Soils report 3 – John Leahy, Athea

Introduction

This dairy farm is located to the west of Athea, Co. Limerick only 3 km from the county border with Kerry (Plate 1). The farm is 60 hectares in total, milking approximately 90 cows. Annual precipitation is on average 1320 mm at the met station 4.3 km away. Slopes are 4 to 6 degrees. The River Galey runs adjacent to the most northern paddock.

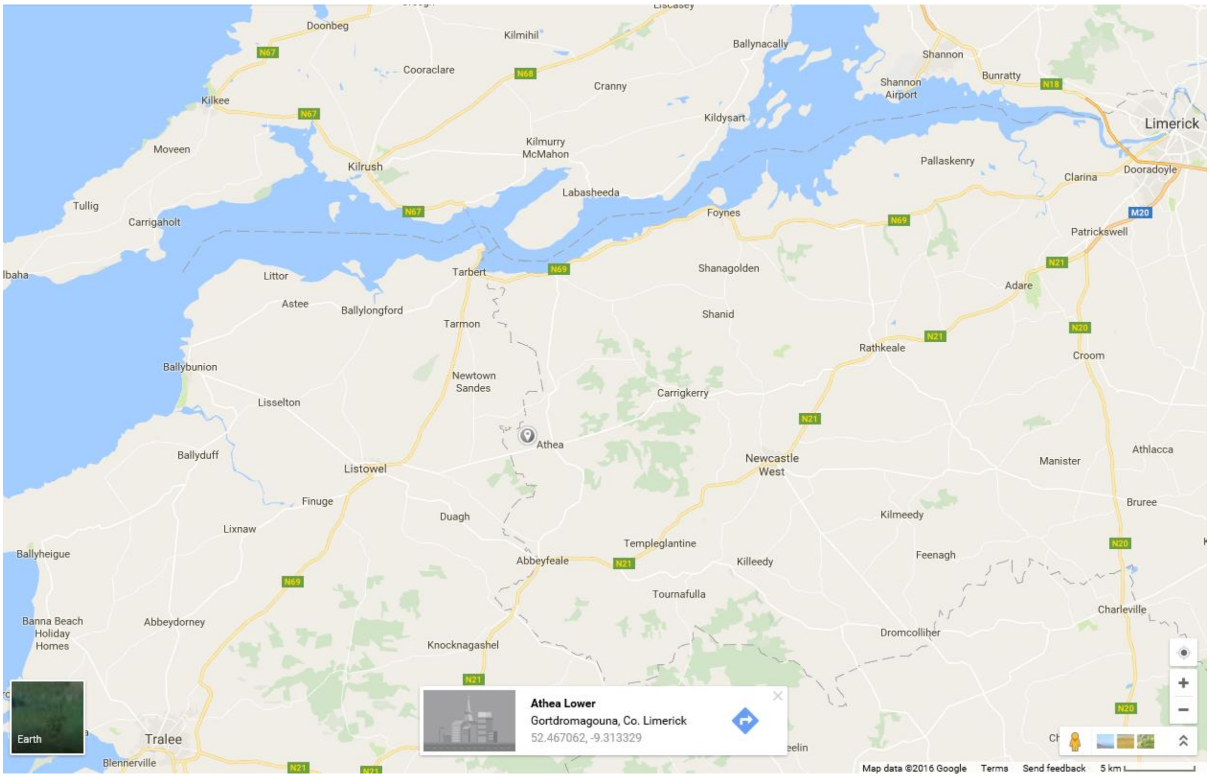

Plate 1.Leahys farm west of the town of Athea, Co. Limerick.

The area has high rainfall and peat has developed in the plateau areas of the farm. The concentration of surface water from the hills and a rising water table in the subsoil produce anoxic conditions. Most of this peat has been hand-cut over recent times and the remnants are regularly turned with an excavator to prevent peat build up and allow greater productivity. Springs were noted at two points in the farm. The steeper slopes of the farm have shallower soils with shattered shale beneath allowing for good drainage. In some cases on the upper slopes, Podzols with iron pan have been deep ploughed to allow greater drainage. The shallower slopes have deeper heavier mineral soils and these allow very little vertical drainage, due in part to high silt and clay contents.

The region has bedrock dominated by Shales and Sandstones. These were derived from ancient River deltas and swamps. Focussing on West County Limerick, there is a predominance of carboniferous shale which has had a significant glacial influence, resulting in the area finally being covered in Milestone Grit deposit. This was where limestone was eroded, the process stopped and then deposition resumed with muds and sands.It is considered highly likely that the erosion of the shale in the area could result in the layer of limestone bedrock below to have an influence on the hydrology due to its porosity.

The Saale glaciation extended through most of the county. However the subsequent Weichsel glaciation removed most of these deposits except for the most western parts of the county, where Athea lies. Therefore this area is a zone of transition between the two glacial events. A Boulder clay plain lay down by the Weichsel glaciation extends westerly to the town of Athea (Finch and Ryan, 1966).

In relatively more recent times fluvio-glacial processes occurred. A re-advance of the last ice sheet in late Weichsel time halted along a line joining Carrigkerry to Newcastle West. An Alluvial bench formed as a result of the valley of the River Deel being dammed, forming a lake between the ice sheet and the hills.

Alluvium from inflowing streams was deposited in the lake. As the ice retreated, melt waters cut a channel through the end-moraine north-east of Newcastle West and thus drained the lake, leaving an alluvial 'bench' at an elevation of about 100 metres which formed part of the new landscape. When this process occurred, alluvial deposits may also have been transported west through subsequent moraines, resulting in the high silt content of the soils around Athea. This may also be a reason for the high silt in the plateau areas of the farm.

Historical soil information

The Soils of County Limerick, Soil Survey Bulletin No. 16 (Finch and Ryan, 1966) was produced by An Forais Talúntais covering the area of the farm. From the accompanying map, the soil series dominating the area of the farm is Abbeyfeale, a Gley on solifucted material of sandstone and shale origin. There is a relatively small polygon to the south east of the Brown Podzolic, Mountcollins derived from shale drift. There are large polygons of Blanket peat (Aughty series) to the north and the south of the farm but none encroaching directly into its footprint.

The subsequent Irish Soil information System (Creamer et al 2014), differs mainly by giving large polygon coverage to river alluvium (Boyne association) on the northern end of the farm beside the River Galey. This soil would be of recent origin and be relatively free draining (Plate 2). The polygon of Brown Podzolic (Borrisoleigh association) on the southern end of the farm has been extended east-west forming a much larger area overall. This area would be moderately to well drained. A Surface-water Gley (Kilrush association) still dominates most of the area of the farm and is imperfectly drained. There is an area of peat just to the west of the farm (Aughty series, poorly drained). This would imply that there is likely to be peat in the footprint of the farm itself.

With the updating of the national soils series list, the Abbeyfeale series has now been rationalised into the Kilrush series. Mountcollins is now part of the Brown Podzolic series, Borrisoleigh.

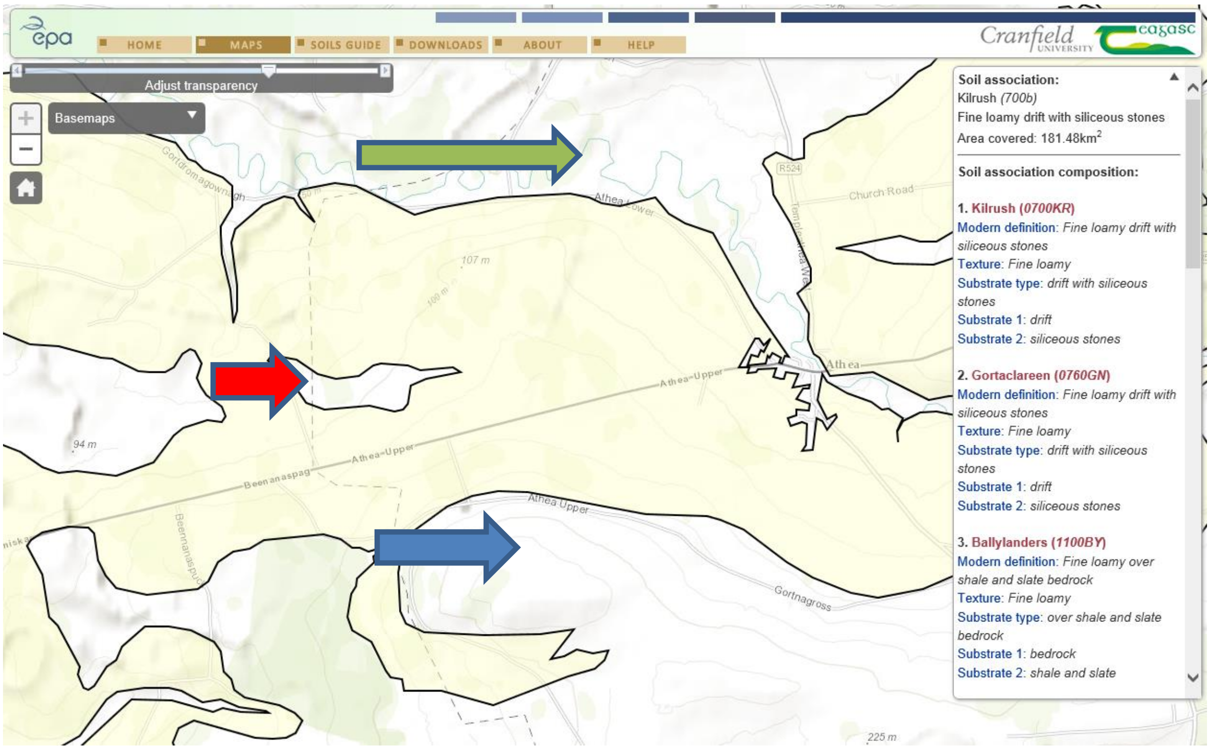

Plate 2.Irish SIS map of the area of the Athea farm. Soil association, Kilrush (yellow polygon) dominates the area. Green arrow Boyne association along River Galey, northern end of farm. Red arrow, peat Aughty association, outside the farm to the west. Blue arrow is the Brown Podzolic association Borrisoleigh to the south of the farm.

Auger campaign

<u>Method</u>

The distribution of the farm paddocks are in Plate3. An auger bore was carried out on average every hectare to investigate the soil physical features.In practice more or less augers were used based on landscape complexity. Their resulting distribution was an even coverage in this area (Plate 4). The Dutch auger was driven into the soil to a depth of 1 metre if possible. The soil features were described and recorded on a field tablet. Horizon type, depth, texture, colour, mottling, structure, roots and stones were recorded along with many more physical attributes detailed in the Irish SIS soil profile handbook (Simo et al 2014).

In total there were 48 augers covering the area of Leahys farm. In general the main farm (paddock 1 to 20) is dominated by two catenas (slope complexes), with very similar soils found at steeper inclines, shallower inclines and at the toe slopes/plateaus. The upper slopes tend to be Stagnic Brown Podzolics or Typical Brown Podzolics. These soils are shallow having been formed from the bedded shale bedrock beneath and are moderately drained to well drained (Plate 5). The mid slopes produce combinations of Typical Brown Earths and Stagnic Brown Earths, the soil is deeper in places with the bedrock having been covered in some drift.

Athea Farm

Plate 3. Paddock arrangement on Leahys farm, Athea, Co. Limerick. The River Galey runs along the northern border of paddock 21. The road east to Athea is between paddock 1 and paddock 20.

The Toe slope at the first plateau (paddocks 17 and 20) is dominated by Humic Surface-water Gleys. The toe slope at the 2nd plateau at lower elevation (paddocks 8, 6 and 7) is more dominated by the groundwater and is a Humic Groundwater Gley. The northern alluvial catena is dominated by Groundwater Gleys and Drained Alluvial soils. Overall the soil textures were generally clay loam, silt loam or silty clay loam.

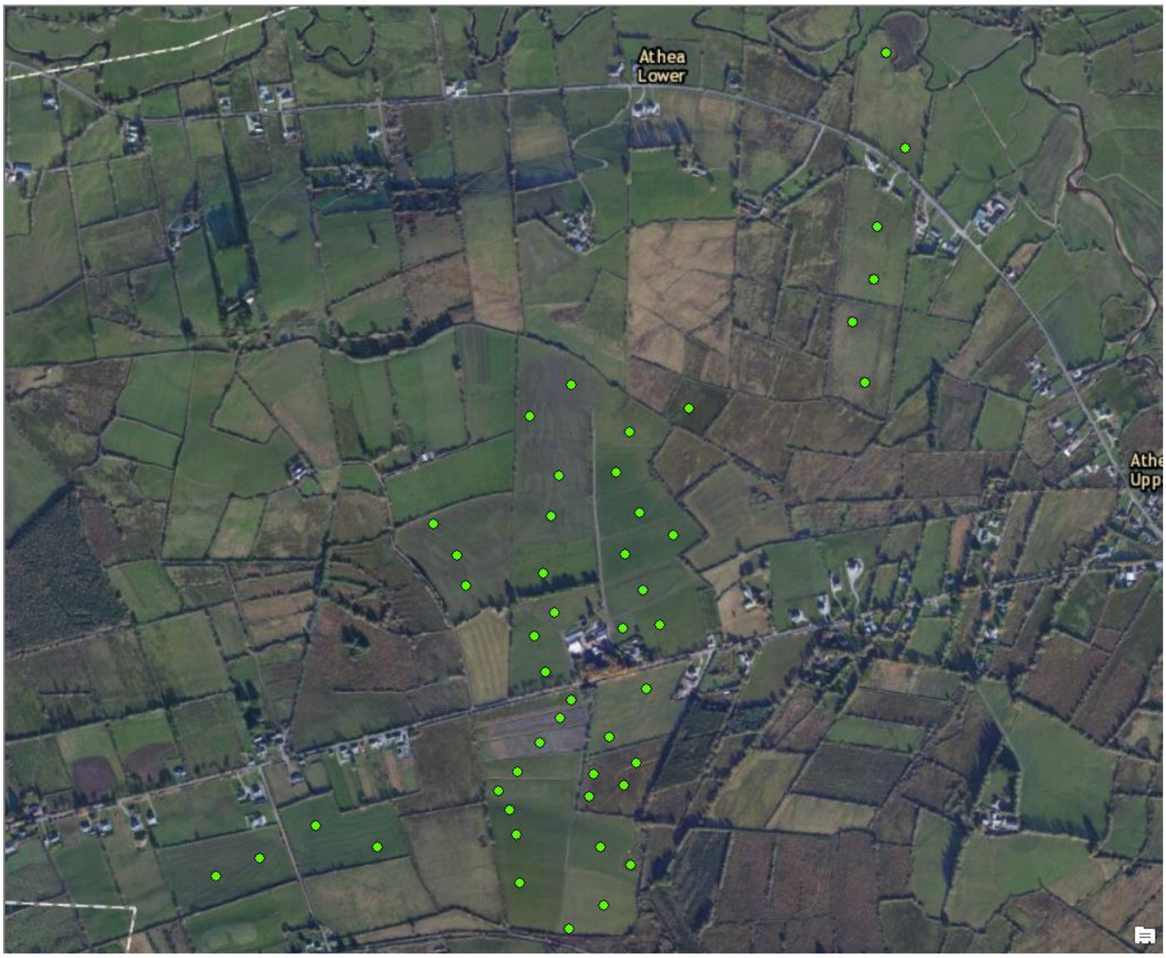

Plate 4. Distribution of the soil auger points on the Athea Heavy soil farm, Co. Limerick.

<u>Humic/Histic</u>

A humic or histic layer was noted in eleven of the augers suggesting long periods of stagnation, where organic material builds up as it cannot break down (anaerobic conditions) and accumulates in the upper horizons. The stagnation occurs due to the high amounts of rainfall in the area and the shallow inclines becoming pooling areas from slope runoff (Plate 5). In this scenario the water tries to percolate downwards but is impeded by increased soil bulk density with depth. This is also confounded by the higher clay and silt contents found in the sub soils (Bt and Btg horizons). There is reduced porosity as a result and the water cannot move downwards quickly, leading to a perched water table. The humic or histic paddocks are: 14, 15, 17a, 17c, 19a, 19b, 19c, 19d, 20a, 20b, 23b.

Another reason for the humic layer is the remnant organic material from cutover peat. This layer has condensed over time and has become earthy as the peat has dried out and the organic material has become completely decomposed. Without the turning by the excavator on the farm, it is likely the peat layer would build up again over time.

In some cases the soils from the field auger, would be designated the histic qualifier, however there is no Histic SWG option, therefore the humic qualifier was used as a best fit. The qualifier for Histic GWG are only in the cases where the definition is coarse loamy drift siliceous or a calcareous gley, fine loamy over limestone bedrock. Neither were found on the farm so again the closest fit was applied.

Plate 5. The Cataena of the highest slope looking south on Leahys farm. Upper slopes on border with paddock 18 have Brown Podzolic soils. Paddock 18 itself is Brown Earth. Paddock 17 in the foreground is Humic Surface-water Gley.

<u>Bedrock and stones</u>

Shallow stones impeded the use of the auger to 65 cm depth or less in 26 paddocks (17E , 18, 18 A1, 18 A2, 18 B1, 18 C1, 18 C2, 0, 1, 2, 3 A, 3 B, 5, 6, 7, 8, 9, 10, 11, 16, 16 A, 12, 13, 14, 24 B, 25 A and 25 B). Generally the slope in these areas was between 2 and 5 degrees. Therefore many of the soils definitions were described as bedrock shale rather than drift siliceous. Most of these soils were described as Typical Brown Earths or Stagnic Brown Earths with Bw or Bg horizons (Plate 6). The stagnation occurred due to the dominance of the coarse fractions (gravel and stones) and the low soil content of the matrix. These soils had very little water holding capacity. Anoxic conditions would prevail for short periods and iron would be precipitated out of solution on the return to aerobic conditions. These soils are considered moderately or imperfectly drained based on stagnation occurrence. Three of these augers had humic material at the surface, two were Surface-water Gleys and one was a Groundwater Gley. They are considered poorly drained.

Spodic Horizon.

A Stagnic Brown Podzolic was found in paddock 24 (Plate 7) and paddock 18 C2. Despite paddock 24 s elevation it was in a level inlcine area allowing water to influence the organic matter breakdown (Stagnation). Coupled with this the bedrock is shallow and illuviation and/or biochemical weathering of silicates has taken place in situ to such an extent that there is a build-up of iron in the lower horizons (Bs). Podzols with an iron pan would form if this process was not deep ploughed over time.

Plate 6. View to the north (paddocks 6, 7 and 8) from paddock 11.

Watertable

A watertable was noted between 50 and 70 cm in paddocks 19 B, 19 D, 20 B, 7 and 15. All these paddocks were recorded as Humic Surface-water Gleys except for paddock 7 a Groundwater Gley. The Surface-water Gleys had a perched watertable above the groundwater table that was causing a significant barrier to drainage. This was due to the high silt and clay content, as there was not many stones or gravel in the shallow subsoil. These soils would be considered poorly drained. It is no coincidence that most of the drainage measures are in this area. Paddock 17 at the same level of incline, shows how the drains are working where there is no shallow groundwater table recorded. It is now considered imperfectly drained as a result. In these augers a white silt layer was noted just below the topsoil, indicating a short period of alluvial deposition.

In paddock 7 the groundwater table itself was causing the major drainage problem, an artesian well was later found in the pit excavated in this paddock. This soil was described as soils series Noonan, fine silty drift with siliceous stones, as there is no clayey drift definition.

More Groundwater Gleys were found on the Alluvial Catena in the northern out farm, running to the River Galey (Paddocks 22a, 22b and southern part of 21).

Plate 7. Stanic Brown Podzolic soil in paddock 24. Imperfectly drained on a shallow incline.

<u>Alluvial soil</u>

The Alluvial soils were all found on the alluvial floodplain to the south of the River Galey in paddock 21. The soil here is very deep, brown in colour and free draining, due to the light soil texture class, loam. The inclines in this area are much shallower and paddocks 22 and 23 running down the slopes are Groundwater Gleys. They have humic topsoils so they are poorly drained. The most elevated part of paddock 23 is a Surface-water Gley. Paddocks 22 and 23 had augers with a white silt layer which was noted just below the topsoil, indicating a short period of alluvial deposition.

These soils would be imperfectly to poorly drained in most cases.

In conclusion of the auger survey description, there were 24 augers with Stagnic/Typical Brown Earths. 15 augers with Humic/Typical Surface-water Gleys, 4 with Humic/Typical Groundwater Gley and two with Stagnic Brown Podzolics. There was one Typical Brown Alluvial Soil described in the auger campaign (Table 1). A drainage class was assigned based on the description of Schulte et al (2015) in relation to the soil moisture deficit hybrid model.

Plate 8. View along the flood plain on the southern side of the River Galey, paddock 21. The river channel can be seen on the right.

Table 1. Field observations of soil type during the auger campaign on Athea Heavy Soil Farm. Paddocks are listed with Subgroup and Soil series based on the Irish SIS (Creamer et al 2014). The drainage class is described in Schulte et al (2015).

Paddock	SUBGROUP	SERIESNAME	Drainage class
17A	0760 Humic SWG	Ballygree	Poorly
17B	0760 Humic SWG	Ballygree	Poorly
17C	0760 Humic SWG	Ballygree	Poorly
17D	0760 Humic SWG	Ballygree	Poorly
17E	0760 Humic SWG	Ballygree	Poorly
18	1130 Stagnic Brown Earths	Duarrigle	Imperfectly
18 A1	1130 Stagnic Brown Earths	Duarrigle	Imperfectly
18 A2	1130 Stagnic Brown Earths	Duarrigle	Imperfectly
18 B1	1100 Typical Brown Earths	Ballylanders	Moderately
18 B2	1130 Stagnic Brown Earths	Moord	Imperfectly
18 C1	0700 Typical SWG	Ballybrannagh	Imperfectly
18 C2	0930 Stagnic Brown Podzolic	Corriga	Moderately
19 A	0760 Humic SWG	Ballygree	Poorly
19 B	0760 Humic SWG	Ballygree	Poorly
19C	0760 Humic SWG	Ballygree	Poorly
19 D	0760 Humic SWG	Ballygree	Poorly
20 A	0760 Humic SWG	Ballygree	Poorly
20 B	0760 Humic SWG	Ballygree	Poorly

Table 1 continued.

Paddock	SUBGROUP	SERIESNAME	Drainage class
0	1100 Typical Brown Earths	Ballylanders	Moderately
1	1100 Typical Brown Earths	Ballylanders	Moderately
2	1100 Typical Brown Earths	Ballylanders	Moderately
3 A	1100 Typical Brown Earths	Ballylanders	Moderately
3 B	1100 Typical Brown Earths	Ballylanders	Moderately
4	1100 Typical Brown Earths	Ballylanders	Moderately
5	1100 Typical Brown Earths	Ballylanders	Moderately
6	0760 Humic SWG	Ballygree	Poorly
7	0660 Humic GWG	Noonan	Poorly
8	0660 Humic GWG	Noonan	Poorly
9	1130 Stagnic Brown Earths	Duarrigle	Imperfectly
10	1130 Stagnic Brown Earths	Duarrigle	Imperfectly
11	1131 Stagnic Brown Earths	Duarrigle	Imperfectly
16	1130 Stagnic Brown Earths	Moord	Imperfectly
16 A	1130 Stagnic Brown Earths	Moord	Imperfectly
16 B	1130 Stagnic Brown Earths	Moord	Imperfectly
12	1130 Stagnic Brown Earths	Moord	Imperfectly
13	1130 Stagnic Brown Earths	Moord	Imperfectly
14	1130 Stagnic Brown Earths	Moord	Imperfectly
15	0760 Humic SWG	Ballygree	Poorly
24 A	0930 Stagnic Brown Podzolic	Corriga	Imperfectly
24 B	1130 Stagnic Brown Earths	Duarrigle	Imperfectly
25 A	1130 Stagnic Brown Earths	Duarrigle	Imperfectly
25 B	1130 Stagnic Brown Earths	Duarrigle	Imperfectly
21 A	0660 Humic GWG	Noonan	Poorly
21 B	0570 Typical Brown Alluvial soil	Suir	Imperfectly
22 A	0600 Typical Groundwater Gley	Kilpierce	Imperfectly
22 B	0600 Typical Groundwater Gley	Kilpierce	Imperfectly
23 A	0660 Humic GWG	Noonan	Poorly
23 B	0760 Humic SWG	Ballygree	Poorly

Representative soil profile pits

Using the auger survey as a guide, four pits were selected to represent the dominant soils on the farm and to investigate the principal drainage restrictions identified. Paddock 18 C was to represent the relatively free draining/shallow soils in the mid slopes of both of the home farm catenas. Paddock 18 B was chosen to represent the more spodic version of these soils with the increase in iron. Paddock 20 was to represent the majority of soils on the farm with a drainage problem, Humic Surface-water Gleys. Paddock 7 was to represent the next largest group of soils with a drainage problem, the Humic Groundwater Gleys.

Plate 9. Locations of soil pits described at the Heavy Soil Farm in Athea, Co. Limerick. Paddock 7 to the north, paddock 20 to the south of the farm yard. Paddock 18 C to the south of this. Paddock 18 B a cutting in the dyke on the southern perimeter of the farm indicated by the red arrow.

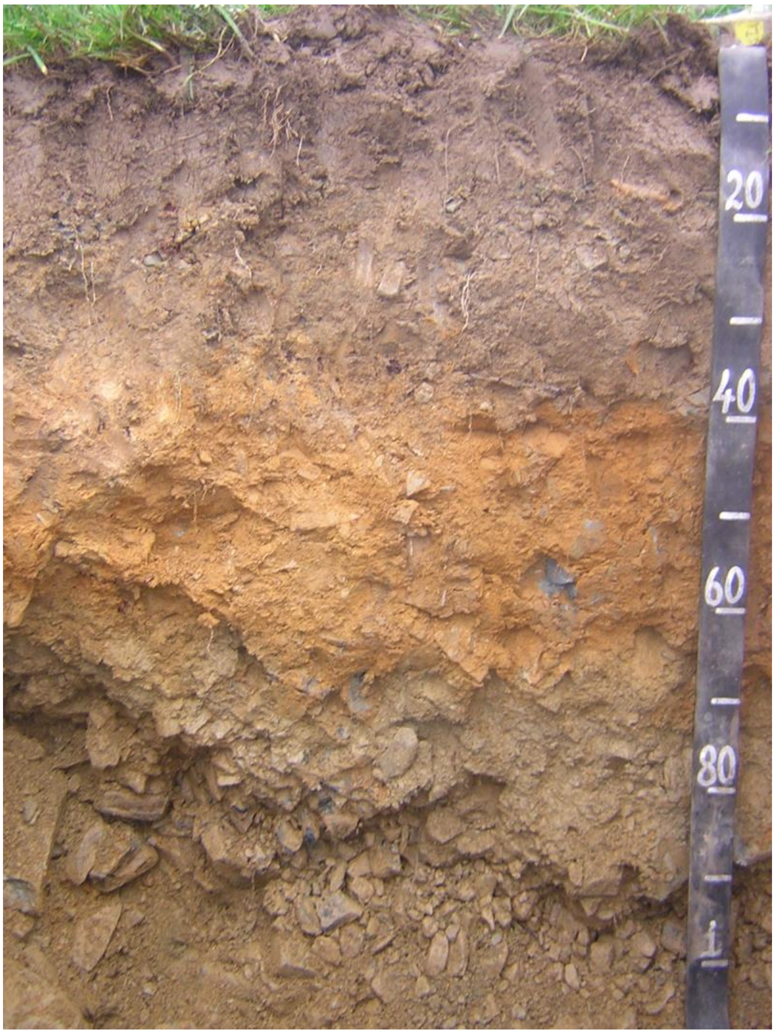

Plate 9. Paddock 18 C, Typical Brown Earth 1100, series Ballylanders.

Table2. Soil profile description of Paddock 18 C, Athea HSP Farm.

Horizon depth (cm)	Horizon designation	Description
34	Ap	Rich brown colour, many root mottles, clay loam, silt lens bottom of hz
62	Bw	Light brown to orange colour, few mottles, loam, dead roots present. Common to abundant stones, light packing density
83	Cr	Dead roots, high packing density, loam with more silt. Abundant to dominant stones
110	R	Shale bedrock

This profile has developed from the weathering of the shale bedrock beneath. There are many to dominant stones in the third horizon. As the stones weather iron has illuviated down the profile resulting in the orange/red colour of the Bw horizon. It is likely that the soils fluctuate from Ballylanders to Cupidstownhill (Brown Podzolic) in the area when the iron content increases significantly in the lower horizons. The bulk density of horizon 1 and 2 were similar. Otherwise this soil is relatively free draining, and had good productivity.

Plate 10. Paddock 18 B. Typical Brown Podzolic 0900, series Cupidstownhill

Table 2. Soil profile descritpions of paddock 18 B (Open dyke 3 metres deep), Athea HSP farm.

Horizon depth (cm)	Horizon designation	Description
22	Ap	Brown colour, few to common mottles, clay loam to loam in places, few stones
55	Bs	Red brown colour, few mottles, loam, common stones, greasy feel
105	Cr	Light brown colour few mottles loam, abundant stones
250	R	Stones and boulders of shale

Paddock 18B is located on a dyke on southern end of the farm, on the hill incline running east west. It is a 30 m long trench, approximately 3 m deep. The soil is shallow, 60 to 80 cm in places. There is Bedded shale further down the profile. The increase in iron in the Bs horizon makes the soil matrix feel greasy. This is therefore described as a Typical Brown Podzolic, Fine loamy over Shale bedrock series. Cupidstownhill.

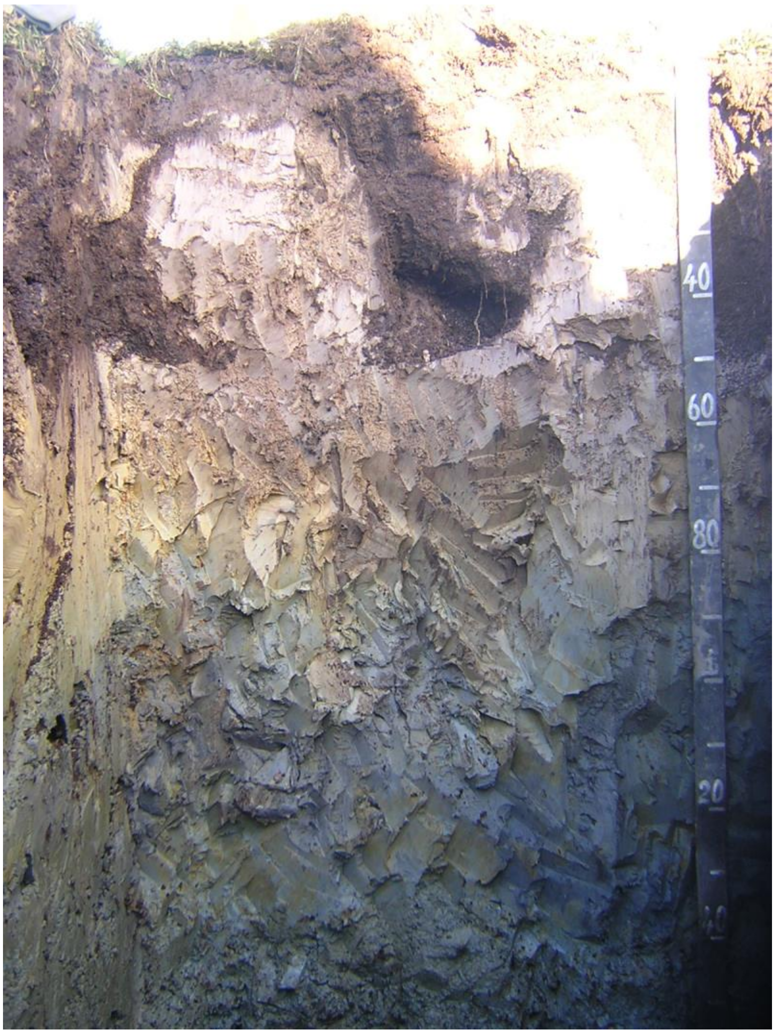

Plate 11. Paddock 20. Humic Surface Water Gley 0760, series Ballygree.

Table 3. Soil profile description of paddock 20, Athea HSP farm.

Horizon depth (cm)	Horizon designation	Description
40	Ap/O	Brown to black colour in places. Mixed hz of original O and B, dug with excavator. Clay loam, few mottles.
62	Btg	Light coffee/brown colour. Luvic due to increase in clay. Silty clay texture massive structure. Manganese present. Some mottling. Water entering at 50 cm.
140	Cg1	Yellow grey colour. Abundant mottles. Compacted, firm and plastic. Silty clay loam.
170	Cg2	Grey colour as above with dominant stones

Paddock 20 contained Clayey to silt clay loam drift with siliceous stones. Series Ballygree but there may be Cluggin in places where the clay content remains high throughout. The topsoil is clearly turned to a depth of 50 cm to combine the fertility of the top soils with the bearing capacity of the subsoil. This leads to an Irregular horizon boundary which allows the perched water table to fluctuate. There were old drains from the 1960/70s in the area. But recently newer open and subsoil drains have been added to the paddock. There are lenses of silty drift indicating for a time at least there was an alluvial influence (possibly due to the bench described previously).

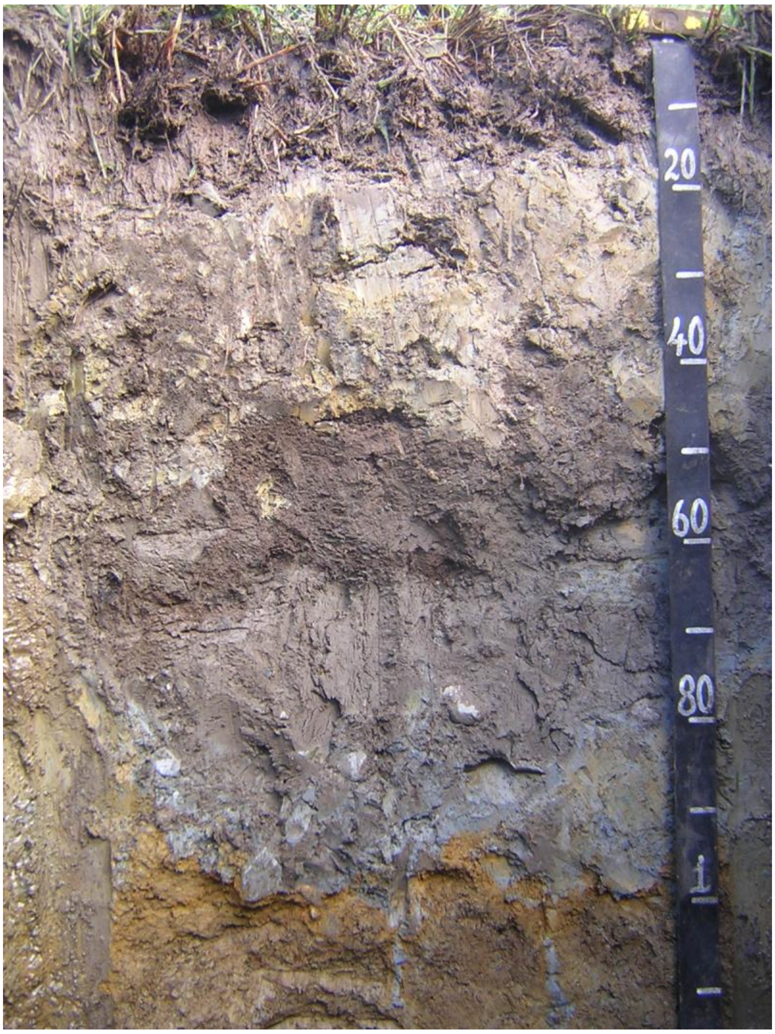

Plate 12. Humic Groundwater Gley 0660, series Tourmakeady.

Table 4. Soil profile description of paddock 7. Athea HSP Farm.

Horizon depth (cm)	Horizon designation	Description
15	Ap	Humic, dark brown colour. Clay loam. Saturated few mottles. Root mat from rushes.
43	BA	Light cream and gley colours. Clay loam. Abundant mottles, few stones Water entering at 50 cm. Sticky. Dead roots.
73	AC	On average, Loam. Clay loam in places and org material. Gley colours and dark brown. Abundant mottles many stones. Dead roots. A hz introduction evident. Watertable at 50 cm.
100	Cg	Gley coloured matrix. Abundant mottles. Compacted, few stones. Dead root.
140	Cr	Weakly cemented. Abundant stones. Manganese concentrations continuous. Stagnic channels evident.

Paddock 7 has a water table at 50 cm. Water entered the pit at 50 cm under pressure, suggesting an artesian well nearby. As with the other plateau area in paddock 20, this area has been dug with an excavator and turned. The original A horizon is evident in horizon 3. It has served to reduce the soil density in this horizon. There is a jump in bulk density in the 2^{nd} hz to 1.5 g cm^{-3}. This drops again to 1.0 g cm^{-3} in hz 3 and again rises by 50 % in hz 4 to 1.6 g cm^{-3}. This introduction allowed a lowering of the water table to approximately 1 metre as is evidence by the stagnic channels present there. However if these measures are not continually renewed the water table will influence up to 50 cm depth. The remnant gley colours in the BA are testament to this.

Conclusions

Over all the soils in this farm are of contrasts. There are poorly structured soils, based on very dense glacial till, which has silt loam and clay loams dominating. There is silty clay in places. The heavy rainfall creates a serious drainage issue due to the flat topography and run off from surrounding hill collecting there. The soils suffer from perched surface water tables and to a lesser extent groundwater tables in some cases. Generally the Surface-water Gleys dominate, with the perched water table restricting the productivity greatly.

In contrast there are shallow Brown Earths and Brown Podzolics that are moderately to well drained in places. These are newer soils resulting from the breakdown via weathering of the shale bedrock beneath them. The rainfall does not have major restriction on the productivity of these paddocks except where there is continuous rain and poaching may exacerbate the colluvic process leading to erosion of the soil in runoff. In the upper most slopes in the area there may be productivity issues due to Podzols if the iron pan has not been broken by deep ploughing.

The various drainage measures employed in the past have not redeemed the situation, however the most recent efforts in paddocks 17 indicate that the groundwater table has remained below 80 cm. It is likely that the new measures in paddocks 20 and 19 will prove as fruitful. The farmer has already noted the greater ease of vehicular use and reduction in poaching by the livestock. These same systems could be applied in paddocks 6, 7, 8, 22 and 23.

The alluvial soil in the north is very similar to the mineral soils and effectively acts as a Brown Earth. Some of the drained Alluvial soils have deep A horizons, loam texture classes and are relatively free draining.

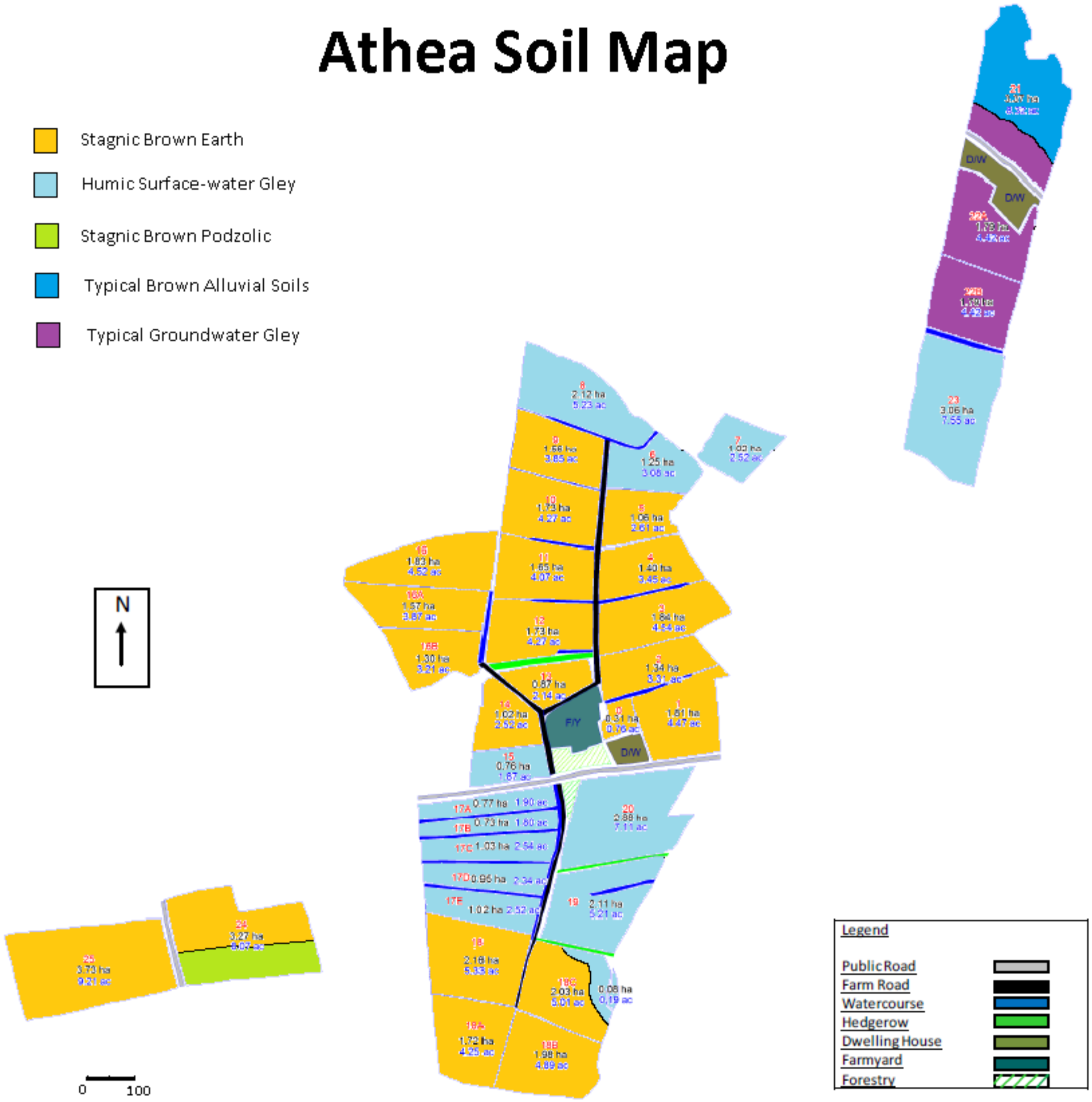

Plate 13. Distribution of soils on the Athea HSP farm based on the 2015 auger campaign and pit excavations, coupled with laboratory data from field sampling.

References

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Appendix.

Table 6. Laboratory data for samples taken from soil pits at Athea HSP farm.

Label	Paddock	Sample	Clay (%)	Silt (%)	Sand (%)	Dry Density (g/cm^3)	Bulk Density (g/cm^3)	Gravimetric Moisture Content (%)	Total Exchange Capacity (meq/100 g)	pH	Organic Matter (%)	Estimated Nitrogen Release (#'s N/acre)
JL 1	7	HZ1	35	36	29	0.37	1.20	233.07	9.00	5.6	15.44	128
JL 2	7	HZ2	24	45	31	1.52	1.96	27.49	6.74	5.5	1.3	46
JL 3	7	HZ3	21	34	45	1.04	1.61	54.17	5.56	5.2	6.09	105
JL 4	7	HZ4	24	36	40	1.60	2.01	22.33	7.49	5.3	0.9	36
JL 5	7	HZ5	25	35	40	1.68	2.03	14.16	11.45	5.5	0.89	36
JL 6	18C	HZ1	35	43	22	0.90	1.43	55.40	10.80	6.6	6.35	107
JL 7	18C	HZ2	26	45	29	0.90	1.42	39.74	6.99	6.1	5.51	103
JL 8	18C	HZ3	14	38	48	Too many stones-no samples			5.14	5.9	2.25	65
JL 9	20	HZ1	34	26	40	0.29	1.11	311.24	4.50	5.6	59.6	> 130
JL 10	20	HZ2	42	51	7	1.11	1.68	51.05	7.93	4.7	4.54	95
JL 11	20	HZ3	33	54	13	1.31	1.85	40.29	7.76	4.3	1.66	53
JL 12	20	HZ4	22	55	23	1.87	2.26	15.64	2.88	4.5	0.88	35

Table 6, continued.

Label	Paddock	Sample	S* (ppm)	P* (mg/kg)	Bray II P (mg/kg)	Ca* (mg/kg)	Mg* (mg/kg)	K* (mg/kg)	Na* (mg/kg)	Ca** (%)	Mg** (%)	K** (%)	Na** (%)
JL 1	7	HZ1	22	101	140	872	134	134	44	48.44	12.41	3.82	2.13
JL 2	7	HZ2	14	6	6	565	140	53	36	41.91	17.31	2.02	2.32
JL 3	7	HZ3	15	27	17	408	83	51	32	36.69	12.44	2.35	2.5
JL 4	7	HZ4	9	2	3	342	274	34	47	22.83	30.49	1.16	2.73
JL 5	7	HZ5	8	11	11	658	438	55	47	28.73	31.88	1.23	1.78
JL 6	18C	HZ1	14	10	22	1738	75	56	40	80.46	5.79	1.33	1.61
JL 7	18C	HZ2	20	2	2	967	46	24	93	69.17	5.48	0.88	5.78
JL 8	18C	HZ3	18	5	5	703	23	26	36	68.39	3.73	1.3	3.05
JL 9	20	HZ1	13	42	61	398	71	97	40	44.22	13.15	5.53	3.86
JL 10	20	HZ2	20	10	5	468	70	58	41	29.51	7.36	1.88	2.25
JL 11	20	HZ3	48	6	5	284	92	49	43	18.3	9.88	1.62	2.41
JL 12	20	HZ4	11	15	33	86	43	38	39	14.93	12.44	3.38	5.89

Table 6, continued.

Label	Paddock	Sample	Other Bases** (%)	H** (%)	B* (mg/kg)	Fe* (mg/kg)	Mn* (mg/kg)	Cu* (mg/kg)	Zn* (mg/kg)	Al* (mg/kg)
JL 1	7	HZ1	6.2	27	0.7	510	27	1.23	12.1	718
JL 2	7	HZ2	6.4	30	0.39	376	4	2.17	0.79	740
JL 3	7	HZ3	7	39	0.38	355	4	2.31	0.75	752
JL 4	7	HZ4	6.8	36	0.24	208	5	4.15	1.33	768
JL 5	7	HZ5	6.4	30	0.22	168	44	1.19	1.26	643
JL 6	18C	HZ1	4.8	6	0.55	302	40	1.97	1.29	919
JL 7	18C	HZ2	5.2	13.5	0.29	249	7	1.01	0.52	1544
JL 8	18C	HZ3	5.6	18	< 0.20	131	3	0.75	0.82	1768
JL 9	20	HZ1	6.2	27	< 0.20	260	1	0.6	1.27	301
JL 10	20	HZ2	8	51	0.33	512	1	0.59	< 0.4	1412
JL 11	20	HZ3	8.8	59	0.43	574	3	1.65	1.25	1532
JL 12	20	HZ4	8.4	55	0.58	974	4	6.29	3.29	796