COMBINED TECHNOLOGIES FOR WATER, ENERGY AND SOLUTE RECOVERY FROM INDUSTRIAL PROCESS STREAMS

Deliverable 5.1

Current State Assessment

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[1] **R**=Document, report; **DEM**=Demonstrator, pilot, prototype; **DEC**=website, patent fillings, videos, etc.; **DMP**=Data Management Plan

[2] **PU**=Public, **SEN**=Sensitive

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Acronyms

AGWA	Alliance for Global Water Adaption
AI	Artificial Intelligence
AMBR	Anaerobic Membrane Bioreactors
AMR	Automated Meter Readings
AOPs	Advanced Oxidation Processes
API	Application Programming Interface
ATEX	ATmosphere EXplosible
AWS	Alliance for Water Stewardship
AXA-WISE	AXA Water Impact and Sustainability Evaluation
BATs	Best Available Techniques
BMPs	Basin Management Plans
CBA	Cost Benefit Analysis
CDP	Carbon Disclosure Project
CDSB	Climate Disclosure Standards Board
CEO	Chief Executive Officer
CLP	Classification, Labelling and Packaging of Substances and Mixtures
CO_2	Carbon Dioxide
CSDDD	Corporate Sustainability Due Diligence Directive
CSRD	Corporate Sustainability Reporting Directive
ECHA	European Chemicals Agency
EEA	European Environmental Agency
EFRAG	European Financial Reporting Advisory Group
EIA	Environmental Impact Assessment
EIB	European Investment Bank
ELD	Environmental Liability Directive
EMAS	EU Eco-Management and Audit Scheme
EPR	Extended Producer Responsibility

E-PRTR	European-Pollutant Release Transfer Register Regulation
EQSD	Environmental Quality Standards Directive
ESG	Environmental, Social, and Governance
ESRS	European Sustainability Reporting Standards
ESRS E1	European Sustainability Reporting Standards Environmental 1 (Climate Change)
ESRS E2	European Sustainability Reporting Standards Environmental 2 (Pollution)
ESRS E3	European Sustainability Reporting Standards Environmental 3 (Water and Marine Resources)
ESRS E4	European Sustainability Reporting Standards Environmental 4 (Biodiversity and Ecosystems)
ESRS E5	European Sustainability Reporting Standards Environmental 5 (Resource Use and Circular Economy)
ESRS S3	European Sustainability Reporting Standards Social 3 (Affected Communities)
ETS	EU Emissions Trading Systems (Directive)
EU	European Union
FEM	Facility Environmental Module
FSLM	Facility Social & Labor Module
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GICS	Global Industrial Classification Systems
GRI	Global Reporting Initiative
GW	Groundwater
GWI	Global Water Intelligence
IED	Industrial Emission Directive
IEPR	Industrial Emissions Portal Regulation
IPPC	Integrated Pollution Prevention and Control
IRO	Impacts, Risks, and Opportunities
ISO	The International Organization for Standardization
IWMI	International Water Management Institute
KPI	Key Performance Indicators
LIFE	EU Regulation Programme for the Environment and Climate Action

LULUCF	Land-Use, Land-Use Change, and Forestry (Directive)
M^3	Metre cubed
MBR	Membrane Bioreactor
ML	Machine Learning
MSFD	Marine Strategy Framework Directive
MSI	Material Sustainability Index
Mtoe	Million tonnes of oil equivalent
NECPs	National Energy and Climate Plans (Regulation)
NGOs	Non-Governmental Organisations
P.E.	Population Equivalents
PFAS	Per- and polyfluoroalkyl substances
PM	Production Module
PoM	Programmes of Measure
PPE	Personal Protective Equipment
QQC	Quantity, Quality, and Cost
RBMPs	River Basin Management Plans
RCP	Representative Concentration Pathways
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals (Regulation)
REFIT	Regulatory fitness and performance programme
RO	Reverse Osmosis
ROI	Return On Investment
RRR	Reuse, Recycling, and Regeneration
SCS	Scientific Certification Systems
SDG	Sustainable Development Goal
SME	Small- and Medium-sized Enterprise
SSP	Shared Socioeconomic Pathways
SBTi	Science Based Targets Initiative
STEP	Strategic Technologies for Europe Platform
SW	Surface Water
TEV	Total Economic Value

UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US EPA	United States (of America) Environmental Protection Agency
USD	United States (of America) Dollars
USGS	United States (of America) Geological Survey
UWWTD	Urban Wastewater Treatment Directive
VWBA	Volumetric Water Benefit Analysis
VWB	Volumetric Water Benefits
WASH	Water, Sanitation and Hygiene
WBCSD	World Business Council for Sustainable Development
WEF	World Economic Forum
WFD	Water Framework Directive
WP	Work Package
WRAF	Water Resilience Assessment Framework
WRI	World Resources Institute
WWF	World Wildlife Fund

Executive Summary

With global demand for freshwater estimated to outstrip supply by 2030, industry as one of the main water users in Europe has an important role to play in transforming how water is currently used in process industry practice. The overall goal of the EU-funded CORNERSTONE project is to focus on water, energy, and solute recovery in three identified sectors (steel, pulp and paper and chemicals). CORNERSTONE aims to unlock the potential of currently difficult to treat wastewater streams, via the use of novel technologies to enable the reuse of wastewater, energy and solutes and deliver long lasting impacts to a sustainable European industrial water management approach.

Work Package 5 of this project focuses on the development of Decision Support Tools for digitally enabled industrial water, energy and solute recovery. The first deliverable in Work Package 5, this document provides an analysis of the current state context for industrial water engagement and activity in practices including water efficiency, water re-use and water stewardship.

This document provides an analysis of the key drivers for industrial water user engagement in these practices, an overview of the key EU policy developments of relevance to industrial water users across the practices outlined above, and an analysis of key industrial sector trends, based on both primary and secondary research.

Methodology

The research methodology for this report consisted of 3 steps:

Step one involved a comprehensive desk review of 74 white papers, reports, peer reviewed articles and other recent Industrial Water articles to identify recurring drivers and emerging trends in industrial water practices, nine high-level categories and 38 sub-categories. These categories supported the design and development of a high-level survey of industrial water users. The findings from this desk review feature in Section 3 of this document.

Step two involved the creation of a database of 169 EU policy and legislative documents which were grouped into six categories for an in-depth analysis of policies of the most potential relevance to industrial water users across Europe. A total of 68 policies, identified by the project team as most relevant, were examined in detail and their impact on industrial water users was assessed under seven pillars: water quantity, water quality, water governance, environment, energy, solutes, and circularity. The findings from this policy analysis are provided in Section 2 of this document.

The final step in the process was a survey of the current state of industrial awareness and activity across water stewardship, circularity and resources. A total of 41 EU based industrial water-user sites (with an average water usage of 178,000m3 per annum) responded to the survey. A quantitative analysis was carried out on survey responses to summarise key respondent demographics, trends, drivers, barriers and enablers.

Key Findings

The key findings of this report, presented by category are as follows:

Drivers for Water Stewardship, Circularity and Resource Recovery across Industrial Water Users

- For both internal and external drivers, the industry perceives drivers as more important if they relate to current industry demands, as opposed to a driver with delayed pay-off.
- The **most important external drivers** for the industry in progressing water circularity and resource recovery activities are effluent discharge regulations, environmental policies, and sustainability reporting requirements.
- The **least important external drivers** are shared water challenges, technology advancements, and mitigation of impact from climate change.
- The **most important internal drivers** for the industry in progressing water circularity and resource recovery activities are cost of wastewater treatment and discharge, resource shortages/competition, and supply chain resilience.
- The **least important internal drivers** for the industry in progressing water circularity and resource recovery activities are corporate net zero ambitions, potential return on investment from circular initiatives, and advances in internal data and digitalisation infrastructure.

EU Policy and Legislative Context

- Over 60 EU policies have been identified that have varying degrees of relevance to industrial water users across the interconnected areas of water, energy, circularity and solute recovery
- In addition to key EU environmental policies such as the Green Deal and the Corporate Sustainability Reporting Directive, policies in domains such as water, energy, waste and circularity, soil and land; and industrial safety have been identified as relevant to industrial water users on the topics of water stewardship, circularity and resource recovery.

Industrial Trends in Water Stewardship, Circularity and Resource Recovery

- A growing recognition of both the cost and value of water to industry as demand for industrial water continues to grow globally, with an estimated 400% increase forecast across manufacturing sites alone by 2050
- The emergence of water risk and resilience planning across industry, supported by mechanisms such as the Corporate Sustainability Reporting Directive's drive to mandate industry to undertake double materiality assessments to identify the impacts, risk and opportunities of their business activities on the environment and vice versa
- The need for greater stakeholder and supply chain engagement in protecting water resources, including through collaborative, catchment-based approaches such as those found in industrial water stewardship activities.
- Promoting water circularity approaches to create a resilient water management system that supports both human and environmental needs
- New advances in water and waste technologies can play a key role in reducing environmental impacts across process industries, though collaboration, knowledge sharing and competency development are critical factors in ensuring successful adoption

1. Introduction

1.1. CORNERSTONE Project

CORNERSTONE is a 4-year EU-funded project under Horizon Europe, established to focus on water, energy, and solute recovery in three identified sectors (steel, pulp and paper and chemicals). With global demand for freshwater estimated to outstrip supply by 2030, industry as one of the main water users in Europe has a key role to play in transforming how water is used in existing process industry practices.

CORNERSTONE aims to unlock the potential of currently difficult to treat wastewater streams, via the use novel technologies to enable the reuse of wastewater, energy and solutes and deliver long lasting impacts to a sustainable European industrial water management approach.

Figure 1 - CORNERSTONE Project Overview

1.2. Document Overview

This document is Deliverable 5.1 (Industrial Current State Assessment report) of the CORNERSTONE project and a key activity under Work Package 5 of the project – *Development of Decision Support Tools for digitally enabled industrial water, energy and solute recovery*.

The objective of this document is to undertake an analysis of the current state context for industrial water engagement and activity in practices including water efficiency, water re-use and recovery and water stewardship. This document provides an analysis of the key drivers for industrial water user engagement in these practices, an overview of the key EU policy developments of relevance to industrial water users across the practices outlined above, and an analysis of key industrial sector trends, based on both primary and secondary research. The methodology used to underpin this document is provided in Section 1.3.

1.3. Methodology

The methodology adopted in this activity (Task 5.1 – Industrial Current State Assessment) involved combining a mix of desk research and an industrial water user survey to assess the current state across

industry regarding water circularity, re-use and broader aspects of water stewardship. The approach used to identify, collate and assess findings contained a three-step approach of:

a) Completion of Desk Review of Drivers and Emerging Trends in Industrial Water Stewardship, Circularity and Resource Recovery
b) Desk review of EU policies relevant to industrial water users, focussing on industrial water stewardship, circularity and resource recovery
c) Industrial Current State Assessment survey for industrial water users

1.3.1. Desk Review of Drivers for and Emerging Trends in Industrial Water Stewardship, Circularity and Resource Recovery

A literature review on 74 identified white papers, reports, peer reviewed articles and other articles related to industrial water stewardship, circularity and resource recovery, published in the period 2018-2024 was undertaken to identify key business drivers and other emerging trends from industry. Emerging themes were split into an initial nine high-level categories and 38 sub-categories, covering areas such as water governance, quantity, quality, data, water finance, risk, circularity, technology, digitalisation, and collective action. The dominant themes were identified from a detailed analysis of this review and examined in greater detail, including a more comprehensive regulatory analysis (see Section 1.3.2.) and as input into the Industrial Current Statement Assessment survey (see Section 1.3.3.).

1.3.2. EU Policy Review

An analysis of EU policy was subsequently carried out to identify the policy and legislative context for industrial water users in relation to industrial water stewardship, circularity and resource recovery. In total, 169 EU policy and legislative documents were grouped into six categories for an in-depth analysis of policies of most potential relevance to industrial water users across Europe.

The identified policy groupings were as follows: general environmental policy, water policy, energy policy, solute recovery policy, circularity, industrial safety, and soil and land. A total of 68 policies, identified by the project team as most relevant, were examined in detail and their impact on industrial water users assessed under seven key pillars (the first four of which are pillars of water stewardship): water quantity, water quality, water governance, environment, energy, solutes, and circularity. Figure 3 in Section 2.1. presents this high-level overview of this mapping of EU policy and legislation of relevance to industrial water users.

Analysis of the EU Policy and Legislative content for industrial water users is presented in Section 2.

1.3.3. Industrial Current State Assessment Survey

Following from the activity presented in Section 1.3.1., an industrial current state assessment survey was designed based on the most prominent thematic areas identified in literature because of the completion of secondary research. The scope of this survey was to assess industrial water users' awareness of and engagement in implementation of water, energy, and solute recovery initiatives. In addition, is multiple surveys sought to identify industrial perception of the trends, drivers, barriers and enablers of circularity adoption across water / wastewater processes.

The sample of respondents were obtained by the CORNERSTONE partners through distributing an online survey invitation to their industrial water user networks in the EU in January and February 2025. The survey was comprised of 17 questions and took approximately 10-15 minutes to complete.

A total of 41 EU based industrial water-user sites responded to the survey. A quantitative analysis was carried out on survey responses to summarise key respondent demographics, trends, drivers, barriers and enablers.

The respondents mainly occupy a managerial role (63%), while consultants (10%), analysts (7%) and operators (7%) featuring to a lesser extent.

Food and Beverages (27%) are a key industry within the sample, followed by Chemicals (20%), Life Sciences & Pharmaceuticals (15%), Manufacturing (12%) and Utilities, Energy, & Extraction (7%). The remaining 'Other' category includes the Pulp & Paper, Aerospace, Steel, and Construction industries.

1.4. Business Drivers for Water Stewardship, Circularity and Resource Recovery in Industry

This section contains a short summary of several key internal and external drivers identified based on both desk research and findings from the Industrial Current State Assessment survey.

This section is presented in the Introduction section of this document to provide readers initial insights into current industry engagement in water stewardship, circularity and resource recovery. A more detailed analysis of policy and industry trends are then presented in Sections 2 and 3.

1.4.1. External Drivers

1.4.1.1. The Industrial Water Landscape and the Growing Awareness of Water-related Risk

Two-thirds of the world's population may face water shortages by 2025 (WWF, 2025). A vital resource for industries in Europe, industrial water use currently accounts for 40% of freshwater use in Europe while demand for industrial water is expected to grow globally, with an estimated 400% increase forecast across manufacturing sites alone by 2050 (UNESCO, 2021).

The 2025 Global Risk Report has identified five of the top ten risks facing humanity in the next ten years as environmental. All five of these risks (extreme weather events, biodiversity loss and ecosystem collapse, critical change to Earth systems, natural resource shortages, and pollution) link heavily to water while the financial implications of water risk are becoming clearer to business leaders across the globe (CDP, 2023). Estimates of economic losses of up to US$5.6 trillion by 2050 have been calculated if water risks are not addressed (CDP, 2023). Agriculture, food and beverages, mining, semiconductors, energy, and mining are identified as the industries that are potentially impacted the most by water risks (Famiglietti et. al., 2022)

1.4.1.2. EU Regulatory Landscape

As of February 2025, the impact of the proposed Omnibus package, a set of proposals to amend the Corporate Sustainability Reporting Directive (CSRD) and Corporate Sustainability Due Diligence Directive (CSDDD), is yet to be ascertained, the introduction of mandatory sustainability reporting requirements represents a significant new external driver for industry focus on water. Drafted to incorporate key elements of existing EU policies and directives, the ESRS E3 (Water and Marine Resources) will require organisations in scope to assess the material importance of water to their organisation as well as the impact of their water related activity on the environment. ESRS E3 will also require organisations to report on their water-related impacts, risks and opportunities (IRO) at a corporate level (European Commission, 2024). The regulatory landscape is investigated in further detail in Section 2.

1.4.1.3. Survey Findings – External Drivers

63% of respondents to the survey are based in Ireland, followed by Germany which represents 22% of site locations, with the remaining 15% located elsewhere in the EU.

To examine **external drivers** for engagement with circular water practices, the CORNERSTONE Industrial Current State Assessment Survey asked respondents "What are the key external drivers for progressing water circularity and resource recovery activities within your site?".

To answer this question, respondents ranked seven external driver options provided from most to least important. These options were based on themes highlighted in Section 1.3.1.

Response options included drivers such as 'Shared water challenges in the catchment / river basin', 'National and regional environmental policies' and 'Stakeholder demands to meet sustainability targets. During analysis stage, an average score was created for each external driver out of seven, with the highest scores representing the drivers with the highest average rank (See Figure 1).

The results are presented in Figure 1 for each external driver in the format of an average importance score/7. National and EU-level regulatory obligations are ranked highest by industrial 'National/local authority effluent discharge regulations' emerges as the most important external driver, receiving an

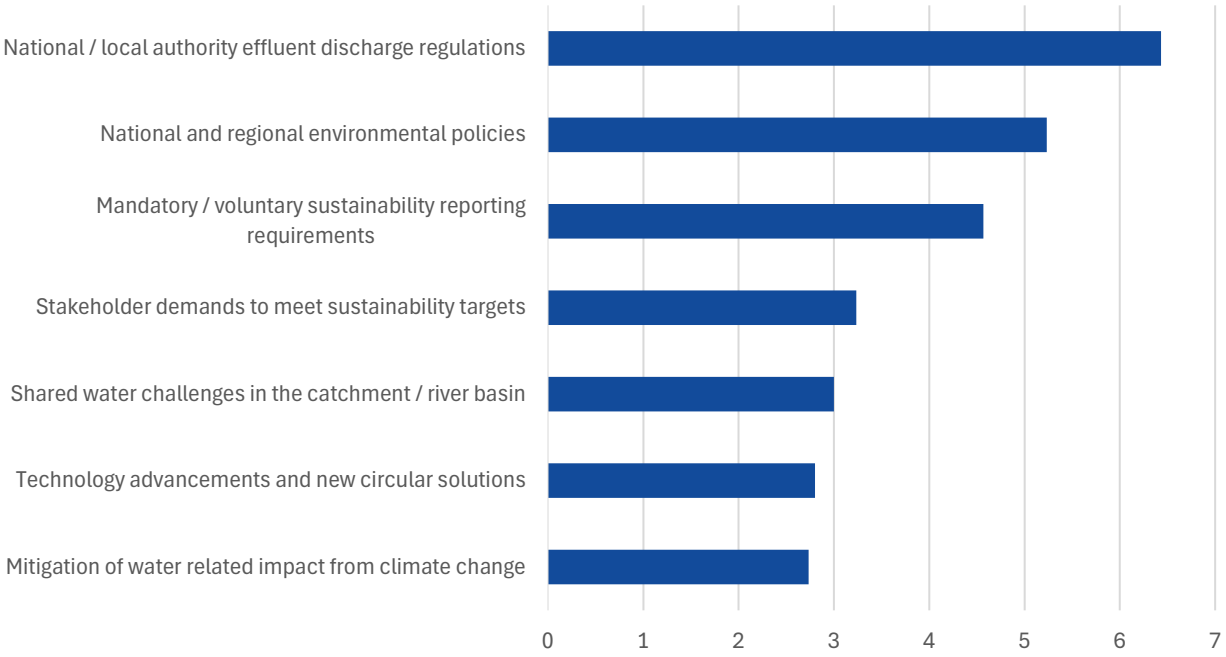


Figure 2 - Survey Findings - External Drivers for Industrial Water Circularity Activities (n=29)

average importance score of 6.43/7 while 'National and regional environmental policies (e.g. EU Green Deal, Circular Economy Action Plan etc.)' achieves the second highest score (5.23/7). This is followed by 'mandatory / voluntary sustainability reporting requirements (e.g. CSRD, CSDDD, SBTi, GRI) (4.57/7).

The external drivers which were ranked as least important were those which require looking to the future for 'Technology advancements and new circular solutions' (2.80/7) and 'Mitigation of water related impact from climate change' (2.73/7). Whilst reporting requirements such as CSRD or CSDDD require an orientation towards future externalities for the site, when it comes to progressing water circularity, the fulfilment of current demands at a national level are ranked as more important than future potentialities.

1.4.2. Internal Drivers

To examine **internal drivers** for engagement with circular water practices, respondents were asked, "What are the key internal drivers for progressing water circularity and resource recovery activities within your site?".

To answer this question, respondents had to rank seven internal driver options provided from most to least important. Response options included drivers such as 'Process Improvement', 'Corporate net zero/positive water ambitions' and 'Potential return on investment from implementing circular

initiatives.' At analysis stage, an average score was created for each internal driver out of 7, with the highest scores representing the drivers of highest importance (See Figure 2).

The results are presented in Figure 2 for each internal driver in the format of an average importance score/7. Both 'Cost of wastewater treatment and discharge' and 'Identification of resource shortages / competition for resources' emerge as key internal drivers for engagement with circular water practices (4.70 / 7).

They are closely followed by 'Maintaining supply chain resilience' (avg. score 4.47/7) and 'Process improvement' (avg. score 4.30/7). 'Advances in internal data and digitalisation infrastructure' was ranked the lowest as its potential to drive engagement with circular water practices (2.17/ 7).

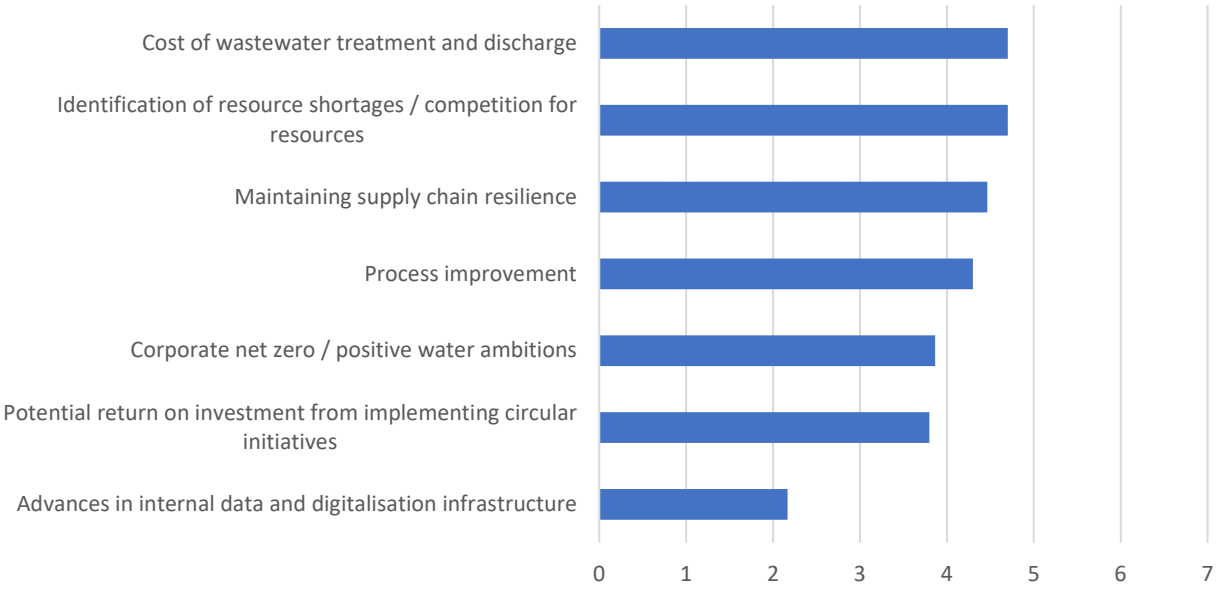


Figure 3 - Survey Findings - Internal Drivers for Industrial Water Circularity Activities (n=29)

Aligning closely to findings on external drivers, the industry perceives internal drivers as more important if they have immediate benefit for industrial operations and finances, as opposed to future opportunities.

1.4.3. Summary of Business Driver Analysis

Outlined below is a summary of the findings from the business driver section of the Industrial Current State Assessment survey results. These factors will be important considerations for the development of the Decision Support Toolbox for Circular Water Stewardship (CORNERSTONE WP5: Deliverable 5.3).

- For both internal and external drivers, industry perceive drivers as more important if they relate to current industry demands, as opposed to a driver with delayed pay-off.

- The **most important external drivers** for industry in progressing water circularity and resource recovery activities are effluent discharge regulations, environmental policies, and sustainability reporting requirements.
- The **least important external drivers** are shared water challenges, technology advancements, and mitigation of impact from climate change.
- The **most important internal drivers** for industry in progressing water circularity and resource recovery activities are cost of wastewater treatment and discharge, resource shortages/competition, and supply chain resilience.
- The **least important internal drivers** for industry in progressing water circularity and resource recovery activities are corporate net zero ambitions, potential return on investment from circular initiatives, and advances in internal data and digitalisation infrastructure.

1.5. Document Structure

The structure of the remainder of this document is as follows:

- Section 2 – EU industrial Water Policy and Legislative Analysis (building on the initial high-level findings in regard to external regulatory drivers, identified in Section 1.4.1.).
- Section 3 – Industrial Trends in Water Stewardship, Circularity and Resource Recovery (building on the initial high-level internal and external drivers identified in Section 1.4.1. and 1.4.2.).
- Section 4 – Overview of Current Water Assessment Support Tools for Industry
- Section 5 – Conclusion

2. EU Industrial Water Policy and Legislative Analysis

2.1. Introduction

This section of the document presents an analysis of the EU policy and legislative content for industrial waters users engaging in water stewardship, circularity and resource recovery practices.

Adopting the methodology outlined in Section 1.3.2. of this document, key pieces of EU policy and legislation have been identified, grouped and analysed across seven pillars relating to water stewardship, circularity and resource recovery.

Figure 4 (larger version available in Appendix 7.3.) outlines the mapping of 68 identified polices and pieces of legislation across six categorised policy groups. The legend in this map provides a colour code for each of the seven environmental pillars and highlights their alignment with the identified policies. The polices and their relevance to industry are highlighted in greater detail in Section 2.2. below.

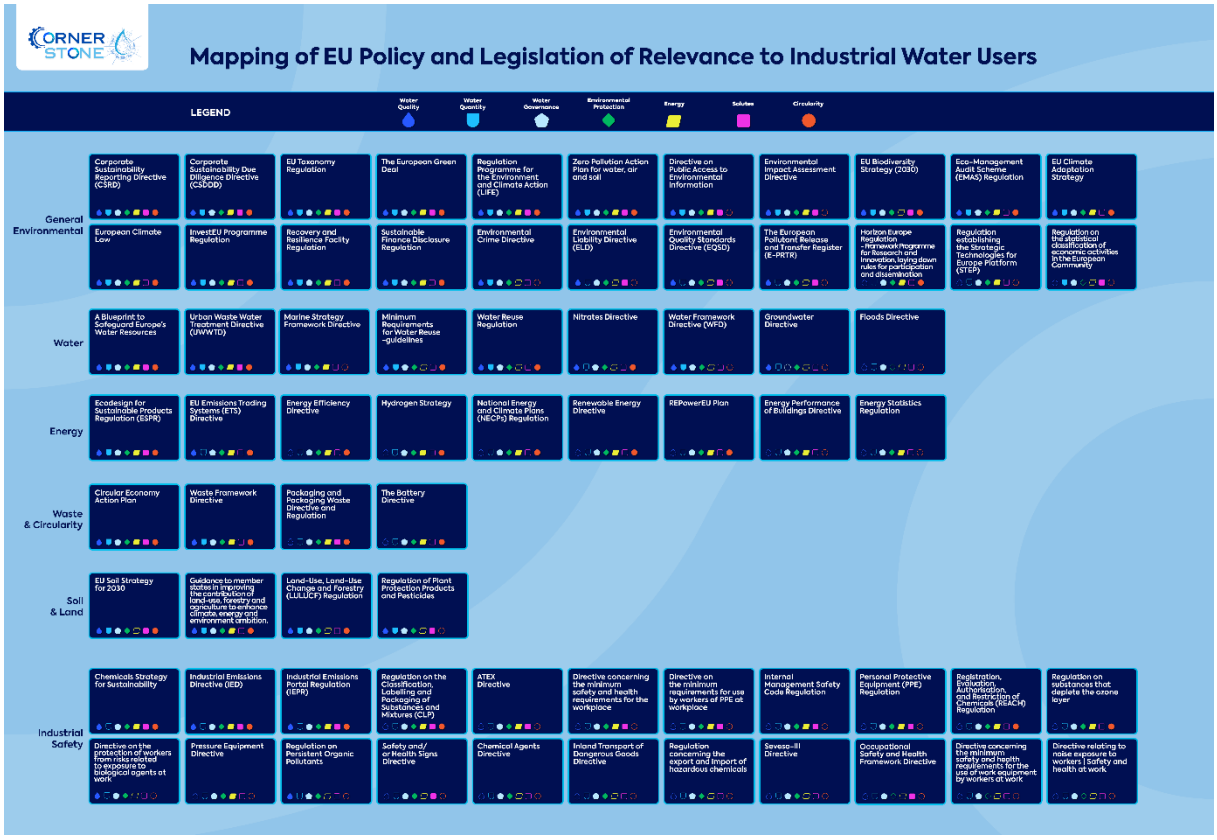


Figure 4 - Mapping of EU Policy and Legislation of Relevance to Industrial Water Users

2.2. EU Policy Analysis - Industrial Water Users and Water Stewardship, Circularity and Resource Recovery practices

This section of the report provides an analysis of the existing EU policy and legislative context for industrial water users engaging in Water Stewardship, Circularity and Resource Recovery practices. Each sub-section contains an analysis of the identified policy, year published/year most recent amendment made, summary of the policy, summary of its relevance to industrial water users undertaking stewardship, circularity and resource recovery initiatives, and a summary of the key sections of the policy that are of relevance to industrial water users including identification of alignment with the 7 environmental pillars identified in Section 2.1.

2.2.1. Analysis of General EU Environmental Policy relevant to Industrial Water

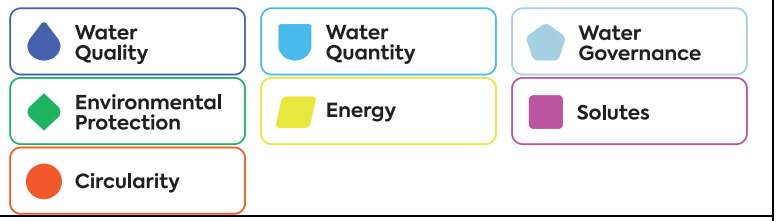
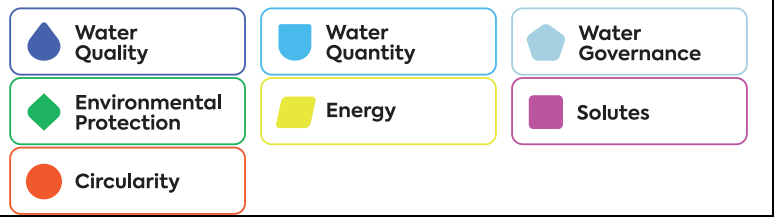
The EU faces complex environmental issues including, but not limited to, climate change, pollution, and biodiversity loss (Kurrer.,C., Petit., A., 2025). To mitigate against these issues, the European environmental policy has (supported by the launch of the EU Green Deal in 2019) positioned these environmental issues at front and centre of EU policymaking. The EU's Environmental Policy is based on 4 principles (European Parliament, 2025):

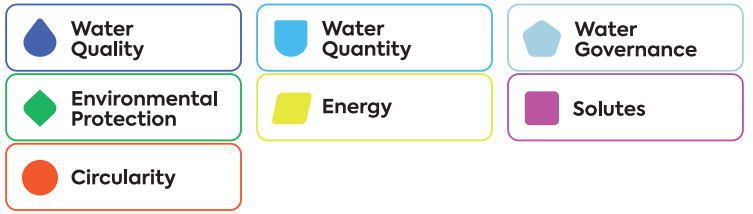
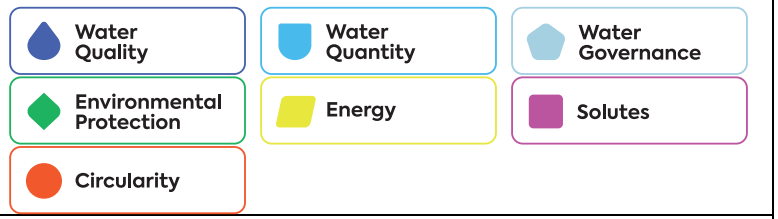
- Precaution
- Prevention
- Rectifying pollution at source
- 'Polluter pays'

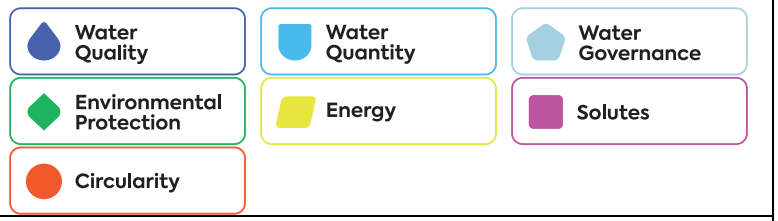
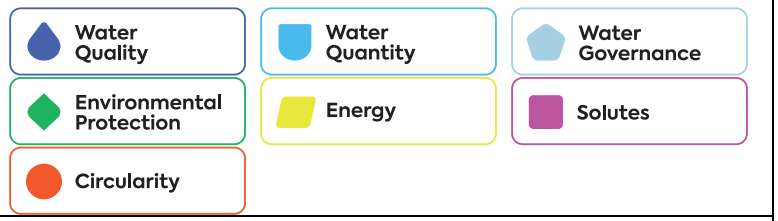
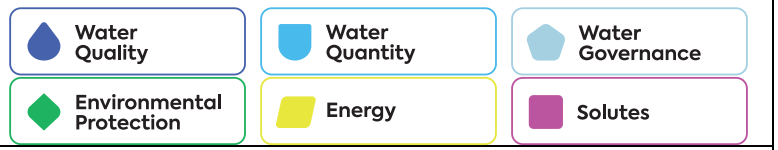
Table 1 provides an overview of the key general environmental policies, legislation and regulations pertaining to industrial water users.

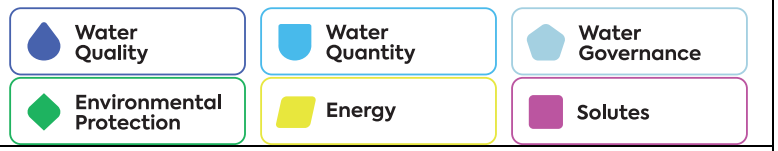
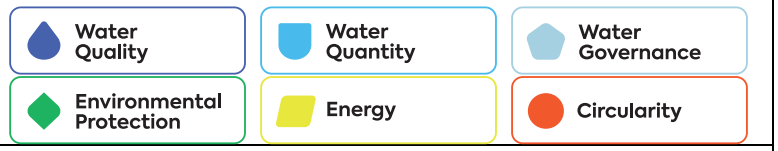
Funded by the European Union. Horizon Europe Grant Agreement No. 101138504. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor the granting authority can be held responsible for them.

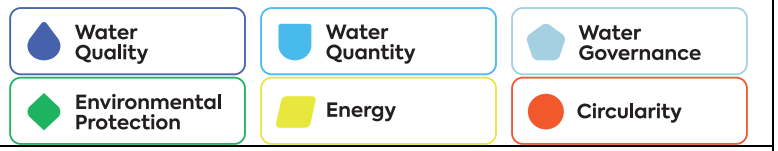
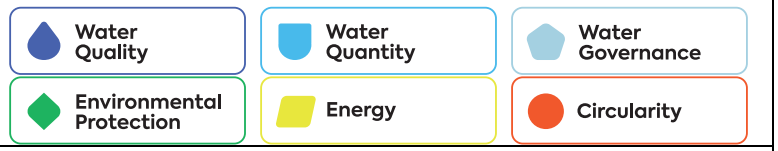
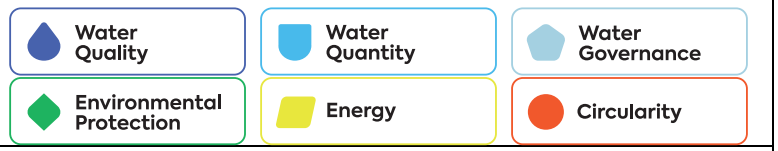
Table 1 - General EU Environmental Policy and its relevance to Industrial Water Users

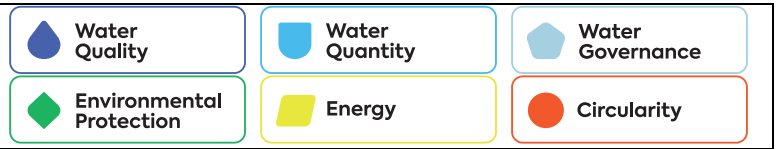
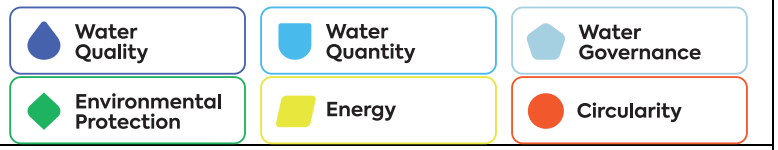
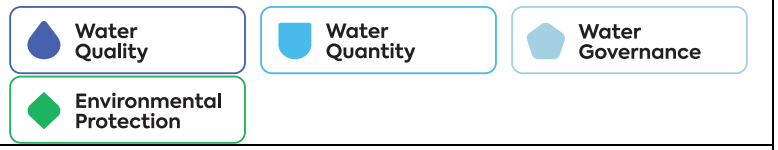
Policy Title	Year published and most recent amendments	Summary of policy legislation	Summary description of importance to industrial water users
Corporate Sustainability Reporting Directive (CSRD)	2022, Delegated Acts 2023	Directive aims to ensure companies are meeting environmental social and governance factors both in their own site and upstream and downstream throughout their supply chain and value chain. Eventually organisations will need to assess double materiality outside of the EU too with regards to their branches.	The Corporate Sustainability Reporting Directive requires in-scope industrial water users to evaluate and report on their water-related materiality to their site and production processes, and in addition, water-related materiality along their value chain. The disclosure requirements specify that organisations to report on their water-related risks, impacts and opportunities to their catchment, value chain, communities, ecosystems, and any plans to improve water-related impacts and mitigate water-related risks. 
Corporate Sustainability Due Diligence Directive (CSDDD)	2024	The overall objective of the CSDDD is to establish sustainable and responsible corporate behaviour throughout an organisation, including their value chain, addressing their ESG impacts both inside and outside Europe, where relevant, focusing on the organisation, and its value chains impact on social rights, rights of workers, legal transparency, risk management, and environmental resilience.	The CSDDD affects industrial water users through impacts in their value chain including the communities they operate within, and any plans to mitigate the impacts and risks they cause to the individuals affected by their use of the water within those catchments, river basins and communities. 

EU Taxonomy Regulation	2018	This regulation sets out the EU sustainable finance framework for alignment of investments in economic activities to environmental targets set out in the EU Green Deal. The main areas of environmental protection set out in this regulation pertain to mitigation and adaptation to climate change, support the transition to a more circular economy, pollution prevention and control, the protection and restoration of biodiversity, and promoting the sustainable use and protection of water and marine resources.	This regulation concerns industrial water users through their activities and the effect these activities have on the consumption of water, the protection of water and marine resources to pollution from industrial activities, the reuse of water and preventing inefficient use of resources which negatively impact water quantity or quality. 
EU Green Deal	2019	The EU Green Deal provides guidelines and policy for EU member states to transform various areas, sectors, provisions from linear resource use to align with a circular economy model to be more sustainable in order to tackle environmental and climate challenges.	The Green Deal Industrial Plan enhances the competitiveness of Europe's net-zero industry and is accelerating the transition to climate neutrality. The Green Deal outlines plans for digitisation of monitoring aspects both on and off site, accounts for the effects of transport on water use and other external factors to industry which need to be addressed. The main focus is incorporating future industrial plans to tie environmental risks into planning and the effect of industrial activities and products produced may have on the environment. 
Regulation Programme for the Environment	2021	This programme regulation aims and ambitions of transitioning the EU towards a more circular, sustainable, climate-neutral	This programme/regulation concerns industrial water users through the protection of water resources from extraction to discharge, the efficient use of resources throughout

and Climate Action (LIFE)		and energy-efficient economy with focus on the protection and restoration of environmental resources, biodiversity, water, air and soil.	production, and the efficient use of energy through water-related processes. 
Zero Pollution Action Plan for water, air and soil	2021	Guidelines set out for meeting social and economic standards while providing benefits to public and environmental well-being through sustainable changes and alternatives within each member state	This plan places emphasis on the human health consequences of contaminated waters with references to where this will be addressed in other water documentation. This is relevant to Industrial water use in preventing pollution and contamination of water resources from certain industries. 
Directive on Public Access to Environmental Information	2003	This directive sets out the rules and guidelines on the access to the public of environmental information of each member states and industries on activities within these countries which effect the environment	This directive concerns industrial water users as the effects they have on the environment through their economic and industrial activities may be made publicly available, particularly their effects on water quality and quantity within the catchments, river basins, and countries in which they operate. 
Environmental Impact	2011,	Environmental Impact Assessments (EIA) are conducted prior to development of new	This directive concerns industrial water users through any buildings or developments which will impact the water quality

Assessment Directive	last amended 2014	buildings or projects for their impact on the environment including any impacts or affects to water, soil, biodiversity, air, climate, cultural heritage, public health, material assets, and landscape.	or quantity as a result of their development, or any of the environmental factors listed as part of their assessment. 
EU Biodiversity Strategy (2030)	2020	The EU Biodiversity Strategy sets out a long-term plan for protection of nature and aims to reverse ecosystem degradation by 2030. Following the Covid-19 pandemic, this strategy also aims to protect against future threats highlighted during the pandemic such as food security, protecting from disease outbreak, and protection of wildlife from adverse environmental conditions such as climate change and forest fires.	This strategy effects industrial water users through the discharge quality of their wastewater, the effects of water abstraction on ecosystems, and any attributed adverse effects from water pollution caused by industrial activities. 
Eco-Management Audit Scheme (EMAS) Regulation	2009, last amended 2023	The EMAS regulation provides the rules and guidelines for the EMAS tool where organisations can manage their environmental performance, and energy and resource use optimisation. The tool itself allows industries to evaluate, report and improve on their environmental performance.	This regulation concerns industrial water users by the evaluation of their environmental performance pertaining to their water consumption, the quality of water released and the impacts associated with these reporting indicators. 
EU Climate Adaptation Strategy	2021	The Climate Adaptation Strategy aims to use robust risk assessments and data to combat the effects of climate change, risks posed by climate change, the protection of the environment from climate change, and safeguard water availability.	The Climate Adaptation Strategy concerns industrial water users through the need for safeguarding water supplies throughout the EU which will directly impact their allowance for water abstraction, the effects from water quality from the discharge of wastewater to the environment, through the need for sustainable water use and sustainable water management, the promotion of water-saving technologies on industrial sites,

			the promotion of water-monitoring technologies on industrial sites, and the introduction of water-permitting systems where water security is a challenge on shared water resources. 
European Climate Law	2021	European Climate Law is a set of regulations predicated on the guidelines set out in the European Green Deal. Sets out targets to reach climate neutrality by 2050, and net zero carbon emissions.	Relevant to industrial water users as member states will create relevant legislation, policies, directives, etc., based on the contents within this Law relating to water use and stewardship. 
Invest EU Programme Regulation	2021, last amended 2024	Invest EU Programme Regulation sets out to support sustainable investments, job creation and innovation across Europe through mobilising private and public funds to finance projects in key sectors such as digitalisation and green energy.	This programme regulation concerns industrial water users through investments and innovation in projects which enhance water quality, optimise water-related processes, improve water-related infrastructure, or increase the water quantity. 
Recovery and Resilience Facility Regulation	2021, last amended 2024	The Recovery and Resource Facility Regulation sets out the aims and criteria for funding towards promotion of environmental, social and economic cohesion within the EU Member states such as providing crisis preparedness, resilience, digital transition, and energy security. As it	This regulation concerns industrial water users through the management of water as a resource, the treatment of water to a quality which protects the environment, the energy-efficient treatment of water and wastewater, and research into the digitalisation of water-related processes.

		pertains to environmental cohesion within the member states the regulation promotes green transition, digital transformation, and sustainable, smart and inclusive growth.	
Sustainable Finance Disclosure Regulation	2019, last amended 2024	The Sustainable Finance Disclosure Regulation (SFDR) specifies how member states, authorities, and markets to consider sustainability-related risks and impacts within their products and processes.	This regulation concerns industrial water users through the sustainable investment into water-related products and processes including energy-efficiency and efficient resource use. 
Environmental Crime Directive	2008, repealed 2021, repealed by the new Environmental Crime Directive 2024	The Environmental Crime Directive addresses environmental crimes which pose threat to human health and wildlife or pose threat to the degradation of ecosystems, such as illegal dumping or pollution through the release of hazardous chemicals.	This directive concerns industrial water users through the illegal abstraction or over abstraction of water resources, the cross-border pollution of water resources, and the deterioration of water-related ecosystems as a result of over extraction or effects to water quality. 
Environmental Liability Directive (ELD)	2004, Last amended 2019	Directive based on the "polluter-pays" principle i.e. making those that have caused environmental damage liable for remediation, Regulation primary focus on environmental liability regarding the prevention and remedying of environmental damage.	This directive is relevant to Industrial Water Use and the remedial actions which may need to be taken by certain industries if they are to contaminate water resources or ecosystems as a direct result of their organisation's actions. This may affect Industry's reputation within area and will be a basis of condemnation for any incidents they may have regarding water resources.

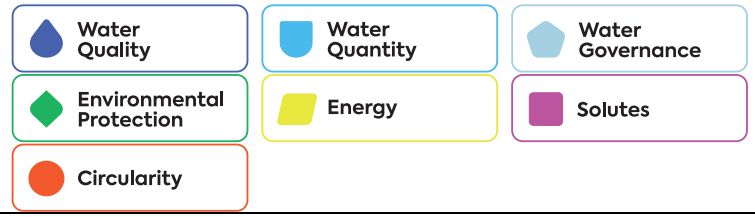
			Water Quality; Water Governance; Environmental Protection; Solutes
Environmental Quality Standards Directive (EQSD)	2008, last amended 2013	The EQSD outlines priority pollutants which pose risk to human health or aquatic environments. The EQSD sets the standards for priority substances and eight other pollutants including cadmium, lead, mercury, nickel, and any of their compounds, polyaromatics hydrocarbons, benzene, and various pesticides. Many of these priority substances are classified as hazardous and have limits for their concentration in water.	The EQSD notes the components of Industrial Water User's wastewater and the emissions to the environment from their water if containing any of the pollutants listed within the EQSD. This may make them liable to remediation measures if a case of waterbody pollution occurs from their site or activities, possible fines or other retribution for environmental or ecosystem damage as a result of their activities. Water Quality; Water Governance; Environmental Protection; Solutes
European Pollutant Release and Transfer Register (E-PRTR)	2006, Last amended 2020	E-PRTR gives reporting requirements for industries both member states of EU and countries which are within the EEA, for pollutant releases and transfers which are aligned with permit conditions under the industrial Emissions Directive (IED). Data collected for the E-PRTR is transparent and available for public viewing.	All industrial water users if emitting any wastewater to various water sources must report on their release methods and components and keep in line with local, national, and any international laws and regulations to ensure the safe release of these components and pollutants into the environment. This will soon account for both on-site release and the responsibility of organisations to ensure any off-site or contracted release is of a safe standard. This document sets out some of the European guidelines' member states must follow and a list of pollutants and their recommended release threshold in kg/year. Water Quality; Water Governance; Environmental Protection; Solutes

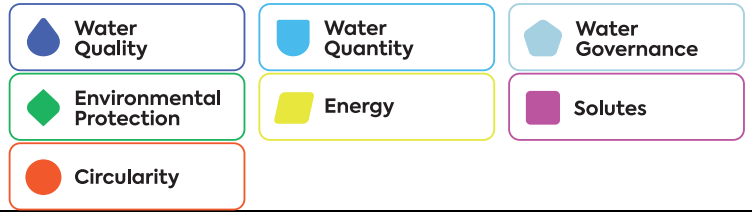
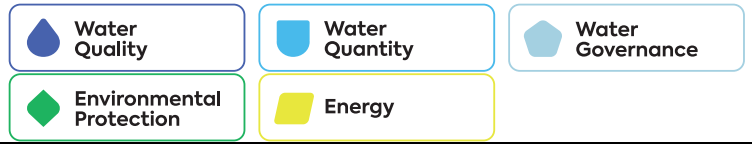
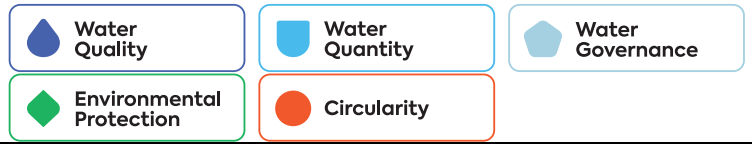
Horizon Europe Regulation - Framework Programme for Research and Innovation, laying down rules of participation and dissemination	2021, last amended 2024	This regulation aims to establish a framework for governing research and innovation in terms of science an technological objectives, clarify rules for participation and dissemination, this includes the financial framework for the projects.	This regulation concerns industrial water users through the effects of research and innovation on promoting sustainable water use, the effects of water quality on the environment, and the promotion of innovation and technological solutions for resource management pertaining to water and water-related products and processes. 
Regulation establishing the Strategic Technologies for Europe Platform (STEP)	2024	The STEP Regulation sets out the objectives supporting the development of technological solutions in three target areas of digitalisation, clean and resource efficient technologies, and biotechnologies.	This regulation relates to industrial water users through the implementation of resource-efficient technologies and digitalisation as it pertains to water use, water and wastewater treatment. The developments in biotechnologies will also concern industrial water users in their treatment of water and wastewater and possible use of biotechnologies in their processes, including in medicinal products. 
Regulation on the Statistical classification of economic activities in the European Community	1990, last amended 2008	The aims of this regulation is to establish classification and statistics of economical activities that are comparable across all EU Member States, and which take into account economical and technological developments and advancements.	This regulation pertains to industrial water users through the quantities of water used in heating and cooling, in collection, purification, and distribution of water, and water effected in transport, production and development projects. 

2.2.2. Analysis of EU Water Policy of relevance to Industry

To ensure good water quality and quantity statuses, the EU has developed multiple directives and regulations which incorporate the need for good ecological and chemical status of water, the repercussions of damage to water sources, and the promotion of sustainable water projects. The directives and regulations listed in Table 2 also encounter water quality, quantity, recovery, reuse, and sustainable and resilient management of water resources, focusing on those which solely concern water and where water is encountered through general environmental directives and regulations also.

Table 2 - EU Water Policy and its relevance to Industrial Water Users

Policy Title	Year published and most recent amendments	Summary of policy legislation	Summary description of importance to industrial water users
A Blueprint to Safeguard Europe's Water Resources	2012	Plans/Guidelines to implement policy action to further improve water legislation, how it is applied and integration of water policies with other related policies. Focuses on Water resource efficiency and sustainable water management.	This blueprint outlines the changes that may need to be made to current and upcoming legislation regarding the maintenance of water quality in European member states. This will be relevant to industrial water use as it outlines the directives, regulations, policies, etc., that industries will have to adhere to when in place. 
Urban WasteWater Treatment Directive (UWWTD)	1991, Last amended 1998, recast 2024	UWWTD requires collection and treatment in all urban areas of up to and exceeding 1,000 population equivalent (p.e.) by 2035, secondary treatment of all urban areas of more than 2,000 p.e. Tertiary treatment of urban areas with 150,000 p.e. and above by 2039, and quaternary treatment by 2045 for the same agglomeration.	The UWWTD is relevant to Industrial Water Use as it outlines the rules to follow for correct emission of effluents of wastewater from industrial sites and the outcomes of their contamination of water sources if regulations are not met. Pertaining to recast and the introduction of quaternary treatment to agglomerations of 150,000 or above by 2045 for the removal of micropollutants, industries who are the main producers responsible for the micropollutants in the

		Treatment facilities processing wastewater of 10,000 p.e. and above to power facility from their own energy generation by 2045. Pre-authorisation of all urban wastewater discharges from food-processing industry and industrial discharges into urban wastewater collection systems, monitoring of performance treatment plants and receiving waters, control of sewage sludge disposal and reuse, and treated wastewater reuse whenever appropriate.	water must contribute a minimum of 80% in cost to the treatment facilities through an extended producer responsibility scheme (EPR) following the 'polluter pays' principle. 
Marine Strategy Framework Directive	2008, last amended 2017	EU's main tool to conserve health of coasts, seas and the ocean. Focus on sustainable use of marine resources and activities related to maritime economy and society.	This directive mainly focuses on what the authoritarian bodies of the member states can achieve regarding marine waters. It becomes relevant to each industry specific to if they are discharging effluents to these marine bodies and the ecological and water quality statuses of these marine bodies. 
Minimum Requirements for Water Reuse - guidelines	2022	Guidelines provided for the minimum requirements for water reuse - based upon the Water Reuse Regulation.	This document is relevant to industrial water use in terms of circularity and water reuse. 
Water Reuse Regulation	2020	Regulation sets out minimum water quality requirements for safe reuse of treated urban wastewaters in agricultural irrigation, minimum monitoring requirements, risk management provisions to assess and address potential additional health risks and possible environmental risks, permitting requirements, provisions on	This document refers to the risk management, monitoring and minimum water quality requirements to be met for water to be reused. This legislation is relevant to the industrial water use as water recovery and solute recovery are clear outcomes or goals of the project and will also align with the circularity and sustainability of water in these areas.

		transparency, whereby key information on every water reuse project is made available to public.	Water Quality; Water Quantity; Water Governance; Environmental Protection; Circularity
Nitrates Directive	1991, last amended 2008	Directive aims to protect ground and surface waters across Europe from agricultural sources by promoting good farming practice. Monitoring nitrate concentrations in waterbodies, designating nitrate vulnerable zones and establishing good agricultural practices and measures ensures prevention of nitrate pollution of these waterbodies.	The nitrates directive is relevant to industrial water users for intensive agriculture, food and beverage production pertaining to the use of nitrates on land as fertilisers and the impact they have on the ecosystem, catchment, river-basin, or any relevant waterbody. Water Quality; Water Governance; Environmental Protection; Circularity
Water Framework Directive (WFD)	2000, last amended2014	WFD ensures qualitative and quantitative health of waterbodies by reducing and ultimately removing pollution for enough water to support wildlife and human needs. Member States must adhere to River Basin Management Plans (RBMPs) and Programmes of Measures to protect and restore water bodies to maintain healthy status both chemically and ecologically and ultimately prevent deterioration of water bodies. Mainly focuses on surface water and groundwater in legislation.	The purpose of the directive is to ensure the protection inland surface waters, transitional waters, coastal waters and groundwater, while also protecting their associated ecosystems and promoting sustainable water use. These areas will be addressed through member states monitoring their own River Basin Districts. While this is important on a stewardship and catchment scale for local and national authorities of the member states - the legislation that prevails from this is important for sites to follow for industrial water use. Water Quality; Water Quantity; Water Governance; Environmental Protection
Groundwater Directive	2006, last amended 2014	Directive provides procedures for meeting WFD's environmental objectives for groundwater quality by setting EU-wide groundwater quality standards for small number of pollutants. Provides an outline of quality standards and guidelines for effective monitoring and interpretation of chemical results.	This directive is relevant to industrial water use via the extraction and emission of industrial water from and to groundwater sources. Water Quality; Environmental Protection
Floods Directive	2007	The floods directive encourages development of flood risk management plans, also supports objectives of the WFD. Provides foundation for	This directive is relative to the industrial water use as it encourages those companies in flood-risk zones (also non-flood risk zones) to think of flood management plans. This becomes relevant when

		establishing policy and implementation with EEA member countries also.	stormwater gulleys and other outlets are affected by flood waters and contamination of other water sources occurs as a consequence. 

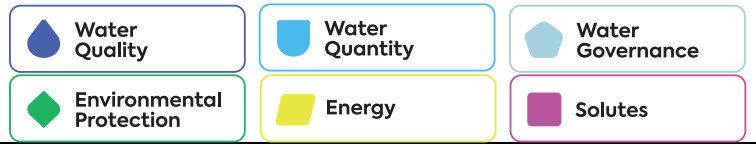
2.2.3. Analysis of EU Energy Policy of relevance to Industrial Water Users

EU energy policy is designed to ensure the functioning of the energy market in Europe and to ensure security of energy supply. EU energy policy is based on 4 key principles (European Commission, 2025):

- Decarbonisation
- Competitiveness
- Security of supply
- Sustainability

With a number of measures aimed at achieving a complete Energy Union within the EU, Table 3 lists the Energy Policies, Legislation and Regulations pertaining to industrial water users.

Table 3 - EU Energy Policy and its relevance to Industrial Water Users

Policy Title	Year published and most recent amendments	Summary of policy legislation	Summary description of importance to industrial water users
Ecodesign Directive for Sustainable Products Regulation (ESPR)	2024	Ecodesign for Sustainable Products Regulation (ESPR) replaces the Ecodesign for Energy Related Products (2009, last amended in 2012). The aim of this directive is to achieve a more sustainable economy in the EU by moving towards a circular economy approach as laid out in the ne Circular Economy Action Plan (CEAP). The directive is categorised in the energy section due to the	This regulation is important for industrial water users through the aims for resource-efficient products and the rules encountered in the regulation regarding carbon and environmental footprints. 

		primary aim of meeting EU energy reduction targets by 2030.	Circularity
EU Emissions Trading Systems (ETS) Directive	2003, last amended 2024	The EU ETS directive aims to reduce the emission of GHGs in the power and industrial sectors by using the 'cap and trade' principle. This principle is applied through emission allowances of CO2 which are sold in auctions and allowed to be traded among industries which qualify. Companies must monitor their emissions annually under this directive and allow for their emission cap.	This directive relates to industrial water users through the emissions cap and their allowance when it pertains to their water-related production and emissions and the treatment of their water to and from their site(s). Water Quality, Water Governance, Environmental Protection, Energy, Circularity
Energy Efficiency Directive	2023	Sets out guidelines for energy efficiency regarding overall energy consumption by setting out energy and climate rules to achieve 55% reduction in GHG emissions by 2030.	This directive while focused on energy and energy consumption, it also addresses water consumption in line with energy consumption. Similarly, it addresses the domestic water usage and energy consumed to heat domestic water uses - may be used with industrial water use and recovery processes for the project. Water Governance, Environmental Protection, Energy, Circularity
Hydrogen Strategy	2020	Outlines plans for promoting hydrogen as fuel for climate neutral Europe.	Similar to the Renewable Energy Directive outlined below, this document may be only needed if technologies are gearing towards electrolysis-based energy, heating and other water/energy-based recovery processes. Water Governance, Environmental Protection, Energy, Circularity
National Energy and Climate Plans (NECPs) Regulation	2018, last amended 2023	The National Energy and Climate Plans were introduced as part of the regulation on the governance of the energy union and climate action. The plans outline the need for EU Member States to address decarbonisation,	This regulation relates to industrial water users through their NECP relative to the countries in which they operate. The exact plans will differ among the needs of each state, but overall plans will relate to the promotion of decarbonisation, energy efficiency, energy security, internal energy market, and research into this field. This will be

		energy security, energy efficiency, internal energy market, and research and competitiveness. EU Member States plans were published in 2020, and each country must submit a progress report every 2 years.	encountered through the energy use in water treatment and processes which are water and energy intensive and also give opportunity for organisations to research and investigate measures to make their water-related processes and treatment facilities more energy efficient or to decarbonise these processes. 
Renewable Energy Directive	2018, last amended 2024	Directive promoting the use of renewable energy where applicable, discusses some areas with reference to water both in industry and as natural resource for renewable - hydro- energy.	Relevant to water and energy recovery. 
REPowerEU Plan	2022	This plan was introduced to promote the use of renewable energy within the EU and ultimately encounter the reliance of member states on the use of fossil fuels for energy.	This plan applies to industrial water users through the promotion of renewable energy within industry and to move energy intensive processes to be powered by more renewable resources. 
Energy Performance of Buildings Directive	2010, last amended 2021	This directive concerns the energy performance of buildings and includes some SMEs and small industries within its scope. The directive encounters the issues of energy losses and promotes energy savings through energy efficiency.	This directive concerns industrial water users as in the assessment of industries and SMEs of their energy performance they must include wastewater uses and the energy used, lost, and potential for savings. 
Energy Statistics Regulation	2008, last amended 2024	This regulation allows for a common framework among EU member states of energy statistics which are comparable for public.	This relates to industrial water users for the comparing of their energy use of water-related energy uses such as heating, the energy use of water-related processes and treatment across other users of the same kind within the EU. This can aid in decision-making at a national and international level.

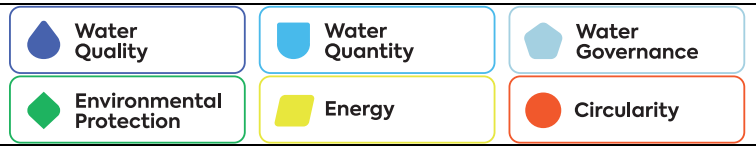
			Water Governance; Environmental Protection; Energy

2.2.4. Analysis of EU Waste and Circularity Policy of relevance to Industrial Water Users

The EU's transition to a circular economy aims to make Europe cleaner and more competitive. This transition will reduce the pressure on natural resources, create sustainable growth and support EU 2050 targets to become climate neutral and half biodiversity loss (European Commission, 2025). Table 4 outlines Waste & Circularity Policies, Legislation and Regulations pertaining to industrial water users.

Table 4 – EU Waste and Circularity Policy and its relevance to Industrial Water Users

Policy Title	Year published and most recent amendments	Summary of policy legislation	Summary description of importance to industrial water users
A New Circular Economy Action Plan	2020	Building Block of European Green Deal, outlines European agenda for sustainable growth. Initiatives based around life cycle of products, promoting sustainable consumption, ensuring resources are kept in EU economy as long as possible. Lays groundwork for legislations.	This plan is relative to industries based on its goal to track unintentional release of microplastics and the circular focus on water reuse regulation set out as a goal of this project. This doc., outlines how European 'Commission will facilitate water reuse and efficiency, including in industrial processes.'. This will be a key component to reference in the literature review backing up further info. in the Water Reuse Regulation documents. Water Quality; Water Quantity; Water Governance; Environmental Protection; Energy; Solutes; Circularity
Waste Framework Directive	2008, last amended2024	Waste Framework Directive sets out basic concepts for all of EU and defines waste management including recycling and recovery. Outlines main waste management principles so to ensure human and environmental health, no risk to water, soil, air, flora or fauna, introduces "polluter pays	Relevant for any breach of disposals to water bodies particularly of chemicals that are flammable or toxic when they react with water - environmental health and safety breaches. Also applicable for not polluting waterways directly from industrial site.

		principle" and "extended producer responsibility".	
Packaging and Packaging Waste Directive and Regulation	Directive 1994, last amended 2018, Regulation 2025	The Packaging and Packaging Waste Directive (PPWD) and now Regulation (PPWR) set out the rules and parameters regarding the materials involved in packaging and packaging waste for multiple sectors including industry, and the management of these materials. Both the directive and the regulation outline the need for recycling, reuse, and promote a more sustainable and circular economy.	This directive and regulation concern industrial water users through packaging containing PFAs and the impacts on water quality through the emission of PFAs to water sources, and the pollution of water and its effects on the water quality. 
The Battery Directive	2006, last amended 2018	This directive aims to ensure that the lifecycle of batteries within the EU is sustainable and where applicable circular through the collection, recycling and repurposing of batteries throughout their lifecycle. The sustainable use of batteries aids in achieving clean energy transition aims of the EU.	This directive interacts with industrial water users through the industrial use of batteries and any interactions with batteries and water-related processes, it also interacts with possible pollution of water resources in the case of incorrect disposal. 

2.2.5. Analysis of EU Soil and Land Policy of relevance to Industrial Water Users

The EU has an explicit aim to improve soil health to benefit people, food, nature and climate (European Commission, 2025). Table 5 contains Soil and Land Policies, Legislation and Regulations pertaining to industrial Water Users.

Table 5- EU Soil and Land Policy and its relevance to Industrial Water Users

Policy Title	Year published and most recent amendments	Summary of policy legislation	Summary description of importance to industrial water users
EU Soil Strategy for 2030	2021	Strategy sets out framework and concrete measures to protect and restore soils, and to ensure they are used sustainably. Is key deliverable of EU biodiversity strategy for 2030 and contributes to the objectives of European Green Deal.	This section refers to soils and the purpose of maintaining high soil quality for filtration of nutrients and water. This may be relevant to organisations disposal of wastewater and extraction of groundwater for industrial use. One of the aims of this strategy is to 'reach good ecological status and chemical status in surface waters and good chemical and quantitative status in groundwater by 2027'. 
Guidance to member states in improving the contribution of land-use, forestry and agriculture to enhance climate, energy and environment ambition.	2023	Guidance document addressing the contribution land use, forestry and agriculture has to affect positively and negatively climate energy and the environment as a whole - mainly addressing positive actions that could be taken.	This guidance concerns industrial water users through interactions with pollution of fresh water resource, water quality, correct treatment of wastewater, water quantity, sustainable water management, and emissions from intense water users. 
Land-Use, Land-Use Change, And Forestry (LULUCF) Regulation	2018, last amended 2023	Regulations based on LULUCF to account for GHG's and removal of any source from land.	This document relates to land change uses which may be relevant to industrial water use if organisation is implementing construction on land not previously used for intentions of water facilities. The document focuses on preventing the change in land use for declining climate resilience, affecting vital resources (freshwater) and damaging necessary ecosystems.

			Water Quality; Water Quantity; Water Governance; Environmental Protection; Circularity
Regulation on Plant Protection Products and Pesticides	2009, last amended 2022	This regulation mainly addresses the protection of crops against pests, diseases and competing plants in regard to food production and crops for industrial food and beverage production.	This regulation interacts with industrial water users through the impact of pollution on water quality, the treatment of this water or costs for restoration, the adverse effects on ecosystems due to the pollution of the water resource. Water Quality; Water Quantity; Water Governance; Environmental Protection; Solutes

2.2.6. Analysis of EU Industrial Safety Policy of relevance to Industrial Water Users

This section of the document outlines the key industrial safety and associated emissions / pollution prevention policies of the EU in relation to industry. Table 6 lists key Industrial Safety Policies, Legislation and Regulations pertaining to industrial water users.

Table 6 - EU Industrial Safety Policy and its relevance to Industrial Water Users

Policy Title	Year published and most recent amendments	Summary of policy legislation	Summary description of importance to industrial water users
Chemicals Strategy for Sustainability	2020	Guidelines for innovation of safe and sustainable chemicals/chemical use with public health and environmental protection as a key focus. Built upon existing European chemical laws.	This document in alignment with the REACH regulation emphasises the need for correct handling and use of chemicals to ensure no pollution, contamination or incident of misuse regarding chemicals and their interaction with on-site water and water resources in the wider catchment. The document addresses the use of PFAs by organisations in their processes or as a by-product of their processes and how to correctly handle these substances regarding other safety and environmental legislation. Similar to other documents this addresses the industrial water use aspect by ensuring no contamination of water into site or discharged from the site.

			
Industrial Emissions Directive (IED)	2010, last amended 2024	Regulations for each member state to impose on industries within their state in order to regulate pollutant emissions from these industries. Permits granted by each member state should be based off of the IED, which itself is a predecessor of the IPPC - Integrated Pollution Prevention Control Directive.	This directive introduces an integrated approach to dealing with multiple emissions, emission factors and environmental factors which must be addressed when emitting from an industrial site. The document approaches the rules, regulations and best available techniques for safe emissions from sites. This encompasses any emissions to any water source. It will be relative to all industrial water use and regulations for their emissions of water off-site. 
Industrial Emissions Portal Regulation (IEPR)	2024	The IEPR replaces the European Pollutant Release Transfer Register Regulation (E-PRTR). IEPR aims to provide transparency among the Industrial Emission Directive (IED) permitted sites and the public.	The IEPR links with IED 2.0 through the transparency, which is intended to encourage the public and industries to work cohesively on the environments they inhabit. The IEPR enables industrial water users to quantify impacts for their reporting in CSRD both individually and for their value chain and affected communities. 
Regulation on the Classification, Labelling and Packaging of Substances and Mixtures (CLP)	2008, last amended 2024	Regulations regarding proper classification, labelling and packaging of substances and mixtures as both a human and environmental health and safety concern.	This regulation interacts with industrial water users through water consumption, water governance, and the environmental impact of incorrect labelling and packaging pertaining to materials used in water-related processes and water and wastewater treatment. 

ATEX Directive	2014	The ATEX directive sets out the equipment and protective systems to be employed in potentially explosive atmospheres, including the health and safety requirements and conformity assessment procedures to be applied prior to introduction to EU markets.	This directive relates to industrial water users through safety of using equipment in water-related processes and water and wastewater treatment process, and the environmental effects if not employed in explosive atmospheres. 
Directive concerning the minimum safety and health requirements for the workplace	1989, last amended 2019	This directive lays out the minimum health and safety requirements required for a safe work environment scoping multiple industries and sectors, including hygiene and transport.	This directive interacts with industrial water users through the establishment of safe working environments pertaining to water and water-related processes including heating, cooling, and treatment. 
Directive on the minimum requirements for the use by workers of PPE at workplace	1989, last amended 2019	This directive conveys the minimum requirements for the use of personal protective equipment in the workplace, where risks cannot be controlled by technical or organisational measures.	This directive pertains to industrial water users through the requirements of PPE needed by workers at wastewater treatment plants, laboratories, and other related processes where water is involved. 
Internal Management Safety Code Regulation	2006, Last amended 2019	This regulation pertains to the safe operation and safety of ships and companies who use those ships for trade and transport, and the prevention of pollution emanating from those ships.	This regulation pertains to industrial water users through the prevention of pollution effecting water quality. 

Personal Protective Equipment Directive (PPE) Regulation	2016	This regulation entails the legal obligations that cover the production and marketing of PPE. Ensuring compliance at an EU level	This regulation relates to industrial water users through the proper standard of PPE needed when interacting with water, wastewater and other agents relating to the water-related processes and treatment. 
Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation	2006, Last amended 2024	REACH Regulation is based on the regulation, evaluation, authorisation and restriction of chemicals on main EU law for human health and environmental protection from the risk imposed by use of chemicals and proper disposal.	This regulation aligns with workplace communities and environmental legislations focusing primarily on chemical data and repercussions or cautions to be taken when using, handling and producing of chemicals on site. This will affect water treatment within water use and if water is a danger to safety when used with specific 'flammable with water' chemicals that may be used on-sites. For the specifics of the project, it may be useful in the cases of industries which are performing water and solute recovery that will need chemicals during the process or create chemicals as a product of the process. 
Regulation on substances that deplete the ozone layer	2009, repealed 2024	this regulation sets out the ambitions under the EU Green Deal for a fair and prosperous society, zero pollution ambitions and the protection of public health with regard to products and their effects on the ozone layer	This regulation relates to industrial water users through environmental protection which may lead to the degradation of water-related ecosystems, impact crop production, and the use of products which negatively impact the ozone layer in water-related processes or the treatment of water and wastewater. 
Directive on the protection of workers from risks related to	2000, last amended 2020	This directive sets out the minimum health and safety requirements pertaining to workers who may be exposed to biological	This relates to industrial water users where biological agents are used in water or wastewater treatment processes or in water-related processes.

exposure to biological agents at work		agents in the workplace, and any risks pertaining to this exposure.	Water Quality; Water Governance; Environmental Protection
Pressure Equipment Directive	2014	This directive outlines the manufacturing and conformity assessment needed for stationary pressure equipment, and the recommended health and safety requirements relative to the equipment.	This directive relates to industrial water users through the equipment used in water-related processes such as heating, and in the discharge of water and wastewater. Water Governance; Environmental Protection; Energy
Regulation on Persistent Organic Pollutants	2019, last amended 2024	This regulation encounters the release of persistent organic pollutants into the environment, restrictions related to their release, and the reduction in manufacturing and marketing of persistent organic pollutants through the precautionary principle.	This regulation concerns industrial water users through the release of persistent organic pollutants to water, through the use of persistent organic pollutants in water and wastewater treatment, and the effects on water quality from the release. Water Quality; Water Governance; Environmental Protection
Safety and/or Health Signs Directive	1992, last amended 2019	This directive outlines the requirements of organisations to establish health and safety signs in the workplace where risks may still be encountered following corrective or preventative measures.	This directive interacts with industrial water users through the placement of signs related to health and safety warnings relative to water-related processes, risks encountered in the location of laboratories, treatment plants, and other water-related processes necessary for the protection of workers and accident prevention. Water Governance; Environmental Protection; Solutes
Chemicals Agents Directive	1998, last amended 2024	This directive outlines the requirements for the protection of workers from potential risks due to the use and exposure to chemical agents in the workplace.	This directive interacts with industrial water users through chemical agents which may be used in conjunction with the treatment of water or wastewater, and the use of chemical agents in water-related processes. Water Governance; Environmental Protection
Inland Transport of Dangerous Goods Directive	2008, last amended 2025	This directive outlines the requirements for the safe transport of dangerous goods and the mitigation and prevention of risks pertaining to environmental pollution across road, rail and inland waterways.	This directive interacts with industrial water users through the prevention of pollution of waterways containing waste materials from water-related production and treatment processes.

			Water Governance; Environmental Protection
Regulation Concerning the export and import of hazardous chemicals	2012, last amended 2025	This regulation sets out the requirements for the trade of hazardous chemicals, the protection of human and environmental health through the promotion of safe transportation of hazardous chemicals, and the safe use hazardous chemicals.	This directive interacts with industrial water users through the use of hazardous chemicals in water-related production and treatment processes, the prevention of water-related ecosystems from pollution caused by the improper transport of hazardous chemicals and the prevention to negative impacts to human health through the release of hazardous chemicals. Water Governance; Environmental Protection
Seveso-III Directive	2012	Directive regarding industrial safety and the control of major-accident hazards involving dangerous substances.	This directive is relative to industrial water use by means of the transportation of dangerous substances and how it will affect water resources if there are accidents or incidents. It also encompasses site accidents and incidents affecting onsite water uses and contaminations and the laws which will affect organisations of non-compliance. Water Governance; Environmental Protection
Occupational Health and Safety Framework Directive	1989, last amended 2008	This directive outlines the health and safety requirements of workers at work, including the identification and elimination or prevention of health and safety risks in the workplace. This directive also outlines the training requirements of workers in the workplace to the health and safety measures required.	This directive interacts with industrial water users through health and safety measurements pertaining to water-related production and treatment processes. Water Governance; Solutes
Directive concerning the minimum safety and health requirements for the use of work equipment by workers at work	2009	This directive outlines the minimum health and safety requirements regarding the use of work equipment at work including working at height, the safe use of mobile work equipment, and safe lifting of heavy loads.	This directive interacts with industrial water users regarding water-related production or treatment processes which require training prior to action such as those described in the directive description. Water Governance

Directive relating to noise exposure to workers| Safety and health at work	2003, last amended 2019	This directive outlines the minimum health and safety requirements for protection of workers exposed to noise to prevent the risk of hearing loss.	This directive interacts with industrial water users where water-related processes or treatment or equipment used in these treatment processes may cause risk to hearing loss. Water Governance

2.3. Analysis and Summary – Key Discussion Points

This section of the document presents discussion points arising from the analysis of EU environmental policy and its role in supporting industry in contributing to the EU's key climate objectives.

2.3.1. Economic and Environmental Impact for Industry of Integration of Circularity Policies

The integration of circularity policies into industrial practices has profound economic and environmental impacts. These policies, which emphasize the reuse, recycling, and regeneration (RRR) of materials, aim to create a sustainable economic model that minimizes waste and resource consumption. The benefits of adopting circularity policies are significant, but they also come with challenges that need to be addressed for successful implementation.

Economically, circularity policies can lead to substantial cost savings for businesses by reducing the need for raw materials and minimizing waste disposal costs (Mannina et al, 2021. The EU has been actively exploring and implementing circular economic principles in the water and wastewater sectors. One study delves into the opportunities and challenges within the policy, process, and procedural frameworks that govern water circularity in key sectors across Europe. Another case study proposes a comprehensive framework focusing on the reduction, reuse, recycling, recovery, and reclamation of water resources. It emphasizes the effective removal of pollutants and the adoption of sustainable water management practices, showcasing practical applications of circular economic principles in the sector (Qtaishat et al, 2022).

By keeping materials in use for as long as possible, companies can lower their production costs, reduce waste, conserve resources, and increase their competitiveness. For instance, the adoption of circular economic practices in the European Union is projected to generate net economic benefits of €1.8 trillion by 2030 (McKinsey & Company, 2015).

Additionally, circularity can open new revenue streams through the creation of secondary markets for recycled materials and refurbished products. Companies that embrace circularity can also enhance their brand image and attract environmentally conscious consumers, leading to increased customer loyalty and market share.

From an environmental perspective, circularity policies significantly reduce the ecological footprint of industrial activities. By promoting the reuse and recycling of materials, these policies help conserve natural resources and reduce the environmental impact of resource extraction and processing. For example, the circular economy model can reduce greenhouse gas emissions by up to 39% and cut down on waste generation by 80% (WEF, 2022). This shift towards a more sustainable production model also helps mitigate the adverse effects of climate change and biodiversity loss, contributing to the overall health of the planet.

2.3.2. Industrial Challenges in meeting regulatory requirements and transitioning to a circular economy

Although there are benefits to transitioning to a circular economy as highlighted in the sections above, the transition to a circular economy is not without its challenges. One of the primary obstacles is the

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initial investment required to redesign products and processes to fit the circular model. Companies may need to invest in new technologies and infrastructure, which can be costly and time-consuming. Additionally, there is often a lack of standardized guidelines and regulations to support the implementation of circularity policies, leading to inconsistencies and inefficiencies.

Another challenge is the need for a cultural shift among consumers and businesses alike. Changing long-standing habits and practices to embrace a circular mindset requires education, awareness, and a willingness to adopt new behaviours.

Moreover, the circular economy faces technical challenges related to the quality and purity of recycled materials. Over time, impurities in recycled materials will be released via wastewater, leading to complex wastewater streams that cannot be treated in standard biological wastewater treatment plants (WWTPs), requiring more advanced and costly treatment methods

3. Industrial Trends in Water Stewardship, Circularity and Resource Recovery

3.1. Introduction

This section of the document provides a summary of the key industrial trends in water stewardship, circularity, and resource recovery based on both desk and primary research. This section of the document also details the key barriers and enablers of engaging in industrial water management practices across these material areas The final part of this section provides some discussion points based on the analysis.

3.2. Trends Analysis

This section provides an overview of some of the emerging trends facing industrial water users as they grapple with an evolving landscape in industrial water management, key internal and external drivers (see Section 1.4) and emerging approaches to water stewardship, circularity, and resource recovery.

3.2.1. Understanding the Value of Water withing Industry

Water as a resource is typically undervalued on a global and local scale. Water is viewed as an infinite resource with insignificant monetary value, which coincidentally leads to inefficient use and poor water management by industries globally (Famiglietti *et al.*, 2022). This perceived view combined with the often-unclear Return on Investment (ROI), competing site priorities and uncertain outcomes often results in industrial water initiatives failing to commence (Gaskin *et al.*, 2023).

It is estimated that by 2050 water demand for domestic and industrial sectors will increase by 50-70% (WBSCD, 2020) with a 400% overall increase expected across manufacturing sites alone (UNESCO, 2021). Industries use twice the amount of water as domestic households in their business activities, making industry a significant market for emerging water-related technologies and solutions but also considerably exposed to water risk within their business operations (Gasson *et al.*, 2024). Global Water Intelligence (GWI) has estimated that value at risk from water-related climatic events may reach $3.1trillion by 2034 (Gasson *et al.*, 2024).

The WWF splits the total economic value of water into three separate categories: the use value, the non-use value, and the option value of water (WWF, 2023). The use value is further viewed in two areas, the direct use value of water, referring to the benefits to business and society from consuming and utilising freshwater resources, and the indirect use value of water, pertaining to the benefits to businesses and society which derives from the ecosystem services provided by freshwater resources such as flood regulation or carbon sequestration. The non-use value of water is defined as the benefits to humans from freshwater that do not utilise the resource, such as mental-health benefits or the bequest value of water for future utilisation. The third category described by the WWF is the option value of water which is derived from the value of preserving the resource for future use or the

maintenance of the resource if currently being utilised, including the recognition that conditions of the water resource may change or need to be improved (WWF, 2023).

With the focus on how water is valued by industry currently, the WWF have highlighted that industrial activities rely on 600 billion cubic metres of water per annum (WWF, 2023). GWI have also identified water to be in both the category of expenditure and risk in the eyes of industry. Water is viewed in the category of expenditure as a requirement for most industrial processes and it is currently estimated that 3% of corporate expenditure is afforded to water-related systems and infrastructure (Gasson *et al.*, 2024). Industries often undervalue water as they equate the value of water to the price on their water bill, not accounting for the price of extraction, transportation, usage, pollution, or any external factors associated with these activities (CDP, 2023).

In July 2024, a review of responses to the CDP Water Security Questionnaire was conducted by Watermarq, specifically focusing on questions related to internal water pricing. A respondent sample of 188 companies was propagated following filtering for organisations who are endorsers of the CEO Water Mandated and on the CDP Water Security 'A' List. The focus of the review was centred around the CDP question W7.4. "Does your company use an internal price on water?". The review analysis was supplemented by the inclusion of relevant information from organisations annual sustainability reports, water stewardship reports, and other publicly available documents where available. The starting hypothesis of the report is that external water pricing is typically a poor allocative signal for organisations reflecting the value of water, thus many organisations are compensating for this by allocating internal water pricing. Organisations have encountered benefits from utilising internal water pricing for value creation by optimising internal capital allocation and investment in water stewardship projects (Watermarq, 2024).

Organisations must view the value at risk as value creation opportunities where water is concerned. Viewing water related business risk as opportunities for investment and water-security are key to mitigating the external risks to business (Gasson *et al.*, 2024). Valuing both internal and external risks in the overall value of water allows industries to safeguard their supply chains, mitigate internally and externally along their value chain from climate change and consequential extreme weather events and implications (CDP, 2023).

Value creation within industrial water systems takes multiple forms to address various water-related risks and challenges. Emerging technologies and solutions to deal with water demand, process efficiency, and water quality at an industrial level have also seen value creation from these solutions, such as the value-from-waste emanating from the implementation of circular technologies (Gasson *et al.*, 2024). Technological advancements in big data, AI and cloud computing are enhancing the industrial efficiency of water management and value creation, while also streamlining data collation for auditing and disclosure reporting (Dobson *et al.*, 2023). An organisation's investments into water-reuse technology not only mitigates the risks posed by external water-related risks and water security pressures, such as basin stress or flooding, but also holds potential for value creation in the savings on water bills or investment into resources within the water that may be recovered such as raw materials and energy (Gasson *et al.*, 2024).

The value of water has also been intrinsically linked with the value of nature and biodiversity conservation. This has become more prominent with the emerging role of nature-based solutions are holding in water stewardship and conservation projects globally, specifically with disclosure reporting

and maintenance of freshwater resources and ecosystem preservation against climate change (Dobson *et al.*, 2023). Water Europe have established a Water-Smart Society model where the value of water is at the core of investments, decision-making, and stakeholder engagement for water governance throughout society. The white paper calls for industries, among other societal sectors, to view the value of water at the core of three main objectives; water resilience against the impacts of climate change, water security for prevention of scarcity and pollution, and water sustainability where governance and management systems pertaining to water are prepared for future scenarios (Rubini *et al.*, 2024)

The holistic approach Water Europe calls for in emphasizing the value of water includes five innovation concepts under the three key objectives listed prior, Circular Water referring to circular water systems which capture losses, Multiple Waters: which considers water security and resilience through incorporating alternative water sources of varying quality such as groundwater and brackish water, Digital Water: which refers to connecting smart monitoring systems and networks from multiple sources to individual end users, Inclusive Water: which considers the governance of water systems in a comprehensive manner to adequately meet the demands of all stakeholders in the system design, maintenance and management, and Resilient Water: referring to hybrid water systems of green and grey water incorporated for business and societal resilience against internal and external risks and impacts on the collective water system without disrupting essential activities (Rubini *et al.*, 2024). Businesses that do not comprehend the full value of water often omit water-related risk planning in their business strategies (WBCSD, 2018). Industry is a key stakeholder within the proposal for a Water-Smart Society, but the same principles should be applied internally for water management systems to acquire the full value of water across internal operations to an industry and possible expansion to their supply chain, with an ultimate governance goal of comprehensive water management across the value chain.

3.2.1.1. Survey Findings – Water Governance Activity

To examine the extent to which industrial water users focus on water by viewing the uptake of industrial water governance activities, a question was posed to respondents asking, “Has your organisation implemented any of the following governance activities?” Respondents were provided with a list of

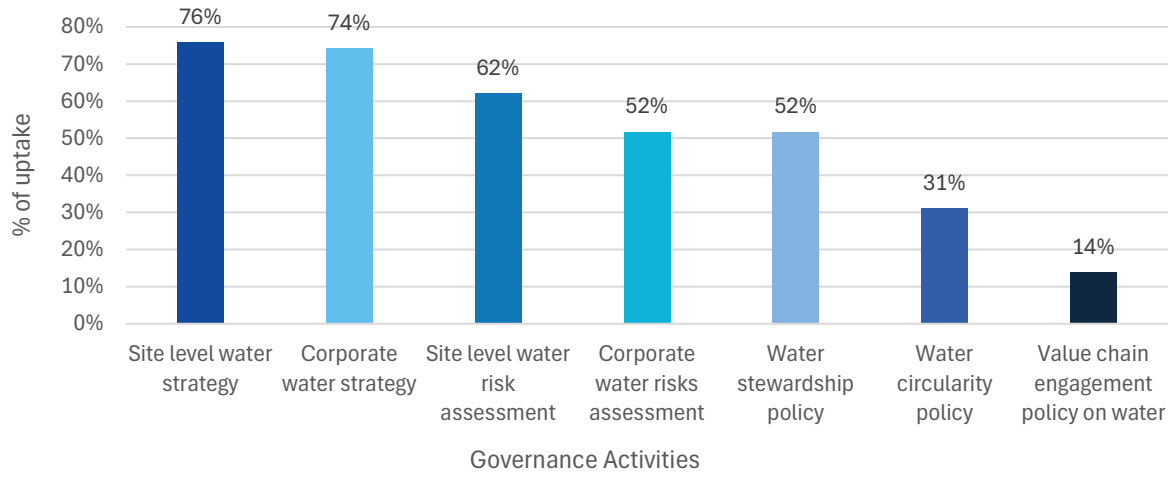

Figure 5 – Survey Findings - Water Governance Assessment

governance activities, from which they selected all items that they have engaged in. The response list included items such as 'Corporate water strategy', 'Water stewardship policy' and 'Site level water strategy'.

The results presented in Figure 5 indicate that industry engages with an average of four governance activities relating to water. The two most common water governance activities are a 'Site level water strategy' (76%) and a 'Corporate water strategy' (74%). These strategies involve adopting practices that promote sustainable water use, protect water resources, and ensure the well-being of surrounding communities and ecosystems.

Risk assessments also receive a high level of industrial engagement, both in terms of a 'Site level water risk assessment' (62%) and 'Corporate water risks assessment' (52%), alongside a 'Water stewardship policy' (52%). This proactive approach to risk management ensures that industries are better prepared to handle potential water-related challenges, thereby safeguarding their operations and reducing vulnerabilities.

Furthermore, nearly one third of respondents have a 'Water Circularity Policy' (31%). Engagement with water circularity policies is notable, indicating efforts to promote the reuse and recycling of water within industrial processes. This approach not only helps in conserving water resources but also reduces the environmental impact of industrial activities by minimizing wastewater generation and promoting resource efficiency.

However, few industries demonstrate having a 'Value chain engagement policy on water' (14%). The low uptake of such policies reflects how industry approaches the value of water as a site / organisation specific responsibility but are yet to extend their influence further down the value chain in promoting strong water stewardship practices.

3.2.2. Increasing Industrial Focus on Water Risk and Resilience

Water is material to most business and is vital to their business operations (Le Sève *et al.*, 2024). The impacts of climate change and population growth are increasing the demand on water resources, disruptions to hydrological cycles, and declining quality producing multiple risk factors for industries to overcome within their water management strategies (Famiglietti *et al.*, 2023). Climate-related water risks have influence on multiple systems including energy and food production, which has the potential for significant socioeconomic damage (Delgado *et al.*, 2021). Water-related risks can be local in nature and operational contexts but can cause business interruptions globally creating financial implications for industry and damaging corporate reputations (WBCSD, 2020).

As a requirement of businesses reporting environmental disclosures, they are obligated to complete a materiality assessment, such as required for CSRD. The materiality assessments while a requirement, have multiple benefits for the organisation in understanding their materiality risks or potential environmental, social, and governance (ESG) impacts and opportunities. Through proactively addressing these risks, organisations can reduce their exposure to future regulatory and legal risks, reputational risks, operational and infrastructural risks, and financial risks (Ayley *et al.*, 2024). Voluntary water reporting standards and non-voluntary reporting standards, such as CSRD, have directed organisations to water risk tools, such as the WWF Water Risk Filter, in order to identify their potential

current risks within their basin (CSRD delegated act, 2023). Publications and tools provided by the CEO Water Mandate, Ceres, WWF, WRI, and WBCDS offer organisations information on the initial steps they should take to indicate corporate and site level water monitoring and water-related risk assessments (Gramlich *et al.*, 2023). This allows organisations to set a baseline of their water use and emissions to water and in the case of the WWF Water Risk filter allows organisations to view projected scenarios of their current risks if unchanged, an optimistic scenario, and a pessimistic scenario (WWF et al., 2024). The three main risk types reviewed under the WWF Risk Filter tool informed upon by the CEO Water Mandate are physical risks, regulatory risks, and reputational risks, these are similar in other water risk indicator tools also recommended by reporting bodies such as the WRI Aqueduct tool (WWF 2024; Kuzma *et al.*, 2023). More analysis on water risk tools is provided in Section 5.

Businesses, through water-related reporting standards, are required to give their impacts on stakeholders within their basins or catchments with regard to water quality and quantity of freshwater resources they interact with such as rivers, lakes, etc. The impacts on communities within these catchments can pose a risk to the organisation when they are contributing to the pollution of these freshwater bodies that are also dependent on the freshwater resource (Onyima *et al.*, 2024). Wastewater volumes increase annually, and while efforts have escalated to match the volume created to the volume treated, untreated wastewater continues to remain a severe global challenge with over half of the wastewater discharged to the environment not appropriately treated (UNEP, 2023).

The industrial sector, like many others, is dependent on water of high quality and abundance to ensure the continuity of operational activities. Deteriorating water quality and water supply local to businesses are creating global financial impacts on their organisations, while also creating reputational risks for the organisation as water users are interdependent and affect other stakeholders and society within their catchment (WBCSD, 2018). The WEF Global Risks Report 2025 found that global environmental risks of 'Extreme weather events' and 'Pollution' ranked second and sixth place, respectively, by the overall respondents for projected risks encountered in the short-term of two years. However, respondents from the private sector, including industries, have ranked the same environmental risks as fourth and ninth, respectively, within the same timeframe. In the risks ranked over the short-term of two years, the private sector has ranked societal, geopolitical, and technological risks among their highest risks to the sector, with societal risks being the most frequent within the top ten risks ranked (WEF, 2025).

In comparison to the short-term environmental risks ranked by industry, the long-term environmental risks over a 10-year timeframe environmental risks rank quite high based on respondents' results. Environmental risks account for the top four global risks, with 'Extreme weather events' ranked as the number one risk overall. This stays true when analysed per stakeholder group with environmental risks accounting for the top three risks as scored by the private sector, with 'Extreme weather events' remaining as the highest-ranking risk to the private sector (WEF, 2025).

While it is key for industries to evaluate their on-site materiality they may overlook risks along their supply chain. In 2023, 1 in 5 organisations reported to CDP that water-related supply chain risks are increasing annually and causing significant risks for organisations (Le Sève *et al.*, 2024).

Water resilience is defined as the ability of water and wastewater utilities to withstand and recover from natural- or man-made disasters. The opportunities to reform water management systems

within an organisation range from the updating of infrastructure to implementing new and improved technologies to aid in water quality improvements and monitoring consumption.
(US EPA, 2024).

Water resilience advancements to wastewater systems at a private and public level are essential in climate adaptation projects, these adaptations projects are further aided through collaborative action to address water risk and resilience challenges to water systems (Ayley *et al.*, 2024).

3.2.2.1 Survey Findings – Risks to Site Water Management

To examine the uptake of industrial perception of **risk** to site water management, a question was posed asking respondents, "What would you consider to be the greatest risks to water management at your site?" To answer this question, respondents had to rank six risk categories, from greatest to lowest perceived risk. The response list included items such as 'Supply Chain Risk', 'Operational Risk' and 'Reputational Risk'.

The results are presented in Figure 6 for each risk in the format of an average score/6. The results indicate that Industry perceives 'Regulatory Risk' (4.94/6) to be the greatest risk to site water management, closely followed by 'Operational Risk' (4.88/6). The timing of the current survey likely plays a large role in respondent answers, having been conducted in February 2025, soon after the first set of eligible companies published their CSRD reports in January 2025. Furthermore, given that the average respondent is a large water user, consuming 156,872 m^3 of water per annum, water is likely to be a key material concern for their operations.

In comparison, 'Financial Risk' (3.41/6), 'Supply Chain Risk' (3/6) and 'Reputational Risk' (2.97/6) are all ranked moderately lower. As mentioned earlier, water-related supply chain risks are increasing annually (Le Sève *et al.*, 2024), creating global interruptions to water quantity and quality, ultimately damaging financial and reputational implications (WBSD, 2020). There is a potential vulnerability for industry in this regard if their perception of risk in these areas is not aligned with the increasing trend of global water related disruptions.

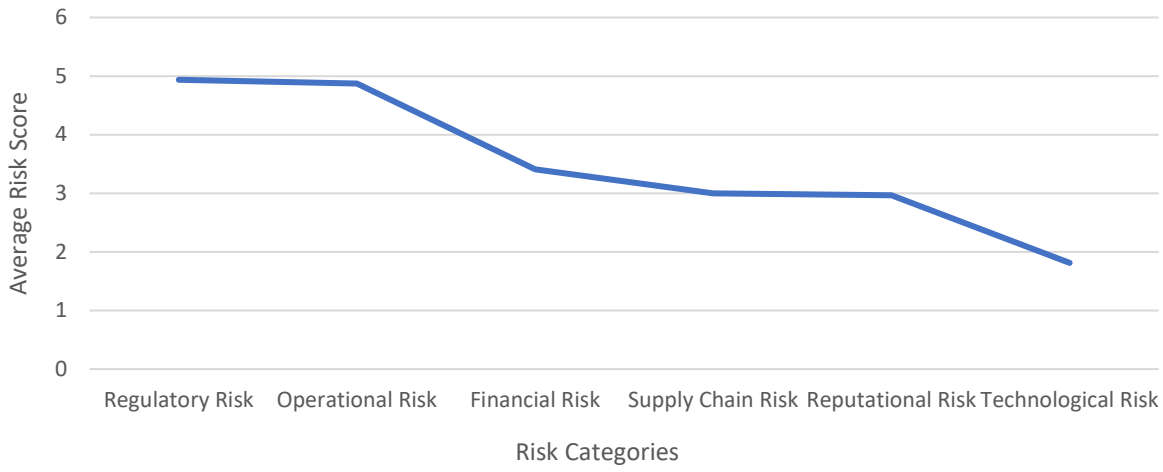

Figure 6 - Survey Findings – Risks to Site Water Management (n=29)

'Technological Risk' (1.81/6) is ranked lowest by industry in terms of the risk that it poses to site water management. This differs from existing research on non-water-specific technological risk, whereby the private sector ranks technological risk among their highest risks to the sector over the next two years (WEF, 2025). The results of this current survey demonstrate that despite an acceleration in technology for circular water management, industry does not yet perceive change in this area to pose as much risk as changes in the field of water regulation.

3.2.3. Collaborative Action and Catchment-Based Approaches to Water Management

Enhanced engagement with stakeholders and their supply chains through water stewardship activities in enabling organisations to tackle shared water challenges to the business. Stakeholders and supply chains can be typically local to the site of organisations main business activities and operations; thus, they may share the same catchment or river basin and share the nature-related risks and impacts experienced within the catchment or river basin, (dtic, 2021). WWF has identified that organisations' greatest exposure to water risks and impacts is within their supply chains, to deal with these risks and impacts supply chain and stakeholder collaboration is key (Dobson et.al., 2023). For organisations to take a holistic approach to sustainable water management, an understanding that catchment-level impacts from water pollution and over abstraction of water from a basin have corresponding economic, environmental and social issues which must be mitigated and addressed (Lucas,O. et.al., 2024).

Water-related risks and impacts are not created by one company or organisation alone, thus the principle of tackling these issues alone may not be feasible to incur long-term mitigation and positive impacts. Considering all stakeholders and their uses and impacts, allows organisations to cooperate with these stakeholders in tackling these issues through collective action (Lucas,O. et.al., 2024). Collective action with stakeholders, suppliers, buyers, and other key players in the value chain can build closer relationships among these parties and subsequently generate improved products and solutions, (CDP, 2023). Employing multi-sector and cross-industry collaborations to protect water as a shared resource can enable system-level changes to protect the security of water through multiple catchments, (Famiglietti. J. et.al., 2022). The benefits from engaging with stakeholders and suppliers in collaboration include improved processes reducing waste and impacts, improved supplier capabilities, reduction in cost of production, improved production timescales, enhanced trust and loyalty between suppliers, stakeholders and industry, and supply chain resilience against climate impacts and extreme weather events, (Dobson et.al., 2023).

To mitigate the catchment and basin-level risks identified, businesses and organisations must place the water-related risk issues as core elements in their strategic water planning and adjacent policies (dtic, 2021). Gaining an understanding of the effects of the organisations water use from abstraction to discharge and how this in-turn effects the catchment's chemical and ecological status allows for shared-water challenges to be understood and encountered by organisations engaging with other key actors to go beyond regulatory compliance obligations (dtic,2021).

At the time of writing, while the scope of organisations reporting to CSRD has been lessened significantly than previously stated, organisations who were encountering the disclosure requirements for water-related risks, impacts and opportunities were required to disclose on their impacts upstream and downstream within their value chain. This scope allowed organisation to confront supply chain

water resilience and collaborative action to make their supply chains more resilient to physical water related risks, such as drought, and enhance their water management systems (CDP, 2023). Collaboration with upstream and downstream value chain partners through incentivisation to adopt water conservation, reuse and safe discharge of wastewater can contribute significantly to mitigating catchment and basin-level risks, (WBCSD,2020).

Addressing catchment-level water stewardship actions through stakeholder engagement and collaborative action must not be addressed in the exact same manner as addressing site-level water risks and using the same performance indicators may not adequately address catchment-level risks, (Lucas,O. et.al., 2024). Industries within the private sector and investors hold positions to enhance adaptation and innovation where water-related risks and impacts are concerned, engagement with stakeholders, supply chains and collaborative actions to mitigate these will be enhanced by systematic changes through governmental collaboration and policy change, (Famiglietti. J. et.al., 2022).

As stated previously catchment-level risks are accompanied by their own environmental, economic and social risks and impacts. Collaborative action among stakeholders to encounter social issues as a result of poor water quality can be addressed through supporting communities within the value chain in ensuring clean water, sanitation and hygiene (WASH) is accessible to those they impact including their employees, (Famiglietti. J. et.al., 2022). Collaborations that can benefit industry and their value chains alike is with technology providers and enhance technological innovations to aid in the reuse and treatment of water efficiently aiding in providing positive impacts to the organisations, value chains and catchments they interact with to combat shared-water risks, (WBCSD, 2020).

3.2.4. Circular Water Management Practices and Strategies

Circular water management practices and strategies are essential for addressing the growing challenges of water scarcity and ensuring sustainable water use. These practices focus on the principles of reducing, reusing, and recycling (RRR) water to create a closed-loop system that minimizes waste and optimizes resource efficiency.

One of the key strategies in circular water management is the reduction of water consumption. This can be achieved through the implementation of water-efficient technologies and practices, such as low-flow fixtures, efficient irrigation systems, and process optimization in industrial settings including automatization of sites. By reducing the amount of water used, we can significantly decrease the demand for freshwater resources and reduce the environmental impact of water extraction and treatment. The current work showed that installation of water meters and strategies to collect and analysis the water-related data on sites can significantly benefit the reduction of water use.

Reusing water is another critical component of circular water management. This involves treating wastewater to a quality suitable for its intended reuse, such as irrigation, industrial processes, or even potable use in some cases. Advanced treatment technologies, including membrane separation processes, ultraviolet disinfection, and advanced oxidation processes, can effectively remove contaminants from wastewater, making it safe for reuse. By reusing water, we can reduce the need for freshwater withdrawal and decrease the volume of wastewater discharged into the environment.

Recycling water involves the recovery of water from various sources, such as stormwater, greywater, and industrial effluents, and treating it for reuse. This approach not only conserves freshwater resources but also helps in managing water quality by reducing the pollutant load entering natural water bodies. Implementing decentralized water recycling systems, such as rainwater harvesting and greywater recycling, can enhance water security and resilience, particularly in urban areas.

In addition to these core strategies, circular water management also emphasizes the restoration and recovery of water resources. Restoration efforts focus on rehabilitating degraded water ecosystems, such as wetlands and rivers, to improve their natural water retention and purification capacities. Recovery strategies aim to extract valuable resources, such as nutrients and energy, from wastewater, turning waste into a resource and contributing to a more sustainable and circular economy.

Overall, circular water management practices and strategies offer a holistic approach to water sustainability with the strong support of the UN Sustainable Development Goals as identified in Figure 7 below.

	**Clean Water and Sanitation** Ensuring availability and sustainable management of water and sanitation for various stakeholders (industry, communities, citizens).
	**Zero Hunger** Sustainable water use enhances agricultural productivity and food security.
	**Good Health and Well-being** Access to clean water reduces waterborne diseases and improves public health.
	**Sustainable Cities and Communities** Proper water management supports urban resilience and prevents water-related disasters.
	**Climate Action** Water conservation strategies help mitigate the effects of climate change.

Figure 7 - Holistic Approaches: Aligning Circular Water Management with the UN SDGs

By integrating reduction, reuse, recycling, restoration, and recovery, we can create a resilient water management system that supports both human and environmental needs

Delgado *et al.* (2021) addresses how the circular economy has emerged as a resilient pathway for multiple economic factors to deviate from the current unsustainable linear model of 'take, make,

consume, and waste'. The circular economy model offers industry multiple opportunities for resilience and risk mitigation but also allows for value creation currently not considered by the linear model. Value creation pertaining to water and wastewater through the reuse or recirculation of water in various quality states but also allows for recovery in other components of the water lifecycle within industry such as energy recovery and nutrient recovery, among others (Delgado *et al.*, 2021). Wastewater is relatively unexplored as a sustainable resource for reuse with regards to water, energy, nutrients, or other materials (WBCSD, 2020).

Water circularity combats multiple risk factors which affect industries. Financial risks are combatted by investments into circular water systems limiting abstraction through implementation of technologies for reuse and optimisation of water used on site. Investments into technologies for recovery and reuse via pollution reduction can produce new revenue streams for the industry in question (Nelson, A. 2024). Regarding water reuse the financial benefits to organisations, including those where water pressures do not currently exist, is the financial savings from less abstraction or incoming water and savings in discharge costs (Gasson *et al.*, 2024).

3.2.4.1 Survey Findings – Current levels of industrial engagement in Circularity and Resource Recovery

To examine industrial engagement with circularity and recovery streams, respondents were asked to "indicate the current status of your site circularity and/or recovery activity for each stream below". To answer this question, respondents rated their activity in each stream on a four-point scale, ranging from 'No, and we are not planning to take action' to 'Yes, and we are planning to do more'.

Results in Figure 8 show that Water recovery is the area where most respondents are either active or planning to take action (84%), followed by Energy recovery (82%). The least amount of industrial activity occurs in the Solute recovery stream, whereby 66% of respondents are neither actively engaging with the stream nor planning to. These findings demonstrate that EU industry has yet to realise potential value creation and resilience from recovering nutrients and other materials in the solute stream.

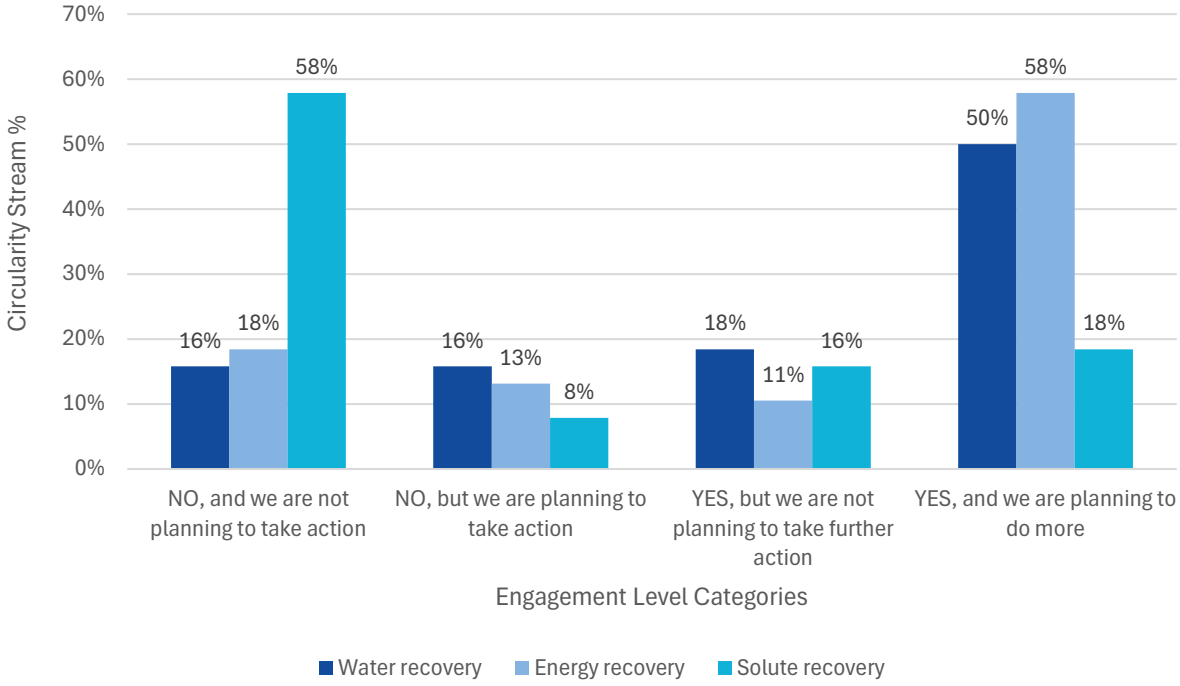

Figure 8 - Survey Findings – Current and planned industrial engagement by Circularity Stream (n=38)

3.2.5. Advances in Water Innovation and Technology and their Uptake by Industry

Effective management of industrial water and wastewater is crucial for environmental sustainability and regulatory compliance. Different industries in the EU have developed best practices tailored to their specific needs and challenges. Before implementing any treatment process, it is essential to thoroughly assess the quality of wastewater generated by industrial operations. This involves identifying the types and concentrations of contaminants, including organic and inorganic compounds, suspended solids, and pH levels. Regular monitoring ensures that treatment processes remain effective and compliant with regulations. The UWWTD was updated in 2024 indicating that new contaminants such as PFAS should be monitored and reported to the EU governmental authorities.

One of the most effective ways to manage wastewater is to reduce its generation. Industries can adopt various strategies to minimize water usage, such as optimizing production processes, recycling process water, and implementing water-efficient technologies. For example, the textile industry in Europe has successfully reduced water consumption by adopting closed-loop (circular) water systems. In LIFE ANHIDRA project funded by the EU, reducing water consumption by up to 92% and reusing up to 98% of water, resulted in annual savings of millions of cubic meters of water (European Commission, 2025).

Advanced treatment technologies play a vital role in removing contaminants from industrial wastewater. Membrane bioreactors (MBRs), advanced oxidation processes (AOPs), and electrocoagulation are some of the cutting-edge technologies used across different industries. In Portugal and Spain, the food and beverage industry has effectively utilized MBRs to achieve high-quality

effluent suitable for reuse. Recovering valuable resources from wastewater not only reduces environmental impact but also provides economic benefits. Industries can recover water, energy, and nutrients from wastewater. For instance, the chemical industries in Ireland, Norway, and Sweden have recently implemented anaerobic digestion to produce biogas from wastewater, which is then used as a renewable energy source.

Educating employees about the importance of wastewater management and best practices is essential for successful implementation. Regular training programs and awareness campaigns can help employees understand their role in minimizing water usage and ensuring proper treatment of wastewater. In the pharmaceutical industry, companies have established comprehensive training programs to promote sustainable water management practices. In Ireland, the Certified Water Stewardship programme, delivered by 20FIFTY Partners and with support from national stakeholders, Uisce Éireann and Skillnet Ireland was successfully implemented to provide employees at various levels with knowledge and skills related to the best water management practices.

Collaboration between industries, governments, and research institutions fosters innovation in wastewater management. Sharing knowledge and best practices can lead to the development of more efficient and sustainable solutions. For example, the current Horizon project provided industrial participants with the platform to partner with academic institutions to research and implement innovative treatment technologies.

By adopting these best practices, industries can not only enhance environmental sustainability and regulatory compliance but also achieve significant cost reductions through improved water reuse and resource efficiency. Additionally, the valorisation of recovered solutes can create new revenue streams, turning wastewater into a source of valuable raw materials. Beyond financial benefits, industries that lead in sustainable water management strengthen their market position, enhance brand reputation, and meet growing consumer and stakeholder expectations for environmental responsibility. Continuous improvement and innovation are key to addressing the evolving challenges of industrial wastewater management while unlocking economic and competitive advantages.

3.2.4.1 Survey Findings – Industrial Engagement with Emerging Water Circularity and Resource Recovery Technologies

To examine industrial engagement with various technologies and innovation in the water and wastewater sector, respondents were asked to “indicate the extent to which you have interacted with each at your current site”. To answer this question, respondents rated their activity in each stream on a three-point scale, ranging from ‘I am not aware of this technology’ to ‘I am aware of this technology and it is used at our site’.

The results are presented in Figure 9 for each technology in the format of an average score/3. ‘Reverse Osmosis’ (2.29/3) is the technology most commonly known and used amongst EU industry respondents. This is followed by ‘Nanofiltration’ (1.91/3), ‘Anaerobic Membrane Bioreactor (AMBR)’ (1.71/3) and ‘Membrane Distillation’ (1.75/3). However, other technologies such as ‘Forward Osmosis’ (1.60/3), ‘Membrane Crystallization’ (1.51/3) and ‘Bipolar Electrodialysis’ (1.49/3) display the least levels of recognition and implementation across EU industry.

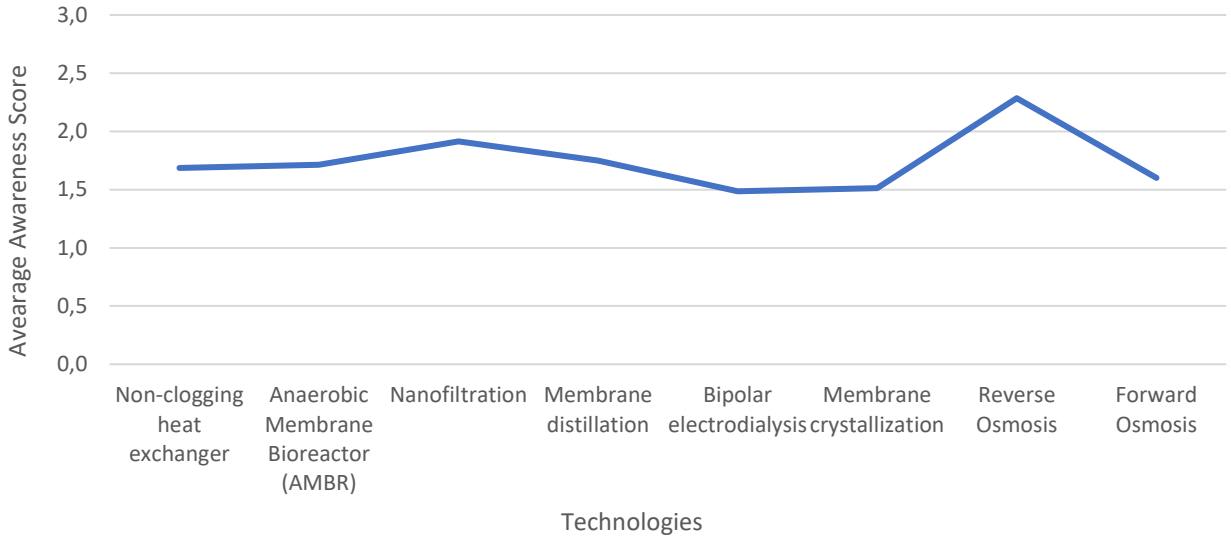

Figure 9 - Survey Findings – Awareness Score for Emerging Water Circularity and Resource Recovery Technologies (n=35)

3.2.4.2 Survey Findings – Important factors in Selecting Circular Water Technologies

To examine what is important to industry when selecting circular water technologies, respondents were asked "Please rank the below items in order of their importance to your organisation when selecting a wastewater treatment technology". To answer this question, respondents ranked a selection of factors from the most important factor to least important factor. The list provided included factors such as 'Lifecycle cost', 'Impact on Production Processes' and 'Environmental Impact'.

The results are presented in Figure 10 for each factor in the format of an average score/7. 'Adherence to regulatory policy' (5.45/7) is by far the most important factor to EU industry when selecting circular water technology. This is in alignment with previous findings on external drivers (see section 1.4.1) and risk to site water management (see section 3.2.2). This indicates that ensuring compliance with environmental regulations and standards is a top priority for industries when selecting water technologies. Other factors of importance to industry selection of circular water technology are 'Environmental Impact' (3.97/7) and 'Impact on Production Processes' (3.64/7). The least important factor perceived by industry is 'water recovery/lowest waste volume generated' (2.39/7).

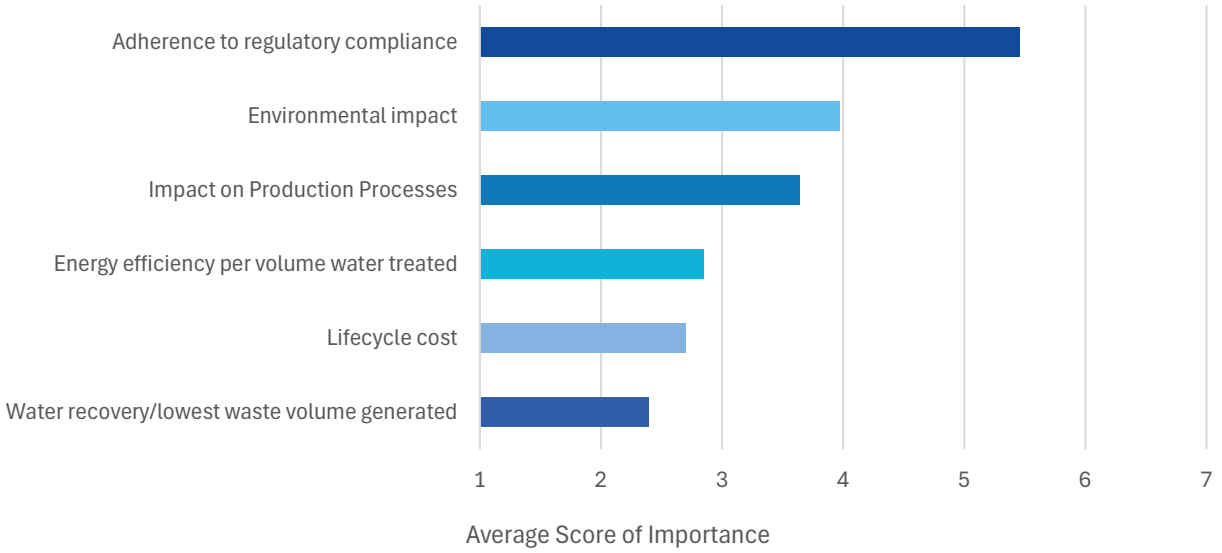

Figure 10 - Survey Findings – Importance to Selecting Circular Water Technologies (n=34)

The survey results indicate that industries prioritize regulatory compliance, environmental impact, production process integration, energy efficiency, lifecycle cost, and water recovery when selecting circular water technologies ensuring that those support sustainable, efficient, and cost-effective water and wastewater management practices. It shows a multi-fold criteria range motivating industrial sites to integrate circular and sustainable technologies in daily water and wastewater-related operations.

Regulatory compliance helps industries avoid legal penalties and maintain their social license to operate. Environmental impact is also highly rated, reflecting the growing emphasis on sustainability and the need to minimize the ecological footprint of industrial activities. Technologies that reduce pollution, conserve water resources, and protect ecosystems are preferred.

Impact on production processes is another critical factor, as it directly affects the efficiency and effectiveness of industrial operations. Technologies that integrate seamlessly with existing processes and enhance productivity are highly valued.

Energy efficiency is an important consideration, as it influences both operational costs and environmental sustainability by reducing their carbon footprint and achieves cost savings. Lifecycle cost per volume of water treated is a key economic factor, highlighting the importance of cost-effectiveness in technology selection and searching for the long-term financial benefits by minimizing total costs.

Water recovery and the generation of the lowest waste volume are also significant factors, emphasizing the importance of circularity and resource efficiency. Technologies that maximize water recovery and minimize waste generation contribute to sustainable water management practices.

3.3. Barriers and Enablers in Delivering Water Stewardship, Circularity and Resource Recovery in Industry

This section of the report outlines the key barriers and enablers of water stewardship, circularity and resource recovery. These findings will be considered in the design and development of a suite (integrated toolbox) of decision support tools for industry (CORNERSTONE WP5 key deliverable).

3.3.1. Survey Findings - Barriers to delivering water stewardship, circularity and resource recovery initiatives in industry

To examine **barriers** to investing in circular solutions, a question was posed to respondents asking them to, 'Please indicate the extent to which each of the items below are a barrier to investing in circular solutions for your site'. To answer this question, respondents had to rate a selection of barriers on a four-point scale from 'Not a Barrier' to 'Extreme Barrier'. The selection of barriers included items such as 'Internal buy-in', 'Absence of national water reuse standards' and 'The risk of product becoming contaminated'. At analysis stage, an average score was created for each barrier out of 4, with the highest scores representing the highest barriers to investment.

The results are presented in Figure 11 for each barrier in the format of an average score/4. Costs are the highest barrier to investment in circular solutions, both in terms of 'High Capital Costs' (avg. score 3.24/4) and 'High Operation and Maintenance Costs' (2.93/4). Risk to internal processes and obtaining internal support are the next highest set of barriers, featuring 'The risk of product becoming contaminated' (2.79/4), 'Internal buy-in' (2.39/4) and 'Perceived impact on production' (2.36/4). In comparison to cost, regulations and standards are not considered to be a high barrier to investment in circular solutions.

'Inability to meet regulatory or required water quality standards' (2.14/4), 'Insufficient clarity in the regulatory framework' (2.14/4) and 'Absence of national water reuse standards' (2.10/4) all consistently received low rankings. The lowest barriers to investment in circular solutions are 'Opposition by public, stakeholder, or elected officials' (1.4/4) and 'Insufficient skills and competencies' (1.93/4).

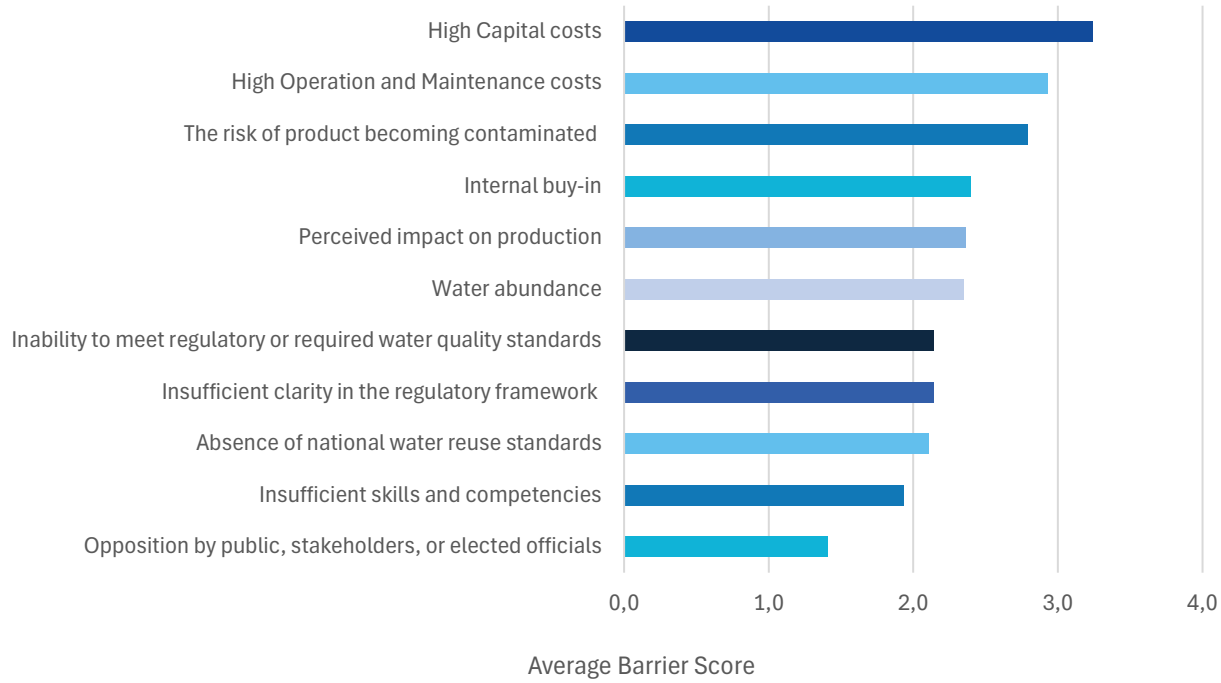

Figure 11 - Survey Findings – Barriers to Investment in Circular Solutions (n=29)

3.3.2. Survey Findings – Enablers to support water stewardship, circularity and resource recovery initiatives in industry

To examine **enablers** of industrial uptake in circular water solutions, a question was posed to respondents asking, 'What are the enablers or supports that would drive uptake of water circularity solutions at your site?' Respondents were provided with a list of potential enablers, from which they selected all items which would drive uptake of circular solutions at their site. The response list included items such as 'External technical support', 'Information on potential external funding/ investment sources' and 'Opportunity mapping across water lifecycle'.

The most important enabler (see Figure 12) to driving industrial uptake of circular water solutions is the 'Ability to build a strong business case for new technology' (72%). Prioritisation of this enabler makes sense in the context of respondents who have identified high costs and internal buy-in as key barriers to investment in circular technologies. Enablers providing a 'Site / organisational roadmap for water circularity' (55%) and 'Information on potential external funding / investment' (52%) also emerged as potentially useful supports. In comparison, there was low confidence in the ability of a 'Circularity maturity assessment' (14%), 'Digital Solutions' (14%), and 'External technical support' (14%) to enable the uptake of circular water solutions. See Figure 10.

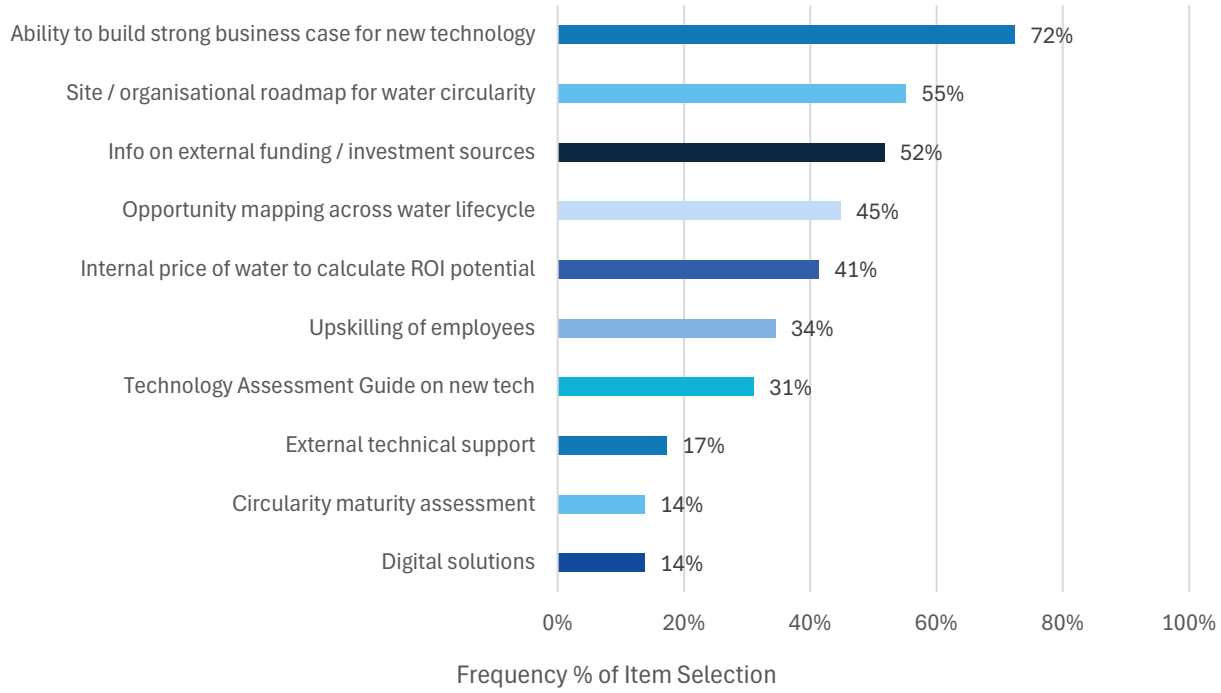

Figure 12 - Survey Findings – Enablers to Industrial Uptake of Circular Water Solutions (n=29)

To examine industrial engagement with **digital tech solutions** for water management, respondents were asked to "indicate the extent to which you have interacted with the following digital solutions for water management at your site". To answer the question, respondents rated a list of five tech solutions on a three-point scale ranging from 'I am not aware of this solution' to 'I am aware of this solution, and it is used at our site'. The list of digital tech solutions included items such as 'Smart Water Monitoring', 'Artificial Intelligence (AI)' and 'Digital Twins'.

The results are presented in Figure 13 for each Digital Tech Solution in the format of an average score /3. Results indicate that both 'Automated Meter Readings (AMR)' (2.53/3) and 'Smart Water Monitoring' (2.5/3) receive the highest levels of industry engagement. In comparison, 'Artificial Intelligence (AI)' (2/3) and the 'Internet of things (IoT)' (1.97/3) are engaged to a lesser extent. Industry engages the least with 'Digital Twins' (1.79/3) relative to other Digital Tech Solutions.

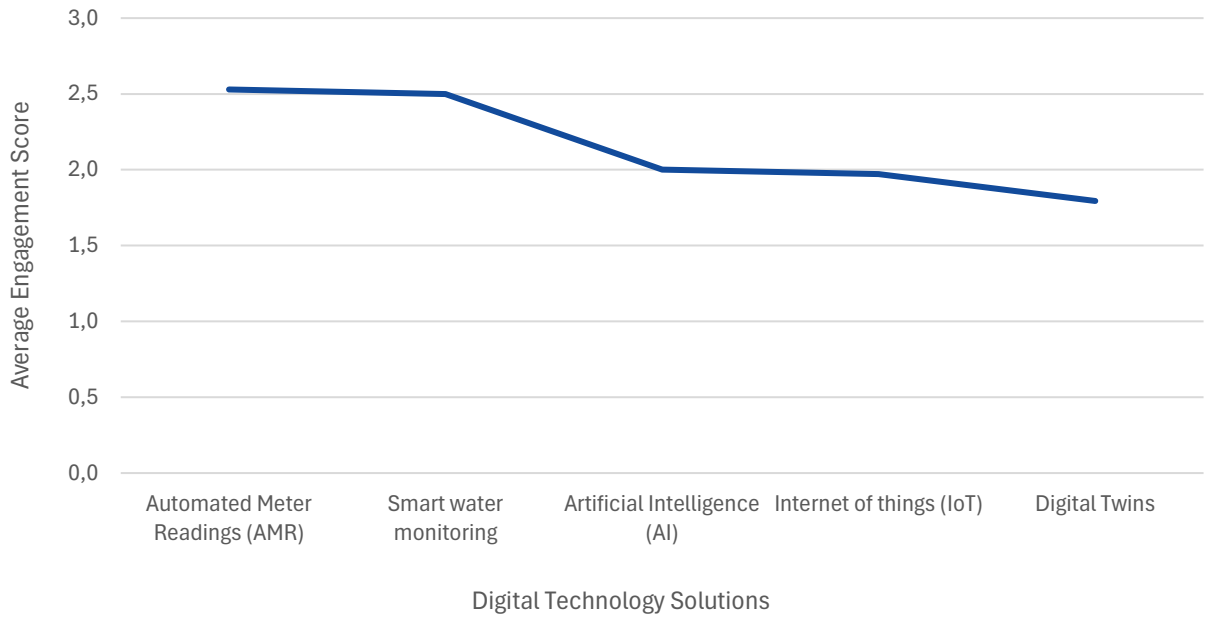

Figure 13 - Survey Findings – Engagement with Digital Technology Solutions (n=29)

3.4. Analysis and Summary – Discussion Points

This section of the document contains several discussion points arising from the analysis of emerging trends in industry water stewardship and circularity.

3.4.1. Long-term Sustainability Considerations including climate resilience, global frameworks and future technology adoption trends

Long-term sustainability considerations are crucial for ensuring a resilient and equitable future. Climate resilience can be achieved through a combination of technological advancements, infrastructural improvements, policy changes, and community-based strategies. For example, constructing seawalls to protect coastal areas from flooding or restoring natural ecosystems to serve as barriers against climate impacts are practical measures that can enhance resilience. The ultimate goal is to reduce vulnerability and ensure that societies can maintain their functionality and well-being in the face of climate challenges.

In addition to climate resilience, the Sustainable Development Goals (SDGs) established by the United Nations in 2015 provide a comprehensive framework for addressing a wide range of global challenges. By aligning water and wastewater-related policies and initiatives with the SDGs, EU countries and organisations can contribute to a more sustainable and equitable future. The interconnected nature of these goals underscores the need for collaborative efforts to address complex global issues.

Looking ahead, several key trends are expected to shape the sustainability landscape. One significant trend is the increasing emphasis on decarbonisation, driven by the urgent need to address climate change. Companies and governments are likely to intensify efforts to reduce greenhouse gas emissions and transition to renewable energy sources and integrating RRR principles with respect to water consumption and wastewater utilization. Another important trend is the growing importance of sustainable finance, with green bonds and ESG-linked financial products gaining traction. This shift will mobilize capital for sustainability initiatives and encourage companies to integrate environmental, social, and governance (ESG) considerations into their water consuming operations.

Technological advancements will also play a crucial role in promoting sustainability. Innovations such as artificial intelligence, smart grids, and climate modelling tools will enhance the industrial ability to manage resources efficiently and mitigate environmental impacts. The circular economy model, which focuses on reducing waste and promoting the reuse and recycling of materials, is expected to gain momentum by keeping certain disadvantages to wastewater treatment, e.g., high initial investment cost, process complexity, public acceptance, and technological limitations. As sustainability reporting and disclosure requirements become more stringent, companies will face increased scrutiny and the need for greater transparency in their sustainability water and wastewater-related practices. Consumer awareness and market demand in promoting eco-friendly and sustainable branding might also play a role in driving companies to innovate and adopt more sustainable water management practices. Ultimately, companies that proactively embrace these changes may gain a competitive advantage, enhance their brand reputation, and contribute to a more sustainable future.

The KPI-related monitoring and tracking of ESG integration at industrial sites will be linked to tackling risks which can create both financial implications and reputational damage (WBCSD, 2020). The materiality assessments while a requirement, have multiple benefits for the organisation in understanding their materiality risks or potential environmental, social, and governance (ESG) impacts and opportunities and with proactively addressing these risks organisations can reduce their exposure to future regulatory and legal risks, reputational risks, operational and infrastructural risks, and financial risks (Ayley *et al.*, 2024).

3.4.2. Continuous Improvement to Achieve Circularity and Recovery Objectives

Continuous improvement in industrial water and wastewater management is essential for achieving circularity and recovery objectives ensuring that water resources are used efficiently, waste is minimised, and valuable materials are resourced and used according to RRR principles. By adopting a continuous improvement strategy, industries can contribute to environmental sustainability, reduce operational costs, and comply with increasingly stringent regulations.

One of the key aspects of continuous improvement is the integration of advanced technologies (See Section 3.2.4). These technologies not only improve the quality of treated water but also enable the recovery of valuable resources such as nutrients and energy. Process optimization is another critical component of continuous improvement. Implementing real-time monitoring and automated control systems allows industries to optimize resource utilization and reduce operational costs. For instance, smart sensors and data analytics can provide insights into water usage patterns, enabling more efficient

water management and early detection of potential issues. By continuously monitoring and adjusting treatment processes, industries can ensure that they operate at peak efficiency and comply with the strict EU environmental regulations. Using Zillertal wastewater treatment plant near Innsbruck as a case study, by focusing on nitrogen and phosphorus removal, the real-time monitoring and automated controls led to higher annual electricity production than its consumption (Wett et al, 2007). Similarly, the Ede wastewater treatment plant in the Netherlands faced challenges in meeting EU effluent standards due to increased load and anticipated growth. By implementing the Hubgrade Wastewater Plant Performance digital solution, which leverages live data, analytics, and artificial intelligence, the plant achieved real-time process optimization. This not only ensured compliance with EU standards but also reduced the plant's carbon footprint and operational costs (Veolia, 2021).

Energy efficiency and related process optimization is a significant focus of continuous improvement efforts. Adopting energy-efficient practices and technologies, such as anaerobic digestion for energy recovery and solar-powered systems, can help industries reduce their carbon footprint and operational costs. This not only supports the circular economy by recovering energy from waste but also contributes to overall sustainability goals.

Quality assurance and compliance are essential for ensuring that treated water meets regulatory standards and environmental requirements. Continuous improvement involves implementing rigorous quality assurance protocols and regularly updating them to reflect the latest best practices and technological advancements. This ensures that industries remain compliant with regulations and can adapt to emerging challenges such as population growth and industrial expansion.

Collaboration and partnerships are also vital for achieving continuous improvement in industrial water and wastewater management. By working with industry experts, research institutions, and regulatory bodies, industries can share knowledge, exchange best practices, and drive innovation. Collaborative efforts can lead to the development of new treatment methodologies and technologies that further enhance efficiency and effectiveness.

3.4.3. Role of Digitalisation in supporting Water Stewardship, Circularity and Resource Recovery in Industry

The transition from a linear economy to a circular economy has become a central objective in industrial sustainability efforts. The implementation of circularity approaches offers industries new business opportunities. A circular approach requires the collaboration of different industrial players (suppliers, manufacturers, services, support, etc.) who must share data about a product (e.g., lifetime, materials used, parts, construction plans, etc.). A diversity of data is required to make circularity successful and avoid product downcycling. Digitalisation can enable business ecosystems to collaborate effectively across geographies and organizations, thereby realizing a global circular economy. Industries can thus optimize resource use, minimize waste, and enhance transparency.

3.4.3.1. Digital Technologies as enablers of circularity

Several enabling digital technologies fall under the term Industry 4.0. They enable real-time monitoring, data collection and analysis, predictive maintenance, and closed-loop supply chains. They

play a fundamental role in enabling circularity across the entire product lifecycle—spanning manufacturing, usage, repair, recycling, and recovery. Among these, Big Data, Digital Twins, and Artificial Intelligence (AI) play a central role by improving efficiency in manufacturing, extending product lifespan, and optimizing material recovery. The survey on the industrial current state assessment highlights the low awareness of ”new” technologies such as Digital Twins and AI, with an awareness score of 1.79/3; respectively, only 15% have such technologies in use (survey in section 3.3.2). AMR (automatic/automated meter reading, or smart meters) had the highest awareness. As this technology was already market-ready in the 1970s, it will not be further elaborated on in this section.

Big Data provides the foundation for circularity by structuring vast amounts of information related to materials, product performance, and supply chain interactions. These databases enable traceability, ensuring that materials and components can be reused, repaired, or recycled efficiently. By integrating data across different stages of a product’s lifecycle, industries gain real-time insights to enhance sustainability efforts and comply with regulations such as the Ecodesign for Sustainable Products Regulation (ESPR).

Digital Twins create virtual representations of physical products, processes, and systems. They originate from the field of systems theory, where models were used to get insights into complex systems. These models allow manufacturers to get information on the use of their products, optimize and predict resource use, and facilitate simulation-driven design, ensuring products are built for durability, repairability, and efficient material recovery. By simulating end-of-life scenarios, businesses can design products with circularity in mind, reducing waste and improving material reuse strategies.

Artificial Intelligence (AI) is key to managing the complexity of circular systems. AI-powered analytics and machine learning models support and optimize decision-making in areas such as predictive maintenance, automated sorting for recycling, and demand forecasting for remanufactured products. AI enhances lifecycle assessments (LCA) by identifying patterns in product usage, helping industries design more sustainable solutions. Additionally, algorithms improve resource allocation, logistics, and closed-loop supply chains, ensuring minimal environmental impact.

3.4.3.2. Reshaping Industry with Circular Business Models

Embedding circular business models is a strategic opportunity for industry. Companies that integrate circularity into their operations can create new revenue streams, reduce costs, and foster stronger customer loyalty. With digital tools enhancing transparency, efficiency, and compliance, businesses are well-positioned to transition toward a more sustainable future. This transition means that traditional business models must shift away from single-use production toward designing for durability, repairability, and recyclability (Ecodesign).

Product-as-a-Service (PaaS) or pay-per-use (PPU) models, where companies retain ownership and lease products rather than selling them outright, encourage the production of high-quality, long-lasting goods. By integrating customer-driven feedback loops, businesses can continuously refine their products based on real-world usage and evolving sustainability expectations, ensuring greater efficiency and resource conservation.

Industries are increasingly driven toward circularity by two key factors: resource shortages and rising costs of wastewater treatment and discharge, both scoring 4.7/7 in impact assessments, indicating significant risks related to production security and operational costs (survey results in section 1.4.2).

These pressures demand that future businesses develop resilience strategies to mitigate risks, ensuring stable operations amid fluctuating resource availability and stricter environmental regulations.

A crucial pillar of circular business models is the ability to recover and repurpose materials, maximizing value even after a product's primary lifecycle ends. The high pressure on the automotive sector has, for example, established secondary material markets (Kleber, R. et.al., 2020). They reintroduce recycled components and materials into production, significantly reducing dependency on virgin raw materials. This not only lowers costs but also protects against supply chain disruptions caused by resource scarcity.

Digital twins facilitate transparency and efficiency across the supply chain by providing real-time data on product status and location. This visibility supports effective resource management, enabling the reuse and recycling of materials. For example, digital twins can simulate disruptions like supplier delays or transportation issues, allowing companies to proactively mitigate risks and maintain a resilient, circular supply chain (Maersk, 2023; Preut et al., 2021).

3.4.3.3. Regulatory and Policy Support

As circularity becomes a global priority, businesses must align with sustainability regulations. The importance of selecting new digital technologies for ongoing manufacturing processes aligns closely with the need for regulatory compliance (Industrial Current Statement Assessment survey, score 5.45/7), rather than voluntary stewardship alone. By embracing digital tools like the Digital Product Passport and adhering to policies such as Extended Producer Responsibility and the Circular Economy Action Plan, businesses can comply with regulations, drive innovation, enhance brand reputation, and achieve long-term sustainability goals.

The **EU Circular Economy Action Plan** introduces initiatives along the entire life cycle of products, targeting how products are designed, promoting circular economy processes, encouraging sustainable consumption, and aiming to ensure that waste is prevented and resources are kept in the EU economy for as long as possible. It introduces legislative and non-legislative measures targeting areas where action at the EU level brings real added value. Complementing this, projects like CEI BOOST - which focuses on enhancing policies to facilitate the twin transition of green growth and digital transformation - play a pivotal role in advancing circular economy objectives. In regions like Päijät-Häme, Finland, CEI BOOST has facilitated the integration of digital innovations in waste management, leading to a 99.5% utilization rate of municipal waste. Such initiatives underscore the importance of combining policy enhancement with technological innovation to achieve sustainable resource management and circularity across various sectors (Päijät-Häme, 2025).

The **Digital Product Passport (DPP)** is a pioneering initiative by the European Union designed to enhance transparency and sustainability within supply chains until 2030. Serving as a digital repository of a product's lifecycle information, the DPP includes essential details such as a unique product identifier, compliance documentation, and information on substances of concern. By offering a detailed digital record of a product's journey, the DPP enhances supply chain management, ensures regulatory compliance, and helps companies identify and mitigate risks related to authenticity and environmental impact.

Supply chain transparency laws require companies to track and disclose the environmental impact of their sourcing and production processes, ensuring accountability at every stage. Additionally, Ecodesign

and Extended Producer Responsibility (EPR) policies push businesses to take ownership of their products beyond the point of sale, ensuring sustainable management throughout their lifecycle. While regulatory compliance may present challenges, it also provides businesses with a competitive advantage—early adopters of circular models stand to benefit from incentives, such as improved brand differentiation, and long-term cost savings.

3.4.3.4. Challenges and Prospects

Adopting digital technologies requires substantial investments in infrastructure, training, and system integration. Many organizations, particularly small and medium-sized enterprises (SMEs), may lack the necessary **financial resources** or incentives to undertake such transformations. The absence of green finance options and supportive regulations further exacerbates this issue, hindering the widespread adoption of digital solutions essential for circular economy practices.

Successfully implementing digital technologies necessitates a workforce proficient in these new tools and systems. However, there is a notable **shortage of digital skills** among professionals in sectors aiming to transition to circular models. This skills gap impedes the effective deployment and utilization of digital solutions, slowing down progress toward a circular economy. Developing centralized digital platforms for circular business models requires collaboration among competitors, which is often challenging. Companies may be reluctant to share data or cede control, hindering the establishment of unified platforms that facilitate circular practices. This competitive tension can stall industry-wide digitalisation efforts essential for a circular economy.

While digitalisation and Industry 4.0 will be a necessity to realise high standards in industries, it not only poses a challenge to human interaction in industrial environments but also imposes high pressure on workforce and management. These “new skills” create skill-gaps, reduce direct collaboration, and lead to a more mechanised work environment. However, if strategically implemented, digital tools can enhance rather than replace interpersonal interactions, fostering a balance between technological progress and human engagement in circular and resource recovery systems.

Despite these challenges, digitalisation has the potential to drive profound economic transformation and ecological restructuring. By enabling more efficient resource management, enhancing product lifecycle tracking, and facilitating new business models, digital technologies can support the shift towards sustainable practices. Embracing digitalisation is crucial for achieving the broader goals of a circular economy, leading to value creation and environmental sustainability.

Digital technologies have a high barrier to entry for non-professionals. Thus, in recent years, multiple national and international initiatives have been launched across Europe to digitise industries, supporting diverse technologies, establishing standards, and providing maturity models to facilitate early-stage adoption of digital technologies **(European Commission, 2021).** Maturity models for industries have been summarized and further developed within the EU project "Industrial Water" . They offer valuable guidance by enabling industries—particularly SMEs—to systematically integrate digital technologies into circular practices (Gaskin, et.al., 2023).

Embracing digitalisation through these collaborative and structured approaches are crucial for achieving the broader goals of a circular economy, ultimately leading to sustained value creation and environmental sustainability.

4. Overview of Current Water Stewardship Support Tools and Standards for Industry

4.1. Introduction

This section of the document provides an overview of some of the identified Water Stewardship supports, tools and standards for industry. These tools and supports have been categorised into one of four categories: Financial, Monitoring, Risk and Standards. A further analysis of these tools identifies the scope or level at which the tools have been developed – process level, site level, catchment level and corporate level. Figure 14 provides an overview of these tools on where they are in regard to category and level (Appendix E contains a larger version of Figure 14).

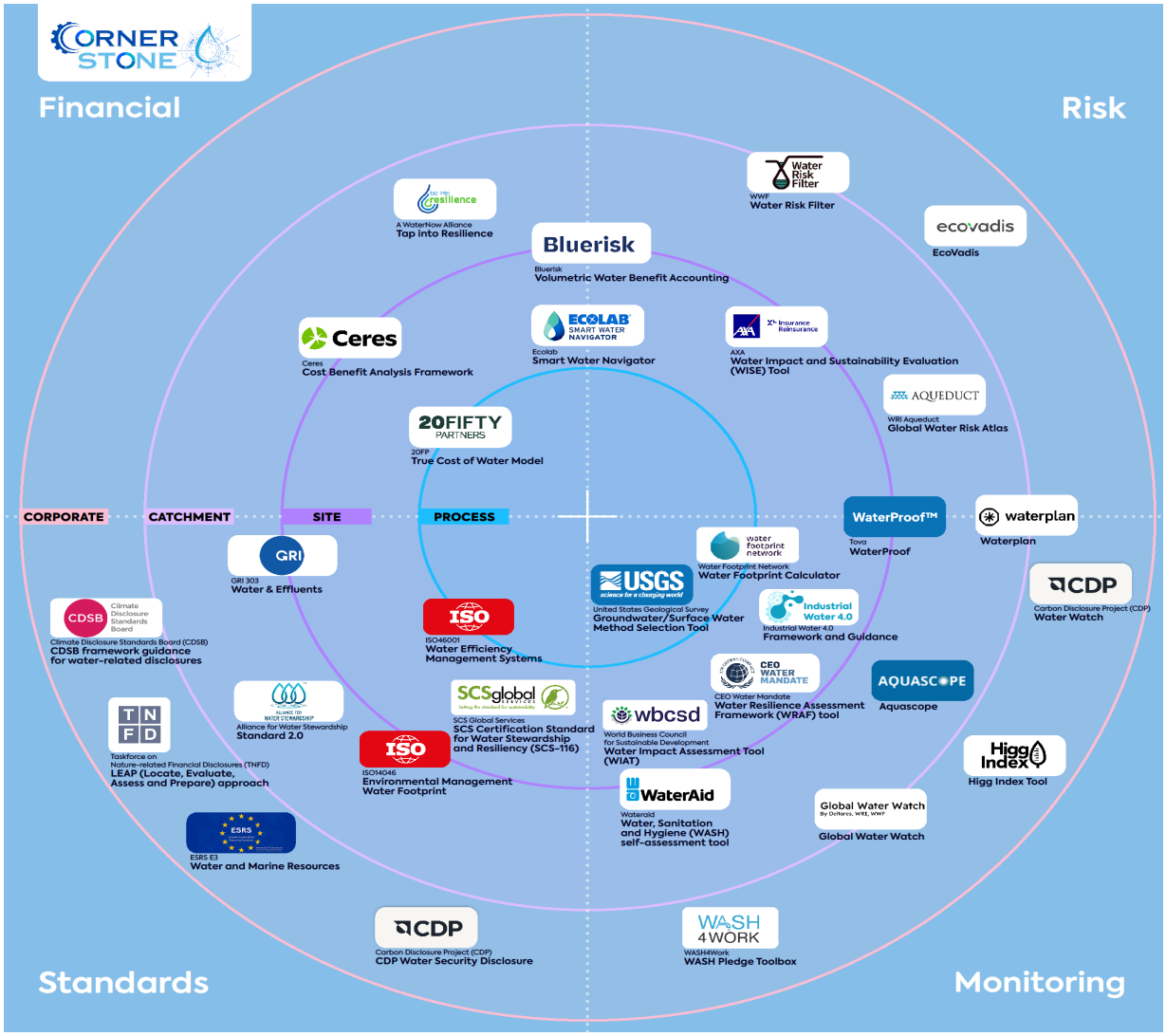

Figure 14 - Overview of Water Stewardship Support Tools for Industry

4.2. Overview of Water-Related Tools and Standards

This section of the report provides an overview of some of the identified water stewardship tools and standards for industry. This section is structured by tool type: Financial, Risk, Monitoring and Standards.

4.2.1. Financial Tools

Table 7 – Water-related Financial Tools for Industry

Tool Name	Alignment	Description	Datasets and usage
Ceres Cost Benefit Analysis (CBA) Framework	Site/Catchment Based	Ceres CBA Framework allows organisations to quantify the cost of the full value of water from water-related risk mitigation projects and estimate potential benefits to business and society from the project implementation. CBA calculations due to the input of users may be subject to human error. (Ceres 2023)	Builds on existing water valuation initiatives, including the Valuing Water Initiative, cost of action assessment methods, including WRI Achieving Abundance working paper. Societal benefits used are from Beyond Volumes: Exploring the Societal Value of Corporate Water Stewardship Projects (Vionnet et al. 2022), which incorporates SROI ratio (Social Value UK 2012), the Natural Capital Protocol (Capitals Coalition 2016), and Social & Human Capital Protocol (Capitals Coalition 2019). (Ceres 2023)
True Cost of Water Tool	Process/Site Based	Allows industry to measure the maturity of their water stewardship practices and map their water lifecycle onsite to establish a true cost of water to this lifecycle. This allows them to make site-specific business cases for future water stewardship projects. (Gaskin, et.al., 2023)	900 trainees in the Certified Water Stewardship course have received training in how to use the TCW tool.
Tap into Resilience Toolkit	Catchment Based	Allows users to view lessons learned from previous water-related projects including stormwater management, water management,	Toolkit provides US-based information on funding for projects within communities, a reference library with global case studies relative to project type, information on public and private infrastructure, opportunity to

		wastewater management, drinking water facility management. The tool allows users to view and plan providing similar cases financing, infrastructure solutions, efficiency programs, reuse projects, and identify possible benefits and outcomes to project. (WaterNow, 2024)	contact experts in certain water-related and project specific fields for advice. (WaterNow, 2024)

4.2.2. Risk Tools

Table 8 – Water-related Risk Tools for Industry

Tool Name	Alignment	Description	Datasets and Usage
World Resources Institute (WRI) Aqueduct Global Water Risk Atlas	Catchment based	The WRI Aqueduct Global Risk Atlas maps an organisations catchment based risk following user input of their site related water use. Organisations can gauge their overall water risk exposure at a global level and can use scenario analysis to view their projected risks for 2030, 2050, and 2080 under pessimistic, optimistic, or business-as-usual scenarios. (Kuzma et al., 2023)	WRI Aqueduct uses the WRI water risk framework for the 13 water-related risk indicators. 5 of the 13 indicators a global hydrological model known as PCR-GLOBWB 2 (PCRaster Global Water Balance) is used for novel datasets on sub-basin water use and supply. The projected scenarios use PCR-GLOWB-based hydrological projection of future water states with Coupled Model Intercomparison Project phase 6 (CMIP6) (HYPFLOWSCI6). Business-as-usual SSP 3 RCP7.0 Optimistic SSP 1 RCP 2.6 Pessimistic SSP 5 RCP 8.5 (Kuzma et.al., 2023)
World Wide Fund (WWF) Water Risk Filter	Catchment/corporate based	The WWF Water Risk Filter allows organisations to gauge their basin risks and operational risks following a self-assessment questionnaire of their corporate related water risk mapped to catchment related water	For scenario Analysis WWF WRF uses IPCC CMIP5 RCP (Representative Concentration Pathways) and socio-economic scenarios IIASA Shared Socio-economic Pathways – SSP Weightings are informed by stakeholder consultations and peer reviews from experts across

		risk data obtained by WWF. (WWF, 2024)	academia, financial institutions, business, NGOs and trends from CDP Water Security data. Common scale of river basins (HydroSHEDS HydroBASINS level 7) are used in projections also. 42 global datasets inform the risk indicators. (WWF, 2024)
AXA-WISE (Water Impact and Sustainability Evaluation) Tool	Site/ catchment based	Consultancy tool allowing organisations to gauge their site related water risks from a self-assessment questionnaire and receive custom dashboard of site and catchment-based risks and suggested improvements for mitigation and efficient water management strategy. (AXA, 2023)	Tool uses water atlases from WRI and WWF, (AXA, 2023)
EcoVadis	Corporate based	Allows organisations to assess their material sustainability impacts via a questionnaire tailored to the industry type, review of sustainability competencies by experts and gauge where your organisation lays in comparison to peers and impact analysis results from 21 sustainability criteria ranging over four themes of environment, labor & human rights, ethics and sustainable procurement. (EcoVadis, 2024)	Measure companies' sustainability management through Policies, Actions and Results, separated into a further seven management indicators of endorsements, reporting, measures, certifications, 360º Watch Findings, policies, and coverage – deployment of actions. The areas listed above originate from the PDCA Cycle (or Plan-do-check-act/adjust) (EcoVadis, 2024)
CDP Water Watch	Catchment/ corporate based	CDP Water Watch Tool allows organisations to evaluate which business activities possess the most significant impact to the catchments they operate within. The tool	

		is comprised of a qualitative assessment undergone by the user which is ranked in comparison to similar industrial frontrunners to gauge where the organisation stands in comparison to peers. (CDP, 2025)	
Ecolab Smart Water Navigator	Site based	The Ecolab Smart Water Navigator allows organisations to evaluate their water-related risks and provides context-based targets to the user as a result in order to address the risks identified and build a water resilience management plan. (Ecolab, 2024)	The tool was developed with collaboration with partners and advisors from the World Resources Institute, CEO Water Mandate, Pacific Institute, S&P Global Sustainable 1, Alliance for Water Stewardship. The Smart Water Navigator Platform leverages insights from industry, advanced analytics and Azure Cloud technology from Microsoft. (Ecolab, 2024)
Tova Waterproof Tool	Site/ catchment based	The Waterproof Tool allows organisations to measure their water-related risks to their site, receive solutions in the form of a risk mitigation project, and a dashboard for reporting disclosures. (Tova Earth, 2024)	Remote sensing, Geospatial Data, Infrastructure Data, Climate Methods, In Situ Data, Water Use Data collated to ML Data Assimilation to provide an outlook on Water Risk. (Tova Earth, 2024)
Waterplan	Catchment/ corporate based	Waterplan tool measures local water risk to the user's site, provided by the user from a self-assessment of their site risk through questionnaire, analyse global scenario projections for mitigating projects which will incur the greatest risk and provides a dashboard of results and continuous monitoring feature for the users across multiple individual sites. (Waterplan, 2025)	Uses data inputted by users

4.2.3. Monitoring Tools

Table 9 – Water-related Monitoring Tools for Industry

Tool Name	Alignment	Description	Datasets and Usage
Bluerisk: Volumetric Water Benefit Accounting (VWBA)	Site/catchment based	VWBA allows industries to quantify and display their volumetric water benefits emerging from their corporate water stewardship activities. VWBA is given as the volume of water resulting from water stewardship activities, relative to a unit in time which beneficially modifies the hydrology to help reduce shared water challenges within a basin or catchment. (Reig et al, 2023)	Guided by risk indicators from WRI Aqueduct and WWF Water Risk Filter. (Reig et al, 2023)
CEO Water Mandate: Water Resilience Assessment Framework (WRAF)	Site based	The Water Resilience Assessment Framework is a framework where organisations can self-assess their current water management system to identify areas of optimisation for resilience, build these areas for action into their water management strategy and evaluate continuously for optimum results. (Chapagain, et.al., 2021)	Used as framework alongside other datasets sought out independently by user, (Chapagain, et.al., 2021)
United States Geological Survey: Groundwater/Surface Water (GW/SW) Method Selection Tool	Process based	This tool is a decision support tool for organisations regarding site parameters and process project goals for their effect on the groundwater and surface-water of their catchment. This is completed following collation of available hydraulic, chemical, temperature, geophysical and remote sensing methods. This is to aid in the planning of water-related projects prior to implementation. (USGS, 2024)	US-based Microsoft Excel tool with data collected physically. (USGS, 2024)
WaterAid WASH self-assessment tool	Site/catchment based	WaterAid WASH self-assessment tool allows organisations to take part in	Builds on UNICEF WASH@Work tool and

		implementing safe and sustainable water, sanitation and hygiene projects and management both on their site if not up to standard but also in their catchment and value chain. This provides safe and sustainable resources for communities in need of water related management. (WaterAid, 2021)	WBCSD Revised Self-Assessment Tool. (WaterAid, 2021)
Aquascope	Catchment based	Aquascope is an online tool which allows industries to assess their short-, medium-, and long-term water resource planning upstream and downstream of their site. Users complete a baseline self-assessment of their water use and discharge quality and Aquascope allow for scenario planning and forecasts on their tool for the organisation to evaluate which areas for project planning and optimising water management for their site and value chain. (Aquascope, n.d.)	Uses information from satellites, catchment water quality models, and data from sensors and sampling. (Aquascope, n.d.)
Global Water Watch	Catchment/ corporate based	The Global Water Watch is a tool which provides free, accessible, and near-real-time data of more than 70 000 global reservoirs, this aids industry in planning for areas of high water stress and implementation of mitigation projects. (Global Water Watch, 2025)	Uses earth observation-based data. (Global Water Watch, 2025)
Higg Index Tools	Corporate based	Higg index tools are a suite of five tools allowing industries to view their social and environmental competencies throughout their value chain. The five tools cover life cycle assessment of resources, materials sustainability index for choosing material prior to production, environmental impacts at each production	Uses data inputted by organisations (Cascale, 2024)

		stage, facility social and labour modules to assess the treatment of workers in the value chain, and a brand and retail tool which allows for optimisation within production activities and supply chains. (Cascale, 2024)	

4.2.4. Water Standards

This section of the report provides an overview and analysis of a select number of key international water management and water stewardship standards and frameworks that have been identified in the research as globally recognised,

These frameworks and standards have emerged as a response to a need to develop and share best practice approaches to water stewardship and address critical water challenges (Stockil *et al.*, 2018).

Table 10 - Summary of Internationally Recognised Water Standards and Frameworks

Initiative	Initiative Type	Year established	Description	Uptake
European Commission CSRD ESRS E3: Water and Marine Resources	Legislation	The first reporting year for CSRD was 2025 for the 2024 year. Enforced 2024	**CSRD: ESRS E3 Water and Marine Resources** is one of five environmental topics covered in the Corporate Sustainability Reporting Directive (CSRD). On January 5th, 2023, the Corporate Sustainability Reporting Directive (CSRD) was introduced as an initiative of the EU Green Deal. CSRD requires organisations within the EU, both large organisations and SMEs, to disclose relevant environmental, social, and governance (ESG) information material to their value chain. There is also a requirement for organisations within the scope of CSRD to conduct a double materiality assessment to report their impact, risks, and opportunities (IROs) on what is material to their operations	Originally estimated at 50,000 EU companies – Following the CSRD Omnibus directive proposal, this number may drop to circa 7,000 organisations in scope for reporting currently. These factors for current scope include if the undertaking employs 1000 people or more and has one of the following - €50 million or above turnover, or - Balance sheet above €25 million, (European Commission, 2025).

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			upstream and downstream of their value chain. CSRD requires organisations to incorporate two overarching standards from European Sustainability Reporting Standards (ESRS) ESRS 1 and ESRS 2 outlining the general requirements and general disclosures for reporting, respectively. The ESG requirements are encapsulated in five environmental reporting factors. For organisations that must comply with CSRD, water-specific disclosure requirements will include information on metrics such as water consumption, withdrawal and discharges, total water recycled, total water stored and water intensity in addition to areas such as materiality and policy (EFRAG, 2024)	
Alliance for Water Stewardship	Voluntary Standard	2014	The **Alliance for Water Stewardship** is a membership organisation comprising businesses, NGOs, and the public sector. The Alliance for Water Stewardship Standard, more commonly referred to as the AWS standard is a universal framework for the sustainable use of water. The first version of the AWS standard (V1.0) was approved in April 2014,	335 certified sites (as of March 10th, 2025) 69 of which are European and of those 69, 49 companies are within EU Member States. (AWS, 2025)

			and the current version (V2.0) was published in March 2019 and at the time of writing, (August 2024), version V3.0 is due to be updated by mid-2025 (Alliance for Water Stewardship, 2024). The AWS standard is a voluntary standard, primarily used to identify, address and mitigate from shared water risks at a site and catchment level, including some considerations to supply chains where applicable. To identify key water risks to the site and catchment organisations must employ stakeholder engagement and develop a water stewardship plan with their stakeholder's involvement.	
SCS Certification Standard for Water Stewardship and Resiliency (SCS-116)	Voluntary Standard	2024	**The SCS Certification Standard for Water Stewardship and Resiliency (SCS-116)** provides organisations third-party verification of their site-specific water stewardship and water resilience practices. The SCS Standard provides guidance to organisations for implementation of site-specific actions and decision-making by providing performance criteria for climate-and water - related risks, quality monitoring, and responsible water use practices. The standard can be applied by any organisation aspiring to improve	Unknown

			their water metrics, water-related risks, and identify water-related opportunities regardless of the organisations size or primary business activity. (SCS Standards, n.d.). Similar to other certification schemes the SCS standard allows organisations to apply data from other third-party certification standards, such as AWS, within their reporting scope and the applied certification levels allow organisations to identify where they stand in comparison to their peers through achieving water stewardship best practices (SCS Standards, n.d.).	
ISO46001	Voluntary Standard	2019	According to the International Organization for Standardization (IS0) **the ISO 46001-2019-Water Efficiency Management Systems** standard is applicable to all types and sizes of organisations which use water. The standard is focused only on water use on and organisations site, but it does not account for the local catchment, or the organisations supply chain. The scope of this standard extends to consider the organisation and its circumstances, needs and expectations of	Unknown ISO46001 does not require organisations to be certified, they can be certified but it is not a requirement. As of March 2025, statistics on the completion of this standard are not clear but guidelines for reuse and recycling of water are a good indicator for organisations in the decision-making and improvement processes of

			stakeholders, and the efficiency of water management system(s). The ISO46001 standard also takes into account water-related risks and opportunities, future projections and forecasting of the organisations water use, and evaluation of the success of water efficiency management systems in place. The standard requires organisations to establish and assess a water use review, including identification of current water sources, water intense areas and processes, and past, present, and future water use. Organisations are also required to identify and implement water targets and KPIs. (ISO, 2019).	their site water management systems.
ISO 14046	Voluntary Standard	2014	The International Organization for Standardization (ISO) ISO 14046 Environmental Management Water Footprint sets out requirements and guidelines for organisations in relation to their water footprint assessment of products, processes and their whole organisation based on life cycle assessment (LCA). The standard also gives guidelines for whether an organisation wants to conduct a stand-alone water footprint assessment or as part of a comprehensive environmental	As of a survey conducted in 2023, a total of 300,410 organisations across 189 countries are certified in ISO14001, thus they will have completed ISO14046 as part of this certification. Of these 300,410 sites, 123,531 certified companies are within 50 European countries where 94,916 of certified organisations are across 27 EU member states

			assessment. Emissions from soil and air that impact water quality are the only emissions included in the assessment, but not all are included. The results of conducting the water footprint assessment are dependent on the users' application, results may be in the form of a single value or as a profile of impact indicator results (ISO, 2014).	
GRI303: Water and Effluent	Voluntary Standard	2018	**GRI 303: Water and Effluent** standard is a constituent of a larger suite of the GRI sustainability reporting standard. The standard requires organisations to disclose their effects on the water as a shared resource and how they govern their actions related to freshwater withdrawals, freshwater consumption, discharge of wastewater and any procedures for setting water-related goals. The standard also requires organisations to report out on their water-related impacts, such as the minimum quality of effluent discharge. The GRI standard provides guidance documents to users on water-specific reporting templates, methodology for calculating water use, etc. (GRI 2025)	GRI has over 500 community members across over 70 countries. 391 organisations across 80 countries are publicly available on their website, of these 391 companies 155 are on the European continent across 30 countries, 101 of these companies are within 20 EU member states. (GRI, 2025)

CDP Water Security	Framework	2010	The **Carbon Disclosure Project (CDP)** is a non-profit charity that runs a voluntary global disclosure system for investors, companies, cities, states and regions to manage their environmental impact. CDP is funded by a wide-ranging of financial sources and is directed by a board of Trustees and board of directors (CDP, 2025). Unlike a standard, such as AWS, submission to CDP follows a questionnaire-based process with companies completing a range of questions related to water use, water security, supply chain operations and governance. The questionnaire responses are validated and scored, between A-D, by CDP, with a company score of 'A' considered as 'corporate leader on environmental performance and transparency'. (CDP, 2025) [In 2024, 757 organisations within Europe submitted their Water Security questionnaire responses to CDP and were graded as previously explained. The publicly available results found that 34 companies received an A score, 73 companies received an A- score, 128 a B score, 37 received a B- score, 130 received a C score,12 received a C- score, 27	Access to CDP 2025 water data not available at time of writing.

			received a D score, 1 company received a score of D-, 42 companies were not scored, and a total of 273 were not made publicly available. This was further reviewed to encounter EU Member States only and of the 757 organisations 503 organisations are within EU member States. The scores made public are as follows: 16 organisations received an A score, 46 received an A- score, 83 received a B score, 20 received a B- score, 63 received a C score, 10 received a C- score, 18 received a D score, 1 company received a D- score, 30 organisations were not scored, and 216 organisation scores were not made publicly available. (CDP 2025)	
CEO Water Mandate	Commitment	2007	**The CEO Water Mandate** was established in 2007 to prompt global business leaders to advance water stewardship. A partnership between the UN Global Compact and the Pacific Institute, this initiative provides a platform for organisations to solve critical shared water challenges by adopting best practice in water stewardship. The platform provides almost 600 resources to support organisations in achieving better water stewardship via its	- 480 countries endorse globally, - 158 European countries endorse, - of which 100 are within EU Member States. (CEO Water Mandate, 2025)

			water stewardship toolbox. Organisations must commit to 10 principles in order to become an endorsed member. The initiative is responsible for over 2,100 water projects since its inception. (CEO Water Mandate, 2025)	
Climate Disclosure Standards Board	Framework	2021	The **Climate Disclosure Standards Board (CDSB) framework application guidance for water -related disclosures** was originally developed to complement the CDSB framework for reporting environmental and social information (Climate Standards Disclosure Board, 2021). The CDSB was amalgamated into the International Financial Reporting Standards (IFRS) Foundation on the 31st of January 2022 (CDSB, 2024) whereby the CDSB framework for water-related disclosure was converted to a supporting guidance document for the requirements of environmental disclosure to International Sustainability Standards Board (ISSB) S1 and S2. This guidance delineates the first six reporting requirements of the CDSB framework such as performance and comparative analysis and the identification of governance, risks and opportunities (CDSB, 2021).	Unknown

			Water-related guidance is incorporated into each of the six reporting requirements mentioned previously, including external examples, and examples of best practice in water reporting, considering the site water use, and water use within the organisations supply chain.	
Taskforce on Financial Related Disclosures (TNFD)	Voluntary Standard	2020 – formally launched 2021	The TNFD aims to support businesses, society and financial institutions alike with the necessary information on how their impact and dependencies on nature pose risks but also opportunities for their business or service activities. Recommendations are provided through corporate reporting on their business or service activities where nature-related assets are material to their continuity. They receive nature-related risk management plans for strategic planning for opportunities which may arise.	553 organisations across 54 countries have committed to making TNFD disclosures. Of these 553 organisations 198 organisations across 21 European countries, 101 organisations are within 16 EU Member States. (TNFD, 2025).

5. Conclusion

The key findings and discussion points of this report will provide crucial input into the design and development process of the remaining tasks of WP5 of the CORNERSTONE project as the WP team develops a toolkit of decision support tools to facilitate the mainstreaming of water and wastewater technologies and other related water initiatives within industry.

5.1. Summary of Findings

The key findings presented by category are as follows:

Drivers for Water Stewardship, Circularity and Resource Recovery across Industrial Water Users

- The **most important external drivers** for industry in progressing water circularity and resource recovery activities are effluent discharge regulations, environmental policies, and sustainability reporting requirements while the **least important external drivers** are shared water challenges, technology advancements, and mitigation of impact from climate change.
- The **most important internal drivers** for industry in progressing water circularity and resource recovery activities are cost of wastewater treatment and discharge, resource shortages/competition, and supply chain resilience while the **least important internal drivers** for industry in progressing water circularity and resource recovery activities are corporate net zero ambitions, potential return on investment from circular initiatives, and advances in internal data and digitalisation infrastructure.

EU Policy and Legislative Context

- In addition to key EU environmental policies such as the Green Deal and the Corporate Sustainability Reporting Directive, policies in domains such as water, energy, waste and circularity, soil and land; and industrial safety have been identified as relevant to industrial water users on the topics of water stewardship, circularity and resource recovery.

Industrial Trends in Water Stewardship, Circularity and Resource Recovery

- A growing recognition of both the cost and value of water to industry as demand for industrial water continues to grow globally, with an estimated 400% increase forecast across manufacturing sites alone by 2050
- The emergence of water risk and resilience planning across industry, supported by mechanisms such as the Corporate Sustainability Reporting Directive's drive to mandate industry to undertake double materiality assessments to identify the impacts, risk and opportunities of their business activities on the environment and vice versa
- The need for greater stakeholder and supply chain engagement in protecting water resources, including through collaborative, catchment-based approaches such as those found in industrial water stewardship activities.
- Promoting water circularity approaches to create a resilient water management system that supports both human and environmental needs

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- New advances in water and waste technologies can play a key role in reducing environmental impacts across process industries, through collaboration, knowledge sharing and competency development are critical factors in ensuring successful adoption

5.2. Summary of Discussion Points

A summary of the discussion points identified as part of the research are listed below:

- The integration of circularity policies into industrial practices has profound economic and environmental impacts. the adoption of circular economy practices in the European Union is projected to generate net economic benefits of €1.8 trillion by 2030 while circularity polices can significantly reduce the ecological footprint of industrial activities.
- Numerous challenges exist in the transition to a circular economy for industry including cost, lack of guidance, the cultural shift needed amongst both consumers and businesses and the technical challenges associated with continued materials reuse that cannot be treated using conventional systems
- Long-term sustainability considerations are crucial for ensuring a resilient and equitable future. Climate resilience can be achieved through a combination of technological advancements, infrastructural improvements, policy changes, and community-based strategies.
- Continuous improvement in industrial water and wastewater management is essential for achieving circularity and recovery objectives ensuring that water resources are used efficiently, waste is minimised, and valuable materials are resourced and used according to RRR principles. By adopting a continuous improvement strategy, industries can contribute to environmental sustainability, reduce operational costs, and comply with increasingly stringent regulations.

6. References

Alliance for Water Stewardship (2025). *Certified sites*. Available at: https://a4ws.org/certification/certified-sites/#:~:text=As%20of%203%20March%202025%2C%20there%20are%20328,of%20this%20table%20will%20be%2010%20March%202025 (Accessed: 10 March 2025).

Aquascope (n.d.). *Aquascope | Home*. Available at: https://www.aquascope.com (Accessed: November 2024).

Alliance for Water Stewardship (AWS) (2024) *The AWS Standard 2.0*. Available at: https://a4ws.org/the-aws-standard-2-0/ (Accessed: 2024).

AXA (2024). *Water Impact and Sustainability Evaluation Tool*. Available at: https://axaxl.com/-/media/axaxl/files/pdfs/campaign/water-risk-consulting/axa-xl-water-impact-and-sustainability-evaluation-tool.pdf (Accessed: 2024).

Ayley, S., Black, D., Brown, A., Burlon, L., Stratford, C. and Wade, S. (2024). *Water resilience: Unlocking local and global benefits through collaboration - a view from UK-based specialist providers*. British Expertise International Working Group on Water Resilience.

Cascale (2024). *Higg Index Brochure*. Available at: https://cascale.org/resources/publications/higg-index-brochure (Accessed: 2024)

CDP (2023). *Financial institutions are valuing water: How the financial sector is responding to the water crisis*. Available at: https://www.cdp.net/en (Accessed: October 2024).

CDP (2023). *Water security: Corporate water risks and opportunities*. Available at: https://www.cdp.net/en/water (Accessed: February 2025).

CDP (n.d.) 'Water Watch', *CDP*. Available at: https://www.cdp.net/en/disclose/question-bank/water-security/water-watch (Accessed: February 2025).

CDP (2022) *Water Security 2022 Reporting Guidance*. Available at: https://guidance.cdp.net/en/guidance?cid=35&ctype=theme&idtype=ThemeID&incchild=1&microsite=0&otype=Guidance&tags=TAG-597%2CTAG-607%2CTAG-599 (Accessed: 2024).

Climate Disclosure Standards Board (CDSB) (2022) *CDSB framework for reporting environmental & social information: Advancing and aligning disclosure of environmental and social information in mainstream reports*. Available at: https://www.ifrs.org/content/dam/ifrs/groups/cdsb/cdsb-framework-2022.pdf (Accessed: March 2025).

CEO Water Mandate (2025) *CEO Water Mandate Introduction Deck*. Available at: https://ceowatermandate.org/wp-content/uploads/2025/02/2025-CEO-Water-Mandate-Introduction-Deck-1.pdf (Accessed: March 2025).

CEO Water Mandate (n.d.) *Endorsing companies*. Available at: https://ceowatermandate.org/about/endorsing-companies/ (Accessed: March 2025)

Ceres (2023). *Development of a company level cost-benefit analysis framework: Assessing the full value of water stewardship investments to business and society*. Available at: https://www.ceres.org (Accessed: 2024)

Chapagain, A., Strong, C., Brill, G., Morrison, J., Matthews, J.H., Davis, K. and Ruckstuhl, S. (2021). *Water Resilience Assessment Framework*. Alliance for Global Water Adaptation, CEO Water Mandate, International Water Management Institute, Pacific Institute, and World Resources Institute.

Delgado, A., Rodríguez, J., Amadei, D., Makino, C. (2021). *Water in circular economy and resilience (WICER)*.

Department of Trade, Industry and Competition (the dtic) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2021). *Water Stewardship for Sustainable Water Management: Standard Operating Procedures for Industrial Parks*. Pretoria, December 2021.

Dobson, R., Watt, J. and Morgan, A., (2023), Collaborating with key suppliers to advance water stewardship.

Dobson., R., Morgan., A., (2023), Scaling up water stewardship: WWF's refreshed water stewardship vision.

Ecolab (2024). *Smart Water Navigator*. Available at: https://www.ecolab.com/corporate-responsibility/environment/water-stewardship/smart-water-navigator (Accessed: 2024)

EcoVadis (2024). *Scoring principles: Document classification | EcoVadis public EcoVadis 2024 V1.5*.

EFRAG (2024) *ESRS E3 Water and Marine Resources*. Available at: https://www.efrag.org/sites/default/files/media/document/2024-08/ESRS%20E3%20Delegated-act-2023-5303-annex-1_en.pdf (Accessed: 2024).

European Commission (2021) 'Implementing the Digitising European Industry actions', *Futurium*. Available at: https://ec.europa.eu/futurium/en/content/digitising-european-industry-catalogue-initiatives.html (Accessed: 3 August 2021).

European Commission (2024). *Corporate sustainability reporting*. Available at: https://ec.europa.eu/info/business-economy-euro/company-reporting-and-auditing/corporate-sustainability-reporting_en (Accessed: January 2025).

European Environmental Agency (2024). *Aqueduct Global Water Risk Atlas (WRI)*. Available at: https://www.wri.org/aqueduct (Accessed: December 2024).

European Parliament (2025). *Environment policy: General principles and basic framework*. Available at: https://www.europarl.europa.eu/ (Accessed: March 2025).

European Commission (2023). *Commission Delegated Regulation (EU) 2023/2772 of 22 December 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards*. Official Journal of the European Union.

European Commission (2025) 'LIFE ANHIDRA Project: Unique and Sustainable System for Producing Garments Without Water Discharges'. Available at: https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE21-ENV-ES-LIFE-ANHIDRA-

101074372/unique-and-sustainable-system-for-producing-garments-without-water-discharges (Accessed: 16 March 2025).

Famiglietti, J., Palash, S., Xu, L., Bluhm, K., Garvey, K. and Ferris, M. (2022). *Global assessment of private sector impacts on water*. Ceres.

Gaskin, C., Stockil, K., Track, T., Horan, W., Lucht, A. and Conheady, P. (2023). *Industrial Water 4.0 – A framework for catchment-based digitally integrated industrial water stewardship*. EPA.

Gasson, G. and Rees, C. (2024). *Investing in a water-secure future: Value creation strategies in a changing world*. XPV Water Partners

Global Water Watch (n.d.). *Services • Global Water Watch*. Available at: https://www.globalwaterwatch.org (Accessed: January 2025).

Gramlich, D. and Walker, T. (2023). *Water risk modeling: A framework for finance*. Journal of Environmental Management.

GRI (2025). *GRI - Home*. Available at: https://www.globalreporting.org (Accessed: January 2025).

ISO (2014). *Environmental management — Water footprint — Principles, requirements and guidelines*. ISO 14046:2014. Available at: https://www.iso.org/standard/43263.html (Accessed: March 2025).

International Organization for Standardization (ISO) (2019) *ISO 46001:2019 – Water efficiency management systems — Requirements with guidance for use*. Geneva: ISO.

Kleber, R., et al. (2020). 'Proprietary parts as a secondary market strategy', *European Journal of Operational Research*, 281(1), pp. 45-57. Available at: https://doi.org/10.1016/j.ejor.2019.11.062

Kurrer., C., Petit., A., (2025), FACTSHEETS Environment Policy : general principles and basic framework

Kuzma, S., Bierkens, M.F.P., Lakshman, S., Luo, T., Saccoccia, L., Sutanudjaja, E.H. and Van Beek, R. (2023). 'Aqueduct 4.0: Updated decision-relevant global water risk indicators', *Technical Note*. World Resources Institute, Washington, DC. Available at: https://doi.org/10.46830/writn.23.00061 (Accessed: 2024).

Le Sève, D. and de Souza, M. (2024). *Stewardship at the source: Driving water action across supply chains*. CDP.

Lucas, O., Bromley, E., Steen, B. and Mhonda, J. (2024). *Water Stewardship: Current Perspectives and Approaches*. Prepared for: BSI (British Standards Institution).

Maersk (2023). *Transforming decision-making in supply chain logistics with digital twins*. Available at: https://www.maersk.com/news/articles/2023/01/20/transforming-decision-making-in-supply-chain-logistics-with-digital-twins (Accessed: 19 March 2025).

Mannina, G., Badalucco, L., Barbara, , L., Cosenza, A., Di Trapani, D., Gallo, G., Laudicina, V.A., Marino, G., Muscarella, S.M.,Presti, D., Helness , H., (2021), Enhancing a Transition to a Circular Economy in

the Water Sector: The EU Project WIDER UPTAKE. *Water* **2021**, *13*(7), 946; Available at https://www.mdpi.com/2073-4441/13/7/946

McKinsey & Company (2015) *Europe's Circular-Economy Opportunity*. Available at: https://www.mckinsey.com/business-functions/sustainability/our-insights/europes-circular-economy-opportunity (Accessed: 16 March 2025).

Nelson, A. (2024). *Navigating Troubled Waters: A Briefing for Directors of Financial Institutions*. June 2024. Strategic Advisor to CDP on Financial Institutions.

Onyima, B.N., Nwabueze, L.N., Nnadozie, C.F., Omovoh, G.O., Mmachaka, T., Omovoh, B.O., Arimoro, F.O., Uku, J.E., Akamagwuna, F.C., Onyima, G.O. and Odume, O.N. (2024). 'Livelihood risks arising from urban river pollution in selected marginal communities in the Federal Capital Territory, Nigeria', *Urban Ecosystems*, 28(1), pp. 1–12. https://doi.org/10.1007/s11252-024-01646-7

Päijät-Häme (2025). *CEI Boost*. Available at: https://paijat-hame.fi/projektit-2/cei-boost/ (Accessed: 24 March 2025).

Preut, A., Kopka, J.P. and Clausen, U. (2021). 'Digital twins for the circular economy', *Sustainability*, 13(18), pp. 10467. Available at: https://doi.org/10.3390/su131810467 (Accessed: 19 March 2025).

Qtaishat, Y., Hofman, J., Adeyeye, K., (2022) Circular Water Economy in the EU: Findings from Demonstrator Projects**,** *Clean Technol.* **2022**, *4*(3), 865-892; **https://doi.org/10.3390/cleantechnol4030054**

Reig, P., Reeve, T., Weintraub, L. and Walker, S. (2023). *Volumetric water benefit accounting 2.0: Development of additional principles, terms, and best practices for reporting the volumetric benefits of water stewardship activities*. Bluerisk.

Rubini, A. (ed.), Townsend, G., Chapanova, G., Rovira, M., Pasi, M.C., Swinnen, N., Nieuwenhuis, H. (2024). *Water smart industry white paper*. Water Europe.

SCS Global Services (n.d.). *Water Stewardship and Resiliency Certification*. Available at: https://www.scsglobalservices.com/services/water-stewardship-and-resiliency-certification (Accessed: March 2025).

Smart Water Magazine (2023) 'New analysis framework to help investors and companies understand true value of water stewardship'. Available at: https://smartwatermagazine.com/news/ceres/new-analysis-framework-help-investors-and-companies-understand-true-value-water (Accessed: February 2025).

Tova Earth (2024). *Tova Earth*. Available at: https://www.tova.earth/ (Accessed: 2024).

TNFD (2024). *TNFD Adopters List*. Available at: https://tnfd.global/engage/tnfd-adopters-list/?_sfm_adoption_year=2024-%2C-2025&_sfm_hq-country=Australia (Accessed: March 2025).

TNFD (n.d.). *Recommendations*. Available at: https://tnfd.global/recommendations/ (Accessed: March 2025).

Trubetskaya, A., Horan, W., Conheady, P., Stockil, K., Merritt, S. and Moore, S. (2021) 'A methodology for assessing and monitoring risk in the industrial wastewater sector', *Water Resources and Industry*

United Nations Environment Programme (2023). *Wastewater – Turning Problem to Solution: A UNEP Rapid Response Assessment*. Nairobi. Available at: https://doi.org/10.59117/20.500.11822/43142 (Accessed: 2024).

UNESCO (2021). *The United Nations World Water Development Report 2021: Valuing Water*. UNESCO, Paris. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000375724 (Accessed: 11 March 2025)

US EPA (2024). *Basic information about water reuse*. Available at: https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-water-reuse (Accessed: 17 October 2024).

USGS (2024). *GW/SW-MST: A Groundwater/Surface-Water Method Selection Tool*. Available at: https://water.usgs.gov/water-resources/software/GW-SW-MST/#:~:text=The%20Groundwater%2FSurface-Water%20Method%20Selection%20Tool%20%28GW%2FSW-MST%29%20is%20a,use%20in%20groundwater%2Fsurface-water%20%28GW%2FSW%29%20exchange%20and%20hyporheic%20studies (Accessed: 17 October 2024).

Veolia. (2021). Hubgrade Wastewater Plant Performance: Ede Wastewater Treatment Plant. Available at: Veolia.

WaterAid (2021). *Delivering a resilient supply chain: WASH self-assessment tools*. Available at: https://washmatters.wateraid.org/publications/delivering-a-resilient-supply-chain-wash-self-assessment-tools (Accessed: 2024)

Watermarq (2024). *Internal water pricing: Application, challenge and opportunity*. Watermarq.

WaterNow (2024). *Toolkit*. Available at: https://tapin.waternow.org/toolkit/ (Accessed: 2024).

Waterplan (2024). *Measure | Waterplan*. Available at: https://www.waterplan.com/platform/measure (Accessed: 2024).

WBCSD (2018). *CEO Guide to Water: Building resilient business*. World Business Council for Sustainable Development

WBCSD (2020). *Wastewater Zero: A call to action for businesses to raise ambition for SDG 6.3*. World Business Council for Sustainable Development

WBCSD (2023). *Business guidance on the assessment of wastewater-related impacts*. World Business Council for Sustainable Development.

Wett, B., Buchauer, K., & Fimml, C. (2007). Energy self-sufficiency as a feasible concept for wastewater treatment systems. Water Science and Technology, 57(10), 1555-1561.

World Economic Forum. (2022). *21 circular economy solutions for a more sustainable world*. Available at: [https://www.weforum.org/stories/2022/03/21-circular-economy-solutions/] (Accessed: 16 March 2025)

World Economic Forum (2025). *The Global Risks Report 2025: 20th Edition*. Available at: https://reports.weforum.org/docs/WEF_Global_Risks_Report_2025.pdf (Accessed: March 2025).

World Resources Institute (WRI) (n.d.) *Aqueduct Global Water Risk Atlas*. Available at: https://www.wri.org/aqueduct (Accessed: 2024).

World Wildlife Fund (n.d.). 'Water Scarcity | Threats'. *Water Scarcity | Threats | WWF*. Available at: https://www.worldwildlife.org/threats/water-scarcity (Accessed: March 2025).

World Wildlife Fund (2023). *High cost of cheap water: The true value of water and freshwater ecosystems to people and planet*. Available at: https://www.worldwildlife.org/publications/high-cost-of-cheap-water (Accessed:2024).

World Wildlife Fund for Nature (2024). *WWF Water Risk Filter Indicator & Scenario Documentation (2.0)*. Zenodo. Available at: https://doi.org/10.5281/zenodo.13693590 (Accessed: February 2025)

World Wide Fund for Nature (2024). *WWF Risk Filter Suite 101 Guidance (2.0)*. Zenodo. Available at: https://doi.org/10.5281/zenodo.13691613 (Accessed: February 2025).

World Wide Fund for Nature (2024). *WWF Risk Filter Suite Guidance on Location Data (2.0)*. Zenodo. Available at: https://doi.org/10.5281/zenodo.13692614 (Accessed: February 2025).

World Wide Fund for Nature (2024). *WWF Water Risk Filter Methodology Documentation (2.0)*. Zenodo. Available at: https://doi.org/10.5281/zenodo.13768279 (Accessed: February 2025).

WWF, The Nature Conservancy (TNC), WaterAid, IDH - Sustainability Initiative Fruit and Vegetables (SIFAV), Global Water Partnership, Alliance for Water Stewardship, CEO Water Mandate, Good Stuff International, SHARE Sustainability, Watermarq, Water Integrity Network, AstraZeneca, The Rivers Trust, WRAP, Water Witness International, Nature's Pride Foundation (2024). *Unpacking collective action in water stewardship: shared solutions for shared water challenges*.

7. Appendix

7.1. Appendix A – Industrial Current State Assessment Questionnaire

Survey Overview

Funded by the European Union, the CORNERSTONE project (Horizon Europe Grant Agreement No. 101138504) is conducting an industrial current state assessment survey to understand the current awareness and activity levels in regard to the usage of circular water technologies in industrial settings.

This survey, carried out by Work Package 5 Leads 20FIFTY Partners and partners DECHEMA and AEE INTEC, will aid the development of a Decision Support Toolkit to support the adoption of water, energy and solute recovery solutions in industry. By sharing your answers, you will help the project to identify the trends, drivers, barriers and enablers of circularity adoption across water / wastewater processes in industrial settings.

The survey will take approximately 10-15 minutes depending on your answers, and all responses given will be treated in the strictest confidence. Responses will only be viewed in aggregate in the form of a statistical report to be included in deliverable 5.1. Industrial Current State Assessment report.

Survey Objectives

- Assess awareness of circularity and resource recovery in water and wastewater processes across industry;
- Assess circularity and resource recovery implementation activity across industry;
- Analyse barriers and enablers to the adoption of circularity and resource recovery technologies and approaches in water and wastewater processes across industry.

Data Protection

This interview will be conducted in accordance with 20FIFTY Partners Privacy Policy. Your personal data will not be shared outside of 20FIFTY Partners. Only anonymised data will be shared with the CORNERSTONE project partners, which may only be shared with universities on request for research

purposes only. No data from this survey will ever be passed onto any marketing or advertising company.

1. Are you happy to proceed with this survey?

1	Yes
2	No

2. Which of the following best describes the principal industry of your organization?
Please select one option only from the list below.

1	Aerospace
2	Automotive
3	Business Support & Logistics
4	Construction
5	Chemicals
6	Food & Beverages
7	Information & Communication Technologies (ICT)
8	Life Sciences & Pharmaceuticals
9	Manufacturing
10	Medtech
11	Pulp & Paper
12	Retail & Consumer Durables
13	Steel
14	Utilities, Energy, & Extraction
15	Other (please specify) [text box]

3. What is your current role in the company that you work for?
Please select one option only from the list below.

1	Manager
2	Operator
3	Consultant
4	Analyst
5	Other (please specify) [text box]

4. Which country is your site located in?
Please select one option only from the list below.

1	Austria	19	Malta
2	Belgium	20	Netherlands
3	Bulgaria	21	Norway
4	Croatia	22	Poland
5	Cyprus	23	Portugal
6	Czech Republic	24	Romania

7	Denmark	25	Slovakia
8	Estonia	26	Slovenia
9	Finland	27	Spain
10	France	28	Sweden
11	Germany	29	Switzerland
12	Greece	30	United Kingdom
13	Hungary	31	Other (please specify) [text box]
14	Ireland		
15	Italy		
16	Latvia		
17	Lithuania		
18	Luxembourg		

5. How much water does your site consume each year?
   Please select one option only from the list below.

1	Less than 1,000m^3
2	Between 1000m^3 and 19,999m^3
3	Between 20,000m^3 and 249,999m^3
4	Equal to or greater than 250,000m^3

6. Does your organisation currently treat wastewater on site?
   Please select one option only from the list below.

1	Yes
2	No [skip Q.7 and go to Q.8]
3	Don't Know

7. How many m3 of wastewater does your organisation treat per annum?
   Please select one option only from the list below.

1	Less than 1,000m^3
2	Between 1000m^3 and 19,999m^3
3	Between 20,000m^3 and 249,999m^3
4	Equal to or greater than 250,000m^3

8. Please indicate the current status of your site circularity and/or recovery activity for each stream below.
   Please select one option only from the list below.

		NO, and we are **not planning** to take action	**NO**, but we **are planning** to take action	**YES**, but we are **not planning** to take further action	**YES**, and we **are planning** to do more

1	Solute recovery				
2	Water recovery				
3	Energy recovery				

9. Below is a list of available technologies used for circular water management. Please indicate the extent to which you have interacted with each at your current site.
Select one answer only per technology.

	Randomise ⇩	**I am not aware** of this technology	**I am aware** of this technology, but it is **NOT used** at our site	**I am aware** of this technology, and it **IS used** at our site
1	Non-clogging heat exchanger			
2	Anaerobic Membrane Bioreactor (AMBR)			
3	Nanofiltration			
4	Membrane distillation			
5	Bipolar electrodialysis			
6	Membrane crystallization			
7	Reverse osmosis			
8	Forward osmosis			
9	Other (Please specify)	[text box]		

10. Please indicate the extent to which you have interacted with the following digital solutions for water management at your site.
Select one answer only per solution.

	Randomise ⇩	**I am not aware of this solution**	**I am aware** of this solution, but it is **NOT used** at our site	**I am aware** of this solution, and it **IS used** at our site
1	AMR (Automated Meter Reading)			
2	Smart water monitoring			
3	Artificial Intelligence (AI)			
4	Internet of things (IoT)			
5	Digital Twins			

6	Other (Please specify)	[text box]

11. Please rank the below items in order of their importance to your organisation when selecting a wastewater treatment technology. Rank from 1 to 7, with 1 = the most important factor, 7 = the least important factor. [Rank]
    To rank an item, click on it, then drag and drop it into the relevant numerical position. Alternatively, you can click on the up or down arrows beside each item to move them into the desired order.

⇩	Randomise
1	Lifecycle cost
2	**Energy efficiency per volume water treated**
3	**Impact on Production Processes**
4	**Environmental impact**
5	**Water recovery/lowest waste volume generated**
6	**Adherence to regulatory compliance**

12. Has your organisation implemented any of the following governance activities?
    Please select all that apply from the list below.

⇩	Randomise (bar last row 'None of the above')
1	Corporate water strategy
2	Site level water strategy
3	Corporate water risks assessment
4	Site level water risk assessment
5	**Water circularity policy**
6	**Water stewardship policy**
7	**Water circularity KPIs**
8	**Value chain engagement policy on water**
9	**None of the above**

13. What would you consider to be the greatest risks to water management at your site? Please rank from 1 to 6, with 1 = the greatest perceived risk and 6 = the lowest perceived risk to your site? [Rank]
    To rank an item, click on it, then drag and drop it into the relevant numerical position. Alternatively, you can click on the up or down arrows beside each item to move them into the desired order.

⇩	Randomise
1	Financial Risk
2	Regulatory Risk
3	Supply Chain Risk
4	**Reputational Risk**
5	Technological Risk
6	Operational Risk

14. What are the key internal drivers for progressing water circularity and resource recovery activities within your site? Please rank from 1 to 7, with 1 = the most important driver and 7 = least important driver. [Rank]
    To rank an item, click on it, then drag and drop it into the relevant numerical position. Alternatively, you can click on the up or down arrows beside each item to move them into the desired order.

⇩	Randomise
1	Identification of resource shortages / competition for resources
2	Maintaining supply chain resilience
3	Cost of wastewater treatment and discharge
4	Potential return on investment from implementing circular initiatives
5	**Process improvement**
6	**Advances in internal data and digitalisation infrastructure**
7	Corporate net zero / positive water ambitions

What are the key external drivers for progressing water circularity and resource recovery activities within your site? Please rank from 1 to 7, with 1 = the most important driver and 7 = least important driver. [Rank]
To rank an item, click on it, then drag and drop it into the relevant numerical position. Alternatively, you can click on the up or down arrows beside each item to move them into the desired order.

⇩	Randomise
1	National / local authority effluent discharge regulations
2	National and regional environmental policies (e.g. EU Green Deal, Circular Economy Action Plan etc.)
3	Mandatory / voluntary sustainability reporting requirements (e.g. CSRD, CSDDD, SBTi, GRI)
4	Technology advancements and new circular solutions
5	**Shared water challenges in the catchment / river basin**
6	**Mitigation of water related impact from climate change**
7	Stakeholder demands to meet sustainability targets

15. Please indicate the extent to which each of the items below are a barrier to investing in circular solutions for your site.
    Select only one answer per item, with level of barrier ranging from 'Not a barrier' to 'Extreme barrier'.

	Randomise ⬇	Not a barrier	Somewhat of a barrier	Moderate barrier	Extreme barrier
1	Water abundance i.e. there is no need for water reuse				
2	High Capital costs				
3	High Operation and Maintenance costs				
4	Insufficient skills and competencies				
5	**Absence of national water reuse standards**				
6	Insufficient clarity in the regulatory framework to manage risks associated with water reuse				
7	Inability to meet regulatory or required water quality standards				
8	Opposition by public, stakeholders, or elected officials				
9	Perceived impact on production				
10	The risk of product becoming contaminated by reused water				
11	Internal buy-in				
10	Other (Please specify)	[text box]			

16. What are the enablers or supports that would drive uptake of water circularity solutions at your site?
    Select all that apply.

	Randomise ⬇
1	Upskilling of employees in water / wastewater reuse and circularity
2	Ability to build strong business case for new technology
3	Opportunity mapping across water lifecycle

4	Site / organisational roadmap for water circularity
5	**Technology assessment guide to provide guidance on / benchmark new technologies**
6	**Digital solutions**
7	Internal price of water to calculate ROI potential
8	Information on potential external funding / investment sources
9	Circularity maturity assessment
10	External technical support
11	Other (please specify) [text box]
12	None of the above

Thank you for taking part in this survey.

7.2. Appendix B – Detailed Summaries of EU Policies

EU Green Deal

As part of the EU Green Deal, organisations and EU members are encouraged to promote and invest in a digital transformation necessary for the change towards a more digitalised society. It is estimated that the potential to transform an industrial sector and all associated value chains takes 25 years. To meet the 2050 deadline for transforming Europe into a circular and environmentally clean economy, change is needed urgently. Regarding industry and modelling a circular economy for Europe, access to resources is a strategic security question posed by the European Green Deal. Section 2.1.3. *Mobilising industry for a clean and circular economy* details the ambition of the Green Deal for industries to advance from the linear model of resource use to a more circular model introducing the reuse of materials through a new circular economy action plan, sustainable products policy, advancements in digitalisation throughout industry, etc. In relation to the extraction from and pollution of water the EU Green Deal promotes the enabling of digital technologies to meet sustainability KPIs, targets and needs for the future. Digitalisation of the resources from energy to water allows for monitoring and optimisation for the resource use.

Sections 2.1.6. *From 'Farm to Fork': designing a fair, healthy and environmentally-friendly food system* and section 2.1.7. *Preserving and restoring ecosystems and biodiversity* encounters water pollution and consumption of water for the agriculturally intense industries and their impact on the environment. Section 2.1.8. *A zero pollution ambition for a toxic-free environment* again pursues the change from the linear model of resource use to circular model and the reduction of impacts from water pollution and inefficient consumption. This section also highlights the need for increased digitalisation for monitoring throughout all sectors, and the review of current EU measures to deal with pollution emanating from large industrial installations to align with policy ambitions for circularity.

To ensure a smooth transition, sufficient supply and recirculation of critical raw materials is necessary. Raw materials are essential for clean technologies, digital applications, and supplies for water treatment and resilience. The EU Green Deal's ambition for industry to be 'climate and resource frontrunners' requires a digital transition and breakthrough of clean technologies throughout all sectors. The demand for clean technologies and alternative sources of raw materials allows for opportunities within the water treatment demographic and for industries to expand their water, energy and chemical resilience.

Circular Economy Action Plan

A New Circular Economy Action Plan for a cleaner and more competitive Europe highlights the excessive consumption levels of our society and economy but also promotes the necessary adaptions needed to sustain our essential resources by 2050 as per the EU Green Deal ambitions. Resource extraction and processing is quoted to impact 90% of both biodiversity loss and water stress. This circular economy action plan intends to combat the excessive resource use and waste accumulated from a linear economy approach. The plan guides the industrial sector, among others, to contribute sufficiently to the climate neutrality objective by 2050 through decoupling economic growth from resource use.

For industry to contribute successfully to the climate neutrality aim, set by the EU, circularity must be met in all areas of their business. As per section 2.3. *Circularity in production processes* industrial production processes are highlighted be the main contributor in emissions for most industries via air, water and soil. Therefore, production processes should be the main area(s) of material savings through circularity for individual industries, while also shifting the focus towards climate neutrality and long-term competitiveness. These material savings may generate supplementary value to the organisation and provide further economic opportunities. Section 2.3. aligns how the EU Commission will promote circularity with regard the industrial processes through review of the Industrial Emissions Directive (IED) including Best Available Techniques documents, introducing industry-led reporting and certification system for industrial symbiosis, digital technology promotion for the monitoring, tracking and mapping of resources.

This may be achieved through the adoption of Best Available Techniques in lieu of their emissions from industrial processes, implementing industrial symbiosis, supporting a sustainable and circular bio-based sector, promoting green technologies, and the promoting of digital technologies for tracking, tracing and mapping of resources.

The new Circular Economy Action Plan for a cleaner and more competitive Europe thus encourages the Water Reuse Regulation through agriculture but also the reuse and efficient use of water in the industrial sector through their own processes. The plan also calls for further development of nutrient management and opportunities for sectors to recover nutrients from their own processes while encouraging the sustainable application of these nutrients across their processes. This will be further optimised through the proposed updates of the urban wastewater treatment directive, which takes into scope sewage sludge and nutrient removal.

The New Circular Economy Action Plan also encourages the aim of a toxic-free environment set out in the EU Green Deal. This aim is enhanced by chemical policies, such as REACH, which encourage protection of the environment and its citizens through a shift to 'safe-by-design chemicals' and substitution of hazardous substances. The commission will aid in the safety of use in secondary raw materials as the shift to circularity is promoted. Some secondary raw materials may be compromised due to persistent substances, banned in the EU, that may be present in recycled feedstock. These compromised materials aim to be combatted by further development in sorting and removal of contaminants in waste, development of methodologies to minimise substances which pose environmental and health problems, co-operate with industry to provide systems for tracking and managing substances of high concern, re-evaluate the Regulation on Persistent Organic Pollutants with industrial and technological processes and promote recovery and recycling through improvements to the classification and management of hazardous waste streams.

Corporate Sustainability Reporting Directive

The European Union (EU), as part of the EU Green Deal, have implemented the Corporate Sustainability Reporting Directive (CSRD) which requires organisations to take a holistic view of their industrial activities and evaluate the risks they pose and impacts they have on the environment and communities in their locality and their upstream and downstream supply chains. This evaluation of the impacts, risks and opportunities upstream and downstream of the organisation is coined by the term 'double materiality'. CSRD has encompassed multiple Environmental, Social and Governance (ESG) factors into

their reporting requirements to provide transparency among the organisation and the public on the full life-cycle impact of the industry and its inputs and outputs.

CSRD incorporates European Sustainability Reporting Standards (ESRS) into its scope. The ESRS is composed of two over-arching standards outlining the general requirements, ESRS 1, and the general disclosures, ESRS 2. There are a further 10 ESRS documents which encapsulate the ESG factors of the reporting, five environmental reporting standards, four social reporting standards, and one governance standard. The environmental ESRS standards include climate change (E1), pollution (E2), water and marine resources (E3), biodiversity and ecosystems (E4), and resource use and circular economy (E5). The social requirements encompass an organisations own workforce (S1), workers in the value chain (S2), affected communities (S3), and consumers and end-users (S4). The governance document spans business conduct and the requirements for reporting within.

These ESRS documents guide companies to report on their impacts, risks and opportunities both within their operations and also upstream and downstream on their value chain in what has been coined 'double materiality'. The double materiality assessment conducted by organisations for CSRD is to evaluate, under the ten standards stated above, what is material to their organisation and their operations and how internal and external factors to their value chain affect their material elements.

Water is material to almost all businesses with varying degrees of importance to their operations. Organisations must disclose all material aspects related to water and how they impact water bodies in their own locality and along their value chain. Once their double materiality assessment on water has been analysed, they must then disclose:

- How they plan to manage or are currently managing and monitoring their material impacts, risks, and opportunities concerning water and marine resources,
- Any business strategies in place influencing their material impacts, risks, and opportunities with regard to water and marine resources,
- And any policies or actions implemented relating to their material impacts, risks, and opportunities regarding water and marine resources.

Water and marine resources are the main reportable section on water within the standards provided for CSRD, but water reporting interacts with five other ESRS standards. Water if material to each case must also be reported in ESRS E1 climate change, ESRS E2 pollution, ESRS E4 biodiversity and ecosystems, ESRS E5 resource use and circular economy, and ESRS S3 affected communities.

The disclosure requirements set out by ESRS E3 water and marine resources state that organisations must report on their material impacts whether they be positive or negative on water and marine resources and also to disclose any potential impacts they may have on water and marine resources. Organisations must disclose any actions they have taken or may take in the future, and the results of these actions in the mitigation or prevention of negative impacts on water and marine resources.

At this point, they must disclose their water consumption and reference any risks or opportunities associated with their actions and consumption on water and marine resources. Organisations must then take into account how they have contributed to the EU Green Deals ambition for fresh air, clean water, healthy soil and biodiversity as well as a sustainability within the fisheries sector and blue

economy by addressing or accounting for the Water Framework Directive (WFD) and the EU Marine Strategy Framework Directive. Organisations are required to disclose their plans and capacities to adopt strategies and business models in fostering a sustainable water use projection in lieu of protecting water resources, aquatic ecosystems, and restoration of freshwater and marine habitats. Organisations reporting must also evaluate and disclose their dependencies on water and marine resources, any management plans addressing their IRO's (impacts risks and opportunities) associated with their dependencies, and any financial effects attributed to their dependencies.

Organisations, referred to as undertakings in the context of ESRS documents, are required to disclose the above requirements in relation to both surface water and groundwater, including in their reports their activities, products and services which require water consumption, water withdrawals and any water discharges resulting from these operations. Similarly, marine resources are encompassed in the same manner of reporting, requiring organisations to disclose any extractions or discharges associated with their activities.

As mentioned previously the ESRS documents relate to each other and interact so as to not repeat relative information unnecessarily. In this instance, water interacts with all four of the other ESRS environmental standards and one of the social standards. Water and marine resources interact with:

- ESRS E1 climate change through the physical risks associated with climate change and its effects on water through various natural phenomena including weather events (precipitation, temperature change), sea level rise, droughts, floods, water stress, etc.
- ESRS E2 pollution interacts with water and marine resources (E3) through the water discharges and other emissions to water, including oceans, and the introduction of microplastics.
- ESRS E4 biodiversity and ecosystems interacts through the potential impacts on freshwater aquatic ecosystems and through the conservation and sustainable use of our oceans and seas.
- ESRS E5 resource use and circular economy interacts with ESRS E3 through waste management, in particular plastics, and through the extraction of non-renewable resources of wastewater and recycling of wastewater.
- ESRS S3 affected communities interacts with ESRS E3 through the material impacts the organisations effect of withdrawal and discharge can affect people and communities both through their local operations and along their value chain.

This project, and the outcome of a decision support tool, should not only encounter impacts from the use of water, as is material to the demonstration organisations and their associated industrial sectors, but also promote organisations to combat risks through opportunities relating to circularity. ESRS E5 resource use and circularity builds on the EU Circular Economy Action Plan and requires organisations to disclose any potential actions and opportunities they may enact to combat exploitation of raw resources and adopt a circular approach to operations. Organisations as part of ESRS E5 (resource use and circular economy) must report on their resource use, resource efficiency, avoidance of resource depletion, sustainable sourcing of resources and use of renewable resources and the potential positive or negative material impacts associated. Organisations must disclose any actions taken or proposed actions in prevention or mitigation of negative impacts from resource use and measures to address decoupling of economic growth from resource use, and any associated risks and opportunities.

Organisations must also report any strategies and business models in the promotion of circular economy principles, any risks and opportunities related to dependencies in relation to resource use and circular economy, and the financial effects as a result of addressing their material impacts, and risks and opportunities of those dependencies. Organisations are required to disclose the resource inflows and resource outflows, these can include any circularity in material resource inflows encompassing both renewable and non-renewable resources, and information on materials, products and waste arising from resource outflows.

ESRS E5 resource use and circular economy describes circularity as '*an economic system in which the value of products, materials and other resources in the economy is maintained for as long as possible, enhancing their efficient use in production and consumption, thereby reducing the environmental impact of their use, minimising waste and the release of hazardous substances at all stages of their cycle, including through the application of the waste hierarchy. The goal is to maximise and maintain the value of the technical and biological resources, products and materials by creating a system that allows for durability, optimal use or re-use, refurbishment, remanufacturing, recycling and nutrient cycling.*'

ESRS E5, resource use and circular economy, interacts with the four environmental ESRS standards and also one social standard, ESRS S3 affected communities. The interaction of ESRS E5 with the other standards displays the effects resource use can have both on environmental impacts but also on the communities affected by the resource use, abstraction, depletion or effects to the environment where those communities reside. These impacts must be reported under CSRD whether they are deemed to affect the environment or communities positively or negatively and any plans or strategies to maintain or improve the material impacts from the first assessment.

Resource use and circular economy, (ESRS E5), affects climate change (ESRS E1) through interactions with greenhouse gas (GHG) emissions and energy resources, in particular energy consumption. Pollution (E2) interacts with resource use and circular economy via emissions, in particular substances of concern, to water, air and soil. The water and marine resources (E3) along with any emissions to water encountered in the interactions with pollution also is addressed in interactions with resource use and circular economy (E5) through water consumption and the consumption of marine resources. Finally, resource use and circular economy interacts with ESRS E4 biodiversity and ecosystems through the disruption or exhaustion of ecosystems, species and raw resources. Collectively these interactions, along with the other environmental ESRS standards, through the resource stress and impacts of waste created from the use of resources is addressed in ESRS S3 affected communities and encourages a push towards circular economy to alleviate the stresses on the affected communities.

When organisations are reporting on their material impacts risks and opportunities under each of the twelve ESRS standards (5 environmental, 4 social, 2 cross-cutting standards and 1 governance), they do not need to repeat information where the standards interact. Once an organisation has completed their double materiality assessment any interactions noted between the ESRS standards is only required to be mentioned once and referenced back to the location of report following to address each interaction. (EFRAG, 2024)

Environmental Impact Assessment (EIA) Directive

Traditionally full Environmental Impact Assessments have been required within the planning stages of the development of buildings and projects in both urban domestic and industrial sectors. EIAs are a requirement when projects will directly impact the environment from the offset of the construction through all further uses of the construction for example motorways, railways, waste disposal facilities, dams, etc. Where projects are not a constant disturbance to the natural progressions of the environment, they are at the discretion of the individual EU member state to decide if an EIA is a requirement prior to construction. These possible EIA requirements include flood-relief works, industrial development projects, etc. the location of project and the scale of the project are also criteria in the decision of EIA requirements.

The EIA assessments evaluate both direct and indirect impacts associated with the project on various environmental factors including biodiversity, soil, water, air, population, human health, etc. The following must be included in the project details in order for approval to be considered; project description including size and location, potential significant effects, appropriate alternatives, any project features or measures taken which prevent, reduce or offset significant impacts on the environment. The EIA Directive also states the public must be informed, possibly via public consultation, on any projects which will affect them directly or possibly affect their health or their environment locally. In recent amendments, the EIA Directive now scopes for assessments to be completed on additions to projects and any added projects with transport or the capture and storage of CO_2.

Environmental Liability Directive (ELD)

The Environmental Liability Directive (ELD) was adopted in 2007 with the aim of implementing a framework based upon the *'polluter-pays'* principle to ensure liability for, prevention, and remediation of environmental damage. The ELD ensures those responsible for environmental damage are liable for the remediation of the ecosystems damaged, thus incentivising pollution prevention particularly in the industrial and agricultural sectors.

The ELD defines environmental damage as any damage caused "*to protected species and natural habitats, to water and to soil*." The European Commission guidelines in March of 2021 to clarify the scope of environmental damage for the EU Member States. The guidelines defined damage as 'measurable adverse change in a natural resource or measurable impairment of a natural resource service which may occur directly or indirectly.' The adverse effects stated in the definition of damage may be caused by 'occupational activities' as a cause of the 'operators', referring to those who are liable as 'operators' and the actions taken to cause the environmental damage as the 'occupational activities.'

The guidelines and directive state the three main obligations of operators which include where the environmental damage is imminent but has not yet occurred. Operators must act immediately to implement required preventative actions, where the damage has occurred and operators must take immediate action to *'control, contain, remove, or otherwise manage'* the factors which caused the damage and prevent further damage. Finally, if environmental damage has occurred the operators are required to identify remedial measures and have them approved by their competent authority. There are three types of remedial action related to ELD which are primary, complementary and compensatory. Remedial action implemented at the affected site which reverts the natural resources

to their original state is termed primary remedial action. When primary remedial action cannot be achieved or was ineffective, complimentary remediation must be considered and implemented. Complementary remediation or remedial actions refer to providing a similar level of remedial action to primary remedial action at a site geographically linked to the damaged site. If both primary and complementary remedial action are unsuccessful in restoration or remediation, compensatory remediation must be pursued to account for the loss and/or damage of the natural resource.

In the context of the ELD water may be damaged by effects from the land, through the leaching of pollutants through soil or by run-off containing contaminants which may be harmful to humans, animals and the environment, or water may be polluted directly through the emitting of pollutants directly to waterways. Water damage is defined in the ELD as damage of any kind which adversely affects the ecological, chemical, or quantitative status of the water, any damage which may affect the ecological potential of the aquatic environment, adversely affect the ecological status of marine waters and marine ecological environment, or any damage to aquatic environments listed in the Marine Strategy Framework Directive (MSFD) or the WFD. Thus, 'operators' whose 'occupational activities' cause any form of water damage are liable under ELD to take remedial action and report to their competent authority. The remedial action taken can span from primary, complementary, or compensatory remediation but it must be approved by the relevant and competent national authority.

Waste Framework Directive

The proposed solutions or actions for waste incorporated into the new Circular Economy Action Plan will be further supported by revisions and amendments to the Waste Framework Directive made in 2023-2024. The Waste Framework Directive clarifies when waste becomes a secondary raw material and aids in distinguishing between waste and by-products. The directive also introduces the *"polluter pays principle"* and the *"extended producer responsibility"*. To address the move to circularity the 2023-2024 revisions and amendments of the Waste Framework Directive have focused on the textiles industry and promotion of technologies which support circularity across all sectors to design and create more circular products.

EU Taxonomy Regulation

Concerning the adherence of EU member states to the objectives set out in the European Green Deal for Energy and climate targets by 2030 and net-zero by 2050, the EU Taxonomy regulation was entered into force in July 2020. The taxonomy regulation provides a classification system for which sustainability definitions and economic activities are aligned. The taxonomy allows for investment to be directed towards economic activities and projects which are most needed to ensure a successful transition to a more circular and sustainable economy. The EU taxonomy also outlines the economic activities that relate to environmental goals outside of the climate realm. The definitions outlined in the EU taxonomy regulation apply to both financial and non-financial organisations to allow for cohesion on economic projects and activities which may be considered environmentally sustainable. Ultimately, the EU taxonomy regulation allows for the EU Member States to progress sustainable investments, creating security for their investors, and protects from greenwashing. This will be key for organisations marketing new projects and tools to apply a cohesive term in line with the taxonomy regulation.

The EU Taxonomy regulation also sets out the definitions for which a project or activity may be classified as aiding the transition to a circular economy including waste prevention, re-use and recycling where

natural resources are used more efficiently as either primary or secondary raw materials or where efficient resource and energy is a key component, where the project increases the durability, reparability, upgradability or reusability of the product either in the design or manufacturing of the product, where the recyclability of the product is improved or individual materials within the production are more recyclable, where the production of the product significantly reduces or completely eliminates the use of hazardous substances or substances of very high concern, where the design of the project promotes a prolonged use of the product via reuse, longevity, repurposing, disassembly, remanufacturing, upgrades or reparation, where the project improves the use of secondary raw materials and the quality of those materials, the project reduces waste generation throughout the life-cycle of product, increases the preparation for recycling and reuse, promotes development in waste management infrastructure, or prevents or minimises the incineration of waste and waste to landfill.

For projects aligned with water, the taxonomy regulation describes projects as economically sustainable when the activities contribute substantially to achieving a good water status, prevents deterioration of surface water bodies or bodies of groundwater, or achieves good environmental status of marine waterbodies and prevents their deterioration. This may be achieved by projects which prevent pollution of waterbodies from urban and industrial wastewater discharges, projects which protect from contamination of drinking water and therefore protecting human health, projects which improve water management and efficiency including sustainable water use and projects which improve the sustainable use of marine resources.

Zero Pollution Action Plan for Air, Water and Soil

The EU Green Deal launched the Zero Pollution Action Plan: *Towards zero pollution for air, water and soil* as a deliverable with two other action plans on chemical strategy for sustainability and revising measures to address pollution from large industrial installations. The goal of the Zero Pollution Action Plan is that by the year 2050, a toxic-free environment will be achieved, and pollution levels of air, water and soil will no longer be harmful to human health or the environment, but they will also be within a limit to which our planet can cope. Following the Covid-19 pandemic and a fall in the pollution levels within the EU the action plan acknowledges that a halt in economic activities is not a viable solution to achieving the target of zero pollution but a development to circular economy will progress this target significantly. The plan calls for an economic conversion to circularity rather than linearity by implementing sustainable business models, low-emission technologies, clean transport, nature-based solutions and sustainable digitalisation to enhance a collective resilience within the EU.

The Zero Pollution Action Plan has six main targets set out to achieve by 2030 to ensure progress to the main objective of zero pollution by the year 2050. The targets which align most significantly to the predicted outcome of this study are Targets 5 and 6. Target 5 set out in the action plan insists that by 2030 there should be a 50% reduction of plastic waste at sea and 30% reduction in microplastics released to the environment. This target will be aided in progression through rules and guidelines set out in the Single Use Plastics Directive, MSFD, and REACH Regulation. Target 6 aims that by 2030 the EU as a collective should have a significant reduction in total waste generation and 50% reduction of residual municipal waste. This target was called for and will be aided by the commission through the Circular Economy Action Plan and the Waste Framework Directive. These targets align more

prominently with the study at hand due to the circularity aspect addressed in the project and the reduction in emissions to water which may contain plastics.

European Climate Law

European Climate Law was adopted in 2021 with the objective of enforcing goals set out in the European Green Deal, specifically around the goals for the economy and society to achieve climate neutrality by 2050. Climate Neutrality is described within the document as achieving net zero GHG emissions, this law aims to achieve this goal through the legal promotion of cutting GHG emissions, investing in green technologies and protecting the natural environment. The EU 2030 Target is also included in this law, which aims at a goal of reducing net greenhouse gas emissions by 55% compared to 1990 levels of GHG emissions. These reductions by 55% is part of the 'Fit for 55' legislation.

Corporate Sustainability Due Diligence Directive (CSDDD)

The Corporate Sustainability Due Diligence Directive, (CSDDD), entered into force within the EU on July 25th, 2024. The overall objective of CSDDD is to establish sustainable and responsible corporate behaviour throughout an organisation, including its value chain. Organisations in scope must address their ESG impacts both inside and outside Europe where relevant. The Directive focuses on the organisation, and its value chain's impact on social rights, rights of workers, legal transparency, risk management, and environmental resilience. CSDDD applies to Large EU companies and partnerships with over 1000 employees, or over €450 million net turnover worldwide, and Large non-EU companies with €450 million net turnover in the EU. Currently, micro companies and SMEs are not in scope for CSDDD directly but may be affected via their position in a larger organisations value chain.

Businesses must bear the cost of establishing the due diligence operations internally and any transition costs for their own organisation and value chain. CSDDD shall be enforced through '*Administrative supervision'* at multiple levels and '*Civil Liability'*. The Administrative supervision will be at EU and national level, with the European Commission establishing a '*European Network of Supervisory Authorities'* where representatives from designated national authorities of each EU member state will convene to collaborate and assure a coordinated approach. Civil Lability will be governed on a national level by the EU Member States ensuring victims receive compensation for any resulting damages of negligence and or intentional failure of organisations to honour CSDDD.

Industrial Emissions Directive (IED)

The Industrial Emissions Directive (IED) is a successor to the Integrated Pollution Prevention and Control (IPPC) Directive, hence the provisions of the IED are relatively similar in outlining the rules for integrated prevention and control of pollution emanating from industrial sources and activities. This directive outlines rules to prevent emissions to air, water and soil and to prevent the generation of waste with the ultimate aim of environmental protection from these emissions. The original IED adopted in 2010 and amended in 2012 has now been revised and updated to IED 2.0, this amendment was introduced to promote digitalisation to the sector encouraging the adoption of new technologies and techniques but also to account for livestock rearing emissions which also contribute sufficient emissions to air, water and land. IED 2.0 serves as an amendment to the Original IED.

Amendments made from the original IED to IED 2.0 include a change in title, both in abbreviation and formal, thus it now contains 'industrial and livestock rearing emissions (integrated pollution prevention and control)'. Another alteration made in IED 2.0 to IED is the inclusion of 'resource efficiency', 'circular

economy' and 'decarbonisation' which were terms not commonly used within the monitoring landscape prior to the drafting of the EU Green Deal and the Circular Economy Action Plan. The IED2.0 also accounts for 'human health' in conjunction with environment to aid in the circularity promotion and effects of pollution on humans when consumed or disrupting the ecosystems they inhabit.

IED 2.0 was entered into force on August 4th, 2024, with the previously stated objective of reducing harmful emissions from intensive agriculture and the industrial sector as to reduce the impact of those pollutants on the environment and human health. The IED 2.0 aims to promote innovative and transformative techniques and tools to reduce emissions and encourage circular practices and efficient resource use. These aims can be furthered by the introduction of stringent emissions limit values and conditions to reduce the emissions emanating from industry and intensive agriculture but also include more industrial activities in scope for IED permitting such as manufacturing of batteries, mining of metals, waste landfills, etc. IED permitting will now be streamlined under IED 2.0 through the introduction of a new 'Industrial Emissions Portal Regulation' which shall enhance public access to environmental information. The transparency of environmental information with the public and accountability of organisations in the industrial and intensive agricultural sectors will also encourage another objective of the IED 2.0 and the original IED of the 'polluter pays' principle. The original IED had adopted the 'polluter pays' principle but IED 2.0 aims to further develop this in line with the rights of the public and allowing the public to seek justice and compensation from any damages to their health caused by illegal pollution from an IED permitted site.

IEPR – Industrial Emissions Portal Regulation

The Industrial Emissions Portal Regulation (IEPR) replaces the European Pollutant Release Transfer Register Regulation (E-PRTR). IEPR aims to provide transparency among the IED permitted sites and the public. This transparency will be achieved through the collection and publishing of data on the quantities of industrial pollutant releases, off-site waste transfers, pollutants in wastewater, and the consumption of water, energy and raw materials. The IED 2.0 and IEPR are linked in scope similarly to how the original IED and E-PRTR were linked as their predecessors. The key difference in the links with IED 2.0 and IEPR is the public consultation elements and transparency which is intended to encourage the public and industries to work cohesively on the environments they inhabit. The IEPR should also enable organisations to quantify impacts for their reporting in CSRD both individually and for their value chain and affected communities. This will also help with estimating future risks through the available comparable data on shared basin risks, opportunities and impacts when it comes to water reporting for CSRD.

REACH Regulation

While EQSD aims to prevent chemical pollution of our waterways which may in turn damage our aquatic ecosystems and cause harm to human health, the remainder of the environment and ecosystems is covered by chemical pollution and its effects by the REACH Regulation. This regulation aims to protect human health and the environment from risks associated with chemical pollution by requiring registration, evaluation, authorisation and restriction of chemicals used in the EU, hence 'REACH'. The identification of intrinsic chemical properties of priority chemical substances allows for their phasing out or restriction when they are classified as substances of high concern. This extends to EU industry by providing them the responsibility of managing their risks posed by the chemicals and providing the public with safety information on the substances. These chemical properties must be published in ECHA, the European Chemicals Agency, to ensure full transparency of the risks with the public. REACH also poses the opportunity for the EU to enhance its innovation and competitiveness in

the search for non-hazardous alternatives to the necessary hazardous chemicals seen and used in production of EU industrial products. REACH also promotes the search for alternative methods of assessment of hazardous substances, specifically development of experimentation on animals.

Biocidal Products Regulation

Similar to the REACH Regulation the Biocidal Products Regulation is also reportable on ECHA and intends to protect against humans and the environment against the excess use of biocidal products in our ecosystems. Biocidal products are marketed and used with the expectation of protecting humans, animals and other materials against invasive or harmful organisms such as rodents or bacteria. These biocidal products must be approved before being placed on the market similar to chemicals approved by ECHA and EU Member States. Some biocidal products may be approved by individual states and not others due to their own needs relative to the organisms they intend to limit the existence of. Biocidal products are also subject to evaluations and may be restricted if found in excess in soil, air, or water causing harm to humans or the environment or species not intended to be harmed by the substances within the product.

Energy Efficiency Directive

The Energy Efficiency Directive was first introduced in 2012, to promote the efficient use of energy by EU Member States to meet the EU's climate ambition and reduce overall energy consumption. At the time of publishing, the EU Energy Efficiency Directive was last revised in 2023. The revision of the directive saw a change to the EU energy efficiency target to an additional 11.7% reduction in energy consumption by 2030 collectively by EU member states. Thus, overall EU energy consumption "should not exceed 99.25 million tonnes of oil equivalent (Mtoe) for primary energy and 763Mtoe for final energy." This collective aim shall be met by the EU Member States setting their own indicative national contributions. The revised directive also increased the annual energy savings obligation by 2028. This revision to the directive aims to increase energy savings in 'end-use sectors', these sectors include buildings, transport and industry. This directive also broadens the scope of energy audit obligations to include companies that consume energy above a certain threshold, regardless of the company size. Therefore, both large industries and SMEs would be required to conduct energy audits for potential energy savings. This directive also ensures the monitoring and optimisation of energy efficiency in large industrial energy consumers via mandatory energy management systems.

The European Parliament introduced an energy efficiency target of 32.5% energy savings, at least, at EU level to achieve by 2030.

Renewable Energy Directive

The Renewable Energy Directive, first introduced in 2009, establishes renewable energy use targets for the EU member states. The last revision of this directive at the time of writing was in 2023, this revision of the Renewable Energy Directive introduced two solutions to enable the production and use of renewable energy in the industrial sector.

REPowerEU Plan

The REPowerEU Plan was introduced by the EU in 2022 to respond to an over-dependence on Russian coal, gas, and oil imports. It was introduced to phase out the purchasing of Russian fossil fuels by EU

Member States and replace them with diversified energy supplies and promote the production of clean energy within the EU.

The focus on industry within this plan is highlighted by the need for buildings, industry and transport sectors to phase out the use of fossil fuels where possible which is promoted by increased targets under the Renewable Energy Directive, mentioned previously, particularly the inclusion of solar energy in building design, increased wind energy deployment, the introduction of heat pump technologies, and promote research and development in electricity storage.

In particular, when it pertains to the transport and industries sectors, renewable hydrogen will be crucial in decarbonising these sectors. To support the electrification and hydrogen uptake in the transport and industrial sectors the European Commission will introduce carbon contracts, under the Innovation Fund, to aid in the full switch from natural gas to renewables in existing hydrogen production in industry and aid in the transition towards hydrogen-based production processes for industries not currently utilising hydrogen or hydrogen-based solutions. The European Commission also aims to offer support by publishing guidance for EU Member States on both renewable energy and power purchase agreements. Finally, the European Commission will support the industrial and transportation sectors by providing a technical advisory hub, in collaboration with the European Investment Bank (EIB), to encourage industrial investment in renewable energy projects.

This hub will support three project areas in particular, the first area will deal with innovation in electrification and hydrogen utilisation within the industrial sector, the second project area aims to support the manufacturing of clean technology, and the final project area aims to support mid-sized pilot projects for experimenting, validating and optimisation of new and innovative solutions.

Water Framework Directive

The Water Framework Directive (WFD) is the principal legislation for the protection and maintenance of qualitative and quantitative health of our waterways. WFD encompasses inland waterbodies, transitional waterbodies, maritime waterways and groundwater within its legislative documents. The aim of WFD is to ensure the conservation of both inland and coastal surface waters and groundwaters of healthy status and restoration of those waterways in stress, while also maintaining a balance of water consumption for the ecosystems associated. The health status of water is evaluated both for the chemical and ecological quality of the water. In order to achieve and conserve the quality of our waterways, the WFD requires the EU Member States to evaluate their waterways and report on their status to the public through River Basin Management Plans (RBMPs) and Programmes of Measures (PoMs). These initiatives also enable member states to plan and manage the restoration of low-quality waterbodies and the prevention of further deterioration.

WFD legislation outlines provisions and exemptions to meet these quality statuses. The annexes of the WFD states the specific details required for monitoring, assessing water quality status, and inclusions for the RBMPs. To achieve good chemical status EU Member States must monitor a list of priority substances registered in Annex X of the WFD and adhere to the standards set out for each of the priority substances. The standards for these priority substances are outlined in the Environmental Quality Standards Directive (EQSD), which will be discussed later. Similarly to the achievement of good chemical quality status, to achieve good ecological status EU Member States must acquire the

Environmental Quality Standards for substances of national concern and update them accordingly every 6 years to maintain good ecological and chemical status of water quality.

Urban Wastewater Treatment Directive (UWWTD)

In October 2022 the European Commission proposed a revision and update to the UWWTD originally adopted in 1991. This Directive has since been revised following a REFIT evaluation conducted in 2019. The REFIT evaluation focused on the revision of the UWWTD to support extended treatment of pollution from urban sources including rain/stormwaters and decentralised facilities, among others, thus extending the treatment from the centralised facilities and pollution from primarily domestic sources. Due to the passage of time since the original directive was adopted, the limit values declared in the 1991 Directive are now outdated for many of the pollutants listed, and new pollutants have also emerged since the adoption of the original directive. These emerging pollutants include micro-plastics or micro-pollutants which are harmful to both the environment and public health even at low concentrations.

Revision of the UWWTD was needed to adapt to emerging policies and ambitions for meeting trends and objectives relative to climate change. The EU Green Deal has set out ambitions and aims to aid in the fight against climate change, including a reduction in environmental degradation and a promotion of circularity across all sectors and the economy in general. Wastewater can attribute to these ambitions via reduction in GHG emissions, reductions in energy consumption, and increasing circularity through the reuse of treated water and the improvement of sludge management for nutrient and organics recovery.

Water/wastewater governance, or lack thereof, was required in the revision of the UWWTD. Audits concluded that the 'polluter pays' principle is not applied as it should be if at all, and monitoring and reporting methods could be enhanced through digitalisation. If updated sufficiently the UWWTD will provide impact both on the ground in terms of environmental benefits and economic benefits through the implementation of circular actions but also provides sufficient and updated information for reviews of other relevant policy areas directly attributed to the UWWTD including Water Framework Directive (WFD), Marine Strategy Framework Directive (MSFD), Industrial Emissions Directive (IED), etc.

In November 2024, the revised Urban Wastewater Treatment Directive (UWWTD) was published. The revised UWWTD has extended to include the minimum standard of collection and treatment of wastewater from all agglomerations exceeding 1000 population equivalents (pe), in comparison to the previous threshold of 2000 pe. By 2035, all agglomerations between 1000pe and 2000pe should be connected to the urban wastewater treatment facilities currently treating the agglomerations above 2000pe. While EU Member States are in the process of connecting these agglomerations to urban wastewater treatment facilities; to prevent any further discharges of untreated urban wastewater and thus pollution to the environment, these agglomerations will be equipped with collection systems.

Further update targets set out by the revised UWWTD include the employment of secondary treatment and removal of all biodegradable organic matter from the wastewater prior to discharge into the environment, this is to be deployed by 2035 across most member states. There are derogations to this target as new member states to the EU where coverage of collection systems is low and requires significant investment. New Member States such as Romania, Bulgaria and Croatia, may benefit from such derogations having invested considerably into meeting the requirements of the previous directive.

Tertiary treatment, specifically the removal of nitrogen and phosphorus, will be mandatory for urban wastewater treatment plants serving agglomerations of 150 000pe and above by 2039. Quaternary treatment, specifically the removal of micropollutants will be mandatory for these plants by 2045. However, the main producers of the micropollutants, pharmaceutical and cosmetic industries, will be required to contribute a minimum of 80% of the additional costs for the quaternary treatment through an extended producer responsibility (EPR) scheme following the 'polluter pays' principle.

The revised directive has also introduced a target to aid the EU in achieving its climate neutrality objective. The directive introduces an energy neutrality target for all agglomerations equalling and exceeding 10000pe by 2045, requiring these urban wastewater treatment plants to power their plant using the energy generated at their own facilities.

Sewage Sludge Directive

The Sewage Sludge Directive outlines regulations for the agricultural sector on the use of sewage sludge on land, and for any other purposes, so as to not cause environmental degradation or impact water quality of either surface water or groundwater. The directive instructs on how the agricultural sector, particularly farmers, must use sewage sludge as a fertiliser, the composition and chemical and biological components of the sludge, records of quantity of sludge used and produced within the agricultural activities, treatment and site type where sludge is used, and the sampling and analysis of the sludge and the soils where the sludge is used. Typically, the sludge should be treated to reduce fermentability and the resulting health risks from its use. Untreated sludge may be used in some EU Member States if it is injected directly or worked into the soil. The Sewage Sludge Directive also outlines instances where sludge cannot be used, these include if the sludge is used on soil where fruit and vegetable crops will be grown with the exemption of fruit trees, if the sludge is to be used on grassland or forage land where animals will graze or land will be harvested within three weeks of the sludge spreading, and less than ten months prior to fruit and vegetables being harvested or when the crops will be in direct contact with the sludge and may be eaten raw.

The Sewage Sludge Directive aims to meet the requirements above by limiting the heavy metals emitted to soil and water in the sewage sludge spreading process and thus allowing for the increased use of sewage sludge on land for fertilisation use, etc. This will be achieved by monitoring, sampling and analysis of the soil used in this process to ensure the heavy metals in the sludge do not accumulate or exceed the concentration limits set out in the Sewage Sludge Directive. Soil sampled will be tested for seven heavy metals in sewage sludge including cadmium, nickel, copper, lead, zinc, mercury and chromium. If soils or sludge exceed the limits of these heavy metals set out in the Sewage Sludge Directive, the sludge is banned from use on the land.

As part of the Circular Economy Action Plan the Sewage Sludge Directive was reviewed and considered still relevant with context to the regulations given but needs updating as to the emerging pollutants present currently that were not present in 1986 when the directive was first adopted. The emerging pollutants which should be monitored and regulated as part of the Sewage Sludge Directive include organic compounds, microplastics, pharmaceuticals, etc. The review also saw benefits to the continuous promotion of the Sewage Sludge Directive as it is viewed as more cost-efficient than incineration of the sludge. It is recommended to further review for the management of sludge tying into a more circular and sustainable management of the sludge from a zero pollution and environmental quality viewpoint. The factors of climate and climate change must also be included. The

above points are also highlighted in the review of the UWWTD proposed revision and update, this update may state new limitations to the use of sludge generated from urban wastewater treatment.

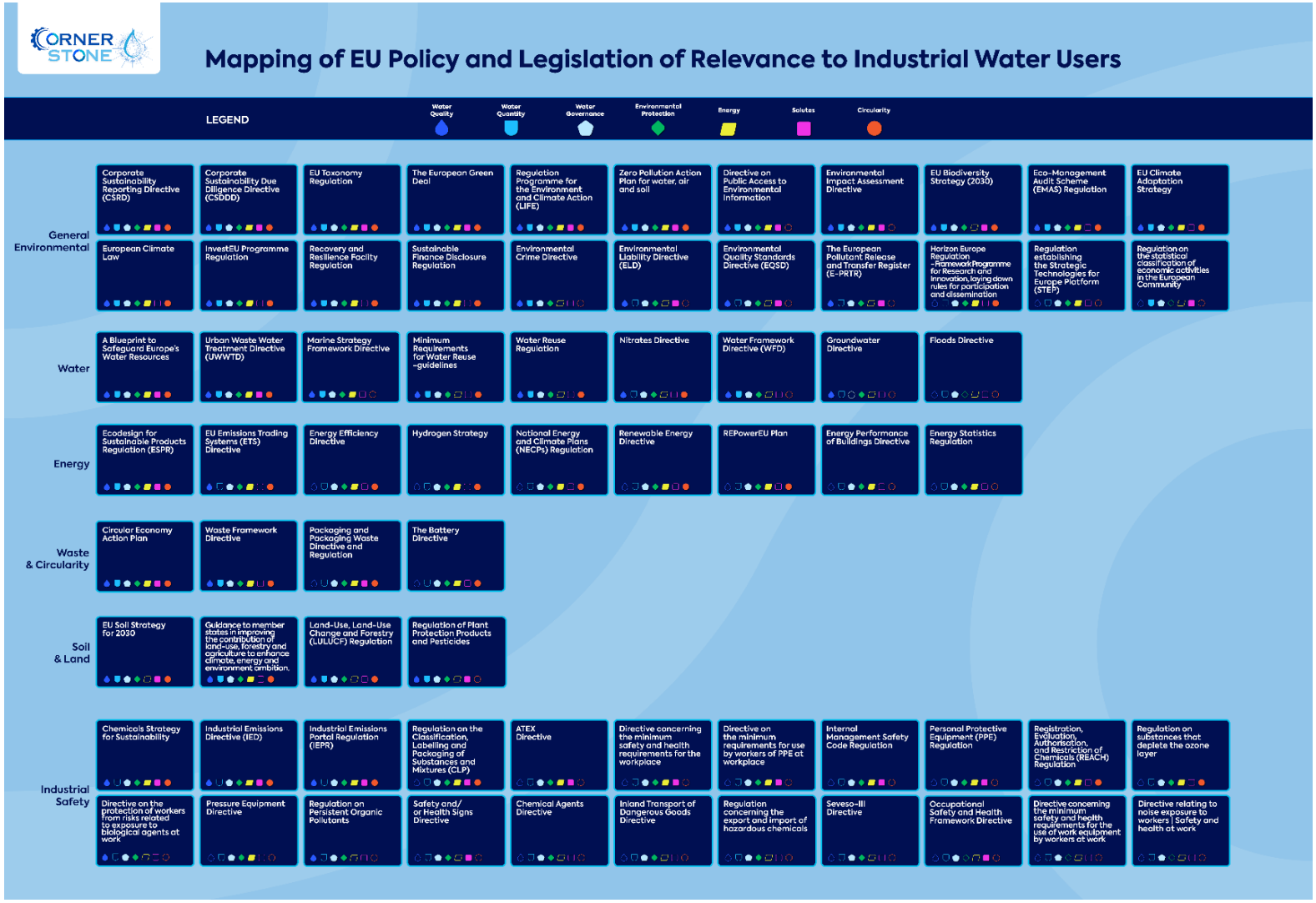
Water Reuse and Minimum Requirements

The Circular Economy Action Plan, EU Green Deal and CSRD place emphasis on limiting resource use and promoting circularity streams across all sectors and environmental areas, including water. The Water Reuse Regulation and the Minimum Requirements for Water Reuse promote the aims of reducing resource use and promoting recovery and reuse in the area of water. The Water Reuse Regulation outlines the general integrated water management requirements including management of water, infrastructure and quality risk, and other relevant requirements for water quality monitoring. The main purpose of the Water Reuse Regulation is to maintain a safe water quality for agricultural irrigation in order for both reuse and to maintain a safe environmental standard to avoid pollution when discharged. These standards can also be applied within other sectors of the EU, including industry/the industrial sector. The Water Reuse Regulation and Minimum Requirements for Water Reuse are mainly designated for the reuse of treated urban wastewater for agricultural irrigation and must meet certain quality criteria to be used safely on the land.

Environmental Quality standards

Environmental quality standards apply for the presence of priority pollutants which pose a risk to human health or aquatic environments. Similar to the testing for heavy metals in sludge the Environmental Quality Standards Directive (EQSD) sets the standards for priority substances and eight other pollutants including cadmium, lead, mercury, nickel, and any of their compounds, polyaromatics hydrocarbons, benzene, and various pesticides. Many of these priority substances are classified as hazardous and have limits for their concentration in water. If concentrations thresholds exceed the limits set in EQSD the waterbody will fail to reach a good chemical quality status as set out in WFD. As the River Basin Management Plans set out in the WFD are completed, typically every 5 years, the list of priority substances will expand due to the emergence of more pollutants present in the water causing harm to aquatic environments and human health. Amendment of the EQSD will follow the next RBMP evaluation as it is intended that priority substances lists shall decrease in stringencies if the standards are successful. These priority substances are currently listed on the European Chemical Agency (ECHA) website.

7.3. Appendix C – Figure 4: Mapping of EU Policy and Legislation of Relevance to Industrial Water Users (Enlarged)



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7.4. Appendix D – Detailed Description of Industrial Water Support Tools

CERES Cost Benefit Analysis Framework

Ceres Cost Benefit Analysis (CBA) framework allows organisations to "*assess the full value of water stewardship interventions across their value chains".* Some organisations currently have internal analysis to account for their water-related business risks, the Ceres CBA framework accounts for the full value of water through estimating and evaluating both the cost of solutions and the potential business and societal benefits of water management strategies. (Smart water magazine, 2023). The CBA framework is applicable across all areas of an organisations value chain and aims to encapsulate the cost and benefits of water stewardship projects in addition to the return on investment and societal return of these projects. The CBA framework is informed upon by the water related risks to the business, the cost of viable solutions to these water-related business risks, and the business-related water impacts on society (CERES., 2023).

The CERES CBA framework aims to account for the cost of solution rather than just the cost of risk mitigation projects, true cost of water, and remedial costs to damage produced. The framework, as previously mentioned, would like to incorporate the societal benefits of the water projects conducted as well as the benefits to business from engaging in water stewardship. The objective of the tool is to incorporate the full value of water and the cost of implementing solutions into the into the decision-making process for business cases related to water. This coupled with an organisation's understanding of how the water stewardship solutions may benefit both the business and society will allow investors and stakeholders to strengthen their business case in addition to identifying the areas for greatest impact (CERES, 2023).

The CBA tool allows organisations to communicate their business risks to investors and stakeholders but also the social impacts of their business activities both pertaining to water to allow for business and societal value creation. This can be used both in mandatory and voluntary reporting standards such as CSRD. The framework builds on water value creation initiatives to produce a holistic view of the cost of actions and value creation both on-site and along an organisations value chain. There are four main steps to the framework 1) Customizing the framework for the industry in question, taking into account key areas of their value chain, business activities with water as a material component to their organisation, and the water impact pathways on the industry and society. Step 2) Collation of data on the specific company and their associated industrial sector with water at the focus, taking into consideration the publicly available information with regard to the industry type and company, purchase volumes for material, water abstraction and consumption, wastewater treatment compliance, cost of solution implementations. The third step in the framework is to 3) Calculate the cost and benefit of each identified impact pathway for the entire value chain, taking into consideration the financial implications of water-related risks to business and impacts to society, the estimated cost of solutions to the identified risks and impacts, finally estimate the benefits of implementing the solutions. The final step in the CBA framework is to 4) Aggregate the impact pathways to quantify the full cost and value of the business and society along with relative metrics for investment return for both business and society.

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True Cost of Water Model

The Industrial Water 4.0 paper established a framework from 20FIFTY Partners which aimed to equip industry with site-specific maturity of their water stewardship practices and the ability to map their water lifecycle on site and establish a true cost of water to this lifecycle, allowing them to make site-specific business cases for future water stewardship projects. Following a trial with three industrial partners and refining the framework from feedback from a further 30 industrial sites, the framework was developed to allow these organisations to take initiative in proactive steps towards water stewardship, plan for future scenarios, enable digitalisation into their water lifecycle, and address water conservation, circularity, water resilience strategies, effective wastewater treatment, and pollution prevention measures. The framework consists of the industrial water 4.0, water mapping methodology, a quantity, quality, and cost (QQC) model and template, true cost of water methodology, and future state scenario planning. The water stewardship maturity model was created as a "one-size-fits-all" cross-sectoral approach, taking into account two main components of water stewardship and the digitalisation of their water lifecycle. The water stewardship component of the model consists of water quality, water quantity and water governance, while the digitalisation of the water lifecycle consists of supply chain interaction, digitalisation in industrial water, and water management and industrial production interaction (Gaskin *et al.*, 2023).

The results of the maturity model allow organisations to see where they place in accordance with the component in question from 1 to 5, where 1 is ad-hoc, 2 is defined, 3 is managed, 4. is advanced, and 5 is optimised. Feedback from the industrial sites and organisations found three main challenges. The first challenge identified was initial high-cost of water projects and project return limitations from organisations, the second most prominent challenge was lack of awareness or understanding of water stewardship or digitalisation of water management from top-down management, and the third challenge faced by organisations is the lack of risk assessments across operations and supply chains. To address some of the challenges listed above a site water mapping section of the framework was developed from the US EPA Lean & Water Toolkit whereby organisations plot their water lifecycle in five stages. The five stages are as follows, 1) supply and distribution of water from abstraction, mains supply, rainwater, alternative supply, 2) pre-treatment of water such as reverse osmosis, demineralisation, 3) end users in operations such as heating or cooling, domestic applications, ingredient in production, 4) post treatment of water or wastewater, and 5) sink i.e. public sewer, waterbody, tanker. The water mapping aided organisations in their water lifecycle, areas of high-water use, areas of uncontrolled loss of water, potential for areas of water reuse. The mapping of the water lifecycle is simple visual of areas for stakeholders, visualise water management across the site, can inform on true cost of water and areas for potential cost savings. The mapping allowed for development of auditable water management tool for identifying risks to inform the QQC model within the framework (Gaskin *et al.*, 2023).

The quantity data can be collated via building management systems, flow meters, programmable logic controllers, the quality data was collated via inline monitors, laboratory systems, and third-party reports, while the cost data was informed by financial systems, energy systems, and maintenance systems. To identify key areas for action a risk assessment risk assessment methodology was published (Trubetskaya *et al.*, 2021a). This allows organisations to identify key areas of risk mitigation for water projects on site. The data audit tool was approached in four key steps 1). Identifying the key inputs and output risk assessment parameters of significant water users to the site, 2). Establish a data audit plan for the significant water users factoring in the availability and accessibility of data, 3). Performa data audit assessment of the data quality of each key parameter, and 4). Perform a risk assessment following the data audit. Following the collation of data and risk parameters identified, the next step for industry

is to conduct a true cost of water assessment. The mapping of site water and the audit plan factor into the true cost of water analysis for industrial sites by incorporating the water specific data with indirect financial factors, such as energy consumption and cost and treatment costs. The risk assessment and true cost of water interact as the true cost of water analysis is a process-based approach for better insight into which water users are most significant and which will need to be addressed with the highest risk and cost return (Gaskin *et al.*, 2023).

WRI Aqueduct Global Water Risk Atlas

The Aqueduct Global Water Risk Atlas is catchment-based risk mapping tool run by the World Resources Institute as part of the Aqueduct data platform. The Aqueduct tool is described to give users *catchment-level information on water-related risks* to allow users to analyse their exposure to water risk at a global level. The Aqueduct Global Water Risk Atlas peer reviewed methodology allows users to generate customised, high-resolution global water risk maps (WRI, n.d.).

From desk-based research conducted in October 2024, Aqueduct Global Water Risk Atlas data was noted to be last updated in August of 2023(Aqueduct 4.0). It is estimated from prior updates that the data of the tool is updated every 4-5 years. The latest updated is said to include higher resolution, new indicator sets, additional granular data, improved tool functions for user and *access to underlying hydrological models* (EEA, 2024).

The Aqueduct tool categorises risks for evaluation under *Overall Water Risk* which consists of three main risk categories. In accordance with the most up-to-date technical note at the time of writing the risk categories investigated under the tool are *Physical Risks, Reputational Risks, and Regulatory Risks*, however, the reputational and regulatory risks are evaluated together under one risk category of "*Regulatory and Reputational Risk*" while the physical risks are split into "*Physical Risk Quantity*" and "*Physical Risk Quality"*. The most recent updates to the tools have been under the *Physical Risk Quantity* category specifically under the subsections of "*Baseline water stress, Baseline water depletion, Interannual variability, Seasonal variability"*. (Kuzma et al., 2023)

The Aqueduct tool and platform have been utilised by various organisations, governments, academics and water sector practitioners globally. Strengths of the tool are the comparison abilities across local geographies due to the consistency in global data and methodology used, and the ability for screening and prioritising of water-related risks. Weaknesses listed for the tool include limitations to applicability at a localised level, in this instance, users are encouraged to pursue data at a local level and prioritise locations independently alongside the aqueduct data, and a further weakness identified is the hydrological model used does not account for inter-basin transfers of water or non-renewable resources including fossil groundwater. (EEA, 2024)

Indicators chosen following literature review spanning relevant water issues, existing water-based indicators, and existing data sets. Following the literature review an analysis of the potential relevant data sources was conducted evaluating multiple parameters for the future aqueduct tool. These parameters included spatial and temporal coverage, granularity, consistency, credibility of sources, and relevance to water users. Industries, the Public Sector and Academics in water were all consulted during the indicator selection process. (Kuzma et al., 2023).

WWF Water Risk Filter

The World Wide Fund for Nature (WWF) established a tool aimed at allowing organisations and financial institutions globally to assess, at a corporate and portfolio level, their nature-related risks, impacts and dependencies through the Risk Filter Suite. The WWF Risk Filter Suite collectively allows these organisations to evaluate their water-related risks and biodiversity-related risks under the WWF Water Risk Filter and WWF Biodiversity Risk Filter, respectively. The Water Risk Filter and Biodiversity Risk Filter can be accessed for free and evaluated separately by the user in question to gauge a screening of their current risk status (WWF, 2024).

The WWF Risk Filter Suite assimilates information on biodiversity and water related risks from more than 80 global datasets to allow users to evaluate and report on risk across their operations, investments, value and supply chains. WWF recommends upon identifying areas of high risk that organisations or financial institutions independently collect, and review data localised to the area of high risk for an advanced assessment (WWF, 2024). WWF states that the Water Risk Filter is not intended to provide real-time site-specific water risk conditions, thus further independent analysis is necessary prior to decision making on business strategies and investment (WWF, 2024).

With focus on the WWF Water Risk Filter, organisations and financial institutions are enabled to review and account for water-related risks and mitigation in corporate strategies and investment decisions and build business resilience while supporting river basins of the catchments they encounter (WWF, 2024). The water-related risks assessed in the WWF Water Risk Filter are analysed under two main risk areas, basin risks referring to risks surrounding the risks in the catchments and river basins organisations sites are located within, and operational risks referring to an organisation's consumption factors and resource use (WWF, 2024). Both the basin and operational risk assessments are comprised of risk types, risk categories, and indicators.

The risk types utilised within the WWF Water Risk Filter are comprised of categories defined by the CEO Water Mandate, regulatory risk, reputational risk, and physical risks. Compared to the WRI Aqueduct Global Water Risk Atlas, the WWF Water Risk Filter does not couple regulatory risk type with reputational risk type, or branch physical risks into two risk streams based on quantity and quality. The risk types are further composed of multiple risk categories for both basin risk and operational risk. The risk categories are informed upon by indicators, basin risk categories are informed by 42 indicators which are annually reviewed, and operational risk categories are informed following a questionnaire of between 10 or 22 questions for the user which inform the basis of the operational indicators. The operational risk indicators questionnaire is based on informing the tool on site level risks which may be short (10 questions), or detailed (22 questions). Users of the Water Risk Filter are encouraged to complete the detailed 22 questions in comparison to the shorter questionnaire to establish long-term and comprehensive operational risk assessment in comparison to the shorter questionnaire which will provide basic operational risk, both questionnaires will yield recommendations for improvement in risk score (WWF, 2024).

The users are asked to evaluate the risk categories on a scale of 1. Very Low Risk, 2. Low Risk, 3. Moderate Risk, 4. High Risk, and 5. Very High Risk. The risk score classification system listed for the user to choose from is consistent for all risk types, categories, and indicators mentioned previously, however the score incurred from the evaluation differs from risk indicators to risk categories and types. The risk indicator scores are provided as integers while the risk categories and risk types receive an aggregated

risk score in decimal form from less than or equal to 0.1 or greater than or equal to 5.0. (WWF, 2024). Following completion of the risk assessment users will receive a combined risk score. WWF have indicated a risk score above 3.4 is deemed to be high, but they recommend users scoring a 3.0 or above to pay attention to mitigating water risks at those sites. WWF then recommend the users to address the high-risk sites similar to the assessment, identifying the most prominent risk type, then identify the risk category which is driving the risk score and finally use the indicators to inform the direction of action to take. (WWF, 2024)

The WWF Water Risk Filter also provides coverage of 26 industrial sectors, allowing for assessment of corporate activities with different weighting for traditionally water intensive sectors compared to light water users. The industries used by the WWF Water Risk Filter are a collation of industries from the GICS (Global Industrial Classification Systems), CDP industry classification systems, among others and are narrowed to 26 industries used for the weightings. These industry specific weightings come into play during the evaluation of operational risk, which differs from industry to industry but is scored with the same output as basin risk for the indicators and aggregated risk types and categories. The Overall risk score is calculated by the sum of the risk category score by indicator score, and may differ from industry to industry, as mentioned previously.

WWF recognises that addressing current water risks is important but as climate change accelerates projections are needed to form a resilient and informed business strategy. Thus, WWF provides the option of scenario analysis to the user to inform of potential effects on risk evolution as a result of climate change. The scenarios provided by WWF Water Risk Filter are for projections of potential risk by the years 2030 and 2050, and may be viewed for both years through pessimistic, current, or optimistic pathways (WWF, 2024).

Limitations to the WWF Water Risk Filter stated by WWF, include how the tool is merely a score of the organisations risk from its location and water status of the organisations location, it does not account for the organisations readiness to deal with potential water threats to business, cannot score the potential for the risks to emerge, or to what degree organisations will be exposed to specific water-related risks. The tool scenario function acts as an estimation from the baseline given by the users' answers and cannot account for factors privy to the users' subjective score of their site. As previously stated, the tool may only estimate the potential water risk to the sites and without having the knowledge of a site's preparedness to deal with these potential risks, they cannot estimate the financial impacts which may occur to the business if mitigation measures or response action plans are not mature or equipped to deal with the potential level of impact to the site. The Water Risk Filter does not incorporate any opportunities developing from water risk, this an organisation would have to research independently, however, recommendations are given. One of the current major limitations to the WWF Water Risk Filter is that the data they are currently using for the current state of water risk for users is from 2015 overall with some updates made in 2021, but these do not span the entire globe. This could lead to inaccuracies in the report where organisations believe they are at low risk for one of the risk categories upon evaluation but later encounter an issue with this category and were ill-prepared to deal with the impacts to their business. This is another reason for WWF to insist organisations complete an assessment following the indicator scores received from the risk assessment using the Water Risk Filter. The WWF Water Risk Filter currently only allows for the site locations to be reviewed as a point source and not a polygon or linear structure on the mapping function of the tool. This limits the risk score where a user may be looking for a risk score spanning multiple basins or sites,

this can be worked around manually by the user. The one to five score used for the risk evaluation may also become a limitation when referring to ecological data which is vastly different across the globe. Applying a common rating score to this can cause the omission of important risk factors where users are encouraged to research further the ecological data at their point source. The tool is mainly relying on the data they collect to be robust and accurate as in most cases it may not be from direct sources. Some risks which may be important to a specific site may have been omitted from the indicator assessment due to multiple factors including data availability at the time of collation, usefulness to the majority of users, etc. Again, WWF recommends further research and evaluation of local risk factors independently.

AXA- WISE tool

The Axa-Water Impact and Sustainability Evaluation (WISE) tool is a risk consultancy-based tool to allow organisations to assess their water risks and act upon mitigation projects. The tool is remote and customisable allowing users to evaluate their own water risks and enabling them to act upon these risks through the deployment of an efficient water management programme. The main risks components assessed by the AXA-WISE tool are physical risks, regulatory risks, and reputational risks. The risk scores for these three risk components are aggregated to provide an overall site-operational risk score. Similar to above the with the WWF Water Risk Filter Tool, the AXA-WISE tool evaluates water risk through basin risks to the business and operational risks to the business. Basin risks are calculated through desk-based assessment of hydraulic basins under current and future climate conditions. Operational risks are evaluated via user input of site-specific risks and opportunities related to water and company-specific variables. The tool provided enables site-specific water scores are displayed in a quantitative risk screening framework to inform strategic decision making for water risk mitigation and water-related opportunities (AXA, 2023).

The tool provides the assessment in three steps, the first step is a preliminary desk analysis where the user provides data on their specific site, basin mapping and risk assessment is conducted, and users are provided with an AXA WISE checklist for completion on their site specific current state, finally the users are provided with the AXA water risk algorithm, including drivers and weights which are tailored to the site specific information provided by the user. The second step in the process is an online survey completed by the users for the collection of information and to manage reporting requirements and reminders. The final step in the process is a risk analysis of the survey information provided by the users by implicating a custom algorithm to calculate the users' site-specific operational risk score, if more comprehensive analysis is required for sites experiencing high-risk exposure AXA risk consulting experts will review the primary data they have collated from the tool user. The results collated by the AXA consultants and delivered to the user via an interactive dashboard. The operational risks provided by the user are assessed by the AXA consultants in a risk evaluation multi-level hierarchal framework, where Level 1 provides the user with risk indicators which were calculated from their answers to the WISE checklist, Level 2 of the framework is grouping and scoring of the risk indicators from Level 1 into Risk Categories, and finally Level 3 is the grouping and scoring of the risk categories from Level 2 into the three main risk types discussed previously, regulatory risks, reputational risks, and physical risks (AXA, 2023).

The risks incurred from the analysis are displayed to the user on the AXA-WISE interactive dashboard where users can create a business case for mitigating their site related risk for risk mitigation projects

and investments. The users are enabled to view basin risk scores, operational risk scores, risk drivers, risk categories and risk grades for visualisation on the interactive dashboard which they can export and use in reporting and business cases. A limitation of the AXA-WISE tool is their use of third-party mapping for site locations and basin atlases, they prompt the user to use the WRI Aqueduct tool or WWF Water Risk Filter in their display of this information (AXA, 2023).

CDP Water Watch

CDP Water Watch is an Impact Index tool which allows industries to evaluate which of their business activities provide the most significant impact on water (CDP, 2025). The business actions are from a collation of more than 200 industrial activities spanning 13 industries and ranks them based on their potential impacts on water quality and water quantity. The tool assesses companies of specific industries water-related impacts emanating from their operations, product use, and supply chain activities (CDP 2025). The 13 industries defined by CDP are following high-level grouping of the overall industrial activities, they are Apparel, Biotech, Healthcare and Pharma, Food, Beverage and Agriculture, Fossil fuels, Hospitality, Infrastructure, International bodies, Manufacturing, Materials, Power Generation, Retail, Services, and Transportation services (CDP, 2022).

The CDP Water Watch tool is comprised of a qualitative assessment, based on independent academic, scientific, and industry recognised sources, to assess an organisation's impacts on freshwater resources from business activities across their value chain (CDP 2025). The tool analyses environmental impacts caused by the business in comparison to other tools which focus on water-related risks to the business. CDP have acknowledged the correlation between business impacts on water and water-related business risk affirming that organisations with high impacts on water will have potential for prominent exposure to water-related risks (CDP 2025).

Similar to other tools described in this section, the CDP Water Watch tool can be used by financial institutions and larger companies to evaluate their water-related impacts on their investments and value chain. The overall water impact rank is scored numerically by the CDP Water Watch tool and these scores are displayed by the 'water impact 2022' banding. The impact ranks of business activity are informed by water intensity metrics and pollutant types from effluent discharges, guidance for business on the impact type and the scale of the impacts expected from business activity ranking, comparison of the impact against examples of each ranking level, for supply chains the impact rankings are for products supplied or key material production, and for production use the impact rankings are for activities where product or service of the business is used (CDP, 2022).

As stated previously the tool assesses water impacts along the organisations value chain specifically an organisation's operations, product use, and supply chain. The product use stage evaluated by CDP includes both the use and disposal of the product in question (CDP, 2022). These three value chain stages are ranked for two main criteria throughout the assessment: the dependence of the business activity on high volumes of freshwater abstraction and consumption, and degradation potential or pollution potential of water quality following the business activity (CDP, 2025).

The rank received by the users of the CDP Water Watch tool ranges from 0 to 3 with a rank of 0 indicating to the user that there is 'no impact' or damage caused to freshwater resources, a rank of 1 indicates the business activity caused minor damage or short-term damage, a rank score of 2 indicates the business actions caused significant damage to freshwater resources, and finally a rank of 3 indicates

the business activity brought about 'high impact' and major damage to freshwater resources (CDP, 2022). The ranking by user will be asked for both the quality and quantity impacts on water where the rank of 0 where 'no impact' or damage occurs because of the activity may translate to a 'not relevant' score by user as the activity is not water intensive when reviewing the quantity impact, similarly if the business activity does not cause any pollution or does not result in effluent of water the user can select the 'not applicable or zero pollution' scale of impact on freshwater for quality impact. If the business activity is determined by the user to receive a rank score of 1 where it will have minor damage or short term impacts on freshwater for quality it would mean the pollutants may be diluted when released from site or in small quantity, and for quantity the business activity will have a low impact on water when the business activity does not require high volumes of water, possibly small volumes from municipal supply. If the user scores a business activity as a 2, where the activity has a significant impact on the water quality this may be where a high volume of pollutants are released but they are not deemed hazardous by the environmental authorities and are treated to some degree prior to discharge, or the impact may occur where accidental leak or system failure may cause high impact if discharged to freshwater, or in the case of the supply chain where a supply is needed for the industrial activity but may not be a continuous occurrence such as once off manufacturing of product with significant impact on freshwater, and in the case of product use the final disposal may result in hazardous release to the environment this may be deemed a 2 for quality impacts on water. The quality impacts on water may incur a 2 when the user evaluates the business activity to be water intensive but not in comparison to other water users in the basin or country of activity, or with regard to supply chain where the business activity needs a significant quantity of water for production, but this usage is not continuous, similar to the quality score 2 for supply chain impacts on freshwater. The final score a business activity may receive on water impacts is 3 where there is major impacts on freshwater resources for quality could be the potential for widespread release of untreated hazardous pollutants to the freshwater catchment or basin, and major quantity impacts may be scored when the business activity is water intensive in comparison to other water users in the country or freshwater basin or particularly high for the sector (CDP, 2022).

The score received from the ranking above by the user will incur a summation score and be given the overall impact water rank from 0 to 18 which translates to the 6 banding water impacts the business actions have scored. If the industrial/business activity the user has scored is between 0-4 that results in a banding of 'low/not relevant' impact on water, a score of 5-7 receives a banding result of 'medium' impact on water, if the activity scores 8-10 the resulting banding is the activity has a 'high' impact on freshwater, scores of 11-14 will receive a banding of 'very high' impact on water, and finally scores of between 15-18 will receive a banding score of 'critical' impact on freshwater (CDP, 2022).

Limitations of the CDP tool, as stated by CDP, are that the overall water impact rank is only a proposed indication of the potential impacts the company's business activities or investments will have on the freshwater resources and not a definite or actual indication of their impacts on freshwater resources. The overall water impact rank does not account for any potential water security risks that may result from the organisations impacts on their freshwater resources. The ranking or scoring system used by CDP currently accounts for global assessment of industry norms and present-day technologies but it does not account for geographical context where water impacts may be more profound on the communities they operate within due to environmental or climatic factors that externally impact the freshwater resources, such as drought. The overall water impact rank does not account for what actions

a company or organisation may take to address the impacts identified from using the CDP Water Watch tool (CDP, 2022).

Ecolab: Smart Water Navigator

The Ecolab Smart Water Navigator is an online tool which evaluates organisations water risks and sets context-based water goals for organisations to develop a water resilience plan and support business growth by allowing organisations to tackle the identified water risks. The Ecolab Smart Water Navigator Tool provides assessment of the impact that deteriorating water quality and quantity has on an organisation's operations and supplies these organisations with actionable information to target these identified water risks. The Ecolab Smart Water Navigator utilises a holistic corporate water management approach coupled with guides to sustainable water practices at facilities level to ensure achieve a water resilient business plan (Ecolab, 2024). Ecolab suggests using the Smart Water Navigator if the user is involved in business decision-making roles which set or wish to achieve business strategies pertaining to sustainable water management across their operations, supply chains, sustainability, engineering, and quality. Ecolab also recommends the tool to site level facilities and operational managers to improve water resilience at a local level, business consultants who are creating strategies for water resilience at a corporate level, and NGOs which aim to influence sustainable water management, water resilience, and water stewardship strategies (Ecolab, 2025).

The Smart Water Navigator evaluates businesses' incoming water quantity and quality risks and outgoing quality risks through a series of risk metrics and quantifies these risks in financial terms for the user (Ecolab, 2024). The output received by the user highlights both the risk types to business but also identifies which water-related projects or investments will return the most significant value to the business, thus providing a business case for the actions against the risks identified (Ecolab, 2024).

The Smart Water Navigator tool prompts the user to provide internal information on their water use, water costs, and production data and calculates both the incoming and outgoing water risk to the site (Ecolab, 2024). The monetary value assigned by the Smart Water Navigator Tool to the water risks provided considers the geography and water demand of the business location and provides scenarios across a 3, 5 and 1- year projection. The tool calculates the possible loss in revenue for incoming quantity risks across the same projections. The Smart Water Navigator Tool also calculates the likelihood of the costs of water being realized through triggers including physical risk triggers such as increased water stress, as well as regulatory and reputational risk factors. The Smart Water Navigator Tool combines the results of the magnitudes and likelihoods into an overall water risk rank to identify areas for risk mitigation and reduce the businesses overall risk profile (Ecolab, 2024).

The tool allows for screening of priority risks to facilities within the business for specific water related projects and investment to these facilities. The tool has a built-in enterprise risk analysis which allows for assessment of each facilities risk based on the growth projections, mentioned previously, and the water risks specific to their site location. These facilities are displayed in water risk quadrants categorised by whether the facilities are low or high growth and low or high water scarcity, for effective prioritisation (Ecolab, 2024).

Smart Water Navigator tool allows for business development action plans and corporate water strategies where they can align their water management plans to their corporate sustainability goals, assess and monetise the materiality of water to their business, prioritise water actions based on site-

specific risk, identify opportunities for risk mitigation while also enhancing value creation centred around water. Ecolab recommends establishing water management plans using the "plan-do-check-adjust" cycle to enhance business growth and maturity. (Ecolab, 2024) The Smart Water Navigator tool allows businesses with or without current water targets to use the tool and address their maturity but also includes downloadable reporting outputs to support businesses in voluntary or mandatory reporting of water-related disclosures (Ecolab, 2024).

The Smart Water Navigator tool recognises 4 main water related risk categories of operational risk, legal & regulatory risk, reputational & marketing risk, and financial risk to business. The Smart Water Navigator tool utilises publicly available data sets from WRI and WWF among others but has enhanced outputs to meet business needs. This was combined into a 4-step approach within the tool of first identify risk, secondly creating targets to address the risks identified, the third step is to take action on the targets created, and final step is to track progress of the actions taken to reassess any updates for optimisation (Ecolab, 2024).

To quantify the risks Ecolab Smart Water Navigator tool describes the full value of water as being the summation of market value (tangible) and non-market value(non-tangible). Non-market value in the context of this tool is taken from environmental economics to calculate water risk premiums which includes costs and benefits of water not included in the market price paid for water, such societal benefits to water. (Ecolab, 2024) The tool also includes the basin share of water available to all stakeholders in the locality and calculates the required water to generate revenue so that once the water required is not available in the basin share the revenue is quantified as potentially at risk. (Ecolab, 2024)

To evaluate the incoming water quality and quantity risk assessment to site the Smart Water Navigator Tool uses the Bassline Water Stress Metric from WRI's Aqueduct Tool. The Smart Water Navigator tool prompts users to input their incoming water price (in USD per cubic meter) along with their incoming quantity (in cubic meter) and uses this information to forecast for the projections over the 3, 5, and 10 year using historical data from country-level incoming water tariffs. To obtain the full value of water the tool takes the incoming quantity and quality risk premiums and uses the Total Economic Value Framework (TEV) to focus on the non-consumptive values of water within the TEV Framework. Market values include the administration, capital, and operations and maintenance from the incoming water price, while the non-market value includes future treatment cost from the incoming quality risk premium, as well as the human-health impacts, environmental impacts, and domestic value from the incoming quantity risk premium (Ecolab, 2024).

The incoming risk premium is calculated from the users' inputs to a water risk decision tree from their prompted answers. The likelihood of increasing cost to water from the incoming water risk is scored as high, medium or low risk dependent on the user inputs, based on seven variables of baseline water stress, future water stress, inter-annual variability, seasonal variability, national or local regulatory risk, national or local reputational risk, and historical changes in national or local water tariffs. Each of the variables is assigned a value between zero and one and is weighted in accordance with its importance in the likelihood score. Current and future water stress are weighed the highest at 25% due to the correlation between quantity risk and operational costs. The variability in quantity is weighted at 6.25% and the national and local risks are weighted at 12.5%. The variables have each an existing boundary of high, medium and low which were also assigned values of zero to one to create new risk thresholds,

where a high risk is a threshold above 60%, medium risk threshold between 30% - 60%, and low risk threshold below 30%. (Ecolab, 2024)

The outgoing quantity risk is calculated by the tool in the same manner as the incoming water risk stated previously and can be forecasted in the same manner. The outgoing quality risk premium is quantified by the Smart Water Navigator Tool by considering the quantity and quality of water discharged from site, local water quality thresholds, and impacts of water pollution on the local basin. The quality risk premium is also calculated using the TEV framework similar to the incoming quality risk premium. The outgoing risk adjusted price is calculated by the summation of outgoing water bill unit price (USD per cubic meter) with the outgoing risk premium (USD per cubic metre). The outgoing risk adjusted price accounts for the amount which would be paid per cubic metre for future water treatment costs and currently unpriced environmental and human-health impacts of water pollution at local basin (Ecolab, 2024).

The outgoing likelihood risk score is similarly scored as the incoming likelihood risk score but is based on five variables of baseline water stress weighted at 29%, future water stress also weighted at 29%, National or local regulatory risk weighted at 14%, national or local reputational risk weighted at 14%, and population density weighted at 14%. Unlike the incoming likelihood risk score, the outgoing likelihood risk score contains an amplifier to incorporate whether the water is treated on-site or by a third-party treatment facility, given a weighting of “x2”. Each variable was also mapped to the variables listed and given a value between zero and one to obtain new risk thresholds. The threshold hold score of high risk is above 50%, medium risk is between 25% to 50%, and low risk is below 25%.

The revenue at risk likelihood score is quantified the same as the incoming and outgoing risk likelihoods, in the case of revenue there are a total of six variables, each given a value between zero and one and weighted in accordance with their importance on the likelihood score. The six variables are baseline water stress weighted at 25%, future water stress weighted at 25%, Water requirement of industry per unit of revenue weighted at 12.5%, Water requirement of specific industry per unit of revenue weighed at 12.5%, National or local regulatory risk weighted at 12.5%, Importance of the industry to the national or local economy weighted at 12.5%. There is also an amplifier weighted “x2” for historical revenue loss to water stress within the previous reporting year. In this instance, physical risks were weighted the highest due to their correlation to loss of revenue. Similar to the incoming and outgoing risk likelihoods the revenue at risk likelihood variables are also mapped to boundaries which are valued between zero and one and create new risk thresholds of high risk above 50%, medium risk between 25% and 55%, and low risk below 25%.

Target setting within the Smart Water Navigator tool are centred around water stress. The tool takes the water withdrawal risk against the baseline water stress evaluated in the risk assessment. The water withdrawal levels against the baseline water stress give the needed annual water use decrease for the user, a risk level weighted to the amount needed to decrease and a recommended strategy. Annual Water use decrease needed of above 50% is weighted a high risk level and recommended investments in water strategies immediately, annual water use decrease of between 25% and 50% is given a medium risk level and recommendation to invest in smart water strategies, decrease levels of less than 25% are scored a low risk and recommended monitoring of water issues and investment in smart water strategies, Less than 0% decrease in annual water use levels is given no risk score but the user is recommended monitoring for any future changes to the score (Ecolab, 2024).

The Smart Water Navigator tool incorporates a water maturity Curve as stated previously into their tool. For a site to be mature it must score well in four smart water management themes of site management, water management practices, target setting, and water stewardship. The four areas listed allow the tool to map the facility in question to the curve where they are scored on time and water management. Where a facility has not adopted any smart water management practices they are placed in the 'Untapped' section of the water maturity curve, where a facility is focused on water conservation with successful water reduction projects in place it will be situated in the 'Linear' section of the water maturity curve, facilities with water conservation in place successfully and deploying circular water management as well as stakeholder engagement will be placed in the 'Exploratory' section of the curve, smart, circular water management is fully embedded in facility decision making and operations while actively engaging in water issues in the surrounding locality are deemed 'Water-Smart' and placed in the correlating section on the curve. (Ecolab, 2024).

The Water Action Assessment online asks users to complete a 13-question assessment (Blahoski, 2019), over the four measurement themes discussed previously. The user is prompted with five options equating to different levels of water maturity and associated scores ranging between 0-40 points. The corresponding scores are summed depending on their threshold placement and water maturity stage listed previously is given to the facility (Ecolab, 2024). The answer options given for the first 12 questions include "don't know" associated with a score of 0, "untapped" associated with a score of 20, "Linear" with associated score of 20, "Exploratory" associated with a score of 30, and "Water-Smart" with ana associated score of 40. The final 13th question is an optional yes or no question with yes receiving the full 40 points but weighted if yes to Between 0-25%, Between 25%-50%, Between 50-75%, or Above 75% (Ecolab, 2024). A user dashboard provides a high-level summary to the user of the Smart Water Navigator tool of their performance of production sites allowing the user to benchmark their maturity performance against other industry leaders.

Limitations to the Ecolab Smart Water Navigator tool is that it does not provide a detailed facility-specific water risk assessment to the user. Challenges with addressing local challenges in a globally relevant tool are gaps in the data. Uncertainty in forecasting similar to previous tools which include scenario analysis. Secondary source data for revenue values, water pollutants, water risk premium calculations. GDP is not calculated at water basin level. Basin water allocation may not consider economic output (Ecolab, 2024).

Bluerisk: Volumetric Water Benefit Accounting

Bluerisk in collaboration with LimnoTech, Bonneville Environmental Foundation, and The World Resources Institute (WRI) established Volumetric Water Benefit Accounting (VWBA) to provide a common framework for industries to quantify and display their volumetric water benefits emerging from corporate water stewardship activities (Reig *et al.*, 2024). Volumetric water benefits are defined as the volume of water which results from water stewardship activities, relative to a unit in time, that beneficially modify the hydrology helping to reduce shared water challenges relating to water quality, water quantity, access to water, water governance and water-related ecosystems (Reig *et al.*, 2019).

VWBA 1.0 guidelines published in 2019, established the first VWBA 3-step method. The first step of the method is for the user to identify their shared water challenges with their locality providing an understanding of the local context, this step is split into steps 1.1 and 1.2 which are to identify the root cause of the shared water challenges within the catchment and communicate with stakeholders within

the catchment to gauge ongoing water stewardship activities, respectfully. The second step in the methodology is for the user to define their water stewardship project activities and partners, this step is also split into 2.1 and 2.2 where the first action within the step is to select project partners and activities based on VWBA activity guidelines and determining the allocation of volumetric water benefits. The third step of the methodology occurs following the implementation of the water stewardship project which is to calculate the volumetric water benefits following data collation, this step is split into 4 separate steps where the first action prompts the user to provide a document baseline, the user must then select VWB indicator and complementary indicators and following this data collation and calculation of VWBs must be performed and finally VWBs and complementary indicators must be allocated (Reig *et al.*, 2019).

The VWB indicators mentioned in the 2019 guidance paper expressed as volume of water relative to a unit of time includes avoided runoff, improved flow regime, increased recharge, maintained recharge, reduction in consumption, reduction in runoff, reduction in water withdrawals, volume captured, volume provided, and volume treated (Reig *et al.*, 2019). Some complementary indicators given in the 2019 guidance paper include flood frequency measured by frequency, income measured by currency over time, pollutant load measured by mass over time, and stream protected or restored measured as length (km, meters, etc.) over time, to name a few. (Reig *et al.*, 2019).

In August 2024 Reig, P, et.al., released guidance on updated VWB calculation methods. Seven principles had been developed from the existing VWB 1.0 guidelines, they are to calculate the volumetric output from project activities, align indicators and methods with the activity objectives, apply practical and scientifically defensible methods, use conservative inputs and assumptions, use appropriate temporal scale, compare with and without project conditions, and finally avoid double counting of volumes. The steps outlined in version 1.0 have since been updated in version 2.0 to assist water stewardship practitioners in selecting VWB indicators and methods which address their activity-specific objectives. Step 1 has been updated to identify the primary volumetric objective to ensure the shared water challenges are addressed with a volumetric output. Examples given of the common volumetric objectives of the water stewardship activities include reduction in water demand, increased water availability, improved resilience for mitigation against flood and drought, improved access to water, sanitation, and hygiene (WASH), improved water quality through point-source pollution reduction, etc. The guidance notes that while the objective may inform the selection of an indicator, the indicator will measure the outputs of the activity, the scale of which may provide a sufficient measurable change in addressing shared water challenges. (Reig, P, *et. al*, 2024)

Step 2 in the updated guidance is to select the VWB indicator suitable to the volumetric objective which addresses shared water challenges in a beneficial manner, such as reducing water demand, or through other means such as improving water quality. Step 3 is updated to Select a VWB method based on the previously selected objective and VWB indicator.

VWBA does have limitations, it is important to note the VWBA is supposed to be used as a complementary benefit to water stewardship activities where applicable in corporate water stewardship projects not as a full business strategy to inform on risk or impacts to a business water strategy. Limitations noted in the VWBA 1.0 in 2019 state the framework cannot account for long-term value with regards to water stewardship projects and in this instance the estimating environmental, social and economic benefits is preferred to ensure delivery of long-term value with water stewardship

projects. Further limitations with the framework are that it does not account for three water stewardship activities that do not generate volumes of water necessary to modify hydrology and thus cannot be quantified in the methods available for VWBA. These water stewardship activities are sanitation and hygiene activities, agricultural best management practices (BMPs) for agrochemical, management activities, and in-stream channel rehabilitation activities. The benefits of these three water stewardship activities can be measured with complimentary VWBA indicators.

Tova – Waterproof Tool

The Waterproof Platform tool introduced by Tova allows organisations to measure their water-related risks to site, receive solutions in the form of risk mitigation projects, and receive a dashboard of reporting and disclosure aids for reporting disclosures for voluntary and mandatory sustainability reporting (Tova, 2024).

The tool is powered by a collation of remote sensing, geospatial data, climate models, in situ data, infrastructure data, water use data to provide ML Data Assimilation and a Water Risk Outlook (Tova, 2024)

Waterplan

The Waterplan tool allows organisations to measure local water risks to the user's site(s) through their risk assessment where the user can view their areas of vulnerability to the site's water-related risks, to prioritise locations of high-risk and implement risk mitigation strategies. Waterplan tool enables users to measure their facility's water accounting metrics which include water consumption, water discharges from site(s), water balance, and the cost of water. This allows the user to identify and track their opportunities as a result of identifying risks at both a site and global level. The Waterplan tool incorporates a Scenario Analyses Builder Tool into their package to project site specific scenario projections for future risks to the user's site which are aligned with the CDP projections discussed previously. This allows the organisation to evaluate its business value at risk and create a business case for risk mitigation projects and also opportunities for return on investment (Waterplan, 2024).

The Waterplan tool enables users to view their data in multiple forms for reporting including data needed for custom, domestic or international standard reporting. The reports included in their package include global hazards & vulnerability reports, site specific reports, water strategy and policy, volumetric water benefit reporting, context-based water target reports, or inputs for disclosure in standards and frameworks such as ESRS, CDP, etc. The tool offers to centralise the user's organisation data and display it in multiple forms for reporting requirements. The tool benefits industries where all stakeholders are able to access the data in a single location providing consistency for reporting and alignment for strategies. The platform also offers water data, other tools, and guidance to improve disclosure reporting for accurate user reports (Waterplan, 2024).

The Waterplan tool enables the user(s) to set water-based targets and track them using the tool and offers a top-down or bottom-up approach to the targets dependent on the wants of the user. The target simulator tool available on the waterplay platform allows for scenario analysis, decision making, and sustainable water management. The platform provides an implementation partner tool where they can partner the user's site with project partners to suit their needs for implemented or planned projects. All water projects and data are collated in one place for the user(s) allowing for easy project collaboration, tracking of progress, decision-making, and reporting (Waterplan, 2024).

Water Resilience Assessment Framework (WRAF) – CEO Water Mandate

The Water Resilience Assessment Framework (WRAF), established by CRO Water Mandate in partnership with the World Resources Institute (WRI), Alliance for Global Water Adaptation (AGWA), Pacific Institute, and International Water Management Institute (IWMI). The aim of the Water Resilience Assessment Framework (WRAF) is to support resilience-building efforts for businesses, cities, utilities and farms against climate change, extreme weather events, and other anthropogenic impacts. The WRAF Framework consists of four steps, 1) visualise the system, 2) develop a resilience strategy, 3) Test the resilience strategy, and 4) evaluate. Under Step 1 of the framework processes users are prompted to visualize the system by defining system boundary, system components, identify water status and trends, identify drivers, shocks and stresses. Step 2 prompts the user to develop a resilience strategy through consideration of a suitable resilience strategy, identifying key resilience characteristics, develop resilience actions, identifying resilience indicators. Step 3 test the resilience strategy developed in steps 1 and 2, the user is prompted to stress test the impact of resilience actions. Step 4 prompts the use to evaluate and alter the resilience framework to encompass any points missed. Stakeholder Engagement is needed across all steps in the evaluation process (Chapagain *et al.*, 2021).

Aquascope

Aquascope tool is an online platform which allows for long-, medium-, and short-term water resource planning both upstream and downstream of the user's site. The first step in this process is allowing for baseline assessments of the user's water quantity and quality to lay the foundation for resilience planning and decision making on projects. Aquascope is another platform which offers the users scenario planning to forecast possible planning scenarios for project planning on water risks and sustainable management. The scenario analysis, as observed previously, will aid in the introduction of business cases and investment strategies for the users. The Aquascope tool also offers live forecast functions and advanced warnings for water flows and quality. Aquascope also provide comprehensive data reports for seasonal variations in river basin health allowing them to inform users of extreme weather events (Aquascope, n.d.).

The Aquascope platform utilises data from satellites in collaboration with data from sensors employed by aquascope as well as in-situ partners to provide real-time auditable data for the users. The platform allows users to integrate their own site-level data with catchment-level data on water quality provided by the Aquascope Team. Aquascope provides the data to the user in an API (Application Programming Interface) to enable integration of water-related data into existing software applications or systems to allow for information upload in real time which enables users to provide collaboration among multiple stakeholders. The platform similar to Waterplan and the Waterproof tool, enables users to provide a reporting option to the user to provide visual and numerical report on water data for audits and reporting disclosures. Similarly to tools mentioned previously the Aquascope also provides users with dashboards for progress monitoring with the water projects (Aquascope, n.d.).

Global Water Watch

Global Water Watch is a tool launched by Deltares, World Resources Institute (WRI), and WWF to provide free, accessible, near-real-time information on over 70,000 global reservoirs. The global Water Watch tool is supported by Google.org, the European Space Agency, and the Water, Peace, and Security Partnership. The Global Water Watch aids industry in decision making and sustainable, equitable, and

efficient use of our global reservoirs. This tool may be used to receive current information on an organisations value chain, particularly in areas of high water stress. The tool specifically gives water quantity information in cubic meters for global reservoirs and also near-real-time data for extreme weather events such as drought or flood (Global Water Watch., 2025).

Higg Index Tools

The Higg Index is a suite of five tools, launched by Cascale, which measure the social and environmental competencies of both an organisations value chain and the impacts of their products, particularly in the textile industrial sector however elements of the tool can be applied in wider scope to other industrial sectors. The first set of tools are pertaining to production and the choosing of materials prior to production. The material sustainability index (MSI) calculates the environmental impacts of and translates this calculation into a sustainability score. The second tool in the production tools is the Higg production module (PM) which differs from the material sustainability index by measuring the full life-cycle assessment and environmental impacts of resources from abstraction, through production, to end of use. Water is addressed in both of these tools through items 02 and 03 of the assessment 02. Nutrient pollution in water (eutrophication) and 03. Water scarcity, looking at both the consumption and quality of the water in these industries for reporting to mandatory and voluntary reporting disclosures (Cascale, 2024).

The Higg Index Facility Tools are used to identify areas for opportunity in sustainability optimisation in manufacturing facilities. The Higg Index Facility Tools are split into two separate tools. The Higg Facility Environmental Module (FEM) allows organisations to assess the environmental impact of product manufacturing at all stages of production highlighting areas of risk for mitigation or optimisation projects and creates clear communication for stakeholder engagement. Water is the main focus of two separate areas of the FEM tool, section 03) Water Use and 04) Wastewater. The second tool under the Facility Tools section is The Higg Facility Social & Labor Module (FSLM) which primarily focuses on the social aspects of ESG, particularly workers in the value chain (Cascale, 2024).

Brand and Retail tools are the final tools in the Higg Index suite. The Brand and retail tools offer industries particularly textile, apparel, and footwear industries the capabilities to identify areas for optimisation within their production operations and supply chain. This tool in particular aligns with regulations for environmental, social, and governance factors (ESG) for improved production projects or risk mitigation still in line with reporting standards and compliance of environmental authorities (Cascale, 2024).

7.5. Appendix E – Figure 14: Overview of Water Stewardship Support Tools for Industry (Enlarged)