New South Wales Government
Independent Planning Commission

Independent Planning Commission NSW

PUBLIC MEETING NOTICE
We encourage you to participate

A084-18 Crown Cemetery Development, Wallacia

We're holding a public meeting to listen carefully to the community's views and encourage you to have your say!

The Minister for Planning has delegated his functions under the *Environmental Planning and Assessment Act 1979* to the Independent Planning Commission in relation to this Crown development application lodged by the Catholic Metropolitan Cemeteries Trust for a new cemetery and parklands at the Wallacia Golf Club, at 13 Park Road and 512 Mulgoa Road, Wallacia.

The Chair of the Commission, Professor Mary O'Kane AC, has appointed a three-member Panel, comprising Ms Dianne Leeson (Panel Chair), Mr Adrian Pilton and Mr Ross Carter, to scrutinise the development application.

The Commission will then direct the Sydney Western City Planning Panel, which is the consent authority, to determine the application.

The Commission will hold a public meeting at **Wallacia Hotel,1590 Mulgoa Road, Wallacia NSW 2745**, from **9:00am** on **Wednesday, 27 March 2019** to listen to the community's views on the development application. However, if we receive a large number of applications to speak at the meeting, we may need to hold an additional session on Thursday 28 March 2019 to hear from as many people as possible.

Anyone wishing to speak at the public meeting must complete an expression of interest form and return it via email to **ipcn@ipcn.nsw.gov.au** so that it's received by no later than **5 pm on Wednesday, 20 March 2019.**

And if you can't make it or just don't like public speaking, that's not a problem! You can make a written comment up to one week after the meeting. Written comments are weighed the same as spoken presentations.

This public meeting will be recorded, and a written transcript published on our website.

Speakers should familiarise themselves with the Commission's *'Public Meeting Guidelines'* prior to presenting to the Panel.

For more information

You can find all information in relation to this project on our website: **www.ipcn.nsw.gov.au** under A084-18 Crown Cemetery Development, Wallacia.

Please Note: Any information given to us may be published on our website, unless explicitly stated otherwise. All personal contact details (other than names) will be removed before online publication, but may be provided to relevant government departments. Before writing to us, please read our *Privacy Statement* at www.ipcn.nsw.gov.au or call us on (02) 9383 2100.

Contact: Commission Secretariat on (02) 9383 2100 or Email: ipcn@ipcn.nsw.gov.au
Independent Planning Commission NSW: Level 3, 201 Elizabeth Street, Sydney NSW 2000

From: [redacted]
To: [redacted]
[redacted] [redacted] plans, maps for Mulgoa and Wallacia?
Date: Wednesday, 27 March 2019 12:25:20 PM

---------- Forwarded message ---------
From: [redacted]
Date: Tue, 3 Jul 2018 14:50
Subject: Koala conservation plans, maps for Mulgoa and Wallacia?
To: Australian Koala Foundation [redacted]

Thank you again Aaron for speaking with me this morning and in advance for forwarding this request to Dave for AKF IP permission to hopefully prepare a map from your database of Koala conservation management planning for Mulgoa and Wallacia country communities, rural villages.

I remember my father saying that there were koala at "Grove Farm", 2595 Silverdale Road, Baines Hill, Wallacia (a NSW Government Gazetted nature reserve from the C19th colony) up until WWII when I recall at age 54, from my 85yo father's oral history, another Blue Mountains bushfire wiped that population out.

Several of us are excited to recently learn of koala sightings being recorded after over half a century, around the rural village of Mulgoa so as we're mindful of the conservation value of nearby Wallacia Golf Course becoming another proposed 88000 cemetery, 2-3bodies deep (ie 176000-264000 bodies) over these next 140 years with two crematoria belching mercury and other heavy metals (such as radioactive isotopes from radiation treatments) also bodily fluids leaching into the surrounding soil profile then epi- and benthic aquatic flora and fauna, many of us are naturally very concerned about Jerry's Creek valley and Upper Nepean Catchment management at and for Wallacia thus downstream through the Nepean Gorge to Penrith then Richmond, Windsor Hawkesbury River Catchment.

I hope you appreciate the key , koala are as another arboreal marsupial environmental indicator as well as internationally significant species demoted on Australia's $200 gold coin?

Sincerely appreciative

Matthew Fowler BSc UWoll 1988

From: [redacted]

Subject: WPA Golf Course EIS & was 1873 the highest flood level recorded, does that also have legal significance?
Date: Wednesday, 27 March 2019 12:27:55 PM

Dear WPA MC, particularly Darrell, etal

I heard Darrell (and others) speak again at our last Special Community Meeting of the various flood events in living memory. While Darrell obviously has an excellent community memory, the highest flood level recorded, 1873 flood that Billy Baines marked with a brass plaque on a sandstone square block at "Grove Farm", in addition to the frog mark carved into the pole at the old barn, former Nepean Valley Museum.

Record Floods | NSW State Emergency Service
February 1873
Gauge: Wallacia Weir
Peak Height: 20.62m
https://www.ses.nsw.gov.au/local-region-information/swr/record-floods/

What concerns me is that our WPA MC, despite having a lawyer, hasn't clearly communicated our legal duties of care in terms of 1 in 100 and 1 in 1000 year flood level environmental hazard/s as another country community.

Likewise, the 17m raising of Warragamba Dam Wall has not been properly dealt with in their EIS as ongoing community concerns demonstrate at,
https://m.facebook.com/groups/203820906933981/permalink/327249564591114/

Our Intergovernmental Committee
http://www.icsm.gov.au/

https://en.m.wikipedia.org/wiki/High_water_mark refers to legal significance.

For example,

In the United States, the high water mark is also significant because the United States Constitution gives Congress the authority to legislate for waterways, and the high water mark is used to determine the geographic extent of that authority. Federal regulations (33 CFR 328.3(e)) define the "ordinary high water mark" (OHWM) as "that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas.[10]For the purposes of Section 404 of the Clean Water Act, the OHWM defines the lateral limits of federal jurisdiction over non-tidal water bodies in the absence of adjacent wetlands. For the purposes of Sections 9 and 10 of the Rivers and Harbors Act of

1899, the OHWM defines the lateral limits of federal jurisdiction over traditional navigable waters of the US.[11] The OHWM is used by the United States Army Corps of Engineers, the United States Environmental Protection Agency, and other federal agencies to determine the geographical extent of their regulatory programs. Likewise, many states use similar definitions of the OHWM for the purposes of their own regulatory programs.

In 2016, the Court of Appeals of Indiana ruled that land below the OHWM (as defined by common law) along Lake Michigan is held by the state in trust for public use. [12]

Philippa Vale

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Sent: Wednesday, 27 March 2019 12:27 PM
To: [redacted]
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[redacted]

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In 2016, the Court of Appeals of Indiana ruled that land below the OHWM (as defined by common law) along Lake Michigan is held by the state in trust for public use. [12]

Philippa Vale

From: [redacted]
Sent: Monday, 4 March 2019 6:59 PM
To: [redacted]

I was surprised to learn (*pers comm*) last Sunday (yesterday) that there were platypus seen at the Jerry's Creek mouth onto the Upper Nepean River by "Dick" (Richard) Dunbar (by Silverdale Road, Wallacia) about a decade ago.

Dick's late father-in-law "Harry" Cross's place at Water Street, Wallacia borders lower Jerry's Creek. Wollondilly Shire Council Deputy Mayor and North Ward Cr said that he saw platypus in Nepean Gorge 2-3 years ago.

Sincerely

Matthew Fowler BSc UWoll 1988
Figtree Networks - continuing mission since 1996 'community synergy through community, professional & personal development'
[redacted]

---------- Forwarded message ---------
From: [redacted]
Date: Fri, 18 Apr 2008 at 22:04
Subject: RE: Nepean River platypus
To: [redacted]

Dear Matthew,

A nice try, but the river is too polluted. I think the platypus were once in the pool at the bottom of the weir where I took you all to swim. You might remember that we used to walk across the weir to get to it? It was the same sandy beach where we saw the brush-tail wallaby having a drink at dusk one evening.

Love, Dad

-----Original Message-----
From: [redacted]
Sent: Friday, 18 April 2008 7:20 PM

To: APC; FOWLER
Subject: Re: Nepean River platypus

Thank you Geoff

Do let me know if there is more information you think we could provide.

Do you think then that it is possible for the reintroduction of platypus to the Nepean River above the Wallacia weir and thus help our national biodiversity and environmental indicators?

Cheers, Matthew

On 18/04/2008, [redacted] wrote:

Hi Matthew,

Please thank your Dad for the extra info - much appreciated.

Geoff Williams

Australian Platypus Conservancy
P.O. Box 22
Wiseleigh VIC 3885
Tel: [redacted]
Website: www.platypus.asn.au

----- Original Message -----

From: [redacted]

To: [redacted]

Sent: Thursday, April 17, 2008 8:22 PM

Subject: Re: Nepean River Wallacia weir water rats c1980

Thanks Dad I'm sure Geoff Williams below will appreciate the detail update.

Love, Matthew

On 17/04/2008, **FOWLER** [redacted]:

Dear Matthew,
Mrs Metcalfe the elderly lady on Bents Basin, who lived on our side of the Krix's, who was internationally famous for growing orchids, told me about the platypus's being there in the 1920-30's. I believe June Eisenhuth used to help her pack the orchids for export.
Love, Dad.

Hi Matthew,

Many thanks for the report on water-rats (and your father's historical info on platypus) which is much appreciated.

Such information is of great help to our research.

Best wishes,

Geoff Williams
Australian Platypus Conservancy
P.O. Box 22
Wiseleigh VIC 3885
[redacted]
Website: www.platypus.asn.au

-----Original Message-----
[redacted] [mail[redacted] On Behalf Of Matthew Fowler
Sent: Thursday, 17 April 2008 1:07 PM
To: [redacted]
Cc: FOWLER; Matthew Fowler
Subject: Nepean River Wallacia weir water rats c1980

Dear Australian Platypus Conservancy

I just saw your contact at
http://www.abc.net.au/science/articles/2007/10/04/2185999.htm?site=science/scribblygum
The secret life of water rats By Rachel Sullivan and note your
Australian Platypus Conservancy website http://www.platypus.asn.au/
Recent reliable sightings of Australian water-rats can be reported to the Australian Platypus Conservancy, including details of when and where the animal was seen. The information will be added to a computerised data base, thereby contributing to our understanding of the ecology of both water-rats and platypus!

As an adolescent I grew up on my father's farm by the Nepean River with water rats foraging around the bank about 500m upstream from the Wallacia Weir c1980 while fishing overnight.

I have heard from my father that platypus used to live there too but we haven't sighted any in decades.

Kind regards, Matthew Fowler BSc

Philippa Vale

From: [redacted]
Sent: Sunday, 7 April 2019 1:03 AM
To: IPCN Enquiries Mailbox
Subject: Holt Family Fellowship - General Joseph Holt's Notice Board

[redacted] [redacted]

"Hotel Wallacia against the skyline, built on portion of John Fowler's former sorghum paddock by Keith Fowler with Toohey's Brewery Ltd in 1936. Modelled on the Banff Hotel tourist experience, it was envisaged that it would become 'The 19th hole' for his Wallacia Golf Links and Club."
http://joseph-holt.org/wallacia_post_office_centenary.php gives some indication as to Dad's previous communications, prior to his stroke.

Philippa Vale

From: [redacted]
Sent: Tuesday, 2 April 2019 11:42 AM
To: [redacted]
Subject: I watched, "What a Narcissist Says to You Is NOT as Important as How They Say It" on YouTube

[redacted] [redacted]

https://youtu.be/_yi7CEiX638

Does this relate to Bernard Bratusa & Panthers promises?

Philippa Vale

From: [redacted]
Sent: Wednesday, 6 March 2019 5:25 AM
To: [redacted]
Subject: Re: Nepean River platypus sighted at Jerry's Creek and Nepean Gorge, Wallacia CMCT's cemetery proposal
Attachments: IMG20190303182732.jpg

[redacted] [redacted]

Thanks for those extra platypus data points Ken, Geoff Williams

Australian Platypus Conservancy (APC)
P.O. Box 22
Wiseleigh VIC 3885
[redacted]

Website: www.platypus.asn.au

will certainly appreciate that information too. I genuinely appreciate being encouraged by other villagers. I remind that you can take the boy out of this village but you can't take this village out of the boy, the passionate prodigal son has returned. We in community need to be actively working with each other so we can become far more conservation conversant about our iconic environment indicator, management signature spp. You may've heard me talk about ecology and scientific literacy. Tragically, HM's responsible Premier Gladys Berejiklian's Government of NSW Lands Minister Hon. Paul Toole MP Bathurst clearly lacked awareness, insight, empathy, compassion, respect in addition to the appallingly undemocratic current Crown Lands Management Act since at least 2016.

Thank you again Ken, Matthew

On Wed, 6 Mar 2019 04:44 Ken Samuels, [redacted] wrote:

> Mathew,
>
> I get the impression you are pretty passionate about this sort of stuff. Me too!
>
> My old man has lived on the same corner in Penrith (near the old Log Cabin hotel) for 82 years. Mum with him for 62 of them.
>
> As a young bloke I used to spend a lot of my time fishing, swimming, canoeing, camping and water skiing up and down the river between Norton's Basin and Yarramundi. I knew much of it like the back of my hand. When we got thirsty we simply scooped up a drink of water - at least anywhere upstream of the 'Brown's' sewer creek just down from the weir at Penrith. We frequently saw platypus, lyre birds and other rarities in a number of spots and I know they are still there in a couple of them at least.
>
> My Dad tells a good yarn. One of them is how he and a couple of his mates of a Saturday evening used to "borrow" a row boat from Bill Mahler's boat hire shed, row across the river from the Penrith to the Emu side of Punt Road, then up along River Road to just downstream from the M4 bridge where a small creek still runs in. At this spot they would then firstly release the platypus caught for their pelts in wire traps by the "wog's", destroy the traps and then proceed to gate crash the dances held Saturday night's at Huntington Hall which attracted the good sorts from Sydney who came out on the train for the weekend.
>
> I still fish the river occasionally - but I'd need to be desperately thirsty before I had a drink from it.
>
> Cheers, Ken

On Monday, 4 March 2019, 7:01:04 pm AEDT, [redacted]:

I was surprised to learn (*pers comm*) last Sunday (yesterday) that there were platypus seen at the Jerry's Creek mouth onto the Upper Nepean River by "Dick" (Richard) Dunbar (by Silverdale Road, Wallacia) about a decade ago.

Dick's late father-in-law "Harry" Cross's place at Water Street, Wallacia borders lower Jerry's Creek. Wollondilly Shire Council Deputy Mayor and North Ward Cr said that he saw platypus in Nepean Gorge 2-3 years ago.

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I have heard from my father that platypus used to live there too but we haven't sighted any in decades.

Kind regards, Matthew Fowler BSc

Philippa Vale

From: [redacted]
Sent: Tuesday, 5 March 2019 6:39 PM
To: [redacted]
[redacted] MP Mulgoa, NSW; WPA Hon Secretary Margaret Stepniewski; todd.carney@nswlabor.org.au
Subject: Re: wild orchid response from cmct consultants for da

[redacted] [redacted]

No, I had not Jane, thank you.
This is another example of why I have been consistently going on about holding a writing workshop at WPHall these last 12 months. I have to respect, naturally dislike this social isolationist, text based communication approach.

As you should be aware by now, I'm much more positively stimulated by working with others who want to be positively worked with.

I hope both WPA & MPA seriously accept Tanya Davies stated invitation required for her to revisit both our Halls. Clearly as my father said to me in the early 1980s, we need to represent ourselves to our democratically elected representatives otherwise they're not in a position to represent us.

I don't know who's going to be our Mulgoa MP however I seriously hope that whoever does accept both HM's honour and bottom line responsibilities, a far more positive future for generations to come will in actual fact become where reality is not just more politicised rhetoric. We know that we're hurting as another country community of rural villagers.

There's so much that could, should've been done however I hope that better late than never applies.

Cousin Peter Metcalfe who collected the unnamed, undescribed, endemic *Diuris sp* Donkey, ground (terrestrial) orchid just told me he "*sent off*" the orchid for "*genetic analysis*" so we hopefully will see some sort of response in due course.

With years of mowing the 13th fairway, it's as I mentioned last night, conceivably extinct however "extinct" *spp* have been rediscovered so I don't know and we in community, particularly Golf Club members, could, should be actively interested, perhaps something our Mulgoa Valley Landcare Group could champion as well?

I'm very tired, brain and bodily drained by everything weighing on my mind at present. I hope to regenerate asap.

Sincerely, Matthew

On Tue, 5 Mar 2019 17:20 Wallacia Progress [redacted] wrote:

> Hi Matthew,
>
> I have noticed you constantly refer to the wild orchid in many meetings.
> Are you aware of the cmct responce in da from a hired consultant Travers dated 31.10.18. This is found on the ipc website.
> There you might find the answer to your questions.

Note: There are a lot more reports on their for you to view and write to the ipc about your findings that are a concern.
See attachment.

Regards
Jane
Always for our community!

--
Matthew Fowler BSc UWoll 1988
Figtree Networks - continuing mission since 1996 'community synergy through community, professional & personal development'
[redacted]

J. N. Am. Benthol. Soc., 2005, 24(3):679–689

Relationship of sediment toxicants and water quality to the distribution of platypus populations in urban streams

MELODY SERENA[1]

Australian Platypus Conservancy, P.O. Box 84, Whittlesea, Victoria 3757, Australia

VINCENT PETTIGROVE[2]

Research and Technology, Melbourne Water, P.O. Box 4342, Melbourne, Victoria 3001, Australia, and Centre for Environmental Stress and Adaptation Research, LaTrobe University, Bundoora, Victoria 3083, Australia

Abstract. Live-trapping surveys recorded populations of the platypus, *Ornithorhynchus anatinus*, in 73% of 45 reaches in the Dandenong Creek and Werribee, Yarra, Maribyrnong, Bunyip, and Lang Lang River catchments near Melbourne, Victoria; however, many populations occurred at low density. Our study investigated the relationship between population status and water and sediment quality along 28 stream reaches, including 17 reaches supporting a population of *O. anatinus* and 11 reaches lacking a resident population. Stream attributes included surface water-quality variables (summer concentrations of dissolved O_2, total P [TP], NO_x, total Kjeldahl N [TKN], dissolved organic N, NH_4-N, and 50th, 75th, and 90th percentiles of suspended solids [SS]), concentrations of sediment toxicants (Zn, Pb, Cd, As, Cr, Cu, Hg, Ni), extent of catchment urbanization (as indicated by % imperviousness), and daily discharge. Reaches supporting a medium-density population (mean number of ≥0.5 adults or subadults captured per pair of nets set overnight) were characterized by significantly lower concentrations of streamwater TP, TKN, and SS (90th percentile), significantly lower Cd, Pb, and Zn in sediments, and significantly lower catchment imperviousness than reaches lacking resident animals. The maximum imperviousness associated with a population of *O. anatinus* was 11%, suggesting that this species is sensitive to urban-related change. Capture rate was not significantly correlated with median summer discharge, but was inversely correlated with streamwater TP and TKN. Further studies are needed to determine if pollutants may limit urban *O. anatinus* populations through direct toxicity or indirectly by pollutants reducing their benthic macroinvertebrate food resource.

Key words: platypus, urban streams, nutrient enrichment, sediment toxicants, water quality, biomonitoring, Melbourne.

The Australian biota comprises a high proportion of endemic species, including 74% of described mammals (Ceballos and Brown 1995). Among these is the platypus, *Ornithorhynchus anatinus*, which occupies lentic and lotic waterways along the eastern and southeastern coast of mainland Australia and throughout Tasmania (Grant 1992, Menkhorst 1995). *Ornithorhynchus anatinus* is a carnivore that feeds mainly on benthic insects, although it also consumes decapod and ostracod crustaceans, bivalves and gastropods, nematomorphs, and salmonid eggs. In nearly all areas studied to date, larval Trichoptera and/or Ephemeroptera compose a large proportion of the diet, whereas consumption of chironomid larvae is relatively low, possibly because of their small size (Faragher et al. 1979, Grant 1982, Munks et al. 2000). Based on studies in captivity and the wild, a nonbreeding adult *O. anatinus* consumes ~15 to 28% of its body mass/d to accommodate a daily energy expenditure of ~850 to 1100 kJ kg^{-1} d^{-1} (Krueger et al. 1992, Munks et al. 2000), with food intake of late-lactating females increasing to ~3× the daily consumption of nonlactating females (Holland and Jackson 2002). Animals forage by searching methodically along riffles and undercut banks, as well as by diving to the bottom of runs and pools (Serena 1994). Aerobic capacity limits underwater activity to ~1 min, which generally precludes feeding at depths >5 m (Evans et al. 1994, Bethge et al. 2001, 2003).

Effective conservation of biodiversity in urbanizing catchments requires an understanding of how well species adapt to altered flow regimes, channel morphology, pollutant concentrations, and habitat quality. Platypus popula-

[1] E-mail addresses: platypus@vicnet.net.au
[2] vincent.pettigrove@melbournewater.com.au

tions in the greater Melbourne area (human population ~3.5 million) have been studied since 1995 to identify factors affecting species distribution and abundance in urban streams. In the absence of comparable studies conducted elsewhere in Australia, our initial goal was to map where *O. anatinus* occurred in urban and outlying waterways, and to describe its population density and reproductive success. More recently, our research has focused on identifying bank and instream attributes that may influence platypus foraging patterns and selection of diurnal resting sites. Several significant relationships have been demonstrated between habitat variables and *O. anatinus* behavior in the Melbourne region, including a positive association between stable, undercut banks and distribution of feeding activity and burrows (Serena et al. 1998, 2001). Placement of *O. anatinus* burrows has been linked to abundance of overhanging riparian vegetation, and distribution of foraging effort has been linked to prevalence of riffle habitat and riparian tree cover, abundance of instream large woody debris and coarse particulate organic matter (CPOM), and the proportion of relatively coarse particles in streambed sediment (Serena et al. 1998, 2001). Sightings of *O. anatinus* have been positively correlated with abundance of overhanging vegetation and pool length and depth (up to 2 m) in the upper Macquarie River system in New South Wales (Ellem et al. 1998), and with cobbled substrate and water depth >1.5 m along the Hastings River (Grant 2004b).

The role of pollution in potentially limiting *O. anatinus* populations has not been previously addressed, apart from the issue of animal entanglement in litter (Serena and Williams 1998). The main purpose of our study was to determine whether sediment toxicants and/or physicochemical measures of surface water quality were related to occurrence and abundance of *O. anatinus* populations in urban streams around Melbourne.

Methods

Study area

The study area included streams across 6 catchments in southern Victoria: the Werribee (catchment area = 1450 km^2), Maribyrnong (1550 km^2), Yarra (3780 km^2), and Dandenong (325 km^2) systems draining into Port Phillip Bay, and the Bunyip (740 km^2) and Lang Lang (405 km^2) systems draining into Western Port Bay. Catchments are collectively contained within 3 physiographic regions: 1) Basalt Plains in the western and northwestern parts of the study area, 2) Sedimentary Hills in the northeast and east, and 3) Coastal Areas of consolidated dunes and swamp in the southeast (Savio 1991). A high proportion of the landscape has been subject to residential, industrial, or agricultural development, although tracts of reasonably intact forest remain, especially in the northeast and east. The region's human communities are serviced by separate stormwater and sanitary sewer systems, with septic tanks used to treat waste in some outlying districts.

Platypus population assessment

Surveys of *O. anatinus* were conducted using fyke nets (Iron Strand, Hvide Sande, Denmark), set in the afternoon and monitored at regular intervals through the night, the time when animals are most active. One pair of nets was set per site to detain animals moving either up- or downstream, with the length of each net suspended partly above the water so captured individuals could breathe. Animals were directed into the main body of the nets by panels of netting stretched across the entire width of the channel, and gaps under the netting were eliminated by securing the bottom edge with rocks (Serena 1994). Captured animals were marked uniquely using Trovan transponder tags implanted subcutaneously between the scapulae (Grant and Whittington 1991) and released at the point of capture after nets were removed from the water. Sex and age classes were assigned based on the size and appearance of calcaneal spurs on the hind legs, allowing recognition of 3 male classes (juvenile, ≤10 mo; subadult, 11–23 mo; adult, >23 mo) and 2 female classes (juvenile, ≤10 mo; adult or subadult, >10 mo) (Temple-Smith 1973).

Surveys were conducted from 1991 to 2002, with most trapping effort (96% of a total of 1467 net-nights; 1 net-night = 1 pair of fyke nets set overnight) occurring since 1995. Survey nets were set along 45 reaches (defined as a 4- to12-km stream section sampled at 5 to 9 sites, separated by 0.8- to 1.5-km intervals), including 1 reach in the Werribee River system, 4 in the

Maribyrnong River system, 29 in the Yarra River system, 7 in the Dandenong Creek system, 3 in the Bunyip River system, and 1 in the Lang Lang River system. To both maximize the area sampled and ensure that a high proportion of animals encountered nets in a given survey, the mean distance between consecutive survey sites (1.1 ± 0.3 km, mean ± 1 SE) was equivalent to the mean length of stream channel used by adults and subadults per foraging bout in the Melbourne area (1.1 ± 0.6 km; Serena 1994). Maximum depths during normal discharge were ~2.5 to 4 m, within the range of depths used by *O. anatinus*. Each reach was surveyed on 2 to 19 dates (5.4 ± 4.2 dates/reach, mean ±1 SE), with 95% of surveys conducted from September to May (spring through autumn). The status of *O. anatinus* for a given reach was assigned to 1 of the following 3 abundance categories based on capture frequency: 1) no resident population (animals not captured); 2) low density (mean number of <0.5 adults or subadults captured per site per night); and 3) medium density (mean number of ≥0.5 adults or subadults captured per site per night).

Environmental variables

Proportion of impervious area within the catchment (= imperviousness) upstream of reaches was estimated using methods from Pettigrove and Hoffmann (2003). Daily discharge data recorded by automated gauging stations from 1995 to 2002 were obtained from Melbourne Water's HYDSYS data base (Melbourne Water, P. O. Box 4342, Melbourne, Victoria 3001, Australia). Water-quality variables included dissolved O_2 (DO), the 50th, 75th, and 90th percentiles of total suspended solids (SS50, SS75 and SS90, respectively), total Kjeldahl N (TKN) and its constituents, dissolved organic N (DON) and NH_4-N, nitrate/nitrite (NO_x), and total P (TP). Monthly measurements were made by Melbourne Water (www.melbournewater.com.au) using standard methods and quality assurance procedures (USEPA 1983, APHA 1989), or were obtained from the Victoria Water Resources Data Warehouse (Victorian Department of Primary Industries, www.vicwaterdata.net). Data on streamwater pH were compiled from the same sources in association with NH_4-N data to facilitate assessment of toxicity (ANZECC and ARMCANZ 2000). SS percentiles were calculated from measurements made throughout the year to ensure representative sampling of post-storm flows and base flow. Other water-quality variables and daily discharge were measured in the austral summer (January–March), which is Melbourne's driest season based on the mean number of rain events/mo (www.bom.gov.au), and also marks the energetically demanding period of late lactation and weaning for *O. anatinus* (Grant and Griffiths 1992). Except for Sassafras Creek (data collected in 1993 and 1994), water quality was evaluated from 1995 to 2002. This 8-y period is an appropriate time scale in relation to the life span of *O. anatinus*, which can extend up to 21 y in the wild (Grant 2004a).

Trace metals are generally the most prevalent class of toxic contaminants found in surface runoff and stream sediments in urbanized catchments (Novotny and Olem 1994). In our study, sediments were analyzed for 7 metals (Cd, Cr, Cu, Pb, Hg, Ni, and Zn) and the metalloid As (hereafter called a metal). Surface samples (≤2 cm deep) of fine sediment (<0.063 mm) were collected 2 to 8 times per reach from 1994 to 2000. Samples were air-dried and digested (method 3051 in USEPA 1994) before metals were assayed. Concentrations of As, Cr, Cu, Pb, Ni, and Zn (detection limit = 1 mg/kg) and Cd and Hg (detection limit = 0.1 mg/kg) were measured using inductively coupled plasma/mass spectrometry (method 200.8 in USEPA 1994).

Data analysis

Environmental data were available for 35 reaches surveyed for *O. anatinus*, including 24 reaches where animals were recorded and 11 where none were captured. Seven reaches supporting a population within 3 km of the Yarra River were excluded from statistical analyses because their population status might have been influenced by proximity to the larger and less-degraded mainstem (Serena et al. 1998). Two-sample *t*-tests were used to compare mean DO, TP, TKN, and imperviousness between reaches supporting medium-density platypus populations and those lacking animals. Two-sample Kruskal–Wallis tests, the nonparametric equivalent of a *t*-test, were used to test for differences in median SS concentrations and metals between the 2 groups of reaches. Nonparametric Spearman's correlations were used to test for

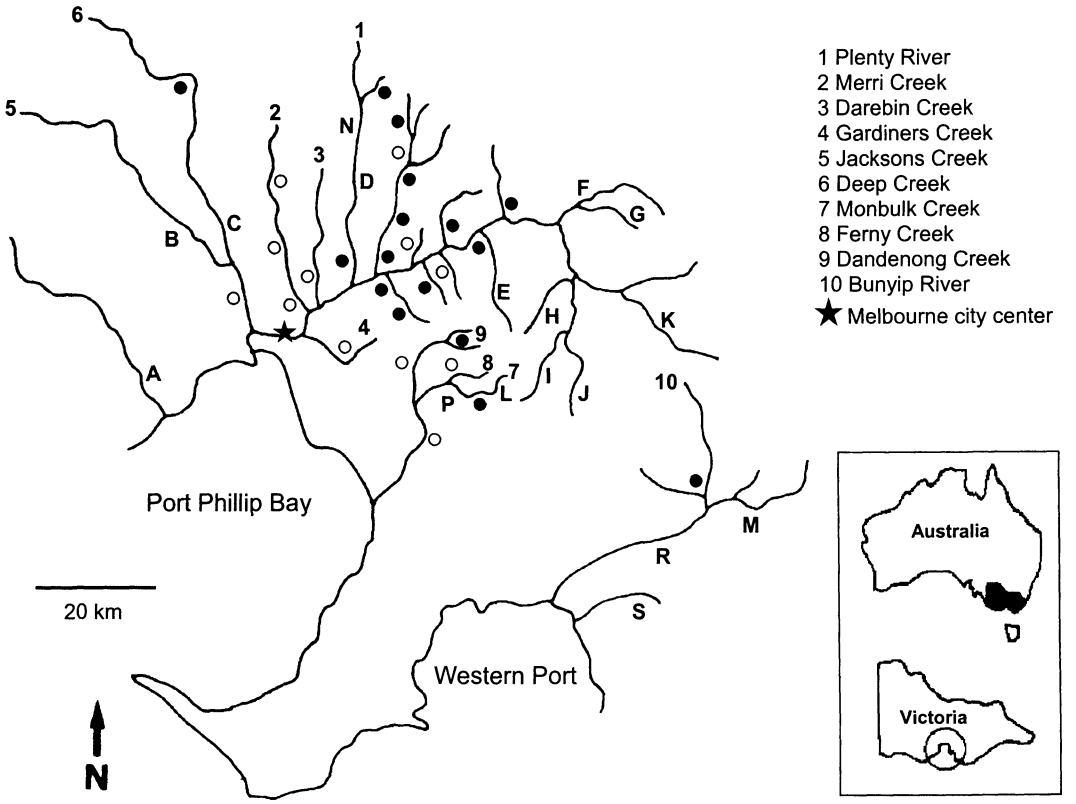

FIG. 1. Locations of the 45 stream reaches surveyed for the platypus, *Ornithorhynchus anatinus*, near the city of Melbourne, Victoria, southeastern Australia. Letters correspond to reaches supporting platypus populations in Table 1, closed circles indicate additional reaches supporting *O. anatinus* populations, and open circles indicate reaches lacking *O. anatinus*.

statistical dependence between environmental variables, and to correlate platypus capture rate and discharge. Given that several environmental variables were intercorrelated, simple linear regression was used to test the relationship between platypus capture rate and environmental variables that differed significantly in relation to animal presence/absence (James and McCulloch 1990). Prior to analyses, binomially distributed imperviousness data were arcsine-transformed, and SS90, Cd, Pb, and Zn data were $\log_{10}$-transformed to minimize influence of outliers and to correct for nonnormality (Zar 1984). α-level was set at 0.05 for all tests.

Results

Platypus population assessment

Ornithorhynchus anatinus was captured in 73% of the 45 reaches included in our study (Fig. 1). In the Yarra River catchment, animals occupied 100% of reaches sampled along streams joining the main stem >30 km upstream of the Melbourne city center (n = 10), but were captured in only 58% of reaches in tributaries closer to the city (n = 19). Animals were consistently recorded from 1995 to 2002 at sites located ~15 km from the city center along the Plenty River (1, Fig. 1), but they were not encountered closer to the city at sites along Merri, Darebin, and Gardiners creeks (2, 3 and 4, respectively; Fig. 1).

Animals were captured west of Melbourne in 1 reach of the Werribee River (A; Table 1, Fig. 1). Northwest of the city center, populations were recorded in the Maribyrnong River catchment along 1 reach of Jacksons Creek (5, Fig. 1) and 2 reaches of Deep Creek (6, Fig. 1), but not downstream of their confluence in the middle parts of the Maribyrnong River (one reach).

TABLE 1. Attributes of study reaches labeled with letters in Fig. 1 and associated populations of the platypus, *Ornithorhynchus anatinus*. Capture rate = mean number of adult or subadult *O. analinus* captured per site per night. NA = data not available.

Reach	Catchment	Reach length (km)	Median summer discharge (m^3/s)	Platypus capture rate	% females
Werribee River (A)	Werribee	7	0.234	0.62	48
Jacksons Creek (B)	Maribyrnong	9	0.079	0.60	50
Deep Creek (C)	Maribyrnong	6	0.021	0.57	75
Plenty River (D)	Yarra	7	0.022	0.52	54
Olinda Creek (E)	Yarra	8	0.076	0.95	56
Watts River (F)	Yarra	8	0.088	0.80	38
Graceburn Creek (G)	Yarra	4	0.009	0.67	75
Wandin Yallock Creek (H)	Yarra	6	0.026	0.60	100
Sassafras Creek (I)	Yarra	5	NA	1.25	50
Cockatoo Creek (J)	Yarra	6	0.097	1.00	20
Little Yarra River (K)	Yarra	9	0.716	0.86	42
Monbulk Creek (L)	Dandenong	6	0.053	1.28	55
Tarago River (M)	Bunyip	9	0.580	1.33	63
Plenty River (N)	Yarra	9	0.003	0.25	0
Monbulk Creek (P)	Dandenong	5	NA	0.41	8
Bunyip River (R)	Bunyip	11	1.464	0.40	0
Lang Lang River (S)	Lang Lang	10	NA	0.25	0

Southeast of Melbourne, animals occurred in the Dandenong Creek catchment along 3 reaches of Monbulk Creek (7, Fig. 1) and the uppermost reach of Dandenong Creek (9, Fig. 1), but not in lower Ferny Creek (8, Fig. 1) or the middle and lower reaches of Dandenong Creek. Animals were recorded in the Bunyip River catchment along 2 reaches of the Bunyip River (10, Fig.1) and one reach of the Tarago River (M; Table 1, Fig. 1), and in the Lang Lang River catchment along one reach of the Lang Lang River (S; Table 1, Fig. 1).

Platypus capture rates varied by 5x across the 17 reaches included in analyses (Table 1). Females composed ≥20% (median = 54%) of adults and subadults captured in the 13 medium-density populations, implying that these populations were capable of reproduction. In contrast, females were rarely or never recorded in the 4 low-density populations, suggesting little or no reproductive capacity. Capture rate was not significantly correlated with stream size, as indicated by median summer discharge ($r_s = 0.370$, $p = 0.197$, $n = 14$).

Environmental variables

There were no significant differences in mean summer concentrations of DO or NO_x between reaches supporting a medium-density *O. anatinus* population and reaches lacking a population (Table 2). However, imperviousness was significantly higher for reaches lacking a population than those with a medium-density population ($p < 0.05$); the same pattern was true for TP ($p < 0.01$) and TKN ($p < 0.05$). In absolute terms, mean imperviousness, TP, and TKN associated with medium-density populations were ~40, 60, and 70%, respectively, of the corresponding values from reaches where animals were not recorded. Median values for TP, TKN, and imperviousness were 0.048 mg/L, 0.55 mg/L, and 6%, respectively, for reaches with a medium-density population, 0.099 mg/L (range = 0.053–0.179 mg/L), 0.67 mg/L (range = 0.46–1.30 mg/L), and 2% (range = 2–18%) for the 4 reaches with a low-density population, and 0.098 mg/L, 0.80 mg/L, and 15% for reaches lacking a resident population.

Reaches supporting medium-density populations and those lacking populations did not differ significantly for SS50 or SS75 or in median sediment concentrations of As, Cr, Cu, Hg, or Ni (Table 3). However, SS90 was significantly higher in reaches lacking animals than in reaches with medium-density populations ($p < 0.05$); the same pattern was true for sediment concen-

TABLE 2. Mean (±1 SE) summer concentrations (mg/L) of dissolved O_2 (DO), total P (TP), NO_3/NO_2 (NO_x), total Kjeldahl N (TKN), and % catchment imperviousness in reaches supporting a medium-density platypus population and reaches lacking a resident population. Significant differences between reach group means tested by 2-sample *t* tests. ns = not significant ($p > 0.05$).

Variable	Medium-density population (*n*)	Range	No resident population (*n*)	Range	*p*
DO	7.9 ± 1.3 (13)	5.7–9.5	8.0 ± 1.5 (11)	5.4–10.9	ns
TP	0.058 ± 0.026 (13)	0.027–0.106	0.098 ± 0.039 (11)	0.035–0.176	0.006
NO_X	0.50 ± 0.62 (13)	0.04–1.83	0.30 ± 0.20 (11)	0.03–0.59	ns
TKN	0.57 ± 0.28 (13)	0.19–1.27	0.80 ± 0.27 (11)	0.40–1.17	0.049
Imperviousness	8 ± 4 (12)	1–11	19 ± 14 (11)	3–37	0.031[a]

[a] Following arcsine transformation

trations of Zn ($p < 0.01$), Pb ($p < 0.05$), and Cd ($p < 0.01$). In absolute terms, SS90 and metal concentrations in reaches with a medium-density population were 25% (Cd), <50% (Zn, Pb), and ~75% (SS90) of the corresponding median values from reaches lacking a population. Median concentrations of metals associated with the 4 low-density *O. anatinus* populations were 0.14 mg/kg (range = 0.05–0.2 mg/kg) for Cd, 15 mg/kg (range = 9–19 mg/kg) for Pb, and 38 mg/kg (range = 33.5–109 mg/kg) for Zn, whereas the corresponding median SS90 was 60.0 mg/L (range = 48–64 mg/L).

Six pairs of environmental variables that differed significantly between reaches with a medium-density population and those reaches lacking a population were significantly correlated. Concentrations of Cd, Pb, and Zn were highly intercorrelated ($p < 0.001$, $r^2 = 0.50$–0.74), as were TP and TKN ($p < 0.001$, $r^2 = 0.39$). In addition, imperviousness was positively correlated with sediment concentrations of Zn and Pb ($p < 0.005$, $r^2 = 0.29$–0.33). Capture rates were not correlated with 5 environmental variables that differed significantly between sites with and without *O. anatinus*, including imperviousness ($r^2 = 0.020$), SS90 ($r^2 = 0.001$), and sediment concentrations of Cd ($r^2 = 0.041$), Pb ($r^2 = 0.026$), and Zn ($r^2 = 0.033$). In contrast, platypus capture rates were negatively correlated with both TP ($r^2 = 0.339$, $p = 0.014$; Fig. 2A) and TKN ($r^2 = 0.252$, $p = 0.040$; Fig. 2B).

TKN mostly consisted of DON at all sites, with NH_4-N accounting for a mean 1 to 6% of TKN in reaches with a medium-density platypus population (range = 0.005–0.032 mg/L, $n = 12$), 1 to 5% of TKN in reaches with a low-density population (range = 0.005–0.036 mg/L,

TABLE 3. Median concentrations (mg/kg) of 8 metals in fine surface sediment, and 50th (SS50), 75th (SS75), and 90th (SS90) percentiles of suspended solids (SS, mg/L) in reaches supporting a medium-density platypus population and reaches lacking a resident population. Significant differences between reach group medians tested by 2-sample Kruskal–Wallis tests. ns = not significant ($p > 0.05$).

Variable	Medium-density population (*n*)	Range	No resident population (*n*)	Range	*p*
Zn	53 (12)	24–150	110 (11)	17–3000	0.008
Pb	15 (12)	8–55	32 (11)	5–490	0.025
Cd	0.1 (9)	0.05–0.25	0.4 (8)	0.1–3.0	0.007
As	4 (12)	0.3–12	4 (11)	2–24	ns
Cr	26 (12)	5.5–49	21 (11)	11–170	ns
Cu	12.5 (12)	5–21	16 (11)	7–210	ns
Hg	0.02 (9)	0.02–0.05	0.05 (9)	0.01–0.50	ns
Ni	12 (12)	6–36	17 (10)	6–110	ns
SS50	10.2 (10)	6–30	11 (10)	8–26	ns
SS75	19.7 (10)	12–38	26.5 (10)	17–79	ns
SS90	39.2 (10)	24–57	51.9 (10)	44–203	0.023

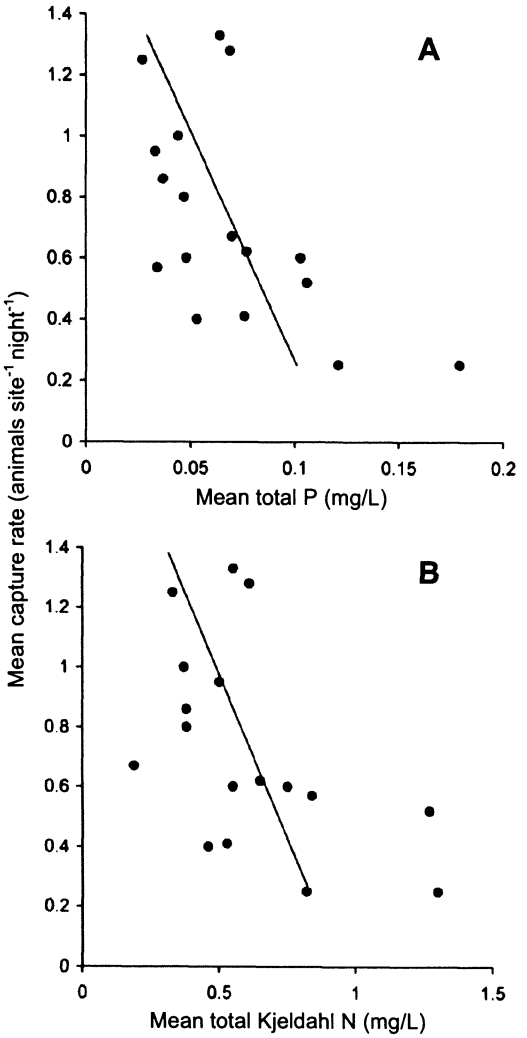

FIG. 2. Relationship between platypus density (as captures rate in reaches with low- and medium-density populations, see text) plotted against streamwater total P (A) and total Kjeldahl N (B).

n = 3), and 1 to 11% of TKN in reaches lacking a resident population (range = 0.005–0.130 mg/L, n = 11). Based on guidelines from ANZECC and ARMCANZ (2000), NH_4-N concentrations were considered potentially toxic in only 1 of 187 samples (0.5%) obtained from reaches supporting a medium-density *O. anatinus* population (Jacksons Creek), 1 of 42 samples (2.4%) from reaches supporting a low-density population (Lang Lang River), and 2 of 278 samples (0.7%) from reaches lacking a resident population (both from Gardiners Creek). Combined median concentrations of NO_x and NH_4-N were 0.26 mg/L (range = 0.06 to 1.84 mg/L) in 12 reaches with a medium-density *O. anatinus* population, 0.19 mg/L (0.17–0.56 mg/L) in 3 reaches with a low-density population, and 0.29 mg/L (0.05–0.72 mg/L) in 11 reaches lacking a resident population.

Discussion

Ornithorhynchus anatinus was seen regularly in the Yarra River within 5 km of central Melbourne as recently as the 1950s (Faithfull 1987). Our surveys indicate that the species persists in many streams in the greater Melbourne area, although few animals currently occur within a radius of <15 km from the city center. Platypus capture rate was not correlated with mean summer discharge in the perennial streams included in our study, suggesting that the importance of stream size is outweighed by other factors in limiting platypus population density. In particular, our results support the hypothesis that the status of platypus populations in reaches around Melbourne is influenced by catchment imperviousness and the distribution of surface water and sediment contaminants associated with urbanization.

Along with drainage connection, catchment imperviousness is an important determinant of increased storm runoff and decreased base flow (Leopold 1968, Walsh et al. 2005a), thereby contributing to urban stream degradation (e.g., Walsh et al. 2001, Hatt et al. 2004, Taylor et al. 2004). Several studies have suggested a stepped relationship between urban stream quality and imperviousness (reviewed by Walsh et al. 2005b), with a lower threshold defined by loss of sensitive stream elements and a higher threshold defined by progression to a highly degraded state. Estimates of critical boundary values for these two thresholds are ~8 and 12% (Wang et al. 2001), 10 and 25% (Schueler and Claytor 1997), or 12 and 30% catchment imperviousness (Klein 1979). In our study, reaches supporting a platypus population were characterized by a maximum of 11% imperviousness, suggesting that *O. anatinus* is appropriately classified as being sensitive to urban-related change at the catchment scale.

That catchment imperviousness varied significantly between reaches supporting a platypus population and those lacking animals does not preclude the possibility that other environmen-

tal variables may function more directly than imperviousness in determining platypus abundance. In our study, 3 water-quality variables, TP, TKN, and SS90, varied significantly with platypus population status in the Melbourne region. Of these, TP varied most strongly between reaches where *O. anatinus* were present or absent and, along with TKN, was negatively related to the rate of platypus captures per reach. Nutrient enrichment in streams and rivers near Melbourne has been linked to increased numerical dominance of small dipterans and oligochaetes over larger-bodied macroinvertebrate taxa more typically consumed by *O. anatinus* (Pettigrove 1990, Walsh et al. 2001). P enrichment in Melbourne's streams is also correlated with increased benthic algal biomass (Taylor et al. 2004). This shift in biotic conditions may reduce platypus foraging efficiency if high autotrophic biomass impedes prey detection or capture, as occurs in predatory fish (Glass 1971, Mittelbach 1981, Crowder and Cooper 1982, Werner et al. 1983).

The case for TKN being functionally related to *O. anatinus* abundance in its own right, as opposed to being a proxy for TP, is weak. TKN mainly consisted of DON, which is not readily assimilated by aquatic producers (Hvitved-Jacobsen 1986), and so is unlikely to have reduced *O. anatinus* population density by contributing to eutrophication. In theory, the NH_4-N component of TKN both provides primary producers with readily absorbed N and, depending on concentration, may reduce *O. anatinus* food resources by acting as a toxicant to macroinvertebrates (Hickey and Vickers 1994, Hickey and Martin 1999, Hickey et al. 1999). However, neither mechanism appears to have been an important influence on platypus abundance in our study area. NH_4-N did not contribute to consistently more assimilable N being available to producers in reaches lacking *O. anatinus* as compared with reaches supporting animals. As well, NH_4-N concentrations were potentially toxic in just 0.7% of samples obtained from reaches lacking *O. anatinus*, as compared to 0.9% of samples from reaches where animals occurred.

In contrast, suspended solids (i.e., SS90 in our study) provide a plausible mechanism linking platypus abundance and urbanization. Others have shown that increased SS caused by storms trigger catastrophic drift by macroinvertebrates, which may reduce benthic densities by >50% in 24 h (Culp et al. 1986). Such losses of macroinvertebrates, if significant in Melbourne streams, may directly reduce food resources for *O. anatinus*. In addition, fine sediment may impair platypus foraging efficiency: animals have been found to feed preferentially at sites dominated by substrates coarser than sand (Serena et al. 2001) or gravel (Grant 2004b).

Sediment concentrations of Zn, Pb, and Cd, which vary with local geology and quality and quantity of urban runoff near Melbourne (Pettigrove and Hoffmann 2003), also may contribute to variation in abundance of *O. anatinus* in urban streams. Exposure to each of these 3 metals can be lethal to freshwater vertebrates (Davies et al. 1976, Smith and Heath 1979, Calamari et al. 1980) and invertebrates (Rehwoldt et al. 1973, Thorp and Lake 1974, Anderson et al. 1980, Hatakeyama 1989), and elevated Zn (Weatherley et al. 1967), Cu, Pb, and Zn (Lake et al. 1977), and Cd, Cu, Pb, and Zn (Norris et al. 1982) have been linked to reduced macroinvertebrate diversity and abundance in Australian streams. Based on sediment-quality guidelines from MacDonald et al. (2000), "threshold effect concentrations" for Zn, Pb, and Cd (TEC, below which measurable adverse effects on benthic organisms are unlikely to occur), are 121, 35.8, and 0.99 mg/kg, respectively, whereas corresponding "probable effect concentrations" (PEC, above which adverse effects are likely to occur) are 459, 128, and 4.98 mg/kg, respectively. Assuming these metals influence platypus abundance in the Melbourne area by restricting macroinvertebrate prey, their maximum concentrations along reaches supporting this species are predicted to lie within, or possibly above, the range delimited by TEC and PEC values. In our study, this situation occurred for Zn (highest concentration for a medium-density population = 150 mg/kg) and Pb (55 mg/kg), but not Cd (0.25 mg/kg). However, without toxicological information describing accumulation and/or tolerance of Cd by *O. anatinus*, it remains possible that this species is adversely affected by sediment concentrations of Cd below those of its macroinvertebrate prey.

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When Sydney becomes an inland sea, we'll need the pool

Melinda Howes, CEO, Actuaries Institute
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Large parts of Sydney are built on a floodplain - a fact that many Sydneysiders don't want to know and don't want to hear. Flood experts, hydrologists, the SES and others have been warning for years that a major flood in Sydney is a disaster waiting to happen.

Last week as we watched scenes of devastation in Wagga Wagga and the Riverina, it's easy to think that this cannot happen here. We're in a major capital city. We're safe. Surely housing for tens of thousands of Sydneysiders would not have been built on a flood plain. Would it? This is exactly what has happened in Sydney in recent decades of development.

So what is the problem, and what should we be doing about it?

A major flood can and will happen in Sydney

A search of publicly available material about Sydney and flood risk paints a sobering picture.

The Hawkesbury-Nepean River is one of the major river systems in NSW, and the unique topography of the 22,000km catchment area (from Goulburn in the south and almost to Singleton in the north west with only one outlet at Broken Bay) means that water flows into the valley at a far higher rate than it can flow out. An East Coast Low Pressure System over Sydney (like last week) with exceptionally heavy rain over several days can lead to severe, and very deep, flooding. Hydrologists tell us that:

"The narrowing of the valley downstream at Castlereagh controls the flow of water between the wide floodplain at Penrith and the even larger floodplain at North Richmond and Wilberforce. The flow of water is restricted by the narrow gorges downstream of Wilberforce which act like a bottleneck and result in backing up of floodwater producing flooding much deeper than on a typical coastal river in NSW." [1]

The SES Emergency plan[2] says the primary floodplain is mostly located within the Penrith, Hawkesbury, Blacktown and Baulkham Hills local government areas. It goes on to say that the main area of urban development in the Hawkesbury-Nepean Valley is in the primary floodplain, with distinct sub-floodplain areas in Camden, Wallacia, Emu Plains/Castlereagh and the largest at Richmond/Windsor/Wilberforce.

So at some point we are likely to experience a major flood in Sydney. It will be deep, and it will affect a very built-up area.

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[1] Reconciling development with flood risks: the Hawkesbury-Nepean dilemma, by Catherine Gillespie, Paul Grech & Drew Bewsher, Australian Journal of Emergency Management, Autumn 2002.

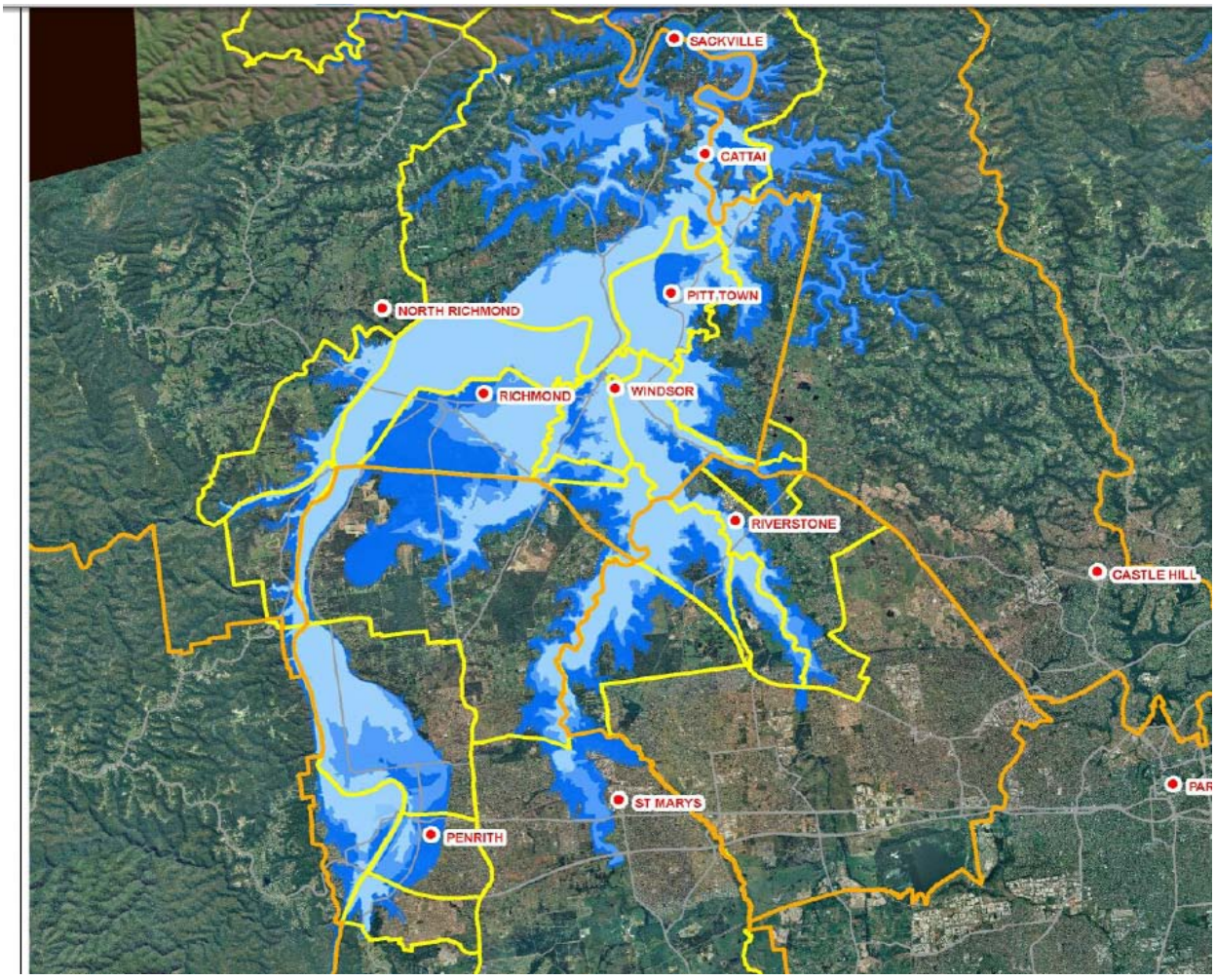
[2] NSW SES, 2005. Hawkesbury/Nepean Flood Emergency Sub Plan, 2005. Hawkesbury/Nepean Flood Emergency Sub Plan, NSW State Disaster Plan (State DISPLAN).

Several of the most severe floods experienced on the Hawkesbury-Nepean River have resulted from East Coast Low Pressure Systems. Among these was the highest recorded flood of June 1867. This flood was also the worst in terms of lives lost and the destruction of property and livestock.

The Sydney Morning Herald published on 24 June 1867 reported:

"*The flood in this district is said to be by far the highest which has occurred since its settlement by Europeans. The town of Windsor itself is almost entirely submerged, and the country for miles around is under water. The expanse of flood is so great, that everybody is astonished at the tremendous accumulation of water, and it will seem incredible to all who have not actually seen it. Places which since the settlement of the colony, have never known to be flooded are now lost to view. The plain on which Windsor is partly situated unites with South Creek and Eastern Creek to form a vast inland sea over the surface of which when the wind has been high the broken crested billows roll with as much force and volume as they do during moderately squally weather in Sydney Harbour. A boat may now be taken through deep water from Riverstone to the Blue Mountains - a distance of about 15 miles; and from Hall's at Pitt Town to the Kurrajong - some twenty miles.*"

The mid blue section on this map shows the 1867 flood:



Source: NSW SES, 2005. Hawkesbury/Nepean Flood Emergency Sub Plan, 2005. Hawkesbury/Nepean Flood Emergency Sub Plan, NSW State Disaster Plan (State DISPLAN).

But what about Warragamba dam, built in 1960 – won't it save us from a major flood? The Sydney catchment Authority website says:

"Some believe that Warragamba Dam...protects the Hawkesbury-Nepean Valley from flooding. In fact, Warragamba was never designed as a flood mitigation dam... it can only mitigate floods to a limited extent."[3]

In fact the second and third highest recorded floods for river were experienced just after Warragamba was built in November 1961 and June 1964. In the 141 years from 1867 to 2005 there were 11 major floods – an average of 1 every 13 years.

Major Floods in the Valley: Year	Height at Windsor (m AHD)
1867	19.20
1961	15.00
1964	14.60
1864	14.40
1978	14.30
1956	13.61
1870	13.49
1990	13.36
1879	12.98
1988	12.65
1873	12.50
1949	11.96

Source: NSW SES, 2005, Hawkesbury/Nepean Flood Emergency Sub Plan, NSW State Disaster Plan (State DISPLAN).

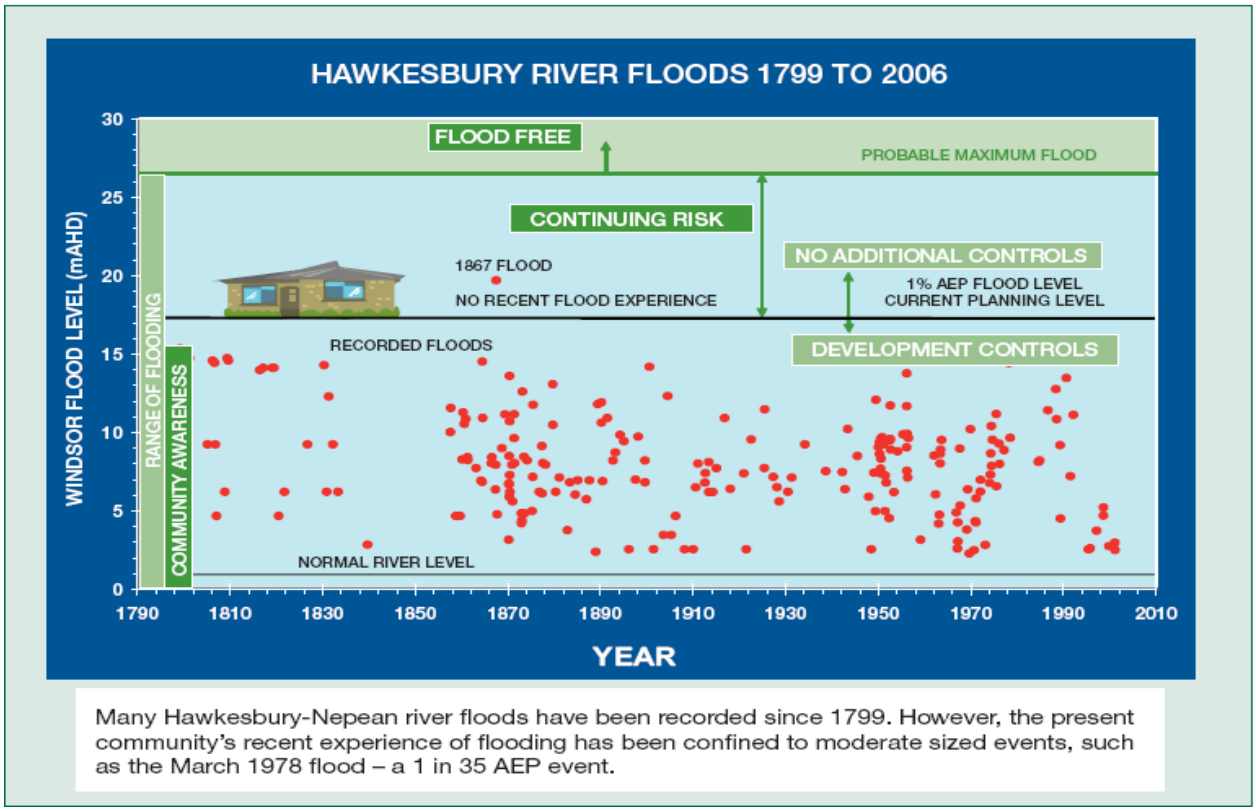
[3] http://www.sca.nsw.gov.au/dams-and-water/major-sca-dams/warragamba-dam/warragamba-a-dam-full-of-myths

So for western Sydney:

Table 2 - Flood Frequency Probability	Wallacia Flood Level (at Blaxland Bridge) m AHD	Penrith Flood Level (at Victoria Bridge) m AHD	Windsor Flood Level (at Windsor Bridge) m AHD
1 in 5 years = 20%	36.8	20.1	11.1
1 in 20 years = 5%	42.5	23.4	13.7
1 in 100 years = 1%	45.8	26.1	17.3
The 1867 flood, now estimated probability of 1 in 170 = 0.4%		26.1-26.9	19.2

Source: NSW SES, 2005. Hawkesbury/Nepean Flood Emergency Sub Plan, 2005. Hawkesbury/Nepean Flood Emergency Sub Plan, NSW State Disaster Plan (State DISPLAN).

Local Councils plan their development around the 1 in 100 year flood level – they use a depth of 17.3m at Windsor, and 26.1m at Penrith. Below this level, development controls are put in place, as can be seen in this diagram for Windsor, which also shows as red dots all the recorded floods:



Source: Managing Flood Risk Through Planning Opportunities - Guidance on Land Use Planning In Flood Prone Areas, prepared for the Hawkesbury-Nepean Floodplain Management Steering Committee, June 2006.

The problem, as stated by flood risk consultants, is that *"Above the 100 year level, it is assumed, wrongly, by the general community that the land is 'flood free'."*[4] Most Councils do not have development controls above the 100 year flood level, although as shown above there is continuing risk above this level.

The paper goes on to say that:

"Windsor and Richmond are now thriving urban centres... Expansion in the 1980's and 1990's with the new suburb of Bligh Park has resulted in a total population of 35,000 in Windsor, Richmond South Windsor and Bligh Park. Parts of Penrith, Emu Plains and Riverstone are all major urban areas with growing populations. All are vulnerable to Hawkesbury-Nepean flooding."

This problem is not confined to Sydney – it's national. There are examples of inappropriate development all over Australia. For example, the Insurance Council of Australia states that *"many thousands of residential properties on Queensland's Gold Coast have been authorised and constructed in locations that place them at extreme risk of catastrophic flooding and coastal inundation."*[5]

The highest risk properties are uninsurable for flood – for this 2-3% of dwellings it's not a possibility that they will be flooded, it's a certainty. It is best to let the insurance market operate freely where it can, but insurance doesn't work in these circumstances because the cost to insure these properties is unaffordable. If these properties go uninsured, the next time there is a major flood, the damage will be extensive and the problem of how to pay for that damage will come up once again.

The cost of insuring flood prone properties must be brought down to an affordable level and a national problem requires a national solution. Most commentators (including the Actuaries Institute) believe that the long term focus needs to be the mitigation of flood risk. However in the short term a solution is required to the cost of insuring high risk properties. The Insurance Council of Australia wants the Government to pay direct amounts to householders and business owners in flood-prone areas to subsidise their insurance premiums. The Actuaries Institute believes that a national funding pool should be set up temporarily to subsidise the cost of insuring high risk properties.

A temporary national pool

The underlying cause of potential flood losses, inappropriate development, needs to be addressed as a priority. The Government needs to mitigate the risk of flood through measures such as revising current building codes, building or improving dams and levees, re-location of high risk properties, and renovations to existing buildings and infrastructure. Every dollar spent in mitigation can save many dollars in future loss payments.

Even if mitigation action starts immediately, it will take 10-15 years to fully implement and become effective. In the interim, the Actuaries Institute recommends government intervention in the market via a temporary national pool for high risk properties, which will facilitate government subsidy of insurance premiums for those in high risk areas. Currently these high risk

[4] Reconciling development with flood risks: the Hawkesbury-Nepean dilemma, by Catherine Gillespie, Paul Grech & Drew Bewsher, Australian Journal of Emergency Management, Autumn 2002.

[5] "Improving Community Resilience to Extreme Weather Events", Insurance Council of Australia, April 2008.

property owners or tenants either cannot obtain home and contents cover for flood at all, or such cover is prohibitively expensive.

In order for these flood mitigation solutions to be successful, local Councils and State Governments must be encouraged to, and rewarded for, undertaking flood mitigation. Councils and Governments need to have "skin in the game" – to have a vested interest in the outcome. The pool can help achieve this.

The Natural Disaster Insurance Review Inquiry into flood insurance recommended in its report last September that *"an agency sponsored by the Commonwealth Government be created to manage the national coordination of flood risk management and to operate a system of premium discounts and a flood risk reinsurance facility, supported by a funding guarantee from the Commonwealth."* The Federal Government will be consulting on this recommendation later this year.

The Actuaries Institute believes that a funding pool will be more successful than direct premiums subsidies from the Government for a number of reasons.

1. The pool encourages actions to reduce risk – the pool would subsidise premiums but it would only do so for homes in areas where the local Council and State Government is carrying out flood mitigation measures. This is the key – tying premium subsidies to incentives to reduce the flood risk in future.
2. A national pool can do more than just reduce premiums – any leftover funds can also provide funding to help State Governments and Councils pay for risk mitigation activities which are otherwise very expensive.
3. When floods occur, the pool can pay out the owners of affected properties where the flood risk is so high that the properties are effectively uninsurable. Having the pool pay out those high risk properties when floods happen rather than trying to insure them, means that insurance premiums will be less expensive, because the insurer is no longer covering those extreme risks.
4. A direct premium subsidy will only make payments to people who are currently insured. But many people are not insured, perhaps because insurance has already become too expensive. A pool would also pay out to uninsured people in high risk properties.

There are lots of options to create funding for such a pool, some of which were explored after Cyclone Tracy. For example funding could come from a combination of a small levy on property premiums, a small levy on local Councils, perhaps payments from property developers, and some Government support. Ideally the pool would be self-funding, and provide funds for mitigation which will decrease future losses.

Over time as the number of high risk properties is reduced, the need for a Government pool will also be reduced. The Actuaries Institute advocates that the pool be wound down over time as the insurance market is able to operate effectively.

Australians also need better information on flood risks, and a pool can also provide funds for national flood mapping. It's encouraging to see that the Government has committed[6] to providing access to existing flood mapping data through Geoscience Australia. Whist much more work is required to beef up flood mapping data, this is a step in the right direction.

Lastly, Sydneysiders need information on the flood risk of our properties. Once better information is available, simple risk classifications can be assigned - either Extreme, High, Medium or Low risk. Insurers will be able to provide all policyholders with a one-page flood risk fact sheet specific to the insured's property. For those without insurance, this information can be provided by their Council in their rates notices.

Maybe the one good thing to come out of the devastating flood events of the last two summers will be increased awareness of flood risk, and a willingness by householders, town planners, local, State and Federal Governments to do more to address it.

Appendix 1

How is the chance of flood measured?

The probability of floods occurring is measured as a 1 in 5, 1 in 50 or 1 in 100 year flood. However this does not mean that a 1 in 100 year flood will only happen once every 100 years. This measure is simply the chance each year of having a particular level of flooding e.g. 1 in100 means one chance in hundred each year on average, or a 1% chance of such a flood occurring each year. Each probability of flood has a depth of water associated with it, expressed in AHD (Australian Height Datum) which represents metres above the low flow level of the river, i.e. the water level of the river after a long dry spell.

[6] "Reforming flood insurance, A proposal to improve availability and transparency", Federal Government Consultation paper, November 2011

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