Lake Eildon Houseboat Greywater Review

DELWP

Final Report

RO058200-R02 | Rev. 2

29 March 2017

Contract No. 331968

Lake Eildon Houseboat Greywater Review

Project No:	RO058200
Document Title:	Final Report
Document No.:	RO058200-R02
Revision:	2
Date:	29 March 2017
Client Name:	DELWP
Client No:	331968
Project Manager:	Simon Kelly
Author:	S. Kelly, F. Gilbert
File Name:	J:\RP\Projects\PI\RO058200\21_Deliverables\FINAL\March - Modified WQ Data\Eildon Houseboat Greywater Review Final 29-03-2017.docx

Jacobs Group (Australia) Pty Limited
ABN 37 001 024 095
Floor 11, 452 Flinders Street
Melbourne VIC 3000
PO Box 312, Flinders Lane
Melbourne VIC 8009 Australia
T +61 3 8668 3000
F +61 3 8668 3001
www.jacobs.com

Document history and status

Revision	Date	Description	By	Review	Approved
FINAL	02-02-2017	Final Release	S. Kelly & F. Gilbert	A. Brinkley	A. Brinkley
1	09-02-2017	Minor formatting correction	S. Kelly & F. Gilbert	A. Brinkley	A. Brinkley
2	29-03-2017	Additional GMW Water Quality Data Included	S. Kelly & F. Gilbert	A. Brinkley	A. Brinkley

JACOBS

Contents

List of Figures

List of Tables

Executive Summary

Lake Eildon is the only inland waterway in Victoria that allows houseboats. It has been home to a substantial houseboat fleet since the early 1960s, with regulation and licencing introduced in 1971. While houseboats play a significant role in the local and regional economy, stakeholders are generally in agreement that the water quality of Lake Eildon needs to be protected.

Houseboat owners on Lake Eildon are required to manage black water using storage tanks and GMW provides pump out facilities for its disposal. Most houseboats do not have a greywater system and are discharging waste water from kitchens, showers, baths, basins, spas and laundries directly into the lake.

Houseboat operations and greywater discharge contribute to pollutants in the waterway, including nutrients, microbes and oils. These pollutants can cause, contribute to or exacerbate water quality issues that affect environmental values, recreational amenity, and the health and safety of Lake Eildon and its users. Water quality at Lake Eildon is critical for downstream communities that use it for irrigation, drinking water, commercial, agricultural and recreational activities.

Existing water quality

A review of the available water quality data for Lake Eildon found:

- Greywater discharge from houseboats is not expected to impact on general water quality parameters (Electrical Conductivity, Dissolved Oxygen, turbidity, pH) on a lake-wide scale. Lake water generally meets most Water Quality Objectives (WQOs).
- Some measures of nutrient levels in the lake exceed some water quality objectives. High nutrient levels are a key factor contributing to the risk of algal blooms. Greywater discharge contains a high concentration of nutrients, but due to the volume of the Lake and typical catchment inflows, the greywater discharge represents a very small fraction of total nutrients entering the lake overall. Under certain conditions, including low water levels, and particularly in harbour/marina areas (where boat use and hence discharge is concentrated and lake water is shallower and less well mixed), the houseboat discharge represents a more significant local input of nutrients, which could increase the risk of an algal bloom occurring.
- Discharge of pathogens (e.g. bacteria, viruses) associated with greywater represents a small but plausible health risk to recreational users (including houseboat operators) in harbour and marina areas.
- The impacts of greywater discharge are expected to be minimal in the whole-of-lake context, but add to health and environmental risks in specific locations and conditions.

Implementation of existing greywater regulations

Regulations introduced in 2013 require fitting all houseboats on Lake Eildon (approximately 720 in total) with an approved on-board greywater treatment system by 1st July 2020. Approximately 50 houseboats currently have an approved Greywater Treatment System (GWTS) installed.

In 2013, when the regulations were first introduced, the houseboat industry did not have a proven GWTS available for the full range of houseboats styles (sizes/types/capacities) in place on Lake Eildon. In response the houseboat and greywater treatment industry developed a number of GWTS units, the early versions of which experienced a number of design and integration issues.

These issues related to the odour, noise and reliability of units as well as the required electrical loads. Contributing to the early performance issues with GWTS units is their infrequent and intermittent operation, and in some cases a lack of an ongoing power supply with houseboats typically in use for only part of the year. Further contributing to these issues is the lack of available space on some houseboats which requires non-uniform installation.

In most instances the GWTS units need to be retrospectively installed, which also increases the costs of compliance with the regulations. While these costs vary, they typically cost in excess of eighteen thousand dollars ($18,000) to purchase and install.

Four GWTS units are approved as compliant with the Australian Standard (AS4995), however, two of these units are no longer being manufactured. The manufacturer of the third GWTS is currently assessing whether to continue supplying the market. Both remaining GWTS manufacturers acknowledge the initial issues with their GWTS units and their installation. They also note significant improvements to their units and installation processes and believe they have resolved the issues experienced with the installation of the initial GWTS units.

Concerns about potential reliability issues with the GWTS units and the cost of their installation were reported by some houseboat owners as the primary reason for not installing these systems. However, a number of boat owners who installed GWTS units more recently have reported they were satisfied with their performance.

Potential opportunities for changes to the implementation of the regulations

This study has reviewed the existing regulations in light of stakeholder feedback, water quality and technical and practical issues of installation.

The study has identified potential opportunities for adjustments to the current regulations, which could reduce barriers to compliance while meeting the desired water quality outcomes. Key potential options include:

- Modify AS4995 or the *Water (Lake Eildon Recreational Area) (Houseboats) Regulations 2013* to permit use of filtration based treatment systems that work in conjunction with the storage of kitchen waste as part of the black water system.
- Revise the timeframe for complete implementation across all houseboats to align installation to the 5-7 year slipping of every houseboat.
- Provide a grace period for the installation of GWTS units following houseboat sales (either a 12 month period or at some time connected to the next licence renewal date).

The existing regulations should remain unchanged for houseboats in the following categories:

- New houseboats.
- Houseboats subject to major upgrades.
- Category six (6) houseboats.
- Houseboats upgrading to category six.

Further detail and discussion of these and other potential options is contained in this review report. DELWP may wish to consider these adjustments to the existing regulations to better enable houseboat owners to comply while meeting the desired water quality outcomes for Lake Eildon.

Important notes about this report

The sole purpose of this report is to describe the findings of the Lake Eildon Houseboat Regulations review project findings for DELWP. An investigation of technical, social and environmental issues has been provided in accordance with the scope as commissioned.

This discussion paper is intended for internal use within DELWP but may be made available to stakeholders on request. A shorter summary and discussion paper has been developed by Jacobs primarily for public consultation purposes.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information provided by third parties, including all raw water quality data and technical information.

Unless otherwise stated, Jacobs has not verified the accuracy or completeness of any information provided in publically available reports and databases. If the information is subsequently determined to be false, inaccurate or incomplete, then it may be possible that observations and conclusions expressed in this report may be impacted. All data sources are referenced throughout the text and listed in the reference section in this report.

Jacobs derived the data in this report from information sourced at the time/s outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.

Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above. No other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report. This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, DELWP and is subject to, and issued in accordance with, the provisions of the contract between DELWP and Jacobs.

Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Abbreviations and Acronyms

Abbreviation	Description
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment Conservation Council
AS	Australian Standard
BGA	Blue-Green Algae
Black Water	Black Water is wastewater directly from toilets and bilges.
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DELWP	Department of Environment, Land, Water and Planning
DO	Dissolved Oxygen
EC	Electrical Conductivity
EPA-SA	Environmental Protection Agency – South Australia
EU	European Union
FSL	Full Supply Level
GMW	Goulburn-Murray Water
Greywater	Greywater is wastewater that has been produced from laundering, bathing, washing and showing activities. This includes kitchen waste and water containing dissolved or suspended solids such as fat and oils, food scraps, nutrients, household chemicals, soap and detergents. (AS4995)
GVW	Goulburn Valley Water
GWTS	Greywater Treatment System
LOWMP	Lake Eildon Land and On Water Management Plan
NHMRC	National Health and Medical Research Council
NOx	Sum of nitrate (NO_3^-) and Nitrite (NO_2^-)
NTU	Nephelometric Turbidity Unit
pH	pH units
SEPP	State Environment Protection Policy
SEPP (WoV)	State Environment Protection Policy (Waters of Victoria)
SRWSC	State Rivers and Water Supply Commission
SS	Suspended Solids
TBN	To be Nominated
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorous
WMIS	Water Measurement Information System
WQ	Water Quality
WQO	Water Quality Objectives
YTD	Year to Date

1. Purpose of this Report

Houseboats on Lake Eildon must be licensed by GMW, and must comply with licence conditions relating to disposal of black water and greywater from boats. Regulations introduced in 2013 require all houseboats to be fitted with on-board greywater treatment systems from July 1st 2020.

Houseboats owners have raised concerns about the regulations and lobbied DELWP to seek exemptions. As a result, DELWP has been asked to investigate the issue and in response has commissioned this study to:

- Provide a description of the current situation and the issues that are being experienced by all parties, and provide the results of the review (Sections 3, 4, 5 and 6).
- Provide a description of the current situation with respect to the Regulatory Framework (Section 7).
- Propose a number of potential options for reform (Section 7).
- Provide an overview of the submissions made by stakeholders (Appendix A).

Since the release of a Public Discussion Paper, Jacobs have received a large number of submissions from houseboat owners and other stakeholders. These have been reviewed and where applicable addressed in this final Report.

The findings of the study are presented in this final report to the DELWP for consideration.

2. Context and Background

2.1 History

Lake Eildon is the only inland waterway in Victoria where houseboats are permitted to operate.

Houseboat licensing was introduced to Lake Eildon in 1971, which coincided with the requirement for houseboat owners to manage black water using storage tanks and the State Rivers and Water Supply Commission (SRWSC), now Goulburn-Murray Water (GMW), providing pump out facilities. The licensing system was implemented with categories that reflected size and therefore levels of use.

The number of houseboats operating on Lake Eildon increased rapidly in the early and mid-1970s. In 1976 the SRWSC “froze” the allocation of houseboat licences pending an evaluation of the recreational capacity of Lake Eildon. At that time there were a total of 630 houseboats permanently moored on Lake Eildon.

An independent recreational evaluation recommended that, as an interim measure, the number of licences issued for all Category 1 (see Section 5.1.1 for GMW Categories) boats should not exceed 50 and that the combined total of all other houseboats remain at 630. They further recommended that any future increases in houseboat numbers should not exceed 3% of the total number in any one year.

The ceiling on houseboats remained unchanged until 1983 when the SRWSC decided to increase the number of privately owned houseboats (559) by 80 (639). This decision was made with regard to the following factors:

1) Substantial improvements were proposed to increase the operating efficiency of the Jerusalem Creek sanitation barge.
2) Adequate marina moorings were made available for the increased supply.
3) Monitoring of water quality indicated that an increase of 80 houseboats would not have any significant adverse effect on the waters of the Lake.
4) Public demand was evidenced by a waiting list of 150 applicants.

In 1990, the Shire of Alexandra expressed concerns that houseboat greywater was permitted to be discharged directly into Lake Eildon. State Environment Protection Policy (SEPP) stated that waste should be discharged to land in preference to water whenever practicable and environmentally beneficial.

The GMW Houseboat Licence Agreement and Operational Rules (Ref. J) state that since 2003, GMW has been advising houseboat owners that in the future a sullage (greywater) tank or treatment system will need to be installed on every houseboat.

In 2009, following extensive work conducted by the South Australia Environmental Protection Agency (EPA-SA) and other related parties, the Australian Standard AS4995:2009 (Ref. K) was first published. Shortly after, GMW initiated a plan for the implementation of on-board greywater treatment for Lake Eildon houseboats.

In 2012 the maximum size of a permitted houseboat was increased from 13.7 m (60’) x 5.48m (18’) (excluding duckboards and walkways) to 20m × 8m.

On 12 June 2013 the Victorian Government introduced the Water (Lake Eildon Recreational Area) (Houseboats) Regulations 2013 (Ref. I) replacing the existing 2003 regulations. These Regulations are still currently in force and require that from 1 July 2020 all houseboats must be fitted with an on-board greywater treatment system.

As of the middle of 2016, GMW records show that 56 houseboats have had a GWTS installed. A further 26 houseboats have either implemented containment, kitchen waste diversion, or have installed preliminary pipework. Since the introduction of the Regulations, a group representing houseboat owners has lobbied DELWP and the Minister for Water to seek exemption for existing vessels from compliance with the greywater requirements in the Regulations.

A number of stakeholders within the houseboat community have raised concerns regarding compliance with the Regulations (Ref. I), specifically the requirement for the treatment of greywater and the installation of on-board greywater treatment systems. Concerns have also been raised in respect to the water quality discharge criteria specified by the Regulations (Ref. I) and Australian Standard (Ref. K). Some houseboat owners have also raised concerns about the perceived reliability, operational noise and odours of approved treatment systems. Concerns have also been raised about the feasibility of installing greywater treatment systems on some houseboats.

2.2 Process Undertaken

The process undertaken in conducting this investigation and compiling this report is described below:

Stage 1 Jacobs met with a number of stakeholders and reviewed the existing information and regulations. These meetings included inspection of a range of houseboats, with and without greywater treatment systems installed to familiarise with some of the issues related to implementation.

Stage 2 Jacobs prepared a Draft Discussion Paper and Public Discussion Paper which was distributed to stakeholders for review and comment.

Stage 3 Further stakeholder comment was received over a period of approximately 5 weeks.

Stage 4 The additional stakeholder feedback was reviewed and where applicable incorporated into this final Report.

2.3 Inputs to the review

Input to this review has included existing reports and documentation (as listed in Section 2.3.1). Jacobs also met with a number of key stakeholders including:

- Houseboat Owners (with and without GWTS installed)
- Greywater Treatment System Manufacturers
- Greywater Treatment System Installers
- Houseboat Builders
- Lake Eildon Houseboat Industry Association – Representative Body
- Goulburn-Murray Water (GMW)
- Goulburn Valley Water (GVW)
- Environmental Protection Agency (Victoria)
- Department of Health and Human Services
- Environmental Protection Agency – South Australia (EPA-SA)

2.3.1 References

The following documents and standards are referenced in this Report:

A. Goulburn-Murray Water - Lake Eildon Land and On-Water Management Plan – 2012.

B. Victorian Safe Drinking Water Act – 2003.

C. Lake Eildon Houseboat Greywater Risk Assessment – ECOS environmental consulting – September 2006.

D. Report prepared for Goulburn-Murray Water by Ecos Environmental Consulting, Water Futures and Ecowise.

E. Environmental September 2006.

F. Blue-Green Algae Circular 2015-16 Co-ordination Framework Department of Environment, Land, Water and Planning 2015.

G. http://www.depi.vic.gov.au/water/rivers-estuaries-and-wetlands/blue-green-algae/blue-green-algae-resources.

H. Environment Protection Act 1970 STATE ENVIRONMENT PROTECTION POLICY (WATERS OF VICTORIA) 23/2/1988, No. S13, Gazette 26/2/1988.

I. Water (Lake Eildon Recreational Area) (Houseboats) Regulations 2013 – S.R. No. 60/2013.

J. Goulburn-Murray Water – Lake Eildon Houseboat Licence Agreement and Operational Rules – Feb. 2015.

K. Australian Standard (AS) 4995 – Greywater treatment systems for vessels operated on inland waters. – 2009.

L. Goulburn-Murray Water – Houseboat Information Sheet - January 2015, GMW #3893128v4.

M. Goulburn-Murray Water – Feedback from houseboat greywater information sessions – 2015.

N. EPA – South Australia – FAQ: Greywater requirements for vessels on inland waters. – Updated June 2014.

O. EPA – South Australia – Wastewater requirements for vessels on inland waters – Updated June 2014.

P. Victorian Water Act 1989 - No. 80 of 1989 - Version incorporating amendments as at 28 October 2010.

Q. Lake Eildon – Houseboat Greywater Meeting Workshop Outcomes Report. – December 2015 – DELWP.

R. Lloyd’s Register Rules and Regulations for the Classification of Ships – July 2011.

S. State Rivers and Water Supply Commission - Lake Eildon Bacteriological and Limnological Studies 1967-1976.

T. Lake Eildon Bacteriological and Limnological Studies 1967 -1971 – State Rivers and Water Supply commission Victoria, January 1978.

U. NSW Health Department – Domestic Greywater Treatment Systems Accreditation Guidelines, Part 4, Clause 43(1), February 2005.

3. Lake Eildon Water Quality Analysis

This chapter describes issues relating to water quality in Lake Eildon, including background, land and water use, key water quality issues and risks, legislative context and water quality objectives, and an analysis and summary of current and historical water quality data. The purpose of this analysis is to characterise current water quality conditions, in order to assess the likely or potential impacts of greywater discharge from houseboats under different regulatory systems.

3.1 Background, land and water use

Lake Eildon was constructed as a water storage reservoir, and its primary purpose is to provide water to downstream communities and consumptive users. Lake Eildon is an important supplier to downstream irrigation and environmental users, supplying approximately 60% of water used in the Goulburn Murray Irrigation District (Ref. A). It is estimated that water supplied from the lake provides billions of dollars' worth of economic benefits to regional economies every year. The costs of dam operation and maintenance, as well as lake and foreshore monitoring and management costs are funded by fees collected from downstream water users for the provision of a regulated water supply (Ref. A).

Approximately 96% of the water is delivered for irrigation or environmental purposes, while 4% is supplied to urban water authorities for domestic water supply (Ref. A). Some stock and domestic customers around the lake also draw water for domestic use. The lake also provides drinking water for the township of Bonnie Doon. Until 2011, it also supplied drinking water for the township of Eildon; Eildon's drinking water (and that of other towns including Thornton, Alexandra, Seymour and Shepparton) is now drawn from the Goulburn River downstream of the lake (Ref. A).

Lake water is not potable, and urban water authorities (GVW) are responsible for water treatment prior to supply to customers (Ref. A). Lake water is, however, pumped directly onto houseboats for use in showers, toilets and kitchens.

Water levels fluctuate with weather, rainfall, inflow levels and irrigation and environmental demands. Fluctuating water levels have implications for recreation and for water quality (Ref. A).

Recreation

Lake Eildon is also a highly popular recreational waterway. Over many years a local recreation and tourism industry has developed around Lake Eildon, and the significant economic and social benefits to the local region that this provides are acknowledged (Ref. A). Recreational and tourism ventures that are sustainable and that will not adversely impact on lake operations, water quality, environmental values or public safety and access are encouraged (Ref. A). Recreational activities at Lake Eildon need to be carefully balanced against the lake's primary role as an irrigation water supply storage and to ensure impacts on the environment are minimised (Ref. A).

Lake Eildon is also the only inland waterway in Victoria on which the use of houseboats is permitted, and has been home to a substantial houseboat fleet since the early 1960s, with regulation and licencing introduced in 1971 (Ref. A). Approximately 720 houseboats are currently licenced by GMW to operate on Lake Eildon, in accordance with the Water (Lake Eildon Recreational Area) (Houseboats) Regulations 2013 (Ref. I). Houseboating plays a significant role in local and regional industry and economy. Other popular recreational activities at Lake Eildon are both land-based (bushwalking, camping, picnicking, trailbike riding) and water-based (boating, swimming, canoeing/kayaking, jet skiing, fishing).

Potential effects of greywater discharge.

The operation of houseboats and the discharge of greywater into the lake contributes pollutants to the waterway, including nutrients, microbes and oils. These have potential to cause, contribute to or exacerbate water quality issues that affect environmental values, recreational amenity, and the health and safety of lake and water users.

Water quality issues relating to houseboats have long been considered a concern, and have been noted previously in documents including GMW's "Lake Eildon Land and On Water Management Plan (LOWMP)" (Ref. A) which recommended that GMW "Continue to implement measures to minimise the impacts of greywater discharge from houseboats."

Regulations introduced in 2010 specified that "As of 1 September 2010 all new houseboats approved to operate on Lake Eildon must contain all greywater or have an on-board greywater treatment unit that achieves the discharge standards required by the AS4995-2009 Greywater Treatment Systems for Vessels Operated on Inland Waters (Ref. K)". The Houseboat Regulations (Ref. I) were introduced in 2013 and required all houseboats to install greywater treatment systems by 2020 to minimise the level of pollutants entering the lake. See Section 7 for more details.

The LOWMP also recommended that houseboat regulations be revised to allow additional licences and larger houseboats to be considered (Ref. A). However, GMW has advised that this and other related issues cannot be addressed until the issues surrounding greywater discharge from current houseboats are resolved.

3.2 Key water quality issues

Water quality at Lake Eildon is critical for the communities that use water from Lake Eildon for irrigation, drinking water, commercial, agricultural and recreational activities. Recreational users of the lake have the potential to impact on water quality, but are also in turn impacted by the effects of poor water quality. Good water quality is also important for the preservation and health of aquatic habitat and ecosystems (Ref. A).

Water quality in the lake is influenced by a number of processes, and a variety of land and water-based activities. Water quality in Lake Eildon's tributary waterways (including Brankeet Creek, the Goulburn, Big, Delatite, Howqua and Jamieson Rivers) can be poor, which impacts water quality in Lake Eildon. Water quality in the lake can also be directly impacted by point and diffuse sources within the immediate Lake Eildon catchment, including runoff from agricultural land, housing developments and forestry (Ref. A). Recreational activities, including swimming, boating and shore-based recreation can affect water quality in the lake. Greywater discharge from houseboats is an additional direct source of pollutants that can impact on the water quality.

Key water quality issues for the lake are both environmental, and related to public health. Key issues include;

- eutrophication, and the risk/occurrence of algal blooms,
- general environmental condition and water quality as impacted by nutrients and pollutants (including metals, pesticides and herbicides) and indicated by general 'health' measures such as pH, dissolved oxygen, turbidity and electrical conductivity, and
- public health risks relating to the presence of pathogenic microbes in the water which have potential to cause illness to downstream water users, houseboat operators and other lake users.

Previous reports and documents have highlighted water quality issues, and recommended regulation and improved control of greywater discharge. Targeted investigations have occurred in response to water quality problems (for example, the water quality sampling program that occurs in response to reported algal blooms).

Greywater discharge has the potential to directly affect water quality in the lake, particularly in regard to the key water quality issues of nutrient eutrophication and algal blooms, and public health risks. Greywater discharge contains potentially pathogenic microbes, high levels of nutrients, oils and grease.

Water quality in Lake Eildon has been analysed in this study to provide an assessment of current background water quality in the lake, changes over the longer term, and the potential impact of greywater discharge.

These water quality issues were assessed by the analysis of data and key indicators as described in Section 3.5.

3.3 Water Quality Data

Data from several sources was analysed to provide a picture of current and long-term water quality in the lake. Water quality monitoring in Lake Eildon is conducted by a variety of agencies for a variety of purposes. Accurate water quality data helps to improve understanding of the conditions and trends in biophysical and chemical parameters in inland rivers, water storages and streams. This allows water resource managers to manage water quality decline and any threatening processes impacting on the water resource, and develop strategies to manage the aquatic environment and biodiversity of the system. Where water is also used as a drinking water or as an irrigation source, monitoring is required to ensure that the water is safe to use for its intended purpose and to inform treatment processes. Monitoring also often occurs to collect data to inform management of a specific water quality issue such as cyanobacterial (blue-green algal) blooms.

Water quality data used to analyse Lake Eildon water quality conditions was obtained from three key sources.

1) **Goulburn Murray Water** – Major Storages Operational Monitoring Program
2) **Goulburn Valley Water** – Drinking water offtake monitoring
3) **The Water Measurement Information System** – Online data published by The Department of Environment, Land, Water and Planning (DELWP), which monitors and reports on the health and availability of Victoria's water resources through a number of programs and partnerships.

The different data sets varied in location, parameters, timeframe, and frequency of sampling. Where data for particular parameters was collected from multiple sites or in multiple programs, the analysis and presentation of results compares all sites. The three data sets are described below.

Another important data source was the "Lake Eildon Houseboat Greywater Risk Assessment" report commissioned by GMW in 2006. In addition, a 1978 water quality report provided by GMW (Ref. T) was also reviewed for additional water quality data.

3.3.1 GMW – Major Storages Operational Monitoring Program

GMW provides raw water from Lake Eildon to downstream irrigators and drinking water suppliers. Water quality in Lake Eildon has been regularly monitored since 1992 as part of the Major Storages Operation Monitoring Program. Two sites have been regularly monitored as part of this program; Site 405258 (Eildon Outlet) and Site 405254 (Bonnie Doon).

At site 405258 (Eildon Outlet Tower), regular monitoring has been completed for: Chlorophyll-a, Electrical Conductivity (EC), NOx, pH, Phaeophytin-a, Phosphate (F), Total Kjehldahl Nitrogen (TKN), Total Nitrogen (TN), Total Phosphorous (TP), turbidity and ammonia. These parameters have been monitored between 1992 and 2016 (ammonia from 1999 only). Generally, monitoring was conducted monthly, though some months contain no data and monitoring often occurred bi-monthly in some summer months. Major ions and alkalinity were monitored approximately six-monthly from 2010 onwards.

GMW also collects additional data as part of algal bloom monitoring and response programs. As part of this monitoring program, water samples collected from a variety of locations around the lake were analysed and biovolume was recorded. Biovolume refers to the volume of cells in a unit amount of water (normally quoted in cubic millimetres per litre) and is used as an indicator of algal concentration.

Site 405254 (Bonnie Doon) was also monitored under the Major Storage Operational Program and a similar range and frequency of parameters was monitored; chlorophyll-a, electrical conductivity, NOx, pH, Phaeophytin-a, Phosphate (F), TKN, TN, TP, turbidity from 1992 – 2016, and ammonia from 1999 only. A small amount of alkalinity data was also collected but no major ions or other parameters. When water levels in Lake Eildon were too low for sample collection at Bonnie Doon, the data was collected from Peppin Point (summer of 1999-2000, and much of 2005-2011). Site locations for the GMW monitoring program data are shown in Figure 3-1.

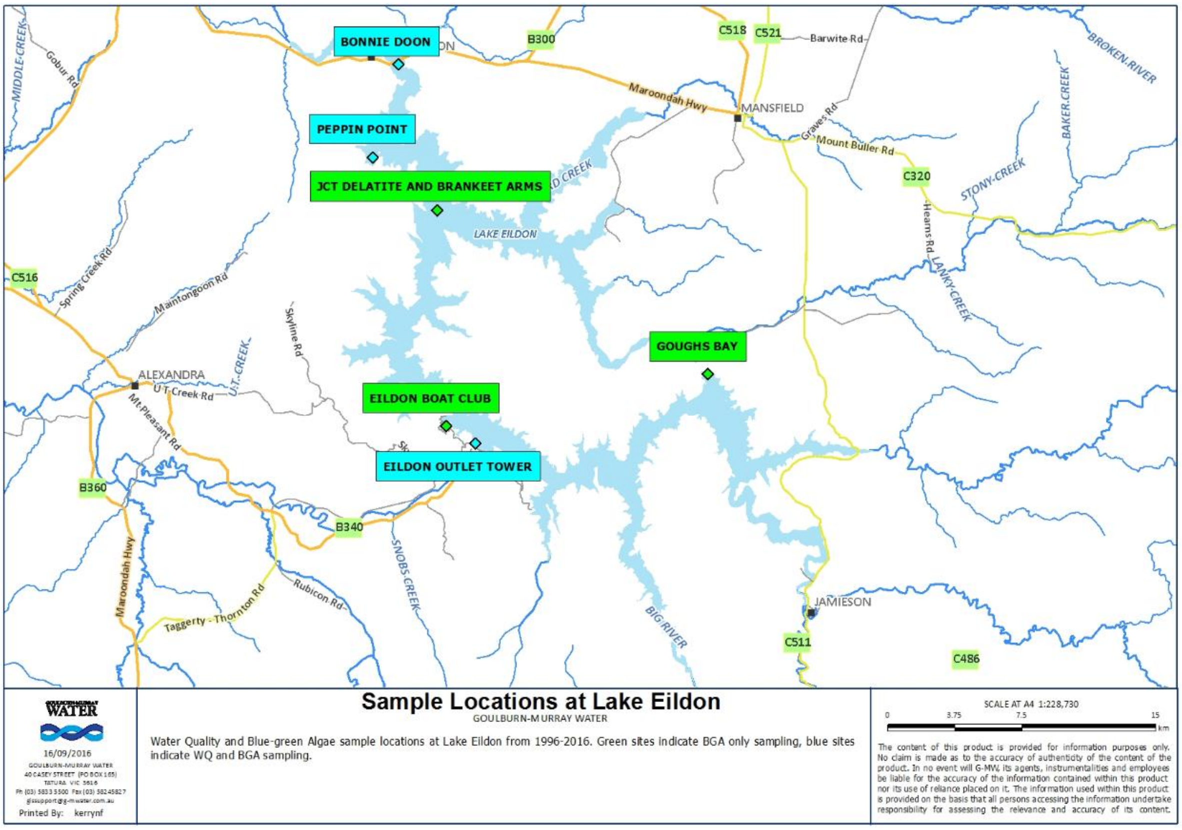

Figure 3-1 : Sampling locations for the GMW water quality sampling sites (image provided by GMW)

Sites 405258 (Eildon Outlet Tower) and 405254 (Bonnie Doon) represent the most complete suite of water quality data available for Lake Eildon. Data from these two sites was analysed to characterise major environmental risks and conditions, through analysis of key indicators including nutrients, chlorophyll-a, EC, pH, and turbidity. No bacterial or pathogen data was collected from these sites.

3.3.2 GVW – Offtake monitoring

GVW monitors water quality at the Eildon offtake and Bonnie Doon, at sites close to the GMW sites. Water authorities have an obligation under the Victorian Safe Drinking Water Act 2003 (Ref. B) to identify and where possible, mitigate risks to drinking water safety. Monitoring of water quality occurs to identify risks to drinking water and to inform management actions. The offtake at Bonnie Doon supplies the Bonnie Doon township and water at the Bonnie Doon reservoir been monitored from 2004 to 2016. The Eildon township was previously supplied from the Eildon offtake, and water quality monitoring data was collected from 2004 to 2011, when drinking water supply from there ceased.

Although the GVW and GMW sites are located close to each other, a different range of parameters were sampled. Unlike the GMW data, the GVW data includes a large number of pesticide and hydrocarbon compounds, and some bacterial/microbial parameters.

The parameters overlapped to a some degree, with GVW data also including some basic physico-chemical parameters (EC, pH, turbidity) and nutrients, however there were differences in the exact location, duration (time period) and frequency of monitoring. Where parameters overlapped, the data were analysed separately, with comparisons made between the two different data sets.

At the **Bonnie Doon** site, monitoring has been conducted continuously from 2004 to 2016, as follows;

Bacterial: E coli ~ monthly, 2004 – 2016, Coliforms ~ monthly, 2005-2016

Nutrients: 2005 – 2016, ~ monthly. Ammonia, nitrate, nitrite, nitrogen (oxidised), total phosphorous (2013-2015 only)

Physico-chemical: Electrical conductivity (EC), ~ quarterly, 2005 – 2016, pH ~ monthly, total suspended solids (mostly 2013 data only), temperature ~ monthly 2005-2016, turbidity ~ 2004 - 2016.

At the **Eildon** site, monitoring was conducted between 2004 and 2011, as follows:

Bacterial: E coli ~ monthly, 2004 – 2011, ~ monthly, Coliforms ~ weekly, 2004 – 2011. Single data point for cryptosporidium and giardia, both below detection, faecal streptococci, 1 data point only.

Nutrients: Ammonia, 2005-2011 ~ quarterly; nitrate 2007-2011 ~ quarterly; nitrite 2007-2011 ~ quarterly; nitrogen oxidised 2004-2011 ~ quarterly, TP 2009-2015 ~ weekly.

Physico-chemical: Electrical conductivity (EC) ~ quarterly 2005-2011; turbidity 2005-2011 ~ weekly, temperature ~ 2005-2011 weekly.

Additional data for pesticides, hydrocarbons, and other minor parameters was also provided. Preliminary analysis of this data showed that almost all of these parameters were below detection limits and within water quality objectives on almost all sampling occasions. This data indicates that there are no serious water quality problems relating to these parameters, which also bear minimal relevance to greywater discharge and key water quality issues in the lake. No further analysis was conducted on this data.

3.3.3 The Water Measurement Information System (WMIS)

Publically available water quality data from sites around Lake Eildon was accessed via the Victorian Water Measurement Information System (WMIS) (the ‘Victorian Water Data Warehouse’). http://data.water.vic.gov.au/monitoring.htm, this site is managed by DELWP, which monitors and reports on the health of Victoria's water resources through a number of programs and partnerships. The WMIS is the primary access point to download surface water monitoring data collected by DELWP and its partners.

All potentially relevant sites were located through the map search feature. The WMIS site included data from the lake at Eildon and Bonnie Doon, however this overlapped with the more complete data set for these sites that was available from GMW and GVW. Data was downloaded from the site for the other potentially relevant sites, which were all located in tributary rivers of the lake. There were no additional in-lake sites. Figure 3-2 shows the location of monitoring sites. (Note: Yellow stars mark sites from which data were collated and analysed in this report. Image reproduced from Water Measurement Information System, http://data.water.vic.gov.au/monitoring.htm).

Figure 3-2 : WMIS Measuring Sites

Monitoring data available on the site has been collected by a variety of agencies, over different time frames and for different purposes. Frequency, duration, and monitored parameters varied between sites.

A summary of data downloaded and reviewed is presented in Table 3-1.

Site Number	Site Name	Date Range and frequency of monitoring	Parameters
405214	Delatite River at Tonga Bridge	1990 – 2016, monthly. Approximately 320 data points.	pH, dissolved oxygen, temperature, turbidity, electrical conductivity, colour, total suspended solids, NO2+NO3, Kjeldahl N, Total phosphorous, FRP.
405203	Goulburn River at Eildon	1990- 2016. Main parameters monthly, larger group of parameters monitored only occasionally. Approximately 200-300 data points	EC, Colour, pH, Alkalinity, TSS, Ca – total, Cl, Mg, NO2+NO3, Kjeldahl N, Total P, FRP (mg/l), K (mg/l), Na, SO4
405215	Howqua River at Glen Esk	1990 – 2008 only. Approximately 31 data points.	pH, DO, Temperature, Turbidity, EC, Colour, TSS, NO2+NO3, Kjeldahl N, Total P, FRP,
405218	Jamieson River at Gerrang Bridge	2007 – 2008 only, Approximately fortnightly, approx. 25 data points.	DO, temperature, turbidity, EC, colour, TSS, NO2+ NO3, Kjeldahl N, total P, FRP. Single data points for major ions etc.; (Ca, Cl, Mg, Alkalinity, K, Na).
405219	Goulburn River at Doherty's	1993 – 2016. Varies, often monthly 85 (ions etc) to 277 (nutrients etc) data points	EC, Colour, pH, alkalinity, TSS, Ca, Cl, Mg, Total NO2+NO3, Kjeldahl N, Total P, FRP, K, Na, SO4.
405314	Lake Eildon @ Peppin Point	2006 – 2009	EC, pH, Total NO2 + NO3, Ammonia as N, Kjeldahl N, total P, FRP, Chlorophyll-a and phaeophytin. (analysed as part of GMW data.)

Table 3-1: Summary of data downloaded and analysed from the Victorian WMIS

3.3.4 Data limitations

The water quality review analysed available data relevant to the water quality of Lake Eildon and the potential impacts of houseboat greywater discharge. The review was constrained by the data available. For some sites and parameters, consistent long term data sets were available; comprehensive analysis could be conducted and comparisons made to water quality objectives. However, there were gaps in available data with respect to parameters of interest, frequency and/or duration of data collection, and data collection sites. Specifically, there is a lack of data from marina and harbour areas where greywater discharge effects would likely be the greatest.

There is little or no data relating to some parameters of interest in terms of greywater composition and discharge criteria, for example suspended solids, grease content and BOD (biological oxygen demand), meaning that the impact of greywater on these parameters cannot be assessed. There is also a lack of data relating to the specific composition of greywater discharge from the Lake's houseboats. Where no site-specific data is available, typical greywater composition data have been obtained from relevant scientific literature (Ref. C).

The supplied Blue-Green Algae (BGA) data (biovolume) was reviewed. This data was collected only during specific periods and data was limited at most sites. Long term trends were considered, within the constraints of historical data reliability. Data from the 1978 water quality report provided by GVW was also reviewed; data was not directly comparable with existing data sets (e.g. different sampling locations) but report findings have been included where relevant. 'Background' water in the lake also includes current and historical greywater discharge, so may already have been impacted. These limitations are further detailed in relevant sections of the WQ analysis and impact assessment sections below.

3.4 Data analysis and comparison to Water Quality Objectives (WQOs)

In order to assess the 'background' water quality of Lake Eildon, data was analysed and compared to relevant water quality objectives. Relevant guidelines referred to include both state and national water quality guidelines, and the National Health and Medical Research Council (NHMRC) Recreational guidelines.

Water quality objectives for Victorian waters are typically those set out under the SEPP Waters of Victoria (Ref. H). Ref. H specifies water quality objectives to be met in order to protect defined beneficial uses in waterways. Beneficial uses and the associated WQOs vary according to the type and location of waterbody.

Objectives are set according to ‘segment’ and geographic location. There are three segments that are potentially relevant to the Lake Eildon data analysis:

- Aquatic Reserves – The aquatic reserves segment consists of surface waters in conservation reserves, state wildlife reserves and national parks. Significant parts of Lake Eildon are surrounded by National Park, making the objectives for this segment relevant.
- Wetlands and Lakes – this segment is clearly applicable, consisting of surface waters in reservoirs and large open lakes
- Rivers and Streams – of relevance to the data from the rivers flowing into the Lake (i.e. Goulburn, Howqua and Jamieson River sites from Victorian WMIS). The Rivers and Stream segment also contains specific objectives for the Eildon geographic area, providing more relevant context than state-wide objectives. The relevant objectives are those for the Forests – B area.

Specific protected beneficial uses and WQO apply to each segment. In the cases of the Aquatic Reserves segment, the objective is simply that ‘environmental quality needs to remain at background levels’ - no specific WQO are given. This means that to meet this objective, houseboat greywater discharge should not be affecting background environmental water quality in the Lake. This objective is more likely to be applicable to natural lakes fully within reserves, or to the tributary rivers that are fully within national park/reserve areas.

For Rivers and Streams (Forests B), objectives are set for indicators that can be used to assess the key risks to beneficial uses; pH, Electrical Conductivity, Turbidity, Dissolved Oxygen, Total Nitrogen, and Total Phosphorus (Table 3-2)

In addition, where primary contact recreation is a beneficial use (as it is for Eildon), specific indicators are needed to measure pathogens in the water and therefore the suitability of water for recreation. *Escherichia coli (E. coli)* and Enterococci are used in SEPP to indicate faecal contamination. SEPP guidelines are based on the ANZECC and NHMRC Recreational Water Guidelines.

The wetlands and lakes segment does not have specific objectives under SEPP, due to inadequate data. In this instance the SEPP refers to default WQOs (or ‘trigger values’) set out in the ANZECC guidelines.

The water quality objectives used for comparison to the analysed data are therefore the SEPP WQOs for Rivers and Streams (forests B) and the default ANZECC data where no SEPP WQOs are set. It should be noted that these WQOs – while regionally specific – are for rivers and streams, and not lakes, so should be considered as an indicative guide only. ANZECC sets default WQOs for Freshwater Lakes and Reservoirs in south-east Australia; these guidelines apply to all Lakes and reservoirs including Eildon, but are not regionally specific. The ANZECC guidelines also set out water quality trigger values for a wide range of parameters including metals and toxicants for which SEPP WQOs are not set.

Both SEPP and ANZECC values have therefore been considered in the assessment of lake water quality. Table 3-2 shows a summary of applicable WQOs for relevant parameters under SEPP and ANZECC.

Parameter	Data	SEPP Rivers and Streams (Forests B)	ANZECC Default SE Aust. Freshwater lakes and reservoirs
Total Phosphorous (µg/L)	75th Percentile	≤ 25	10
FRP (µg/L)			5
Total Nitrogen (µg/L)	75th Percentile	≤ 350	350
NOx (µg N/L)			10
NH4 (µg N/L)			10
Dissolved Oxygen % saturation	25th Percentile	≥ 90	90 (lower limit)
	Maximum	110	110 (upper limit)
Electrical conductivity (µS/cm)	75th Percentile	≤ 100	
Salinity (µS/cm)			20-30
Turbidity (NTU)	75th Percentile	≤ 5	Jan-20
pH	25th Percentile	≥ 6.4	6.5 (lower limit)
	75th Percentile	≤7.7	8.0 (upper limit)
E. coli (org/100ml)*	Primary contact	≤ 150	
	Secondary contact	≤ 1000	

Table 3-2 : Summary comparison of SEPP and ANZECC parameters

* Based on recreational guidelines

Finally, the National Health and Medical Research Council (NHMRC) Recreational Guidelines were considered. These guidelines provide additional objectives for water in use for primary or secondary contact recreation. In some cases these relate to amenity/recreation objectives only, for example objectives for water clarity for swimming. In some cases these overlap with environmental objectives (for example with pH), but relate to the effects on human contact rather than ecological objectives.

The recreational guidelines provide additional objective values for faecal coliform bacteria, which are an indicator of faecal contamination, which can have adverse health impacts. Additional qualitative guidelines apply to amenity-based water quality issues; for example the guidelines for oils and petrochemicals state that no visible film should be visible on the water and there should be no detectable odour. The recreational guidelines also have guidelines for faecal coliforms; for primary recreation, the concentration of faecal coliforms should be < 150 orgs/100ml; and for secondary recreation < 1000 orgs/100ml.

Water quality data were compared to relevant water quality objectives set out under SEPP and ANZECC. Section 3.5 provides a series of plots and summary tables that show comparison of water quality data to relevant objectives.

3.5 Water Quality Analysis

This section presents the findings of the Lake Eildon water quality analysis. This water quality analysis provides an overall assessment and summary of water quality within the Lake in order to provide context to the analysis of risk from greywater discharge.

This analysis includes:

- **Analysis of long term data**, in order to understand water quality condition at the lake over the long term and any trends or patterns of change over that time

- **Comparison of summary water quality data between different sites,** in order to understand conditions at different locations within and surrounding the lake
- **Comparison to Victorian and Australian water quality objectives (WQOs),** in order to understand whether water quality at the Lake meets the requirements for a healthy aquatic system, or poses a risk of water quality and ecological impacts.

The results for key parameters and variables - based on the key water quality issues identified in Section 3.2 - are presented in Sections 3.5.1 to 3.5.1.43.5.5. For most parameters, data were available from a number of different sites, and from one or more of the three main data sets described in Section 3.3.

For each parameter, a summary table is presented that shows key statistical summary data from each site and each data set. This enables ready comparison of the data across different sites and different data sets. For example, the Victorian WMIS data relates to tributary rivers of the lake; the GMW and GVW data is from lake locations. The number of samples and the period over which they were collected also varies between data sets. Data is more limited at some sites than others. While the data is therefore not directly comparable, it enables comparison at a glance of typical conditions at each site and a ready comparison to water quality objectives (noting the limitations identified in Section 3.4).

In addition to the summary table from all sites, a plot is presented for each parameter that shows data from Eildon Outlet tower and Bonnie Doon over the period of 1992-2016. This data is from the GMW Major Storages Operational Monitoring Program and represents the most relevant, consistent and long-term data set available for water quality in the lake. Microbial data is not collected as part of the GMW program. For the analysis of *E. coli* and coliform levels, data was sourced from the GVW drinking water outlet tower sampling program and these data plotted against WQOs.

Relevant SEPP and ANZECC guidelines are plotted against water quality data for comparison. Potential WQOs of relevance are described in Section 3.4. The water quality analysis (including summary tables and plots) compares available data to these objectives. Where SEPP objectives are included in the plots and summary tables, these are the SEPP objectives for the Rivers and Streams, which contain specific WQOs for the Eildon area (see Section 3.4). Although designed for rivers and streams, they are specific objectives for the region, and are therefore included for local context. There are no specific objectives for the SEPP Wetlands and Lakes; instead, SEPP guidelines refer to the default ANZECC trigger values. Both the SEPP Rivers and Streams WQOs, and the ANZECC values (default Wetland and Lakes WQOs) have some relevance and generally both are included in the analysis and plots. Where there are specific SEPP WQOs as well as default ANZECC trigger values, both are included; where only a single objective applies the appropriate guideline is used for comparison.

It should be explicitly noted that comparison to water quality guidelines should be based on summary data or a particular statistical analysis of the data set. For example, SEPP objectives typically relate to the 75th percentile data. ANZECC trigger values typically relate to median data, or a specified range (set minimum and maximum values). There are specific requirements for particular parameters; for example *E. coli* guidelines are based on the collection of 5 samples within a month. However, the data collected did not typically meet the requirements for the statistical comparison to WQOs as set out in the guidelines. Summary data is presented to give an indicative assessment of background WQ against objectives, and where applicable for direct comparison i.e. 75th percentile data against SEPP objectives and median data for ANZECC trigger values.

3.5.1 Lake Physio-chemistry

A number of naturally-occurring physical and chemical stressors can cause serious degradation of aquatic ecosystems when ambient values are too high and/or too low. These parameters are commonly monitored as they provide a good indication of overall waterbody conditions, key indication of general water quality, and an early warning of any water quality issues.

These parameters can be indicative or *de facto* measures of other problems (e.g. electrical conductivity is related to high salinity), can interact with other parameters to make other things more toxic (e.g. the toxicity of metals increases at low pH), or pose a direct risk to aquatic life (e.g. low dissolved oxygen levels).

As these parameters are typical indicators and can be monitored cheaply and easily *in situ*, there is also a large data set available to assess these parameters. Water quality objectives also apply to most of these parameters, enabling a ready benchmark of overall lake conditions.

Lake data is available for EC, pH, turbidity and dissolved oxygen. Analysis results are summarised in Section 3.5.1.1 to 3.5.1.4 below.

It should be noted that the Victorian WMIS data is from tributary streams and rivers, rather than in-lake sites. This provides an indication of water quality inflows to the Lake. Other data is from different locations in the lake (principally Bonnie Doon and the Eildon Outlet Tower). Differences in water quality conditions between these two sites is likely a reflection of different sampling locations with reference to location of tributary inflows, and different catchment conditions. The northern part of Lake Eildon (closer to the Bonnie Doon site) receives catchment inflows from a predominantly agricultural catchment, compared to the southern part near the Eildon Outlet Tower which drains a catchment characterised by significant areas of forest and national park. Water quality data is also heavily influenced by both long and short term weather, hydrology and climate conditions.

3.5.1.1 Electrical Conductivity (EC)

Electrical Conductivity (EC) measures the capacity of water to conduct an electrical current. This is directly related to the concentration of salts dissolved in water and provides a measure of the salinity in a system. Salinity levels in water are important as aquatic plants and animals are adapted to a specific salinity range, and can be negatively impacted if exposed to salinity levels outside this range. In addition to its direct effects on aquatic life, salinity also affects water chemistry and water density. EC data is therefore a useful indicator of overall water quality conditions.

Conductivity data were available from all sites and data sets; no salinity data were available. EC data were analysed from all WMIS, GMW and GMV sites, and compared to the SEPP WQOs.

Table 3-3 shows EC data at different sites and from different data sets. The highest median EC values were at the Delatite River and at Bonnie Doon. All sites met the 75^{th} percentile SEPP objective for EC except for Bonnie Doon (GVW data). There is no set ANZECC trigger value for EC. The GMW data for Bonnie Doon (with a higher number of samples, and over a longer time period) met the SEPP 75^{th} percentile objective. EC was consistently higher at Bonnie Doon than at Eildon.

Site	SEPP Objective	405203 Goulburn River at Eildon	405214 Delatite River at Tonga Bridge	405215 Howqua River at Glen Esk	405219 Goulburn River at Doherty's	405258 Lake Eildon Outlet	405254 Bonnie Doon	Eildon Offtake	Bonnie Doon
		Victorian Data Warehouse Online Sites				Goulburn-Murray Water Data		Goulburn Valley Water Data	
Count		318	323	31	312	396	275	24	71
Minimum		39	33	35	30	37	48	43	41.5
25th percentile		49	58	45	37	50	64	48.75	87.25
Median		52	67	49	41	53	66	53.5	120
75th percentile	≤ 100	56	84.5	51.5	47.4	55	72	57.75	230
Maximum		280	198	74	110	104	290	83	320

Table 3-3 : EC (summary data µS/cm) (minimum, 25th percentile, median, 75th percentile, and maximum values from each site) and comparison to SEPP WoV objectives for Rivers and Streams (Forests B)

Figure 3-3 shows time series data (GMW data, 1992-2016) for Eildon Outlet Tower and Bonnie Doon with comparison to the SEPP objective.

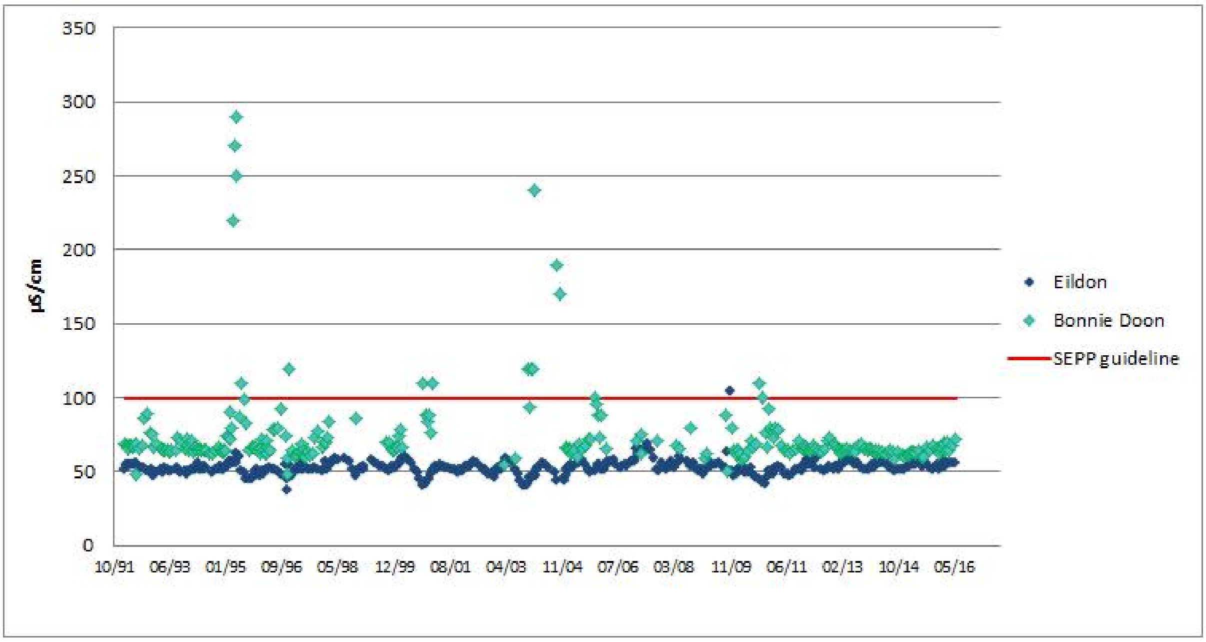

Figure 3-3 : EC (µS/cm) at Eildon Offtake and Bonnie Doon (GMW data, 1992-2016) with comparison to ANZECC trigger value

Figure 3-3 highlights the isolated, individual recordings of very high EC at the Bonnie Doon site, which affect the overall median and percentile values. EC varies between sites and seasons, with particularly high values recorded on isolated occasions, but no consistent long-term trend was observed in the data.

Overall, EC levels in Eildon comply with SEPP objectives and greywater discharge is not expected to have a significant impact on conductivity. EC in a water body is closely linked to inflow, water levels and catchment conditions; and these factors will have a greater effect on EC than greywater discharge. The Regulations do not specify WQ criteria for conductivity.

JACOBS

3.5.1.2 Turbidity

Turbidity is a measure of the relative clarity or cloudiness of the water column, based on the amount of light scattered by particles in the water column. Turbidity, recorded in Nephelometric Turbidity Units (NTU), is related to the amount of suspended materials such as clay, silt, and microscopic organisms in the water column. Turbidity is important because high turbidity levels reduce the amount of light that can penetrate the water. This can affect photosynthesis, affecting primary productivity of the system and reducing the levels of dissolved oxygen in the water which can be harmful to aquatic life.

Turbidity can also indicate a high level of suspended solids, which can damage aquatic organisms while in the water column (through the blocking of gills or filter feeding mechanisms, or through abrasion or lack of visual clarity) and after settling out of the water column (e.g. by the smothering of benthic organisms and habitats).

Turbidity is therefore an important indicator of water quality, and maximum turbidity levels are set in both SEPP and ANZECC water quality objectives. The SEPP WQO for turbidity is a 75th percentile of less than 5 NTU; ANZECC specifies a range of 1-20 NTU.

Table 3-4 shows that the 75th percentile SEPP objectives are exceeded at many sites, though all median and 75th percentile values are within the ANZECC guidelines. Median values were relatively similar at all sites, with Bonnie Doon recording the highest median turbidity. Very high maximum values were recorded at several sites. These turbidity spikes are typically associated with high inflow events, though flow data is not available for direct correlation with this data.

			Victorian Data Warehouse Online Sites				Goulburn-Murray Water Data		Goulburn Valley Water Data	
Site	SEPP Objective	ANZECC trigger value	405203 Goulburn River at Eildon	405214 Delatite River at Tonga Bridge	405215 Howqua River at Glen Esk	405219 Goulburn River at Doherty's	405258 Lake Eildon Outlet	405254 Bonnie Doon	Eildon Offtake	Bonnie Doon
Count			315	322	31	310	396	275	226	266
Minimum		**1**	0.50	0.80	0.40	0.50	0.30	0.20	1.00	0.10
25th percentile			1.90	3.00	2.30	1.60	1.30	4.80	2.30	3.67
Median			3	5	3	3	2	8	3	5
75th percentile	**≤5**		4.50	7.78	4.80	6.28	2.60	16.08	4.30	7.48
Maximum		**20**	65.00	154.00	18.40	882.00	16.00	110.00	44.00	37.00

Table 3-4 : Turbidity (NTU) summary data (minimum, 25th percentile, median, 75th percentile, and maximum values from each site), with comparison to SEPP WoV and ANZECC objectives

Figure 3-4 and Figure 3-5 show the individual turbidity data measurements from Bonnie Doon and Eildon, highlighting the high maximum 'spikes' in turbidity and the consistent pattern of elevated turbidity at Bonnie Doon compared to Eildon. There is a slight long term decreasing trend in turbidity at Bonnie Doon, due to the period of elevated turbidity values in the mid-1990s; no trend is evident in the Eildon data.

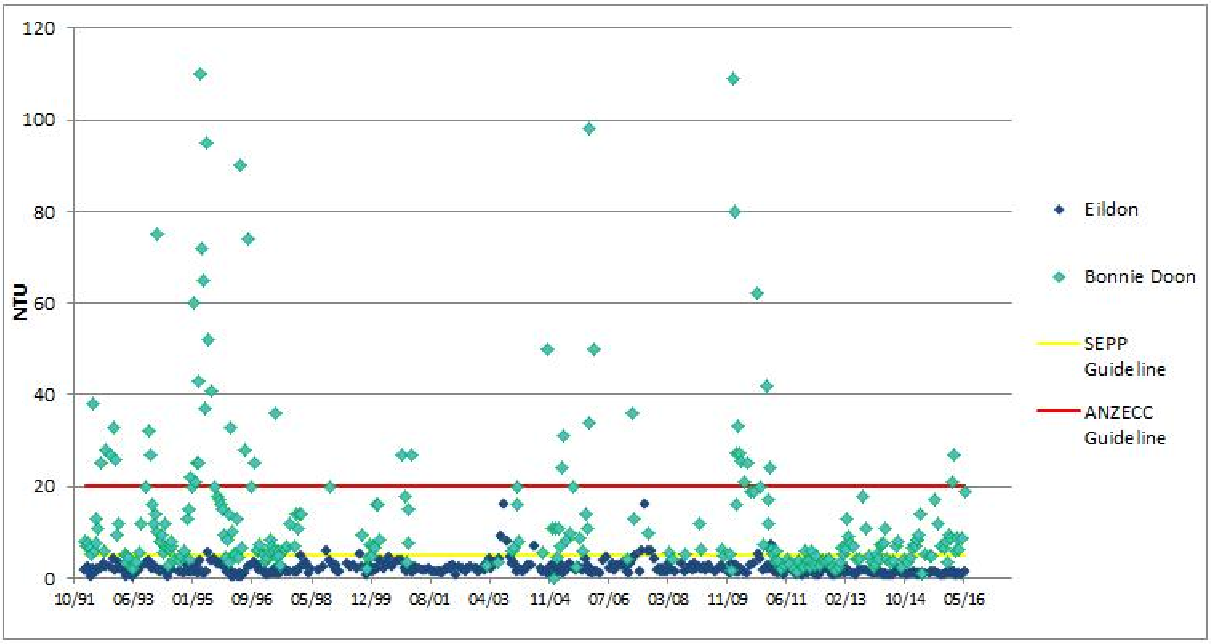

Figure 3-4 : Turbidity (NTU) at Eildon Offtake and Bonnie Doon (GMW data, 1992-2016) with comparison to SEPP objectives and ANZECC trigger value

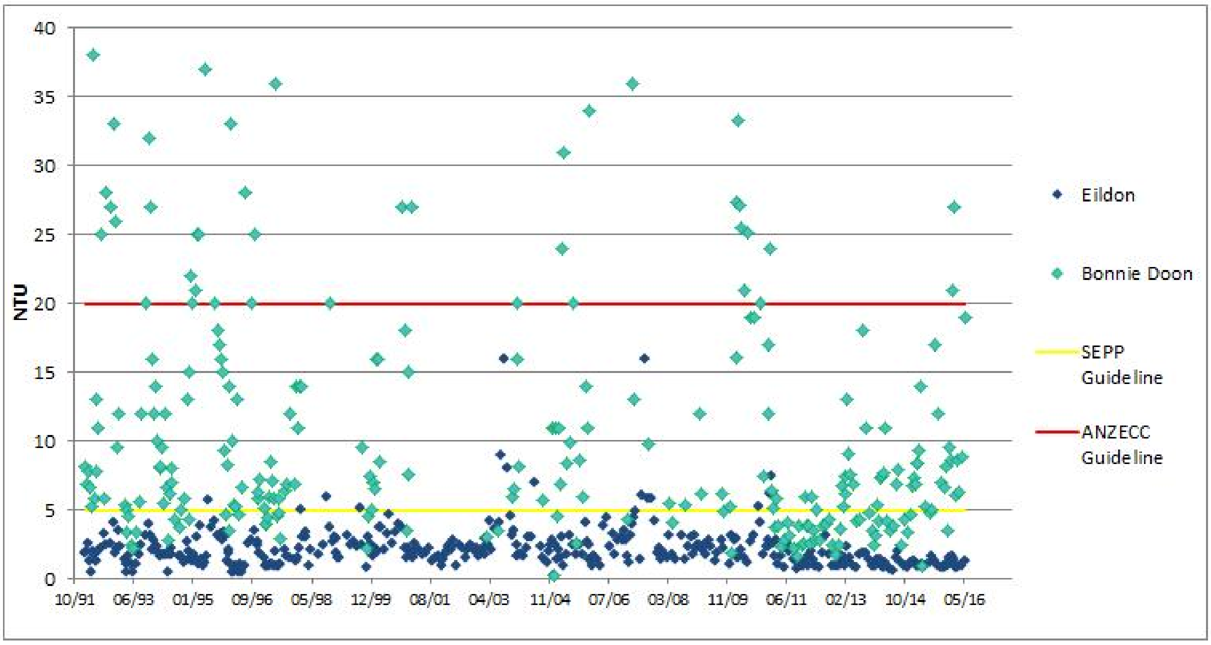

Figure 3-5 : Turbidity (NTU) at Eildon Offtake and Bonnie Doon (GMW data, 1992-2016) with truncated scale, showing comparison to SEPP objectives and ANZECC trigger value

Turbidity on a lake-wide scale is not likely to be directly affected by grey water discharge, though temporary increases in turbidity would be likely in the immediate discharge area. The Regulations do not specify WQ criteria for turbidity.

3.5.1.3 pH

pH is a measure of the level of acidity in water, and is reported as a number between 0 and 14. The lower the number the more acidic the water is; the higher the number, the more basic, with a pH of 7 being considered 'neutral'. pH is monitored because extremes of pH can be detrimental to aquatic organisms, with most preferring a range between 6.5 and 9.0. In addition, changes in pH can also affect other critical water chemistry processes. For example, lower pH levels can increase the toxicity of metals in the aquatic environment by increasing their solubility, thereby making them more readily available for uptake by aquatic animals. High pH can also increase the toxicity of ammonia.

Water quality objectives are therefore set for minimum and maximum pH levels. The SEPP objectives specify a 25th percentile value of ≥ 6.4 and a 75th percentile value of ≤ 7.7. ANZECC objectives specify that pH values should be within the range of 6.5 and 8.

Table 3-5 shows that pH levels across river and lake sites generally met both SEPP and ANZECC objectives. Maximum pH levels exceeded the ANZECC trigger value at several sites including Bonnie Doon (both data sets) and Eildon outlet (GMW data). Several river sites also recorded minimum pH values that were below the ANZECC minimum guideline. Almost all values between 25th and 75th percentiles were within both SEPP and ANZECC limits. Median values at all sites were relatively similar and all within guidelines.

			Victorian Data Warehouse Online Sites				Goulburn-Murray Water Data		Goulburn Valley Water Data	
Site	SEPP Objective	ANZECC trigger value*	405203 Goulburn River at Eildon	405214 Delatite River at Tonga Bridge	405215 Howqua River at Glen Esk	405219 Goulburn River at Doherty's	405258 Lake Eildon Outlet	405254 Bonnie Doon	Eildon Offtake	Bonnie Doon
Count			311	319	31	305	396	275	242	334
Minimum		**6.5**	4.90	5.10	6.40	5.30	6.40	6.60	6.20	6.60
25th percentile	**≥ 6.4**		6.50	6.70	6.70	6.60	7.20	7.20	6.69	7.39
Median			6.70	6.90	6.90	6.80	7.30	7.38	6.80	7.65
75th percentile	**≤7.7**		6.90	7.10	7.15	7.00	7.50	7.50	7.00	7.90
Maximum		**8**	7.70	8.10	7.40	7.90	8.40	8.40	7.70	9.20

Table 3-5 : pH summary data (minimum, 25th percentile, median, 75th percentile, and maximum values from each site), with comparison to SEPP WoV and ANZECC objectives

Figure 3-6 shows pH values at Eildon and Bonnie Doon between 1992 and 2016, with comparison to ANZECC guidelines. The data shows the variation in pH data, typically between 7 and 7.5, and the general compliance with guidelines. A slight trend of increasing pH occurs over the long term. The Regulations do not specify WQ criteria for pH.

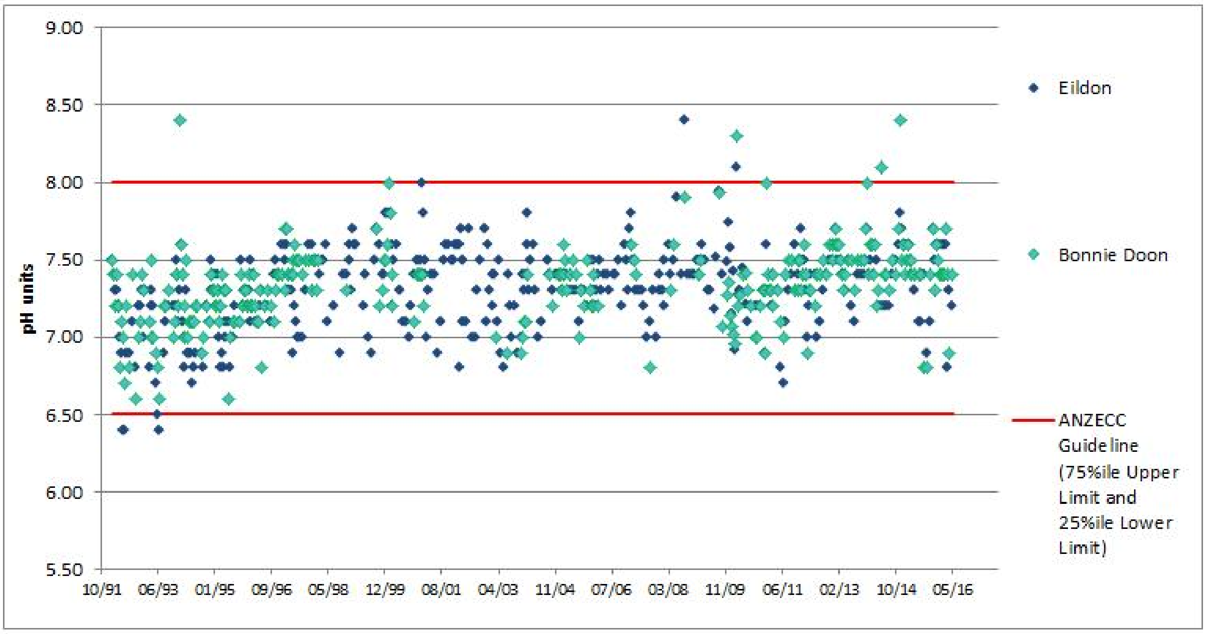

Figure 3-6 : pH at Eildon Offtake and Bonnie Doon (GMW data, 1992-2016) with comparison to ANZECC guidelines

3.5.1.4 Dissolved Oxygen (DO)

Dissolved Oxygen (DO) measures the amount of oxygen dissolved in the water. DO concentration is affected by temperature, salinity, biological activity (microbial, primary production) and rate of transfer from the air. Significant natural variability occurs in DO over a daily (or diurnal) period. DO is essential for aquatic life, and low DO concentration has an adverse effect on many aquatic organisms including fish, invertebrates and microorganisms. Low DO can also create reducing conditions in sediments, whereby the sediments release previously-bound nutrients and toxicants to the water column where they can affect aquatic life.

DO can be measured in mg/L or percentage saturation. Cold water can ‘hold’ more oxygen than warm water, and percentage saturation takes into account the effect of temperature on the amount of oxygen that can be held in the water under those temperature conditions. Other physico-chemical conditions including lake stratification can significantly influence DO levels and affect interpretation of results.

The ANZECC and SEPP objectives both state objectives for DO in terms of percentage saturation (90 – 100%). However, the only available data (from the Victorian WMIS) has been measured in ppm (mg/L) which cannot be readily converted to percentage saturation without contemporaneous temperature and pressure measurements. DO measurements are difficult to interpret given the large natural variation that occurs in DO levels over a diurnal cycle, and the effect of temperature.

Temperature data (where available) shows minimum temperatures of between three and eight degrees, and maximum temperatures of between 18 and 24 degrees. 100% DO saturation at these temperatures would be approximately 8.6 -9.6 mg/L (at maximum temperatures) and 11.9 to 13.5 degrees (at minimum temperatures). Summary data (Table 3-6) shows that DO is generally within this range, though minimum values fall well below this level. The 1992 ANZECC Guidelines recommended that dissolved oxygen should not normally be permitted to fall below 6 mg/ L or 80−90% saturation, determined over at least one diurnal cycle.

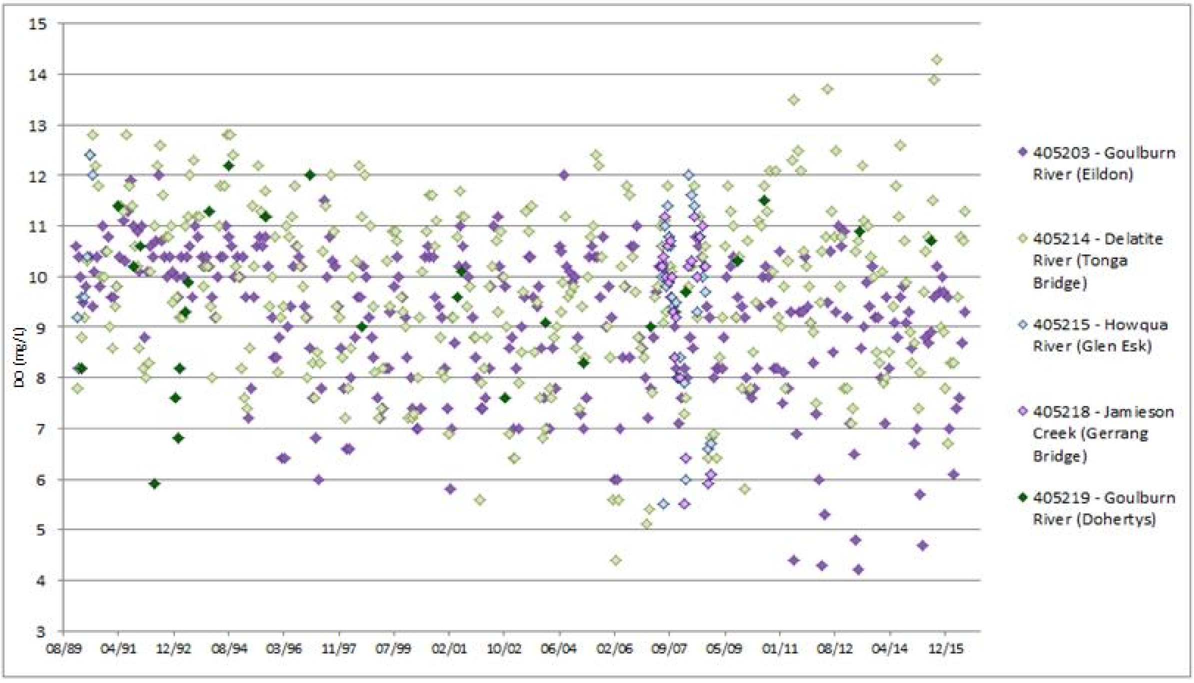

Figure 3-7 : DO measurements from VMIS river sites

Figure 3-7 shows DO measurements, which are generally higher than 6 mg/L. No data is available from within the lake; inflow tributary data is provided to establish indicative typical conditions only.

Greywater discharge could affect lake DO levels by contributing nutrients which increase the risk of algal blooms, and an associated drop in oxygen as the plants decay. The Regulations do not specify WQ criteria for DO.

Victorian Data Warehouse Online Sites				
Site	**405203 Goulburn River at Eildon**	**405214 Delatite River at Tonga Bridge**	**405215 Howqua River at Glen Esk**	**405219 Goulburn River at Doherty's**
Count	318.00	322.00	31.00	310.00
Minimum	4.20	4.40	5.50	4.50
25th percentile	8.20	8.50	8.80	8.60
Median	9.40	9.80	9.60	9.80
75th percentile	10.20	11.00	10.80	10.78
Maximum	12.00	14.30	12.40	12.90

Table 3-6 : Summary DO data from WMIS river sites

3.5.2 Nutrients

Nutrients, particularly nitrogen and phosphorous, play a critical role in aquatic chemistry and ecology. Nitrogen and phosphorous occur naturally and are essential to plant growth. However, in high concentrations, phosphorus and nitrogen can result in excessive growth of aquatic plants including phytoplankton, cyanobacteria ('blue-green algae') and macrophytes. This excessive growth can lead to a number of problems including toxic effects from some cyanobacteria, reduction in dissolved oxygen concentrations when plants die and decompose, blocking of light in the water column, a reduction in recreational amenity; blocking of waterways and standing waterbodies by macrophytes; and changes in biodiversity.

In addition to the chronic effects of eutrophication and the potential to cause algal blooms, some forms of nutrients (i.e. nitrogen in the form of ammonia) can also be acutely toxic to aquatic life in high concentrations, particularly if pH and temperature are also elevated.

Nutrients enter the lake from a variety of catchment sources, and are also typically found in high concentrations in greywater (Ref. C). Given the importance of nutrient levels to aquatic systems, they are commonly monitored and a good data set exists for Eildon.

3.5.2.1 Nitrogen

Total Nitrogen (TN)

Total Nitrogen (TN) is a measure of all forms of nitrogen in the water. This includes dissolved organic and inorganic, including nitrate/nitrite and ammonia, and particulate nitrogen suspended in the water column. TN is typically measured in µg/L or mg/L.

SEPP specifies a guideline objective for 75th percentile TN concentration of ≤ 350 µg/L (0.35 mg/L). The ANZECC trigger value for TN is also 350 µg/L.

Table 3-7 shows summary data for TN at different sites. There is no TN data for GVW data; and the WMIS data recorded TN as its separate components (Nitrite/Nitrate or NOx, and Total Kjehldahl Nitrogen, or TKN) which were then summed to derive a TN concentration.

Summary GMW data shows that the Eildon Outlet site met the SEPP objective for TN, while Bonnie Doon TN concentrations were well in excess of the objective. TN concentrations were particularly high at Bonnie Doon. The data for the tributary creeks shows data close to, or exceeding guidelines at the Delatite and Howqua sites. This indicates that the catchment and tributary streams of the lake are a source of nitrogen and contribute to nitrogen concentrations/loads in the Lake.

		Victorian Data Warehouse Online Sites				Goulburn-Murray Water Data		Goulburn Valley Water Data	
Site	SEPP Objective	405203 Goulburn River at Eildon	405214 Delatite River at Tonga Bridge	405215 Howqua River at Glen Esk	405219 Goulburn River at Doherty's	405258 Lake Eildon Outlet	405254 Bonnie Doon	Eildon Offtake	Bonnie Doon
Count		311	314	24	277	396	276	ND	ND
Minimum		67.0	50.0	20.0	10.0	11.0	120.0	ND	ND
25th percentile		230.5	180.0	210.0	103.0	198.0	311.9	ND	ND
Median		270.0	240.0	370.0	140.0	235.5	391.5	ND	ND
75th percentile	**≤ 350**	340.0	360.0	590.0	203.0	290.0	559.5	ND	ND
Maximum		860.0	3430.0	1000.0	7800.0	1309.0	2440.0	ND	ND

Table 3-7 : TN summary data (minimum, 25th percentile, median, 75th percentile, and maximum values from each site), with comparison to SEPP WoV and ANZECC objectives

Figure 3-8 shows long term data for TN at Eildon Outlet and Bonnie Doon showing variation in TN over time, the consistently higher TN at Bonnie Doon, and the comparison with SEPP objectives (noting that the SEPP objective applies to the 75th percentile of the data, not individual values).

TN concentrations were close to, or exceeding guidelines at several locations. Bonnie Doon had particularly high TN levels; with even the 25th percentile data close to exceeding the 75th percentile objective. Extremely high maximum concentrations (an order of magnitude greater than objectives) contributed to the high percentile statistics for the site and indicate conditions in Lake Eildon that pose a high risk of algal blooms. The high nitrogen concentrations at Bonnie Doon reflect the local conditions affecting water near the sampling site, namely agricultural runoff from the catchment and local tributaries, and typically lower water levels, with less dilution and mixing than in the Lake overall. The Eildon outlet site met the SEPP objective for 75th percentile data but also recorded high maximum concentrations, which contribute to the risk of algal blooms.

The regulations specify a WQ criteria of total nitrogen content of less than 10 mg/L (10,000 µg/L), which is significantly higher than WQ objectives (0.35 mg/L) or typical, median background concentrations (0.14 – 0.39 mg/L).

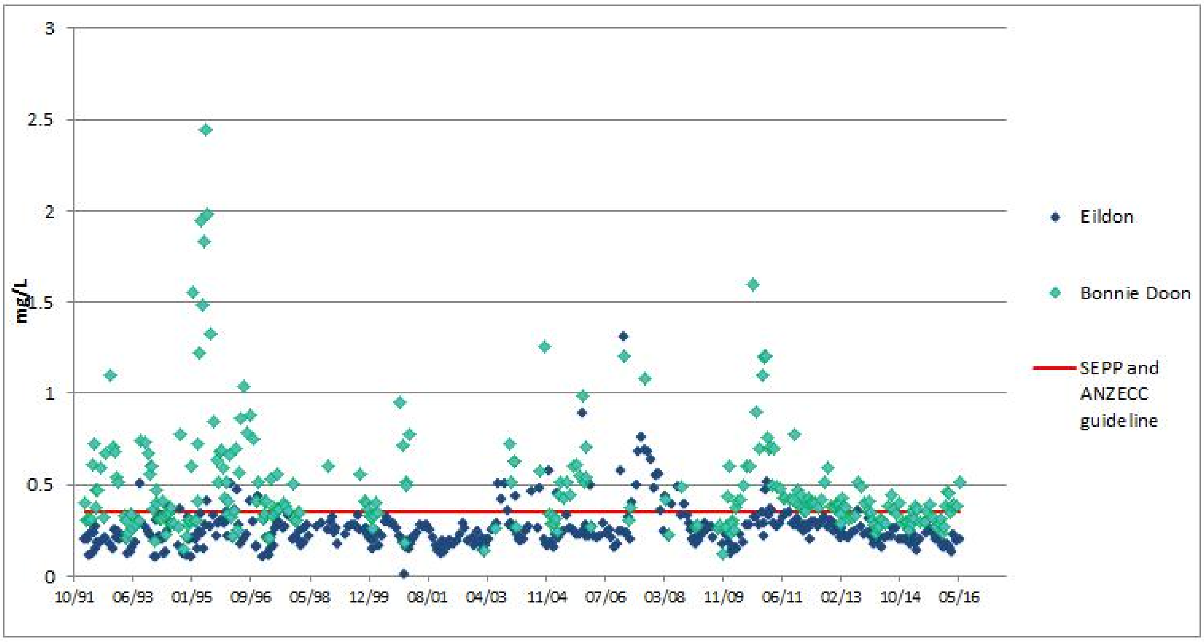

Figure 3-8 : TN concentrations (mg/L) at Eildon Outlet and Bonnie Doon (G-MW data, 1992-2016) with comparison to guidelines

Oxidised Nitrogen (NOx)

Oxidised Nitrogen (nitrate and nitrite, or NOx) is a component fraction of total nitrogen, and refers to forms of nitrogen that are bioavailable – that is, can be readily taken up by plants and used for growth. High NOx concentrations can lead to nuisance plant growth and algal blooms which can be detrimental to aquatic systems.

There is no SEPP objective for NOx but an ANZECC trigger value of 10 µg/L applies. Table 3-8 shows that median values exceed the ANZECC objective at all sites, typically by a significant margin and up to an order of magnitude. In contrast to other water quality parameters, NOx concentrations are as high, or higher, at Eildon than at Bonnie Doon. Figure 3-9 shows the long term data for NOx and Eildon and Bonnie Doon, highlighting the range of values, the very high 'spikes' and the high recorded data compared to the ANZECC at both sites (noting guideline applies to median values, not the individual data points plotted).

		Victorian Data Warehouse Online Sites				Goulburn-Murray Water Data		Goulburn Valley Water Data	
Site	ANZECC objective	405203 Goulburn River at Eildon	405214 Delatite River at Tonga Bridge	405215 Howqua River at Glen Esk	405219 Goulburn River at Doherty's	405258 Lake Eildon Outlet	405254 Bonnie Doon	Eildon Offtake	Bonnie Doon
Count		311	314	24	277	397	276	26	68
Minimum		3.0	2.0	3.0	2.0	1.0	1.0	30.00	5.00
25th percentile		80.0	8.0	32.5	7.0	11.0	9.8	157.50	10.00
Median	10.0	110.0	30.0	240.0	20.0	40.0	42.0	200.00	40.00
75th percentile		150.0	120.0	432.5	60.0	96.0	100.5	217.50	117.50
Maximum		550.0	2600.0	830.0	1200.0	690.0	940.0	550.00	1500.00

Table 3-8 : NOx summary data (minimum, 25th percentile, median, 75th percentile, and maximum values from each site), with comparison to SEPP WoV and ANZECC objectives

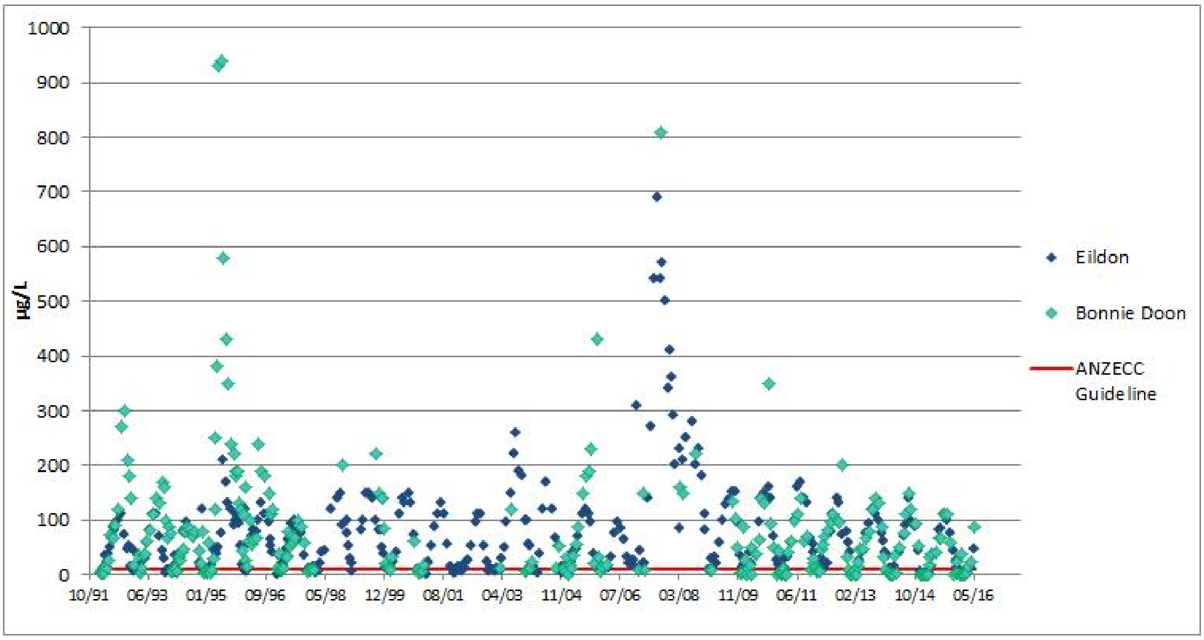

Figure 3-9 : NOx at Eildon Offtake and Bonnie Doon (GMW data, 1992-2016) with comparison to ANZECC guidelines

Ammonia

Ammonia is a form of nitrogen that is toxic to aquatic life in high concentrations. The only available ammonia data is from the Goulburn-Murray Water data set, which includes ammonia monitoring at Eildon and Bonnie Doon for the time period October 1999 to June 2016.

No SEPP guidelines are set for ammonia, but two trigger values for ammonia are specified in the ANZECC guidelines. A default trigger level of 10 µg/L is set; this relates to long term conditions and the risk of eutrophication. In addition, ANZECC also specifies trigger values for toxicants. The toxicity trigger value for ammonia is 900 µg/L; this reflects a concentration of ammonia that could have acute, toxic effects on aquatic life.

Figure 3-10 and Figure 3-11 show ammonia concentrations, relative to the ANZECC guidelines. The median values for Lake Eildon Outlet and Bonnie Doon sites were 5 and 9 µg/L respectively, meeting ANZECC guidelines. Numerous individual values exceeded the 10 µg/L trigger value, but typical and maximum values were well below the 900 µg/L toxicity trigger value. Figure 3-10 shows ammonia data and comparison to the ANZECC acute toxicity values of 900 µg/L; Figure 3-11 shows the same data with comparison to the ANZECC trigger value of 10 µg/L.

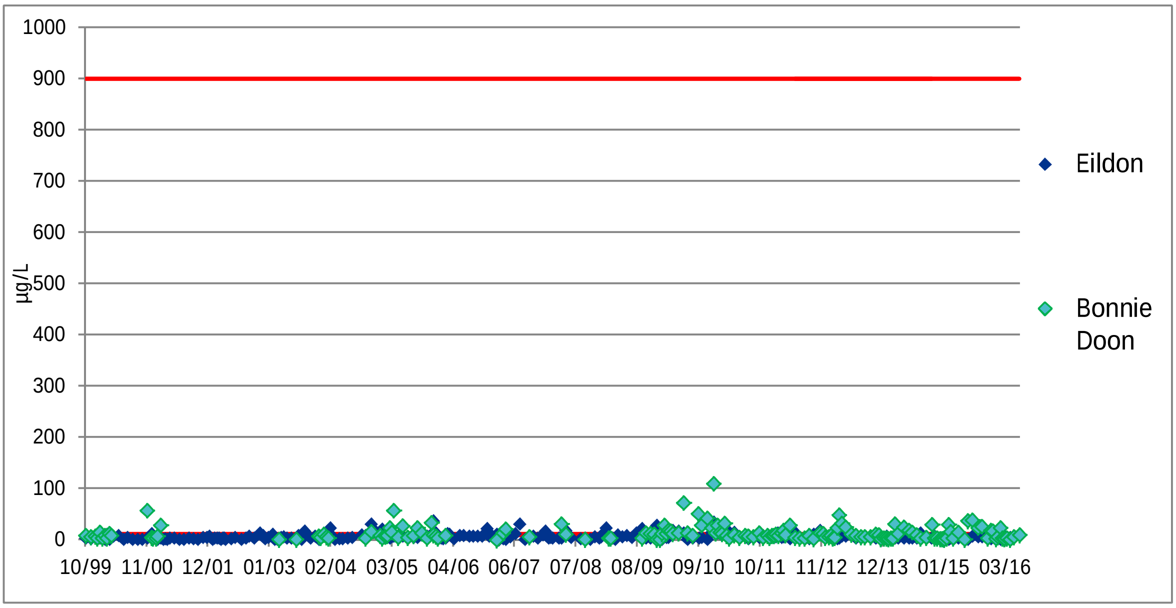

Figure 3-10 : Ammonia (µg/L) with comparison to ANZECC toxicity guideline (900 µg/L)

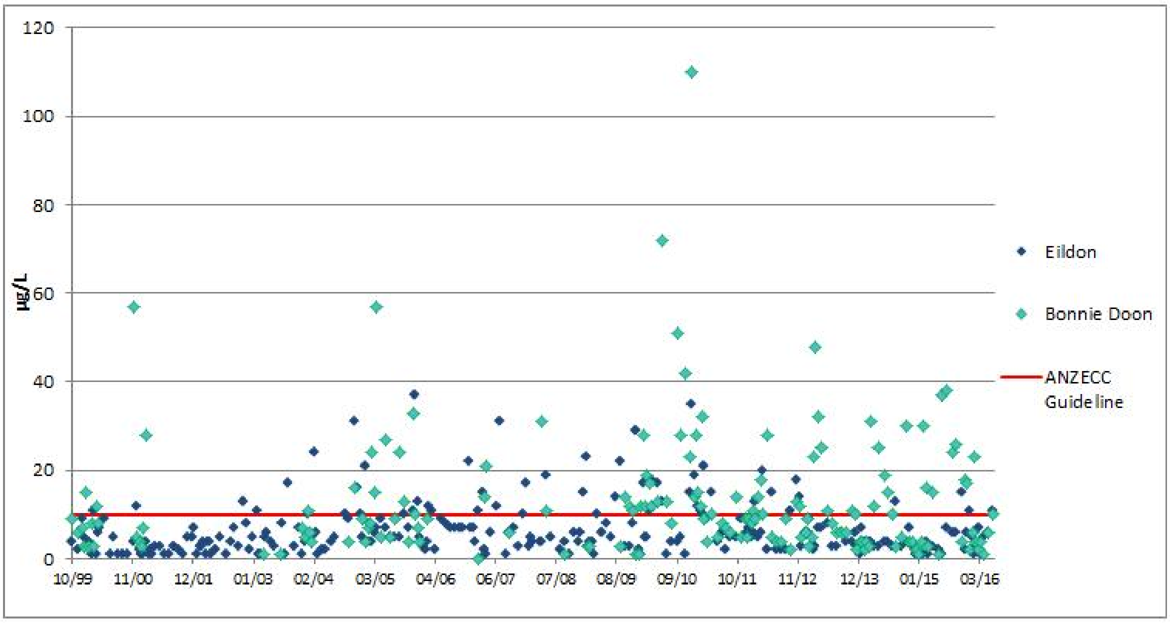

Figure 3-11 : Ammonia (µg/L) with comparison with ANZECC trigger value (10 µg/L)

3.5.2.2 Phosphorous

Total phosphorous (TP) (typically recorded in µg/L or mg/L) is an essential element but similarly to TN, in elevated concentrations it stimulates the excessive growth of aquatic plants and algae.

Water quality objectives are set under both SEPP (75th percentile ≤ 25 µg/L) and ANZECC (median ≤10 µg/L).

Table 3-9 shows a summary of TP data from all lake and tributary sites, and shows that TP guidelines were met at all sites, with the exception of Bonnie Doon.

			Victorian Data Warehouse Online Sites				Goulburn-Murray Water Data		Goulburn Valley Water Data	
Site	SEPP Objective	ANZECC trigger value*	405203 Goulburn River at Eildon	405214 Delatite River at Tonga Bridge	405215 Howqua River at Glen Esk	405219 Goulburn River at Doherty's	405258 Lake Eildon Outlet	405254 Bonnie Doon	Eildon Offtake	Bonnie Doon
Count		**<10**	311	315	240	278	397	276	ND	260
Minimum			10.0	10.0	10.0	0.0	2.0	2.5	ND	20.0
25th percentile			10.0	10.0	10.0	10.0	6.0	16.0	ND	50.0
Median			10.0	10.0	10.0	10.0	9.0	22.0	ND	50.0
75th percentile	**≤25**		10.0	20.0	12.5	10.0	13.0	36.0	ND	50.0
Maximum			100.0	260.0	30.0	740.0	330.0	260.0	ND	80.0

Table 3-9 : TP summary data (minimum, 25th percentile, median, 75th percentile, and maximum values from each site), with comparison to SEPP WoV and ANZECC objectives

Figure 3-12 and Figure 3-13 show TP concentrations (mg/L) at Eildon Outlet and Bonnie Doon over time. Consistent with other water quality parameters, Bonnie Doon shows higher TP concentrations than Eildon. TP concentrations typically exceed both guidelines by up to an order of magnitude (noting guidelines apply to summary median and 75th percentile values, not individual data points).

The regulations specify a WQ criteria of total phosphorous content of less than 1 mg/L (1000 µg/L), which is significantly higher than WQ objectives (0.25 mg/L, or 0.1 mg/L) or typical, median background concentrations (0.09 – 0.22 mg/L).

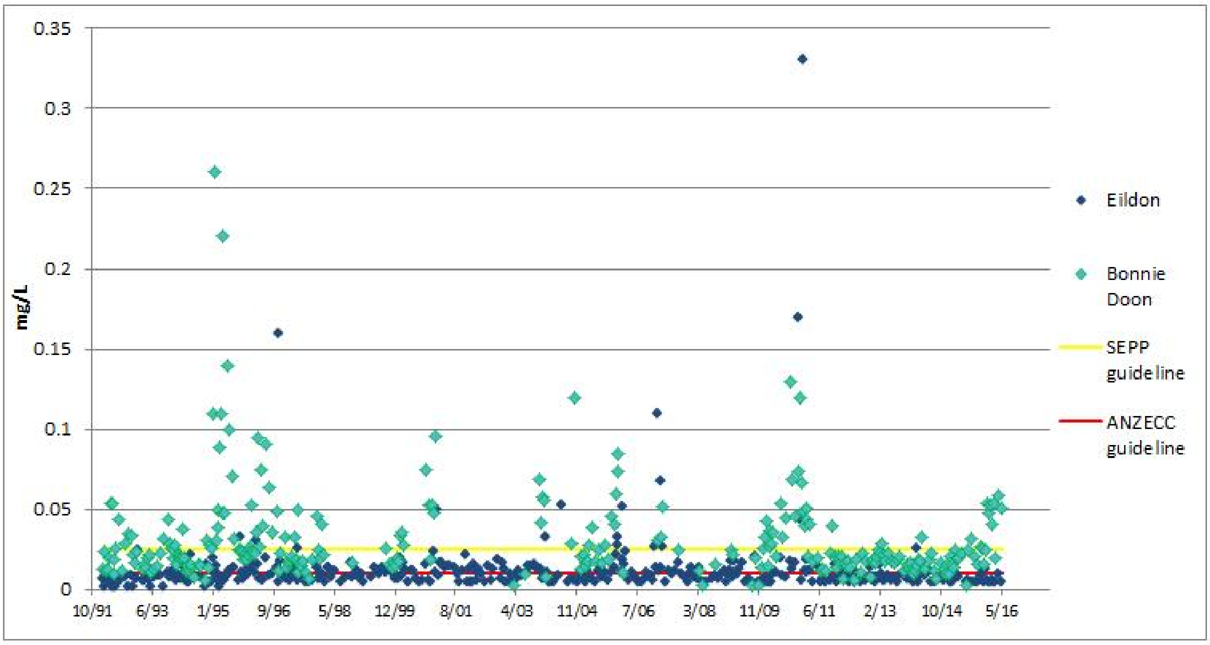

Figure 3-12 : TP concentrations (mg/L) at Eildon Outlet and Bonnie Doon (G-MW data, 1992-2016) with comparison to guidelines

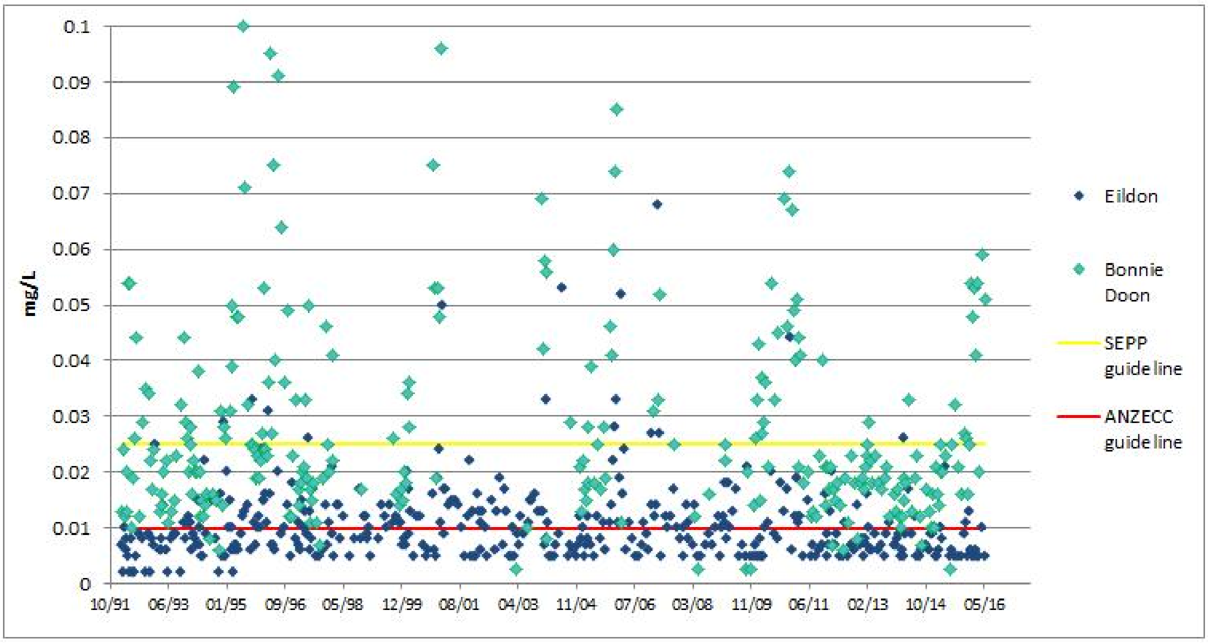

Figure 3-13 : TP concentrations (mg/L) at Eildon Outlet and Bonnie Doon (G-MW data, 1992-2016) with comparison to guidelines and truncated scale

3.5.3 Chlorophyll-a

A key water quality issue of concern in Lake Eildon (from both environmental and public health and recreation perspectives) is 'blooms' of cyanobacteria (Blue-Green Algae, BGA). BGA occur naturally but can have damaging environmental, health and recreational impacts if blooms of very large numbers occur. Algal blooms can result in the smothering of aquatic biota, the release of toxins from some species, public health and recreation issues caused by odours and skin irritation, loss of amenity and scenic values, contamination of drinking water supplies, and decay of organic material (an oxygen-consuming process) leading to a drop in oxygen levels in the water. Lake Eildon has experienced documented cyanobacteria blooms in the past, particularly during low water periods.

As described in Section 3.5.2, elevated nutrient concentrations are a key contributing factor to the risk of algal blooms. The ratio of nitrogen to phosphorous and other environmental factors also affect the risk of algal blooms, and the type of bloom (BGA, green algae) that is likely to occur. While increased nutrient levels contribute to the risk of algal blooms, nutrient data does not directly correlate with algal concentrations. Algal concentrations can instead be estimated by measuring concentrations of chlorophyll-a. Chlorophyll is the colour pigment found in plants, algae and phytoplankton and is vital for photosynthesis. Nutrients alone cannot indicate whether a system has a nuisance plant problem therefore measuring chlorophyll indicates that plants, algae or cyanobacteria are actually growing. This can be used to indicate the level of risk of an algal bloom.

ANZECC sets WQOs for chlorophyll, with a trigger value of 5 µg/L. The guidelines take a risk assessment approach for algal blooms. If median test values are less than trigger values, there is low risk of adverse biological effects and no further action is required, except for regular monitoring of the key condition indicators including nutrients. Concentrations above that are considered eutrophic and at risk of algal blooms.

Chlorophyll-a data was available only from GMW data, for the Eildon and Bonnie Doon sites. The Regulations do not specify WQ criteria for chlorophyll-a.

Eildon data generally met the ANZECC guidelines. Chlorophyll data at Eildon had a minimum value of 0.25 µg/L, a maximum of 18 µg/L and a median of 2.55 µg/L, below the trigger value of 5 µg/L. In contrast, Bonnie Doon concentrations ranged from 0.3 to 68 µg/L, with a median value of 6.5 µg/L. This median concentration exceeds the ANZECC trigger value and indicates a risk of algal blooms. The very high individual chlorophyll concentrations recorded at Bonnie Doon on a number of separate occasions suggest algal bloom conditions. Figure 3-14 and Figure 3-15 show chlorophyll concentrations at each site over time.

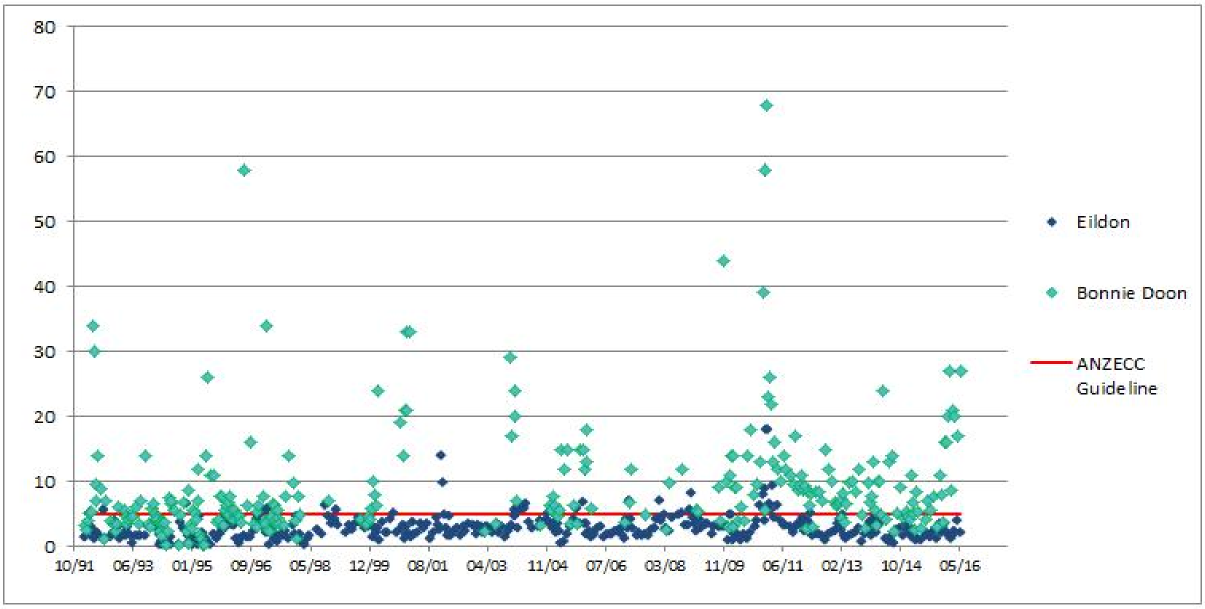

Figure 3-14 : Total Chlorophyll-a concentrations (µg/L) at Eildon Outlet and Bonnie Doon (G-MW data, 1992-2016) with comparison to guidelines

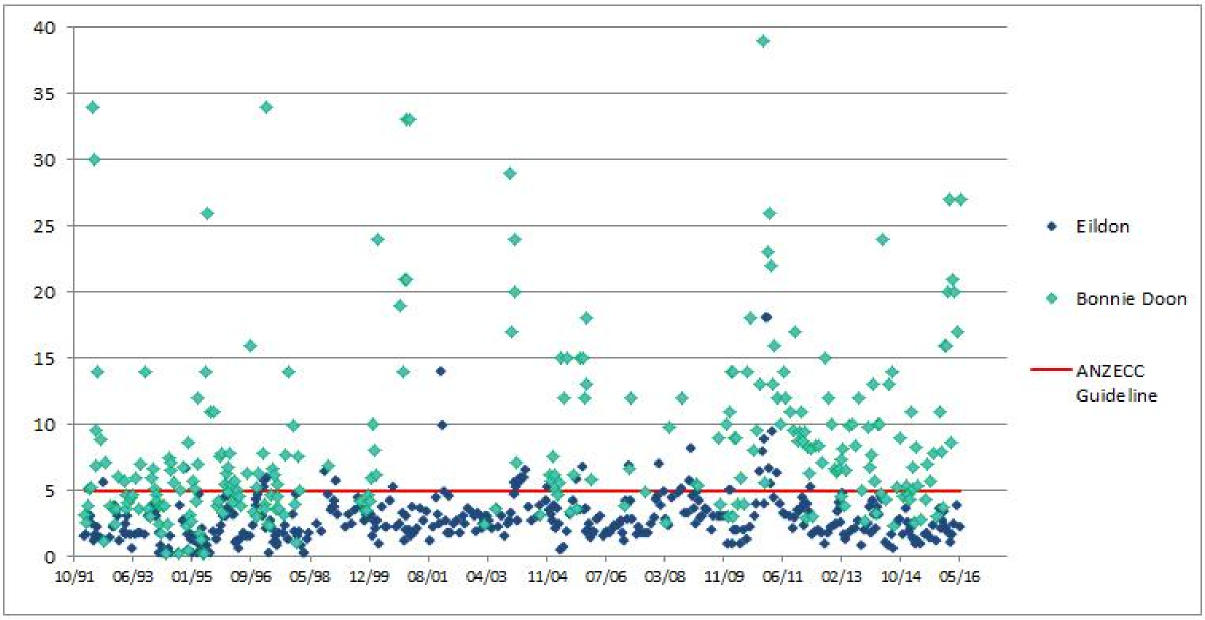

Figure 3-15 : Total Chlorophyll-a concentrations (µg/L) at Eildon Outlet and Bonnie Doon (G-MW data, 1992-2016) with comparison to guidelines and truncated scale

JACOBS

3.5.4 Biovolume

As detailed in Section 3.5.3, cyanobacteria (blue-green algae) are an issue of concern in Lake Eildon. Chlorophyll-a concentrations can be used as a measure of algal levels (Section 3.5.3). Total biovolume is also used as a measure of algal biomass. Biovolume is a calculation of the volume of algal cells in a unit amount of water (usually mm^3/L). Biovolume can be calculated for an individual species, a mix of species or a specific group of species (e.g. cyanobacterial species). Biovolume is calculated from the total sum of the cell counts (cells/ml) multiplied by the mean cell volume (μm^3).

Long term total biovolume data for cyanobacteria species for Bonnie Doon and the Eildon Outlet from 1998. Total biovolume data from 1998-2007 was retrospectively calculated by GMW based on a large number of assumptions, and this data is not considered sufficiently reliable for analysis. Data of moderate reliability is available from these (and additional) sites for the period 2007-2009. From 2009 onwards, a reliable data set for total biovolume data exists. This data includes regular samples from Bonnie Doon and the Eildon Outlet, and a smaller number of samples from other locations around the lake. There are two datasets for the Lake Eildon outlet location; Lake Eildon Outlet (2010-2011) and Lake Eildon Outlet (integrated) (2007-2017). The data labelled 'integrated' was collected using a trial alternative sampling method. Data was collected from the same location using standard sampling methods and the data compared. No significant difference was found between the two data collection methods.

A summary of the data from all sites from 2009 onwards is provided in Table 3-10. This table shows the number of data records from each site, the time period during which they were recorded, and summary statistics including average and median values.

Table 3-10 : Summary biovolume data, 2009 -2017 from Lake Eildon sites.

Date	Delatite Arm Reserve	Bonnie Doon	Coller Bay	Ford Inlet	Gough Bay	Howqua Inlet	Jerusalem Creek	Junction of Delatite and Brankeet Arms	Lake Eildon Boat Club	Main Arm at Big River	Lake Eildon - Outlet	Lake Eildon - Outlet (integrated)	Peppin Point	Taylor Bay
COUNT	2	139	2	8	40	1	15	7	33	4	144	99	10	10
Date Range	Dec 2010 to Jan 2011	Apr 2009 to Feb 2017	Nov 2010 to Feb 2011	Jan 2011 to Nov 2014	Jan 2011 to Feb 2011	Nov 2010 to Feb 2017	Nov 2010 to Jan 2012; Feb17	Nov 2010 to Jan 2012; Feb17	Sep 2008 to June 2011; Feb17	Nov 2010 to Feb 2017	Apr 2009 to Feb 2017	April 2009 to July 2015	Sep 2007 to Apr 2011	Nov 2010 to Mar 2011
Minimum	2.55	0.00	0.09	0.56	0.01	0.22	0.03	0.02	0.01	0.01	0.00	0.00	0.05	0.04
Average	16.79	1.10	0.31	11.58	2.60	0.22	2.08	9.73	3.07	10.47	0.42	0.32	8.30	1.72
Median	16.79	0.09	0.31	5.32	0.21	0.22	0.43	0.33	0.21	4.14	0.06	0.05	2.41	0.72
Maximum	31.03	89.53	0.53	36.03	65.08	0.22	10.79	63.33	38.91	33.61	6.97	5.25	30.05	7.09

Direct comparison between sites is difficult due to the variation in the number of samples collected, and the different time periods over which they were collected. Additional sampling (at additional sites) also typically occurred during blooms or bloom warning periods. This skewed the average biovolume data, as biovolumes will be higher during the sampled periods. Bonnie Doon and Lake Eildon Outlet have been monitored more consistently and provide a more representative data set for typical long term biovolume.

There are no ANZECC guidelines for biovolume. The NHMRC Recreational guidelines do contain biovolume objectives for cyanobacterial species, which vary depending on whether the cyanobacteria are dominated by toxic or non-toxic species (Table 3-11).

Table 3-11 : Cyanobacterial alert levels for recreational water (Taken from NHMRC Guidelines for Managing Risks in Recreational Water, Table 6.2)

Green level Surveillance mode	Amber level Alert mode	Red level Action mode
≥500 to <5000 cells/mL *M. aeruginosa* or biovolume equivalent of >0.04 to <0.4 mm^3/L for the combined total of all cyanobacteria.	≥5000 to <50 000 cells/mL *M. aeruginosa* or biovolume equivalent of ≥0.4 to <4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume[a]. or[b] ≥0.4 to <10 mm^3/L for the combined total of all cyanobacteria where known toxin producers are not present.	Level 1 guideline: ≥10 µg/L total microcystins or ≥50 000 cells/mL toxic *M. aeruginosa* or biovolume equivalent of ≥4 mm^3L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume. or[b] Level 2 guideline: ≥10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present. or cyanobacterial scums are consistently present[c].

Data provided by GMW shows that during the bloom period of 2010-2011, the biovolume was dominated by toxic species. At other times, the percentage of toxic species is lower and more variable. The applicable guideline limits therefore change over time and space, but were generally below Amber and Red levels except during bloom conditions. Long term data from Bonnie Doon and Lake Eildon Outlet was more typically within the “Green level” range.

Figure 3-16 shows a plot of total biovolume at all sites from 2009-2017. The bloom conditions between 2010 and 2011 are reflected in the elevated biovolumes recorded during that period at all sites. The Amber line at $4mm^3$ corresponds to the Amber alert level for times when biovolume is dominated by toxic species (see Table 3-11). At other times, alert levels are higher.

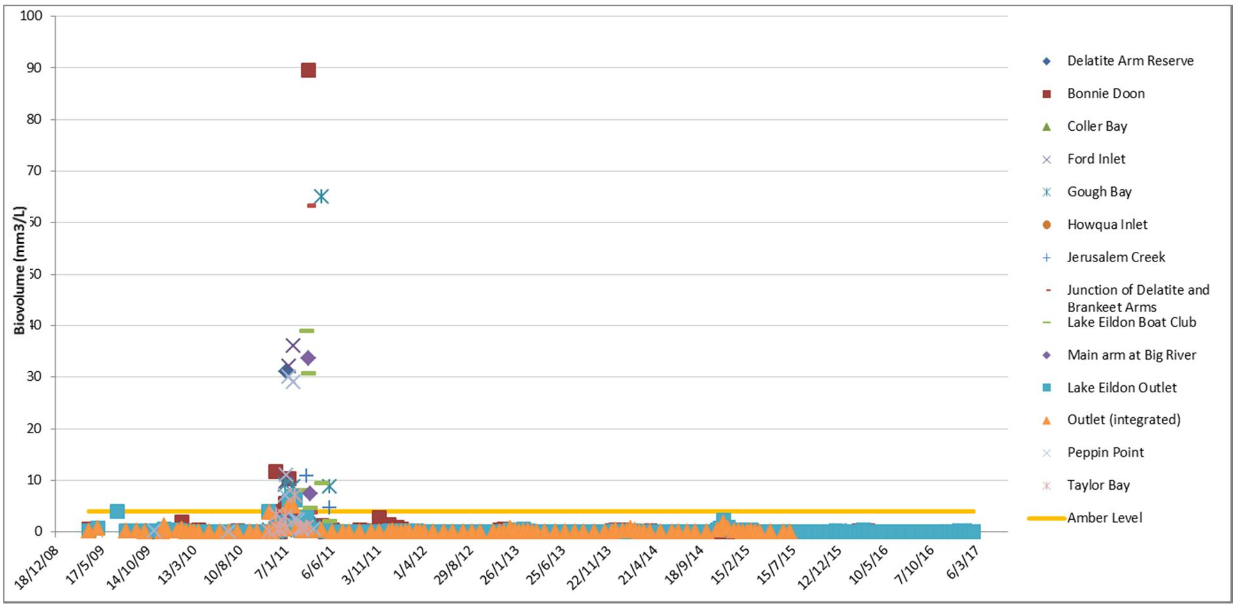

Figure 3-16 : Total biovolume (mm3/L) for all Lake Eildon sites, 2009-2016

Figure 3-17 shows the same data, during the period 2010-2011 only. Bonnie Doon recorded the highest maximum value; other sites including Gough Bay, Ford Inlet, Peppin Point and Eildon Boat club also recorded high biovolume concentrations. Lake Eildon Outlet typically recorded lower values than other sites.

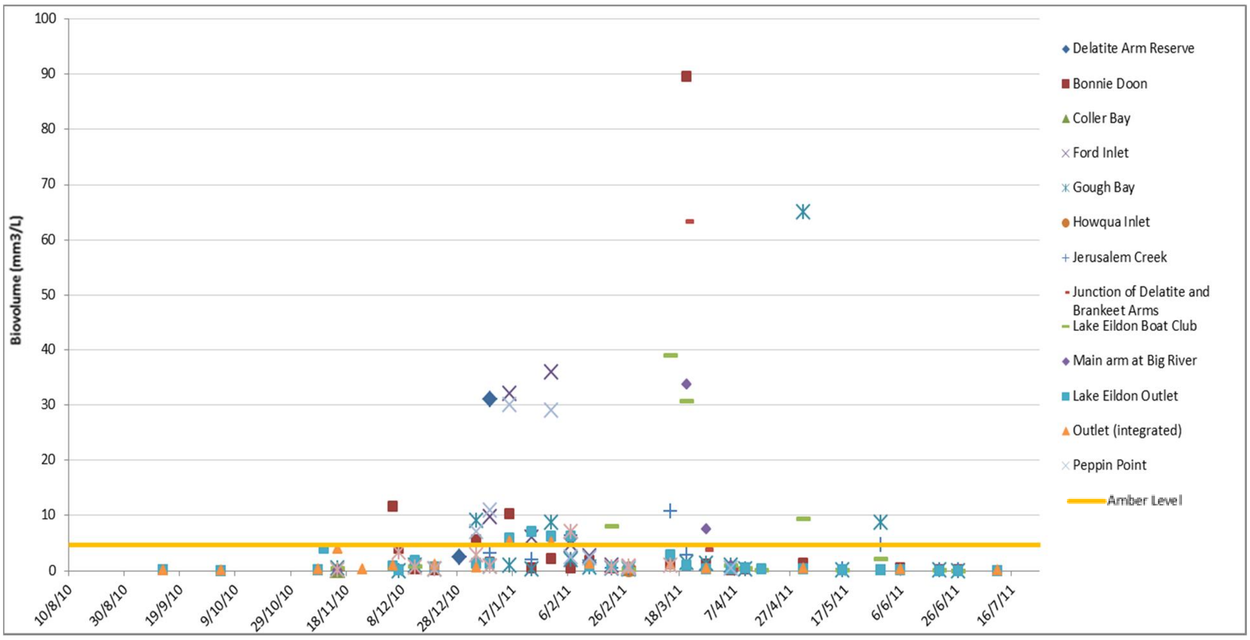

Figure 3-17 : Total biovolume (mm^3/L) for all Lake Eildon sites, 2010-2011

Long term (2007-2017) data analysis from Bonnie Doon and Eildon outlet shows the increased biovolume during the bloom period (2010-2011) compared to long term average levels, but does not suggest long term trends of increasing biovolume.

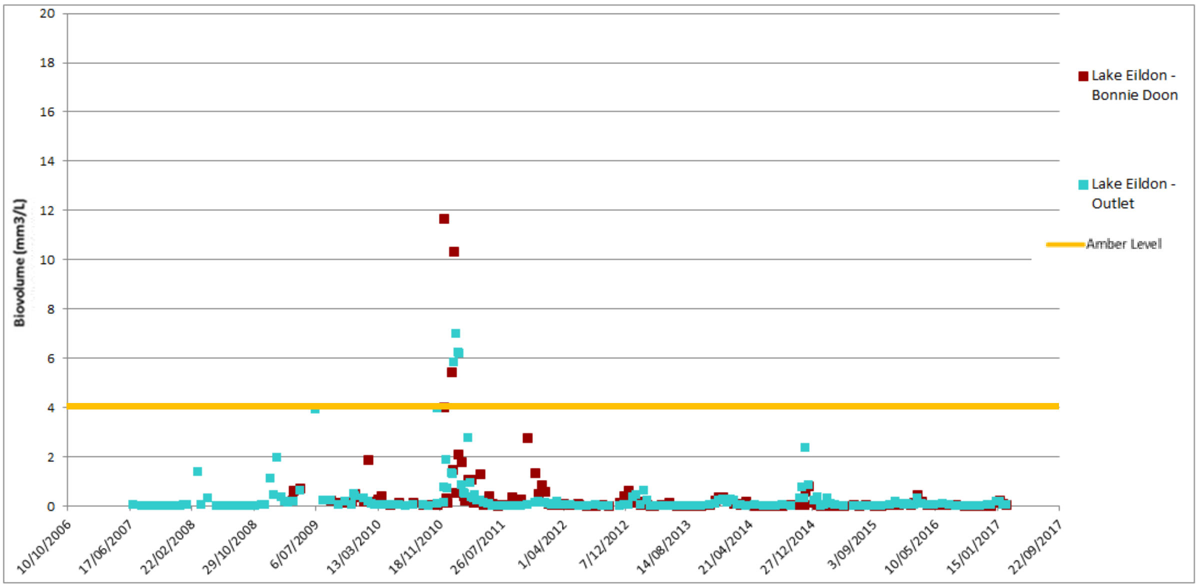

Figure 18 : Total biovolume (mm^3/L) for Bonnie Doon and Lake Eildon Outlet (2007-2017)

3.5.5 Bacteria

Of direct relevance to houseboaters and other recreational lake users is the health risk posed by microbial agents including bacteria, parasites and viruses that can be associated with greywater.

Raw lake water is non-potable but poses potential health risks if accidentally or deliberately ingested during primary and secondary contact recreation activities. Raw lake water is pumped on board houseboats for water supply, and pathogens in water can be ingested through showering and kitchen (i.e. food washing) activities.

Bacteria including *E. coli* and enterococci can cause gastro-enteritis type illnesses and are indicative of faecal contamination in the lake water. These and other microbial agents including viruses and parasites can be present in grey water as a result of faecal contamination either directly (for example, washing of nappies in on-board laundries, where laundry water forms a part of greywater discharge) or from handwashing or showering. Other bacteria are associated with kitchen waste; raw meat, for example, can be associated with significant risk of pathogens. Kitchen waste forms part of greywater and represents a key potential source of microbial contamination of lake water.

The only available data to assess microbial levels in Lake Eildon comes from the GVW data. GVW monitors these parameters as they are health-related and their water supply is for drinking water. *E. coli* and coliforms were monitored by GVW approximately monthly, from 2004 – 2016 at Bonnie Doon and from 2004 – 2011 at Eildon. The GMW dataset does not include any microbial data.

E. coli bacteria are generally not directly harmful, but are used as an indicator of faecal contamination; where concentrations are elevated there is a risk of infection with other faecally-associated bacteria, protozoa or viruses.

Figure 3-19 shows the concentrations of *E. coli* at Bonnie Doon and the Eildon Outlet tower between 2004 and 2016 (Eildon Outlet Tower data only available from 2004 – 2011). The data shows that *E. coli* levels in the lake were generally below the SEPP guideline of <150 org/100ml for primary contact recreation. The SEPP guideline stipulates that the data to be compared to the guideline is the median concentration from 5 samples over a 30 day period; that data frequency is not available in this instance, but data is shown for comparison to guideline.

Some very high concentrations were recorded on isolated occasions; if median values were taken, compliance with the guideline is likely to be higher as median data smooths out ‘spikes’. Individual ‘spikes’ of *E. coli* do not represent a risk to the environment but can pose a health risk to recreational users and boat owners using lake water on-board.

Bonnie Doon data generally showed higher *E. coli* levels overall (Figure 3-19). Figure 3-20 shows the same data but with a truncated scale to show greater detail in data at lower concentrations. The scale shows a maximum of 400 orgs/100 ml; only 3 recorded values were greater than 400 org/100ml over the period of data collection.

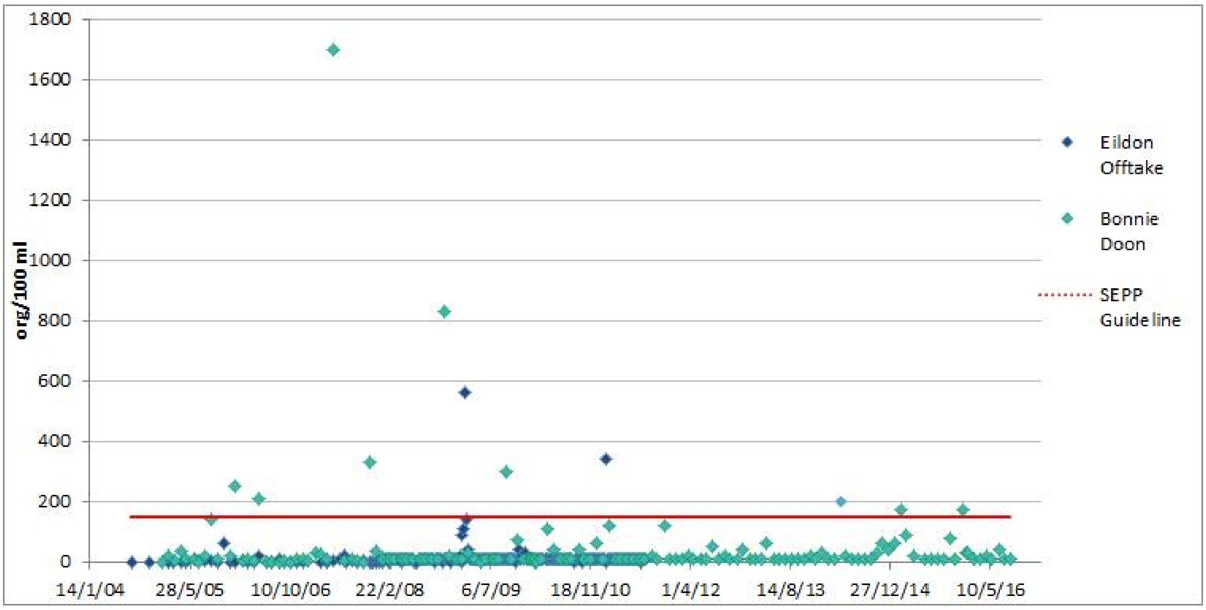

Figure 3-19 : E. coli concentrations (org/100ml) at Eildon Offtake and Bonnie Doon (GVW data, 2004-2016)

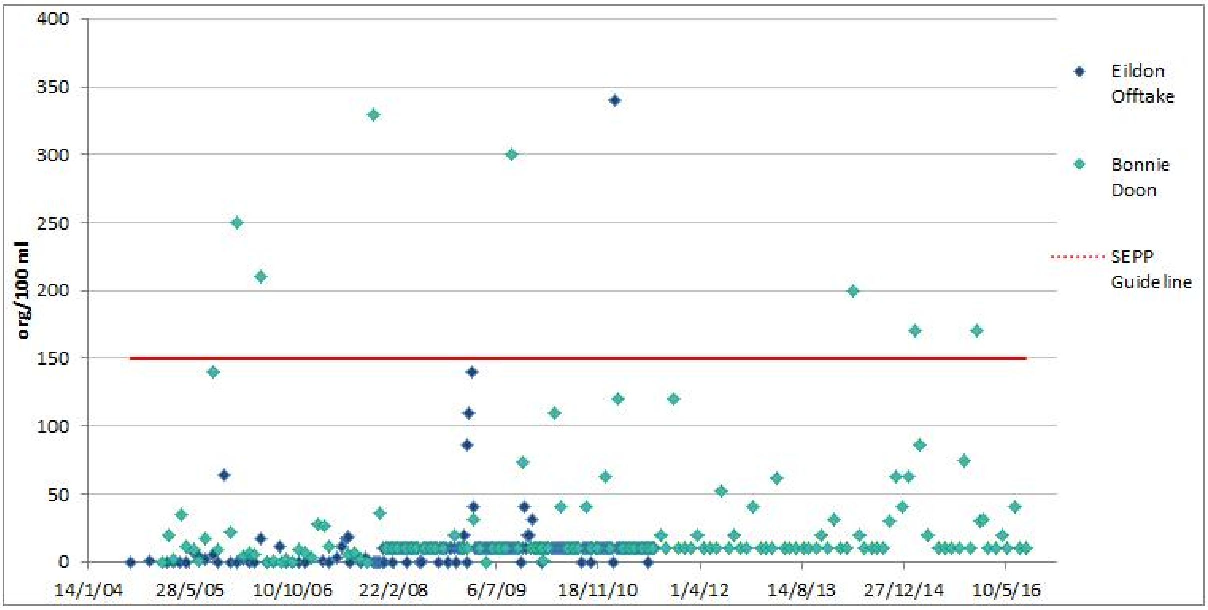

Figure 3-20 : E. coli concentrations (org/100ml) at Eildon Offtake and Bonnie Doon (GVW data, 2004-2016) with truncated scale

Figure 3-21 shows coliform data from the same period (2004 – 2016) and source (GVW) as the *E. coli* data. There are no applicable water quality guidelines. As with *E. coli*, Bonnie Doon recorded higher coliform data than Eildon Outlet Tower.

There is no long term trend of increasing coliform levels.

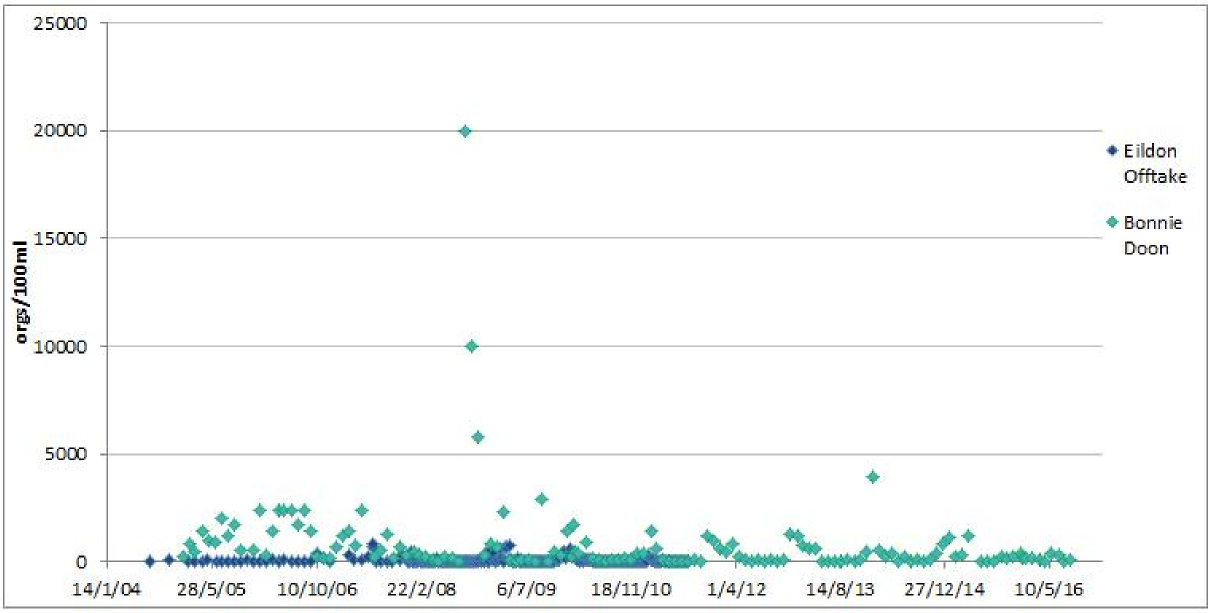

Figure 3-21 : Coliform concentrations (org/100ml) at Eildon Offtake and Bonnie Doon (GVW data, 2004-2016)

Figure 3-22 shows the same data but with truncated scale in order to show detail at lower concentrations. The scale maximum is 5000 org/100ml; only three data points were recorded over that level

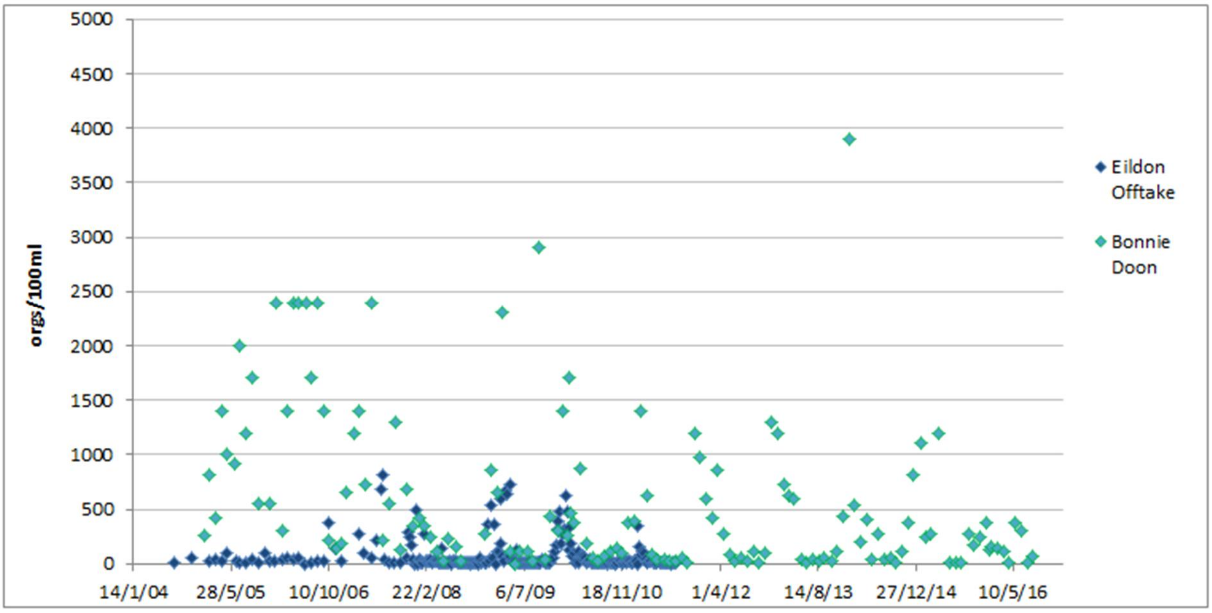

Figure 3-22 : Coliform concentrations (org/100ml) at Eildon Offtake and Bonnie Doon (GVW data, 2004-2016) with truncated scale

The major data sets do not include data from marina and harbour areas, where concentrations would be expected to be elevated compared to open water locations.

The Regulations specify a WQ criteria for bacteria: enterococci concentration must be less than 40 cells/100 mL.; *E. coli* concentration must be less than 100 cells/100 mL. Specific enterococci data are not available; the Regulations criteria of < 100 cells/100 mL are not dissimilar to typical background levels.

4. Water quality and greywater risk assessment

4.1 Water quality summary

The water quality analysis in Section 3 provides background and context for an assessment of the potential impacts of greywater discharge on the Lake's water quality and aquatic systems.

Data was analysed from three main, distinct sources; GMW routine monitoring (Bonnie Doon and Eildon Outlet), GVW routine monitoring (Bonnie Doon and Eildon) and the Victorian WMIS online data (stream and river tributaries to Lake Eildon). The data set varied in frequency, location and duration of monitoring, and the water quality indicators assessed. An overall analysis was undertaken to provide a general indication of conditions.

In general, water quality in Lake Eildon meets water quality objectives for most key indicators. General water quality indicators such as EC, pH, turbidity and DO meet WQOs in most cases, with some high values causing exceedances. These indicators are heavily influenced by catchment, inflow and storage conditions and on a lake-wide scale greywater discharge is not expected to have a significant impact on these factors. The data analysis showed that water quality was consistently worse at Bonnie Doon than at Eildon.

Nutrient levels were close to, or exceeding WQOs in some cases. Total nitrogen levels met WQOs at Eildon but exceeded objectives at most other sites, particularly at Bonnie Doon. NOx concentrations exceeded WQOs at all sites. Median ammonia concentrations met WQOs but individual values were well above trigger levels for eutrophication, though not at levels considered toxic to aquatic life. Total phosphorous concentrations exceeded WQOs at Bonnie Doon.

Bacterial data are more difficult to assess due to being less directly comparable against guidelines, but the high concentrations of microbial pathogens in greywater are known to pose a risk of gastro-enteritis type illness in boaters due to ingestion of lake water containing pathogens from greywater discharge (Ref C, 2006). *E. coli* data from the main sampling locations generally met WQOs, with isolated 'spikes' exceeding guidelines.

There are limited or no data on several water quality parameters that are directly relevant to greywater discharge, including oils/grease, suspended solids, and biological oxygen demand. It is not possible to quantify the contribution from greywater discharge to the water quality in the lake with respect to these parameters.

The total volume of greywater discharged to Lake Eildon represents a very small percentage of inflows and lake volume. Catchment runoff and tributary inflow volume and pollutant loads are many times greater than the volume of water, and load of pollutants entering the lake through greywater discharge. Overall lake water quality is unlikely to be affected by greywater discharge as dilution factors are high. However, at times of low water and in marina and harbour areas, the impact of greywater discharge is more significant. There is an increased risk of health impacts (gastro-intestinal illness among recreational users including houseboaters), recreational effects (e.g. visible oils and films on water) and environmental impacts (nutrient inputs leading to increased risk of algal blooms) in these areas associated with greywater discharge.

Overall, the water quality analysis was consistent with the key water quality issues and risks previously identified, namely eutrophication leading to increased risk of algal blooms, and health risks caused by presence of microbial pathogens in the water.

4.2 Greywater risk assessment

Several previous studies were considered in this analysis of water quality and assessment of risks posed by greywater discharge, including a risk assessment study completed for GMW in 2006 - Lake Eildon Houseboat Greywater Risk Assessment (Ref. C).

The *Lake Eildon Houseboat Greywater Risk Assessment* investigated:

a) the risks to human health posed by pathogens in greywater (including risks to boaters and to drinking water consumers)

b) the risks to environmental water quality in Lake Eildon from nutrients in greywater (including acute risks from heavy nutrient loads in the marina at Anderson Harbour, and chronic risks associated with elevated nutrient concentrations in the lake as a whole)

The study modelled inputs of pathogen concentrations in greywater and black water effluents, along with volumes and probabilities of effluent discharge, leakage and spills. Dilution and inactivation was modelled in lake water and health risks estimated based on exposure to lake water. Boaters were considered to be those staying overnight in one of the four main boat harbours, and several exposure risks were considered including incidental ingestion during other intended uses of lake water i.e. swimming, washing food, and showering.

4.2.1 Pathogen assessment

Bacterial contamination of Lake Eildon and associated drinking water has long been a concern, with bacteriological testing beginning in 1962 following allegations that houseboat activity on the Lake was responsible for contamination of the Goulburn River below the Lake, and associated drinking water supplies. Sampling of *E. coli* in lake surface water began in August 1968, with seven sites. The study reports that the highest *E. coli* concentrations were consistently recorded from areas of high recreational activity, 'particularly in the most popular houseboat anchorages' (Ref. T). In common with the current available data, most sites did not show significant contamination months (Ref. T). Inlets in the northern half of the Lake also showed highest counts; these are areas where runoff into the Lake is from agricultural/grazing land. This is again consistent with current data and the patterns of water quality at Bonnie Doon compared to Eildon.

The key difficulty in assessing current health risks to boaters is the lack of current data from the highest risk areas; that is, within harbour and marina areas where the density of boats and the volume of discharge is greatest, and the water volume for dilution smallest.

The most comprehensive risk assessment data comes from the *Lake Eildon Houseboat Greywater Risk Assessment* (Ref. C). This study modelled risks of illness from a variety of pathogens expected to be present in greywater from houseboats on Lake Eildon, based on literature values for known concentrations of infected and non-infected people; and transmission rates. The pathogens investigated included *Cryptosporidium* (a protozoan parasite), Norovirus (a virus known to cause gastro-intestinal illness), and *Campylobacter* bacteria. Exposure assumptions were modelled for Lake Eildon based on concentrations and loads of pathogens taking into consideration occupancy rates (winter and summer), average number of people per boat, average volume of greywater generated per person per day, and dilution factors based on the total water volume of boat harbour and wider Lake areas. Bacteria, protozoans and viruses decay or become inactivated in water over time, with decay rates affected by a number of variables; decay rates were considered in the study.

The risk of an outbreak of gastro-intestinal illness was investigated in the study, which noted that '*an outbreak among boaters is plausible because each boater is exposed to low level ingestion of the diluted faecal material shed by other boaters*'. The risk assessment found that an outbreak of gastroenteritis is plausible among boaters, and outbreaks are particularly likely from norovirus because of its short incubation period. This means that individuals rapidly become infected and within a few days shed further pathogens into the water, passing infection onto others. The authors estimated that enteritis outbreaks would not be expected to occur frequently (perhaps every 50-100 years) but could be 'realistically expected to take place' (Ref. C). Ref. C also recommended that boaters be made aware of health risks to themselves and other lake users; and costs of additional treatment required to ensure safe water supplies.

Lake Eildon provides pre-treatment drinking water supply and therefore pathogens in the water provide an increased risk to consumers. Standard drinking water treatment processes are generally effective at treating bacteria; viruses and protozoa can be harder to treat using conventional processes and may add cost and risk to drinking water supply processes. No data is available on these pathogens.

Bacteria and pathogens enter the Lake from a variety of sources, including spillage from or failure of black water systems or pumps, other recreational users and catchment and tributary inflows. There is insufficient data to quantify the proportional contribution of houseboat inputs compared to other sources, though the risk assessment study (Ref. C) suggests houseboat black water contributions are small compared to greywater contributions, assuming systems are operating correctly. Other potential sources are the subject of management activities including upgrades to toilet facilities and land-based greywater and planning regulations.

4.2.2 Nutrient assessment

A key issue that has been raised by stakeholders is the contribution of nutrients from greywater discharge relative to:

a) the volume of the lake and the quantity of inflows from other sources (i.e. tributary waterways), and

b) the concentrations and loads of nitrogen entering Lake Eildon via catchment and tributary inflows.

It is acknowledged that greywater discharge represents only a very small percentage of total inflow and lake volume, and therefore of total nutrient contribution to Lake Eildon. Ref. C calculated nutrient input from greywater discharge, and concluded that the contribution of greywater discharge to the overall nutrient load of the Lake is almost negligible (approximately 0.013 % to 0.016% for Nitrogen, and 0.116 to 0.613% for Phosphorus). However, at lower water levels and within smaller volume harbour areas where contributions were higher and water volumes smaller and less well mixed, the additional nutrient input was sufficient to result in a high probability of algal blooms in warm weather (Ref. C).

The impact of greywater discharge on the concentration of nutrients in Lake Eildon is affected by the nutrient concentration of the effluent, and amount of dilution with background lake water. In general, the level of nutrients in greywater is much higher than background concentrations in the lake, or maximum concentrations set under WQOs. The Risk Assessment study (Ref. C) study used a literature review process to establish 14 mg/L as a typical expected concentration of nitrogen in greywater. The proposed regulations stipulate discharge criteria of no more than 10 mg/L. In contrast, median background concentrations of TN are 0.23 mg/L (at Eildon) and 0.39 mg/L (at Bonnie Doon), and the WQO limit is 0.35 mg/L. The nitrogen concentration in typical untreated greywater discharge is therefore approximately 40 times the WQO, and approximately 60 times the background levels at Eildon. If greywater was treated to the Regulation standard of 10 mg/L, this would represent a reduction in TN concentrations to approximately 28 times the WQO, and 43 times the background level at Eildon.

Phosphorous levels in greywater are even higher compared to background and WQO concentrations. Ref. C assumed TP levels in greywater of 17 mg/L, though noting that this could be significantly reduced if only low phosphorous detergents were used on-board. If the value of 17 mg/L is assumed, this represents a TP concentration of 680 times the WQO, 772 times median background concentration at Bonnie Doon, and 1888 times the concentration at Eildon. If greywater was treated to the level recommended in the regulations (< 1mg/L) this would represent a discharge at approximately 45 times the background Bonnie Doon concentration, and 111 times Eildon background levels.

The Risk Assessment study calculated an estimated daily discharge from all Lake Eildon houseboats in peak periods at 74,685 L. Based on the estimated nutrient concentrations in greywater, this volume of discharge would represent an additional **daily** nutrient load of 1 kilogram of nitrogen and 1.2 kilograms of phosphorous to the lake (Ref. C).

Based on the estimated peak daily discharge of 74,685 L, reducing nitrogen concentration from estimated untreated levels of 14 mg/L, to the treated greywater criteria set out in the Regulations (10 mg/L) would result in a reduction of 109 kg of nitrogen entering the Lake each year. It should be explicitly noted that this calculation assumes an annual discharge volume of 27.2 ML, calculated as (74, 685 litres/day × 365 days = 27,260,025 litres). This is highly conservative (i.e. likely to overestimate discharge volume by some margin) as it is based on peak daily flows, which would occur for relatively short peak holiday periods. Based on an annual discharge equivalent to 6 months of peak flow (assuming approximately 2 months per year of peak flow, and 10 months of low flows), the corresponding reduction in nitrogen input would be 54.5 kg.

Using the same calculation process, treating greywater from the estimated ‘untreated' phosphorous concentration of 17 mg/L to the regulations criteria of 1 mg/L would result in an annual reduction of 436 kg/year, or 218 kg/year assuming annual discharge equivalent to 6 months of peak usage. The estimated untreated greywater concentrations vary widely and the risk assessment report does note that greywater phosphorous concentrations could vary from as low as 5 mg/L to as high as 60 mg/L depending on the phosphorous content of laundry detergents used on the boats.

Greywater discharge contains nutrients at significantly greater concentrations than background levels (based on Eildon and Bonnie Doon data) and WQOs. However, the volume of houseboat greywater discharge is extremely small when considered as a relative contributor to overall lake inflows and lake volume. Therefore, in terms of overall nutrient loads entering the lake, the proportion contributed by houseboats discharge is less than 1% (TP) and less than 0.1 % (TN), based on figures quoted in Ref. C. The dilution factor in the lake means that a specific, quantifiable effect of greywater on lake water quality data is unlikely to be observed, and the current available lake dilution volumes are sufficient to maintain background water quality. However, during periods of low water, and in harbour and marina areas the impact of the discharge is proportionally greater and represents an additional load that could trigger algal blooms in already impacted areas. For this study, water quality data is not available from harbour and marina areas, where concentrations would likely be significantly higher and effects on water quality in the immediate area of discharge more likely to be observed.

Jacobs can see some benefit in conducting a regimented water quality study particularly focussing on the harbours and marinas with typically high concentrations of houseboats and areas with high public access to day trippers. The water quality study could assess some or all of the range of criteria described above and be analysed monthly or fortnightly for a 12 month or 2 year period to determine if there is a trend in water quality degradation due to houseboat use from a seasonal perspective.

4.3 Summary

- Houseboat greywater discharge represents a small but controllable input of nutrients, potential pathogens and other pollutants. Water quality issues such as eutrophication are typically (as in this case) affected by a large number of diffuse sources, including various catchment based inputs (i.e. fertiliser from farm run-off, livestock waste, river inflows and housing) and recreational uses (campers, day-trippers and other water users). Efforts have been made, and continue to be made, to minimise other pollutant sources to the Lake through a number of measures, including planning regulations for developments in the Eildon catchment, upgrades to sewage facilities for houseboats, and upgrades to toilets. It is considered both important and reasonable that all contributing parties make efforts to reduce impacts. Restrictions and regulations apply to other potential inputs into the lake and houseboats need to be a part of this regulation and control.

- Legislative requirements for reducing pollution are applicable to houseboat use and greywater discharge. There is an obligation under SEPP to minimise pollution to waterways, and GMW has a responsibility under the Safe Drinking Water Act (2003) to manage risks to the quality of raw water supplied to drinking water suppliers.
- There is interest in expanding the size of the Eildon houseboat fleet and the maximum allowable boat size. It is in the interests of the recreational facility and industry to expand, but this can only occur if the greywater impacts are managed.
- Houseboat owners have identified the importance of water quality in the Lake and a willingness to take steps to protect it. During the 2015 workshop of stakeholders including boat owners, it was acknowledged that water quality is important to prevent blue-green algal blooms, protect the lake resource, and to maintain water quality for downstream users including irrigators and drinking water suppliers. The identified consequences of water quality decline included failure to meet legal obligations, lack of protection of the lake resource, and reputational risks (affecting tourism, quality of life). Boat owners acknowledged that water quality affects all users of the Lake and that house boaters are themselves at risk of illness from bacterial contamination if water quality is not maintained.
- Greywater discharge represents a very small proportion of the overall lake volume and total nutrient load. However, the existing lake nutrient levels mean that even small additional inputs from greywater will increase the risk of algal blooms. The risk of algal blooms and health impacts from pathogens in greywater are significantly increased in harbour and marina areas. In these areas concentration of houseboats (and therefore volume of discharge) is highest and the water volume and dilution/mixing capacity is lowest. This increases small-scale concentrations of nutrients and pathogens and significantly increases risk of algal blooms or illness. The exact level of risk cannot be precisely quantified based on available data.

5. Lake Eildon Houseboats

5.1 The Current Situation

5.1.1 Houseboat Numbers and Categories

Goulburn-Murray Water (GMW) currently manages the houseboat licences through 6 categories (1 further category for commercial houseboats). The categories are based on the size (length and breadth) of the houseboat and also the number of decks (levels).

CATEGORY	MAXIMUM SIZE	DESCRIPTION	Quantity 2016/17
1	10m × 3.5m	A trailable houseboat (upgradeable to category 2)	41
2	10.6m × 4.5m	One enclosed level (not upgradeable)	8
3	10.6m × 4.5m	Two or more enclosed levels (upgradable to category 6)	23
	13.7m × 5.5m	One enclosed level (upgradable to category 6)	
4	13.7m × 5.5m	Two or more enclosed levels (upgradable to category 6)	287
	15.2m × 6.25m	One enclosed level (upgradable to category 6)	
5	15.2m × 6.25m	Two or more enclosed levels (upgradable to category 6)	222
	18.3m × 7.25m	One enclosed level (upgradable to category 6)	
6	18.3m × 7.25m	Two or more enclosed levels (not upgradable)	123
7	20m × 8m	Special - Commercial houseboat (limited to 5 licenses)	5
TOTAL			721 (exc. Cat. 7)

Table 5-1 : GMW Houseboat Categories

The numbers of houseboats in each category described in Table 5-1 have been provided by GMW. Category 1 houseboats are considered trailable (i.e. can be removed from the lake without a permit). Category 3, 4 and 5 houseboat licences can be upgradable to a Category 6.

5.2 Perceived barriers to complying with the Regulations

During the consultation phase some houseboat owners identified a number of concerns about GWTS related to houseboat design. Advice from the installer of one of the units stated that he had not seen a houseboat that could not be fitted with a GWTS. However, Jacobs considers that some smaller older houseboats will not be able to physically integrate the approved GWTS.

There are four critical design aspects which need to be considered when installing a GWTS. These are:

- Physical space available for the treatment unit and holding tanks.
- Electrical capacity (peak load and battery storage).
- Displacement (Freeboard) – weight capacity.
- Non-uniform installations & suitability of existing services.

The impact of these four critical design aspects is directly related to the overall cost of the installation.

A summary of each of these design aspects and their impact are detailed below:

5.2.1 Lack of available space

Differences in length, breadth, number of decks, pontoon size and shape mean that effectively no two houseboat GWTS installations will be the same. The three approved GWTS follow the common method of collecting the various greywater sources in a single storage tank before then pumping a set quantity of greywater into the treatment unit. The size of the collection tank (sometimes called a buffer tank) is sized to suit the number of people nominally berthed on the houseboat. The treatment tanks range in size depending on type and model of the treatment unit selected.

Some houseboats have limited space available to hold their greywater and to house their GWTS. In some instances, to enable the units to fit into the available space, different elements of the treatment system have to be installed in different orientations to the way they were designed and tested. While this is not considered a high risk of causing failure, it is another element that can potentially affect the reliability of each system.

Smaller/older boats are more likely to not have readily available space (i.e. in the pontoons) for the treatment units and collection tanks. Therefore, owners of older/smaller houseboats are more likely to be impacted by the installation. Upper deck space is likely to be required for the treatment unit and the collection tank is more likely to be required to be hung between the buoyancy pontoons.

The most suitable location on newer and larger houseboats is inside the buoyancy pontoons and the majority of GWTS installations on new vessels and for major upgrades use this method. The older and smaller vessels typically do not have the large buoyancy pontoons and therefore would have to position the treatment units on available deck space on the vessel. The collection tanks would be able to be designed to be hung between the buoyancy pontoons in a similar manner to some of the black water tanks and battery banks.

The treatment units for the Aerofloat (1000mmH × 750mmW × 570mmD) and Aquatreat models are quite large and bulky and would not be easily positioned on an open deck in a position where the appearance of the houseboat would be maintained.

The Wastewater Australia unit is a more compact stainless steel tank (950mmH × 850mmW × 350mmD, which could be more easily installed on an open deck without dramatically impacting the aesthetics of the houseboat. The Aerofloat and Aquatreat units would need to be shielded or covered as they have a complicated array of pipework which could be considered unsightly.

Those houseboats with small forward or aft decks could potentially position treatment units internally or on the upper decks (roofs) depending on the capacity of transfer pumps and piping systems.

5.2.2 Electrical Capacity

All five approved GWTS utilise some combination of pumps, aerators, ultraviolet lights, and electronic controlling system. Accordingly, they require electrical power. Houseboats must be able to generate and store their electrical power on board. Older houseboats have commonly used alternators and small generators to charge 12V batteries which in turn power small low-voltage appliances. This method is similar to the electrical systems seen on cars, small boats and caravans.

The increased capacity and efficiency of commercially available solar panels and batteries, along with the increasing demand of electrical consumers, has seen the electrical systems of newer houseboats align more closely to an “off-grid” house. Most newer houseboats have large battery storage and large solar panel arrays, backed up by small diesel generators. The voltage of electrical systems ranges from 24-48 Volts.

As all houseboats are somewhat unique there is no ‘one rule’ that describes the need for a houseboat to upgrade its electrical system to enable a GWTS to function. In general, an older 12 Volt system will not be sufficient to power a GWTS without some form of upgrade. This means that either additional solar panels, and/or more/larger battery banks will be needed. This corresponds to an increase in installation cost and a weight impact to the houseboat.

Commercial/domestic greywater systems are commonly powered by the national electricity grid which provides a constant uninterrupted power supply to the treatment unit. Houseboats are required to generate and store their own power. Power generation is typically through the use of small petrol/diesel generators, or solar panels and small wind turbines. The power generated is stored in battery banks to provide constant power to consumers on board. Smaller and older boats tend to use lead-acid car/truck batteries (12V), while the newer, larger houseboats have large battery banks of deep-cycle gel type batteries (48V). The finite amount of electrical power, particularly in smaller/older boats means that when not in use, the batteries are isolated.

In addition, through winter it has been highlighted by some boat owners that there are times when the weather is so poor that the solar panels do not receive enough sunlight to keep the batteries charged. During these periods the GWTS is required to keep operating (at a lower power requirement) but still continues to drain the batteries until completely empty.

Therefore, commercial/domestic GWTS that are designed to have components of the system running when not in use, may not be suitable for a houseboat when it goes into shut-down mode.

5.2.3 Displacement (Freeboard)

A number of houseboat owners have raised the issue that the increased weight due to the installation of a GWTS will make some boats unsafe. In physical terms, increasing the mass of a floating object coincides with an increase in the resistance force through buoyancy. In practical terms, the heavier a houseboat is, the lower it sits in the water. The distance between the waterline of the vessel and the main deck is called the Freeboard.

If increasing the displacement of a houseboat through the addition of a GWTS is considered a potential safety issue, the identification of a suitable limit for safety becomes necessary.

Vessels designed and built to operate on open waters are required to prove they meet certain criteria of stability and reserve buoyancy. There are different stability criteria for different types of vessels - catamarans, monohulls, small boats and large ships.

The privately owned houseboats on Lake Eildon do not appear to have to meet any predetermined stability or minimum reserve buoyancy criteria standard. They do not fit under the umbrella of Maritime Safety Victoria, which polices the implementation of Australian Maritime Safety Authority (AMSA) regulations for commercial vessels in Victorian waterways. This raises questions as to who determines if a houseboat is considered safe from a stability and reserve buoyancy perspective.

The addition of a GWTS (when empty) will potentially add between 100kg and 150kg for the collection tank, treatment tank, control unit and related pipework. Depending on the size of the collection tank, when full of greywater, the weight increase could be in the vicinity of 1 tonne or more with a larger collection tank.

As the size of the greywater collection tank is related to the number of berths, it would be expected that smaller boats will require smaller collection tanks. The weight impact would be relative to the size of the vessel.

An additional increase in weight could be expected if an upgrade to electrical systems and batteries was required.

The impact on the trim and heel of the houseboat could be an issue if the treatment unit and collection tank were co-located in one corner of the houseboat. This could lead to a houseboat that does not float with level heel or trim. This can be countered by ballast positioned in an opposite location, but this further increases the overall displacement.

In summary, the impact of additional weight on the safety of a houseboat is difficult to measure as there are no apparent stability or minimum reserve buoyancy requirements which are required to be met. See Appendix B for more details.

5.2.4 Non-uniform installations and suitability of existing services

While some houseboats are similar, each houseboat is unique. As a result, every installation of a GWTS is different and presents a unique set of challenges. Greywater discharge points (showers, sinks, washing machines etc.) are in different locations on each houseboat. Black water storage tanks are of different sizes and positioned in different locations. The structure and internal design of the houseboats are different, meaning the running of black and greywater ventilation piping is different. Power supply storage and positions are different. As a result there is no standard installation; every installation offers slightly different risks and a greater chance that there might be issues with a GWTS installation.

As part of all GWTS installations the consolidation of the greywater services into a single location must be undertaken. Additionally, all systems need to implement a ventilation pipe which should be vented to the highest position on the vessel (similar to the requirement for the black water). Differences in the arrangement of showers, sinks, dishwashers etc. leads to customisation of the greywater piping system. In some instances, access holes in structure need to be arranged to permit the running of pipework.

5.2.5 Cost

The base cost of an installation of an approved GWTS is around $18,000 including the collection tank. This price varies based on the configuration of the individual houseboat and the specific requirements for pipework, hull penetrations, etc. In addition, each houseboat needs to be slipped to install the Unit. The rough order of magnitude for the cost for a slipping is around $3,000 (at the Eildon Boat Club slipway) or $5,000 using the local heavy–lift transport trailer. If the houseboat does not have sufficient electrical power, an upgrade of the electrical system and battery storage is also required; this could increase the cost by of $3,000 to $5,000. Thus, the potential installation cost of a GWTS could vary from $21,000 to around $30,000. This figure excludes the potential need for additional buoyancy (centreline hulls or similar) for boats with limited amounts of reserve buoyancy.

Comparatively, the cost of installation on smaller or older boats is more likely to be higher than for newer or larger vessels. This is because:

1) The installation is likely to be more difficult due to space restrictions; older boats are typically smaller and with only single enclosed levels;

2) There is an increased likelihood that the electrical system will require an upgrade;

3) In some instances, additional buoyancy could be required to offset the additional weight of GWTS and upgraded power system.

As a result, the owners of older and smaller houseboats are more likely to be disadvantaged (with higher installation costs) by the current regulations due to an increased likelihood for the installation to require an electrical upgrade, additional buoyancy and a greater impact on the aesthetics (and potentially usability).

Additionally, the market value of the older/smaller houseboats is at the lower end of the range. Category 3-4 houseboats at the lower end of the market may have a market value of $100,000 to $200,000. Nominally, the value of the houseboat licence is $60,000. Therefore, a $25,000-$35,000 upgrade to a houseboat valued at only $120,000 may not be considered a worthwhile investment and would be hard to justify.

5.2.6 Summary

Most boats, particularly the larger boats (category 4, 5 and 6 boats) should be able to install a GWTS without large modifications to the boat, however costs in the vicinity of $18,000 to $25,000 would be common.

Smaller or older boats could potentially install a GWTS, but this may require modifications as follows:

- Physical Space - can be found by modifying or adding to the existing structure and arrangement of the houseboat. However, the cost of major modifications will be high.
- Electrical Capacity – can be added to a houseboat through the addition of more solar panels, additional generators, and more battery storage. However, there is a cost related to adding this capacity. In addition, physical space may need to be included to permit the additional electrical capacity.
- Displacement – Could present an issue, but is unlikely for most vessels. However, in the event that Physical Space and Electrical Capacity are required to be added then the likelihood of additional displacement being required is higher.
- Suitability of existing services – can be re-arranged to suit, however the costs can be high if the pipework is not easily accessible inside internal panelling.

6. Greywater Treatment Systems

In 2013, when the regulations (Ref. I) were first introduced, the houseboat industry did not have a proven GWTS available for the full range of houseboats styles (sizes/types/capacities) in place on Lake Eildon.

Both the EPA-SA and GMW had approached manufacturers of domestic treatment systems to develop new products or to modify commercial/domestic products for implementation on houseboats. The Australian Standard AS4995 (Ref. K) was created in 2009 to define the discharge targets that the treatment systems were to be designed to meet. Some units had been manufactured and set to work on houseboats on South Australian waterways as part of their state based programs.

As a result of there not being an approved GWTS suitable for implementation on houseboats on the market in 2009, a number of companies put in a substantial amount of time, effort, and money to develop approved systems.

Five companies are known to have developed an approved GWTS in the period from 2009 to 2016. Based on GMW figures, 55 GWTS have been installed on Lake Eildon houseboats. However, all five models were in effect at varying stages of readiness for commercial application. While it is apparent to Jacobs that considerable bench testing and research and development was undertaken, and the GWTS were approved as compliant in accordance with the AS4995 (Ref. K), none had been tested or trialled for an extended period of time on-board a houseboat under the unique conditions that would be expected with respect to frequency of operation, electrical capacity or on-board piping and ventilation systems.

Most houseboats are used in a similar manner to a holiday home, where owners/guests come to the houseboat for the weekend and over holiday periods. Typically the peak season for houseboat usage is between Melbourne Cup weekend (Early November) through to Easter (March/April). Outside of the peak season some houseboats may not be used at all. Commercial/domestic greywater systems are designed for near constant use. Intermittent use leads to a number of issues including pump seals drying out and the build-up of anaerobic bacteria leading to strong odours (in the treatment unit and buffer tank).

The four earlier models of GWTS, all experienced a number of design issues and most have been subject to further modifications to improve their performance. The North Eastern Engineering Fabrication unit has only recently been approved and installed and at the time of writing was operating successfully.

A breakdown of installed GWTS, by manufactures, is provided below:

- Wastewater Australia (UltraGTS) 38 Units.
- Aerofloat 9 Units.
- Aquatreat (Status) 6 Units.
- Newtreat 1 Unit.
- North Eastern Engineering Fabrication (NEEF) 1 Unit

A summary of the current status of the operability of each of the units is provided below:

6.1 Wastewater Australia

This is the most commonly installed GWTS unit on Lake Eildon. As part of the investigation, Jacobs has attempted to make contact with all houseboat owners that have had a GWTS installed and had responses from 12 who have installed the Wastewater Australia unit. Of the 12, in general terms, 6 have not had any major issues with the unit and were relatively positive, 2 had experienced some issues, but these had been resolved, and 4 had experienced serious issues and had a very negative opinion of the system. One owner who had previously been relatively positive, modified the response noting that over the summer period they had been discomforted by noise and strong odours during operation.

Wastewater Australia has a single unit on the market which is capable of treating 1000L/day.

Figure 6-1 and Figure 6-2 show examples of the Wastewater Australia Unit installed in the pontoons below the rear deck and internal cabin.

Figure 6-1 : Wastewater Australia Unit installed in Pontoon - Rear Deck

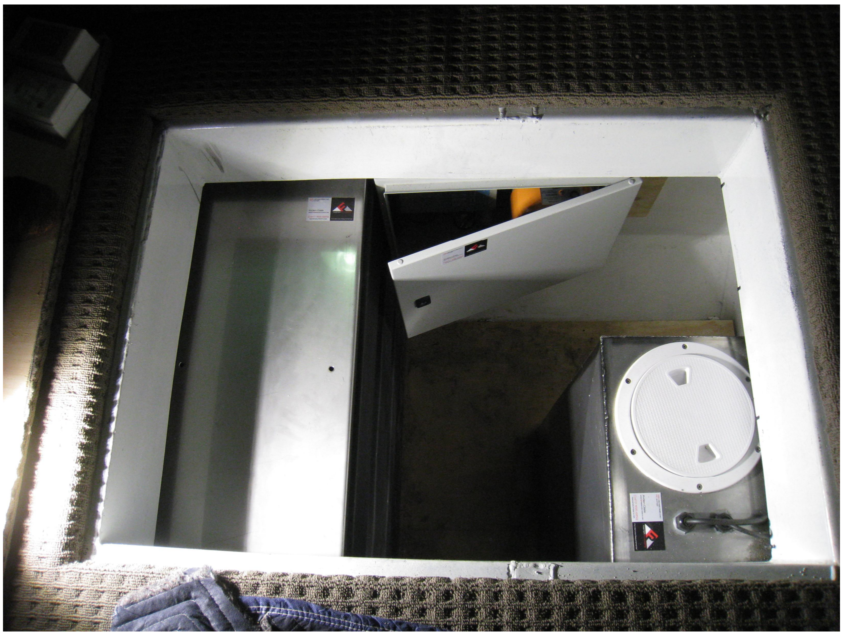

Figure 6-2 : Wastewater Australia Unit installed in Pontoon - Internal Cabin

The common trend among the responses were related to the odour and the high power usage of the GWTS being a problem.

During discussions with the Wastewater Australia's local installer, it was acknowledged that there had been issues with smell/odour and high power usage for some of the earlier installations. Solutions to these issues had been implemented and consequently the newer installations were functioning more reliably and with less issues. Based on feedback from some houseboat owners, the evolution of these solutions is on-going as some houseboat owners with newly installed systems are still encountering issues.

To date, the cost of the modifications and setting to work of the GWTS post installation have been covered under warranty and borne by the installing plumber.

6.2 Aerofloat

The Aerofloat unit has been installed on 9 houseboats and was initially supported in Eildon by The Houseboat Factory. Some teething issues have been experienced and the installer confirmed that there had been a lack of flexibility from the manufacturer to making the unit more modularised so it could be installed in smaller spaces (particularly in the pontoons).

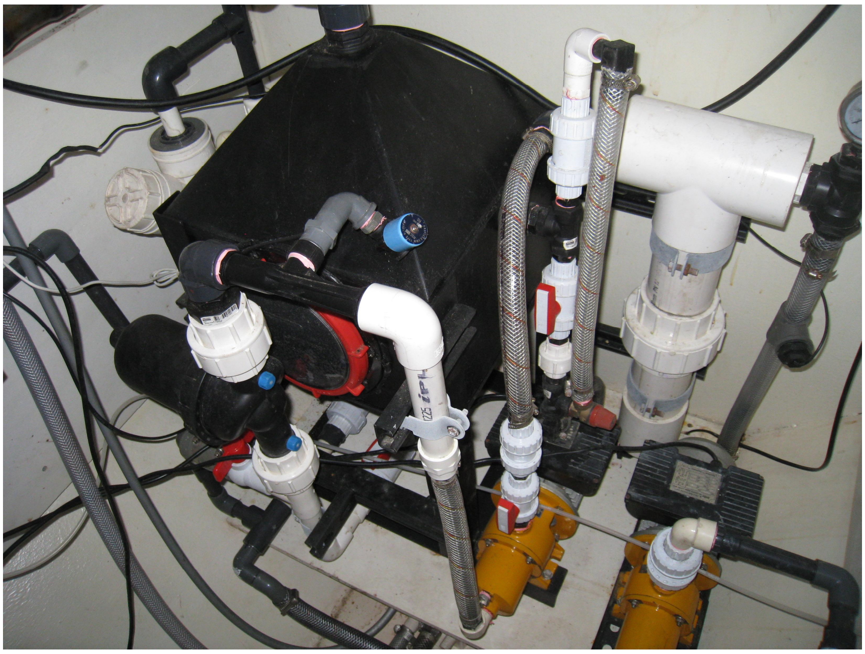

Figure 6-3 : Aerofloat unit installed in the houseboat Pontoon

It is understood that that Aerofloat were contemplating ceasing to pursue the houseboat GWTS market as they had invested too much money for little return and had decided to cut their losses to concentrate on the domestic/commercial market. It is now understood that subsequently Aerofloat had identified a new local agent and were actually looking to continue to supply and support the market, which contradicted earlier information received.

Aerofloat manufactures two different sized units; an Aerofloat 7 (420 L/hour) and an Aerofloat 13 (780 L/hour).

The Aerofloat unit has had some problems with the early installations; in particular odour, which was resolved through the use of a "Chlorine Block". It was also acknowledged that it would be difficult to install the Aerofloat system on a smaller boat. Advice from the installers is that these units have only been installed on new vessels and on vessels that are undergoing a sale transfer

Jacobs had two response from a houseboat owner with an Aerofloat system and feedback was positive, except for teething issues which resulted in a change to the system and the inclusion of another tank. A second houseboat owner had stated that their system had failed over the recent summer period.

6.3 Aquatreat (Status)

The Aquatreat unit was developed by Aquatreat in conjunction with Status Houseboat builders. It has been installed on only new boats manufactured by Status Houseboats. It has had a number of issues with reliability, and at this point in time the houseboat builder has ceased installation until they had addressed these reliability concerns.

Figure 6-4 : Aquatreat Unit installed in Pontoon - Internal Cabin

Status Houseboats is currently installing the Wastewater Australia unit into at least one new houseboat under construction.

During an inspection of one of the houseboats which had the Aquatreat Unit running, it was noted that it was considerably noisier than the Wastewater Australia Unit, although the space in which the unit was installed had no sound damping material incorporated. Advice from the houseboat owner is that over the summer period this unit has had further failures and has been disconnected.

6.4 Newtreat

Jacobs understands that Newtreat is longer in business. GMW records show that only a single unit is installed on a Lake Eildon houseboat. The owner has stated that this unit is not currently operational.

6.5 North Eastern Engineering Fabrication (NEEF)

NEEF is currently fabricating 2 units (different sizes). This is a new unit on the market that has only recently been added to the GMW list of suppliers.

It is currently installed on one houseboat and the owner has reported that it is functioning without issue. Advice from NEEF is that they believe the design of their unit eliminates most of the problems experienced by the other units. This unit may in time be proven to have eliminated all of the issues highlighted above, but at this stage it hasn't been in operation long enough to make that judgement.

6.6 Approval and Certification

Five companies have developed GWTS approved to meet the Greywater Discharge Standard as described in accordance with Appendix A of AS4995 (Ref. K). There are other requirements detailed in Sections 3 and 4, and Appendix B of Ref. K which it is not clear that the current systems meet. Some of the requirements can only be assessed when the GWTS is physically installed. These include:

Section 3.1 (b) Means shall be provided for venting gases to the exterior atmosphere of the craft. The vent pipe shall-

- *(i) Have an effective nominal diameter of not less than 40mm unless otherwise approved by the authority having jurisdiction.*
- *(ii) Be designed and constructed to prevent clogging either by the contents of the tank or as a result of climatic conditions (e.g. snow and ice), and shall be capable of resisting the suction created by the pumping system.*
- *(iii) Be covered with an insect screen fitted onto the outlet end of the pipe;*
- *(iv) Be located at least 1.5 m from any source of ignition; and*
- *(v) Be installed to prevent gases entering an air intake.*

Section 4.3 GASTIGHTNESS

The greywater treatment system shall be installed to minimise the emission of malodorous gases and prevent the introduction of poisonous gases (such as Hydrogen Sulphide) into the vessel.

Section 4.7 ELECTRICAL SYSTEMS

The electrical supply shall be capable of maintaining a continuous output that meets the greywater treatment system manufacturer's requirements and provide a net current output of at least twice the greywater treatment system's demand.

Appendix B – TYPE AND BATCH TESTING PROTOCOL

B1 Type Testing

Type testing is performed to demonstrate that the material , component, joint or assembly is capable of conforming to the requirements given in the relevant Standard. Type testing is required where there is a change in the design of the system (e.g. material, component, joint or assembly and technology.)

B2 Batch Testing

A batch release test is performed by a manufacturer on a batch of products, which has to be satisfactorily completed before the batch can be released.

The requirement for the GWTS to meet the Greywater Discharge Standard (Appendix A) of the AS4995 (Ref. K) is only one element of the testing and installation required to meet all of AS4995. It is not clear to Jacobs if the other requirements listed above have been met in the past, if they continue to be met and if so how is this part of the approval process managed and audited.

6.7 Summary

Five companies have developed GWTS approved AS4995 (Ref. K) for use on Lake Eildon houseboats and included in GMW's list of suppliers.

Four GWTS have experienced teething problems and have required modifications to make them function better. Two manufacturers have ceased production of GWTS, and another has stated that it is planning to step away from the houseboat greywater market. The other has only very recently been added to the list of suppliers and has only been installed on a single houseboat.

The original systems developed were practically at a prototype stage at the commencement of the regulation coming into force. This has meant that a lot of the problems some houseboat owners have experienced could be described as teething issues that would be typically expected for the implementation of any new product or system. Unfortunately the resulting bad publicity and ill will directed at the systems (and therefore the Regulation) has made houseboat owners less likely to take the lead and install a GWTS.

The manufacturers have described different difficulties in the design and testing phases meeting some of the discharge criteria: The fats, oils and clay were highlighted as one of the difficulties, Phosphorous and Nitrogen offered a different set of challenges and required a different treatment process. Based on the information from manufacturers, the reliability of the units does not appear to be related to any specific discharge criteria.

In discussions with houseboat owners who are resisting installation, the lack of confidence in the reliability and functionality of available GWTS is among their primary concerns.

Had all the GWTS been tested and proven on houseboats before the installations commenced, it is likely that the issues observed would have been identified, and potentially eliminated prior to installation across the houseboat fleet.

Houseboat owners have made comment relating to the noise levels generated by the current systems. While no noise level measurements were taken, during inspections GWTS were in operation and could be heard.

The Aquatreat unit was found to be considerably noisier than the Wastewater Australia unit. In general, the noise level was considered to be low, however, the nuisance caused due to noise relative to noise levels of the surrounding environment. In busy periods in the marina with other boats and people using the surrounding waterways it is likely that the noise from a GWTS would not be noticed. However, on a quiet night in a sheltered inlet, ambient noise could be near non-existent. In these instances the noise of a GWTS turning on/off at random times could definitely be considered a nuisance.

Sound dampening resilient mounts and sound absorption panelling could be used in some installations to reduce both ambient and structurally transmitted noise. There is no maximum sound level requirement for GWTS in either the AS4995 (Ref. K) or the Houseboat Regulations (Ref. I).

The manufacturers of GWTS have worked on solutions to prevent and minimise the odours that are typically caused by the grey water sitting stagnant for extended periods of time. However, some owners of units more recently installed have stated that they have still had some problems with odours. The odour generated by the systems, while at rest and during operation, has been an issue raised consistently through the submissions of houseboat owners.

While there have been teething issues, it appears that the Wastewater Australia unit and Aerofloat units are now being installed mostly without issue. To date, the Wastewater Australia unit has proven the most popular and Wastewater Australia is committed to provide local support to those units installed. The Aerofloat units have been successfully installed but have some additional limitations related to the required space envelope. Since the submission of the draft report, Aerofloat has identified a new local agent who has indicated a commitment to support the through life maintenance and support. The NEEF units are manufactured locally (in Eildon).

7. Regulatory Framework

7.1 Legislative and Management Context

7.1.1 Houseboat Regulation

Lake Eildon and the bounding land surrounding the Lake is under the control and management of Goulburn-Murray Water (GMW) as described under Section 122ZA of the Water Act 1989 Legislation (Ref. P).

Houseboats are permitted to operate and are licensed to operate on Lake Eildon in accordance with the Water (Lake Eildon Recreational Area) (Houseboats) Regulations 2013 (Ref. I). The Regulations (Ref. A) are made under Sections 12ZF and 324 of Reference P.

Reference I provides for the management of houseboats including:

1) Application, issue and transfer of licences.

2) Numbers and types of houseboat licences.

3) Control of waste, including standards for black water and greywater treatment

4) Fees for administration of licences.

As described in Section 2.1, the Water (Lake Eildon Recreational Area) (Houseboats) Regulations 2013 (Ref. I) were introduced to replace the 2003 regulations by the Victorian Government on 12 June 2013. These Regulations are still currently in force and require that from 1 July 2020 all houseboats must be fitted with an on-board greywater treatment system.

7.2 Comparison of Water Quality Discharge Criteria

An assessment of the AS4995:2009 provides the following discharge criteria for GWTS under Section 3.2 “Water Quality Discharge Criteria and Testing”:

> *Treated greywater discharged by the greywater treatment system shall meet the requirements of the authorities having jurisdiction or, as a minimum, the following water quality criteria (whichever is the lesser):*
>
> *(a) Suspended Solids (SS) must be less than 50 mg/L*
>
> *(b) Total grease content must be less than 25 mg/L*
>
> *(c) Total nitrogen content must be less than 10 mg/L*
>
> *(d) Total phosphorus content must be less than 1 mg/L*
>
> *(e) Enterococci concentration must be less than 40 cells per 100 mL*
>
> *(f) E. coli concentration must be less than 100 cells per 100 mL*
>
> *(g) Biochemical Oxygen Demand (BOD) must be reduced by digestion, oxidation or other recognized treatment method.*

Jacobs has investigated other greywater discharge standards here in Australia and internationally to try to compare the criteria measured and the acceptable limits. While some criteria are commonly used, the acceptable values and method of measurement are varied.

From an Australian domestic greywater standpoint, an Australian Standard AS1546.4 “On-site domestic water treatment units – Part 1: Domestic greywater treatment systems” is currently at a draft level. As an interim EPA Victoria recommends using the NSW Health Department’s “Domestic greywater treatment systems accreditation guidelines” (Ref. U). There are a number of differences in the testing protocol and a range of criteria depending on the disposal method. For comparison purposes Jacobs has used the “Surface Irrigation” as the disposal method. See Table 7-1 below.

Surface Irrigation	BOD (mg/L)	SS (mg/L)	T. coliforms (cfu/100mL)	TKN (mg/L)	TN (mg/L)	TP (mg/L)	Free Cl_2 (mg/L)
90% of samples	< 20	< 30	< 30	TBN	TBN	TBN	> 0.2 to < 2.0
Max. Threshold	< 30	< 45	< 100	TBN	TBN	TBN	< 2.0

BOD: Biological Oxygen Demand
SS: Suspended Solid
T. coliforms: Thermotolerant coliforms
TKN: Total Kjeldahl Nitrogen
TN: Total Nitrogen
TP: Total Phosphorus
TBN: To be nominated by manufacturer.
Cl_2: Free Chlorine (where chlorine is the disinfectant).

Table 7-1 : Discharge Criteria for Domestic Greywater Treatment Systems (Ref. U). for Surface Irrigation

It is difficult to compare directly the discharge criteria as different terminology and criteria are used. It can be seen that temperature, pH, turbidity, grease and oil are not measured for domestic systems yet the criteria for SS and BOD are less stringent for GWTS on houseboats. In addition, the criteria for TN and TP are nominated by the manufacturer.

It is difficult to compare the discharge criteria of domestic systems to the discharge criteria of a GWTS for a houseboat. Australian domestic GWTS are designed as a water conservation device to enable bathroom and laundry waste water to be reused in either gardens and/or toilet flushing and washing machines. The GWTS for houseboats are designed to discharge directly into a waterway. The AS4995 regulations do require additional criteria to be met compared with the domestic standards identified. Temperature, pH, turbidity, grease and oil are additional criteria above those identified in domestic standards.

7.3 Alignment between GMW Regulations and Australian Standard

7.3.1 Current Status

Currently there is a potential inconsistency between the GMW Regulations (Ref. I) and the AS4995-2009 (Ref. K) particularly in relation to the option to separate out the kitchen greywater and treat it separately. Reference I states:

PART 3 – Section 5 - Application for and issue of a houseboat licence

Requirement 3 – The Water Corporation (GMW) may issue a houseboat licence if it is satisfied that –

…

(b) there is installed on the houseboat the following installations which are in good working order –

…

(ii) either –

(A) An on-board greywater treatment system that is able to treat both greywater and kitchen wastewater to a standard equal to, or greater than the greywater discharge standard; or [Nominally described in this report as a Type A]

(B) An on-board greywater treatment system that is able to treat greywater to a standard equal to or greater than, the greywater discharge standard, together with a kitchen wastewater installation which connects to an approved on–board black water system; [Nominally described in this report as a Type B]

To meet the requirement, the houseboat owner is provided with two options of satisfying the objectives of water quality improvement. Firstly the option of installing a GWTS that will treat "both greywater and kitchen wastewater" to a standard "greater than or equal to the greywater discharge standard, "Type A". Secondly the option of separating out the kitchen waste to an approved black water system and treating the residual greywater waste to a standard equal to, or greater than the greywater discharge standard, "Type B".

In effect, the greywater discharge standard is met by either option; the only difference being that the GWTS installed under Type A is required to treat kitchen waste, while Type B does not.

The inconsistency is made apparent by a further inspection of Reference IK, in "Part 2 - Specification for on-board Greywater Treatment Systems on Houseboats" under the section titled "System Design, Manufacture and Performance" the following is stated:

1.1 System design, manufacture and performance of the on-board greywater treatment system must be in accordance with requirements specified in Australian Standard (AS 4995-2009), Greywater treatment systems for vessels operated on inland waters, published on 9 Sept. 2009.

An assessment of the AS4995:2009 provides the following requirements for GWTS under Section 3.2 "Water Quality Discharge Criteria and Testing":"

Treated greywater discharged by the greywater treatment system shall meet the requirements of the authorities having jurisdiction or, as a minimum, the following water quality criteria (whichever is the lesser):

(a) Suspended solids must be less than 50 mg/L

(b) Total grease content must be less than 25 mg/L

(c) Total nitrogen content must be less than 10 mg/L

(d) Total phosphorus content must be less than 1 mg/L

(e) Enterococci concentration must be less than 40 cells per 100 mL

(f) E. coli concentration must be less than 100 cells per 100 mL

(g) Biochemical oxygen demand must be reduced by digestion, oxidation or other recognized treatment method.

The water quality criteria listed above are typical of the elements that are measured to determine water quality. All those listed above are common to the elements considered in the Water Quality Analysis performed as part of this investigation (Section 3.5). Additionally, *Manufacturers must demonstrate that they have tested the on-board greywater treatment system under simulated operating conditions using a synthetic greywater that effectively mimics the potential pollutant loads and concentrations.* ***Testing protocol, type and batch testing (to ensure a practical, robust and repeatable testing method to apply to vessel greywater treatment technologies) must be in accordance with Appendix A and Appendix B of Australian Standard (AS 4995-2009),*** *Greywater treatment systems for vessels operated on inland waters, published on 9 Sept. 2009.*

As highlighted in bold in the last paragraph *"Testing protocol, type and batch testing (to ensure a practical, robust and repeatable testing method to apply to vessel greywater treatment technologies) must be in accordance with Appendix A and Appendix B of Australian Standard (AS 4995-2009)".* Therefore, for a GWTS to be approved as meeting the Standard, and therefore compliant with the Regulations it has to be tested in accordance with Appendix A and Appendix B of Reference K.

Appendix A of AS4995-2009 provides details of the "Testing Protocol" including a "Recipe for Synthetic Greywater" that "shall be prepared in accordance with the formula outlined in Table A1". Table A1 is provided below:

TABLE A1 – SYNTHETIC GREYWATER RECIPE

INGREDIENT	***AMOUNT IN 100L***	***PRODUCT EXAMPLE***
Sunscreen or Moisturizer	*1.5 g 1 g*	*Commercially available sunscreen or moisturizer*
Toothpaste	*3.25 g*	*Commercially available toothpaste*
Deodorant	*1 g*	*Commercially available Deodorant*
Na_2SO_4 – SODIUM SULFATE	*3.5 g*	*Analytical Grade*
$NaHCO_3$ – SODIUM BICARBONATE	*2.5 g*	*Commercially available product*
Na_2PO_4 – DISODIUM PHOSPHATE	*3.9 g*	*Analytical Grade*
Clay	*10 g*	*Industrial Grade*
Vegetable Oil	***50 mL***	***Commercially available vegetable oil***
Vegetable Soup	***50 g***	***Commercially available product***
Full Cream Milk	***60 mL***	***Commercially available Full Cream Milk***
Lard	***25 g***	***Commercially available product (100% animal fat)***
Shampoo/handwashing liquid	*72 g*	*Commercially available shampoo/ handwashing liquid*
Laundry	*15 g*	*Commercially available laundry powder*
Dishwashing (sink) detergent	***1 mL***	***Commercially available dishwashing detergent***
Dishwasher detergent	***5 g***	***Commercially available dishwasher detergent***
Secondary Effluent	*4L*	*Collected from secondary clarifier*

The Recipe for Synthetic Greywater detailed in Table A1 includes ingredients that would not be present in the houseboat greywater where the kitchen waste has been diverted to the black water system.

The rules as they are currently written offer no benefit in removing the kitchen waste from the greywater prior to treatment as the greywater treatment system, to meet the AS4995-2009 (Ref. K), must be able to treat kitchen waste (see the ingredient mix above).

This inconsistency limits the potential benefits and simplifications of treatment systems that could be available to the market. Discussions with manufacturers confirmed that the main difficulties were removing the oils/fats and also the phosphate and nitrogen. The majority of oils and fats are associated with the kitchen waste.

One solution would be for the AS4995 (Ref. K) to offer a second synthetic greywater recipe that could be used for Greywater Treatment Systems that aren't required to treat kitchen waste. This could be offered as a Type A and Type B Greywater Treatment System or similar. Type A would be designed and tested to meet the requirements of all Greywater (including kitchen waste). Type B could be a category for GWTS designed and tested to meet the requirements of greywater (excluding kitchen waste).

This inconsistency in the regulations has been identified as an issue by some houseboat owners who have been drawn into the Australian Building Code regulations to try and find an approved greywater treatment system that is not required to treat kitchen waste.

The issues described above are similar to those experienced by the Environmental Protection Agency - South Australia (EPA-SA). The resulting requirement will be something closer to the current solution that has been accepted for houseboats operating in South Australian waterways and is described in more detail in Section 7.3.2.1.

GMW have previously made provisions for kitchen greywater to be transferred to the black water tank and for all other greywater supply points to be terminated, negating the need to fit a GWTS. This is a potential option for smaller and older houseboats with very basic kitchen arrangements and minimal greywater supply points.

7.3.2 Potential Opportunity to modify current Regulations

The regulations could be modified to allow alternative solutions for houseboat owners that want to consider taking up the option of capturing of the kitchen waste into the black water tank and treating the remaining greywater.

This option is available in the GMW Regulations (Ref. I) but the current wording of the Australian Standard (Ref. K) does not strictly allow this option.

This has been identified by the EPA-SA who have now revised their regulatory requirements.

7.3.2.1 The South Australian Option

In South Australian waterways, similar regulations were brought into place for houseboat greywater and as could be expected, the issues encountered by the houseboat operators (in particular commercial vessels) were much the same as those which have been experienced on Lake Eildon. The situation in South Australia reached the stage where the operators had to disconnect the units because they were having so much trouble with reliability. In addition, the houseboats on the Murray River are so widely distributed it was very difficult to arrange for repairs and maintenance to be conducted.

In 2012, a domestic GWTS manufacturer of a filtration based system was approached to provide one of its gravity fed units to The Houseboat Association of SA. The Houseboat Association of SA installed a unit on three different houseboats, and then proceeded to work out a way to sanitize and filter the water without the use of electrical power.

Trials and tests were conducted on the actual houseboats, and while the results were encouraging it became apparent that galley waste from the kitchen sink/dishwashers would need to be diverted to the black water storage.

Laboratory trials were conducted via the EPA-SA in 2015, and now EPA-SA has given approval for the use of this solution on houseboats in South Australia.

South Australia's new policy (August 2016) resolved to split the waste system, i.e. separate out the higher risk waste (all greywater from the galley, containing organics, grease, oil, detergent, raw meat wash water, pathogens etc.) and treat this via the black water system (and eventual transfer through to town system).

The remaining lower risk waste water stream (greywater including waste from bathrooms, laundry, showers, hand basins, washing machines, etc.) is treated using a residential-style greywater treatment box, providing filtration and the ability to add bromination/chlorination tablets.

The resulting change "Temporary Exemption from the Code of Practice for vessel and facility management (marine and inland waters)" has been supported by the EPA-SA. The requirements for treatment of non-galley greywater includes:

Details of Non-galley greywater treatment units.

The proposed non-galley treatment units must meet the following criteria

1. *Fabricated from:*
    - *Stainless steel*
    - *Fibre-composite (FRP)*
    - *Polypropylene (PP)*
    - *Polyethylene (PE)*
    - *Polyvinyl Chloride (PVC), or,*
    - *Other corrosion-resistant material e.g. non-ferrous metal*
2. *If made out of pipe, the unit must be no less than 150mm diameter*
3. *If installed below deck on multi-hull vessels, must be protected behind a pontoon, or deflector plate, as described in Appendix3 of The Code.*
4. *Units must have a minimum holding capacity of 5L per person (berth) on the vessel with disinfection achieved by 1 × 20g 1-Bromo-3-chloro-5,5-dimethylhydantoin (BCDMH) spa-type tablet (not stabilised Trichlor swimming pool) in a floating dispenser, for every four persons on the vessel, topped up weekly, i.e.*
    - *2-4 berth 1 tablet*
    - *6-8 berth 2 tablets*
    - *10-12 berth 3 tablets*
5. *Considerations must be made for the ability of the unit to cope with expected maximum flow rate under gravity head, to avoid greywater backing up into showers etc., or bypassing filter pads (i.e. greywater treatment box must meet boat greywater flow needs).*
6. *Greywater must be gravity fed through a minimum 240mm thickness of filter pads (e.g. 6 × 40mm) to remove coarse solids and assist settling/capture of finer materials.*

Suitable filter media include polyester Japanese (Koi) Filter Mat or thermal poly-propylene/ethylene compound (TPPC/TPEC) Matala® type.

7. *Pump discharge is not recommended nor endorsed.*

8. *All filter pads must be washed out, using a high pressure hose away from the riverbank and the vessel, after every two weeks of use for commercial vessels and four weeks for private vessels. However, for vessels which are only used occasionally, it is recommended that filter pads and the greywater unit be cleaned at the end of each period of use, to avoid them standing unused in an unclean state for an extended period, which may result in putrefaction and subsequent odour and bacteria risks.*

9. *Boat operators and owners must document maintenance records and provide details upon request by the EPA.*

10. *Operators must use gloves and eye protection when cleaning and handling used filters, to minimise health risks.*

Advice from EPA-SA is that the method proposed above does not completely meet the discharge criteria for AS4995-2009 (Ref. K), but those guidelines relate to the treatment of *ALL* greywater on board including the most toxic galley greywater. The non-galley greywater has been tested through the treatment unit described above during several houseboat hires on-board a commercial vessel with positive results. Upon completion and medication to the units, discharge requirements met the code and AS 4995-2009 (Ref. K) for all parameters.

The EPA-SA has also included requirements for houseboat users that all soap powder, soap, shampoo, conditioner and shower gels must be low in nitrogen and phosphorous, to reduce the extra nutrient released into the rivers.

Advantages with the South Australian Option

1) Greywater treatment units can be developed which do not need to treat the fats and oils that are typically found in kitchen based greywater.

2) This option would potentially allow more simplistic gravity-based filtration based units which will not require pumping systems and electronically controlled systems, reducing or eliminating the additional electrical load.

3) This option would potentially allow more simplistic filtration-based units which will not require large holding tanks to permit treatment.

4) The implementation of a simplistic filtration-based unit will be more cost-effective for the houseboat owner, with estimated retail value in the range of $1,000 to $3,000 (excluding installation) compared to around $18,000.

5) This option would still provide a meaningful improvement in greywater discharge quality, while reducing the impact on houseboat owners (Points 2, 3 and 4), particularly those with older and smaller vessels.

6) Consideration needs to be given to which houseboats this option is made available to. In reality, if the system is approved as a Type A (Full Treatment System) or a Type B (Filtration System) and it meets the water discharge quality objectives of AS4995. Then each type of unit could be made available to all houseboats. **NOTE:** The exact discharge standard approved for use by EPA-SA is not known.

7) Education programs instructing houseboat owners on the preference to use soap powder, soap, shampoo, conditioner and shower gels that are low in nitrogen and phosphorous, to reduce the extra nutrient released into the Lake.

Disadvantages with the South Australian Option

1) Some houseboats have the greywater piping (kitchen, laundry and bathroom) combined into single runs. To split out the kitchen waste may require significant re-working of existing piping.

2) The storage of kitchen waste in the black water tanks will result in the black water tanks filling more quickly and as a result require more frequent trips to the sanitation barges to empty the black water tanks.

GMW Regulations require that the toilet and on-board black water system must have a capacity for storing wastes not less than 60L for houseboats up to 4 berths, and up to 130L for greater than 6 berths. Advice from the houseboat industry is that commonly the black water storage tanks are between 200L and 1,000L with the majority between 400L and 500L. Some smaller and older houseboats are reported to have very small black water storage tanks in the vicinity of 90L.

EPA-SA (Ref. N) states that the average greywater production rates for standard domestic appliances are as follows:

Appliance	Type	Average flow	Reference
Taps	Standard	15-18 L/min	Aust. Govt. (DSEWPC)
	Water Efficient	2 L/min	Aust. Govt. (DSEWPC)
Dishwasher	Standard	40 L/cycle	Sydney Water
	Water Efficient	18 L/cycle	Sydney Water

Table 7-2 : Kitchen Waste Water Figures

The most commonly installed houseboat toilets are currently either the Dometic 510 traveller or the Planus Macerator Toilet which are reported to use between 1.1 and 1.5 L per flush. Advice is that some older houseboats employ units similar to a "Porta-Potti" style camping toilet which use around 0.5 litres per flush.

If it is assumed that each person on-board a houseboat generates 10L of black water per day and each houseboat has berths for 6 people (60L/day) and a black water storage tank of 400 L. Then based on these figures a houseboat would have to empty its black water tank after 6 days.

Estimating the volume of kitchen waste generated is difficult as houseboats with different numbers of people onboard and different eating and washing up habits (sinks or dishwashers, etc.) leads to a wide range of greywater generation volumes. Based on operating a dishwasher for 1 cycle, and a kitchen sink running for 5 minutes (both efficient models) per day, an additional 28 L/day would be added to the 60 L/day, meaning that the storage tank of 400 L would have to be emptied after 4 days.

Based on these figures, diverting the kitchen waste would result in approximately a 50% increase in quantity of waste in the black water system. Houseboats with owners that focus on minimising kitchen waste would be able maximise the time between emptying the black water tanks.

Some houseboats with smaller black water tanks may have to increase the size of the storage tank to increase the operational time between emptying.

3) There is a higher requirement for maintenance, cleaning filters etc. which means that access to the units needs to be provided. There is also the risk that some houseboat owners could chose to rinse/clean the filters in the Lake, thereby eliminating the benefits of the filtration system altogether. While it is noted that it would be difficult to enforce regular maintenance and the cleaning of filters for a Type B systems, changes to the regulations could be introduced to require boat operators to have the filters cleaned or replaced by a qualified to technician to ensure they are not being rinsed directly into the Lake. The use of qualified technicians with the provision of a compliance certificate to GMW would serve the same outcomes as that currently being performed for the Wastewater Australia unit.

4) The storage of kitchen waste in the black water tanks will result in an increased load on GMW downstream assets, sanitation barges and pipelines, and Goulburn Valley Water (GVW) assets such as the treatment plants. It is not known what impact this increased load will have downstream, but the sanitation barges are already heavily utilised during peak periods.

   It is also not known what impact adding kitchen waste will have on the performance of the existing GMW black water transfer systems. Both the suction pipework on the sanitation barges and the transfer pumps on land, nor the capability of the GVM treatment plant.

   Further investigation into the impact of an additional load of kitchen waste into the GMW pumping stations and the GVW treatment systems will need to be conducted. However, it should be noted that the current regulations do allow for the kitchen waste to be stored with the black water for pumping into the land based system. Therefore it could be assumed that an investigation may have been conducted in the past.

5) Further investigation into the ability of Type B systems to meet to the discharge quality standards will need to be conducted. Some examples of the Type B systems that should be considered for testing include Storm Plastics (Adelaide), Just Water Solutions and Wavebrite™. The Aqua2use unit is another unit which has been suggested as a potential solution. The difficulty for filtration type for systems to reduce Nitrogen and Phosphorous levels from the greywater remains an issue for filtration (Type B) systems.

   The further investigation into Type B systems should include an assessment of the capability of these units using both standard soaps and detergents and using low nutrient bathroom and laundry products to compare the outcomes. The combination of a Type B system with the use of biodegradable, pure soap or soap-based substances may result in the same or similar greywater discharge outcomes as required current regulations. EPA South Australia has compiled a list of low nutrient bathroom and laundry products which could be used as a basis for the comparisons.

Potential Breakdown of Requirements based on Houseboat Categories.

One potential breakdown of the houseboat categories allowed to use Type A and Type B is described below and also shown in Table 7-3.

Category 1 houseboats are ‘trailerable’ and will have serious difficulties installing any form of GWTS and could be exempted from the GWTS requirements with kitchen waste to be captured.

The limited size and number of decks/levels of Category 2 houseboats is likely to make installation of a GTWS very difficult. Additionally, due to the size limitations, Category 2 houseboats are likely to be limited in the number of berths (2-4) and are less likely to have washing machines or dishwashers. Therefore the impact of showers and laundry waste is more likely to be limited. As there are currently only eight Category 2 houseboats on Lake Eildon, it is considered that Category 2 houseboats could be exempted from the GWTS requirements with kitchen waste to be captured.

Similarly, there are currently only 23 Category 3 houseboats on the Lake, according to advice from the Lake Eildon Houseboat Industry Association (LEHIA) these boats are the most likely to come off the lake in the next 5-10 years as their licences become more valuable than the physical boats. It is considered that Category 3 houseboats could be exempted from the GWTS requirements with kitchen waste to be captured.

Category 4 and Category 5 houseboats can install either a Type A or Type B treatment system.

New houseboats, Category 6 houseboats, those upgrading to Category 6 and those undergoing a major upgrade, would be required to install a Type A only system. Category 6 houseboats are likely to be newer, larger with increased electrical capacity, and therefore generate more greywater. For this reason they should be required to install a Type A system.

CATEGORY	DESCRIPTION	Quantity 2016/17
1		41
2	Excluded from GWTS requirements as the vessel size is too restrictive. Kitchen water should be captured.	8
3		23
4	Treatment Type A and B allowable for use.	287
5	Treatment Type A and B allowable for use.	239
6	Only Type A treatment systems allowable.	123
New houseboats or those upgrading to Category 6, only Type A treatment systems are allowed		

Table 7-3 : Proposed Treatment Units by Houseboat Category

Consideration was given to alternative methods of differentiation that might provide better determination of likely occupancy and expected greywater generation of each houseboat. By determining the likely greywater generation the regulations could be better tailored to higher greywater generators. Unfortunately, the database of houseboat information currently managed by GMW does not include specific information on numbers of berths, bathrooms, kitchens, washing machines, and dishwashers, therefore this was not possible. If this information was available, it doesn't describe the actual amount of time each houseboat is being utilised nor the number of people on-board at any one time.

7.3.3 Options for encouraging houseboat owners to take up Type A units over a Type B

Based on the current options discussed at Section 7.3.2, it is considered likely that most houseboat owners will prefer to take up the option of a Type B unit as the cost will be considerably less. In doing so, this will increase the load on the existing sanitation barges and sewerage transfer and treatment systems as the kitchen waste will now be stored with the black water. From a GMW perspective, more Type A GWTS is preferred as it reduces the load on the sanitation barges and supporting infrastructure.

Currently, the infrastructure for collecting and transferring the black water is funded by the annual houseboat licence fee and the amount charged is based on the Category of the houseboat.

To encourage houseboat users to take up the Type A system (Full treatment), one option would be to meter the black water transferred to the sanitation barges and charge the users based on a user pay system. Therefore those houseboats that are transferring more black water (and those capturing kitchen waste) will be paying more than those that are treating all their greywater through an approved treatment system.

The charge rates ($/litre) would need to be calculated in such a way that it wasn't seen from houseboat owners that GMW were "double-dipping" on fees that they are already paying. One suggested method would be to reduce the licence fees and then estimate the amount of black water being generated and put a dollar value per litre on the black water to bring the total value of the black water in line with the amount offset by the reduction in the licencing fees.

Ideally if houseboat owners had clear visibility of how the cost differences between a Type A and Type B system could be amortised over a 10 year period, more would potentially take up the full treatment option (Type A).

The risk in a user pays system is that the sanitation system as it currently operates is seen as a free system. Some houseboat owners will potentially go out of their way to reduce the amount of black water and kitchen waste being captured in their tanks. Diverting pipework, using the lake for washing and cleaning plates and dishes or not using on-board toilets could potentially result in a worse outcome.

The other monetary options that could provide an incentive to push houseboat users to Type A system could include a meaningful discount on licence fees for those with a Type A system; or an extended licence period (3-5 years) with a discount included.

7.3.4 Impact of Changing the Regulations

Any changes to the existing regulations that reduce the requirement could lead to houseboat owners that have already invested in installing a GWTS to be out of pocket for doing the right thing. By meeting regulations that have subsequently been reduced, they are effectively paying for an upgrade that is no longer required. In these instances, Jacobs would consider that compensation in either a reduction in licence fees or similar recompense could be put in place for those affected. Of the houseboats that have incorporated a GWTS it is understood that the majority were new boats and those undertaking major upgrades, therefore the number of affected houseboats would be minimal.

7.4 Transfer of Ownership

7.4.1 Constraints with the current system

Sections 11 and 12 of the Houseboat Regulations (Ref. A) state:

11 Transfer of a houseboat licence (switching licence to a new houseboat).

If a holder of a houseboat licence wishes to transfer the licence to another houseboat, that licence must be relinquished and an application for a new houseboat licence must be made under Regulation 5 in respect of the second houseboat.

12 Transfer of ownership of a houseboat. (selling a houseboat & licence to a new owner).

(1) The Water Corporation may transfer a houseboat licence in respect of a houseboat to a new owner of that houseboat on receipt of an application in a form and manner approved by the Water Corporation and on payment of the transfer fee specified in Schedule 2.

(2) The requirements of Regulation 5(3)(b)(ii) only apply to an application to transfer a houseboat licence made on and from 1 July 2015.

NB. Regulation 5(3)(b)(ii) is the requirement for the installation of a GWTS.

Some owners have expressed concerns that the Regulation puts the onus on the current owner of the houseboat, even though it is for sale. Currently, the houseboat could be sold, but the new owners would be unable to apply for the transfer of licence unless a GWTS has been installed. So in effect, the new owners could be in possession of a houseboat which they cannot use (as they do not have a licence) until a GWTS is installed. This means that it is harder to sell a houseboat without a GWTS.

To get around this issue, the sale of houseboats has been occurring through a perceived loophole in the current legislation. Sellers of houseboats officially transfer ownership through the VicRoads Vessel Registration System such that the legal owner of the houseboat is correct. However, the seller does not also transfer ownership of the accompanying GMW licence. In effect, the seller retains the houseboat licence, pays the fees etc. and then the new owner reimburses the seller.

Some points for consideration:

Based on the current system, the current owner may not be able to afford to install a GWTS as the sale may be due to financial hardship reasons. Therefore forcing the current owner to find $15,000 - $25,000 on a houseboat they are trying to sell may not be financially viable.

If someone is in the market for a houseboat, it should be made clear by the broker that the new owner will have to slip and install a GWTS within a nominated period and that they should include a $15,000 to $25,000 allowance in their budget.

7.4.2 Potential Opportunity

Providing a grace period after the time of transfer (either a 12 month period or some time connected with the next licence renewal date) would take the onus from the seller and place it on the buyer. The new boat owner would need to understand that the licence would only be valid until a nominated date following the transfer.

7.4.2.1 Advantages

1) As a process of the transfer of the houseboat ownership and licence a GWTS will be installed, the change removes the onus of installation from the seller to the buyer.

2) A potential houseboat owner should be made aware prior to the sale that in the next 12 months (or at a determined period of time) the vessel will need to be slipped and a GWTS will need to be installed.

3) Any change in the regulations would need to be appropriately worded to ensure another loophole was not created.

7.4.2.2 Disadvantages

1) The strict alignment to the slipping schedule would have to remain in force to prevent the houseboat owner simply having the houseboat on the market to avoid the installation of a GWTS.

2) Potentially, someone with a houseboat for sale for an extended period of time will have to slip a vessel during the period it is for sale and be required to install a GWTS. This will be unavoidable, however the potential availability of cheaper GWTS units will reduce the impact.

7.5 The Implementation Timeframe

7.5.1 Status

The regulations were first introduced in June 2013, approximately 3.5 years ago. To date less than 60 out of 720 houseboats have installed one of the approved GWTS. To meet the current regulations over the remaining time (3 years, 8 months), around 660 houseboats will need to be slipped and have a GWTS installed.

Based on those numbers (660 houseboats in 44 months), 15 houseboats will have to undergo the installation every month between now and July 2020. Discussions with houseboat builders and people in the industry in Eildon, indicate that this will not be possible due to scheduling, usage and availability of slipping facilities.

Typically the houseboat "peak season" runs from Melbourne Cup weekend (early November) though to Easter (March/April). A further "shoulder season" extends this busy period by encompassing AFL Grand Final Weekend (end of September) and Queens Birthday Public Holiday (early June). As a vast majority of owners want their houseboats available during peak season, it limits the amount of time during the year available for slipping work. In effect, the available months are limited to between mid-April and the end of October (around 28 weeks out of 52) - only 7 months. Therefore a more realistic number of houseboats that could be modified are 660 houseboats in 18 months or 35 houseboats per month.

It should be noted that it is not impossible for houseboats to be slipped during the peak periods and some houseboat owners would potentially chose to use this period.

There are limitations on the facilities at Eildon for handling houseboats. To remove a houseboat from the water there are three options available: The Eildon Boat Club slipway, and the use of a heavy load trailer run by Lake Eildon Marina and Houseboat Hire, and the Jerusalem Creek boat ramp.

The following is a list of available spaces around Eildon for the removal of houseboats as provided by the Eildon Houseboat Industry.

Facility	Number of covered sites	Number of open sites (hardstands)
Eildon Boat Club (Inc. Status Luxury Houseboats)	10	3-4
Lake Eildon Marina	-	4
Jerusalem Creek Marina	-	6
Below are facilities at the Masonite Factory – Eildon*		
The Houseboat Factory	2	2
Anchorage Houseboats	4	4
Unique Houseboats	1	4
Status Luxury Houseboats	4	
TOTAL	**21**	**24**

Table 7-4 : Lake Eildon Houseboat Land Based Sites

* Note there are a further 15-20 hardstands at the Masonite Factory used by private houseboat owners.

The Eildon Boat Club slipway is restricted for use by Eildon Boat Club Members and is also used by Status Luxury Houseboats. It has a capacity of 10 houseboats at any one time, but for large period of time spaces are taken up by new builds – potentially 2-4 boats at any one time.

Using a heavy load trailer, houseboats can be removed from the lake via boat ramps at the Lake Eildon Marina and at Jerusalem Creek. There is a small area at Lake Eildon Marina where work on houseboats can be conducted (approx. 4 houseboats). The majority of the work will need to be carried out at the large facility in the township of Eildon (Masonite Factory) which includes The Houseboat Factory, Anchorage Houseboats and Unique Houseboats. This location would be able to hold around 12 houseboats with work being undertaken. As per the Eildon Boat Club facility, some of the spaces available will be occupied by new builds and others may be occupied by houseboats having upgrades other than GWTS.

In a practical sense, it is considered that around 8-10 houseboats at any one time could be out of the water having work related to the GWTS.

Advice from those involved in the installation of GWTS have stated that on average an allowance of a week would be a suitable time frame. This assumes that only work related to the GWTS is conducted. However, it is considered that the majority of houseboat owners will use the opportunity while the houseboat is out of the water to perform other maintenance tasks, painting, patching, repairs and upgrades. Therefore a single week for each houseboat is considered an optimistic amount of time out of the water.

Assuming 8 houseboats are out of the water having GWTS work performed and each installation takes two weeks, only 4 houseboats could be upgraded every week. Therefore, approximately 112 houseboats per year (28 weeks × 4 houseboats/week) could be upgraded to include GWTS. At that rate it would take an estimated 5.9 years (660 houseboats/112 per year) for the implementation of GWTS onto all houseboats. Starting at the end of 2016, a completion date of 2022 would be considered an achievable but probably optimistic timeframe.

The risk in leaving the installation in the hands of the owners, as it has been to date, is that there is nothing stopping the houseboat owners getting to 2022 and realising that (again) there is not enough time to complete the task. It was acknowledged that some owners were likely to wait until 2019/2020 to plan for the installation (before 2020) and then claim it is not their fault that there are not enough facilities to allow them to install. If the date is extended, there needs to be a mechanism in place to compel houseboat owners to install a GWTS on a regular basis.

Year	Houseboats Slipped	GWTS Installed (or Prov. Plumb.)
Prior to 2008		3
2008	49	0
2009	44	2
2010	79	4
2011	77	5
2012	94	1
2013	85	8
2014	69	14
2015	70	16
2016 (YTD)	9	3

Table 7-5 : Houseboats Slipped Compared to GWTS installed

Table 7-5 shows the annual number of houseboats slipped over the past 9 years and the corresponding number of GWTS installed, based on data from GMW.

Since the implementation of the regulations in 2013, 233 houseboats have been slipped and only 41 GWTS have been installed (or provisional plumbing has been introduced). A further 15 have had units installed prior to 2013. That is a conversion rate of less than 20%. In reality, most of those installations have been new houseboats or major conversions or upgrades.

GMW Licence Agreement and Operational Rules (Ref. J) state that all houseboats have to be slipped every 5 to 7 years. The primary purpose of the slipping schedule is for water quality purposes i.e. inspection of the fuel and effluent systems.

The installation of a GWTS needs to be linked to the scheduled slipping for every houseboat. Otherwise the same issue will likely present itself in 5 years time. As part of the re-licensing following the scheduled slipping, there needs to be some way to force the houseboat owner to install a GWTS.

7.5.2 Potential Opportunity

The installation of a GWTS could be formally linked to the scheduled slipping for every houseboat i.e. every 5-7 years.

7.5.2.1 Advantages

1) This method commits all houseboat owners to installing a GWTS within a 7 year period.

2) It will remove the likelihood of large numbers of houseboat owners delaying installation until late in the allowable period, in the knowledge that there aren't sufficient facilities to install the GWTS in a short period of time.

3) Aligning the installation to the scheduled slipping takes away part of the cost of GWTS installation as the slipping (around $3,000) has already been paid for.

7.5.2.2 Disadvantages

1) This will require a greater level of oversight by GMW in their role as houseboat managers. GMW will need to provide notification of the requirement for slipping and highlight clearly that during the slipping period a GWTS will need to be installed.

2) Removes some of the flexibility currently available to houseboat owners surrounding installation.

7.5.3 Other Potential Opportunity

Another option to address the issue of timeframe is to apply the regulations to new houseboats and those subject to major upgrades only, and rely on the natural attrition and turnover of older houseboats. There is a common trend in the submissions from houseboat owners related to the appropriateness of enforcing the Greywater Regulations to houseboats built before the introduction of the Greywater Regulations in 2013. Many have questioned the appropriateness of enforcing these new regulations on houseboats that were deemed compliant with all regulations prior to 2013.

The Regulations could be modified to state that all houseboats built and launched after 2013 (when the Regulations were introduced) must install a GWTS. Houseboats launched prior to 2013 would be exempt from the requirement to install GWTS, unless they undergo a major upgrade. The impact of changing the Regulations in this manner is the overall timeframe it will take for all houseboats to be treating their greywater.

The current Regulations require that all houseboats are fitted with an approved GWTS by 1 July 2020, which effectively allowed a 7 year period for full implementation. As described in Section 7.5, realistically this target date cannot now be met.

If the Regulations were modified to be made applicable to only:

- New houseboats (manufactured post the implementation of the 2013 Regulations)
- Those upgrading to Cat. 6, and
- Those subject to major upgrades.

It is considered that between 20 and 30 houseboats per year would be transitioned to those with GWTS fitted. This figure is based on advice from the Lake Eildon Houseboat Industry Association (LEHIA).

7.5.3.1 Advantages

From a practical perspective, all the barriers to complying with the regulations (described in Section 5.2) are eliminated. The designer and builder of the houseboat can take into consideration the space, weight, power, piping and ventilation requirements to make sure the GWTS is fully integrated into houseboat.

7.5.3.2 Disadvantages

Based on a rate of attrition (assumed 25/year), the number of Cat. 3, 4, 5 and 6 houseboats (632) and taking into account that around 55 are already fitted; it would take an estimated 24 years for all houseboats on Lake Eildon to be treating their own greywater. This considers that the cap on houseboat licences is maintained and new houseboats continue to replace existing older/lower value houseboats.

This time frame excludes the potential for increased take-up as technology improves and the price of GWTS decreases.

Modifying the Regulations to apply to houseboats built after 2013 will still reduce the amount of untreated greywater generated by houseboats but at a slower rate.

7.6 The Monitoring System

7.6.1 Status

Currently the Regulations only require that the GWTS is installed and that a certificate is provided by the builder/installer to state that a unit is installed and functioning correctly. Once the houseboat is back in the water there is no requirement for the system to be regularly inspected or tested to verify that the system is still functioning correctly.

As part of the regular servicing (6 months after installation and then annually) of the Wastewater Australia unit (UltraGTS), the service provider provides a certificate/letter to the owner and to GMW to confirm that the unit has been serviced and is operational. However, no testing of the discharge is performed once the unit is installed.

Testing of the system once installed will prove a difficult, time consuming, and costly exercise, and one which GMW are not currently resourced to perform.

With 720 houseboats on the lake an annual survey and test of every installed GWTS would take almost 3 years (based on a single test per working day). To enable this sort of testing regime the following would be required:

- Access to all houseboats, at all times – it is understood that for GMW to access a private houseboat, the owner is required to receive formal notification in advance.
- GMW staff would have to have a pre-prepared synthetic greywater mix that they could transfer to a houseboat's GWTS.
- GMW would need ready access to either the discharge pipe or a test-point valve to enable a sample to be taken.

- The sample would have to be recorded and sent to a NATA laboratory for assessment. It is understood that there are strict requirements on the time taken before analysis and the temperature range that the sample is allowed to be exposed to as it affects the results.

- The results then need to be recorded in a database and the results provided to the houseboat owner.

Under the requirements of the NSW Health Guidelines (Ref. U), at each anniversary of accreditation, the GWTS manufacturer is required to provide a list of all their installed GWTS to NSW Health and the nominated product certification body. NSW Health then randomly nominate a minimum of 10% of installed GWTS for monitoring. Sampling and analysis is managed by the product certification body, and analysis performed by a NATA accredited testing agency for the criteria tested. The results are then reported to NSW Health.

This process is something that could be implemented by GMW for the houseboat GWTS as a routine or random check of the correct functionality of the installed GWTS. The random nature of the checking would be difficult to implement as it would have to be arranged with the houseboat owner prior.

In a practical sense, performing this task for all 720 houseboats would require considerable logistic effort and is something currently outside the scope and resources available to GMW.

The annual service/survey performed by licenced plumbers by the installers of the Wastewater Australia unit is a good system to check that the system is working and installed correctly. By providing a copy of the service report to GMW, they are informed of which units have been serviced and by extension which units have not been serviced regularly.

Overall the database used to manage houseboats on Lake Eildon is out-dated and heavily reliant on manual input. There is an opportunity to modernise the houseboat database to ensure consistent and compliant data management and assist with the overall houseboat administration. For GMW to be able to monitor and manage elements required to be controlled such as: slipping schedule, GWTS installation, GWTS service, a dedicated asset management database will be required and resources allocated to manage it.

The annual servicing and provision of a certificate from a registered inspector/plumber that the system is functioning correctly (and hasn't been diverted) is the most effective way to manage the GWTS installations.

7.7 Other options for storing and treating greywater

Capturing and storing greywater before pumping it out for treatment as is currently done for black water has been considered as an option but the practicalities of capturing the greywater alone make it an unlikely workable solution.

Estimates of greywater production vary but the Lake Eildon Houseboat Greywater Risk Assessment (Ref. B) used an average greywater production value of 130L/person/day. This value is similar to that used in Lloyd's Register Rule and Regulations for the Classification of Ships (Ref. R), which estimates that treatment systems are sized for 120 L/person/day.

Based on a rate of 130L/person/day, a family of 6 on a houseboat over a long-weekend (3 days) would generate around 2,340L of greywater.

Discussions with some houseboat owners indicated that it is common to head away from the marina/boat club for 7 days at a time. A family of 6 on a houseboat for 7 days could generate around 5,500L of greywater.

Storing these large quantities of greywater, will lead to a number of issues including:

- Available volume – storing 5,500L of greywater means identifying space for 5.5 m^3.
- Weight impact – 5.5 tonnes of water is a significant increase in displacement and will impact freeboard, trim and heel if not evenly distributed or located centrally on the houseboat.
- Ventilation – storing greywater for an extended period of time will result in similar odour issues as those that have currently been experienced with GWTS.

For these reasons, the capture of all greywater has not been considered as a practical and viable option.

In addition, it is predicted that the current sanitation barges and transfer system would not be able to handle such a large increase in load.

Consideration was given to the implementation of fixed greywater treatment barges on the Lake which could be used to capture and treat greywater on-site. While this would solve the issue of overloading the current sanitation barges and transfer system, it would still require the on-board storage of greywater, which as described above is not considered practical or viable.

8. Summary

8.1 Summary of Findings

A review of the available water quality data for Lake Eildon found:

- Greywater discharge from houseboats is not expected to impact on general water quality parameters (Electrical Conductivity, Dissolved Oxygen, turbidity, pH) on a lake-wide scale. Lake water generally meets most WQOs.

- Some measures of nutrient levels in the Lake exceed some water quality objectives and there is a potential risk of algal blooms. Greywater discharge contains high concentrations of nutrients that increase the risk of algal blooms, particularly in harbour areas and at low water levels. Greywater discharge represents a very small fraction of total nutrients entering the Lake, but under some conditions increases the chance of algal blooms.

- Discharge of pathogens (e.g. bacteria) associated with greywater presents a small but plausible health risk to recreational users (including houseboat operators) in harbour and marina areas.

- The impacts of greywater discharge are expected to be minimal in the whole-of-lake context, but add to health and environmental risks in specific locations and conditions.

The findings of the investigation into the houseboat greywater issues are able to conclude:

- In 2013, when the regulations were first introduced, the houseboat industry did not have a proven GWTS available for the full range of houseboats styles (sizes/types/capacities) in place on Lake Eildon. In response the houseboat and greywater treatment industry developed a number of GWTS units, the early versions of which experienced a number of design and integration issues.

- These issues related to the odour, noise and reliability of units as well as the required electrical loads. Contributing to the early performance issues with GWTS units is their infrequent and intermittent operation, and in some cases a lack of an ongoing power supply with houseboats typically in use for only part of the year. Further contributing to these issues is the lack of available space on some houseboats which requires non-uniform installation.

- In most instances the GWTS units need to be retrospectively installed, which also increases the costs of compliance with the regulations. While these costs vary, they typically cost in excess of eighteen thousand dollars ($18,000) to purchase and install.

- Five GWTS units are approved as compliant with the Australian Standard (AS4995), however, two of these units are no longer being manufactured. Two of the remaining GWTS manufacturers acknowledge the initial issues with their GWTS units and their installation. They also note improvements to their units and installation processes and believe they have resolved most of the issues experienced with the installation of the initial GWTS units. The third system has only recently been approved and installed on a single houseboat.

- Concerns about potential issues with the GWTS units and the cost of their installation were reported by some houseboat owners as the primary reason for not installing these systems. However, a number of boat owners who installed GWTS units more recently reported they were satisfied with their performance.

8.2 Summary of Potential Opportunities

The high level objectives of improvement in water quality remains applicable.

The objectives of any reform to the regulatory framework identified are to make the options available to houseboat owners more realistically achievable, while still providing improvement in the Lake Eildon water quality.

1) The regulations should to be modified to allow alternative solutions for houseboat owners wanting to consider taking up the option of capturing the kitchen waste into the black water tank and treating the remaining greywater, as per Section 7.3.2.

2) A potential breakdown of the implementation of the Regulations based on the GMW houseboat categories and the allowance to use Type A or Type B systems is described below in Table 8-1 and described in Section 7.3.2.

CATEGORY	DESCRIPTION	Quantity 2016/17
1	Excluded from GWTS requirements as the vessel size is too restrictive. Kitchen water should be captured.	41
2		8
3		23
4	Treatment Type A and B allowable for use.	287
5	Treatment Type A and B allowable for use.	239
6	Only Type A treatment systems allowable.	123
New houseboats or those upgrading to Category 6, only Type A treatment systems are allowed		

Table 8-1 : Proposed Treatment Units by Houseboat Category

3) Providing a grace period after the time of transfer (either a 12 month period or some time connected the next licence renewal date) would take the onus off the seller and place it on the buyer. The new boat owner would need to understand that the licence would only be valid until a nominated date following the transfer, as per Section 7.4.2.

4) The installation of a GWTS should be formally linked to the scheduled slipping for every houseboat i.e. every 5-7 years, as per Section 7.5.2.

As an alternative opportunity, an improvement in water quality will remain, albeit the timeframe from complete compliance will be longer, should the retrospectivity of the regulation be removed, as per Section 7.5.3.

Appendix A. Summary of Stakeholder Discussions

Following the release of the Public Discussion Paper that summarised the draft findings, Jacobs received around one hundred formal submissions. Approximately 95 submissions were from houseboat owners and the remainder were from GWTS manufacturers, the Lake Eildon Houseboat Industry Association (LEHIA), GMW and other government organisations. All of these submissions have been reviewed by Jacobs and provided to DELWP for their records.

Houseboat Owners

The approximately 95 submissions from houseboat owners represented a response from approximately one-seventh of the Lake Eildon houseboat fleet, which is considered an excellent level of response.

In general terms, the concerns highlighted by the houseboat owners were consistent and covered three major aspects of the regulations. These were:

1. Concern that the GWTS currently approved for use were not functioning, and/or not reliable and were still having issues with noise and odours. Around one-third of the submissions raised this concern.

2. Concern that the amount of houseboat greywater generated was insignificant and that the water quality of Lake Eildon has not deteriorated over many years of houseboat operations. Around one-third of the submissions raised this concern.

3. Concerns surrounding the cost of implementation of the GWTS and the difficulty likely to be experienced with installation, in particular the feasibility for older and smaller boats. Almost two-thirds of the submissions raised this concern.

4. Concerns related to the retrospective nature of the regulations and that it the regulations should apply to new or near new houseboats only. Around one-third of the submissions raised this concern.

Other themes that could be extracted from the submissions included:

- The recommended mandated use of low nutrient bathroom and laundry products,
- The alignment of the requirements for GWTS to the installation of a dishwasher or washing machine,
- Introduction of payment plans for high-cost installations,
- The need for simpler and cheaper solutions.

Greywater Treatment System Manufacturers

Jacobs has had meetings and phone conversations with three of the four manufacturers of systems that have been approved and another that is currently in the process of being approved. Additional correspondence has been had with manufacturers looking to take advantage of the filtration type systems.

The three manufacturers that have been approved have described the significant amount of time and money they have spent in research and development to come up with a system that meets the requirements of the AS4995 standard. Figures upward of $750,000 have been quoted and while government grants have been available to some, all have stated that they are yet to recoup the costs they have outlaid.

In some instances the manufacturers believe that the issues experienced on some of the units are likely to have been caused by houseboat owners not following the manufacturer's guidance from an operational and maintenance perspective.

There is also a feeling of frustration among the manufacturers that the reviews and investigations (such as this Jacobs investigation) are slowing the process because some houseboat owners believe the requirements will be scrapped.

Also there is a concern amongst manufacturers that if the Regulations are scrapped, they will lose a market which is already only relatively small.

Goulburn-Murray Water and Monitoring Compliance

Discussions with GMW centred on the issues that have already been described in Sections 3 and 36.

The additional issues raised related to how the Regulations are currently implemented and policed and how any new or changed regulations are going to be implemented or policed in the future.

Currently the Regulations only require that the GWTS is installed and that a certificate is provided by the builder/installer to state that a unit is installed and functioning correctly. Once the houseboat is back in the water there is no requirement for the system to be regularly inspected or tested to verify that the system is still functioning correctly.

As part of the regular servicing (6 months after installation and then annually) of the Wastewater Australia unit (UltraGTS), the service provider provides a certificate/letter to the owner and to GMW to confirm that the unit has been serviced and is operational. However, no testing of the discharge is performed once the unit is installed.

Testing of the system once installed will prove a difficult, time consuming, and costly exercise, and one which GMW are not currently resourced to perform.

With 720 houseboats on the Lake an annual survey and test of every installed GWTS would take almost 3 years (based on a single test per working day). To enable this sort of testing regime the following would be required:

- Access to all houseboats, at all times – it is understood that for GMW to access a private houseboat, the owner is required to receive formal notification in advance.
- GMW staff would have to have a pre-prepared synthetic greywater mix that they could transfer to a houseboat's GWTS.
- GMW would need ready access to either the discharge pipe or a test-point valve to enable a sample to be taken.
- The sample would have to be recorded and sent to a NATA laboratory for assessment. It is understood that there are strict requirements on the time taken before analysis and the temperature range that the sample is allowed to be exposed to as it affects the results.
- The results then need to be recorded in a database and the results provided to the houseboat owner.

In a practical sense, performing this task for all 720 houseboats would require considerable effort and is something currently outside the scope and resources available to GMW. Random testing could be performed on houseboats, but as GMW are required to notify houseboat owners of their intention to inspect, the randomness of an audit is somewhat diminished.

In reality the annual servicing and provision of a certificate from a registered inspector/plumber that the system is functioning correctly (and has not been diverted) is the most effective way to manage the GWTS installations.

Other issues highlighted by GMW include a lack of trust between GMW and houseboat owners (both ways), but it was mentioned that GMW feel that houseboat owners do not tell them they are having trouble with their GWTS. Potentially this is because owners are worried that they will have difficulty with their licence renewals if they tell GMW that their unit is not working. Therefore, GMW feels that they are not getting a clear picture of the success, failures, and/or issues that are being experienced.

Other issues impacting efficiency and effectiveness

Another factor to consider with respect to the treatment of greywater is the scalability of the manufacturing. The current investigation is only looking at options for Lake Eildon. The requirements being set are only applicable to Australia, which means that the market for Greywater Treatment Systems that need to meet there regulations is limited to the Australian market. Lake Eildon has some 700 houseboats. It is understood that South Australia has some 2500 houseboats on the Murray River.

From an industrial point of view (technology development, design, construction, maintenance and support) 3,250 houseboats is a much greater incentive for treatment manufacturers to invest money in the design, development and certification than 750 houseboats.

Jacobs understands that these policies are state based and therefore many different lobby groups have different drivers influencing their regulations. However, it makes some logical sense to have a country wide policy to maximise commonality across the Australian Market.

Water quality considerations

Many of the responses received from the discussion paper raised objections relating to water quality. These typically related to a perception that the Regulations were either:

- **Unnecessary** – e.g. water quality in the Lake is good, there is no evidence of decline in water quality since the introduction of houseboats, we have never experienced illness or water quality problems in a long time holidaying on our boat; or, the same improvements to WQ could be achieved via other methods such as the compulsory use of low-phosphate detergents.

- **Disproportionate/unfair** – e.g. the regulations put an unfair burden on the houseboat owners, given the significant cost associated with installation of the systems and the tiny amount of pollution contributed by houseboats compared to the whole lake and catchment volume/load. Many comments related to a perceived imbalance between the costs of implementing the regulations vs the water quality benefits that are likely to be achieved. There is a genuine sense that houseboat owners are being unfairly targeted and many have stated they simply cannot afford the treatment systems.

- **Ineffective** – e.g. comments questioning whether the GWTS installation would actually improve WQ outcomes, given the small contribution of houseboat greywater and the numerous technical failings of the GWTS, even if they worked 100% of time, improvements to WQ would be small, and perception is that GWTS are not delivering the WQ specified by the manufacturers.

There were many requests/queries about specific water quality issues that were addressed in the full report, but not the discussion paper (for example, quantitative analysis of proportion of contribution from houseboats vs inflows; multiple factors influencing algal blooms) etc. Many comments requested clarification or detail of topics that were covered in the report; the existing report addressed most of these but some additional clarifications have been added.

Some comments were incorrect – e.g. “pathogens released into the water are in fact non-existent after 4 seconds in cold water”. This is factually incorrect. Decay rates of bacteria and pathogens vary in the environment but can remain infectious for periods of at least several days and can be resistant to treatment; report includes mention of this.

Some requests were made regarding water quality issues that were outside the scope of the review, such as independent water quality testing.

Comments from both boat owners and DHS/GMW reflected a perception that the review was not able to “prove” water quality. DHS and GMW comments noted that the review does not prove that there is no impact to water quality from greywater discharge, and that the regulations should therefore be retained. Comments from boat owners reflected to the converse of this concept – the review does not prove that the greywater discharge does have an impact, therefore the regulations should not be applied. These comments reflect different positions on the same issue, but also reflect a lack of detail in the discussion paper addressing these issues. The full report review adequately analyses and discusses available water quality data, addresses data limitations, and provides a scientific position on water quality for consideration in the regulatory review. It is not always possible to provide definitive ‘proof’ of complex water quality issues to the satisfaction of stakeholders.

Appendix B. Other Issues for Consideration

Safety Related Design Criteria for Houseboats

During the investigation and preparation of this discussion paper, it became apparent that the design and construction of houseboats on Lake Eildon do not currently fall under an existing regulatory framework.

As the majority of houseboats on the lake are private entities (not commercially operated) they do not fall under the control of Maritime Safety Victoria. Maritime Safety Victoria is responsible for the effective day-to-day operation of the National System for Domestic Commercial Vessel Safety in Victoria under delegation from the Australian Maritime Safety Authority (AMSA). Part of this delegation includes the regulation of certificates of survey, certificates of competency, and certificates of safe operation.

In accordance with the AMSA guidelines, for new vessels a Certificate of Survey will be required if a vessel is:

- greater than or equal to 7.5m in length
- carrying passengers
- operating beyond sheltered waters
- otherwise high risk

Therefore because private houseboats on Lake Eildon are not operating beyond sheltered waters they are exempt from the requirement to obtain a Certificate of Survey.

Additionally, as houseboats are not “on land” they do not specifically fall under the requirements of the Australian Building Code. It is understood that compliance with the requirements of gas systems and fabrication is regulated through the use of licenced gasfitters, similarly electrical work is required to be performed by qualified electricians.

According to Maritime Safety Victoria, the overall safety requirements of houseboats are managed by GMW who are responsible for the licensing of all houseboats for operation within the Lake Eildon Recreational Area. GMW have stated that they do not inspect buoyancy or seaworthiness.

The Houseboat Regulations (Ref. I) cover the design and installation of systems for storage, treatment, and transfer of black water and greywater, but include no safety specific requirements. The Houseboat Information Sheet (Ref. L) lists Licensing Requirements for new vessels with the following information required as part of the submission of houseboat plans:

- the scale of your plan;
- the length and width of the houseboat deck and structure, including all appendages & motors;
- method of intended appendage retraction or folding information;
- a bow, stern and port elevation of the houseboat structure;
- the number of enclosed levels;
- a floor plan, including the internal dimensions;
- a minimum of 450mm freeboard, or as otherwise determined by a competent person;
- the location of all sewerage/greywater & fuel tanks, including their capacity and dimensions;
- details of greywater installation of a treatment system complying with AS4995-2009;

- the location and type of toilet/s, details of capacity, make and model; and
- motor size and model.

The only safety related requirement described above is *“a minimum of 450mm freeboard, or as otherwise determined by a competent person”*.

From a naval architecture, vessel stability, and reserve buoyancy perspective this statement is vague and open to interpretation, without the subjectivity of “a competent person”. The requirement provides no specifics related to:

- Where on the houseboat the freeboard is measured, (forward, midships or aft).
- What the loading condition of the houseboat is, i.e. full load, lightship or some other.
- Whether the freeboard is related to the buoyancy hulls or the main deck of the houseboat (see Figure B.1 for details).

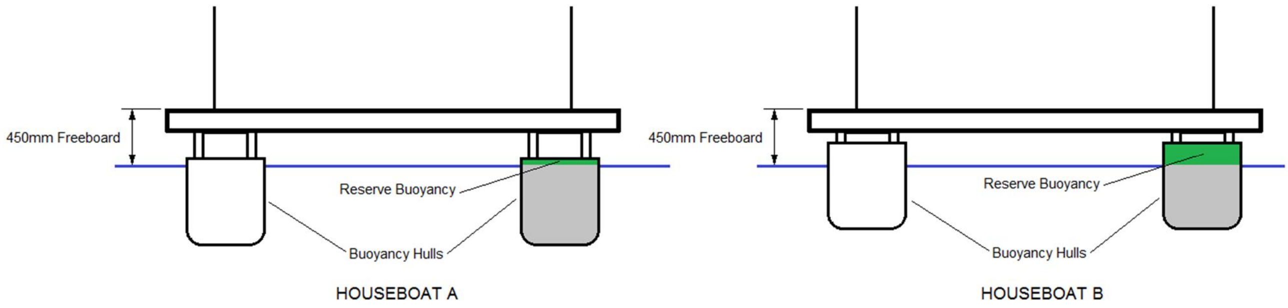

Figure B.1 : Houseboat Reserve Buoyancy Comparison

Figure B.1 shows two houseboats both with a measured Freeboard of 450mm, yet Houseboat A has far less reserve buoyancy (and therefore less stable) than Houseboat B.

Additionally, it is not clear how often the freeboard requirement is surveyed to make sure houseboat freeboards remain above the 450mm minimum. GMW have confirmed that the primary purpose of the slipping schedule is for water quality purposes i.e. inspection of the fuel and effluent systems.

The reason that this is highlighted is related to the statement that some houseboat will be unsafe by adding the weight of a GWTS. The definition of whether a houseboat is safe or unsafe needs to be clearly defined before such a statement is validated.

Non Watertight Hatches and openings in pontoons

Another potential issue that should be highlighted is related to the incorporation of non-watertight hatches/openings in the buoyancy pontoons. Some of these openings have been included for storage and others have been included to facilitate the installation and access of GWTS.

It was noted in the few cases witnessed that these access openings are covered with a lid and not a secure watertight hatch. In most instances it is expected that the vertical position of the hatches would be above the 450mm minimum freeboard. However, there may be some instances where the loading of the houseboat (draft and trim) could reduce the freeboard to a level where larger waves (particularly those from larger and deep draft wakeboarding boats could spill water through the non-watertight hatch.

Jacobs has not done an investigation into the compartment sizing and spacing of the pontoon watertight bulkheads so it is not clear how much of a safety risk this potential flooding of these compartments is. Jacobs considers that from a safety perspective any hatch accessing a pontoon providing buoyancy for a houseboat should have a dedicated closing latch and should be watertight.