STUDY REPORT

IAH STUDY REF: IAH C44

STUDY TITLE:	**Provision of low cost all weather cow tracks on dairy farms utilising scrap motor tyres**
STUDY LOCATION:	**Institute for Animal Health** **Compton, Nr. Newbury** **Berkshire, RG20 7NN** **UK**
STUDY SPONSOR:	**Milk Development Council** **Stroud Road** **Cirencester** **GL7 6JN** **Tel No: 01285 646 515** **Fax No: 01285 646 501**

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Study Sponsor	x 2 bound, x 1 unbound, 1x signature page (1 x bound & sig. page to return to IAH)
Investigator	x 1 unbound, if required
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STUDY PROTOCOL: **FINAL version - 25 May 2005**

STUDY DATES: **April 2005 – February 2007**

KEY WORDS: **Lameness; low cost cow tracks; locomotion scores; economics**

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SIGNATURE PAGE

The undersigned accepts this report on behalf of the Sponsor:

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Position: ....

The undersigned certify that, according to the best of their knowledge and ability, that this report is a complete and accurate description of the data generated during the study.

Investigator:

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Position: ....

Report authorised by the Head of Applied Research Group (formerly Contracts Group):

Signature: .... Date: ....../....../......

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Position: Head of Applied Research Group (formerly Contracts Group)

The Institute for Animal Health, Compton, carries out efficacy studies according to GCP standards VICH* GL9 (GCP) June 2000 implemented in July 2001 and relevant Parts of Directive 92/18/EEC. The protocol clarifies the delegations of responsibility to the IAH from the Sponsor.

* *International Co-operation on Harmonisation of Technical Requirements for Registration of Veterinary Medicinal Products (VICH).*

The Applied Research Group (formerly Contracts Group) is accredited for BS EN ISO 9001:2000 'Quality Management systems – Requirements'.

The Study Sponsor was responsible for quality assurance monitoring. All raw data will be returned to the Sponsor for archiving at the end of the study.

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Staff involved in the study were briefed on their responsibilities prior to commencement of the study. The *curriculum vitae* for the Investigator and details of the IAH organisational structure are available in the Trial Master File.

The Investigator ensured that emergency and out-of-hours contact telephone numbers of key staff were available to key personnel working in the animal unit(s). For reasons of staff security and privacy, these were not included in this protocol or the Trial Master File.

IAH C44

Low cost all weather cow tracks

SUMMARY

This study aimed to investigate low cost, all weather cow tracks comparing the existing recommended track type of woodchip peelings with a novel sand and recycled rubber tyre chippings track. The investigation included studies of cow locomotion and behavioural preferences, along with an economic evaluation of each track type and a determination of the differences in maintenance between the different tracks.

Two parallel tracks were constructed, one with a top layer of woodchip peelings and the other with a top layer of sand laid on a permeable membrane of terram on top of recycled rubber tyre chippings. A number of sub-cores were used in the track construction as there are geographical differences in product availability and indigenous materials, these will influence economic decisions when selecting the composition of sub-cores. Over the two year period that the study ran there were no problems associated with any of the sub-cores. During the course of the study the tracks were assessed for drainage and even after periods of heavy rainfall both tracks drained well. Faecal soiling on both tracks was evaluated and faecal material was rapidly dispersed equally well on both types of track.

The terram membrane did occasionally rise to the surface. This layer needs to be firmly fixed and care needs to be taken when using mechanical equipment on the track. Two problems were encountered with the sand track. Initially bedding sand was used, but this proved to be too light and there were some instances of sand blowing off the track. This problem was overcome by the use of heavier sand. Similarly at the collecting yard sand was carried into this area from the track until fibre sand was added to the mix. This entirely resolved the problem. Fencing was erected after the tracks were laid and this caused some problems with the sub-cores ideally any fencing should be erected as the tracks are built.

Lameness in dairy cattle is both a welfare issue and a major source of economic loss to the dairy industry. It is reported as having a significant negative effect on both milk production and fertility (Rowlands, et al., 1986). Summer lameness is a cause for concern and one of the major factors that influence lameness is the type of track used to access the pasture (Clackson and Ward, 1991). On some tracks cows walk considerably faster than on others and differences in cow comfort are not always reflected in a change in gait. This study aimed to investigate a more sensitive method for evaluating locomotion in dairy cows and to appraise this method on the different tracks.

Current scoring systems use a categorical system and allocate scores taking into account various factors including tracking up of feet, degree of adduction of affected legs and arching of back and are described in the literature. However, an assessment of lameness through gait alone does not reflect the ability of the cow to walk comfortably. The speed at which a cow walks is a direct reflection of the degree of pain and the comfort of the

surface e.g. firmness and traction of the track surface. Therefore the speed of walking demonstrates the confidence and comfort of the cows walking on that surface.

In the first study year it was determined that existing methods of scoring locomotion were not suitable for this study. Thus a more sensitive method for evaluating locomotion in dairy cows which included a measure of speed which represented comfort and confidence of the cows in the tracks surfaces was developed. This still used a categorical system relying on a locomotion scoring as referred to by Manson and Leaver, 1988; (Sprecher, et al., 1997 and Whay, et al., 1997 but it also included a score which reflected the speed of walking. Cows were scored from 1 to 5 for lameness with 5 being the most lame. They were also scored for the speed at which they walked along the track on a score of 1 - 3 with 3 being the slowest. Cows were scored in small groups and were allowed to walk at their own pace along the different tracks; i.e. they were not driven down the track. To avoid possible bias, each cow was scored by the same observer for each different track type, on one occasion only. The lameness and speed scores were summated to produce a "lameness:speed index" that fully incorporated both facets of locomotion and increased the sensitivity and resolution of the assessment.

Analysing the data using a two way ANOVA showed that both track type and cow were significant factors on the lameness:speed index, (track type $F_{2,232}$=181.6, P<0.001; cow number $F_{76,232}$= 7.5, P<0.001) with track type the more significant. Further analysis showed that cows walking on the wood peelings (t=-9.8, P<0.001) and sand and recycled rubber tyre chippings(t=-19.1 P<0.001) were scored significantly lower than when walking on the chalk track, and that cows walking on the sand and recycled rubber tyre chippings had lower lameness:speed scores compared with the wood peelings (t=-9.3, P<0.001).

Mechanical or biological reasons for lameness are unlikely to resolve spontaneously. Thus in the short term, the degree of lameness in itself is unlikely to decrease depending on the track on which the cows are walked. However, the speed at which the cows walk down any track is a reflection of an improvement in gait and confidence in the track and comfort of the track, and this can be evaluated by the lameness-speed index.

Both tracks were used by all cows and no cows refused to use either track. There was a preference for the woodchip peeling track and this was demonstrated in both years. A strong leader cow was also demonstrated with subsequent cows always following the lead cow in their choice of cow track.

This study confirms earlier work that the type of track that cows walk on does have an influence on lameness, but it also has an effect on the speed at which cows choose to walk down it. Even severely lame cows tended to walk more rapidly on certain types of track demonstrating that the combined locomotion score:speed index gives a better evaluation of the track surface than a lameness score alone.

Economic analysis showed that the sand and recycled rubber tyre chippings track was more expensive to construct but that maintenance for this track type was lower and that total costs over five years including start up costs would cost less. Both track types required some maintenance but this was more for the woodchip peeling track than for the sand and recycled rubber tyre chippings track.

	Set up cost/m^2 (£)	Maintenance costs/m^{2}/year over 5 years (£)	Total Cost/m^2 (£) over 5 years including set up and maintenance
Woodchip peelings	6.90	1.86/year	3.24
Sand + rubber track	11.50	0.27/year	2.57

Both track types resulted in a saving not only attributed to cost savings due to reduced lameness, but also as a result of time saved in bringing in cows from the grazing areas. These savings are similar on either cow track Typical financial loss for an episode of lameness requiring veterinary treatment includes about £72 in direct costs and when reduced fertility and production are included this rises to about £246 (Kossaibati and Esslemont, 1999). In this study the incidence of lameness was reduced by 10% which resulted in savings of £720 in direct costs per 100 cows and £2460 in indirect costs per 100 cows. The labour saving on this is between £530 to £711 per year, depending on the skill type of the worker employed.

STUDY BACKGROUND

1.1 Aim

To investigate low cost, all weather cow tracks, in terms of cow locomotion and behavioural preferences and maintenance of the tracks, along with an economic evaluation of each track type.

1.2 Introduction and justification

Matters of quality assurance, study administration and contractual considerations are detailed in Appendix 1 of the Final version of the Protocol.

Lameness in dairy cattle is both a welfare problem and a major source of economic loss to the dairy industry. It has a significant impact on milk production (Rowlands, Russell and Williams, 1986) and an association between lameness and reduced fertility has also been reported (Lucey, et al., 1986). Therefore early detection of lameness is essential to minimise the impact on cow health (Green, et al., 2002).

Lameness is considered a major problem in dairy cows both during housing and grazing periods. When cows are housed in the winter lameness is increased (Manson and Leaver, 1988). However summer lameness is also a cause for concern and one factor that can influence summer lameness in dairy cattle is the type of track along which they walk (Clackson and Ward, 1991).

Lameness is a multi-factorial problem and includes cow factors such as conformation and management factors such as floor surfaces. Under field conditions lameness can be scored using a rank scoring system which has been shown to be both rapid and highly repeatable (Manson and Leaver 1988). Cows are scored walking away from the observer over a distance of 5 to 10 metres. This method has been adapted to give a simple five point scoring system (with no half scores), where 1 is considered normal and 5 is considered severely lame (Whay, Waterman and Webster, 1997, Wells, et al., 1993). These scores include a category for imperfect locomotion or uneven gait for cows that are unsound but not clinically lame and this simpler system was adopted for UK trials on farm lameness (Faull, et al., 1996, Hassall, et al., 1993). It has been reported that floor and track surfaces influence cow locomotion, in terms of foot pathology, gait and speed of walking (Phillips and Morris, 2001).

Major factors when considering a cow track are not only the initial economic cost of the track installation, but also its likely longevity and the impact of ongoing maintenance costs. The cost benefit relationships of the different track types were determined and this included initial costs and the results from the durability studies.

MATERIALS and METHODS

2.1 Study outline

Two parallel tracks were constructed, one with a top layer of woodchip peelings and the other with a top layer of sand laid onto a permeable membrane of terram on top of recycled rubber tyre chippings. A number of sub-cores were used in the track construction as there are geographical differences in product availability and indigenous materials, and these will influence economic decisions when selecting the composition of sub-cores.

The study was carried out over two years and split into preference and locomotion studies for each of the two years. The tracks including sub core and top core were identical for both years. It was intended to take samples for analysis of the track composition, during both study periods, to determine track durability but this proved not to be feasible.

In the first year, the preference study consisted of between 50 to 100 early to mid lactation cows using the tracks over a six week period. For the first two weeks the cows were allowed access only to the woodchip peelings track; for the subsequent two weeks they had access the to sand and recycled rubber tyre chippings track. For the fifth and final week cows were allowed access to both tracks and towards the end of this period their preferred track was determined.

In year two, a second preference study was carried which additionally took into account the lead cow effect and whether this influenced subsequent cows' choice of track.

In the locomotion study covered both gait and walking speed were assessed. During 2005 there was an initial study period during which it was realised that the cows walked too quickly on the sand and recycled rubber tyre chippings track or woodchip peelings track to score them as indicated in the literature. Normally scoring as the cows walked away over five to ten metres was reported as being feasible but it required a much longer observation period on the tracks to generate scores in this study. The lameness scoring and speed of walking was reassessed for the second year in order to be able to generate data and the scores were then combined to give a lameness speed index which was felt to be a more accurate reflection of the cows' response to the tracks.

Samples from top surfaces of both the tracks were taken in the first year and analysis of the samples was carried out by the Diagnostics Laboratory to indicate if there was any difference in bacteriological isolates.

An economic analysis was carried out after the first year, taking account of both initial track costs as well as ongoing maintenance costs. This was continued for the second year and subsequently ongoing costs over a five year period were calculated from the two study periods.

2.2 Masking

Masking was not undertaken in this study.

INVESTIGATIONAL and COMPARATOR PRODUCTS

Test product:	Track 1 - comparator	Track 2 - investigational
Identification:	Wood chippings	Sand/rubber chippings
Product composition:	Wood peelings	Sand/recycled rubber tyre chippings
Sub core:	See table below	See table below

There were two parallel tracks, each 200 metres long and 3 metres wide. Track 1 had a top layer of 120 mm of woodchip peelings and track 2 had a top layer of approximately 120-180 mm of sand, laid on a terram membrane (permeable membrane) on top of 120mm of recycled rubber tyre chippings. Along the length of each track at either 25 or 50 metre intervals, the sub core changed. The composition of the sub core was as follows: starting nearest to the milking parlour exit was 50 metres of Type 1 aggregate (350mm), then 25 metres of open stone (200mm), then 25 metres of cement bound granular sub-base (350mm), then 50 metres of recycled aggregate (350mm) with 50 metres of ground rock chalk last. Along the length of both tracks above the sub core but below the top surface was a terram membrane. A terram membrane was also present below the sub core for the woodchip peelings track alone (Figures 1 and 2).

Figure 1 – Cross sectional diagram along length of track to indicate different track construction

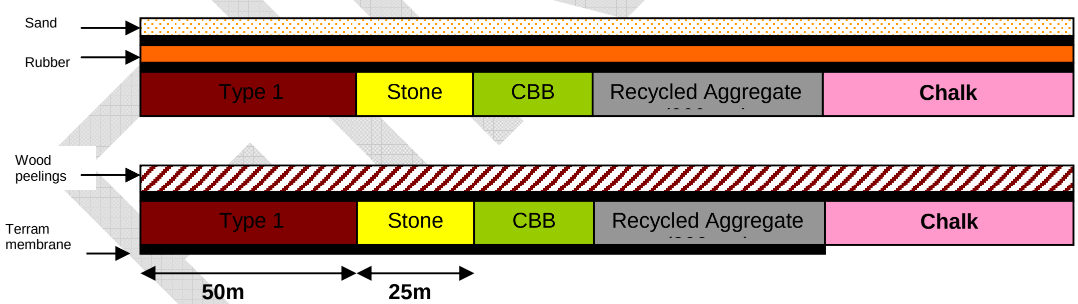
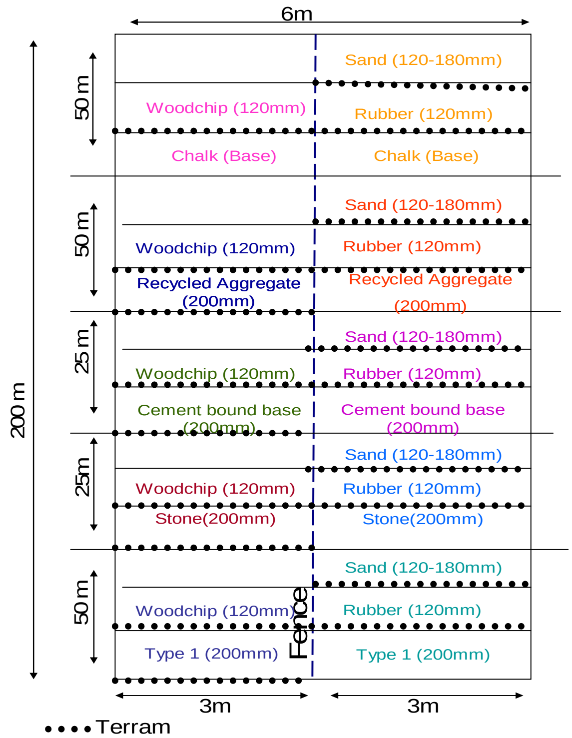


Figure 2 - Cross section at 25 or 50m intervals along the length of the track to show the different constructions



ANIMAL SELECTION

4.1 General information:

Species	Bovine
Breed	Holstein Friesian mixture
Number	Approximately 350 cows in total
Gender	Female
Approx. age on Day 1	Adult
Supplier	IAH farm – Mayfield Dairy Unit
Health status	Not applicable

4.2 Inspection and screening of animals

Animals were inspected at intake and a foot map was provided by a qualified foot trimmer Data Capture Forms (DCF) 1 and 2. Animals were inspected as required either by the study investigator, farm veterinary services or study observer and foot maps were recorded whenever necessary.

4.3 Animal inclusion/exclusion and post-inclusion removal criteria

All animals using the cow tracks on a regular basis were included in the study. Animals were excluded following discussion with the study sponsor.

4.4 Animal identification

Animals were uniquely identified by means of double ear tags, freeze branded numbers. Freeze brand numbers were used throughout the study for recording data and the electronic system to identify cows for milking.

4.5 Allocation to track and randomisation (SOP AP/1006)

For the preference study, cows were allocated to the woodchip peelings track alone for the first two weeks and then to the sand and recycled rubber tyre chippings track for the following two weeks. Then the cows were allowed to choose their preferred track for one week. This study ended at this time point.

For the locomotion study, all cows were allocated to one of four management groups (high yielders, mid yielders, low yielders and heifers); two management groups were allocated to one of the two tracks. In approximately July, mid grazing period, the management groups were changed to the other track. Each track was used by each management group for approximately equal time periods. Only two management groups were allocated per track at any one time, to ensure even use of each cow track.

ANIMAL MANAGEMENT

5.1 Location and housing, feeding, water and routine husbandry

The study was carried out at the Mayfield Dairy Unit under full commercial conditions. Some animals were housed overnight, depending on climatic and management factors.

The cows were fed a mixed, balanced forage diet; diet details were recorded as part of routine farm management and were retrieved only as necessary.

Chlorinated water from the chalk strata supplied from IAH's own borehole was available.

Cows were milked in the main 36-unit rapid-exit herringbone milking parlour. The cows were milked according to management group, from approximately 05.00h and approximately 15.00h daily for the whole monitoring period.

5.2 Disease precautions and safety when handling animals

There were no special disease precautions.

Routine safety precautions were followed with regard to handling animals.

OBSERVATIONS AND MONITORING

6.1 Clinical examinations and scoring

Foot trimming was carried out prior to the cows using the cow tracks and the data were recorded in DCF 1 and DCF 2 where appropriate.

Foot examinations were carried out where necessary.

Preference study

The cows were checked at weekly intervals to ensure there were no problems using the allocated track.

First study period

A preference study was carried out on one group of cows, after all the cows had been allowed access to both tracks in August.

A second preference study was carried out in September on a second group of cows that had been allowed to walk only on the woodchip peelings track for two weeks and then only on the sand and recycled rubber tyre chippings track for two weeks. After approximately five days of access to both tracks, an assessment of cow preference and speed of walking on the chosen track was carried out. Scores were recorded on DCF 4.

Second study period

A preference study was carried out in the second study year to take into account the lead cow effect, as it had been noted that cows, as herd animals, frequently follow the cow in front. The purpose was to attempt to separate cow preference from the leader cow effect and to identify actual cow preference. After a period during which the cows had been allowed to access either track, the tracks were then closed and access restricted.

For the first week, the cows were allowed access only to the woodchip peelings track; during the second week they accessed only the sand and recycled rubber tyre chippings track. On the third and final week cows were allowed access to both tracks and towards the end of this period their preferred track was noted.

On one occasion observations were made twice. Their preference was noted when they walked from the field to the collecting yard and then again when they walked from the collecting yard to the field. They were released in groups of 10-12 animals and observed from a point near the beginning of the tracks, with the observers hidden from their view.

Locomotion study

First study period

Approximately 3 to 4 weeks after foot trimming and turn out, it was intended to score cows for gait and speed of walking. However the cows walked too fast on both the tracks and the foot was covered by the sand particularly making scoring of gait very difficult. Dr Bell from Bristol University visited and agreed that it was not possible to score the cows for gait on the tracks (particularly the sand and recycled rubber tyre chippings track). Speed was scored using a scale of 1 to 3, where 1 is equivalent to fast pace and 3 is equivalent to slow pace. However, all the cows walked much faster on the tracks than on concrete, so the cows were subsequently timed over set distances. Scores were recorded on DCF 3.

Second study period

In the second year the lameness and speed were both scored using the following system. The lameness and speed scores were combined to give to lameness:speed index which was more sensitive than a lameness score alone. This was felt to be more representative than a lameness score alone for the track types being considered. A low score represented a relatively sound cow walking at a fairly fast pace and a high score was equivalent to a very lame cow walking at a slow pace.

Lameness and speed scoring system

Score	Description	Assessment
Lameness scoring system		
1	Normal	Cow stands and walks with a level back. Gait is normal.
2	Mildly lame	Cow stands with a level back, but develops an arched back to walk. Gait slightly abnormal
3	Moderately lame	Arched back is evident both standing and walking. Gait is short strided.
4	Lame	The cow's back is always arched and the gait is one deliberate step at a time. Cow favours one or more legs
5	Severely lame	Cow is reluctant to weight bear on one or more legs. May refuse to move from a lying position.
Speed scoring system		
1	Rapid	Cow moves very quickly along the track faster than a comfortable walking pace.
2	Moderate	Cow moves at comfortable walking pace.(brisk human walk)
3	Slow	Cow moves very slowly.
Combined lameness speed scoring index		
2	Rapid walking normal	No lameness observed and brisk walking speed.
8	Slow severely lame	Slow speed and cow is reluctant to walk or weight bear on one or more legs.

In the second study period the two different types of track were evaluated against the chalk track that led into the two tracks from the field. This track was felt to be reflective of a good farm track. Eighty low to mid yielding Holstein dairy cows were divided up into smaller groups of 5-6 cows and allowed to walk down the sand and recycled rubber tyre chippings track, followed by the wood peelings track and finally down the sand and recycled rubber tyre chippings track. As they walked along each track they were scored on a score of 1-5 for lameness, with 5 being the most lame and for the speed at which they walked along the track on a score of 1 - 3 with 1 being the fastest. The cows were allowed to walk at their own pace, they were not driven down the track by a herdsperson or dog. Each cow was scored on all three types of track at one time point and by the same observer for each different track type, to avoid possible bias in observer.

6.2 Suspected adverse drug reactions (ADRs), unexpected events and incidental occurrences

There were no suspected ADRs, unexpected event or incidental occurrences.

RESULTS AND DISCUSSION

Track construction

Track construction was carried out as detailed in the protocol without any deviations. The tracks on either side were finished off with either peelings or sand onto a terram membrane (as appropriate to the main track type) before joining a common well tamped chalk track which gave final access to the fields.

No difference was observed over the two year study period, in relation to the sub core and it was assumed that all sub cores were suitable for the top cores used in this track construction.

The selection of sub core composition is related to various geological factors and the most important are soil and drainage type.

There were occasional incidences of the terram membrane surfacing. This was overcome by fixing this layer down more robustly. It was also essential that the use of mechanical equipment to rake the track was undertaken by trained personnel.

Fencing was erected after the completion of the tracks and this did cause some difficulties. When constructing tracks it would be advisable to construct any fencing required at the same time as the tracks.

Table 1 - Ground type and foundation requirements

Type of ground	Condition of ground	Test	Undrained shear strength (kPa)	Foundation requirement
Rock	Equivalent to sandstone, limestone or firm chalk	Requires mechanical pick or pneumatic for excavation	>150	None, can be built direct onto ground subject to suitable drainage
Gravel or sand	Medium dense	Requires pick for excavation	100 – 150	100mm of hardcore fully compacted.
Clay or sand	Stiff	Cannot be moulded by fingers, can by slightly indented by thumb	75 – 100	200mm of inert hardcore, Type 1 or recycled aggregate fully compacted
Clay or sandy clay	Firm	Can be moulded by strong finger pressure. Thumb makes impression easily	50 -75	200mm of inert hardcore, Type 1 or recycled aggregate fully compacted.
Sand **Silty sand** **Clayey sand**	Loose	Can be excavated easily by spade	40 – 50	250mm of inert hardcore, Type 1 or recycled aggregate fully compacted.
Silt **Clay** **Sandy clay**	Soft	Can be moulded by light finger pressure and finger pushed in up to 10mm	20 – 40	300mm of inert hardcore, Type 1 or recycled aggregate fully compacted
Silt **Clay** **Sandy clay**	Very soft	Finger pushed in up to 25mm	<20	Refer to specialist advice

Note: This table is for guidance only. Ground conditions can vary widely even within a very small area, so if there is any doubt about foundation requirement, specialist advice should be sought.

Ground conditions of sand and sand types or clay and clay types are sometimes suitable for lime or cementitious soil stabilisation techniques, which would reduce the foundation requirement. Such soils can be stabilized in a variety of ways, but usually use the addition of a hydraulic binder (cement, lime, pfa, slag) to consolidate the ground. This reacts with the alumina and silica to form calcium alumino silicates which exhibit hydraulic properties. This means that the soil now shows good load bearing capabilities and are thus stabilised for sub-base construction.

Gradient

Both tracks were along an incline which increased along the length of the track from the housing towards the pasture areas. The gradient by the housing was 4%, which increased to 8% 75 metres along the track, finally finishing at a gradient of 12.5% near the fields.

Track maintenance

The tracks were completed in May 2005 and all cows had access to the tracks by the end of May 2005. Cows were still using the tracks in October but by a greatly reduced number.

After two months it was felt that large amounts of the sand were being blown on to the concrete collecting yard from the adjacent track area. The initial sand used on the track was fine sand similar to that used for bedding. It was decided that coarse concrete sand with a particle size of 4 to 5 mm would reduce this problem. Although the remaining sand on the track would have become coarser over time, with a larger particle size, it was felt necessary to top up this area to speed up the process for purposes of the study. Similarly at the beginning of the study sand was carried off the track into the collecting yard. This was overcome by the addition of fibre sand to the last 5 meters of the track.

The peelings on the woodchip peeling track disintegrated over a period of two to three months and it became necessary to top up this track in the middle of the grazing period. It was apparent by the end of the first grazing period (early October 2005), that this track also required topping up. However it was felt more appropriate to leave this until the new grazing period in 2006 as the track would have minimal use over the winter.

The tracks required occasional raking for maintenance. Raking was required in particular after the winter break period where rain water had flowed down the track causing erosion. This was especially noticeable on the sand and recycled rubber tyre chippings track. However, as soon as cows started using the track again the sand became more evenly distributed. Both tracks were used on a daily basis by mechanised vehicles (quad bike). This practice did lead to obvious wear on the peelings track where the vehicle tyres went, but had no adverse effects on the sand and recycled rubber tyre chippings track.

Over the two year period of the study the tracks were evaluated on a monthly basis for drainage and even after very heavy periods of rain both tracks continued to drain well. The tracks were also assessed for faecal soiling and on both tracks the accumulation of faecal material did not occur. Occasional assessment of bacterial counts on the tracks similarly revealed no serious contamination problems on either track.

For those tracks on an incline, especially greater than 8%, additional maintenance and extra topping up after the winter period may be necessary due to rain running down the tracks.

Cow movements

Cows were able to use both tracks without any obvious problems. The tracks in this study had been constructed at 3 metres wide to accommodate use by mechanised vehicles. However, it was noted that cows infrequently tried to walk down the tracks two abreast and that this only occurred on occasions where a cow tried to overtake another cow that was walking more slowly. Previous observations by other groups on cow track movement also noted that the cows tended to walk in single file and that the width of the track only needed to be 1.2 metres wide (MDC Reaseheath Study). This study similarly concluded that tracks 1.2 metres wide were sufficient if a track was to be solely used for cows.

First study period (June 2005- October 2005)

Preference studies

Initial preference studies carried out after cows had been allowed free access to both tracks did not indicate a large difference in preference. This may have been due to the fact that all cows had not tried both tracks and were using the track first accessed on going out to graze and had not changed or tried the other track. The weather was sunny and temperature 24^{o}C.

Table 2 - Initial preference study

Track	Woodchip peelings	Sand/shredded tyre
01.09.05	40 cows	37 cows
02.09.05	42 cows	35 cows
Average	41 cows (54 %)	36 cows(46 %)

A second preference study was carried out at the end of September on a second group of cows which had been allowed access to only one track for two weeks and then the second track for the next two weeks and then allowed to access either track. This showed a preference for the woodchip peeling track (55 cows (65 %) to 31 (35 %) respectively). The weather was cold (12 ^{o}C) with intermittent rain.

Lameness and speed trials

The cows walked much faster on both tracks than had been initially expected. It was not possible to score for gait abnormalities on either track for the whole herd as detailed in the protocol. All cows walked or trotted down the tracks with a very obvious slowing up when leaving the track and entering the concrete area adjacent to the collecting yard. Only those cows with a lameness score of 4 and over were still obviously lame on the cow tracks.

A series of speed trials were carried out on a group of 10 to 40 cows over distances of 50 to 100 metres, going both and down the tracks and on the level on concrete. The cows exhibited a range of lameness scores in order to standardise for normal farm conditions.

Table 3 - Speed trial times

Speed in seconds	Woodchip	Sand	Concrete
Speed uphill over 100m(10 cows)	93	73	Not available
Speed downhill over 100m (10 cows)	93	77	Not available
Speed on level over 50m (10 cows)	Not available	Not available	47
Speed uphill over 50 m (40 cows)	40	35	Not available
Average speed (in seconds over 50 metres)	40	35	47
Range in seconds	35 to 52	31 to 40	38 to 60

However, all walked much faster on the tracks than on the concrete, with the sand and recycled rubber tyre chippings track being faster than the woodchip peeling track. There was a wide range of times over all the tracks and a direct comparison between concrete and the tracks was not possible, as the concrete area was on the level and both tracks had an incline over the whole of their length. Average speed on the woodchip peelings track was taken for the larger group of cows over the shorter period.

Second study period (April 2006 to October 2006)

The lameness and speed scores were summed to produce a lameness:speed index that fully incorporated both facets of locomotion and increased the sensitivity and resolution of the assessment. The normal (not lame) cow walking at a brisk pace would have a low score (2) but a severely lame cow walking slowly would have a high score (8) and there would be a range of cows with scores in-between, dependent on both their lameness score and speed score.

This was $\log_{10}$ transformed and used as the response variable in a two way general linear model (Minitab 14.0, Minitab Inc., PA, USA), with cow number and track type as factors. Both factors significantly affected the lameness:speed index, (track type $F_{2,232}$=181.6, P<0.001; cow number $F_{76,232}$= 7.5, P<0.001), with track type the more significant factor. Tukey post hoc tests showed that cows walking on the wood peelings (t=-9.8, P<0.001) and sand and recycled rubber tyre chippings(t=-19.1 P<0.001) had significantly lower lameness:speed score than when walking on the chalk track (Figure 2). The cows walking on the sand and recycled rubber tyre chippings had a lower lameness:speed score compared with the wood peelings (t=-9.3, P<0.001). This is illustrated in Figure 2.

Figure 2 - The mean (±s.e.) lameness-speed score of 78 cows walked sequentially down three different types of cow track; a chalk track, a track composed of wood peelings and a track composed of sand and recycled rubber tyre chippings

Second preference study

The cows still showed a preference for the woodchip peelings track.

There was shown to be a strong lead cow effect with five to ten cows following the lead cow when released in groups.

Economic costs

The costs for the tracks were subdivided into the sub core costs and the top core costs.

The different sub cores equate to those suitable for all geographical regions in the United Kingdom, along with a cost for recycled aggregate. For many farms recycled aggregate would possibly be free, depending on the individual circumstances. However, it will be necessary to ensure that the aggregate is suitable for the top core and it may need to be broken up and levelled. The Institute for Animal Health is on a chalk sub core and this was given a zero pricing on the cost table. These costs are exclusive of labour used to lay the sub cores. This will be dependant on individual farm circumstances and could involve substantial earth moving or just a simple laying of sub core in a suitable area. Construction of the tracks does not constitute as landfill.

Table 4 - Sub core costs

	Section Length	Quantity used (units)	Cost per unit (£)	Total cost/track (£)	Total cost/m^2 (£)	Original estimated costing (£)
Natural Chalk	50m	Nil	Nil	Nil	Nil	Nil
Recycled aggregate	50m	120 tonnes	£7.50/ tonne	450	3.00	5.36
Cement bound base	25m	30 m^3	£53/m^3	840	11.20	12.88
Stone	25m	60 tonnes	£11.50/ tonne	345	4.60	Not available
Type 1	50m	120 tonnes	£11.50/ tonne	690	4.60	6.99

Table 5 - Top core costs for first year and maintenance costs for subsequent years

	Length	Quantity (units)	Cost per unit (£)	Total cost/track (£)	Cost/m^2 (£)	Maintenance cost/ m^2 /year
Woodchip peelings*	200m	100m^3	£8/ m^3	900.00[a] 1237.50[b]	1.50[a] 2.06[b]	1.86 [b]
Rubber	200m	40 tonnes	£57.30/tonne	2292.00	3.82	Not relevant
Sand	200m	180 tonnes	£9/tonne	1620.00	2.70	0.27
Terram	350m (Wood peelings) 400m (Sand & Rubber)	Not applicable	0.55/m^2	577.50 660.00	0.55/ m^2	Not relevant

* Includes material used to top up
[a] Excluding cost of haulage, [b] including cost of haulage
Each terram roll £120 per 400/m^2 roll and price includes 0.25/m^2 cost of laying

Table 6 - Total cost of each track type over 600 m^2, Year 1

	Total cost sub core	Total cost top core	Terram cost	Total track cost (£)	Cost/m^2 (£)
Woodchip peelings	2325.00	1237.50	577.50	4140.00	6.90
Sand + rubber track	2325.00	3919.00	660.00	6897.00	11.50

- Exclusive of VAT and labour
- Assuming materials used for sub core were split equally between the two tracks and so total cost for the sub core has been divided in half.
- Top up for sand and wood chips has been included.
- Including haulage

Ongoing costs

Assuming the sand and recycled rubber tyre chippings track is topped up by 25% for only the sand every 2-3 years (2.5 years for calculations), the cost of the track after 5 years is estimated at £0.27 /m^2/year (£6897 set up cost + (2 x £405 Sand top up)/600m^2/5 years).

As the woodchip peelings are less durable, it is estimated that this track would need to be topped up by 50% at turnout and a further 50% mid-season; this is equivalent to £1.86 /m^2/year (includes nine peelings top ups (£5568.75) and two sets of haulage costs: one at the start of the year and mid grazing season ; (£4140 set up+ £5568.75) /600m^2/5 years).

Both estimates include haulage costs but exclude VAT and labour and inflation. Assumed costs are as indicated in Tables 4 - 7. It is also assumed that the terram and sub-cores would not need to be augmented within a five year period.

Over a five year period the wood chip peeling track would cost £9.30 /m^2 and the sand and recycled rubber tyre chippings track would cost £1.35 /m^2 if topped up every 2 to 3 years and £3.38/m^2 if topped up every year.

Looking at the entire cost of the tracks, including set up costs and maintenance costs spread over a five year period, the sand and recycled rubber tyre chippings track would cost less to set up and maintain than the woodchip peelings track (£2.57/m^2/year compared with £3.24/m^2/year) (Table 7).

Depending on the terrain and gradient of the land (8% and greater), additional maintenance after the winter period may be necessary with a further requirement for topping up with sand or whatever bedding type.

Table 7 - Total cost of each track type over 5 years

	Set up cost/m^2 (£)	Maintenance costs/m$^{2/}$year over 5 years (£)	Total Cost/m^2 (£) over 5 years including set up and maintenance
Woodchip peelings	6.90	1.86/year	3.24
Sand + rubber track	11.50	0.27/year	2.57

Savings attributed to using a cow track

These can be mainly assumed to be due to reduced lameness due to using a purpose designed cow track and will include decreased veterinary costs, decreased lameness treatment costs and decreased culling. Such savings would be equivalent to either cow track Typical financial loss for an episode of lameness requiring veterinary treatment includes about £72 in direct costs and when reduced fertility and production are included this rises to about £246. In this study the incidence of lameness within the herd decreased. In the summer of 2004 before the tracks were introduced the incidence of lameness recoded on 'interherd' was 16% (58 recorded instances of lameness in a herd of 370) after the cow tracks were introduced this decreased to 6% (27 recorded instances of lameness in herd of 490) in the summer of 2006.Using the figures above the savings attributable to a reduction in lameness of 10% were £720 in direct costs per 100 cows and £2460 in indirect costs per 100 cows.

For both tracks it was observed that bringing in the cows for milking was much faster. This would probably equate to 15 minutes as opposed to 30 minutes. Assuming an entire grazing season of 180 days with twice daily milking, this would be equivalent to 90 hours saving in labour. Taking a minimum wage of £5.35 (for those over 22 years of age) or an agricultural wage of £6.31 to £7.18 for an agricultural worker (Grade 3 to Grade 5), this represents a saving of approximately £530 or between £625 and £711 per year.

Table 8 - Lameness cost/benefit for 100 m^2 of track for 100 cows over 5 years

	Cost per cow for track over 5 years including set up and maintenance(£)	Direct cost saving per cow over 5 years (£)	Indirect cost saving per cow over 5 years (£)
Woodchip peelings	3.24	360	1230
Sand + rubber track	2.57	360	1230

Discussion

Assessment of lameness through gait alone is not purely representative of the cow's ability to move comfortably without including also a measure of the speed at which it walks. The speed at which the animal can walk is also a direct reflection of lameness and also the confidence of the animal in the surface type – e.g. firmness, rebound, traction of the track surface.

The degree of lameness is unlikely to improve regardless of the track on which the cows are walked. Mechanical or biological reasons for lameness are unlikely to spontaneously resolve. However the speed at which the cows walk down any track is a reflection of the combination of traction, of the track upon which it walks and this can be evaluated by the lameness:speed index.

This study confirms earlier work that the type of track that cows walk on does have an influence on lameness, but it also has an effect on the speed at which cows choose to walk down it. Even the more severely lame cows tended to walk more rapidly on certain types of track. For this type of study on tracks, the combined locomotion score gives a better evaluation of the surface than a lameness score alone, where the differences between the tracks were not so easy to evaluate.

The cows used both tracks without problems. A slight preference was shown towards the woodchip peelings track but no cows refused to use either track. Speed and locomotion studies have been carried out with the sand and recycled rubber tyre chippings track, resulting in significantly improved locomotion:speed indices compared with the woodchip peelings and chalk tracks.

The two year study period meant that the new track type could be evaluated over an initial grazing period and also over a winter and second grazing period. The change of sand in the first year meant that less sand was blown off the tracks, and although sand was still taken off on cows' feet; it was considerably less compared to the first year. Both tracks were run with minimum maintenance, although topping up particularly on the woodchip peelings track was required over the grazing period and after the winter rest period.

Initial costings show that the woodchip peelings track is less expensive to install. Predicted ongoing costs over a five year period predict that the sand and recycled rubber tyre chippings track will be cheaper to maintain than the woodchip peeling track (£12.70/m^2/year for sand and recycled rubber tyre chippings track compared with £18.35/m^2/year for woodchip peelings track). It should also be possible to use cheaper sand than the type used in this study, as there is no reason why recycled bedding sand (if used for bedding) could not be used as top sand. Recycled bedding sand has been shown to be much coarser than new bedding sand and will be appropriate for this use.

Both track types resulted in a saving not only attributed to cost savings due to reduced lameness, but also as a result of time saved in bringing in cows from the grazing areas. These savings are similar on either cow track Typical financial loss for an episode of lameness requiring veterinary treatment includes about £72 in direct costs and when

reduced fertility and production are included this rises to about £246. In this study the incidence of lameness was reduced by 10% which resulted in savings of £720 in direct costs per 100 cows and £2460 in indirect costs per 100 cows. The labour saving on this is between £530 to £711 per year, depending on the skill type of the worker employed.
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