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Proposed methodology for highway salting trials

by Morteza Zohrabi and Marilyn Burtwell

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TRL Limited

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PROJECT REPORT CPS/03/02

PROPOSED METHODOLOGY FOR HIGHWAY SALTING TRIALS

by Morteza Zohrabi and Marilyn Burtwell

Prepared for: **Project Record: NSSRG**
Client: National Salt Spreading Research Group
Highway Authority Consortia
David Wilson (Chairman of Steering Group)

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EXECUTIVE SUMMARY

Scope of the project

Recent estimates have shown that approximately £140 million is spent each year in keeping highways in the UK free of frost, ice and snow. Traditionally, this has been achieved by the application of dry rock salt at or very close to its natural moisture content of about 3.5 per cent. In the UK, basic application methods for salting have changed little during the last two decades. However, more recently, techniques developed in continental Europe and North America have received increasing attention from highway winter maintenance practitioners in the UK. These techniques utilise the pre-wetting of salt, in which high purity salt is combined with saturated brine at the spreading mechanism. The National Salt Spreading Research Group commissioned TRL Limited to undertake initial performance trials under controlled conditions on the TRL research track in Berkshire (to commence in May 2001 and conclude in April 2003). Experience obtained from the results of a set of preliminary performance tests would then be applied to selected field trials undertaken by various members of the Working Group designed to corroborate or otherwise, the results obtained from the initial performance trials.

This report describes a proposed methodology for trials of the treatment of roads using either pre-wetted salt, dry rock salt or brine. The individual results of these trials in the form of a research report together with a guidance document will be accessible to all those contributing to the salting trials on a secure web site hosted by TRL.

Summary

TRL Limited was commissioned by the National Salt Spreading Research Group (NSSRG) to evaluate track and field performance of various spreaders used for salting. The aim of the field trials is to determine the most cost efficient and effective methods of salting by study of existing de-icing methods and techniques. Comparative performance testing is being undertaken on different manufacturers distribution systems to seek assurance that the different systems are capable of delivering the required performance standards, in terms of the required coverage and rate of spread of salt, salt grading and salt moisture content in dry, pre-wetted and brine forms.

Implementation

Evidence from the field trials will assist NSSRG with decisions concerning the use of dry, pre-wetted salt or brine on their road networks, salt grading, salt moisture content and any necessary future spreader design improvements.



1 INTRODUCTION

Recent estimates (Thornes, 1998) have shown that approximately £140 million is spent each year in keeping highways in the UK free of frost, ice and snow. Traditionally, this has been achieved by the application of dry rock salt at or very close to its natural moisture content of about 3.5 per cent. In the UK, basic application methods for salting have changed little during the last two decades. However, more recently, techniques developed in continental Europe and North America have received increasing attention from highway winter maintenance practitioners in the UK. These techniques utilise the pre-wetting of salt, in which salt is combined with saturated brine at the spreading mechanism.

Stage 1:

Ongoing performance trials at TRL research track. This has thus far included testing of Foden, Econ (conventional and low-throw), Epoke and two Schmidt spreaders (Nido Stratos and one with a large spinner).

Stage 2:

Field trials to verify the performance of various spreaders (tested in stage 1) on the public highway under traffic. Concerns have also been expressed about the spread rate for modern surfacings, e.g. thin surfacings such as Safepave, Masterpave, Colrug, Hitex, and Porous Asphalt when using both dry salt, pre-wetted salt or brine. To address these concerns, the adopted methodology would also be applicable to such surfaces.

The proposed methodology has been designed for pre-wetted salt application. It is, however, equally applicable to either dry salting or brine only applications, the only exceptions being a change to the rate of spreading, the salt particle size and the moisture content of the salt. The methodology described in the report is a generic approach to the trials for different road layouts. A schematic plan of each individual site identified for a trial will also be prepared for use by the personnel involved and for planning the work programme.

1.1 Background

The performance trials are being undertaken in two parts:

1. Initial performance trials under controlled conditions on the TRL research track to confirm the spread rate and spread patterns of dry salting, pre-wetted salting and brine application, through dynamic performance testing (to commence May 2001 and conclude April 2003).
2. Comparative performance testing upon different manufacturers distribution systems to seek assurance that the different systems are capable of delivering the required performance standards, in terms of required coverage and rate of spread of salt in dry, pre-wetted and brine forms (to commence October 2002 and conclude April 2003).

It has previously been agreed between the NSSRG Steering Committee and TRL that:

- Activities involving the organisation of the field trials, materials, equipment and traffic management will be the responsibility of the NSSRG;
- Capital costs of the field trials will be attributed to the NSSRG;



- It is understood that TRL will present the proposals contained in this report on the methodology to the NSSRG so that agreement can be reached on the scope of the trials prior to commencement of the work.
- TRL will be responsible for monitoring the trials, the preparation of the final report and the drafting of a guidance document.
- The field trials should enable a direct comparison to be made between dry salting techniques, pre-wetted salting techniques and the use of brine only.

1.2 Objectives

The objectives of the field trials are:

1. To undertake salt trials on the highway in order to determine the efficacy of different salt products with different spreaders. These field trials are to be undertaken by various members of the Working Group designed to corroborate, or otherwise, the results obtained from the initial performance trials.
2. To determine the optimum salt grade, purity and moisture content for dry salting, pre-wetted and brine applications.
3. To confirm the spread rate and spread pattern for pre-wetted salt or brine application and whether any change in spreading technique, either by changing the calibration method or, more fundamentally, changing the lane passes or vehicle speed if necessary.
4. To determine optimum spreading speeds and rates of spread of different salting techniques.
5. To identify the most cost-effective treatments in relation to the effectiveness of the treatment.
6. To observe any other practical problems associated with the spreading of pre-wetted salt or brine, e.g. visibility problems behind the spreader compared to traditional dry salting.
7. To determine the possible salt carry-over effects from one surface (including thin surfacing where possible) to another at the boundary.
8. To complete the initial research and analysis of both performance and field trials and produce a report of the findings by June 2003.

In summary, the aim of the research is to identify the most cost efficient and effective methods of salting by careful study of existing de-icing methods and techniques.

2 METHODOLOGY

A proposed methodology has been agreed for the track-based performance trials. The Working Group further agreed that the results of the techniques and methods used as part of this approach should be used to help produce a more detailed methodology for the local field-based trials. The Steering Group and TRL would jointly formulate this detailed methodology for the field-based trials. Field trials can take place at any location with support from a relevant Highway Authority. Suitable trial sites will be identified by the NSSRG (see section 4).

The following sets out a proposed methodology for the field based performance trials using a range of rock salts and spreading equipment. After spreading, the measurement of residual salt and the trafficking of the site will be undertaken in the same manner for each salt type. It is envisaged that a number of combinations of salt size/ grade/ moisture content, spread rates, brine concentrations/ratios and different spreading equipment will be evaluated.

Traffic counts, traffic management, carriageway sweeping, measurements of residual salt, monitoring, weather conditions, spreader calibration and weighing and salt spreading will be undertaken during the progress of the trial.

For trials on motorways, two lanes must be closed to comply with safety guidelines. The following methods for dry, pre-wetted salt or brine are based on motorway trials, two-lane and single-lane closures.

2.1 Trial sequence

1. Prior to the trial starting, during the trial and at the end of the trial, a record of the weather conditions will be taken. If a weather station is present on or very near to the site, a record of the wind speed and direction, ambient temperature, humidity, road surface temperature and road surface condition will be made. Otherwise, a general assessment of the conditions will be noted.
2. Traffic counts will be taken for the trial section for a minimum of 15 minutes before the traffic management is implemented. Traffic counts should comply with the Department for Transport (DfT) Traffic regulations.
3. The trial section will be subject to static traffic management in the appropriate lanes, including a 500m clearance between the start and ending of coning and the ends of the trial section.
4. The trial section will be swept for a period lasting no longer than 15 minutes, by a mechanical sweeper with the number of passes of the sweeper being noted.
5. Residual salt levels will be measured in two 1m² quadrates in the appropriate lanes prior to salt being spread by the methods described later in this report (see Figures 1, 2 and 3).
6. The general weather conditions at the trial section will be noted.
7. The trial site will be subject to an application of dry salt, pre-wetted salt or brine at 10g/m² or 20g/m² from a salting vehicle travelling in the spreading lane, so as to cover one or more adjacent lanes (see Section 4.3 for salt specifications). The nominal maximum salt grain size will be 10mm. The salting will commence approximately 300m in advance of the trial section and will cease approximately 300m after the end of the trial section.



8. The start and finish position for salting and the start and finish of the trial section will be conspicuously marked in the verge, footway or hard shoulder.
9. The salting vehicle will be calibrated for pre-wetted salt or brine only and weighed on leaving the operational depot and upon its return. The combined weight of dry salt and pre-wetting agent used will be calculated. The volume of pre-wetting agent used will be determined using flow meter data (where fitted), allowing the amount of dry salt used, to be calculated by subtraction (if the spreader has an on-board weighing mechanism, the driver will need to note the road-mark at the start and end points). From the analysis of the dry salt and/or brine used (or the combined total salt spread) across the lanes, an operational check can be made on the spread rate achieved.
10. The salting vehicle should adopt “normal” spinner speed and travelling speed for precautionary salting operations at 10g/m² or 20g/m². Under no circumstances, should the salting vehicle speed exceed 50 km/h.
11. A 1.2m wide strip adjacent to the work zone will be used as a safety zone and no measurements will be carried out in this zone (refer to Chapter 8 of Traffic Signs Manual).
12. Residual salt concentrations will be measured in the appropriate lanes immediately after the salting operation has been completed (see Figures 1, 2 and 3). This operation will be carried out at two longitudinal locations of 200m apart. To determine the salt concentration across each lane, the lane widths will be divided into 0.5m wide strips giving, for example, a total of 7 strips in lane 1 (ignoring approximately the first 150mm of the near-side), based on a 3-lane motorway (see Figure 1). A further 5 strips will be measured in the remaining 2.5m width of any adjacent lane (takes into account the 1.2m safety margin). A 1m² quadrat (0.5m wide x 2.0m long) will be placed at the 12 adjacent positions in each test lane (placed so that the longer edge is parallel to the line of traffic), with the salt lying within the quadrat being swept up using a wet Hoover method. This will allow the total amount of distributed salt (both the salt grains and the pre-wetting agent) to be calculated. The methodology for determining the salt content from the collected solutions will be the same as that used for the track performance trials and is discussed further in Section 2.2.
13. The static traffic management will be removed and the trial section will be subjected to unrestricted traffic flows for a minimum period of 60 minutes. Traffic counts will again be taken during this period.
14. After this 60 minute period has elapsed, the appropriate lanes will again be subjected to traffic management / control. The aim will be to successfully re-instate the static traffic management provision within 30 minutes.
15. Starting as soon as possible after the successful completion of the traffic management provision, residual salt concentrations will be assessed in two longitudinal positions, 200m apart, across the test lanes in the same manner as that used during the initial residual concentration measurements. Since the total salt is being collected, the amount of salt already in solution will not affect the results. The locations of these strips are marked clearly (in grey shaded boxes) in Figures 4, 5 and 6 such that there is a clear distance of 100m between the strips used in pre- and post-trafficking measurements.
16. Another parameter that is investigated during the field trials is the rate at which the salt on the trafficked surface goes into solution. For example, in a 3-lane motorway arrangement, this is measured at seven adjacent positions within lane 1 and at 5 adjacent positions in lane 2, as marked clearly in Figure 4 (in clear boxes). Notice that both the greyed and clear boxes



are longitudinally adjacent to one another. Starting from the N/S of lane 1, at each position marked on Figure 4, the salt deposited in a 0.5m x 2.0m quadrat will be swept up using a wet Hoover so that the total amount of residual salt (both that dissolved and that still as salt grains) can be calculated. The principle of the method is equally applicable to 2-lane and single lane roads (Figures 5 and 6).

17. Immediately following this, the dry salt deposited in a quadrat of the same size (alongside the first quadrat) will be swept up by a dry Hoover method in order to determine the amount of salt that has not dissolved. The salt grains will then be placed in absorbent kitchen towels to fully dry and be stored for later analysis. The difference in weight of salt from the two quadrats will give the weight of salt that has been dissolved. The same operation is repeated every 15 minutes at another pair of adjacent positions, as shown in Figures 4, 5 and 6 for 3-lane motorways, 2-lane and single lane roads, respectively. To save time during the operation, the dry Hoover of quadrats within lanes 1 and 2 will be carried out simultaneously (starting with N/S quadrat of lane 1 and the N/S quadrat of lane 2). Under ideal conditions, the weight of the salt recovered, by the dry Hoover method, from the quadrats should decrease with time assuming that the salt grains are dissolving. This will provide a profile of total salt distribution across the surface as well as a profile of dry salt distribution left on the surface after trafficking.
18. On completion of the measurements at the trial section, the static traffic management will again be withdrawn allowing unrestricted traffic to flow.

2.2 Measurement of residual salt levels on the carriageway

Residual salt measurements are taken by using special vacuum cleaners and also by use of a SOBOMeter.

2.2.1 Vacuum method

Because of the concerns regarding the inaccuracy in collecting the applied pre-wetted salt and brine by hand brush into a dustpan, a new wet vacuum cleaner technique has been developed and used by TRL for measuring the residual salt level. This involves washing the surface of the 1m² quadrats twice, then dry vacuuming the surface to collect any excess moisture remaining on the surface. This method also ensures that any brine remaining inside the hose-pipe is flushed out. The collected salt and brine are carefully transferred from the vacuum cleaner into a plastic bottle and sent off for laboratory analysis. Although very tedious and time consuming, this operation allows the complete recovery of both the brine and the partially dissolved salt from the pavement.

2.2.2 SOBOMeter testing

Although concerns currently exist about the accuracy and reliability of a SOBOMeter 20 in gauging the actual amount of residual salt on the surface, it is considered necessary to assess its performance against the actual salt concentration determined during the dry salt and pre-wetted salt operations. The SOBOMeter is a complementary tool to the Hoover method and could give added value in providing further data about the usefulness and reliability of the device. Before use in the trials, the SOBOMeter should be calibrated for the various salts. SOBOMeter measurements should be made adjacent to the test panels as shown in Figures 1 to 6.



3 TIMELINE OF ACTIVITIES FOR AN OVERNIGHT OPERATION

A typical timetable for operation is proposed as follows, provided local police give the clearance after the evening rush hour traffic has passed. Each site will be reviewed prior to a trial and a revised timeline will be produced to take account of the location, number of measurement points and traffic flow etc.

1. Initial measurements (including spot measurements of salt concentration at two locations in each test lane) and site sweeping after initial site closure (approx. 9 -10:30pm).
2. The trial sections in the appropriate lanes will be subject to an application of dry salt, pre-wetted salt or brine from a salting vehicle travelling in lane 1 (approx. 10:30 - 11pm).
3. Residual salt measurements after spreading - 2 or 3 teams of two staff to carry out the two sets of measurements on 12 adjacent locations (e.g. for a 3-lane motorway, 7 in lane 1 and 5 in lane 2) (approx. 11 - 00:30am).
4. The static traffic management to be removed (approx. 00:30 - 01:00am).
5. The trial section to be subjected to unrestricted traffic flows for a minimum period of 60 minutes. Traffic counts to be taken during this period (approx. 01:00 - 02:00am).
6. Traffic management / control will be re-installed in the appropriate lanes to carry out the post-trafficking residual salt measurements (approx. 02:00 - 02:30am).
7. Residual salt concentration and the rate of salt entering into solution measurements in two longitudinal positions, 200m apart, across each test lane in the same manner, but different locations, as that used during the initial residual concentration measurements. Each team of four to carry out the measurements in each adjacent strip across each lane (approx. 02:30 - 04:30am).
8. Removal of traffic management at the end of the trial (to be finished by 05:30am at the latest).

4 REQUIREMENTS FOR TRIAL SITES

4.1 Generic requirements for the trial sites

Traffic counts, traffic management, carriageway sweeping, measurements of residual salt, performance monitoring, weather conditions, spreader calibration and weighing and salt spreading will be undertaken during the progress of the trial. In order to pre-plan the work, the authorities are requested to inform TRL about details of the site layout and characteristics well in advance of the trial start date. This should ensure that a timeline and plan of the trial can be produced for all personnel.

The generic requirements are:

1. Sites should be within a 20-mile radius of a highway maintenance depot.
2. Sites should be remote from junctions to simplify traffic management arrangements.
3. Sites should have surfacings of approximately equal (and even) age and should not have been resurfaced within the last 12 months.
4. Sites should, where possible, have one or more different surfacing materials for test. It would be desirable if at least one of the materials was a thin surfacing, e.g. Safepave.
5. The trials should take place after traffic has dropped below a level that allows single lane running to avoid congestion. Also, for consistency of results, the trials should be carried out at similar times, with similar traffic flows on each night.
6. A representative traffic flow count (for 15 minutes) should be taken before and during the trials.
7. Trial sections should be at least 500m in length.
8. Where possible sites should be selected which include road surface sensors that are utilised as part of an Ice Prediction System.
9. The trials should operate in dry, frost-free conditions or on nights where the road surface temperature (RST) falls below zero and the road state is wet/damp with the propensity for ice formation. There should be no strong winds and the relative humidity should be greater than 80 per cent.
10. Due to the nature of the measurements to be taken and for safety reasons, it is considered essential that any night work is carried out along an adequately lit stretch of road.
11. A daily record of weather parameters should be used to determine the best conditions to undertake the field trials in order to replicate typical salting operations on the highway. Each Highway Authority will need to alert TRL to an appropriate weather 'window' with at least 48 hours notice.

4.2 Spreading vehicle requirements

- The selected spreader should have a valid manufacturer's calibration certificate, obtained prior to the commencement of the winter maintenance season. Also, it is recommended that a static calibration of the spreader is carried out with the salt being used for the trial.



- The vehicle should, if possible, possess a functioning data logging facility, able to record data that includes times of operations (i.e. spinner on and off), spinner speeds, vehicle speeds etc.
- The pre-wet vehicles should have a facility for measuring the amount of brine and actual dry salt used (or at least the total theoretical quantity of salt + brine used) and preferably been specifically purchased for pre-wetted salting operations, rather than a retrofitted vehicle usually used for dry salting operations.

4.3 Salt specifications

The specifications for the different salts should ideally replicate those used in the performance trials at TRL and will be the choice of each Highway Authority. Therefore, the following specifications are proposed:

(a) Pre-wetted salt:

- 6.3mm rock salt as the dry component and Sodium Chloride as the pre-wetting agent or that suggested by the pre-wetted salt supplier.
- Pre-wetting agent - 23.5 per cent concentration.
- Ratio of dry salt to pre-wetting agent - 70:30.

(b) Dry salt:

- Nominal 10mm maximum size rock salt or other.
- Moisture content (to be determined prior to each trial).

(c) Brine:

- Saturated brine solution – 23.5 per cent concentration.

4.4 Specification for depot facilities

The following specification is proposed:

1. The fully operational depot should be within a reasonable distance of the trial sites chosen so that dead mileage can be kept to a minimum.
2. The depot should possess suitable facilities for dry salting and/or pre-wetted salting and/or brine operations and resources for traffic management on motorways, dual carriageways and single-lane roads. As far as possible the permutations used in the track performance trials will apply to the trials.
3. The depot should possess a weighbridge facility or equivalent facility, e.g. portable weigh pads to enable salting vehicles to be weighed when entering and leaving the depot.



4. The depot should possess a suitable flat area for pre-trial calibration checks. Alternatively, the pre-trial performance checks could be undertaken at TRL where a flat area has previously been used for winter maintenance performance trials.

4.5 Staff requirements

Experiments require a total of two persons per team to collect the deposited salt for each individual section within the trial length. Three persons from TRL are required to oversee the operation for each section on the site – two persons will work with the operatives to train them in the procedures and the other person will liaise with the traffic management team, traffic counter operatives, spreader driver and collect the salt sample bottles for transporting back to TRL. TRL can also provide additional staff, at a rate to be agreed with each Highway Authority, if more than two trial sections are to be used per site and / or two different material surfacings are to be treated and measured.



5 ACKNOWLEDGEMENTS

The work described in this report will be carried out in the Infrastructure Division of TRL Limited. The Project Manager is Mrs M H Burtwell and the Quality Audit Review Officer is D Colwill OBE. The authors wish to thank the members of the National Salt Spreading Research Steering Group for continuous support and encouragement throughout the performance trials. The assistance of the many Highway Authorities, equipment and material suppliers and contractors who have contributed towards the performance trials is gratefully acknowledged.



6 REFERENCES

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British Standards Institution (1989). BS1622: Spreaders for winter maintenance. British Standards Institution, London.

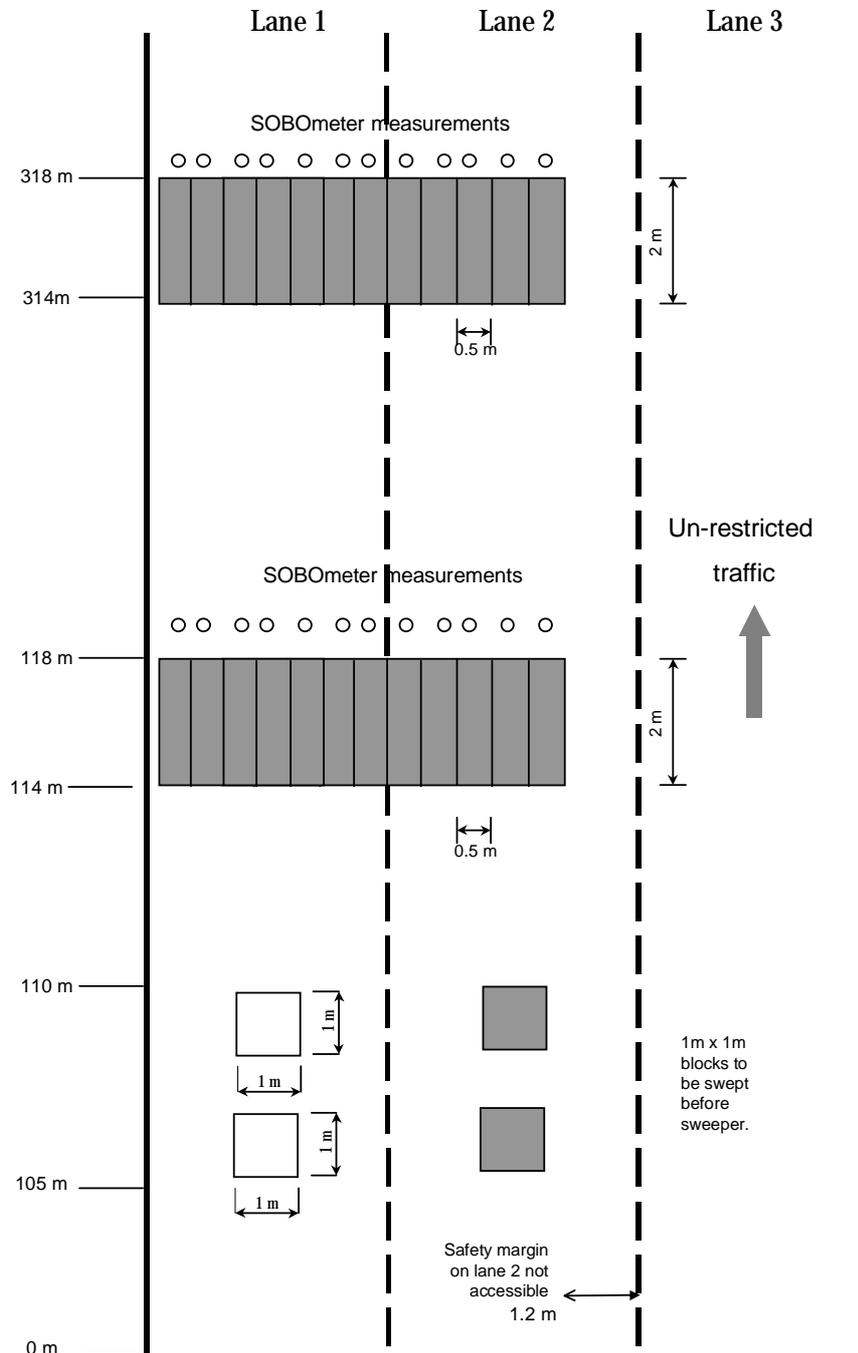


Figure 1. Zones of salt collection for a 3-lane motorway immediately after spreading

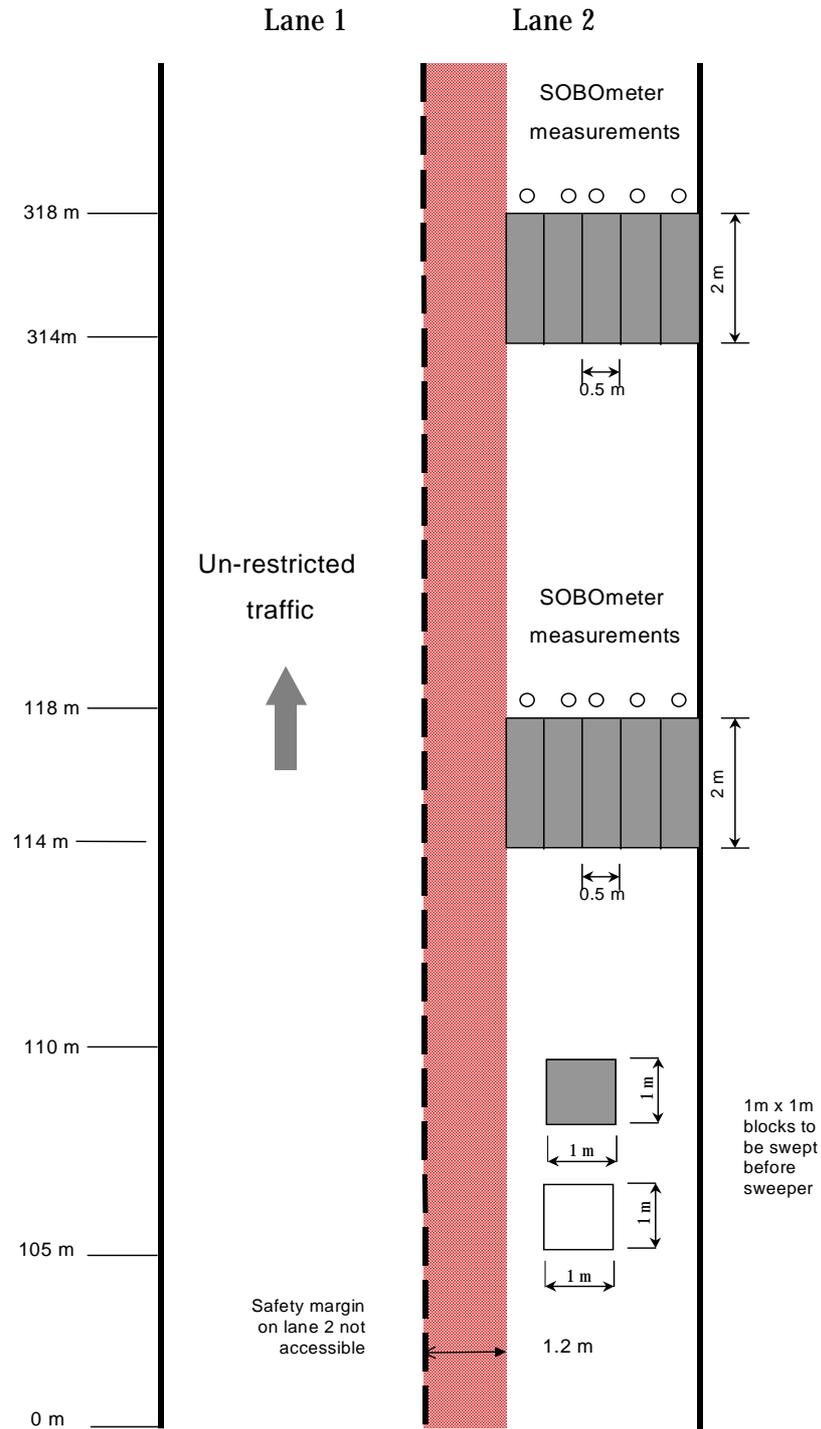


Figure 2. Zones of salt collection for a 2-lane motorway/dual carriageway immediately after spreading

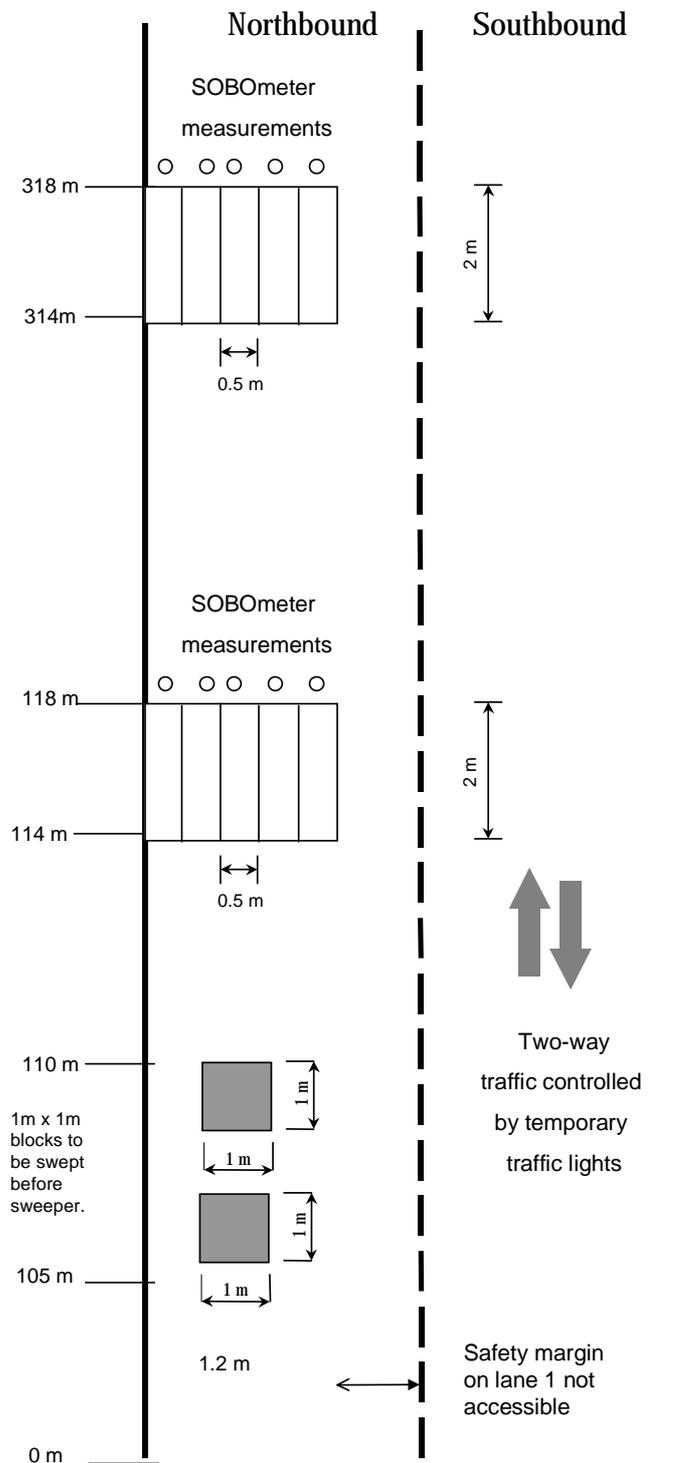


Figure 3. Zones of salt collection for a single carriageway road immediately after spreading

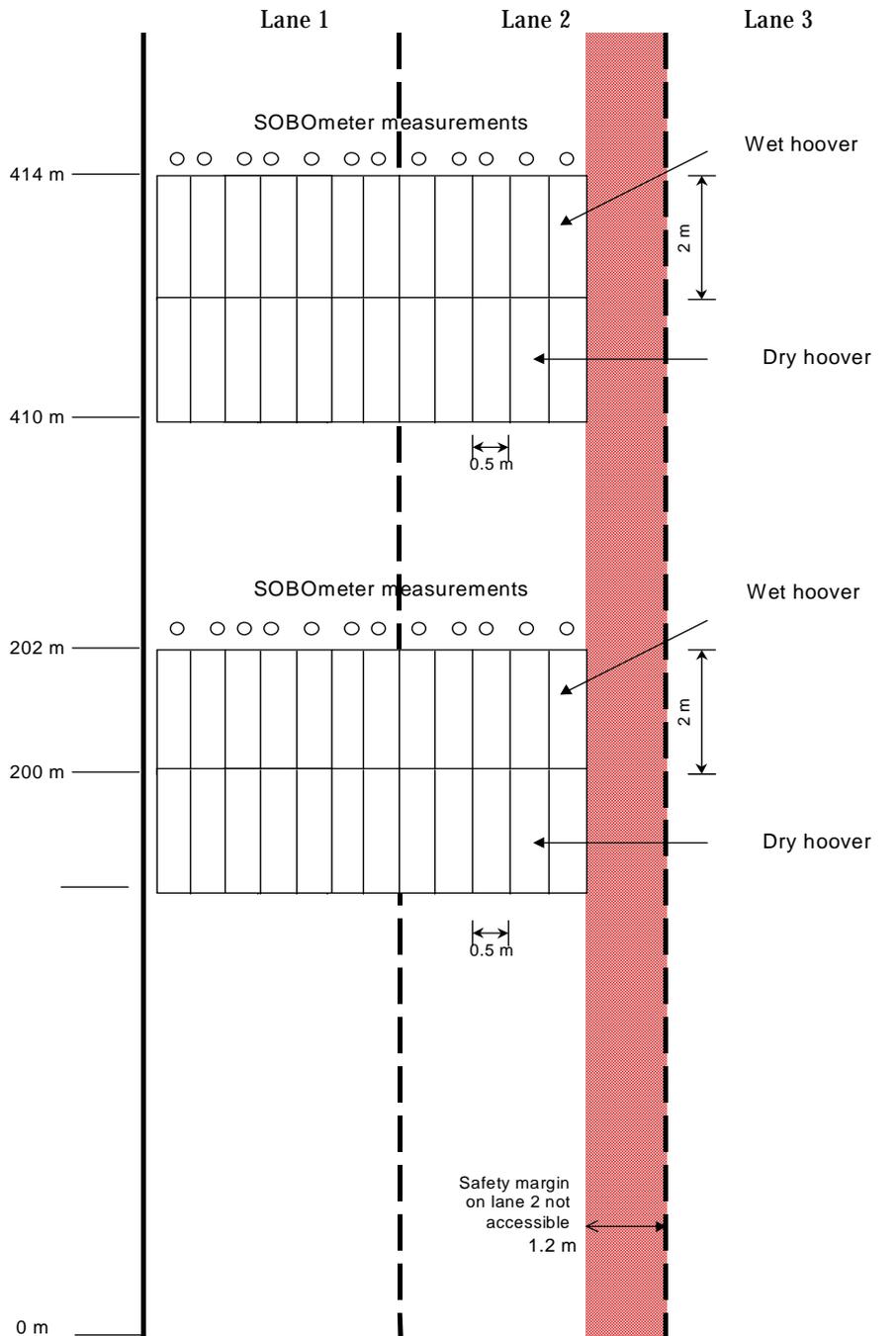


Figure 4. Residual salt measurements on a 3-Lane motorway immediately after trafficking

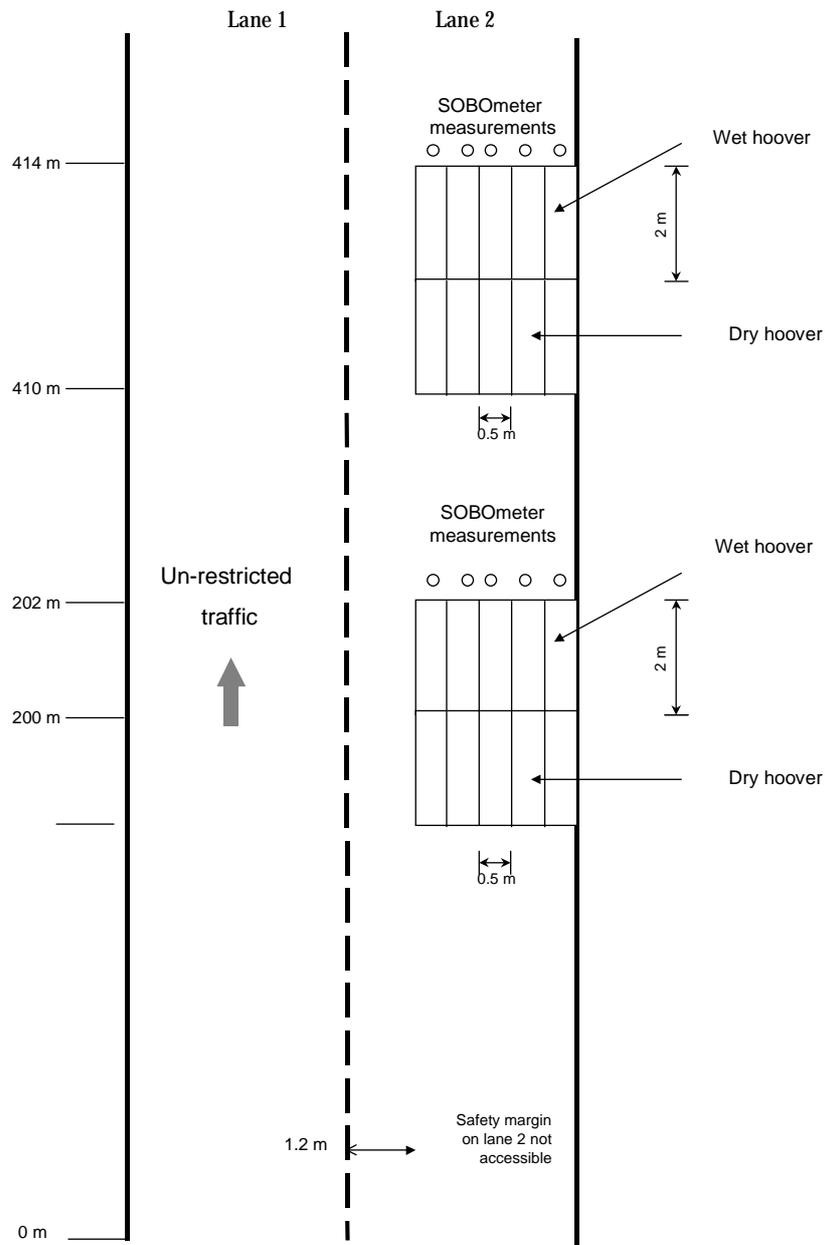


Figure 5. Residual salt measurements on a 2-lane motorway/dual carriageway immediately after trafficking

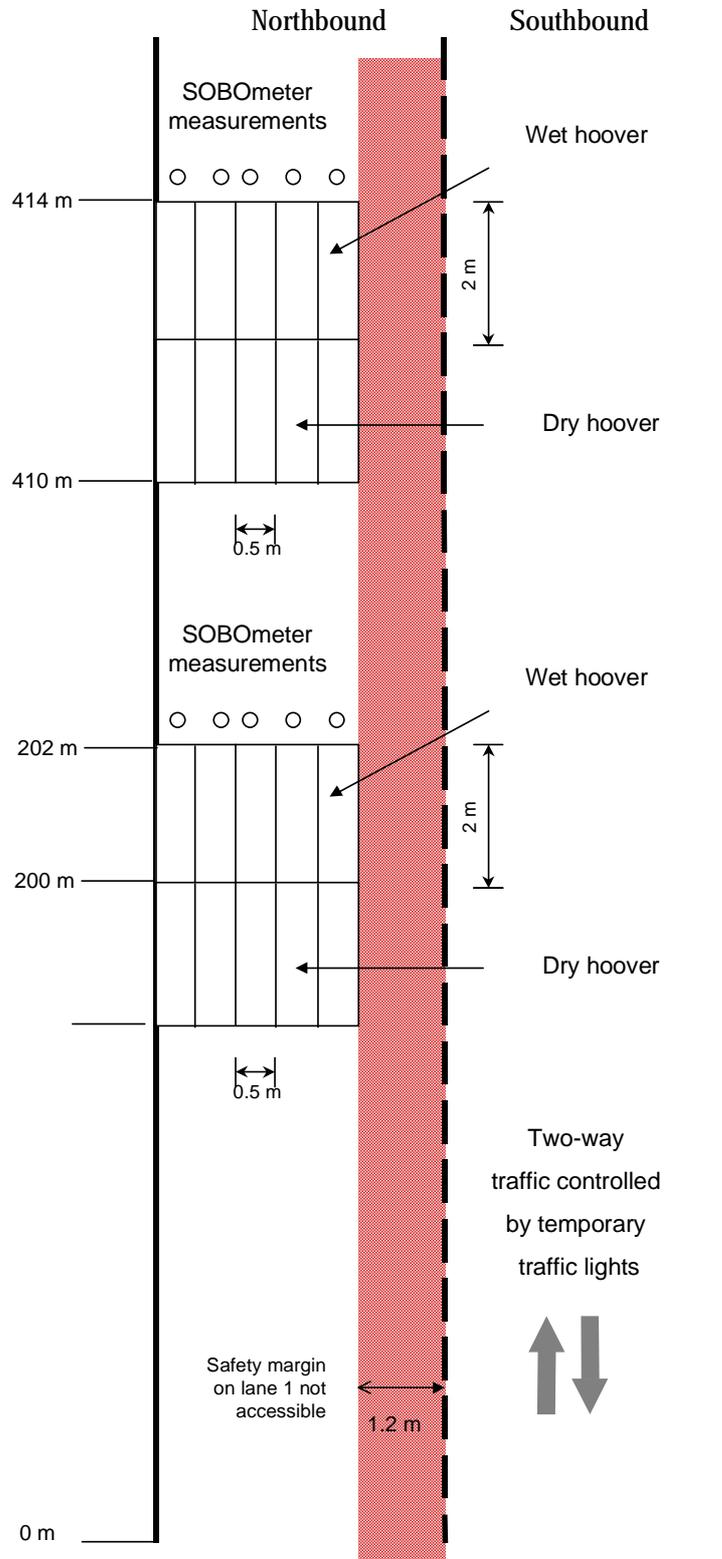


Figure 6. Residual salt measurements on a single carriageway road immediately after trafficking



APPENDIX A: EQUIPMENT AND MATERIALS



A1. Equipment and materials to be provided by TRL

- 2, 3 or 4 Wet and dry hoovers (industrial – Numatic Extraction Cleaner CTD572 110v model)
- 2 Portable generators
- Road weather forecasts for each site location
- 2 Measuring wheels
- Labelled containers for dry salt/pre-wetted salt solutions
- Measurement of the dry salt moisture content (at TRL)
- 4 Quadrates
- Marker pens
- SOBometer 20
- Portable weigh pads
- Road chalk for marking site and template
- Plan of site with measurement positions marked
- Estate vehicle with beacon and Motorway Maintenance sign
- 2 Traffic counters (hand-held)
- 2 Cameras
- 2 Battery torches

A2. Equipment and materials to be provided by NSSRG

- 2 Trial sites with an asphalt surfacing
- 2/3 Portable generators per site
- Portable lighting (where necessary)
- Mechanical road sweeper
- Dry salt spreader with functional data logger (where possible)
- Pre-wetted salt spreader with flow meter fitted (where possible)
- Pre-wetted salt (tonnes to be advised)
- Pre-wetted salt saturator
- Weighbridge
- 2 Calibration certificates – dry salt and pre-wetted salt spreaders
- Traffic management
- Verification of road weather forecasts for each site