Crops Environment &
Land Use Programme
Johnstown Castle

Animal & Grassland
Research and
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Moorepark

Moorepark Dairy Levy Research Update
Teagasc Heavy Soils Programme Open Days
Moorepark Animal & Grassland Research and Innovation Centre

Con & Neilie Lehane, Ballinagree, Co. Cork - 6th May, 2015
Sean O' Riordan, Kishkeam, Co. Cork - 7th May, 2015
Donal & Michael Keane, Lisselton, Co. Kerry - 13th May, 2015
Alan Wood, Crossmolina, Co. Mayo - 2nd September, 2015

Series No. 29

Teagasc Agriculture and Food Development Authority · Kerry Agribusiness · Aurivo · Dairygold

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Teagasc Heavy Soils Programme

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Heavy Soils Open Days:

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Teagasc
Agriculture and Food Development Authority

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Introduction

There is a total of 6.64 million hectares of land in the Republic of Ireland (*exclusive of urban areas and roads*) of which 4.39 million hectares is classified as lowland mineral, 1.47 million hectares mountain and hill and 0.78 million hectares is classified as blanket and basin peat. The lowland mineral category can be subdivided into 2.95 million hectares of dry land and 1.44 million hectares of wet land. For the purpose of this project, the peats and the wet lowland mineral soils are classified as heavy soils. A large proportion of milk and meat produced in Ireland originates from farms where the soils that can be classified as heavy. Heavy soils add complexities to the production system that are aggravated by inclement weather conditions. A total of nine grassland farms have been selected based on soil type and location. A site-specific drainage system has been installed on a site (*approx. 2 ha*) in each of the participating farms. Additionally, various soil fertility programmes, soil and pasture renovation techniques and grazing farm infrastructures are being evaluated. In each of the participating farms, all inputs (*fertilizer, concentrates, purchased forages, etc.*) and outputs (*grass, milk and meat production*) are being monitored.

The objective of the Heavy Soils Programme, is to increase the profitability and sustainability of farming on heavy soils through increased grass production and utilization by

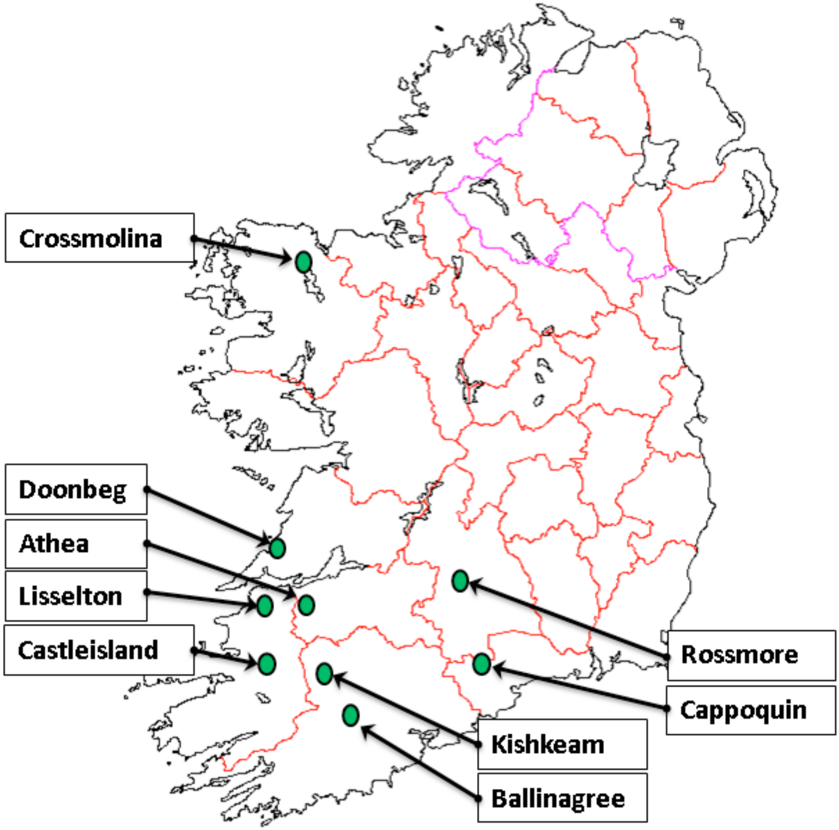
- Designing and installing drainage systems to remove excess water from soil,
- Optimizing the soil fertility (*P, K and pH*) status of poorly drained soil in high rainfall regions,
- Designing farm grazing infrastructure that facilitates grazing in difficult weather conditions while at the same time minimizes pasture poaching,
- Developing grassland management systems that optimize production efficiency,
- Evaluating methods of renovation of damaged pasture and soils to reduce surface roughness, increase plant density and reduce soil compaction,
- Communicating the innovations coming from the research programme to the main stakeholders.

The financial support for the research programme from state grants and Dairy Research Trust is gratefully acknowledged. Similarly separate financial support from Kerry Agribusiness, Dairygold Co-op and Tipperary Co-op is greatly appreciated.

The Heavy Soils Programme management team: James O' Loughlin, Pat Tuohy, Pat Dillon, Owen Fenton, David Wall, Ger Courtney and John Maher.

With Thanks to Tim Gleeson and Jim Kiely (*formerly Teagasc*) for guidance throughout the programme and Simon Leach (*Teagasc Agricultural Catchments Programme*) for assistance in digital mapping of programme farms.

Heavy Soils Programme Farms



- **Alan Wood**, Crossmolina, Co. Mayo
- **Danny Bermingham**, Doonbeg, Co. Clare
- **John Leahy**, Athea, Co. Limerick
- **Donal & Michael Keane**, Lisselton, Co. Kerry
- **John O' Sullivan**, Castleisland, Co. Kerry
- **Sean O' Riordan**, Kishkeam, Co. Cork
- **Con & Neilie Lehane**, Ballinagree, Co. Cork
- **TJ & Tom Ryan**, Rossmore, Co. Tipperary
- **Daniel O' Donnell**, Cappoquin, Co. Waterford

A Teagasc initiative operated jointly by Teagasc research and advisory personnel and supported by Kerry Agribusiness and Dairygold and Tipperary Co-operatives.

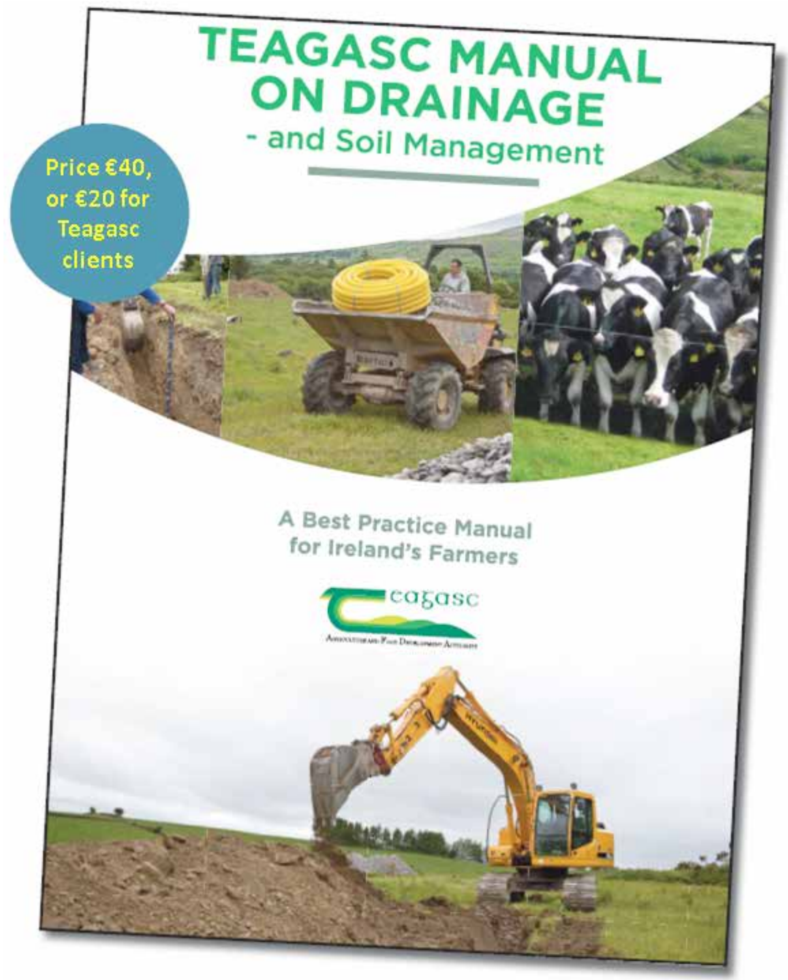
Useful Publications

Land Drainage Booklet

A freely downloadable practical guidebook to grassland drainage is available today. Alternatively it is accessible via the Teagasc website, *www.teagasc.ie/publications.* Search "Land Drainage"

Land Drainage Manual

The Teagasc Manual on Drainage - and Soil Management is available from Teagasc offices or can be ordered online via the Teagasc website, *www.teagasc.ie/publications.* Search "Teagasc Manual on Drainage and Soil Management"



Land Drainage Design Summary

Detailed guidance is available in publications (*previous page*)

- No drainage work should be carried out before the drainage characteristics of the soil are established by a site and soil test pit investigation.
- Two types of drainage system exist: a groundwater drainage system and a shallow drainage system. The design of the system depends entirely on the drainage characteristics of the soil.
- Distinguishing between the two types of drainage systems essentially comes down to whether or not a permeable layer is present (*at a workable depth*) that will allow the flow of water with relative ease. If such a layer is evident a piped drain system is likely to be effective, at this depth. If no such layer is found during soil test pit investigations, it will be necessary to improve the drainage capacity of the soil. This involves a disruption technique such as mole drainage, gravel mole drainage or sub-soiling in tandem with field drains.
- Drains are not effective unless they are placed in a permeable soil layer or complimentary measures (*mole drainage, sub-soiling etc.*) are used to improve soil drainage capacity. If water isn't moving through the soil in one or other of these two ways, the watertable will not be lowered.
- Outfall level must not dictate the drainage system depth. If a permeable layer is present, it must be utilised.
- Drain pipes should always be used for drains longer than 30 m. If these get blocked it is a drainage stone and not a drainage pipe issue.
- Drainage stone should not be filled to the top of the field trench except for very limited conditions (*the bottom of an obvious hollow*). Otherwise it is an extremely expensive way of collecting little water.
- Most of the stone being used for land drainage today is too big. Clean aggregate in the 10–40 mm (*0.4 to 1.5 inch approx.*) grading band should be used. Generally you get what you pay for.
- Sub-soiling is not effective unless a shallow impermeable layer is being broken or field drains have been installed prior to the operation. Otherwise it will not have any long-term effect and may do more harm than good.
- Most land drainage systems are poorly maintained. Open drains should be clean and as deep as possible and field drains feeding into them should be regularly rodded or jetted.

Con & Neilie Lehane, Ballinagree

6th May, 2015

Farm Performance

Table 1 shows a steady improvement on herd EBI with a strong emphasis on fertility. The bad weather in the summer of 2012 had a huge effect on grass grown that year.

Table 1: Farm Physical Performance 2011-2014

Year	Herd size	Stocking rate (LU/Ha)		Herd EBI		6 week calving rate (%)	Milk solds/ ha (kg)	Grass grown (T DM/Ha)
		Farm	*MP**	*Total*	*Fertility*			
2011	83	1.44	1.58	88	47	58	708	8.9
2012	82	1.43	1.56	106	67	60	687	6.6
2013	83	1.45	1.58	123	72	74	727	9.2
2014	81	1.42	1.54	130	83	79	726	10.8

*MP = Milking platform area

The higher costs associated with the wet summer of 2012 had a negative impact on margins in 2012 with a carryover into 2013 with higher spring costs (*Table 2*).

Table 2: Farm Financial Performance 2011-2014

Year	Gross Output		Total Costs		Net Margin	
	€/Ha	*c/litre*	*€/Ha*	*c/litre*	*€/Ha*	*c/litre*
2011	3,212	36.3	1,560	17.6	1,652	18.7
2012	3,218	38.6	1,852	22.2	1,366	16.4
2013	3,445	39.0	1,978	22.4	1,467	16.6
2014	3,480	39.3	1,784	20.1	1,696	19.2

Soil Fertility

Investment and Trends

There has been a considerable increase in fertilizer cost over the years, mostly accounted for by a strong emphasis on correcting and maintaining soil fertility (*Table* 3).

Table 3: Fertilizer & Lime Expenditure 2010-2014 (€)

	2010	2011	2012	2013	2014
Fertilizers	14,541	19,995	17,570	25,901	26,000
Lime	1,636	340	720	3,600	0
Total	16,177	20,335	18,290	29,501	26,000

Improving soil PH is the next soil fertility challenge on this farm (*Table* 4).

Table 4: Soil Fertility Trend 2010-2014

Year	pH	P (ppm)	K (ppm)
2010	5.8	5.6	129
2013	5.8	5.3	120
2014	5.8	5.4	140
Target	6.2	5.1-8.0	101-150

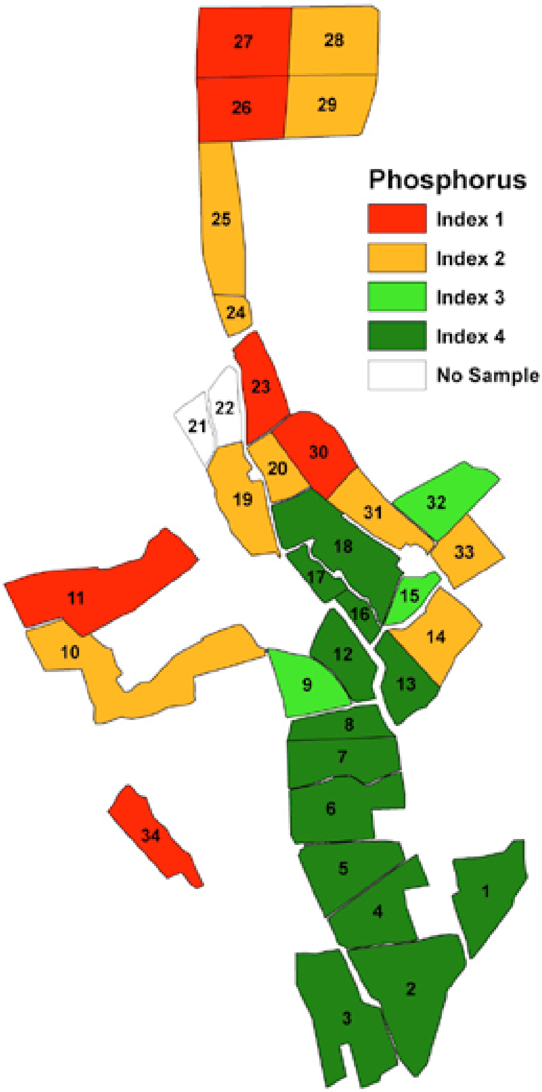


Figure 1: *Phosphorus Index Farm Map (December 2014)*

Soil Fertility Summary (*December 2014*)

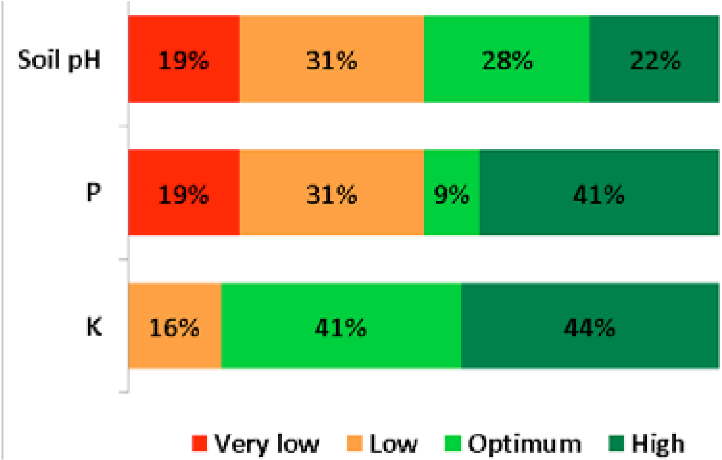


Figure 2: *Percentage of the farm within soil indices for Soil pH, P and K*

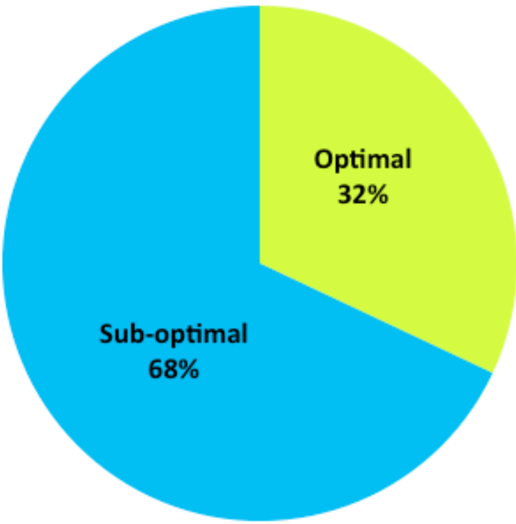


Figure 3: *Percentage of soils with optimal soil pH, P & K status*

Land Drainage

Site Investigation

As is standard procedure, a site investigation in association with the farmer and local advisor was carried out as the first step in the design process. This involved walking the site and noting outfall conditions, field slope, historic features, areas of poor grass growth, poor underfoot conditions or abundant water loving vegetation as well as existing drains (*in-field and open*) and natural water-courses. After these initial observations the history of the site was explained in detail by Con and Neilie, this revealed that some pre-existing open drains had been closed and rerouted close to the site. A rough sketch (*Figure* 4) of the site noted all relevant features.

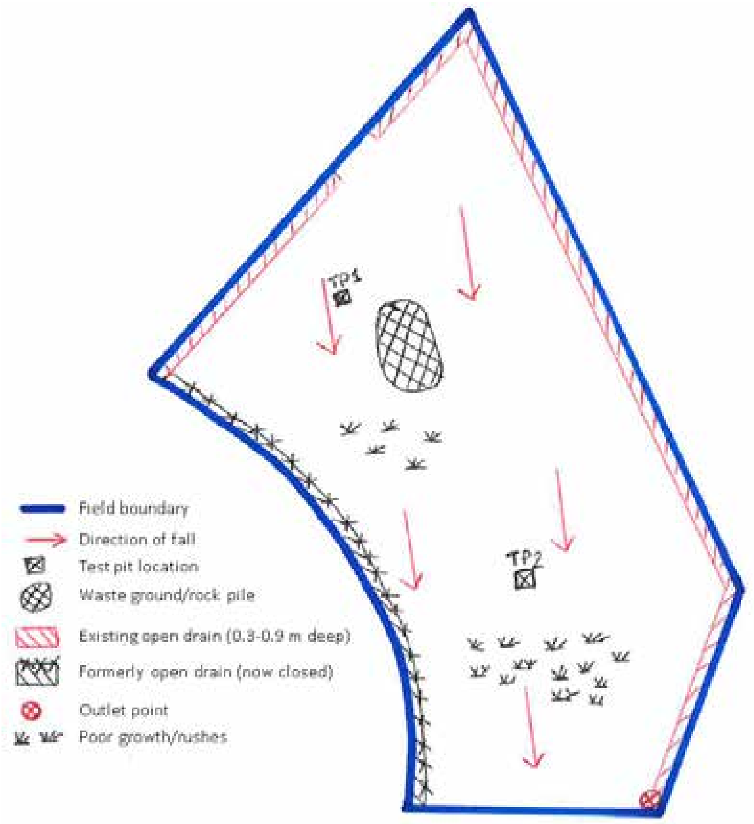


Figure 4: *Site investigation sketch*

The next step involved digging test pits on the site to be drained. The profile uncovered (*Figure 5*) was not overly heavy but still contained evidence of slow water infiltration (*drainage*) and movement. Strong seepage of groundwater into the pit was noted from approximately 1.5 m depth. Given the position of the site in the landscape (*mid-slope on steep high ground*) it was concluded that groundwater, moving downslope, was maintaining a shallow watertable and inhibiting surface water infiltration. Drainage on this site would have to remove this excess water to control the watertable depth and allow increased surface water infiltration. The design required is classed as a groundwater drainage system, comprising field drains located in the layer where groundwater can move (*from approx. 1.5 m depth in this case*). Soil test pits also uncovered a number of large stones and boulders (*0.1 – 0.8 m approximately in size*). Such stones would make excavation of field drains and removal of soil more problematical.

The final phase of the site investigation involved measurement and mapping of the site. This allowed for field levels and geometry to be established and most importantly outfall conditions to be assessed. On this site, field slope and outfall conditions were never in doubt but in most cases a level survey is required to optimise the location of field drains and ensure adequate falls.

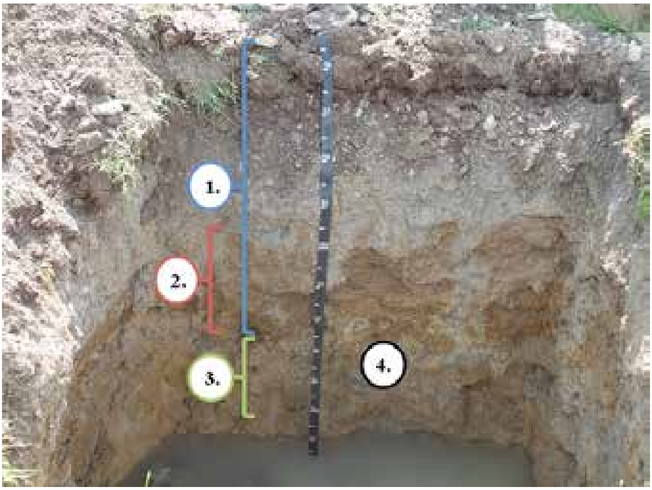


Figure 5: *Typical soil profile at Ballinagree site*
(1) Moderately permeable (*0.0-1.5 m depth*) with moderate to good porosity, and strong granular structure (*natural cracking*), (2) common mottling (*discolouration*) (*0.9-1.5 m depth*), (3) highly permeable (*1.5-2.0 m depth*) with consistent in-flow of groundwater and strong granular structure (*natural cracking*), water visible at base of soil test pit and (4.) field drain invert level (*1.7m*).

Teagasc
Agriculture and Food Development Authority

Detailed Drainage Specifications

Land Owner
Con & Nellie Lehane

Paddocks/Area
12

Date: 20/06/2013

Paddock	OUTLINE DESIGN	Detail
	Open Drains	
	• Existing open drain at northern site boundary must be deepened to 1.7 m	Total length 95 m
	• Existing open drains at eastern site boundary must be deepened to 2.0 m	Total length 226 m
	• Bank slope must not be steeper than 2:1 (vertical:horizontal)	
	• Spoil may be removed or where good quality spread. large stones/boulders will need to be buried over drainage aggregate backfill (see note below)	
	Field Drains	
	• 10 x field drains across slope at 20 m spacing (as per specification map)	Total length 900 m
	• To a minimum graded depth of 1.7 m	
	• Use 80 mm corrugated pipe with 1-2m sewer or concrete shore at all outlets	
	• Add 400 mm depth porous fill being 10-40 mm washed stone	
	• Backfilled thereafter with soil, spoil to be spread	
	• Where large stones/boulders raised during drain excavations are present these can be used to backfill field drain trenches also (after placement of porous fill)	
	Miscellaneous	
	• Existing waste ground (rock-pile) will need to be reduced in size to allow for field drain installation	

Figure 6: *Drainage design specification*

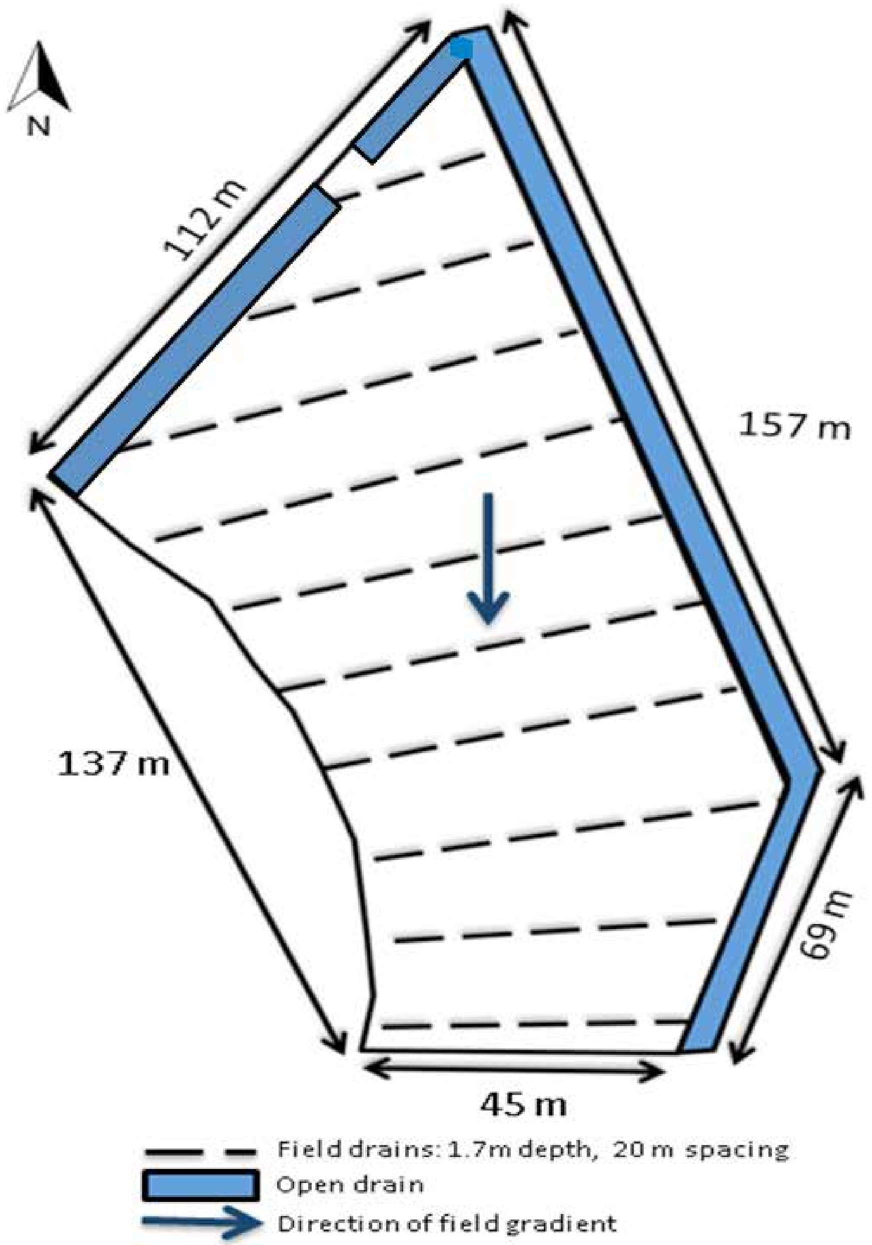


Figure 7: *Drainage design map*

Notes on Drainage Design and Installation

The information gathered from the opening of on-site soil test pits indicated that the site was underlain by a consistent layer of highly permeable soil, first encountered at an approximate depth of 1.5 m below the surface. The high stone and gravel content as well as the proliferation of roots and structural cracks to substantial depths within the profile indicated that there was sufficient capacity for infiltration (*drainage*) of water through the profile to a groundwater drainage system. The purpose of the drainage system designed for the site was to target this highly permeable layer at 1.7 m and exploit the water carrying capacity it has.

It was decided to install groundwater drains to a minimum depth of 1.7 m and a 20 m spacing (*Figure 7*) spanning the width of the site and running across the main field gradient. The existing open drain at the eastern side of the site was cleaned and deepened to a depth of 2 m to act as an outfall for the new field drains. The existing gullet at the field outlet point was lowered to allow for this. The existing open drain at the northern end of the site was also deepened to 1.7 m, to intercept as much groundwater and surface water (*coming from the adjacent forestry*) as possible before it could enter the site. Field drains were installed in two stages in order to avoid difficulties related to subsidence and collapse of the field drain trench during installation. Initially a 1.0 m deep trench was excavated using a wide moulding bucket (*Figure 8*), after this a narrower tile drainage excavator bucket (*Figure 9*) was used to complete the drain to its final depth (*1.7 m*). Each drain was installed and backfilled immediately. The groundwater drains consisted of an 80 mm corrugated perforated PVC pipe with a gravel aggregate envelope (*10 - 40 mm grade*) backfilled to within 1.3 m of the soil surface (*to ensure maximum connection to the high permeability soil layer*) and thereafter backfilled with soil (*and larger stones/boulders raised during drain excavation*). The drains were installed from June 20th to 22nd, 2013.

Figure 8: *Trapezoidal moulding bucket*

Figure 9: *Narrow tile drainage bucket*

Costs

Table 5: Costs	
Item	**(€)/ha**
Drain installation @ €45/hr (*73/hrs*)	3,285
Drainage pipe @ €0.89/m (*592 m*)	525
Drainage stone @ €13.87/t (*118 t*)	1,640
Total cost	**5,450**

The mean cost of the drainage systems installed was €5,740/ha, with a range of €3,420/ha (*Kishkeam*) to €7,155/ha (*Athea*), (*Figure 10*). The cost of the drainage systems was dependent on a number of factors. These included

- The suitability of existing open drains as outfalls for the proposed field drains.
- The type of drainage system, particularly if a shallow drainage system was required.
- The intensity of field drainage required.
- The cost of and time taken by the contractor.
- The cost of materials, particularly stone aggregate.

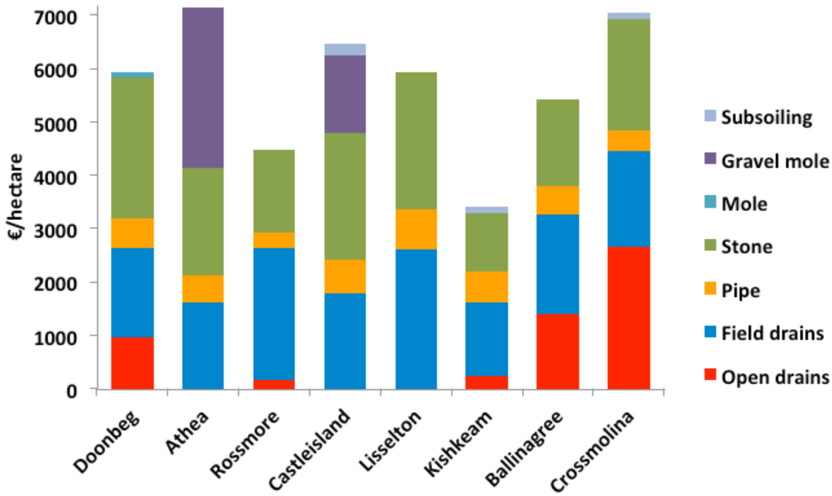


Figure 10: *Comparative costs (€/ha) of land drainage works on all programme farms*

Farm Infrastructure

Table 6: Assessment of Infrastructure Adequacy			
Infrastructure	**Adequacy**		
	Good	*Adequate*	*Needs Attention*
Grazing			
Paddock size	X		
Farm roadways		X	
Water troughs	X		
Milking parlour			
No. of rows	X		
Collecting yard	X		
Drafting			X Priority 2015
Farmyard			
Slurry storage		X	
Silage slab	X		
Cubicle spaces		X	
Head feed space			X
Calf facilities		X	
Calving facilities			X Priority 2015

Sean O' Riordan, Kishkeam

7th May 2015

Farm Performance

Table 7 shows steady organic growth in herd size with excellent EBI and fertility bias reflected in six week calving rate. The weather effect of 2012 is shown in the poor grass grown figure that year.

Table 7: Farm Physical Performance 2011-2014

Year	Herd size	Stocking Rate (LU/Ha)		Herd EBI		6 week calving rate (%)	Milk solids/ ha (kg)	Grass grown (T DM/Ha)
		Farm	MP*	Total	Fertility			
2011	75	1.56	2.53	104	60	78	890	8.5
2012	81	1.46	2.26	118	73	77	699	5.9
2013	77	1.22	2.21	143	78	87	836	8.8
2014	89	1.44	2.22	168	93	87	826	10.4

*MP = Milking platform area

The higher costs associated with the wet summer of 2012 had a negative impact on margins in 2012 with a carryover into 2013 with higher spring costs (*Table 8*).

Table 8: Farm Financial Performance 2011-2014

Year	Gross Output		Total Costs		Net Margin	
	€/Ha	*c/litre*	*€/Ha*	*c/litre*	*€/Ha*	*c/litre*
2011	2,614	36.1	1,430	19.7	1,184	16.4
2012	2,025	34.1	1,542	26.0	483	8.1
2013	2,406	39.9	1,788	29.6	618	10.2
2014	2,875	42.9	1,436	21.4	1,439	21.5

Soil Fertility

Investment and Trends

There has been a considerable increase in fertilizer cost over the years, mostly accounted for by a strong emphasis on correcting and maintaining soil fertility (*Table* 9).

Table 9: Fertilizer & Lime Expenditure 2010-2014

	2010	2011	2012	2013	2014
Fertilizers	14,200	21,500	22,600	28,735	16,565
Lime	750	730	361	720	1,880
Total	14,950	22,230	22,961	29,445	18,445

Soil fertility remains "a work in progress" soil pH, P and K levels will continue to be targeted for improvement (*Table* 10).

Table 10: Soil Fertility Trend 2010-2014

Year	pH	P	K
2010	5.4	3.8	106
2013	5.9	1.9	43
2014	5.6	2.0	88
Target	6.2	5.1-8.0	101-150

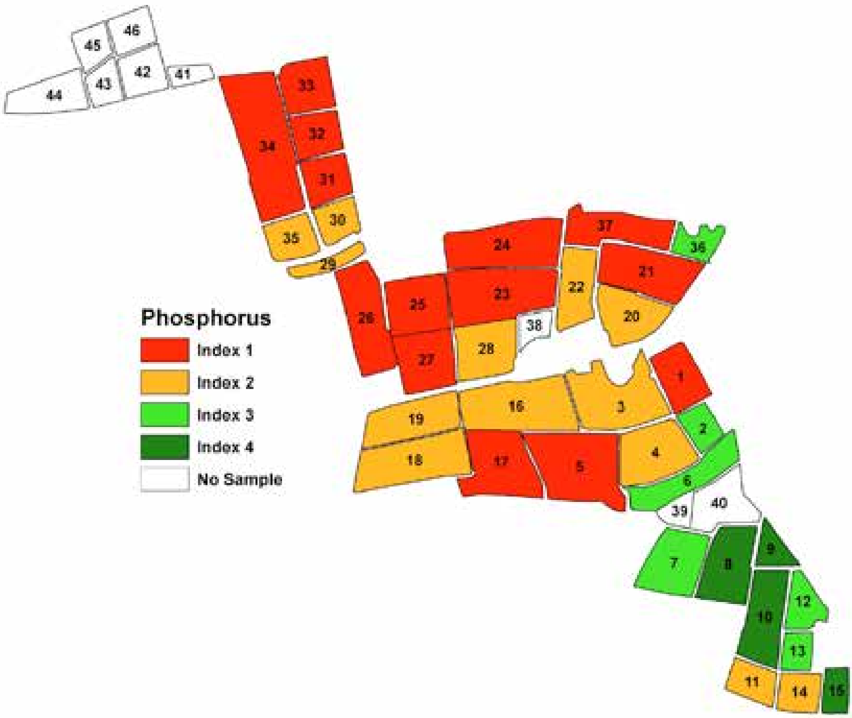


Figure 11: *Phosphorus Index Farm Map (December 2014)*

Soil Fertility Summary (*December 2014*)

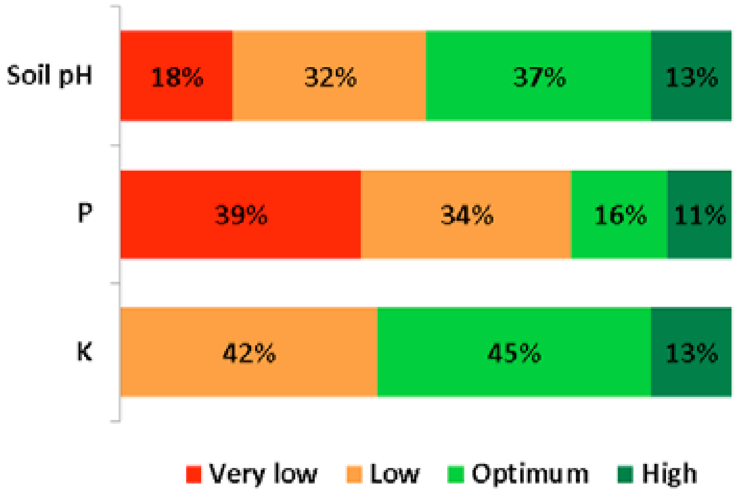


Figure 12: *Percentage of the farm within soil indices for Soil pH, P and K*

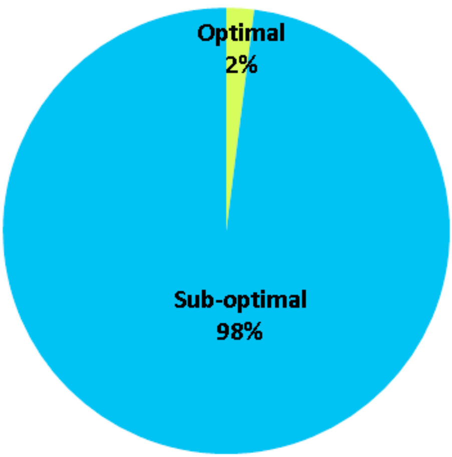


Figure 13: *Percentage of soils with optimal soil pH, P & K status:*

Land Drainage

Site Investigation

As is standard procedure, a site investigation in association with the farmer and local advisor was carried out as the first step in the design process. This involved walking the site and noting outfall conditions, field slope, historic features, areas of poor grass growth, poor underfoot conditions or abundant water loving vegetation as well as existing drains (*in-field and open*) and natural water-courses. After these initial observations the history of the site was explained in detail by Sean. A rough sketch of the site (*Figure 14*) noted all relevant features.

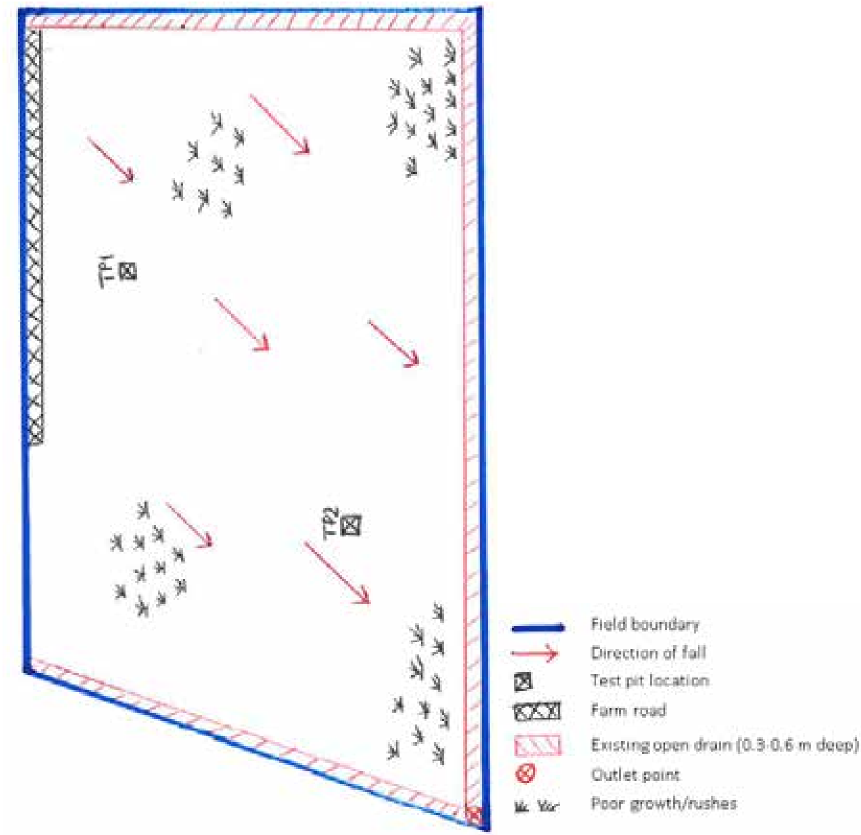


Figure 14: *Site investigation sketch*

The next step involved digging soil test pits on the site. The profile uncovered (*Figure 15*) contained a tightly consolidated and high clay content subsoil. There was increased stone content with depth and bedrock (*shale*) at depths of 2.5 to 3.0 m. There was some inflow of groundwater at depths of 1.0 – 1.2 m but this was not consistent in all soil test pits. This water movement indicated that a groundwater drainage system at this depth could be beneficial. However, as it was not consistent throughout the site, other means of drainage would need to be employed to ensure a successful outcome. The layer at 0.3 – 1.0 m depth is a heavy clay with no apparent structure (*natural cracking*). It was classed as poorly permeable and would require the intensity of drainage provided by a disruption technique (*mole or gravel mole drains or sub-soiling*) being supplemented by a network of collector drains. Mole drainage was not feasible on this site due to the large amount of stones present. Given the high cost associated with gravel mole drainage and the level of groundwater discharge naturally facilitated by suitably deep collector drains, it was decided that sub-soiling the site would be an adequate method of subsoil disruption.

The final phase of the site investigation involved measurement and mapping of the site. This would allow for field levels and geometry to be established and outfall conditions to be assessed. A laser-level survey was used to assess falls and provide guidance on the most appropriate positions of field drains.

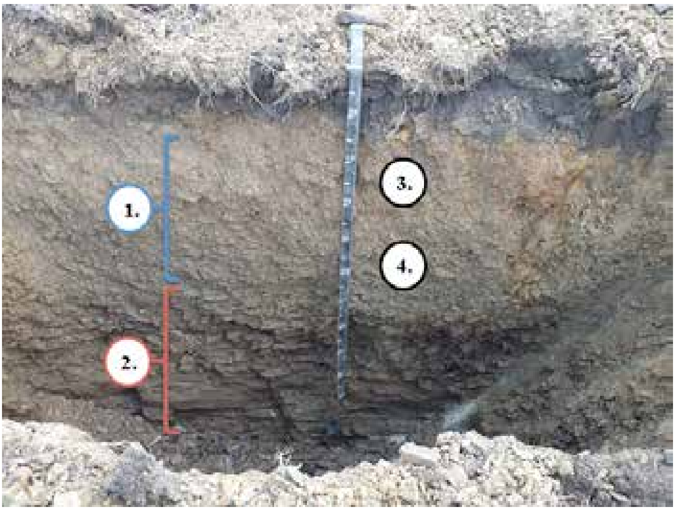


Figure 15: *Typical soil profile at Kishkeam site*

(1) Poorly permeable structureless high clay content soil (*0.3-1.1 m depth*), (2) increasing stone content (*1.1-2.5 m depth*), (3) sub-soiler channel invert level (*0.6 m*) and (4) field drain invert level (*1.1 m*).

teagasc
Agriculture and Food Development Authority

Detailed Drainage Specifications

Land Owner
Sean O' Riordan

Paddocks/Area
23

Date: 04/07/2013

Paddock	OUTLINE DESIGN	Detail
	<u>Open Drains</u>	
	• Existing open drains at eastern site boundary must be deepened to 1.5 m	Total length: 100 m
	• Bank slope must not be steeper than 2:1 (vertical:horizontal)	
	• Spoil may be removed or where good quality spread	
	<u>Field Drains</u>	
	• 6 x field drains across slope at 15 m spacing (as per specification map)	Total length: 900 m
	• To a minimum graded depth of 1.1 m	
	• Use 80 mm corrugated pipe with 1-2m sewer or concrete shore at all outlets	
	• Add 800 mm depth porous fill being 10-40 mm washed stone	
	• Backfilled thereafter with soil, spoil to be spread	
	<u>Subsoiling</u>	
	• Subsoiling to be carried out at 0.6 m depth and 1.5 m spacing using single-leg winged subsoiler	
	• Subsoiler will be pulled uphill from lower end of site and cross field drains at right angle	

Figure 16: *Drainage design specification*

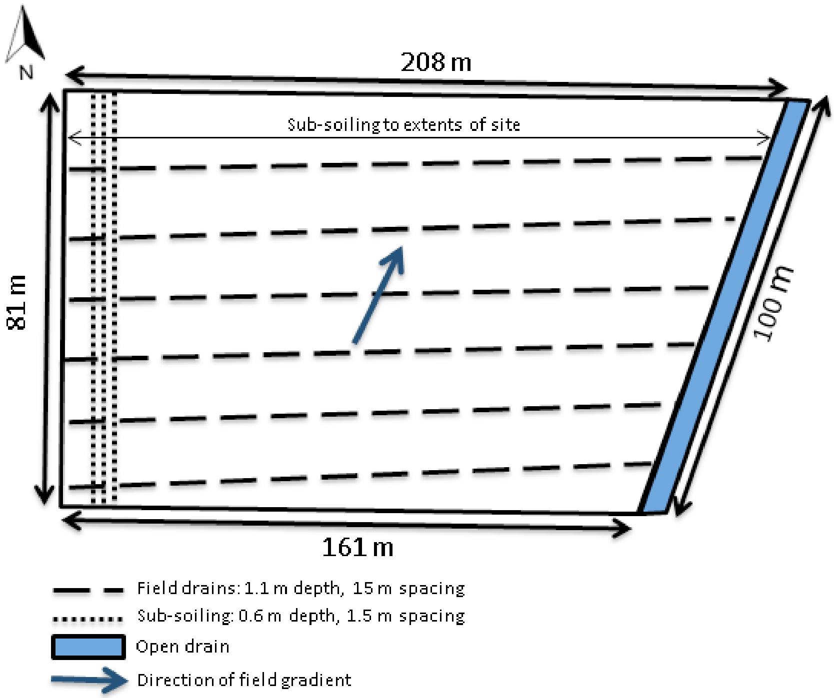


Figure 17: *Drainage design Map*

Notes on Drainage Design and Installation

The information gathered from opening of on-site soil test pits indicated that the soil profile was consistently heavy and dense with abundant stones. In some areas there were lenses or zones of higher permeability with the potential for significant groundwater movement (*at depths of 1.0-1.2 m*). Drainage design in this case would have to provide an outlet for this groundwater while also improving the infiltration capacity of the heavy and dense subsoil commonly found.

It was decided to install a series of collector drains across the main field gradient at a spacing of 15 m (*Figure 17*). While the drains act predominantly as conduits for surface water being collected, the in-flow of groundwater at 1.0 – 1.2 m depth in certain areas of the site allows for groundwater drawdown. For this reason all collector drains were installed to a minimum depth of 1.1 m. The existing open drain at the eastern side of the site was cleaned and deepened to a depth of 1.5 m to act as an outfall for the new field drains. The drains consisted of an 80 mm corrugated perforated PVC, with a gravel aggregate envelope (*10 - 40 mm grade*) backfilled to within 0.3 m of the soil surface (*to ensure maximum connection to the disturbed (sub-soiled*) soil and topsoil) and thereafter backfilled with soil.

Sub-soiling was carried out with a single leg winged sub-soiler (*Figure 18*) to improve permeability of the upper layers and increase the level of infiltration of surface water into the soil profile and ultimately into the collector drains. The collector drains (*Figure 19*) were installed on July 4 – 6, 2013. Sub-soiling was carried out at a depth of 0.6 m and a spacing of 1.5 m on July 22, 2013 when good weather ensured dry soil conditions and allowed for the maximum level of soil disturbance. The depth of sub-soiling was set to ensure maximum fracturing and disturbance of the soil. The spacing was determined as the closest spacing allowable given the width of the tractor used for drawing the sub-soiler and the need to avoid tracking over the newly formed disruption channels.

Figure 18: *Single leg winged sub-soiler*

Figure 19: *Collector drains*

Costs

Table 11: Costs	
Item	**(€)/ha**
Drain installation @ €45/hr (36/*hrs*)	1,625
Drainage pipe @ €1.03/m (566 *m*)	585
Drainage stone @ €10.78/t (*101 t*)	1,085
Sub-soiling	125
Total cost	**3,420**

The mean cost of the drainage systems installed was €5,740/ha, with a range of €3,420/ha (*Kishkeam*) to €7,155/ha (*Athea*). The cost of the drainage systems was dependent on a number of factors. These included

- The suitability of existing open drains as outfalls for the proposed field drains.
- The type of drainage system, particularly if a shallow drainage system was required.
- The intensity of field drainage required.
- The cost of and time taken by the contractor.
- The cost of materials, particularly stone aggregate.

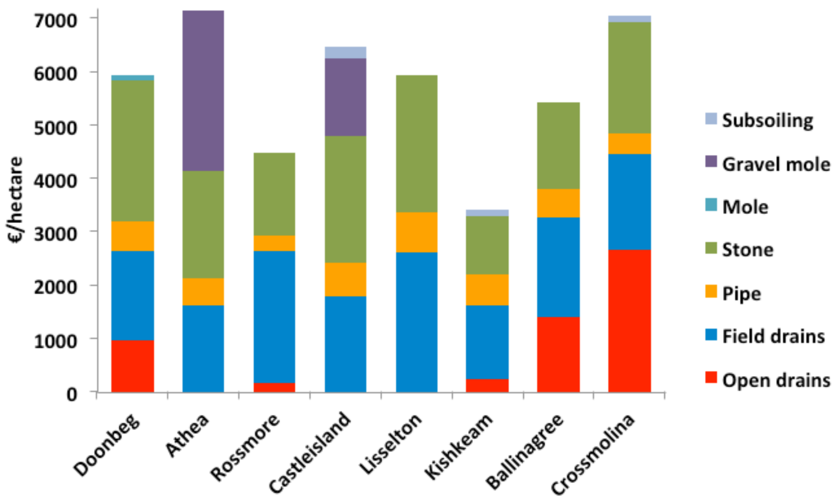


Figure 20: *Comparative costs (€/ha) of land drainage works on all programme farms*

Farm Infrastructure

Table 12: Assessment of Infrastructure Adequacy			
Infrastructure	**Adequacy**		
	Good	*Adequate*	*Needs Attention*
Grazing			
Paddock size	X		
Farm roadways		X	
Water troughs	X		
Milking parlour			
No. of rows		X	
Collecting yard		X	
Drafting			X
Farmyard			
Slurry storage	X		
Silage slab		X	
Cubicle spaces		X	
Head feed space	X		
Calf facilities		X	
Calving facilities			X

Donal & Michael Keane, Lisselton

13th May 2015

Farm Performance

Table 13 shows steady growth in herd size with a strong emphasis on herd EBI with fertility as an important component. The bad summer of 2012 and poor spring of 2013 is evident from grass grown data.

Table 13: Farm Physical Performance 2011-2014

Year	Herd size	Stocking rate (LU/Ha)		Herd EBI		6 week calving rate (%)	Milk solids /ha (kg)	Grass grown (T DM/Ha)
		Farm	*MP**	*Total*	*Fertility*			
2011	79	2.01	2.79	61	26	61	1,220	10.4
2012	78	2.18	2.76	114	75	67	1,062	8.9
2013	82	2.21	2.90	135	81	66	1,174	8.2
2014	85	2.42	3.00	147	81	68	1,229	10.0

*MP = Milking platform area

The higher costs associated with the wet summer of 2012 had a negative impact on output and margins in 2012 with a carryover into 2013 with higher spring costs (*Table 14*).

Table 14: Farm Financial Performance 2011-2014

Year	Gross Output		Total Costs		Net Margin	
	€/Ha	*c/litre*	*€/Ha*	*c/litre*	*€/Ha*	*c/litre*
2011	4,150	35.9	2,131	18.4	2,019	17.5
2012	3,820	34.7	2,629	23.9	1,191	10.8
2013	4,618	40.1	3,106	27.0	1,512	13.1
2014	4,845	39.5	2,982	24.3	1,863	15.2

Soil Fertility

Investment and Trends

Steady investment in fertilizers to maintain good soil fertility. As it is mostly an organic/peat soil type farm there is not a lime requirement. The drop in fertilizer used in 2012 reflects the difficulties of being able to travel the land to apply fertilizers in often waterlogged conditions that year (*Table 15*).

Table 15: Fertilizer & Lime Expenditure 2010-2014

	2010	2011	2012	2013	2014
Fertilizers	12,721	14,817	6,577	15,837	16,500
Lime	0	0	0	0	0
Total	12,721	14,817	6,577	15,837	16,500

Soil pH is adequate for peat type soil, P levels are at the target level while some work remains to be done on K (*Table 16*).

Table 16: Soil Fertility Trend 2010-2014

Year	pH	P	K
2010	5.3	10.9	118
2013	5.7	7.0	112
2014	5.7	7.2	83
Target	5.5	5.1-8.0	101-150

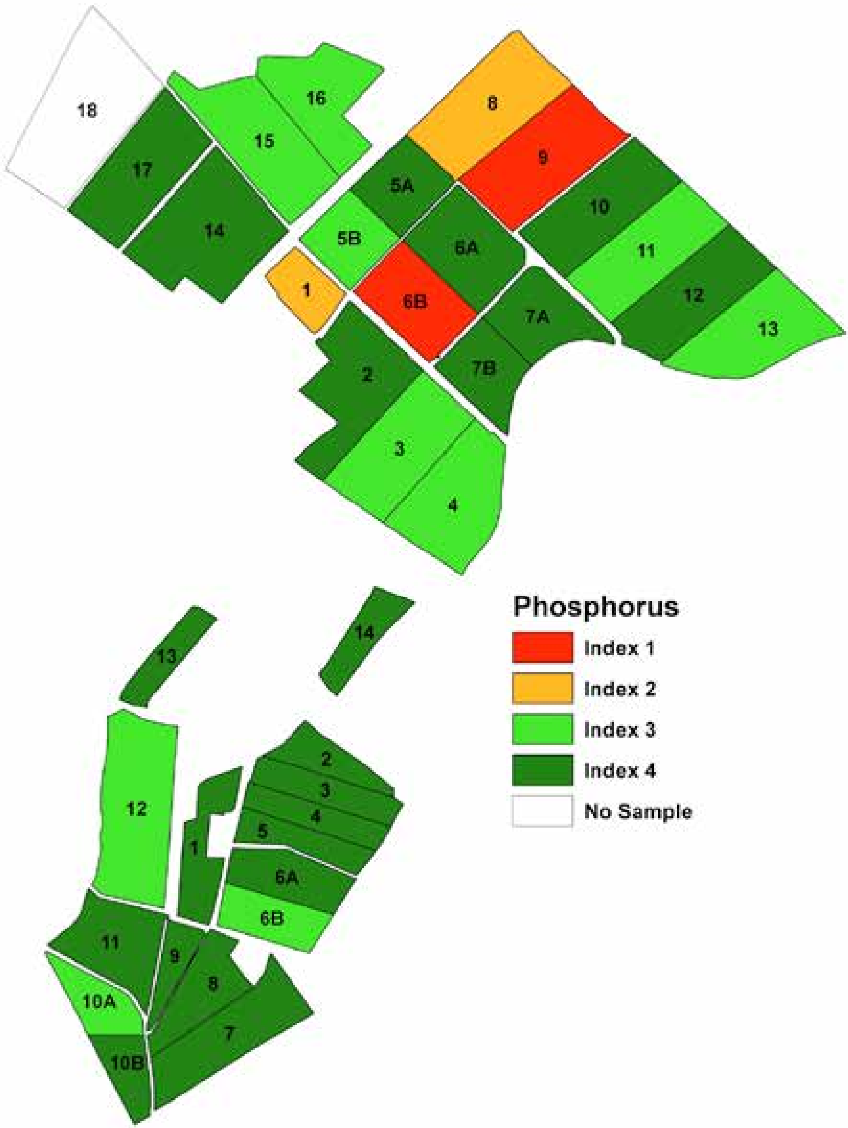


Figure 21: *Phosphorus index farm map (December 2014)*

Soil Fertility Summary (*December 2014*)

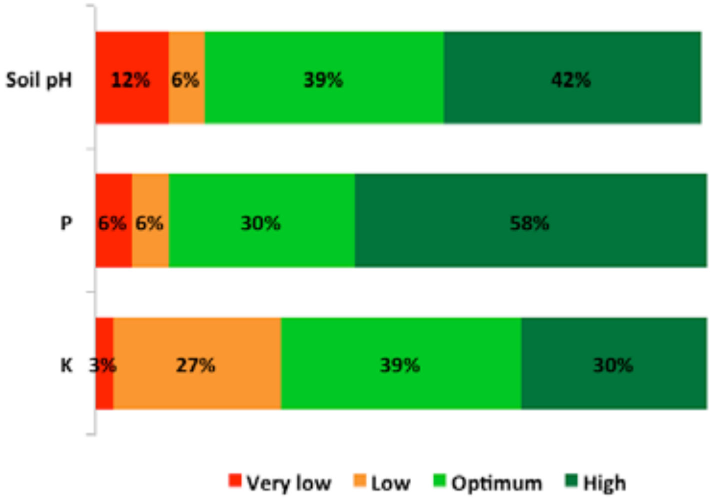


Figure 22: *Percentage of the farm within soil indices for Soil pH, P and K*

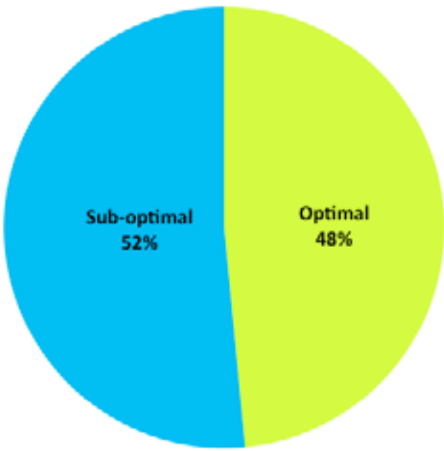


Figure 23: *Percentage of soils with optimal soil pH, P & K status*

Land Drainage

Site Investigation

As is standard procedure, a site investigation in association with the farmer and local advisor was carried out as the first step in the design process. This involved walking the site and noting outfall conditions, field slope, historic features, areas of poor grass growth, poor underfoot conditions or abundant water loving vegetation as well as existing drains (*in-field and open*) and natural water-courses. After these initial observations the history of the site was explained in detail by Donal & Michael. A rough sketch of the site (*Figure* 24) noted all relevant features.

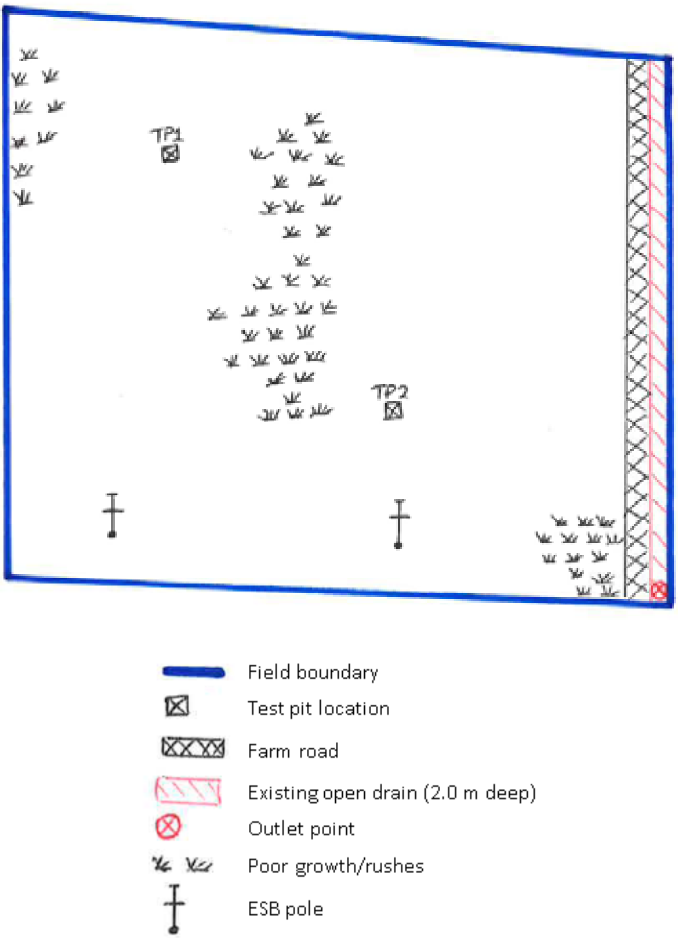


Figure 24: *Site investigation sketch*

The next step involved digging soil test pits on site. The profile uncovered (*Figure* 25) comprises of a highly organic/peaty topsoil (*to 0.8 m depth*) underlain by a thin heavy layer (*approximately* 5-15 *cm thick*) and a highly permeable silt with significant inflow of groundwater consistently across the site. Strong seepage of groundwater was noted from depths of 1.1 to 1.8 m and generally increasing with depth. Effective drainage on this site would need to target this depth. The most appropriate drainage system for this site would be a groundwater drainage system which would remove excess groundwater and allow surface water to infiltrate through the profile. In this case the drains would be located in the layer where groundwater can move, at approximately 1.3 to 1.7 m.

The final phase of the site investigation involved measurement and mapping of the site. This would allow for field levels and geometry to be established and outfall conditions to be assessed. A laser-level survey was used to assess falls and provide guidance on the most appropriate positions of field drains.

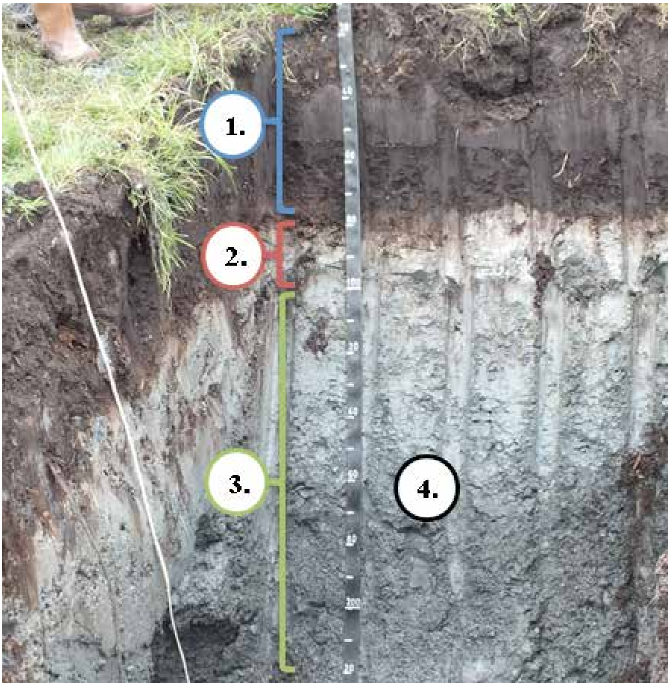


Figure 25: *Typical soil profile at Lisselton site*

(1) Organic clay loam with good porosity (*0.0-0.85 m depth*), (2) heavy layer (*0.85-1.0 m depth*), (3) highly permeable (*>1.0 m depth*) with consistent in-flow of groundwater, silty texture and granular structure, some sidewall collapse and (4) field drain invert level (*1.7 m*).

Teagasc
Agriculture and Food Development Authority

Detailed Drainage Specifications

Land Owner
Donal & Michael Keane

Paddocks/Area
14

Date: 12/08/2013

Paddock	OUTLINE DESIGN	Detail
	<u>Field Drains</u> • 10 x field drains across slope at 15 m spacing (as per specification map) • To a minimum graded depth of 1.7 m • Use 80 mm corrugated pipe with 1-2m sewer or concrete shore at all outlets • Add 400 mm depth porous fill being 10-40 mm washed stone • Backfilled thereafter with soil, spoil to be spread	Total length: 1400 m

Figure 26: *Drainage design specification*

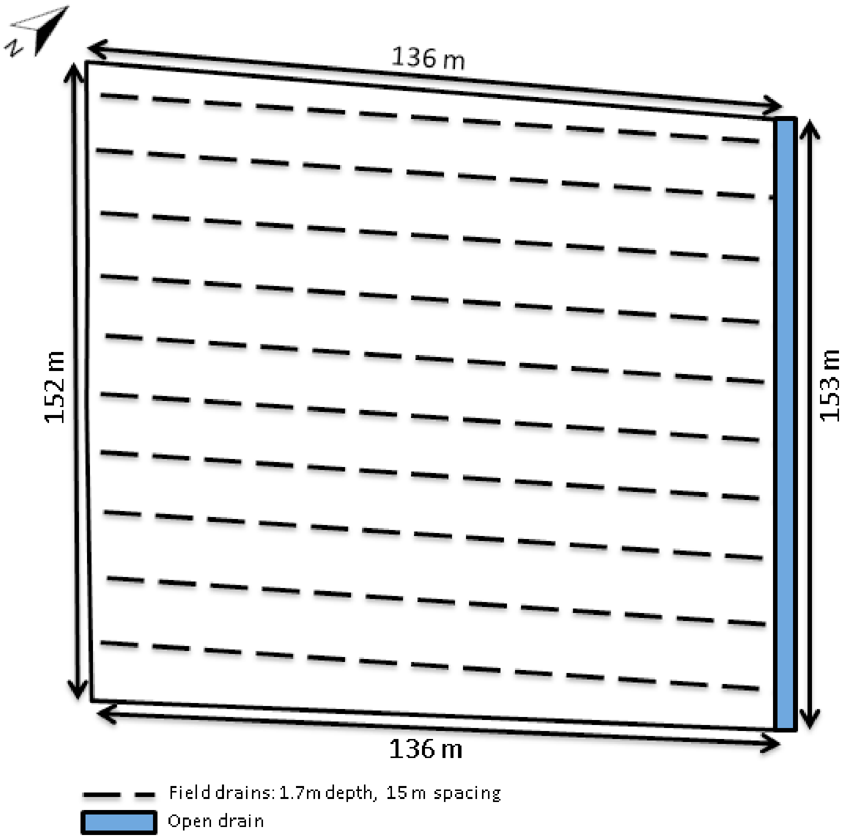


Figure 27: *Drainage design map*

Notes on Drainage Design and Installation

The information gathered from opening of on-site soil test pits indicated that the site was underlain by a highly permeable layer, first encountered at an approximate depth of 1.1 m below the surface but showing greater permeability with depth to 1.8 m. The purpose of the drainage system designed for the site is to target this highly permeable layer and exploit the water carrying capacity it has. This is the most effective way of removing excess water and controlling the watertable.

As the seepage of water into the soil test pits increased with depth up to 1.8 m, it was decided to install groundwater drains to a minimum depth of 1.7 m and a 15 m spacing (*Figure 27*). This close spacing was selected to account for the significant depth of the highly organic topsoil and the need for efficient watertable drawdown to maximise the discharge of excess water from this layer. The existing open drain on site is maintained by the O.P.W. and therefore did not require deepening to act as an outfall for the new field drains (*this was a significant time and cost saving, when compared with some other sites on the programme*). Drains were installed in two stages in order to avoid difficulties related to subsidence and collapse of the field drain trench during installation. Initially a 1.0 m deep trench was excavated using a wide moulding bucket, after this a narrower tile drainage excavator bucket (*see page 18*) was used to complete the drain to its final depth (*1.7 m*). Each drain was installed and backfilled immediately. The groundwater drains consisted of an 80 mm corrugated perforated PVC pipe, with a gravel aggregate envelope (*10 - 40 mm grade*) backfilled to within 1.3 m of the soil surface (*to ensure maximum connection to the high permeability soil layer*) and thereafter backfilled with soil. The drains were installed between August 12th and 14th, 2013.

Costs

Table 17: Costs	
Item	**(€)/ha**
Drain installation @ €40/hr (65/*hrs*)	2,610
Drainage pipe @ €1.09/m (700 *m*)	765
Drainage stone @ €12.30/t (209 *t*)	2,570
Total cost	**5,945**

The mean cost of the drainage systems installed was €5,740/ha, with a range of €3,420/ha (*Kishkeam*) to €7,155/ha (*Athea*). The cost of the drainage systems was dependent on a number of factors. These included

- The suitability of existing open drains as outfalls for the proposed field drains.
- The type of drainage system, particularly if a shallow drainage system was required.
- The intensity of field drainage required.
- The cost of and time taken by the contractor.
- The cost of materials, particularly stone aggregate.

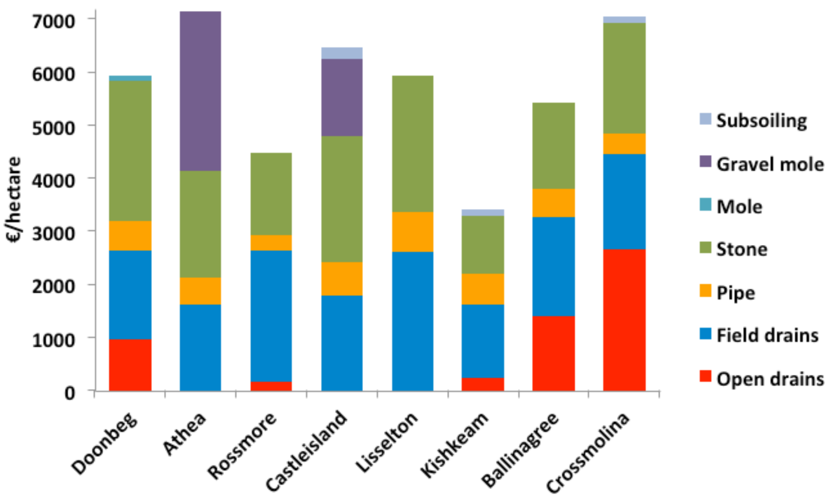


Figure 28: *Comparative costs (€/ha) of land drainage works on all programme farms*

Farm Infrastructure

Table 18: Assessment of Infrastructure Adequacy			
Infrastructure	**Adequacy**		
	Good	*Adequate*	*Needs Attention*
Grazing			
Paddock size	X		
Farm roadways	X		
Water troughs	X		
Milking parlour			
No. of rows	X		
Collecting yard		X	
Drafting		X	
Farmyard			
Slurry storage	X		
Silage slab	X		
Cubicle spaces	X		
Head feed space	X		
Calf facilities			X
Calving facilities			X

Alan Wood, Crossmolina

2nd September 2015

Agriculture and Food Development Authority

Heavy Soils

Soil Fertility

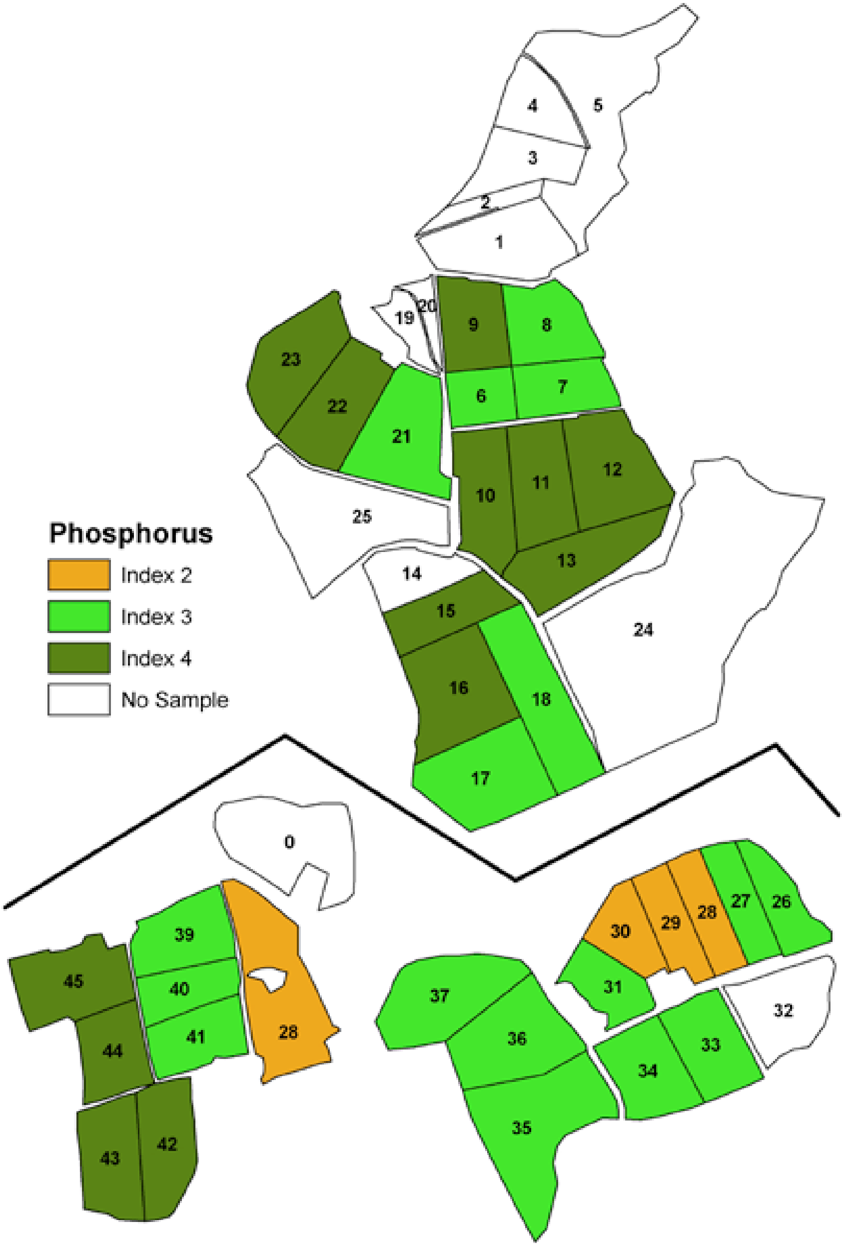


Figure 29: *Phosphorus Index Farm Map (December 2014)*

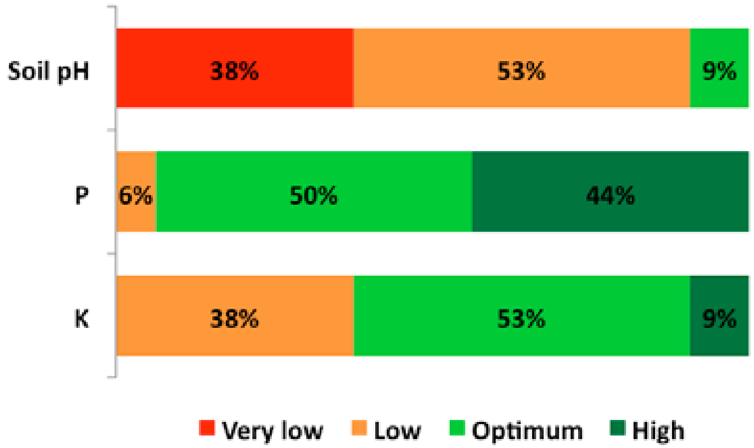


Figure 30: *Percentage of the farm within soil indices for Soil pH, P and K*

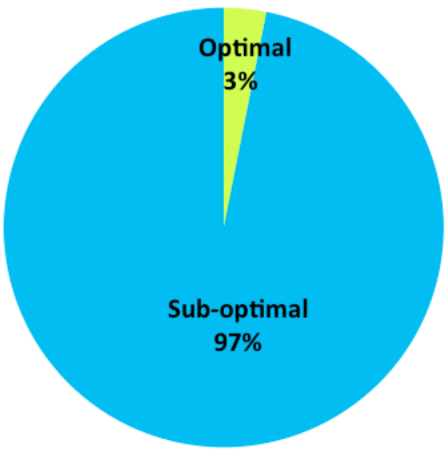


Figure 31: *Percentage of soils with optimal soil pH, P & K status*

Land Drainage

Site Investigation

As is standard procedure, a site investigation in association with the farmer and local advisor was carried out as the first step in the design process. This involved walking the site and noting outfall conditions, field slope, historic features, areas of poor grass growth, poor underfoot conditions or abundant water loving vegetation as well as existing drains (*in-field and open*) and natural water-courses. After these initial observations the history of the site was explained in detail by Alan. A rough sketch of the site (*Figure 32*) noted all relevant features.

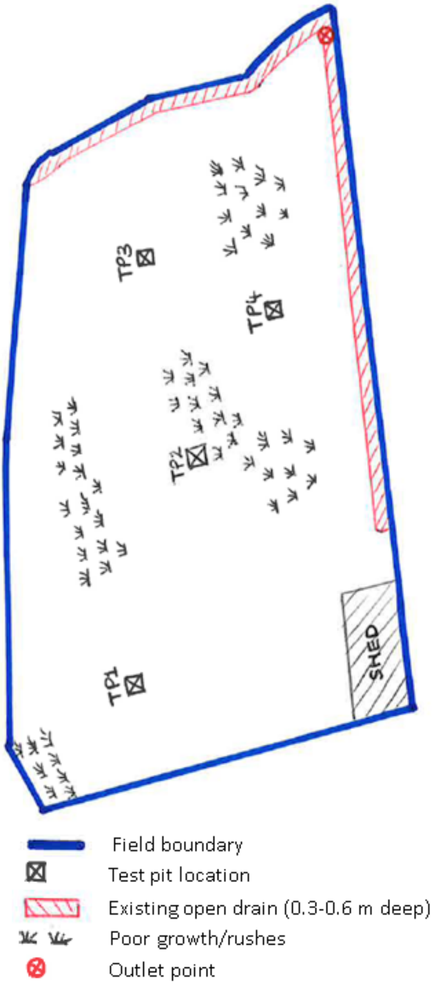


Figure 32: *Site investigation sketch*

The next step involved digging test pits on the site to be drained. The profile uncovered (*Figure* 33) contained evidence of slow water infiltration (*drainage*) and movement. A thin topsoil was underlain by a uniform silt with some mottling (*discolouration*) becoming more permeable from 1.4 m depth. Strong seepage of groundwater into the pit was noted from approximately 1.4 m depth consistently across the site. The most appropriate drainage system for this site would be a groundwater drainage system which would remove excess groundwater and allow surface water to infiltrate through the profile. In this case the drains would be located in the layer where groundwater can move, at approximately 1.4 to 1.7 m.

The final phase of the site investigation involved measurement and mapping of the site. This would allow for field levels and geometry to be established and outfall conditions to be assessed. A laser-level survey was used to assess falls and provide guidance on the most appropriate positions of field drains.

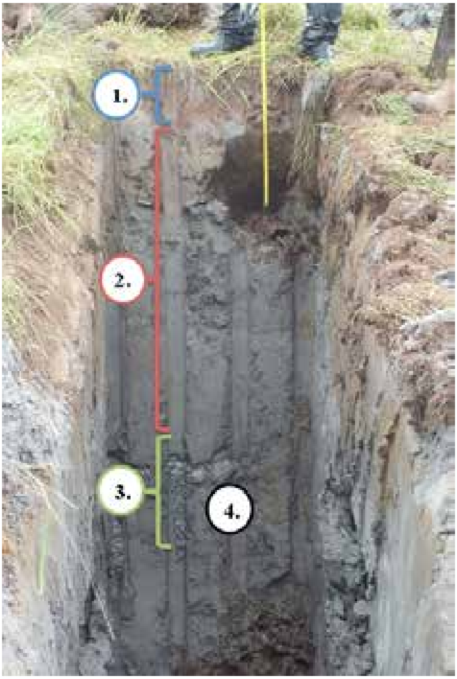


Figure 33: *Typical soil profile at Crossmolina site*

(1) Topsoil (*0.0-0.15 m depth*) with good porosity and strong granular structure (*natural cracking*), (2) Moderately permeable uniform silt subsoil (*0.15-1.4 m depth*), (3) highly permeable (*1.4-2.0 m depth*) with consistent in-flow of groundwater and strong granular structure, some sidewall collapse and (4) field drain invert level (*1.7 m*).

	Detailed Drainage Specifications	
	Land Owner	
	Alan Wood	
	Paddocks/Area	
	26,27	
	Date:	16/07/2014

Paddock	**OUTLINE DESIGN**	**Detail**
	Outlet	
	• No suitable outlet exists,substantial works are required to provide an outlet at the required depth.	
	• Culvert under public road needs to be upgraded (to 18' pipe) and deepened.	
	• Approximately 250 m of open drain needs to be upgraded and deepened below this culvert to provide a suitable outlet (to back swamp of lough)	Total length: 250 m
	Open Drains	
	• Existing open drain at southern site boundary must be deepened to 2.0 m	Total length:170 m
	• Existing open drains at eastern site boundary must be deepened to 1.8 m	Total length:160 m
	• Bank slope must not be steeper than 2:1 (vertical:horizontal)	
	• Spoil may be removed or where good quality spread	
	Field Drains	
	• 5 x field drains across contours (as per specification map)	Total length: 1100 m
	• To a minimum graded depth of 1.7 m	
	• Use 80 mm corrugated pipe with 1-2m sewer or concrete shore at all outlets	
	• Add 500 mm depth porous fill being 10-40 mm washed stone	
	• Backfilled thereafter with soil, spoil to be spread	
	Subsoiling	
	• Subsoiling to be carried out at 0.6 m depth and 1.5 m spacing using single-leg winged subsoiler	
	• Subsoiler will be pulled uphill from lower end of site and cross field drains at right angle	

Figure 34: *Drainage design specification*

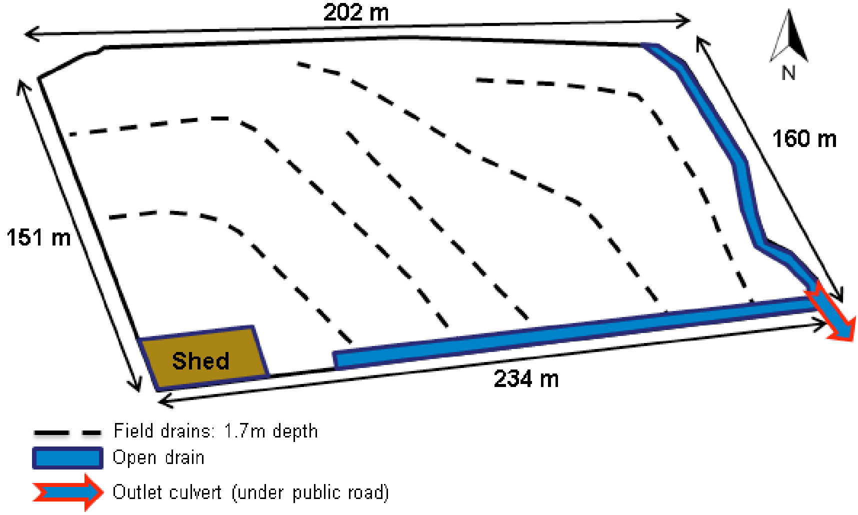


Figure 35: *Drainage design map*

Notes on Drainage Design and Installation

The information gathered from the opening of on-site soil test pits indicated that the site was underlain by a consistent layer of highly permeable soil, first encountered at an approximate depth of 1.4 m below the surface. The high silt content as well as the presence of roots and structural cracks to substantial depths within the profile indicated that there was sufficient capacity for infiltration (*drainage*) of water through the profile to a groundwater drainage system. The purpose of the drainage system designed for the site was to target the highly permeable layer (*from 1.4 m depth*) and exploit the water carrying capacity it has.

It was decided to install groundwater drains to a minimum depth of 1.7 m (*see map*) spanning the width of the site and running across the main field gradient. The placement of the drains did not follow any set pattern and was dictated by the field topography. Drains were positioned in natural depressions and along slope contours to ensure the natural flow of water was encouraged into drains. The existing open drain at the southern side of the site was cleaned and deepened to a depth of 2.0 m to act as an outfall for the new field drains. The existing culvert at the field outlet point was lowered to allow for this. This culvert was under a public road which had to be cut during the works and re-laid thereafter. Providing an outlet from the field was a major undertaking, an additional 250 m of open drain had to be excavated and the works required in the digging of this and removal of associated spoil added significantly to the overall cost. The existing open drain at the eastern side of the site was also deepened to 1.8 m, to intercept as much water (*coming from the adjacent areas*) as possible before it could enter the site. Drains were installed in two stages in order to avoid difficulties related to subsidence and collapse of the field drain trench during installation. Initially a 1.0 m deep trench was excavated using a wide moulding bucket, after this a narrower tile drainage excavator bucket (*as described earlier*) was used to complete the drain to its final depth (*1.7 m*). Each drain was installed and backfilled immediately. Even using this strategy there was particular sections which collapsed and slowed the progress of installation. The groundwater drains consisted of an 80 mm corrugated perforated PVC pipe with a gravel aggregate envelope (*10 - 40 mm grade*) backfilled to within 1.2 m of the soil surface (*to ensure maximum connection to the high permeability soil layer*) and thereafter backfilled with soil.

Costs

Table 19: Costs	
Item	**(€)/ha**
Open drain installation @ €35/hr (76 *hrs*)	€2,670
Field drain installation @ €35/hr (51 *hrs*)	€1,790
Drainage pipe @ €1.13/m (338 *m*)	€380
Drainage stone @ €11.07/t (189 *t*)	€2,100
Sub-soiling	€125
Total Cost	**€7,065**

The mean cost of the drainage systems installed was €5,740/ha, with a range of €3,420/ha (*Kishkeam*) to €7,155/ha (*Athea*). The cost of the drainage systems was dependent on a number of factors. These included;

- The suitability of existing open drains as outfalls for the proposed field drains.
- The type of drainage system, particularly if a shallow drainage system was required.
- The intensity of field drainage required.
- The cost of and time taken by the contractor.
- The cost of materials, particularly stone aggregate.

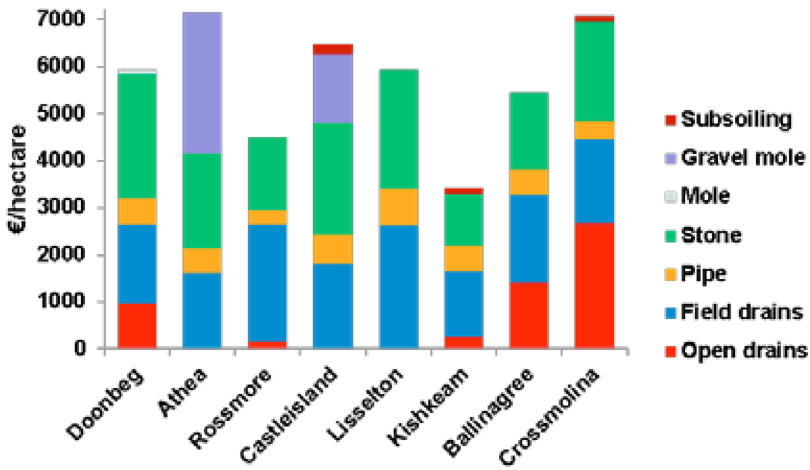


Figure 36: *Comparative costs (€/ha) of land drainage works on all programme farms*

Farm Infrastructure Guidelines

Figure 37: *Cow Flow*

Cow Flow

- Ensure that cows are lined up towards the parlour entrance
- Cows should be lined up on entering the collecting yard i.e. enter the rear of rectangular yards and enter circular yards from the front of the parlour
- There should be no steps at entrance or exit to parlour
- There should be no doors at parlour entrance
- All surfaces should be non-slip
- There should be good light at parlour entrance and exit
- The front of the parlour should be spacious

Cow Handling

- Good flow into a cattle crush is more important than the length of the cattle crush
- Avoid turning cows around corners into crushes
- Cows should be funnelled into crush at 30° angle (*straight on one side*)
- The basic instinct of animals is to return to where they came from. This should be taken into account when siting a crush.
- Traditional cattle crushes are good for restraining animals but not good for accessibility to animal, batch crushes provide greater accessibility
- Foot hoisting facility should be provided

Figure 38: *Drafting*

Drafting

- Milker should be able to draft without having to leave pit
- Farmers with good drafting facilities are inclined to AI for longer
- Drafting systems can be manual (*rope and pulley*) or automatic
- Front exit parlours make manual drafting easier
- Side exit parlours can also be drafted manually with a gate at exit.
- Holding pens for drafted animals should be large enough to hold 10% of herd
- Exit gates from parlour that can be operated from anywhere in pit are essential. Scissors gates are ideal in that they can be both opened and closed from anywhere in the pit.

Figure 39: *Calf Housing*

Calf Housing

- Simple multi-purpose design
- Well ventilated
- Easily cleaned
- Group pens
- Batch feeding

Figure 40: *Grazing Infrastructure – roadways*

Cows will make up to 600 return journeys from paddocks to the milking parlour each year. Road layout must allow for good cow flow and have a suitable surface for walking speed and hoof welfare. Road layout must allow access to all paddocks.

Table 20: Construction of roadway

Roadway type	**Options**
Topsoil removed	Build up with stone
	Necessary for heavy machinery
	Most expensive option
No topsoil removed	Must be prepared during dry weather
	Not suitable for heavy machinery
	Geo textile may be used
	Suited for roads away from farmyard
	Less expensive option

Key considerations

- Is the road to be used for cows' only, light machinery or heavy machinery?
- Does top soil need to be removed?
- Is there hard core available on the farm?

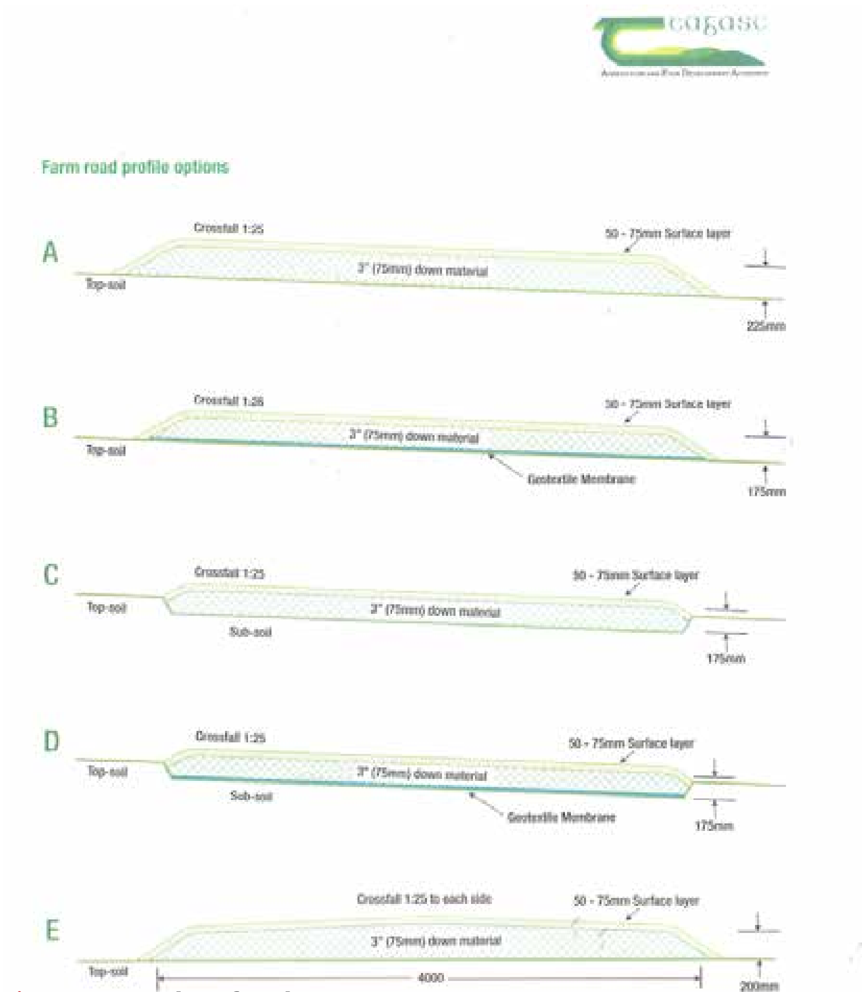


Figure 41: *Camber of roadways*

Construction

- Remove top soil – ideally in dry conditions
- Lay base material and shape to give a curved surface that will shed water onto the grassland
- Compact with a large vibrating roller to a minimum height above the ground level of 100 mm at the outer edge and 150 mm in the centre of the roadway
- Allow roadway to settle
- Cover with 50 - 75 mm of slig / binding material and compact with a large vibrating roller

Guideline Building Costs

Table 21: Estimated cost of roadway construction €/ metre of road	
Top soil removal	€4
Hard core material (20 *cm*)	€7/8
Fine material (5-7 *cm*)	€5
Hired roller	€1
Total	**€17/18**

Table 22: Design guidelines	
Road width	50 cows - 3 m, 100 cows -4 m, 250 cows - 5.5m
Falls/ slope	1:25 one sided slope, 1:15 two sided slope
Construction	20 – 25cm hard core plus 1-10 cm fine material
Cow walking speed	2-3 km/hr. on good road surface
Road slope	Max of 3:1
Fencing	45 cm from edge of road
Approx. cost	€15 – 25 / metre

Setting up a road system

- Get a map of the farm
- Mark the locations of dry areas, wet areas and any obstacles to roadways
- Location of the milking parlour
- Design a system that allows road to reach every paddock on the farm
- Establish if the road system is for cows only or machinery
- Minimise bends, angles and corners on road to create good cow flow to and from milking parlour
- Avoid sharp bends with no bend less than 90 degrees
- Walk the proposed roadway for any issues that do not appear on a farm map e.g. ESB poles
- Construct roadways on the southern side of hedgerows
- Do not impede the flow of surface water or otherwise create barriers to natural drainage

Problems associated with roadways

- Narrow roads – cows stop walking due to any obstruction. Also cows can push in from the electric fence causing increased lameness
- Uneven surface – this will reduce cow walking speed and increase lameness
- Sharp bends – slow walking and increased lameness due to pushing at bends

- Water trough on road – slow walking speed

Cow tracks (*spur roadway*)

- Can be installed as extra roadway off the normal roadways
- Useful for access to out of the way paddocks or on silage ground
- 150 mm of material laid on surface of the ground, compacted and topped off with a fine surface layer
- Tracks may be 0.6 to 1.8 metres wide
- Not designed for machinery

Table 23: Guideline building costs

Items	Units Used	Cost per item, €
Building milking parlour (*shed, yard*)	per unit	4,000 – 5,000
Milking machine	per unit	2,000 – 8,000
Bulk Tank	per unit	1.70 – 2.50
Cubicle shed + slatted tank	per cow	1,000 + 500
Topless cubicle and lined lagoon	per cow	400 + 300
Silage slab	per cow	550
Specific building items		
Roof	per	50
Slatted tank (*18 wk. storage for 100 cows*)	per	90
Stanchion bases	each	25
Cubicles and cubicle beds	each	190
Concrete floors	per	22
External walls	per linear metre	140
Feeding barriers	per bay	180
Automatic scrapers	per passage	2,800
Electrical work	per bay	250
Cubicle Mats	each	46
Other		
Water pipes	per metre	1.50 – 2.00
Farm roadways	per metre	15 - 25
Water troughs	per litre	0.25 – 0.50

Notes

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