guardians of drinking water quality
DRINKING WATER INSPECTORATE

f i n a l   r e p o r t

Research Contract DWI 70/2/150

Review of the Benefits and Disbenefits for Drinking Water Storage within Premises

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BINNIE BLACK & VEATCH

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Executive Summary

Background

In Southern England it has been common practice to provide drinking water directly from the supply main at the kitchen sink only. All other taps, both hot and cold, are supplied from storage within the premises. The practice in Northern England is different where all water comes directly from the supply mains.

The Water Supply (Water Quality) Regulations will require that drinking water taps in domestic premises and public buildings deliver water that is wholesome. The regulations include detailed standards for the definition of wholesome water.

Storage within premises represents a risk of potential deterioration in bacterial quality. Since it is not feasible for a householder to implement a monitoring and maintenance regime similar to that carried out by water companies for their service reservoirs, compliance with quality standards cannot be reliably maintained if water is stored within consumer's premises.

The review

Since the mid 1990s the majority of new domestic premises either have unvented installations, where both the hot and cold water supplies are drawn directly from the mains, or all the cold water supplies are taken from the mains and only the hot water system is supplied from storage. Although consumers may draw supplies for drinking or cooking from the hot water system, the practice is contrary to advice and is considered a misuse of the supply. This review considers the potential for eliminating from older premises cold water storage from which water for drinking and cooking purposes may be drawn.

Storage within premises buffers the effects of a short term s interruption to the supply, smoothes and reduces internal pressures, can help to reduce short term peak demands in localized areas of the distribution system and can reduce internal plumbing installation costs. The disbenefits of storage are potential water quality deterioration through contamination, stagnation and high temperatures, the risk of pipework freezing in roof spaces during cold weather and the costs associated with regular maintenance of the storage facilities. Storage may be necessary for some types of buildings to ensure continuity of supply for legal, commercial or other obligations in the event of a supply interruption.

For older low rise domestic premises, the internal plumbing could be modified so that all cold water supplies are drawn direct from the mains and cold water storage is retained only to supply the hot water system. The estimated cost for the modifications is £240 per premises. When all the cold water supplies are drawn from the mains, there will be a greater instantaneous demand on the system. Where the condition of the communication and service pipe constrains the flow into some of these premises, the pipe may require replacement in order to restore the previous levels of service.

The review examined the impact on distribution performance from higher instantaneous demands that would arise from switching all cold water supplies directly onto the mains whilst retaining cold water storage to supply the hot water system. Although the instantaneous demand from individual properties would be higher, the duration over which supplies are taken would be shorter and the review concluded that where the number of properties exceeded 15, there would be very little impact on the distribution system. Any distribution system deficiencies would therefore tend to be localised.

In high rise domestic and non-domestic premises, water often has to be pumped to roof tank or intermediate storage for distribution to individual premises within the building. The pipework for new buildings could be designed to provide all drinking water supplies direct either from the mains or from the pumped system riser pipe. The impact on the distribution network is unlikely to be significantly greater than where cold drinking water storage is currently provided.

A variety of supply arrangements exist in high rise buildings and many could be modified to supply all cold water directly from the mains or existing pumped riser pipes. The modifications are generally straightforward and could be carried out as part of periodic refurbishment of the structure. The impact on the distribution system of supplying cold water directly from the mains is likely to be minimal due both to the collective effect of groups of premises and to ground storage where provided as part of the buildings pumped system.

Prohibiting cold drinking water storage would create health benefits and cost savings through the omission of tank maintenance and elimination of burst pipes in roof spaces during cold weather. However valuing these benefits has been problematic. Although there are documented risks associated with bacteriological deterioration of stored water, records are not kept of consequential illness. Similarly there are no records of the costs related to cold weather leaks. However in order to meet the expectations of the Drinking Water Directive, a robust storage tank maintenance regime is required in public and other buildings to demonstrate due diligence. The annual maintenance cost for a single tank installation is likely to be between £2,600 and £3,000.

Recommendations

Because of the risk of deterioration in drinking water quality from storage within premises, it is recommended that all supplies to the cold water taps and other cold water services in domestic premises normally used for drinking or cooking purposes should be supplied directly from the water company distribution network or from a rising main pumped either directly or indirectly from the distribution network. Where ground level storage is deemed necessary, it should be designed, sized and maintained to ensure that any stored drinking water remains wholesome at all times.

Where the plumbing arrangements in existing domestic premises are renovated, the premises owner should be encouraged to design the plumbing arrangements so that all cold water supplies used for drinking or cooking purposes are connected directly to the incoming main.

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1 Introduction

The Drinking Water Inspectorate has commissioned Binnie Black & Veatch to undertake a comprehensive review of the rationale for the provision of storage within premises including domestic, industrial and public buildings. The review includes an evaluation of the benefits and disbenefits of storage within buildings and also assesses the possible likely implications of a policy to discourage storage.

2 Background

Historically, it has been common practice in Southern England to provide household hot water from vented systems and drinking water directly from the supply main at the kitchen sink only. All other taps, whether hot or cold, are supplied from storage (SE arrangement). This differs from practice in Northern England where all water comes directly from supply (NE arrangement).

Storage within premises may provide a limited reserve of water in the event of a supply interruption and can help smooth short term peak demands in small distribution systems. However, storage carries the possibility of adverse effects particularly in respect of potential deterioration in bacterial quality. It is not feasible for a householder to implement a maintenance regime akin to that used by water companies for maintaining water quality in their service reservoirs. For this reason, compliance with quality standards cannot be reliably maintained if water is stored within consumer's premises.

This concern about water quality may not be relevant if storage supplying drinking water is properly managed as in some apartment blocks, hotels and public buildings. It is also recognised that there are circumstances where benefits of assured continuity of supply warrant storage for industrial, commercial and institutional purposes.

Although consumers in domestic premises are generally advised only to drink water directly from the kitchen tap, many are unaware of this advice. The DWI has recently surveyed water company records of complaints about water quality. A significant number of these reports indicate that gross pollution of stored water has occurred due to ingress of animals and insects or because of poor design or maintenance of storage. It is probable that water quality deterioration within premises is significantly under recorded

Wholesome water is defined by reference to the standards and other requirements of the Water Supply (Water Quality) Regulations 1989[1]. The Water Supply (Water Quality) Regulations 2000[2] which give effect to the 1998 revision of the Drinking Water Directive[3], will require that drinking water taps in domestic premises and public buildings deliver water which is wholesome as defined in the Regulations.

Although since 1994 most new supplies have direct systems for both hot and cold water, many existing systems within buildings incorporate internal storage. The Directive gives rise to the expectation that its standards will be met at all points where consumers draw water for drinking purposes. It will therefore be essential that water supplies do not deteriorate within premises so as to cause the water as consumed to contravene the relevant quality standards.

3 Objectives of the review

The objectives of the review are to:

(i) Review the benefits and disbenefits of requiring provision of storage within premises, clearly identifying those aspects that affect the water company and those that affect the owner of the premises;

(ii) Carry out a cost/benefit analysis on the implications of prohibiting future use of storage in new premises;

(iii) Carry out a cost/benefit analysis on the implications of removing storage from existing premises including a draft methodology on a procedure for removal of storage from premises;

(iv) Make recommendations, if appropriate, for changes to current practice regarding the provision of storage within domestic premises.

4 Approach to the review

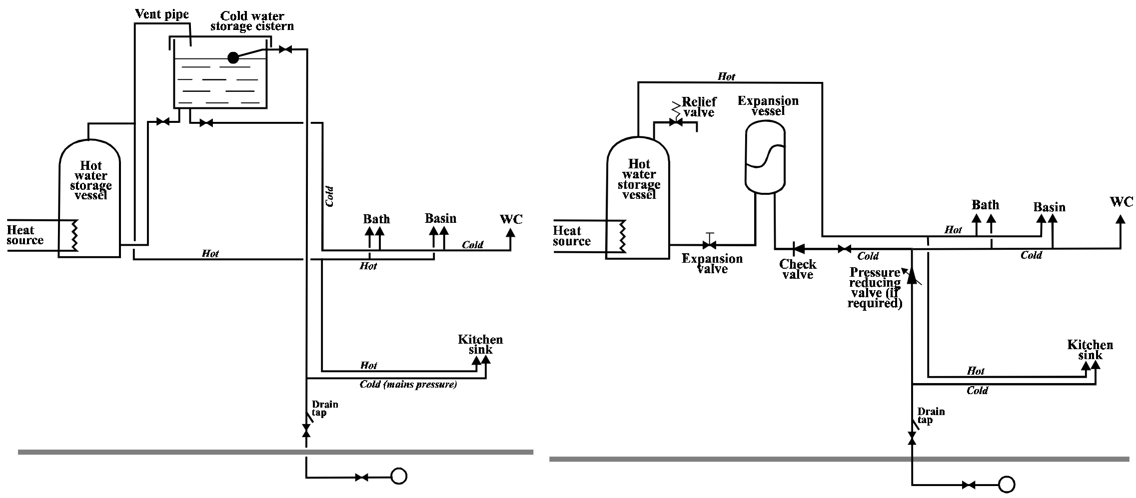
The review is principally concerned with benefits and disbenefits of storage within domestic premises but does also consider the implications of storage within non-domestic premises.

Those premises with storage may have a single storage cistern serving both the cold water taps and the hot water and central heating systems or separate storage facilities for each. The review focuses on the benefits and disbenefits of cold water storage supplying the cold water taps only as these provide the main source of wholesome water. Whilst it is recognised and has been documented[4] that consumers sometimes draw water from the hot water system for drinking and cooking purposes, it is considered that this is a misuse of the supply. The review does not therefore consider in the same way changing the storage arrangements supplying hot water systems although it does examine the implications of having supplies taken entirely from the distribution network for new low-rise domestic properties.

5 Benefits and disbenefits of requiring storage in premises

5.1 Basic arrangements

Figure 1 below illustrate both the traditional SE arrangement for a water supply involving storage in domestic premises and the basic NE water supply arrangement where all the cold water supplies are drawn from the supply main at water company pressure (or pressure reduced as required).



Typical domestic installation with loft tank storage

SE Arrangement

Typical domestic installation with direct supplies

NE Arrangement

Figure 1: Typical alternative domestic installations

In the traditional SE arrangement, the cold water supply to the kitchen tap is direct from the supply main at distribution system pressure. All other cold water supplies are drawn from the cold water storage cistern. The cold water cistern also provides supplies for the hot water system, which in this case is of the vented type.

This traditional arrangement may apply to buildings containing more than one premises and where the storage is shared by the premises such as in apartment blocks, houses converted into flats and purpose built, low-rise, multiple dwelling units. Since the mid 1990s, however, new domestic properties have normally either been supplied entirely from the distribution network or have all their cold water supplies from the network and internal storage only for serving the hot water system. For high-rise properties, supplies may need to be pumped to lift them to the common storage tank or tanks.

5.2 Benefits of storage within premises

The perceived benefits of storage within premises are summarised as:

Item	Customer benefit	Water company benefit
Supply security (1)	Short term maintenance of supply during an interruption.	Fewer consumers lose supply during a short term supply interruption and for a shorter period during a longer interruption.
Supply security (2)	In some water-using processes storage may be essential to ensure continuity of supply in the event of an interruption.	Maintenance or repairs can be carried out without providing alternative supply arrangements.
Pressure (1)	Any excessive pressures are reduced through discharge into the storage cistern.	
Pressure (2)	Steady pressure irrespective of variations within the distribution network.	
Pressure (3)	Surge effects (water hammer) reduced through lower pressures and presence of cold water cistern.	
Pressure (4)	Lower pressure rated pipes and fittings can be used for supplies from the cold water cistern.	
Pressures (5)	In those areas where pressures at peak times are close to the regulatory minimum, the storage cistern provides normal supplies within the premises.	Reduced pressure complaints in those areas operating at close to the regulatory minimum at peak times.
Instantaneous flows		Cold water storage cisterns provide a buffer, reducing localised instantaneous flows and the capacity requirement for smaller distribution networks.
Installation costs	Installation costs for direct feed systems in low-rise domestic premises are typically 15% higher than for systems with cold water storage for the hot water system.	

5.2.1 Supply security

Where there is storage in domestic premises the cistern capacity is typically 225 litres (50 gallons). Should there be a supply interruption in the distribution network, the internal storage should maintain a supply to the cold and hot water systems supplied from the cistern for at least

20 minutes at time of maximum demand and for longer at other times during the day. The cold water drinking supply to the kitchen tap would however be lost for the period of the interruption.

In apartment blocks and public buildings where drinking water storage is provided, storage is typically designed to provide 10 litres per person or 23 litres (5 gallons) per apartment.

Internal storage can therefore provide a means of maintaining a supply during a short term interruption and of shortening the period of loss of supply during a longer term interruption but these supplies are limited to those drawn from the internal storage. Those supplies drawn directly from the distribution network would be lost immediately. However, with the improvements in water company infrastructure, supply interruptions now occur less frequently and there is a greater emphasis on restoring supplies as quickly as possible, reducing the benefit of internal storage. Furthermore, the gradual increase in *per capita* consumption over time means that the period over which supplies can be maintained from storage is diminishing.

There are some commercial and industrial users where a continuity of supply is essential and its loss would result in suspension of the process leading to direct revenue consequences instead of just inconvenience. Examples of such users would include food processors, bottling plants, abattoirs and breweries. In these premises, the consumer may wish to provide storage to ensure that normal activities can continue even if there is an interruption of supply. In NHS hospitals the guidelines[5] for designing potable water supplies recommends the provision of storage to meet 12 hours of the daily demand and management measures to be triggered to economise on water use should there be an interruption in supply. The Department of Education and Employment guidelines[6] do not give any recommendations on storage requirements in schools except that storage tanks should be as small as possible taking into account the reliability of supply and should not in any event exceed 25 litres per pupil.

5.2.2 Pressures

Storage in low-rise premises breaks distribution pressures and provides the controlling head for the pipework supplied from the storage cistern. Where distribution pressures are high, the pressure reduction provided by the storage cistern reduces the risk of surge effects (water hammer) and allows pipework with a lower pressure rating to be used although it is now common practice to have pipework and fittings upstream and downstream of the storage cistern with the same pressure rating. The cistern also smoothes any variations in pressure that may occur in the distribution network during the day.

Water companies have a statutory requirement to provide as a minimum a supply of 9 litres a minute at a pressure of 10 metres at the boundary stopcock of premises. Guidance on the Water Supply (Water Fittings) Regulations 1999[6] indicates that domestic supplies should be designed for a total demand of 18 litres per minute (0.3 l/s). In areas where water company pressures are close to the statutory minimum, internal storage in premises assists in meeting the design demand which might not otherwise be met by supplies drawn directly from the distribution system.

5.2.3 Instantaneous flows

Storage within premises is replenished by inflows from the distribution system regulated by a float valve or other similar device. In simple gravity systems, instantaneous demands supplied from the cold water cistern draw down storage allowing the float valve to partially open. As the level in the storage cistern further declines, the float valve eventually moves into the fully open position and the inflow increases to its maximum. Once the demand has declined and the level in the cistern begins to rise, the float valve starts to close reducing the inflow. The configuration of storage with float valve regulation, therefore reduces the effects of instantaneous demands from individual premises by extending the period over which the demand is met from the distribution system and by limiting the demand to the maximum that will pass through the float valve.

In tower blocks and other high-rise buildings with storage, pumped assistance may be required to lift supplies to the higher floors and to storage. Pump controls may be through level or pressure switches which trigger operation to replenish storage and satisfy demands. Pumps tend to operate to give a steady delivery that may be less than the instantaneous demand. Ground level storage may also provide a reservoir for the pumps further reducing the instantaneous demand.

In small distribution systems, storage within premises may provide performance benefits by flattening the instantaneous demand thereby reducing hydraulic losses as supplies pass through the network thus maintaining higher pressures at peak times. As distribution systems become larger, the benefits reduce and eventually disappear altogether because of the overall damping effects on peak demands that larger systems exhibit.

5.2.4 Installation costs

A national house builder estimates that the plumbing cost for new houses with all the supplies direct from the distribution system is about 15% higher than that where the hot water system is supplied from a cold water cistern. Most of the extra cost is associated with the additional fittings and higher pressure rating required for the closed hot water system.

5.3 Disbenefits of storage within premises

The perceived disbenefits of storage within premises are summarised as:

Item	Customer disbenefit	Water company disbenefit
Water quality (1)	Without regular maintenance, debris and insects can enter the cold water cistern resulting in the water no longer being wholesome.	Water companies may receive dirty water or other complaints that are related to the condition in the storage cistern rather than of the water emanating from the distribution network.

Item	Customer disbenefit	Water company disbenefit
Water quality (2)	During periods of absence from the premises, water in the cold water cistern may become stagnant and unwholesome requiring flushing prior to reuse.	
Water quality (3)	The consumer is unlikely to be aware that water in the cold water cistern may have become unwholesome and may use water drawn from the cistern for drinking or cooking.	
Water quality (4)	During a supply interruption the drinking water supply to the kitchen tap would be lost and consumers may then be inclined to use the cold water supply from the cistern for drinking or cooking.	
Water quality (5)	Use of point of entry treatment devices to remove hardness or other characteristics can also remove the disinfectant.	
Water quality (6)	The trend towards directly connected appliances reduces storage utilisation encouraging stagnant water	
Water quality (7)		Water companies may incur costs in processing and investigating water quality complaints that may be attributable to deterioration within storage in premises.
Water quality (8)		Water companies are responsible for enforcing the Water Supply (Water Fittings) regulations and this implies ensuring that drinking water within premises remains wholesome.
Taste	Water can become stale or tainted when held in storage reducing its attractiveness leading to the use of alternative sources of drinking water (bottled water).	Reduced water company revenue where premises are metered.
Encrustation	With certain waters, hard deposits can build up eventually leading to clogging or jamming of the float valve resulting in emptying of the tank or overflow.	

Item	Customer disbenefit	Water company disbenefit
Noise	Prolonged tank filling can cause noise nuisance.	
Temperature (1) Cold weather	Water fittings connected to cold water cisterns are particularly vulnerable and can freeze in very cold weather leading to an interruption in supply and damage when thawed.	
Temperature (2) Hot weather	In exceptionally warm weather, the water temperature in the cold water cistern could exceed the preferred maximum of 20^0C leading to accelerated bacterial deterioration.	
Pressure	Showers may need to be pumped to achieve required operating pressures.	
Maintenance cost	To ensure water quality is maintained, there is a cost associated with managing and maintaining storage.	
Eye infections	Potential risk of infection to wearers of contact lenses who clean their lenses using water from storage.	
Legionella	Potential risk of Legionella bacteria developing in warm, little used storage tanks.	

5.3.1 Water quality

In older domestic premises with storage it has been common practice to provide household hot water from vented systems and drinking water directly from the supply main at the kitchen sink only. Although consumers in domestic premises are generally advised only to drink water directly from the kitchen tap, many are unaware of this advice. They may draw water that may not be wholesome for drinking purposes including the brushing of teeth from taps supplied from the cold water cistern. In all other premises, the guidance document accompanying the Water Supply (Water Fittings) Regulations 1999[7] requires that all taps supplied with cold water that is not wholesome should be labelled "***Not Drinking Water"***.

The regulations covering the design of cold water cisterns are intended to minimise the risk of any deterioration in the quality of water but regular maintenance is nevertheless required to ensure that the risk continues to be minimised. The maintenance regime would include regular inspection, the periodic removal of deposit accumulations, cleansing and sterilisation of the cistern and ensuring that animals, insects and debris cannot enter the cistern whilst maintaining the free flow of air. In public and other managed buildings, regular sampling is required to demonstrate that the water remains wholesome at all times.

Whilst maintenance regimes applied in larger groups of domestic premises such as apartments can ensure the maintenance of quality, it is unlikely that such regimes would be followed in individual domestic premises. It is therefore unlikely that compliance with quality standards can be reliably maintained where water is stored within such consumer’s premises.

During periods of prolonged absence from the premises when there is little or no use of water from the cold water cistern, the stored water may become stagnant and unwholesome. This stagnation can be accelerated if the absence coincides with a period of warm weather. Flushing of the storage tank would be required prior to use of water for drinking purposes. Maintenance regimes in public buildings and in schools in particular need to ensure that adequate flushing has been carried out and the water sampled to demonstrate that any drinking water drawn from storage is wholesome.

Where water in a storage cistern is no longer wholesome for whatever reason, there may not be any obvious signs that this is the case and consumers may therefore be unaware of the risks associated with using water from taps supplied from the cistern for drinking or cooking purposes.

In the event of an interruption in supply, the drinking water supply to the kitchen tap would be lost but water would still be available from the cold water cistern. Consumers may be tempted to use this supply for drinking purposes during the interruption and could expose themselves to risk if the water is not wholesome.

Consumers have increasingly higher expectations of the quality of water they wish to drink and this has led to greater use of bottled water and water chiller dispensers in public buildings and offices. Water companies have worked hard to improve the quality and taste of the water they supply but this effort is sometimes lost when drinking water is stored on premises where it can age and become tainted.

With certain waters, hard deposits can build up which affect the operation of the devices that regulate the flow into the storage cistern. This in turn can lead to uncontrolled overflows if the regulator should fail open or loss of supply if the regulator should fail closed.

Water treatment devices fitted on the incoming supply main to remove hardness or change other characteristics can also remove the residual disinfection rendering the water biologically at risk. Subsequent storage would make the water more vulnerable to bacterial deterioration.

The trend amongst consumers to connect water-using appliances (washing machines, dishwashers, power showers, water heaters), outside taps and the downstairs toilets directly to the incoming supply main reduces the utilisation of storage, increasing the risk of stagnation of stored water and of bacteriological deterioration.

Water companies may incur costs for dealing with water quality complaints, which on investigation are attributable to deterioration in quality arising from the storage arrangements within premises.

Water companies are responsible for ensuring compliance with the Water Supply (Water Fittings) Regulations 1999 that are designed to ensure that drinking water within premises remains wholesome. Should drinking water within premises become unwholesome, it implies that either the water delivered to the premises was unwholesome or that there has been non-compliance with the regulations within the premises and that water quality has been affected as a result. The responsibility for both delivering wholesome water to the premises and for enforcing the regulations within premises lies with the water companies. This responsibility may extend to ensuring that maintenance regimes in public and other buildings are appropriate so that drinking water remains wholesome at all times. Maintenance of drinking water storage is particularly important in preserving water quality and its presence within premises may place a greater burden on water companies in enforcing the regulations.

5.3.2 Temperature

Freezing of water pipes can occur in periods of prolonged cold weather when pipes are exposed to low temperatures even if they are insulated. Water pipes and fittings connected to cold water cisterns, which are often sited in the roof space, are particularly vulnerable to freezing. Pipe freezing can be aggravated during periods of absence when the temperature in the premises is reduced or the heating is turned off altogether.

Freezing of pipes and fittings at the cold water cistern can lead to an internal loss of supply and once a thaw has set in, damaging leaks from pipes and fittings.

In prolonged periods of hot weather, the temperature in the roof space can rise significantly and remain at high levels raising the temperature of water in the cold water cistern possibly above the preferred maximum of 20^{0}C. High water temperatures accelerate bacterial deterioration and can make the water unwholesome.

5.3.3 Noise

The noise and noise nuisance from prolonged filling of the cistern is greater than the noise associated with direct supplies from the distribution network.

5.3.4 Pressure

In some premises and in single storey premises in particular the lack of head from the storage cistern may affect the operation of appliances (showers) and alternative arrangements such as pumped assistance may be required.

5.3.5 Maintenance costs

For individual domestic installations, there is unlikely to be any formalised maintenance of the cold water storage but for larger residential, commercial and industrial premises, maintenance of storage is likely to follow a prescribed regime and have associated costs.

5.3.6 Eye infections

Acanthamoeba keratitis is a potentially blinding eye infection occurring almost exclusively amongst contact lens wearers in the United Kingdom. There have been about 400 cases in the United Kingdom since the disease was first recognised in 1971. Acanthamoeba is a common soil and water amoeba and is found in most natural and man made water environments.

Acanthamoeba can gain access to contact lenses and their storage cases from any environmental source but studies indicate that the most likely source of contamination is from bathroom tap drawn from water storage during lens cleaning. Although contact lens wearers are advised to cleanse their lenses using sterilised water, this advice is not always followed. A survey of tap water in the homes of 26 patients diagnosed by Moorfields Eye Hospital as suffering from this infection found amoebae present in the samples taken from 23 of the 26 homes and acanthamoeba in 7 of the homes. In 5 homes, the strains of acanthamoeba showed identical mitochondrial DNA RFLPs between the patient's corneal isolate and that from the tap water firmly implicating the water as the source of infection[8]. In February 1997 the Department of Health issued a warning that wearers of contact lenses should avoid washing lens storage containers in tap water and should instead use sterile solutions or boiled tap water cooled to 70^0C.

5.3.7 Legionella

Legionella organisms thrive in warm, non sterile water environments and have been responsible for a series of outbreaks of Legionella disease, the first and most notable of which occurred in 1976 at the American Legion convention in Philadelphia where 29 people died. Most cases of Legionella are however not associated with outbreaks with 75% of reported cases in the UK classed as sporadic (single cases). The source of infection is not often identified but most sporadic cases are associated with hot water systems.

Legionellae enter cold and hot water systems and cooling water systems through contamination of exposed water or through the mains water supply. The bacteria remain inactive at temperatures below 20^oC or above 46^oC and require non sterile conditions to multiply.

There is therefore a potential risk of Legionella bacteria developing in cold water storage tanks if hot weather coincides with a period of little water use leading to stagnation and the storage tank is non sterile.

6 Impact assessment of storage prohibition on instantaneous demands

The prohibition of storage within premises for the cold water supplies for drinking and cooking purposes will have an effect on the instantaneous demand from individual premises and from groups of premises. This in turn may have a performance impact on the distribution system.

To assess the implications on instantaneous demands and for the distribution network performance from the prohibition of cold water storage in premises, tests have been carried out as part of this review on domestic properties with different supply arrangements. These tests indicate that where cold and hot water is supplied from internal storage, the flow through the service pipe is largely governed by the capacity of the float valve regulating supplies into the storage cistern. Where cold water is supplied directly from the distribution system and hot water from a cistern supplied from cold water storage, the flow through the service pipe is then governed by its capacity and that of the internal plumbing. As an example, the flows in the service pipes to two similar properties are illustrated in Figure 2 below.

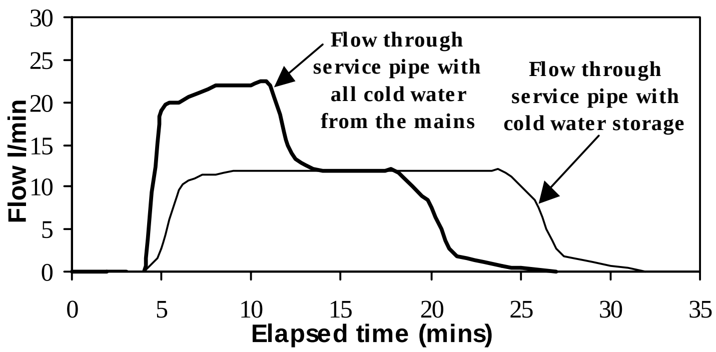


Figure 2: Flows in service pipes with and without cold water storage

The volume of water drawn by both properties is the same at 250 litres. The bold line shows the flow in the service pipe for the property with all the cold water supply drawn directly from the distribution system and the hot water from storage. The flow-rises to 22 litres/minute whilst both the hot and cold taps are running but declines to 12 litres/minute when the taps are closed and all the flow enters the storage cistern. As the cistern fills, the flow gradually declines and eventually ceases after about 20 minutes.

The lighter line illustrates the flow in the service pipe to a property with storage for the hot and cold water supplies. The hot and cold taps are operated for the same duration but as all the water is drawn from storage, the flow through the service pipe is limited to 12 litres/minute, the maximum flow through the float valve. As all the water is drawn from storage, the flow into the cistern continues for longer and last for about 25 minutes.

It is worth noting that the above measured service pipe flow rates are both higher than the water company requirement to supply a minimum level of service of 9 litres/minute and the internal flow rates exceeded the Water Supply (Water Fittings) Regulations design guidance of 18 litres/minute.

Transferring the cold water supply from the storage cistern onto the supply pipe is likely to raise instantaneous flows but the magnitude of these flows will be limited by the capacity of the service pipe. In many properties the transfer would be seamless but in some that have lead or galvanised iron service pipes with a build up of deposits, a reduction in flow performance may become apparent. To maintain the same flow rates to these properties, it may be necessary to replace the service pipe and or the communication pipe.

A spreadsheet analysis has been developed to assess the impact on instantaneous flows of transferring all the cold water supplies within domestic premises from storage directly onto the distribution system. Although for an individual property the maximum flow is higher when supplies are drawn directly from the mains, the duration over which the supply is taken is shorter than in those premises with cold water supplies drawn from a storage cistern. The chances of two consumers drawing water at the same time within the peak hour are therefore slightly less for cold water supplies taken directly from the distribution network.

The analysis looks at how instantaneous demands are affected by increasing numbers of properties and compares peak instantaneous flows for the two supply arrangements with the following results.

Number of properties	**Average peak factor**
1 to 5	1.8
6 to 15	1.6
16 to 25	1.1
Greater than 25	1.0

The average peak factor in the table above is the amount by which instantaneous demands from properties with cold water supplies taken directly from the mains is higher than those from properties with their cold water taps supplied from storage. The analysis indicates that the average peak factor declines as the number of properties increases and when there are more than about 15 properties, there is very little difference in instantaneous flows.

The results of this analysis are supported by the observation that new distribution networks are similarly sized whether they supply properties with direct feed systems or with cold water storage for the hot water system.

In existing high-rise buildings it is not uncommon for ground level storage to be provided to reduce the impact on the distribution from pump operation when supplies are lifted to storage in the building. The presence of ground level storage will tend to minimise any effects on distribution performance arising from switching supplies from elevated drinking water storage to the rising mains within the building.

In WRc's Technical Report TR137, the impact on peak demands of eliminating domestic storage was assessed. The study concluded that the elimination of storage would not significantly change the requirements for distribution mains sizing or reservoir capacity. The study found that the effect of storage on peak demands for individual premises was pronounced but less so for groups of premises. Storage was considered to have little or no effect on peak demands for a supply area in excess of 400 premises. WRc's study was however based on the elimination of all storage within premises and the introduction of a fully pressurised direct system whereas this review is concerned only with the prohibition of storage of cold water supplies used for drinking and cooking purposes. The retention of storage as a supply for the hot water system will clearly greatly reduce the impact on the distribution network.

7 Cost/benefit analysis on the implications of prohibiting future use of storage in new premises

The cost benefit analysis concentrates on the implications of prohibiting future use of storage in new domestic premises but does also consider the implications for non-domestic premises. Furthermore, the analysis is principally concerned with the prohibition of storage associated with the cold water services used for drinking and cooking purposes. Although consumers may from time to time draw water from the hot water system for cooking or drinking, this is considered a misuse of the supply and does not in itself provide justification for prohibiting the future use of cold water storage for the hot water system. The analysis does however present the cost implications of supplying all new domestic premises with direct feed systems.

The analysis attempts to compare the additional costs of prohibition with the value of the benefits and costs savings from not having storage. Physical installation changes can be quantified and costed relatively easily. The anticipated resultant water quality and health benefits are less easily quantified because there is limited documented evidence and data upon which to draw conclusions and quantify benefits and from which to then derive financial benefits.

7.1 Installation cost difference for new premises with and without storage

7.1.1 New low-rise domestic premises

Since the mid 1990s the majority of new supplies to low-rise domestic premises have comprised either unvented installations with both the hot and cold water supplies taken directly from the distribution system or all the cold water supplies taken directly from the distribution system and storage provided for the cold water feed to the hot water system. Indications are that approximately 65% of new dwellings have all their supplies direct from the network and most of the remainder have cold water storage for the hot water system only.

Because the majority of new low-rise domestic properties do not have storage that supplies the cold water taps, there are no implications from the prohibition of such storage in new low-rise domestic premises and therefore no associated cost differences.

Although not driven by water quality considerations, the prohibition of all storage within premises so that both the hot and cold water systems are supplied directly from distribution would affect about one third of all new low-rise domestic premises. The additional cost of direct feed systems is estimated by one national house builder at between £500 and £700 per property.

Factors that influence the additional cost include geographic location, number of units being built and local supply operational service levels. According to DTLR's National House Building Statistics press release issued on 7 March 2002, there were 166,800 domestic completions in 2001 in England and Wales. Based on this number of completions, the estimated additional cost of providing pressurised direct feed systems to those premises that would otherwise have cold water storage for the hot water system is approximately £35M (35% of 166,800 properties at £600 per property). However the vast majority of this extra cost will be associated with the hot water system and not drinking water facilities.

The analysis in Section 6 above indicates how the impact of instantaneous demands decreases as the number of properties supplied increases. There comes a point where direct feed systems exert no additional instantaneous demand burden on the network. This threshold might be as little as 15 to 20 properties. Any additional infrastructure requirements will tend to be localised and their costs can be recovered by water companies through developer contributions. This additional cost would be in addition to the £35M additional cost discussed above.

7.1.2 New high-rise domestic premises

In high-rise domestic premises it has often been the case that the kitchen tap at least has been supplied either directly from the distribution system or indirectly by pumping from the system (or from a ground level reservoir fed from the system). In some cases, however, drinking water has been provided from dedicated storage rather than from the rising main.

Many new high-rise buildings already have all their supplies to the cold water taps taken directly from the distribution system but where drinking water storage is contemplated for a new building, it would be straightforward to redesign the plumbing arrangements so that direct supplies to all the cold water taps are provided. Cold water storage for the hot water systems and for fire fighting purposes would be unaffected.

The supply to the kitchen tap in each apartment would normally be taken from the rising main within the building but could be extended to serve the other cold taps in the apartment. This design revision might result in a modest increase in the instantaneous demands on the rising main in smaller high-rise buildings (up to 20 dwellings) thereby requiring the diameter of the rising main to be increased in size. In larger high-rise buildings the damping effect of more properties reduces the impact on instantaneous demands and is likely to have less effect on the sizing of the rising main. Instead of utilising storage for the cold water supplies, the pumping plant will need to respond to immediate demands and its controls and pressurised storage will need to be arranged accordingly. However, there would be savings arising from the reduced cold water storage requirement and from smaller diameter mains needed to distribute cold water supplies to the hot water systems.

The design modifications required to provide all cold water taps within new high-rise buildings with direct supplies from the mains are considered modest and the associated costs are unlikely to be significant.

For some high-rise buildings, ground level storage is provided as part of the normal design to reduce the impact of demands on the local distribution network and to provide a constant suction head for the pumping plant. This ground level storage contains supplies destined for drinking but provided the storage tank is properly designed, correctly sized including water quality considerations and regularly maintained, supplies will remain wholesome. In rural areas, water companies often make us of quite small service reservoirs and break pressure tanks, which are properly maintained, to ensure wholesome supplies.

7.1.3 New non-domestic premises

Non-domestic premises cover commercial, institutional and industrial types of premises. In some of these premises maintaining a drinking water supply in the event of an interruption is considered essential for the safe or secure functioning of the premises and there may be legal obligations in ensuring continuity of supply. Unless the owner can negotiate an undertaking with the water utility to provide the required level of supply security, the owner will need to decide on the most appropriate level of drinking water storage to meet his responsibilities.

Elsewhere, where there are no such obligations, the provision of direct supplies to all cold water taps used for drinking and cooking purposes would follow the same principles as those for new domestic premises. The arrangements are likely to be straightforward and without significant additional costs.

7.2 External costs

External costs cover the impact on the distribution system of having all water supplies within premises taken directly from the network.

7.2.1 New low-rise domestic premises

Since the majority of all new low-rise domestic premises already have the supplies to their cold water taps directly from the distribution system, there are no implications arising from the prohibition of cold water storage for the cold water service and therefore no associated external costs.

7.2.2 New high-rise domestic and new non-domestic premises

For new high-rise domestic and new non-domestic premises, water companies will need to know the burden on the distribution network arising from the development and may seek a contribution from the developer to ensure adequate infrastructure provision. The provision of cold water services to the cold water systems direct from the distribution network or via pumping is unlikely to have a significant impact on the infrastructure requirements particularly for larger developments because of their damping effect on instantaneous demands. It is therefore considered that any additional external costs arising from the prohibition of storage for the cold water services in those premises where prohibition is appropriate are unlikely to be significant.

7.3 Value of benefits and cost savings from the prohibition of storage

7.3.1 Illness associated with water quality deterioration

Whilst there have been recorded occurrences of gross pollution of internal storage, there have been no related records of directly associated illnesses possibly because gross pollution is often apparent through the smell or colour of the tap water. However, because of the known and documented risks associated with bacterial deterioration of stored water, it is possible that people have suffered illness and have not necessarily associated it with the stored drinking water. Any illness attributable to stored drinking water does however increase the burden on the nation's health care resources.

In Section 5.3.7 above, the linkage between stored water and the eye infection acanthamoeba keratitis was discussed and whilst this arises from not following cleansing advice, the infection causes intense pain, loss of vision and requires prolonged medical treatment for the patient who may lose earnings or employment. Both the cost of medical treatment and the loss of earnings can be high. There have been 400 cases of the infection since it was recognised in 1971, an average of about 14 cases a year. It is not known what proportion of the diagnosed cases is attributable to stored water but assuming that half are and each case has a cost of £50,000, the annual cost of infections attributed to stored water is estimated at £350,000.

7.3.2 Damage associated with burst water pipes

Cold water storage is often located on roofs or within unheated lofts. Although tanks and pipework are insulated, long periods of cold weather can result in the water freezing, a subsequent fracture through expansion and significant damage when the water thaws. The inlet and outlet pipes to storage cisterns are particularly vulnerable to freezing.

Although water damage from freezing is not restricted to pipes connected to storage cisterns, indications are that a significant proportion of such events are. Insurance companies do not record data of claims for burst pipes, nor do they know the proportion of houses they cover that have cold water storage in the roof. No published data have been found that identify the cost of damage from burst water pipes within premises and it has not therefore been possible to identify any direct costs associated with freezing of storage cisterns, pipes and fittings.

7.3.3 Maintenance of storage cisterns

The Water Supply (Water Quality) Regulations 2000 which give effect to the 1998 revision of the Drinking Water Directive, will require that drinking water taps in domestic premises and public buildings deliver water which is wholesome as defined in the Regulations. The Directive gives rise to the expectation that its standards will be met at all points where consumers draw water for drinking purposes. It will therefore be essential that water supplies do not deteriorate within premises so as to cause the water as consumed to contravene the relevant quality standards.

To ensure that water contained in storage cisterns used for drinking purposes remains wholesome, the storage needs to be managed and maintained. In low-rise domestic premises where the responsibility for managing and maintaining storage lies with the occupier, it is unlikely and probably impractical for there to be a formal maintenance regime in place. In other premises where the responsibility for maintaining storage lies other than with the occupier or user, a maintenance regime will be essential in meeting the obligations of the regulations.

As a minimum, any maintenance regime will need to involve the regular inspection of the storage with rectification of any faults, routine cleaning, removal of debris and cleansing, periodic flushing to remove stagnant water particularly after periods of little or no use and routine sampling and testing to demonstrate that the water remains wholesome. The frequency of sampling may need to vary with ambient temperature changes. In some cases, on site treatment of stored water may also be required.

From the information gathered as part of this review, current maintenance regimes in municipal, commercial and industrial premises tend to be variable and in some cases fall short of what would be required to ensure that stored drinking water remains wholesome.

Examples of routine maintenance cost are:

36 bed nursing home	6 monthly sterilisation of storage tank with analysis of up to 3 water samples - £1,000/annum
Major hospital	Sampling only of stored water - £1,500/annum
18 storey office block	6 monthly Legionella risk assessment with sampling at all water service points - £2,900/annum
12 storey block of 48 municipal flats	Annual maintenance contract including periodic water quality sampling and analysis £1,000 to £1,200 per annum.

The costs given in these examples may not reflect the true cost of a maintenance regime that would be necessary to guarantee that drinking water supplies remain wholesome at all times.

BS 6700:1997[9] gives guidance on the maintenance aspects of drinking water supplies for domestic use. It states that for premises other than single dwellings and depending on the size, type and complexity of the installation, it should be inspected at least once a year in addition to any statutory inspections. It also states that regular analysis of water samples should be carried out at intervals not exceeding 6 months wherever drinking water is stored.

To meet the expectations of the Drinking Water Directive, a robust drinking water storage maintenance regime that goes beyond the requirements of BS 6700 is likely to be required not only to meet the Directive but to demonstrate due diligence.

A typical maintenance regime would cover the following:

Activity	**Frequency**	**Scope**	**Estimated cost**
Inspection	6 monthly but possibly more frequently as the installation ages	Inspect against check list, grills, vent pipe, lid security, inside of tank for ingress of debris, vermin or insects, general condition and document	£100 to £150 per inspection but less if part of caretakers duties
Tank cleansing	Annually but less or more frequently based on need	Discharge to waste, clean, flush and disinfect	Approximately £400 per tank but dependant on size and access
Sampling	Not less than monthly but frequency dependent on risk	Sample and test for plate count, total coliform, chlorine residual and temperature	Obtaining samples and on site testing say £100. Transport and laboratory testing approximately £75
Flushing	Periodic after periods of low use	The removal of stagnant water following a period of little or no use (eg the end of the school holidays)	£150 approximately per flush
		Total	**£2,600 to £3,000 per annum**

The above maintenance cost range is for an installation with a single drinking water storage tank. The higher figure includes for 2 periodic flushes and assumes that the monthly sampling will coincide with a flushing activity. In complex installations with several storage tanks the annual maintenance costs are likely to be higher.

7.4 Cost benefit analysis

As there are no implications for new low-rise domestic premise from the prohibition of storage supplying the cold water services, there is no cost benefit analysis to be undertaken.

In high-rise domestic premises and in non-domestic premises the main measurable benefit arises from not having to implement a storage maintenance regime. Where drinking water storage is provided, such a maintenance regime is unavoidable to satisfy the obligations of the Water Supply (Water Quality) Regulations.

Whilst an attempt has been made to identify typical annual drinking water storage maintenance costs, any amortised additional costs of omitting drinking water storage and providing direct supplies from the distribution network will depend on the type and scale of the development. The previous discussion suggests that the modifications that would be required during the design stage of the development would be modest and that there may be savings from the omission of drinking water storage. Because of the range of different developments and associated cost differences any meaningful cost benefit analysis is probably not realistic.

8 Cost/benefit analysis on the implications of removing storage from existing premises and the methodology for doing so

The cost benefit analysis on the implications of removing storage from existing premises only considers storage used to supply the cold water taps used for drinking or cooking within premises and which needs to meet the expectations of the Regulations. The analysis does not concern itself with storage used to supply the hot water systems in premises.

Furthermore, the reference to removing storage means omitting storage from the supply route rather than physically removing cisterns from within premises. Storage may be reserved for other uses or decommissioned and left in place.

It is recognised that the removal of cold water storage will shorten the detention time of cold water passing through the premises and will reduce chlorine decay. The transfer of cold water supplies direct to distribution may lead to an initial increased perception of the presence of chlorine in the drinking water although the supplies will be no different from those originally drawn from the kitchen tap.

8.1 Costs of providing all cold water supplies directly from the mains

8.1.1 Low-rise domestic premises

Newer low-rise domestic properties either have unvented systems with both the hot and cold water supplies drawn from the distribution system or internal storage for the hot water system and all cold water taps supplied directly from distribution. For these newer domestic properties, there are no implications arising from the removal of storage supplying drinking water as these supplies are already directly from the mains.

In older low-rise domestic properties, it is more common for the kitchen sink tap to be the only cold water supply connected directly to the distribution system. All other cold water taps tend to be supplied from internal storage often located in the loft. In the simple system illustrated in Figure 3 below, it would be straightforward to cross connect the storage cistern supply pipe to the cold water outlet from the cistern. The cold water outlet would need to be cut and capped to prevent reintroduction of water from the cistern. The outlet pipe from the cistern would then be subject to distribution pressure and it may be necessary to introduce a pressure reducing valve to protect the cold water reticulation. The cistern would continue to operate but would be used solely as a cold water supply for the hot water system.

The cost of the pipework and fittings for undertaking this work including the provision of a pressure reducing valve and a double check valve is in the order of £40. Allowing a registered plumber half a day to install the pipework and fittings, the total cost per premises would be around £200. This cost may however be influenced by the geographic location of the premises.

There may also be adverse effects for the operation of domestic water-using appliances particularly where balanced pressures are required. With showers, for example, changing the cold water supply from the cistern to the mains could result in pressure fluctuations when cold water is drawn elsewhere in the premises. The proportion of hot water to the shower head could rise possibly scalding the user. Such appliances might therefore need to be fitted with a suitable protection device such as a thermostatically controlled blending valve. Such devices cost around £45 plus fitting.

As older premises are renovated and modern domestic water-using appliances installed there is an increasing occurrence of cold water supplies being taken directly from the mains. It is now common practice to connect water-consuming appliances such as dishwashers and washing machines directly onto the incoming mains and some consumers are choosing to bypass the cold water cistern altogether for their cold water supplies.

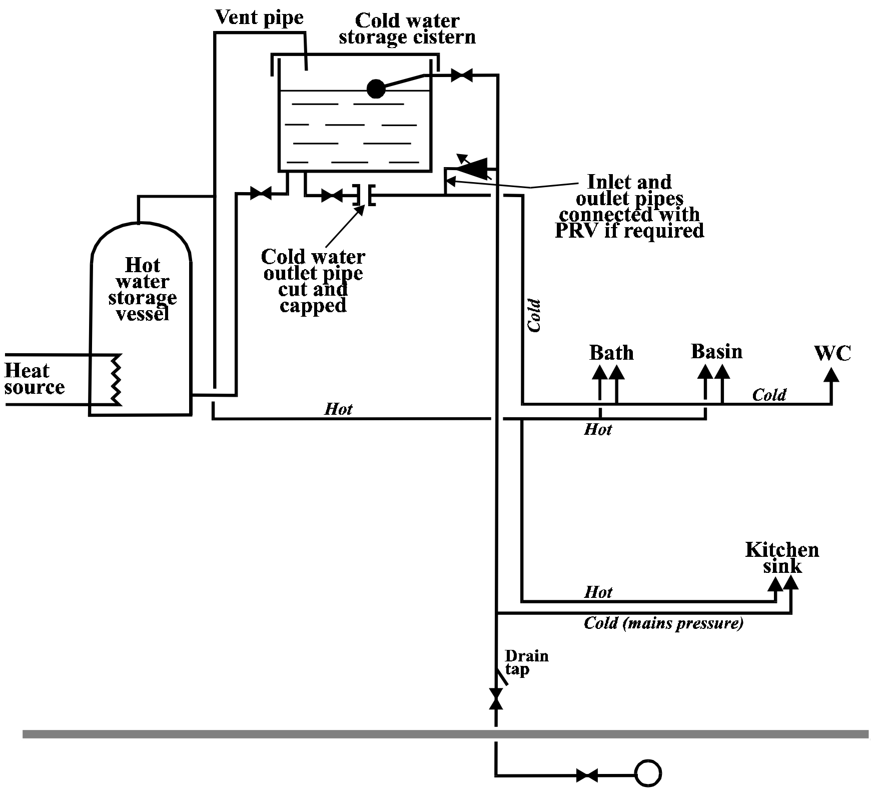


Figure 3: Domestic system modification to bypass cold water storage

The discussion above deals with the internal pipework alterations. The impact and implications of increased demand due to direct supplies on the distribution network is discussed in Chapter 6 above and in Section 8.2, below. The potential restriction is the communication and service pipe where its size or condition limits the supply available to the premise to the statutory minimum; 9 litres/minute at 10m available head or less at the first tap into a premise. Since the consumers have previously benefited from a better supply, albeit because of the cold water storage, levels of service could be restored by replacing the service pipe. This will be particularly relevant where the service pipe is in poor condition, for example old lead or galvanised iron pipe and where there is a common service pipe (two or more premises share supply off the same communication and service pipe).

Many water companies offer a subsidised or free lead service pipe replacement service as part of their lead communication pipe replacement strategy and so for those properties with lead service pipes, the cost of replacement may be modest and is justified by reasons other than flow performance. The cost of replacing poor performing galvanised service pipes will depend of their length and on the type of ground. Establishing the extent of service pipe replacement and associated costs that would arise from transferring all cold water supplies direct to the mains is a major undertaking and is beyond the scope of this review.

Communication and service pipe replacement costs are;

Communication pipe	Renew long side	£378/unit	Range £299 to 701/unit.
	Renew short side	£222/unit	Range £222 to 467/unit.

(Ref OFWAT Benchmark Unit Rates).

Service pipes	Supply and lay (750 mm deep)	£25/metre.
	Additional cost for connecting through walls, allow	£30.
	Additional cost for deep trenching, allow	£15/metre

In premises where cold water storage is disconnected, there will be a number of locations where the service pipe will also need to be replaced. Assuming an average length of service pipe of 4 meters, the additional cost per premises could be in the order of £350 to £750 and significantly more where adverse installation and ground conditions are encountered.

8.1.2 High-rise domestic premises

Domestic high-rise properties covers blocks of flats where in the majority of cases there is insufficient mains pressure to supply the facilities on the higher floors and the supply is boosted to these properties. Most of the older blocks have separate supply arrangements for the kitchen tap drinking water and the other cold and hot water services generally involving storage of both.

Historic guidance on the design of cold water services to tall buildings is given in HMSO's Design Bulletin No 3[10] in which there are a variety of arrangements, some of which are briefly listed below and illustrated in Figure 4:

- Roof and/or intermediate storage supplied by mains pressure with kitchen tap drinking water supplied from the rising main and cold and hot water services supplied from storage (Figure 4a).
- Pumped rising main to roof storage with separate drinking water storage. Kitchen tap drinking water supplied from the rising main and from drinking water storage. Cold and hot water services supplied from main storage (Figure 4b).
- Pumped rising main with pressure vessel and all water services supplied from the rising main and no storage (Figure 4c).
- Pumped rising main with pressure vessel with kitchen tap drinking water supplied from the rising main. Cold and hot water services supplied from storage located in individual or groups of flats (Figure 5).

There are variations on these basic arrangements such as intermediate storage to break pressures from the roof tank, combinations of pumping arrangements with and without pressure vessels and ground level storage from which the booster pumps draw. Where storage is provided it is sometimes used as a reserve for fire fighting purposes.

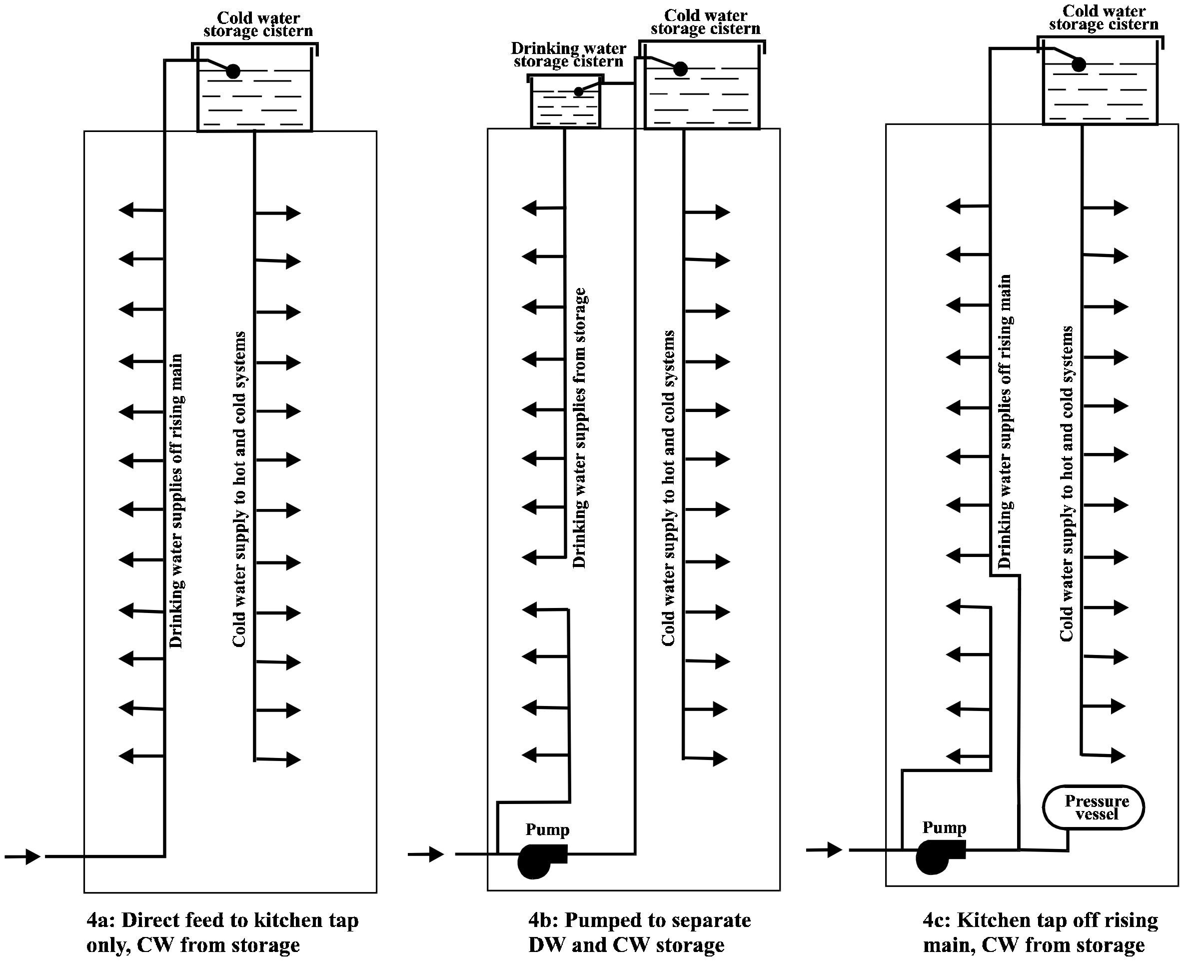


Figure 4: Cold water service to tall buildings design guidance (HMSO Design Bulletin No 3)

Within each apartment or groups of apartments there may be a storage cistern serving the hot and cold water systems or just the hot water system. Typical arrangements within apartments are illustrated in Figure 5 below.

In low-rise domestic premises, the approach has been to reconfigure the supply arrangements so that all the cold water services are supplied directly from distribution and any storage is then used to serve the hot water system only. This approach separates the cold water service from the hot water service. A similar approach can be applied within apartments in high-rise buildings that have their own cold water storage cistern. It should be reasonably straightforward to disconnect the cold water supplies serving the bath, basin and WC from the cold water cistern and reconnect them to the supply pipe to the cistern or to the rising main. The only supplies from the cistern would then be to the hot water cylinder.

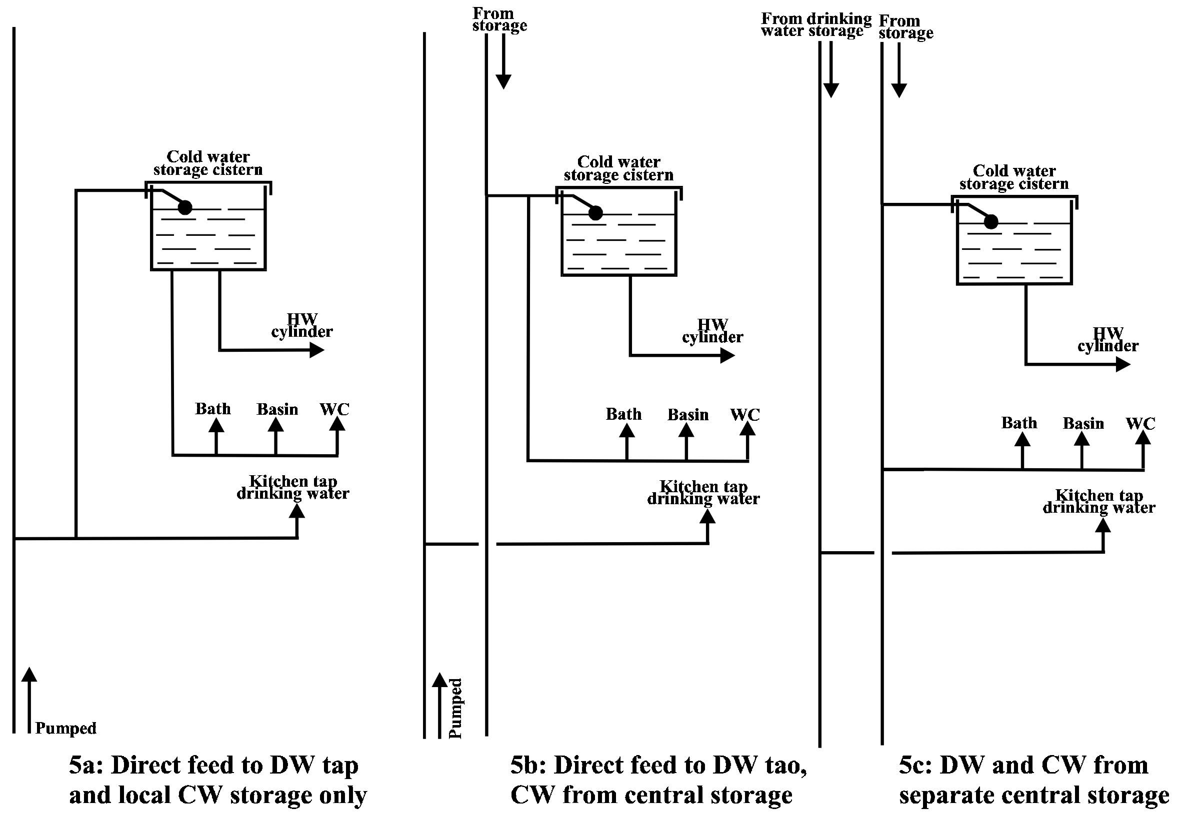


Figure 5: Cold water service arrangements within apartments

Although this arrangement would allow cold water supplies to bypass the storage cistern within individual apartments, in many cases the cold water supply would still come from storage either from the roof tank or from an intermediate level. To provide all the cold water supplies directly from distribution there are a number of options:

- Extend drinking water supplies off the rising main to all cold water services and abandon drinking water storage. Retain the existing supply from roof storage to provide a cold water supply to the hot water cylinder in each apartment.
- Provide a new cold water supply main from the roof to each apartment and connect this new main to the rising main. Retain the existing supply from roof storage to provide a cold water supply to the hot water cylinder in each apartment.
- Provide the cold water supply to each apartment from the rising main and retain the cold water storage as a supply to the hot water systems.

Extend cold water supplies off rising main

Bypassing roof tank drinking water storage by connecting the rising main to the cold outlet from the tank would mean that all demands to the cold water taps would be met directly from the rising main and from distribution. The analysis in Section 6 for low-rise domestic premises indicates that as the number of properties increases the impact on instantaneous demands of switching all the cold water supplies from storage directly to distribution diminishes. In larger high-rise premises this would infer that the rising main should have sufficient capacity to convey the demands under the new regime. However, as there would no longer be any storage for the cold water services, the pumping plant would have to respond to demands as they arose. To provide for instantaneous demands, it is likely that the pump controls would need to be modified and a pressure vessel introduced where none exists or the enlargement of existing pressurised storage. The existing supply main from roof storage would then only convey cold water to the hot water systems in each apartment and would therefore have more than adequate capacity to convey these lower demands.

Provide a new cold water supply main

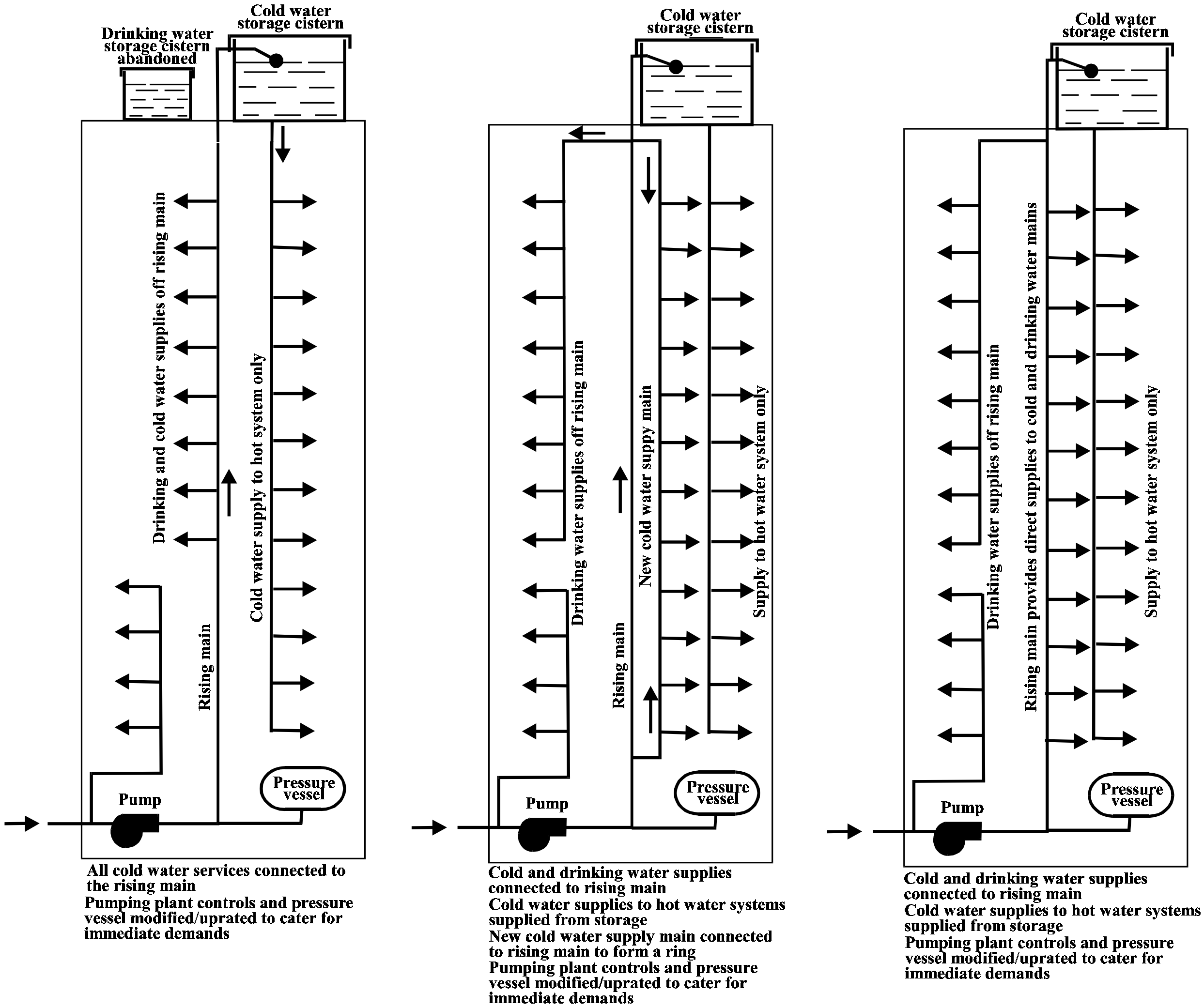
A new cold water supply main connected to the rising main would allow the cold water supply in individual apartments to be separated from that used for the hot water system which would still be supplied from storage. The new cold water main could perhaps be connected to the existing rising main at the top and bottom of the building to form a ring providing added security and flexibility. The pumping plant controls would need to be modified to respond to the direct demands from the new cold water supply main and pressurised storage may need to be introduced or modified.

Provide a cold water supply to each apartment from the rising main

Cold water supplies to individual apartments would be directly from the rising main either from a new connection off the rising main or by extending any existing connection as described above. The cold water supply to the hot water systems would be retained and supplied from storage. Again the pumping plant controls would need to be modified to respond to the direct demands from the new cold water supply main and pressurised storage may need to be introduced or modified.

The cost of all the modifications discussed above will depend on the size and water supply configuration in each high-rise building and could perhaps be minimised when carried out as part of periodic refurbishment. Within apartments however, the cost of replumbing is likely to be modest and comparable to that for low-rise domestic premises.

These three arrangements are illustrated in Figure 6 below.



6a: Extend supplies off rising main to all cold water services

6b: Provide new cold water supply main

6c: Provide separate new cold water supply off rising main

Figure 6: Tall building plumbing modification options

8.1.3 Non-domestic premises

In non-domestic premises the need for drinking water storage may be governed by security, revenue or legal considerations and it would be inappropriate in these situations to consider removal or decommissioning of storage. In other premises where there are no such considerations, there may be benefits in quality terms from omitting drinking water storage. In these cases, the principles for rearranging the supplies would follow those outlined for low and high-rise domestic premises.

8.2 External costs

For low-rise domestic premises any external costs for restoring distribution performance in meeting increased direct supplies are likely to be limited to small groups of properties where distribution performance is already close to the statutory minimum. These situations are difficult to quantify and cost because of their ad hoc nature. It may be, though, that in these situations water companies would in any event wish to improve distribution performance to avoid any future statutory failures because of deterioration in hydraulic performance over time and the gradual increase in consumption.

Some high-rise domestic premises have ground level storage to provide a steady pump suction head and to reduce the impact on the distribution network from pump operation. With these arrangements transferring drinking water supplies directly to the pumping main is unlikely to have any impact on distribution performance. The transfer of all cold water drinking supplies onto the pumping main is likely to require the provision of a pressure vessel where none exists or the uprating of the existing vessel. In either case, the presence of a pressure vessel will provide some smoothing of instantaneous demands where there is no ground level vented storage and in larger premises the number of properties taking their supplies at different times will tend to dampen any potential increase in instantaneous demands. The impact on the distribution network is therefore likely to be modest.

In non-domestic premises where the transfer of cold water supplies for drinking purpose from storage directly to distribution is contemplated, the impact on the distribution will depend on the drinking water use in the premises. For office buildings, which have pumped supplies, the impact may be modest and similar to that for high-rise domestic premises. Elsewhere in high water use premises the cost of improving the distribution network to meet direct drinking water demands may be significant. Clearly, the external costs associated with transferring cold water supplies for drinking purposes from storage directly to distribution in non-domestic premises will depend of the capacity of the local infrastructure and the scale of any increased instantaneous demands. These are likely to be variable in nature and it is therefore not realistic to generalise on the costs involved.

8.3 Value of benefits

The value of benefits has been discussed when considering the prohibition of storage in new premises. The benefits arising from the removal of storage in existing premises will be similar except that older premises with aged water infrastructure may be more prone to water quality deterioration requiring more extensive maintenance and more frequent repair. Annual maintenance costs for drinking water storage tanks may therefore be higher. Assuming that the inspection and sampling activities will be similar for both cases, additional costs will be associated with increased tank cleaning and flushing and could increase the total annual costs to between £3,000 and £4,000

8.4 Cost benefit analysis

In low-rise domestic premises, the plumbing modifications required to transfer the cold water supply from storage directly onto the incoming main would in most cases be straightforward and costs would be of the order of £200 per property. For some properties, these costs could rise if poor service pipe performance made replacement necessary to restore flows to the level previously experienced when supplied from storage. There may also be costs for the installation of control devices where balanced pressures are required. Costs associated with improving the distribution network to accommodate higher instantaneous demand are likely to be limited and localised to small groups of properties where performance is already close to the statutory minimum. Alternatively, communication and service pipe enhancements would help to improve the level of service within the premises.

Because of the uncertain maintenance regime for water storage in low-rise domestic premises, the main benefit from the omission of storage for drinking and cooking purposes would be the maintenance of water quality and the removal of the risks associated with water used for drinking but which has become unwholesome through storage. This benefit is however difficult to quantify and cost because of the limited availability of data.

In high-rise domestic premises, the principles involved in reconfiguring the cold water supplies to individual apartments are likely to be similar to those for low-rise domestic premises but in high-rise buildings there may be the complication of modifying the pumping arrangements and rising mains to accommodate direct cold water supplies. The costs of modifications could be minimised if this work was done as part of a refurbishment programme. Because of the variety of supply arrangements in high-rise buildings there will be a range of unit costs for the modifications.

The impact on the distribution network from providing direct cold water supplies will depend on the size of the building and on whether there is ground level storage. Where there is storage, there will probably be little effect and the same is so for larger developments because of the damping effect on instantaneous demands. Smaller buildings without storage may have the greatest impact and may require distribution system enhancements.

In an attempt to understand the options available, a number of high-rise buildings were inspected as part of this review. Details of the inspections are included in Appendix A. No clear picture could be drawn from the variety of facilities inspected except that each set of circumstances was unique and would require a building survey and discrete design solution to implement.

The main benefit from the omission of drinking water storage in high-rise domestic buildings is the costs savings from not having to maintain the storage. An indication of the possible annual storage maintenance costs has previously been presented but once again it is problematic to undertake a cost benefit analysis because of the uncertain costs of the water supply modifications required for the buildings.

9 Recommendation for changes in current practice

The recommendations for changes in current practice relate to domestic premises only.

Because of the risk of deterioration in drinking water quality from storage within premises, it is recommended that all supplies to the cold water taps and other cold water services in domestic premises normally used for drinking or cooking purposes should be supplied directly from the water company distribution network or from a rising main pumped either directly or indirectly from the distribution network. Where ground level storage is deemed necessary, it should be designed, sized and maintained to ensure that any stored drinking water remains wholesome at all times.

Where the plumbing arrangements in existing domestic premises are renovated, the premises owner should be encouraged to design the plumbing arrangements so that all cold water supplies used for drinking or cooking purposes are connected directly to the incoming main.

References

1 The Water Supply (Water Quality) Regulations 1989, Statutory Instrument 1989 No. 1147
2 The Water Supply (Water Quality) Regulations 2000, Statutory Instrument 2000 No. 3184
3 Drinking Water Directive 80/778/EEC
4 Drinking Water Consumption in Great Britain, Hopkin SM and Ellis JE, WRc Technical Report TR137, 1980
5 Health Technical Memorandum 2027, NHS Estates
6 Building Bulletin 87, Guidelines for Environmental Design in Schools (Revision of Design Note 17), Department of Education and Employment, 1997.
7 The Water Supply (Water Fittings) (Amendment) Regulations 1999, Statutory Instrument No. 1506 and The Water Supply (Water Fittings) Regulations 1999, Guidance Document relating to Schedule 1: Fluid Categories and Schedule 2: Requirements for Water Fittings, DEFRA.
8 Through a Glass Darkly – Contact Lenses and Personal Hygiene, Simon Kilvington, Microbiology Today, Volume 27, May 2000.
9 BS6700:1997 Specification for the Design, Installation, Testing and Maintenance of Services Supplying Water for Domestic use within Buildings and their Curtliges
10 HMSO Service Cores in High Flats, Cold Water Services, HMSO Design Bulletin No.3 Part 6

Appendix A

Site Visit Details

NHS E. Surrey Hospital.

Date of visit: Thursday 7th February 2002

There is a requirement for 24 hours storage of drinking water within each premises to cover periods when water mains maintenance or interruptions could occur because a constant drinking water supply is required at all times.

Background information:

The hospital has 500 beds with approximately 1,000 staff members present all the time and has an extensive water distribution network.

The mains inlet into the hospital is approximately 6 inch in diameter. The main divides into three and supplies fire service water, cold water storage for the hot water system and cold drinking water used from storage.

The outlet from the cold drinking water usage tank is 2 inch in diameter.

The hot water is treated using chlorine dioxide (as a preventative measure against Legionella) as well as softening agents to reduce scaling problems.

Two identical cold drinking water storage tanks are installed each with a capacity of 87,600 litres.

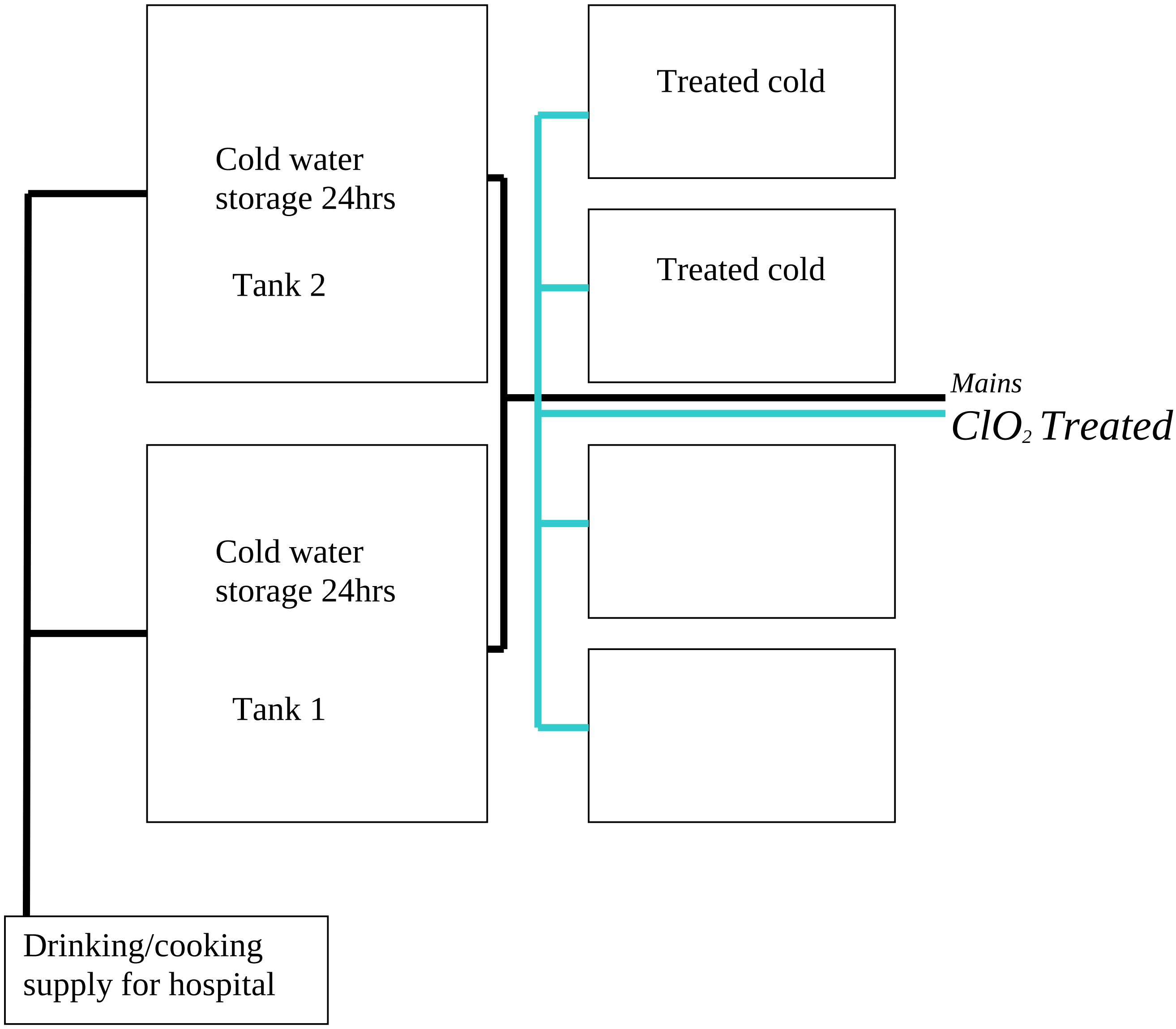
There are also two similar treated water storage tanks each with a capacity of 34,500 litres that are used to supply the hot water system.

The diagram following illustrates the plant room layout on the third floor.

Approximate costs:

The hospital employs a contractor to undertake water quality testing of samples from the storage tanks. This includes monthly TVC (Total Viable Count). The annual sampling and testing costs are about £1,500/year.

Approximately £5,000 to £6,000 per year is spent on chemicals for treating cold water used for the hot water system.

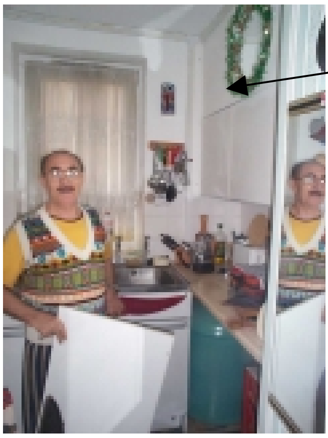

Treated cold
Cold water
storage 24hrs
Tank 2
Treated cold
Mains
ClO2 Treated
Cold water
storage 24hrs
Tank 1
Drinking/cooking
supply for hospital

<u>Site visit to Hackney Borough Council:</u>
Date of visit: Wednesday 13th February 2002.

<u>Site 1:</u>
Wayman Court (Hackney Housing) is shown in the photograph alongside. It has 15 floors with 5 flats a floor giving 75 flats in the building.

There is a kitchen sink and bathroom basin in each flat. The wall separating the kitchen and bathroom incorporates a service duct in which is located the rising main supplying the kitchen sink and the cold water supply from roof tank storage.

The photograph below shows the kitchen in one of the flats and the location of the boiler and its header tank.



Each kitchen has its own hot water header tank with the boiler directly below.

Originally the kitchen taps on the first 5 floors of the building were supplied direct from the mains but now the entire building's drinking supply is boosted.

The incoming supply main is 2 inches in diameter and the rising main pipe is 1.5 inches in diameter.

A ground level storage tank shown in the photograph alongside with a capacity of 24,000 and measuring 4 metres by 2 metres by 3 metres deep provides the suction for the booster pump. The lid of the tank is securely bolted to the tank's body.

Site 2:
Boscobel House (Hackney Housing) is shown in the photograph alongside. It has 12 floors with 4 flats a floor giving 48 flats in the building.

As with Wayman Court, each flat has a kitchen sink and a basin in the bathroom. The kitchen backs onto the bathroom, with the boiler and hot water header tank installed in a cupboard in the dividing wall. The arrangement is shown in the photograph below.

Approximately 3 metres of pipework connect the down service cold water pipe with the hot water header tank.

The bathroom cold tap on the other side of the wall is directly behind the boiler. It would be straightforward to connect the bathroom cold water taps to the rising main. The mains pipe into the building is 2 inches in diameter and the rising main pipe 1.5 inches in diameter.

A ground level storage tank with a capacity of 2,300 litres and measuring 1.8 metres by 1.3 metres by 1 metre deep provides the suction for a booster pump which lifts supplies to roof tank storage. The arrangement of storage tank, booster pumps and pressure vessel is shown in the photograph alongside.

Roof tank storage has a capacity of 27,000 litres and measures 6.5 metres by 2.8 metres by 1.5 metres deep and is shown in the photographs below.

At the time of the visit the building was being refurbished and the roof plant room was open to the elements. Normally if there is any remedial work required this is reported and carried out immediately.

Additional information:

- The booster pumps and associated equipment is maintained every 2 months including an overhaul twice a year, which includes a water sample and analysis.

- Water quality samples are not collected at any other points in the building (even the roof storage) except in cases where animals might have gained access. It is only drinking water that is sampled.

- The roof tanks are chlorinated on a 5-year plan with the condition of the tanks taken into consideration and any amendments carried out (such as maintenance).

- The water supplying the fire systems is separate from the roof storage.

- The cost for the maintenance contract and water quality sampling is approximately £1,000 to £1,200 per year. Water quality sampling is not a major factor in these costs.

- It is understood that many of the residents in similar blocks are converting to combined or Combee type heating systems which draw directly from the mains reducing the requirement for roof tank storage. In some blocks, the roof tank storage has been taken out of service altogether because of problems with stagnation.

Site visit to Taberner House, London Borough of Croydon

Date of visit: Thursday 21st February 2002.

The building is 18 floors of council offices and is shown in the photograph alongside. Each floor except the twelfth has the same layout with a kitchen unit and ladies and gentlemen's toilet facilities. Break pressure and drinking water storage tanks are located on the twelfth floor. Drinking water dispensers are provided on each floor.

All water services on the basement and first two floors are supplied at water company mains pressure. Supplies to the rest of the building are boosted.

Drinking water to all floors above the second is supplied from storage tanks. The photograph below left is of the roof tank and the photograph below right is of the tank on the twelfth floor.

Both tanks are similar and are 1.1 metres by 0.6 metres by 0.65 metres deep each giving a capacity of 430 litres.

The roof tank supplies drinking water to floors 11 to 18 and the tank on the twelfth floor supplies floors 3 to 10.

The roof cold water storage tank supplying the toilets and hot water system has an approximate capacity of 36,000 litres. The tank also provides a backup for fighting which has a separate boosted system. The roof tank is shown in the photograph alongside.

The cold water storage tank on the twelfth floor is supplied from the roof tank and acts as a breaks pressure tank. It is shown in the adjacent photograph

The cold water booster pump installation is shown in the photograph below left and the fire fighting booster pumps are shown in the photograph below right. Both pump sets draw directly from the water company mains.

Additional information:

- All the boilers within the building are maintained every 6 months, with particular attention paid to the removal of scale in affected areas. Scale accumulations are a problem even though inline filters are fitted.
- Every 6 months a Legionella management company undertake sampling from all the water service points within the building. In January 2002, a Legionella risk assessment was carried out on four council buildings at a cost for the year’s service of £5,780.

Site Visit to The Dome, Reigate Housing

Date of visit: Wednesday 27th February 2002.

The Dome has 10 floors with 5 flats on each floor giving 50 flats in the building. The building is shown in the photographs below.

Each floor has 3 one bedroom and 2 two bedroom flats. Each fat has a 180 litre hot water storage tank. Heating in the flats is by economy 7 night storage heaters.

There is no roof tank storage and all water supplies are direct from the mains at water company pressure. There are two incoming 2 inch diameter mains one of which supplies the two bedroom flats and the other the one bedroom flats. The incoming mains are shown in the photograph.

Survey of people with roof storage: 15/02/02.

Question: Do you know if you have any cold water storage within your home?

50 staff members in the Redhill office of BBV were questioned,

Results:

33 people know they have a cold water tank that feeds everything but the kitchen tap.

9 people were unsure (mostly graduates, who are living in temporary accommodation)

6 people have a direct mains feed to everything within their house

2 people have systems where all the cold taps within the house are mains fed and the hot water system is fed from a storage cistern.

Typical example of Domestic Premises Cold Water Storage