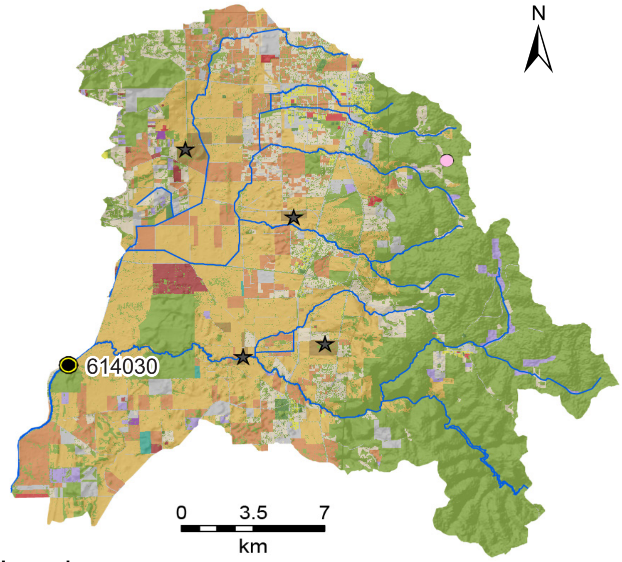
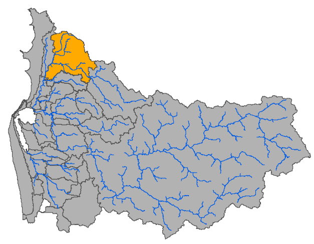
Department of **Water and Environmental Regulation**
Department of **Primary Industries and Regional Development**
GOVERNMENT OF WESTERN AUSTRALIA

Upper Serpentine River

This data report provides a summary of the nutrients at the Upper Serpentine River sampling site in 2019 as well as historical data from 2005–19. This report was produced as part of Healthy Estuaries WA. The river continues downstream of the site, passing through the Serpentine Lakes before discharging into the Peel Inlet.





Location of Upper Serpentine River catchment in the greater Peel-Harvey catchment.

About the catchment

The Upper Serpentine River has a catchment area of about 490 km^2, just more than half of which has been cleared, mostly for beef and sheep grazing on the Swan Coastal Plain. There are four dairies and a piggery present in the catchment. The Serpentine River is a natural waterway, though it is dammed just upstream of the Upper Serpentine catchment boundary by the Serpentine Dam. The northern part of the catchment is drained by Birriga Main Drain. There are numerous other drains present which were constructed to remove water from agricultural land.

Soils on the coastal plain portion of the catchment have a low phosphorus-binding capacity. This is often so poor that any phosphorus applied to them can be quickly washed or leached into drains and other waterways. The soils present in the Darling Scarp have a high phosphorus-binding capacity, helping to prevent it entering drains and other waterways.

Water quality is measured at site 614030, Dog Hill, near Wilkinson Road in Baldivis. The catchment area upstream of the sampling site is about 333 km^2.

Results summary

Nutrient concentrations (total nitrogen and total phosphorus) were moderate (nitrogen) and high (phosphorus) at the Upper Serpentine River sampling site. Total nitrogen and total phosphorus loads were moderate compared with the other monitored catchments. The combination of agricultural land use, highly modified rivers and construction of drains to reduce surface water ponding all contributed to the nutrient concentrations and nutrient loads at this sampling site.

Facts and figures

Sampling site code	614030
Catchment area	490 km^2
Per cent cleared area (2015)	55 per cent
River flow	Permanent
Main land use (2015)	Native vegetation and beef and sheep grazing

Estimated loads and flow at Upper Serpentine River

614030	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Flow (GL)	63	9.7	35	49	51	7.7	46	16	33	25	6.2	22	38	51	17
TN load (t)	113	14	61	88	91	10	82	22	58	41	8.0	34	66	91	26
TP load (t)	16.5	2.01	8.68	12.9	13.2	1.42	12.1	2.98	8.18	5.68	1.11	4.80	9.77	13.4	3.70

Upper Serpentine River

Nitrogen over time (2005–19)

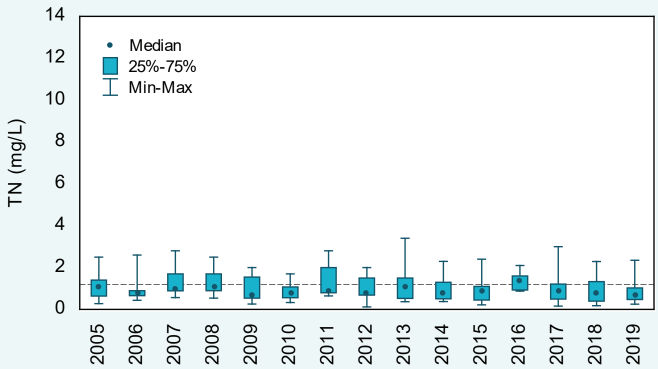
Concentrations

Total nitrogen (TN) concentrations fluctuated over the reporting period at the Upper Serpentine River sampling site. While all years had some samples above the Bindjareb Djilba (Peel-Harvey estuary) Protection Plan water quality target for TN concentrations, all annual medians (with the exception of 2016) were below the water quality target. Using the State Wide River Water Quality Assessment (SWRWQA) methodology, all years were classified as moderate and, compared with the other sites sampled in the Peel-Harvey catchment, TN concentrations at the Upper Serpentine River sampling site were also moderate.

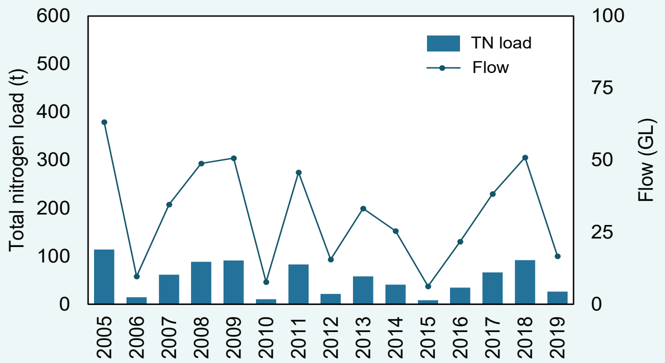
Estimated loads

Estimated TN loads at the Upper Serpentine River sampling site were large compared with the other sites in the Peel-Harvey catchment. In 2019, the Upper Serpentine had an estimated TN load of 26 t, the third largest of the 10 sites where it was possible to calculate loads. Only the sites in the Harvey River (99 t) and Middle Murray (89 t) had larger loads. The load per square kilometre was moderate, at 78 kg/km^2 in 2019, similar to the site in the Peel Main Drain catchment which had a load of 77 kg/km^2. TN loads were closely related to flow volume; years with large annual flow volumes had large TN loads and vice versa.

Upper Serpentine River



Total nitrogen concentrations, 2005–19 at site 614030. The dashed line is the protection plan TN target.



Total nitrogen loads and annual flow, 2005–19 at site 614030.

The weir at the Upper Serpentine River sampling site with the gauging station in the background, October 2016.

Upper Serpentine River

Nitrogen (2019)

Types of nitrogen

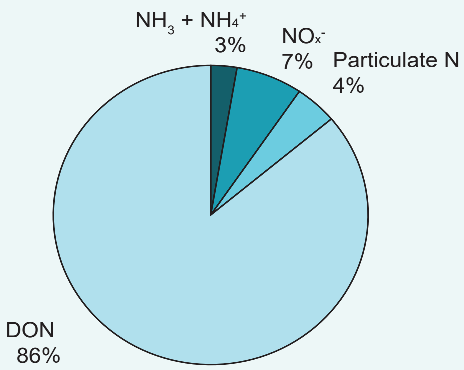
Total N is made up of different types of N. At the Upper Serpentine River sampling site, most of the N was present as dissolved organic N (DON) which consists mainly of degrading plant and animal matter but may also include other types. Most types of DON need to be further broken down to become available to plants and algae, though some types are readily bioavailable. Ten per cent of the N was present as highly bioavailable dissolved inorganic N (DIN – consisting of total ammonia, $NH_3 + NH_4^+$ and nitrate, NO_x^-). Likely sources of these types of N include fertilisers and animal wastes as well as natural sources.

Concentrations

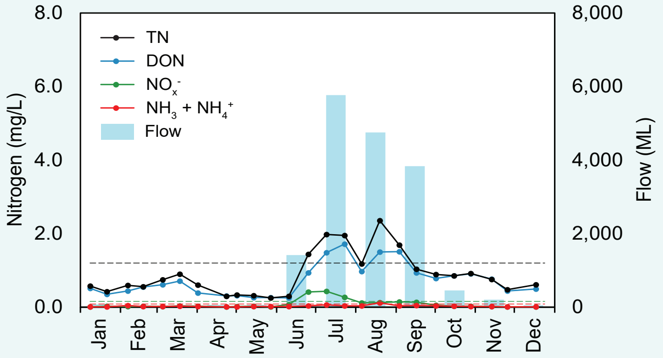
Total N, DON and nitrate all showed a seasonal pattern in 2019, being at their highest during the period when rainfall and flow were at their largest. Much of this N was probably the result of mineralisation of organic N in soils and drains over the summer period, and runoff of high-concentration water from agricultural land use in the catchment which build up with fertilisers and animal waste over the summer. Groundwater and in-stream sources were the largest contributors of N for the rest of the year.

The dip in TN and DON in August was probably a result of a dry spell which caused parts of the catchment to dry out, therefore no longer contributing nutrients. This dip was present at many of the Peel-Harvey catchment sites in both N and phosphorus concentrations.

Upper Serpentine River



2019 average nitrogen fractions at site 614030.



2019 nitrogen concentrations and monthly flow at 614030. The black dashed line is the protection plan TN target, the red and green lines are the ANZECC trigger values for total ammonia and nitrate.

Looking upstream from the sampling site, March 2016. While the Serpentine River normally flows year round, it will cease to flow following a low-rainfall year.

Phosphorus over time (2005–19)

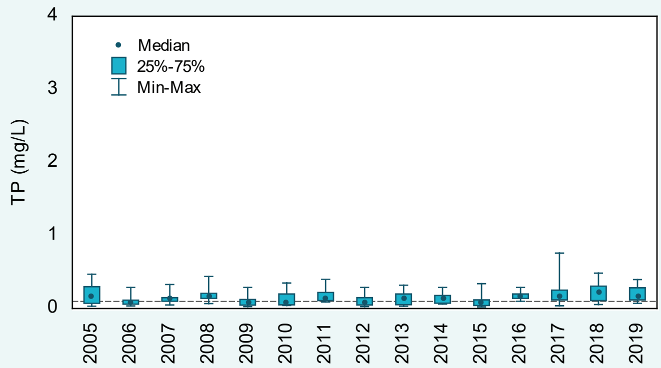
Concentrations

Total phosphorus (TP) concentrations fluctuated over the reporting period, with two-thirds of the annual medians below the protection plan water quality target for TP concentrations. Using the SWRWQA methodology, all years were classified as having a high TP concentration.

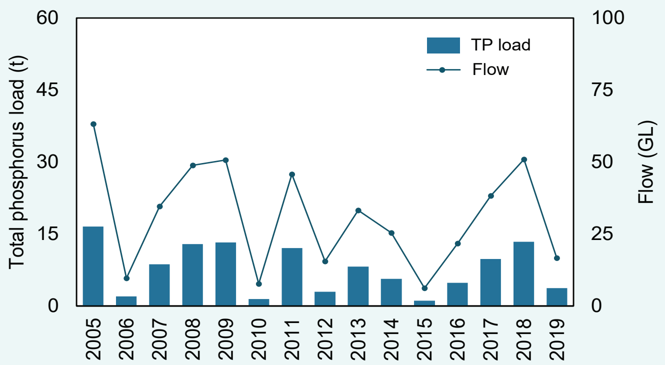
Estimated loads

Estimated TP loads at the Upper Serpentine River sampling site were large compared with the other sites in the Peel-Harvey catchment. In 2019, the site had an estimated TP load of 3.70 t, the second largest TP load of the 10 sites in the Peel-Harvey catchment where it was possible to calculate loads. The only catchment with a larger load was the Harvey River (12.6 t). The load per square kilometre of 11.1 kg/km^2 was moderate compared with the other Peel-Harvey sites. TP loads were closely related to flow volume; years with large annual flow volumes had large TP loads and vice versa.

Upper Serpentine River



Total phosphorus concentrations, 2005–19 at site 614030. The dashed line is the protection plan TP target.



Total phosphorus loads and annual flow, 2005–19 at site 614030.

Elevated nutrient concentrations contribute towards excess macrophyte growth in warm shallow waters. The sampling site, December 2008.

Phosphorus (2019)

Types of phosphorus

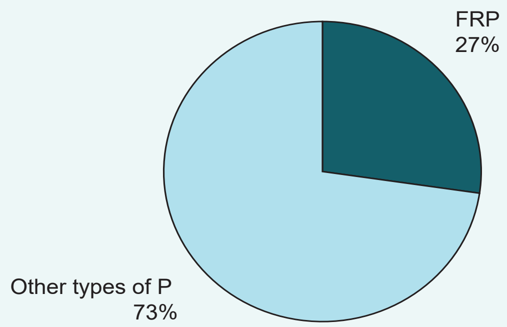
Total P is made up of different types of P. At the Upper Serpentine River sampling site nearly a third of the P was present as highly bioavailable phosphate; measured as filterable reactive P (FRP). In surface waters this is mainly present as phosphate (PO_4^{3-}) species. The phosphate was likely sourced from fertilisers and animal waste as well as natural sources. The remaining P was present as either particulate P or dissolved organic P (DOP) or both (shown as 'Other types of P' in the chart below). Particulate P generally needs to be broken down before becoming bioavailable. The bioavailability of DOP varies and is poorly understood.

Concentrations

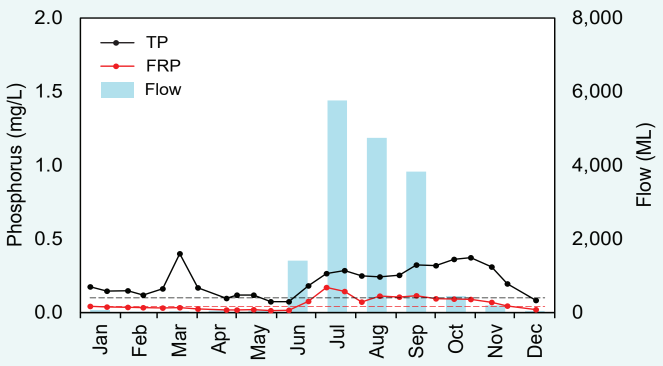
Total P and phosphate both showed a seasonal pattern at the Upper Serpentine River sampling site. With the exception of the peak in TP in March, TP and phosphate concentrations were relatively low in the beginning of the year. When rainfall and flow increased in June so did TP and phosphate concentrations, suggesting P was being washed into the drain via surface flows at this time as well as coming from in-stream sources. Both phosphate and TP remained relatively high for some time after this, only falling again near the end of the year. Why TP and phosphate did not fall along with streamflow is unclear. It may be because of the part of the catchment contributing flow at that time.

The dip in phosphate in August was probably because of a dry spell which caused parts of the catchment to dry out, therefore no longer contributing nutrients. This dip was present at many of the Peel-Harvey catchment sites in both N and P concentrations.

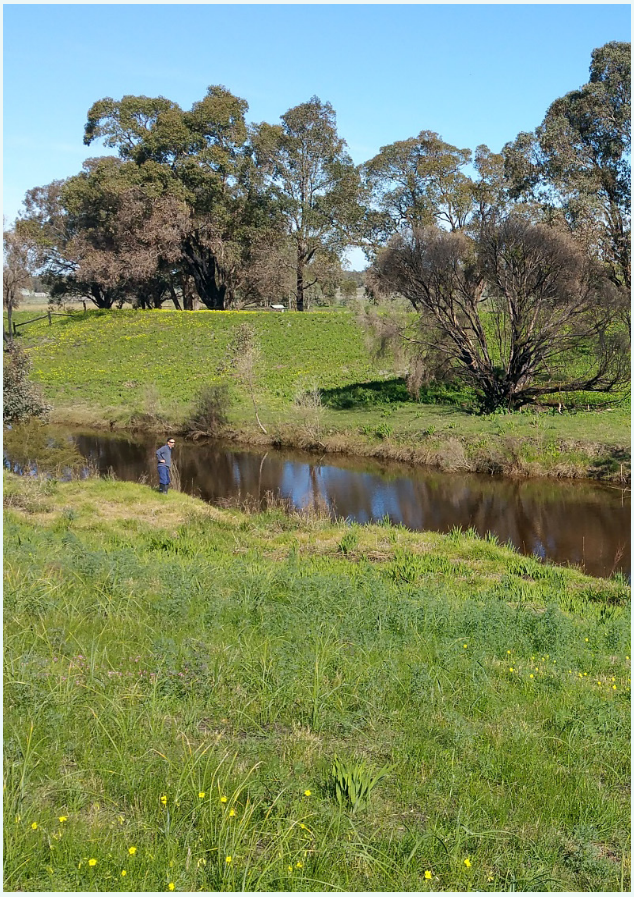
Upper Serpentine River



2019 average phosphorus fractions at site 614030.



2019 phosphorus concentrations and monthly flow at 614030. The dashed black line is the protection plan TP target, the red is the ANZECC trigger value for phosphate.



In some places, the Upper Serpentine River has been converted into a drain, July 2015.

Upper Serpentine River

Dissolved organic carbon over time (2005–19)

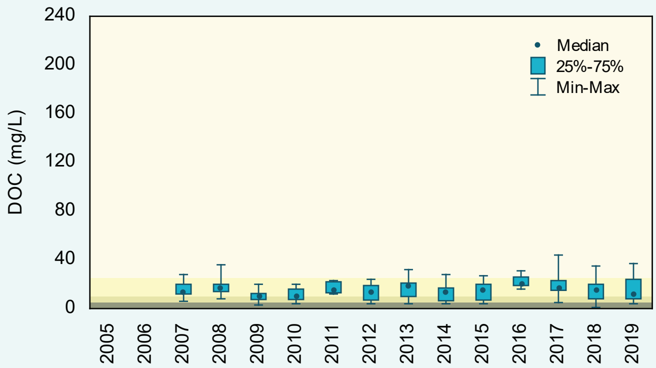
Concentrations

Dissolved organic carbon (DOC) concentrations fluctuated over the reporting period at the Upper Serpentine River sampling site. Using the SWRWQA methodology, all years were classified as having high DOC concentrations.

Estimated loads

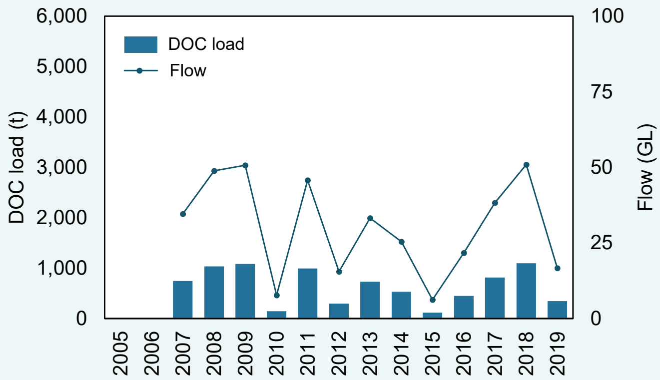
Estimated DOC loads at the Upper Serpentine River sampling site were moderate compared with the other sites in the Peel-Harvey catchment. In 2019, the estimated DOC load was 347 t, the third largest of the 10 sites in the Peel-Harvey catchment where it was possible to calculate loads. The load per square kilometre of 1,043 kg/km^2 was also moderate compared with the other Peel-Harvey catchment sites. DOC loads were closely related to flow volume; years with large annual flow volumes had large DOC loads and vice versa.

Upper Serpentine River



Dissolved organic carbon, 2005–19 at site 614030. The shading refers to the SWRWQA classification bands.

low moderate high very high



Dissolved organic carbon loads and annual flow, 2005–19 at site 614030.

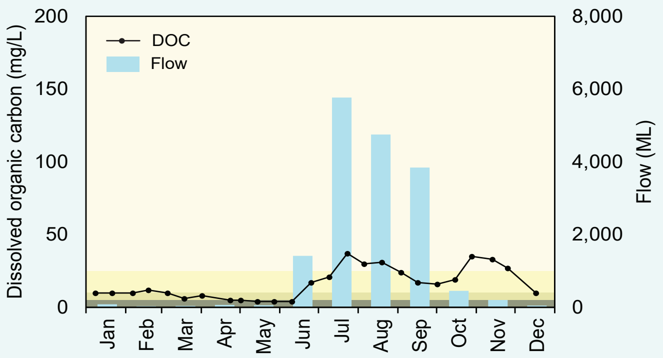
A weir on the Serpentine River, upstream of the Serpentine Dam. The river here is in a much more natural state than further down on the Swan Coastal Plain, August 2017.

Dissolved organic carbon (2019)

Concentrations

DOC concentrations showed a seasonal pattern at the Upper Serpentine River sampling site. Concentrations increased in June as rainfall and flow increased before peaking in July. After the peak, concentrations fell again. There was a second peak, later in the year in October, similar to the peak in TP concentrations. The reason for this peak is unclear, it may be a result of the part of the catchment that was contributing flow at this time. DOC is sourced mainly from degrading plant and animal matter, including from agricultural land and natural organic matter in soils and wetlands. At the Upper Serpentine River sampling site, DOC was coming from surface flow and groundwater as well as in-stream sources.

Upper Serpentine River



2019 dissolved organic carbon concentrations and monthly flow at 614030. The shading refers to the SWRWQA classification bands.

low | moderate | high | very high

Taking flow measurements during high flow at the Upper Serpentine River sampling site, June 2014.

Upper Serpentine River

Total suspended solids over time (2005–19)

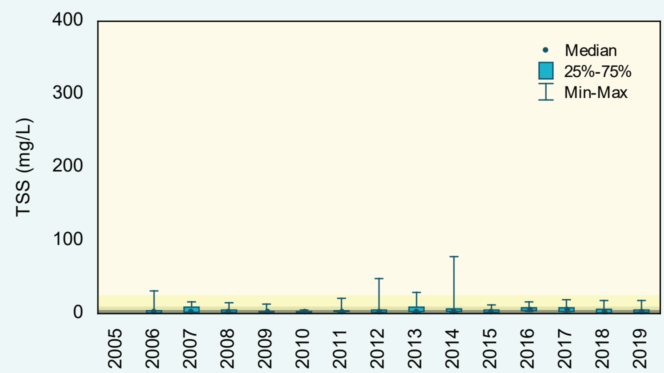
Concentrations

Total suspended solids (TSS) concentrations fluctuated over the reporting period at the Upper Serpentine River sampling site, though they were generally low compared with the other sites sampled in the Peel-Harvey catchment. Using the SWRWQA methodology, all annual TSS concentrations were classified as low, with the exception of 2017 and 2018 which were classified as moderate.

Estimated loads

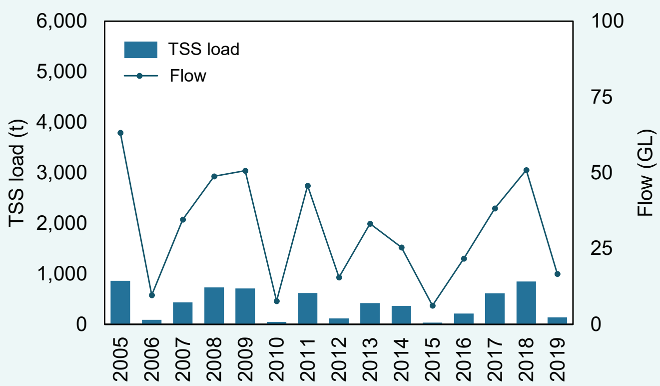
Estimated TSS loads at the Upper Serpentine River sampling site were large compared with the other 10 sites in the Peel-Harvey catchment where it was possible to calculate loads. In 2019, the estimated TSS load at this site was 138 t. The load per square kilometre of 414 kg/km^2 was also large compared with the other Peel-Harvey catchment sites. TSS loads were closely related to flow volume; years with large annual flow volumes had large TSS loads and vice versa.

Upper Serpentine River



Total suspended solids concentrations, 2005–19 at site 614030. The shading refers to the SWRWQA classification bands.

low moderate high very high



Total suspended solids loads and annual flow, 2005–19 at site 614030.

Trees growing next to the Upper Serpentine River at the sampling site flooded during high flows, July 2018.

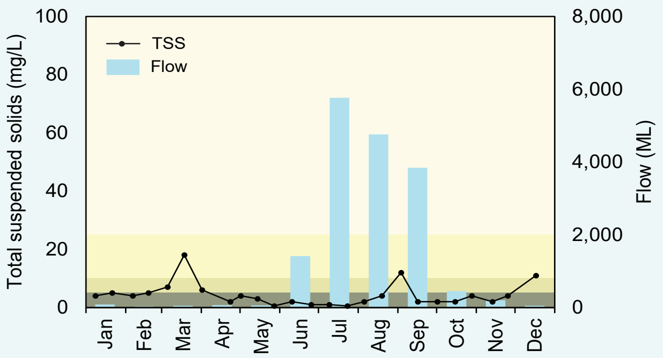
Upper Serpentine River

Total suspended solids (2019)

Concentrations

Most of the TSS samples collected in 2019 at the Upper Serpentine River sampling site fell into the low band of the SWRWQA. There were three peaks in TSS in March, September and December. The reason for the peaks in March and December are unclear; perhaps the bed or banks of the river had been disturbed shortly before sampling, dislodging particulate matter. The peak in September occurred after nearly a week of rainfall, suggesting that particulate matter was washed into the river from surrounding land use as well as potentially being dislodged from the river via erosion.

Upper Serpentine River



2019 total suspended solids concentrations and monthly flow at 614030. The shading refers to the SWRWQA classification bands.

low moderate high very high

The weir at the Upper Serpentine River sampling site during high flows, June 2014. High flows generally transport more particulate matter than low flows.

Upper Serpentine River

pH over time (2005–19)

Levels

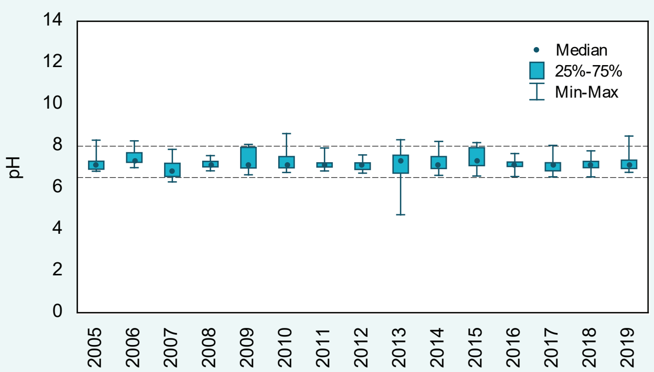
pH at the Upper Serpentine River sampling site fluctuated over the reporting period. However, all annual medians were between the upper and lower Australian and New Zealand Environment and Conservation Council (ANZECC) trigger values.

pH (2019)

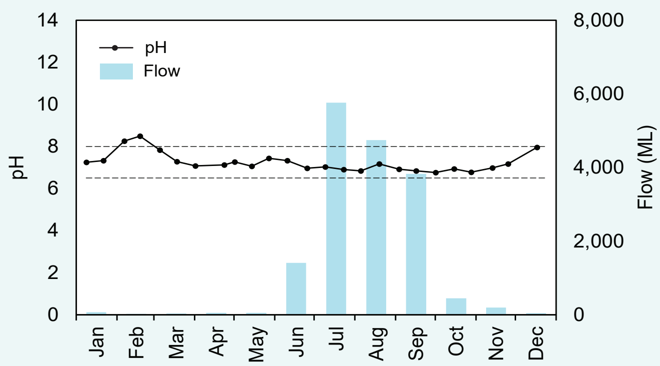
Levels

In 2019, pH at the Upper Serpentine River sampling site showed a very slight inverse relationship to flow. pH levels were slightly lower during the wetter part of the year. The reason for the peak in pH in February is unclear. It is possible that the groundwater is slightly less acidic than the surface water at this site. In-stream processes may also have increased the pH in the early and late part of the year.

Upper Serpentine River



pH levels, 2005–19 at site 614030. The dashed lines are the upper and lower ANZECC trigger values.



2019 pH levels and monthly flow at 614030. The dashed lines are the upper and lower ANZECC trigger values.

The Serpentine River flowing under Karnup Road Bridge during high flows, August 2005.

Upper Serpentine River

Salinity over time (2005–19)

Concentrations

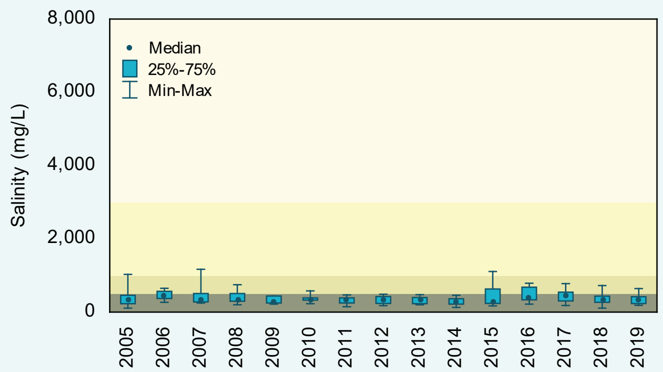
Salinity at the Upper Serpentine River sampling site fluctuated over the reporting period. Using the Water Resources Inventory 2014 salinity ranges, all years were classified as fresh (note, in 2018 the SWRWQA salinity bands were used).

Salinity (2019)

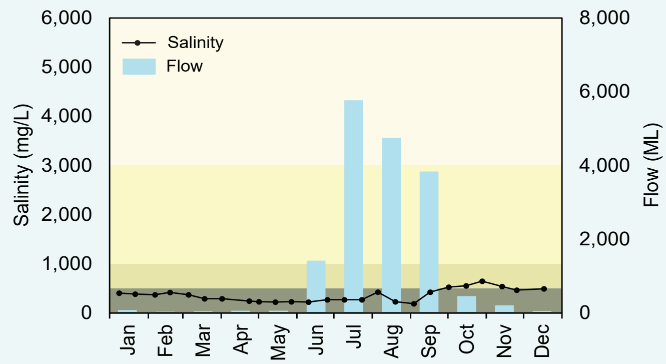
Concentrations

In 2019, most of the salinity readings at the Upper Serpentine River sampling fell into the fresh band of the Water Resources Inventory 2014 salinity ranges. Salinity showed a slight inverse seasonal pattern, generally being lower during the middle of the year when rainfall and flow were at their greatest. This suggests that the groundwater may be slightly more saline than the surface water at this site (though it is still generally quite fresh). It is likely that salt is entering the river via both surface flow and groundwater at this site.

Upper Serpentine River



Salinity concentrations, 2005–19 at site 614030. The shading refers to the Water Resources Inventory 2014 salinity ranges.



2019 salinity concentrations and monthly flow at 614030. The shading refers to the Water Resources Inventory 2014 salinity ranges.

fresh | marginal | brackish | saline

Native forest alongside the Serpentine River, upstream of Serpentine Dam, November 2015.

Upper Serpentine River

Background

Healthy Estuaries WA is a State Government program launched in 2020 and builds on the work of the Regional Estuaries Initiative. Collecting and reporting water quality data, such as in this report, helps build understanding of the whole system. By understanding the whole system, we can direct investment towards the most effective actions in the catchments to protect and restore the health of our waterways.

Nutrients (nitrogen and phosphorus) are compounds that are important for plants to grow. Excess nutrients entering waterways from effluent, fertilisers and other sources can fuel algal growth, decrease oxygen levels in the water and harm fish and other species. Total suspended solids, pH and salinity data are also presented as these help us better understand the processes occurring in the catchment.

You can find information on the condition of Peel-Harvey estuary at estuaries.dwer.wa.gov.au/estuary/peel-harvey-estuary/

Healthy Estuaries WA partners with the Peel-Harvey Catchment Council to fund best-practice management of fertiliser, dairy effluent and watercourses on farms.

- To find out how you can be involved visit estuaries.dwer.wa.gov.au/participate
- To find out more about the Peel-Harvey Catchment Council go to peel-harvey.org.au
- To find out more about the health of the rivers in the Peel-Harvey Catchment go to rivers.dwer.wa.gov.au/assessments/results

Methods

Variables were compared with the Bindjareb Djilba (Peel-Harvey estuary) Protection Plan concentration targets or ANZECC trigger values where available, or the SWRWQA bands or the 2014 Water Resources Inventory ranges. They were classified using the SWRWQA methodology. Standard statistical tests were used to calculate trends and loads. For further information on the methods visit estuaries.dwer.wa.gov.au/nutrient-reports/data-analysis

Glossary

Bioavailable: bioavailable nutrients refers to those nutrients which plants and algae can take up from the water and use straight away for growth.

Concentration: the amount of a substance present per volume of water.

Evapoconcentration: the increase in concentration of a substance dissolved in water because of water being lost by evaporation.

First flush: material washed into a waterway by the first rainfall after an extended dry period. The first flush is often associated with high concentrations of nutrients and particulate matter.

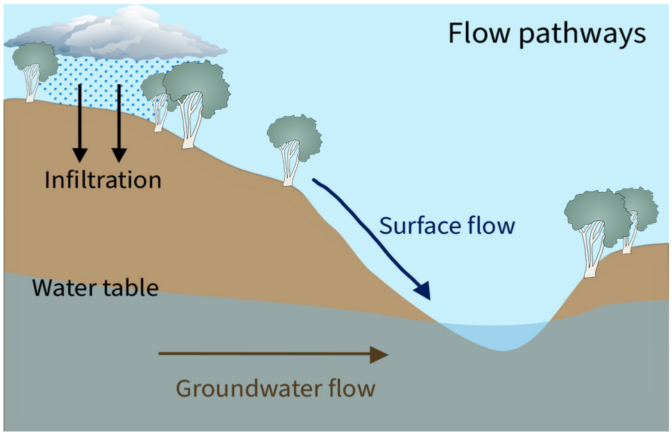
Laboratory limit of reporting: (LOR) this is the lowest concentration of an analyte that can be reported by a laboratory.

Load: the total mass of a substance passing a certain point.

Load per square kilometre: the load at the sampling site divided by the entire catchment area upstream of the sampling site.

Nitrate: The measurement for the nutrient nitrate actually measures both nitrate (NO_3^-) and nitrite (NO_2^-), which is reported as NO_x^-. We still refer to this as nitrate as in most surface waters nitrite is present in very low concentrations.

The schematic below shows the main flow pathways which may contribute nutrients, particulates and salts to the waterways. Connection between surface water and groundwater depends on the location in the catchment, geology and the time of year.



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