NL	-1.03	*	NL	0.54		nl	2.96		NL
Swan Hill	1.1480	-0.22		NL	-0.64		nl	**-5.76**	**		3.27		nl
Kyalite	1.1491	**-1.64**	**	NL	**-2.17**	**	NL	-1.39			2.51		
Euston Weir	2.1828	**-0.94**	**	NL	**-1.89**	**	NL	**-11.29**	**	NL	**-15.06**	**	
Merbein	2.0807	-0.59		NL	-1.49	*	NL	**-28.29**	**	NL	**-32.48**	**	nl
Burtundy	8.8229	**-2.88**	**	NL	**-4.00**	**	NL	7.22		NL	**17.27**	**	NL
Lock 9	3.1654	**-1.63**	**	NL	**-1.98**	**	NL	4.22			**11.90**	**	nl
Morgan	3.4032	**-2.04**	**	NL	**-2.14**	**	NL	5.16		nl	**8.93**	**	NL

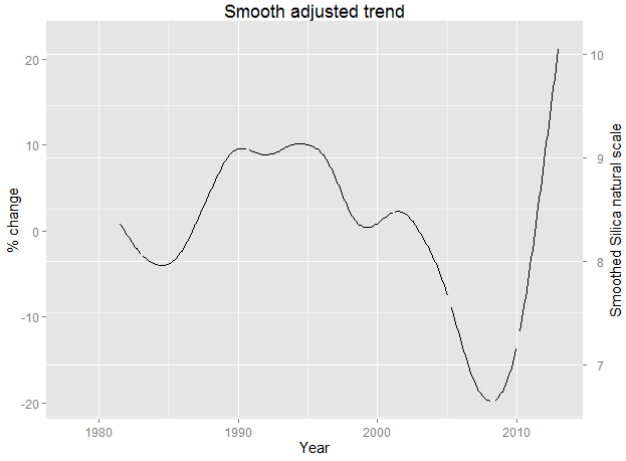
Monitoring Site	Geometric Mean	Relationship to Log flow	Significance	Amplitude(log scale)	Seasonal Peak	Autocorrelation
Jingellic	8.1016	-	**	0.1257	8.2823	0.6811
Tallandoon	9.6894	-	**	0.0523	7.5114	0.5457
Heywoods	3.1974	+	*	0.5729	11.3919	0.6600
Bandiana	7.8088	+	*	0.0552	4.9657	0.5363
Peechelba	7.8566	+	**	0.0373	2.9162	0.4708
Yarrawonga	3.0135	+	**	0.3955	9.1119	0.5080
Torrumbarry	1.4484	+	**	0.3729	7.2478	0.4056
Kerang	2.6612	+	**	0.0932	8.0073	0.5874
Capels Flume	3.1467	+	**	0.1176	11.3105	0.3107
Swan Hill	1.1480	+	**	0.2108	7.1071	0.3489
Kyalite	1.1491	+	**	0.1305	6.4634	0.5740
Euston Weir	2.1828	+	**	0.0828	9.3264	0.3667
Merbein	2.0807	+	**	0.0736	8.9687	0.4087
Burtundy	8.8229	+	**	0.1060	4.6169	0.5256
Lock 9	3.1654	+	**	0.2820	1.5427	0.5452
Morgan	3.4032	+	**	0.3246	3.7923	0.6704

RIVER MURRAY - Jingellic

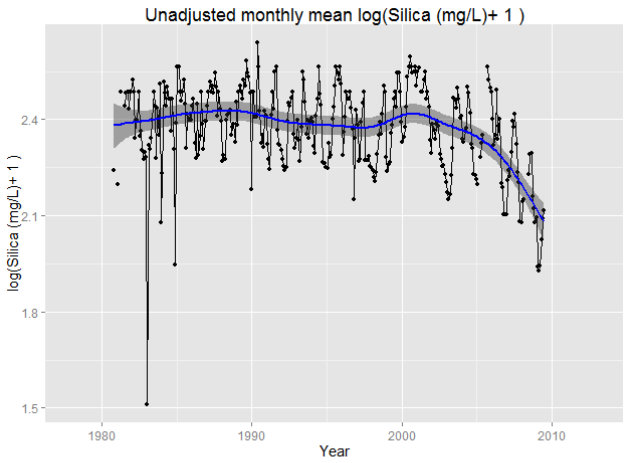


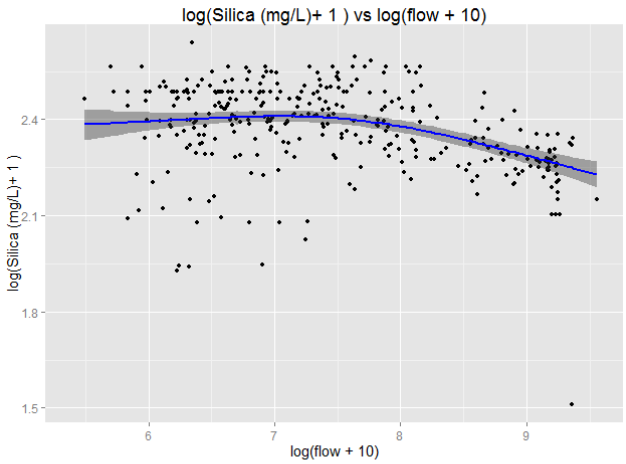


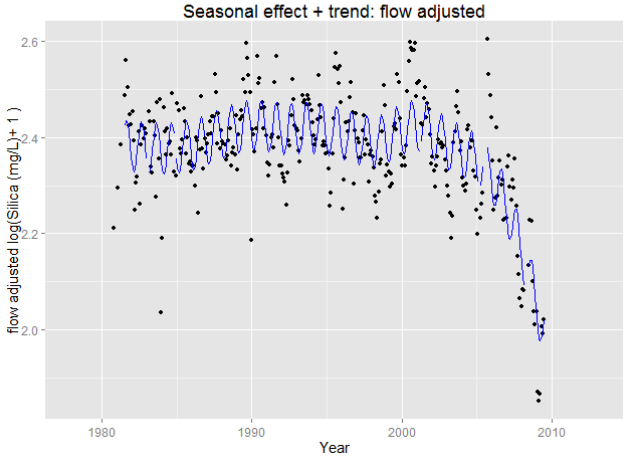


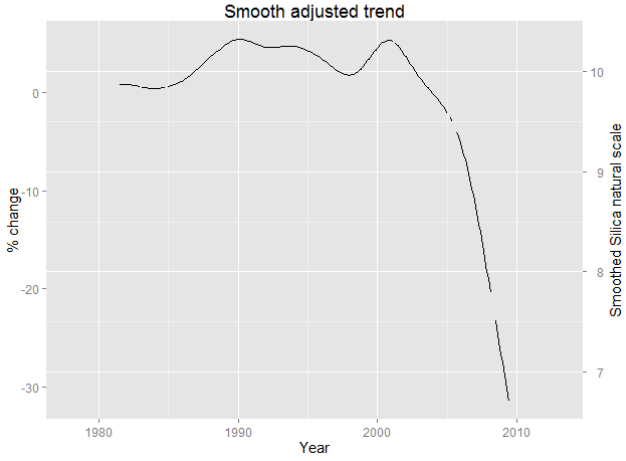


RIVER MURRAY - Tallandoon

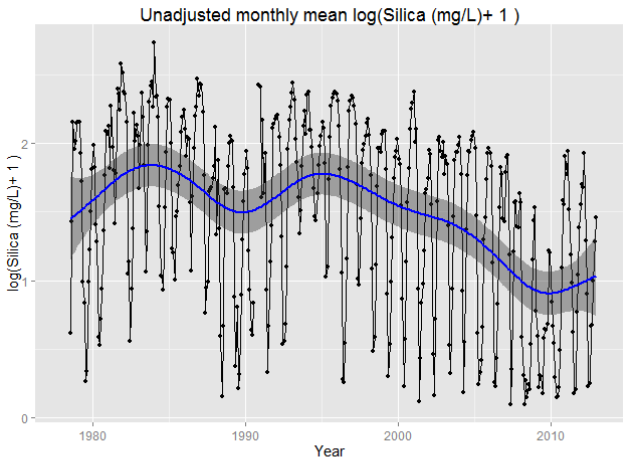


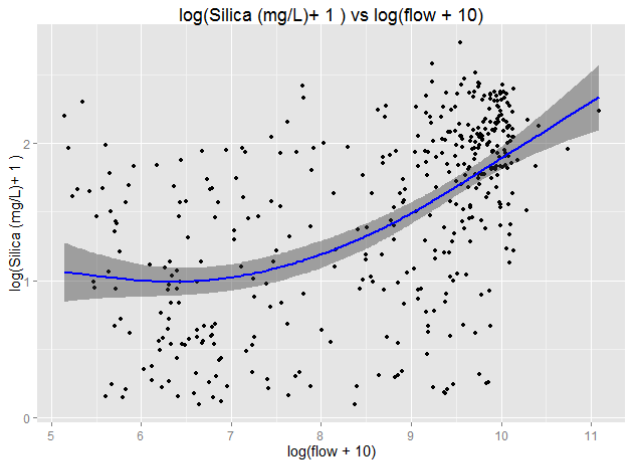


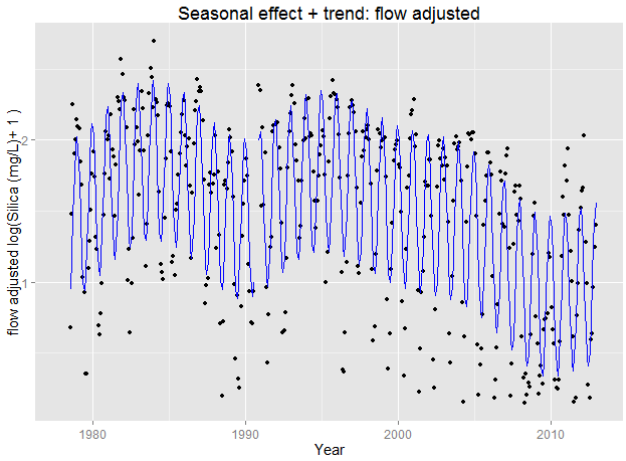


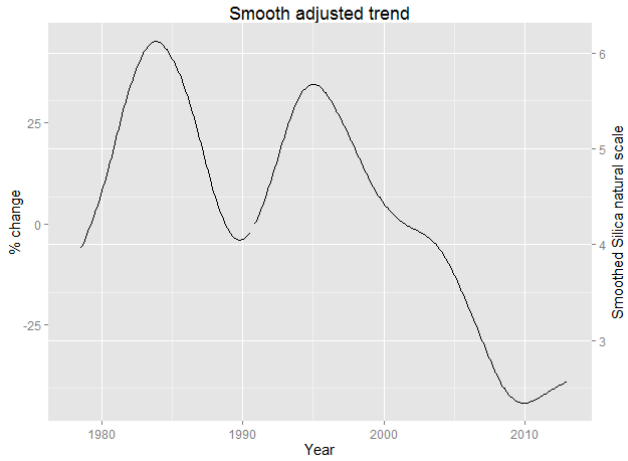


RIVER MURRAY - Heywoods

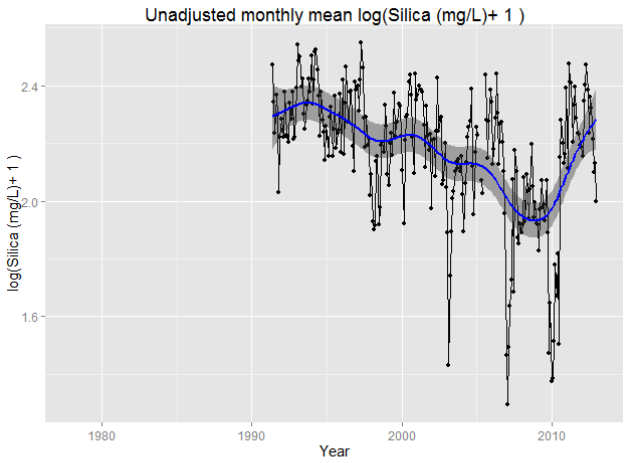


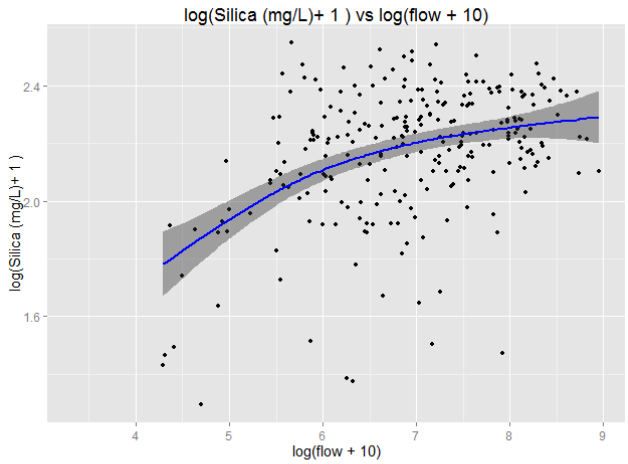


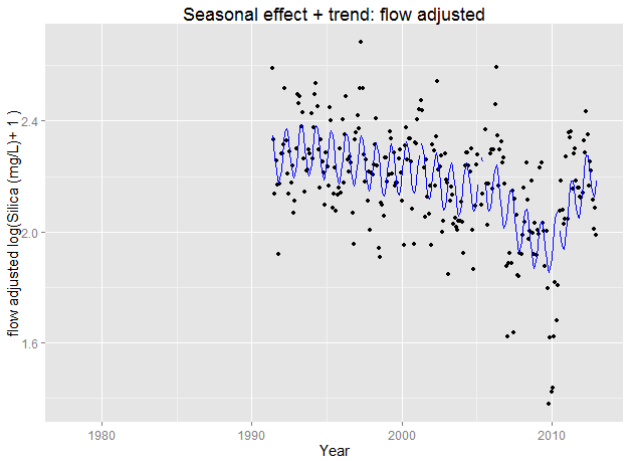


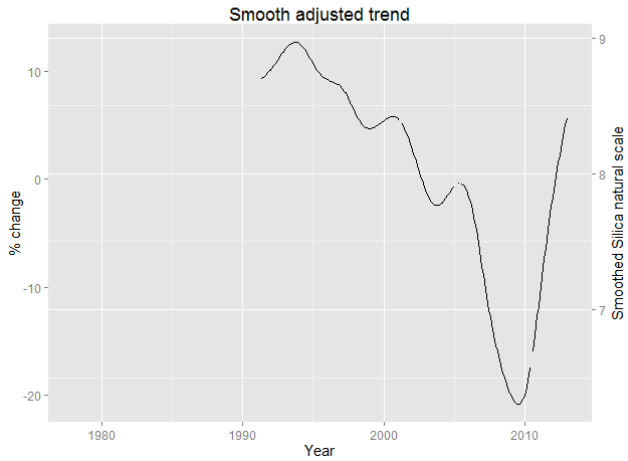


RIVER MURRAY - Bandiana

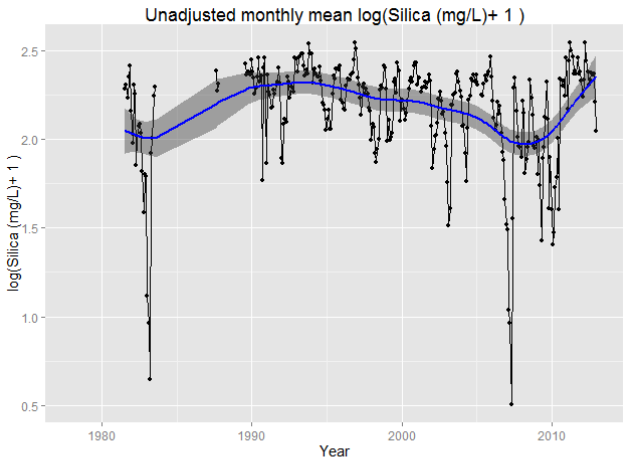


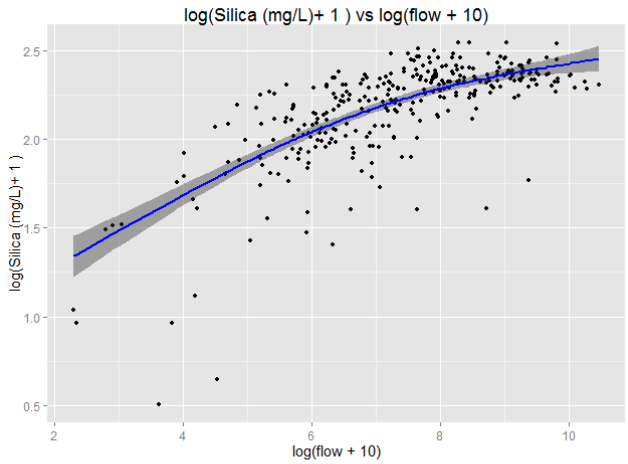


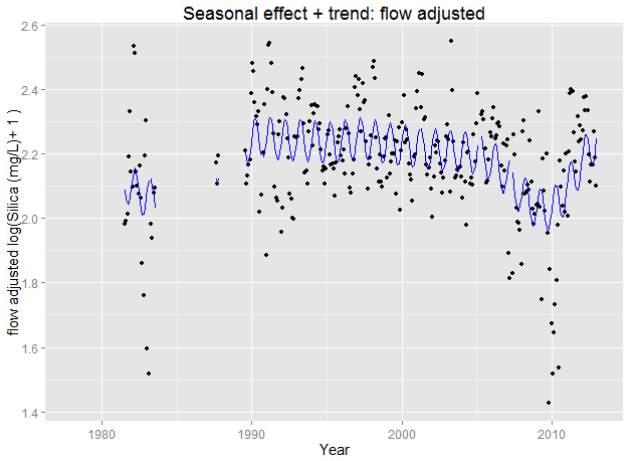


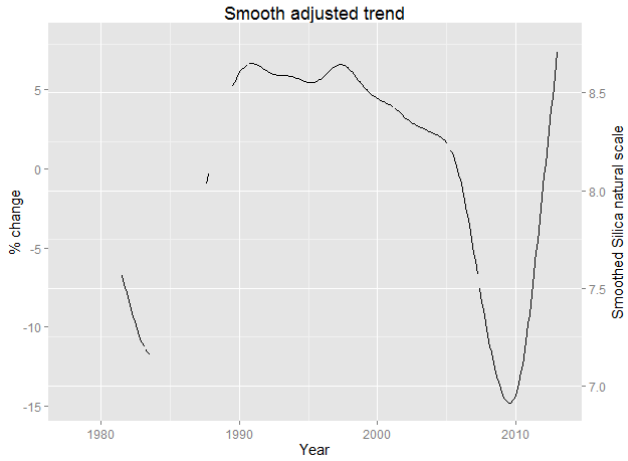


RIVER MURRAY - Peechelba

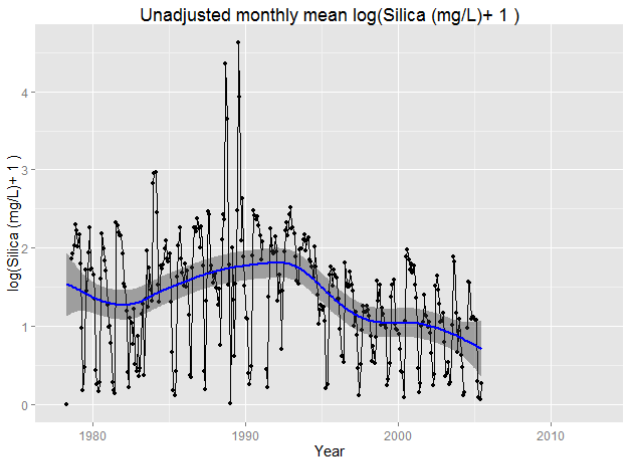


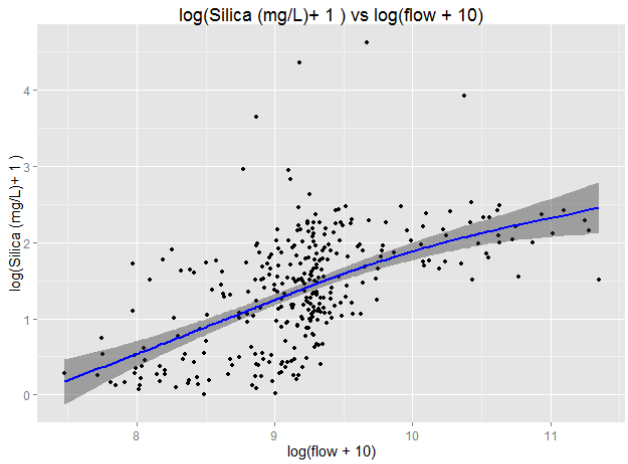


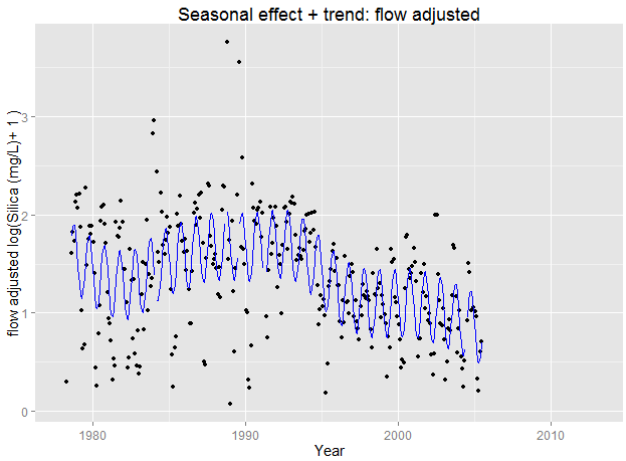


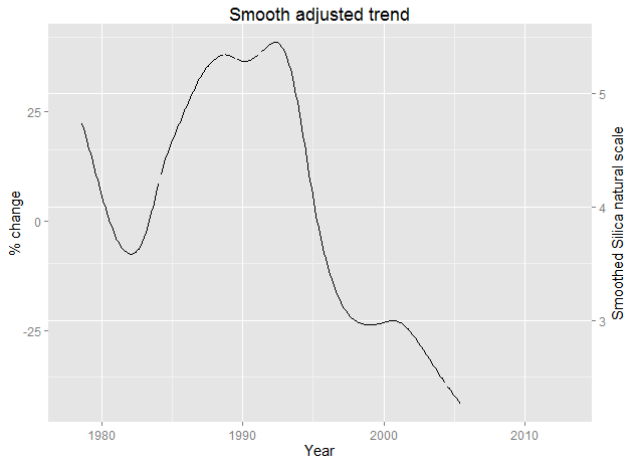


RIVER MURRAY - Yarrawonga

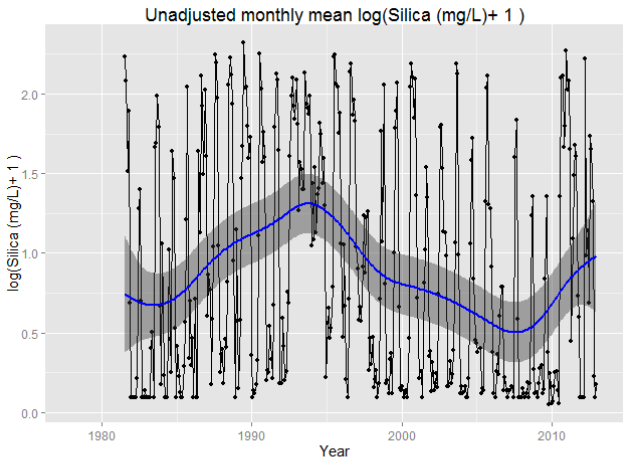


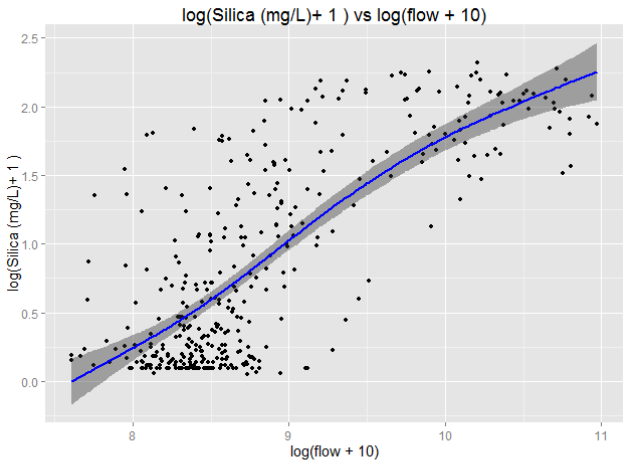


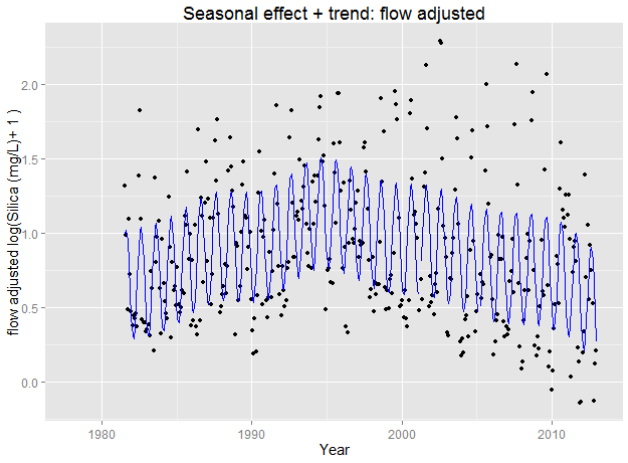


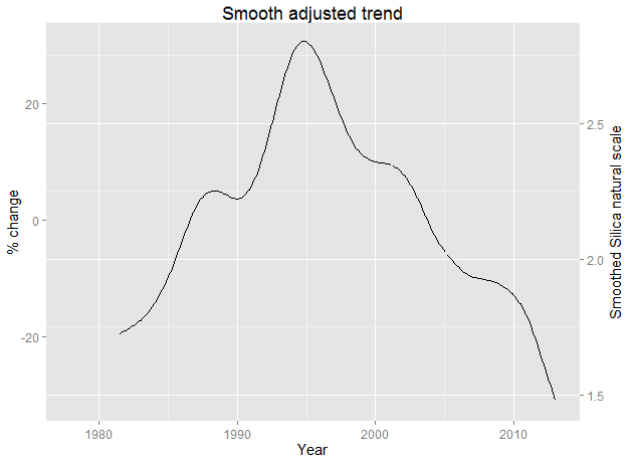


RIVER MURRAY - Torrumbarry

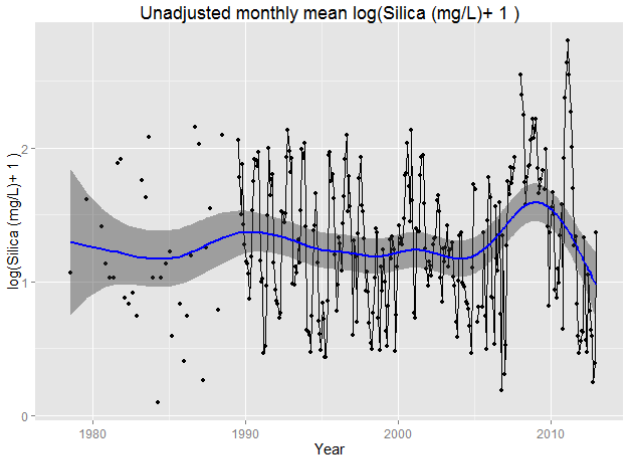


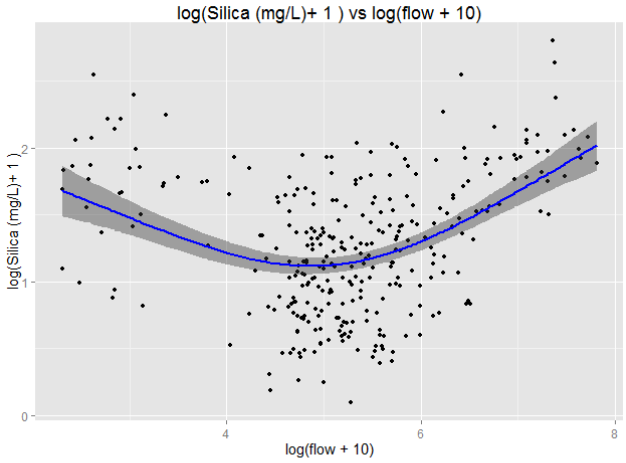


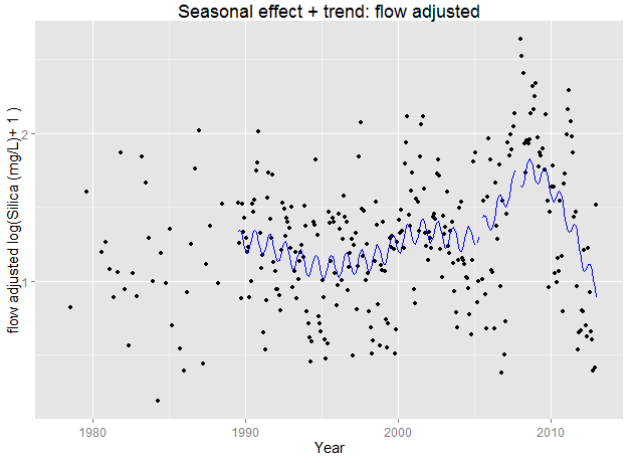


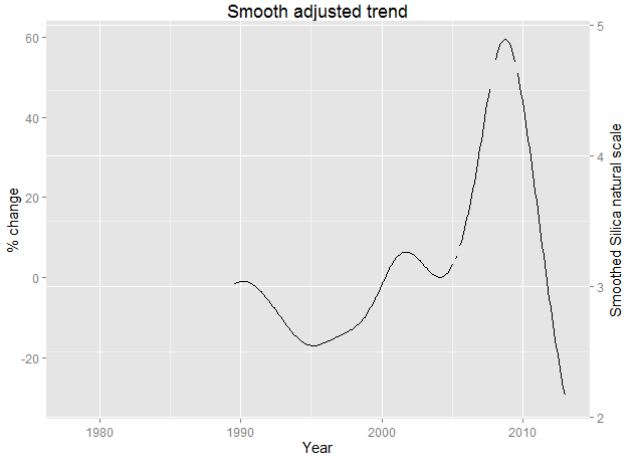


RIVER MURRAY - Kerang

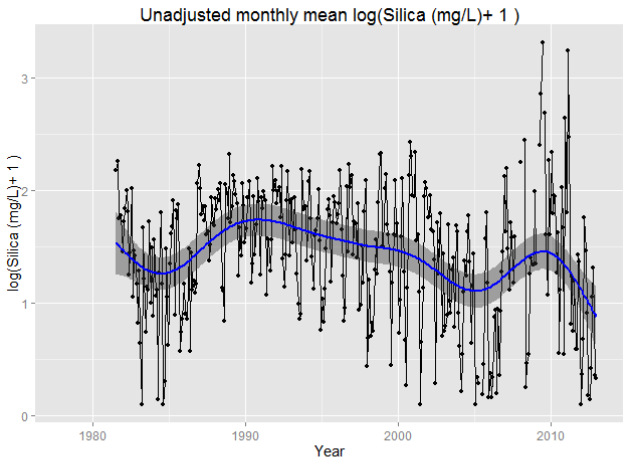


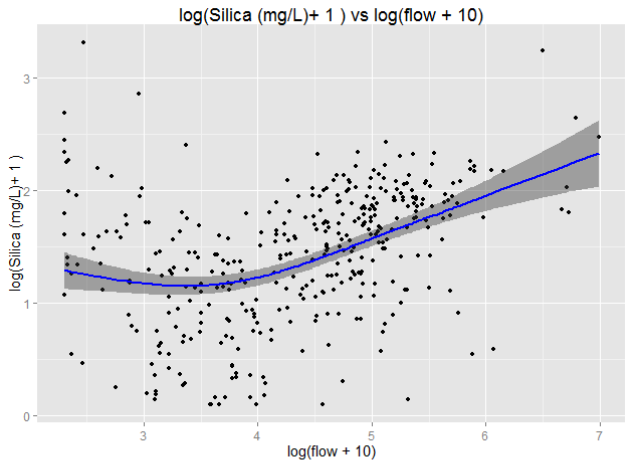


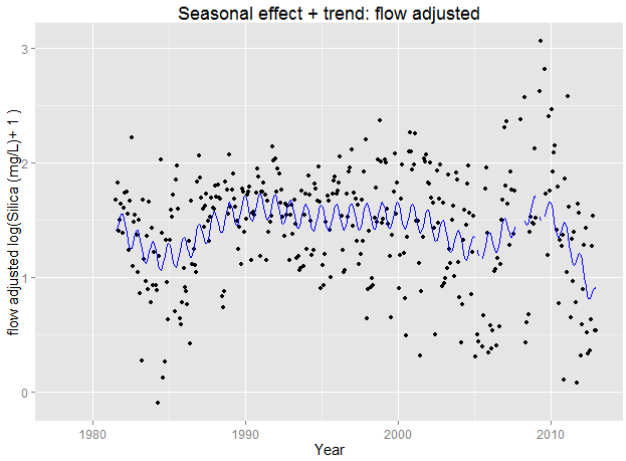


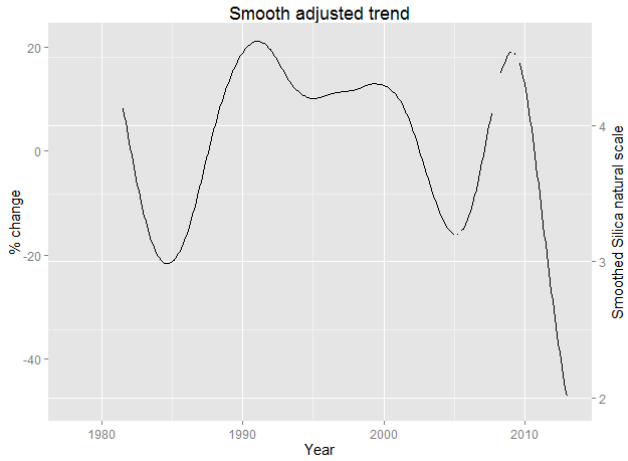


RIVER MURRAY - Capels Flume

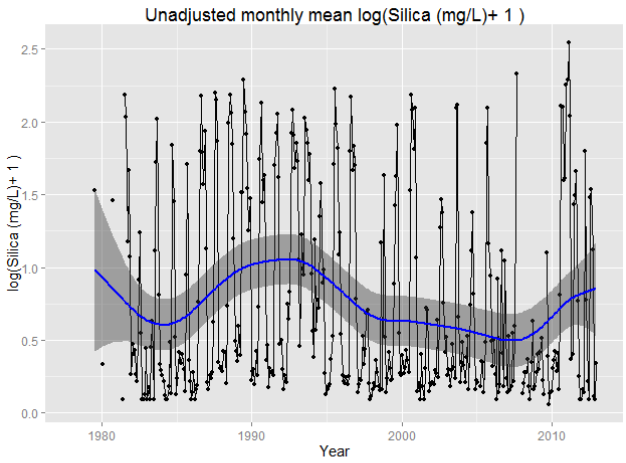


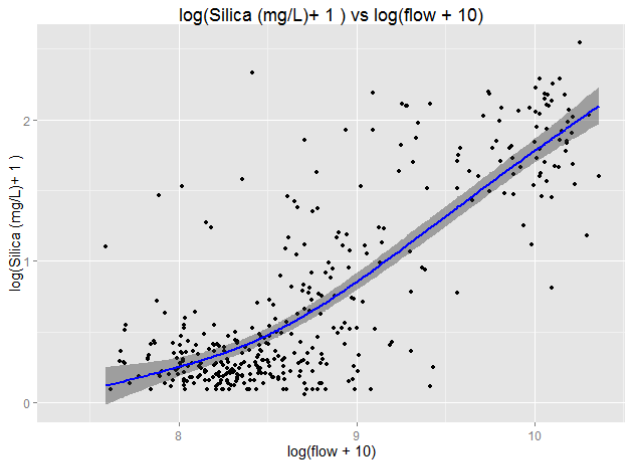


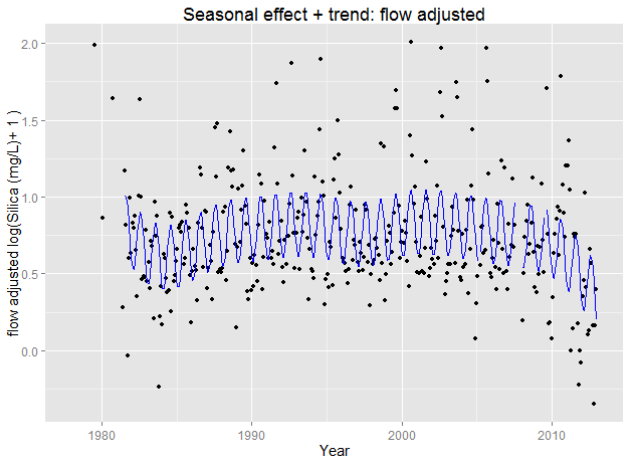


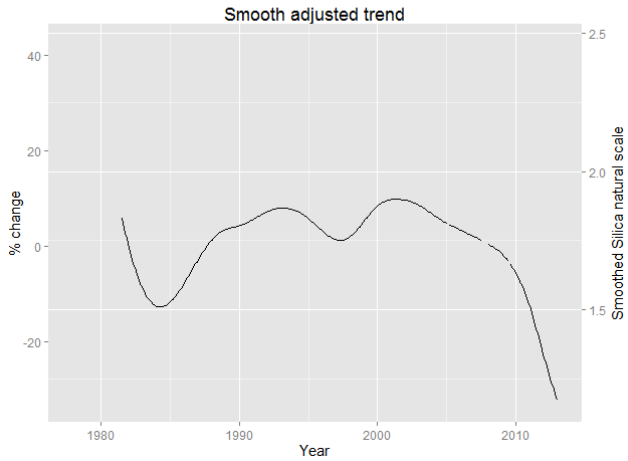


RIVER MURRAY - Swan Hill

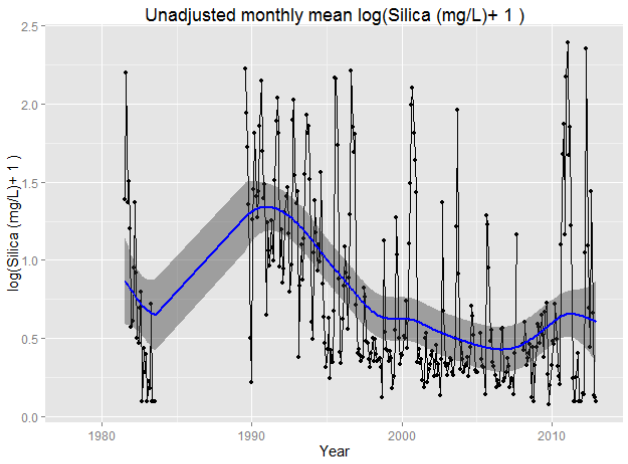


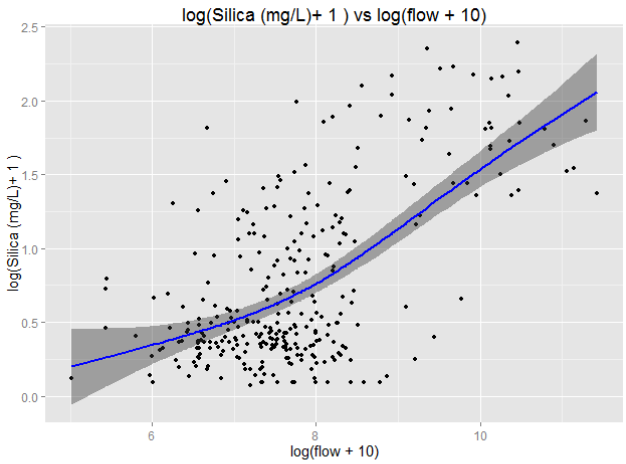


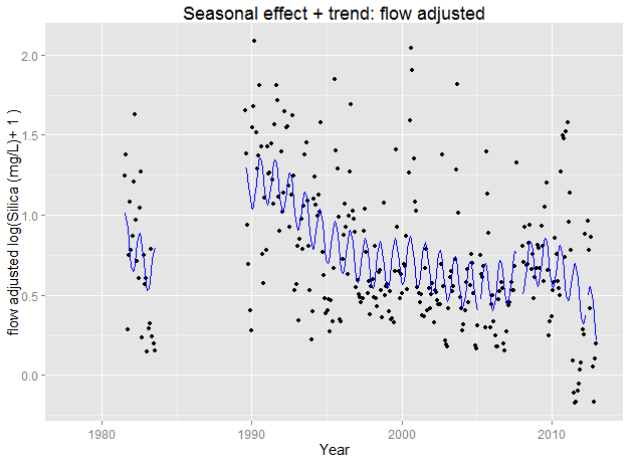


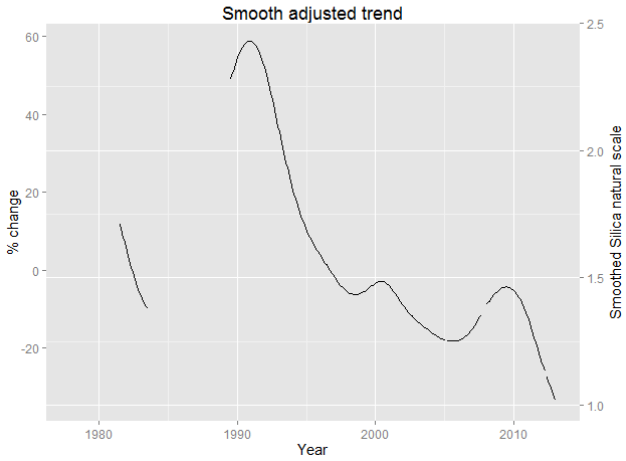


RIVER MURRAY - Kyalite

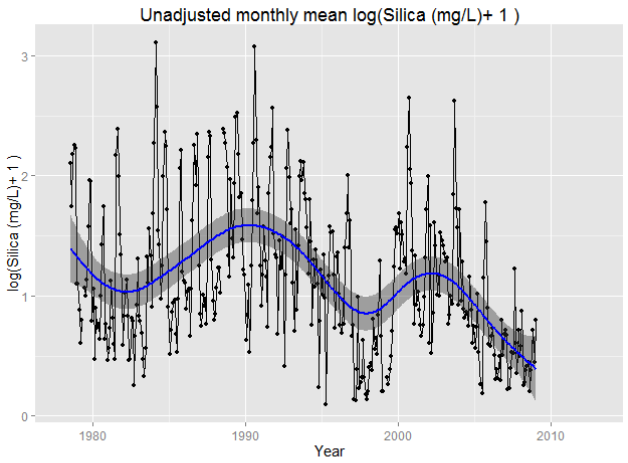


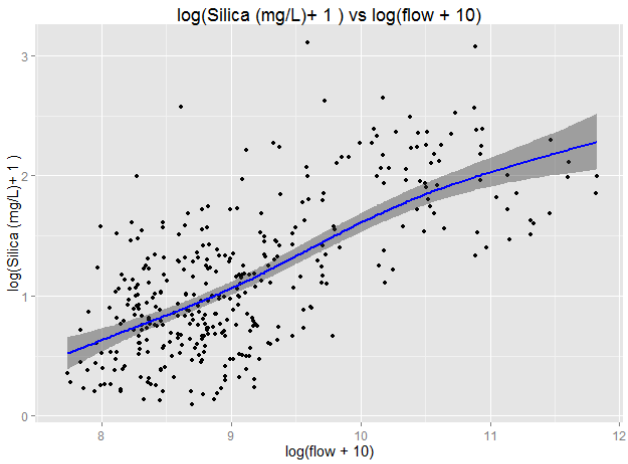


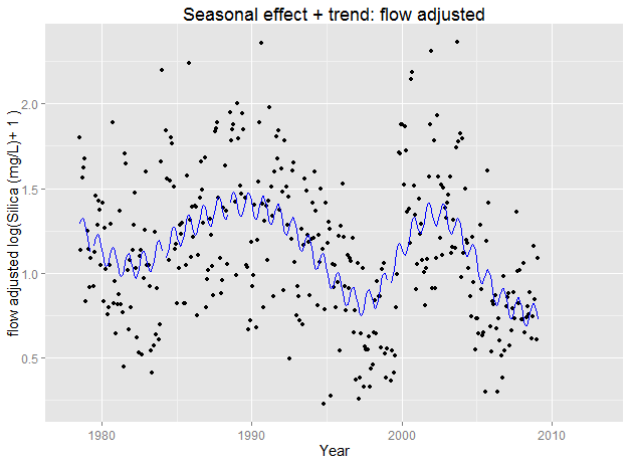


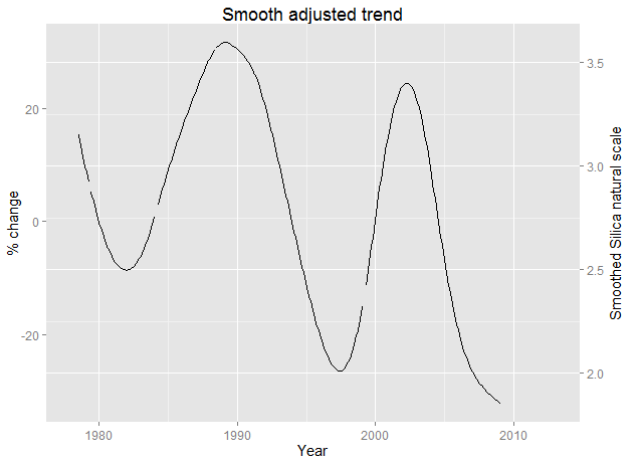


RIVER MURRAY - Euston Weir

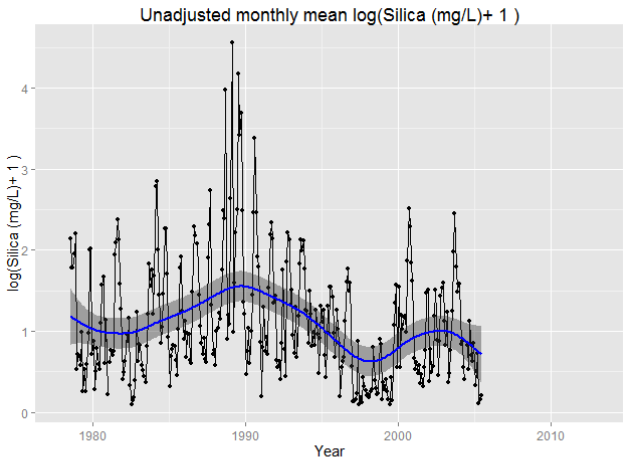


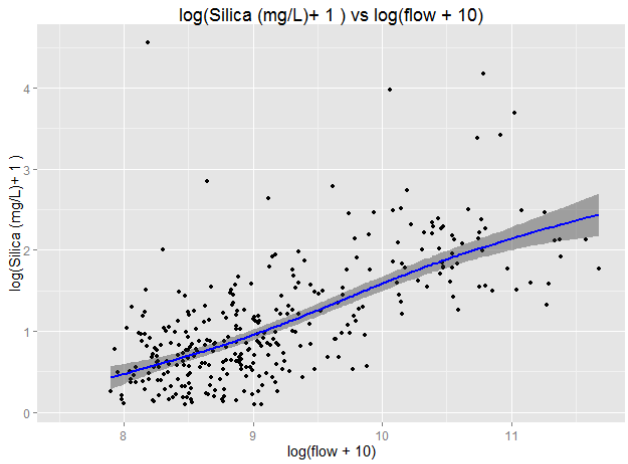


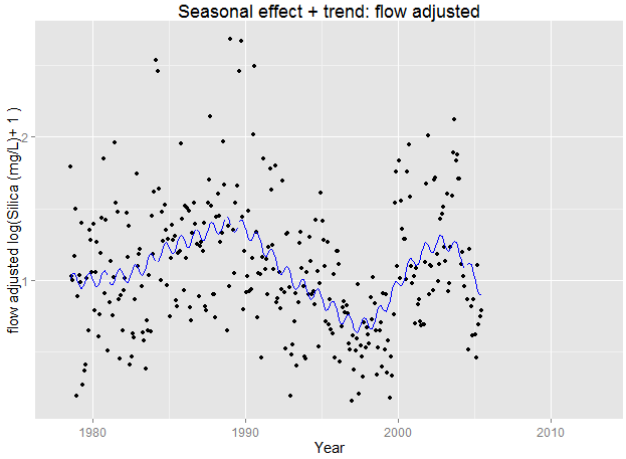


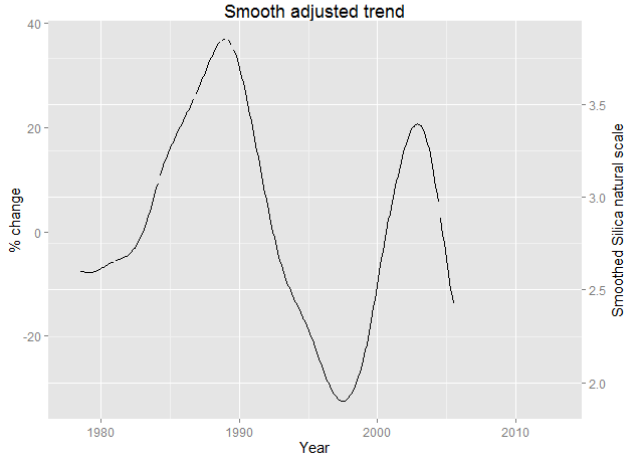


RIVER MURRAY - Merbein

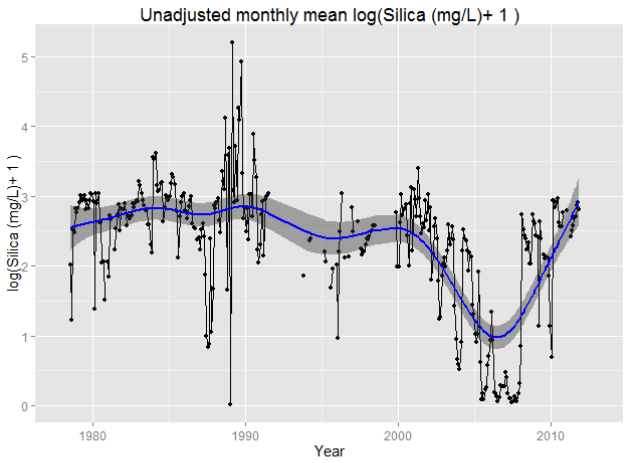


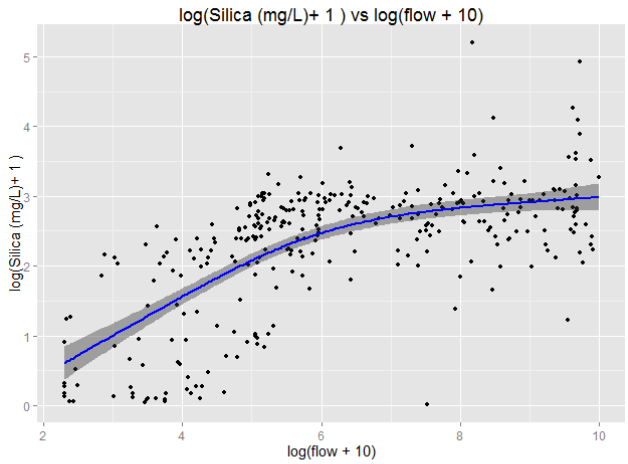


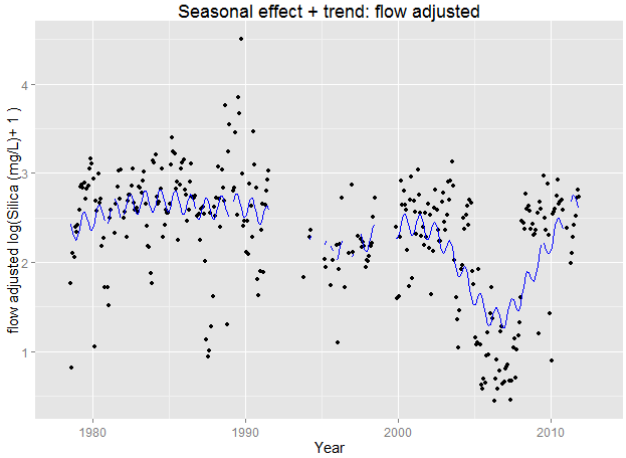


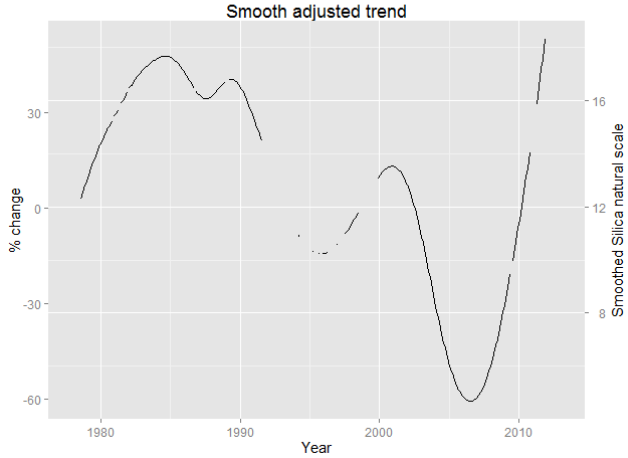


RIVER MURRAY - Burtundy

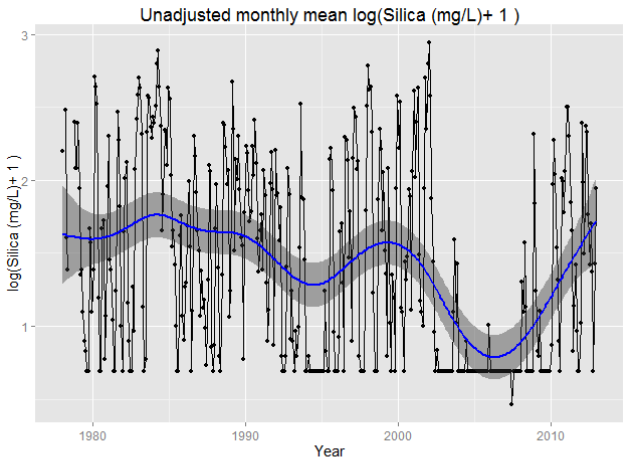


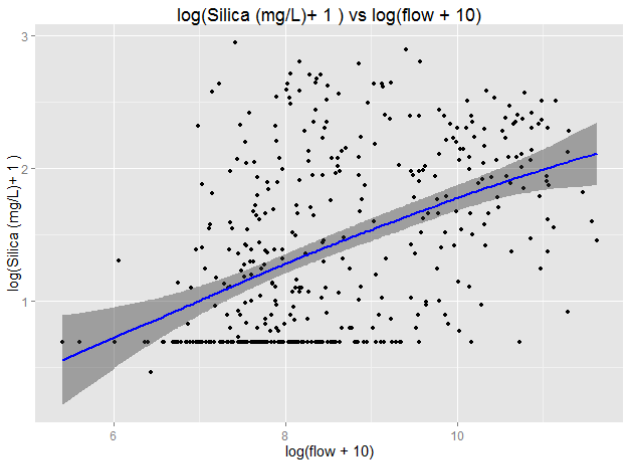


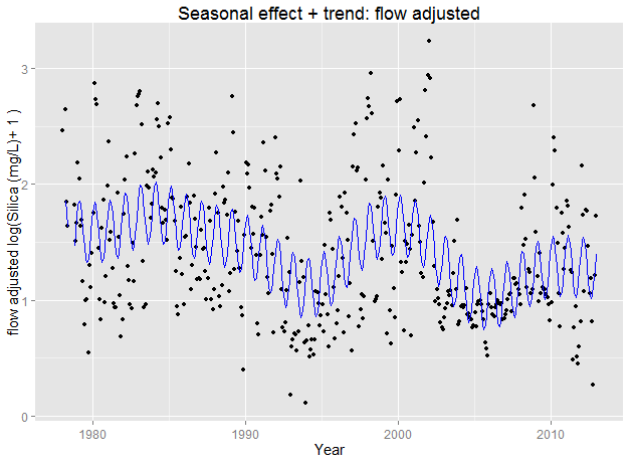


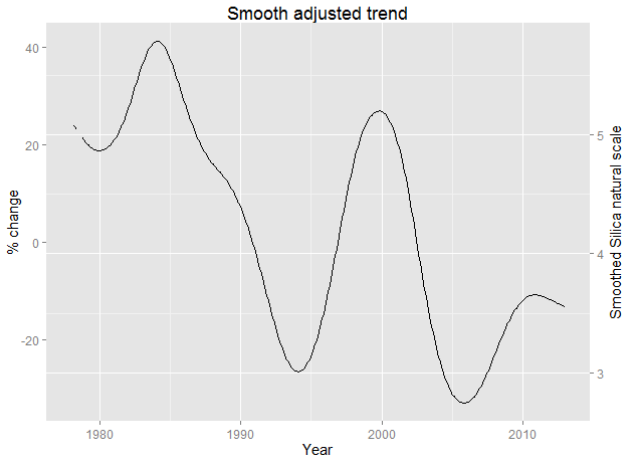


RIVER MURRAY - Lock 9

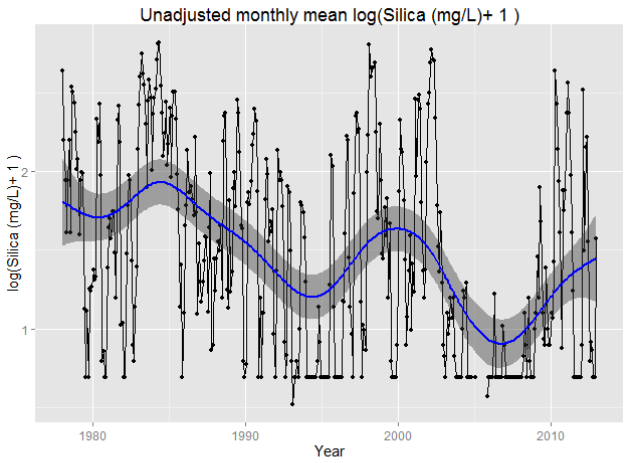


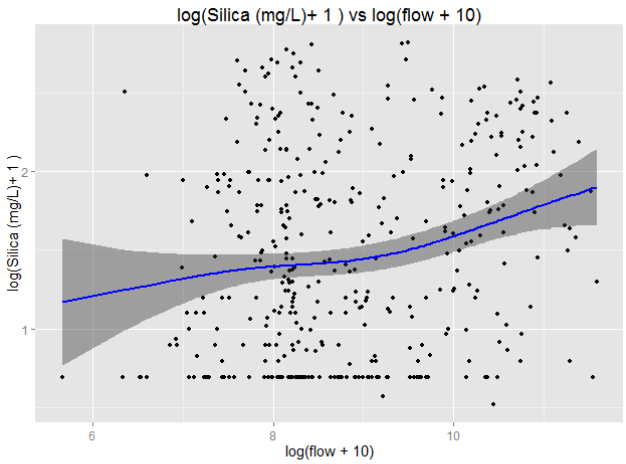


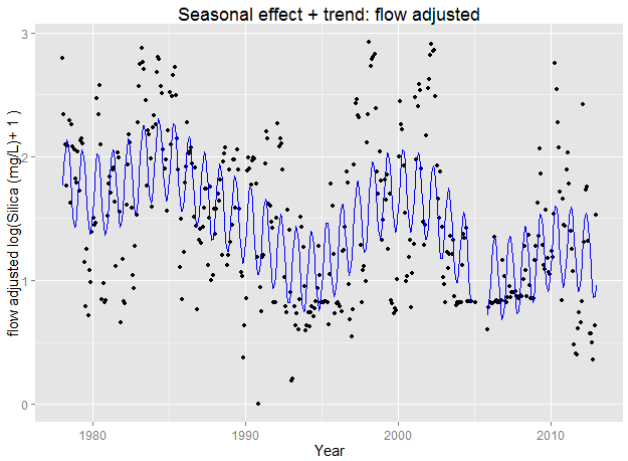


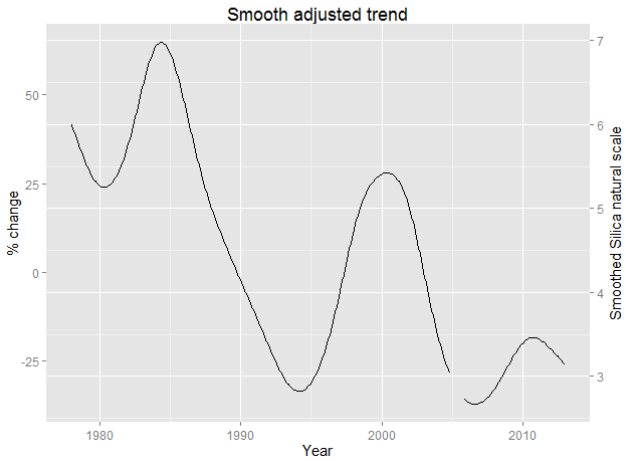


RIVER MURRAY - Morgan









CONTACT US

t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

YOUR CSIRO

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves governments, industries, business and communities across the nation.

FOR FURTHER INFORMATION

CSIRO Computational Informatics / CSIRO Water for a Healthy Country Flagship
Brent Henderson
t +61 2 6216 7095
e Brent.Henderson@csiro.au
w www.csiro.au/cmis