Denmark River

This data report provides a summary of the nutrients at the two Denmark River sampling sites in 2018 as well as historical data from 2004–18. This report was produced as part of the Regional Estuaries Initiative. Downstream of the southern sampling site, the river discharges to Wilson Inlet. 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.

About the catchment

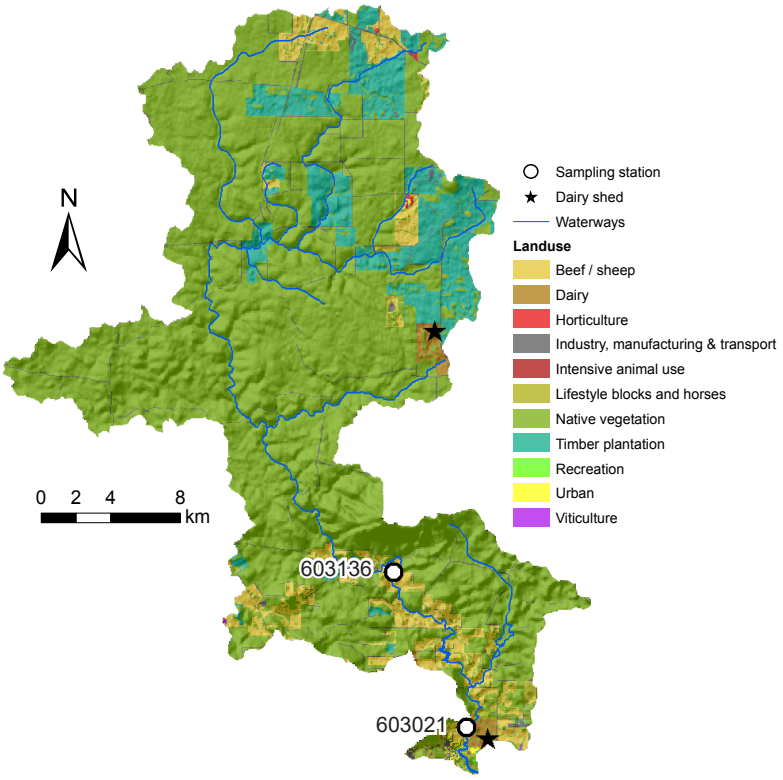
Denmark River has a catchment area of about 600 km^2 and receives flow from three major tributaries, Yate Flat Creek and the Quickup River from the east and Scotsdale Brook (which is a monitored catchment; site 603023) from the west. There are timber plantations present in the Yate Flat Creek catchment while the Quickup River catchment is largely uncleared and contains one of the potable water supply dams for the town of Denmark. There is a second dam, the Denmark Dam, which is on the Denmark River between the two sampling sites shown on the map. Clearing in the upper catchment caused elevated salinity levels in the Denmark Dam, making the water unfit for use. Extensive revegetation has reversed this salinity trend and, together with the Quickup Dam, the Denmark Dam is now part of the integrated scheme that provides for Denmark's ongoing water needs.

Just over three-quarters of the catchment is covered in native vegetation. The other major land uses are plantations and beef cattle, though combined these cover less than a fifth of the catchment.

There are two sites monitored on the Denmark River, one near the WA College of Agriculture, Denmark, which is below the confluence with Scotsdale Brook (Denmark Ag; site 603021) and the other, further upstream, near Mt Lindesay (Denmark ML; site 603136).

Results summary

Nutrient concentrations (total nitrogen and total phosphorus) in the Denmark River were low. The nutrient loads were small to moderate compared with the other monitored catchments, and the loads per square kilometre were small.



Location of Denmark River catchment in the greater Wilson Inlet catchment.

Facts and figures

Sampling site code	603021 (Denmark Ag) 603136 (Denmark ML)
Rainfall at Denmark (2018)	776 mm
Catchment area	604 km^2 (670 km^2 combined Denmark and Scotsdale Brook catchment)
Per cent cleared area (2014)	22% (Scotsdale Brook is 60% cleared)
River flow	Flows year-round at Denmark Ag. Two water supply dams in the catchment; Denmark Dam and Quickup Dam
Annual flow (2018)	14.3 GL (Denmark Ag) 5.6 GL (Denmark ML)
Main land use (2014)	Native vegetation (Denmark River catchment)

Denmark River

Nitrogen over time (2004–18)

Concentrations

Total nitrogen (TN) concentrations were reasonably low in the Denmark River and fluctuated over the reporting period. The two sites had some of the lowest median TN concentrations in 2018 (Denmark Ag 0.52 mg/L, Denmark ML 0.59 mg/L). The median TN concentrations were below the Australian and New Zealand Environment and Conservation Council (ANZECC) trigger value at both sites for all years monitored. While there were some differences in TN concentrations between the two sites, overall they were very similar and low.

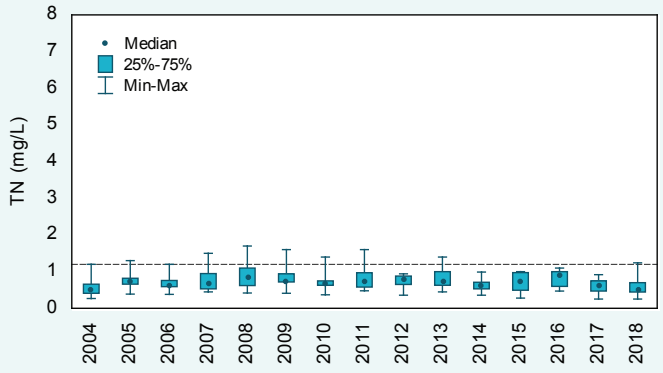
Trends

There were no short- (2013–17) or long-term (2003–17) trends present at Denmark Ag. As regular monitoring was not conducted at Denmark ML between 2012 and 2016 it was not possible to test for trends at this site. A minimum of five years of data are required to test for trends.

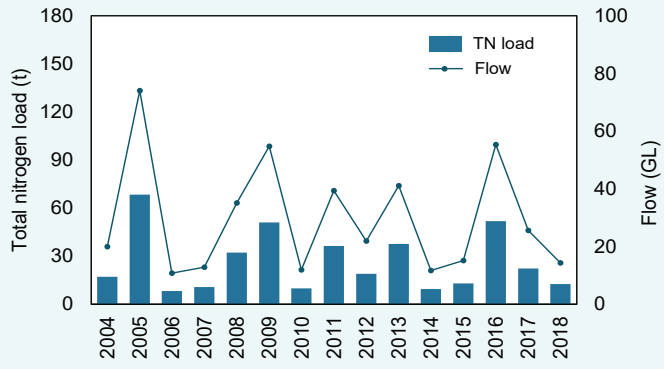
Estimated loads

Estimated TN loads at the Denmark River sampling sites were moderate compared with the other sites in the Wilson Inlet catchment. In 2018, Denmark Ag had the third smallest load of the six monitored catchments that discharge to Wilson Inlet (12 t; Sunny Glen Creek had 2 t and Little River 6 t) and the second smallest load per unit area of 19 kg/km^2. TN loads were larger at Denmark Ag than Denmark ML because of a number of factors, mainly the larger flow volumes at Denmark Ag caused by the larger catchment area (including Scotsdale Brook which discharges into the Denmark River above the Denmark Ag sampling site). Annual TN loads were closely related to flow volumes; years with high annual flow had large TN loads and vice versa.

Denmark Ag

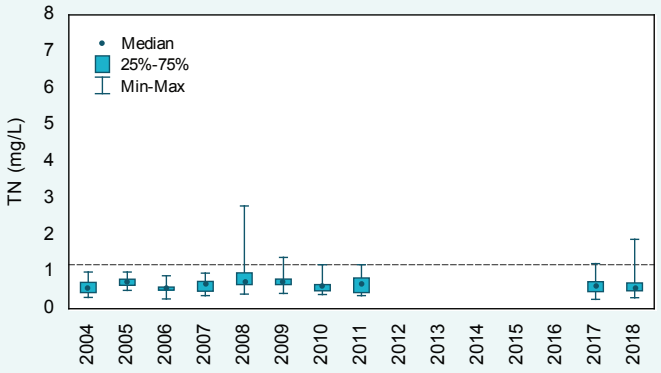


Total nitrogen concentrations, 2004–18 at site 603021. The dashed line is the ANZECC trigger value for lowland rivers.

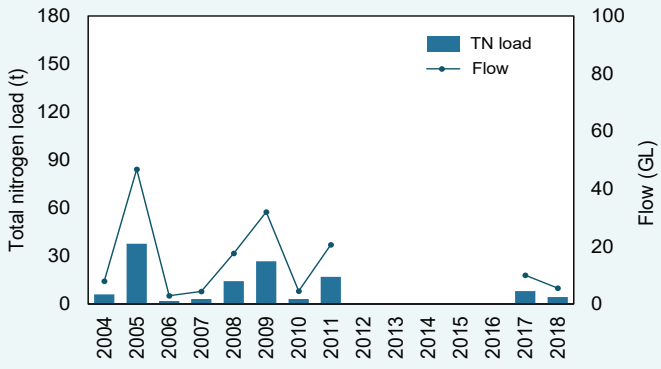


Total nitrogen loads and annual flow, 2004–18 at site 603021.

Denmark ML



Total nitrogen concentrations, 2004–18 at site 603136. The dashed line is the ANZECC trigger value for lowland rivers.



Total nitrogen loads and annual flow, 2004–18 at site 603136.

Denmark River

Nitrogen (2018)

Types of nitrogen

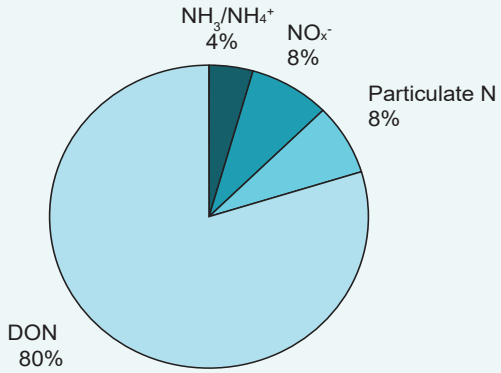
Total N is made up of many different types of N. The relative proportions of the different types of N were very similar at the two Denmark River sites. Most of the N was present as dissolved organic N (DON) which consists mainly of degrading plant and animal matter but may include other, bioavailable, forms. Particulate N is composed of plant and animal detritus. Most forms of particulate N and DON need to be further broken down to become available to plants and algae, though some DON forms are readily bioavailable. Only a small amount of N was present as dissolved inorganic N (ammonia N – NH_3/NH_4^+ and oxides of nitrogen – NO_x^-), which is bioavailable to plants and algae and, like some other forms of DON, can be used to fuel rapid growth.

Concentrations

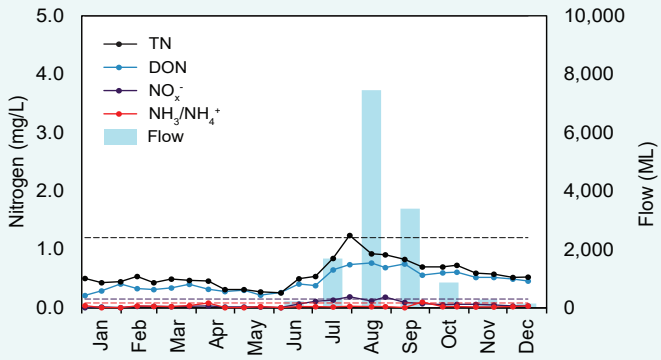
N concentrations varied in a similar way at both sites during the year, with some evidence of a seasonal pattern in TN, DON, and NO_x^-. These were highest from about June to October, when there were higher flow volumes. This suggests that DON and NO_x^- were entering the river during the wetter months via surface flows, with groundwater and in-stream sources contributing proportionally less. During the drier months, groundwater and in-stream sources were likely contributing proportionally more N.

Where there are no data shown in the Denmark ML graph, the river was not flowing.

Denmark Ag

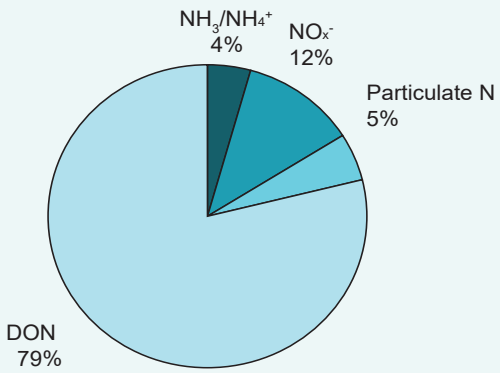


2018 average nitrogen fractions at site 603021.

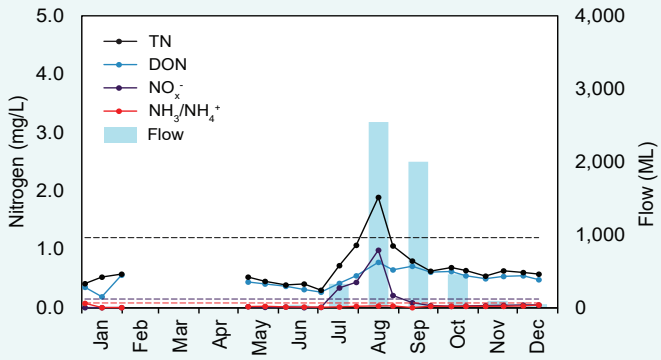


2018 nitrogen concentrations and monthly flow at 603021. The dashed lines are the ANZECC trigger values for lowland rivers for the different N species.

Denmark ML



2018 average nitrogen fractions at site 603136.



2018 nitrogen concentrations and monthly flow at 603136. The dashed lines are the ANZECC trigger values for lowland rivers for the different N species.

Denmark River

Phosphorus over time (2004–18)

Concentrations

Total phosphorus (TP) concentrations were generally low in the Denmark River and while there were some samples over the ANZECC trigger value in previous years, there were none in 2018 (at either site). TP concentrations were slightly higher at Denmark Ag than Denmark ML because of the more intensive land use between the two sampling sites. In 2018, Denmark ML (0.016 mg/L) and Denmark Ag (0.025 mg/L) had some of the lowest median TP concentrations (only the two sites on the Hay River were lower with 0.009 mg/L and 0.017 mg/L).

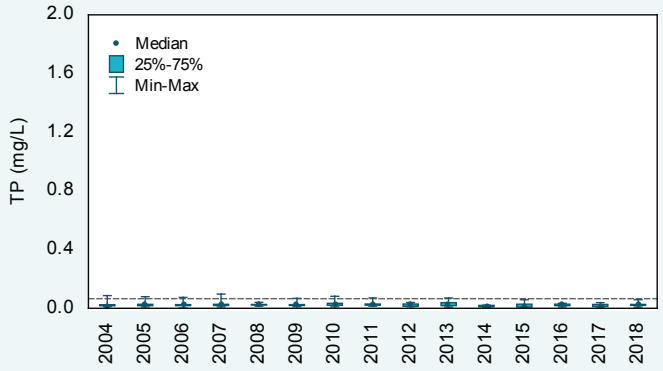
Trends

There was no short- (2013–17) or long-term trend (2003–17) in TP concentrations at Denmark Ag. As regular monitoring was not conducted at Denmark ML from 2012–16 it was not possible to test for trends. A minimum of five years of data are required to test for trends.

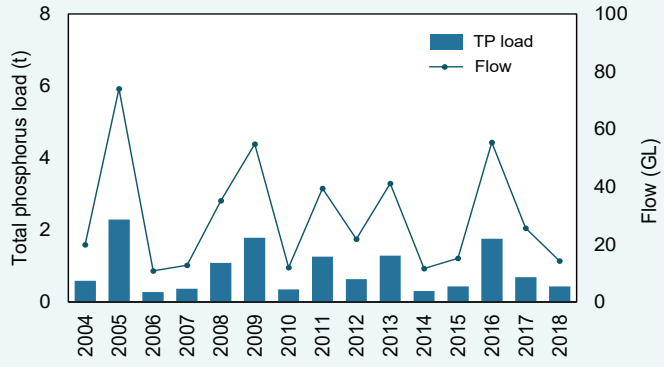
Estimated loads

The Denmark River Ag site had a relatively small estimated TP load, having the third smallest estimated load of the six catchments in 2018 (0.43 t). It also had one of the smallest loads per unit area with 0.6 kg/km^2 being exported in 2018. TP loads were larger at Denmark Ag than Denmark ML because of a number of factors, including the larger catchment area contributing to the load at Denmark Ag (including Scotsdale Brook which discharges into the Denmark River above this sampling site) and the more intensive land use in the Scotsdale Brook and lower half of the Denmark River catchments (most of the catchment above Denmark ML is uncleared). In 2018, Scotsdale Brook had a TP load of 0.46 t, more than the load at Denmark Ag. Annual TP loads were closely related to flow volumes; years with high annual flow had larger TP loads and vice versa.

Denmark Ag

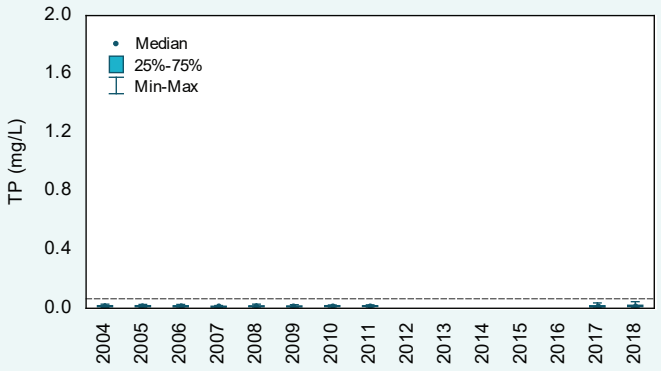


Total phosphorus concentrations, 2004–18 at site 603021. The dashed line is the ANZECC trigger value for lowland rivers.

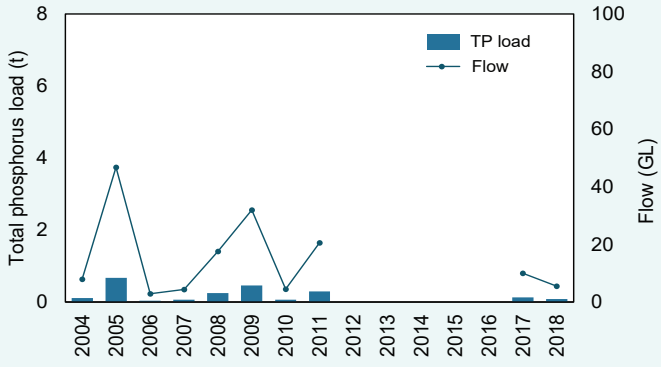


Total phosphorus loads and annual flow, 2004–18 at site 603021.

Denmark ML



Total phosphorus concentrations, 2004–18 at site 603136. The dashed line is the ANZECC trigger value for lowland rivers.



Total phosphorus loads and annual flow, 2004–18 at site 603136.

Denmark River

Phosphorus (2018)

Types of phosphorus

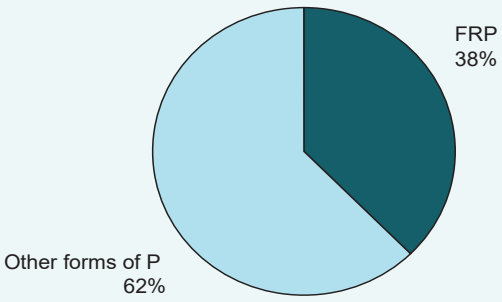
Total P is made up of different types of P. The proportion of P present as filterable reactive phosphorus (FRP) was similar at the two Denmark River sites. FRP is a readily bioavailable form of P, meaning it can be used to fuel rapid plant and algal growth. The remainder of the P was present as either particulate P or dissolved organic P (DOP) or both. Particulate P generally needs to be broken down before becoming bioavailable to algae. The bioavailability of DOP varies and is poorly understood.

Concentrations

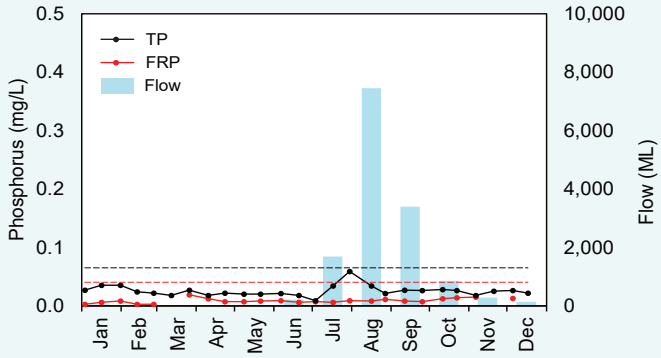
P concentrations were very low in the Denmark River (below the relevant ANZECC trigger values on all sampling occasions) and were often close to or below the level at which the laboratory can detect them, especially for FRP. TP and FRP concentrations fluctuated slightly throughout the year. The peak in TP at Denmark Ag in July to August coincided with a peak in TSS concentrations, suggesting it was largely particulate matter. During the drier months, the majority of the P was entering the river via groundwater and in-stream sources, with surface flows contributing less. During the wetter months, surface flows contributed proportionally more P.

Where there are no data shown in the Denmark ML graph, the river was not flowing.

Denmark Ag

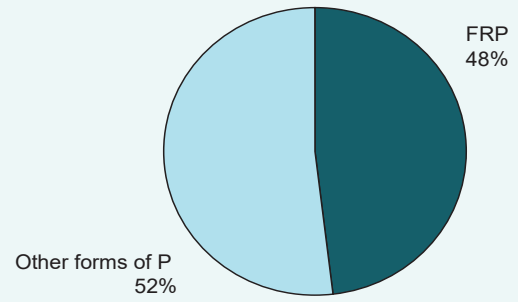


2018 average phosphorus fractions at site 603021.

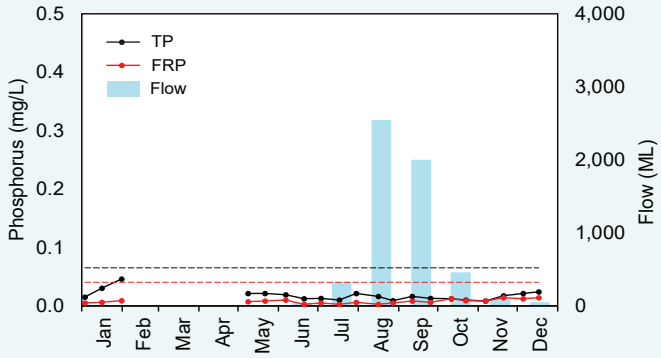


2018 phosphorus concentrations and monthly flow at 603021. The dashed lines are the ANZECC trigger values for lowland rivers for the different P species.

Denmark ML



2018 average phosphorus fractions at site 603136.



2018 phosphorus concentrations and monthly flow at 603136. The dashed lines are the ANZECC trigger values for lowland rivers for the different P species.

Denmark River

Total suspended solids over time (2004–18)

Concentrations

Total suspended solids (TSS) concentrations were low in the Denmark River. Using the Statewide River Water Quality Assessment (SWRWQA) bands, the median TSS concentrations at both sites were classified as low for all years with data between 2003 and 2017. The range of concentrations at the Denmark Ag site was much lower in 2009 and 2017 than in other years. In 2018, the median TSS concentrations were some of the lowest of all sites in the Wilson Inlet catchment (Denmark ML 0.5 mg/L, Denmark Ag 2 mg/L).

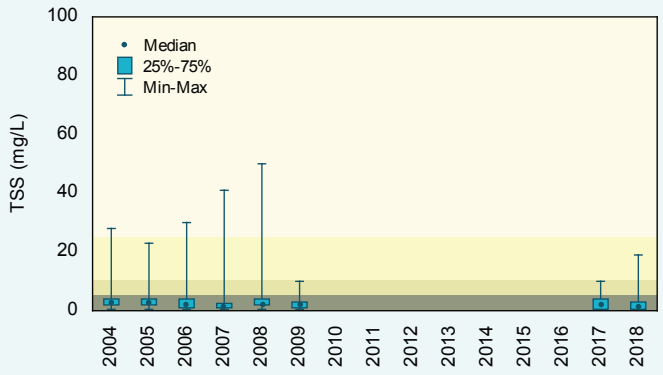
Trends

As regular monitoring for TSS was not conducted between 2010 and 2016 at either of the Denmark River sites, it was not possible to test for trends. A minimum of five years of data are required to test for trends.

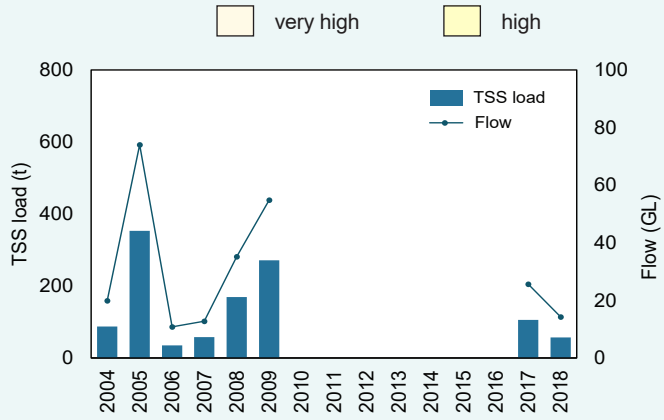
Estimated loads

Estimated TSS loads entering at the Denmark River Ag site were moderate (they were very low upstream at Denmark ML), with the Denmark Ag site having the third largest TSS load of the monitored catchments in 2018. The load at Denmark Ag (57 t in 2018) was much larger than at Denmark ML (6 t in 2018), probably because of the influence of Scotsdale Brook which had a large TSS load (112 t in 2018) as well as the more intensive land uses found downstream of Denmark ML. As the Denmark River has a relatively large catchment area, the TSS load per unit area was low (85 kg/km^2 in 2018, the second lowest load per unit area of the Wilson Inlet catchments). Annual TSS loads were closely related to flow volumes; years with high annual flow had large TSS loads and vice versa.

Denmark Ag

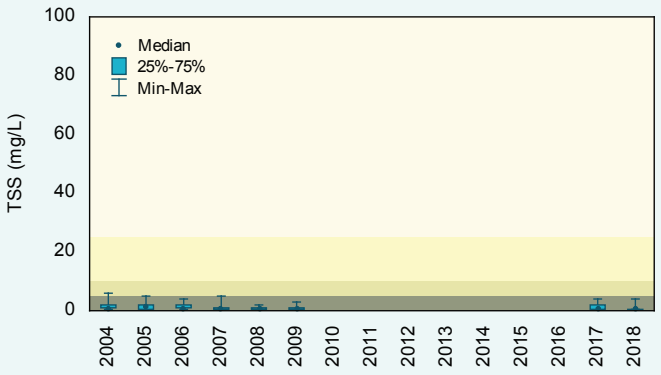


Total suspended solids concentrations, 2004–18 at site 603021. The shading refers to the SWRWQA classification bands.

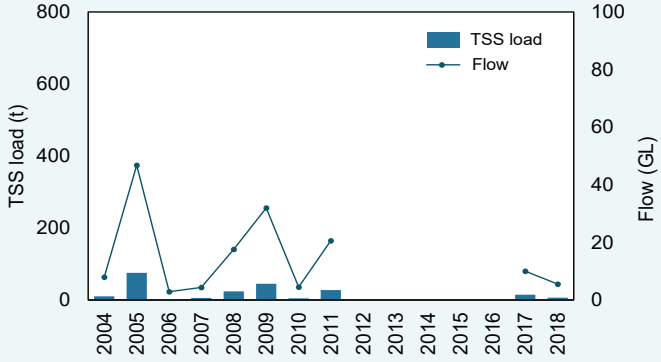


Total suspended solids loads and annual flow, 2004–18 at site 603021.

Denmark ML



Total suspended solids concentrations, 2004–18 at site 603136. The shading refers to the SWRWQA classification bands.



Total suspended solids loads and annual flow, 2004–18 at site 603136.

Denmark River

Total suspended solids (2018)

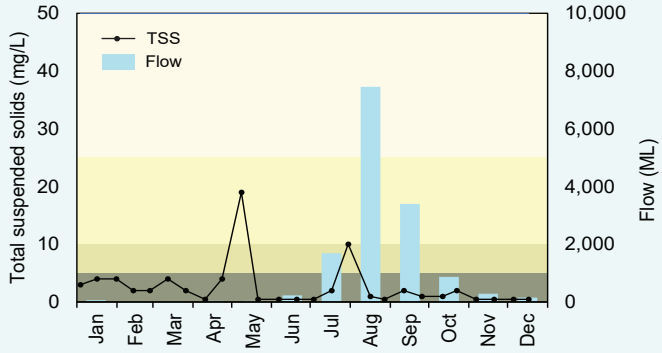
Concentrations

In 2018, most of the samples were classified as low with the exception of two samples at Denmark Ag which were moderate and high. The midyear peaks at Denmark Ag were probably because of increased particulate matter entering the river via surface run-off as well as in-stream erosion. At Denmark ML, most of the samples collected were below the laboratory limit of reporting.

Where there are no data shown in the Denmark ML graph, the river was not flowing.

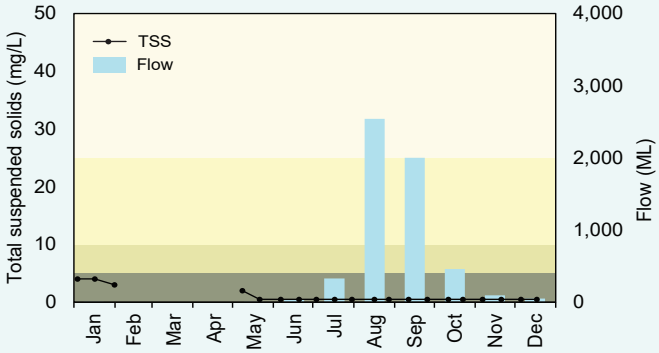
The Old Railway Bridge just upstream of Wilson Inlet, July 2019.

Denmark Ag



2018 total suspended solids concentrations and monthly flow at 603021. The shading refers to the SWRWQA classification bands.

Denmark ML



2018 total suspended solids concentrations and monthly flow at 603136. The shading refers to the SWRWQA classification bands.

very high high moderate low

Weir on the Denmark River, September 2016.

Denmark River

pH over time (2004–18)

pH values

pH fluctuated over the reporting period at both sites in the Denmark River. The values recorded in 2016 and 2017 may have been lower than the actual in-stream pH (see comment under 'pH (2018)'). In 2018, pH was slightly higher at Denmark Ag than Denmark ML.

Trends

There was no short- (2014–18) or long-term trend (2004–18) in pH at Denmark Ag. As regular monitoring was not conducted at Denmark ML from 2012–16 it was not possible to test for trends. A minimum of five years of data are required to test for trends.

pH (2018)

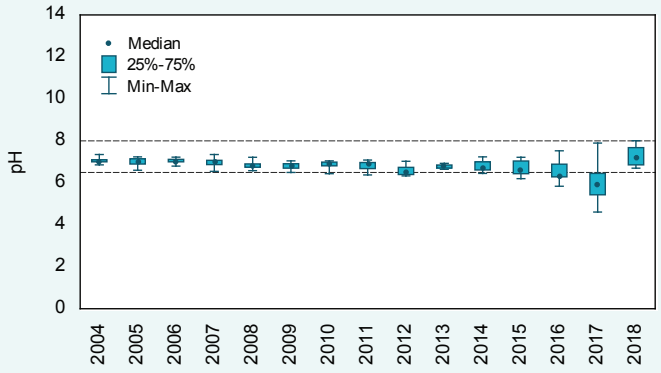
pH values

At both sites, pH was higher in the first half of the year, when groundwater contributed a relatively larger portion of the streamflow than surface water. This suggests the pH of the surface waster is lower than the groundwater at these sites.

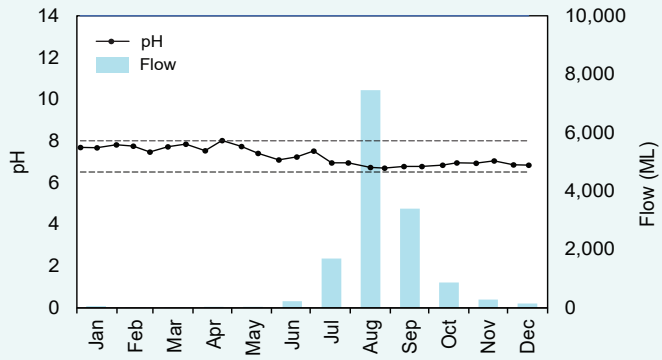
Where there are no data shown in the Denmark ML graph, the river was not flowing.

There is some concern the probe used to collect the pH data from the catchments of Wilson Inlet (including the Denmark River sites) from about October 2016 to October 2017 was not functioning correctly. This may have caused the low pH shown in the graphs below. After October 2017, a new probe was used and the pH values increased and stabilised. Although there is no way of verifying the 2016–17 data, they have still been presented here.

Denmark Ag

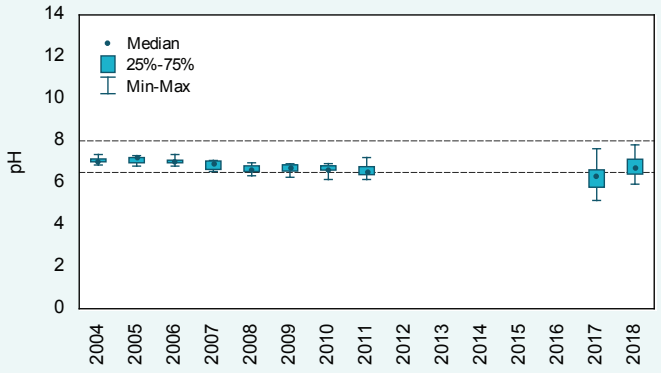


pH levels, 2004–18 at site 603021. The dashed lines are the upper and lower ANZECC trigger values for lowland rivers.

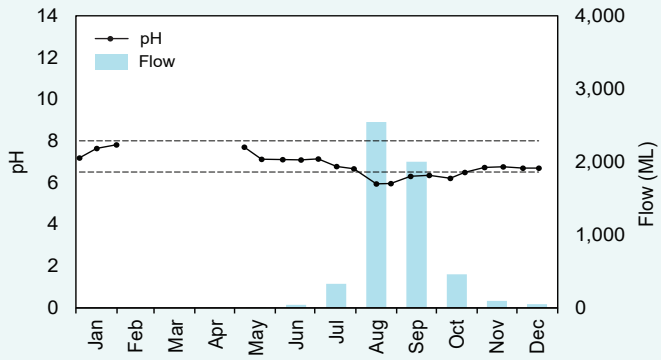


2018 pH levels and monthly flow at 603021. The dashed lines are the upper and lower ANZECC trigger values for lowland rivers.

Denmark ML



pH levels, 2004–18 at site 603136. The dashed lines are the upper and lower ANZECC trigger values for lowland rivers.



2018 pH levels and monthly flow at 603136. The dashed lines are the upper and lower ANZECC trigger values for lowland rivers.

Denmark River

Salinity over time (2004–18)

Concentrations

Salinity fluctuated over time at Denmark Ag. Using the SWRWQA classification bands, the median salinity was fresh at both sites for all years that had data available, the exception being 2018 at Denmark ML when it was just classified as marginal. In 2018 the median salinity at the Denmark River sites were the third- and fourth-lowest of the nine sites sampled (Denmark Ag 440 mg/L, Denmark ML 510 mg/L). The only sites with lower median salinity concentrations were Little River (225 mg/L) and Scotsdale Brook (275 mg/L).

Trends

There were no trends present in salinity at Denmark Ag. There were not enough data to test for trends at Denmark ML. A minimum of five years of data are required to test for trends.

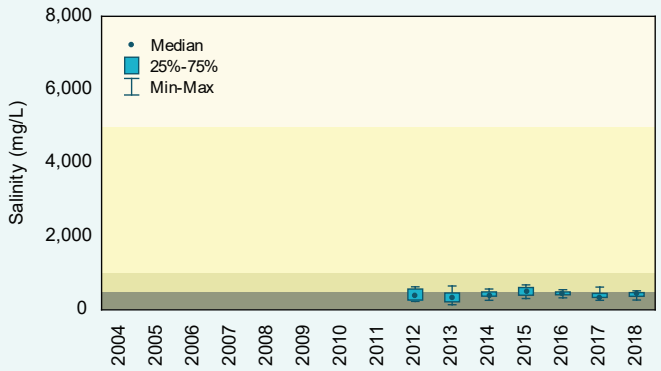
Salinity (2018)

Concentrations

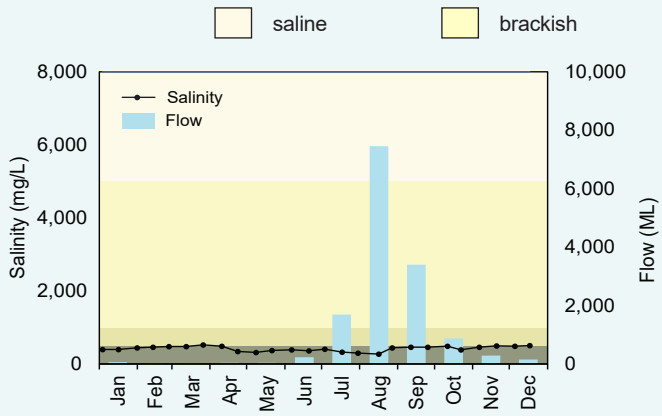
Salinity concentrations fluctuated in 2018 at both sites. Denmark Ag was the fresher of the two sites, with almost all samples falling into the fresh SWRWQA band. At Denmark ML, just over half of the TN samples collected in 2018 fell into the marginal band. It is likely the salinity in the Denmark River is being diluted by the fresher water entering the river from Scotsdale Brook between the two sampling sites.

Where there are no data shown in the Denmark ML graph, the river was not flowing.

Denmark Ag

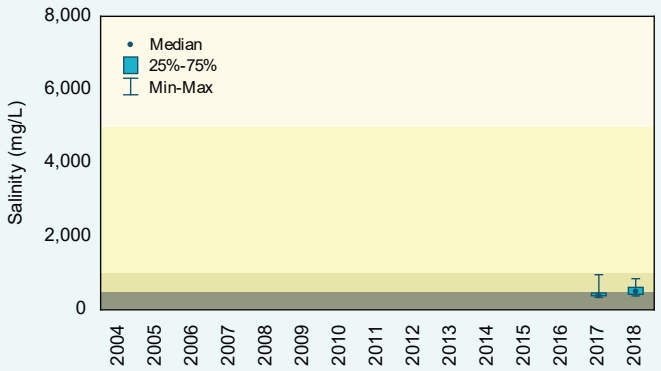


Salinity concentrations, 2004–18 at site 603021. The shading refers to the SWRWQA classification bands.

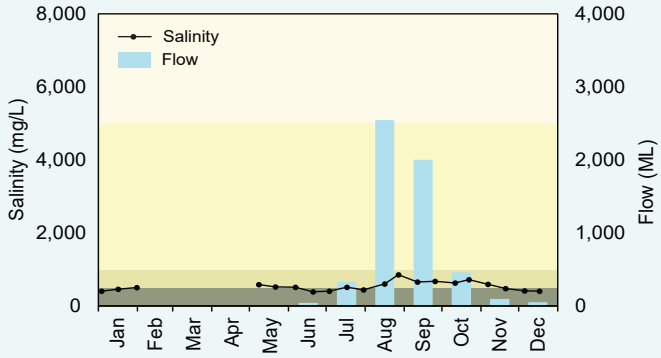


2018 salinity concentrations and monthly flow at 603021. The shading refers to the SWRWQA classification bands.

Denmark ML



Salinity concentrations, 2004–18 at site 603136. The shading refers to the SWRWQA classification bands.



2018 salinity concentrations and monthly flow at 603136. The shading refers to the SWRWQA classification bands.

Denmark River

Background

The Regional Estuaries Initiative is a State Government program to improve the health of waterways and estuaries in the south-west of Western Australia. Healthy Estuaries WA is a Royalties for Regions program launched in 2020 and will build 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.

You can find the latest data on the condition of Wilson Inlet at estuaries.dwer.wa.gov.au/estuary/wilson-inlet/

The Regional Estuaries Initiative partners with the Wilson Inlet Catchment Committee to fund best-practice fertiliser, dairy effluent and watercourse management on farms.

- To find out how you can be involved visit estuaries.dwer.wa.gov.au/participate
- To find out more about the Wilson Inlet Catchment Committee go to wicc.org.au
- To find out more about the health of the rivers in the Wilson Inlet catchment go to rivers.dwer.wa.gov.au/assessments/results

Methods

Where possible, parameters were compared with the ANZECC trigger values for lowland rivers in south-west Australia. These values provide a value above which there may be a risk of adverse effect. For pH there is both an upper and lower trigger value which represent the acceptable pH range. Where there were no ANZECC trigger values available (for TSS and salinity) the SWRWQA classification bands were used to allow samples and sites to be classified and compared.

Trend testing was carried out using either the Mann or Seasonal Kendall tests as appropriate. Where there were flow data available and there was a flow-concentration relationship, the data were flow-adjusted before trend analysis.

Annual loads were calculated by multiplying daily flow with daily nutrient concentrations and aggregating over the year. Measured daily concentrations were not available as samples were collected fortnightly at best, so daily concentration data were calculated using the locally estimated scatterplot smoothing algorithm (LOESS).

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 in the water.

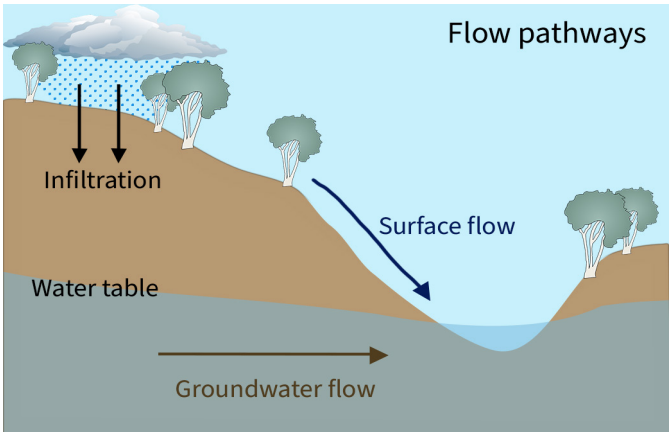
Evapoconcentration: the increase in concentration of a substance dissolved in water because of water being lost by evaporation.

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

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

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

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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