Moorepark Dairy Levy Research Update

MOOREPARK DAIRY PRODUCTION RESEARCH CENTRE

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Latest Results on Alternative Low Cost Winter Accommodation and Crossbreeding Studies at Moorepark

Teagasc
Agriculture and Food Development Authority

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Introduction

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The ability of the dairy farmer to remain profitable into the future is dependent on having information to make informed decisions which would allow increased efficiency and scale of production. Acquiring and applying newer skills and knowledge for more efficient milk production are essential. New technology will allow dairy farmers to increase scale while at the same time reduce the unit cost of production.

Milk production systems in Ireland are based mainly on seasonal calving, with the vast majority of milk being produced from grazed grass. To exploit fully the seasonal grass production profile, a high pregnancy rate following a planned start of mating and subsequent short time interval is needed to achieve a concentrated calving pattern in the following season. Similarly, this type of cow needs to be an efficient converter of grazed grass into milk solids. The question arises as to whether a cross-bred cow (Holstein-Friesian x alternative breed) may offer a better means of optimising resources on mainstream Irish dairy farms. A cross-breeding programme may allow dairy farmers to combine desirable traits, and, at the same time, take advantage of any hybrid vigor. Two studies are under way at Moorepark to investigate the potential role of alternative breeds/crossbreeding. The first, at the Ballydague Research Farm is focused on assessing the biological and economic efficiency of Holstein-Friesian, Jersey and Holstein-Friesian x Jersey cows under two grass-based spring milk production systems. The second is an on-farm study comparing Holstein-Friesian, Norwegian Red and Holstein-Friesian x Norwegian Red cows. The results for the first year of these two studies are now completed. The implications of these results are very relevant to dairy farmers given that the upcoming breeding season is only a number weeks away and ICBF have just launched their crossbreed genetic evaluation index.

It is now accepted that the EU milk quota regime will be removed by 1 April 2015. To allow for expansion, extra housing and milking facilities will be required on many Irish dairy farms. The capital cost of conventional housing systems at present for a 100 cow herd is estimated at approximately €250,000. Recent innovations in using out-wintering pads and earth bank tanks have shown huge potential as alternative reduced cost housing and effluent management facilities for dairy cows. A major advantage of low capital cost wintering systems is that it allows farmers with limited resources to put facilities in place and, thereby, gain control over the consolidation or expansion of their business. The specifications for the construction of these structures have recently been agreed with the relevant Government bodies and these should be eligible for grant aid under the new Farm Waste Management Scheme. At the open days in Moorepark these specifications will be discussed in detail and the results from the research on cow performance and health will be presented.

These Open Days provide an opportunity for dairy farmers and the service industry to farming to discuss these recent developments in technology with Teagasc research and advisory staff. The financial support for the research programme from state grants and dairy levy research funds is gratefully acknowledged.

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Wintering Options for Dairy Stock

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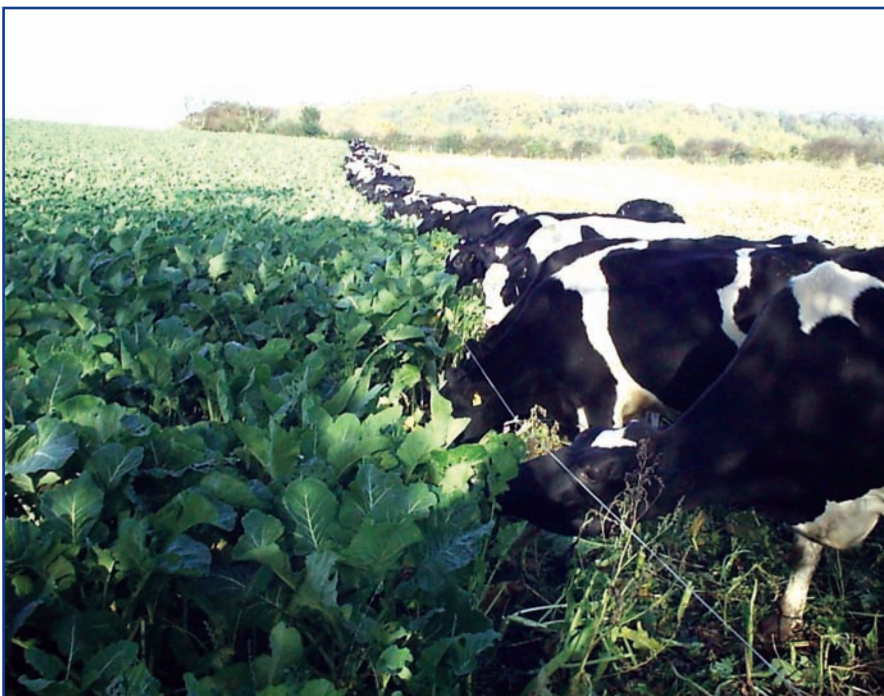
Executive Summary

- The total cost of wintering dry, spring-calving dairy cows in conventional sheds and fed grass silage ranges between €240 and €375/cow/year depending on grant rate available on the initial capital investment
- It is anticipated that grant aid will be available for low-cost accommodation systems (clay lined out-wintering pads (OWPs) and slurry tanks) in 2007
- The wintering systems compared had very little impact on milk production or reproductive performance in the subsequent lactation
- Self-feeding grass silage on clay lined OWPs with clay lined tanks for slurry storage will be the most economically and labour efficient systems for wintering cows at approximately €170/cow/year
- Further significant cost savings (€40/cow/year) can be made by grazing forage crops *in-situ*. However, underfoot conditions will restrict this to suitable soil types, particularly with high yielding crops such as fodder beet and swedes



Introduction

The provision of winter accommodation and feed is the single biggest cost in Irish spring-calving systems of milk production even though little or no milk is produced during this period. The increasing cost of inputs such as labour, oil and building materials are continuously increasing the wintering cost of cows. The main cost contributors to the conventional wintering system are capital required for construction and labour and machinery for bringing the feed to the cows.

Any alternative wintering system to conventional facilities needs to have a low capital cost, a low running cost, be labour efficient and be environmentally secure. It is also imperative that any alternative wintering system has no negative impact on cow productivity or welfare.

Over the last three years, research at Moorepark has evaluated a range of alternative systems for wintering dry spring-calving cows and has focused on the impact of these systems on production (body condition score, weight and feed intake), labour input and running costs, health (hoof health, dirtiness score, mastitis level, limb lesion score, locomotion score and incidence of clinical disease), behaviour and the environment. The systems evaluated included alternative designs of OWPs and *in-situ* grazing of forage crops (kale and swedes).

Winter Accommodation Systems

A range of alternative designs of OWPs were constructed in Ballydague in autumn 2004. These pads were used as a complete winter facility for herds of approximately 50 spring-calving cows over the winters of 2005 and 2006.

The four winter accommodation systems compared over the two years were:

(1) indoor cubicle housing with one rubber matted cubicle/cow
(2) an uncovered OWP at a space allowance of 12m^2/cow with an easi-feed silage system
(3) an uncovered OWP at a space allowance of 16m^2/cow with a self-feed silage system on the OWP and 4m^2 of silage/cow.
(4) an OWP at a space allowance of 6m^2/cow with a windbreak and plastic cover overhead

All cow groups, except the self-feed system, had an adjacent concrete feed face which allowed 0.6 m of feed space/cow. Animals remained on treatment from December 6 until calving. Due to delays in setting up the experiment, the silage used on the self-feed system was harvested much later and was of lower quality (65% DMD) than that of all other treatments (72% DMD) during the first winter (2005), but was of similar quality to that on the other treatments during the second winter.

The performance results from both years are shown in Table 1. The cows on the self-feed pad had poorer condition score gain in the first winter, probably due to the poorer silage quality; however, it had no negative impact on their subsequent milk production. The cows on the outdoor pads had approximately 4% higher milk solid yield in the subsequent lactations in both years, but this was not statistically significant. The cows on the pads had significantly heavier calves than the cows accommodated indoors in both years even though gestation length was similar as was the incidence of calving difficulty. There was no negative impact of wintering cows on pads on cow welfare and some minor improvements in welfare traits such as hoof and limb condition at calving and behaviour during the dry period were observed.

Table 1: The effect of winter accommodation system on performance of spring-calving dairy cows

	Conventional shed	Self-feed OWP	Easi-feed OWP	Covered OWP
2005 results				
Silage intake (kgDM/cow/day)	10.3		11.2	10.3
Milk solids yield (kg)*	418	434	424	428
Calf birth weight (kg)	38.8	41.7	41.4	41.7
Live-weight gain (kg/day)	0.11	-0.11	0.17	0.12
Condition score change	0.074	-0.063	0.027	0.13
6 week in-calf rate	63.4	57.1	66.7	61.9
Mastitis incidence				
Pre-calving	2	2	2	2
Post-calving	1	2	1	0
2006 results				
Silage intake (kgDM/day)	10.2	9.9	9.8	10.4
Milk solids yield (kg)**	345	363	356	345
Calf birth weight (kg)	36.7	38.7	38.2	37
Live-weight gain (kg/day)	0.65	0.57	0.60	0.52
Condition score change	0.15	0.19	0.13	0.27

*Winter silage quality on self-feed pad was poorer due to late harvesting; *Kg fat and protein from calving to 1 Nov, 2005, ** Kg fat and protein from calving to 22 Oct, 2006*

Tables 2 and 3 outline the capital (excluding VAT) and operating costs of a range of alternative winter accommodation systems in two scenarios. Table 2 data represents a scenario with rainfall figures of 27mm/week and a 20 week winter storage requirement similar to those experienced in County Cavan. Table 3 data represents a scenario with winter rainfall of 37 mm/week and a 16 week storage period similar to that applying in County Cork. In all cases the initial capital investment was depreciated at 5%/annum and the capital investment was financed with borrowed money at 6% interest.

The current upper grant limit of €120,000 would build conventional facilities for approximately 45 cows. However, in facilities designed for relatively small herds of cows, it is likely that labour input demand would be higher than that used in the following cost calculation (achieved on the most labour efficient farms with over 100 cows).

In both scenarios, self-feeding grass silage on clay lined OWPs with clay lined tanks for slurry storage was the most economically and labour efficient system for wintering cows. However, certain soil types are not suitable for the construction of these structures and in that situation plastic lined OWPs and plastic lined slurry tanks are the most economically attractive options.

There are a number of other advantages to these structures which are not evident from Tables 2 and 3, such as:
1. OWPs are very flexible and may be used for different types of animals. This would accommodate possible future changes in enterprise mix
2. A greater proportion of OWP costs are associated with running costs rather than capital costs, thus, if the dairy enterprise ceased before the end of lifespan of the facility, then the subsequent costs would be reduced further, relative to high cost conventional systems.

Table 2: The effect of winter accommodation system on construction cost, operating cost and annualised housing cost assuming different grant rates, a 20 week closed period and 27 mm/week winter rainfall

		Plastic lined		Clay lined	
	Conventional shed	Self-feed OWP	Easi-feed OWP	Self-feed OWP	Easi-feed OWP
Construction costs					
Pad area		18	12	18	12
Slurry storage requirement (m^3)	6.6	13.9	10.8	13.9	10.8
Lying area/cow (€)	1350	198	132	108	72
Slurry storage cost (€)	818	445	346	209	162
Head feed cost/cow (€)	295		76		76
Silage pit cost (€)	205		205		205
Total Construction cost (€)	2668	643	759	317	515
Depreciation & interest/annum (€)	213	51	61	25	41
Running cost (€) (100 day winter)					
Cleaning & bedding (€)	9.5	19.8	13.2	19.8	13.2
Slurry spreading+ agitation (€)	9.6	14.2	11.5	14.2	11.5
Wood chip spreading (€)		15.6	9.4	15.6	9.4
Feeding (€)	36.5	6.3	36.5	6.3	36.5
Sub Total (€)	55.6	55.9	70.6	55.9	70.6
Total housing cost/ cow/year (€)	269	95	124	74	107
70% grant on eligible fractions (€)	120	77	97	74	107
40% grant on eligible fractions(€)	184	78	102	65	92

Table 3: The effect of winter accommodation system on construction cost, operating cost and annualized housing cost assuming different grant rates, a 16 week closed period and 37 mm/week winter rainfall

	Conventional shed	Plastic lined Self-feed OWP	Plastic lined Easi-feed OWP	Clay lined Self-feed OWP	Clay lined Easi-feed OWP
Construction costs					
Pad area		18	12	18	12
Slurry storage requirement (m^3)	5.28	12.19	9.71	12.19	9.71
lying area/cow (€)	1350	198	132	108	72
Slurry storage cost (€)	655	390	311	183	146
Head feed cost/cow (€)	295		81		81
Silage pit cost (€)	205		200		200
Total Construction cost (€)	2505	588	724	291	499
Depreciation & interest (€)	200	47	58	23	40
Running cost (€) (100 day winter)					
Cleaning & bedding (€)	10	20	13	20	13
Slurry spreading+ agitation (€)	8	14	11	14	11
Wood chip spreading (€)		16	9	16	9
Feeding (€)	37	6	37	6	37
sub Total (€)	54	56	70	56	70
Total housing cost/ cow/year (€)	254	103	128	80	110
70% grant on eligible fractions (€)	134	85	103	N/A	N/A
40% grant on eligible fractions (€)	174	85	104	70	94

Grazing Forages *In-situ*

One strategy to reduce the cost of wintering cows is to utilise feeds which can be grazed *in-situ*, thereby reducing both variable (harvesting cost) and fixed costs (housing and machinery). Perennial ryegrass, the dominant forage on livestock farms, has limitations for out-of-season grazing (December and January). The quantity of DM that can be accumulated for winter grazing is limited and, additionally, as the quantity accumulates the quality decreases. There are a variety of other crops available which grow at lower temperatures than perennial ryegrass and can accumulate higher yields without a decline in feeding value.

Some options are swedes, kale, rape, turnips, forage cereals and short rotation grasses. Forage brassicas such as swedes, kale, turnips and rape are used extensively in other grass based dairy and beef industries as a source of cheap high quality out of season feed which can be utilized *in-situ*. Swedes and kale are full season biennial crops usually sown from mid-May to mid-July. The earlier they are sown the higher the utilisable yield. These are used from November to March. Rape and stubble turnips are annuals that need to be set later than swedes and kale for use during the same period. These will have a lower yield than either swedes or kale. There would appear to be great potential in Ireland in sowing rape or stubble turnips after harvesting cereals in August to provide a low cost winter feed. Although other crops such as short-term ryegrasses and grazed cereals such as forage oats, rye and triticale can be used in a similar manner to brassicas, there is very little information available on their potential in Ireland. There is, however, on-going research in Moorepark evaluating the potential of all these crops.

In June 2005, crops of kale and swedes were sown in Moorepark after harvesting first-cut silage and they yielded approximately 11 and 15 tDM/ha, respectively, by early winter. In early December 2005, groups of 22 cows were assigned to one of four winter diets which were allowances of:

8 kg kale and 4 kg bale silage
8 kg swedes and 4 kg silage
12 kg autumn-grown grass
Ad-lib silage fed indoors

The cows remained on their respective diets until approximately one week before calving in mid-February. The cows adapted to the kale very quickly and utilisation was over 80% for most of the winter, however the cows took approximately three weeks to begin eating the swedes and during this time lost approximately 0.3 of a condition score. Once the cows adapted to eating the crops, performance and condition score gain was very satisfactory. The impact of the different winter diets on cow performance and welfare traits is shown in Table 4. The quality of the silage offered to the indoor group was excellent (77% DMD) and they achieved the highest condition at calving. The cows offered kale and swedes achieved target condition scores at calving (>3.15). However, the cows offered grass only were well below target condition at calving.

Table 4: The effect on performance of wintering dry spring calving dairy cows on crops grazed *in-situ* relative to grass silage fed indoors

	Kale	Swedes	Grass	Silage/ indoor
*BCS at dry-off	2.99	3.03	3.03	3.00
Calving BCS	3.17	3.17	2.77	3.51
BCS 4 wk post calving	2.87	2.88	2.64	3.2
Calf birth weight (kg)	47	50	47	47
Colostrum yield (kg)	7.21	7.29	6.36	5.92
Milk solid production (kg)	440	452	455	452
Calving to conception interval (days)	92	94	88	86
Empty rate (%)	13	17	6	13

* Body Condition Score

Winter Feed Costs

The productivity parameters and costs of production and utilisation of a range of feeds suitable for wintering of dry spring-calving dairy cows are shown in Table 5. In order to economically compare any of the ensiled crops to those grazed *in-situ*, the feed costs/100 days in Table 5 should be added to the relevant accommodation systems in Tables 2 and 3 and the total wintering costs compared (bottom of Table 5).

Fodder beet gives a higher yield of energy/ha than any other crop which may be grown at this time and even though it is quite expensive to grow it is the cheapest feed for cows when grazed in-situ. However, the soil types in which the grazing of high yielding crops in situ may be practiced is limited, since the cows move very slowly though the crop and there may be cross compliance issues with excessive soil poaching. It is necessary with all brassicas to feed a proportion of the diet as fibrous forage and in the current study, 3 kgDM of baled grass silage/cow was offered.

If reseeding of the land back to grass has to be included in the costs of the crop production (i.e. where a good ryegrass sward is ploughed up to grow the crop) then the costs of these crops increase significantly and low yielding crops such as rape become non-viable. However, in most situations these crops can be integrated in a necessary reseeding programme.

Table 5: Yields and costs of a range of feeds for wintering of dry spring-calving dairy cows

	Maize silage	Grass silage	Straw/ conc.	Fodder beet	Kale	Swedes	Rape	Deferred grass
Yield (tDM/ha)	15.5	10.5		18	10	12	4.2	2.8
Utilisation	0.82	0.75		0.7	0.7	0.7	0.7	0.6
UFL/kg DM	0.8	0.772	0.7	1.12	1.05	1.12	1.05	0.85
Total materials/ha (€)	673	150		580	198	373	177	51
Contractor costs/ha (€)	492	456		293	140	184	152	10
Land charge included (€)	262	183		314	262	262	104	104
Land maintenance and storage costs (€)	50	35		60	50	50	20	20
Total Cost per hectare(€)	1477	824		1247	650	869	454	185
Cost per tDM (€)	116	105		99	93	103	154	110
Cost/UFL (€)	0.15	0.14		0.09	0.09	0.09	0.15	0.13
Bale silage (kgDM)	0	0		3	3	3	3	0
Crop (kgDM)	9.8	10.2		5.4	5.8	5.4	5.8	9.8
Cows wintered/ha	16.2	9.7		29.2	15.2	19.4	6.4	2.1
Feed cost/100 days (€)	114	107	118	94	94	96	129	109
Total wintering costs/cow (€)	See Tables 4 + 5 for costs other than feed cost			127	127	129	163	142
Including reseeding costs (€)				144	160	155	241	

The Welfare of Dairy Cattle on Out-wintering Pads

In recent years, two trials have been conducted in Ballydague to evaluate different designs of OWPs in terms of cow welfare. In addition, two separate studies were conducted at Moorepark with yearling and in-calf Holstein Friesian heifers accommodated on a conventional OWP and fed from an adjacent concrete apron. In all of these studies the control animals were housed indoors in cubicles and a wide range of welfare indicators were used to evaluate the different conditions. These included behaviour, foot and limb lesions, measurements of immune function and of the climatic energy demand (CED) of the out-wintered animals. The latter involved detailed measurements of body temperature, climatic conditions and feed intake which were used to establish whether or not animals were cold stressed.

In these studies, the OWPs were associated with a dramatic reduction in injuries to the limbs. For example, of 48 yearlings housed indoors in cubicles, seven were affected with adventitious bruises on the limbs compared to none outdoors. The main reason for these findings is that almost no trips, slips or falls were recorded on OWPs while these are a major problem for animals indoors trying to negotiate narrow passageways, difficult turns, automatic scrappers and slippery slats.

When it comes to hoof health the results are less clear cut. It certainly appeared that the cushioning properties of the wood chips offered some protection to the feet in the latter stages of pregnancy when physiological changes combined with heavy bodyweight make the feet particularly susceptible to sole bruises. However, work with 150 cows in Ballydague and 70 heifers in Moorepark revealed that animals on conventional OWPs suffered more severe sole bruises in early lactation than cows housed indoors during pregnancy. Exposure of hooves to moisture softens them and makes them more susceptible to injury. When cows were out-wintered on pads without shelter, their hooves were exposed to more moisture than the hooves of animals indoors. This could explain why they were so easily bruised when turned out to grass after calving and had to walk on the farm roadways. This is supported by the fact that the bruise scores of cows in the covered OWP, where conditions were relatively dry, were similar to that of the cows wintered in cubicles after calving. Nevertheless, other aspects of hoof health, namely heel erosion and infectious conditions of the skin of the foot, such as digital dermatitis, were improved on OWPs probably because of the less abrasive and more hygienic conditions on the wood-chip pad. Foot lesions caused 90% of lameness in dairy cows and the pain caused by lameness makes it one of the most serious of all farm animal welfare issues. Furthermore, the economic implications of lameness are considerable and include reduced milk yield, poor fertility, higher replacements rates and veterinary charges. Hence, even small improvements in hoof health are of critical importance.

In dairy cattle, lying behaviour promotes effective rumination, is associated with reduced lameness and increases uterine blood flow, which may benefit the growing foetus during late gestation. It is, therefore, very important to dairy cow welfare. Cows are reluctant to lie down on wet, muddy surfaces and in periods of heavy rainfall. In one study, no heifer was observed to lie down in 12 hours of observation conducted during incessant rain. Nevertheless, reluctance to lie down during bad weather is likely to be a transient problem. However, a wet and muddy surface on the wood-chips can arise even in the absence of wet weather due to overstocking and/or inadequate depth of wood-chip. In this instance, standing can be prolonged to the extent that it has a negative impact on both short and long-term wellbeing. Excessive standing in itself can also adversely affect weight gain in cattle possibly due to the increased energetic cost of standing and the negative effects of stress hormone activation on anabolic metabolism.

A wider range of positive behaviours are observed on OWPs compared to cubicle systems. Young dairy animals in particular perform more play and locomotory behaviours. These have physiological benefits with regard to physical strength and endurance and help the heifers develop social skills and hence cope with social stress. Furthermore, more self and social grooming is seen in dairy animals of all ages on OWPs compared to cubicles. These behaviours are good indicators of the general health of cattle and they can contribute to a less stressful social environment.

Undoubtedly the behaviour of the animals on the OWPs in these studies was greatly affected by the weather and the expression of certain behaviours varied considerably depending on the prevailing conditions. However, CED measurements show that heat loss from the out-wintered animals did not exceed heat production during any of the recent winters which have been remarkably mild and dry. This indicates that the animals did not experience cold stress. When the problem of the tight stocking density in covered pads resulting in very dirty, albeit dry conditions is considered, it could be argued that there is no need for shelter on OWPs. Indeed, this might be true when animals are well nourished, have a generous space allowance and a deep bed; otherwise some form of shelter is recommended.

In general, the findings indicate that there is great potential for the welfare of dairy cattle to be improved on OWP compared to housing indoors on concrete. Generally, OWPs offer more comfortable underfoot conditions, more space and unrestricted movement compared to cubicle housing. Nevertheless, dairy animals on OWPs may be susceptible to poor welfare owing to poor pad management and adverse weather conditions.

Specification for Out-wintering Pads

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Executive Summary

- Out-wintering pads (OWPs) will be eligible for grant aid but will require planning permission and must be built to a standard specification
- A site assessment will be required to determine the suitability of the site and most appropriate design
- Effluent collected from all pads shall be regarded as slurry and shall require appropriate storage facilities
- Out-wintering pads may be lined with soil if the site is suitable or otherwise must be lined with an approved plastic
- Out-wintering pads can be designed to allow animals to feed on the pad or on a separate appropriate facility

Introduction

The specifications for the construction of out-wintering pads (OWPs) have recently been agreed with the relevant Government bodies and should be eligible for grant aid under the new Farm Waste Management Scheme. There are three distinct phases to the building of an OPW: planning, site assessment and construction. Each section is summarised below; however before any farmer undertakes construction of an OWP, it would be advisable to first read the detailed specification which will be published by the Department of Agriculture and Food.

Planning an Out-wintering Pad

The construction of OWPs will require the granting of full planning permission. However, if an OWP is less than 200m^2 and the overall area of Class 8 structures is less than 300m^2, then planning permission may not be needed. When sizing an OPW, the minimum space allowances are set out in Table 1 below:

Table 1: Minimum space allowances for animals accommodated on an OWP system

Animal type	Minimum space requirements per animal (m^2) On-pad feeding	Off-pad feeding
Dairy cow	18	12
Suckler cow	16	10
Beef cattle (> 2 years)	16	10
Cattle (1 to 2 years)	12	8
Cattle (< 1 year)	10	6

Sizing of Effluent Storage

The Department of Agriculture and Food has specified that all effluent collected from the under drainage system or off-pad feeding areas shall be considered to be slurry and shall require management as such.

Effluent from on-pad feeding

Where it is planned to feed the animals on the OWP the volume of effluent produced from the OWP shall be calculated using the following equation and the relevant tables in the Nitrates regulations:

$E= (PxR) + (NxV) - (Px0.013)$

where:

- E = effluent produced, ($m^3.wk^{-1}$)
- P = pad area, (m^2)
- R = net rainfall on the pad, ($m.wk^{-1}$)
- N = no. of animals on the pad
- V = neat excreta produced per animal per week, ($m^3.wk^{-1}$)

Effluent from off-pad feeding

Where it is planned to feed the stock off the OWP, the volume of effluent produced on the pad shall be calculated using the following equation:

$E= (PxR) + (NxVx0.66) - (Px0.013)$

Additionally, provision must be made for collection and storage of slurry and net rainfall deposited on the off-pad feeding facilities, (when incorporated into the OWP system). The volume of effluent produced may be calculated using the following equation:

$E= (AxR) + (NxVx0.013)$

where:

- E = effluent produced, ($m^3 \cdot wk^{-1}$)
- A = area of off-pad feeding facilities, (m^2)
- R = net rainfall on the off-pad feeding facilities, ($m.wk^{-1}$)
- N = no. of animals using the facilities
- V = neat excreta produced per animal per week, ($m^3.wk^{-1}$)

On-pad feeding facilities

Where the animals are fed on the OWP this may be achieved by allowing the animals to self-feed silage on top of the OWP surface at the highest point on the OWP. This can be done by placing the silage pit on the edge of the OWP on top of the woodchip layer. In this situation the minimum depth of woodchip underneath the silage pit shall be 300 mm.

Off-pad feeding facilities

Animals may be fed on existing structures provided they are of sound structure and comply with directives on cross compliance and nitrates. Where new concrete head feed aprons are being constructed, the subsoil liner shall extend a minimum of 1m under the feed apron. Where existing structures are in place, the subsoil liner shall make full contact with the existing facility and shall have a minimum of 0.5m vertical height of the line in contact with the existing facilities.

Site restrictions
There are a number of restrictions which need to be satisfied before embarking on the construction of an OWP. A proposed OWP shall not be considered for:

- sites within 60m of any well or spring used for potable water
- sites within either:
    - o the inner protection zone of public water drinking supply source ($>10m^3.d^{-1}$ or PE >50) (groundwater) where the vulnerability rating is classified as extreme, or
    - o where an inner protection zone has not been identified and the vulnerability rating has been classed as extreme, within 300m up gradient of the abstraction point
- sites where the minimum design requirements cannot be achieved
- sites within 10m of an open watercourse where effluent can enter
- sites within 50m of a lake
- sites within 15m of a karst feature
- sites liable to flooding
- sites where construction of the OWP will damage or destroy a site of potential natural or cultural heritage value
- sites that are steeply sloping

Minimum design requirements
In general, all subsoil-lined OWPs shall be underlain by at least 0.5m of moderate to low permeability unsaturated subsoil, enhanced by compaction to ensure that a maximum permeability of $1 \times 10^{-8} m.s^{-1}$ is achieved. The clay content of the subsoil being used as a compacted liner shall be at least 10% as determined in the laboratory. Additionally, the compacted subsoil liner shall be underlain by at least 0.25m of unsaturated subsoil.

Where a regionally important aquifer is present and the groundwater vulnerability rating is high/extreme or the regionally important aquifer is karstified, or where high permeability sand and gravel is encountered and is in vertical hydraulic continuity with the main water table, the minimum thickness of the compacted unsaturated subsoil liner shall be 0.75m. Suitable subsoil may need to be imported to form the liner. Additionally, the compacted subsoil liner shall be underlain by at least 0.25m of unsaturated subsoil.

Where the subsoil is at least 1.0m thick and is characterised as moderate to low permeability, unsaturated, impervious, free of preferential flowpaths and has a clay content of at least 13%, the surface of the excavated portion of the OWP will only require plastering with remoulded subsoil.

All geomembrane-lined OWPs shall be underlain by at least 0.15m of unsaturated subsoil, the upper 0.05m of which may be a protective fine sand layer depending on the requirements of the lining contractor. The geomembrane shall be overlain by subsoil with a minimum thickness of 0.2m of low to moderate permeability and plastered with remoulded subsoil.

The lining contractor

If a decision is made to install a geomembrane-lined OWP then a lining contractor shall be appointed. The lining contractor, who shall be a specialist in this form of construction, shall be accepted as such by the Department of Agriculture and Food. The full installation of the lining shall be carried out directly by the lining contractor. All other works relevant to the installation of the geomembrane shall be completed either by the lining contractor or in accordance with the lining contractor's instructions.

Site Assessment for an OWP

The objective is to collect sufficient information to:

- determine if an OWP can be developed on the site, without creating a negative impact on the environment
- provide adequate data to enable the optimal design to be achieved

Site assessment may incorporate various tasks including desk study, visual assessment and site tests in order to satisfy the objectives. The site assessment is the basis of the OWP design and the data collected shall be used to optimise the construction of the proposed OWP. A site assessment form has been developed for the collation of data and shall act as a check list and thus, aid in the process of decision making.

Steps in the Site Assessment

The following steps shall be undertaken:

A. Collation of background information
B. Visual assessment
C. Trial holes and site tests
D. Decision process and preparation of recommendations

Based on the findings of the site assessment, the client may wish to proceed with the laboratory testing to accurately determine the clay content of the proposed subsoil liner horizons in the trial holes in order to facilitate the site assessor in making a decision as to the suitability of the site for a subsoil-lined OWP. Without this testing, a subsoil-lined OWP cannot be recommended. Alternatively, if the site is deemed suitable for a geomembrane-lined OWP and the client decides that he/she wishes to proceed with this system, further laboratory testing is not required.

Interpretation of trial hole results

The results of testing shall meet the following requirements (Table 2).

Table 2: Minimum acceptable criteria for OWP

Liner type	Minimum acceptable criteria	Subsoil thickness required below drainage layer
In-situ subsoil liner	13% clay or greater Low/moderate permeability subsoil, impervious and free of preferential flowpaths	Minimum 1.0m
Compacted subsoil liner	10% clay or greater	Minimum 0.5m compacted subsoil liner underlain by minimum 0.25m unsaturated subsoil
	10% clay or greater Regionally important aquifer present with groundwater vulnerability rating classified as high or extreme or regionally important karstified aquifer present or High permeability sand and gravel encountered in vertical continuity with the main water table	Minimum 0.75m compacted subsoil liner underlain by minimum 0.25m unsaturated subsoil
Geomembrane liner	At least 0.2m of low/moderate permeability subsoil between drainage layer and geomembrane liner (may be imported if suitable subsoils not encountered) At least 0.15m subsoil beneath geomembrane	Minimum of 0.2m above liner and 0.15m below liner

The Certificate of Site Assessment shall be completed in full. It is the site assessor's responsibility to state if the site is suitable for the construction of an OWP. The site assessor shall also give details on depth to bedrock, thickness of liner required, depth to suitable layer of subsoil for liner, thickness of suitable layer of subsoil for liner, depth to suitable layers of subsoil for perimeter construction, geomembrane requirements (if applicable) and any other special conditions for the site.

Construction of an OWP

Construction of subsoil-lined OWP

Working conditions

All works shall be carried out in dry weather conditions. Subsoil for the liner shall not be left exposed and allowed to dry out unnecessarily. The subsoil moisture content shall be kept within the recommended plasticity range for optimum compaction of the subsoil liner.

Site preparation

All topsoil and any other unsuitable layers (as indicated in the site assessment report) shall be removed completely from the surface leaving only suitable subsoil for pad construction. All trees within 10m of the OWP footprint shall be removed. All material unsuitable for use as liner, as encountered, shall be "thrown" to the outside of the OWP footprint.

Removal of old drains

All existing drains, percolation systems' pipe-work and associated backfill aggregate encountered during excavation shall be completely removed to at least 7m beyond the outside of the footprint boundary and all exposed vacant channels shall be thoroughly filled and compacted with plastic subsoil.

Lowering of water table

Where deemed necessary by the site assessor, a groundwater control drainage system shall be installed. This shall be undertaken by the installation of deep cut-off drains 7m outside the OWP footprint and extending at least 600mm and preferably 750mm below the invert of the OWP containment layer.

Construction of subsoil liner

The base of the OWP shall consist of a mineral layer which satisfies permeability and thickness requirements with a combined effect in terms of protection of soil, groundwater and surface water at least equivalent to a permeability of 1 x 10^{-8}m.s^{-1} with a minimum thickness of between 0.5m and 0.75m depending on the underlying aquifer classification and subsoil/bedrock conditions. Additionally, the compacted subsoil liner component shall be underlain by 0.25m unsaturated subsoil. If there is not enough suitable material present in the OWP area, additional suitable subsoil material may be brought onto the site. However, this material shall first have been assessed by the same person who completed the initial soil assessment in order to be deemed suitable for the construction of the liner.

The compacted subsoil liner component shall be built in layers/lifts of 150mm and each layer/lift compacted until the desired permeability has been achieved. The excavator shall make a minimum of four passes per lift (two each in cross directions) over the liner soil so as to compact the material for 0.5m and 0.75m thick compacted liners. Each layer comprising the compacted subsoil liner component shall be fully compacted prior to placement of the next layer.

Compaction shall be effected by means of a hydraulic excavator with a minimum weight of 20 tonne, capable of exerting a ground pressure of at least 40kPa (40kN.m^{-2}) (e.g. a 20 tonne excavator with tumbler length 3.7m and track width 0.6m, shall exert a ground pressure of 44.17kPa). Alternative suitable compaction equipment may be used if it can be demonstrated that, at least, equivalent compaction can be effected.

Construction of subsoil ridges

Subsoil ridges shall be at a minimum spacing of 3.0m and at least 0.15m high. The ridges shall be constructed by placing and compacting moderate/low permeability subsoil in ridges perpendicular to the OWP effluent collection pipe at the rear of the pad. The subsoil shall be free of sharp protuberances, not be comprised of topsoil and be of moderate permeability at minimum. The ridges shall run the whole length of the pad. Alternatively, the compacted subsoil liner can be installed to the minimum design height and a further 0.15m of moderately compacted subsoil placed on the liner before subsoil ridges are then formed using suitable equipment. The ridges should be plastered and their surfaces smoothed off and plastered with remoulded subsoil.

Construction of drainage system

The drainage pipes shall be a minimum of 80mm internal diameter and installed in the trenches formed by the subsoil ridges. They shall be installed at minimum 3.0m spacing. The drainage pipes shall be connected to a solid walled pipe for effluent transfer to the storage facility. The drainage pipes shall have a slight fall towards the effluent collection pipe and this pipe shall, in turn, fall towards the effluent storage facility. A fall of at least 2% (1:50) is recommended. Most perforated solid-walled or flexible-walled land drainage pipes will be suitable for use. It may be preferable in areas of trafficking by very heavy vehicles to use solid-walled perforated underdrainage pipes. The drainage stone shall be similar to that used as filter drain material in road works and shall be at least 300mm deep. This material is classified in the Specification for Road Works as follows:

Table 3: Range of grading of filter drain material (adapted from Specification for Road Works Volume 1 Series 500)

Material	Percentage by Mass Passing BS Sieve Sizes (mm)					
	63	37.5	20	14	10	5
Type B	100	85 ~ 100	0 ~ 20	-	0 ~ 5	-

Alternative underdrainage systems may be used if it can be demonstrated that, at least, equivalent drainage is achieved.

Construction of geomembrane-lined OWP

Subsoil surface preparation

The excavated and/or made-up ground must be finished uniform and smooth and free of any sharp protuberances. In particular, the surfaces to be lined must be free of water, jagged rock, debris, roots or any matter that could damage the lining material. Where subsoil surface conditions are unsuitable, a fine sand layer (50mm minimum thickness) shall be installed to provide underlying protection to the geomembrane. The total minimum subsoil depth beneath the geomembrane (*in-situ* + sand layer (if required)) shall be 150mm. A protection geotextile may be placed over the geomembrane depending on the lining contractors requirements.

Lining and drainage installation

Geomembranes are vulnerable to the underlying and overlying environment. They can be punctured by sharp protuberances such as jagged rock, debris, roots etc. In addition, they may be damaged by excessive loading. Many geomembranes are vulnerable to continual ultraviolet (UV) ray exposure. The geomembrane liner used shall be approved by the Department of Agriculture and Food and installed by an accepted lining contractor.

Construction of subsoil layer

A minimum 0.2m thick subsoil layer shall be installed over the geomembrane system. The site assessment report gives details of the suitable layers of subsoil and only this material shall be used for the subsoil layer. The subsoil shall be of low/moderate permeability and free of sharp protuberances. If there is not enough suitable material present in the OWP area, additional suitable subsoil material may be brought on to the site.

Woodchip bedding

There shall be a minimum depth of 200mm of woodchip bedding placed on all OWPs. The woodchip used shall be less than 50mm thick and may be produced from sawmill by-product, chipped logs or recycled timber. In all situations the woodchip bedding shall not contain any material that is not derived from wood. The woodchip shall be placed on the drainage layer, taking every reasonable precaution not to disturb the drainage layer underneath. It can be done using a tractor loader or an industrial loader and is done by placing the woodchips on the nearest point initially and gradually covering the pad by driving on the lain woodchip.

Certification

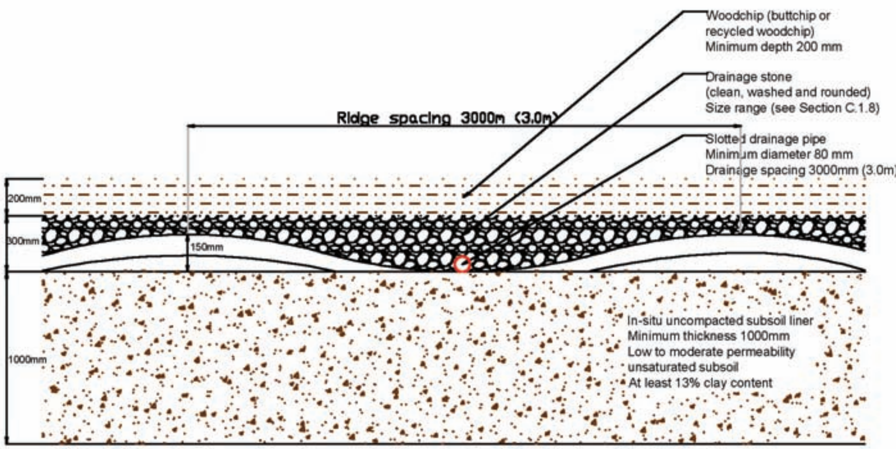
The following Certificates shall be provided to the farmer (where applicable) for his retention.

- concrete certificate
- site assessment report

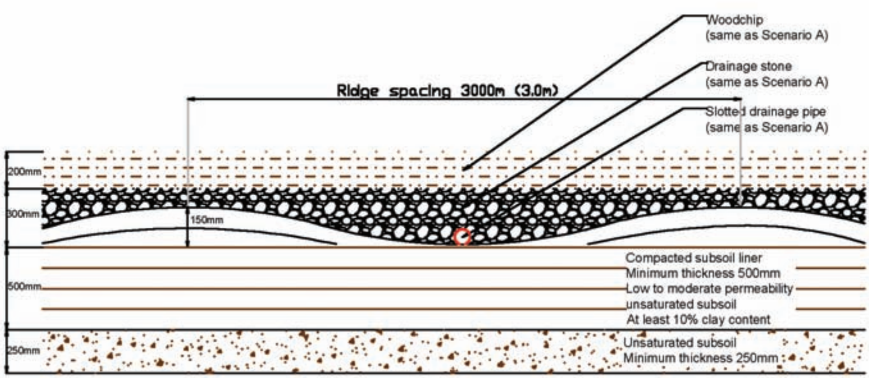
- contractor's certificate of installation of subsoil-liner for subsoil-lined OWP
- contractor's certificate of ground preparation and leak tightness for geomembrane-lined OWP
- planning permission

Cross Sections through typical OWPs

In-situ subsoil-lined OWP (scenario A)
OWP underlain by 0.5m thick compacted subsoil liner (scenario B) and 0.25m unsaturated subsoil
OWP underlain by 0.75m thick compacted subsoil liner (scenario C) and 0.25m unsaturated subsoil
Geomembrane-lined OWP

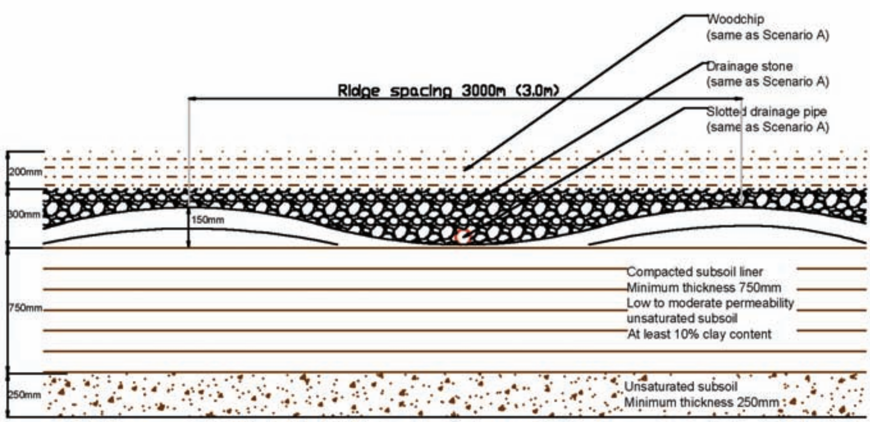


Subsoil Liner Scenario A

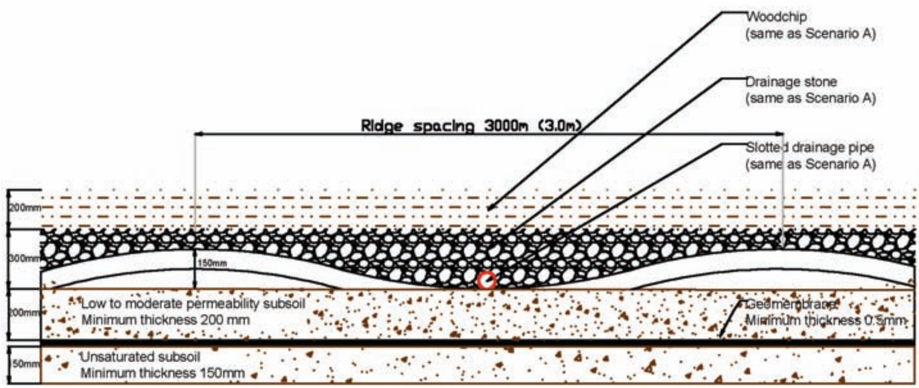


Subsoil Liner Scenario B

Subsoil Liner Scenario B



Subsoil Liner Scenario C



Geomembrane Liner

Crossbreeding the Dairy Herd - THE WAY TO GO?

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Summary

- The cow required for future Irish milk production systems must be robust and 'easy care' as well as being capable of producing high milk solids, the majority of which must come from grazed grass.
- Crossing the Holstein-Friesian with an alternative dairy breed sire can provide farmers with an alternative opportunity to increase overall animal performance by increasing herd health, fertility and milk value. This is due to the introduction of favourable genes from another breed and through hybrid vigour.
- Genetic gain must not be neglected i.e. only the best sires of both breeds should be used when crossbreeding. That means using high EBI.
- Two studies are currently under way at Moorepark evaluating the potential of dairy crossbreeding: one study is evaluating the Norwegian Red and Norwegian Red crossbred cows across 46 commercial dairy herds, and the second trial is evaluating the Jersey and Jersey crossbreds at Ballydague. In both studies the cows have just completed 1st lactation.
- Early results from the Norwegian Red on-farm study suggest that Norwegian RedxHolstein-Friesian cows produce similar milk yields with similar milk composition compared to Holstein cows. The yield of milk produced by the pure Norwegian Reds was slightly lower, with lower fat content. Crossbred cows also displayed similar live weight to the Holstein-Friesian but had higher body condition score at all stages of

lactation. Fertility and udder health were also in favour of the Norwegian Red and crossbred cows.

- The first year results from the Ballydague Jersey trial show that milk volume was highest with the Holstein-Friesian and lowest with the Jersey. However, a substantial lift in milk constituents with the Jersey and Jersey crossbred resulted in a similar yield of solids for all three breed groups. Jersey and Jersey crossbred cows were lighter than Holstein-Friesian cows but maintained higher body condition score at all stages of lactation. Fertility performance was in favour of the Jersey and JerseyxHolstein-Friesian cows.
- Both Norwegian Red and Jersey calves are easily born and early maturing.
- To present economic comparisons for the studies presented at this point is considered premature. However, these preliminary data suggest that crossbreeding with the Norwegian Red or Jersey are real options for Irish dairy farmers.

Introduction

Whether crossbreeding or not, the choice of AI sires this spring will have a significant influence on the future profitability of the dairy enterprise. Reducing milk price and increasing emphasis on milk quality make this all the more true. Pressure is on to reduce costs. The cow required under this type of scenario must be robust and 'easy care' as well as being capable of producing high milk solids, the majority of which must come from grazed grass. Optimal financial performance requires a 365-day calving interval and an empty rate after a defined breeding season (failure to conceive culling rate), after approximately 13 weeks breeding of less than 10%. Currently on Irish dairy farms fertility performance is somewhat below this optimum; empty rates around 13% from an average of 16 weeks breeding.

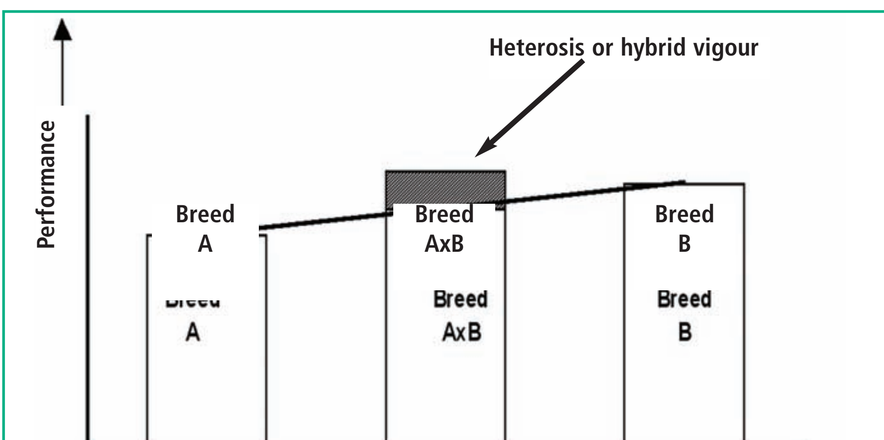
Crossing the Holstein-Friesian (HF) with an alternative dairy breed sire can provide farmers with an alternative opportunity to increase overall animal performance; key areas include herd health/fertility and milk content. Thus dramatically improving herd profitability. This is achieved through the introduction of favourable genes from another breed selected more strongly for traits of interest, by removing inbreeding depression, and for many traits by capitalising on what is known as heterosis or hybrid vigour (HV). HV means that crossbred animals usually perform better than that expected, based on the average of their parents.

New Zealand is probably the best example of where crossbreeding is used to a large extent to capitalise on the benefits of HV. There, the Black and White and Jersey breeds in many respects are very similar having been selected through a common index for many years. In their scenario the added performance obtained through HV is seen as a prudent means of achieving higher profitability. In New Zealand HV values of 5-6% are observed for production traits and values of up to 18% for reproduction and health traits are observed. Put simply, in New Zealand 20% more crossbred cows survive to 5th lactation compared to Holstein-Friesians. Thus, almost 50% of heifers entering herds in New Zealand in recent years are crossbred. HV will generally be higher in traits related to fitness and health i.e., traits which have lower heritabilities. The decision to crossbreed for many in the Irish context is likely to be somewhat different to that in New Zealand. Here, the driver is most likely borne out of poor herd health/fertility, or more recently with the introduction of A+B-C payment schemes, a desire to significantly increase milk value through improved milk composition. HV is an important consideration, but true genetic gain must not be neglected i.e. only the best sires of both breeds should be used when crossbreeding. Here that means using high EBI. An across-breed evaluation is not quite up and running in Ireland yet but preliminary EBI values estimated by ICBF for a number of alternative breed AI sires suggests that many high EBI sires do exist within the more popular alternative breeds available. In the meantime using appropriate progeny tested AI bulls, with high breeding values for traits deemed important here, will be an important component of a well-planned crossbreeding program. Breeds that don't have good progeny testing programs will be limited in how effectively they can contribute to a crossbreeding program.

Crossbreeding Research at Moorepark

Since 1996, studies have been run at Moorepark evaluating the merits of a number of alternative breeds for crossbreeding under Irish conditions. The ultimate aim of the research is to provide a greater insight into the potential of these breeds via crossbreeding and to assist the identification of a greater variety of top EBI (high profit sires) for use by Irish dairy farmers. The breeds of particular interest currently are the Norwegian Red (NRF) and the Jersey (J). The studies under way will assist the development of an across breed evaluation. Paramount is the requirement to determine the relative breed effects (difference between alternative breed and the Holstein-Friesian), and the level of HV observed in the crossbred (see figure 1). Two studies are under way; 1) evaluation of NRF and NRF crossbreds across 46 commercial dairy herds, and 2) evaluation of Jersey and Jersey crossbreds at Ballydague. The animals in both studies have just completed 1st lactation and early results from both studies suggest a favourable response to crossbreeding.

Figure 1: Heterosis or hybrid vigour is defined as the advantage in performance of crossbred animals above the mid-parent mean of the two parent breeds



Evaluation of Norwegian Red and Norwegian RedxHolstein-Friesian

NRF cows have been on trial at the Ballydague research farm since 2001. Interest in the breed stems from the fact that since the 1970's female fertility, resistance to mastitis, and other functional traits have been included in the breeding program of the breed. The relative weighting for the traits in the NRF index currently stands at 15% for female fertility, 22% for mastitis resistance, and 23% for protein yield. This relatively low level on milk production is thought by Norwegian geneticists to be critical in getting the balance right between selection for milk production and functionality. Progeny testing for fertility and health traits is based on large daughter groups (over 200 daughters per sire). Since 2001, the cows at Ballydague have performed well. The reputed characteristics of the breed, ease of calving, high female fertility and low SCC/mastitis incidence have been observed with the small numbers on trial. Therefore, in 2004 a large scale study was set up by Moorepark involving the importation of almost 400 pure-bred NRF heifer calves. These animals were spread across 50 dairy farms and along with a similar number of crossbreds (NRFxHF) and Holstein-Frisians, and now form part of one of the most unique research studies in the world: a very comprehensive study aimed at conclusively evaluating the merits of the NRF breed and the potential benefits of crossbreeding under Irish conditions. Currently the study includes just over 1,300 cows across 46 herds. The Norwegian and crossbred cows are by 10 proven bulls. The HF group represent a mix of HF genetics from around the world, having been sired by a broad spectrum of North American Holstein, New Zealand and British Friesian type sires. All cows on the trial were born in 2004 and calved for the first time in the spring of 2006.

Calving Ease

The NorwegianxHF calves out of Holstein dams when compared to the pure Holstein calves born on each farm in 2004 had more normal calvings - 82% compared to 78% - significantly fewer difficult calvings - 2.7% versus 5.3%, and lower stillbirths. Only 1.7% of the NorwegianxHF calves were born dead or died shortly after birth, versus 3.2% stillbirths for the HF calves. The 2006 data has not yet been analysed.

Proportion of Maiden Heifers Cycling Prior to the Start of Breeding

Maiden heifers account for 20-30% of animals that are bred during the breeding season. As a group they are likely to represent the highest genetic material in the herd. They also have the potential to significantly improve slippages in calving pattern. However, to deliver greatest benefit they must conceive early in the breeding season. So logically, first and foremost, they must be cycling at the beginning of the breeding season. Research and anecdotal evidence from commercial farms suggest some breeds mature later than the HF posing difficulties for a two-year-old calving system. In order of importance, body condition score, live weight and age were found to influence the likelihood of maiden heifers having cycled at least once prior to the start of the breeding season. There was no difference across breed group regarding the proportion of heifers cycling. The analysis has highlighted the importance of having well grown, well conditioned heifers. Except for very young heifers (under 14 months) age was not of major stumbling block to getting heifers cycling. At condition scores of 3.0 and over, the data indicated that one can expect to have 80-90% of heifers cycling prior to the start of breeding. However, at scores of 2.75 or less, cyclicity rates of around 65% can be expected. In terms of target weights, heifers weighing 320kg and over had cyclicity rates in the region of 85%, compared to 65% for heifers weighing 290kg or less.

Milk Production and Udder Health

The first lactation milk production data is shown in Table 1. The 305 day milk yield of the HF and NRFxHF was similar at 5,356 kg and 5,339 kg, respectively. That of the pure NRF was slightly lower at 5,149 kg. The level of HV is estimated to be just over 100 kg of milk or about 2%. Fat content was highest for the HF at 3.99%, lowest for the NRF at 3.93%, while that of the crossbreds was intermediate (3.96%). Milk protein content was not different across groups. The NRF and NRFxHF displayed superior udder health compared to the HF, as measured by SCC (Table 1) and the proportion of cows recorded with mastitis at least once during lactation (Figure 2). Simply accounting for milk lost and antibiotics used, one incidence of mastitis costs in the region of €50.

Table 1: Effect of breed group on 305 day milk production parameters and SCC

	HF	NRF x HF	NRF
Milk yield (kg)	5356	5339	5149
Milk yield (gallons)	1144	1141	1100
Fat (%)	3.99	3.97	3.93
Protein (%)	3.46	3.45	3.45
Fat + protein yield (kg)	399	396	380
Lactation average SCC	190,000	137,000	131,000
Lactation average SCC >400,000 cells/ml	9.5	6.9	5.7

Figure 2: Incidence of cows with mastitis

Body Condition and Live Weight

Body condition score (BCS) and live weight were measured on three occasions during 2006: pre-calving, during the breeding season, and at dry-off. The NRF consistently had the highest BCS: 3.29 pre-calving, 3.03 at breeding (Figure 3), and 3.01 at dry-off. Comparable values for the HF were 3.17, 2.85 and 2.81. The BCS of the crossbreds at 3.26, 2.97 and 3.01 was 0.03 units higher than the mean of the two parent breeds at all stages i.e., indicating hybrid vigour of 1%.

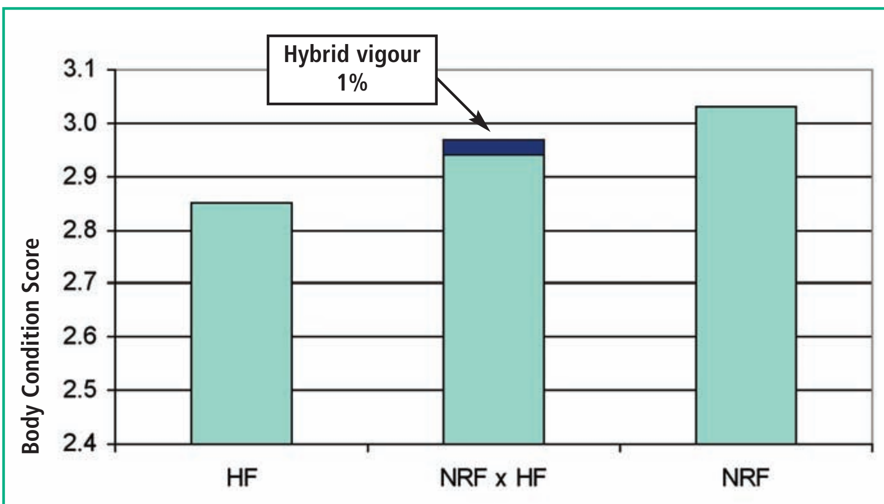


Figure 3: Body condition score at breeding for the HF, NRFxHF and NRF cows

The NRF consistently had the lowest live weight: 514 kg pre-calving, 446 kg at breeding, and 526 kg at dry-off), approximately 20 kg lighter than the HF and crossbred cows. The HF and NRFxHF were similar at all stages of lactation. HV estimates varied from 2.9% pre-calving to 2% at dry-off. Figure 4 shows live weight at breeding for the three breed groups.

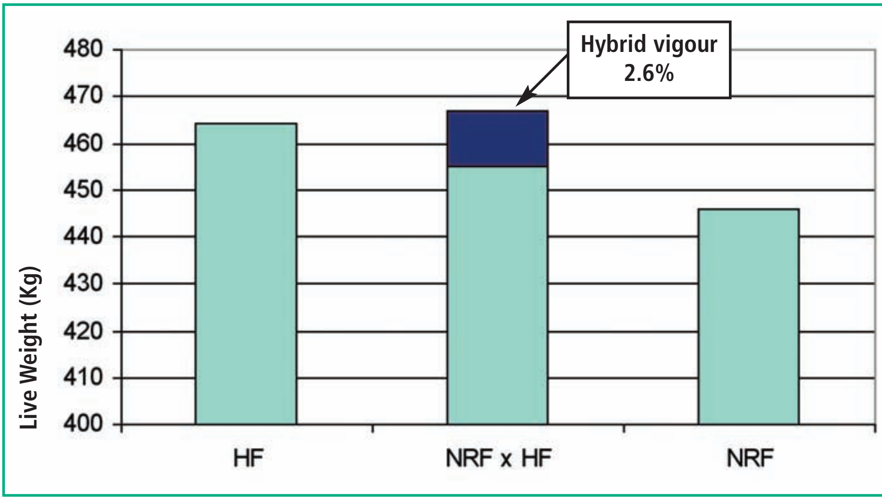


Figure 4: Live weight at breeding for the HF, NRFxHF and NRF cows

Reproductive Efficiency

Fertility performance data was available for 42 of the 46 study herds (others yet to be added). While not optimum, fertility performance including all cows was up on recent estimates using a similar range of farms (Farm Fertility Study) pregnancy rate to first service of 52% and in-calf rate (after 16 weeks breeding) of 87%. Nonetheless, analysis of the available data indicates a tendency for improved reproductive efficiency with the NRF and NRFxHF cows compared to the HF. The calving to service interval for all groups was similar at 80 days. Pregnancy rate to first service was 57% for the HF and 60% for both the NRF and NRFxHF. Empty rates were 9%, 7% and 5% for the HF, NRFxHF and NRF cows, respectively.

Evaluation of Jersey and JerseyxHolstein-Friesian at Ballydague

Internationally, the Jersey is one of the most popular breeds after the Holstein-Friesian. Here in Ireland, many are asking if the Jersey (Jersey cross) is the cow of the future. Interest here is likely being fuelled by the breed's popularity in New Zealand. There crossbreeding with the Jersey is considered to leave the most profit; high solids production at high stocking rates, coupled with increased survival. Currently the national herd in New Zealand consists of 18% pure Jersey and 25% Jersey x HF. It is anticipated that the Jersey influence will increase in New Zealand over the coming years.

At the Moorepark Ballydague research farm, 2006 saw the introduction of 30 purebred and 30 crossbred Jersey heifers. As with the Norwegian on-farm study, these animals have just completed their first lactation alongside 30 Holstein-Friesian heifers. The Jersey cows at Ballydague are by sires from both New Zealand and Denmark. As well as production, energy balance, fertility and health characteristics such as mastitis incidence, the research is keen to evaluate the reputed superior feed efficiency and potential stocking density of the Jersey breed, and what a crossbreeding strategy involving the breed might offer Irish dairy farmers. The superior feed conversion efficiency of the pure Jersey has been estimated previously to be about 6% greater than the Holstein across a range of feeding systems. However, most of the historic studies were short-term rather than 'full production cycle' studies as will be the case here.

Table 2 outlines the milk production performance and incidence of mastitis data recorded at Ballydague during 2006. Mean calving date was the February 20. Lactation length averaged 285 days. For the purpose of comparability with the NRF study the milk production data presented are that obtained from the national milk recording database (ICBF). As illustrated, significant differences in both milk yield and milk composition were observed across the breeds/crossbreeds. Milk yield ranged from 4,761 kg for the HF cows to 3,974 kg for the J cows. The JxHF cows were intermediate at 4,372 kg. Large differences in milk fat content were evident: 4.07% for the HF, 5.31% for the J, and 4.78% for the JxHF. The J also had the highest milk protein content at 3.97%, compared to 3.44% for the HF and 3.71% for the JxHF. However, when the milk yields are adjusted for the milk content (solids corrected milk yield or fat+protein yield) little difference is observed between the breed groups. Udder health as indicated by somatic cell count (SCC) was excellent at Ballydague for all breed groups; however, the incidence of cows getting mastitis was somewhat high.

Table 2: Effect of breed group on 305 day milk production parameters and SCC

	HF	J x HF	J
Milk yield (kg)	4761	4372	3974
Milk yield (gallons)	1017	934	849
Fat (%)	4.07	4.78	5.31
Protein (%)	3.44	3.71	3.97
Solids corrected milk yield (kg)	4528	4650	4539
Fat + protein yield (kg)	358	371	369
Lactation average SCC	75,000	73,000	65,000
Incidence of Mastitis (%)	30	14	25

Body Condition and Live Weight

Table 3 shows the average weight and BCS of the HF, JxHF and J cows at Ballydague during 2006. BCS tended to be lowest at all stages during lactation with the HF cows and highest with the JxHF. The increase in BCS with the JxHF represents a HV for this trait of between 5% and 6%. This is higher than that observed between the NRF and HF on the on-farm study. In terms of live weight, the HF cows were heaviest at all stages of lactation and the J cows were lightest. The JxHF were on average about 40 kg lighter than the HF and about 65 kg heavier than the pure J. This suggests HV for live weight of about 2.4%, consistent with that observed with the NRFxHF cows.

Table 3: Effect of breed group on BCS and live weight during 1st lactation

	HF	J x HF	J
Live Weight (kg)			
Average during lactation	465	417	350
At dry-off	530	486	410
BCS			
Average during lactation	2.92	3.09	2.99
At dry-off	2.84	3.01	2.99

Fertility Performance

The fertility performance from the Ballydague study is presented in Table 4. The breeding season began on the last week of April and ran for 13 weeks. All cows were bred by AI only. Tail paint was used throughout the breeding season as an aid to heat detection. The mean calving to 1st service interval and to a lesser extent the mean calving to conception interval were influenced by differences in mean calving date between the breeds. This was unavoidable due to the circumstances of the study set up. Thus, care is needed when interpreting these two parameters. However, that aside, large differences in pregnancy rates and consequently empty rates were observed. The fertility performance of the HF was poor compared to that generally obtained on previous trials at Moorepark with HF cows in 1st lactation. By comparison that observed with the J and JxHF was excellent. Embryo loss occurred in one HF and one J. If these animals did not break down, pregnancy rates to 1st service for the HF and J would have been 47% and 68%, respectively.

Table 4: 1st lactation fertility performance of HF, JxHF and J cows at Ballydague

	HF	J x HF	J
Mean calving date	Feb-19	Feb-12	Feb-27
Calving to 1st service interval (days)	80	80	65
Submission rate in the 1st 3 weeks (%)	80	90	86
Pregnancy rate to 1st service (%)	43	66	64
Pregnancy rate after 6 weeks breeding (%)	57	76	75
Empty rate (%)	17	3	7
Calving to conception interval (days)	98	93	79
Number of services per cow	2.01	1.55	1.57

EBI Proofs

The EBI and EBI sub-indices are presented for the HF, JxHF and J cows at Ballydague in Table 5. These are the most recent estimates available from

ICBF. However, it must be stressed that the across breed evaluation is currently in its infancy and therefore the breeding values included for some of the Jersey and Jersey crossbred cows has low reliability. Also, it is important to note, the breeding values of the crossbred cows does not include the effect of HV. This would be extra.

Table 5: EBI and sub-indices for HF, JxHF and J cows at Ballydague

	EBI	Milk	Fert	Calv	Beef	Health
HF	58.8	33.5	22.4	9.3	-5.3	-0.1
J x HF	83.4	47.4	56.3	14.2	-24.6	-0.3
J	70.3	29.1	85.2	9.9	-52.8	-1.2

Conclusion

The data presented are from the first year of two studies, the objective of which are to evaluate the potential of dairy crossbreeding for Irish dairy farmers going forward. Both studies are expected to be continued for a further two years. Paramount to profitability is the performance of mature cows, and potential differences that may arise in traits such as milk yield, fertility, health and survival. Thus, to present economic comparisons for the studies at this point would be premature. However, the preliminary data presented does suggest that crossbreeding with the Norwegian Red or Jersey are real options for Irish dairy farmers.

Acknowledgements

The Norwegian Red on-farm study described is one of the most unique research studies to be carried out by Moorepark, indeed, throughout the world. It represents a very comprehensive study, the implications from which are being awaited by farmers both here and around the world. The commitment and diligent efforts of the farmers involved is to be commended. Their input to date and continued commitment is sincerely appreciated. The assistance of Ann Geoghegan at Moorepark, and Sean Coughlan, Rachel Woods and the team at ICBF is also gratefully acknowledged.

Earth-Line Slurry/Effluent Stores

Research conducted by Teagasc and a summary of Department of Agriculture and Food Specification (S131)

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Executive Summary

- An earth-lined tank is a storage system to store organic fertilisers and farmyard effluents, constructed using soil which is sufficiently impermeable
- Earth-lined slurry stores have been proven to be an environmentally secure method of storing slurry and soiled water when constructed to the appropriate specification
- Earth-lined slurry stores will be eligible for grant aid but will require planning permission and must be built to a standard specification
- A site assessment will be required by a trained site assessor to determine the suitability of the site and most appropriate design
- All earth-lined slurry store construction will need to be overseen and certified by a chartered professional

Introduction

Conventional slurry storage facilities in Ireland include concrete tanks beneath slatted sheds, overground steel and underground concrete storage tanks. There is a large capital investment associated with such facilities, the cost of which may be prohibitive for the farming sector. Although earth-banked tanks (earth-lined stores) have been widely used throughout the world as an effective means of slurry storage (Parker *et al.*, 1999), (Davis *et al.*, 1973), (CIRIA 126, 1992), (AWMFH, 1999 etc.), their possible incorporation into an Irish farming context has never previously been examined in detail. Teagasc has now conducted research examining the environmental and economic sustainability of earth-banked tanks.

What is an Earth-Banked Tank?

An earth-banked tank is a storage system designed to store organic fertilisers and farmyard effluents and is generally constructed using soil which is sufficiently impermeable to contain the seepage rate of the slurry from the tank within acceptable limits. A typical earth-banked tank (Figure 1) is constructed using a standard 'cut and fill' technique, the banks of the tank extending about 1.5 m above original ground level, with the tank invert being about the same distance below ground level. In order to ensure that the tank is watertight, the sides and floor of the tank must be constructed of cohesive soil, and all permeable material (e.g. sand and gravel) should be removed and replaced with impermeable soil (i.e. dense clay). The tanks can be constructed on most soils, but loam and heavier soils are most suitable; sites with gravel or broken rock must be avoided or, if present in thin layers, should be removed and replaced with suitably impermeable soil. Internal side slopes of 1:2 are recommended, particularly for alluvial soils, but 1:1.5 is satisfactory for strong till soils.

The tank should be sized to store the maximum expected quantity of animal slurry produced during the closed period on a farm, in addition to the expected rainfall on the tank. A minimum freeboard must also be maintained within the tank for safety. Access points for slurry agitation, emptying and filling should be constructed to a high standard and an appropriate safety fence installed around the periphery of the tank.

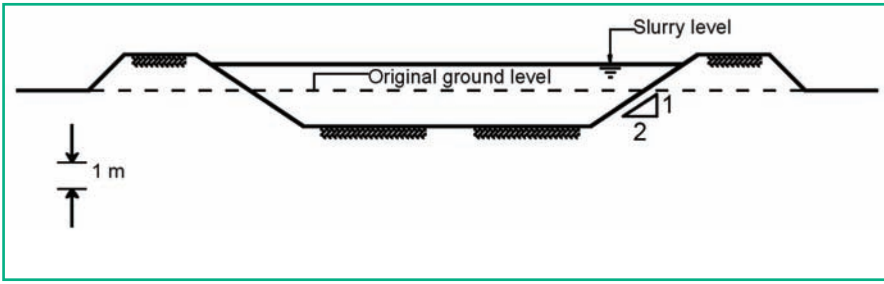


Figure 1 Schematic of typical earth-banked tank

Earth-Banked Tank Study

This study examined the feasibility of using earth-banked tanks (EBTs) as an alternative and economical means of winter storage for animal and other farmyard wastes. The study contained a detailed literature review on the subject, the results of a series of laboratory-scale experiments, field studies and a predictive model of the transport process through the soil liner of an earth-banked tank.

For the laboratory studies, soils were sampled at four different locations throughout Ireland. These soils were subjected to soil classification and hydraulic conductivity tests. Since this series of experiments had been conducted using water as the permeating fluid, further investigation was undertaken to examine the effect of animal slurry flowing through a soil liner. It was concluded that the presence of suspended solids in the slurry had a pronounced sealing effect on the soil liner, significantly reducing the effective permeability of the soil due to the deposition of solids on the soil surface and within the pores of the soil.

An investigation of a full-scale earth-banked tank at the Teagasc Grange Beef Research Centre at Dunsany, Co. Meath was undertaken. Groundwater quality, groundwater level and slurry infiltration rates were monitored after the tank was filled with animal slurry. As a result of the monitoring programme, it was concluded that well-constructed earth-banked tanks could successfully store animal slurry and that the quality of the groundwater around the tanks was well within permissible limits post filling and compared favourably with the groundwater quality prior to the installation of the tanks. A novel methodology for measuring infiltration rates through a subsoil liner and sampling groundwater quality from directly beneath the subsoil liner of an earth-banked tank was developed. A pilot-scale tank was constructed which enabled direct sampling of the quality and measurement of the quantity of the permeate from the tank. The slurry infiltration rate was significantly below acceptable limits and declined with time, indicative of a sealing of the pores of the soil due to the deposition of bio-solids. Examination of groundwater quality data in the vicinity of the pilot-scale earth-banked tank showed no discernible deterioration in quality.

A mathematical model of the soil sealing due to the physical transport of suspended solids contained in the animal slurry through the soil liner was presented. The model described the following hydraulic conditions: falling head, constant head and rising head. The model was validated for the falling head case using suspensions of cattle slurry at three different total solids concentrations. The proposed model may be useful to regulatory authorities, enabling an estimate of the likely soil sealing by suspensions flowing through soil liners to be made.

Laboratory Experiments

- basic soil tests such as particle size distribution and Atterberg limits give a good indication of the suitability of the soils for lining municipal leachate or agricultural slurry containment facilities
- the presence of suspended solids in the slurry had a pronounced sealing effect on the soil liner, significantly reducing the effective permeability of the soil due to the deposition of solids on the soil surface and within the pores of the soil
- under relatively high pressures (~ 10.3 m head), animal slurry of low total solids content (1.5 %) had the ability to almost completely seal a column of sand after a relatively short period of time
- animal slurries do form a seal on soil, and if this effect is accounted for in the design of earth-banked tanks, then the risk of excessive seepage is minimal

Field Work

- the full-scale earth-banked tank constructed at Teagasc Grange Beef Research Centre had no significant effect on the groundwater quality around the tank footprint
- the level of the groundwater table had no discernible influence on the quality of the groundwater in the vicinity of the earth-banked tank
- the direct method of measuring slurry infiltration proved to be much more reliable than the indirect method of measurement by a water balance calculation
- the quality of the effluent sampled directly beneath the pilot-scale earth-banked tank was well within permissible limits

Modelling Work

- conceptual models for the various field conditions of seepage flow from open channels and impoundments could be used to describe the conditions encountered for earth-banked slurry storage tanks
- a methodology was developed which involves the laboratory measurement of the specific resistance to filtration of an animal slurry, coupled with a mathematical model, enabling the reduction in seepage due to the solids contained in an animal slurry to be estimated
- the proposed model may be useful to regulatory authorities, enabling an estimate of the likely extent of soil sealing by suspensions flowing through soils and subsoil liners to be made
- a worked example of a practical application of the model has been presented

The overall conclusion of the study is that well-constructed earth-banked tanks using suitable soil that is adequately compacted can be successfully used to temporarily store highly polluting liquids such as animal slurries. The enhanced slurry-storage capacity resulting from the use of earth-banked tanks should reduce the pressure on farmers to spread slurry on land at inappropriate times, thereby contributing to an improvement in the quality of watercourses adjacent to agricultural activities.

Summary of Requirements of S131

(Minimum specification for earth-lined slurry/effluent stores ~ Department of Agriculture and Food)

Earth-lined stores (ELSs) were approved by the Technical Working Group (TWG) in October 2005. The approved specification (S131) and guidance document were posted on the Department of Agriculture and Food's website in March 2006. ELSs are now approved structures and can be grant-aided under the waste management scheme.

Main Requirements

1. **All earth-lined stores require planning permission**
2. **A site assessment must be carried out by a suitably trained site assessor**

The person undertaking the site assessment, shall have an appropriate training and shall be approved by the relevant Planning Authority.

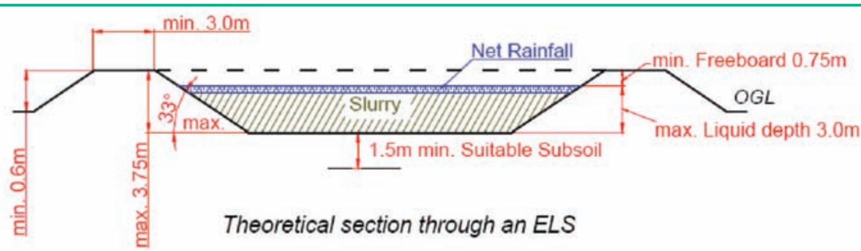
3. **Construction supervisor must oversee and certify ELS construction**

The Construction Supervisor shall be an appropriate Charterd Professional (e.g.: Charterd Civil Engineer, Chartered Structural Engineer or Chartered Geo-technical Engineer), or a person who has successfully completed a specialised training course that has been approved for this purpose by both the Department of Agriculture and Food and the Department of Environment, Heritage and Local Government. The Construction Supervisor shall be required to certify that works have been designed and completed to the standards required.

4. **Site restrictions: ELSs shall not be considered for:**
   a. sites within 60 m of any well or spring used for potable water
   b. sites within either:
      i. (a) the inner protection zone of public water drinking supply source (>10m3.d-1 or PE >50) (groundwater) where the vulnerability rating is classified as extreme, or
   c. where an inner protection zone has not been identified, within 300 m up gradient of the abstraction point
   d. sites where the minimum design requirements cannot be achieved
   e. sites within 10 m of an open watercourse where slurry effluent can enter
   f. sites within 50 m of a lake
   g. sites within 15 m of a karst feature
   h. sites underlain directly by sand/gravel in vertical hydraulic continuity with the main watertable
   i. sites underlain by peat or other unstable material that is impracticable to remove
   j. sites liable to flooding
   k. sites where construction of the ELS will damage or destroy a site of potential natural or cultural heritage value
   l. sites that are steeply sloping

5. ELS Configuration

Maximum liquid depth	*m*	*3.0*
Maximum freeboard depth	*m*	*0.75*
Maximum ground level to top of banks	*m*	*0.6*
Maximum inner bank slope	*deg*	*33*
Maximum outer bank slope	*deg*	*33*
Maximum width of top of banks	*m*	*3.0*



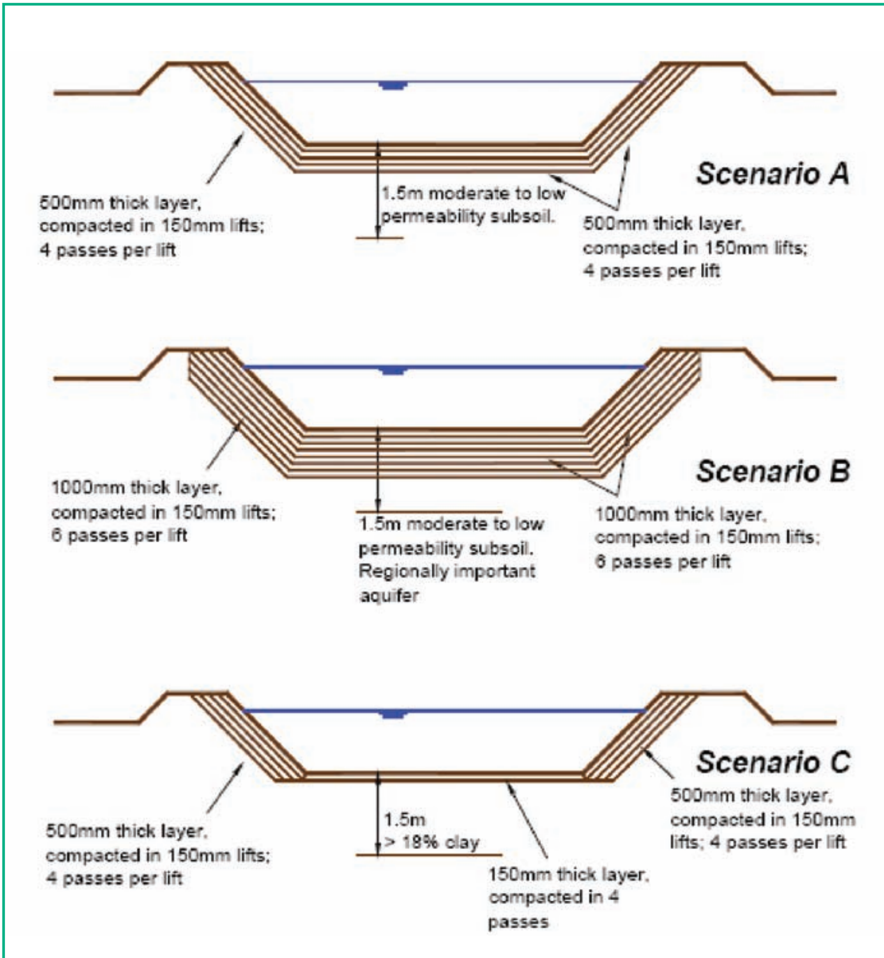
Theoretical section through an ELS

6. Subsoil Liner Requirements

- all ELSs shall be underlain by at least 1.5 m of moderate or low permeability subsoil with the upper 0.5 m having a permeability of less than 1 x 10^{-9} $m.s^{-1}$
- where a regionally important aquifer is present the total thickness shall

be at least 1.5 m with the upper 1.0 m having a permeability of less than 1 x 10^{-9} $m.s^{-1}$

- where the required permeability in the upper 0.5 m or 1.0 m has to be enhanced, this shall be achieved by the construction of a compacted liner as described in the technical specification
- in cases where the site assessment indicates that the *in-situ* subsoil has a clay content greater than 18%, is impervious (equivalent to a natural permeability of 1 x 10^{-9} $m.s^{-1}$), free from preferential flow paths (e.g. rootlets, worm burrows, cracks) and that the required depth of subsoil (1.5 m minimum) is present, then the excavated portion of the tank will require one layer of compacted subsoil (4 passes) and plastering with remoulded subsoil.



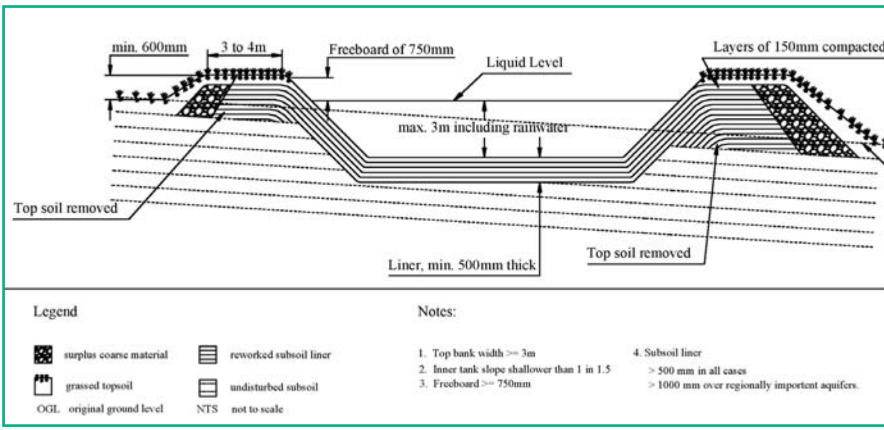
7. Further Comments

a. Fencing requirements of S131 should be strictly enforced
b. All Heath and Safety requirements should be followed.
c. ELSs should be routinely inspected for overfilling, erosion, fencing etc.

8. ELS Capacity Calculations

The required liquid capacity of an ELS may be calculated using the following methodology making reference to the requirements of the Nitrates Regulations

- the amount of slurry produced is calculated based on the number of cattle on the farm
- the existing slurry storage capacity is calculated
- the required slurry storage capacity on the farm is calculated based on the most up-to-date regulations
- the shortfall in slurry storage and any other effluent suitable for storage is calculated
- the net rainfall capacity is calculated and the ELS sized accordingly



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NATIONAL DEVELOPMENT PLAN

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