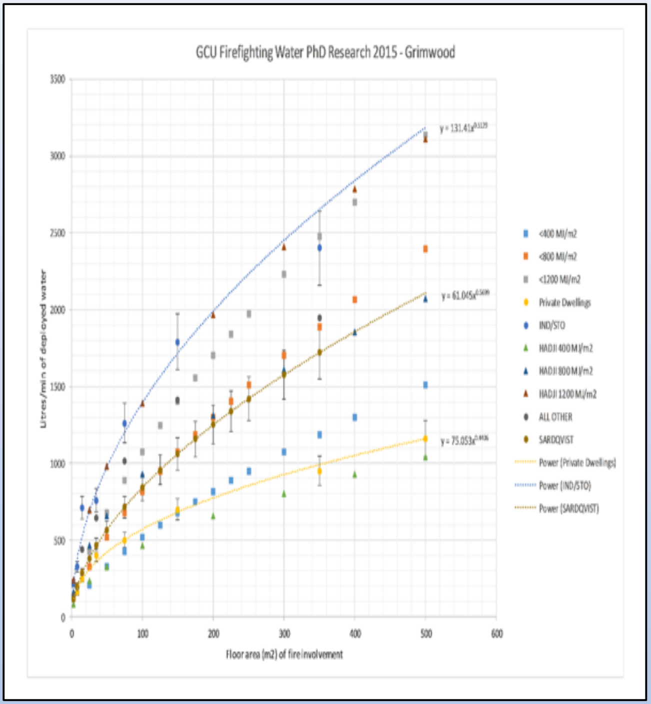
‘Adequate’ Firefighting Water

There is a legal requirement placed on the UK fire service to ensure that the water flow-rates used for fire suppression are of an *‘adequate’ amount*. As there was no actual definition for what was meant by ‘adequate’, my 2012 PhD research (*that technically began in 1989*) demonstrates what were considered (a) *critical*; (b) *minimum and (c) optimum* (adequate) amounts of firefighting water in a range of occupancies.

An important factor in this research was the decrease in heat exposure and positive impacts on firefighter physiology as the length of time on the hose-line was reduced due to applications of adequate flow-rate. As fire loads and compartment sizes increase, a greater quantity (L/min) should be deployed at the earliest opportunity and building designs should support this need. This work was also linked to the decreasing amounts of building fire damage observed as a result of adequate firefighting water deployment.

This research by Kent FRS in association with Glasgow Caledonian University (Fire Engineering)was to form the basis of firefighting water design codes (BS PD 7974-5-2015 [Rev.2020]) and National Operational Guidance (Optimum Firefighting Flow-rate)

The author's PhD research included analysis of the quantities of firefighting water used for suppression at 5,401 'working' building fires in the UK between 2009 and 2012. The lower line represents private dwellings and apartments with an upper line representing industrial units and warehouse fires. All other fires fall between these two lines, as represented by a median line of data provided by the Sardqvist research into non-residential premises. It should be noted that construction styles during this research in the UK is widely solid masonry and structure fires are in general, only tactically ventilated at the point when fire is under control, or at least is 'surrounded'. However, lightweight building construction is now becoming more widely predominant in both the UK and Europe in general.



More information -

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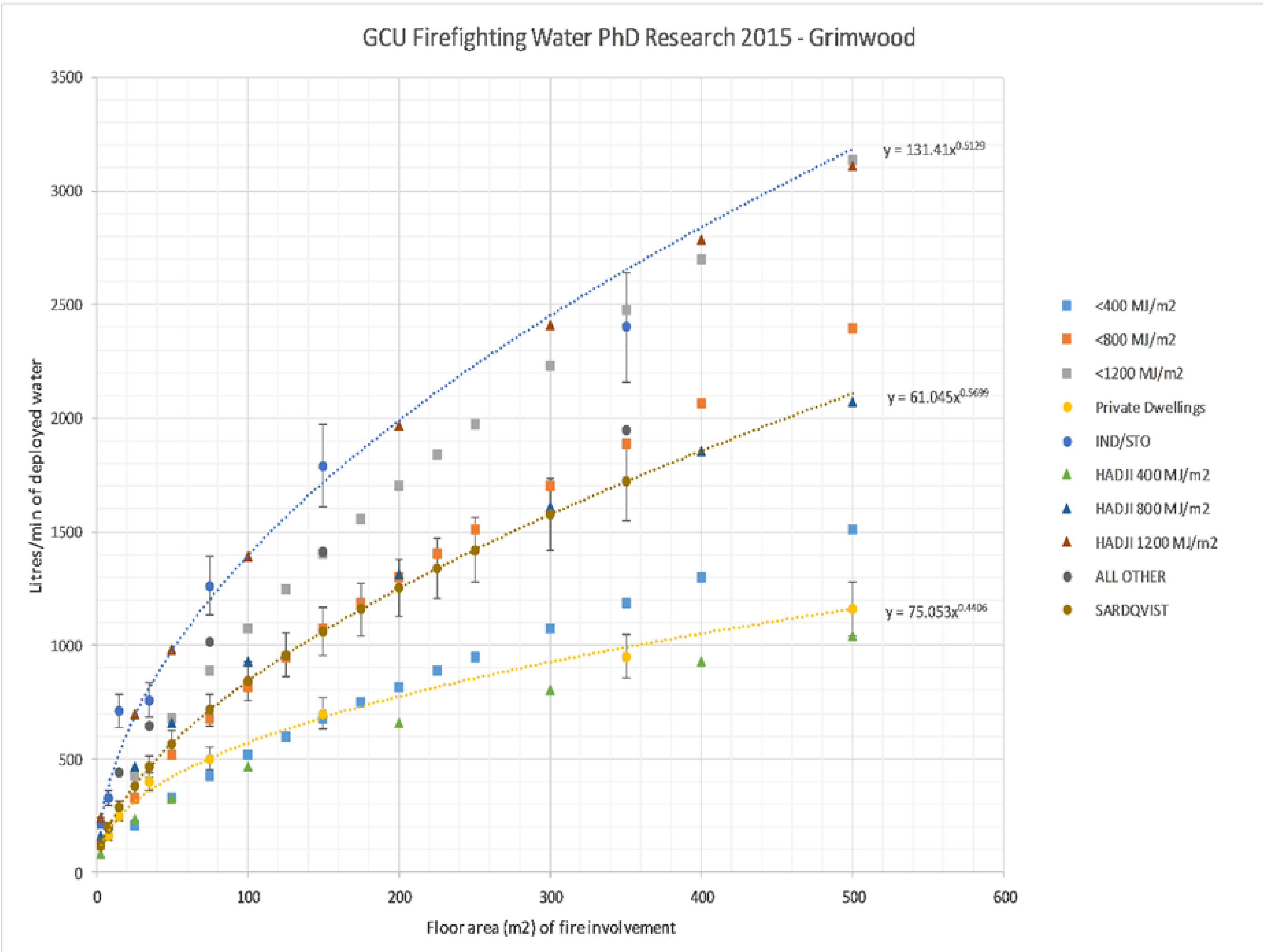
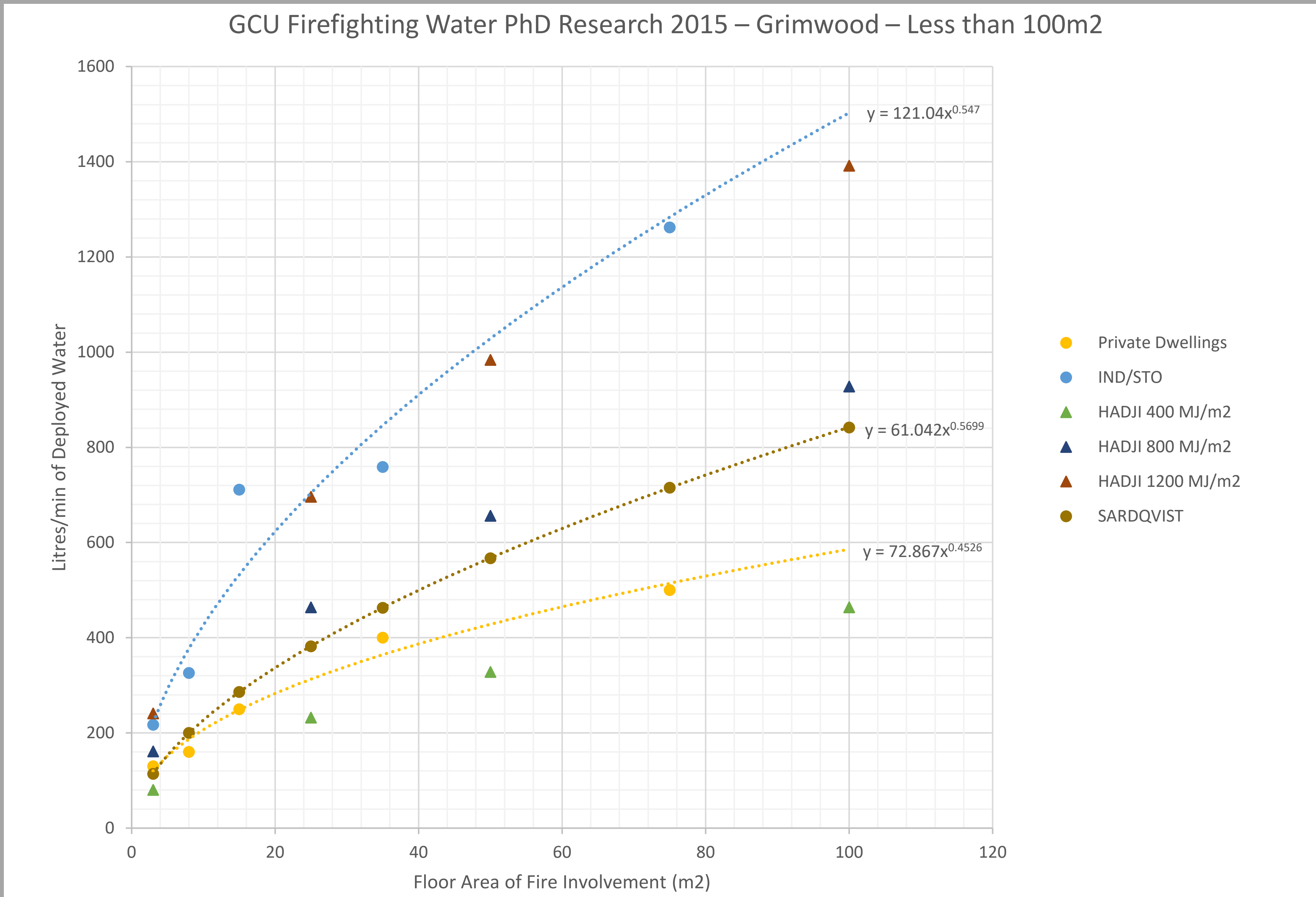


GCU Firefighting Water PhD Research 2015 - Grimwood
Litres/min of deployed water
Floor area (m2) of fire involvement
3500
3000
2500
2000
1500
1000
500
0
0
100
200
300
400
500
600
y = 131.41x0.5129
y = 61.045x0.5699
y = 75.053x0.4406
<400 MJ/m2
<800 MJ/m2
<1200 MJ/m2
Private Dwellings
IND/STO
HADJI 400 MJ/m2
HADJI 800 MJ/m2
HADJI 1200 MJ/m2
ALL OTHER
SARDQVIST



GCU Firefighting Water PhD Research 2015 – Grimwood – Less than 100m2
Litres/min of Deployed Water
Floor Area of Fire Involvement (m2)
0
200
400
600
800
1000
1200
1400
1600
0
20
40
60
80
100
120
y = 121.04x^0.547
y = 61.042x^0.5699
y = 72.867x^0.4526
Private Dwellings
IND/STO
HADJI 400 MJ/m2
HADJI 800 MJ/m2
HADJI 1200 MJ/m2
SARDQVIST

National Operational Guidance Firefighting Flow-rate

At its simplest, the flow rate is the amount of extinguishing media being applied to a fire at any one time, referred to in litres per minute (L/min).

Required flow rate may be simply viewed as the amount of firefighting media required to control and ultimately extinguish a fire. This introduces many variables; more precisely two flow rates need to be considered:

- **Critical flow-rate** (CFR): typically this would be the absolute minimum amount of firefighting media flow needed to fully suppress a fire at any given level of involvement.
- **Optimum (Tactical) Flow-rate** is the target flow for a primary attack hose line or lines

The actual critical flow rate is dynamic; it is directly related to the phase of the fire and this may be unknown. It also has no built-in safety factor. More relevant is the tactical flow rate, which more accurately represents the flow rates required by firefighters to deal with a given fire in a known compartment or occupancy type.

The concept of firefighting flow rate requirements can be based theoretically in matching the flow of firefighting media against known rates of heat release in compartment fires (measured in megawatts or MW).

It can also be empirically based on fire loads, in established floor space, against the flow of firefighting media needed to suppress fires during their growth or decay stages. The latter is generally a defensive application.

It is recognised that flow rate i.e. the amount of firefighting media, extinguishes fire, not pressure.

Relying on pressure alone as the basis to deliver firefighting media does not provide information on the litres per minute being delivered and may be insufficient to prevent fire growth and spread.

The mathematical calculations for the amount of water required to extinguish a given fire are relatively complex. However, as a fire ground **rule of thumb for fires between 100 to 600m^2**, the following calculation could be considered:

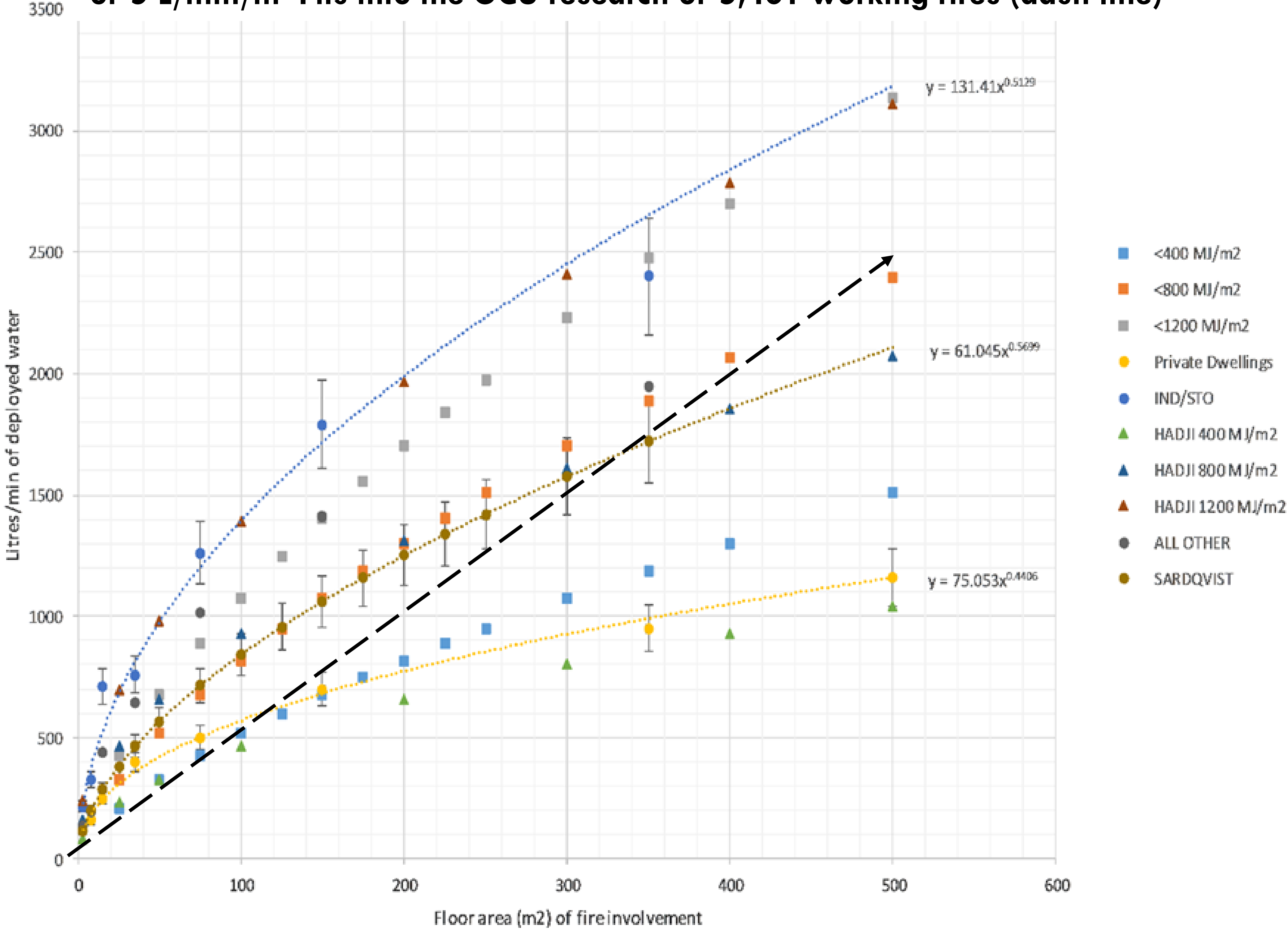
Optimum flow rate (L/min) = fire area (m^2) x 5

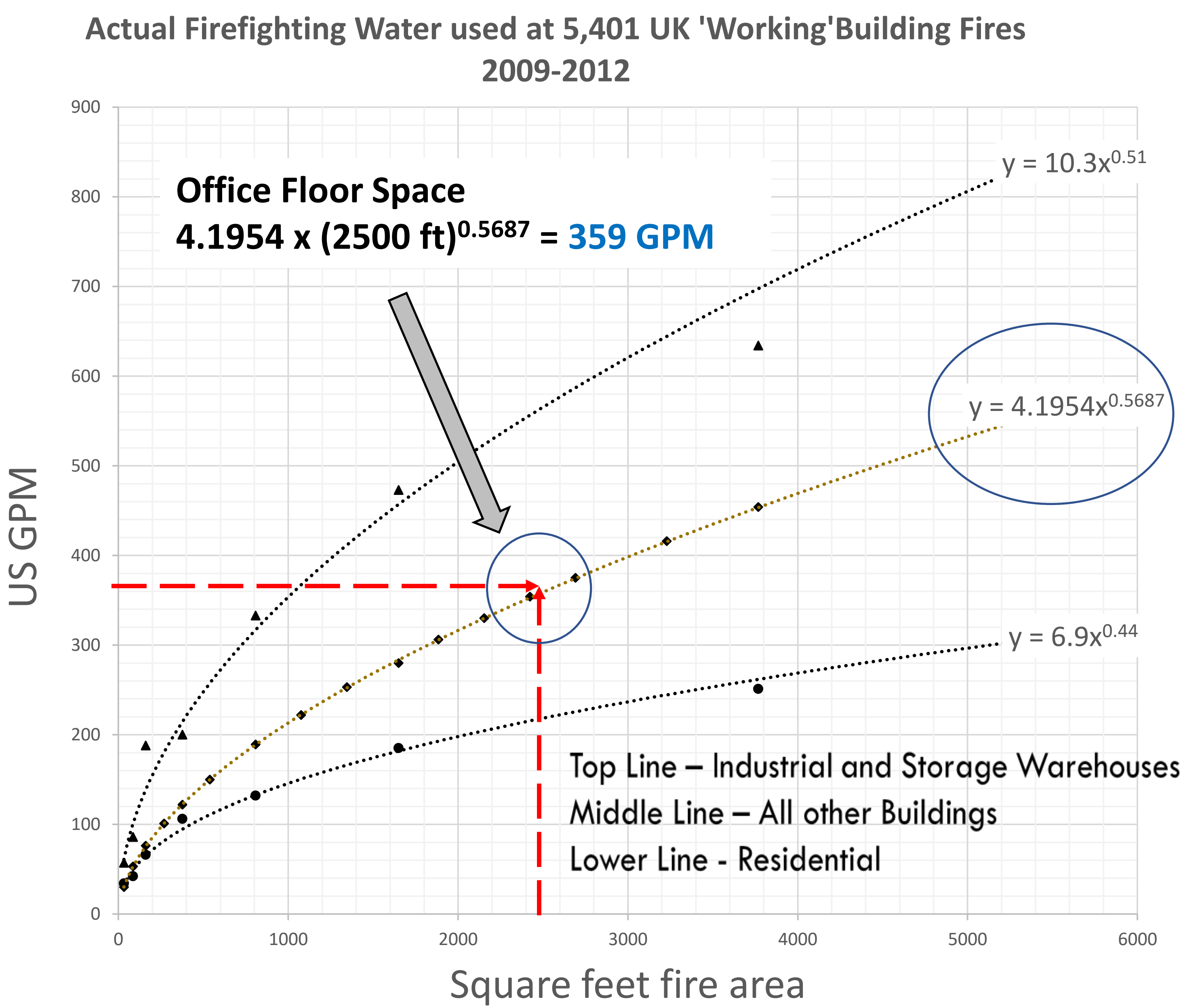
For example, in a situation with a fire in an open plan flat measuring 90 m2

Optimum flow = 90m^2 x 5 = 450 L/min

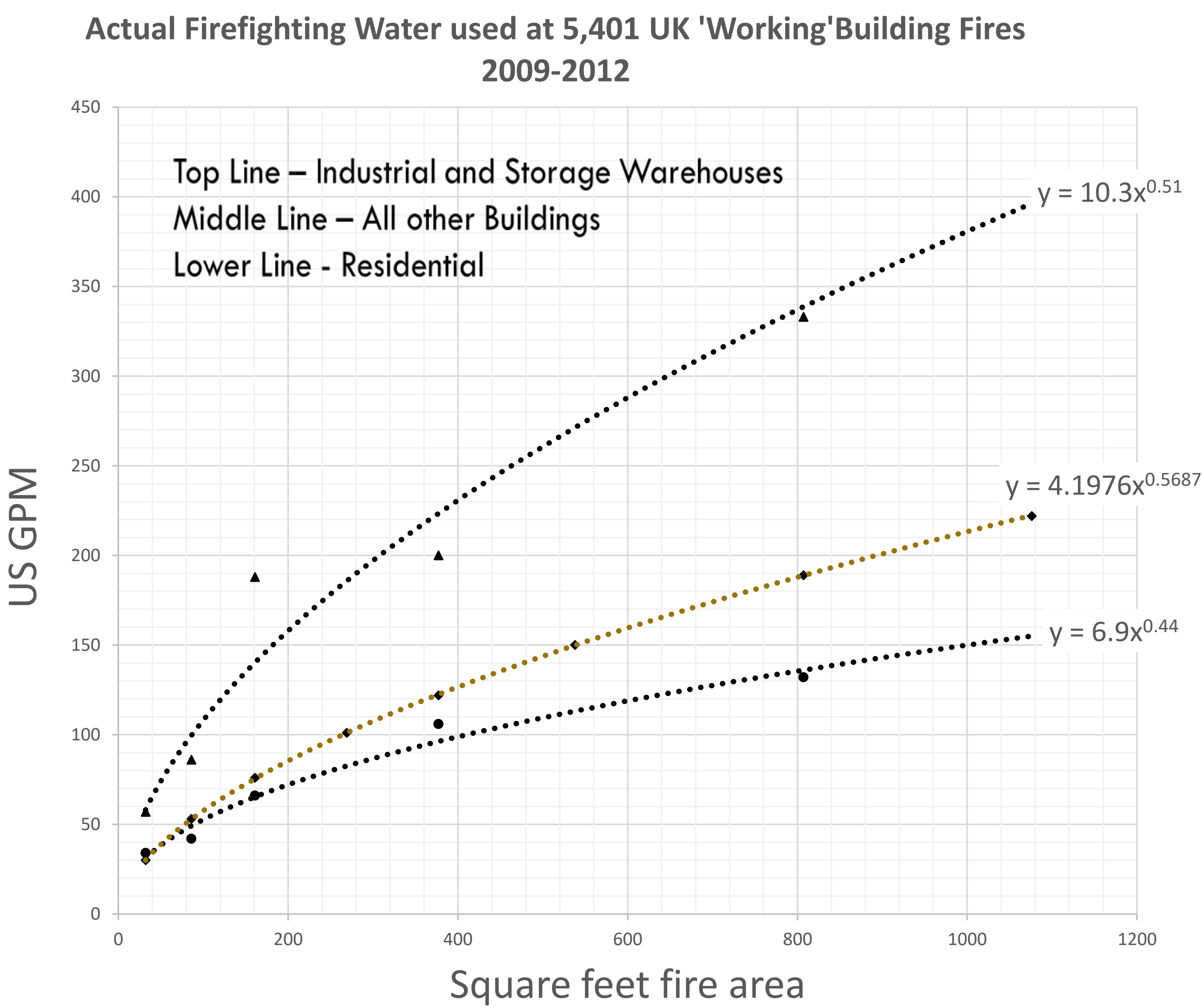
This shows that an estimated flow rate of at least 450 L/min would be required as a minimum to extinguish the fire safely and effectively by lessening the amount of heat exposure firefighters may be subjected to, over time on the hose-line.

How the National Operational [Fireground] Guidance Optimum Flow-rate of 5 L/min/m^2 Fits into the GCU research of 5,401 working fires (dash line)





Actual Firefighting Water used at 5,401 UK 'Working'Building Fires
2009-2012
Office Floor Space
4.1954 x (2500 ft)^0.5687 = 359 GPM
y = 10.3x^0.51
y = 4.1954x^0.5687
y = 6.9x^0.44
Top Line – Industrial and Storage Warehouses
Middle Line – All other Buildings
Lower Line - Residential
US GPM
Square feet fire area
0
100
200
300
400
500
600
700
800
900
0
1000
2000
3000
4000
5000
6000



Actual Firefighting Water used at 5,401 UK 'Working'Building Fires
2009-2012
Top Line – Industrial and Storage Warehouses
Middle Line – All other Buildings
Lower Line - Residential
$y = 10.3x^{0.51}$
$y = 4.1976x^{0.5687}$
$y = 6.9x^{0.44}$
US GPM
Square feet fire area
0
50
100
150
200
250
300
350
400
450
0
200
400
600
800
1000
1200

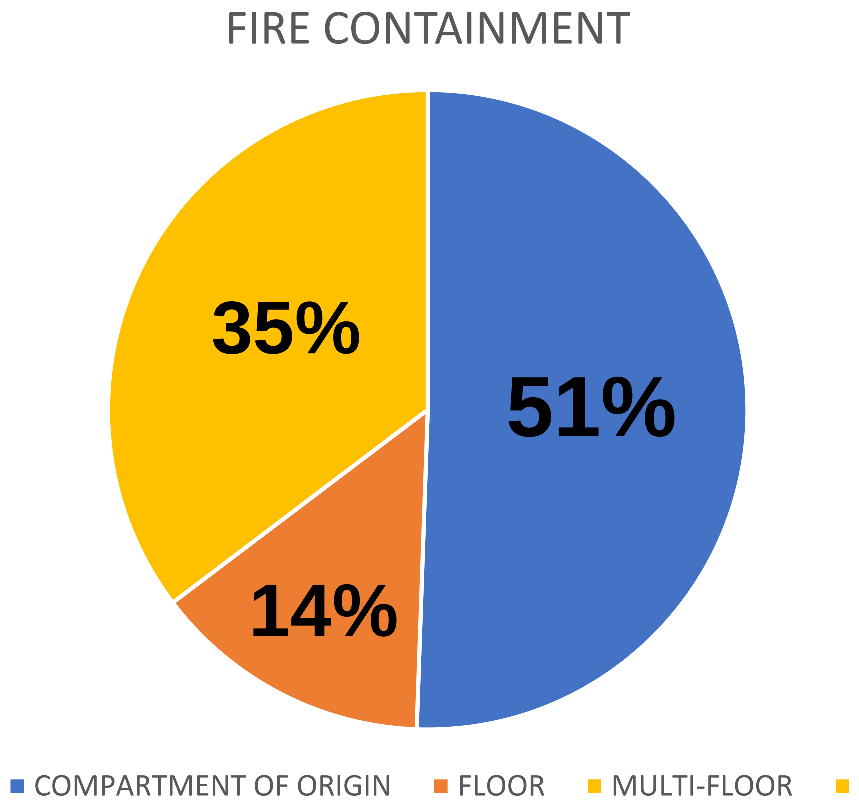
‘Adequate’ Firefighting Water

The Kent Fire and Rescue Service responded to their own internal capability review in 2012 in several ways to optimize response and service delivery further. It was noted in the firefighting water flow-rate research that due to demographics; they were seeing greater building fire damage than a Metropolitan Fire and Rescue Service who responded with greater weight of attack and more closely spaced fire stations and reduced response times.

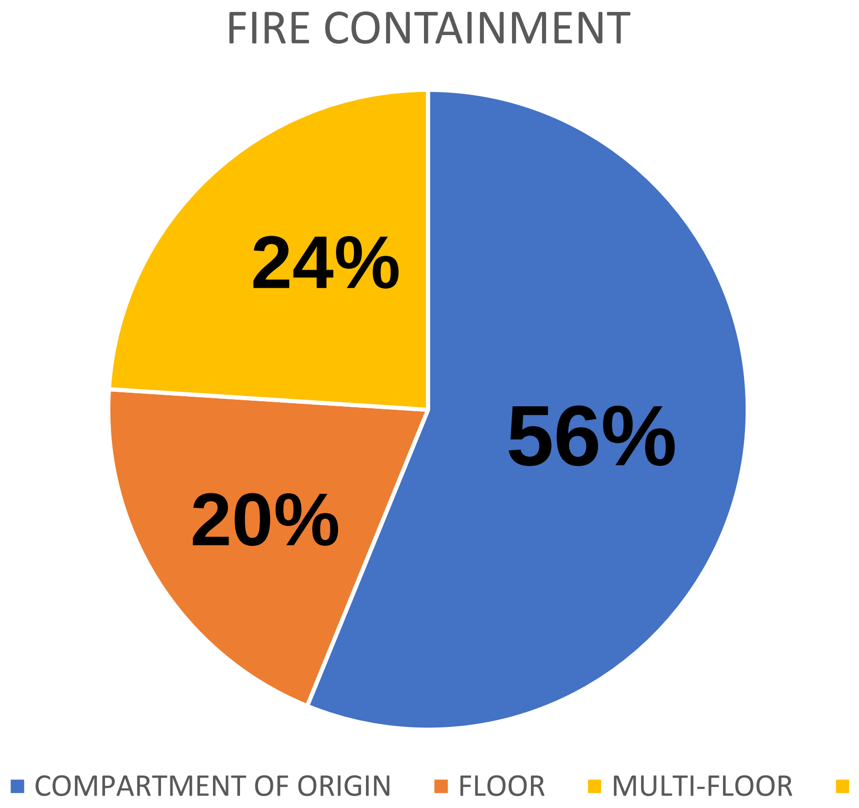
The KFRS firefighting water flow model was adapted by 2015 to deliver the same quantity of water as delivered previously but in a more rapid way. This was achieved through 22mm Hose-reels (replacing 19mm) and 22mm smooth-bore branches (augmenting some automatic branches).

The reductions seen in building fire damage were dramatic and inline with the Metropolitan FRS.

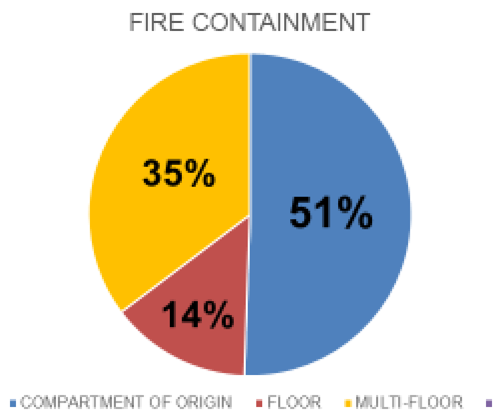
COUNTY FIRE CONTAINMENT 2012-15



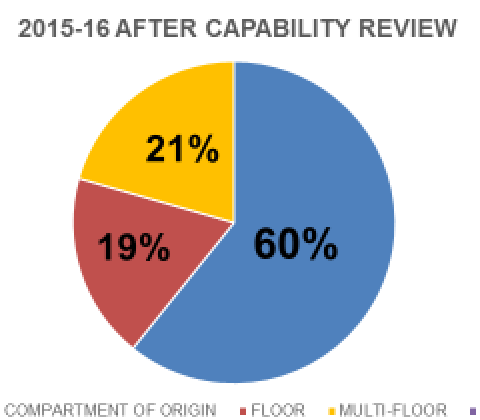
METRO FIRE CONTAINMENT 2012-15



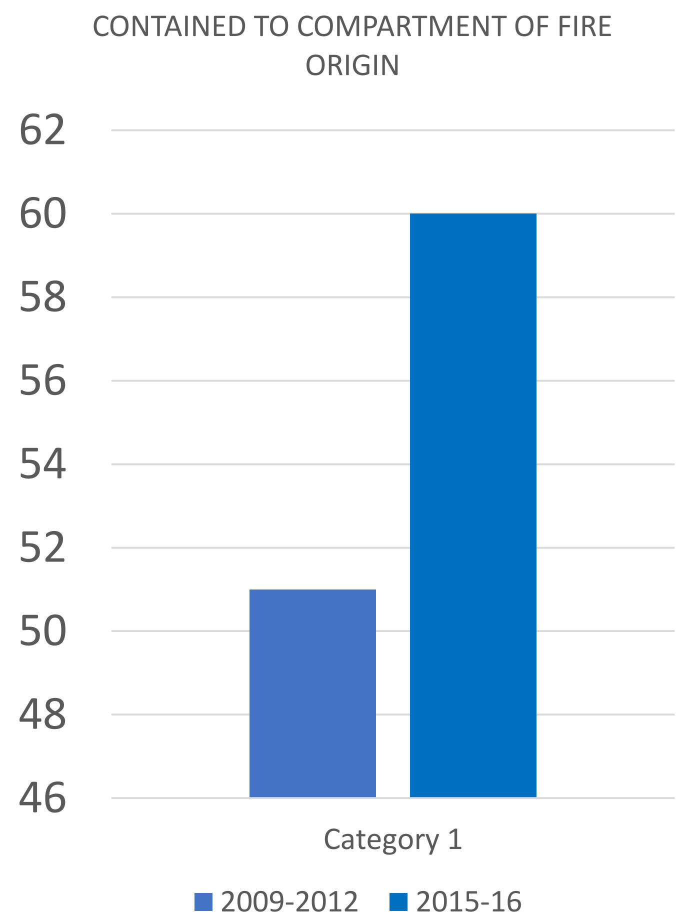
COUNTY FIRE CONTAINMENT



COUNTY FIRE CONTAINMENT



The link between flow-rate and fire damaged area was shown when the County increased their primary flow-rates by approximately 50% in 2015-16 (22mm hose-reels and smooth-bore main nozzles)

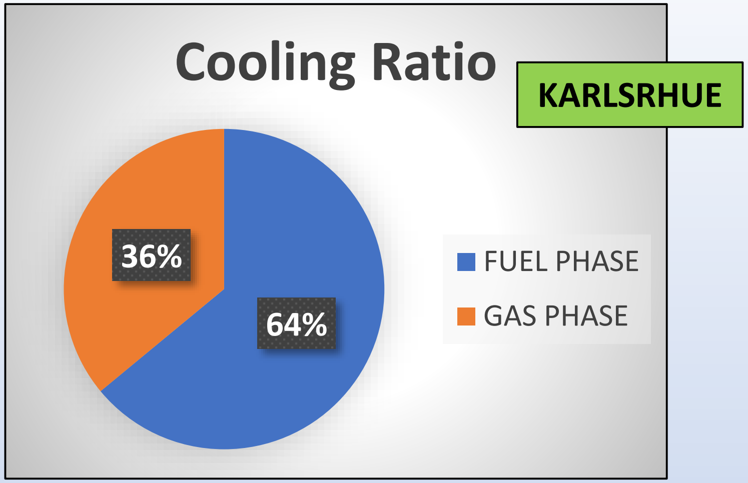


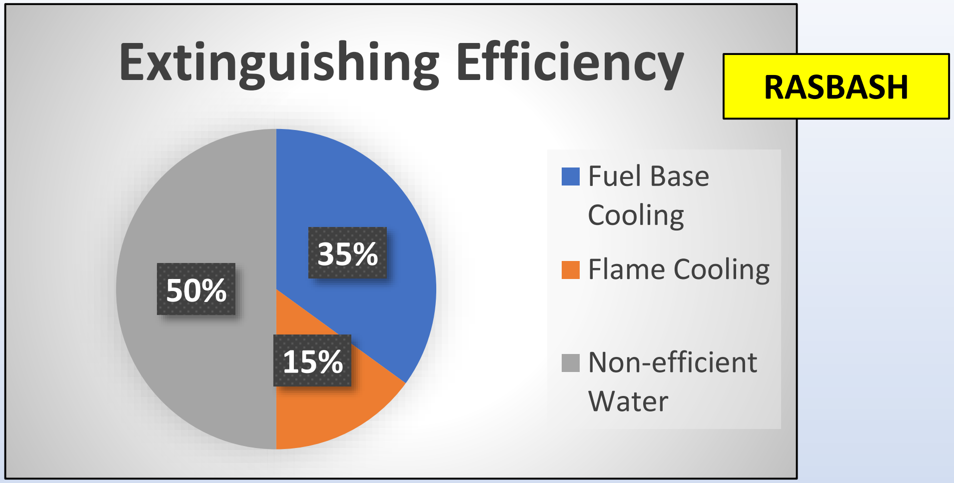
Cooling Ratios and Mechanisms of Extinguishment

Research (reported in 1979-1984) from several full-scale ventilation-controlled fire tests at Karlsruhe University (Fire Research Station) in Germany revealed some commonality during the overall extinguishing process, where 36 percent of applied water was seen to suppress active (flaming) combustion, with the remaining 64 percent cooling the fuel base surface fire. This was noted in the live fire tests and then validated using a complex mathematical model developed to support the test process.

So too is there generally some major water run-off when firefighting water is delivered directly onto a burning fuel base. Estimates in research have placed this efficiency of applied firefighting water at around 30-50 percent. That is, for every 100 litres applied, only 30-50 will take part in the suppressive and cooling phase, with the remainder possibly finding its way onto the floor and out of the structure. Researchers have broken this down to 35 percent efficiency when applied into the fuel base and 15 percent efficiency when applied into the gas-phase (total 50 percent). Research by *Rasbash* suggested primary efficiency factors that conform to later work by Barnett in producing a cooling efficiency factor.

EuroFirefighter 2 – 2017 (p239 on)



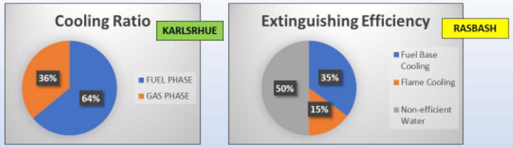


Flame Suppression	0.36 x 3.6 MJ/kg x (1/0.3) x 26.2 L/s x 0.15	=	16.96 MW
Fuel Base Cooling	0.64 x 2.6 MJ/kg x 26.2 L/s x 0.35	=	15.25 MW
Total		=	32.21 MW
Q_s		=	32.21 / 0.5 (k_F)
Total Heat Absorption Capacity (Q or Q_{max})		=	64.42 MW
26.2 L/s / 64.42		**=**	**0.407 L/s/MW**

1,572 L/min (26.2 L/s) (**415 GPM US**) is required to deal with **32.21 MW$_{Actual}$ (64.42MW$_{Total}$)**

Q_s = is the heat absorption capacity of firefighting water in L/s and k_F = is the assumed combustion efficiency of the fire taken as 50%

BSPD 7974:5-2020 (Glasgow Caledonian University)



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Fuel Base Cooling	0.64 x 2.6 MJ/kg x 26.2 L/s x 0.35	=	15.25 MW
Total		=	32.21 MW
Q_s		=	32.21 / 0.5 (k_c)
Total Heat Absorption Capacity (Q or Q_{max})		=	64.42 MW
26.2 L/s / 64.42		**=**	**0.407 L/s/MW**

1,572 L/min (26.2 L/s) (**415 GPM US**) is required to deal with **32.21 MW_{Actual}** (**$64.42MW_{Total}$**)

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