TOPIC FOUR - FIRE SUPPRESSION RURAL

CONTENTS

Section 1	Wildfires	1-1
2	Fire Fighting Procedures	2-1
3	Hazard Reduction	3-1
4	Map Reading	4-1
5	Chainsaw and Associated Equipment	5-1

SECTION ONE - WILDFIRES

CONTENTS

Section 1	Wildfires	1
1.1	Introduction	1
1.2	Policies and Responsibilities	1
1.3	Types and Parts of Wildfires	3
1.4	Causes of Wildfires	5
1.5	Combustion	6
1.6	Heat Transfer and Fire Spread	6
1.7	Wildfire Behaviour	6
1.8	Fire Danger Index	12
Section 1	Illustrations	
Fig 1.1	Ground Fire	3
1.2	Surface Fire	3
1.3	Crown Fire	4
1.4	Parts of a Wildfire	5
1.5	Combustion Triangle	6
1.6	Effect of Uphill Slope	6
1.7	An Example of the BKDI for NSW	8
1.8	Visual Indicators of Stability	11
1.9	Night Inversion	11
1.10	Forest Fire Danger Meter MkV	14
1.11	Grassland Fire Danger Meter MkIV	15
Section 1	Tables	
1A	Variations in Rate of Spread	12
1B	Forest Fire Danger Index	13
1C	Example of Probable Fire Behaviour	13

1 WILDFIRES

1.1 Introduction

Although the NSWFB primary role is focused upon urban area of the state, many people are surprised to find out that statistically, bush and grass fires (commonly known as wildfires), are the most numerous type of fires attended. An examination of major wildfires over the past century reveals that the vast majority of death and destruction caused by wildfires occurs at the *urban/bushland interface* within Fire Districts (e.g. Blue Mountains 1957, 1968, 1977, 1994; Warringah/Pittwater 1979, 1994; Hornsby/Kurringai 1968, 1975, 1994; Sutherland 1968, 1994)

For this reason, the NSWFB devotes a large proportion of it's training and resources to wildfire control, and to co-operation with the various other authorities involved, particularly the Rural Fire Service (RFS) and Volunteer Bushfire Brigades.

The nature of the wildfire threat in NSW makes it impracticable for any authority to cope alone on the periodic occasions that major wildfires occur. Co-operation and mutual respect for each services' capabilities are the key to successful operations and minimisation of death, injury and damage.

1.2 Policies and Responsibilities

1.2.1 Wildfire Control Responsibilities in NSW

The NSWFB is the combat agency for wildfires occurring within Fire Districts, and has the legislative authority to operate outside Fire Districts. The major focus of the NSWFB is wildfire control in the urban/bush land interface, where life and property are most at risk. The NSWFB provides direct protection to over 90% of the NSW population and property valued at over $1200 billion.

Outside Fire Districts, Volunteer Bushfire Brigades operated by Local Government cover large areas of the State. RFS provides guidance and advice to Councils on operational, planning, and financial issues affecting bushfire brigades, and administers the Bushfire Fighting Fund established by the State Government.

Other organisations which have a major input into wildfire control are the National Parks and Wildfire Service (NPWS), and State Forests of NSW.

1.2.2 Rural Fire Service

The Rural Fire Service (RFS) is a State Government Department which has the duty of advising the Minister on matters relating to wildfire control, administering the bushfire fund, and co-ordinating services to bushfire brigades. Although the RFS is not a Combat Agency, it provides support to major fire fighting operations by co-ordinating assisting agencies and fire fighting support through its State Operations Centre in Sydney and Regional Co-ordinators.

The Commissioner of RBS has a dual role as head of the Department, and as Chief Co-ordinator of Bushfire Fighting (See *S.41F* of the *Bushfires Act*). The Chief Co-ordinator delegates emergency co-ordination powers to local officers during major wildfires.

The *Bushfires Act 1949* is the principal piece of Legislation relating to wildfire control, and includes the powers, duties and authorities of bushfire brigades and their officers, fire prevention requirements including the statutory bushfire danger period, declaration of Total Fire Bans, and co-ordination measures for major fires (*S.17* and *S.41F*).

Due to the many different organisations with roles in wildfire control, *S.41A* of the *Bushfires Act* provides for planning processes through District Bushfire Management Committees. The committees, formed on a local government area basis, include representatives from local emergency services, support services, land management authorities, and local councils. They provide a forum for the formulation of local plans for major wildfire fighting operations, and fuel management (hazard reduction). The NSWFB is represented on District Bushfire Management Committees in most areas of the State.

The Executive of each Committee comprises the senior local representatives of the four fire fighting authorities (NSWFB, Bushfire Brigades, NPWS, State Forests). When major wildfires occur, the Executive meets and continually monitors the situation. Should the fire escalate to the point where local fire fighting agencies are overwhelmed, the Executive may recommend to the Chief Co-ordinator that an appointment be made under *S.41F* of the *Act* (in western areas, the Mayor appoints a Controller under *S.17* of the *Act*).

1.2.3 Role of the NSWFB Rescue/ Bushfire Section

The NSWFB Rescue/Bushfire Section's role has three components.

- Policy;
- Administration; and
- Training

The Rescue/Bushfire Section is located at Amarina Avenue, Greenacre, and its main responsibilities are to:

- advise the Commissioner on wildfire policy and other matters;
- assess the current and anticipated likelihood of extreme wildfire danger occurring and co-ordinate NSWFB strategies to maintain operational readiness to combat wildfires; and
- identify wildfire hazards within Fire Districts and co-ordinate the work necessary to remove those hazards in accordance with the principles set out in the NSWFB publication *Hazard Reduction for the Protection of Buildings in Bushland Areas*;
- train personnel in the use of wildfire fighting equipment, i.e. water tankers, chainsaws, portable pumps, knapsacks;
- train personnel in suppression tactics, safety and various other aspects of bushfire control work;
- monitor and advise on the requirements for wildfire fighting equipment for the NSWFB throughout the state;
- attend Regional Fire Association meetings; and
- attend the State fire Command Centre on Total Ban/Bushfire Alert Days (Sydney Region) to monitor the progress of wildfires and the need for co-ordination requirements.

1.2.4 Bushfire Alert

Bushfire Alerts are declared on days of Very High to Extreme Fire Danger. Fire fighting authorities move to a higher level of operational readiness during a Bushfire Alert, to ensure rapid response to reported fires e.g. Volunteer Bushfire Brigades may staff Control Centres, lookout towers, and stations during Stage 2 Bushfire Alert. The NSWFB cancels any activities which may delay response, and places senior officers on alert to act as Incident Controllers. Reserve appliances may be staffed and deployed strategically.

1.2.5 Fire Classifications

Class 1: A fire, or call to a fire, where action is being taken by the responsible fire authority.

Class 2: A fire where action is being taken by the responsible fire authority and where assistance from other authorities though not normally required, is being given due to the location of the fire or other circumstances.

Class 3: A fire where action is being taken of necessity by two fire authorities or more under locally organised arrangements, one or more of the fire authorities in attendance having a substantial resource commitment.

Class 4: A potentially major wildfire situation where local resources are committed, and outside assistance must be used.

Class 5: A major wildfire or fire where a *Section 17* or *41F* appointment has been made, or is imminent.

⚠ **NOTE**

It is the responsibility of the NSWFB Incident Controller to classify wildfires burning within Fire Districts. On reaching Class 3, the NSWFB representative on the District Bushfire Management Committee Executive (usually the Zone Commander), must be informed and will usually respond to the nominated Bushfire Control Centre.

1.3 Types and Parts of Wildfires

Wildfire is a general or generic term. They may be described more specifically as forest, **scrub** or **grass fires**, depending on the vegetation types in which they burn.

Wildfires can be fires burning in the open air in living or dead vegetation in such a way as to pose an actual or potential threat to natural resources or property and life. Not all fires that burn in the open air are wildfires. Controlled fire can be used in accordance with appropriate legal requirements for many useful purposes, e.g. clearing land, hazard reduction and providing fire-breaks. Only if they escape from control can they be designated as wildfires.

In districts between the coast and the Dividing Range, areas of grassland are usually limited in size. The majority of wildfires in this region are forest or scrub fires with an occasional grass fire component.

Wildfires of various sizes can be described as **ground, surface** or **crown fires** (see Fig 1.1 to Fig 1.3 inclusive).

The term **ground fire** refers to fires slowly burning or smouldering below the surface of the terrain in thick layers of vegetation such as peat. These are rare in Australia.

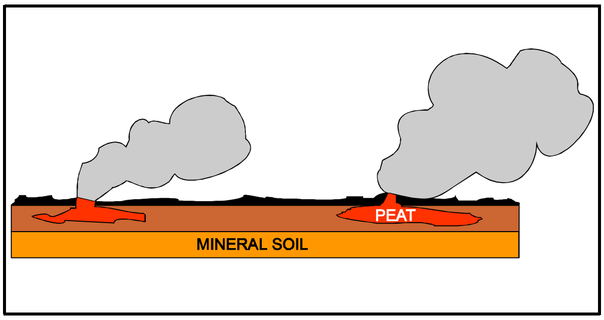

Fig 1.1 Ground Fire

The term **surface fire** embraces all true fires and also forest fires when fuel consumption is confined to surface fuels and scrubs or other lower storey vegetation. Although the crown of trees are not consumed they may be so scorched by heat that the leaves subsequently wither, turn brown and fall.

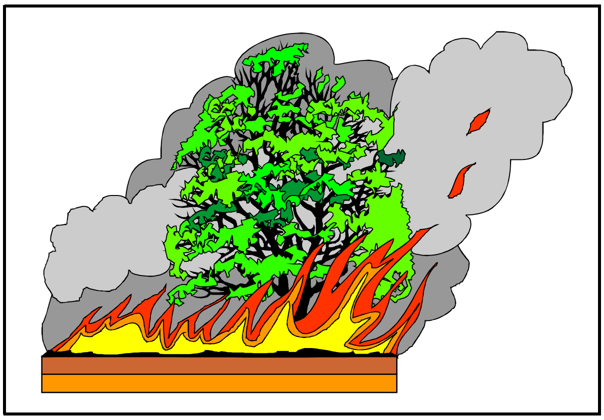

Fig 1.2 Surface Fire

Crown fires occur when the burning of surface and lower storey vegetation in forest areas produces flames of sufficient height or heat of sufficient intensity to ignite the foliage in the crowns of trees.

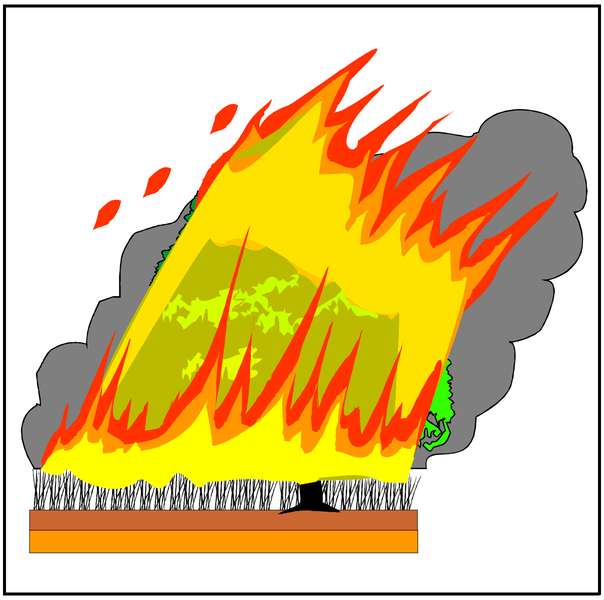

Fig 1.3 Crown Fire

Spot fire is another term of great importance in Australia. Spot fires occur when sparks or pieces of burning or smouldering material are projected beyond the perimeter of a bushfire and start new fires. Knowledge of the extent to which spotting is taking place or could take place is vital. The range is enormous and can vary from a few metres in the case of a relatively low intensity fire to the 20 kms or more that has occasionally been recorded for fires burning under extreme weather conditions.

There are several other terms relating to the parts of a wildfire that require definition.

If the wind strength is negligible, the terrain flat and fuel uniform, fires are likely to spread at an even rate in all directions and become circular, however, most fires assume shapes which are influenced by the wind and/or by variations in fuel or topography.

This part of the perimeter where the fire is making most progress is known as the **head**. Sometimes there may be more than one head i.e. the fire is **fingering out**.

The area of least progress is at the **heel** and is generally close to the point of fire origin. The **point of origin** is the area where the fire started. The sides, or **flanks**, can be referred to as the right and left flank, east or west flank, etc. Knowing where these various parts of the fire are located is important to the development of suppression strategy and tactics (see Fig 1.4).

Back-burn refers to a fire deliberately set by firefighters at a prepared or existing break (road, trail, river, etc), designed to burn out fuel in the path of an existing wildfire.

⚠ NOTE

It is incorrect to refer to hazard reduction burns as back-burn.

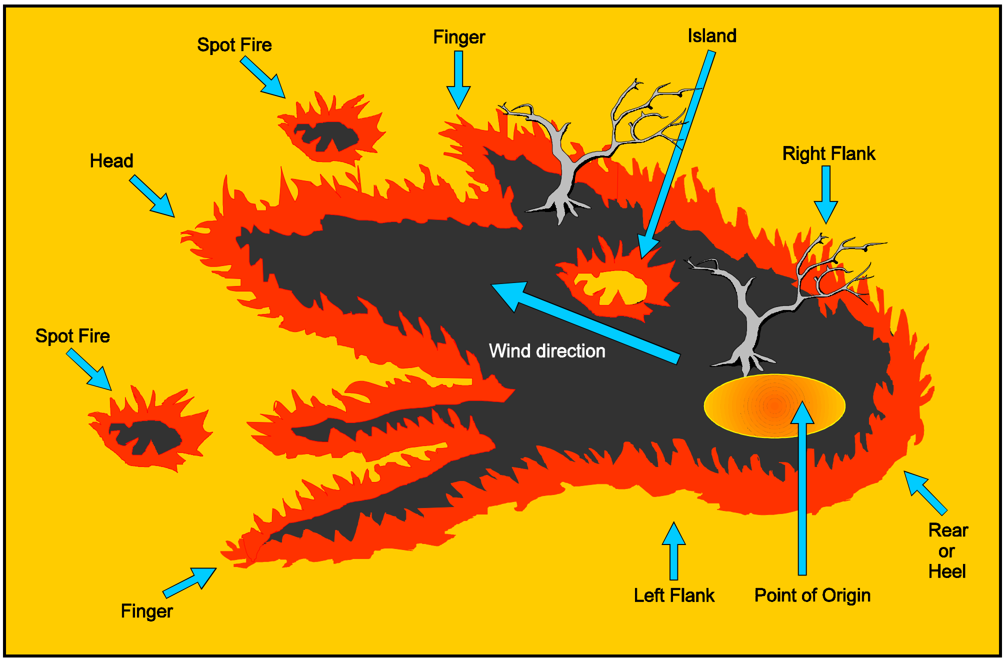

Fig 1.4 Parts of a Wildfire

1.4 Causes of Wildfires

Firefighters have more than just fire suppression to think about. Knowing about fire causes is necessary to enable development of programs to prevent fires. Wildfire causes can be divided into two main categories; natural causes and human causes.

Natural

Lightning is a far more frequent natural cause of wildfires than most people realise. The places where it may strike are difficult to predict and therefore reducing the fuel loading in such places is seldom practicable.

Human

Human causes of wildfires:

- camp fires;
- burning off;
- prescribed burns;
- the operation of trains, motor vehicles, welding plant, waste disposal;
- children playing with matches and arson.

Preventing such fires is a major challenge.

In past years many of the wildfires that have caused massive damage in south-east Australia have originated from electricity transmission lines arcing during extreme fire weather. Coping with this problem is a difficult task for the relevant authorities.

Fires due to carelessness, malice, attempted insurance fraud and other forms of incendiarism are unfortunately common.

Identifying problems that could cause wildfires in a particular area is essential as part of pre-planning.

1.5 Combustion

The combustion triangle diagram (see Fig 1.5) provides a means of demonstrating that before we can have a fire, we must bring fuel, oxygen and heat into combination.

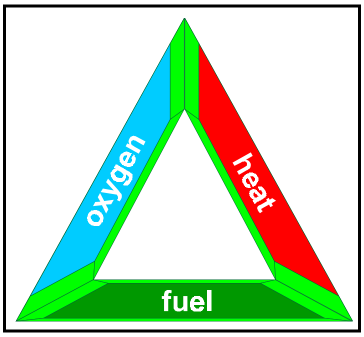

Fig 1.5 Combustion Triangle

1.6 Heat Transfer and Fire Spread

Dry grass, forest litter and flammable shrubs or trees provide the fuel for wildfire. Naked flames, embers, sparks or lightning supply the source of heat. Oxygen is present in open air.

Once started, the spread of fire is like a chain reaction. As each fuel particle burns, more heat is produced. The heat raises the temperature of neighbouring fuel causing its moisture content to evaporate. The fuel then ignites and in turn heats other neighbouring fuel and so on.

In wildfires, heat transfer by conduction has little importance when fire is spreading freely, but after the main fire has swept through, it may contribute considerably to the heat transfer process during the burning or smouldering of fallen logs or other massive fuels.

Radiation is a far more important means of heat transfer in wildfires.

Radiant heat transfer decreases with the distance from the heat source, however, there can be so many heat sources that fuel ahead of a flame front may be subjected to massive radiated heat.

Convection is important too. Hot air rising from a surface fire in a forest, in combination with heat radiated vertically, may cause scorching and, if the heat source is sufficient to induce ignition, it could cause a crown fire situation.

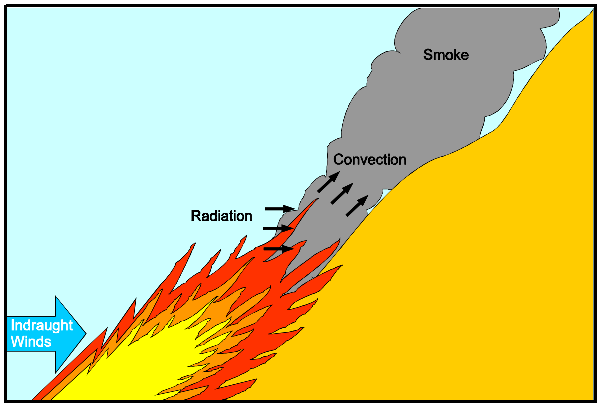

Fig 1.6 Effect of Uphill Slope

The effects of both convection and radiation are accentuated when the angle of flames to the ground surface becomes acute, either on steep slopes or due to the effect of the wind (see Fig 1.6). The rate of ignition from one fuel particle to another increases, partly due to acceleration of the pre-heating effect and partly to the bending of flames.

The flight through the air of sparks is a fourth means of fire transfer. Spot fires have been mentioned earlier.

The suppression measures which are adopted by firefighters can be describe as breaking one or more of the three arms of the combustion triangle; by using water to cool the fuel, smothering with earth or Class A foam to reduce the supply of oxygen, or starving the fire of fuel by fuel separation.

1.7 Wildfire Behaviour

Factors Affecting Wildfire Behaviour

The major determining factor of wildfire behaviour is the weather. Recent rainfall, low temperatures and light winds may combine to prevent bush igniting. However, in late spring after weeks of drying westerly winds and frosts, when hot weather is accompanied by low relative humidity and high winds, bush and grass can be extremely flammable.

Normally, the wildfire season commences in southern Queensland in September, then moves progressively south reaching a peak in the Sydney area in November/December, and the South Coast and Western areas from January to March.

Fire weather is most serious when hot/dry winds blow from the inland, particularly from a north-westerly direction. The passage of anticyclones (high pressure systems) during spring is such that much of NSW comes under the influence of these winds on a regular basis, from late September to December. As summer weather patterns become established high pressure systems tend to move through lower latitudes and lead to hot but moister conditions on the coast.

Other specific factors affecting wildfire behaviour are:

- quantity, type, distribution arrangement of fuel;
- air temperature and sunlight;
- relative humidity;
- wind direction and velocity;
- atmosphere stability;
- slope and aspect; and
- fuel moisture content.

1.7.1 Fuel

This refers to kindling such as leaves, twigs, grass, ferns and shrubs. Fuel is measured in tonnes per hectare (t/ha) taking into account material which is 6 mm or less in diameter (pencil thickness). The method of measurement is described in the NSWFB publication *Hazard Reduction for the Protection of Buildings in Bushland Areas*. Anything larger than this tends to burn after the main flame front has moved through and therefore does not influence fire intensity to a large degree.

Depending upon the arrangement of fuel i.e. if it is well aerated and continuous, shrubs above 1 m in height may also be included in calculations. A fuel loading of 5 to 7 t/ha is considered to be light, and firefighters would have a good chance of success of controlling a wildfire even under extreme weather conditions.

Fuel loadings above 15 t/ha are considered hazardous and present difficulties for firefighters. Loadings in dry sclerophyll forest around Sydney often reach 20-25 t/ha and under certain conditions can be as high as 45 t/ha.

⚠ **NOTE**

At this loading, decomposition of lower layers will be about equal to deposition.

Fire intensity is calculated using the following formula:

$$I = \frac{hwr}{600}$$

I = fire intensity (kilowatts/metre)

H = heat yield in kilojoules/kg (for bushland fuels this figure is approximately 20 000 kJ/kg, however, in calculations the figure 16 000 is generally used to allow for fuel moisture)

W = weight of fuel (tonnes/ha)

R = rate of forward spread of flame front (metres/minute)

A suitable abbreviated formula is I = 30WR

Thus fire intensity is about 300 kW/m for a fire burning 5 t/ha and advancing at 2 m/min.

NOTE

Referring to a figure for fire intensity is a handy way of communicating information without having to provide full details of the fire behaviour characteristics of the quoted fire intensity.

Hazard reduction performed under the mild weather and relatively moist fuel conditions of the **off season** is usually done within the range of 100 to 500 kW/m.

At 3000 to 4000 kW/m controlling the head of a forest fire is likely to be impracticable and flank attack or indirect fire fighting methods are needed.

Fires burning in heavy fuels at high rates of spread under extreme weather conditions may have a fire intensity of 40 000 kW/m or more. Such NSW January 1994 type situations may be rare but preparing to cope with such conditions is what wildfire protection is all about and why fuel management by hazard reduction is so important.

1.7.2 Fuel Dryness

Fuel dryness also makes a significant contribution to ease of ignition, and fire intensity. Even dead grass, leaves and twigs retain a degree of moisture. The amount of moisture is dependent upon the effects of recent rainfall, air temperature and humidity. A rule of thumb is that fuels will generally absorb moisture from the air if the humidity is above 50%. Below 50%, fuels will lose moisture to the air and below 25%, fuel moisture content reaches a critically low level. Fuels in direct sunlight will lose more moisture than identical fuels in shade.

1.7.3 Drought Index

The Bureau of Meteorology issues weekly drought index figures for representative stations based on progressive rainfall and temperature recordings. This index is known as the *Byram Keetch Drought Index (BKDI)* and provides a broad indication of current fuel conditions but does not cover fluctuations from hour to hour during one day or over several days (see Fig 1.7).

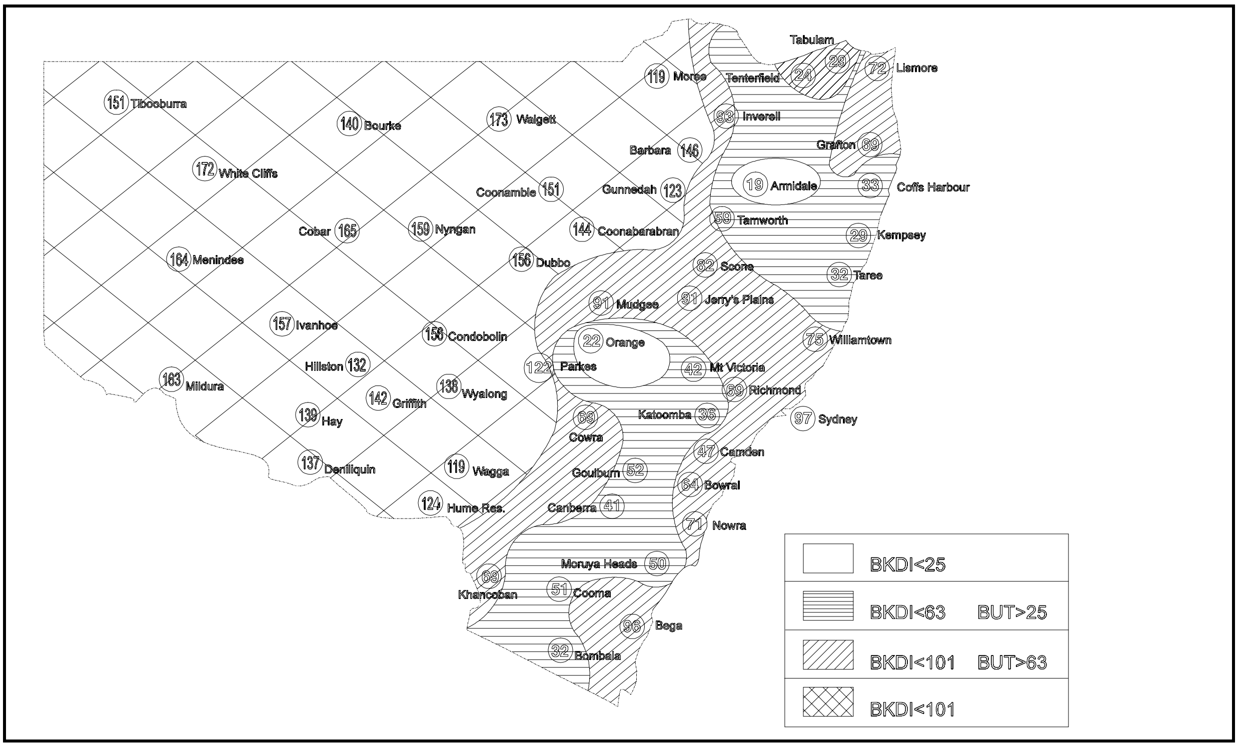

Fig 1.7 An Example of the BKDI for NSW

The BKDI is in basic terms a measure of the amount of rain in mm required to totally saturate the soil.

A figure of zero indicates that the ground is saturated and fires will not burn. A figure of 200 indicates a severe drought condition where more than 200 mm of rain is required to saturate the soil.

A figure above 100 indicates moderate drought conditions and combined with adverse weather can lead to extreme bushfire behaviour.

1.7.4 Diurnal Fluctuations of Fuel Moisture Content

The reference here is to the variations which take place from hour to hour in the moisture content of fine fuel. Research programs have established the effect of various combinations of shade temperature and relative humidity on the moisture content of fine fuel in open grassland and in forests for various degrees of shading.

In eucalypt litter a 20% to 25% fuel moisture content is generally sufficient to prevent ignition and halt combustion. Above 15% fire intensity is low and fire behaviour is predictable. Conditions become increasingly more difficult for firefighters at figures below 7%. A drop of about 2%, e.g. from 7% to 5% could result in doubling the rate of spread of a fire. The lowest figure that can probably be reached in dead or cured fire fuels in Australia is 3%. Rates of spread are then likely to be at least four times greater than when the fuel moisture content is 10%.

1.7.5 Temperature and Sunlight

Fuels in direct sunlight will dry out more than those in shaded areas and be up to 30° C hotter. The higher the temperature of fuels the closer they are to their ignition point and therefore fires will not only ignite more easily but will spread more quickly and allow burning brands to ignite **spot fires**. Areas exposed to the afternoon sun can be subject to extreme fire behaviour.

1.7.6 Humidity

Humidity is a measurement of moisture in the air. Fuel moisture content is closely related to relative humidity. Low relative humidity leads to more intense and erratic burning, allows burning brands to remain ignited in the air and easier ignition of spot fires.

1.7.7 Wind Direction and Velocity

Wind direction is critical as it determines to an extent the temperature and relative humidity. Winds originating over the ocean e.g. north east, east and south east, may be moister, lead to higher humidity and therefore less intense burning. Winds which originate over the inland areas e.g. west, north west and south west will be much drier and sometimes hotter. Generally winds from a northerly direction are warmer than those from the south.

The worst wildfire winds are therefore north westerlies and westerlies as they are often very hot and dry. Southerly winds moving through directly after severe fire weather can lead to intense burning as fuels can take more than an hour to absorb the increased moisture levels in the air.

Wind strength is critical - strong winds will increase the rate of spread by:

- bending flames forward and therefore drying and preheating unburnt fuels;
- supplying additional oxygen to the fire; and
- carrying burning brands ahead of the fire front to ignite spot fires.

North westerly winds are usually at their strongest immediately preceding passage of a cold front i.e. the well known **southerly buster**.

1.7.8 Level of Atmospheric Stability

Atmospheric stability refers to the vertical movement of air masses which occur when hot air rises and is replaced by cooler air. Atmospheric stability also determines, to a large extent, cloud development and in particular the possibility of thunderstorm development (see Fig 1.8).

In **stable** atmospheric conditions:

- stratus type clouds (the clouds are in layers) are present
- smoke columns drift apart after limited rise;
- the vertical movement of air is limited;
- there are fog layers; and
- the winds are generally light and predictable.

⚠ **NOTE**

Fire behaviour will be predictable in these circumstances.

In **unstable** atmospheric conditions, fire behaviour is erratic. Convection columns will develop rapidly and intense spotting may occur with little warning. In turn, the airflow into the fire at low levels is increased, and this has a marked effect on fire intensity.

In **unstable** atmospheric conditions:

- cumulus (cotton wool) type clouds show noticeable vertical growth;
- smoke columns can rise to great heights;
- winds are gusty and unpredictable;
- lightning strikes may occur from thunderstorms; and
- dust whirls (willy willies) may occur.

⚠ **NOTE**

Fire behaviour can be unpredictable under these conditions.

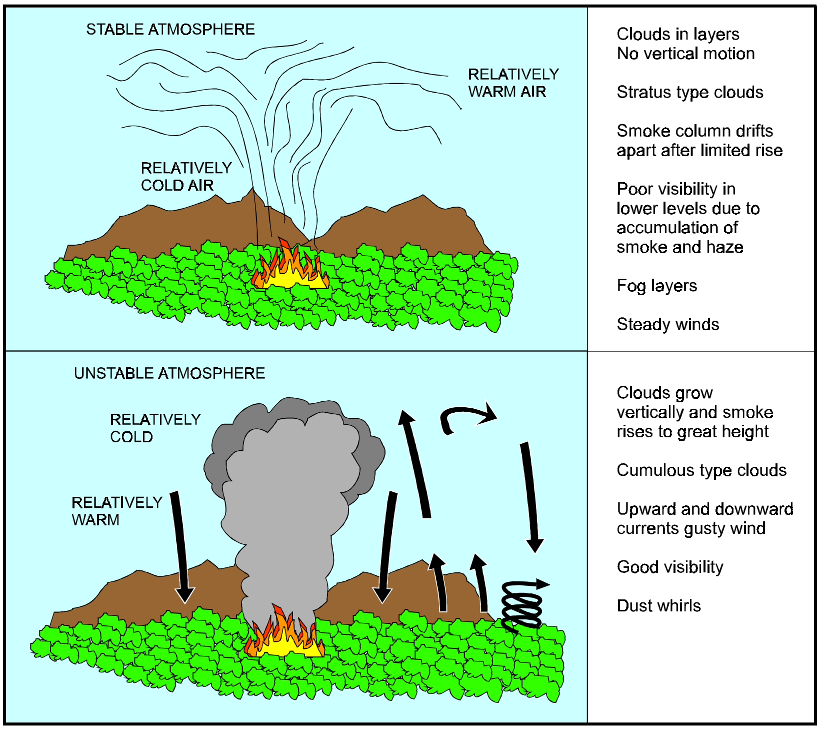

Fig 1.8 Visual Indicators of Stability

Atmospheric Stability and Night Inversions

After the sun sets, the ground begins to cool and therefore cools a thin layer of air above it. This layer gradually deepens as the night progresses and forms a surface inversion. This is a surface layer in which the temperature increases with height. Such an inversion may involve a temperature change of as much as 18° C in 100 m (vertical). The cold air is dense and readily flows down slopes and gathers in valleys. Surface inversions forming at night are commonly referred to as night inversions. Within the thermal belt (see Fig 1.9), wildfires can remain active during the night.

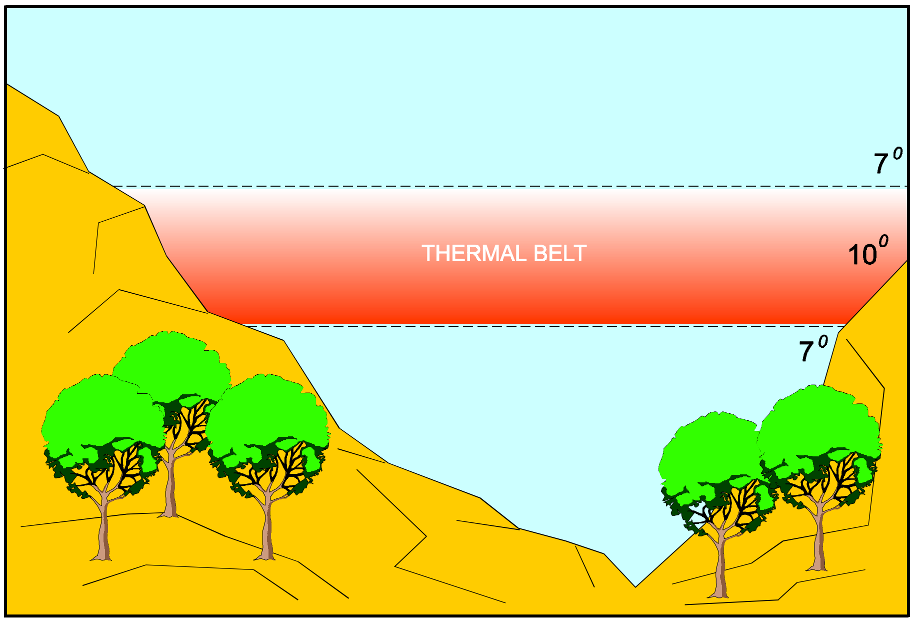

Fig 1.9 Night Inversion

Below the thermal belt, fires are in cool, humid, and stable air, often with down-slope winds. Above the thermal belt, temperatures decrease with height. However, the effect of the lower temperatures, may be offset by stronger winds and less stable air as fires penetrate the region above the thermal belt.

After sunrise, surface heating begins to warm the cold air, and the inversion top may actually rise slightly from this expansion. As heating destroys the inversion along the slopes, upslope winds begin. The transport of air from the base of the valley up the slopes may actually cause the inversion top to lower over the middle of the valley. Finally, with continued heating and mixing, the inversion layer is completely dissipated.

⚠ **NOTE**

Behaviour of a fire burning beneath an inversion may change abruptly when the inversion is destroyed.

Meteorologists can estimate when inversions will break, and these forecasts can be valuable to fire controllers, particularly giving early warning for high winds. For example, on 8 January 1969 the inversion broke early in the morning and the wind speed suddenly increased between 0240 - 0430 hours, compared to the usual time of 0700 - 0800 on hot days. The ensueing fires at Lara, Victoria, killed 11 people.

1.7.9 Slope and Aspect

Slope has an important bearing on fire behaviour. The effect on rate of spread is discussed in a later section dealing with weather and the fire danger index.

Aspect also is often important to the way in which fire behaves. The vegetation growing on slopes facing to the east and south is often more lush and less flammable than is the vegetation growing on exposed ridges and on slopes facing to the north and west.

Due to the greater exposure to heat as the sun moves across the sky, fine fuels on northern and western slopes are usually warmer and drier than those facing to the east and south. The combination of the warmer, drier NW to SW winds and the warmer, drier N and W slopes causes the fire to burn more fiercely than on the cooler slopes facing S and E. During extreme conditions however, any difference may be minimal. If fuel and weather conditions remain constant rates of spread (m/min) are likely to vary as set out in Table 1A.

SLOPE ANGLE	UP SLOPE	DOWN SLOPE
0 (flat)	x	x
5°	1.5 x	0.75 x
10°	2 x	0.5 x
15°	3 x	0.33 x
20°	4 x	0.25 x

Table 1A Variations in Rate of Spread

Because of the abbreviated formula I = 30WR, which was mentioned earlier, fire intensity also varies in the manner shown in Table 1A.

1.8 Fire Danger Index

People concerned with the prevention and control of wildfires need to have ready access to information about probable fire behaviour under current or anticipated fuel and weather conditions.

This need is met by the two *McArthur* Fire Danger Meters; one for use in forest and another for grassland. Both come in the form of circular meters which are suitable for office or field use. The information they contain may also be programmed into computers.

Experienced firefighters know that these meters provide reliable broad guidelines and are aware that they must take account of local variations in fuel, topography and wind when shaping strategy and tactics to the requirements of anticipated fire behaviour.

1.8.1 Forest Fire Danger Meter

The Forest Fire Danger Meter is used on a daily basis by the Weather Bureau and fire agencies to predict fire weather, and as a basis for declaration of Total Fire Bans and Bushfire Alerts.

Two main processes are involved in calculating fire danger. The first deals with fuel condition and the second with average wind speed.

The fuel condition assessment involves three steps and takes into account the long term weather effects which the *Byram Keetch Drought Index* provides, the wetting or moistening effect of recent rain, and the short term, e.g. hourly, fluctuations in moisture content which are influenced by temperature and relative humidity.

When the average wind speed has been determined, a forest fire danger index is provided by reading the scale on the outer wheel of the meter. This index is detailed in Table 1B.

WORDS	FIGURES
Low	0 - 5
Moderate	6 - 12
High	13 - 24
Very High	25 - 50
Extreme	51 - 100

Table 1B Forest Fire Danger Index

The value of 100 represents the condition in Victoria on Black Friday 1939, a day with a fire intensity that may have been somewhat exceeded on Ash Wednesday 1983.

Fire behaviour information relevant to various degrees of fire danger are provided on the reverse side of the meter.

In the example which follows (Table 1C), calculations of fire intensity, which do not appear on the meter, have been added to emphasise the effect that heavy fuels have on fire behaviour. The figures are based on a Fire Danger Index of 60 and indicate the probable fire behaviour on flat terrain for various fuel loadings.

DETAIL	5 T/HA	10 T/HA	20 T/HA
ROS (km/hr)	0.34	0.67	1.44
ROS (m/min)	5.5	11	24
Fire Intensity (kw/m)	825	3300	14 400
Flame Height	4	10	Crown fire
Spotting (km)	1	2.1	3.4

⚠ **NOTE**

ROS = Rate of forward spread of head fires. Rates of spread and other aspects of fire behaviour are less on the flanks.

Table 1C Example of Probable Fire Behaviour

1.8.2 Instructions for Using the Forest Danger Meter MkV

The fire danger index given by the Forest Fire Danger Meter MkV (see Fig 1.10) is directly related to the chances of a fire starting, its rate of spread, intensity and difficulty of suppression according to various combinations of temperature, relative humidity, wind speed and with long and short term drought effects.

An index of one means that fires will not burn, or burn so slowly that control presents little difficulty. An index of one hundred means that fires will burn so fast that control is virtually impossible.

The meter is designed for general fire danger forecasting purposes and is based on the expected behaviour of fires burning for an extended period in high eucalypt forest carrying a fuel quality of 5 t/h or greater, and travelling over level to undulating topography.

The behaviour of individual fires can be predicted with reasonable accuracy providing the effect of fuel quantity and slope is taken into account.

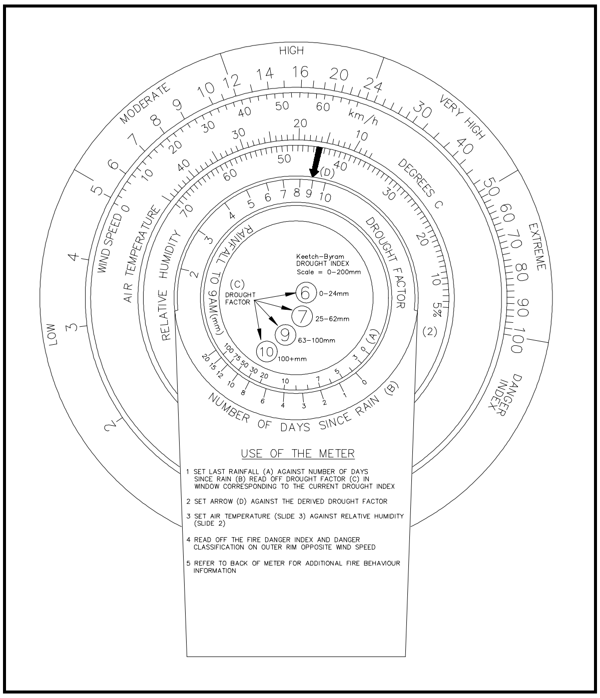

Fig 1.10 Forest Fire Danger Meter MkV

To use the Forest Fire Danger Meter MkV, proceed as follows:

- obtain the BKDI reading for your area from the Bushfire Section, the reading obtained will be between 0 mm and 200 mm;
- align the number of days since rain (B) with the amount of rainfall to 9 am by turning wheel (A);
- obtain the Drought Factor reading (C) from one of the four cut-out holes that aligns to the BDKI reading for your area;
- set the Drought Factor arrow (D) to the correct Drought Factor reading. The Drought Factor reading will be between 2 and 10 on your meter;

⚠ **NOTE**

Once set, the arrow must not move off the selected number as this will give you a false reading.

- align the air temperature reading to the relative humidity reading;
- the meter is now set. By reading off the local wind speed for your area, you will obtain the Forest Danger Index (Low 2-5, Moderate 5-12, High 12-24, Very High 24-50, Extreme 50-100); and
- look at the reverse side of your meter to obtain Fire Behaviour Prediction reading.

⚠ **NOTE**

To obtain the predicted fire behaviour for your area, cross reference the fuel quantity reading in the left column with the Fire Danger Index on the top line of the table. This figure will give you the Predicted Rate of Spread/Flame Height/Spotting distance for a wildfire or hazard reduction.

1.8.3 Grassland Fire Danger Meter

This meter (see Fig 1.11) has the most application in open country to the west of the Dividing Range. The operator does not have to worry about the BKDI or days since rain. Instead he/she feeds an estimate of the extent of grass curing and follows up with entries of temperature, relative humidity and wind information.

The resultant fire danger index runs from 0 to 100 and information is supplied relevant to fire behaviour and suppression tactics for fires burning at fire danger ratings ranging from low to extreme.

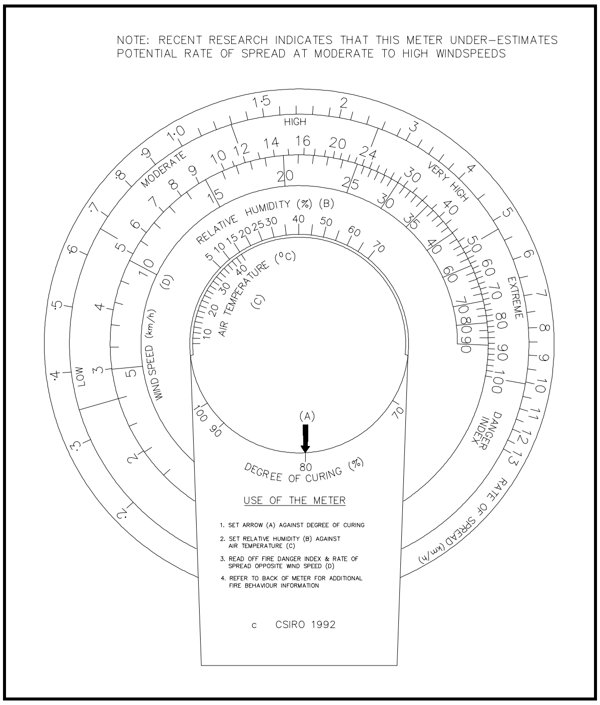

Fig 1.11 Grassland Fire Danger Meter MkIV

1.8.4 Instructions for Using the Grassland Fire Danger Meter MkIV

The grassland fire danger index is calculated from the measurement of air temperature, relative humidity, wind speed and is varied according to the amount of greenness in the pasture. It provides a figure that is directly related to the chances of a fire starting, its rate of spread, difficulty of control and the amount of damage it will do.

An index of one or two means that fires will not burn, or burn so slowly that control presents little difficulty. An index of one hundred means that fires will burn so fast that control is virtually impossible.

The meter is designed for general fire danger forecasting purposes and is based on the expected behaviour of fires burning through grassland.

The behaviour of individual fires can be predicted with reasonable accuracy providing the effect of grass quantity is taken into account.

To use the Grassland Fire Danger Meter MkIV, proceed as follows:

- set arrow (A) against the degree of curing;
- set relative humidity (B) against air temperature (C); and
- read off the fire danger index and rate of spread opposite wind speed (D).

⚠ **NOTE**

Additional information regarding fire behaviour is contained on the back of the meter.

SECTION TWO - FIRE FIGHTING PROCEDURES

CONTENTS

Section 2	Fire Fighting Procedures	1
2.1	Extinguishing Methods	1
2.2	Strategy and Tactics	3
2.3	Methods of Attacking Fires	4
2.4	Incident Control System	11
2.5	Safety and Survival	12
2.6	Fundamentals for Survival	17
2.7	Public Education	22
Section 2	Illustrations	
Fig 2.1	Direct Attack	5
2.2	Indirect Attack	6
Section 2	Tables	
2A	Flame Height Indicator	10
2B	Heat Stress Symptoms/Treatment	13
2C	Heat Exhaustion Symptoms/Treatment	14
2D	Heat Stroke Symptoms/Treatment	14
2E	OIC's and Firefighters Safety Procedures	18
2F	Fundamental Survival Actions	19

2 FIRE FIGHTING PROCEDURES

2.1 Extinguishing Methods

2.1.1 Use of Water

Water is used lavishly or sparingly during bushfire fighting depending on its availability and the suppression strategy chosen. When coping with grass fires to the west of the Dividing Range, the NSWFB mainly burn back from roads or other barriers or apply water directly to the flanks in a pinching out operation. Keeping pumpers and tankers supplied with sufficient water is a considerable logistics problem.

Fires in remote areas require mainly dry methods of fire fighting, using hand tools for a direct attack, the parallel method (line construction), or back-burning from roads and tracks. Opportunities for directly applying water are limited and so it is used principally for mopping up. Sometimes water can be pumped from creeks into hose lines. Mostly, it is carried in tankers and used sparingly when mopping up smouldering logs and trees.

2.1.2 Use of Foam

Foam is a blanketing and cooling agent and is used to improve the efficiency of water in fire fighting. Foams extinguish fire by:

- interrupting radiant heat from the flames and preventing it from reaching the adjacent fuel surfaces; and
- cooling the fuel and isolating it from the oxygen in the air.

Bush Fire Fighting Foam

The most common type of foam used in wildfire suppression is Bush Fire Fighting Foam (BFFF), which is a Class A foam, especially formulated for use on fires in natural fuels. These foams:

- lower the surface tension of water, allowing it to penetrate fuels more easily;
- cling to vertical surfaces, reducing waste through run off;
- are visible when applied, allowing firefighters to avoid under or over-application; and
- enable fires to be put out more efficiently.

This foam is produced by mixing BFFF concentrate with water to form BFFF solution. This solution is then aerated to form lots of bubbles called foam.

BFFF can be applied to a fire through a spray nozzle or a special foam making nozzle, or it can be dropped by aircraft.

Precautions

BFFF concentrate is a powerful detergent which can remove skin oils. Drums of this concentrate should be handled carefully. The lids or caps should remain properly sealed to prevent spillage or splashing.

Gloves, eye protection and long sleeves should be used when emptying containers of BFFF concentrate. Hands and faces should be washed after using this product.

CAUTION

BFFF concentrate can pollute the environment if not cleaned up. The concentrate should not be allowed to enter, or be handled near creeks or rivers. Do not drink from tanks into which BFFF concentrate has been placed.

⚠ **NOTE**

Do not confuse BFFF (Class A) foams with AFFF (Class B) foams. AFFF foams are designed for use on oil or petroleum fires, and are not normally used in wildfire fire fighting operations.

Foam Use

Foam should be applied to a fire as gently as possible ensuring uniform coverage. It can be applied on scrub or trunks of stringy bark trees near the edge of a control line just before lighting a backburn. The maximum projection of the stream should be used, letting the foam do the work. Foam is also particularly effective in mopping-up work.

Fire Retardants

A retardant is any fire fighting substance applied on, or ahead, of a fire's flame front to reduce the fire's rate of spread or intensity, rather than directly suppress combustion in the flaming zone. Fire retardants can be broadly categorised as short term and long term.

Short Term Retardants

Short term retardants, the most common example of which is bush fire fighting foam (BFFF), rely almost entirely on their ability to retain moisture, thereby cooling the fire and keeping fuels ahead of the fire too moist to burn. Once the water evaporates the retardant action ends. BFFF foams may be effective for 20 - 40 mins when used as a retardant, depending on the foam concentration and weather conditions.

Long Term Retardant

Long term retardants are chemicals (usually ammonium salts) which are mixed with water to form a slurry with a consistency similar to tomato sauce. The slurry not only coats the fuel, therefore acting as a physical barrier, but the chemical also retards the combustion process. Long term retardant slurries are effective after the water has evaporated from them, and may continue to retard combustion for more than 24 hrs.

Long term retardants can be applied by tanker type equipment, but are more commonly used in aerial fire bombing operations, particularly to slow the spread of fires in remote areas whilst ground crews travel to them. Long term retardents are not widely used in Australia.

2.1.3 Wildfire Situations

When dealing with wildfires the NSWFB encounters three types of situations.

- fire is closely approaching houses on a perimeter of a suburb or town and there is no chance of spread beyond the perimeter i.e. the fire is running out of fuel and so the immediate objective is not to halt the wildfire, but to save the houses. Fire fighting generally consists of running out hose lines and protecting property while containing the fire;

- a situation where it may be possible to develop the attack in bushland, away from property using long hose lines augmented by water from tankers; and

- the fire is beyond the reach of reticulated water and fire fighting is a combination of dry and wet methods.

⚠ **NOTE**

Firefighters should not assume that pressure and volume from the mains will always meet the requirements fully. When large fires threaten houses, many hydrants may be in use and dozens of taps may be turned on while residents dampen vulnerable property. Firefighters are always advised to use water sparingly and similar advice is relevant when supply from the mains is diminished by multiple use. Dampening down bush long before the fire front arrives is wasteful, and probably useless, due to evaporation.

Water Attack

When a jet is needed to knock down flames, aim first at the base bouncing the water off the ground at a low angle, preferably parallel to, rather than at right angles to, the fire edge.

When the straight stream has done its job, turn to the more economical spray or fog and switch off completely, rather than waste water on cooled ground. Throw pieces of smouldering wood into the fire and open up logs or other fuel concentrations to allow better water penetration.

⚠ **NOTE**

Lavish use is sometimes necessary temporarily, but making a little water go a long way is the hallmark of an efficient firefighter.

2.2 Strategy and Tactics

All fires start small. The objective is to keep them small, controlling them before they cause injury or damage property.

Strategies are overall plans of action to control the fire. The strategy may be to protect threatened buildings and mount a direct attack when possible. Tactics are techniques to accomplish the strategy including deployment and methods of direct action on the incident ground.

2.2.1 Size-Up

Size-up is the development of a mental picture of what is happening; what the fire is doing or will do. It is a continuous process that is only concluded once the fire is controlled. The following questions would constitute the size-up of a fire situation:

- What are the weather conditions and current Fire Danger Rating? How will they affect fire conditions?
- What is the fire behaviour and rate of spread? Is the fire burning too intensely for a direct attack? Is the fire spotting or crowning?

⚠ **NOTE**

Determining the intensity is crucial; it will dictate the strategy and tactics. Consider the time of day in the determination of present and *anticipated* fire behaviour.

- Is the fire spotting? Low humidities, low fuel moisture, and wind contribute to the potential for spotting. Spot fires create safety problems and will greatly increase the fire's rate of spread.
- Is a smoke column visible while responding? A lot can be discerned from observing the smoke column. Thick white/light brown smoke may indicate a grass fire. A column going straight upwards indicates no wind. If the smoke column is thick, brown to black, and bent over, a major fire is in progress and spotting is likely.
- What is the rate of spread? There is no need to be overly technical in assessing rate of spread. Fast or slow are sufficiently detailed indicators for an initial size-up.
- What are the weather conditions? Is there a wind? What is it's direction and velocity? Temperature and humidity? In view of the weather conditions, can the fire be held with the appliance/s and crew/s on scene?
- Fuel and Topography. Are there continuous fuels, or is it a contained area with nowhere to spread? Is the fire approaching any steep slopes - if so, can it be held once it accelerates?
- Properties: What is near the fire? Are there homes, factories or other assets in the path of the fire?

- Water: Are there sufficient supplies?
- Assistance: Have other stations/ appliances been responded? What is their ETA? Is more assistance required? Are sufficient officers at the scene to effectively manage the incident?

The initial size-up should be carried out as quickly as possible, and suppression commenced wherever the threat is greatest, i.e. usually at the head of the fire, where properties are threatened, or where the fire can escape.

2.3 Methods of Attacking Fires

2.3.1 Fire Suppression

On arrival at the fire, suppression action against hot spots is usually started immediately.

Sometimes the initial action is deferred while the OIC makes the reconnaissance. Points of attack may then be chosen and decisions made about the need or otherwise of reinforcements. The main objectives are to limit fire spread and make the fire safe. The normal procedures are as follows:

- check blazing fronts and blazing trees or snags which may cause spot fires;
- cut off the outer edge from access to new fuel;
- in the case of very small fires, extinguish all internal blazing material, or in the case of larger fires, allow most of the internal material to burn out; and
- mop up the perimeter for a suitable width and patrol until safe.

The two basic firefighting strategies are **offensive** and **defensive**.

An **offensive** strategy aims at immediately limiting fire spread, while a **defensive** strategy aims at life and property protection and containment of large, rapidly moving fires.

Firefighters have a choice of four main tactical methods of dealing with fires. These are known as:

- the direct attack;
- the parallel method;
- the indirect method or back-burning; and
- property protection.

Frequently their choice is influenced by such factors as rate of spread, personnel safety and the availability of personnel and equipment.

During extreme conditions, the main focus of NSWFB crews will be protection of life and property in the urban/bushland interface. This is a specialised form of fire fighting which will be dealt with separately.

2.3.2 Offensive Strategies

Direct Method

In this method, work is applied directly to the fire edge which then becomes the established control line (see Fig 2.1). This may be achieved by applying water, beating, pushing burning fuel into the fire, smothering with earth and throwing in any logs or sticks which might lie across the edge.

The direct method is the most common strategy employed by the NSWFB. This method has advantages and disadvantages.

Fig 2.1 Direct Attack

Advantages

- sections of the fire edge which have extinguished of their own accord become part of the control line;
- the fire is robbed of new material, reducing the burn-out period and keeping the area burnt to a minimum; and
- the momentum of the fire is checked and time and effort which might have to be spent in back-burning is saved.

Disadvantages

- working close to a fire exposes firefighters to heat and smoke; and
- a long, irregular line is usually established, making supervision and subsequent patrol activities difficult.

Parallel method

In this method a fire line is constructed parallel to, and just far enough from the fire edge, to allow firefighters and equipment to work effectively away from heat and smoke. Sometimes the line is shortened by cutting across unburnt fingers. The strip of fuel between the fire and the control line is normally burnt out as soon as possible after the fire line is constructed. The basic principle is to keep fairly close to the edge of a fire, but latitude is allowed for, dropping back to avoid intense heat and for manoeuvring to by-pass obstructions. In practice, this distance may vary from a few metres to 50 m or more.

Advantages

- it can be used in front of reasonably hot forest fires but the crew must be able to make their way onto burnt ground in an emergency;
- supervision is simplified and the line can be kept short;
- mechanical equipment may be used for constructing the fire line; and
- the area burnt by the fire is not greatly increased.

Disadvantages

- an unnecessary fire line might be established in proximity to a burnt-out edge;
- fires used to burn out heavy fuels might get out of control and endanger both the crew and the suppression operation; and
- there is also a possibility that a patch of unburnt fuel may threaten the security of the fire line if subsequently ignited, especially if fire danger increases.

2.3.3 Defensive Strategies

Indirect Method or Back-burning

This method consists of burning back from natural barriers, roads or firebreaks, or from trails or fire lines constructed to suit the occasion (see Fig 2.2). It usually involves dropping back a considerable distance from a fire front and burning out a strip of sufficient width to provide an effective barrier against the main fire. Unlike the parallel method, firing does not follow close on the heels of line construction crews and is usually delayed until the fire line has been substantially completed and conditions are favourable for back-burning.

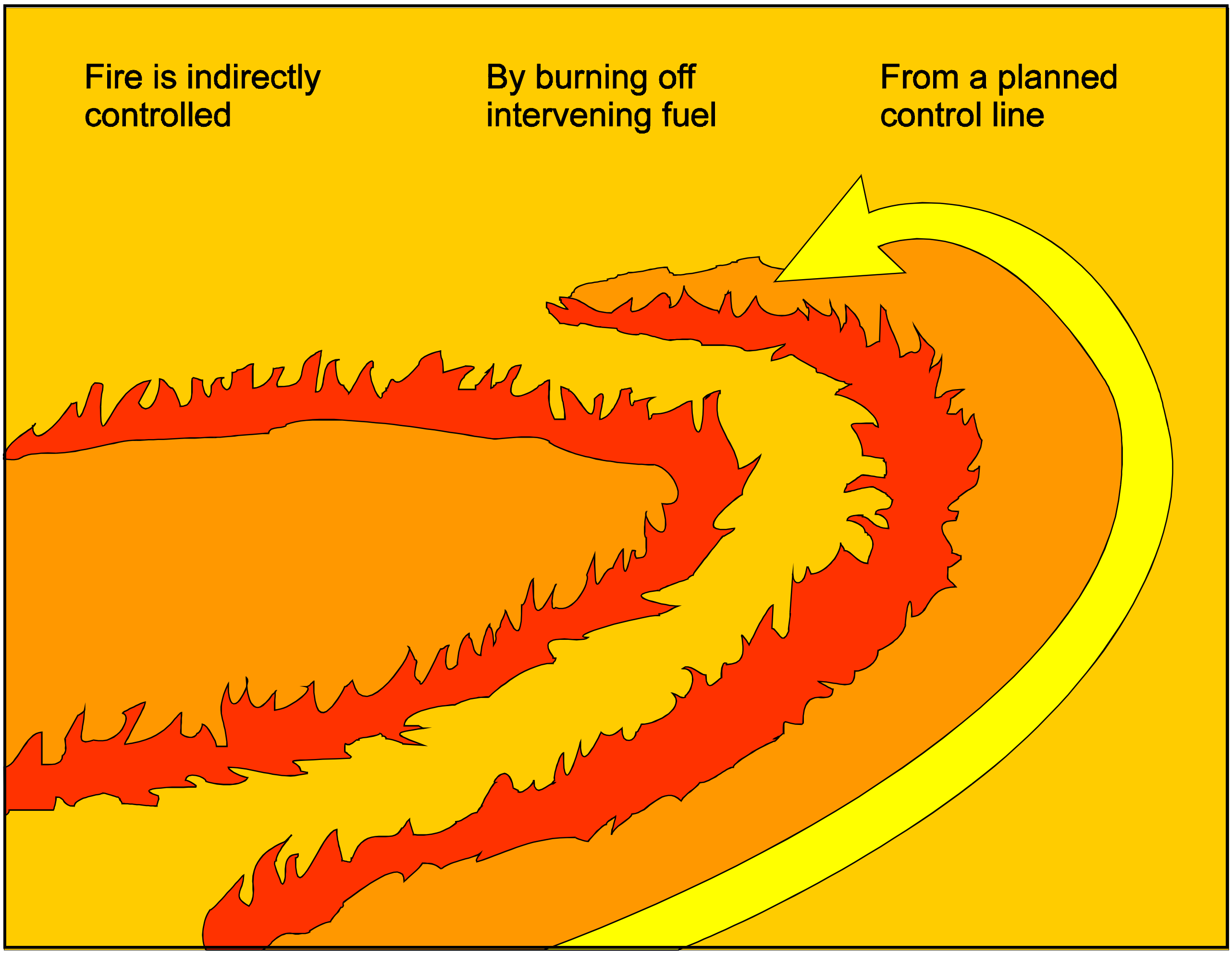

Fig 2.2 Indirect Attack

The width of the fire line depends on local circumstances. In practice, as firefighters are usually working against time, a line is seldom as wide as they might desire but, although they may have to make do with narrow trails, it is important that the fuel should be cleared away entirely down to bare earth. Consideration should be given to isolating particularly flammable fuels on the side of the fire line closest to the fire, and even on the other side under some circumstances. In forest and grassland areas it generally pays to rake around dead and fibrous-barked trees near the fire line prior to back-burning.

If fires are burning on blow-up days when fire danger is towards the top part of extreme, it may be unwise even to consider the practice. Indeed, the decision may be taken out of the hands of the firefighters because of their total involvement in saving property. The decision to back-burn must be communicated to all parties involved in fire fighting before commencement.

Advantage

- this is often the only practicable means of dealing with rapidly moving fires, fires that are spotting freely, and fires which have an irregular perimeter with difficult access.

CAUTION

It must be stressed that back-burning can be an extremely dangerous practice unless carried out with a full knowledge of fire behaviour. There have been instances in the past of independent groups of firefighters working on their own in ignorance of the tactics employed by other groups. In setting back-burns which firefighters had no hope of containing they have sometimes endangered other firefighters and spread fire unnecessarily. On some days of extreme fire danger it may be impossible to hold even the smallest fire, much less a large back-burn.

Disadvantages

- the size of the fire may be considerably extended;
- there could also be a failure to take advantage of portions of the front which have gone out, thus creating the re-establishment of a solid front of fire;
- sometimes fire cannot be made to burn back after a line has been established. This work will be wasted effort if the main fire subsequently crosses the line; and
- back-burning sometimes produces intense heat and care has to be taken to avoid spot fires being thrown onto the lee side of the fire line. When back-burns meet the main fire, it is common for fires to flare up, crown, and throw spots for long distances.

2.3.4 Property Protection

The special expertise of the NSWFB in bushfire operations is property protection. Urban firefighters are trained and equipped to stand their ground under the most dangerous conditions, and can cope quickly with any buildings which catch fire.

Extreme Conditions

Under extreme conditions, many streets and dozens of homes may be under simultaneous threat - the number of homes at risk may well exceed the number of available appliances. Firefighters will be in a defensive mode, with the fire driving incident strategies, and leaving no time for detailed action planning.

Normal strategies **will not work** under such conditions, and special strategies and tactics are called for. Under such conditions:

- appliances must remain mobile, and try to keep ahead of the fire. **Do not** hook up to hydrants or waste time mopping up or hosing buildings which are well alight;

- water will be limited. Maximise the effectiveness of every drop. **Do not** wet down bush long before the fire arrives. Use hose directly from standpipes - use the appliance tank as an emergency reserve. Use portable pumps with swimming pools, dams, tanks etc.

- do not wait for instructions by radio, the Command Centre will probably be overwhelmed. Think ahead of the fire; and

- triage buildings; you may not be able to save them all and attempting to do so may mean losing more.

Structure Triage

One of the hardest decisions a fire officer will ever have to make is to abandon a burning structure in order to save others. However, such decisions **must** be made during extreme conditions such as those in January 1994. Failure to do so may mean destruction of many more buildings. An example of when such a decision was made follows:

On January 8, 1994 at Como/Jannali, the Operational Commander successfully halted the conflagration by dropping back to another street and mounting a major defensive attack. Although nearly 100 homes were burned, many more would have been lost if not for his critical strategic decision.

A technique to maximise the effectiveness of fire fighting resources is known as *Structure Triage*.

As with the treatment of casualties, structures are divided into three classifications depending on their condition. These three categories are:

(1) **Threatened -** capable of being saved;

(2) **Not threatened -** remote from fire; and

(3) **Hopeless -** too dangerous to protect. No cleared area (defensible space); no refuge area for firefighters; bush and trees close to structure; roof and guttering full of leaves.

The decision should be taken to defend as many structures as possible, rather than defending one at all costs and losing the rest.

Factors to Consider During Triage

The following are factors that are to be considered during triage:

- **Proximity of fuels -** is there a defensible space around the structure? What is the fire intensity, and how much defensible space is required?

- **Construction materials** - Is the house weatherboard or brick? Are there openings beneath it or open eaves?

- **Timing** - Is there time to set up in a defensive position?

- **Safety -** can the structure be protected without placing firefighters at undue risk? Remember - houses can be rebuilt.

Allocating Resources

Appliances should be deployed only to those structures considered savable. Structures falling into categories **(2)** or **(3)** should not be allocated resources under extreme conditions.

Should structures subsequently catch fire, the OIC must make the decision whether or not to attack the fire. Generally, where the building is burning internally, with broken windows and windy conditions, the decision may be taken to abandon it if the fire cannot be knocked down with the water available in the appliance tank, **and** other structures are under threat.

Requirements

If possible, one appliance should be assigned to each building being threatened. Where homes are close together (<15 m), one pumper may be able to protect more than one structure.

Additional appliances should be held in reserve at a Staging Area ready to respond to spot fires or assist other crews.

Tactics

The following tactics should be adopted;

- when protecting structures, 38 mm hose is preferred to 70 mm due to its lightness (firefighter fatigue), manoeuvrability, and lower water usage;
- sufficient hose should be available to go right around the structure;
- a ladder should be placed against the roof of a structure; and
- if time permits, firefighters should remove leaves from roof and guttering, fill the gutters with water (after blocking downpipes), close all windows, curtains and doors, and place a ladder up to the ceiling access hole inside the house.

2.3.5 Application of Fire Attack Methods

No one method of attack is followed throughout the progress of fire fighting. In some sectors, offensive strategies may be practicable most of the time but if conditions become too hot close to the fire, firefighters may drop back for a while and temporarily use defensive strategies, until it is possible to resume work along the fire edge. Under some circumstances, work may be going on close to a fire while a fire line is being prepared simultaneously some distance away as a back-stop, which may be needed if the direct attack fails.

The choice of the points of attack on fires depends on the rate of spread, fire intensity, spotting potential, size of the attack force and other factors such as the nature of the fuel lying in the path of a fire.

Provided the safety of firefighters can be assured, either the direct or parallel method should be used at the head of a fire, to arrest its development in the zone of greatest spread and damage potential. Table 2A indicates the type of fire fighting attack related to flame height.

If the head of the fire is too hot or too fast to handle, the attack may be made from the flanks, working from the tail to the head, in the process called *pinching out*. Sometimes it may not be necessary to take action along one flank due to its proximity to bare ground.

Alternatively, the action along one flank may be delayed because attention to the other flank is temporarily considered to be more important.

On days of high to extreme fire danger it may not be possible to stop the forward spread of a fire burning in continuous fuel. A much different position applies on the flanks where the rate of lateral spread is relatively slow. A rapidly spreading fire is usually long and narrow in shape. However, if there is a wind change a flank fire may become a wide head fire and multiply the original damage many times. Thus it is not possible to overstress the importance of controlling the flanks, **especially the north-eastern flank** as this may become a head fire with the approach of a cold front.

Anchor Point

Whatever the method of attack chosen, an anchor point should be established. An anchor point is a place where the fire meets a road, trail, creek etc and provides a path of escape via burnt ground for firefighters should conditions deteriorate.

Mopping up and Patrol

When the spread of fire has been stopped, the perimeter **must** be secured. It is quite usual to deal with all smouldering or burning material within 10 m of the established fire line, but it may be desirable to provide a greater width under circumstances. Also, it is often necessary to deal with burning trees or snags for a width of up to 100 m. A high standard is required before the mop up operations and subsequent patrol can be terminated, with the knowledge that no chance remains of the fire escaping.

FLAME HEIGHT (M)	INTENSITY (KW/M)	FLAME HEIGHT	MEANING
0 - 0.5	0 - 50	Low	Fires generally self extinguish
0.5 - 1.5	50 - 500	Moderate	Handtool line should hold the fire direct attack recommended
1.5 - 3.0	500 - 2000	High	Fires too intense for direct attack parallel attack recommended
3.0 - 10	2000 - 4000	Very High	Crown fire at upper intensities, indirect attack recommended
> 10	> 4000	Extreme	Crowning, spotting and major fire runs likely, control efforts probably ineffective

Table 2A Flame Height Indicator

2.3.6 Fire Line Establishment

Whether a fire line is being established during direct attack or by the parallel or the indirect method, crews should work systematically. This will ensure greater personal safety and more efficient line production and is particularly necessary in thick scrub. Even in open country, where firefighters and machines have ample space to manoeuvre, they should follow orderly procedures.

A group of firefighters who have had no previous experience of fire line construction with hand tools tend to bunch together or walk past the persons ahead in search of a new section. If space is limited firefighters may obstruct the work of others and possibly injure them with the tools they are using. It is preferable that each firefighter maintain the same relative position in the line as was assumed at the start of the job. This can be achieved by the *step-up method* and the *one-lick method*, as taught by the Rescue/Bushfire Section.

Step-up Method

In this method of fire line construction the crew members space themselves along a proposed line or trail so that each one has a section to complete. When an individual reaches the end of the work available to them, they call out *step-up*. This signal is repeated all along the line and each firefighter then steps forward until he/she finds some fresh work to do.

One-lick Method

This method is used when the job requires the use of a variety of hand tools e.g. in the sequence of axe, brush hook, *Mcleod* tool and rake. As the firefighters move forward, each does some work which is appropriate to the tool he/she is using.

Firstly, heavy material such as fallen limbs and shrubs are dealt with. Then, the grass and other surface vegetation is chipped out. Finally, the rakers leave the line in a bare condition.

The same principles can be applied if two or more tankers are being used in tandem along a track. The first unit reduces some of the severity of the fire and those that follow complete extinguishment.

At a grass fire, two hose reels may be used from the same tanker as it drives along the fire edge. The first hose jet knocks down the flames, the second completes extinguishment.

2.4 Incident Control System

Every firefighter needs to know where they fit into the incident ground organisation and what their particular tasks are. The person in control of the incident ground needs to know what the fire is doing, what it is likely to do next and the resource commitment and deployment.

To do this speedily and effectively there needs to be a good communications system, which is used to good effect. The latter is achieved through the effective use of an Incident Control System (ICS).

ICS - The Four Functions

An ICS is a structure of delegation to ensure that all incident ground management and information functions are adequately carried out.

An ICS is divided into four functional areas:

- Control;
- Operations;
- Planning; and
- Logistics.

Control:

The Control function is the overall direction of response activities at a fire/incident. The Incident Controller is designated by the agency/service responsible for overall management of the fire/incident.

Operations:

The Operations function is to combat the fire/ incident through directing tactical activities and deployment.

Planning:

The Planning function is to support activities at the fire/incident by:

- collecting and analysing information on the fire/incident;
- predicting fire/incident behaviour;
- keeping track of resources; and
- proposing strategies to control the fire/incident.

Logistics:

The Logistics function is to support activities at the fire/incident by providing:

- facilities;
- services; and
- materials.

At a small fire/incident, or during the early stages of a larger fire/incident, these four functions may be carried out by one person. However at a larger, well developed fire/ incident, each may be carried out by a different person assisted by specialised staff. The ICS should grow to match the incident.

ICS is to be implemented at all wildfires involving more than one appliance.

2.5 Safety and Survival

2.5.1 Causes of Death

There are five different ways a person can die in fire:

- the body's heat regulation capability fails;
- the person is overcome by smoke and lack of oxygen (anoxia);
- the person is poisoned by carbon monoxide or other toxic gases;
- the lungs are seared by superheated gases; and
- the body is burnt.

NOTE

The most common cause of death is failure of the body's heat regulation system. People who survive do so largely by protecting themselves from radiant heat.

The passage of the fire front at any one point may take up to 4 mins in a forest fire and 30 secs in a grass fire. Intense radiation will be experienced during this period and then decrease during the burn out period after the front has moved through.

When the body's heat regulation capability fails, death comes from heat stroke caused by excessive radiation. This has been confirmed by both laboratory and field studies, including case histories of people surrounded by grass or forest fires.

Generally, people trapped in a bushfire are not overcome by lack of oxygen, or affected by their lungs being seared by hot gases. The danger is more that a person will act irrationally and be exposed to excessive radiation.

CAUTION

Radiant heat intensity decreases as the distance from the fire increases. Always keep a safe distance from the fire front by employing flank attack, parallel or indirect fire fighting methods when flame heights above 1.5 m are expected.

If trapped by fire, the best protection against radiation is to shield yourself from burning materials and flames by placing a barrier between your body and the heat source. Opaque materials such as clothing, wood, earth, stones and metal can be good barriers.

2.5.2 Clothing

Laboratory tests have verified that it is the thickness of clothing material which is the main factor in reducing the amount of radiated heat affecting the body. As much as possible, exposed skin should be covered.

Firefighters should always be correctly dressed in protective clothing when attending any incident. The following items of clothing equipment should be worn at bushfires:

- helmet (baseball cap may only be worn at grass fires, helmets **must** be worn at wildfires);
- lightweight woollen trousers and workshirt or bushfire jacket;
- boots;
- work gloves; and
- goggles should also be available for protecting the eyes from flying particles and smoke.

The balance necessary in clothing selection is to provide essential protection from physical injury i.e. abrasions and lacerations from vegetation, direct burns from hot ash and embers as well as radiant heat. At the same time, to avoid the added burden of heat stress by not trapping body heat resulting from physical activity.

Keep your sleeves rolled down and loosely buttoned at the wrist but allowing free air flow when operating near flames. Remember, there is always a margin for flexibility in the way we are dressed. There may be some advantage in having the forearms bare at certain times, particularly when there is no fire burning in the immediate vicinity, to obstruct as little as possible the escape of heat from the body by the evaporation of sweat. Observe your surroundings and use common sense.

⚠ **NOTE**

When protecting structures, full turnout clothing and BA may be required.

2.5.3 Heat Stress

Heat stress is the most common condition which affects firefighters. It all too frequently affects their welfare, but more importantly, it affects their judgement and competence in the field.

⚠ **NOTE**

If heat stress is left undetected or untreated, it can quickly lead to a life threatening situation.

All firefighters must be able to recognise the symptoms of:

- heat stress;
- heat exhaustion; and
- heat stroke.

If you are to quickly recognise the symptoms of these three stages, you need to understand what is happening to the body and its ability to regulate its own temperature.

Body heat, which we know as metabolic heat, results from muscular work. Heat is also absorbed from the environment i.e. the radiant heat from the fire or the sun. The body also gains heat by convection when the air temperature is 36° C and above.

The body controls its temperature by circulation and sweating. The heart increases its rate, and pumps the blood near to the skin and, at the same time, the body sweats. The face may become flushed. As the sweat evaporates, it draws heat from the body in the same manner that a canvas water bag keeps the water cool - evaporation requires heat - the heat is drawn from the water - hence it is cooled.

Individuals differ in their responses to the same heat stress, because each person has a different ability to regulate his/her own heat tolerances. Firefighters who are physically fit are better able to cope with strain and therefore have a greater tolerance of heat stress.

If water is not taken regularly, sweating will lead to dehydration of the body and heat illness will result.

Working in a heated environment imposes severe heat stress. A crew leader has the responsibility of watching for the warning signs in the members of the crew. The symptoms and recommended treatment for heat stress are described in Table 2B.

SYMPTOMS	TREATMENT
Weakness Dizziness Nausea	(1) Move the patient away from the work environment (2) Sit the patient in the shade (3) Loosen clothing (4) Give regular sips of plain water

Table 2B Heat Stress Symptoms/Treatment

If the symptoms of heat stress are recognised early enough, the firefighter will recover quickly.

2.5.4 Heat Exhaustion

If the symptoms of heat stress are not recognised, the firefighter will move into a stage of heat exhaustion.

Consider what is happening. The brain recognises that the body is overheating due to stress and dehydration. It slows down the system.

The symptoms change accordingly as does the treatment. Table 2C details both the symptoms and the immediate treatment for heat exhaustion.

2.5.5 Heat Stroke

If the symptoms of heat exhaustion are not recognised, the patient will progress into a state of **heat stroke**.

Consider what is happening. The brain has become affected and no longer instructs the body to cool down. **The body's metabolism has failed and the result is detailed in Table 2D**.

SYMPTOMS	TREATMENT
Weak pulse (blood pressure is lowered) Shallow breathing (breathing increasing) Clammy skin (sweating) Pale face (result of lowered blood pressure)	(1) Seek medical attention (2) Lay the patient in the shade (3) Remove or loosen clothing (4) Sponge with cool water and fan to increase ventilation and evaporation (5) Give frequent drinks of water. (6) Remove from the incident ground for rest

Table 2C Heat Exhaustion Symptoms/Treatment

SYMPTOMS	TREATMENT
(1) Rapid and strong pulse (increased heat rate) (2) Hot, dry skin (dehydration - no sweating) (3) High temperature (body heat not controlled) (4) Flushed face (increased circulation and temperature) (5) Patient likely to be irritable, confused, apathetic and may lose consciousness	Urgent medical attention is essential (1) Have someone radio for an ambulance (2) Lay the patient in the shade (3) Remove and/or loosen clothing (4) Sponge copiously with water and fan to increase evaporation ⚠ **NOTE** **Every minute's delay in cooling the patient increases the likelihood of permanent injury or death** (5) Give frequent drinks of water (6) Hospitalisation is necessary ⚠ **NOTE** **Evacuation should not be attempted before treatment, as the body must be cooled immediately.**

Table 2D Heat Stroke Symptoms/Treatment

2.5.6 Fluid Replacement

The human body may be regarded as being similar to a water cooled engine; muscles and internal organs are the heat source, the blood is the coolant, and the skin is the radiator. Heat is removed from the skin by the evaporation of sweat (or water).

Studies indicate that many firefighters may fail to replace body fluids, even though they may drink sufficiently to quench their thirst. Strenuous exercise in a heated environment, such as fire fighting, can result in body fluid losses in excess of **1 L/h**. Fluid replacement, when taken according to thirst, will usually replace only about half the quantity actually lost by the body; so that serious dehydration can occur quite quickly.

Whenever your surroundings are warmer than your skin (a common enough situation in fire fighting), your body is unable to lose heat by radiation and convection. The evaporation of sweat, then, becomes your sole means of preventing overheating.

Sweating is sensitively adjusted to the body's need for cooling, and the only way to reduce sweating is to reduce heat stress. If sweating stops while heat stress continues, (this is a very grave sign), body temperature rises steeply and heat stroke follows.

Dangerous dehydration can occur in as short a time as 1 or 2 hrs of hard work on the incident ground. It is clear therefore that frequent water intake is essential.

It is not difficult to replace these salt and water losses, it is simply a matter of maintaining a sensible food and water intake. Consider the following simple rules:

- there is no immediate need to replace salt - this can be done with normal food intake; **Do not take salt tablets**;
- drink plenty of water. You will become thirsty; however your thirst is not sufficient to tell you how much you need to drink. There is a time lag within your body and you may, in fact, begin to suffer the effects of dehydration before you realise it. You know when you are perspiring so begin then to drink water at regular intervals;
- drink plenty of water before you start work on the fire line; and
- drink more than you feel you need.

Persons involved in strenuous activities are advised to drink to replace their sweat loss, rather than simply satisfy their thirst. For firefighters on the incident ground, the amount is at least **1 L/h**.

⚠ **NOTE**

Do not become dehydrated - drink water. The emphasis must be on water replacement.

Water replenishment is vital for the health and safety of all firefighters. It is especially so for less fit individuals.

Previous training material made reference to cordial, tea, etc, to enhance liquids and make them more palatable. Medical research now indicates that this is not wholly desirable as the sugar content reduces the rate at which water is absorbed into the blood stream. In the wildfire fighting situation, when we are active on the fire ground, plain water is best. Cool water is naturally preferred, if it is available.

Never chill your drinks though as this leads to stomach cramps and tends to artificially quench your thirst.

During rest periods, sweetened beverages such as cordial, etc, are suitable and assist in restoring energy. Milky or fat-containing drinks should be avoided, as should any drink containing alcohol. There is no place for alcohol on the incident ground, nor should alcohol be consumed by firefighters prior to commencing duty.

Be careful when operating out of your own area; the water supply in some areas can cause stomach upset if you are not used to it. Water suitable for drinking may not be available in the area in which you may be operating at a given time. You are well advised to carry containers of fresh water, particularly when assisting out of your own area. During the wildfire danger period, water containers on appliances should be checked at the commencement of each shift.

2.5.7 Food

The most suitable foods to eat both before and during prolonged periods of wildfire fighting are those that contain sufficient carbohydrate. If largely carbohydrate foods such as bread, pasta, cakes and potatoes are eaten, the carbohydrate stores are filled and hard work can be continued for well over 3 hrs.

2.5.8 Rest and Recovery

When crews are expecting to return to the incident ground, attention to rest and recovery will help to ensure that they remain effective. They have three important requirements:

- to cool off;
- to rehydrate; and
- to replace energy.

As far as possible, they should rest in the shade where there is a breeze. Again, where possible, clothing should be removed to allow the most effective cooling.

They should drink sufficient water - certainly more than their thirst dictates.

Food should be predominantly high in carbohydrate. Large quantities of sugar (or glucose), whether in food or drinks, should be avoided.

2.5.9 Communications

Communications are a vital requirement in wildfire suppression activities, and as management techniques, radio and electronics improve, communication will play an even greater role.

The word communications when used in relation to safety and survival extends across the whole range of passing and receiving information and will cover such aspects as person to person, group to group, organisation to organisation and information passing.

Methods which are used to actually communicate may be any of the following.

- word of mouth;
- written instructions or notes; and
- the multitude of electronic aids radio, telephone, computer, facsimile, etc.

Regardless of the direction of the communication or the method employed to achieve any information transfer, the following criteria needs to be understood.

- the person passing the information needs to have a clear understanding of what task he/she is detailing to others;
- persons receiving information should be given all the information about the task; and
- the information needs to flow up, down and across all concerned.

2.5.10 Role

When dealing with safety and survival requirements, it is essential that each individual's role be defined and as far as possible all roles understood. Roles can be divided into three areas.

- those whose role it is to determine the strategy to be employed;
- those whose role it will be to implement the strategy and tactics; and
- those whose role it will be to physically carry out the tasks to achieve the strategy.

It is essential that the three areas do not become separated and isolated from one another e.g. it is absolutely necessary for those who are actually carrying out the tasks to work towards the given objective. But, it is equally necessary that the strategy devised is not beyond the resources available, or simply impossible, then, that information must be transmitted to those who devised the strategy. Adjustments and a new strategy can then be implemented.

The Incident Control System facilitates effective command, control, co-ordination and communications.

2.5.11 Escape Routes and Safe Areas

When engaged on wildfire suppression activities, and irrespective of whether you are part of a pumper crew or a foot party, attention to the type of terrain you are working in, is an essential requirement.

Escape routes are the responsibility of all concerned, planners and developers must provide them, fire trail and forest roads systems need to have them built in when construction is undertaken. Strategists need to know the existence or non-existence of escape routes when determining tactics. Where it is impossible to provide alternate routes then turning circles need to be provided.

The most important feature of escape routes and safe areas is that firefighters must actively seek them out, know their location, size, etc., and plan activities on the incident ground around safe areas and escape routes.

A safe area could be a large expanse of rock, a swamp, or any feature where fuel is absent or sparse.

2.6 Fundamentals for Survival

2.6.1 An Outline of Safety Procedures for Officers in Charge

Table 2E describes a series of safety procedures to be adopted by OIC's and individual firefighters when involved with hazard reduction tasks.

OFFICERS IN CHARGE	INDIVIDUAL FIREFIGHTERS
(1) Remind crew members of their responsibilities for the safety of themselves and others.	(1) Be dressed correctly and if driving take care.
(2) Start each operation from a safe anchor point and develop other places of refuge as the work progresses..	(2) Use hand tools and other equipment carefully. Watch for falling or potentially dangerous areas or limbs.
(3) Use orderly fire line construction methods, e.g. *step-up* and *one-lick.*	(3) Avoid exposure to excessive radiation ; always be alert for escape routes to places of refuge.
(4) Do not attack fires at the head unless safety can be assured. Avoid such action on steep slopes carrying heavy fuel. Pinching Out or backburning may be preferable.	(4) Avoid heat stress ; drink sufficient fluids to replace lost sweat. Protect yourself from radiated heat.
(5) Assess the adequacy of safety measures before starting a backburn. Think carefully before burning back from narrow bush tracks.	(5) Without bunching up, maintain contact with other crew members.
(6) Contact members of the public who may be endangered by the spread of fire. If necessary seek help from the police and other authorities to ensure public safety.	(6) Remain calm - don't panic Place yourself where there is the least amount of fuel.

Table 2E OIC's and Firefighters Safety Procedures

2.6.2 Safety for Individual Firefighters

Table 2F details the fundamental survival actions for an individual caught in a fire whilst in a house, a vehicle or on foot.

Remember - Although fires may appear unpredictable, fire does behave according to a few basic principles which we can study and understand - a knowledge of the basic principles allows for safety and survival on the incident ground.

SURVIVAL IN A HOUSE	SURVIVAL IN A VEHICLE	SURVIVAL ON FOOT
Close all doors, windows	Do not leave the vehicle, stay in vehicle until the fire passes.	Do not run uphill or away from approaching fire
Block crevices between doors and windows	Park in least flammable area.	Do not run through fire unless you can see the other side.
Stay in section of house remote from approaching fire.	Turn ignition off leaving headlights on.	Choose an open space and lie face down on ground.
If time permits, fill gutters, provide emergency water supplies.	Wind up windows, close air vents.	Clear away flammable material.
After fire passes, inspect house, attend to any small fires in and around home.	Get on floor, cover self - radiated heat.	Shelter in surface water, if available, not tanks.
If fires in house cannot be extinguished move to burnt ground outside.	Do not drive through smoke.	Cover exposed skin.

Table 2F Fundamental Survival Actions

2.6.3 Use of Vehicles

Parking

If it is necessary to park a vehicle during fire fighting operations the following points should be observed:

- choose large, open, cleared areas where possible;
- do not block roads or tracks;
- face in the direction of escape route;
- close all doors and windows if the vehicle is unattended;
- apply parking brake and leave in gear; and
- do not lock doors or remove ignition key.

Driving and Operations

When travelling in smoke or dust, reduce speed, switch on flashing lights and headlights and sound the horn and/or siren. Whenever practical, work from burnt or clear ground. Do not block access or escape routes. When travelling on a fire trail ensure turning areas are available and beware of other vehicles on the trail. Reverse appliances into operating positions so that they can be driven away rapidly if evacuation is necessary.

2.6.4 Survival

In Vehicles

Make maximum use of the bodywork of the vehicles to provide protection from flames and radiated heat during fire fighting operations. If trapped by the fire:

- park the vehicle in a burnt or clear area;
- switch on headlights and hazard warning lights;
- close all doors, windows and vents;
- lie down in the driver's cabin or crew compartment and cover your body with a blanket; and

- leave the pump running as the fire approaches if water is available to operate hose reels.

Away from Vehicles

Survival on foot in a forest or grass fire is not easy - even for experienced people. The following principles offer the best course to follow:

- try to move on to bare or burnt ground;
- do not run uphill or away from the fire unless you know a safe refuge is handy;
- move across the slope out of the path of the head fire and work your way downslope towards the back of the fire;
- do not attempt to run through flames unless you can see clearly behind them. This generally means that the flames are less than 1.5 m high and less than 1.5 to 3 m deep at the back or on the flanks of the fire;
- lulls in the fire often result in the flames in these parts being low enough to step or run through to the burnt ground beyond;
- when conditions become severe use every possible means to protect yourself from radiation. On bare ground cover yourself, use wheel ruts, depressions, large rocks or logs to give protection;
- take refuge in ponds, running streams or culverts, but avoid elevated water tanks. Water at ground level does not heat up quickly, but in elevated tanks it becomes warm very rapidly. A body emersed in luke-warm water cannot sweat and at a temperature of 44° C a state of collapse will be reached in about 3 mins; and
- remain calm and do not run blindly from the fire. If you become exhausted you are much more prone to heat stroke and you may easily overlook a safe refuge. Consider an alternative course of action.

⚠ **NOTE**

A recommended practice in the past was to burn an area as a safe refuge and to move into this area as the main fire approaches. THIS IS NO LONGER A RECOMMENDED PRACTICE.

Research indicates that this practice can have the effect of advancing the main fire toward you with greater intensity. The time needed to employ this tactic safely is sufficient for you to move to a safe area. You are better advised to do so.

Near Buildings

A house or other substantial building can offer the best shelter in the event of a bushfire; it will provide a better shelter than remaining on foot in the open, or in a vehicle. Even though a building may burn down later, it will provide protection for its occupants whilst the main intensity of the fire passes.

It is advisable to stay outside the building for as long as possible, extinguishing small outbreaks. When you are no longer able to stay outside, move into the building, watching for and extinguishing any outbreaks, paying particular attention to the roof spaces.

When conditions permit, move outside and continue to extinguish outbreaks until the building is safe and/or additional assistance arrives.

2.6.5 Dangerous Situations

Fatalities mostly occur when there is a sudden change in fire behaviour associated with a change of:

- slope;
- wind speed and direction;
- spotting activity.

Fatalities may occur during extreme fire weather but also occur under relatively mild conditions in deceptively light fuels.

Crown fires in eucalypt forests can occur only if supported by an intense surface fire in heavy fuels. However, to ensure safety, there needs to be an area, without fuel, large enough for the heat from the surface to be dissipated in the tree crown. Under extreme conditions, a forest fire may travel up to 100 m in the tree crowns over burnt ground.

Fires burning downslope under the influence of an eddy wind may appear particularly mild. Rates of spread and flame heights can increase more than 30 times once the fire commences to run upslope with the prevailing wind.

Spot fires landing ahead of the main fire may appear to be surprisingly mild - they are. These fires do not reflect the intensity of the main fire as they are burning in an area of low winds. A sound knowledge of fire behaviour will allow firefighters to recognise dangerous situations. The following situations are ones which require a high degree of caution:

- you are on a steep slope with fire below you;
- you are approaching a fire burning slowly downslope from across a steep gully;
- you are immediately downwind of a large fire;
- spot fires start to fall in the area around you. This situation is critical. You must evacuate the area immediately. **Do not** attempt to suppress multiple spot fires unless a **large** safe refuge is nearby;
- you have heavy fuels between you and the fire edge; and
- you are in an area where there are fine suspended fuels extending some height above the ground.

The following danger signs may give advance warning of an increase in the rate of fire spread. Seek confirmation from someone outside:

- there is an increase in wind;
- there is a sudden drop in wind strength. This may mean that
  - you have moved to a sheltered location;
  - a change in wind direction (and perhaps an increase in strength) is about to occur;
  - you are directly downwind of an intense fire;
- you have low-level smoke blowing directly above you;
- the fire sends up puffs of intense black smoke occasionally or pulsates; and
- the relative humidity drops below 25%.

NOTE

Always observe smoke columns and cloud formations closely. These will usually give advance warning of wind changes and indicate direction of fire spread.

Avoiding dangerous situations requires the officer to make an appreciation of the fire to avoid putting crews into potentially dangerous situations. The Incident Controller must then interpret changes in fire behaviour in terms of the likely effect on crew safety.

The Crew Leader's responsibilities will be met by a team approach to safety which takes account of:

- the leader adopting a sound tactical plan;
- every person knowing the plan;
- a safe control point being established, publicised, and used as a base for operating;
- an escape route being planned and discussed;
- local knowledge of terrain or good map craft being the basis for judgments;

⚠ **NOTE**

Do not panic - remain calm at all times.

2.6.6 Watch out Situations

The following are considered a list of **watch out** situations:

- fire not scouted and sized up;
- in country not seen in daylight;
- safety zones and escape routes not identified;
- unfamiliar with weather and local factors influencing fire behaviour;
- uninformed on strategy, tactics and hazards;
- instructions and assignments not clear;
- no communication link with crew members/supervisors;
- constructing line without safe anchor point i.e. starting from a road, trail, creek etc;
- building fire line downhill with fire below;
- attempting frontal assault on fire;
- unburnt fuel between you and the fire;
- cannot see main fire, not in contact with anyone who can;
- on a hillside where rolling material can ignite fuel below;
- weather is getting hotter and drier;
- wind increases and/or changes direction;
- getting frequent spot fires across line;
- terrain and fuels make escape to safety zones difficult; and
- having a sleep near the fire line.

2.7 Public Education

2.7.1 Wildfires and Your Home

The advice normally given to householders is to stay put when a wildfire approaches, emerge after flaming has subsided, and then deal with any fires that may have been ignited in some part of the house structure.

This advice needs to be qualified and can be regarded as valid only if a considerable width surrounding the house has been maintained free or nearly free of fuel.

2.7.2 Evacuation

The NSWFB does not favour large scale evacuation as a general strategy in wildfire fighting operations.

Properly prepared homes should be capable of withstanding the initial passage of a fire front, and provide a relatively safe refuge.

The guidelines for Structure Triage should be applied to determine whether or not evacuation is necessary. Homes which are ill prepared and difficult to protect may have to be evacuated.

Able-bodied residents should not be denied the opportunity to protect their family home if it is well prepared, sufficient fire fighting resources may not be available, and evacuation may lead to the loss of such homes after the fire has passed.

When deciding whether or not to evacuate consider:

- whether the house is prepared (defensible space, clear gutters etc); and
- whether the residents are able-bodied.

⚠ **NOTE**

There are several categories who should be evacuated including:

- **the old;**
- **the infirm;**
- **children; and**
- **those who cannot cope with the stress of fire.**

When evacuating consider:

- evacuation routes and effect on responding appliances;
- availability of Police and/or SES to assist; and
- location of evacuation centres (see local *DisPlan*)

2.7.3 Vehicles and Wildfire

A similar qualification should apply to the recommendation that car travellers should crouch down within their vehicles when a fire approaches, and emerge when flaming has subsided.

The advice is reasonable enough for fast moving grass fires, when flaming is over quickly. In forest areas, where flaming usually persists much longer than in grassland, sheltering in a vehicle should be regarded as the last resort if a creek or an appropriate area of bare ground is not available for survival.

SECTION THREE - HAZARD REDUCTION

CONTENTS

Section 3	Hazard Reduction	1
3.1	Prescribed Burning	1
3.2	Firebreaks	1
3.3	Activities other than Burning	1
3.4	Broad Area Prescribed Burning	2
3.5	Activities on the Fringe of Towns/Villages	2
Section 3	Illustrations	
Fig 3.1	Inner Fuel Free Zone/Outer Hazard Reduced Zone	3
3.2	Recommended Positioning of Firebreaks	3

3 HAZARD REDUCTION

3.1 Prescribed Burning

The term **firebreak** generally conjures up the picture of relatively narrow barriers of bare ground which are intended to bring fires to a halt.

In Australia they are seldom capable of achieving this objective under all circumstances and might be described better as *fire brakes*, which are more useful for slowing, than stopping fires, and should be supplemented by other activities designed to control the quantity of fuel.

When fire is the principal agent for such reduction the terms fuel reduction burning, hazard reduction, control burning, controlled burning and prescribed burning have been used.

Here the generic term **hazard reduction** and the specific term **prescribed burning** are used.

3.2 Firebreaks

Any area of bare ground or water which has the capacity to halt or divert a fire, or provide refuge for man or animals, can be regarded as a firebreak. Some such as stretches of water, bare rock and rain forest are entirely natural. Others such as roads, railway easements, irrigated paddock and land under fallow are man-made. Narrow bush tracks or even cattle pads may hold up fire under some circumstances. Additional clearings can be made to extend the basic framework so fortuitously provided by man and nature. Some of these, such as fire trails, also provide access for firefighters.

Almost all of these barriers are capable of containing the spread of fire when wildfire danger is low to moderate. Many are similarly effective and/or provide suitable base lines for backburning when fire danger is high to very high.

When fire danger is extreme they are essential for the protection of buildings and some other classes of property. Due to the effect of long distance spotting their capacity to bring fires to a halt is diminished but this deficiency may be improved by hazard reduction activities carried out previously.

3.3 Activities other than Burning

These activities include slashing or mowing low vegetation on road verges, in small parks and on private allotments.

The resultant debris is sometimes removed, or burnt in heaps, or may become matted down into a compact form, which is less favourable to the spread of fire, than if left in its normal condition of vertical arrangement.

Although each operation is usually on a small scale, the sum total of many such activities that are carried out each year, contribute considerably to the hazard reduction work which is desirable for the protection of country towns and the outer suburbs. Unfortunately, the work tends to be piecemeal, and more promising results could be achieved if a greater degree of continuity could be provided within each locality.

Picking up and removing fuel in bushland on the fringe of some suburbs has been arranged to a small extent in recent years. The intentions of those who do this work must be respected but there is usually more concentration on removing relatively heavy material and leaving most of the fine fuel behind. Furthermore, the length covered by this work has been only a slight fraction of the total perimeter where bushland adjoins houses.

Grazing serves a useful purpose in reducing fuel in many areas but has little effect on fuel quantity in the bushland areas which lie within or near the NSWFB Fire Districts.

Fuel reduction by burning carried out to extend the width of firebreaks, or in the form of prescribed burning over larger areas, has more practical significance.

Improving the Roads as Firebreaks

Apart from roadside slashing which was mentioned earlier, opportunities for providing more effective firebreak widths sometimes present themselves. Such work includes the burning of strips between parallel roads or tracks or where a road adjoins a railway line.

When carrying out this work signs warning motorists of smoke hazard ahead must be displayed, and the presence of police to control traffic may be warranted under some circumstances.

3.4 Broad Area Prescribed Burning

Although the NSWFB is not directly concerned in these operations, it is represented on various public bodies, which are responsible for organising the prevention and control of fires in some of the large areas of bushland in the eastern part of NSW.

In some areas this work is carried out by ground parties within a framework of roads and other barriers. These days however, most of the work is done by dropping delayed action ignition devices from fixed wing aircraft or helicopters in a process known as aerial ignition.

Low intensity fires are lit in a grid pattern in the more flammable fuel types. A mosaic hazard reduction pattern is sought whereby, the chances of wildfires starting in remote places and spreading there, will be lessened, and firefighters can operate safely and with better prospects for success.

As noted in Section 2, fire intensity, rate of spread, flame height and spotting potential are reduced when the amount of available fuel is decreased.

3.5 Activities on the Fringe of Towns/Villages

When areas on the fringe of certain Sydney suburbs and some other towns and villages within 150 km of Sydney are taken into account, the total number of houses at some degree of risk in the relevant Fire Districts probably exceeds 200 000.

Large numbers of houses intermittently come under threat from major fires in the Blue Mountains and elsewhere and on various occasions many buildings have been lost, e.g. in the Blue Mountains 123 in one day in 1957, 49 in one day in 1977, 205 in NSW January 1994.

The problem of protecting buildings is two-fold, involving the provision of an adequate width of virtually fuel free firebreaks adjoining buildings which is known as the inner zone, and the inclusion of an outer, or hazard reduced zone, which is usually in bushland beyond the boundaries of properties.

Both the Inner Fuel Free Zone (A) and the Outer Hazard Reduced Zone (B) need to be wider on steep slopes to isolate houses, householders and firefighters from the flames and heat of wildfires (See Fig 3.1).

Prescribed burning activities are being progressively devolved to local Fire Station staff, with support and training provided by the Rescue/Bushfire Section.

Only those officers who have received such training are authorised to supervise burning operations.

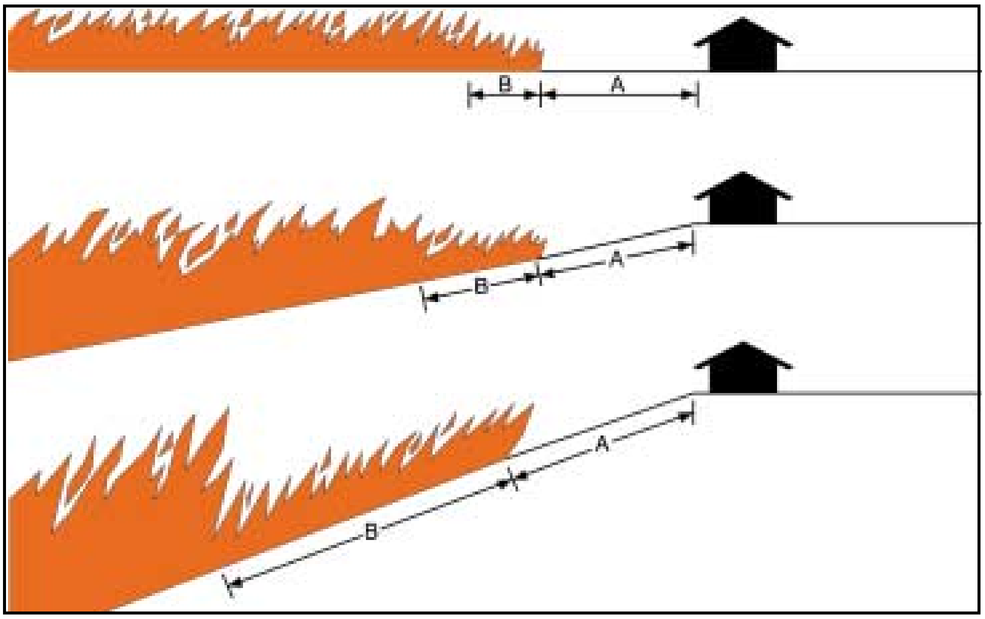

Fig 3.1 Inner Fuel Free Zone/Outer Hazard Reduced Zone

Fig 3.2 details the recommended minimum width in metres of firebreaks adjoining buildings in bushland areas.

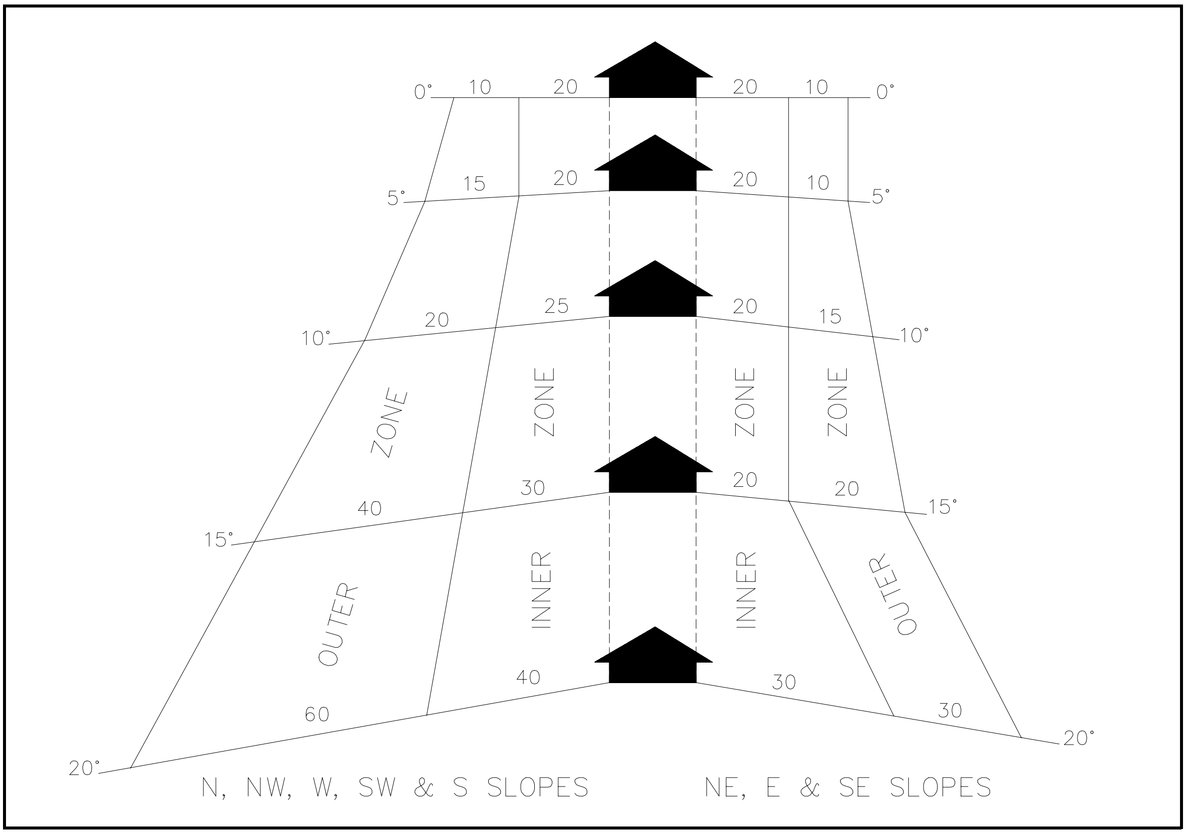

Fig 3.2 Recommended Positioning of Firebreaks

SECTION FOUR - MAP READING

CONTENTS

Section 4	Map Reading	1
4.1	Topographic Maps	1
4.2	Map Size	1
4.3	Revision	1
4.4	Border Information	2
4.5	References and Grids	3
4.6	Calculation of Distances from Grid Co-ordinates	4
4.7	Interpretation	4
4.8	Map Symbols	5
4.9	Methods of Showing Relief	6
4.10	Terms Used	7
4.11	Height Representation	9
4.12	The Magnetic Compass	9
4.13	Finding Direction Without a Compass or a Map	10
4.14	Conversion of Bearings	11
4.15	Map Orientation	12
4.16	Cross Country Navigation	13
4.17	Following a Course with a Compass	15
Section 4	Illustrations	
Fig 4.1	Some Examples of Border Information	3
4.2	Grid Reference Sample	4
4.3	Examples of Some Common Map Symbols	5
4.4	Example of Showing Hachures	6
4.5	Example of Showing Hill Shading	6
4.6	Method of Showing Contour Lines and Height	7
4.7	Physical Features Shown on Maps	8
4.8	Using the Southern Cross	11
4.9	Bearing conversion - Example 1	11
4.10	Bearing Conversion - Example 2	11
4.11	Using a Back Bearing	12
4.12	Use of the Protractor	12
4.13	Orienting a Map	13
4.14	Using a Non-adjustable Compass	16
4.15	Using a Swinging Dial Compass	17
4.16	Using an Adjustable Dial Compass	18
Section 4	Tables	
4A	Terms Used in Map Reading	8S

4 MAP READING

4.1 Topographic Maps

Maps have been used since ancient times as a means of indicating the relative positions of features of the earth's surface.

Maps may be used as an aid to detailed planning and development of any area of land from residential sections to entire countries.

Many map users are more vitally concerned with deriving information that will assist them to find their way about an area with a foreknowledge of the terrain and obstacles that may lie in their path. Topographic maps are ideal for this purpose, showing the earth's natural physical and cultural, or main-made features in such a way that close study of the map can give the user a detailed picture of the area represented.

Topographic maps are a pictorial representation of all significant natural features (hills, creeks, timber coverage) and man-made features (roads, railways, townships, buildings) and many descriptive notes. They are a form of communication to convey to the map user the special relationship of features on the earth's surface.

Most of NSW is now covered by detailed topographic maps at scales of 1:25 000 along the coastal area, 1:50 000 inland and 1:100 000 in the far west.

4.2 Map Size

The words large and small when used to describe map scales are a source of confusion to many people. A common misunderstanding is that a large scale map covers a large area and a small scale map a small area.

If you were to look at two maps of the same area but at different scales, the map on which features appeared larger would be the larger scale map of the two.

Scale is the ratio of the size of a feature as it appears on a map to its actual size. This ratio is known as the representative fraction, for example 1:100 000 - one to one hundred thousand - is a smaller fraction than 1:50 000. Thus a 1:100 000 map is a smaller scale map than a 1:50 000 map.

At 1:250 000 (a smaller scale) it takes 544 maps to cover Australia, but it would take about 50 000 maps to cover the same area at 1:25 000 (a larger scale).

4.2.1 Map Scales and Distances

Ground features are shown on a map in the same relative position as their actual location, but symbolically reduced to a fraction of their true size. The amount or reduction applied is known as the representative fraction.

This fraction represents the relationship of a distance on the map to the actual distance on the ground, e.g. a map with a representative fraction of 1:25 000 means that one unit of distance on the map represents 25 000 units on the ground.

Thus, 1 cm (on the map) = 25 000 cm (on the ground) or 250 m or 0.25 Km Clearly map reading becomes much easier with metric distances.

4.3 Revision

It will be appreciated that while natural features remain relatively undisturbed, cultural features are subject to constant change, and therefore the information on a map must be constantly revised.

Maps showing such a wealth of information as that on the topographic maps would need to be revised continuously in order to keep them completely up to date but with a large number of maps to produce this is not possible.

The rate and amount of change varies greatly from urban to remote areas and therefore maps are not all revised at definite intervals or to the same extent.

The needs of the map users for up-to-date maps are considered in selecting maps for revision. Map users can assist by providing information on apparent errors or omissions to the producer of the particular map.

4.4 Border Information

All map users should be familiar with information available in written and pictorial form around the edges of the map. This information identifies and explains the map, it also supplies details applicable to its use, the date of the information, and the sources from which it was obtained (see Fig 4.1).

The type of information and the layout may differ slightly from one map to another. Listed are items that are normally part of the standard layout.

- map title;
- type of map (e.g. topographical, geological);
- map edition and sheet number;
- magnetic variation diagram;
- grid reference block;
- legend of symbols;
- control and production data;
- index to adjoining sheets;
- map scale representative fraction;
- linear scale bar; and
- contour interval.

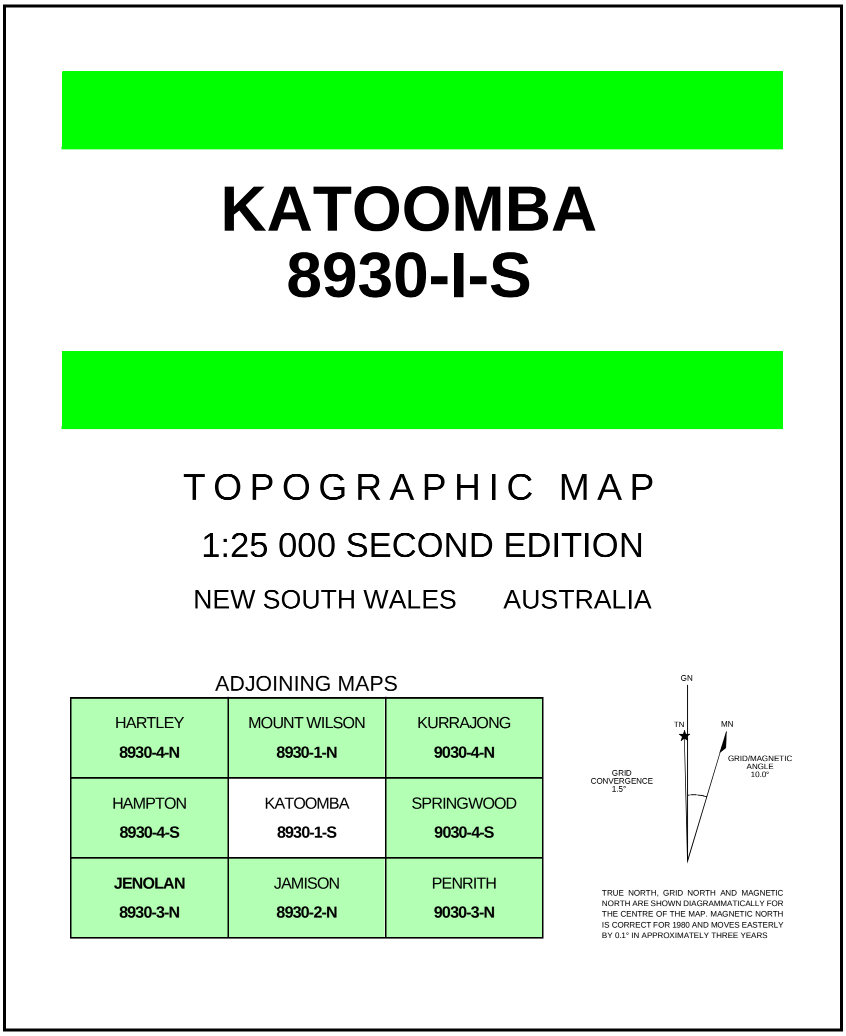

Fig 4.1 Some Examples of Border Information

4.5 References and Grids

Maps are provided with a system of squares called a grid and the ground distance represented between the grid lines that form the squares is usually quoted in the marginal information of the map. On the 1:25 000 topographical map series, the ground distance represented between grid lines is 1000 m or 1 km.

The values quoted for the grid lines are their distances from a selected position called the false origin which is outside the map to the south-west. Thus all values are positive east and positive north from this false origin. This means that all positions on the map can be referred to by their eastings and northings.

In a grid reference, the eastings are always quoted first. The full grid value is always shown in the margins near the south-west corner. For the remainder of the grid lines, only the digits, representing thousands of metres are shown.

A grid reference is generally represented by six numbers. Suppose you wished to plot a grid reference 559727 on Fig 4.2; the steps are as follows:

- divide the grid reference into two parts **559 727**;
- find the easting grid line 55 along the top or bottom of the map;
- measure and mark 9/10th of the grid interval to the east of the grid line 55;

- find northing grid line 72 along the west or east edge of the map;
- measure and mark 7/10th of the grid interval to the north of the grid line 72; and
- extend these marks into the map area parallel to the grid lines. Where they intersect is the map position required.

To determine the grid reference for a feature on the map, simply reverse the process.

⚠ **NOTE**

Before giving a grid reference, users should state the number and name of the map e.g. 8930-1-S KATOOMBA 559727. Notes on the grid reference system are generally shown in the border of topographical maps.

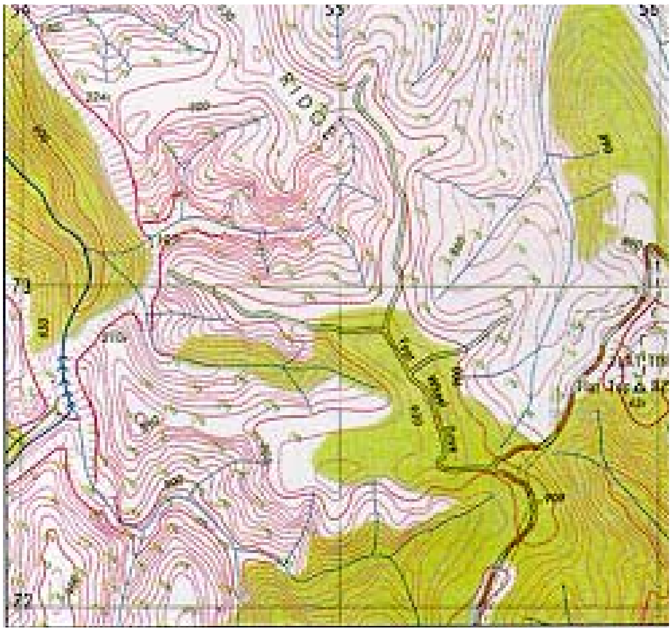

Fig 4.2 Grid Reference Sample

4.6 Calculation of Distances from Grid Co-ordinates

Since any two points on the map can be expressed by their grid references, it follows that the distance between them can be calculated using these values. Suppose we have two features with the grid references 063 168 and 152 207. By carrying out the following calculations (using a calculator) you can find the distance between the two grid references.

- subtract the second figure from the first for each group of figures.

15.2	20.7
06.3	16.8
8.9	3.9

- square both values 8.9 and 3.9 = 79.21 15.21
- add the values together = 94.42
- take the square root of the figure and the distance is 9.72 km or 9717 m.

4.7 Interpretation

Map interpretation is the art of extracting from a map all the information it contains so that a picture can be drawn in the mind of the shapes and slopes of the ground, the pattern of streams and rivers, the vegetation cover and the location and nature of man-made features. Maps are sometimes described as *pictures of the earth as seen from above* and their purpose is to allow a person to visualise far more of their surroundings than they are able to see when standing on the ground.

By being able to immediately identify the symbolisation on a map with the natural and man-made features, you are then able to understand the nature and form of the ground and the relative position and direction of one feature in respect to another.

Map reading is best learnt through experience, out of doors, by comparing the detail on the map with the actual area of country it portrays. You can also study a map of a well known piece of country and again compare it to your knowledge of the area. This knowledge can be used in reverse to gain an appreciation of unknown terrain from the map e.g. by comparing the spacing of contour lines in a known area to those in an unknown area, the relative steepness of a slope may be determined.

Familiarisation with map symbols is paramount to ensure a complete understanding of information depicted on topographic maps. You will appreciate the variety of information available by studying the legend in Fig 4.2, e.g. there are five classifications of roads shown. As legends may vary with differing map scales (and sometimes, for maps of the same scale) it is essential to study and become familiar with the symbols in the legend before any map interpretation is undertaken.

4.8 Map Symbols

Symbols are used on maps to represent features which exist on the ground, and draw to the map users attention significant features that would not be so easily recognised if they were drawn to scale and shape. A building of 10 m x 10 m at ground scale would appear as a speck at 1:100 000.

This would be far too small for easy identification. For this reason, a symbol is substituted for clarity of classification. In many cases these features are easily recognised by their symbols (buildings, streams, roads).

However other symbols, represent intangible features such as administrative boundaries and contours. These will not be seen on the ground although they are some of the most important and useful symbols represented on the maps.

A sample of some of the more common symbols are detailed in Fig 4.3.

The symbols used on a map are chosen because they add usefully to the information shown on the map, and are designed so that they are readily identifiable with the feature they represent.

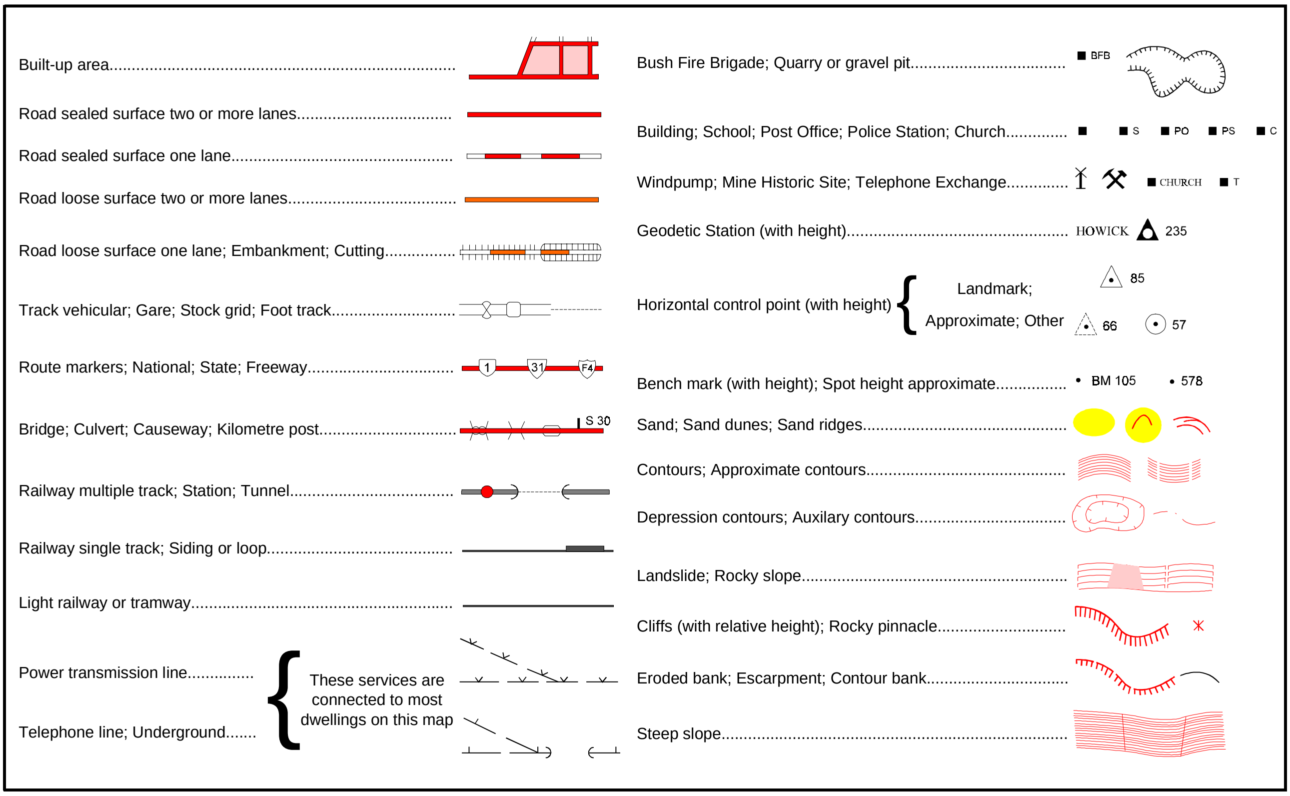

Fig 4.3 Examples of Some Common Map Symbols

The use of colour is an additional aid to identification. Generally, blue for water features, black for culture (man-made) and green for vegetation are International Standards. Other colours are then selected to show as clearly as possible any further information such as relief, road classification etc., so that the overall effect is pleasing and, more importantly, a legible combination of colour, symbols and type.

4.9 Methods of Showing Relief

There are many ways of showing relief on a map, including:

- hachures;
- hill shading; and
- contours.

4.9.1 Hachures

With this method rising ground is shown by a shading of fine lines drawn down the line of the slope and heaviest on the steepest slopes. Hachures give a good impression of the shape of the ground but they have two disadvantages:

- they do not show exact information regarding height, only the illusion of height and therefore heights and slopes cannot be measured; and
- the hachure lines tend to obscure other detail on a map.

Hachures show the relief by means of short disconnected lines. Short, dense lines depict steep slopes while longer and more spaced out lines suggest more gentle slopes (see Fig 4.4).

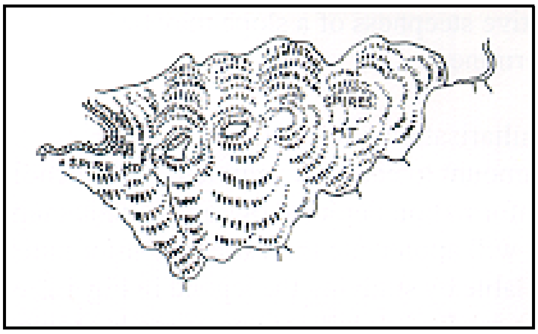

Fig 4.4 Example of Showing Hachures

4.9.2 Hill Shading

Hill shading shows, by darkness of colour, what hachures show by lines. The shading may be applied so that colours darken as the ground rises or it may be applied as if the light was coming from one direction, so that one side of a hill is shown in a lighter shade than the other, for greater definition (see Fig 4.5).

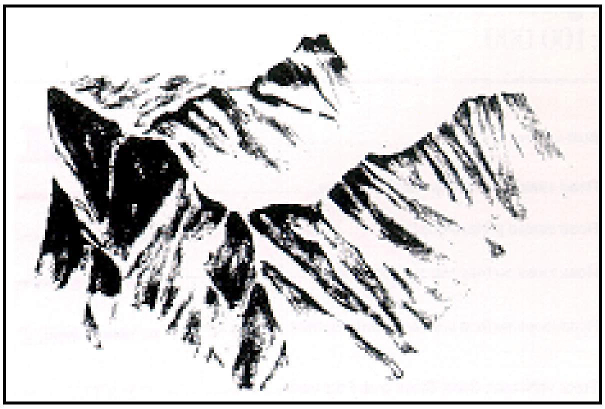

Fig 4.5 Example of Showing Hill Shading

Hill shading is sometimes used on modern maps in conjunction with contour lines. First class maps have been produced using this method.

4.9.3 Contour

The standard way of showing the shape of the ground on modern maps is by the use of contour lines. Contour lines make no attempt to give any visual illusion of relief and it is the failure to recognise this that causes difficulty, with some people, in understanding them.

The idea of a contour is very simple. It is an imaginary line drawn on a map, joining all places of equal height above a fixed datum line (usually at sea level). In Australia, the datum used is the Australian Height Datum (AHD).

4.9.4 Height of Contours

On a map, each contour is drawn at a specific height above a fixed datum and the vertical distance between contours does not vary. The difference in height between contours is called the Vertical Interval (VI) and is shown in the marginal information on a map. It is from the height and spacing of the contours that the shape of the ground can be deduced.

Contour lines are drawn through points on the ground having the same height above Mean Sea Level (MSL).

Some contours have the height shown at intervals along their length. On CMA maps, these heights are mostly printed so that they read facing uphill. This can be of great assistance in determining the direction of high ground.

NOTE

On CMA maps the VI is 10 m 1:25 000, 20 m at 1: 50 000 and 40 m at 1:100 000.

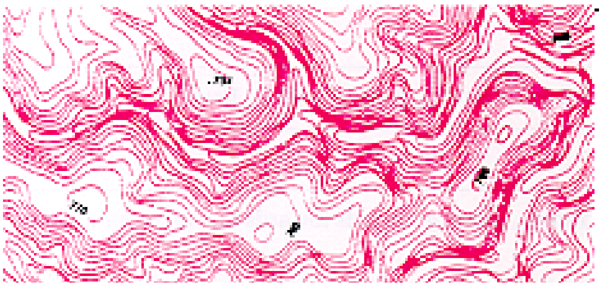

Fig 4.6 Method of Showing Contour Lines and Height

Contour Patterns

Each topographical feature, such as a spur or a knoll, is represented by its own particular contour pattern. The most important points to remember about contour patterns are:

- contour lines close together indicate steep slopes;
- contour lines far apart indicate gentle slopes;
- evenly spaced contours indicate uniform slopes;
- when the spacing of contour lines (reading from high to low), decrease, the slope is convex; and
- when the spacing of contour lines (reading from high to low), increase, the slope is concave.

4.10 Terms Used

Some common terms used in map reading to describe various physical features are illustrated in Fig 4.7 and described in Table 4A.

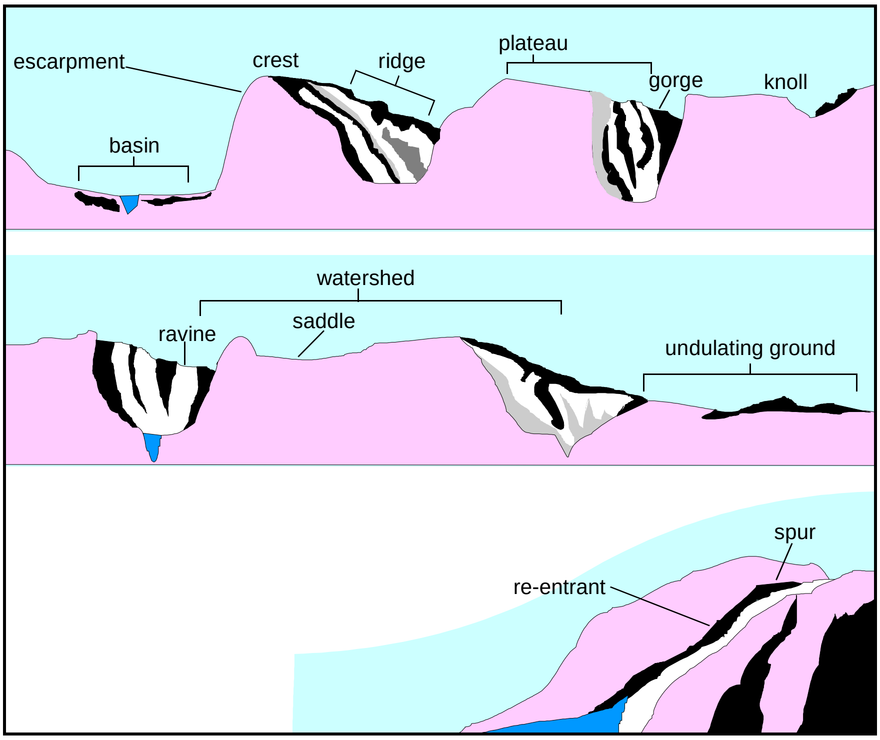

Fig 4.7 Physical Features Shown on Maps

TERM	DESCRIPTION
Basin	An area of reasonably level ground surrounded or nearly surrounded by hills, or an area drained by a river and its tributaries
Crest	The highest part of a hill or mountain range, that line on a range of hills or mountains from which the ground slopes down in opposite directions
Escarpment	The steep hillside formed by a sudden drop in the general ground level, usually from a plateau
Gorge	A deep ravine, usually with steep sides
Knoll	A small knob-like hill
Plateau	A tableland; an elevated region of considerable extent, generally fairly level
Ravine	A long deep valley worn by a stream
Re-entrant	A valley or ravine, usually between two spurs, running inwards towards the hill or mountain top
Ridge	The line along a hill or range of hills or mountains from which the water flows in opposite directions; sometimes the crest of a line of hills as it appears along the horizon
Saddle	A depression between adjacent hill or mountain tops; also called a col
Spur	A minor feature, generally in the form of a ridge running out from a hill or mountain
Undulating Ground	Ground which rises and falls gently

Table 4A Terms Used in Map Reading

4.11 Height Representation

Heights (or elevations) above sea level at specific points are depicted in several ways, the more common being:

- Bench Mark;
- Geodetic Stations; and
- Spot Elevation.

4.11.1 Bench Mark

These have the most precise heights. They are permanent survey marks placed at intervals along levelling routes. The height given is that of the mark, the level of the ground e.g. BM.162

4.11.2 Geodetic Stations

These are usually shown on maps and are defined on the ground normally by a mark in a concrete block under a survey beacon or concrete observing pillar e.g. Boban ^ 176

4.11.3 Spot Elevation

These are less accurate heights and are without a definite mark on the ground. They are selected to indicate the height of the ground at ruling points such as tops of hills e.g. 146

Direction Finding

True North is the direction towards the Earth's geographic North Pole. **Grid North** is the direction of all the vertical grid lines on a topographical map.

Grid North and not True North is normally used as the reference direction for measurement of bearings i.e. grid bearings on a map.

⚠ **NOTE**

The angular difference between Grid North and True North varies across the country but on maps with the Australian Map Grid it is always less than 2°.

Magnetic North is the direction in which the magnetic compass needle points, i.e. towards the north magnetic pole. Across Australia, the direction of Magnetic North varies from about 5° west to about 15° east of Grid North.

The map border information will state the actual Grid Magnetic (G-M) angle for the area covered by the map. The change in the G-M angle over the years (caused by the slight movement of the north magnetic pole) is also shown.

4.12 The Magnetic Compass

4.12.1 Introduction

The magnetic compass is an important aid to route finding and one should be carried by any venturer into untracked country. Magnetic compasses work on the principal that the pivoting magnetised needle, or the north point of the swinging dial always point to the north magnetic pole. Thus, a compass with graduations marked on it can be used to measure the bearing of a direction line from magnetic North.

4.12.2 Pivoted Needle Non-adjustable Compass

The simplest type has a magnetised needle swinging on a pivot with a fixed graduated dial on the body of the compass. This type is not usually **damped,** that is, it does not have the facility to steady the excessive swinging of the needle to bring it quickly to rest.

4.12.3 Prismatic Compass

By incorporating a damping system and a prism magnifier to read the bearings more accurately, the Prismatic Compass is the most refined of the range of hand held compasses.

Taking a Bearing

Hold the compass in a steady position, in both hands with a thumb through the ring, the lid vertical and the prism turned over in the reading position. Looking through the prism, line up the object with the hair line in the centre of the prism slot and read off the bearing on the card against the hair line.

Finding Direction for a Bearing

Look though the prism, turn the compass until the hair line cuts the given bearing and then note some object in the distance which is in line with the hair line. This object will be on the required bearing.

4.12.4 Taking a Grid Bearing from a Map

To take a grid bearing from a map carry out the following actions:

- place the long edge of the compass plate along the desired bearing, making sure that the direction arrow on the compass plate points in the direction you wish to travel;
- turn the compass housing so that the meridian lines are parallel with the grid lines (eastings) on the map; and
- read the grid bearing on the housing where the index line intersects it. Do not forget to apply the G-M angle to the grid bearing, to convert it to the correct compass (magnetic) bearing.

Setting the Compass to Travel on a Magnetic Bearing

To set the compass to travel on a magnetic bearing carry out the following actions:

- set the magnetic bearing on the compass by rotating the compass housing until the required location is in line with the index line on the compass plate;
- holding the compass flat in the palm of the hand, turn it around until the red end of the compass needle points to the north mark on the compass housing and is parallel to the meridian lines; and
- the direction arrow now points along the required magnetic bearing.

To take a Magnetic Bearing

To take a magnetic bearing carry out the following actions:

- hold the compass with the direction arrow pointing to the object;
- rotate the compass housing until the red arrow of the meridian line is directly beneath the red (north) end of the compass needle; and
- read the magnetic bearing on the housing where the index line intersects it. In this case the G-M angle must be applied to convert this magnetic bearing to a grid bearing.

4.13 Finding Direction Without a Compass or a Map

4.13.1 By day (sun visible)

Point the figure 12 on a watch towards the sun, then true north is approximately halfway between the 12 and the hour hand.

4.13.2 With the Southern Cross and the Pointers Visible

Method 1: If the stars are visible, extend the long axis of the Southern Cross from its tail by 4.5 times its length; this point is almost directly above true south (see Fig 4.8).

Method 2: Draw an imaginary line to join the two pointers and then bisect that line with another at right angles to it. The direction of the South Pole will then be directly below the intersection of that line and that which is a prolongation of the long axis of the Southern Cross (see Fig 4.8).

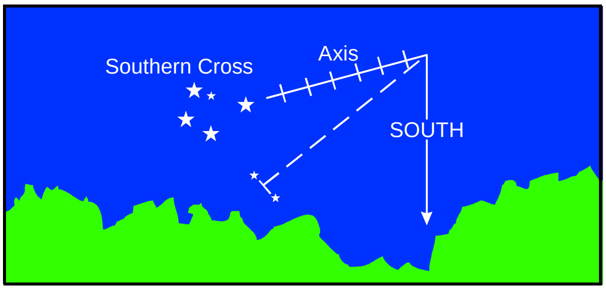

Fig 4.8 Using the Southern Cross

⚠ **NOTE**

All the above methods only apply in the Southern Hemisphere.

4.14 Conversion of Bearings

4.14.1 Introduction

Compass bearings taken on the ground must be converted to grid bearings for plotting on a map. Conversely, grid bearings taken from a map will have to be converted to magnetic bearings before they can be used with a compass on the ground. To convert a bearing from grid to magnetic or magnetic to grid, add or subtract the magnetic variation. (G-M angle).

Example 1: A magnetic bearing of 50° has to be converted to a grid bearing. The magnetic variation is 5° west (see Fig 4.9).

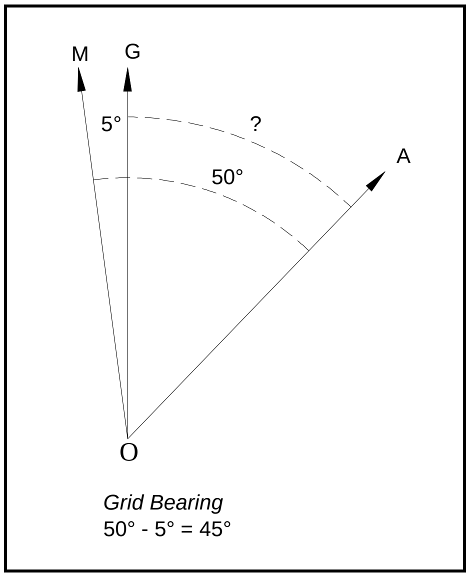

Fig 4.9 Bearing conversion - Example 1

Example 2: A grid bearing of 89° has to be converted to a magnetic bearing. The magnetic variation is 5° west (see Fig 4.10).

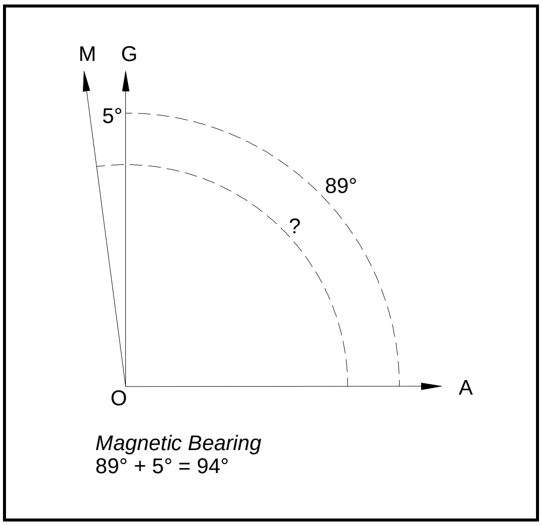

Fig 4.10 Bearing Conversion - Example 2

Back Bearings

A back bearing gives the direction from the object back to the point of observation. The difference between the bearing and the back bearing is 180° (see Fig 4.11). Therefore, given the bearing, to find the back bearing, add 180°, or if the bearing is more than 180°, subtract 180°.

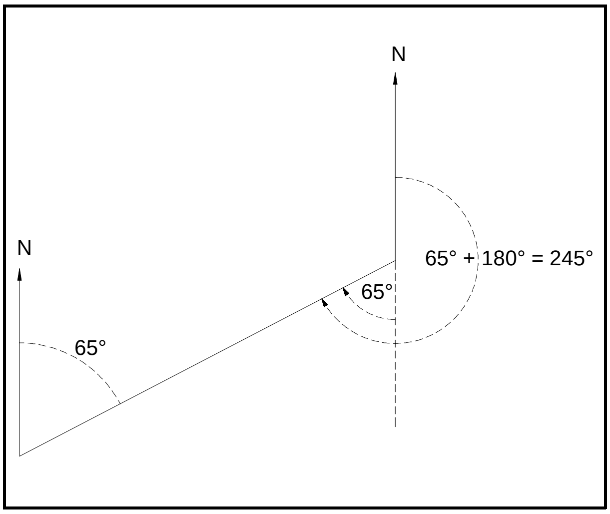

Fig 4.11 Using a Back Bearing

Using a Protractor

To accurately measure a bearing on a map, a protractor may be used. There are many different types of protractors available and although they differ in design and shape, they are used in much the same way. The outer edge of the protractor is graduated in degrees from 0° to 360° clockwise (or when the protractor is half circle 0° to 180°).

Fig 4.12 Use of the Protractor

To measure the bearing from the house at point O to Blue Mountains Ù 727 at point A (see Fig 4.12) carry out the following actions:

- using a straight edge and a fine pencil, join O to A;

NOTE

If the distance between the two points is small, it is best to extend the line through the object to which the bearing is to be taken, so that the line is visible when the protractor is positioned on the map.

- place the protractor on the map and position it so that the centre point or hole is directly over the house at point O, and the north line is pointing to grid north, i.e. parallel to the eastings;
- the bearing can then be read off the graduated edge of the protractor where the pencil line meets it.

Plotting a Grid Bearing

To plot a grid bearing on a map carry out the following actions:

- place the protractor on the map and position it so that the centre point or hole is directly over point O (the point on the map from which the bearing is to be plotted) and the north line is pointing to grid north;
- read off the bearing required on the graduated edge of the protractor and mark the map with a pencil; and
- remove the protractor and draw a thin line through point O and the pencil mark. This line is the required grid bearing.

4.15 Map Orientation

A map is said to be oriented when it is placed so that directions on it correspond to the directions to the same features on the ground. This may be done by holding the map horizontally and rotating it until identifiable features lie in the same direction on the map as they do on the ground (see Fig 4.13).

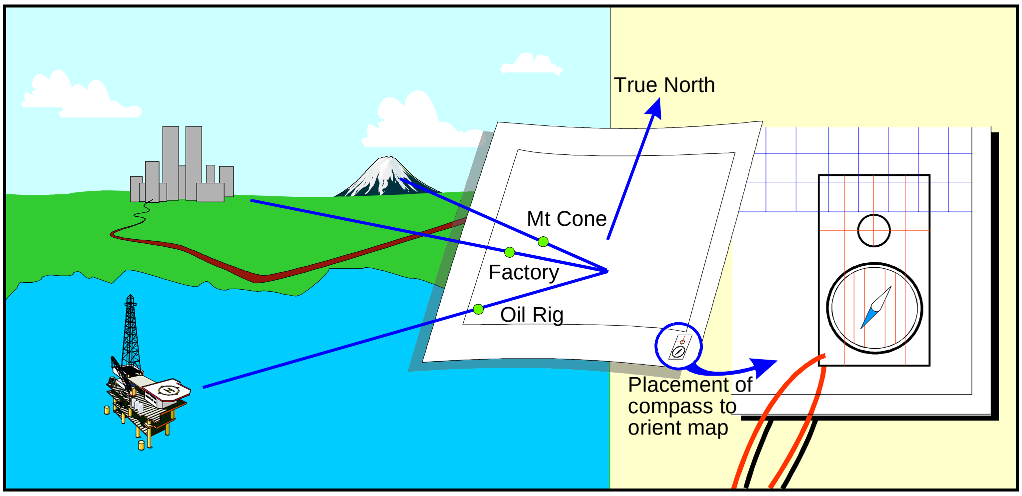

Fig 4.13 Orienting a Map

However, if none of the surrounding features can be identified, the following method, using a compass is suggested:

- the compass points to Magnetic North;
- the angle between Grid North and Magnetic North (the G-M angle) is given in the border notes. This gives the bearing of all grid lines in relation to Magnetic North;
- supposing the G-M angle is 10° East. This means Magnetic North is 10° East of Grid North;
- with the map laying flat, rotate the map until the north-south grid lines are on a compass bearing of 350°. The map is now correctly oriented.

⚠ NOTE

Rule: If Magnetic North is east of Grid North, subtract the G-M angle. If Magnetic North is west of Grid North add the G-M angle.

4.16 Cross Country Navigation

4.16.1 Navigation Aids

Maps and Aerial Photographs

A map is the single most important navigation aid and should be carefully studied, together with aerial photographs, if available, as a preliminary to cross-country navigation. The confidence of the user will be greatly increased by having foreknowledge from a map of the general lie of the land and consequently the best route to take and the areas to avoid.

Compasses

The compass is an invaluable aid when traversing country where landmarks are sparsely separated or identification of them is difficult, such as at night.

4.16.2 Planning

Planning is essential before setting off on a course. A detailed study of the map is made, involving the following;

- topography;
- roads;
- ridges; and
- rivers.

Topography

It is far easier to follow the natural topography of the country than to go against it and therefore, a direct route in the form of a straight line is practical only in relatively flat, open country.

Roads

The following types of warning are included on most maps.

Depiction of roads and tracks does not necessarily indicate existence of a road on the ground.

Unsealed roads may be impassable after rain.

Depiction of cadastral roads does not necessarily indicate existence of a road on the ground.

⚠ **NOTE**

If your think you might be trespassing by choosing a certain route, seek permission first.

Ridges

It is easier to travel on ridges than in valleys as the vegetation is usually less dense and animal tracks are most likely to exist.

Rivers

Although rivers are useful aids to direction keeping, it is generally poor policy to follow them as they are usually winding and bordered by dense vegetation.

Navigation Data Sheet

Before commencing a course, the route to be taken should be divided into legs that should terminate at some easily recognisable object. Having done this, the next step is to produce a Navigation Data Sheet for the complete route.

This provides the significant information required for each leg of the overall route and becomes a ready reference for the user.

4.16.3 Course Corrections

Once a course commences, checking must be continuous. Areas requiring particular attention are covered below:

- location;
- distance travelled; and
- predicted walking time.

Location

All features, hills and rivers should be checked as they are reached and identified on the map. Note the direction of flow of all streams and rivers and check with the map.

Tracks should always be regarded with suspicion. It is easy to place too much confidence in a track which may not be the one marked on the map.

Distance Travelled

It is very important, particularly when moving through vegetation, to know the distance which has been covered. There are two basic methods of achieving this:

- pacing; and
- time.

Pacing

This is generally accepted as being the more reliable method. Distances can be counted in number of paces. Experience has shown that over long distances, it is better to count right foot paces only, rather than each pace. For an average pace of 80 cm, 625 right foot paces will equal one 1 km. When estimating distance from the map, allowances must be made for the rise and fall of the ground as a person is inclined to take shorter paces when climbing or descending than when travelling on flat ground.

Time

Distance can also be calculated by knowing that, with an 80 cm pace, the average walking speed over fairly flat country is about 5 km/h each hour walked means 5 km travelled.

Predicted Walking Time

A rule for predicting walking time in Australian conditions for an average walker carrying a medium pack, allow one (1) hr for:

- every 5 km of easy going;
- every 3 km of easy scrambling;
- every 1 km of extremely rough country, deep sand, soft snow or thick bush; and
- plus one extra hour for every 500 m up and 1 hr for every 100 m down.

4.16.4 Conclusion

Cross country navigation is not easy, but the difficulties are easily overstated. Providing methodical map study and planning are undertaken, followed by careful use of the map and compass, many of the problems should be overcome. With experience, the individual will gain confidence in the ability to use both map and compass.

4.17 Following a Course with a Compass

To set a magnetic compass bearing on a desired direction of travel indicated from the map, and to subsequently check that the course is being followed, one of the following methods (depending on the type of compass) may be used.

4.17.1 Using a Non-Adjustable Compass

- orient the map, using the compass (see Fig 4.14);
- place the compass on the map with the compass centre on the line of travel and rotate the compass until the **N** point of the base is under the needle point;
- sight across the compass (or stretch a length of string) along the general line of travel shown on the map, then read the magnetic bearing on the destination side of the compass;
- memorise the magnetic bearing before moving on in that direction;
- to check the course occasionally during the travel, hold the compass horizontal and steady and turn it until the **N** point of the base is under the needle point; and
- the desired direction is in line with the memorised magnetic bearing.

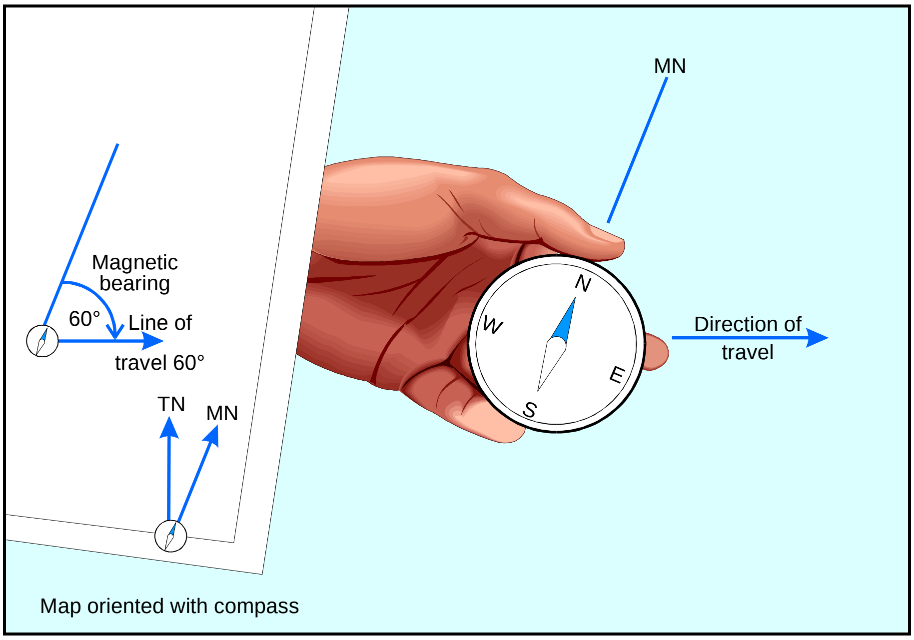

Fig 4.14 Using a Non-adjustable Compass

4.17.2 Using a Swinging Dial Compass

- orient the map using the compass (see Fig 4.15);
- place the compass on the map with the sighting line aligned along the next stage of the route;
- read the magnetic bearing from the compass dial in the direction of travel at the sighting line;
- memorise the magnetic bearing before moving on. Alternatively, if the compass has an adjustable lubber line, rotate the lubber line until it is over the **N** point of the swinging dial; this will save having to memorise the bearing.
- to check the course during travel, hold the compass steady and turn it until the sighting line is at the memorised bearing. Alternatively, if the lubber line has been set for the course, turn the compass until the lubber line is over the **N** point of the swinging dial. The sighting line now points in the desired direction.

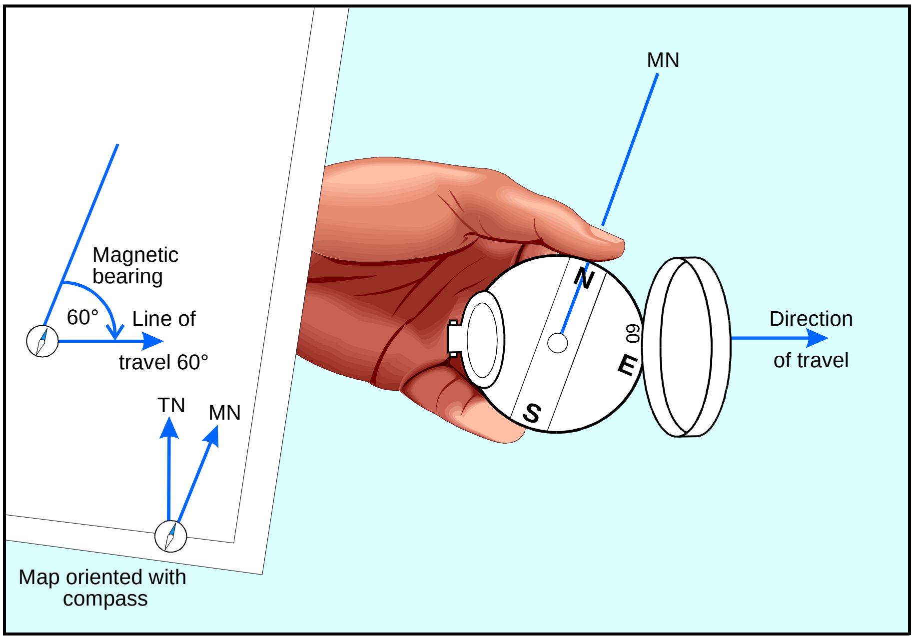

Fig 4.15 Using a Swinging Dial Compass

4.17.3 Using an Adjustable Dial Compass

- orient the map, using the compass (see Fig 4.16);
- place the compass on the map with the edge of the base plate along the next stage of the route, and the direction of travel arrow pointing towards the destination;
- rotate the adjustable dial until the **N** point is at the needle point;
- the magnetic bearing of the destination is indicated on the dial at the direction-of-travel arrow, but the bearing need not be memorised provided the dial is not subsequently rotated; and
- to check the course during travel, hold the compass steady, then turn the whole compass until the **N** point on the dial is at the needle point. The direction-of-travel arrow now points in the desired direction.

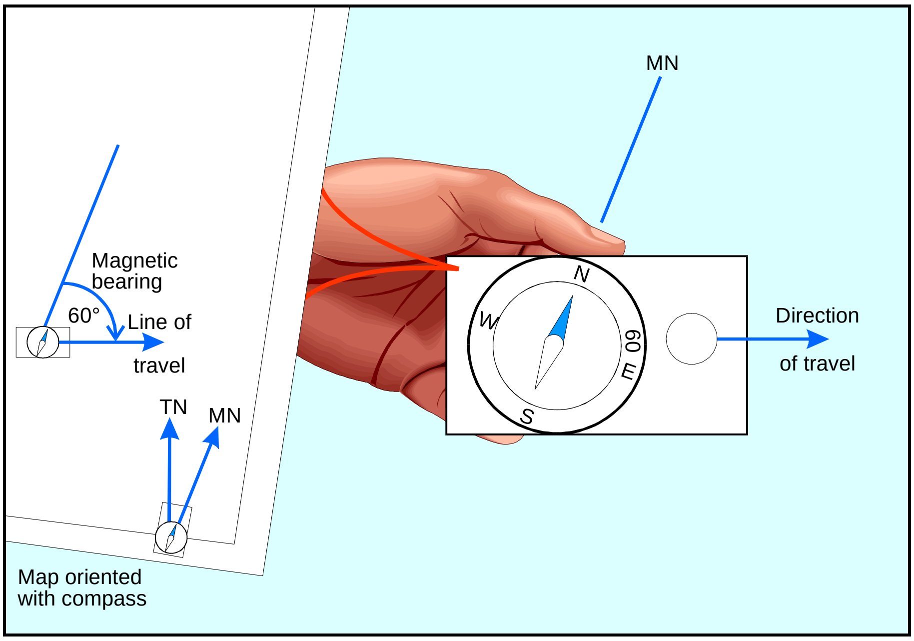

Fig 4.16 Using an Adjustable Dial Compass

4.17.4 Finding Present Position

If surrounding features can be identified on the ground and the map, the following method may be used to find the present position of the observer:

- select a feature (^) and take a grid bearing on it;

- plot the grid bearing on the map placing the compass on the map with the edge of the base plate on the feature. Pivot the whole compass around (keeping the edge of the base plate on the feature) until the orienting arrow on the adjustable dial is parallel to the North-South grid lines on the map and is pointing northwards; and

- the present position lies somewhere along the edge of the base plate which passes through the feature. If on a known ridge or river, or other long, narrow feature, the present position will be where it is intersected by the edge of the base plate.

However, if present position is not on any recognisable feature, it will be necessary to pencil in the first bearing and then take a grid bearing on a second feature (o) and, using the same steps as above, pencil in the second bearing. Where the bearing lines cross is your position.

Greatest accuracy will be achieved by application of the following:

- use a third bearing if another feature is recognisable. The present position should lie within a small triangle formed by the three plotted bearings.

- if taking a single bearing only, choose a feature as near as possible to 90° from the line of ridge or river.

- if taking two bearings, select features as near as possible to an angle of 90° apart.

SECTION FIVE - CHAINSAW AND ASSOCIATED EQUIPMENT

CONTENTS

Section 5	Chainsaw and Associated Equipment	1
5.1	Introduction	1
5.2	General Description	1
5.3	Operator Guidelines	2
5.4	Professional Attitude	4
5.5	Occupational Hazards	4
5.6	Kickback	5
5.7	Safety	9
5.8	Associated Fire Fighting Equipment	10
Section 5	Illustrations	
Fig 5.1	Chainsaw Component Parts (right side)	1
5.2	Chainsaw Component Parts (left side)	1
5.3	Development of Ramp on Link Strap	7
5.4	Second Generation Safety Chain	7
5.5	Location of Chain Brake	8
5.6	Restrictions on Restarting a Chainsaw After Refuelling	9
Section 5	Tables	
5A	Chainsaw Component Definitions	2

5 CHAINSAW AND ASSOCIATED EQUIPMENT

5.1 Introduction

The chainsaw is a major item of rural fire fighting equipment. To be authorised to operate a chainsaw every firefighter is required to complete a course of instruction held by the Rescue/Bushfire Section.

Because of the specialist nature of this piece of equipment certain aspects will not be covered in this section, these include:

- the cutting attachment;
- crosscutting;
- limbing;
- wedges; and
- servicing.

The aim of this section is to give the firefighter an insight into the general description of the chainsaw and some guidelines on its operation, to provide details on the correct attitude to adopt when using the equipment, and the occupational hazards and safety aspects associated with its use.

5.2 General Description

The NSWFB currently use two models of chainsaw, the *Stihl 034* and *036*. Both models are identical in appearance and have the same characteristics. Fig 5.1 and 5.2 gives a general view of the chainsaw from left and right sides, and Table 5A defines each component part.

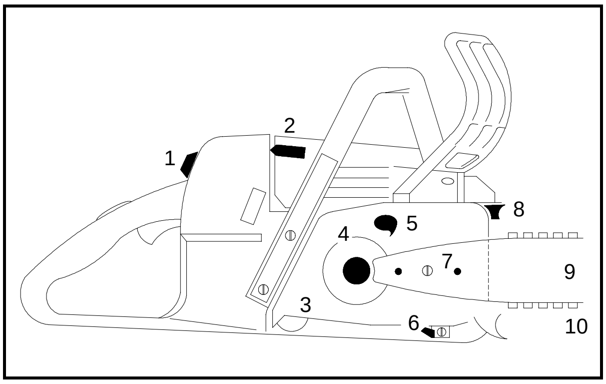

Fig 5.1 Chainsaw Component Parts (right side)

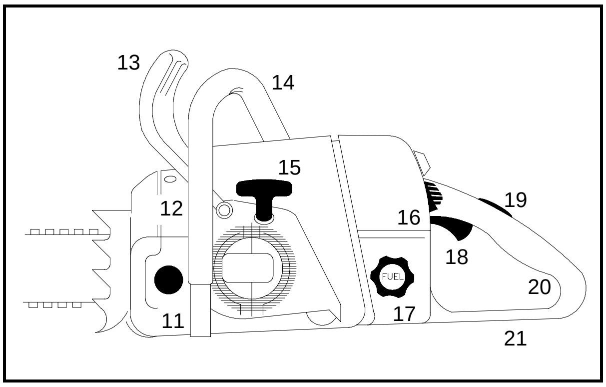

Fig 5.2 Chainsaw Component Parts (left side)

ITEM	COMPONENT	PURPOSE
1	Carburettor box cover twist lock	Locks carburettor box cover
2	Spark plug terminal	Connects the spark plug with the ignition wire
3	Chain sprocket cover	Covers the clutch and the sprocket
4	Chain sprocket	The toothed wheel that drives the saw chain
5	Chain brake	A device to stop the rotation of the chain if activated in a kickback situation by the operator's hand or by inertia
6	Chain catcher	Helps to reduce the risk of operator contact by a chain when it breaks or comes off the bar
7	Chain tensioner	Permits precise adjustment of chain tension
8	Spiked bumper	Toothed stop for holding saw steady against wood
9	Guide bar	Supports and guides the saw chain
10	Oilomatic saw chain	A loop consisting of cutter / tie straps / drive links / rivets
11	Oil filler cap	For closing the oil tank
12	Muffler	Reduces engine exhaust noise and directs the exhaust
13	Front hand guard	Provides protection against projecting branches and helps prevent left hand from touching the chain if it slips off the handle bar
14	Front handle	Handle bar for the left hand at front of saw
15	Starter grip	The grip of the starter for starting the engine
16	Master control lever	Lever for choke control / starting throttle / run & stop switch position
17	Fuel filler cap	For closing the fuel tank
18	Throttle trigger	Controls the speed of the engine
19	Throttle trigger interlock	Must be depressed before the throttle trigger can be activated
20	Rear handle	The support handle for the right hand located at or towards the rear of the saw
21	Rear hand guard	Gives added protection to operator's right hand

Table 5A Chainsaw Component Definitions

5.3 Operator Guidelines

5.3.1 General

The following general guidelines should be observed by all chainsaw operators:

- the guide bar cover (scabbard) is to remain on the bar at all times when the saw is not in use;
- whenever the fuel tank is refilled, the oil reservoir must also be refilled. This prevents the saw being run without lubrication for the running chain;

- before carrying out any cutting with the chainsaw:

  - check to ensure chain brake is operating correctly and

  - check to ensure oil is being fed along the bar

- the carburettor adjusting screws are only to be adjusted by a chainsaw dealer;

- when replacing the rim sprockets, always ensure that the cavities are facing out to allow for the escape of wood particles;

- do not work alone. Keep within calling distance of others in case help is required;

- take extreme care in wet and freezing weather (rain, snow, ice). Put off the work when the weather is windy, stormy or rainfall is heavy. Clear the area where you are working; and

- chainsaws can **only** be used right handed;

CAUTION

Avoid stumbling on obstacles such as stumps, roots or rocks and watch out for holes or ditches. Be extremely cautious when working on slopes or uneven ground.

- never work on any ladders, in a tree or on any other insecure support. Never use the saw above shoulder height;

- when carrying the saw on level ground, or when ascending a slope, the engine must be stopped with the bar behind you and the muffler away from the body. When descending a slope, the engine must be stopped with the bar in front of you and the muffler away from the body; and

- when clearing a work area or preparing an escape route prior to felling, this clearing is to be performed by utilising the axe. The chainsaw is only to be used for the clearing of larger obstacles.

NOTE

The axe is an important tool to be used in conjunction with the chainsaw. It must be kept sharp so that it can be used for cleaning out scarf cuts, chopping out the jammed saw bar etc. The back of the axe is also used for the positioning of wedges.

5.3.2 Hydraulic Platforms

A chainsaw may be used in the cage of a hydraulic platform provided the following precautions are observed:

- the saw operator is to be the only person in the cage

- the saw is to be started on the floor of the cage. **Do not drop start**; and

- operator safety is to be considered as a priority.

5.3.3 Starting

When starting a chainsaw observe the following guidelines:

- your chainsaw is a one-person saw, do not allow other personnel to be near the chainsaw. Start and operate the saw without assistance;

- do not drop start, this method is very dangerous because you may lose control of the saw. Correct starting methods reduce the risk of injury;

- place the chainsaw on firm ground in an open area. Maintain good balance and secure footing. Engage the chain brake prior to starting;

- should the saw fail to start, place the master control lever to the stop position. Pull the starter grip approximately six times, then place the master control lever to the start position **(do not engage the choke)**;

- place the right foot through the rear handle and left hand on the front handle;

- ensure that the guide bar and chain are clear of you and all other obstructions and objects, including the ground. When the engine is started, employ the starting throttle (lock), engine speed will be fast enough for the clutch to engage the sprocket and turn the chain (if the chain brake is not engaged); and

NOTE

If the bar touches any object, it may cause kickback to occur.

- when you pull the starter grip, do not wrap the starter rope around your hands. Do not allow the grip to snap back, but guide the starter rope slowly back to permit the rope to rewind properly.

CAUTION

Failure to follow this procedure may result in injury to hand or fingers and may damage the starter mechanism.

5.3.4 Gunning Sights

The 034 and 036 models are fitted with gun sights. The purpose of these is to allow the operator the means of accurately locating the scarf cut, to ensure the tree falls in the desired direction.

5.4 Professional Attitude

It is essential that all chainsaw operators develop a professional attitude towards all aspects of chainsawing.

Factors that can influence your professional attitude are:

- caring for equipment. Carry out regular chainsaw maintenance including minor repairs;

- possess a keen sense of safety, to yourself, other people and their equipment;

- possess a sense of responsibility towards the environment; and

- have a sound knowledge of the theory behind the various cross-cutting techniques.

Features that help to make a **competent operator** are:

- forward planning;

- steady work pace;

- concentration at **all** times; and

- the use of sound low risk techniques.

5.5 Occupational Hazards

5.5.1 Falling Limbs and Branches

Always wear a safety helmet and keep a sharp watch for hanging limbs and branches.

5.5.2 Eye Injuries

To protect against eye injuries always wear safety goggles.

5.5.3 Industrial Deafness

Hearing can be seriously impaired by chainsaw noise, always wear ear protectors. Remember a hearing aid will not overcome high frequency hearing loss.

5.5.4 Foot Injuries

Wear heavy work boots with a deep patterned sole and adequate ankle support. Safety boots with steel toe caps are ideal.

5.5.5 Reynaud’s Phenomenon

This phenomenon is sometimes referred to as white fingers and mainly occurs in cold climates. Initially a tingling sensation occurs in the tips of the fingers, finally they become white and numb. Keep hands warm and ensure the saw’s anti-vibration mounts are in good condition.

5.5.6 Back Injuries

Seek assistance when lifting heavy or awkward objects and always use correct lifting techniques.

5.5.7 Kickback

Inspect the chain brake regularly. Do not operate the saw if the brake is not functioning correctly. Only use a safety anti-kick chain.

5.5.8 Environment

Avoid using chainsaws in wet or windy conditions. When using a chainsaw watch out for hidden stump holes and abandoned mine shafts. Always keep fire extinguishing equipment handy.

5.5.9 Safety Distance

To prevent hearing damage (when not wearing ear protection) always maintain sufficient distance from the chainsaw operator.

5.5.10 Hand Tools

Keep all hand tools correctly sharpened and their cutting edge covered when not in use.

Replace damaged handles and never use steel wedges with burred heads.

5.6 Kickback

5.6.1 Introduction

Kickback is one of the most common cause of chainsaw accidents. It occurs when a moving chain contacts an obstacle and rather than cutting through it, a recoil occurs. The chain will recoil when:

- too much of the cutter bites into the wood and cannot sever it; and
- an obstacle strikes the front of the depth gauge.

5.6.2 Cutter Unable to Sever

There are three reasons why this first instance would occur:

- depth gauge to low;
- depth gauge not rounded; and
- depth gauge buries into the wood.

5.6.3 Obstacle Striking Depth Gauge

When the cutter hits an obstruction it cannot cut, an opposing force is delivered to the guide bar. The bar is thrown out of the cut (backwards or upwards) and can hit the operator if they are in line with the bar when this occurs. Lacerated left hands are quite often the end result of kickback, because the operators lose their grip on the machine.

NOTE

Speed of flight of the guide bar can approach 80 kmh - much faster than a normal person’s reaction time.

5.6.4 Avoiding Kickback

By following these guidelines the chainsaw operator will help to reduce kickback:

- maintain a firm grip (straight wrist and thumb behind front handle), also maintain a good footing and keep the saw close to the body;
- cut at peak revs, this gives you more chance of cutting through an obstruction;
- be conscious of where the nose of the bar is at all times;
- use correct boring techniques;
- avoid limbing with upper section of guide bar nose;
- sharpen and tension chain correctly;
- ensure the correct depth gauge setting;
- keep the front of depth gauges well rounded;
- ensure the chain brake is functioning correctly;
- only use a safety chain (anti-kickback chain); and
- use the sprocket nose guide bars. Kickback is effectively reduced due to the extra tension of the chain and reduced nose danger area.

5.6.5 Chain Design

Over a number of years there has been worldwide research to find answers to the problems of kickback.

Some years ago, chain makers designed a ramp into the link strap between the cutters. The purpose of the ramp was to ease the cutter's depth gauge over the obstacle. This design was the First Generation safety chain (see Fig 5.3).

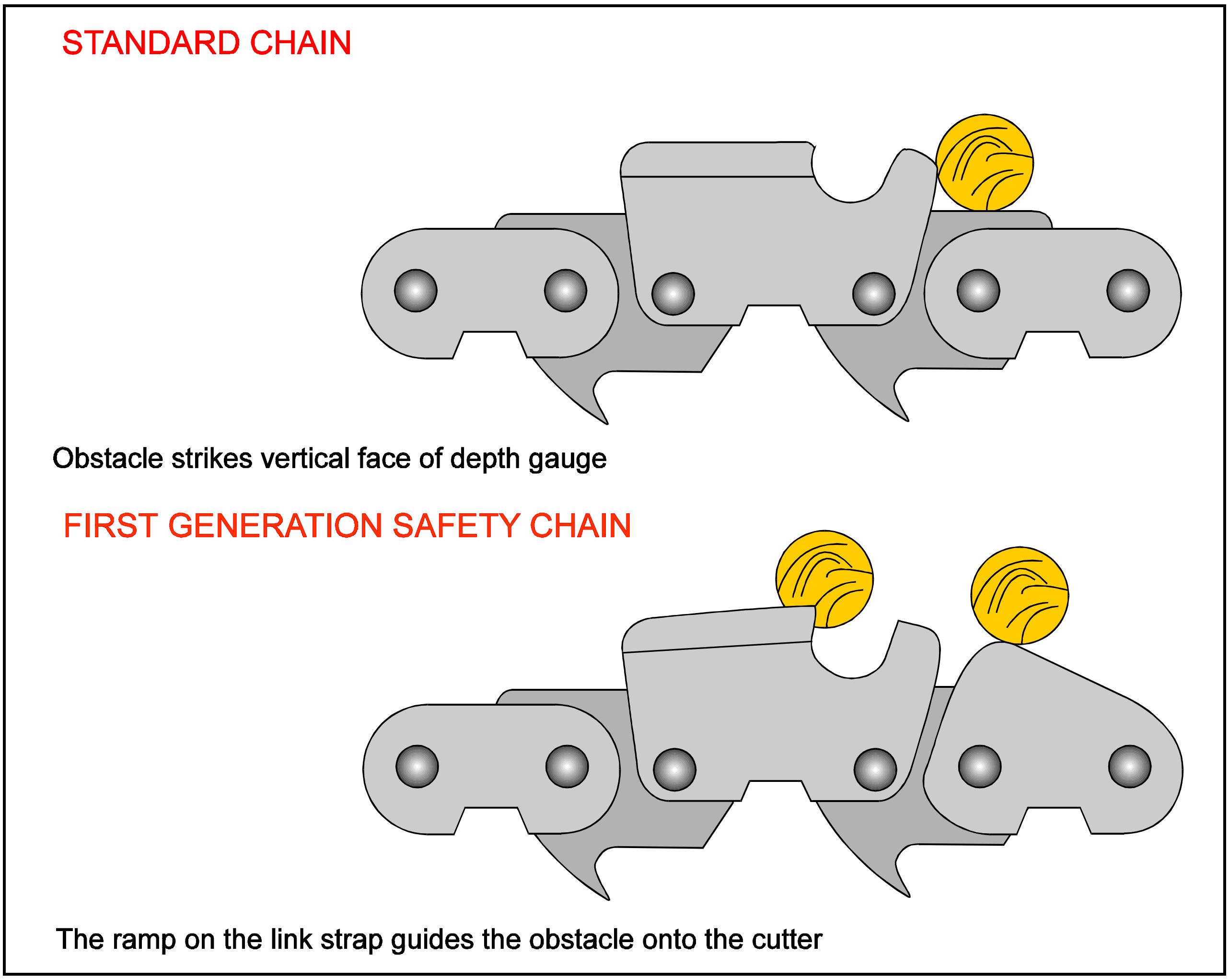

Fig 5.3 Development of Ramp on Link Strap

Further development of this design was to do away with the ramp on the link strap and design it into the tooth's depth gauge. This design was the Second Generation safety chain (see Fig 5.4).

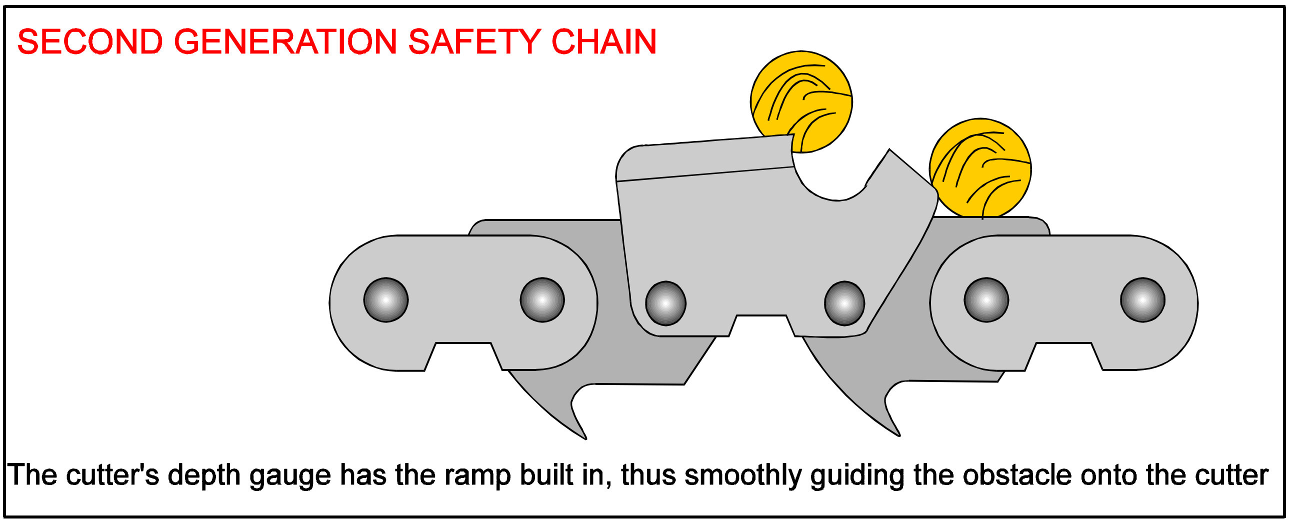

Fig 5.4 Second Generation Safety Chain

5.6.6 Guide Bar Design

A great deal of work has also been done to reduce the actual **danger area** on the guide bars nose.

- Standard hard nose bars have been produced with a narrower profile.

- To allow the chain to be tensioned tighter, thus reducing **tooth jump** as the cutter travels around the nose of the bar, whilst in contact with timber, the sprocket nose bar was developed. The sprocket nose coupled with a narrow profile bar is effective in reducing kickback.

A further development along these lines is the shark nose bar. This design is not a consideration in large saws because the shark nose is not efficient in the boring operation.

5.6.7 Chain Brake

It is essential that the chain brake is operative at all times. The chain brake must be checked prior to using the saw. By frequent operation of the brake throughout the day, the brakes internal components are kept free from an accumulation of dirt and saw dust (see Fig 5.5).

Frequent lubrication of the pivot or sliding surfaces is necessary to ensure effective operation. For chain brake adjustment, refer to a competent chainsaw mechanic.

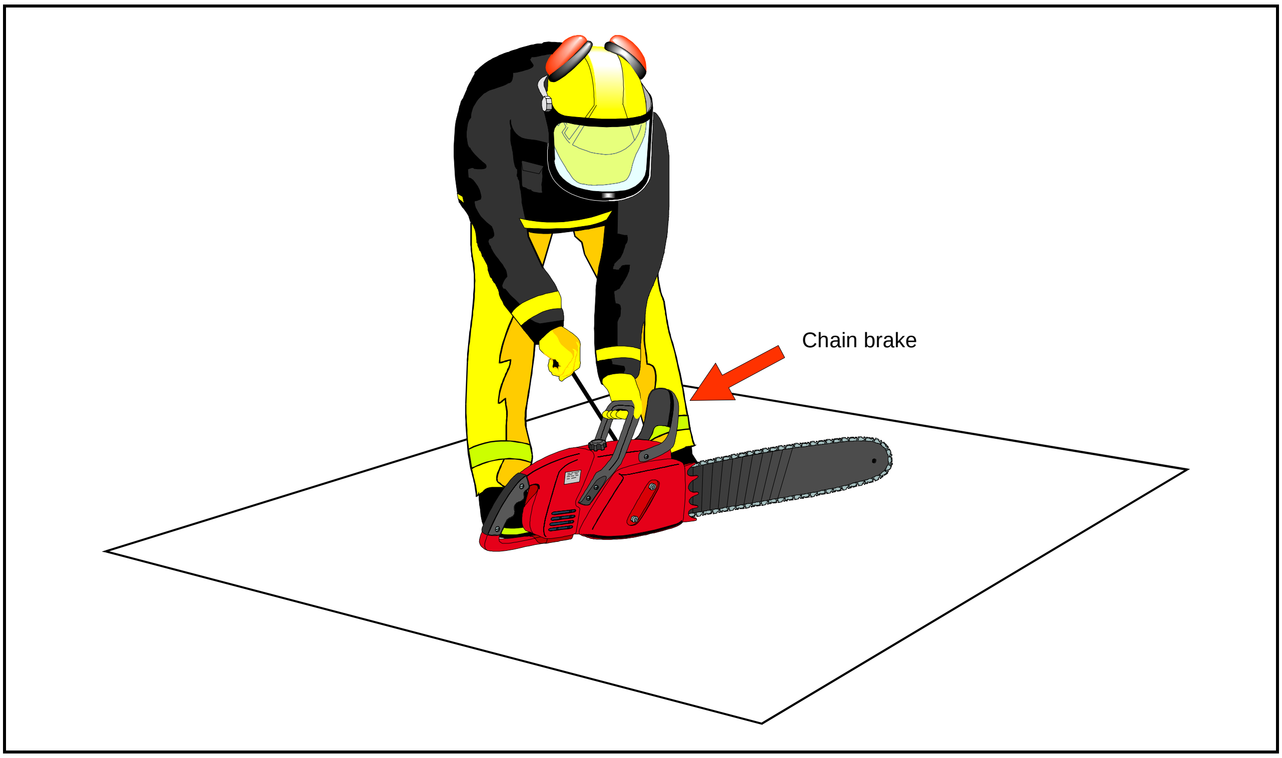

Fig 5.5 Location of Chain Brake

5.7 Safety

5.7.1 Introduction

Chainsawing is a one person operation. After you have learned the skills and techniques of chainsaw operation, your best defence against accidents is to use your own common sense. A chainsaw operator should be suitably attired prior attempting any cutting.

5.7.2 Refuelling

It is important that your chainsaw is using petrol of the correct fuel/oil mixture. The NSWFB recommends a 25:1 fuel/oil ratio. Always stop the engine prior to refuelling and do not smoke when handling petrol. Do not restart the chainsaw at the location where it has been refuelled (see Fig 5.6).

When cutting, hold the saw firmly with both hands and with the thumb locked around the front handle. Do not start cutting until you have a clear place in which to stand, a firm footing and a safe exit from falling timber or rolling logs.

Always be on constant alert against kickback. Never attempt to cut with a loose or dull chain. For optimum performance, it is essential that the chain be kept sharp.

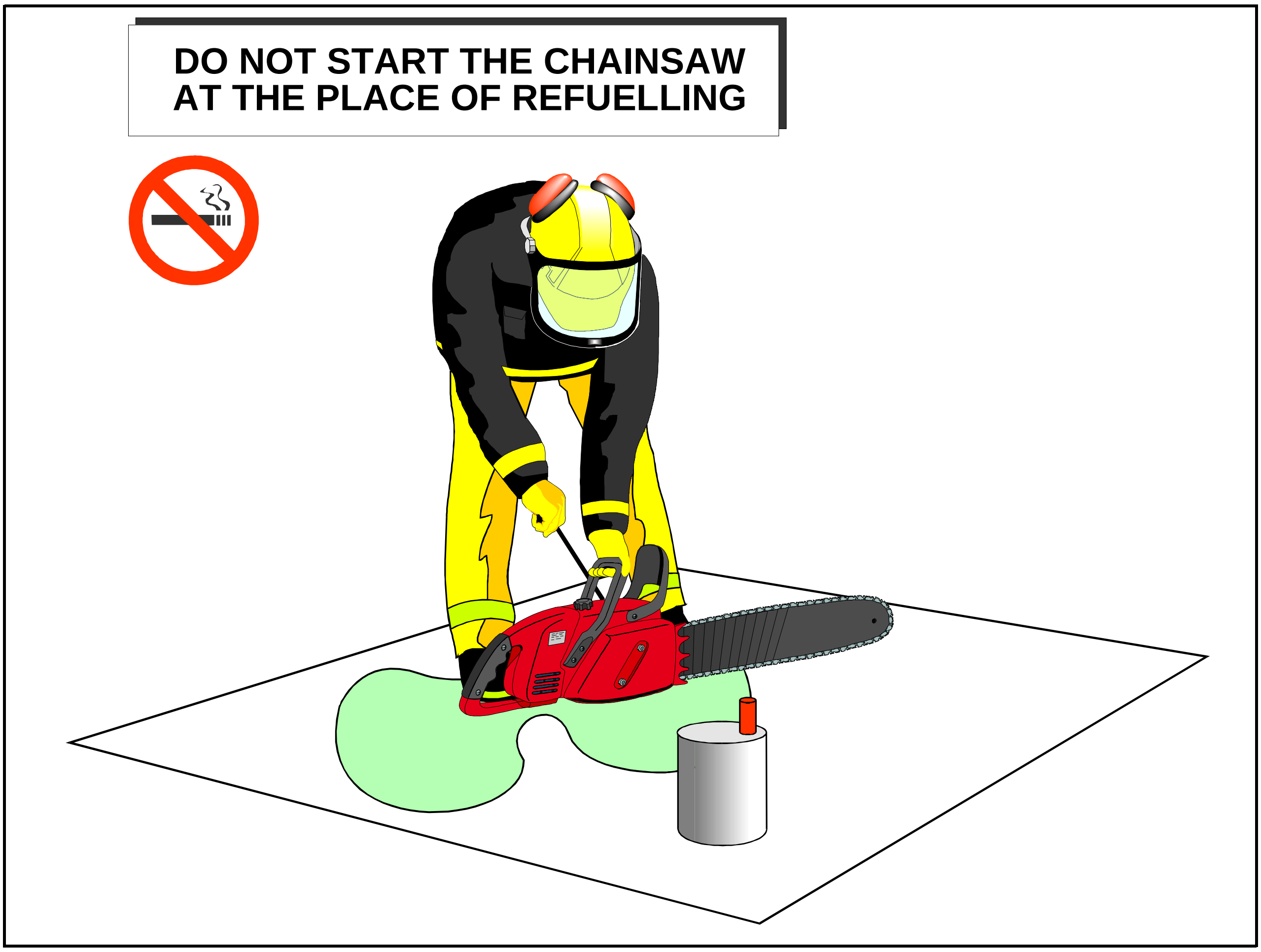

Fig 5.6 Restrictions on Restarting a Chainsaw After Refuelling

5.8 Associated Fire Fighting Equipment

5.8.1 Brush Hook

A brush hook is used to cut fire breaks in heavy foliage in bushland areas. The tool is used in a sweeping motion with the back edge angled towards the ground.

5.8.2 Drip Torch

A drip torch is used to ignite ground litter for the purpose of back-burning or hazard reduction operations.

The 4 L tank on the torch contains a mixture of 2/3 diesoleum and 1/3 petrol. The flow of the fuel is controlled by opening a stop cock on the feed tube and the air valve on top of the container is used to control the flow rate of the mixture when the feed tube is directed downwards.

The mixture is ignited as it passes over a lighted wick below the end of the feed tube and the flaming drops continue to burn and ignite the ground litter.

5.8.3 Goggles

Goggles are used to protect your eyes from exposure to flying cinders and smoke during bush fire fighting operations.

5.8.4 Knapsack Tank and Pump

The knapsack tank and pump is used for extinguishing or controlling low intensity bush or spot fires.

The high density plastic tank holds 16 L of water. The tank is carried on the back of the operator. A double acting hand pump is connected to the tank by a short length of hose. You can use it to apply either a jet or a spray onto the fire.

CAUTION

Sometimes these tanks are filled from ponds or creeks and the water in the tank may be polluted. It should not be used for drinking.

Service Checks

You should inspect the filter in the tank for blockage. If necessary, you can unscrew the filter, remove it, clean it or replace it.

Prior to the bushfire season, this unit should be serviced to prevent difficulty in pumping.

To service the pump, unscrew the knurled nut that retains the pump plunger remove the pump plunger tube. Lightly smear the tube and O ring with vaseline or grease before you replace them.

5.8.5 McLeod Tool

A *McLeod* Tool is used for establishing firebreaks, cutting light foliage, raking ground litter, and turning over and pulling apart rubbish and debris.