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Salt spreading road trial on the A33 near Newdown Farm

(Version 2)

by M H Burtwell and M Zohrabi

CPS/64/03

UNPUBLISHED PROJECT REPORT

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SALT SPREADING ROAD TRIAL ON THE A33 NEAR NEWDOWN FARM

Version: No. 2

by M H Burtwell and M Zohrabi (TRL Limited)

Prepared for: Project Record: **National Salt Spreading Research Group (NSSRG)**

Client: **Hampshire County Council (Kevin Fuller)**

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Project Manager	**Marilyn Burtwell**
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Contents

Executive summary

TRL Report PR/CPS/64/03 Salt spreading road trial on the A33 near Newdown Farm
By M H Burtwell and M Zohrabi

Project Reference:	Salt spreading performance trials 2001-2003
Project Sponsor:	Mr K Fuller, Hampshire County Council
Project Manager:	Mrs M H Burtwell, TRL Limited

Scope

This report describes a salt spreading road trial that was carried out on the A33 near Newdown Farm, a dual carriageway, for Hampshire County Council. The road trial followed initial spreader performance trials, under controlled conditions on the test track at TRL. Experience gained from the performance trials was used to design, plan and undertake the road trial. The road trial was undertaken in accordance with the specification prepared by Zohrabi (2003). The results of the TRL performance trial were reported by Zohrabi and Burtwell (2002).

The road trial was carried out over two nights. An Epoke spreader (Sirius SW3501 – 2003 model) travelling on the northbound carriageway was set up to spread 6.3mm rock salt pre-wetted with a 24.7 per cent brine solution onto lanes 1 and 2 (no salt was to be spread onto the nearside and offside hard shoulders).

The performance of the spreader during the operation was assessed against the following parameters:

- Achieving the target spread rates
- Performance of the spreader in targeting the main test zones accurately
- Wastage to the roadside edge and verge
- Transverse and longitudinal snaking effects of the spreader
- Salt spread patterns before and after trafficking
- Residual salt level on the carriageway after trafficking

Summary

An Epoke spreader (Sirius SW3501 – 2003 model) travelling in the nearside lane was set up to spread 6.3mm salt pre-wetted with a 24.7 per cent brine solution in lanes 1 and 2 of the northbound carriageway. The spreader was set up for asymmetrical 2-lane spreading with a spread width setting of 5m and travelled at 50km/h in lane 1. The normal spinner speed for precautionary salting was adopted at a spread rate of 10g/m². After spreading the salt was collected from three strips, 100m apart. The results showed that the target spread rate was only achieved in the last test strip, with the overall under salting amounting to 17 per cent of the target spread rate in the main target area. The differences from strip to strip may be attributed to longitudinal snaking. The overall discharged salt from the spreader appeared to be uniformly distributed across both lanes. The amount of salt spread onto the nearside hard shoulder and both verges amounted to 9 per cent of the discharged salt. The residual salt level remained uniform across the two lanes after one-hour of trafficking, although the volume of traffic was not significant. After a period of 20-hours of trafficking, salt loss was on average 62 per cent of the spread salt being 73 and 52 per cent in lanes 1 and 2 respectively. This is considered important in determining the need for repeated applications. The average rate at which the pre-wetted salt entered into solution after only one hour of trafficking was uniform between the three

test strips, amounting to 44 and 9 per cent of the salt in lanes 1 and 2 respectively, despite the similar, but small amount of trafficking in each lane. This rate did not appear to be a function of the time after trafficking. The overall results showed more salt entering into solution in the nearside wheel track than elsewhere across the two lanes. The road surface may have been warmer within lane 1 due to higher traffic flows earlier in the day. The salt dissolution would have been more rapid with higher traffic volumes.

Implementation

Evidence from the field trials will assist local Highway Authorities with operational decisions concerning the set up of their spreaders and their performance in discharging pre-wetted salt onto the roads.

Abstract

This report describes the results of a salt spreading trial carried out on the A33 near Newdown Farm, a dual carriageway, for Hampshire County Council. An Epoke spreader (Sirius SW3501 – 2003 model) travelling in the nearside lane was set up to spread 6.3mm salt pre-wetted with a 24.7 per cent brine solution in lanes 1 and 2 of the northbound carriageway. After spreading the salt was collected from three strips, 100m apart. The spreader was set up for asymmetrical 2-lane spreading with a spread width setting of 5m and travelled at 50km/h. The normal spinner speed for precautionary salting was adopted at a spread rate of 10g/m². The results showed that the target spread rate was achieved in the last test strip, but over all three strips there was under salting amounting to 17 per cent of the target spread rate in the main target area. This may be attributed to longitudinal snaking. The salt appeared to be uniformly distributed across both lanes, but nine per cent of the total salt discharged was spread onto the nearside hard shoulder and both verges. The residual salt remained uniform across the two lanes after one hour of trafficking, although the amount of traffic was not significant. After a period of 20 hours of trafficking, salt loss in lanes 1 and 2 was, on average, 62 per cent of the spread salt being 73 and 52 per cent respectively. The percentage of salt in solution after one hour of trafficking was 44 and nine per cent in lanes 1 and 2, respectively, despite the similar, but small amount of trafficking in each lane. More salt entered into solution in the nearside wheel track than elsewhere.

1 Introduction

This report describes a salt spreading road trial that was carried out on the A33 near Newdown Farm, a dual carriageway, for Hampshire County Council. The road trial followed initial spreader performance trials, under controlled conditions on the test track at TRL. Experience gained from the performance trials was used to design, plan and undertake the road trial. The road trial was undertaken in accordance with the specification prepared by Zohrabi (2003). The results of the TRL performance trial were reported by Zohrabi and Burtwell (2002).

The road trial was carried out over two nights. An Epoke Sirius SW3501 – 2003 model spreader travelling in lane 1 of the northbound carriageway was set up to spread 6.3mm rock salt pre-wetted with a 24.7 per cent brine solution onto lanes 1 and 2. The performance of the spreader and the salting operation were assessed against the following parameters:

- Achieving the target spread rate
- Performance of the spreader in targeting the main test zones accurately
- Wastage to the roadside edge and verge
- Transverse and longitudinal snaking effects of the spreader
- Salt spread patterns before and after trafficking
- Residual salt level on the carriageway after trafficking

2 Background

It is recognised that, because of difficulties in consistent and accurate calibration of salt distribution systems, there is a tendency for some spreaders to distribute salt beyond the edges of the carriageway. Subsequently, this salt is wasted in terms of de-icing the carriageway, and the vegetation on adjacent verges can be subject to damage from chloride. Some spreaders that are imported into the UK from continental Europe have been designed for the European left-hand drive system, which is opposite to the UK road system. The efficacy of using such systems in the UK therefore must be investigated by monitoring the rate of spread to the carriageway, and the pattern and uniformity of spread across the carriageway before and after trafficking.

Results of selected track calibration trials carried out by TRL (Zohrabi and Burtwell, 2002) for the National Salt Spreading Research Group (NSSRG) recognised the need to determine the efficacy of pre-wetted salting compared to that of dry salting under 'live' carriageway traffic. In order to promote a better understanding of salting issues, a specification for the trial on the A33 was prepared under guidance from Hampshire County Council (Zohrabi, 2003). The specification details a methodology for investigating the performance of an Epoke Sirius SW3501 – 2003 Model spreader, owned by Hampshire County Council, in treating roads with virgin salt and pre-wetted salt with brine.

3 Objectives

The aim of the road trial was to evaluate the efficacy of pre-wetted salt under 'live' carriageway traffic.

The objectives were:

- to confirm the achieved spread rate and spread pattern of pre-wetted salt compared to that obtained in the TRL performance trials;
- to compare the spread patterns before and after trafficking;
- to assess the residual salt level after a period of trafficking; and
- to assess the performance of the Epoke spreader in delivering to the required standard, in terms of required coverage and rate of spread of pre-wetted salt.

4 Equipment

4.1 De-icing chemical

The de-icer comprised a virgin 6.3mm rock salt from Salt Union Ltd with a moisture content of 1.29 per cent that was pre-wetted with brine. The brine comprised a saturated Sodium Chloride (NaCl) solution with approximately 24.7 per cent concentration, prepared from 3mm high purity rock salt supplied by Salt Union Ltd. Therefore, the target Sodium Chloride content was 7.7g/m² at the target spread rate of 10g/m².

The particle size distribution of the 6.3mm salt used in the trial, determined in accordance with BS 1377 (BSI, 1990), is shown in Figure 1. It can be seen that the grading curve generally fits within the limits given in BS 3247 (BSI, 1991).

4.2 Salt spreader

The spreader used for the trial was an Epoke spreader [Sirius Model SW3501 with 5m^3 capacity]. A similar spreader was used during the performance trials on the track at TRL (the same Model but with a capacity of 9m^3), as shown in Figure 2. The salting vehicle was required to adopt the "normal" spinner speed for precautionary salting operations at a spread rate of 10g/m². The maximum spreader speed was 50 km/h. The spreader was set up for asymmetrical 2-lane spreading with a spread width setting of 5m.

4.3 Spread rates

The surfacing material on the A33 trial site is hot rolled asphalt (HRA). The dry salt was mixed with the brine in the ratio 70:30, i.e. 70 per cent salt to 30 per cent brine. This is the most common combination for pre-wetted salt spreading for current applications in the UK. Therefore, with a brine

concentration of 24.7 per cent, the target application of 10 g/m^2 of pre-wetted salt used for the trial should have produced a total Sodium Chloride concentration of 7.7 g/m^2.

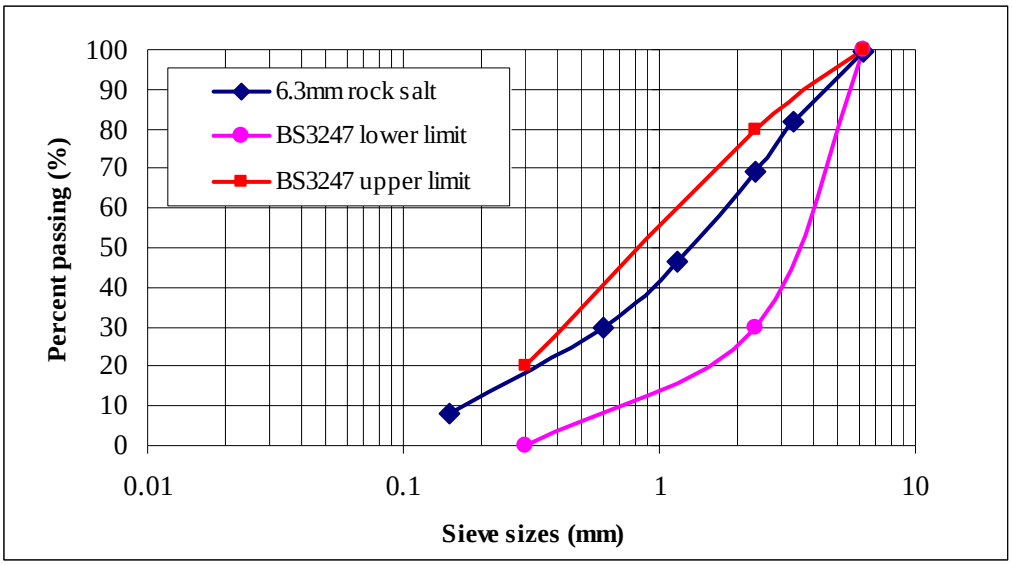

Figure 1. Grading of 6.3mm rock salt used for the road trial

Figure 2. A typical Epoke spreader during the TRL performance trial

5 Testing methodology

The detailed methodology for the road trial is summarised in this section of the report. The location of the A33 site is shown on an OS map in Figure 3. A schematic diagram of the test strips and test zones where salt was collected is shown in Figure 4. The trial site was on a slightly uphill straight section of the road with a slight bend towards the northern end of the site. The salting operation commenced approximately 1km before the start of the trial site.

5.1 Climatic conditions

The climatic conditions were monitored throughout the first night of the trial. It was generally warm with little wind. The relative humidity ranged from 78 per cent (at 18:00 hrs before commencing the first night of the trial) to 95 per cent (at 06:00 hrs the following morning at the end of the first night). The relative humidity during the second night was similar to that during the first night, ranging from 67 per cent (at 18:00 hrs) to 93 per cent (at 06:00 hrs the following morning). The relative humidity was greater than 85 per cent during the one-hour trafficking period on night 1, providing ideal conditions for salt dissolution.

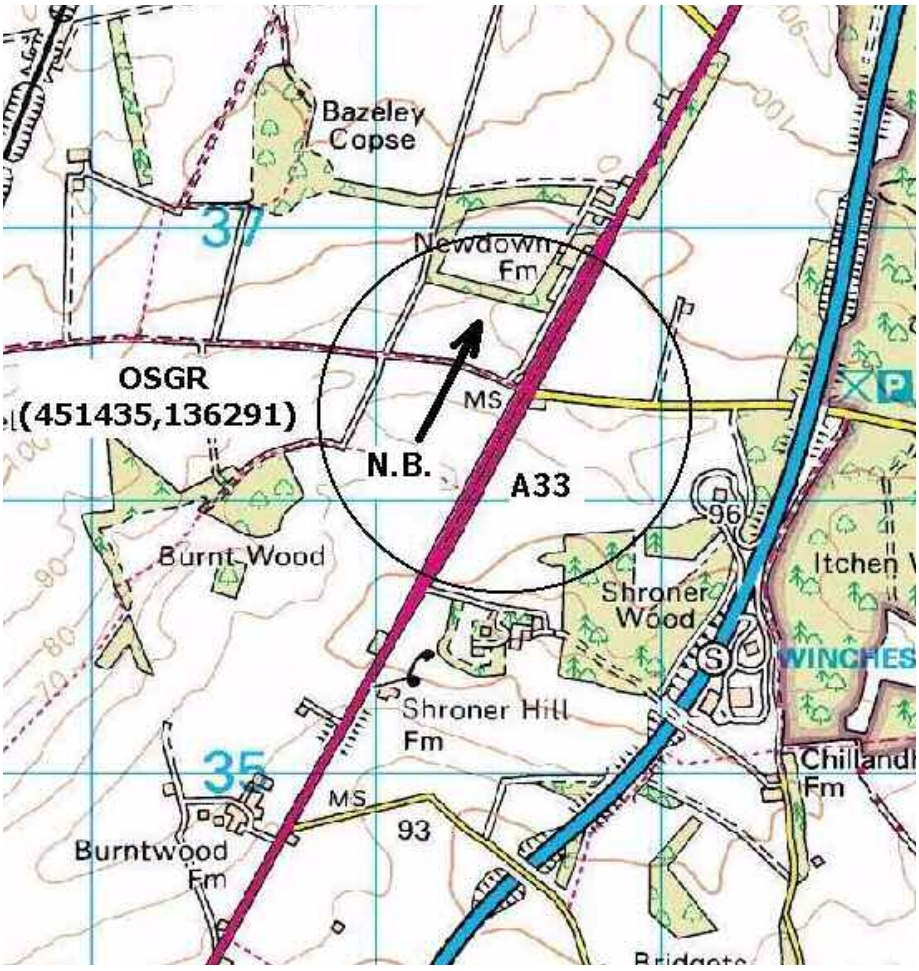

Figure 3. Location of the A33 trial site near Newdown Farm

6 Residual salt measurements

6.1 Before trafficking

Five minutes after the spreading was completed, the salt discharged was collected from three transverse strips in lanes 1 and 2 spaced 100m apart. The strips are identified as strips 1, 3 and 5 in Figure 4. To determine the salt concentration across each lane, the 3.3m lane widths were divided into 1.0m^2 quadrates to give a total of seven zones in the two lanes. There was a further 2.0m x 0.5m quadrate in the nearside hard shoulder as shown in Figure 4. To capture any salt spread onto the nearside verge, polythene sheets measuring 1.5m x 1.8m were placed on the verge, immediately beyond the hard shoulder (see Figure 4). The salt lying within the quadrates was swept up using a wet-hoover method (Zohrabi and Burtwell, 2002). This enabled 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 has been reported by Zohrabi (2003).

6.2 After trafficking

The residual salt level was assessed after one hour of trafficking on the night that the salt was applied (night 1), and after a total of 20 hours of trafficking on the following night (night 2).

6.2.1 Night 1

Once the before trafficking measurements were completed approximately two hours after spreading, the static traffic management was removed and the trial section was subjected to unrestricted traffic flows for a period of about one hour. Static traffic management was then imposed on the entire site and the residual salt was collected from a further three transverse strips, identified as strips 4, 5 and 6 in Figure 5 (grey shaded boxes), that were 100m apart and were located 25m south of strips 1, 3 and 5 respectively. The salt content was determined using the same method as for the initial residual concentration measurements.

After the salt had been collected from the test strips, the static traffic management was removed and the trial site was subjected to unrestricted trafficking until the following night.

6.2.2 Night 2

After a further 19 hours of trafficking, the site was again closed to traffic and the residual salt was collected from three transverse strips (using the wet-hoover method), identified as strips 7, 8 and 9 in Figure 6. These strips were located 75m to the south of strips 1, 3 and 5 respectively. A further transverse strip (number 10) was located 500m beyond strip 5, adjacent to Newdown Farm. These measurements were made in order to measure the residual salt level on the road surface and to assess the need for further salt application after 20 hours of trafficking on the road.

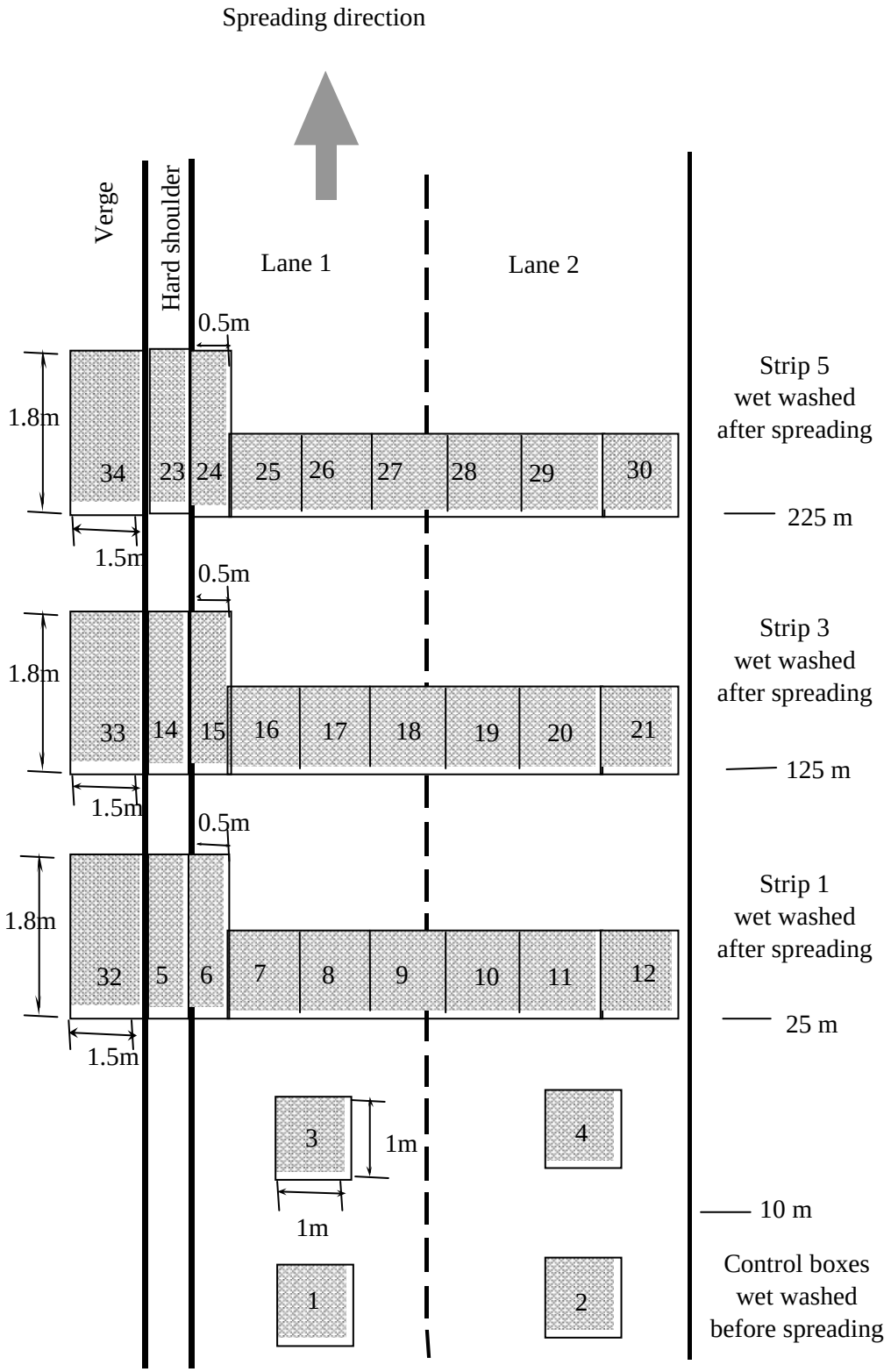

Figure 4. Zones of salt collection from the two lanes immediately after spreading

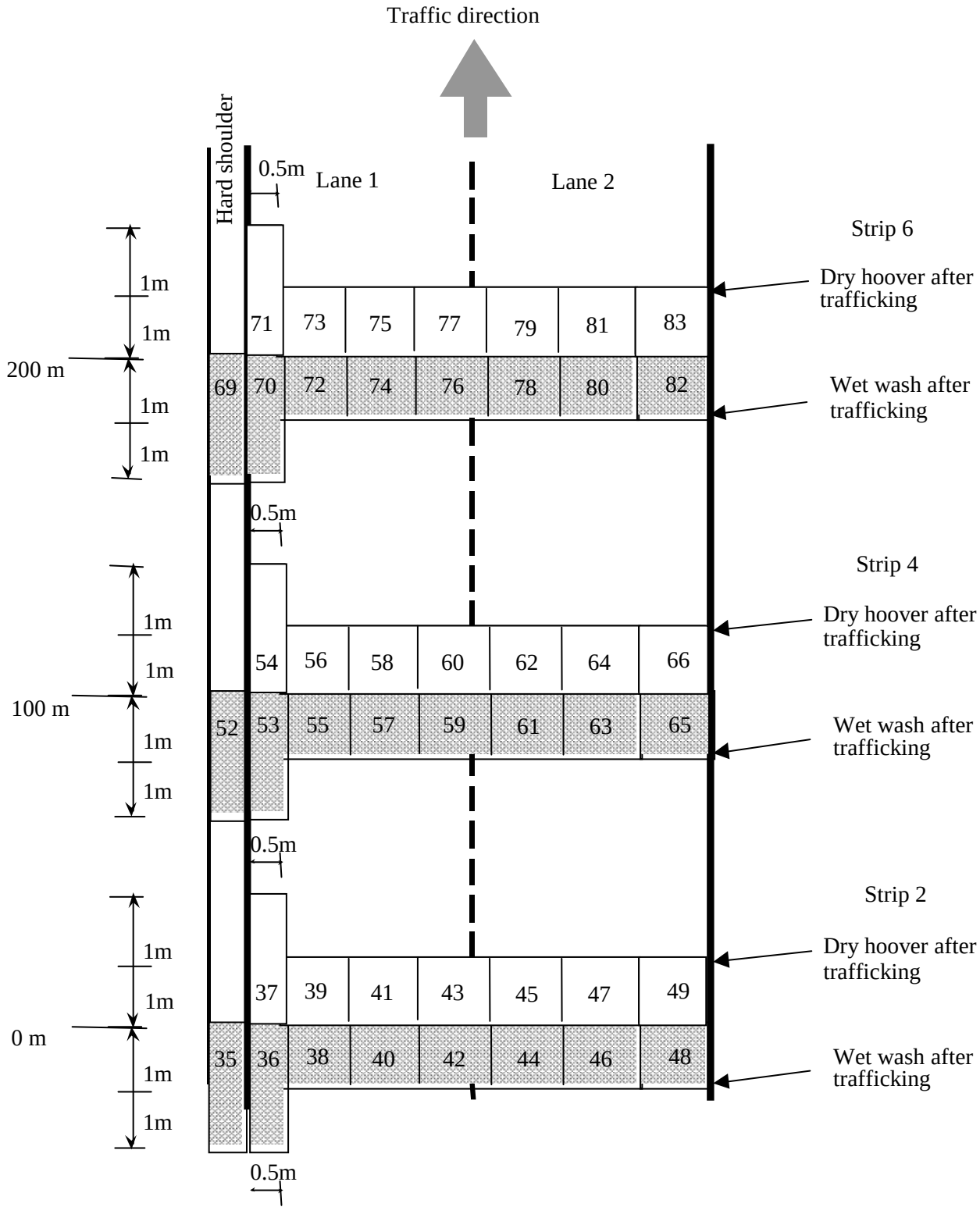

Figure 5. Residual salt measurements on the two lanes immediately after trafficking

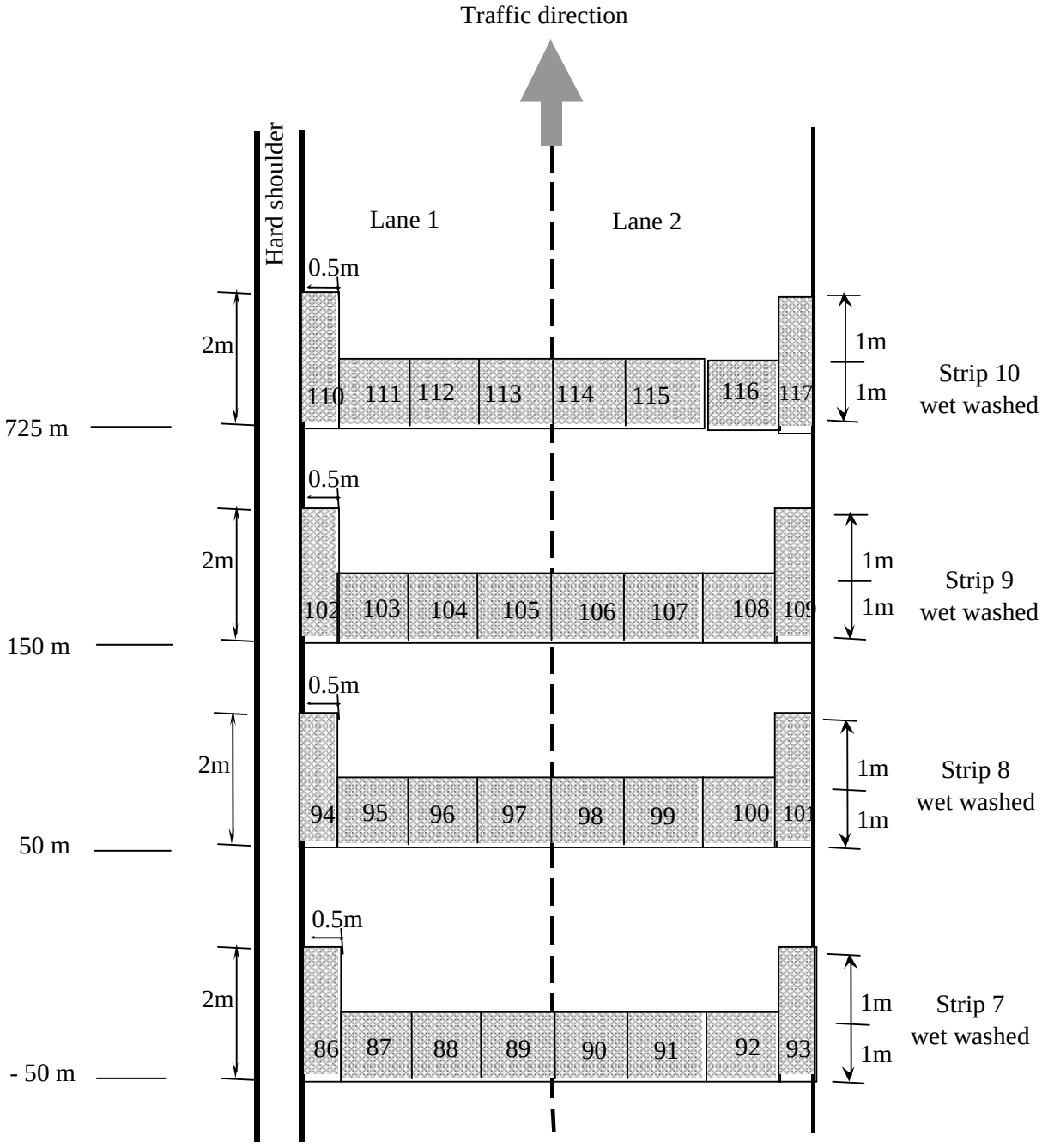

Figure 6. Residual salt measurements on the two lanes during night 2 (after 20 hours of trafficking)

6.3 Summary of results

Profiles of the salt distribution for each test strip, before and after trafficking, are given in Figures A.1 to A.3 in Appendix A.

6.3.1 Overall discharged salt

In order to check the static calibration of the spreader [see BS 1622 (BSI, 1989)] against the dynamic calibration, the total amount of salt discharged from the spreader has been quantified against the

specified target rate set on the spreader control box. The total salt discharged was estimated by fitting a second order polynomial to the data for each strip and by calculating the area under the curve as shown in Figure A.1 of Appendix A. A lane width of 3.3m was assumed to calculate the achieved spread rate as a percentage of the target spread rate. When the quadrates of the strips did not cover the full width of lane 2, the salt delivered to this lane was calculated by extrapolating the data from the quadrates nearest to the offside verge. The results are tabulated in Table 1 for the individual strips in both lanes.

The total salt discharged ranged from 108 per cent to 141 per cent of the specified target value (the spread width (5m) x the target salt spread rate (7.7g/m²)). The average for the three strips was 120 per cent. The salt delivered to lanes 1 and 2, respectively, was on average 84 and 81 per cent of the target level. The wastage was, on average, nine per cent of the salt discharged.

Table 1. Percentage of target spread rate achieved across the carriageway before trafficking

Configuration	Lane 1	Lane 2	Avg. of 2 lanes	Overall discharged salt (including the N/S hard shoulder and both verges)*
Strip 1	75	74	75	108
Strip 3	71	77	74	113
Strip 5	107	92	100	141
Avg. of 3 strips	84	81	83	120

* Estimated from second-order polynomial curve fitting to salt distribution profiles for each strip

6.3.2 Snaking effects

Longitudinal snaking is judged by the differences in the amount of salt collected from the individual test strips. The comparison of the profiles in lane 1 before trafficking for strips 1 and 3 with that of strip 5 indicates that there was some longitudinal snaking (see Table 1).

6.3.3 Effect of trafficking

The salt collected from the northbound carriageway after one hour and 20 hours of trafficking is summarised in Table 2. The salt loss in both lanes as a percentage of the salt delivered is shown in Table 3. The average salt collected before and after trafficking is illustrated in Figure 7. The amount of trafficking in each lane is shown in Table 4.

One hour of trafficking appears to have caused some salt loss from strips 4 and 6 and some salt gain in strip 2. On average 10 per cent of salt was lost across the two carriageways. The loss was reasonably uniform between the two lanes. The difference between the test strips may be caused by longitudinal snaking or the re-distribution of salt due to trafficking, even though there was little traffic during the one-hour trafficking period (see Table 4). On average, the residual salt was 75 per cent of the target spread rate.

The 20-hour distributions of residual salt levels indicate high salt loss across both lanes, with the loss amounting to 73 and 52 per cent of the spread salt in lanes 1 and 2, respectively. On average, the residual salt was 34 per cent of the target spread rate. This is important in determining the need for repeated applications after 20 hours of trafficking or longer.

Table 2. Percentage of target spread rate remaining across the carriageway after trafficking

Configuration	After one hour of trafficking			Configuration	After 20 hours of trafficking		
	Lane 1	Lane 2	Avg. of 2 lanes		Lane 1	Lane 2	Avg. of 2 lanes
Strip 2	89	82	85	**Strip 7**	13	29	24
Strip 4	60	61	61	**Strip 8**	22	33	29
Strip 6	79	76	78	**Strip 9**	34	57	45
	Not measured			**Strip 10***	18	34	26
Avg. of 3 strips	76	73	75	**Avg. of 4 strips**	23	39	34

*A 4th strip was monitored during the 20-hour trafficking period on night 1 in order to provide additional data.

Table 3. Percentage of salt loss due to trafficking across the lanes

Test strips compared	After one hour of trafficking			Test strips compared	After 20 hours of trafficking		
	Lane 1	Lane 2	Avg. of 2 lanes		Lane 1	Lane 2	Avg. of 2 lanes
Strip 1 and Strip 2	-18	-11	-14	**Strip 1 and Strip 7**	74	60	67
Strip 3 and Strip 4	16	20	18	**Strip 3 and Strip 8**	59	53	61
Strip 5 and Strip 6	26	18	22	**Strip 5 and Strip 9**	69	38	54
	Not measured			**Avg. of Strips 1, 3 and 5 with Strip 10**	78	58	68
Average values	10	10	10	**Average values**	73	52	62

Note: negative values indicate salt gain

Table 4. Number of light-goods and heavy-goods vehicles on A33 during the two trafficking periods

Route	Traffic in one-hour period*		Traffic in 20-hour period**
	LGV count	HGV count	LGV + HGV count
Lane 1 Northbound	14	2	3181
Lane 2 Northbound	12	0	

* Manual counts

** Automatic counts

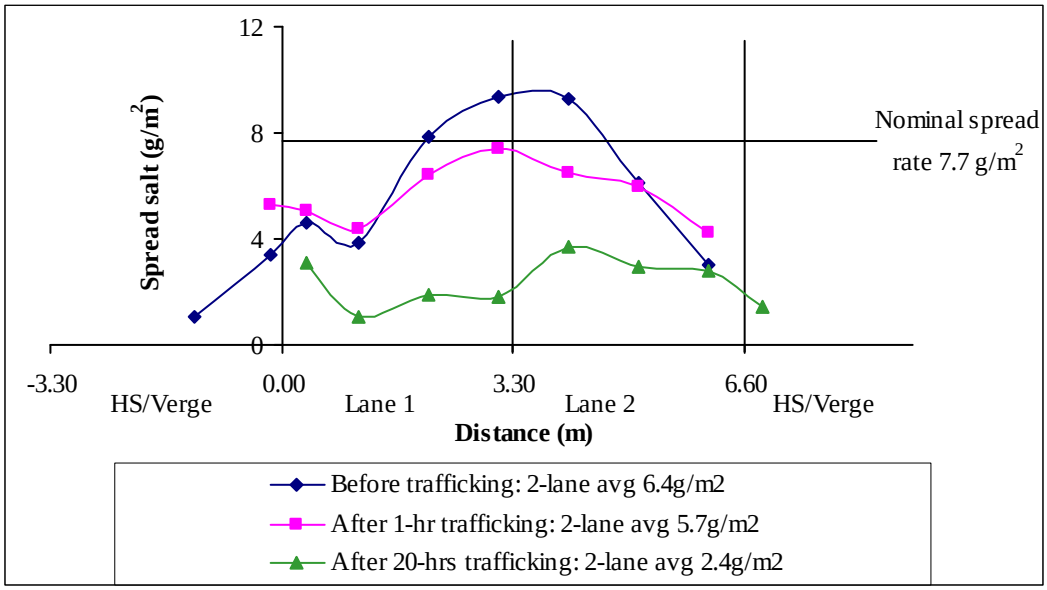

Figure 7. Averages of salt distribution profiles before and after trafficking

6.3.4 Change in salt dissolution after trafficking

The speed at which the salt dissolved was investigated in the road trial. This was measured at seven adjacent positions within lanes 1 and 2, as marked clearly in Figure 5 (in grey and clear boxes). Both the grey and clear boxes were longitudinally adjacent to on another. Starting from the nearside of lane 1, at each position marked on Figure 5, the salt deposited in a $1m^2$ quadrate was swept up using a wet hoover so that the total amount of residual salt, both that dissolved and that still as salt grains, could be calculated. Immediately following this, the dry salt deposited in a quadrate of the same size (alongside the first quadrate) was swept up by the hoover operating in dry mode in order to determine the amount of salt that had not been dissolved. The content of the vacuum cleaner was washed in the same manner as that used for wet-hoover method so that entire contents of the hoover was flushed out into sealed containers for later chemical analysis. The difference in the weight of salt from the two quadrates gives the weight of salt that had dissolved. The same operation was repeated every 15 minutes at another pair of adjacent positions, as shown in Figure 5. Under ideal conditions, the difference in the weight of the salt recovered from the quadrates should increase with time as the salt grains are dissolving. The climatic conditions throughout the trafficking as well as the after trafficking periods were suitable for the salt to go into solution (i.e. high relative humidity).

The profiles of the three strips together with the average of all three strips are shown in Figure 8. This has been broken down to individual lanes in Table 5. The results indicate a slight variation between the strips, mostly in lane 2 rather than in lane 1. Despite the same level of trafficking in each lane, the average values indicate that 44 per cent of the salt was in solution in lane 1 whereas only 9 per cent of the salt was in solution in lane 2.

The results indicate a slightly higher dissolution in the nearside wheel track of lane 1 than elsewhere across the two lanes. The road surface in lane 1 may have been warmer than in lane 2 due to higher traffic flows earlier in the day. The salt dissolution would have been higher with higher traffic volumes.

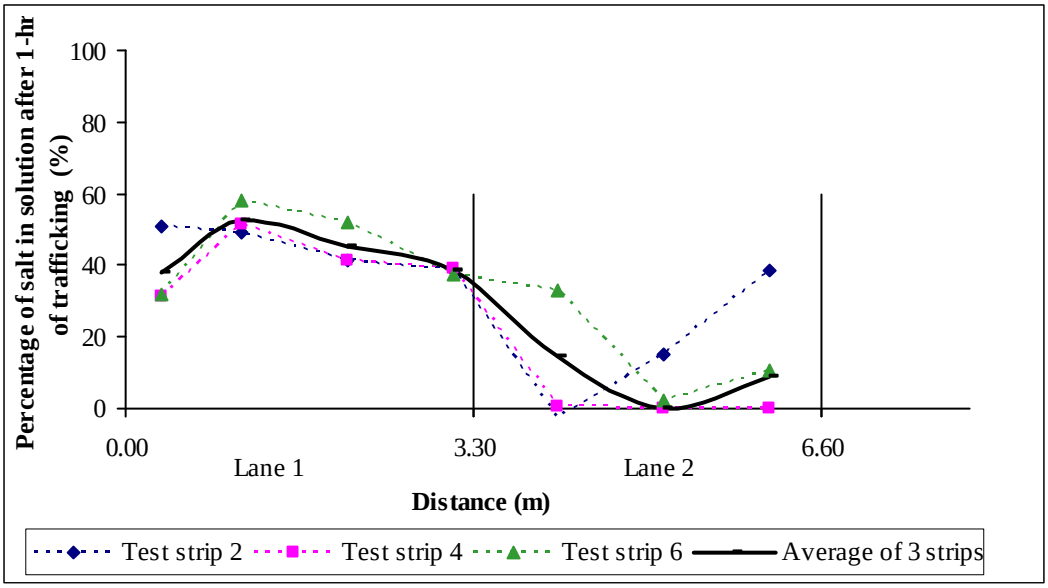

Figure 8. The amount of salt in solution across the two lanes after one hour of trafficking

Table 5. Percentage of salt in solution across the two lanes in different test strips

Position on the carriageway	Lane 1 average (%)	Lane 2 average (%)	Average of 2 lanes (%)
Strip 2	43	20	32
Strip 4	42	-20	12
Strip 6	46	21	32
Average of 3 strips	44	9	27

7 Conclusions

The general conclusions from the study of the performance of the Epoke Sirius SW3501 – 2003 model spreader are that:

1. The amount of salt discharged at three locations immediately after spreading was calculated to be, on average, 120 per cent of the target spread rate. The percentage varied from 108 per cent to 141 per cent along the carriageway.
2. The asymmetrical spread setting produced a uniform salt distribution before trafficking and, on average, 84 and 81 per cent of the target spread rate in lanes 1 and 2, respectively. Therefore, on average, the under salting was 17 per cent.
3. Comparison of the salt discharged and the salt collected from the two lanes shows that, on average, around nine per cent of the spread salt was delivered beyond the two lanes.
4. Although there was little traffic, the residual salt level remained uniform across the two lanes after one hour of trafficking, and the loss was 10 per cent of the salt delivered.
5. After 20 hours of trafficking, the residual salt loss was 73 and 52 per cent in lanes 1 and 2, respectively. This is considered important in determining the need for repeated applications.

6. The dissolution of salt was uniform between the three test strips in lane 1, being, on average, 44 per cent of the spread salt. The dissolved salt in lane 2 amounted to nine per cent of the spread salt, despite a similar, but low volume of traffic to that in lane 1. The road surface may have been warmer within lane 1 due to higher traffic flows earlier in the day. There was a slightly higher dissolution in the nearside wheel track in lane 1 than elsewhere. It is thought that there would have been more dissolution with higher traffic volumes.

8 Recommendations

Based on the pre-wetted salt spreading tested under live road conditions, there are no recommendations for further investigation.

9 Acknowledgements

The authors wish to thank Hampshire County Council for their financial contribution and for providing site assistance in carrying out the trials. The assistance of the equipment and material suppliers and contractors who contributed towards this trial is also gratefully acknowledged.

The authors wish to thank Richard Jordan of TRL for his quality audit review of the report and Robert Beaumont of TRL for his assistance with the road trial.

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Appendix A. Salt distribution profiles before and after trafficking

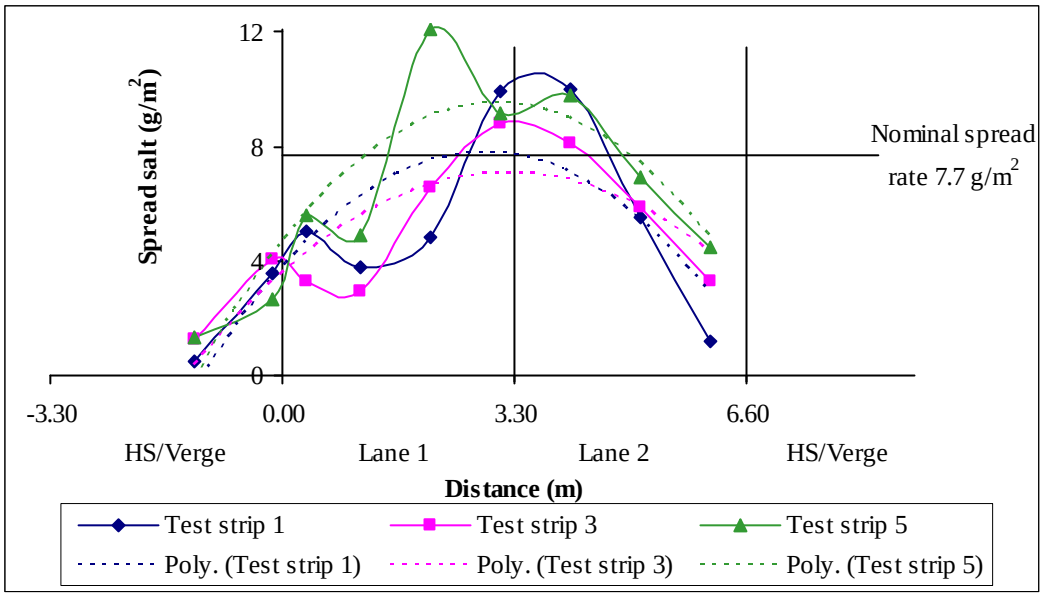

Figure A.1 Pre-wetted salt distribution profiles across three strips (100m apart) before trafficking

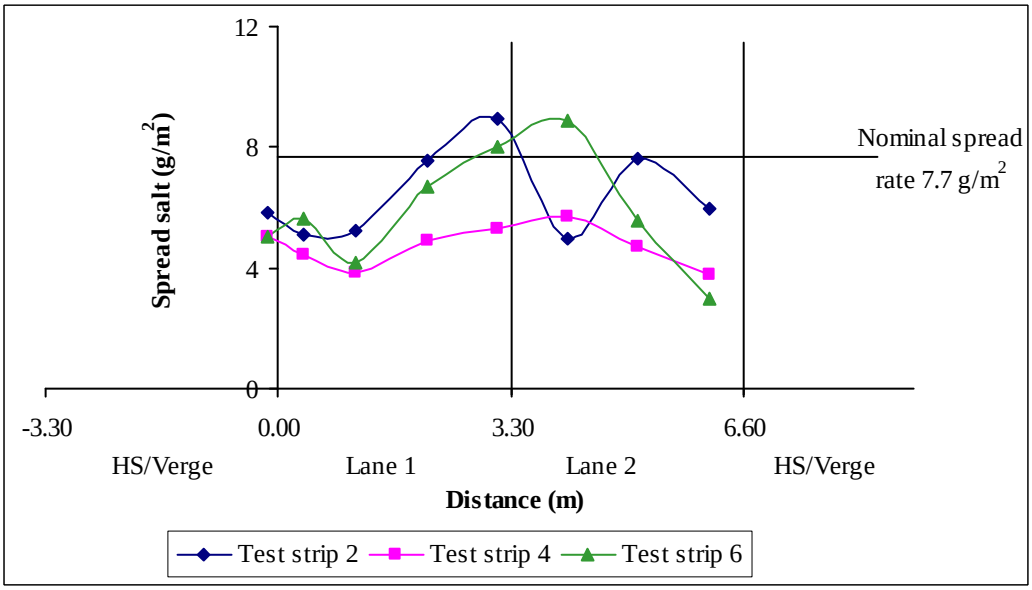

Figure A.2 Pre-wetted salt distribution profiles across three test strips (100m apart) after one hour of trafficking

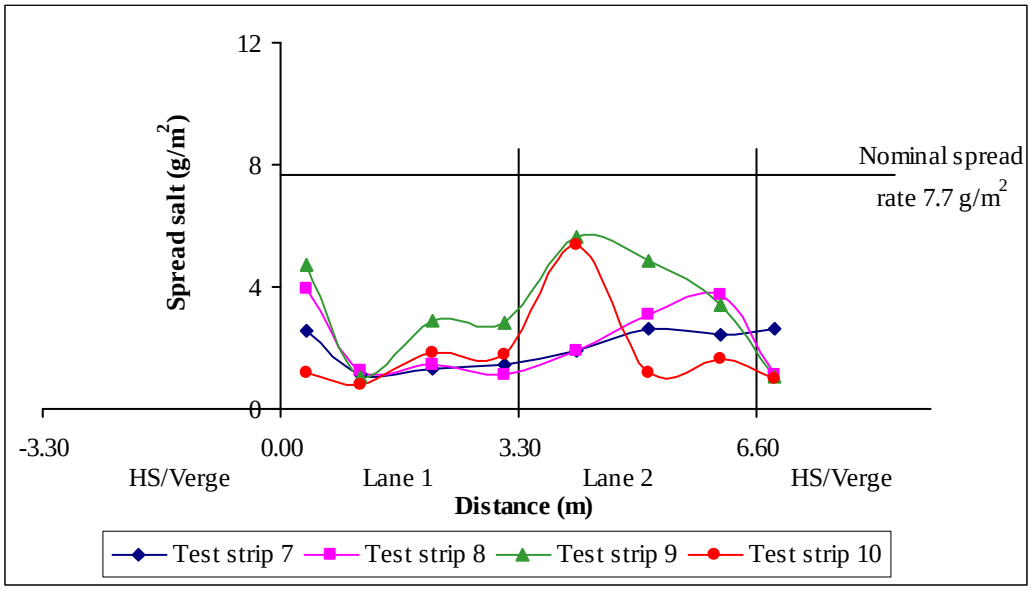

Figure A.3 Pre-wetted salt distribution profiles across three test strips (100m apart) after 20 hours of trafficking