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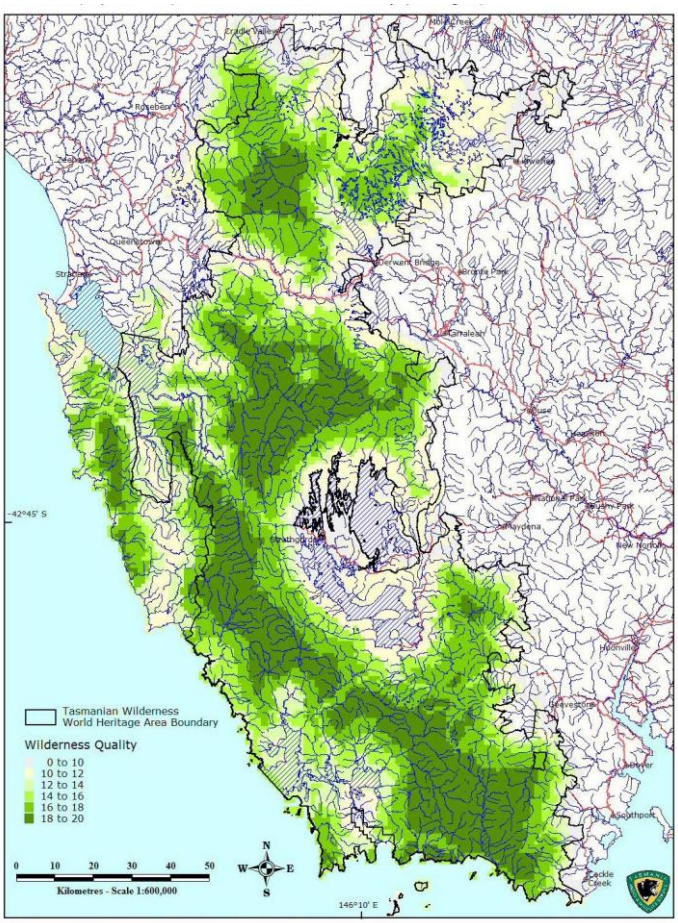
Tasmanian Wilderness World Heritage Area Wilderness Mapping Project 2005

Assessments of wilderness values using established (NWI) and revised methodologies



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Summary

This paper describes the processes and outcomes of a project that involved mapping the wilderness values of the Tasmanian Wilderness World Heritage Area using two methodologies: the established National Wilderness Inventory (NWI) methodology, and a revised methodology that takes walking track grades and walking conditions into account.

The results of the NWI assessment were compared with those obtained using the same method in 1995, as part of the Region Forest Agreement process. The comparison revealed some gains in wilderness where roads or vehicle tracks had been closed and where huts had been removed, and some losses due to track and infrastructure development. Other apparent losses and gains were probably a result of inaccuracies in either the 1995 or 2005 datasets.

The revised methodology is designed to correct some deficiencies in the NWI approach, mainly by replacing the 'Remoteness from Access' component with a new variable based on estimates of travelling times from points of mechanised access. The methodology yields reduced wilderness values in the Port Davey area and along much of the West Coast, due to the relative ease of boat access in these areas. It also gives slightly increased weighting to major artefacts such as roads and impoundments, and slightly reduced weighting to features such as vehicle tracks, walkers' huts and jetties.

1 Background

The WHA wilderness mapping project was initiated by the Parks and Wildlife Service in May 2005 to fulfil the requirements of the 1999 TWWHA Management Plan. The Plan's prescription for wilderness methodology (p 94) is to:

> 'Develop an enhanced methodology for the quantification of wilderness which more accurately reflects the Tasmanian situation eg incorporates the effect of the three dimensional nature of the terrain on viewfields and deals systematically with the effects of walkers' huts and walking tracks'.

The plan notes (p 92) that this is likely to involve the implementation of a modified version of the National Wilderness Inventory methodology. However, it does not restrict the PWS to the use of this methodology.

The objective of the first phase of the project (Module 1) was to use the existing NWI methodology to assess wilderness values in the WHA and in specified adjacent areas, based on the latest available information on roads, walkers' huts and similar infrastructure.

In the second phase (Module 2), wilderness was to be assessed using revised criteria taking into account walkers' huts, tracks and time-remoteness. The assessment of viewfields has been postponed to a future study.

This report outlines the development of both phases and discusses their results.

2 NWI methodology – How it works

2.1 Overview

The National Wilderness Inventory methodology was developed by the Australian Heritage Commission in the late 1980s and early 1990s to identify wilderness quality across Australia. The methodology is described in detail in the NWI *Handbook of Procedures, Content and Usage* (Lesslie and Taylor 1995), which is published in hard copy and on the internet.

The methodology was used to assess wilderness quality in Tasmania during the development of the Regional Forest Agreement in 1997. Concerns have been expressed by some observers that the RFA assessment involved some inaccuracies, and that the NWI methodology has inherent deficiencies as a measure of wilderness quality.

The NWI methodology does not attempt to differentiate between wilderness and non wilderness. Rather it assesses wilderness values as a continuum, varying in degree from pristine to urban. As noted in the NWI Handbook, "the procedure can more properly be described as a remote and natural lands assessment."

2.2 Components of Wilderness Value as defined by the NWI system

The NWI methodology estimates wilderness value based on four separate variables: Remoteness from Settlement, Remoteness from Access, Apparent Naturalness and Biophysical Naturalness. These variables are explained in the following table.

Table 1. Component variables of Wilderness Value in the NWI system

Variable	Explanation
Remoteness from Settlement	Remoteness from towns, settlements and isolated residences.
Remoteness from Access	Remoteness from points and corridors of access such as roads, walking tracks and functioning airstrips.
Apparent Naturalness	Remoteness from features that impinge on the perception of naturalness such as settlements, roads, impoundments and transmission lines.
Biophysical Naturalness	Extent to which a defined area (typically a grid square) is free from evidence of changes caused by modern technological society – specifically logging and grazing.

The first three of these variables are distance-based. That is, the value assigned to a sample grid-square is determined by the distance of the centre of the square from specified types of geographical features, regardless of whether they lie inside or outside the square.

The fourth variable is determined only by local conditions. That is, the value assigned to a grid-square is determined only by conditions within the square. For any given grid-square in a region of interest, the values of the four variables are calculated independently and then summed to yield the wilderness value of the square.

2.3 Calculating remoteness

For each of the three distance-based variables, geographical features are assigned weightings to reflect their perceived impact on wilderness values. For example, in calculating Remoteness from Access a walking track one kilometre distant is assigned a 'high grade equivalent' distance of 9 km, so that it has the same impact on RA class as a major road 9 km away.

The high-grade equivalent distance HGED of a geographical feature Y from a defined point X is given by

$$HGED = (1 + D)/W - 1$$

where D is the map distance between X and Y and W is a weighting factor assigned to the category of geographical feature concerned. All distances are in kilometres. For example, in calculating Remoteness from Access roads are assigned a weighting W = 1.0, whereas walking tracks are assigned the weighting W = 0.2. (For other values see Table A3 in the appendices.)

For each of the distance-based variables, the high-grade equivalent remoteness HGER of any point X is defined as the minimum HGED of X from any of the geographical features relevant to that variable. For example in calculating Remoteness from Access, a point X which is 1 km from a walking track and more than 12 km from all other points or corridors of access (including roads) is assigned a HDER of 9 km.

2.4 Calculating class for the distance-based variables

For each grid-square in the study area and for each of the three distance-based variables, class is calculated from the high-grade equivalent remoteness of the centre X of the square by the formula

$$\text{Class} = 4 \times \sqrt{(\text{HGER}/F)}$$

where HGER is the high grade equivalent remoteness of X in kilometres, and F takes the values 15, 10 and 6 for RS, RA and AN respectively.

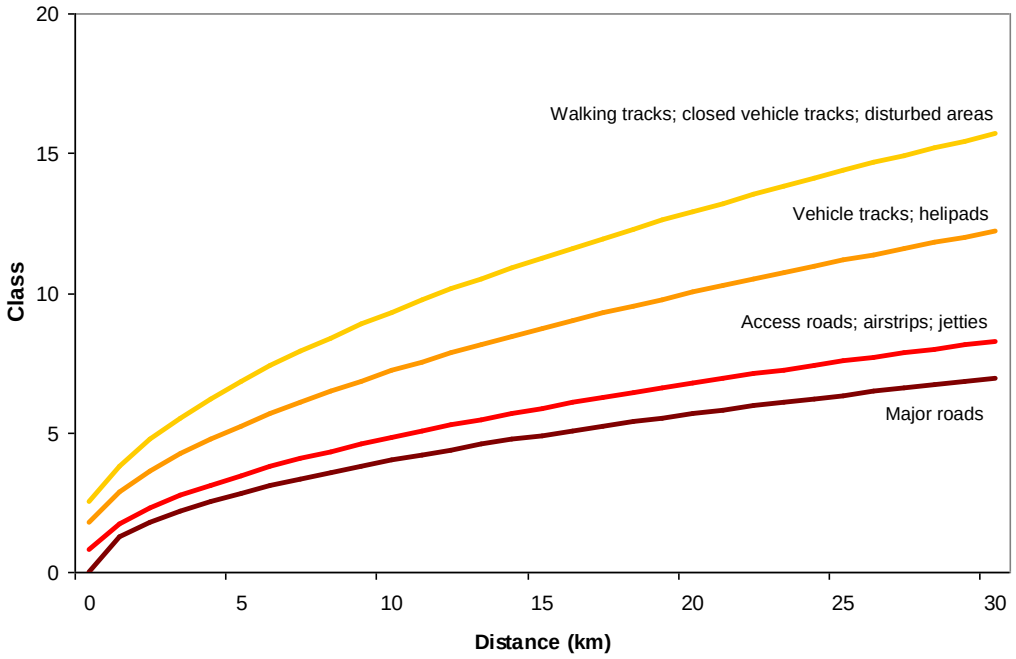
Note that the values assigned to F could be adjusted to vary the weighting assigned to each component variable.

Class values for the three distance-based variables are truncated at 5.

One way of illustrating the relationship between remoteness and class is to plot class as a function of map-distance for each category of geographical feature, as has been done for Remoteness from Access in Chart 1. For example, from Chart 1 one can see that a point X which is 5 km from a walking track would have a Remoteness from Access class of approximately 7. If X were also 10 km from a major road, its RA class would be reduced to 4.

Charts of the relationship between class and distance for Remoteness from Settlement and Apparent Naturalness are shown on pages 8 and 11.

Chart 1. Class as a function of distance – Remoteness from Access (NWI methodology)



2.5 Calculating class for Biophysical Naturalness

Biophysical Naturalness is assessed on a scale of 1-5, with 5 corresponding to minimum disturbance. In the current study only three values of Biophysical Naturalness were used: 1 (for impoundments, logging coupes, plantations and cleared land), 2 (for selectively logged or intensively grazed land), and 5 (for land or inland waterways with minimal disturbance). Insufficient information was available to assign values of 3 or 4, which correspond to land with low historical levels of grazing or selective logging.

2.6 Calculating Wilderness Value

Wilderness Value (WV) is defined as the sum of the class values of the four component variables. Since none of these exceed 5, WV can take values between 0 and 20. In the NWI-generated map of WV that accompanies this report, values in the range 0-10 have been combined as a single group as was done in the 1995 assessment.

2.7 Reliability of the NWI methodology

The NWI Handbook makes it clear that '[the] distance decay functions and class limits used in standardising index values were essentially arbitrary'. The Handbook also suggests that the methodology has 'a level of detail and reliability that satisfy requirements for national and regional evaluations'; but warns, 'Where there is interest in specific site conditions, (particularly for site evaluation and management planning purposes) results generally should not be relied upon.'

In the context of the current project, obvious limitations of the NWI methodology include the fact that it does not distinguish between different grades of walking track and does not take walking speeds or viewfields into account. These points are discussed further in 4.1.

3 NWI methodology – Discussion of results

3.1 General comments on the maps

Maps were generated at a resolution of 5 km until obvious errors had been corrected. The final maps were generated at a resolution of 1 km. One 5 km map of wilderness values is included with this report to illustrate the inferiority of the information available at this resolution.

When appraising the maps, the choice of data-output ranges should be borne in mind. Arithmetic ranges (0-1, 1-2 etc) were chosen for all maps because the components of Wilderness Value are combined additively, and because an arithmetic scale was used in the original 1995 map. Different data-output ranges would provide different information. For example, if the range [4-5] were subdivided into the ranges [4.0 - 4.5] and [4.5 - 5.0], the impacts of walking tracks would be more evident on the map of Apparent Naturalness.

3.2 The study area

The project contract specified that wilderness values were to be assessed in the WHA, the Melaleuca–Cox Bight enclave and the area south of Macquarie Harbour.

As part of the second phase of the project (Module2), the consultant assessed the location of country in and adjacent to the WHA that is at least three hours remote from the nearest point of mechanised access (helicopter access excepted). Wilderness values in both modules were assessed in all of these areas, including those that extend beyond the WHA boundary.

For convenience, the area in which wilderness values were assessed in both modules will henceforth be referred to as the study area.

3.3 Remoteness from Settlement

The impact of towns and settlements is clearly evident, particularly around the southeast, West Coast and Western Tiers fringes of the study area. Isolated residences (such as Melaleuca) have roughly two-thirds the impact of major towns.

3.4 Remoteness from Access

The RA map illustrates the impact of roads, vehicle tracks, walking tracks, airstrips, helipads, jetties, and mechanised boat access. Note the high impact of the Lyell Highway and Gordon and Scotts Peak Roads compared to that of vehicle tracks and walking tracks. Under the NWI scheme all walking tracks are given equal weighting. Hence, the 'Grade 6' track on the Pelion circuit has the same degree of impact as the South Coast Track.

The Murchison Impoundment has an impact on Remoteness from Access (RA), even though it is inaccessible to powered boats. This is because under the NWI system, impoundments have a 'Very Low' RA ranking – the same as for walking tracks – regardless of their accessibility to powered boats.

3.5 Apparent Naturalness

The AN map illustrates the impact of all the geographical features listed in 3.4, as well as buildings, impoundments, beacons, towers, lighthouses, towns and settlements, areas of disturbed land and several other categories.

Note that walking tracks show up only intermittently because AN class increases to 4 at a distance of only 120m from a walking track.

Buildings are classified among the features that have the greatest impact on AN – hence the large circles of low AN class around walkers' huts and other remote buildings.

Note that AN class values are low across almost the entire eastern sector of the Central Plateau because of the proximity of vehicle tracks and the frequency of huts in this area.

3.6 Biophysical Naturalness

The only features that have BN class less than 5 are Hydro Impoundments, one clearfell coupe in the Picton Valley and one selectively logged area on the southern Central Plateau. Most other logged or cleared areas are outside the study area.

A disturbance only affects the BN class of a grid square if it occupies more than 50% of the square by area. This was not true in the case of Lees Paddocks (which have been recently grazed), the Gell River airstrips, or most of the Murchison Impoundment.

3.7 Wilderness Value

The WV map shows the distribution of wilderness values, defined as the sum of the four component variables.

3.8 Losses and gains in wilderness values since 1995

The original 1995 map has a nominal resolution of 200m, but data was interpolated. The original resolution was probably between 1 and 2 km.

As the numerical values of Wilderness Value were available from the 1995 study, it was possible to construct a map showing losses and gains in WV relative to 1995. A major drawback in interpreting the results is that the original data from which the 1995 values were calculated (eg the location of roads etc) were not available. Hence, while the causes of some of the observed discrepancies can be guessed with confidence, others remain unexplained.

Significant gains (or apparent gains) in Wilderness Value are evident in the following areas:

- Southern Central Plateau, probably due to the closure and/or disappearance of vehicle tracks.
- Forth Valley – possibly because mining tracks were recorded in 1995 and are no longer listed.
- Little Fisher Valley, probably because roads have been downgraded to vehicle tracks.
- Lower Murchison Valley – unexplained.
- Western Central Plateau – possibly due to huts being overlooked in the current survey.
- Alma Valley – due to closure of road.
- Vicinity of King William Saddle – unexplained.
- Gell River airstrips – due to closure of airstrips.
- Middle Denison Valley – unexplained. The discrepancy is in an area too far south to be associated with the (now revegetated) Gell River track.
- Lower Gordon – due to disappearance of walking tracks (which probably occurred before 1995).
- Area southeast of the Gordon Impoundment – unexplained. The assessment of Biophysical Naturalness in the current survey may be inaccurate in this area because only two small logging coupes could be identified from the satellite images, and logged areas are not evident on the vegetation layer in this area.
- Junction Creek and Cracroft Crossing – due to removal of walkers' shelters.

Significant losses (or apparent losses) are evident in the following areas:

- Pelion traverse – probably because of walking track development.
- Lower Gordon – due to development at Heritage Landing and infrastructure on the Elliot Range. (The latter was established in the early 1980s and must have been overlooked in the 1995 survey)
- Lower Jane River – due to Hydro hut (now a ruin), which must have been overlooked in the 1995 survey.
- Jane River Track – presumably because the mining hut was omitted from the 1995 survey, although the apparent loss in WV is not uniform.
- Area south of Macquarie Harbour – presumably because tracks in this area were omitted from the 1995 survey.
- Davey Gorge – presumably because the hut there was omitted from the 1995 survey, although the apparent loss in WV is not uniform.

One surprising result is the apparent lack of change in wilderness values along the eastern boundary of the WHA south of the Lyell Highway. Assuming the 1995 analysis was reliable, this indicates that the additional roading and logging that has occurred near this boundary during the past ten years has involved no new major incursions into wilderness. Where incursions have occurred, they may have been offset by other factors – eg the removal of the makeshift walkers' shelter at Blakes Opening.

4 Revised methodology – What's been changed and why

4.1 Shortcomings of the NWI methodology

The NWI methodology has been criticised for a number of shortcomings. These may be summarised as follows:

- It gives inappropriate weighting to some categories of geographical features. For example, walkers' huts and other buildings are assigned the same weighting as roads and impoundments; no distinction is made between different grades of walking track; and there is little difference between the impact of settlements, regardless of their population.
- It fails to take terrain and vegetation, and hence walking conditions, into account.
- It fails to take viewfields into account.

As noted earlier, the assessment of viewfields was beyond the scope of the current study.

In the revised methodology adopted in Module 2, the weightings assigned to categories of geographical features have been changed and some features have been moved to different categories. The formulas for calculating high-grade equivalent distance and high-grade equivalent remoteness remained basically unchanged (see 2.3), although the weighting factors were changed. For details of the changes see sections 4.3 and 4.5.

To take terrain and vegetation into account, the variable Remoteness from Access was replaced with the new variable Time Remoteness, as explained in 4.4.

The formula for calculating class was modified as explained in the following section.

4.2 Redefining class as an exponential function

Under the NWI system class is a weighted square root of high-grade equivalent remoteness, and the class values of each of the component variables of Wilderness Value are truncated at 5 (see 2.4).

A problem with this approach is that information is lost whenever one or more of the component variables has a class value exceeding 5. If values are not truncated, one or more of the component variables (eg Remoteness from Settlement) may carry undue weight in some areas.

To avoid this problem, it was decided to replace the square-root formula with an exponential function so that each of the distance-based variables approaches an asymptotic value of 5 as distance increases. For Remoteness from Settlement (RS) and Apparent Naturalness (AN), class was defined by the formula

$$\text{Class} = 5 \times (1 - \exp(-F \times \text{HGER}))$$

Where HGER is the high-grade equivalent remoteness in kilometres (see 2.3) and F takes the values 0.10 and 0.15 for RS and AN respectively.

For Time Remoteness (TR), class is given by

$$\text{TR Class} = 5 \times (1 - \exp(-1.5 \times T))$$

where T is the remoteness in days. Since T only takes the values 0, 0.5, 1.0 and 2.0 (corresponding to the Non-remote, Half-Day, One-Day and Two-Day zones respectively), TR class can take the values 0, 2.64, 3.88 and 4.75.

4.3 Remoteness from Settlement

Under the NWI system there is little difference between the impact of settlements with different categories of population (see Chart 2). The weightings have been revised to give slightly lower weighting to smaller settlements (see Chart 3). Note that these charts have different vertical scales.

Chart 2. Class vs distance – Remoteness from Settlement (NWI methodology)

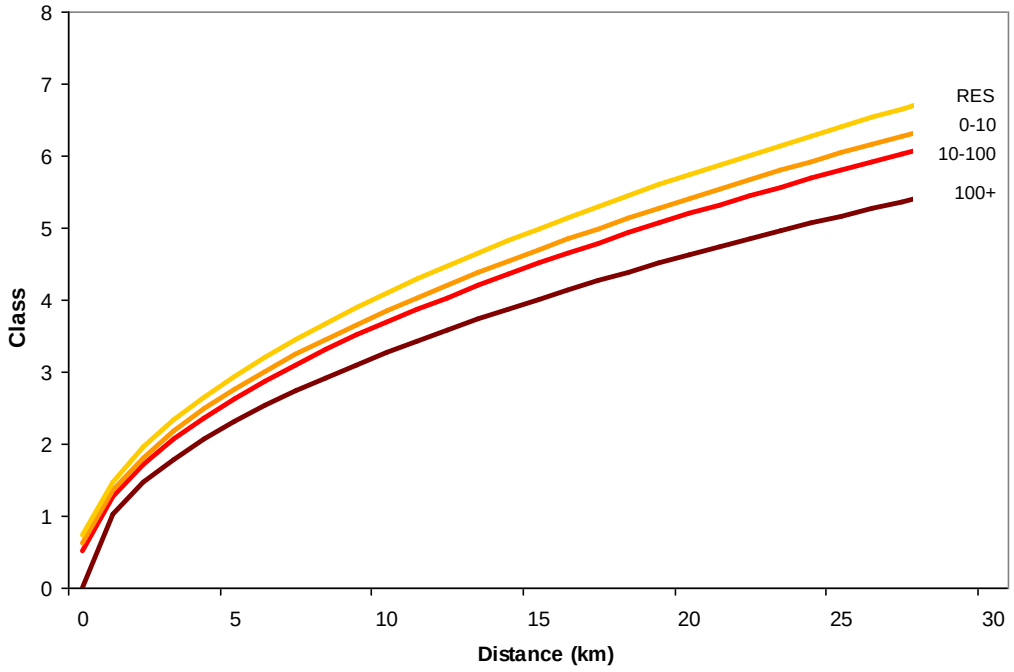
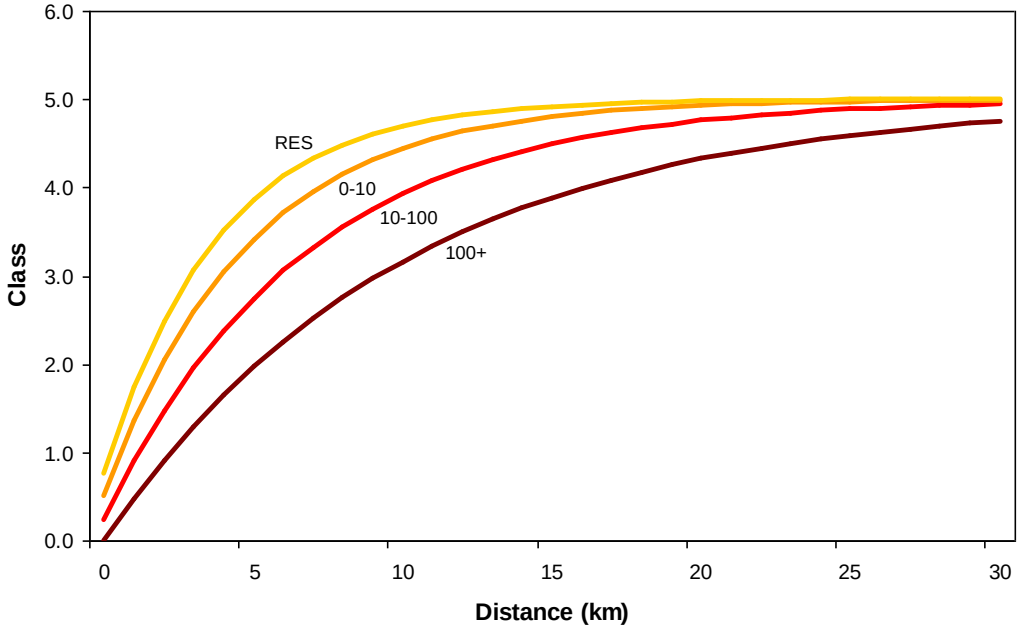


Chart 3. Class vs distance – Remoteness from Settlement (Revised methodology)



4.4 Time Remoteness

Under the NWI system, Remoteness of Access (RA) is assessed by measuring the distance from points and corridors of access such as roads, walking tracks and navigable waterways. As explained in 2.3, these are weighted so that (for example) a walking track 1 km distant has the same impact on wilderness values as a road 9 km distant.

One deficiency of this approach is that there is no direct link between wilderness values and remoteness from points of mechanised access. For example, a point in trackless country 5 km from the nearest road will have a higher RA Class than a point on a walking track 30 km from the nearest road. Moreover, RA takes no account of the impact of vegetation and terrain on travelling times.

In the revised approach RA has been replaced by Time Remoteness (TR). This is an assessment of the travelling time (on foot, or in rare cases by raft) from points and corridors of mechanised access. The latter include roads, vehicle tracks, functioning airstrips, inland waterways accessible to motorised boats, and sections of coastline that can be accessed easily by boat in calm to moderate conditions.

In this context, helipads are not regarded as points of mechanised access because existing helipads in the WHA are generally used infrequently and only for management purposes.

The shorelines of hydro impoundments have been taken as those corresponding to full supply level, and it has been assumed that powered boats can land anywhere along the shorelines of navigable inland waterways.

Estimates of minimum travelling times were based on terrain, vegetation and the location and class of walking tracks. This information was obtained from 1:25,000 maps, supplemented in places by the Tasmanian vegetation database and by local knowledge.

The following rules of thumb were used in estimating walking speeds:

Table 3. Walking speeds assumed in estimating Time Remoteness

Walking conditions (on level terrain)	Walking speed
Closed vehicle track; walking tracks class 1-3	Up to 3 km/hr
Walking tracks class 4-6; open heath or sedge	Up to 2 km/hr
Open woodland (mainly Central Plateau)	1-1.5 km/hr
Dense forest and scrub	0.5 km/hr

An additional hour was allowed for every 300m gain in altitude.

Rivers were assumed to be crossable by fording or swimming, except where rapids or fast currents prohibit safe crossing even at low water.

The Time Remoteness of any given point is the travelling time via the fastest access route to that point, regardless of whether or how frequently that route is used by walkers. Moreover TR is based on travelling times only – that is, it takes no account of breaks (for rest, admiring the view etc), the location of campsites, or time spent in camp.

Draft maps of Time Remoteness were checked by the Parks and Wildlife Service's Track Monitoring Officer, who suggested modifications in places. The fact that these modifications were minor suggests that the process of estimating TR is reasonably objective, providing the people doing the assessment have sound knowledge of walking conditions in the WHA.

Only four categories of TR were identified – namely 'Non remote', 'Half-day', 'One-day' and 'Two-day'. Given the error margin in estimating TR, the time-consuming nature of the

estimation process, and the fact that TR is only one of the four component variables of WV, it was not considered worthwhile to assess additional categories. If additional resources were available, however, it might be worth identifying a 1.5-day zone and a 3-day zone in future studies.

Points in the WHA were awarded values of TR class based on the criteria listed in the following table:

Table 4. TR class as a function of Time Remoteness

TR Zone	TR (Hours)	TR Class
Non remote	0-3	0.00
Half day	3-6	2.64
One day	6-12	3.88
Two day	>12	4.75

4.5 Apparent naturalness

The following changes were made to the criteria for assessing apparent naturalness:

- An additional category of AN Grade was introduced.
- Major artificial features such as roads and impoundments were given greater weighting than under the NWI system.
- The AN Grade for jetties, boat ramps, disturbed areas, powerlines, buildings, ruins, towers and automatic lighthouses was downgraded from 'Major' to 'Medium'.
- The AN Grade for beacons was downgraded from 'Major' to 'Minor'.
- The AN Grade for trig points was downgraded from 'Minor' to 'Very Low'.
- Walking tracks were divided into two categories. Tracks with classification 1-4 were assigned an AN Grade of 'Minor', and tracks with classification 5-6 were assigned an AN Grade of 'Very Low'.

Water bodies and shorelines were assigned AN Grades using the criteria listed in the following table:

Table 5. AN grades for water bodies and shorelines

Category of water body / shoreline	AN Grade	Comments
Natural water bodies inaccessible to powered boats	Not graded	Includes lakes, lagoons and rivers.
Exposed coastline where boats cannot put ashore	VLO	The grading reflects the fact that exposed coastal waters are accessible to powered boats, even though the shoreline may be inaccessible.
Natural inland water bodies accessible to powered boats	MIN	Includes the lower Gordon River, Lake St Clair, Macquarie Harbour and Port Davey.
Sections of coastline where powered boats can put ashore	MIN	Includes well-sheltered sites (eg New Harbour beach) and sites where fishermen or other visitors regularly put ashore (eg Nye Bay).
Jetties and boat ramps	MED	
Artificial waterways (ie impoundments), regardless of boat access	MAJ	

Charts 4 and 5 show the relationship between map distance and AN class under the NWI and revised methodologies. Note that these charts have substantially different vertical scales.

Chart 4. Class vs distance – Apparent Naturalness (NWI methodology)

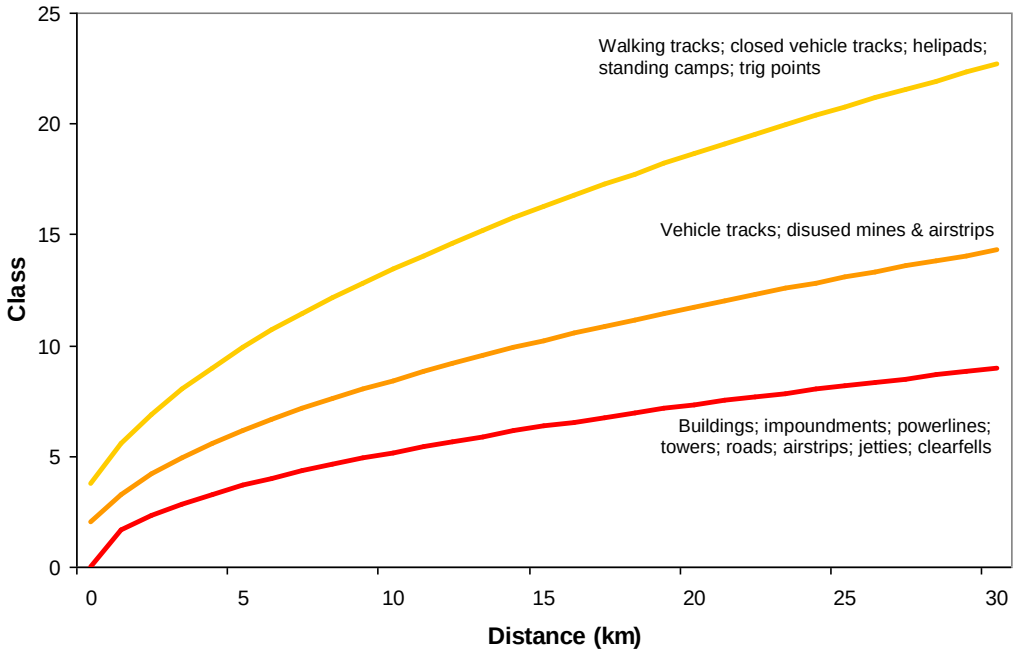
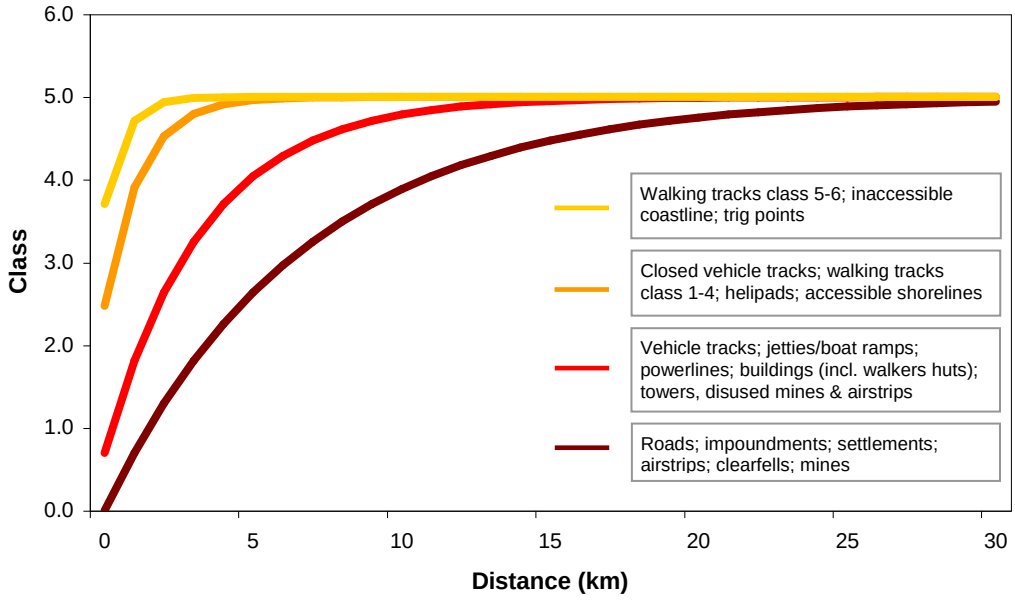


Chart 5. Class vs distance – Apparent Naturalness (revised methodology)



5 Revised methodology – Discussion of results

5.1 Remoteness from Settlement

Compared to the NWI result, the main difference is that small towns (such as Strathgordon) and residences (such as Melaleuca) have less impact on RS Class. Large towns (such as Maydena) have slightly more impact.

5.2 Time Remoteness

The main effects of substituting TR for RA are as follows:

- TR is lower than RA in the vicinity of Port Davey, Bathurst Harbour and the West Coast, because these areas are accessible to powered boats. Indeed TR is zero along much of the West Coast, substantially lowering overall wilderness values in this region.
- Unlike RA, TR is not directly dependent on distance from walking tracks.
- TR is clearly influenced by terrain and vegetation – for example on the Central Plateau, where TR values tend to be lower than the corresponding RA values.

5.3 Apparent Naturalness

The main differences relative to the NWI results are:

- Major features such as roads and impoundments have greater impact.
- Minor features such as buildings, jetties, beacons and trig points have less impact.
- Tracks of class 1-4 have greater impact.
- AN is reduced in the vicinity of accessible shorelines.

5.4 Biophysical Naturalness

The result is identical to the NWI result, since the criteria were not changed.

5.5 Wilderness Value

The revised methodology shows slightly lower wilderness values overall. The category [WV 18-20] derived from the NWI methodology corresponding approximately to the category [WV > 17] under the revised system.

The revised methodology also shows:

- Substantially lower wilderness values in the country bordering Port Davey, Bathurst Harbour and the West Coast, and in the country south of Macquarie Harbour.
- More extensive wilderness impact due to roads, impoundments and other major artefacts.
- Reduced impacts due to low-grade walking tracks.
- Reduced impacts due to walkers' huts and other buildings.

Although the influence on wilderness values of terrain and vegetation is discernible in some areas using the revised methodology, it is not especially pronounced. This is partly because Time Remoteness is only one of four component variables, and partly because in the Central Plateau, where walking times are substantially faster than in most other parts of the WHA,

wilderness values are substantially reduced by other factors – notably the presence of numerous huts and vehicle tracks.

6 References

Lesslie, R. and Maslen, M., 1995 *National Wilderness Inventory Australia: Handbook of Procedures, Content and Usage* (2nd ed), Australian Heritage Commission, May. This document is available at http://www.heritage.gov.au/anlr/nwi/handbook.html.

Appendix 1: Notes on data sources

The assessment undertaken in Module 1 was based on data obtained or derived from the following sources:

- The Tasmanian Government's LIST database – specifically the layers on Assets, Roads, Towns, Hydro Lakes, Hydro structures, Beacons, Vegetation and Transmission lines. Information on the date and accuracy of this data is available at www.thelist.tas.gov.au/asdd/.
- Visual-light, colour-adjusted SPOT satellite imagery recorded in 2002. The images covered most of the region of interest and were mostly cloud-free. The nominal resolution of 20 metres allowed identification of most roads and recent clearfell coupes. It also allowed identification of some selectively logged areas on the southern Central Plateau, and of the cleared corridor associated with a dismantled power line near the Great Lake.
- The Tasmap 1:25,000 topographic coverage of the region.
- The Parks and Wildlife Service's walking tracks database.
- A field trip undertaken by the consultant in the Butlers Gorge area, to record the location of new logging roads using a GPS.
- Personal knowledge – principally that of ranger staff, the Parks and Wildlife Service's Tracks Monitoring Officer and the consultant himself.
- The 2001 Census count on the Australian Bureau of Statistics website, which provides information on the populations of larger towns. No official figures are available for the populations of small towns and settlements such as Lune River and Miena. These were estimated from the size of the towns as indicated on 1:25,000 maps, supplemented in some cases by local knowledge.

Table A1 lists the geographical features that were relevant in calculating Wilderness Value, the sources of data for each of these features, and additional comments where relevant.

Table A1. Data sources

Geographical feature	Data sources	Comments
Roads	LIST 'Roads_25k' dataset supplemented with satellite images and local knowledge.	• Some recent roading may have been overlooked, but omissions are likely to be minor.
Vehicle tracks	LIST 'Roads_25k' dataset supplemented with satellite images and local knowledge.	• Information on the status of vehicle tracks outside the WHA is limited. For example, some tracks south of Macquarie Harbour listed as accessible to vehicles may be inaccessible and vice versa.
Walking tracks	PWS walking tracks database supplemented with local knowledge	• The PWS database is likely to be reliable and up to date, although some minor tracks may be unrecorded. • Only limited information is available on walking tracks outside the WHA, eg south of Macquarie Harbour.
Railways	LIST 'Roads_25k' dataset.	

Geographical feature	Data sources	Comments
Airstrips	LIST 'Assets_Prod1' dataset.	
Helipads	LIST 'Assets_Prod1' dataset.	• Some Hydro or other helipads may have been overlooked. However, it is likely that any unrecorded pads would be used very infrequently.
Jetties / Boat ramps	LIST 'Assets_Prod1' and 'WHA_Hydro_Structures' datasets.	
Hydro impoundments	LIST 'Hydro_Lakes' dataset.	
Mechanised boat access	WHA Management Plan and ranger staff.	• It was assumed that all the navigable areas of Port Davey and Bathurst Harbour are accessible to mechanised boats. Although such access is discouraged in some areas, there is no effective prohibition. • The limits of mechanised boat access on the lower Gordon and Franklin Rivers were chosen as points beyond which such access very rarely occurs (i.e. probably no more than once a year).
Accessible coastline	Ranger staff	• Sections of coastline were listed as accessible to powered boats if they are easily accessed for shore landings under calm to moderate conditions. Most of the sections in this category were north of Port Davey.
Logged and grazed areas	LIST 'Tas_Vegetation' dataset supplemented with satellite images and local knowledge.	• Some clearfelled areas may have been overlooked, particularly those with advanced regrowth (which may not have been discernible on the satellite images). Omissions would influence values of Apparent Naturalness and Biophysical Naturalness. • Some selectively logged areas may have been omitted, particularly on the Central Plateau.
Pine plantations	LIST 'Tas_Vegetation' dataset.	
Mines and quarries	1:25,000 maps and LIST 'Tas_Vegetation' dataset.	
Cleared land	LIST 'Tas_Vegetation' dataset.	
Transmission lines	LIST 'Transmission_Lines_Major' dataset.	
Buildings	LIST 'Assets_Prod1' and 'WHA_Hydro_Structures' datasets, supplemented with local knowledge.	• Some walkers' huts and other buildings (eg Hydro huts) may have been omitted.

Geographical feature	Data sources	Comments
Standing camps	LIST 'Assets_Prod1' dataset.	• There is only one standing camp in the WHA.
Ruin	LIST 'Assets_Prod1' dataset, supplemented with local knowledge.	• Minor ruins (such as Gordonvale) were disregarded since they do not consist of standing structures and have minimal impact on wilderness values.
Lighthouses	LIST 'Assets_Prod1' dataset.	
Towers and beacons	LIST 'Beacons' and 'WHA_Hydro_Structures' datasets.	• Information on Telstra and other private telecommunications infrastructure was not available for this study. • Under the NWI scheme, towers have a major impact on Apparent Naturalness. However, if any towers have been overlooked they are likely to be on the fringes of the WHA.
Trig points	LIST 'Beacons' dataset.	
Beacons	LIST 'Beacons' dataset.	
Hydro sampling stations		• This information was not available for this study.
Towns and villages	Location data: LIST 'Towns' dataset. Population data: 2001 Census; 1:25,000 maps; local knowledge	• Populations of small settlements were inferred from their size on 1:25,000, supplemented with some local knowledge. • Inaccuracies in population estimates for small settlements would have minimal impact on estimates of wilderness values in the WHA.
Isolated residences	Location and population data: 1:25,000 maps and local knowledge.	• See previous note. • Limited information was available on the location of isolated residences, eg in the Huon Valley and the vicinity of the Great Western Tiers.

Appendix 2: Summary of defining criteria and formulas

A2.1 NWI methodology

A2.1.1 Grading system

Table A2. Grading system for geographical features (NWI methodology)

Geographical feature	RSGrade	RAGrade	ANGrade	BNGrade	Comments
Road - Sealed; 2 or more lanes unsealed	N	MAJ	MAJ	0	
1 lane unsealed, 2WD	N	MED	MAJ	0	
4WD track; dozer track	N	LOW	MED	0	
Closed road/ closed vehicle track	N	VLO	MIN	0	
Walking track	N	VLO	MIN	0	
Railway - used	N	MED	MAJ	0	
Airstrip - used	N	MED	MAJ	0	
Helipad	N	LOW	MIN	0	
Jetty / Boat ramp	N	MED	MAJ	0	
Impoundment - accessible to powered boats	N	VLO	MAJ	1	
Inland waterway (natural) - accessible to powered boats	N	VLO	N	5	
Clearfell or intensive grazing	N	VLO	MAJ	1	
Disturbed area - Repeated selective logging or moderate grazing	N	VLO	MAJ	2	
Pine plantation	VLO	VLO	MAJ	1	
Mine or quarry - large, in use	N	N	MAJ	1	
Cleared land	N	VLO	MAJ	1	
Impoundment - inaccessible to powered boats	N	VLO	MAJ	1	
Powerline	N	N	MAJ	0	
Misc. building incl walkers' huts	N	N	MAJ	0	
Mine or quarry < 1 ha and/or abandoned	N	N	MED	0	
Standing camp	N	N	MIN	0	
Ruin	N	N	MAJ	0	
Lighthouse - staffed	RES	N	MAJ	0	

Geographical feature	RSGrade	RAGrade	ANGrade	BNGrade	Comments
Lighthouse - automatic	N	N	MAJ	0	
Tower	N	N	MAJ	0	
Trig point	N	N	MIN	0	
Airstrip - disused	N	N	MED	0	
Dam or weir	N	N	MED	0	
Beacon	N	N	MAJ	0	
Undisturbed land	N	N	N	5	Relevant only to Biophysical Naturalness
Inland waterway (natural) - inaccessible to powered boats	N	N	N	5	Relevant only to Biophysical Naturalness
Cleared area < 1 ha	N	N	MED	0	Not relevant to this study.
Hydro sampling station	N	N	MIN	0	Data not currently incorporated into analysis
Railway - disused	N	N	MIN	0	Not relevant
Pipeline	N	N	MAJ	0	Not relevant
Disturbed area - 1ce off selective logging or infrequent grazing	N	N	N	3	Insufficient data available to allow use of this parameter.
Drain	N	N	MED	0	Not relevant
Settlement: >100	MAJ	VLO	MAJ	1	
Settlement: 11-100	INT	VLO	MAJ	1	
Settlement 1-10	MIN	VLO	MAJ	1	
Settlement - residence only	RES	N	MAJ	0	

A2.1.2 Calculating high-grade equivalent distance/remoteness

The high-grade equivalent distance HGED of a geographical feature Y from a defined point X is given by

$$HGED = (1 + D)/W - 1$$

where HGED is the high-grade equivalent distance in kilometres, D is the map distance in kilometres, and W is a weighting factor whose value is given in the table below.

Table A3. Weighting factors for calculating HGE (NWI methodology)

Component	Grade	Weighting factor (W)
RS	MAJ	1.00
	INT	0.80
	MIN	0.74
	RES	0.66
RA	MAJ	1.00
	MED	0.71

	LOW	0.33
	VLO	0.20
	MAJ	1.00
AN	MED	0.40
	MIN	0.16

For each of the distance-based variables, the overall remoteness of any point X is defined as the minimum 'high grade equivalent' distance of X from any of the geographical features relevant to that variable. That is,

$$HGER = \min (HGED)$$

where HGER is the high-grade equivalent remoteness of X, and HGED is the high-grade equivalent distance of X from each of the relevant geographical features.

A2.1.3 Calculating class

For each grid-square in the study area and for each of the three distance-based variables, class is calculated from the high-grade equivalent remoteness (HGER) of the centre X of the square by the formula

$$Class = 4 \times \sqrt{(HGER / F)}$$

where HGER is the high grade equivalent remoteness of X in kilometres, and F is a factor whose value is given in the table below.

Table A4. Weighting factors for calculating class (NWI methodology)

Component	Weighting factor (F)
RS	15
RA	10
AN	6

A2.2 Revised methodology

A2.2.1 Grading system

Table A5. Grading system for geographical features (Revised methodology)

Geographical feature	RSGrade	ANGrade	BNGrade	Comments
Road - Sealed; 2 or more lanes unsealed	N	MAJ	0	
1 lane unsealed, 2WD	N	MAJ	0	
4WD track; dozer track (accessible to vehicles)	N	MED	0	
Closed road/ closed vehicle track	N	MIN	0	
Walking track Class 1-4	N	MIN	0	
Walking track Class 5-6	N	VLO	0	
Railway - used	N	MAJ	0	
Airstrip - used	N	MAJ	0	
Helipad	N	MIN	0	
Jetty / Boat ramp	N	MED	0	
Impoundment - accessible to powered boats	N	MAJ	1	
Inland waterway (natural) - accessible to powered boats	N	MIN	5	
Exposed coastline	N	VLO		
Coastline accessible from offshore vessels	N	MIN		
Clearfell or intensive grazing	N	MAJ	1	
Disturbed area - Repeated selective logging or moderate grazing	N	MED	2	
Disturbed area - 1ce off selective logging or infrequent grazing	N	N	3	Insufficient data available to allow use of this parameter.
Pine plantation	N	MAJ	1	
Mine or quarry - large, in use	N	MAJ	1	
Cleared land	N	MAJ	1	
Impoundment - inaccessible to powered boats	N	MAJ	1	
Powerline	N	MED	0	
Building incl walkers' huts	N	MED	0	

Geographical feature	RSGrade	ANGrade	BNGrade	Comments
Mine or quarry < 1 ha and/or abandoned	N	MED	0	
Standing camp	N	MIN	0	
Ruin	N	MED	0	
Lighthouse - staffed	RES	MAJ	0	
Navigation light	N	MED	0	
Tower	N	MED	0	
Trig, cairn, pole, pillar	N	VLO	0	
Airstrip - disused	N	MED	0	
Dam or weir	N	MED	0	
Beacon	N	MIN	0	
Cleared area < 1 ha	N	MED	0	Not relevant to this study.
Hydro sampling station	N	VLO	0	Data not currently incorporated into analysis
Railway - disused	N	MIN	0	Not relevant
Pipeline	N	MED	0	Not relevant
Drain	N	MED	0	Not relevant
Undisturbed land	N	N	5	Relevant only to Biophysical Naturalness
Inland waterway (natural) - inaccessible to powered boats	N	N	5	Relevant only to Biophysical Naturalness
Settlement: >100	MAJ	MAJ	1	
Settlement: 11-100	INT	MAJ	1	
Settlement 1-10	MIN	MAJ	1	
Settlement - residence only	RES	MAJ	0	

A2.2.2 Calculating high-grade equivalent distance/remoteness

The high-grade equivalent distance HGED of a geographical feature Y from a defined point X is given by

$$HGED = (1 + D)/W - 1$$

where HGED is the high-grade equivalent distance in kilometres, D is the map distance in kilometres, and W is a weighting factor whose value is given in the table below.

Table A6. Weighting factors for calculating HGE (Revised methodology)

Component	Grade	Weighting factor (W)
	MAJ	1.00
RS	INT	0.67
	MIN	0.48

	RES	0.38
	MAJ	1.00
AN	MED	0.50
	MIN	0.18
	VLO	0.10

For each of the distance-based variables, the overall remoteness of any point X is defined as the minimum 'high grade equivalent' distance of X from any of the geographical features relevant to that variable. That is,

$$HGER = \min (HGED)$$

where HGER is the high-grade equivalent remoteness of X, and HGED is the high-grade equivalent distance of X from each of the relevant geographical features.

A2.2.3 Calculating class

For each grid-square in the study area and for each of the three distance-based variables, class is calculated from the high-grade equivalent remoteness (HGER) of the centre X of the square by the formula

$$Class = 5 \times (1 - \exp (-F \times HGER))$$

Where HGER is the high-grade equivalent remoteness and F = 0.1 for RS and 0.15 for AN.

For Time Remoteness (TR), class is given by

$$TR\ Class = 5 \times (1 - \exp (-1.5 \times T))$$

where T is the remoteness in days.

Since T is a discrete variable, its values are given in the table below:

Table A7. TR class as a function of time remoteness

Zone	TR (Hours)	Class
Non remote	0-3	0.00
Half day	3-6	2.64
One day	6-12	3.88
Two day	>12	4.75