

# COMMENTARY TO AG:PT/T251 - BALL PENETRATION TEST

## PREFACE

This test method is an update of the method originally prepared by the Bituminous Surfacing Research Reference Group on behalf of Austroads.

## FOREWORD

This test has been developed from work initially undertaken by South African researchers and it has been adapted and validated for use in Australia.

## SCOPE

This test method describes the procedure for measuring the penetration depth of a standard steel ball into a road surface under the impact of a standard hammer.

The output of this test is used as

- a) an input in the Austroads sprayed seal design method AP-T68/06 to allow for the potential embedment of the sealing aggregate into granular pavements. At this stage it is commonly used when designing new seals and seals over primed pavements, but not for designing seals over primerseals or for reseals over existing bituminous surfacings.
- b) an indication of both the level of compaction and dry-back that has been achieved, and whether it is suitable to apply the prime or initial seal or whether more work is required. This test may be performed in addition to or in conjunction with pavement compaction and /or dry-back testing.

Statistical techniques (similar to that used to locate nuclear density gauge testing of pavements) shall be used to determine the location of the individual test sites within a lot.

# BALL PENETRATION TEST

## 1 REFERENCED DOCUMENTS

- AP-T68/06 Update of the Austroads sprayed seal design method. Austroads 2006
- AP-T90/07 Temperature susceptibility of the ball penetration test – stage 1: laboratory assessment. Austroads 2007
- AP-T127/09 Ball penetration test – stage 2: Field validation. Austroads 2009
- AS 2891.5 Determination of stability and flow – Marshall Procedure
- Marais, CP, 1979, Advances in the design and application of bituminous materials in road construction, PhD Thesis, University of Natal, Durban.

## 2 DEFINITIONS

- a. Road surface: includes unsealed granular road base, primed or primersealed granular base, and existing bituminous surfacings such as sprayed seal, slurry, or asphalt wearing courses.
- b. Soft surface: A road surfacing is considered to be soft when the ball penetration hammer leaves an imprint on the surface under its own static weight.

## 3 APPARATUS

The following apparatus is required:

- a. Ball penetrometer unit
  - I. **Type 1.** A ball penetrometer unit without a self-standing frame (Figure 1 and Figure 2). It shall conform to a Marshall hammer mass and drop height as given in AS 2891.5. It shall be fitted with a 19 mm case hardened hemispherical foot and a method of measuring the relative penetration of the steel ball to the nearest 0.5 mm (either the shaft can be scribed with 0.5 mm divisions or a dial gauge with a minimum resolution of 0.5 mm can be fitted). It shall be fitted with a levelling bubble to ensure the hammer is vertical during operation.

or

- II. **Type 2.** A ball penetrometer unit with a self-standing frame (see Figure 3, Figure 4 and Figure 5). It comprises a drop hammer conforming to a Marshall hammer mass and drop height as given in AS 2891.5, supporting frame with adjustable feet to ensure that the hammer is held vertical, a method of measuring the relative penetration of the steel ball to the nearest 0.5 mm, 19 mm case hardened steel ball, a screw-in 19 mm case hardened hemispherical foot and a screw-in 19 mm case hardened flat (blank) foot, and a method of measuring the relative penetration of the steel ball to the nearest 0.5mm.

It is expected that both types of ball penetrometer units provide similar results, but there have been no correlation studies undertaken at the time of printing.

- b. If testing over an existing bituminous surface, a thermometer graduated in degrees Celsius (0 to 100°C and with a limit of accuracy of 1°C) suitable for measuring road surface temperature is also required.

## 4 PROCEDURE

Note: five measurements are to be taken at each test site.

### 4.1 Safety precautions.

- a. Hands are to be kept clear of the collar around the base of hammer at all times.
- b. To carry the penetrometer unit, grip the external frame at just below  $\frac{1}{2}$  the height and lift gently. The hammer collar will move down into the sleeve (see Figure 3)
- c. When transporting the penetrometer unit between locations ensure that all of the transit locking pins are in place.

### 4.2 Type 1 ball penetrometer unit.

- a. Remove the transit locking pin (Figure 1).
- b. Place the hemispherical ball foot. For a granular pavement (untreated or primed), place the hemispherical ball foot on the pavement surface. If the granular pavement is a coarse graded material, ensure that the hemispherical ball foot is not resting directly on a piece of aggregate, as this would result in a non representative test value. For an existing bituminous surfacing, position the hemispherical ball foot in interstices between aggregates on the road surface.
- c. Attach the dial gauge if fitted (Figure 2).
- d. Zero the collar against the scribed shaft and reset the dial gauge (if fitted).
- e. Remove the dial gauge (if fitted).
- f. Ensure the unit is vertical by using the levelling bubble.
- g. Complete a single drop of the hammer by gently raising the hammer to the full height without jarring and allowing it fall freely to the road surface.
- h. Reattach the dial gauge (if fitted) and read the ball penetration depth using the scribed shaft or the dial gauge.
- i. Repeat the steps (b) to (h) another four times for each location. (If the measured penetration is due to aggregate breakdown from impact, discard and repeat the test.) Determine the mean and record the results of the tests to the nearest 0.5 mm (Pen Tt). Each repeat test shall be carried out within 100 mm of the initial test.
- j. For an existing bituminous surfacing, record the temperature of the road surface for each set of readings to the nearest 1°C (Tt).

### 4.3 *Type 2 ball penetrometer*

Prior to testing place the frame on the road shoulder (such that the operator faces the centre line) and level. A gap of approximately 10 mm should always exist between the collar and the base sleeve. Work with the self-standing frame at this orientation until the camber of the road reverses, (i.e., at centre line.) The unit is then rotated 180 °C. This pre-adjustment allows for faster testing on the road surface.

The frame should only be removed from the penetrometer when it is evident that the hammer leaves an imprint on the surface under its own weight. In these situations, procedure 4.2.2 applies.

#### 4.3.1 *To measure ball penetration on a typical road surface.*

- a. Remove the ball penetrometer transit locking pins B & C (Figure 4).
- b. Place the hemispherical ball foot. For a granular pavement (untreated or primed), place the hemispherical ball foot on the pavement surface. If the granular pavement is a coarse graded material, ensure that the hemispherical ball foot is not resting directly on a piece of aggregate, as this would result in a non representative test value. For an existing bituminous surfacing, position the hemispherical ball foot in interstices between aggregates on the road surface.
- c. Level the ball penetrometer, with the levelling feet until bubble is approximately centred.
- d. Zero the direct measurement scale, by adjusting the thumb screw and locking nut on top of the hammer. Locking of the thumb screw is optional.
- e. When the unit is stable and ready for operation, complete a single drop of the hammer by gently raising the hammer to the full height without jarring and allowing it fall freely to the road surface.
- f. Measure and record the depth of ball penetration in millimetres to the nearest 0.5 mm (If the measured penetration is due to aggregate breakdown from impact, discard and repeat the test).
- g. Repeat the steps (b) to (f) another four times within a 100 mm of the first test. Determine the mean and record the results of the tests to the nearest 0.5 mm (Pen Tt).
- h. For an existing bituminous surfacing, record the temperature of the road surface for each set of readings to the nearest 1°C (Tt).

#### 4.3.2 *To measure ball penetration on a soft seal.*

- a. Replace the case hardened screw-in ball tip with the blank screw-in tip (Figure 5).
- b. Remove pins A, B and C (Figure 4).

- c. Detach base of Penetrometer frame by removing the two base thumb screws. The detached upright section, minus the gauge pin, is not used in this part of the procedure (Figure 5).
- d. Assemble depth gauge (from pin of direct measurement scale) by removing graduated pin and reinserting perpendicularly in the slot provided.
- e. Remove the 19 mm case hardened steel ball from the base and place on an area typical of the road surface to be sealed. To prevent the ball from rolling on flushed or graded surfaces, lay a transit locking pin on the road and place the ball inside the circular end.
- f. Centre the ball penetrometer base over the steel ball.
- g. Place assembled depth gauge into the slots of the base sleeve (with the knurled end facing the steel ball) and measure down to the top of the steel ball by releasing the screw and lowering the knurled end onto the steel ball. Remove gauge and note measurement to the nearest 0.5 mm.
- h. Place the hammer through the collar in the base so that the blank tip contacts the steel ball.
- i. When the unit is stable and ready for operation, complete a single drop of the hammer by gently raising the hammer to the full height without jarring and allowing it fall freely to the road surface.
- j. Remove hammer and replace the depth gauge. Measure to the top of the steel ball. Record, in mm, the determined difference (penetration) between the first and second readings to the nearest 0.5 mm. (If the measured penetration is due to aggregate breakdown from impact, discard and repeat the test).
- k. Repeat the steps (e) to (j) another four times for each location. Determine the mean and record the results of the tests to the nearest 0.5 mm (Pen Tt). Each repeat test shall be carried out within 100 mm of the initial test.
- l. Record the temperature of the road surface for each set of readings to the nearest 1 °C (Tt).

## 5 CALCULATIONS

An average ball penetration for each test site is obtained by averaging the five penetration depths obtained at each site and using this average as Pen Tt, and correcting to the mean summer temperature for the area, as calculated from the following formula:

$$\text{Pen } T_s = \text{Pen } T_t - K(T_t - T_s)$$

Where:

Pen Ts = Penetration depth (mm) at standard summer road temperatures for region.

Pen Tt = Penetration depth (mm) at time of test.

Tt = Road surface temperature (°C) at time of test.

Ts = Standard temperature (°C) of road for region (from Figure 6 through to Figure 12).

K = Temperature susceptibility of penetration (mm/ °C).

Note: for granular bases (not primed) temperature correction is not required and therefore Pen Ts = Pen Tt

K factors recommended for:

- Single/single and double/double seals (not fatty) 0.04 mm/ °C
- primer seals (not fatty) 0.06 mm/ °C
- fatty seals, slurries and dense graded asphalt 0.08 mm/ °C
- granular bases (not primed) 0.00 mm/ °C

## 6 INFORMATION TO BE REPORTED

- a. Location and date of test
- b. Name of operator
- c. Description of surface being tested
- d. Air temperature and road surface temperature
- e. Moisture content, if known, when testing unsealed granular bases.
- f. Report the individual ball penetration values to the nearest 0.5 mm
- g. Report the average ball penetration value to the nearest 0.5 mm
- h. Reference to this method, i.e. AG:PT/T251.

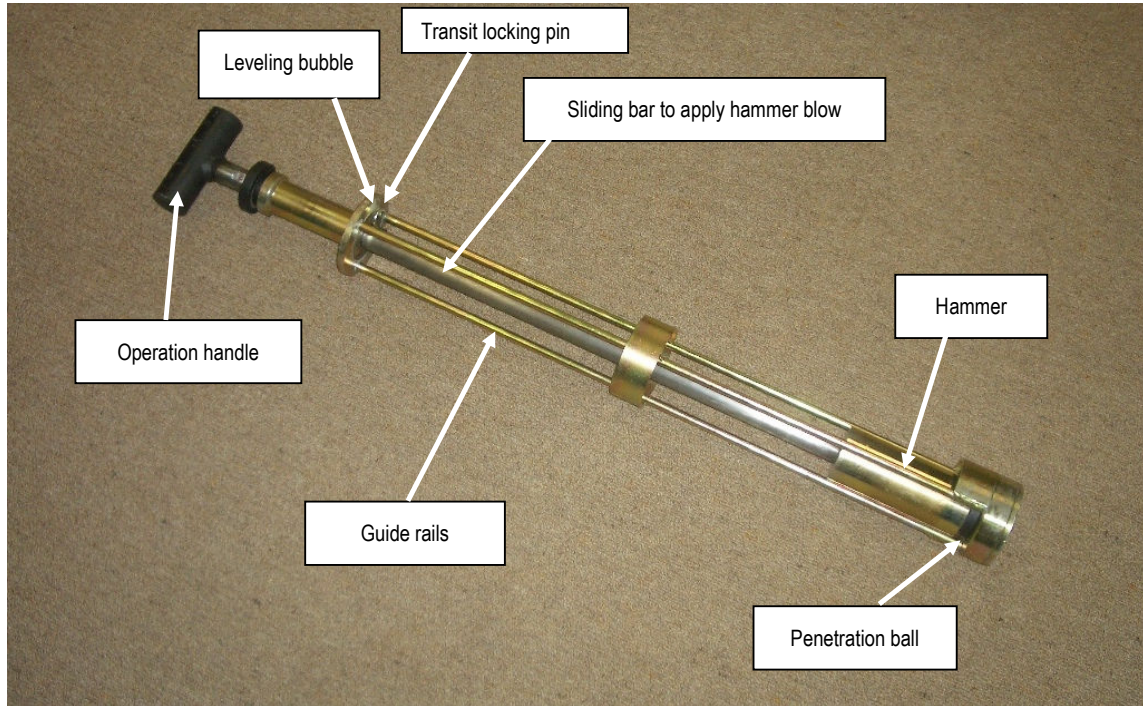


Figure 1: Type 1 ball penetrometer



Figure 2: Scribed shaft and optional dial gauge (digital version shown here)



Figure 3: Type 2 ball penetrometer

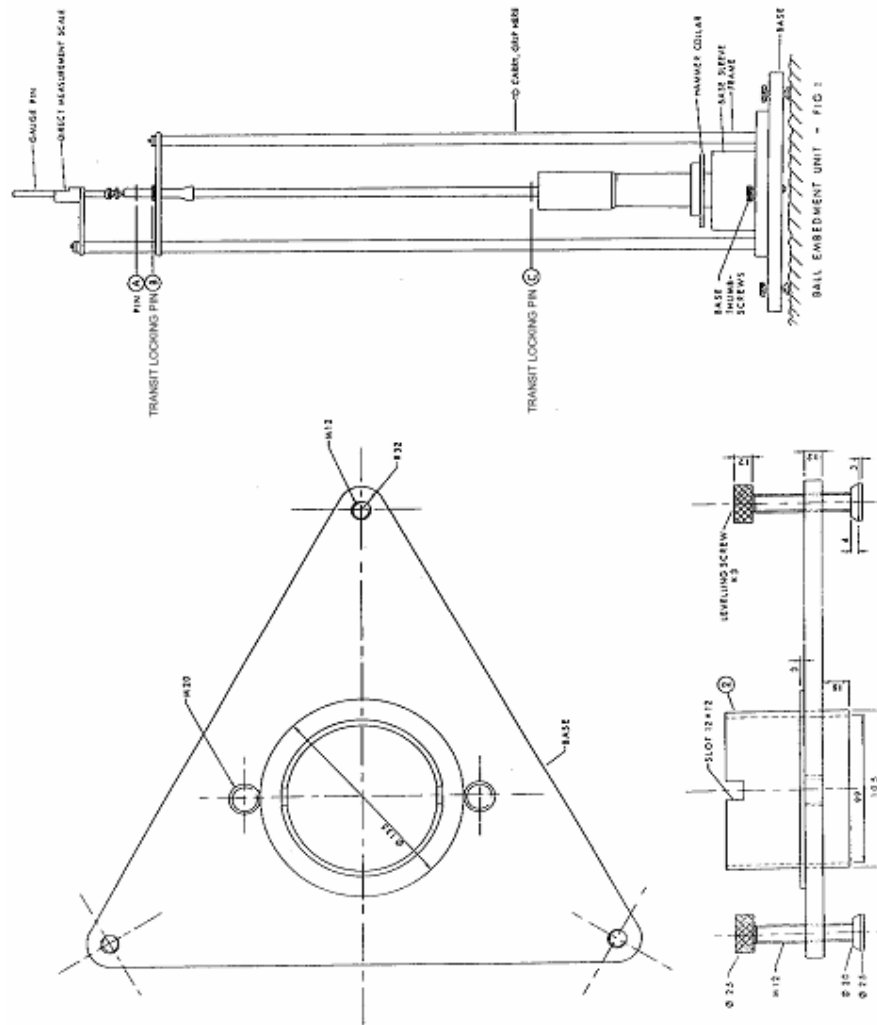


Figure 4: Type 2 ball penetrometer

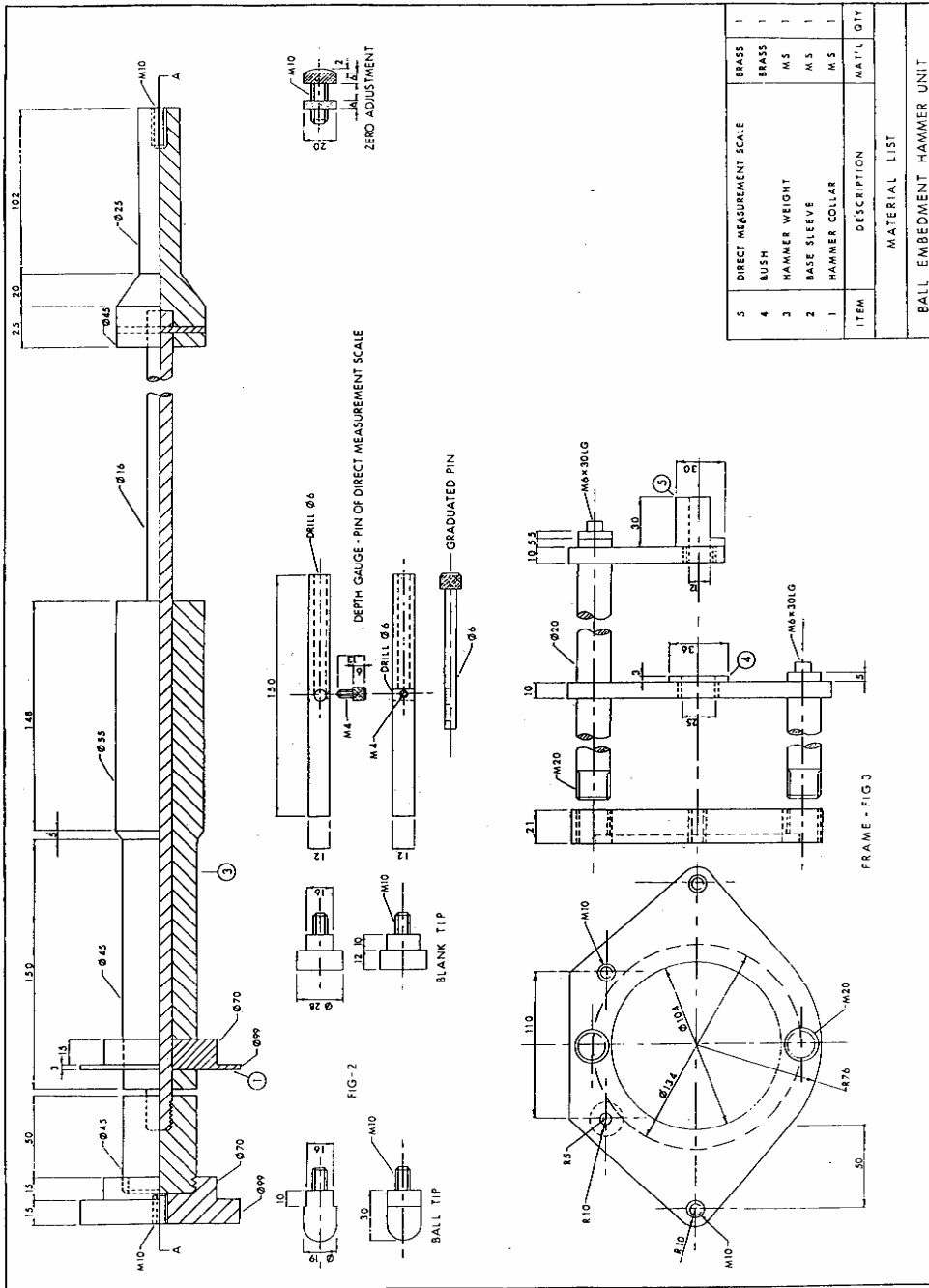


Figure 5: Type 2 penetrometer modification for soft seals

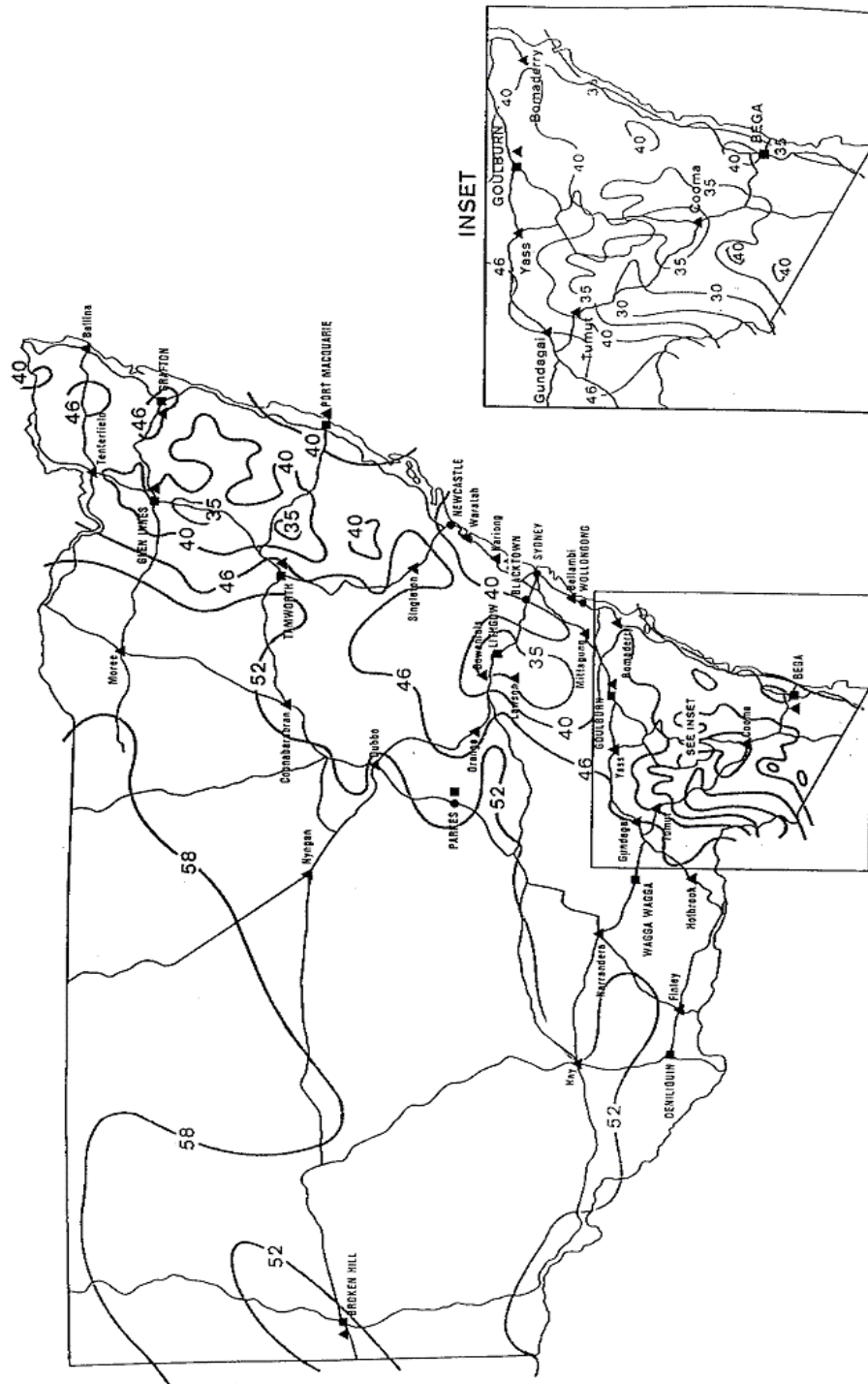


Figure 6: New South Wales Standard Summer Road Surface Temperature

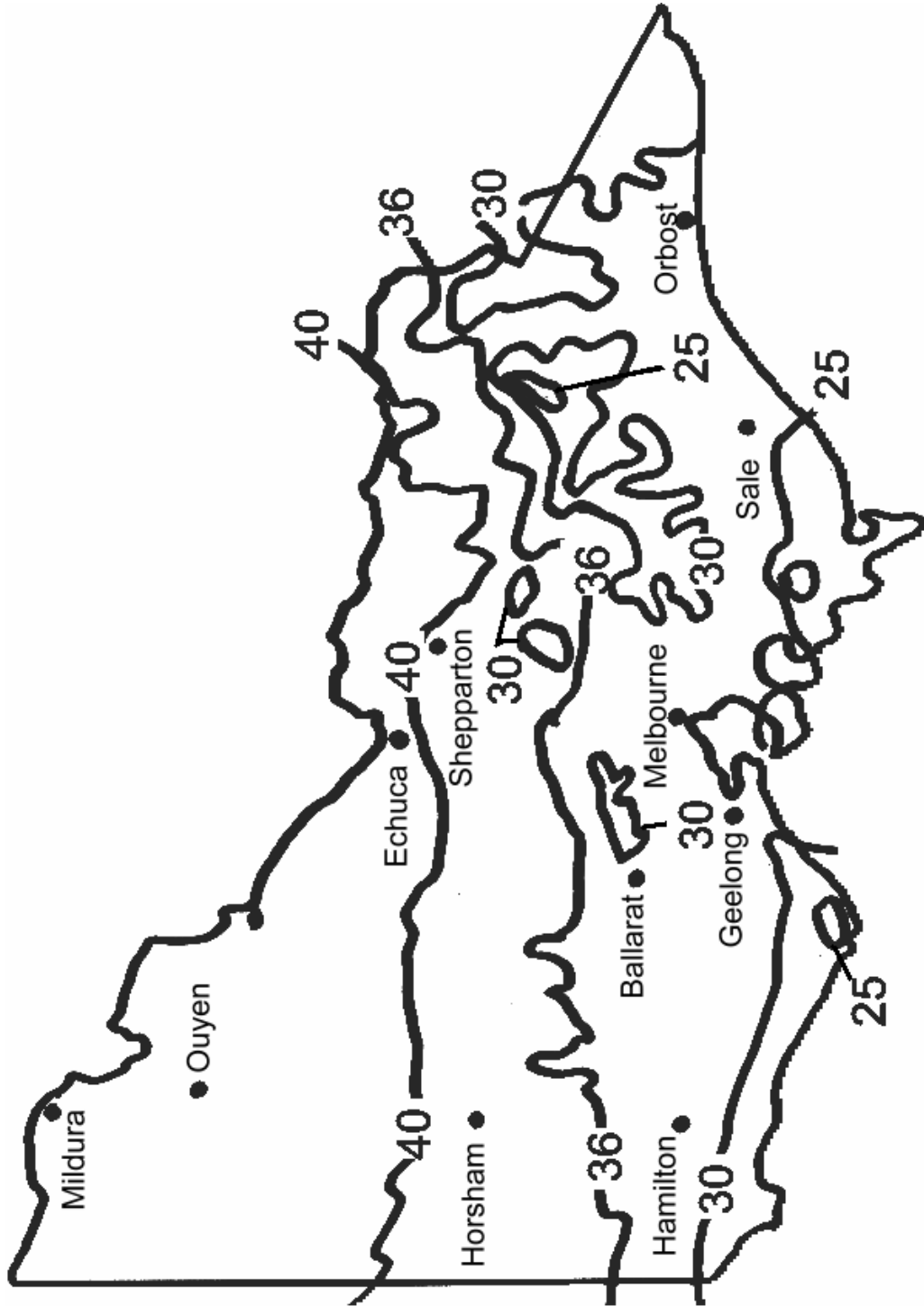


Figure 7: Victoria Standard Summer Road Surface Temperatures

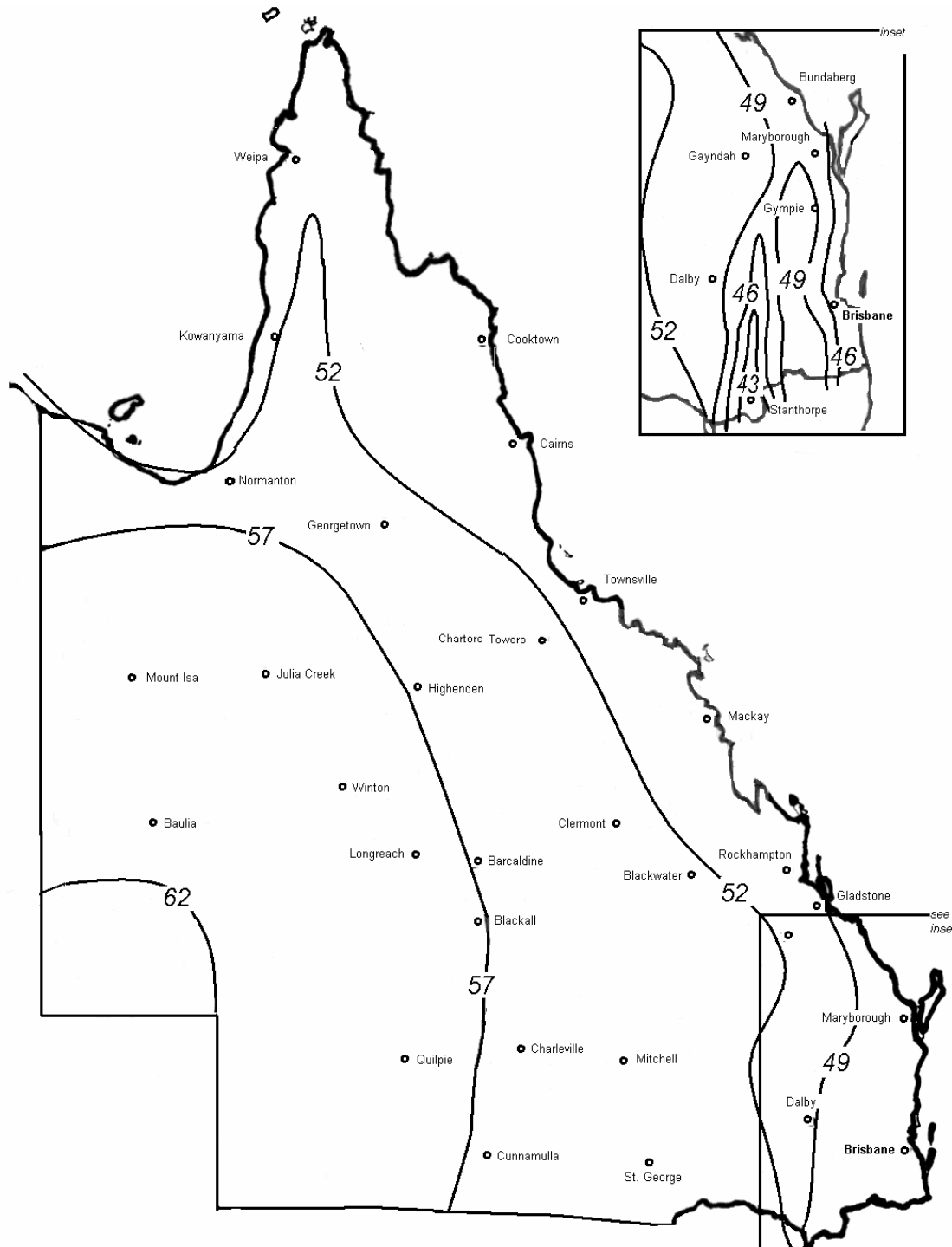


Figure 8: Queensland Standard Summer Road Surface Temperatures

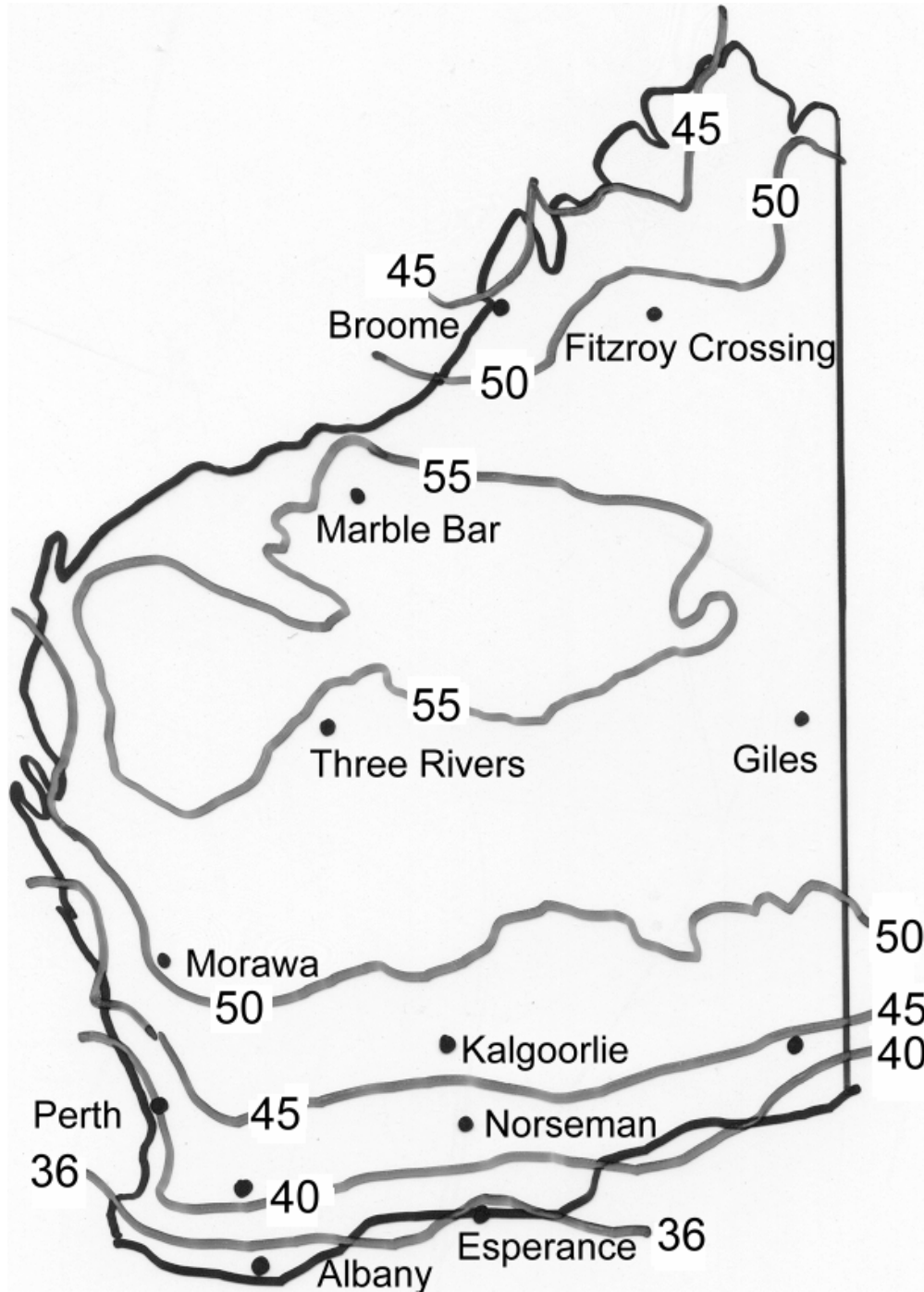


Figure 9: Western Australia Standard Summer Road Surface Temperatures

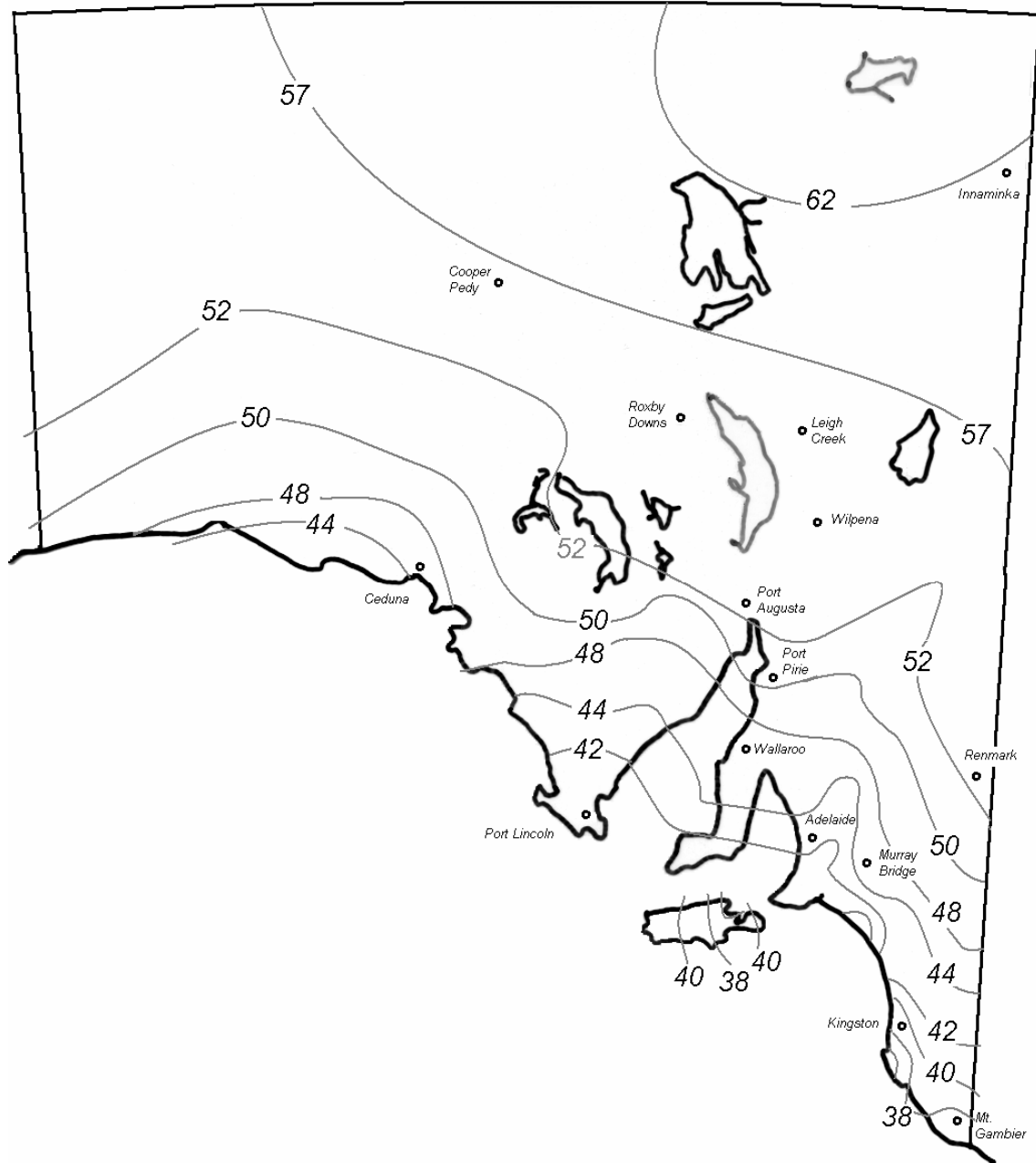


Figure 10: South Australia Standard Summer Road Surface Temperatures

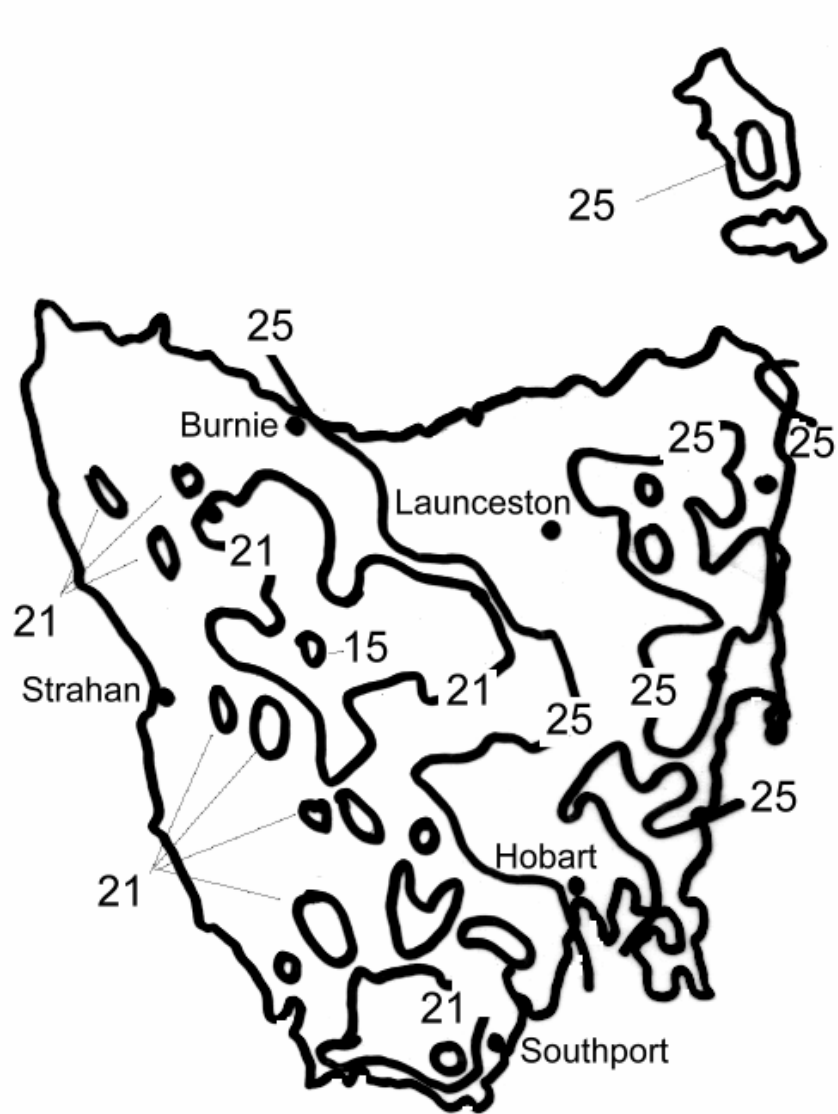


Figure 11: Tasmania Standard Summer Road Surface Temperatures

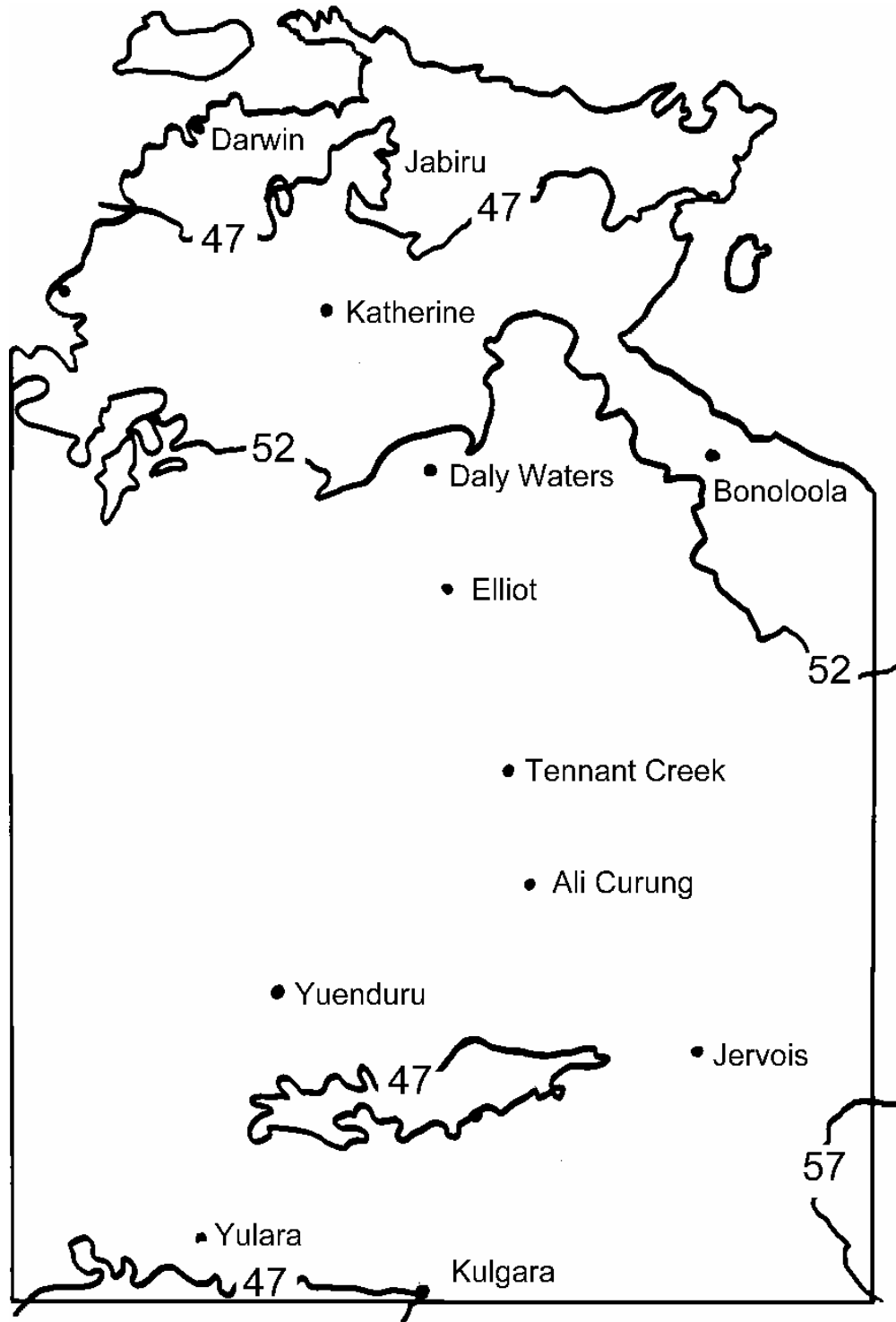


Figure 12: Northern Territory Standard Summer Road Surface Temperatures

## AMENDMENT RECORD

Amendment No.	Clauses amended	Action	Date
1	Commentary Page	New	June 2005
	Footer and header	Format	
	Applied revised test method number	Format	
	Applied new styles	Format	
2	Preface	Substitution	June 2006
	Referenced documents	Removed	
3	Added a variation on the ball penetrometer device	New	Jul 2009
	Added framed penetrometer image	New	Nov 2009
	Minor editorial throughout	Substitution	
4	Minor editorial throughout	Substitution	Jan 2010

## Key

Format	Change in format
Substitution	Old clause removed and replaced with new clause
New	Insertion of new clause
Removed	Old clauses removed