Upper Serpentine River

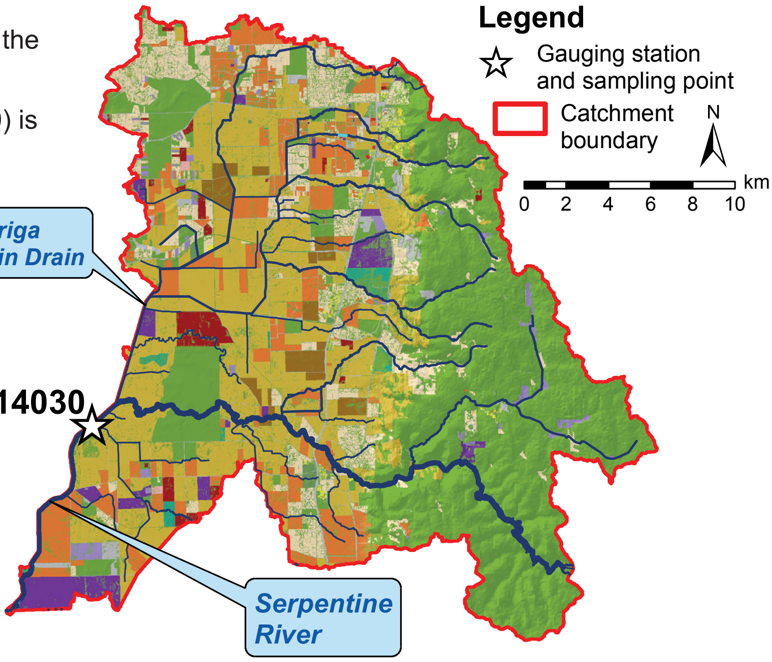
The upper Serpentine catchment comprises land draining to the Serpentine River between Lake Amarillo and the Serpentine Dam. Birriga Main Drain drains the north of the catchment.

The Serpentine River sampling site at Dog Hill (614030) is one of three long-term monitoring sites within the Peel-Harvey catchment. Flow has been measured since 1979 and nutrients monitored from 1983.

Before 2002 the Serpentine River flowed year-round. Since 2002 the river has ceased to flow from around January to March with the exception of 2009 when it flowed year-round.

A mixture of soil types is found within the catchment and only a very small percentage is subject to flooding (5%). More than half the catchment has a low or very low risk of phosphorus leaching to the waterways (62%).

To the Darling Scarp's east the catchment remains relatively undisturbed. West of the scarp the land has been cleared, mostly for agriculture (e.g. stock grazing) and lifestyle blocks. More intensive land uses such as sheep feedlots, poultry farms and piggeries are also present.




Serpentine River at Dog Hill – August 2001

Land use classification (2006)		Area (km^2)	Area (%)
Animal keeping – non-farming (horses)		47	9.3
Cattle for beef (predominantly)		120	24
Cattle for dairy		8.6	1.7
Conservation and natural		235	47
Horticulture		5.2	1.0
Industry, manufacturing and transport		17	3.4
Intensive animal use		6.6	1.3
Lifestyle block		43	8.6
Mixed grazing		13	2.5
Offices, commercial and education		0.34	0.07
Plantation		2.5	0.50
Recreation		1.4	0.28
Residential		2.1	0.42
Viticulture		0.36	0.07
Total		**502**	**100**

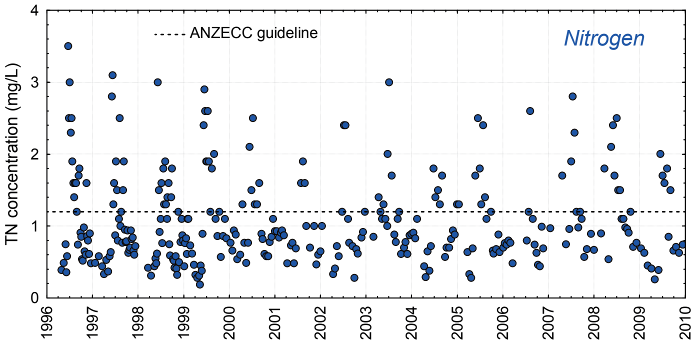
Nutrient summary: median concentrations, loads and status classification at 614030

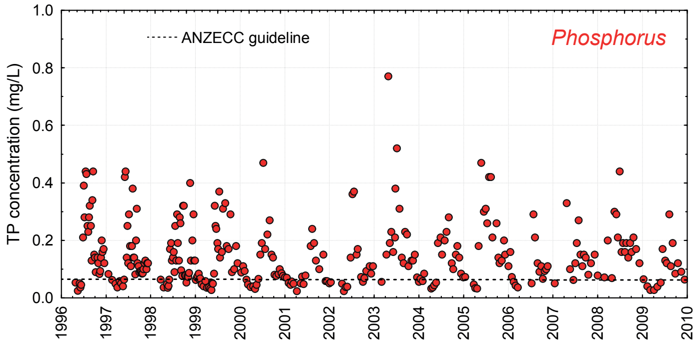
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Annual flow (GL)	120	48	42	66	95	17	31	59	34	63	9.7	35	49	51
TN median (mg/L)	0.91	0.81	0.87	0.86	0.84	0.91	0.75	1.1	0.86	1.2	0.75	1.0	1.1	0.70
TP median (mg/L)	0.16	0.12	0.13	0.09	0.09	0.07	0.08	0.19	0.11	0.20	0.10	0.13	0.18	0.09
TN load (t/year)	328	120	111	134	202	30	59	120	68	129	19	80	103	107
TP load (t/year)	67	22	23	23	40	4.8	10	21	10	24	2.7	12	16	18

Status classification: Low | Moderate | High | Very high

Status reported for three-year period end (i.e. 1996–98 reported in 1998)
TN = total nitrogen TP = total phosphorus

Total nitrogen (TN) and total phosphorus (TP) concentrations (1996–2009)





TN concentration:

The annual percentage of TN samples that exceeded the ANZECC[1] guideline for lowland rivers (1.2 mg/L) ranged between 6% (2006) and 42% (2005).

Between 1996 and 2004, 27% of samples exceeded the guideline. This value increased slightly to 30% for the period between 2005 and 2009.

TN trend:

Trend analysis was undertaken using data from 2005 to 2009 inclusive.

Once the data were adjusted for flow and seasonality, no trend was detected.

Winter flow at Dog Hill – August 2001

TP concentration:

The annual percentage of TP samples that exceeded the ANZECC[1] guideline for lowland rivers (0.065 mg/L) ranged between 53% (2001) and 100% (2008).

Between 1996 and 2004, 75% of samples exceeded the guideline. This value increased to 81% for the period between 2005 and 2009.

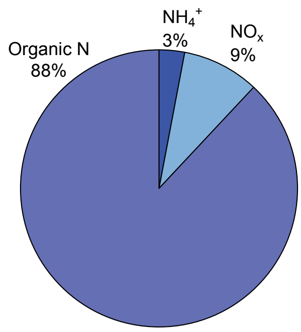
TP trend:

Trend analysis was undertaken using data from 2005 to 2009 inclusive.

Once the data were adjusted for flow and seasonality, no trend was detected.

Downstream view at Dog Hill showing in-stream vegetation and sediment – September 2008

Nutrient fractions (2005–09)



Nitrogen:

Most of the nitrogen (N) was organic in nature. Organic N consists of both dissolved organic and particulate nitrogen. It is derived from degrading plant and animal matter and fertilisers. It often needs to be further broken down before it can be used by plants and algae.

The remaining N was dissolved inorganic N (DIN) such as ammonium (NH_4^+) and N oxides (NO_x).

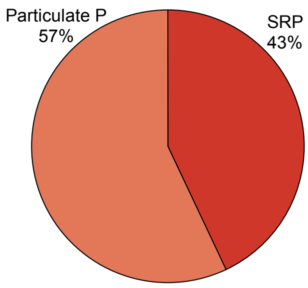
DIN is also derived from animal wastes and fertilisers but is readily available to plants and algae.

Serpentine River (Dog Hill) had the lowest percentage of NH_4^+ (3%) of the sites sampled in the Peel-Harvey catchment.

Phosphorus:

More than half of the phosphorus (P) was present as particulate P, which consists of sediment-bound forms of P and organic waste materials.

Particulate P is not readily available for uptake by plants and algae, but may become available over



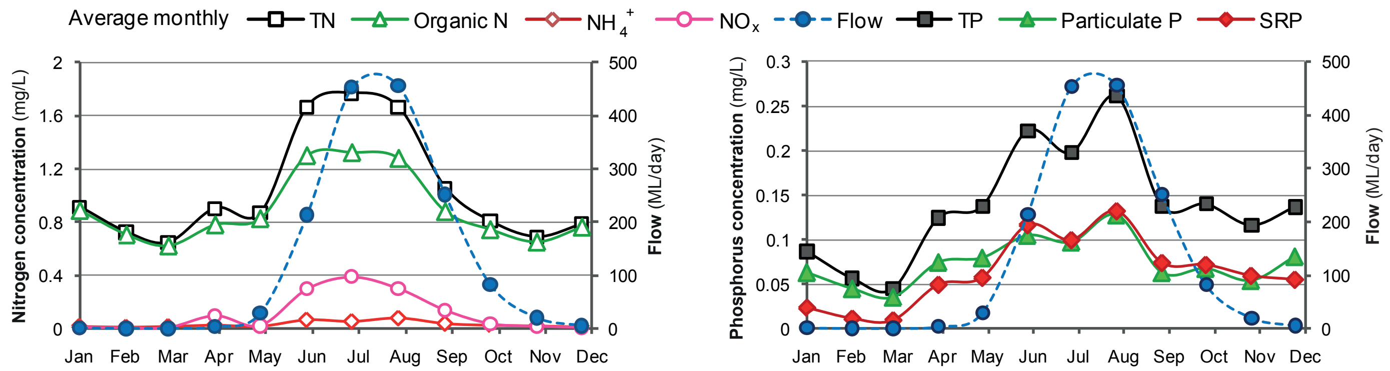
time as organic matter decomposes or soil particles release bound phosphorus.

The remaining P was present as soluble reactive phosphorus (SRP). SRP is derived from fertilisers and animal wastes and is readily available for uptake by plants and algae.

Only four sites had a greater percentage of SRP than the Serpentine River (Dog Hill). All but one (Meredith Main Drain) drained to the Serpentine River downstream of Dog Hill.

Upstream view at Dog Hill showing weir and gauging station – December 2006

Seasonal variation in nutrient concentrations and riverine flow (2005–09)



Nitrogen:

Average monthly nitrogen concentrations showed a seasonal pattern, increasing with the first-flush in April and being highest during winter.

Increases in total and organic N during summer were possibly caused by decaying plant matter and evapo-concentration.

Average monthly concentrations of TN and NO_x exceeded ANZECC[1] guidelines throughout the winter months.

Average monthly NH_4^+ concentrations did not exceed guideline concentrations.

August 2005

Phosphorus:

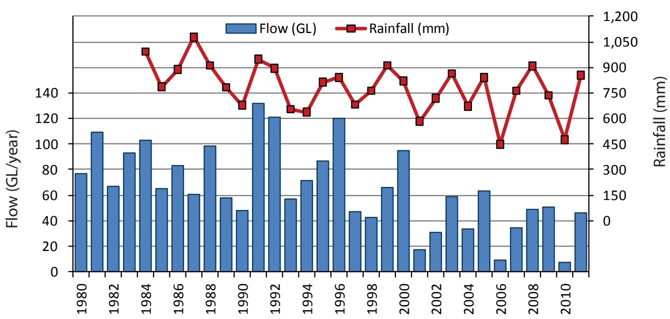
Average monthly phosphorus concentrations showed a seasonal pattern, increasing with the first-flush in April and being highest in winter. A decrease in average concentration was observed in July when peak flows may have diluted concentrations.

Average monthly SRP concentrations were greater than particulate P concentrations between June and November.

Average monthly TP and SRP concentrations exceeded ANZECC[1] guideline values for most of the year.

	ANZECC 2000	Months exceeded
TN	1.2 mg/L	Jun – Aug
NH_4^+	0.08 mg/L	None
NO_x	0.15 mg/L	Jun – Aug
TP	0.065 mg/L	Apr – Jan
SRP	0.04 mg/L	Apr – Dec

Long-term flow and rainfall (1980 – 2011)



Flow has been measured at Dog Hill since February 1979, and rainfall from June 1983. Total annual flow and rainfall appear to be declining.

Total annual flow ranged from 7.7 GL in 2010 to 132 GL in 1991. Total annual rainfall ranged from 451 mm in 2006 to 1079 mm in 1987.

Before 2002 the Serpentine River generally flowed all year. Since then flow has regularly ceased during the summer and autumn months.

	Months when flow ceased	Number of days
1980	Feb	4
1988	Mar	1
2002	Feb – Mar	53
2003	Jan – Mar	46
2004	Mar	16
2005	Jan – Mar	37
2006	Dec	3
2007	Jan – Apr	82
2008	Feb	1
2010	Mar	19
2011	Jan – May	123

Winter flow – July 2007

Vegetation and sedimentation

By January 2009 sediment accumulation immediately downstream of the weir was found to be creating a backwater (which can affect flow readings) and contractors were brought in to remove it during April.

Sedimentation and plant growth – January 2009

Sediment removal – April 2009

Modelled results (1997–2007)[2]

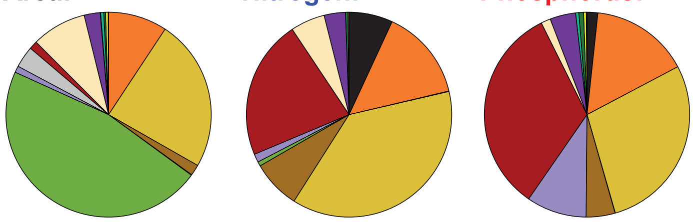
This page reports results from the Streamflow Quality Affecting Rivers and Estuaries (SQUARE) model. It estimated flow, nitrogen and phosphorus loads from the 13 subcatchments of the Peel-Harvey estuary.

Nutrient sources

There were three main sources of nutrient loads in the upper Serpentine catchment: 'cattle for beef', 'intensive animal use' and 'animal keeping'. The three land uses were responsible for 74% of the nitrogen and 77% of the phosphorus load from the catchment despite only accounting for 35% of the area.

'Intensive animal use' was the most intensive land use with 1.3% of the catchment area contributing 22% of the nitrogen and 33% of the phosphorus load. 'Horticulture' also contributed a relatively large phosphorus load (9.5%) for its area (1%).

Area: **Nitrogen:** **Phosphorus:**



Annual exports to Peel Inlet

The upper Serpentine catchment is 5.9% of the area that drains to the Peel Inlet. On average it contributed to the Peel Inlet:

- 11% of the flow (55 GL/year)
- 15% of the nitrogen load (106 tonnes/year)
- 30% of the phosphorus load (21 tonnes/year).

Remediation priority

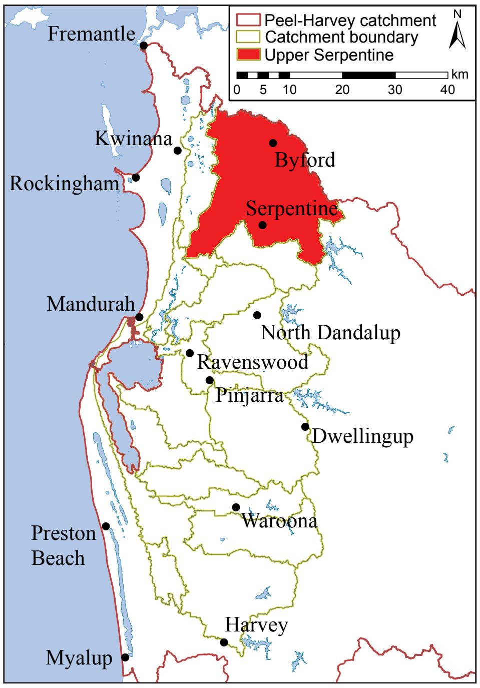
The SQUARE-modelled data indicated that based on nutrient loads per cleared area (kg/ha/year):

- The upper Serpentine catchment requires medium-priority nitrogen and phosphorus remediation action

The upper Serpentine catchment is only 6% of the area draining to the Peel Inlet, however it contributed 30% of the phosphorus load.

'Intensive animal use' and 'horticulture' contributed large nutrient loads compared with their areas and should be further investigated.

How the upper Serpentine fits within the Peel-Harvey catchment: location and statistics



Catchment draining to estuary	Area (km²)	Flow (GL)	TN load (tonnes/ year)	TN load per cleared area (kg/ha)	TP load (tonnes/ year)	TP load per cleared area (kg/ha)
Peel Main Drain	120	11	26	3.0	4.5	0.52
Upper Serpentine	**502**	**55**	**106**	**3.8**	**21**	**0.75**
Dirk Brook – Punrak Drain	134	18	51	7.5	5.6	0.82
Nambeelup	143	19	44	3.6	10.5	0.86
Lower Serpentine	94	6.2	9.7	1.6	2.9	0.49
Mandurah	24	3.0	7.9	5.0	1.3	0.84
Upper Murray	6 752	286	204	0.51	4.9	0.01
Lower Murray, mid Murray and Dandalup	638	74	198	6.4	4.9	0.16
Coolup (Peel)	151	23	42	3.2	15	1.2
Subtotal Peel Inlet	**8 558**	**496**	**701**	**1.4**	**73**	**0.14**
Coolup (Harvey)	113	16	26	3.3	14	1.8
Mayfield Drain	119	19	33	3.1	7.1	0.67
Harvey	710	142	259	6.9	39	1.0
Meredith Drain	56	11	16	4.3	8.3	2.2
Subtotal Harvey Estuary	**998**	**188**	**334**	**5.6**	**69**	**1.2**
Total Peel-Harvey Estuary	**9 556**	**684**	**1 035**	**1.8**	**142**	**0.25**

References

[1] ANZECC & ARMCANZ 2000, *Australian guidelines for water quality monitoring and reporting,* National Water Quality Management Strategy, Paper no. 7, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

[2] Kelsey, P, Hall, J, Kretschmer, P, Quinton, B & Shakya D 2010, *Hydrological and nutrient modelling of the Peel-Harvey catchment*, Water Science Technical Series, Report no. 33, Department of Water, Western Australia.

www.water.wa.gov.au

For further information please contact the Water Science Branch, Department of Water
catchmentnutrients@water.wa.gov.au

ISBN 978-1-921992-73-5 (online)