Making smarter water management decisions

Hydro International

# How to design, implement, and operate a water management project to mitigate flood risk

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# Contents

“Flooding is one of the most costly natural global disasters, with damages soaring to $175 billion in 2016 alone...”



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# Foreword

**Mark Goodger**: Regional Technical Manager, Hydro International

**“As a result of various high-profile disasters over recent years, addressing flood risk and flood risk management has become an urgent global goal.**

The headline damage figure is likely to rise considerably as climate change continues to affect weather patterns. The UN Office for Disaster Risk Reduction (UNISDR) warns that climate change and ocean warming will bring more intense storms and more destructive events. Even with the shocking current data and official confirmation of the challenges that lie ahead, the economic figures can neither convey the disruption and heartache that flooding causes those affected, nor the impact of the significant global death toll.

As a result, there is considerable pressure on consultants and contracting engineers, who play key roles in flood mitigation, to set things right. They are entrusted with translating aims that have significant political and public impact into effective, robust and sustainable solutions.”

"Their challenges include complying with stringent national and regional regulatory requirements, and liaising with clients, their main contractors and other consultants, as well as local communities and the wider supply chain, including the manufacturers of the products being specified.

Minimising flood risk is one of the most urgent tasks facing the world's drainage engineers today, and one that requires significant expertise to guarantee success. To ensure solutions are appropriate, sustainable, economical and practical to maintain, all stakeholders in this vital field must commit to working closely together to these ends."

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# Speed Read

Due to climate change, urbanisation and construction on flood plains, flooding is an increasingly common global problem and engineers are under considerable pressure to provide effective, sustainable and cost-efficient solutions.

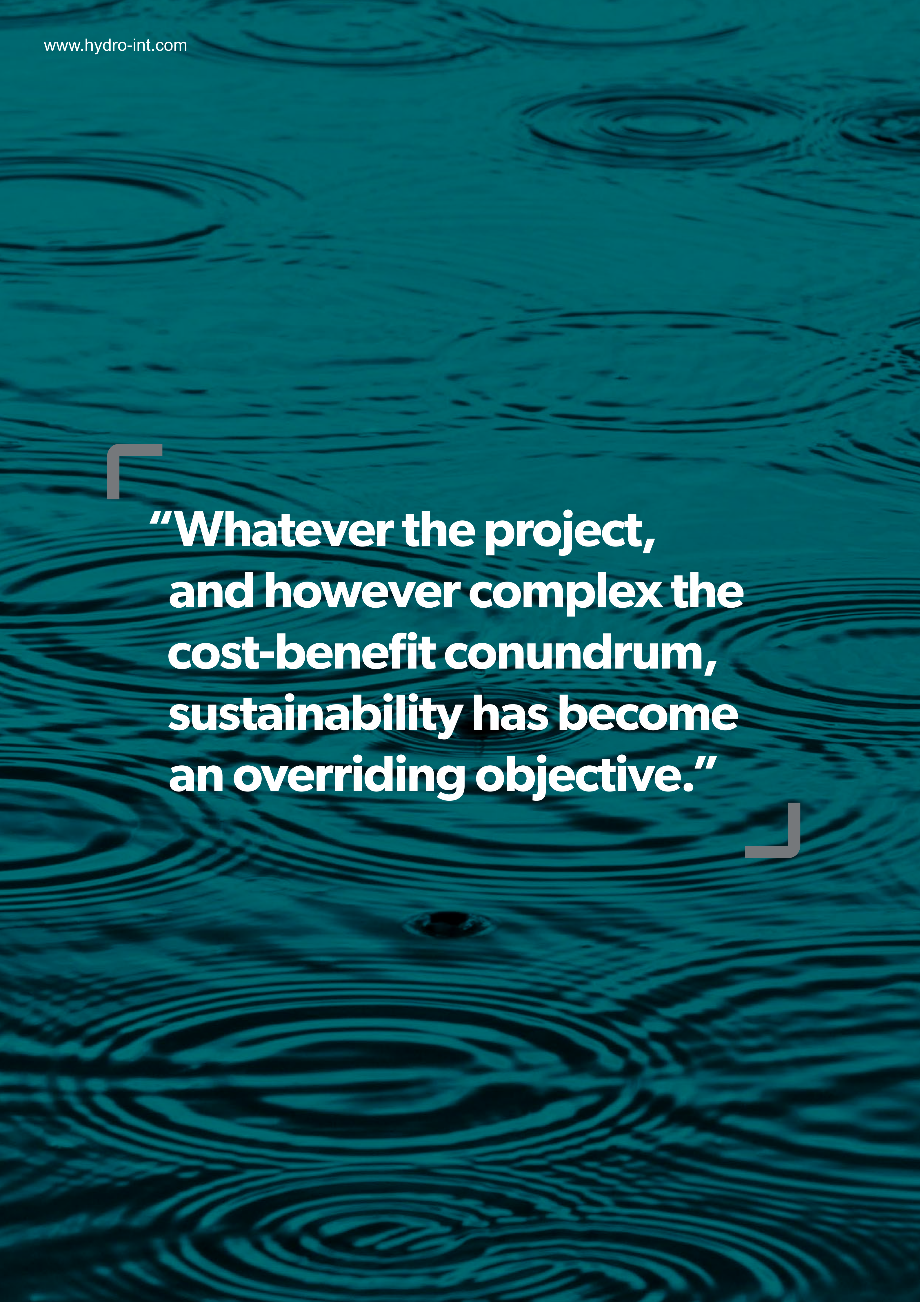
Identifying key environmental and stakeholder data through surveys, modelling, research and collaboration with project partners is an essential preliminary stage in the project planning process.

Guidance is available for all stages of the process from planning to maintenance. Most countries have developed legislation, regulation and/or guidance on how to undertake a flood mitigation project.

Design engineers can benefit from discussions with manufacturers of flood mitigation systems from the earliest stages of a project, to ensure that the design stays within budget and that the capabilities and advantages of the potential solutions are fully understood.

Consider the upstream and downstream consequences of a proposed project. Computer simulation is an important tool in understanding impacts and choosing the option with the least negative and the best positive results.

It is also important not to forget the costs of operation and maintenance, and the likely lifetime of the system. The most robust, least complex solution is likely to provide the best overall results.

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# Introduction

**For consultants and contractors involved in flood mitigation schemes, there are several key factors that are critical to ensuring that the planning, design, implementation and operation of flood management projects minimise the risks and maximise returns.**

Choice of flow control is critical in achieving a cost-effective flood risk management solution. There are a number of important considerations that need to be taken into account, which this guide will cover in detail.

Whatever the project, and however complex the cost-benefit conundrum, sustainability has become an overriding objective. To achieve this, projects, and any related products, must continue to operate effectively throughout their anticipated lifetime. This means that proper end-to-end management and maintenance is a key element to be considered in conjunction with capital costs.

Operating efficiencies, which are vital to delivering the best possible total expenditure (Totex, or lifetime cost) on a project, are therefore a significant consideration. Whole-life costs, and successful optimisation of related ecosystem services, play a major role in determining the success or failure of a scheme.

Data – information – is also important. To deliver the optimum design, getting the specifications, documentation, and basic delivery framework right is essential. This guide will look at how to design and deliver a successful flood risk alleviation project that completes on time, with the best balance between cost and complexity, compliant with legal regulations and planning requirements, while keeping operating efficiency front of mind.

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# Planning and design

**The design process for any flood risk mitigation project is led by the objective, which is usually a response to inadequate performance or failure of an existing asset, operational inefficiency, or a flood event.**

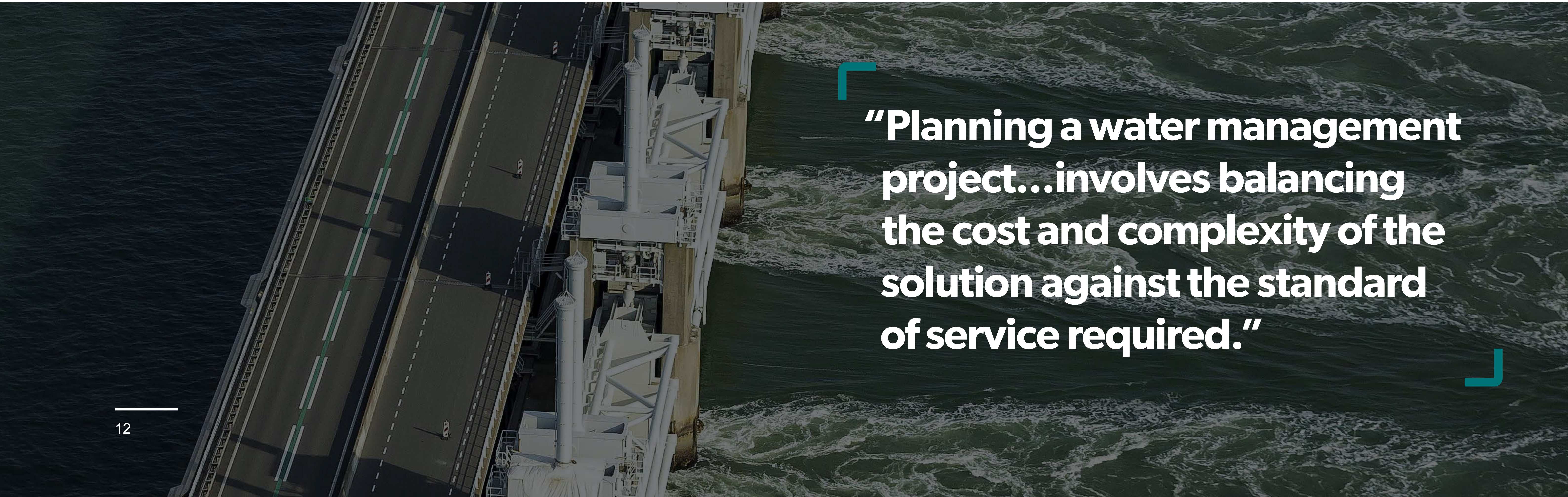
One size does not fit all, however. The form mitigation takes will depend on many factors, and can range from simple soakaways to flood storage reservoirs with associated control structures, embankments, or floodwalls.

New developments may require Sustainable Drainage Systems (SuDS) in the UK, Low-Impact Development (LID) in the US and Water-Sensitive Urban Design (WSUD) in Australia, incorporating features such as swales, retention ponds, permeable paving and storage and infiltration systems.

Solutions are often required to provide protection for 1 in 30 year, 1 in 100 year and 1 in 200-year storm events, and sometimes even higher. In planning a water management project to reduce and manage the impacts of such storm events, it is important to recognise that flood storage reservoirs and other assets could potentially sit unused for many years, but must operate as designed, when required.

Planning a water management project to reduce and manage the impacts of flood events to the chosen level of protection involves balancing the complexity and cost of the solution against the standard of service required.

The maximum capacity of the watercourse and predicted storm flows for the required storm event, ground and topographic data are required to determine the sizing and nature of the flood control solution (and therefore the cost). Client and legal requirements for discharge quantity and quality as well as any stakeholder considerations must also be factored in.



**“Planning a water management project…involves balancing the cost and complexity of the solution against the standard of service required.”**

# Specification and implementation

**Considerations that must be taken into account to ensure water management products are correctly specified include ease of use and access, as well as sustainability and durability.**

The minimum product lifetime identified at the specification stage is dependent on the type of system being employed. A basic rule is that the fewer moving parts, the longer the potential lifetime and the more reliable the solution will be. Understanding the likely lifetime and reliability will enable designers to identify solutions that meet the client's design life requirements.

A site-specific Flood Risk Assessment (FRA) (Flood Consequence Assessment in Wales), if required, plays a key role in the solutions specified. This will have to demonstrate how flood risk will be managed across the lifetime of the project, taking climate change into account, and whether the measures proposed are appropriate.

**The first stage in the specification process is to understand and define the flood risk and the asset performance objectives. Work with experts who can offer:**

- **Practical advice around your mitigation project**
- **Design, modelling, maintenance intervals and end-of-life services**
- **Help to shape a sustainable solution with maximum cost-benefit.**

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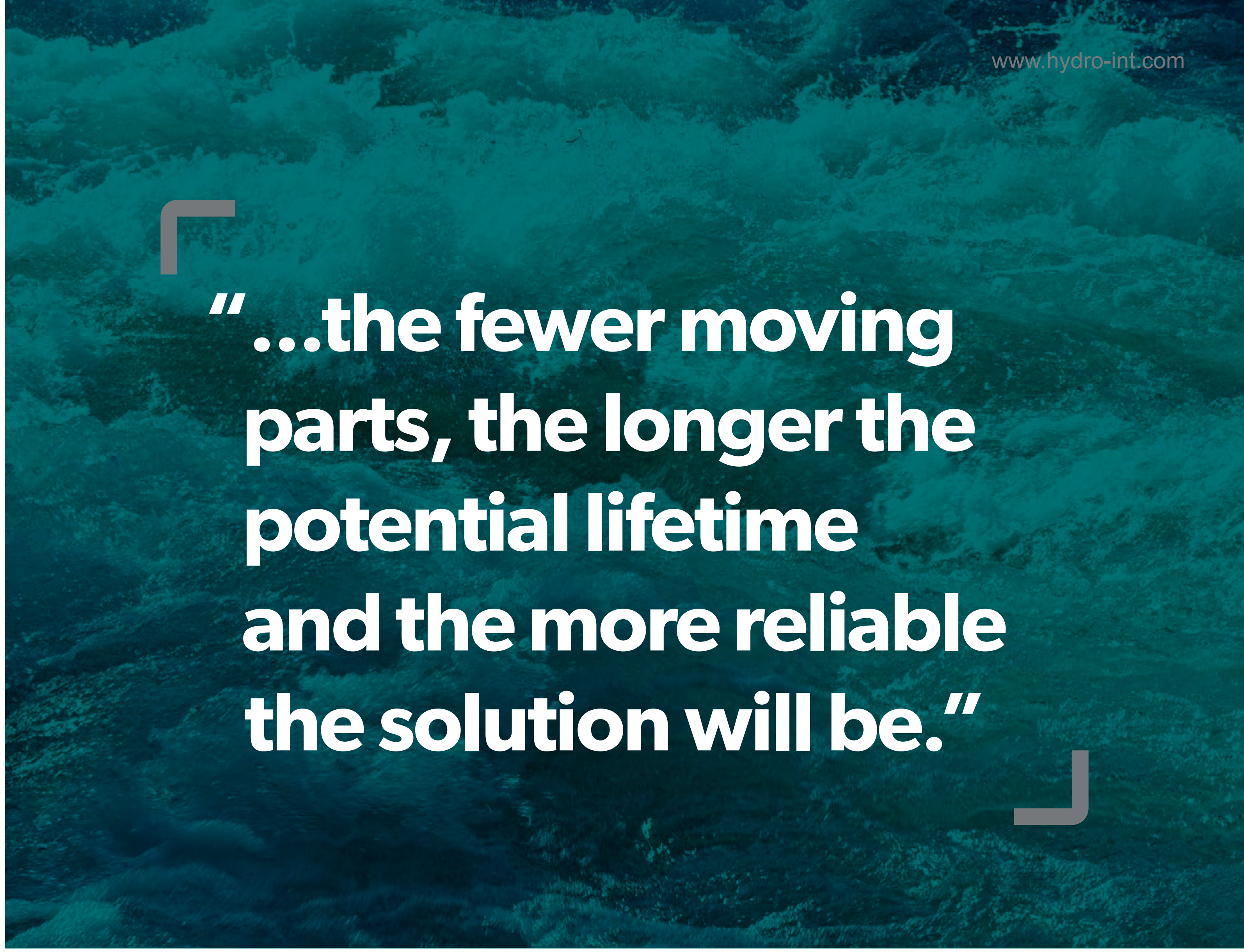

**"...the fewer moving parts, the longer the potential lifetime and the more reliable the solution will be."**

When the objectives have been defined, the designer must identify the optimum solution to achieve them, and ensure this can be built and managed across its design life.

Assessing the performance requirements will involve undertaking surveys and investigations, searches of historic records, and computer modeling to identify all sources of flooding and the potential impacts of any proposed solutions. In this way, the optimum result for the best cost-benefit can be identified.

Careful product selection is vital to the successful implementation of a project. Close liaison with the manufacturers of solutions from an early stage is invaluable in ensuring that the design comes in within budget, and takes advantage of and stays within the capabilities of the proposed asset.

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# Operation and maintenance

> “Correct operation and maintenance of a solution will ensure that its lifetime is maximised and the operating efficiency of the project is maintained.”

**To ensure that a water management project will function as planned under future flood scenarios throughout its design life, priority should be given to:**

- Products with few or no moving parts and easy access.
- Products that require no power to activate or operate.
- Products which ensure that any solids, such as silt or grit washed in with floodwaters, do not accumulate within the structure.

Vortex flow control technologies for upstream flow attenuation and geocellular storage and infiltration systems, fulfil this remit. With no moving parts, they require minimal maintenance, and with no moving parts they have no operational costs. They are also manufactured from long-life, durable materials such as stainless steel to avoid the risk of materials failure.

Proprietary treatment products provide planned and predictable maintenance and can be used to protect, enhance or enable natural SuDS features such as retention ponds and swales, and ensure their long-term viability.

**The three main challenges (and solutions) for maintaining flood mitigation are:**

- Choosing the correct products to ensure optimum functionality throughout the identified project lifetime by selecting the least complex, most robust control structures.
- Identifying the optimum maintenance periods for the chosen solutions in close consultation with the manufacturer’s. Accessibility for the purposes of maintenance is an important factor that needs to be considered from the outset.
- Ensuring that the chosen solution has no upstream or downstream flooding impacts or any potential pollution transport implications. This can be achieved through intensive computer simulation of the catchment.

   

# Case studies from the UK and US

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# Case study: UK

## Issue

In recent years, flooding has become an increasingly prevalent issue in Northampton. Businesses and residential properties are often flooded, causing physical and financial damage. Due to increased rainfall, the chance of a major flood increased to every three years.

## Solution

To alleviate the problem and mitigate the effects of future flooding, the Environment Agency (EA) and their engineering consultants evaluated two options: enlarging the conveyance channels running through the centre of the village, and providing stormwater storage upstream. Specifying a dam to contain floodwater in the catchment area, the key component of the project was a 6.5 tonne, 2 metre diameter flow control system.

## Results

- A dramatic 66% reduction in land take required for the 1 in 3 year storm.
- Minimised effects of reservoir ponding on agricultural land.
- Reduced costs due to no power, no moving parts and minimised maintenance.

# Case study: US

## Issue

Evanston, IL is a place that isn't a stranger to flooding. It's infrastructure has been unable to copy with increasingly heavy rainfalls, leading its sewer systems to become overloaded and sewer backups flooding hundreds of of basements up to six times a year. The city needed to develop a cost effective abatement programme to prevent these sewer problems.

## Solution

Rather than opting for the traditional, but disruptive, solution of relief sewer/sewer replacements, estimated to cost $290 million, MWH Global recommended an innovative plan that coupled inlet flow control with partial sewer separation to alleviate basement backups without having to install storm sewers on every street.

## Results

- During one of the wettest months in recent history, city officials only received two sewage-related calls.
- The valves cost the city 50% less than the alternative, traditional systems.
- A combination of rehabilitation, separation and upstream inlet control improved overall performance.



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# Regulatory guidance across UK, USA and Australasia

# UK regulations

**The regulatory framework for floodwater management in England and Wales is mainly set out in the Water Resources Act 1991, the Environment Act 1995 and the Land Drainage Act 1991.**

England and Wales also need to take heed of EU regulation. The Flood and Water Management Act, and the Flood Risk Regulations 2009, transpose the EU Floods Directive into law in England and Wales.

With Brexit around the corner, the Flood Risk Regulations will be amended by the Great Repeal Bill. Even if they remain essentially unchanged, contractors and engineers will need to be mindful of potential alterations to regulatory requirements.

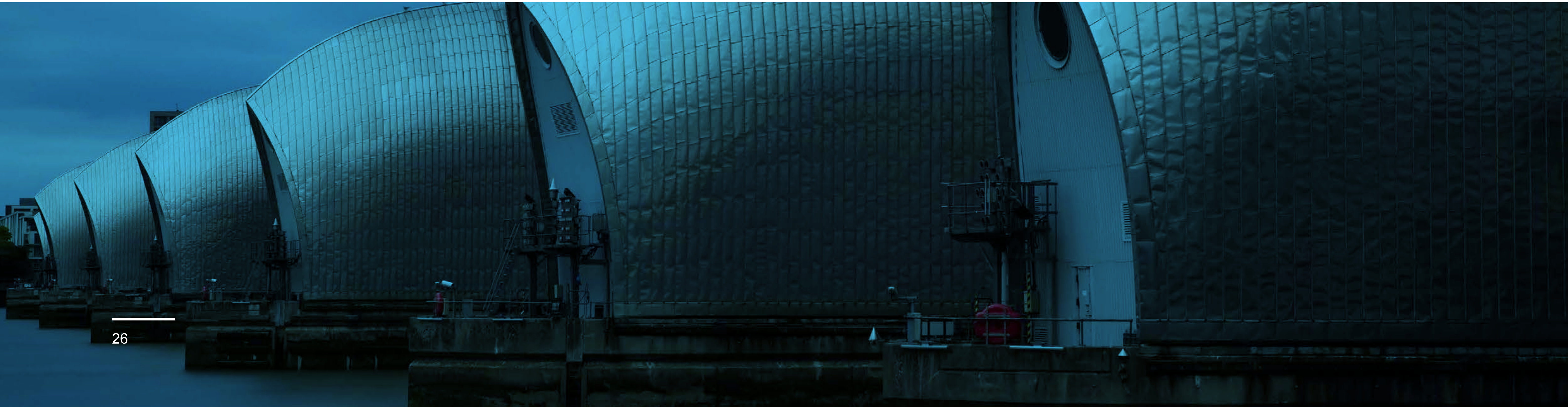
In Scotland, regulation is laid out by the Water Environment and Water Services (WEWS) Act 2003 and the Flood Risk Management Act (Scotland) 2009.

These documents describe the "operating authorities", which are principally the Environment Agency in England (or the Scottish Environment Protection Agency (SEPA) in Scotland, and a multi-regulatory body, Natural Resources Wales, in Wales), who are responsible for all main rivers. The FWMA also identifies Risk Management Authorities (RMAs) which can be the EA / NRW, Local Authorities, Internal Drainage Boards, Water & Sewage Companies.

In terms of advisory documents, the Environment Agency's Fluvial Design Guide provides a comprehensive guide to design, operation and maintenance of flood mitigation assets, and supports delivery of projects in line with government strategy as set out in Defra's 2005 Making Space for Water report. The Environment Agency also offers comprehensive guidelines, research and analysis in design, operation and adaptation of reservoirs for flood storage.

The design guide sets out regulatory expectations for assets (such as floodwalls, sluice structures, river channels and revetments) and the functions that they are expected to fulfil. Another key source of information for engineers is the British standard, BS 8582:2013 Code of Practice for surface water management for development sites.

For SuDS systems, CIRIA's highly-regarded SuDS Manual (C753) incorporates the latest research, industry practice and guidance. In delivering SuDS, there is a drive to meet the framework set out by central government's 'non-statutory technical standards' for design, operation and maintenance of these systems. Changes to the planning system set out in 2014 are also intended to increase use of SuDS solutions. Local SuDS guidelines are also available from some Local Authorities.



# US regulations

**In the USA, responsibility for flood risk management is shared between multiple Federal, state and local government agencies.**

At a Federal level, the lead flood control agency is the US Army Corps of Engineers (USACE) with the Federal Emergency Management Agency (FEMA) taking the main role in emergency situations.

USACE's Civil Works Strategic Plan 2014-2018 sets out aims for flood damage reduction projects to "simultaneously reduce flood risks and sustain healthy ecosystems". Another key source of information is the Federal Support Toolbox for integrated water resources management (IWRM).

Certification body FM Approvals' Approval Standard 2510, Flood Abatement Equipment, is an accepted standard that evaluates both the performance of flood mitigation product in realistic flood conditions and its components and materials.

FEMA also provides a practical guide that discusses design considerations in Chapter 2 and flood protection measures in other chapters (early chapters outline 'dry' floodproofing options and chapter 4 discusses floodwalls, levees, and so-called 'wet' floodproofing).

The US uses the term Low Impact Development (LID) or Best Management Practice (BMP) when referring to SuDS schemes, and the US EPA provides a range of useful fact sheets and technical reports for designers and constructors.

The Water Environment Research Foundation (WERF) supported BMP database provides performance analysis for a wide variety of sustainable drainage devices, with data for parameters such as total suspended solids (TSS), concentrations of various metals including copper, lead and zinc, phosphorus and nitrogen.

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# Australasia regulations

**Flood risk management in Australia involves multiple stakeholders:**

- All three levels of government.
- The State Emergency Services (SES).
- The catchment management authorities.

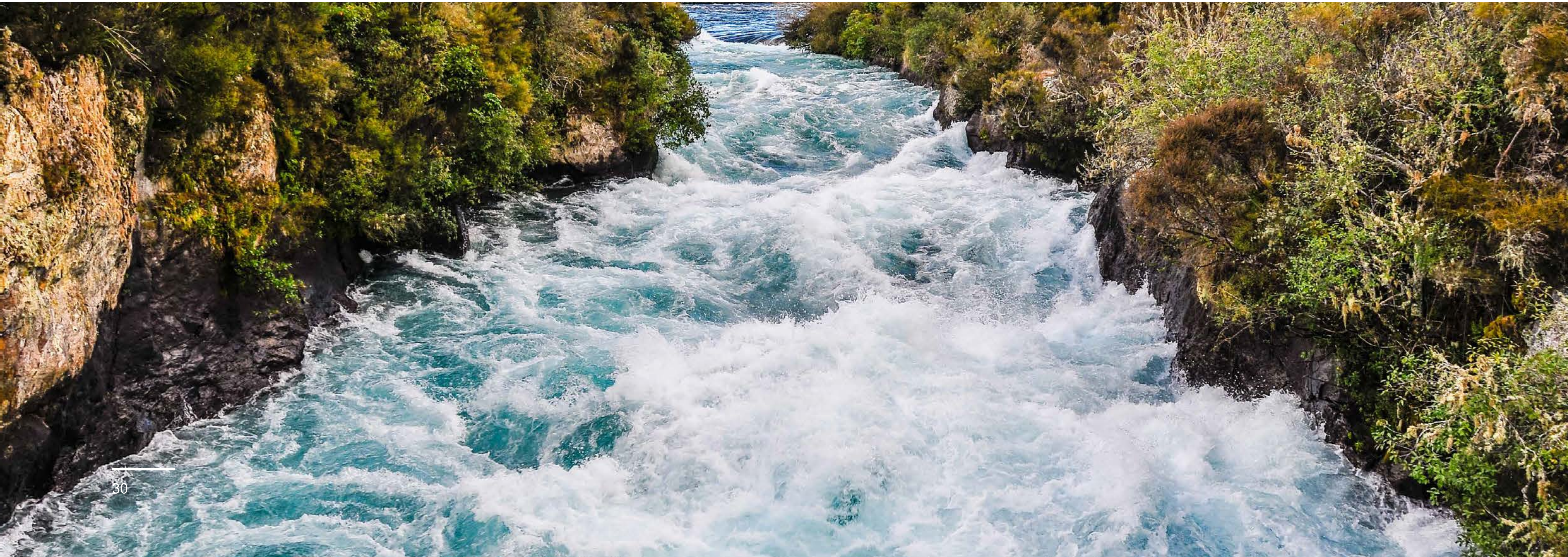
The Australian Institute for Disaster Resilience publishes a guide to best practice in flood risk management that provides useful information on roles and responsibilities, while Australia's National Climate Change Adaptation Research Facility's Living with Floods report calls for full cost and benefit analysis for flood plans and recovery programs.

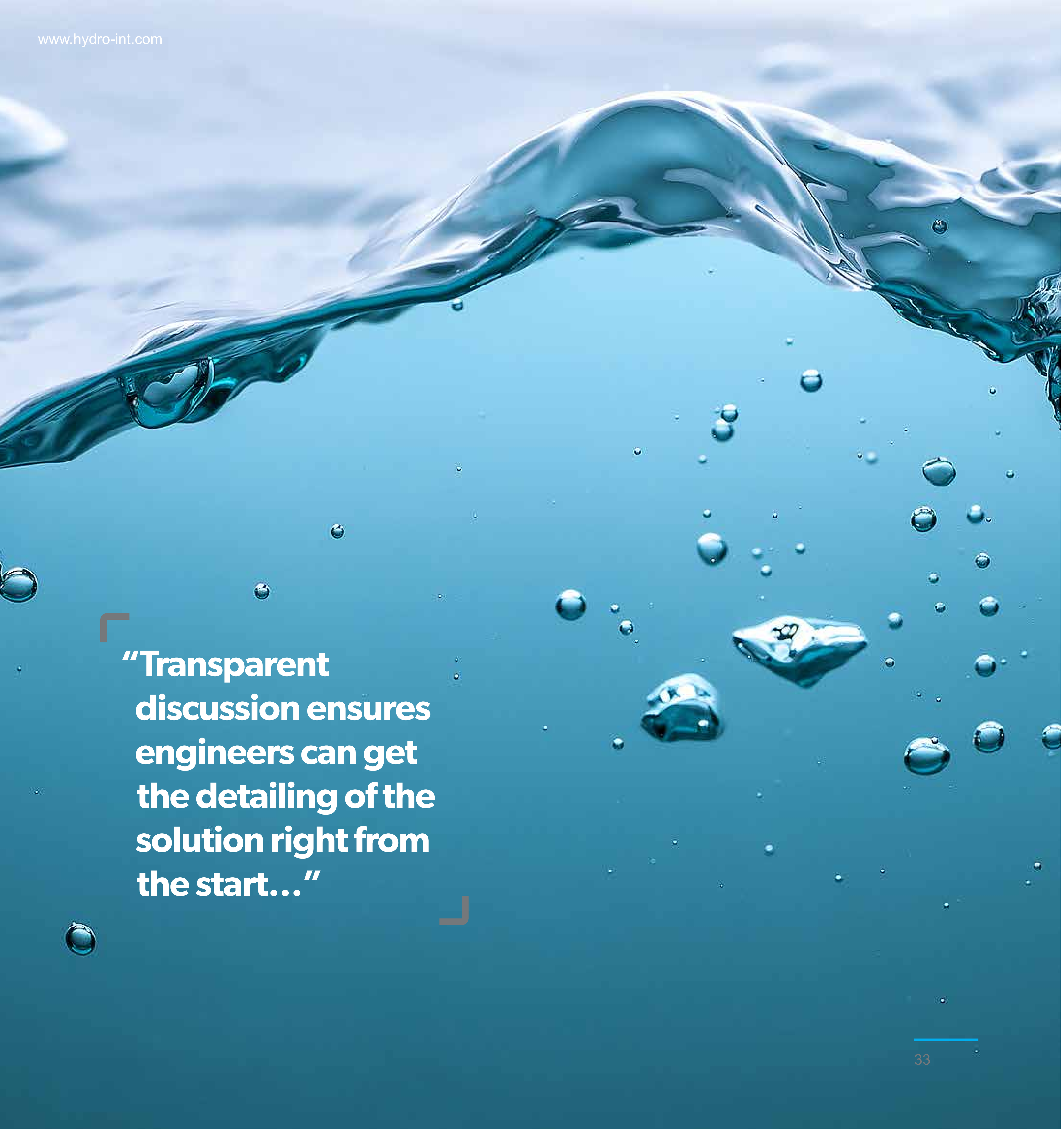
There is no current Australian standard for flood protection products, with manufacturers tending to rely on the British standard PAS 1188 as the guide to product performance. The lack of a national standard means that the sector effectively self-regulates.

In New Zealand, a similarly wide-ranging approach to flood management applies. The Ministry for the Environment identifies flood mitigation as being the responsibility of everyone, from central to local regional, city and district governments, to communities and individuals, with local governments playing a lead role.

The main standard, NZS 9401:2008 Managing Flood Risk, was published in 2008, and the general approach is best described as "local solutions to local problems". The approach also embraces a mix of options, including structural flood control measures alongside land use control and emergency planning.

The Ministry also recommends the international standard, ISO 31000:2009 Risk Management – Principles and Guidelines, a generic risk management guide, as the overarching approach for managing climate change-associated risks.





> “Transparent discussion ensures engineers can get the detailing of the solution right from the start…”



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# Conclusion

**When designing, implementing, operating and maintaining a flood mitigation scheme and associated technologies, it is vital to take holistic consideration of the landscape it will be sited in.**

Given the importance of collecting data before deciding on a solution, it is encouraging that key actors, such as the Environment Agency in the UK, are increasingly making historical records free and open for use in flood mitigation schemes.

Collaboration between the main stakeholders and solution manufacturers at the earliest possible stage is good practice that regulators are now encouraging. This ensures that preliminary optioneering is undertaken with the fullest possible knowledge of the capabilities, operation and maintenance requirements and likely lifetime of potential control structures.

Transparent discussion ensures engineers can get the detailing of the solution right from the start, and have a comprehensive understanding of the pricing and likely on-costs. In this way, the overall cost-benefit of structures can be properly identified and any project risks minimised.

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# Takeaways

The key steps in reducing stormwater effects, legal and financial risks and preventing environmental damage from subsequent pollution are:

Close and full consultation with clients, regulators, manufacturers and other identified key stakeholders to get the fullest possible information about the scheme from the start.

Intensive surveying, modelling and use of historical flood data to identify as much information as possible about the environment into which the scheme will be introduced, and its potential upstream and downstream impacts.

Construction of the chosen option utilising data-rich techniques such as building information modelling (BIM) to ensure all stakeholders hold the same information, and can determine the optimum installation sequence to ensure cost-efficient, time-effective delivery.

Ongoing consultation with manufacturers to ensure that operation of control structures is undertaken with due regard to their capabilities and capacities.

Use of technologies with the least complexity, fewest moving parts and lowest power requirement to ensure that maintenance of structures is minimised.

Speak to our experts directly to get first-hand advice on designing or contracting a project that mitigates the effects of flooding.

**REQUEST A CALLBACK**