

# Private water supplies and the local economic impacts in Scotland





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**Front cover photos:** Paul Teedon, GCU

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# Executive Summary

## Introduction

There are approximately 22,000 private water supplies in Scotland serving a population of nearly 197,000 people<sup>1</sup>. Many of these are also micro- and other businesses which rely on these supplies for their existence: frequently providing services to a broader public as visitors and tourists particularly in remote rural areas of the country.

This study provides evidence of the impact private water supply reliance has upon social and economic infrastructure; business development; costs of clean water; land management and stewardship and support needs. It also highlights indicative issues within three sectors (tourism, dairy farming and forestry) that are likely to be more widely pertinent.

The findings reveal the complexity of private-supply arrangements and infrastructure, and the considerable gaps to be bridged to ensure future rural social and economic sustainability, system effectiveness, and to reduce localities' vulnerabilities.

## Background

Private water supplies in Scotland are largely governed by Regulations<sup>2</sup> which require 'regulated supplies' to be tested annually by local authorities. In addition many businesses are monitored by other regulatory requirements notably food hygiene regulations.

## Method and case study areas

This qualitative study, undertaken in four remote rural locations in Scotland, collected (interview and other) data from 72 individuals, including a cohort largely reliant upon private water supplies for their business operations, and a range of other key stakeholders from strategic agencies with relevant remits.

## Findings & Recommendations

### Economic infrastructure

#### Findings:

- Private water supplies play a vital role in remote rural communities in Scotland and in ensuring resilience in the local economy.

1 Drinking Water Quality Regulator for Scotland (2019) Drinking Water Quality in Scotland 2018 Private Water Supplies p.3

2 The Water Intended for Human Consumption (Private Supplies)(Scotland) Regulations 2017

- As local economies in remote rural Scotland are dominated by micro-businesses (with less than 10 employees), they are particularly vulnerable to private-supply unreliability.
- This vulnerability particularly amongst these businesses is exacerbated by a lack of (system and technical) knowledge and associated skills in remote rural areas, limiting communities' adaptive capacity.
- Rural businesses reported having reactive, short-term, effective contingency plans in place; operationalised when supply is interrupted. However they often lack longer-term resilience planning and risk management, leaving businesses exposed.
- Switching to a mains-network supply to ensure a resilient supply would be welcomed by some private-supply business users, but others were resistant due to the (perceived) costs involved, particularly in dairy farming due to the large quantities of water used.

#### Recommendations:

- Greater recognition is needed amongst stakeholders of the importance of private supplies in local economies and consequently there is a need for enhanced national strategic oversight.
- There is a need for greater resilience planning, and development of local and regional infrastructure for private water supply reliance, with appropriate stakeholder support to manage the associated risk and uncertainty.
- Action is required to ensure that skilled professionals are consistently part of the Scottish remote-rural private-supply infrastructure planning.
- There is a need for greater clarity and appropriate support for those who might seek to access mains-network water supply.

### Business development and investment

#### Findings:

- Business and economic development agencies are largely unaware of the strategic importance of private water supply issues and associated challenges to both economic development and growth.
- Financial investment in private supply systems is variable and carries an increased risk of failure.

#### Recommendations:

- To improve rural resilience, better engagement between business and economic development agencies and other stakeholders is needed, as well as

recognition and understanding of the role of private water supplies in local economies: there may be value in exploring commonalities with approaches adopted in Scandinavia and North America.

- Expertise held within multiple institutions and agencies could be exploited more effectively and be supportive of locally-held expertise. Developing mechanisms for sharing that expertise with private-supply users would be useful and require careful planning.

## Costs

### Findings:

- Managing a private-supply system has significant costs for micro-businesses both in terms of cost and staff time.
- Maintenance costs are highly variable and dependent on the local environment and social variables, including terrain and availability of suitably-skilled tradespeople.
- There is limited awareness of business liabilities as a (potential) cost and risk to operation.

### Recommendations:

- There is an urgent need to set out liabilities and associated (legal) responsibilities by a range of stakeholders. This should include reference to and information on other relevant (sometimes sector-specific) regulatory legislation.

## Land management and stewardship

### Findings:

- Stakeholders at local level, and private-supply users themselves, have concerns about the effective management and stewardship of private supplies. Land-management agreements around private-supply stewardship present a considerable challenge for some supply users. Fragmented management structures with opaque lines of responsibility add to local uncertainty over supplies and their reliability.

### Recommendations:

- There is a need for more consistent approaches to supply-management with appropriate support mechanisms (for example, mediation and conflict resolution), and for varied models of good practise.

## Supporting communities

### Findings:

- The importance of water supplies to communities and local economies rarely features in local authority economic development planning.
- Demographic change is exacerbating skills loss in rural areas, as new migrants rarely bring skills in private-supply stewardship, management or maintenance
- Local authorities and other strategic bodies hold considerable knowledge about all aspects of private supplies but no simple mechanism for sharing this with users and communities (as evidenced by the studied areas).

### Recommendations:

- Mechanisms for sharing local authority knowledge and data about supplies as well as keeping this updated, within and across agencies and other communities who can benefit should be explored.

## Sector-Specific Summary

### Findings:

- Variation in private water supply based issues exists across different sectors. In tourism, there is evidence of changing demands as the sector expands. Dairy farming which appears considerably vulnerable given its reliance on substantial water quantities for a range of its functions faces a number of challenges and vulnerabilities. In addition, amongst those with significant land-management roles for example, forest operators face considerable management and engagement challenges.

## Conclusion

Businesses reliant upon private supplies in remote rural Scotland face considerable challenges to their existence and sustainability. These businesses play a key role in local economies and, whilst often stoical, business owners (and residents) would benefit from knowledge, skills and resource support to enhance their resilience and reduce their vulnerability. The awareness of these challenges and associated issues within strategic and other agencies is uneven: many would benefit from greater levels of dialogue and knowledge which could improve business-support initiatives and economic development planning for businesses dependent upon private supplies.

# 1. Introduction

The report provides qualitative evidence collected in response to the work commissioned by CREW to investigate the following question: 'Private water supplies: Are they inhibiting growth and flexibility of the rural economy, or impacting population distribution?'<sup>3</sup>

This study explored whether relying on private water supplies has an economic and socio-demographic impact, both on the small-scale micro level (drawing on evidence from four Scottish remote-rural areas), and on the wider regional or national level. In particular, it presents evidence on microeconomic impacts, especially to individuals, households, or businesses and the ways in which their reliance on a private water supply constrains their economic activity. The study draws into the discussion the need for clear distinctions to be made between the imperative for rural economic development and the desired economic growth. Here, economic growth can be seen simply as an increase in output and income, whilst economic development concerns an economy's productive capability to organise and transform its productive activities. Economic development is traditionally a role played by local government: the potential of private water supplies to impact the economy of an area is therefore an important variable within economic development planning. This report presents exploratory findings evidencing the impact of private water supply reliance upon productive activities, particularly on the key role of microbusinesses, before concluding with recommendations for enhancing this supply infrastructure and thus enhancing local economic development.

The study builds on work previously undertaken (Teedon et al, 2017<sup>4</sup>) in which the experiences of communities reliant on private water supplies were explored.

The report addresses its key themes in two ways: the perspectives of on-the-ground operation of private supplies for business activity, and by looking at broader, often more strategic (largely stakeholder) perspectives.

During the fieldwork it became apparent that three particular sectors of the economy had particular pertinence to private supply issues: tourism, forestry and dairy farming. The report offers observations on these as indicative of complex issues (in Section 6).

A key role is identified for a range of strategic bodies to play in ensuring community resilience and considerations are then offered on this.

<sup>3</sup> We have abbreviated the project title to 'Private water supplies and the local economic impacts in Scotland'

<sup>4</sup> Teedon, P., Currie, M., Helwig, K., and Creaney, R. (2017) Engaging communities around private water supplies. CRW2014\_12. Available online at [www.crew.ac.uk/publications](http://www.crew.ac.uk/publications)

The report concludes with recommendations for future local and strategic action.

## 1.1 Methodology & research approach

This exploratory research investigated the experiences of residents, businesses and communities reliant upon private water supplies. It considered the consequent impacts this reliance has upon their economic activity, their perceptions of the benefits this offers and the challenges it presents.

### 1.1.1 Case study areas and participants

Four very remote rural<sup>5</sup> Scottish case study areas were chosen. The selection criteria were devised with the Project Steering Group and required that each area had a prevalence of private water supplies and, where possible, differed from the other three case studies, differences in socioeconomic profiles, land use, land-holding structures, and business activities. The resulting four case study areas, all of whom were active in the tourism sector to varying degrees, are profiled as follows:

Case Study 1 – contains a number of community 'buy-outs'

Case Study 2 – socio-economic reliance on traditional large-estate activities

Case Study 3 – prevalence of dairy farms, forestry activities and wind farms

Case Study 4 – pasture-based island-farming economy

The qualitative research engaged directly with 72 individuals. For each of the areas a range of participants were identified, and these were broadly categorised according to following criteria:

- Domestic and business users of private water supplies.
- Stakeholders who had direct or indirect responsibility for private water supply provision or related policy / regulation either in the specified study areas or beyond.
- Stakeholders with no direct responsibility for private supplies (in the specific areas) but whose work might impact their development particularly if they operated at a strategic level.

<sup>5</sup> All four areas are classified as 'very remote rural' locations according to the Scottish Government eight-fold Urban Rural Classification. Scottish Government (2018) Scottish Government Urban Rural Classification 2016 Geographic Information Science & Analysis Team Rural and Environment Science and Analytical Services Division



## 1.1.2 Methods and analysis

Interviews were conducted by telephone or in person at locations which were chosen by the participants using two bespoke interview topic guides, one for private supply users and one for strategic stakeholders. Those who used private supplies for domestic or business purposes were presented with prompts under the following themes: water quality; reliability; costs; personal impacts and business impacts. Strategic stakeholders' topic guide contained prompts grouped under five themes, namely decision making; management; economic impacts; strategic facilitators and challenges and testing.

The data collected from the interviews and discussion groups were transcribed and organised in Nvivo under the five topic-guide themes appropriate to the participant's profiles. A thematic analysis was then conducted which categorised emergent patterns, and then discussed across the research team to increase confidence in the analytical categories. The resulting analysis produced six themes:

- Health Impacts;
- Operational challenges for businesses;
- Private Water Supply Infrastructure;
- Stewardship and governance;
- Industry specific private-supply issues;
- Strategic support issues and institutional challenges

These themes are used to organise the presentation of the analysis in the following sections.

## 2. Health Impacts

Poor water quality is associated with the potentially dangerous health impacts and participants in this study were aware of this. Some respondents had their own experiences of negative, supply-related, health impacts. One participant<sup>6</sup> (a business owner) reported her son had contracted cryptosporidium and subsequently developed Crohn's disease and ulcerative colitis. Testing by SEPA found no contamination of her supply, but she reported she was now "extremely anxious" about the quality of her private supply which served both her home and her husband's professional-services business. Another, who had considerable concerns about water quality at her home, had previously taken her children "for probably the first four years of their lives" to bathe at a cousin's house because she was concerned they might accidentally swallow water from their baths at their own house.

<sup>6</sup> Unless stated otherwise (eg if identified as different forms of 'stakeholder') all quoted respondents were reliant upon a private water supply

After installing a UV filtration system, the respondent did bathe the children at home, but still boiled the water before the children drank it. Their supply had not been tested, although they intended to, once the ongoing work for which they intended to apply for grant funding was completed, as this was a requirement under the grant scheme.

Participants were not always moved to improve systems by incidents involving the private supply itself. For example, a local plumber recounted a family who previously had no filtration system had suffered a decline in health, and as a result installed new supply infrastructure as a precautionary measure to avoid exacerbating their health conditions.

The domestic-supply stoicism seen in our previous research (Teedon et al, 2017<sup>7</sup>) was also evidenced here, particularly with respect to the quality of water consumed for personal use. Such acceptance was often associated with lifestyle choices, particularly amongst those who had migrated or returned to these remote areas. As one business manager noted:

"I mean the risks from a stream are animals, animal faeces, these sorts of things. But it's moving the water and we've never had a problem ... the two boys, they were born and bred with it and none of us have ever had an issue."

And similarly, a discussion-group participant said:

"Occasionally we get the odd dead deer in the water. It happened in the water this year, but it was pulled out and no problem."

Respondents did not ignore potential concerns, but there was variance in the level it was expressed. For example, one letting-business owner identified potential contaminants in her supply as iron and manganese but had not installed filtration. She recognised the poor quality of her supply, yet it was disregarded:

"Well, I've brought up three sons and they're all still living. All the grandchildren, they all drink it... But at certain times of the year it does look fairly murky ..."

It should be said, however that this stoicism was rare when individuals referred to their business operations.

### 2.1 Health concerns - business impacts

The quality of the water and concerns about potential health effects impacted both those involved in business activities and those reliant on private supplies. For business operations, drinkability of water supplies was a central

<sup>7</sup> Teedon, P., Currie, M., Helwig, K., and Creaney, R. (2017) Engaging communities around private water supplies. CRW2014\_12. Available online at [www.crew.ac.uk/publications](http://www.crew.ac.uk/publications)

public-health concern. As a water engineer and business manager indicated:

“Generations of people have drunk from these supplies without really having much problem, but increasingly more houses are being let out for holiday lets in this part of the world and so you have an issue there. If you’ve got paying customers, you’ve got to have potable water.”

This was of particular concern for businesses particularly when they had been linked with specific infections with a small business owner indicating:

“You’re really worried that there is some kind of pathogen in there and it’s going to make somebody sick.”

One organisation reported a case of *E.coli* infection, though noted the source of the infection was never effectively identified. Over 50 other people were consuming the same water but did not contract it. The organisation’s business manager speculated that “it was probably food poisoning” contracted elsewhere.

For guests, customers, employees and others using business premises on a private supply, when water quality was compromised there was an immediate loss of business productivity. Some accommodation owners reported losing business because of compromised water quality. For example, a non-resident holiday-let business owner had been unable to display ‘boil notices’ immediately (as they were not in the vicinity) when a supply was impacted by forestry operations.

Another business owner stated they had been impacted by the same ‘boil-notice’ incident and had lost “quite a few thousand quid” as a result.

Businesses identified complex and often costly systems they had installed to ensure water used by customers/ guests was potable.

### 3. Operational challenges for businesses

Almost without exception, businesses in this study, of all sizes, had experienced a range of water quality based challenges. The viability and sustainability of private supplies for businesses and / or domestic use were found to be largely dependent on individual circumstances. From an economic perspective, such ‘micro-circumstances’ relating to private supplies can comprise a wide range of factors including:

- proximity of both business and associated supply to the rest of the community: clearly this can represent a fragmentation of the supply infrastructure, as being ‘off grid’ means there is often limited networking of the supplies

- the cohesiveness of the local community: a lack of cohesiveness can hinder the establishment of informal institutions that can ensure effective management of private supplies
- the knowledge and ability contained within that community, which ebbs and flows over time and can impact good management, often as an informal support system
- accessibility of professional expertise and support particularly those who are water engineers (their skills often go beyond those of plumbers)
- availability of information on a range of installation and maintenance issues, but also those associated with the regulatory-testing requirements as well as support mechanisms
- the geographical circumstances: these can be associated with the immediate geographic conditions of a particular supply but also wider considerations associated with a community’s location which impact supply quality

Enabling micro-circumstances which facilitate good supply management are particularly important for sole traders and micro-businesses (less than 10 employees). These play a significant role in remote rural economies representing 37 per cent of employment<sup>8</sup>.

#### 3.1 Managing water quality as a business imperative

There was a general recognition of the need for good quality water, including the colour of the supply, when businesses operated with customers who may consume water directly. Discolouration of water filtered through peat was a common concern. Whilst the view held was that this water was drinkable, this had to be explained to concerned visitors. As a small holiday-let business owner indicated:

“Some of the people go, “Why’s the water that colour?” because it has a slight brown tint to it ... you have to explain that it’s just off the hill and there is peat involved and all this, and there is a colour and there will be slight iron things going on, but there’s no issues, it’s just... it’s fine. And if they get really worried you have to say, “Well, as long as it’s boiled, it’s less...,” you know...?”

Whilst visitors could be reassured, the colour change in water reminded businesses that everyday management and maintenance were essential for effective business operation as a water engineer pointed out:

“If you’ve got visitors in there [*holiday accommodation*]

<sup>8</sup> Scottish Government (2018) Rural Scotland Key Facts 2018: People and Communities Services and Lifestyle Economy and Enterprise, National Statistics, October, Edinburgh.

and something goes wrong... you end up having to pay someone like me to trawl down there and unblock a pipe or deal with an airlock or something... you can't necessarily ask paying customers to bludgeon around in the back garden looking for valves and climbing the hill and poking around in pipes and whatever, so there's a cost implication to that."

Some businesses had incurred significant costs to ensure their water supply became or remained fit for consumption. For example, a small catering business, situated three miles from a mains supply, reported having to spend "a lot of money ... nearly £2,000" on installing a new filtration system to bring the business's supply up to standard. However, that investment enabled them to expand their operations to supply a local restaurant with prepared food.

Business owners in this study were aware that effective management and appropriate investment provided "peace of mind" and increased safety. For some this was particularly important as water quality was seen as a positive element for their business. A holiday-lettings owner indicated:

"It doesn't mean people book here because we've got a private water supply but I think for them it's an interesting feature... the water is coming off the hill at the back of the house and so it's certainly not a negative thing at all in terms of the business."

Some business owners highlighted the 'naturalness' of the local water supply was part of thinking about 'the Highlands' as a tourist destination. One café owner drew a positive inference from customers:

"People often remark on the cup of tea, particularly ... I think the water quality has a lot to do with that."

However one local authority stakeholder sought to caveat this 'natural selling point', noting that a number of self-caterers and hotels on private water supply stated in their marketing materials that "premises are benefited (*sic*) from a natural spring water supply" and claim "it's regularly tested and it always meets the standards." The officer stated:

"Then we've discovered them and they've never been tested and when they have been tested, they don't (pass)."

Nevertheless, as businesses reported to us, they were (generally) acutely aware of the need to ensure water was of an appropriate quality to ensure business survival.

## 3.2 Managing health impacts: meeting regulatory demands and addressing liabilities

Business owners and managers were found to have thought carefully about their daily private water supply use. Their awareness of public health risks focused business operators' attention as well as their business-operation strategy. One small business-owner noted that when she used to grow vegetables for a local hotel:

"I was always very careful not to wash it and to be quite clear that it was up to them to wash it, because obviously you could be contaminating it"

While a small business operator stated:

"I keep bees ... when I'm extracting that honey ... everything gets washed out with crystal sodas, hot water and crystal sodas, and then you rinse it out with hot water and then you rinse it out with cold water. Now if you're just rinsing it out with cold water off a private supply that's got no treatment, you're just contaminating everything."

The quality of private water supplies was cited by some business owners as a constraining factor in business development. One small-business owner elaborated that:

"There's certain things we couldn't do here because of our water supply... cooking-wise... I have been stopped because I know my water isn't a hundred per cent there."

One of the discussion-group participants related that the lack of good water quality has at times been detrimental to small businesses:

"We did have people selling bread and stuff at the doorstep... as soon as [*local authority*] Environmental Health [*department*] found out about it... that was the end of it because their water supply was not good enough. And we had somebody who used to do soup and sandwiches... and the Environmental Health people stopped them (*as well*) because of the water."

Much of the context for these discussions was predicated upon the water-testing requirements. Business owners adapted to regulatory changes to meet these legal requirements. One holiday-letting operator noted that before testing, his water had contained both *E.coli* and lead, yet he had thought (at the time) it was not only safe but "lovely spring water". On receiving the test results, he immediately fitted an ultraviolet light and removed all the lead piping. This changed his view of testing:

"When it was introduced we all complained about it but I think it was a wakeup call to us ... I think everybody's water should be tested regardless of whether you're dealing with the public or you're producing food."

Some business operators recognised the value of testing as it provided a degree of certainty, that when dealing

with customers they could be confident, as a community stakeholder indicated, “that the water supply is clear” even if “there’s no real economic benefit”.

Not all business owners had a positive response to the testing regime. One discussion-group landowner argued its introduction had been “annoying”, partly because of the “worry” potential failure induced. She stated it was “a damn bureaucratic interference.” This view was supported by a minority of other participants with some individuals expressing frustration about testing requirements and regarded them as unnecessary. One supply user believed she was the best judge of her water quality:

“One gets worried that we will be failed because the water is showing up slightly tinged peaty-coloured. There’s absolutely nothing wrong with it ... It’s got no chemicals put in it and I feel it’s very healthy, good and nice to be chemical free and soft water.”

Another, who had a letting business, revealed a reluctance to have the water tested:

“It’s a little bit frightening getting your water tested. I know what they’re going to say, they’ll say it’s contaminated and I shall get worried. So, I’d rather not have the water tested and just believe that it’s probably okay. I’ve drunk it all this time.”

Overall, participants in this study supported testing and valued it as providing reassurance. A number of business owners recognised the need to adapt their operations and invest whenever regulatory requirements had changed. In one case a former dairy farm had been transformed into a training centre and from the outset the new business had replaced piping in the system from asbestos to alkaline pipework. However, the regulations changed again some years later from single-point to multi-point sampling, and the centre’s business manager was forced to further improve the system to comply. The manager noted that their system was particularly prone to flash flooding and consequent silting, and hence they had developed plans to cope with unpredictable impacts.

Several business owners had responded to their desire to protect public health for example, by installing new filtration systems. However, there was confusion amongst many smaller businesses about liability. No-one expressed the specific term ‘liability’ in this study, and many business owners stated they had not considered liability until they were asked about it in the interview. In response to the prompt during interview, one business owner responded: “... it is a concern and it’s not one I had before I met you this morning!”

Another discussion-group participant (a hotel and land manager) had discussed liabilities with their insurance company, and were told to state the following to avoid litigation:

“If a ...(*client*)... says ‘Can I drink from this burn?’ you can say ‘I do, but you... do it at your own risk’.”

Public health impacts of low-quality private water supply were indicated by many of those we spoke to. One farming stakeholder reported that people were more aware of water quality issues, so, for example, some businesses now valued testing as providing liability protection as well as protecting the public. However, amongst local environmental health officials there were concerns that people took risks with their business supplies. One environmental health officer indicated a worrying picture:

“I’m not convinced they (*businesses*) necessarily take it terribly seriously ... Some of them, to be fair, do, and if we’ve taken a sample, for example, and it fails... (*they ask*)... “Why has my maintenance not worked?” and things like that. But a lot of them take the view, “Well, it’s some bugs, they’ll be alright, I’ve always drunk it,” ... you hear a lot “So and So’s always drunk this water and they’ve never been ill.” So that’s by and large the attitude we do tend to get back from a lot of businesses, unfortunately.”

On the whole businesses expressed to us a clear awareness of the needs to ensure water quality in the context of changing regulatory needs and for some – though more limited – an awareness of the potential liabilities.

### 3.3 Managing existing business needs

The reliability of supply was important to most businesses. One dairy farmer indicated they used 8.5 million litres of water a year (see Section 6.3), noting “we wouldn’t survive long if there was no water coming out of the tap”. He was confident of his supply reliability however, stating the supply “has been running for hundreds and hundreds of years”.

For landowners there were also issues of business growth. One large estate owner was planning what he termed a “major development” but stated he was concerned they were not going to have enough water in the longer term. The summer 2018 drought in the North East of Scotland (see below) had reinforced these concerns.

A hotel owner reported major disruption to their small community’s supplies, stating it had been caused by forestry operations. He also noted the crucial importance of private supplies in their village. Amongst their 22 houses, a local boating company and his own ten self-catering lets, he noted that on a peak day their community used 55,000 litres from their private supply: “...there can be anywhere between 200-300 people at the height of the season relying on that water supply.”

Further, a community stakeholder mentioned a hotel that ran out of water in peak season and subsequently closed down.

External demand, particularly around water testing, resulted in some landlords being forced to upgrade their supply's quality before they could expand their business. For example, one second home / small-business owner indicated:

"We really didn't have any choice about it because we had to have the water supply upgraded if we were able to let it and it's the lettings that enables us to keep it"

Other businesses were found to excel at self-regulation, such as a large ice cream making business in one region, as a local authority official noted:

"...they have had to sink additional boreholes, put in additional treatment and they sample their water just about on a weekly basis which costs them quite a bit of money. Now, that's above and beyond what the properties who are on the mains have to do... So, it will have an (*economic*) impact. A lot of the businesses just take risk. They just say, "The water's going to be fine," and they ignore the fact that they're... on a private supply."

For many businesses meeting existing and future needs was a complex juggling act, something they clearly reflected upon regularly.

### 3.4 Contingency and resilience planning: managing the unexpected

The fieldwork for this study was undertaken during the summer of 2018. Scotland was experiencing drought conditions in many rural areas. In response to the initial drought in June 2018, local authorities co-ordinated plans to ensure local communities could access supplies. To support farmers the Scottish Government moved forward the National Basic Payment Support Scheme (NBPS) in 2018 from December to October, providing loans for drought-affected farmers.

In one area, participants noted that there had been considerable problems with a lack of water. One discussion-group participant indicated neighbours who let out houses "were very close to having no water", jeopardising their business at least temporarily. Elsewhere a local festival was cited as being forced to engineer water-supply contingency measures for the event to ensure they did not lose their license for that commercial event, nor jeopardise the local population's drought-limited water supply.

Fire-risk was threatening dried vegetation in areas across Scotland, with the potential consequences of wildfire not only impacting infrastructure but also jeopardising

businesses and farms. One estate owner indicated they had to set aside water supplies specifically to deal with any fire risk. He had also put in place strategic resilience-planning maintaining the private supply despite the drought. Measures they introduced to cope included additional supply sources and mobile 5,000-litre tanks they could deploy as needed. They also retained a 1,000-litre fire trailer in case of need, as well as high-pressure pumps.

Some business managers did reference the impact an unreliable supply would have on their business and had conducted business-resilience planning for that scenario. For one such business that accommodated young people, the manager listed how their implemented resilience plan would ensure (young) people accommodated at their centre would be restricted in toilet-flush use; everyone would drink bottled water; and, he suggested, everyone (being young and resilient) could wash in the sea instead of showering. Other businesses did have contingency plans in place but these generally focused on resolving short-term reliability issues. Another manager of a tree nursery noted they had planned for unreliable supply:

"I had researched an alternative five or six years ago ... just... in case we ever needed it and this year we did need it. So I had to hurriedly set that up in the middle of summer, so running lots of pipes up to ... about 500 metres away."

Contingency planning was also required for unexpected rapid success for example one business's turnover had apparently risen from approximately £55,000 per annum to £210,000 as a result of the North Coast 500 route (NC500). That business struggled with water quality and volume, noting they wanted to expand their vegetable growing while maintaining adequate supplies for the hosing of their deer larder.

There was a recognition by some business owners that their current supply was inadequate for increased use in future, either due to supply unreliability or a requirement to improve the water quality. Others that were contemplating further developments were planning relatively limited expansion and hence water-supply reliability was not expected to be a significant factor and so had not significantly impacted upon their plans.

Some individual businesses in each area studied had sought to make use of private supplies when expanding their business because they saw this as providing (significant) costs savings, particularly those in agriculture who were not using their water supply for human consumption. For those businesses, the volumes of water they required were such that they anticipated significantly increased costs if they used the mains supply.

It was coincidental that the fieldwork for this study was undertaken at a time of considerable drought – raising

real concerns in some quarters. But it indicated the vulnerability of many of the communities to extremes and the need in many of these for enhanced resilience.

## 4. Private Water Supply Infrastructure

A number of businesses had invested heavily in both time and money to ensure that they had the appropriate infrastructure and maintenance plans in place and could ensure both water quality and reliability. Cost was discussed by all supply owners, and it was often significant. One water engineer indicated it could cost “several thousand pounds” for a supply owner to produce a system that meets local authority standards.

### 4.1 Source development

Amongst a number of businesses there was a clear recognition that private water supplies were their only option; as one business manager indicated “There’s obviously no available alternative, you kind of just get on with it”. The recognition that mains supply might not be available in any realistic time frame led some to acknowledge the need to look for new innovative approaches to finding sources or supplies of water. One resident and prospective business owner noted:

“We’re about to build a house, me and my partner, and we’ve decided to use rain water harvesting and there’s quite good tanks you can get put under the ground... I know it’s got its own issues and expense associated with it, but I think in the modern era people are maybe finding solutions more creatively about how to deal with the water and with technology you can purify it easier...”

Both engineers and supply owners reported they had to identify new sources for clients or themselves, either because an existing one was inadequate or polluted, or because it had become too unreliable for their needs. More often, this was an issue with over-ground burns, and often the chosen solution was to drill a borehole.

#### 4.1.1 Boreholes

There was anecdotal evidence of a growth in the development of boreholes as locality-based solutions. Sometimes these were developed from scratch, for example where a source had dried up, but occasionally additional boreholes were needed when a business was starting-up or expanding. The manager of one major

tourism-based investment project noted that since their borehole had been sunk, their private water supply had “massively improved” in both quality and reliability.

Boreholes are significantly more expensive than rudimentary investments needed for burn-fed supplies. The costs to the emerging tourism development were cited as £40,000 for two recent boreholes and related treatment works. Another discussion-group participant (a business manager) indicated they had had to take out a mortgage for £25,000 to obtain a decent (borehole) supply, previously their supply had been a spring “but it had no pressure.” Often, this initial investment in source infrastructure was the major expenditure.

There is also a high risk associated with this as there is no guarantee of potable water being sourced: in our previous study (Teedon, et al 2017<sup>9</sup>) it was revealed that one individual had spent £10,000 sinking a borehole to find water contaminated with manganese (so it was unusable). Similarly, here contamination by both sea water (notably on the island case study) and heavy metals were considered a particularly high risk. For some, there was a wariness of drilling new boreholes, and as one senior business manager stated:

“...boreholes are an expensive failure when they don’t work, and we were looking at a bore hole for here. You could spend ten grand and end up with nothing... you can get highly sulphurous water, you can get high iron content ... some of the water is absolutely undrinkable and yet there are boreholes where it’s utterly gorgeous, superb water. You flip a coin when you drill a borehole but they’re very expensive...”

There was concern expressed at the poor service provided by some borehole specialists who were brought in to one area. A letting-business owner commented that “we were all very fed up” when the contracted engineer had refused to dig more than 500ft. It is indicative of the vulnerability of communities who need to rely on available skill (whatever its value) and shows the (perceived) risks when undertaking major infrastructural work.

### 4.2 Storage

Several individuals indicated they had recognised the inadequacy of their storage facilities when first acquiring the properties and, soon after, invested in extra capacity to ensure their business could operate effectively. Some of these were ad hoc solutions: to ensure she had water for her farm sheep stock, one farmer had purchased six orange-juice transportation tanks at £80 each with a capacity of 375 litres. Another small-business owner had

9 Teedon, P., Currie, M., Helwig, K., and Creaney, R. (2017) Engaging communities around private water supplies. CRW2014\_12. Available online at [www.crew.ac.uk/publications](http://www.crew.ac.uk/publications)

bought a property (ten years previously) which already had a 20,000 litre tank and had subsequently invested in a second one to ensure reliable supply (for his property and associated holiday lets), at a cost of £700 - £800.

Some recognised their current storage arrangements were inadequate or poor quality in the context of the drought conditions, and subsequent impact upon source reliability (whether or not they had been directly impacted). One business manager using a lochan source for both business and residential purposes stated:

“We probably should have ... a polythene tank, plastic tank up on the hill above the house. Pump to that, and then feed the house... We'd get a better bar pressure and actually it would be much easier to control the quality of the water as well.”

One large estate indicated that storage was becoming a major concern, not only because of the recent drought, but also a general reduction in rainfall year-round due to climate change. The estate owner reported they were going to “invest substantial amounts of money in building much larger storage tanks”.

Some supply systems were found to be particularly complex, particularly where a reliable business supply was essential. Sourcing materials required for such complex systems was itself a challenge in remote rural Scottish areas, as one hotel owner noted:

“There was not enough storage... I went to Oban. I bought all the water pipe that was in Oban. I had to go to Glasgow to get some more... I spent about £6000, the first summer... I probably spent more like about £18,000 myself, and since then I've probably spent ... towards £30,000, of my own money.”

The costs incurred by this hotel owner were not only essential to meet his business needs, but also the high standard of the installation was required to meet regulatory demands.

Storage maintenance did not emerge as a major consideration – presumably because it was not required on a regular basis. As one shop owner indicated:

“Now we don't clean the tanks out every year... we probably will clean them out in this spring next year, prior to the season ... I think the last time, I can't remember, is eight or ten years ago.”

Whilst storage was not generally presented as a major consideration by those we spoke to, a combination of growing demand caused by economic changes (e.g. growth in tourism) and vulnerabilities associated with climate changes may raise its importance.

### 4.3 Treatment and filtration systems

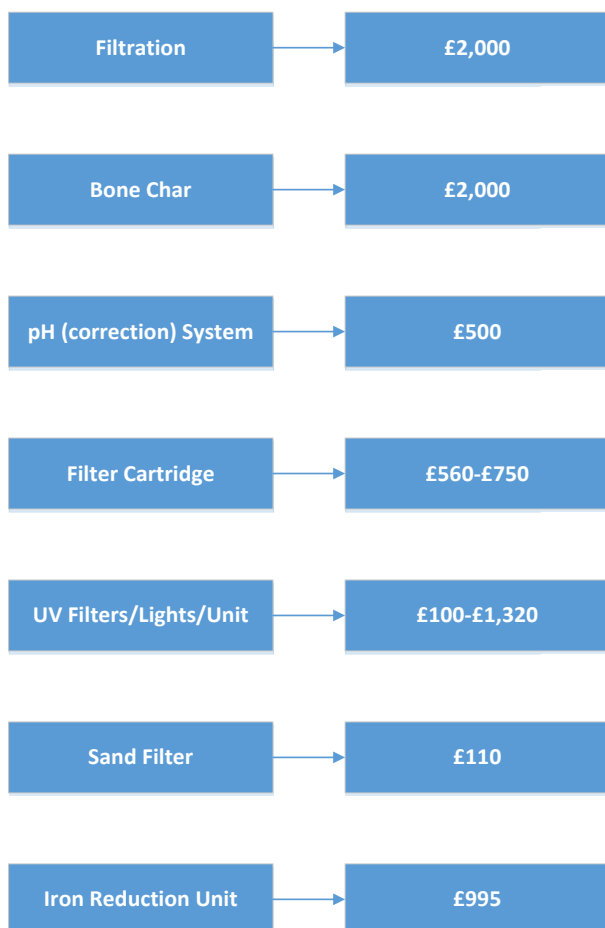
The impetus for the installation of filtration and other systems often came when individuals had decided to develop business activity or immediately after buying the premises. However correctly selecting an effective system initially was often trial-and-error and as Figure 1 indicates, the range of options to private-supply users chosen was considerable as was the variation in costs incurred.

Where business activities involved commercial food preparation, the respondents spoke almost unanimously about investing significantly to make sure they reached an adequate water quality standard. However, one shop owner had only adapted their domestic system to filter the supply in their commercial coffee shop. They chose to install a UV filtration system because they believed it was effective for their (untested) private supply. This coffee shop had not had any filtration until they adapted the domestic system for business purposes.

One property-let landlord lived in southern England and managed his supply remotely through a locally-based contractor. He had invested in a small treatment works at the property, costing £6,000, to ensure the letting business had good water quality and allow him to be confident in that water supply.

Another non-resident landlord described her supply system as akin to the cost and complexity of space exploration, referring to it as “Mission Control, Houston”. Her system used a bone char filtration system which had cost £2,000 and lasted “two to three years”. However, this technology had produced its own problems, as when it required replacing “... it tends to bring in a very sort of stagnant foul taste to the water”. To compensate for this, and ensure she could continue to let the property, they had developed a filter-replacement sequence which additionally reduced the “considerable outlay”. This business owner stated her motivation in adopting this expensive system was to ensure that paying guests “... got spring water that is basically very, very naturally and clearly filtered”.

The complexity of water supply installations and filtration not only required considerable forethought, but also an unexpected and unattained level of expertise for many amongst those we engaged with. Often supplies served both domestic and business needs and in a number of cases were shared with neighbours. Where business owners were seeking to expand their business it required a further reconfiguration of the existing system to support this and negotiation with the neighbour. Costs could be saved by sharing in the filtration expense, as one business owner highlighted:



**Figure 1.** Filtration indicative costs (extracted from participant interviews).

“we’re currently looking at the possibility of having the UV filter... closer to the tanks to allow the two domestic supplies to be UV filter protected, as well as down here at the coffee shop separately...”

Effective filtration and treatment systems were a key element to source protection but was also perceived as one of the most complex areas of the supply system for individual owners to understand and therefore to manage.

#### 4.3.1 Filtration maintenance

While maintaining the entire system is important, the participants reported that their main regular maintenance was of their filtration systems, and the costs for this varied considerably. For example, one dairy farmer reported:

“The only maintenance is just replacing the UV lamp or replacing the filters. That’s got to be done on a regular basis... A UV lamp is about £100 and a set of filters is about £50. They need to be changed every two months.”

Domestically, one resident reported that the cost of ongoing maintenance including her filtration system was minimal indicating that:

“the capital costs have been considerable; the start-up costs if you like... the renewal of the pump about ten years ago. But no, I mean it doesn’t cost me anything, really. I’ve got a huge box of filters there and it’ll keep me going and I think just the cost of the electricity itself ... I don’t think that will be very much.”

Another resident reported spending less than £100 maintaining their system, saying the filters only needed changed once a year. Other owners tried to minimise costs through reducing maintenance as one small business owner commented:

“Filters are quite expensive to buy anyway so we try and make them last as long as possible”

Other participants had no choice but to replace filters more frequently due to the fouling from their supply. One business manager noted his organisation’s expenditure had been considerable:

“(It costs)... a lot of money. These companies charge a fortune, I mean the actual hardware is phenomenally expensive, you’re looking at the UV filters, they’re £400-£500 ... we are still spending. A filter cartridge is £20 that during a period of heavy use will probably last us a week or so and then you’ve got to replace it. So we’re spending hundreds of pounds on filter charges.”

A similar financial burden was expressed by a business owner and community stakeholder for example with the regular replacement of UV tubes, but more worryingly he speculated that

“I imagine a lot of people are just not changing the UV tube.”

Filtration maintenance appeared to be a significant ongoing financial burden for those with poorer quality supplies. As one discussion group participant noted:

“I’ve had to put in pH equipment and I’ve had to have filters and UV filters and I have to pay, ... it’s probably about £500, by the time I’ve had to have somebody to come in to install everything. So I don’t have to have the pH done every year but it’s maybe every 2 or 3 years I have to have that done.”

For some, the costs of maintaining the filtration went beyond the financial expense of the filters themselves. As a letting-business owner indicated:

“And then you’ve got to get all the filtering systems, then you’ve got to clean them, and you have backwashing ... and I think to myself, you know, “I’d rather filter it through my teeth.”

One fisheries business manager had had considerable problems ensuring there were no coliforms. He felt interacting with the local authority had been particularly frustrating as they could not offer technical advice on how



to comply with appropriate standards. Instead he devised his own informal solution using sterilising fluid commonly used for baby items, stating:

"I came up with the [named brand]<sup>10</sup> thing because babies' things...are sterilised in [named brand], so I thought "Well, that must be good enough. If I follow their direction, I'll just start off with a level and I'll take it up to a point where it doesn't cause us a problem, but it keeps all the bugs at bay that we know of."

The business manager noted that having a test kit they could use to sample and check their own supply would also be helpful and allow them to address any issues quickly. He described the process as follows:

"We got wash-and-go filters and we changed it once a month, once a week, or once 'as required' - whenever we knew the weather had been dire ... every month you wipe down the quartz and make sure everything's good for the UV system and I change the lamp every year really, if not, twice a year if you have to. But it's usually every year we've found... And recently we've gone down the way that we flush the systems locally with [brand name] fluid, and that keeps everything at bay that we know of..."

The process he then followed was:

1. Shut the water off
2. Take the quartz out
3. Clean it because it gets a brown foam that stops the transmission of the UV
4. Put in a new tube if we need it, or rebooting the tube that's there
5. Seal that
6. Put in a clean filter
7. Top up the water with [brand name] to our concentration and then flush it into the system
8. Let it settle overnight
9. Flush it through the next day.

Many businesses had had to go to considerable lengths to ensure an adequate system was in place, even though in many cases the solutions were ad hoc.

## 4.4 Supply management alternatives and maintenance costs

A range of regular supply management and maintenance issues emerged, but the response to these depended on the individual supply owner. One local authority Environmental Officer stated:

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<sup>10</sup> A propriety brand was indicated – accordingly this is not named here.

"...you can put in the treatment system, but unless you look after it and maintain it regularly, the quality of the water will still deteriorate. A lot of people just take for granted ...they don't think about their supply and where it's coming from ... They just don't bother ..."

Another concern for local authorities was the lack of association that private water supply users made between limited maintenance and the potential direct consequences on their physical health. As one Environmental Health Officer explained:

"They've got a UV system. They've never maintained it for the last six or seven years, and then they wonder why they're having stomach upsets."

Some believed that there are potential savings associated with private supplies. This business manager noted the costs were minimal annually because they had invested in infrastructure and developed skill in the system's operation:

"I would suspect our water supply in total is less than £100 a year... it's probably cheaper to have a private water supply in our case..."

For some, the costs of private water supply were high in comparison with mains (networked) supplies. The same participant indicated:

"I would probably chew your hand off to get mains<sup>11</sup> water... it's a reliable source and probably cheaper, actually. When... everything is working fine, it doesn't cost us very much. But it just needs something to go wrong... it doesn't take an awful lot to upset that balance."

For a number of businesses who use large quantities of water, private supply use was economically beneficial. In the agriculture sector, for example, a dairy farmer who used large quantities of water identified a considerable cost saving by using his supply to cool milk before chilling (see also Section 6.3 below). In tourism, a local caravan park remained on private supply when it "could very easily be on the mains... it's more an economic decision..." according to one local authority official.

Despite these perceived economic benefits, however, there remained a degree of economic ignorance around the cost of private water supply per litre versus mains-networked supplies per litre: as one dairy farmer conceded "I don't know what the price of water is". For businesses, even where private supply presented opportunities for economic benefits, it remained an unpredictable utility in both supply and maintenance costs, and tangible economic costs of each supply were therefore complex

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<sup>11</sup> The conventional terminology to describe these supplies is 'mains network' or 'networked supplies'. All those we spoke to referred to this as 'mains' water so in direct quotations we utilise this expression.

and changeable per litre. This uncertainty over a fundamental utility did make business planning, and particularly planning for business growth, more difficult.

According to a Local Authority stakeholder, the belief that mains-networked supply was a more expensive alternative was misplaced. A Local Authority Stakeholder reported:

"...if they're doing it (*private supply maintenance*) properly, it's much more expensive than connecting to the mains. So, to be honest, people probably don't do it as well as they should."

One landlady argued private supply is better left unfiltered in the accommodation she and others rented out in her local area:

"I don't think you'll find many of the houses here do have filtering systems ... you can't rely on your tenants to actually clean the filters and buy the UV tubes, and they turn round to you and say, "Oh well it's the landlady's responsibility." So, you're better off not having filters, not having UV tubes and all that stuff ..."

This landlady's resistance to private water supply filtration was unexpected and appeared to ignore other unforeseen expenditure that could arise from unfiltered water. For example, one owner noted her boiler had failed due to her supply being too acidic. This unexpected element to managing private supplies was often stressful as well as inconvenient. One professional-services business owner had developed a strategy to cope with this:

"...we have spares of everything where we live because you just know that something is going to go wrong. So, you always just make sure you're fairly self-reliant in that sense because it's much easier to say to somebody "Can you come out? We've got a pump problem, but we've got a spare pump." It's an easy fix for somebody and keeps the bills down in the long-term."

Private supplies can be unpredictable, and new installations carry no guarantee of 'success'. As the partner of a local plumber noted, the costs can spiral unexpectedly:

"A few years ago my husband did a quote for a treatment for water which was really terrible but he didn't want the job because he said, "Actually at the end of this I can't guarantee that it is going to be okay." And most people spend £6,000, £7,000, £8,000 on the materials and equipment to put all the aggregate and all the different (elements in)... to treat these things, and at the end of it they could still fail the test by a small amount and have to add some other system. Because basically if you speak to any water treatment guy they'll say, you know, start off with the minimum and then work up. So, I mean, you can actually get a quote for something and you'll be spending a lot more on top."

There was no general pattern to the direct maintenance costs incurred by businesses, however, there did appear to be a clear indication (unsurprisingly) that owners sought to minimise these. This was often because of the financial burden but also because there were often considerable doubts about the most appropriate solution(s).

#### 4.4.1 Quantifying time spent on maintenance

It emerged in this study that a considerable amount of repairs and ongoing maintenance are undertaken by owners directly, particularly where residents have lived at a property for a considerable amount of time and are experienced in the demands of their private supply configurations. As one business owner indicated:

"...if you were to add up all the hours over the year, it's got to be a couple of weeks work... we just have to find the time to do it... if the water fails the check then... I can't do bed and breakfast."

While discussion of filtration for example largely centred around cost, there was also a considerable time investment for many of those who self-maintained their systems. As one business owner indicated there are longer term costs of maintaining a private supply, explaining:

"...it's labour... if you count my time... I have to change the oil once a year... eventually it will need a rebuild, probably in the next two or three years, so that's half a day's work to take all the bearings out, rebuild the pump. Anything that takes time... is money... So, it's probably cheaper, actually to have a public water supply in the bigger scheme of things."

A similar picture emerged amongst those with domestic supply, who reported having both scheduled maintenance and unexpected demands on their time. One resident and business owner noted they had to maintain their system frequently when there was a problem:

"...could be changing filters...sorting out problems if it's a cold winter, things that have seized up. I mean it proportions out to probably once a month really, but it could be... 12 occasions all in one week."

The time spent on supply maintenance was considerable for some, and some were able to quantify it as one small businesses owner indicated:

"I check the water every day, I check the water intake, I check the pump every day... it's five minutes, ten minutes every day... if there's a problem then obviously I can be at it all day... if I can't fix the pump myself I've got to take the pump through to Nairn which is two hours from here, two hours back."

A senior business manager indicated that their organisation's private supply labour needs were "between 70 and 100 hours a year" and he noted:

“... it’s my wage. I’m in management... because I know how it works... it’s probably costing a few thousand a year.”

Reasons for self-maintenance of private water supply varied but several themes emerged across all locations. Firstly, some maintenance tasks were perceived as simple to complete. Secondly, in some areas there was a lack of local supply of skilled plumbers and engineers capable of doing the work. Importing their skills could be prohibitively expensive for some, particularly on the island study area, where one individual estimated to bring a (specialist) plumber on to the island would cost in the region of £500. In a few areas, supply owners expressed concerns about the competence of local tradesmen who did attempt to offer such services.

The costs then associated with the effective management of private supplies, is exceptionally complex particularly as many of these are hidden in the time spent by owners in self-maintenance.

In economic terms these can represent a potentially very high opportunity cost particularly where maintenance is undertaken, taking individuals away from more direct business operations.

## 4.5 Knowledge gaps

The study found gaps in knowledge about private supply systems and maintenance amongst the participants. These could have considerable cost implications for owners. For example, a lack of knowledge about existing water-system infrastructure where it was and how to manage it effectively impacted directly on maintenance costs. One owner noted that over the previous 20 years she had never found the sources of her supply “despite hunting high and low and three prospective wind farm folks hunting”. Similarly, lack of knowledge could lead to individuals investing unnecessarily. One letting business had bought an unnecessary filtration system: filtering all the water into the property rather than simply that needed for direct consumption. She only became aware of this when a new water engineer she employed indicated how she might save (considerable amounts of) money.

Where issues were complex, for example, managing minerals and pH balances, the level of maintenance needed could be underestimated, or the scale was unexpected, amongst the participants where their knowledge was limited.

Similarly, there were (often considerable) cost implications for owners caused by knowledge gaps where:

- Individuals lacked awareness of where to obtain (technical and other) advice
- There was a lack of awareness as to the issues associated with maintaining supplies

- They had limited technical understanding of appropriate solutions to ensure water quality
- In-migrants buying properties had no experience of using, maintaining or managing private supplies (in some cases not realising the property was on a private supply)
- Water engineers had limited experience of maintaining private supplies

This could generate a vicious circle where owners had to maintain their own supplies as they learned to fill their knowledge gaps – where local engineers (or imported ones) either were reluctant to undertake work or felt the owner had greater knowledge.

In some cases, this led to supply owners holding expertise on their own systems and supply that surpassed professionals they hired as one small business operator said:

“There’s a plumber... he says... “You’ll know more about the system than I do now,” because I live with it.”

Owners then often continued to maintain their supplies absorbing the cost as they learned more, often only bringing local skill when necessary: one small business owner indicated she did this because she saw local engineers as ‘bodgers’.

## 4.6 Micro-circumstances and cost impacts

The micro-circumstances of each private water supply, including the source type; environment and topography of the area; owner preferences; private water supply system type; treatment choices; and building architecture directly influenced both the financial costs and the amount of time required for the initial investment and for its ongoing maintenance. Often outside expertise had been rejected, again because of the supposed unique circumstances of the system, as one business manager indicated:

“...we spent thousands of pounds on different solutions... A lot of the professional solutions that were suggested simply don’t work.”

As a result of the lack of workable solution from the professionals, the company eventually did a refit themselves, stating “it’s taken us a long time to get there and a lot of heartache and bad advice to arrive at a solution”.

Quantifying intangible costs associated with often unreliable private supplies, and in particular their impact upon business activity and development, is a considerable challenge. This is further impeded by the micro scale and diversity of many of the small businesses in each community, and the anecdotal references to ‘unofficial’ businesses which are not known to regulators but have

value to residents in each area. Fully understanding this micro-ecosystem of water consumption in remote rural Scotland and its quantification would require more detailed study.

The micro-circumstances of each supply directly influenced both the financial costs and the amount of time required for the initial investment and for its ongoing maintenance. The evidence shows that micro-circumstances surrounding each private supply significantly impacted owners' initial investments, including in the range of equipment and labour; tanks; gravity feeds; pipes; water pumps; and boreholes. Together these costs were found to range from £5000 to £25000. In addition, maintenance of the system required investments for: filters; sterilisers; UV lamps; electricity; water testing and water treatment. Additional less tangible costs were incurred in informal time spent maintaining the system. Maintenance costs varied depending on size of the supplied properties and demands on both volume and quality. For some the costs were under £100 annually, but for larger organisations maintenance was found to cost thousands of pounds each year. The financial costs are difficult to quantify due to the heterogeneity and complexity of private water supply systems, and the differing demands of volume and quality amongst different users.

Figure 2 illustrates the factors which can condition the potential for private supply sustainability and even viability often with attendant cost implications.

Reliance on private supplies can be more complex in some areas than others, and increased complexity requires greater investments of often finite local resources, including money and time. Rural economies in Scotland often largely depend on agriculture and tourism, so such private-supply resource costs can reduce productivity elsewhere. Less time, money and labour directed towards the business can reduce an organisation's 'dynamic efficiency', i.e. its ability to reduce its operating costs by implementing new processes and potentially enhancing its efficiency. Therefore, whilst we found considerable informality around the labour costs of private water supply systems and their maintenance, all labour directed towards one activity undermines the labour investment in other activities, such as business growth and innovation. But these cost impacts are not the sole determinant of its 'viability' as effective stewardship and governance are crucial elements.

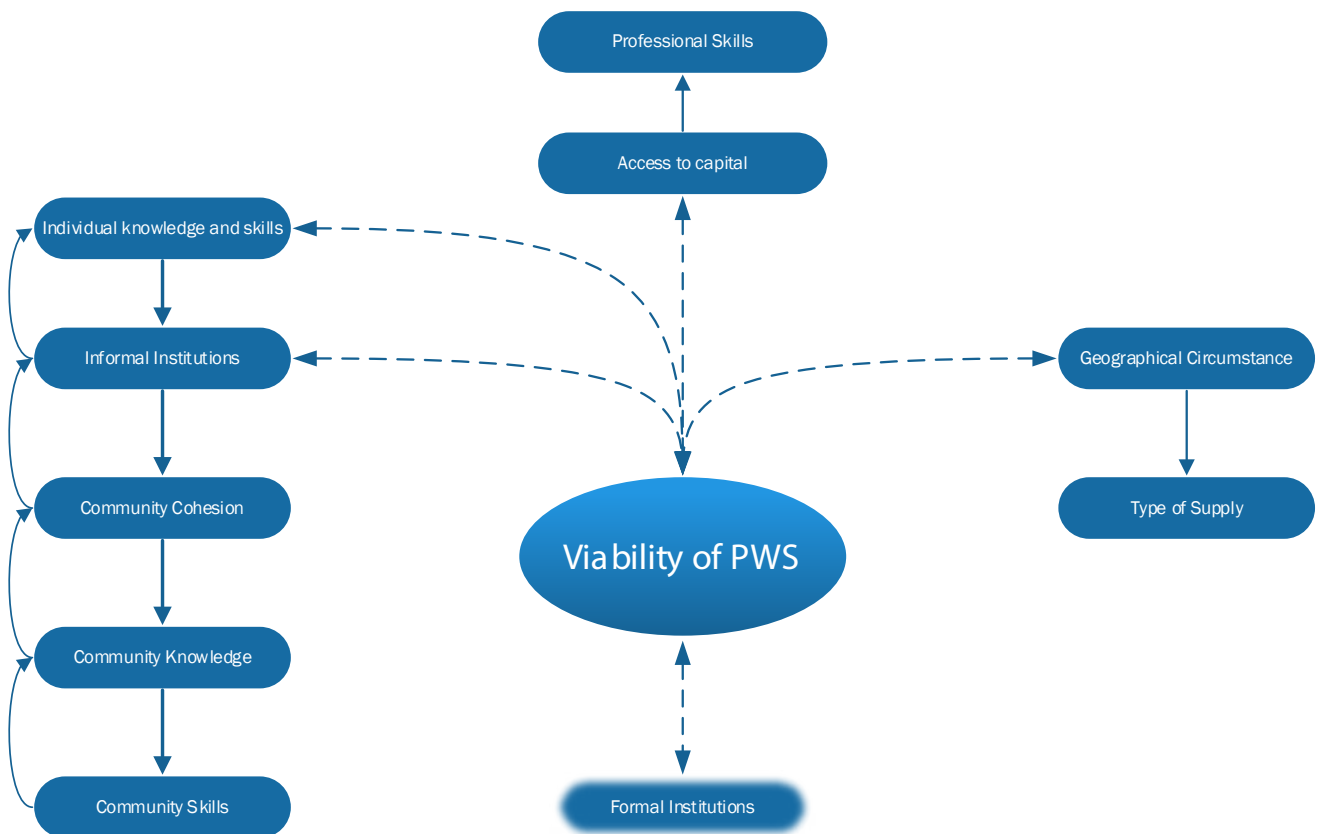


Figure 2. Micro-circumstances influencing the viability of private water supplies

## 5. Stewardship and governance

Private water supply systems can be seen as 'common pool resources'. Such resources are difficult to manage due to their variability. These diverse systems were found to lead to the emergence of informal organisational arrangements to manage the variety of supplies. Communities have developed a range of roles surrounding managing their private supplies. For example, individuals have become responsible for particular roles within communities depending on their level of proficiency in managing a private supply (for example community skills and knowledge indicated in Figure 2). These informal institutions were crucial in areas found to have good community management of supplies, and consequently might be central to community resilience. For example, in one remote community the more vulnerable residents could rely on others within the community to ensure they had water when supplies were scarce.

However, informal institutions supporting local community resilience around private water supply were lacking in other areas, and this appeared to be because of the absence of the cohesive, co-operative community membership necessary to govern the management of local supply systems.

### 5.1 Common agreement and informal institutions

There were a variety of arrangements individuals had in place to ensure effective overall (strategic) management of their supplies, particularly where access and / or responsibilities needed to be shared. Participants reported a range of agreements over access to supplies from the informal to writing water supply clauses into the deeds of properties. The responsibility for maintaining the joint supply was often borne by the largest user, and these tended to be businesses which required the supply system to run efficiently to maintain their productivity. Individuals often resolved problems through negotiation; particularly where the private water supply was not owned by the inconvenienced user. As one private supply user indicated:

"We weren't going to fall out with the farmer over it because we thought he could make our life a lot more awkward ... we just asked if he'd be willing to dig the trench for us to re-lay the new pipe and we'd deal with it all and he was quite happy to do that."

Some businesses negotiated local informal agreements through goodwill where they had been unable to secure water of sufficient quality. For example, a fisheries outlet had reached an agreement to allow a neighbouring

(fishing and shooting) estate to share their borehole as the one the estate had dug was contaminated with iron despite installing a large filtration system.

Such goodwill-based common agreements were regarded by those participants exposed to them as the ideal way to deal with supply management issues. However, the issue of inequality in power during negotiation was also raised, as was the water supply recipient's vulnerability through relying on the goodwill of one landowner. Relationship breakdowns were discussed, particularly where there was a lack of clarity about responsibilities for shared supplies or unwillingness to take on formal responsibilities. As one discussion-group participant indicated:

"It was in the deeds ... but the man refused to let them have the water... if somebody decides that they are not going to play ball ... that is a problem."

Additionally, there was concern amongst local authority stakeholders that the informal institutions would exacerbate vulnerability and could undermine resilience. In some areas there were no formal or informal management arrangements. In these cases, the responsibilities lay with individuals, and the local authorities noted people were made aware of their responsibilities through their governing communications with owners. One local authority official noted however that often there was miscommunication amongst those sharing supplies: "... they just assume that others are dealing with it ... (they)... don't want to know... (they don't want to) ...take on responsibilities."

#### 5.1.1 Conflicts

Disagreements about private supply produced a number of conflicts and, in some cases, uncovered during the study and many had considerable cost implications. Some of these disputes were ongoing at the time of the fieldwork. Shared supplies with neighbours could be difficult to manage if the relationships had broken down. For example, one participant reported they shared a supply with a farm and had their share of the water supply turned off following a separate dispute with the farmer over a wind turbine development.

Where governing agencies acted to support shared private supplies, they found they were often unable to mediate disagreements effectively amongst communities. For example, one official noted:

"We tried ... with grants to encourage people to work together and collectively put in treatment but, to be honest, most of that really came a cropper when folk couldn't agree on where stuff was going to go; how it was going to get paid for; who was going to pay for the electricity; and whose land it was going to go on. And sorting out any deeds to property with regards

to the treatment...they just essentially wanted to put the treatment at their own premises and deal with it themselves”

Environmental Health Officers held a role in local conflict resolution, one indicating:

“We are a bit of an intermediary and we do sort of try with both sides to get things sort of amicably sorted out. It depends very much on individual supplies. Sometimes people would ask us to get involved, being a third party, that we might carry some jurisdiction or whatever. Other times they would rather we weren't involved because that makes it a bit too formal and they would rather do things on a casual sort of basis with the landowner or whatever.”

It was clear that in some cases, conflicts had become entrenched and often adopted a “*let-sleeping-dogs-lie*” approach for the sake of a peaceful (if inconvenienced) life.

## 5.2 Existing management structure practices

In a few cases, attitudes to water safety in contractual arrangements appeared potentially confrontational. One property-letting business owner indicated that:

“...anybody who's ever taken a lease of the house, I've said, “This is the water situation, you can drink it because it's not contaminated but it is heavy in minerals. And if you don't like it go and fetch your water from the village.”

Mid-sized supplies of more than several households were noted as being more difficult to manage, and sometimes lacking formal management agreements. An Environmental Health Officer cited as an example a supply of 20-30 premises in his region, noting:

“it becomes quite difficult when looking at how to effect improvement on the supplies... I think they're the biggest challenges in many respects... there isn't any shared responsibility and then something goes wrong and it usually comes to the Council as to “What are you going to do about it?”

One participant suggested the solution to these management issues could be simple off-the-shelf templates, groups on shared supply could use to manage their private water supply collectively.

## 5.3 Second or holiday homes development

The development of second or holiday homes raised concerns amongst permanent residents about impacts on current supply provision. Some individuals drew attention to concerns they had about further sharing of existing

supplies as new people moved onto neighbouring land or where additional houses were built. They were wary these supplies might have limited capacity and therefore not be able to serve business expansion. In a case where an existing resident was known to have planning permission to demolish one house and replace it with two, a neighbour sharing the supply noted:

“I was concerned thinking ... there'll be showers and baths and washing machine, there might be dishwashers. And people on holiday, they're just not interested in conserving water or working with other people to conserve water.”

There was no hostility towards holiday-home owners; however, there was concern that these developments were skewing other aspects of the local economy partly because new (temporary) residents had unreasonable assumptions about the reliability and availability of water supplies.

In one case-study area, when people moved there, they were often looking for properties that could function as a business location. Their presence was valued amongst existing residents due to the known need for further economic and business development. However, concerns remained about the pressures these additional businesses put on limited private water supply resources.

The perception that new migrants had different expectations often also reflected the stoicism we have drawn attention to in this report and also found in our previous work (Teedon et al 2017<sup>12</sup>) where many small business owners recognised the challenges faced as being part of the compromise made in order to live in these rural places.

There are then considerable variations in the management of private supplies particularly with respect to informal institutions and related levels of community cohesion; potentially impacting their resilience and, consequently, their overall viability. Whilst some areas have seen the development of trusting relations with neighbours and land / supply owners there are other areas where tensions have emerged – in some cases persisting over considerable periods. The doubts about responsibility and often the desire to avoid direct face-to-face conflicts means these are hard to resolve. By extension there is some evidence of local authorities playing a role in mediation – where both parties in conflict are willing to accept this.

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12 Teedon, P., Currie, M., Helwig, K., and Creaney, R. (2017) Engaging communities around private water supplies. CRW2014\_12. Available online at [www.crew.ac.uk/publications](http://www.crew.ac.uk/publications)

## 6. Industry specific private-supply issues

### 6.1 Tourism

Tourism in rural and urban areas is a major contributor to the Scottish economy, generating more than £11.2 billion from 166 million tourism trips to Scotland in 2017 alone, including 3.2million overseas visitors<sup>13</sup>. The number of accommodation providers in rural Scotland has significantly increased as online tools like Airbnb simplifies attracting customers, particularly for second home-owners. For example, in the Highlands alone, listings increased from 280 in July 2014 to 3,100 in July 2017, while Argyll & Bute saw an increase of over 900 per cent, from 100 to 920 in the same period<sup>14</sup>. The study found the experience of regional tourism was not homogenous, however. In Argyll and Bute for example, tourism accounts for almost 25 per cent of private sector employment<sup>15</sup>, generating over 8 per cent<sup>16</sup> of the total GVA (gross value added) in the area - three times the national tourism GVA (3 per cent) (*ibid*). The value of the sector is growing, with latest figures suggesting it had increased by 15 per cent<sup>17</sup>.

Private water supply owners whose businesses relied upon tourists, including retailers, estates, and holiday accommodation providers, reported pressure to improve their supply standards to ensure there were no issues for their customers. Water colour was a particular issue, as it prompted tourists to query its purity. Where there was concern or doubt, supply owners often developed strategies to compensate. Where there was doubt about quality reliability or it was particularly variable, one strategy was to ask people not to drink the water. As one plumber indicated:

“you either stick a sign on every tap saying, “This water is not suitable for drinking”, which is not great PR ... or you spend quite a lot of money on putting some filtration system in place to deal with that.”

Another strategy to combat erratic quality was to provide tourists with bottled water in each room. One B&B owner noted that if she could access a networked supply; she

13 Source: VisitScotland <https://www.visitscotland.org/binaries/content/assets/dot-org/pdf/research-papers/insights-trends-2017.pdf>

14 AirDNA, MarketMinder 2019 <https://www.airdna.co/vacation-rental-data/app/gb/default/highland/occupancy>.

15 Argyll and Bute Economic Forum Report: February 2016 [https://www.argyll-bute.gov.uk/sites/default/files/argyll\\_report\\_260216-v2.pdf](https://www.argyll-bute.gov.uk/sites/default/files/argyll_report_260216-v2.pdf)

16 Tourism in Scotland: the economic contribution of the sector: April 2018

<https://www.gov.scot/publications/tourism-scotland-economic-contribution-sector/pages/4/>

17 Scottish Annual Business Statistics, August 2017 (Using RESAS Classification, 2018)

could avoid the business expense of supplying these bottles. Other businesses reported concerns over the unpredictability of water colour, forcing businesses to be reactive. For example, another accommodation provider who did not live near their property reported:

“it’s ... one of my bigger concerns in letting the property ... if it’s particularly bad weather the water in the stream gets very stirred up and becomes even more peaty ... if it’s very, very dry weather it gets very peaty because the water comes ultimately out of the loch and of course the level of the loch drops and it gets the more peaty water from the bottom of the loch.”

Another second home / business owner reported advertising their new water treatment system on the website, noting this allowed the business to remove notices saying the water is coming straight from a stream. He reported this was a direct result of tourists’ comments about the water colour:

“it’s just the fact that once or twice people have commented saying, “Oh the water was quite brown,” and you just wonder that has affected their overall view of their holiday and perhaps whether they’d come back. I mean, they’ve never said, “We’re not coming back because of it,” but you never quite know.”

However, it was reported by several participants that tourists in privately provided accommodation that share supplies with other properties in these areas, are often unaware of the impacts of their water use on the area. As one long-term resident observed:

“they don’t understand that washing machines and other things like this are actually luxury here.”

Participants also noted that tourists were unaware of the impacts of bathing or disposing of waste in local burns or water courses, contaminating supplies to local properties.

Stakeholders in one study area highlighted it as being particularly vulnerable to unreliable water supplies across its 20+ campsites, the largest of which accommodates approximately 300 units in peak season. The area’s remoteness made speedy deployment of alternative water supplies complex, and current private supplies were vulnerable to drought. One caravan park had successfully drilled a borehole to stabilise their supply, but as discussed earlier, boreholes are not always a reliable or feasible alternative. Another had installed its own treatment plant and chlorination system to ensure the supply could be maintained throughout periods of poor quality e.g. after heavy rain. The difficulties with obtaining reliable water supplies to tourist accommodation in the area was such it prompted one local authority stakeholder to note that the business owners in the area “take the water seriously”.

In contrast, a number of participants in a different study area context were very positive about their water quality and generally about the reliability of supply. In this region,

some participants considered the water a unique selling point as it could be factored into the 'wildscape' of the scenery. Some older participants in this area mentioned a mains-networked supply might be preferable, citing their age and the physicality of maintaining private supplies as the reason for wanting mains supply.

The area had seen considerable investment in private-supply infrastructure to supply individual developments. For example, two substantial initiatives noted spending tens of thousands on water-supply infrastructure and further development of these was anticipated. At the other end of the spectrum, small businesses had also invested in their supplies even though there was clear evidence that they have a high degree of fragility as business opportunities. Tourism-focused businesses reported supply concerns including water quality, where it might be consumed by visitors either directly or in (small-scale) food production. In one area there was concern about the increase in 'fast tourism' from the development of the North Coast 500. Rather than stay for a week, tourists were now staying overnight, making communicating environmental protection and water supply sustainability guidance more challenging.

The development of a small harbour and its jetty was raised as an infrastructural concern. The harbour was still in a state of dilapidation and had no water supply. Improvement of the jetty was advocated by some as it could help facilitate more effective transport (and therefore further development) on the nearby island which was seeing considerable investment. Lack of investment in the pier was reported as a major constraint on future tourism initiatives around marine activity. However, the community had already taken on significant management burdens with other community ownership initiatives and were cautious of over commitment.

The potential infrastructural investment at the pier had been seen as an important economic development initiative for many years, and water supply has been one of the challenges discussed. Further, it has also been proposed as a site for new housing, but lack of water supply is potentially preventing that development, as one community stakeholder states:

"...water adds to the expense in the budget. It's ... a big expense ... we've discussed the possibility of making housing sites there ... it's reasonably close to the road. Close to the power supply. But is getting water to that site going to be an issue?"

Diversification of the local tourism economy, including expanding 'marine tourism', was creating greater demands on water supplies. Besides the constraints on housing and harbour development, another participant noted that limited water supply had prevented the expansion of a local croft into poly-tunnel vegetable production. Participant interviews and a review of grey literature

suggested that crofting is facing challenges in the same area<sup>18</sup>, and this was reflected in the discussion group's debate about the future of local crofting, and particularly potential for diversification. And for some this issue was directly linked with a loss of young people, and lack of affordable housing was perceived as a challenge to keeping a stable sustainable population. As discussed earlier, this can be tangibly related to decisions not to generate housing developments due to water supply concerns.

## 6.2 Forestry

Forestry contributes £954m to Scottish GVA<sup>19</sup>. One third of Scotland's Forest is part of the National Forest Estate, the remainder is either privately or community owned. In 2015, the forestry industry employed more than 25,000 in FTE jobs and supports around 6,000 related FTEs in rural communities. In our previous work (Teedon et al., 2017<sup>20</sup>) forestry was perceived as having an impact on private water supplies. Specific incidences that might result in adverse effects on water quality included felling and planting operations as well as pesticide spraying. Reference was made to complex contracting and subcontracting arrangements, which hindered communications between community members and those responsible for the activities impacting on quality.

Various Forestry Commission documents refer to water and / or private supplies. According to the UK Forestry Standard<sup>21</sup>:

"...management can add to water treatment costs [...]. Private water supplies are particularly vulnerable to disturbance since they often undergo limited or sensitive forms of water treatment and there may be little scope for finding replacement sources in the event of pollution."

In addition, the document lists a legal requirement that "*Forestry operations must not lead to harmful or polluting substances contaminating public or private water supplies.*" (UKFS p168). Cultivation, drainage, harvesting, road building, quarrying, a lack of road maintenance, and fording of water courses by forestry vehicles are all identified as potentially disrupting for water supplies at various places in the document.

18 The recent report commissioned by the Crofting Commission confirms this and interestingly advocates that effective crofting policy should 'protect water courses and water supplies' Gwyn Jones (2018) Support for Crofting; A report prepared for the Crofting Commission. Inverness p.49

19 Source: <https://forestry.gov.scot/images/corporate/pdf/economic-contribution-forestry-2015.pdf> p.4

20 Teedon, P., Currie, M., Helwig, K., and Creaney, R. (2017) Engaging communities around private water supplies. CRW2014\_12. Available online at [www.crew.ac.uk/publications](http://www.crew.ac.uk/publications)

21 Forestry Commission (2017) The UK Forestry Standard. Forestry Commission, Edinburgh.



The Forest and Water Guidelines (5<sup>th</sup> edition, 2011<sup>22</sup>; see Appendix D) emphasise the importance of forest planning, early consultation with local authorities on the location of private water supplies, and the identification of buffer zones around water courses. Around private water supplies, the minimum buffer width is 50m (UKFS p170). The documents mention each 'Forest Management Unit' should have a forest management plan, an operational plan or site plan and a contingency plan (in case of accidental spillages or breaches of the guidelines). Occasionally, as one FCS stakeholder indicated, the 'forest plan'<sup>23</sup> is collaboratively developed with residents and businesses, as the community holds greater expertise on pipework locations and water sources.

One Forestry Commission official directed us to a recent guidance document "Protecting private water supplies during forestry activities"<sup>24</sup>. This document presents specific guidance on working around private supplies in a single place and is more succinct than the UKFS, although the guidance contained in it is not new.

In some cases, the Forestry Commission clearly endeavoured to maintain good relationships with communities and private supply owners. As one Commission official indicated: "private water supplies on our land ... can be a hindrance but we work with them, and we know that people have rights and obviously everyone has a right to water ... and we're quite happy to support requests for water supplies."

Despite these efforts and the fact that "operations must be planned and carried out in a way that avoids damaging the PWS" (FCS official, by email) a forestry commission official conceded that mistakes happened, and that these are likely "...down to human error or bad practice."

Confirming our previous finding (Teedon et al., 2017<sup>25</sup>), the use of subcontractors by the forestry industry was found to undermine the effort to follow guidelines on practise and mitigation. One land management stakeholder noted:

"Usually the guy chopping trees down, he has no awareness that he has to keep his machinery away from the burn."

Our data also suggest that on occasion information on private supplies is difficult for the FCS to obtain, as one of its officials outlined by email:

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22 Forestry Commission (2011). Forests and Water. UK Forestry Standard Guidelines. Forestry Commission, Edinburgh.

23 NB It was unclear precisely which type of plan this referred to

24 Protecting private water supplies during forestry activities. Available at: <http://www.confor.org.uk/media/247132/guidance-on-forestry-activities-near-pws-sept-2018.pdf>

25 Teedon, P., Currie, M., Helwig, K., and Creaney, R. (2017) Engaging communities around private water supplies. CRW2014\_12. Available online at [www.crew.ac.uk/publications](http://www.crew.ac.uk/publications)

"...Often the root of the problem is a lack of information about where the private water supply is located and draws its water from, or who is responsible for what".

An FCS stakeholder illustrated the challenges the industry sometimes faced where supplies were sometimes adapted or rerouted without the forest owner being informed:

"... even when the actual route of the servitude is noted on the title deeds they'll maybe take another supply somewhere else and we obviously won't be informed about it ... first we know is when there's a complaint because their water supply is full of needles ... So, I think a lot of people's legal understanding... they think if they've got the right to water then they can take it from wherever they want."

It is perhaps noteworthy that this Forestry Commission official refers to title deeds as the source of information on private supplies, rather than the local authority. It is possible that this is more widespread, as in one region a local authority official reported the FC to have consistently failed to consult with the authority:

"I have never been approached by a forestry company about what private water supplies are in this area. Never."

The new guidance document<sup>26</sup>, issued in September 2018, clearly outlines the steps forest managers should take in order to locate private supplies, which may help prevent issues in the future as it is embedded more widely.

There appeared to be significant variation in how forest managers respond when damage does occur. One FCS official indicated that in such cases FCS can offer to repair the damage, and sometimes even improve the infrastructure:

"If we are perceived to have damaged the supplies then [*for historic private supply infrastructure*] it's very difficult to reinstate like for like, so generally the Forestry Commission will almost install a new system at the cost of the taxpayer."

The same official reported paying, on occasion, for networked connections or boreholes to avoid supplies being compromised in the future. If private-supply pipework is not where it should be, the official thought FCS were not legally responsible, although he noted they may still repair damage as a gesture of goodwill.

The research team was also alerted to a case outside the study areas and obtained a hydrological report commissioned from an environmental consultant<sup>27</sup> of adverse impact from forestry operations. The consultant concluded that the guidance provided by Forestry &

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26 Protecting private water supplies during forestry activities. Available at: <http://www.confor.org.uk/media/247132/guidance-on-forestry-activities-near-pws-sept-2018.pdf>

27 Reference to this is not provided as it was offered in confidence and the document's details would reveal the owner's identity.

Water Scotland<sup>28</sup> and the UKFS<sup>29</sup> did not appear to have been followed; removal of vegetation and machinery tracks close to the water course had led to significant run-off, resulting in failures on parameters for microbiological contamination and iron. Water quality in a private supply, serving multiple business and residential properties, was affected. The extent of the contamination was such that tourist businesses suffered direct economic impacts as they had to refund bookings. The hydrological assessment of the incident – carried out at the expense of the property owner - concluded that it was likely the adverse impacts on quality would be felt for a period of at least six months. Solutions proposed in the assessment report included an upgraded treatment facility, able to cope with the higher levels of contamination, or drilling of a borehole to serve the community.

The private supply users affected by the damage described here had formed a group and sent their evidence to a local authority official, requesting they mediate the dispute. This officer contacted SEPA and FCS and requested a copy of the forest plan for the work to assess what mitigations had been proposed. The local authority had received no response from FCS or SEPA and was considering making a formal application to access the forest plan in order to be able to move towards resolution. At the time of the field work this issue had not been resolved.

According to an FCS stakeholder, the Commission does not collate records of incidents in which private supplies are impacted adversely and further research would be needed to establish the extent to which these occur.

Both the FCS document 'Managing forest operations to protect the water environment' and the UKFS (2017) mention The Environmental Liability Directive (2004/35/EC), but neither goes into any detail in what this means for forest operators or for those impacted by operations, nor does it refer to the relevant UK or Scottish regulations that implement the Directive. Indeed, all FCS documentation we viewed placed a strong emphasis on prevention but did not appear to give guidance on what to do in case of damage, e.g. on procedures for offering repair or compensation to private supply owners. The only stipulation was that SEPA should be notified in case of a breach of the guidelines.

In summary, there is a perception that in some areas, forestry might play a more effective role with respect to private water supply stewardship. Despite guidance published by the FCS and, in some cases, considerable goodwill by forestry officials, the most up-to-date information on the location of private-supply infrastructure appears to be not always available or

28 Protecting private water supplies during forestry activities. Available at: <http://www.confor.org.uk/media/247132/guidance-on-forestry-activities-near-pws-sept-2018.pdf>

29 UK Forestry Standard. Available at: <https://forestry.gov.scot/sustainable-forestry/ukfs-scotland>

accessed by, or communicated to, site operators (although why this has been the case is not clear). The guidance itself, specifically what to do and what not to do, appears clear and comprehensive. Where damage does occur, there is variability in the extent to which compensation or repairs is offered to private supply owners. Further research would be required into the exact origin of the issues (for example with regard to information sharing) and the extent to which they occur.

## 6.3 Dairy Farming

SEPA (2019) estimates that dairy production was worth over £400million to the Scottish rural economy<sup>30</sup>. Dairy farming uses water to chill milk before shipping, as well as for animal consumption as one farmer indicated:

"...for a dairy cow to produce a litre of milk she needs to drink 5 litres of water. So, we're producing 1.7 million litres of milk in a year... That's not counting what we're using in the house and what we're using washing up the dairy utensils and what young cattle are drinking. So, it's a lot of litres."

Private water supply is seen therefore cost-effective for milk production but requires a reliable supply. Significant costs were reported by some dairy farms for sinking boreholes to ensure the supply was not interrupted. Dairies produce food for human consumption therefore their equipment must be washed in clean water. Water supplies to the dairy premises are therefore regulated.

One farming stakeholder reported a local authority drive to connect dairy farmers to the network where possible because they were classified as food producers. Some dairy farmers had already changed to a networked supply as a result of a Scottish Water investment programme, particularly where their private supply did not meet the regulations.

Milk is tested daily for a number of safety parameters. However, it can pass even when the water supply is failing test standards, leading to concerns about regulatory standards.

Dairy farms were also suffering during the drought conditions during the summer of 2018 which contextualised this research. There was some anecdotal evidence of dairy farms running short of water. As one dairy farmer and community stakeholder commented upon another farmer's experience:

"...he was having to shirk water out of burn with a tanker to feed cows because the source... almost dried up. It was just dribbling and no more... there are a few and they're

30 Source: [https://consultation.sepa.org.uk/sector-plan/dairy-production/user\\_uploads/dairy-production-sector-plan-1.pdf](https://consultation.sepa.org.uk/sector-plan/dairy-production/user_uploads/dairy-production-sector-plan-1.pdf) p.10

in the more hilly areas where they struggle to get water.”

Dairy farms are more vulnerable to drought conditions than other farm types. As well as running short of animal drinking water and water to cool the milk during production, dairy farms often irrigate their fields to ensure livestock have plentiful grass for feed. Without rainfall and sufficient grass growth in summer, farms have to buy in food for the cows.

This study found however that a considerable number of dairy farms had adopted a dual system, using private supplies where possible to save on water charges, but switching to the network when drought or other issue becomes problematic. In these cases, a non-return valve should be mandatory to ensure that private supply water does not contaminate the network. Scottish Water was reportedly working with farmers to upgrade non-return valves where they were substandard. However, concerns were expressed by one Environmental Health Officer about a lack of non-return valves in common shared pipework linking the two systems, raising the risk of possible contamination of the network.

## 7. Strategic support issues and institutional challenges

### 7.1 Informal support and advice

We have already indicated that there were a range of informal community support strategies and behaviours in a number of the areas and on the whole were found to function. Each community had informal institutions providing support which ordinarily would have an economic cost, such as in times of supply-loss providing each other with access to functioning supplies for bathing, as well as helping elderly/vulnerable neighbours with maintenance and some on a much larger scale sharing supplies.

These informal arrangements enabled the maintenance of idiosyncratic and often complex local supply systems through harnessing local expertise and hence minimising the costs incurred when specialist engineers had to be brought in. However, as we have also indicated these were often ad hoc and not necessarily as effective as they might be.

## 7.2 Formal support roles

### 7.2.1 Local authority role

Local authorities have a key role to play in a number of areas with respect to private water supplies, notably having a specific regulatory role testing water quality as well as planning-regulation and in addition an economic development function.

#### 7.2.1.1 Environmental Health and Planning

Environmental Health departments in the local authority regions studied were responsible for ensuring supply quality through testing regimes<sup>31</sup>. Their central concern was public health. Environmental Health Officers were particularly concerned about animal grazing polluting water sources, and the potential threat of *E.coli* O157.

There was considerable appreciation for the work done by Environmental Health Officers amongst study participants, who were reported to be supportive and helpful when businesses were attempting to pass regulatory testing. One business manager noted their local authority had supported the business and gave them time to install appropriate systems after the business failed a regulatory test. An Environmental Health Officer gave an example of the process:

“...we would tend to say, “Right have you considered X, Y, Z?” ... We quite often get “Well we’ve treated microbiologically, we’ve put in some treatment,” and we’ll come back and say, “Yeah, but it’s a burn supply, we know that it’s regularly going to be failing for colour and iron and things like that so you need to take that into account in your treatment system, you can’t just stick on a UV and say, ‘That’s going to be fine’...”

Participants reported the local authority supplied grants of £800 towards improving private supply infrastructure, but this was stated as inadequate by several when compared to the costs incurred for infrastructural improvements. One local authority official drew attention to the need for greater oversight after grants were awarded, suggesting there should be follow-up visits to assess the systems, as individuals were failing to maintain systems adequately, thereby negating the grant investment.

Environmental Health stakeholders reported that when infrastructural developments such as new housing were being proposed, they were seldom approached for their insight around water supply. One development manager noted:

“from the private supply side, housing and accommodation it can definitely be an issue constraining economic growth.”

<sup>31</sup> The Water Intended for Human Consumption (Private Supplies)(Scotland) Regulations 2017

This same individual noted that, in their experience, access to (electricity) power and phone connectivity were of greater concern for commercial developers.

In one authority there was reported to be close relations between Environmental Health and Planning. This had led to closer working on housing developments, enabling them to ensure planned developments had adequate supplies. Indeed, Environmental Health Officers who oversee private-supply regulation assess housing development proposals reliant on private supplies in the region. One indicated:

“Our comments are usually fairly standard comments that would say before development they should satisfy us by means of a hydrological report that there’s enough sufficiency for the development and also that the standards legislation can be met by regards to quality.”

This involvement in commercial development increased if it was thought there was additional public vulnerability due to the nature of the business, e.g. food production. One Environmental Health Officer cited a kindergarten development example of where:

“we do get involved in making sure that the developer is considering the private water supply and what they’re going to do to make sure that the supply to the premises is adequate and is going to be safe... “Right, these are the principles that we expect you to be able to achieve, now you go away and figure out how to do it, go and get a water engineer involved...”

Similarly the authority indicated they could require hydrological reports if an existing supply user was worried that a proposed development might reduce their supply – an aspect specifically encountered in this research on the island case study area, where one particular interviewee reported her experience was that “Planning” did not notify neighbours if developments are going to border their land and/or use their private supply.

One landowner was reported to have had allocated land for housing plots but had not progressed the development, remaining doubtful about the water supply, as one community stakeholder noted:

“...it was a concern... finding a proper supply to ... (*ensure*) there was enough water for another two buildings ... It would have meant putting in a pumping house because it’s quite a steep hill to come up so I don’t know whether that would have justified it.”

A business manager also reported regretting having to abandon plans to develop housing away from a networked-supply location “it was just hopeless, it was just a no-goer.”

The research found one case of a development which has gone ahead without assessing the water supply, only to discover there was no supply available, as recounted by a discussion-group participant:

“There’s a boy building a huge house... Even the planners don’t know how they gave planning permission for it. It’s going to be about ten bedrooms, and he’s built it expecting he’s going to get water, and he’s not got any water.”

Local authorities have clear statutory and regulatory roles relating to private water supplies and these go beyond water testing: this may need further consideration.

### 7.2.1.2 Economic Development

There was then a second clear role which local authorities play; that associated with economic development. In attempting to assess if private water supplies were inhibiting the economic growth and flexibility of Scotland’s rural economies, this research found that a certain level of strategic economic development is first required to facilitate and foster sustainable economic growth. Infrastructure is an essential contributor to economic development. Without the necessary infrastructure to ensure reliable access to water supplies, economic growth is likely to be vulnerable and hence potentially unsustainable. As a consequence, private water supplies and effective water management should form a core component of any progressive strategy for encouraging sustainable economic growth in remote rural economies. By laying these strategic foundations, greater reliability and efficiency in both local production and productivity can be sustained.

The evidence from this study suggests that there was little awareness of private supply-related economic development issues within strategic bodies. None of the strategic stakeholders interviewed acknowledged the importance of including water supplies as a core component of their agency’s / organisation’s strategy for encouraging sustainable rural economic growth. A number expressed views similar to that revealed by a local authority economic development officer:

“Working in economic development ... I don’t get a lot of people talking to me about water, to be honest.”

Private water supply provision was referred to as either not a consideration in strategic economic development planning and infrastructure, or only a minor concern. Private supplies were often overshadowed by concerns about other utility provision such as electricity, land-purchase costs and broadband connectivity. Yet one stakeholder drew attention to individuals who had “walked away” from developments because of inadequate access to reliable, sustainable water supplies. The lack of organised strategic support for private supply business users was summarised by one strategic stakeholder:

“There isn’t a huge amount of effort or planning going into the private water supply system. And that really is left

up to entrepreneurs to get on with it themselves.”

A reluctance to engage with the private-supply related issues issue – perhaps seen as another burden for was reported in some local authorities. One council officer indicated that, when considering a wider strategic perspective:

“{Named} Council has a {named locality} wide policy of not encouraging development in locations that would create a demand for inordinate public expenditure. In a time of increasing reductions in Council budgets we believe this to be a sensible approach.”

However, there was an interest in the issue amongst stakeholders interviewed, not least because of the drought and future climate change impacts. One local authority official, speculating on future climate change impacts, anticipated increased levels of concern. This stakeholder drew specifically upon evidence from the recent drought which emphasised a pressing need to engage in strategic planning of any future water-dependent infrastructural and economic developments.

Investment was emphasised by community stakeholders as a vital component in the generation of increased economic activity, particularly amongst microbusiness private-supply users: enterprises which form the bedrock of rural economies. There was also a substantial concern with the changing demographic structures within these communities and the desire for the creation of more sophisticated labour markets; not only to encourage younger people to stay in the area, but also to have skilled professional career prospects. One community-based trust provided scholarships to individuals to further their education in the hope they would return to the community, yet there remained a lack of skilled professional employment opportunities.

Private water supply issues are currently a somewhat ‘hidden’ agenda in both economic and policy development, with evidence from this study suggesting a lack of awareness and engagement in local private water supplies as an important component of rural economic development infrastructure. Business owners and users in this study indicated they would welcome more support from local organisations and institutions to ensure their private water supplies were reliable, sustainable, and affordable.

## 7.2.2 Business support and advice

A specific need was identified for business support in managing their private supplies to ensure effective business operation. The often poor resilience of community and individual private water supplies focussed attention on this.

Business operators requested greater guidance from statutory agencies, particularly where they were seeking to meet standards. In some cases, this was a need for (statutory and other) agencies to provide credible answers to identified challenges, for example by supplying effective, long-term filtration solutions. Several business users highlighted a lack of problem-solving guidance to assist them manage specific issues. As previously illustrated, (at Section 4.3.1) one fisheries manager indicated he had struggled – despite considerable effort – to find precise information on what interventions might work to ensure both water quality and hence the resilience of his business.

Local authorities did support and advise individuals, as indicated by examples throughout this report, and also maintained supply quality through testing as required. However, there was a suggestion by one local authority stakeholder that testing failure should be investigated to a greater degree and more ongoing risk-assessment work undertaken, such as going beyond the (obligatory) sampling and looking at bacteriological causes and chemical failures. However, the participant stated that this could have substantial cost implications (for both parties) so was probably unrealistic.

One local authority stakeholder was concerned that associated costs meant businesses were not maintaining their supplies as effectively or as rigorous as advised:

“If you’re a business and you’re sampling your water ... you’re looking at about £100 a week for sampling. They’re doing it once a week. Now, if you’re a small business, you can’t afford to do anything like that. To maintain your system via a company, you’re probably looking at £150-£200 per year.”

This study found while local authorities were proactive in offering grants and following up on offers of support; they were met with ambivalence amongst some participants.

## 7.2.3 New Regulations 2017

There was some evidence of uncertainty within local authorities about the developing regulations<sup>32</sup>, where there had been agreement with Scottish Government that the implementation of the regulations would be ‘cost neutral’. However, the requirement to test water supplies of tenants was predicted to increase the number of tests by 300 each year in one local authority area, with additional associated impacts on risk assessments also requiring resourcing. An estate manager noted during interview that any increased costs in testing from forthcoming regulatory changes would be directly passed on to their tenants, who may already be enduring financial

32 The Water Intended for Human Consumption (Private Supplies)(Scotland) Regulations 2017

hardship. The increased testing costs to water supply owners, in one area, were anticipated to rise from £210 to £265 under full-cost recovery.

One local authority stakeholder reported the implementation of the regulations could provide an opportunity to encourage supply owners to be more diligent about maintenance to reduce their sampling costs. However, this participant also cautioned that local authorities must also ensure that they did not rely on single samples to reduce costs. The heterogeneity of private supplies in Scotland results in expert judgement being applied by local authority staff to determine the number of sampling points required. As one local authority officer explained:

“...we try and look at it and say “Where is the risk?” and “Let’s try and look at that”, rather than necessarily just focus on what exactly the regulations may or may not say as sometimes they are a bit blurry... supplies vary so much ...The idea that there is a source that goes to a property – there is not necessarily that many of them that are that simple.”

It may be that the new regulations bed down quickly but at the time of fieldwork cost implications were still raising considerable concerns.

#### 7.2.4 Water Safety Plans

The World Health Organisation<sup>33</sup> generated proposals for water safety planning, and several local authority officers were keen to use these Water Safety plans to develop a new ethos around water supplies:

“We’re trying to encourage users, businesses, whatever to develop the Water Safety Plans, but they are very limited in their numbers at the moment. But we just want to try and get people thinking about their supply and how they’re going to manage the supply. What they do in emergencies. You know, quality failures or quantity failures, routine maintenance treatment.”

There was a clear recognition of the positive role local authorities play with respect to private supply regulation and management. Similarly, there was a view from both authorities and private supply users that there were additional roles they might or should play: providing more specific (and defined technical support) by some users and a greater oversight role by some officials.

### 7.3 Scottish Water support and networked supplies

Participants were split over whether networked supplies or private water supplies were preferable. As indicated in earlier sections, there was a misunderstanding amongst some of the participants that networked supplies were always more expensive even for domestic consumers, as one business owner reported about his neighbour:

“he is on a private supply even though the Scottish Water pipework is within sight distance of his property. It’s very, very, very close to him and his supply is appalling. It’s absolutely terrible. It’s a tiny little tank, built about probably 60-70 years and it comes from a miserable little stream...earlier this year I cleaned out the tank for him and it had two inches of mud in the bottom of it and it was absolutely disgusting. But he won’t go onto the public water because he doesn’t want to face a Scottish Water bill.”

Most businesses appeared aware of the testing requirements and maintaining their supply and often managed this effectively, nevertheless as one business manager indicated:

“...for us to be on a public networked water supply would be fantastic here. We just know we would never have a problem. It wouldn’t need testing. It costs us £150 a year just to test it, and if they come back out to retest it, it costs another £150 ...”

However other businesses, like dairy farmers and some tourism-focused businesses were keen to remain on their private supply.

There were some concerns expressed about communication with Scottish Water particularly with respect to the guidance on accessing networked supplies: often seen to be protracted and lacking clarity. Some speculated the introduction of new regulations drawing in larger numbers into the testing regime might also increase demand for networked supplies.

There were equally positive comments of the support offered particularly by one large, developing business that had made use of its consultancy service to ensure the water quality at the business from a recently drilled borehole.

33 See for example: [https://www.who.int/water\\_sanitation\\_health/water-quality/safety-planning/en/](https://www.who.int/water_sanitation_health/water-quality/safety-planning/en/) and <http://www.wspportal.org/>

## 8. Conclusions

Overall, businesses were found to have invested considerable amounts in their private supplies. A concern about reliability and resilience remained prominent within most businesses and were magnified by drought. While some evidence of strategic planning and resilience was evident in almost all businesses interviewed, this had not been formalised by any business. This vulnerability is of particular importance given the central role micro businesses play in these local economies. These small businesses were found to be generally less resilient to volatility because their adaptive capacities were more limited, i.e. they were not well equipped to absorb often unpredictable system costs in comparison to larger businesses.

Rural economic development can be supported by efficient private supply infrastructure, though it is presently not possible to fully quantify the impact of private water supplies upon the wider macro-economy of rural Scotland. This study found that the current infrastructure and thus economic capabilities of rural economies are limited by current private water supply circumstances. Private supplies will remain vulnerable, particularly to the impending impacts of climate change, and so greater strategic support for private supply infrastructure is a pressing concern.

As well as a lack of crisis planning, local authority officials reported many supply owners underestimated the amount of maintenance each supply required, placing these supplies at risk of routine failures in both testing and equipment.

Whilst there was obvious local expertise and individuals did appear to know their own systems in most cases, the study found significant gaps in knowledge and skill nevertheless, particularly around how to cope with contamination, resilience planning, and fragility of water sources. New residents and in-migration posed additional challenges to the operation of private supply systems in communities. Firstly, the arrival of new residents often marked the loss of local expertise to outward migration, or in the case of older residents, loss through the knowledgeable individual passing away. Secondly, new residents generally had little knowledge of private water supply management, nor essential maintenance, creating pressure on existing services (plumbers; local knowledgeable people etc.).

The case of the fisheries business manager highlights an extreme case of overreliance on self-maintenance of supplies. Whilst there was clear confidence amongst some participants about their abilities to maintain their supplies, this might be of some concern as it diverts those individuals from other economic activities and the

confidence may not be matched by tangible skills, leading to potentially unrecognised risks in their supplies.

Management and stewardship of private supplies requires further investigation, as this project suggested that the sharing of supplies can lead to inadequate attention paid to management and in some cases to conflict. Evidence from this study also suggested investment in new holiday residences and letting properties are also generating conflict in private supply management.

The sectors studied in this research highlighted a number of issues with private supplies. The increased number of holiday-lets reliant on private supplies has impacted upon local businesses and residents, as water is used by weekly or nightly guests without awareness of vulnerability issues. For dairy farming, the drought brought the issues around the volume of water essential to their successful and sustainable operation to the forefront of thinking. Forestry also brought issues, particularly around guidance apparently being ignored as forestry operational work was subcontracted. Both Forestry and Tourism appeared to generate conflict within some communities over private supply accessibility.

There was concern amongst local authority and community stakeholders that management of private supplies was not being undertaken in the most effective way in most areas. Indeed, maintenance appeared to be the central issue of concern in this report, including its costs in time and money; its impact if the supply failed to satisfy testing regulations and proper understanding and awareness of its critical importance. More investigation is needed into how maintenance can be addressed. In addition, the support offered by key agencies is seen as important but appears inconsistent in its aims (beyond formal regulatory roles) and there is a clear demand for an enhanced support role with respect to a range of needs.

The impact on the wider local economy is difficult to quantify, it is always likely to be particularly difficult to quantify if reliance upon private water supplies inhibits economic growth or job creation, due to the variability of the micro-circumstances which have been uncovered during this research. Due to this variability of private supplies the monetary costs cannot be definitively ascertained, and thus neither can a method of reducing these. However, the costs of a private water supply extend further than traditional monetary measures and where there is more readily available information and services on managing a private supply, can significantly reduce the opportunity cost. This would make operating a private supply less knowledge and labour intensive and lead to significant time savings. Reducing the knowledge and labour-intensive nature of a private supply would allow for the expansion in the productive capacities, of individuals and businesses, elsewhere.

It is clear from the qualitative data that private supplies restrict remote rural communities from expanding their productive capabilities and activities. This has implications for these communities' ability to attain economic growth beyond a certain level, and for the sustainability of any growth. Economic development (as a direct investment for example in infrastructure) and in terms of improved resources and information in regards to private supplies would provide existing and prospective businesses with a greater degree of certainty and efficiency, allowing them to increase their productive capacity, which could potentially encourage domestic growth within the communities themselves but also inward growth from other parts of Scotland.

stakeholders. This should include reference to and information on other relevant (sometimes sector-specific) regulatory legislation.

#### **Land management and stewardship**

- There is a need for more consistent approaches to supply-management with appropriate support mechanisms (for example, mediation and conflict resolution), and for varied models of good practise.

#### **Supporting communities**

- Mechanisms for sharing local authority knowledge and data about supplies as well as keeping this updated, within and across agencies and other communities who can benefit should be explored.

## **8.1 Recommendations**

There is a need to consider the following:

### **Economic Infrastructure**

- Greater recognition is needed amongst stakeholders of the importance of private supplies in local economies and consequently there is a need for enhanced national strategic oversight.
- There is a need for greater resilience planning, and development of local and regional infrastructure for private water supply reliance, with appropriate stakeholder support to manage the associated risk and uncertainty.
- Action is required to ensure that skilled professionals are consistently part of the Scottish remote-rural private-supply infrastructure planning.
- There is a need for greater clarity and appropriate support for those who might seek to access mains-network water supply.

### **Business development and investment**

- To improve rural resilience, better engagement between business and economic development agencies and other stakeholders is needed, as well as recognition and understanding of the role of private water supplies in local economies: there may be value in exploring commonalities with approaches adopted in Scandinavia and North America.
- Expertise held within multiple institutions and agencies could be exploited more effectively and be supportive of locally-held expertise. Developing mechanisms for sharing that expertise with private-supply users would be useful and require careful planning.

### **Costs**

- There is an urgent need to set out liabilities and associated (legal) responsibilities by a range of



## 9. References

Argyll and Bute Economic Forum Report: February 2016

Available at: [https://www.argyll-bute.gov.uk/sites/default/files/argyll\\_report\\_260216-v2.pdf](https://www.argyll-bute.gov.uk/sites/default/files/argyll_report_260216-v2.pdf)

CJC Consulting (2015) The economic contribution of the forestry sector in Scotland. CJC Consulting Ltd, Oxford accessible at <https://forestry.gov.scot/images/corporate/pdf/economic-contribution-forestry-2015.pdf>

Drinking Water Quality Regulator for Scotland (2019) Drinking Water Quality in Scotland 2018: Private Water Supplies. Available at: <https://dwqr.scot/media/43310/dwqr-annual-report-2018-private-supply-final-report-approved-by-sp-for-publication-17-september-20192.pdf>

Forestry Commission (2011). Forests and Water. UK Forestry Standard Guidelines. Fifth Edition. Forestry Commission, Edinburgh.

Forestry Commission Scotland (2017) The UK Forestry Standard: The governments' approach to sustainable forestry. Forestry Commission, Edinburgh. Available at: <https://forestry.gov.scot/sustainable-forestry/ukfs-scotland>

Forestry & Water Scotland (2018) Protecting private water supplies during forestry activities. Available at: <http://www.confor.org.uk/media/247132/guidance-on-forestry-activities-near-pws-sept-2018.pdf>

Jones, G. (2018) Support for Crofting; A report prepared for the Crofting Commission. Inverness. Available at: <http://www.efncp.org/download/SupportforCrofting-FULLREPORT.PDF>

Scottish Environment Protection Agency (2018) Dairy Production Sector Plan Draft For Consultation. SEPA, Stirling. Accessible at [https://consultation.sepa.org.uk/sector-plan/dairy-production/user\\_uploads/dairy-production-sector-plan-1.pdf](https://consultation.sepa.org.uk/sector-plan/dairy-production/user_uploads/dairy-production-sector-plan-1.pdf)

Scottish Government The Water Intended for Human Consumption (Private Supplies)(Scotland) Regulations 2017. Edinburgh. Available at: <http://www.legislation.gov.uk/ssi/2017/282/made/data.pdf>

Scottish Government (2018) Scottish Government Urban Rural Classification 2016 Geographic Information Science & Analysis Team Rural and Environment Science and Analytical Services Division. Available at: <https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2018/03/scottish-government-urban-rural-classification-2016/documents/scottish-government-urban-rural-classification-2016/scottish-government-urban-rural-classification-2016/govscot%3Adocument/00542959.pdf>

Scottish Government (2018) Rural Scotland Key Facts 2018: People and Communities Services and Lifestyle Economy and Enterprise, National Statistics, October, Edinburgh.

Scottish Government (2018) Tourism in Scotland: the economic contribution of the sector: A report commissioned by the Tourism Leadership Group. Edinburgh. Available at: <https://www.gov.scot/publications/tourism-scotland-economic-contribution-sector/pages/4/>

Teedon, P., Currie, M., Helwig, K., and Creaney, R. (2017) Engaging communities around private water supplies. CRW2014\_12. Available online at [www.crew.ac.uk/publications](http://www.crew.ac.uk/publications)

VisitScotland (2016) Insight Department: Trends 2017. Edinburgh. Available at: <https://www.visitscotland.org/binaries/content/assets/dot-org/pdf/research-papers/insights-trends-2017.pdf>

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