VNPA Navigation Guide

Bushwalking and Activities Group

This guide is intended for use by members of the Victorian National Parks Association (VNPA) bushwalking and activities group only and is not for further distribution.

Edition 5 September 2012

Contents

1. The art of navigation

Welcome to the VNPA Navigation Guide, which could also be named “How Not To Get Lost”.

Being a good navigator allows you to confidently and safely undertake trips to outdoor locations, without getting lost. In order to navigate, you need to know about maps, compasses and how to plot a course across a landscape.

Probably the most important skill in navigation and central use of a map is being able locate your position on the map by examining your surroundings. This requires you to compare what you are seeing with your understanding of the landscape as obtained from the information on the map.

You also need to be able to plot a sensible course from your known position across the landscape and then maintain that course.

This guide will explain maps and compasses, and help you to use them to locate your position and plot and follow a course. There is also some related information on trip planning and using a GPS.

You cannot learn navigation by just reading about it – you need to head into the field and practice it.

2. Maps

2.1 Types and care

The main type of map used for navigation is the standard topographic map. These show contour lines, natural features like creeks and peaks, basic vegetation type, and man-made features such as roads and buildings.

There are many other types of maps. Some show land tenure (eg, private and crown land), some show geological information and/or detailed vegetation type, and there are even gravity maps.

Currently available topographic map series useful for bushwalking in Victoria include the government produced VICMAP series, VMTC/Brookes maps, a 1:30 000 DSE series available for a fee off the Internet (see references), and the privately published “Rooftop” series. The VICMAP series is being progressively updated, so some of these maps may have information that hasn’t been updated since the 1980s.

When in the field it is important to protect your map from the weather, so it is a good idea to use a transparent plastic map case or similar. Lamination also provides good protection, but with the disadvantage that the map then becomes difficult to write on.

2.2 Map border information

Maps provide essential interpretative and contextual information on their borders (margins), such as the name, number, date, edition and reprint date of the map.

It is important to know the date of the map as man-made features may have changed. It is also relevant to magnetic variation (defined later). The map date may appear within a copyright notice.

The border will also provide a legend (key, table) which explains the symbols on the map. For example, the legend may show that sealed roads are a solid pink line, unsealed roads a dashed line, creeks a blue line and so on. You should examine the legend carefully so that you are familiar with the symbols used.

Border information also includes the map scale, grid and contour intervals, how the map grid fits into the universal reference system, the direction of north and the map datum – all discussed below.

2.3 Map scale

The scale of a map is provided as a term such as “1:25 000” or “1:50 000”.

These terms express (as a fraction) the amount by which real distance is reduced when represented on the map.

So on a 1:25 000 map, a distance of 1 kilometre is reduced to 1 / 25,000 x 1 kilometre = 4 centimetres. Four centimetres on this map represents one kilometre of distance on the ground. Or put another way, 1 cm on the map represents 25,000 cm (1 / 4 km) on the ground.

For a 1:50 000 map, two centimetres on the map represents one kilometre of distance on the ground. More land is represented on this map per unit of map distance.

For a 1:100 000 map, one map centimetre represents one kilometre on the ground.

Note that on an area basis, a 1:100 000 map provides only 1 / 16th of the detail provided by a 1:25 000 map.

Common topographic map scales are 1:25 000 and 1:50 000, though other scales such as 1:30 000 and 1:15 000 are sometimes used.

A caution: if you photocopy part of a map and enlarge or reduce it, the absolute map scale (ground distance per unit of map distance) will no longer be correct. However the *scale bar* on the map border (showing ground distance represented by map distance), will still be correct in relation to the rest of the map.

2.4 Map grid and grid interval

Topographic maps are overlain with a *grid* of numbered vertical and horizontal lines. This grid helps you to judge distances and to locate features on the map.

The vertical grid lines are known as *eastings* and the horizontal lines are known as *northings*. The numbers for eastings get larger as you move right (east) and the numbers for northings get larger as you move up (north).

Figures 1a and 1b depict (in abstract and in use respectively) an example of the map grid including the eastings and northings and the squares created by them, plus the numbering of the eastings and northings on the map edge. Some latitude and longitude numbers are also present.

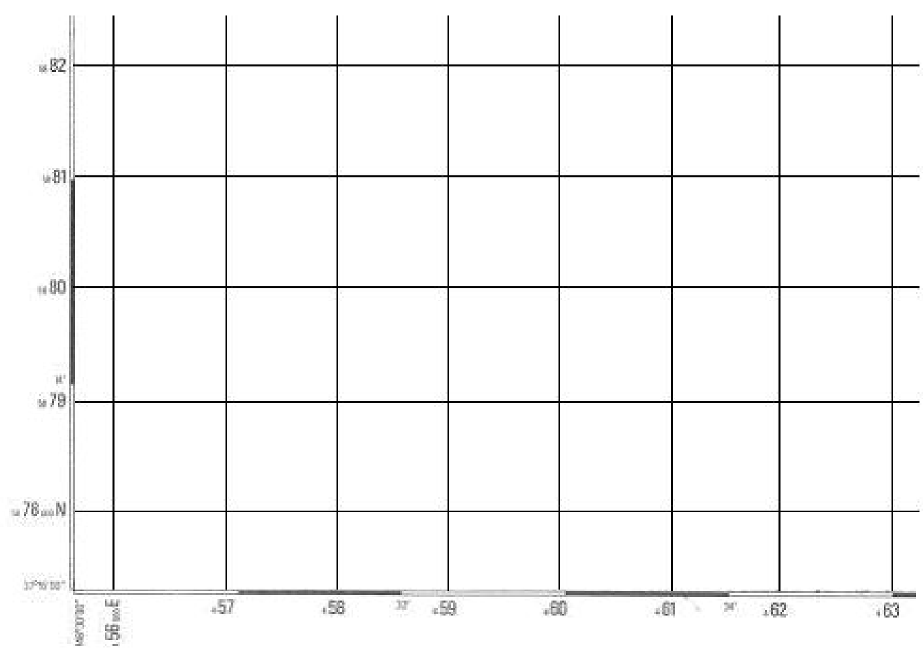


Figure 1a. An example of the map grid in abstract

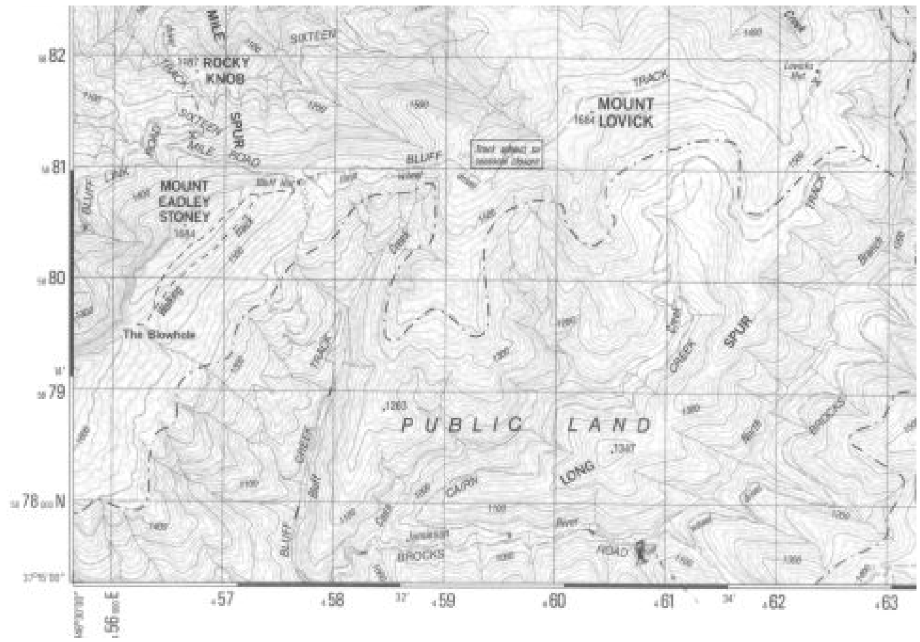


Figure 1b. An example of the map grid overlying represented land

The numbers on the grid lines are part of a world-wide numbering system, based on metric distances. To simplify vertical line numbering, the world is divided into zones. For example, most of Victoria is in "Zone 55". Knowing this, less numbers need to be provided for the vertical lines on maps within this zone, eg, 4**68**. Longer numbers are provided for the horizontal lines, eg, 58**86.** The last two numbers are often bolded or enlarged for ease of reading, as they are the most relevant for an individual map.

The *grid interval*, is the distance (in on-the-ground terms) between the grid lines. For standard 1:25 000, 1:50 000 and 1:100 000 scale maps, the grid interval is *one kilometre*.

2.5 Six figure grid references

A grid reference is a way of describing a location on a map. This can be useful to communicate or record important locations such as water points, camp sites or the position of an injured person.

By convention, six figures are used for standard topographic map grid references. An example of a six figure grid reference is "686-855". That is the grid reference for the summit of Mt Howitt on the VICMAP Howitt-Selwyn map (8223-N; Second Edition 1991; Datum: AGD66). The six figures identify a square on the map, plus a rough location within the square. The first two figures are the easting (vertical line) to the left of your feature **–** so 68 is the number of the line to the left of Mt Howitt. The next number is the rough number of tenths across the distance between line 68 and line 69. So Mt Howitt is about 6/10ths the way across. Similarly, the last three figures do the same for the northings (horizontal lines). Mt Howitt is positioned above horizontal line 85, and is about 5/10ths the way up. To help remember which three figures are which, you can use the mnemonic "read right up". That is, you read across from the left to *right* (first three figures), then up from the bottom (second three figures). Figure 2 shows a map grid square divided into tenths to obtain the third east and third north figures of a six figure grid reference. You would normally do this only in your head. On the map in figure 2 the building at point A is at 413-167.

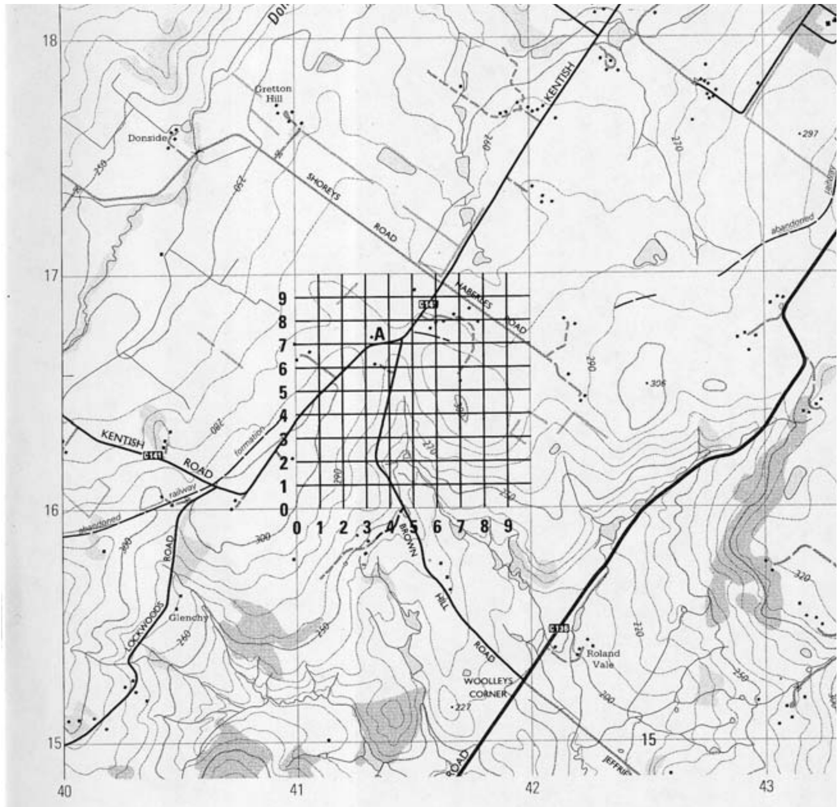


Figure 2. Dividing a grid square into tenths in order to obtain a six figure grid reference (Ref 6)

In most cases you should state the name and issue or datum of the map used along with your grid reference – mainly for the reason explained in the next section.

[Exercise – locate features at particular grid references on a map, and give the grid references of particular features]

2.6 Comparing maps - map datums

The map grid system needs a reference point (loosely, a *map datum*). In Australia, this reference point was changed at the start of the year 2000 to fit in with an international system, thereby simplifying the use of Global Positioning System (GPS) receivers. The old map datum was called Australian Geodetic Datum (AGD, AGD66, AGD84). The new map datum is called Geodetic Datum of Australia (GDA, GDA94). GDA94 is basically equivalent in Australia to the term WGS84 (WGS = World Geodetic System).

The map datum is not relevant if you are just using one map (and not using a GPS). However, *grid references taken from maps using different datums will refer to different locations*. So if you are communicating or recording grid references, you need to specify the datum of the map used to obtain them, and if using a GPS, you may need to set it to the appropriate datum.

The difference in position between references using the two datums is significant, though not huge. A GDA map reference applied to an AGD map will indicate a position about 200 metres north-east of the desired location. This is relevant on a 1:25 000 map, but not on a 1:100 000 map.

There are some other terms concerning datums you may come across. There are names for the grid system created by using a particular datum. Australian Map Grid (or AMG) refers to the grid created using AGD, while the newer Map Grid of Australia (MGA) corresponds to the GDA grid.

So in summary:

	Old (though not uncommon)	New
Datum	AGD	GDA, WGS
Map grid	AMG	MGA

The NSW and Victorian governments have started producing topographic maps using GDA, although many are still in AGD.

For further information on the change of map datums in Australia, see the Intergovernmental Committee on Surveying and Mapping (ICSM) website – the URL is listed in the reference section.

See section *7. GPS – use and limitations* for more information about datums and GPS.

2.7 The three norths

There are three “norths” on a map: *true north* (TN), *grid north* (GN) and *magnetic north* (MN).

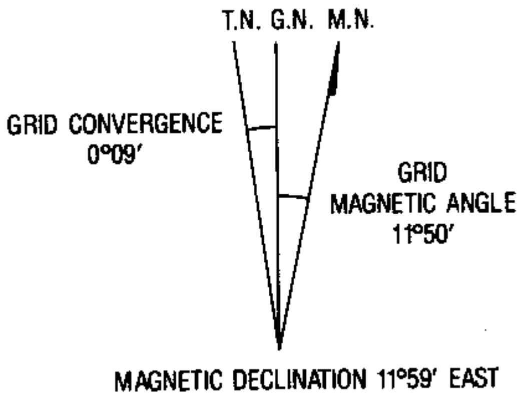


Figure 3. An example of the “direction of the three norths” diagram on a standard topographic map

True north is the point where the earth’s axis of rotation intersects with the ground in the northern hemisphere (the North Pole).

Grid north is the orientation of the map’s vertical grid lines. Due to inaccuracies caused by fitting a flat grid to the curved earth, this is not exactly the same as true north, though very close (within one or two degrees). Grid north is usually taken to be equivalent to true north. The difference between grid north and true north is called the *grid convergence*.

Magnetic north is the direction a compass needle (red end) points to, which is to the north pole of the earth’s magnetic field. The magnetic field is not aligned with the earth’s axis, and it moves gradually over time. The magnetic north pole is currently located in northern Canada. Maps indicate the direction and speed of movement of magnetic north – eg, magnetic north as shown on a 20 year old map may be one degree too far west (further discussed in section 3.5).

The difference between true north and magnetic north is called *magnetic declination*. In most of Victoria the magnetic declination is about 10-11 degrees to the east of true north. In New Zealand it is about 16 degrees to the east. In the west of Western Australia it is a few degrees to the *west* of true north.

The difference between grid north and magnetic north is called the *grid magnetic angle*, or *magnetic variation*. This is *the difference between the vertical direction on your map and the direction your compass needle points to*. This is the most important angle for obtaining a bearing relevant to the map from your compass, or vice versa. As true and grid north are very close, magnetic declination is often used to mean magnetic variation.

Note that the angles in map illustrations showing the three norths such as figure 3 are not shown literally, and also that GN is sometimes to the *left* of TN (even within Victoria).

[Exercise – find the number and name, date, zone, scale, grid and contour intervals, and magnetic variation of a particular map]

2.8 Latitude and longitude

You will also find latitude and longitude indicators (expressed in degrees, minutes and seconds) on the edges of a topographic map. Why not use these for the lines of the grid? Because they are not related to the metric system (there would be some odd number of metres between the lines), and, as the distance between the longitude lines changes with latitude, the grid would not be square.

2.9 Contour lines and the contour interval

Contour lines (or just *contours*) are lines on a map which represent a particular elevation by joining together adjacent points of the same altitude. They reveal the height, steepness and shape of the landscape.

For example, using contour lines, an isolated hill would be represented as a series of concentric loops (figure 4).

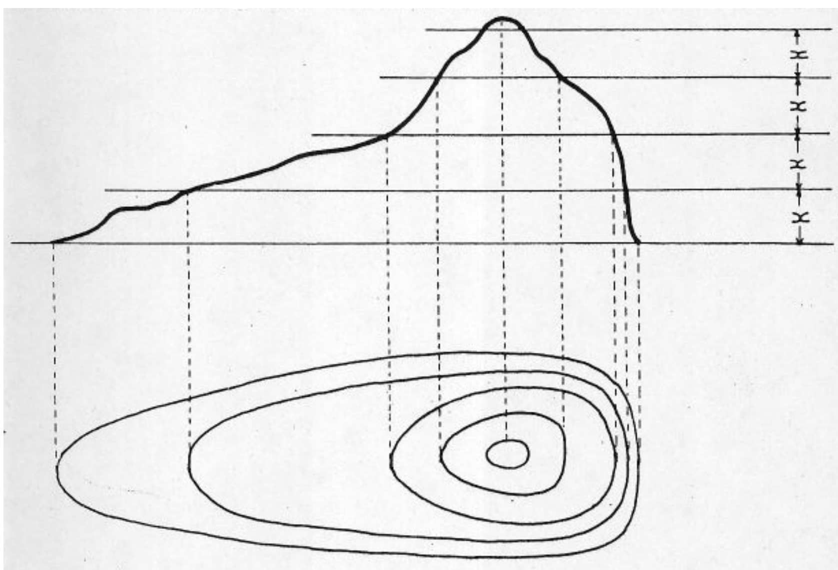


Figure 4. An isolated hill represented by contour lines. The contour interval is ‘x’. (Ref 7)

On standard topographic maps, contour lines appear as many (usually brown) wavy lines. For ease of reading, every fifth line is often printed a darker colour. These darker lines also represent multiples of 100 metres in elevation. Numbers denoting the elevation of the contour line in metres are written on some lines, particularly the darker lines.

The *contour interval* refers to the difference in altitude represented by adjacent lines. For example, on a map with a contour interval of 20 metres, if a particular line represents the altitude of 1,000 metres above sea level then the lines either side of it must represent 980 and 1,020 metres.

On standard 1:25 000 and 1:50 000 scale topographic maps the contour interval is *20 metre*. Note that the contour interval on VMTC/Brookes 1:50 000 maps is a much larger 100 metre, which means there are only one fifth as many contours on these maps.

Sometimes landscape features such as small knolls are not high enough to be able to be represented by their own contour line. That is, they occur *between* the contour lines. This is most likely to occur in undulating country and where there are small peaks on ridges. The surrounding contours may suggest the existence of a feature – ie, the feature is “implied”.

2.10 Cross sections

It is useful to follow the course of your route across a landscape and plot or observe its height gain and loss by examining the contour lines it crosses (this will affect the difficulty and timing of the walk). In so doing, you are taking a *cross section* of the map.

Say you are following the course of a track on the map. A section which runs *parallel* to contours will be basically flat (within the contour interval). A section which *crosses* contours is heading uphill or downhill. Where the crossed contour lines are close together, the track is steep. The more contour lines the track crosses on a slope, the longer the hill.

How do you tell whether a track crossing contour lines is heading uphill or downhill? There are two complementary methods.

The first is to look for the altitude numbers on any nearby contours. You may need to follow contour lines on the slope you are investigating for some distance to find the nearest numbers for those lines, but you will be able to determine in which direction the lines are getting higher by their marked altitudes.

The second is to examine the features of the landscape around the track, looking for peaks and valleys. More information is provided on this in the next section. An example map cross section is shown in figure 5.

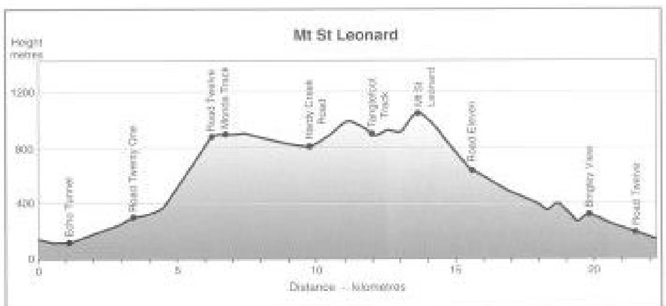


Figure 5. Cross-sectional view of a track traversing Mt St Leonard (Ref 8)

Taking a number of imaginary cross sections (for tracks or just straight lines) will help you to visualise the entire map, that is, comprehend the indicated *relief* (variation between high points and low points) of the landscape.

[Exercise – plot on graph paper the cross section of a track heading through hilly terrain, by measuring and recording altitude every 200 metres]

2.11 Reading the topography and land features

Contour lines reveal the shape (topography) of the landscape. An experienced map reader can see peaks, ridges, valleys, saddles, bluffs, etc, almost in three dimensions by looking at the contours of a topographical map. A few hints for reading these lines follow.

As would be apparent from the isolated hill example, small loops surrounded by larger loops represent a peak (provided the altitude is rising towards the centre). The peak may also be labelled with a name or spot altitude reading.

In steep country there are many contour lines. A flat area (such as a flood plain, the bottom of a wide valley or a plateau) contains few contour lines.

Creeks and rivers always cross contour lines as they head lower. Gullies containing creeks appear as a bends in lines where the apex of the bend is centred on the creeks. The steeper the creek, the closer the lines that are crossed by it. The downhill flow direction of the creek is indicated by its pattern of convergence with other creeks – tributaries join up as the altitude drops.

The peak of a hill or mountain will usually appear as a small loop (the highest point being in or near the centre of this loop). Ridges dropping off peaks are represented by bends in the lines between the creeks and rivers. The apex of the bends will not be centred on a creek, and will generally face away from the peak the ridge runs off. A “razorback”-style ridge will appear as a series of end-to-end skinny loops in between parallel lines.

A saddle between two peaks may appear as an empty space between two small loops, often with creeks running away either side.

Figures 6 and 7 show common landforms in “3D” illustration form and as expressed by contours.

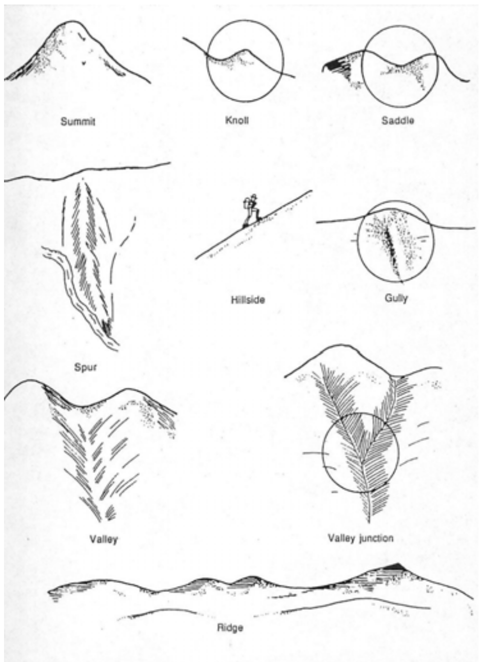


Figure 6. Common landforms

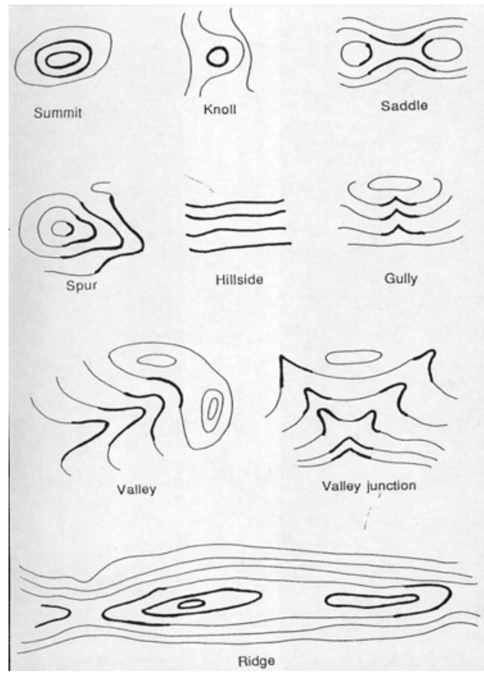


Figure 7. Common landforms as expressed by contours

[Exercise – draw some contours representing two hills, a ridge, a saddle, two creeks coming together, and an implied knoll]

[Exercise - obtain a topographic map of a mountainous region and carefully review all areas until you can confidently locate features such as peaks, slopes, ridges, valleys, creeks and rivers]

3. Compasses and bearings

3.1 Compass features and types

A compass is basically a combination of a north-pointing magnetic needle and a set of markings arranged in a circle around the needle, used for measuring angles.

Most compasses feature a magnetic needle floating in an enclosed glycerine-filled compartment (housing, capsule), a dial and a base plate.

The red end of the needle points to magnetic north when the compass is held flat.

The *dial* or *bezel* is a ring (which is often attached to the housing) which can be rotated around the needle and has degree (0 to 360) and directional (N, S, E, W) markings.

The needle housing and dial sit on a transparent *base plate*. The base plate has a printed arrow along its long axis, and often a ruler along its side, useful for measuring distances on a map. The base plate is transparent so that a map can still be seen through a compass placed directly on it.

Some compasses do not have a base plate. These should be avoided as you need to use a protractor as well as the compass to determine bearings. Some have a hinged cover with a central marking line or wire (sighting line). This may or may not contain a mirror (sighting mirror). With these compasses you look “through” the sighting line and/or mirror to directly view a feature in the landscape and so more accurately determine its bearing (direction). Some compasses also have a magnetic variation adjuster.

The direction of a compass needle can be affected by nearby metallic objects, so stay clear of metal items such as car bonnets, glasses and jewellery while taking a reading. In addition, avoid taking readings with the compass on the ground as rocks in some locations possess magnetic fields which can interfere with the needle direction (such regions are often indicated on your map – a Victorian example is Mt Jim on the Bogong High Plains).

Due to variation in the surface direction of the Earth’s magnetic field, compasses are weighted for different regions of the earth. For this reason, a compass purchased in Europe or North America will not work correctly in Australia and vice versa. However, compasses bought in Australia and New Zealand will work correctly in both countries.

3.2 Taking a compass bearing

Taking a compass bearing means establishing the direction from your current location to an object. As an example, a bearing of zero degrees from your current position would be the exact direction north, 180 degrees the exact direction south, and 90 and 270 the exact directions east and west respectively. After obtaining a compass bearing, an adjustment is usually made to obtain a direction relevant to the grid on your map (grid bearing – discussed below).

To take a bearing from your compass:

1. Holding your compass flat, point the arrow on the compass base plate (or compass sighting line if there is one) at the object of interest.

2. The needle always points north, so rotate the dial so that the north marking on the dial is aligned with the north (red) end of the needle.

3. Read off the number on the dial corresponding to the direction of the base plate arrow. This will give you the *magnetic bearing*.

Note that obtaining compass bearings is not an exact procedure – two people will often report bearings differing by several degrees.

[Exercise – take a compass bearing of the door to this room from your current location]

3.3 Back bearings

A *back bearing* (or *resection*) means the direction opposite to the one you are travelling in, or the direction from a landmark back to you. Converting a bearing to a back bearing means determining the position opposite to it on the circular compass dial. So if the original bearing is more than 180 degrees, subtract 180 from it to obtain the back bearing. If the original bearing is less than 180 degrees, add 180 to it. For example, the back bearing of 283 degrees is 103 degrees, and the back bearing of 45 degrees is 225 degrees.

3.4 Bearings on the map

Bearings on the map are referred to as *grid bearings*. A grid bearing is just like a magnetic bearing, but is in relation to grid north rather than magnetic north. You determine a grid bearing using your compass dial as if it were a protractor (ignoring the needle). A grid bearing is the angle in degrees between the map’s vertical direction (parallel to the vertical grid lines) and a line running from a reference point (your location) to a feature on the map (your destination).

To obtain a grid bearing from your map:

1. Place the side of your compass along a line between your location and destination.

2. Rotate the compass dial to align the north and south markings, or the orienting lines at the base of the capsule, with the vertical grid lines on the map, and so that 0 degrees is at the top of the dial (pointing to grid north).

3. Read off the grid bearing from the dial at the point where the base plate arrow starts.

3.5 Taking a bearing from compass to map (= magnetic to grid)

This is done when you want to translate a compass bearing to an object into a bearing (direction) relevant to your map. You do this by adjusting the compass bearing to allow for the magnetic variation relevant to the map.

The map border information provides the magnetic variation, and in eastern Australia this is always added to the magnetic bearing to obtain the grid bearing.

To determine the relevant amount of magnetic variation, look at the diagram on the map border which shows the three norths (described in section 2.7). You will see a line something like “Magnetic declination 11 degrees east”. Now check the age of the map and rate of movement of magnetic north. For example, if the map was issued in 1985 and magnetic north moves at 3 minutes east annually, then there has been 20 x 3 = 60 minutes or one degree (1 degree = 60 minutes) eastward change since the map was issued. So add 11 + 1 to arrive at 12 degrees current magnetic declination. Now subtract the grid convergence to obtain the magnetic variation. As the grid convergence is usually very small, magnetic declination will be almost the same as magnetic variation, eg, it will probably still be 12 degrees.

This means you have to *add 12 degrees* from your magnetic north bearing to get the bearing relevant to the map (the grid bearing).

For example, if I obtain a magnetic north bearing from my compass for a nearby peak of 34 degrees, to correctly identify the direction of that peak on my map, I need to add 12 degrees (obtaining 46 degrees).

So, to take a bearing from compass to map:

1. Read the *magnetic* bearing to an object of interest from your compass (section 3.2).

2. Add* the magnetic variation to obtain the *grid* bearing.

3. Rotate the compass dial so that the baseplate arrow is aligned with the just-calculated grid bearing (ignore the needle).

4. Place your compass on the map with the side touching your current position.

5. Rotate the whole compass around that position until the north-south axis of the dial lines up with the vertical grid lines on the map. The side of the compass now is aligned with the bearing and should point to the object of interest on the map.

An alternative to this process is to add the 12 degrees at the time of taking the reading, that is, you align the dial to the north end of the compass needle at 12 degrees east rather than zero degrees.

* In Eastern Australia.

3.6 Taking a bearing from map to compass (= grid to magnetic)

This is done when you want to use your compass to indicate which direction to head in, based on a direction taken from your map.

To take a bearing from map to compass:

1. Draw a line (real or imaginary) on your map from point A (eg, your current location) to point B (eg, the place you wish to go).

2. Obtain the grid bearing of the line as in 3.4.

3. Now *subtract** the magnetic variation (eg, subtract 12 degrees) from this angle to obtain the magnetic bearing – the one you need to determine your direction in the landscape.

4. Rotate the dial on the compass so that the baseplate arrow is aligned with the magnetic bearing you have just calculated.

* In Eastern Australia.

3.7 Memory aids

There are two useful memory aids for remembering (in Eastern Australia) when to add or subtract magnetic variation.

The first is to remember the word "MAGS". This stands for "Magnetic Add – Grid Subtract". Note that this refers to your *starting* bearing, ie, if you are starting with a magnetic bearing and converting this to a grid bearing, you add (MA) the variation.

The second is to visualise what you are doing with the compass and map, with reference to the map. So when you are taking a bearing from the compass *to* the map, you *add* the variation. But when you are taking a bearing *off* the map on to the compass, you take the variation *off* or *subtract* it.

4. Navigating - using your map and compass

4.1 What maps to take into the field

1:25 000 and 1:50 000 scale topographic maps are most commonly used for bushwalking navigation. A 1:50 000 scale map is the minimum level of detail required (and may be the only scale available). It can be useful to bring more than one map of the same area if they show different features (eg, a VICMAP and a VMTC/Brookes map). If your route takes you near the edge of a map, you should bring the next adjacent map in case you walk off your main map. Additional surrounding or smaller scale maps showing more terrain are also useful in providing the location of visible landmarks (prominent features of the landscape) that are not on your main map. Finally, ensure your map has sufficient detail (eg, VMTC/Brookes maps alone may be inadequate due to their fewer contour lines), and is as up-to-date as possible.

4.2 Uses of the compass

The main ways you use your compass while navigating are as follows:
- orienting your map
- obtaining your location from the surroundings
- obtaining your direction from the map
- maintaining your direction.

4.3 Finding your location from the surroundings

To find your location, you need to orient your map then obtain your bearings from the surroundings.

4.3.1 Orienting the map

Orienting (or *setting*) the map means rotating the map until north on the map is pointing in the same direction as north in the landscape.

To orient the map, place your compass on the map with the arrow on the base plate pointing to magnetic north as indicated on the map.

Now rotate the map and compass together until the red end of the compass needle points in the same direction as the arrow on the base plate. That is, magnetic north as indicated by the compass is in the same direction as magnetic north as shown on the map.

If you already know roughly where you are, it is also possible to orient the map without a compass by rotating it until landmarks on the map line up with landmarks you can see.

[Exercise – orient your map now]

4.3.4 Identifying and checking your location

Having oriented the map, you may now be able to identify where you are by examining what you can see behind, in front of and beside you and performing an informal triangulation (see next) – ie, referring to the shape and features of the landscape as depicted by the map without using your compass. It is useful to check your hypothesised location by determining the direction from you to a landmark. To do this, determine the compass bearing from your current position to the landmark, then convert this to a grid bearing as per the procedure of “taking a bearing from compass to map”. Now check that this grid bearing matches the grid bearing you should obtain given your hypothesised location. Alternatively, you can take a bearing from map to compass and check that the landmark is on that compass bearing.

If your observation does not match your hypothesised location, reassess your location on the map, and perform further checks. If you are still unsure of your location, performing a more formal triangulation may be useful.

4.3.5 Triangulation

Triangulation means obtaining your location by determining the direction back to you from three known landmarks you can see. You should be at the point where the three directions meet.

This involves

1. Identify three widely positioned, known features in your surroundings (eg, mountain peaks). For each landmark, perform steps 2 – 4 below.
    2. Take a compass bearing and adjust this for magnetic variation as per the procedure of “taking a bearing from compass to map” (3.5).
    3. Convert each bearing to a back bearing.
    4. Draw a (real or imaginary) line on your map from the landmark, heading in the direction indicated by that bearing.
5. You will usually find there is a small triangle where the three lines meet - your current position will be within or close to that triangle.

You may need to move to higher ground and/or a location with a better view in order to observe the necessary landmarks.

4.4 Following a direction

4.4.1 Obtaining your direction from the map

If you are walking on a marked track, after locating your position you may only need to decide whether to proceed or turn back. However, if you are walking off-track or have lost your path, you will need to determine a direction in which to head (your bearing) by using your map and compass.

To obtain your direction from a map (Grid to Magnetic):

1. Draw a line (real or imaginary) on your map from your current location to the place you wish to go.

2. Obtain the grid bearing of the line and determine the compass bearing as per the procedure “taking a bearing from map to compass” (3.6).

3. Having set the compass dial to the magnetic bearing, if you now orient the whole compass – holding it flat - so that its needle points to north on the dial, the base plate arrow will be pointing in your direction of travel.

As long as you ensure the compass needle is pointing to north and the base plate arrow is pointing straight ahead, you will continue to face in the correct direction. The need to keep the red end of the needle pointing north can be remembered as “keeping red in the shed”.

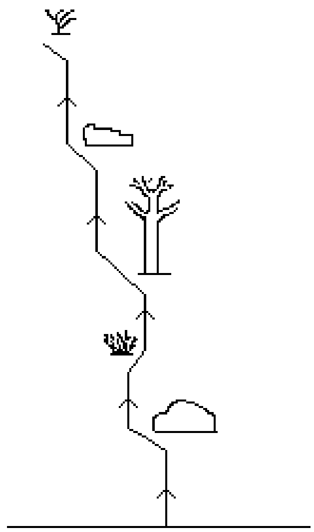
You can use another method in which you start by orienting the map as in section *4.3.1 Orienting the map*. Holding the oriented map, align the straight side of the base plate with the line between your current location and the place you want to go to. Rotate the dial of your compass until magnetic north on the dial is aligned with magnetic north on the map (ie, grid north plus the magnetic variation). The vertical grid lines will be, for example, 12 degrees to the west of north, ie, at 348 degrees on the dial. As before, you can take your compass off the map and the base plate arrow will be pointing in your direction of travel as long as the compass is held with the needle pointing to north on the dial.

Note that you can calculate the magnetic bearings for sections of a walk at home and refer to these notes later when in the field (see section *6.1 Preparing a route plan*).

[Exercise – using your compass only as a protractor, provide the magnetic bearing from one point to another on your map]

4.4.2 Moving in a straight line

You will get almost certainly get lost if you just head off in the direction pointed to by the compass baseplate arrow with the needle pointing north. This is because you are still facing in the correct direction even if you move left or right, and you will inevitably drift. Figure 8 shows small obstacles causing you to drift, but even if there are no obstacles you will still drift imperceptibly.



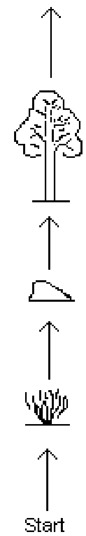


Figure 8. Drifting off course due to minor left and right movements – to be avoided

Figure 9. Moving in a straight line from object to object

The usual procedure to ensure movement in a straight line is to look in the exact direction pointed to by the baseplate arrow until you find a suitable landmark, usually a tree or rock with some memorable feature. You can now ignore your compass and head to that landmark. When you get to the landmark, you use your compass to locate another landmark along your intended bearing, then travel to that landmark, and so on.

If you want to check that you are heading in your intended direction, you can turn around and take a compass bearing on the point you left from (another version of a *back bearing*). It should be 180 degrees opposite to the bearing you are trying to follow.

You may also want to record the bearing in case the compass dial gets knocked while you are traversing rough ground, or if you are taking a back bearing.

4.5 Practical route plotting

4.5.1 Take the topography and vegetation into account

In reality, you can rarely travel in an absolutely straight line. There will be fallen trees, rocks, patches of blackberry, cliffs, deep valleys, creeks, etc, in your path. Sometimes a straight line is not the most efficient route to take if, for example, it means a large descent and ascent when you could follow a contour and stay at the same altitude. Practically, you must devise a route which is easy to follow and avoids obstructions and thick vegetation.

How do you combine this requirement with using your compass? The answer is to use your compass to identify more or less distant landmarks along your bearing, depending on the conditions. If the bush is thick and visibility poor, choose close landmarks. If visibility is good, you can choose a more distant landmark and devise the best, possibly circuitous, route to get there.

4.5.2 Aiming off

Aiming off is a technique used to ensure you arrive at the correct location on a linear feature such as road or track which is perpendicular to your direction of travel. This can be useful if, for example, you are returning to a car parked on a road. If you attempt to follow a bearing directly to the car, it is likely, particularly after some distance, that you will be too far left or right when you hit the road. If you cannot see the car, you may then be unsure whether to head left or right to find it.

If, however, when setting your initial bearing, you "aim off" to the left by an amount which takes into account some degree of drift, you can be pretty certain you will be left of your vehicle when you hit the road, and know to turn right in order to find it.

Aiming off can also be useful if you are trying to locate a track or creek junction when approaching the track or creek from the side.

4.5.3 Hand rails

A *hand rail* is a feature in the landscape such as a ridge, creek, road or fence line which is heading in the same direction you are heading. You can use this feature to maintain your direction by heading along it or beside it. Note that man-made features are less reliable than natural features for this purpose as the former are more likely to be displayed inaccurately on maps. Hand rails should be regarded as an aid and not supplant the use of map and compass.

4.5.4 Catching features

A *catching feature* is a linear feature of the landscape such as a creek, track or road which you know you must cross if you head in a particular direction. This will ensure you will not go too far, and may also catch you if you drift too far left or right. A catching feature can also be used to tell you that you have travelled too far and need to turn back, perhaps to find a missed turnoff.

[Exercise – plot the most sensible off-track course you can between two points on your map]

4.5.5 Judging distance to objects

This may be required to determine whether you can reach an object in a given time. It can be done *roughly* via four (overlapping) methods.

Unit of measure method – use a familiar unit of measure, eg, "it is four football fields away". May be difficult if not all ground is visible.

Appearance method – judging distance by comparing the appearance of an object with its surroundings. Prone to biases due to stunted trees, etc.

Bracketing method – take the average between the minimum and maximum estimates of distance.

Group average – ask everyone in the group and average it. Often quite accurate in an experienced group.

All these methods are prone to biases. Objects seem closer than they really are when they are brightly lit up, bigger than objects around them, higher up than the viewer or when there is hidden ground between them and the viewer. Objects seem further away than they really are when poorly lit, they are surrounded by smaller objects, the viewer is looking across a valley or down a ravine, the viewer is lying down, or the object is against a dark background.

4.6 Staying on your intended route

The safest and easiest way to traverse a route is to be aware of your location at all times. This requires constant checking of a number of factors, challenging your assumptions, and being alert for any unexpected observations.

The main check to perform is that the features of the landscape are as they should be, given that you are where you think you are. Do the directions, distances and shapes of the peaks, valleys and creeks that you see accord with their representations on your map from your current point of view?

Also, try to guess what you should see next, then check to see if this occurs.

Other possible checks to include are:

If you are heading uphill or downhill, are the slope direction and steepness what you would expect?

If you are heading along a ridge, do the ridge direction and any knolls you cross match with what you are seeing on your map?

Is the time you have taken to travel between the last known point and your current position, (as an indicator of distance – see section *6.4 Estimating trip time*) congruent with the distance you think you have travelled?

It is also important not to miss features such as track or creek junctions. Remember where you have just been – a notepad and pencil/pen can be handy for this.

Constant checking means that if you become uncertain of your position, you will never be far away from your intended route. Just head back to your last known position and re-assess.

5. Handling difficult situations

5.1 No compass – sun, watch and stars as tools

It can be helpful when navigating to remember that the sun rises in the east and sets in the west, and in the southern hemisphere follows an arc in the northern half of the sky – with the arc the lowest on the shortest day in winter. The southern side of trees (and slopes) is often wetter than the northern slopes.

During daylight hours you can use your (analogue) watch to *roughly* determine the direction of north in the southern hemisphere. Point the twelve at the sun. North is in the direction of a line half way between the 12 and the current position of the hour hand. Remember to adjust for daylight savings.

The Southern Cross can be used to locate south on a clear night. Draw an imaginary line (Line A) along the long axis of the Cross. Draw another line (Line B) joining the two Pointers. Draw a further line (Line C) starting halfway along Line B and crossing it at right angles. The celestial south pole is located where Lines A and C meet. Drop a final line directly down from this point to the horizon to find south.

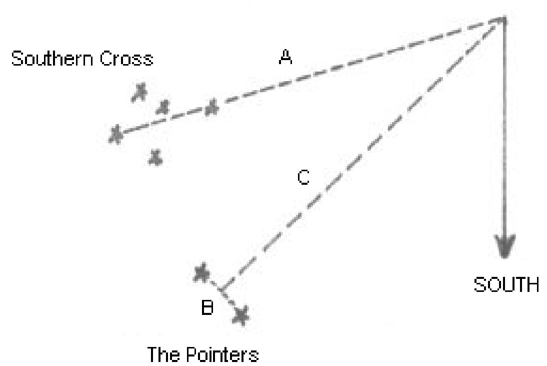


Figure 9. Finding south from the Southern Cross

5.2 White-outs

White-out conditions (which occur most commonly in alpine areas) are particularly dangerous due to the absence of visible landmarks. It is often best to just make camp and wait for the mist to clear.

If you need to move and know your direction of travel, you can use another person as your bearing point. You stand at the known point and direct the other person to move along the bearing to a position where you can still see them. Tell them to stop there (you may need to establish a set of hand signals for communication beforehand if there is a high wind). You then proceed towards the other person, and repeat the process (this is basically as described in section 4.4.2 Moving in a straight line). Ideally, use a length of cord or rope to link the two of you together, so that in the event that you suddenly can no longer see the other person you can pull them back towards you (at the known position) at least until you can see them again.

If there are snow poles (hidden by mist) along your route and you have a long enough cord (about 40 metres), you can try to move along the snow pole line by a method whereby you stay at the known point and the other person moves in an arc at the end of the cord until they locate the next snow pole. Snow poles are often numbered, run in straight lines for some distance, and supply the bearings of the forward and back line of poles on corners.

The lay of the land (as determined by careful scouting of the immediate area) may also assist with navigation in a whiteout.

If you are completely lost in a white-out, a GPS may be the only means of establishing your location.

5.3 Night navigation

This is similar to navigation in whiteout conditions, with visibility being basically limited to the 'throw' of your torch. Due to the potential for injury, off-track night navigation should be avoided unless necessary. You could attempt the same manoeuvre as above using a second person as your bearing point, ideally with a rope. The Southern Cross, and/or a dark outline of the surrounding hills, and/or the lights of towns may also be visible and so provide a general sense of direction.

5.4 What to do if lost

If you have become lost but were aware of your map position for most of your walking, it is unlikely you are very far from your route. If you can remember the way you have come, you should try to return to the position where you last knew your location.

If you find yourself completely unsure of your location, it is important not to panic. Heading off at speed in any direction may cause you to completely lose the direction came from, and you may end up far from any track.

If there are other walkers nearby, you may want to use your whistle to give the universal emergency signal of three blows, a second apart.

Sit down and assess the situation. Are there any prominent features that can help you locate your position? Are they the ones you know just viewed from a different angle? Try to work out where you went wrong – could you have drifted too far left or right, overshot or undershot? Seeking a nearby high point may provide enough extra information to reveal your location.

It may also be useful to estimate how far you have travelled from your last known point (based on time) then draw a circle on your map centred on that point and with a radius of your estimated distance travelled. You are likely to be somewhere within this circle.

You may be able to proceed in a search pattern to locate a track or known landmark. Mark your start position with some broken sticks, piles of rocks etc. Conduct your search in a radial (spoke-like) pattern. Using your compass, head out from your position along bearings following each of the four main compass points (N, S, E, W) for about five minutes and return, then repeat for each of the points between these (NE, SE, SW, NW).

Note that moving far from your starting position is inadvisable if you are expecting a search party.

If darkness is approaching, it is usually best to wait until morning. On VNPA walks, the emergency contact arrangements will be activated and a search party will come looking for you. You may need to build a fire or keep moving around a small area to stay warm.

6. Trip planning

6.1 Preparing a route plan

Pre-prepared routes are often available in books, but you may wish to devise your own.

If so, start with the best maps you can find of the area.

Check the land tenure of where you wish to walk. National and state parks and state forests are open to the public, but not private property without permission.

Plan your route to take advantage of features in the landscape such as peaks and ridges that are easy to find and follow. Navigationally, ascents are easier on ridges and descents are easier in or nearby gullies (depending on vegetation). Consider what would happen if visibility deteriorated – you may be able to devise a route which minimises the chance of getting lost, eg, by avoiding large undulating areas.

Take into account the efficiency and difficulty of your route. A large detour may be worthwhile to avoid a strenuous section. It may be preferable to diagonally traverse a mountain side than take a more direct but exhausting route.

Be cautious planning a route which crosses creeks or ascends steep faces. These may not be passable. Bridges for creek crossings may no longer exist.

Your route should avoid areas of vegetation that are difficult to traverse. Remember that gullies and south facing slopes generally have thicker vegetation than ridges and north facing slopes.

For overnight pack carries, ensure water is available along or nearby the route at the appropriate times. Ensure suitably sized campsites are available.

If the route is in a national park, it can be useful to phone the appropriate parks service office for up to date advice. Undertaking a personal reconnoitre where possible is advisable.

You need to accurately estimate the distance and time involved to ensure that the walk can be completed by your party in the time available – see next section.

To ensure the greatest possible accuracy, you can prepare a fully-fledged *route plan* or *route card* containing, by reference to a map, a list of all legs with grid references, compass bearings, estimated times, height gain or loss and other information for each leg. A blank route card is provided at Appendix A. Other variations exist.

[Exercise – prepare a route plan with all of the above information]

6.2 Estimating trip distance

You need to estimate the distance of your route to be sure it is within your group's capacity. This can be done by tracing your intended route on the map with dividers, a length of string, the edge of a piece of paper, a ruler (eg, on the side of a compass) or a special map distance measuring instrument called a map measurer or opisometer. The side of your compass is most useful in the field. You then calculate the ground distance by referring to the map scale or grid interval (usually, the side of one grid square equals one kilometre). For example, 40 cm on the map would equal 10 km on the ground using a 1:25 000 scale map on which 4 cm represents 1 km.

For a day walk, 10-16 km would be a common distance undertaken. On a pack carry, 8-12 km would be a standard day. These distances are for moderately fit walkers in terrain of medium difficulty.

6.4 Estimating trip time

You must ensure there will be sufficient time to complete the walk within daylight hours, including breaks and some contingency time. You may also need to ensure that you arrive at a particular lunch spot by lunch time, and so on. Additionally, allow for the fitness of the people in your group and the amount of daylight and sunrise / sunset times at that time of the year.

Speed of travel on a walk depends greatly on the type of terrain. A useful heuristic is “Naismith’s Rule”:

For an average walker with a medium pack, allow one hour for travelling

- 4 km of easy going
- 3 km of easy scrambling
- 1.5 km of rough country, deep sand, soft snow or thick bush.

To these times, add

- one hour for every 500 metres ascent, and
- one hour for every 1000 metres descent.

Off track walks can be very unpredictable, so you should leave plenty of time to account for unforeseen circumstances.

[Exercise – how long would it take to walk for 4 km on a good flat track, followed by 3 km of easy off track with a height gain of 500 metres, followed by 3 km of difficult off track with a height loss of 500 metres? Assume the slower estimates of walking times apply.]

6.5 Escape routes

It is a good idea to include in your plan an escape route (a side route that allows you to cut the trip short) in case you cannot finish your intended route in the time available. This may be required due to bad weather, an injury or other unforeseen event.

7. GPS – use and limitations

A Global Positioning System receiver (“GPS”) is a useful aid to navigation, but you must understand and carry maps and a compass in order to use one.

Firstly, be sure you are aware of which map datum your GPS is set to. GPS units usually have an initialisation procedure which allows you to set the unit’s datum to match that of the map you are using. In Victoria, this mostly still means AGD – it may be called AGD, AGD84 or even AUST 84. If you have a recent map, you may need to set your GPS to the newer GDA. This may be called GDA or GDA94. If neither is these is available, look for WGS84.

The most useful function of a GPS is to provide your location on a map by displaying your current position as a grid reference. You may need to first ensure your GPS is set to provide grid references rather than latitude and longitude. A GPS reference will be within 15 metres of the true position 95 per cent of the time. Altitude data is less accurate. A GPS can be used to obtain “spot readings” of location (then turned off), or it can be kept on to constantly update the location reading (more battery-draining). A GPS taking constant readings is less likely to fail to obtain a position in conditions of poor satellite visibility than one which is newly switched on.

Some models can also tell you your speed of travel and the distance and/or direction back to your starting point.

You can usually program the grid references for “waypoints” into a GPS before a trip. These may be camp sites or other significant locations. As you approach your camp site, the GPS will provide you with the direction and distance to it, useful if visibility is poor.

When purchasing a GPS receiver, ensure that it can process data from up to 12 satellites at a time. Older ones used fewer satellites and so are less capable of obtaining a reading under trees. For bushwalking a unit should be small, light and water-proof. The display should be sensibly configured and easy to read, and buttons ideally easy to use with gloves.

Always carry spare batteries for your GPS. All GPS units use power even when turned off. If you have not used the unit for some time, you may find the batteries drained. Always carry maps and compass as well as a GPS.

It is not wise to rely totally on a GPS. They may fail for a number of reasons – the tree coverage may be too thick or you may be in too narrow a gorge to allow a reading; the batteries may run flat or become too cold to operate; or the unit may be dropped and broken, lost etc.

[Exercise – if you have a GPS, determine the map datum in use by reference to your manual. Set to the grid reference system rather than to latitude and longitude. Obtain your current grid reference. What degree of detail is provided by the reading?]

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2. Hans Fah. Zen and the art of navigation. Wild Magazine. Vol 38, 1997.

3. John Poppins. GPS receivers. Wild Magazine. Autumn 2003.

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6. Land Information Services, Tasmanian Department of Environment and Land Management. Map Reading Handbook. 1997.

7. Robert Rankin. Australian Wilderness Skills. Robert Rankin Publishing. 1983.

8. John Chapman, Monica Chapman and John Siseman. Day Walks Victoria. First edition 2001.

9. Various VNPA BWAG documents prepared in-house: “Maps – scale, measuring distance and judging distance”, “Map reading terminology – physical features”, “The Compass”, “Navigation – using a compass”, “Navigation – more about using a compass”, “Judging distance”.

Source of figures

Figure 1b – corner section of VICMAP Selwyn 1:50 000 topographic map
Figure 2 – reference 6
Figure 4 – reference 7
Figure 5 – reference 8
Others – created in-house or unknown/BWAG archives

Abbreviations

AGD	Australian Geodetic Datum
AMG	Australian Map Grid
BWAG	Bushwalking and Activities Group
DSE	Department of Sustainability and the Environment
GDA	Geodetic Datum of Australia
GN	Grid North
GPS	Global Positioning System
MGA	Map Grid of Australia
MN	Magnetic North
TN	True North
VMTC	Victorian Mountain Tramping Club
VNPA	Victorian National Parks Association
WGS	World Geodetic System

Resources

Map Reading Guide (Geoscience Australia)

- http://www.ga.gov.au/topographic-mapping.html > Map Reading Guide

On-line Topographical Maps (VicMap)

- http://services.land.vic.gov.au/maps/topo30maps.jsp

Map Shops

- http://www.bookshop.vic.gov.au
- http://www.melbmap.com.au
- http://www.mapsdownunder.com.au

Park Maps for Victoria

- http://www.parkweb.vic.gov.au (under Publications>Parknotes)

Fun with Mapping and Navigation

- http://www.vicorienteering.asn.au
- http://vra.rogaine.asn.au

Interesting Publications

- http://www.mountainsafety.org.nz/Resources > Free Pamphlets
- T. Lamble, 1998. Paddy Pallin's Bushwalking and Camping, Paddy Pallin
- P. Pallin, 1987. Never Truly Lost, UNSW Press

Gear Information

- http://www.silva.se
- http://www.suunto.com
- http://www.magellangps.com

Intergovernmental Committee on Surveying and Mapping

- http://www.icsm.gov.au/

Appendix A – Route card

Stage	Objective	Grid reference	Bearing	Km	Height gain or loss	Terrain	Stage Time	Estimated Time of Arrival & Remarks