CHAPTER 7
Water Supply Issues

Having established simple design rules for the implementation of the proposed system within the protected property and confirmed its hydraulic performance, the main emphasis on taking the concept forward requires accurate geographical knowledge of likely water pressures and flows at the householder’s isolation valve and the means for improvement where insufficient.

A knowledge elicitation meeting was held with a representative of Yorkshire Water Services, Mr Ian Whittaker. The full list of questions posed and Mr Whittaker’s responses are detailed in Table 47 below.

<table>
<thead>
<tr>
<th>Table 47 Water company Knowledge elicitation questions</th>
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</thead>
<tbody>
<tr>
<td>Water supply issues – pressure and flow</td>
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</table>

(1) What factors effect the mean domestic water supply pressure daily and to what extent

- Many factors can have an effect (including network design, age/type of mains supply pipes, industrial demand).
- Areas supplied by gravity fed systems (e.g. water towers, reservoirs) may experience higher than average pressures at night when water usage is less.
- In pressure managed areas water companies may reduce the supply pressure (to help reduce leakages) when demand is low – typically this will be at night but may occur during the daytime.
- Not practical to estimate the extent of variations as they may vary greatly.

(2) What factors effect the mean domestic water supply pressure weekly and to what extent

- Domestic habits (e.g. car washing/garden watering at weekends) might possibly affect mains water supply pressures but this would be very difficult to quantify.

(3) What factors effect the mean domestic water supply pressure annually and to what extent

- Prolonged cold spells in winter can cause problems due to burst pipes.
- Down time could vary from several hours up to days depending on the size and location of the burst.

(4) Are supply pressures changed specifically to address issues such as drought

- In pressure managed zones it is possible that the water supply pressure could be dropped to restrict water usage during droughts although this is unlikely.
- In extreme cases it is possible that commercial water usage could be restricted.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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</table>
| Are supply pressures changed specifically to address issues such as leakage mitigation | - The volume of water leaked from supply networks is linked to the water pressure in supply pipes.  
- In pressure managed areas the mains supply pressure may be reduced at times of low water demand to help reduce water leakage. |
| Do pressures vary geographically for reasons other than elevation (if so why) | - The use of different sized supply pipes or long pipe runs may affect the water pressure experienced by geographically close areas. |
| What area of the supply network might be affected by a mains failure and to what extent | - The number of properties affected by a mains failure could vary from a few tens of houses to thousands depending on the size and location of supply pipe damaged.  
Cases of unplanned interruptions are reported to OFWAT form DG3. For the period 2001/02 to 2003/04 the percentage of connected properties experiencing unplanned and unwarned supply interruptions were as follows;  
0.36% > 6 hours, 0.14% > 12 hours, 0.06% > 24 hours (average values across all water companies) |
| What % downtime might be expected per household in a typical year | - This is also covered by DG3 reporting to OFWAT  
For the period 2003 to 20004 the number of connected properties experiencing planned and supply interruptions were as follows;  
545,503 > 6 hours, 77,465 > 12 hours, 75,714 > 24 hours (total values across all water companies) |
| Is maintenance work conducted at a particular time of day; day of week; month of year | - Planned work is mostly performed in the daytime where practical.  
- If work involves affecting public roads then the work would probably be conducted at night or over weekends. |
| Why might one area have relatively steady mean pressures and another (geographically close) show large excursions | - Possibly as a result of the network design or presence of large commercial users |
| How much does employed equipment/delivery technique affect pressure and variations | - Probably significantly, but difficult to quantify (dependant on many factors). |
| Do any water users place periodic demands of a magnitude that might significantly affect the supply pressures to domestic dwellings – what might these ‘industries’ be – are occurrences random or do they occur at agreed times | - Some companies may, for example, fill storage tanks a certain times of day which may or may not affect domestic supplies depending on how the supply network has been designed.  
- Particularly large planned demands would normally be agreed with the water companies in advance and might be scheduled for night time. |

15 Taken from the OFWAT document ‘Levels of service for the water industry in England and Wales 2003–2004 report’
(13) Would supply rates of 60/85/120 L/min to a property be likely to impact greatly on the supply main pressure – if so, to what extent

- Domestic flow rates of this magnitude should not significantly affect the mains water supply pressure under normal circumstances.

**Water supply issues – Hardware**

(14) Are all houses connected directly to the main – if not, what configurations are out there (how common is it for multiple houses to share a single mains connection)

- Historically it was not uncommon for multiple houses to have their water provided via a common supply pipe. Although this is no longer allowed there is still likely be a proportion of properties (probably single figure %’s) connected in this way.

(15) Is supply pipe bore a good measure of the narrowest point in the system – are there any jointing arrangements that would reduce this

- There are potentially several items that could impose additional flow restrictions, including:
  - Stop taps,
  - Internal sleeves at joints of plastic supply pipes
  - Standard methods of making new connections to iron and PVC pipes (Talbot/banjo connector or other) might represent a significant restriction. However there are alternative solutions available at little extra cost but theses would need to be requested/specified. Examples of these mains connection methods are detailed in Annex E.

(16) What equipment items are placed in the supply pipe to domestic properties – do any of these inflict a significant pressure drop in comparison to the pipe it replaces

- Conventional stop taps fitted in supply pipes are likely to cause significant pressure losses. However, if upgrading existing supplies or in new supplies full bore gate valves or ¼ turn valves could be used to reduce pressure losses.
- Water meters (in all new build houses) – pressure losses are a function of meter size and flow rate.

(17) What bore of supply is currently normally installed to new houses

- Most (if not all) new houses will be connected to the mains by a 25mm MDPE pipe.

(18) Are there any occasions where a larger bore is used (32mm)

- Instances where a property is a long distance from the water main may require larger bore connection pipes.
- Larger bore pipes may be specified/required for properties in which new types of pressurised hot water systems are installed, to ensure that there is sufficient flow for both the cold water and hot water.

(19) Are there implications for metering ‘larger than normal’ supply pipes in terms of cost/accuracy/equipment availability

- Water companies reserve the right to approve the type of water meter chosen for use with domestic properties.
- The main concern with using larger water meters is in the reduced accuracy of measurement at lower flow rates. Currently the water companies require Class D meters to be used.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>(20) Will water authorities object to residences having a greater draw-off capability (metered or not)</td>
<td>• Whilst the ability to draw-off greater than normal flow rates is, in itself, unlikely to cause any significant concern, there is a possibility that the action of doing so could cause the dislodgement of any sediment that has built up in the water main. It is considered that this could possibly result in the water meter becoming jammed, thus preventing any further flow of water.</td>
</tr>
<tr>
<td>(21) Does age of the supply network affect delivery</td>
<td>• In some cases older pipes may have reduced flow due to a build up of material.</td>
</tr>
<tr>
<td>(22) Are there any issues of equipment compatibility in respect of joining newer supply pipe types to old mains</td>
<td>• Not in general. Modern MDPE Plastic pipes can be fitted to older types of mains supplies using a range of connections.</td>
</tr>
<tr>
<td>(23) Is there an ongoing policy to upgrade unsuitable supply pipes – what would it be normal to replace them with</td>
<td>• Water companies can require customers to repair/replace supply pipes if excessive leakages are suspected.</td>
</tr>
<tr>
<td>(24) Are there commonly experienced adverse factors that may impact upon the pipe bore such as corrosion, crushing and silting</td>
<td>• Any of those factors might impact on the flow characteristics of pipes.</td>
</tr>
<tr>
<td>Information availability</td>
<td></td>
</tr>
<tr>
<td>(25) Are the supply pipe details available for all dwellings – e.g. pipe type, pipe bore, number of bends and distance from main</td>
<td>• Records are kept for the mains supply pipes in the distribution network but not for customers service pipe details.</td>
</tr>
</tbody>
</table>
| (26) What proportion of properties are connected to the mains by – lead/galvanised steel/plastic/25mm MDPE supply pipes | • It is very unlikely that detailed values of the numbers of properties connected by different types of supply pipes could be determined. However it may be possible to make a crude estimate of the numbers of properties connected by plastic pipe by considering the average annual number of houses built yearly since the mid 1980’s (when MDPE plastic pipes were introduced).  
• Lead pipe was used until around the 1940’s to 50’s. After that several materials were used, including PVC and galvanised steel. |
| (27) What is the geographical resolution of information – e.g. by postcode, by property, by district | • See answer to (25) above.                                                                                                                                                                                                                               |
| (28) What information must/can the water authority provide in respect of a request for pressure/flow characteristic at a householder’s isolation valve | • Can provide details of water pressure availability but unlikely to be able to detail flow characteristics of flow characteristics without direct measurement (which would have to be paid for by the householder/developer requesting such information). |
(29) Will the supplied response be based on recorded data (in part) or calculated – what assumptions are made in the process

- Likely to be based on measured values for general area, calculation of network model, or a combination of both, depending on level of detail required and location of household.

(30) How recent can the information be expected to be

- Fairly recent.

(31) What factors may adversely affect computed data

- Network models tend to cover the main distribution pipes but not some of the smaller pipes. However this should not significantly effect the accuracy of the models.

Ownership responsibilities

(32) What would be the process for instigating a mains supply connection upgrade

- Process is started by the customer or their nominated plumber formally applying to the water company for a new/upgraded service connection to the mains supply. Most water companies should have standard forms for this which will enquire about the purpose of the connection and pick up on sprinkler installations.
- The water company would make the connection after inspecting the new supply pipe provided by the householder (from the house to the boundary box).

(33) Who would do the work

- Normally, for re-connections of existing properties and initial connections of new properties the householder/construction company would provide the supply pipe and the water company would make the connection to the mains and fit the communication pipe.
- Recent changes to the UK water regulations now allow developers to ‘self lay’ not only the supply pipe, but also the boundary box, the water meter, the communication pipe and all connected components up to the water main. There are specific requirements for allowing this that will be detailed by the water companies.

(34) Who would pay for each part

- The customer is liable for material and labour costs for all aspects of the connection. Water companies have fixed prices for connections which are controlled by Ofwat.
(These prices seem to be generally available on the web sites of water companies)

(35) Who would ‘own’ each part of the supply

- The water company is responsible for all parts of the water supply up to and including the boundary box.
- The homeowner is responsible for all parts of the water supply from the boundary box up to and including the domestic plumbing in the house.

(36) Would a householder have to pay for the water meter if non existed previously

- Water meters are mandatory in all new build properties. The customer would be charged for the meter (see question 34).
- Water meters do not need to be fitted to existing properties when a new connection to the mains is made.
(37) Would a householder have to pay for the water meter where one previously existed (given that a 32mm meter may be required)

- Yes (see question 34).

**Domestic plumbing issues**

(38) Would the envisaged system be considered acceptable to water authorities

- There are Water Industry concerns about the risks of stagnation through lack of turnover in pipe networks because it is difficult to predict/prove that normal demand patterns will draw fresh water into all legs of the system. Increased and effectively unnecessary (from a domestic supply perspective) lengths of pipework will cause more warming of water within dwellings and customers to draw more water off before they obtain cold water which is always more palatable to drink. Water companies are required to endeavour to ensure the economical usage of water.

- If the individual legs to sprinkler heads are significant they may become effectively “dead legs” with stagnant water in them which may on occasions drift back into the clean water causing water quality problems or complaints.

- Normal domestic meters would be unlikely to support the level of demand for sprinkler operation and still accurately measure low domestic usage.

- There is a potential risk with meters in that a sudden increased flow on a service pipe may bring any fine debris in the mains or service pipe into suspension and possibly block the meter, this could stop or greatly inhibit the water supply to the sprinkler heads.

- Need to establish the compatibility of sprinkler heads with the Water Supply (Water Fittings) Regulations 1999.

- Ultimately, the acceptability of this type of combined plumbing system would need to be assessed by a water regulations committee.

(39) We anticipate that this system will not require additional backflow protection above that which will already exist in the domestic system – would you agree

- Probably yes, subject to a detailed evaluation of the system by a water regulations committee.

(40) Our hydraulic calculations show that the envisaged system would not have any dead legs (or regions of static water when the house is in normal use) – would you agree

- Yes, providing it can be ensured that the branches leading to the sprinkler heads are kept short.

(41) What do you consider a ‘normal’ and ‘peak’ domestic water demand – is this based on estimates or recorded data

- Difficult to estimate but unlikely to be much more than 10 to 15L/min in properties with small bore supply pipes.

**Contractual**

(42) Can a water authority decline a request for the installation of a 32mm supply (including suitably sized fittings and water meter)

- Potentially – but unlikely to happen.

- Water companies are required to ‘provide adequate supply for normal domestic systems’ which could require the use of 32mm supply pipes.
(43) How is permission sought for direct pump draw-off from the supply in a property (i.e. use of a booster pump) – on what grounds might it be refused in the context of this project?

- Direct pump draw off is allowed – with certain restrictions. This issue is covered in the Water UK guidance document.

(44) What would be the procedure for new housing developments intending to implement sprinkler systems to request provision of adequate supplies (above statutory minimum), i.e. could the developers request that the water companies supply pipes be sized to ensure adequate flow + pressures.

- This is covered by the new ‘self lay’ amendments to the water regulations – basically a developer could install all elements of the water supply to houses on a new site, up to the final connection with the water companies main pipe.
CHAPTER 8
Discussion

8.1 A UK version of the BRANZ combined plumbing sprinkler system

8.1.1 ADAPTATION OF THE BRANZ APPROACH TO THE UK

The anticipated sprinkler system design borrows much from the BRANZ methodology. Water is distributed at each floor via a large diameter supply ‘loop’ to which the sprinkler heads are attached and domestic supplies are fed from above on smaller bore pipe. This arrangement maximises flow to the sprinkler heads and prevents water stagnation at any point within the system. The prototype system is simple in its design, and uses off-the-shelf components. The installation detail does not represent a major culture change for domestic plumbing engineers, although additional safeguards in terms of quality assurance may be required. The simplicity of the system and constant monitoring through its dual use function means that savings in maintenance akin to those recognised in BRANZ can also be considered.

8.1.2 KEY SYSTEM REQUIREMENTS

- The principal feature of the prototype system is that a single mains water supply is used to feed both domestic water system and the sprinkler system via a common plumbing pipework.

- The system should be capable of supporting two sprinkler heads operating simultaneously.

- A detailed study of the local water supply shall be required to determine the potential effectiveness of the system prior to installation. This study shall include temporal pressure variations in a 24 hour period, weekly, and seasonally if the data is available. Information should also be sought from the local water authority in respect of any future plans that will act to affect water supplies to the system.

- To ensure adequate provision of water pressure and flow rate the service pipe connecting the property to the water main will need to be implemented using 32mm diameter MDPE plastic pipe.

- It is preferable that a water meter is not used when upgrading the connection of existing properties.
Where a new connection is required the water meter should be selected to minimise pressure losses. The meter should have an internal bore of no less than 20mm and where possible should be specified as 25/30mm.

When specifying the service pipe any joints, inline devices (such as stop taps) and changes in pipe direction should be minimised and implemented so as to minimise incurred pressure losses.

The method of connection of the service pipe to the water main should be chosen to minimise constrictions to the waterway and any incurred pressure losses.

The householder’s isolation valve should be of the full bore \( \frac{1}{4} \) turn ball valve type.

A drain valve should be fitted at the hydraulically lowest point of the system (to facilitate draining of the pipework) in accordance with normal plumbing practices.

The main internal plumbing should be implemented in 22mm copper pipe, unless a hydraulic assessment indicated the need for larger bore pipe to supply the required flow rates.

Drop pipes to sprinklers should be kept to the minimum possible length (less than 150mm) and should be plumbed in 22mm copper pipe up to the point of sprinkler connection.

Off-takes from the main pipework, connecting to domestic utilities, should be plumbed in 15mm copper. Connections for the bathroom and kitchen water supplies should be made at the furthest possible point on the supply loops from the incoming water supply to maximise flushing of the system.

All pipework in the loft should be suitably protected to minimise the risk of pipes freezing.

### 8.1.3 ADDITIONAL REQUIREMENTS FOR SYSTEM IMPLEMENTATION

- Specific training qualification for system installers.

- Consultation with local water provider to establish;
  
  - Prevailing local water pressures and normal variations

  - Compliance of proposed design with water regulations

- Linked, mains powered, smoke alarms should be fitted in the main living areas and escape routes.
• ‘WARNING’ sign near main householders isolation valve – should clearly indicate to the homeowner that isolating the incoming water supply will also disable the sprinkler system.

• Documentation detailing:
  – Installer contact details
  – Installation date
  – Brief system description
  – General maintenance checks for householder
  – Essential user information (e.g. avoiding damage to sprinkler heads/covers, requirements for modifying/extending the plumbing pipework)
  – Emergency contact numbers

• Registration on national/local/fire service database (currently there is no public record kept of properties protected by sprinkler systems).

8.1.4 DEVIATIONS FROM BS9251

The proposed prototype combined plumbing sprinkler system deviates from the current requirements of BS9251 in the following respects – it is expected that the system should comply with BS9251 in all other respects:
8.1.5 SYSTEM MAINTENANCE

Sprinkler systems designed and installed to the current standard, BS9251, are required to be inspected annually by an “experienced sprinkler contractor” to ensure the following;

(i) That the sprinklers’ heat sensing capacity and their spray pattern is not impeded (i.e. that the sprinklers' bulb/solder link and cover plate have not been tampered with or obstructed in any way).

(ii) That the minimum flow rate recommended in BS is achieved at the drain and test valve.
(iii) That the alarm is effective and can be heard in all parts of the building.

(iv) That the system has not been modified except in accordance with the BS.

Furthermore, it requires that the system be tested as follows:

(v) Wherever possible, the system should be visually inspected for leaks. If a leak is suspected the pipework should be pressure tested to 1.5 times working pressure for 1 hour.

(vi) Both internal and external alarms should be left active so that their satisfactory operation can be audibly verified.

(vii) The sprinkler system should be flow tested for 1 minute at the drain and test valve or the highest test point of the installation pipework to ensure that the minimum BS flow rates are met.

(viii) Stop valves should be exercised to ensure free movement.

(ix) Where trace heating is installed check operation.

(x) The person carrying out the inspection should complete and sign the Log Book as recommended in 7.3.

Whilst these inspections are necessary and proportionate to the complexity of the installed systems (as illustrated in section 3.4.3) they are both costly and sustained for the life of the system. Consequently, the cost of maintenance has been identified in several studies as an item that would need to be significantly reduced in order to make domestic sprinkler systems more affordable to the target housing sector.

This is one of several key issues that influenced the design of the BRANZ sprinkler system and of the prototype system described in this report. The design of the prototype system removes the need for several of the checks detailed above, in particular;

- The sprinkler systems’ water supply is combined with the normal domestic plumbing. This has a number of benefits with regards to maintenance;
  - There is no dedicated valvset or priority demand valve to maintain
  - Since the system is permanently pressurised and delivering water to other domestic utilities it should be reasonable to assume that any leaks in the system would be identified by the property’s tenants; removing the need for check (v).

- The system does not incorporate an alarm valve (the system recommends the installation of smoke alarms for this purpose): removing the need for items (iii) and (vi) above
Because of the cost restraints for this system it is envisaged that trace heating would not be specified in the majority of cases; removing the need for check (ix).

Since the system relies on the town mains pressure rather than an installed pump, checks (ii) and (vii) above would provide little useful information due to the potential local pressure variations identified in the water pressure survey. An alternative method of assessing the pressure available to properties may need to be developed to address this issue.

This could significantly reduce the effort and hence cost of any maintenance requirement that was specified for this type of system. A revised maintenance regime might therefore include;

- A visual inspection of sprinkler cover plates to ensure that they have not been tampered with, over-painted etc. In properties identified as high risk it may be necessary to remove cover plates and ensure that the sprinkler heads have not been tampered with.

- A visual inspection of the system plumbing to ensure that it has not been modified except in accordance with appropriate guidance.

- Operation of householders main isolation valve to ensure free movement.

- Record inspection in log book.

Whilst this should help significantly reduce maintenance costs below that of BS9251 compliant systems it is possible that further savings may be necessary for the system to be cost beneficial in certain circumstances. Examples of options that could be considered include;

- For rental properties the landlord could be required to have the system checked (either annually, when tenants change or some other time interval) in much the same way as they are currently required to ensure that gas and electric supplies are correctly maintained.

- Depending on the number of installations involved it might be possible for regional fire and rescue services to perform inspections as part of their community fire prevention programmes.

- Incorporation of sprinkler inspections into service and maintenance contracts offered by other utility suppliers, including gas, electric and water.

An alternative option that may need to be considered in future policy decisions is that of removing the requirement for an annual inspection altogether. Whilst this would realise the greatest possible saving in ongoing costs it would be likely to significantly reduce the effectiveness of such sprinkler systems over time.

Since the implementation and cost of any maintenance regime is likely to depend on investigations and decisions that have not yet been made it is beyond the scope of this work to specify a precise set of requirements for such
a regime (beyond the suggestions detailed above). Consequently, for the purpose of the cost benefit analysis presented later no allowance has been made for ongoing maintenance costs.

8.2 Assessment of the prototype combined plumbing sprinkler system

8.2.1 HYDRAULIC ASSESSMENT

Measurements made during the experimental hydraulic study compared favourably with the computer generated data. From these studies the following conclusions can be drawn:

- The prototype combined domestic/sprinkler system is pressure efficient and this is achieved with commonly used pipe sizes (22 mm).

- Small design details, such as the use of 15mm drops, have the potential to severely impair the performance of the system and this will need to be recognised and highlighted in any future design guidance.

- Houses connected to the town main via a 15mm pipe will be unable to meet the minimum pressure/flow requirements of the system.

- The use of 32mm diameter supply pipe from the main has significant performance benefits over the use of 25mm diameter supply pipe, particularly over extended distances.

- Irrespective of supply pipe diameter, the mains pressure required to meet the BS EN 9251 (2005) sprinkler head demand is probably higher than that generally available, and as such, without additional measures being taken, may not result in a system that is suitable for mass implementation. Measures which may be considered include:
  
  – Increasing domestic plumbing pipe sizes
  
  – Relaxation/removal of 25 l/min supplementary domestic flow requirement
  
  – Relaxation of minimum pressure/flow requirements to UL approved head rating value
  
  – Reduction in performance (firefighting) expectations
  
  – Use of storage tanks and pumps

- When these compromises are combined with the use of larger orifice domestic sprinkler heads, supply requirements are more in keeping with those that may be available from the town main supply as determined from the water supply survey.
8.2.2 **DISTRIBUTION AND SIDE WALL WETTING TESTS**

Wall wetting tests with both of the sprinklers indicated that BS9251 requirement for wall wetting could be met with flow rates below 60 l/min. Distribution tests with the sprinklers demonstrated that their spay patterns were not significantly altered by reducing the water flow rate to 42 l/min (for the K59) and 49 l/min (for the K71), although at the lower flow rates the water was distributed slightly more evenly. Both sets of tests indicate that a slight reduction in flowrate, below 60 l/min, does not result in any significant change to distribution characteristics of the sprinklers, with a large proportion of the supplied water being directed to the boundary walls to tackle vertical flame spread in the room.

8.2.3 **FIRE FIGHTING PERFORMANCE**

The fire tests detailed in the BRE report highlighted both the difficulty in obtaining repeatable fire conditions (even when the starting conditions are replicated accurately from test to test) and how slight variations in the fire progression can significantly affect the outcome for any occupants. This would suggest that a very large number of tests, covering a wide range of fire scenarios/room types/furnishings would be required to build up a truly accurate picture of the overall effectiveness of any sprinkler system. Clearly this would not be an appropriate approach to take with a prototype system and consequently this study concentrated on a few indicative tests, primarily as a visual demonstration of system performance at reduced flow rates. In all of the fire tests conducted the sprinkler system performed well, both controlling the fires and improving tenability conditions in the room of origin and beyond. Little degradation in fire fighting performance was noted in decreasing the sprinkler flow rate from 60L/min to 49L/min.

8.2.4 **TENABILITY**

Tenability factors that will directly impact upon a person’s capability to effect an escape from a fire include:

- Irritation of the eyes resulting from smoke production (can effect ability to find exits if excessive).
- Irritation of respiratory system due to smoke.
- Gradual asphyxiation due to the inhalation of toxic gaseous fire products (eventually leading to unconsciousness and then death if occupant not removed from room).
- Temperature effects, pain/burns, resulting from convective heat from the fire.
- Radiation effects, pain/burns, resulting from radiated heat.

The effects of inhaling toxic gases and exposure to elevated temperatures are cumulative and thus can become rapidly more serious the longer an occupant
remains in the room. If evacuation from the room is not achieved then both types of exposure can result in incapacitation of the occupant and eventually death.

The data collected here is suitable for assessing the effects of asphyxiation, convective heat and loss of visibility. Using a method outlined by Prof. D. Purser\textsuperscript{16} the following tenability criteria are defined and have been calculated for each of the fires;

- **Optical Density per metre:** $\text{OD/m}\textsuperscript{17}$
  - Calculated from the time varying smoke density at head height

- **Fractional Effective Dose of asphyxiant:** $\text{FED}_{\text{asphyxiant}}$
  - Calculated from recorded time varying $O_2$, CO and CO\textsubscript{2} levels

- **Fractional Effective Dose of convective heat:** $\text{FED}_{\text{heat}}$
  - Calculated from recorded time varying compartment temperature at head height

Survivability limits for these FED’s are set as follows:

- $\text{OD/m} \geq 0.2$ Smoke causes irritation to respiratory system
- $\text{OD/m} \geq 0.5$ Visibility limited to approximately 2m. Ability to locate escapes impaired
- $\text{FED}_{\text{asphyxiant}} \geq 1$ Loss of consciousness through asphyxiation
- $\text{FED}_{\text{asphyxiant}} \geq 2$ Death
- $\text{FED}_{\text{heat}} \geq 1$ Extreme pain resulting in incapacitation

Both of these Fractional Effective Doses are cumulative over time and have been calculated from the moment of ignition of the bedroom and lounge fires. For the kitchen tests the FED values are calculated from the point at which the oil is started heating.

The table below summarises the timings of key events in and details the associated tenability times for each of the tests. Figure 141 to Figure 143 detail the Fraction Effective Doses (both for convective heat and asphyxiant gases) calculated from data collected during the fire tests.

(b) Purser D, Toxicity assessment of combustion products, Chapter 6, SFPE Handbook.
\textsuperscript{17} $\text{OD/m} = \text{[optical path length]-1 x Log}_{10}(T_0/T)$
where $T_0$=100\% transmittance and $T$=transmittance during test
Figure 144 summarises the compartment gas temperature at head height for each of the bedroom and lounge tests. This provides a simple but good overall illustration of the significant improvement to conditions in the room of origin provided by the use of a sprinkler.

<table>
<thead>
<tr>
<th>Sprinkler flow rate</th>
<th>Alarm activation time</th>
<th>Visibility reduced to &lt;2m</th>
<th>FED &lt;i&gt;heat ≥ 1&lt;/i&gt;</th>
<th>FED &lt;i&gt;asphyxiant ≥ 1&lt;/i&gt;</th>
<th>Time to incapacitation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bedroom</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsprinklered</td>
<td>t = 25sec</td>
<td>t = 2min 21sec</td>
<td>t = 2min 20sec</td>
<td>t = 3min&lt;sup&gt;18&lt;/sup&gt;</td>
<td>2min 20sec (not survivable)</td>
</tr>
<tr>
<td>60L/min</td>
<td>t = 55sec</td>
<td>t = 2min 10sec</td>
<td>never reached 1 (0.02 after 15min)</td>
<td>t = 12min 3sec</td>
<td>12min 3sec (survivable)</td>
</tr>
<tr>
<td>49L/min</td>
<td>t = 42sec</td>
<td>t = 2min 22sec</td>
<td>never reached 1 (0.037 after 15min)</td>
<td>t = 6min 26sec</td>
<td>6min 26sec (survivable)</td>
</tr>
<tr>
<td><strong>Lounge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsprinklered</td>
<td>t = 1min 37sec</td>
<td>t = 2min 36sec</td>
<td>t = 3min 21sec</td>
<td>t = 4min 10sec</td>
<td>3min 21sec (not survivable)</td>
</tr>
<tr>
<td>60L/min</td>
<td>t = 1min 40sec</td>
<td>t = 2min 38sec</td>
<td>never reached 1 (0.027 after 30min)</td>
<td>never reached 1 (0.35 after 30min)</td>
<td>Indefinite (&gt;30min)</td>
</tr>
<tr>
<td>49L/min</td>
<td>t = 1min 42sec</td>
<td>t = 2min 57sec</td>
<td>never reached 1 (0.033 after 15min)</td>
<td>never reached 1 (0.39 after 15min)</td>
<td>Indefinite (&gt;30min)</td>
</tr>
<tr>
<td><strong>Kitchen</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsprinklered</td>
<td>t = -24min&lt;sup&gt;19&lt;/sup&gt;</td>
<td>t = 35sec (briefly) and then 4min</td>
<td>never reached 1</td>
<td>never reached 1</td>
<td>—</td>
</tr>
<tr>
<td>60L/min</td>
<td>not recorded</td>
<td>t = 1min 5sec (briefly) and then 3min 20sec</td>
<td>never reached 1</td>
<td>never reached 1</td>
<td>—</td>
</tr>
<tr>
<td>49L/min</td>
<td>not recorded</td>
<td>t = 5sec (briefly) and then 2min 40sec</td>
<td>never reached 1</td>
<td>never reached 1</td>
<td>—</td>
</tr>
</tbody>
</table>

18 Some gas concentration data lost for this test, estimated values used in calculating FED.
19 Smoke alarm in lobby initially activated 24minutes prior to ignition of oil. Operation of alarm was intermittent until towels ignited later in test.
Development of a lower-cost sprinkler system for domestic premises in the UK

Figure 141 Fraction effective doses for bedroom fires
Figure 142 Fraction effective doses for bedroom fires
Figure 143 Fraction effective doses for kitchen fires

- Sprinklered fire (49L/min)
- Sprinklered fire (60L/min)
- Unsprinklered fire

Development of a lower-cost sprinkler system for domestic premises in the UK
IN SUMMARY:

**Bedroom and lounge tests**
- In all of the bedroom and lounge tests visibility in the compartment was sufficiently reduced after 2 to 3 minutes to present difficulties in locating the room exit.
• Operation of the sprinklers in these tests did not improve visibility but otherwise significantly improved the tenability conditions.

• In the unsprinklered bedroom and lounge fires the tenability time for any occupants in the room were very short, with initial incapacitation resulting from the effects of elevated temperatures. If rescue of the occupant did not occur soon after this incapacitation then death would be certain. It is safe to assume that these fires would, if unchecked, spread to the rest of the house and threaten any occupants of other rooms.

• Sprinkler protection of these rooms, at both flow rates, significantly cooled the compartment and maintained the value of \( FED_{\text{heat}} \) well below the tenability threshold value of 1.

• In the bedroom scenario fire tests the sprinkler rapidly controlled the fire, containing it to a small amount of burning on the book case shelves, prior to full extinguishment. Post test assessment of the compartment revealed damage to be minimal and very localised. Little visible difference in performance was evident between the two flow rates used, although at the lower flow rate a small residual level of burning continued until the test end and resulted in marginally more charring of items of the shelf unit. In both of these tests, sufficient materials were burnt and toxic gases produced prior to sprinkler operation to cause the tenability limit for asphyxiant gases (resulting in unconsciousness) to be reached after several minutes. However, use of the sprinkler in these tests significantly improved tenability times, providing valuable additional time for any occupants in the room of origin to escape.

• Due to dilution and the time required for the spread of smoke and toxic gases it can be assumed that tenability times for any occupants in other rooms in the property would be significantly longer than those quoted for the room of origin.

• In the lounge scenario tests the sprinkler rapidly controlled the fires, initially with some limited burning of shielded sections of the unmodified foam sofa, prior to full extinguishment. Post test assessment of the compartment revealed damage to be limited to minimal charring of items on the shelf unit and partial loss of the sofa foam. Very little visible difference in performance was evident between the two flow rates used. At both flow rates conditions in the compartment remained tenable for the duration of monitoring (30min).

Kitchen tests
• Preliminary tests illustrated that the time required to heat a chip pan sufficiently to auto ignite can vary significantly depending on the local conditions. Whilst the auto ignition temperature of the oil is generally constant (around 360°C for pure vegetable oil), factors such as the pan size, quantity of oil, heat output of the cooker, etc can affect the rate of heating of the oil and thus the time required to reach the critical temperature. In the process of heating the oil to auto ignition in these tests a significant quantity of volatile fractions were boiled off, producing an atmosphere which, whilst not necessarily toxic, would be likely nonetheless to cause...
respiratory difficulties to anyone in the room and be immediately obvious to anyone conscious in the vicinity.

- Whilst flame spread in the unsprinklered kitchen fire was limited in extent the test demonstrated the potential for progression of fire from the chip pan. In real domestic properties the potential for flame spread to other furnishings in the kitchen would depend on local conditions.

- During the sprinklered kitchen test, activation of the sprinkler initially caused the chip pan flames to increase significantly in size. However, this did not lead to any increased consequential damage and suppression was achieved relatively quickly thereafter.

- The tenability criteria (detailed previously) were not breached during these tests.

All tests
- In all of the fire tests little degradation in fire fighting performance was noted in decreasing the sprinkler flow rate from 60L/min to 49L/min.

- The drop in tenability time seen in the bedroom tests is largely attributed to slight variations in the initial fire growth rate and consequently the quantity of toxic gases produced prior to the sprinkler operation.

- As reported in other domestic fire studies, the benefit of smoke detectors, both in the room of origin and the adjoining corridors, was clearly demonstrated.

- The data collected form these tests indicates significantly improved tenability times for the sprinklered fires compared with the unsprinklered cases, even when the water flow rate was reduced. Whilst this is an encouraging result it must be considered in context with the limited range and number of tests conducted. It is possible that some slow growing, low heat output fires might not produce sufficient temperature rises to activate the sprinkler head but could produce incapacitating levels of toxic smoke (examples of this type of fire are detailed in the BRE report). However, such scenarios would affect sprinkler systems conforming with BS9251 and not just the prototype system described here.

8.3 Plumbing and mains water connection issues

A number of issues raised during the knowledge elicitation exercise are considered to be particularly important to the developed sprinkler system and these issues are re-iterated in Table 49, together with the anticipated consequences.
### Table 49 Critical plumbing and water connection issues and their consequences

| Question                                                                 | Response                                                                                                                                                                                                                                                                                                                                 | Consequence                                                                                                                                                                                                                       |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Questions 1-6: What factors effect domestic water supply pressures and to what extent? | There are many factors that can cause mains water pressure to drop including domestic and commercial usage, planned maintenance and repairs, pressure management to reduce leakages, and unexpected damage to the system.  
*It is not practical to estimate the extent of the effect of these factors.* | It is not possible to estimate the impact that mains pressure fluctuations would have on the effectiveness of the prototype sprinkler system.                                                                                                                                                      |
| Questions 7&8: If the water supply is interrupted how long might this last? | OFWAT collates and reports details planned and unplanned water stoppages. Prolonged stoppages (>24 hours) are very rare (affecting less than 0.06% of UK properties.)  
*There is no readily available data on the duration of reductions in mains pressure (other than complete stoppages).* | It is not possible to estimate the proportion of any day/season/year for which the prototype sprinkler system would be ineffective.                                                                                                                                                                                                          |
| Question 13: Would the supply mains pressure be significantly affected by domestic off takes of 60/85/120 L/min? | *Domestic flow rates of this magnitude should not significantly affect the mains water supply pressure under normal circumstances.* | Assuming suitably sized pipework, the water main should be able to supply both the sprinkler system and normal domestic load without a drop in the mains pressure.                                                                                                                                                   |
| Question 19: Regarding the use of larger than normal water meters | Water companies reserve the right to approve the type of water meter chosen for use with domestic properties.  
The main concern with using larger water meters is in the reduced accuracy of measurement at lower flow rates. *Currently the water companies require Class D meters to be used.* | Class D meters appear to be limited to bore sizes of 20mm – which would impose significantly higher system pressure losses than for larger bore meters.  
However, there may be exceptions to this – see section 8.4.1                                                                                                                                                                                       |
| Question 33: Who would be responsible for implementing new water mains connections | Normally, for re-connections of existing properties and initial connections of new properties the householder/construction company would provide the supply pipe and the water company would make the connection to the mains and fit the communication pipe.  
*However, Recent changes to the UK water regulations now allow developers to 'self lay' not only the supply pipe, but also the boundary box, the water meter, the communication pipe and all connected components up to the water main. There are specific requirements for allowing this that will be detailed by the water companies.* | Estimating the water connection costs for new build properties where self lay is used is not practical due to the wide range of installation options that would be available.                                                                 |
Note on the issue of water stagnation: The total retained water volume in this combined plumbing system, after the house holder’s isolation valve, is 5.3L – including both the 22mm and 15mm pipework. Of this, the 15mm pipework accounts for 1L, so the sprinkler system adds just over 4L of additional retained water above what would normally occur in a domestic property of this size. This is a relatively small volume of water, which would be consumed many times over in the normal course of domestic activities.

8.4 Pressure losses arising in the mains water connection

In the vast majority of cases, roll-out of this system to the existing housing stock will require an upgrading of the supply pipe to 32mm. However, this specification alone may not give the desired result if all other elements of the system are not sized accordingly. For example, some jointing methods employed between the water main and supply pipe can inflict a very severe pressure penalty on the connection, thereby losing much of the anticipated benefit.

Clear guidance and instructions should be made available to water authorities and installers alike to ensure the appropriate selection of connection method and fittings to minimise pressure losses through the connection.

<table>
<thead>
<tr>
<th>Question 33: Who would bear the cost of new water meters?</th>
<th>Water meters are mandatory in all new build properties. The customer would be charged for the meter (see question 34). Water meters do not need to be fitted to existing properties when a new connection to the mains is made.</th>
<th>If water meters are not required for new connections to existing properties then this would help reduce the mains water pressure requirement and minimise any potential effects of sediment build up in the service pipe.</th>
</tr>
</thead>
</table>
| Questions 38-40: Regarding the acceptability of the prototype system to water companies | There are Water Industry concerns about the risks of stagnation through lack of turnover in pipe networks because it is difficult to predict/prove that normal demand patterns will draw fresh water into all legs of the system. 

There is a potential risk with meters in that a sudden increased flow on a service pipe may bring any fine debris in the mains or service pipe into suspension and possibly block the meter, this could stop or greatly inhibit the water supply to the sprinkler heads. 

Ultimately, the acceptability of this type of combined plumbing system would need to be assessed by a water regulations committee. | Any future work will need to investigate the possible risks of water stagnation and the potential for water meter blockages. In addition to this, an in depth dialogue with the water industry and water regulations committees will be necessary; this would need to either firmly establish the acceptability of this combined plumbing sprinkler system or identify and rectify any non-compliances. |

### Table 49 Critical plumbing and water connection issues and their consequences (cont.)

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 33: Who would bear the cost of new water meters?</td>
<td>Water meters are mandatory in all new build properties. The customer would be charged for the meter (see question 34). Water meters do not need to be fitted to existing properties when a new connection to the mains is made.</td>
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</tr>
</tbody>
</table>
| Questions 38-40: Regarding the acceptability of the prototype system to water companies | There are Water Industry concerns about the risks of stagnation through lack of turnover in pipe networks because it is difficult to predict/prove that normal demand patterns will draw fresh water into all legs of the system. 

There is a potential risk with meters in that a sudden increased flow on a service pipe may bring any fine debris in the mains or service pipe into suspension and possibly block the meter, this could stop or greatly inhibit the water supply to the sprinkler heads. 

Ultimately, the acceptability of this type of combined plumbing system would need to be assessed by a water regulations committee. | Any future work will need to investigate the possible risks of water stagnation and the potential for water meter blockages. In addition to this, an in depth dialogue with the water industry and water regulations committees will be necessary; this would need to either firmly establish the acceptability of this combined plumbing sprinkler system or identify and rectify any non-compliances. |
The principal aspects are:

- The method and components used in physically connecting the service pipe to the water main.
- In-line stop taps or other control valves.
- The components used for coupling inline devices to the service pipe.
- Bends and/or kinks in the service pipe.
- Water meter selection.

Water meter selection is discussed in detail below.

8.4.1 DOMESTIC WATER METERS

All new build properties are required to have a water meter fitted to monitor water usage. There are many types and sizes of water meter available, however only certain classes of meters may be used for domestic supplies. The following details regarding the permissible types of water meters were taken from the National Weights and Measures Laboratory (NWML) web site.

Cold-water meters used “for measuring any supply of water for domestic purposes in England or Wales” are controlled by the Measuring Equipment (Cold-water Meters) Regulations, SI 1988/997. These Regulations are made under powers in the Weights and Measures Act 1985. The effect of these Regulations is, in brief, that:

- The type or design of the meters used must be approved by the Secretary of State for Trade and Industry (NWML).
- All meters must be tested, passed as fit for use for trade and stamped before being put into use.
- Meters must be appropriate meters for the installation in question having regard to the criteria in clause 2 of BS 5728: Part 2: 1980.
- Meters in use are subject to inspection and test by Trading Standards Officers; where a Trading Standards Officer tests a meter and finds it registering outside the allowed limits of error, there is power for the meter to be taken out of use.

Where a meter may be (in accordance with clause 2 of BS 5728: Part 2: 1980) of accuracy class\(^{20}\) A, B or C as specified in Council Directive 75/33/EEC, then the procedures set out in that Directive for EEC pattern approval and EEC initial verification may be followed. However, generally in the UK water meters for domestic supply are of class D, which is not covered in the Directive. The above

\(^{20}\) Cold-water meters are classified according to their flow range into classes A, B, C and D, based on the Directive 75/33/EEC and BS 5728: Part 1: 1979 (as amended in July 1986), class A having the lowest turndown ratio and class D the highest.
Regulations are complemented by the Water (Meters) Regulations 1988, SI 1988/1048 as amended, which provide for the testing of meters by the undertaker, as he sees fit, and on the request of the customer.

Taken together these provisions ensure that only accurate meters are put into service, and that there are adequate testing possibilities where a customer doubts the continued accuracy of the meter supplying their premises.

This requirement to use only Class D meters for domestic properties is expounded by water companies (see section 7) and could potentially impact on the system being developed. Class D meters appear to be available only with connection sizes of 15mm and 20mm which incur significantly higher pressure losses than meters with 25mm or greater connections (which are available with Class C meters).

However, the NWML web site goes on to detail the following FAQ which suggests that Class C meters may be acceptable in certain circumstances.

**Q:** Can class C water meters be used in the UK?

**A:** A meter used for measuring the supply of water for domestic purposes must comply with Statutory Instrument 997, The Measuring Equipment (Cold-water Meters) Regulations 1988. Section 4 states that the meter must be appropriate for the installation regarding the criteria in clause 2 of BS 5728: Part 2: 1980(f), one of which is the expected flow rate.

In most domestic applications with an indirect feed system, i.e. a storage tank, a class D meter is appropriate. For installations with a direct water supply class C meters may be considered appropriate. It is the responsibility of the water authority to select the appropriate meter.

By way of example, the Kent V100 water meter, see Figure 145, is designed for the measurement of cold potable water and is commonly used in the water industry. The meter can be installed in any position, operates on the volumetric rotary piston measurement principle and can achieve high levels of reading accuracy even at low flow rates. Table 50 below details the various meter sizes available, their flow properties and their current cost\(^2\). All of these meters are available as Class C but only the DN15 and DN20 are available as Class D meters. Pressure loss curves for the DN20, DN25 and DN30 meters, shown in Figure 146, illustrate the significant difference in flow characteristics resulting from relatively small differences in meter bore size. Table 51 details the pressure losses incurred for each of these metres at key water flow rates. Further details of this water meter are provided in Annex E.

\(^2\) Obtained from [www.johnsonvalves.co.uk](http://www.johnsonvalves.co.uk) – these are retail prices for single units. It is possible that these costs might be lower for meters purchased through water companies or in larger numbers.
From the data obtained for the V100 water meter it is possible to estimate the flow induced pressure losses for different meter sizes at key flow rates.

### Table 50 Details of V100 water meter

<table>
<thead>
<tr>
<th>Model</th>
<th>Thread size</th>
<th>Min. continuous flow @ +/- 5% accuracy (L/min)</th>
<th>Min. continuous flow @ +/- 2% accuracy (L/min)</th>
<th>Max. continuous flow @ +/- 2% accuracy (L/min)</th>
<th>Max. measurable flow rate (L/min)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN15</td>
<td>½”</td>
<td>0.38</td>
<td>0.25</td>
<td>25</td>
<td>50</td>
<td>£58</td>
</tr>
<tr>
<td>DN20</td>
<td>¾”</td>
<td>0.63</td>
<td>0.42</td>
<td>42</td>
<td>84</td>
<td>£74</td>
</tr>
<tr>
<td>DN25</td>
<td>1”</td>
<td>0.88</td>
<td>0.58</td>
<td>58</td>
<td>116</td>
<td>£110</td>
</tr>
<tr>
<td>DN30</td>
<td>1¼”</td>
<td>1.5</td>
<td>1.00</td>
<td>100</td>
<td>200</td>
<td>£239</td>
</tr>
<tr>
<td>DN40</td>
<td>1½”</td>
<td>2.5</td>
<td>1.67</td>
<td>166</td>
<td>332</td>
<td>£321</td>
</tr>
</tbody>
</table>

### Table 51 Water meter pressure losses

<table>
<thead>
<tr>
<th>Flow rate (L/min)</th>
<th>Din 20 meter</th>
<th>Din 25 meter</th>
<th>Din 30 meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>0.25</td>
<td>0.14</td>
<td>0.05</td>
</tr>
<tr>
<td>60</td>
<td>0.37</td>
<td>0.22</td>
<td>0.07</td>
</tr>
<tr>
<td>85</td>
<td>0.76</td>
<td>0.44</td>
<td>0.15</td>
</tr>
<tr>
<td>2 x 42 (2 sprinkler operation)</td>
<td>0.73</td>
<td>0.42</td>
<td>0.14</td>
</tr>
</tbody>
</table>
8.5 Mains water pressure requirements of prototype combined plumbing sprinkler system

To establish the potential of the envisaged system for mass implementation there is a need to make some major assumptions in respect of what constitutes a ‘typical’ installation in terms of:

- House layout.
- Water connection detail (distance from main).
- Water meter requirement and selection.
- Household plumbing arrangement.
- Operational flowrates and pressures.

and marry this up with a generalised water supply model for the UK from the supplied water authority survey information. Some of the information that is used in this undertaking must be considered of suspect quality and in some instances was simply not available and so has had to be inferred. To this end the conclusions that are ultimately drawn from this analysis, whilst being very specific to the described design, will only ever be indicative and as such a detailed case by case study will be required before the true cost benefit can be known.
The ensuing calculations rigorously assume:

a) All houses are identical to the model described in the hydraulic study (this is clearly not the case as some will be greater than 2 storeys high).

b) The connection to the HIV from the main (in all but one case) is 32mm HDPE pipe.

c) The supply pipe length is 10 metres.

d) No fitting in the supply pipe inflicts a pressure drop greater than the length of the item.

e) All internal pipework relevant to the supply of water to the sprinkler heads is in 22mm copper pipe.

f) K71 sprinklers are used throughout.

Any excursion from these values may warrant a different outcome.

Calculations are given for five relevant scenarios varying:

- Required flowrate.
- Supply pipe diameter.
- The need for a water meter (new build installation vs. retrofit).

<table>
<thead>
<tr>
<th>Design example</th>
<th>Mains supply pipe diameter</th>
<th>Internal Plumbing system</th>
<th>Flow rate Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 32mm 10m</td>
<td>22mm copper</td>
<td>85L/min from 1 head*</td>
<td></td>
</tr>
<tr>
<td>B 32mm 10m</td>
<td>22mm copper</td>
<td>60L/min from 1 head*</td>
<td></td>
</tr>
<tr>
<td>C 32mm 10m</td>
<td>22mm copper</td>
<td>49L/min from 1 head*</td>
<td></td>
</tr>
<tr>
<td>D 32mm 10m</td>
<td>22mm copper</td>
<td>85L/min from 1 head</td>
<td></td>
</tr>
<tr>
<td>E 32mm 10m</td>
<td>22mm copper</td>
<td>60L/min from 1 head</td>
<td></td>
</tr>
<tr>
<td>F 32mm 10m</td>
<td>22mm copper</td>
<td>49L/min from 1 head</td>
<td></td>
</tr>
<tr>
<td>G 25mm 10m</td>
<td>22mm copper</td>
<td>60L/min from 1 head</td>
<td></td>
</tr>
</tbody>
</table>

*Depending on the specific hydraulic details, the pressure requirement for single head operation may be more onerous than that for two heads (as is the case in these example design solutions), see Table 10.
The actual mains pressure required by each of the design examples to provide the required sprinkler flow rates is determined from:

\[
\text{Hydraulically calculated mains pressure requirement to produce the required flow of each design example} + \\
\text{Pressure loss incurred by water meter (where installed)} + \\
\text{Estimated additional pressure losses arising in the service pipe}
\]

These calculations have been performed for single sprinkler actuation although the full flow pressure drop of two sprinklers operating has been used for the estimation of water meter pressure loss penalty.

### Table 53 Estimated mains pressure requirements of the seven design examples

<table>
<thead>
<tr>
<th>Design example</th>
<th>Mains pressure (ignoring additional losses in service pipe)</th>
<th>Pressure loss from water meter</th>
<th>Estimated additional pressure losses</th>
<th>Estimated mains pressure requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retro fit systems (assume no water meter required)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>2.81</td>
<td>n/a</td>
<td>0.73</td>
<td>3.5</td>
</tr>
<tr>
<td>B</td>
<td>1.66</td>
<td>n/a</td>
<td>0.73</td>
<td>2.4</td>
</tr>
<tr>
<td>C</td>
<td>1.32</td>
<td>n/a</td>
<td>0.73</td>
<td>2.1</td>
</tr>
<tr>
<td>New build systems (water meter is required)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>2.81</td>
<td>0.73</td>
<td>0.73</td>
<td>4.3</td>
</tr>
<tr>
<td>E</td>
<td>1.66</td>
<td>0.73</td>
<td>0.73</td>
<td>3.1</td>
</tr>
<tr>
<td>F</td>
<td>1.32</td>
<td>0.73</td>
<td>0.73</td>
<td>2.8</td>
</tr>
<tr>
<td>G</td>
<td>2.29</td>
<td>0.73</td>
<td>0.73</td>
<td>3.8</td>
</tr>
</tbody>
</table>

This table represents the absolute minimum pressure requirement of the optimised envisaged system. Caution is advised in the marrying up of these values with ‘mean’ water pressure data supplied by the water authorities. Temporal variations caused by periods of high use, or night-time leak reduction measures will impact upon system performance for the period over which suppressed pressures are experienced.

### 8.6 Water pressure survey

Full details of the responses obtained from the water pressure survey are reproduced in Annex B. Table 54 below summarises the data relating to the proportions of properties in each region having mean pressures equal to or greater than 1.5bar, 2.0bar, 2.5bar etc. This table clearly shows the variability in the amount of information provided by different water authorities. In total, responses were obtained from 20 of the 27 UK water companies, which represent approximately 83% of all UK domestic properties. However 11 of the companies that did respond to the survey provided data that was insufficient for further analysis in this report.
The remaining 9 companies that provided sufficiently detailed responses are summarised in table 54 (to assist in the analysis of this data a small number of pressures have been interpolated – highlighted in blue). These regions represent 39% of all UK dwellings. Figure 145 plots the mean of this dataset together with single data sets from regions having the highest and lowest pressures for comparison.
With such variability in regional mean supply pressures a limitation is immediately placed on the effectiveness of this benefit analysis by the use of a mean dataset comprising only those companies supplying complete datasets. A future study might consider ‘regional’ analysis pending the supply of better water authority data.
Consideration must also be given to the comparison of design pressures to the supplied ‘mean’ pressure data by the water authorities. Although few were explicit in relation to the detail of pressure managed areas, the knowledge elicitation revealed that pressure controlled regions could experience a night-time pressure reduction of up to 30% of the mean value in line with the reduced night time demand. A modified dataset for the UK is given below:

![Graphic illustrating mains pressure to properties modified to allow for pressure management](image-url)

**Figure 148 – Mains pressure to properties modified to allow for pressure management**

### 8.7 UK roll-out potential of combined plumbing sprinkler system

By combining the estimates of the ‘idealised’ system requirement and the generalised water supply pressure profile for the UK, the proportion of properties in which the prototype system could potentially be installed can be estimated for Design Examples A to G. Consideration is only given to the portion of the UK housing stock comprising 2 storeys or less which is approximately 84% of the total.

**Potential for system implementation in existing properties (retro-fit)**

Assuming a 10m long water main connection that has been upgraded to 32mm diameter plastic pipe with no water meter, and a 22mm copper pipe internal plumbing system:

- It is estimated that mains pressure sufficient to achieve a flow rate of **85 l/min** at the hydraulically most disadvantaged sprinkler might be available in approximately **20-55%** of all UK properties.
- It is estimated that mains pressure sufficient to achieve a flow rate of **60 l/min** at the hydraulically most disadvantaged sprinkler might be available in approximately **60-75%** of all UK properties.
- It is estimated that mains pressure sufficient to achieve a flow rate of **49 l/min** at the hydraulically most disadvantaged sprinkler might be available in approximately **65-80%** of all UK properties.
For properties built since the introduction of using 25mm plastic pipe mains connections (again assuming a 10m service pipe and no water meter):

It is estimated that between **15-50%** of all UK properties that are fitted with a 25mm connection would have a water mains pressure sufficient to achieve a flow rate of **60 l/min** at the hydraulically most disadvantaged sprinkler without upgrading the mains connection.

**Potential for system implementation in new build properties**

Assuming 10m long x 32mm diameter water main connection, with a water meter and a 22mm copper pipe internal plumbing system:

It is estimated that mains pressure sufficient to achieve a flow rate of **85 l/min** at the hydraulically most disadvantaged sprinkler might be available in approximately **5-35%** of all UK new build properties.

It is estimated that mains pressure sufficient to achieve a flow rate of **60 l/min** at the hydraulically most disadvantaged sprinkler might be available in approximately **35-65%** of all UK new build properties.

It is estimated that mains pressure sufficient to achieve a flow rate of **49 l/min** at the hydraulically most disadvantaged sprinkler might be available in approximately **45-70%** of all UK new build properties.

### 8.8 Potential reduction of domestic fire deaths

Using the fire statistics and consensus values of sprinkler effectiveness presented previously the following section will estimate the number of casualties per year that might be prevented by implementing sprinkler systems in UK dwellings. This entails a number of broad assumptions, all of which are detailed.

The average number of casualties arising from accidental fires in domestic dwelling fires per year (based on 2002 & 2003 data) is:

- Deaths per year: 375
- Injuries per year: 10,804

These figures relate to fires arising from accidental ignitions only and exclude deliberately started fires; ODPM published fire statistics only provides detailed analysis of accidental dwelling fires.

**Stage 1 – allowance for sprinkler coverage within dwellings**

**Assumption:** the sprinkler system will only be suitable for fitting in dwellings that are buildings and possibly mobile homes. The ODPM fire statistics definition of buildings also includes any non-permanent structures used solely as a dwelling, such as caravans and houseboats. These are unlikely to be suitable for sprinkler protection; fires in these dwelling types only account for about 0.5% of the total number of UK dwelling fires.

**Assumption:** the sprinkler system will omit sprinklers from lofts, store rooms and bathrooms.

**Assumption:** the deaths and injuries listed as ‘unspecified’ are distributed around the house in sprinkler protected rooms.
Deaths potentially preventable due to reduced system coverage 97.2%
Injuries potentially preventable due to reduced system coverage 96.8%

**Stage 2 – accounting for effectiveness of sprinkler systems**

UK fire statistics indicate that approximately half of the people who die in accidental dwelling fires are found in the room in which the fire originated. The capability of the installed system to impact upon this figure will depend upon many aspects specific to the fire scenario and the individual’s state of health. For example:

a) A healthy person may not wake before toxic gases overcome them from a slow, smouldering fire

b) A disabled person may not be able to effect an escape even when alerted early to the fire

c) Someone under the influence of drink or drugs might only be alerted to the fire after a significant delay, and may thereafter be unable to effect an escape.

For the purposes of this study it shall be assumed that the *sprinkler effectiveness* values detailed below (obtained from experience in other countries) take into account the issue of occupant mobility and their location in relation to the room of origin but clearly this is an area where better supporting data is required.

**Assumption:** all properties fitted with sprinkler systems are also fitted with smoke alarms.

**Assumption:** each of the prototype combined plumbing sprinkler system design options has a comparable level of effectiveness as other sprinkler systems (this is unlikely to be the case and performance will change for each water supply option).

**Assumption:** the socio-economic population over which the data was collected accurately describes the occupants of the UK target housing sector.

Using the details from section 3.4.2 and the above assumptions the effectiveness of the sprinkler system (in conjunction with smoke alarms) will be taken as:

Effectiveness in preventing deaths 76%
Effectiveness in preventing injuries 57%

Note: the limited amount of available UK data on sprinkler performance necessitates using the above figures (calculated from consensus figures for other countries as detailed in section 3.4.2). It is entirely possible that the definition of ‘injury’ may vary between countries and so the following figures for preventable fire injuries should be treated as indicative only (figures published in the BRE sprinkler report suggest an average value for the UK of 30%).
Stage 3 – accounting for the proportion of properties for which the proposed system would be suitable

**Assumption**: both the fire related casualties and the sprinkler protected properties are evenly distributed throughout the UK.

**Assumption**: all dwellings with sufficient mains pressure for a particular design option are fitted with a sprinkler system. As noted above, this could potentially include mobile homes but does not include caravans, house boats and non-permanent dwellings.

**Assumption**: all previous assumptions in the derivation of these figures.

### Table 56  Estimate of preventable casualties in UK accidental dwelling fires

<table>
<thead>
<tr>
<th>Design example</th>
<th>Required mains Pressure (bar)</th>
<th>Proportion of properties with adequate pressure and fitted with sprinkler system</th>
<th>Potential maximum number of preventable casualties</th>
<th>Deaths per year</th>
<th>Injuries per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrofit in existing properties, upgraded mains connection, no water meter required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>3.5</td>
<td>20 – 55%</td>
<td>55 – 152</td>
<td>1100 – 3200</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>2.4</td>
<td>60 – 75%</td>
<td>166 – 208</td>
<td>3500 – 4400</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2.1</td>
<td>65 – 80%</td>
<td>180 – 222</td>
<td>3800 – 4700</td>
<td></td>
</tr>
</tbody>
</table>

**Design example A**: Supply pipe [10m long, 32mm MDPE], Internal plumbing [22mm copper]
Required flow rate [85L/min from 1 head]

**Design example B**: Supply pipe [10m long, 32mm MDPE], Internal plumbing [22mm copper]
Required flow rate [60L/min from 1 head]

**Design example C**: Supply pipe [10m long, 32mm MDPE], Internal plumbing [22mm copper]
Required flow rate [49L/min from 1 head]

It should be noted that Table 56 details the number of casualties from accidental dwelling fires that could potentially be prevented by wide scale implementation of the prototype sprinkler system in conjunction with smoke alarms. It indicates that between 55 and 222 deaths might be prevented per year, depending on the minimum system specification selected. However, accidental fires only account for 86% of the total yearly fatalities in dwellings. If it were assumed that occupants in dwellings subject to non-accidental fires were protected to the same extent as detailed above then the number of annually prevented deaths could potentially rise to between 64 and 257 per year.

It is recognised that all of the figures used and the assumptions made in this analysis presuppose the most favourable set of operating conditions and consequently the estimates of casualty prevention represent the upper end of what might be achievable. Additional future work (detailed later) is required to refine the data used in these calculations and hence improve confidence in predicted benefits.
8.9 Illustrative installation costs of prototype system

The actual cost of installing the described sprinkler system into real domestic properties will depend on a number of factors, including:

- Installation into an existing or newly built property.
- Whether being undertaken as part of an overall refurbishment of the property.
- Whether the building contractor intends to ‘self lay’ the service pipe/water meter/etc.
- The size and complexity of the layout of the property and distance from the main.
- Whether a water meter is required.
- Variations in material and labour costs of different plumbing contractors.
- Potential cost reductions if multiple systems are being installed.
- Whether or not an upgraded mains connection is required.
- Ongoing maintenance requirements.

As detailed previously, there are options available which might greatly reduce or even remove the burden of ongoing maintenance costs from private home owners. For the purpose of this costing exercise it has been assumed that there is no direct additional cost arising from annual inspections and maintenance.

The costs that would be incurred in implementing the proposed sprinkler system fall into three main categories:

a. Interior plumbing – all labour and material costs associated with installing the sprinkler distribution and domestic utilities pipework, including any preparation work and making good that is required.

b. Service pipe laying – all labour and material costs associated with trench digging and laying of an upgraded service pipe (where needed) up to the property boundary, including removal of old pipework (if required) and making good.

c. Mains connection – standard installation charges by water companies for connecting the property owners service pipe (at the property boundary) to the water main, including excavation and making good, a water meter and stop taps.
The following sections detail examples of these costs for three specific installation scenarios:

(A) Retrofitted system in a fully furnished property that requires both the internal domestic plumbing and the mains connection to be upgraded. (Representing the most costly retrofit scenario.)

(B) Retrofitted system in a fully gutted property awaiting refurbishment. Requires new domestic plumbing and can therefore be offset against the cost of the combined system. Mains connection requires upgrading. (Representing the least costly retrofit scenario.)

(C) Newly built property. The cost of both the internal plumbing and the mains connection required for the proposed sprinkler system can be offset against the cost of installing the standard domestic plumbing and mains connection. (Likely to represent the lowest possible installation cost.)

### 8.9.1 INTERNAL PLUMBING AND SERVICE PIPE LAYING COSTS

The following illustrative costs were obtained from the plumbing company that installed the prototype system on the test rig. Details of the guidance given in obtaining these costs are detailed in Annex F.

<table>
<thead>
<tr>
<th>Item</th>
<th>Labour Cost</th>
<th>Materials Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newly built property costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation of a standard internal cold water plumbing system</td>
<td>£400</td>
<td>£120</td>
</tr>
<tr>
<td>Installation of internal combined plumbing system (domestic plumbing items and sprinkler pipework)</td>
<td>£525</td>
<td>£185</td>
</tr>
<tr>
<td>Net additional cost of combined plumbing sprinkler system</td>
<td>£125</td>
<td>£65</td>
</tr>
<tr>
<td>Installation of standard (25mm MDPE) house supply pipe, including water meter and boundary box (excluding trench digging)</td>
<td>£130</td>
<td>£115</td>
</tr>
<tr>
<td>Installation of 32mm MDPE house supply pipe, including water meter and boundary box (excluding trench digging)</td>
<td>£150</td>
<td>£185</td>
</tr>
<tr>
<td>Net additional cost of enlarged mains supply</td>
<td>£20</td>
<td>£70</td>
</tr>
<tr>
<td>Retro-fit property</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated additional costs for removal and replacement of furniture/etc (not including carpets) if installing in a fully furnished house (if required)</td>
<td>£100</td>
<td>£0</td>
</tr>
<tr>
<td>Removal of existing plumbing system</td>
<td>£200</td>
<td>£0</td>
</tr>
<tr>
<td>Installation of internal combined plumbing system (domestic plumbing items and sprinkler pipework)</td>
<td>£600</td>
<td>£185</td>
</tr>
<tr>
<td>Replacement of existing mains water connection pipework with a 32mm MDPE supply pipe (including excavation) up to property boundary</td>
<td>£200</td>
<td>£100</td>
</tr>
</tbody>
</table>

### 8.9.2 WATER COMPANY INSTALLATION CHARGES

A number of water companies provide details on their web site of the processes and costs involved in implementing new connections to the water main. These
costs can vary from property to property and will depend on factors such as the type and length of excavation required to install the pipework. These charges do not cover the excavation from the property to the boundary box.

Examples of costs of the ‘supply connection’ are detailed below for two water companies, Severn Trent and Thames Water. An additional fee known as the ‘infrastructure charge’ is levied on property developers for connecting new properties. However, since the same charge would be incurred for a standard 25mm connection on new properties it is not included as an addition incurred cost for the combined plumbing sprinkler system.

Table 57 details the cost of new water service connections up to 32mm external diameter MDPE charged by Severn Trent. The standard connection charge includes the connection to the water main, laying up to 12m of service pipe, providing a controlling tap, a meter and connecting, usually at the property boundary, to the customer’s pipe. The actual charge depends on the surface that must be excavated. An additional charge, per metre of pipe applies for services over 12m in length.

<table>
<thead>
<tr>
<th>Surface type</th>
<th>Surface definition</th>
<th>Charges include provision for metering each new supply.</th>
<th>Standard charge including up to 12m of pipe</th>
<th>Additional per metre charge for pipes over 12m long</th>
</tr>
</thead>
<tbody>
<tr>
<td>No excavation</td>
<td>Where no excavation or backfill needs to be done by Severn Trent. (Specific conditions apply to this category).</td>
<td></td>
<td>£278.20</td>
<td>£3.60</td>
</tr>
<tr>
<td>Unmade</td>
<td>Grass verges, soil or virgin ground are included in this category</td>
<td></td>
<td>£362.40</td>
<td>£24.30</td>
</tr>
<tr>
<td>Part made</td>
<td>Where tarmac or stone are present and/or imported backfill is required.</td>
<td></td>
<td>£495.30</td>
<td>£46.50</td>
</tr>
<tr>
<td>Complete</td>
<td>Where a highway surface is fully constructed and we have to either excavate it or bore under it and reinstate. – Work entirely in footpaths – Where work extends into/under a roadway</td>
<td></td>
<td>£525.70</td>
<td>£59.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>£683.00</td>
<td>£79.50</td>
</tr>
<tr>
<td>Self connection</td>
<td>Connection administration fee (This facility is only available to pre-registered installers working on development sites).</td>
<td></td>
<td>£132.60</td>
<td>—</td>
</tr>
</tbody>
</table>

Table 58 details Thames Water’s connection charges. The charges shown are for 25mm and 32mm MDPE supplies and includes the work required to excavate, lay and reinstate (if required) the first metre of pipework from the water main in the street up to the site boundary of the property. It also includes the installation of a stop valve, boundary box and water meter. The property owner will need to excavate the pipework on the property so it is visible in order for the connection to be made. Any customer-led variations to the costs associated with the connection will be payable by the applicant.
8.9.3 ILLUSTRATIVE TOTAL INSTALLATION COSTS OF PROTOTYPE SYSTEM

All of the following costs are presented for illustrative purposes only. Both material and labour costs may vary considerably between plumbing contractors and will almost certainly be affected by the number of properties in which systems are to be fitted.

Installation scenario A:
Retro fit of a fully furnished existing property (same size and layout as the test rig described in this report), unsuitable domestic plumbing requires replacement, and existing mains connection (10m long, part made ground) requires upgrading to 32mm plastic pipe.

<table>
<thead>
<tr>
<th>Labour cost</th>
<th>Materials cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>£2080</td>
<td></td>
</tr>
</tbody>
</table>

Note: additional costs might be incurred in this scenario, particularly in regards of removal/replacement of carpets and any building works required in removing/replacing domestic plumbing elements.

Installation scenario B:
Retrofit of a fully gutted property (same size and layout as the test rig described in this report), domestic plumbing already removed and requires replacing, existing mains connection (10m long, unmade ground) requires upgrading to 32mm plastic pipe

<table>
<thead>
<tr>
<th>Labour cost</th>
<th>Materials cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>£200</td>
<td>£0</td>
</tr>
<tr>
<td>£100</td>
<td>£0</td>
</tr>
<tr>
<td>£600</td>
<td>£185</td>
</tr>
<tr>
<td>£0</td>
<td>£200</td>
</tr>
<tr>
<td>£200</td>
<td>£100</td>
</tr>
<tr>
<td>£495</td>
<td></td>
</tr>
</tbody>
</table>

The total estimated cost for installation scenario A is: £2080

Note: additional costs might be incurred in this scenario, particularly in regards of removal/replacement of carpets and any building works required in removing/replacing domestic plumbing elements.
The total estimated cost for installation scenario B is: £1050

Installation scenario C:
Installation in a newly built property (same size and layout as the test rig described in this report), including a 32mm plastic pipe mains connection (10m long, no excavation required), installed under self lay guidelines.

<table>
<thead>
<tr>
<th></th>
<th>Labour cost</th>
<th>Materials cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of sprinkler heads</td>
<td>£0</td>
<td>£200</td>
</tr>
<tr>
<td>Excavation and laying of 32mm MDPE service from property boundary to HIV</td>
<td>£200</td>
<td>£100</td>
</tr>
<tr>
<td>Net cost of excavation</td>
<td>£0</td>
<td>£0</td>
</tr>
<tr>
<td>Net cost of installing a 32mm water mains connection pipe and water meter</td>
<td>£20</td>
<td>£70</td>
</tr>
</tbody>
</table>

The total estimated cost for installation scenario C is: £480

Installation in newly built properties is likely to be significantly cheaper than retrofitting existing properties, as many of the costs can be offset against normal build costs.

8.10 Cost benefit analysis

A cost benefit analysis (CBA) of the three installation scenarios detailed above was conducted using the model developed by BRE for their work on sprinkler effectiveness (see Annex H). Slight changes to the data set necessitated recalculating the CBA and the updated figures are detailed below.

The CBA shows that implementation of the proposed sprinkler system is cost beneficial for new build houses but not for existing, fully furnished houses. The case of retrofitting into an existing but fully gutted house is borderline.

This initial analysis assumes the wide scale implementation of the sprinkler system into all domestic dwellings regardless of the risk associated with properties by virtue of age, type, location, social demographics etc. By targeting
higher risk properties/social groups it may be possible to improve the cost benefit ratios significantly. An example is given in the following section.

<table>
<thead>
<tr>
<th>Table 59</th>
<th>Cost benefit analysis for general implementation into all UK housing stock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Most expensive retro-fit</td>
</tr>
<tr>
<td>Millions of units considered</td>
<td>24.63</td>
</tr>
<tr>
<td>Total number of deaths</td>
<td>439</td>
</tr>
<tr>
<td>Total number of injuries</td>
<td>11900</td>
</tr>
<tr>
<td>Capital cost of system (per unit)</td>
<td>£1,085</td>
</tr>
<tr>
<td>Water connection charge (per unit)</td>
<td>£995</td>
</tr>
<tr>
<td>Capital recovery factor</td>
<td>0</td>
</tr>
<tr>
<td>Annual cost of loan</td>
<td>£88.68</td>
</tr>
<tr>
<td>Annual inspection cost</td>
<td>£0.00</td>
</tr>
<tr>
<td>Total annual costs</td>
<td>£88.68</td>
</tr>
<tr>
<td>Deaths per million units</td>
<td>17.8</td>
</tr>
<tr>
<td>Sprinkler effectiveness factor</td>
<td>0.76</td>
</tr>
<tr>
<td>Deaths saved per million units</td>
<td>13.5</td>
</tr>
<tr>
<td>Monetary value per life saved</td>
<td>£1,243,000</td>
</tr>
<tr>
<td>Monetary benefit per single unit</td>
<td>£16.84</td>
</tr>
<tr>
<td>Injuries per million units</td>
<td>483</td>
</tr>
<tr>
<td>Sprinkler effectiveness</td>
<td>0.57</td>
</tr>
<tr>
<td>Injuries saved per million</td>
<td>275.4</td>
</tr>
<tr>
<td>Monetary value per injury saved</td>
<td>£58,300</td>
</tr>
<tr>
<td>Monetary benefit per single unit</td>
<td>£16.06</td>
</tr>
<tr>
<td>Fires per million units</td>
<td>2615</td>
</tr>
<tr>
<td>Sprinkler effectiveness factor</td>
<td>0.5</td>
</tr>
<tr>
<td>Unsprinklered property damage</td>
<td>£7,540</td>
</tr>
<tr>
<td>Reduced property damage per fire</td>
<td>£3,770</td>
</tr>
<tr>
<td>Monetary benefit per single unit</td>
<td>£9.86</td>
</tr>
<tr>
<td>Total benefit per unit</td>
<td>£42.75</td>
</tr>
<tr>
<td>Cost benefit ratio</td>
<td>0.48</td>
</tr>
</tbody>
</table>

8.10.1 TARGETING OF HIGHER RISK GROUPS

Many methodologies could be adopted for the targeting of the envisaged system at high risk individuals or geographical groups of properties, such as those classified by FSEC as high or very high risk.
Certain fire and rescue services already 'target' such high risk groups and provide them with specific fire safety advice/equipment as part of their community fire safety programmes. As part of any future work programme it should therefore be feasible to collate this information to identify those properties that would most benefit from the fitting of sprinkler systems.

By doing this it should be possible to minimise the number of fire related casualties and reduce the amount of property damage for the least expenditure; thus greatly improving the cost benefit ratios detailed previously. This is illustrated in the example below.

**Example of targeting a ‘high risk group’:**
The UK fire statistics provides the following information on smoke detectors;

- Approximately 75% of all UK dwellings are fitted with one or more smoke detectors.

- A smoke alarm was absent in 55% of dwelling fires (average for 2002 and 2003).

- Those fires accounted for 57% of annual deaths and 55% of non-fatal casualties.

From this it follows that over half of all reported dwelling fires, and half the fire related deaths and injuries, occur in the 25% of properties currently without smoke detectors. Clearly then, tenants of those properties currently without smoke detectors are at a significantly increased risk of death/injury/property loss through fire.

If it is assumed that the combined plumbing sprinkler system (including smoke alarms) were installed in the 25% of dwellings that are currently unprotected then the cost benefit analysis for retrofitted solutions is modified as shown in Table 60.

In this simple example the cost benefit ratio for both retro fit scenarios has more than doubled, making it probable that installation of the system in this housing sector would be cost beneficial.
<table>
<thead>
<tr>
<th></th>
<th>Most expensive retro-fit option</th>
<th>Least expensive retro-fit option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All properties</td>
<td>Properties currently with no detector</td>
</tr>
<tr>
<td>Millions of units considered</td>
<td>24.63</td>
<td>6.2</td>
</tr>
<tr>
<td>Total number of deaths</td>
<td>439</td>
<td>261</td>
</tr>
<tr>
<td>Total number of injuries</td>
<td>11900</td>
<td>6100</td>
</tr>
<tr>
<td>Total number of fires</td>
<td>64400</td>
<td>35800</td>
</tr>
<tr>
<td>Capital cost of system (per unit)</td>
<td>£1,085</td>
<td>£390</td>
</tr>
<tr>
<td>Water connection charge (per unit)</td>
<td>£995</td>
<td>£660</td>
</tr>
<tr>
<td>Capital recovery factor</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Annual cost of loan</td>
<td>£88.68</td>
<td>£44.77</td>
</tr>
<tr>
<td>Annual inspection cost</td>
<td>£0.00</td>
<td>£0.00</td>
</tr>
<tr>
<td>Total annual costs</td>
<td>£88.68</td>
<td>£44.77</td>
</tr>
</tbody>
</table>

**Deaths** per million units
- 17.8
- 40.7
- 17.8
- 17.8

**Sprinkler effectiveness factor**
- 0.76
- 0.83
- 0.76
- 0.76

**Deaths saved per million units**
- 13.5
- 33.8
- 13.5
- 13.5

**Monetary value per life saved**
- £1,243,000
- £1,243,000
- £1,243,000
- £1,243,000

**Monetary benefit per single unit**
- £16.84
- £41.97
- £16.84
- £16.84

**Injuries** per million units
- 483
- 1056
- 483
- 483

**Sprinkler effectiveness**
- 0.57
- 0.65
- 0.57
- 0.57

**Injuries saved per million**
- 275.4
- 686.2
- 275.4
- 275.4

**Monetary value per injury saved**
- £58,300
- £58,300
- £58,300
- £58,300

**Monetary benefit per single unit**
- £16.06
- £40.00
- £16.06
- £16.06

**Fires** per million units
- 2615
- 5814
- 2615
- 2615

**Sprinkler effectiveness factor**
- 0.5
- 0.5
- 0.5
- 0.5

**Unsprinklered property damage**
- £7,540
- £7,540
- £7,540
- £7,540

**Reduced property damage per fire**
- £3,770
- £3,770
- £3,770
- £3,770

**Monetary benefit per single unit**
- £9.86
- £21.92
- £9.86
- £9.86

**Total benefit per unit**
- £42.75
- £103.89
- £42.75
- £42.75

**Cost benefit ratio**
- 0.48
- 1.17
- 0.95
- 2.09
CHAPTER 9
Conclusions

This project has investigated the potential for mass implementation of a town mains fed sprinkler system based upon the combined sprinkler/domestic plumbing configuration adopted by BRANZ in New Zealand. The process is complicated by:

- Low water pressure service standards.
- Poor availability of data in respect of local water supplies.
- Leak reduction strategies used by the water authorities that give rise to sizeable temporal pressure variations.
- The requirement for new properties to have water meters.
- Limited availability of sprinkler effectiveness data relevant to the UK.

However, indicative performance calculations have been made for a number of design options based upon the following general assumptions:

- The experimental test rig is representative of the entire 2-storey UK housing stock to which the UK fire death and injury statistics are applicable (this excludes HMOs).
- That the sprinkler effectiveness statistics are appropriate to the UK and the proposed system (no degradation with de-specification).
- Averaged water authority data from those regions who supplied it in sufficient detail is representative of the whole of the UK.

Depending upon the flow design option taken, the system is suitable for installation into 20 to 80% of the current UK housing stock and between 5 to 70% of new build properties (due to the requirement for water meters in new premises). Associated casualty savings range from 55 to 222 deaths and 1100 to 4700 injuries. The large ranges applied to these figures are a result of the 30% water pressure contingency allowed for pressure managed areas – refinement is only possible through detailed local knowledge.

Whilst it is clear that a system required to meet the BS9251 flow demand of 85 l/min will fail to achieve the roll-out necessary to save enough lives for this to be a viable undertaking (55-152), at 60 l/min a better balance may be struck between roll-out potential and effectiveness (166-208). System costs are the same for each flow design option and range from £2080 for a fully furnished house, to £1050 for a gutted property, to £480 for a new build. These are
individual property costs and further savings would be expected for bulk purchase. A significant proportion of the total cost of implementing the system in existing properties arises from the implementation of a new water supply pipe and mains connection. In the two retrofit scenarios detailed, the costs associated with the mains connection vary from 40% to 60% of the total system cost.

Of most concern in the presentation of these findings is the accuracy of the relationship between sprinkler system effectiveness and water supply. Water supply flowrates as low as 49 l/min have been shown to adequately tackle the fires presented during the limited test programme. However, water supplies are not steady state and to design to ‘mean’ values may be problematic since over the ‘actual’ range experienced in a 24 hour cycle the ‘effectiveness’ of the system may vary from 100% to 0%. If the local pressure is demand controlled, then at times of low demand, such as the night, there may be insufficient water pressure available for the system to be viable. Although the figures presented should be ‘worst-case’, local detailed analysis will be required to refine the effectiveness calculation.

In conclusion, the life saving benefits of sprinklers in the home have been known for some time. This project has determined that the combined plumbing system detailed in the BRANZ study, appropriately modified is: hydraulically efficient; fire fighting capable; unlikely to breach water authority regulations, and can be delivered at a through life cost more palatable to mass implementation. Inherent within the design is the upgrading of the water supply pipe to 32mm which, as an aside, enables the direct connection of sprinkler pumps for the provision of water in pressure limited areas or houses in excess of 2 storeys. Given this aspect, if 32mm supply connections become commonplace then this will act beneficially on the pricing of more traditional domestic sprinkler systems as the cost of water storage is removed and perhaps the work of previous studies in determining cost/benefit warrant revisiting.

Aside from repairing the main water network, pressure reduction remains an effective means by which water authorities reduce leakage. Mains fed systems such as this would benefit from improvement of the very low minimum service standards currently applied to the provision of water to domestic properties.
CHAPTER 10
Future Work

It is recommended that future work programmes should concentrate on:

• Improving the quality of data used in this study.
• Confirmation of costs and procurement procedures.
• Confirmation of capability.
• Preparation of guidance.
• Quality assurance.
• Long term performance evaluation (Pilot study).
• Alteration of established water main connection method.

10.1 Improving data quality

This study has been conducted on a macroscopic scale and by definition has had to assume mean values for the UK in respect of both water supply data and statistical fire data. Accordingly, the results of the work are indicative only and would benefit from consideration on a smaller scale. A number of options exist but perhaps the most benefit could be drawn from considering in isolation each of the major cities of the UK. As a whole these studies would quickly identify the UK roll-out potential to the majority of the target population whilst appreciating local variation in building design, fire statistics and water supplies. The location of quality local information and engagement of key stakeholders would also be easier and there would be scope for local fire and rescue services to ‘champion’ the project deriving experience and knowledge. The provision of quality temporal pressure supply information by survey or experiment is paramount to the success of the undertaking.

An additional consideration might be the development of a UK database of available water supplies at postcode resolution. Given the experiences of this project this might be a very difficult undertaking and the nature of the information required must be carefully investigated if it is to fulfil its remit.
10.2 Confirmation of costs and procurement procedures

The costing and procurement process is complicated by the number of implementation scenarios possible and property specific layout features. There would be great benefit in undertaking and recording the procurement process of a conversion scenario through to completion of works. An appropriate scenario might be the conversion of an entire street of ‘2 up 2 down’ terrace houses. The project would record:

- Pre-procurement water supply evaluation procedures.
- System design.
- Water authority engagement process.
- Supply pipe specification.
- Costing of all works.
- Timetabling of works.
- Testing.
- Evaluation of performance against design over time.

This data would support the investment case for propagation.

10.3 Confirmation of capability

Limited scale fire testing of this system to date has been restricted to 3 scenarios in a relatively simple enclosure. The development of this system would benefit from further fire testing in larger (taller than two storeys) and more complex enclosures that might require 2 sprinklers to operate.

10.4 Preparation of guidance

Once the viability of the system has been confirmed across a range of scenarios there will be a need to encapsulate the knowledge gained from all studies in a readily digestible form for specifiers and installers. Given that the envisaged system will be installed by plumbing engineers rather than specialist sprinkler installers, the presentation of information must be carefully considered and the BRANZ design guide (2002) may be a good model for this.
10.5 Quality assurance

Having decided upon the design detail, as a life safety system, consideration should be given to the adoption of installer qualifications akin to the Corgi scheme for gas systems.

10.6 Long term performance evaluation (Pilot study)

Ideally, the system should be evaluated in-situ across a housing population large enough to appreciate its performance over say a 5 year period. This pilot study would be specifically aimed at the high risk target sector for which the system has been developed and could be monitored against a ‘placebo’ population with similar characteristics.

10.7 Alteration of established water main connection method

The cost effectiveness of the described system, and more traditional domestic sprinkler systems, could be improved over time if all future planning applications for residential properties required a 32mm supply pipe connection (with appropriate fittings). This would allow for greater innovation and flexibility in domestic fire suppression system design which can only act to improve performance and reduce costs with time. It is likely that this would require collaboration with the regional water authorities and DEFRA.
ANNEX A

Information request to water companies

The following two letters were sent to all 27 water companies as detailed in section 3.6.3.

Fire Protection Association
London Road
Moreton in Marsh
Gloucestershire
GL56 0RH
Tel: 01608 812500
Fax: 01608 812501

REQUEST FOR INFORMATION REGARDING MAINS WATER SUPPLY PRESSURES TO DOMESTIC PREMISES FOR AN ODPM SPONSORED FIRE SPRINKLER STUDY

Water company name here
Contacts title/position here

Dear XXXX,

The Fire Protection Association on behalf of the Offices of the Deputy Prime Minister is carrying out a feasibility study on encouraging the wider uptake of domestic fire sprinkler systems in the UK. Every year approximately 600 people die and a further 11,000 are injured in UK domestic house fires and the ODPM is committed to reducing these losses.

The intention is to develop a low cost solution that will be able to provide a limited but defined level of fire protection in houses for which a conventional sprinkler system would probably be too expensive. In order to design such a system and to provide information on the degree of protection that could be expected we require certain information regarding the supply of mains water to domestic properties. Please find attached a letter from our ODPM sponsor confirming our participation in this work.

The Fire Protection Association is the UK’s National Fire Safety Organisation. It is a not-for-profit company and its primary business is in fire safety training, consultancy, education and the dissemination of advice. We would like to assure you that any information you supply will be treated in strict confidence and will not be reproduced or published without prior agreement with yourselves. Our intention would be to use the data for design purposes and to help provide statistics relating to the overall national effectiveness of any developed system. We would be very grateful if you could provide as much and as detailed information as possible in relation to the issues detailed below.

Please note:
1) This information is required only to help in the development of a suitable fire suppression system and for a statistical assessment of the potential effectiveness that such a system might have if implemented in the UK.
2) All of the UK’s water companies are being contacted to request the same information.
3) This request is for recent historical data on water pressures and NOT necessarily for commitments to current and/or future water supplies (unless you choose to provide additional details on this).
4) Any information you are able to supply will be treated with complete confidentiality, unless you indicate that specific items are publically available information.

In all of the questions below please assume that ‘supply water pressure’ refers to the mains water supply pressure at the boundary of domestic properties.

25/02/2005
1) The OFWAT report “Levels of service for the water industry in England and Wales” states that “Companies are required by law to provide water at a pressure that will, under normal circumstances, enable it to reach the top floor of a house. In order to assess whether they satisfy this requirement, companies are required to report against a reference level of ten metres head of pressure, at a flow of nine litres per minute,” and that “For ease of measurement, companies adopt a surrogate pressure (usually 15 metres head) in the adjacent water main serving the property.” Can you indicate what ‘surrogate pressure’ is adopted by your company for assessing compliance with this requirement.

2) Does your company have a normal and/or minimum service level of water pressure for domestic properties? If so;
   a. Is this information published or publicly available?
   b. Does it vary regionally/daily/seasonally?
   c. What are the service levels?

3) Based on historical data for the last couple of years;
   a. What is the mean water supply pressure across your region of coverage
   b. In general what proportion of the population actually receive that pressure and for what proportion of (i) each 24 hour period and (ii) each year period

4) Based on historical data for the last couple of years please provide as much information as possible for the following table (we appreciate that it may not be feasible to fully complete this table but would ask that you provide as much detail as you are able.)

<table>
<thead>
<tr>
<th>Pressure (bar)</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
<th>5.5</th>
<th>6.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Proportion of properties within your area of coverage that received this pressure at the point of supply to the property.</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>b) Proportion of any defined 24 hour period during which the supply pressure to those properties was at least this value.</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>c) Proportion of any year/season period during which the supply pressure to those properties was at least this value.</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
</tbody>
</table>

Due to time limitations for this work we would be most grateful if you could respond to this letter as soon as possible. If there are any questions or issues arising from this request that you would like to discuss then please do not hesitate to contact either myself or my colleague directly, our contact details are provided below. Thank you in anticipation of your response and assistance in this matter.

Regards,

James Glockling

Contact Details:

<table>
<thead>
<tr>
<th>Dr James Glockling</th>
<th>Dr Stuart Campbell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Director</td>
<td>Senior Technical Consultant</td>
</tr>
<tr>
<td>Fire Protection Association</td>
<td>Fire Protection Association</td>
</tr>
<tr>
<td>Telephone (Direct): 01608 812516</td>
<td>Telephone (Direct): 01608 812521</td>
</tr>
<tr>
<td>Fax: 01608 812501</td>
<td>Fax: 01608 812501</td>
</tr>
<tr>
<td>Email: <a href="mailto:iglockling@thefpa.co.uk">iglockling@thefpa.co.uk</a></td>
<td>Email: <a href="mailto:scampbell@thefpa.co.uk">scampbell@thefpa.co.uk</a></td>
</tr>
</tbody>
</table>
Development of Low cost Domestic Fire Suppression System – Survey of water pressures

The Fire Statistics and Research Division has begun a project to look at the feasibility of low cost domestic fire suppression systems to improve fire safety in the home. A key part of the project is to determine the water pressure available to homes in the Great Britain, both the average pressure available, and indications of how and to what degree this pressure may fluctuate either daily or seasonally. The information will allow us to determine in what proportion of houses such a system would be effective. This part of the project is being carried out by the Fire Protection Association, and we would be grateful for any help you are able to provide.

Yours faithfully,

Aidan McCormack
Fire Statistics and Research Division,
Office of the Deputy Prime Minister
ANNEX B
Responses from water companies

Water and sewerage service companies

ANGLIAN WATER SERVICES LTD

James Glockling
Technical Director
Fire Protection Association
London Road
Moreton-in-Marsh
Gloucestershire
GL56 0RH

23 May 2005

Dear Mr Glockling,

In response to your letter in March requesting information regarding mains water supply pressures to domestic premises I can outline our position as follows:

1) AWS uses the accepted reference level (10 metres head at a boundary stop tap with a flow of 9 litres per minute) in determining its compliance with the OFWAT DQ2 reporting requirements. However, investigations into potential DQ2 problems are typically triggered when pressure logging or modelling suggests mains pressures of less than 15m.

2) AWS does have a minimum service level of water pressure and this is the standard of 10 metres head at a boundary stop tap with a flow of 9 litres per minute. Furthermore, under our customer charter, Anglian Water will make a payment where the pressure in the communication pipe falls below 7m (static) head for at least an hour on two separate occasions within a 28 day period.
   a) The Customer Charter is a published document and available as is the Water Industry Act.
   b) Our minimum standard does not vary. Clearly actual pressures will vary subject to demand, reservoir levels etc.
   c) See above.

3) With reference to the historical data for recent years we can only give general confirmation on the points you have specifically requested:
   a) Pressures in our systems range from <10m to >60m but more common pressures are in the range 20-40m.
   b) To provide the detailed statistical data you have requested we would need to carry out significant further analysis of our models (and to a limited extent our telemetry data). We trust that you will appreciate we cannot commit to that expenditure for this
specific request alone. However, we have enclosed a summary spreadsheet
of average zonal night pressures for our supply zones that should provide
some of the information you require.

4) Please see enclosed spreadsheet.

I hope that I have been able to answer all your questions.

Yours sincerely

Peter Simpson
Chief Operating Officer

Enc

DWR CYMRU CFFYNGEDIG (WELSH WATER)

Fire Protection Association
London Road
Moreton-in-Marsh
Gloucester
GL56 0RH

Date: May 2005
Enquiries: 01443 452359
Our Ref: RC/
Your Ref:

Dear Sirs

REQUEST FOR INFORMATION REGARDING MAINS WATER SUPPLY PRESSURES
TO DOMESTIC PREMISES FOR AN ODPM SPONSORED FIRE SPRINKLER STUDY

Thank you for your letter dated 31st March 2005 and apologise for the delay in responding.

I have answered your questions below:-

1. 15 metres.

2. Dwr Cymru have a minimum standard of service of 15 m and as part of the company
   drive for efficiency reducing leakage and improving the availability of water resources in
   a drought year the company is committed to controlling excessive pressure in the
   network.

3. This information is not available and would be difficult to obtain in the diverse
   topography of Wales.

4. (a) | < 1.5 | 1.5-2.0 | >2.0 |
    | bar | bar | bar |
    | 0.02% | 4.28% | 95.70% |
    | prop | prop | prop |

(b) Unable to comment.
Development of a lower-cost sprinkler system for domestic premises in the UK

Yours faithfully

R G Curtis
Company Secretary

NORTHERN IRELAND WATER SERVICE

Head Office
Northland House
3 Frederick Street
Belfast BT1 2NR

Mr James Glockling
Fire Protection Association
London Road
Moreton-in-Marsh
Gloucestershire GL56 0RH

Tel: (028) 9024 4711
Fax: (028) 9035 4888

Dear Mr Glockling,

Re: REQUEST FOR INFORMATION REGARDING MAINS WATER SUPPLY PRESSURES TO DOMESTIC PREMISES FOR AN ODPM-SPONSORED FIRE SPRINKLER STUDY

Thank you for your letter of 31 March 2005 to our Water Supply Manager, Mr McKee. It has been passed to me for reply. I regret that much of the detailed information you have asked for is not available and respond as follows:

1) The Department for Regional Development, Water Service is under no statutory obligation to provide water at a specific pressure. Water Service does, however, aim to achieve the UK water industry minimum standard “surrogate” pressure of 15 metres head at the point of connection to the water mains.

2) a & b – see 1 above
   c. Water Service’s standards of service are set out in the attached Customer Charter. There is no standard set in respect of water pressure.
3) This information on Water Supply pressures is not available.
4) This information is not available.

Yours sincerely

Charles Gallagher
Operations Support

Enc: Water Service Customer Charter

NORTHUMBRIAN WATER LTD

See response for Essex & Suffolk (combined response)
Scottish Water does not report to OFWAT, we report to the Water Industry Commissioner (WIC).

The Water Scotland Act states:

"Para 25 Duty of undertakers as respects constant supply and pressure.

Subject as hereinafter provided, the undertakers shall cause the water in all pipes on which hydrants are fixed, or which are used for giving supplies for domestic purposes, to be laid on constantly and at such a pressure as will cause the water to reach to the topmost storey of every building within the limits of supply:

Provided that—

(a) nothing in this section shall require them to deliver water at a height greater than that to which it will flow by gravitation through their existing mains from the service reservoir or tank from which the supply in question is taken;

(b) they may in their discretion determine the service reservoir or tank from which any supply is to be taken; and

(c) the provisions of this section shall not apply if the undertakers are prevented from complying therewith by reason of frost, drought, unavoidable accident, or other unavoidable cause, or during the execution of necessary works."

As in England and Wales Scottish Water adopts a 15m surrogate to assess compliance.

Yes in Scottish Water’s "Guaranteed Standards for Household Customers" that states:

"we aim to supply water at a minimum pressure of 10 metres static head (static head is the pressure that would be recorded when no water is flowing in the pipe to the property). The pressure would be high enough to fill a 10 litre household bucket in around one minute or to fill a storage tank in the attic of a two storey building."

There are no regional, daily or seasonal variations.

10 metres static head.

53.24m is the Property Weighted Average Zonal Night Pressure (AZNP).

Scottish Water does not currently monitor and maintain records of Average Zonal Pressure (AZP). 50.14 is an estimated inferred AZP based on the following:

\[
AZP = AZNP \times (HDF/24)
\]

Hour Day Factor (HDF)

Scottish Water considers these AZP’s to be higher than necessary. During Q&S3, 2006 to 2014, Scottish Water shall where hydraulically possible reduce pressure as part of its leakage control and network management initiatives.

It is not possible to predict the likely extent of pressure reduction as this shall depend on local hydraulics and network topography. Therefore Scottish Water can only guarantee the pressures will be above the reference "surrogate" level of pressure.
Responses from water companies

Table below shows current regional AZNP values:

<table>
<thead>
<tr>
<th>Sub Region</th>
<th>Data</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayrshire &amp; Inverclyde</td>
<td>Average of AZNP 52.21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 258,764</td>
<td></td>
</tr>
<tr>
<td>Borders</td>
<td>Average of AZNP 48.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 32,979</td>
<td></td>
</tr>
<tr>
<td>Dumfries &amp; Galloway</td>
<td>Average of AZNP 53.65</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 69,678</td>
<td></td>
</tr>
<tr>
<td>Edinburgh</td>
<td>Average of AZNP 49.99</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 247,285</td>
<td></td>
</tr>
<tr>
<td>Fife</td>
<td>Average of AZNP 48.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 172,233</td>
<td></td>
</tr>
<tr>
<td>Forth Valley</td>
<td>Average of AZNP 51.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 294,826</td>
<td></td>
</tr>
<tr>
<td>Glasgow</td>
<td>Average of AZNP 51.21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 432,946</td>
<td></td>
</tr>
<tr>
<td>Grampian</td>
<td>Average of AZNP 46.29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 180,908</td>
<td></td>
</tr>
<tr>
<td>Highlands &amp; Skye</td>
<td>Average of AZNP 53.46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 133,903</td>
<td></td>
</tr>
<tr>
<td>Lanarkshire</td>
<td>Average of AZNP 57.07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 183,936</td>
<td></td>
</tr>
<tr>
<td>Lothian</td>
<td>Average of AZNP 50.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 139,692</td>
<td></td>
</tr>
<tr>
<td>NW Argyle &amp; Bute</td>
<td>Average of AZNP 52.27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 19,673</td>
<td></td>
</tr>
<tr>
<td>Orkney</td>
<td>Average of AZNP 53.46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 10,270</td>
<td></td>
</tr>
<tr>
<td>Shetland</td>
<td>Average of AZNP 53.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 10,635</td>
<td></td>
</tr>
<tr>
<td>SW Argyle &amp; Bute</td>
<td>Average of AZNP 53.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 32,106</td>
<td></td>
</tr>
<tr>
<td>Tayside</td>
<td>Average of AZNP 48.17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 183,351</td>
<td></td>
</tr>
<tr>
<td>Western Isles</td>
<td>Average of AZNP 54.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sum of Properties 13,443</td>
<td></td>
</tr>
<tr>
<td>Property Weighted Average of AZNP</td>
<td>53.24m</td>
<td></td>
</tr>
<tr>
<td>Total Sum of Properties</td>
<td></td>
<td>2,404,219</td>
</tr>
</tbody>
</table>

3b (i) Scottish Water does not currently monitor and maintain records of Average Zonal Pressure (AZP). There are unique diurnal fluctuations in each zone based on network demand and hydraulic capacity.

3b (ii) Scottish Water does not currently monitor and maintain records of Average Zonal Pressure (AZP). There are unique seasonal fluctuations in each zone based on network demand and hydraulic capacity.

4a The current low pressure register estimates that 11,839 properties supplied by Scottish Water are receiving less than the reference “surrogate” level of pressure.

<table>
<thead>
<tr>
<th>Operational Area</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>South West</td>
<td>3,703</td>
</tr>
<tr>
<td>North West</td>
<td>2,906</td>
</tr>
<tr>
<td>North East</td>
<td>3,761</td>
</tr>
<tr>
<td>South East</td>
<td>1,779</td>
</tr>
<tr>
<td>TOTAL</td>
<td>11,839</td>
</tr>
</tbody>
</table>

The 11,830 equates to 0.49% of properties supplied by Scottish Water receiving less than 15m.

Therefore 2,382,380 properties (99.51%) supplied by Scottish Water receive pressure in excess of 15m.

4b Scottish Water does not currently monitor and maintain records of Average Zonal Pressure (AZP). There are unique diurnal fluctuations in each zone based on network demand and hydraulic capacity.

4c Scottish Water does not currently monitor and maintain records of Average Zonal Pressure (AZP). There are unique diurnal fluctuations in each zone based on network demand and hydraulic capacity.
From: Pat.Spain@severntrent.co.uk
Sent: 31 August 2005 10:15
To: Stuart Campbell
Subject: Re: Water Pressure Survey

Stuart

1. 15 metres at the property boundary as a minimum

2. We aim to manage pressure as a means to control leakage so where possible we aim for a maximum pressure of 25mH at the critical point of at District Meter Area (a hydraulically isolated network of approximately 1500 properties). Depending on the topography of the area pressures normally exceed 25mH. We provide individual service PRVs for where pressures would exceed 100mH.

   a. no this data is not published but if customers enquire we will provide them with information on the pressure they receive b. yes c. 15 metres at the property boundary as a minimum

3.a. The average zonal night pressure is approximately 45MH, Average pressures over 24 hours would be 30mH 3.b.i. 60% of the population receive average or greater pressure 3.b.ii Not sure what you mean here daily variation in pressure greatly exceeds seasonal variation in pressure

4a 0.5 100%, 1.0 100%, 1.5, 99.7%, 2.0 80%, 3.0 60%, 4.0 30%, 5.0 10% 6.0 3%

Regards
Pat

Pat Spain
Asset Protection Manager (West)
Operations and Maintenance Drinking Water
Dear Dr Glockling

REQUEST FOR INFORMATION REGARDING MAINS WATER SUPPLY PRESSURES TO DOMESTIC PREMISES FOR AN ODPM SPONSORED FIRE SPRINKLER STUDY

I acknowledge your letter dated 31st March 2005 concerning the above.

In response to your questions raised:-

1. South West Water adopts a surrogate pressure of 15 metres head in the adjacent water main serving the property.

2. South West Water has a minimal service level of water pressure for domestic properties.
   a) Yes.
   b) There is no regional/daily/seasonal variations.
   c) For DG reporting purposes the adopted service level is 10 metre head of pressure at a flow of 9 litre/minute at the property boundary.

3. a) The mains water supply pressure across our region of coverage is 5.5 metres head.
   b) From the table below 55.1% of our connected properties receive a water pressure of 5.5 metres head or greater for 50% of the time.

<table>
<thead>
<tr>
<th>Bar</th>
<th>&lt;0.5</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
<th>5.5</th>
<th>6.0</th>
<th>&gt;6.0</th>
</tr>
</thead>
</table>
| a) Proportion (%) of premises water supply area of which the pressure at the point of supply is above the property.
   | 0    | 0   | 0.02| 0.01| 0.05| 0.25| 2.4 | 5.67| 6.8 | 13.5| 16.2| 15.6| 18.3| 21.2|
| b) Proportion (%) of any defined 24 hour period during which the supply pressure to those properties was at least this value.
   | -    | -   | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  |
| c) Proportion of any measurement period during which the supply pressure to those properties was at least this value.
   | -    | -   | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  | 50  |

Yours sincerely

George Delve
Distribution Manager

247
Stuart,

I attach a spreadsheet that gives the Average Zonal Night Pressure (AZNP) for each of our water supply zones. The ‘number of drops’ is the Addresspoint count in each zone and equates to the number of properties. I also attach a .jpg file of a network study (Darland) that illustrates the variation in minimum pressure throughout quite small geographical areas. However, for substantial periods of the day the pressure will be well in excess of the minimum shown and you may see this by comparing the AZNP for Darland at 45m plus.

Our standard for mains pressure is a minimum of 15 m and less than 0.05% of properties receive a pressure less than 15m head for more than 1 hour in the day. There are pressure variations throughout the day and seasonally and I can send copies of pressure logging (do you want samples?) to illustrate the wide variation, not only against time but also spatially within a zone as some parts of the system are subject to much higher pressure variation than others.

As I explained, I have been trying to find a way to give you useful information, but without a very large amount of data processing it is difficult to give an overall position, although for any identified point we can make a good assessment. I hope the attached is helpful but if you think of specific information that will further help, then please contact me and I’ll try to put something else together. For a quick ‘feel’ I would say that 90% of properties have a pressure in excess of 25 m head for more than 18 hours a day.

Regards,
Geoff

Geoff Tute
Water Capital Maintenance Strategy Manager
THAMES WATER UTILITIES LTD

Dr Stuart Campbell
Senior technical Consultant
Customer Services
Fire Protection Association
London Road
Moreton in Marsh
Gloucestershire
GL56 0RH

Your ref
Our ref JE/dm/050912 FPA
Name Jerry England
Phone
E-Mail Jerry.england@thameswater.co.uk

12 September 2005

Dear Stuart,

Domestic sprinkler systems – ODPM study.

Further to your letters, and the conversations you have had with Duncan McCombie, I trust the attached will address the information requirements you have for your report to the ODPM. I do apologise for the time it has taken to get this information to you.

Notwithstanding the fact the data demonstrates that we deliver in excess of 1 bar across the vast majority of our water network, we are only obliged to supply 1 bar at the property boundary. We are working extensively throughout our water supply areas to effectively and efficiently manage the water network, making improvements where possible to benefit, primarily customers but also improve the operation of the whole network, both locally and more generally. This will result in changes to the pressure in the water supply zones which have been used for supplying the data and therefore it should be treated as a “snapshot” of pressures at the specific time.

The data provided is mean average zonal pressures so will include fluctuations over the year due either to demand or operational incidents. The calculations are based on the properties that fall within 99 of the 242 zones that we have the most accurate data for.

All properties that fall beneath 1.5 bar are recorded on our DG2 register, which is shared with Ofwat in the Levels of Service report. Over the past year the number of properties in this situation has dropped to 2215 representing 0.06% of connected properties. This is within Ofwat’s ‘Acceptable’ band, but we will continue to implement work, resolving leakage and addressing customers pressure concerns. But we will also be replacing 850 miles of water mains in the next five years. This will tackle both leakage and the problems associated with
an ageing infrastructure, one third of which in London is over 150 years old, but it will also result in changing pressures in the areas where the work is undertaken.

Our longer term plan envisages further major work to improve the network over at least the next 20 years, though the reduction in leakage achieved each year will gradually decline as the worst areas of the pipe network are being tackled first, but a more stable network will result from this work.

Should you have any additional questions please do not hesitate to contact Duncan, who will ensure you get a full reply.

Yours sincerely
Jerry England

Chief Operating Officer

Pressure maps and values detailed in attached spreadsheet.

<table>
<thead>
<tr>
<th>Pressure (m)</th>
<th>Property Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
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</tr>
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</tr>
<tr>
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</tbody>
</table>
Responses from water companies

From: Champness, Dave [mailto:Dave.Champness@uuplc.co.uk]
Sent: 30 August 2005 09:32
To: Stuart Campbell
Cc: Jones, Rob G

Subject: RE: Water pressure survey

Stuart – we have done a trawl using regional averaged data for 3million connections and can offer the following information.

During the financial year 2004/5 the average pressure recorded across all of our critical monitoring points was 30.9m available head (obviously there will be diurnal variation with pressures likely to be higher at night, although we pressure manage a large percentage of properties [again] especially at night). We have calculated that, on average, properties are 9.1m below the critical monitoring points and therefore the average daily pressure experienced by our customers is 40m available head.

At the extremes we have one discrete pressure area that has an average minimum available pressure of 7.2m and one area with an average maximum available pressure of 110m available head – but these are extremes affecting very small numbers of properties.

It should be noted that the figure of 40m is an average, and before any sprinkler system is designed, UU should be consulted to provide advice on the local diurnal pressure range.

I trust that this information will help in your research.

Thanks,
Dave Champness

Water Strategy & Planning Area Mgr
(Cumbria/N & East Lancs + Network Strategies)
Thirlmere House, Lingley Mere, Warrington, WA5 3LP

In response to a further query regarding the distribution of water pressures in this region, Mr Champness responded:

Stuart – I estimate that 99% of properties have an average pressure of >2 bar and 0.5% of properties would have a pressure >6bar. You could infer a normal distribution curve between those two extremes.
Dear Dr. Glocking,

Request for Information Regarding Mains Water Supply Pressures to Domestic Premises for an ODPM Sponsored Fire Sprinkler Study

Further to your request for information of 31 March, 2005, and your subsequent telephone conversation with my Network Maintenance Manager, Nigel Martin, I am pleased to offer the following response.

Wessex Water is supportive in assisting the introduction of Domestic Sprinkler systems and has worked closely with a member of specialist installers within our region to achieve successful installations.

Understanding the hydraulic characteristics of the supply network and ensuring the appropriate technical standards are adhered to have been key to achieving a functional installation at the discrete locations considered to date.

With flow and pressure values being so critical to the correct function of the sprinkler installation and our network being installed across a very diverse topography, we believe it could be potentially misleading to schedule pressure and consistency data, preferring to rely on site specific performance measurement when requested.

However, in general terms, recognising the crucial fire fighting requirements of both the Fire and Rescue Services and private sprinkler installations, Wessex adopted some time ago a voluntary design standard of achieving a minimum pressure head of 20.0 metres at the “critical point” in any pressure control zone.

Therefore, the following responses to your specific questions are deliberately worded to reflect the statutory minimums Wessex is obliged to meet:

1) Wessex has adopted a surrogate pressure of 15.0 metres head of water.

2) The minimum service level of water pressure for domestic properties is 7.0 metres head, no value is calculated or quoted for “normal” water pressure

   a) The minimum pressure is published and available to the public.

   b) Regional/daily/seasonal variation in delivered pressure does exist, the range of pressure variation in any discrete zone depends entirely on topography, demand pattern and system hydraulic characteristics; in general, the range of that variation has narrowed with increased deployment of variable demand pressure management.

   c) Service level standards are those demanded by statute - i.e. 10 metres head delivering 9 litres/minute discharge.

3) Historical pressure data:

   a) Historical “mean” water supply pressure - the “mean” pressure value is not one Wessex calculates or records, believing it to be of little value in designing and maintaining the supply system. Gross changes in topography, network infrastructure and demand pattern within any zone make it necessary to determine the “critical point” location and design pressure control to achieve a comfortable margin over the statutory minimum pressure and flow requirements at that point. Typically, the “critical point” pressure target pressure will be set at a minimum of 20.0 metres head.

   b) This “critical point” target pressure achieves 99.96% compliance with the statutory minimum pressure and flow requirements at the customer boundary out of a connected property count of circa. 350,000.

4) See my opening comments, pressure data to this detail across our region is not available.

I hope this information is useful to you, if you need to discuss the matter further, please contact Nigel Martin direct on 01202 643125.

Yours sincerely,

John Delaney
Networks General Manager
Good Afternoon Stuart,

I was just asked to deal with this aspect of your work in addition to coming to you to discuss more detailed aspects of these sprinkler systems and the water supply/water regulations.

With regards to your questions, a comprehensive and thoroughly researched answer to the details you require will take some time to pull together and we may even have to charge for the resource to interrogate various data sources in order to get to the level of detail you suggest you require.

Instead I will try to describe the factors around water distribution networks and how these affect pressures then some overview of how these factors affect our region and the consequent pressure regimes.

In order to put these figures into some context though, I will first put my assumptions down about pressure and flow requirements for sprinkler systems.

(I have been involved in revising DD251 and writing technical guidance notes for water supplies to residential and domestic sprinkler systems, so my assumptions will be based on the water supply requirements for these (domestic) systems, though as it is normally the type of head and its discharge listing that fix the water supply requirement, I assume these may be similar).

My presumption is that you will be looking at a potential for two heads to operate and therefore a minimum of 86 litres per minute flow in line with established efficacy of this flow/discharge in dealing adequately with domestic fire loads.

I then assume that the heads will require a minimum operating pressure under flow conditions of 0.5bars to provide an effective spray pattern.

You then have to consider static head losses through the elevation of the highest head which could be 7metres if loft protection is involved or 5metres if just two floors, must also remember that 3 storey buildings are often the ones most frequently sprinklered to preserve fire escape routes without fire resisting doors, therefore these could be 7 to 10 metres static losses.

If you put this flow rate down a 32mm (outside diameter) MDPE service pipe - 25mm nominal bore (which is one size larger than normal service pipe installed for new domestic dwellings and many times the hydraulic capacity of older...
service pipes to dwellings which may be as small as 3/8" bore) then you have a
hydraulic gradient of 1:3, so if you have a 20metre length service pipe from the
main to the point of entry to the dwelling, then you lose 6 to 7 metres head.

Ignoring any potential meter involvement, you will have a series of fittings from
the connection ferrule or tapping saddle to a stop tap and possibly a non return
valve, these are likely to incur losses of at least 5metres head.

In addition economical design of the sprinkler system will mean that pipe sizing
and any fittings will also incur losses which you are probably better qualified to
quantify.

Without system losses we are already looking at just short of 2bars head losses
plus the operating requirement of around 0.5bar, so a conservative pressure
requirement in the main is 2.5bars.

I would anticipate that in all but areas with highly variable pumped pressures,
diurnal variations could be 30% of normal night-time max, so depending on
your attitude to when the minimum pressures might occur and for how long,
you might like to see a minimum mains pressure of 3 bars.

Coincidently 2.5 to 3bars would often be a desirable design pressure where
systems are being extended or reinforced and this pressure can be made
available from the source of the water being used. If not we would normally aim
to deliver as near this as practical but always to meet the surrogate pressure and
a small margin.

Predominantly flat lowland areas using below ground water sources or river
abstraction tend to rely on pumping to maintain pressure and or feed via water
towers. The pressure generated by pumping or the static head from water
towers will be limited by energy constraints or the physical height of water
towers (usually no more than 20-30 metres). Areas such as these are never likely
to have sufficient mains pressures to operate sprinkler systems with any margin
of safety for diurnal variation or demand growth in networks that may drag
pressures down.

Areas with hilly topography tend to have service reservoirs situated on high
ground supplying lower areas and where there is development near these
reservoirs then a water tower or pumped system may be provided to assure
adequate pressure at elevations close to that of the reservoir. These hilly area
can have pressures varying from 2.5 bars to as high as 10bars in exceptional
cases. The number of properties in different pressure bands will be entirely
dependant upon the topography of the area and where residential development
has taken place.

To apply these factors and the likely pressure requirements for domestic
sprinkler systems (plus my experience to date in arranging for water supplies to
these systems in our area) I would estimate that 60% of domestic properties in
our region would have mains pressures sufficient to operate systems on direct
mains pressures.
However you cannot use this number directly because I would estimate that 99.999% of domestic properties in our region (and others) would not currently have service pipes from the main to the house of a size large enough even to carry the required flow for 2 heads operating let alone at a pressure that is sufficient. You are therefore necessitating a new service pipe which could easily cost £750 to £1000 to install in total, you then no longer have a “low cost system” and are back towards the sort of costings that were a problem in the earlier BRE study for the ODPM.

I think to take this any further at this stage would not be productive and we are better discussing the situation in further detail when we meet next week.

Just as a reminder for myself and prompts for discussion on the system types under consideration, I will note a few points below regards “networked pipe systems” as I understand them from previous meetings with a potential installer.

1. There are Water Industry concerns about the risks of stagnation through lack of turnover in pipe networks because it is difficult to predict/prove that normal demand patterns will draw fresh water into all legs of the system. Increased and effectively unnecessary (from a domestic supply perspective) lengths of pipework will cause more warming of water within dwellings and customers to draw more water off before they obtain cold water which is always more palatable to drink. The individual legs to sprinkler heads may become effectively “dead legs” with stagnant water in them which may on occasions drift back into the clean water causing water quality problems or complaints.

2. All new English and Welsh domestic properties are metered and if you have a single supply to a house that feeds both domestic and sprinkler usage then both sides are metered. Normal domestic meters cannot support the level of demand for sprinkler operation and still accurately measure low domestic. Such mixed use pipework networks are impractical to install on normally metered supplies. The other risk with meters is that a sudden increased flow on a service pipe may bring any fine debris in the mains or service pipe into suspension and possibly block the meter, this could stop or greatly inhibit the water supply to the sprinkler heads. You would need some form of pressure/flow actuated by-pass for any meter, but this could be subject to tampering by customers or physical failure to allow unmeasured consumption. The question of ownership and maintenance of such apparatus would have to be resolved as it is critical to correct measurement of water consumed and the performance of the sprinkler system.

3. BS 9251 systems may include the use of priority demand valves to ensure full pressure and flow from the service pipe is available to feed the sprinkler system in case of operation, by shutting off the supply to normal domestic demand points. With a network system this is impractical therefore any significant domestic usage occurring at the time of required sprinkler operation will detract from that available to operate the system.

4. Installing a networked pipe system in an existing dwelling does not appear to be an economical means of installing a sprinkler system when
replacement of existing domestic plumbing may not be required. It must be cheaper to retrofit an independent pipe system in such cases.

5. I always understood that the potentially limited duration of operation of domestic sprinklers was on the premise that the relatively low levels of water discharge would only control a fire or limit its spread whilst occupant could be made aware of the emergency and evacuate the premises.

With a networked system, there are obviously issues about how these system might trigger an alarm to inform occupants to evacuate as there will always be flows occurring in the pipe system due to domestic demands.

6. I am not clear if the materials of sprinkler heads, installed in line with normal domestic demand and fresh water regularly passing them, would be sufficiently resistant to corrosion to be durable and avoid discolouration to domestic water. Sprinkler heads are normally installed on static lines of water which is (a) protected by check valves to prevent movement back into domestic supply, (b) soon depleted of oxygen that may otherwise cause corrosion of ferrous pipe or components in contact with the water.

7. There is an increased risk of a customer or his plumber tapping into part of the pipe network and placing a new demand on the system that disrupts the intended flow pattern and water retention times or the potential flows to the sprinkler heads and their performance.

As you say, it appears we will have a full and interesting discussion on Thursday. I look forward to meeting you then.

Regards
Ian Whittaker
BOURNEMOUTH & WEST HAMPshire WATER PLC

Mr James Glockling
Technical Director
Fire Protection Association
London Road
Moreton-in-the-Marsh
GL56 0RH

Deer Mr Glockling

REQUEST FOR INFORMATION REGARDING MAINS WATER SUPPLY PRESSURES TO DOMESTIC PREMISES FOR AN ODPM SPONSORED FIRE SPRINKLER STUDY

Thank you for your questions with regard to the above which we have done our best to answer below.

1) In our view there is only one surrogate and that is the one accepted for ORWAT levels of service (1.5m in the Company main). The actual standard is 9 l/min at the main stop tap at 10m head.
2) The above is our minimum service level.
3) Our estimated mean supply pressure is 40m.
4) We cannot populate your table as we do not collect data at that level of detail.

We would like to comment that looking at pressure alone without any flow is of little use. As soon as there is any flow the system hydraulic (dynamic) losses can become significant.

If the supply pipe on the customer side is not of adequate size then the dynamic losses as a result of flow can significantly reduce the available head despite there being adequate availability at the boundary.

Pressures in the network vary during the day as a result of demand placed on the system by customers. Every part of the system will react differently to this demand but inevitably the variation will be significant. Typically 40m at night, 20/25m at morning and evening peak flows.

We do remain concerned that pressures should not be looked at in isolation from flow and hope that you find our contribution useful.

Yours sincerely,

John Bolt
Network Strategy Manager
BRISTOL WATER

INFORMATION ON WATER SUPPLY PRESSURES

Question 1

The Company uses the surrogate pressure of 15m for a single property. In response to customer queries we will usually measure the flow and pressure at the property boundary stop tap when we use the 9l/min and 10m reference standard. For multiple properties, the pressure and flow are increased in accordance with Ofwat guidelines.

This is not generally published but is available on request.

The standard does not vary regionally, daily or seasonally.

Questions 2, 3 and 4

We have looked at the average zonal night pressure for each of our DMAs which has allowed us to produce the following summary table.

Proportion of properties that received this pressure at the point of supply to the property

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
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<td>3.7%</td>
</tr>
<tr>
<td>&gt;6.0 bar</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

These values would generally be available for 24 hours of each day throughout the year.
From: Mick Thurman [mailto:MickThurman@cambridge-water.co.uk]
Sent: 25 April 2005 13:58
To: Jim Glockling
Cc: Bob Hardy

Subject: Survey of Mains Water Pressures

Dear Dr Glockling,

Thank you for your letter dated 31 March 2005, addressed to Stephen Kay, requesting information on mains water pressures within the Company’s area, for use in a study on domestic fire sprinklers.

In answer to the questions you raised:

1) The surrogate pressure adopted by the Company for assessing compliance with OFWAT’s requirement is 12.5 metres head.

2) In its published guaranteed standards scheme, which also appears on its website, the Company quotes a minimum static water pressure of 7 metres head in the communication pipe.

3) and 4) We regret that we are unable to provide answers to either of these two questions, as we do not have the date available to us.

I hope the above is of some use to you in your study.

Yours sincerely,
Mick Thurman
Engineering Services Manager
From: Smith Chris [mailto:Chris.Smith@DeeValleyGroup.com]
Sent: 13 April 2005 16:23
To: Jim Glockling

Subject: Re: Mains water supply pressures

James,

Your letter regarding the above has been passed to me to provide a response.

Items 1-3 are relatively straightforward to answer and will be answered in due course.

For item 4, to ensure that we provide you with relevant information, I propose the following:

The data provided under item 4a will be based on “average-day” calibrated computer network models of our supply area. A model simulation will be carried out for each separate supply area and the numbers of properties in each pressure band will be counted at the time of maximum demand/minimum pressure, which for our networks is assumed to be 8:00am.

I will be unable to provide you with the data requested for item 4b. The amount of data processing required is excessively prohibitive.

For item 4c the demands on the “average-day” calibrated model network will be factored by 1.56 (seasonal adjustment) to simulate peak seasonal demands that we have measured in our area thus producing the minimum seasonal pressures on the computer models. I acknowledge that this is slightly different to that which you have requested but it will provide you with information on the number of properties that are affected by seasonal changes.

I trust this will go some way to answering your request for information and would be grateful if you could confirm that the approach suggested for items 4a and 4c will be acceptable.

Regards
Chris Smith
Planning Engineer
Dee Valley Water plc
From: Jeremy Downer [mailto:JeremyD@waterplc.com]
Sent: 13 April 2005 18:10
To: Jim Glockling

Subject: Mains Water Supply Pressure Information

Dear Dr Glockling

Please find below information in relation to your letter of 31 March 2005 to Mike Hegarty, Operations Director, Sutton & East Surrey Water.

1. 15m

2. The Company only operates to a minimum level of service for water pressure. We do not have a ‘normal’ level of service.

   Our minimum level of service is in accordance with the OFWAT DG2 Performance measure. The target level of service published in our 2004 Final Business Plan is that no more than approximately 50 properties will receive pressure lower than the surrogate level. This level of service remains in all areas throughout the year.

3. Mean water supply pressure is 48m. This is measured by estimating the pressure at the time of average demand during the day at a location within a District Meter Area (DMA – area of approx. 1000 properties segregated for leakage management purposes) which has the mean elevation. The average pressure in each DMA is then averaged to get a mean supply pressure.

   By definition, assessing pressure at the average demand time during a day will mean that pressure is higher for 12 hours and lower for 12 hours. During peak demand periods the pressures would be reduced slightly. This would increase the lower pressure bandings in the following table, although I envisage that the change would be marginal as over 60% of this Company’s network is pressure controlled and hence seasonal peak demand pressure will not alter by very much.

   Of the DMA assessed, approximately 70% have average pressure less than 48m. The following table illustrates this.
4. Table below.

<table>
<thead>
<tr>
<th>low</th>
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<th>cum % props</th>
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<td>+</td>
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</tr>
</tbody>
</table>

I hope that this information is of use to you. Please contact me if you would like any further information.

Kind regards
Jeremy Downer
Distribution Manager

ESSEX & SUFFOLK WATER

From: eric.styan@nwl.co.uk [mailto:eric.styan@nwl.co.uk]
Sent: 16 September 2005 12:48
To: Stuart Campbell
Cc: graham.neave@nwl.co.uk; dennis.dellow@nwl.co.uk; mike.madine@nwl.co.uk; denis.ellerington@nwl.co.uk

Subject: Water Pressure Survey

I refer to your e mail 5 August to our Operations Director, Mr G Neave, that has been forwarded to me.

Unfortunately, we do not hold information in the type of detail you requested however, I have provided some information that I hope will be helpful at this stage. To provide the information you require would take quite a resource commitment and we would probably need to seek to recharge costs if you wished to pursue it. In fact in the Northumbrian Water area (North-east England), we would need detailed models to answer the questions you raise and such models are still under development as part of an AMP4 programme.

The following answers are for Northumbrian Water and Essex and Suffolk in the south east.
Taking your specific questions in turn:

1. Our surrogate pressure is 15 metres in the mains.

2. Although we have some internal guidelines on pressure for design of network schemes, we have no stated service levels other than the regulatory minimum, and nothing published or publicly available.

3a. The mean water supply pressure across Essex and Suffolk is 33 metres. The average zonal night pressure (AZNP) in Essex and Suffolk is 45 metres.

   We do not have a figure for the mean water supply pressure currently for Northumbrian Water.

   A figure of 45 metres for the AZNP in Northumbrian Water has been used in the past but cannot be considered totally reliable.

3b. We do not have this information.

4. We do not have this information. We can only comment that, as you are aware, we have a DG2 standard for pressure at the customers tap. This performance measure gives the percentage of properties that receive less than 15 metres pressure in the main for more than one hour on at least 5 occasions during the year (excluding short term operational events such as bursts).

   - For ESW this figure is 0.018% of properties
   - For NW this figure is 0.035% of properties

I hope this is clear and of use. Please direct any further requests directly to me.

Regards
ERIC STYA
Dear Dr. Glockling,

Request for Information Regarding Main Water Supply Pressures to Domestic Premises for an ODPM sponsored Fire Sprinkler Study

I refer to your correspondence of the above date and wish to apologise for the delay in formally responding to its content.

The information you seek in reply to your questions for our area of coverage is given in the table below. I feel it important to provide a brief description of our particular statistics. The Company operates a public water supply to an area covering approximately 420 square kilometres in the south east of England. The local topography ranges from sea level to 187 metres above ordnance datum. The water distribution is mostly by gravity from elevated reservoirs with pressure management devices providing relatively stable downstream pressures and flows. Some rural areas receive boosted supplies.

I have answered your questionnaire as fully as I am able but regret that some information is not retained in the format you require and I apologise for these omissions.

I trust the information provided is sufficient for your needs and should you require any further advice or assistance please do not hesitate to contact me again.

Yours sincerely,

A P Dowling
Network Management Controller

Fire Sprinkler Study Questionnaire

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<th>Question</th>
<th>Comments</th>
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<td>A surrogate pressure of 15 metres head is applied.</td>
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<td>2</td>
<td>(a) The information is publicly available.</td>
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<td>(b) There are no regional, daily or seasonal changes other minor hydraulically induced variations.</td>
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<td>(c) The levels are those set by OFWAT. Where pressures exceed 15 metres head these cannot be guaranteed.</td>
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<td>(a) The ‘mean’ pressure is 65 metres head.</td>
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<td>(b) This data is not recorded and therefore difficult to determine but may be as low as 10 to 15%.</td>
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<td>See table below. The figures relate to pressure-managed areas. It does not show data for areas/zones that lie outside of the managed zones as we do not keep this information readily available.</td>
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Dear Dr Glocking,

REQUEST FOR INFORMATION REGARDING MAIN WATER SUPPLY PRESSURES TO DOMESTIC PREMISES FOR AN ODPM SPONSORED FIRE SPRINKLER STUDY

Further to your letter received today addressed to Jonson Cox, please find below information to assist in the feasibility study:

1. Hartlepool Water’s ‘surrogate pressure’ is 15 metres head.
2. Hartlepool Water does have a minimum service level of water pressure for domestic properties:
   a) This information is publicly available
   b) The pressure in the mains vary regionally/daily/seasonally, however, Hartlepool Water maintains the same minimum service level throughout these variations.
   c) The service level is 15 metres head at the stop tap.
3. a) 27.6 metres head
   b) 78% of Hartlepool Water customers receive an average pressure of 27.6 metres head of pressure.

I trust this is the information you require.

Yours sincerely,

Shaun Rowden
Performance and Water Regulation CoOrdinator
30 August 2005

Dr James Glosling
Technical Director
Fire Protection Association
London Road
Moorick-in-Marsh
Gloucestershire
GL96 9RH

Dear Dr Glosling

Re: Request for Information Regarding Mains Water Supply Pressures to Domestic Premises for an OOPM Sponsored Fire Sprinkler System

I refer to your letter dated 25 February 2005.

The information that you requested is as follows:-

1) The 'surrogate gauge' adopted by Mid Kent Water is 15m.

2) Normal and minimum service level of water pressure for domestic properties.
   a) This information is both published and publicly available via Ofwat. The total number of properties on our register at risk of failing below 15m for more than one hour for 2004-2005 was approximately 9,000.
   b) The pressure does vary regionally, daily and seasonally.
   c) The service levels are 15m.

3) Historical data for the last couple of years is as follows:-
   a) The mean water supply pressure across our region of coverage is 44m. The approximate proportion of properties receiving this pressure at the point of supply is given in Table 1, Section a). Please note, the range over the Company’s area of supply is from 1.5 bar to 17 bar.
   b) For Sections b and c, no accurate information is available because the Company has not undertaken this type of study. In order to obtain the relevant data, Mid Kent Water would need to consider the properties within our area of supply based on the following criteria -
      - property location
      - property elevation
      - seasonal and operational changes

As you can appreciate, this would require considerable time and resources to produce an accurate picture of the variation in pressure over a 24 hour, yearly and seasonal periods.

4) Table 1.

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<td>10.34%</td>
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<td>b) Proportion of any defined 24 hour period during which the supply pressure to those properties was at least this value.</td>
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I hope that this information is satisfactory and suitable for your purposes.

If you require any further assistance, please do not hesitate to contact me.

Yours faithfully,

John R Beachey
Head of Asset Delivery & Procurement
Dear Dr Glockling

Many thanks for your recent letter, which included questions relating to the water pressures in our distribution network. The answers below are in the same order as the questions posed in your letter. The information is indicative only and is given on your assurance that it will be treated in strictest confidence and will not be reproduced or published.

1. We assess the level of service to customers against the reference standard of a flow of 9 litres per minute at a pressure of 1 Bar, at the property boundary.

2. We aim to provide the reference standard of flow and pressure as a minimum and this is stated in our information packs to new developers and when answering customer queries. I attach a leaflet which has just been commissioned to explain pressure to our customers and would refer you particularly where we state our obligations on Page 6.

Pressure varies daily and seasonally with demand on the distribution system. There may be times when we cannot meet our level of service, particularly during high summer demand periods.

3. As you will be aware, water pressure varies with demand throughout a 24-hour day. Consequently, an average pressure may be of limited value to you, as for a proportion of the day the pressure may be below any minimum value you need.

However, about half the population have an average pressure of over 40 metres, in a 24-hour period.

4. This question has been answered assuming a property base of all Three Valleys' properties. Consequently, as the pressure rises on the table there are a declining percentage of properties meeting the criteria. No answer has been submitted under 4 (c) as data for 4 (a) and 4 (b) assumes values during peak summer demand.

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<td>a) Proportion of properties within your area of coverage that received this pressure at the point of supply to the property</td>
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<td>b) Proportion of any defined 24-hour period during which the supply pressure to those properties was at least this value</td>
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**Note 1:** Figures rounded to nearest percentage point, e.g. 100% denotes >99.5%

**Note 2:** To assist with the interpretation of this table, as an example, this information denotes 81% of properties in the TVW supply area receive a pressure of 3 bar for 92% of a 24-hour period.

I hope you find this information useful.

Yours sincerely,

Jeff Bishop
Operations Director
PORTSMOUTH WATER PLC

No response supplied

SOUTH EAST WATER PLC

10 May 2005

Our Ref: DG2-300-JWS-CO-001
Your Ref:

Dr James Glockling
Technical Director
Fire Protection Association
London Road
Moreton-in-Marsh
Gloucestershire GL56 0RH

Direct Line: 01444 448302
Email: Jsparks@southeastwater.co.uk

Dear James,

REQUEST FOR INFORMATION REGARDING MAINS WATER SUPPLY PRESSURES TO DOMESTIC PREMISES FOR AN ODPM SPONSORED FIRE SPRINKLER STUDY

Further to your letter dated 31/03/05 please find responses to your questions below:

1. South East Water operate to a 15 metre surrogate pressure. This in most cases will guarantee the regulatory service level of 10 metres pressure at the property boundary when drawing a flow of 9 litres per minute. In practice some properties may receive a pressure slightly below the 15 metre and still achieve the regulatory service level as the properties are connected to South East Water's distribution system by new or short lengths of pipe.

2. Yes, Ofwat reporting requirements set this out, SEW are funded to maintain this level of service.
   a) The information is not published but is available to the public on an individual basis, however, SEW will not guarantee pressures to be maintained at that level. This information is primarily used by developers/plumbers to determine whether they require boosters or larger storage tanks in order to supply their development. Where existing pressures are significantly above their required level developers may choose not to install boosters as a drop in pressure is unlikely to compromise the performance of the domestic plumbing systems. However, in some cases developers have over specified their systems and then had to retrospectively install boosters at their cost.
   b) Yes, significantly.

Regionally: properties within areas situated at higher elevations will generally experience lower pressures and vice versa. This is due the area's topography.

Daily: as a rule all properties will experience a diurnal pressure profile as shown in Figure 1 throughout the year. The size of the drop from nocturnal pressures will vary with area. Some properties situated near South East Water's sites may experience a more stable pressure profile as hydraulic losses that occur within the system are not so pronounced at their property.
Seasonally the principle outlined above still stands and is often more pronounced. Minimum pressures will tend to occur in the evening.

c) 10 metres pressure at the property boundary when drawing 9 litres per minute.

3. The only recognised figure is the Average Zone Night Pressure (AZNP), this is a measure of pressure achieved to all the connected properties in the distribution system at night. The figure is used to determine a volume of leakage from the distribution system and private supplies. South East Water are actively trying to reduce its current AZNP of 54m in order to reduce leakage.

4. See table below

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<th>% of props receiving pressure at point of supply</th>
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<td>99.9</td>
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<td>60%</td>
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South East Water’s preferred option for domestic fire sprinklers is outlined in the enclosed leaflet.

Figure 1

Yours sincerely

John Sparks
Network Strategy Manager
In all of the questions below please assume that 'supply water pressure’ refers to the mains water supply pressure at the boundary of domestic properties.

1) The OFWAT report “Levels of service for the water industry in England and Wales” states that “Companies are required by law to provide water at a pressure that will, under normal circumstances, enable it to reach the top floor of a house. In order to assess whether they satisfy this requirement, companies are required to report against a reference level of ten metres head of pressure at a flow of nine litres per minute,” and that “For ease of measurement, companies adopt a surrogate pressure (usually 15 metres head) in the adjacent water main serving the property.” Can you indicate what 'surrogate pressure' is adopted by your company for assessing compliance with this requirement.

Surrogate Pressure adopted by Company = 15 metres head in adjacent water main

2) Does your company have a normal and/or minimum service level of water pressure for domestic properties? If so:
   
a. Is this information published or publicly available? YES
   
b. Does it vary regionally/daily/seasonally? There are variations in pressure dependant upon demand but the minimum level does not change
   
c. What are the service levels?

We aim to provide a supply of water for domestic purposes at a minimum pressure of 10 metres head at a flow rate of 9 litres per minute at the boundary for a single supply.

3) Based on historical data for the last couple of years:
   
a. What is the mean water supply pressure across your region of coverage

   The average 24 Hr pressure supplied to 81.7% of properties within the SSW distribution network is 45.7mHd.

   b. In general what proportion of the population actually receive that pressure and for what proportion of (i) each 24 hour period and (ii) each year period

   Unable to answer the above

4) Based on historical data for the last couple of years please provide as much information as possible for the following table (we appreciate that it may not be feasible to fully complete this table but would ask that you provide as much detail as you are able.)
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From: Medler, Julie [mailto:julie.medler@thws.co.uk]
Sent: 15 April 2005 16:37
To: Jim Glockling; Stuart Campbell

Subject: Mains Water Pressures to Domestic Premises

Dear Dr Glockling

Request for Information Regarding Mains Water Supply Pressures to Domestic Premises for an ODPM Sponsored Fire Sprinkler Study

Andrew Smith has asked me to respond to your letter dated 31 March 2005.

Tendring Hundred has unusually low pressures compared to industry norms due to the very flat area supplied. The Company also has comprehensive pressure control systems that actively increase pressure with demand such that the normal pressure rise due to lower friction losses associated with low demand periods is partly offset for some zones.

The Company’s average day time and night time pressure is therefore equal at 25m. Pressures only exceptionally drop below 15m or exceed 35m at any of the 65,000 connected properties. The responses to your detailed questions are:

1) 15m or 1.5 bar.

2) a) Customers are sent a comprehensive booklet every year and the information can be found on the company’s web site www.thws.co.uk.

   b) There are variations to some supplies regionally, daily and seasonally but these are limited and generally remain within the overall 15m-35m 1.5-3.5 bar range stated above.

3) a) 25m or 2.5 bar.

   b) Approximately 50% at all times

4) In all cases a), b) and c) we estimate that the % will decrease from 100% at 1.0 bar to 0% at 4.0 bar with say 99% and 1% at 1.5 bar and 3.5 bar respectively.

I trust this response is sufficient for your present purpose and as we are likely to represent the low end of the industry pressure range, we will be please to try and help further if required.

Yours sincerely

Martin Henderson
Head of Operations