INTEGRATED RISK MODEL 2015-2019:

HOW WE CALCULATE AND MODEL RISK IN BERKSHIRE

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Introduction

Under Integrated Risk Management Planning (IRMP) all Fire & Rescue Services (FRSs) are obliged to consider how best to mitigate risk by a balance of Prevention, Protection and Response (PPR). To provide risk treatments by PPR requires a knowledge and understanding of the risks. This report outlines the concepts of mapping and modelling that Royal Berkshire Fire & Rescue Service (RBFRS) uses to calculate risk and risk location within Berkshire.

Concepts

Risk

Risk[1] is commonly calculated by the equation:

Risk = Likelihood x Severity.

This basic principle is used throughout our risk modelling model and is measured by geographic areas within Berkshire in terms of **societal risk** and **incident risk**. To give the greatest possible level of flexibility, a concept matrix was developed to illustrate how all risks can be combined, in any number of ways, to form an assessment of risk (Appendix A).

In some cases, the model will give a score for **absolute risk**. For example, the number of incidents of a particular type may be seen as the 'likelihood' and the number of fatalities and injuries may be used as a measure of 'severity' (more detail below).

Most importantlythough, the output from the model (of all and any combined risks) *compares* areas of risk. It is a **relative risk** model. By this it is meant that one area will be measured as more (or less) risky than another area. The reason is that RBFRS can then **target risk treatments** by Prevention, Protection and/or Response most efficiently, effectively and economically. This means that there will always be some apparent high risk areas, whereas they should be seen as high risk compared to all others.

[1] Risk here is 'public risk'. Other risks such as organisational (financial, legal etc) and staff (including FF) are not considered, unless people have been hurt. Further, risks to animals and the environment are only considered in as much as there has been harm caused (or not) to people.

Geographic Area

The geographic area can be of virtually any description, shape or size. For a Berkshire wide approach to IRMP, **Lower Super Output Areas (LSOAs)** are used as they enable a reasonable level of detail across the whole of Berkshire, thereby giving a sensible breakdown of risk, whilst not becoming so detailed that it is impossible to see the overall Berkshire risk picture. Further, other FRSs are using LSOAs in their risk mapping.

LSOAs[2] are used nationally and, for example, the **Indices of Multiple Deprivation (IMD)** are issued by the Department for Local Government & Communities (DCLG) using LSOAs.

There are 537 LSOAs in Berkshire to which are added 'Motorway LSOAs'. Motorway LSOAs allow us to extract motorway incident data from the geographical risk areas and calculate them separately[3]. Using LSOAs allows RBFRS to calculate relative risk across Berkshire.[4]

Datasets

Incident data is extracted from the mobilising system on a rolling six year cycle. At the time of writing (13 April 2016) work is ongoing to input data for the 2010/11-2015/16 inclusive. The incident data is mapped to the incident types listed at appendix B. Numbers of incidents by type are given, in addition to rescue, casualty and fatality data.

IMD data[5] is provided nationally by LSOA and gives local authority and population statistics mapped to societal risk data, as listed at appendix C. IMD data is a national relative risk calculation of the damaging lack of material benefits considered to be basic necessities. Correlations have been found to emergency incidents.

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[2] **LSOAs** (Lower-layer Super Output Areas) are small areas designed to be of a similar population size, with an average of approximately 1,500 residents or 650 households. There are 32,844 Lower-layer Super Output Areas (LSOAs) in England. They were produced by the Office for National Statistics for the reporting of small area statistics. Source: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015

[3] It can be seen that this tool could be used to extract data from other facilities (for example an airport) where the risk is related to the infrastructure rather than the area.

[4] It would be possible to give relative risk across Thames Valley or all England. Currently, we can only show relative risk on a wider geographical basis for IMD scores, as this is the only dataset available. If all incident and social risk data become available nationally, then it would be possible to show relative risk nationally.

[5] All of the data files and supporting documents for the English Indices of Deprivation 2015 are available from: www.gov.uk/government/statistics/english-indices-of-deprivation-2015

Risk Calculation Methodology

Two Excel spreadsheets have been designed and independently validated[6] to manage the necessary data ready for input to the mapping and modelling tool[7]. The first spreadsheet[8] is extracted from the mobilising system (Incident spreadsheet). This is cascaded into the second[9] spreadsheet (LSOA risk spreadsheet), which is a very large file populated with relevant incident and societal data by Berkshire and all England LSOAs (respectively).

Incident Risk

A rolling 6 years of incident data is exported from the mobilising system to the relevant incident data Excel file. It is sorted into 34 incident types (plus 'blanks' and 'false alarms') and gives rescues, casualties and fatalities by incident type.

This data is used to ascertain the points on the map that are input into Cadcorp and correlated by LSOA. In this way it is known how many incidents of each type are in each LSOA and these are inputted into the LSOA risk spreadsheet.

The numbers of fatalities, casualties and rescues inform the 'severity' tab of the LSOA Risk spreadsheet, where a severity score for each incident type is calculated, using the following formula:

$$\textit{Incident type Severity} = \frac{\#^{10}\textit{rescues} + (\#\textit{casualties} \times 10) + (\#\textit{fatalities} \times 100)}{(1+\#\textit{incidents of type})}$$

In this way we can ascertain the severity of the incident if you, as a member of public, are involved in an incident of this type (appendix D).

As an aside, if we again use the formula: Risk = likelihood x severity and the likelihood of an incident is the number of incidents of type (e.g. Berkshire) we can calculate an overall risk assessment for each incident type (Appendix E).

Once we know the number of incidents of each type in each LSOA and the severity of each incident type, the severity score is inputted into the LSOA risk spreadsheet. The incident risk for each incident type is then calculated for each LSOA.

Each incident risk is scored by LSOA. This score is rated by population:

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[6] Risktec Solution Ltd. 22/2/16 …"we believe that the methodology and its implementation are robust for the purpose for which it is to be used (i.e. looking at relative risk levels across RBFRS and to allow prioritisation of resources to be made"

[7] RBFRS uses Cadcorp Workload Modeller that is an application built into the Cadcorp Geographical Information System (GIS).

[8] Currently called – "Incidents_2009-2014 for incident type risk analysis MASTER 04-02-16"

[9] Currently called – "LSOA Risk - Societal and Incident - MASTER - 17-02-16"

[10] # = 'number of'

Incident type risk rate in LSOA = incident risk in LSOA/LSOA population.

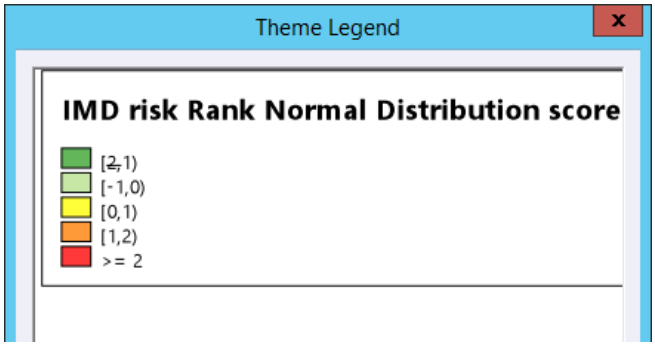
Then standard deviation is used to give a 'rank'. Formula given as:

LSOA Rank = Standard Deviation of (LSOA incident type1 risk)

This risk rate is for each incident type gives the risk rank that may be mapped:

Risk score 1 = <-1 s.d. (Dark Green)
Risk score 2 = >-1 s.d. to <0 s.d. (Light Grn)
Risk score 3 = >0 s.d. to <1 s.d. (Yellow)
Risk score 4 = >1 s.d. to <2 s.d. (Orange)
Risk score 5 = >2 s.d. (Red)

(where s.d. = standard deviation)



This is the **relative** risk rank – compared to all other LSOAs 'normalised'[11].

To combine one,or more incident risks, the following formula is used:

Total Incident Risk Rate[12] *in LSOA =*
(Risk 1 rate) + (Risk 2 rate) + (Risk 3 rate) etc

The total incident risk rank is given as:

LSOA Rank = Standard Deviation of (Total Incident Risk rate in LSOA)

And this risk score ranking may be mapped similarly to above.Societal Risk

A list of risks under consideration is at Appendix C.

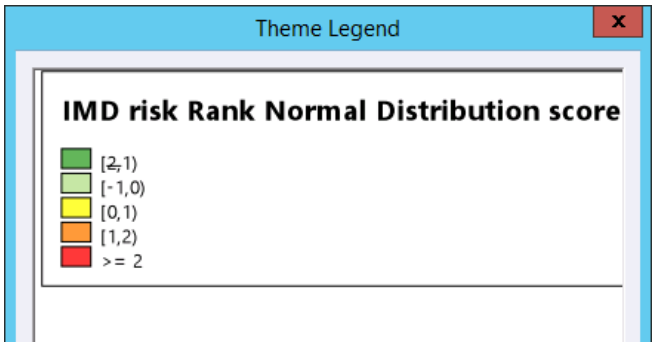
Each societal risk is scored by LSOA. This score is rated by population[13]. Then standard deviation is used to give a 'rank'. Formula given as:

LSOA Rank = Standard Deviation of (LSOA societal risk 1 score/LSOA population)

[11] By filtering on Column D (local authority area) in the LSOA risk spreadsheet, it is possible to normalise the risk ranks by the filtered areas. This applies to all normalisations here.
[12] Following advice from the independent validation, suicides were removed from this total incident risk calculation.
[13] IMD data is most often already given by population rate.

All LSOAs are then ranked by their standard deviation, similarly to the individual societal risks, using the same framework, in the following way:

Risk score 1 = <-1 s.d. (Dark Green)
Risk score 2 = >-1 s.d. to <0 s.d. (Light Grn)
Risk score 3 = >0 s.d. to <1 s.d. (Yellow)
Risk score 4 = >1 s.d. to <2 s.d. (Orange)
Risk score 5 = >2 s.d. (Red)



This allows each societal risk to be mapped individually on a 5 colour map.

To combine one or more, the following formula is used:

Total Societal Risk in LSOA =
(Risk 1 rank x weight) + (Risk 2 rank x weight) + (Risk 3 rank x weight) etc

Using the sum of 'ranks' avoids the problem of data skewing due to the calculation methodology[14].

The weights sum to '1' and are given by professional judgement. Currently the weightings are:

IMD = 0.6 *Arson (deliberate) fire = 0.3* *Non-residential fire = 0.1*

The total societal risk rank to give the relative societal risk is given as:

LSOA Rank = Standard Deviation of (Total Societal Risk in LSOA)

And this risk score ranking may be mapped similarly to above.

Combining Societal Risk and Incident Risk

Total risk in each LSOA is calculated by the following:

[14] The validation noted that calculated IMD risk rates were many orders of magnitude larger than other societal risks considered and recommended use of ranks and weighting.

Total LSOA risk =

(Total Societal risk rank x weighting) + (Total incident risk rank x weighting)

The weightings sum to 1. The current weighting used is 0.5/0.5, given by professional judgement.

Again, this score can be ranked by standard deviation and then mapped.

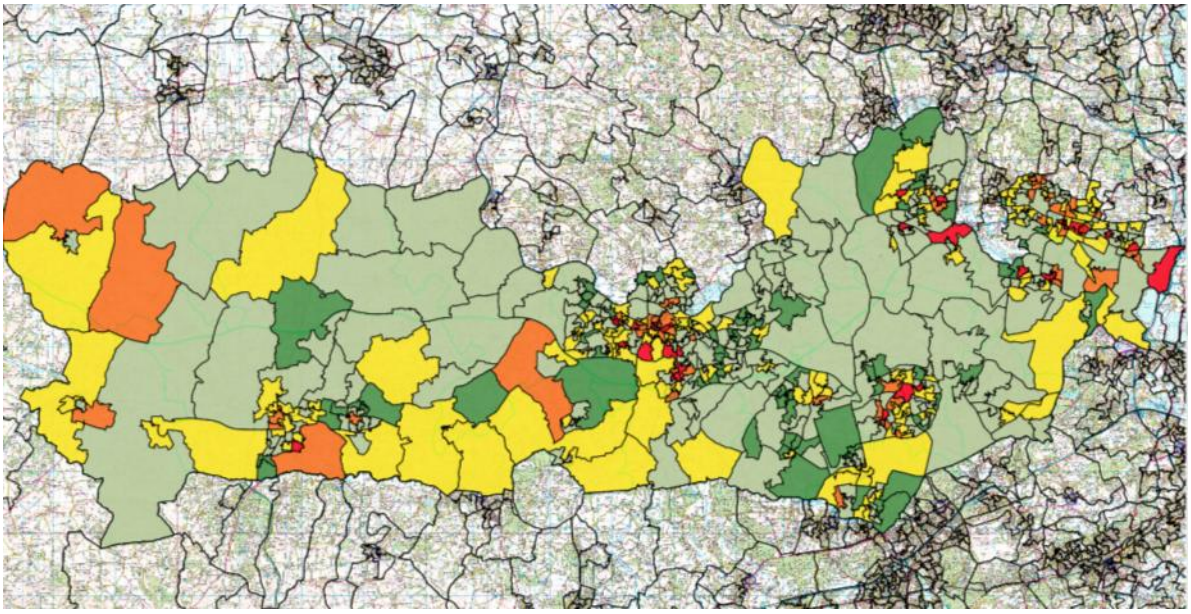
Although any weighting may be used (for example, to give precedence to incidents, 0.1 / 0.9 could be used), it is felt that to fully reflect the broader agenda (across all of PPR) requires a higher weighting for societal risk. In any event, one or more risks can be combined, mapped and used to indicate appropriate treatments, prior to this weighting being needed.

Risk Mapping and Modelling

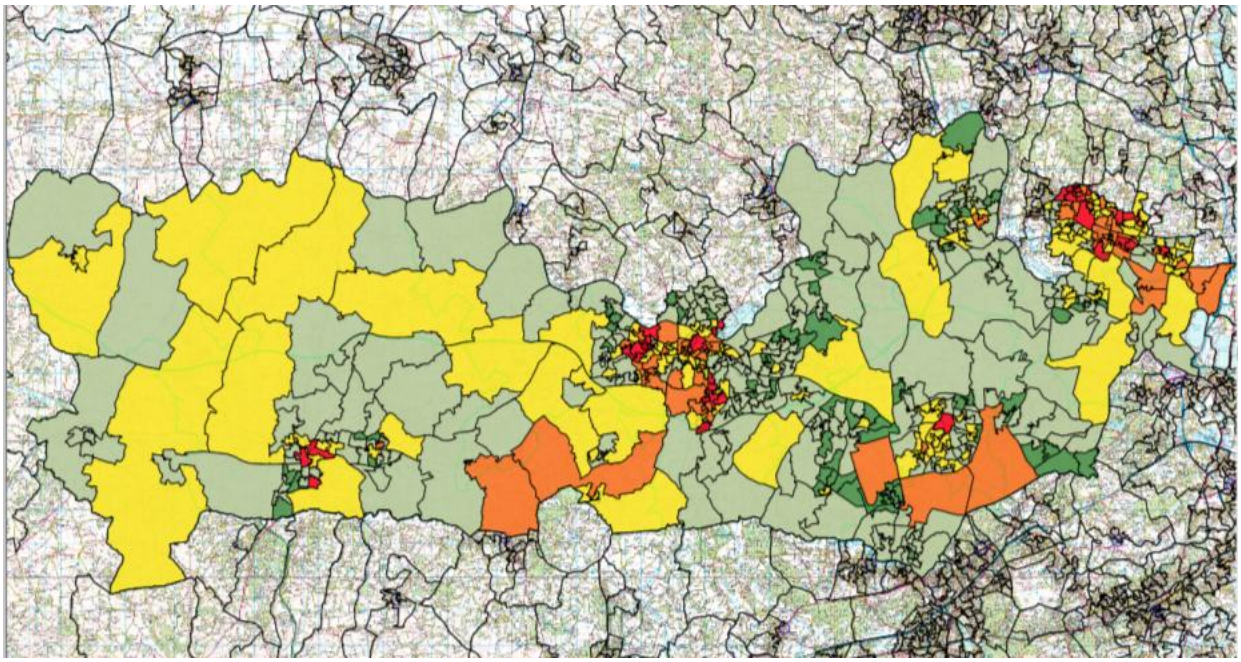
The above calculation methodology is to ensure that the correct data is inputted into the Cadcorp mapping (GIS) and modelling (Cadcorp Workload Modeller) system. Once data is inputted there are two basic operations, and it is prudent to think of these here as ‘black box’ operations. They are risk mapping first and modelling second.

Risk Mapping

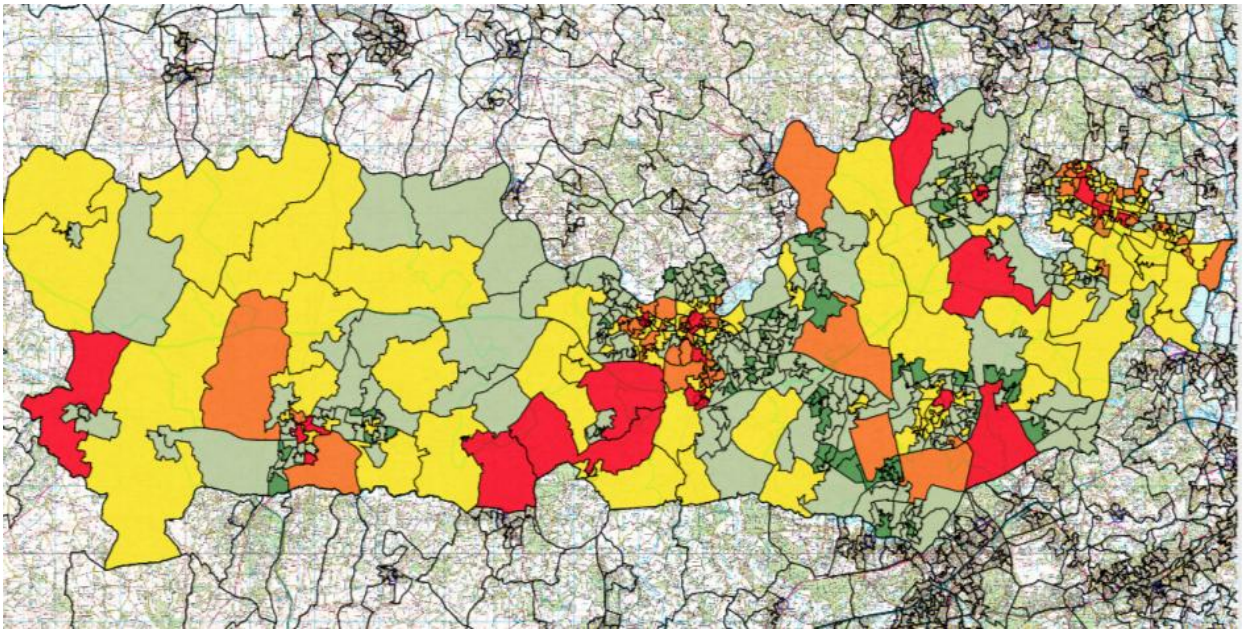
It is possible to see a risk map of any one, or more risks in any combination.



Fire dwelling - Normal Distribution

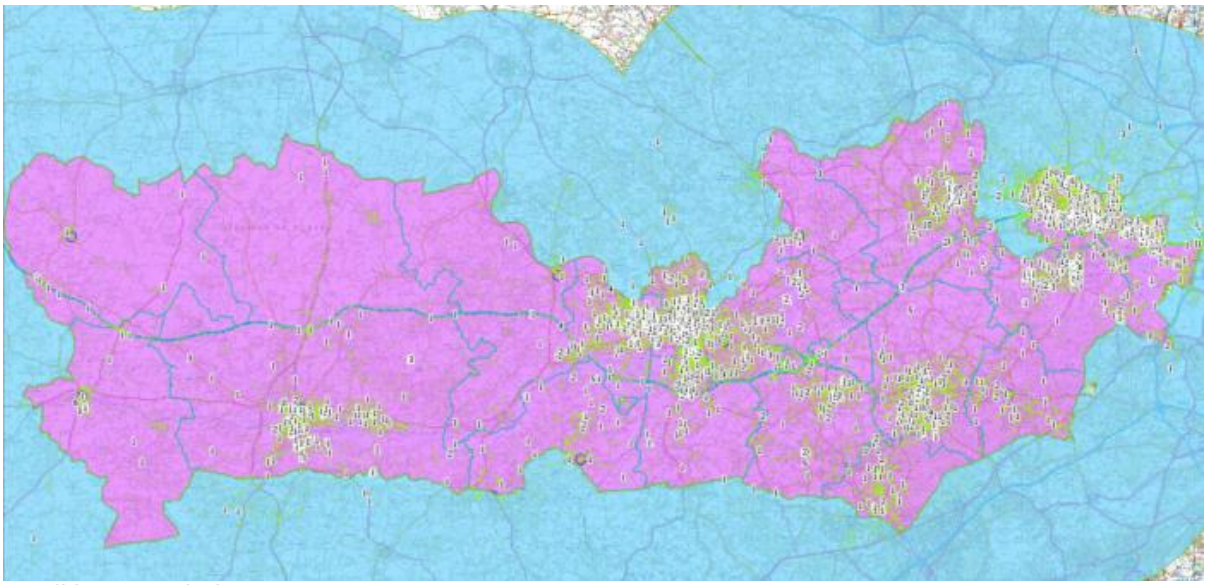


Societal Risk - Normal Distribution

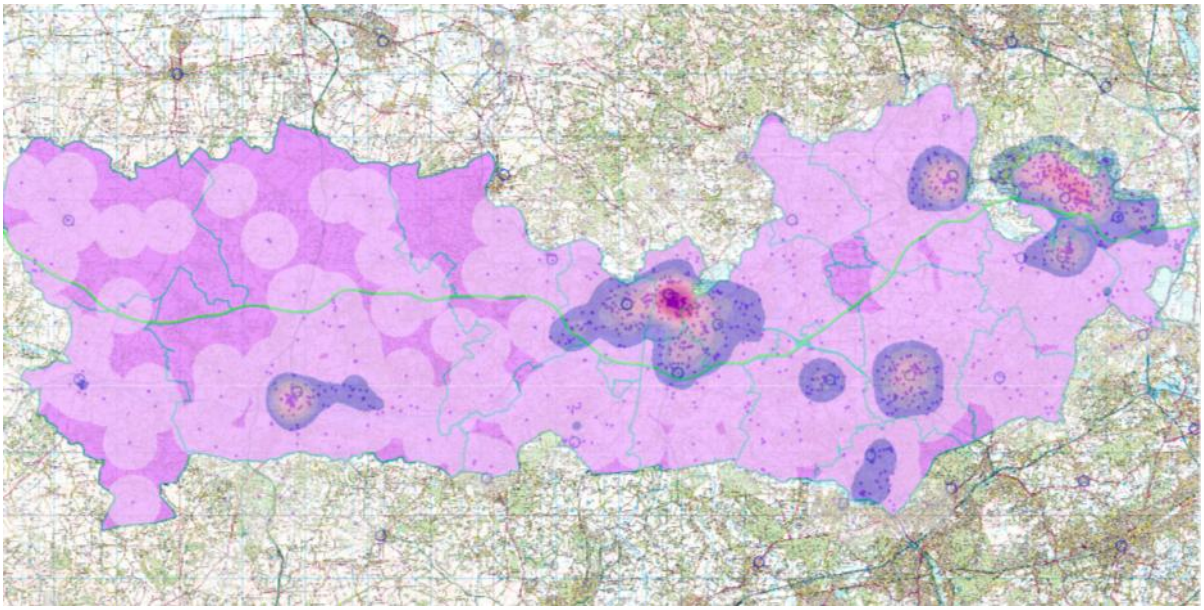


Total Risk - Normal Distribution

IIt is also possible to see the risk in different ways:



Fatalities recorded



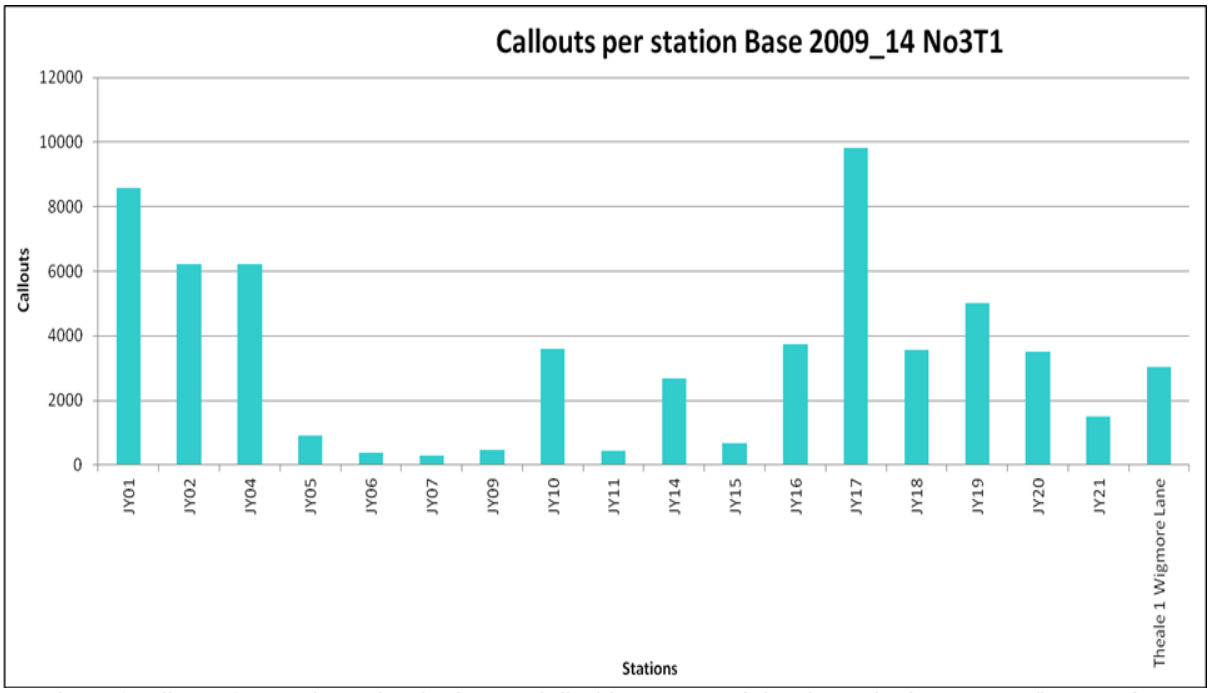
Incident Type Risk – Non-residential fires 'Hot spots'

Risk Modelling

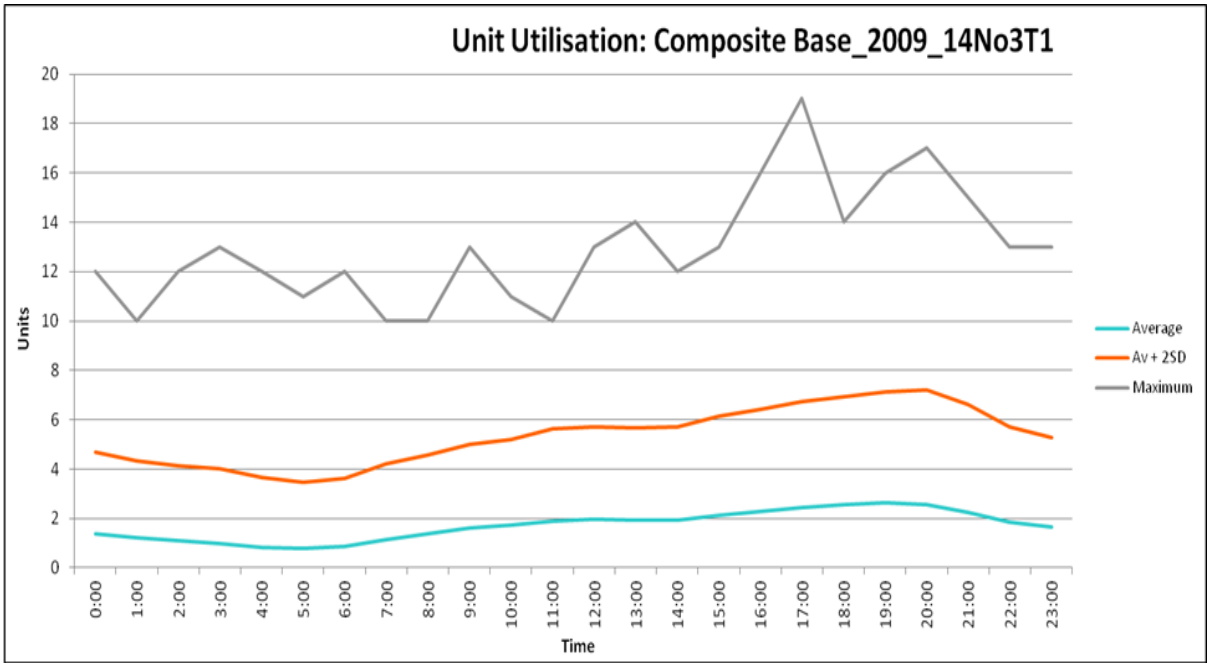
The second 'black box' is modelling (in Cadcorp Workload Modeller (CWM)). Modelling is used to consider resource location and redistribution in order to be efficient and cost effective. Cadcorp is a powerful modelling tool able to compare virtually limitless changes and options one against the other.

A limitation of Cadcorp is that it cannot generate a 'green-field' option. That is, for example, it will not answer the question: "We have 10 fire engines, where are the best locations in Berkshire?"

What Cadcorp can do efficiently, is compare a different location (or times, or crewing arrangement etc) against the current distribution of resources. It is only possible to give an indication of the output from the model as the variables are virtually limitless. Some examples are given below:(These must not be seen as possible future scenarios for RBFRS – just examples that were used to confirm the methods.)



Number of callouts for each station in the modelled base case (Theale replacing Dee Rd) 6 yrs data



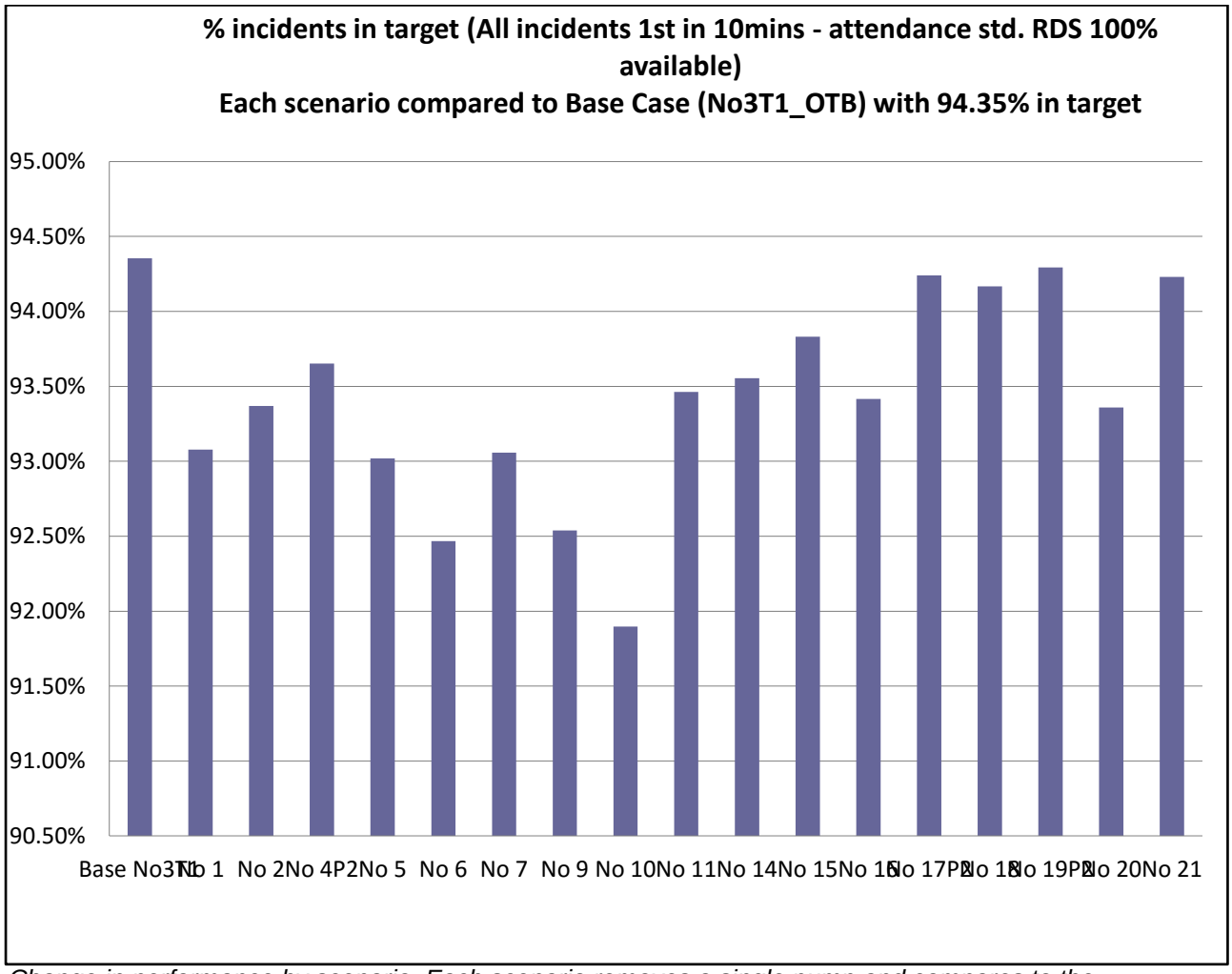
Pumps in use by hour of day in the modelled base case (Theale replacing Dee Rd) 6 yrs data

The ‘compare’ function in CWM allows a comparison across a number of scenarios. The table below is exported to Excel and shows worsening of performance of the scenarios relative to each other. This example removes one firenegine at a time:

Scenario	Description	Number of incidents no longer in target (1 in 10)	%incidents in target	% drop in target	Number of DWF and RTC Extrications no longer in target (1 in 10)
Base	Base No3T1	0	94.35%	0%	0
1	No 1	-544	93.08%	-1.28%	-54
2	No 2	-420	93.37%	-0.99%	-34
3	No 4P2	-299	93.65%	-0.70%	-29
4	No 5	-569	93.02%	-1.34%	-69
5	No 6	-804	92.47%	-1.89%	-83
6	No 7	-553	93.06%	-1.30%	-50
7	No 9	-774	92.54%	-1.82%	-64
8	No 10	-1047	91.90%	-2.46%	-92
9	No 11	-380	93.46%	-0.89%	-34
10	No 14	-341	93.55%	-0.80%	-26
11	No 15	-223	93.83%	-0.52%	-10
12	No 16	-400	93.42%	-0.94%	-38
13	No 17P2	-49	94.24%	-0.12%	-4
14	No 18	-80	94.17%	-0.19%	-6
15	No 19P2	-26	94.29%	-0.06%	-2
16	No 20	-424	93.36%	-1.00%	-46
17	No 21	-53	94.23%	-0.12%	-4

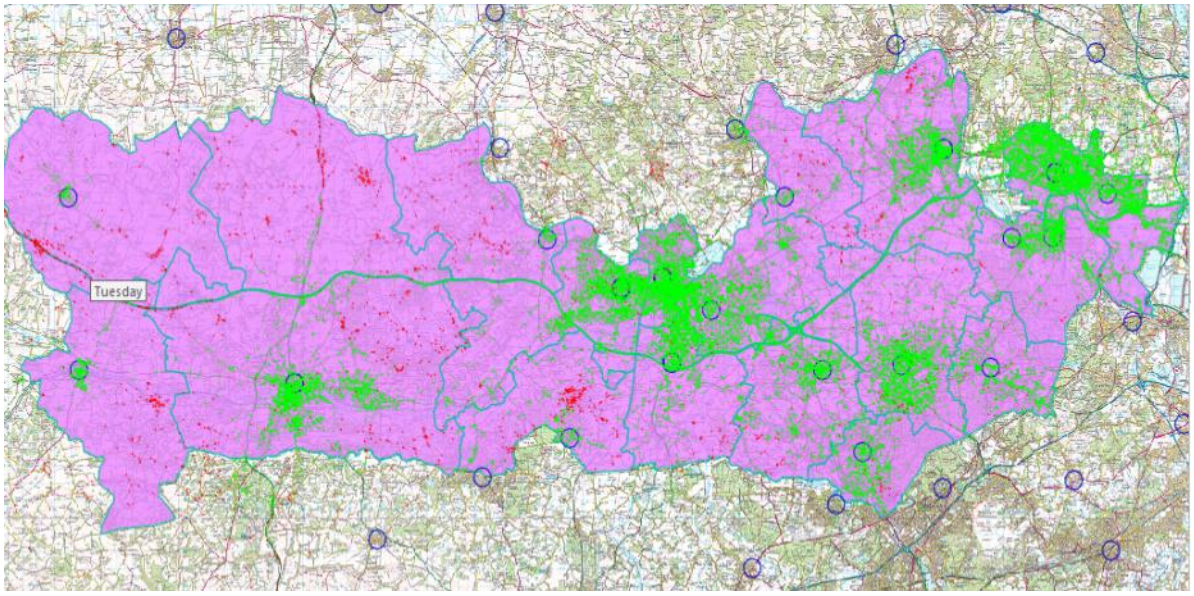
This illustrares that removing Station 21 reduces the number of dwelling fires and RTCs not attended within 10mins by 4 incidents (modelled across 6 yrs data). Whereas, removing Station 10 reduces these by 92.

The same data is represented as a graph below:



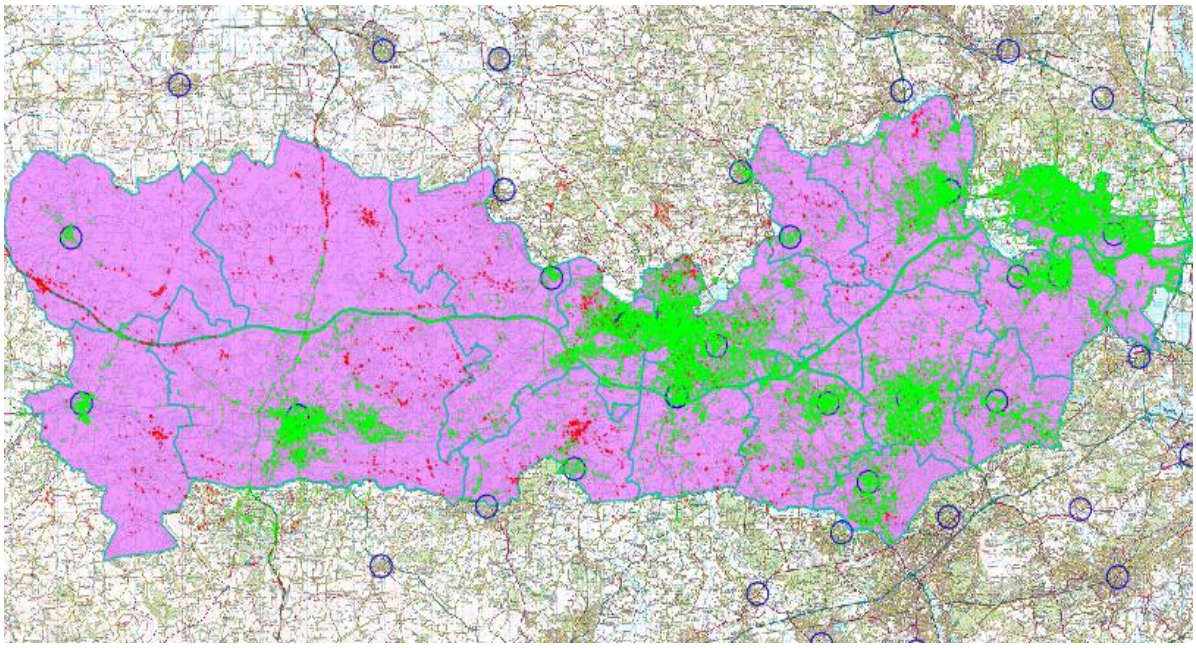
Change in performance by scenario. Each scenario removes a single pump and compares to the base case. (Theale replacing Dee Rd) 6 yrs data.

The data is also modelled onto a map:



Base Case Pass & Fails (1st in 10 attendance std) (No 3 - Theale 1. 6 yrs data)

The scenario comparison is also modelled (in this case, the removal of Station 1):



No 1 Pass & Fails (1st in 10 attendance std) (No 3 - Theale 1. 6 yrs data)

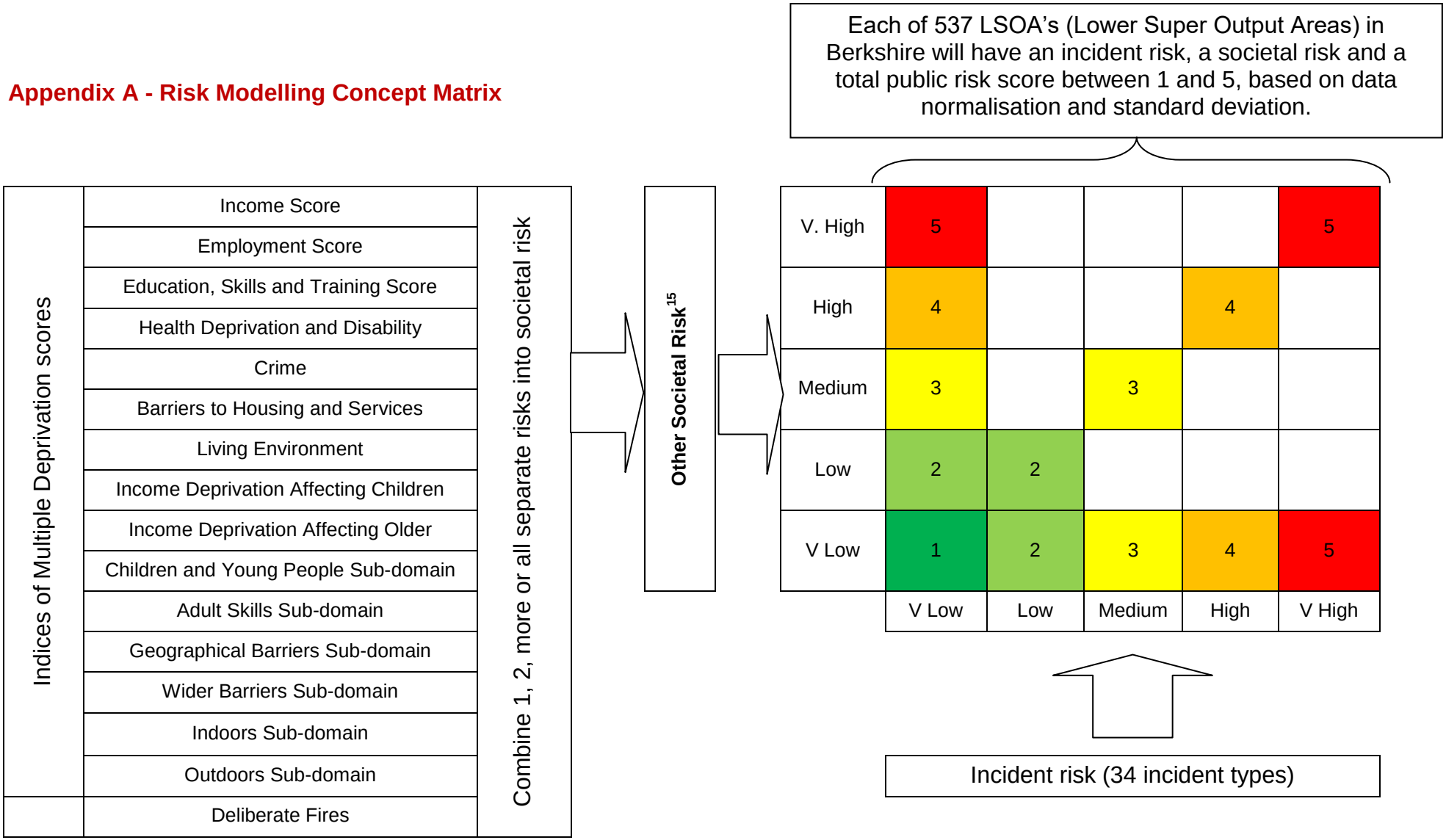
Whilst risk mapping is able to show all risks, it is probably fair to say that CWM concentrates on changes in performance by re-distribution of resources – primarily response resources. However, the mapping aspect allows a more focussed targeting of treatments across all of Prevention, Protection and Response.

Summary

An extensive methodology is described within this report and, even so, it is only possible to give an indication of the whole process. In brief:

1. Six years of rolling data is extracted from the mobilising system, including all rescues, casualties and fatalities.
2. The incident data is collated into 34 incident types.
3. An incident type severity is calculated.
4. Likelihood and severity are used to calculate incident risk by LSOA.
5. IMD data is combined with other societal risk data by LSOA (including weighting.)
6. Incident and Societal risk data may also be combined by LSOA (including weighting.)
7. Any risk or combination of risks may be ‘normalised’ by LSOA across any geographical range, up to all England (providing all England data is available - as it is for IMD.)
8. Cadcorp GIS is used to map any one, two, more or all *relative* risks by LSOA (also considering motorway LSOAs).
9. The risk maps may be used to target treatments.
10. Cadcorp Workload Modeller is used to model resource changes and the outputs are given by comparison (table, graph or map.)

Appendix A - Risk Modelling Concept Matrix



[15] Does not include Organisational Risk

Appendix B: List of incident types

- Chimney
- Fire
- FireAircraft
- FireBoat
- FireDwelling
- FireNonResidential
- FireOtherResidential
- FireOutdoor
- FireOutdoorStructure
- FireRailVehicle
- FireRoadVehicle
- Special Service (not RTC) Standby/no action/other
- Special Service (type not noted)
- Special Service Advice
- Special Service Animal
- Special Service Assist other agencies
- Special Service Effecting entry/exit
- Special Service Flooding
- Special Service Hazmat/Environment
- Special Service Lift release
- Special Service Making safe (not RTC)
- Special Service Medical (called as Ambulance)
- Special Service No action (not false alarm/service not req.)
- Special Service Other transport incident
- Special Service Removal of Objects
- Special Service Rescue/Release (not RTC)
- Special Service RTC Advice only
- Special Service RTC Extrication of person/s
- Special Service RTC Make safe
- Special Service RTC Medical only
- Special Service RTC Release of person/s
- Special Service RTC Standby/no action/other
- Special Service Suicide/threat/attempt
- Special Service Water (not flooding)

Appendix C: Societal risks

List of IMD risks

- Income Score
- Employment Score
- Education, Skills and Training Score
- Health Deprivation and Disability Score
- Crime Score
- Barriers to Housing and Services Score
- Living Environment Score
- Income Deprivation Affecting Children Index (IDACI) Score
- Income Deprivation Affecting Older People (IDAOPI) Score
- Children and Young People Sub-domain Score
- Adult Skills Sub-domain Score
- Geographical Barriers Sub-domain Score
- Wider Barriers Sub-domain Score
- Indoors Sub-domain Score
- Outdoors Sub-domain Score

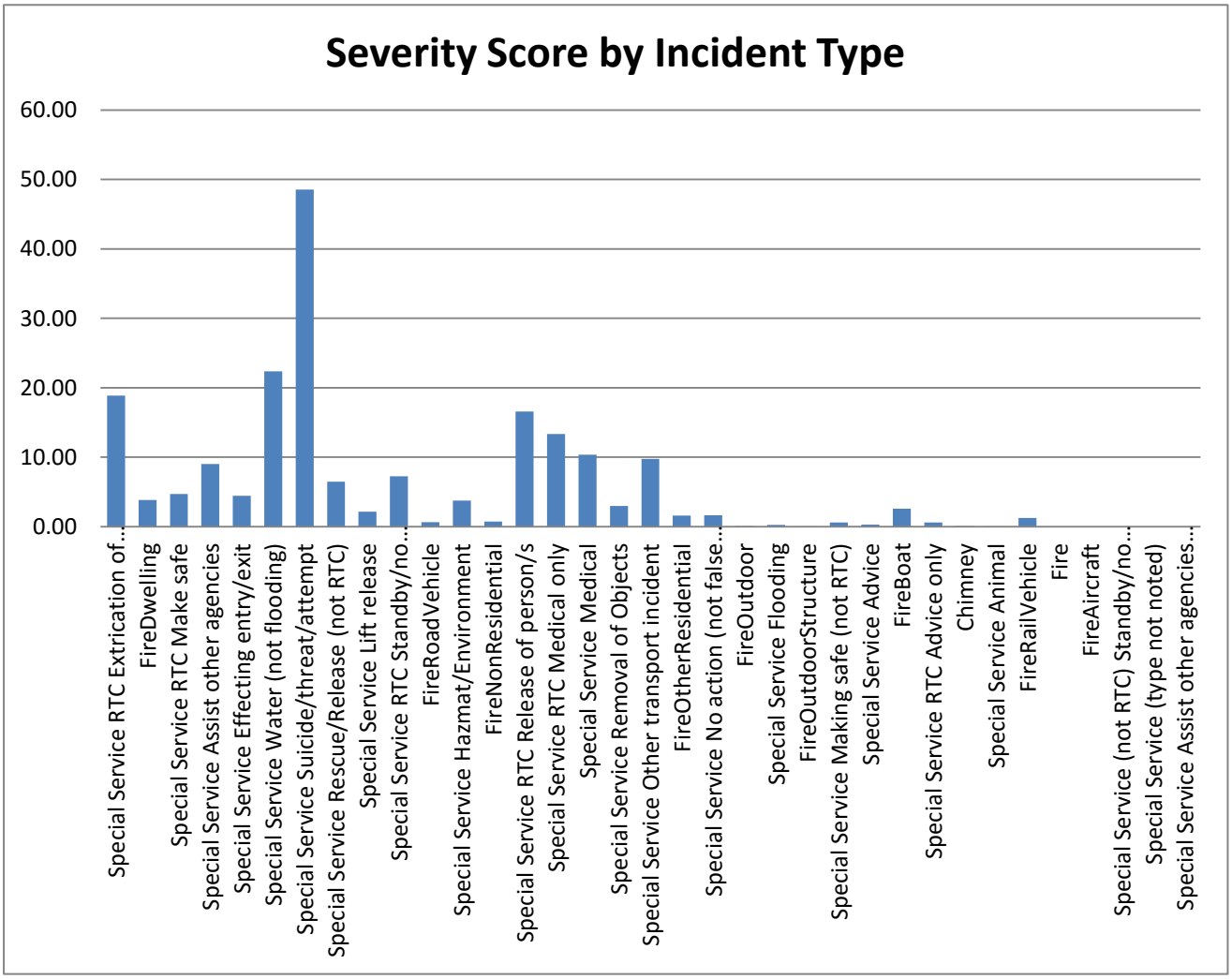
List of additional societal risks currently in the calculation

- Arson (Deliberate fire) data
- Non-residential building score (Protection score from IBIS)

List of societal risk data to be included – as and if data permits

- SaFer data
- False Alarms
- Smoking
- Alcohol related incidents
- Falls
- Mental Health

Appendix D: Incident Type Severity Score



Appendix E Berkshire public risk scores