

Chapter 3: CAMPFIRE findings

3.1 Turbidity and sediment

	Obs	Fire severity	Min	Max	Mean	Std dev	Median
Gudgenby Catchment							
Hospital Creek South	17	low	<10	22	9.76	3.15	9
Hospital Creek Central	11	low	<10	9	9	0	9.00
Hospital Creek North	14	low	<10	70	14.3	16.2	9
Bogong Creek South	16	low	<10	9	9	0.00	9.00
Bogong Creek Central	11	low	<10	10	9.09	0.30	9.00
Bogong Creek North	17	low	<10	9	9.00	0.00	9.00
Little Dry Creek	11	low	<10	9	9	0	9.00
Middle Creek	10	low	<10	21	12.4	4.99	10
Rendezvous Creek	4	low	<9	80	37	34.6	29.5
Naas River Catchment							
Glendale Crossing	6	very high	<10	10	9.2	0.44	9
Naas Crossing	8	low	<10	50	21.1	15.8	13
Orroral River Campsite	24	very high	<10	36	12.5	7.27	9
Murrumbidgee River							
Angle Crossing	7	high	<17	10	22	13.09	12
Tharwa Bridge	31	low	<10	43	17.8	7.78	17
Point Hut Crossing	14	high	<10	55	21.4	13.7	14.5
Pine Island	26	high	<10	80	21.3	15.5	17
Kambah Pool	31	high	<10	200	26	34.1	20
Casuarina Sands	21	very high	<10	410	43.8	85.3	21
Uriarra Crossing	23	high	<10	60	27.3	14.1	30
Tuggeranong Creek Catchment							
Tuggeranong Creek	9	moderate	<10	30	15.3	8.06	12
Paddys River Catchment							
Upper Gibraltar Creek	14	moderate	<10	15	9.43	1.6	9.00
Lower Gibraltar Creek	13	very high	<10	400	39.2	108	9
Upper Tidbinbilla River Site	23	very high	<10	125	17.2	24.9	9.00
Lower Tidbinbilla River Site	23	high	<10	35	11.6	6.87	9.00
Flints Crossing	25	low	<10	330	34	65.9	12
Murrays Corner	25	very high	<10	250	31.5	48.6	20
Cotter River Catchment							
Condor Creek	21	very high	<10	22	10.1	3.18	9.00
Molonglo River Catchment							
Weston Creek GPT	12	high	<10	50	16.8	9.8	15
Coppins Crossing	25	high	<10	15	9.6	1.66	9
Dams/Wetlands							
Cooleman Ridge Dam	17	high	<10	200	89.9	54.3	80

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 e.g. 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.
- Reduced light passing through the water lowers plant photosynthesis and 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.

3.2 Sedimentation after a bushfire—landscape triggers

CAMPFIRE volunteers have detected a distinctive set of triggers in Canberra’s fire affected landscapes that, when coupled together, can lead to a significant amount of sediment ending up in our waterways. Landscape and bushfire characteristics including fire severity, topography, post fire rainfall patterns and geology can, when coupled together, conspire to create ideal conditions that move significant amounts of exposed soil and depositing it in streams during heavy rain events.

Excess levels of sediment deposited into streams and rivers after bushfires can severely impact aquatic wildlife and water quality, cause fish kills, destroy in-stream habitats, change flora composition, and change flooding characteristics.

The following pages set out to explore these triggers and investigate what has happened in the two years after the 2003 ACT bushfires.



3.3 Fire severity and vegetation recovery

Fire severity refers to a qualitative measure of the effects of fire on a natural environment. A range of different factors including energy release, fire duration, fuel loading, vegetation type and topography can influence the severity of a bushfire.

The 2003 Canberra bushfires resulted in significant areas of the ACT being impacted by high intensity fires (Fig. 4). This type of bushfire removes vegetation cover, exposes soil and reduces evapotranspiration. High intensity fires influence the time it takes for vegetation to recover, causes soil to become water repellent and fragile, and can even sterilise the soil influencing the rate and type of regeneration of vegetation.

Two years after the Canberra bushfires, much of the area affected by high intensity fires continues its slow recovery. Many volunteers have documented an increase and sometimes domination of weed species, particularly grasses, which almost certainly arrived via an airborne process.

Forestry land use areas were significantly impacted by the bushfires. A major clearing effort of burnt pine forests was undertaken in the first year after the fires. This clearing continued into the second year and the establishment of contour banking has reduced the susceptibility of landscape erosion in these areas.

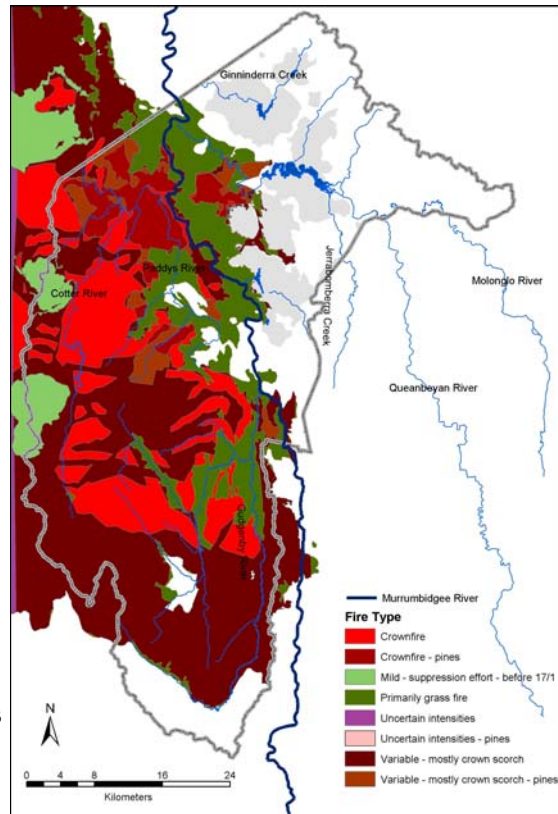


Figure 4: Fire severity from the 2003 ACT bushfires

3.4 Post fire rainfall and storm events

Results from the first year of CAMPFIRE reporting indicated that a substantial amount of ash, sediments and nutrients were ending up in waterways following rain events.

In Paddys River, a rainfall event in August 2003 (Fig. 5) produced a 2,000 mega litre (Mg/L) per day flow which resulted in a significant amount of sediment being deposited at several CAMPFIRE sites. However, a check of Paddys River flow data since 1957 (Fig. 6) reveals much larger flow events occurred previous to the fires. The biggest event occurred in 1975 when 10,000 Mg/L (4½ times the August 2003 event) flowed down the river in one day.

A similar flow event could occur at any time and the impact of this in our fire affected catchment would be considerable. The energy created by a 1975 type event would eclipse the 2003 results. Sediment already deposited in stream beds and further mobilisation of soil from surrounding hills would move along our waterways as a 'sediment slug'. This slug would eventually find its way into the Murrumbidgee River threatening stream health.

Although there is an ever present threat of a major 1975 storm event occurring, the magnitude of its impact decreases as the vegetation cover regenerates. In the ACT, vegetation recovery rates remain inconsistent in many catchments with many fire-affected landscapes still susceptible to erosion from storm events.

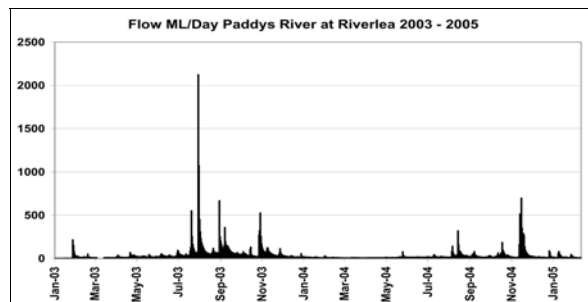


Figure 5: Flow data from Paddys River 2003–2005

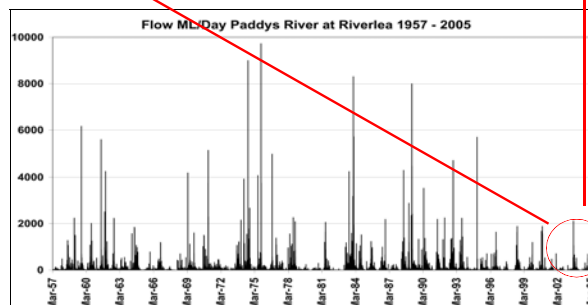


Figure 6: Flow data from Paddys River 1957–2005

3.5 Hill slope analysis

Slope gradients can significantly influence the erodability of an area after a bushfire. This is particularly apparent in areas of high intensity fire where vegetation, including root structures, are destroyed. In these areas stormwater energy can increase by many orders of magnitude on steep hill slopes influencing the amount of sediment mobilised during a rain event.

By undertaking a hill slope analysis and overlaying fire severity and land use maps, environment and land managers can identify areas in the landscapes vulnerable to erosion and design strategies to reduce the threat.



3.6 Hill slope analysis of Tidbinbilla valley



1. Tidbinbilla Nature Reserve Upper Site



2. Tidbinbilla Nature Reserve Lower Site



3. Gibraltar Creek Upper Site



4. Gibraltar Creek Lower Site

A hill slope analysis of Tidbinbilla Valley has identified sections of streams that are vulnerable to sediment build up. These sections of stream (Gibraltar Creek Lower and Tidbinbilla Upper sites) are surrounded by steep terrain in areas of high fire severity. Other sections of stream (Gibraltar Creek Upper and Tidbinbilla Lower sites) are less prone to sediment accumulation due to the flatter topography, lower fire severity and larger riparian buffering zones.

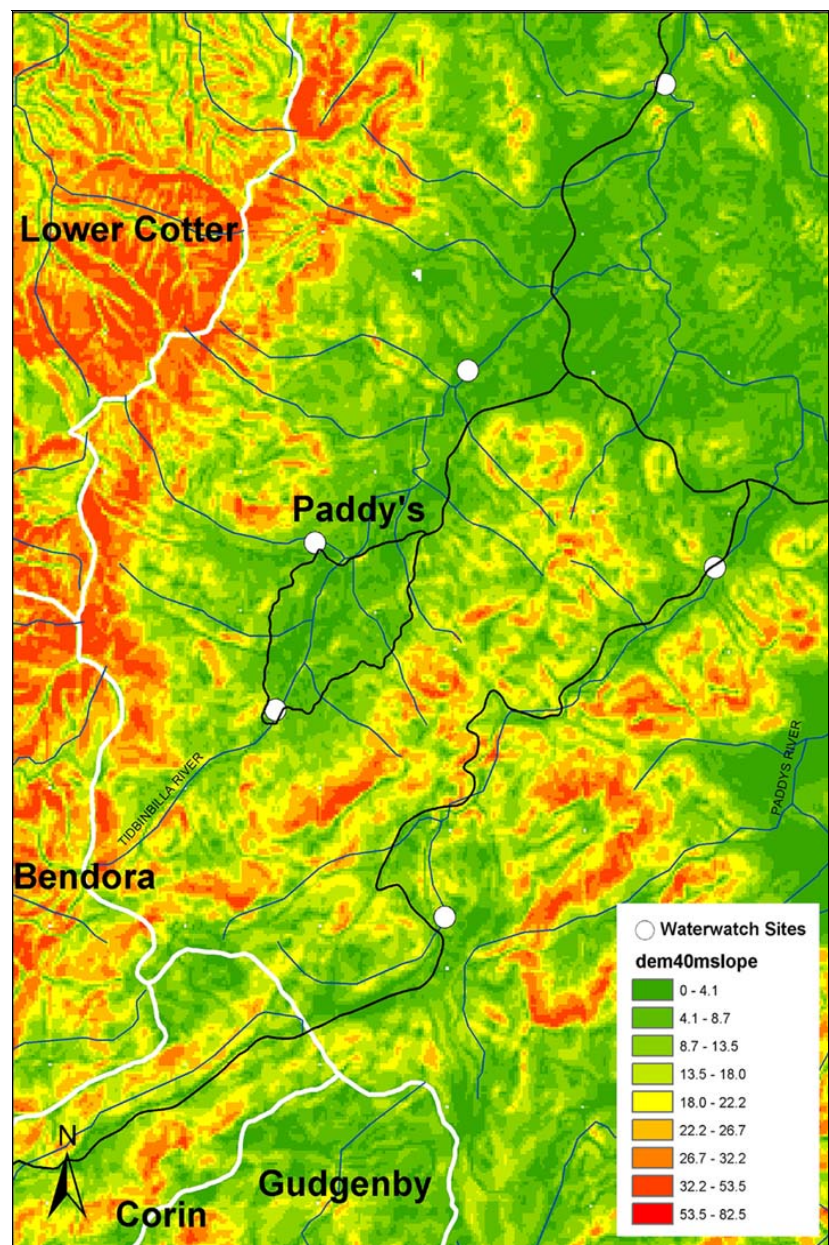


Figure 10: Hill slope analysis of Tidbinbilla valley.

3.7 Turbidity and flow

Energy created by high stream flows can have a large influence on turbidity by mobilising already deposited in-stream sediment. Sediment builds up after bushfires when storm water surges off burnt catchments picking up large amounts of exposed soil and depositing it into streams and rivers. The larger, denser particles such as sand and gravel eventually settle smothering vital in-stream habitat. This sediment will remain inactive until stream flows are powerful enough to mobilise the sediment again. In some instances a 'channel maintenance flow' can assist stream health by flushing out fine sand and silt that accumulates in streams. After severe bushfires, however, enormous amounts of sediment can be mobilised during a severe flow event and impair the health of downstream waterways, lakes and floodplains.

Increased flows in the Murrumbidgee River may not necessarily be the result of local rainfall. Other causes of high flows include snow melt and environmental dam releases.

Effective management of sediment requires an understanding of the sediment dynamics including where the sediment has originated. Remedial actions will differ depending on sediment origin.

ACT Hill slope analysis

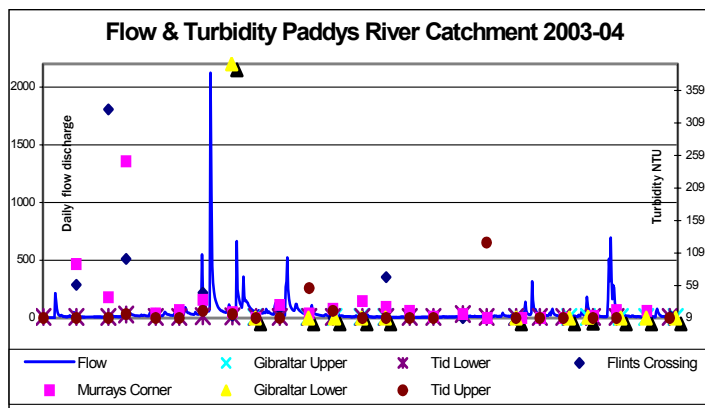
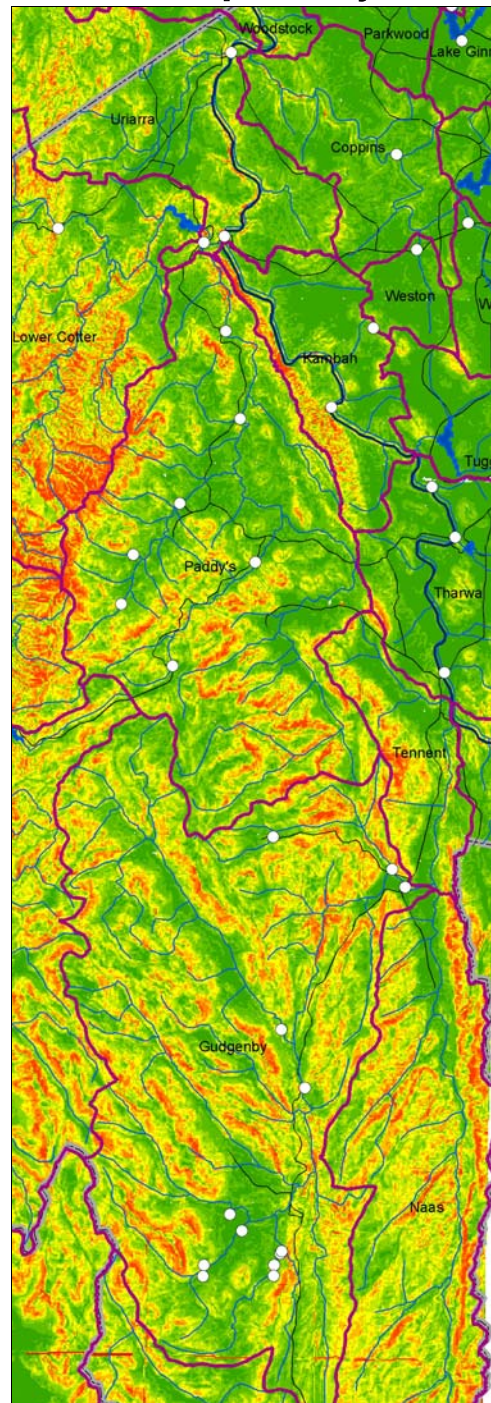
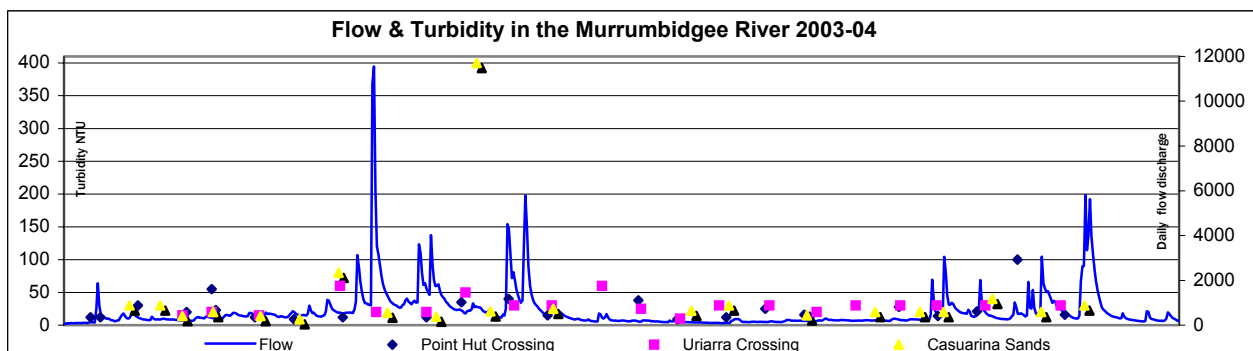


Figure 7 (above): Dry conditions experienced since the 2003 bushfires have resulted in sustained period of low flows in the Paddys River catchment. A rain event in August 2003 resulted in a sharp increases in turbidity levels.

Figure 8 (below): The seasonal flow variations in the Murrumbidgee River at Lobbs Hole can be attributed to environmental flow releases from the Cotter and Tantangara dams. Riffle maintenance and channel maintenance flows are designed to mimic the natural condition of a river and are important for the maintenance of aquatic ecosystems.



3.8 Phosphorus Mg/I P

	Obs	Fire severity	Min	Max	Mean	Std dev	Median
Gudgenby Catchment							
Hospital Creek South	17	low	0	0.26	0.087	0.07	0.05
Hospital Creek Central	11	low	0	0.1	0.033	0.04	0.02
Hospital Creek North	14	low	0	0.15	0.057	0.04	0.065
Bogong Creek South	17	low	0	0.02	0.007	0.01	0.005
Bogong Creek Central	11	low	0	0.05	0.01	0.015	0.01
Bogong Creek North	17	low	0	0.04	0.0135	0.015	0.01
Little Dry Creek	10	low	0	0.02	0.003	0.007	0
Middle Creek	3	low	-0	0	0	0	0
Rendezvous Creek	0	low	-*	-	-	-	-
Naas River Catchment							
Glendale Crossing	8	Very high	0	0.04	0.01	0.01	0.01
Naas Crossing	8	low	0	0.04	0.02	0.01	0.02
Orroral River Campsite	0	Very high					
Murrumbidgee River							
Angle Crossing	7	high	0	0.03	0.01	0.01	0
Tharwa Bridge	27	low	0	1.11	0.086	0.211	0.03
Point Hut Crossing	11	high	0	0.13	0.033	0.04	0.01
Pine Island	24	high	0.01	0.250	0.038	0.051	0.03
Kambah Pool	31	high	0.00	0.2	0.035	0.043	0.02
Casuarina Sands	18	Very high	0	0.8	0.186	0.188	0.1
Uriarra Crossing	21	high	0.00	0.4	0.053	0.091	0.02
Tuggeranong Creek							
Tuggeranong Creek	9	moderate	0	0.02	0.003	0.06	0.01
Paddys River Catchment							
Upper Gibraltar Creek	14	moderate	0	0.03	0.012	0.012	0.01
Lower Gibraltar Creek	12	Very high	0	0.05	0.021	0.015	0.02
Upper Tidbinbilla River Site	22	Very high	0.03	0.21	0.076	0.043	0.07
Lower Tidbinbilla River Site	22	High	0	0.07	0.03	0.025	0.004
Flints Crossing	24	low	0.00	0.35	0.051	0.09	0.02
Murrays Corner	25	Very high	0.00	0.34	0.055	0.091	0.01
Cotter River Catchment							
Condor Creek	21	Very high	0	1	0.226	0.266	0.125
Molonglo River Catchment							
Weston Creek GPT	25	high	0	0.93	0.12	0.19	0.07
Coppins Crossing	24	high	0	0.11	0.034	0.029	0.03
Dams/Wetlands							
Coleman Ridge Dam	17	high	0.02	1.6	0.464	0.416	0.3

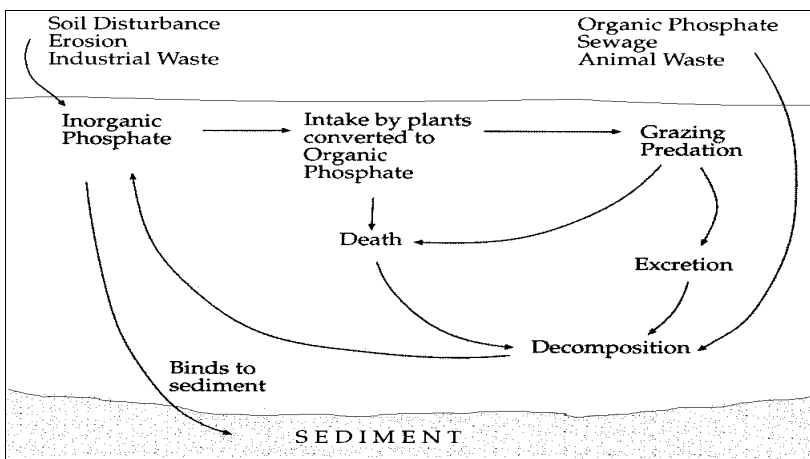
Phosphorus is a nutrient that occurs naturally at low concentrations in water and is essential for plants and animals that make up the aquatic food web.

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.

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.



Excellent	Good	Fair	Poor	Degraded
<0.08	<0.05	<0.03	<0.10	>0.10

ANZECC Guidelines 1992 (Guide for interpretation only)

Figure 9: The phosphorus cycle. Phosphorus changes form as it cycles through the aquatic environment. (Adapted from Behar, S. 1997) Waterwatch Tasmania Technical Manual.

3.9 Phosphorus in the Murrumbidgee and Paddys rivers

Phosphorus in streams is either dissolved in water or attached to sediment. CAMPFIRE volunteers test for **inorganic** or **ortho phosphorus** which refers to the configuration of covalent bonds between phosphorus and oxygen. This type of ortho phosphorus is dissolved in the water column, and is in the form required for plant growth.

After the bushfires, increased amounts of nutrient rich soil, ash and organic material were washed into our waterways. This resulted in increased phosphorus levels in the first few months after the fires (Fig. 10). This organic rich sediment can contain significant amounts of phosphorus that can become attached or bound to sediment. This phosphorus bound sediment can settle at the bottom of the stream acting as a nutrient storage sink. During warmer weather, increased biological activity can release this sediment bound phosphorus into the water column as happened in Paddys River (Fig. 10).

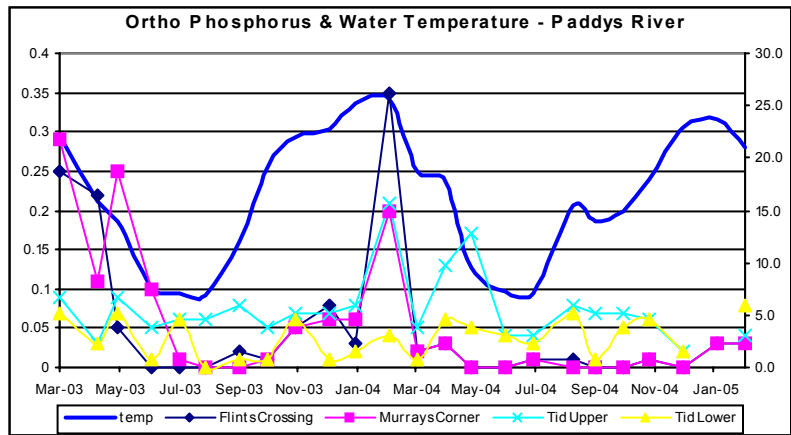


Figure 10: High phosphorus levels immediately after the fires and during the 2004 summer period. Higher temperatures and lower flows in summer months can cause significant increases in phosphorus levels as happened in Paddys River.

In larger rivers like the Murrumbidgee, significant amounts of nutrient rich fine sediment can be deposited on existing sand bars (Fig. 11). Low water levels and high water temperatures in summer can cause this nutrient rich organic sediment to dry out along the stream edge. This drying process can cause a sudden release of phosphorus in the waterway.

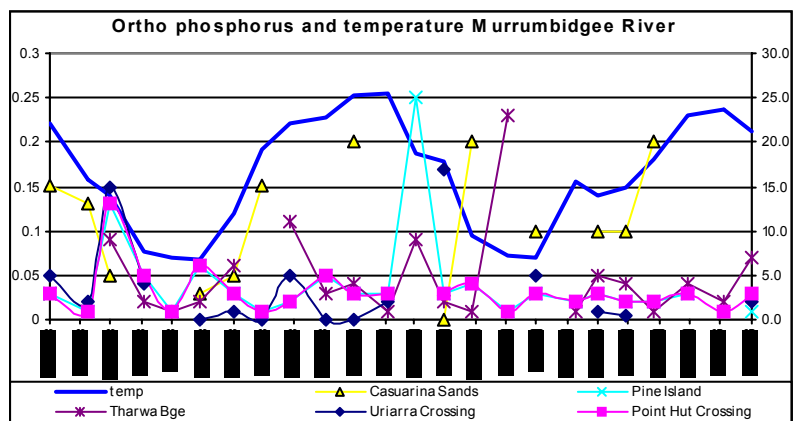


Figure 11: In larger rivers such as the Murrumbidgee, nutrient rich sediment from the bushfires settled on the shoulders of the River. This sediments goes through a cycle of drying and rewetting which when combines with seasonal temperature variations release significant amounts of phosphorus into the waterway.

Lower phosphorous values were recorded in the Murrumbidgee River during the cooler months when lower temperatures and increased flows diluted the phosphorous present. By spring 2005, increased drought breaking rains and associated higher flows made conditions less favorable for significant phosphorus pulses.

3.10 Dynamics of the Murrumbidgee River at Tharwa after the bushfires



February 2003— after years of drought the Murrumbidgee River stopped flowing at Tharwa.



Soon after the bushfires highly turbid water washed from fire affected catchments.



After a wetting/ drying process, this sediment can release its nutrients into the water column.



As the water level recedes nutrient rich sticky black scum was deposited on the rivers edge.

3.11 Black water in Gudgenby

The Gudgenby Bush Regenerators have been monitoring the water quality of Hospital, Bogong and Little Dry creeks since April 2003. This stream monitoring is incorporated into replanting of native vegetation on the site of the old Boboyan pine plantation, which had its last pine harvested in April 2005.

Hospital Creek water quality results reveal an alarming increase in phosphorus levels mostly during the summer months. An investigation was undertaken by a team of intrepid hikers who trekked 10 km along the stream in search of the nutrient source.

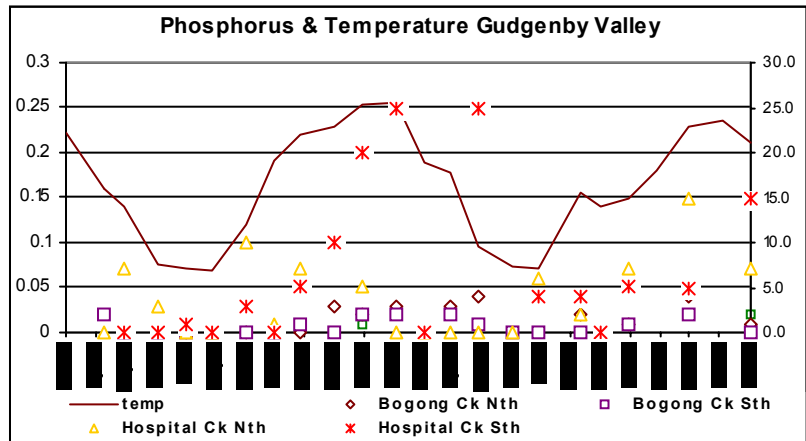


Figure 12: Unusually high phosphorus readings in Hospital Creek. These increases in phosphorus was usually during the summer months.



The expedition found a chain of ponds along the ephemeral stream. Some of these ponds were distinctively black in colour, were high in phosphorus and turbidity and low in dissolved oxygen. They also had an intense sulphur odour.

These symptoms depict a classic anaerobic bacteriological pond processes or what has been called 'black water'. One possible explanation of these 'black water' ponds is the concentration of dissolved organic matter that may be influencing these pools.

The low fire intensity may have resulted in large amounts of unburnt or scorched leaf litter being delivered to stream ponds as organic sediment. This layer of organic sediment can settle on the bottom of the pond and as there is no flow the still water doesn't transfer oxygen to the sediment. Bacteria decompose the sediment anaerobically with sulphur because no oxygen is available. The by-products of this are sulphide (which produces a rotten egg smell) and carbon dioxide (a weak acid). The acid then facilitates the release of phosphorus from the sediments. These ponds are called bacteriological dominated ponds (left).

Analysis done by Allie Mokany, a PhD student from the Australian National University showed a phosphate reading of 3.91 mg/l in one of these ponds.

Phytoplankton dominated ponds (far left) were also discovered in Hospital Creek, which were bright green in colour and low in phosphorus and turbidity.

Left—Images from the Hospital Creek Waterwatch expedition. A team of intrepid hikers undertook monitoring along Hospital Creek to find the source of unexplained high phosphorus. The group found an unusual chain of ponds which had there own unique characteristics.

3.12 Water temperature

	Obs	Fire severity	Min	Max	Mean	Std dev	Median
Gudgenby Catchment							
Hospital Creek South	17	low	4.5	19.1	11.2	5.07	10.1
Hospital Creek Central	11	low	6.1	25.4	13.2	6.18	13.1
Hospital Creek North	18	low	6.3	23.5	14.3	5.63	14.1
Bogong Creek South	18	low	3.9	22.1	10.8	5.8	9.75
Bogong Creek Central	11	low	4.3	16.5	8.75	3.87	8.1
Bogong Creek North	28	low	4	21.7	11.1	4.88	10
Little Dry Creek	13	low	7	23.5	13.9	4.89	13
Middle Creek	9	low	6	17	9.44	3.57	9
Rendezvous Creek	6	low	9	14.5	12.7	2.04	13.3
Naas River Catchment							
Glendale Crossing	15	Very high	5	24	12.8	5.71	13.3
Naas Crossing	14	low	6	25	15.2	5.63	15.5
Orroral River Campsite	16	Very high	5	27	15.4	5.44	15
Murrumbidgee River							
Angle Crossing	7	high	8	25	15.2	6.57	14
Tharwa Bridge	31	low	2.00	26.00	15.7	7.01	15.4
Point Hut Crossing	26	high	6.7	26	17.2	6.09	18.1
Pine Island	26	high	7.50	26.1	17.3	6.11	18.1
Kambah Pool	28	high	8.5	29.2	18.3	6.6	19.4
Casuarina Sands	23	Very high	6	26	15.7	5.83	16
Uriarra Crossing	11	high	8.5	30	18.87	6.91	19
Tuggeranong Creek							
Tuggeranong Creek	9	moderate	10.3	31.5	16.43	6.81	15
Paddys River Catchment							
Upper Gibraltar Creek	14	moderate	4	17	12.7	4.08	14.5
Lower Gibraltar Creek	14	Very high	9	27	19.2	5.48	21
Upper Tidbinbilla River Site	25	Very high	5.00	21	13	4.9	13.5
Lower Tidbinbilla River Site	24	high	4.8	25	14.6	6.04	16.3
Flints Crossing	25	low	5.2	26	16.6	5.99	17.8
Murrays Corner	22	Very high	6.8	25.6	15.7	6.25	15.7
Cotter River Catchment							
Condor Creek	20	Very high	6	25.7	15.7	6.19	15.6
Molonglo River Catchment							
Weston Creek GPT	25	high	5.5	27	17.6	6.76	20
Coppins Crossing	14	high	7	23.5	16.3	5.91	16.5
Dams/Wetlands							
Coleman Ridge Dam	15	high	5.5	26	16.6	5.13	17

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 affects 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 animals more vulnerable to toxic wastes, parasites, and diseases.

Potential Impacts

Every aquatic animal has a temperature range that is best for its health.

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.

Waterwatch monitoring undertaken by the Friends of Tidbinbilla since 1994 has established a link between the bushfires and changes in water temperature. In fire-affected catchments, vegetation cover was removed and streams were more vulnerable to changes in climatic weather conditions. In summer months more direct sunlight reached the stream and resulted in higher water temperatures. Conversely in winter the vegetation cover that acted to shelter streams from winter frosts was removed and as a result water temperatures were much lower than normal.

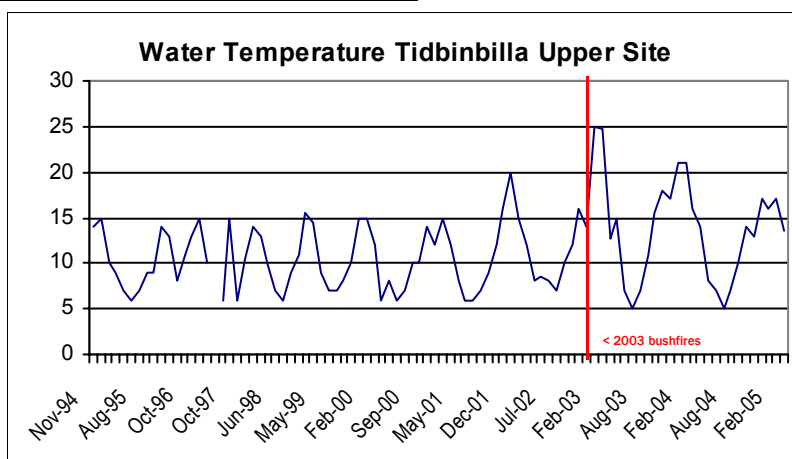


Figure 13: Tracking water temperature before and after the 2003 bushfires.

3.13 Electrical conductivity summary ($\mu\text{S}/\text{cm}$)

	Obs	Fire severity	Min	Max	Mean	Std dev	Median
Gudgenby Catchment							
Hospital Creek South	17	low	84	293	178	52.5	172
Hospital Creek Central	11	low	86	247	164	48.2	163
Hospital Creek North	14	low	101	376	213	104	168
Bogong Creek South	16	low	35	83	58	15.2	58.5
Bogong Creek Central	11	low	78	119	99.8	11.9	100
Bogong Creek North	17	low	40.2	76.4	76.4	40.2	60
Little Dry Creek	11	low	46	113	63.5	18.7	58
Middle Creek	2	low	-	-	-	-	-
Rendezvous Creek	0	low	-	-	-	-	-
Naas River Catchment							
Glendale Crossing	9	Very high	32	99	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	28	low	40	180	95.9	34.3	80
Point Hut Crossing	12	high	50	325	127	77.6	107
Pine Island	23	high	40	220	105	51.5	90
Kambah Pool	29	high	50	213	113	38.1	100
Casuarina Sands	18	Very high	69	233	114	41.9	102
Uriarra Crossing	23	high	68	257	120	46.1	105
Tuggeranong Creek							
Tuggeranong Creek	9	moderate	140	440	200	93.21	184
Paddys River Catchment							
Upper Gibraltar Creek	13	moderate	20	30	23.8	5.06	20
Lower Gibraltar Creek	14	Very high	30	50	14.4	5.35	40
Upper Tidbinbilla River Site	24	Very high	12	156	89.4	33.1	81.5
Lower Tidbinbilla River Site	24	High	30	140	73.75	26.9	70.5
Flints Crossing	24	low	46	218	94.9	33.6	92
Murrays Corner	25	high	31	252	101	42.2	98
Cotter River Catchment							
Condor Creek	20	Very high	58	94	73.5	9.83	74.5
Molonglo River Catchment							
Weston Creek GPT	27	high	30	1171	555	291	608
Coppins Crossing	25	high	200	828	389	110	386
Dams/Wetlands							
Coleman Ridge Dam	18	high	126	700	460	161	465

Electrical conductivity (EC) 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 possibly disappear.

3.14 Electrical conductivity in Paddys River Catchment

The electrical conductivity results at the Upper Tidbinbilla monitoring site since 1995 shows peaks in EC immediately after the fires and during times of low flow. One possible explanation for this may be that organic and mineral matter being flushed into this small stream may carry conductive ions that can cause these increased results.

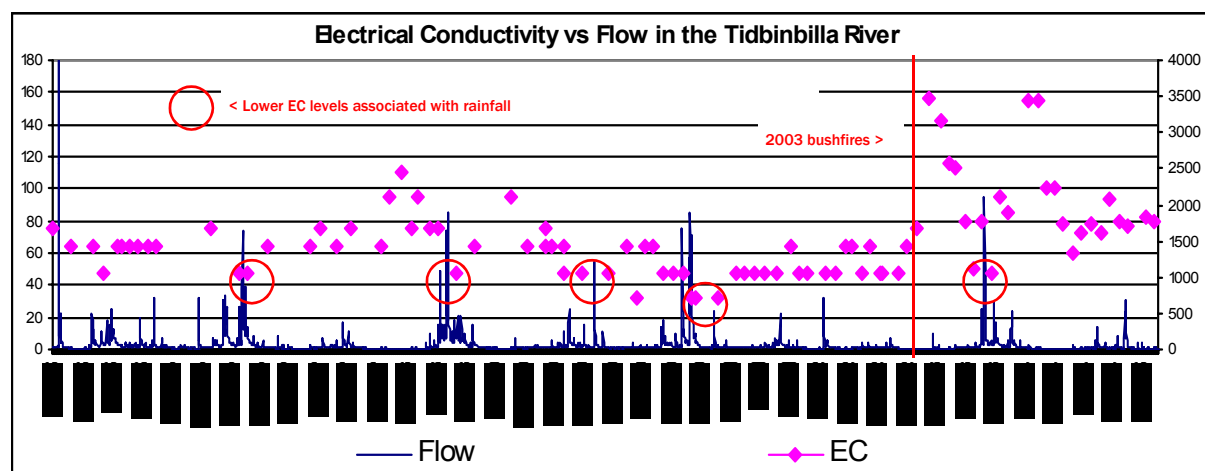


Figure 14: Electrical Conductivity before and after the 2003 bushfires highlights a drop in EC after rainfall and increases in EC levels after the bushfires.

3.15 Electrical conductivity in the Murrumbidgee River

Determining the impact of the 2003 bushfires on a large river system like the Murrumbidgee is not an easy task. This is particularly so for EC as many factors can influence this water quality parameter.

When we try to interpret the Murrumbidgee River CAMPFIRE results we need to take into account seasonal temperature fluctuations, rainfall trends, flows, catchment size and of course fire impacts.

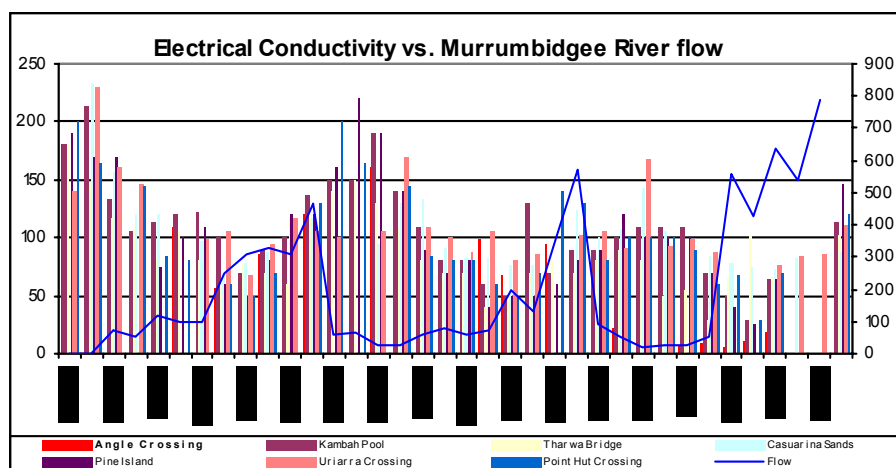


Figure 15: EC levels in the Murrumbidgee River vs monthly average flow at Lobbs Hole. A clearly defined seasonal trend in EC levels can be recognised.

At first glance the Murrumbidgee EC graph appears to have a seasonally declining trend. But is this declining trend due to the fires, or are other factors at play?

The seasonal EC fluctuations are usually associated with changes in flow. In summer, lower flows result in less fresh water dilution and as a result higher EC levels, conversely higher flows in winter usually result in higher fresh water dilution and lower EC levels. If we undertake a covariance analysis (i.e. adjust for the correlation between flow and conductivity) it appears that the fires had no significant influence on the electrical conductivity levels in the Murrumbidgee River. This is probably due to the significant size of the Murrumbidgee catchment and all its associated catchment influences.

3.16 Electrical conductivity and environmental flows

Waterwatch volunteer, Victoria Tanner has been monitoring two sites in the Cotter River Catchment. These sites, Condor Creek and Cotter River Reserve, are both in bushfire affected areas and were established because of their proximity to the Cotter Dam.

The Condor Creek monitoring site is located high on Brindabella Road at Thompsons Corner, 5km downstream of Blundells Flat. This mountain stream is not affected by any major reservoir or weir. The Cotter River Reserve site is located close to the confluence of the Cotter River and is downstream of the Cotter, Bendora and Corin dams. Data collected from these sites can be used to assess the impact of bushfires on water quality, as well as provide an insight into the influences of the Cotter reservoirs.

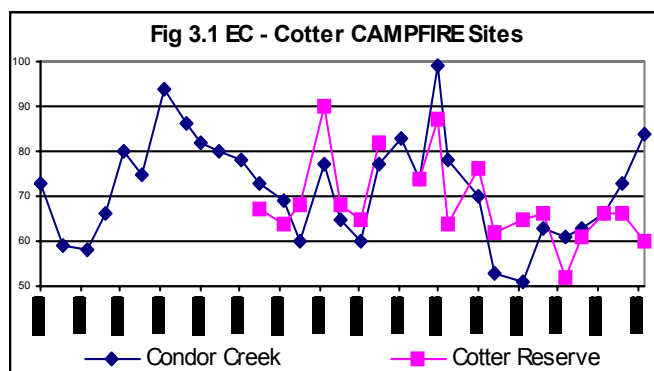


Figure 16: EC readings in Condor creek and Cotter confluence.

In rivers that have been dammed normal flow is changed. To compensate for this, water is released from dams at certain times to allow rivers to function normally. These releases are called environmental flows, and are designed to mimic the natural flows thereby maintaining aquatic ecosystem health.

The 2003 bushfires had a devastating affect on the Cotter catchment with many studies undertaken to assess the impact on Canberra’s water supply. One interesting aspect of the CAMPFIRE data is the alternating higher EC readings at the two CAMPFIRE sites. When we compare results from Condor Creek and the Cotter Reserve we can observe alternating higher monthly EC reading at these sites. One possible explanation is that typically there is a larger seasonal and rainfall EC variation in mountain streams when compared with water discharged as environmental flows from the Cotter Dam.

3.17 pH summary (pH units)

	Obs	Fire severity	Min	Max	Mean	Std dev	Median
Gudgenby Catchment							
Hospital Creek South	17	low	6.8	8.1	7.26	.355	7.2
Hospital Creek Central	11	low	6.1	7.8	7.01	.52	7.1
Hospital Creek North	14	low	6.1	7.9	7.01	.565	6.95
Bogong Creek South	16	low	6.6	7.8	7.17	.294	7.25
Bogong Creek Central	11	low	6.4	7.6	7.02	.36	7
Bogong Creek North	16	low	6	7.20	6.66	.348	6.65
Little Dry Creek	10	low	5.9	7	6.46	.327	6.5
Middle Creek	2	low	-	-	-	-	-
Rendezvous Creek	0	low	-	-	-	-	-
Naas River Catchment							
Glendale Crossing	9	Very high	6.4	7.6	7.06	0.42	7.1
Naas Crossing	8	low	6.6	7.3	6.98	0.25	6.95
Orroral River Campsite	0	Very high	-	-	-	-	-
Murrumbidgee River							
Angle Crossing	7	high	7.8	8.4	8.09	0.20	8.1
Tharwa Bridge	30	low	6.80	8.4	7.65	.476	7.75
Point Hut Crossing	12	high	7	8.2	7.52	.413	7.55
Pine Island	24	high	6.9	8.2	7.62	.326	7.65
Kambah Pool	28	high	6.80	8.50	7.72	.431	7.8
Casuarina Sands	20	Very high	6	8.3	7.22	.736	7
Uriarra Crossing	23	high	5.9	8.7	7.21	.635	7.2
Tuggeranong Creek							
Tuggeranong Creek	7	moderate	7.5	9	8.44	.583	8.7
Paddys River Catchment							
Upper Gibraltar Creek	14	moderate	7	8.4	7.84	.392	7.9
Lower Gibraltar Creek	9	Very high	6.6	8.1	7.69	.533	8
Upper Tidbinbilla River Site	23	Very high	6.1	8.1	7.3	.517	7.4
Lower Tidbinbilla River Site	24	high	6.2	8.3	7.39	.63	7.5
Flints Crossing	24	low	6.5	8.4	7.27	.534	7.25
Murrays Corner	24	high	6.4	8.80	7.27	.615	7.15
Cotter River Catchment							
Condor Creek	21	Very high	6.70	7.8	7.31	.241	7.30
Molonglo River Catchment							
Weston Creek GPT	24	high	6.7	9	7.4	.6	7.40
Coppins Crossing	25	high	6.55	7.7	6.92	.443	7
Dams/Wetlands							
Coleman Ridge Dam	18	high	6.4	9.1	7.93	.941	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

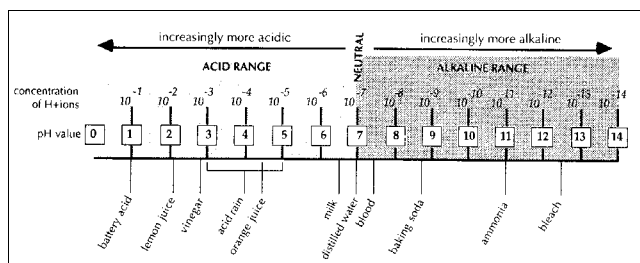
Stormwater systems such as Weston Creek GPT and Tuggeranong Creek were usually higher in pH. The Coleman Ridge Dam was higher in pH, which may have come from algal growth in the stagnant water.

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

Figure 17: 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)

3.18 Dissolved oxygen summary (mg/L)

	Obs	Min	Fire severity	Max	Mean	Std dev	Median
Gudgenby Catchment							
Hospital Creek South	17	1.5	low	10.7	7.16	2.89	8
Hospital Creek Central	11	3.6	low	9.3	6.7	2.20	7.2
Hospital Creek North	14	3	low	10.7	7.12	2.88	8.15
Bogong Creek South	16	4.5	low	11.7	8.97	1.96	8.9
Bogong Creek Central	11	5	low	9.2	7.09	1.22	6.8
Bogong Creek North	17	3.5	low	9.7	6.69	1.89	6.8
Little Dry Creek	11	1.0	low	9.4	6.68	2.54	7
Middle Creek	3	8.0	low	10	9.03	1.00	9.10
Rendezvous Creek	0		low				
Naas River Catchment							
Glendale Crossing	9	6.5	Very high	10	7.97	1.29	7.75
Naas Crossing	8	4.9	low	11.0	7.99	2.02	7.90
Orroral River Campsite	0	-	Very high	-	-	-	-
Murrumbidgee River							
Angle Crossing	7	7.0	high	10	9.27	1.12	10
Tharwa Bridge	28	4.1	low	12	8.27	1.88	8.1
Point Hut Crossing	13	6	HIGH	10.00	7.95	1.11	8.2
Pine Island	24	4.8	high	12	7.51	1.83	7.1
Kambah Pool	29	4	high	12.8	8.23	1.98	8.1
Casuarina Sands	21	6	Very high	14.8	9.1	2.00	9
Uriarra Crossing	22	4.5	high	10.6	7.53	1.64	7.55
Tuggeranong Creek							
Tuggeranong Creek	9	7.0	moderate	10.6	8.79	1.16	8.9
Paddys River Catchment							
Upper Gibraltar Creek	14	7.2	moderate	10.3	8.82	0.87	8.6
Lower Gibraltar Creek	12	6.3	Very high	16.5	9.16	3.51	7.7
Upper Tidbinbilla River Site	24	5.9	Very high	10.0	7.56	1.77	7.3
Lower Tidbinbilla River Site	24	2.5	high	11	7.3	2.39	7.2
Flints Crossing	25	4.5	low	12.4	8.57	1.93	8.4
Murrays Corner	25	4.3	high	12	8.4	2.04	7.8
Cotter River Catchment							
Condor Creek	21	3	Very high	13	6.3	2.40	6.2
Molonglo River Catchment							
Weston Creek GPT	23	1.7	high	13	7.1	2.80	7.4
Coppins Crossing	25	2.7	high	10.3	5.91	2.17	6
Dams/Wetlands							
Coolleman Ridge Dam	18	0.7	high	11	6.99	3.45	7.8

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 (DO) 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 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).



3.19 Fish kills after the firestorm

'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 readings in the ACT with 2.7 Mg/L.

Fish kills should be reported immediately to the ACT Government to ensure an early response. You should report them in terms of the numbers, species, weight and size distributions.