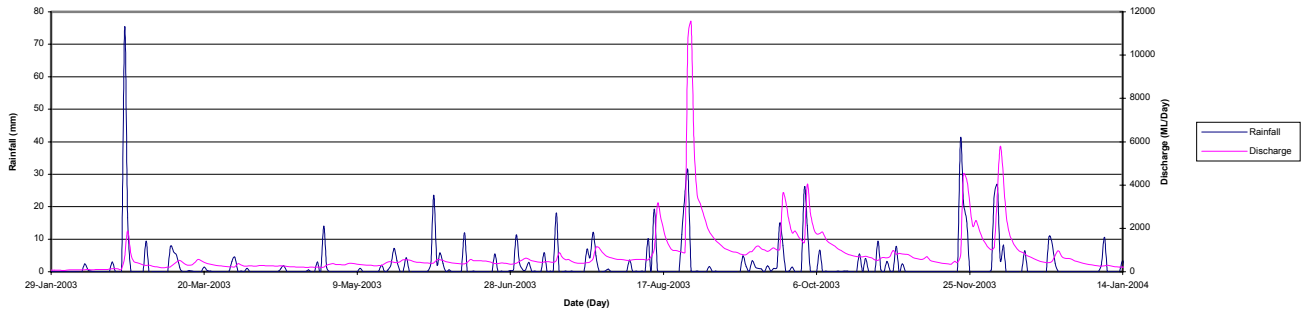


Part 4: CAMPFIRE Year 1 Report Findings

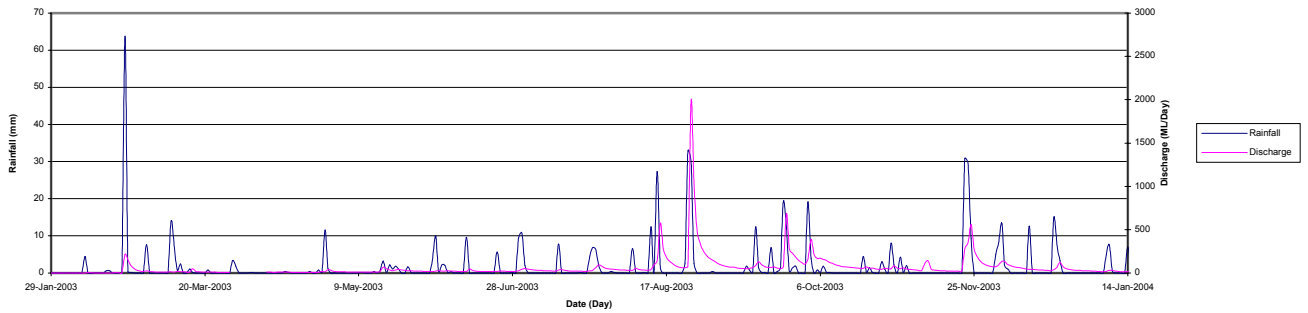


ACT Rainfall and Discharge

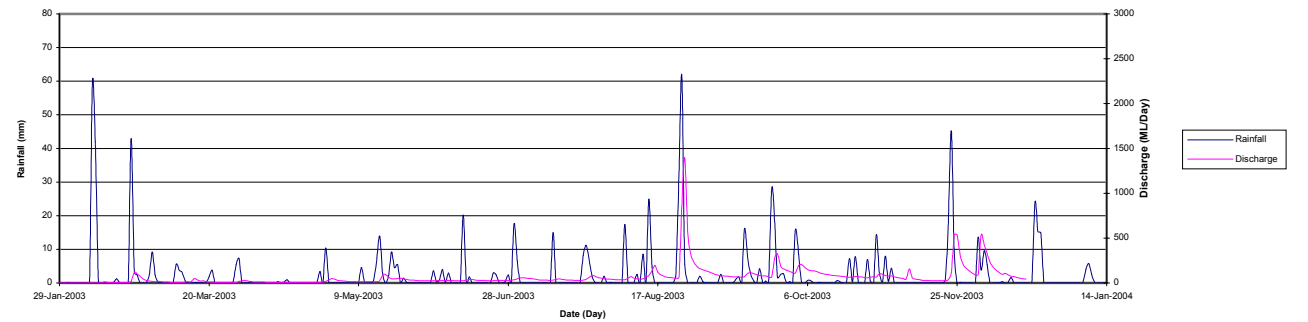
Murrumbidgee River



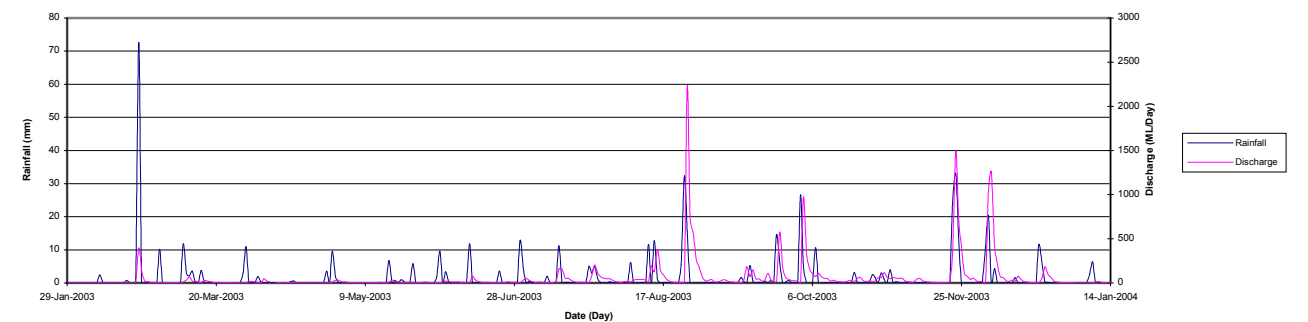
Paddys River



Gudgenby River



Molonglo River



Turbidity Summary (NTU)

	Obs	Fire severity	Min	Max	Mean	Std Dev	Median
Gudgenby Catchment							
Hospital Creek South	9	low	<10	22	10.44	4.33	9.00
Hospital Creek Central	8	low	<10	9	9.00	0.00	9.00
Hospital Creek North	13	low	<10	16	9.85	2.15	9.00
Bogong Creek South	10	low	<10	9	9.00	0.00	9.00
Bogong Creek Central	8	low	<10	9	9.00	0.00	9.00
Bogong Creek North	13	low	<10	9	9.00	0.00	9.00
Little Dry Creek	9	low	<10	9	9.00	0.00	9.00
Middle Creek	9	low	<10	21	12.78	5.14	10.00
Rendezvous Creek	9	low	<10	400	62.67	127.56	17.00
Naas River Catchment							
Glendale Crossing	20	very high	<10	200	31.10	44.49	13.00
Naas Crossing	11	low	<10	70	21.64	18.94	15.00
Orroral River Campsite	10	very high	<10	36	13.50	8.80	9.00
Murrumbidgee River							
Angle Crossing	7	high	<10	22	13.29	4.99	12.00
Tharwa Bridge	17	low	<10	32	17.76	7.00	19.00
Point Hut Crossing	13	high	<10	55	22.00	14.11	15.00
Pine Island	12	high	<10	37	19.42	9.67	18.00
Kambah Pool	15	high	11	200	35.47	46.43	21.00
Casuarina Sands	12	very high	<10	410	59.33	112.01	23.00
Uriarra Crossing	11	high	<10	60	26.82	15.48	20.00
Tuggeranong Creek Catchment							
Tuggeranong Creek	9	moderate	<10	30	14.78	7.33	12.00
Paddys River Catchment							
Upper Gibraltar Creek	4	moderate	<10	15	10.50	3.00	9.00
Lower Gibraltar Creek	4	very high	<10	400	106.75	195.50	9.00
Upper Tidbinbilla River Site	12	very high	<10	55	15.67	13.13	9.00
Lower Tidbinbilla River Site	12	high	<10	30	11.75	6.21	9.00
Flints Crossing	11	low	<10	330	57.18	94.97	15.00
Murrays Corner	11	very high	<10	250	50.18	70.03	23.00
Cotter River Catchment							
Condor Creek	6	very high	<10	22	11.17	5.31	9.00
Molonglo River Catchment							
Weston Creek GPT	13	high	<10	50	19.31	11.74	15.00
Coppins Crossing	12	high	<10	15	9.58	1.73	9.00
Dams/Wetlands							
Cooleman Ridge Dam	8	high	<10	150	62.38	42.86	55.00

* <10 recorded as 9 for mean, standard deviation and median

ANZECC Guidelines 1992 (Guide for interpretation only)

	Excellent	Good	Fair	Poor	Degraded
Mountain	<5.0	<7.5	<10.0	<12.5	>12.5
Valley	<10.0	<12.5	<15.0	<22.5	>22.5
Plain	<15.0	<17.5	<20.0	<30.0	>30.0

CAMPFIRE Findings

The severity of bushfire impacts on turbidity levels ultimately depended on fire severity, land use, post fire rainfall amount and timing, and catchment geology. The most obvious impact has been the increased amount of ash, sediments and nutrients ending up in the waterways. With vegetation cover removed, storm water surges off burnt catchments quickly picking up large amounts of exposed soil. This surge of storm water energy is only temporary but can transport enormous amounts of soil off the surrounding hills and into the waterways. As storm water levels recede the energy created decreases. The larger and denser particles such as sand and gravel eventually settles smothering vital in-stream habitats. Turbidity readings were highest within 24 hours of a rain event at sites where the fires were at their most severe.

Turbidity is a measure of water clarity. Particles such as clay, silt, sand, algae, plankton, ash, and other substances suspended in the water, scatter the passage of light through the water. To the naked eye, turbidity appears as cloudy or muddy water. It differs from colour—water can have high colour and low turbidity, eg tannin rich waters.

Potential Impacts

High turbidity can often affect aquatic ecosystems in a number of ways.

- Particles can absorb more heat raising water temperature which can reduce the concentration of dissolved oxygen.
- Reduces the light passing through the water lowering plant photosynthesis and lowering dissolved oxygen.
- Suspended materials can clog fish gills, reduce resistance to disease, lowering growth rates, and affect egg and larval development.
- Particles and sediments may settle in the stream smothering vital in-stream habitats.
- Suspended sediments provide a place for both harmful bacteria to breed and to carry attached pollutants such as excess nutrients and toxic materials.



Glendale crossing after heavy rain. Picture M. Chalk

Turbidity Summary (NTU)

	Obs	Fire severity	Min	Max	Mean	Std Dev	Median
Gudgenby Catchment							
Hospital Creek South	9	low	<10	22	10.44	4.33	9.00
Hospital Creek Central	8	low	<10	9	9.00	0.00	9.00
Hospital Creek North	13	low	<10	16	9.85	2.15	9.00
Bogong Creek South	10	low	<10	9	9.00	0.00	9.00
Bogong Creek Central	8	low	<10	9	9.00	0.00	9.00
Bogong Creek North	13	low	<10	9	9.00	0.00	9.00
Little Dry Creek	9	low	<10	9	9.00	0.00	9.00
Middle Creek	9	low	<10	21	12.78	5.14	10.00
Rendezvous Creek	9	low	<10	400	62.67	127.56	17.00
Naas River Catchment							
Glendale Crossing	20	very high	<10	200	31.10	44.49	13.00
Naas Crossing	11	low	<10	70	21.64	18.94	15.00
Orroral River Campsite	10	very high	<10	36	13.50	8.80	9.00
Murrumbidgee River							
Angle Crossing	7	high	<10	22	13.29	4.99	12.00
Tharwa Bridge	17	low	<10	32	17.76	7.00	19.00
Point Hut Crossing	13	high	<10	55	22.00	14.11	15.00
Pine Island	12	high	<10	37	19.42	9.67	18.00
Kambah Pool	15	high	11	200	35.47	46.43	21.00
Casuarina Sands	12	very high	<10	410	59.33	112.01	23.00
Uriarra Crossing	11	high	<10	60	26.82	15.48	20.00
Tuggeranong Creek Catchment							
Tuggeranong Creek	9	moderate	<10	30	14.78	7.33	12.00
Paddys River Catchment							
Upper Gibraltar Creek	4	moderate	<10	15	10.50	3.00	9.00
Lower Gibraltar Creek	4	very high	<10	400	106.75	195.50	9.00
Upper Tidbinbilla River Site	12	very high	<10	55	15.67	13.13	9.00
Lower Tidbinbilla River Site	12	high	<10	30	11.75	6.21	9.00
Flints Crossing	11	low	<10	330	57.18	94.97	15.00
Murrays Corner	11	very high	<10	250	50.18	70.03	23.00
Cotter River Catchment							
Condor Creek	6	very high	<10	22	11.17	5.31	9.00
Molonglo River Catchment							
Weston Creek GPT	13	high	<10	50	19.31	11.74	15.00
Coppins Crossing	12	high	<10	15	9.58	1.73	9.00
Dams/Wetlands							
Coolleman Ridge Dam	8	high	<10	150	62.38	42.86	55.00

* <10 recorded as 9 for mean, standard deviation and median

	Excellent	Good	Fair	Poor	Degraded
Mountain	<5.0	<7.5	<10.0	<12.5	>12.5
Valley	<10.0	<12.5	<15.0	<22.5	>22.5
Plain	<15.0	<17.5	<20.0	<30.0	>30.0

ANZECC Guidelines 1992 (Guide for interpretation only)

CAMPFIRE Findings

The severity of bushfire impacts on turbidity levels ultimately depended on fire severity, land use, post fire rainfall amount and timing, and catchment geology. The most obvious impact has been the increased amount of ash, sediments and nutrients ending up in the waterways. With vegetation cover removed, storm water surges off burnt catchments quickly picking up large amounts of exposed soil. This surge of storm water energy is only temporary but can transport enormous amounts of soil off the surrounding hills and into the waterways. As storm water levels recede the energy created decreases. The larger and denser particles such as sand and gravel eventually settles smothering vital in-stream habitats. Turbidity readings were highest within 24 hours of a rain event at sites where the fires were at their most severe.

Turbidity is a measure of water clarity. Particles such as clay, silt, sand, algae, plankton, ash, and other substances suspended in the water, scatter the passage of light through the water. To the naked eye, turbidity appears as cloudy or muddy water. It differs from colour—water can have high colour and low turbidity, eg tannin rich waters.

Potential Impacts

High turbidity can often affect aquatic ecosystems in a number of ways.

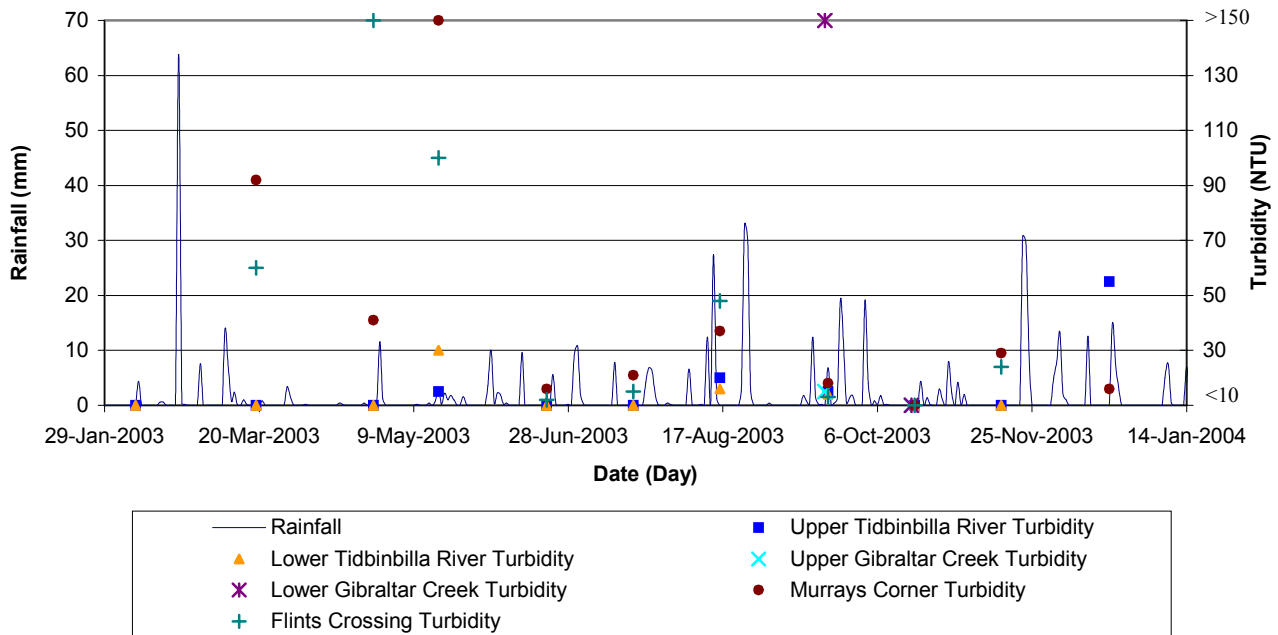
- Particles can absorb more heat raising water temperature which can reduce the concentration of dissolved oxygen.
- Reduces the light passing through the water lowering plant photosynthesis and lowering dissolved oxygen.
- Suspended materials can clog fish gills, reduce resistance to disease, lowering growth rates, and affect egg and larval development.
- Particles and sediments may settle in the stream smothering vital in-stream habitats.
- Suspended sediments provide a place for both harmful bacteria to breed and to carry attached pollutants such as excess nutrients and toxic materials.



Glendale crossing after heavy rain. Picture M. Chalk

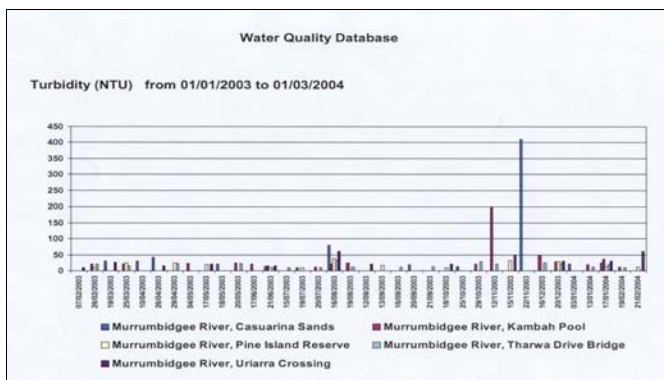
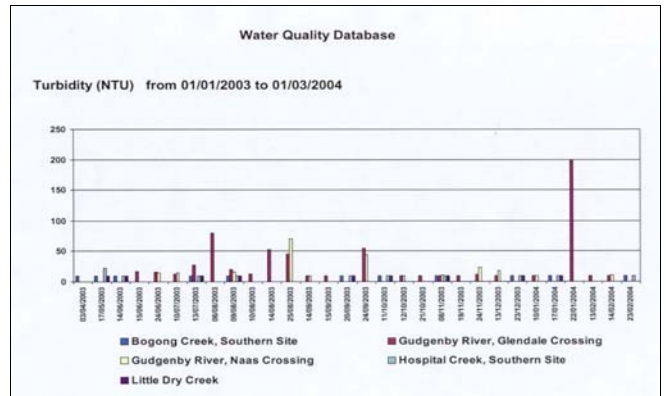
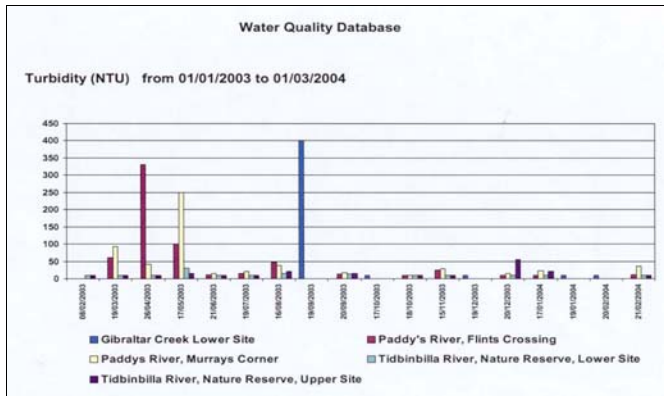
Turbidity and Rainfall

Paddys River Turbidity and Rainfall



Rainfall was found to have a great influence on turbidity. In the Paddys River catchment, high turbidity readings were recorded in the first few months after the fires at Murrays Corner and Flints Crossing. With farm fences lost to the fires, stock accessing the river may have contributed to these peaks. From June to August turbidity levels stabilised as rainfall patterns were well below average. Turbidity spikes were again recorded including an incredible >400NTU's at the Lower Gibraltar Creek site during a large rain event in October. These extreme turbidity peaks were still continuing even a year after the January 2003 bushfires.

It All Happens in 24 Hours or Less



Data collected by volunteers found that turbidity spikes of over 100 NTU's were recorded sporadically across the year. These high turbidity peaks were usually recorded within 24 hours of rain. Pictorial evidence suggests that movement and build up of sediments happens during this critical time, when massive amounts of sediments can enter the waterway.

Heavy sedimentation of streams and rivers can severely impact aquatic wildlife and water quality, cause fish kills, destroy in-stream habitats, change flora composition, and change flooding characteristics.



Phosphorus Summary (Mg/l P)

	Obs	Fire severity	Min	Max	Mean	Std Dev	Median
Gudgenby Catchment							
Hospital Creek South	9	low	0.00	0.20	0.04	0.07	0.01
Hospital Creek Central	8	low	0.00	0.10	0.03	0.04	0.00
Hospital Creek North	9	low	0.00	0.10	0.05	0.04	0.05
Bogong Creek South	10	low	0.00	0.02	0.00	0.01	0.00
Bogong Creek Central	8	low	0.00	0.01	0.00	0.01	0.00
Bogong Creek North	9	low	0.00	0.03	0.01	0.01	0.00
Little Dry Creek	9	low	0.00	0.01	0.00	0.00	0.00
Middle Creek	3	low	0.00	0.00	0.00	0.00	0.00
Rendezvous Creek	0	low					
Naas River Catchment							
Glendale Crossing	8	Very high	0.00	0.04	0.01	0.01	0.01
Naas Crossing	8	low	0.00	0.04	0.02	0.01	0.02
Orroral River Campsite	0	Very high					
Murrumbidgee River							
Angle Crossing	7	high	0.00	0.03	0.01	0.01	0.00
Tharwa Bridge	14	low	0.00	1.11	0.11	0.29	0.03
Point Hut Crossing	11	high	0.00	0.13	0.03	0.04	0.01
Pine Island	11	high	0.01	0.13	0.04	0.03	0.03
Kambah Pool	13	high	0.00	0.20	0.05	0.06	0.03
Casuarina Sands	9	Very high	0.03	0.20	0.10	0.06	0.10
Uriarra Crossing	11	high	0.00	0.15	0.03	0.04	0.01
Tuggeranong Creek							
Tuggeranong Creek	9	moderate	0.00	0.20	0.03	0.06	0.01
Paddys River Catchment							
Upper Gibraltar Creek	4	moderate	0.01	0.03	0.01	0.01	0.01
Lower Gibraltar Creek	3	Very high	0.01	0.02	0.02	0.01	0.02
Upper Tidbinbilla River Site	11	Very high	0.03	0.09	0.07	0.02	0.07
Lower Tidbinbilla River Site	11	High	0.00	0.07	0.03	0.03	0.02
Flints Crossing	10	low	0.00	0.25	0.07	0.09	0.04
Murrays Corner	10	Very high	0.00	0.29	0.09	0.10	0.06
Cotter River Catchment							
Condor Creek	5	Very high	0.02	0.15	0.06	0.05	0.06
Molonglo River Catchment							
Weston Creek GPT	12	high	0.01	0.10	0.06	0.03	0.05
Coppins Crossing	12	high	0.00	0.12	0.04	0.04	0.04
Dams/Wetlands							
Coleman Ridge Dam	6	high	0.02	0.13	0.08	0.04	0.09

Phosphorus is a nutrient that occurs naturally at low concentrations in water and is essential for plants and animals that make up the aquatic food web. There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater, run off from fertilised lawns and cropland, failing septic systems, animal manure, disturbed land area, drained wetlands, detergents in stormwater runoff, etc.

We test for **inorganic** or **Ortho phosphorus** which refers to the configuration of covalent bonds between phosphorus and oxygen. Ortho phosphorus is in the form required by plants for growth. Both inorganic and organic phosphorus can either be dissolved in water or attached to suspended particles in the water column or in bottom sediments (see Fig. 16).

Potential Impacts

High phosphorus can often affect aquatic ecosystems in a number of ways.

- Low levels of phosphorus limit growth of aquatic plants. A sudden increase in phosphorus can stimulate great increases in large aquatic plants (macrophytes) or microscopic plants (algal bloom). Algal blooms can lead to increased turbidity, pH changes, a reduction in biodiversity, and the occasional production of toxins and unpleasant odours. Australia has the 'world record' for the largest blue-green algal bloom of approximately 1,000 km in the Darling River in 1991/92.
- Continued addition of phosphorus can lead to choking with aquatic weeds and decaying vegetation, which in turn elevates temperature and changes river characteristics e.g. macroinvertebrate and fish populations. Rivers in this condition are described as eutrophic and the process of nutrient enrichment is eutrophication.

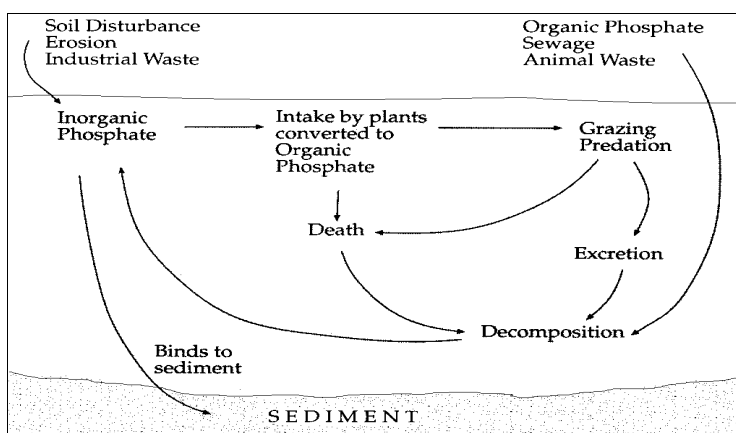
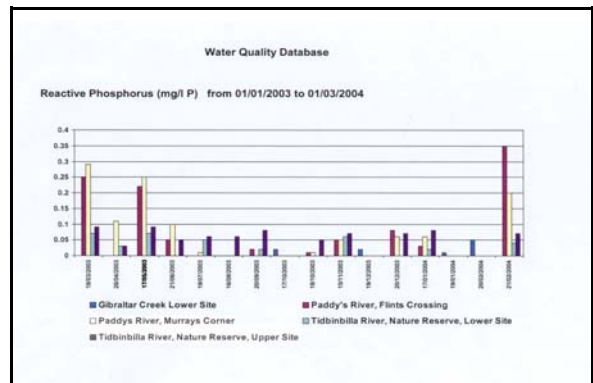
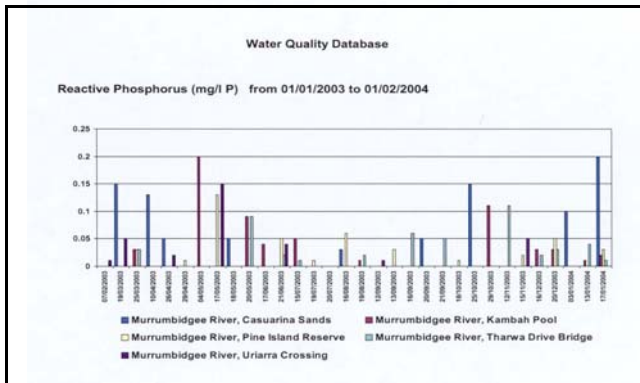


Figure 16 The phosphorus cycle. Phosphorus changes form as it cycles through the aquatic environment. (Adapted from Behar, S. 1997.) Waterwatch Tasmania Technical Manual

Excellent	Good	Fair	Poor	Degraded
<0.008	<0.025	<0.050	<0.10	>0.10

ANZECC Guidelines 1992 (Guide for Interpretation Only)

Phosphorus Summary (Mg/l P)

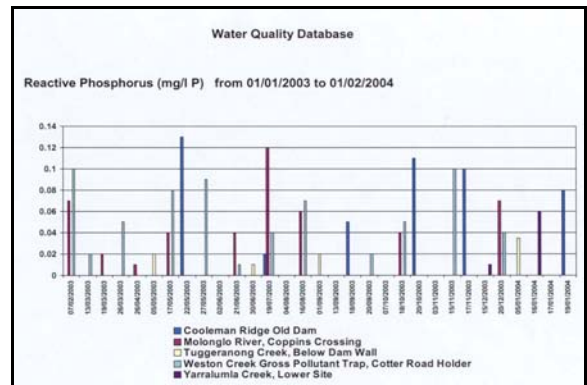


Murrumbidgee and Paddys River

Phosphorous measurements varied throughout the year. There was an increase in phosphorus in the first few months following the fire, probably due to nutrient-rich sediment and ash being washed into the river. Lower phosphorous values were recorded in the cooler months where lower temperatures and increased flows most likely diluted the phosphorous present.

Phosphorus in streams are either dissolved in water or attached to suspended sediment. Since the bushfires, increased soil, ash and organic material have been transported into these waterways. This sedimentation can act as a nutrient storage sink which, if conditions are right, can release its nutrients into the waterway.

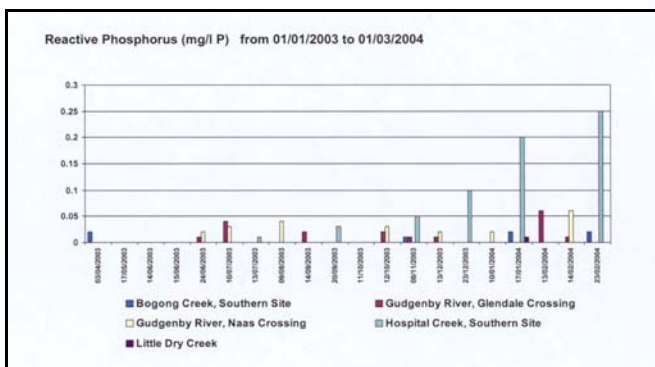
Phosphorus levels began to rise in the warmer months possibly due to greater biological activity that can release sediment bound phosphorus particles into the water column. Lower water levels can also cause nutrient rich organic sediments to dry out along the stream edge. These drying sediments may release significant amounts of phosphorus into the water column.



Urban Region

Measurements in the urban streams varied throughout the year. Urban stormwater pollutants are likely to be the cause of these fluctuations. Coolman Ridge Dam consistently recorded high phosphorus readings. As the water level drops these small drought affected dams can release phosphorus from the drying bank sediments. This is accentuated by the nutrient rich ash from the fires.

Gudgenby Investigation



Gudgenby Area

The Gudgenby Bush Regenerators found unusually high unexplained phosphate levels in Hospital Creek.

Investigating this high phosphorus, intrepid hikers found a chain of markedly different pond types along this drought and fire affected creek bed. Of interest were the bacteriological dominated ponds (left) which were black in colour and high in phosphorus. Analysis done Allie Mokany, PhD student from the Australian National University showed a phosphate reading of a whopping 3.91mg/l in one of these ponds. Phytoplankton dominated ponds (far left) were also discovered, which were bright green in colour and low in phosphorus and turbidity.



These ponds can be found in mountain streams or local creeks that have stopped flowing. They can be dominated by a mat of algae, or be black in colour, completely clear or bright green with phytoplankton. The investigation continues...

Water Temperature Summary (Degrees Celsius)

	Obs	Fire severity	Min	Max	Mean	Std Dev	Median
Gudgenby Catchment							
Hospital Creek South	9	low	5.60	19.10	11.42	5.61	10.00
Hospital Creek Central	8	low	6.90	25.40	13.24	6.58	11.55
Hospital Creek North	11	low	6.80	23.50	14.43	5.73	14.20
Bogong Creek South	10	low	4.50	22.00	11.19	5.99	10.95
Bogong Creek Central	8	low	5.00	16.70	9.53	4.22	9.05
Bogong Creek North	12	low	4.00	21.70	11.67	5.82	10.60
Little Dry Creek	9	low	7.00	19.00	12.34	4.38	11.00
Middle Creek	8	low	6.00	21.00	10.38	4.78	9.00
Rendezvous Creek	6	low	9.00	22.00	15.58	5.14	15.25
Naas River Catchment							
Glendale Crossing	13	Very high	5.00	22.00	12.50	5.74	13.00
Naas Crossing	9	low	6.00	20.00	13.84	5.43	15.00
Orroral River Campsite	6	Very high	13.00	23.50	17.75	4.13	16.75
Murrumbidgee River							
Angle Crossing	7	high	8.00	25.00	15.21	6.57	14.00
Tharwa Bridge	17	low	2.00	26.00	16.54	8.09	15.90
Point Hut Crossing	14	high	0.04	25.50	15.77	7.82	17.15
Pine Island	12	high	7.80	25.50	17.55	6.80	19.60
Kambah Pool	16	high	7.20	28.00	16.99	7.81	14.20
Casuarina Sands	12	Very high	7.00	26.00	15.98	6.62	16.00
Uriarra Crossing	11	high	8.50	30.00	18.87	6.91	19.00
Tuggeranong Creek							
Tuggeranong Creek	9	moderate	10.30	31.50	16.43	6.81	15.00
Paddys River Catchment							
Upper Gibraltar Creek	4	moderate	7.00	16.00	13.25	4.27	15.00
Lower Gibraltar Creek	4	Very high	11.00	27.00	20.00	6.63	21.00
Upper Tidbinbilla River Site	12	Very high	5.00	25.00	14.90	6.69	15.25
Lower Tidbinbilla River Site	12	high	5.50	30.00	15.77	7.52	16.25
Flints Crossing	11	low	5.20	26.00	15.27	6.88	15.10
Murrays Corner	11	Very high	6.80	25.30	15.89	6.86	15.90
Cotter River Catchment							
Condor Creek	6	Very high	6.00	23.40	14.22	6.24	14.25
Molonglo River Catchment							
Weston Creek GPT	13	high	9.00	30.00	17.62	7.13	18.00
Coppins Crossing	12	high	7.00	24.00	16.18	6.45	15.50
Dams/Wetlands							
Coleman Ridge Dam	8	high	5.50	21.00	14.75	5.18	14.75

Water Temperature is important because it affects the rate of many biological and chemical processes in the waterway, and the amount of oxygen gas which can be dissolved in the water. Thus the well-being of aquatic life, from bacteria to fish, can be influenced by temperature.

An increase in temperature can have significant effects on aquatic ecosystems. Temperature changes can affect the dissolved oxygen content of water as warmer water holds less oxygen than cooler water, decreasing the amount of oxygen for the animals to breath. It can also change the rate of photosynthesis by aquatic plants, alter the metabolic rate of animals, and the rate of which they process food, change the rate of decay by bacteria, and make animal more vulnerable to toxic wastes, parasites, and diseases.

Potential Impacts

Every aquatic animal has a temperature range that is best for its health. For example, fish and most aquatic animals are cold blooded, and their metabolic rate and growth change with temperature. Some fish process food best in colder water, while others prefer warmer water. Spawning success depends on temperature. Each species has its own preferred temperature range for spawning. The survival of newly hatched embryos is dependant on the temperature being within a certain range. If the temperatures are above the maximum for a long time, the embryos will die. Macroinvertebrates that live on the bottom of a waterway are also sensitive to water temperature. Many species move along the stream to find the temperature range that suits them best.

ANZECC Guidelines 1992 (Guide for Interpretation Only)

Temperature

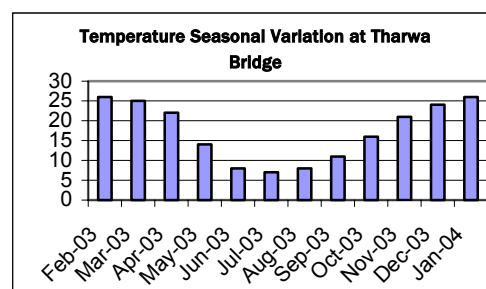
The maximum increase in the natural (baseline) temperature of any inland waters should not be by more than 2°C.

CAMPFIRE Findings

Stream vegetation cover was removed by the fire along many of the severely affected catchments in the ACT. Stream temperatures were expected to be greater with more direct sunlight reaching the water surface. This was accentuated by the above average daytime temperatures recorded in the first 12 months after the fires. Also, due to the drought, lower water levels may have also contributed to higher temperatures than usual.

Highest values were observed at Tuggeranong Creek and Weston Creek sites (coloured blue). Cooler temperatures were observed at higher elevation sites such as Upper Gibraltar Creek and Upper Tidbinbilla River sites (coloured green).

It is important to monitor water temperature to detect rapid fluctuations or thermal pollution. Several other valuable water quality parameters depend on water temperature as well.



Electrical Conductivity Summary ($\mu\text{S}/\text{cm}$)

	Obs	Fire severity	Min	Max	Mean	Std Dev	Median
Gudgenby Catchment							
Hospital Creek South	9	low	114	293	179.33	62.59	160
Hospital Creek Central	8	low	127	247	174.38	43.71	165
Hospital Creek North	9	low	113	325	188.11	80.42	152
Bogong Creek South	10	low	37	83	55.80	15.53	55
Bogong Creek Central	8	low	94	119	104.38	8.83	103
Bogong Creek North	9	low	46	130	67.33	28.01	54
Little Dry Creek	9	low	50	113	65.56	19.87	58
Middle Creek	2	low	50	76	63.00	18.38	63
Rendezvous Creek	0	low					
Naas River Catchment							
Glendale Crossing	9	Very high	32	90	63.67	24.21	65
Naas Crossing	8	low	48	120	75.38	26.83	65
Orroral River Campsite	0	Very high					
Murrumbidgee River							
Angle Crossing	6	high	69	143	108.67	26.66	112
Tharwa Bridge	15	low	60	180	103.07	33.89	106
Point Hut Crossing	12	high	50	325	127.25	77.64	107
Pine Island	10	high	50	190	107.50	45.29	105
Kambah Pool	14	high	60	213	117.07	40.42	107
Casuarina Sands	10	Very high	69	233	124.50	50.61	119
Uriarra Crossing	11	high	68	230	125.55	43.27	116
Tuggeranong Creek							
Tuggeranong Creek	9	moderate	140	440	200.00	93.21	184
Paddys River Catchment							
Upper Gibraltar Creek	4	moderate	20	30	22.50	5.00	20
Lower Gibraltar Creek	4	Very high	40	40	40.00	0.00	40
Upper Tidbinbilla River Site	12	Very high	12	156	94.42	44.78	90
Lower Tidbinbilla River Site	12	High	30	140	78.17	36.35	77
Flints Crossing	10	low	30	218	96.50	54.98	94
Murrays Corner	11	high	20	252	103.73	65.71	101
Cotter River Catchment							
Condor Creek	6	Very high	58	80	68.50	8.96	70
Molonglo River Catchment							
Weston Creek GPT	13	high	30	1171	648.00	321.65	720
Coppins Crossing	12	high	200	828	405.00	149.93	403
Dams/Wetlands							
Coolleman Ridge Dam	8	high	126	491	331.25	115.74	350

Electrical Conductivity can be measured in terms of the ability of water to pass an electrical current. This ability depends on the presence of salts and ions in the water. Organic compounds like oil, alcohol and sugar conduct electricity poorly and have a low conductivity when measured in water. Pure deionised water does not conduct at all since it contains no ions.

Potential Impacts

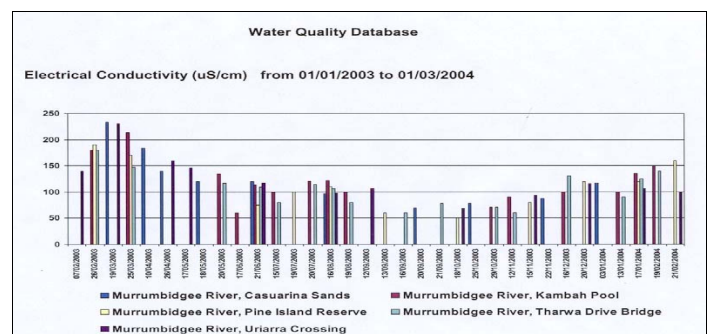
Aquatic plants and animals require natural salts contained in water for growth. Some species are adapted to a low range of salts while others need higher levels. However, if conductivity increases above the normal range of a particular waterway, the natural community will become stressed and, depending on their degree of sensitivity, the species will start to disappear.

CAMPFIRE Findings

The water mostly exhibited higher electrical conductivity values in summer and lower values in winter. Lower conductivity levels were also found in mountain streams such as Gibraltar Creek, Tidbinbilla River, Condor Creek and streams in the upper Gudgenby area. Water flowing from urban areas at Weston Creek, Coppins Crossing and Tuggeranong Creek (coloured blue) were found to be higher in electrical conductivity possibly due to urban pollution and concrete channels. Electrical conductivity is greatly influenced by the base flow or groundwater input. Lower flows associated with lower than average rainfall may contribute to increases in stream conductivity levels, however the data collected does not indicate significant increases in conductivity levels post bushfires.

Purpose of Water Use	Conductivity ($\mu\text{S}/\text{cm}$)
Drinking water for humans (desirable level)	< 800
Irrigation:	
excludes very low tolerance crops	650-1300
medium/high tolerance crops only	1300-3000
high tolerance crops only	3000-5000
generally too high	5000-8000
too saline for irrigation	>8000
Livestock:	
poultry	<3000
pigs	<5000
dry dairy cows, horses	<7000
beef cattle	<9000

General guide to tolerance levels for various uses of water (Australian Water Quality Guidelines for Fresh and marine Waters, ANZECC 1992).



	Excellent	Good	Fair	Poor	Degraded
Mountain	<30	<90	<150	<225	>225
Valley	<80	<240	<500	<750	>750
Plain	<100	<250	<500	<750	>750

ANZECC Guidelines 1992 (Guide for Interpretation Only)

pH Summary (pH Units)

	Obs	Fire severity	Min	Max	Mean	Std Dev	Median
Gudgenby Catchment							
Hospital Creek South	9	low	7.10	8.10	7.47	0.33	7.40
Hospital Creek Central	8	low	6.10	7.80	7.16	0.51	7.25
Hospital Creek North	9	low	6.60	7.90	7.12	0.48	7.00
Bogong Creek South	10	low	6.90	7.80	7.23	0.26	7.25
Bogong Creek Central	8	low	6.50	7.60	7.05	0.34	6.95
Bogong Creek North	9	low	6.00	7.20	6.66	0.33	6.70
Little Dry Creek	8	low	6.10	7.00	6.50	0.29	6.50
Middle Creek	2	low	7.70	8.20	7.95	0.35	7.95
Rendezvous Creek	0	low					
Naas River Catchment							
Glendale Crossing	9	Very high	6.40	7.60	7.06	0.42	7.10
Naas Crossing	8	low	6.60	7.30	6.98	0.25	6.95
Orroral River Campsite	0	Very high					
Murrumbidgee River							
Angle Crossing	7	high	7.80	8.40	8.09	0.20	8.10
Tharwa Bridge	17	low	6.80	8.40	7.71	0.51	7.80
Point Hut Crossing	13	high	6.90	8.20	7.55	0.42	7.60
Pine Island	11	high	6.90	8.20	7.45	0.39	7.40
Kambah Pool	16	high	6.80	8.50	7.67	0.50	7.70
Casuarina Sands	12	Very high	6.00	8.40	7.33	0.74	7.00
Uriarra Crossing	11	high	6.80	8.70	7.65	0.52	7.70
Tuggeranong Creek							
Tuggeranong Creek	7	moderate	7.50	9.00	8.44	0.58	8.70
Paddys River Catchment							
Upper Gibraltar Creek	2	moderate	7.00	8.00	7.50	0.71	7.50
Lower Gibraltar Creek	2	Very high	6.60	8.00	7.30	0.99	7.30
Upper Tidbinbilla River Site	12	Very high	6.10	8.10	7.06	0.54	6.90
Lower Tidbinbilla River Site	12	high	6.20	8.00	6.99	0.54	6.90
Flints Crossing	10	low	6.80	8.40	7.70	0.46	7.65
Murrays Corner	10	high	7.20	8.80	7.76	0.46	7.65
Cotter River Catchment							
Condor Creek	6	Very high	6.70	7.50	7.20	0.30	7.30
Molonglo River Catchment							
Weston Creek GPT	12	high	6.70	8.40	7.48	0.58	7.40
Coppins Crossing	12	high	6.60	7.50	7.14	0.31	7.15
Dams/Wetlands							
Coleman Ridge Dam	8	high	6.80	8.90	7.97	0.84	8.25

pH is a measure of the acidity of water and varies on a scale from 0 to 14 units. The acidity of water increases as the pH gets lower. pH is measured on a logarithmic scale. A drop in the pH of a water sample of 1.0 unit is equivalent to a 10 fold increase in acidity.

Dissolved minerals from rocks and soil contribute to pH, but the reaction of dissolved carbon dioxide with water is a major determinant. It is critical for the survival, growth, and reproduction of fish and macro invertebrates to have a stable pH range.

Potential Impacts

All animals and plants are adapted to a certain pH range but most prefer 6.5-8.0. An increase or decrease in pH outside the normal range of a water body will cause a loss of species depending on their sensitivity.

CAMPFIRE Finding

No significant changes in pH were observed during the monitoring period, and the ranges of recorded values were within a safe range for biological activity.

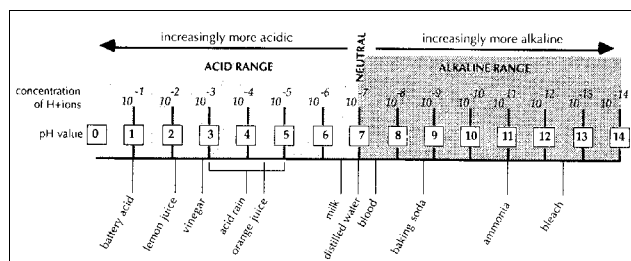
The pH measured for Tuggeranong Creek and Weston Creek (coloured blue) exhibited slightly higher values than the other rural locations, probably due to more basic water coming from urban waterways.

The Coleman Ridge Dam (coloured green) measured slightly more basic pH as well, which may have come from algal growth in the stagnant water.

Other factors such as land use or bedrock type may also influence pH readings. It is important to monitor the pH to detect notable changes or extreme values.

Use of water	Recommended pH Range
Protection of freshwater aquatic ecosystems.	6.5 - 9.0
Recreational waters.	5.0 - 9.0
Drinking water supply.	6.5 - 8.5
Agricultural water uses.	4.5 - 9.0

Recommended pH ranges (Australian Water Quality Guidelines for Fresh and marine Waters, ANZECC 1992).



pH scale and pH of selected liquids. (Behar, S. 1997)

Excellent	Good	Fair	Poor	Degraded
6.0 - 7.0	5.5 - 6 or <8.0	8.0 - 8.5	5.0 - 5.5 or 8.5 - 9.0	<5.0 or >9.0

ANZECC Guidelines 1992 (Guide for Interpretation Only)

Dissolved Oxygen Summary (mg/L)

	Obs	Min	Fire severity	Max	Mean	Std Dev	Median
Gudgenby Catchment							
Hospital Creek South	9	2.70	low	10.70	7.96	2.28	8.00
Hospital Creek Central	8	3.60	low	9.30	6.79	2.19	7.35
Hospital Creek North	9	3.00	low	10.70	7.28	3.26	9.30
Bogong Creek South	10	4.50	low	11.70	9.07	2.13	9.10
Bogong Creek Central	8	5.50	low	9.20	7.37	1.17	7.30
Bogong Creek North	9	4.70	low	9.10	6.84	1.67	6.70
Little Dry Creek	9	1.50	low	9.40	6.98	2.41	7.00
Middle Creek	3	8.00	low	10.00	9.03	1.00	9.10
Rendezvous Creek	0		low				
Naas River Catchment							
Glendale Crossing	9	6.50	Very high	10.00	7.97	1.29	7.70
Naas Crossing	8	4.90	low	11.00	7.99	2.02	7.90
Orroral River Campsite	0		Very high				
Murrumbidgee River							
Angle Crossing	7	7.00	high	10.00	9.27	1.12	10.00
Tharwa Bridge	15	4.10	low	11.00	8.08	1.83	7.80
Point Hut Crossing	13	6.00	high	10.00	7.95	1.11	8.20
Pine Island	12	4.80	high	9.20	6.76	1.44	6.50
Kambah Pool	15	4.00	high	12.80	8.22	2.39	7.90
Casuarina Sands	12	6.00	Very high	14.80	9.57	2.20	9.20
Uriarra Crossing	11	4.50	high	8.90	7.15	1.48	7.40
Tuggeranong Creek							
Tuggeranong Creek	9	7.00	moderate	10.60	8.79	1.16	8.90
Paddys River Catchment							
Upper Gibraltar Creek	4	7.80	moderate	9.80	8.80	0.88	8.80
Lower Gibraltar Creek	3	6.30	Very high	16.00	9.90	5.31	7.40
Upper Tidbinbilla River Site	12	3.90	Very high	10.00	6.77	1.75	6.50
Lower Tidbinbilla River Site	12	2.50	high	10.20	5.95	2.27	5.85
Flints Crossing	11	6.20	low	12.00	8.83	1.76	8.70
Murrays Corner	11	6.00	high	11.50	8.71	2.19	9.20
Cotter River Catchment							
Condor Creek	6	3.80	Very high	13.00	7.53	3.43	7.70
Molonglo River Catchment							
Weston Creek GPT	10	4.50	high	13.00	7.45	2.76	7.05
Coppins Crossing	12	2.70	high	8.60	5.87	2.28	6.35
Dams/Wetlands							
Coolleman Ridge Dam	8	1.90	high	10.60	7.64	3.06	8.60

Oxygen is necessary for all living things and for many of the chemical processes that take place in water. Most aquatic animals breathe the oxygen dissolved in water. Water with consistently high dissolved oxygen levels are capable of supporting many different kinds of aquatic animals.

Oxygen is both added and removed from water. Water gains oxygen from the atmosphere and from plants as a result of photosynthesis. In addition, the churning of running water helps add dissolved oxygen. Respiration (breathing) by aquatic animals, decomposition, and various chemical reactions, consume oxygen from the water body.

Potential Impacts

If more oxygen is consumed than is produced, DO levels decline and some sensitive animals may move away, weaken or die.

Scientific studies suggest that 4.5mg/L DO is the minimum amount that will support a large and diverse fish population. The levels in good fishing waters generally average about 9mg/L. When they drop below 3mg/L, even the hardy fish die.

CAMPFIRE Findings

Values of less than 4mg/L were recorded in the Hospital Creek, Little Dry Creek, Upper & Lower Tidbinbilla, Condor Creek Coppins Crossing and Coolleman Ridge Dam.

Fish kills in the Molonglo River were recorded in the first few months after the fires (see below).

Wetland Workshop PSB (Guide for Interpretation Only)

Dissolved Oxygen

Indicator of environmental stress on aquatic life. Fish kills would be expected at concentrations of dissolved oxygen below the guideline value of 4mg/L. DO is highly dependent on temperature, salinity, biological activity (microbial, primary production) and rate of transfer from the atmosphere.

Fish Kills After the Firestorm



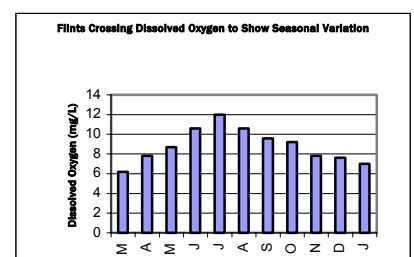
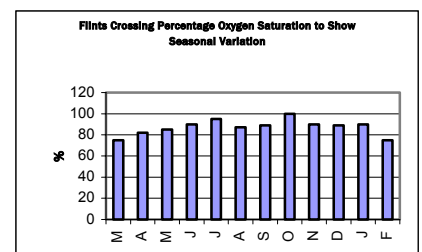
Fish kill at Coppins Crossing, Molonglo River

'Fish kills' refers to an unexpected short lived event, leading to the death of a large number of fish.

Fish kills often occur when dissolved oxygen concentrations drop to lethal levels during the decomposition of organic matter.

These dead fish were photographed in the Molonglo River at Coppins Crossing immediately following the fires. It is unclear what killed these fish, however this site recorded one of the lowest dissolved oxygen reading in the ACT with 2.7 Mg/L.

Fish kills should be reported immediately to Environment ACT to ensure early response. You should report them in terms of the numbers, species, weight and size distributions. Environment ACT Helpline: 6207 9777.



Percent Dissolved Oxygen Saturation Summary (%)

	Obs	Fire severity	Min	Max	Mean	Std Dev	Median
Gudgenby Catchment							
Hospital Creek South	9	low	30	85	72.44	17.59	77
Hospital Creek Central	8	low	35	77	64.13	14.57	69
Hospital Creek North	9	low	34	103	68.67	25.67	77
Bogong Creek South	10	low	54	104	82.20	12.95	83.5
Bogong Creek Central	8	low	55	76	65.63	6.57	65
Bogong Creek North	9	low	45	70	62.00	9.46	67
Little Dry Creek	9	low	16	80	65.00	19.59	68
Middle Creek	3	low	65	80	74.00	7.94	77
Rendezvous Creek	0	low					
Naas River Catchment							
Glendale Crossing	9	Very high	58	90	73.67	9.95	72
Naas Crossing	8	low	55	90	76.63	11.55	76
Orroral River Campsite	0	Very high					
Murrumbidgee River							
Angle Crossing	5	high	85	100	91.80	6.10	90
Tharwa Bridge	15	low	50	105	81.67	14.87	84
Point Hut Crossing	13	high	67	105	84.08	10.52	83
Pine Island	12	high	52	98	71.75	13.21	70
Kambah Pool	15	high	43	112	84.93	19.12	85
Casuarina Sands	12	Very high	75	115	93.83	10.54	94
Uriarra Crossing	11	high	56	100	78.82	14.83	78
Tuggeranong Creek							
Tuggeranong Creek	9	moderate	70	100	87.11	10.41	90
Paddys River Catchment							
Upper Gibraltar Creek	4	moderate	82	92	85.75	4.50	84.5
Lower Gibraltar Creek	2	Very high	79	140	109.50	43.13	109.5
Upper Tidbinbilla River Site	12	Very high	33	100	67.50	17.23	68.5
Lower Tidbinbilla River Site	12	high	22	92	60.00	20.80	62.5
Flints Crossing	11	low	75	100	88.36	6.48	89
Murrays Corner	11	high	71	116	87.45	13.20	87
Cotter River Catchment							
Condor Creek	6	Very high	48	115	73.50	24.78	73.5
Molonglo River Catchment							
Weston Creek GPT	11	high	43	110	76.64	23.42	70
Coppins Crossing	12	high	20	99	59.75	22.34	63.5
Dams/Wetlands							
Coleman Ridge Dam	8	high	29	112	75.13	24.79	77.5

Percent dissolved oxygen saturation is the amount of oxygen dissolved in a litre of water and is measured as mg/L. Percent saturation is the amount of dissolved oxygen in water relative to the total amount the water can hold at a given temperature. Water is fully saturated with oxygen when it cannot hold any more oxygen at a given temperature. At this point, it is 100% saturated. As water temperature rises, oxygen diffuses out of the water into the atmosphere.

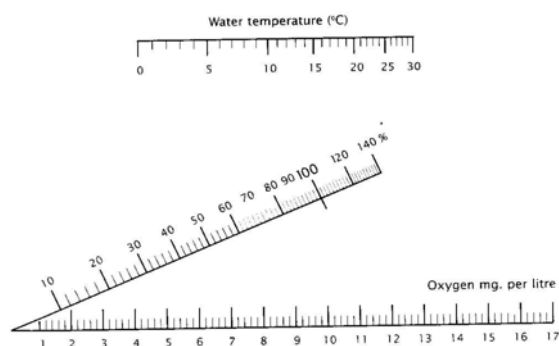
Supersaturation (>100% saturation) may temporarily occur when more oxygen molecules have dissolved in the water than it is capable of holding at the current temperature. For example, supersaturated solutions of oxygen frequently occur in turbulent streams. The turbulence forcibly mixes oxygen from the air into the water. Supersaturation can also occur on a sunny day when a large number of plants produce oxygen, through photosynthesis, at a faster rate than diffuses back into the atmosphere.

CAMPFIRE Findings

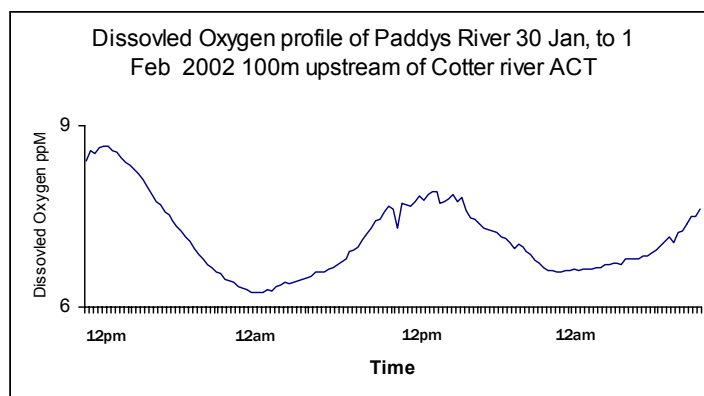
Dissolved Oxygen of below 30% were recorded at Little Dry Creek, Lower Tidbinbilla, Coppins Crossing and Coleman Ridge Dam.

Streamline Guidelines (Guide for Interpretation Only)

Dissolved Oxygen
Flowing Streams:
 Values should exceed 80% saturation during the day and 70% at night. Lower values may occur after storms.
Lakes or large waterholes in slow flowing streams:
 Surface values would normally be expected to exceed 70% saturation. In deeper water, values may fall below 10% saturation.



Percentage Saturation Dissolved Oxygen Nomogram (Redrawn from West S., 1998.) This graph is used to convert dissolved oxygen from mg/L to percent saturation.



Graph courtesy of the Cooperative Research Centre for Freshwater Ecology, Richard Norris 2002. The irregular drop and curve at 12pm was due to rainfall.

Summary **CAMPFIRE** Observations

1. How have streams been affected by fire in their catchment?

- Catchments responded very quickly to rainfall, releasing large amounts of sediments, ash and organic debris to waterways.
- Many streams in fire affected areas had significant sediment deposits.
- Highest turbidity readings were recorded within the first few hours of a severe rain event, however readings stabilised quickly, usually within 24 hours after a rain event.
- Recovery of riparian vegetation differed from site to site depending on fire severity, land use and geology.
- Monthly phosphorus readings fluctuated during the year. Fifty percent of CAMPFIRE sites in November recorded as poor or degraded. *(ANZECC guidelines 1992)

2. How long will it take for streams to recover?

- Increased sedimentation and nutrient levels are expected to impact many streams for several years.
- Recovery of catchment vegetation is determined by fire severity, land use, weather, geology and subsequent human impacts. Continued monitoring will identify stream recovery rates.

3. What are the implications for stream ecology?

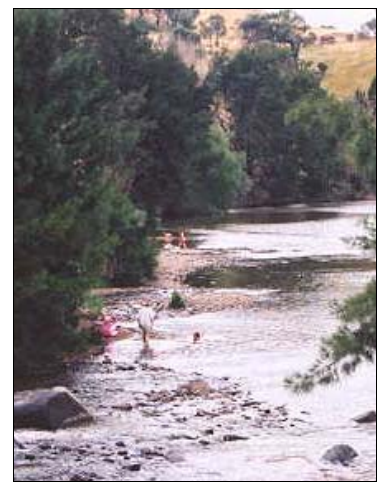
- Increased sedimentation and nutrient levels will pose significant and on-going threats to aquatic biodiversity;
- Fish species are at particular risk from water quality and sedimentation impacts; and
- Impacted riparian habitats and water quality may affect terrestrial communities including birds, reptiles, mammals and invertebrates.

4. What are the implications for human uses?

- Increased water temperatures and nutrient levels can trigger algal growth. Community algal monitoring to continue.
- Recreational uses have been affected. Communities need to take care to ensure minimal disturbance in recovery areas, and be aware of potential hazards and threats when taking part in activities in fire affected areas.

5. What are the implications for stream rehabilitation programs?

- A medium to long term rehabilitation phase is recommended to address issues of further soil loss and erosion control, pest plants and animals, protection of high priority flora and fauna species and communities particularly for rare and threatened species.
- All works should include a research assessment and monitoring program that investigates improvement in ecological values and knowledge of bushfire affects on aquatic ecology.
- It will take several years for some vegetation and ecosystems to recover. Recovery works can help minimise soil erosion.
- Scientific and community organisations can both get involved in shared recovery programs.



Spring 2003 Upper Murrumbidgee Macro-invertebrate Snapshot

Tolerance Ranking	Common Name	Paddy's River Flints Crossing	Paddy's River Murray's Corner	CIT Detention Pond 1	Queanbeyan R Glebe Park	Dunlop Pond	Jerraberra Ck Plialligo	Hospital Creek North Edge	Hospital Creek North Riffle	Bogong Creek North Edge	Tidbinbilla Upper Site Riffle (Oct)	Tidbinbilla Upper Site Edge (Oct)	Tidbinbilla Lower Site Riffle (Nov)	Tidbinbilla Upper Site Edge (Nov)	Murrumbidgee R Point Hut	Murrumbidgee River Pine	Molongio River Coppins Xing (riffle)	Molongio River Coppins Xing (edge)	Stoney Ck Carwoola	Jerraberra Ck Royalla	Gibraltar Creek Lower Site	Gibraltar Creek Upper Site	Gudgenby River Naas Xing	Gudgenby River Naas Xing Edge	Gudgenby River Glendale Xing (riffle)	Gudgenby River Glendale Xing (edge)	David Street Wetland	Girralang Pond	Yarralumia Ck Curtin 2	Yarralumia Creek Curtin	Mt Clear Fire Affected	Mt Clear fire unaffected Site	Ginninderra Creek Barton Highway					
Very sensitive to most pollutants	Stonefly nymph	•	•					●		●	●	●	•	•					•		•	•	•		•	●						•	•					
	Mayfly nymph	●	●	●				•	•	●	●	●	•	•	•	•	●	●	●	●	●	●	•	•	●	●	•			•		•	•	●	●			
	Alder fly larva	●	•						•				•		•	•						•	•												•			
	Caddis fly larva		•		•	•	•				•	•	•	•	•			•	•	●						•		•								•		
Sensitive to most pollutants	Horsehair worm					•										•																			•			
	Water mite				•	•	•						•	•				•	•	•							•	•					•	•	•			
Moderately tolerant of most pollutants	Beetle or beetle larva	•	●	•	●		●	•	•	•	•	•	●	•	•	●	•	•	•	•	•							•						•	•			
	Yabby or shrimp		•		●	•	●								●	●	•	•			●						•								•			
	Dragonfly or damselfly nymph	•	•	●	●	•	•	•	•	•								•	•	•	•													•	•	•		
	Fly larva or midge		•	•	●	•	•	●	●	•	•	•	●		●	●	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
	Mussel or clam				•	•									•																							
	Nematode	•	●						•	•	•			•																								
	Side swimmer																																					
Very tolerant of most pollutants	Flatworm			•	●			•					•						•	•															•	•		
	Freshwater Slater	•		•	•																•															•	•	
	Moth caterpillar													•																						•	•	
	segmented worm	•		•	●	•	•				•	•	•						•							•		•	•	•	•	•	•	•	•	•	•	
	True bug or true bug nymph		•	●	●	•	•				•	•							•	•	•														•	•		
	Leech				•		•																	•	•		•	•	•	•	•	•	•	•	•	•	•	
	Snail	•	•	●	●	•	•	•	•	•	•		•	•		•	•	•	•	•	•						•	•	•	•	•	•	•	•	•	•	•	•

Results adapted from SIGNAL 2 A scoring system for macro-invertebrates (Water Bugs) in Australian Rivers, Bruce Chessman Version 2 November 2001

Weight table (number of species found)

● >20 ● 7-20 ● 1-6



Photographs taken from the John Hawking Macroinvertebrate Training Course, sponsored by the Cooperative Research Centre for Freshwater Ecology. Special Thanks to John Hawking, Ruth O'Connor and the CRCFE.