

# R&D Roadmap

June 2007

## The need for a Research Road Map

Short and long-term business needs within the water and wastewater sector requires targeted investment in research and innovation.

The *Barriers to Innovation Report* (2007) commissioned by UKWIR, Defra and Ofwat identified a misalignment of expectations between the supply-chain and the water companies, regulators and government.

It recommended “*to replace fragmented, ad-hoc or short-term strategies with an aligned multi-stakeholder vision, strategy and implementation plan for the UK water industry’s innovation needs and priorities*”.

The six largest UK water utilities, acting as the Research Foresight Partnership (RFP) with WRc, have developed some high level R&D roadmaps and asked UKWIR to build on them to produce a strategic view for the industry.

## UKWIR’s Research Strategy

UKWIR has captured the major challenges faced by the industry in twelve themes that comprise six ‘*vertical*’ business processes of the water industry and six ‘*horizontal*’ (cross-cutting) issues.

Relationships between these twelve strategic research themes are presented as a matrix, shown overleaf with the UKWIR Board’s strategic intent.

This matrix has been used to provide an overview of the industry’s investment during the past AMP cycles, which have then been projected forward to 2030.

## Drivers for Innovation and Research

The contour maps show that the greatest investment is associated with *Asset Stewardship* and that this is consistent across all AMP periods. The changing response to the key regulatory directives is apparent: Drinking Water Directive in 1984-1999, Urban Wastewater and Bathing Directive in 1995-2004, Cryptosporidium regulations in 2000-04.

Projecting forward, the key issues relate to the Water Framework Directive, metering, ageing assets (those installed in AMP1 and AMP2 in addition to the pre-existing underground infrastructure), energy and carbon emissions, sustainability and climate change.

This view accords with UKWIR’s set of high level drivers for the next 20 years, some of these are more certain than others.

## ROAD MAP THEMES

**Energy Management**  
*Energy-optimised conventional treatment and networks new carbon-neutral and carbon-negative processes.*

**Underground Assets**  
*Real-time condition monitoring and early warning of failure with full 3D location and mapping.*

**Leakage**  
*Localisation and repair of leaks in live systems within an agreed ‘sustainable-level-of-leakage’ regulatory framework.*

**Intelligent Metering**  
*Universal metering with tariff structures that support demand management and provide real-time data on consumption.*

**Chemical Free Treatment**  
*Biological nutrient removal from wastewater at all scales, ‘chemical-free’ production of drinking water and accepted direct re-use of wastewater.*

Thirty specific issues were identified by the RFP, and five prioritised themes have been developed into detailed Research Road Maps.

They show business focused outcomes that can be achieved through investment in research over the next 25 years (see figures 1 to 5).

**The strategic view – what next?**

These maps set out a new shared industry vision: a framework that provides direction for the supply chain and the research community that leads to the water utilities medium and long term needs.

Government can use them to target research and innovation platforms that support the development of new technologies and systems that can directly benefit the UK.

These roadmaps, if appropriately supported, can help both the research community to target their efforts and the supply chain to provide the required technologies and systems when they are needed.

## Knowledge Integrated Communities

This coherent view of need will help to provide a focus to enable stakeholders to work together to agree plans and strategies. There are examples of how this approach is working.

**The VISTA programme** is developing the software and systems to enable 3D mapping of the underground asset base, it has mobilised £2.9m (£1m from DTI) and has brought together universities, utilities and their supply chain.

**The Fats Oils and Greases (FOG) programme** will reduce the problems created by disposal of Fats, Oils and Greases to sewer, currently costing the UK £20 million a year. It has brought together Government, universities and utilities and has mobilised £1.3m.

These aspirational programmes have defined outcomes linked to improved operational and capital efficiency. The focus on climate change, and the UK Government's aspirations may well lead to a need for further expansion of the Road Maps to include:

### Reduced per capita 'Water footprint'

- improved location and repair of leakage
- intelligent use of metering and tariffs
- increased reuse and recycling
- water efficient home appliances.

### Reduced 'Carbon Footprint'

- new energy generating processes for waste and wastewater treatment
- real-time network & pumping optimisation
- improved location and repair of leakage
- energy efficient treatment processes.

### Reduced disruption due to failure

- accurate real-time condition, performance and control of underground assets
- intelligent assets, accurately mapped, easy to locate
- robust, resilient, and responsive materials for replaced assets
- low/no-dig for asset repair and replacement.

These Road Maps are a starting point. They will be used to stimulate debate and will be further developed and updated in discussion with regulators, government, the research community and the supply chain.

## Additional background to the RFP Maps

The maps shown in Figures 1 to 5 were developed by the RFP following a series of workshops attended by operational, planning, procurement, managers and scientists, academics and representatives from the supply chain.

The maps represent the views of the Utilities R&D community and set out the likely pressures on the water sector over the next 25 years.

They define the required outcomes and identify where benefits could be obtained from investment in research and innovation by the water utilities, the supply chain and the research community. They provide a coherent medium and long-term research road map for the water industry to 2030.

## UKWIR Strategic Matrix and overview of industry spend/need from 1990 to 2030

UKWIR Strategic Matrix						
THEMES	Water resources	Water treatment	Water distribution	Sewerage	Wastewater treatment	Waste management
Asset Stewardship			Asset performance & levels of service			
Customer Service						
Balancing Supply & Demand	Demand-side research		Integrated Water Safety Plans and DOMS	Surface water management		
Environmental & Public Health Protection						
Sustainable Development			Climate change and asset performance; Carbon footprinting		Integrated catchment management	Biosolids recycling to land
Regulation	Simplifying regulations and balancing sustainability obligations					

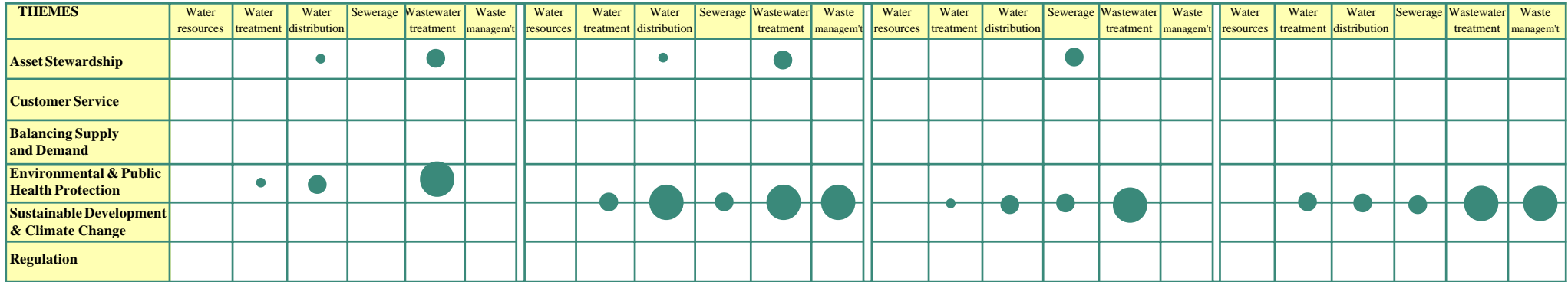
Figure 6 shows each regulatory period with a forecast to 2030. OFWAT reports have been used to build a picture of the capital and operational spend over each of the past regulatory period, which has then been distributed across the UKWIR matrix.

The pictures can be viewed as contour maps, with peaks representing the greatest spend. The future projections are based on industry views of the pressures that the industry may face.

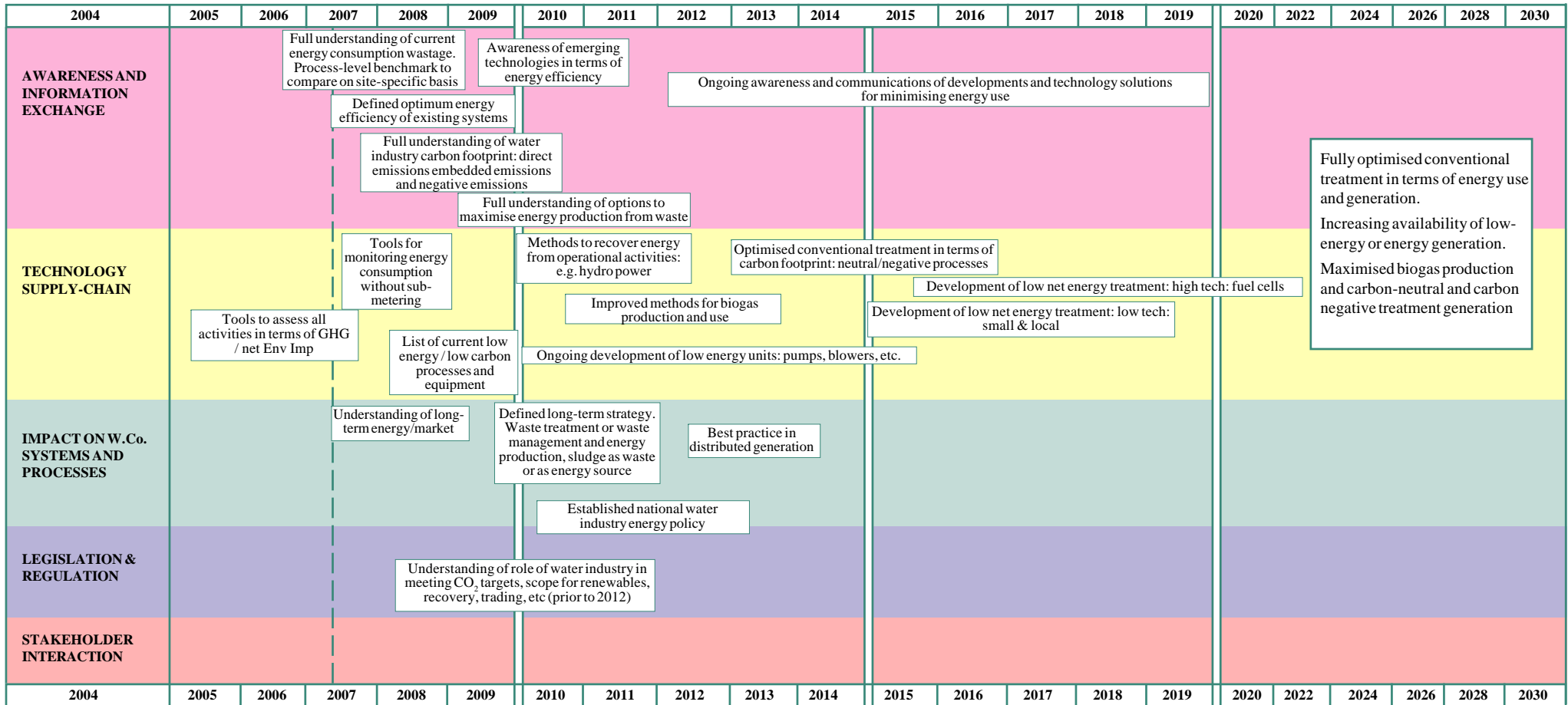
Each map is a summary of the main drivers that shape the pattern of investment, an indication of the main technology areas of capex/opex spend and an estimate of annual total spend on R&D by the industry.

Figure 1. STRATEGIC MAP: ENERGY

Size of blot approximates level of importance/activity/spend (high, medium, small)



KEY REQUIRED OUTCOMES



**Figure 2. STRATEGIC MAP: UNDERGROUND ASSETS - Condition, location, risk management**

Size of blot approximates level of importance/activity/spend (high, medium, small)

THEMES	Water	Water	Water	Sewerage	Wastewater	Waste	Water	Water	Water	Sewerage	Wastewater	Waste	Water	Water	Water	Sewerage	Wastewater	Waste	Water	Water	Water	Sewerage	Wastewater	Waste
	resources	resources	treatment	distribution		treatment	managem't	resources	treatment	distribution		treatment	managem't	resources	treatment	distribution		treatment	managem't	resources	treatment	distribution		treatment
Asset Stewardship			●	●					●	●					●	●					●	●		
Customer Service			●	●						●						●						●		
Balancing Supply and Demand			●						●															
Environmental & Public Health Protection				●						●														
Sustainable Development & Climate Change									●	●					●	●					●	●		
Regulation																								

**KEY REQUIRED OUTCOMES**

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030	
<b>AWARENESS AND INFORMATION EXCHANGE</b>							Defined 'lead indicators' of deterioration for predictive modelling and full understanding of regional granularity																
<b>TECHNOLOGY SUPPLY-CHAIN</b>							Understanding and awareness of technologies and systems applied by other owners of underground assets																
<b>IMPACT ON W.Co. SYSTEMS AND PROCESSES</b>							Software to generate 3-D images at street level																
<b>LEGISLATION &amp; REGULATION</b>							Passive/intelligent asset tags, located from above ground with database/embedded information																
<b>STAKEHOLDER INTERACTION</b>							Robust Capex and Opex models																

On-going awareness and communication of developments and technology solutions for locating, monitoring and assessing underground assets

Failure database for sewers and water mains: old and new assets: continuously updated

Deterioration and failure and consequence models: continuously updated

Methods to locate and identifying neighbouring assets

Ground probing radar able to locate plastic pipes

Methods for on-line inspection of water mains

Integration of accurate GPS (Galileo - 2012)

Methods for on-line non destructive testing of the condition of sewers and water (esp trunk) mains

Records and maps of underground assets in 3-D

Robust forecasting tools, KPIs and deterioration lead indicators

Robust whole-life costing and risk management

Strategic optimisation and investment tools

Effective risk management strategy and tactics

Full co-operation and co-ordination with other asset users, to common format and data source

- \* Real-time condition monitoring and early warning of failure
- \* accurate location of all assets in 3-D from above the ground assets and 3-D visualisations at street level
- \* risk-based prioritisation based on real data and accurately calibrated deterioration models
- \* consistent risk management across all assets



Figure 4. STRATEGIC MAP: INTELLIGENT METERING

Size of blot approximates level of importance/activity/spend (high, medium, small)

THEMES	Water						Sewerage						Waste					
	resources	treatment	distribution	Wastewater treatment	Wastewater treatment	Waste managem't	resources	treatment	distribution	Wastewater treatment	Wastewater treatment	Waste managem't	resources	treatment	distribution	Wastewater treatment	Wastewater treatment	Waste managem't
Asset Stewardship			●						●						●			
Customer Service			●						●				●		●			
Balancing Supply and Demand	●						●		●				●		●			
Environmental & Public Health Protection																		
Sustainable Development & Climate Change							●											
Regulation							●						●					

KEY REQUIRED OUTCOMES

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
<b>AWARENESS AND INFORMATION EXCHANGE</b>					Full understanding of the technical capabilities of existing systems, integration of the experience and technology from overseas, and gas and electricity sectors			Ongoing awareness and communication of developments and technology solutions for metering across utility sector														
<b>TECHNOLOGY SUPPLY-CHAIN</b>					User specifications for meter systems, including date & functional requirements		Agreed standards		On-going technology development/improvement				Ongoing steering of development/improvement				Cost-effective, universal customer metering delivering: * tariff structures which support demand management, are equitable and address affordability issues * wider benefit for network operators					
<b>IMPACT ON W.Co. SYSTEMS AND PROCESSES</b>				Cost-benefit models		Added benefits identified and quantified	List of development/adaptation needs		On-going technology development/improvement				Delivery of cost effective solutions				Full integration and implementation of new company systems					
<b>LEGISLATION &amp; REGULATION</b>								Universal metering funding agreed with OFWAT		Fully tested tariff and charging models to replace rateable value												
<b>STAKEHOLDER INTERACTION</b>					Full understanding of customer attitudes, affordability and social issues				Identified solutions for 'difficult cases', flats etc			Education campaign for customers to demonstrate benefits of wider metering			Full acceptance by customers of wider metering							

Figure 5. STRATEGIC MAP: (CHEMICAL FREE) TREATMENT

Size of blot approximates level of importance/activity/spend (high, medium, small)

THEMES	Water resources						Water treatment						Water distribution						Sewerage						Wastewater treatment						Waste management					
	Water resources	Water treatment	Water distribution	Sewerage	Wastewater treatment	Waste management	Water resources	Water treatment	Water distribution	Sewerage	Wastewater treatment	Waste management	Water resources	Water treatment	Water distribution	Sewerage	Wastewater treatment	Waste management	Water resources	Water treatment	Water distribution	Sewerage	Wastewater treatment	Waste management	Water resources	Water treatment	Water distribution	Sewerage	Wastewater treatment	Waste management						
Asset Stewardship								●						●						●						●										
Customer Service								●						●						●						●										
Balancing Supply and Demand								●						●						●						●										
Environmental & Public Health Protection		●			●	●		●				●		●				●		●				●		●			●	●						
Sustainable Development & Climate Change		●			●	●						●						●						●					●	●						
Regulation																																				

KEY REQUIRED OUTCOMES

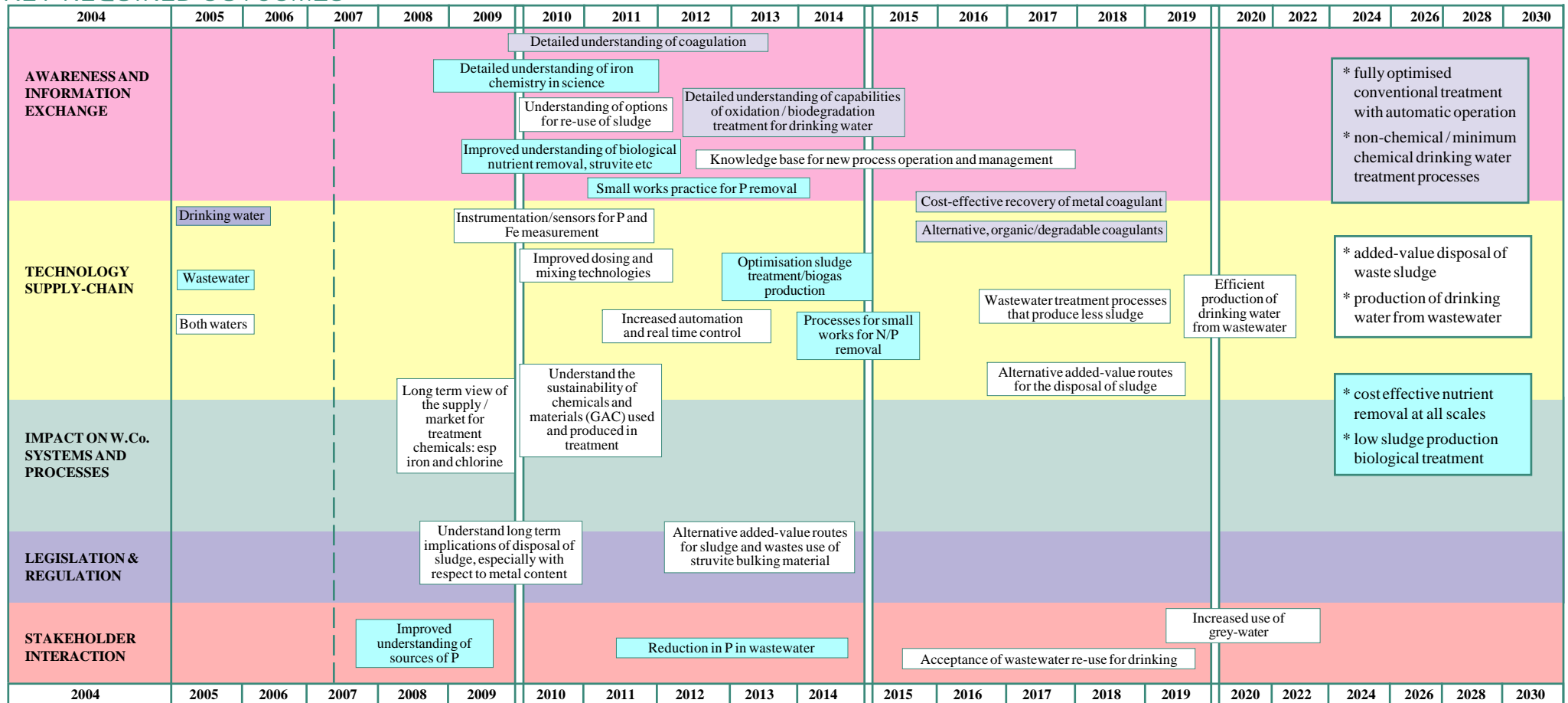


Figure 6. Percentage of total spend allocated to each cross cutting theme

	Water Resources	Water treatment	Water distribution	Sewerage	Wastewater treatment	Waste management		
1989-94	Asset Stewardship							
	Customer Service	2%	AMP1 1989-1994 Total Spend c £25bn					
	Balancing Supply & Demand	15%	Principal drivers: EU Drinking Water Directive					
	Environmental & Public Health Protection	40%	GAC, Ozone, Coagulation					
	Sustainable Development & Climate Change	0%	Improved (new) wastewater treatment					
Regulation	0%	R&D spend £36m pa: AMP 1& 2 technologies						
1995-99	Asset Stewardship							
	Customer Service	57%	AMP2 Total spend c £30bn					
	Balancing Supply & Demand	1%	Principal drivers: EU Urban Wastewater Treatment / Bathing Water Directives, DWQ at customer's tap					
	Environmental & Public Health Protection	31%	Mains rehabilitation, replacement, leakage					
	Sustainable Development & Climate Change	0%	Wastewater disinfection, sludge treatment					
Regulation	0%	R&D spend £40m pa: AMP 2 & 3 technologies and systems						
2000-04	Asset Stewardship							
	Customer Service	60%	AMP3 Total spend c £31bn					
	Balancing Supply & Demand	5%	Principal drivers: OFWAT cost efficiencies, Leakage, Cryptosporidium,					
	Environmental & Public Health Protection	9%	Water treatment-membranes					
	Sustainable Development & Climate Change	26%	Leakage, water mains, operating systems					
Regulation	0%	Nutrientremoval, sludge disposal						
2005-09	Asset Stewardship							
	Customer Service	65%	AMP4 Total spend £32.6bn					
	Balancing Supply & Demand	7%	Principal drivers: Sewer Flooding, Capital Maintenance, Common Framework,					
	Environmental & Public Health Protection	9%	Energy efficiency,					
	Sustainable Development & Climate Change	19%	Leakage, mains renewal					
Regulation	1%	Sludge, waste disposal						
2010-14	Asset Stewardship							
	Customer Service	0%	R&D Spend £24m pa: AMP 4 Opex PR09 submission					
	Balancing Supply & Demand	49%	AMP5 Total spend £33.6bn					
	Environmental & Public Health Protection	3%	Principal drivers: WFD, supply- demand management, universal metering, AMP 1 asset renewal					
	Sustainable Development & Climate Change	11%	Leakage, metering, strategic renewal of trunk mains and large diameter sewers, adopting private sewers					
Regulation	26%	Water/wastewater asset renewal, energy efficiency, carbon emissions reduction, waste disposal						
2015-30	Asset Stewardship							
	Customer Service	0%	R&D spend £40m pa: energy from waste, smart assets					
	Balancing Supply & Demand	44%	AMP 6/7 Total spend £36.5bn (@ AMP)					
	Environmental & Public Health Protection	4%	Principal drivers: carbon emissions, supply demand management, smart meters and tariffs, water and waste recovery and recycling, energy from waste					
	Sustainable Development & Climate Change	10%	Strategic asset renewal, next generation treatment, e.g. energy efficient desalination, real time asset control and condition monitoring, intelligent urban networks (multi-utility)					
Regulation	27%	R&D spend: £50m pa: fuel cells, energy from waste						
Regulation	14%							
Regulation	0%							