Soils report 1 – TJ Ryan, Rossmore

Introduction

This dairy farm is approximately 50 hectares in size and it is 100 metres above sea level. It is 4 km south of Rossmore village, in county Tipperary (Plate 1). Annual precipitation averages at 980 mm from the meteorological station at Gurteen 6 km away. There is a conservative approach to grazing where the cattle are housed when ground conditions are poor. This is most likely to occur when there has been consecutive days of rain.

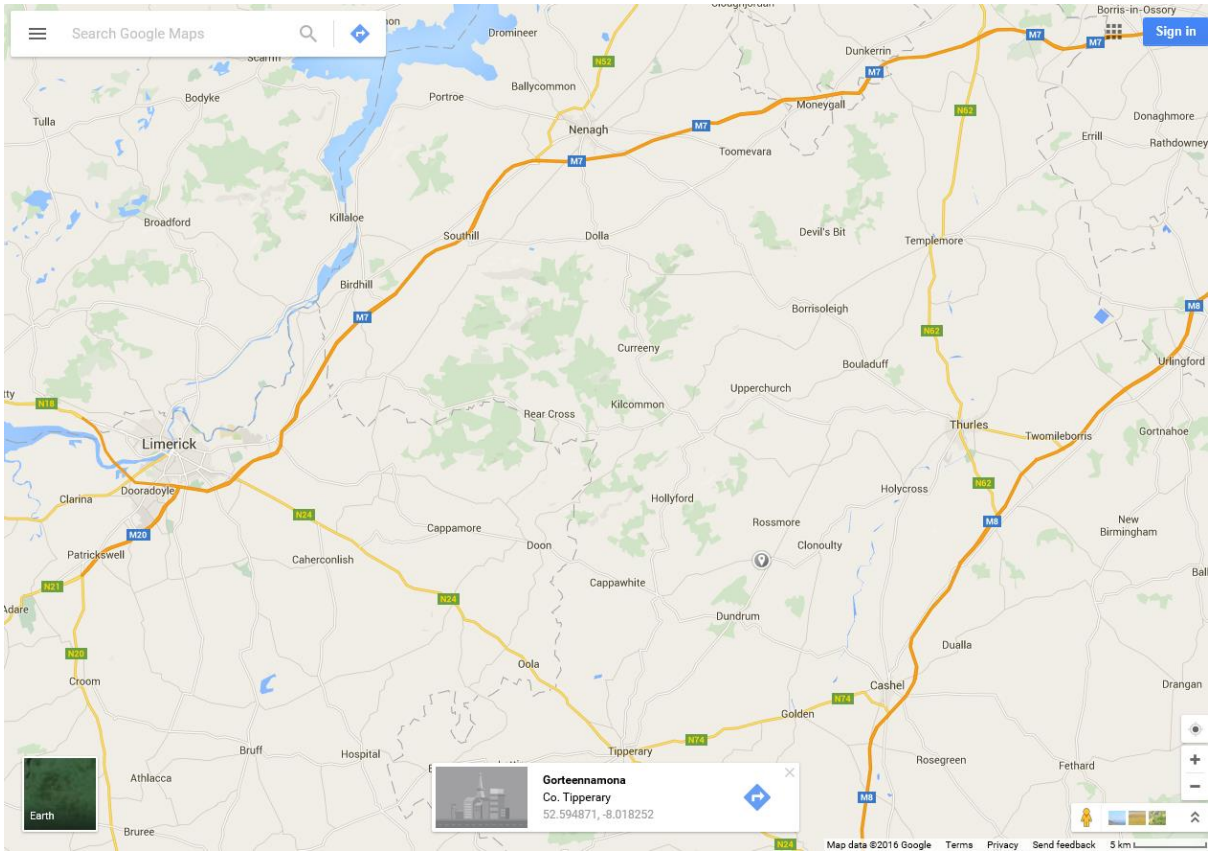

Plate 1.Ryans farm south of the village of Rossmore in the townland of Gorteenamona, Co. Tipperary.

As this is a heavy farm the problems arise in two ways: either a rising of the groundwater table or the prevention of vertical movement downwards due to a perched water table or the combination of both. The slopes in the main area of the farm are no greater than 2%, indicating that lateral movement is not a key factor generally, paddocks 1 to 17 plus paddock 22 (Plate 2 & 3). Where this may be an issue is the area containing paddocks 18 to 21 to the northwest of the farm yard. Here the slope was 4 degrees allowing run off into depressions and allowing stagnic conditions to develop there (Plate 2).

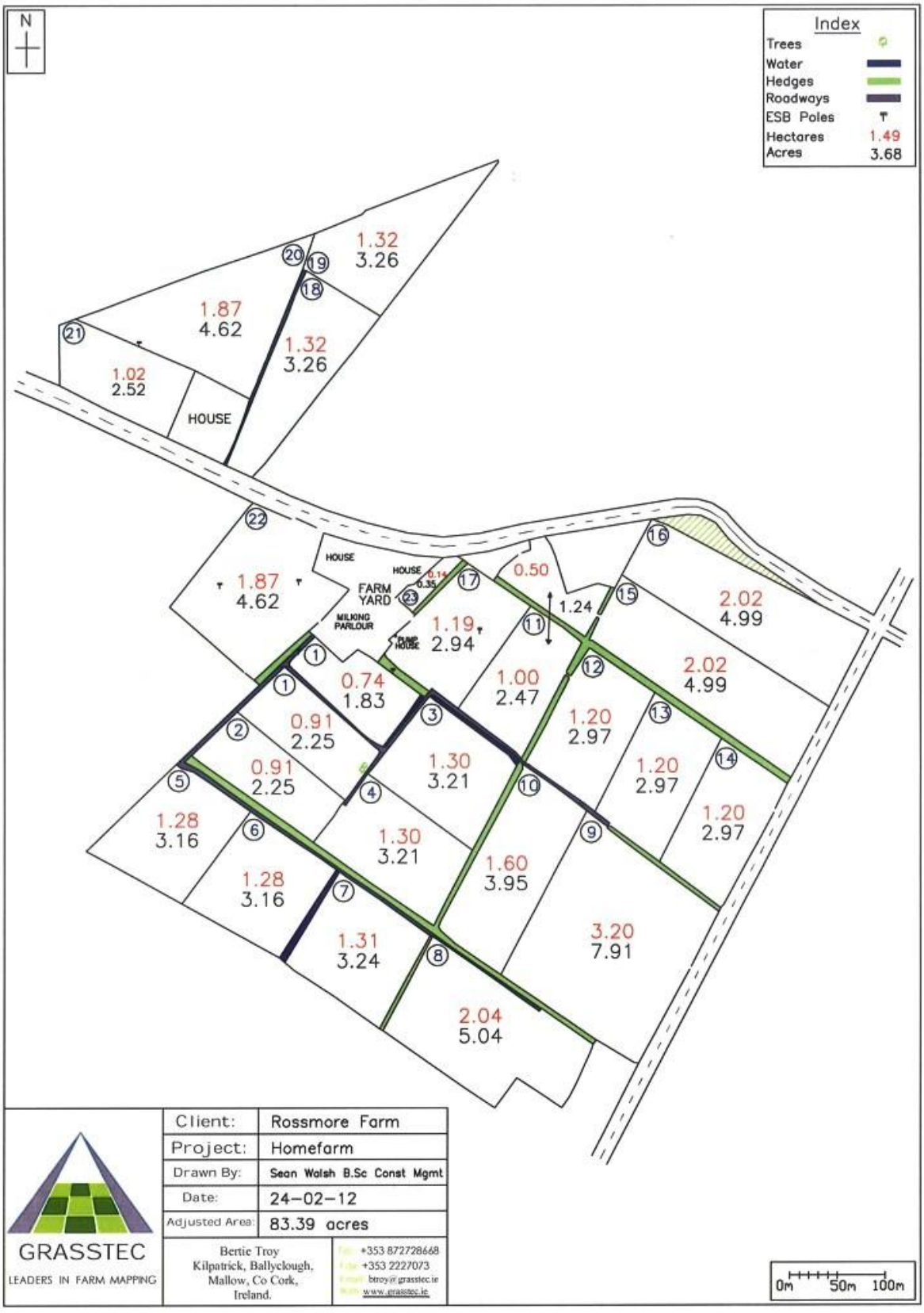

Plate 2. Paddock arrangement on the Rossmore farm, Co. Tipperary.

Plate 3. The main body of the farm has less than 2 degrees incline.

The principal geology in the area is old red sandstone derived from semi-arid mountains and deposited by large river systems. There is also limestone bedrock to the east and sandstone and shale in the west. The latter two may have an influence if glacial till has originated from there. From the GSI bedrock map, the local geology at 1:100,000 level, is part of the Cappagh White Sandstone formation. Described as red & white sandstone, conglomerate (Archer et al 1996).

The area has been coated in drift from a recent episode of the Midlandian glaciation. This was a Drumlin re-advance which was confined to the hills to the north west of this area. In places the ice could pour between the hills and morraines are present to support this. These morraines led to outwash filling the valleys to the south. This fluvio-glacial process has left the soils on the main part of the farm unusually loose. The soil was deposited with a layer of sorted stones starting after 40 cm depth. The main body of the drift is coarse loamy, with parts heavier in places due to alluvial transport mentioned above and mixed drift derived from shales and mudstones.

Historical soil information

The area of south county Tipperary (formerly known as Tippeary South Riding) does not have Soil Survey Bulletin (An ForaisTalúntais/Teagasc) published on it. The Soil Survey Bulletin No. 42, on the Soils of Tipperary North Riding (Finch and Gardiner, 1993) is a valuable guide with detailed soil description and mapping to within 5 km north of the farm. This information was to 1:126,000 resolution with some of the soils described within it found on this farm. Taking the landscape of the current farm into consideration against the landscape described a relatively short distance away two

soil series are likely to be prominent, Kilcommon and Knocknaskeaha. These are now known as Kilrush and Clashmore in the Irish Soil Information System (SIS) (Creamer et al, 2014).

Without any other local soil survey,The IrishSISis the principal guide to investigating soils in a general area. Two major soil associations are described in the area, Kilrush (Plate 4) and Elton (Plate 5). A third soil association of Boyne (Plate 6), describing river alluvium is indicated at the southern boundary of the farm. The information is based on a 1:250,000 resolution and not as detailed as a Soil Survey Bulletin.

The Kilrush association is led by the Surface-water gley, soil series Kilrush and the Elton association is led by the Luvisol of the same name. Both of these great groups have increased clay contents in the subsoil which can lead to a perched water table. The third association Boyne, covers silty river alluvium. This would likely be of recent origin and be relatively free draining.

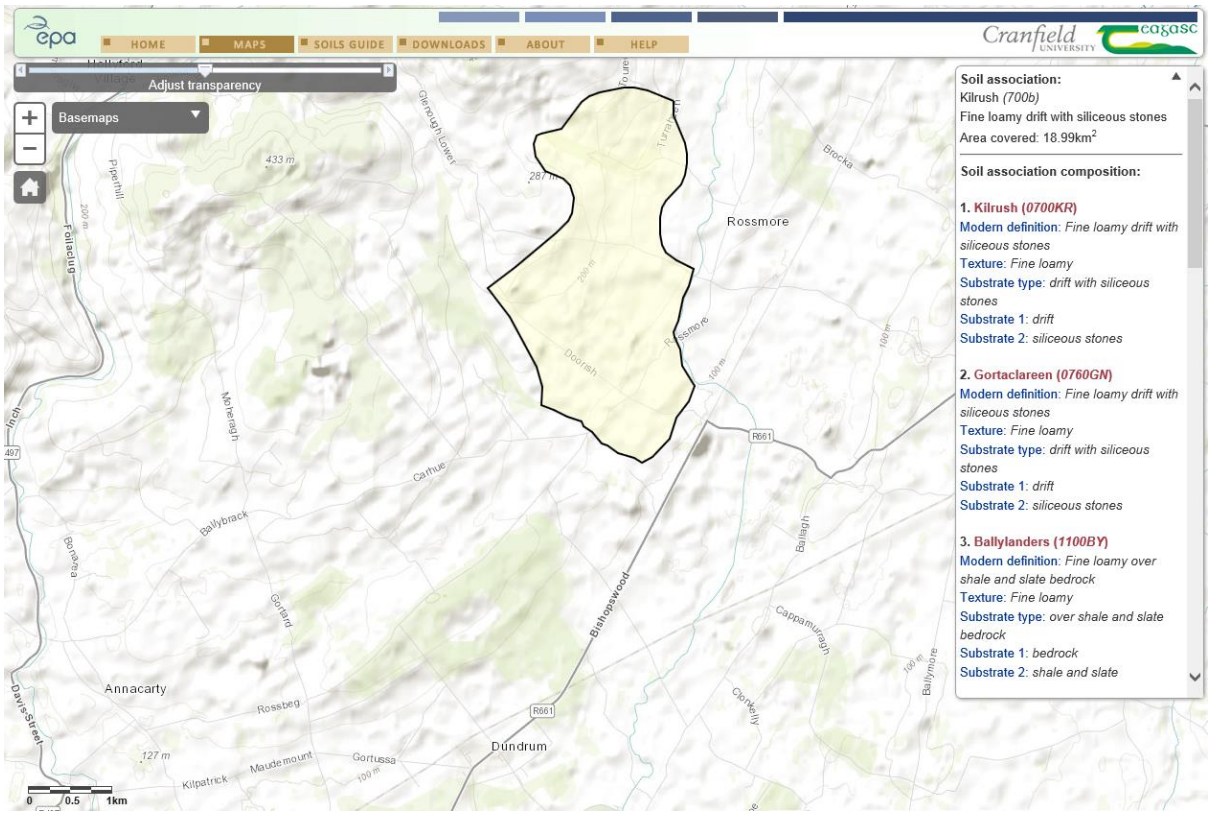

Plate 4.Kilrush association on the Irish SIS predicted to cover the largest area within the farm.

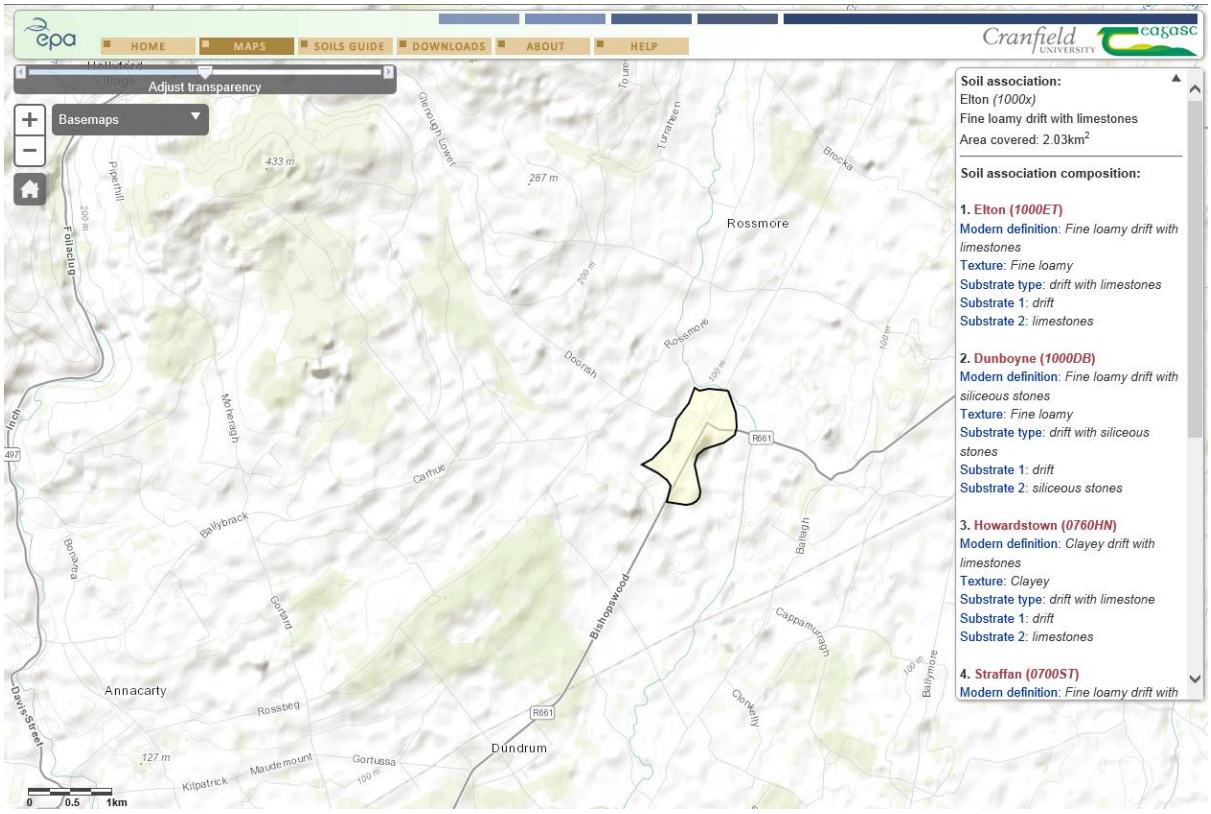

Plate 5.Elton association on the Irish SIS, predicted to be on the eastern side of the farm.

The Elton association is described as drift with limestones (Plate 5).This was not the case on the ground where there was no reaction to HCl in any of the augers, indicating the lack of prevalence of Limestone or $CaCO_3$ in the soil matrix. Limestones were noted in part of paddock 15 (Plate 2) on the western side, but they appeared to be transported in there recently due to levelling in the development of a house nearby.

The Boyne association (Plate 6) was not found with the auger campaign therefore it is not likely to be a prevalent in any part of the farm. The River Muiteen flows to the north and east of the farm and is not within flood plain range. The river was also canalised near Thomastown Demesne, however there are no river terraces or other features to suggest the river course was closer to the eastern side of the farm previously. The Aughnaglanny River flows to the south of the farm and again appears to have low influence on the soil formation there (no auger representation).

In conclusion most soils found on the farm are likely to belong to the Kilrush soil association.

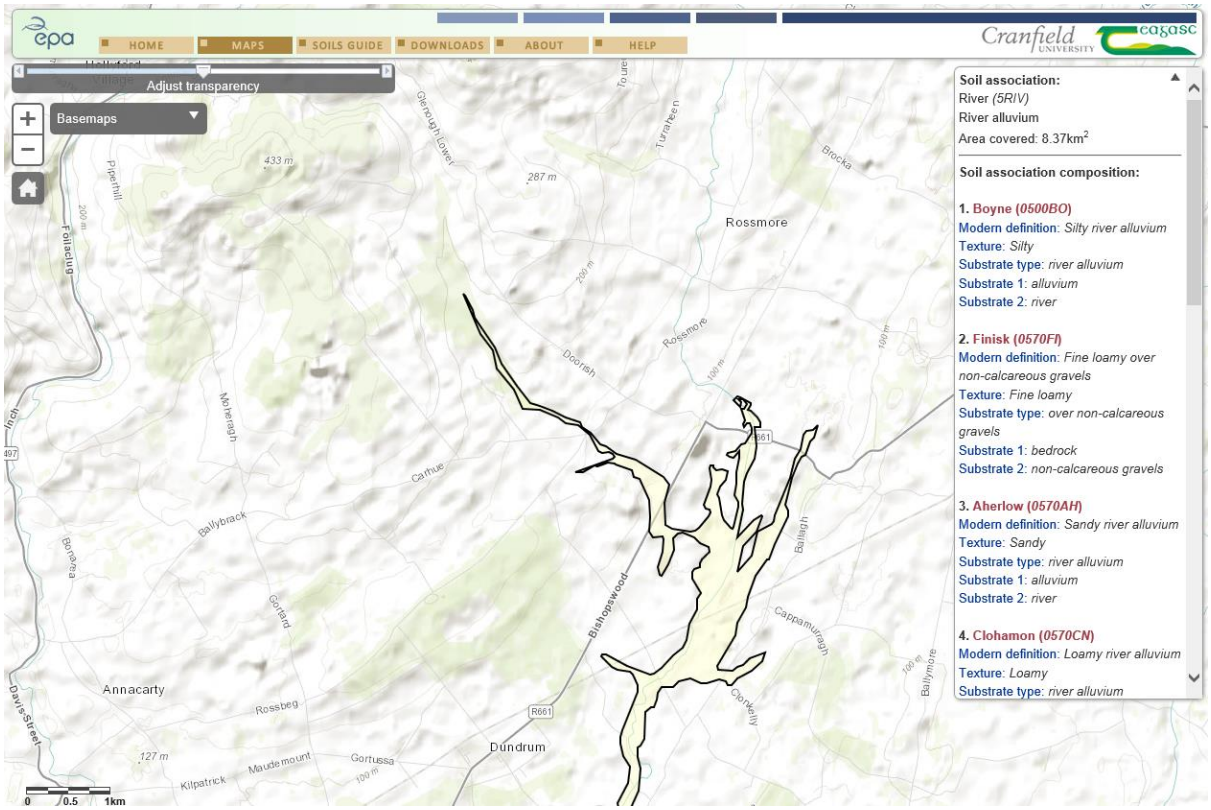

Plate 6. Boyne association predicted to be on the southern and eastern sides of the farm.

Auger campaign

Method

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 distributionwas an even coverage in this relatively small area (Plate 7). 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).

Weathered material

In general the main distinguishing factor of the augers was the red colour in the upper horizon associated with old red sandstone till having been cultivated for many generations (Ap or Apg). Generally the upper horizons were loams occasionally being Sandy Loam or Clay Loam. A multi-coloured band of stone material at around 40 cm depthwas also found (Plate 8). These stones were weathered in situ in many augers resulting in a multi-coloured matrix band at this depth. This band was seen in most augers in the main part of the farm excluding paddocks 18 to 21 and the eastern fringes (Plate 2). This band tended to have higher clay content (sometimes silt) than the other soil layers and was designated Bt or Btg. This had the potential to cause a restriction on the downward water flow in the soil. Occasionally this results in a perched water table. The soils which had weathered stone in situ resulted in the addition of clays and silts to the matrix. Therefore these soils

were more likely to belong to the Kilrush association based on siliceous stones (transported and weathered sandstone).

Plate 7. Distribution of auger positions on the Rossmore farm.

The layer of stones appeared to be water sorted indicating that after the initial deposition of the old red sandstone deposit there was a period of fluvio-glacial activity. These Alluvial soils dominated for a period before subsequent deposition of more recent till and changing climate occurred. This would follow the North Tipperary soil survey (Finch and Gardiner, 1993) of glacial outwash filling the areas to the south of hills found to the north of this farm.


Plate 8. Soil matrix of multi-coloured weathered stone band, found at 40 cm depth in most augers.

When the soils in this area had sufficient mottles above 40 cm they were designated the Typical Surface-water Gley, Kilrush. If the mottles were only sufficiently present below 40 cm and there was a gleyed subsurface horizon they were designated the Typical Groundwater Gley, Kilpierce. If there were very few mottles present the augers were assigned to the Typical Brown Earths Clonroche if fine loamy or Clashmore if coarse loamy. If there was a clay increase (Bt horizon) Typical Luvisols of the Dunboyne series were assigned. There was once instance of a Stagnic Brown Earth, soil series Moord in paddock 22a where there were mottles present however there was no gleyed matrix colour in the horizon.

Humic/Organic layer

Six of the augers contained an organic horizon namely paddock 3 associated with repeated manure additions (close to the farmyard and silage pits to the north). Paddock 18a in the northern section had a humic layer in the sub soil. Paddock 17b also had a buried peat layer at 30 cm depth, possibly indicating an old fen in both cases (subsequently drained). Paddocks 22b, 4a and 12a also had a surface humic layer due to more severe stagnation leading to the accumulation.These soils were designated as Humic Surface-water Gleys, Gortaclareen and Ballyhaise Lithic phase (over shallower bedrock).

Watertable

A shallow water table was recorded in paddocks 22b, 2, 5, 7, 12a, 12b, 15b, 17b, 19 and 21. The depth was found to be between 50 and 60 cm in the western paddocks and 65 to 80 cm depth in the eastern paddocks. The auger campaign took place following three days of heavy rain. However it was apparent in most augers that severe mottling and gleyed horizons were not pronounced at depth. This would suggest that the shallow groundwater table does not rise for sufficiently long periods for the mottling to develop. Another factor could be the old red sandstone matrix colour masking the appearance of red or orange mottles indicating the presence of iron.

In the eastern paddocks 8 to 16, the coarse fragments (stones) increased closer to the surface and the multi-coloured weathered stone band was less prominent. As a result of the lack of clays in the matrix, many of the soils in this area were moderately drained. Typical Brown Earths, Clonroche and Clashmore were recorded.

In Table 1, the auger campaign soil subgroup is listed. The Surface-water Gleys dominate the area in 15 augers, with three more with humic features. The next largest group is 7 Brown Earths, followed by 3 augers of Luvisol and 3 of Groundwater Gleys.

Table 1.Field observations of soil type during the auger campaign on Rossmore Heavy Soil Farm. Paddocks are listed with Subgroup and Soil series based on the Irish SIS (Creamer et al 2014). Drainage class based on the soil moisture deficit model of Schulte et al,(2015) also included.

Paddock	SUBGROUP	Soil series	Drainage Class
1a	0700 Typical Surface-water Gleys	Kilrush	Poorly
1b	0700 Typical Surface-water Gleys	Kilrush	Poorly
2	0600 Typical Groundwater Gleys	Kilpierce	Poorly
4	1000 Typical Luvisol	Dunboyne	Imperfectly
3	0700 Typical Surface-water Gleys	Kilrush	Poorly
5	0600 Typical Groundwater Gleys	Kilpierce	Imperfectly
6	0700 Typical Surface-water Gleys	Kilrush	Poorly
7	0700 Typical Surface-water Gleys	Kilrush	Poorly
8a	1000 Typical Luvisol	Dunboyne	Moderately
8b	1100 Typical Brown Earth	Clonroche	Well
9a	1100 Typical Brown Earth	Clonroche	Well
10	1100 Typical Brown Earth	Clashmore	Well
9b	0700 Typical Surface-water Gleys	Kilrush	Poorly
12a	0700 Typical Surface-water Gleys	Kilrush	Poorly
12b	0760 Humic Surface-water Gleys	Gortaclareen	Poorly
13	0760 Humic Surface-water Gleys	Ballyhaise lithic phase	Poorly
14	0700 Typical Surface-water Gleys	Kilrush	Poorly
16a	0700 Typical Surface-water Gleys	Kilrush	Poorly
16b	1100 Typical Brown Earth	Clonroche	Well
15b	0700 Typical Surface-water Gleys	Kilrush	Poorly
15a	0700 Typical Surface-water Gleys	Kilrush	Poorly
11	0700 Typical Surface-water Gleys	Kilrush	Poorly
18a	0760 Humic Surface-water Gleys	Gortaclareen	Poorly
18b	0700 Typical Surface-water Gleys	Kilrush	Poorly
19	0700 Typical Surface-water Gleys	Kilrush	Poorly
20a	0700 Typical Surface-water Gleys	Kilrush	Poorly
20b	0600 Typical Groundwater Gleys	Kilpierce	Poorly
21	1100 Typical Brown Earth	Clonroche	Well
17	1160 Humic Brown Earth	Schull	Imperfectly
22a	1130 Stagnic Brown Earth	Moord	Imperfectly
22b	1000 Typical Luvisol	Dunboyne	Imperfectly

Representative soil profile pits

Using the auger survey as a guide, three pits were selected to represent the dominant soils on the farm and to investigate the principal drainage restrictions identified. Paddock 7 was to represent the most common soil found on the farm, a Surface-water Gley. It was also located close to the area recently fitted with drainage measures by the Heavy Soils project (paddock5 and 6). Paddock 17b was of interest due to a buried amorphous peat layer found in this part of the farm, indicating much wetter conditions in the past. Paddock 20a was used to represent the hill region in this part of the farm.

Plate 9. Location of three soil pits on the Rossmore farm. Paddock 20a top, paddock 17b centre and paddock 7 bottom.

Plate 10.Paddock 17b, HumicSurface-water gley, series Gortaclareen. Formerly Humic Alluvial Gley, Kilcullen.

Table 2. Soil Profile description paddock 17b Rossmore Farm.

Horizon depth (cm)	Horizon designation	Description
0 – 26	AC	Red brown, many root mottles, Loam.Evidence of mineral soil additions and mixing, sandy clay loam
27-37	Oa	Black, amorphous peat, clay lens on right hand side of pit.
35-52	Ea,	Elluviated layer, white to grey, many dead roots, no mottles, sandy clay loam, sandy loam in places.
53-90	C	Old red sandstone deposit, many weathered stones, dead roots, some mottles.., Sandy loam
91-140	Cr	as above with stones becoming abundant

The pit in paddock 17b,had strong evidence of stagnation in the AC horizon (Plate 10). There were abundant root mottles indicating standing water for long periods. The heavy C part of this horizon was preventing water infiltration. The horizon also qualifies as humic as there is greater than 3.5 %

organic carbon present. The Oa previously would have had some water holding capacity, but now has become denser (earthy) with less pore spaces exacerbating the problem in the horizon above. The eluviatedEa layer indicates that the ground water rises periodically and has washed much of the clay and silt in general from this horizon. There are some remaining clay patches and weathered stones in this layer. All the roots are dead from other vegetation, suggesting anoxic conditions at one time. The Bulk density increases by 33 % as would be expected from the change over from an organic horizon to a mineral horizon. The C horizon has many mottles and a sandy loam texture. The groundwater rises periodically to create these conditions. The 5th horizon Cr is very similar to the above horizon with the water table pressure exacerbated by many more stones.

An old stone drain was located in this pit on the right hand side, which has reduced the water problems in this area. Some water did seep from the drain into the pit and it was filled in less than 24 hrs (Plate 11). These old drains still perform a crucial role in keeping the water table low in the profile.

Plate 11. Effectiveness of old stone drains demonstrated by infilling of profile pit after 24 hours.

Plate 12.Soil profile from paddock 7.

Table 3.Soil profile description paddock 7 Rossmore farm.

Horizon depth (cm)	Horizon designation	Description
0 – 28	Apg,	Red brown, with many root mottles, Loam
29 – 50	Eg,	Light grey, reduced iron layer., sandy loam
51 – 90	C	Red orange colour, no mottles. Many weathered stones multi coloured sandy clay loam, possibly water sorted. Left hand side of pit.very light orange, glacial stream separated sand, could be glacial outwash. Changing textures.
91 – 140	Cr	Typical old red sandstone – till, Abundant stones sub rounded stones, clay lenses in places. Dead roots and weathered stones.

Paddock 7.was located beside the drained field. Formerly a Brown Alluvial soil now is functioning as Typical Surface-water Gley. The weathered stone layer is very evident between 40 cm and 80 cm (plate 12). This layer spans the Eg and C horizons. The Eg horizon was very loose in places having a bulk density of one third of the horizons above and below. Its texture was of pure sand and structure was massive to single grain. Therefore pore space would be very low and stagnation likely when

heavy rain events occur. The third C horizon had very little mottling, if the groundwater table does rise it does not stay in situ for long periods. The coarse fractions in horizon 4, Cr would prevent much water movement due to the lack of pore space at this depth. However no mottling was noted at this depth, further evidence that this soils problem is from stagnation in the upper horizons.

Plate 13.Paddock 20a.

Table 4.Soil profile description for Paddock 20a, Rossmore farm.

Horizon depth (cm)	Horizon designation	Description
0 – 30	Apg	Brown, abundant mottles, Loam
31 – 53	Eg	Grey, many mottles, Sandy loam
54 – 70	Btg	Brown orange, Clay lens, weathered stones, dead roots, Sandy Clay loam
60 – 110	C1	Red, Many weathered stones sand lens, Sandy clay loam
100 – 140	C2	Patches compacted, stagnic channels, Sandy loam

Paddock 20a was located on the northern, more inclined part of the farm. It was clear from looking at the Apg and the Eg that this profile had severe stagnation problems, both having abundant and

many mottles respectively. At the soil surface level there was severe poaching evident. This stagnation was due to the Btg horizon where there was a 5 % increase in clay content. This horizon also contained clay lens with higher clay contents exacerbating this problem. The weathered stones found in these horizons were not of the same multicoloured nature as those found in the rest of the farm. There were dead roots found in this horizon, suggesting recent changes possibly due to compaction.

In the C1 horizon there were sand lenses and few mottles. The stones found in this area were sub rounded again evidence of an alluvial deposit at one stage. Some cracking from 80 cm was recorded and an increase in compaction. In the C2 horizon the compaction was even more pronounced and large clods up to I metre long began to cleave laterally from the side walls of the pit. These showed evidence of preferential flow along stagnic channels (plate 14). The mottles had become many and common in this horizon. Also the numbers of stones fell to very few. This evidence suggests lateral flow in this area throughout the year.

Plate 14.Paddock 20a, preferential flow along stagnic channels, most of which is lateral on these slopes in the subsurface.

Conclusions

On reviewing the auger campaign and the detailed description of the soils pits, the dominating drainage problem is in the upper horizons of the soil. Generally there was not conclusive evidence of prolonged periods of gleying caused by elevated groundwater levels and the corresponding mottles in the lower horizons. There are some Groundwater Gleys present but they are in a much smaller proportion to the dominant Surface-water Gleys.

In the mostly level terrain of this farm Groundwater Gleys are sporadic and likely to be associated with rises in the underlying bedrock. The elevated water table levels in some augers supported this. Groundwater Gleys by their very nature can be localised and may appear in more paddocks if greater auger coverage was used.

There may be more Kilpierce soils series (Cly) associated with the Kilrush (Fly)areas and more Knockroe seires (Cly)associated with the Newport Groundwater Gleys (Fly) based on the prevalence of Sandy loam textures from the soil pit data (Appendix).

The weathered stone layer at 40 cm in many augers resulted in a Bt or Btg horizon with a corresponding increase in clay. This is a common indicator of Surface-water Gleys. The chemistry data taken from the soil profile pits indicated accumulation of organic carbon at the surface in some of the augers and pits. This is a restriction of organic matter breakdown due to stagnation at the surface. The deeper horizons had increased bulk density which results in less pore space and water holding capacity. Therefore downward water movement would be restricted and build up likely in the upper horizons.

Increasing the movement of water through these deeper horizons at depth will improve the overall drainage status in this farm.

In areas where there was no clay increase and lower bulk densities, Brown Earth and Luvisols were likely with more moderately draining features.

An indicative soil map has been produced for the farm at 1:5000 resolution (Plate 15).

Plate 15.Rossmore soil map 1:5,000

References.

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Appendix.

Table 5. Laboratory data for samples taken from soil pits at Rossmore 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)
TJR 1	7	HZ1	15	16	69	1.48	1.55	5.12	9.14	5.9	5.58	103
TJR 2	7	HZ2	4	8	88	0.42	1.78	318.05	2.63	6	0.36	14
TJR 3	7	HZ3	14	27	59	1.44	1.88	27.66	5.73	5.9	0.8	32
TJR 4	7	HZ4	14	17	69	Too many stones-no samples			5.23	6.9	0.56	22
TJR 5	17	HZ1	14	20	66	0.90	1.53	89.04	13.57	6.2	12.04	126
TJR 6	17	HZ2	28	29	43	1.09	1.20	9.69	32.56	6.3	36.67	> 130
TJR 7	17	HZ3	12	23	65	1.63	2.01	23.14	6.18	7.2	0.97	39
TJR 8	17	HZ4	12	26	62	1.71	2.08	21.28	9.74	7.8	0.38	15
TJR 9	17	HZ5	13	30	57	1.87	2.13	11.39	56.45	8.1	< 0.10	4
TJR 10	20	HZ1	15	27	58	1.16	1.56	34.41	10.07	5.2	5.12	101
TJR 11	20	HZ2	12	31	57	1.50	1.81	20.25	4.90	6.3	1.05	41
TJR 12	20	HZ3	17	23	60	1.61	1.93	19.42	4.59	6.4	0.88	35
TJR 13	20	HZ4	10	21	69	1.67	1.97	15.75	5.86	6.4	0.48	19
TJR 14	20	HZ5	6	10	84	1.69	2.10	24.20	3.07	6.5	0.45	18

Table 5, 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** (%)
TJR 1	7	HZ1	12	49	81	1195	82	61	38	65.37	7.48	1.71	1.81
TJR 2	7	HZ2	8	14	13	307	46	24	27	58.37	14.58	2.34	4.46
TJR 3	7	HZ3	8	3	18	667	101	32	27	58.2	14.69	1.43	2.05
TJR 4	7	HZ4	8	6	52	747	115	46	25	71.41	18.32	2.26	2.08
TJR 5	17	HZ1	17	32	55	1870	194	51	32	68.9	11.91	0.96	1.03
TJR 6	17	HZ2	21	8	33	4705	447	28	37	72.25	11.44	0.22	0.49
TJR 7	17	HZ3	11	4	60	874	159	46	24	70.71	21.44	1.91	1.69
TJR 8	17	HZ4	26	3	38	1478	202	77	28	75.87	17.28	2.03	1.25
TJR 9	17	HZ5	49	1	< 1	10406	267	80	29	92.17	3.94	0.36	0.22
TJR 10	20	HZ1	15	34	28	849	101	80	33	42.15	8.36	2.04	1.42
TJR 11	20	HZ2	11	16	5	665	68	53	25	67.86	11.56	2.77	2.22
TJR 12	20	HZ3	12	3	2	637	62	49	27	69.39	11.26	2.74	2.56
TJR 13	20	HZ4	16	12	11	809	70	50	66	69.03	9.95	2.19	4.9
TJR 14	20	HZ5	10	6	7	434	40	28	26	70.68	10.86	2.34	3.68

Table 5, 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)
TJR 1	7	HZ1	5.6	18	0.46	562	23	0.72	1.1	468
TJR 2	7	HZ2	5.4	15	0.21	240	26	0.59	4.14	219
TJR 3	7	HZ3	5.6	18	< 0.20	184	57	1.35	0.93	425
TJR 4	7	HZ4	4.5	1.5	0.22	195	61	2.81	1.47	320
TJR 5	17	HZ1	5.2	12	0.82	555	31	1.66	3.8	404
TJR 6	17	HZ2	5.1	10.5	0.82	509	27	1.09	0.43	517
TJR 7	17	HZ3	4.2	0	0.33	216	15	3.56	0.72	351
TJR 8	17	HZ4	3.6	0	0.35	335	30	3.67	1.7	280
TJR 9	17	HZ5	3.3	0	0.28	157	107	3.34	2.33	15
TJR 10	20	HZ1	7	39	0.41	475	11	1.61	1.16	500
TJR 11	20	HZ2	5.1	10.5	< 0.20	165	9	0.51	< 0.4	748
TJR 12	20	HZ3	5	9	< 0.20	200	9	0.81	< 0.4	741
TJR 13	20	HZ4	5	9	0.29	111	53	2.24	0.99	721
TJR 14	20	HZ5	4.9	7.5	< 0.20	135	32	0.78	0.49	484