

FIRE SERVICE RESOURCE PLANNING AND ALLOCATION

AN AUSTRALIAN PERSPECTIVE

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1. Introduction

Fire service resource planning is dominated by two factors, time and distance. All fire services operate in a spatial environment because their core emergency services are always delivered to a geographical point and, though we can't predict the exact circumstance of an individual incident, we can say that on most occasions the situation will get worse with the passage of time. The growing attention paid to the areas of prevention, preparation and recovery by fire departments has led to the introduction of a range of products that are not time critical but are still geographically based, usually within a station service delivery area. The location of fire stations is therefore the foundation of fire service delivery and a fundamental element of a risk management approach to emergency management.

The purpose of this paper is to describe how the New South Wales Fire Brigades developed a robust resource planning and allocation model using GIS as the underpinning technology.

1.1 Background - The NSW Fire Brigades

With its headquarters in Sydney, Australia, the New South Wales Fire Brigades (NSWFB) has 336 stations throughout the State of New South Wales. It employs 6500 career and part time firefighters serving a population of 6,300,000 across an area of 800,000 km². The organisation was founded in 1884 as the Metropolitan Fire Brigades when the Colonial Government amalgamated all existing volunteer, Insurance and Local Government brigades in Sydney under a Board of Fire Commissioners. This became the NSWFB in 1909 when the State Government extended this arrangement across the State. It is now a State Government department operating under the Fire Brigades Act and is responsible to the Minister for Emergency Services.

1.2 History

The existing fire station network in New South Wales was built over an extended period with some stations dating back to the 1880s. Some stations were located on the basis of how far a horse drawn appliance could travel in five minutes, some were located according to criteria adapted from Britain's Home Office model while others were located according to ad hoc planning. Most were designed and built to support firefighting equipment and staffing arrangements of another era.

There was rapid growth of new urban areas following the Second World War. Additionally many older areas underwent significant social, economic, commercial and environmental change. Throughout the 1960s, 70s, and 80s the NSWFB increasingly fell behind in terms of the number of fire stations, their location, firefighting equipment and staffing levels. Furthermore, research showed quite clearly that a greater risk to life exists in residential areas rather than commercial and industrial areas where previous planning had concentrated resources.

The development of a new approach to determining appropriate equipment and staff levels to accommodate these changes into the future was clearly needed. A research project was established in 1990 to develop a more systematic approach to the allocation of combat resources. The project consisted of a number of related elements that have been brought together to provide a comprehensive planning model for the delivery of services. The first step involved more fully identifying the problems inherent in the current spatial distribution of fire stations and crewing compositions.

The second step involved collecting and analysing demographic data; infrastructure development data, incident response data and many other forms of information. The third step involved exploring several options before developing the most cost-effective solution based on a strategic approach to fire service planning.

One element developed was referred to as the Standards of Fire Cover methodology, which evolved into the Station Location Module described later in this paper. The methodology was based on the relationship between time, distance, fire behaviour, and potential hazard and incorporated the outcomes of research conducted in Australia and overseas. This approach provided a solution to locating fire stations that assures an equitable distribution within an integrated strategic network.

The underpinning research methodology is based on a critical period of time beyond which fire behaviour becomes more serious, and beyond which the potential for saving life, reducing injury, reducing property damage and protecting the natural environment, rapidly diminishes.

Another key element was the Hazard Categorisation Project. This focused on assessments of structural fire hazard for the purpose of defining crew and vehicle configurations at fire stations.

1.3 Current Position

The NSWFB Operations Research Unit (ORU) is conducting ongoing research and development of these projects. The integration of previous research with outputs from a number of recent risk-based assessment projects has resulted in a practical and adaptable resource allocation methodology termed the Fire Service Resource Allocation Model (FSRAM), which is suitable for the operating environment of the NSWFB. This model utilises quantitative assessments of hazard, population and emergency call levels as well as qualitative assessments of risk related factors, to produce a comparative model for the allocation of resources and the delivery of service outcomes attuned to community expectations and aligned to Government policy.

The model should be seen as a consistent and comprehensive **guide** to resource allocation, rather than being the ultimate answer in itself. As such the model provides NSWFB Management the opportunity to incorporate local considerations within a standard organisation-wide resourcing framework.

2. FSRAM Purpose

FSRAM is a planning model that provides a systematic and comprehensive guide to all levels of management regarding the allocation of NSWFB combat resources across the state. Key features of the model include the following:

- Integrates research from a number of contemporary risk-based projects into a single comprehensive planning model.
- Clarifies the role of this model as a resource planning and allocation tool and not an incident response standard.
- Provides a functional and clear methodology that can be easily understood by stakeholders, particularly staff, governments and local communities.
- Utilises comparative data to ensure equity and consistency in resource allocations.
- The model is flexible enough to allow for the incorporation of future evolutionary refinements.
- Flexibility, enabling appropriate input from local staff to account for localised variables.
- Provides the potential for a standardised resourcing methodology which is applicable across the range of environments in NSW including rural, bushland, the urban interface and urban areas. At this time the focus has been on urban and urban interface areas.

2.1 FSRAM Scope and Limitations

FSRAM is aimed specifically at providing guidance in the allocation of appropriate Fire Brigade resources, directly for suppression activities and indirectly for prevention, education and mitigation activities.

Some highly specialised resources including BA (Breathing Apparatus) Units are currently not within the scope of FSRAM. In addition, the distribution and placement of NSWFB Rescue Units, is the

responsibility of the State Rescue Board and not the NSWFB. The allocation of the following resources is within the scope of the FSRAM:

- Permanent firefighter crewing
- Part time firefighter crewing
- Mixed crewing configurations
- Fire stations and locations
- Types 1 - 5 Urban Pumpers
- Minor and major aerial appliances
- HazMat appliances

2.2 FSRAM Structure

The FSRAM is structured around the concept of resources having both static (fire station) and dynamic (staff and vehicle) components, both of which can be utilised (with specific programs) to deliver prevention, mitigation and community safety outcomes, as well as suppression activities. FSRAM consists of a number of separate but related modules which come together to form a single comprehensive planning model. These modules are:

- Station Location Module } the static resource component of the Model.
- Crew Configuration Module }
- Pumper Allocation Module } the dynamic resource
- Hazmat Allocation Module } components of the Model.
- Aerial Allocation Module }

Currently, work is continuing on some of these resourcing modules and the results of this research will be progressively built into the Model.

There is an interactive relationship between the Station Location Module and the other modules in that, the position/location of the station will have a direct bearing on its service footprint or service area. This will affect the station “catchment area” for defining hazard, population and other inputs to FSRAM, which in turn will influence the resource recommendation.

2.3 Station Location Module

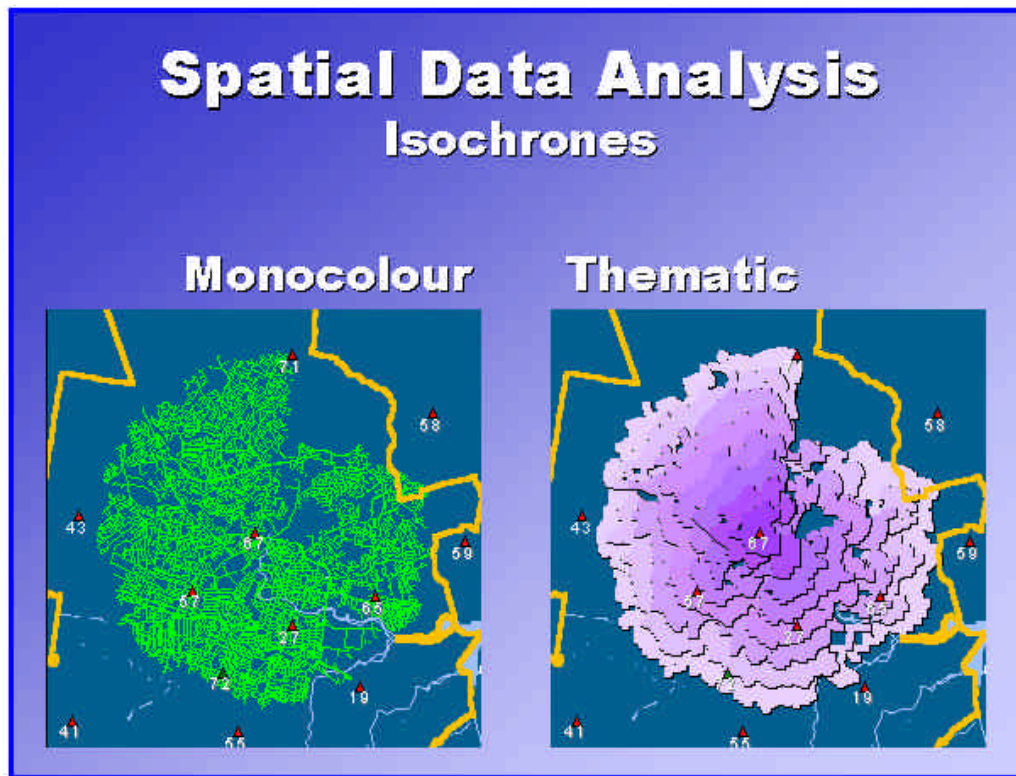
The Station Location Module addresses the static component of resource allocation. It is used to define the optimum location for siting fire stations to ensure an appropriate network and service footprint is provided to the community. It is based on the principles and outcomes of the initial Standards of Fire Cover project and related research carried out subsequently by the NSWFB.

Key elements of the Station Location Module include:

- the objective to provide an integrated station network and appropriate service footprint,
- the location of fire stations is determined on the basis of distance as it relates to response time,
- the assumption of a crew size of at least four firefighters on each pumper, and
- the critical timeframe of 7 to 8 minutes from time of call, which is shown by NSWFB statistical data to result in confinement of fire to the room of origin on 90% of occasions at dwelling fires, is adopted as the nominal response time for planning purposes.

GIS analysis with computer generated isochrones (Refer Diagram 1.) is used in determining the optimum location for stations. This makes service gaps and overlaps clearly apparent. Different travel speeds, the nature of the area are used in generating response isochrones.

DIAGRAM 1. – RESPONSE ISOCHRONES



3. Hazard Categorisation Project

This model is used by NSW Fire Brigades to classify Hazard levels according to level and type of structural development across urban areas of NSW. A summary of Hazard Categories is included at Table 1.

Maps of urban areas are divided into 500m x 500m grid squares aligned to the Australian Map Grid (AGD66) for the purpose of classification. Grid squares were chosen as the base unit because they are consistent in size and can be identified in a standard Street directory by all members of the organisation. The same level of examination is possible across all urban areas of NSW by using grid squares rather than variable size regions such as census collection districts or suburbs.

Hazard categorisation was originally done by a street-by-street drive-by of the target area and by consulting the local Station Officer. Input by the local fire station crew was added to that collected by the drive-by. This process is now being supported by the use of high-resolution aerial photography and satellite imagery. These show the density of structural development and the type of land use – whether it is residential, commercial or industrial. It can also be used to identify significant features such as static water supplies.

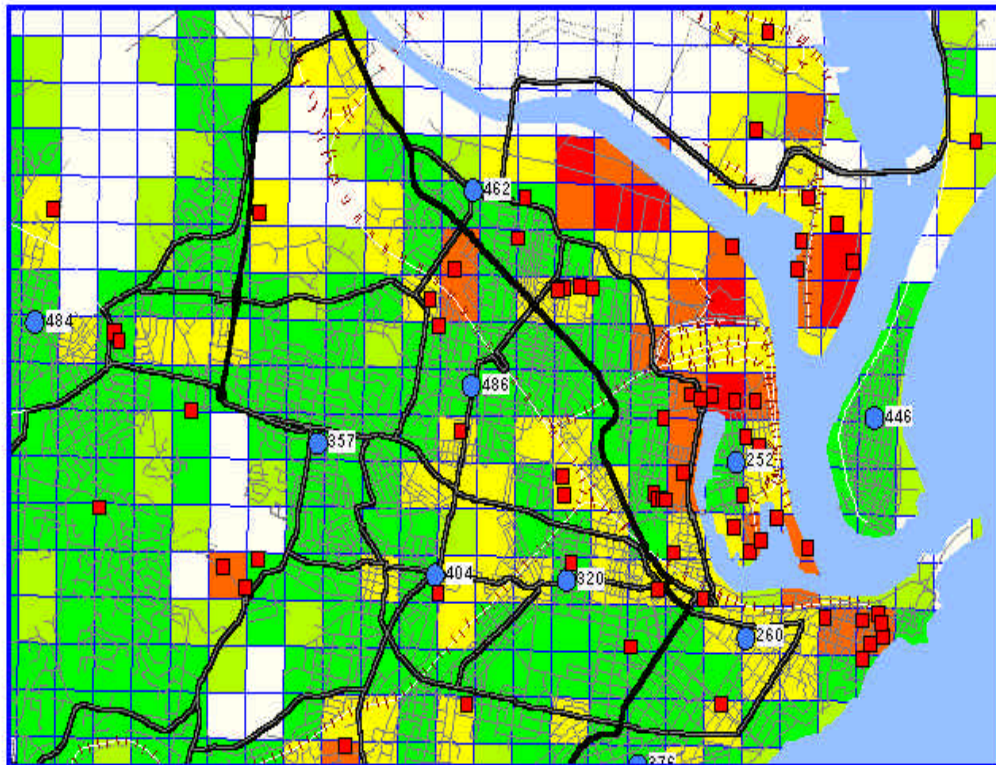
The greatest aid to continuous, close to real time hazard categorisation would be access to the many relevant data sets maintained by departments of State and Local Government. This is being pursued both by seeking individual arrangements with some information custodians and through membership of “Whole of Government” information management committees.

TABLE 1. – HAZARD CATEGORISATION SUMMARY

General Hazard Level	Specific Hazard Category	Map Colour code	Brief Description of Hazard Category
Special Hazard	Category 1	Red	A site that poses extreme hazards for people property or environment, eg some hospitals and aged hostels, major LPG depots, chemical plants, oil refineries etc.
Intermediate Hazard	Category 2	Orange	May include some high hazard residential – but basically high hazard industrial/commercial occupancies with a high level of structural density within USS
	Category 3	Yellow	May include some high hazard residential – but basically high hazard industrial/commercial occupancies with a low/moderate level of structural density in USS
Low Hazard	Category 4	Dark Green	A fully developed area of residential and low hazard industrial/commercial occupancies
	Category 5	Light Green	A partially developed area of residential and low hazard industrial/commercial occupancies

USS – refers to a Unit Survey Square. A USS measure 500m by 500m and is the base unit of Hazard assessment as represented in the Hazard Profile Map Grid Pattern.

DIAGRAM 2. HAZARD CATEGORISATION OF NEWCASTLE URBAN CENTRE



4. Crew Configuration Module

FSRAM is used to provide guidance regarding the staffing type that is most appropriate for different stations. In NSW, this could be one of the following:

- Part time (retained) firefighters only
- A combination of permanent and part time staff in a number of different configurations, or
- Permanent firefighters available 24 hours every day.

NSWFB stations provide service to a wide range of urban communities which vary in size from towns of about one thousand people up to major cities.

Key elements of the crew configuration include:

- Consideration of a number of different factors such as the level of emergency calls, the population and the level and type of structural development within the service area,
- The level of emergency calls within the service area is determined using historical data collected through the Australian Incident Reporting System (AIRS), or in the case of new areas without a recorded incident history, through the application of a proxy figure from a similar area,
- The population within the service area is derived from Census data collected by the Australian Bureau of Statistics,
- The capacity of the crew configuration to effectively participate in prevention, preparation, education and mitigation activities, in line with community safety objectives and local needs,
- Population and level of emergency calls trends (decline, static, growth),
- The impact of special service roles on crew configurations,
- The capacity of the crew configuration to effectively meet service targets/guarantees with regard to service barriers such as natural landforms and the size of the area covered, and
- Pressures on the retained staff system and on individual retained members of meeting increasing corporate demands in regard to training, administration, prevention work and daytime response.

5. Pumper Allocation Module

To meet its operational needs the NSWFB requires a range of vehicles that are designed and constructed to meet a variety of operational tasks, working environments and financial constraints. The general concept is an urban type pumper that is generic in nature and is cost effective. Design and performance is tailored to an identified risk and end-use application. A system of classifying Urban Pumpers from Type 1 to 5 has been developed in order to facilitate this.

Pump performance is linked to the type classification and is a logical increment from lowest to highest (1 - 5):

- Type 1 Urban Pumper - (Composite)
- Type 2 Urban Pumper - (Town)
- Type 3 Urban Pumper - (Regional)
- Type 4 Urban Pumper - (Metropolitan)
- Type 5 Urban Pumper - (Super Pumper)

The Type 1 Urban Pumper is suitable as a secondary appliance providing fire cover, primary rescue or HazMat intermediate services and to serve as the primary pumper in towns which:

- are characterised by structures of 1 or 2 storeys
- have a population of up to 1500 people
- have a level of emergency calls of up to 60 responses per year. (averaged over 3 years), and
- have urban/bush interface risks.

The Type 2 Urban Pumper is suitable as a secondary appliance in regional/metropolitan centres and to serve as the primary pumper in towns which:

- are characterised by structures of 1-2 storeys
- have a population of 1,300 to 18,000 people (the overlap with Type 1 is deliberate), and
- have a level of emergency calls of up to 550 responses per year. (averaged over 3 years).

The Type 3 Urban Pumper is suitable to serve as the primary pumper in regional centres or within metropolitan areas which:

- are characterised by structures of up to 3 storeys
- a population of more than 18,000 people, and
- a level of emergency calls of up to 1,000 responses per year. (averaged over 3 years).

The Type 4 Urban Pumper is suitable to serve as the primary pumper in metropolitan areas or large regional centres that display:

- > 3 storey structures,
- a population of more than 18,000 people, and
- a level of emergency calls of more than 900 responses per year. (averaged over 3 years).

Type 5 Urban Pumps will be strategically located to provide major water supplies to aerial appliances in metropolitan areas and to provide a major pumping capability for high rise, major industrial and chemical complexes or in areas of “special” risk.

6. Aerial Allocation Module

Aerial appliances are separated into two broad groupings. The term ‘Minor Aerial’ refers to Aerial Pumps, while the term ‘Major Aerial’ refers to Turntable Ladders and Hydraulic Platform type vehicles.

In developing a methodology for locating major and minor aerial appliances the following factors are used as inputs to a systematic approach to assessment and to provide a consistent guide to allocation:

- The ability to use these appliances as a common resource to service a number of adjoining station areas.
- An areas proximity to or isolation from (in terms of response time), the operational support of aerial appliances in adjoining locations.
- The population of an area as an indicator of industrial and commercial development.
- The structural fire hazards present in the area, and
- A risk assessment for the area based upon incident history.

Census data provides an aggregated assessment of the location of medium and high rise residential development while industrial/commercial areas are identified through data obtained from the NSW Department of Urban Affairs and Planning, other State Government agencies and Local Councils. Real estate agents are good sources on information on the rate at which approved development is actually occurring. All of this information is displayed spatially using a GIS and then linked to response isochrone analysis to define the distribution of aerial appliances.

7. HazMat Allocation Module

HazMat resources are allocated on the basis of a three tiered approach, which ranges from a basic capability (most stations), an Intermediate Support capability (10 stations) and a highly Specialist capability (3 stations).

The determination of each stations HazMat status within this three category system is influenced by:

- analysis of the history of hazMat incidents in NSW,
- the proximity of the station to major road and rail routes,
- the proximity of the station to major dangerous goods manufacturing, storage or transfer sites, and
- the strategic state-wide placement of Intermediate HazMat stations (providing high level support) within approximately 1 hour response of stations with a basic capability.

8. Economic Appraisal

To improve public sector resource allocation, the NSW Government decided in December 1998 that economic appraisal techniques should be applied to all capital works proposals. Consequently, before each proposed new fire station is finally approved, it is subjected to the rigorous examination of an Economic Appraisal, which must show a net benefit to the community.

Economic appraisal is a way of systematically analysing all the costs and benefits associated with the various ways of meeting an objective. An important feature of an economic appraisal is that various methods of achieving the stated objective are assessed.

The conduct of the economic appraisal requires that only the incremental costs and benefits of the 'do something' options, in comparison with the 'do nothing' (continue as is) situation, should be incorporated into the economic appraisal. That is, the 'do nothing' situation is the benchmark against which the fire station development scenario or any other options, which might be identified as part of economic appraisal, are compared.

With an improved spatial location of fire stations, incident response efficiency can be expected to improve with a resultant reduction in losses by the community. These reductions will have a number of environmental and social benefits and are the subject of post implementation assessments.

9. Future FSRAM Directions

9.1 Risk Management Needs

The history of incidents in a given area is an indicator of likelihood in relation to the level and type of incidents that area will experience in the future, provided other factors remain stable. A spatial dataset of 1.3 million incidents attended by the NSWFB since July 1987 (AIRS) is used as the source data to spatially analyse likelihood. The density of incidents within a boundary is a significant measure of likelihood when comparing unequal size areas.

NSWFB has used data from the Australian Bureau of Statistics 1996 Census to spatially analyse community vulnerability by concentrating on the following vulnerable demographic groups;

- indigenous and non english speaking background populations
- children and the elderly
- the unemployed
- populations living in public housing
- low income populations

By spatially comparing hazard, likelihood and vulnerability, the fire service needs of many areas can be compared with one another. The fire service needs of one area is a relative measure based purely on the comparison with other areas.

While a spatial analysis of hazard likelihood and vulnerability does not identify the fire service risk management solutions for each area, it does provide a consistent way to analyse the needs of each area and generated additional information by examining the relationships between hazard likelihood and vulnerability. This framework can be used to support decision making about program budgets and staff configuration, including the skills and attributes that might be required.

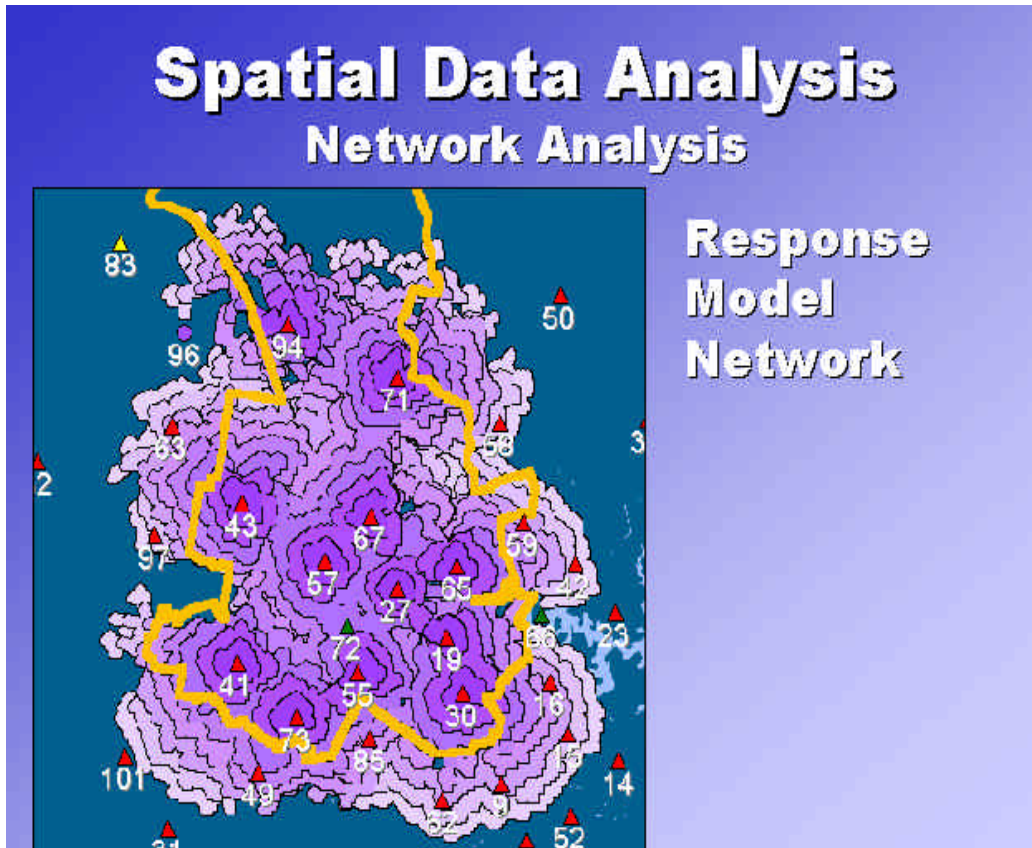
The attainment of service delivery outcomes and the allocation of resources will continue to be influenced by a number of important factors such as:

- The operating environment of the NSWFB
- Political considerations (at both State and Local levels)
- Consideration of current staffing situation,
- Community expectations and beliefs,
- Industrial considerations, and
- Cost/Benefit considerations (cost efficiencies and service effectiveness).

The Model is under constant review and subject to continuous improvement. The goal is to maintain a systematic, equity based approach to resource planning and allocation for areas of comparable community profiles.

It is envisaged that future improvements to assessing risk levels in different communities and understanding each community's vulnerability will see the emergence of a need to supplement some current processes.

DIAGRAM 3. Network Analysis.



9.2 Network Model

An isochrone model has been developed which shows the modelled response capabilities of all stations in the NSWFB network.

This is used to improve understanding of how proposed changes to the network of stations will affect the level of fire service provided. The use of this model allows NSWFB to examine the effectiveness of its station network with changes to station locations and staffing configurations by incorporating the response capabilities of permanent crew and retained crew stations in the model.

We believe this work will also be important in a current project to better understand surge and sustainment during large protracted incidents, such as the 1999 Sydney hailstorm that damaged 20,000 homes or the 2001/02 bushfires.

9.3 Station Impact Model

The station impact model is being developed specifically to examine and predict what the impact of one fire station in a network has on the responses of surrounding fire stations. It involves the spatial analysis of the changes to the responses of stations around an area where the station network has been modified. The model uses response time data from the AIRS database as its source.

10. Program Summary

The application of the methodology has underpinned the development of a number of strategic programs. These programs have received broad Government and stakeholder support that involved extensive consultation and explanation of the methodology.

As a result of the application of this methodology, the NSW Government has made the following changes to resources across the State since 1993;

- a total of 24 new fire stations have been built,
- 11 stations have closed,
- 3 are under construction,
- 21 more are planned including 11 relocations,
- staffing has been upgraded at 14 locations,
- staffing has been downgraded at 4 locations and
- a substantial upgrading of the appliance fleet has begun.

11. Conclusion

The success of the FSRAM has involved a number of critical factors. Certainly the methodology itself must be sound but it must also be easily understood. Regardless of the complexities underpinning the model, it is essential that the concepts are simple and intuitive. For the model to be successful a wide range of people who have no expertise in fire and emergency management, including politicians, union officials, treasury officials and community organisations, must accept it. Inevitably not everyone will agree with all of the changes indicated by the model but a substantial majority must accept it as a valid and impartial approach or it will never be applied and implemented.

This acceptance starts within the fire service. The community must see that the concept they are being asked to accept is unanimously supported and advocated by their fire service's leadership. It then requires constant marketing at every opportunity and an extensive process of consultation with affected parties.

After a decade of experience the NSWFB perspective on fire service resource planning and allocation is that it is at least as much about understanding people and good leadership as it is about good science.

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