.BRITISH STANDARD

**BS 5618:1985**

*Incorporating Amendment Nos. 1 and 2*

## Code for practice for

# Thermal insulation of cavity walls (with masonry or concrete inner and outer leaves) by filling with urea-formaldehyde (UF) foam systems

UDC 678.652'41'21:692.232.2:699.86

# Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Plastics Standards Committee (PLM/-) to Technical Committee PLM/46, upon which the following bodies were represented:

Association of Building Component Manufacturers Ltd.
Brick Development Association
British Board of Agrément
British Plastics Federation
British Rigid Urethane Foam Manufacturers' Association
British Urethane Foam Contractors' Association (BUFCA)
Calcium Silicate Brick Association Limited
Chief and Assistant Chief Fire Officers' Association
Department of the Environment (Building Research Establishment)
Department of the Environment (Building Research Establishment — Fire Research Station)
Department of the Environment (Housing and Construction Industries)
Department of the Environment for Northern Ireland
Department of the Environment (Property Services Agency)
Engineering Equipment and Materials Users' Association
Fire Offices Committee
Flat Roofing Contractors' Advisory Board
Greater London Council
Institute of Refrigeration
Ministry of Defence
National Cavity Insulation Association
National Coal Board
National Federation of Roofing Contractors
National House-building Council
Phenolic Foam Manufacturers' Association
Royal Institute of British Architects
Shipowners' Refrigerated Cargo Research Association
Structural Insulation Association

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Building Employers' Confederation
Eurisol (UK) Association of Manufacturers of Mineral Insulation Fibres
Welwyn Hall Research Association

This British Standard, having been prepared under the direction of the Plastics Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 July 1985



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# Contents

# Foreword

This revision of BS 5618, which has been prepared under the direction of the Plastics Standards Committee, supersedes BS 5618:1978 which is withdrawn.

Greater use is being made of insulation in new construction as a consequence of changes in building regulations. The committee has therefore taken recent studies into account.

The use of urea-formaldehyde (UF) foam has proved to be an effective means of providing higher standards of thermal insulation in buildings of cavity wall construction having inner and outer masonry or concrete leaves, and having an external cavity wall of maximum height 12 m.

This British Standard indicates criteria for the selection of suitable buildings and defines the procedures and precautions to be followed to provide for the satisfactory injection of a foam system into the cavity wall.

Evidence strongly suggests that water penetration is more related to the quality of the design, workmanship in construction and the presence of defects such as cracks, than to the type of masonry units used in the wall cavity.

Attention is drawn to BS 8208-1 which is the basis of the assessment of suitability used in this standard.

It is believed that the suitability selection procedure has been improved with the introduction of more recent information. A new appendix has been introduced to give guidance on the quality of the installed foam, and another to introduce a new method of determining driving-rain index which may, in future, succeed the present method if proven to be an improvement in the assessment of suitability. Yet another has been introduced to give methods of ascertaining cavity width.

The procedural advice and the controls needed on site have been strengthened.

BS 5617 specifies suitable (UF) foam systems and gives the tests to be carried out at all stages of the foam system preparation to ensure that the requirements for successful injection of the foam system and its performance in situ are achieved when the practices described in this standard are applied.

The recommendations concerning the performance in storage of urea-formaldehyde resin were amended in 1989.

It is strongly recommended that an independent surveillance authority (e.g. the British Standards Institution) should carry out random surveys to ensure that the installation contractor follows this British Standard.

The maps in this British Standard are based on the Building Research Establishment Report "Driving-rain index" (1976) by R E Lacy, BSc (Eng), FRMetS, by courtesy of the Director, BRE. The maps have been revised with additional contour lines, and have been reproduced (with a photograpic reduction of 10 %) from the Ordnance Survey 1:625 000 Map with the permission of the Controller of Her Majesty's Stationery Office, Crown copyright reserved.

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**Summary of pages**

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 56, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

## 1 Scope

This British Standard code of practice describes recommendations for the installation of urea-formaldehyde (UF) foam systems which are dispensed on site, to fill the cavities of suitably situated and constructed external walls of maximum height 12 m, which have masonry or concrete inner and outer leaves, thereby providing additional thermal insulation to such walls. It defines what are suitably situated and constructed external walls and indicates essential procedures and precautions for the filling process. Walls built of random rubble are not covered by this code.

NOTE The titles of the publications referred to in this code are listed on the inside back cover.

## 2 Definitions

For the purposes of this British Standard the following definitions apply.

**2.1**
**cavity**

an air space between two leaves of an external wall

**2.2**
**urea-formaldehyde (UF) foam**

an infusible cellular matrix of cured urea-formaldehyde resin insoluble in water and other common solvents

**2.3**
**urea-formaldehyde (UF) foam system**

a mixture of urea-formaldehyde resin, hardener, surfactant, water, air and water additives

**2.4**
**hardener**

a chemical additive that causes the UF resin to polymerize and change to a water-insoluble solid

**2.5**
**surfactant**

a chemical added to a liquid that has the effect of lowering the surface tension of the liquid and thus enabling it to form a foam

**2.6**
**indicator stick**

a rod, typically 5 mm diameter and 250 mm long, inserted through an injection or sight hole in the leaf of a wall into the cavity to monitor the movement of the UF foam system in the wall at that point during the filling process

**2.7**
**installation contractor**

a company or organization that undertakes the insulation of building structures to improve their thermal insulation by injecting a suitable urea-formaldehyde (UF) foam system

**2.8**
**independent surveillance authority**

an independent body that monitors the quality of service provided by an installation contractor

**2.9**
**recessed joints**

joints where the mortar line has been deliberately formed or cut back to leave the top surface of the brick exposed

**2.10**
**sight hole**

an additional hole drilled through either leaf of a wall into the cavity, used only to check that the foam system has reached that point in the cavity

**2.11**
**unit area plan**

a method of dividing up the exterior walls of the building to show the sequence of foaming through the injection holes

**2.12**
**damp proof course** (d.p.c.)

a layer of impermeable material so placed in the building that the passage of moisture between the parts it separates is negligible

**2.13**
**cavity closer**

a building feature closing a cavity around an opening in the wall

NOTE Examples are a sill or a lintel.

**2.14**
**stop end**

a vertical cavity closer, such as a reveal block, which limits the horizontal travel of a foam system during injection

**2.15**
**vapour check**

a surface within a building structure which has a very high resistance to the movement of water vapour through it

**2.16**
**masonry**

walling constructed of natural stone, reconstituted stone, brick, concrete, breeze block or any combination of these materials

## 3 Suitability of cavity walls for insulation

### 3.1 General

The thermal conductivity of cavity walls is substantially reduced by the presence of UF foam in the cavity. Experience has shown that the presence of UF foam is compatible with the weather-resisting function of external walls provided that due allowance is made for the construction and the exposure to wind-driven rain.

It is essential that only if the installation contractor considers the building to be suitable or capable of being made suitable, should installation be carried out (see **3.2**).

### 3.2 Determination of suitability

BS 8208 covers all aspects which should be taken into account when assessing the general suitability of cavity walls for insulation.

The particular factors and the appropriate suitability criteria relevant for the purposes of this standard are as follows.

a) The cavity walls to be filled should be structurally sound. Rectification of obvious defects should form part of the contract. Cavity wall insulation cannot make up for defects in the existing construction and may accentuate existing faults (see Appendix A).

b) To minimize the chance of significant quantities of water crossing the cavity, the materials of construction and the degree of exposure of the external walls to wind-driven rain should be within the limits stated (see Appendix B, Appendix C, Appendix D, Appendix E and Appendix F).

c) Where a cavity is being used as a source of combustion air or as a flue, it is essential not to fill it until suitable trunking or other devices have been installed (see **A.8**).

d) It is essential that the foam system is not installed between vapour barriers, because it cannot then dry out.

e) To contain the foam system, and any gas which might evolve from it, within the cavity, the internal leaf should be checked for continuity (see Appendix G).

f) It is essential that the upper boundary of the foam is physically protected from water ingress. If this is not done, the top surface of the foam could act as a bridge for water to cross the cavity.

g) Where a vapour check has been installed on the cold side of the foam, condensation can form in cold weather conditions on the inside surface of the vapour check (see **A.1.7** and **A.5**). In the case of new construction allowance should be made for this in the design of the building.

## 4 Material composition

It is essential that the insulating material used in the filling process is a urea-formaldehyde foam system that complies with BS 5617.

## 5 Thermal performance of installed foam

For design purposes an effective thermal conductivity value for UF foam installed in masonry cavity walls should be taken to be 0.04 W/(m·K) (see Appendix J).

## 6 The filling process

### 6.1 General

Aqueous resin and hardener solutions and compressed air are supplied separately to foam system generating equipment either from pressurized pots or from a pump system. The compressed air should previously have been passed through an oil separator.

The foam system is mixed in the system generating equipment and is fully expanded before injection into the wall cavity.

The foam system is injected into the cavity wall through a series of holes, drilled in a predetermined pattern, in the wall. The extent of the foam system travel in a wall should be monitored by the use of indicator sticks in adjacent holes.

The foam system which is fluid at the time of injection, sets shortly afterwards. It then dries by evaporation through the fabric of the building to form an inert cellular matrix.

NOTE Because foam can be difficult to remove when cured, particularly from glass, any spillage should be cleaned up as soon as it occurs.

### 6.2 Performance in storage of urea-formaldehyde resin

**6.2.1** If the resin is stored at temperatures below 20 °C it should remain usable for a period of at least three months from the date of quality control release testing stated by the foam system supplier for each container. During storage the properties of the resin change due to a slow process of polymerization which is accelerated by heat.

NOTE Although storage of resin below 5 °C is not detrimental to resin quality, when used at these temperatures the resin may be more difficult to mix with cold water due to an increase in viscosity. In such cases it would be advisable to use warm water or warm the resin prior to use.

Therefore if the temperature of the stored resin rises above 20 °C, at any time subsequent to its delivery, or if the resin is older than three months from the date of quality control release, its quality or suitability for use shall be retested (see **6.5**).

**6.2.2** After testing a batch of resin in accordance with **6.2.1**, the installation contractor should not combine it with a different batch without retesting the blend.

### 6.3 Foam system generating equipment

The equipment used to generate a foam system should be capable of being adjusted to enable flow rates of the resin solution, hardener solution and air to be controlled in order to produce a foam system that complies with BS 5617. The equipment is to be fitted with controls to ensure that the quality of the foam system can be maintained throughout its installation into the cavity.

### 6.4 Material preparation

The installation contractor should ensure that the operator checks and corrects the hardness of the water if necessary, using the method declared by the foam system supplier as specified in **4.2** of BS 5617:1985.

The resin solution, which is normally supplied in a concentrated form should be diluted with water before use. The quantity of water should be stated by the installation contractor as declared by the foam system supplier. This should be added to the resin whilst stirring until complete homogeneity is obtained.

NOTE Resin should never be added to water because the limited solubility of the resin may cause resin separation or coagulation.

If coagulation or separation of the resin solution occurs during its preparation, the solution should be rejected as unsuitable.

The hardener should be diluted to the concentration stated by the installation contractor as declared by the foam system supplier, and the solution should be thoroughly stirred.

### 6.5 Quality checks

It is essential that the operator should carry out quality checks as listed in Table 1 prior to an installation, if the resin temperature has risen above 20 °C at any time subsequent to its delivery, if the resin is more than three months old, after equipment is adjusted, and when there is reason to suspect any fault in, or malfunction of, the equipment. The operator should also produce a sample suitable for carrying out the effective density and linear shrinkage tests as given in Table 2 of BS 5617:1985 for each installation.

The installation contractor should monitor on-site operations and should carry out the effective density and linear shrinkage quality control tests at a frequency of at least one test per installation crew per working week.

It is also essential that a sample produced on site from each building each day should be retained for at least one subsequent working day to check its appearance by the method described in Appendix G of BS 5617:1985.

**Table 1 — Quality checks on site during or prior to installation**

| Test | Test method |
|---|---|
| Gel time | Appendix E of BS 5617:1985 |
| Foam stability | Appendix F of BS 5617:1985 |
| Appearance | Appendix G of BS 5617:1985 |
| Wet density | Appendix D of BS 5617:1985 |

### 6.6 Pre-installation building checks

Access to the building for internal checks is essential prior to, during and after installation. The installation technician should confirm the assessment of the suitability of the building (see **3.2**).

The following checks are also essential.

a) All combustion appliances with flues against, through or adjacent to a cavity wall that is to be filled are to be operated prior to foam system injection to observe their performance (see Appendix H);

b) The position and purpose of all flues and vents are to be noted so that a proper drilling and injection pattern can be planned for the building (see **7.1.2**);

c) Holes in the cavity wall, especially the inner leaf, are to be effectively sealed (for example with mortar) to limit the entry of a foam system and formaldehyde into the occupiable parts of the building (see **A.2**).

## 7 Installation of the UF foam system

### 7.1 Drilling

**7.1.1** To avoid the production of excessive amounts of rubble in the cavity, which could lead to bridging, pure percussion drills without rotary cutting action should not be used.

**7.1.2** The objectives of a correct hole pattern are:

a) to ensure that the foam system reaches all parts of the cavity to be filled;

b) to ensure that the foam system does not penetrate areas of the building where its presence could be deleterious;

c) to avoid over-pressurization of the cavity which could result in structural damage;

d) to ensure that the foam system is not pumped into any one injection point for longer than 75 % of its gel time.

To satisfy a) to d), injection holes should be spaced no more than 1 m apart. If the cavity is wider than normal or if the foam system gel time is short a closer drilling pattern may be required.

**7.1.3** A hole pattern, as shown in Figure 1, should be used except where special conditions apply as detailed in a) to c) as follows. Distances between holes need not be exact and on fair-faced masonry they should be reduced as necessary to bring the hole into the nearest mortar line.

The pattern should be modified in areas near to various building features of the wall. The most important pattern variations occur near the following features.

a) *Horizontal damp proof course*. Where it is desired to prevent the foam system extending to the footings below the damp proof course, the injection holes in the lowest row should be closer together, e.g. only 500 mm apart and 600 mm above the damp proof course as shown in Figure 2. This technique will produce a scalloped boundary at the approximate level of the damp proof course.

b) *Cavity closers*. To avoid leaving any gaps in the foam around the edge of windows, doors and ventilators, extra holes may need to be drilled around these areas to ensure that they are completely filled. However, care should be taken to avoid damaging damp proof courses.

c) *Floor or ceiling joints*. The drilling pattern should be designed to avoid having a row of injection holes at the same level as ceiling joists or staircase support timbers in order to minimize the intrusion of the foam system into the building via faults in the inner leaf.

### 7.2 Sight holes

Sight holes should be used to ensure that the foam system does not spread into undesirable areas and to avoid overpressurization in the following areas.

a) *Party line*. When dealing with the dividing line of an attached property which is not being insulated it is essential to leave a vertical boundary of foam adjacent to the neighbouring cavity, so that water running down the untreated cavity will not collect at any point on the edge of the filled area.

This is best ensured by drilling the first column of holes in a vertical line, 500 mm apart and no less than 500 mm from the dividing line between the houses. This is illustrated in Figure 2. Sight holes should be used to prevent the foam system spreading across the party line.

b) *Gables*. On gables, no injection holes should be closer than 450 mm to the tiles or the pressure of the foam system may lift the tiles. Sight holes should, however, be drilled not less than 200 mm from the tiles.

c) *Chimneys and flues*. Great care is to be taken to establish the line of the chimney and its position relative to the cavity and to ensure that the flue is not punctured during the process. Care is required in examining the chimney construction to see if there is any possibility of the flue having been constructed in, or adjacent to, the cavity. In these cases, either sight holes should be drilled on both sides of the flue line or each side of the flue should be treated in the same way as for a semi-detached house at the party line.

d) *Flat roofs*. Sight holes are used to check foam system travel to ensure that it does not interfere with ventilation of the roof space.

### 7.3 Foam system injection

**7.3.1** *Injection sequence*. It is essential that all drilling in each elevation and at least the first metre of adjacent elevations is completed before filling the cavity of that elevation.

The injection pattern should ensure that, as far as possible, the freshly injected foam system is always keyed into an area of existing foam system that is still fresh, thus giving the strongest possible bond. One possible plan for a typical semi-detached house is shown in Figure 3. The areas have been numbered to show a suitable injection sequence in which they could be tackled.

When the job cannot be completed in one day, the work should be arranged in such a way as to finish with the shortest possible diagonal or vertical line of foam. It is essential never to leave a horizontal line of foam in a partly filled wall other than the base line.

Injection along the bottom horizontal rows should start at the end of an elevation or a stop-end and continue until a stop-end or boundary is reached.

Vertical boundary lines should be built-up from the base line.

Where it is desired to prevent the foam system passing below a horizontal damp proof course, it is suggested that at least 10 min should be allowed, or longer if gel time necessitates, between injecting through the row of holes nearest to the damp proof course and the subsequent injection. A similar procedure can be adopted for the column of holes next to the party line or any attached property not being injected at that time (see **A.3**).

In each of the main sections, injection should proceed on a diagonal front to ensure that no injection hole is missed and that the cavity is filled from the bottom upwards. To prevent voids occurring, injection should commence at a stop-end within the cavity and the injection should continue until the foam system reaches the adjacent horizontally and vertically placed holes (see Figure 4).

While injection of the foam system is in progress, attention should be paid to the following points.

a) It is essential to use indicator sticks during injection. These should be placed in the holes adjacent to the injection point, their movement signalling the arrival of the foam system at these holes.

b) A foam system should not be injected into a hole for more than 75 % of its gel time, which should have been previously determined. Injection for a longer time can cause the foam to split. If an indicator stick fails to move when expected, injection should cease and the reason should be determined. The delay could indicate that the foam system has penetrated through a fault in the inner leaf. This is particularly important around critical building features such as chimneys.

c) Care should be taken at all times to prevent over-pressurization of the cavity, particularly when the completion of injections is approaching at soffit level, gable ends, cavity closures or untrunked vents.

**7.3.2** *Uncapped cavities.* Care should be taken to limit excessive foam system extrusion above the cavity in order to avoid restriction of the roof space ventilation.

Where a cavity wall extends over a gable end up to the ridge of the roof, it is essential to fill the whole cavity with the foam system right up to the ridge. If the inner leaf extends only to the top floor ceiling level, it is important to ensure that any water which might come through the outer leaf above this point cannot be conveyed on to the inner leaf by the foam in the cavity.

**7.3.3** *Wide cavities.* As the cavity width increases it may be necessary to adjust the hole pattern to ensure that the hole to hole injection time does not exceed 75 % of the gel time. It is also essential with wide cavities that the drilling pattern is adjusted to ensure that any horizontal or vertical boundary lines are installed correctly.

**7.3.4** *New construction.* It is highly desirable that the cavity should be weathertight, i.e. that the roof is in place and all cavity openings, such as those around doors and windows, are permanently protected, to avoid water ingress on to the foam.

## 8 Post-installation activities

Drill holes should be made good to match the wall finish as closely as possible.

The site should be left at least as clean and tidy as it was found.

All chimney flues and combustion air ducts, and air vents with an essential function as part of, or adjacent to, the foamed cavity, should be demonstrated as being clear of any blockage. Blocked or partially blocked flues can cause a combustion appliance to malfunction, which could cause lethal fumes to enter the building. Methods of test for flues are given in Appendix H.

It is essential that an inspection of the inside of the property is made. Any visible foam should be removed from occupiable areas and the hole through which it passed should be effectively sealed (see Appendix G).

CAUTION. There is a slight possibility that a fuel-burning appliance could malfunction after the installation team has left the premises. It is therefore essential for the installation contractor to leave a WARNING CARD with the householder advising him to switch off all such flued appliances should a malfunction be suspected and giving the appropriate emergency telephone number(s).

During the drying process, a small amount of free formaldehyde is evolved from the foam system, which is normally dissipated through the outer well. Occasionally some vapour may enter the building which can cause irritation to the eyes, nose and throat. The WARNING CARD should also advise that this transitory situation can normally be alleviated by additional temporary ventilation, but, should the problem persist, the householder should notify the installation contractor.

## 9 Records

It is essential that the installation contractor keeps records of every contract at least for the period of legal liability which should include at least the following details:

a) the type of equipment and foam system used;

b) the results of the assessment of suitability of the property;

c) the results of the check carried out by the operators on the water and foam system;

d) the results of the vent and flue checks;

e) the quantities of materials used and suppliers' names and batch numbers;

f) the names of operators carrying out the contract;

g) the job sheet with records of time worked and weather conditions during the time of working;

h) any difficulties or peculiarities noticed, and action taken during the installation.

## 10 Declaration

It is essential that after the installation, the installation contractor gives a declaration to the client that the installation has been carried out in accordance with BS 5618 with a UF foam system complying with BS 5617 and giving the supplier of the UF foam system and the supplier's description or reference number which identifies the system.

## Appendix A Criteria for suitability of external cavity walls

### A.1 The outer leaf

**A.1.1** The outer leaf of walls to be insulated should be of masonry or concrete construction. If the outer leaf is built of random *stone* rubble, none of the wall is covered by this code unless the stone is dressed and laid in courses as exemplified by illustrations A and D of Figure 4a (which is a copy of Figure 6 of BS 5390:1976). It follows that rubble walls complying with illustrations B, C, E and F of Figure 4a are unsuitable for UF foam cavity wall insulation.

**A.1.2** The maximum height of the external leaf of buildings covered by this code is 12 m.

The maximum height *H* of the external leaf is measured from the lowest horizontal d.p.c. of the external leaf to the highest point of any wall (see Figure 5).

In general, the maximum heights of buildings are as follows:

| | |
|---|---|
| single storey | 5 m |
| two storey | 7.5 m |
| three storey | 10 m |

**A.1.3** If the external leaf is fully protected against rain penetration, there is no exposure index limit. An example of full protection is weather-boarding or cladding on masonry or concrete, using materials such as slates, tiles, timber, metal or materials of equivalent performance.

**A.1.4** For other forms of external leaf construction, the following building exposure index limits are applicable (see Appendix B, Appendix C and Appendix D).

a) On new construction the rendered finish should comply with BS 5262. On existing construction it is essential that the rendered finish is of a cementitious nature, in a good state of repair, showing no more than hairline cracks, firmly adhering to the wall and with no signs of crumbling or erosion. It is essential that the exposure index *E* for such walls does not exceed 109.

b) If the external leaf is constructed from natural stone [the porosity of which exceeds or equals 20 % by volume (see Appendix B)] or facing clay or calcium silicate brickwork, and the mortar joints are not recessed, it is essential that the exposure index *E* does not exceed 100.

c) If the external leaf is constructed from cut natural stone [the porosity of which is less than 20 % by volume or stone type is unknown (see Appendix B)] or random stone rubble which is dressed and coursed and the inner face is reasonably regular, or concrete bricks or blocks, or reconstituted stone, and the mortar joints are not recessed, it is essential that the exposure index E does not exceed 88.

d) If the external leaf is of any masonry construction, and it has recessed mortar joints, it is essential that the exposure index *E* does not exceed 88, and the external cavity wall height does not exceed 7.5 m.

When assessing whether a wall is in accordance with either **A.1.3** or **A.1.4**, ignore any small decorative panels of stonework or brickwork under windows which do not exceed the width of the window and are protected by an adequately projecting sill. Ignore also any decorative brickwork or stonework surrounds to door or window openings or quoins (see **A.1.13**).

**A.1.5** If there are visible structural faults, e.g. cracking due to movement or settlement, it is essential that these be reported to the customer and a course of remedial action agreed.

**A.1.6** If problems have been encountered with the cavity insulation of structures of similar construction or situation, installation should only proceed if it is judged that effective remedies are available.

**A.1.7** Where the outer leaf has been covered with a material of very low vapour permeability, e.g. chlorinated rubber paint, the cavity should not be filled.

**A.1.8** The outer leaf should be generally sound, weather resistant and showing no evidence of frost damage. Badly eroded pointing or damaged or defective rendering, for example, require remedial action to be agreed with the customer. Gaps around frames, unsealed expansion joints, unfilled perpends and small cracks should be made good during the installation.

NOTE Extensive horizontal cracking along mortar joints could indicate an unsound structure due to corrosion of wall ties, settlement or sulphate attack.

**A.1.9** Where there are parapets it is essential to ensure that water cannot be conveyed to the inner face of the foam from the exposed inner leaf or capping.

**A.1.10** Where there are exposed ring beams or slabs it is essential to ensure that water will not track back along the underside of the beams or slabs.

**A.1.11** If the d.p.c. of the outer leaf is visibly defective then the structure is unsuitable for installation unless prior remedial action has been agreed with the customer.

**A.1.12** The survey document should record the positions of all features such as essential vents, flues and chimneys and of any service entries.

**A.1.13** Particularly in a situation where the exposure index of the structure is close to the permitted limit it is essential that it should be established that there are no features which are visibly causing an excessive local concentration of rain water on the wall. Examples of features which can cause such problems are:

a) flush sills or sills with inadequate drips;

b) impermeable cladding with no effective form of construction at the base designed to shed run-off clear of the wall beneath;

c) inadequate or non-existent overhangs at verges;

d) faulty chimney detailing at the roof line;

e) projecting string courses or other horizontal ledges;

f) roofs abutting external walls without adequate drainage;

g) faulty rainwater goods;

h) wrongly installed overflow pipes.

Where such problems exist, remedies should be recommended.

### A.2 The inner leaf

**A.2.1** The inner leaf of the cavity should be of masonry or concrete construction. If the inner leaf is built of random rubble, none of the wall is covered by this code.

**A.2.2** The cavity should be isolated from the occupiable areas of the building by the following methods in order to inhibit ingress of formaldehyde (see Appendix G).

a) The cavity should be effectively sealed (e.g. with mortar) at any point in the occupiable areas where there is a break in the inner leaf, i.e. where sections of the inner leaf are missing or have been removed.

NOTE The voids above suspended ceilings and rooms in the loft space are classed as occupiable areas.

b) Small holes around pipes and cracks around frames within the occupiable areas should be made good as part of the installation procedure.

**A.2.3** If there are signs of water penetration to or dampness on the internal surface other than that caused by condensation, e.g. rising damp or penetrating damp, the cause of the problem should be ascertained and remedies applied or agreed to be applied as part of the contract before proceeding with the installation.

NOTE This should include examination of areas around intentional cavity bridges such as ducts and flues.

**A.2.4** If the inner leaf extends only to top floor ceiling level but the wall carries gables or if there are parapets, it is important to ensure that any water which may penetrate these features would not be conveyed onto the inner leaf by the foam in the cavity.

**A.2.5** Areas of the inner leaf which would render the adjacent cavity unsuitable for filling according to this code of practice should be identified on the survey record.

**A.2.6** The positions of ducts, flues, chimneys and service entry points should be recorded on the survey document.

### A.3 Nature and condition of cavity

A free cavity generally of at least 40 mm width should be available over the areas to be filled.

Because cavity width may vary significantly within the wall of a building, cavity width should be confirmed by direct measurement at different points during the drilling operation by method 1 of Appendix K. For an initial survey, an estimation of cavity width will normally suffice estimated by method 2 of Appendix K.

NOTE There is a high risk of mortar bridging the cavity if the cavity width is generally less than 40 mm. However, a cavity width of less than 40 mm at isolated points is acceptable.

Rat trap bond or any other use of standard format bricks as wall ties renders the cavity wall unsuitable for filling.

Cavities capped with concrete gutters should be rejected unless the gutters are watertight, weathered and throated to throw water away from the wall.

If the cavity extends more than 0.5 m below ground level in a basement wall this should be noted in the survey record as it is essential in such circumstances that the foam should not extend below the outside ground level.

If the cavity is found to be in excess of 100 mm then inspection is required to determine whether there are frames within or across the cavity which could cause water penetration problems if insulation is installed and whether the greater volume of foam needed will give rise to problems with formaldehyde ingress into the building.

If any cavity barriers or stops are known to be present their position should be taken into account in determining the drilling pattern.

**A.4 Buildings at the design stage**

If it is intended that cavity insulation should be used then the installation contractor should liaise with the designer to ensure that the recommendations of this code are understood and incorporated.

**A.5 Buildings under construction**

The installation contractor should liaise with the builder to ensure that the recommendations of this code of practice are fully understood. The installation contractor should also ensure that the building contractor gives him the opportunity to inspect the cavity during construction (see note).

NOTE One possible way of meeting this recommendation would be for the builder to omit selected corner bricks.

The installation of the foam system should be arranged to suit all parties but should not be before the cavities have been made weathertight.

If the structure is to be dry lined every attempt should be made to achieve well filled mortar joints on the inner leaf and if the foam system is to be injected through the inner leaf before lining then the injection holes should be sealed.

**A.6 Existing structures**

The older the building the more likely it is to have been tested by spells of bad weather and any constructional defects will have become apparent. If the building is less than three years old it may be helpful, if possible, to examine the original drawings and it is particularly important to take note of local experience (see **A.1.6**).

**A.7 Services in cavity**

If it is established that there are pipes or ducts within the cavity then their position should be identified on the survey record to ensure that a drilling pattern can be designed that will not cause damage. To minimize possible damage to electric cables and other services which may be in the cavity, the fitting of distance pieces to drills ensures that there is not excessive penetration of the bit into the cavity.

NOTE Comparison of the position of features noted on the inner and outer leaf survey records is often helpful on this point.

**A.8 Ventilation**

Determine which vents it is essential to retain, e.g. vents for appliance air supply, fume extraction, room and structure ventilation, particularly sub-floor and roof ventilation.

All essential vents connecting to occupiable areas should be trunked and made continuous through both leaves. All essential vents should be recorded on the survey document to ensure that they are checked after foam installation.

Cavity vents, other than weepholes, should be sealed.

## Appendix B Natural stones used in the construction of masonry walls

The following table lists the more common natural stones that are used in the construction of masonry walls. The stones have been classed as being suitable for an exposure index *E* either of up to 100, i.e. their porosity exceeds 20 % by volume, or of up to 88, i.e. their porosity is less than 20 % by volume. In cases where the stone type is unknown or not listed in the table, and the porosity is unknown or is less than 20 % by volume, the stone should be classed as being suitable for an exposure index *E* of up to 88.

| Stone type | Maximum value of *E* |
|---|---|
| Ancaster Free Bed (L) | 100 |
| Ancaster Weatherbed (L) | 88 |
| Anston (ML) | 88 |
| Barnack (L) | 100 |
| Bath (L) Combe Down | 100 |
| Box Ground | 100 |
| Corngrit | 100 |
| Crosham | 100 |
| Farleigh Down | 100 |
| Hartham Park | 100 |
| Monks Park | 100 |
| Stoke Ground | 100 |
| Westwood Ground | 100 |
| Beer (L) | 100 |
| Binnie (S) | 88 |
| Blaxter (S) | 100 |
| Bramley Falls (S) | 88 |
| Caen (L) | 100 |
| Casterton (L) | 100 |
| Chilmark (L) | 100 |
| Clipsham (L) | 88 |
| Corsehill (S) | 100 |
| Craigmillar (S) | 88 |

| Stone type | Maximum value of $E$ |
|---|---|
| Craigleith (CS) | 88 |
| Crosland Hill (S) | 88 |
| Darney (S) | 88 |
| Doultin (L) | 88 |
| Dunhouse (S) | 88 |
| Dunston | 100 |
| Elland Edge (S) | 88 |
| Forest Marble (L) | 100 |
| Forest of Dean (S) | 88 |
| Gifnock (L) | 88 |
| Guiting (L) | 100 |
| Ham Hill (L) | 100 |
| Hard York (S) | 100 |
| Spinkwell/Crosland Hill | 88 |
| Hillhouse Edge | 88 |
| Silex | 88 |
| Temple Church | 88 |
| Headington (L) Hard | 88 |
| Soft | 100 |
| Hollington (S) | |
| Red | 100 |
| Mottled | 100 |
| White | 100 |
| Light Salmon/Park | 100 |
| Hopton Wood (L) | 88 |
| Hornton (L) Blue | 100 |
| Brown | 100 |
| Huddlestone (ML) | 100 |
| Kentish Rag (L) | 88 |
| Kerridge (S) | 88 |
| Ketton (L) | 100 |
| Ketton Weatherbed (L) | 100 |
| King's Cliffe (L) | 100 |
| Laxonby (S) | 88 |
| Leoch (S) | 88 |
| Locharbriggs (S) | 100 |
| Mansfield Woodhouse (ML) | 100 |
| Pennant (S) | 88 |
| Pilough (S) | 88 |

| Stone type | Maximum value of $E$ |
|---|---|
| Portland (L) Whit | 88 |
| Base | 88 |
| Roach | 100 |
| Prudhoe (S) | 88 |
| Purbeck Marble (L) | 88 |
| Reigate (S) | 100 |
| Robin Hood (S) | 88 |
| Roche Abbey (ML) | 88 |
| Rubislaw (G) | 88 |
| St. Bees (S) | 100 |
| Spinkwell (S) | 88 |
| Springwell (S) | 88 |
| Stamford Stone/Casterton (L) | 100 |
| Stancliffe (S) | 88 |
| Sussex Sandstone (Wealden) (S) | 100 |
| Tadcaster (ML) | 100 |
| Taynton (L) | 100 |
| Tor Down (G) | 88 |
| Totternhoe (L) | 100 |
| Tregarden (G) | 88 |
| Treglidgwith (G) | 88 |
| Trevone Medium Grey (G) | 88 |
| Trevor (G) | 88 |
| Trolvis Grey (G) | 88 |
| Wansford (L) | 88 |
| Wealden (L) | 100 |
| Whatstandwell (S) | 88 |
| Woolton (S) | 100 |

**Key**

L : Limestone
ML: Magnesian limestone
S : Sandstone
CS: Calcareous sandstone
G : Granite

## Appendix C Calculation of the exposure index *E* of a building (tabular method)

NOTE The procedure summarized here is based on the Agrément Board publication "Method of assessing the exposure of buildings for urea-formaldehyde cavity wall insulation" (Information Sheet No. 10)[1].

### C.1 Derivation of exposure index

The climate local to a building in relation to driving rain (its exposure index) is affected by:

a) the geographic factor *G* dependent on the location of the building geographically;

b) the topographic factor *T* dependent on the nature of the country surrounding the building;

c) the terrain roughness factor *R* dependent on the degree of protection given by local buildings, trees and other wind breaks, or the lack of protection if the building is situated on or near a steep slope.

The exposure index $E = G + T + R$

### C.2 Calculation procedure

The exposure index can be derived from tables of *G*, *T* and *R* or by calculation (see Appendix D). The result derived by calculation is to be preferred.

### C.3 Geographic factor *G*

Using the driving-rain index maps, determine the local driving-rain index *D* of the building in question. Read off the corresponding value from Table 2.

**Table 2 — Geographic factor *G***

| Driving-rain index ($m^2/s$) | *G* factor |
|---|---|
| Greater than 2 up to and including 2.5 | 15 |
| Greater than 2.5 up to and including 3 | 18 |
| Greater than 3 up to and including 4 | 22 |
| Greater than 4 up to and including 5 | 26 |
| Greater than 5 up to and including 6 | 29 |
| Greater than 6 up to and including 7 | 31 |
| Greater than 7 up to and including 8 | 33 |
| Greater than 8 up to and including 10 | 37 |

*Examples:*

a) a building in Kidderminster would have a *G* factor of 22 (greater than 3 $m^2/s$, up to 4 $m^2/s$);

b) a building in the centre of Plymouth would have a *G* factor of 31;

c) a building at Ashburton would have a *G* factor of 37.

### C.4 Topographic factor *T*

The topographic factor is determined from Table 3.

**Table 3 — Topographic factor *T***

| Topographic category | *T* factor |
|---|---|
| a) Sites known to be abnormally windy such as:<br>1) on the crest of a hill<br>2) on an exposed hill slope<br>3) in valleys so shaped as to produce a funnelling of wind | 38 |
| b) All cases except those in a) and c) | 37 |
| c) Sites that are more sheltered than normal such as those in steep-sided valleys at right angles to the strongest rain-bearing winds | 35 |

### C.5 Terrain roughness factor *R*

**C.5.1** The *R* factor is determined from Table 4, knowing the degree of local protection offered by the surrounding terrain on the side of the building facing the prevailing wind-driven rain and the effective height of the building, $H_E$, for exposure purposes. Guidance on the direction of the prevailing wind-driven rain is given in map 31; in some cases it may be necessary to consider separately two or more sides of the building.

**C.5.2** The effective height of the building $H_E$ for exposure purposes will be as in a) or b) as follows.

a) If the building is on generally level ground, or on sloping ground of gradient less than 1 in 3, the effective height $H_E$ is the same as the external cavity wall height *H* defined in **A.1.2**, or the maximum height of the unprotected cavity wall, whichever is less (see Figure 6).

b) If the building is:

i) on a slope[2] having an average gradient equal to, or exceeding, 1 in 3 (e.g. position A in Figure 7); or

ii) within 4*Z* of the point Y in Figure 7, at the upper end of such a slope, at which the average gradient changes to less than 1 in 3, *Z* being the height of Y above point X in Figure 7, at the lower end of the slope, at which the average gradient changes to less than 1 in 3 (e.g. position B in Figure 7);

then the effective height, $H_E$, is the height described in **C.5.2** a) plus the height of the location, $H_L$, above point X in Figure 7.

[1] Available from The British Board of Agrément, PO Box 195, Bucknalls Lane, Garston, Watford, Hertfordshire WD2 7NG.

[2] The term slope includes any hill, cliff or terrace.

**Table 4 — Terrain roughness factor *R***

| Terrain category | Description | *R* factor | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Effective building height, $H_E$ (m) | | | | | | | |
| | | 5 | 7.5 | 10 | 15 | 25 | 50 | 75 | 100 |
| 1 | Inland sites with long stretches of open, level or nearly level country with no shelter. Examples are fens, airfields, grassland, moorland or farmland without hedges or walls around fields | 35 | 36 | 37 | 38 | 39 | 41 | 42 | 43 |
| | When such sites are within 8 km of the coast or large estuary | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
| 2 | Flat or undulating country with obstruction such as walls or hedges around fields, scattered windbreaks of trees and occasional buildings. Examples are most farmland and country estates with the exception of those parts that are well wooded | 31 | 32 | 34 | 35 | 37 | 40 | 41 | 42 |
| 3 | Surfaces covered by numerous large obstructions. Examples are well wooded parkland and forest areas, towns and their suburbs and the outskirts of large cities | 27 | 28 | 29 | 31 | 34 | 37 | 39 | 41 |
| 4 | Surfaces covered by numerous large obstructions with a general roof height of at least 25 m. This category covers only the centres of large towns and cities where the buildings are not only high but are also not widely spaced | 23 | 24 | 25 | 26 | 29 | — | — | — |

NOTE 1 If the values of *R* are read from the table, the next highest value of $H_E$ should be used, i.e. the values in the column for $H_E = 25$ would cover all values of $H_E$ for $15 < H_E \leqslant 25$ m.

NOTE 2 For most dwellings: 1 storey $\leqslant$ 5 m
2 storeys $\leqslant$ 7.5 m
3 storeys $\leqslant$ 10 m

## Appendix D Calculation of the exposure index *E* of a building (formula method)

### D.1 General

This appendix gives the formulae from which the factors in making up the exposure index can be calculated. The formulae should be used where interpolation of data is required.

### D.2 Calculation of *G*

$$G = 36.686 \log_{10} D$$

where

*D* is the driving-rain index (in $m^2/s$) for the location.

### D.3 Calculation of *T*

$$T = 36.686 \log_{10} S$$

where

*S* is the topographic factor obtained from Table 5.

**Table 5 — Topographic factor *S***
(as derived from the topographic categories in Table 3)

| Topographic category | *S* factor |
|---|---|
| a) | 11 |
| b) | 10 |
| c) | 9 |

### D.4 Calculation of *R*

$$R = 36.686 \log_{10} B_c$$

where

$B_c$ is calculated from the appropriate formula in Table 6.

**Table 6 — Equations for $B_c$**

| Height zone | Terrain category | | | | |
|---|---|---|---|---|---|
| | 1(a) | 1(b) | 2 | 3 | 4 |
| Critical height $E_c$ | $E_c$ = 10 m | $E_c$ = 10 m | $E_c$ = 12 m | $E_c$ = 20 m | $E_c$ = 35 m |
| $H_E > E_c$ | $11.3\left(\frac{H_E}{10}\right)^{0.14}$ | $10.0\left(\frac{H_E}{10}\right)^{0.17}$ | $8.6\left(\frac{H_E - 2}{10}\right)^{0.21}$ | $7.5\left(\frac{H_E - 10}{10}\right)^{0.24}$ | Not applicable |
| $3 < H_E \leqslant E_c$ | $\sqrt{72 + 5.6\ H_E}$ | $\sqrt{56 + 4.4\ H_E}$ | $\sqrt{29 + 3.8\ H_E}$ | $\sqrt{20 + 1.8\ H_E}$ | $\sqrt{13 + 0.93\ H_E}$ |
| $H_E \leqslant 3$ | 9.4 | 8.3 | 6.3 | 5.1 | 4.0 |

NOTE 1 The equations in Table 6 have been simplified from Agrément Board Information Sheet No. 10 by multiplying out the various constant coefficients.
NOTE 2 $E_c$ is the symbol used in CP 3:Chapter V-2 to designate the height at which the form of the wind speed equations changes.

*Examples:*

a) Terrain category 2, $H_E$ = 2.5 m

therefore $B_c$ = 6.3

therefore $R = 36.686 \log_{10} 6.3 = 29.3$

b) Terrain category 1, $H_E$ = 7.5 m

therefore $B_c = \sqrt{56 + (4.4 \times 7.5)} = 9.43$

therefore $R = 36.686 \log_{10} 9.43 = 35.8$

c) Terrain category 3, $H_E$ = 50 m

therefore $B_c = \left(\frac{50 - 10}{10}\right)^{0.24} = 10.46$

therefore $R = 36.686 \log_{10} 10.46 = 37.4$

### D.5 Comparison of methods

Consider a building which has a map value for $D$ of 7 m²/s, is in gently rolling countryside [topographic category (b)], is in terrain category 2, and has an effective height, $H_E$, of 7.5 m (2 storeys).

Determine the exposure index $E$:

a) Using tables:

$G$ = 31 (Table 2)

$T$ = 37 (Table 3)

$R$ = 32 (Table 4)

$E = G + T + R = 100$

b) By calculation:

$G = 36.686 \log_{10} 7 = 31.0$

$T = 36.686 \log_{10} 10 = 36.7$

$B_c = \sqrt{29 + 3.8 H_E} = 7.58$

$R = 36.686 \log_{10} 7.58 = 32.3$

$E = G + T + R = 100.0$

In case of dispute, the value of E obtained by calculation and rounded to the nearest whole number is to be preferred to that derived from the tables.

## Appendix E Driving-rain index

### E.1 Definition

The driving-rain index, $D$ (m²/s), is the product of the average annual rainfall, $\bar{d}$ (m), and the average annual hourly windspeed, $\bar{v}$ (m/s), the latter being corrected to terrain category 1(b) of Table 6 and a height of 10 m above ground level.

$D = \bar{d}\,\bar{v}$ (m²/s)

### E.2 Driving-rain index maps

The maps in this code are based on those first prepared by R E Lacy (see foreword) with the addition of contour lines for $D = 6$ m²/s and $D = 8$ m²/s, and some minor additions at other driving-rain indices.

Maps 1 to 30 on a scale of 1:625 000[3)] show contours of the driving-rain index. Interpolation between the contours is permitted when the calculation procedure is being used. Guidance can be obtained from annual rainfall maps on the same scale.

### E.3 Calculation of the driving-rain index from meteorological data

Research is being carried out by the Meteorological Office to improve the data on which the driving-rain index maps are based. When this is complete a revision of this appendix may be issued. Because of the complexity of computing the windspeed data, the driving-rain index should not be calculated from local meteorological data.

3) The linear scale has been reduced by approximately 10 % for convenience of reproduction in this British Standard. The numbers in bold type adjacent to the contour lines are driving-rain indices (m²/s).

### E.4 Determination of the direction of the prevailing wind

Map 31 shows annual mean driving-rain "roses" for various meteorological stations in different parts of the British Isles. In each "rose" the length of each of the radiating lines is a measure of the mean driving-rain index received from the direction shown.

In assessing the direction of the prevailing wind at any location, the longest line of the nearest "rose" on the map will give a good guide. Account should also be taken of any major local geographical features and any local evidence such as the shape of surrounding trees in deciding the prevailing or most frequent wind direction(s).

## Appendix F Comparison of methods for assessing exposure to wind-driven rain

The scheme given in this code (see Appendix E) has been widely used for assessing the exposure of buildings and is based on maps of an omnidirectional annual driving-rain index which is the product of average annual rainfall and average wind speed. The scheme in DD 93 uses a different set of maps based on the latest Meteorological Office data showing the quantity of rain falling on vertical surfaces during the worst likely spell of bad weather in any three year period from a given direction.

Since DD 93 does not present omnidirectional spell indices a direct comparison with this code is only possible after carrying out some simple, though quite laborious calculations. Some comparisons are given in Table 7.

Figure 8 is a plot of the exposure index *E* given in this code against the associated maximum directional spell index from DD 93.

**Table 7 — Comparisons between exposure values in DD 93 and in this code**

| Maximum directional spell index (DD 93) | | | Equivalent exposure index *E*(BS 5618) | Exposure category (BS 5628-3) |
|---|---|---|---|---|
| Log-scale value | L/m$^2$ ($D_{LS}$) | m$^2$/s (DRI) | | |
| 12 | 12.6 | 0.063 | 80 | Very Sheltered |
| 18 | 25.2 | 0.126 | 88 | Sheltered or Sheltered/Moderate |
| 27 | 71.2 | 0.356 | 100 | Moderate/Severe or Severe |
| 31 | 113.0 | 0.565 | 105 | Severe or Very Severe |
| 34 | 160.0 | 0.800 | 109 | Very Severe |

## Appendix G Formaldehyde

### G.1 General

Formaldehyde is a compound that can be found in almost all environments. It is formed naturally in the human body, as a combustion product and by the action of light on hydrocarbons in air. The concentration of formaldehyde can be substantially increased locally by vehicle exhaust fumes, open fires or cooking by natural gas.

At low levels of exposure, formaldehyde is not classed as a health hazard and whilst the irritation may be unpleasant its effects are transitory at levels which are tolerable. The Chief Medical Officer of the Department of Health and Social Security has indicated that the completed studies of people exposed to formaldehyde vapour have not found any evidence that it causes cancer, changes in lung structure, or permanent impairment of lung function in man[4].

Formaldehyde has a distinctive pungent smell. People's sensitivity to formaldehyde varies and it can be detected by nearly all people at a low level of concentration, typically 0.5 p.p.m. by volume, but some people can detect it at a level as low as 0.2 p.p.m. while others may be unaware of its presence below 1.0 p.p.m. Above 0.5 p.p.m. it can be irritating to the eyes, nose and respiratory tract.

### G.2 Formaldehyde in UF foam system installations

Formaldehyde is given off by UF foam systems during the curing and drying process. The evolution of formaldehyde within the cavity is an equilibrium process which decreases over a period of time. Extensive experience in the UK has shown that the resistance of the masonry inner leaf normally ensures that the penetration of formaldehyde is insufficient to increase the existing concentration of formaldehyde to noticeable levels within the building. Occasionally, however, UF foam cavity insulation can result in a noticeable level of formaldehyde within the occupiable part of the building. The installer should therefore include in his pre-installation inspection an assessment of the likelihood of formaldehyde penetration and take whatever preventive measures are considered necessary to ensure that there is an essentially continuous barrier between the injected foam system and the occupiable parts of the building.

Inner leaves which have unplastered masonry surfaces left exposed for decorative purposes, or which are dry lined, are likely to be more permeable to formaldehyde than plastered leaves. Buildings with these features should only be insulated with UF foam during construction so that the formaldehyde in the newly installed foam system will be dispersed before occupation, unless either the brick or block work is of high quality or the inner surface is effectively sealed.

Where a recirculating air system exists, the system should not draw air from any part of the building that is open to the filled cavity.

In prefabricated structures or where buildings are of frame construction, usually institutional type buildings or system-built structures, particular care is required in their assessment from the standpoint of water and formaldehyde penetration. In buildings where the masonry walls are used as infill panels the joints and cavity closers need to be carefully assessed.

Unless the survey shows that the cavity closers are an effective barrier or can be sealed so that there is no direct access from the cavity into the building, particularly at ceiling level, the building should be regarded as unsuitable for insulating with UF foam.

## Appendix H Flue checks for appliances of rated input not exceeding 60 kW

### H.1 General

It is essential that every flue system adjacent to, or in contact with, a wall cavity that has been filled with a UF foam system is checked after installation to ensure that the flue remains clear, and that the combustion products are completely discharged to the outside air. The appropriate methods of inspection and testing for various types of flue system have been taken from BS 5440-1:1978 and are reproduced below, with appropriate additions for UF foam installations.

Because of the wide variety of fuel-burning appliance designs, difficulties may arise in establishing whether the flue performance is satisfactory. Should this occur, it is important that the relevant fuel undertaking or appliance maintenance contractor is called in to carry out the appropriate tests.

[4] Hansard, 18 March 1982; volume 20, c 193.

### H.2 Flues where no appliance is fitted

Where practicable, a visible check with the aid of a mirror should be made to see that no foam has entered the flue. If a satisfactory visual inspection cannot be made, a rough check on the efficacy of the flue system should be carried out by a smoke test at each appliance position in turn; all the smoke should be drawn into the flue, and where there is a group of individual flues or a shared flue system, no smoke should issue from any other opening within the building (including the immediately adjoining premises). In certain conditions, there may be spillage of smoke due to inversion caused by the flue being colder than the outside air; in such cases some heat is necessary and the test should be repeated 10 min later.

Smoke may be generated from, for example, a smoke pellet a smoke match or burning newspaper. The first two do not generate heat and, if it is not possible to burn newspaper in the appliance position, the heat from a blow lamp can be passed into the flue opening for 1 min just prior to repeating the smoke test.

### H.3 Pre-installation checks where appliances have been fitted

It is essential that each appliance is operated prior to installation of a foam system to ensure that the flue is functioning correctly. This permits a better comparison of the performance of the appliance before and after installation, especially the flame appearance where this can be observed. With convector type gas fires check that there are no scorch marks on the outer casing just above the flame enclosure, which would indicate existing flue problems.

Where a flue is found to be faulty, installation of the UF foam system should be delayed until the appropriate remedial action has been taken.

### H.4 Post-installation checks of room-sealed appliances

Whenever possible, it should be ascertained visually that the flue and the air inlet are unobstructed.

A guide to the correctness of the installation is the appearance of the flame in the combustion chamber in comparison with the pre-installation check. A clear, well-defined flame generally denotes that the flue and air-way are unobstructed. (It should be appreciated that the flame of a correctly operating appliance will be dependent upon the fuel being used and the burner.)

Where a flue or duct serves a number of appliances, its performance should be checked against its design predictions by the local fuel supplier.

### H.5 Post-installation checks of open-flued appliances

The flue performance with all doors and windows in the room closed is to be checked by carrying out a test for spillage (see **H.7**) at the base of the draught diverter or, in the case of a gas fire, at the canopy. No spillage should occur. If there is an extracting fan in any room of the premises or the particular flat or maisonette concerned, the spillage test should be carried out with the fan in operation.

NOTE The term fan includes extractor fans, fans in open-flued appliances, fans in cooker hoods and the circulating fans of warm air heating systems.

### H.6 Procedure for determining flue products spillage

Proceed as follows:

a) close all doors and windows in the room containing the appliance and turn on extractor fans;

b) turn on the appliance;

c) after five minutes carry out a spillage test (see **H.7**).

Momentary spillage should be ignored, but if it is persistent, action is necessary to remedy the situation. Spillage may also be due to inversion, caused by the flue being colder than the outside air; therefore, if spillage occurs, the test should be repeated 10 min later.

If the spillage is persistent, obtain expert advice from the fuel supplier.

### H.7 Spillage test methods

The presence of combustion products spillage may be detected in one of the following ways.

a) Hold a smoke match so that the flame is approximately 3 mm up inside the lower edge of the draught diverter or the canopy of a gas fire. Spillage is indicated by the smoke being displaced outwards from the draught diverter or canopy.

b) Hold a lighted taper so that the flame is just below the lower edge of the draught diverter. Spillage is indicated by the flame being displaced outwards from the draught diverter.

c) Hold a piece of cold, polished metal or a mirror close to the lower edge of the draught diverter. Spillage is indicated by the bright surface becoming dimmed by condensation.

d) Direct smoke, e.g. from a smoke puffer, just below the lower edge of the draught diverter. Spillage is indicated by the smoke being displaced outwards from the draught diverter.

e) Ignite a smoke pellet in the combustion chamber of the appliance and observe whether smoke emerges from the draught diverter. This method is useful when access to the draught diverter is difficult: for example, where a rear-flue ducted air heater is installed in a compartment.

NOTE In the above methods the whole of the draught diverter perimeter or edge of the gas fire canopy should be checked.

## Appendix J Properties of the installed (UF) foam

The improvement in thermal insulation achieved by the installation of UF foam results primarily from the fact that the foam restricts air movement within the cavity (still air being a very good insulant). In many structures however, additional advantage is gained from the sealing by the foam of gaps in the inner and outer leaves that were previously responsible for substantial heat loss.

These objectives are realized with a rigid foam which effectively fills the cavity.

Foam strength is related to the foam density, hence there is a desirable minimum density in the wall cavity of 6 $kg/m^3$ for any system. This standard recommends that test samples are prepared but these are obviously unaffected by conditions within the cavity. The formulations recommended in this standard are therefore designed to give test sample values which build in large factors of safety as in good building practice. Thus, whilst generally the differences between the installed density and test sample values would be expected to be small, even if the installed density is as low as 50 % of the test sample target value, it should still have adequate strength.

Because the foam system is wet when injected, during the drying and curing process a small amount of shrinkage will occur. Whilst it is required by BS 5617 that the foam systems should be formulated to ensure that the linear shrinkage of the test samples does not exceed 10 %, test results are invariably well below this value (see Table 2 of BS 5617:1985). However, shrinkage within the cavity can vary from point to point due to conditions within the cavity and whilst the overall shrinkage would normally be expected to be within the test sample limits localized shrinkage of up to 20 % could be detectable without detracting from the effectiveness of the insulation.

The effect of shrinkage has been taken into account in recommending the use of a design thermal conductivity value of 0.04 W/(m·K) compared with the requirements in BS 5617 that the measured thermal conductivity is not to exceed 0.035 (see Table 1 of BS 5617:1985).

## Appendix K Methods for determination of cavity width

### K.1 Principle

The cavity width is obtained by subtracting the thickness of the outer leaf from the measured distance from the outside of the outside leaf to the cavity side of the inner leaf.

### K.2 Method 1. Direct measurement

**K.2.1** ***Apparatus***

**K.2.1.1** *A cavity measuring gauge.*

**K.2.1.2** *A leaf gauge.*

**K.2.1.3** *A masonry drill.*

**K.2.2** ***Procedure***

Drill a hole normally through the outer leaf, large enough to insert the cavity gauge until it makes contact with the cavity side of the inner leaf. Measure the distance between this contact point and the outside surface of the outer leaf $L$ to the nearest mm. Insert the leaf gauge to determine the thickness of the outer leaf $T$. If the outer leaf has been rendered then this second measurement will include the thickness of rendering (see Figure 9).

**K.2.3** ***Calculation***

Calculate the cavity width $C$ (in mm) from the equation:

$$C = L - T$$

where

$L$ is the distance from the outer surface of the outer leaf including any rendering to the cavity side of the inner leaf (in mm);

$T$ is the thickness of the outer leaf including any rendering (in mm).

### K.3 Method 2. Estimation

Provided the basic materials of construction are known, an estimation of cavity width can be obtained by measuring the overall wall thickness as shown in Figure 10, and subsequently subtracting the nominal thicknesses of the wall components.

NOTE 1 An indication of the thickness of external renders can be obtained where the bottom edge of the render is above ground level.

NOTE 2 A wet plaster finish applied to an inner leaf is normally considered to be 12 mm thick.

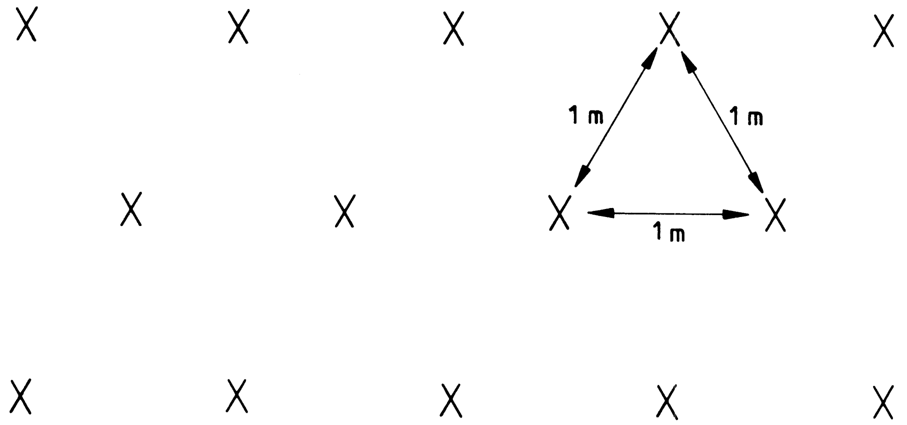



**Figure 1 — Staggered drilling pattern (representing maximum spacing)**

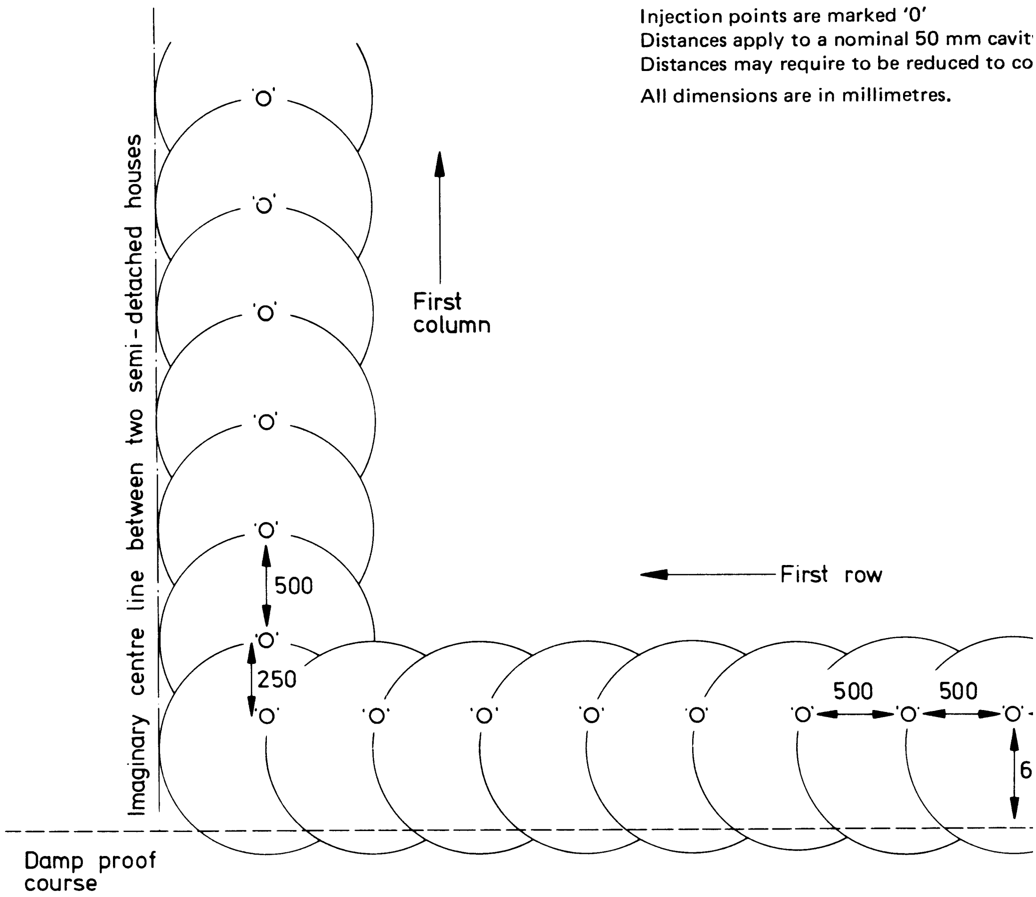
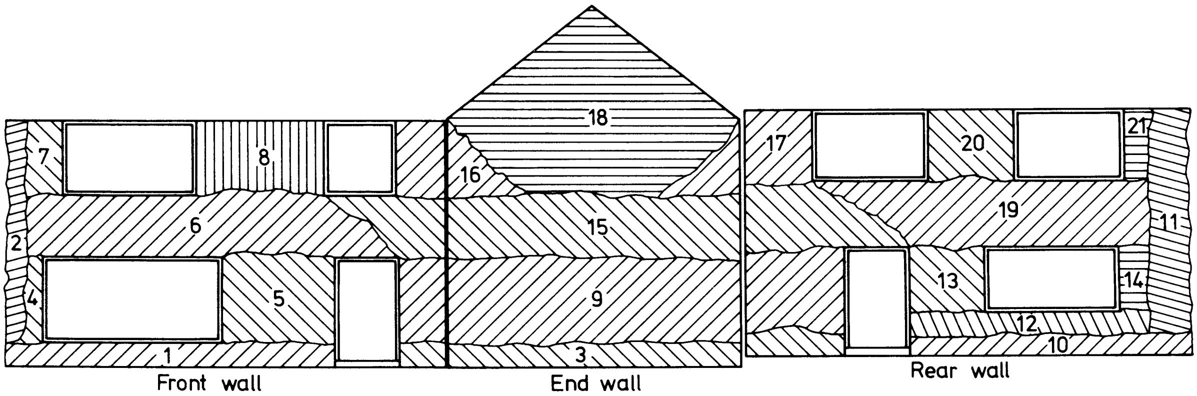



**Figure 2 — Drilling and filling patterns at damp proof course and party lines**




NOTE This is one of a number of possible sequences

**Figure 3 — Unit area plan**

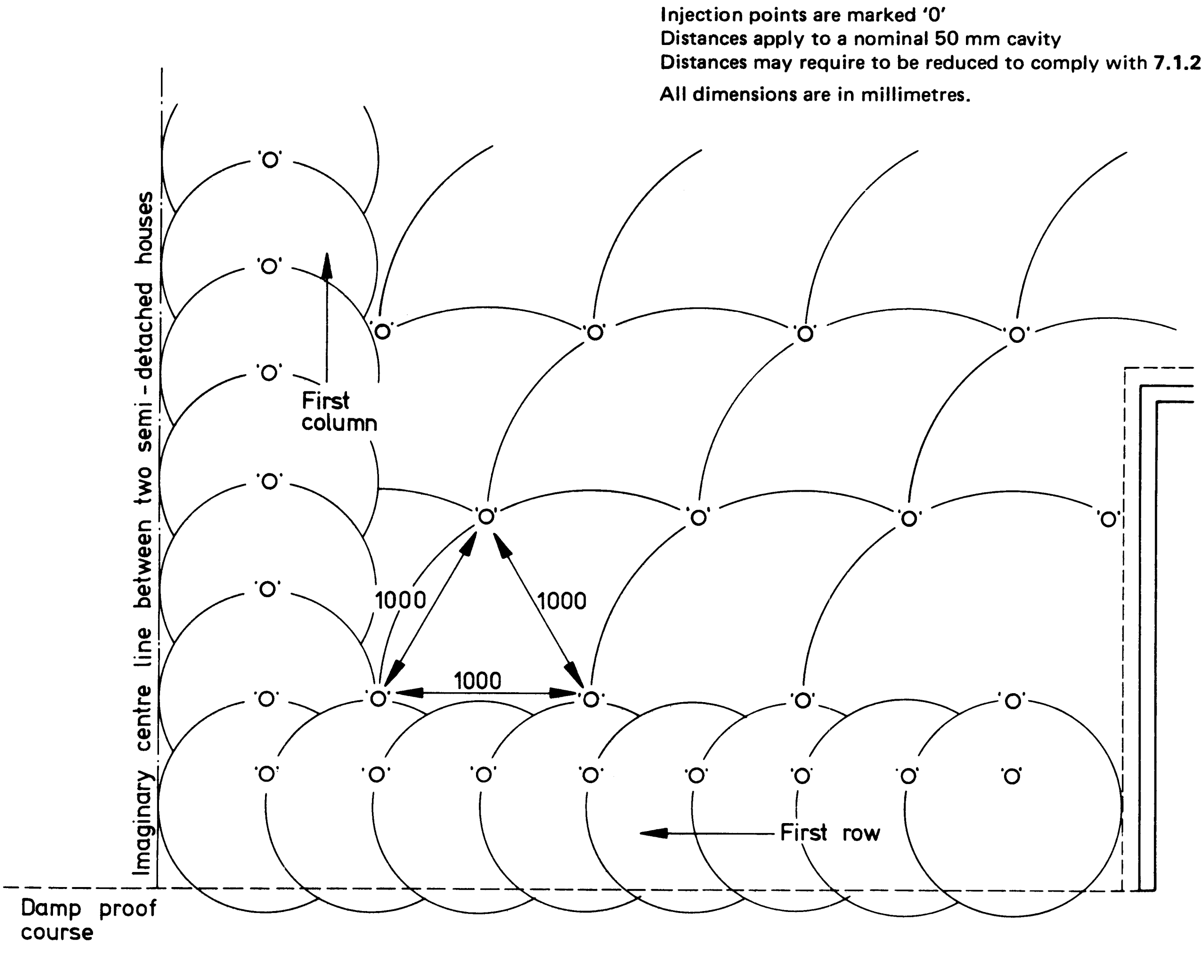



**Figure 4 — Overall pattern of filling for a nominal 50 mm width cavity**

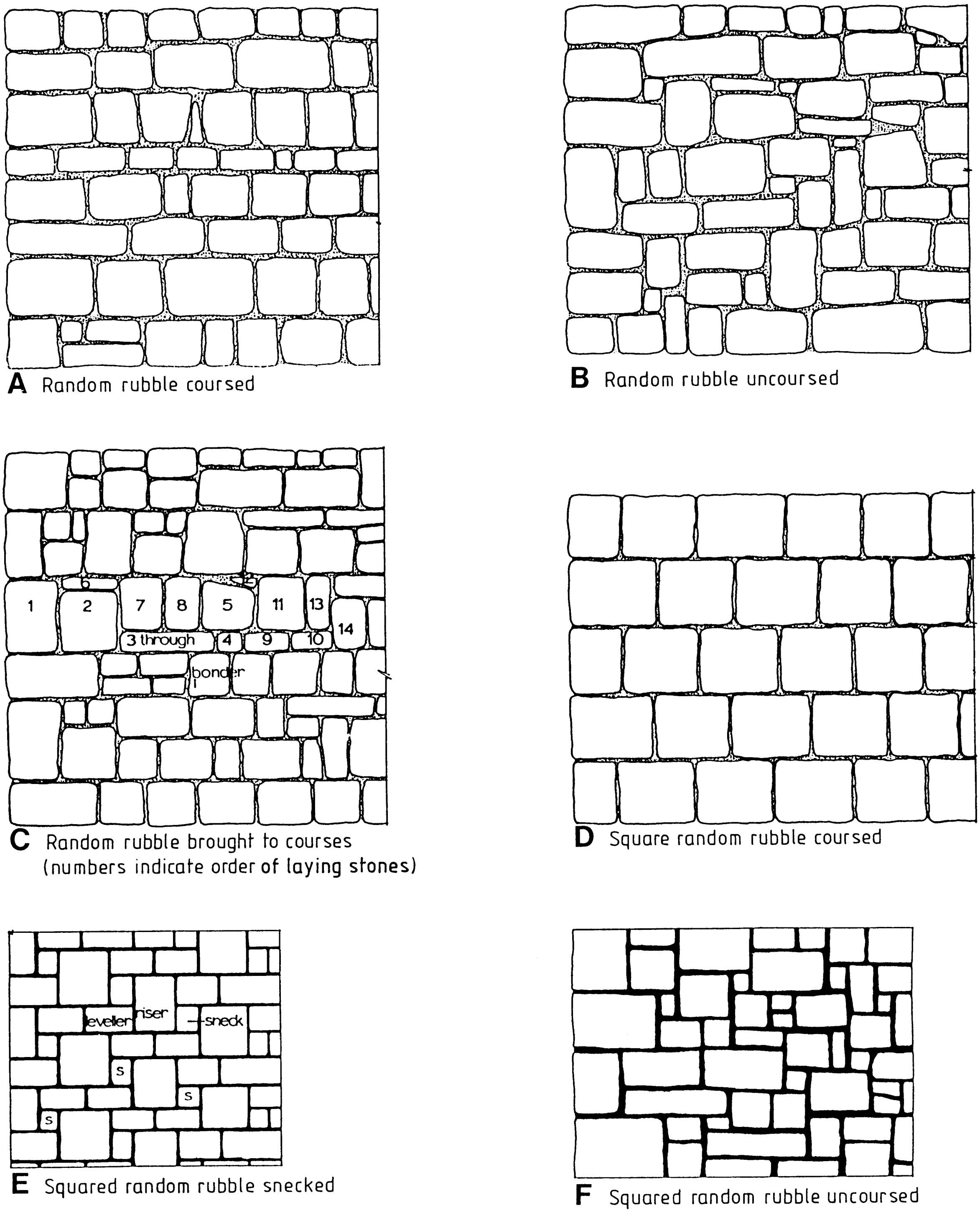



**Figure 4a — Types of rubble walling**

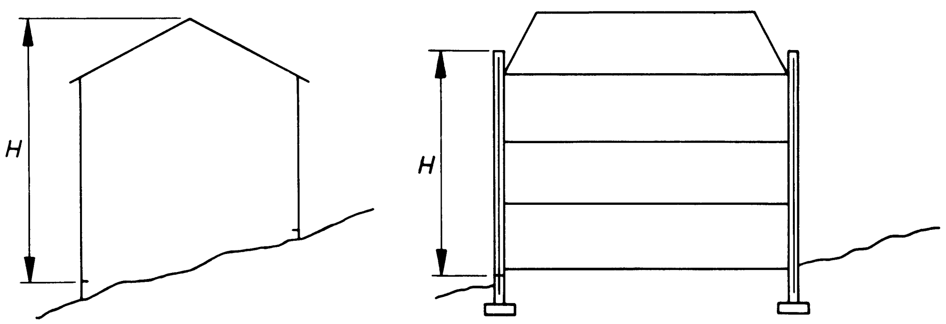



**Figure 5 — Maximum height of external cavity wall**

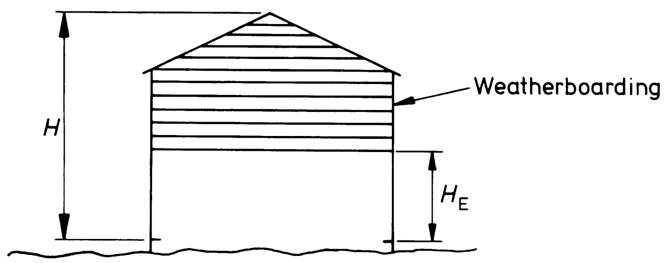



**Figure 6 — Effective height of a partially protected cavity wall**

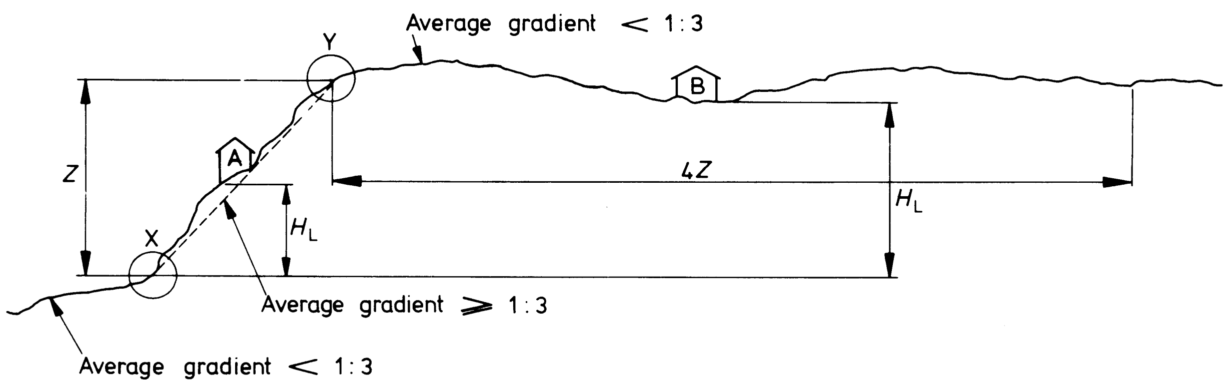



**Figure 7 — Height of location for buildings on or close to steeply rising ground**

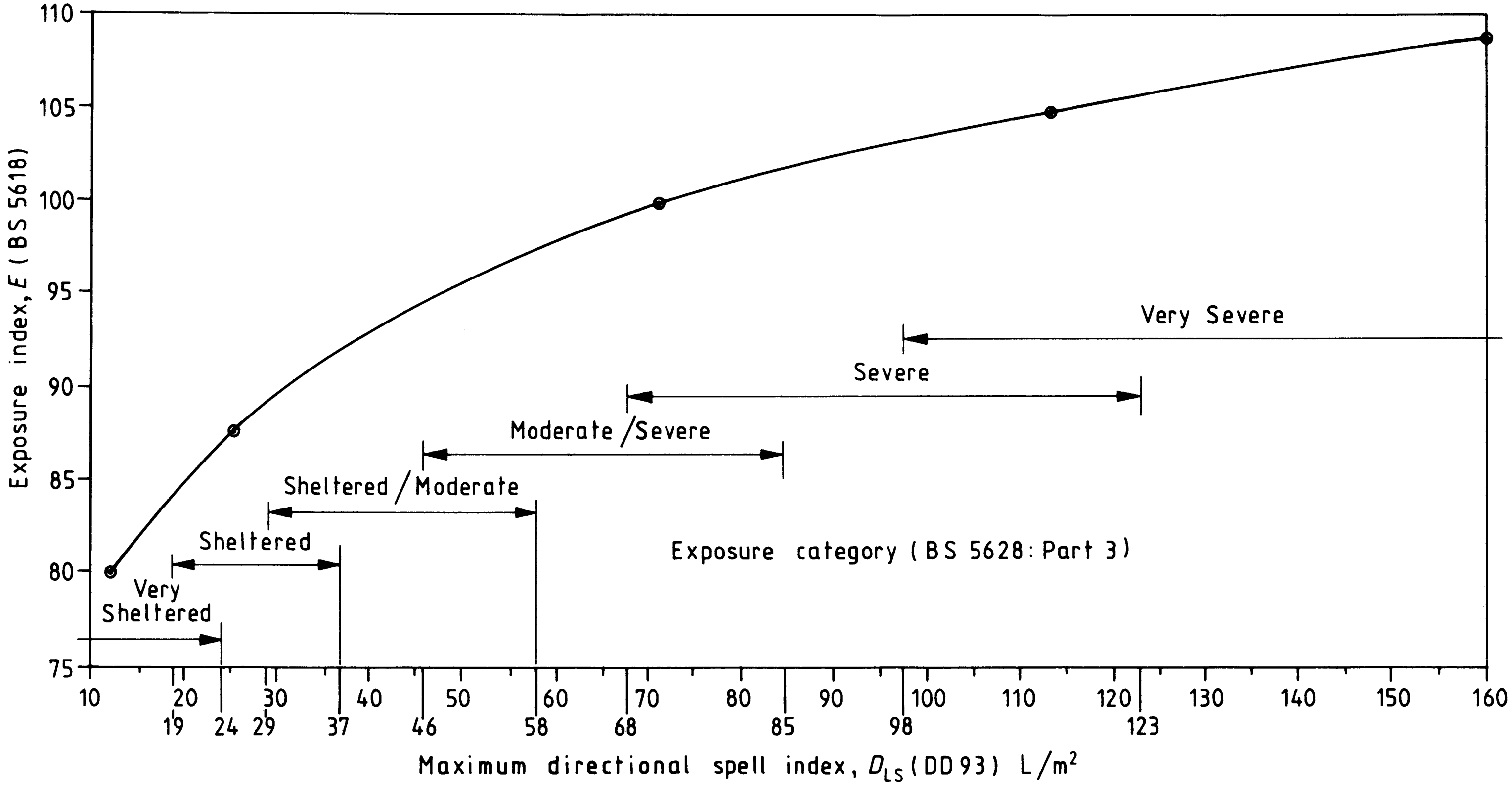



**Figure 8 — Relationship between the exposure index used in this codes and the maximum directional spell index in DD 93**

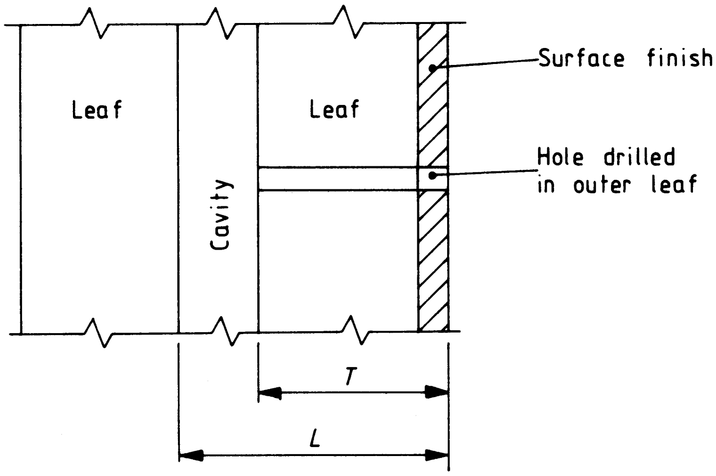



**Figure 9 — Measurement of cavity width** (see method 1 of Appendix K)

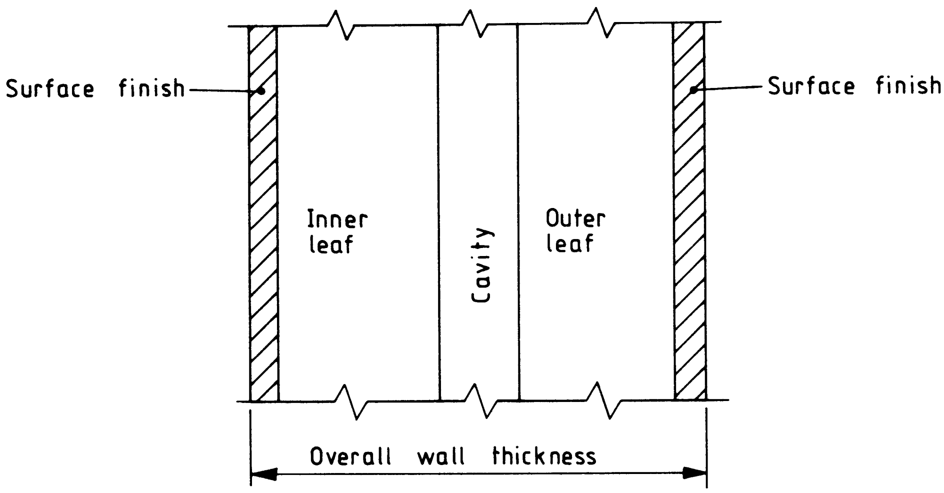
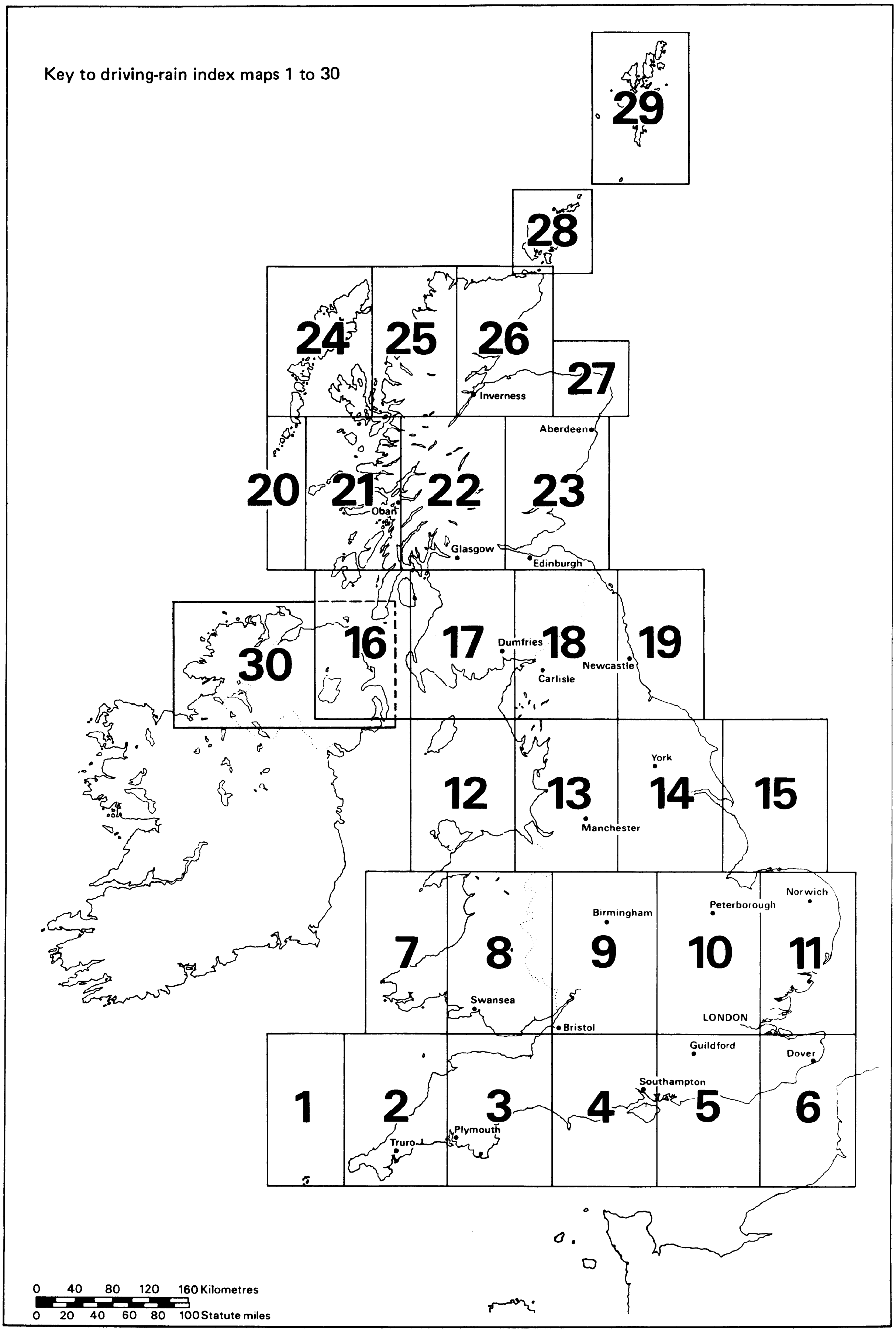


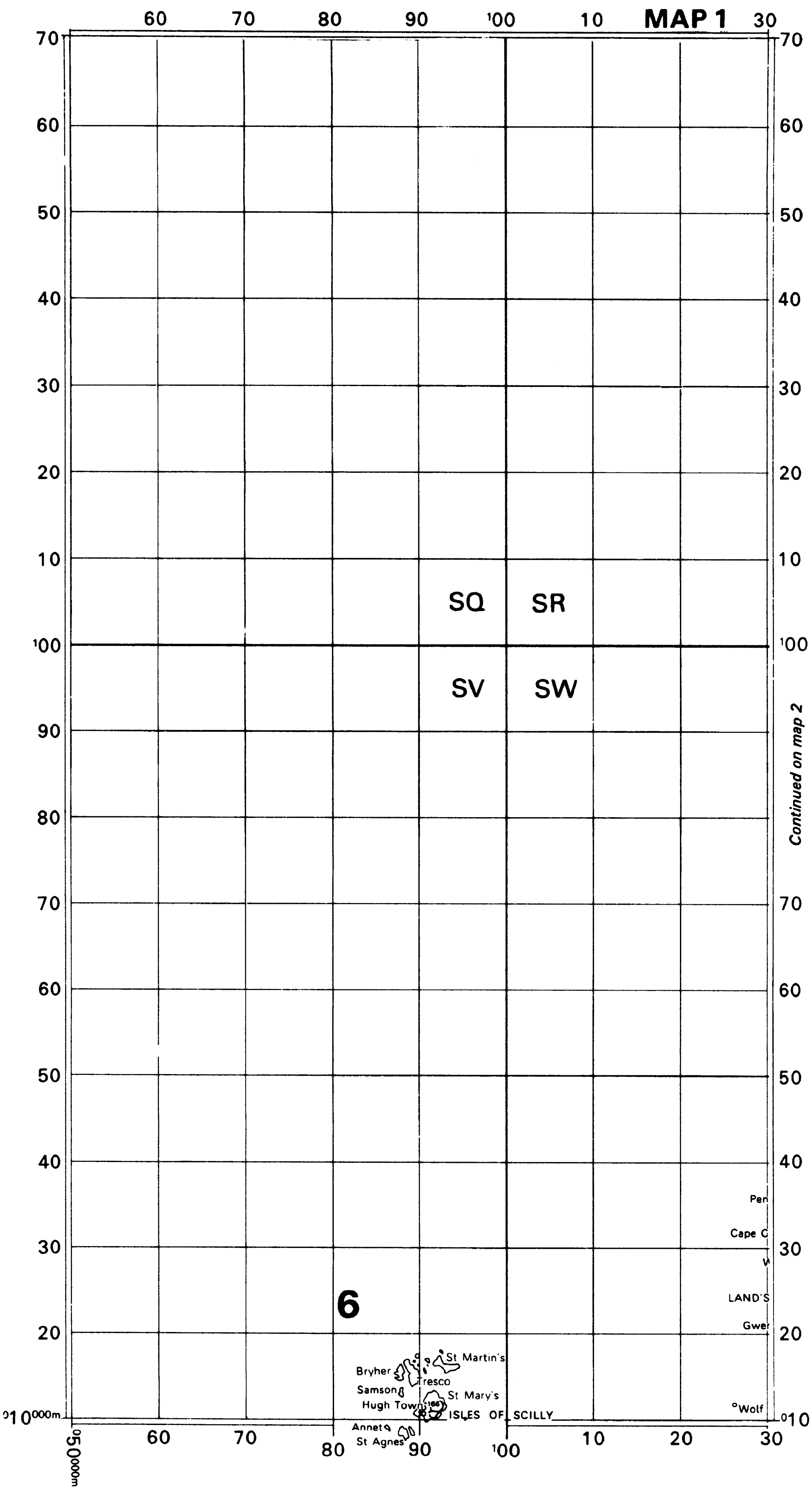

**Figure 10 — Estimation of cavity width** (see method 2 of Appendix K)






NOTE 1. See foreword and appendix F for details of the origin and scale of the maps.

NOTE 2. The numbers in large bold type adjacent to the contour lines in maps 1 to 30 are driving-rain indices ($m^2/s$).

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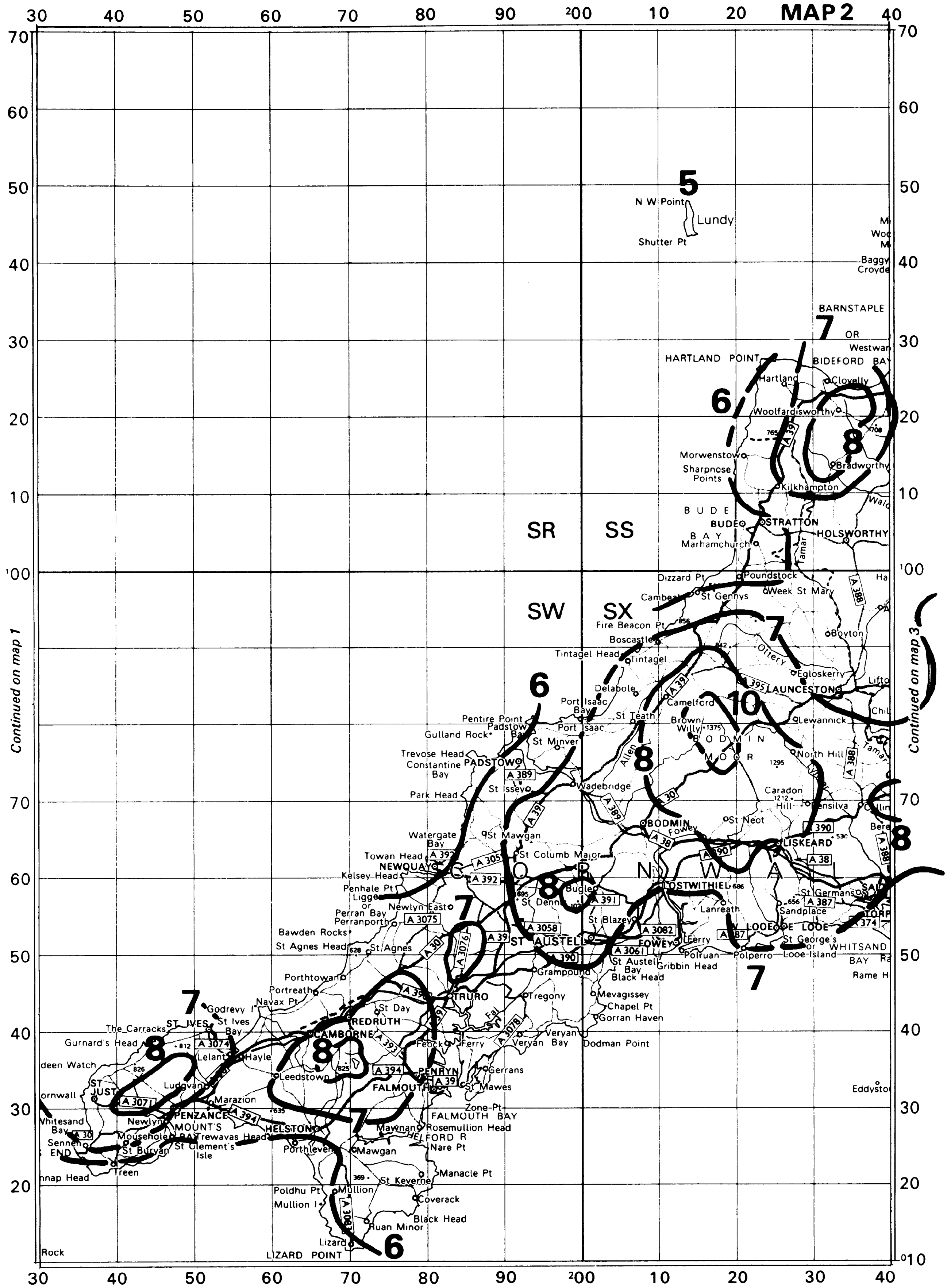


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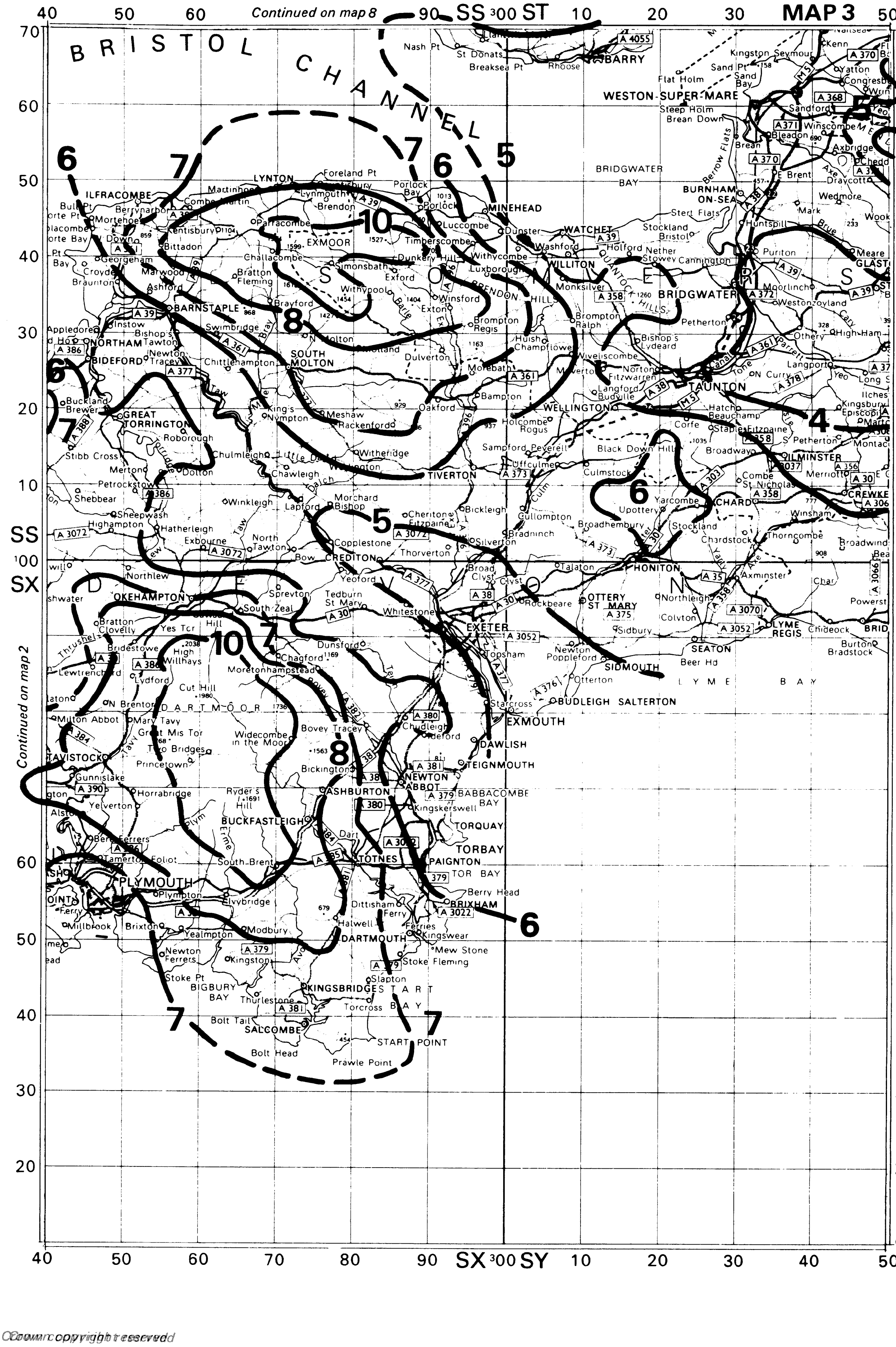
MAP 3
Continued on map 8
Continued on map 2
Continued on map 4
BRISTOL CHANNEL
BRIDGWATER BAY
LYME BAY
START BAY
SS
ST
SX
SY
ILFRACOMBE
LYNTON
MINEHEAD
WATCHET
WILLITON
BARRY
WESTON-SUPER-MARE
BURNHAM-ON-SEA
BRIDGWATER
BARNSTAPLE
SOUTH MOLTON
NORTHAM
BIDEFORD
GREAT TORRINGTON
TAUNTON
WELLINGTON
TIVERTON
ILMINSTER
CHARD
CREWKERNE
HONITON
CREDITON
OKEHAMPTON
EXETER
OTTERY ST MARY
SIDMOUTH
LYME REGIS
SEATON
BUDLEIGH SALTERTON
EXMOUTH
DAWLISH
TEIGNMOUTH
NEWTON ABBOT
TORQUAY
TORBAY
PAIGNTON
BRIXHAM
TOTNES
DARTMOUTH
ASHBURTON
BUCKFASTLEIGH
TAVISTOCK
PLYMOUTH
KINGSBRIDGE
SALCOMBE
EXMOOR
DARTMOOR
BRENDON HILLS
QUANTOCK HILLS
Start Point
Prawle Point
Bolt Head
Bolt Tail
Berry Head
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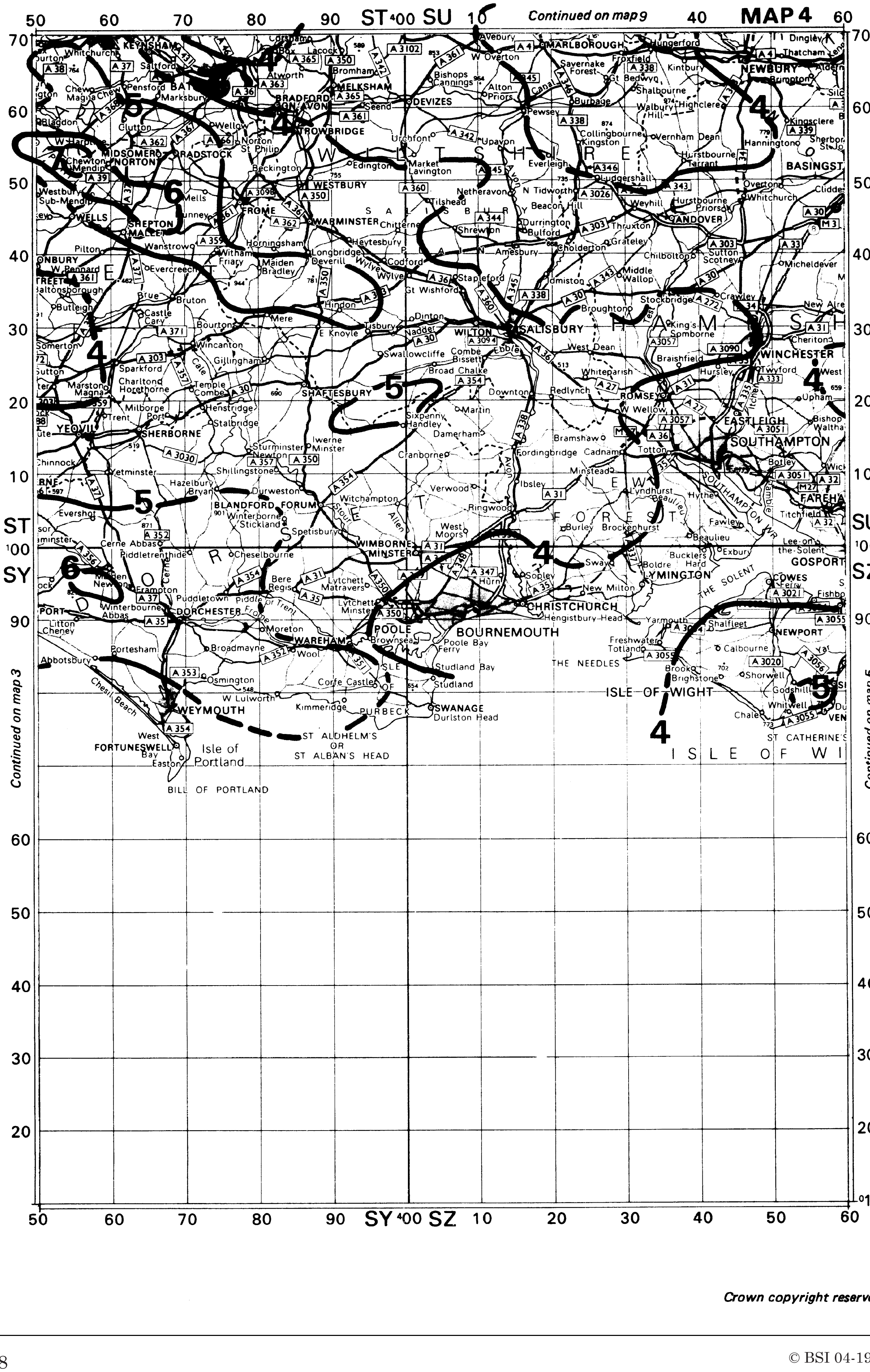
MAP 4
Continued on map 9
Continued on map 3
Continued on map 5
ST
SU
SY
SZ
KEYNSHAM
BATH
BRADFORD ON AVON
MELKSHAM
DEVIZES
MARLBOROUGH
Hungerford
NEWBURY
TROWBRIDGE
MIDSOMER NORTON
RADSTOCK
WESTBURY
FROME
WARMINSTER
WELLS
SHEPTON MALLET
BASINGSTOKE
ANDOVER
SALISBURY
WILTON
WINCHESTER
ROMSEY
EASTLEIGH
SOUTHAMPTON
SHAFTESBURY
SHERBORNE
YEOVIL
BLANDFORD FORUM
WIMBORNE MINSTER
DORCHESTER
POOLE
BOURNEMOUTH
CHRISTCHURCH
LYMINGTON
WAREHAM
SWANAGE
WEYMOUTH
Isle of Portland
BILL OF PORTLAND
ST ALDHELM'S OR ST ALBAN'S HEAD
THE NEEDLES
ISLE OF WIGHT
NEWPORT
COWES
GOSPORT
FAREHAM
THE SOLENT
NEW FOREST
WILTSHIRE
SALISBURY PLAIN
HAMPSHIRE
DORSET
SOMERSET
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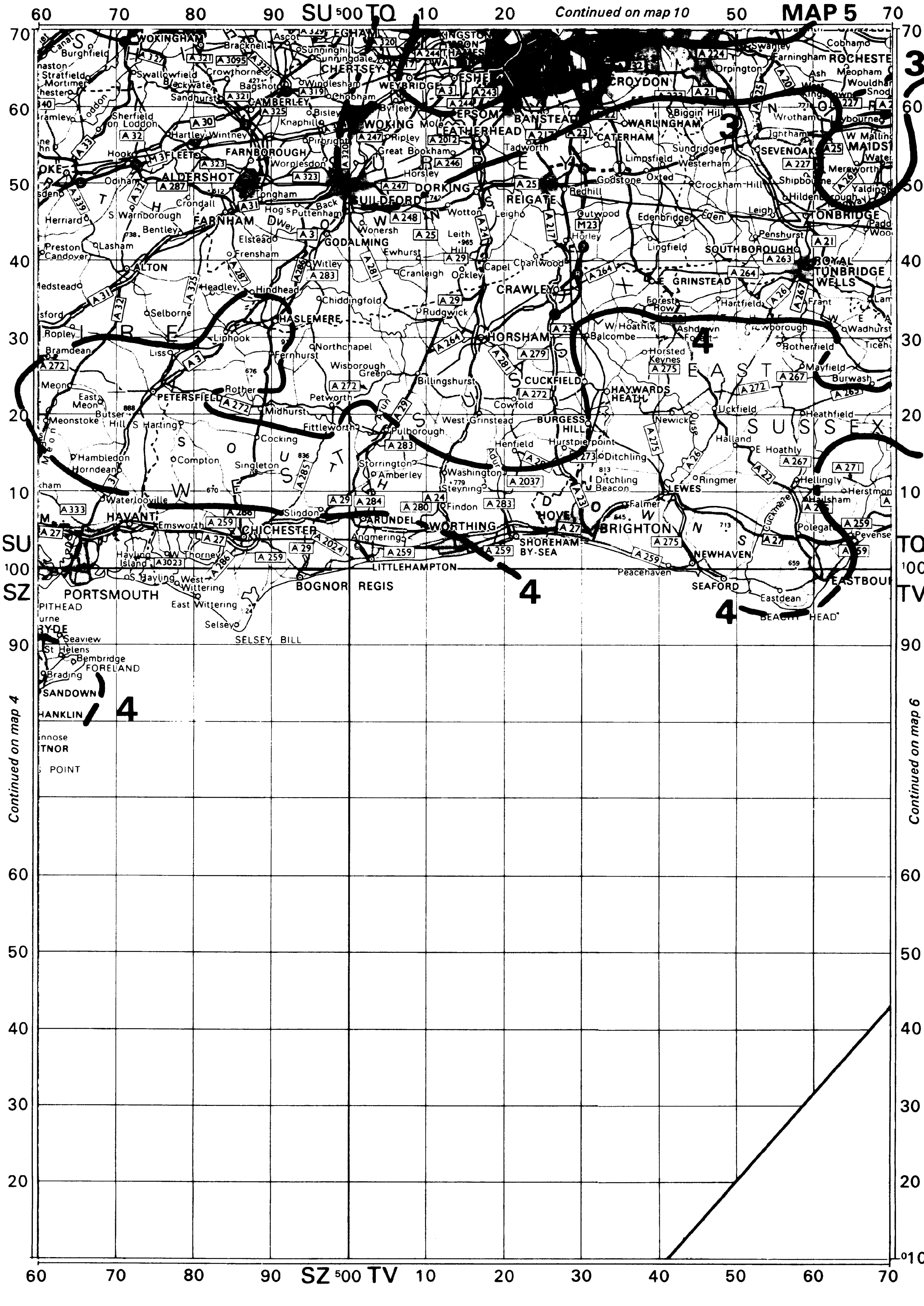


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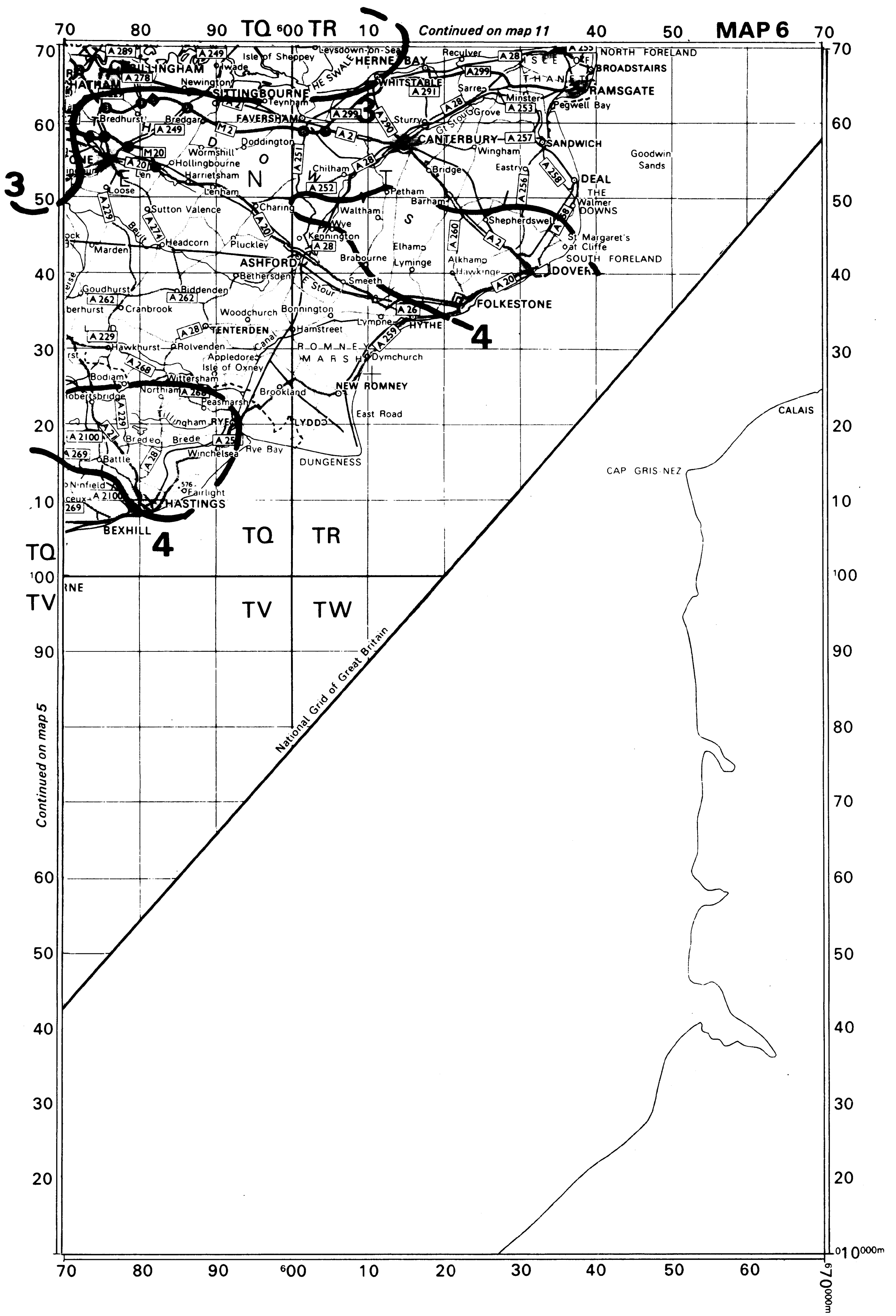


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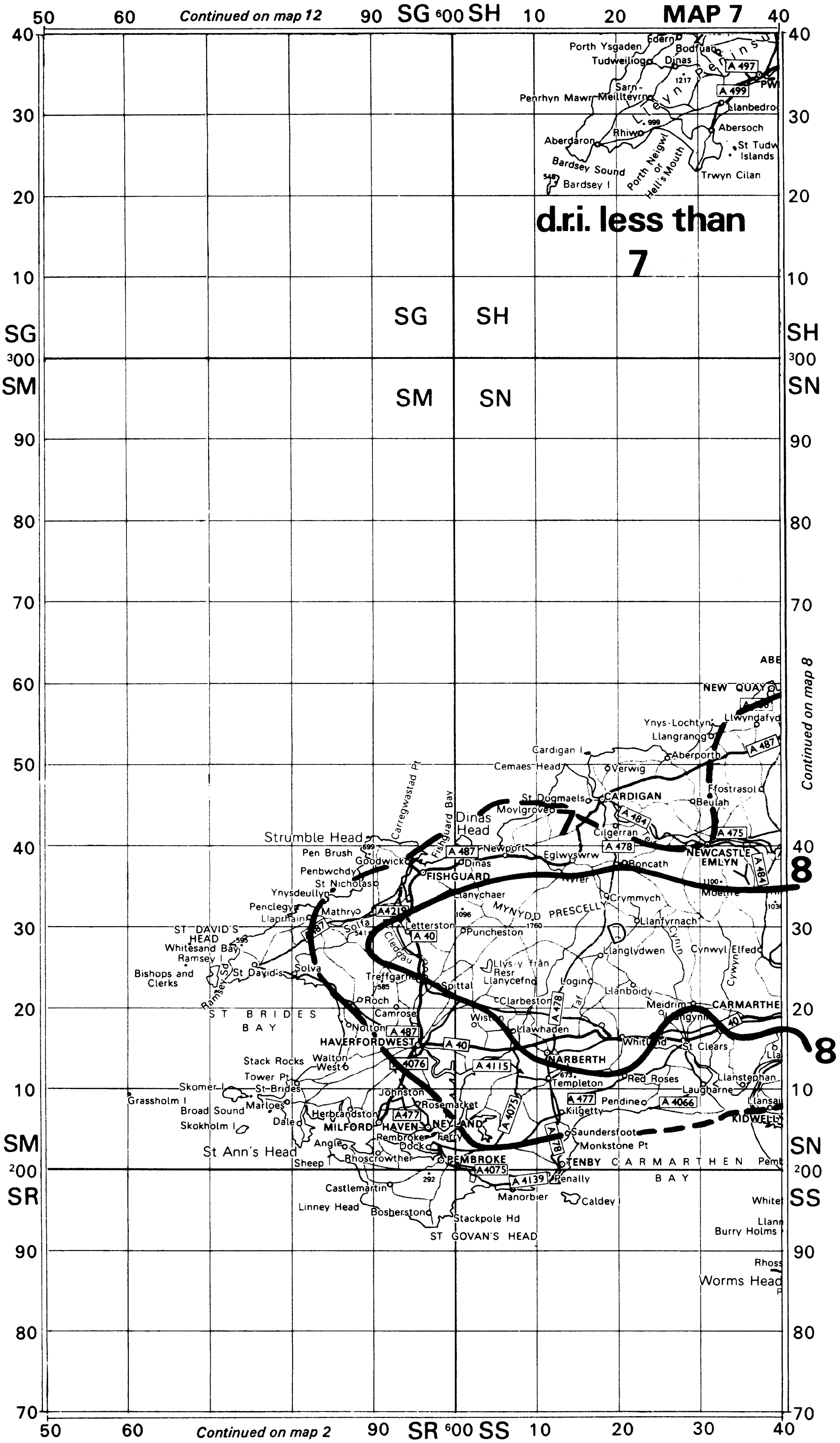


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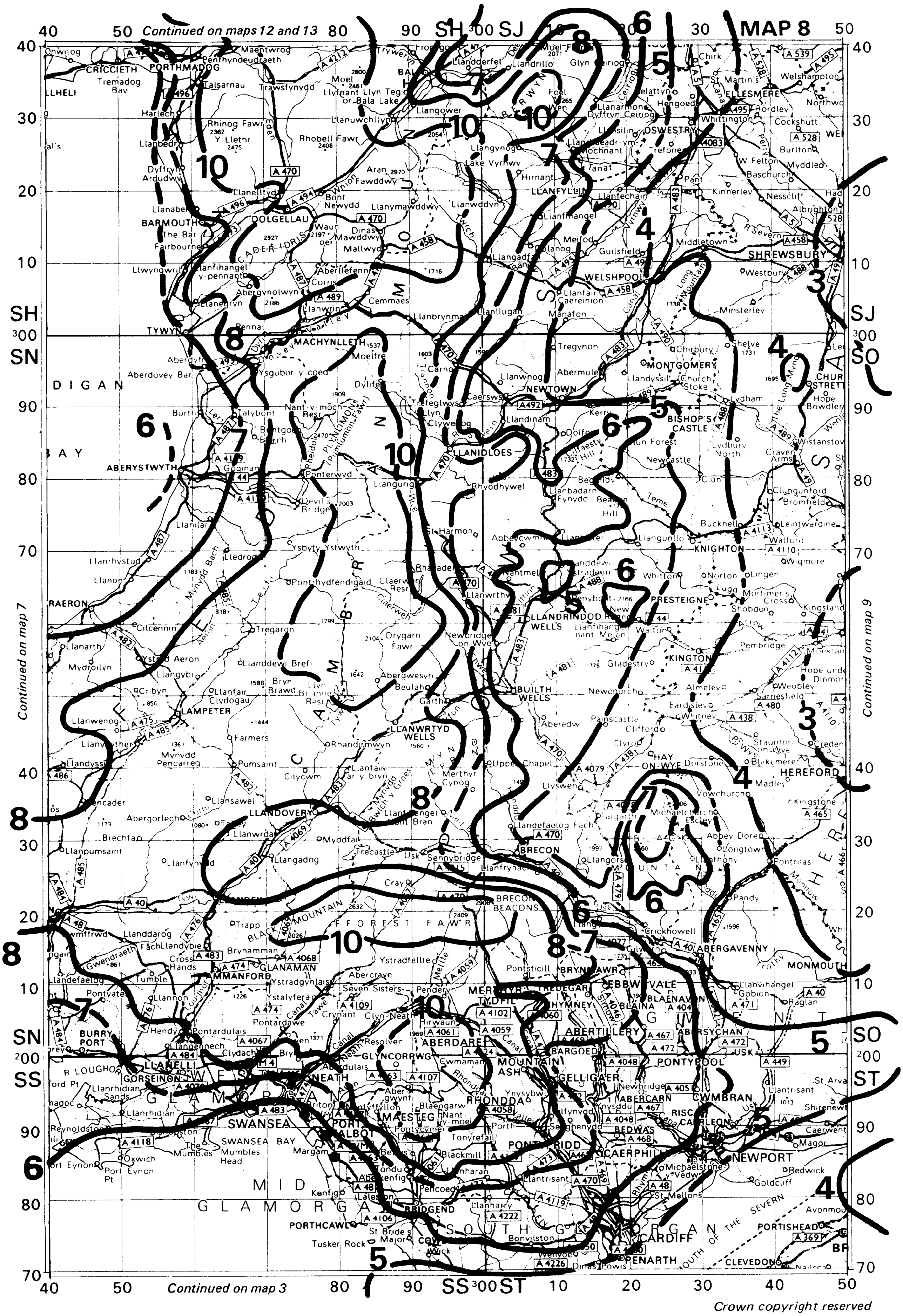
MAP 8
Continued on maps 12 and 13
Continued on map 7
Continued on map 9
Continued on map 3
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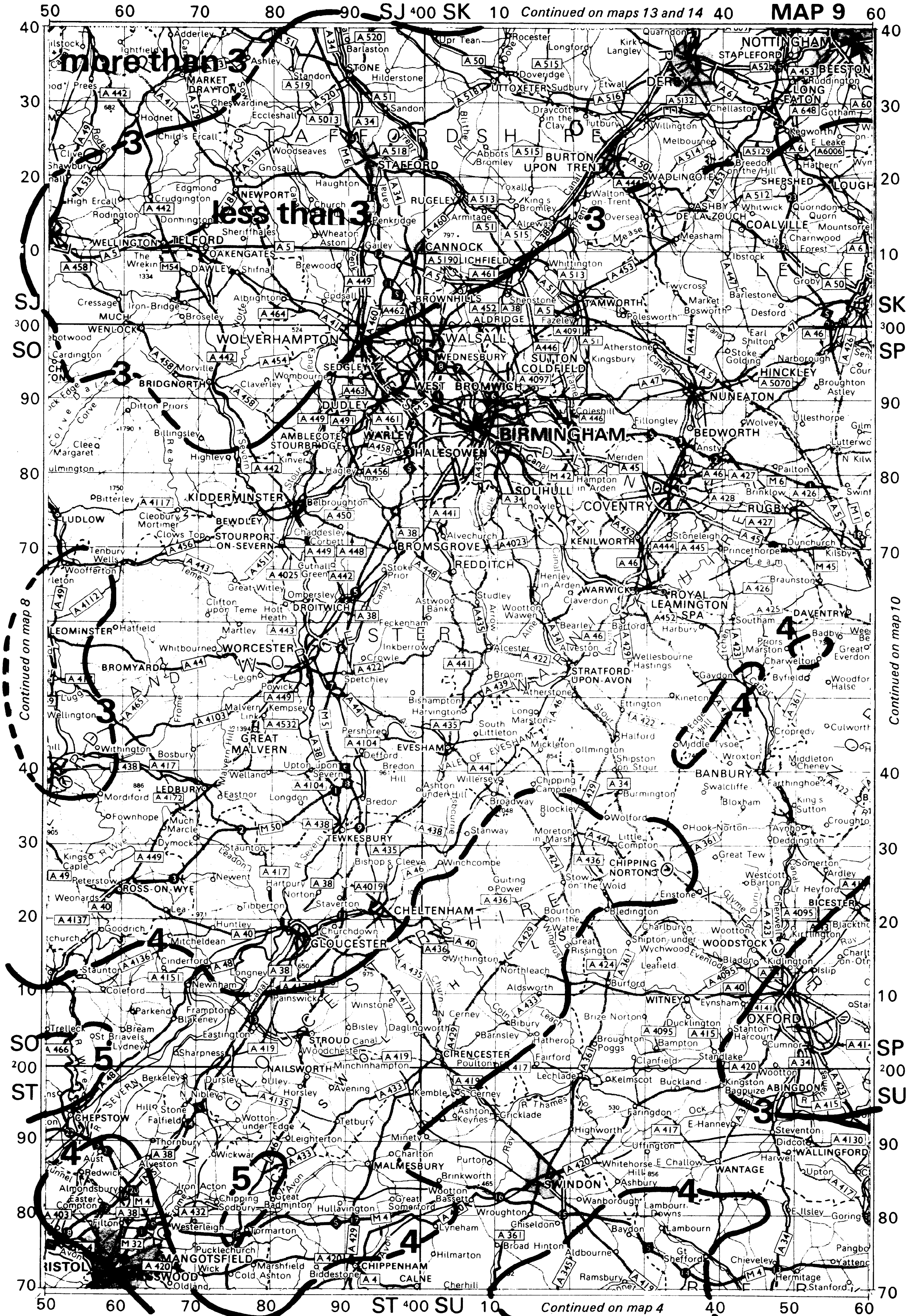


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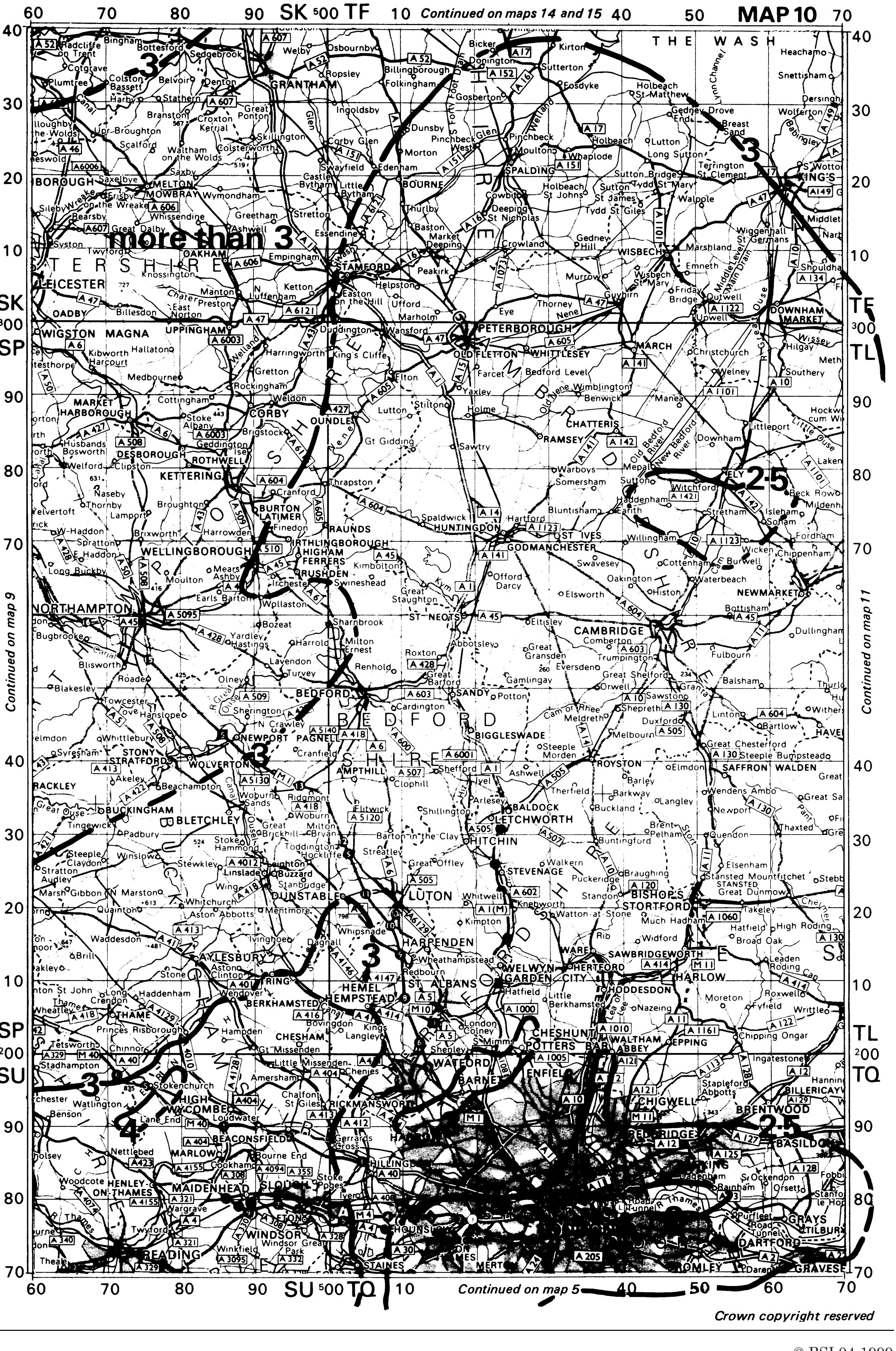


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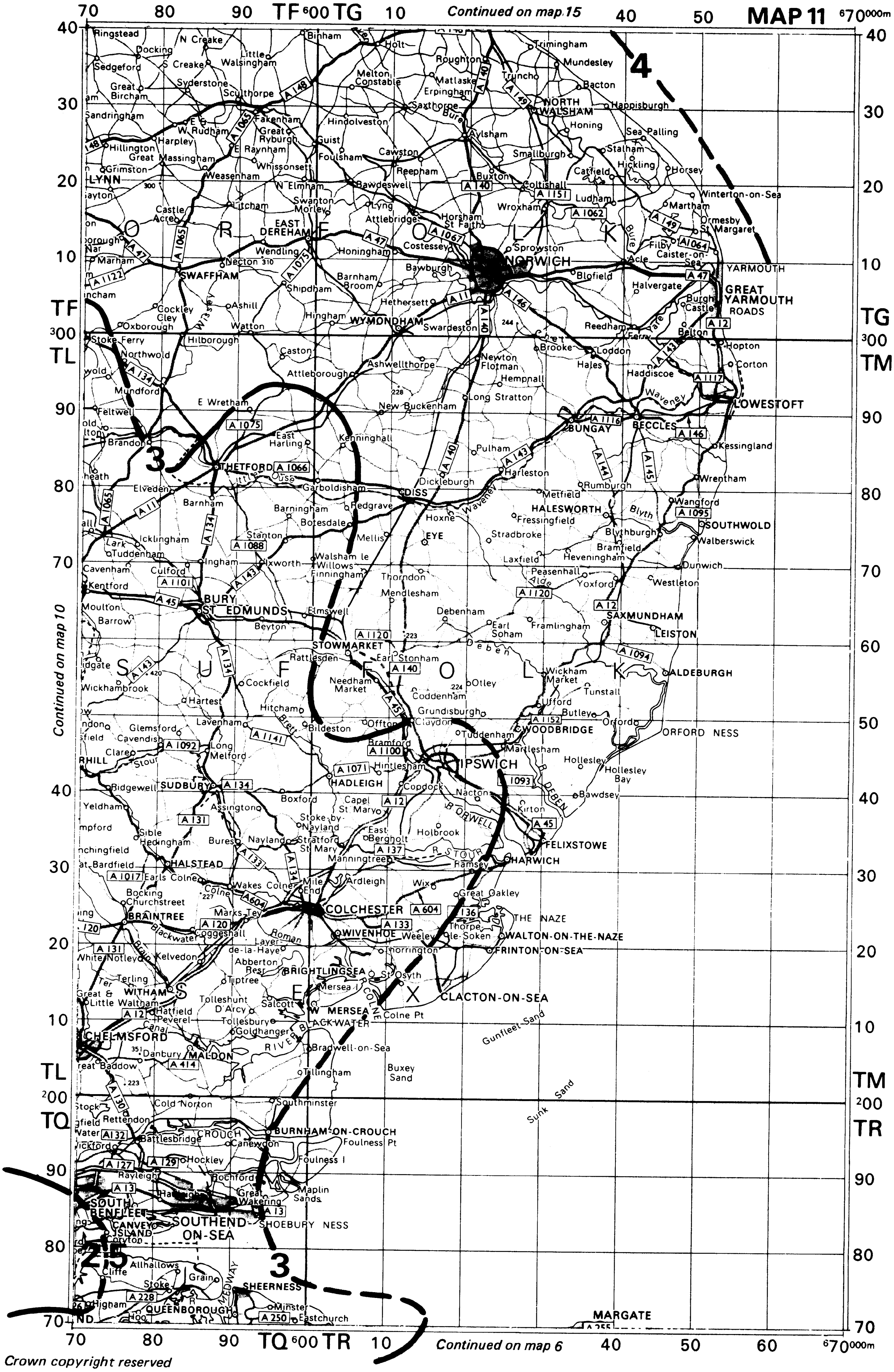


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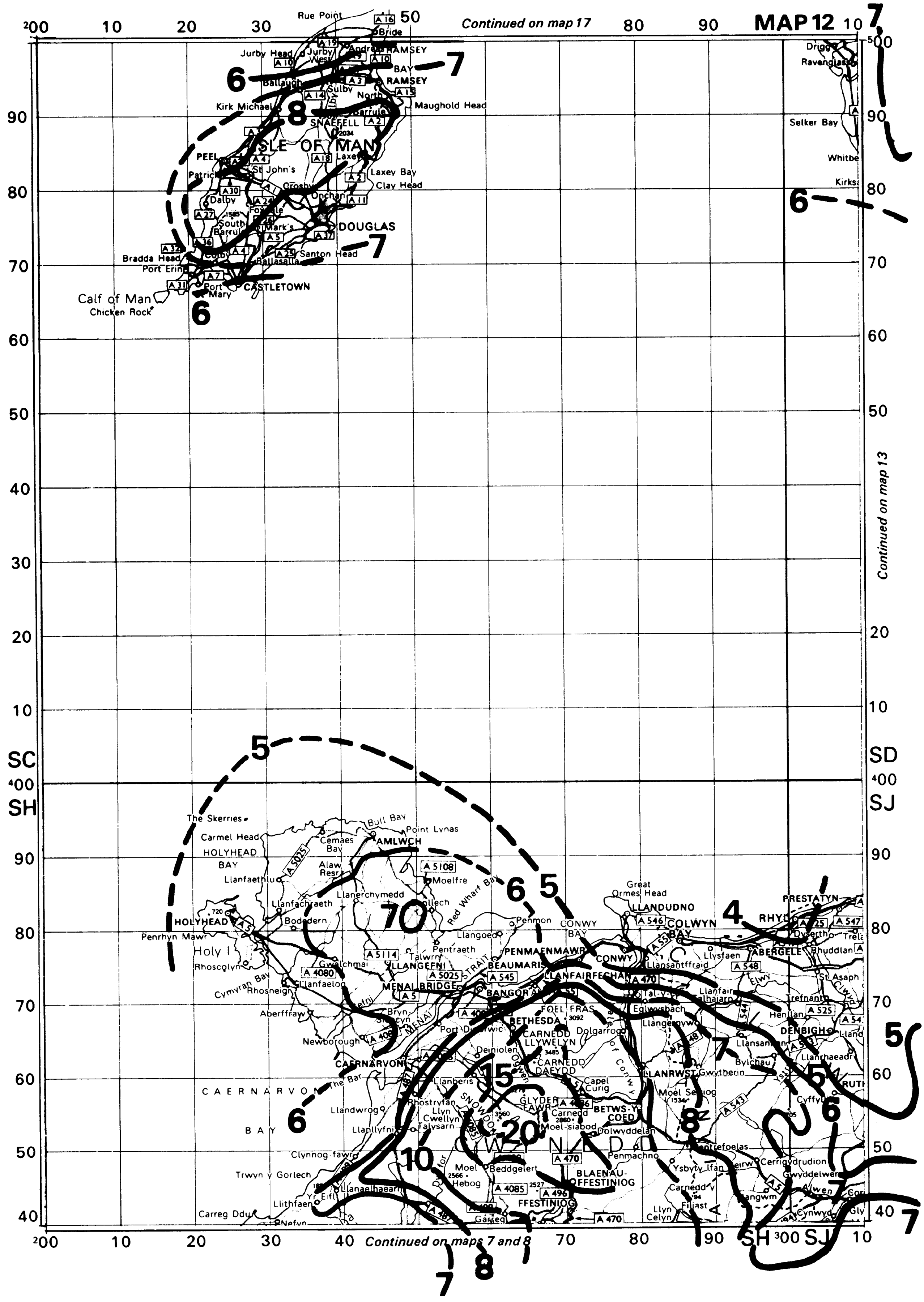
MAP 12
Continued on map 17
Continued on map 13
Continued on maps 7 and 8
ISLE OF MAN
RAMSEY
RAMSEY BAY
PEEL
DOUGLAS
CASTLETOWN
Port Erin
Bradda Head
Calf of Man
Chicken Rock
Kirk Michael
Jurby Head
Maughold Head
Laxey Bay
Clay Head
Santon Head
Rue Point
Bride
Andreas
Sulby
Ballaugh
SNAEFELL
St John's
Dalby
Crosby
Onchan
Ballasalla
Port St Mary
Drigg
Ravenglass
Selker Bay
Whitbe
Kirks
SC
SD
SH
SJ
The Skerries
Carmel Head
HOLYHEAD BAY
HOLYHEAD
Holy I
Penrhyn Mawr
Rhoscolyn
Cymyran Bay
Rhosneigr
Aberffraw
Newborough
Llanfaethlu
Llanfachraeth
Bodedern
Cemaes Bay
Bull Bay
Point Lynas
AMLWCH
Alaw Resr
Llanerchymedd
Moelfre
Red Wharf Bay
Penmon
Llangoed
Pentraeth
Talwrn
BEAUMARIS
LLANGEFNI
Gwalchmai
Llanfaelog
MENAI BRIDGE
BANGOR
CAERNARVON
CAERNARVON BAY
Llandwrog
Clynnog-fawr
Trwyn y Gorlech
Llithfaen
Nefyn
Carreg Ddu
Great Ormes Head
LLANDUDNO
COLWYN BAY
CONWY BAY
CONWY
PENMAENMAWR
LLANFAIRFECHAN
PRESTATYN
RHYL
ABERGELE
Rhuddlan
Dyserth
St Asaph
Trefnant
Henllan
DENBIGH
Llansannan
Bylchau
Llanrhaeadr
Cyffylliog
Cerrigydrudion
Gwyddelwern
Cynwyd
LLANRWST
Gwytherin
Eglwysbach
Llangernyw
Llysfaen
Llansantffraid
BETHESDA
FOEL FRAS
CARNEDD LLYWELYN
CARNEDD DAFYDD
Dolgarrog
Capel Curig
GLYDER FAWR
Carnedd Moel-siabod
BETWS-Y-COED
Dolwyddelan
Penmachno
BLAENAU-FFESTINIOG
FFESTINIOG
Llanberis
Deiniolen
Rhostryfan
Llyn Cwellyn
Talysarn
Llanllyfni
SNOWDON
Moel Hebog
Beddgelert
Garreg
Pentrefoelas
Ysbyty Ifan
Carnedd y Filiast
Llyn Celyn
Moel Seisiog
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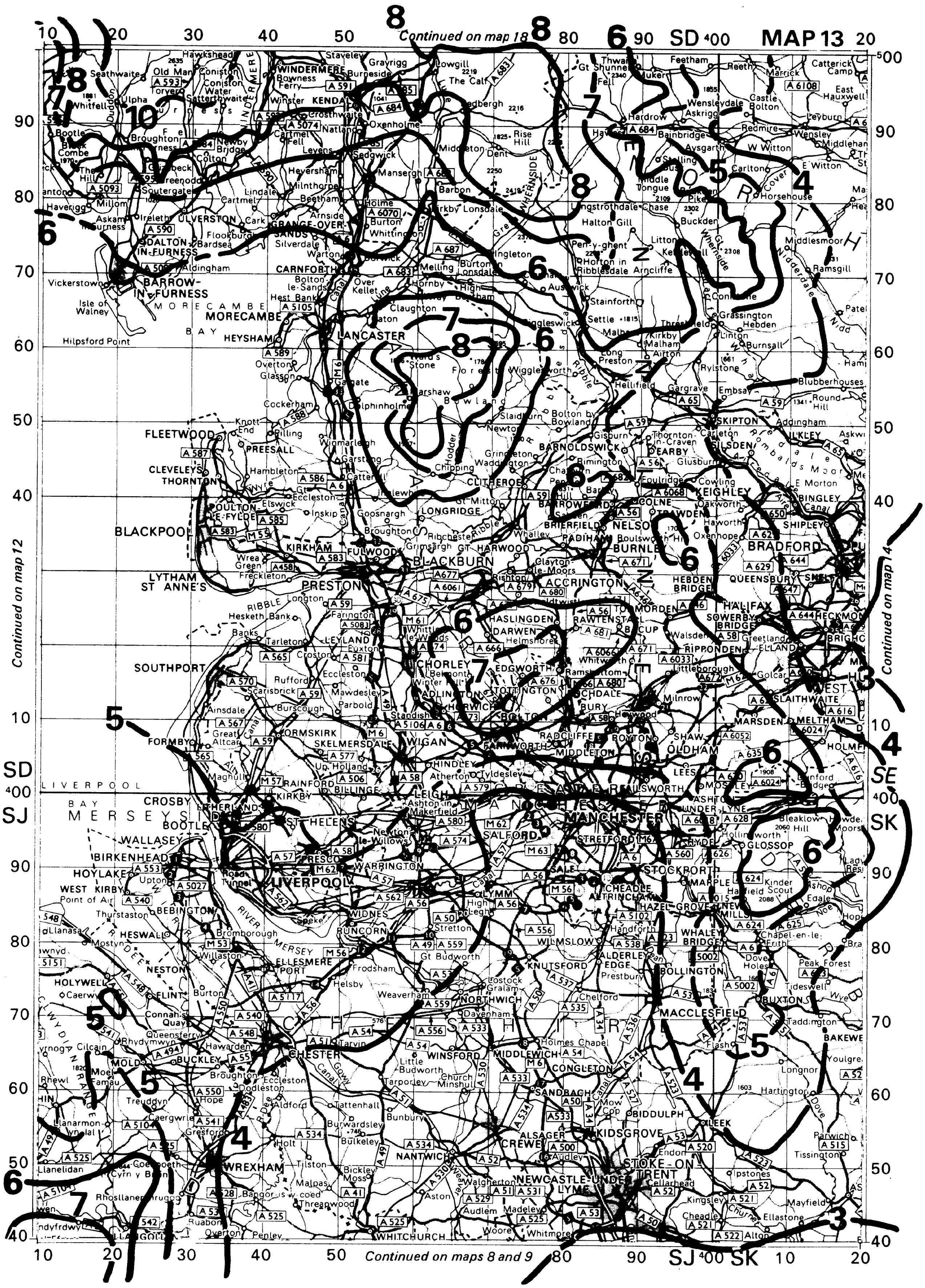
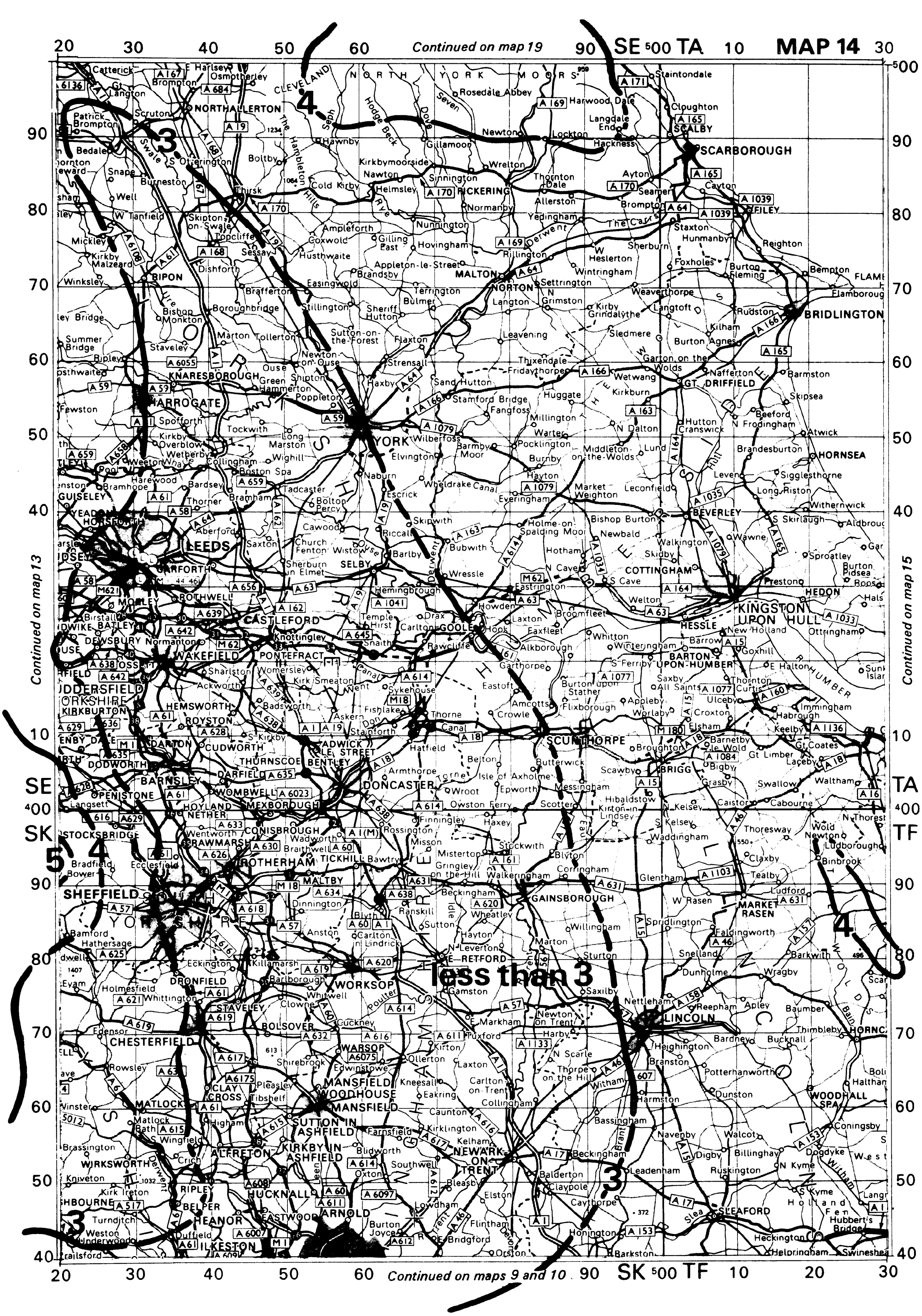

MAP 13
Continued on map 18
Continued on map 12
Continued on map 14
Continued on maps 8 and 9
SD
SJ
SE
SK
LANCASTER
MORECAMBE
BLACKPOOL
PRESTON
BLACKBURN
BURNLEY
BRADFORD
HALIFAX
SOUTHPORT
WIGAN
BOLTON
OLDHAM
LIVERPOOL
MANCHESTER
STOCKPORT
WARRINGTON
CHESTER
WREXHAM
MACCLESFIELD
STOKE-ON-TRENT
CREWE
KENDAL
SKIPTON
KEIGHLEY
BARROW-IN-FURNESS
FLEETWOOD
BIRKENHEAD
BUXTON
GLOSSOP
LEEK
WHITCHURCH

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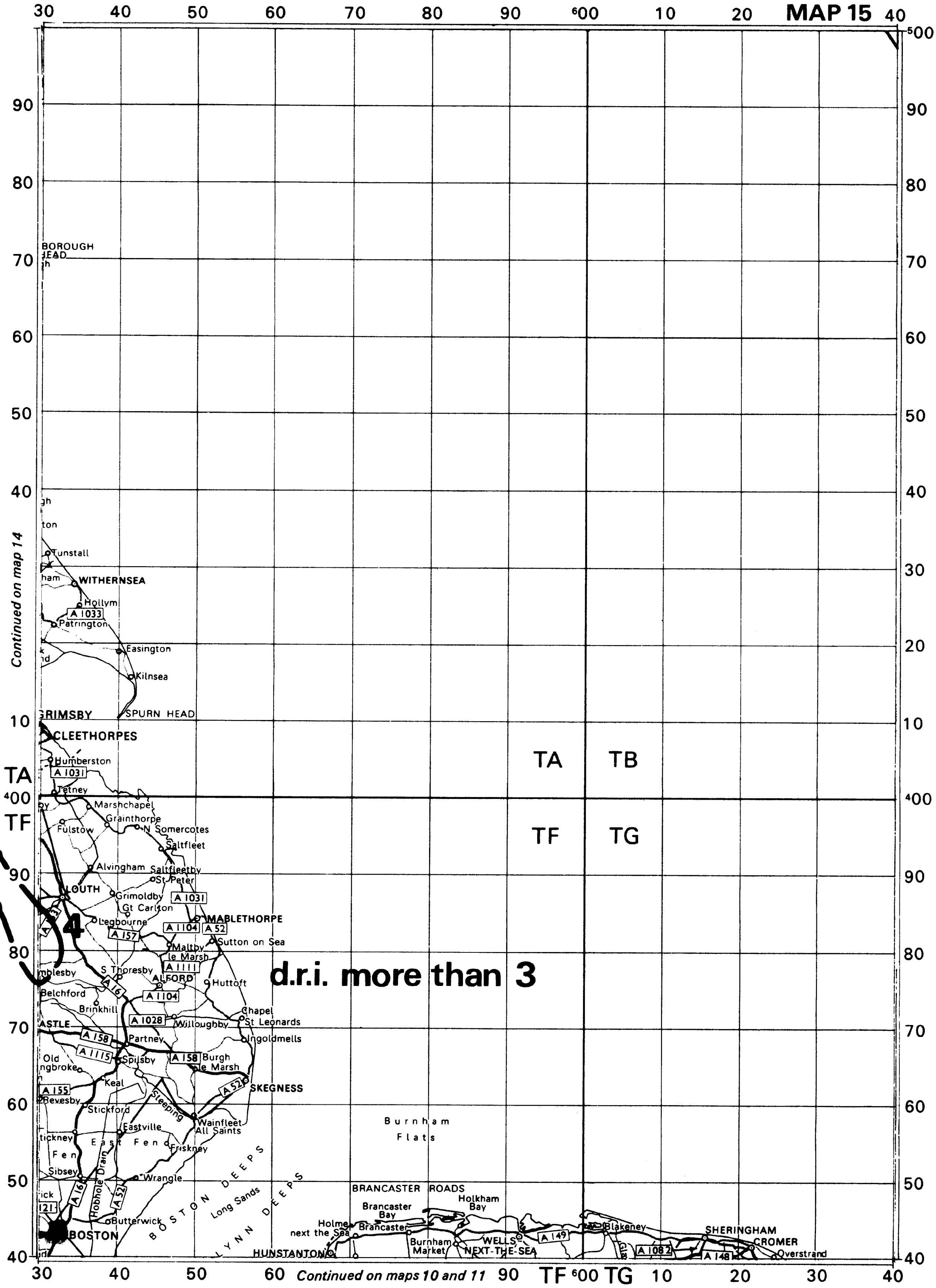
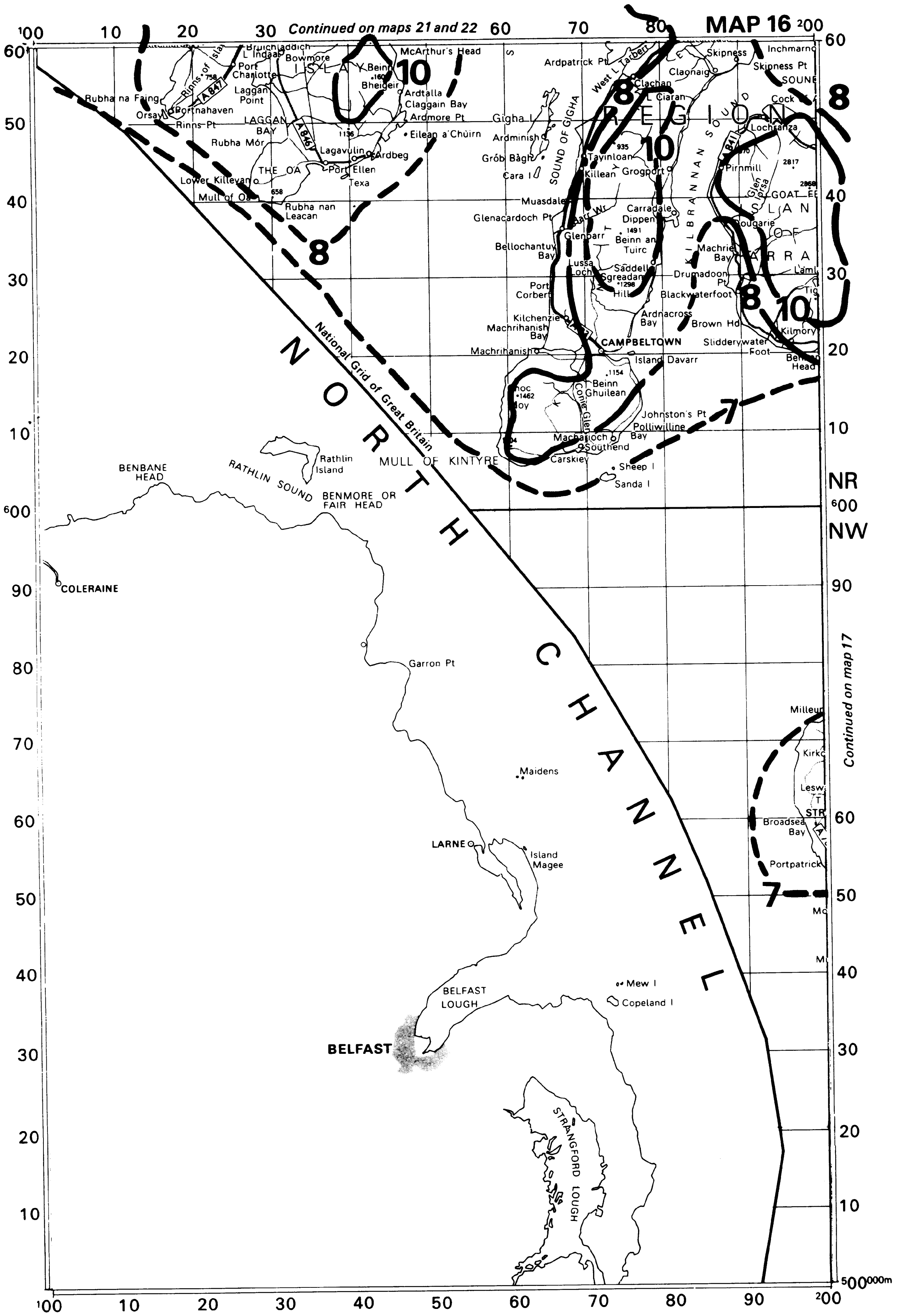

MAP 15
Continued on map 14
Continued on maps 10 and 11
TA
TB
TF
TG
d.r.i. more than 3
BOROUGH HEAD
Tunstall
WITHERNSEA
Hollym
A 1033
Patrington
Easington
Kilnsea
SPURN HEAD
GRIMSBY
CLEETHORPES
Humberston
A 1031
Tetney
Marshchapel
Grainthorpe
Fulstow
N Somercotes
Saltfleet
Alvingham
Saltfleetby St Peter
LOUTH
Grimoldby
Gt Carlton
A 1031
Legbourne
MABLETHORPE
A 1104
A 52
A 157
Sutton on Sea
Maltby le Marsh
A 1111
S Thoresby
ALFORD
Huttoft
Belchford
Brinkhill
A 1104
Chapel St Leonards
A 1028
Willoughby
A 158
Partney
Ingoldmells
A 1115
Spilsby
A 158
Burgh le Marsh
A 155
Keal
SKEGNESS
A 52
Revesby
Stickford
Wainfleet All Saints
Eastville
East Fen
Friskney
Sibsey
Wrangle
Hobhole Drain
A 16
A 52
Butterwick
BOSTON
BOSTON DEEPS
Long Sands
LYNN DEEPS
Burnham Flats
BRANCASTER ROADS
Holkham Bay
Brancaster Bay
Holme next the Sea
Brancaster
HUNSTANTON
Burnham Market
WELLS NEXT-THE-SEA
A 149
Blakeney
A 1082
SHERINGHAM
A 148
CROMER
Overstrand

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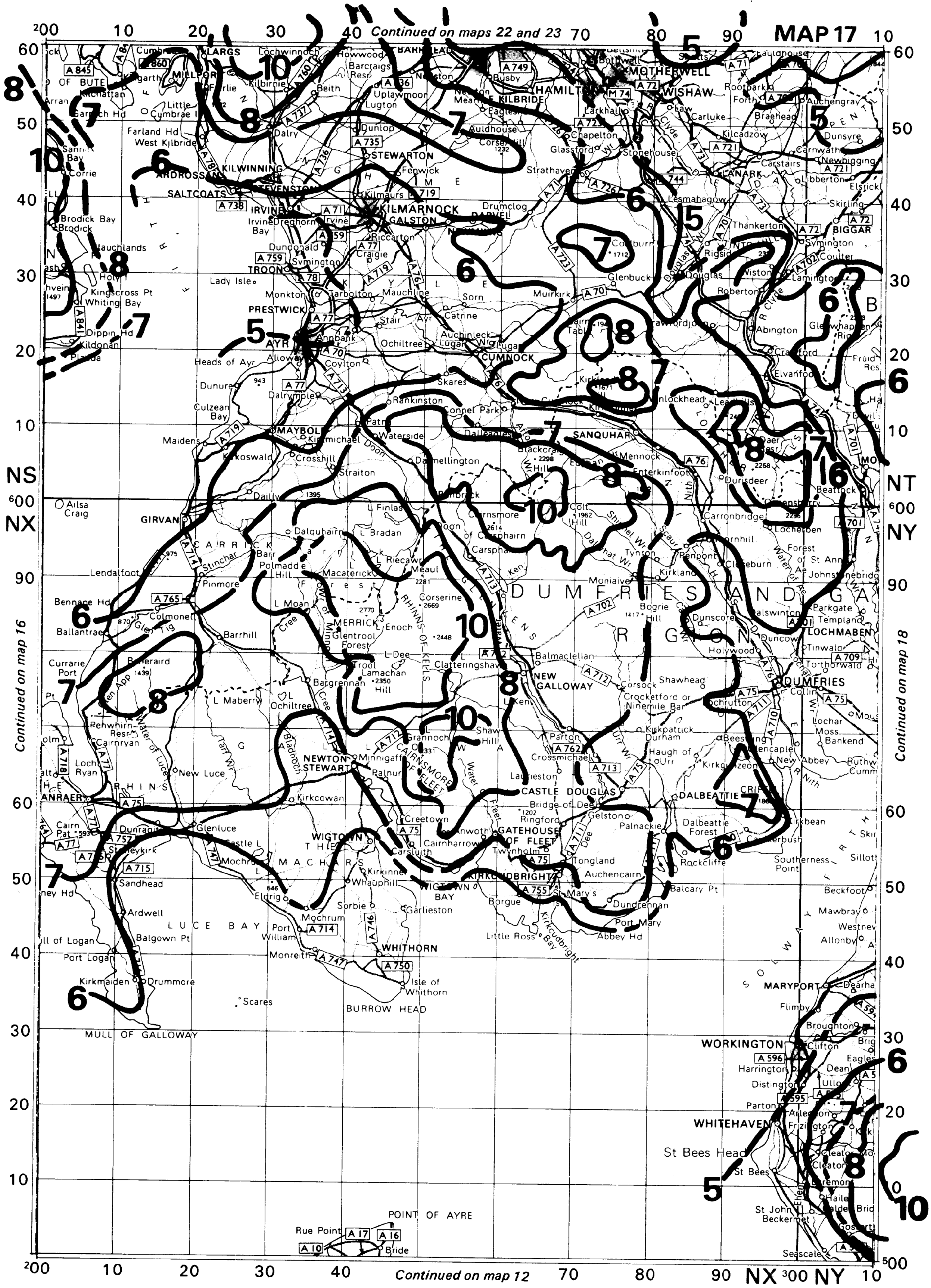
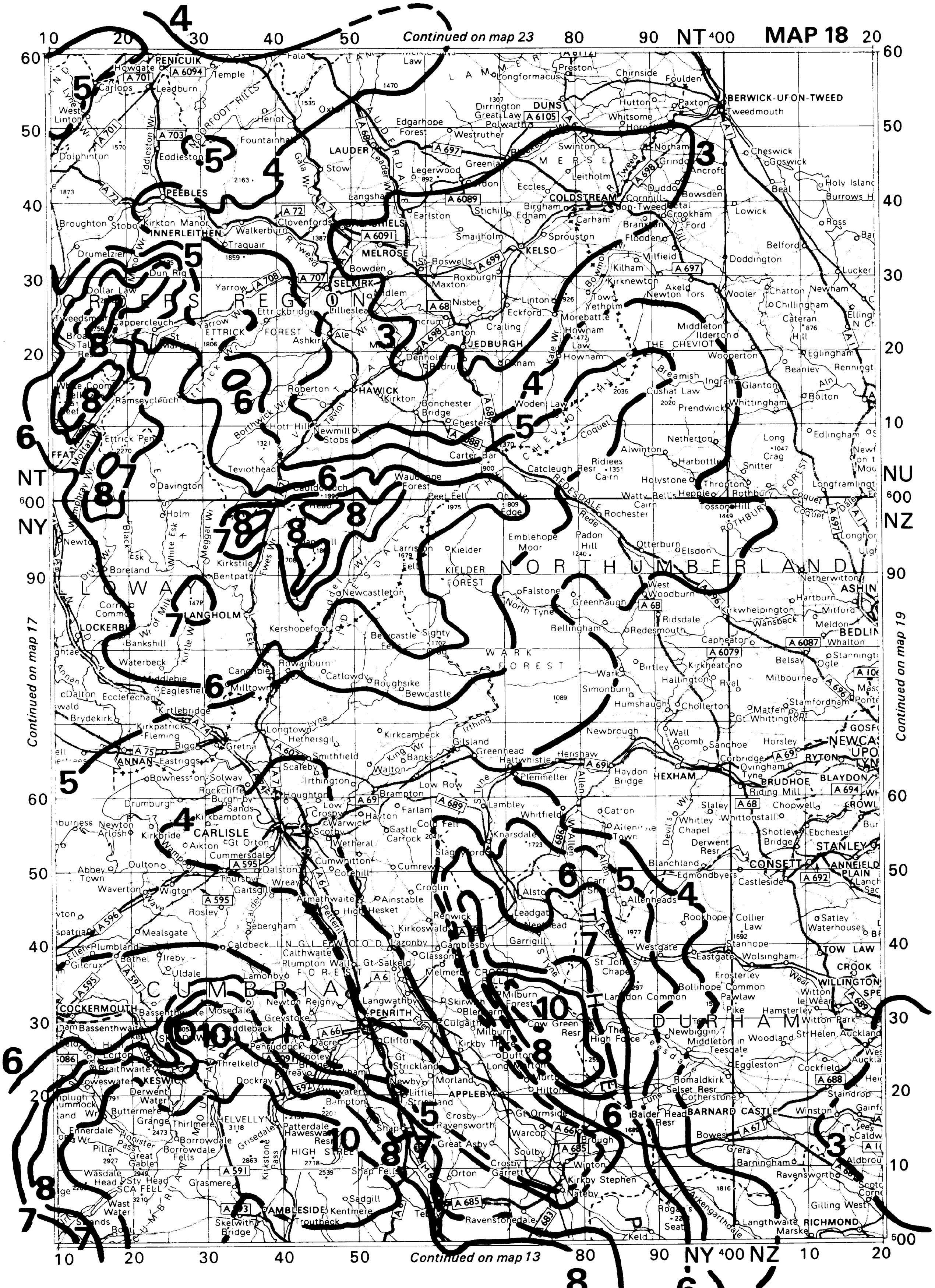

MAP 17
Continued on maps 22 and 23
Continued on map 16
Continued on map 18
Continued on map 12
NS
NX
NT
NY
DUMFRIES AND GALLOWAY REGION
KILMARNOCK
IRVINE
AYR
PRESTWICK
TROON
GIRVAN
NEWTON STEWART
WIGTOWN
WHITHORN
KIRKCUDBRIGHT
CASTLE DOUGLAS
DUMFRIES
LOCHMABEN
SANQUHAR
CUMNOCK
NEW GALLOWAY
GATEHOUSE OF FLEET
DALBEATTIE
WORKINGTON
WHITEHAVEN
MARYPORT
MOTHERWELL
HAMILTON
WISHAW
LANARK
BIGGAR
STEWARTON
KILWINNING
ARDROSSAN
SALTCOATS
LARGS
MILLPORT
MAYBOLE
LUCE BAY
MULL OF GALLOWAY
BURROW HEAD
POINT OF AYRE
St Bees Head

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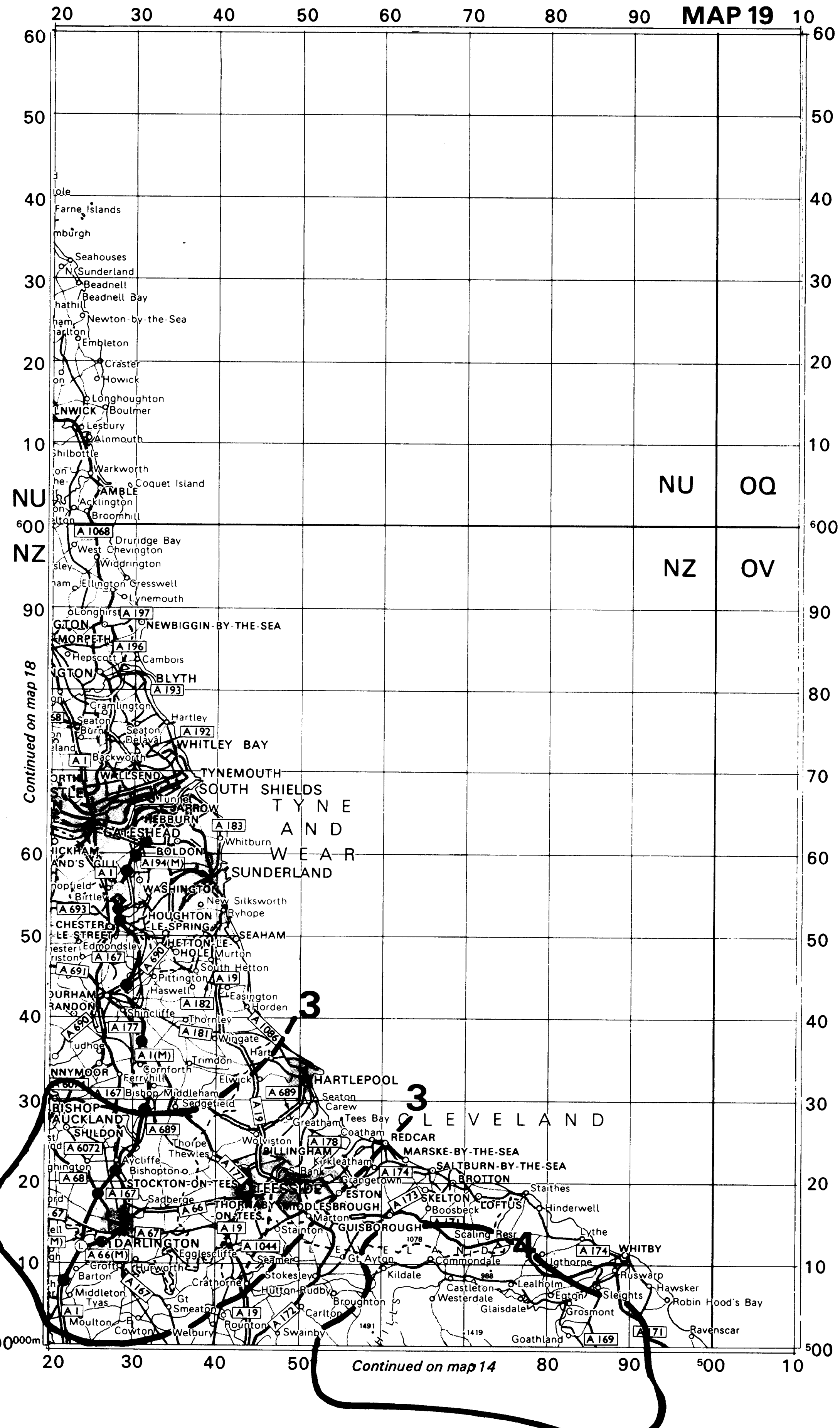


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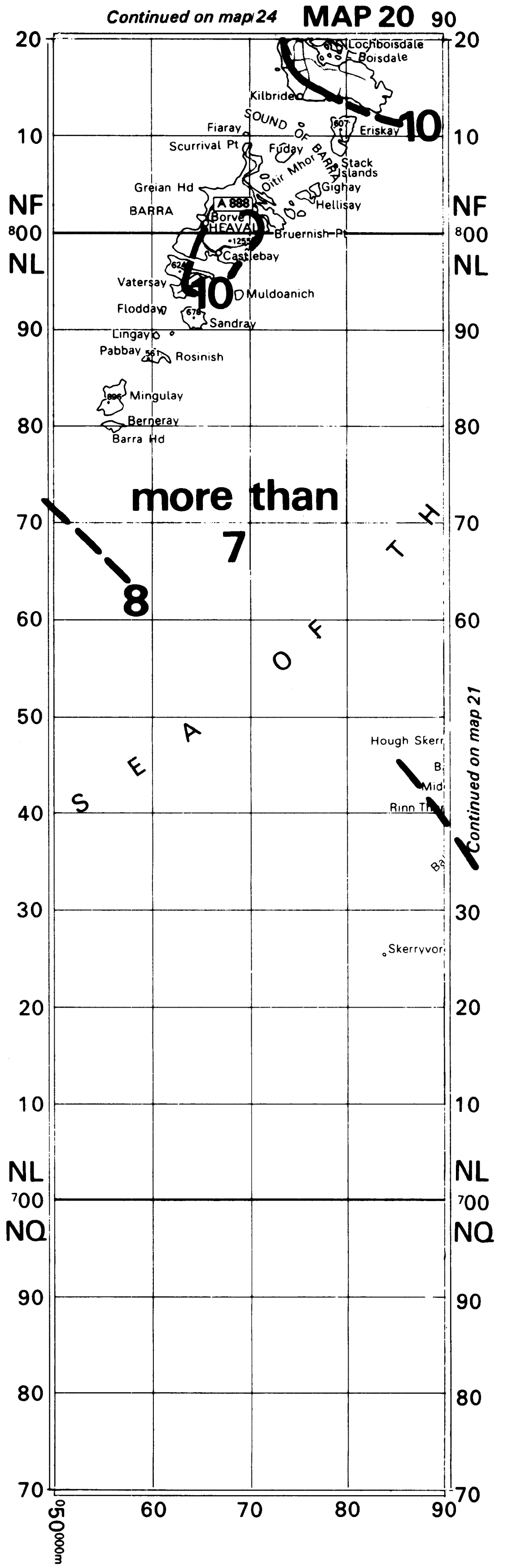
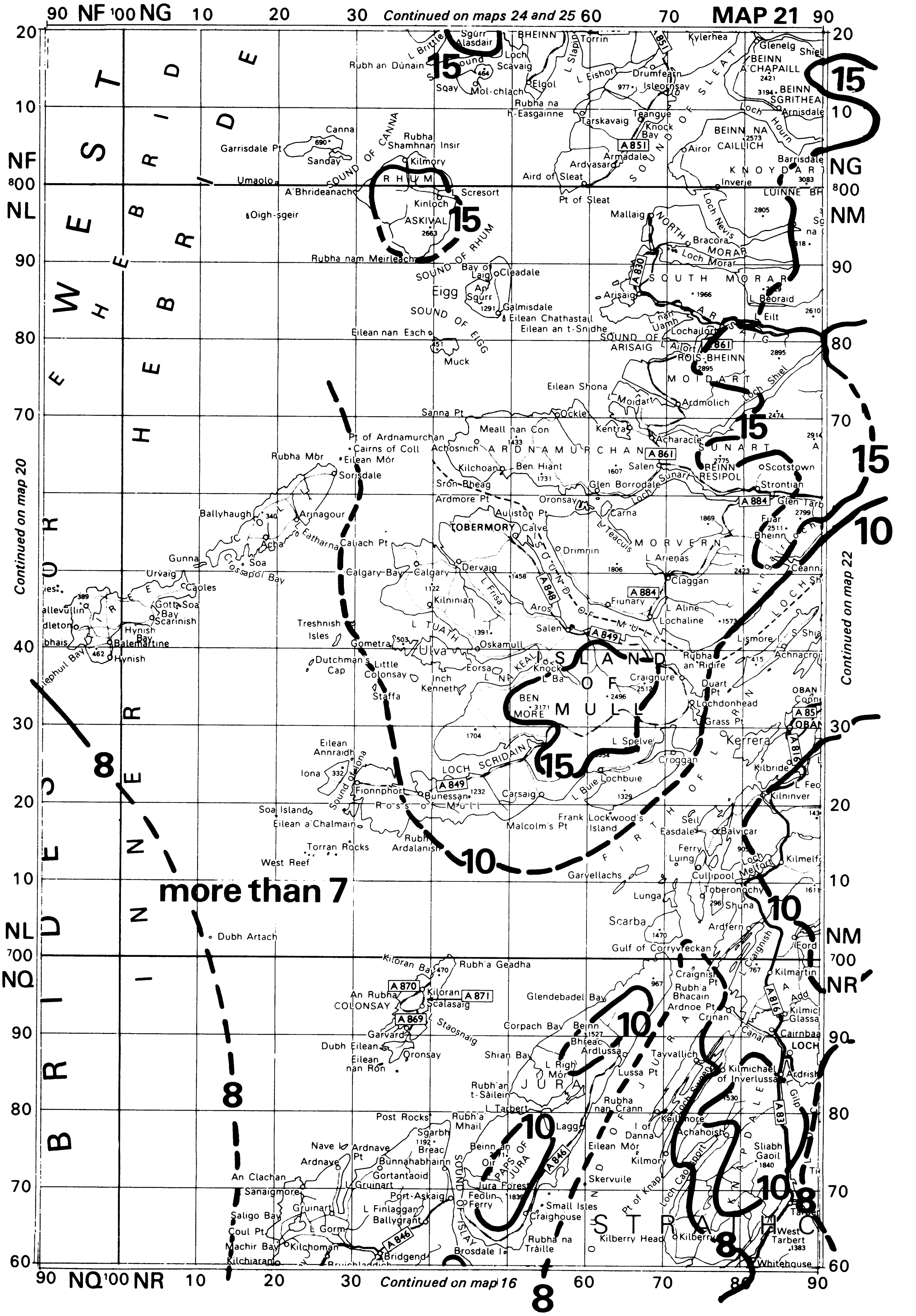

Continued on map 24
MAP 20
Lochboisdale
Boisdale
Kilbride
SOUND OF BARRA
Eriskay
Fiaray
Scurrival Pt
Fuday
Stack Islands
Oitir Mhor
Gighay
Greian Hd
Hellisay
BARRA
A 888
Borve
HEAVAL
Bruernish Pt
Castlebay
Vatersay
Muldoanich
Flodday
Sandray
Lingay
Pabbay
Rosinish
Mingulay
Berneray
Barra Hd
10
10
more than 7
8
SEA OF THE
Hough Skerr
Skerryvor
Continued on map 21
NF 800 NL
NL 700 NQ
50000m
60
70
80
90

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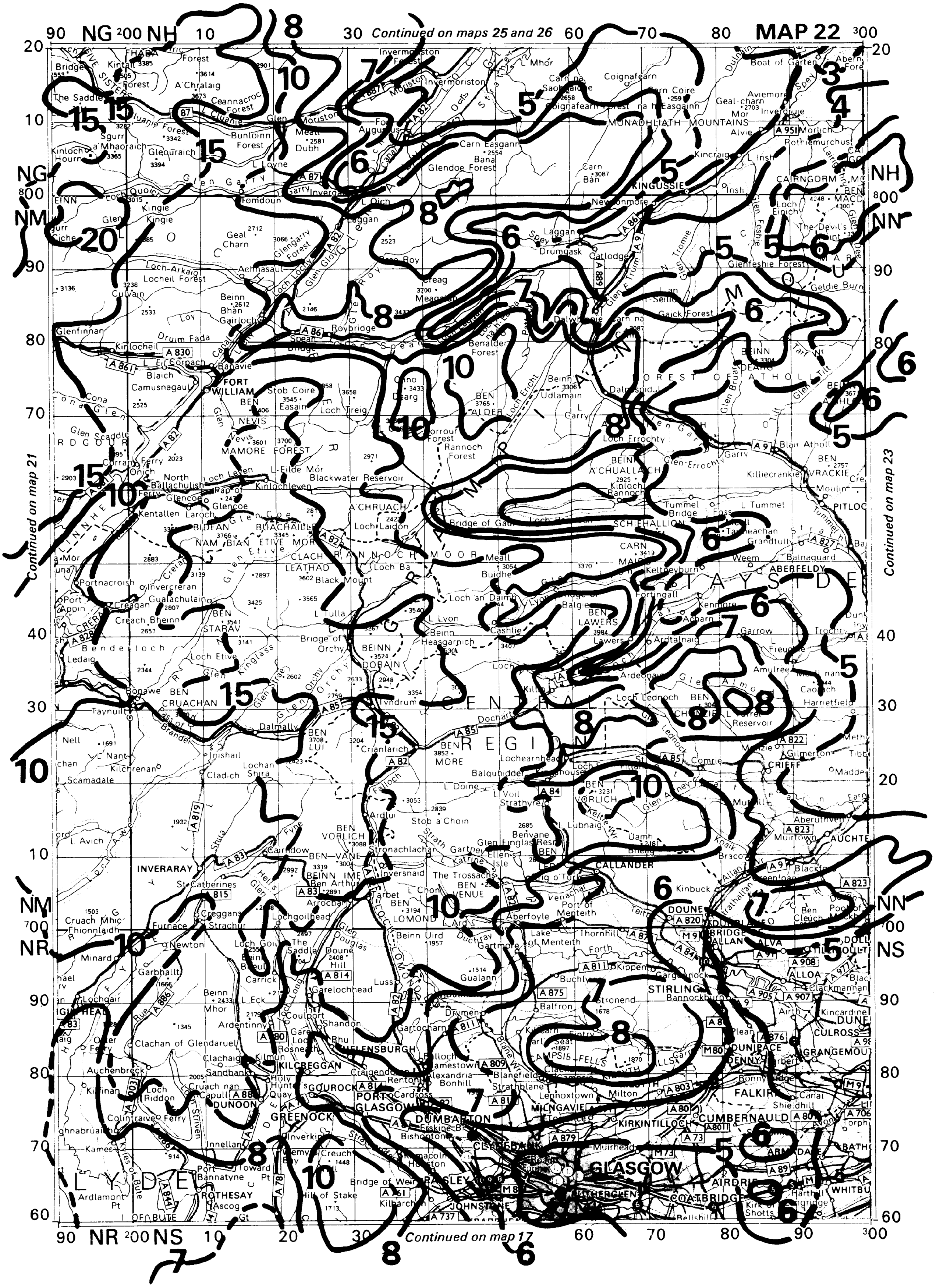


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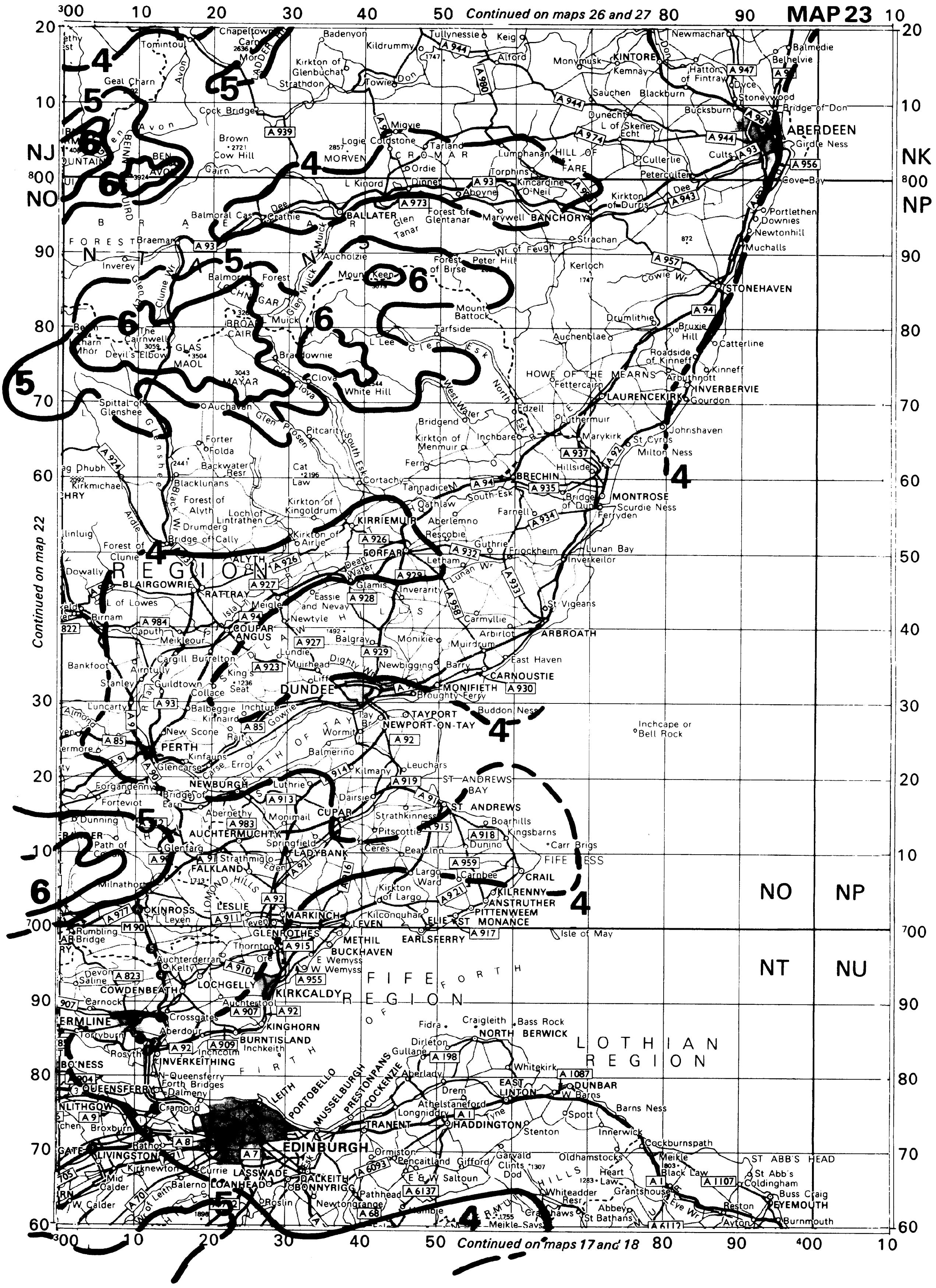


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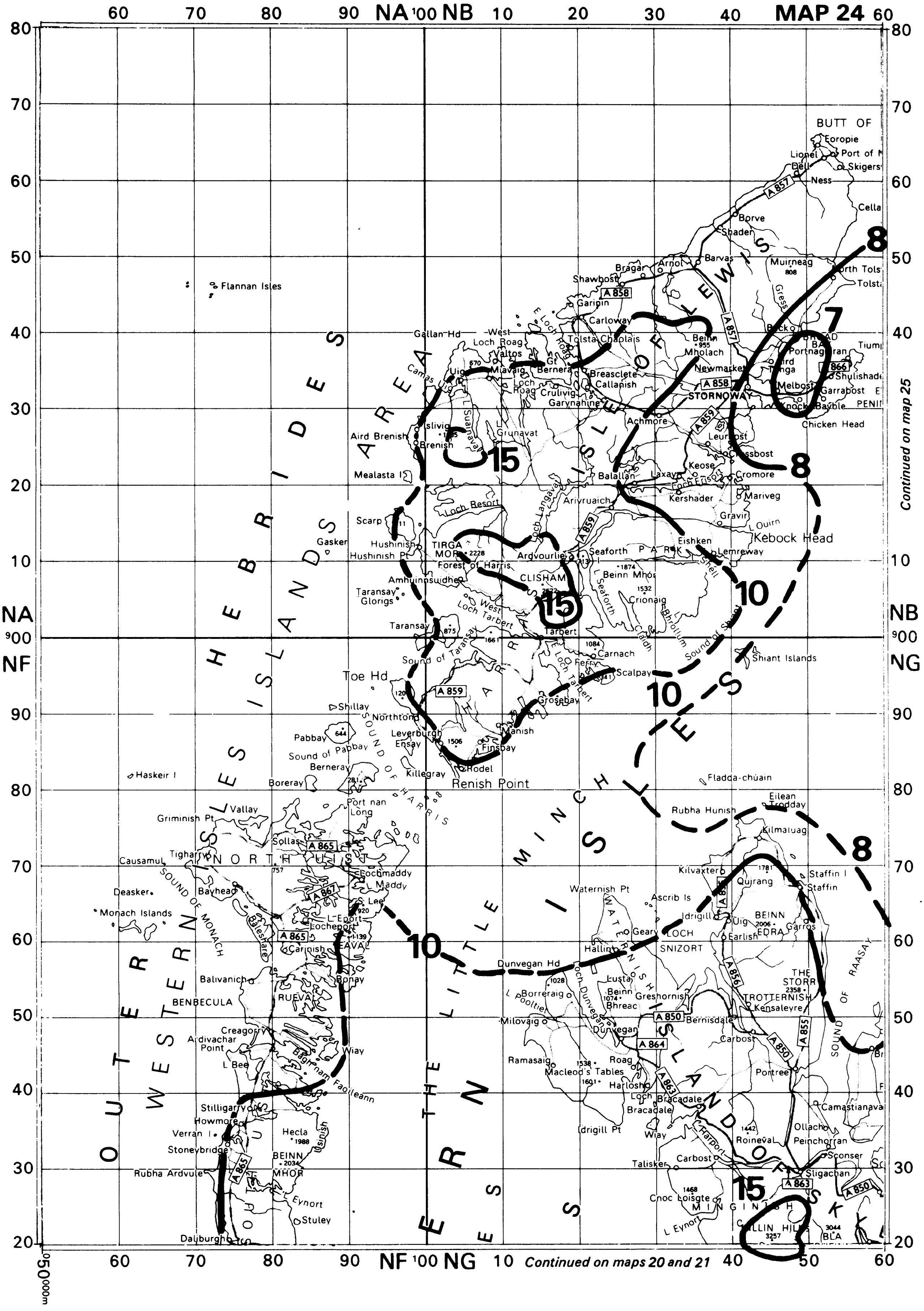


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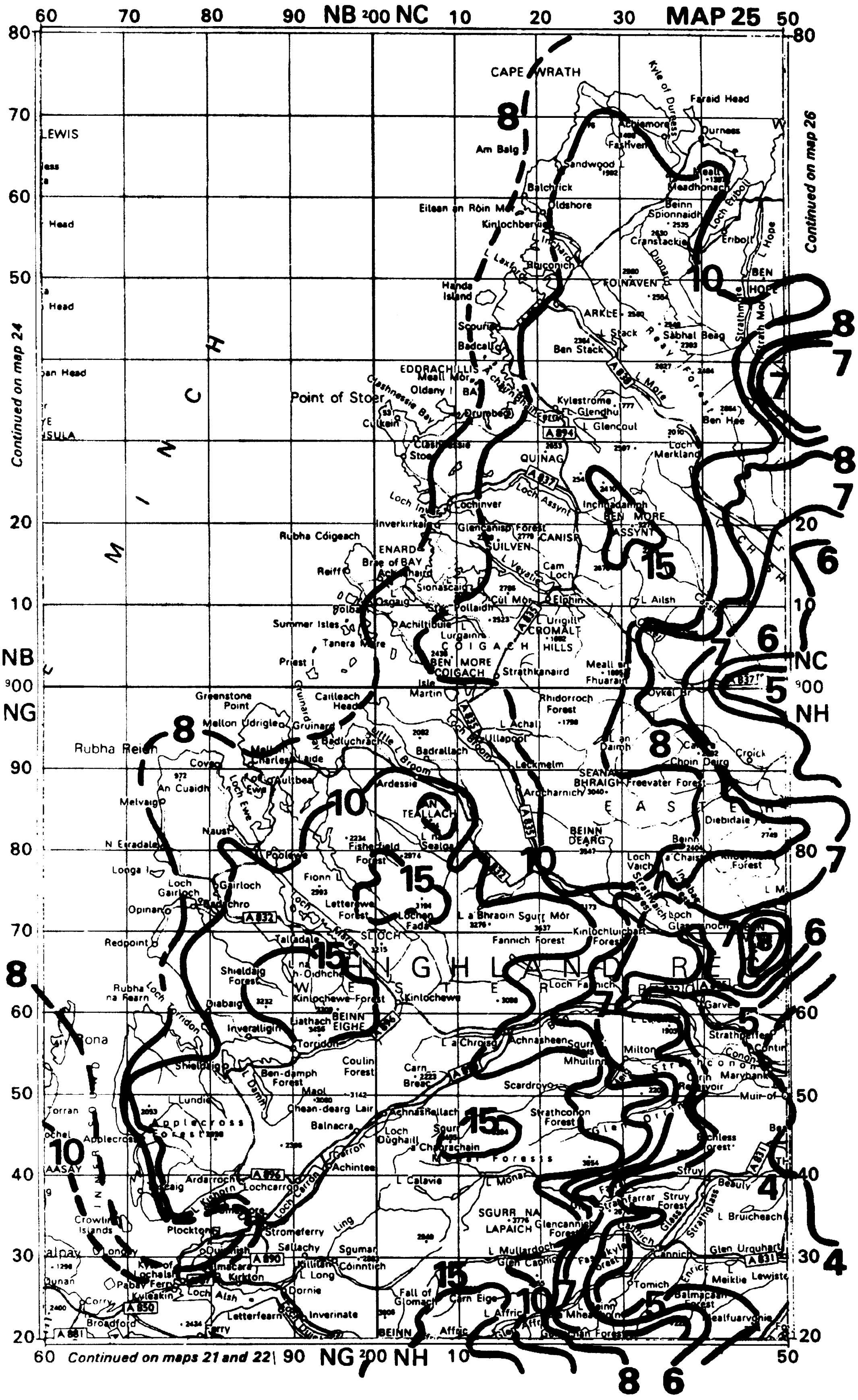


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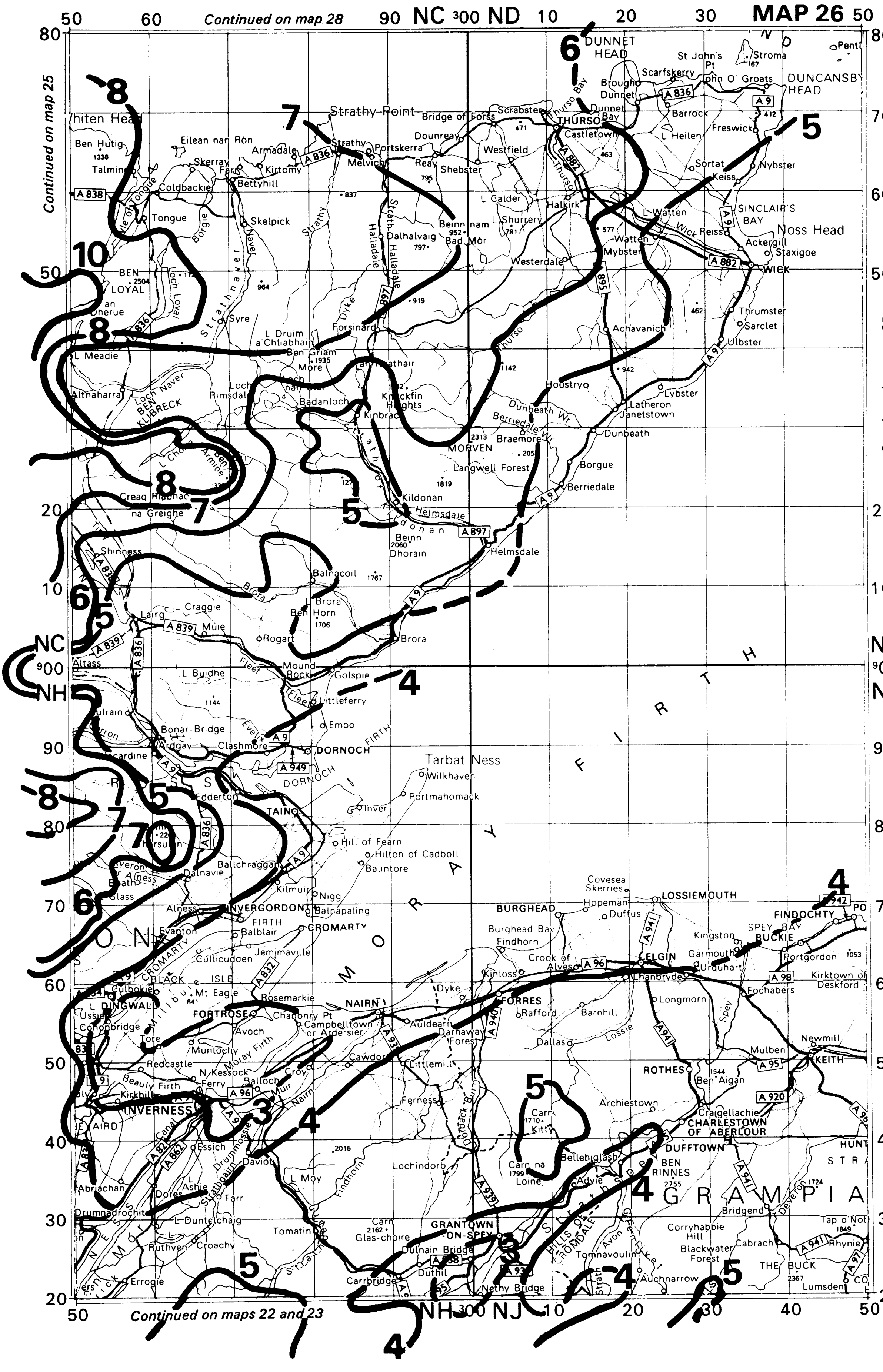


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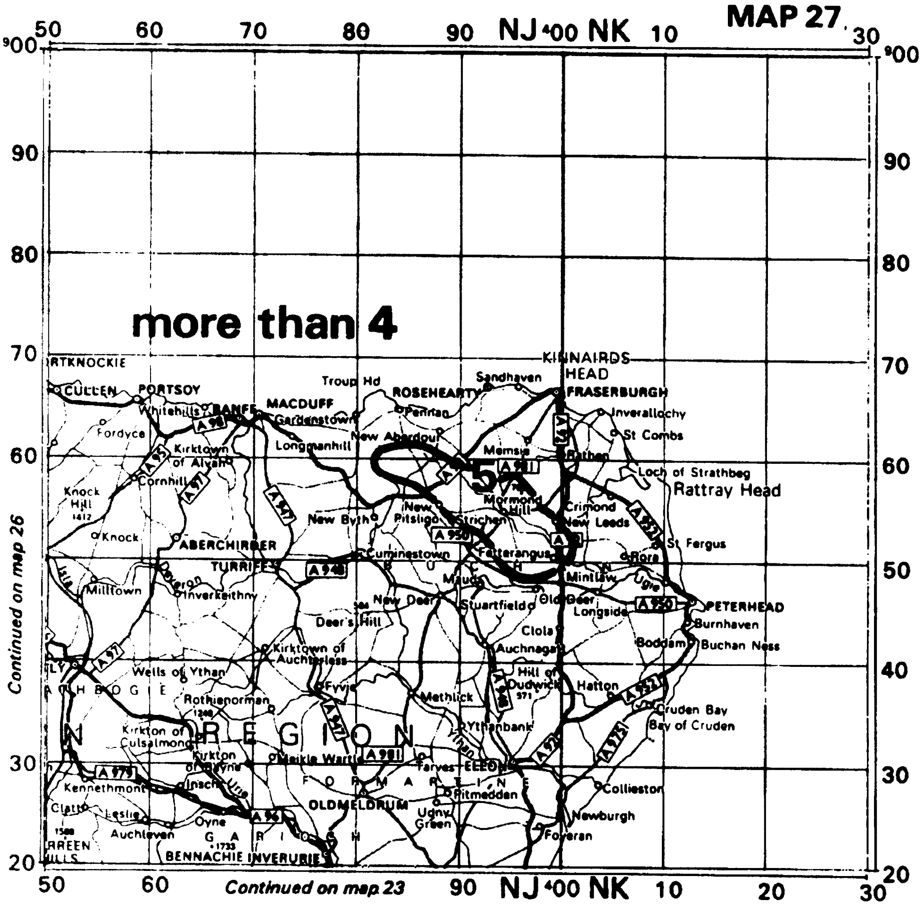


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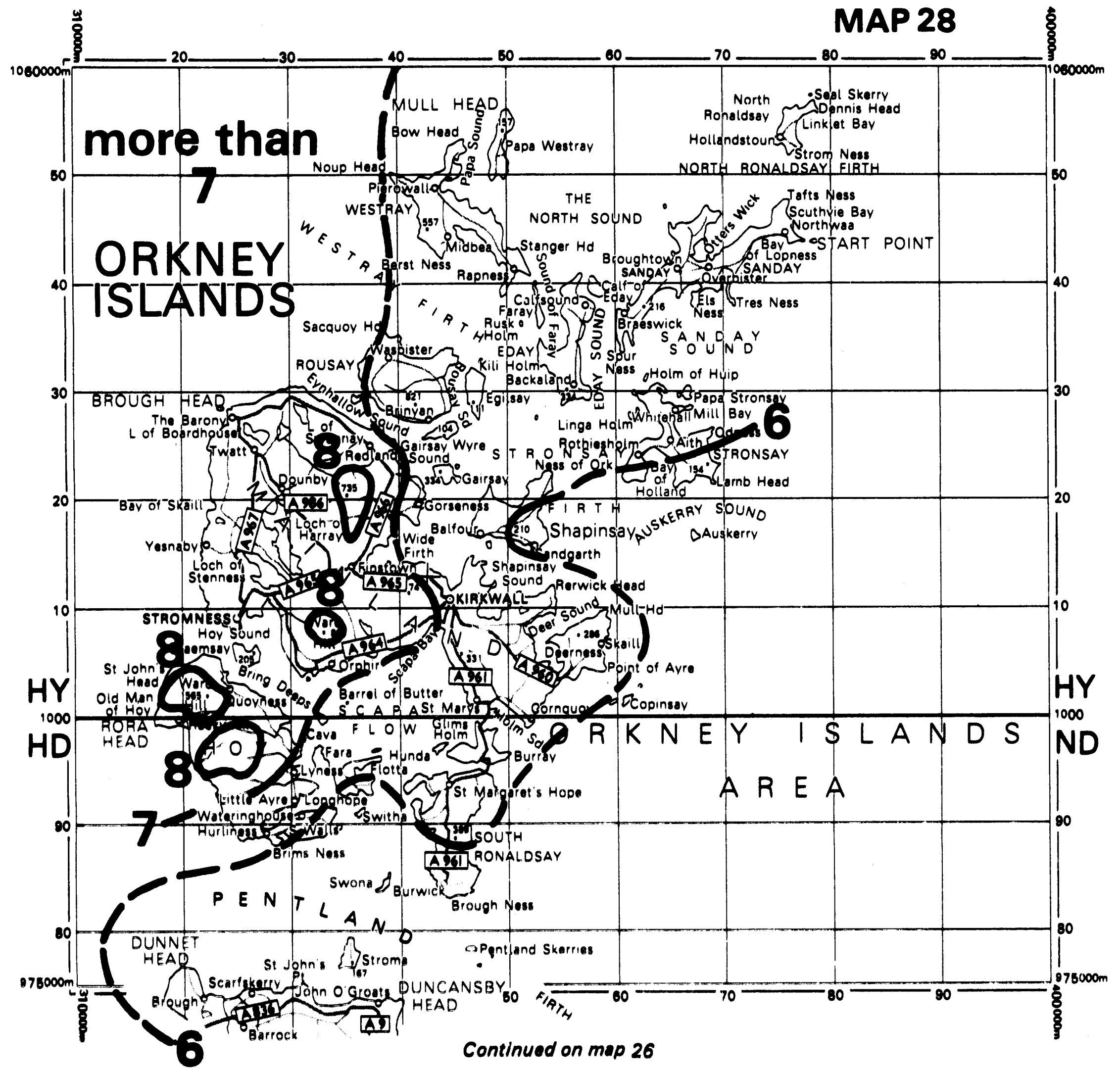
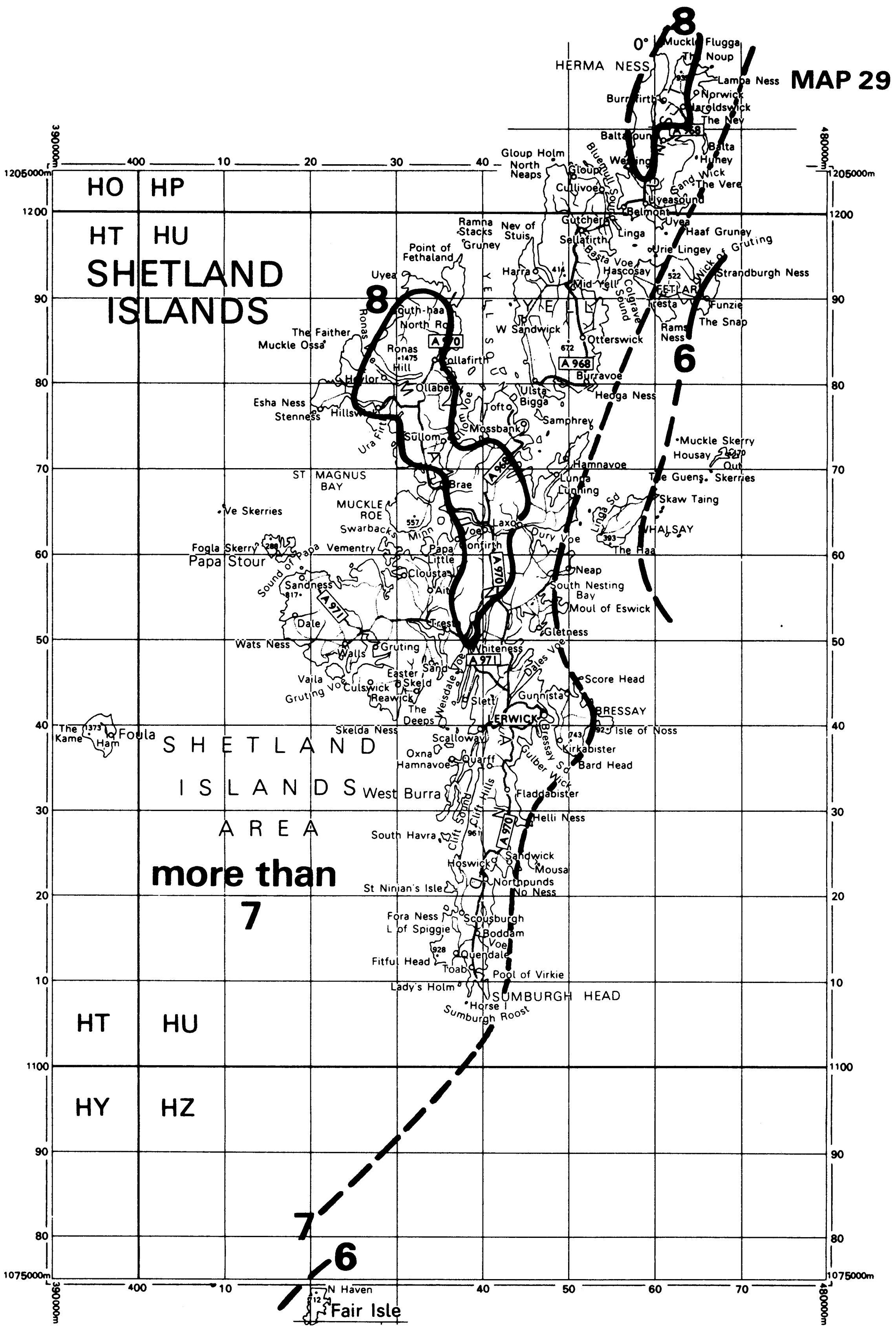



Continued on map 26

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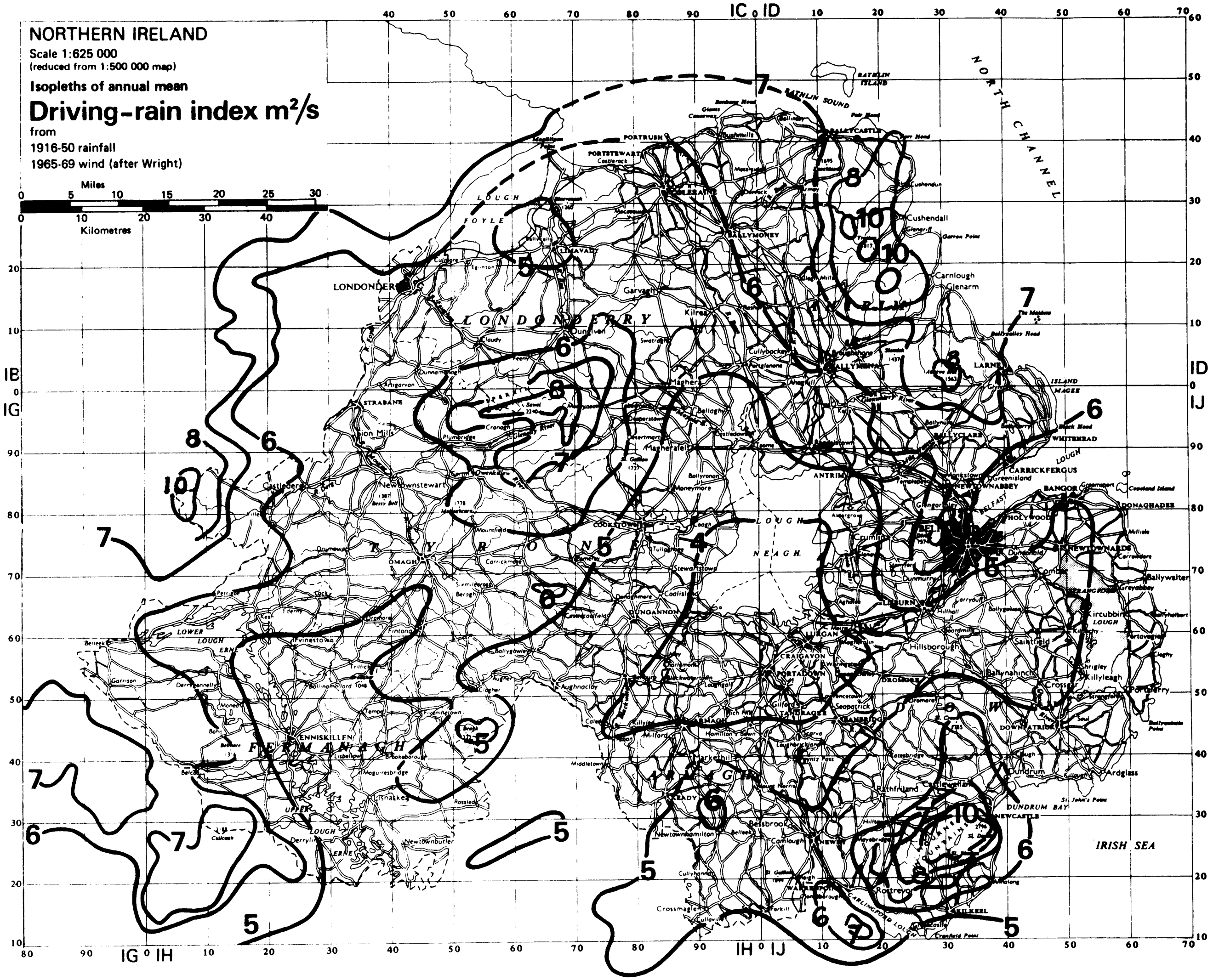
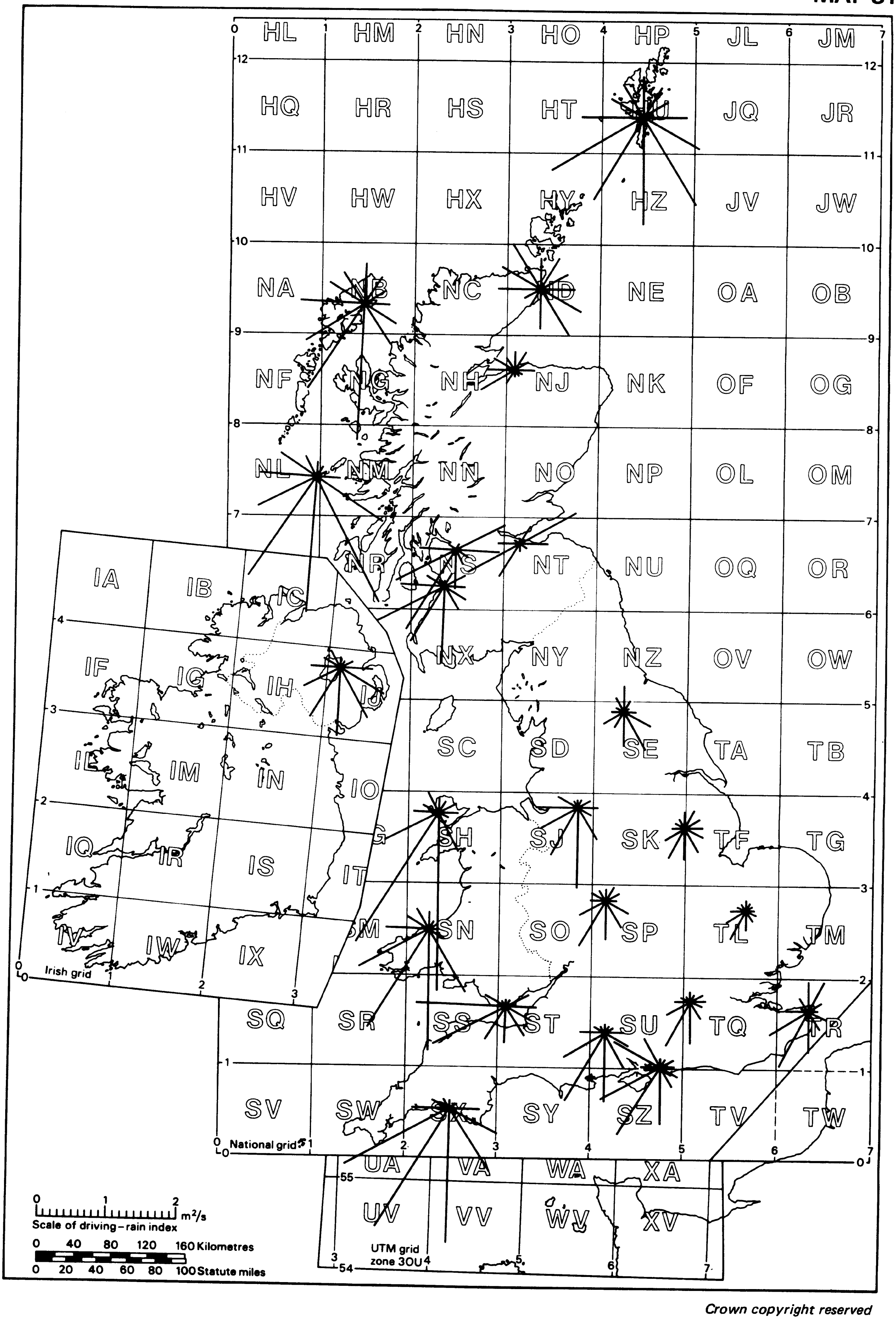
## MAP 30




Climate data from UK Meteorological Office and Meteorological Service, Dublin. Map based on Ordnance Survey.

**MAP 31**




**Annual mean driving-rain index 'roses' (from Meteorological Office analysis of hourly data over ten years).**

*blank*

# Publications referred to

BS 5262, *Code of practice for external rendered finishes.*

BS 5390, *Code of practice for stone masonry.*

BS 5440, *Code of practice for flues and air supply for gas appliances of rated input not exceeding 60 kW (1st and 2nd family gases).*

BS 5440-1, *Flues.*

BS 5617, *Specification for urea-formaldehyde (UF) foam systems suitable for thermal insulation of cavity walls with masonry or concrete inner and outer leaves.*

BS 5628, *Code of practice for use of masonry.*

BS 5628-3, *Materials and components, design and workmanship.*

BS 8208, *Guide to assessment of suitability of external cavity walls for filling with thermal insulants.*

BS 8208-1, *Existing traditional cavity construction.*

CP 3, *Code of basic data for the design of buildings.*

CP 3:Chapter V, *Loading.*

CP 3-2, *Wind loads.*

DD 93, *Methods for assessing exposure to wind-driven rain.*

Method of assessing the exposure of buildings for urea-formaldehyde cavity wall insulation (Information Sheet No. 10)[5].

[5] Available from The British Board of Agrément, PO Box 195, Bucknalls Lane, Garston, Watford, Hertfordshire WD2 7NG.

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