Title: Future Water Resources Management: Reform of the Water Abstraction Regulation System **IA No:** DEFRA1365	Impact Assessment (IA)
Lead department or agency: DEFRA	**Date:** 14/10/2015
Other departments or agencies: Welsh Government, Environment Agency and Natural Resources Wales	**Stage:** Final
	Source of intervention: Domestic
	Type of measure: Primary legislation
	Contact for enquiries: Henry Leveson-Gower

Summary: Intervention and Options

RPC Opinion: GREEN

Cost of Preferred (or more likely) Option				
Total Net Present Value	**Business Net Present Value**	**Net cost to business per year** (EANCB on 2009 prices)	**In scope of One-In, Two-Out?**	**Measure qualifies as**
£447m	£447m	£-14.7m	Yes	Zero Net Cost

What is the problem under consideration? Why is government intervention necessary?

Water, in rivers and aquifers, is a common property resource and therefore needs a system of regulation to manage its use. This use, called abstraction, is currently regulated by a system of licences set up in the 1960s. This system is not flexible or responsive enough to deal with the triple challenges of: climate change impacting on water supply; a growing population and economy impacting on water demand; and the need to protect the environment. Reforming the abstraction regulation system effectively is key to tackling these three issues and thereby promote resilient economic growth while protecting the environment in a manner which is fair and adaptable at reasonable cost.

What are the policy objectives and the intended effects?

The UK Government is committed to introduce a reformed water abstraction regulation system in England able to promote resilient economic growth while protecting the environment in a manner which is fair and adaptable to future uncertainty at a reasonable cost. As a result economic activity and the environment should be less affected by issues of water availability particularly during longer periods of dry weather. The Welsh Government is committed to reform the abstraction management system to ensure robust and resilient water resources which support healthy communities, the environment and green growth.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

Option 0: current system with no reform; Option 1: Current System Plus takes some of the characteristics of the previous system, such as flow based restrictions on abstraction, but makes the system more flexible, responsive to water availability, fairer for abstractors and more supportive of trading; Option 2: Water Shares, includes many of the elements of Current System Plus, but also introduces a new share-based system which explicitly establishes abstractors' interest in a jointly managed variable resource and facilitates more extensive and shorter-term trading. Option 3: Hybrid Option also introduces a new share-based system but implements it in a more gradual way . We have not considered non-regulatory options as we are looking at reforming a regulatory system required for a common property resource. The hybrid option is the preferred option as it is most likely to maximise benefits by being most adaptable to future climate change and socio-economic challenges.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** 01/2020

Does implementation go beyond minimum EU requirements?			Yes / No / N/A		
Are any of these organisations in scope? If Micros not exempted set out reason in Evidence Base.	**Micro** Yes	**< 20** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)			**Traded:** Minimal		**Non-traded:** Minimal

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible SELECT SIGNATORY: Rory Stewart Date: 14 October 2015

Summary: Analysis & Evidence

Policy Option 1

Description: Current System plus

FULL ECONOMIC ASSESSMENT

Price Base Year 2013	PV Base Year 2013	Time Period Years 25	Net Benefit (Present Value (PV)) (£m)		
			Low: 167	**High:** 647	**Best Estimate: 450**

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	19			19
High	19	1		19
Best Estimate	19			19

Description and scale of key monetised costs by 'main affected groups'

Transition costs totalling £19m arise from moving existing abstraction licences into a new system (e.g. converting licences into new permissions and establishing IT systems) and are passed through to businesses on a cost recovery basis by the regulator. Ongoing administrative costs (£21m NPV), driven mainly by telemetry have been netted off against administrative savings – these are captured in the admin cost savings category below.

Other key non-monetised costs by 'main affected groups'

None

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0		11	**186**
High	0	0	41	**666**
Best Estimate	0		29	**469**

Description and scale of key monetised benefits by 'main affected groups'

Businesses benefit from admin savings, access to high river flows and from abstraction licence trading. This increases profits ('gross margin') earned by non-public water supply businesses, e.g. from using water more efficiently, produce more output/ different, more profitable products (~£235m central PV). A more efficient allocation of water allows mainly public water supply businesses to change their investment profile ('adaptation benefits': ~£109m central PV). There are on-going admin cost savings (net of cost increases of £21m NPV, as indicated above) of ~£126m central NPV.

Other key non-monetised benefits by 'main affected groups'

No attempt has been made to monetise the benefits to the environment as all options (including the baseline) achieve the same environmental outcomes set in EU legislation. However qualitative assessments suggest that this option could improve how quickly and effectively these outcomes are achieved. The improved abstraction market should facilitate competition in the water industry and increase the economic benefits of upstream competition in England (estimated at £1.7bn).

Key assumptions/sensitivities/risks — **Discount rate (%)** 3.5

A key sensitivity of the results is to the different climate conditions. We have used a range of climate scenarios to represent the potential range of future climate conditions. Unintended risks from facilitating markets have been assessed and are not considered to require regulatory intervention.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			In scope of OITO?	Measure qualifies as
Costs: 0.6	**Benefits:** 15.4	**Net: 14.8**	Yes	Zero net cost

Summary: Analysis & Evidence

Policy Option 2

Description: Water Shares

FULL ECONOMIC ASSESSMENT

Price Base Year 2013	PV Base Year 2013	Time Period Years 25	Net Benefit (Present Value (PV)) (£m)		
			Low: 155	High: 600	**Best Estimate: 372**

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	23	1		**23**
High	23			**23**
Best Estimate	23			**23**

Description and scale of key monetised costs by 'main affected groups'

There are transition costs to government as a result of moving the existing abstraction licences into a new system totalling £23m when compared to the baseline. Water Shares is slightly more expensive to implement as it requires more extensive development of rules for pre-approval of trades, a system to predict water availability over allocation periods and more work in changing existing volumetric licences into shares. Ongoing administrative costs (£42 m NPV) have been netted off against administrative savings – these are captured in the admin cost savings category below.

Other key non-monetised costs by 'main affected groups'

None

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	0	0	11	**178**
High	0		38	**623**
Best Estimate	0		24	**395**

Description and scale of key monetised benefits by 'main affected groups'

Increases in business profits ('gross margin'~£206m central PV). A more efficient allocation of water, allows mainly public water supply businesses to change their investment profile ('adaptation benefits', ~£84m central PV). There are on-going administration cost savings (net of admin cost increases of £42m NPV) of ~£104m central NPV.

Other key non-monetised benefits by 'main affected groups'

No attempt has been made to monetise the benefits to the environment that result as all options, including the baseline, achieve the same environmental outcomes set in EU legislation. However qualitative assessment suggests that this option could improve how quickly and effectively these outcomes are achieved. The improved abstraction market should facilitate competition in the water industry and increase the economic benefits of upstream competition in England.

Key assumptions/sensitivities/risks — **Discount rate (%)** 3.5

A key sensitivity of the results is to the different climate conditions. We have used a range of climate scenarios to represent the potential range of future climate conditions. Unintended risks from facilitating markets have been assessed and are not considered to require regulatory intervention.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			**In scope of OIOO?**	**Measure qualifies as**
Costs: 0.8	**Benefits:** 13	**Net: 12.2**	Yes	Zero net cost

Summary: Analysis & Evidence

Policy Option 3

Description: Hybrid Option

FULL ECONOMIC ASSESSMENT

Price Base Year 2013	PV Base Year 2013	Time Period Years 25	Net Benefit (Present Value (PV)) (£m)		
			Low: 162	**High: 646**	**Best Estimate: 447**

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	23	1	0	**23**
High	23		0	**23**
Best Estimate	23		0	**23**

Description and scale of key monetised costs by 'main affected groups'

There are transition costs to government as a result of moving the existing abstraction licences into a new system totalling £23m when compared to the baseline. Hybrid Option is slightly more expensive to implement as it requires more extensive development of rules for pre-approval of trades, a system to predict water availability over allocation periods and more work in changing existing volumetric licences into shares. Ongoing administrative costs (£22m NPV) have been netted off against administrative savings – these are captured in the admin cost savings category below.

Other key non-monetised costs by 'main affected groups'

None

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	0	0	11	**185**
High	0		41	**670**
Best Estimate	0		29	**470**

Description and scale of key monetised benefits by 'main affected groups'

Increases in business profits (gross margin) (~£240m central PV). A more efficient allocation of water, allows mainly public water supply businesses to change their investment profile ('adaptation benefits' ~£105m central PV). There are on-going administration cost savings (net of admin cost increases of £22m NPV) of ~£124m central NPV.

Other key non-monetised benefits by 'main affected groups'

No attempt has been made to monetise the benefits to the environment that result as all the options are designed to achieve the same environmental outcomes set in EU legislation. However modelling results suggest that this option could improve how quickly and effectively these outcomes are achieved. The improved abstraction market should facilitate competition in the water industry and increase the economic benefits of upstream competition in England.

Key assumptions/sensitivities/risks **Discount rate (%)** 3.5

A key sensitivity of the results is to the different climate conditions. We have used a range of climate scenarios to represent the potential range of future climate conditions. Unintended risks from facilitating markets have been assessed and are not considered to require regulatory intervention.

BUSINESS ASSESSMENT (Option3)

Direct impact on business (Equivalent Annual) £m:			**In scope of OIOO?**	**Measure qualifies as**
Costs: 0.8	**Benefits:** 15.5	**Net: 14.7**	Yes	Zero net cost

Executive Summary

The problem

Water in rivers, referred to as surface water, and water in aquifers, referred to as groundwater, is a common property resource[1] and therefore needs a system of regulation to manage its use. This use, called abstraction, is currently managed by a licensing system set up in the 1960s.

The current abstraction management system, which regulates how water is taken from rivers and aquifers, is not flexible enough to cope with the challenges of climate change (likely to impact on supply), increased demand from a growing population, and the need to improve and at least not degrade our natural capital as set out in legislation such as the Water Framework Directive. This current system has become a regulatory failure in managing a public resource and essentially arises because many licences have been rigidly defined in volume terms and have inadequate links to actual and future availability, and can be slow and expensive to change or to trade.

We are already beginning to experience issues with water availability in some catchments, and this is likely to increase in future as pressure grows on water resources from climate change and a growing population. Reforming the abstraction management system is essential to avoid impacts on the economy and risks to the environment due to pressures on water ecosystems.

Policy objective

The UK Government's 2011 Water White Paper, Water for Life, set out a vision, direction and process to reform the abstraction management system to make it more responsive to future uncertainty and enable us to manage England's water resources more effectively. The UK Government is committed to introducing a reformed water abstraction management system able to promote resilient economic growth and protect the environment. By resilient economic growth we mean growth that is not unduly impacted by problems with water availability in the short and/or long-term.

In 2014 the Welsh Government issued a draft water strategy for consultation. It highlighted the challenges facing water resources in Wales and how a reformed abstraction management system could help ensure robust and resilient water resources which support healthy communities, the environment and green growth. Responses to the 'Making the Most of Every Drop' consultation on reforming the abstraction management system indicated broad support for reform of the system and evidence has shown how this will improve water availability and resilience. Following this the Welsh Government has confirmed its commitment to reform the abstraction management system.

Options

To meet the policy objective we developed initially two reform options which would improve the efficiency of the management system and better harness market forces. These were

[1] This is a natural resource which is limited, accessible by all and potentially exhaustible if free access is allowed to it.

consulted on in 2013-14 and taking into account consultation responses[2], have since been refined to include the development of a hybrid option which seeks to reflect valuable elements of both initial options.

The first option, **Current System Plus (CSP)**, takes some of the characteristics of the existing system, such as restrictions on abstraction when flows are low, but makes the system more flexible, responsive to water availability, fairer for abstractors and more supportive of trading. The latter allows some price signals to emerge and facilitates better allocation of water to high-value uses.

The second option, **Water Shares (WS)**[3], includes many of the elements of Current System Plus, but introduces a new share-based system which explicitly establishes abstractors' interest in a jointly managed variable resource and facilitates more extensive and shorter-term trading through the use of short-term allocations.

The third option, the **Hybrid Option (HO)**, also introduces the share-based system of Water Shares. This happens mainly in enhanced catchments[4]. In these catchments full water shares with short-term allocations is only implemented in a limited number of catchments where short-term allocations are most likely to deliver most benefits. This reflects our and some stakeholders' views[5] that introducing the shares framework could unlock significant potential to manage abstraction more flexibly, effectively and efficiently in some catchments. Fully utilising its potential for short-term controls is highly innovative but potentially complex, so needs to be trialled and refined. It may also not be appropriate for all types of catchments (e.g. ones that have highly variable flows). So under the Hybrid Option, most catchments would have annual controls on volumes and controls linked to flows in a similar way to the Current System Plus option but with the potential to adapt provided by the shares framework.

All options, including the current system, are designed to achieve consistent levels of environmental protection meeting statutory requirements such as in the Water Framework and Habitats Directives. The three reform options are designed to deliver these levels of environment protection more effectively and efficiently at lower costs to businesses than the current system. This is done through facilitating an integrated, risk based approach to reviewing abstraction permissions at a catchment level and removing the requirement to compensate abstractors in some circumstances

Methodology

Quantifying the costs and benefits of abstraction reform options is challenging as it requires:

- Understanding long-term future scenarios to take into account risks of future water scarcity both within the baseline and alternative options;

[2] See https://www.gov.uk/government/consultations/reforming-the-water-abstraction-management-system-making-the-most-of-every-drop

[3] Development of Water Shares has drawn on learning from a successful system in Australia taking into account the different conditions here.

[4] Enhanced catchments are those in which trades are pre-approved and improved links are made between access to water and flows – see page 7 for further explanation. Exactly where the shares framework is implemented will be decided as part of implementation.

[5] For example the Chemical Industries Association stated: '*Current System Plus will be more flexible but very similar to the existing system and shouldn't need a complicated transition. Water shares offers a novel and potentially engaging approach from a catchment wide perspective but is more complicated and needs more technical / IT resource…*'.

- Representation of complex trading rules and environmental protection processes linked to continuously varying water resources[6]; and
- Representation of short and long-term abstractor decision making on water management in the context of uncertainty.

To meet this substantial challenge we have developed combined "agent-based" behavioural and hydrological models of 10 representative catchments (6 making up the Trent and Derwent basin), running in daily steps between 2025 and 2050. In these models abstractor "agents" make short and long term decisions on water management, trading and investment, driven by economic and other factors, drawing on behavioural economics. The results from four of these carefully-selected case studies[7] have then been used to produce aggregated results at an England and Wales level. The six catchments that make up the Trent and Derwent have been used as a sensitivity test for these results due to modelling resource capacity constraints. The assessment examines impacts between 2025 and 2050 to take into account climate change impacts. A range of equally probable climate change and socio-economic scenarios have been used taken from previous Environment Agency work which are shown on the "x" axis in **Figure A** (see below)[8]. Further explanation of these scenarios can be found in the detailed methodology section (see page 36, section on Modelling the future).

The methodology, coding and outputs has been quality assured by a panel of expert independent external peer reviewers on an ongoing basis during model development; and has drawn on extensive interactions with stakeholders spanning over two years, drawing directly on their evidence to model agents in catchment models. The models have also been significantly developed and improved since the consultation impact assessment. Responses to the consultation focussed mostly on option design but there were also some comments on the impact assessment particularly on:

- Providing better information on sectoral impacts;
- Incorporating modelling of the Trent and Derwent; and
- Better estimating the impacts on water companies given their security of supply obligations.

We have sought to address these issues, in particular that latter issue through detailed close working with water companies and consultants facilitated by the UK Water Industry Research organisation including detailed case studies of potential impacts on water companies' security of supply[9]. As a result, we have changed how water companies' licences are transitioned in the reform options so their security of supply obligations are not affected.

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[6] The focus of quantifying costs and benefits are on water resources and flows rather than other aspects of water quality. It is assumed that reform does not have significant impacts on other aspects of water quality which are regulated under the Water Framework Directive.

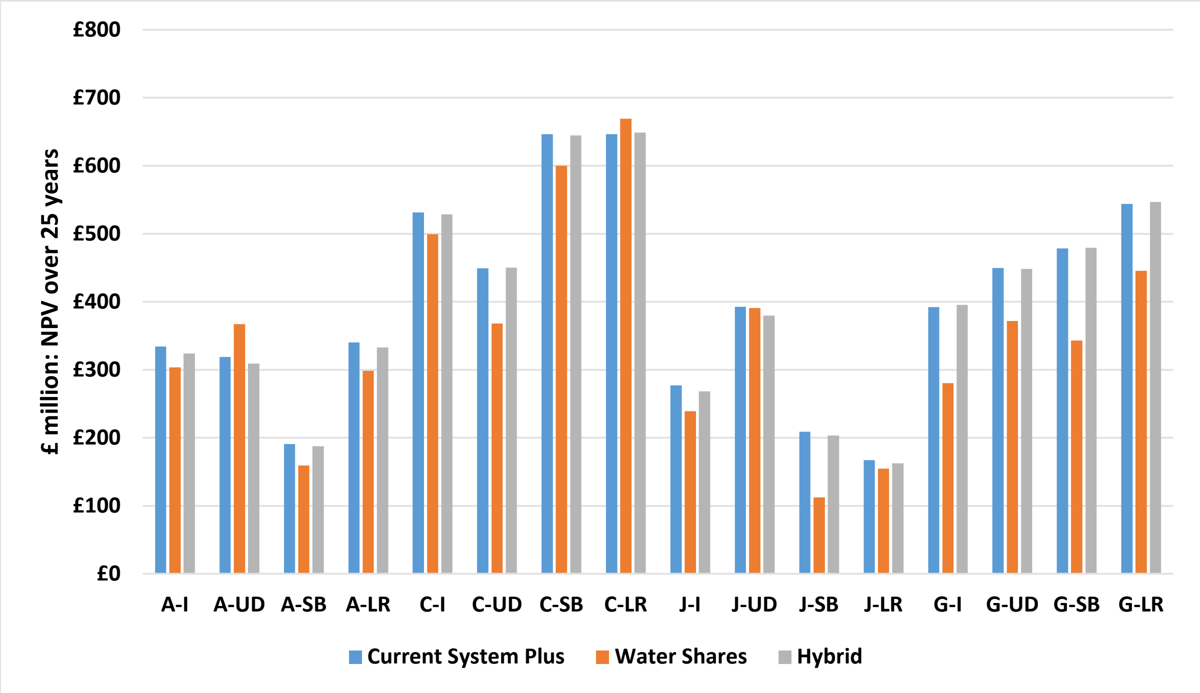
[7] The case studies were chosen by the project board to be representative of different regions and types of catchment in terms of the nature of abstractors and the balance between groundwater and surface water. The selection was based on analysis by hydrological and economic experts in the Risk Solutions consortium – see Annex A.

[8] Explanation of x-axis notation in figures A and B: **Letter before hyphen is climate change scenario**: A involves less significant change in climate (and hence flows); C, G or J involve greater changes in flows at different locations. **Letters after hyphen are socio-economic scenarios**: Innovation (I); Uncontrolled demand (UD); Sustainable Behaviour (SB); Local Resilience (LR) (**See page 36 for more on the scenarios**)

[9] UKWIR Report Ref 14/RG/08/7, Evaluating Abstraction Reform Proposals Phase 2 – Testing the Principles ISBN 1 84057 741 X.

Summary of costs and benefits

Figure A: Reform Net Benefits (£m NPV over 25 years) for England and Wales under different scenarios and options



Initial results indicate that the reform options provide net economic benefits compared with the current system in all scenario combinations ranging, in England & Wales, from about £100m up to about £650m net present value (NPV) over 25 years (see Figure A).

As can be seen in Figure A, benefits tend to be higher in climate change scenarios C and G as these, as well as being drier than the current climate, also contain more variable weather with some very dry periods when much of the benefits are generated as the reform options provide greater resilience to very dry periods. The A climate scenario is the least dry while the J scenario is reasonably dry but does not have many periods of very dry weather so benefits are lower in both these scenarios. Socio economic scenarios are less significant in driving variation in benefits as they have less effect on water availability than climate change scenarios. See page 37 for section on Modelling the future for further explanation of the scenarios.

Table A: Costs and Benefits for England and Wales for the central case, £m NPV

ENGLAND AND WALES		CSP	WS	HO
Costs	Transition costs to business	19	23	23
	TOTAL COSTS	**19**	**23**	**23**
Benefits/ Cost Savings	Change in production gross margin for business	235	207	240
	Administration cost savings for business	126	104	125
	Adaption cost savings for business	109	84	105
	TOTAL BENEFITS	**469**	**395**	**470**
NET PRESENT VALUE		**450**	**372**	**447**

[Note: due to rounding the combined figures do not always total precisely]

Table A provides a breakdown of the key cost and benefit categories. The benefit categories are driven mainly by the following factors:

- Change in production gross margin for business : increased profits to abstractors, mainly to industry and agricultural irrigators, particularly under more water scarce scenarios as they are able to achieve increased production mainly due to trading providing increased access to water and better access to high flows to fill reservoirs – ranging from £207m to £240m across the options in the central case;
- reduced administration costs for business (net of recurring admin costs ranging from £21m to £42m NPV across the three options) due to savings from more efficient regulatory systems, for example the need for fewer investigations – ranging from £104m to £126m across the options in the central case; and
- adaptation cost savings for business due to reduced or delayed water company investment due to changes in the pattern of regulatory interventions to protect the environment as the climate changes because water is used more efficiently – ranging from £84m to £109m across the options in the central case.

The transition costs to business relate to set up costs, ranging from about £19-23m. Water Shares and the Hybrid Option are more expensive due to the need for more complex systems.

Figure B: Low[10], central & high reform benefits (£m NPV over 25 years) for England & Wales by cost/ benefit category for all options.

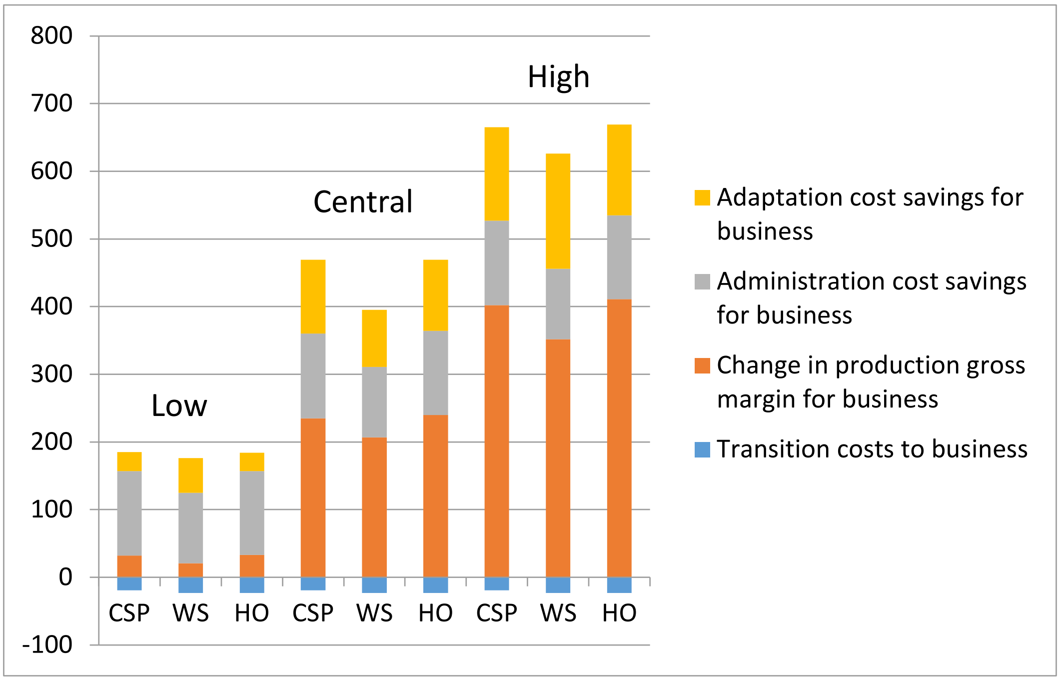


Figure B shows how these vary between the low and high scenario. The largest varying element is the benefit from changes in production gross margin to businesses, particularly in the low case. This is because in the high (low) scenario combination, the climate change scenario has longer very dry (less dry) periods, where there are greater (lower) benefits from trading.

Of the above benefit categories, benefits from reduced or delayed water company investment ('adaptation cost savings') are subject to the greatest uncertainties: They are highly variable and sensitive to the specific nature of particular catchments and water companies' investment options under different climate change and socio-economic

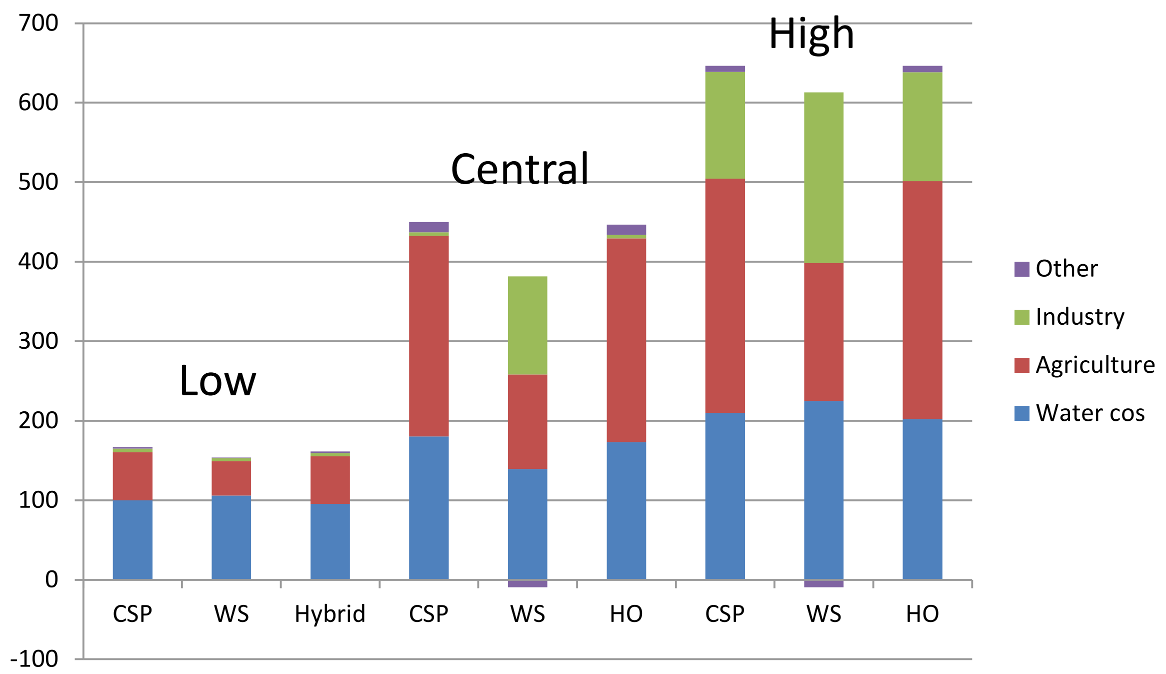
[10] Note the low case is chosen on the basis of the lowest value for the preferred option, the hybrid option. Under this scenario WS is not at its lowest value.

scenarios. Hence they are the most difficult to aggregate from our catchment case studies. In the central case, these benefits constitute around 25% of the overall benefits. As can be seen in Figure B, net benefits remain across all scenarios if these benefits are removed ranging from about £100m to £500m NPV over 25 years.

Figure C breaks net benefits down by sector:

- Agriculture is the main beneficiary across all options as they are generally most able to benefit from trading due to the varying seasonal need for water;
- Water companies and by extension their customers benefit most from adaptation cost savings due to their reduced costs of meeting their statutory obligations to provide security of supply; and
- Industry tends to benefit mainly in climate change scenarios with very dry conditions (which form the basis for the 'high' scenario) when small amounts of trading give them substantial benefits.

Figure C: Reform Net Benefits (£m NPV over 25 years) for England and Wales by sector[11]



For all three reform options (Current System Plus (CSP), Water Shares (WS), and the Hybrid Option (HO)),components to better link abstraction to flows and facilitate trading will only be introduced in catchments where there are clear economic benefits from the potential for trading. Trading will only deliver benefits where:

- there are constraints on available water so abstractors have to trade to access water rather than seeking available water from the regulators; and
- there are a range of abstractors willing to trade (e.g. agricultural irrigators).

Catchments that meet this criteria are labelled as '**enhanced catchments'**. This means that much of the benefit of reform will only be seen in the enhanced catchments. It also means

[11] Note the low case is chosen on the basis of the lowest value for the preferred option, the hybrid option. Under this scenario WS is not at its lowest value.

that some elements of administration systems such as smart meters and rules for pre-approval of trading will only exist in enhanced catchments.

Catchments that do not show clear economic benefits for enhanced reform will undergo basic reform only (e.g. introduction of the system of reviewable permits). These are labelled as '**basic catchments'**.

As the climate changes, the number of enhanced catchments delivering benefits is likely to increase. More detail on the differences between basic and enhanced reform is provided in the detailed description of the reform options in Annex B.

The administrative costs of operating the "basic" reformed water abstraction management system are lower than it is under the current system. The costs of implementing Enhanced reforms to allow trading are higher than Basic reforms and will only be introduced where the benefits of trading are expected to outweigh the costs in 50% or more of combined socio-economic and climate change scenarios. Under this approach, about 30% of catchments in England would be initially enhanced with about 10% becoming enhanced in 2037. This does vary somewhat between option (see Table 4 on page 44).

In general, when the financial benefits associated with enhanced catchments are high for a particular sector of the economy in the catchment models, these become the dominant contributors to the overall NPV figures estimated by the Aggregation Model. When the financial benefits are marginal, it is the administrative cost savings that become more significant.

In Wales, the case is less clear as initially no catchments are enhanced until 2037 when there is one enhanced catchment under water shares and the hybrid option. Wales does get immediate benefits of moving away from the current system of individual investigations, potentially involving a requirement to compensate abstractors for any losses due to variations in licences, to a more efficient and effective catchment review approach. There are also administrative cost savings of reforming the system. Furthermore in the future, reform would allow Wales to introduce enhanced catchments, which could become beneficial under climate change scenarios not anticipated in our modelling. More detailed studies may also justify enhancement of some catchments as this impact assessment only represents a broad assessment.

The modelling to date suggests there is no significant difference in benefits between the reform options. However, necessary simplifications in the model may be leading to some under-reporting of the level of trading that might be expected under Water Shares as 'put and take trading'[12] is not represented. A relatively small increase in the benefits of trading under Water Shares would make it the option with highest benefits in a number of scenario combinations particularly where water is scarce. These benefits would also be possible under the Hybrid Option operated with short-term allocations. It is not possible to determine at this stage how significant this effect is. The benefits of upstream trading for the Hybrid Option have also not been estimated further underestimating the benefits of the hybrid option.

Many of the benefits are driven by improved facilitation of trading and we are aware that some stakeholders are concerned about unintended consequences of markets. We have therefore systematically assessed the risk of market distortions and unintended impacts (e.g. from dominant market participants) and have concluded with Ofwat that regulatory intervention is not required (see Annex F).

[12] Where water is released from reservoirs or re-use schemes into rivers to be traded with others which is only facilitated by short-term allocations.

Non-monetised

No attempt has been made to monetise the benefits to the environment as all options, including the baseline (current system), are designed to be consistent with and support the achievement of the water quality objectives as set out in the Water Framework Directive and Habitat Directive. Reform options are designed to more efficiently and cost effectively protect the environment through:

- changing licensed quantities on implementation to reduce risks to the environment from currently underutilised licences being used in the future;
- introducing a more systematic, fairer and cost-effective approach of catchment reviews to protect the environment; and
- for the hybrid and water shares options, introducing the potential of short-term allocations to better manage water in appropriate catchments[13].

See Annex B for more detailed description of the reform options.

However the modelling has not been able to distinguish between the options in terms of their environmental benefits due to the complexity of the systems and challenges in modelling a complex environmental review process.

All options provide effective mechanisms to adapt given the uncertainty of climate change risks through the potential to change basic catchments into enhanced catchments as such a change becomes potentially beneficial. The hybrid option provides further potential adaptation benefits as it can operate in a manner similar to current system plus or with short-term allocations similar to water shares where this is beneficial.

There are also wider potential benefits that should be greater under the hybrid and water shares options due to the introduction of the shares framework and the more extensive abstraction market they potentially facilitate. Introducing shares establishes the principle that water resources in catchments are a shared resource which should encourage careful management on a catchment basis. Shares also create a more secure asset than reviewable permitted volumes[14] as they provide more certainty and better facilitate business planning as recognised by stakeholders such as Anglian Water. A more extensive abstraction market should facilitate competition in the water industry and increase the economic benefits of upstream competition in England (estimated at £1.7bn without abstraction reform)[15]. Businesses may also be able to diversify their income by developing a business in water management through investing, for instance, in reservoirs. There are also likely to be benefits to non-abstractors and the rural economy from more efficient use of water.

However the risks, in terms of delay and cost, involved in implementing water shares are the highest as this involves implementing a highly innovative approach to water management in all enhanced catchments. This has only been implemented in Australia under different conditions. The hybrid option reduces these risks of implementation by only using short-term allocations in a small number of catchments.

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[13] Catchments where flows in rivers are lower changing due to strong connections with groundwater are likely to benefit from management with short-term allocations while fast changing or flashy catchments are probably better protected with fast responding flow based controls on abstraction known as hands off flows.

[14] Annual permitted volumes may need to be changed to better protect the environment but there is less likelihood that shares would need to be changed as their related allocations can be changed if necessary to protect the environment. Hence shares can be seen as a more reliable asset.

[15] http://www.parliament.uk/documents/impact-assessments/IA13-19N.pdf

Summary conclusion

All reform options deliver benefits compared to the current system under all scenarios (see Figure A) even if the less certain benefits from changes in water company investment patterns are excluded. Current system plus and the hybrid option generally give greater benefits than water shares (see Table A for the central case). However this is probably not significant given the limitations of modelling. In particular there is a tendency for the model to over-estimate the benefits of trading in the current system plus compared with water shares and the hybrid option. Water shares tends to provide greater benefits than current system plus in more challenging climate change scenarios which would be more significant if the trading bias was removed. However water shares also poses the greatest implementation risks while the hybrid option has the flexibility of implementation to reduce risks.

Our preferred option therefore is the hybrid option as it:

- has the potential to operate in a similar manner to current system plus where that system is most economically and environmentally beneficial, while due to the creation of the share accounting framework in enhanced catchments, it can also facilitate upstream trading thereby increasing benefits over current system plus;
- has the potential to operate in the 'full' water shares mode with short-term allocations increasing trading possibilities, particularly where 'put and take' trading could be widely used;
- creates shares in water recognising the essentially shared nature of this resource encouraging water efficiency and collaborative catchment management, while also creating a more secure asset in a share than a reviewable permitted volume; and
- it has reduced implementation risks compared to full water shares as the more innovative elements will only be used initially in a small number of catchments to trial them and optimise their benefits.

The Hybrid Option has a slightly lower NPV than CSP: given the underlying model mechanics we think this is within the margins of uncertainty, with benefits potentially understated for the reasons outlined above. Overall the hybrid option by introducing, where appropriate, the new shares framework provides the most adaptive option while minimising implementation risks compared to the water shares option.

One-In-Two-Out Methodology

Overall these options maintain the same environmental standards as the current system, while reducing the regulatory burden on business in achieving those standards, so although they introduce regulatory change, they actually deliver direct business savings compared to the baseline [across all of our scenarios] and so they are an 'IN' with 'zero net cost' as with the consultation impact assessment. The main sources of savings due to the reforms are:

- reduced/delayed water company investment due to changes in the pattern of regulatory interventions; and
- increased profits to other abstractors, mainly agricultural irrigators, as they are able to achieve increased production mainly due to trading and better access to high flows to fill reservoirs.

Water company investments are in water resource development (e.g. reservoirs, leak reduction, re-use schemes etc) to meet their security of supply obligations to customers. A direct result of the reform options is to reduce environmental interventions to take back water access from water companies. Water companies are thus, able to delay or reduce the level of these investments while still meeting their security of supply obligations. Hence they need to do less to meet their statutory obligations under reform.

The reform options all directly facilitate trading. This is a regulatory change which is permissive in nature as abstractors are not forced to trade. We assume that abstractors will only enter into a trade if it is cost-beneficial to them. We have included elements from behavioural economics in the results, such as inertia, which ultimately assumes not everyone is rational which will limit the amount of trading that occurs, hence our estimates are conservative.

The profits from trading and savings from delayed/lower investment ('adaptation benefit') have been quantified and included in the one-in-two-out analysis.

Administration costs to business arise mainly from regulatory activity costs fully recharged to business. There are total set up costs for the system of about £19m NPV for CSP and -£23m NPV for WS and HO which are dominated by the costs of changing current licences into new permissions under the reform options. There are total ongoing admin costs to business (£21m NPV for CSP/£22m NPV for HO; and £42m NPV for WS). These ongoing costs have been netted off against the ongoing savings in administration costs which are more significant (around £147m NPV for CSP and HO) The main driver of these savings (80% of total savings) is due to reduced costs of protecting the environment due to:

- Fewer permissions needing to be investigated as the removal of unused licensed water at transition will significantly reduce the potential for them to pose risks to the environment; and
- More efficient and effective processes for changing permissions through integrated catchment reviews rather than individual permission investigations.

These costs and savings are direct and included in the one-in-two-out analysis.

The net benefit to business was calculated using the latest BIS impact assessment calculator[16] to derive the Equivalent Annual net cost to business (EANCB) in 2009 prices. Table B shows that businesses can achieve a cost saving in England under all three reform options under the best estimate. Note that a minus sign preceding figures denotes a cost saving/benefit.

[16] https://www.gov.uk/government/publications/impact-assessment-calculator3

Table B: Net cost to business per year best estimates (EANCB on 2009 prices) (£m)

ENGLAND		CSP	WS	HO
Costs	Transition costs to business	0.7	0.8	0.8
	TOTAL COSTS	**0.7**	**0.8**	**0.8**
Benefit category	Change in production gross margin for business	-7.2	-6.8	-7.9
	Administration cost savings for business	-3.9	-3.4	-4.1
	Adaptation cost savings for business	-4.3	-2.8	-3.5
	TOTAL BENEFITS	**-15.4**	**-13**	**-15.5**
EANCB		**-14.8**	**-12.2**	**-14.7**

[Note: due to rounding the combined figures do not always total precisely]

The One-in-Two-Out approach to regulation is not the policy of the Welsh Government and applies only In England, however a reformed abstraction licencing regulations will be easier to access and understand for users, as well as resulting in a fairer system for all businesses in Wales, improving our regulatory approach.

Next steps

The UK Government has developed a shared approach to abstraction reform with the Welsh Government. The UK Government is committed to implement reform of the current abstraction licensing system in England by the early 2020s. We will continue to work closely with our Welsh counterparts moving towards implementation.

Contents

Problem under consideration

Individual and industrial abstraction

1. While most individuals and businesses obtain water via the public water supply, many others rely on access to untreated water abstracted directly from the environment. This water can come from surface water, such as rivers, or from groundwater, in aquifers. Abstracted water is significantly cheaper than treated public water supplies and can provide large volumes of water where it is needed.

2. Examples of abstractors include farmers who use water for irrigating crops, manufacturers and industry who use water for processing products and power generating companies who use water for cooling. Reliable access to water supports economic growth and investment in many sectors.

3. In Table 1 and Table 2 abstraction varies between sectors (respectively for England and Wales) both in volumes used and numbers of licences. The largest abstractor group from freshwater is water companies. The largest numbers of licences are found in spray irrigation, which is mostly agricultural, however they have some of the smallest volumes actually abstracted.

4. Different uses also return (discharge) different proportions of the water originally abstracted back to the river. The proportion of water lost is known as consumption. Consumption of water impacts how much is available for other abstractors and the environment. Different sectors use water differently and return different proportions of what they take[17]:

- Sectors such as hydropower and fish farming are almost totally non-consumptive returning nearly all water back very close to the point of abstraction;
- Industry (including power sector freshwater abstraction) returns substantial amounts close to the point of abstraction although varying amounts are lost to evaporation in cooling or incorporated into products;
- The Public Water Supply returns much of what is abstracted but generally at substantial distances from the point of abstraction often into the sea, transporting water through their supply networks and the sewage system; and
- Irrigators consume all of their water without discharging any directly back to rivers.

[17] Please note that all returns of water are subject to water discharge regulation to ensure water quality standards are met.

Table 1: Abstraction by sector in England 2011 from freshwater (million m^3)[18]

Licensed purposes for each category			Abstraction from all sources except tidal			
	Number of Licences[19]	%	Actual Volume	%	Licensed Volumes[20]	%
Electricity (thermal)	177	0.9	208	2.4	531	2.2
Hydropower	232	1.2	1,225	14.2	9,790	41.4
Public water supply	1,455	7.4	5,173	59.9	8,196	34.6
Other industry	3,541	17.9	1,068	12.4	2,832	12.0
Fish farming, cress growing, amenity ponds	627	3.2	808	9.4	1,728	7.3
Spray irrigation	9,723	49.2	116	1.3	329	1.4
Other	198	1.0	0	0.0	125	0.5
Agriculture (excl. spray irrigation)	2,818	14.3	25	0.3	91	0.4
Private water supply	981	5.0	9	0.1	37	0.2
Total	19,752	100	8,632	100	23,659	100

[18] Source: Environment Agency.

[19] *Number of licenses includes those relating to surface water, ground water and tidal water.*

[20] Some l*icensed volumes are estimated based on the ratio of actual abstraction to total licensed volumes for all sources.*

Table 2: Abstraction by sector in Wales 2011 from freshwater (million m^3)[21]

Licensed purposes for each category			Abstraction from all sources except tidal.			
	Number of Licences[22]	%	Actual Volume	%	Licensed Volumes[23]	%
Electricity (thermal)	15	1.0	2	0.1	16	0.2
Hydropower	95	6.2	2,467	76.6	5,712	75.5
Public water supply	162	10.6	655	20.4	1,129	14.9
Other industry	355	23.2	54	1.7	534	7.1
Fish farming, cress growing, amenity ponds	58	3.8	39	1.2	112	1.5
Spray irrigation	607	39.7	1	0.0	9	0.1
Other	12	0.8	0	0.0	37	0.5
Agriculture (excl. spray irrigation)	174	11.4	1	0.0	4	0.1
Private water supply	50	3.3	0	0.0	11	0.1
Total	1,528	100	3,219	100	7,564	100

5. The tables show the number of licensed purposes (some licences may have more than one purpose) and volumes licensed and used by the different sectors from freshwater sources. They set out gross abstraction and do not take into account how much these sectors consume. Overall, there are around 19,500 licences[24].

6. The number of licences will soon increase significantly. The New Authorisations project aims to bring a variety of abstractors, who are currently exempt, into the abstraction management system. This includes activities like dewatering of quarries, transfers into canals, some types of irrigation and abstractions from groundwater in areas that are currently exempt. Around 4,500 abstractors in England and 500 abstractors in Wales will be brought into the licensing system and it is intended that this will happen before transition to the new abstraction regulation system. This will be subject of a separate impact assessment.

Environmental protection

7. Water abstraction can significantly affect water flow and levels. In rivers, this can have an impact on the quality and type of habitat; the amount and type of sediment that is carried in the water and where it is deposited; and on water quality (temperature, dissolved oxygen, dilution of pollutants, and residence time of chemicals). In aquifers, abstraction can affect the availability of water for wetlands and rivers, damaging the environment or allowing saline intrusion. Saline intrusion, where saltwater is able to flow into freshwater aquifers due to a loss of pressure, can damage the environment and contaminate drinking water supplies. Depending on the sector, much of the water abstracted is returned to surface water.

[21] Source: Environment Agency.

[22] Number of licenses includes those relating to surface water, ground water and tidal water.

[23] Some licensed volumes are estimated based on the ratio of actual abstraction to total licensed volumes for all sources.

[24] Some licences can have more than one purpose so our counted separately.

However, there can be substantial changes in flow patterns, as abstraction and discharge can be substantial distances apart, leaving depleted river reaches and lowered groundwater levels.

What challenges are we facing?

8. Regulating water abstraction efficiently and effectively is likely to become more difficult in the future as the UK faces substantial challenges from changing climate and the possibility of increasing water demand. We already face challenges in water availability. Many catchments have no spare water that can be allocated for abstraction due to it already being allocated to others and a need to protect the environment - in some locations abstraction is harming nature conservation sites or the ecological health of catchments.

> **Box 1: Water Framework Directive.**
>
> The Water Framework Directive (WFD) requires Member States to prevent deterioration in the status of water bodies and aim to achieve good ecological and chemical surface water status and good chemical and quantitative groundwater status by 2015. Good ecological status indicators for surface waters include Environmental Flow Indicators which are used to assess whether the quantity and variation of the flow of water in a river are sufficient to support healthy biodiversity and habitats. Groundwater abstraction needs to be balanced with recharge to maintain its chemical quality and surface waters and habitats. No deterioration is the key standard for ongoing management of water, where the ecological status of a water body shouldn't be allowed to get worse.

9. Currently the Environment Agency and Natural Resources Wales are investigating about 335 licences in England and 26 in Wales where there are significant risks that abstraction is damaging important conservation sites including Natura 2000 sites and Sites of Special Scientific Interest. Following previous investigations, a total of 107 abstraction licences in England and 43 in Wales have already been changed to protect Natura 2000 sites. Abstraction pressures are instrumental in the failure of some water bodies to meet EU Water Framework Directive obligations on good ecological status (GES) - see Box 1. The impacts of abstraction may be causing or contributing to the failure to support GES in up to 11% of river water bodies in England[25] and 2% of water bodies in Wales[26]. This pressure on the environment combined with the level of water already allocated to abstractors means that there is limited reliable water available for new abstractors. This impacts on the ability of new businesses to start up that need access to water therefore potentially impacting on economic growth. The Environment Agency's Case for Change[27] states that at present, a quarter of water bodies in England and seven per cent of water bodies in Wales can no longer provide a reliable source of water for new consumptive abstraction. This is because these water bodies can only provide water for new abstractions 30 per cent or less of the time.

10. Problems with water availability could have impacts on economic growth, reducing economic activity in the short-term and reducing economic opportunities in the long-term.

[25] Abstraction and Flow Problem: Significant Water Management Issues , Environment Agency (2013) http://www.geostore.com/environmentagency/Abstraction_and_Flow_Technical_Summary_v1_external.pdf

[26] Living Waters for Wales – Supporting Information for Wales Challenges & Choices Consultation http://naturalresourceswales.gov.uk/our-work/consultations/list-of-current-consultations/challenges-and-choices-consultation/?lang=en

[27] The Case for Change – current and future water availability. Environment Agency (2011): Report No: GEHO1111BVEP-E-E

For instance, 20% of electricity generation depends on abstracted freshwater[28] and problems in water availability could affect the affordability of electricity. A wide range of other industries rely on abstracted water, particularly the chemical, metals, paper and food & drinks industries, with the main use being process cooling. Droughts can result in reduced yields or even losses of crops such as potatoes for farmers, which can be very costly, particularly for small businesses.

11. The Environment Agency's Case for Change has provided the main source of evidence for the future challenges we face- see Box 2.

[28] Environment Agency, 2013, Energy and Water: Key Facts https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297281/LIT_8990_7a4691.pdf

Box 2: Case for Change

The Environment Agency developed its *Case for Change: current and future water availability* report in 2011 in support of the UK Government's Water White Paper. It set out current evidence on the availability of water now and in the future. It includes a range of projected futures, based on different climate change, environmental and socio economic scenarios. In understanding the potential range of futures we can begin to understand the risks for future water availability.

The analysis uses four socio-economic scenarios, of possible future water demand and describes what this means for future water availability under four climate change scenarios. The socio-economic scenarios look at futures where water demand is set in the context of sustainable behaviour, local resilience, innovation or uncontrolled demand. The four climate change scenarios were selected to cover a reasonable range of scenarios from a larger set in a national assessment of changes in river flows and groundwater levels up to the 2050s. The analysis also takes into consideration different levels of environmental protection involving different assumptions on the water flow requirements for future environmental protection.

The Case for Change analysis of 2050 water availability has been updated in 2013 to include the recently developed projections for water demand relating to the electricity generation sector. It also includes refreshed demand forecasts relating to the agriculture sector, industry and commerce sectors, and household. The analysis now includes an additional environmental protection scenarios relating to Water Framework Directive principle of 'no deterioration'.

The refreshed 2013 case for change concludes that:

- Changing lifestyles and an increase in population could have a substantial impact on demand for water. By the 2030s, the total population of England and Wales is expected to grow by an extra 9.6 million people, rising to 15 million by the 2050s, so despite forecasts of reductions in per capita consumption as a result of recent demand management initiatives by water companies, overall use is likely to grow although the range is from 28 per cent lower to 49 per cent higher than today in 2050
- The climate change scenarios predominantly show decreases in summer flows through the UK, but range from +20 per cent to -80 per cent.
- The combined impacts of climate change and increases in population show there are significant risks of less water available for people, businesses, agriculture and the environment than today.
- The challenge of future water resource availability is not likely to be limited to the south and east of England. Catchments across Wales, south west and northern England are predicted to experience significant unmet demand under many of the scenario combinations.
- As the severity of pressures on water resources may vary across England and Wales, the approach for managing them will need to be adaptive and flexible.

Rationale for intervention

12. The licensing system created under the Water Resources Act 1963 evolved with the introduction of the Water Resources Act 1991 and the Water Act 2003. The Water Act 2003 introduced time limits for all new licences and deregulated around 20,000 licences not exceeding 20m^3/day. It also provided mechanisms to make trading easier, and a greater focus on efficient and sustainable water use. However, these changes mainly affected licences granted after their introduction, leaving many older licences unchanged.

13. Even with these changes, as our understanding of the water environment has developed, it has become clear that this system has weaknesses and government intervention is needed again to address remaining regulatory failures from the initial set up. In economic terms, there can be **negative externalities** inherent in water abstraction from a common property resource. This means the private costs of abstraction to an individual abstractor can be less than the social costs, in terms of damage to the environment or lack of availability to other users. The licensing system is an attempt to "internalise" these externalities through regulation, but this is not being done effectively or efficiently.

14. The weaknesses of the current system (set out below) may constrain economic growth due to reduced resilience and getting less economic value from water while increasing risks to the environment. This effect will become increasingly important as the climate changes and population grows increasing pressures on our water resources.

15. **The current system does not systematically link access to water to the volume available for abstraction in rivers**, to control the negative externalities of abstraction when availability is low. Only some licences, generally newer ones, have flow-based limits on abstraction, called Hands Off Flows (see Box 3). The system also does not generally allow higher flows, where there may be additional water, to be abstracted. This is particularly true for those with winter licences who cannot use periods of higher flows in the summer to fill reservoirs, a particular issue in the recent 2010 – 2012 drought. Discharges also are often not accurately accounted for so cannot always be relied upon and exploited by those downstream.

Box 3: What is a 'hands off flow'?

A hands off flow or HOF is a regulatory condition applied to abstraction licences which requires abstractors to stop abstracting when the flow in a river drops to a certain point. They are mostly crude, 'on-off', controls which mean that abstraction must be ceased entirely once flows have dropped below a certain level. Hands off levels can be used in the same way but related to levels rather than flows.

16. **The current process to change most licences that cause damage to the environment is expensive and time consuming.** Most licences have no expiry date. To change the conditions of licences which are not time-limited the regulator (Environment Agency or Natural Resources Wales) has to follow a slow and expensive regulatory process. In the Case for Change, it was noted that enforcing a licence change "from investigation to issue of a licence change, can take at least two years and cost between £50,000 and £100,000 per scheme in staff time and legal costs"[29]. This means that reducing current unsustainable abstraction is time consuming and expensive, and will become more so. As the climate changes and flows potentially reduce, more licences are likely to require changes, making this problem much worse. The cost of compensating abstractors for changing their licences is currently funded by other abstractors, meaning the costs for other abstractors could also increase in the future.

[29] Environment Agency Case For Change-Reforming Water Abstraction Management in England, pg 20

17. The current system does not facilitate trading of access to water and so does not provide price signals to promote efficient water management, nor facilitate efficient allocation of water rights. At present there is little trading or sharing of licences to abstract (see Box 4). This is due to complexity in the current system which increases the cost and time taken to trade. As a result, there are no price signals to inform decisions about trading or investing in water efficiency, as an alternative to abstraction, and infrastructure such as reservoirs to build resilience. The charges for abstracting water are generally administrative, and not linked to actual use. As such, they do not incentivise efficient water management. Neither does the current system allow efficient allocation of licensed volume. In some catchments, much of the water that is licensed is not actually used. But because abstractors are licensed to use that water, the Environment Agency and Natural Resources Wales cannot make it available to someone else. So for instance, only around 40 per cent of licensed volume for freshwater in England and Wales was actually abstracted in 2011 (see tables 1 and 2).

Box 4: Trading

It is currently possible for holders of abstraction licences to trade their rights to water. To do so, they must enter into a commercial private transaction, between licences in hydrologically linked water bodies, generally in the same catchment and subject to approval from the regulator. The trade actually happens through the seller applying for a variation in their licence and the buyer applying for a similar level of variation or a new equivalent licence in a different location. The regulator will investigate the potential environmental impacts of any such trade before agreeing it. Between 2003 and 2014 there have been 61 trades, with the main traders being agricultural irrigators in East Anglia.

The Environment Agency and Ofwat commissioned work in 2009 to assess if there were any unnecessary barriers to trading in abstraction licences. One identified barrier was confusing rules, which prompted the Environment Agency to publish new guidance. The EA continues to work on simplifying and encouraging trading in the short-term. However, some of the complexity is due to the nature of the current system and reform of this system presents the greatest opportunity to simplify trading.

18. **The system fails to incentivise abstractors to manage risks from climate change at least cost.** Under the current system abstractors pay into a fund used which is used to compensate a small number of licence holders who suffer a loss when they have their licences changed by the regulator to make them sustainable. This approach may be able to deal slowly with the legacy of unsustainable abstraction, but it does not encourage abstractors to invest and proactively manage their own risks. This actually creates a disincentive to adapt to climate change.

19. These weaknesses significantly affect England and Wales's ability to address the future challenges of water availability. There is a clear rationale for intervention to correct the failings of the current system and future proof abstraction regulation. Without this, England and Wales face the following risks:

Impacts on economic growth particularly due to a lack of resilience to issues with water availability

- Access to water at high flows may be unnecessarily limited mainly in agriculture, reducing water availability that could be stored to build resilience to water availability issues;
- A lack of ability and incentives to make more efficient use of water and trade water may reduce the economic value derived from water resources, prevent new market

entrants from accessing water and reduce investment in infrastructure to improve resilience to underpin economic growth.

- Cumbersome and slow processes to change most licences on the one hand and on the other hand uncertain time-limited licences may undermine the ability of businesses to plan and invest.

Risks to the environment

- Delays in resolving unsustainable abstraction and a lack of controls on abstraction when flows are low will increase risks to the environment particularly as the climate changes.

Lack of adaptive capacity

- This inflexible system will not be able to respond effectively to longer-term uncertain changes in climate and population while not providing incentives for abstractors to invest to adapt and manage their risks from climate change.

With unfair impacts

- The system will become increasingly unfair, with newer abstractors generally facing the greatest impact from problems with water availability as they will be the ones with time-limited licences, while historic licences locked up unused water.

High administration costs

- The system will become increasingly expensive to administer, particularly due to the increased need for investigations into potential environmental damage due to abstraction as the climate changes.

Policy objectives

20. The UK Government initially committed to reform of the abstraction management system in the Natural Environment White Paper published in June 2011 and then set out the proposed direction, principles and process for reform in the Water White Paper[30] in December 2011 (see Box 5). We are committed to introducing a reformed water abstraction management system able to promote resilient economic growth while at the same time protecting the environment, which is adaptable to future climate change. By resilient economic growth we mean growth that is not unduly affected by water availability problems.

21. The same abstraction management system is in place in Wales. Although many of the water resources in some parts of Wales are not currently as stressed in the same way as some of those in England, the potential pressures are the same. The Welsh Government has therefore agreed the need for reform in Wales.

Box 5: The Water White Paper vision

A reformed abstraction regulation system should:

- Give clear signals and regulatory certainty on the availability of water, to drive efficient investment to adapt to climate change and meet water needs;
- Better reflect the value of water to customers, its relative scarcity, and the value of ecosystems services to ensure our rivers, lakes and aquifers are protected;
- Reflect the benefit of discharges to river systems;
- Drive efficiency in water use, using market forces and smart regulation to lower costs and reduce burdens;
- Be fair to all abstractors, taking into account current licences;
- Be flexible and responsive to changes in supply and demand, including providing greater access to water when more is available; and
- Meet our water needs for people and the environment at least cost to water bill payers, and the consumers of other products and services which depend on water.

Detailed objectives

22. Over the policy development period, we have developed detailed objectives building on the Water White Paper vision (Box 5), and informed by our policy development and evidence gathering.

Promoting resilient economic growth

- Water availability is linked to water flows, taking into account discharges, to maximise water available particularly for storage to create resilience.
- Trade is facilitated to maximise the economic value from available water, encourage water efficiency, allow new entrants access to water and incentivise investment in infrastructure to deliver resilience to underpin economic growth in the face of future uncertainty.
- The system for setting water availability over the short and long-term is transparent and provides reasonable certainty for abstractor business planning.

[30] Water for Life, Defra 2011

While protecting the environment

- Water ecosystems are protected to meet legal requirements through linking water availability to water flows and reviewing water availability regulation over the longer term, taking into account discharges.
- Initial abstraction permissions on reform do not create risks of environmental deterioration.

In a manner that is fair

- No groups are unfairly discriminated against including potential future abstractors.
- Current licences and actual abstraction are taken into account in providing initial abstraction permissions on reform.

And adaptable to future uncertainty

- Abstraction management is able to respond as water availability changes over the longer-term.
- Abstractors face incentives to manage risks from and adapt to climate change efficiently.

With reasonable administrative costs

- Costs of regulatory transactions are minimised.
- Regulation is risk based.

Description of options considered (including do nothing)

23. This section summarises the process of developing the options, and the options themselves. Further details can be found in Annexes A and B.

Options development

24. The process for gathering evidence to develop options for this policy has been extensive. It started following the publication of the Water White Paper in December 2011[31] and was managed by Defra and the Environment Agency.

25. Project oversight and governance has been provided by the following bodies:

- A project board comprising personnel from Defra, Welsh Government, Environment Agency, Natural Resources Wales, Natural England and Ofwat; and
- The Abstraction Reform Advisory Group (ARAG) comprising representatives of abstractors from a wide range of sectors across England and Wales. A list of members can be found in Annex C with related information in Annex A.

26. During the options development phase, a wide range of research was commissioned in order to design the options for assessment. This included exploration of international best practice and market development and regulation. Following the options development work we arrived at 3 options: the current system, the current system plus enhancements ("current system plus") and the "water shares" approach.

27. Following an extensive series of workshops with stakeholders, we held a formal consultation on these options which closed in March 2014.

28. The main directions of reform were supported in the consultation[32]. Key themes included:

- Support for the principle of linking water abstraction to water availability;
- Agreement from many that quicker and easier trading would benefit abstractors;
- Broad agreement that there should be a more consistent approach to making changes to abstraction conditions;
- The importance of defining how much water is "available"; how we use the Environmental Flow Indicator (EFI) and the need for site-specific understanding of environmental requirements; and what exactly constitutes the high flows which would be available for additional abstraction;
- The importance of a guaranteed water supply to a range of businesses, and the impact on business planning of the perceived uncertainty arising from these proposals;
- Concerns about the process of moving to a reformed system, particularly around licensed volumes;
- The need for further information on how abstraction of groundwater would be linked to availability in a new system;

[31] Water for life, Defra, (2011)

[32] See https://www.gov.uk/government/consultations/reforming-the-water-abstraction-management-system-making-the-most-of-every-drop

- The need for clarity on how these proposals interact with drought management; and
- Reasonable support for the concept of having basic and enhanced catchments, though some respondents.

29. Of those who expressed a preference, a majority supported current system plus and many indicated worries about the feasibility of water shares.

30. These views have fed into further refining the options and also developing the Hybrid Option which seeks to combine the better aspects of the current two options.

31. Further details of the options development process can be found in Annex A.

The options

32. These options have been developed and specified for the purposes of the impact assessment. Although options have different mechanisms for protecting the environment, it is assumed that all will be operated in order to meet legally required environmental objectives such as in the EU Water Framework and Habitats Directives and other relevant Directives. Many of the changes are focused on abstraction from surface water given its variability rather than groundwater which generally changes in quantity at a much slower rate. The full details of the options can be found in Annex B.

Option 0 - Do nothing/Current system

33. The current system uses daily and annual abstraction limits, and in some cases hands off flows, to control abstraction, maintain environmental protection and protect the rights of downstream abstractors. Some permissions[33] (particularly those for agricultural abstractions) have seasonal restrictions. Water trading is possible but uncommon and not quick enough to meet short term changes in demand. Most permissions have no end or review date and can only be varied if resulting losses are compensated for in many cases.

Option 1 - Current System Plus

34. The current system plus option aims to refine the current system to make it more flexible and capable of supporting abstractors as they adapt to changing water availability. This option uses the current system approach of annual and daily volumetric abstraction controls, and hands off flow conditions. However, it aims to refine these tools to improve the link between water availability, discharges and abstraction. This includes moving from seasonal conditions to availability-based conditions, low flow controls on all licences and the ability to abstract additional water at high flows. Groundwater regulation largely remains unchanged from the current system although trading is simplified. Permissions would no longer be time limited instead all would be subject to transparent and risk based catchment reviews to protect the environment without compensation being payable. It also makes it easier and quicker for abstractors to trade water with pre-approval of low risk trades.

Option 2 - Water shares

35. The water shares option explicitly embeds the principle that abstractors have a share in the available water resource rather than an absolute allowance whatever the water resources available. For a particular period, assumed to be a fortnight for surface water

[33] 'Permissions' is the term used to cover all forms of licences, permits and general rules that allow and control abstraction.

abstractors in the modelling, abstractors receive a water allocation based on water availability and depending on the reliability[34] and size of their share in a particular resource. This creates the potential to implement a more systematic approach to accounting and managing water in rivers, including from discharges, to reflect the variability in their flows, and facilitate shorter-term and higher risk trading (e.g. trading up stream). Because groundwater levels are slower to respond to changes in availability annual allocations are issued to groundwater abstractors that only change slowly in response to long term changes in groundwater recharge. This option includes many of the changes proposed in "current system plus", for example:

- Linking abstraction to water availability by moving from seasonal to availability-based conditions; and
- Introducing transparent and risk based reviews of catchment regulation to protect the environment while providing reasonable certainty to allow business to plan and invest.

Option 3 – Hybrid Option

36. The Hybrid option is based on the principle applied in water shares that abstractors have a share in the available water resource rather than an absolute allowance[35]. However, under this option, short-term fixed allocations as used in the Water Shares option will only be implemented initially in a very small number of enhanced catchments where there are likely to be most benefits). This will also allow us to learn more about this approach given concerns over the implementation challenges of short-term fixed allocations. For most enhanced catchments, allocations will be annual combined with hands off flows which will be very similar to the Current System Plus option but the use of the shares system will allow pre-approved upstream trading which will make more trades possible.

Implementation to maximise benefits

37. For all reform options, components to better link abstraction to flows and facilitate trading will only be introduced in catchments where there are clear environmental and economic benefits due to problems with water availability and the potential for trading. Catchments where this is the case are called **enhanced catchments**. In option 3, the hybrid option, most of these enhanced catchments will operate in a similar manner to current system plus, while a small number will be the same as water shares. This means that much of the benefit of reform will only be seen in these enhanced catchments. It also means that some elements of administration systems such as smart meters and rules for pre-approval of trading will only feature in enhanced catchments. However as the climate changes, the number of enhanced catchments is likely to increase and reform will provide the foundation necessary for all catchments, if necessary, to move to enhanced status in the future. (Other catchments are termed **basic catchments**).

[34] Some shares will be in highly reliable resources ie available at most flow levels of rivers, while other shares may only be in high flow resources with low reliability. Abstractors with reservoirs are likely to have low reliability shares so they can fill their reservoirs when flows are high.

[35] Shares would definitely be created in enhanced catchments and not created where there is available water. However the extent to which they will be created more widely will be decided as part of implementation.

Options summary

	Option 0: Current System	Option 1: Current System Plus	Option 2: Water Shares	Option 3: Hybrid Option
Linking abstraction to water availability	Abstractors generally have fixed volumetric limits. Around a quarter of abstractors have hands off flows or levels.	Surface water abstractors may have enhanced hands off flows, access to additional water at high flows and will all have a requirement to stop abstracting at very low flows.	Abstractors have a share of available water. Surface water abstractors receive short-term fixed allocations based on water availability and the size and reliability of their share.	In enhanced catchments, abstractors have a share of available water. In a small number of catchments, short-term fixed allocations are issued similar to option 2.
Discharges	Some abstractors have requirements to return water	All abstractors that return some water linked directly to an abstraction permission have to return a proportion of what they abstract.		
Trading water	Trades are possible but they require individual approval and take up to four months.	Low risk trades are pre-approved and therefore quicker than option 0.	Shorter-term trading is possible and a wider range of trades can be pre-approved than under options 0 and 1.	Low risk trades are pre-approved and therefore quicker than option 0. A wider range of pre-approved trades are possible than under options 0 and 1. Where there are short-term allocations, shorter-term trading is possible as with option 2.
Making changes to permissions	Some licences are time limited and some are not. If the latter are changed, compensation can be payable for any resulting losses.	Time limits are removed and a clear and consistent approach to changing permissions is introduced based on risk and evidence based reviews. Permission holders will not be compensated for any losses resulting from changes to permissions.		
Application to different catchments	One system applied in all catchments with approaches tailored to local needs.	A basic or an enhanced version of the system can be used depending on the benefits from enhanced elements.		A basic or an enhanced version of the system can be used depending on the benefits from enhanced elements. A small number of enhanced catchments have short-term allocations

Transition and system assumptions

38. The modelling of options includes assumptions on initial abstraction constraints and whether catchment management is "enhanced" or not (i.e. in an enhanced catchment), which impacts on costs and benefits. Assignment of enhanced status in the modelling is based on current environmental risks and estimated trading benefits. Under the hybrid option, short-term allocations are implemented in a small number of catchments where it is assessed they could have greatest benefits from evidence of the performance of the full water shares option. It is assumed that 12 years after transition additional catchments have short-term fixed allocations introduced but this is not modelled.

39. A key element of transition is to reduce unused licensed volumes to prevent risks of environmental deterioration. In 2011 around 40% of licensed volumes in freshwater were actually abstracted. As water demand increases and a greater proportion of licensed water is used, the pressure on the environment would increase. Furthermore all reform options facilitate trading which can lead to unused licensed volumes becoming available for use and so significantly increasing abstraction and risks to the environment. This was a key lesson learnt from international case studies of trading schemes particularly Australia. For the purpose of the impact assessment, for enhanced catchments the total volume of water that may be abstracted under an individual permission is based on the lower of:

- Their current licensed volume; and
- A proportion of the available water based on the average annual volumes used across three peak years between 2003 and 2012.

40. It is assumed that there will be no change to permission volumes in basic catchments. Further work and consultation will be done before the final approach is decided including considering further grounds for appeal.

41. We have also made assumptions on the practical and technical requirements of each of the options. Key assumptions are the need for water accounts for all catchments, and smart meters[36], enhanced telemetry and trading "bulletin boards" in enhanced catchments. These costs are included in the administrative costs of reform to business. The transition and administrative costs are in particular greater for Water Shares and slightly greater for the Hybrid Option – these are set out on page 48.

42. We have also assumed that private sector brokers will facilitate trading in all enhanced catchments and that they will charge a fee which has been netted off the benefits from trading.

43. Further details of each of these areas can be found in Annex B.

Non regulatory options considered

44. We have not considered options which do not involve any regulation, but we have sought to harness market forces better in reforming the existing regulatory system. This Impact Assessment looks specifically at reforming a regulatory system required for a common property resource to make it more efficient and effective in particular through improving market aspects. We are also required under the WFD to have a permitting system in place as we do now, which will require regulation. Although demand-reduction measures would also help to achieve some of our objectives, these are being taken forward elsewhere.

[36] See section on Small and Micro Businesses Impact Assessment, page 63, for proposed opt out arrangements.

Other options considered

Variable administered pricing

45. We previously considered a variable administered pricing option, as part of the options development process. Under this option, the Environment Agency or Natural Resources Wales would regularly set a water price according to local water availability. This price, which would increase as water availability decreases and decrease as water availability increases, would help to constrain demand and ensure environmental protection. In addition to this, all abstractors would require a basic permit which would tie them to a specific abstraction point and include local environmental conditions.

46. The pricing approach presented significant technical issues. In complex hydrological systems each abstractor's actions impact the water available for other abstractors in different ways and often with long time delays. This would require many different prices to be calculated and regularly changed with associated technical and administrative challenges. The task of estimating required prices to meet environmental requirements on a frequent basis was judged to be very complex, risky and costly.

47. For these reasons the pricing approach is not assessed further.

Methodology

48. Quantifying costs and benefits of the reform options has been challenging as it has required:

- Understanding long-term future scenarios to take into account risks of future water scarcity;
- Representation of complex trading rules and environmental standards linked to continuously varying water resources; and
- Representation of short and long-term decision making on water management in the context of uncertainty.

49. To meet this challenge we have used detailed modelling in a range of case study catchments to explore the costs, benefits and risks of the different reform options when compared with the baseline. For each catchment a fully integrated hydrological and agent based model was developed. The model estimates the overall costs and benefits of each reform option against the baseline in day steps over a 25 year appraisal period to be consistent with the available data on climate change and socio economic scenarios. Climate change, which has a significant effect on the hydrology and abstractor responses, has longer time frames than standard periods for assessment of benefits. Flow Duration Curves, which are used to determine environmental needs and therefore water availability, are based on 18 year averages for this reason to reduce the impact of short term drought / surplus over a few years skewing the results.

50. The results for the catchments (which were carefully selected to represent a range of types) have then been aggregated and scaled up to provide an indication of costs and benefits for England and Wales.

51. Leading external technical experts in modelling, economics, hydro-geology and water policy were brought in to provide quality assurance of the methodology, model coding, outputs and to establish priority areas for the modelling project . The experts were:

- Professor Jon Stern (City University), specialising in policy decision making and economics (until April 2014);

- Professor Julien Harou (Manchester University), specialising in hydro-economic modelling (from April 2014);
- Rob Soley (AMEC) specialising in hydrological modelling (until April 2014);
- Dr Kieran Conlan (Cascade Consulting) specialising in water management;
- Professor Scott Moss (Scott Moss Associates) specialising in agent-based modelling; and
- Robin Smale (Vivid Economics) specialising in Economics.

52. The development of models drew extensively on interactions with abstractors in the relevant catchments both through workshops and individual meetings to understand how abstractors would make decisions on production and water management.

53. Administrative costs and savings are mainly driven by changes in regulation processes and systems and so were mostly estimated based on expert regulatory input. The main regulatory change for abstractors would be:

- the ability to trade so costs were estimated for this based on comparable international experience and external estimates of costs of trading platforms; and
- the requirement to fit smart meters which was estimated based on information from potential suppliers.

54. The models have been significantly developed and improved since the consultation impact assessment. Responses to the consultation focussed mostly on option design but there were also some comments on the impact assessment particularly on:

- Providing better information on sectoral impacts;
- Incorporating modelling of the Trent and Derwent; and
- Better estimating the impacts on water companies given their security of supply obligations.

55. We have sought to address these issues, in particular that latter issue through detailed close working with water companies and consultants facilitated by the UK Water Industry Research organisation including detailed case studies of potential impacts on water companies' security of supply[37]. As a result, we have changed how water companies' licences are transitioned in the reform options so their security of supply obligations are not affected.

56. Further details on the approach to evidence gathering and quality assurance on the methodology are included in Annex A and Annex G.

Why adopt this approach?

57. Abstraction management is very complex and the level of benefits from the reform proposals will be critically dependent on the characteristics of the catchments including the local hydrology (which determines for example who *can* trade with whom) and the characteristics of the abstractors (which determines who *will* trade with whom). Further, the determination of the level of benefit must take account of complex interactions and feedbacks between the hydrology, weather, the management regime and abstractor

[37] UKWIR Report Ref 14/RG/08/7, Evaluating Abstraction Reform Proposals Phase 2 – Testing the Principles ISBN 1 84057 741 X.

behaviour, and between agents. Agents also range significantly in their type from water companies with substantial water management capacity and subject to economic regulation, through large industry needing very reliable water, to (small) farmers irrigating potatoes in dry years.

58. Traditional "top down" economic modelling (e.g. at regional or national scale) struggles to deliver meaningful conclusions in these situations because it is difficult to represent the complex interactions. It is also difficult to model differences between options that arise, for example, due to differences in the detail of implementation. Nevertheless, we have used a "top down" model as part of our wider analysis to complement, and provide some degree of comparison with, the "bottom up" (catchment) models, especially when results of the latter are aggregated. The top down modelling approach used and its key findings and limitations are detailed in Annex E. The top-down modelling work has reinforced, however, the importance of the hydrological aspects of the main "bottom up" (catchment-based) modelling approach.

59. **Agent-based modelling** has emerged as a key methodology for developing understanding of the interactions between people and their environment in situations such as these. Drawing on techniques from social sciences (in particular **behavioural economics**[38]) and ecological modelling, agent-based modelling allows the investigation of several key issues including: the effects of policy on decision-making, inertia, the impact of heterogeneity for example of agents, and feedbacks between agents such as learning, imitation and communication; and feedbacks between environmental change and agent actions. Further, agent-based modelling is a bottom-up approach that allows more specific local arrangements, rules and complexities to be incorporated (such as local hydrology, real licence conditions and production process specific requirements). As such, agent-based modelling has been used in our main catchment-based modelling approach.

Case study modelling

60. For this impact assessment, modelling results from the following case studies are being used:

- Cam and Ely Ouse;
- Hampshire Avon;
- Stour;
- Usk; and
- Trent and Derwent.

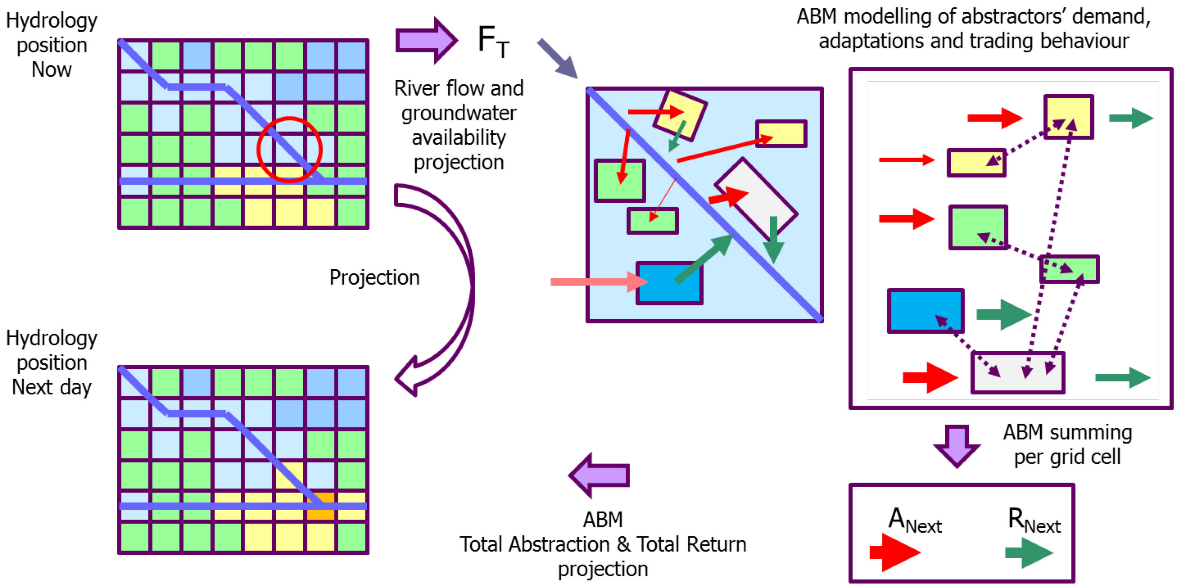
61. These were selected to be representative of different hydrological and abstractor types across regions in England and Wales. They were selected by the project board on the basis of analysis by hydrological and economic experts in the Risk Solutions consortium.

[38] The literature on this branch of economics was summarised in a paper by Defra[38] in July 2013 that looked at how key theories and empirical studies could be applied to policy. The conclusion was that there is a role for behavioural economics both in 'fine tuning' existing policies and in thinking about how best to design new policies. See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/223835/pb13986-behavioural-economics-defra.pdf

The integrated hydrological – agent based model

62. Figure 1 shows the interaction between the hydrological model and the agent based model (the Abstractor Behaviour Model or ABM) applied at catchment scale. For each case study catchment the hydrological model calculates the river flow and groundwater for a point in time for each 1km² cell[39] - F_T. The agent based model estimates both Public Water Supply (PWS) and non-PWS abstractors' demand requirements, and determines their behaviour taking into account the information received from the hydrological model. It determines abstraction and return flows (A_{NEXT} and R_{NEXT}), and passes this information back to the hydrological model, which in turn enables it to calculate the hydrological position for the next day.

Figure 1: Interaction between the hydrological model and ABM



Key:

F_T River Flow predicted for next time step,

A_{Next} River Abstraction predicted during the next time step

R_{Next} Return to River predicted during the next time step

63. In addition to day to day operational decision making (for example, whether to irrigate crops, or from which source to abstract water to serve PWS customers) the model also determines abstractors' longer term decision making. This may include for example a decision to stop producing a particular product, to invest in infrastructure, to leave, or enter a catchment. At each step the model establishes the costs to abstractors associated with water abstraction and investment decisions.

64. The model then calculates the water abstractions and returns in the next time period for each hydrological model cell based on abstractors' water requirements, adaptation behaviour and responses to reform options. Agents located in one cell may make abstractions and returns to other cells depending on their particular circumstances. In particular it considers how abstractors might react to price signals to make adaptations, and how they might interact with each other as individual abstractors make choices about cooperation, investment and market opportunities.

39 Groundwater is actually modelled as a series of aquifer blocks comprised of a number of 1km cells.

Modelling abstractor behaviours

65. Abstractor decisions are modelled to represent their changing ability to access abstracted water as water levels change on a day to day basis following changes in rainfall. Their resultant decisions depend on the profit they make from their use of water and the options they have to reduce their need for water (e.g. changing their production choices). The economics of their use of water has been determined from a number of sources.

66. The EA and Natural Resources Wales hold information about all live abstraction licences held in England and Wales. This includes maximum annual and maximum daily abstraction limits. This database provides an indication of the purpose or purposes for which the water is abstracted and the location of the abstraction point or points associated with the licence. Details of actual abstractions (volumes, location and discharges) are recorded in databases by the EA and Natural Resources Wales. This provided initial information on how abstractors use water.

67. Engagement with real abstractors, and with abstractor representatives, was then crucial, in helping understand the challenges abstractors face, what drives decision making around water in their industry, and how they might respond to new constraints and opportunities. This was supplemented with information gathered from workshops and one to one consultations, information from experts, from the behavioural literature and about responses to similar changes in the UK and overseas. Information about product prices, production costs, supply and demand was required to establish the context within which decisions about water are made. These were sourced from data sources such as business surveys, market reports and manuals, as well as the consultations.

Modelling the future

68. Key sources of future uncertainty are climate and socio-economic change, so the four climate projections and four socio economic scenarios in the Environment Agency Case for Change analysis were used. The four climate change projections were selected from a national assessment of seasonal changes in river flows and groundwater levels for the 2050s to reflect a reasonable range of a wider set of projections. These are designated:

- A - less significant change in flows; and
- C, G and J, greater changes in flows at different locations.

69. Our current understanding of the impact of climate change on water resources in England and Wales is based on the latest UK Climate Projections (UKCP09)[40]. UKCP09 provides projections of future climate that is based on current understanding of the climate system - there may be scientific unknowns that would affect the information provided. Hence UKCP09 should be seen as providing possible projections rather than absolute predictions or forecast of future climate. The overall pattern is varied, reflecting the complex nature of UK weather patterns and uncertainty in the impact of climate change. **No one projection is more likely to occur than any other.**

70. Four socio-economic scenarios were used which are summarised in Box 6:

- “Sustainable behaviour”;
- “Local resilience”;
- “Innovation”; and

[40] http://ukclimateprojections.metoffice.gov.uk/

- “Uncontrolled demand”.

71. The relationship between growth and forecast demand is complex. Many factors will determine how much water people and businesses will use in the future including the climate, water efficient technology, incentives for people and businesses to use water wisely and regulations. When thinking about the demand for water we have to make assumptions about how people will live and work, the technology that will be available, how people will use their leisure time and how they'll value the environment. We have looked at the potential effect growth, societal change and climate will have on future demand. It is impossible to know what the future will look like and if we had based our analysis on one possible future then we would almost certainly be wrong.

72. To overcome this, the assessment looks at a range of potential future scenarios based on different types of society (conservationist through to consumerist) and governance (growth-focused through to sustainability focused). We considered the demand from households, from industry and commerce, from agricultural spray irrigation, water company leakage and from power generation. This identifies an envelope of possible future demands within which the actual future may lie, **with no one scenario more likely to occur than any other.**

73. Given that none of the combination of projections and scenarios are more likely to occur than any other and represent an envelope of possible futures, we have chosen a central result as the best estimate.

Box 6: Short descriptions of the Socio-economic scenarios

Scenarios are a tool for thinking about different possible futures. The Environment Agency developed its original scenarios in 2006 to explore uncertainties relating to future water demand and highlight issues or potential options. The 2012 versions of the scenarios are the refreshed 2050 socio-economic scenarios for water resources and quality. They were revisited and reviewed given recent world events and on-going shocks to the socio-economic system to ensure they were robust and fit for purpose. The following summarises the four scenario narratives used in the modelling.

'Innovation' - "Our scientists and technologists can solve the problems of environmental damage through their ideas and innovation"

In response to a stagnating economy, the government chooses to drive the UK into a large scale wave of industrial investment in sustainable technologies, attempting both to kick-start the economy and avoid an impending wave of resource shortage. The result is a world in which sustainable behaviour is 'designed in' to urban and social life. One consequence is a 'corporatist' world, in which the interests of business and government are aligned.

'Uncontrolled demand' -"The rich shall inherit the earth – because we're worth it"

Political and economic systems were dominated by the interests of the wealthy, and as a result, they were able to shrug off protests designed to provoke a rethink of prevailing political and economic models. Increasing resource shortage meant that previous patterns of polarisation between the rich and poor intensified. The top 20% continue to consume without moderation, while the less affluent people are squeezed, relying on handed down products and poorer infrastructure. Security, water, energy and health move from being publicly provided to being increasingly privatised, with minimal basic provision levels supplied for all.

'Local resilience' - "It is better to have fewer wants than greater resources"

Sustained political and economic crises of the 2010s were not successfully resolved, leaving the UK in a low-growth world despite the best efforts of politicians. Rationing and unwillingness for countries to work together made the UK turn inwards, and local regions focus more on how to solve their own problems. The direction of economic innovation has been away from international financial flows and finance, concentrating on helping money circulate locally to support local and regional economies. Consumption is less intensive and more focused on local services than expensive (often imported) manufactured products.

Sustainable behaviour' - "We can cut out resource use through new ways of managing our societies and our relationships"

With growth hard to find, government focused on social welfare as the way to keep citizens content, while environmental disasters in the 2010s provoked international engagement with the low carbon agenda, and tighter regulations. Consumers choose to be green, pushed along by more regulation, which makes products reflect the full costs, including the pollution, they cause. The sense of a collective project and collective action around environmental protection for social welfare means they are happier to trust the government to legislate for the national good. There is a greater role for public management, also driven by infrastructure costs that are unattractively high for private sector firms.

Aggregation

74. Seven catchments were chosen initially to be as representative as possible of the agent types and hydrological conditions across England and Wales following extensive analysis of the range of catchments and consultation with stakeholders. Initial analysis suggested that two catchments, the Tees and Dee, would not provide representative results

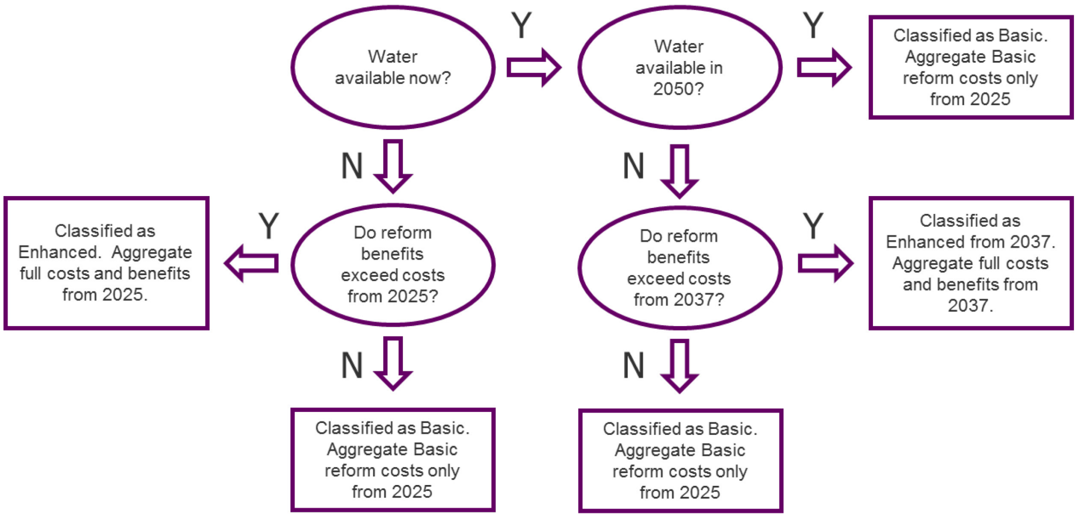
in terms of the likely costs and benefits of the options; the first due to its link to the Kielder dam and the second due to its specialised river regulation system. These were therefore excluded from the modelling.

75. A spreadsheet-based “aggregation model” reads the ABM outputs and scales up the results for all catchments in England and Wales. It is designed to explore whether the benefits of full (enhanced) implementation in only a proportion of catchments, outweighs the broader costs associated with minimum (basic) implementation nationally. It does this by calculating each catchment as a weighted average of the four modelled catchments based on the sectoral mix. This is explained further in Annex H.

76. In a ‘run’ of the aggregation model each catchment is classified into one of two types, according to the flow chart in Figure 2. So, for instance, catchments are only implemented as enhanced if there is no water available for new abstractors and benefits of reform exceed costs.

77. Basic catchments undergo basic reform only. This results in some administrative costs and benefits, but any additional costs and benefits arising from the introduction of full trading reforms under Current System Plus, Water Shares or the Hybrid Option are not applicable in these catchments. “Enhanced” catchments undergo enhanced reforms. As well as the administrative costs and benefits they are also able to achieve the full benefits from trading possible under the reform options.

Figure 2: Catchment classification flowchart



78. The ABM model generates results for Current System Plus and Water Shares; the aggregation model estimates the costs and benefits for the Hybrid option by combining these together. This is best explained with an example. Suppose that for a particular scenario combination there were ten Enhanced catchments. In eight of the ten catchments the net benefits were higher for Current System Plus and in two of the catchments the net benefits were higher for Water Shares. The aggregation model makes the assumption that the net benefits for the Hybrid option are in the same proportion, i.e.:

> Benefits for Hybrid (10 catchments) = Benefits for Current System Plus (8 catchments) + Benefits for Water Shares (2 catchments).

79. This assumes that the hybrid option operating with annual allocations has equivalent benefits to current system plus. This is a conservative assumption as the hybrid option allows upstream trading, which current system plus doesn’t so in fact the benefits of the hybrid option is likely to be higher.

80. The administration costs/savings of the hybrid option were separately estimated and included in the aggregation.

81. Applying the aggregation process to all 16 scenario combinations results in a different decision about whether each catchment is Basic or Enhanced. For example, Table 3 shows how many times each of the four modelled catchments fall into each category.

Table 3: Number of scenario combinations (out of 16) where each of the four modelled catchments is classified as either 'Basic' or' Enhanced'

	Current System Plus: catchment classification		**Water Shares: catchment classification**		**Hybrid Option: catchment classification**	
Catchment	Basic	Enhanced	Basic	Enhanced	Basic	Enhanced
Cam and Ely Ouse	0	16	0	16	0	16
Hampshire Avon	11	5	12	4	12	4
Stour	3	13	4	12	4	12
Usk	14	2	9	7	9	7

82. In practice the Environment Agency and Natural Resources Wales will have to decide whether to implement enhanced reform in a catchment without knowing in advance which climate change or socio-economic scenario is likely to materialise in reality. For the results presented here we have therefore assumed that the Environment Agency and Natural Resources Wales choose to implement enhanced reform only in those catchments where the model results show a cost benefit case in at least 50% of the scenario combinations. Based on Table 3 above therefore, Cam and Ely Ouse would be an Enhanced catchment; Hampshire Avon would be a Basic catchment; Stour would be an Enhanced catchment; and Usk would be a basic catchment. This approach means all the uncertainty around future scenarios is reflected in the Regulator's decision.

Risks and assumptions

83. The main approach to exploring the robustness of the impact estimation results has been through using a range of climate change and socio-economic scenarios which are aimed at representing the outer envelope of possible outcomes, so the actual outcomes should be within these bounds. These are discussed in analysing the range of potential results.

84. We also explored the risks of distorted markets or unintended outcomes of market activity such as

- water market manipulation by dominant abstractors;
- collusion of market participants;
- low market liquidity; and
- concerns of government intervention during droughts.

85. We considered the need to mitigate these risks and concluded, supported by Ofwat, that they did not require regulatory intervention to address (see Annex F).

86. We have also highlighted the implementation risks involved in the highly innovative water shares option which is a key factor in the selection of the preferred option. See Summary and preferred option with description of implementation plan.

87. The modelling involved the integration of hydrological models with a bespoke abstractor behaviour model (ABM). It was therefore necessary to make a number of simplifications such as how trading markets work, the nature of constraints on abstraction and how reviews are triggered and adjust abstraction to protect the environment. These are detailed in Annex D, along with the likely impact on the results due to any changes to these assumptions.

88. Also a range of sensitivity analyses were carried out on key assumptions for the consultation IA and final IA, such as

- An increased and relaxed constraint on economic growth;
- Making agent decision making more or less rational; and
- Basing environmental protection requirements on more or less stringent assumptions

89. These are detailed in Annex G.

90. Overall the results were not particularly sensitive to these. The results are far more sensitive to different climate change and socio-economic scenarios, which are explored in depth in the main text.

91. Furthermore, we also carried out some less sophisticated top-down modelling as detailed in Annex E to explore the impact of reform through a different approach. The results of this high-level analysis indicate that our benefit estimates are conservative, while also underscoring the value of our granular bottom-up modelling approach in giving more robust results and insights.

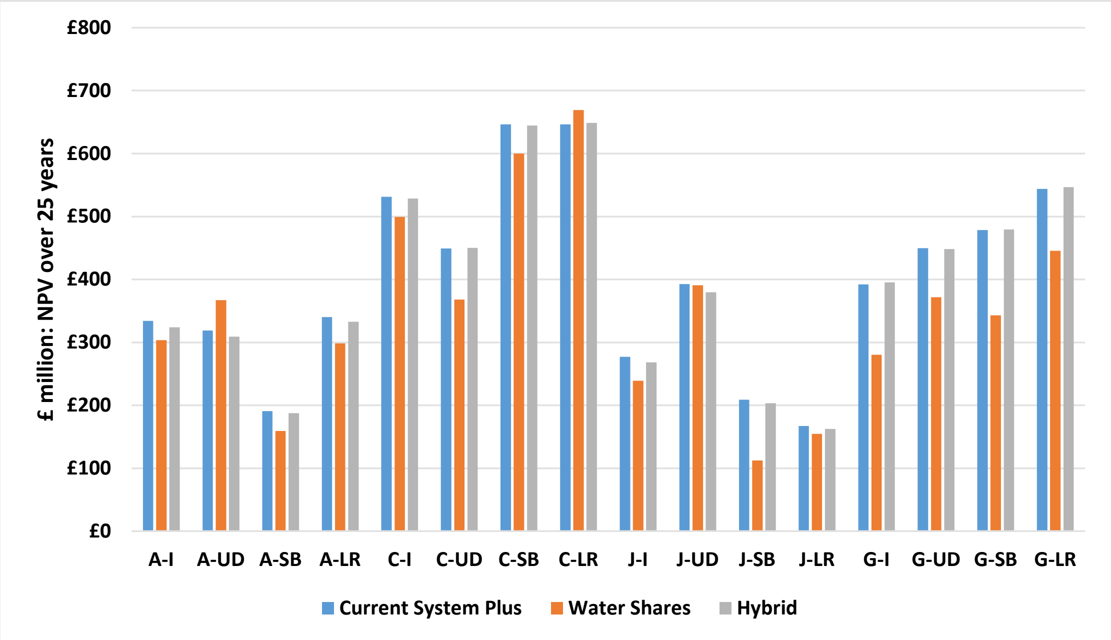
Monetised costs and benefits

Overview of monetised costs and benefits

92. The total NPV of reform for **England & Wales** across all scenarios and reform options yields net benefits. Figure 3 shows that the net benefits of reform in England and Wales varies between about £100 million and almost £650 million, with Current System Plus and the Hybrid Option tending to generate higher benefits in most scenario combinations.

93. Net Benefits tend to be higher in climate change scenarios C and G[41] as these, as well as being drier than the current climate, also contain more variable weather with some very dry periods when much of the benefits are generated as the reform options provide greater resilience to very dry periods. The A climate scenario is the least dry while the J scenario is reasonably dry but does not have many periods of very dry weather so benefits are lower in both these scenarios. Socio economic scenarios are less significant in driving variation in benefits as they have less effect on water scarcity than climate change scenarios.

Figure 3: Total NPV of reform for England and Wales for each scenario combination.

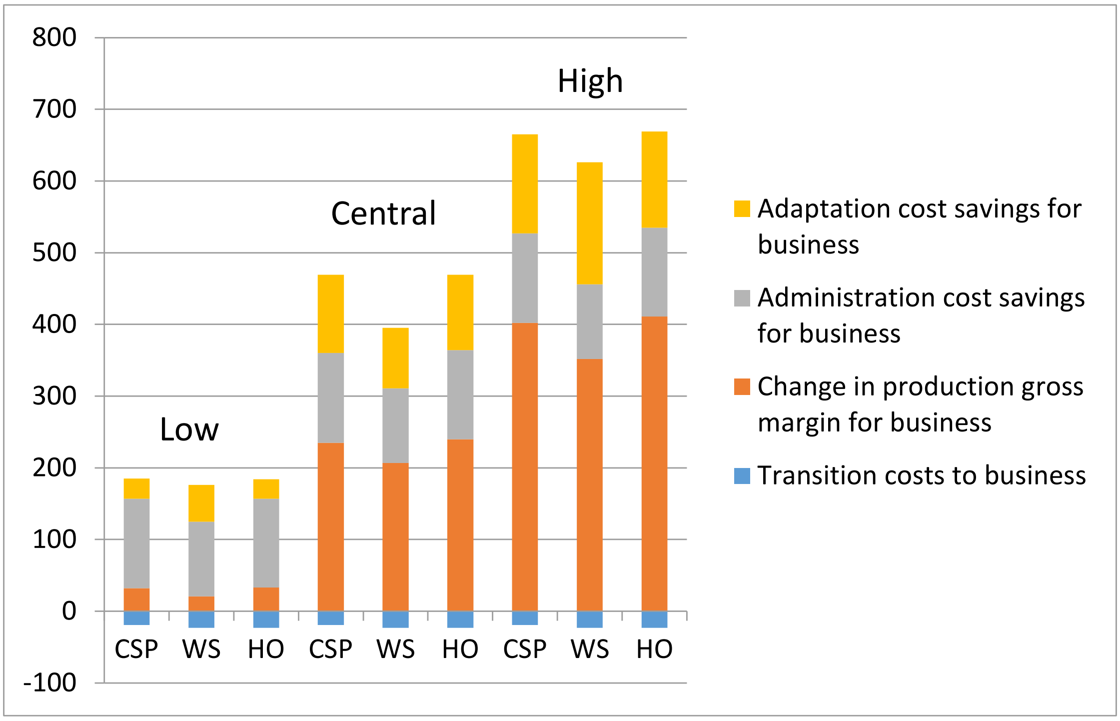


94. Figure 4 breaks down the net benefits for different options under the low, central and high estimates[42] for each option. This shows how the changes to production gross margins dominate results in most scenarios. These scenarios are selected from the different scenario combinations which are all equally likely (see page 36 section on Modelling the future).

[41] The climate change scenarios are derived from separate climate change models based on based on the latest UK Climate Projections and the socio-economic scenarios were separately developed by the Environment Agency. See page 36 for further details.

[42] The low scenario is J-Local Resilience; the central G-Uncontrolled Demand; the high C-Sustainable Behaviour. See Box 6 for descriptions of the socio-economic scenarios.

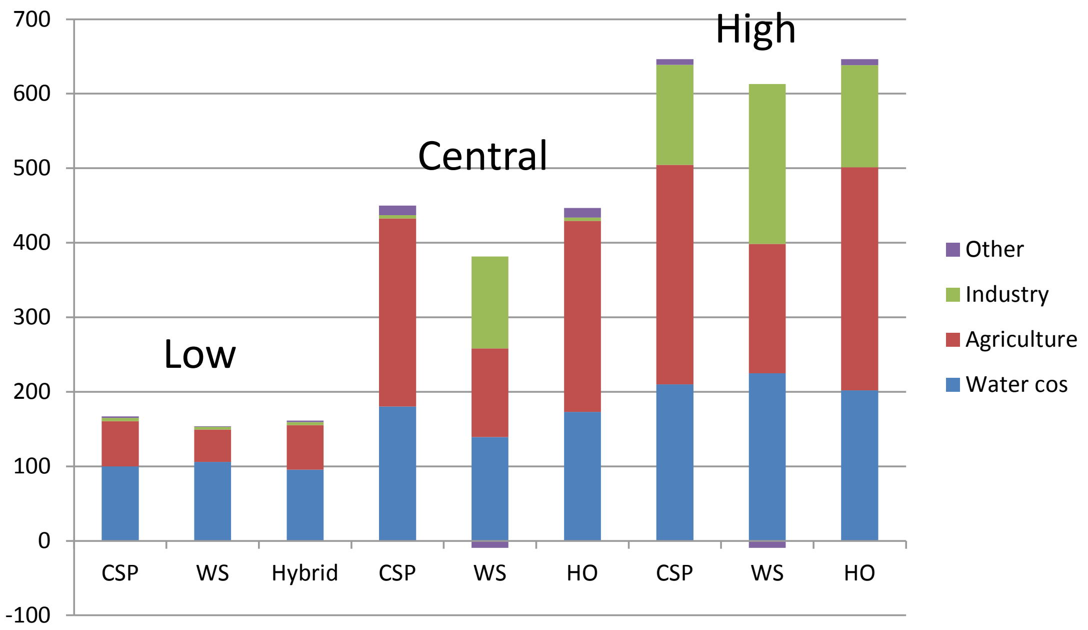
Figure 4: Low[43], central & high reform estimates (£m NPV over 25 years) for England & Wales by cost/ benefit category for all options



95. Figure 5 breaks down the production and adaptation cost saving benefits by main sector. Agriculture and industry are the main beneficiaries of production benefits, of which industry benefits more under drier climate change scenarios. Agricultural irrigators do most of the trading but industrial abstractors, although they trade less often, tend to gain more value for each trade. See further analysis below and in Annex I.

43 Note the low case is chosen on the basis of the lowest value for the preferred option, the hybrid option. Under this scenario WS is not at its lowest value.

Figure 5: Reform Benefits for England and Wales by sector (£m NPV over 25 years)[44]



96. Table 4 shows a breakdown of the number of Basic and Enhanced catchments in each Environment Agency region and Wales by option.

Table 4: Number of Basic and Enhanced catchments predicted for England and Wales

	Current System Plus		**Water Shares**		**Hybrid Option**	
Region	Basic	Enhanced	Basic	Enhanced	Basic	Enhanced
Anglian	9	5	6	8	6	8
Midlands	8	5	8	5	8	5
North West	10	3	10	3	10	3
South East	7	19	6	20	6	20
South West	12	6	10	8	10	8
Yorkshire and NE	10	2	11	1	11	1
Wales	20	0	19	1	19	1
Total	76	40	70	46	70	46

97. Of these, some are immediately enhanced while others are not enhanced until 2037:

- Under current system plus, 30 are initially enhanced, while 10 are enhanced in 2037; and
- Under water shares and the hybrid option, 34 are initially enhanced, while 12 are enhanced in 2037.

[44] Note the low case is chosen on the basis of the lowest value for the preferred option, the hybrid option. Under this scenario WS is not at its lowest value.

Central (Best) estimate

Table 5: Summary of best estimate discounted costs and benefits (£m)

ENGLAND		CSP	WS	HO
Costs	Transition costs to business	18	22	22
	TOTAL COSTS	**18**	**22**	**22**
Benefits/ Cost Savings	Change in production gross margin for business	235	205	240
	Administration cost savings for business	118	98	117
	Adaption cost savings for business	109	85	105
	TOTAL BENEFITS	**462**	**388**	**462**
NET PRESENT VALUE		**444**	**366**	**440**

WALES		CSP	WS	HO
Costs	Transition costs to business	1	2	2
	TOTAL COSTS	**1**	**2**	**2**
Benefits/ Cost Savings	Change in production gross margin for business	0	2	2
	Administration cost savings for business	7	7	7
	Adaption cost savings for business	0	0	0
	TOTAL BENEFITS	**7**	**9**	**9**
NET PRESENT VALUE		**6**	**7**	**7**

ENGLAND AND WALES		CSP	WS	HO
Costs	Transition costs to business	19	23	23
	TOTAL COSTS	**19**	**23**	**23**
Benefits/ Cost Savings	Change in production gross margin for business	235	207	240
	Administration cost savings for business	126	104	125
	Adaption cost savings for business	109	84	105
	TOTAL BENEFITS	**469**	**395**	**470**
NET PRESENT VALUE		**450**	**372**	**447**

[Note: Base year 2013,due to rounding the combined figures do not always total precisely]

98. Scenario G-UD is a central estimate with net benefit for all the reform options. As all the scenarios are equally likely (as previously discussed), we have chosen this as the best estimate. Table 5 shows the discounted costs and benefits separately for England and Wales and England & Wales combined. The reforms are modelled over a 25 year period from 2025, to be consistent with climate change and socio economic scenarios. The major driver of the NPV across all options in England is the change in production gross margin (£240m for HO). It should be noted that the admin cost savings category includes recurring admin cost increases that have been netted off (refer to page 47 for more information).

Further information on the methodology underpinning this estimate can be found in Annex H.

99. More detail on the factors driving the above cost and benefit categories is provided below.

Key cost and benefit categories

Costs

100. The costs fall into two categories: transition costs to business; and recurring administrative costs/admin savings to business. All costs fall on business as this regulatory system is based on cost recovery and will continue to be so under reform. These cost categories are described below, with further detail provided in Annex J.

Transition costs to Business

101. These are assumed to occur in Year 1, which represents 2025 although in practice they will be incurred prior to this over about 4 or 5 years and hence their NPV would be marginally less. In the first instance these costs fall to the Environment Agency and Natural Resources Wales as a result of moving the existing abstraction licences into a new system: they are then passed through to businesses on a cost recovery basis. Transition costs items for all options are set out in table 6 – the cost figures correspond to Water Shares and the Hybrid Option (further detail is provided in Annex J).

Table 6: Analysis of transition costs for Water shares and the Hybrid Option (£m NPV)

Cost item	Brief description	Cost
Revised water resource assessment process/ tools	Converting current licences into new permissions for the reformed system	9
New IT systems	Developing and implementing new information technology systems to support the reformed system	5
Creating new permissions	Administrative costs of converting current licences into new permissions	2
Issuing water shares (WS and HO option only)	Before a shares based scheme can be implemented abstractors will have to be issued shares, which could be in various reliability pools/ water management units within a catchment.	4
Smart Meters	Businesses in enhanced catchments will generally require smart meters unless they request a SMB opt out. Some abstractors will not require an upgrade, but others will require more than one meter. Individual purchase and installation cost of £640[45] per meter was estimated.	3
Total cost		23

102. The costs for the current system plus option are lower (£19m NPV). Water Shares and the Hybrid Option are slightly more expensive to implement (an extra £4m) as they require more extensive development of rules for pre-approval of trades, a system to predict water availability over allocation periods and more work in changing existing volumetric licences into shares. For further information see Annex J.

Recurring Administrative costs/savings to Business

103. There are two dimensions to this category: cost increases and cost savings. The cost increases are small relative to the costs savings; hence they have been netted off against the cost savings and presented as a single category ('Admin cost savings for business') in the summary tables (e.g. Table 5).

104. The cost increases relate to annually recurring operational costs associated with implementing the reform options. These total costs are around £21m for CSP, £22m for HO and £42m NPV for WS. Refer to Annex J for more information.

105. The administrative cost savings generated by the reform options relative to the baseline are more significant (£147m NPV under CSP). See Table 7 for the analysis of the administrative costs/savings of current system plus. The main driver of these savings (£115m NPV over 25 years; ~80% of total admin savings) is due to a reduction in the administrative costs associated with protecting the environment, as follows:

- Fewer permissions needing to be investigated as the removal of unused licensed water at transition will significantly reduce the potential for them to pose risks to the environment; and

[45] Cost obtained from Elster metering and ratified by discussion with other suppliers and installers

- More efficient and effective processes for changing permissions through integrated catchment reviews rather than individual permission investigations.

106. Savings are around 15% lower for water shares (difference of around £20m NPV relative to HO and CSP) due to increased costs of running this system, particularly in terms of forecasting available water for short-term allocations.

Table 7: Summary analysis of recurring administrative costs/saving to business under Current System Plus (£m NPV)

Cost item	Brief description	Cost
Cost increases		
Telemetry	Reform options required increased measurement of flows to operate them.	17
Other	Increased compliance due to new systems and increased maintenance of meters	4
Total cost increases		**21**
Savings		
Reduced costs of environmental protection	Avoided costs of increased investigations under the current system	-87
	Reduced reviews in reform options due to transition to the new system reducing unused licensed quantities and resultant risks to the environment	-28
Reduced costs of compliance	Avoided costs of increased compliance checking in the current system as pressures increase on water resources	-14
Avoided costs of renewing time limited licences	Under reform options, there will no longer be time-limited permissions that need reassessment at renewal	-14
Other		-4
Total savings		**-147**
Net savings		**-126**

107. In Wales, savings from reductions in operating costs under all reform options are significantly lower. This is because there are fewer licences in Wales that could be subject to the complex and expensive baseline mechanisms, hence there is less potential to save money by switching to a reformed System.

108. For further information see Annex J.

Benefits

109. As well as the administrative cost savings outlined above, benefits are also driven by changes in production gross margin and changes in adaptation costs. These two benefit categories are set out below.

Change in production gross margin for business

110. These are incurred over the full appraisal period and are driven mainly by abstraction trading largely carried out by industrial and agricultural irrigators. Trading allows the purchasing business to generate additional profits above the cost of the trade.

111. The costs of brokerage and abstractor decision making on trading have been netted off these benefits as they effectively directly reduce the direct benefits of trading. Estimates of likely broking charges have been made of 3% of the value of trades for sellers and 1.5% for buyers. These are based on market rates for comparable trading markets and experience in Australia as well as being tested as reasonable against rough order of magnitude estimates of the cost of electronic trading platforms. We have also assumed that businesses incur familiarisation costs (understanding market codes, assessing feasibility of trading) of 1% of trade values for buyers and sellers. Clearly these costs vary depending on the levels of trading but under a median scenario amount to about £1.5m per annum in England.

112. Production benefits tend to be higher under current system plus and the hybrid option, than water shares because in some circumstances the constraints of short-term allocations can counteract the benefits of trading, reducing benefits. This is particularly true for those abstractors who have highly variable demand for water and need to take large volumes over a short period (e.g. agricultural crop growers). Under WS abstractors are granted a 14-day allocation of water which represents 1/26th of their annual licensed volume. Under CS and CSP (providing no HOF conditions have been triggered) the same abstractor could take 14 times their daily abstraction limit during a fortnight, which typically equates 1/13th of their annual licensed volume. Thus affected abstractors would need to either trade to get the same volume of water, or modify their production, both of which come at a cost. This constraint potentially better protects the environment though this has not necessarily been captured due to limitations of the modelling.

113. In Wales there are some benefits from changes in production gross margin for business under water shares and the hybrid option as there is one enhanced catchment created in 2037 under these options. There are no such benefits under current system plus as there are no enhanced catchments.

114. These benefits are further discussed in the section on catchment case study analysis, page 57, and in Annex I.

Change in adaptation costs to business

115. These are incurred from Year 0 through to Year 24. This is the change in capital investment (and associated operating costs) incurred in the catchments as agents seek to balance supply and demand as the climate changes over time.

116. The main driver is the change in investment profile made by the regulated water companies[46]. Under some circumstances the more efficient use of water in the catchment under the reform options when compared to the baseline can result in a water company being able to make less future investment, or delay the investment from one year to another, while still balancing supply and demand. This generates an NPV benefit for the water company[47] that should ultimately feed through into lower prices for customers, but we have not attempted to estimate this second round effect. In other cases water companies are able to engage in the abstraction market, for example reducing costs by selling licences

[46] Regulated water company investment costs and decision making are based on the Water Resource Management Planning process which minimises the cost of meeting customer water demands over a 25 year period. This approach was agreed with water companies. See Annex D for further information.

[47] The catchment models include the costs of investments in the years in which they occur. These costs are then discounted to calculate the net present value (NPV). Hence if an investment is put back a year, the NPV of that cost will reduce as it will be discounted by an extra year.

to agricultural and industrial abstractors and replacing the water for their regulated customers by bringing forward investment options.

117. The change in the 25 year profile of additional capital and operating costs under the reform options compared to the baseline is converted into an equivalent annual figure for the modelled catchments, and it is these values that are scaled up to all 116 catchments to determine the national change in adaptation costs. The circumstances of each water company across the country are quite different to each other and very complex. Hence these estimates are significantly less certain than the production benefits but as can be seen they are not nearly as significant as them. In the median scenario they range from 23% to 24% of net benefits. Even in the low scenario where they are more significant, net benefits would still remain even if they were set to zero.

118. This category also includes investments made by other abstractors such as for the construction of new water storage reservoirs on farms but these are not nearly as significant as water company investment affects.

Variation of results between high and low cases

119. The following tables show the discounted figures for the high and low cases. For each scenario below we have identified the main factors underpinning the costs and benefits.

High case

120. Table 8 shows the discounted figures for climate change scenario C and socio-economic scenario Sustainable Behaviour which is the high case. Net benefits are between 40 and 60% higher with WS showing the greatest increase compared to the median.

Table 8: High case scenario: C- Sustainable Behaviour (£m, NPV)

ENGLAND		CSP	WS	HO
Costs	Transition costs to business	18	22	22
	TOTAL COSTS	**18**	**22**	**22**
Benefits/ Cost Savings	Change in production gross margin for business	402	352	410
	Administration cost savings for business	118	98	117
	Adaption cost savings for business	138	159	129
	TOTAL BENEFITS	**658**	**610**	**656**
NET PRESENT VALUE		**640**	**588**	**634**

WALES		CSP	WS	HO
Costs	Transition costs to business	1	2	2
	TOTAL COSTS	**1**	**2**	**2**
Benefits/ Cost Savings	Change in production gross margin for business	0	0	0
	Administration cost savings for business	7	7	7
	Adaption cost savings for business	0	7	7
	TOTAL BENEFITS	**7**	**14**	**14**
NET PRESENT VALUE		**6**	**12**	**12**

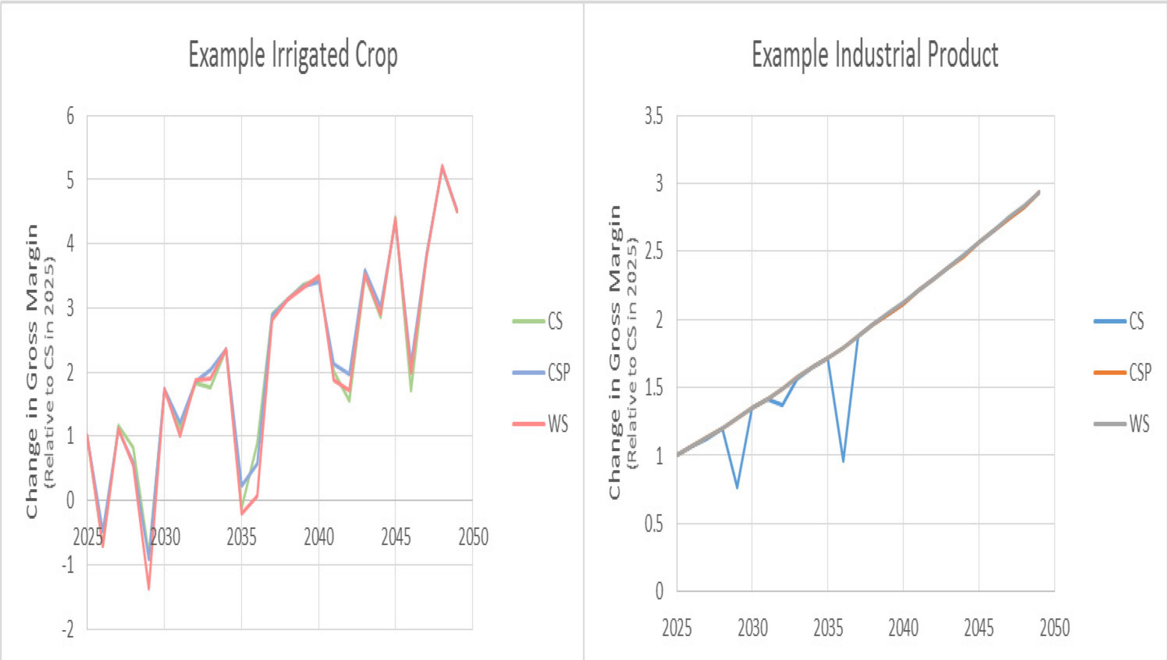
[Note: due to rounding the combined figures do not always total precisely]

121. C-SB represents a drier but moderately variable climate change scenario with a moderate growth socio-economic scenario. In this set of circumstances, while each individual sector is affected in different ways, the dominant sectors that drive the benefits are agricultural crops and industry; the crop sector is significant because there are a large number of such abstractors; the industrial sector is significant because there is small number of economically dominant operators.

122. The fundamental driving force for the benefits is the anticipated price rises for irrigated crops and some key industrial products in this socio-economic scenario, and this leads to these two sectors trying to grow their production. Abstractors plan for similar growth in all three policy options, but under current system there are particular years in which surface water supplies are less reliable and the abstractors are not able to secure all the water they need to support full production. However, reform options provide enough flexibility (in terms of increased access to water at periods of high flows and the ability to trade) that these shortfalls in production are avoided or reduced. Figure 6 shows the

impact that this has on the gross margin of two of the contributing products in these sectors. In the case of the irrigated crop, water reliability presents a challenge to profitability in many years, but reform (and CSP/HO in particular) provides opportunities for a modest percentage gain in margin (2-4%), which when applied to the total market size is a significant sum. The industrial product is much less affected by moderate variability in water reliability, but in years when there is more significant water shortage, trading provides the means to access the water to maintain production and hence margin.

Figure 6: The change in production gross margin in the best case for two example products



Low case

123. Table 9 shows the discounted figures for climate change scenario J and socio-economic scenario local resilience. Benefits are about 60% lower than the median case. This is chosen as the low case as benefits are lowest for the preferred option, the hybrid option.

124. J-LR represents a consistently drier climate change scenario with modest growth socio-economic scenarios.

125. In this set of circumstances, while each individual sector is affected in some way, the dominant sector that drives the benefits are agricultural irrigators The fundamental mechanisms are the same, with product price rises encouraging some sectors to grow. However, the industrial sector (which contributed significantly to benefits in the high case) is generally not seeking to grow so much (so is less dependent on accessing new sources of water) and the climate while generally drier, is less variable between years so does not have many very dry periods. Together these two interacting factors mean that this sector is generally able to access the water it needs under all policy options, and there is little differential benefit for reform for this sector.

Table 9: Low case scenario: J-Local Resilience (£m, NPV)

ENGLAND		CSP	WS	HO
Costs	Transition costs to business	18	22	22
	TOTAL COSTS	**18**	**22**	**22**
Benefits/ Cost Savings	Change in production gross margin for business	32	21	33
	Administration cost savings for business	118	98	117
	Adaption cost savings for business	28	55	32
	TOTAL BENEFITS	**179**	**174**	**182**
NET PRESENT VALUE		**161**	**152**	**160**

WALES		CSP	WS	HO
Costs	Transition costs to business	1	2	2
	TOTAL COSTS	**1**	**2**	**2**
Benefits/ Cost Savings	Change in production gross margin for business	0	0	0
	Administration cost savings for business	7	7	7
	Adaption cost savings for business	0	(3)	(3)
	TOTAL BENEFITS	**7**	**4**	**4**
NET PRESENT VALUE		**6**	**2**	**2**

[Note: due to rounding the combined figures do not always total precisely]

126. This same combination of more modest growth and low climate variability has a similar effect on the agricultural agents and the instances when production is affected by water scarcity are reduced. When water is in short supply, reform does in most cases provide some benefit (through trading) to enable a small percentage gain (1-3%) in margin. Figure 7 shows the impact that this has on the gross margin of two of the contributing products in these sectors.

Figure 7: The change in production gross margin in the worst case for two example products

Table 10: Best estimate Net Present Value over 25 years

ENGLAND AND WALES		CSP	WS	HO
Costs	Transition costs to business	19	23	23
	TOTAL COSTS	**19**	**23**	**23**
Benefits/ Cost Savings	Change in production gross margin for business	235	207	240
	Administration cost savings for business	126	104	125
	Adaption cost savings for business	109	84	105
	TOTAL BENEFITS	**469**	**395**	**470**
NET PRESENT VALUE		**450**	**372**	**447**

[Note: due to rounding the combined figures do not always total precisely]

127. Table 10 shows the net present values for England and Wales combined. We use a central value to provide the best estimate given all scenarios are equally likely.

128. The results indicate that the central NPV for reform is likely to be positive and in the range £370m to £450m across the three options over 25 years.

129. In England the administrative cost of operating a reformed water abstraction licensing system is lower than it is under the current system. This is primarily due to

- the introduction of a new electronic permitting system; and
- a reduction in the number of investigations required to manage local environmental damage.

130. The costs of implementing enhanced reforms to allow trading are higher than basic reform and will only be introduced where the benefits of trading are expected to outweigh the costs. The numbers of catchments falling into the basic or enhanced category depends on both the reform option.

131. In general, when the financial benefits of reform are high for a particular sector of the economy in the catchment models, these become the dominant contributors to the overall NPV figures estimated by the Aggregation Model. However, the actual dominant sectors vary between catchments and scenarios. In some cases the industrial sector dominates; this is often caused by a small number of economically significant businesses achieving small benefits in particular circumstances. In others it is the power sector; again because they are economically large and only need to make small gains to contribute significantly. However, the sector that tends to achieve significant benefits in a wider range of circumstances is the agricultural sector; here total benefits arise from the accumulation of lots of small impacts for many abstractors. When the financial benefits are marginal, it is the administrative cost savings that become more significant.

132. In Wales all catchments are assessed as being basic under current system plus and one as enhanced under water shares and the hybrid system in 2037. This reflecting both higher water availability and much fewer seasonal irrigators. In fact more detailed analysis might justify some more water resource units being enhanced as this is only a broad based assessment. In addition, administrative cost savings are lower because there are relatively few investigations required in Wales under the current system. So the case for reform in Wales depends more on un-monetised benefits of adaptability.

133. The modelling demonstrates that reform can provide benefits in a number of ways, and (depending on the catchment and scenario combination) different factors become more or less important:

- The removal of seasonal restrictions (summer/winter licences) and the provision of "bonus water" at times of high flows:
    - allows agents access to more water;
    - provides additional flexibility for agents to manage their annual water allocations through water scarce periods; and
    - enables agents to make better use of existing reservoirs and makes building new reservoirs more attractive.
- The reduction of barriers to trade through pre-approval of trades makes it easier for agents with spare water to trade it with those who have a need. We see evidence in the model that this:
    - increases the total volume of water that is being used for economic benefit;
    - allows water to move to those who can generate more economic benefit from it;
    - enables some water companies to buy abstraction rights and thus delay high cost infrastructure projects; and
    - enables other water companies to sell abstraction rights and replace these with earlier implementation of low cost infrastructure projects.
- Periodic allocation of water (under Water Shares):
    - explicitly clarifies how much water can be abstracted in the next period and allows agents in the model to identify how much water they need or have spare, which enables them to trade from a position of knowledge; and
    - increases short term trading, which maximises the water being used for economic benefit, and helps agents to manage short-term high demand/low supply situations better.

134. Which sector contributes most to the production benefits depends on a number of factors associated with the climate scenario, socio-economic scenario, and local catchment features. For example, some production benefit arises from being able to achieve and maintain a particular production profile under reform that cannot be achieved under current system. Socio-economic scenarios in which there is significant production growth anticipated therefore provide the circumstances in which reform may allow those benefits to be realised. Similarly, one of the principal threats to achieving production profiles is the availability of water, but these circumstances often only arise once the flows fall below certain trigger points. Thus climate change scenarios which have wider swings between wet and dry periods often generate more opportunities for reform to add benefit. Each sector is affected by a different combination and so their relative contributions change under different circumstances.

135. Industrial abstractors tend to have more constant need for water, and so are only really in danger or losing production in prolonged dry periods. But when these circumstances arise they have significant economic power to be able to trade and get hold of the water they need. Thus they contribute to the production benefit in circumstances where industrial growth is anticipated, the climate is likely to produce a higher likelihood of very dry years, and under policies that enable short term trading. Agricultural abstractors have highly variable water demand and are much more directly impacted by short term water availability issues. Thus they contribute more to the production benefit in circumstances where irrigated crop growth is anticipated, there are regular short term

periods of low flows, and in localities where there are a large number of other abstractors nearby who are willing to trade.

Catchment Case Study Analysis

136. Overall we find that the differences in outcomes between the reform options are small, depend strongly on the economic and geographic particulars of each basin, and in many cases will be within the error margins of the modelling.

137. We see most economic benefit where there is a strong seasonal demand for water (e.g. for water sensitive crops), and where lots of abstractors can benefit from trading. Where this is the case there is value in providing flexibility to a community of abstractors to reallocate resources at times of low flow. The modelling assumes that most abstractors will be willing to trade and that trades are matched efficiently to maximise trading volumes. Reluctance to trading has been explored using sensitivity tests and the results suggest that a significant proportion of the overall benefits are dependent on participants being receptive to the trading opportunities. This is consistent with the response to the consultation where the majority of those who indicated an opinion considered that faster and easier trades would be useful.

138. We find the impact on PWS companies can vary significantly between catchments and scenarios. Some of this variability occurs as a result of the finely balanced nature of the catchment hydrology and the potential interactions between abstractors under different policy options. However, a significant proportion arises from the model's limited ability to represent the operational balancing and incremental investment planning that can be achieved in practice. We anticipate PWS companies will have a greater ability to respond to these challenges than we can represent in the modelling, and that the variability of impacts seen will be lower in real life.

139. The modelling has demonstrated that the interactions between the reforms, abstractor behaviours, and the hydrology in each catchment are very complex. A range of competing drivers are at work and can be finely balanced. It is often specific local factors (hydrology, abstractors' relative abstraction rates, abstractor's relative economic power, PWS companies remaining investment options and constraints) that determine the direction of a particular scenario, which in turn can lead to swings in the benefits and costs. For example, relatively small changes in patterns of abstraction under different reform options can trigger different patterns of take-back of water. These in turn trigger different responses from abstractors and in particular the PWS. Where the operation of reform is more highly constrained, and the benefits are marginal, these local effects can dominate results.

140. In practice it will be difficult to predict how abstraction patterns and their impact at the local level might change as the climate changes and the reform options begin to have effect. Any abstraction licensing system will therefore need the flexibility to identify and adapt to emerging challenges at the local level. The findings therefore support a hybrid or 'incremental' system whereby more sophisticated licensing can be brought in as required to enable an adaptive and proportionate approach.

141. The modelling has allowed the proposed policies to be refined by encouraging more systematic consideration of their design and greater understanding of their possible impacts with analysts and stakeholders.

142. See Annex I for further details.

Limitations in the results

143. The above findings are subject to a number of caveats. The main limitations are as follows:

Aggregation

144. The Aggregation Model runs are based on four ABM catchment models: Stour, Hampshire Avon, Cam and Ely Ouse and Usk.

145. A case study based on the Trent and Derwent catchment has also been constructed. The size and complexity of this catchment has meant that it has not been possible to develop the model to the state of completeness necessary to allow it to be included in the aggregation. However it has been used for sensitivity testing – see Annex G.

146. The Aggregation Model reflects the water availability, level of abstraction and mix of abstractors in each catchment, but it still assumes that the four modelled catchments are an unbiased representation of all 116 real catchments. This is more likely to be true in scenarios that are generally dry everywhere in the country (e.g. Scenarios G and J), but is less likely to be true in scenarios that are much wetter in some parts of the country than others (e.g. Scenario C).

147. The Aggregation Model assumes that all cost and benefit elements can be scaled from the 4 catchments to the whole of England, and separately Wales. As there are only about 35 enhanced catchments in all scenarios and this is where benefits are scaled to, this is a reasonable sample. Adaptation costs to business are generally dominated by PWS impacts. As there are only a very few water companies in each catchment, and their plans are sometimes different in nature, this assumption is less likely to be reliable for this element of the costs.

148. See page 39 for section on Aggregation for further details of aggregation methodology.

The Abstractor Behaviour Model

149. The Abstractor Behaviour Model has under gone significant improvements to address a number of the weaknesses identified in the initial Impact Assessment.

150. In particular the model now includes:

- a mechanism to ensure that there is a temporal delay between ground water abstraction and its impact on local river base flows;
- a number of additional trading mechanisms;
- improvements to the modelling of water company option choices and sequencing;
- improvements to the environmental damage assessment and licence review process;
- improvements to the balancing of abstraction for large, complex and spatially distributed abstractors (in particular PWS companies); and
- the addition of evolving environmental protection measures.

151. However, there are still elements of the modelling that (in order to remain tractable or allow completion in the timescales) still contain simplifications that have implications for the analysis.

152. Modelling results therefore need to be understood in the context of four key issues:

1) Water company abstractions through the year are in reality managed and controlled by a team of water resource managers. The ABM uses an optimisation routine to simulate this process, but there are operational situations in which it does not always find the best solution. Thus water companies' ability to make best use of their licences is not as efficient as would be expected in practice and the actual abstraction patterns may be different especially in dry periods. We anticipate that in reality PWS companies will be much better able to balance their abstractions, resulting in less environmental damage and fewer licences being curtailed as part of the review process. Thus the model is over-estimating the investment impacts in all policies, and this is likely to mean overall differential investment benefits/costs will be smaller than stated.
2) Water companies' investment choices will in reality be much more able to consider the long term environmental impacts of particular options. The ABM uses an optimisation routine to identify the lowest NPV solution to the currently anticipated shortfall profile and implements options regardless of future environmental damage, which in turn may require further investment to resolve. Thus the model is sometimes creating problems for water companies that in reality they will be able to avoid or ameliorate. This is likely to mean that PWS investment benefits/costs are likely to be less variable between policies than stated.
3) It has not been possible to include the modelling of 'Put –Take' trading where an upstream abstractor releases water into the river in order to allow this water to flow to a downstream abstractor. Thus the model is underestimating a benefit of reform that Water Shares and the Hybrid Option with short term allocations would facilitate.
4) Production benefits arise partly from the direct growth in profits arising from anticipated price increases and the consequential production growth that such prices would generate. It is the relative differences between policies that is reported. The model is not designed to accurately predict the actual behaviour of individual abstractors, but instead it is intended to represent the broader system behaviours that arise when a group of individuals start to make similar decisions. In some cases, the production growth arises from the decision making within the model of a small number of economically significant abstractors. While the model is indicating that abstraction reform could produce a significant economic benefit in these circumstances, the actual decision making of these abstractors is likely to be based on many other factors. Where we believe that such decision making is unlikely to represent real behaviour but is rather an artefact of the modelling, we have chosen to exclude the benefits. As the behaviour of the agents affects other agents in the model, it is difficult to say what effect this has on the overall results, but we suspect that we may be underestimating the production benefits.

153. A common feature of all of these limitations is that in reality abstractors have to manage significant complexity and be able to react quickly to emerging economic challenges or water scarcity situations if they are to succeed. While it is not always possible to confidently predict the actual production or investment benefit that might arise from reform, what the various elements of reform do provide are more tools to allow abstractors the flexibility to manage their abstraction in the best way to suit their particular circumstances.

154. Where possible, these limitations have been subject to sensitivity analysis as described in Annex F.

Non-monetised costs and benefits

Benefits to the Environment

155. No attempt has been made to monetise the benefits to the environment that result as all the options are designed to be consistent with and support the achievement of the water quality objectives as set out in the Water Framework Directive and Habitat Directive. The options could differ in how effectively they achieve these outcomes while enabling abstractors to make full use of the available water.

156. All reform options at transition reduce unused portions of licences reducing potential future pressure on the environment. Options differ though in terms of their effectiveness in managing environmental protection in different circumstances. The water shares option (and hybrid option operating with short-term allocations) creates greater constraints on access to water through short-term allocations, potentially reducing pressure on the environment. Short-term allocations create a defined amount that can be taken over a short period compared to annual allocations which can be used at any time subject to daily limits and hands off flows. However annual allocations with hands off flows may be more effective where flows are fast changing. Overall the hybrid option, as it allows approaches to allocation to be tailored to catchments, is likely to provide the best approach to environmental protection in any particular catchments.

157. The modelling is unable to distinguish between the options as the overwhelming driver for risk to the environment is falls in flows associated with climate change which swamps other factors at the aggregate level. Table 11 shows the average proportion of the catchment suffering breaches over the 25 year period.

Table 11: Average proportion of the CE&O catchment suffering environmental damage under four scenarios.

	CS	CSP	WS
A-I	5%	5%	5%
C-SB	17%	18%	18%
G-LR	12%	12%	12%
J-UD	5%	6%	6%

158. More extensive analysis of catchments shows a range of different complex patterns due to multiple interacting system elements with no clear dominant pattern so it is difficult to draw any further conclusions.

Other non-monetised costs and benefits

Option 0: Do nothing/Current system

Costs

159. This option carries no upfront implementation costs as it is a continuance of the existing system. However, over time unexpected costs could arise due to the inherent problems of the current system set out previously. The uncertainty around time-limited licences and the licence modification process for users could lead to inefficient business planning and investment, particularly to manage risks of climate change. There may also be costs incurred by new users of the system.

Benefits

160. This option is a known system to abstractors, hence provides benefits of continuity and familiarity.

Option 1: Current system plus

Costs

161. A key element of this option is facilitation of trading markets. There are risks of unintended impacts due to such things as market abuse and distortion. We have investigated potential risks and considered the need for further regulation, which at this point we, including Ofwat[48], do not consider necessary to deliver the trading benefits in this impact assessment (see Annex F).

162. There may also be costs for abstractors in better understanding their water needs and the value of water to them, which we have not monetised.

Benefits

163. This option offers broad non-monetised benefits for all from increasing flexibility to adapt to a range of climate change outcomes. There will also be better systems providing information on water use and availability allowing more efficient water management. Businesses may be able to diversify their income by developing a business in water management by for instance investing in reservoirs. The facilitation of competition in the water industry due to easier access to abstraction of new entrants could increase the overall economic benefits of upstream competition[49] in England. There are also benefits to non-abstractors and the rural economy from more efficient use of water.

Option 2: Water shares

Costs

164. This option delivers even greater facilitation of trading markets. There are therefore greater risks of unintended impacts due to such things as market abuse and distortion. We have investigated potential risks and considered the need for further regulation, which at this point we, including Ofwat[50], do not consider necessary to deliver the trading benefits in this impact assessment (see Annex F).

165. There may be risks around implementation of this innovative approach to allocating water which we have not monetised as they are not known. It has only been implemented internationally in Australia under very different conditions.

166. There may also be costs for abstractors in better understanding their water needs and the value of water to them, which we have not monetised. However these should not be significantly greater than the costs of managing water needs without reform.

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[48] Ofwat have confirmed they agree with this assessment.

[49] Upstream market competition can be thought of as a series of three inter-related parts:

- The Abstraction market involving all abstractors covered by this impact assessment;
- Trading of bulk water via pipes (and sewerage services) amongst current incumbent water companies; and
- Trading of bulk water via pipes (and sewerage services) by new entrants to the public water system as well as incumbents: for example, entrants putting water into the public water supply network (or taking and treating sewage).

[50] Ofwat have confirmed they agree with this assessment.

Benefits

167. This option offers greater non-monetised benefits than option 1 for all from increasing flexibility to adapt to a range of climate change outcomes. This is due to the increased ability to accurately manage water if problems in water availability increase, including the ability to facilitate 'put and take' trading e.g. from reservoirs and re-use schemes. There will also be better systems providing information on water use and availability allowing more efficient water management.

168. This could provide greater investment certainty for abstractors than option 1 as they would be guaranteed a proportion of available water through their shares. Anecdotal evidence from Australian irrigators suggests that the share system provides an improved basis for abstractors to plan and invest. This view was also put by Anglian Water in their consultation response. Having a share in joint resources could also encourage cooperation to better manage shared water resources. This should all provide greater resilience to water availability.

Option 3: Hybrid option

Costs

169. This option also facilitates markets. We have investigated potential risks and considered the need for mitigation measures, which at this point we, including Ofwat, do not consider necessary to deliver the trading benefits in this impact assessment (see Annex F).

170. This is also an innovative option as with water shares, but implementation risks are reduced as only a small number of catchments will use short-term water allocations meaning the approach can be trialled.

Benefits

171. This option, like Water Shares, offers greater non-monetised benefits than option 1 for all from increasing flexibility to adapt to a range of climate change outcomes. This is due to the increased ability to accurately manage water if problems in water availability increase. This option reduces the associated risks of this innovative approach due to more limited initial implementation of fixed short-term allocations.

172. This could provide greater investment certainty for abstractors than option 1 as they would be guaranteed a proportion of available water through their shares. Anecdotal evidence from Australian irrigators suggests that the share system provides an improved basis for abstractors to plan and invest. This view was also put by Anglian Water in their consultation response[51]. Having a share in joint resources could also encourage cooperation to better manage shared water resources. This should all provide greater resilience to water availability.

Small and Micro Business Assessment

Context

173. A significant number of Small and Micro Businesses[52] rely on water abstraction for their operations. While the largest volume of abstraction is by water supply and power generation companies, the agriculture sector has the largest number of abstraction

[51] See consultation response summary in https://www.gov.uk/government/consultations/reforming-the-water-abstraction-management-system-making-the-most-of-every-drop

[52] These are businesses with up to 49 employees.

licences. Agricultural businesses tend to be mostly SMBs - around 94.5% SMB. This means that a significant proportion of licences, 17,436 out of 21,280 or 82%, are likely to be owned by SMBs – see Table 12. It is important to note that some SMBs, such as large horticultural farms, can be very significant users of water which bears no relationship to their number of employees.

174. Following implementation of the Water Act 2003, the UK Government deregulated a significant number of small volume abstractors, not exceeding 20m^3/d, to reduce the administrative burden on small operators while still protecting other abstractors and the environment. These were predominantly rural abstraction licences for agricultural and domestic purposes. For context, 20 m^3 is 20,000 litres and is a significant amount of water per day for an individual business. This is enough to supply more than 130 people's daily water demand for domestic uses or just under 60 households. Alternatively it would be enough water for a herd of around 140 dairy cows, including drinking, milking and washdown needs.

175. In considering reform options, we reviewed whether this level of deregulation remained appropriate and looked at evidence on impacts of the previous deregulation. We concluded that increasing the level of deregulation to any significant extent would be likely to create risks of derogation to regulated abstractors. This would mean that unregulated abstractors could potentially be using water that would reduce the access to water of those that are regulated. Particularly as water scarcity increases and its traded price increases, there is a risk that numbers of unregulated abstractions could increase substantially affecting the available water to regulated abstractors. There could also be a risk to the environment. Hence we have focused reform on modernising the management system including the administrative processes so it is generally easier to use for all abstractors including SMBs.

Table 12: Analysis of SMBs by sector affected.

Number of abstraction licences in force by purpose: England and Wales (2011), DEFRA ENV15 statistics	Number of licensed	Likely % of SMBs[53]	Number of SMB licences estimated
Electricity supply industry (c)	519	56.0	291
Public water supply	1,617	56.0	906
Other industry	3,896	56.0	2,182
Fish farming, cress growing, amenity ponds	685	95.4	653
Spray irrigation (a)	10,330	95.4	9,855
Agriculture (excl. spray irrigation)	2,992	95.4	2,854
Other	210	56.0	118
Private water supply	1,031	56.0	577
Total	**21,280**		**17,436**

53 Percentages taken from the BIS "Business Population Estimates for the UK and Regions 2012" dataset.

Impacts

176. The impacts on SMBs will be in line with the impacts on business more generally, identified in the monetised and non-monetised sections of this impact assessment. Overall SMBs should experience benefits although some may not have the capacity to exploit trading benefits. Having said that, to date farmers and growers have been the most active traders of water and trading provides the opportunity for SMBs to diversify their businesses into water management. They will certainly all experience the benefits of improved administration systems, such as water accounts.

177. Current reform options do potentially include some immediate direct costs to abstractors. In enhanced catchments smart meters could be required to allow the better regulation of water to deliver the benefits of reform. While larger businesses would also be affected by the cost of metering, the estimated cost of £850 per smart meter is likely to be easily absorbed in large organisations. For SMBs, their size and resource constraints could mean that this had a greater relative impact. Hence we have decided to allow SMBs to opt out of needing smart meters where this is not absolutely necessary:

- Under option 1, SMBs could opt out but would not be able to participate in short term, pre-approved trading or have graduated controls on abstraction; and
- Under option 3, SMBs could opt out in enhanced catchments with annual allocations but again would not be able to participate in short term, pre-approved trading or have graduated controls on abstraction.

178. Those SMBs would also lose out on the benefits of smart meters meeting their abstraction data reporting requirements.

179. Systems with short fixed allocation periods would require smart meters to operate so there could be no opt out under option 2 or option 3 where these are implemented.

180. Furthermore this estimate assumes that an abstractors' current meter can't be easily upgraded to be 'smart' and does not assume a bulk buying approach which could be organised. We will investigate these issues further during implementation.

181. Another area of impact could be the transition to a new system, which may cause administrative burden and cost abstractors time and effort to adapt to. As SMBs are smaller organisations, this could also have a greater relative impact.

Options to mitigate impacts

182. **Exemption:** The default mitigation is full exemption. Exempting all SMBs from regulation is likely to have undesirable environmental impacts, as the size of business does not correlate to amount abstracted and hence the risks to the environment. For example irrigators can be major users at times of dry weather and low river flows posing significant risks to the environment if not regulated. While there are still a significant number of agricultural and other SMB licences left, all remaining licences will be over the $20m^3/d$ threshold. Exemption will also prevent businesses from gaining benefits from trading. Therefore, this is not a feasible mitigation for this policy.

183. As part of implementation we will consider:

- **Specific information campaigns or user guides, training and dedicated support for smaller businesses:** This mitigation could help with the administrative burden of transitioning to the new system. We will engage with SMBs as part of transition, to ensure that there are user guides, training and dedicated support services which help explain the changes, and support SMBs through the transition period. We are likely to engage with SMBs and their representatives in the development of this material, building on the engagement with SMBs throughout the development of this policy. Costs for this should not significantly affect implementation costs, as this will only marginally extend substantial planned engagement with abstractors as part of transition to the new system – see Annex J.

Next steps

184. Following decisions on policy direction, there will be further work on implementation and opportunities to design the user experience so it minimises impacts on SMBs and maximises the benefits to them. It is also important to note that the intention of this reform is to modernise and develop more risk based and lower cost regulation overall. This principle will help to ensure that the impact on business, and in particular SMBs, is lower cost and proportionate.

Rationale and evidence that justify the level of analysis used in the IA

185. The ABM approach was chosen instead of traditional top down economic modelling following workshops with experts and an open tendering process with a wide range of proposals. Annex A also details the evidence gathering process that has gone on for this impact assessment detailing the drivers determining the chosen methodology and the response to the consultation which mainly focused on the design of the options rather than the evidence base. Annex G shows how input from abstractors was used to gather evidence and validate the model. This was considered appropriate due to the complex nature of the abstraction system involving both hydrology and a large number of abstractors, and the uncertainties surrounding the future. Given the significance of these reforms for the long-term and the complexity of the system to be modelled, we have invested substantially in bespoke models and extensive stakeholder interaction. Following the previous consultation IA, we have examined a further case study of the Trent and Derwent in terms of sensitivity analysis. This ensures the analysis in this final IA includes consideration of a very large catchment or basin and the power sector, a key abstractor.

Wider impacts

186. The wider areas which are likely to be impacted by the proposed reforms are detailed below.

Economic / Financial

187. We can expect a positive impact on competition from these proposals, as all reform options are designed to increase the market activity which should make it easier for new entrants to access water via markets. Wider impacts are unclear but may generally not be that significant given that the overall abstractor sector is not that large. The most significant benefit may be the synergies with upstream water industry reform in England[54], further

[54] Upstream market opportunities can be thought of as a series of three inter-related parts:

- Abstractions / trading: trading of abstraction licences / raw water abstraction capacity between all licence holders, not just water companies (which is not part of this IA);
- Trading of water (and sewerage services) amongst incumbents; and
- Trading of water (and sewerage services) by entrants as well as incumbents: for example, entrants putting water into the network (or taking and treating sewage) within the WSL regime.

facilitating new entrants, which will become clear as the detail of upstream reform is developed carefully coordinated with abstraction reform.

Social

188. There is expected to be a positive impact on some rural areas, as these are the areas which are most likely to abstract and trade water, particularly farmers.

Environmental

189. All the options are designed to be consistent with and support the achievement of the water quality objectives as set out in the Water Framework Directive and Habitat Directive.

190. There may be some impacts on the landscape if the proposals are successful in incentivising the construction of infrastructure that supports resilience, such as reservoirs.

191. The impact on the emission of greenhouse gases is expected to be minimal.

Summary and preferred option with description of implementation plan.

192. All reform options deliver benefits compared to the current system under all scenarios even if the less reliable benefits from changes in water company investment patterns are excluded. Differentiating between reform options is more challenging given modelling uncertainty and the systematic bias in terms of modelling trading in water shares and the hybrid option reducing their benefits.

193. Our preferred option is the hybrid option as it:

- has the potential to operate in a similar manner to current system plus where that is most economically and environmentally beneficial, while due to the creation of the share accounting framework, it can also facilitate upstream trading increasing benefits over current system plus;
- has the potential to operate in the 'full' water shares mode with short-term allocations where that is most beneficial, particularly where 'put and take' trading could be widely used; and
- creates shares in enhanced catchments in water recognising the essentially shared nature of this resource encouraging water efficiency and catchment management, while also creating a more secure asset in a share than a reviewable permitted volume.

194. The UK Government has developed a shared approach to abstraction reform with the Welsh Government. The UK Government is committed to implement reform of the current abstraction licensing system in England by the early 2020s. We will continue to work closely with our Welsh counterparts moving towards implementation.

Annex A: Evidence gathering and methodology

Options development

195. The objective of the options development phase was “to develop a shortlist of feasible abstraction reform options to support the goals set out by the UK government in the Water White Paper”. To achieve this goal the project team built on potential reforms identified whilst developing the case for change. Views were gathered from internal and external workshops as well as previous engagement with experts. After compiling previous work we set up workshops, initially attended by internal Environment Agency and Environment Agency Wales (now Natural Resources Wales) staff and later by external water experts to review our thinking and continue to shape our ideas.

196. To identify potential options and good practice more widely, we commissioned analysis of different international approaches from AEA; research on the Australian water management system from Professor Mike Young, and international case studies of market formation and development from NERA Economic Consultancy:

International Review

- To understand what we could learn from approaches to abstraction regulation internationally, the reform team commissioned a review which focused on countries where we could learn the most, focusing particularly on countries where changes have been made to abstraction management[55].
- The most useful findings from this review were around the Australian approach to abstraction regulation which contributed significantly to the water shares option.

Australian Abstraction Regulation

- To learn more about the Australian approach, we worked with Professor Mike Young from Adelaide University who published two papers, as below
- The first focused on lessons to be learned generally from abstraction reform in Australia and other leading edge international practice.[56] This recommended a reform approach which significantly informed the development of the Water Shares option.
- The second focused on the Gwydir catchment in Australia which shares more characteristics with catchments in England and Wales than the examples previously reviewed[57]. The latter of these two reports also helped understand the likely regulatory costs of implementing abstraction reform.

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[55] Review of international abstraction regulation, AEA Technology plc for Defra (2012)

[56] Towards a generic framework for the abstraction and utilisation of water in England and Wales, Professor Mike Young (2012) http://www.ucl.ac.uk/environment-institute/research/ei_fellowship_report

[57] Australian case study project: the Gwydir river catchment, Professor Mike Young and Christine Esau (2013) http://randd.defra.gov.uk Project Code WT1504

Market development and regulation

- Stakeholders have raised concerns about the possible consequences of reforms which promote a more market-based approach to water abstraction management. Within this context, NERA Economic Consulting were commissioned to review the experience of transitions to market-based approaches in selected other sectors and countries[58].
- This work took the form of case studies to draw out lessons that may be relevant for water abstraction from the experiences of how other markets were both developed and regulated. These covered a wide range of experiences, such as Individual Transferable Quotas (ITQs) in New Zealand and Iceland's fisheries, airport slots trading in the United States, emissions trading in the European Union, trading of gas transport capacity rights in the United States, and measures to improve liquidity in the market for spot electricity price hedging instruments in New Zealand.
- This work informed consideration of market design and regulation (see Annex F).

197. To ensure we could manage all the abstraction reform ideas emerging from international reviews, internal and external engagement and technical support from experts, the team developed a conceptual framework that linked potential individual reforms (components) to key abstraction reform functions. This made it possible to combine different components to meet the functions required of an abstraction regulation system in different ways and therefore construct a range of options.

198. In some instances the process of developing options consistently favoured some approaches over others. For example, review conditions were consistently favoured over time limits as the way of making changes to licences whilst balancing long term flexibility and regulatory certainty. These approaches were therefore included in all the reform options. The consultation responses also broadly supported this approach.

199. To ensure the project gathered evidence on how abstractors respond to a broad range of regulatory approaches, it was agreed that we should initially test three options that span the range of tools available. Interpretation of the options modelling would then inform which elements work best under which circumstances and support decisions around reform. The reform options identified were an enhanced version of the current system, a system of 'water shares', and an administered pricing option. While the first two were considered feasible and are discussed in detail below, the final option was found to have significant technical issues with implementation. For these reasons it was ruled out- more detail can be found under 'Other Options Considered' – and the impacts were not modelled.

200. AMEC water consultants provided expert support to the technical development of the abstraction reform options including how the options should be represented and differentiated between in the modelling work. This involved applying agreed rules to define the licence conditions to transition into the model as well as translating the conceptualisation of the options into model inputs.

201. Since the consultation on options in early 2014, we have further developed options based on responses and developed the Hybrid Option.

Options assessment

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[58] A Cross-Sector and Cross-Country Review of Approaches to Transitioning to Markets, Nera (2013) http://www.nera.com/67_8142.htm

202. Developing an evidence strategy to assess the impacts of reform options was a major challenge. We needed to explore how options might perform under different future scenarios of climate and socio-economic change over a reasonably long period, taking into account both the detail of particular hydrological systems, and an England and Wales overview. We also needed to capture the range of behaviours of different abstractors under different scenarios and uncertainty.

203. Following consideration by the Project Board and a workshop with experts, we developed a broad approach based on:

- Working with abstractors to understand how they used water and changes in water availability would impact on them;
- Developing a number of catchment case studies with different hydrological and abstractor types covering different areas of the country;
- Examining a period of 25 years soon after reform implementation up to 2050. This is the period for which we had reasonably detailed future climate and socio-economic scenarios; and
- Aggregating up from catchment case studies to England and Wales based on an understanding of the key factors affecting the impacts of options in catchments.

204. With this broad approach, we went out to tender following an extensive information exercise to facilitate the development of consortia covering the range of expertise and ensure we got the best possible proposal for detailed evidence approaches.

Box 7: Workshops

There were 3 phases of engagement with abstractors for the Risk Solutions Project: sector workshops, catchment case study workshops with local abstractors, and a final phase of multi-sector workshops.

The purpose of the first phase was to understand how potential changes might affect different abstracting sectors, understanding how they currently use water and how this might change with future scarcity, and how they might respond to water markets and changes to licensing systems.

The second phase involved workshops with abstractors in the seven original case study catchments which introduced the different potential reform options, explored how policy reform might affect abstractors and how they might operate their abstraction in response both as individuals and working together.

The final phase involved four multi-sector workshops which allowed stakeholders an opportunity to influence the reform options before they were finalised for public consultation and to help the design of the consultation by testing the new multi-media ways of explaining the options.

205. We selected a consortium led by Risk Solutions which involved hydrological, economic, social and agent based modelling expertise. This project used an integrated hydrological and behavioural modelling approach to develop catchment case studies. The modelling to achieve this was carried out between February 2012 and September 2014 by a consortium comprising Risk Solutions, HR Wallingford, London Economics, Wilson Sherriff, AMEC and Vivid Economics. AMEC also worked with the Environment Agency to represent future abstraction licences and regulatory conditions under the reform options and provided support troubleshooting early model outputs. Additional expertise was provided by Mott Macdonald, ADAS, Cranfield University, Simon Less Consulting, The Centre for Ecology and Hydrology, The British Geological Survey and Blackwell Water Consultancy.

206. The model examined how well the options performed between 2025 and 2050 in terms of producing economic value and protecting the environment. Both the process of building the model (thinking through how each option should be represented in the model and how the various actors may respond) and examination of results emerging from the modelling, informed the design of the options.

207. During the evidence gathering, the ARAG steering group was involved in the evidence process, our core model was subject to scrutiny from a peer review panel and informed by workshops with local and sectoral stakeholders (see Box 7).

208. See Annex G for how this process was used to provide evidence to support the design of decision making and estimation of costs.

Administrative Costs

209. The Environment Agency commissioned URS to develop a spreadsheet tool to allow for flexible analysis of the administrative costs and costs to abstractors from the reform options.

210. The needs of each option were assessed to understand the actions and systems would be required to run it. Data on how much each of these actions and systems would cost was determined by considering increases or decreases in these costs gathered from a variety of sources, including market quotations from experts, the 2012 published accounts of the Environment Agency and experience of Environment Agency and Natural Resources Wales staff of operating the current abstraction regulation system. As some of this work was undertaken before 1 April 2013, references to Environment Agency include information held by Environment Agency Wales, which now forms part of Natural Resources Wales. This work has been further refined in 2014 for this impact assessment.

Top-down modelling

211. The more simplistic, top-down model, is a set of calculations and code in Microsoft Excel which can compare a trading policy option with no trading, considering a variety of water availability and demand scenarios. Further detail can be found in Annex E.

Annex B: Detailed descriptions of options considered

212. This annex presents a fuller description of the options; the key assumptions and simplifications made to support modelling of the options are described in Annex D.

Option 0 - Do nothing/Current system

Summary

213. The current system uses daily and annual abstraction limits and hands off flows to control abstraction, maintain environmental protection and protect the rights of downstream abstractors. Water trading is possible but uncommon and approval takes too long for trading to meet short term changes in demand. Most licences have no end date and can be varied if losses are compensated for in many cases. Charges are set to recover management costs and are not designed to react to water availability.

Linking Abstraction to water availability

214. As water has become scarcer, licences have been issued with progressively more restrictive conditions such as hands off flows. These are specified river flows or levels at which abstraction must stop. Around a quarter of licences, generally those issued more recently, include conditions which crudely link the amount of water that can be taken to water availability.

215. Some licences (largely agricultural licences for Spray Irrigation) are restricted to winter or summer use only. Winter use licences are generally used to give access to winter high flows to fill reservoirs, while summer licences generally provide access to low flows for irrigation. Winter only licences pay significantly less for their water than the summer only licences.

Discharges

216. Some abstractors such as fish farms have a condition on their licences to return water close to the point of abstraction. Consumptiveness of abstraction is also taken into account in charging.

Trading water within catchments

217. Abstraction trading is possible but not straightforward or quick. Each individual trade is subject to 3 to 4 month approval procedures by the regulator and abstractors have to find willing trading partners independently. Short term trades are generally not feasible under standard procedures due to the slowness of the system. Trading is currently rare.

Making changes to permissions

218. Licences or permissions are generally changed if they are unsustainable. Demonstrating that a licence is unsustainable (removing more water than the environment is able to cope with) requires investigation. If required, permanent licences can be amended voluntarily under section 51 of the Water Resources Act (1991) or compulsorily under section 52, with compensation paid in some cases for resulting losses if changed through this compulsory route. Compensation is funded through the Environment Agency and

Natural Resources Wales' charges scheme using the Environmental Improvement Unit Charge (EIUC), a tax on abstractors. Licence changes cannot be made until the full expected compensation amount has been collected. To keep the burden on abstractors down, this has to be collected over a number of years, and therefore licence changes can take years to fund. This increases the time that the environment is at risk from over abstraction.

219. There is a mix of time limited and non-time limited licences. New licences and licence variations have been time limited since 2001. These typically require renewal after 12 years. At the end of the time limit there is a presumption that the licence will be renewed unless the abstraction is damaging the environment, the abstractor no longer has a reasonable need for the water or is not using the water efficiently. Licences granted before 2001 are unlikely to be time limited and therefore not subject to the renewal process.

Administrative approach

Regulatory tools

220. The administration of this system is based on paper licences. Abstractors are informed of changes to their HOFs by phone call, text or letter. There are annual and daily limits on the volume which can be abstracted.

Charging

221. In option 0, abstractors are charged for the quantity authorised to be abstracted. Spray irrigators with a 'summer only' licence can opt to use a two part tariff that charges for a combination of usage and licensed volume. Abstraction charges vary according to the season an abstractor is permitted to operate in, whether they abstract from a supported source and how consumptive they are (assessed using standard estimates of the consumptiveness of different sectors). Charges are designed to recover regulatory costs and are relatively low (significantly below the value of the water to the abstractor).

Regulatory threshold

222. All of the options apply to all abstractors wishing to take more than 20m^3 per day.

Application to different catchments

223. Under this option, the use of regulatory tools varies somewhat across England and Wales according to local requirements, historic approaches and the different characteristics of catchments but there is no systematic approach to variation.

Option 1: Current system plus

Summary

224. The current system plus option aims to refine the current system to make it more flexible and capable of supporting abstractors as they adapt to the impacts of climate change. This option uses the current annual and daily volumetric abstraction controls, and hands off flow conditions from the current system. However, it aims to refine these tools to improve the link between water availability and abstraction including removing seasonal restrictions. No permissions would have a set end date but they would all be subject to transparent and risk based catchment reviews to protect the environment. It also makes it easier for abstractors to trade water. In line with the other reform options, the more

sophisticated aspects of this would only be used in 'enhanced' catchments where water is scarcer.

Linking abstraction to water availability

225. Allowed abstraction would be linked to water availability more closely as follows:

- Seasonal conditions are replaced with flow based conditions allowing, for instance, surface water abstractors who previously had winter permissions for storage for spray irrigation access to high flows at all times of the year.
- Any surface water abstractor is allowed to take additional water at the highest flows.
- There are enhanced hands off flow conditions that apply to surface water abstractors so that abstraction controls are more gradually imposed.
- There are new controls on abstraction at very low flows that apply to non-PWS abstractors. Spray irrigators face more frequent restrictions. These restrictions are not applied to water companies so their obligations to provide security of supply are not affected. The exact definition of these controls will be the subject of further consideration prior to implementation.
- The total permitted abstraction from groundwater will respond to long term changes in groundwater recharge and level by varying total groundwater abstraction from an aquifer, and spreading this change across relevant abstractors. Groundwater management will be tailored according to the local aquifer type, aquifer properties and abstractor demands. In some locations it may be possible to develop rules that allow abstraction to temporarily increase at particular locations under certain circumstances to maintain or increase total abstraction whilst managing environmental risks.

Discharges

226. Abstractors that return a proportion of water to rivers will be required to continue to do so as part of their abstraction permission conditions. The quantities they do not return but consume are the amounts they are able to trade and they can change their level of consumptiveness through trading.

227. We are separately considering how discharges not connected with a particular abstraction point should be managed.

Trading water within catchments

228. Low risk water trades would be pre-approved so trades that fit within the pre-defined rules could be processed almost immediately. Due to the limitations of the current water accounting system, the majority of trades that could be pre-approved would be low risk temporary trades. Between surface water abstractors these would typically involve upstream abstractors selling to abstractors downstream. In groundwater these would typically involve trades that move abstraction away from sensitive receptors, such as wetlands, to lower risk locations. The system would inform all abstractors which trades were pre-approved to facilitate trading. A system would be introduced to make it easier for abstractors who want to buy or sell water to get in contact. At present, this is envisaged as a trading platform- see the section on system requirements below.

Making changes to permissions

229. In contrast to the current system where some licences are permanent and others time limited, all abstraction permissions in future would have the same status. No permissions would be time limited but the regulator would be able to change abstraction conditions if published environmental conditions[59] were breached due to abstraction. Abstractors would be given notice of any such changes. Where changes are made and abstractors are given appropriate notice, abstractors would not be compensated for changes to the conditions that determine how much they can abstract. Improving the link between water availability and abstraction should reduce the likelihood of breaching environmental conditions. The regulator would maintain the right to intervene at any time should abstraction cause serious environmental damage.

Administrative approach

Regulatory tools

230. Option 1 manages abstraction through controls set out in three ways. These are:

- Site-specific permits;
- Catchment abstraction rules; and
- Water accounts.

231. Site specific permits are a prerequisite for abstraction and include local conditions that apply to abstraction, for example, the maximum daily abstraction volume or the requirement to have a certain type of fish screen (to prevent fish from getting into the water being abstracted) on an abstraction point. These permits ensure that local sensitivities are not overlooked and allow conditions to be tailored to local requirements.

232. Catchment abstraction rules documents include conditions specific to the catchment, such as trading rules, standard hands off flow conditions and review conditions. Detailing the rules in one place allows them to be applied transparently and consistently. It also makes trading easier and clarifies environmental requirements.

233. The water account details how much each abstractor can abstract over a set period, for example, over one year. This would be expressed as net abstraction, meaning that the water the abstractor returns to the system would be accounted for. Separating the periodic abstraction constraint from local conditions and catchment conditions enables water to be traded quicker and more simply. Understanding net abstraction allows water to be traded between different types of usage. A better understanding of how much water abstractors consume will allow the system to more accurately account for water.

Charging

234. Charging would continue to be based on recovering the costs of water resource management. Charges would be scaled based on a variety of considerations such as the size of the permitted volume, actual use, how much water is returned to the environment (consumptiveness) and how reliable an abstraction licence is. The detailed approach will be subject to further consideration prior to implementation.

[59] The Environment Agency have commissioned three projects to examine best methodology for setting Environmental Flow Indicators (EFIs) to inform this consideration. These include a review of best international practice, a review of completed investigations into unsustainable abstraction and a wide ranging systematic review of EFIs.. Assumptions made for the purposes of the Impact Assessment are described in Annex D.

Regulatory threshold

235. All of the options apply to all abstractors wishing to take more than 20m^3 per day.

Application to different catchments

236. Where there are competing demands for water between abstractors and water ecosystems are sensitive, there will be a greater need to facilitate trading and regulate flows to protect the environment. This requires a more sophisticated and costly approach to abstraction regulation that cannot be justified where the pressures don't exist. To reflect this, we have split the reform options into universal components which will have to be in place regardless of the type of catchment, and enhanced components, which will only be put in place where there are likely to be economic and environmental benefits. Hence some catchments will only have basic components whereas others will have enhanced components. The main extra components in enhanced catchments are:

- Abstractors have access to additional high flow water;
- Hands off flows on abstraction are gradually implemented rather than being simple on/off mechanisms as in basic catchments; and
- Pre-approval rules are developed to facilitate trading.

237. In order to allow these enhanced components to function, abstractors in these catchments may be required to have smart meters compatible with Environment Agency and Natural Resources Wales telemetry systems.

238. Over time, environmental conditions or levels of demand for trading may change, and decisions can be made to introduce enhanced components to catchments.

Option 2: Water shares

Summary

239. The water shares option centrally embeds the principle that abstractors have a share in the available water resource rather than an absolute allowance whatever the water resources available. For a particular period, assumed to be a fortnight for surface water abstractors in this impact assessment, abstractors receive a water allocation based on water availability and depending on the reliability and size of their share in a particular resource (see Box 8). This creates the potential to implement a more systematic approach to accounting and managing water in rivers to reflect the variability in their flows and facilitate shorter-term and more types of trading. Because groundwater levels are typically slower to respond to changes in availability, annual allocations to groundwater abstractors can be adjusted over the long term in response to long term changes in groundwater availability.

> **Box 8: Shares**
>
> A share is a right to a proportion of the water available in the catchment. The actual volume of water is defined by an allocation in a given period, which sets out what that proportion allows you to abstract during that period. An abstractor may own shares equivalent to 10% of the water available in that catchment. That 10% could provide 10,000m3 in a wet period, but the allocation may be shrunk to 8,000m3 or 6,000m3 during a dry period where flows have dropped.
>
> Allocations define how much water an abstractor can use during a fixed period of time and are uninterruptible. For the purposes of modelling the options, we have trialled fortnightly allocations. However we are aware that this may not be the right duration and that the appropriate duration may vary in different catchments
>
> Shares would be grouped by reliability. For example, more reliable shares allow abstraction at both lower and higher flows and less reliable shares allow abstraction only at higher flows. These groups of shares may allow abstractors to tailor their portfolio of shares so they can abstract at different flows as required
>
> Shares would be initially allocated based on previous water usage. The exact details of this process are to be finalised.

240. This system includes many of the changes proposed in the current system plus, for example:

- linking abstraction to water availability by moving from seasonal to availability-based conditions;
- separating and simplifying permission conditions; and
- introducing a more consistent way of changing abstraction conditions in response to environmental pressures.

241. The approach to groundwater is the same under this option and option 1 aiming to facilitate pre-approved low risk trades and to allow total abstraction from an aquifer to adapt to long term changes in availability.

Linking abstraction to water availability

242. By varying allocations, abstractors can take more when more is available and less when less is available. In this system, because the volume of water that can be abstracted is linked to the volume available the number of shares held by abstractors would not need

to be modified to keep abstraction within environmental limits. Instead, short-term allocations would be altered to ensure abstraction was within environmental limits.

243. Highly reliable or group 0 shares will have the same low flow controls as in current system plus. The exact settings of these controls will be the subject of further consideration prior to implementation.

Discharges

244. Abstractors that return a proportion of water to rivers will be required to continue to do so as part of their abstraction permission conditions. The quantities they do not return but consume are the amounts they are able to trade and they can change their level of consumptiveness through trading. Their share in water resources takes into account their consumptiveness or net abstraction.

245. We are separately considering how discharges not connected with a particular abstraction point should be managed.

Trading Water within catchments

246. Under this option it will be possible to pre-approve trades up stream as well as downstream due to improved water accounting. It will also be possible to facilitate short-term trading during the period of allocation. So a wider range of trades will be possible with lower transaction costs than with the current system or current system plus. Because the long term right to a proportion of water is separated from the short term right to abstract a specific volume of water, abstractors can make short term trades by trading in allocations, or by transferring water through 'put and take' trading (putting water into a river from a reservoir or other storage mechanism to be taken out further downstream) without impacting their long term entitlements. There will then be a market in both short-term allocations and in long-term shares. This will be facilitated by a system, such as a trading platform, in the same way as Option 1. Only those with a need to abstract water or owning land on which there is a need to abstract water will be allowed to apply for permissions and hence trade.

Making changes to permissions

247. This would happen through a review system in a very similar way to the one in Option 1. However, rather than changing the number of shares held by abstractors, changes could be made to the rules for setting allocations to better protect the environment. Changes could also be made to the site-specific conditions associated with each abstraction if appropriate. Notice would be provided to abstractors before changes are implemented.

Administrative approach

Regulatory tools

248. Option 2 manages abstraction through controls set out in three ways similar to option 1. These are:

- Site-specific permits;
- Catchment abstraction rules; and
- Water accounts.

249. The main difference is that catchment abstraction rules will include rules on how allocations are derived from shares and the water accounts will also include records of share holdings and trading.

Charging

250. Charging would be the same as option 1.

Regulatory threshold

251. All of the options apply to all abstractors wishing to take more than $20m^3$ per day as with option 1.

Application to different catchments

252. As with option 1, some catchments will only have basic components whereas others will have enhanced components. The main extra components in enhanced catchments are:

- Allocations vary gradually in enhanced catchments while they are on or off in basic catchments; and
- Pre-approval rules are developed to facilitate trading.

253. In order to allow these enhanced components to function, abstractors in these catchments may be required to have smart meters compatible with Environment Agency and Natural Resources Wales telemetry systems.

Option 3: The Hybrid Option

Summary

254. The hybrid approach aims to combine the most useful elements of the two original reform proposals, current system plus and water shares. The hybrid approach would be set up like the water shares option and would be based on a system of shares assigned to different levels of reliability and different management units. However shares would only definitely be created in enhanced catchments[60]. In most enhanced catchments, rather than assigning short-term fixed allocations, the Hybrid option would use a much longer, potentially annual, interruptible allocation period. Abstraction would then be managed in year using principles taken from the current system plus option (daily limits can be altered based on flows on any day as defined by hands off flow thresholds, which would be common within a reliability group). Elements of reform that were common across current system plus and water shares remain included in the hybrid approach. For example:

- Linking abstraction to water availability by moving from seasonal to availability-based conditions;
- Separating and simplifying permit conditions; and
- Introducing a more consistent way of changing abstraction conditions in response to environmental pressures.

255. All three options use the same approach to groundwater management whereby pre-approved low risk trades are facilitated and total abstraction from an aquifer can be changed to adapt to long term changes in water availability.

256. This option maintains the potential for better accounting of water provided by moving to a shares framework. This framework also offers better protection of the environment and more pre-approved trading possibilities. The hybrid option allows these innovations to be implemented, where appropriate, in a more evolutionary manner reducing the risks of unexpected problems. This responds to concerns that the Water Shares option was very complex and introduced risks in terms of its implementation.

Linking abstraction to water availability

257. Although in enhanced catchments, abstractors would be allocated shares under the hybrid approach, in most of these catchments it would operate more like the current system plus with graduated hands off flows. Fixed allocations over short periods would only be introduced in a small number of catchments where they could provide the greatest environmental and economic benefits. This would also provide an opportunity to understand better how to make this innovative approach work best and its suitability to different types of catchment. So, for instance, fast responding or flash catchments may work best with hands off flows rather than short fixed allocations even where water is scarce and demand is high.

258. Highly reliable or group 0 shares will have the same low flow controls as the current system plus. The exact settings of these controls will be the subject of further consideration prior to implementation.

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[60] Decisions would be made later as to exactly when shares are created. They are not required in catchments with available water and abstractors can be allocated an annual permit. Once a reliability class of water is fully allocated, annual permits could be converted to shares but this is a matter for decisions on implementation. In enhanced catchments, shares will definitely need to be created to allow upstream trading and short-term allocations.

Discharges

259. Abstractors that return a proportion of water to rivers will be required to continue to do so as part of their abstraction permission conditions. The quantities they do not return but consume are the amounts they are able to trade and they can change their level of consumptiveness through trading.

260. We are separately considering how discharges not connected with a particular abstraction point should be managed.

Trading water within catchments

261. Abstractors would remain able to trade both shares (which give the right to allocations) and fixed allocations. In enhanced catchments, the geographical scope for trading (i.e. including upstream trading) would be the same as it is in water shares. The difference would be that in most catchments allocations would be annual and the water traded would not be a guaranteed quantity as it would be linked to flow conditions. In some catchments, or particular sub-catchments, we would introduce fixed allocations (the full water shares approach). In these catchments the full functionality of water shares would be available so short-term fixed allocation trading would be available. As with water shares, only those with a need to abstract water or owning land on which there is a need to abstract water will be allowed to apply for permissions and hence trade.

Making changes to permissions

262. The approach to changing abstraction conditions would be very similar to that in option 2 (water shares). Changes would be focused on the rules for setting allocations and flow based restrictions, rather than changing the shares that abstractors hold. Changes could also be made to the site-specific conditions associated with each abstraction if appropriate. Notice would be provided to abstractors before changes are implemented.

Administrative approach

Regulatory tools

263. Under option 3, the hybrid approach, regulatory tools are split into the same three main elements as option 1 and 2. These are:

- Site-specific permits;
- Catchment abstraction rules; and
- water accounts.

264. Water accounts would include periodic allocations and shares in enhanced catchments. Catchment rules would set out how allocations are determined.

Charging

265. Charging would be the same as option 1 and 2.

Regulatory threshold

266. All of the options apply to all abstractors wishing to take more than $20m^3$ per day.

Application to different catchments

267. As with option 1 and 2, the hybrid approach can be implemented in a more or less sophisticated way depending on demand for trading and environmental sensitivity of catchments. This ranges from a level of implementation that would feel similar to the basic version of current system plus to full water shares. In practice there are a wide range of potential designs in terms of, for instance, the periods for allocation and the pre-approval of different types of trades. For the impact assessment, we have assumed three versions. These are:

- Basic catchments;
- Enhanced (annual allocation) catchments;
- Enhanced (fixed short-term allocation) catchments.

Basic catchments

268. In basic catchments the hybrid would be run like the basic version of option 1 (current system plus) and the associated regulatory costs would apply. In these catchments, shares would not be created and abstractors would only have permitted volumes similar to option 1.

Enhanced (annual allocation) catchments

269. In these catchments, for example, where there is particular environmental sensitivity or in a fast reacting catchment, it would operate like the enhanced version of current system plus (option 1), but abstractors would hold shares. The costing would be based on the costs associated with enhanced option 1.

Enhanced (fixed short-term allocation) catchments

270. In these catchments, it would operate like full water shares and therefore use the regulatory costs associated with full water shares.

271. The process of moving to a system based on shares sets the foundation for moving to full water shares. This means that the regulation of catchments could evolve over time depending on the benefits and appropriateness of short-term fixed allocations. The introduction of shares allows the lengths of allocations to be tailored for all catchments.

Transition

272. How the transition to a new system is managed is a key area of importance for implementing a new abstraction management system. Various factors will need to be taken into account before we change existing licences to move them into a new system. These include:

Proportionate implementation

273. As discussed above, the reform options can be implemented in a basic or enhanced version depending on the demand for trading and the environmental sensitivity of catchments. At transition, an initial assessment will be made for each catchment as to what version of the chosen reform option is appropriate and will provide most benefits given the costs.

Permitted volumes/shares

274. A key element of transition is to reduce unused licensed volumes to prevent risks of environmental deterioration. In 2011 under 40% of licenced volumes in freshwater were actually abstracted. As water demand increases this could lead to increasing pressures on the environment. Furthermore abstraction reform aims to increase the proportion of licensed water that can be used through facilitating trading. Therefore it is important that only the water that is genuinely available above environmental limits is allocated in the reformed system. If more water was allocated initially than was available this could lead to environmental deterioration and breach our obligations under the Water Framework Directive. This means that, where catchments are over licensed, it will not be possible to transfer full licensed volumes into the new system. The precise rules for transitioning licences are yet to be determined, but the intention is that abstractors initially retain sufficient flexibility to meet operational requirements recognising that this may vary from year to year.

Previous licence conditions

275. The UK Government has committed to taking into account previous abstraction licences as well as water usage when moving to a new system. The reliability of access to water in the reform options has been set to be comparable to the reliability of current licences.

Compensation

276. As per the transition principles, we do not intend to fund compensation for any losses individual abstractors incur in the change to a new system. However, losses are unlikely in most cases as we are seeking to provide existing licence holders with volumes very similar to what they currently use with similar reliability.

System requirements

Online accounts and catchment conditions

277. In option 0, abstraction licences are written documents. Under the three reform options, paper licences would be replaced with an electronic water account that would track licensed quantities or shares and allocations, and individual conditions such as HoFs, online.

278. Historic abstraction conditions, such as the basis for hands off flows, would be standardised and detailed in a set of catchment abstraction rules. Local permits would hold any site-specific requirements and would be a prerequisite for any regulated abstraction.

Metering

279. Currently there is no legal requirement to have accredited meters on abstractions. However, accredited smart meters may be essential or highly desirable in the reformed system. In option 0, abstractors have to record meter readings frequently. For those abstractors with a two-part tariff for spray irrigation, taking a daily meter reading is part of their charging agreement[61]. In Option 1, catchments using the enhanced tools will require frequent recording and reporting of abstraction data. In option 2, the two-weekly allocation and trading period which we are currently considering would require abstractors to record or report their readings every two weeks. In option 3, there will be similar requirements depending on the nature of the catchment. The level of reporting required is likely to be proportionate to the size of abstraction and potential risk. For the impact assessment, we are assuming that in all enhanced catchments abstractors would have smart meters linked to telemetry systems.

Trading systems

280. For all reform options, trading information and facilitation will be needed to make it easier for trading to happen. This would include information on what trades are pre-approved, and a facility for abstractors to advertise their wish to buy and/or sell and to register their trades within their catchment. It is currently assumed that the Environment Agency and Natural Resources Wales will provide the systems to enable this on a cost recovery basis where there is demand but would not actually broker or fulfil commercial transactions.

281. It is also assumed that private sector brokers would emerge to facilitate bilateral and multilateral commercial trading transactions. Estimates of likely broking charges have been made of 3% of the value of trades for sellers and 1.5% for buyers. These are based on market rates for comparable trading markets and experience in Australia. Brokers' fees in a median scenario are in the order of £1m per annum across England and Wales while a rough order of magnitude estimate to create an electronic market clearing system was £1m plus or minus 60% with operating costs of £45k per annum plus or minus 40%. This would suggest brokers' charges are not significantly underestimated especially in the context of the significance of administration costs.

[61] Top tips for complying with your water abstraction licence, Environment Agency (2011) http://www.environment-agency.gov.uk/static/documents/Business/water_abstraction_Top_tips_July2011.pdf

Annex C: ARAG Stakeholder Members

John Adlam – Horticultural Trade Association

Philip Burston – Royal Society for the Protection of Birds

Andy Limbrick – Energy UK

Adam Comerford – Canal and Rivers Trust

Luke DeVial – Wessex Water

Sarah Mukherjee – Water UK

Colin Fenn – World Wildlife Fund

David Bellamy – Food and Drink Federation

Chris Brett - British Hydropower Association

Susanne Baker – EEF: The Manufacturers Association

Nicola Owen – Mineral Products Association

Damian Testa – Country Land and Business Association

David Pollard – Chemical Industries Association

Debbie Stringer – Confederation of Paper Industries

Paul Hammett - National Farmers Union

Andrew Smith - British Trout Association

Rhian Nowell-Phillips – Farmers Union Wales

Ian Brown - Welsh Water

Simon Wood – EDF Energy

Annex D: Key assumptions and simplifications

282. The modelling used involved integration of hydrological models (complicated systems in their own right) with a bespoke abstractor behaviour model (ABM). Catchments are generally large areas (from 1000 to over 8000km^2), with a large number of abstractors.

283. The ABM has been designed to capture the behaviour of a wide range of different types of abstractor, with different requirements for water and different capacities to respond effectively to changing water availability and the abstraction reforms. There are a large number of agents, producing a wide range of products each with a number of options for how and when they may respond to the various drivers of change. We have not tried in developing the models to reproduce reality. Instead we have aimed to capture sufficient of the diversity and complexity of both the system and the reform options to fulfil three aims:

- To shape thinking around how the reform options are likely to work in practice and therefore help shape their design to optimise desirable impacts and minimise undesirable impacts;
- To present a sufficiently varied challenge to the reform options to enable us to compare and contrast their performance; and
- To provide input to estimation of costs and benefits included in this Impact Assessment.

284. It was necessary to make a number of simplifying assumptions, both to make the modelling tractable and to allow us to model options where final detailed design decisions are yet to be made. The main assumptions and simplifications are detailed below.

Hydrological modelling

285. For each case study catchment a hydrological model based on the CatchMOD model[62], is used to estimate river flows and groundwater levels in each 1 km grid cell at a daily time step. It takes account of:

- Abstractions
- Discharges
- Precipitation
- Evapo-transpiration
- Land use, and
- River flows.

286. Data sources include:

- Abstraction Licensing Records
- CAMS Ledgers

287. Information is passed, on a daily basis, from the hydrological model to the abstractor behaviour model.

288. The most important assumptions and limitations in the model are described below.

62 Cloke, H. L., Jeffers, C., Wetterhall, F., Byrne, T. Lowe, J. and Pappenberger, F. (2010) Climate impacts on river flow: projections for the Medway catchment, UK, with UKCP09 and CATCHMOD Hydrological Processes, 24, pp 3476–3489

Groundwater modelling

289. The simple approach to groundwater modelling in CatchMOD has been improved to:

- Accommodate an approximation of the spatial distribution of groundwater abstractions on river flows using information already held within EA and Natural Resources Wales' Water Resources GIS and CAMS Ledgers; and
- Delay and smooth the impacts of groundwater abstraction on river flows with time, with the level of delay being dependent on the average size of the abstraction and the distance from the river, and taking into account other information about impacts as identified in the CAMS Ledgers.

290. Assumptions for the spatial distribution of groundwater abstraction impacts remain simple. All groundwater abstractions within the same hydrological model cell, regardless of their size, are assumed to have the same pattern of impact distribution across the network of surface water bodies draining the aquifer. In reality the impacts of larger abstractions would be expected to spread more widely than the impacts of smaller sources.

291. A more realistic simulation of the temporal and spatial distribution of groundwater abstraction impacts would only be possible using more sophisticated groundwater models, which could not be linked to the Agent Based Model. Separate research is being carried out by the Environment Agency to consider the hydrological impact implications of abstraction reform proposals for groundwater.

Behavioural modelling and decision making

292. We have constructed an agent-based model to simulate the behaviour of abstractors (agents) operating in the context of a catchment area (topology) while being subject to a licensing regime (rules). Choices about adaptations, responses to pricing signals, and interactions with other abstractors are incorporated into agents' abstraction behaviour. The individuality of each agent is determined by its water needs, location, relationships with other abstractors, and the localised water availability challenges it is subjected to. In this way, the modelling framework can explore how individual abstractor behaviour is likely to combine to produce overall abstraction behaviour, with its consequential impact on environmental flows. These rules have been established through detailed consultations and literature review.

293. The agent-based model has been developed using a Rapid Application Development (RAD) environment called Delphi[63]. The model calculates the water abstractions and returns in the next time period for each hydrological model cell based on abstractors' water requirements, adaptation behaviour and responses to reform options. Agents located in one cell may make abstractions and returns to other cells depending on their particular circumstances. In particular it considers how abstractors might react to price signals to make adaptations, and how they might interact with each other as individual abstractors make choices about cooperation, investment and market opportunities.

294. The most important assumptions and limitations in the model are described below.

Characterising agents

295. It was not possible to model every agent in each catchment precisely. We were unable to fully represent the complexity of their production processes or accurately model

63 http://www.embarcadero.com/products/delphi

the economics of their operations. Instead we made a number of simplifying assumptions. For example, we identified a series of generic products or services in each sector and assumed production was confined to these. Further we had to impute the levels of current production of these products from estimates of the amount of water required per unit of production and the amount of water currently abstracted by each agent. We also had to impute the location and nature of agricultural businesses that may become abstractors in the future. While these are major simplifications it has provided us with a rich mixture of different type of abstractor, delivering different products or services with different requirements for water and different levels of price sensitivity providing us with a suitable test bed for the options.

Non-Public Water Supply agent decisions

296. We assume that non-Public Water Supply (non-PWS) agents (mainly agricultural and industrial abstractors) must accept the market price for their output (i.e. they are *price takers*). That is, there is no dependency between the amount of output an agent produces and the unit price of their output (so they can increase or decrease production without affecting the price). This means, for example, that if an individual agent experiences an increase in input costs that is specific to them they cannot pass this on to their customers through an increase in prices.

297. In the ABM non-Public Water Sector agents are not represented as purely profit maximising, in the same way as they would be in a traditional economic model. Agents do not take decisions (such as determining their output level) in order to generate the maximum theoretically feasible level of profit. Although agents do take expected profit into account in their decisions, many agents act in a variety of 'sub-optimal' ways identified from the behavioural economics literature and through our consultations. For example:

- Agents use 'rules of thumb' to specify the range of production levels and the investment options that they will consider;
- They exhibit delays in their decision making (compared to optimum timing of decisions), for example in the timing of their investment decisions;
- Some agents imitate their peers rather than calculating their own optimum strategies;
- *Satisficing behaviour* (i.e. targeting satisfactory profits rather than maximum profits) is reflected in the behaviour of some agents; and
- Agents' decision making may change depending on their recent experience.

298. During model development we tested the impact of assuming different levels of economic rationality on model outputs. The findings are reported in Annex G.

Water Company long term (investment) decision making

299. Over the modelling period to 2050, our water company or Public Water Supply (PWS) agents take decisions about how to invest in water resource management schemes in a way that is intended to broadly follow the approach that water companies in England and Wales are currently required to take in their Water Resource Management Plans (WRMPs). At a workshop with the water industry in January 2013 there was broad acceptance that this was a sensible approach given that there was no way of knowing now how companies might be required to take these decisions in future.

300. The main difference between our modelled approach and the approach the companies actually undertake is that the companies are required to undertake a Strategic Environmental Assessment (SEA) of options chosen for potential implementation. We do not model this process. We note however that we use company options from the feasible

options list and in many cases these have already been screened for environmental impacts, though we recognise that this is not the same as a full SEA, which for example, may shift the balance of options towards demand side management options.

301. Most of our catchment case study models use WRMP data published in 2008, because this was the most consistent and finalised source at the point of model development. While these often include options for implementation over the whole modelling period this is not always the case. We also recognise that in practice water companies will identify additional options, in subsequent WRMP rounds, and that these may be implemented in preference to options already included in the lists. To replicate this process of 'discovery' we have included in the lists additional options derived by considering the current contents of the lists and options proposed elsewhere. These are unlikely to be optimal, especially in the higher demand scenarios (Unconstrained Demand and Innovation).

302. While the choice of some options is constrained by planning and construction delays we have tried to model the fact that water companies will be aware of potential take backs of their licences and may implement options early in order to protect their deployable output[64] in advance of the take back occurring. So when options are being implemented to address environmental take back we remove the delay constraints. However the modelling does not permit water companies to take advantage of these options before the point of take-back, and so may slightly over-estimate the resulting environmental damage.

303. Finally PWS investment strategies are typically focused around Water Resource Zones (WRZs), the regions within which PWS companies manage their water resources. While we model PWS decisions at the WRZ level, we need to incorporate these outcomes into our catchment level models as the latter define the principal regions in which trading of water abstraction rights can occur. WRZs generally do not correspond with catchments but cross over a number of catchments. We have therefore had to scale PWS abstractor responses within the WRZs to represent the overall impact in the associated catchments. We have tried to model PWS decision processes as closely as we can, to provide a sound test bed for the reform options, but we are in no way attempting to second guess what water companies will actually do in each of the catchments. We cannot replicate all nuances of either their operational or investment decision making. We find that PWS investment impacts estimated by the model can vary significantly from scenario to scenario. In case study catchments where the impact of reform is marginal they can be significant swing items with small changes in the timing or nature of decisions dominating the overall impacts in a small number of scenarios. In practice we would expect water companies to more effectively optimise their operations in both the shorter and longer term, than they do in the model, and that we will in general over-estimate any negative impacts.

Modelling the options

Linking abstraction to water availability - Surface water controls

304. The reform options consist of a number of controls that link abstraction to the water availability.

Access to high flows

305. Under CSP, once the surface water flows on a day exceed a certain level then any abstraction made on that day are not considered as part of the annual licence volume. Thus water taken under these circumstances is effectively free. Abstractors who are able to make use of water in these circumstances can increase their total take in the year beyond their licensed volumes.

[64] This is the available output from licences in different conditions of wetness/dryness.

Hands off Flow (HOF) limits

306. Under CSP, all surface water abstractions are subject to HOF limits. A HOF will operate when the flow at a specified assessment point falls below a defined level. For the purpose of modelling we have assumed that abstractors will modify their abstraction behaviour as the flow in the river approaches a HOF limit, so that they take as much as they need but only up to the point at which they will not trigger the limit the next day.

307. In addition, many licences have ‘soft’ or variable HOFs associated with them as well. This is the flow at which the maximum amount that can be taken in a day is reduced to half the daily pumping limit. Again we assume that abstractors manage their abstraction as these limits are approached in order to minimize heavier restrictions being imposed the next day.

Water Share Allocation

308. Under WS the amount of water that can be taken over a period of time is granted as an allocation. For the purpose of modelling we have assumed a 14-day allocation period. At the start of each 14-day period every share-holding is granted an allocation of water based on the size and reliability of the shareholding and the current surface water flows. The allocation is the maximum volume that can be taken in the 14-day period, but the abstractor is also still constrained by the daily pumping limits.

The no go below flow limit

309. Protection of the environment is considered using the same methodology under both CS and all the reform options. For the purposes of modelling the quantity of surface water (flows in rivers) reserved for the environment has been defined as the no go below flow (NGBF) limit. This limit is based on a key requirement of the Water Framework Directive to prevent deterioration of the ecological status of the water environment. Breaches of the NGBF limit will trigger reviews of abstraction licences in the model (see below). All the other controls described above that ensure that abstraction is linked to water availability (such as HOFs and share allocations) are set based on the NGBF.

310. The NGBF limit has been defined as the lower of the Environmental Flow Indicator (a threshold used to indicate when flows are sufficient to support the environment) and the flows that would occur if the permitted volumes transitioned into the system were fully used. This standard has been designed to provide a reasonable flow threshold that should prevent deterioration. NGBF limits have been defined for all the water bodies in each of the modelled catchments. (It is important to note that the NGBF has been designed as a basis for comparing reform options. It is not a prediction of anticipated progress toward compliance with the Water Framework Directive.)

Evolution of the NGBF

311. In future the EFI may be adjusted as specific evidence on the ecological needs of catchments evolves and in particular the climate changes, potentially changing the nature of water ecosystems requiring protection.

312. For the purposes of modelling we have adopted an approach in which the NGBF evolves if and when the natural flows decrease due to climate change. This simulates a process in which the EFI is adjusted to reflect reduced natural flows, but any remaining over-abstraction that has not been addressed on the basis of disproportionate cost is still retained. Flows in the river are reassessed every six years. Thus the NGBF limit associated with each Water Body is changed dynamically as natural flows decrease. In addition any HOF conditions linked to the NGBF are adjusted to minimize the effects of climate change on surface water reliability. So, for example, if under CSP a licence has a HOF that corresponds with the minimum flow allowed 50% of the time under the original

NGBF, then when the NGBF is adjusted the HOF limit is also adjusted so that it still corresponds the minimum flow allowed 50% of the time.

313. The NGBF may change in a non-linear manner, and this in turn would lead to a change in the total shareholding available at different levels of reliability. However, modelling these impacts within the model is not possible. Instead we have assumed that shareholdings are not reduced as natural flows decrease, and that the reduction in allocation that will occur as flows approach the NGBF is a sufficient control. However, this could result in more environmental damage occurring under Water Shares in the model than would occur in real life.

Very low flow controls

314. There are new controls on abstraction at very low flows. The exact nature of these controls will be the subject of further consideration prior to implementation. For the purposes of modelling we have assumed that for most non-PWS abstractors, 100% reduction in daily abstraction (CSP and Hybrid) or in allocations (WS and Hybrid) is required if flows in a river fall below levels recorded 0.01% of the time or less according to historical records.

315. Spray irrigators face more frequent restrictions; these have been modelled as a 50% reduction required if flows in a river fall below levels recorded 2% of the time or less according to historical records. This is to approximate the impacts of spray irrigation controls under S.57 of WRA91[65].

316. Similar restrictions are placed on PWS licences. However these are lifted if the WRZ is considered to be in drought, so their obligations to provide security of supply are not affected.

Groundwater controls

317. Under reform each groundwater licence has an associated maximum additional volume that could be safely abstracted. Trading of groundwater licences is allowed (within the same localised aquifer structure) but only up to this defined limit. Further, no long term trades are allowed in the model, and regular leasing is also prevented.

318. Temporary increases in permitted abstraction of groundwater have not been modelled and are therefore not included in the impact assessment. Such increases would lead to higher benefits so the assumptions are conservative.

Discharges

319. The model estimates the impact of both abstraction and discharges. Information about abstractions, their net impact and any additional (but separate) discharges is recorded in the CAMS Ledgers kept by the EA and Natural Resources Wales. This was supplemented by information obtained through engagement with real abstractors.

320. We have assumed that future abstractions will retain the same proportionate level of consumptiveness unless adaptations are implemented, and that in particular sewage treatment work (STW) discharges do not change significantly. This possibility that significant changes to STW may occur in some catchments as part of wider PWS WRZ management is examined in a separate impact assessment.

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[65] Section 57 of the Water Resources Act 1991 gives the Environment Agency / Natural Resources Wales powers for "Emergency variation of licences for spray irrigation purposes when there has been an exceptional shortage of rainfall or other emergency." Groundwater licences can also be restricted through this power if the abstraction is likely to affect the flow or level of the river.

Trading

Trading mechanisms

321. There are a number of ways in which permissions to abstract may be traded. Licences can be sold permanently, leased for a number of years, or unused portions of annual licences may be loaned to someone else for the remainder of the year. Shares may also be sold or leased. Allocation arising from a shareholding may be sold during a 14-day period, or offered as an option on a forward market.

322. Further, because licences and shareholdings are linked to a point of abstraction, the selling and buying locations are also important. In addition, the reliability of water associated with some trades is not guaranteed, and transfers of licences between surface water and groundwater are complicated by local factors and so have been prevented in our modelling.

323. Specific share holdings are (by design) associated with specific water bodies, and since this is the fundamental level at which trading can be managed, for the purpose of modelling we have assumed that a separate trading unit exists in each surface water body. In addition trading units also exist for groundwater (based on linked aquifer structures) and each interconnected level managed area.

324. The rules associated with ensuring trades are low risk (and can therefore be undertaken more easily under reform) require the trades to be hydrologically linked, and in most cases only allow a seller to trade with buyers downstream (and vice versa). This means that in many cases a buyer could buy water from a number of trading units, and a seller could sell to a number of trading units, but the exact number and combination of buyers and sellers in each trading unit will vary based on the location of the participants. This variation leads to variation in the price at which water will trade.

325. The situation is complicated further for abstractors who:

- have a mixture of surface and groundwater licences that could be reduced or increased through trading;
- are geographically spread (or have land close to two or three separate river reaches or aquifer structures) allowing them to operate in multiple hydrologically unlinked markets; and
- want to select the most cost effective trading or adaptation solution from a range of opportunities.

326. In these cases, bids and offers for water may be conditional upon other bids or offers succeeding. For example an abstractor may have water they are happy to sell permanently, but if the value of that water on the lease market is high enough may wish to keep the licence and earn an income through leasing. However, once it is leased this year it is no longer available to be sold. Similarly, in some cases the selling of a portion of a licence may mean that the price that would be accepted for the rest of it may actually go down. However, that secondary offer cannot become active until the first trade is completed.

327. Thus both buyers and sellers may quickly have a large array of options for trading at different prices and volumes. In most practical instances a single bi-lateral trade will not meet the aspirations of both buyer and seller since that requires an exact match of volume, quality, price and reliability as well as hydrological linkage.

328. For the purpose of modelling the operation of these markets we have therefore devised a common market clearing mechanism. The model uses a consistent algorithm to systematically match bids and offers across all trading units in order to clear all the various

trading markets simultaneously. This algorithm ensures that those willing to pay the most get first choice in the market and also get the best price in the available trading units that they could operate in. This approach is optimistic in that it is likely to over-estimate the volume of water traded achievable in practice because it ignores local contact inefficiencies or less than fully rational behaviour. The mechanism has not been tested using economic experiments or other methods. We have assumed that there is no collusion in the market, or any anti-competitive practices (see Annex F).

329. The modelled approach is therefore more closely aligned with the assumption that a centralised brokering service is available (especially for short term trades), and has also assumed that abstractors will be prepared to participate in such a market. However, the trading patterns observed in the model suggest that most agents actually only trade with a small number of other agents and that these are often repeat trades. Thus, similar patterns of trading could well be generated through individual agent networking.

Barriers to trade

330. In order to model barriers to trading, including both the financial costs and other barriers such as the difficulty of gaining approval and reluctance to trade we have introduced in the model the concept of inertia costs. These sums are not used in deriving economic outputs, but are taken into account by agents when deciding whether to trade or not, and what price to pay or accept for water.

331. The following approach was applied when setting the value of these barriers:

- Approval must be sought for any trades carried out under the Current System. Levels of trades are currently very low. The barrier for non-preapproved trades has been set to be high (£10,000) such that low levels of trade are observed.
- Sales and leases of permissions and forward trading, even when these can be facilitated by on-line trading systems and can be pre-approved under reform, are likely to require significant thought and analysis. The barrier for these types of trade has been set to a medium level (between £500 and £1000).
- Short term allocation trading will be designed to be very easy and will be facilitated via an online platform. Inertia costs here are set to zero.

332. There is little evidence available for what these values should be, particularly for the short term markets as there are no previous examples of centralised brokering service globally; all other active water markets involve voluntary decentralised pair-wise trade. The values were set in consultation with the Project Board. We have explored the significance of trading to the overall results in the sensitivity testing (see Annex G).

Water release or 'put and take' trading

333. It has not been possible to model all trading mechanisms that could be made available to abstractors. In particular, water release or 'put and take' trading is not modelled. These are trades involving releasing water from reservoirs or re-use schemes into rivers so they are available to be abstracted by others.

Making changes to permissions

334. The model simulates each abstraction management system intervening to permanently adjust abstraction limits if there is a significant breach of the NGBF. For the purposes of modelling, we have defined a 'significant breach' as having occurred where modelled actual abstraction is more than five percent below the NGBF, for more than five percent of the time, over five of the last six years. We have explored sensitivities around

this. Any changes made to abstraction limits to preserve the NGBF are only applied to permissions that are contributing to the damage.

335. If damage is considered to be occurring in a water body then any unused portions of permissions for abstraction in that water body are removed in order to prevent future growth in abstraction. The remaining permitted volumes that are actually contributing to the damage are then reduced proportionally. However, this process also takes into account the value that each abstractor places upon the abstraction and focuses buy back/take back on those permissions that will result in lowest economic impact. This is based on the assumption that reverse auctions will be used in CS and trading will equalise economic impacts under reform options. Further, the damage is corrected in the lowest flow region first. This is the most important region to fix, and often involves reducing groundwater abstraction licences which actually have an impact on damage at higher flows as well. Similarly, damage is fixed in the most upstream water bodies first, because any reduction in abstraction will also provide improvements further downstream.

Transition

336. For the purposes of the impact assessment, we have assumed in the catchments enhanced to facilitate trading that abstractors will receive an amount based on the greater of:

- The average annual consumption used across the three years with the greatest abstraction from that licence between 2003 and 2012; or
- The Recent Actual annual abstraction volume used in the Environment Agency's CAMS assessments.

337. If annual returns data were not available for a licence, the transitioned volume was set to a default calculation of the CAMS Recent Actual abstraction rate plus 20% of the original licensed volume. This was to ensure that, in the absence of peak year data, abstractors still maintained more flexibility than they would from an average assessment. In all cases, the transitioned volume was capped at the current licensed volume.

338. A slightly different approach was taken in the Hampshire Avon catchment, where changes to licences agreed through the Habitats Directive Review of Consents have been made alongside the WFD assumed reductions without further reductions to licences.

339. Water companies are treated somewhat differently due to their duties to provide security of supply. Their permitted volumes/shares have been divided into two types:

- Normal permitted volumes/shares which are calculated on the same basis as other abstractors; and
- Special permitted volumes/shares which are provided based on water company need to meet the security of supply obligations.

340. Water companies are only able to access these special permitted volumes/shares if their ability to provide security of supply is under threat. Once these are accessed, they are unable to trade so they gain no financial advantage from their ability to access special permitted volumes/shares. For the purposes of modelling, these special permitted volumes/shares are assumed to be the balance of their previously licensed volumes having received their normal permitted volumes/shares.

341. The approach to calculating permitted volumes/shares will be considered further and finalised prior to implementation.

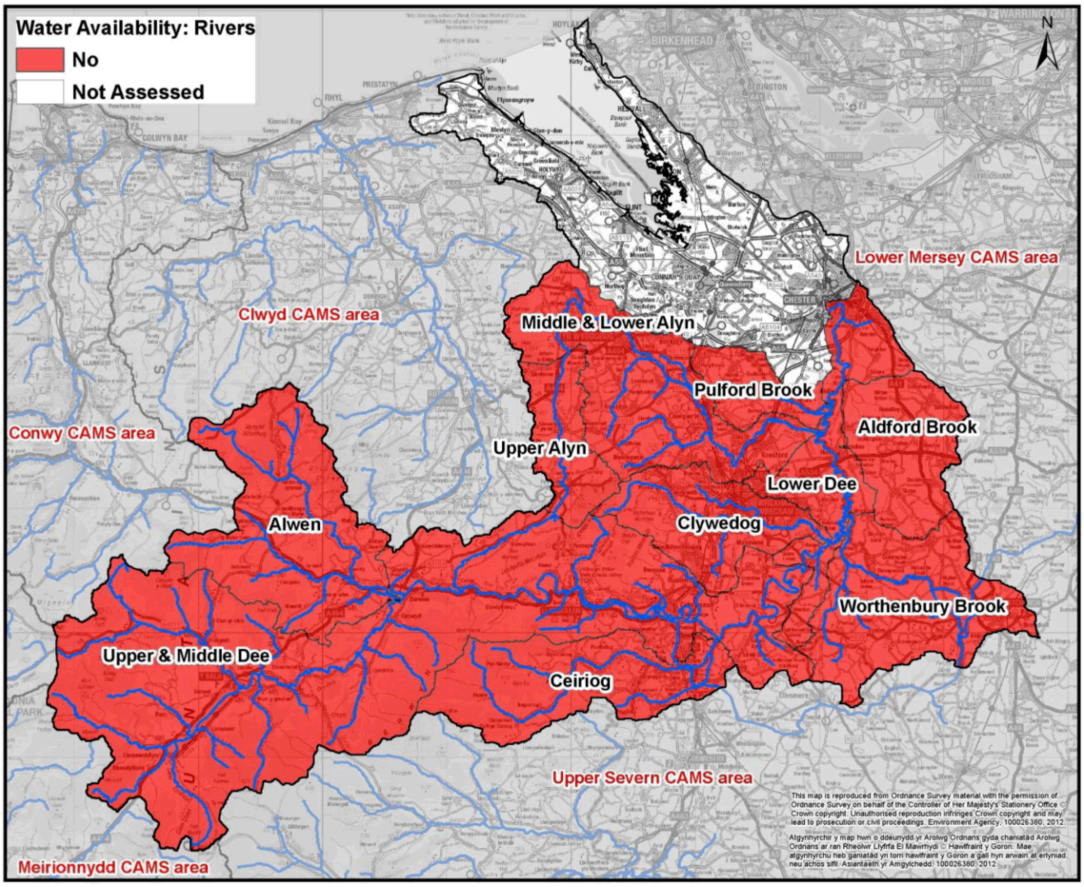
Aggregation modelling

342. The results for the catchments are aggregated and scaled up to provide an indication of costs and benefits for England and separately Wales using an aggregation model.

343. The aggregation model is spreadsheet based. It reads in ABM outputs and scales up the results for all catchments in England and separately Wales using an appropriate scaling method depending on the type of output. The catchments are allocated to country (England or Wales) by reference to the agreed operational responsibility rather than geographical location.

344. For example, the Dee catchment and its neighbouring catchments are as shown below (taken from the Dee CAMS documentation on the Environment Agency web site).

Figure 8: The Dee and its neighbouring catchments



345. In the aggregation model the Dee, Wye, Clwyd, Conwy, and Merionnyth catchments are allocated to Wales and the Upper Severn and Lower Mersey catchments are allocated to England.

346. It is designed among other things to explore whether the benefits of full (enhanced) implementation in only a proportion of catchments, outweighs the broader costs associated with minimum (basic) implementation nationally. It produces outputs that can be copied straight into the Government's Impact Assessment calculation template. It produces two main outputs:

- Yearly net costs and benefits from 2025 to 2050 for England and separately Wales
- The classification of catchments as Basic or Enhanced.

347. The model also produces sectoral impacts for the case study catchments to highlight whether there are any major distributional effects in the overall cost benefit case.

348. For modelling purposes, catchments have been split into three groups; those only requiring the basic (universal) components over 25 years, those requiring enhanced components for the full 25 years and those that introduce enhanced components after 12 years. This classification is driven by levels of water scarcity under different climate change scenarios and estimated benefits from trading compared to the costs of introducing enhanced components. It differs depending on the policy option and climate change/socio-economic scenario combination. As it will not be possible to know precisely how the climate and socio-economic environment will evolve at the time a decision to implement reform is taken, catchments are allocated to category by looking across the results for all the scenarios to establish a 'median' categorisation. This is then used for all 16 scenario combinations. Using this approach a catchment that is categorised as Basic under water shares in 50% or more of the scenarios, is allocated as a Basic catchment for all scenarios.

349. The fundamental assumption at the heart of the aggregation modelling is that the benefit of reform in each catchment across England and Wales can be estimated from the benefits calculated for each case study catchment on the basis of the amount of water abstracted and the mix of sectors present in each sector. This approach captures two key influencing factors:

- The level of demand for water, and
- The presence of abstractors with a large seasonal demand for water who can benefit from trading.

350. The modelling has demonstrated the critical role of local factors in determining the impact of reform, including local hydrological factors, and the importance of large, economically significant abstractors such as the PWS. It is very hard to scale results to the national level in these circumstances. In addition we cannot fully represent the incremental approach to implementation of reform that enables the introduction of enhanced components over time as environmental conditions or levels of demand for trading change. Any approach to aggregation will provide only a broad brush estimate of costs and benefits. The approach to aggregation we have adopted seeks to establish how the cost benefit case may vary by exploring the results:

- Under a range of different climate change and socio-economic scenarios, without assuming perfect knowledge of how either will play out in the future; and
- With and without Investment benefits, which are dominated by PWS investments, which depend critically on the individual circumstances of each catchment.

Interpreting results

351. Simplification has been necessary as described above. However it is important to remember the aims of this work. We are not trying to accurately reproduce catchment and abstractors' behaviour, but to understand how different potential abstraction reforms will operate in practice and the impacts they might have, to inform the design of the new system. This means that, for example, detailed modelling of all aspects of the hydrogeology is not necessary, provided the main features of the system that will drive abstraction behaviours are captured.

352. The fundamental challenge has therefore been to ensure that the principal drivers are identified and represented appropriately within the model and that the impact of the remaining assumptions and uncertainties are explored either through uncertainty and sensitivity analysis, or when interpreting the results.

Annex E: Top Down Modelling Results

353. The model estimates the economic value generated by improving water trading in England and Wales, known as the 'gains from trade', to be in the order of £300 to £1,300 million per year (undiscounted) in dry years. Dry years occur with a frequency of around one year in four or five. The gains from trade are lower in normal or wet years. For a full decription, see report The Impacts of Abstraction Reform: Top Down Economic Modelling[66].

354. These gains from trade arise solely from exchanges of water between abstractors and are small relative to the value of water in use, in the order of less than 1 per cent of the value of water in use. This is because the amounts of water changing hands are small, again less than 1 per cent of total abstracted volumes. The explanation for these low figures is that only abstracters that place low value on water are willing to sell their rights, although this result depends on the assumptions made about relative values of water.

355. Public water supply-demand balance investments can generate additional value, enabling additional water to be sold to other abstractors. The estimates of the benefits from these investments suggest that they could be an order of magnitude higher than the basic gains from trade. These figures indicate that, in some places, it may be desirable to build new infrastructure as demand increases and as a means of adapting to climate change.

356. Future demand and climate are uncertain. Circumstances in which the gains from trade are largest, demand growth and a dry climate, lead to gains about double the central estimate. The opposite circumstances lead to estimates about half the central estimate.

357. The model shows that at the values of water assumed for various types of user, public water supply is the principal buyer of water from other abstractors. The estimated gains from trade are sensitive to the assumed values of water for the various users, especially for public water supply. The estimates of the value of water in the literature are few and wide ranging, and the values for water used in the model are highly uncertain.

358. The other main limitations include:

- the limitations of the model structure that assumed that all water can be traded by all parties in the model, without geographical restriction, across a catchment, but without inter-catchment interactions. The first overstates of the number of permitted trades and gains from trade, and the second may under- or over-state trades;
- the absence of data on volumes and costs for catchment-specific public water supply investment options, such as reservoirs, and non-public water supply investments, such as on-farm storage; and
- the quality of the abstraction licensing data; and the need to use supply options from only four catchments and apply them to all of England and Wales.

359. This modelling provides estimates of benefits of about 2 orders of magnitude higher than the benefits estimated in the modelling used for estimating impacts. This demonstrates the importance of the bottom-up detailed modelling used but also suggests that the results used maybe conservative.

66 http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18182#RelatedDocuments

Annex F: Economic Regulation of Abstraction Markets

Introduction

360. In our consultation impact assessment we said there could be risks of unintended impacts from the facilitation of trading markets due to issues such as market distortion. We have carried out further work also involving HM Treasury, the Central Markets Authority, external stakeholders and market experts to identify and assess these risks, and establish whether economic regulation was required to address them.

Method

- **Literature review of possible market risks:** We investigated what the potential risks could be from facilitating a trading market; this included drawing on work by NERA Economic Consulting[67] and other economic analysis of markets.
- **Workshop on market development and regulation:** We ran a workshop with stakeholders and market experts to identify what they believed necessary to facilitate a successful trading market and what were the potential risks.
- **Risk assessment:** Drawing upon the literature review and workshop we developed our risk assessment working with key internal stakeholders and experts.
- **Regulatory implications:** Once we had identified and assessed the risks again working with key internal stakeholders and experts we considered the need for new regulation to mitigate the risks considered to be medium or high.

[67] A Cross-Sector and Cross-Country Review of Approaches to Transitioning to Markets, Nera (2013) http://www.nera.com/67_8142.htm

Risk Assessment Results

361. Risks assessed as greater than low are detailed in Table 11.

Table 13: Risks assessed as medium or high

Risk name and assessment level	Risk description
1. Abuse of market dominance (medium/low)	Market dominance leading to anti-competitive behaviour could occur in catchments where a large proportion of the permitted water is held by a small number of abstractors; in most cases they will be water companies.
2. Tacit collusion/anti-competitive agreements (medium/low)	Competition may be threatened when a number of firms engage in tacit collusion, as a result of which their behaviour may approximate that of a single dominant firm.
3. Regulatory complexity (medium/low)	Market regulatory structures may create excessive complexity and high transaction costs, thereby restricting even a minimum level of market participation.
4. Government intervention in a drought (Medium)	The Government intervenes in the trading market during times of drought. This would mean abstractors do not feel secure about entering into trading.
5. Low market activity (medium)	The market may fail to develop into a viable market due to risk adverse behaviour leading to reluctance to sell abstraction permissions by abstractors and/or a mismatch of supply and demand particularly during droughts.

Regulatory Implications

362. From the expert / stakeholder workshop the key theme that emerged was an emphasis on the need for as limited regulatory burden as possible in the market while facilitating a transparent market. We therefore have set a high evidential burden to justify regulatory intervention while being aware that the market will require monitoring to assess whether these risks eventuate in practice. We have made an initial assessment of regulatory requirements set out in Table 13.

Table 14: Mitigation options and regulatory implications

Risk name and assessment level	Mitigation	Regulatory implications
1. **Abuse of market dominance (medium/low)**	Ofwat are encouraging water companies to develop their own water trading codes which should include avoiding anti-competitive behaviour; We will work with Ofwat and water companies with the aim that these codes are adequate to cover abstraction markets. If codes are not considered adequate to mitigate risks, Ofwat would consider changing water supply licence conditions to address any remaining risks.	No additional regulation is needed to address this risk at this stage. It will be revisited once water companies have developed trading codes. Existing Ofwat powers would be sufficient to change water supply licence conditions if this turns out to be necessary.
2. **Collusion/anti-competitive agreements (medium/low)**	Existing competition law should be adequate to deal with collusion. We will promote market transparency as far as possible to reduce risks of collusions.	No additional regulation is needed to address this risk. Existing competition law covers most forms of collusion.
3. **Regulatory complexity (medium/low)**	We will continue to take a light touch approach and keep rules and requirements as simple and transparent as possible.	No additional regulation is needed to address this risk. To deal with this risk we would want to aim to avoid regulation where possible.
4. **Government intervention in a drought (medium)**	We will ensure that rules for government intervention in or suspension of markets during drought are clearly communicated as far as possible to provide certainty to the market.	No additional regulation would be needed to deal with this risk.
5. **Low market activity (medium)**	The policy proposals for facilitating trading for all abstractors and allowing short term trading should reduce the risk of low market activity.	We do not consider a regulatory intervention appropriate while we have no experience of real market functioning.

Conclusion

363. We do not believe that additional regulation is needed to mitigate risks of unintended outcomes and market distortion from facilitating trading. The risks identified as medium or high should be reduced through the use of existing regulations and through our policy proposals for abstraction reform. We therefore do not believe that further regulation is required to deliver the benefits from trading identified in this impact assessment. We will monitor these risks closely once real markets develop. This opinion is shared by Ofwat.

Annex G: Quality assurance of the model results

364. The process of quality assurance has been on-going throughout model development and testing.

365. The factors that drive the results are complex, with many possible interactions and pathways being possible. All of these require careful checking. There is no simple subset of drivers that explain the results at the aggregated level. Instead, it is the specific circumstances of the individual catchments, and individual water bodies within the catchments, and their agents that provide the explanation in many cases.

366. Specialist software has been used to ensure rigorous version control. To support the process of quality assuring the model our researchers have developed a number of tools that help focus model checking activities by, for instance, identifying agents that have a particularly significant impact on the results. An example of a set of agents that presented a particular challenge is non-profit-maximising agents such as canal operators. Methods of representing these agents more realistically in the modelling have been developed and implemented. Box 9 describes the steps we took to improve modelling of these agents. Box 10 describes how we ensured horticultural agents were appropriately represented in the model.

367. Presentations to the Project Board, ARAG and Peer Reviewers, has also

Box 9: Improving agent characterisation

Canals are important for a number of reasons, they:

- Abstract and store large volumes
- Transport / translocate large volumes
- Leak large volumes in some places
- Are currently exempt but assumed to be subject to basic licence controls and Environmental protection processes
- Are often not that well defined in CAMS Ledgers.

Consultations with the Canal and River Trust (CRT) allowed us to represent canals more accurately in the model using CRT data. Operational rules to feed and refill sections of canal (pounds), overspill at locks, evaporation and leakage to rivers and seepage into aquifers and discharge into a river or out of the catchment are all now represented in the model.

Box 10: Improving agent characterisation

While we had rich information about agricultural use of water from both the workshops and Cranfield University, we did not have a great deal of relevant information about the horticultural sector's use of water.

The Horticultural Development Company were able to provide us with technical information about industry systems such as the different irrigation systems used and their efficiency.

To understand how these are used in practice, and to supplement information provided by participants at the workshops, we visited two nurseries, one producing hardy ornamental nursery stock (e.g. pot plants) and one producing fruit and protected cropping (e.g. tomatoes and peppers). We were able to explore in more depth topics such as how rainwater harvesting is operated and what treatments are required when using different sources.

The visits helped us understand the vulnerability of horticultural crops to short term water availability, and how the risks are managed through use of stores. It allowed us to represent these processes more accurately in the model.

helped focus quality assurance activities.

The Peer Review process has involved a series of group and one to one meetings, at which the model assumptions, interim outputs and emerging findings have been presented and discussed. The group meetings were structured and led by an expert facilitator, who ensured that a wide range of topics were examined, and that issues were identified and prioritised based on their potential impact on the results. The Project Board helped to further prioritise issues for resolution.

368. An example of an issue identified by the peer reviewers was the modelling of groundwater. If the groundwater aquifers are coupled too tightly to surface water base flows in the model, abstraction of groundwater will have a more immediate impact on flows in rivers than it would in practice. The model would see more breaches of environmental limits and subsequent triggering of take back, which in reality wouldn't happen. As take backs are significant drivers of impact in the model, it was considered important to improve this aspect of the modelling. In response we developed this aspect of the model as described in Annex D above. Subsequent model runs have confirmed the importance of groundwater/surface water interactions.

369. A number of sensitivity analyses have been carried out, generally on a small number of scenario combinations. A long list of potential sensitivities was identified with the help of project board members and the peer reviewers. A final list of sensitivity runs was then prioritised, to focus on investigating the limitations of the modelling and to understand their potential impact on the emerging results for the initial consultation impact assessment. This included the impact of explicitly modelling behaviours such as social interactions in the model – as this is a key feature of the agent based approach, which differentiates it from many, more traditional top down approaches.

370. Following submission of the consultation impact assessment, the project board were asked to identify priorities for a final set of sensitivity tests. The final choice took into account the results of previous tests. The results of the sensitivity tests, including previous tests where relevant, are described below.

Sensitivity Analysis

371. The results of a number of the sensitivity tests are described below.

Economic Growth Rates

372. Constraints on growth such as physical or funding constraints are not explicitly included in the model. To account for this the model assumes in the base case that no individual agent can grow more than 3% a year (year on year, not accounting for inflation).

373. Decreasing the growth rate cap on individual agents from 3% to 1% generally leads to a small decrease in benefits

374. Increasing the growth rate cap from 3% to 10% generally lead to a small increase in the overall benefit of reform in England under Current System Plus. This is usually caused by growing agents making decisions about water which then result in changes in PWS investment sequencing. These changes tend to involve moving large value investments forwards or backwards by one or two years. This introduces a certain amount of noise to the NPV calculations. This can be seen in the first Policy Comparison plot shown below, where the model estimates a relatively large increase in the Annual Average Net Benefit under the higher growth sensitivity test.

375. The results presentation format is described in Figure 9.

Figure 9: Results presentation – graph showing comparisons between the two reform options

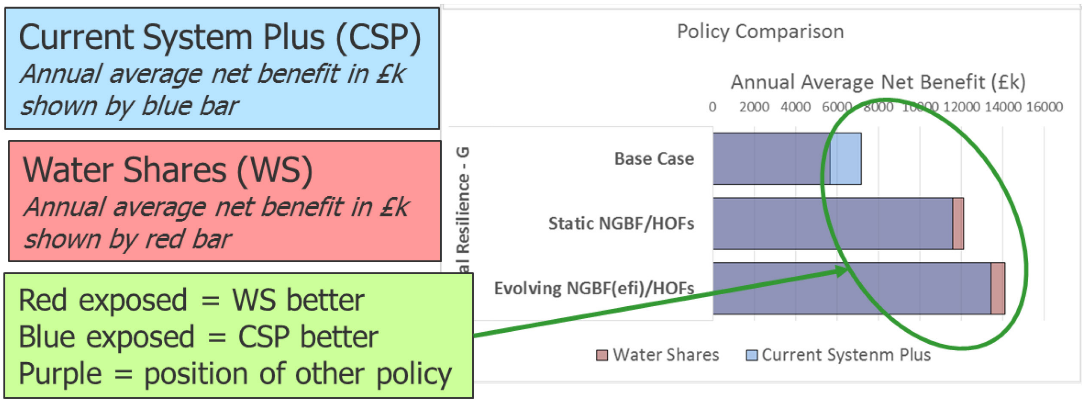


Figure 10: Economic growth sensitivity analysis for two socio-economic scenarios for the Stour Case Study catchment - Policy Comparison

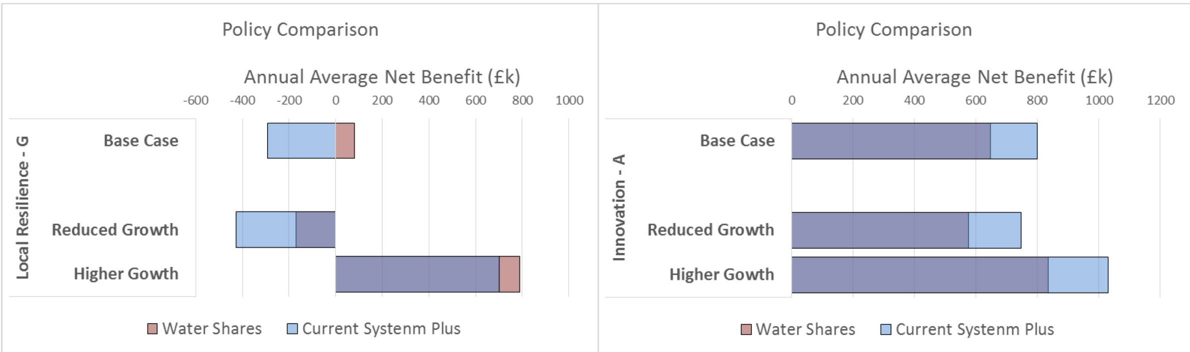
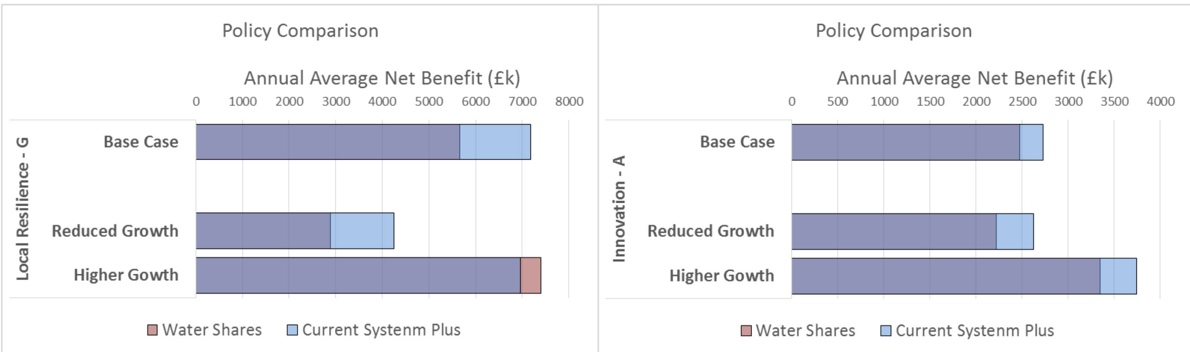


Figure 11: Economic growth sensitivity analysis for two socio-economic scenarios for the Cam and Ely Ouse Case Study catchment - Policy Comparison



Agent Behaviours

376. One of the principal (and innovative) elements of the modelling approach adopted in this project has been the consideration of abstractor behaviour. Agents are modelled as making decisions in order to achieve profitability, but the level to which they act with complete economic rationality can be varied.

377. Thus while agents do take expected profit into account when they make decisions about production levels and future investment and adaptation options, agents have been modelled as acting in a number of sub-optimal ways, such as:

- Only considering a sub-set of production levels and the investment options
- Accepting satisfactory profits, and being reluctant to change until overall profitability is threatened
- Imitating peers rather than calculating their own optimum strategies
- Making a decision based on their most recent experience rather than with a longer term perspective, and
- Being unwilling to sell unused water even if there was economic advantage to do so.

378. We find that changes in behavioural characteristics may increase or decrease the benefits of reform but generally the variations are small.

379. Where agents are highly economically irrational and are reluctant to adopt new practices we generally find that this leads to lower benefits from reform compared to the Current System. In cases of higher economic irrationality, there will be less permission/share trading in the model, so more agents with potential problems of shortfall. These emerge because the actual climate experienced is drier than the historical climate on which they base their assessments and decisions.

Environmental protection

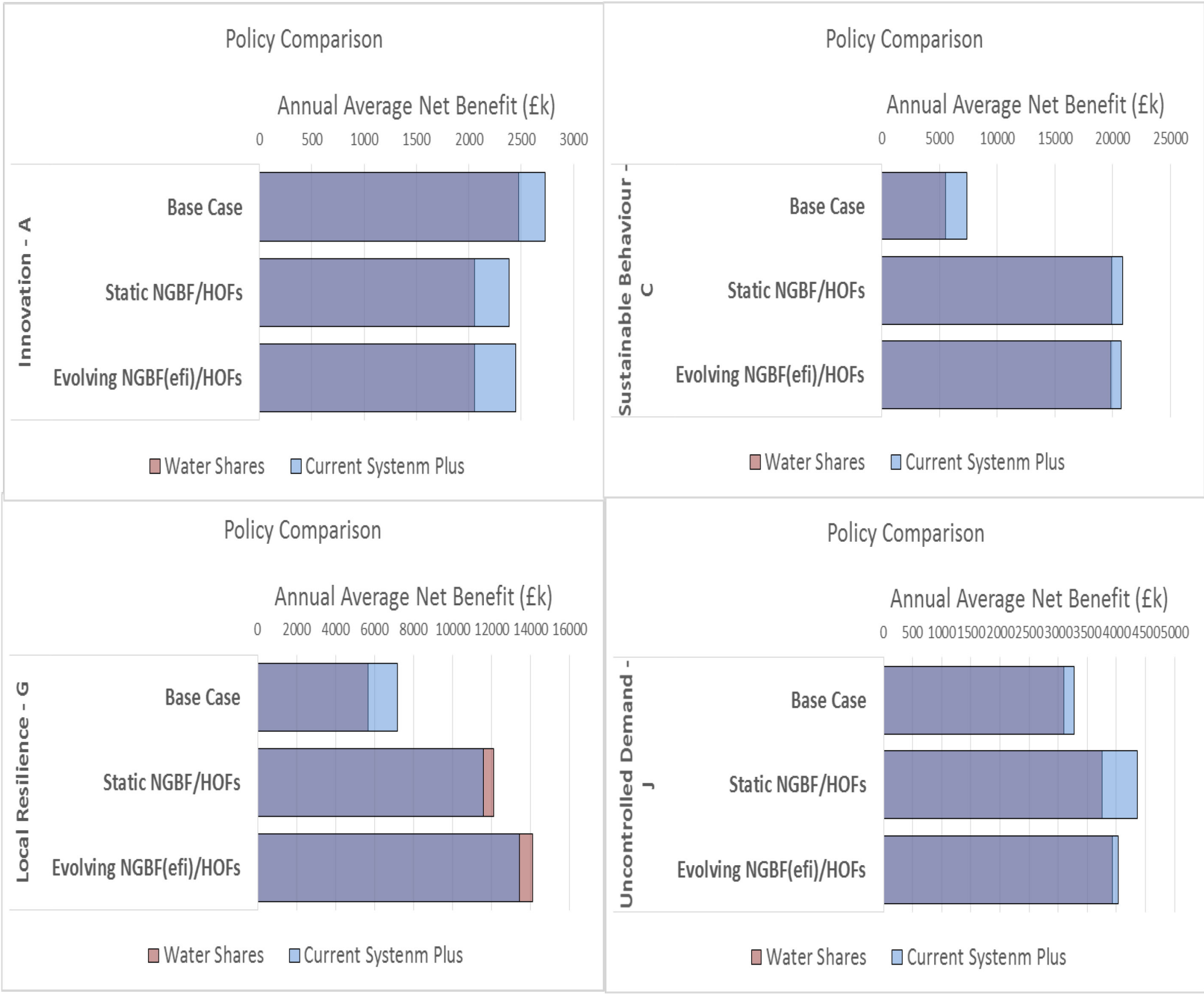
380. In the modelling we have assumed that environmental protection limits will evolve as the climate changes (potentially changing the nature of water ecosystems requiring protection) or specific evidence on the ecological needs of catchments emerges. There are a number of ways in which these limits could change in reality. However the method we have adopted in the base case allows the most adaptation and retains more water for abstractors than other potential approaches. The figures below show the results we obtain if the environmental protection limits do not evolve at all, or are more constrained in their development. The options we explored are:

- **Evolving NGBF and evolving HOFs** (the **base case**). In this case the original NGBF is assumed to fall in proportion with a fall in the Natural flows, and HOF limits are reduced to stay aligned with the NGBF.
- **Static NGBF and Static HOFs**. In this case the original NGBF and HOFs remains fixed throughout the mode runs.
- **Evolving NGBF (with EFI) and evolving HOFs**. In this case the EFI is assumed to fall in proportion with a fall in Natural flows, and the NGBF is adjusted if the new EFI falls below it. HOF limits are reduced to stay aligned with the evolving NGBF.

381. In these situations, where abstractors are more constrained, we generally see the reforms delivering improved benefits. Again the sensitivity to large and economically significant abstractors introduces a level of variability in the results.

Figure 12: Environmental protection sensitivity analysis for four socio-economic scenarios for the Stour Case Study catchment - Policy Comparison

Figure 13: Environmental protection sensitivity analysis for four socio-economic scenarios for the Cam and Ely Ouse Case Study catchment - Policy Comparison



Trent and Derwent

382. The Trent and Derwent catchment was used to perform a sensitivity test of the benefits from increases in gross margins and adaptation cost savings. In the main results the Trent and Derwent six catchments were all assessed as basic due to having water available in most scenarios up to 2050. Hence no benefits are included in the results from these catchments. The Trent and Derwent model was run for 4 combinations of scenarios to cover a reasonable range of the 16 scenarios. The results were as follows:

Table 15: Results from Trent and Derwent Model Runs (£k average annual)

Policy Option	CC Scenario	SE Scenario	Production	Investment	Total
Current System Plus	A	Sustainable Behaviour	575	1	**577**
Current System Plus	G	Uncontrolled Demand	50	0	**50**
Water Shares	A	Sustainable Behaviour	637	1	**638**
Water Shares	G	Uncontrolled Demand	58	-0	**58**

383. This suggests that there could be some benefits from these catchments in some scenarios but the aggregated results are unlikely to be significantly underestimated by their exclusion.

Annex H: Calculating the weighted averages

384. If 3 catchments are modelled and the benefit per m^3 of water abstracted was £1 in Catchment 1, £2 in Catchment 2 and £3 in Catchment 3, we could take a straight average of these three numbers (= £2 per m^3) and assume that this benefit per m^3 of water abstracted applied to all the other catchments.

385. However, the level of benefit will depend not only on the amount of water abstracted per year, but also a number of other factors. The most significant of these is expected to be the mix of different sectors in the catchment. For example, in the ABM model we observe trading occurring between agricultural agents; therefore we would expect a catchment with a high proportion of agricultural abstractors to have higher benefits from trading.

386. We also find the split between surface water and groundwater abstraction is important.

387. The weightings are calculated by matching the total sectoral split across the catchment, giving greater weight to the results from modelled catchments that have a similar split of agents to the catchment under consideration. So for example, if Catchment 1 is dominated by agriculture but Catchment 2 is dominated by PWS, a catchment in the aggregation model that is also dominated by PWS would have a higher Catchment 2 weighting percentage and a lower Catchment 1 weighting percentage.

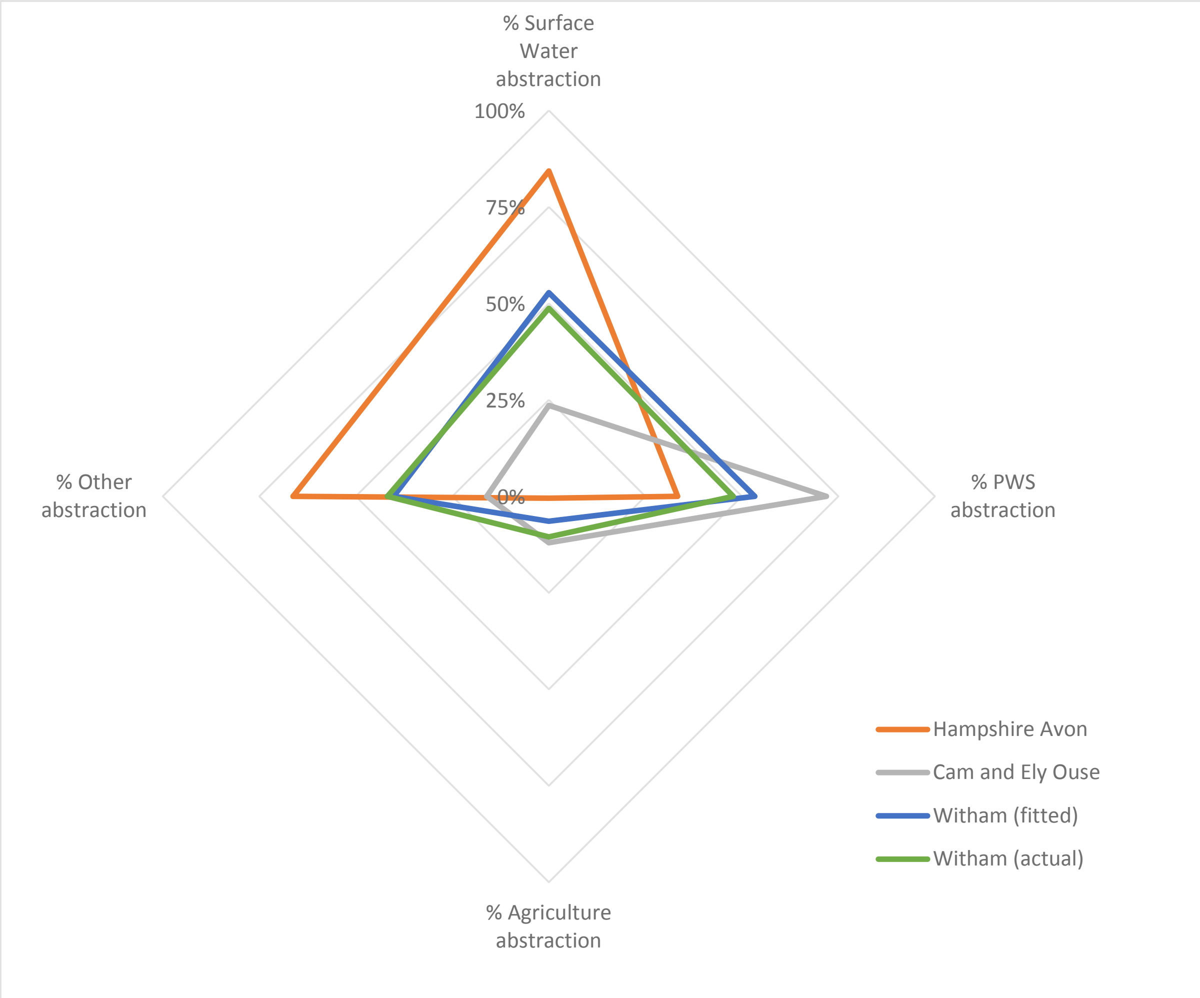
Example: The Witham catchment

388. The Witham catchment is in the Anglian region of England. According to Environment Agency data and the Case for Change, Witham can be characterised as follows:

- It will be short of water in 2025;
- In the Sustainable Behaviour socio-economic scenario and under climate change scenario C, it will also be short of water in 2050 (hence face some water stress over the full appraisal period); and
- It is not classified as high environmental risk.

389. By applying the flowchart in **Error! Reference source not found.** we can see that a cost-benefit test should be applied to determine whether Witham will become an Enhanced catchment from 2025. In order to do this we need to determine what linear combination of the four modelled catchments (Stour, Hampshire Avon, Cam and Ely Ouse, Usk) is the closest match to Witham using the sectoral split to determine this.

390. The spider diagram below shows that a weighting of 0.52 x Cam and Ely Ouse + 0.48 x Hampshire Avon gives a close representation of Witham. This is based on optimising the surface water / ground water split and the abstractor mix (% PWS abstraction, % Agricultural abstraction and % Other abstractors). The blue fitted line for Witham is close to the green actual line in all four corners of the spider diagram plot.



391. The Witham catchment is smaller than Hampshire Avon and Cam and Ely Ouse, so the production benefits and investment benefits are scaled pro-rata per m3 of water abstracted:

392. Witham production benefits per m3 = 0.52 x Cam and Ely Ouse production benefits per m3 + 0.48 x Hampshire Avon production benefits per m3

393. The administrative costs however are scaled pro-rata based on the number of licences in Witham.

394. The final results for Witham are as follows:

Cost and benefit category	**Equivalent annual value £k**
Benefits	
Increase in production gross margin, net of trading brokerage costs	404
Saving from deferred investment	114
Costs	
Increase in transition costs for an Enhanced catchment	62
Increase in catchment management costs for businesses	(6)
Net Annual Benefit (excluding transition costs)	524

395. The net benefits per year are positive. On this basis the cost/benefit test is passed and the Witham catchment would be classified as an Enhanced catchment from 2025 in the C-SB scenario.

396. This process is repeated for each of the 116 catchments and the costs and benefits are accumulated. The final step is to calculate the total NPV of the cost and benefit profiles.

Annex I: Case Study Catchment Analysis

397. In the following sections we present the results of the ABM modelling for the case study catchments. This provides an indication of the sector impacts, key economic, behavioural and climate drivers and key interactions between them.

Introduction

398. The case studies aim to capture the diversity and complexity of the real catchments they are based on, in order to provide a realistic challenge to the options. They are not, however, meant to precisely reproduce them. These results should not therefore be taken as representative of what might happen in the real catchments but rather they illustrate the range of possible outcomes.

399. The summary results are presented graphically in the formats shown below. These graphs show the impact at the catchment level in economic terms, excluding the cost to government of setting up and managing the regimes. These are included in the full aggregation.

Figure 14: Results presentation – illustrative graph showing comparison of one reform option with the Current System to explain the format

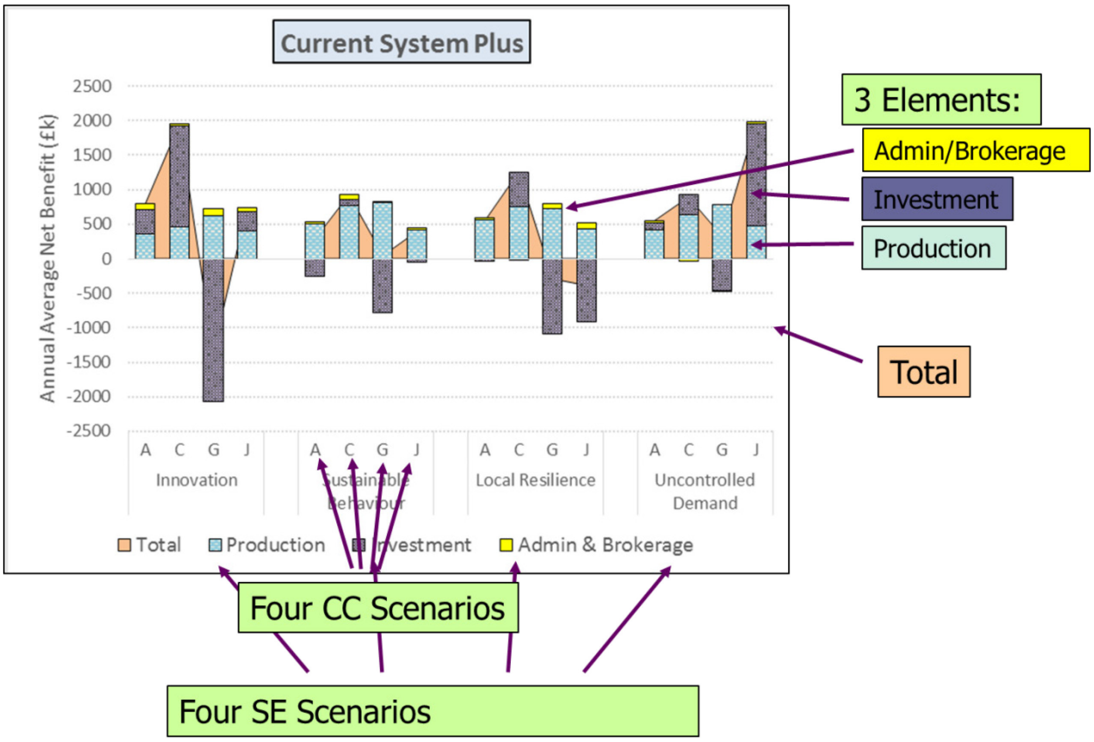
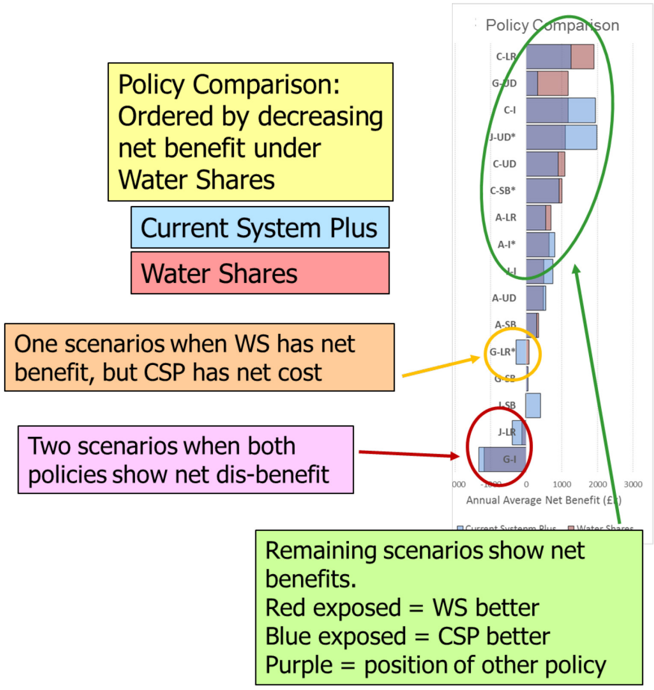


Figure 15: Results presentation – graph showing comparisons between the two reform options



Catchments where reform is largely beneficial

400. Where there is a strong seasonal demand for water (e.g. for water sensitive crops), and where lots of people can benefit from working co-operatively through trading, we find reform delivers benefit. Which reform policy delivers most benefit depends on local factors. The catchment case studies based on the Cam and Ely Ouse (C&EO) and Stour show examples of this, and both catchments have higher concentrations of crop growing.

401. The results for the C&EO case study are shown in Figure 16.

Figure 16: Catchment level impacts (C&EO)

402. Benefits accrue from both production gains to industry and agriculture, and investment gains principally to the PWS.

403. Production benefits arise where agents are better able to get the water they require to support production plans. Trading is important. There is a large population of agricultural agents in this catchment producing, among a range of products, water sensitive crops such as potatoes and field vegetables. We see high-levels of short term trading between these agents as farmers seek to obtain the water they require to meet crop needs, or release water they find they do not need. In a small number of cases we see farmers prepared to sacrifice some production because they can realise better returns by trading permissions.

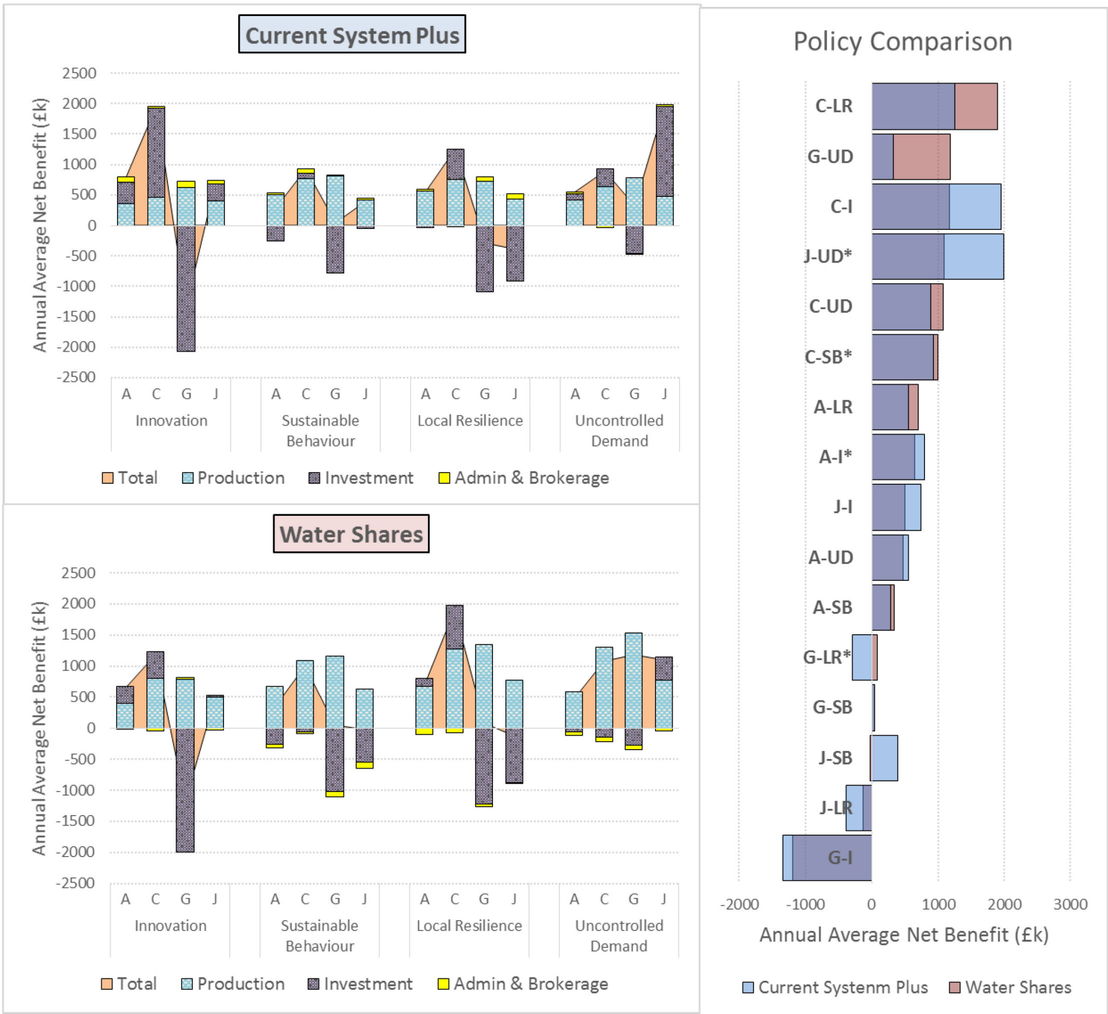
404. In this case study catchment reform delivers average annual benefits of up to £10m under C and G. Benefits under A and J are more modest. This is because a small number of economically important abstractors are trying to grow, and the particular climate challenges that the C and G scenarios present in their locality mean that they are unable to deliver high production levels in specific very dry periods. These particular weather based circumstances do not occur as frequently under A and J.

405. CSP performs better in economic terms than WS. While trading allows abstractors greater freedom to manage their actual water requirements and overcome the effective fall in water reliability associated with reform, the 14-day allocation period under WS provides additional constraints to abstractors who wish to make large short term abstractions. This increased competition for water under WS tends to push up prices and thus limit the

number of abstractors who can achieve trading benefits. CSP is less constraining than WS and the large number of people available and willing to trade ensures that the CSP markets are relatively liquid. The difference between the options is however generally very small, of the order of a few hundred thousand to a few million pounds per annum averaged over the 25 year period.

406. In the Stour case study (Figure 17) we also see net benefits from reform in most of the scenarios. The level of benefit is small, with net average annual benefits generally less than £1m). The case for reform is marginal in about 25% of the scenarios.

Figure 17: Benefits of reform (Stour)



407. Production benefits are always positive with WS consistently providing improved benefits for producers compared to CSP of a few hundred thousand pounds (median value £305k).   Most of the agricultural agents in the Stour that would participate in trading are located in the level managed areas at the bottom of the catchment. Thus opportunities to trade under CSP, which does not permit upstream trading, are therefore more limited.   The investment benefits are more variable than the production benefits. The reason for this is discussed below.

408. Although the variable Investment benefits introduce some noise in the results, we again see only very small differences between the options in the clear majority of cases.

Case studies where reform is marginal or brings dis-benefit

409. The modelling has demonstrated how complex the overall system is. We see the reforms changing patterns of abstraction in each catchment as abstractors react to minimise the impact of the different types of constraint imposed by the options. This results in different patterns of environmental damage. Responses to environmental damage are always delayed, on a 6-year cycle, and based on a threshold being breached rather than on a continuous basis. Thus we find that the impact of environmental protection measures can easily switch and fall on different abstractors, at different times, under each reform option. Similarly, the impact of reform therefore results from a range of competing factors, working at the local level.

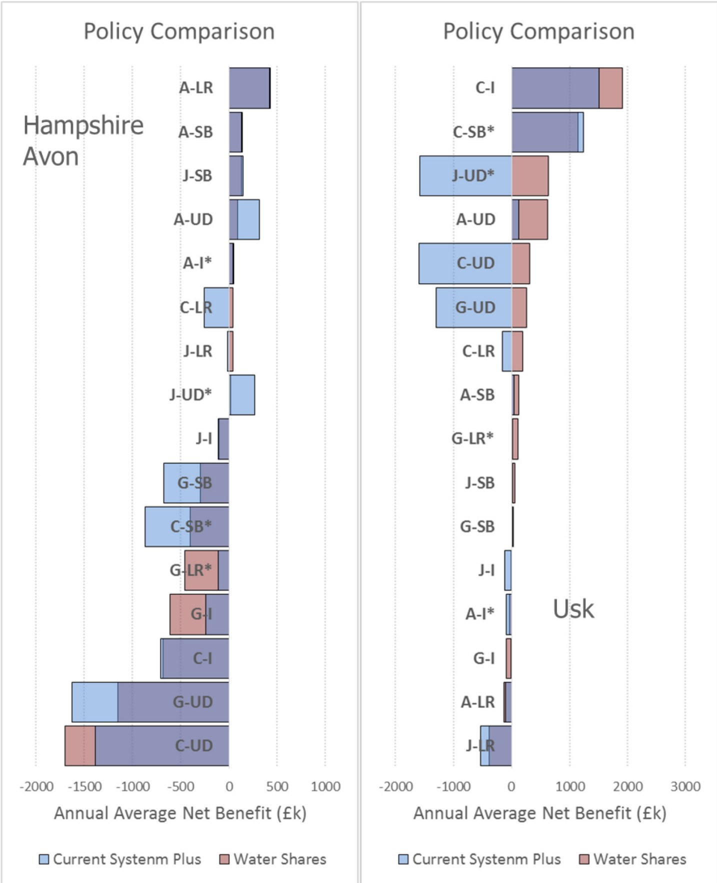
410. Where the operation of reform is more constrained, the various different factors at work can be finely balanced. We see this particularly in our Hampshire Avon and Usk case studies. In these catchments the opportunities for reform to deliver benefits is constrained by a number of factors:

- Trading opportunities are limited by the small population of people who would benefit from trading and small markets; and
- Some reaches of the Usk are effectively managed by reservoir releases under future modelling so support downstream abstraction and maintain flows. This reduces the likelihood of lower flows occurring and hence the situations in which reform provides benefit.

411. In these case study catchments we find that production benefits are generally small (and in some scenario combinations, negative). We also find that the difference between CSP and WS is variable, with no clear policy delivering better production performance overall.

412. The figure shows the policy comparison plots for Hampshire Avon and Usk. Reform can be seen to be marginal in most scenario combinations. The larger negative impacts accrue under extreme scenarios (e.g. UD) and are due to very localised effects. In practice local decision making is likely to ameliorate these impacts

Figure 18: Benefits of reform (Hampshire Avon and Usk)



[41]

Sources of benefit

413. Benefit accrues from both production gains and PWS investment decision-making.

Production benefits

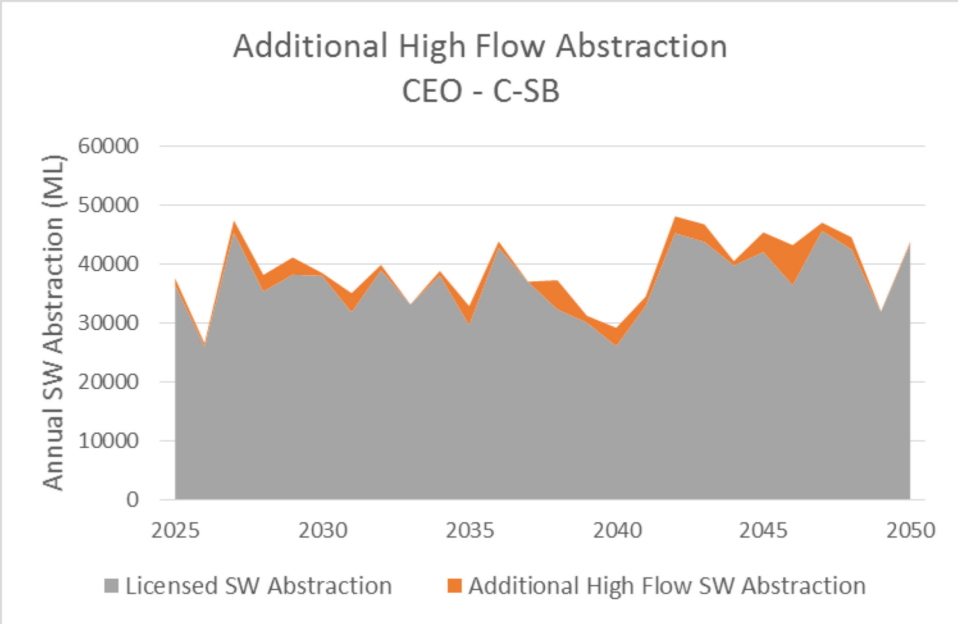
414. Production benefits only occur for non-PWS agents. They come from allowing abstractors to:

- Reduce costs by increasing access to cheaper water (e.g. abstractors are able to use more directly abstracted surface water rather than PWS water);
- Minimize costs associated with having unreliable water by:
- Buying more reliable permissions; and
- Buying additional short term supplies.
- Make more product; and
- Change the balance of products made towards water intensive products that make more profit.

415. Reform reduces water reliability at low flows but it increases access to water at high flows and increases trading opportunities.

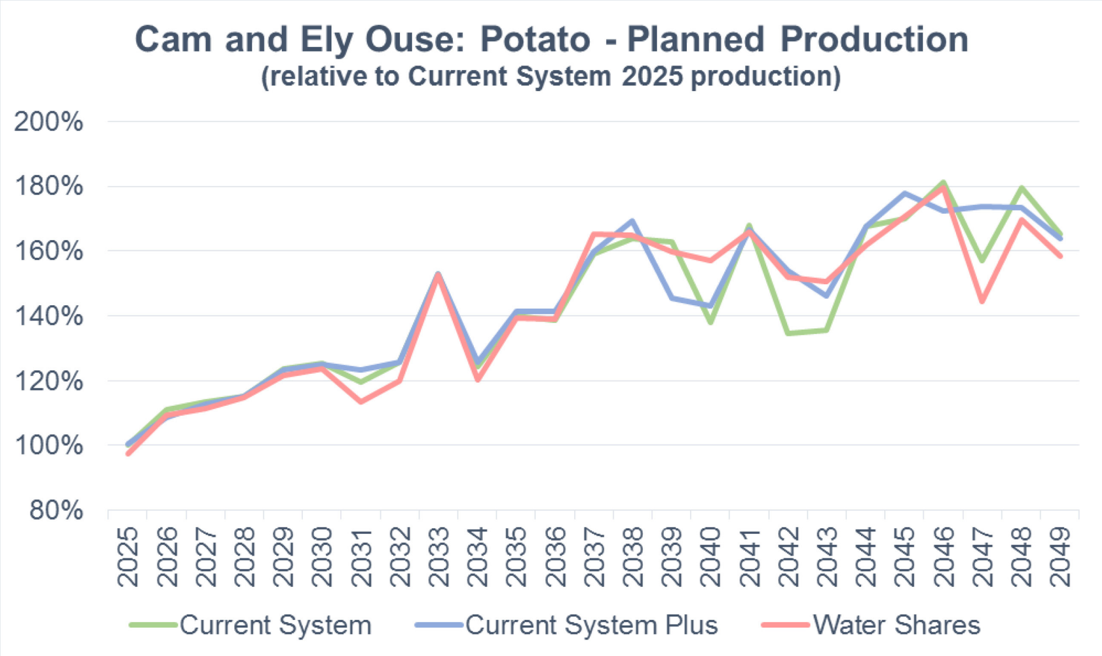
416. We see in the model that agents are able to access more water at high flows (typically ~5% more water – see Figure 19).

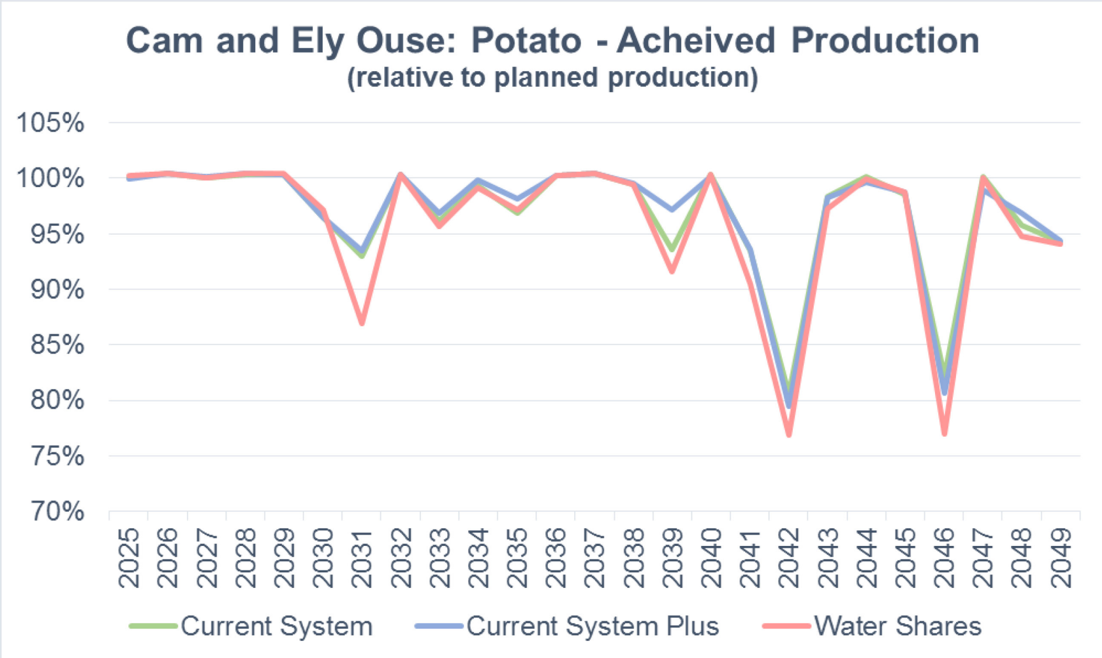
Figure 19: Example of high flow abstraction



417. We discuss trading below.

Figure 20: Example of production benefits





418. There are a number of competing factors that lead to production benefits. In Figure 20, we see the relative performance of Potato production under the three different policies, in a high demand socio-economic scenario.

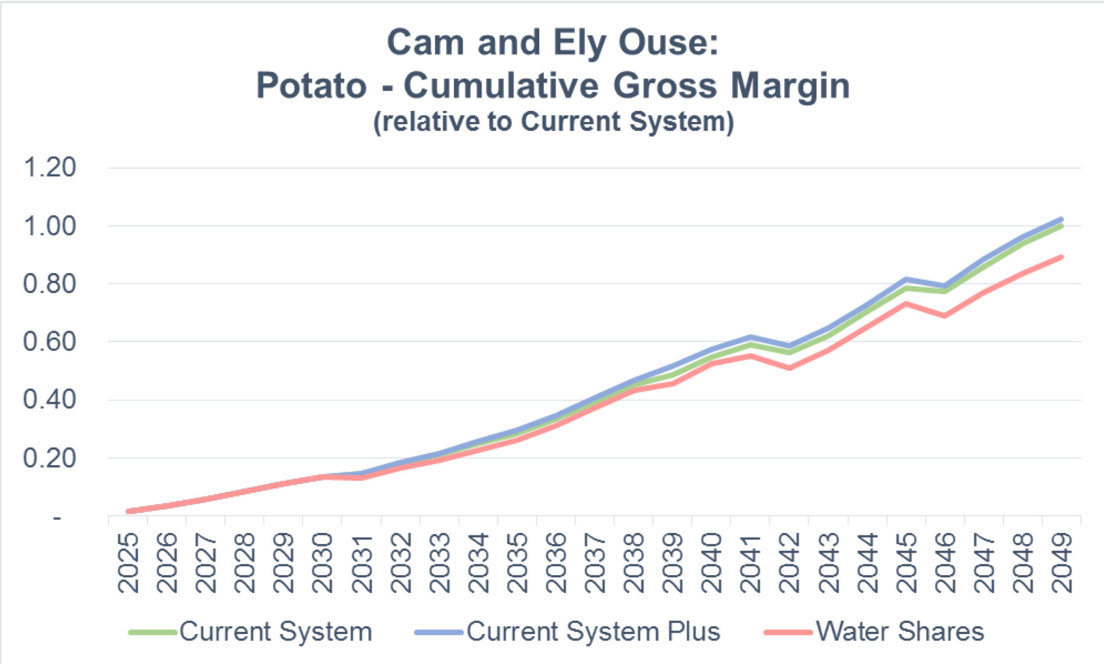
419. The top chart shows how the planned production generally increases as product prices increases. However, as the different policies start to affect water reliability in slightly different ways, the overall planned production begins to diverge between policies. In particular, the additional constraints that WS places on abstractors who wish to concentrate their abstraction in the summer months, causes a slight reduction in the attractiveness of potato cropping in the early 2030s due to a fall in the potential water reliability in dry years. However, increased buy back of water under CS and CSP in the late 2030s results in a slight shift away from potato production.

420. The lower chart shows the actual production achieved as a proportion of planned production. This shows that CSP enables abstractors to achieve a greater proportion of their planned production in a number of years when water availability is decreased. This benefit arises from short term trading (allowing water to move to those who most need it at the point of need) and increased access to water at times of high flows (which effectively allows licences to last longer during dry periods, and also ensures local farm storage is slightly fuller when the dry summer months begin. Water Shares actually results in more instances of reduced production especially in the acute dry years. This is because WS allocation constrains irrigators more than CSP, and in periods of significant shortage there are not enough abstractors with spare water willing to trade to offset this constraint.

421. Figure 21 shows that the cumulative effect of slightly higher planned production levels and more regular achievement of these plans results in CSP out performing CS and delivering overall production benefits. While the apparent differences only represent a few percent, this can still lead to significant overall monetary benefits due to the total size of the sector.

422. The chart also shows that the combination slightly lower production levels in the early years and more regular failure to achieve full production under WS leads to an overall disbenefit relative to Current System in this example.

Figure 21: Example of variation in cumulative gross margin



Investment benefits

Non-PWS abstractors

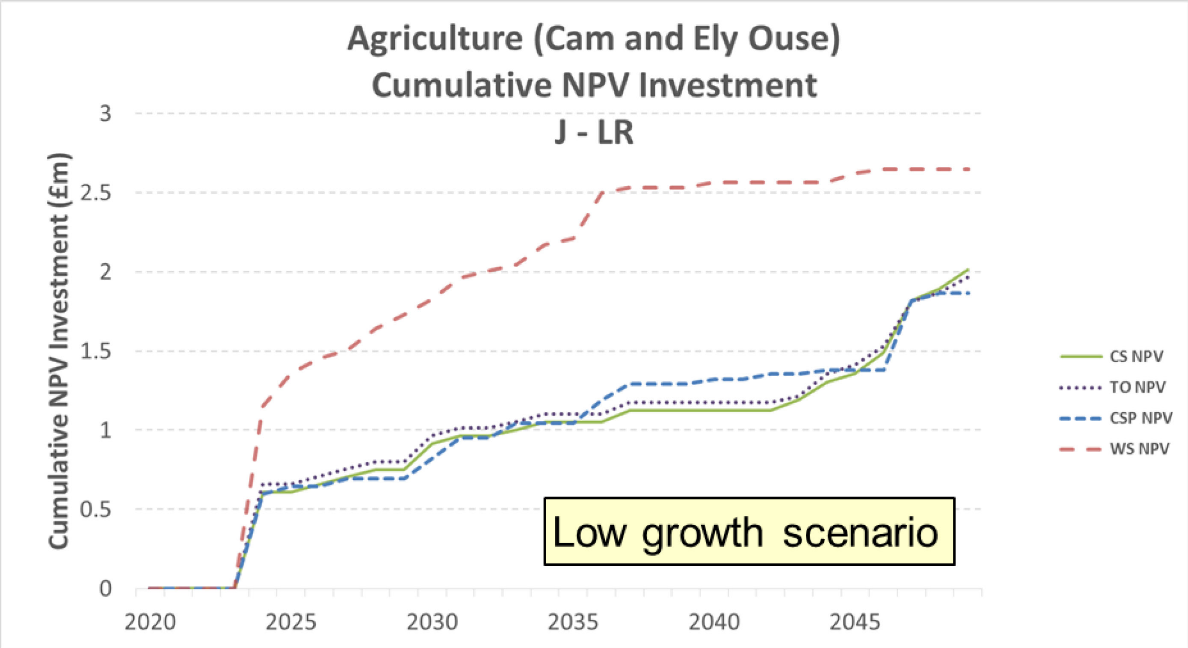
423. Non-PWS abstractors invest in measures such as storage, rain water capture, process efficiency and new sources. Much of this type of investment is actually triggered by changes in water reliability associated with reform and so generates a differential cost relative to Current System. However, there are often still overall benefits associated with these investments but these would be included in the Production benefits as they will arise when abstractors start to be able to make use of investment assets to access more water, improve the reliability of their supplies or reduce their exposure to the risk of low water reliability.

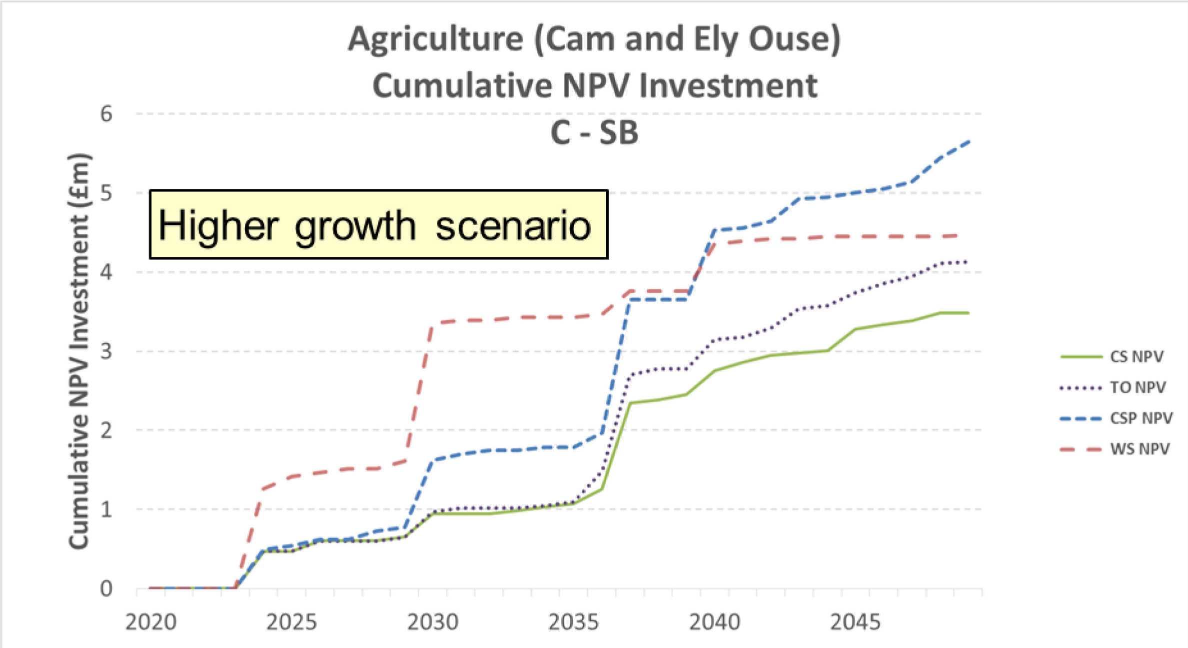
424. Typically we see the greatest amount of non-PWS investment occurring in Water Shares, and this is primarily local On-Farm Reservoir construction arising from

- the additional constraints that WS applies to the volumes that can be abstracted in the short term, and
- growth being hampered by licence constraints and the environmental review process.

425. Figure 22 shows how in Low Growth scenarios, the investment tends to be bigger under WS than other policies, and this effectively reduces the benefit of reform for this policy since the adaptations are primarily required to reduce the impact of the constraints associated with the 14-day allocation period. In higher growth scenarios, investments are primary driven by abstractors' needs to ensure they have access to more water, or to increase water security so that their growth plans are realistic and achievable.

Figure 22: Example of Non-PWS Cumulative Investment





PWS abstractors

426. Investment benefits come from abstractors spending less money (capital or operating expenditure) under reform or spending money later. As PWS expenditure is 2 to 3 orders of magnitude larger than Non-PWS expenditure it is this that dominates the investment impacts estimated by the model

427. PWS abstractors invest money in:

- Supply side options (e.g. reservoirs, transfers, new sources, improved WRZ balancing); and
- Demand side options (e.g. leakage reduction, efficiency, water reduction campaigns).

428. Some water companies have sufficient headroom to enable them to meet future demand projections, even in the face of Licence Buy/Take Back to protect the environment. However, in most cases the impact of reform and climate change results in long term reduction in the reliability of abstraction sources and a fall in the available supply. At the same time population growth and other socio economic factors are expected to lead to rising demand. Thus many PWS companies face a supply demand shortfall in the period 2025 to 2050. However, the actual shortfall that emerges is dependent on a number of factors that vary within the model runs, and this leads to changes in the both the size and timing of investments required to address the shortfall.

429. Figure 23 to Figure 25 provide an example of how one particular example PWS responds under the three policies. All three figures show the supply demand balance over the 25 year period of a model run. The PWS abstractor tries throughout the model run period to ensure that the available supply (green line) remains greater than the demand (blue line). The pale green and blue lines show the original PWS forecasts for supply and demand as published in their WRMP. The dark green and blue lines show how the supply and demand are adjusted as the PWS agent implements investment options, trades licence permissions and reacts to changes in supply reliability or environmental take back. The red text describes what actions are taken in each year, and the pale brown shading shows the NPV of investment costs accumulating over the model run period.

430. Figure 23 shows the response under CS. In 2025 at the start of the model run there is a reduction in the supply due to WFD licence reductions (this is common across all three policies) which results in it being unable to meet its operational demand at certain points during the year and a small shortfall emerging. The PWS company implements a number of small supply side and demand side options to address the shortfall. This costs approximately £1m. In 2030 growing demand leads to the need for more investment options. At this point the PWS company also takes into account the fact that the approaching 2034 environmental review is likely to curtail some licences and it calculates that the lowest cost long term solution is to implement £19m of options now that will allow that take back to be accommodated. A similar situation arises in the period between 2036 and 2040 with another £21m of options being selected to manage immediate shortfalls and those anticipated in the next 5-6 years due to environmental take back. Further take back in the late 2040s requires another £12m of options to be implemented. The total investment costs (CAPEX and OPEX) over the model run are £53m.

431. Figure 24 shows the response under CSP. In 2023 at the start of the model run, the PWS company is able to buy some additional licences form other abstractors. This is sufficient to resolve the operational shortfalls that emerge when the WFD reductions are implemented. Further trading in 2029 and 2030 is also sufficient to minimize the need for larger scale investment costs in 2030, because there is less environmental damage occurring and no buy back is planned at that stage. Buy back does however occur in 2034, and the PWS company implements £18m of options. Further buy backs in 2040 and 2046 result in total investment costs over the model run of £47m. The early trading and reduced need to address environmental damage in 2028 results in an NPV investment benefit compared to CS of £6m.

432. Figure 25 shows a similar pattern emerging under WS. Again early trading of permanent licence permissions allows the company to minimize the impact of WFD licence reductions, and reduced environmental damage in 2028 allows them to avoid significant investment at this point. Environmental damage in 2034 and 2040 is similar to that experienced in CSP and leads to similar investment choices. However WS appears to reduce the damage occurring in 2046 and so the total investment costs sum to £40m. The early trading and reduced need to address environmental damage in 2028 and 2046 results in an NPV net investment benefit compared to CS of £13m.

Figure 23: Example PWS investing to manage supply and demand – Current System

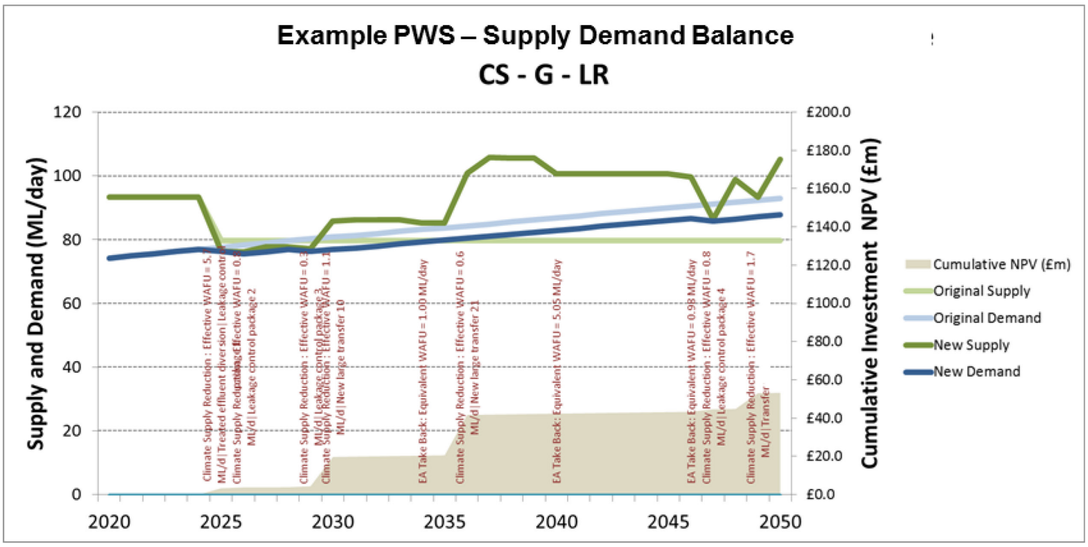


Figure 24: Example PWS investing to manage supply and demand – Current System Plus

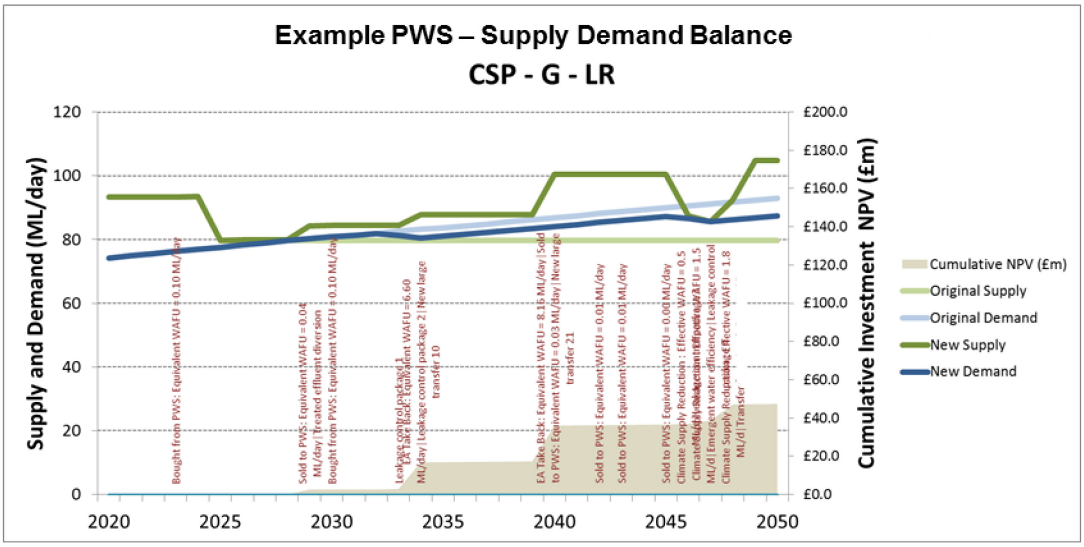
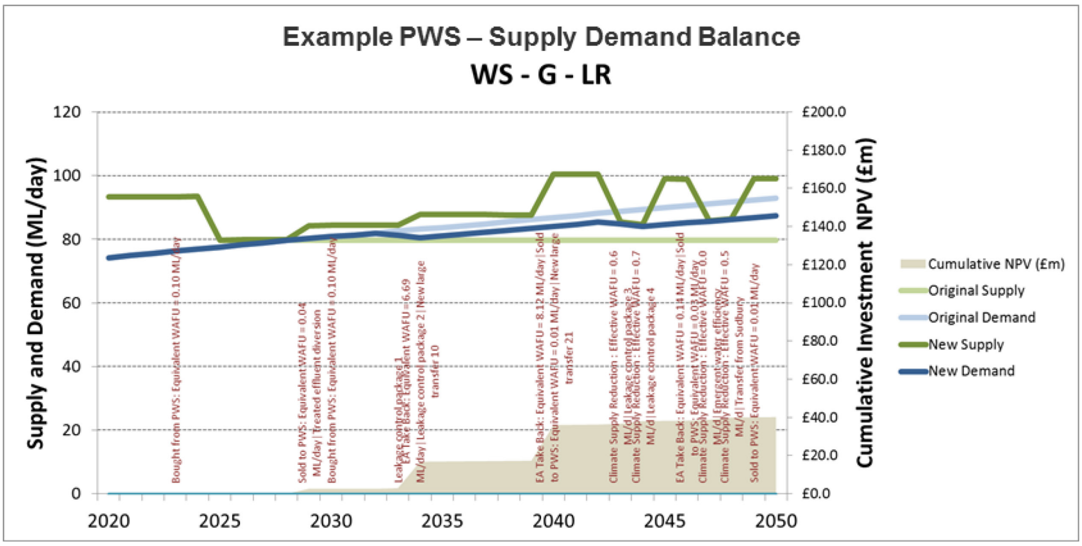


Figure 25: Example PWS investing to manage supply and demand – Water Shares



433. Overall we see that the PWS investment impacts can vary significantly from scenario to scenario much more than production benefits. This is because they arise from the differences between the actions of a few economically significant agents who are all subject to three key effects that are 'lumpy' in nature.

434. Firstly, the investment options available to PWS companies are discrete packages of work which deliver a range of additional water supply. While the model seeks to find the most cost effective long term solution, there are often situations in which a small shortfall can only be addressed by implementing a large expensive option. If this situation arises in only one policy option and not another it leads to a swing in benefits. We also know that inherent simplifications in the modelling required to make it tractable do lead to a less smooth response by PWS agents to emerging challenges than might happen in practice. For example the model cannot reproduce very local decision making processes that will optimise operation of individual water bodies. Nor does it reproduce the SEA process carried out with OFWAT to ensure the sustainability of options are considered. Thus if one policy results in a supply side option being implemented and another leads to a similarly costed demand side option, the demand side option may well lead to less longer term

environmental damage because the overall abstraction will be reduced. The model does not consider these effects.

435. Secondly, the environmental review process only takes place every 6 years, and is based on damage reaching a set of threshold criteria. If these criteria are just met in one policy and not in another then the requirement to deal with the damage is effectively delayed by six years. This represents an NPV reduction of 19% (assuming an annual discount rate of 3.5%). Thus delaying a £5m investment by 6 years is worth £1m.

436. Finally, each policy creates slightly different levels of reliability for surface water sources. This in turn leads to changes in abstraction patterns and, at certain times, an increase in the use of ground water sources. Thus the effective temporal and spatial abstraction in a catchment varies between policies and leads to different levels of environmental damage in different places. Even if policies result in the same level of overall damage that needs addressing, the mix of abstractors affected and the specific sources that are curtailed may well change. PWS abstractors are the ones who are most exposed to this effect, and it leads to variations in the level of take back that they have to address, and the investment costs they incur.

437. These factors taken together do introduce a level of 'noise' into the overall results, and lead to unexpected swings in overall investment benefit that can often dominate the results, especially in case study catchments where the impact of reform on production benefits is marginal.

Trading and leasing

438. Trading and leasing are important ways the reforms deliver benefit facilitating both investment and production benefits.

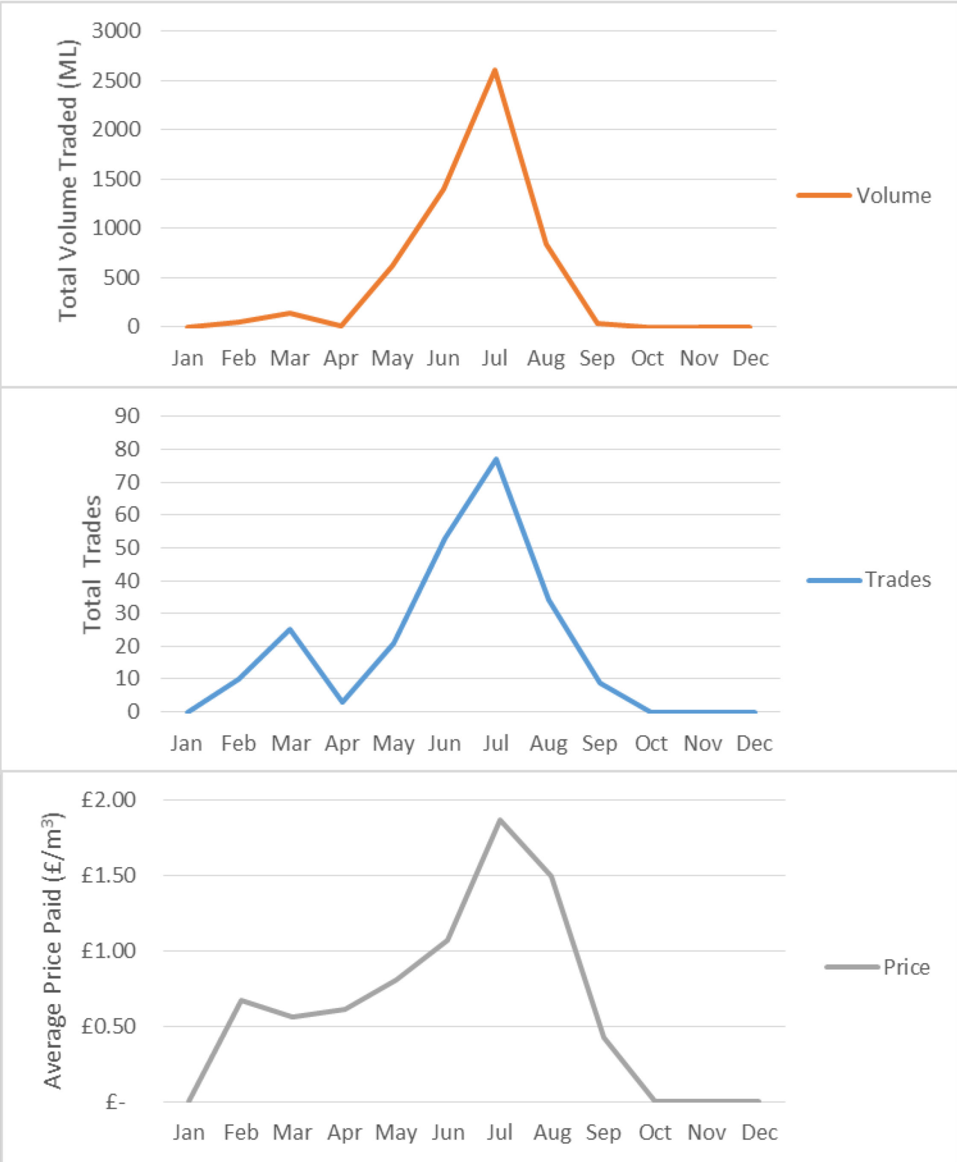
439. Licences can be traded and leased under the current system. However, very few transactions are observed. This is because it requires significant planning and negotiation and EA or Natural Resources Wales agreement. Under reform, trading in enhanced catchments will be facilitated.

440. In the modelling we assume:

- Permitted volumes / share permanent sale / lease will be slightly easier due to the decoupling of permissions; and
- Permitted volumes short term loan and share allocation will be much easier, due to preapproved low risk trades.

Within-year permitted volume trading market (CSP)

Figure 26: Example of within-year Loan Trades



441. We see an active within-year trading market under CSP, especially in the agriculture-dominated and level managed areas of the CEO and Stour. In the example shown in Figure 26 ~10% of the annual volume is loaned over the year. Prices tend to rise through the year, especially in years where the anticipated water demand starts to exceed the remaining availability. More water becomes available later in the season as the remaining water requirements become clearer.

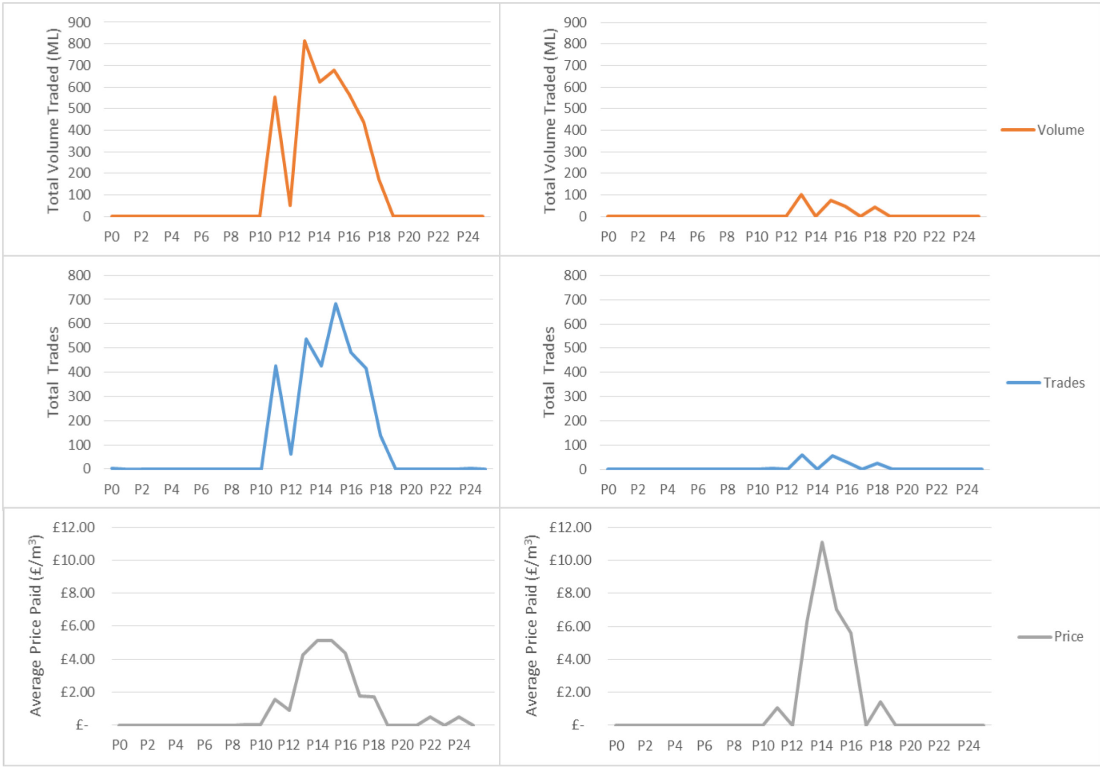
Allocation trading (WS)

442. We also see an active within-year allocation trading market under WS. Again this is most active in the agriculture-dominated and level managed areas of the CEO and Stour. At one point in the example shown in Figure 27 A 33% of available Surface Water allocation in a period is traded. Prices tend to rise through the year, especially in years where the anticipated water demand starts to exceed the remaining availability.

443. Most trades are abstractors selling water that they are not using. In this case total water abstracted increases. However, if the price is high enough agents will consider selling production water i.e. water they would have used to increase crop production. In this case water moves to those who value it more highly. Figure 27 B shows allocation trading of production water. Again prices tend to rise through the year, especially in years where the anticipated water demand starts to exceed the remaining availability. Thin markets can lead to price spikes. For example in P14 only one trade is made and this is the point at which the average price rises.

Figure 27: Example of within-year Allocation Trades

A: Unused Water Trades **B: Production Water Trades**



The market mechanism

444. The production benefits are dependent on agents participating actively in a series of complex water markets that can be efficiently cleared. The approach used to clear markets in the model ensures that those willing to pay the most get first choice in the market and also get the best price in the available trading units that they could operate in. This approach is optimistic in that it is likely to over-estimate the volume of water traded achievable in practice because it ignores local contact inefficiencies or less than fully rational behaviour.

445. This approach is consistent with the assumption that a centralised brokering service will be available (especially for short term trades), and that abstractors will be prepared to participate in such a market. However, the trading patterns observed in the model suggest that most agents actually only trade with a small number of other agents and that these are often repeat trades. Thus, similar patterns of trading could well be generated through individual agent networking, or that the rules for trading could be used to pre-generate a shortlist of suitable trading partners for each abstractor.

Analysis of Trading Patterns in the Cam and Ely Ouse

446. The Cam and Ely Ouse is the case study catchment where trading was most likely to be significant. The ABM model includes three types of trade between abstractors:

- Temporary lease of permissions (for example, licences or shares)
- Permanent transfer (sale) of permissions
- Trading of allocation for a 14 day period

447. All these trades involve the transfer of permission to consume a volume of water. Thus an abstractor who has a licence to take 1000 m^3 but consume 60% of it can only sell 600m^3 of water to someone who wishes to consume all of the water they take. Further, having sold the consumptive element of their permission the seller would then only be able to take water for non-consumptive use, which in most cases would mean they stopped abstracting entirely. A traded permission is subject to the HOF conditions that existed for the seller, and the daily pumping limits that the buyer is constrained by.

448. ***Temporary lease of permissions*** is possible under Current System Plus and Water Shares. This type of trade is modelled as an annual lease or loan of a quantity of water that can be used from the date of the transaction to the end of the year. In practice the leases may be let for more than one year at a time (e.g. over five years), and in the model we often see agents renewing the lease every year.

449. ***Permanent transfer (sale) of permissions*** is possible under all policy options. This type of trade provides long term access to water, and new entrants may prefer the security provided by buying permanent permissions. Abstractors may offer permissions for permanent sale when business requirements change their long term requirements. In the model abstractors will permanently sell permissions where their decision making suggests that the realised value of a sold licence is worth more than the NPV of future production income or lease income.

450. ***Trading of allocation for a 14 day period*** is only possible under Water Shares (and the Hybrid Option in Water Share mode). This type of trade has no effect on an abstractor's long term abstraction permissions. It provides a guaranteed quantity of water over a period that is not affected by the weather over that period. Hence it is a less complicated trade to decide on. Actual water demand is much easier to anticipate over a short term period, and so we find that more water is made available for sale (because sellers have greater confidence they do not need it), and competition for the water is greater (because buyers have an actual need and a much clearer idea what a shortfall will cost them.

Differences between options

451. Under the ***Current System*** abstraction trading is possible but not straightforward. Each individual trade is subject to 3 month approval procedures by the regulator and abstractors have to find willing trading partners independently. Short term trades are generally not feasible due to the slowness of the system. Trading therefore rarely occurs.

452. Under ***Current System Plus*** low risk water trades would be pre-approved so some trades would be processed almost immediately. The majority of low risk trades that could be pre-approved would be temporary lease trades involving abstractors trading with other abstractors downstream of them. The system would inform all abstractors which trades were pre-approved to facilitate trading.

453. Under ***Water Shares*** it will be possible to pre-approve some trades upstream as well as downstream. Abstractors will also be able to make short-term trades during the period of allocation, or by transferring water through put and take trading, without impacting their long term entitlements.

454. The different trading mechanisms and rules are included in the model with the exception of 'put and take' trading.

Variation in trading under different socio-economic and climate scenarios

455. We have examined the variation in trading patterns occurring under a range different socio-economic and climate scenarios. The analysis focused on a 'diagonal slice' of four scenario combinations in the Cam & Ely Ouse: A-I, C-SB, G-LR and J-UD.

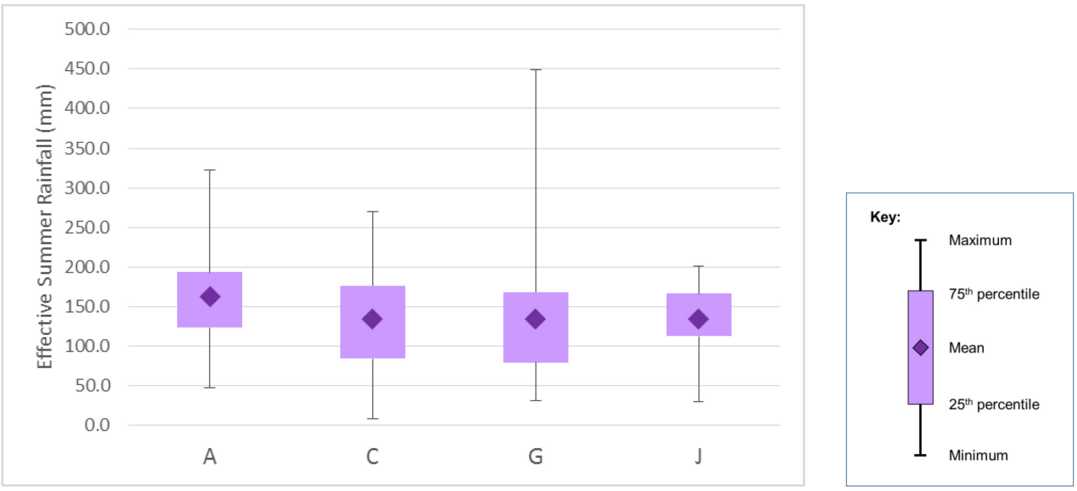
456. The principal variations presented by the socio-economic scenarios are different levels of population growth (which causes PWS abstraction to vary) and changes in product prices (which leads to relative growth or decline in different products).

457. Overall, I and UD represent scenarios in which overall demand for water increases, while SB and LR represent futures in which growth is less significant overall, but relative growth between sectors is still present.

458. Variations in rainfall and evapotranspiration affect both the demand for water (especially for rain-fed crops) and the available supply.

459. Figure 28 shows the effective rainfall (precipitation less evapotranspiration) over the summer months (June to August) for each climate scenario. While these are generally all drier than today's climate, there is a significant variation in rainfall from year to year. However, if you compare the distribution of rainfall over the period 2025 to 2050 then A is the wettest overall (it has the highest average rainfall and a medium variation between wet and dry). The other three all have a similar average summer rainfall but with different distributions. C has the driest single year but a medium variation in rainfall, G is drier more frequently, but has some very wet summers, and J is much more consistently dry, but without really extreme wet or dry summers.

Figure 28: Distribution of effective rainfall over the summer months – Cam & Ely Ouse



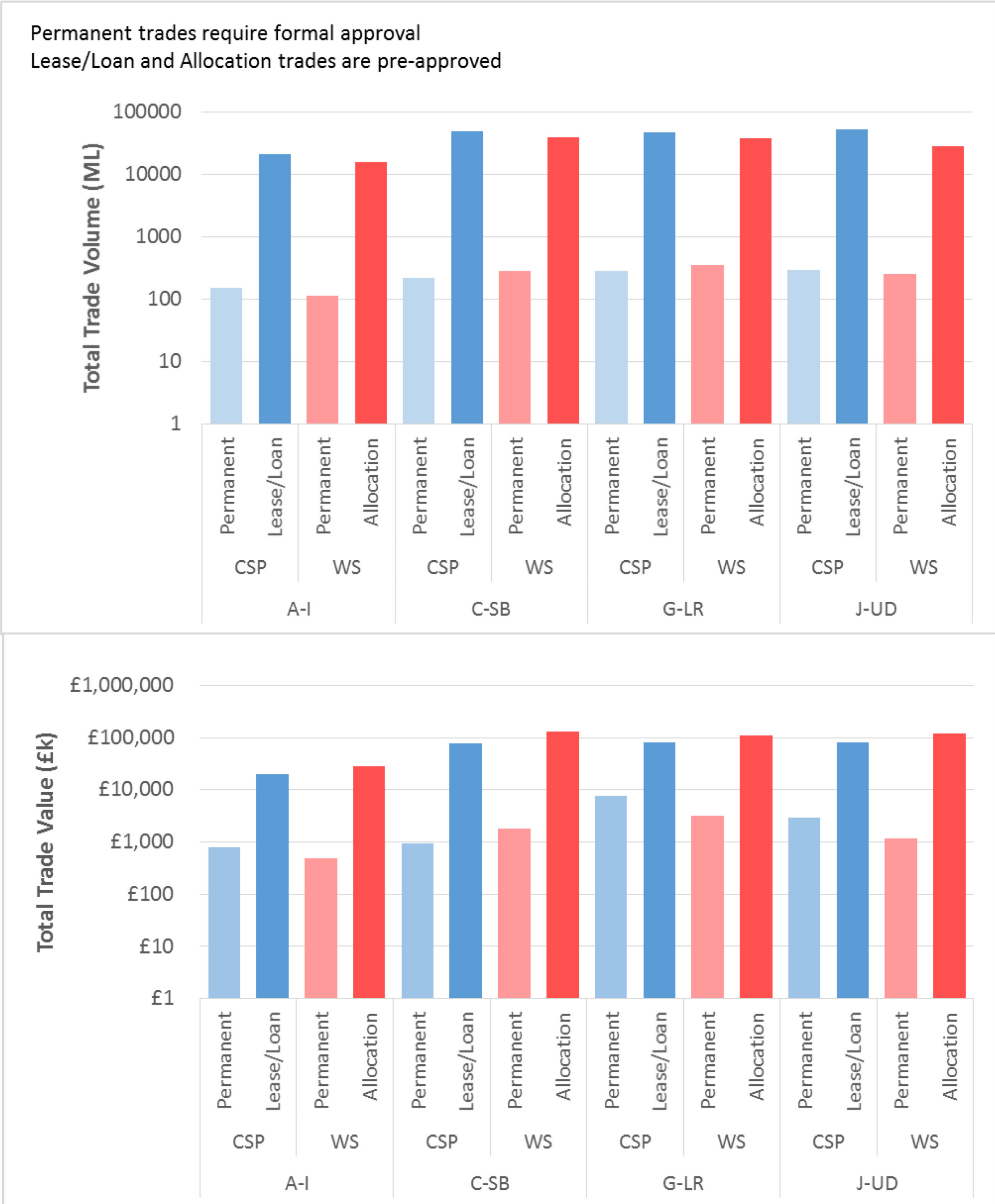
Balance of Trading

460. Figure 29 shows the volume and value of the different types of trade recorded in the current model runs for the four scenario combinations.

461. This figure shows that the vast majority of trades occurring are pre-approved short term trades of licence permissions or allocation. Permanent sales of licences or share-holdings (which are not pre-approved) represent typically less than 1% of the trading volumes and 2-5% of the trading values.

462. Permanent trades tend to occur at significantly higher prices (typically 8.5 times higher) because they involve an agent selling an asset that would enable them to generate an on-going income (ether through production or leasing).

Figure 29: Overall trading volumes and values for CEO



Trading patterns in Current System Plus

463. Figure 29 shows that the most significant type of trade in the Cam & Ely Ouse under Current System Plus is the temporary lease of permissions. This trade type is analysed in detail in this section and summarised in Figure 30.

464. Overall, we see low volumes and low prices in A-I as this scenario is relatively wet and demand growth is not excessive. Higher trading volumes occur in the drier scenarios, and volumes tend to increase as the effects of climate change become stronger.

465. The average price at which water is traded tends to increase as volumes increase. This is a more significant effect in G-LR and J-UD because these are the driest climate scenarios and the socio-economic scenarios in which high water use product prices tend increase with time. The combination of higher demand for water and abstractors who are willing to pay more drives the price increase.

466. Figure 31 shows that most of the temporary lease of permissions is for surface water.

467. Figure 32 shows the breakdown of trades for one scenario (G-LR). Agriculture is by far the biggest buyer, followed by sports and recreation. This suggests that the main driver for trades is irrigation demand.

468. An analysis of the volume of within-year loan trades in a year with the effective summer rainfall (Figure 33) shows that trading activity generally increases in all scenarios when there is less effective summer rainfall (i.e. in drier summers). However the correlation is not all that strong. This is not surprising in that the market is partly driven by abstractors' assessments of the probable water demand and availability in a dry-year scenario, and it is only as the actual water availability emerges that the market becomes more directly driven by the effective rainfall that year.

469. A more detailed breakdown of buyers and sellers (annual average volume) can be seen in Table 14 to Table 17. These tables show that most dominant trades are agriculture to agriculture. These represent between 60-85% of the total trades by volume in the four scenarios presented.

470. Figure 34 shows a breakdown of the trading by agricultural agents

471. Taking scenario G-LR as an example, there are 80 (58%) agricultural agents who make fewer than 25 trades over the full 25 year period of the model run (i.e. 1 or fewer trades per year). However there are some agents who make multiple trades per year, e.g. there are 5 (4%) agents who make between 101 and 125 trades in total (an average of 4 or 5 trades per year).

472. Overall there are between 110 and 162 agricultural agents who engage in trading as buyers of water at least once during the 25 year model run. This is in the context of a total population of around 1,900 agricultural agents in the catchment as a whole, i.e. just less than 10% are active traders. Each buyer has on average between 4.5 and 5.8 different trading partners (Figure 35).

473. The rules for deciding who can trade with who (and therefore which trades can be pre-approved) are complicated by the need for hydrological linking, but in practice once these rules have been specified it therefore appears that a relatively simple trading pattern emerges. This may have implications for what type of trading system is required.

Figure 30: CSP pre-authorised leasing of permissions – traded volumes and volume weighted average price

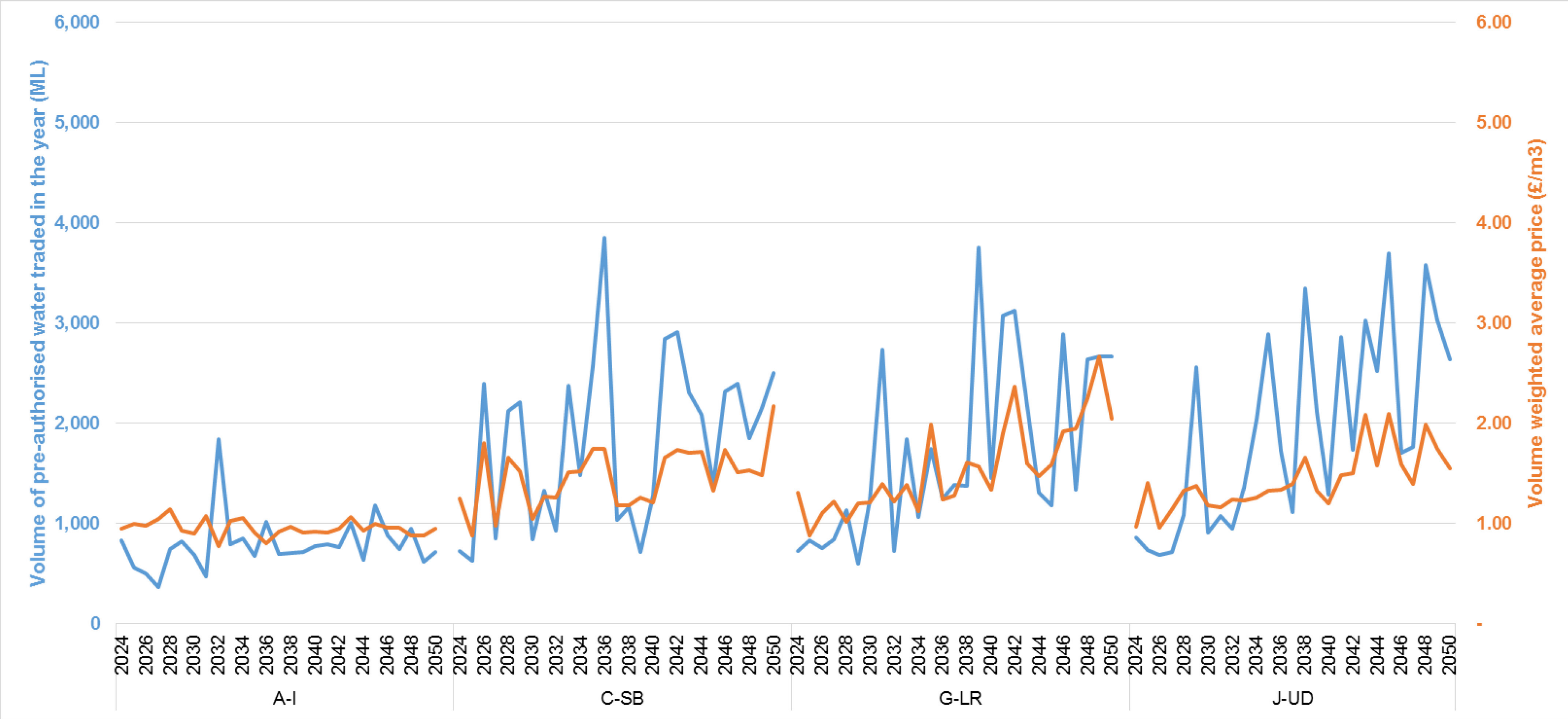


Figure 31: CSP pre-authorised within-year loans – trade volumes grouped by type of water

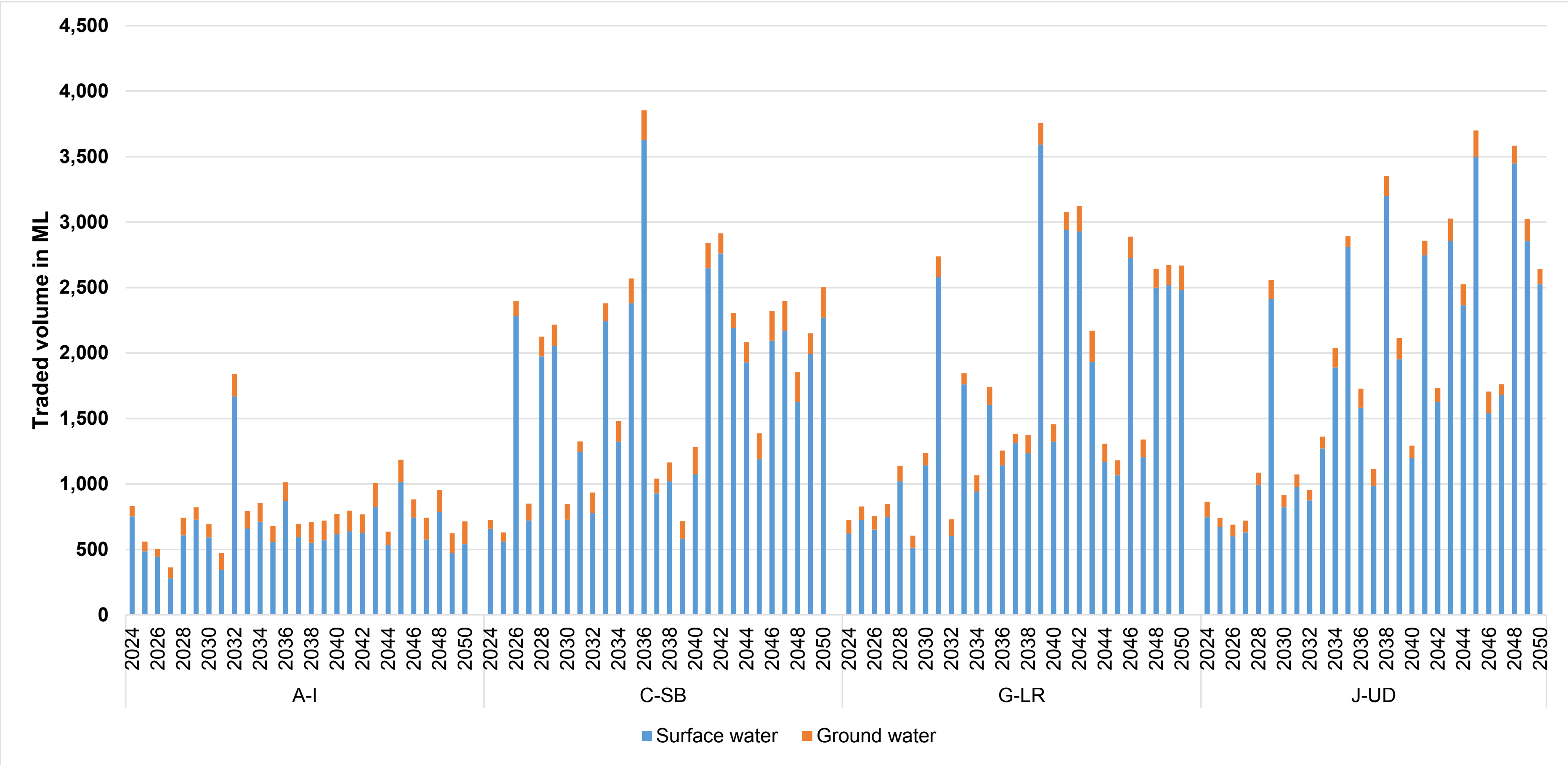


Figure 32: CSP pre-authorised within-year loans for G-LR – trade volumes grouped by sector

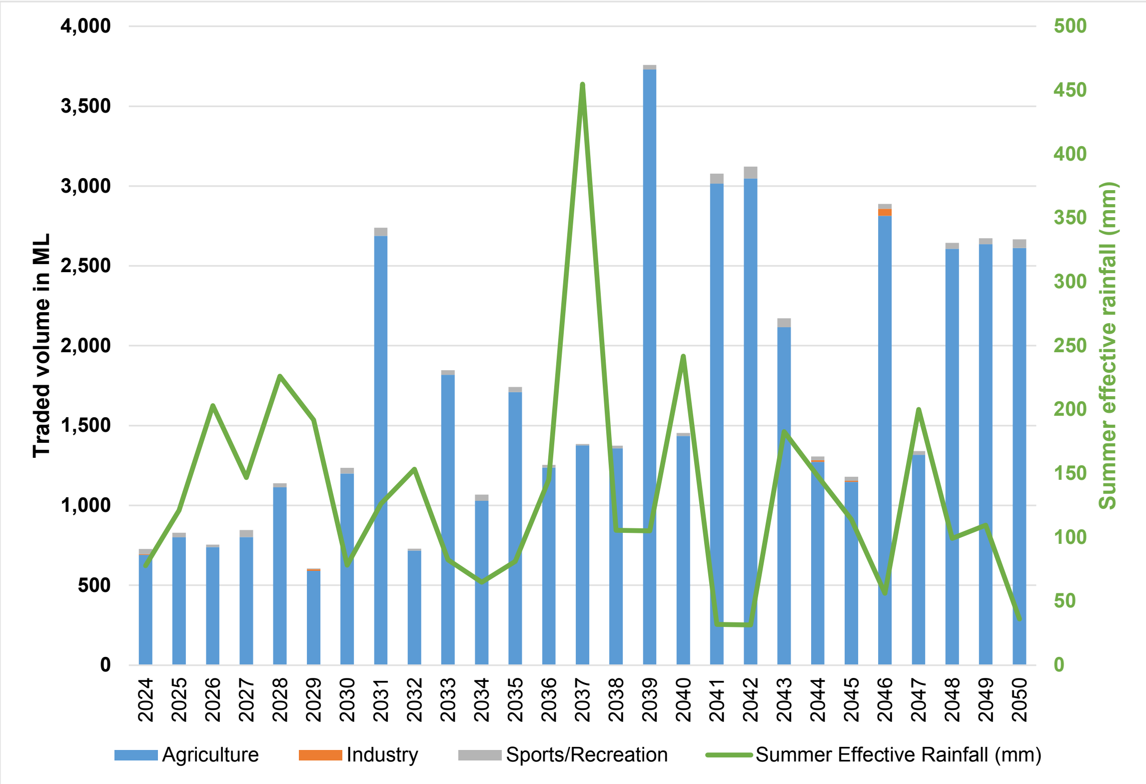


Figure 33: CSP pre-authorised within-year loans for G-LR – correlation with effective summer rainfall

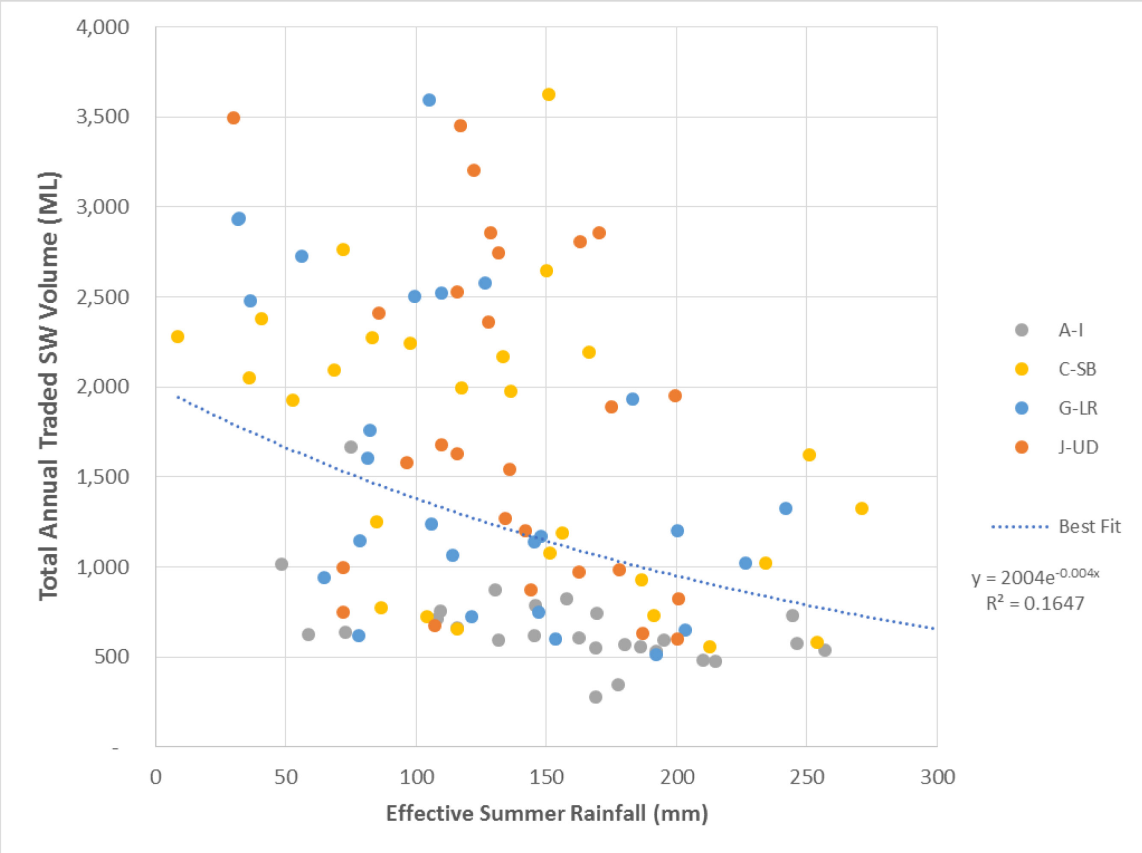


Table 16: Average traded volume in ML per year for Scenario A-I

	Buyers		
Sellers	Agriculture	Industry	Sports & Recreation
Agriculture	476		22
Industry	24		2
Sports/Recreation	33		
Water Companies		2	
Others	233		0.2

Table 17: Average traded volume in ML per year for Scenario C-SB

	Buyers		
Sellers	Agriculture	Industry	Sports & Recreation
Agriculture	1,479	1	34
Industry	24		4
Sports/Recreation	28		
Water Companies	4	1	
Others	247	4	0.3

Table 18: Average traded volume in ML per year for Scenario G-LR

	Buyers		
Sellers	Agriculture	Industry	Sports & Recreation
Agriculture	1,402	2	26
Industry	26		5
Sports/Recreation	46		
Water Companies	1	1	
Others	215		0.2

Table 19: Average traded volume in ML per year for Scenario J-UD

	Buyers		
Sellers	Agriculture	Industry	Sports & Recreation
Agriculture	1,624	0.2	27
Industry	17		3
Sports/Recreation	42		
Water Companies	0.3	0.5	
Others	212		1

Figure 34: CSP pre-authorised within-year loans – agricultural abstractor trading patterns

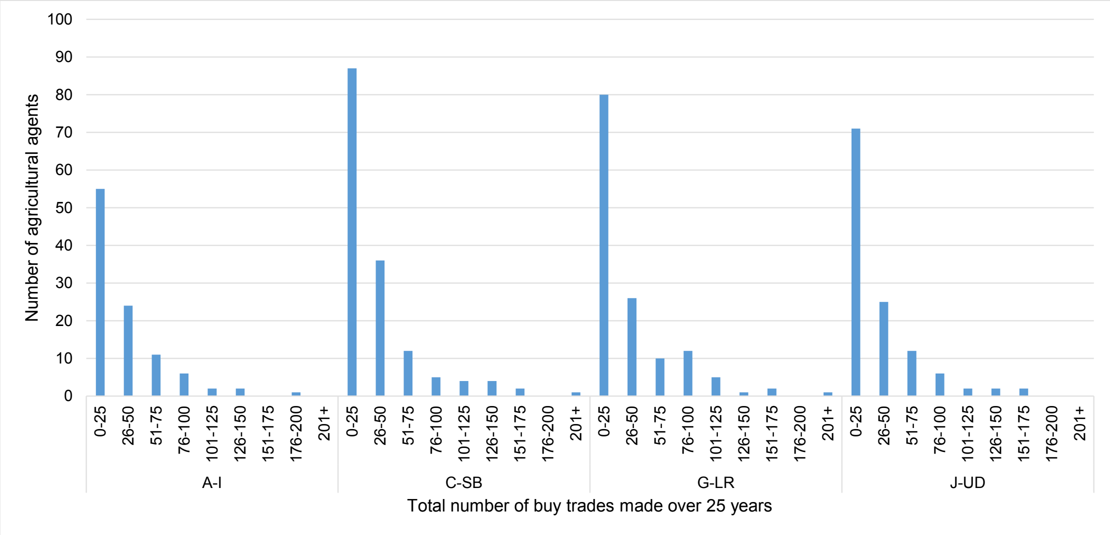


Figure 35: CSP pre-authorised within-year loans – agricultural abstractor trading partners

Trading patterns in Water Shares

474. Figure 29 shows that the most significant type of trade in the Cam & Ely Ouse under Water Shares is the trading of 14-day allocation. This trade type is analysed in detail in this section and summarised in Figure 36. As with CSP, we see lower volumes and prices in the A-I scenario (relatively wet and lower demand growth). Higher trading volumes occur in the drier scenarios, and volumes tend to increase as the effects of climate change become stronger.

475. Prices are more variable than was the case for CSP lease trades but as before the average price at which water is traded tends to increase as volumes increase. This is a more significant effect in G-LR and J-UD because these are the driest climate scenarios and the socio-economic scenarios in which high water use product prices tend increase with time. The combination of higher demand for water and abstractors who are willing to pay more drives the price increase. Prices are generally 50-80% higher than under CSP lease trades. This is because WS allocation trading is (by nature) driven by shorter term issues (primarily recent rainfall and current flows), and so demand is more acute in times of shortfall and the markets are therefore more competitive.

476. Figure 37 shows the breakdown of trades for one scenario (G-LR). Agriculture is by far the biggest buyer, followed by Industry. This suggests that the main driver for trades is still irrigation demand. However the fact that industrial abstractors are also buying in the market is indicative of the fact that at times of low flows even the most reliable shareholdings are not generating full allocation, and even abstractors with more constant water demands are being impacted by water availability.

477. An analysis of the volume of allocation trading with the effective summer rainfall (Figure 38) shows that trading activity increases in all scenarios when there is less effective summer rainfall. The correlation is stronger under WS than CSP because the allocation market is much more directly linked to the actual availability of water over the next 14 days which is predominantly driven by the effective rainfall.

478. A more detailed breakdown of buyers and sellers (annual average volume) can be seen in Table 18 to Table 21. These tables show that most dominant trades are again agriculture to agriculture. These represent between 88-95% of the total trades by volume in the four scenarios presented.

479. Figure 39 shows a breakdown of the number of agricultural agents engaging in trades. It shows a histogram of how many 14 day periods they trade in over the 25 year period. This is a better metric than the number of trades because (for calculation purposes) the model splits up trades into smaller units than would probably happen in practice. For example 101 farmers trade in 10 or fewer allocation periods in C-SB over 25 years, i.e. they trade less than 1 year in 2. The histogram is stretched for J-UD as we would expect, with a significant number of farmers trading in more than 70 allocation periods (i.e. 3 or 4 allocation periods per year on average).

480. Overall there are between 151 and 242 agricultural agents who engage in trading as buyers of allocation at least once during the 25 year model run. This is in the context of a total population of around 1,900 agricultural agents in the catchment as a whole, i.e. 8-12% of agricultural abstractors are active traders. Each buyer has on average between 14 and 22 different trading partners (Figure 40).

481. The general increase in the number of trading partners indicates that demand is most efficiently met by more complex combinations of allocation trades, which suggests an automated market clearance system as part of a more centralised trading platform may be required.

Figure 36: WS pre-authorised sale of 14-day allocation – traded volumes and volume weighted average price

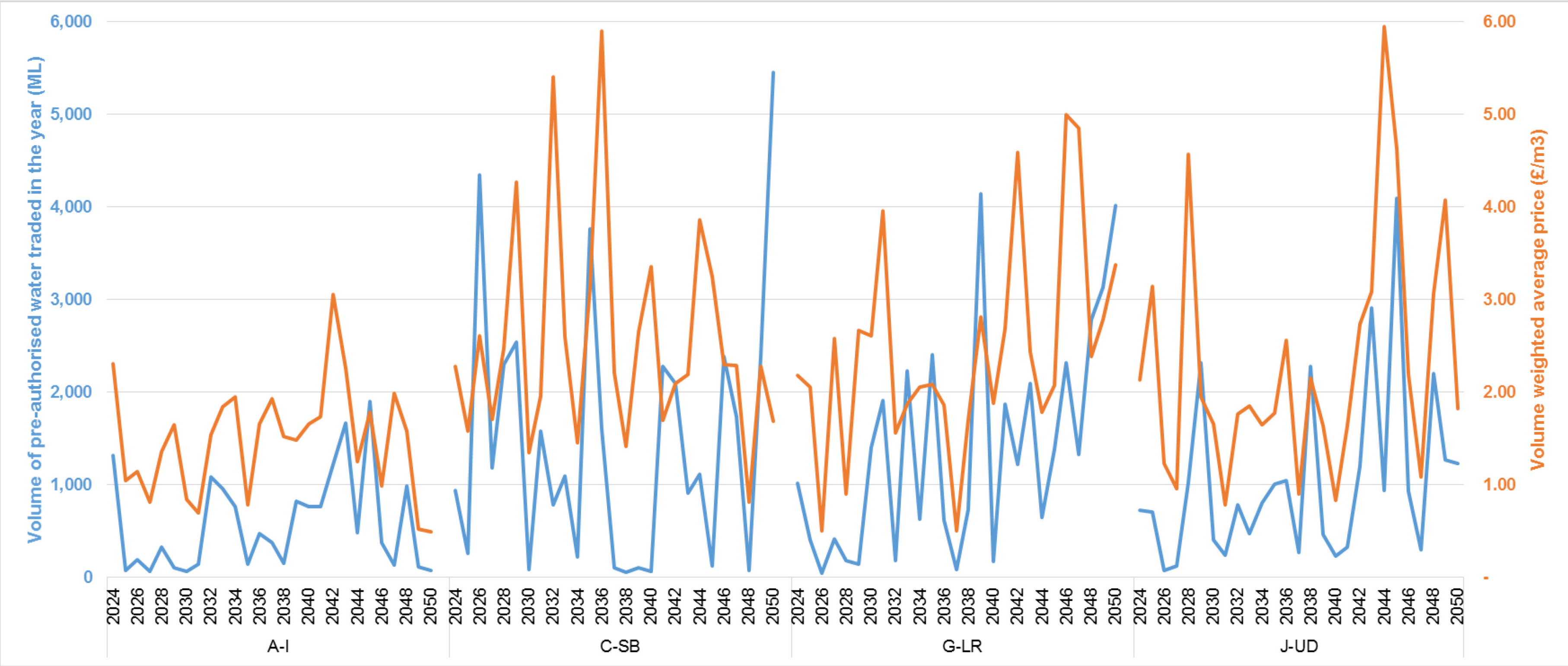


Figure 37: WS pre-authorised sale of 14-day allocation for G-LR – trade volumes grouped by sector

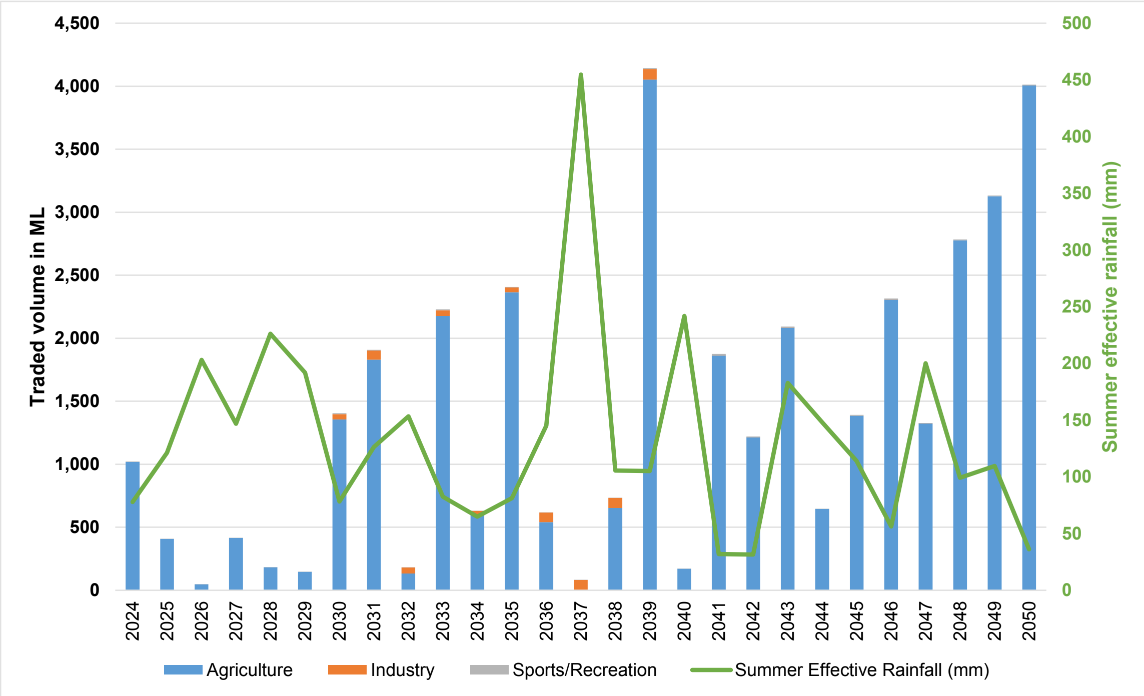


Figure 38: WS pre-authorised sale of 14-day allocation – correlation with effective summer rainfall

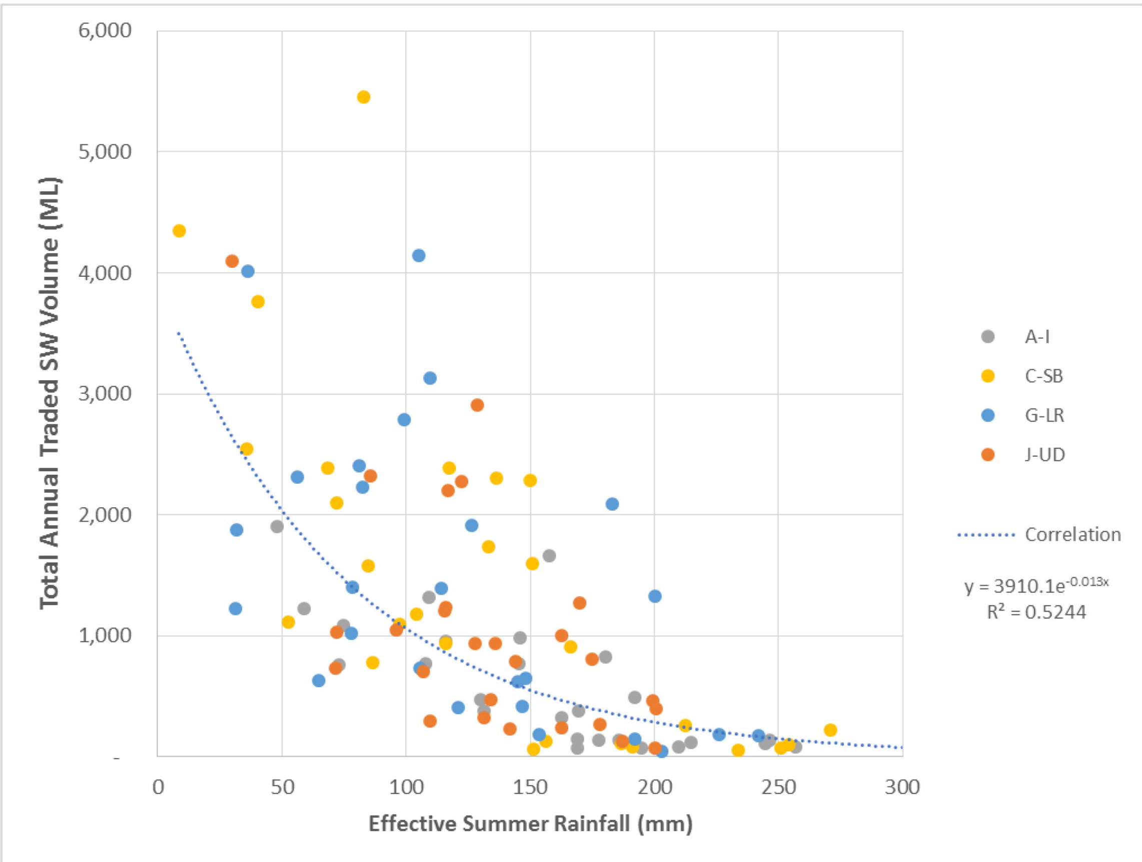


Table 20: Average traded volume in ML per year for Scenario A-I

	Buyers		
Sellers	Agriculture	Industry	Sports/Recreation
Agriculture	506.4	34.4	1.6
Industry	1.3	-	-
Sports/Recreation	13.7	-	0.1
Water Companies	5.4	-	-
Others	14.1	0.0	0.3

Table 21: Average traded volume in ML per year for Scenario C-SB

	Buyers		
Sellers	Agriculture	Industry	Sports/Recreation
Agriculture	1,399.1	30.3	3.6
Industry	2.2	0.0	-
Sports/Recreation	12.2	0.4	0.2
Water Companies	0.7	0.1	-
Others	17.7	0.0	0.2

Table 22: Average traded volume in ML per year for Scenario G-LR

	Buyers		
Sellers	Agriculture	Industry	Sports/Recreation
Agriculture	1,317.9	20.2	3.7
Industry	2.1	-	-
Sports/Recreation	16.0	1.7	0.2
Water Companies	9.1	0.1	-
Others	18.6	0.0	0.2

Table 23: Average traded volume in ML per year for Scenario J-UD

	Buyers		
Sellers	Agriculture	Industry	Sports/Recreation
Agriculture	923.2	82.7	2.3
Industry	1.6	0.0	-
Sports/Recreation	12.7	0.5	0.1
Water Companies	11.1	2.1	-
Others	14.8	0.1	0.3

Figure 39: WS pre-authorised sale of 14-day allocation – agricultural abstractor trading patterns

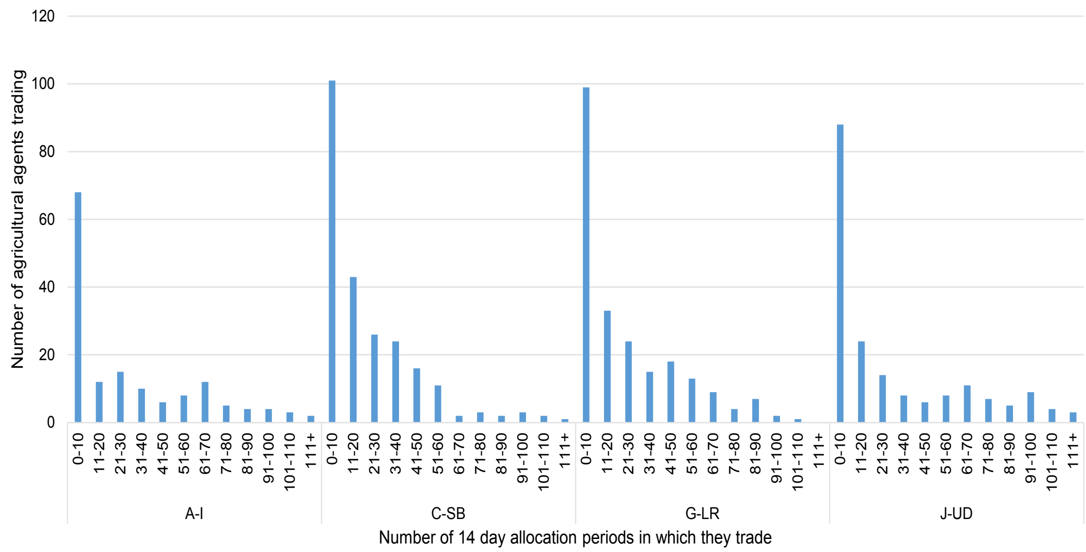


Figure 40: WS pre-authorised sale of 14-day allocation – agricultural abstractor trading partners

Annex J: Assessment of transition and administration costs

Approach

482. As previously indicated, the abstraction reform proposals will be implemented either at basic or enhanced levels in catchments depending on the benefits of enhancement. In basic catchments there will be minimal changes to the existing permissions and practices of abstractors. In enhanced catchments there will be more significant changes resulting in higher administrative costs for both the regulator and the abstractor. By allowing implementation to different levels the overall administrative costs will be minimised while meeting environmental protection requirements and supporting resilient economic growth.

483. To calculate the regulatory administrative costs of implementing and running the three reform options, compared to staying with the current system, a bottom up cost assessment was completed.

484. Firstly, tasks common across all options and those specific to individual reform options were identified for both abstractors and regulators. Trivial costs, or those not affected by reform were either excluded, when trivial, or combined into a single cost item (valued at £94M per year). Approximately 90 potentially significant option sensitive elements were identified and costed for each option through this process[68]. Baseline costs were obtained from Environment Agency (including Environment Agency Wales - now superseded by Natural Resources Wales) business accounts, budget reporting and employee time recording data. Data gaps were filled by interviews with appropriate professionals in the Environment Agency and Natural Resources Wales or by consultant, supplier or contractor research.

485. The next step was to assess the degree to which each cost varied for each option and each level of reform. This process involved discussions with specialists in the Environment Agency and Natural Resources Wales.

486. Finally, each cost element (under each option and each level of implementation) was then compared to the tasks undertaken in 2012 (the baseline year for the assessment). This variance was used to inform the estimates of the incremental costs of the reform options.

487. The time at which costs were incurred was also considered. The costs can be split into:

- ‘One off’ implementation costs
- ‘Recurring’ running costs

488. All costs were collated and considered in a spreadsheet tool developed by consultants URS[1]. The calculated catchment costs for each option were then input into Risk Solutions’ aggregation model to give costs of reform under 16 different socio-economic and climate change scenarios.

489. Costs are incurred by the abstractor and the regulator under all options. The impacts on administrative costs incurred by the abstractor were found to be essentially unaltered between all options and relatively insignificant compared to the abstraction charges passed

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[68] Environment Agency / Natural Resources Wales: Assessing the Regulatory Cost of Abstraction Reform - Supporting Evidence on Component Costs, September 2013 – available on request from abstraction_reform@defra.gsi.gov.uk

through to abstractors by the regulators under their scheme of charges[69]. This is because regulatory changes should not be significant for business except in terms of:

- Facilitating trading, the transaction costs of which are estimated and netted off the benefits of trading (see Change in production gross margin for business section on page 50); and
- the need for smart meters, the costs of which are specifically considered below.

490. The baseline costs of all activities and infrastructure incurred by the regulators in England and Wales was approximately £141m per year. Of these costs approximately £45m is spent on activities directly related to managing abstraction licences, the remaining covers wider costs associated with managing water resources issues and are not affected by the choice of reform option.

Description of Significant Changes in Costs under Reform

491. To allow easy comparison, the costs of retaining the current system into the future and the costs of implementing and running a reformed system are shown separately. There are many common tasks required to run all the reform options, so additional costs associated with using a shares based system (water shares or the hybrid option) are identified separately. All costs shown below represent combined costs for England and Wales.

492. In summary implementation costs vary between £19m and £23m with some increased costs due to the costs of creating shares in the water shares and hybrid options (see Table 22 and Table 23). These are balanced by savings in recurring regulatory costs over 25 years with avoided recurring cost increases of the current system £111m NPV over 25 years and reduced recurring costs of reform of £14m NPV over 25 years. The main factors are:

- Avoided increases in costs under the current system due to increased investigations of £92m NPV over 25 years (see Table 24); and
- Reduced costs of reviews under reform due to transition reducing the risks to the environment of £34m NPV over 25 years (see Table 25).

493. Savings are reduced under water shares and the hybrid option to a much lesser extent due to the costs of forecasting short-term allocations.

[69] Abstraction Charges Scheme - https://www.gov.uk/government/publications/abstraction-charges-scheme-april-2014-to-march-2015

Transition costs

494. There are a number of costs incurred by both abstractors and regulators when implementing reform (also known as transition). Most of the costs are common across all reform options. The key implementation costs are described below. All will ultimately fall on business through cost recovery charging.

Table 24: Implementation costs of reformed systems 2020-2025 (£M)

Description of cost variance	Costs
Smart meters will be required in enhanced catchments. Some small abstractors will not require an upgrade, but others will require more than one meter. We judged that all small, non-strategic licence holders in enhanced catchments would require a smart meter and that large abstractors already have them[70]. Individual purchase and installation cost of £640[71] per meter was estimated.	3
Implementation of reform requires the development of a revised water resource assessment process and tools; both based on that used in the current system by regulators. Costs also arise due to the population of data and running of the updated process in order to assess availability of resources ahead of reform and determine all abstractors new permissions. This cost also includes the production of new catchment rules documents.	9
Administrative costs of changing existing licences into site permits, water account entries and cross referencing with catchment rules documents. This also includes contacting abstractors to inform them of changes to licences.	2
Development of new IT systems including the 'water account' to hold abstractor details and to manage billing of abstractors, and a basic trading platform[72] is required for reform. Costs also cover trading rules development to underpin the trading platform in enhanced trading catchments	5
Total	**19**

495. Insignificant or insensitive costs that were considered include: administrative tasks for abstractors in becoming familiar with reformed systems as new systems should be more user friendly than current systems. Costs to support abstractors in adjusting to the new system have been included in the regulators costs. This support will minimise impacts on abstractors.

Table 25: Additional Water Shares and Hybrid Option Implementation Costs 2020 – 2025 (£M, NPV)

Description of cost variance	Cost*
Before a shares based scheme can be implemented abstractors will have to be issued shares, which could be in various reliability pools and may be held in different water management units within a catchment. Work will be needed to issue shares to the appropriate abstractor.	4

70 Assessment of meter information submitted by abstractors with 2013 Annual Returns

71 Cost obtained from Elster metering and ratified by discussion with other suppliers and installers

72 Figures from Rough Order of Magnitude enquiries to software developers

Changes in recurring (running) costs due to reform

Savings from avoided increased costs of the current system

Table 26: Avoided recurring cost increases of current system (£M NPV)

Description of cost variance	Costs
Due to increasing demand and climate change it is expected that there will be an increasing number of site investigations needed into the impact of abstractions on the environment. It is expected that these costs will increase over time and will be 2.5 times the baseline by 2050[73].	-87
Increased pressure in catchments due to increased demand and climate change will lead to more effort checking compliance with licence conditions. A 20% increase in effort over baseline costs nationally is judged reasonable.	-14
Total	**-101**

Changes in Costs due to reform options

496. The key ongoing costs incurred by abstractors and the regulator under all reform options are described in table 25. Some of the costs vary over time, in response to increasing pressures or due to increasing familiarity with systems and processes. There are also a number of savings over the baseline costs (denoted by a minus sign preceding the figures) which can be expected under reform.

Table 27: Running costs of current system plus (£M NPV)

Description of cost variance	Cost
Smarter flow constraints on abstractors require more confidence in flow monitoring data and thus an increase in maintenance and support costs for hydrometry and telemetry assets. It is judged that a 20% increase in regulator expenditure maintaining systems would be required in basic catchments and a doubling in enhanced catchments.	17
In basic catchments compliance activities will initially increase, by 20% as abstractors will have new permits to understand. This will decrease back to baseline costs as abstractors become familiar with systems. In enhanced catchments initial effort would be increased by 20%, while abstractors become used to operating under new system, then decreasing by 20% reflecting more auditable data from smart meters over time.	3
The automatic assessment of abstraction data submitted by smart meters will result in erroneous data being quickly identified. Abstractors will have to maintain their meters to a high standard. Routine maintenance figures are based upon conservative estimates of maintenance[74].	1
Total costs	**21**

[73] Estimates approved by Environment Agency specialists managing investigations

[74] Costs for smart meters maintenance provided by Elster meters.

Description of cost variance	Cost
Action taken on transition into reform that modifies licence volumes to reduce risk of deterioration will significantly reduce the number of investigations that will be needed, reducing costs to abstractors.	-28
By removing time limits on permissions savings are made on administrative and technical assessment costs associated with reviewing and renewing licences which will occur without reform. These savings apply across all catchments in England and in Wales.	-14
Under reform the regulator will only re-assess water availability when there is an environmental trigger. The current process of a 6 yearly full review cycle will cease in basic catchments replaced by a simplified review. It is judged that there will be a 30% reduction in basic catchment costs as a result of this change. More work will be involved in enhanced catchments, so it is judged that there will be a 20% increase in full review costs in enhanced catchments.	-4
Total savings	**-46**
Net savings from implementation of current system plus	**-25**
Net savings including avoided costs from Table 24	**126**

497. Other ongoing costs which were considered, but found to be insignificant or invariant across the options included:

- Abstractors investigating alternative supply options. Under all options an abstractor's demand for water may be greater than that allowed by their permission. The reform proposals will not alter the need for abstractors to investigate alternative supply options. The reforms will, however, make some trading based alternatives easier to undertake.
- Some abstractors in enhanced catchments will report usage more frequently than under the current system. Costs to abstractors in enhanced catchments from reporting usage more frequently than currently required[75] will be offset by the replacement of the current paper based system with an online system that accepts automatic smart meter input.

Additional Running Costs (covering both Water Shares and Hybrid Option)

498. There are some additional costs which would only be incurred by the water shares and to a very small extent with the hybrid option. These are described below.

75 https://www.gov.uk/government/publications/water-abstraction-metering-good-practice-manual

Table 28: Additional Shares Running Costs (£M NPV)

Description of cost variance	Cost	
	WS	HO
Forecasting flows and water levels in enhanced catchments to establish allocable volumes of water for the subsequent allocation period[76].	21	1

Welsh only administrative costs/savings

499. Welsh costs and savings are relatively small compared to total costs but could be significant for Wales so are provided here at a higher level of detail against summary headings.

Implementation costs

Table 29: Welsh implementation costs of reformed systems 2020-2025 (£'000)

Description of cost variance	Costs
Smart meters required in enhanced catchments.	92
Revised water resource assessment process and tools	401
Changing existing licences into new permissions	51
Development of new IT systems	640
Total	**1,184**

Table 30: Additional Water Shares and Hybrid Option Implementation Costs 2020 – 2025 (£'000)

Description of cost variance	Cost*
Issuing shares in enhanced catchment	85

Changes in recurring (running) costs due to reform

Table 31: Avoided recurring cost increases of current system (£'000 NPV)

Description of cost variance	Costs
Avoided increased investigations	-4,174
Avoided increased compliance	-1,723
Total	**-5,897**

[76] Costs based upon maintenance of hydrological models and rainfall predictions similar to those used for flood forecasting by National Flood Forecasting Centre

Changes in Costs due to reform options

Table 32: Running costs of current system plus (£'000 NPV)

Description of cost variance	**Cost**
Maintenance and support costs for hydrometry and telemetry assets	377
Increased compliance activities.	338
Total costs	**715**
Reduced licences changes	-468
No need to renew time-limited licences	-346
Reduced assessment of water availability	-1,352
Total savings	**-2,166**
Net savings from implementation of current system plus	**-1,451**
Net savings including avoided costs from Table 26	**-7,348**

Annex K: Calculation of the NPV and EANCB

500. The underlying time series for the NPV and EANCB calculations for each of our three policy options is set out below. The following points related to these figures should be noted:

- All costs and benefits are assumed to be incurred directly by businesses. This is because regulatory costs incurred by regulators are recharged to business under cost recovery rules. Other costs and benefits are directly incurred by businesses.
- Recurring administrative costs associated with reform options have been netted off the admin cost savings category, as explained on page 48 in the section on Recurring Administrative costs/savings to Business.
- The time profile is based on the aggregation methodology as explained on page 39, which gives a generally stable profile. There is a shift in year 13 (2037) as some catchments become 'enhanced' from 2025 (year 1) and some catchments are only 'enhanced' from 2037[77]. The key underlying drivers at a catchment level are highlighted below for 'gross margin' and 'investment savings' benefits. Administrative cost savings are included at the aggregation stage as average annuals and are not affected by the different scenarios that drive the high and low estimates.
  - **Gross margin benefits** are dependent on short term weather as the main difference between policy options is often the behaviour of spray irrigators. Because we don't know which years are actually going to be wet and which are going to be dry we calculate an annual average production benefit without discounting and assume this applies every year.
  - **Saving in investment benefits** are more dependent on long term climate change, regulator take back and population growth. Timing of investment is important so we don't smooth the investment profile. The change in the 25 year profile of additional capital and operating costs under the reform options compared to the baseline is converted into an equivalent annual figure for the modelled catchments, and it is these values that are scaled up to all 116 catchments to determine the national change in adaptation costs.

[77] For example, total gross margin benefits from 2025 = sum of production benefits for each catchment that is enhanced from 2025, repeated for every year from 2025 to 2049; and total gross margin benefits from 2037 = the above plus the sum of the extra gross margin benefits for each catchment that is enhanced from 2037, repeated for every year from 2037 to 2049.

Option 1: Current System Plus

NPV, £m		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Costs, £m																									
19	**Transition**	19																								
	Benefits, £m																									
235	**Gross Margin Best**	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
32	**Low**	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
402	**High**	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8
109	**Savings in investment costs - Best**	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
28	**Low**	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
138	**High**	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
126	**Saving in admin costs Best**	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
126	**Low**	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
126	**High**	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6

Note : figures may not sum due to rounding.

Option 2: Water shares

NPV, £m		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Costs, £m																									
23	**Transition**	23																								
	Benefits, £m																									
206	**Gross Margin Best**	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
21	**Low**	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
352	**High**	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
84	**Investment savings - Best**	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
53	**Low**	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
166	**High**	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
	Saving in admin costs																									
104	**Best**	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
104	**Low**	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
104	**High**	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3

Note: figures may not sum due to rounding.

Option 3: Hybrid Option

NPV, £m		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Costs, £m																									
23	**Transition**	23																								
	Benefits, £m																									
240	**Gross Margin Best**	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3
33	**Low**	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
411	**High**	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
105	**Investment savings - Best**	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
27	**Low**	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
134	**High**	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
	Saving in admin costs																									
124	**Best**	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
124	**Low**	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
124	**High** 7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5

Note: figures may not sum due to rounding.