Government of **Western Australia**
Department of **Water**

Avon River catchment Water Quality and Nutrient Monitoring Program for 2007

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March 2009

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Department of **Water**

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AVON CATCHMENT COUNCIL

Australian Government

Jointly funded by the Avon Catchment Council and the Western Australian and Australian governments through the National Action Plan for Salinity and Water Quality.

AVON RIVERCARE PROJECT

Department of Water

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All photographs have been taken by Charissa Marwick unless otherwise stated. For more information about this report, contact

Charissa Marwick, Natural Resource Management Officer – Avon

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Abbreviations

ACC	Avon Catchment Council
ANDA	Avon Natural Diversity Alliance
AWC	Avon Waterways Committee
DAF	Department of Agriculture and Food
DEC	Department of Environment and Conservation
EEI	Engineering Evaluation Initiative
NAP	National Action Plan for Salinity and Water Quality
NRM	Natural resource management
RRP	River recovery plan
SPA	Saltland Pastures Association
WDE	Wheatbelt Drainage Evaluation
WWF	WWF-Australia

Summary

The occurrence of algal blooms, increasing salinity and the general lowering of water quality has been of increasing concern to the Avon Catchment Council. The council provided funding for a monitoring program to assess the quality of the waters in the Avon River catchment, with a specific focus on nutrients. In the Avon natural resource management strategy (2005) water quality targets for nutrients were set at 1.00 mg/L for total nitrogen and 0.1 mg/L for total phosphorus at the gauging station in Walyunga National Park.

Sampling sites were chosen to include the main tributaries of the Avon River and several gauging stations that could provide flow data. There were 39 sites. The majority of sampling sites had median total nitrogen results higher than the target and median total phosphorus results lower than the targets.

The salinity of the Avon River catchment during 2007 was found to be very high, with salinity increasing towards the eastern side of the catchment. The western side of the Avon River catchment was noticeably less acidic than in 2006. Total suspended solids were generally within the normal range, except during high flows which carry more particulate matter. The pH values of the samples collected were neutral to slightly alkaline except in the eastern side of the catchment where the water became more acidic. A pH reading as low as 2.76 was collected during the 2007 snapshot in the Lockhart River catchment. During high flows, the total suspended solids, total nitrogen and total phosphorus were usually higher and the total dissolved salts were lower than at other times during the monitoring period.

This monitoring report has been produced to aid natural resource management programs by identifying areas which are high in nutrients, or where other water quality problems exist within the Avon River catchment. Knowledge of areas which are high in nutrients will enable the identification of ‘hotspots’, and targeting of management actions. The 2006 and 2007 water quality reports will, with further data to be collected in the future, allow longer term trends in the water quality of the Avon River catchment to be understood.

The purpose of this report is to summarise the water quality monitoring conducted during 2007, compare the data to that collected in 2006, evaluate and review the results and identify possible trends across the catchment. The report will be used to establish baseline data for future reference and to determine if the water quality of the Avon River catchment is being maintained, improved or if it is deteriorating.

1 Introduction

The water quality of river systems is important for the social, economic and ecological function of the surrounding environment. The degradation of water quality in many of these areas has been attributed to the large-scale clearing and settlement of the riparian zone of major rivers since European settlement (Harris 2001).

Historically, there has been only limited research into the nutrient concentrations of the Avon River and its tributaries. Several studies have carried out research in small sections of the river system, or work has been based on ad hoc results from a variety of sources such as community groups (Harris 1996).

The natural cycling of nutrients in river systems occurs slowly. The human activity surrounding the river systems enriches the waterways with nutrients at an accelerated rate and causes a variety of detrimental effects (Sharpley et al. 1994). The accelerated rate of nutrient input into waterways can cause eutrophication. The occurrence of eutrophic conditions is becoming more common in Australian river systems such as the Swan–Avon River system in Western Australia. Nutrient enrichment causes a decline in water quality and ecosystem health and can pose a health risk to humans (Zammit, Sivapalan, Kelsey, & Viney 2005).

The Swan–Avon River catchment has a history of problems associated with the influx of nutrients into many of its watercourses. These nutrients cause algal blooms and eutrophication problems in the estuarine and freshwater parts of the Swan and Avon rivers. The nutrients that intensify this algal growth are nitrogen and phosphorus (D.A. Lord & Associates Pty. Ltd. 2001).

The Avon Catchment Council (ACC) target for the Avon River states that the average monthly concentration should not exceed 1.00 mg/L for total nitrogen and 0.1 mg/L for total phosphorus at the gauging station at Walyunga National Park. These levels are exceeded mainly during large summer rainfall events and often contribute to algal blooms in the Swan River Estuary and the Avon River itself *(Environmental Protection Act 1997)* (Ryan & Cobb 1999). This report will help identify areas within the Avon River catchment that have elevated nutrient concentrations and assist land managers to implement strategies to reduce the risk of nutrient enrichment.

1.1 The Avon River catchment

The Avon River is one of the great rivers of Australia. The vast Avon River catchment stretches from the coastal plain to Dalwallinu in the north, to the east beyond Southern Cross, and to the south beyond Lake Grace. The Avon River catchment has an area of over 120 000 square kilometres, larger than the state of Tasmania. The Avon River becomes the Swan River at the confluence of Wooroloo Brook at Walyunga National Park (Ruprecht & Hatton 2001). Map 1 shows the catchment boundary and the major tributaries to the Avon River.

Map 1
Avon River Catchment

LEGEND

- Major town
- Town
- Major watercourse
- Minor watercourse
- Avon River basin boundary

N

0 20 40 60 80

Kilometres

Datum and projection information

Vertical datum: AHD
Horizontal datum: GDA 94
Projection: MGA 94 Zone 50

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Hydrographic catchments, basins - DOE - 23/03/2005

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Department of Water

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From a geographic perspective, the Avon River is unusual. In contrast to 'normal' rivers, it arises in a broad, flat, geologically ancient landscape, and for most of its length has a very low gradient. Long chains of naturally saline lakes dominate the watercourses through the ancient landscape. The salt lakes join up and discharge into the Avon River only during exceptionally wet years (Ruprecht & Hatton 2004). As the river leaves the areas of ancient drainage and flows downstream through areas of mature, then rejuvenated landscape, the river valley becomes steeper, narrower and more rugged (Ruprecht & Hatton 2001).

Western Australia's first inland settlement was at York, on the Avon River, in 1830. Rapid development of the Avon Valley, then the hinterland of the Wheatbelt followed. Most of the catchment was settled by 1930, cleared and utilised for agriculture by 1970, resulting in considerable disturbance to the river (Ryan & Cobb, 1999).

The rainfall within the Avon River catchment varies considerably. The average annual rainfall in the eastern areas of the catchment, around Southern Cross, over the last 30 years is between 200 and 300 mm, compared to the average annual rainfall of between 800 to 1000 mm in the westernmost areas of the catchment (Bureau of Meteorology 2007). Figure 1 below shows the rainfall anomalies in Western Australia for 2007 and shows that the Avon River catchment had a fairly average year in terms of rainfall. Low rainfall can affect the water quality in a river system in a number of ways. When flows decrease or cease, concentrations of salts and other components of water quality may rise because of reduced flushing of the river system.

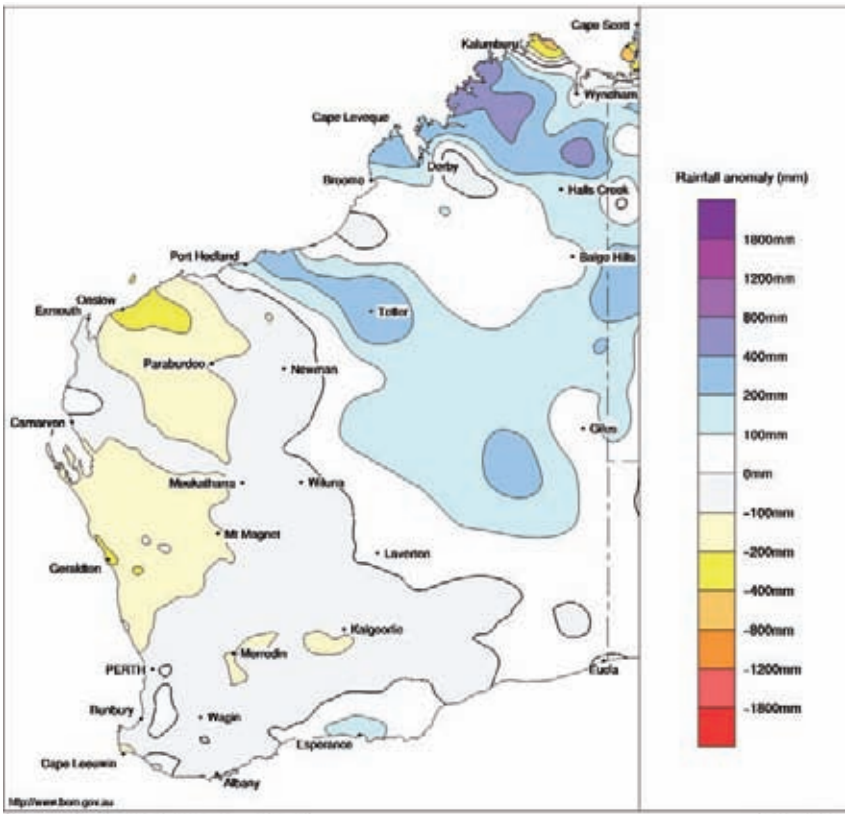

***Figure 1** Rainfall anomalies in Western Australia from 1 January to 31 December 2007.*

Source: National Climate Centre

1.2 Water quality

The chemical and physical water quality parameters examined during the Avon River basin water quality monitoring program for 2007 were:

- total nitrogen (TN)
- total phosphorus (TP)
- total dissolved salts (TDS)
- total suspended solids (TSS)
- pH
- flow information, where it could be obtained.

The nutrients TN and TP are useful means of establishing the trophic status of a waterway. Physical parameters such as TDS, TSS and pH are effective in establishing the overall health of the waterway (Water and Rivers Commission 2001).

The two most essential nutrients for aquatic plants are nitrogen and phosphorus, which in high concentrations can cause the excessive growth of algae and result in eutrophication. Nutrients occur naturally in river systems and are created by nitrogen fixing plants, weathering of soils, breakdown of organic matter and the leaching of nutrients from groundwater (Swan River Trust 2001). Nutrients created from human related activities may come from the clearing of land, application of excessive fertiliser, wastewater treatment plant outlets and stormwater runoff (Swan River Trust 2001). The ACC target for TN is 1.00 mg/L and for TP is 0.1 mg/L at the gauging station at Walyunga National Park (Avon Catchment Council 2005).

The degradation of freshwater systems by the effects of increased salinity is likely to be the most widespread water quality issue in Western Australia (Mayer, Ruprecht & Bari 2005). The Avon River has become increasingly saline as a result of the large scale clearing in its catchment. This has caused the loss of many species of flora and fauna that once inhabited the river system (ARSMC & Waterways Commission 1993).

TSS is the total amount of undissolved matter. It includes the mobile sediments, organic matter and any undissolved chemicals. High levels of suspended solids can have a detrimental effect on the aquatic flora and fauna in a waterway. Suspended solids can block out light, thus preventing photosynthesis, and can carry significant quantities of nutrients bound to the particles. This increases the nutrient concentration in the waterway (Swan River Trust 2001).

The acidity or alkalinity of a waterway is measured on a pH scale. The pH scale ranges from 0 (extremely acidic) to 14 (extremely alkaline). A pH value of 7 is neutral. The majority of healthy freshwater systems are close to neutral, with pH values between 6.5 and 8.5 (ANZECC 1992). Below pH 4, aquatic ecosystems are severely affected. Most of the animal life in water will die at this level. In addition, sudden changes in pH within a normal, healthy range may also be detrimental (Agriculture Western Australia 1996).

1.3 Objectives

This report examines in detail the water quality of the Avon River catchment with a particular emphasis on the levels of nutrients. This allows problem areas and 'hotspots' within the system to be identified (a hotspot is where there is a sudden decrease in water quality due to a point source of pollution, such as an industrial waste outfall). This document forms part of the Avon Catchment Council funded project titled Avon River Waterway Management. A framework has been established for the program, with four priority strategies:

- identify and manage high-risk nutrient loss locations in the Upper Swan, Avon and Mortlock river systems, including the Northam wastewater treatment plant
- determine and map the extent of the flood plain on the Avon River between Toodyay and Beverley
- fencing of both the Avon River and major tributaries, to reduce threatening processes such as eutrophication and erosion
- contribute to land managers' understanding of alternative water management techniques on a catchment-wide scale.

This report will aid in implementing the strategy 'identify and manage high-risk nutrient loss locations in the Upper Swan, Avon and Mortlock River systems, including the Northam wastewater treatment plant, by identifying areas which are high in nutrients or where poor water quality is evident within the Avon River catchment. This will lead to the identification of hotspots, and aid the identification of water quality trends across the catchment, enabling land managers and planners to manage them more effectively, and ensure that management effort is concentrated in these areas.

A sampling site downstream of the Northam wastewater treatment plant was added to the 2007 water quality monitoring program, as the Katrine Bridge sampling site was found to be inadequate for determining the downstream effects of the wastewater treatment plant.

2 Methodology

2.1 Sampling sites

The sampling sites for the 2007 water quality monitoring program are shown in Map 2. The sites were selected to include all the main tributaries of the Avon River, various locations along the length of the river and several sites to examine the effects of wastewater discharge on water quality in the river. Seventeen sites are located at gauging stations so that flow data can be used in the analysis.

2.2 Sampling program and snapshot

Sampling was conducted fortnightly at all sites. Sampling only occurred if that section of the river was flowing. In situ measurements were collected for uncompensated conductivity, temperature and pH.

Water samples were collected at each site as grab samples into HDPE bottles. Only one sample was collected at each site unless a field duplicate or field blank sample was required. The field duplicate and field blank samples were collected as part of the quality control measures. The samples were cooled in an esky containing ice bricks, kept cold and as soon as practicable were sent by courier to the National Measurement Institute for analysis.

Photo 1 *Sample collection on a fortnightly sampling run in the Avon River catchment (June 2007)*

The bottled samples were analysed every fortnight for total nitrogen, total phosphorous and total suspended solids. Every second fortnight, a field filtered sample was collected at each site and sent to the laboratory and analysed for total oxidised nitrogen (NOx-N), ammonia as nitrogen (NH4-N/NH3-N), filterable reactive phosphorous (FRP), dissolved organic nitrogen (DON) and total suspended solids. Analytical methods and sample preparation can be found in the table below. The National Measurement Institute is a National Accredited Testing Authority.

Table 1 *Laboratory testing of analytes for the 2007 Avon River catchment monitoring program*[1]

Analyte	Sample preparation	Analytical methods	Limits of reporting mg/L
Total nitrogen (TN)	Chilled in an esky with ice bricks	NMI (WL239), persulphate digestion method 4500-N C, (APHA 1998), and the cadmium reduction method 4500-NO3-F, (APHA 1998)	0.025
Total phosphorus (TP)	Chilled in an esky with ice bricks	NMI (WL 239), persulphate digestion method 4500-PB.5, (APHA 1998) and the ascorbic acid colorimetric method 4500-P E. (APHA 1998)	0.005
Total suspended solids (TSS)	Chilled in an esky with ice bricks	NMI (WL 126), APHA method 2540 (D & E 1998)	1
Nitrite and nitrate as nitrogen (NOx-N)	Filter sample with a 0.45 µm membrane, and then chill in an esky with ice bricks	NMI (WL 239), colorimetric method 4500-NO2-B (APHA 1998) and the cadmium reduction method 4500-NO3-F, (APHA 1998)	0.01
Ammonia as nitrogen (NH4-N/NH3-N)	Filter sample with a 0.45 µm membrane, and then chill in an esky with ice bricks	NMI (WL 239), (APHA 1998) phenate method 4500-NH3 G	0.01
Soluble reactive phosphorus (SRP)	Filter sample with a 0.45 µm membrane, and then chill in an esky with ice bricks	NMI (WL 239), ascorbic acid colorimetric method 4500-P F (APHA 1998)	0.005
Dissolved organic nitrogen (DON)	Filter sample with a 0.45 µm membrane, and then chill in an esky with ice bricks	NMI (WL 239) by calculation DON = filtered TN – total organic nitrogen – NH3-N	0.025

[1]*Dissolved oxygen was measured in the field.*

Uncompensated conductivity, temperature and pH were measured on site with WTW meters which were calibrated before and after every sampling session and serviced regularly by the Hydrological Technical Centre. Stage height readings were collected at the gauging station sites included in the sampling program.

Staff members from the Department of Water's Northam office started the sampling program when streams began flowing in April 2007 and continued at most sites until

Map 2
Water Quality Monitoring Sites for 2007

LEGEND

- Monitoring site (Name, ID)
- Major town
- Minor town
- Major watercourse
- Minor watercourse
- Avon River basin boundary

N

0 10 20 30
Kilometres

Datum and projection information

Vertical datum: AHD
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This map is a product of the Department of Water, Regional Support and was printed on 12th March 2009.

This map was produced with the intent that it be used at the scale of 1:800,000 when printing at A3.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the Department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

WONGAN HILLS
DOWERIN
GINGIN
TOODYAY
NORTHAM
BULLSBROOK
WUNDOWIE
CHIDLOW
MOUNT HELENA
PERTH
FREMANTLE
YORK
BEVERLEY
BROOKTON
PINGELLY
QUAIRADING
CUNDERDIN
KELLERBERRIN
BRUCE ROCK
CORRIGIN
ROCKINGHAM
MANDURAH
PINJARRA

Toodyay West Road 6151001
Stirling Tce 615026
Frenches 615013
Downstream of Inflow 6151125
Clark Street 6151008
Katrine Bridge 6151155
Northam Weir 615062
Taylor St Weir 6151278
O'Driscoll's Farm 615020
Gt Eastern Hwy 6151288
Yalliawirra 616019
Karl's Ranch 616001
Gt Northern Highway 616076
Walyunga 616011
Coates Road 6162387
Hawke Ave 6162388
Linley Valley Road 6162389
Spencers Brook 6151518
Quellington Road 6151028
York Town Pool 6151033
Balladong St 615024
Top Beverley-York Road 6151026
Gwambygine 6151157
Beverley Bridge 615025
Waterhatch Bridge 615027
Qualandary Crossing 615022
Yenyening Confluence 615029
Boyagarra 615063
D/Stream Brookton WWTP 6151007
WWTP Outlet to River 6151014
Brookton WWTP 6151011
Brookton Highway 6151052
Salt River Dangin Mears 6151353
Kunjin Creek Dangin 6151350
Dangin-Mears Rd 6151572
Mooranoppin Rock 615011
Gairdner's Xing 615015
Hines Hill North Rd 6151367
Kwolyn Hill 615012

Mortlock River North
Mortlock River East
Mortlock River South
Brockman River
Avon River
Woroloo Brook
Swan River
Helena River
Canning River
Salt River
Yilgarn River
Lockhart River
Wogalin Gully

December 2007. Several sites were still being sampled in January 2008. Water samples were collected as described in the *Sampling and analysis plan: Nutrient monitoring in the Avon and Mortlock river basins* (Burns 2007).

Photo 2 *Use of in situ meters during the fortnightly sampling run (July 2007)*

All results were sent from the laboratory to the Water Information Systems database (Department of Water 2007b). Data was extracted from the database throughout 2007 and checked for errors. The reliability of the results was assessed using the quality control samples throughout 2007 as part of the quality control measures outlined in the sampling and analysis plan (Burns 2007). After all the sampling results had been entered into the database, the complete set of results for the 2007 monitoring program was obtained in a Microsoft Excel format.

The Avon River basin snapshot was carried out over five days from 3 September to 7 September 2007. There were 296 sampling sites of which only 161 were sampled, as many of the sites were not flowing. Four teams sampled different areas of the catchment so that data could be collected at as close to the same time as possible. On site readings were taken with WTW meters for uncompensated conductivity, temperature and pH. The TN and TP samples were chilled with ice bricks and kept in an esky until they could be sent to the National Measurement Institute for analysis. Samples were not collected unless the waterway was flowing, with the exception of lake systems.

2.3 Data analysis and classification

The order of site results in the report is from the most downstream site (Great Northern Highway – Swan River – 616076) upstream, including tributaries along the way to the most upstream site in the Avon River catchment (Dangin Mears Road – Avon River – 6151572). This was done to keep consistency throughout the results and to make it easier to detect any water quality trends throughout the catchment.

Electrical conductivity results were compensated for temperature and then converted to total dissolved salt concentrations. The distribution of the results for total nitrogen, total phosphorus, total dissolved salts, total suspended solids, pH and dissolved oxygen (DO) were examined using box plots, showing the maximum, minimum, median and the lower and upper quartiles (25% and 75%) for comparison between sites. All results recorded as being below detection limits were treated as being zero.

The Brookton wastewater treatment plant site (6151011) was not included in the box plots as it does not reside in the river and was only included in the site analysis for comparison with the sites located downstream on the south branch of the Avon River.

The snapshot data was treated separately and maps were created for the TN, TP, TDS and pH results to show the spatial variation in the Avon River catchment, and to enable the comparison between the 2006 and 2007 Avon River basin water quality snapshot data.

Graphs for TN, TP, TDS, TSS, pH and DO were created for each site to examine the relationships between each of the parameters for individual sites. The nutrient fractions for TN and TP were plotted against the total concentrations to see how the comp osition of the totals varied during events and at different times of the year.

Stream flows are the only data that was continuously recorded. Dotted lines have been used to represent the other data on the graphs. This is a reminder that it is not always valid to interpolate water quality data between samplings. The fortnightly data was used to examine seasonal trends, despite the fact that the data does not reflect any events that may have occurred between sampling sessions. All of the readings and samples taken are only indicative of the waterway at the time of sampling and do not reflect the variations between sampling sessions. Water quality parameters are highly dynamic and can change quickly in relation to changes in flow conditions.

The pH data was graphed on a normal scale to demonstrate its variability during each of the sampling sessions. Discharge measurements were obtained from the WIN database from continuous data collected by the measurement section of the Department of Water. These were plotted against each of the analytes to enable them to be examined together.

It is normal practice to compare results for each parameter to a guideline or particular classification index. The TN and TP results will be compared to the Avon Catchment Council target for Walyunga of 1.0 mg/L for TN and 0.1 mg/L for TP which is based on the targets set in the *Environmental Protection Policy for the Swan and Canning rivers (1997)*. The target was set for Walyunga gauging station in the Walyunga

National Park, but it has been used throughout the report for comparison of all sampling sites. The TN and TP results were classified using an index created for the *Statewide river water quality assessment* (Department of Water 2004).

The TDS results were compared to a classification table created for the report *Stream salinity status and trends in south-west Western Australia* (Department of Environment 2005). All other parameters are classified according to the *Statewide river water quality assessment* (Department of Water 2004).

Table 2 *Classifications used for total nitrogen and total phosphorus*

Classification	Total nitrogen mg/L	Total phosphorus mg/L
Low	<0.75	<0.02
Moderate	0.75–1.2	0.02–0.08
High	1.2–2.0	0.08–0.2
Very high	>2.0	>0.2

Source adapted from Department of Water 2004

Table 3 *Classifications used for total dissolved salts*

Classification	Total dissolved salts mg/L
Fresh	<500
Marginal	500–1000
Brackish	1000–5000
Saline	5000–10 000
Highly saline	10 000–35 000
Brine	>35 000

Source: adapted from Mayer, Ruprecht & Bari (2005)

Table 4 *Classifications used for pH*

Classification	pH
Acidic	<6.5
Neutral	6.5–8.0
Alkaline	>8.0

Source: adapted from Department of Water (2004)

Table 5 *Classifications used for total suspended solids*

Classification	Total suspended solids mg/L
Low	<5
Moderate	5–10
High	10–25
Very high	>25

Source: adapted from Department of Water (2004)

Table 6 *Classifications used for dissolved oxygen*

Classification	Dissolved oxygen mg/L
Low	<8
Oxygenated	8–12
Hyperoxic	>12

Source: adapted from Department of Water (2004)