AHDB
DAIRY

Efficient use of water on a dairy farm

Contents

1 | Introduction

The world's water sources should no longer be taken for granted. On the dairy farm, water is one of the most important natural resources, whether considering direct water consumption (eg for drinking, washing, cleaning and feed processing) or virtual water in the diet (ie water used for grass growth and concentrate feedstuffs).

Water can be categorised into types based on its source and relative quality. Colours are often used to refer to water quality (or type).

- **Blue water** – this is potable water, defined as water which has been treated to a standard suitable for human consumption. For example, in a dairy unit potable water must be used for internal plant cleaning, hand and udder washing
- **Green water** – this is rainwater which falls on land that does not run off or recharge the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation. Green water can be made productive by growing plants (eg grass, forage and feed crops)
- **Grey or dirty water** – this is water which has been used in some way but may still be suitable for additional uses without further treatment. For example, blue water used for cleaning parlours can be considered grey water and could potentially be reused for external parlour/yard wash down on farms. Rainwater or groundwater which has been collected and stored is also considered grey water.

Blue water consumption is proportionally small for milk production under all systems. A third to a half of all blue water used is drinking water, with the remaining being used for cleaning parlours and yards and milk cooling. There is potential for on-farm interventions and technologies to reduce water wastage or leakage, which would, therefore, lead to a reduction of blue water use.

Costed farm data (Promar 2013) shows mains water supply costs on the average dairy farm to be £41/cow/year. On some units (Appendix 1), water costs are significantly higher, at the most extreme rising to over £270/cow/year.

Investigation has calculated that mains water typically costs £1.39/m^3 but disposal costs can be £0.38 to £2.94/m^3. There is considerable variation in prices per cubic metre. Wastewater disposal is, therefore, an important consideration when monitoring water use.

This booklet has been created to increase awareness about water use on dairy farms and to highlight some opportunities where water and money may be able to be saved.

2 | How is water used on dairy farms?

The production of milk requires a large quantity of water, which not only has a significant impact on the cost of production, but also can affect the environment. Costed farm data (Promar 2013) shows that mains water supply costs on the average dairy farm to be £41/cow/year. On some units, water costs are significantly higher, at the most extreme rising to over £270/cow/year (Appendix 1).

The amount of blue (potable) water used on farm is often of particular interest due to the cost associated with it. Investigation has calculated that mains water typically costs £1.39/m^3 but disposal costs can be £0.38 to £2.94/m^3. There is considerable variation in prices per cubic metre. Wastewater disposal is, therefore, an important consideration when monitoring water use.

Higher output dairy systems tend to have slightly lower water consumption per unit of output. Although drinking water per head tends to increase as yield and metabolic demand increases, this higher water consumption per head is usually offset by higher milk output and a smaller proportion spent on maintenance.

About 99% of the water used in milk production is 'green water', this is rainwater which falls on land that does not run off or recharge the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation. This water is made productive by growing plants (eg grass, forage and feed crops). Analysed data shows that the average blue water consumption for a range of dairy production systems ranges from 5-8 litres of water per litre of milk at the farmgate.

Water uses on the dairy farm

- Livestock drinking
- Plate cooler water
- Collecting yard and parlour washing down
- Plant washing – bulk tanks and parlour plant washing
- Flood wash systems
- Irrigation
- Sprayer use
- Domestic use
- General water use

Livestock drinking

- Livestock drinking, typically accounts for a third to a half of the blue water usage on the dairy farm. Adequate provision of drinking water is essential to all dairy systems
- The first of the five freedoms derived by the Farm Animal Welfare Council (FAWC) states that animals should be free from hunger and thirst and should be provided with a ready access to fresh water and a diet to maintain full health and vigour
- The Red Tractor Farm Assurance Scheme requires cattle to have adequate access to a supply of 'fresh and clean' drinking water, for livestock drinking this need not be specifically from a potable source. If you are collecting roof water for drinking or if stock have direct access to watercourses for drinking, you need to be aware of the animal health risks from potential contamination of this water (for example, from bird or vermin droppings). Speak to your vet regarding specific risks to stock on your farm
- Allowing cows to drink directly from streams and other water courses is discouraged due

to disease risks from contaminated water and can lead to water pollution, erosion of banks and habitat damage. Direct access to water courses for livestock drinking may be restricted in the future as a result of the Water Framework Directive and associated daughter directives requiring more stringent water quality standards

- Many farm assurance schemes specify a minimum trough space for drinking. Because dairy cows are sociable in their behaviour, it is important that there is adequate space to allow 10% of the herd to drink at any time
- Standard figures are used for calculating stock drinking requirements. These are related to the type and age of stock, dry matter % of the diet and air temperature. Stock on a particularly dry diet, eg youngstock reared on a straw and concentrate-based ration, will require nearly twice as much water as those on a wet grass silage diet. Dairy cow water requirements are also related to milk yield (approximately three to four times the yield), ie a cow giving 30 litres per day will require between 90 and 120 litres of water.

Table 2.1 can be used to estimate the drinking requirements of lactating cows, examples of other water uses are shown in Table 2.2.

Table 2.1: Daily drinking water requirement for lactating cows (litres)

Average daily milk yield	20 litres			30 litres			40 litres		
Temperature	**<16°C**	**16-20°C**	**>20°C**	**<16°C**	**16-20°C**	**>20°C**	**<16°C**	**16-20°C**	**>20°C**
Ration DM									
30%	50	57	65	71	82	94	93	107	123
40%	54	62	71	76	87	100	97	112	129
50%	57	66	76	79	91	105	101	116	133
60%	62	71	82	84	96	110	105	121	139
70%	64	74	85	87	100	115	109	125	144

Table 2.2: Other examples of water uses

Cattle	Litres/day
Growers and replacements	20
Beef cows and heifers	20
Dairy and beef bulls	20
Beef store cattle	20
Dairy and beef calves	5
Other uses	
Personal use (per person)	149
System wash (per milking point)	18
Tank wash	30
Plate cooler (per cow)	40
Teat wash (per cow)	0.5
Wash down	15

! Think about

Livestock need to be given adequate clean water. There is no opportunity to reduce water use here; although alternative cost-effective safe sources, such as the use of hydraulic ram pumps pasture pumps, solar power pumps or wind powered pumps to abstract water from springs, canals, rivers, and lakes or borehole and/or rainwater harvest may be potential alternative methods to consider instead of mains supply.

Water troughs

- Peak drinking water demands often coincide with the completion of milking and around sunset. Up to 50% of the cows' daily requirement can be consumed during these times. As cows can drink at the rate of 15-20 litres/min, it is important to recognise this and bear in mind trough capacity and water flow rate.

A flow rate to the trough of 10 litres/minute is suggested as a minimum.

- Dirty and contaminated water troughs will reduce water intake – reduced water intake will reduce performance
- Tipping troughs or installation of large bore drain holes (50-75mm) will ease the task of keeping water troughs clean
- If water troughs are unused for a period of time, especially during the winter, they should be drained to reduce the risk of frost damage.

Tipping water trough

Plate cooler water

- Pre-cooling of milk with cold water is intended to make significant savings on milk cooling costs
- Plate cooler water often accounts for as much as 25% of annual water use on a dairy farm so small daily losses here can add up to significant waste annually
- However, if the water that has run through the plate cooler is not reused, what is saved in energy costs can be lost by increased water costs and wastewater disposal costs. It is not uncommon for this water to drain to waste after overflowing from a water trough or other holding tanks
- If the warm plate cooler water can first be linked back to top up a hot water cylinder, this can save energy. However, the water for parlour plant washing has normally already been heated to temperature at the time the plate cooler water is flowing
- To achieve optimum milk cooling, a ratio of 2:1 of water to milk is generally recommended. This generates a significant volume of water to use each day (twice your daily bulk tank volume).

Typical plate cooler

Key steps to take when using a plate cooler

1. Check that all the water has the potential to be reused – either directly for washing or stock drinking but any surplus must be able to be stored
2. Consider linking to your hot water cylinder, if this is appropriate, to make further energy savings
3. Work out the size of tank storage required. What is your peak daily milk production? On twice a day milking, your maximum storage needs could be as much as your daily milk production.

Table 2.3: Potential advantages and disadvantages of reuse of plate cooler water

Potential advantages	Potential disadvantages
• Reuse of plate cooler water saves water use and disposal cost but all the water must be reused • There is some evidence to suggest cows prefer to drink warm water. Cows typically drink three to four times their daily milk yield with peak drinking water demand often coinciding with the completion of milking • Warm plate cooler water can be used as a top-up for your hot water boiler, thus making further energy savings	• If all of the water is not reused, the cost of supply and disposal can negate much or all of any energy savings made by pre-cooling your milk • Timing of reuse can be a problem for warm plate cooler water if trying to make further energy savings by adding this to your hot water cylinder. The hot water normally needs to be at full temperature for wash down at the end of milking. Adding warm plate cooler water to the hot cylinder during milking may reduce the tank temperature • Plate cooler water is often piped to a cattle drinking trough but if the stock do not drink the water fast enough it will drain to waste • Warm water is more prone to bacterial growth if not used immediately

Collecting yard and parlour washing down

- This is an area where water use can be hugely variable, ranging from 5 to 50 litres/cow/day and can account for 5% to 17% of total water use
- Case studies have indicated this process can use up to three times the volume of water used for plant wash down
- Washing during milking will include udder and teat washing, as well as washing away dung from the floors, clusters, etc
- Wash down water for collecting yards and parlours is not restricted to be potable water and, therefore, there is potential to reuse water from plant wash down and/or plate cooling, or harvest rainwater for this task
- Water volumes used for wash down of the parlour and collecting yard can be variable, depending on methods. Volume hoses can be fast and effective for shifting loose dung but can use 10 times the flow rates of pressure washers (reaching 80 to 150 litres/min). Pressure washers will be more effective for dried-on dirt and, typically, use 8 to 12 litres/min.

Cleaning methods

Use appropriate cleaning methods:

- Damping down a parlour prior to milking is common practice, this can speed washing after milking but will obviously use more water
- Pressure washers only use 8 to 12 litres/min and are far more effective for dried-on dirt
- Make use of a yard scraper/squeegee before volume washing
- A brush and bucket can be very effective for some cleaning
- A simple trigger tap on the end of a hose will help save water
- Evidence suggests little difference between general parlour cleanliness and the amount of water used.

Trigger shut-off on hoses – a simple way to help save water

Volume hoses use 80 to 150 litres/min, this is typically 10 times more water than a pressure washer

Table 2.4: Example of washing down costs

	Typical flow rate (litres/min)	Cost (£/5 mins)	Cost (£/30 mins)	Annual cost of an extra 5 mins/day everyday (£)	Annual cost of an extra 30 mins/ day everyday
Typical mains pressure tap (range from 15 to 30 litres/min)	20	0.14	0.84	51.10	306.60
Pressure washer (typical range from 8 to 15 litres/min)	12	0.08	0.50	29.20	182.50
Volume washer (typical range from 80 to 150 litres/min)	80	0.56	3.34	204.40	1219.10

Using a squeegee before the volume hose will help use less water

Plant washing

Bulk tanks

Most tanks now have automatic tank cleaning. The manufacturer will set the wash cycle volumes. Determining the water usage for plant washing will help you evaluate your overall water usage. Make a call to your supplier with the size and model of your tank, they should then be able to give you the pre-wash, wash and rinse volumes.

The single biggest variable in water use will be whether you have daily or every-other-day collections (collections made every other day may halve the water use). Some of the most modern tanks have much faster wash times (to reduce the downtime between collection and next milking). This is achieved by higher pressure washing but with lower volumes of water, these systems are more efficient from a water use point of view.

There is a large range in water use from small ice bank type tanks, requiring up to 30% of the tank capacity, to the largest tanks with fast wash systems, using as little as 1.5% of the tank capacity.

> **! Think about**
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> There is little that can be done about the wash volumes of the existing tank, however, when purchasing a new tank, consideration should be given to wash volumes.

Parlour plant washing

- Typically, this accounts for between 4-10% of total farm water use and includes parlour plant and bulk tank washings
- Dairy hygiene regulations require that any water used for hand, udder or plant washing must be from a potable source. The local Environmental Health Officer will need to assess water quality if non-mains sources are used. This should be done on an annual basis

An in-depth review has been undertaken of the code of practice for cleaning of milking machines (British Standard BS5226:1991). This standard provides a detailed review of two key methods for cleaning, which are:

1. The circulation method (a 3-stage process, briefly comprising a pre-wash, wash with detergent solution and final rinse), which carries a minimum recommendation for 30 litres of water/unit.
2. The acidified boiling water method (a single stage flush with acid incorporated into near boiling water), which carries a minimum recommendation for 18 litres of water/unit.

The ISO standards (British Standard BS5226:1991) set the wash volumes for milking plants at 18 litres/unit. These British Standards were produced in 1991 and reviewed more recently in 2011. However, no significant changes to the recommended minimum cleaning volume of 18 litres/unit have been made. These are now rather old standards and were originally designed for jar plants which, typically, required higher water volumes to wash. Modern direct-to-line plants have the ability to use less water to wash but manufacturers are understandably reluctant to set wash volumes below the standard as the plant would then be non-compliant with the ISO standards.

In practice, the hot wash volumes are set by the capacity of the hot water heater. This is sized in relation to the number of units so as to at least achieve the minimum ISO volumes.

It should be noted that any reduction in water use would only be likely to occur at the pre-wash (designed to flush out the remaining milk and then bring the plant up to temperature with warm water prior to the hot wash) and final rinse stage of the circulation method.

The hot wash volume (detergent solution) must be sufficient to achieve the required wash temperature and fill the plant with sufficient water, maintaining recirculation without drawing air into the plant. Therefore, the volume required would be unlikely to be affected by new technology, unless a significant change to capacity is introduced.

The final rinse is designed to wash the cleaning fluids out of the plant.

Critically, it is unlikely that plant washing volumes could be significantly reduced below the 18 litres/unit minimum recommended by the ISO and BS guidance.

> **! Think about**
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> Waste wash water can be reused, eg for washing down collecting yards.
>
> Avoid using wash water with chemicals around electronic parlour equipment.

Flood wash systems

- The uptake of flood washing in GB has been limited. There has been an interest in this system with large collection yards, due to the difficulties of tractor scraping and the time and cost of manual hosing down. Most flood wash systems make use of recycled separated slurry for the flush but 'fresh water' is likely to be required to reduce odour problems
- Dirty recycled wash water may pose a risk to udder health and foot disease
- It is recommended that to minimise the problem of odours and keep the liquid manageable, 20% of the volume of the stored water should be changed each day.

Flood washing will affect your water usage

Irrigation

Direct irrigation of grassland is not considered to be economic in the UK. However, some mixed farms with dairy and arable operations may use crop irrigation for high-value crops such as potatoes and other vegetable crops. Specific advice on crop irrigation has not been considered in this document.

Sprayer use

A typical water requirement for crop spraying is 200 litres/ha. However, more specialist arable operators or contractors may use as little as 100 to 150 litres/ha due to lower volume nozzles.

Domestic use

Water companies estimate average domestic water use for washing, toilet flushing, bathing, cooking and drinking, etc. to be approximately 150 litres/person/day.

Other general water use

- Activities such as calf pen cleaning and feeding, machinery/tractor washing, biosecurity and other general cleaning will add to your water useage
- On specialist dairy farms this may account for only 1-2% of total water use.

Alternative water sources – consider and cost alternative water supplies but remember alternative sources may be cheaper but are not usually free, don't increase your use just because it is cheaper

Wastewater

- Water leaks in fields can result in increased poaching, which can contribute to diffuse pollution
- Overflowing water troughs and incorrectly set or damaged ball-valves can waste significant amounts of water. You can adjust ball-valves to lower the float so that there is less risk of spillage and overflowing.

Not an uncommon sight? Plate cooler water overflowing a water trough – a double waste

Leak detection

Leaks cost you twice – you will pay for any water leaking out of your supply network but, if this water finds its way to your slurry or wastewater system, you will also have the additional cost of water disposal.

Key steps to detect leaks

1. Sketch a map of your farm's water supply
2. Read and note down your water meter readings
3. Check your meter at a time of low or no use, unfortunately, this is likely to be in the very early hours of the morning
4. Isolate sections of your supply
5. Walk your water supply route
6. Contact your local water company
7. Hire leak detection equipment or find a company specialising in leak detection
8. Consider fitting a smart meter or flow meter and log water use with a data logger.

Table 2.5: How much does a dripping tap cost you?

	Flow rate (litres/ min)	**Annual cost** (assuming water cost at £1.39/m^3)
One drip per second	0.003	Less than £2.20
Drip breaking into a stream	0.063	£46
A stream 1.5mm width	0.222	£162
A stream of 3mm width	0.684	£500
A stream of 6mm width	2.430	£1,775

Step-by-step approach to detecting a leak

1. **Sketch a map of your farm water supply** – Note the location of pipes, meters, stop-valves, troughs, taps and other outlets. You may need to ask for help from family, existing and retired farm workers, previous occupants or companies/ contractors that may have installed pipework. Keep a record of this map even if it is not 100% complete. Others may be able to add to it later.
2. **Read and note down your water meter readings, including the date** – Read meters regularly (ideally every one to three months) or at least until you believe the leak has been found and fixed.
3. **Check your meter at a time of low or no use** – Unfortunately, this is likely to be during the very early hours of the morning when no equipment is using water and minimal stock will be drinking. Be prepared: clear the manhole cover, have a torch handy, ensure the meter is not submerged in water and have a pen and notebook to record the reading. If you find the meter running when you would expect no water use, this may indicate a leak. A digital camera with a flash can also be a useful tool to take a meter reading in a dark, inaccessible manhole.
4. **Isolate sections of your supply** – If you have stop-valves to shut off sections of your supply, try to identify which section may have a leak.

5. **Walk your water supply route** – Make use of your sketch map to walk your system looking for tell-tale signs of leaks. Try to do this after a dry period then look for damp patches in fields or areas where the grass/crop is growing particularly well. Ask yourself why is that corner of the yard always flooded? Why is that ditch or drain always damp or running even after no rain?
6. **Contact your local water company** – If, after trying all the above, you still cannot detect a leak but believe you still have one, contact the local water company. Some water companies may provide free leak detection.
7. **Hire leak detection equipment or find a company specialising in leak detection** – Commercial companies also provide leak detection services but obviously charge for these services. Leak detection equipment can also be hired from most hire centres. To make effective use of these services or equipment, you need to have a fairly clear idea of where your pipes run (having a map of your pipe network is important).
8. **Log water use with a data logger** – Use a water logger, which is an electronic device that can be fitted (with the consent of the water company) to certain types of water meter that will record the water flow rates at set intervals over a period of time. The information the data logger collects can then be downloaded onto a computer for analysis.

The type of water meter can be determined from the model number and digital photographs. This will help determine if the meter is able to be fitted with a data logger and the type of data logger needed.

Reading a water meter

Think about

Planning for the future

Ensure your water meter is easy to read. Install your own meter in an easy-to-read position.

When installing new pipework or putting in new troughs, always install a stop-valve which can isolate sections. Keep a record where these are and ensure they are easy to access.

3 | Where does your water come from?

Water can be categorised into types based on its source and relative quality. Colours are often used to refer to water quality (or type).

- Blue water – this is potable water, defined as water which has been treated to a standard suitable for human consumption. For example, in a dairy unit potable water must be used for internal plant cleaning, hand and udder washing
- Green water – this is rainwater which falls on land that does not run off or recharge the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation. Green water can be made productive by growing plants (eg grass, forage and feed crops)
- Grey or dirty water – this is water which has been used in some way but may still be suitable for additional uses without further treatment. For example, blue water used for cleaning parlours can be considered grey water and could potentially be reused for external parlour/yard wash down on farms. Rainwater or groundwater which has been collected and stored is also considered grey water.

Mains water

Mains water will be charged as either metered or un-metered; some companies may also offer additional 'secondary services' which may include individual field trough rates. These rates are relevant to unmeasured connections and apply per trough or drinking bowl irrespective of the field being in grass or crop. Charges will apply for each trough or drinking bowl. A fixed element is built into each tariff.

Individual water companies have their own charge rates. Your geographic location will determine who your supplier will be. Only those farms on the boundaries of the company regions may have any choice over their supplier.

A growing number of dairy farmers are seeking to source water from alternative sources such as borehole, springs, canals, rivers, lakes or rainwater harvest as the cost of mains water increases.

Other sources of water

Other water sources may include:

- **Abstraction** from surface water (rivers, ponds, lakes, canals) and groundwater (springs and boreholes)
- **Rainwater harvest** eg roof water collection
- **Reuse** eg reuse of water from plate coolers or dairy plant washings for yard wash down or foot baths
- **Stock drinking directly from water courses** eg rivers, ponds, streams, etc.

The cost of water from non-mains sources will depend on individual farm situations. If a private water supply is used for plant washing, the local Environmental Health Officer will need to assess water quality. This should be done on an annual basis.

> **! Think about**
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> Although water from other sources (if available) will, typically, be less expensive than mains supply, it is generally not free.

Prior to any investment in alternative sources, it is recommended to have a full water analysis conducted by a reputable laboratory. Ensure the analysis will provide results against the parameters set out in Table 4.2.

Abstraction from ground and surface water

- **Alternative supply options include:**
  Borehole
  Springs
  Canals
  Rivers
  Lakes
- Depending on the payback period, investment in abstraction could offer a substantial saving. However, inefficient water use can significantly add to wastewater disposal costs
- Test bores are not inexpensive and there is no guarantee of finding suitable quality or quantities of water
- The costs of implementing a borehole can vary significantly:
  - A shallow borehole could cost as little as £5,000 (including investigative work and project set-up)
  - A deep borehole with filters and associated equipment may cost in the region of £30,000.
- Abstraction licenses will be required if a farm is utilising in excess of 20 cubic metres per day. Should this be necessary, the cost of a licence can vary considerably.

Key steps to take if considering abstraction

1. Contact the Environment Agency to check who is currently abstracting from the source and if you can get up to 20m^3/day without a licence. Catchment Abstraction Management (CAMS) shows the degree of water supply in catchments and helps identify areas where water abstraction is under stress, this could potentially affect farm abstraction licences
2. Contact your local borehole driller
3. Get a geologist report
4. Prepare draft costing of capital and running costs
5. Work out potential savings
6. Assess risks.

Table 3.1: Potential advantages and disadvantages of using alternative water sources

Potential advantages	Potential disadvantages
Significant potential cost saving on water purchase cost compared with mains supply	An initial search for water can be expensive. Typically, you would need to commission a geologist's report. Test bores (used in the first instance to see if you can find water, check flow rates and water quality) may add substantial cost
If abstracting less than 20m^3/day, you may not need a licence	There is no guarantee that water of sufficient flow rates or quality will be found
You have the security of your own supply	There is a capital cost to installing a borehole. The total cost for drilling a bore (additional to the test bore), installing a pump, electrical supply, filters, pressure vessels, tanks or reservoirs, etc. could cost between £10,000 and £30,000
	Running costs include electricity or fuel cost for the pump, service and maintenance cost for pumps, filters, etc. labour cost to keep it running and an annual EA licence, if required
	The cost per m^3 abstracted will be significantly less than mains supply but it is not 'free'

> **!** **Think about**
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> The cost of disposal of dirty water can be as expensive as the cost of mains water purchased from a water company. So, if abstracted, borehole water is used excessively, for example, for parlour wash down or plate cooling (without reuse), the cost of dirty water disposal can eliminate much of the savings you hope to achieve.

Regulation and legislation

- From 1 April 2005, an amendment was made to the Water Act 2003 that deregulates abstractions of less than $20m^3$/day. The law now permits you to abstract up to a maximum of $20m^3$/day without the need for a 'Licence to Abstract Water'. This is subject to two important conditions. (1) You have a legal right to the source of supply (ie it is on your land). (2) The abstraction is not part of a series of abstractions from the same source totalling a quantity greater than $20m^3$/day
- If you already abstract $10m^3$/day from a spring and you put in another well or borehole that draws from the same source, that new borehole must take less than $10m^3$/day, ie a total of no more than $20m^3$/day
- If you want to abstract more than $20m^3$/day from a water source, you will need to apply to the Environment Agency for an abstraction licence
- It is important to note that $20m^3$/day is a maximum daily rate and cannot be averaged, so every day you do not pump, you forego $20m^3$ of water
- Planning permission may be required for wells and boreholes and even test bores. Different planning authorities appear to interpret the planning guidance differently. You are, therefore, strongly recommended to speak to your local planning authority before you proceed
- Dairy hygiene regulations require that any water used for hand, udder or dairy plant washing must be from a potable source. If this is not a mains supply, the local Environmental Health Officer will need to assess water quality on an annual basis
- It is recommended you put a meter on your own supply, firstly to monitor your own use but also to demonstrate to the EA that you are complying with your licence or the $20m^3$ exemption.

Water supply (water fittings) regulations 1999 must be complied with on all premises with mains supply. In essence, the backflow of potentially contaminated water must not be allowed to enter a mains supply network. Air gaps are needed between mains supply and non-potable water, an air gap is simply an open space between any device that connects to a plumbing system (like a valve) and any place where water can collect or pool. This is used to protect potable water supplies from contamination or pollution due to backflow.

If you wish to abstract water from an underground source, such as a well or borehole, you will usually require a groundwater investigation consent to construct and then carry out a pumping test before you can apply for an abstraction licence. This helps identify whether the water you want is available and, by monitoring the surrounding sources and groundwater dependent features, assess the impact on other water users and the environment.

Once you have an abstraction licence, (which is issued for a time-limited period, normally 12 years) you forfeit the $20m^3$ exempt right. An abstraction licence will normally have conditions, eg a restriction during drought periods. Once you have a licence, you cannot go back to the 'exempt status' without giving up the licence.

Capital costs

It is important to ascertain the capital and running costs of options prior to installation, Table 3.2 has been designed as an example to work through the running costs and calculate a return on capital of a borehole. Similar principles apply to abstractions from other alternative sources.

Table 3.2: Estimating your capital costs

Item	Estimate your costs (£)
Capital/one-off item cost: For abstractions of 4,000m^3 to 20,000m^3/yr	
Geologists' report	
Abstraction licence application fee (if required)	
Admin fee	
Advertising cost	
Test bore	
Main borehole	
Borehole pump	
Pump shed	
Electrics, tanks, pumps, pressure vessels, pipework, filters, etc.	
Total estimated range in capital or one-off costs	
Annual running costs	
Annualised capital costs	
EA abstraction licence fees (consider length of time and APR, eg over 25years @ 7% APR)	
Borehole maintenance/service cost	
Labour costs	
Electricity costs	
Total annual running costs	
£/m^3	

Rainwater harvesting

- Rainwater harvest/collection off roofs or other clean areas can make a significant contribution to water supply
- Higher rainfall areas or large catchment areas obviously have greater potential
- Quantities collected will also be influenced by roof area, slope and construction materials
- Small volumes can contribute to yard wash down which require minimal filtration but, if collecting larger volumes for stock drinking it is advisable to filter/treat this water to avoid potential contamination
- Water storage can be a significant cost with these systems. If you have or can acquire, inexpensive water storage, this will make the economics much more attractive
- It is not uncommon for collected roof water to contain debris or bacteriological contamination (E.coli and salmonella), the use of diverters should be considered to divert the first portion of collected water to waste, as well as fitting ultra violet (UV) filters or other systems
- Good quality water that has been filtered and passed through a UV filter can be stored for around three weeks, however, untreated water can become unsuitable after three days
- If investing in new buildings, it would be worthwhile considering implementing rainwater harvesting from the outset to keep installation costs at a minimum.

Key steps to take when considering rainwater harvest

1. Find out your local rainfall data
2. Calculate your roof area availability for collection
3. Consider what is an acceptable return period for your business
4. Work out the maximum you can afford to spend to achieve your target return or payback period
5. Work out your water store size and the overall cost of your project.

Table 3.3: Potential advantages and disadvantages of rainwater harvesting

Potential advantages	Potential disadvantages
A significant potential cost saving compared with mains supply	Potential contamination from bird/vermin droppings entering the store is a risk. If water is only to be used for yard wash down, this may not be an issue
Security of additional 'on-farm' water supply	Some roof materials may be unsuitable for this method of water collection, eg bitumen or painted surfaces
No licences required	Filtration/treatment is recommended for drinking water or water used for dairy plant cleaning, this will add to the capital costs
Capital costs can be modest	Rainwater lacks some minerals which may be important for livestock if this is the only source of water used for drinking
Easy to incorporate on a new building for minimal extra capital cost	Water storage will typically be the largest cost
On average, your water collection volumes are predictable and you can plan for a known payback period	Finding a site for a tank or lagoon can be an issue on many existing units
	Running costs: there will be some running costs for pumps, filters, etc. but this will be modest if spread over sufficient volume of collected water

- Don't forget the hidden disposal cost from excessive water use. Collected roof water is often regarded as 'free', however, the cost per m^3 of harvested water will be significantly less than mains supply but not 'free'
- More importantly, the cost of disposal of dirty water can be significantly more expensive than the cost of water purchase from a water company. So, if harvested water is used excessively, for example, for parlour wash down or plate cooling (without reuse), the cost of dirty water disposal must also be taken into account.

Regulation and legislation

- Rainwater harvest/collection is not regulated. It is encouraged by the Environment Agency
- Planning permission may be needed for structures such as tanks, lagoons or pump sheds, depending on size and location. You are, therefore, recommended to speak to your local planning authority before you proceed
- Dairy hygiene regulations require that any water used for hand, udder or dairy plant washing must be from a potable source. If this is not a mains supply, the local Environmental Health Officer will need to assess water quality on an annual basis
- Collected rainwater will need to be filtered/treated to achieve the required standard if it is to be used for hand, udder or dairy plant cleaning
- The Red Tractor Farm Assurance Scheme requires water for drinking to be 'fresh and clean'
- Water supply (water fittings) regulations 1999 must be complied with on all premises with mains supply. In essence, the backflow of potentially contaminated water must not be allowed to enter a mains supply network. Air gaps are needed to protect potable water supplies from contamination or pollution due to backflow.

Table 3.4: Rainwater harvest volume calculator

Enter your figures below

Roof or yard area for collection	Length	Width	Area m²
Parlour, dairy, collecting yard building	48	22	1056
Subtotal of areas m²		a	
Annual rainfall est. mm/1,000 = metres	Rainfall mm/1,000	b	
Total potential annual rainwater harvest (m³)		a x b = c	
Less run-off losses (or drainage coefficient)*	eg x 0.9	d	
Subtotal		c - d = e	
Less filter efficiency factor**	eg x 0.9	f	
Total harvested water available (m³)		e - f = g	

***Run-off factor or drainage coefficient**

Not all rain falling on a roof or collection area will be collected; light rainfall will only wet the roof and then evaporate, heavy rainfall can overflow from the gutters and, therefore, not be captured so a 'run-off factor' or 'drainage coefficient' is used to adjust the rainfall volumes collected. Table 3.5 below shows which drainage coefficient to use for different roof types.

Table 3.5: Drainage coefficient (run-off factor)

Roof type	Drainage coefficient
Pitched roof – tiles or fibre cement corrugated sheets (typical of most agricultural buildings)	0.75 – 0.9
Flat roof smooth tiles	0.5
Flat roof with gravel layer	0.4 – 0.5

****Filter efficiency**

The amount of water captured also depends on the efficiency of filtration if any is used. If a filter system is incorporated, most manufacturers recommend that a factor of 90% of the potential input be used. This means that a filter efficiency factor of 0.9 is also included in the calculation.

Rainwater harvest volumes

Table 3.6: Potential annual collection volumes (m³) after deduction of drainage and filter factors

Collection area m²	Annual average rainfall (mm)										
	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500
250	101	122	142	162	182	203	223	243	263	284	304
500	203	243	284	324	365	405	446	486	527	567	608
750	304	365	425	486	547	608	668	729	790	851	911
1,000	405	486	567	648	729	810	891	972	1,053	1,134	1,215
1,250	506	608	709	810	911	1,013	1,114	1,215	1,316	1,418	1,519
1,500	608	729	851	972	1,094	1,215	1,337	1,458	1,580	1,701	1,823
2,000	810	972	1,134	1,296	1,458	1,620	1,782	1,944	2,106	2,268	2,430
2,500	1,013	1,215	1,418	1,620	1,823	2,025	2,228	2,430	2,633	2,835	3,038
3,000	1,215	1,458	1,701	1,944	2,187	2,430	2,673	2,916	3,159	3,402	3,645
3,500	1,418	1,701	1,985	2,268	2,552	2,835	3,119	3,402	3,686	3,969	4,253
4,000	1,620	1,944	2,268	2,592	2,916	3,240	3,564	3,888	4,212	4,536	4,860
4,500	1,823	2,187	2,552	2,916	3,281	3,645	4,010	4,374	4,739	5,103	5,468
5,000	2,025	2,430	2,835	3,240	3,645	4,050	4,455	4,860	5,265	5,670	6,075

Drainage factor 0.9
Filter factor 0.9

Store size

Tank or lagoon/resevoir size required for water collection will depend on a number of factors, including:

- Local annual rainfall and storm intensity
- Catchment area
- Run-off factor or drainage coefficient
- Filter efficiency factors
- Average water usage rates and daily use fluctuations
- Potential future increase in catchment area.

Think about

As a rule of thumb, a store with capacity to collect approximately 1 to 3% of the annual volume will ensure it has sufficient capacity to collect rainfall during heavy rainfall conditions, assuming consistent daily usage. If usage is less regular, a 5% capacity may be more appropriate.

Think about

Collection from a large single roof area will generally be simpler and cheaper than collection from numerous smaller roofs.

Inexpensive rainwater collection in an old milk tanker body

Table 3.7 and 3.8 below are to help you calculate the capital or one-off costs of a rainwater harvest system. Fill in your own figures below.

Table 3.7: Capital or one-off costs of a rainwater harvesting system

Typical capital one-off items	Notes	Your costs (£)
Alteration of gutters and down pipes	Likely to be minimal cost on new buildings	
Filters for down pipes	DIY or proprietary models are available	
Laying and diverting rainwater pipes to rainwater store		
Rainwater store, eg tank or lagoon	Storage should be approx. 1% to 3% of annual collection. Storage can be second-hand tanks, reservoirs or lagoons	
Pump shed	To house pumps, filters, pressure vessels, etc. A garden shed or second-hand container body could suffice	
Electrics, tanks, pumps, pressure vessels, pipework, filters, etc.	Variable cost depending on what is needed	
Other one-off costs		
Total one-off costs		
Annual depreciation cost	eg depreciation on capital (stores, sheds, etc). £5,000/25 years = £200/year maintenance (filters, pumps, etc.) £500/5 years = £100/year	
Average annual interest charge on capital spent	Use amortisation tables or cost of interest on half the capital spend, eg £2,500 @ 7% = £175	
Average annual depreciation and interest cost	Transfer to table overleaf	

Table 3.8: Annual running costs of rainwater harvest

Typical annual running costs:	Notes	£
Average annual depreciation and interest cost	Transferred from table overleaf	
Cost of electricity to run pumps	Pump kw x cost p/kwh eg 2kw x 12.6 = £0.252/hour run time x 5 hours/week = £65.50/year	
Cost of disposable filters		
Service and maintenance requirements		
Labour input to maintain	Assume 0.5 hours/month 6 hours x £10/hour = £60/year	
Other annual running costs		
Total annual cost		
Estimate of rainwater harvest m^3		
Average cost per m^3 of harvested rainfall		

Return on capital

A simple way to consider return on capital is to set yourself an acceptable return or payback period, perhaps payback over four years. From water volumes collected, you can set yourself a maximum total investment to achieve your target return. For example, if you live in a 1,000mm rainfall area and have 1,500m^2 of roof area you have the potential to collect 1,215m^3 of rainfall (after deduction of drainage and filter factors). If your local water company charges you £1.39/m^3, you have scope to save £1,688/year on your water bill. As long as you spent no more than £6,752 to set up your rainfall collection system, this would give you a payback over four years. This is a better return than many capital investments.

Enhanced Capital Allowance

The Enhanced Capital Allowance Scheme is part of the Government's programme to manage climate change, it enables businesses to claim 100% first year capital allowances on investments in technologies and products that encourage sustainable water use. Businesses are now able to write off the whole cost of their investment against their taxable profits of the period during which they make the investment. This includes rainfall harvest technology. Products must be on an approved list of energy saving criteria to be eligible for the scheme.

Stock drinking directly from water courses

- If you have ditches, ponds, streams or rivers that stock can drink from, you may consider using them, as this can amount to a significant saving in drinking water costs. However, best practice under the Water Framework Directive (WFD) seeks to discourage farmers and land managers from doing this due to disease risks from contaminated water and the likelihood of diffuse pollution as a result of erosion of banks, habitat damage, sedimentation and poaching.
- In future, direct access to water courses for livestock drinking may be restricted as a result of the WFD and associated drinking water regulation requiring more stringent water quality standards.

Think about

There are certain risks and issues associated with allowing stock to drink directly from water courses that must be considered.

- Ensure the stock have access to an adequate supply of clean water from the water course
- There can be health risks to stock from access to water courses. Test the water from any proposed water courses and consult your vet regarding specific risks to your stock on your farm
- Allowing uncontrolled stock access to water courses can cause bank erosion, contamination and damage to habitats and this is a concern to the Environment Agency in certain river catchments. Dedicated and properly constructed access points for stock drinking can reduce some of these risks.

Indirect drinking with the use of pumps to troughs or stock operated drinkers such as pasture pumps can also overcome the problems above. New technology in solar operated pumps may also be an option to consider.

To protect watercourses on your farm

- Fence off watercourses in fields that are regularly used for keeping livestock
- Provide alternative drinking arrangements with pasture pumps, etc.
- Construct livestock crossings for watercourses regularly used by livestock.

Stock operated pasture pump

4 | Understanding water quality on dairy farms

Dairy cows need a plentiful supply of good, clean water to promote good health and encourage effective uptake of nutrients from their diet. It is essential that water is not only supplied in sufficient quantity but also of good quality. Inadequate water quality can lead to reduced milk yields and impact on animal health.

A growing number of dairy farmers are seeking to source water from alternative sources such as borehole, springs, canals, rivers, lakes or rainwater harvest as the cost of mains water increases.

Alternative water supplies can provide a significant reduction in the cost of mains water supply. However, it is essential the potential source is tested for quality and suitability, alongside being resource efficient in terms of water use and management.

Categories of water

The type of water used in livestock units (on-site) and the type of wastewater generated by farm operations determines how much you pay for your water supply and disposal of wastewater.

Table 4.1: Types of water and wastewater in the UK

Water sources	Wastewater types
• Mains water (potable, eg drinkable and non-potable) • Water abstracted from groundwater (borehole) and surface water	• Domestic wastewater (sewerage) • Trade effluent • Surface drainage (roof and site run-off) • Discharge to surface water and groundwater

Source: Envirowise

Water can be categorised into types based on its source and relative quality. Colours are often used to refer to water quality (or type) as described below.

Blue water

This is potable water, defined as water which has been treated to a standard suitable for human consumption. For example, in a dairy unit potable water must be used for internal plant cleaning, hand and udder washing. Water for animal consumption does not need to be of this standard unless specified in the farmer's own farm assurance scheme. However, it may be advisable that water for livestock consumption is 'treated' to some extent, to ensure it does not present any animal or food safety concerns.

Green water

This is rainwater which falls on land that does not run off or recharge the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation. Eventually, it evaporates or transpires through plants. Green water can be made productive for plant growth.

Grey or dirty water

This is water which has been used in some way but may still be suitable for additional uses without further treatment. For example, blue water used for cleaning parlours can be considered grey water and could potentially be reused for external parlour/yard wash down on farms. Rainwater or groundwater which has been collected and stored is also considered grey water.

Effluent

This is wastewater which cannot be used for other purposes. It must either be discharged to the sewer or treated prior to reuse. Water which comes into contact with dairy excrement, either from washing (cleaning) housing, parlours or feeding, loafing and yard areas, **is not classified as effluent** – it is classified as dirty water. However, Integrated Pollution Prevention Control (IPPC) guidance and Code of Good Agricultural Practice (CoGAP) states that this water must be contained separately to slurry/manure storage, it must not be allowed to enter surface or groundwater and should either be spread to land or disposed off site.

Why and how to take a water sample

If non-mains water is being used for drinking water (whether livestock, human or both), the quality of water must be established to ensure it is clean and fresh. Some sources of non-mains water may be suitable for drinking without any further treatment, however, it is essential any contaminated water is purified to prevent the risk of disease. Both collected roof water or water from a borehole has the potential to contain pollutants or debris, be nutrient or mineral rich or have bacteriological contamination (E.coli and salmonella).

! Think about

When collecting the water sample, the following procedure **must** be followed:

- Use a sterilised sample bottle
- Send a sufficient sample size (check with the laboratory how much is required)
- Fill the container, reducing the amount of air space
- Sample during times when animals are drinking
- Sample from the inlet, not from the water trough
- Samples should arrive at the laboratory within 24 hours.

Interpreting water test results

Water quality is measured for chemical, microbiological and indicator parameters. It is vital that potential water sources are within permissible levels. Table 4.2 outlines the mandatory parameters, detailing the unit of measurement and maximum permissible level which drinking water should achieve.

- Chemical parameters cover mandatory requirements such as lead, nitrate, nitrite, copper, cadmium and pesticide levels, among others
- Microbiological parameters cover mandatory requirements such as *Escherichia Coli* (E-coli) and Total Coliform Bacteria
- Indicator parameters cover requirements such as chloride, turbidity, Clostridium Perfringens, conductivity and sulphates, among others.

Depending on the intended use of your water source (eg whether it is purely for animal consumption or whether it needs to be fit for human consumption), there is some flexibility within the permissible levels. The levels presented in Table 4.2 are deemed fit for both human and animal consumption.

Units of measurement:

- mg/l – milligrams per litre (parts per million)
- cfu/100ml – colony forming units per 100ml
- µg/l – micrograms per litre (parts per billion)
- NTU – nephelometric turbidity units
- µs/cm – siemens per centimetre

Table 4.2: Water test analyses

Determination	Explanation	Unit	Prescribed concentration value (PCV) (permissible level)
pH	pH affects water palatability and intake. pH is dictated by the mineral and trace element content of water and is normally between 6.5 and 7.5. The preferred pH of water for dairy cows is 6.0 to 8.5.	-	6.5-9.5
Total dissolved solids (TDS)	TDS is the sum of all of the inorganic contaminants. Drinking water with less than 1,000mg/l TDS is ideal for dairy cows. Levels between 1,000-3,000mg/l are usually satisfactory but may cause reduced performance, depending on the exact contaminant causing the elevated TDS. Levels above 3,000mg/l are likely to cause poor tasting water, which may lead to reduced water intake and milk production.	mg/l	<1,000 = good 1,000-3,000 - satisfactory
Nitrate (NO_3)	Nitrate-Nitrogen levels above 20mg/l in drinking water can begin to present herd health issues. Levels above 100mg/l may affect fertility, growth and oxygen carrying capacity of the blood.	mg/l	50
Nitrite (NO_2)	Nitrite occurs at much lower levels in the environment than nitrate and conversion from one form to another occurs readily. The Regulations also require that the nitrate: nitrite ratio [nitrate]/50+[nitrite]/3 is ≤ 1.	mg/l	0.5
Ammonium Nitrogen (NH_4)	Ammonia is the most reduced form of nitrogen and is found in water where dissolved oxygen is lacking. When dissolved oxygen is readily available, bacteria quickly oxidise ammonia to nitrate through a process known as nitrification. Important sources of ammonia to lakes and streams can include: fertilisers, human and animal wastes.	mg/l	0.5
Cadmium (Cd)	These substances are rarely found in drinking water. On the very rare occasions that they do occur, they are normally derived from rocks through which water has passed or some can arise from industrial processes. Antimony can be leached from non-lead solder in domestic plumbing. The standards provide wide safety margins on known levels of toxicity.	µg/l	5
Calcium (Ca)	Calcium is mostly a measure of water hardness, hard water can cause aesthetic problems by reducing water flow from the build-up of mineral deposits (lime scale) but generally has little effect on animal performance or intake levels. Levels above 500mg/l are considered to be extremely high.	mg/l	500
Magnesium (Mg)	Magnesium is also a measure of water hardness, hard water can cause aesthetic problems by reducing water flow from the build-up of mineral deposits (lime scale) but generally has little effect on animal performance or intake levels.	mg/l	250
Sodium (Na)	Sodium salts occur naturally in water but can be added to drinking water by water softeners if these are not installed properly. Sodium at levels around 200mg/l may cause a salty taste in the water. Sodium in drinking water is rarely a problem for dairy cows.	mg/l	200
Iron (Fe)	Iron is a common pollutant which occurs naturally in groundwater or from nearby mining activities, both cause staining and give a metallic (bitter) taste to water which results in reduced water intake and milk production.	µg/l	200

Determination	Explanation	Unit	Prescribed concentration value (PCV) (permissible level)
Lead (Pb)	Lead was formerly used as a plumbing pipe material. High lead levels can be a health risk, particularly to young children. A significant number of houses, especially older properties, may have lead pipes. Soft water can dissolve lead pipes and we, therefore, treat water to reduce the lead uptake. Water as it leaves treatment works is virtually lead free.	µg/l	25
Manganese (Mn)	Manganese is also a common pollutant which occurs naturally in groundwater or from nearby mining activities, both cause staining and give a metallic (bitter) taste to water which results in reduced water intake and milk production. Manganese concentrations exceeding 50µg/l are sufficient to cause a bitter taste to the water.	µg/l	50
Chloride (Cl)	Chloride may occur naturally in water from deep brines or from activities such as road de-icing, levels above 250mg/l can leave a salty taste which leads to reduced water intake and milk production. Herds with high chloride in the water should consider this when formulating diets to prevent an excess, which could be detrimental to rumen function.	mg/l	250
Sulphates (SO_4)	Sulphur/sulphates when present above 500mg/l can have a laxative effect, therefore reducing feed efficiency. Effects on copper, vitamin E and selenium absorption can also be seen at higher inclusion levels.	mg/l	250
Copper (Cu)	Copper is usually present in water from corrosion of metal pipes, in mining areas or from the treatment of ponds with copper sulphate algaecides. Copper levels above 0.5mg/l may cause a metallic taste, resulting in reduced intake and milk production. High copper concentrations may also cause liver damage.	µg/l	2,000
Aluminium (Al)	Aluminium occurs naturally in water and is also used during treatment to remove impurities. Although an early research study suggested a link between aluminium and Alzheimer's Disease, there is no proven connection and most experts now believe low levels of aluminium in water are not significant.	µg/l	200
Total Coliform Bacteria	Coliform bacteria will be present in all surface waters (streams, ponds) and many groundwater wells. Disinfection during treatment removes bacteria.	cfu/100ml	0
Escherichia Coli	The presence of E-coli bacteria is much more serious than total coliform bacteria. E-coli bacteria occur from direct contamination by animal or human waste. It is recommended that drinking water for cattle should have no E.coli or faecal coliform bacteria.	cfu/100ml	0
Clostridium perfingens	Clostridia have a widespread distribution, mainly occurring in soils. They produce spores which can persist in the environment for years.	cfu/100ml	0
Colour (Pt/Co)	Upland waters passing through peaty soils can have a natural yellowish tinge. The colour is not harmful and can be removed by treatment.	mg/l	20
Conductivity	This is a measure of the level of natural mineral salts contained in water.	µs/cm	2,500
Turbidity	This is a measure of suspended material in the water.	NTU	4

Think about

It is important to consider water intake and quality, as well as the total nutrient intake within the rest of the diet, including forage, concentrates and supplements. This will give an accurate assessment of total minerals and ratios rather than only considering the feed at the barrier or in the parlour.

Improving water quality and purification

There are various options for water purification, the type of purification technique or treatment required will be dependent on remedies required.

Think about

It is recommended to seek professional advice to determine the most practical solution for your farm. Prior to any investment, a review and assessment of an existing borehole (or abstraction source) is recommended before moving onto specific remediation actions.

Water quality improvement and purification methods are explained below, separated into filtration, chemical treatment and membrane processes.

Filtration

- **Ultra-violet filtration (UV)** – sterilisation is a common, non-chemical method which is often used on rainwater harvesting systems which store water. UV treatment allows water to be treated quickly at a relatively low cost due to low capital investment. Good quality water that has been filtered and passed through a UV filter can be stored for around three weeks, however, untreated water can become unsuitable after three days.
- **Rapid gravity filters** – are used to remove particles from coagulated waters. They can also be used to remove turbidity, algae, iron and manganese from raw waters. A granular activated carbon medium is used to remove organic compounds and alkaline filters are used to neutralise the pH of acidic water. The size of a rapid gravity filter is determined by the filtration rate if backwashed automatically or by the retention of solids if backwashed manually. Filters should normally have sufficient area to enable them to be operated at a maximum 6m/hr at peak flow or to retain 1kg of solids per square metre of bed between washes at peak loading, whichever is greater.
- **Adsorption filters** – activated carbon removes contaminants from water by physical adsorption. Adsorption will be affected by the amount and type of the carbon, the nature and concentration of the contaminant, retention time of water in the unit, and general water quality (temperature, pH, etc). Activated carbon filters will remove (to varying degrees) suspended solids, chlorine and organic contaminants including pesticides, trihalomethanes (THMs) and some of the humic substances which are responsible for the yellow to brown colouration in 'peaty' waters.

Chemical treatment

- **Taste and odour removal** – taste and odour can be removed by several methods, including aeration, ozonation and adsorption on activated carbon. The method used will depend on the source of the taste and odour. For example, adsorption on activated carbon is generally the most effective method for the removal of 'earthy' or 'mouldy' taste and odour.
- **Nitrate removal** – is usually achieved by ion-exchange. Water is passed through a column of synthetic resin beads that remove anions, including nitrate and exchange them for equivalent amounts of chloride. When the capacity for exchange is exhausted, the resin is

regenerated by backwashing with a concentrated solution of sodium chloride. This restores the resin to its initial chloride form. The bed is then rinsed with clean water and returned to service. The waste solution and rinse waters, containing high concentrations of sodium chloride, as well as nitrate, require correct disposal.

- **Water conditioners** – the use of ion-exchange softeners can be beneficial to aid the removal of calcium and magnesium in order to prevent scaling and encrustation with limescale from very hard waters. Softening is achieved by cation exchange. Water is passed through a bed of cationic resin, the calcium ions and magnesium ions in the water are replaced by sodium ions. Unlike the carbonates and bicarbonates of calcium and magnesium, sodium carbonates and bicarbonates do not cause scale formation or increased use of soap for washing. When the ion-exchange resin is exhausted, ie sodium ions are depleted, it is regenerated using a sodium chloride solution.

Membrane processes

The membrane processes of most significance in water treatment are reverse osmosis, ultrafiltration, microfiltration and nanofiltration. These processes have, traditionally, been applied to the production of water for industrial or pharmaceutical applications but are now being applied to the treatment of drinking water.

These techniques tend to be cost prohibitive, with high capital expenditure and a long payback. Reverse osmosis can also result in a high volume of water being wasted as it is not fit for consumption, therefore must only be used for activities where potable water is not required. These techniques can cost many tens of thousands of pounds, dependent on required annual volume and flow rate.

Think about

Membrane processes can provide adequate removal of pathogenic bacteria, Cryptosporidium, *Giardia* and potentially, human viruses and bacteriophages. However, they should not be relied upon as the sole means of disinfection as there is no simple means to check membrane integrity to warn of any potential breakthrough of microorganisms.

- **Reverse osmosis** – results in the production of a treated water stream and a relatively concentrated waste stream. Typical operating pressures are in the range of 15-50 bar depending on the application. Membrane pore sizes are less than 0.002 micron.
- **Ultrafiltration** – is similar in principle to reverse osmosis but the membranes have much larger pore sizes (typically 0.002-0.03 micron) and operate at lower pressures. Ultrafiltration membranes reject organic molecules of molecular weight above 800 and usually operate at pressures less than 5 bar.
- **Nanofiltration** – uses a membrane with properties between those of reverse osmosis and ultrafiltration membranes; pore sizes are typically 0.001-0.01 micron. Nanofiltration membranes allow monovalent ions such as sodium or potassium to pass but reject a high proportion of divalent ions such as calcium and magnesium and organic molecules of molecular weight greater than 200. Operating pressures are typically around 5 bar. Nanofiltration may be effective for the removal of colour and organic compounds from water.
- **Microfiltration** – is a direct extension of conventional filtration into the submicron range. Microfiltration is capable of sieving out particles greater than 0.05μm and will remove most bacteria. It has been used for water treatment in combination with coagulation or powdered activated carbon (PAC) to remove viruses, bacteria, dissolved organic carbon and to improve flow.

5 | Management of dirty water

Considerable quantities of dirty water, composed of milking parlour wash-water, milk spillages, run-off from cattle yard areas and, possibly, effluent from silage and manure, are produced on dairy farms.

Almost all dairy farms have at least one form of dirty water storage system, whether as a separate system, combined with slurry storage or a combination of both. The need to store and then dispose of dirty water creates a cost.

You may also hear dirty water referred to as 'grey water', this means that the water has already been used in some way, it may be suitable for additional uses, for example, blue water used for cleaning parlours can be considered grey water and could potentially be reused for external parlour/yard wash down on farm.

Dirty water disposal by tanker adds to your running costs

! Think about

Reducing the amount of water collected and disposed of can reduce costs, particularly energy and labour costs, so effective management of dirty water can be a good opportunity to save money.

The first step in assessing dirty water storage systems should be to review where your dirty water comes from. On many farms, clean water, such as rainwater from buildings or clean yards, enters the dirty water storage system – any clean water entering dirty water systems adds extra cost. Steps taken to divert clean water away from the dirty water storage system are often found to be cost-effective.

Often, diverting dirty water simply requires repairs to existing infrastructure, such as downspouts and leaking pipes and this will almost always be more cost-effective than allowing clean water into the dirty water system. New infrastructure, such as installing new guttering, creating new ditches and roofing over dirty yard areas to divert clean water away from dirty water systems, is often more expensive than repairs to existing infrastructure but it may be economically justified given the cost of managing dirty water. Completing a cost-benefit analysis will allow you to assess this on a per project basis.

Reducing the amount of dirty water that needs to be stored and disposed of is an effective method of reducing costs, for example, by changing the hose type used during wash down. Reducing the amount of rainwater collected in dirty water stores will also support effective management, potentially reducing pressure on slurry storage facilities where these are combined. Intercepting clean water before it becomes dirty is generally the most effective method of achieving this, for example, by using new kerbs, sleeping policemen and adjusting kerb levels.

For farmers within Nitrate Vulnerable Zones, dirty water management can be important when assessing slurry storage requirements. Reducing the amount of dirty water collected in slurry storage facilities could allow slurry storage requirements to be met without needing to build new facilities, while continuing to include rain and wash water at the current rates could mean new slurry storage facilities are required.

Think about

For example, on a 150-cow herd farm with an average rainfall of 633mm between October and February with a surface area of 2,000m^2 draining to the slurry store combined with wash water using a high volume washer, typical water and slurry storage requirements total 627m^3 per month, over this period. If the wash water system was changed to a low volume hose, the storage requirement could be reduced to 582m^3 per month, over this period. Changing yard management to increase the area of clean yards and reduce the area from which rainwater is collected to 1,500m^2 reduces storage requirements to 518m^3 per month.

Where dirty water and slurry storage systems are combined, slurry separation can be used to support the efficient management of these resources. The solid fraction can, for example, be used as higher dry matter manure with higher nutrient concentrations than more dilute mixtures, potentially reducing the amount of artificial fertiliser required (see table below).

Slurry separation reduces liquid volumes by about 20% – potentially reducing the amount of storage required, the liquid component can be pumped and spread more easily and cheaply than thicker slurries. Changing dirty water and slurry application methods can also be effective in maximising the value of nutrients. Using either slurry injection or a trailing shoe can increase the efficiency with which nitrogen is applied and reduce the need for artificial fertiliser.

Slurry separator

The type of storage facility used for dirty water storage and slurry storage if the systems are combined, will also contribute to the overall costs associated with managing dirty water. This means the dirty water storage facility used, particularly if additional capacity is required, could have a significant impact on the costs associated with storing your dirty water.

Table 5.1: Cattle slurry and dirty water – total and available nutrients

	Dry matter (%)	Total nitrogen (kg N/m^3 or kg N/t)	Readily available nitrogen (kg N/m^3 or kg N/t)
Slurries/liquids			
Cattle slurry	2	1.6	0.9
	6	2.6	1.2
	10	3.6	1.3
Dirty water	0.5	0.5	0.3
Separated cattle slurries (liquid portion)			
Strainer box	1.5	1.5	0.8
Weeping wall	3	2.0	1.0
Mechanical separator	4	3.0	1.5
Separated cattle slurry (soil portion)	20	4.0	1.0

6 | Water technologies and other innovative ideas

New developments and technologies can provide opportunities for water use saving.

Certain products/technologies involving water use may deliver positive benefits, for example, for herd health, energy saving or labour saving but may result in more water use.

Smart meter technology

Smart meter technology in itself is not a new technology, however, priority usage has been in areas such as electrical and gas metering. In terms of water consumption, this is still very much an emerging technology, constantly improving through new innovation and development. The concept of smart metering helps you to understand and control your water consumption.

Readings can be taken directly from a laptop or separately using a reader. Information can be collected from up to 100m from its location (distances will vary dependent on obstacles such as walls or if the meter is below ground). This makes collection of information significantly easier than manually reading a meter, as frequently, meters are not easily accessible. Once downloaded to the laptop, the meter information can be displayed, showing the current status of it.

Smart meters will typically provide the following information:

- Type of supply
- Number of operating hours
- Current meter reading
- Total consumption in the last month
- Potential faults detected downstream of the meter
- Submetering of different usage areas on larger farms is possible.

Smart meter

Think about

While smart meters can be of added use for monitoring water use, particular attention should be taken to establish data retrieval processes prior to installation.

As with all available products, carefully consider the potential advantages and disadvantages to your business, prior to investment.

Points to consider with new on-farm technologies and innovative ideas

Examples of innovative ideas which may save water usage

- Low volume foot baths or washing foot baths
- High-pressure bulk tank washing systems can save 30% to 60% over older bulk tank wash systems. This is highly relevant when you are due to change your bulk tank
- If a proportion of summer drinking water could come from a farm's water course (rivers, ditches, ponds or lakes) this could have a significant impact on water costs. Solar technology may provide a solution to reduce bank erosion and contamination as well as reducing the use and cost of mains supply water.

Examples of innovative ideas which may increase water usage

- Teat wash systems – an auto brush wash system for udder cleaning
- Parlour auto floor wash systems – may be very effective for parlour cleanliness and labour saving but may lead to more water use
- Water use in flood washing systems. Volumes of water use are large and so reuse of water is vital on such systems. These systems can provide benefits in terms of labour saving and cow foot health but can provide challenges for water reuse, slurry separation and odour.

Regulation and legislation

- Dairy hygiene regulations require that any water used for hand, udder or dairy plant washing must be from a potable source. If this is not a mains supply, the water needs to be assessed annually by a local Environmental Health Officers to ensure its quality
- The Red Tractor Farm Assurance Scheme requires water for drinking to be 'fresh and clean'
- Water supply (water fittings) regulations 1999 must be complied with on all premises with mains supply. In essence, the backflow of potentially contaminated water must not be allowed to enter a mains supply network. Air gaps are needed to protect potable water supplies from contamination or pollution due to backflow.

7 | Carrying out a water audit and action plan

A water audit is simply a way of working out where, when and how much water you use. The action plan helps you identify where you can reduce the amount of water you use. To carry out a water audit and develop a water management plan, you need to follow five simple steps, (a more detailed investigation may be needed for some farms):

Step 1: Identify how much water you are using and how much it costs

Step 2: Carry out an inventory of the water you use

Step 3: Calculate how much water you should be using

Step 4: Identify and compare water efficiency activities to reduce the amount of water used

Step 5: Create, implement and review your action plan

The following information will help you during these steps:

- Water bills from the last two years (a longer record will make your assessment more accurate)
- Details of any abstraction licence(s) you hold
- The number and type (species and age) of livestock on your farm
- Crop protection and irrigation records
- A map of the water network on your farm showing water pipes and uses.

Step 1: Identify how much water you are using and how much it costs

Identify all your sources of water on the farm

Possible water sources include:

- Mains water supplied by your water supply company; water abstracted from rivers, streams, canals, springs or boreholes
- On-farm ponds or other winter-stored water
- Reused water, such as plate cooling water or harvested rainwater.

Use Form 1 in Appendix 2 to record the amount and cost of the water that you use each year. If you collect or recycle any water, such as rainwater or plate cooling water, you will need to include this.

Table 3.4 Rainwater harvest volumes on page 21 will help you calculate roof water collection volumes. Once you have a record of the water you use, you can use this to help you understand any seasonal changes in your water-use patterns and it will also enable you to watch out for unexpected changes. Plotting your water use on a graph may help.

Calculate the cost of the water you use

Water costs you more than just the amount printed on the bill from your local water company or the Environment Agency, so do not forget the hidden costs.

Costs include:

- Mains water and standing charge (from your water company)
- Abstraction licence charge (from the Environment Agency)
- Recycled water (pumping, storage and capital)
- Dirty water (storage, treatment, disposal and capital)
- Staff time (operational and maintenance).

Understanding the true cost of water is crucial in managing the water you use. Often, costs are unknown and you may make the mistake of thinking they are too low to be of concern.

Step 2: Carry out an inventory of the water you use

Once you have found out how much water you use and how much it costs, the next step is to find out where you use it.

Forms 2 and 3 (Appendix 3) will help you to review how much water your equipment and animals use.

Examine how you use water

After completing forms 2 and 3 you can now examine how you use water. Do you need to:

- Use as much as you do? Are hoses or taps left running? Are dripping taps fixed quickly?
- Use high quality water for that activity? Consider collecting rain and used water for washing down yards. Check whether any hygiene or farm assurance requirements need water of a certain quality to be used.

Map where you use water

A map of the water network will help you pinpoint sources, uses, any potential areas of wastage and where you could collect rainwater.

This map should show the location of all water uses, pipes, water troughs, taps, shut-off valves and stopcocks. You should also identify the sources of both clean and dirty water draining into the dirty-water system.

Clean water sources, such as roof water and run-off from clean yards, may be contributing to the volume of dirty water you produce. This could be increasing your costs and the risk of running out of storage capacity.

Consider whether you could divert this water from the system and possibly collect and reuse it. Remember that while you may save money by changing from mains supply to a borehole, you are not saving water or being more water efficient, simply using a different source of water.

Step 3: Calculate how much water you should be using

When you know how much water you are using, the next step is to work out how efficiently you are using it. Forms 1, 2 and 3 will allow you to compare your expected use against actual use. If your actual use is more than 10% greater than your expected use, this indicates that you are using water inefficiently. Even if the difference is less than 10%, it is still worth regularly monitoring your water usage.

If your expected water use is less than your actual water use, it may be that:

- Your meter is over-recording how much you are using
- You have underestimated the water requirements of your livestock and crops.

Think about

Measuring the water you use

To estimate the amount of water that a piece of equipment uses or a recycling system saves, all you need is a stopwatch and a container of a known volume. Carefully disconnect the outflow pipe and catch the outflow in the container. Time how long it takes for the container to fill. This gives you the flow rate in litres per second (or other appropriate unit). You will then need to multiply this to give you an annual cost by working out how often the equipment is used.

Step 4: Identify and compare water efficiency activities to reduce the amount of water you use

If your actual water use is higher than you expected, then the next step is to calculate which water efficiency activities would be most cost-effective for you.

- Check for leaks
- Could you implement roof water collection?
- Could plate cooling water be reused?
- Are water troughs functioning correctly?
- Could the quantity of dirty water being disposed be reduced?
- Could stock safely drink directly from water courses?

Many of the above actions require little capital investment. By combining your knowledge of how much water you use with the suggestions above, you can calculate the payback period for each option and prioritise your actions. As well as the savings on your water bill, do not forget to include savings from reduced dirty water, energy and treatment costs, and also include any increase in maintenance costs.

Step 5 Create, implement and review your action plan

Creating your plan

Once you have identified which measures you intend to carry out, you should draw up a basic action plan including:

- How you plan to save water
- Targets for water savings
- Targets for financial savings
- Who is responsible for each action.

Actions should be detailed and placed in order of priority for implementation, starting with the most cost-effective measures.

Implementing your plan

Make sure that your action plan addresses the following issues:

- Staff, family and contractors are aware of the need to save water
- Timing of improvements
- Routine maintenance checks
- Monitoring and reviewing progress.

Gaining support from others and promoting successes are just as important as gathering data and setting targets. By involving everyone in the action plan, you are more likely to see continuous improvements. Starting with simple and low-cost actions will help to build enthusiasm.

You should also think about your action plan in the context of other management plans covering nutrients, soil, crop protection and manure.

Reviewing your plan

You should review and update your action plan at least once a year, taking into account seasonal variation. Compare your actual savings against expected savings,and review any actions that have not achieved the savings you expected, to find out any problems.

8 | Glossary

Adsorption – is the adhesion of atoms, ions or molecules from a gas, liquid or dissolved solid to a surface. Adsorption is widely used to capture and use waste heat to provide cold water for air conditioning and other process requirements, adsorption chillers, synthetic resins, increase storage capacity of carbide-derived carbons and water purification.

Aeration (also called aerification) – is the process by which air is circulated through, mixed with or dissolved in a liquid or substance.

Anions – an atom or molecule in which the total number of electrons is not equal to the total number of protons, giving the atom a net positive or negative electrical charge. When an atom gains electrons, it has a net negative charge and is known as an anion.

Bacteriophage – is a virus that infects and replicates within the bacteria.

Blue water – this is potable water, defined as water which has been treated to a standard suitable for human consumption. For example, in a dairy unit, potable water must be used for internal plant cleaning, hand and udder washing.

Dirty water – this is water which has been used in some way but may still be suitable for additional uses without further treatment.

Divalent ions – an atom, ion or chemical group with a valence of two which can, therefore, form two bonds with other ions or molecules.

Effluent – this is wastewater which cannot be used for other purposes. It must either be discharged to the sewer or treated prior to reuse.

Green water – this is rainwater which falls on land that does not run-off or recharge the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation. Green water can be made productive by growing plants (eg grass, forage and feed crops).

Grey water – this is water which has been used in some way but may still be suitable for additional uses without further treatment. For example, blue water used for cleaning parlours can be considered grey water and could potentially be reused for external parlour/yard wash down on farms. Rainwater or groundwater which has been collected and stored is also considered grey water.

Humic substances – are major components of the natural organic matter (NOM) in soil and water as well as in geological organic deposits such as lake sediments, peats, brown coals and shales. They make up much of the characteristic brown colour of decaying plant debris and contribute to the brown or black colour in surface soils.

Ion exchange – is a water treatment method where one or more undesirable contaminants are removed from water by exchange with another substance. Both the contaminant and the exchanged substance must be dissolved and have the same type of electrical charge (+,-).

Monovalent ion – an atom, ion or chemical group with a valence of one, which can therefore form one covalent bond.

Nitrate Vulnerable Zone – is a conservation designation of the Environment Agency for areas of land that drain into nitrate polluted waters or waters which could become polluted by nitrates. Nitrate Vulnerable Zones were introduced by the UK government in response to the EU mandate that all EU countries must reduce the nitrate in drinking water to a maximum of 50mg/l.

Organic contaminant – these include pesticides, herbicides, decayed plant and animal tissues, fossil fuels (centuries old decayed plant and animal tissue) and plasticisers (made from petroleum products).

Ozonation – is a water treatment process that destroys bacteria and other microorganisms through an infusion of ozone, a gas produced by subjecting oxygen molecules to high electrical voltage.

Pathogenic bacteria – pathogenic bacteria are bacteria that cause bacterial infection.

Pesticides – are substances meant for attracting, seducing, destroying or mitigating any pest. They are a class of biocide. The most common use of pesticides is as plant protection products (also known as crop protection products), which in general protect plants from damaging influences such as weeds, plant diseases or insects.

Potable water – defined as water which has been treated to a standard suitable for human consumption.

Purification – is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from contaminated water. The goal of this process is to produce water fit for a specific purpose.

Resin beads – an insoluble matrix (or support structure) normally in the form of small (0.5-1mm diameter) beads, usually white or yellowish, fabricated from an organic polymer substrate. The beads are typically porous, providing a high surface area. The trapping of ions occurs with concomitant releasing of other ions.

Sterilisation – any process that eliminates (removes) or kills all forms of life, including transmissible agents (such as fungi, bacteria, viruses, spore forms). Sterilisation can be achieved by applying heat, chemicals, irradiation, high pressure and filtration or combinations thereof.

Suspended solids – refer to small solid particles which remain in suspension in water, dispersed microscopically throughout another substance. It is used as one indicator of water quality.

Trihalomethanes – are chemical compounds in which three of the four hydrogen atoms of methane (CH_4) are replaced by halogen atoms. Many trihalomethanes find uses in industry as solvents or refrigerants. THMs are also environmental pollutants and many are considered carcinogenic.

9 | Useful contacts

Enhance Capital Allowance Scheme
Phone: 0300 330 0657
Email: ECAQuestions@carbontrust.co.uk
Website: www.gov.uk/energy-technology-list

Environment Agency (England)
Phone: 03708 506 506
Email: enquiries@environment-agency.gov.uk
Website: www.environment-agency.gov.uk

Scottish Environmental Protection Agency
Phone: 0300 099 6699
Website: www.sepa.org.uk

Natural Resources Wales
Phone: 03000 653000
Email: enquiries@naturalresourceswales.gov.uk
Website: naturalresources.wales

Natural England
Phone: 0300 060 3900
Email: enquiries@naturalengland.org.uk
Website: www.naturalengland.org.uk

Met Office
Phone: 0370 900 0100
Email: enquiries@metoffice.gov.uk
Website: www.metoffice.gov.uk

Water Regulations Advisory Scheme
Phone: 0333 207 9030
Email: info@wras.co.uk
Website: www.wras.co.uk

Other useful information

The Environment Agency (EA) publishes a range of literature relating to water conservation and demand management. These are available to download at: www.environmentagency.gov.uk

The Code of Good Agricultural Practice for the Protection of Water produced by Defra, offers interpretation of legislation and provides best practice advice on minimising the risk of causing pollution, while protecting natural resources, is available to download at www.gov.uk/government/publications/protecting-our-water-soil-and-air.

Catchment Sensitive Farming (CSF) is a joint project between the Environment Agency and Natural England, funded by Defra and the Rural Development Programme for England, working in priority catchments within England.

CSF delivers practical solutions and targeted support to enable farmers and land managers to take voluntary action to reduce diffuse water pollution from agriculture to protect water bodies and the environment.

The Capital Grant Scheme is a competitive scheme based on catchment-level priorities.

10 | Appendices

Appendix 1. Benchmark data of mains supply water cost on dairy farms

Promar International's aggregate data from fully costed dairy farms was used to look at a benchmark for mains water supply costs on dairy farms.

Key parameters of the data were as follows:

- Over 100 dairy farms in the sample
- The water cost is that paid to the water company. It will not include the cost of a farmer's own supply (for example, a farm borehole)
- The sample includes farms that use mainly their own water supply to those that use 100% mains supply.

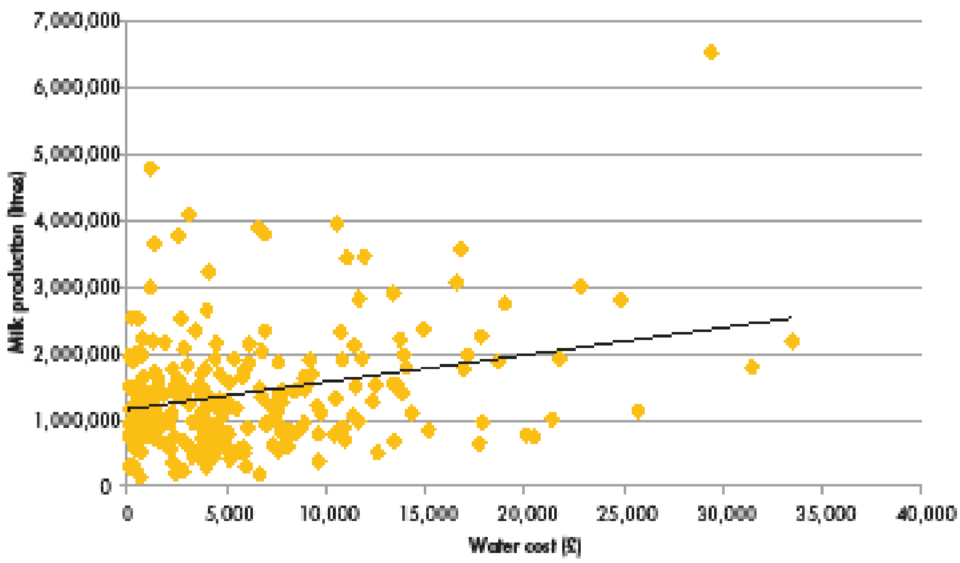
Benchmark data for the average sample farm are as follows:

- They have, on average, a herd size of 181 cows
- They have, on average, a yield per cow of 7,550 litres
- The average farm mains supply water cost is £6,391/year
- The average mains supply water cost per cow is therefore £41.

The range within the sample is as follows:

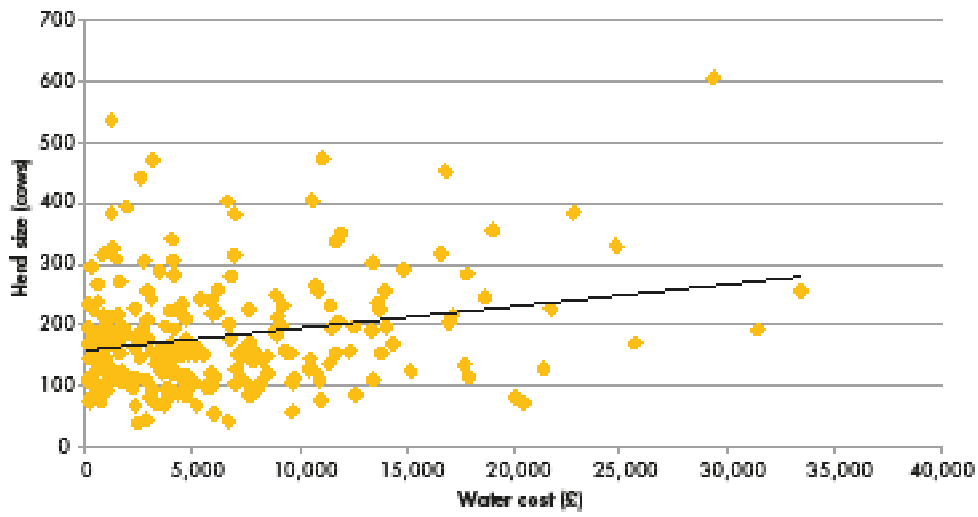
- Herd size from 40 to 605 cows
- Cost per cow £0.38/cow to £274/cow.

Figure 1: Water cost per farm compared to milk production (Promar FBA data collected from 227 UK dairy farms)



- There is considerable variance within the range presented. Clearly, there is a relationship between size of business (by milk produced) and cost of paid water. This figure confirms the need for farmers to conduct regular water audits (ideally, every year) and use as an opportunity to adopt more efficient cleaning practices, as well as looking to train staff and purchase new technology.

Figure 2: Water cost per farm compared to herd size (Promar FBA data collected from 227 UK dairy farms)



- Similar to the previous graph, there is a positive relationship between the size of business (by herd size) and cost of paid water, although the range is very variable
- Within this sample of data, there was no significant relationship between yield per cow and water use, except that higher-yielding cows will consume more water.

Appendix 2

Form 1: Water supply and cost

		Annual quantity (m^3)					
		Quarter 1	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Total**	**Annual cost**
Metered	Mains supply water						
	Abstraction – surface water						
	Abstraction – groundwater						
Total metered							
Unmetered	Stored rainwater (for example, storage tank)						
	Other sources (for example, water drunk by animals directly from farm ditches)						
	Recycled water (for example, plate cooler water)						
Total unmetered							
Other	Dirty water disposal						
	Staff costs (operation and maintenance)						
	Other (for example, capital costs)						
Total other							
	Total annual quantity						

Appendix 3

Form 2: Water use inventory – equipment

Item	Number (A)	Location	Flow rate (litres/minute) (B)	Operating time (minutes/day) (C)	Water used (litres/day) = AxBxC	Source	Comments
Taps	4	Yard	4	30	480	Mains	Left running during washing of equipment

Form 3: Water use inventory – livestock

Item	Number (A)	Location	Activity	Use per animal per day (see table 2.1 and 2.2) (B)	Water used (litres/day) = AxB	Source	Comments
Cows (in milk)	50	Shed 1	Drinking	92	4,600	Mains	Store plate cooling water for drinking?

DAIRY

Agriculture and Horticulture
Development Board
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

T: 024 7647 8702
E: dairy.info@ahdb.org.uk
W: dairy.ahdb.org.uk

AHDB Dairy is a division of the Agriculture
and Horticulture Development Board