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WHITE PAPER

Valuing water to drive more effective decisions



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GLOSSARY

TERM, ACRONYM OR ABBREVIATION	DEFINITION
Abatement cost	Cost of reducing an environmental impact.
Actual Renewable Water Resources (ARWR)	The sum of internal and external renewable water resources. ARWR represents the maximum theoretical amount of water actually available for a country at a given moment. ¹
Benefits transfer	Technique by which an environmental value is transferred from one location to another. This approach aims to overcome barriers to conducting new valuation studies for each site analysed in environmental economics.
Cost of capital	The cost of equity and long and short-term debt.
Direct environmental impacts	Impacts from a company's own operations.
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. Together with deposits of non-renewable resources they constitute "natural capital".
Ecosystem services	Goods (renewable resources such as water and food) and services (such as pollination and purification of water) provided by specific ecosystems to humans. An overview can be found at http://www.teebweb.org/resources/ecosystem-services .
Environmental value	The value to people from environmental goods and services. Where no market price exists, it can be estimated in monetary terms by using environmental valuation methods.
External cost	Cost borne by third parties not taking part in an economic activity.
FAO	Food and Agriculture Organization of the United Nations.
GHG	Greenhouse gas.
Gigalitres	One thousand megalitres.
Impact	Environmental impact in physical units or as a monetary value.
Kl	Kilolitre or 1,000 litres (equivalent to one cubic metre).
m ³	Cubic metre (equivalent to one kilolitre).
ML	Megalitres (equivalent to one million litres or 1,000 m ³).
Natural capital	The finite stock of natural assets from which goods and services flow to benefit society and the economy. It is made up of ecosystems (providing renewable resources and services), and non-renewable deposits of fossil fuels and minerals.
Renewable water resource	Surface flow and recharged ground water available to an area.
Social cost	Cost to society as a whole of an action, such as an economic activity.
Water scarcity	The ratio of total water use to water availability. Water scarcity generally ranges between zero and 100%. It can exceed 100% in exceptional cases (e.g. groundwater mining).

1. EXECUTIVE SUMMARY

Changes in supply and demand are putting growing pressure on water resources in Australia, which is vulnerable to climate change impacts such as more frequent and severe drought and floods. Catchments in Victoria are exposed to lower runoff and higher evaporation rates that could reduce water availability. Managing water resources is a priority. The water industry, regulators and researchers will need to develop new approaches to prioritise the needs of water users, including the environment.

Water use results in direct and indirect costs and benefits for the community and the environment. Water supports ecosystem services such as food production, biodiversity and climate regulation. Risks include water stress and supply shortages. Most of the costs of damages from excessive withdrawals and pollution are not included in market prices, and are therefore known as “externalities”. Environmental valuations are increasingly used to inform integrated water management.

Yarra Valley Water commissioned Trucost to estimate the value of water to Melbourne to help inform thinking around environmental valuations and options to deliver sustainable and economically-efficient water management in Melbourne. This White Paper highlights the results of the water valuation and explores the potential to use environmental economics to strengthen resource allocations and water management. It aims to provoke discussion among stakeholders in the water industry, regulators and researchers to develop approaches to integrate the total economic value of water into decision-making. It aims to inform collaboration to improve efficiency and allocate resources more effectively before stocks and flows of water deteriorate further. It raises questions around the use of environmental valuations to help deliver water infrastructure with environmental outcomes that maximise benefits to communities.

Trucost analysed the total economic value (TEV) of water based on an extensive academic literature review. Findings include:

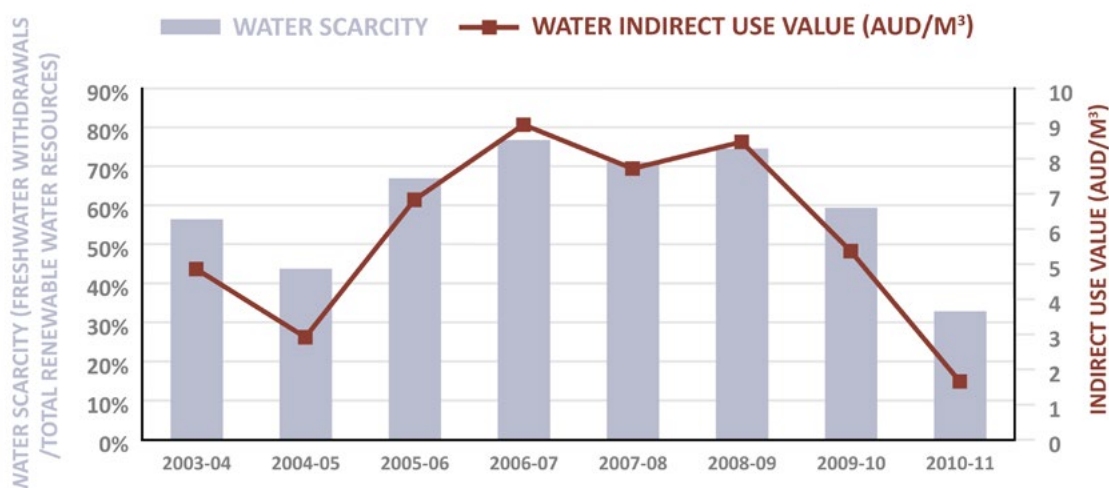
Water is undervalued in resource allocations. The use value of water to society and the environment is more than double the market price of water used in financial decision-making.

Using one cubic metre of water in Melbourne costs society almost AUD6 on average. Each cubic metre of water saved therefore delivers a gain of AUD6 through avoided damages. However, water prices for residential and industrial customers of Yarra Valley Water average approximately AUD1.90 per m³. The total annual value of the ecological functions of water assets in Melbourne is estimated at AUD2 billion. This is almost twice the AUD1B value of Melbourne water retailers’ sales in 2010-11. Investment decisions based on market prices used in traditional financial analysis undervalue options that deliver water savings and environmental benefits.

The high value of groundwater recharge indicates that this should be a priority. The indirect use value for the hydrological function of water is most significant (AUD4.85). Groundwater plays an important role in storing water and generating ecosystem services that indirectly benefit society.

Fluctuating levels of water scarcity caused wide variations in the indirect value of water to Melbourne between 2003-04 and 2010-11. The value of water’s ecosystem functions is highly correlated to water scarcity, which varies over time. Hence when water scarcity increases or declines, the value of water will also rise or fall. The value of water that reflects ecosystem functions ranged from almost AUD2 per m³ when water was relatively abundant in 2010-11, to AUD9/m³ in the most water-scarce year (see Figure 1). At these rates, the value of water as a natural asset used in Melbourne ranges from AUD570 million to AUD3 B over the eight-year period analysed. It is likely to be more cost-effective to protect resources than to incur the high costs of shortages.

FIGURE 1: VARIATIONS IN WATER SCARCITY AND INDIRECT USE VALUES FROM 2003-04 TO 2010-11



IMPLICATIONS OF FINDINGS

Valuing the benefits of water provides one possible approach to improve decisions. Ecosystem services could be incorporated into business risk and opportunity management, information management and accounting systems. Valuations of the consequences of changing water allocations and water management provides decision-makers with a more complete picture of how resource allocations can be reconciled with economic, environmental and social impacts.

Including environmental externalities in decision-making would lead to better outcomes for communities.

A common framework could be developed to monitor the direct and indirect environmental costs and benefits of investment options in Victoria. Systematically evaluating all measurable ecosystem services can help reduce the uncertainties and risks involved in water management and deliver a better outcome for the community. Accounting for water as a natural asset in financial reporting would help ensure board-level recognition of business dependence on the resource.

Potential applications of environmental valuations by the water industry and policy makers include:

- Increasing cross-sector collaboration to develop and apply performance metrics and standards for measuring ecosystem services.
- Strengthening management planning around natural resource use.
- Integrating the range in ecosystems valuations in core business decision-making systems.
- Developing policies to consider the potentially material value of ecosystem services in financial analysis.
- Considering externalities in option (investment) appraisals and the adoption of water-efficiency technologies.
- Applying a precautionary approach to take account of impacts that might result in irreversible damage, despite uncertainties.
- Informing catchment planning, water allocation and shared value assessments, identifying which issues to prioritise in mitigation or restoration activities.
- Identifying opportunities to reduce levies or provide positive financial incentives, such as eligibility for tax relief or subsidies for maintaining assets that generate ecosystem benefits valued by the public, or that operate in a way that conserves natural resources.
- Developing markets for ecosystem goods and services and capturing new income streams from water-saving technologies, services and practices.
- Assessing the benefits of natural capital and highlighting opportunities to reduce costs.

Collaboration is essential to reduce risk and optimise water management. The results of this Paper support Yarra Valley Water's existing environmental valuations included in a community costing framework that estimates a higher value for water than is currently considered in traditional financial analysis. Industry, researchers and policy makers can collaborate to include environmental valuations in investment decision-making and develop tools to allocate water resources more effectively. Decisions on water use to Melbourne could consider the total economic value of water to evaluate options that improve water efficiency, reduce adverse impacts and address water scarcity. Valuations can be used to communicate challenges in balancing financial outcomes with environmental and social costs. Policies on abstraction, environmental levies and water pricing can consider the indirect use values of water to strengthen natural capital management.

The water industry and regulators can help develop business models that provide water-saving services and technologies, removing dependence on expanding water extraction to generate revenues, while depleting resources in the long run. The development of a common framework for environmental valuations in the region could help inform assessments of the direct and indirect costs and benefits of projects, programmes, infrastructure and watershed protection consistently in investment decision-making. The framework could take account of variability in water availability. The goal is to allocate resources to manage water in a way that avoids or limits environmental degradation, rather than incurring damage costs later.

OVERVIEW OF QUESTIONS

The findings in this White Paper suggest that the water industry, regulators and researchers need to develop expertise around environmental valuations. The following are suggested questions that could help frame future work to understand and apply valuations of natural capital and externalities:

1. How do water utilities assess whether financial benefits exceed costs when externalities are taken into account?
2. How can the water industry, regulators and researchers develop a common approach to economic valuations of water in Victoria?
3. What are the barriers to developing a framework for consistent ecosystem valuations by water catchment users, and how can they be addressed?
4. How can stakeholders strengthen consideration of impacts and dependence on functions identified as most material in this study, such as groundwater recharge?
5. How could environmental valuations support more effective resource allocations?
6. How can the value of water savings and ecosystems protection be incorporated into government incentives or levies?
7. How should the water sector work with stakeholders to develop a common approach for including water-related costs in the evaluation of integrated water management options? How can variability in water scarcity be considered in sensitivity analysis?
8. How can water valuations be incorporated into supply-demand modelling and economic assessment for investment decisions?
9. What resources are needed to find ways to include the value of water-related ecosystems in existing financial and business planning procedures that companies already use?
10. How can collaboration be strengthened to determine the most significant externalities of water management in the region, accountability for each externality, and the effectiveness of approaches for managing externalities?

2. INTRODUCTION

“AUSTRALIA IS ALREADY EXPERIENCING CLIMATE CHANGE IMPACTS, WHICH COULD CAUSE A 20% CHANGE IN RUNOFF IN THE CATCHMENTS SUPPLYING MELBOURNE BY 2030.”

Pressures are growing on water resources, with risks from climate change impacts increasing unpredictability about security of supplies. Information on the benefits of water and costs of damages from depleting resources are usually not recognised in market prices. These “externalities” can be internalised to support more efficient water management. Authorities are yet to deliver on commitments to manage externalities. New approaches are required to meet the needs of water users, including the environment. Valuations are increasingly used to understand the role of ecosystem goods and services in the water cycle and set priorities in integrated water resources management.

Yarra Valley Water commissioned environmental economics experts Trucost to estimate the “value of water”. This White Paper builds on the results and aims to provoke discussion among the water industry, regulators and researchers to develop approaches to integrate the total economic value of water into decision-making. It aims to help inform thinking on options to deliver water infrastructure with measurable environmental outcomes that benefit communities. The goal is to allocate resources and manage water in a way that avoids or limits environmental degradation, rather than incurring damage costs later.

2.1 GLOBAL AND NATIONAL PRESSURES ON WATER RESOURCES

Pressure is growing on water supplies globally with population growth, irrigation requirements, economic growth, power generation, resource extraction, urbanisation and environmental change.² Globally, climate change will cause changes in precipitation patterns and intensity, increasing water shortages and uncertainties about future freshwater supplies and demand from the main water use sectors such as agriculture and energy. Temperature increases, more frequent and severe weather events, sea-level rise and droughts will also increase the vulnerability of ecosystems. This will undermine the ability of natural systems to filter water and create buffers to flooding, and affect the capacity and reliability of water supply infrastructure.³ These forces are undergoing accelerating and often unpredictable changes, increasing risks and creating new uncertainties and opportunities for water managers. The industry, regulators and researchers will need to develop new approaches to prioritise the needs of water users, including the environment.

2.1.1 Water and exposure to change in Australia

Australia is one of many countries where vulnerability to drought and the impact of population growth on water demand and the environment make changes in water management critical. The Intergovernmental Panel on Climate Change (IPCC) has identified ecosystems, water security and coastal communities in Australia as particularly vulnerable to climate change.⁴ Climate change could cause up to a 20% change in runoff in the catchments supplying Melbourne by 2030, with changes in rainfall and higher evaporation resulting in less water for dams and catchments. Runoff in the region could fall by up to 50% by 2070.⁵

Australia is already experiencing climate change impacts, including falls in rainfall in the south west, rising temperatures, more severe droughts, increased evaporation and more extreme events such as heat waves and floods. The heat waves in south-eastern Australia⁶ in 2009 and 2013 broke record temperatures, with impacts on human health, infrastructure and ecosystems. All states and territories have seen unusually hot temperatures since mid-2012, exacerbated by dry conditions affecting much of the country.⁷ These incidents follow a decade that was the fifth-warmest on record.⁸ They are consistent with projected changes, demonstrating Australia’s exposure to climate change impacts.

“MANAGING WATER AS AN ECONOMIC GOOD IS AN IMPORTANT WAY OF ACHIEVING EFFICIENT AND EQUITABLE USE.”

The Dublin Statement on Water and Sustainable Development (1992)

Climate change is already affecting water availability and security across Australia. The Australian Government's plans to adapt to climate change impacts recognise the need for rules, policies and programmes around water management to take account of future climate risks. Managing Australia's water resources is a national priority. The Government supports sustainable development, viewed as maintaining or improving the wellbeing of society – the combination of community liveability, environmental sustainability and economic prosperity – over time.⁹ To measure sustainability, the Government has developed indicators for natural capital, including water quality, water consumption and water availability to meet demand.

The Government is investing AUD12.9 billion over 10 years in a climate change adaptation programme as part of “Water for the Future”, an initiative to better balance the water needs of communities, farmers and the environment and help secure water supplies.¹⁰ The Water Act 2007 establishes water entitlements to protect or restore environmental assets.¹¹ Environmental watering is one of several measures to help look after rivers, wetlands and floodplains. Watering actions are assessed against criteria including the ecological significance of the asset to be watered and expected ecological outcomes. The Government recognises that the interconnect- edness of natural systems points to the need to maintain ecosystem functions.

The Productivity Commission (PC) report “Australia's Urban Water Sector” (2011) supports the use of economic evaluation and analysis of projects and options based on community cost. This could help identify which stakeholders benefit more from investments, and how the costs and benefits of water-related activities should be internalised. It calls for Australian, State and Territory Governments to ensure the urban water sector provides water, wastewater and stormwater services in an economic efficiency manner, including environmental, health and other costs and benefits that might not be priced in markets.

2.2 THE EXTERNAL COSTS OF WATER USE

2.2.1 The diffuse costs of depleting and degrading water resources

Water consumption is associated with direct and indirect costs to other users and the environment. Production and consumption can cause pollution and excessive withdrawals that have negative economic impacts. These damages are usually not paid for by the users causing them and are therefore known as external costs or “externalities”. An action by a firm or individual is defined as having externalities if it directly affects either the productive capacity of other firms or the welfare of other individuals.¹² Water use upstream can degrade water quality for downstream users, creating problems such as salinity. These dispersed externalities, such as environmental damage from excessive reductions in in-stream flows, are generally not reflected in market prices of water tariffs. This results in the price being below the full cost.

Rogers, Bhatia and Huber (1998) found evidence that water prices may not cover the basic supply cost (extraction and distribution) and incur an inefficient allocation and exploitation of the resource.¹³ Water prices are typically related to the capital required to supply water and do not reflect the “true” value of the resource to society. Decisions around water use usually only consider the value of water in a monetary sense through its direct uses. But the non-monetary value, such as what it is worth to society or the environment as a result of indirect uses, can be considerable compared to the price paid to consume water resources.

Water revenues often do not cover the costs of water resources management.¹⁴ The inadequate pricing of water is contributing to its inefficient use. Water is over-consumed worldwide and wasted largely because users do not receive appropriate signals about its value. The failure of the market to internalise the full economic value or costs and benefits of water as a public good has led to overconsumption and water quality degradation. The social cost of subsidising increased water use can be high and rising in the mature phase of water economies, while policies are based on the expansionary phase when exploitation of irrigation opportunities had low social costs.¹⁵

The Dublin Statement on Water and Sustainable Development (1992), agreed at the United Nations Conference on Water and the Environment,¹⁶ established the principle that water should be considered as an economic good. Principle No. 4 states: “Water has an economic value in all its competing uses and should be recognised as an economic good... Past failure to recognise the economic value of water has led to wasteful and environmentally damaging uses of the resource. Managing water as an economic good is an important

“NEW APPROACHES ARE NEEDED FOR FINANCIAL DECISIONS TO CAPTURE THE VALUE OF BENEFITS DERIVED FROM AVOIDING THE COSTS OF DEPLETING AND DEGRADING WATER ASSETS. THE WATER INDUSTRY AND REGULATORS NOW HAVE THE OPPORTUNITY TO FIND WAYS TO DEVELOP MORE EFFECTIVE INTEGRATED WATER MANAGEMENT AND RESOURCE ALLOCATIONS BEFORE STOCKS AND FLOWS DETERIORATE.”

way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources.”

2.2.2 Murray-Darling Basin Plan to address externalities

Economic literature on the Murray-Darling Basin illustrates the extent to which economic reasoning can contribute to an understanding of environmental problems and to the development of appropriate policy responses.¹⁷ The Murray-Darling Basin is the catchment for the Murray and Darling rivers and their many tributaries, covering over one million square kilometres (km²) or 14% of Australia.¹⁸ The Basin includes half of Victoria and 23 river valleys and generates one-third of Australia’s food supply and 39% of national income from agricultural production. Water supplies directly support more than three million people.

The Murray-Darling Basin Authority aims to avoid the world’s third-largest catchment playing out the “tragedy of the commons”,¹⁹ where individual self-interest leads to resource destruction. Without management change, water-dependent ecosystems in the Basin will continue to be degraded (see box). The Authority has therefore consulted on a Murray-Darling Basin Plan that aims to restore the system to a state that enables it to avoid lasting damage to rivers, wetlands, forests and soils.²⁰ The plan provides an integrated and strategic framework that includes sustainable diversion limits that generate costs and benefits.²¹ Restoring regular flows will deliver environmental, economic and social benefits, including the improved capacity of rivers and floodplains to provide “ecosystem services” such as increased carbon and nutrient recycling leading to improved soil and water quality, and in turn productivity benefits; groundwater replenishment; a significant reduction in the economic losses associated with algal blooms and salinity; and growth in recreation and tourism industries generated by healthy rivers.

To support the development of the diversion limits, environmental valuations were carried out. Research by Morrison et al (2010),²² used a Total Economic Value framework (see page 12) to review market and non-market studies for the Murray-Darling Basin to provide evidence of the economic benefits of environmental improvements in the Basin. The study recommended capacity building in the areas of environmental valuation. New approaches are needed for financial decisions to capture the value of benefits derived from avoiding the costs of depleting and degrading water assets. The water industry and regulators now have the opportunity to address this challenge in other catchments, and to find ways to develop more effective integrated water management and resource allocations before stocks and flows deteriorate.

BOX 1 External costs internalised in the Murray-Darling Basin

Irrigation has caused salinisation in the Murray-Darling Basin. This has damaged agricultural production, imposing economic costs of more than AUD300 million per year and affecting drinking water quality.²³ Removing too much water from the Basin’s rivers, wetlands and floodplains is causing environmental decline, with falls in bird and fish numbers, and outbreaks of acid sulphate soils that can affect the health of rivers and wetlands. These changes have reduced the environment’s ability to perform important services such as pollination, fish breeding, nutrient recycling and soil replenishment. An audit of the ecological health of the Basin, which looked at factors including hydrology and physical habitat, found long-term degradation in most valleys.²⁴ The main problem is diffuse or nonpoint externalities, which arise when many firms or individuals contribute to an external effect on one or more others.

The Murray-Darling Basin Authority used best available economic techniques to estimate the use and non-use values of benefits of the Basin Plan, which provides a high-level framework to manage water resources in a coordinated, sustainable and integrated way.²⁵ The value of use benefits is estimated at approximately AUD100 million per year, under a scenario for the proposed recovery of 2,750 gigalitres of surface water per year.²⁶ This includes benefits to tourism, floodplain agriculture, recreational and commercial fishing, recreational boating, as well as benefits from avoided costs – for example, associated with managing salinity, water quality and preventing erosion. The plan recognises that it is essential to manage water resources to take account of environment damage and water quality.

2.2.3 Environmental valuations needed in Victoria

The Yarra River catchment is the largest in the Port Phillip and Westernport region, covering over 4,000 km² and supplying around 70% of Melbourne's drinking water in 2011-12.²⁷ Water is set aside for the environment through an Environmental Water Reserve to help maintain Yarra River's many important environmental assets. Some 4,771,000 cubic metres (m³) of water were released in the Yarra River in 2011-12 to improve the habitat for aquatic animals; support fish species; increase flood tolerant vegetation; maintain the shape of the river channel; and avoid a decline in water quality.²⁸

Under the Water Industry (Environmental Contributions) Act 2004, water utilities in Victoria must pay an environmental levy to the Department of Sustainability and Environment to fund initiatives that aim to promote sustainable water management or address adverse water-related environmental impacts. Yarra Valley Water, which serves 42% of the Melbourne population,²⁹ currently pays an annual environmental levy of AUD17.5 million. This is set to increase to AUD29.9 million by 30 June 2016.³⁰

The Victorian River Health Strategy (2002) provides a framework for managing and restoring rivers over the long term. It outlines the importance of a partnership approach to ensure careful evaluation informs decision-making to avoid serious or irreversible environmental damage. Initiatives include valuations of natural capital assets such as ecological vegetation and fish populations to develop a risk-based approach to setting priorities for river protection and restoration.³¹ Evaluations could be used to assess projects and incorporate externalities into funding decisions.

The Ministerial Advisory Council (MAC) report "Living Melbourne, Living Victoria Roadmap" (2011) outlines plans to overhaul the water planning framework to transform the way water resources are managed.³² Priorities for reform include establishing a common approach to economic evaluation and supporting the analysis of projects and options based on community cost.

An independent National Water Commission oversees the Council of Australian Government's National Water Initiative (2004), which aims to increase the productivity and efficiency of water use and to ensure the health of river and groundwater systems. This will be done by establishing clear pathways to return systems to sustainable levels of extraction and increasing the quantity of water for the environment.³³ Under the initiative, States and Territories agreed to manage environmental externalities through regulatory measures, to examine the feasibility of using market-based mechanisms such as pricing to account for environmental externalities linked to water use, and to implement pricing that includes externalities where feasible.

In 2011, the Commission reported inadequate approaches to address over-allocation or over-use and found that arrangements for managing externalities were still required, to determine whether they are optimal. In particular, the States and Territories should "transparently and rigorously determine externalities of concern to the community, the party with accountability for each externality, and the effectiveness of existing and alternative approaches (including externality pricing) for managing the externality."³⁴

2.3 WHITE PAPER TO SUPPORT ECONOMIC VALUATIONS OF WATER SERVICES

Challenges include measuring externalities and finding ways to incorporate environmental benefits alongside financial costs in decision-making. This reflects growing recognition in the water industry and government of the need for a common economic evaluation framework that fairly and rigorously assesses the direct and indirect costs and benefits associated with Integrated Water Cycle Management (IWCM) initiatives.³⁵

Yarra Valley Water therefore commissioned global environmental economics experts Trucost to estimate the "value of water", to help inform thinking on options to deliver measurable, sustainable outcomes. Trucost analysed the total value of water in the region to enable Yarra Valley Water to continue to provide sustainable and economically-efficient water management within the carrying capacity of nature. This White Paper builds on the results and aims to provoke discussion among the water industry, regulators and researchers to develop approaches to integrate the total economic value of water into decision-making. This could inform plans to help deliver water infrastructure with environmental outcomes that benefit communities. The goal is to allocate resources to manage water in a way that avoids or limits environmental degradation, rather than incurring the costs of damages later.

“COMPREHENSIVE VALUATION OF ECOSYSTEM SERVICES IS NOT YET A PRECISE SCIENCE, BUT THE PROCESS ILLUMINATES THE POTENTIAL STAKES AND PROVIDES GOOD COMPARATIVE INDICATIONS OF WHERE PRIORITIES SHOULD LIE.”

United Nations World Water Development Report 4, Managing Water under Uncertainty and Risk, 2012

Valuation is essential to understand the true value of environmental assets and business ventures, according to a study by The Economics of Ecosystems and Biodiversity (TEEB) on how business can identify and manage biodiversity and ecosystem risks and opportunities.³⁶ It says that while information on economic valuation may not be perfectly accurate, especially where non-market values are at stake, it can improve decisions. This White Paper is among Yarra Valley Water’s initiatives that are in line with TEEB’s recommendation for business to:

- Broaden risk assessment and management practices to reflect the materiality of biodiversity and ecosystems.
- Build internal capacity to understand and implement existing standards, frameworks and methodologies; data collection-based tools; as well as modelling and scenario building tools.
- Use biodiversity and ecosystem services valuation to improve decisions around risk management.
- Actively pursue engagements and partnerships with a range of stakeholders.

2.3.1 Valuing water to make decisions that protect natural capital

Water provides far reaching and essential benefits through drinking water, maintaining biodiversity and supporting industrial development. Water underpins ecosystem services such as food production, climate regulation, soil fertility, carbon storage and nutrient recycling. Ecosystem services important to water utilities include protection of water quality and quantity through the water cycle and hydrological processes.

Scarcity and misuse of water create risks to humans, economies and ecosystems. Risks include increased water stress, supply shortages, higher costs of sourcing raw materials such as freshwater, disruptions to business operations and supply chains caused by water restrictions or natural hazards, and higher insurance costs for disasters such as flooding or fire. The economic costs can be material. Opportunities include benefits from increasing water-use efficiency or maintaining or restoring wetlands to eliminate the need for new water treatment infrastructure, and maintaining supplies for future agricultural and industrial production.³⁷

A 2012 United Nations report on Managing Water under Uncertainty And Risk³⁸ highlights the importance of understanding the central role of ecosystems in sustaining the water cycle, and describes tools to assess how risks are generated and transferred. Identifying the full range of ecosystem services involved, where the risks are, who is vulnerable to them and why, can inform an inclusive, holistic and participatory approach to water policy and management. Decisions that favour one ecosystem service over, or at the expense of, another involve trade-offs that can transfer risks. “Water demand” by ecosystems therefore involves identifying ecosystem “deliverables” and managing water accordingly. The UN report says that the valuation of these services is central to this. Valuation of ecosystem goods and services is increasingly considered in integrated water resources management (IWRM) and planning in order to reconcile economic development and ecosystem maintenance.

Growing recognition by governments that water resources are important to national economies, but largely unaccounted for, is fuelling developments in water accounting alongside broader environmental accounting. Initiatives include the UN System of Environmental-Economic Accounting for Water (SEEA), which provides an analytical framework for environmental accounting. The Australian Bureau of Statistics used this to produce experimental water accounts to match physical flows of water to monetary transactions in Australia for the year 2004/05.³⁹ 41% of developed countries are assessing water resources and starting to value water-related or dependent ecosystem services.⁴⁰ Many countries are implementing policies and laws that recognise that water users and polluters should pay for the costs they impose on society through systems for payment for water resources management services, such as supply of raw water and pollution management.

Hybrid water accounts enable the economic costs and benefits of water supply to be matched with physical data on stocks and flows to inform more efficient water allocations.⁴¹ By looking at the value of water, business can better inform management actions and limit wasteful practices.⁴²

3. FINDINGS

Trucost's analysis revealed that the indirect use value of water to Melbourne is significant, averaging AUD5.85 per m³ between 2003-04 and 2010-11. This translates into a natural capital asset value of about AUD2 billion. The indirect use value of water in a year when it was relatively scarce was five times higher than in a year when supply and demand were more balanced. The hydrological functions of water provide the greatest value to the environment, mainly due to the indirect use value of groundwater recharge.

The un-priced indirect use value of water is far higher than its direct use value, based on current market prices for residential users (AUD1.90 per m³). Households would be willing to pay AUD1.89 to avoid reducing water availability by one m³. The gap between the indirect use value of water and willingness to pay is even wider for industrial users. They would be willing to pay a weighted average value of AUD1.25 for each additional m³, far less than its indirect use value.

Findings indicate that water is undervalued as a resource, particularly by manufacturers. Some sectors value water more highly than others, based on the marginal productivity of the natural resource as an input. The Automobiles and Construction sectors value water far more highly than do the Paper and Food industries, despite their high dependency on water as a key input.

The non-consumptive use value of water, based on recreational fishing, is estimated at AUD126 million. Evaluating all ecosystem services that support, or could be depleted by, management options can help strengthen decisions to allocate resources.

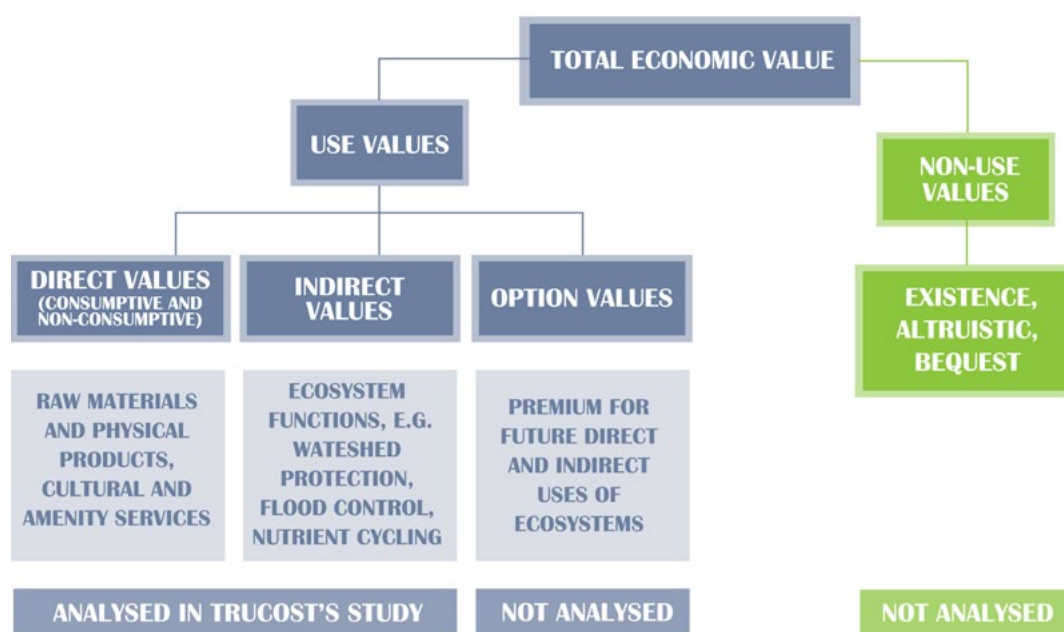
3.1 METHODOLOGY OVERVIEW

This White Paper aims to inform thinking around water and ecosystem valuations in the context of water resources from catchments in Victoria. Trucost conducted an extensive academic literature review to assess the value of water to society in Melbourne.

Several methodologies used in this analysis are also included in the UN System of Environmental-Economic Accounting for Water (SEEA-Water), adopted by the United Nations Statistical Commission in 2007.⁴³ The SEEA-Water framework provides a conceptual framework for integrating water-related and economic information in a coherent and consistent way, based on the UN System of National Accounts (SNA) – a widely-accepted international standard for monitoring economic policies.

The SEEA-Water highlights the Total Economic Value (TEV) framework as one approach to valuing water. Pearce and Turner (1990)⁴⁴ developed the TEV framework to estimate welfare values based on two main categories: Use and non-use values of environmental resources. Use values and non-use values can be estimated for the range of market and non-market benefits that are provided by water bodies and related ecosystem functions. The UN Food and Agriculture Organization (FAO) recommends the TEV framework to value ecosystem services based on the different types of uses drawn from them – direct use, indirect use and the value of keeping the option open to use them later (see Figure 2).⁴⁵

FIGURE 2: COMPONENTS OF THE TOTAL ECONOMIC VALUE OF WATER



SOURCE: WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT (2009), BUSINESS AND ECOSYSTEMS, ISSUE BRIEF, CORPORATE ECOSYSTEMS VALUATION

Direct use values are calculated for water-based or water dependent raw materials or physical products that are used directly for production, consumption and sale. Market prices and “willingness to pay” can be used to estimate the value of consumptive uses of water, including as an input to manufacturing and to meet the basic needs of households. Benefits from non-consumptive uses of water, such as recreation, can also be estimated based on willingness to pay.

Indirect use values are based on the regulating and supporting services provided by ecosystems, such as water purification, groundwater replenishment and biodiversity conservation.

Option values reflect the value of preserving ecosystems for potential future direct or indirect uses.

Non-use values, such as the cultural, aesthetic or heritage worth, are intrinsic to water, regardless of its potential use. An individual might value preserving an ecosystem service without ever using it, or gain satisfaction from knowing that an ecosystem will be conserved for future generations.⁴⁶

TEV was used in this analysis to estimate the economic value of water resources and related ecosystem services, based on their value to those who benefit from them.^{47, 48} This study estimates the use values and indirect use values of water abstracted and distributed by Yarra Valley Water. Option and non-use values were not included in valuations due to limitations in quantifying their monetary value and the difficulty in relating the values to Yarra Valley Water’s supply. The SEEA-Water framework recommends addressing the valuation challenge by including values for all water services that can be estimated with fairly reliable data and techniques.⁴⁹ Excluding option and non-use values from valuations from this analysis helps limit uncertainty inherent in methods and assumptions currently available to derive the economic value of water.

The “cost” of water consumption is the change in the TEV. Values are calculated in Australian Dollars (AUD) and adjusted for inflation to reflect 2012 prices. Inland waters can be measured using a systems approach, which concentrates on measuring stocks and flows.⁵⁰ Stocks are the quantity of a natural resource at a point in time. Flows are the quantity that is added or subtracted from a stock during a specific period of time.⁵¹ This study applied economic valuations to flows of water measured in kilolitres or cubic metres (m³). Estimates are made up of both marginal and average values. The exception is for non-consumptive use of water, where values are aggregated due to complexities in calculating values for fishing for each m³ of water stocks and flows.

**“THE INDIRECT
USE VALUE OF
WATER SUPPLIES
TO MELBOURNE
AMOUNTS TO
AN ESTIMATED
AUD5.85
PER M³.”**

AUD2 B

**The value of the
ecosystem
functions of
natural water
assets**

3.2 INDIRECT USE VALUES

Key findings: The analysis revealed that the indirect use value of water required to supply Melbourne amounts to an estimated AUD5.85 per m³, with total natural assets valued at about AUD2 billion. Variability in water scarcity over time contributes to wide fluctuations in indirect use values year on year. The value of water to Melbourne ranges from AUD1.66/m³ in 2010-11, when water was relatively abundant, to AUD8.97/m³ in the most water-scarce year analysed. The hydrological function has the highest indirect use value of the ecosystem functions analysed (AUD4.85/m³). Of the hydrological functions analysed, groundwater recharge has a far more significant value than freshwater replenishment. Groundwater recharge is the most valuable ecosystem function, and accounts for almost three-quarters of the total indirect value.

Three ecosystem functions of water were analysed – hydrological, biochemical and ecological. These were ranked based on estimates of their indirect economic values (see Table 1). Trucost derived the economic value of each function, and adjusted results according to the ecosystem characteristics of the area from which Yarra Valley Water sources supplies.

TABLE 1: RANKING OF INDIRECT USE VALUES OF WATER – ECOSYSTEM FUNCTIONS

SYSTEM FUNCTION	NUMBER OF STUDIES IN LITERATURE REVIEW	INDIRECT USE VALUE (AUD/M ³)
Hydrological (e.g. groundwater recharge and freshwater replenishment)	54	4.85
Biogeochemical (e.g. waste assimilation)	45	0.71
Ecological (e.g. Habitat maintenance)	158	0.29
TOTAL	257	5.85

3.2.1 Why is the groundwater recharge value so high?

Groundwater recharge accounts for 73% of the total indirect use value of water (AUD5.85/m³). The inland water resource system of a territory is composed of surface water, groundwater and soil water, and the flows between them.⁵² Groundwater generates regulating and supporting ecosystem services from which people indirectly benefit. Terrestrial vegetation, river base flow systems, aquifer and cave ecosystems, terrestrial fauna, estuarine and near-shore ecosystems are among the many ecosystems that depend on groundwater.⁵³ Small changes in the quantity or quality can damage dependent ecosystems.

Groundwater plays an important role in the hydrological cycle, to store and release water. Aquifers' water discharges sustain river flows, springs and wetlands. Groundwater's longer residence time compared to surface water enables it to maintain stream flow during dry seasons or droughts.

Groundwater's biological components generate water purification and waste treatment. As water goes through the ground, biological processes reduce concentrations of many contaminants. Groundwater is a key factor in the control of erosion and floods by absorbing runoff. It is also important for water and nutrient cycling.

Groundwater is particularly important to maintaining significant wetlands and other ecosystem services in the region in which Melbourne sources its water, where overall extraction levels of groundwater are low compared to the average for Australia. Groundwater extraction in the catchment area from which Yarra Valley Water sources supplies is equivalent to 1% of renewable surface water, compared with 14% nationally. This low ratio suggests that the volume of groundwater is relatively small in the region. Hence, the groundwater recharge value for one cubic metre of water is high compared to other indirect use values.

“THERE WAS A WIDE VARIATION IN WATER SCARCITY, WITH VALUES RANGING FROM 33% IN 2010-11 TO 77% IN 2006-07.”

AUD1.66
per m³
–
AUD8.97
per m³

The range in indirect use values of water to Melbourne between 2003-04 and 2010-11

3.2.2 Calculating indirect use values

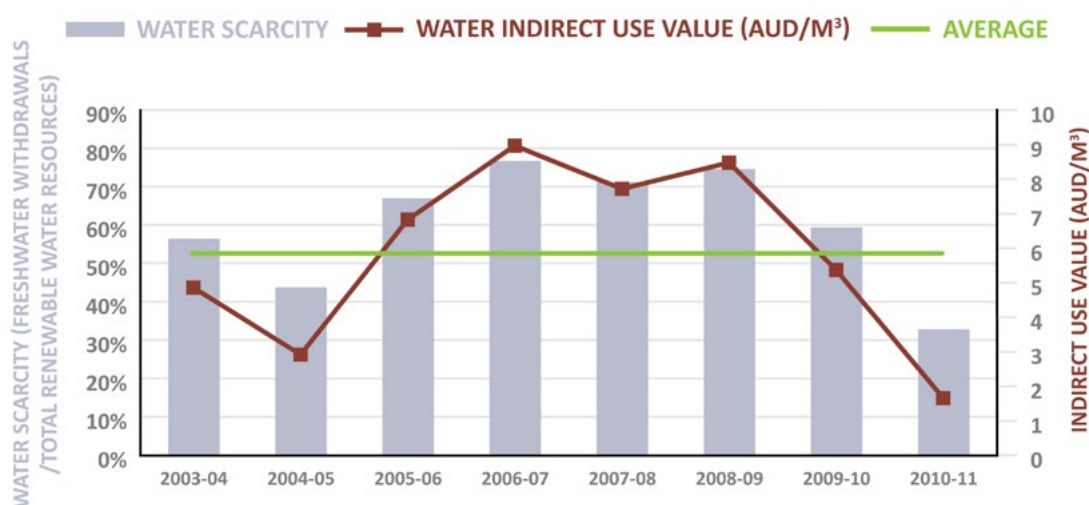
Indirect use values are estimated for biodiversity, groundwater recharge, and other ecological functions identified in academic literature. More than 200 studies in different locations were reviewed to estimate values. Water scarcity is measured as freshwater withdrawals as a percentage of total renewable water resources. Data from 2000 to 2010 from the FAO Aquastat database were used to build Trucost’s valuation model and calculate average water scarcity in Australia.⁵⁴ The analysis of water availability in the hydrological basins supplying Melbourne was based on annual data from the Department of Sustainability and Environment of Victoria between 2003-04 and 2010-11. Water scarcity is calculated based on resources and withdrawals in the Yarra basin, which supplies the majority of water used in Melbourne.

Water accounting is evolving and progress was made in the Victorian Water Accounts in 2006-07, when groundwater within the boundaries of river basins was recorded for the first time. Water scarcity in the hydrological basin supplying Melbourne is calculated as megalitres (ML) of surface water withdrawals relative to total available surface water resources between 2003-04 and 2005-06. Between 2006-07 and 2010-11, it is measured as ML of groundwater and surface water withdrawals as a percentage of total available groundwater and surface water resources. There was a wide variation in water scarcity, with values ranging from 33% in 2010-11 to 77% in 2006-07. Water withdrawals equated to 60% of total renewable resources on average over the eight annualised periods analysed.

A benefit transfer approach was applied to estimate the values of the ecological functions in different areas with varying degrees of water scarcity. A benefit transfer occurs when an estimated value, based on original studies (study sites), is transferred to a site where the new value estimate is needed, known as the “policy site”.⁵⁵ Trucost found a strong relationship between the value of water’s ecosystem functions and water scarcity. A function can be used to estimate the social cost of water in any location where the scarcity is known. The value of water’s ecosystem functions is highly correlated to water scarcity, which varies over time. Changes in water scarcity will therefore contribute to rises or falls in indirect use values for ecosystem services year on year.

Figure 3 shows the variability in water scarcity between 2003-04 and 2010-11 and related fluctuations in the indirect value of water harvested to supply Melbourne. The indirect use value of water to Melbourne ranges from AUD1.66 per m³ in 2010-11 to AUD8.97 per m³. The mean indirect use value of water over the eight years analysed is estimated at AUD5.85/m³.

FIGURE 3: VARIATIONS IN WATER SCARCITY AND INDIRECT USE VALUES FROM 2003-04 TO 2010-11

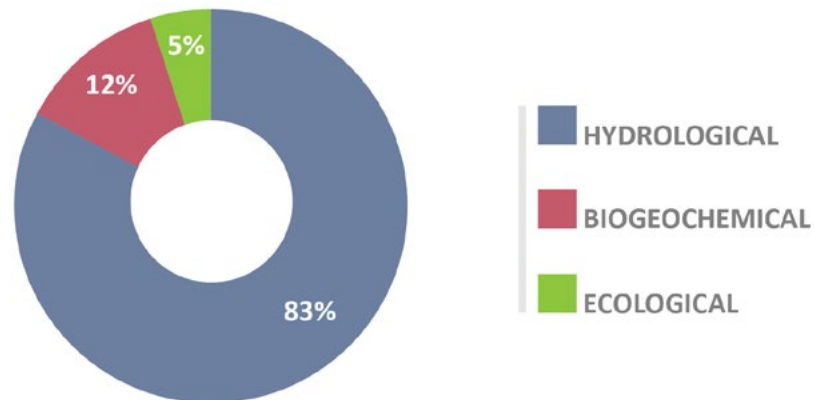


The three metropolitan retailers – Yarra Valley Water, City West Water and South East Water – withdrew 343,600,000 m³ of water to supply customers in Melbourne in 2010-2011.⁵⁶ At AUD5.85/m³, the value of water to Melbourne translates into the consumption of a natural asset valued at more than AUD2 billion. This is far higher than the net value of revenue from urban water sales to the retailers (AUD1.2 billion in 2010-11).⁵⁷ At 1.66 per m³, the ecosystem function value of water used in Melbourne in 2010-11 would amount to

more than AUD570 million. If scarcity levels had been as high as in 2006-07, water assets would be valued at more than AUD3 billion. Planning could take account of the range in valuations and weight forecasts of external costs based on variability in water availability and probability functions. This could take account of the materiality of economic, environmental and social costs from water shortages. The costs of averting shortages are likely to be outweighed by the high costs of inaction.

Figure 4 shows a breakdown of the indirect use value of water in the catchments supplying Melbourne by ecosystem function.

FIGURE 4: BREAKDOWN OF INDIRECT USE VALUES OF WATER TO MELBOURNE



3.3 DIRECT USE VALUES

Direct use values are estimated for consumptive and non-consumptive uses of water. Municipal water utilities provide clean drinking water and remove wastewater for two main customers: Residential households and commercial and industrial users. Non-consumptive values are estimated for recreation.

3.3.1 Consumptive

Key findings: The weighted average market price of water for residential users (AUD1.90 per m³) is in line with the value they are willing to pay (AUD1.89 per m³). Industrial users undervalue water as an input, as their willingness to pay (AUD1.25 per m³) is lower than the average weighted market price (AUD1.91 per m³). However, some sectors value water more highly than others. The Automobiles sector would be willing to pay 32 times more than the Paper industry for each additional m³ of water.

TABLE 2: DIRECT USE VALUES USING WATER DEMAND FUNCTION FOR WILLINGNESS TO PAY

WATER USERS	DIRECT USE VALUE	WEIGHTED AVERAGE VALUE (AUD/M ³)
Residential	Market price	1.90
	Willingness to pay	1.89
Industrial	Market price	1.91
	Willingness to pay	1.25

3.3.2 Calculating consumptive direct use values

Residential uses

The direct use value calculated in this study includes:

- The price charged for residential use.
- An estimate of an individual's willingness to pay (WTP) per kilolitre increase in residential water provided by Yarra Valley Water.

Price charged for residential use

The price of water charged to households mainly covers infrastructure, maintenance and operations, including energy costs to distribute clean water and treat wastewater. Energy use for wastewater disposal is about eight times higher than for water supply in the Melbourne region.⁵⁸ Yarra Valley Water distributes water to 660,000 residential customers in the Yarra Valley Water Area. Prices vary depending on how much water a household uses per day. Based on tariffs in 2012/2013, the weighted average charge to residential customers is AUD 1.90 per kilolitre (kl), equivalent to one cubic metre (m³).

Willingness to pay

Key findings: Residential clients would be willing to pay the weighted average price of AUD1.89 per kl. Households would pay AUD1.89 to avoid water supplies being restricted by one m³, at the weighted average market price of AUD1.90 per kl. Based on the range of residential price tariffs, the marginal willingness to pay to avoid a marginal reduction in water supply of one m³ is estimated to range from AUD1.76/m³ to AUD3.05/m³.

Residential water demand fluctuates, with many empirical price studies showing price to be the most important driver of consumption levels.^{59,60} The Australian Bureau of Statistics found that a 17% increase in household water prices from an average of AUD2.10 per kl in 2009/10 to AUD2.44 per kl in 2010-11 coincided with an 8% decrease in household water consumption to 1,699,000,000 m³ in Australia.⁶¹

The WTP for water is based on the consumer price surplus. Economic models and techniques focus on estimating consumer surplus – the difference between the benefits that people gain from the use of a good and the actual price paid for it. Trucost used a water demand function (Gibbons, 1986)⁶² to measure the marginal value of water to individuals. This function estimates the change in demand with incremental changes in cost per unit of water.

The marginal value of water is an estimate of the WTP for an incremental increase in water quantity or to avoid a unit reduction in water supply. When demand is elastic, a small change in water price causes a large change in the quantity demanded. In contrast, when demand is inelastic, a small change in price results in a small change in water demand. Academic studies indicate a wide range in estimated values for the price-elasticity of water demand. Income, rainfall, evapotranspiration, pricing structure and season influence estimates of price elasticity.⁶³ Water restrictions can also influence demand. Water companies in Melbourne use a Water Outlook Framework to decide on levels of restrictions based on factors such as dam levels, catchment levels and demand trends.

Estimates of WTP for water were adjusted to Australia and calculated for each price step offered by Yarra Valley Water (Table 3).

TABLE 3: RESIDENTIAL TARIFFS PROVIDED BY YARRA VALLEY WATER AND ESTIMATED WTP

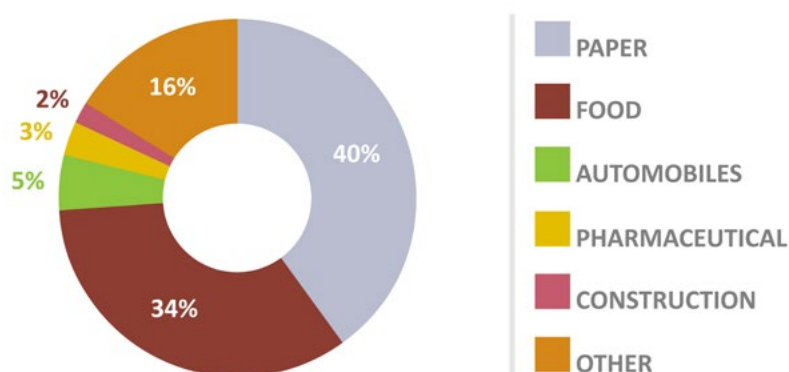
TARIFF	MARKET PRICE (AUD/KL)	% YARRA VALLEY WATER RESIDENTIAL CUSTOMERS	WILLINGNESS TO PAY (AUD/KL)
1	1.7756	78%	1.76
2	2.0832	16%	2.07
3	3.0778	6%	3.05
WEIGHTED AVERAGE	1.9029	100%	1.89

“INDUSTRIAL USERS UNDERVALUE WATER AS AN INPUT, AS THEIR WILLINGNESS TO PAY (AUD1.25 PER M³) IS LOWER THAN THE INDIRECT USE VALUE.”

Commercial and industrial uses

More than three-quarters of the water supplied by Yarra Valley Water to commercial users goes to industrial/manufacturing sectors, such as textiles and plastics producers. Trucost focused on the five sectors that use the most commercial water supplied by Yarra Valley Water – Paper, Food, Automobiles, Pharmaceutical and Construction (see Figure 5).

FIGURE 5: DESTINATION OF YARRA VALLEY WATER’S INDUSTRIAL WATER DISTRIBUTION



The study estimates the direct use value of water used by industrial/manufacturing customers based on:

- The price charged for industrial use.
- An estimate of a business’s WTP per kilolitre increase in water provided by Yarra Valley Water.

Water tariffs for industrial/manufacturing use

Industrial/manufacturing water pricing for Yarra Valley Water supplies is around 1.91 AUD/m³.⁶⁴

Willingness to pay

Key findings: The five sectors analysed would be willing to pay the weighted average value of AUD1.25 per m³. Estimates of the marginal value of water across the sectors range from AUD0.16 per m³ for Paper to AUD5.11/m³ for Automobiles. The marginal values reflect willingness to pay for each additional m³ of water.

Academic studies were used to derive industrial/manufacturing water use estimates. Aylward et al (2010) found a range of use values from US\$0.01/m³ to US\$6.94/m³ (AUD0.01-6.58).⁶⁵ A study by Wang and Lall (2002)⁶⁶ valued water in China using a marginal productivity approach, estimating the variation in production or revenue caused by a change in one unit of water consumed. The study obtains a wide range of direct use values for water across 16 sectors.

The results of the Wang study were used to value water use in production processes in Melbourne, taking sector-specific factors into account. Results indicate a wide range of marginal productivity values for water across the five sectors analysed, as shown in Table 4.

TABLE 4: MARGINAL PRODUCTIVITY OF WATER IN 2012 VS. LEVELS OF WATER SUPPLIED BY YARRA VALLEY WATER

	PAPER	FOOD	PHARMACEUTICAL	CONSTRUCTION	AUTOMOBILES
AUD/m ³	0.16	0.49	0.62	1.47	5.11
Megalitres (1,000 m ³) ⁶⁷	4,573	3,681	308	279	609

3.3.3 Non-consumptive

Key finding: The non-consumptive direct use value of water amounts to an estimated AUD126 million. This is based on the value of access to waterways and recreational sites around Melbourne, where some 33 million visits are made annually.

Calculating non-consumptive direct use values

Direct non-consumptive values estimate the value of water's contribution to human wellbeing, without impacting the availability of water. This analysis focuses on the value of water for recreational fishing in Melbourne and its supply catchments. Academic studies on the value of recreational activities in the region focus on fishing, therefore this is taken as a proxy for all water-related activities.

Random utility models are used to understand and evaluate consumer surplus in recreational activities linked with environmental services. They are elaborated travel cost models that assume people make trade-offs between the expected benefit of visiting a site and the cost incurred to reach it. Modelling analyses how individuals select preferred sites. Flexible random utility model techniques (Sandefur et al., 1996)⁶⁸ involve estimating the probability of an individual choosing a site given various characteristics of the site and similar alternatives in an area. Based on a function of the costs and the expected benefits from those alternatives, they draw conclusions about the value that individuals place on a given environmental service.

This analysis is based on a study of fishing and recreational activity in Western Australia to help policy makers assess all of the financial implication of degrading fish stocks (Raguragavana et al., 2010).⁶⁹ Empirical data for the study came from a National Survey of Recreational Fishing 2000/2001, commissioned by the Department of Fisheries. It includes log book surveys of 778 anglers and analysed 48 fishing sites. The mean value of welfare per fishing trip for all of the sites analysed totalled AUD3.81. The study also calculates the total annual value of access to recreational fishing as the average site access value multiplied by the number of fishing days in a region.

These findings were used to evaluate the recreation activities and fishing for Melbourne. Approximately 33 million visits are made to waterways and recreational sites situated in the region. At AUD3.81 per visit, the total annual access value is estimated at AUD125.8 million. The analysis does not distinguish between people visiting sites for fishing and other recreational activities. Research suggests that individuals value the experience of being in the natural environment more than the physical result of fishing.

3.4 ADDRESSING LIMITATIONS AND UNCERTAINTIES

Since water is an essential commodity in economic terms, its value is infinite in terms of willingness to pay for a basic survival amount.⁷⁰ However, once basic needs are met, economic valuation can make an important contribution to decisions about water management. Economists have developed many techniques to estimate prices to address market distortions, mainly for cost-benefit analysis of projects and policies.⁷¹ A greater focus on the quality and availability of water, ecosystem services, climatic and socio-economic data could help address current limitations and uncertainties. These include:

- Not all of the benefits of water in its different uses can be quantified or expressed in monetary terms. Failure to fully value all of these benefits could contribute to water mismanagement.⁷²
- The standard approach to calculate TEV is to sum all individual components. In practical terms, this is limited to components that can be quantified. However, for ecosystems services, these may be non-additive, and simply adding their values may underestimate the "true" value of ecological services. For instance, the in-stream use value of water recognises its regulating service in maintaining water flow, but does not account for damage mitigation from reductions in sediment load. Producing only one value for two types of services results in underestimates of total value.⁷³
- Valuation studies often produce a range of values because of the uncertainty and judgement underlying the method and its implementation.
- Trucost assumed that half of the groundwater reported in the Victorian Water Accounts from 2006-07 onwards was already accounted for as surface water, to address issues with double counting.⁷⁴ The

amount of groundwater used in calculations is therefore half of that reported. This is unlikely to have a material effect on results, since groundwater equates to a maximum of 1% of surface water in the period analysed.

- The timing of water availability, the quality of water and the reliability of its supply are important determinants of the value of water.⁷⁵
- The estimate of the indirect use value of water to Melbourne is based on data on water scarcity in the Yarra basin, which delivers water to several reservoirs used to supply the city.⁷⁶ More than 90% of entitlements for all three of the Melbourne retailers (Yarra Valley Water, City West Water and South East Water) were for water resources from the Yarra River catchment in 2010-11, with the remainder harvested from the Thompson River, Tarago and Bunyip Rivers and Silver and Wallaby Creeks (Goulburn River basin).⁷⁷ This study uses the level of water scarcity in the Yarra basin as a proxy for levels of water stress in all catchments that supply water to Melbourne. Future studies of the value of water to Melbourne could adjust valuations to take account of water scarcity in the other catchments.
- Taking the specific local context of water supply and demand into account can have high data requirements. Given the variability of water supply in Melbourne over time, valuations using techniques such as willingness to pay are likely to vary in different accounting periods, depending on factors such as season and extreme events such as floods and droughts.

Further analyses could focus on strengthening understanding of impacts and dependence on the hydrological function, in order to focus on the most material use value of water to inform more effective water management. This is in line with Pareto's Principle or the 80/20 rule that about 20% of something is usually responsible for 80% of the results.⁷⁸

Tools that could inform ecosystem assessments and water management include the Corporate Ecosystem Services Review, developed by the World Resources Institute, the World Business Council for Sustainable Development (WBCSD) and the Meridian Institute; and the Global Environmental Management Initiative Water Sustainability Planner Tool.⁷⁹

4. IMPLICATIONS OF FINDINGS

Decision-makers need planning tools which reflect the consequences of decisions on the environment, economy and society. A better understanding of risks would enable the creation of more robust and resilient water systems. Valuing the benefits of water provides one possible approach to improve decisions. Water-related valuations can be used to identify risks and optimal water resource allocations and management options. Valuations of biodiversity and ecosystem services can be included in management and accounting systems to inform decision-making. Effective management of environmental externalities would help ensure that water use and infrastructure and wastewater disposal maximise benefits from resource use.

Environmental valuations could be used to strengthen planning around natural resource use; integrate ecosystems information in business decision-making; include ecosystem services in financial analysis and reporting; and consider externalities in option (investment) appraisals and technology uptake. Companies can consider opportunity costs such as markets for ecosystem services, as well as new revenue streams from water-saving services. Environmental levies could be adjusted to reflect the indirect value of activities that support ecosystem functions. Incentives could help companies cover the costs of projects that reduce externalities and benefit communities. Ecosystem indicators can be useful to communicate environmental performance and challenges.

Findings that each cubic metre of water saved delivers a gain of AUD6 to society could incentivise water savings. The results of this Paper support Yarra Valley Water's environmental valuations that estimate a higher value for water than pricing used in traditional financial analysis. Collaboration is essential to develop standards to measure ecosystem services and change the way water is managed in Victoria. Stakeholders can work together to develop systems to account for water values so that prices better reflect environmental functions. A common framework for environmental valuations in the region could help assess the direct and indirect costs and benefits of projects, programmes, infrastructure and watershed protection to reflect variability in water availability consistently in decision-making. A collective effort can help find ways to manage risk and optimise water use. Industry, researchers and policy makers can collaborate to better allocate water resources and reduce adverse impacts.

Valuing the multiple socio-economic benefits of water provides one possible approach to improve decisions. Risk and uncertainty are inherent in decisions made by water managers and policy makers. The more these risks are understood, the more robustly and resiliently water systems can be designed and managed to reduce the impact of future variability.⁸⁰ Water planners and engineers have to deal with future probabilities of trends and events that are outside the envelope of variability defined by past events – including increasing climatic variability. As water is an input to all economic and social activities, decision-makers need planning tools which reflect the wider consequences of their decisions.

The World Business Council for Sustainable Development (WBCSD) highlighted the business case for water-related valuations. The approach can be used to identify where security of supply may be compromised due to over-use or from ecosystems degradation, and to justify existing or alternative water resource allocations or enhanced watershed management and the optimal societal use of water.⁸¹

While some services are difficult to value, others are easier because information on how much their losses cost is available. Healthy ecosystems deliver clean water and any subsequent investment in treating a human-induced water quality problem can be attributed to the loss of this ecosystem service originally provided for free.⁸² A large proportion of the capital investment and operational cost of physical water infrastructure is in effect expenditure that compensates for the loss of an ecosystem service, which can therefore be used to indicate the value of that service. Evaluating all ecosystem services that support, or could be depleted by, management options can help reduce the uncertainties and risks involved in decisions.

Information on the values of environmental, social and commercial consequences of changing water management provides decision-makers insight into the impact of different resource allocations.⁸³ The UN Committee of Experts on Environmental-Economic Accounting states, “Those determining the development of industries making extensive use of water resources, either as inputs in the production process or as sinks for the discharge of wastewater, need to be aware of the long-term consequences on water resources and the environment in general.”⁸⁴

Allocating scarce water to competing uses lies at the heart of water management.⁸⁵ Choices must be made about how to share, allocate and reallocate increasingly scarce water. Accounting for benefits in water valuation could lead to more efficient water allocation and management, and inform strategic decisions to adapt to growing water stress and supply-demand imbalances. Optimisation models can be used to estimate marginal values for water based on its “optimum” allocation and the corresponding reconfiguration of economic activity and prices.⁸⁶

Environmental valuation is increasingly used in cost-benefit analysis. Economic valuation can be used to develop a more complete picture of the costs and benefits of changing ecosystem services. Environmental levies for water companies could be adjusted according to the indirect value of operating activities that support the maintenance of ecosystem functions. Incentives could help companies to cover the costs of projects that have community value and reduce externalities but may not be preferred options in traditional financial analysis within an organisation’s legal boundaries. Taxes or subsidies could be used to internalise externalities, by equating the marginal private cost of activities that reduce externalities with the marginal social benefits.⁸⁷

Valuations are used to understand stakeholder preferences, in pricing decisions and in litigation in locations including Australia, the United States, Europe and New Zealand.⁸⁸ Valuations are most often used by public policy makers to assess the social values of ecosystem services, but can be applied by industry to evaluate impacts and dependencies. The potential of economic valuation techniques to assess the value of ecosystem services for project appraisals is illustrated in the case studies in this section.

CASE STUDY New York City watershed protection saves billions

In the U.S., the Hudson and Delaware rivers provide 90% of water in a watershed used to supply approximately 1.3 billion gallons of drinking water per day to New York. Declining water quality in the 1990s prompted New York City officials to take measures to ensure adequate drinking water supplies. They compared the cost-effectiveness of a watershed protection plan to safeguard the ecosystems’ capacity to provide water filtration services with building a filtration plant. The plant was estimated to cost up to US\$6 billion for construction, with approximately US\$300 million (AUD288 M) in annual operating expenses. Protecting the watershed involved regulating land use at an estimated cost of US\$2.7 billion (AUD2.6 B).⁸⁹ New York City negotiated land acquisitions and management agreements with landholders to protect the watershed at a cost far lower than the filtration plant.⁹⁰

“FINDINGS THAT EACH CUBIC METRE OF WATER SAVED DELIVERS A GAIN OF AT LEAST AUD5 TO SOCIETY COULD BE USED TO INCENTIVISE WATER SAVINGS.”

Informed decision-making implies integrating biodiversity and ecosystem services into business management and accounting systems. TEEB outlined how ecosystem indicators can be useful to support effective risk and opportunity management and to communicate related performance and challenges to stakeholders.⁹¹ Organisational boundaries might need to be extended beyond operational, legal or financial boundaries to take account of ecosystem impacts or influences. Materiality assessments to prioritise issues need to consider scale and time frames.

Business valuation techniques can be used to take account of the value of impacts on biodiversity and ecosystems. The TEEB study outlines how capital investment decisions that identify opportunities to generate cash flows within a given time frame can use a variety of discount rates, including zero and negative rates, to take account of potential biodiversity loss and ecosystem degradation that is likely to lead to lower levels of some ecosystem services for future generations.⁹² Although discounted cash flow modelling and other valuation techniques can account for uncertainty, probabilities need to be defined for different outcomes. A draft study by Frontier Economics⁹³ (2012) recommends action to establish a robust framework for assessing investment decisions over the medium to long term.

Companies can consider potential opportunity costs such as investment in ecosystem assets. Guidance by the World Resources Institute provides an overview of ways to assess risks and opportunities related to ecosystem services. Economic valuation can be useful to highlight their economic contributions to societal goals and compare the cost-effectiveness of an investment.⁹⁴ Valuing assets can also help build markets for ecosystem services, such as trading in biodiversity credits to offset or compensate for habitat loss.⁹⁵

Markets are already in place for ecosystem services such as carbon storage and watershed protection. Payments for ecosystem services (PES) can be to land managers and others to undertake actions that increase the quantity and quality of valued ecosystem services, which benefit specific users or society.⁹⁶ Examples include payment for forest protection through a Carbon Canopy partnership in the United States, payments for watershed protection in Costa Rica, Nicaragua, Ecuador and France⁹⁷, and the Carbon Farming Initiative in Australia, where farmers can earn carbon credits by storing carbon or reducing GHG emissions on their land.⁹⁸ Payment for watershed services involves water users paying “suppliers” for delivering clean, reliable water supplies. Water funds that draw on funding streams to invest in conservation and restoration projects include a new US\$27 million (AUD26 M) partnership with the Nature Conservancy to capitalise 32 funds across Latin America by 2015.⁹⁹ The funds are based on the premise that practices upstream can provide water to downstream users, who should pay for their maintenance.¹⁰⁰ Water banks, which deal with droughts by enabling urban use of water normally used in agriculture and compensating farmers for the loss, have been implemented in locations including California, Australia, Chile, Mexico, China and Spain.¹⁰¹

Cross-sector collaboration with sectors such as forestry could be used to develop credible markets. For instance, the High Conservation Value (HCV) framework, developed to support Forest Stewardship Council (FSC) certification, could be adapted for the water industry. The water industry could also transform itself to generate revenue from water savings, rather than increasing consumption. New business models could be developed to deliver water savings, rather than purely generating revenue growth by expanding water consumption. This could draw on other industries. For instance, electric utilities are becoming Energy Services Companies (ESCOs) in Europe, where legislation promotes utilities companies that encourage energy efficiency and renewable energy for more sustainable energy, tackling demand and supply (see Box).¹⁰²

BOX 2 Energy Services Companies drive cost-effective demand reductions

ESCOs help overcome barriers to investments in projects that reduce energy demand. They provide energy-saving equipment and building refurbishment services – also financing or arranging finance for the operation of an energy system. They can provide savings guarantees, with remuneration tied to energy savings achieved. ESCOs guarantee energy savings and/or provision of the same level of energy service at lower cost.¹⁰³ Technologies and practices to reduce water use can also lead to energy savings.

“WATER PRICING AND MARKET-BASED INSTRUMENTS ARE ESSENTIAL FOR SUSTAINABLE WATER MANAGEMENT AND SHOULD SUPPORT EFFICIENT WATER ALLOCATION. WATER PRICES AND TARIFF STRUCTURES HAVE TO REFLECT THE TRUE COSTS OF WATER — INTERNALISING ALL EXTERNALITIES, INCLUDING ENVIRONMENTAL AND RESOURCE COSTS.”

European Environment Agency (2012)¹⁰⁹

CASE STUDY Dow Chemical Company: Wetlands cost less than treatment plant

The Dow Chemical Company and The Nature Conservancy began collaborating in 2011 to value ecosystem services such as clean water provision, to inform business decisions. Based on this evaluation, Dow realised that restoring a wetland for tertiary wastewater treatment at its Seadrift, Texas facility was more cost-effective to meet regulatory requirements than a traditional treatment plant. The cost of the wetland restoration was US\$1.4 million (AUD1.3 M), while the infrastructure equivalent would have cost over US\$40 million (AUD38 M).¹⁰⁴

CASE STUDY New Zealand: Waitaki Catchment valuation reveals materiality of environmental change

The New Zealand Ministry for the Environment used the Total Economic Value framework to evaluate the value of a Waitaki Catchment, in light of potential environmental changes caused by development activities such as hydropower or irrigation. The study looked at how components of TEV can be combined and used to examine the economic efficiency of alternative allocation policies. This required evaluation of changes in non-market values linked to alternative management proposals for the catchment under different scenarios. Estimated non-market values showed that these impacts can be of sufficient magnitude to cause otherwise financially viable developments to fail a cost-benefit test.¹⁰⁵

4.1 POTENTIAL APPLICATIONS

Effective management of environmental externalities helps ensure that water use, water infrastructure and wastewater disposal help maximise the net benefits from resource use. externality pricing typically involves applying a price or tax to reflect the external costs associated with an activity, in order to encourage more socially beneficial behaviour.¹⁰⁶

Findings that each cubic metre of water saved delivers a gain of AUD5.85 on average to society could be used to incentivise water savings. Despite the high value of water when ecosystem services are taken into account, natural water assets do not usually appear on the financial statements of water-intensive companies. Values can be factored into investment decision-making for technologies for reuse and desalination, for example. Valuation can inform liability claims or compensation payments from polluting companies upstream, as well as the development of sustainable financing options and conservation actions. Valuations of water and related ecosystem goods and services can be used by the water industry and policy makers to:

- Increase cross-sector collaboration to develop and apply performance metrics and standards for measuring ecosystem services.
- Strengthen management of natural resource use and catchment planning in Victoria.
- Integrate ecosystems information in core business decision-making systems.
- Develop policies to monitor and report on the consideration of ecosystem services in financial analysis.¹⁰⁷
- Consider externalities in option (investment) appraisals and the adoption of water use efficiency technologies.
- Apply a precautionary approach to take account of impacts that might result in irreversible damage, despite uncertainties. Using incomplete information or information containing uncertainties for different variables is better than doing nothing.
- Inform water allocation and shared value assessments, identifying which issues to prioritise in mitigation or restoration activities. Take account of multiple co-benefits, and examine trade-offs between them to determine desirable courses of action.¹⁰⁸

“EFFECTIVE MANAGEMENT OF ENVIRONMENTAL EXTERNALITIES HELPS ENSURE THAT WATER USE, WATER INFRASTRUCTURE AND WASTEWATER DISPOSAL DO NOT HAVE AN UNDUE IMPACT ON THIRD PARTIES (SUCH AS OTHER WATER USERS OR THE WIDER COMMUNITY), WHICH IN TURN HELPS TO MAXIMISE THE NET BENEFITS FROM RESOURCE USE.”

National Water Commission, (2011)¹²⁰

- Identify opportunities to reduce levies or provide positive incentives, such as eligibility for tax relief or subsidies for maintaining assets that generate ecosystem benefits valued by the public, or that operate in a way that conserves natural resources.
- Environmental levies could be linked to water sector investments that maintain ecosystem services, to provide compensation where options that deliver community and environmental benefits result in lower net present values for projects.
- Apply “shadow prices” in the evaluation of alternative allocations of water among competing users. Shadow prices can adjust observed market prices that fail to reflect true economic values.¹¹⁰
- Identify optimal activities that maximise income across stakeholders, using sensitivity analysis to evaluate ranges in values for shadow prices used to evaluate management options.¹¹¹ Probability distributions could be used to estimate likely contingent valuations in cost-benefit analyses.
- Estimate returns from investing in activities that maintain or enhance ecosystem services. Develop markets for ecosystem goods and services, such as watersheds, and capture new income streams from water-saving technologies, services and practices.
- Assess the benefits of ecosystem assets and highlight opportunities to reduce costs, such as the role of wetlands in water filtration and purification, or of vegetation in flood control.
- Identify “no-go” areas – commitments to forego exploitation of natural resources with a value over a certain threshold.¹¹²
- Adopt a policy of no net loss or a net positive impact – only agreeing investments with ecologically neutral or positive impacts by taking actions to conserve or restore ecosystems in other areas to compensate for unavoidable environmental damage.¹¹³
- Consider damage costs and compensation from upstream water users that cause degradation.
- Consider ecosystems in modelling of expected changes in the TEV of water over time. This could take account of forecasts and climate change modelling by organisations such as the IPPC, which is expected to produce its Fifth Assessment Report in 2013/14.¹¹⁴
- Take a long-term view of water issues in scenario analysis, focusing on causal processes, decision points and alternatives. Scenario analysis can be useful when probabilities for events or outcomes are uncertain, whether due to a limited initial understanding of the processes involved, or due to the intrinsic indeterminism of complex dynamic systems.¹¹⁵ Scenario analyses can include variable indicators such as surface water runoff, groundwater recharge and climate variability.¹¹⁶

CASE STUDY Kakado Conservation Zone mining project valuation

In 1990, the Reserve Assessment Commission (RAC) in Australia used a contingent valuation survey to compare the options of opening the Kakadu Conservation Zone for mining reserves of gold platinum and palladium, or combining it with an adjoining national park. Valuations were used to assess the potential economic value of likely damages from mining. Due to uncertainties about the extent of damage, major and minor damage scenarios were considered. People were surveyed across Australia to ask if they would be willing to pay a pre-determined price to avoid damage. An average willingness to pay (WTP) was estimated. Results of the study implied public WTP to avoid damage to the region at AUD435 million, far higher than the net present value of the proposed mine, estimated at AUD102 million. Following the RAC’s report, the Australian Government decided not to issue a permit for mining the site.¹¹⁷

CASE STUDY Hitachi: Valuing water supply

Hitachi Group invested in Male Water and Sewerage Company Pvt. Ltd in the Maldives, which was likely to face water shortages. The water company was planning to expand water supply and treatment capacity to meet increasing demand. Hitachi used corporate ecosystem valuation to monetise the costs and benefits of ecosystems and ecosystem services linked to the water and sewerage treatment business, considering existing operations and expansion plans over the next 30 years. The evaluation looked at the impact from water supply infrastructure and clarified the costs incurred by society and the environment.¹¹⁸ Hitachi is exploring internal processes to use ecosystem valuation results to improve business planning.¹¹⁹

4.2 YARRA VALLEY WATER APPROACH TO INTEGRATING ENVIRONMENTAL COSTS

The results of this Paper support Yarra Valley Water's existing environmental valuations that estimate a higher value for water than is currently considered in traditional financial analysis. Yarra Valley Water operates on the basis that the local community's wellbeing and economic strength depend on the health of the environment. The company has developed a "community cost model" to fill the gap in methodologies. It is an economic cost/benefit analysis that considers the net cost and benefits to water companies, water customers and the broader community as a whole. Yarra Valley Water uses this for all business and infrastructure decisions. The community costing framework is among tools used to quantify and value costs and benefits to help identify feasible projects, programmes or options to maximise benefits to the community.

Yarra Valley Water initially used its community costing framework to assess the financial impact of a proposal or option and then added significant externalities. The proposal that had the least community cost or most community benefit was adopted. Now, its community cost assessment concentrates on the economic efficiency of a project or programme from an overall community perspective rather than from an individual stakeholder's perspective. The assessment includes:

1. Evaluation of additional or avoided costs by taking one course of action rather than another, possibly including infrastructure costs not already sunk.
2. The costs avoided, or additional costs of providing an additional unit of water.
3. Evaluating externalities that can be quantified, monetised and have an impact on the analysis.
4. Evaluating preferred least community cost options.

The framework supports the company's commitment to provide water and sewerage services within the carrying capacity of nature. Environmental costs are included in the community costing framework. Yarra Valley Water begun to incorporate environmental costs into business accounting practices with an Environmental Cost Statement in 2007. It identifies the gaps between costs internalised and annualised average future costs to avoid or restore environmental impacts.¹²¹ This extends beyond traditional corporate accounting boundaries to consider wider impacts on the environment.

Yarra Valley Water currently considers impacts including greenhouse gas (GHG) emissions and nitrogen use, which can be material to decision-making (see Doncaster Hill case study). The company currently applies the carbon price applied to Australia's largest polluters, AUD23/tonne of CO₂ in 2012/13,¹²² to value GHG emissions. Where evaluations result in options with similar community costs, these can be assessed further to take into account non-monetised factors. Other methodologies used to evaluate options include lifecycle cost assessments and multi-criteria assessments that take account of social, economic and environmental factors.

The company's experience to date is that including externalities often changes the proposed development from the traditional (base case) option to a more sustainable one. The company has commissioned this study to investigate how it can refine its existing methodology to include other externalities, including ecosystem functions analysed in this White Paper.

“A COMMON FRAMEWORK FOR ENVIRONMENTAL VALUATIONS IN THE REGION COULD HELP ASSESS THE DIRECT AND INDIRECT COSTS AND BENEFITS OF PROJECTS, PROGRAMMES, INFRASTRUCTURE AND WATERSHED PROTECTION TO REFLECT VARIABILITY IN WATER SCARCITY IN INVESTMENT DECISION-MAKING.”

Collaboration is essential to change the way water and other natural resources are managed. Yarra Valley Water has adopted four principles developed by the non-profit organisation Natural Step, including eliminating contributions to the physical degradation and destruction of nature and natural processes. The principles offer a science-based framework to make activities more sustainable. To help put them into practice, Yarra Valley Water aims to seek the advice of stakeholders and involve them in setting objectives.¹²³ The company has an extensive history of working with stakeholders in the urban water cycle to explore alternative water management options to help diversify supplies and adapt to the impacts of climate variability and population growth.¹²⁴

Stakeholders need to work together to develop a more comprehensive system of economic values for water so that prices better reflect environmental uses. A collective effort can help find ways to reduce uncertainty and manage risk to balance and optimise the many fundamental benefits that water provides.¹²⁵ Industry, researchers and policy makers can collaborate to develop tools for decision-makers to better allocate water resources and reduce adverse impacts.

The development of a common framework for environmental valuations in the region could help overcome barriers to assessing the direct and indirect costs and benefits of projects, programmes, infrastructure and watershed protection to reflect variability in water availability consistently in investment decision-making by different stakeholders.

CASE STUDY Doncaster Hill Development: Environmental costs alter NPV

Yarra Valley Water, Manningham City Council and Melbourne Water worked in partnership on options for a Doncaster Hill Development, with agreed objectives including maximising environmental outcomes. Yarra Valley Water included low and high estimates for environmental externalities in its community costing framework to assess three options: Conventional services strategy, rainwater tanks or a third pipe. The analysis of potable water savings, nitrogen impacts, electricity consumption and GHG emissions showed that recycled water provided by a new third pipe network would have the lowest environmental impacts. Net present value modelling over 25 years showed that the alternative option would be preferred only once community costs are taken into account, as shown in Table 5.

TABLE 5: FINANCIAL OUTCOMES OF NET PRESENT VALUE ASSESSMENT (AUD M)

OPTION	CONVENTIONAL		RAINWATER TANKS		THIRD PIPE ONLY	
Development scenario*	LOW	HIGH	LOW	HIGH	LOW	HIGH
YVW only NPV	30.2	50.0	24.9	43.0	25.2	44.7
Additional community costs						
Nitrogen	-7.5	-13.1	-5.3	-8.5	-5.1	-8.1
GHG abatement cost	-0.5	-0.8	-0.5	-0.8	-0.5	-0.8
Future supply resource augmentation cost	-17.0	-29.7	-12.1	-19.6	-11.7	-18.9
Whole of community NPV	5.2	6.4	7.0	14.1	7.9	16.9

*LOW GROWTH = 2,670 RESIDENTIAL DWELLINGS, HIGH GROWTH = 4,000 RESIDENTIAL DWELLINGS + 50 ML/YEAR IRRIGATION

SOURCE: MATHIESON B. (2010) DONCASTER HILL INTEGRATED WATER STRATEGY, A CASE STUDY FOR LEAST COMMUNITY COST SERVICING

5. CONCLUSIONS AND DISCUSSION

This White Paper shows that the total economic value of water to society is higher than the market price of water that is used in financial decision-making to allocate or use resources. The value of water is high (approximately AUD5.85/m³ or more than AUD2 B on average). Including water asset values in corporate financial accounts could contribute to more informed decision-making. Methods to price the financial value of ecosystems as part of a lost business opportunity or financial impact are in their infancy.¹²⁶ However, the 1992 Rio Declaration on the Environment And Development¹²⁷ states that if an action or policy is suspected of causing environmental degradation, the burden of proof falls on those who would advocate taking the action. Stewardship of business and ecosystem services is fundamental to water utilities' license to operate.

The UN environmental-economic accounting framework, The Economics of Ecosystems and Biodiversity and World Business Council for Sustainable Development are among initiatives working to enable companies to systematically integrate financially material environmental and social factors into decision-making. The WBCSD urges companies to undertake water-related valuation to provide better data and understanding to inform decisions. Ecosystem management incorporating ecosystem services valuation is increasingly being used to help achieve IWRM goals as well as other socio-economic and environmental benefits.¹²⁸

Given the high level of water scarcity in Melbourne, decisions on water use should consider the total economic value of water. The water industry and policy makers can consider environmental valuations in decision-making to deliver water efficiency and more effective resource allocations that help address water scarcity without impacting wellbeing or industry revenues. Valuations that take account of fluctuations in water availability over time can inform investment decisions and be used to communicate challenges in balancing financial outcomes with environmental and social costs. Policies on abstraction, subsidies, environmental levies and water pricing can consider the indirect use values of water to strengthen management of natural capital. Continuous monitoring of water scarcity and related indirect use values could be used to inform planning. Scarcity levels and valuations above certain thresholds could trigger water-saving measures that aim to provide security of supplies at levels agreed across stakeholders.

The water industry and regulators can help develop business models that provide water-saving services and technologies, rather than purely generating revenue growth by supplying increased volumes of water. Water service companies can recognise both impacts and dependence on resources and work with users and regulators to optimise water supply and demand.

5.1 QUESTIONS FOR WATER INDUSTRY, REGULATORS AND RESEARCHERS

The findings in this White Paper suggest that the water industry, regulators and researchers need to develop expertise around environmental valuations. The following are suggested questions that could help frame future work to understand and apply valuations of natural capital and externalities:

1. How do water utilities assess whether financial benefits exceed costs when externalities are taken into account?
2. How can the water industry, regulators and researchers develop a common approach to economic valuations of water in Victoria? What other options might deliver similar outcomes?
3. What are the barriers to developing a framework for consistent ecosystem valuations by water catchment users in Victoria, and how can they be addressed?
4. How can stakeholders strengthen their consideration of impacts and dependence on functions identified as most material in this study, such as groundwater recharge?
5. How could environmental valuations support more efficient and sustainable resource allocations? How can water valuations be used to help allocate resources to maximise social welfare in the long term?

6. How can the value of water savings and ecosystem protection best be incorporated into government incentives or levies? What mechanisms are needed to reward activities that protect water-related ecosystem services?
7. How should the water sector work with stakeholders to develop a common approach for including water-related costs in the evaluation of integrated water management options? How can variability in water scarcity in the region be considered in sensitivity analysis?
8. How can water valuations be incorporated into supply-demand modelling and economic assessment for investment decisions, taking account of seasonal and climatic variability and resilience benefits?¹²⁹
9. What resources are needed to find ways to include the value of water-related ecosystems in existing financial and business planning procedures that companies already use? How can ecosystem values best be considered in the same way as other costs, benefits and management decisions, to incorporate into decision-making?
10. How can collaboration be strengthened to determine the most significant externalities of water management in the region, accountability for each externality, and the effectiveness of approaches for managing externalities?

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Key to our approach is that we not only quantify natural capital dependency, we also put a price on it, helping our clients understand environmental risk in business terms. It isn't "all about carbon"; it's about water; land use; waste and pollutants. It's about which raw materials are used and where they are sourced, from energy and water to metals, minerals and agricultural products. And it's about how those materials are extracted, processed and distributed.

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