THE UNIVERSITY OF MELBOURNE

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Comments on EPA draft urban stormwater management guidance

This submission comes from the Waterway Ecosystem Research Group (WERG, http://thewerg.org), and the Melbourne Law School, both based at the University of Melbourne, and from the Melbourne Waterway Research Practice Partnership (http://mwrpp.org), which is a partnership between WERG and Melbourne Water. This Partnership undertakes research with the aim of improving how waterways are managed across the Melbourne region.

We congratulate the EPA for initiating this project; stormwater has long been shown through empirical studies around the world to be a principal degrading mechanism of urban streams (King, Baker, Kazyak, & Weller, 2010; C. J. Walsh, Sharpe, Breen, & Sonneman, 2000), and improving the way it is managed to mitigate these impacts is critical to the long-term health of the streams of Melbourne and Victoria's regional towns and cities. We recognise that guidance based on best-available knowledge is crucial for assisting developers, affiliated sectors, 'responsible authorities' and public sector entities in understanding and fulfilling their General Environmental Duty. We note that it contributes to the 'state of knowledge'.

We thank you for the opportunity to provide comment on the proposed new guidance on stormwater management (document 1739). In making this submission, we have also reviewed the background information (document 1829) and the science review (document 1919). We refer to the three documents simply as the *guidance*, the *background* and the *science review*.

In framing this submission, we first focus on the substantive issues and principles regarding the proposed draft quantitative objectives for urban stormwater in the *guidance*. We then identify where we believe there is the greatest opportunity to improve the current guidance to reflect "best available knowledge at the time of publication" *(background,* p.15). This entails an alternative set of stormwater objectives with more direct links to the existing SEPP water quality and biological objectives. These alternate objectives derive from the long-running Little Stringybark Creek Project, arguably the most comprehensive experiment of stream restoration via catchment-scale stormwater management, worldwide. We describe the methodological and policy innovations that have been developed to implement these stormwater objectives, the community reception and adoption by the Yarra Ranges Council and the Department of Planning and Community Development. Finally, we consider the current presentation of the documents and opportunities to improve the communication of relevant knowledge to the intended audience.

Draft quantitative performance objectives for urban stormwater

The *guidance* suggests that "Performance against the objectives in Table 1 can be used as a signal of the level of risk of waterway values being lost or impacted." (p.7). Four of the objectives of urban stormwater, total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN) and litter are reduction targets relative to mean annual load. The other three objectives relate to baseflow contribution and reduction in mean annual total runoff volume (flow reduction in priority areas for enhanced stormwater management and flow reduction in areas not identified as priority areas for enhanced stormwater management). Both the *basis* and *nature* of these objectives raise concerns.

The basis for targets; desired condition or accepted level of degradation?

Firstly, the BPEM-based targets for reductions in TSS, TP, TN and litter are *relative to no treatment* at the development site (Notes to Table 1, p.7). This approach aims implicitly to limit degradation in water quality resulting from the development site, but it does not explicitly consider the health and protection needs of receiving waterways. This appears to not directly support the SEPP water quality and biological objectives for streams. The SEPP stream objectives are set in terms of an *acceptable departure from reference condition*, while the BPEM targets are set based on a minimum improvement from the worst possible outcome (i.e. no mitigation). It is not possible from this latter to know how close the outcome is to an acceptable departure from the reference condition. But we note that the site-specific focus also takes no account of the context of development in the surrounding area and within the catchment, and therefore effectively ignores cumulative impacts.

We note that this disconnect between the BPEM targets and the SEPP objectives appears to originate at least in part from what appears to be a misunderstanding of the rationale behind the original BPEM targets, expressed in both the *background* document and *science review*. For example, the *science review* suggests that the BPEM targets (80/45/45/70% annual load reductions for TSS, TP, TN and litter) were "based on previous assessments around the reductions in nitrogen loads required to achieve outcomes in the Port Phillip Bay Study (Harris et al., 1996)"(p. 24). This interpretation is not entirely correct, and indeed, *the science review* also noted that "it is possible that the original load reduction targets were determined based on typical stormwater management technology load reduction performance at the time (Sage et al., 2015a), rather than a consideration of what is actually required to protect urban waterways" (p.24).

The BPEM targets (CSIRO 1999) were authored by a team that includes one of the authors of this submission, Tim Fletcher. We note the BPEM targets were *motivated*, at the time, by an identified need to reduce loads to Port Phillip Bay, but the setting of the targets was based primarily on two complementary pieces of logic:

1. The load reductions achieved by a "typical" stormwater treatment measure of the time (deemed to be a constructed wetland of area 1% of its catchment), drawing largely on research at the time from Duncan (1998),
2. A consideration of typical changes in pollutant loads from "rural residential" to "urban", also based largely on research by Duncan (Duncan, 1995a; Duncan, 1999; Duncan, 1995b)

The BPEM document (CSIRO 1999) considered that these load reduction targets provided a surrogate for the SEPP targets, but noted (p.16) that further monitoring data was required to confirm this, and that the targets are pragmatically based on current achievable practice (in 1996-1999, when this work was undertaken). Importantly, the BPEM guidelines explicitly identified the role of setting receiving water objectives (column 2 of Table 2.1, p.15 where the 80/45/45/70% targets are also presented), providing the load reduction targets as a "current best practice performance objective". It recognised that the proposed targets "may not be sufficient to achieve SEPP requirements in some waterways" (p.17).

Given this history, we believe the EPA should strengthen the *guidance* document to link it explicitly to the SEPP water quality and biological objectives (which are currently not mentioned at all). Below, we draw on lessons and methodological developments of the long-running Little Stringybark Creek project and elaborate on a feasible approach that directly links stormwater management objectives to water quality and biological responses. We would be pleased to work with EPA and relevant stakeholders to translate these into stormwater management objectives and guidance that is transparently linked to receiving water needs.

Mean annual load reduction targets and percentage reduction in mean annual runoff volume targets alone do not adequately capture water quality and flow characteristics that are salient for stream protection

Here we wish to stress and illustrate the tight interdependency between the flow and water quality impacts of urban stormwater runoff, which in our view, does not come through clearly in either the *science review* or the *guidance*. While the *science review* explicitly separated water quality and flow as separate concerns, it is important to recognise that both pollutant loads objectives and the SEPP's water quality concentration targets are as much measures of flow as they are of water quality.

We contend that mean annual pollutant loads targets, while appropriate for protection of coastal embayments and other large receiving waterbodies, are inadequate for protecting receiving waters such as streams and wetlands. A mean annual load calculation takes an estimate of total flow over a year, multiplied by an estimate of pollutant concentration *as a function of flow*. Loads thus integrate across a long period, which is useful for large receiving waterbodies with long retention times, but of considerably less value for dynamic, variable systems such as waterways, and even more dynamic and variable 'flashy' stormwater runoff.

SEPP receiving water objectives for pollutants are expressed in the form of percentile concentration targets (CSIRO 1999), reflecting the understanding, as also noted in the *science review,* that pollutant concentrations can have stronger links to public health and ecological outcomes (p.24-25).

In catchments with minimal human impacts, such as forested catchments, stream pollutant concentrations tend to be correlated with stream discharge (e.g. Fig. 1A). In such catchments, increasingly large (and increasingly infrequent) high-flow events increase mobilization of contaminants from catchment soils, and from bank and bed sediments. The SEPP's 75th percentile concentration target aims to ensure that pollutant concentrations remain low for at least 75% of the time, when dry-weather stream flows are low. Forested Olinda Creek almost meets the relevant SEPP 75th percentile TP target of 0.055 mg/L (Fig. 1A) because in its dominant dry-weather (low flow) condition, concentrations in the creek are almost always below the target concentration.

The importance of stable dominant conditions with infrequent high-flow disturbances, implicit in the SEPP water quality objectives, is consistent with the ecological theory underpinning the principles for stormwater management for the protection of stream ecosystems proposed by Christopher J Walsh et al. (2016). The effects of conventional urban stormwater drainage on these dominant conditions is to reduce dry-weather stream discharge, and increase pollutant concentrations (e.g. Brushy Creek, Fig. 1B). As we can clearly see comparing Figs 1B and 1A, the value of its 75th percentile discharge (vertical dotted line at <0.3 mm/d) is very much lower than that of Olinda Creek (~1 mm/d) and most of its TP concentration measurements sit at much higher levels. Urban streams like Brushy Creek also experience spikes in pollutant concentrations when pollutants drain unpredictably down stormwater drains in dry weather (upper left region of Fig. 1B).

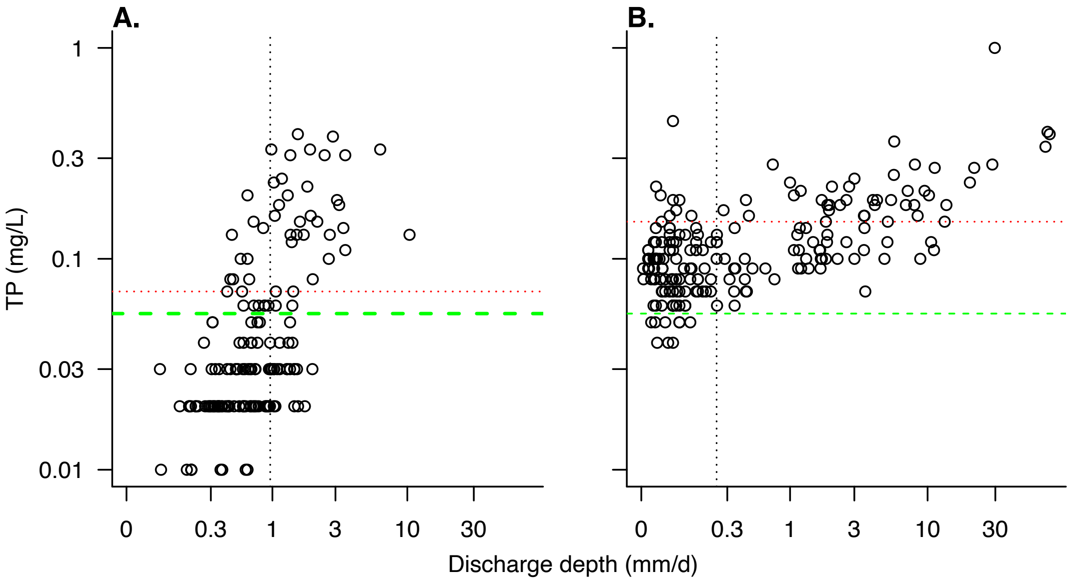


Fig. 1. Total phosphorus (TP) concentrations vs stream discharge for two small streams of similar size A. Olinda Creek (forested catchment with near-zero urban stormwater impacts) and B. Brushy (predominantly urban catchment with 22% effective imperviousness, EI). The vertical dotted line indicates the 75th percentile discharge, and the red horizontal line indicates the 75th percentile TP concentration. The green horizontal line indicates the SEPP objective for 75th percentile TP concentrations for lowland Yarra streams (0.055 mg/L). Data (from 2009-2019) from the Little Stringybark Creek Project.

Conventional urban stormwater drainage reduces dry-weather flows by reducing infiltration into catchment soils (although this effect can be countered by leakage from other water infrastructure in some urban areas: e.g. Bhaskar et al., 2016). It also greatly increases the frequency and magnitude of flow (and concomitant water quality) disturbances, as shown in the daily stream flow patterns of forested Olinda Creek (Fig. 2A) and urbanised Brushy Creek (Fig. 2B) over the course of a typical year.

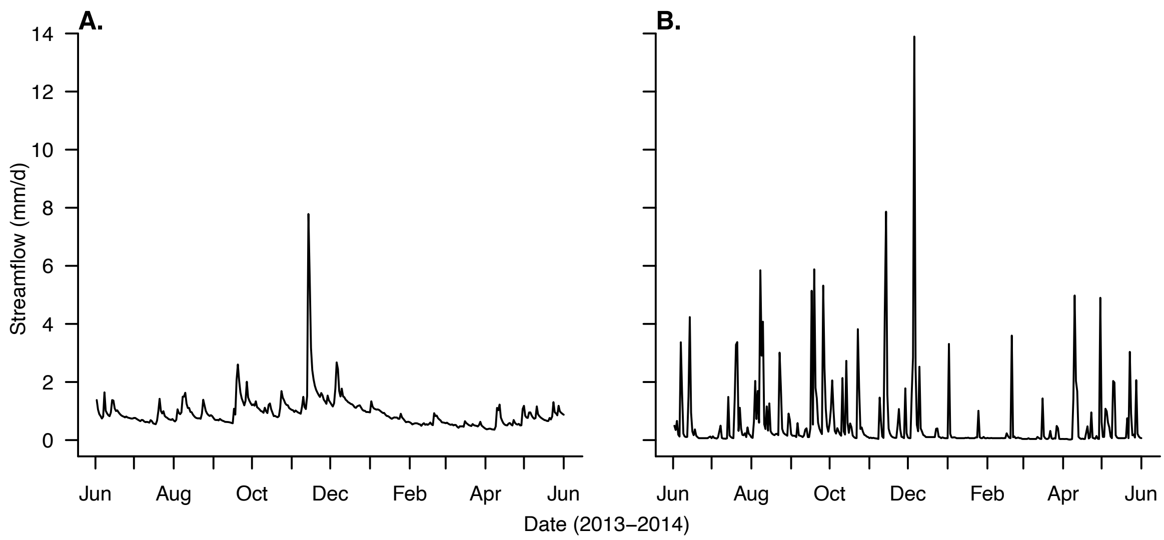


Fig. 2. After Burns, Fletcher, Walsh, Ladson, and Hatt (2012), contrasting daily stream flow patterns over a typical year in: A) Olinda Creek and B) Brushy Creek (see Fig. 1). Note higher baseflows, and much smaller high-flow responses to most rain events, with longer recession times in Olinda Creek. There was a single large high-flow disturbance in Olinda over the year compared to >20 in Brushy Creek.

An effective management response to mitigate these combined flow-regime and water quality effects must begin with a requirement that all impervious surfaces drain first to stormwater control measures that overflow only infrequently (Principles 2 and 3 Walsh et al 2016). Importantly, such a requirement would also provide the basis of means for effectively mitigating the cumulative impacts of stormwater runoff (see also Nelson 2019). Mean annual load reduction objectives *do not* clearly communicate such a requirement (for instance the TP load carried by <75th percentile flows (Fig. 1B) is <1% of Brushy Creek's total TP load).

Arguably, percentage reduction targets in mean annual total runoff volume of 25% (non-priority areas) or 50-90% (priority areas) have a similar shortcoming, when used alone, to mean annual loads as an objective—too long a time-scale for dynamic flowing waters, and also lack of specificity in how they are to effectively ameliorate the greatly increased frequency and magnitude of stormwater runoff flow disturbance.

Since the introduction of load reduction targets in the 1999 BPEM guidelines, design of stormwater control measures (SCMs) has focused primarily on filtration or biotic uptake of pollutants in wetlands or through bioretention systems with rapid flow-through rates. Such systems can reduce loads, but do little to dampen the greatly increased frequency and magnitude of flow disturbance (Burns et al., 2012). After 20 years of urban growth and redevelopment in Victoria under the 1999 BPEM guidelines, the only response to increased urban development that has been observed is further ecological degradation of waterways (e.g. degradation of the Yarra River at Templestowe, or Toomuc Creek downstream of the Pakenham growth corridor, Fig. 3). Alternative approaches to stormwater management for stream protection are clearly required (Christopher J Walsh et al., 2016).

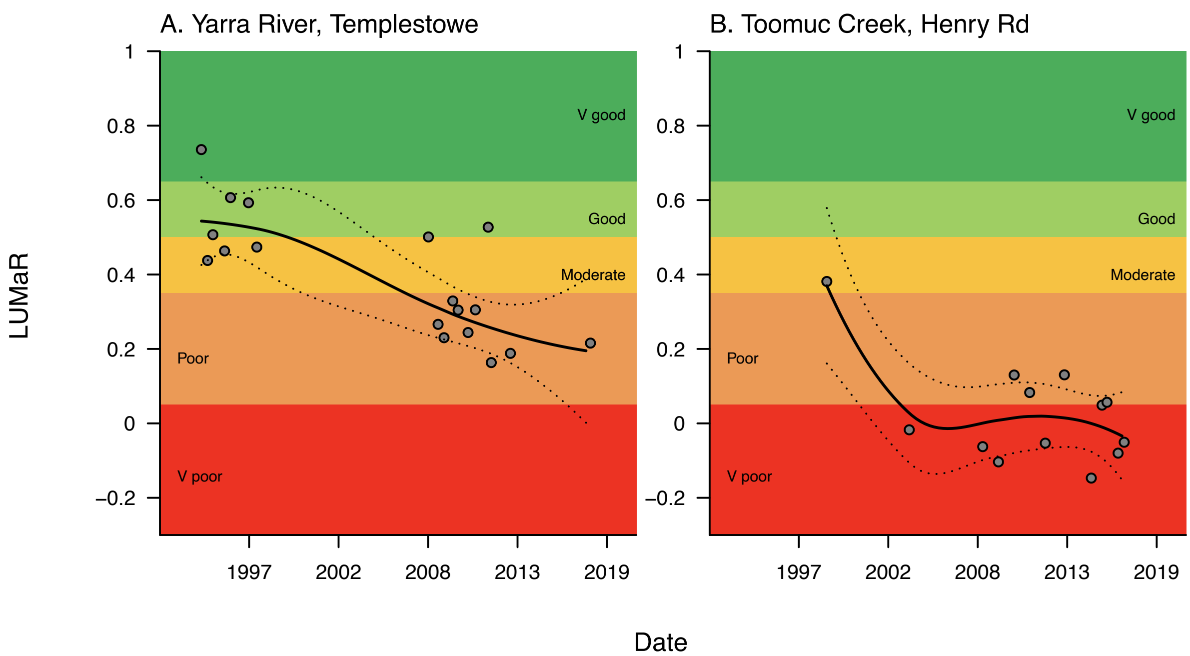


Fig. 3. LUMaR scores (a biotic index based on macroinvertebrate assemblage composition: see C.J. Walsh & Webb, 2013) for A. The Yarra River at Templestowe and B. Toomuc Creek downstream of Pakenham showing degradation over the last 30 years associated with urban growth.

Alternative SEPP-linked objectives for stormwater management and metrics for putting them into operation

Previously, we highlighted the inadequacy of mean annual pollutant loads reduction targets as measures of SCM efficacy for stream protection. We propose metrics for SCM performance that link to effective imperviousness (EI[1]), which is a strong predictor of stream ecosystem response. These metrics permit robust predictions of stream response (including of measures of SEPP compliance) to stormwater management actions that are not possible with loads-reduction objectives proposed by the *guidance*. While the metrics include elements proposed by the *guidance* (baseflow contribution and volume reduction), they are scaled between worst-case (conventional stormwater drainage) and target condition. The four metrics integrate the principles for stream protection proposed by Walsh et al. (2016). They are integrated into a single objective for ease of communication.

In this section, we describe the logic and derivation of our SCM performance metrics. In the following section, we describe how they have been applied as targets, which have been tested, implemented (through the Yarra Ranges Council and the Department of Planning and Community Development), accepted by a catchment community in the LSC Project, and have resulted in in-stream improvement consistent with predictions.

The degradation of stream ecosystems by urban stormwater runoff is well established, primarily through spatial studies that have demonstrated a strong negative relationship between indicators of ecological health and EI (Fig. 4). EI, in its original form (Leopold, 1968), only counted impervious surfaces that drain to a stream directly by lined stormwater conveyances. Impervious surfaces that drain to pervious land (informal drainage), allowing infiltration into catchment soils, were not included. In peri-urban eastern Melbourne, where stormwater infrastructure is heterogeneously distributed, EI is a stronger predictor of in-stream ecological degradation than is total imperviousness (i.e. including all impervious surfaces: Hatt, Fletcher, Walsh, & Taylor, 2004; C.J. Walsh, 2004; C.J. Walsh, Fletcher, & Ladson, 2005). While this is evidence that impervious surfaces are important contributors to stream degradation (even at very low levels), it does not follow that informally drained surfaces have no effect on streams, only that their effect is substantially smaller. While small, the effects of surfaces draining to pervious land are likely to vary with the length and nature of the flow paths between them and the stream.

Like informal drainage, stormwater control measures (SCMs) break drainage connection, and the degree to which they do so is a function of their specifications. SCM performance can be quantified by the degree to which the SCM mimics natural catchment processes (e.g. Walsh et al. 2009) and thereby reduces the EI of upstream contributing impervious areas. We can think of this as how well an SCM or SCM treatment train "discounts" the contributions of impervious areas to EI. For instance, a development with a combined harvesting and infiltration SCM that overflows only as frequently as large flow events occur in the receiving stream (at pre-development level), and provides filtered flows of a similar quality, quantity and flow pattern as from undeveloped parts of the catchment, is essentially fully disconnected. In other words, the contribution of this development to EI is reduced to zero by its SCM (in effect, discounted by 100%). Conversely, a development whose SCM retains only 1 mm of runoff before overflowing continues to count substantively towards EI (discounted by a tiny %).

[1] also known as directly connected imperviousness (DCI): the proportion of a catchment covered by impervious surfaces with direct drainage connection to a stream

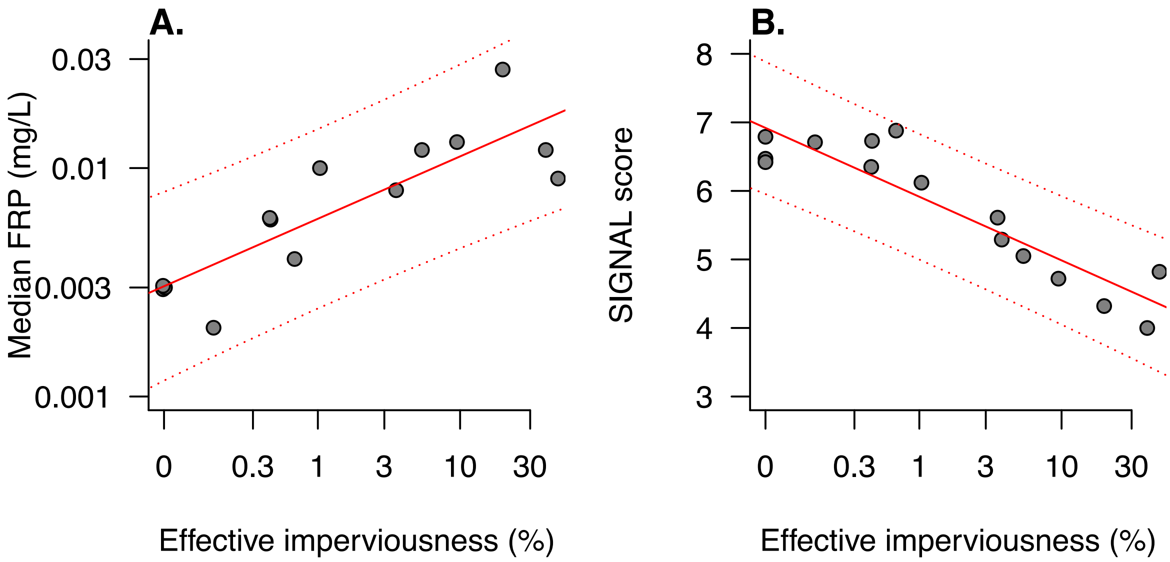


Fig. 4. Two variables related to SEPP water quality and biological objectives: A. Median filterable reactive phosphorus (FRP) concentrations and B. SIGNAL score (of edge samples) plotted against effective imperviousness (*EI*) values used by Walsh et al. (2005). The linear regression against $\log_{10}(EI + 0.001)$—solid red line with dotted 95% confidence limits—differs from the piecewise regression model (used by Walsh et al. 2005, to model a threshold). Five overlapping points are shown by slight jittering.

We developed a combined metric of SCM performance, the "Environmental Benefit" EB index[2] (Fletcher et al., 2011; C.J. Walsh, Fletcher, Bos, & Imberger, 2015), based on the principles for urban stormwater management to protect streams proposed by Christopher J Walsh et al. (2016). The EB index is the *average* of four sub-indices that measure ecologically-meaningful flow and water quality characteristics and *relate them to target/reference conditions*. The four sub-indices are:

1. Runoff frequency (RO) – the frequency of flows[3] that overflow from the SCM or that exceed the maximum acceptable flow rate for filtered flows (set by baseflow behaviour in reference streams). RO monitors runoff from impervious surfaces during dry-weather, and frequent small rain events, to target the primary cause of elevated dry-weather and every-day rain-event pollutant concentrations in degraded urban streams (Fig. 1B).
2. Filtered flow (FV) – the volume of filtered/treated flow contributing to baseflows at a rate not exceeding the maximum acceptable flow rate, where the optimal volume falls between streamflow ranges predicted for forested and pasture catchments (C J Walsh, Fletcher, & Burns, 2012; Zhang, Dawes, & Walker, 2001). FV aims to ensure filtration/treatment of flows returning to streams.
3. Total volume flowing to stream (VR) – the volume of water not lost through harvesting or evapotranspiration, with the target volume being streamflow ranges as for FV.

[2] See also: https://tools.thewerg.unimelb.edu.au/EBcalc/ and https://urbanstreams.net/lsc/EBcalctech.html. The EBcalc website is a compliance tool using open-source code that could easily be integrated into MUSIC freely by eWater, providing a user-friendly tool to industry. Equally, it could be adopted by EPA, DELWP or other agency, as part of the implementation of this new stormwater guidance.

[3] In publications in preparation, flows are weighted by the volume of each flow event: see also Walsh et al. 2009.

4. Water quality (WQ) – mean of indices based on predicted median[4] concentrations of TN, TP and TSS, using MUSIC estimates for conventional drainage, and SEPP concentration targets as reference. WQ aims to ensure that the filtration or treatment process meets SEPP objectives.

Note that each sub-index simultaneously targets both flow and water quality, because they are inter-related and interact to degrade waterways. Each sub-index is scaled between the level observed in the absence of stormwater control (i.e. conventional drainage, discount = 0%) and the target level based on reference (pre-development condition, discount = 100%). The closer to 100% the EB index, the more effective the SCM/SCM treatment train performance in reducing EI.

As an example, consider a 125 ha catchment with 10 ha of impervious surfaces connected to a conventional stormwater drainage system: EI = 8%. The drainage network ends in two separate drains that discharge into the stream, one with 4 impervious ha, and the other with 6. Let us now install many SCMs throughout the catchment, all of which overflow to the drainage network and ultimately either to a wetland at the end of the first pipe (4 impervious ha) or a bioinfiltration system at the end of the second pipe (6 impervious ha). Accounting for the performance of all the upstream SCMs, the wetland scores an EB of 75% and the infiltration system scores an EB of 90%. Discounting EI by these EB scores (EI_{EB}) reduces the catchment EI from 8% to:

$$EI_{EB} = (10 – 4*0.75 – 6*0.9)/125 = 0.013 \text{ (i.e. 1.3\%)}$$

Using data from the study reach where we achieved the greatest level of disconnection, we show the contrast between expected growth in EI over time in the absence of stormwater control (red, dashed EI line) and the reduction in EI achieved by SCM implementation explicitly guided by the EB Index (orange EI_{EB} line) (Fig. 5A). By 2014, SCM implementation had successfully reduced catchment EI from ~6% to <3% (Fig.5A).

The effect of the SCMs on TP (Fig. 5B) was consistent with the predicted response that we had inferred from the relationship between EI and TP among sites: a ten-fold reduction in EI approximately halved TP after 2 mm of rain in the previous day. However, the effect size varied with antecedent rain. Importantly, the effect of the SCMs was strongest during dry weather and the frequent small rain events, meaning that the SEPP target 75th percentile concentration was achieved after installation of the SCMs, but not without SCMs.

Analysis of biological responses is ongoing. We have not yet observed colonization of new taxa that would increase indices of biotic condition such as SIGNAL, but there is evidence that SCM implementation has increased abundance of more sensitive taxa. Recruitment lags and barriers may limit biological recovery. Further reduction in EI may also be necessary to achieve biological recovery.

[4] The use of median concentration for filtered outflows, which can be estimated from the MUSIC algorithm, is an adequate match for the 75th percentile SEPP objectives because stormwater flows are only generated on <40% of days, even in the wettest part of the state.

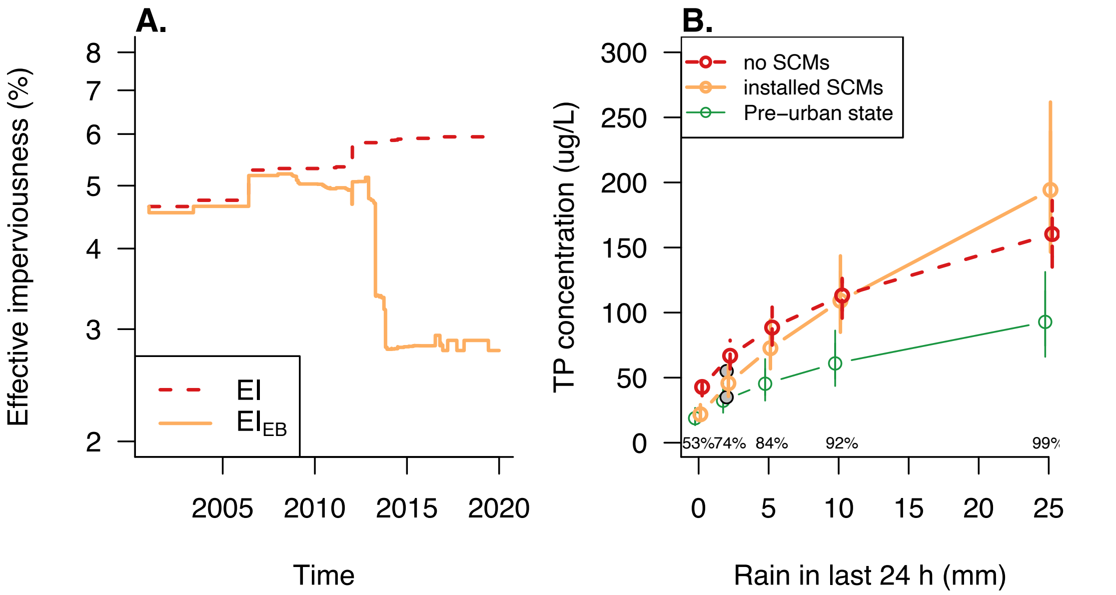


Fig. 5. A. Variation over time in EI (red, dashed line, assuming no SCMs), and EI_{EB} (orange, solid line, showing the reduced EI achieved by SCMs installed in the catchment with performance as estimated by EB scores: see text) in the Wattle Valley Creek catchment, in which the Little Stringybark Creek Project most successfully reduced urban stormwater impacts. B. Total Phosphorus concentrations in Wattle Valley Creek that were achieved in the project (orange, installed SCMs) plotted against rainfall in antecedent 24 h (*rain1*), compared to concentrations in the absence of SCMs (red, dashed) and those observed in reference streams in the absence of urban stormwater impacts (green). The values at each point are medians with 89% (thick) and 97% credible (thin) intervals predicted from a hierarchical model of TP variation over 20 years at 6 experimental sites, 2 control sites and 3 reference sites as a function of *EI*, change in *EI* as measured by EI_{EB} (ΔEI_{EB}, i.e. the effect of the SCMs), *rain1*, rain in antecedent year, channel disturbance and interactions *of EI*, ΔEI_{EB} with *rain1*. (Upublished manuscript in preparation). The percentages indicate the proportion of days with less rain than each value of Rain1. The grey filled points at the 75th percentile rainfall (~2 mm rain1) are the SEPP objectives for TP: 35 µg/L for upper Yarra streams, which matches the pre-urban state well, and 55 µg/L for lowland Yarra streams, which this site was not achieving prior to SCM installation, but was surpassed with SCM installation.

> Our process-based indices permit prediction of stream response if an SCM or SCM treatment trains of known specifications are implemented. The indices thus permit setting of objectives for SCM design and performance that have a high probability of achieving SEPP objectives, and determination of the degree of degradation that is likely for non-complying SCMs.

Real-world application of the alternative stormwater management objectives and their reception by the community, local and state government: the Little Stringybark Creek Project

The LSC Project, as a large-scale experiment, implemented its SCMs using the EB Index to prioritise SCM investment to ensure the greatest protection from urban stormwater runoff for minimum cost, given the finite project budget (Bos & Brown, 2015; Nemes et al., 2016). Further, to ensure the long-term protection of the investment, and to permit progressive increase in stream protection as building stock in the catchment turns over, we worked with Melbourne Water, Yarra Ranges Council (YRC) and the Victorian Department of Planning and Community Development, to develop stormwater management objectives for all new constructions in the Little Stringybark Creek catchment. These objectives are formalised as requirements for all new constructions in the Little Stringybark Creek catchment (Rossrakesh et al., 2012), under a Yarra Ranges Council ordinance (the LSC Environmental Significance Overlay, ESO). The LSC ESO and its objectives, adopted into the

Yarra Ranges Planning Scheme (through the Department of Planning and Community Development), have been well accepted by the catchment community (Melbourne Water, 2017). A survey of planners found fair capacity in administering the ESO and that the ESO process was functioning fairly well (Melbourne Water 2017). The YRC have also committed to ensure any council works not covered by the ESO will also meet the objectives.

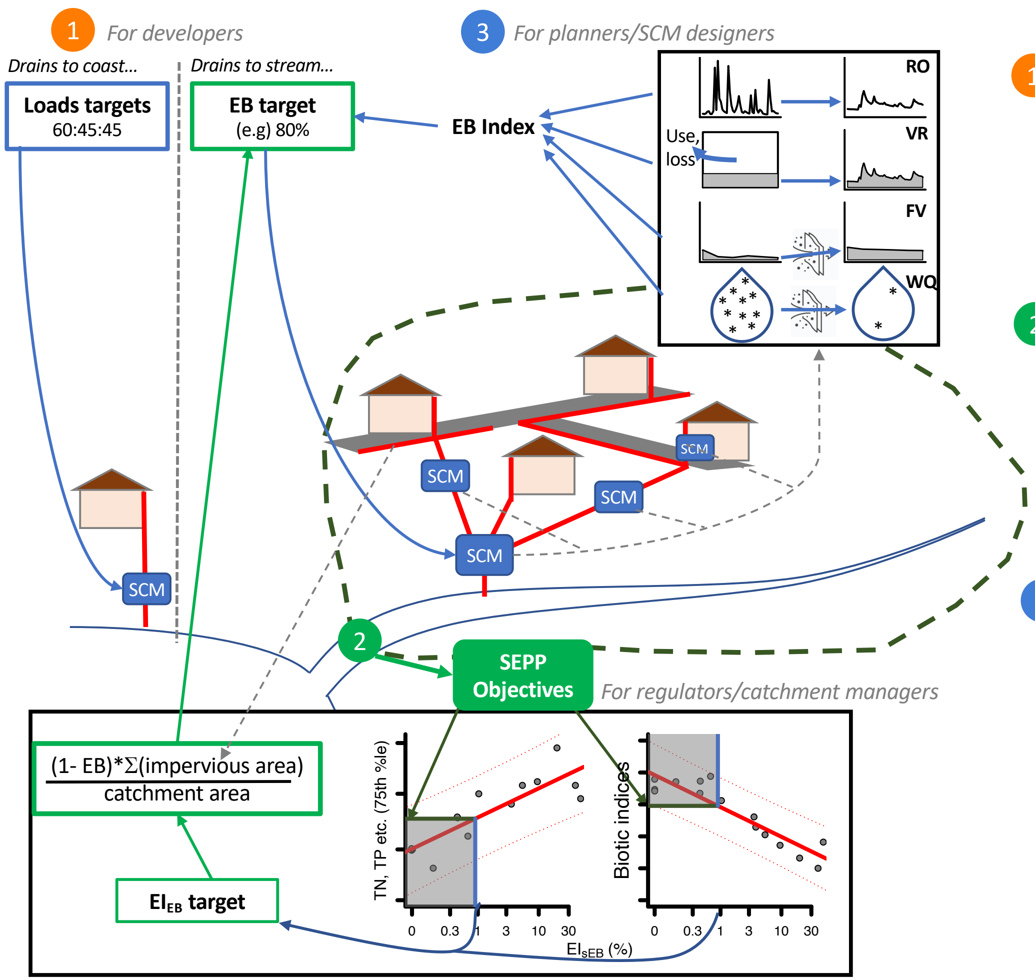
The LSC ESO objectives use a variant of the EB Index (excluding the water quality sub-index, for simplicity of calculation) and require a minimum achievement of 60% of the best possible index score for every development. Compliance has been facilitated and ensured by technical staff providing analyses with custom-built software. EB Index and sub-index scores (including the water quality sub-index) can also be calculated with MUSIC, but a simple-to-use module in MUSIC for this purpose still needs to be developed. Discussions with eWater (the custodians of MUSIC) on the development of this module have commenced and this capability is expected to be available within MUSIC by mid-2021.

Outline of a decision process for the alternative stormwater management objectives
Whilst there is some complexity in the calculations for the EB Index (and its component sub-indices) it can be easily handled with software tools "working in the background". A clear and transparent decision process for implementing the alternative SEPP-linked stormwater management objectives could be framed for developers, affiliated sectors, 'responsible authorities' and public sector entities. We provide a schematic example of such a process with clear decision points and requirements for developers, regulators or catchment managers and planners and SCM designers (Fig. 6). As we can see, the outlined approach takes a 'catchment-view' of developments (not just a site-specific view), thereby allowing the regulator or catchment manager to take account of cumulative stormwater runoff impacts and mitigate these by setting an appropriate EB target.

In summary, these alternative stormwater management objectives:

a) have been successfully trialled, implemented in practice in the Little Stringybark Creek Project and formally incorporated into the Yarra Ranges Council Planning Scheme
b) have the ability to predict SEPP objective compliance (based on the demonstrated relationships between SEPP objective metrics and EI, both in degradation [Fig. 4] and in restoration [Fig. 5B])
c) have demonstrated the possibility of restoration of degraded streams through well-designed SCM implementation explicitly guided by these objectives. (This demonstration provides strong evidence that protection of stream ecosystems in greenfield settings can be achieved with this approach.)
d) are scalable from site scale to catchment scale
e) provide the means to genuinely mitigate the cumulative impacts of urban stormwater

In light of the demonstrated feasibility and benefits, we submit that these alternative stormwater objectives (or similar) and the methods for putting them into practice should be included in the *guidance*.



1 ***For developers***, the proposed standard will require meeting one of two targets. If the development drains directly to coastal waters, **loads target** apply. If it drains to a river, stream, or small estuary, stormwater control for the development must meet a single **Environmental Benefit (EB) target**, expressed as a percentage.

2 ***The target is set by the regulator or catchment manager*** with the aim of meeting the relevant SEPP objectives. The EB target is calculated by determining the effective imperviousness required to meet the SEPP objectives (EI_{EB}). The EB target is then set by estimating the ultimate catchment impervious coverage for the catchment.

3 ***Planners & stormwater control measure (SCM) designers*** can then design SCM treatment trains by maximising performance in each of the EB sub-indices: runoff volume (RO), volume reduction (VR), Filtered flow volume (FV), and water quality (WQ). SCMs upstream of the terminal SCM should improve its EB: for instance, maximal harvesting with no infiltration is acceptable for an upslope SCM, if it improves the EB of the downslope infiltration system. It is highly likely that achieving the EB target will also achieve the loads reduction targets. The proposed volume reduction targets are also met by the VR sub-index.

Fig. 6 Conceptual outline of a decision process for how the proposed stormwater management objectives could be implemented.

We note that in addition to the Little Stringybark Creek Project example, there are other precedents and examples of ambitious, process-based, quantitative stormwater management objectives with stronger links to SEPP objectives. The flow objectives adopted by Melbourne Water's Healthy Waterway Strategy (HWS) are a case in point. The HWS implementation of this objective is superior to that proposed for the guidelines in that the required volume reduction is set as a function of mean annual rainfall, and therefore implicitly scaled to the target condition. Volume reduction is useful because it emphasises that a major challenge in meeting runoff frequency and filtered volume targets is the need to prevent large volumes from flowing to the stream: this is the case both for dry catchments with intermittent or ephemeral streams and wet catchments (Duncan, Fletcher, Vietz, & Urrutiaguer, 2014) with perennial streams (Duncan, Fletcher, Vietz, & Urrutiaguer, 2016). But stream protection also requires explicit emphasis of the need to manage those impacts that directly degrade stream ecosystems: increased frequency and magnitude of polluted flows, and reduced dry-weather flows. It should also be noted that volume reduction is an annual measure, and therefore has similar a shortcoming to loads as an objective – too long a time-scale for dynamic ecosystems such as rivers. However, volume reduction is a useful objective for communication and encouragement of a primary tool for stream protection, if it is used in tandem with RO, FV and WQ.

<u>Other comments on the proposed guidance</u>

Delivering effective stormwater guidance, as outlined above, requires clear communication of the nature of the stormwater problem, and the opportunity that it presents.

The importance of hydrology (and pollutant concentrations)

As noted in the *science review* and *background* document*,* the role of hydrology as a primary degrading mechanism of urban waterway health is now well understood and described by empirical scientific studies, both in Australia and internationally. We note also that reduction of a given volume of stormwater runoff flowing to a stream removes 100% of the pollutants in that flow; the benefits of this are demonstrated in the description of the Little Stringybark Creek Project. This seemingly obvious point is not made in the main body of the *guidance* document, meaning that readers may not understand how central flow regime management is to managing stormwater's impacts on waterway health and water quality. The point is made in the Appendix of the *guidance* document, but we believe it is a point that should be clearly and prominently made early on in the *guidance* document. It could also be supported in the *background* document (e.g. the bullet list on p.6, or the description on p.7 of the BPEM guidelines only being about water quality, which is not correct: see Nelson 2019, p. 786).

It is also important to be consistent on the point of stormwater runoff flows being the cause and conveyor of pollutants, and of spikes in pollutant concentration **(we note here also the importance of concentrations to stream ecosystems, as expressed by the concentration-focus of the SEPP objectives for stream water quality**). For instance, on page 8 of the *guidance* document, the sentence, "Preventing harm from urban stormwater by minimising pollutants and increased flows…" seems to confuse the matter. We believe it would be better to describe stormwater management as needing "*to achieve water quality and flow regimes that can support healthy stream ecosystems"*. Such an argument is far more consistent with the SEPP objectives, which ultimately underpin this guidance.

While the interaction of hydrology and water quality is noted and described by the new *guidance*, there are some surprising omissions in the document that undermine its ability to communicate the combined and interactive effect of changes to flow and water quality regimes. An important example of this omission is in the introductory section on p6 of the *background* document, where a bullet-point list is provided, which includes the need to reduce pollutant loads, but omits the need to "reduce changes to the flow regime" and does not link to SEPP concentration targets. While the authors of the *background* document clearly understand that all are required, omitting this in this vital early stage of the *background* risks reinforcing the common misconception that stormwater management is only about load reduction.

Given the centrality of hydrology as a degrader of waterway health, we would argue strongly that EPA and other stakeholders such as DELWP need to work to ensure that flow targets are supported by appropriate performance standards and compliance arrangements. Perversely, the wording throughout both the *guidance* and *background* documents appears to encourage the reader to ignore flow, repeatedly noting that proposed flow reduction objectives are not compliance requirements (three mentions in the space of 14 pages of the *background*). This seems to guarantee that the flow management guideline will be ignored, just as the BPEM guidelines' flow management target (through Clause 56) has been universally ignored. If this is the outcome, this new *guidance* will have little practical effect, which would be a great pity.

To assist duty holders to understand their duties in a way that recognises the connections between flows, pollutant concentration, harm, and their own responsibilities, the *guidance* should explain the relationship between the flow and pollutant reduction objectives (which are expressed in the aggregate, as cumulative effects) and the factors relevant to what will be considered 'reasonably practicable' at the level of individual duty-holders. In other words, duty-holders need to understand how to respond to their individual contribution to cumulative impacts, which is explicitly recognised in the 'Reasonably Practicable' publication (Pub 1856, p. 9) but not mentioned explicitly in the *science review*, *background* or *guidance* documents. By definition, considering cumulative impacts requires considering the effect of an individual action in the context of all previous and imminent degrading actions. We suggest that the *guidance* explains the relationship between cumulative targets, the 'consequence' of harm, and the assessment of risk of harm that all influence what it is reasonably practicable for the duty-holder to do. We note that other governments consider that the harm of an individual action should be understood as *more* significant (i.e. of higher consequence) where pre-existing cumulative impacts are higher (Australian Government Department of the Environment, 2013; Eccleston, 2006). At minimum, the *guidance* should suggest that the fact that a receiving waterway is relatively degraded does not mean that duty-holders have a reduced obligation to address flows relative to other areas.

On a related note, given that the intent of the General Environmental Duty is to prioritise preventing harm, the *guidance* could also be strengthened by taking every opportunity to emphasise that the first consideration with respect to 'reasonably practicable' is elimination of the hazard/risk (doc 1856, p4). Elimination of the stormwater runoff hazard is currently not mentioned anywhere in the main text of the *guidance*—it only appears in footnote 1 and Figure 2. The notion of using integrated water management thinking and design as a control for preventing harm by eliminating or minimising risks from stormwater runoff is also surprisingly absent from section 2.2 on 'Implementing controls' in the *guidance* document. The following section explains the importance and tangible benefits of these perspectives.

Treating stormwater as a risk, an opportunity, or both?

The *guidance* is explicit in presenting urban stormwater management within a risk framework. While this is a helpful framework, we see the complete omission of opportunity as counter-productive to the aims of this *guidance*. While the EPA's regulatory framework aligns well with a risk-based approach, the ability to convince developers and others of the merits of improving stormwater will also depend on their perception of costs versus benefits.

If the audience of this *guidance* are convinced of the potential benefits—to them—of improved management of stormwater, they will be more likely to comply with the guidance being given. Specifically, section 2 should be re-framed to communicate the potential opportunities that improved stormwater management provides, including:

1. Provision of a cost-effective supplementary or alternative water supply (e.g. Marsden Jacob Associates, 2007)
2. Reduction of flood-mitigation requirements (e.g. Burns, Schubert, Fletcher, & Sanders, 2015)
3. Enhancement of urban amenity (e.g. de Graaf & van der Brugge, 2010)
4. Mitigation of urban heat island effects (e.g. Endreny, 2008)
5. Improved health and resilience of urban vegetation (e.g Grey, Livesley, Fletcher, & Szota, 2018)

Given the imperfect nature of compliance efforts around stormwater management, we believe it is imperative that the EPA's regulatory framework – which is focussed around risk – not constrain the *effective communication* of stormwater as a simultaneous risk and opportunity. Where compliance is imperfect, willing engagement of stakeholders in the prescribed management approach is critical.

The central role of harvesting in any feasible solutions

Given the central role of the flow regime, it is our view that the *guidance* document does not adequately explain the importance and opportunity of stormwater harvesting in the early parts of the document. This means that the reader is not well prepared for the presented scenarios, many of which rely quite strongly on rainwater or stormwater harvesting. Specifically, we suggest:

1. As described previously, revise section 2 (Managing urban stormwater risks) to present both the risks and the opportunities. This could be done in a way that maintains the risk framework as is (ie. as Section 2.1), but adds another section (2.2) on "Managing urban stormwater opportunities"
2. Renaming "stormwater treatment examples" and similar terminology to "stormwater management examples" (and similar). This is a subtle but important change, because the use of "treatment" implies water quality only, adding to an implicit focus in the *guidance* document on water quality alone, rather than properly integrating the combined, interactive threat of flow and water quality regimes.

Differentiating standards between "high value" and "low value" reaches/catchments

The guidance draws on the distinction of priority areas for enhanced stormwater management, from Melbourne Water's Healthy Waterways Strategy. The rationale that high-value waterways should be given highest priority for restoration and protection efforts was first outlined in the Rutherfurd et al.'s (2000) stream rehabilitation manual. This concept argues that investment of (typically public) funds in stream rehabilitation should be prioritised towards waterways with significant value.

We do not believe it is appropriate to simply apply this logic to stormwater management standards. The demonstrated potential for restoration of streams degraded by urban stormwater runoff, and the acceptance of the LSC ESO that will permit progressive reduction in EI as building stock turns over in the catchment, points to the importance of strong objectives for stormwater retention and treatment in catchments draining to streams already damaged by urban stormwater runoff. Allowing development in non-high-value waterway catchments to proceed with lower standards results in greater degradation. This effectively results in future generations subsidising today's developers in non-high-value catchments, transferring the cost of meeting standards today to future generations in restoration efforts. This approach also risks being seen as allowing ecological 'sacrifice zones' in a way that is inconsistent with recognising the social value of waterways (recognised explicitly on p. 11 of the *guidance*). It would appear difficult to justify such differentiated protection of social value. This prioritisation logic also risks undermining significant investment in planned restoration efforts for currently degraded waterways (e.g. Chain of Ponds Collaboration) by applying standards that allow continued and greater degradation depending on the current condition of a waterway.

We believe that the Rutherfurd et al. (2000) prioritisation logic is thus appropriate for guiding of public investment, but should not be used to differentiate the degree of allowable degradation to waterways, based on their current condition.

Utility of the provided scenarios

We believe that the scenarios presented in the *guidance* are a very useful inclusion; they give the practical solutions to achieve the specified objectives. In general, they are clear, practical and helpful. We think it could be helpful to provide some form of conceptual diagram to help guide readers in which scenarios they may apply in what situation.

If you have any questions regarding this submission, please do not hesitate to contact us. We would be happy to provide further information and/or a briefing. We are keen to work EPA and relevant stakeholders on developing stormwater objectives that give our streams a genuine chance of meeting SEPP targets and methods for their implementation.

Yours sincerely,

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Cited references

Australian Government Department of the Environment. (2013). *Significant Impact Guidelines 1.3: Coal Seam Gas and Large Coal Mining Developments—Impacts on Water Resources*. Retrieved from Canberra:

Bhaskar, A. S., Beesley, L., Burns, M. J., Fletcher, T. D., Hamel, P., Oldham, C. E., & Roy, A. H. (2016). Will it rise or will it fall? Managing the diverse effects of urbanization on base flow. *Freshwater Science, 35*(1), 293–310.

Bos, D. G., & Brown, H. L. (2015). Overcoming barriers to community participation in a catchment-scale experiment: building trust and changing behavior. *Freshwater Science, 34*(3), 1169–1175. Retrieved from http://www.jstor.org/stable/pdfplus/10.1086/682421.pdf

Burns, M. J., Fletcher, T. D., Walsh, C. J., Ladson, A. R., & Hatt, B. E. (2012). Hydrologic shortcomings of conventional urban stormwater management and opportunities for reform. *Landscape and Urban Planning, 105*(3), 230–240. doi:doi:10.1016/j.landurbplan.2011.12.012

Burns, M. J., Schubert, J. E., Fletcher, T. D., & Sanders, B. F. (2015). Testing the impact of at-source stormwater management on urban flooding through a coupling of network and overland flow models. *WIREs Water, 2*(4), 291-300. doi:10.1002/wat2.1078

de Graaf, R., & van der Brugge, R. (2010). Transforming water infrastructure by linking water management and urban renewal in Rotterdam. *Technological Forecasting and Social Change, 77*(8), 1282-1291. doi:10.1016/j.techfore.2010.03.011

Duncan, H. P. (1995a). *A bibliography of urban stormwater quality*. Melbourne, Australia: Cooperative Research Centre for Catchment Hydrology (Report 95/8).

Duncan, H. P. (1998). *Urban Stormwater Quality Improvement in Storage.* Paper presented at the HydraStorm 98, 3rd International Symposium on Stormwater Management, Adelaide, Australia.

Duncan, H. P. (1999). *Urban Stormwater Quality: A Statistical Overview* (Report 99/3). Retrieved from Melbourne, Australia:

Duncan, H. P. (Ed.) (1995b). *A review of urban stormwater quality processes*. Melbourne: Cooperative Research Centre for Catchment Hydrology (Report 95/9).

Duncan, H. P., Fletcher, T. D., Vietz, G., & Urrutiaguer, M. (2014). *The feasibility of maintaining ecologically and geomorphically important elements of the natural flow regime in the context of a superabundance of flow: Stage 1 – Kororoit Creek study.* Retrieved from Melbourne:

Duncan, H. P., Fletcher, T. D., Vietz, G., & Urrutiaguer, M. (2016). *The feasibility of maintaining ecologically and geomorphically important elements of the natural flow regime in the context of a superabundance of flow: Stage 2 – McMahons Creek study.* Retrieved from Melbourne:

Eccleston, C. H. (2006). Applying the Significant Departure Principle in Resolving the Cumulative Impact Paradox: Assessing Significance in Areas That Have Sustained Cumulatively Significant Impacts. *Environmental Practice, 8*(4), 241.

Endreny, T. (2008). Naturalizing urban watershed hydrology to mitigate urban heat-island effects. *Hydrological Processes, 22*, 461-463.

Fletcher, T. D., Walsh, C. J., Bos, D., Nemes, V., RossRakesh, S., Prosser, T., . . . Birch, R. (2011). Restoration of stormwater retention capacity at the allotment-scale through a novel economic instrument. *Water Science and Technology, 64.2*, 494–502.

Grey, V., Livesley, S. J., Fletcher, T. D., & Szota, C. (2018). Establishing street trees in stormwater control measures can double tree growth when extended waterlogging is avoided. *Landscape and Urban Planning, 178*, 122-129. doi:https://doi.org/10.1016/j.landurbplan.2018.06.002

Harris, G., Batley, G., Fox, D., Hall, D., Jernakoff, P., Molloy, R., . . . Walker, S. (1996). *Port Phillip Bay Environmental Study - Final Report*. Retrieved from Canberra, Australia.:

Hatt, B. E., Fletcher, T. D., Walsh, C. J., & Taylor, S. L. (2004). The influence of urban density and drainage infrastructure on the concentrations and loads of pollutants in small streams. *Environmental Management, 34*(1), 112–124.

King, R. S., Baker, M. E., Kazyak, P. F., & Weller, D. E. (2010). How novel is too novel? Stream community thresholds at exceptionally low levels of catchment urbanization. *Ecological Applications, 21*(5), 1659–1678. doi:10.1890/10-1357.1

Leopold, L. B. (1968). *Hydrology for urban land planning - a guidebook on the hydrologic effects of urban land use* (554). Retrieved from Washington:

Marsden Jacob Associates. (2007). *The economics of rainwater tanks and alternative water supply options*. Retrieved from Melbourne, Australia:

Melbourne Water. (2017). *Little Stringybark Creek Environmental Significance Overlay: review and future directions*. Retrieved from Melbourne:

Nemes, V., La Nauze, A., Walsh, C. J., Fletcher, T. D., Bos, D., Rossrakesh, S., & Stoneham, G. (2016). Saving a creek one bid at a time: a uniform price auction for urban stormwater retention. *Urban Water Journal, 13*(3), 232–241. doi:10.1080/1573062X.2014.988732

Rossrakesh, S., Walsh, C. J., Fletcher, T. D., Matic, V., Bos, D., & Burns, M. J. (2012). *Ensuring protection of Little Stringybark Creek: evidence for a proposed design standard for new developments.* Retrieved from Melbourne: http://www.urbanstreams.unimelb.edu.au/Docs/LSB_ESO_Technical_report-final.pdf

Rutherfurd, I., Jerie, K., & Marsh, N. (2000). *A rehabilitation manual for Australian streams*. Melbourne, Australia: CRC for Catchment Hydrology.

Walsh, C. J. (2004). Protection of in-stream biota from urban impacts: minimise catchment imperviousness or improve drainage design? *Marine and Freshwater Research, 55*(3), 317–326.

Walsh, C. J., Booth, D. B., Burns, M. J., Fletcher, T. D., Hale, R. L., Hoang, L. N., . . . Wallace, A. (2016). Principles for urban stormwater management to protect stream ecosystems. *Freshwater Science, 35*(1), 398–411. doi:10.1086/685284

Walsh, C. J., Fletcher, T. D., Bos, D. G., & Imberger, S. J. (2015). Restoring a stream through retention of urban stormwater runoff: a catchment-scale experiment in a social-ecological system. *Freshwater Science, 34*(3), 1161–1168. Retrieved from http://www.jstor.org/stable/pdfplus/10.1086/682422.pdf

Walsh, C. J., Fletcher, T. D., & Burns, M. J. (2012). Urban stormwater runoff: a new class of environmental flow problem. *PLoS ONE, 7(9)*, e45814. doi:10.1371/journal.pone.0045814

Walsh, C. J., Fletcher, T. D., & Ladson, A. R. (2005). Stream restoration in urban catchments through re-designing stormwater systems: looking to the catchment to save the stream. *Journal of the North American Benthological Society, 24*(3), 690–705.

Walsh, C. J., Sharpe, A. K., Breen, P. F., & Sonneman, J. A. (2000). Effects of urbanization on streams of the Melbourne region, Victoria, Australia. I. Benthic macroinvertebrate communities. *Freshwater Biology, 46*, 535-551.

Walsh, C. J., & Webb, J. A. (2013). *Predicting stream macroinvertebrate assemblage composition as a function of land use, physiography and climate: a guide for strategic planning for river and water management in the Melbourne Water region.* (13-1). Retrieved from Melbourne:

Zhang, L., Dawes, W. R., & Walker, G. R. (2001). Response of mean annual evapotranspiration to vegetation changes at catchment scale. *Water Resources Research, 37*(3), 701–708.