Nillumbik Shire Council

NILLUMBIK
THE GREEN WEDGE SHIRE

Integrated Water Management Strategy 2013

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Aboriginal Land Statement

Nillumbik Shire Council acknowledges the Wurundjeri as the traditional custodians of the land now known as the Shire of Nillumbik and values the significance of the Wurundjeri peoples' history as essential to the unique character of the Shire.

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Executive Summary

A growing understanding of the emerging challenges in urban water management provides an opportunity to embrace a more holistic and coordinated approach for Integrated Water Management across the Shire of Nillumbik. This approach promotes the integration of multi-functional infrastructure that progressively reduces reliance on mains water supply whilst improving the quality of stormwater and flow patterns discharged to receiving waterways. Integrated Water Management (IWM) recognises projects which deliver multiple benefits such as; water security, protection of receiving waters, ecosystem services, social/political engagement, microclimate benefits, improved liveability and community well-being.

Council has made significant water savings and improvements to stormwater quality over the last decade. There are 100 rainwater tanks, 10 wetlands and one wetland combined with a stormwater harvesting scheme, numerous raingardens, ponds and swales. Collectively, these Water Sensitive Urban Design (WSUD) projects reduce stormwater flow volumes and 60,059 kg of sediment, 122 kg of Total Phosphorus and 798 kg of Total Nitrogen from entering local waterways each year.

Council has exceeded existing water conservation targets (developed under the International Council for Local Environmental Initiatives (ICLEI) program and detailed in the *Sustainable Water Management Plan,* 2008). Analysis of water consumption figures found Council has achieved a 65 per cent reduction and the community (residential and non-residential combined) have achieved a 31 per cent reduction. Achieving further reductions in water consumption will become increasingly difficult. To continue to reduce reliance on mains water supply and to deliver multiple benefits to the environment and the community, new Integrated Water Management Targets replace the existing water conservation targets.

The 2025 Integrated Water Management (IWM) Targets are based on delivering the following (baseline year 2013):

- 7.5 ML/yr of stormwater used to supply non-potable demands across Council assets
- 10 ML/yr of stormwater used across the private domain
- 45 per cent best practice target for stormwater quality. This equates to a mean annual load reduction in:

  Total Suspended Solids (TSS) of 11,770 kg

  Total Phosphorus (TP) of 15 kg

  Total Nitrogen (TN) of 62 kg.

Flow management targets have been established to maintain and improve the condition of the waterways. These are measured using Directly Connected Imperviousness (DCI):

- Diamond Creek catchment – actively disconnecting impervious surfaces to achieve a DCI of less than 2 per cent
- Watsons Creek and Arthurs Creek catchments – no increase in DCI
- Plenty River and Yarra River catchments – no increase in DCI.

To attain these IWM Targets, Council must proactively integrate WSUD projects into asset management plans and open space masterplans. Key areas of focus are:

1. Identifying and constructing key stormwater harvesting projects for irrigating ovals and other amenities.
2. Incorporating WSUD into all new developments to ensure minor runoff events are treated, infiltrated or harvested.
3. Incorporating WSUD when road surfaces are being sealed to ensure minor runoff events are treated and/or infiltrated and they remain disconnected from the waterway.
4. Actively disconnecting impervious surfaces in the Diamond Creek catchment using WSUD.
5. Continuing to promote the uptake of rainwater tanks across the private domain and encouraging connection to outdoor demands and indoor demands, such as toilet flushing.

1.0 Introduction

Water can be a key enabler of sustainable and liveable suburbs, especially where a more variable and drier climate becomes the norm. Adequate water supplies are important to support a growing population, while water can also be an important factor in providing green spaces. Green infrastructure (wetlands, swales, raingardens, etc.) and alternative water supplies conserve potable mains water, improve urban micro-climates, enhance the ecological and social values of receiving waters, and significantly enhance the general amenity of our rural and urban environments.

Council supports many significant environmental assets, including the mid-reaches of the Yarra River and Plenty River, Diamond Creek and Watsons Creek. Fundamental to protecting the ecological health of receiving waters and enhancing social/amenity values of waterways, is the need to consider flow management and water quality management within catchments.

The peri urban nature of the Shire presents some unique opportunities and challenges in terms of new infrastructure and planning associated with Integrated Water Management. The predominant source of alternative water supply is likely to be roof runoff and catchment stormwater given the distance from major wastewater treatment plant pipelines and the groundwater characteristics. Nevertheless, there may be other site specific opportunities such as reclaim-recycle or grey water systems that should be considered on a site by site basis. This study does not deal directly with extreme flood events, however some projects may assist in reducing localised nuisance flooding.

Today the impacts of urban planning and water resource management on our environment are widely acknowledged. The need to plan and respond to unforeseen changes is becoming more evident as Council faces the issues of climate change and rapidly growing urban populations. The Shire has a population of 65,000 which is predicted to increase by about 9,000 over the next 20 years. Challenges associated with a growing population will be largely accommodated through opportunistic infill development that will progressively place pressure on local amenities and the environment.

The severe drought of 1997 to 2010 was also a timely reminder of the importance of proactive water management to improve drought resilience. Recent rainfall has replenished water storages and gives Council time to undertake Integrated Water Management planning. For example, there is now time to identify, design and construct stormwater harvesting schemes (that complement significant demand management measures now in place across the Shire) to provide long term water security for parks and sporting facilities.

These projects will provide immediate savings to Council through reduced purchase of potable mains water. In times of severe drought, they may also extend the period of time for irrigation of open space, although the main benefit might be in avoiding severe restrictions.

The State Government's recent release of the consultation draft July 2013; *Melbourne's Water Future* (Office of Living Victoria, 2013) signals the start of a new era in water planning and management in Victoria. The approach of the Nillumbik IWM Strategy is consistent with this paper.

An IWM strategy built around a diversity of water sources and WSUD to compliment water infrastructure will allow Council the flexibility to access a 'portfolio' of water sources and protect receiving waters from the impacts of urban stormwater. The concept of 'fit-for-purpose' provides a means for prioritising alternative water sources to demands based on a cascading range in quality as shown in Figure 1. With the exception of recycled water (wastewater), the closer the match in quality of the source and demand the less treatment required and generally the less energy intensive and cheaper the provision of the alternative water source. Alternative water supplies have a hierarchal preference for sourcing and each source has a hierarchical preference of use if a number of demands require water.

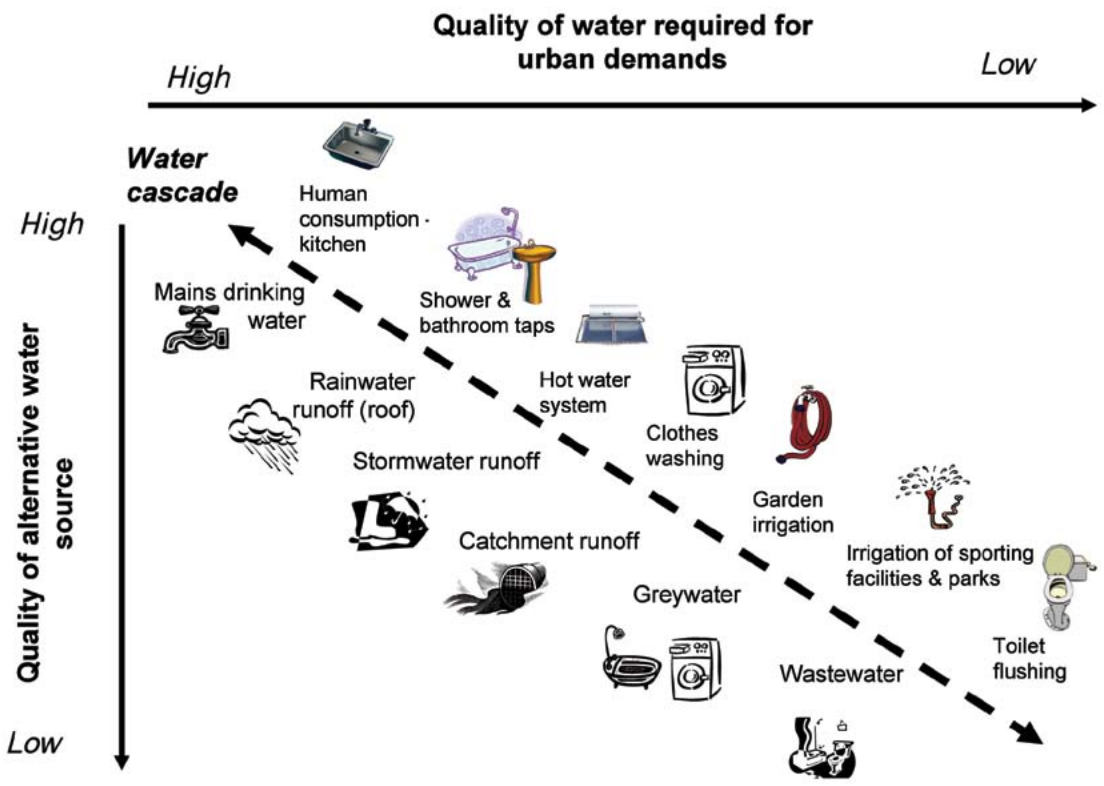


Figure 1 Consideration of cascading quality in defining preferred demands for alterative water sources (modified after Holt, 2003)

In accordance with the *Australian Guidelines for Water Recycling*, alternative water sources should be treated to manage health and environmental risks, and to minimise operational problems according to the Environment Protection and Heritage Council (EPHC), National Health and Medical Research Council (NHMRC) and National Resource Management Ministerial Council (NRMMC, 2008). Treatment requirements for urban stormwater sourced as an alternative water supply can typically be achieved using WSUD treatment measures such as wetlands and raingardens, especially where end-use is for irrigation of open space.

Treatment of stormwater for 'first pipe' uses requires much more extensive treatment. The Yarra Valley Water trial at the Merrifield development at Kalkallo is one such example. A further relevant example is the Wannon Water one at Warrnambool where rainwater has been captured from roofs, taken to storage, then treatment and comes back to houses in the first pipe. Treatment of this water is less expensive than the Kalkallo example where the comparatively pure roof-rainwater is allowed to mix with polluted stormwater before treatment is provided.

1.1 Integrated Water Management principles

Integrated Water Management (IWM) recognises projects deliver multiple benefits across water security, protection of receiving waters, ecosystem services, social/political engagement, microclimate benefits, improved liveability and community well-being. IWM principles that can be achieved and should be considered alongside IWM targets, when assessing the merits of WSUD projects are outlined below.

Treating all water as a resource

Fundamental to IWM is the notion that all water is valuable and if used wisely and in a manner that maximises its value, communities can benefit as a consequence. Thus stormwater and wastewater, far from being a waste product to be disposed of as quickly and efficiently as possible, should be exploited for their utility, especially if this can help protect supplies of precious drinking water. Therefore stormwater and wastewater should be looked upon as a resource capable of replacing potable water for a number of functions including open space irrigation and uses within the home such as toilet flushing as a minimum.

Using locally available water locally

A key principle on which IWM is based is that between stormwater derived from impervious surfaces and water able to be derived from wastewater, there are usually abundant sources of local water available to communities and especially urban communities. Accessing this locally available water will help avoid some of the expensive energy costs associated with pumping water and wastewater considerable distances, either from reservoirs or to major treatment plants.

The challenge then is to understand and exploit these local water sources and to employ them at a scale that is economically viable and hopefully cheaper than water derived from the centralised system.

Ecosystem services

Collectively the community benefits from a multitude of resources and processes that are supplied by our natural ecosystems. These benefits are known as ecosystem services and include products like clean drinking water and processes such as the decomposition of wastes. Protecting and rehabilitating natural ecosystems (e.g. bushland, local creeks, rivers and wetlands) and the services they provide (water quality protection, habitat, etc.) is equally as important as valuing the services provided by constructed ecosystems (protecting water quality, providing landscape amenity).

Social and political capital

Growing and learning from local experiences and knowledge is important to help raise community awareness and understanding about IWM. A smart, sophisticated and engaged community, living a sustainable lifestyle sensitive to the inter-dependent nature of the built and natural environments results from progressive engagement to develop social/political capital. More broadly, this contributes to engaging with the community on sustainable water management practices and promoting the uptake across rural properties and the urban private domain.

Microclimate benefits

Passive irrigation of green infrastructure (e.g. raingardens, tree pits, vegetated swales and wetlands) with alternative water sources improves the health of vegetation and retains water within soils and landscapes. Collectively, this is beneficial to improving urban microclimates. Higher density canopy cover can reduce heatwave impacts by improving the thermal comfort of streetscapes and open spaces. Alternative water sources can provide additional water for active irrigation of open spaces that further reduces the urban heat island effect through enhanced evapotranspiration.

Improved liveability

Educating community to live alongside local waterways, local parks and bushland reserves and minimise their impact on the environment. Public spaces are environments available to everyone, promoting social inclusion and improved liveability. Communities are actively engaged in decision-making and respond to signals in their environments regarding responsible water use.

Community well being

Green infrastructure (e.g. raingardens, tree pits, vegetated swales and wetlands) contributes significantly towards creating high quality streetscapes and open spaces. It is also increasingly becoming recognised for its contribution towards improving community well-being (mental and physical) by promoting passive recreational activities such as walking.

Fundamental to Integrated Water Management is the notion that all water is valuable and if used wisely and in a manner that maximises its value, communities can benefit as a consequence. Thus stormwater and wastewater, far from being a waste product to be disposed of as quickly and efficiently as possible, should be exploited for their utility, especially if this can help protect supplies of precious drinking water.

1.2 Achievements to date

Analysis of water use data shows that Council and the community have exceeded the targets established in the *Sustainable Water Management Plan* (Nillumbik Shire Council, 2008). Since 2000/01 Council has achieved a 65 per cent reduction in mains water use (target was 45 per cent). Similarly residential and non-residential both exceed the 25 per cent reduction target with residential use achieving a 26.5 per cent reduction and non-residential achieving a 70 per cent reduction, since 2000/01. These achievements are to be commended however achieving further reductions in water consumption will become increasingly difficult. To continue to reduce reliance on mains water supply and to deliver multiple benefits to the environment and the community, new targets are required.

Appendix F lists the WSUD projects that are currently located across the Shire and the downstream benefits they provide. 100 rainwater tanks, 10 wetlands and one wetland combined with a stormwater harvesting scheme demonstrate Council's commitment to WSUD. Other WSUD projects include raingardens, ponds and swales. The harvested water is used for a number of purposes including toilet flushing and irrigation of gardens and ovals. Other reductions in stormwater runoff volumes occur through evaporation (ponds and other open water storages), evapotranspiration losses associated with the vegetated treatment systems and/or infiltration.

Collectively the projects reduce stormwater flow volumes and reduce pollutant loads discharged to local waterways. Some treatment measures such as wetlands, raingardens and swales provide physical, chemical and biological treatment of pollutants. Rainwater tanks when plumbed to indoor demands (such as, to supply toilet and laundry) remove stormwater pollutants by the water being discharged to the sewerage system. Stormwater harvesting projects that supply irrigation demands remove pollutants through infiltration to the underlying soils. If over irrigation occurs then runoff may be generated and a proportion of the pollutant may directly enter the waterways, although this should not occur where soil moisture measurement is allied to programming of irrigation regimes.

Runoff generated across impervious surfaces is evaporated or captured and reused preventing 82ML/yr of stormwater from entering waterways. Over 60,000 kg of Total Suspended Solids (TSS), 122 kg of Total Phosphorus (TP) and 798 kg of Total Nitrogen is also removed protecting waterways from the impacts associated with these pollutants.

There are some 250 sediment sumps located on unsealed roads. These structures are effective at trapping course sediment generated from roads across the predominately rural areas of the Shire. Collectively they provide an important role in protecting the downstream waterways from a significant threat associated with sediment material smothering aquatic habitats. The finer sediments (referred to as Total Suspended Solids) pose a range of other threats to the waterways and are more effectively managed using vegetated treatment systems.

Collectively the projects reduce stormwater flow volumes and reduce pollutant loads discharged to local waterways.

Civic Drive Shire office raingarden

2.0 Catchment Context

2.1 Land use characteristics

The Shire of Nillumbik is located less than 25 kilometres north-east of Melbourne, and covers an area of 432 square kilometres. The Kinglake National Park is located in the north of the Shire. There are a number of highly valued waterways within Nillumbik including Diamond Creek, Arthurs Creek, Watsons Creek, Watery Gully Creek and the upper to mid-reaches of the Plenty River and Yarra River (southern boundary). The Department of Environment and Primary Industries has identified 78 biosites within the Shire; there are 22 threatened species, 9 migratory species and one threatened ecological community listed for protection under the *Environment Protection and Biodiversity Conservation Act 1999* (Nillumbik Shire Council, 2012b). Section 2.2 provides additional information about waterway health across Nillumbik.

The quality of the catchments and tributaries vary throughout the Shire, depending on the land use and population density.

Table 1 and Figure 2 provide a summary of the waterways and their catchments located in the Shire of Nillumbik. These major catchments have been used to model the generation of stormwater runoff volumes and pollutant loads.

Land use is predominately rural with urban areas located at the downstream reaches of the catchments. The northern areas of the Shire are characterised by the forested catchments of the Kinglake Ranges and small fast flowing streams. As the terrain becomes less mountainous, larger waterways form through agricultural areas and bushland, where the main land use is grazing. The southern areas of the catchments are largely residential, characterised by urban development and areas of open space abutting the major waterways, as shown in Figure 3. The farming/rural landuse areas contain significant amounts of intact bushland.

Table 1 Summary of waterways located in the Shire of Nillumbik (Nillumbik Shire Council, 2012c)

Waterway	Description
Yarra River	The section of the Yarra River flowing through Nillumbik is classified as the Middle Yarra. The portion downstream of Nillumbik flows into Melbourne CBD and the Port Phillip Bay.
Diamond Creek	Diamond Creek begins on the Kinglake Plateau and flows through St Andrews, Hurstbridge, Diamond Creek and Eltham, before entering the Yarra River at Eltham Lower Park.
Plenty River	Beginning at Mount Disappointment, the Plenty River flows through Mernda and Whittlesea and the urban areas of Greensborough before entering the Yarra River at Lower Plenty.
Watsons Creek	Watsons Creek begins in Kinglake National Park and passes through rural land in Christmas Hills and Kangaroo Ground, before entering the Yarra River at the Bend of Islands Conservation Zone.
Arthurs Creek	Arthurs Creek begins in the Kinglake National Park and flows through rural landscapes where it meets up with the Diamond Creek at Hurstbridge.

The northern areas of the Shire are characterised by the forested catchments of the Kinglake Ranges and small fast flowing streams.

Figure 2 Waterways and major catchments located in Shire of Nillumbik

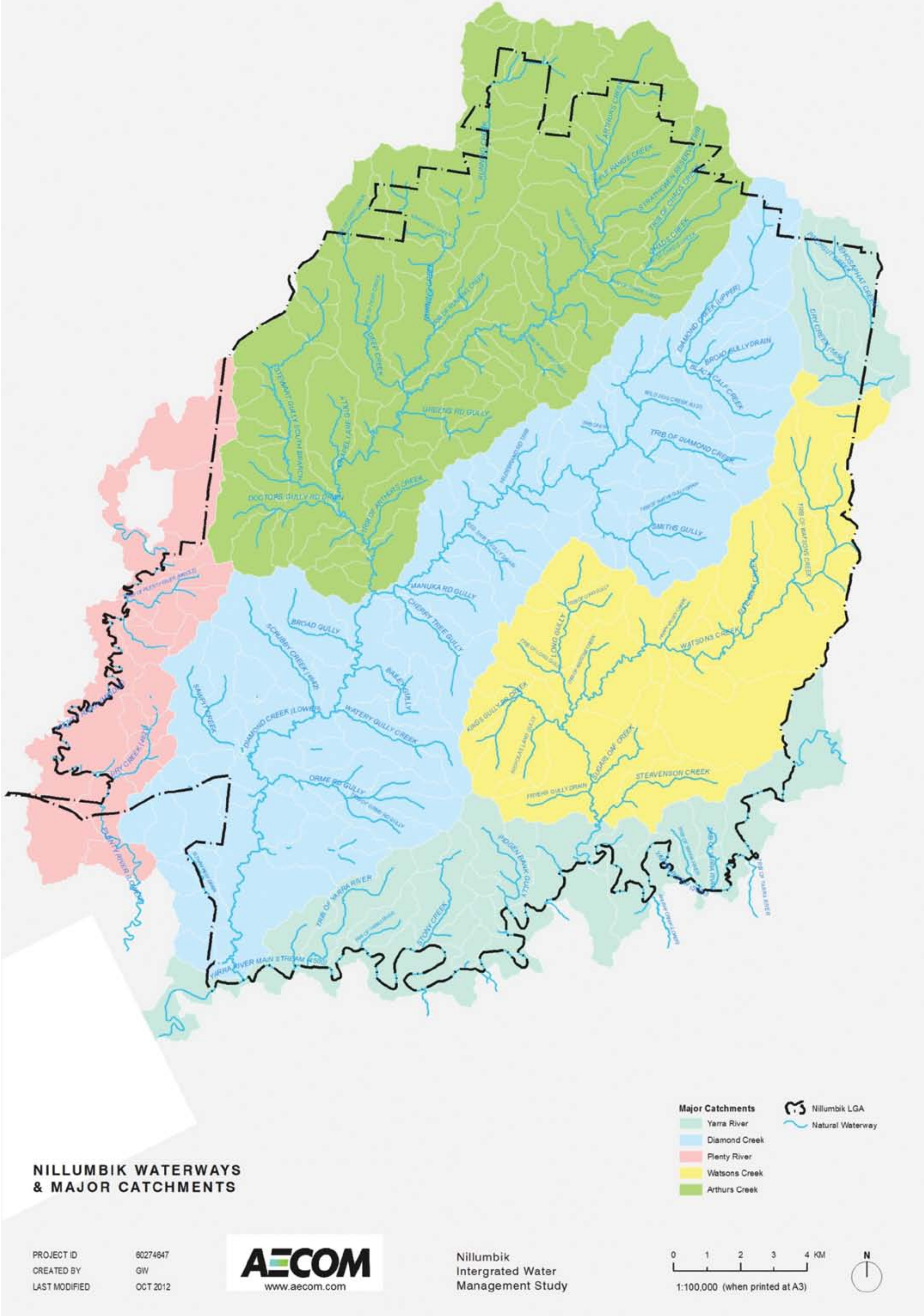
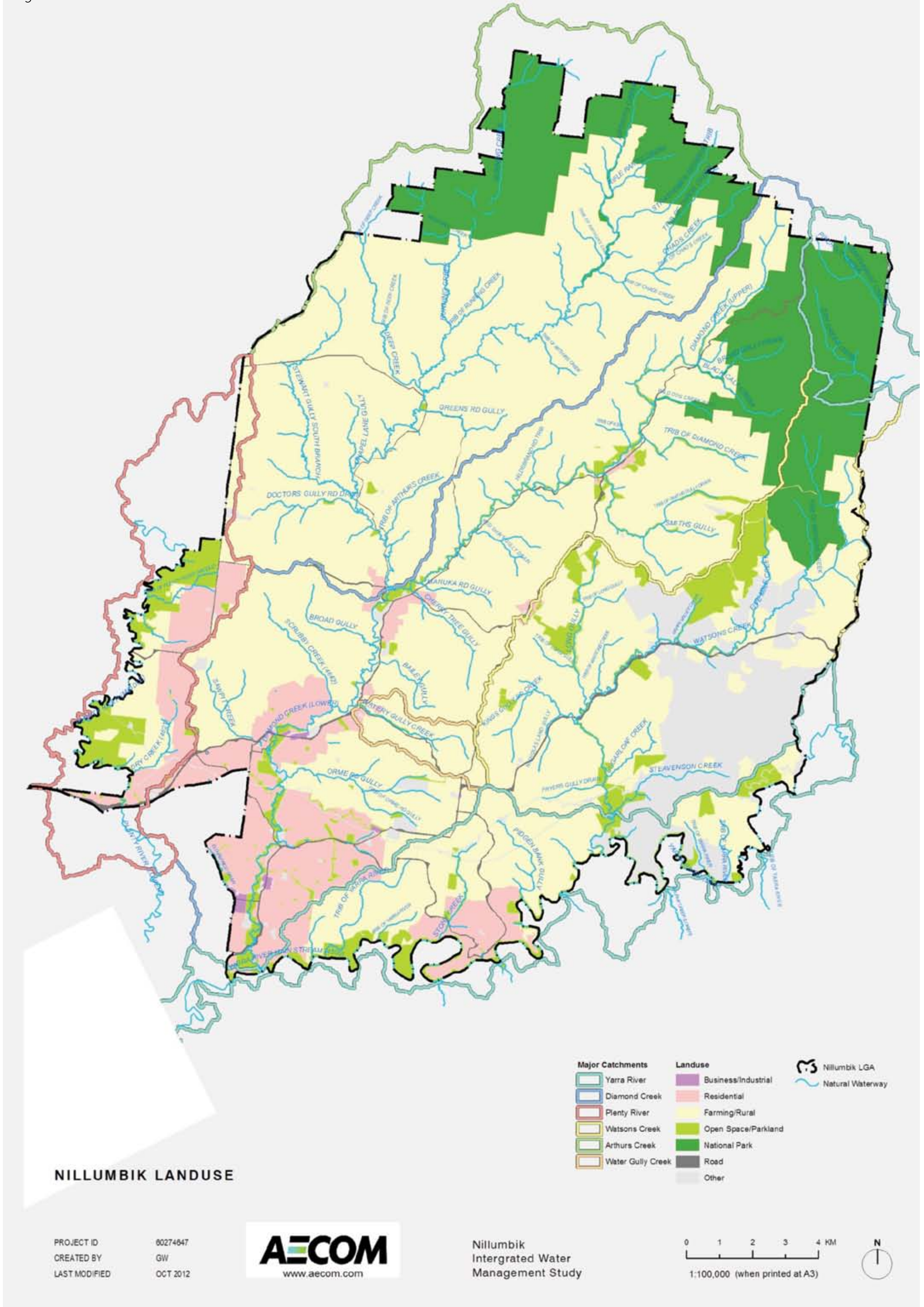


Figure 3 Land use across the Shire of Nillumbik



2.1.1 Land use and surface type

The predominant land use is farming/rural and open space parkland (including national parks and publically owned bushland) representing 36,204 ha. The remaining 7,007 ha are urban areas representing 16per cent of the total Shire. The main land uses within the Shire are summarised in Table 2. Public landuse includes Council owned assets, VicRoad roads and National Parks.

Table 2 Summary of land uses

Land use	Total area in ha (Council)	Total area in ha (private)	Total area in ha
Business/Industry	4	68	72
Farming/Rural and Open Space Parkland	683	3,5521	36,204
Public Use	79	2,212	2,291
Residential	64	3,437	3,501
Road	1	445	446
Special Use	0	697	697
Total	**831**	**42,380**	**43,211**

The breakdown of surface types is summarised in Table 3. As could be expected given the land use patterns, most of the Shire consists of pervious areas.

Table 3 Summary of surface types

Surface type	Total area in ha (public)	Total area in ha (private)	Total area in ha
General impervious	4	154	158
Pervious	1,490	41,077	42,567
Road	258	0	258
Roof	4	224	228
Total	**1,756**	**41,455**	**43,211**

2.2 Waterway health

The Shire of Nillumbik contains part or all of a number of significant waterways including:

- Diamond Creek
- Arthurs Creek
- Watsons Creek
- Yarra River
- Plenty River

The major waterways in Nillumbik form important riparian habitat corridors of significant conservation and recreational value. The water quality in all of the waterways in this area is impacted by runoff from adjacent land uses and in some sections, the discharge of sewage effluent from septic tanks (see further http://www.nillumbik.vic.gov.au/Environment/State_of_Environment/Water/Domestic_Wastewater_Management) E

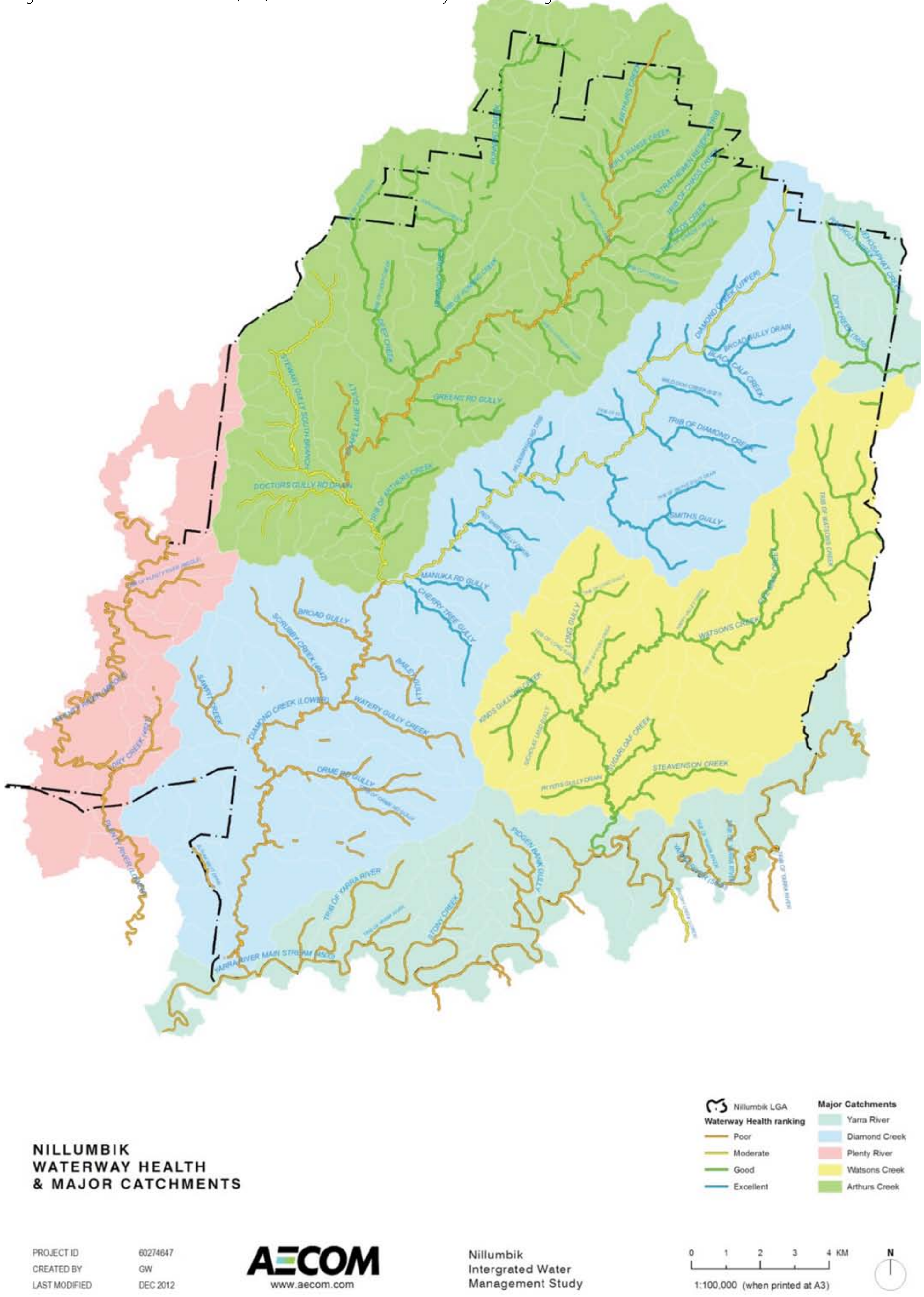
Council's *State of Environment Report* identifies the waterway health within the Shire. This section draws on, and compliments, the information provided. The Index of River Condition (IRC) is used by Melbourne Water (IRC is based on Index of Stream Condition and modified for the urban waterways located in Melbourne Water's operating area). The data available on the Melbourne Water website is from 2004 but given the relatively low rate of development across the Shire it is still considered relevant and useful.

The Index of River Condition (IRC) provides an integrated measure of waterway health and provides scores based on the following components:

- Hydrology
- Physical form
- Streamside zone
- Water quality
- Aquatic life

Based on this assessment, Figure 4 maps the condition of the waterways and shows the overall health range from good and excellent for the upper tributaries of Arthurs Creek and Diamond Creek, through to moderate for most other waterways including Diamond Creek and Watsons Creek, to poor for the reaches of the Yarra and Plenty Rivers that pass through the Shire. The primary reason for the relatively good health of many of the waterways is the relatively low levels of urban development within the catchments and consequently low directly connected imperviousness (refer to Section 2.3). Appendix C provides a breakdown of the assessment for each waterway.

Figure 4 Index of River Condition (IRC) as a measure of waterway health ranking in the Shire of Nillumbik



2.3 Directly Connected Imperviousness (DCI)

It is now well established that increased flow volumes and frequency due to urbanisation can significantly impact upon stream health (Walsh, 2004).

SIGNAL stands for "Stream Invertebrate Grade Number – Average Level' and has been developed as a simple scoring system to assess waterway health based on macro-invertebrates and algal counts. A high signal score (6 or higher) indicates a healthy aquatic ecosystem. Studies undertaken have found that the proportion of a catchment that is both impervious and also directly connected to streams via pipes and sealed drainage channels, called the Directly Connected Imperviousness (DCI) or 'effective' imperviousness is most influential in determining the health of urban streams.

As shown in Figure 5, ecological health, or potential to restore aquatic ecosystem health, declines sharply with increases of DCI areas from 0.5 per cent to 5 per cent. For catchments with effective impervious values greater than 5 per cent stream ecosystem health is nearly always found to be impacted to a significant level (SIGNAL score less than 5).

Catchment imperviousness and connection data is used to estimate the Effective Impervious (EI) fraction. The data is referred to as EI 20 and represents impervious areas within 20m of a drain or waterway. This takes into consideration both the total impervious area and the likelihood that impervious surfaces are actually connected to a waterway to calculate the percentage of directly connected imperviousness for the major catchments.

The average effective impervious fraction for the Shire as a whole is 1.5 per cent. Calculations for each catchment, for the area located within the Shire of Nillumbik, are as follows:

- Yarra River 0.4 per cent
- Diamond Creek 4 per cent
- Plenty River 3.7 per cent
- Watsons Creek 0.1 per cent
- Arthurs Creek 0.2 per cent

Figure 5 The impact of Directly Connected Imperviousness (effective imperviousness) on stream health (Walsh 2004)

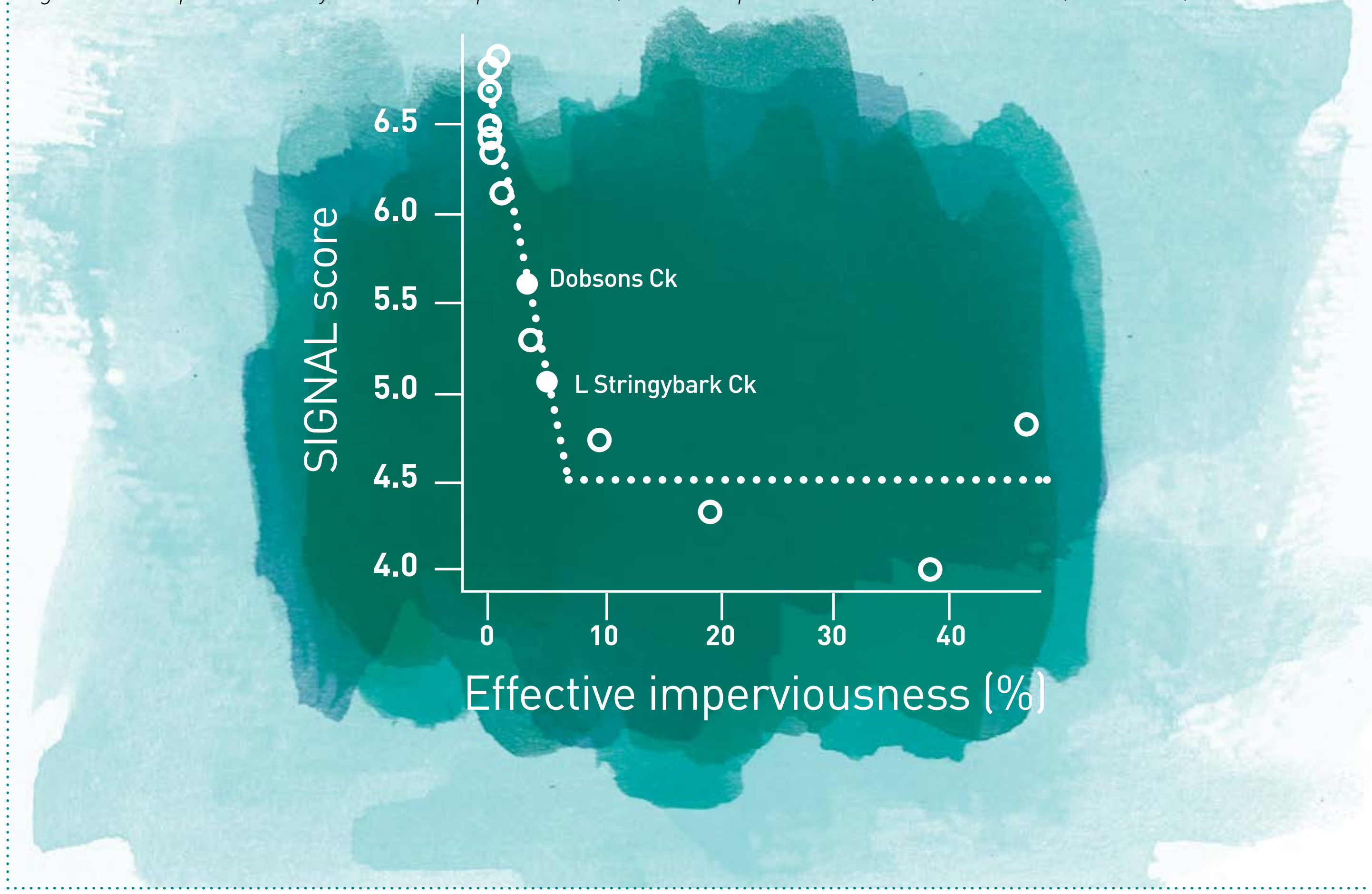


Figure 6 maps the DCI percentages for the major catchments and the IRC rating of the associated waterways. Arthurs Creek and Watsons Creek have low DCI percentages (<0.5 per cent) but whilst Watsons Creek and its tributaries are rated as good, Arthurs Creek rates as good, moderate or poor at different locations. Aquatic life is more impacted in Arthurs Creek than in Watsons Creek.

As neither waterway is impacted by catchment urbanisation it is important to recognise other factors impacting these systems. These include historic land clearing especially and this in itself would appear to explain much of the difference between Arthurs Creek and Watsons Creek systems. Historic land clearing for agriculture has in turn been associated with construction of farm dams and stock access to streams, although clearing of forest and native vegetation cover has been the critical initiating element in land and stream degradation. This, together with the poor structural integrity of local soils has directly caused extensive stream incision in many parts of the Arthurs Creek system with many sections of the stream still actively eroding today.

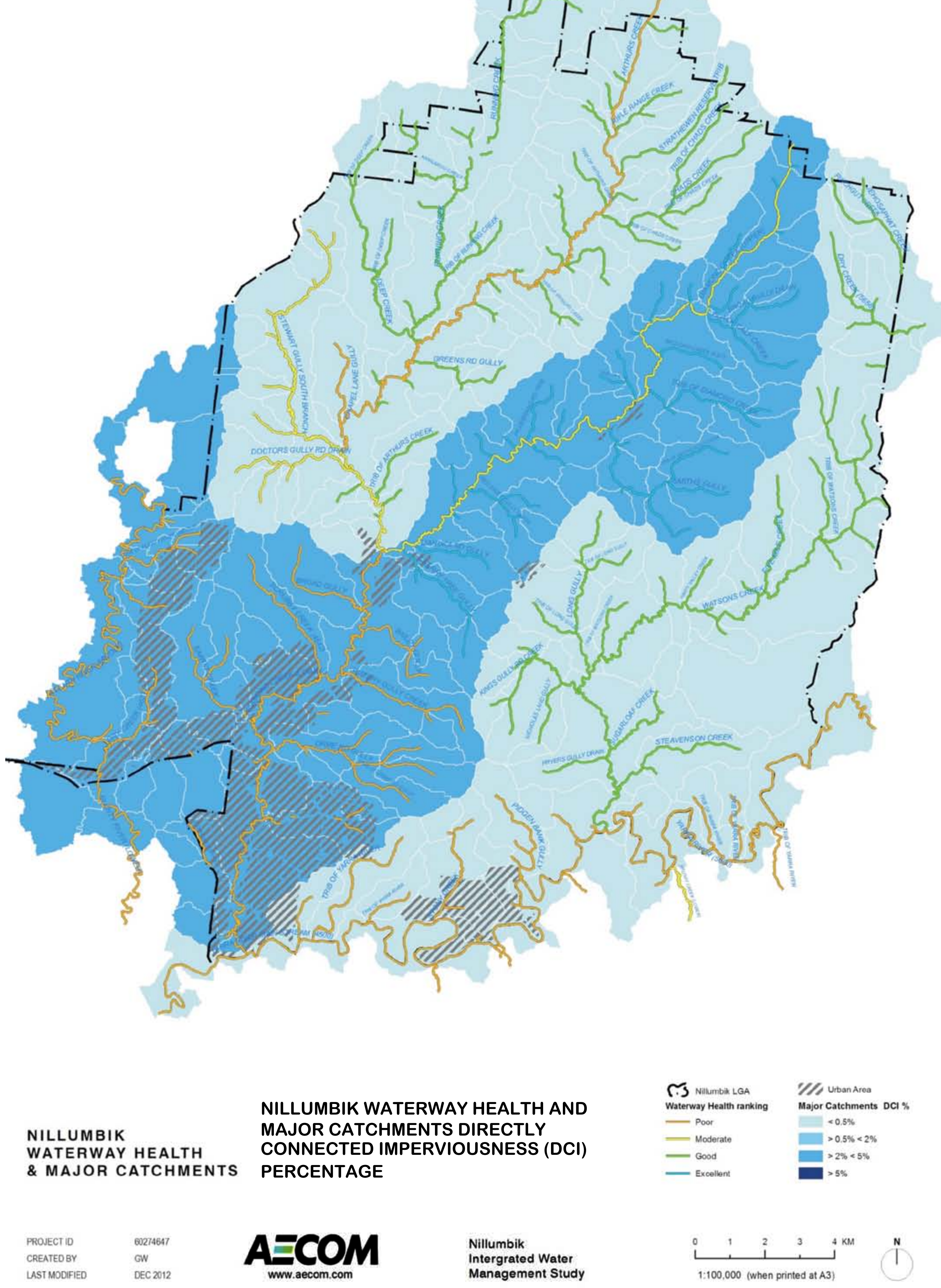
Arthurs Creek, Watsons Creek and the upper reaches of Diamond Creek lie almost entirely within the Shire. They present a significant opportunity for Council to assist Melbourne Water in their management and improvement. Efforts will focus on these catchments as outlined in the action plans of this Strategy.

It is important to recognise that only a small portion of the Yarra River and Plenty River catchments lie within the Shire and efforts to improve these catchments will require contributions from other stakeholders including Melbourne Water.

Even though DCI is not the entire explanation for stream health, the low effective impervious percentages indicates there is merit in establishing flow management targets for the Shire to protect existing stream health from further degradation due to urban development. These targets will be explored further in Section 4.2.2.

Arthurs Creek, Watsons Creek and the upper reaches of Diamond Creek lie almost entirely within the Shire. They present a significant opportunity for Council to assist Melbourne Water in their management and improvement.

Figure 6 Percentage of Directly Connected Impervious (DCI) and its relationship to Index of River Condition (IRC) assigned as waterway health ranking



2.4 Legislative and strategic policy context

Legislative and policy context for sustainable water management occurs at the Commonwealth, State and Local Government level. These are supported by numerous strategic documents and guidelines for best practice. The state policy context is likely to change significantly over the coming years with the Victorian Government's recent establishment of the Office of Living Victoria (OLV). The OLV is responsible for implementing actions identified in the Ministerial Advisory Committee (MAC) *Living Melbourne, Living Victoria Implementation Plan*. Integrated Water Management is a key focus and policy changes will be directed at commitment to better use of all water resources while driving change to improve local environments, increase liveability and deliver better water services.

Commonwealth

The National Water Initiative (NWI) commits all states and territories to innovation and capacity building to create Water Sensitive Australian Cities (Clause 92).

The Environment Protection and Biodiversity Conservation (EPBC) *Act 1999* is the overarching legislation for the protection of native species and enhancement of their natural habitat including the waterways and the species that they support. They provide the enforcement mechanisms for environmental controls in Victoria, including the discharge of waste, including sediment, into water.

The *Building Amendment Act 2011* refined the definition of the Building Code of Australia to include the National Construction Code Series (Volume 1, 2 and 3). This consequently introduced the requirement for all single dwellings, renovations, alterations and additions to comply with the six star standard. Six star includes a water conservation requirement; there is an option to install a rainwater tanks or alternatively a solar hot water system. Nillumbik Shire Council actively encourage a 2kL rainwater tank to be incorporated into the design of new houses and plumbed to a toilet (or similar use where potable water is not required). Anecdotal evidence suggests that Council's active encouragement of tanks has been to good effect.

The *National Strategy for Ecologically Sustainable Development* (ESD) provides strategic directions for governments' policy and decision-making in the use and management of natural resources. The Strategy facilitates a coordinated and co-operative approach to ecologically sustainable development and encourages long-term benefits for Australia over short-term gains. All states and territories adopted the strategy in 1992.

Hurstbridge Wetlands

State

The *Water Act 1989* is the overarching legislation for managing water resources in Victoria. It enables Melbourne Water to act in relation to managing waterways, drainage and stormwater.

The following is a summary of the legislation and documents that support elements of Integrated Water Management.

- The *Planning and Environment Act 1987* is the policy and legislative instrument that provides councils with the greatest ability to influence water management within the community. It allows councils to require developers to incorporate water conservation, water reuse and stormwater quality measures into developments.
- State Environment Protection Policies (SEPP) 2003 (Water of Victoria) established under the *Environment Protection Act 1970* and amendments in 2006 set the statutory framework for protection of waterways throughout the Port Phillip Bay catchment. The SEPPs identify a range of responsibilities for councils in protecting the beneficial uses of groundwater and surface waters. Of particular relevance to this Integrated Water Management Strategy (IWMS) are:
  - Responsibilities for councils *(Clause 17)*: outlining council's role in 'protecting surface waters through a number of responsibilities, including stormwater, floodplain, drainage, and vegetation management, domestic wastewater management including septic tank approvals, local road management and land use planning.'
  - On-site domestic wastewater *(Clause 32)*: ensuring the necessary planning, approvals and monitoring occurs to minimise the transport of nutrient and pathogen and other pollutants to groundwater and surface waters.
  - Urban stormwater *(Clause 46)*: ensuring stormwater does not impact on water quality. Specific reference to the *Urban Stormwater Best Practice Management Guidelines* is made.
  - Unsealed roads *(Clause 57)*: ensuring unsealed roads do not impact on stormwater runoff quality.
- The *Urban Stormwater Best Practice Environmental Management Guidelines* (Victorian Stormwater Committee,1999) establish targets for annual stormwater pollutant load reductions of 80 per cent for Total Suspended Solids (TSS), 45 per cent for Total Phosphorus (TP) and 45 per cent for Total Nitrogen (TN). These targets are now referred to in the State Planning Policy Framework and form part of the attainment program for the SEPP - Waters of Victoria.
- Clear and unambiguous planning policy mandates a number of IWM requirements under the Victorian Planning Provisions. They are:
  - *Clause 15.01* requires decision-making to be consistent with State Environment Protection Policies (Waters of Victoria and specific catchment policies).
  - *Clauses 15.01 and 18.09* require consideration of *Urban Stormwater Best Practice Environmental Management Guidelines*.
  - *Clause 56.07* sets out the planning requirements for potable water reduction, reused and recycled water, waste water and urban runoff quality. It mandates WSUD for residential subdivisions only.
  - *Clause 65.02* of the Victorian Planning Provisions provide Council with the responsibility to issue planning permits that require reticulated sewerage at the time of subdivision where allotments are not capable of containing wastewater onsite.

Henry Arthur Estate Bioretention system

- *The Living Melbourne, Living Victoria Implementation Plan* (Living Victoria Ministerial Advisory Council, 2012) has led to the establishment of the Office of Living Victoria (OLV) who is working with industry to bring about better alignment of urban planning and Integrated Water Management (IWM). The Victorian Government has committed to the following priority actions through the OLV:
  - Administration of the Leading the Way – Living Victoria Fund which is providing grants to councils and other organisations for non-structural projects.
  - Coordination and facilitation of the development of Integrated Water Cycle Management Plans for Melbourne's four growth areas and inner Melbourne. These will replace the previous supply-demand strategies.
  - Preparation of a Regulatory Impact Statement for building controls to improve the water performance of new buildings.
  - Working with the Department of Planning and Community Development to amend the Victoria Planning Provisions to apply current performance requirements for the management of stormwater more broadly. This includes a review of *Clause 56.07-4* which governs residential subdivision design and compliance with the best practice environmental management stormwater quality objectives. Issues being addressed in the review include the effectiveness of the clause, extending its requirements to non-residential subdivision and infill development, and broadening the clause to encompass a wider view of stormwater management and harvesting.
- A number of strategic documents have recently been released to guide industry over the next 5 years. They include:
  - *Melbourne Integrated Water Cycle Strategy* (2012, April draft) also referred to as the Water Supply Demand Strategy.
  - *Melbourne Water's Healthy Waterways Strategy* (2012-2018) has replaced the Port Phillip and Western Port Regional River Health Strategy (Melbourne Water, 2007).
    - Waterway Activity Plans (such as the Darebin Creek, Diamond Creek and Plenty River) provide local guidance and should be considered within the context of the Healthy Waterways Strategy.
  - *Melbourne Water's Stormwater Strategy* (2012-2018).
- Melbourne Water's Stream Flow Management Plans for Diamond Creek and for the Plenty River outline management requirements for water resources of the area in an equitable manner. Both water users and environmental requirements are considered in the plans. The plans set out maximum allocation limits for the water supply protection area. Ban triggers are used to set the minimum seven day rolling average and/or instantaneous flow that must occur before diversions are allowed.

Nillumbik Shire Council

Municipal Local Laws provides a means for Council to undertake compliance activities (such as infringement and penalty notices). In terms of water management this typically applies to Building and Work Codes of Practice for sediment and litter controls from building sites.

Nillumbik Shire Council is committed to the delivery of sustainable water management and this is demonstrated through a range of policy and strategic documents. *Nillumbik Council Plan 2009–2013* states the vision for Nillumbik Shire Council as a sustainable and well-managed natural and built environment. The following summary of documents draws on the legislation and policy review documented in Nillumbik Shire Council (2012a):

- *Nillumbik Environment Charter 2013,* guides Council's commitment to enhancing biodiversity, encouraging sustainable built form, reducing our environmental impact and continuing education around environmental sustainability.
- *Nillumbik Sustainable Water Management Plan 2008* and Implementation Progress Study 2008-2009 provide strategic direction for improved water management for water conservation and improved stormwater quality throughout Council operations and the Nillumbik community (to be superseded by this Strategy).
- *Nillumbik Stormwater Management Plan 2001* Vols 1 & 2 provide an overview of waterway values, threats, risks and recommendations to address key stormwater issues. It seeks to protect waterway values and enhance the environmental, economic, recreational and cultural benefits they bring to the community. Most of the recommendations outlined have been undertaken (to be superseded by this Strategy).
- *Nillumbik Biodiversity Strategy 2012* outlines a proactive and broader landscape approach to conservation management by applying its conservation programs, such as potential planning scheme amendments, targeted land management incentive programs, net gain offsetting and guidance of on-ground works across public and private land, as well as waterways (including creeks, rivers, wetland, floodplains, lakes, etc.).
- *Nillumbik Green Wedge Management Plan 2010-2025 Parts 1 and 2* aim to protect and enhance remnant vegetation, sites of faunal and habitat significance and strategic habitat links; protect and enhance catchments and manage water responsibly; achieve sustainable land management; conserve the landscapes of the Green Wedge for aesthetic, environmental and cultural values.
- Nillumbik Land Management Incentive Program outlines a direction for Council on the delivery of incentive activities for private landholders in the Shire. These activities are further supported by Melbourne Water and catchment management authorities, to provide incentives in the form of grants, rebates, subsidies and educational programs to facilitate better land management and waterways outcomes.
- Nillumbik *Climate Change Action Plan 2010-2015* commits Council to the implementation of practical measures to alleviate the impact of, and adapt to, climate change. Water conservation, provision of alternative water supplies and improvements to stormwater management increase Council's resilience to climate change.
- *Domestic Waste Water Management Plan 2006-2009* purpose is to:
  - Identify current responsibilities, practices, procedures and obligations for domestic wastewater management in the Shire of Nillumbik.
  - Identify the main environmental values and wastewater threats in the Shire.
  - Assist with long term planning and development of unsewered areas in the Shire.
  - Improve public health and environmental protection.

3.0 Nillumbik's Water Balance and Pollutant Budget

3.1 Water balance

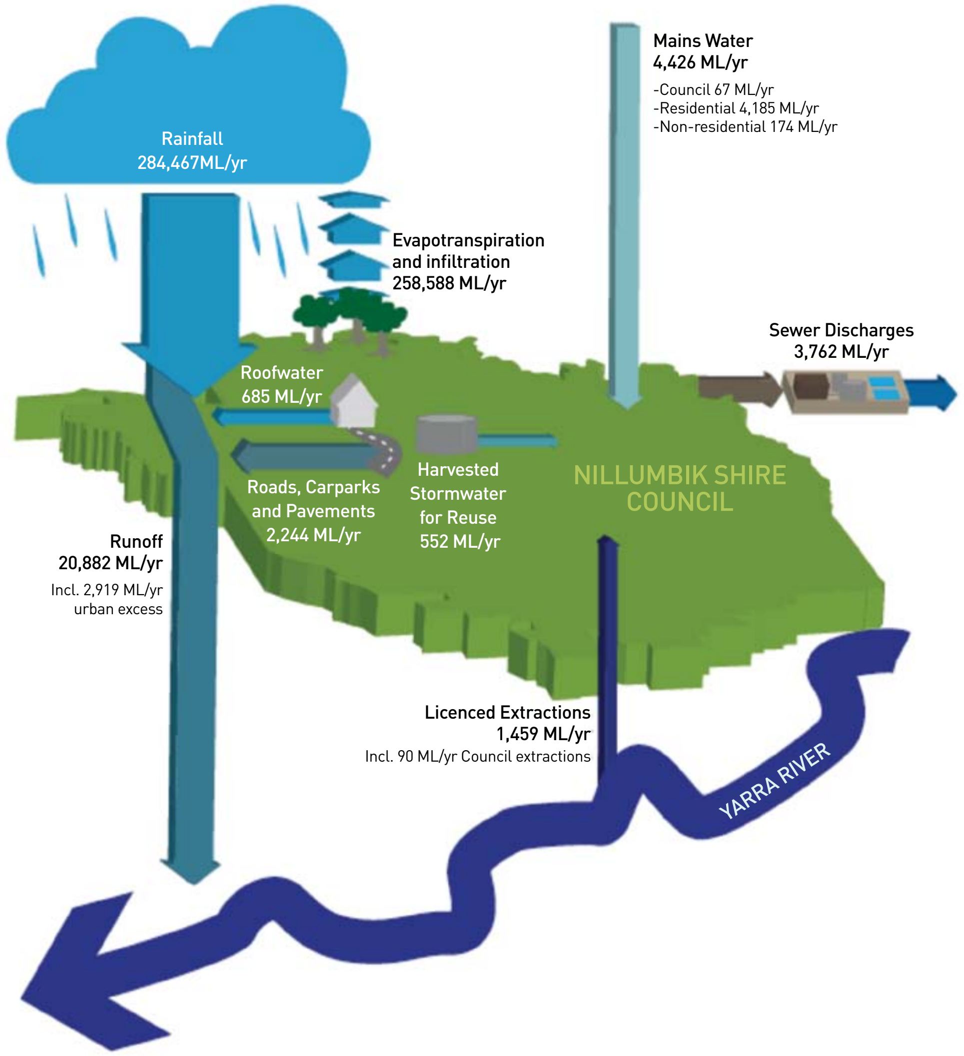
Numerous sources of data were used to calculate the water balance for the Shire. This included rainfall monitoring station data, metered water use data, stream flow data, and GIS data to calculate catchment areas and percentage imperviousness. Catchment areas and imperviousness was used to model stormwater runoff data. Wastewater generation is calculated using an assumed percentage of indoor water use.

The water balance characteristics for the Shire are summarised below and shown in Figure 7.

- Rainfall
  - a total of 284,467 ML/yr of rainwater falls across the Shire.
- Rainfall / Stormwater Losses
  - 258,588 ML of rainwater is lost to evapo-transpiration and infiltration to underlying soils.
  - 20,882 ML of rainfall is discharged as combined rural and urban runoff and base flow which includes 2,919 ML discharged as excess urban runoff (685 ML/yr is generated from roof areas that is not captured in tanks + 2,244 ML/yr from other surfaces such as roads, car parks and pavements).
- Mains Water Demand
  - a total of 4,426 ML of mains water is used annually.
- Stormwater Demand
  - 9.9 ML/yr of stormwater is harvested and used as an alternative water supply across Council assets
  - 542 ML/yr of stormwater is captured in residential rainwater tanks and used.
- Waterway Demand
  - 1,459 ML/yr is extracted from waterways; the bulk of this occurs across the rural areas, including 90 ML/yr extracted from the Plenty River as a water supply for the irrigation of the Yarrambat Golf Course.
- Wastewater
  - 3,762 ML/yr discharged to sewer.

Further descriptions of this water balance are provided in the following sections

Figure 7 Water balance for the Shire of Nillumbik



3.1.1 Water use

There has been a significant reduction in mains water use across the Shire of Nillumbik over the last twelve years. Table 4 provides a summary of Council, residential and non-residential mains water and rainwater (supplied via tanks) demands for 2000/01 and current (2011/12).

Table 4 shows that Council and non-residential demands have reduced by the greatest percentage but residential demands have decreased most significantly in terms of overall volume. Reticulated mains water demand has reduced from 6,463 ML/yr in 2000/01 to 4,462 ML/yr in 2011/12. There has been a 32 per cent reduction in mains water demand across the Shire from 2000/01 to 2011/12.

Table 4 Water demand for 2000/01 and 2011/12

Water source	**Land use**	**Baseline consumption 00/01 (ML/yr)**	**Current consumption 11/12 (ML/yr)**	**Reduction (ML/yr)**	**% reduction**
Mains water	Council	193	67	126	65%
	Residential	5,691	4,185	1506	26.5%
	Non-residential	579	174	405	70%
	Total	**6,463**	**4,426**	**2037**	**32%**
Rainwater	Council	unknown	9.9	N/A	N/A
	Residential	542	>542	N/A	N/A
	Non-residential	N/A		N/A	N/A
	Total		**552**		
Licensed extractions	Council	N/A	90	N/A	N/A
	Residential	N/A	N/A	N/A	N/A
	Non-residential	N/A	1,369	N/A	N/A
	Total		**1,459**		
Other	Council*	N/A	25.4	N/A	N/A
	Residential	N/A	N/A	N/A	N/A
	Non-residential	N/A	N/A	N/A	N/A
	Total		**25.4**		

*water sourced from a private dam for road grading purposes (100 kL per day between November and March and 40 kL per day between April and October)

Roof rainwater harvesting – private rainwater tanks or a comprehensive public system

Rainwater captured in tanks is common across many properties in Nillumbik. In 2008 mains water was connected to 17,828 properties out of 19,250 private dwellings (Nillumbik Shire Council, 2008). Therefore it is estimated 1,422 properties relied on tanks for their supply. Based on average water consumption in 2000/01 for residents living in Nillumbik during this time it is estimated that the total volume of rainwater used for residential purposes is 542 ML/yr.

Over the last decade many new properties were built that did not have access to mains water and it is likely many more properties installed rainwater tanks to supplement their mains water. This assertion is supported by the fact that there has been a very significant general lift in use of rainwater tanks across the entire Yarra Valley Water area since 1999 with the percentage of homes with rainwater tanks growing from less than 5 per cent to 30 per cent over a period of 12 years.

Figures available from water retailers suggest that of the 1.6M houses in the Melbourne area, around 28 per cent, now have rainwater tanks. In Yarra Valley Water's area, a surprisingly low 9 per cent are connected to an indoor use (toilet flushing and in some cases laundry). This means that the vast majority of rainwater tanks in urban areas are used mainly for garden irrigation. The size of rainwater tanks is also quite small compared to roof sizes with the average size tank being around 2,500 litres. With tanks of this size only supplying garden irrigation, overflows are a regular feature.

More comprehensive harvesting systems that seek to collect and treat all roof runoff from a precinct and supply water back to houses via first pipe is also worth exploring, but may not be possible in all established suburbs due to numerous constraints. These could include local topography, space available for storage and treatment within open space areas and being able to operate such a system at a sufficient scale to make it economically viable. However, where it can be employed, it maybe preferable method of rainwater harvesting to lot scale tanks.

Rainwater – Council

It is unknown what volume of rainwater was used across Council assets in 2000/01. Over the recent drought Council and community groups installed many tanks across assets that capture and store rainwater or stormwater. The estimated volume of rainwater (roof runoff) and stormwater (catchment runoff) currently used across Council assets is 9.9 ML/yr. There are 100 rainwater tanks installed across Council assets.

Waterway extractions

1,459 ML/yr is extracted from waterways within the Shire. The bulk of the extraction occurs across the rural areas. 1,369 ML/yr can be extracted under licencing agreements from waterways across the rural areas with an additional 90 ML/yr licence for Council to harvest from Plenty River to fill an off-line dam for the irrigation supply of Yarrambat Golf Course. Water may only be taken from the River from 1 June - 30 November.

Council has had extraction licenses since 2000/01 and a number of other extraction licences are currently not used. They are located at Falkiner Street (from the Diamond Creek near Barak Bushland wetland) and Eltham Lower Park (from the Diamond Creek). A bore is located at Fergusons Paddock and is not currently used.

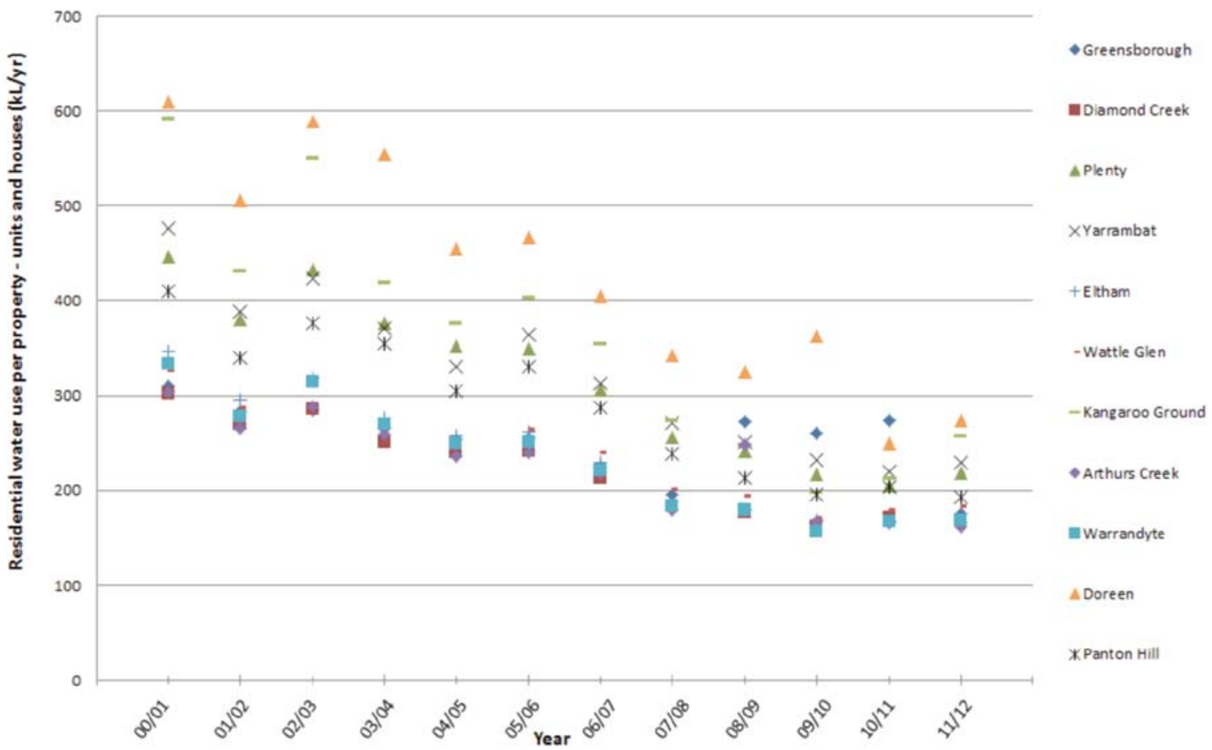
Further detail on mains water use

Figure 8 summarises the annual residential mains water demand by suburb from 2000/01 to 2011/12. Water use data for the post code of Yan Yean was considered to be erroneous and therefore excluded (9 properties that averaged an annual water demand of 1107 kL/yr from 2000 to 2011 with 4 years of missing data). Water use for St Andrews fluctuates significantly and is also likely to be erroneous (and therefore excluded).

The average residential property demand ranges from 300kL/yr to about 600 kL/yr in 2000/01. This has decreased significantly to range between 175 kL/yr to 280 kL/yr currently. All suburbs trend towards a reduction in average property water demand. Interestingly, each year the spread in demand data between suburbs has typically reduced suggesting that education programs and incentives for water conservation have been successful across the entire community and particularly with the high-end water users.

Assuming an average of 3 people per property this equates to 348 l/pp/day (ranging from 274 l/pp/day for Diamond Creek to 557 l/pp/day for Doreen) in 2000/01. Today, this has decreased to an average of 220 l/pp/day (ranging from 148 l/pp/day for Arthur's Creek to 250 l/pp/day for Doreen).

Figure 8 Residential main water use from 2000/01 to 2011/12 by suburb (assumes 3 people per property)

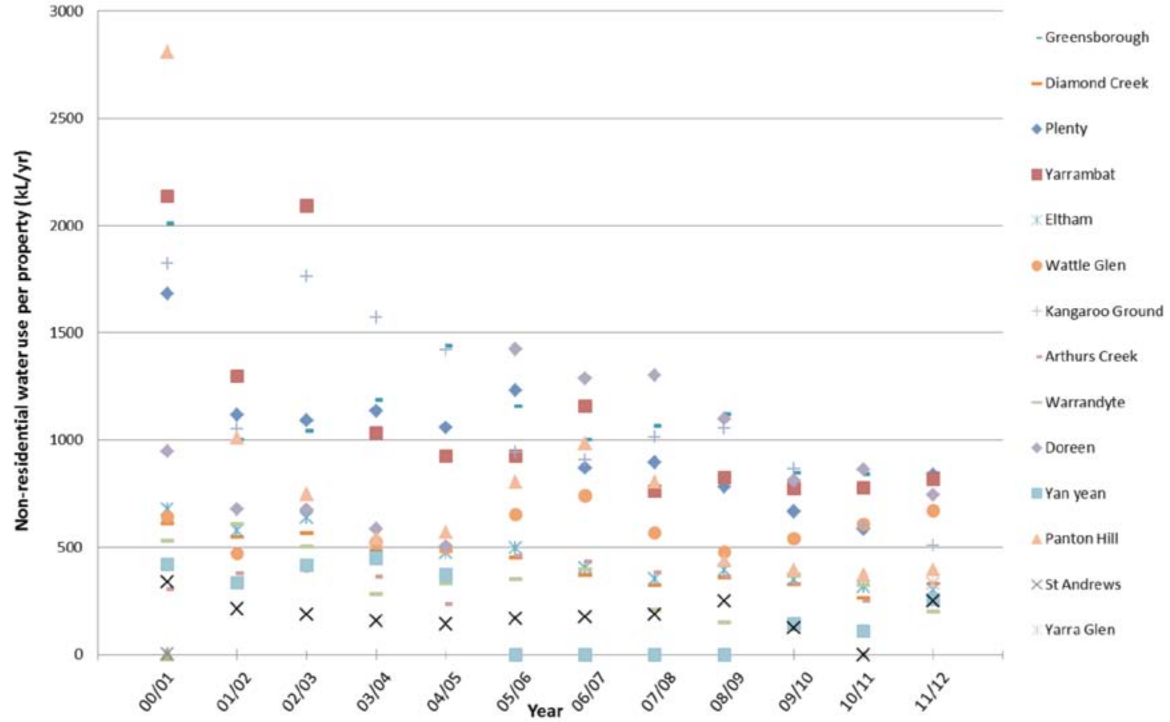


Interestingly, each year the spread in demand data between suburbs has typically reduced suggesting that education programs and incentives for water conservation have been successful across the entire community and particularly with the high-end water users.

Interestingly, Figure 8 shows no evidence of bounce back, water usage from the lifting of water restrictions.

Figure 9 shows that non-residential mains water demand has also seen a similar trend with the average for all properties for each suburb reducing their water demand over time. A similar pattern in the reduction in the spread of demand data is also evident. The average non-residential property demand ranges from 340 kL/yr to 2800 kL/yr in 2000/01. This has decreased significantly to range between 200 kL/yr to 850 kL/yr currently. This is partly attributable to water restrictions imposed during the drought and uptake of demand management fittings, fixtures, as well the loss of some 170 non-residential businesses across the Shire during this period.

Figure 9 Non-residential main water use from 2000/01 to 2011/12 by suburb



3.1.2 Stormwater and surface runoff

Stormwater and surface runoff flows generated throughout the Shire from each of the catchments were estimated. The Shire has a very high proportion of pervious rural areas. While stormwater runoff from impervious is relatively easy to estimate, the prediction of flows from these pervious areas is more difficult. To obtain reasonable estimates of flows and loads from these areas a model calibration was undertaken to estimate soil parameters suitable for use within the Shire.

The results summarised in Table 5 indicate that the use of the recommended Melbourne Water parameters would significantly over-estimate surface runoff from pervious areas. This has important implications for the estimation of surface runoff and pollutants. The calibrated soils parameters were adopted for further modelling of stormwater runoff across the Shire (refer to Appendix H for further information).

Table 5 Mean annual flows for Diamond Creek Catchment including Arthurs Creek (1981-1992) using Yan Yean rainfall (086131)

Data	Mean annual flow (ML/yr)
Diamond Creek observed mean annual flow at stream flow gauge 229223 (ML/yr)	**20,800**
Modelled mean annual flow with MUSIC default soil parameters (ML/yr)	**23,400**
Modelled mean annual flow with Melbourne Water soil parameters (ML/yr)	**45,400**
Modelled mean annual flow with calibrated soil parameters (ML/yr)	**19,400**

Mean annual flows for each of the catchments were estimated using a reference rainfall period matched to the long term average (Bundoora 1985-2004). Table 6 provides a summary of the mean annual runoff volumes for the major catchments located within the Shire of Nillumbik. The mean annual flow generated is 20,881 ML/yr of which 3,471 ML/yr is generated across impervious surfaces (of which 552 ML/yr is currently harvested). Less than 10 per cent of rainfall is converted to runoff with most evapo-transpired and returned to the atmosphere. Note that the flows do not match the figures above due to the use of different catchment areas and rainfall for the calibration.

Table 6 Catchment mean annual flows

Catchment flows	Total area (ha)	Mean annual rainfall (ML/yr)	Mean annual flow (ML/yr)
Arthurs Creek	12,906	84,968	5,421
Diamond Creek	14,952	98,440	8,650
Plenty River	2,064	13,587	1,226
Watsons Creek	8,334	54,869	3,466
Yarra River	4,956	32,630	2,118
Total	**43,212**	**284,494**	**20,881**

A breakdown of flows by surface type is shown in Table 7. The results indicate that most flows are derived from the extensive pervious rural and national park areas. However, while impervious areas represent just 1.5 per cent of the catchment area, they account for 17 per cent of the mean annual flow. This clearly indicates the significant impacts of urbanisation in increasing flow volumes in urban streams.

Table 7 Flows by surface type

Surface type	Public area flow (ML/yr)	Private area flow (ML/yr)	Total flow (ML/yr)
General impervious	20	832	852
Road	1,392	0	1,392
Roof	19	1,208	1,227
Pervious	609	16,801	17,411
Sub-total impervious	1,431	2,040	3,471
Total	**2,040**	**18,841**	**20,882**

Waterway diversions

While stormwater runoff leads to increases in runoff volume and frequency, agricultural waterway diversions can conversely reduce flow volumes. There are numerous farm dams within the Shire and together these represent a significant proportion of total allocations for the area (refer to Table 8). The allocations for Diamond Creek are significantly above the allocation limit due to farm dams being registered and added after the cap was set. Plenty River is also slightly above its allocation limit. As such, no new diversion licenses are likely to be approved in this area.

Table 9 and Table 10 outline the ban triggers for Diamond Creek and Plenty River, respectively.

Table 8 Allocation limits (Sourced: Melbourne Water's streamflow management plans for Diamond Creek and for the Plenty River)

Item	Diamond Creek	Plenty River
Allocation limit (ML/yr)	790	669
Total allocated volume (ML/yr)	1,129.1 (including 445.1 ML farm dam registrations and 38 ML farm dam licenses)	672 (including 286 ML farm dam registrations and 10 ML farm dam licenses)
No. of licenses	81 (including 58 farm dam registrations and 2 farm dam licenses)	37 (including 18 farm dam registrations and 1 farm dam license)
Volume of metered licenses (ML)	590	120

Table 9 Ban triggers for Diamond Creek

Item	Ban applied (ML/day)	Ban lifted (ML/day)
1 July to 31 October	13 (7 day avg) 9 (5 AM flow)	13 (7 day avg) 9 (5 AM flow)
1 January to 31 March	No harvesting	No harvesting
1 November to 30 June	1.5	9.5

Table 10 Ban triggers for Plenty River

Item	Ban applied (ML/day)
1 July to 30 November	2
1 December to 30 June	1.5

Net effect of stormwater excess runoff and waterway diversions

The effects of urban stormwater excess runoff and waterway diversions were evaluated to gain an understanding of their relative contributions to changes in stream flows. While it is recognised that in many years, diverters may only use a small portion of their available cap (as evidenced by very low diversions in recent years), it was assumed that the entire waterway cap may be drawn in a given year. The current mean annual flows were estimated by subtracting potential diversions from the model estimated mean annual flows. The natural flows prior to development or diversions were also estimated by subtracting the urban excess from impervious areas (over and above the flow generated from a corresponding pervious area) from the modelled flow.

The results shown in Table 11 and Figure 10 indicate that stormwater excess far exceeds potential agricultural diversions under the cap, resulting in an overall increase in flows. This can lead to increased erosion and incision of streams, more frequent disturbance of habitat and impacts on stream ecology. *Given these results, it is clear that there is potential for greater use of integrated water management and WSUD within urban areas to increase rainwater and stormwater reuse, evapotranspiration and infiltration to reduce the impacts of increased flows on waterways.*

It is important to recognise the spatial distribution of diversions and stormwater discharges. The ban triggers, discussed above, are directed at managing stream diversions during the drier months to ensure that minimum flows are maintained within the waterways for ecological purposes.

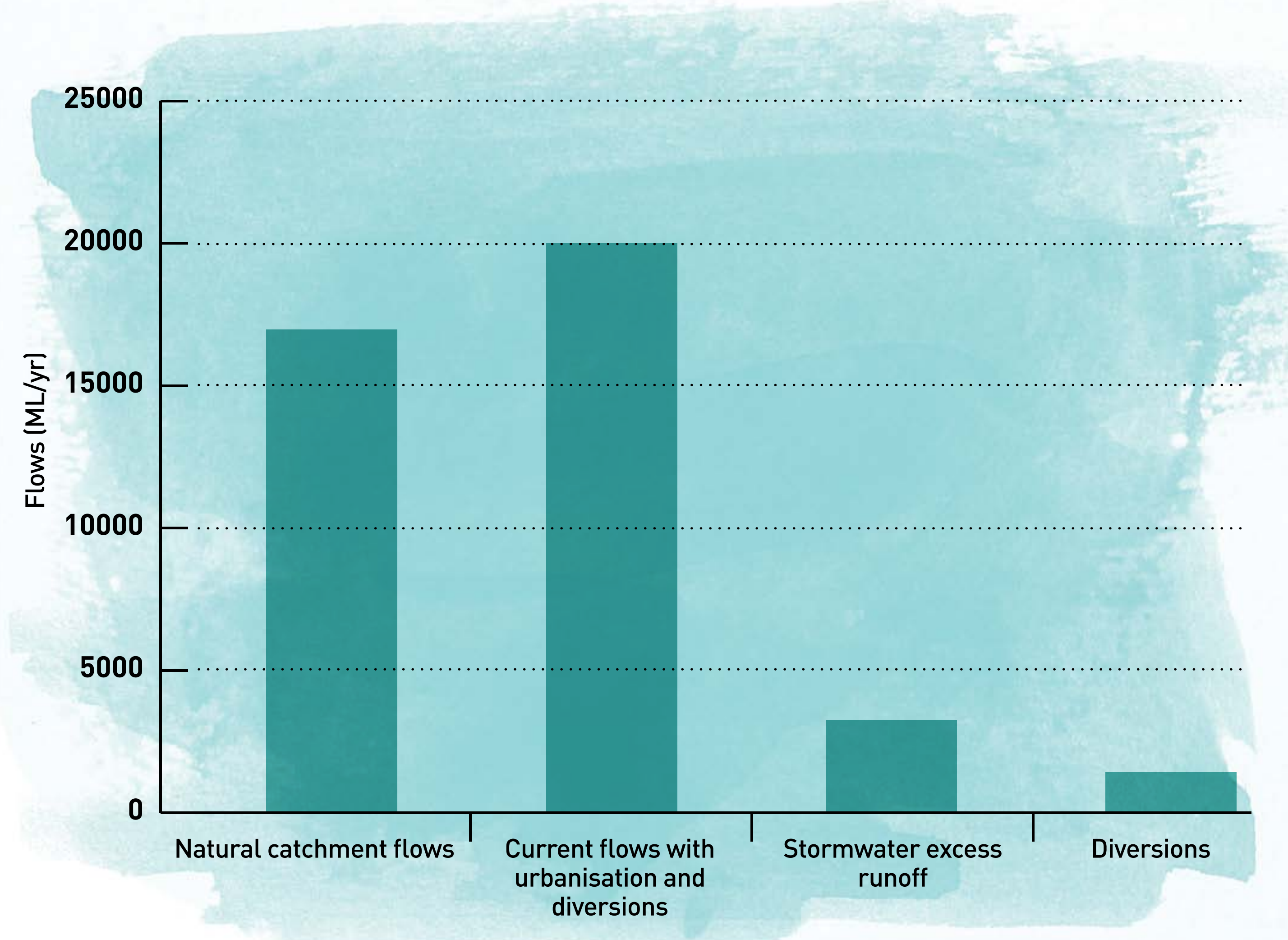
The urban stormwater excess is concentrated in the most downstream reaches of the waterways in the south of the Shire in Eltham, Greensborough and Diamond Creek while most diversions will occur further upstream. Therefore, the urban excess cannot substantiate increased diversions upstream of these townships but rather the harvesting of these flows must occur at its source, within the urbanised areas.

Table 11 Catchment mean annual flows

Catchment	Modelled mean annual flow (ML/yr)	Diversion cap (ML/yr)	Current mean annual flow with diversions and urbanisation (ML/yr)	Estimated natural mean annual flow pre-urbanisation without diversions (ML/yr)
Arthurs Creek*	5,421	0	5,421	5,279
Diamond Creek	8,650	790	7,860	6,114
Plenty River	1,226	669	557	844
Watsons Creek	3,466	0	3,466	3,409
Yarra River	2,118	0	2,118	2,027
Total	**20,881**	**1,459**	**19,422**	**17,673**

* Note that while diversions may occur from Arthurs Creek, these have been incorporated with Diamond Creek as the streamflow management plans do not provide a breakdown of diversions between these creeks.

Figure 10 Comparison of natural and current flows with stormwater excess and diversions across all catchments within Nillumbik



3.1.3 Wastewater

The generation of wastewater across the Shire of Nillumbik is calculated on typical percentages for indoor demands for mains water (assuming all indoor water except the volume consumed is discharged to sewer). The multiplying factors (sewage discharge factor) applied to mains water consumption for Council, residential and non-residential are provided in Table 12, along with the calculated wastewater generation figures. The increase in the discharge factor used from 2000/01 to 2011/12 reflects a shift in the proportion of total water consumption used for outdoor water use compared to non-consumptive indoor water use over this period. There has been a 28 per cent reduction in the generation of wastewater across the Shire. Minimising the generation of wastewater is also related to water conservation measures adopted (such as fitting, fixtures and appliances).

Table 12 Wastewater volumes generated in 2000/01 and 2011/12 as a percentage of mains water consumption

Year	Sector	Mains water consumption (ML/yr)	Sewage discharge factor	Wastewater generation (ML/yr)
2000/01	Council	193	0.50	96
	Residential	5,691	0.80	4,553
	Non-residential	579	0.95	550
	Total	**6,463**		**5,199**
2011/12	Council	67	0.60	40
	Residential	4,185	0.85	3,557
	Non-residential	174	0.95	165
	Total	**4,426**		**3,762**

Septics

It is estimated that there are 6500 septics located across the Shire of Nillumbik. The distribution of these systems are summarised in Table 13.

The majority of those located in residential areas are failing to deliver a satisfactory performance, resulting in threats to public health and pollution of local waterways. In some cases system failure is due to poor maintenance and management practices by property owners and occupiers. In other cases these systems do not comply with current legislative requirements as they were approved for use before legislation required all effluent to be treated and disposed of on-site. This means that only toilet waste is being disposed of via a septic tank and trenches and greywater is either being discharged to the street or on the property untreated.

The environmental impacts associated with domestic wastewater are due to the many pollutants it contains, such as particles of dirt, lint, food and human waste products and chemicals derived from detergents and other cleaning products. These pollutants can build up in the soil, damaging the soil structure, altering soil acidity/alkalinity balances and possibly harming plant growth.

The environmental impacts of domestic wastewater pollution may not be confined to the property where it originates. For example, saturating the soil can cause wastewater to percolate to the surface and run-off into neighbouring properties. The wastewater can also find its way into stormwater drains, rivers and streams, contributing to the pollution loads in these environments.

Domestic wastewater pollution can also present health risks, cause odours and attract vermin and insects. Microbial contaminants such as bacteria, viruses and algal blooms pose a significant public health risk.

From 2003 to 2011 there were 954 applications received by Council to install new septics (some of these would be to replace existing failing systems).

Yarra Valley Water Sewerage Backlog Program

Prior to the 1980s, new developments did not need a reticulated sewerage service and septic tank systems were approved as an interim solution. Since the mid 1980s all new developments are required to provide reticulated sewerage services. As water companies extend their sewerage lines, the properties not provided with reticulated sewerage at the time of development are able to be connected.

There are 1050 properties in North Warrandyte which do not have sewerage and a further 150 in Eltham North and Research whose owners are being invited to connect to the service when it becomes available in 2013/2014 as part of the 'sewerage backlog' program.

At the beginning of the Yarra Valley Water Sewerage Backlog Program Council identified approximately 1,950 properties in the Shire of Nillumbik that are unable to contain their wastewater on site all year round. Some of these properties have since upgraded their systems and now comply with Environment Protection Authority (EPA) Victoria requirements, but some properties still discharge uncontained effluent into the Yarra River (via seepage and surface runoff via drainage lines).

Council has been working with Yarra Valley Water in the development of their sewerage backlog completion program. Regrettably, due to the lack of government funding, the earliest the backlog program began to address any major sewerage issues was 2012. Following are the dates estimated that sewer will be provided to other areas identified as high risk in the Shire:

Table 13: Yarra Valley Water sewerage backlog timing

Backlog Area	Township/Area	Number of lots	Project dates
BA012	Eltham (North)/ Research	194	11/12 - 12/13
BA004	North Warrandyte	1046	12/13 - 13/14
BA005	Eltham (South)	300	25/26 - 27/28
BA007	Hurstbridge/Wattle Glen/ Diamond Creek	91	26/27 – 27/28
BA042	St Andrews	128	27/28 - 28/29
BA041	Panton Hill	148	27/28 - 28/29
BA040	Yarrambat	39	27/28 - 28/29

The program is in place to prevent nutrients, pathogens (which cause human illness) and other pollutants which originate in domestic wastewater from entering the surface and groundwaters.

Once these systems are replaced with a sustainable sewerage service, the risk to public health and the environment is significantly reduced.

Table 14 Number of properties in each suburb that are reliant on septics (Nillumbik Shire Council, 2002)

Township	No. of Properties
North Warrandyte	990
Eltham	506
Yarrambat	464
St Andrews	438
Research	366
Panton Hill	345
Kangaroo Ground	327
Diamond Creek	318
Plenty	309
Hurstbridge	289
Wattle Glen	259
Cottles Bridge	211
Arthurs Creek	151
Smiths Gully	119
Doreen	115
Christmas Hills	115
Bend of Islands	101
Eltham North	94
Nutfield	68
Strathewen	62
Watsons Creek	15
Yan Yean	7
Kinglake	6
Greensborough	5
Kinglake West	1

Given the high cost of sewer works, Yarra Valley Water has been exploring other options for sanitation services in some urban and peri-urban areas. In one recent case at Ringwood South on the Dandenong Creek system, Yarra Valley Water has invested in a series of waterway rehabilitation projects in preference to expensive sewering works. While this may not be applicable in all but a few cases, it does indicate that new approaches are now being considered under an IWM environment to deliver better water outcomes for communities.

3.1.4 Fire fighting

There are 43 fire fighting water tanks distributed across Nillumbik with a total capacity of 2.5 ML. The tanks are filled by the Country Fire Authority (CFA) using either dam, creek or class A recycled water provided by Yarra Valley Water. The location of the tanks and their capacity is summarised in Table 15.

Table 15 Fire fighting water tanks

Township	No. of Tanks	Capacity (kL)
Arthurs Creek/ Strathewen	4	294
Christmas Hills	15	714
Eltham	2	44
Hurstbridge	1	22
Kinglake	1	120
Panton Hill	6	527
North Warrandyte	1	120
St Andrews	11	626
Yarrambat	2	44

3.2 Stormwater pollutant budget

A pollutant budget considers the load of Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN) conveyed in stormwater runoff and treated using WSUD treatment measures such as raingardens, wetlands and stormwater harvesting schemes. Stormwater pollutant loads were estimated for the Shire for the various land uses and surface types and a summary of the results is provided below. For further information refer to Appendix E.




3.2.1 Stormwater pollutants generated from different surface types

The predominantly rural land use across the Shire generates significant runoff volumes and pollutant loads. Of the 43,211 ha of land, 644 ha is associated with catchment urbanisation. Clearing for agricultural purposes, loss of riparian vegetation, poor local soils and stock access to waterways has led to changes in catchment hydrology and impacts on streamside zones and water quality (as discussed in Section 2.2).

17 per cent of the runoff generated is attributed to impervious surfaces, which account for 1.5 per cent of the land use. Stormwater pollutants generated across the impervious surfaces are over an order of magnitude higher, on a per hectare basis.

Table 16 summarises the total flows and pollutant loads generated across the Shire as well as the volume and loads associated with impervious surfaces (urban excess). Therefore, limiting the connection of impervious surfaces to the waterways will provide a significant benefit by reducing flow related impacts and water quality impacts on the waterways. This helps to explain why stream health reduces from good to moderate down to poor in the Watsons Creek catchment and Diamond Creek catchment immediately downstream of urban development (as shown in Figure 6 and described in Section 2.2).

Table 16 Summary of total and urban excess flow generation and pollutant loads

Flow and pollutant	Total	Urban excess
Runoff Volume (ML/yr)	20,882	3,471
TSS Load (kg/yr)	1,630,270	621,908
TP Load (kg/yr)	5,678	1,208
TN Load (kg/yr)	49,365	7,745

Figure 11 shows that while most flows are discharged from pervious areas, in urban areas, roads, roof areas and general impervious surfaces contribute similar proportions of runoff to the receiving waterways. Figure 12, Figure 13 and Figure 14 show the following important results for the generation of pollutant loads across the Shire:

- Pervious areas contribute the highest total pollutant loads due to the relative high proportion of rural areas to other surface types across the Shire; albeit they generated a lower pollutant load per ha of land compared to urban areas.
- Across urban areas Council roads contribute the greatest TSS loads and TP loads due to the higher concentrations found on these surfaces (sediments are largely associated with vehicle activity and phosphorus is predominantly bound to sediments) than found on roof and other impervious surfaces, and
- Across urban areas, roads, roof areas and general impervious surfaces contribute similar proportions of TN to the receiving waterways. This is because nitrogen generation is predominantly due to atmospheric deposition and therefore is evenly distributed across different surface types (these surface types represent similar proportions of impervious surface types across the Shire).

Figure 11 Flow (ML/yr) by surface type

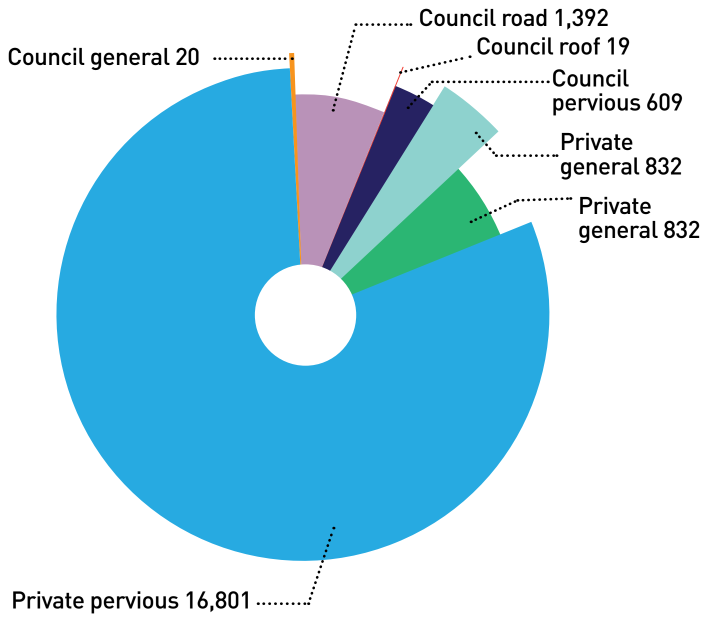


Figure 12 TSS load (kg/yr) by surface type

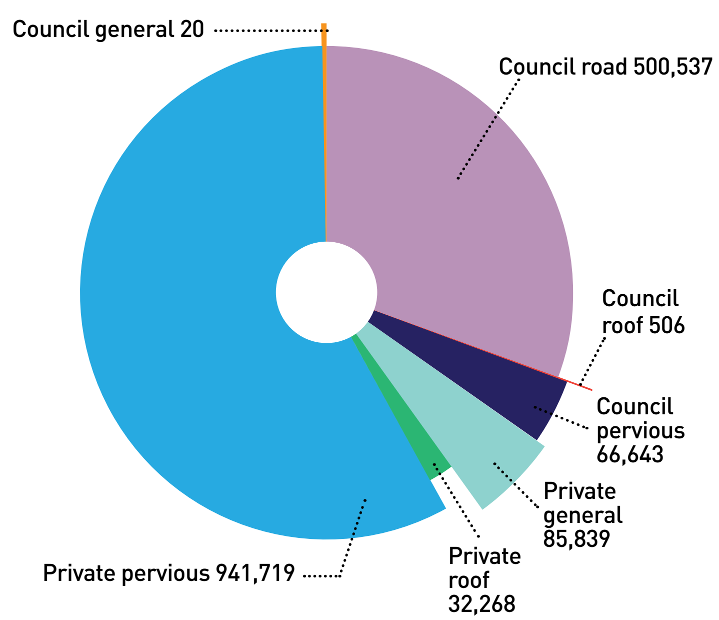


Figure 13 TP load (kg/yr) by surface type

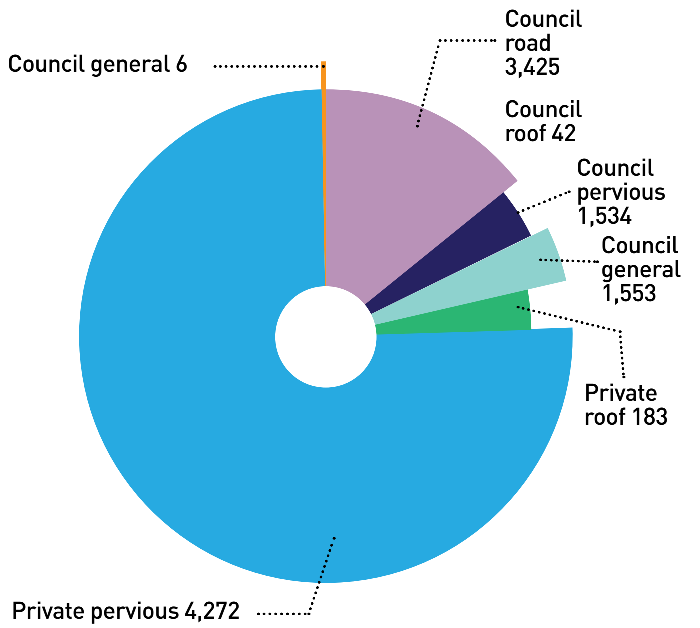
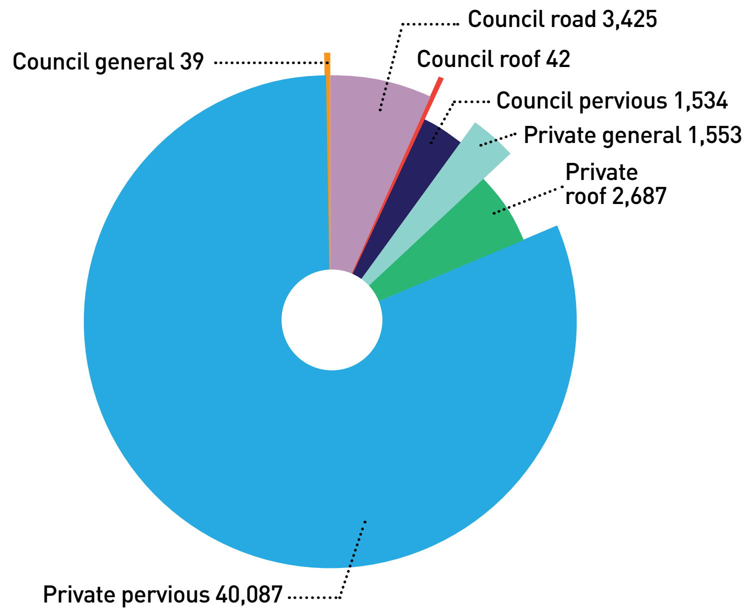


Figure 14 TN load (kg/yr) by surface type



3.2.2 Stormwater pollutants generated from different catchments

Figure 15, Figure 16 and Figure 17 compare the relative significance of stormwater runoff and pollutant loads generated across the 5 major catchments located in the Shire discharging to the receiving waterways. In general, the highest TSS load and TN load are related to pervious areas within the catchments; this is because all catchments are represented by large pervious areas. Diamond Creek catchment has the highest TSS load generated from road surfaces (as shown in Figure 16). Road surfaces in the other major catchment are also a significant source of TSS entering the waterways.

Figure 15 Stormwater flows by catchment and surface type

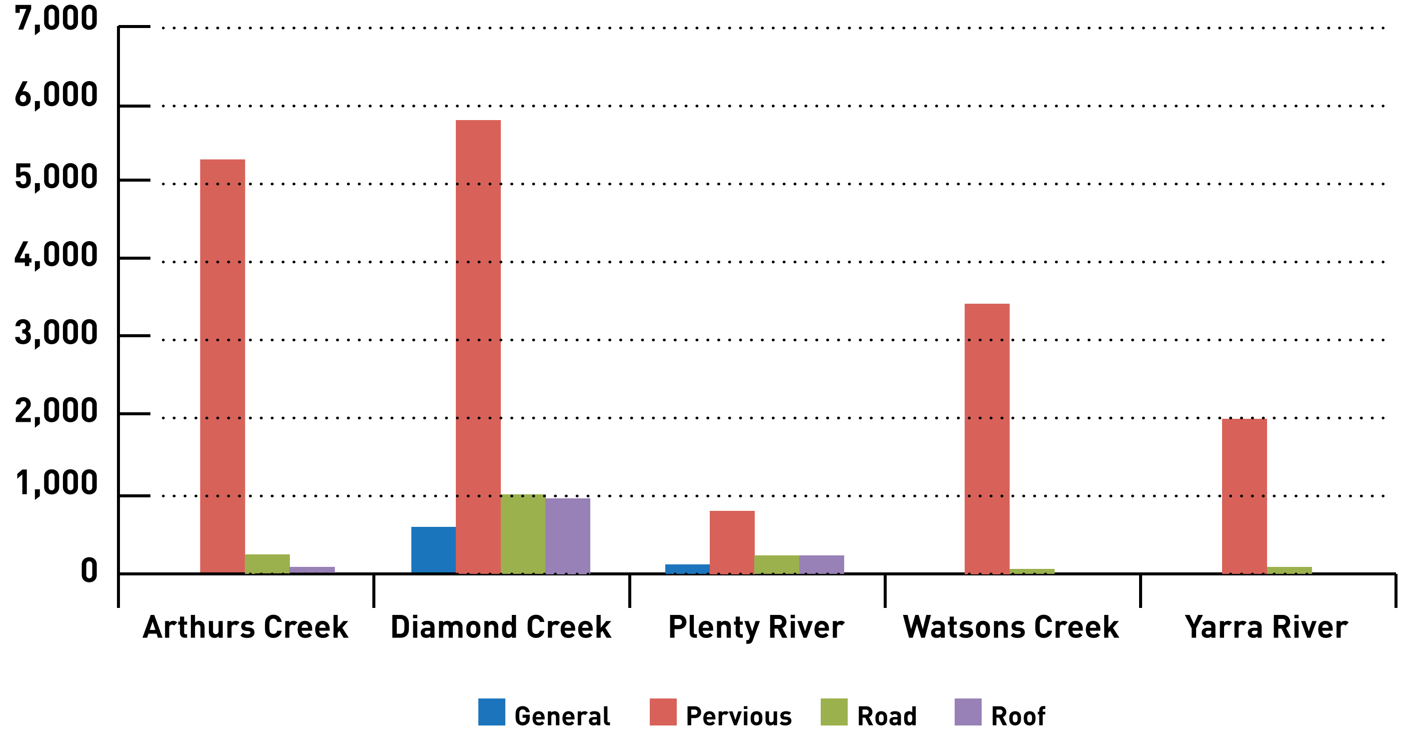


Figure 16 Total Suspended Solids loads by catchment and surface type

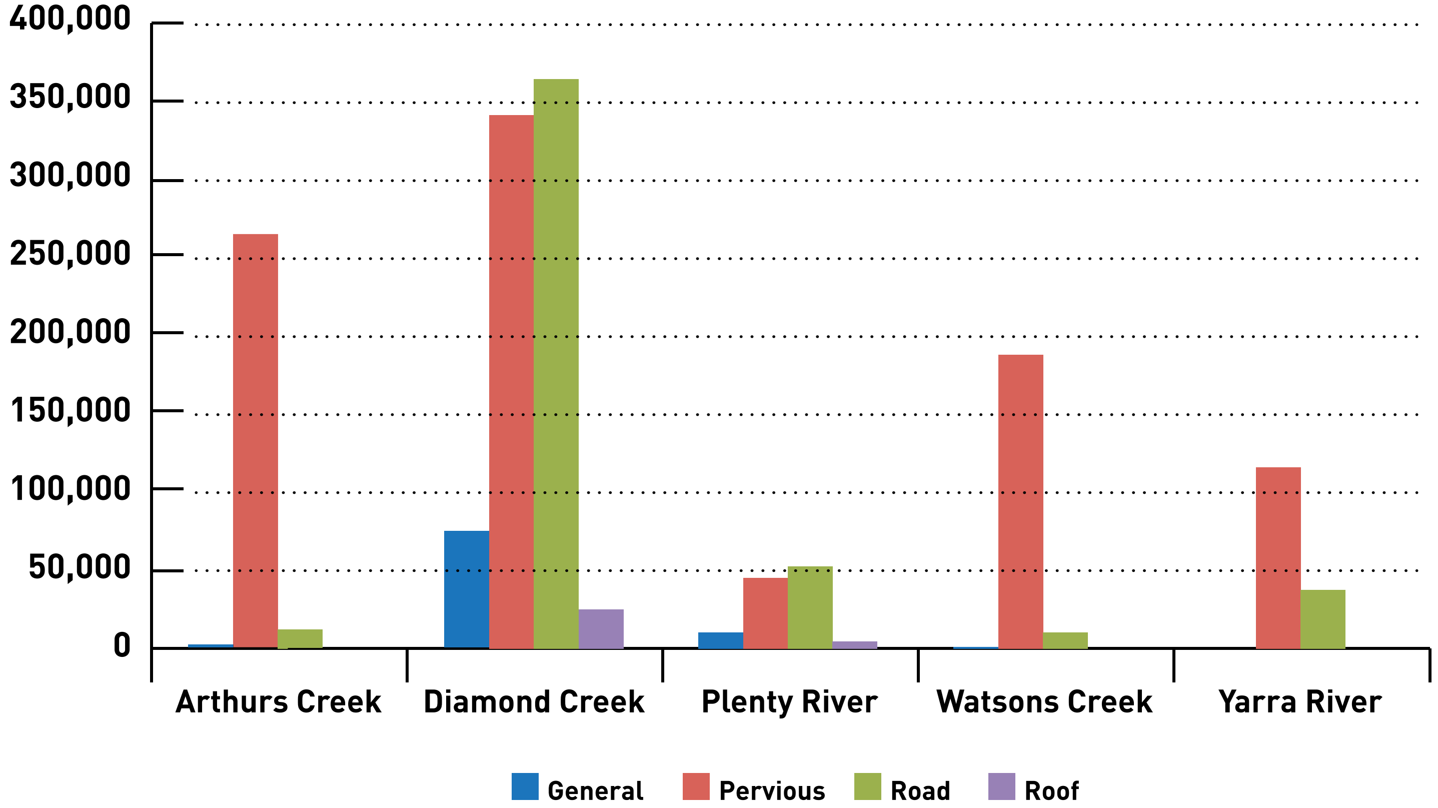
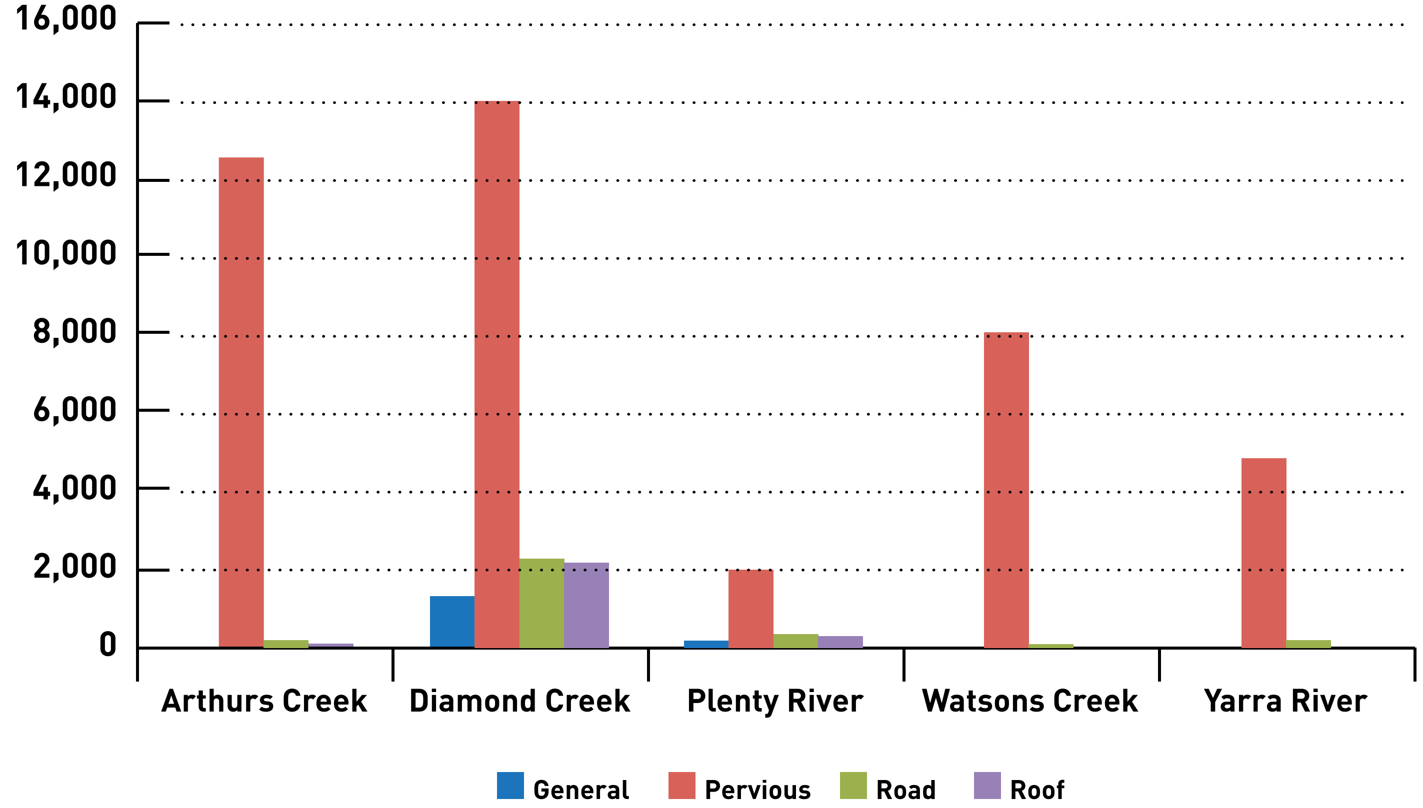
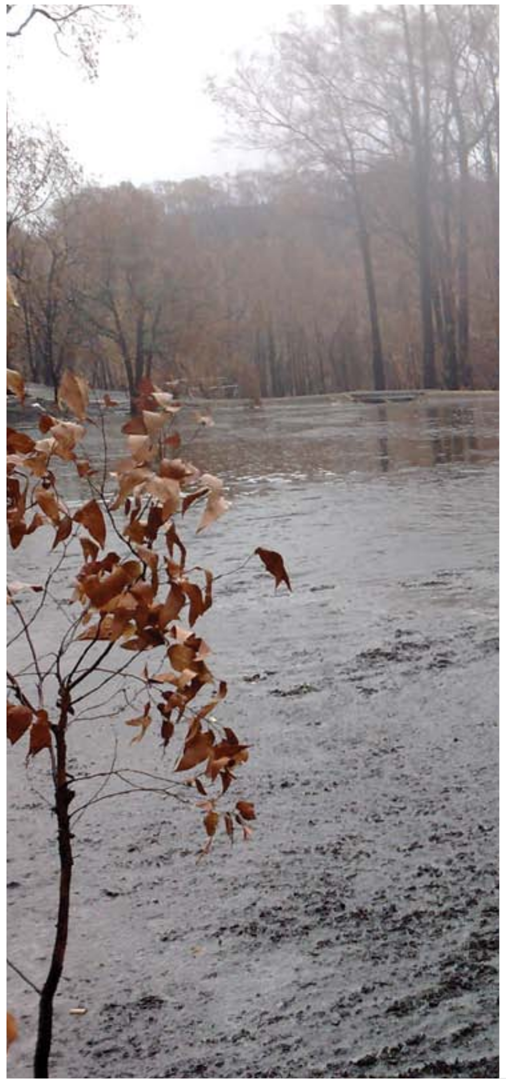


Figure 17 Total Nitrogen loads by catchment and surface type





4.0 Integrated Water Management (IWM) Targets

A Shire wide water balance and pollutant budget for 2011/2012 (current) has been calculated to provide a snapshot of all water flows throughout the Shire to establish a platform for setting Integrated Water Management (IWM) targets. In the future, WSUD project benefits will be measured against targets for the provision of water security and environmental protection of receiving waters.

A tracking tool has been developed to assist Council to record information about projects in a consistent manner as well as measure progression toward attaining water quality and flow management targets (the input data is shown in Appendix F and the tool provided to Council for future use as part of the deliverables from this project).

Integrated Water Management carries an assumption within its title of much greater levels of cooperation across a number of parts of government. Such an approach is clearly supported by the Office of Living Victoria which is responsible for driving this policy change across government.

Within the local Nillumbik context, strong cooperation between Council, Yarra Valley Water and Melbourne Water will be required in order to understand where viable local sources of alternative water can be accessed and to develop plans and designs to use these resources. Further, protection of stream environments and reduction of urban stormwater flows will also be a cooperative exercise between these same authorities – Melbourne Water as the regional drainage and waterway manager, Council as the manager of the local drainage system transferring stormwater to the Melbourne Water system and Yarra Valley Water as the body responsible for distribution of water where alternatives seeking to re-use this stormwater are employed.

Therefore the assessment that follows below assumes the above separation of statutory responsibilities, but that IWM will in itself drive much stronger levels of cooperation to achieve better water outcomes for the community and more liveable local environments.

4.1 Water security targets

While water security is primarily a responsibility of water authorities and not Council, targets broadly aim to ensure future generations have access to a range of water supply options to meet potable and non-potable demands. Council and the community have made significant achievements in regards to water conservation having exceeded targets that were previously established.

Water use data collated for this project and discussions with internal stakeholders revealed that mains water conservation has been achieved through demand management (especially water restrictions during the millennium drought) and source substitution (provision of alternative water supplies). Nearly all Council assets have demand management fittings and fixtures installed and there was general consensus across Council staff that further water conservation efforts need to be directed at provision of alternative water supplies.

All water (mains and alternative water sources) is a precious resource that will be managed accordingly and used on a 'fit-for-purpose' basis. On-going demand management actions for potable water conservation will continue to be adopted.

Demand management will continue to seek to reduce water use through:

- behaviour change (e.g. reduced shower times/ frequency – this is an initiative that can continue to best be led by water retailers, but can also be supported by Council)
- improved water management (e.g. leak detection and repair, drought tolerant planting)
- structural measures (e.g. installation of water efficient fixtures and fittings on Council water appliances and more broadly within the community, especially showerheads, dual flush toilets, tap aerators, hot water recirculation devices etc. – again this is an initiative that can continue to best be led by water retailers, but can also be supported by Council).

These actions will be complemented by initiatives that seek to provide alternative water sources including roof rainwater harvesting and stormwater treatment and re-use.

Setting water security targets will progressively lead to improved water security. Analysis of water consumption figures found Council has achieved a 65 per cent reduction and the community (residential and non-residential combined) have achieved a 31 per cent reduction. Further reductions in water conservation will become increasingly difficult through demand management. Therefore new alternative water supply targets have replaced the existing water conservation targets. These targets include the use of alternative water sources to provide for irrigation of sporting fields (some of which may not be currently irrigated) and for the water required for the road grading program. These alternative water use targets can provide inherent benefits associated with disconnecting potentially large areas of impervious catchment from waterways and reducing pollutant loads entering the waterways.

Greater use of rainwater across the private domain (especially for indoor uses such as toilet flushing) plays an important role in disconnecting roof areas and reducing runoff volumes and nitrogen loads entering the waterways. While water retailers have provided a lead in promoting these activities and offer rebates to customers wishing to install rainwater tanks, Council will continue to strengthen their role in education programs and other incentives to assist with this.

The 2025 target for provision of alternative water to supply non-potable demands is:

- an increase of 7.5 ML/yr of stormwater used to supply non-potable demands across Council assets
- an increase of 10 ML/yr of stormwater used across the private domain.

A focus within these targets is to improve liveability through ensuring sporting fields remain playable for longer via irrigation from alternative sources and reducing reliance on waterway extractions required for irrigation of Yarrambat Golf Course. Provision of an alternative water supply for the road grading program is also important as the current sources of water are at potential risk into the future through changes in land ownership (currently sourced largely from a rural property through good will).

4.2 Environmental protection of waterway targets

Conventional drainage systems discharge untreated stormwater directly to local waterways where pollutants and changes in flow patterns have been shown to directly impact on waterway health. The low percentage of Directly Connected Imperviousness across all waterway catchments in Nillumbik means there is merit in establishing stormwater quality targets and DCI targets (flow management targets). However, as previously mentioned, DCI is not the exclusive determinant of stream health and other works such as strategic farmland reafforestation (where practical), some carefully planned in-stream and stream bank works, continuing emphasis on improved vegetation management and revegetation along stream frontages, as well as other works to help manage farm generated sediment loads and improve runoff quality, will be critical to improvement of stream environments.

4.2.1 Water quality targets

Setting stormwater pollutant load reduction targets is the first step toward protecting local waterways from the impacts of catchment urbanisation. Targets are based on the *Urban Stormwater: Best Practice Environmental Management Guidelines* (Victorian Stormwater Committee, 1999), which sets targets of 80:45:45 for TSS, TP and TN respectively with the exception of TP removal targets. Industry experience and research findings indicate that in most cases a removal rate of 60 per cent (as opposed to 45 per cent) is generally achievable for TP when a WSUD treatment measure is sized to remove 45 per cent of TN and 80 per cent of TSS. It is likely that a 60 per cent TP removal rate will be widely adopted in the future (the Guidelines are currently being revised by Environment Protection Authority (EPA) Victoria and Melbourne Water and the release of the updated targets is due in 2014).

The long term stormwater pollutant load reduction targets for Nillumbik are:

- 80 per cent reduction in the mean annual Total Suspended Solids (TSS) load from 2000/01 load
- 60 per cent reduction in the mean annual Total Phosphorus (TP) load from 2000/01 load
- 45 per cent reduction in the mean annual Total Nitrogen (TN) load from 2000/01 load.

Of the 43,200 ha of land that is located in Shire only 644 ha represents impervious surfaces that generate urban excess runoff. The pollutant loads from impervious surfaces in urban areas are taken into account to establish the load reduction requirements associated with water quality targets for the Shire. Table 17 summarises the long term load removal targets for TSS, TP and TN.

Table 17 Stormwater pollutant targets

Stormwater pollutant	Load associated with urban excess	Long term target - load removal
TSS Load (kg/yr)	621,908	497,526 (80%)
TP Load (kg/yr)	1,208	725 (60%)
TN Load (kg/yr)	7,745	3,485 (45%)

Consideration of the likely investment scenario by Council and the community over the next 12 years to 2025 provides insight to the length of time attainment of Best Practice targets will take. Over this period Council will construct/install a range of WSUD projects. The following projects have been assumed for the purpose of calculating the trajectory and an equivalent level of investment is assumed into the future. Each project identified below could be substituted for an equivalent project if the project identified could not proceed due to unforeseen circumstances (that may become evident during the detailed design phase). Projects included are:

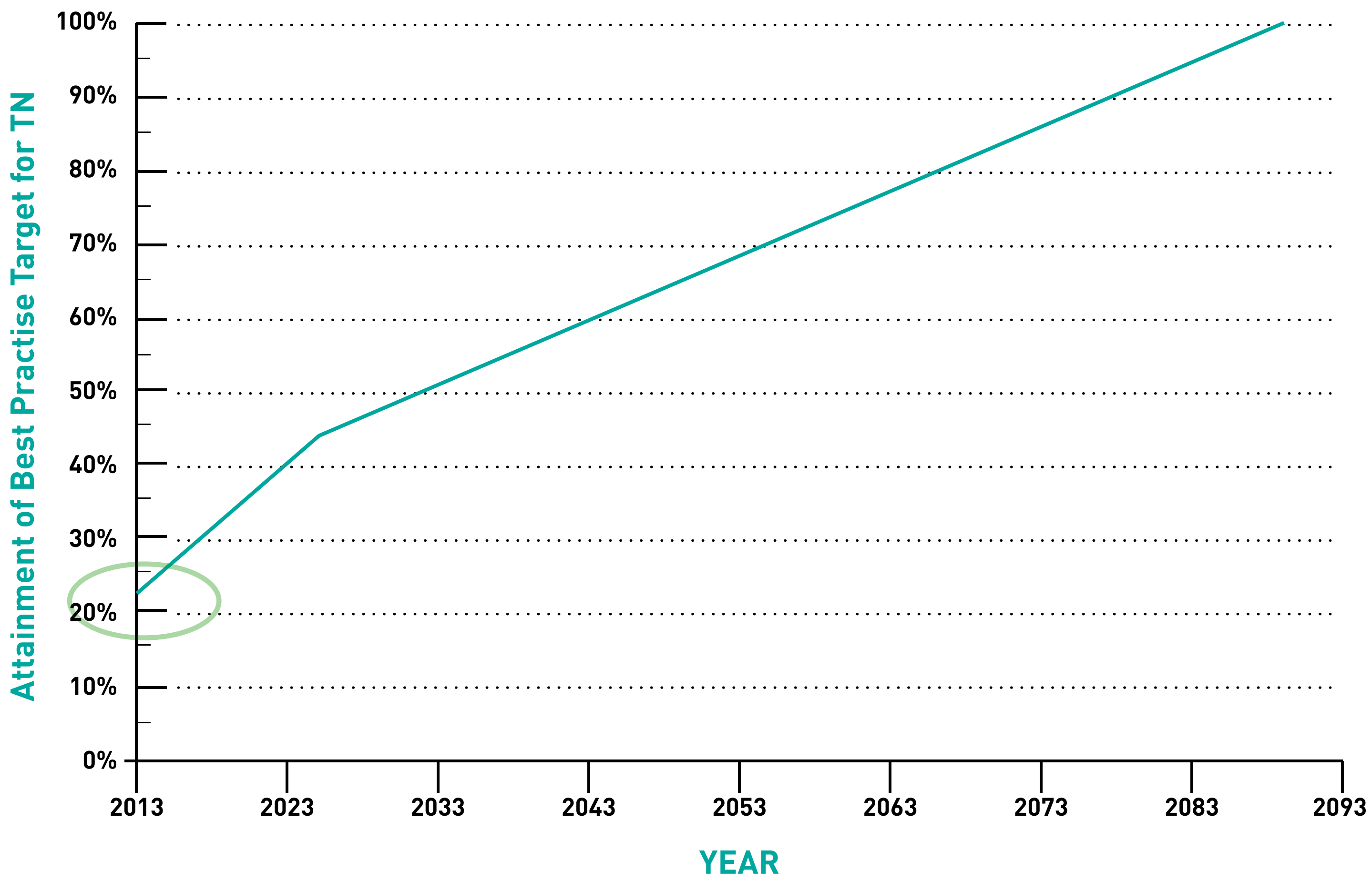
- Investigating the construction of a stormwater harvesting scheme at the Yarrambat Golf Course and retrofit the existing series of ponds into a chain of wetlands to provide stormwater quality treatment for runoff generated from the upstream low density urban catchment.
- Investigating the construction of a stormwater harvesting scheme at the Barak Bushland Wetland site. Provision of storage to the south of the existing wetland system would provide water to supply the irrigation of the two ovals located at Eltham Lower Park.
- Investigating the construction of a stormwater harvesting scheme for the irrigation supply for six ovals.
- Installing rainwater tanks, or upgrade existing systems to supply toilet flushing at five Council sites per year.
- Encouraging the installation of rainwater tanks, or upgrade existing systems to supply toilet flushing at 200 homes per year (180 new properties per year and 20 retrofits).

Setting stormwater pollutant load reduction targets is the first step toward protecting local waterways from the impacts of catchment urbanisation.

Post 2025 the trajectory assumes that new projects implemented each year will be capable of reducing half the pollutant loads achieved each year from projects constructed now to 2025. This is because stormwater harvesting scheme projects (the typical projects to be constructed over the next 12 years) are capable of removing significantly greater pollutant loads than WSUD projects that do not include harvesting. However, stormwater harvesting projects are often fairly expensive and will in many cases be dependent on the involvement of both Melbourne Water and Yarra Valley Water, as well as possibly an additional player such as OLV. Providing these projects can go ahead, by 2026 many of the harvesting scheme project opportunities will be constructed across the Shire resulting in other types of WSUD projects becoming more commonly implemented.

Figure 18 shows the timeline trajectory to attain Best Practice targets for the Shire assuming an average investment of $440K per annum by Council (and supported by external funding) and 200 rainwater tanks installed on residential properties. The trajectory is based on the pollutant Total Nitrogen. It takes into consideration the 23 per cent attainment achieved to date. Based on the investment scenario outlined above the Shire will attain best practice water quality targets by 2088.

Figure 18 Attainment of best practice stormwater quality targets (based on Total Nitrogen)



To facilitate the uptake of these targets interim targets for 2025 have been calculated. A 45 per cent Best Practice target for stormwater quality by 2025 is based on the proposed level of investment into WSUD projects. This equates to a reduction in:

- Total Suspended Solids (TSS) of 153,000 kg
- Total Phosphorus (TP) by 200 kg
- Total Nitrogen (TN) by 810 kg

4.2.2 Flow management targets

The review of the *Urban Stormwater Best Practice Environmental Guidelines* may introduce new flow management objectives that will be required under the *Victorian Planning Provisions (Clause 56.07)* for all new residential subdivision development. Furthermore, the Office of Living Victoria is working to expand *Clause 56.07* across all forms of urban development.

When looking at individual lots and dual occupancies, it is regulated under the building permit process that each new dwelling should have either a solar hot water system or a rainwater tank for toilet flushing. However, it has been seen as reasonable that a requirement for a 2000 kL tank (plumbed to a toilet or similar use where potable water is not required) be applied to all such developments and this has been pursued by Nillumbik Shire Council to good effect (despite not being a requirement of the planning scheme). While a 2,000 kL rainwater tank is certainly better than nothing, its limitations do need to be recognised. Fundamentally, small tanks harvesting from large roofs, especially with minimal indoor connections, will overflow very regularly and do little for potable water replacement due to their small storage capacity. At best, small rainwater tanks also offer some level of detention of stormwater, but at many times of the year that will be minimal or non-existent. Hence, given most tanks in urban areas with mains water are small, the contribution that tanks can make to improvement of stream condition is probably modest, as is their contribution to potable water replacement.

All waterways located in Nillumbik will benefit from establishing flow management targets. The low percentages of Directly Connected Imperviousness (DCI) combined with the moderate to good condition of waterways (based on IRC scores) provide a significant opportunity to protect and/or improve the health of waterways throughout the Shire. However, given that DCI will probably continue to be fairly low given there are no growth corridors in Nillumbik, as indicated in 4.2 above, a variety of other stream works will be required to achieve stream improvement.

Across the Shire all new development and future sealing of road surfaces must incorporate WSUD to ensure minor runoff events are treated, infiltrated to the underlying soils or harvested thereby ensuring these impervious surfaces remain 'disconnected'. The long term DCI targets for the 5 major waterways located in the Shire are described below.

Diamond Creek catchment

Target: Actively disconnecting impervious surfaces to achieve a DCI of less than 2 per cent.

Diamond Creek is located entirely within the Shire and has a DCI value of 3.4 per cent (504 ha of impervious surfaces directly connected to Diamond Creek). The upper tributaries are rated as being in excellent condition and the upper reaches are in moderate condition. The lower reaches are impacted by urban development and are rated in poor condition. Actively disconnecting impervious surfaces using WSUD (this could include an entire precinct treated and harvested as part of an alternative water supply for the irrigation of a sports field or oval) will provide conditions conducive to restoring the health of the waterways in the lower reaches of Diamond Creek. This is equivalent to an area of 210 ha (over the next 85 years).

Watsons Creek and Arthurs Creek catchments

Target: No increase in DCI per cent.

Watsons Creek and Arthurs Creek are also located entirely within the Shire and both have extremely low DCI values of less than 0.2 per cent. The catchments of these waterways have little urban development however land clearing and stock access to the creeks have seriously impacted on their health over many decades and this especially applies to Arthurs Creek. To maximise the benefits achieved through rural land management actions (such as, streamside revegetation programs and fencing out of stock from the waterways) flow management is directed at ensuring all future sealing of road surfaces incorporates WSUD to ensure minor runoff events are treated and infiltrated into the soil. Other works will also be required to improve the condition of Arthurs Creek and these have been outlined in section 4.2 above. These works are mainly within the ambit of Melbourne Water, although Council can play a part in its liaison activities with Landcare groups and through other initiatives.

Plenty River and Yarra River catchments

Target: No increase in DCI per cent.

Only a small proportion of the Plenty River and Yarra River catchments are located in the Shire. The DCI values associated with the proportion of their catchments located within the Shire are low (Yarra River - 0.4 per cent; Plenty River - 4.1 per cent). However, significant urban development located in adjacent municipalities has significantly impacted the health of these waterways (IRC rating is poor). Council can ensure no increase in DCI per cent occurs with new development in Nillumbik. This will provide the opportunity for adjacent municipalities and Melbourne Water to implement flow management targets potentially resulting in the progressive improvement of waterway health.

5.0 Actions and Recommendations

The peri-urban nature of the Shire presents some unique challenges and opportunities in terms of WSUD, stormwater harvesting and planning for Integrated Water Management. To ensure attainment of Integrated Water Management Targets, Council needs to proactively integrate WSUD projects into their asset management plans and open space masterplans, and promote the use of rainwater tanks to supply indoor and outdoor demands across the private domain. Five key areas of focus are recommended:

- Identify and construct key stormwater harvesting projects for irrigation of ovals and other amenities.
- Incorporate WSUD into all new developments to ensure minor runoff events are treated, infiltrated or harvested.
- Sealing of road surfaces must incorporate WSUD to ensure minor runoff events are treated and/or infiltrated into the soils and they remain disconnected from the waterway.
- Actively disconnect impervious surfaces in the lower Diamond Creek catchment using WSUD.
- Encouraging the exploration of opportunities for comprehensive capture and treatment of rainwater from roofs for treatment and supply to first pipe residential uses in recognition that this provides an optimal solution to stormwater reduction.
- Continuing to promote uptake of rainwater tanks across the private domain and where possible encourage their connection to indoor demands such as to supply toilets and/or the washing machine cold water tap in the laundry.

Table 18 provides an annualised summary of what Council is aiming to achieve so that the long term IWM targets outlined in Section 4 are achieved.

Table 18 Annual targets to progress towards long term attainment of Integrated Water Management Targets

Target Area	Annual target to 2025
Alternative water volume – private assets (ML/yr)	10
Alternative water volume – Council assets (ML/yr)	0.6
Disconnection of impervious surfaces in the Diamond Creek catchment (ha/yr)	2.5
Reduction in TSS loads (kg/yr)	11,770
Reduction in TP loads (kg/yr)	15
Reduction in TN loads (kg/yr)	62

The key projects that contribute to Nillumbik reaching a sustainable water future are included in the list of recommended actions identified in Table 19, Table 20 and Table 21. Timing in many cases is dependent on accessing grants and /or partnerships.

Table 19 Recommendations for strategic actions

Actions to provide the fundamental building blocks for mainstreaming sustainable water management across the Shire	Responsibility	Timeframe
Engage with OLV to explore opportunities for Nillumbik's participation in local and regional plans for IWCM as set out in the draft Melbourne's Water Future (p. 52).	Council	Immediate (2013)
Identify road sealing projects on Council's capital works program so that all runoff is treated and the road surfaces remain disconnected from waterways.	Council	Immediate (2013)
Continue to map WSUD projects and their catchment areas onto a GIS layer and update as future projects are implemented. This will form the basis of an asset register to support ongoing maintenance activities.	Council	Immediate (2013)
Utilise the existing Environment Coordination Group to establish a WSUD/ IWM working group (including representatives from urban design, engineering, environment, parks, major projects, leisure, recreation, transport, planning, GIS) to provide updates on the strategy, information, opportunities, monitoring and maintenance and ensure WSUD/IWM are mainstreamed into everyday practice.	Council	Immediate (2013)
Require and prepare precinct or other plans (e.g. Civic Drive Precinct Plans) to ensure there is full incorporation of IWM and that opportunities to further IWM objectives are identified and included in these plans.	Council	Immediate (2013)
Ensure there are clear requirements regarding WSUD/IWM in the Municipal Strategic Statement and develop a local planning policy.	Council	By 2015
Develop the IWM supply corridors concept for the lower Diamond Creek Corridor.	Council	By 2015
Expand the community education program delivered through Edendale and other avenues to: - Inform the community about IWM (what it is and why it's important). - Raise awareness of actions Council are taking to increase water security and protect the health of waterways through stormwater harvesting projects, stormwater quality treatment, and other WSUD projects. - Encourage community actions that disconnect impervious surfaces and improve water quality (e.g. installation of rainwater tanks and the enhanced benefits achieved through connecting the tanks to toilet flushing). - Discourage activities that can impact stormwater harvesting schemes and WSUD measures (e.g. paint down the drain; oil spills).	Council	By 2015

CONTINUED Table 19 Recommendations for strategic actions

Actions to provide the fundamental building blocks for mainstreaming sustainable water management across the Shire	Responsibility	Timeframe
Incorporate WSUD into ongoing capital works planning (including budgeting requirements) to ensure Council is disconnecting impervious surfaces from discharging directly into waterways in the Diamond Creek Catchment and achieving annual pollutant reductions across the Shire by 2025 of: - 153,000 kg of Total Suspended Solids. - 810 kg of Total Nitrogen. - 200 kg of Total Phosphorus. Disconnection and treatment is achieved through installation of rainwater tanks, construction of precinct scale stormwater harvesting projects, construction of raingardens and swales along roads, car parks and other paved areas.	Council	By 2015
Investigate opportunities to supply the road regrading program with close easy access to stormwater systems to undertake the design of a stormwater treatment and harvesting scheme to supply the road grading program. The following sites have been identified by the Infrastructure Maintenance team as desirable locations: - Allendale Wetlands - Proposed Hurstbridge Wetlands - Kangaroo Ground, pump upgrade on old landfill site - Warrandyte/ Christmas Hills South - St Andrews North, Mullers Rd/ Arthurs Creek - Strathewen - Diamond Creek Other sites identified for potential development include: - Challenger Street Wetland, Diamond Creek up to 17.5 ML/year - Coventry Wetland, up to 9 ML/year - Barak Bushlands, up to 12.5 ML/year (32.5 ML/year with second wetland) - Eltham Leisure Centre, up to 1.7 ML/year - Eltham North Wetland, up to 5 ML/year - Eltham Community and Reception Centre, up to 3.4 ML/year *Volumes available exclude other identified demands for each site	Council	By 2016
Investigate the viability of using roof runoff from stadium roof tops (e.g. Community Bank Stadium) to supply water to the evaporative coolers.	Council	By 2018
Continue to develop in-house expertise about water sensitive urban design and IWM for application across Council assets and the private domain at different scales.	Council	On-going
Interlink Council strategies. As internal strategies and plans are updated, ensure commitment to WSUD and *Nillumbik's Integrated Water Management Strategy.*	Council	On-going
Continue to establish warm season grasses (mixed with cool season) and upgrade water efficient irrigation systems across sporting amenities.	Council	On-going

CONTINUED Table 19 Recommendations for strategic actions

Actions to provide the fundamental building blocks for mainstreaming sustainable water management across the Shire	Responsibility	Timeframe
Support, and where possible form partnerships with, organisations such as Yarra Valley Water delivering new and existing water conservation programs.	Council	On-going
Encourage uptake of government rebate schemes such as the Living Victoria Water Rebate Program for homes and business by raising awareness via Council's website and local media.	Council	On-going
Continue to actively seek federal and state government funding when they are announced through: - Department of Regional Australia, Local Government, Arts and Sport's 'Regional Development Australia Fund' - Department of Sustainability, Environment, Water, Population and Community's 'National Urban Water and Desalination Planning: Stormwater Harvesting and Reuse Grant' - Office of Living Victoria Funding rounds - Melbourne Water Living Rivers Program - Melbourne Water's Corridors of Green program.	Council	On-going
Strengthen partnerships with stakeholders (including Melbourne Water, Office of Living Victoria, Yarra Valley Water, adjacent Councils, VicRoads, Parks Vic, etc.) to deliver structural and strategic water projects. Partnerships may involve: - Collaboration in seeking project funding via Government funding programs when they are announced (eg. Living Victoria Fund). - Co-funding of projects with stakeholders (through Melbourne Water's Living Rivers Program). - Shared asset management arrangements with roles and responsibilities clearly articulated within a Memorandum Of Understanding (MOU), etc. - Seeking opportunities with Yarra Valley Water to harvest roof rainwater for storage and treatment and deployment into first pipe.	Council	On-going

Table 20 Recommendations for capital actions

Actions to implement WSUD across Councils own operations providing a direct benefit to the local environment and providing demonstration projects for the community	Responsibility	Timeframe
Construct a raingarden 225m2 located in the south east corner of the Civic Drive Precinct site treating all runoff from the existing car parks and buildings and proposed redevelopment in the north-western and southern precincts. Require all proposed residential lots to install rainwater tanks to supply toilets and laundry (washing machine cold water tap).	Council	By 2015
Construct a stormwater treatment and harvesting scheme at Hurstbridge Oval for the irrigation supply of two ovals and provision of water for the road grading program (subject to external funding).	Council	Immediate (2013-2014)
Convert existing series of ponds at Yarrambat Golf Course into a chain to wetlands to provide stormwater quality treatment for runoff generated from the upstream low density urban catchment. Divert water from the existing storage through the wetlands for treatment. Future upgrade of irrigation system to be supplied from new 'treated water' storage. Refer to study titled (subject to external funding).	Council	By 2015
Investigate the expansion of the Barak Bushland Wetland to incorporate a harvesting scheme. Provide storage to the south of the existing wetland system to supply 6 ML/yr for the irrigation water of the two ovals located at Eltham Lower Park (subject to external funding).	Council	By 2017
Construct a treatment train comprising a sediment basin (150 m2), wetland (1,300 m2) and pond (700 m2) at Danzey's Paddock to supply to the North and South Ovals located at Eltham North Reserve. The scheme will supply on average 3.9 ML/yr and circulate flows to keep all water bodies healthy (subject to external funding).	Council	By 2020
Retrofit the Alistair Knox Park Wetland to enhance the treatment of urban runoff to supply a harvesting scheme for the irrigation requirements at Eltham Central Oval. Using the existing 3 x 22 kL tanks as storage to supply up to 1.5 ML/yr. This requires construction of a transfer pipe from the wetland to the tanks via gravity. Modify wetland bathymetry to improve its water quality treatment performance (subject to funding).	Council	By 2022
Construct a stormwater treatment wetland and harvesting scheme to provide an irrigation supply for the Susan Street Oval and Eltham Rugby Oval. A wetland with a surface area of 1,360 m2 and 200 kL storage will supply 4.3 ML/yr (subject to external funding).	Council	By 2024
Connect all rainwater tanks on Council owned or managed assets to an indoor demand (e.g. toilet flushing) where practical.	Council	On-going
Conserve potable water use in parks and sporting amenities, with consideration of climate change response planning through: - Irrigation efficiencies and determining optimal irrigation. - Understanding soil types and soil moisture needs. - Mulching to prevent evaporation. - Planting climate responsive, drought tolerant species.	Council	On-going

CONTINUED Table 20 Recommendations for capital actions

Actions to implement WSUD across Councils own operations providing a direct benefit to the local environment and providing demonstration projects for the community	Responsibility	Timeframe
Install water efficient showerheads, urinals, flow regulators and dual flush toilets throughout the Shire's public toilets.	Council	On-going
Continue to assess the efficiency of water use in Council buildings and to retrofit with high standard fittings, fixtures and appliances and/or new water savings technologies as they become available.	Council	On-going
Continue to liaise with Yarra Valley Water regarding installation of sewer in areas identified in the Domestic Wastewater Management Plan as being high risk for contamination.	Council	On-going
Advocate to the State Government to accelerate funding to clear the sewerage backlog program	Council	On-going

Table 21 Recommendations for community actions

Actions to support the community in sustainable water management	Responsibility	Timeframe
Support residents with relevant factsheets and information links to participate in: - Installing rainwater tanks and connecting tanks to toilets and laundry cold water taps. - Practical workshops on implementing WSUD on private properties. - Melbourne Water programs like their 10,000 Raingardens. - Yarra Valley Water's water conservation programs like showerhead exchange, toilet exchange. - Activities by community groups to undertake planting and community education. - Developing their own community groups to support sustainable water management and help link interested residents.	Council	On-going
Apply for grants from the Stream Frontage Management Scheme run by Melbourne Water to support streamside enhancement works to address bank stabilisation issues, reduce sediment laden runoff entering waterways and prevent stock access with fencing.	Landholders	On-going
Continue to develop demonstration projects for the community (for example, raingarden display at Edendale). Install meaningful signage to raise awareness of Council's commitment to WSUD/IWM and encourage local community members to better understand and care for WSUD features.	Council	On-going
Use Council's website to provide links to Melbourne Water's factsheets on WSUD on private properties (tanks, raingardens etc.) and links to other tools to assist residents, businesses and developers in implementing WSUD. Provide information forums, events and news.	Council	On-going
Engage in discussions with Yarra Valley Water about septic tank management to devise options capable of reducing pollutant loads to streams and to draw on experiences elsewhere (eg. Park Orchards, Ringwood South) to devise appropriate responses.	Council	Immediate (2013-2014)
Promote the responsible reuse of greywater and review and update educational material that ensures use as per EPA regulations.	Council	2014
Provide an education strategy for households serviced by a septic system to effectively manage and maintain a healthy septic system, including reducing water consumption.	Council	2014

6.0 References

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Appendix A - Glossary

Ecologically Sustainable Development (ESD): Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (United Nations World Commission on Environment and Development 1987).

Evapotranspiration: is the sum of evaporation and plant transpiration from the Earth's land surface to atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and waterbodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves. Evapotranspiration is an important part of the water cycle.

Directly Connected Imperviousness (DCI): DCI is defined as the proportion of the impervious surface of a catchment that is directly connected to a stream through a conventional drainage connection.

Index of River Condition (IRC): is a tool designed to provide an overall integrated measure of the environmental condition of rivers. The Index of River Condition is based on the Index of Stream Condition, developed by Department of Sustainability and Environment for rural rivers and creeks. The Index of Stream Condition has been modified to account for the urban rivers and creeks in Melbourne Water's operating area. It includes data for all of the rivers and creeks that we manage. It combines information on the:

- natural flow regime
- water quality
- condition of the channel
- condition of riparian (streamside) vegetation
- waterbug communities living in the river.

Integrated Water Management (IWM): is the sustainable management of all water sources (potable water, wastewater, rainwater, stormwater and groundwater) so that water is used optimally. It applies to all scales of development and includes infrastructure and water conservation measures to achieve multiple beneficial outcomes that are achieved through coordinated planning, organisational commitment, sustainable development and consideration of related resources (including energy use).

Impervious surface: are mainly artificial structures such as pavements (roads, sidewalks, driveways and parking lots) that are covered by impenetrable materials such as asphalt, concrete, brick and rooftops. Soils compacted by urban development are also highly impervious.

Model for Urban Stormwater Improvement Conceptualisation (MUSIC): MUSIC is a conceptual design tool. The program can be used to estimate pollutant generation from a catchment and to demonstrate the performance of stormwater quality improvement systems.

Stream Invertebrate Grade Number – Average Level (SIGNAL): is a biotic index that grades macroinvertebrate families according to their tolerance to various pollutants (mainly organic). The index is calculated by averaging the scores for all families collected, and can be related to the quality of the water at the site. SIGNAL scores are one component of the State Environment Protection Policy (SEPP) objectives for Victorian Waters.

Total Phosphorus (TP): is measure of all the Phosphorus in water. Phosphorus is a nutrient that occurs naturally at low levels in water and is essential for all forms of life. Excessive levels of Phosphorus can lead to management problems such as blue green algae blooms.

Total Nitrogen (TN): is a measure of all the nitrogen in water (i.e. nitrate (NO3) and Ammonium (NH4)). Nitrogen is recycled continually by plants and animals and is present in freshwater in higher concentrations than phosphate

Total Suspended Solids (TSS): is a measure of the suspended materials in the water. Suspended materials in the water decrease the ability of light to pass through the water column, which can limit plant growth. This in turn affects the fish and invertebrate communities that feed and live on the plants.

Water balance: is used to describe the flow of water in and out of a system. A system can be one of several hydrological domains, such as a column of soil or a drainage basin.

Water Sensitive Urban Design (WSUD): integrates urban planning with the management of the urban water cycle. It ensures the delivery of urban water management is aligned with IWM outcomes for the region. It involves the integration of urban design with demand management, wastewater minimisation, stormwater flow and quality management, and protection of receiving waters (surface and groundwater).

Appendix B – Unsealed Roads

There are approximately 400 ha of roads, of which 155 ha are unsealed in the Shire. These roads provide access throughout much of the northern rural and National Park areas of the Shire. They are also valued for supporting the 'rural character' of the area.

Studies have found that unsealed roads are a major source of sediments and associated pollutants discharged to waterways. The rate of sediment generation is influenced mostly by rainfall, slope, traffic loads and road width. The estimation of sediment loads from unsealed roads is difficult due to their variability, with estimates ranging from 3.2 to 39 t/ha/year (Sheridan and Noske, 2005). This suggests that sediment generation from unsealed roads in the Shire could be 500 - 6,000 t/yr although only a fraction of this is likely to reach waterways (c.f. estimate of Shire sediment load of 1,200 t/yr).

Typically, most sediment is suspended (84 per cent) and is derived from the road surface itself, while a high proportion of the bed load (coarse sediment) is derived from the road batters.

There are a number of sediment control approaches that can be used to manage sediment loads generated by roads:

- **Diversion drains to road-side vegetated areas** - The diversion of road runoff to road-side vegetated areas can be effective in dispersing flows and reducing flow rates. Modelling has suggested this is an effective means of controlling both coarse and fine sediments (Sheridan and Noske, 2005).

- **Vegetated buffer strips, swales and raingardens** - Vegetated buffers, swales and raingardens are effective in dispersing flows and reducing flow rates. This reduces the energy of the flow to transport runoff and allows infiltration and subsequent evapo-transpiration to occur. This can reduce both coarse and fine sediment as well as nutrient discharges to waterways and reduce the frequency of surface runoff reaching streams, providing significant benefits.

- **Rock stabilisation of road-side drains and batters** - Where roadside drains and batter slopes are too steep to support vegetation, significant erosion can occur, resulting in elevated bed loads and damage to the road. It is suggested that this can be managed by stabilising these areas by filling the road-side drain with ballast size rocks. These have the effect of increasing the roughness of the drain and decreasing flow rates to reduce sediment carrying capacity. Such an approach would be targeted at areas where batter slope erosion is occurring such as Turnung Road, Panton Hill.

- **Sediment traps** - Sediment traps are effective for removing coarse sediment (→ 0.05 mm) but are relatively ineffectual for reducing fine sediments (← 0.05 mm) (Sheridan and Nosky, 2005). Sediment traps are most useful for roads with high bed loads such as gravel roads with unstable batters and steep tracks on native soils. Nillumbik Shire has about 150 sediment traps located across the municipality to reduce the amount of sediment entering the waterways. Regular clean out of these traps will ensure the waterways are protected from the potential impact of high sediment loads associated with the unsealed roads.

In selecting the most appropriate control, the characteristics of the site and sediment runoff behaviour should be considered. Yarra Ranges Shire Council, in collaboration with Melbourne Water, are currently trialling the implementation of a number of standard WSUD systems to manage pollutant loads from unsealed roads. Once the outcomes of these trials are complete, Melbourne Water will publish the learnings that arise from their monitoring and observations of these systems.

Any works undertaken to seal roads in the future has the potential to have a significant impact on the ecological health of the downstream waterway. It is important that if any roads are sealed then vegetated buffer strips, swales or raingardens are incorporated into the road design to ensure they remain disconnected. WSUD systems (e.g. swales or raingardens) can be incorporated into the road design to capture and treat flows prior to discharge to the waterway, thereby ensuring the roads remain 'disconnected' and the values of the waterways are not impacted.

Road grading program

Council currently has a grading program to maintain the unsealed roads. These grading efforts require significant volumes of water:

- Summer: 150,000 kL
- Winter: 90,000 kL

The following pick-up points (most of which are hydrant filling stations) are presently used to obtain water for grading:

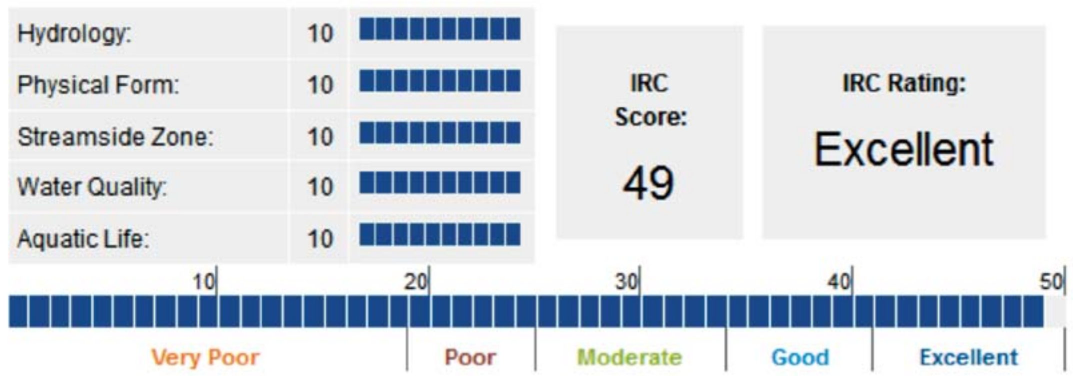
- Eltham Leisure Centre water tank
- Main Road, Research hydrant station
- Operation Centre water tanks
- Kangaroo Ground- St Andrews Road hydrant station
- Arthurs Creek stand pipe
- Private dam on Chadds Creek Road

Appendix C – Breakdown of the IRC Assessment for Each Waterway

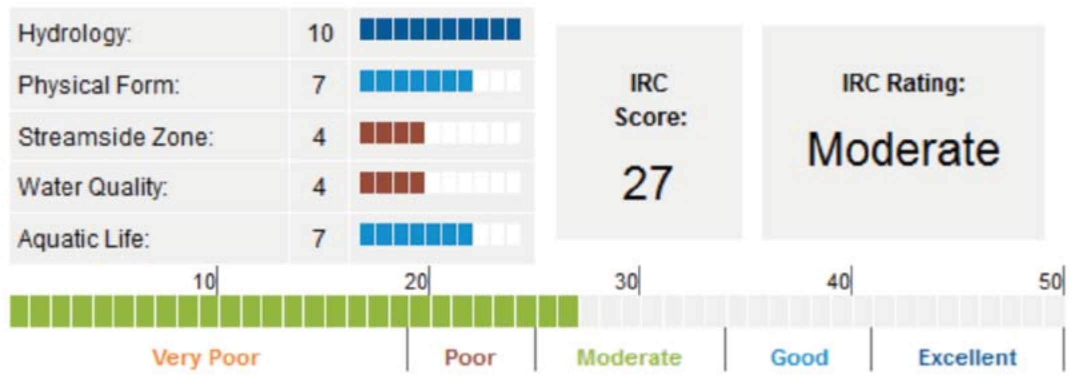
This section provides a breakdown of the Index of River Condition (IRC) assessment for each waterway. It is noted that the hydrology indicator only measures the effects of diversions and regulation while effects of land use (urbanisation) are not captured by the index.

Diamond Creek

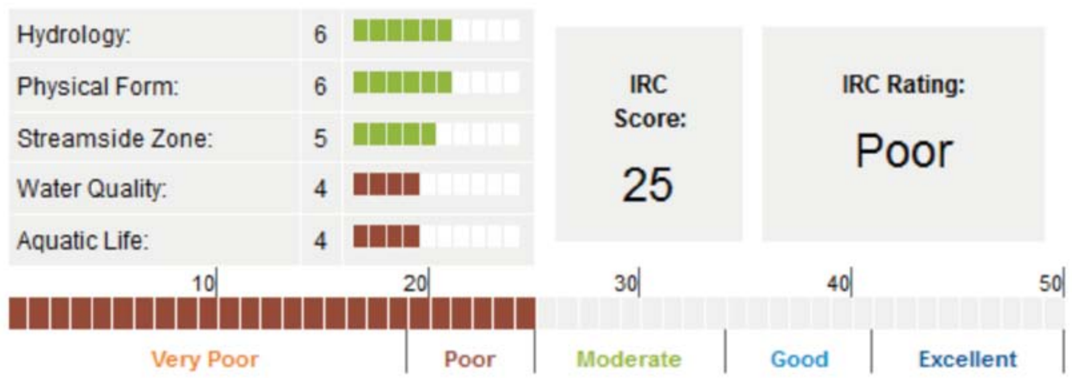
The upper tributaries of Diamond Creek within the Kinglake ranges are among the few waterways in the Melbourne area rated as being in an excellent condition. There are few stressors in these catchments and the main management action is to preserve and protect the existing health.



The upper reaches are in moderate condition with the streamside zone (and hence water quality) scoring poorly. The streamside zone and water quality are impacted by clearing of the catchment and stock access to the waterway.

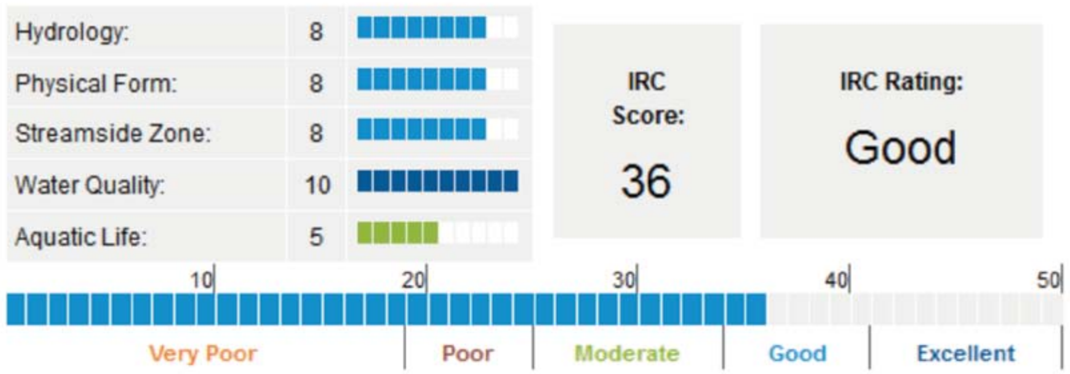


The lower reaches of Diamond Creek are rated in poor condition with poor water quality and aquatic life.

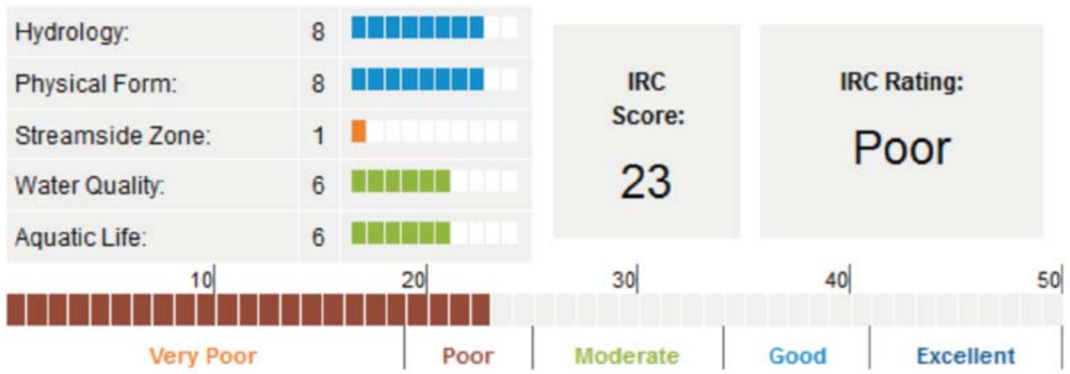


Arthurs Creek

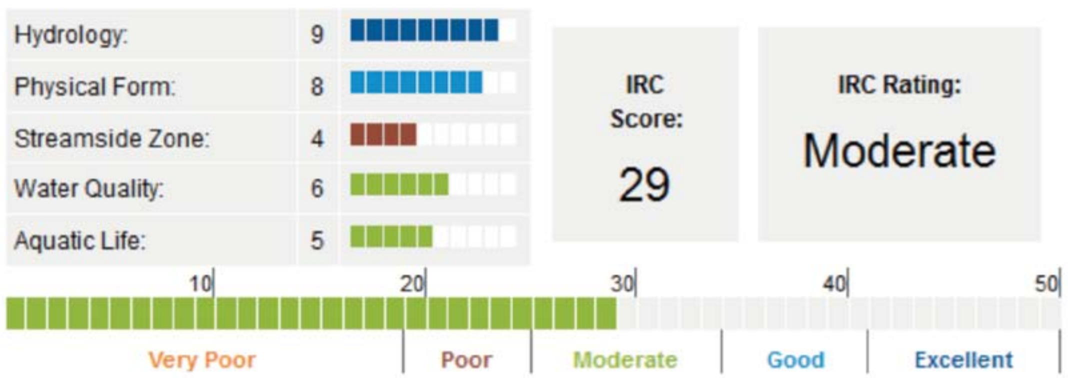
The upper tributaries of Arthurs Creek are in good condition with some impact evident on aquatic life.



The upper reaches are in poor condition with the streamside zone (and hence water quality and aquatic life) scoring poorly. The streamside zone, water quality and aquatic life are impacted by clearing of the catchment and stock access to the waterway.

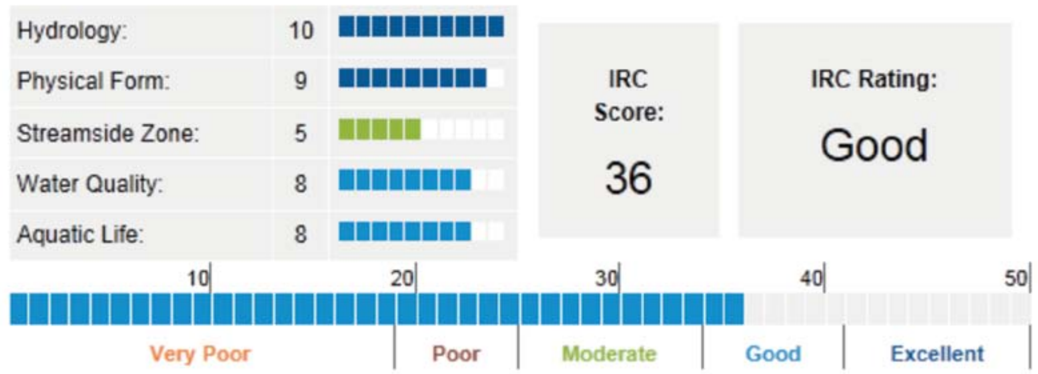


The lower reaches of Arthurs Creek are in moderate condition, with the streamside zone in poor condition but improvement's in water quality and aquatic life evident.



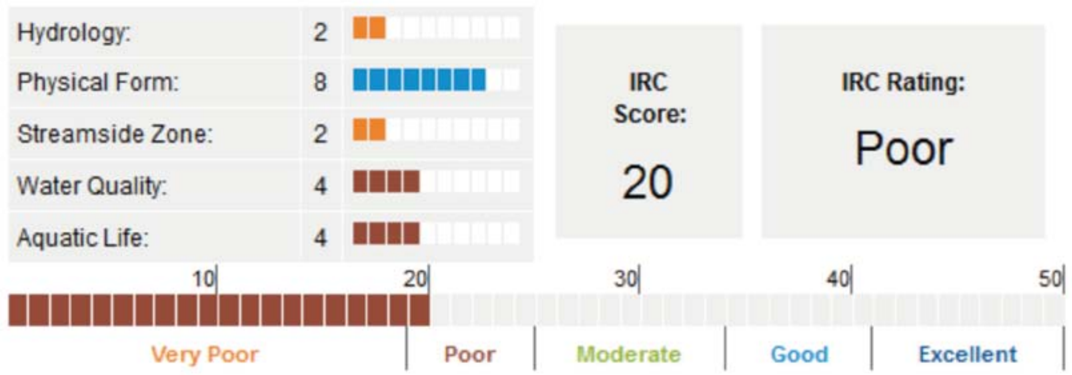
Watsons Creek

Watson Creek is rated as being in good condition however the streamside zone is impacted by clearing of the catchment and stock access to the waterway.



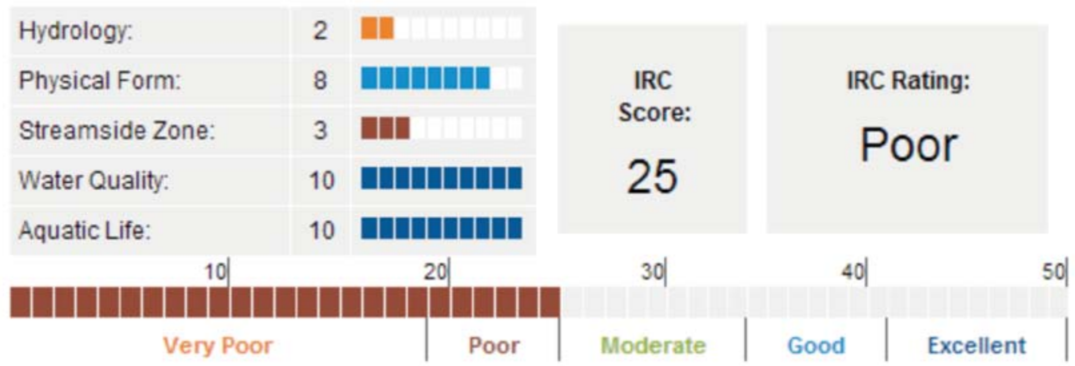
Yarra River (Middle)

The Yarra River where it passes through the Shire is in poor condition and heavily impacted by upstream diversions, catchment disturbance and urbanisation and disturbance of the streamside zone. Given the importance, condition and size of the Yarra River, the Shire's efforts in this catchment should focus on supporting Melbourne Water through the implementation of appropriate planning policies and the maintenance of open spaces adjacent to the river to complement Melbourne Water restoration works.



Plenty River (Middle)

The Plenty River where it passes through the Shire is in poor condition and already affected by upstream diversions, urban development and disturbances to the streamside zone. The Shire's efforts in this catchment should focus on supporting Melbourne Water through the implementation of appropriate planning policies and the maintenance of open spaces adjacent to the river to complement Melbourne Water restoration works.



Appendix D – Stormwater Flows and Pollutant Load Calculations

Catchment areas and characteristics

Catchments within Nillumbik Shire were analysed to determine areas and impervious fractions for different land use, ownership and surface type combinations. A range of data was used to do this:

- Municipal boundary
- Imperviousness layer (from DCI data layer) supplied by Melbourne Water
- Property (cadastre) boundaries
- Melbourne Water major catchments and main drain sub-catchments
- Land use zones, these were summarised to a summary zoning then aggregated to five land use categories, being Residential, Commercial/Industrial, Road, Open Space and Other
- Ownership

A new layer was created to represent the land use and surface type information required for this study. For example, a house lot would be divided into impervious parcel areas (house roof, paving and driveway) and pervious areas (grass, trees). These would then also have a land use and sub-catchment property. Each object has the following attributes:

- Catchment.
- Land use (Residential, Council, Road, Open Space, Other).
- Imperviousness (pervious, impervious parcel, impervious road).
- Ownership (Public, Private).
- Area (m^2).

This data was exported to Excel and Pivot Tables were used to aggregate data across surface types, land use, sub-catchments and ownership as required providing considerable flexibility in analysis of the data.

Modelling

The Model for Stormwater Improvement Conceptualisation (MUSIC) Version 5 was used to calculate stormwater pollutant loads and volumes. Rainfall data recorded at 6 minute intervals over a 19 or 20 year period for two gauges has been used, one to represent Eltham and surrounds and one to represent areas to the north such as Yarrambat. The baselines adopted were the long term averages for the Eltham and Yan Yean daily gauges. There is limited sub-daily rainfall data available for the region. Therefore, for Eltham the period 1975-1993 from the Dandenong South rain gauge (BOM Station # 086224) was used and for the northern areas of the municipality the period 1985-2004 from the Bundoora rain gauge (BOM Station # 086351) was used. These periods were chosen to provide a good match to the long term average rainfall and number of rainfall days. The mean annual rainfalls were 742 mm/year for Dandenong South and 663 mm/year for Bundoora.

Models for the whole municipality and individual catchments were set up using a standard set of nodes allowing for full representation of different land use, surface type and ownership. Fletcher (2007) pollutant concentrations were adopted for storm flows for general urban surfaces, road and roof surface types. Results were extracted, collated and again summarised using pivot tables to enable analysis by land use, surface type and ownership.

Appendix E – Catchment Pollutant Loads

Flows (ML/yr) by catchment and surface type

Item	Arthurs Creek	Diamond Creek	Plenty River	Watsons Creek	Yarra River	Total
Council general	0	19	1	0	0	20
Council pervious	112	1,023	151	31	74	1,392
Council road	0	18	1	0	0	19
Council roof	60	295	94	116	45	609
Private general	20	682	104	16	11	832
Private pervious	22	1,001	156	16	13	1,208
Private roof	5,207	5,613	719	3,288	1,974	16,801
Total	**5,421**	**8,651**	**1,226**	**3,467**	**2,117**	**20,881**

TSS loads (kg/yr) by catchment and surface type

Item	Arthurs Creek	Diamond Creek	Plenty River	Watsons Creek	Yarra River	Total
Council general	4	2,650	91	6	7	2,759
Council pervious	40,964	366,978	54,491	11,220	26,884	500,537
Council road	1	477	26	1	1	506
Council roof	9,360	30,866	8,307	12,131	5,979	66,643
Private general	2,029	70,589	10,525	1,607	1,089	85,839
Private pervious	590	26,760	4,141	419	358	32,268
Private roof	293,705	314,774	40,649	182,310	110,281	941,719
Total	**346,653**	**813,094**	**118,230**	**207,694**	**144,599**	**1,630,271**

TP loads (kg/yr) by catchment and surface type

Item	Arthurs Creek	Diamond Creek	Plenty River	Watsons Creek	Yarra River	Total
Council general	0	6	0	0	0	6
Council pervious	65	597	89	18	44	813
Council road	0	3	0	0	0	3
Council roof	23	94	28	37	16	198
Private general	5	166	26	4	3	203
Private pervious	3	152	24	2	2	183
Private roof	1,340	1,427	182	826	497	4,272
Total	**1,436**	**2,445**	**349**	**887**	**562**	**5,678**

Stormwater pollutant budget by land use

Item	Council						Private					
	Business/ Industry	Open Space	Public Use	Residential	Road	Special Use	Business/ Industry	Open Space	Public Use	Residential	Special Use	Total
Total Surface Area (ha)	9	719	79	223	726	0	62	35,272	2,205	3,223	695	43,213
Runoff Volume (ML/yr)	31	487	43	891	588	0	142	14,508	971	2,937	285	20,883
TSS Load (kg/yr)	10,010	85,828	3,484	309,187	161,905	29	8,122	814,780	53,352	167,252	16,319	1,630,268
TP Load (kg/yr)	17	186	12	509	297	0	28	3,691	240	627	71	5,678
TN Load (kg/yr)	75	1,169	100	2,189	1,506	0	299	34,581	2,282	6,478	686	49,365
Gross Pollutants (kg/yr)	1,150	8,065	440	33,344	12,130	3	4,858	3,379	2,873	67,502	16	133,760

Stormwater pollutant budget by surface type

Item	Council				Private			
	General	Pervious	Road	Roof	General	Pervious	Roof	Total
Total Surface Area (ha)	4	1,490	258	4	154	41,077	224	43,211
Runoff Volume (ML/yr)	20	609	1,392	19	832	16,801	1,208	20,881
TSS Load (kg/yr)	2,759	66,643	500,537	506	85,839	941,719	32,268	1,630,271
TP Load (kg/yr)	6	198	813	3	203	4,272	183	5,678
TN Load (kg/yr)	39	1,534	3,425	42	1,553	40,087	2,687	49,367
Gross Pollutants (kg/yr)	763	0	53,635	733	32,079	0	46,551	133,761

Appendix F – Existing WSUD Projects

Summary of existing WSUD projects and associated stormwater flow reduction and pollutant load reductions

WSUD ID	WSUD Name	WSUD Type	No. of treatments	Flow benefits (kL/yr)		Stormwater flow reduction (ML/yr)	Stormwater pollutant load reduction (kg/yr)		
				Mains water conserved	Wastewater reduction		TSS	TP	TN
Council Ownership projects									
1	Barak bushland wetlands, Eltham	Wetland	1	0	n/a	5.5	5,933	11	59
2	Coventary Oval wetland, Diamond Creek	Wetland & harvesting	2	1.2	n/a	1.2	2,846	5	30
3	Henry Arthur Estate, streetscape WSUD	Series of bioretention swales	series	0	n/a	0.7	1,009	2	11
4	Challenger street wetland, Diamond Creek	Wetland	1	0	n/a	5.3	4,709	10	67
5	Circulatory Road, Eltham	Raingardens	10	0	n/a	n/a	n/a	n/a	n/a
6	Alistair Knox Park wetland, Eltham	Wetland	1	0	n/a	1.5	3,630	7	34
7	Council rainwater tanks	Raingardens	100	9,880	n/a	9.9	2,973	17	205
9	Eltham North carpark, Eltham	Swale	1	0	n/a	0	5	0.01	0.02
10	Eltham Leisure Center carpark, Eltham	Swale	1	0	n/a	0	5	0.01	0.02
11	Edendale, Eltham	Raingardens	1	0	n/a	0	1	0.01	0.004
12	Diamond Valley Library, Diamond Valley	Raingardens	1	0	n/a	0	20	0.02	0.08
13	Dianella Court Wetland, Diamond Creek	Raingardens	1	0	n/a	1.03	1,284	2.37	12.73
14	Dry Creek wetland, Plenty	Wetland	1	0	n/a	1.52	1,940	3.57	19.20
15	Everleigh Drive, Diamond Creek	Ephemeral Wetland	1	0	n/a	0.54	1,671	1.69	17.71
16	Golflinks Drive Wetland, Yarrambat	Wetland	1	0	n/a	0.63	345	0.70	4.40
17	Treetops Estate Wetland, Plenty	Wetland	2	0	n/a	3.9	4,865	8.79	48.60
18	Murrays Wetland, Eltham	Wetland	1	0	n/a	6.5	9,393	17.40	95.30
19	Fergusons Paddock Wetland, Hurstbridge	Wetland	1	0	n/a	15	19,430	35.53	194.00
Total				**9,881**	**0**	**53**	**60,059**	**122**	**798**

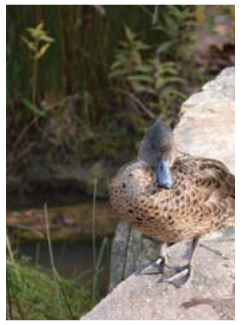
Appendix G – Comparison of Structural Treatment Measures

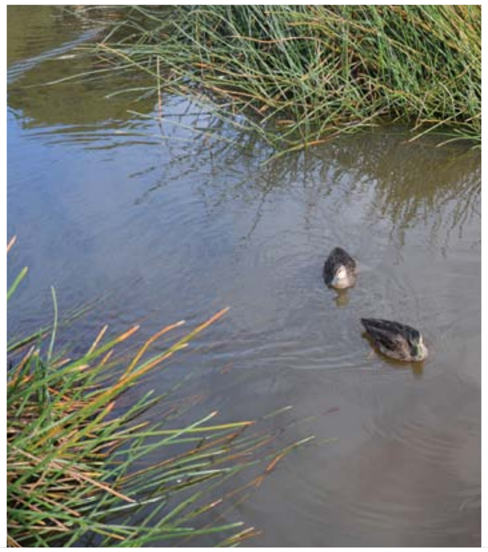
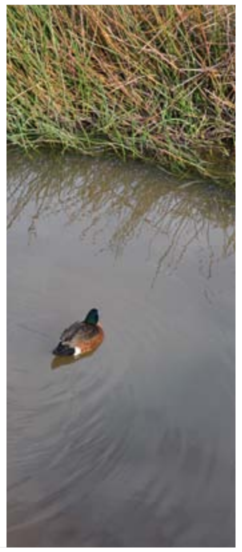
The table overleaf can be used to size WSUD treatment measures based on 'rule of thumb' sizing to calculate the likely surface area of the systems required to treat a given catchment area to best practice. The catchment could be divided into sub catchments and the surface area of the treatment measures adjusted accordingly. For example, 4 raingardens each with a surface area of 20 m2 could be located at 250 m intervals along a 1 km stretch of road instead of a single 80 m2 raingarden.

Also provided are some of the typical capital and maintenance costs (or cost ranges) for typical WSUD treatment measures, along with some common advantages and disadvantages for their use.

This information is intended to help Council during the planning phase of projects. All benefits should be confirmed as part of the concept design phase and refined during the functional/detailed design phase.





'Rule of thumb' treatment areas for various catchment types

WSUD treatment measure and catchment characteristics			Flow reduction and/or water conservation benefit (kL/yr)	Pollutant reduction (kg/yr)			Cost/kg (annualised)	
WSUD Treatment	Catchment	Size of treatment measure		TSS	TP	TN	TSS	TN
Rainwater tank^	1 x 250 m2 roof (tank plumbed to toilet and garden irrigation)	2 KL per household	32	1	0.01	0.08	$70	$1,000
Wetland and harvesting scheme+	10 ha urban (70% impervious)	3000 m2 -300 m3	6500	2900	3.8	23	$6	$700
Raingarden*	100 m2 road or car park (100% impervious)	1 m2	0	10	0.01	0.04	$6	$1,700
Raingardens (or tree pits)*	1 km road (7m wide, 100% impervious)	80 m2	0	700	0.9	2.5	$7 ($16)	$2,000 ($4,500)
Infiltration raingardens (or tree pits)#	1 km road (7m wide, 100% impervious)	50 m2	360	690	0.9	2.6	$5 ($10)	$1,200 ($2,700)

- Life cycle of raingarden is 15 years and wetland, tank, stormwater harvesting project is 25 years
- ( ) cost for street tree pits
- *Raingardens and tree pits assumed to have 150 mm extended detention depth, 500 mm filter depth and 180 mm/hr hydraulic conductivity
- #Infiltration raingardens and tree pits assumed to have 150 mm extended detention depth, 500 mm filter depth, 180 mm/hr hydraulic conductivity and a conservative assumption of 3.6 mm/hr seepage loss.
- ^A typical household consumes 27 L/day for toilet flushing and 36 KL/year for garden irrigation
- +Above ground open storage; best practice wetland and 3 ML/year demand for oval irrigation with 80 per cent reliability of supply

Typical WSUD costs, advantages and disadvantages

WSUD Treatment	Typical Capital Costs	Typical Annual Maintenance Costs	Advantages	Disadvantages
Water tank	$1,000/kL	$100	• Multiple water cycle benefits (mains water conservation and reducing stormwater volumes and pollutant loads discharged to the environment) • Minimal treatment required as roof runoff is considerably cleaner than other alternative sources of supply • Can meet a considerable proportion of residential demands • Provides resilience to climate change through diversity of supply	• Reliability of supply to meet competing demands (indoor and outdoor demands) • Potential increases in pollutant concentrations conveyed to receiving waters from other surfaces across catchment if corresponding treatment of these surfaces is not simultaneously implemented to balance use of roof runoff.
Stormwater reuse – storage & reticulation	$1,000/kL	$450 for tank with UV disinfection and water quality testing	• Multiple water cycle benefits (drinking water conservation and minimising stormwater discharge to the environment thereby reduce pollutant loads to receiving waters) • Provides resilience to climate change • Significant cost savings as the supply of mains water cost increases (associated cost of supply from desalination)	• Storage requirements may be large to account for seasonal differences between supply and demand to ensure adequate reliability of supply • Land uptake for treatment and storage requirements in confined spaces
Wetland	$100/m2	$10/m2 for the vegetated areas	• Systems are scalable and can be used end-of-pipe or at source • Provides landscaping and aesthetic value • Potentially sites of refuge with significant habitat values if located adjacent to waterways	• Land uptake is larger to attain equal treatment performance compared to other treatment measures
Raingarden	($66/m2 to $116/m2)	$200/m2 for the sediment pond	• Decentralised system requiring minimal infrastructure • Effective at stormwater pollutant treatment and therefore require less land uptake to attain equal treatment performance compared to other treatment measures • Regular wetting and drying cycle leads to more stable pollutant fixation of contaminants (such as, phosphorus and metals) in the soil filter layer • Systems are scalable and be designed at source as a garden bed or end-of-pipe as a basin • Incorporation of a saturates zone reduces the land uptake required to treat to best practice	• Industry less familiar with construction techniques (greater risk of poor translation of design into on-ground practice) • Depth of existing drainage may limit soil filter layer depth and therefore reduce treatment performance • Site constraints (i.e. difficult to implement well on steep slopes, location of existing services)
Tree pit	$930/m2	$10/m2 for the vegetated areas	• Decentralised system requiring minimal infrastructure • Greening of streetscapes with shade from trees providing microclimate benefits • Effective at stormwater pollutant treatment and therefore require less land uptake to attain equal treatment performance compared to other treatment measures • Regular wetting and drying cycle leads to more stable pollutant fixation of contaminants (such as, phosphorus and metals) in the soil filter layer	• Industry less familiar with construction techniques (greater risk of poor translation of design into on-ground practice) • Depth of existing drainage may limit soil filter layer and therefore reduce treatment performance • Site constraints (i.e. location of existing services)

Appendix H – Catchment Calibration for Nillumbik

One of the objectives of the study was to estimate pollutant loads for the municipality. This is challenging as much of the area is rural. Significant runoff volumes and pollutant loads potentially occur from pervious catchment areas including national parks and farming areas, however there is high uncertainty in the estimation of these flows and loads.

The streamflow gauge at Diamond Creek (229223) was represented in MUSIC to estimate mean annual flows for Diamond Creek and its tributaries. Both the MUSIC default and Melbourne Water soil parameters were tested and compared with observed flow at the gauge. The period from 1981-1993 was chosen as it had a reasonably complete set of gauged flow data. Daily rainfall data for Eltham (086035) and Yan Yean (086131) were evaluated as these were the gauges in closest proximity to the catchment.

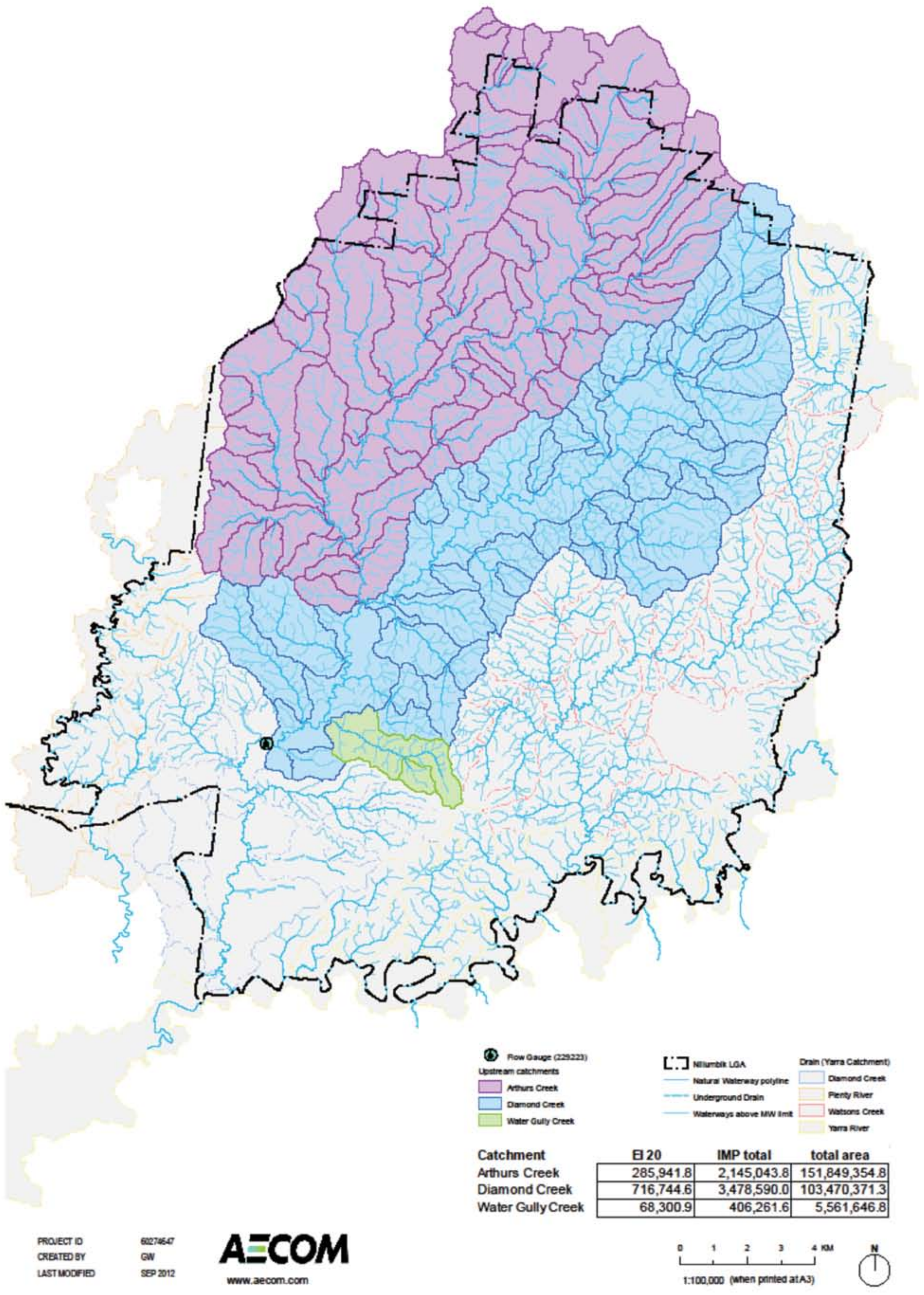
The default soil parameters in MUSIC (which correspond to a catchment in Brisbane) are as follows:

- Soil moisture storage capacity: 120
- Field capacity: 80

Melbourne Water recommends that the soil parameters recommended in the MUSIC manual for use in Melbourne are adopted as follows:

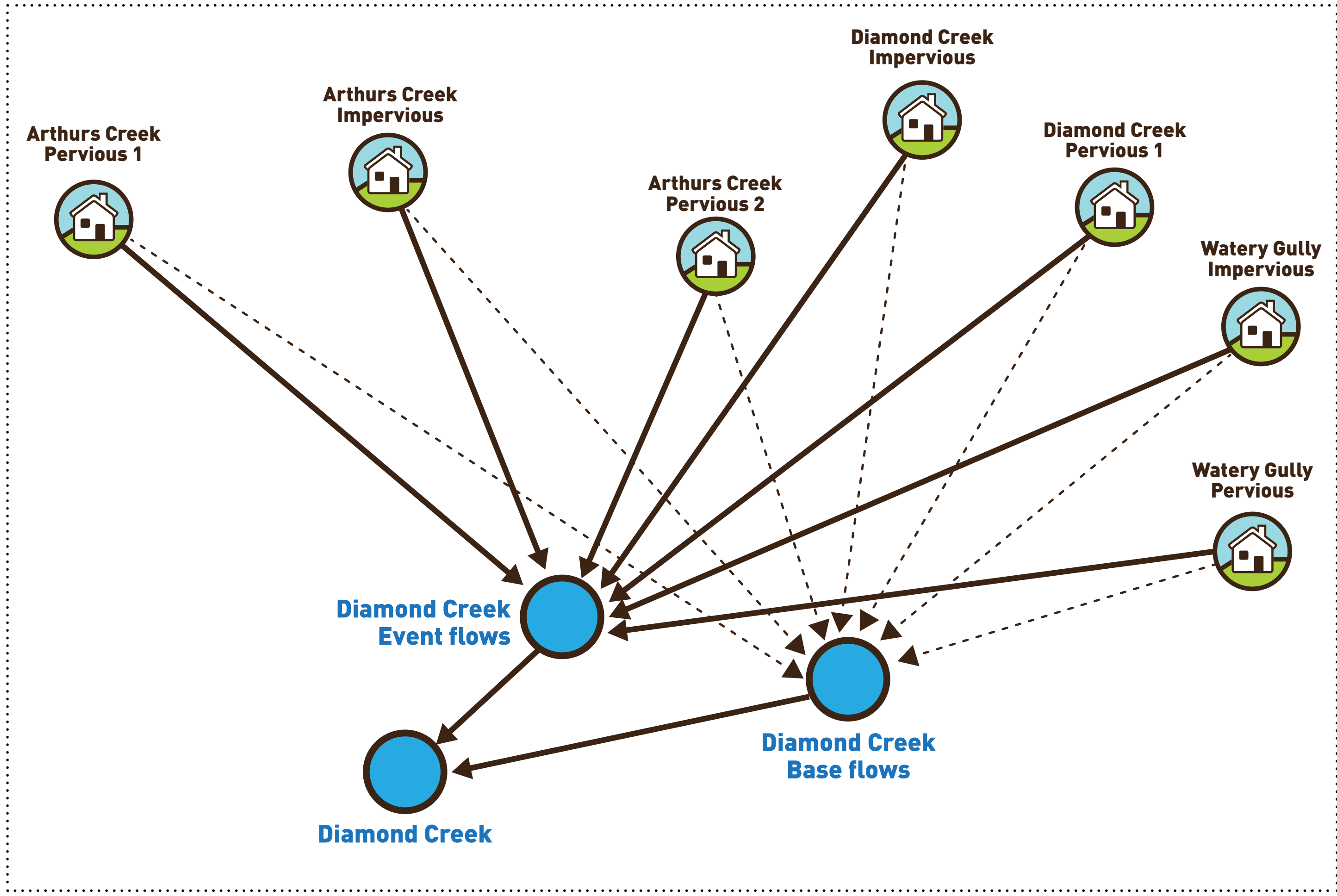
- Soil moisture storage capacity: 30
- Field capacity: 20

Diamond Creek catchment to flow gauge 229223 at Diamond Creek



Catchment	EI 20	IMP total	total area
Arthurs Creek	285,941.8	2,145,043.8	151,849,354.8
Diamond Creek	716,744.6	3,478,590.0	103,470,371.3
Water Gully Creek	68,300.9	406,261.6	5,561,646.8

MUSIC model of Diamond Creek catchment to gauge 229223



Mean annual rainfall and flows for Diamond Creek catchment

Mean annual flows were estimated for the two rainfall gauges and the two soil parameter options and compared with the observed data as summarised in the table below.

	Eltham rainfall (086035)	**Yan Yean rainfall** (086131)
Mean annual rainfall 1981-1992 (mm/year)	764	689
Mean annual rainfall 1981-1992 (ML/year)	197,700	152,600
Diamond Creek observed mean annual flow at stream flow gauge 229223 (ML/year)	**20,800**	
Modelled mean annual flow with MUSIC default soil parameters (ML/year)	33,400	23,400
Modelled mean annual flow with Melbourne Water soil parameters (ML/year)	57,700	45,400

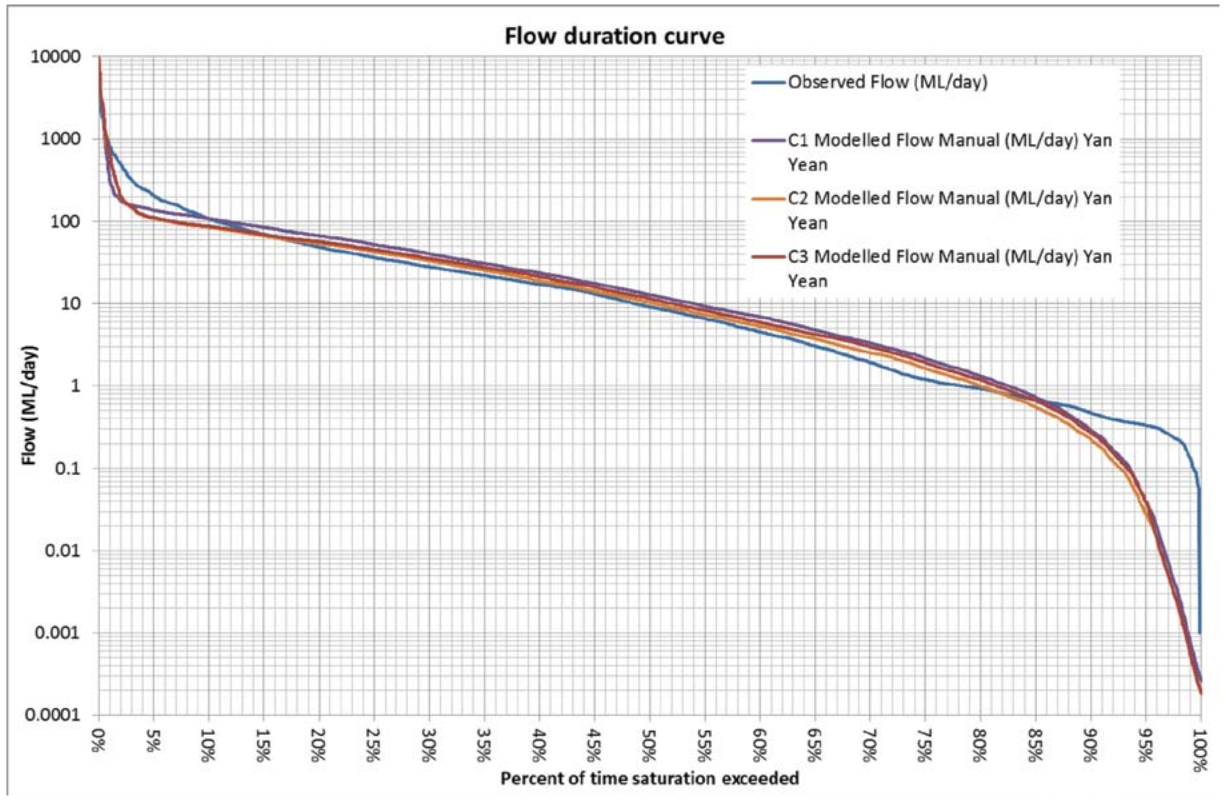
It is apparent from these results that the use of the Melbourne Water recommended soil parameters is likely to substantially overestimate flows and hence pollutant loads from rural areas while the MUSIC defaults are likely to provide a better estimate for this particular catchment. The lower Yan Yean rainfall is likely to be more representative of the catchment as a whole given its location relative to the rest of the catchment. It appears that the runoff coefficient for the catchment is relatively low with just 14 per cent of rainfall (Yan Yean) being converted to runoff.

Further considerations are the relative proportions of surface and base flow and appropriate pollutant concentrations. A manual calibration of the model was undertaken by adjusting the soil parameters to improve the fit. A number of measures of fit were considered for the calibration:

- Mean annual flow.
- Base flow index (BFI) as measured by RAP.
- Nash-Sutcliffe efficiency (monthly flows).
- Flow duration curve.

	Observed flow in Diamond Creek at gauge 229223	Modelled Flow (Calibration C1)	Modelled Flow (Calibration C2)	Modelled Flow (Calibration C3)
Mean annual flow (ML/year)	20,800	19,900	19,400	20,400
Base flow index (RAP)	0.22	0.29	0.24	0.24
Nash-Sutcliffe efficiency	-	0.56	0.55	0.52

The resulting soil parameters have a relatively similar soil moisture storage capacity and field capacity to the MUSIC defaults. However, the base flow parameters are significantly different. As a result, the relative proportion of base flow is much lower for the calibrated model than either the default or Melbourne Water soil parameters. This means that flows are less than would occur using the Melbourne Water parameters but the pollutant loads are higher than would be estimated using the default parameters due to the increased proportion of event flows with higher pollutant concentrations.



Flow duration curves for observed and modelled daily flows 1981-1992.

Most of the curve fits quite well, particularly in the mid range from 10-85 per cent. The highest flood flows are over-estimated then under-estimated within the top 10 per cent, likely largely due to a lack of routing in the model to distribute these flows. Base flows at the low end of the range are also not well represented, likely due to MUSIC's typically poor representation of recession decay curves and base flows as well as difficulties measuring very low observed flows.

Calibrated soil parameters for Diamond Creek

Parameter	MUSIC Default	Melbourne Water	Calibrated
Rainfall threshold (mm/day)	1	1	1
Soil storage capacity (mm)	120	30	110
Initial storage (% of capacity)	25	25	25
Field capacity (mm)	80	20	80
Infiltration capacity coefficient – a	200	200	200
Infiltration capacity exponent – b	1	1	1
Initial groundwater depth (%)	10	10	10
Daily recharge rate (%)	25	25	2
Daily base flow rate (%)	5	5	2
Daily deep seepage rate (%)	0	0	0

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