Environment Waikato Technical Report 2004/18

Subsidence Rates Of Peat Since 1923 In The Hauraki Plains Area

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Acknowledgements

Thanks to land owners who allowed us access to their land.

Contents

1 Introduction

Significant areas of peatland in the Hauraki Plains area have been drained and converted to agriculture, horticulture or mining, although a large undeveloped scientific reserve remains. As a result of conversion, subsidence occurs from consolidation and from losses of organic matter, due to peat mineralization (Schipper & McLeod, 2002). Obtaining information on subsidence rates is important for future land use management as much of the peat and surrounding land is prone to flooding. Information on subsidence rates may also be important for developing mitigation strategies to reduce CO_2 emissions.

2 Background

The Hauraki peatland covers an area of about 23800 ha north east of Hamilton, North Island, New Zealand (latitude 37˚21′26′, longitude 175˚31′31′). There are two main peat areas. The northern most area and margins of the southern area have been largely developed while the southern central area remains as an undeveloped scientific reserve. In 1923, a map was made showing elevation of the peat and clay surface for much of the Hauraki peatland. The measurements were made along transects usually at 10 chain intervals (201.17 m) with transects about 40 chains apart. Since about 1928, most of the area, except the scientific reserve, has been drained and converted to agriculture or horticulture.

The 1923 map is held by Hauraki District Council (Paeroa) and stamped Public Works Office Paeroa 3132.

3 Objectives

To obtain a comprehensive dataset of subsidence rates in the Hauraki peatland, by remeasuring peat thickness at the sites first measured in 1923.

4 Methods

Peat thickness sites on the 1923 plan were transferred to electronic topographic maps of the area (NZMS 260 Sheets S12, T13) by locating an obvious start point, e.g. drain intersect, then setting out electronically the distance measured off the 1923 map. Grid coordinates were then generated for each point. This procedure was accomplished using ArcView GIS. These points were then located in the field using a handheld GPS (Garmin 'Etrex'), with a nominal accuracy of ±5 m. The locations of each transect and station along the transect where peat depth was measured are shown on the accompanying maps. Because drains have since been dug along many of the 1923 stations, the actual point of remeasure was located nearby. Local topography was also taken into account as drains cause the land within close proximity to slope in towards the drain. The point of remeasure was chosen where the height of the land is most representative of the surrounding area. Usually, this was approximately 10 m from the drain.

Once the point was established, the thickness was measured using a steel probe 12 mm in diameter with a 20 mm diameter drill bit attached to the end. A sample of the subsurface material was obtained to ensure that the bottom of the bog had been struck. The subsurface material comprised either blue-grey mud or alluvial sands and silts. A total of 90 stations were measured, over the months of February to April 2003. The thickness of peat at each station was measured and then subtracted from the matching 1923 thickness. This was then divided by 79 (years) to obtain a rate of subsidence per year.

Errors

The largest source of error is in replotting the 1923 transect and stations on the topo maps. Transect lines have been transferred from an old, poorly controlled paper map. The line of the transect has been judged from, for example, a bend in the river or a road intersection. Stations appear to be at 10 chain intervals along each transect but they do vary. It is not clear whether this is due to the quality of the reproduced map or the actual distance between stations varied. In practice stations were assumed to be at 10 chain intervals except where there was obvious discrepancy on the paper map. The size of the error is unknown. Enquiries to the Paeroa office of the Hauraki District Council did not reveal the original field survey books from which stations could be more accurately located.

Using the steel probe, existing peat thickness could be measured to within about 5 cm.

5 Results and discussion

About 90 observations of peat thickness were made along 13 transects around the agriculturally developed areas of the peatland. In about half of the observations the peat had decomposed fully resulting in a dark topsoil only and the soils were essentially mineral soils. For these stations we could not calculate an annual rate of subsidence, as we did not know when the organic soil became fully mineralised.

For the remaining stations, mean subsidence over the 79–year period was 1.46 m, giving an annual rate of subsidence of 1.85 cm y^{-1} with a 95% confidence interval of ±0.20 cm. This rate of subsidence is similar but lower than that reported for the Moanatuatua bog where the annual average rate was calculated to be 3.3 and 3.4 cm y^{-1} (McKenzie & McLeod 2002; Schipper & McLeod, 2002). The rate is similar to the consolidation rates for the 1957–1979 Maukoro–Pouarua and East of Pouarua transects and the1979–1999 Maukoro–Central Road transects reported by Russell (1993). The rate is significantly slower than rates reported on the same transects (4.0–5.3 cm y^{-1}) but including the early (ca. 1923–1957) agricultural development of the peat (Russell 1993). Appendix 1 and 2 shows the full table of results.

There was no relationship between peat thickness and subsidence rate (Figure 1) in this study, unlike the Moanatuatua study (McKenzie & McLeod 2002) where a clear relationship was found (Figure 2). A possible explanation is that the Hauraki data has relatively fewer observations with deep peat.

To gain a wider depiction of subsidence rate the Hauraki peat subsidence data has been combined with that from Moanatuatua (McKenzie & McLeod 2002) and a graph produced showing the relationship between subsidence rate and original thickness of peat (Figure 3). The data still shows that original peat depth accounts for about 50% of the variation in subsidence rate. Note that the trendline is a second order polynomial compared to the linear regression used in the Moanatuatua study (McKenzie & McLeod 2002).

Interestingly, at the sites where peat had decomposed fully, subsidence rate is calculated to be 1.2 cm y^{-1}.

We have not included subsidence rates quoted by Russell (1993) in our calculations because, although they show very useful overall trends, the more recent observations were not necessarily made at the same location as the original observations.

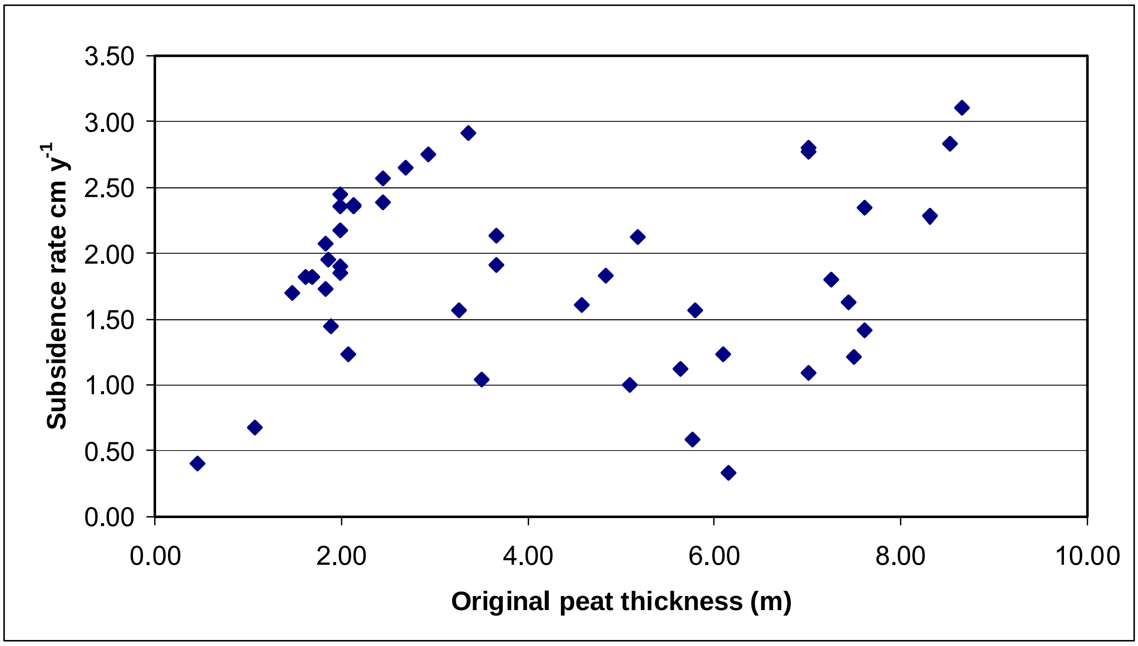


Figure 1: Graph showing the relationship between subsidence rate and original thickness of peat for Hauraki peatland.

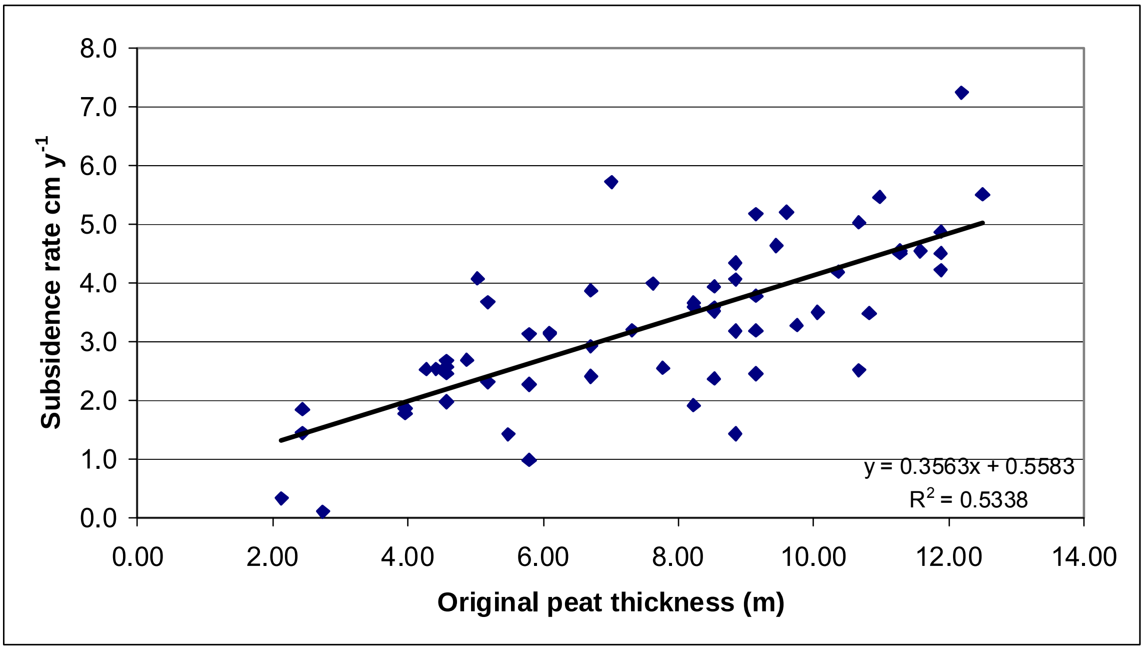


Figure 2: Graph showing the relationship between subsidence rate and original thickness of peat for Moanatuatua peatlands study (McKenzie & McLeod 2002)..

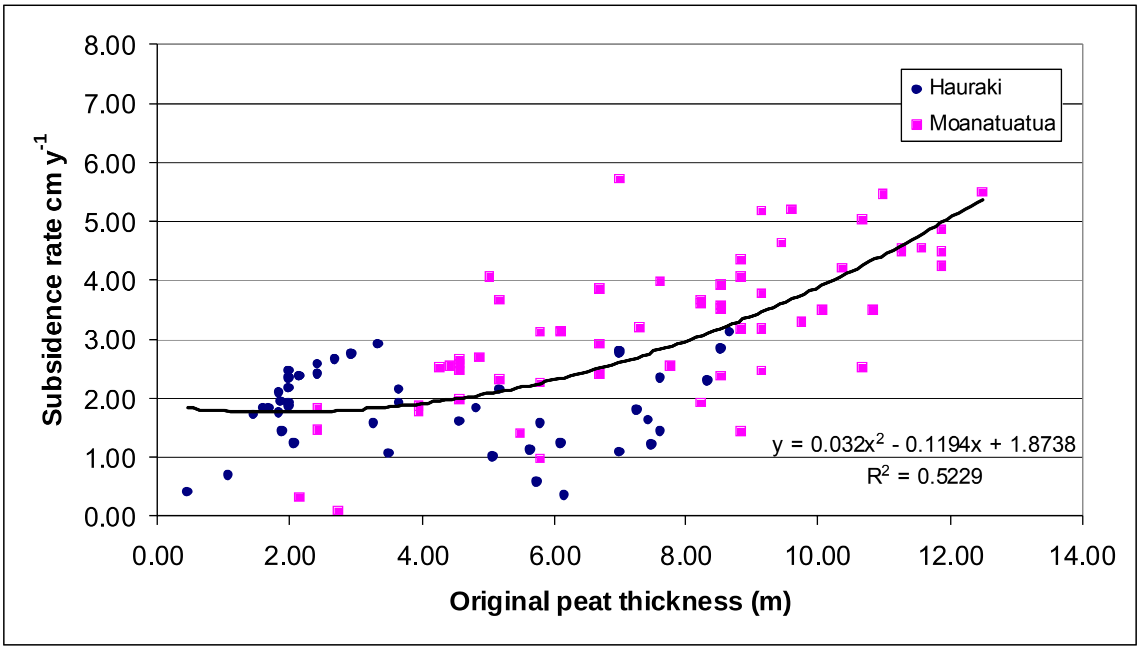


Figure 3: Combined graph showing the relationship between subsidence rate and original thickness of peat for both Moanatuatua and Hauraki peatlands.

Appendix 3 shows cross sections of the transects in a more visual form.

6 Conclusions

Since 1923 the thickness of peat in the Hauraki Plains peatlands has decreased 1.85 cm y^{-1} on average but subsidence rates vary throughout the area. No relationship was observed between 1923 thickness and annual subsidence rate. However, when the Hauraki data is combined with that previously obtained for Moanatuatua, where rate of subsidence increases with increasing peat thickness, peat thickness accounts for a little over 50% of the variation of the combined data.

References

McKenzie, S; McLeod, M. (2002). Subsidence rates of peat since 1925 in the Moanatuatua swamp area. Landcare Research Contract Report LR 0102/128.

Russell, G (1993). The hydrology of the Waitakaruru River and Maukoro canal systems and drainage of the Pouarua peat dome. Waikato Regional Council Technical Report 1991/04.

Schipper, L.A; McLeod, M. (2002.) Subsidence rates and carbon loss in peat soils following conversion to pasture in the Waikato Region, New Zealand. Soil Use and Management. 18 (2): 91-93.

Appendix 1: Stations that have some peat remaining.

Table of results, showing NZMS coordinates 2003 peat thickness,

1923 peat thickness, and related analyses

Station	Easting	Northing	2003 thickness (m)	1923 thickness (m)	Total change (m)	Rate of change (cm y^{-1})
2-5	2737515	6423949	0.12	1.46	1.34	1.70
2-6	2737313	6423949	0.19	1.83	1.64	2.07
3-6	2737493	6423765	0.05	1.98	1.93	2.44
4-4	2739136	6421370	0.14	0.46	0.32	0.40
4-5	2738932	6421372	0.24	1.68	1.44	1.82
4-6	2738732	6421376	0.48	1.98	1.50	1.90
4-7	2738530	6421379	0.52	1.98	1.46	1.85
7-2	2742186	6415045	6.20	8.66	2.46	3.11
7-3	2741979	6415048	5.77	7.62	1.85	2.34
7-4	2741787	6415051	4.55	5.79	1.24	1.57
7-5	2741581	6415048	4.75	5.64	0.89	1.13
7-6	2741380	6415048	5.12	6.10	0.98	1.24
7-7	2741176	6415051	5.30	5.76	0.46	0.58
7-8	2740978	6415051	6.15	7.44	1.29	1.63
7-9	2740772	6415051	6.54	7.50	0.96	1.21
7-10	2740571	6415056	6.50	7.62	1.12	1.42
7-11	2740367	6415053	6.52	8.32	1.80	2.28
8-1	2742509	6413300	3.30	4.57	1.27	1.61
8-2	2742320	6413315	3.39	4.84	1.45	1.83
8-3	2742103	6413324	4.30	5.09	0.79	1.00
8-4	2741903	6413335	3.50	5.18	1.68	2.13
8-5	2741710	6413343	2.15	3.66	1.51	1.91
8-6	2741501	6413356	1.97	3.66	1.69	2.14
8-7	2741299	6413371	2.02	3.26	1.24	1.57
8-8	2741101	6413383	2.68	3.51	0.83	1.04
10-1	2741314	6410726	1.05	3.35	2.30	2.91
10-2	2741113	6410738	0.75	2.93	2.18	2.75
10-3	2740929	6410751	0.75	1.89	1.14	1.44
10-4	2740727	6410767	0.53	1.07	0.54	0.68
10-5	2740547	6410777	1.10	2.07	0.97	1.23
10-6	2740168	6410805	6.30	8.53	2.23	2.83
12-4	2734469	6407926	0.12	1.98	1.86	2.36
12-3	2734422	6408153	0.27	2.13	1.86	2.36
12-2	2734371	6408394	0.18	1.62	1.44	1.82
14-1	2728210	6421628	4.80	7.01	2.21	2.80
14-2	2728051	6421500	4.82	7.01	2.19	2.77
14-3	2727888	6421379	5.83	7.25	1.42	1.80
14-4	2727733	6421255	6.15	7.01	0.86	1.09
14-5	2727575	6421130	5.89	6.16	0.27	0.34
15-2	2726956	6435783	0.32	1.86	1.54	1.95
15-3	2727141	6435860	0.46	1.83	1.37	1.73
16-4	2725812	6436296	0.59	2.68	2.09	2.65
16-5	2725630	6436218	0.55	2.44	1.89	2.39
16-6	2725442	6436133	0.41	2.44	2.03	2.57
16-7	2725261	6436048	0.26	2.13	1.87	2.37
16-11	2724565	6435736	0.26	1.98	1.72	2.18
			Mean	4.15	1.46	1.85
			Standard dev	2.44	0.54	0.69
			95% C.I	0.71	0.16	0.20

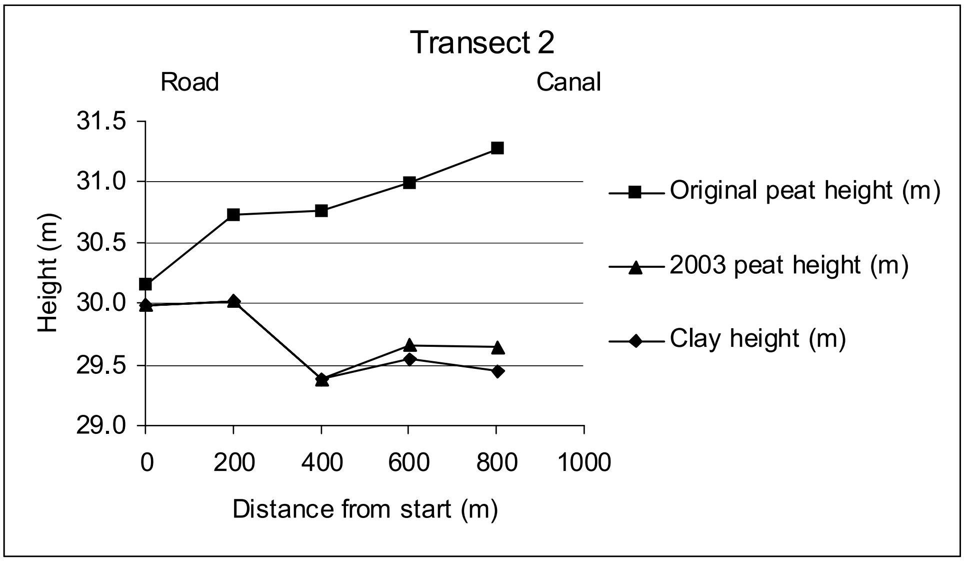
Appendix 2: Stations that have no peat remaining.

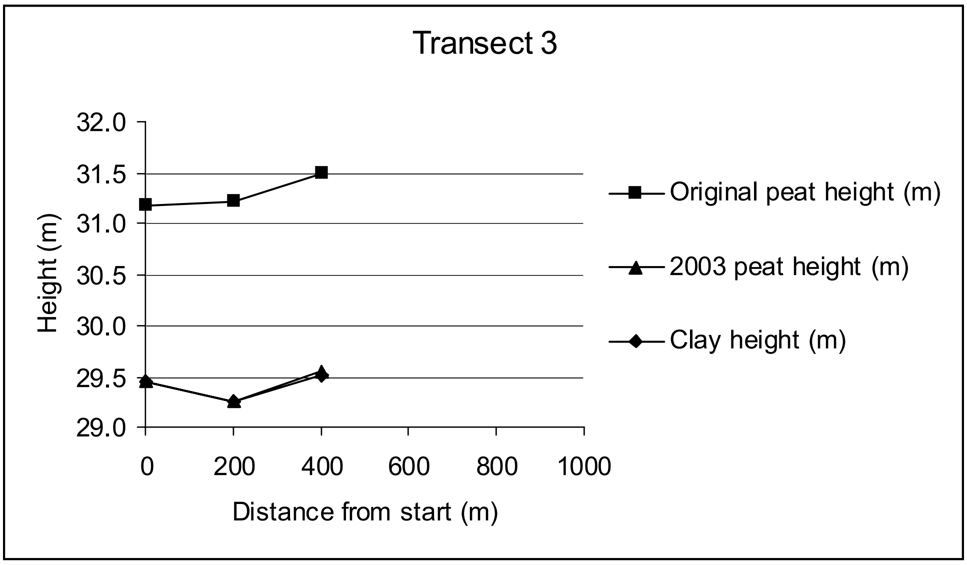
Table of results, showing NZMS coordinates

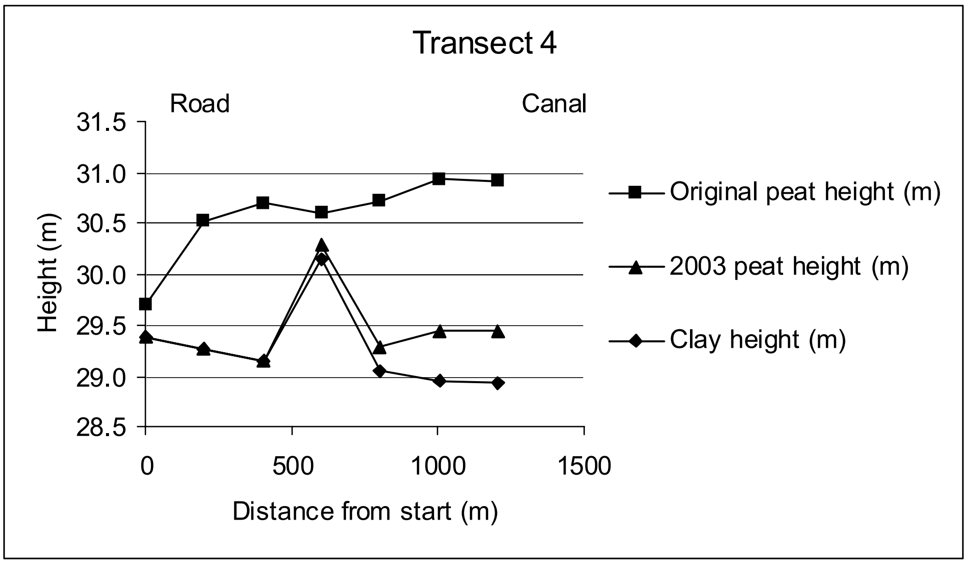
2003 peat thickness and 1923 peat thickness

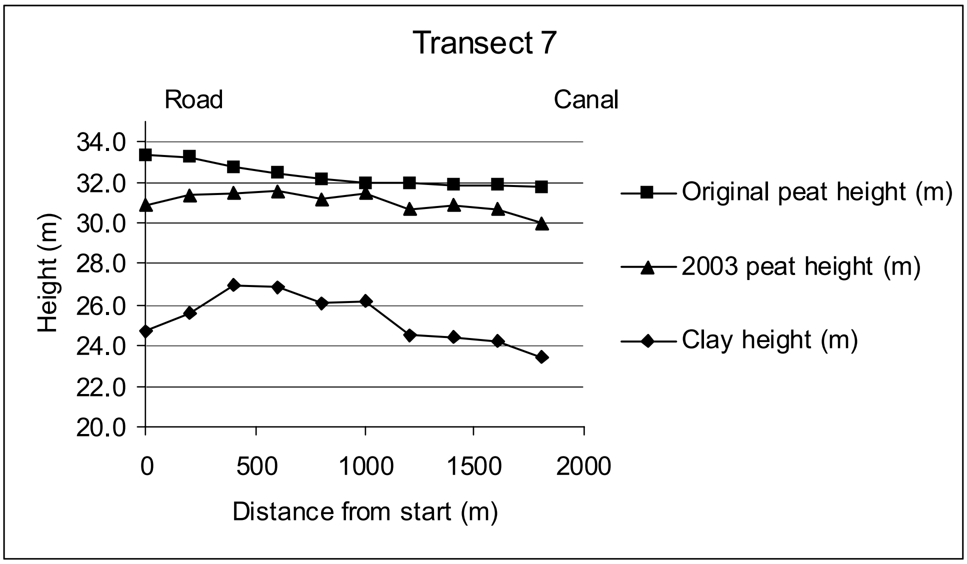
Station	Easting	Northing	2003 thickness (m)	1923 thickness (m)	Total change (m)
1-2	2733061	6426408	0	0.30	0.30
1-3	2733262	6426406	0	0.76	0.76
1-4	2733466	6426401	0	0.91	0.91
1-5	2733672	6426392	0	1.07	1.07
1-6	2734004	6426355	0	1.07	1.07
1-7	2734070	6426378	0	1.16	1.16
1-8	2734273	6426375	0	1.22	1.22
1-9	2734479	6426371	0	1.07	1.07
1-10	2734678	6426363	0	1.22	1.22
1-11	2734877	6426359	0	1.22	1.22
1-12	2735081	6426354	0	1.22	1.22
1-13	2735282	6426352	0	1.22	1.22
1-14	2735485	6426342	0	1.25	1.25
1-15	2735684	6426337	0	1.22	1.22
1-16	2735888	6426330	0	1.07	1.07
1-17	2736084	6426323	0	0.46	0.46
1-18	2736290	6426321	0	0.98	0.98
2-2	2738118	6423949	0	0.15	0.15
2-3	2737917	6423949	0	0.70	0.70
2-4	2737716	6423949	0	1.37	1.37
3-4	2737895	6423770	0	1.74	1.74
3-5	2737691	6423765	0	1.95	1.95
4-1	2739741	6421360	0	0.30	0.30
4-2	2739541	6421365	0	1.25	1.25
4-3	2738932	6421372	0	1.55	1.55
5-2	2740953	6419778	0	0.27	0.27
5-3	2740750	6419781	0	0.18	0.18
5-4	2740565	6419785	0	0.18	0.18
5-5	2740366	6419788	0	0.21	0.21
5-6	2740161	6419791	0	0.18	0.18
5-7	2740122	6419798	0	0.15	0.15
15-4	2727326	6435944	0	0.55	0.55
15-5	2727512	6436028	0	0.52	0.52
15-6	2727662	6436094	0	0.43	0.43
15-7	2727802	6436150	0	0.27	0.27
15-8	2727994	6436238	0	0.40	0.40
15-9	2728162	6436318	0	0.30	0.30
15-10	2728341	6436399	0	0.30	0.30
15-11	2728526	6436476	0	0.21	0.21
16-3	2725995	6436380	0	2.96	2.96
16-9	2724932	6435899	0	2.13	2.13
16-10	2724750	6435821	0	2.07	2.07
16-12	2724381	6435656	0	1.83	1.83
16-13	2724196	6435576	0	1.52	1.52
16-14	2724010	6435493	0	1.68	1.68
			Mean	0.95	
			Standard dev	0.66	
			95% C.I	0.19	

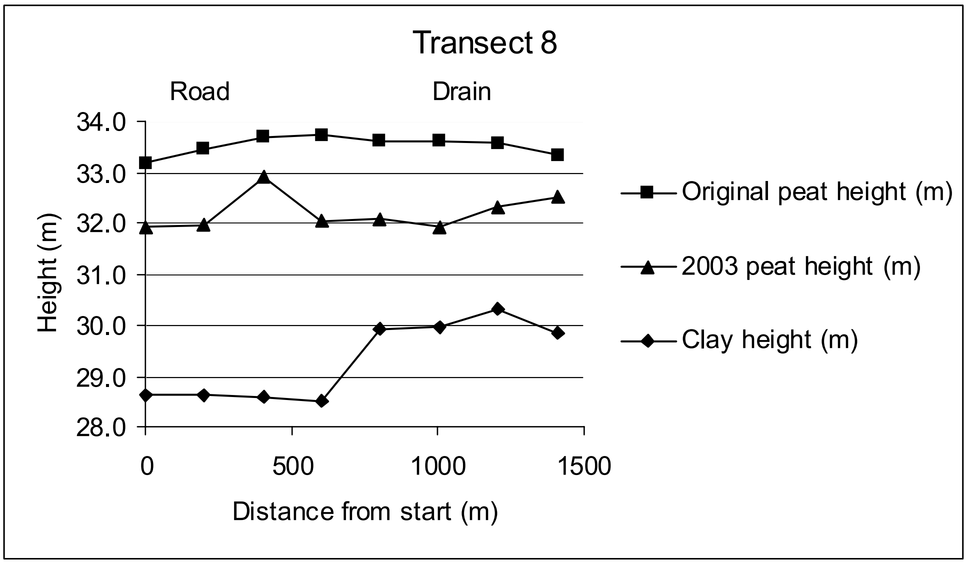
Appendix 3: Graphical representation of transects.

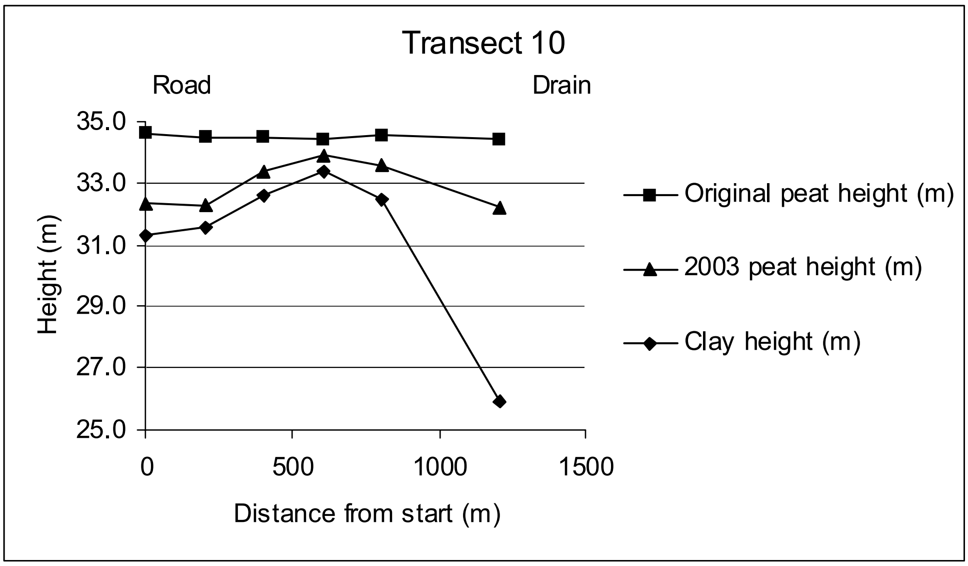







Transect 7
Road
Canal
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
Height (m)
0
500
1000
1500
2000
Distance from start (m)
Original peat height (m)
2003 peat height (m)
Clay height (m)


Transect 8
Road
Drain
34.0
33.0
32.0
31.0
30.0
29.0
28.0
Height (m)
0
500
1000
1500
Distance from start (m)
Original peat height (m)
2003 peat height (m)
Clay height (m)


Transect 10
Road
Drain
35.0
33.0
31.0
29.0
27.0
25.0
Height (m)
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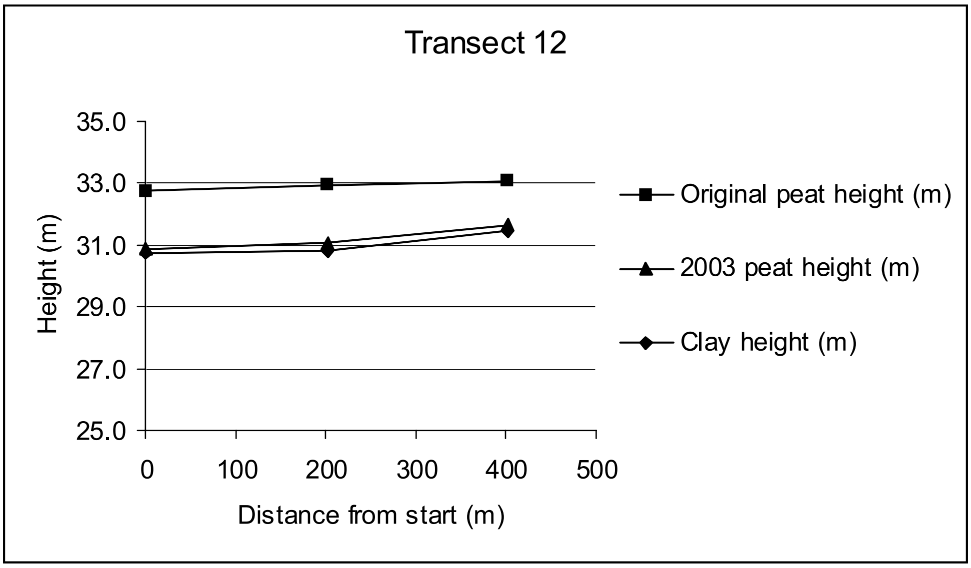
500
1000
1500
Distance from start (m)
Original peat height (m)
2003 peat height (m)
Clay height (m)


Transect 12
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31.0
29.0
27.0
25.0
Height (m)
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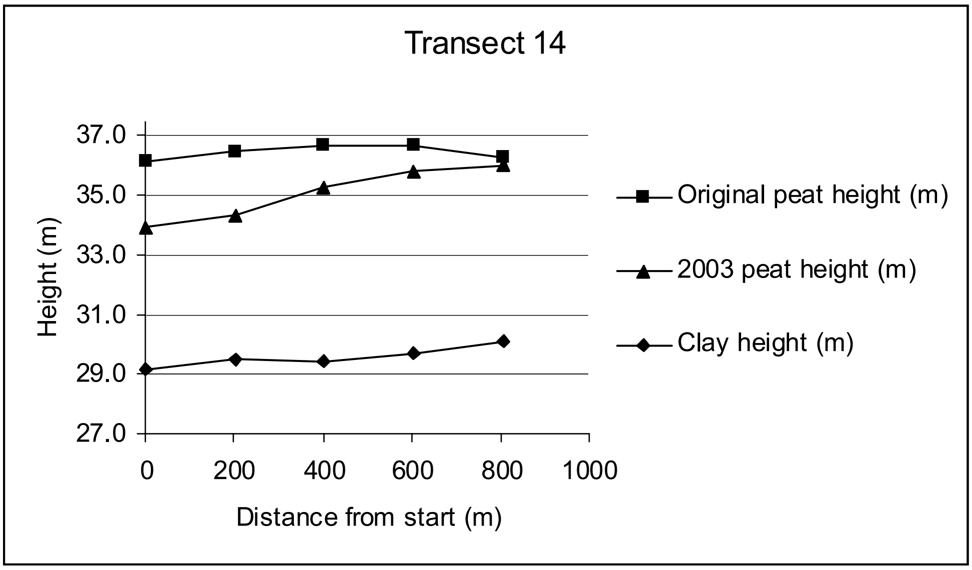
100
200
300
400
500
Distance from start (m)
Original peat height (m)
2003 peat height (m)
Clay height (m)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31.0
29.0
27.0
Height (m)
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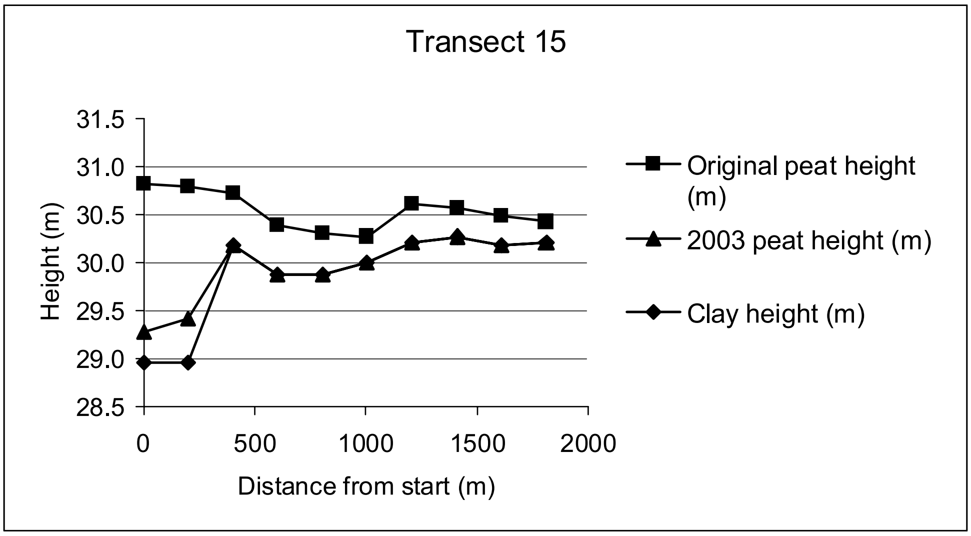
200
400
600
800
1000
Distance from start (m)
Original peat height (m)
2003 peat height (m)
Clay height (m)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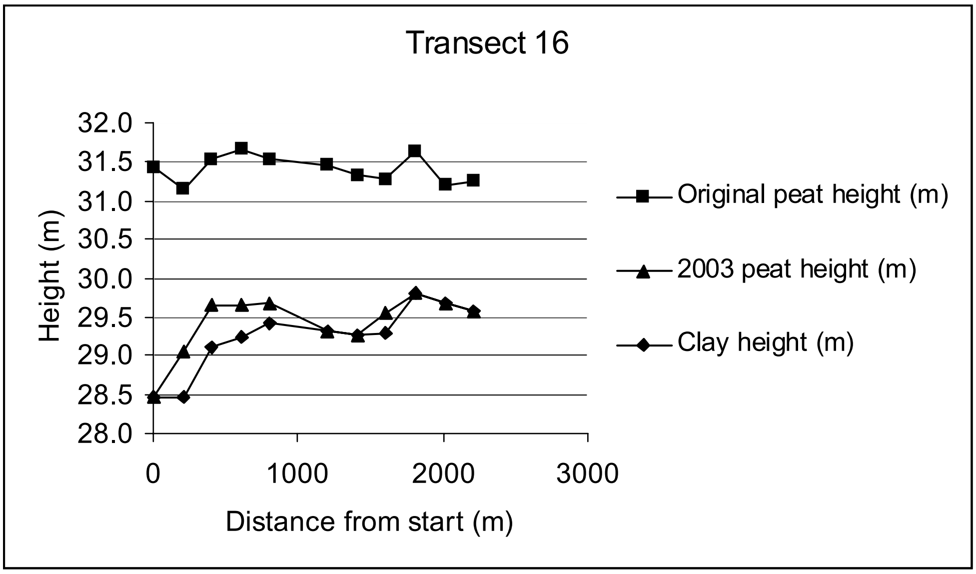
31.0
30.5
30.0
29.5
29.0
28.5
Height (m)
0
500
1000
1500
2000
Distance from start (m)
Original peat height (m)
2003 peat height (m)
Clay height (m)


Transect 16
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
28.0
Height (m)
0
1000
2000
3000
Distance from start (m)
Original peat height (m)
2003 peat height (m)
Clay height (m)

Appendix 4: Locations of stations along transects.

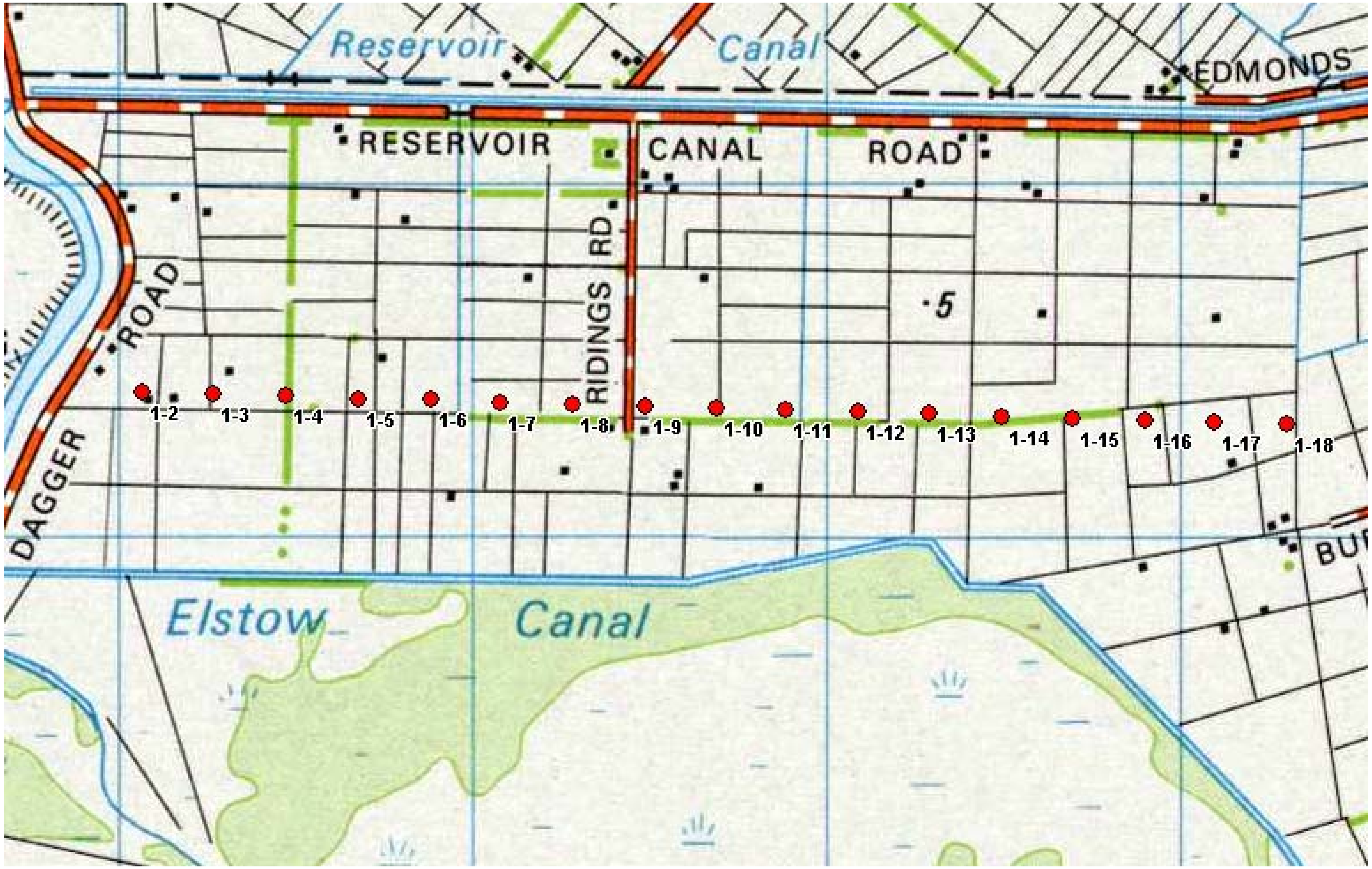


Figure 4:Location of stations along transect 1.

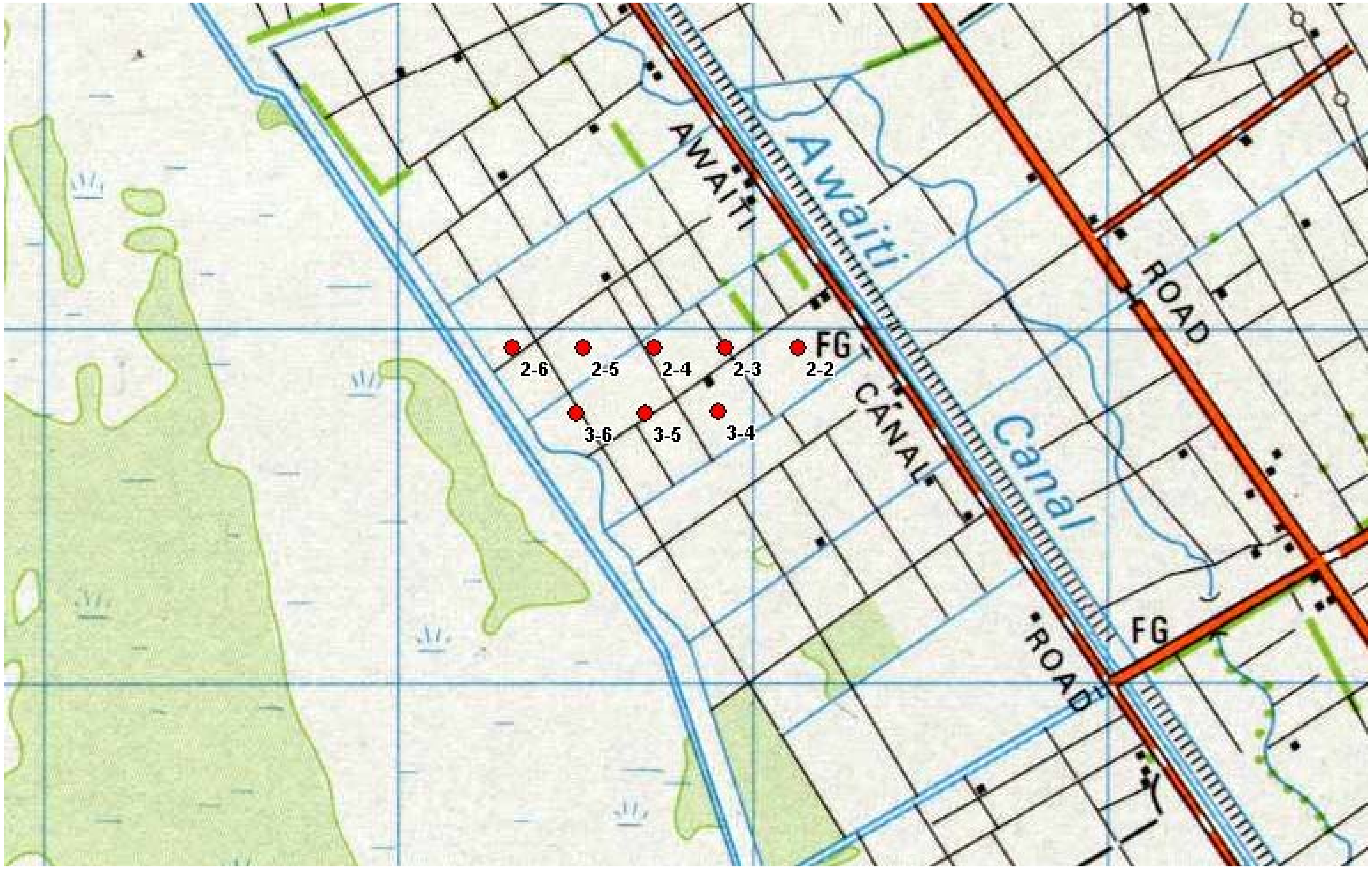


Figure 5: Location of stations along transects 2 and 3.

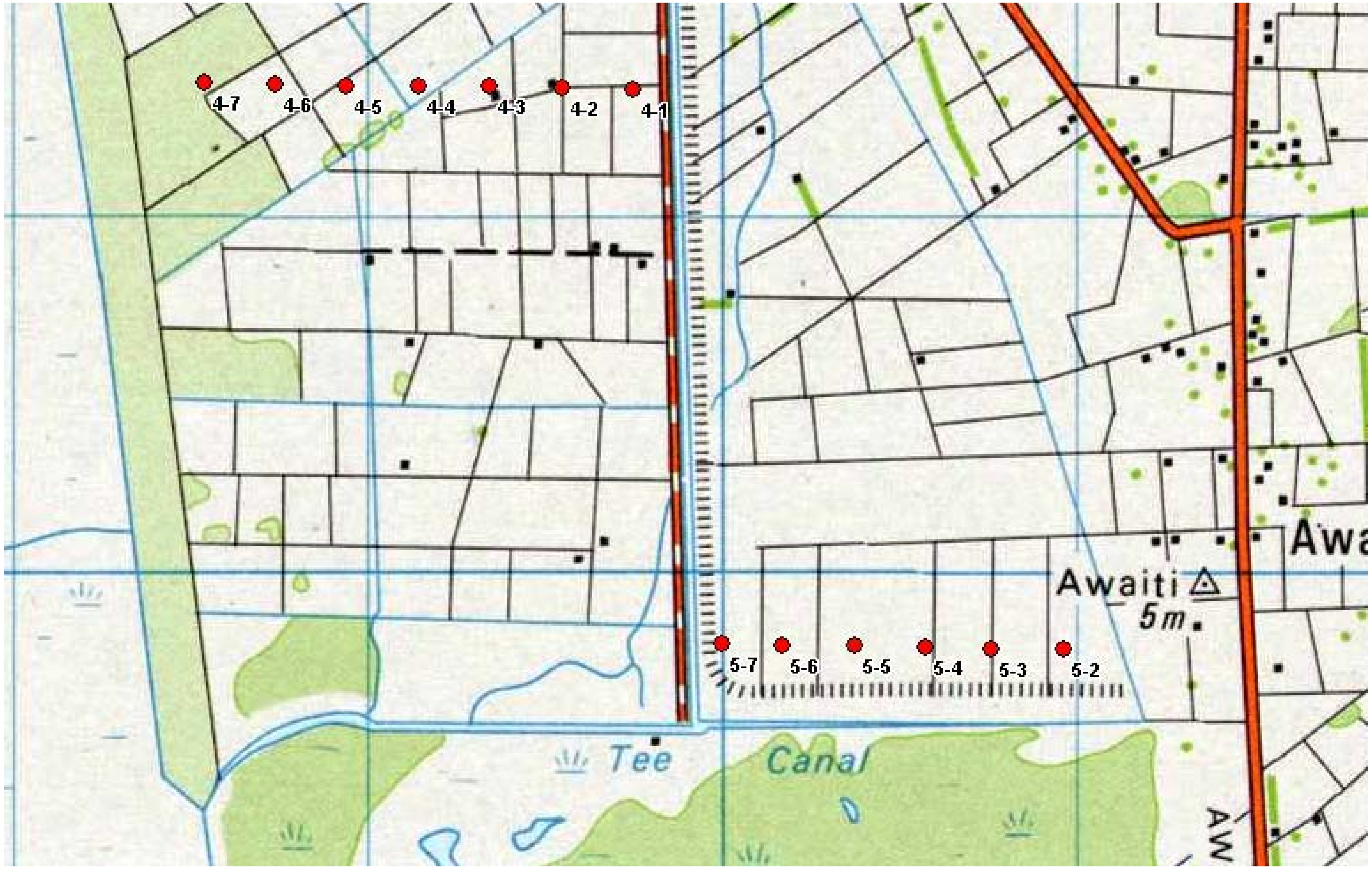


Figure 6: Location of stations along transects 4 and 5.

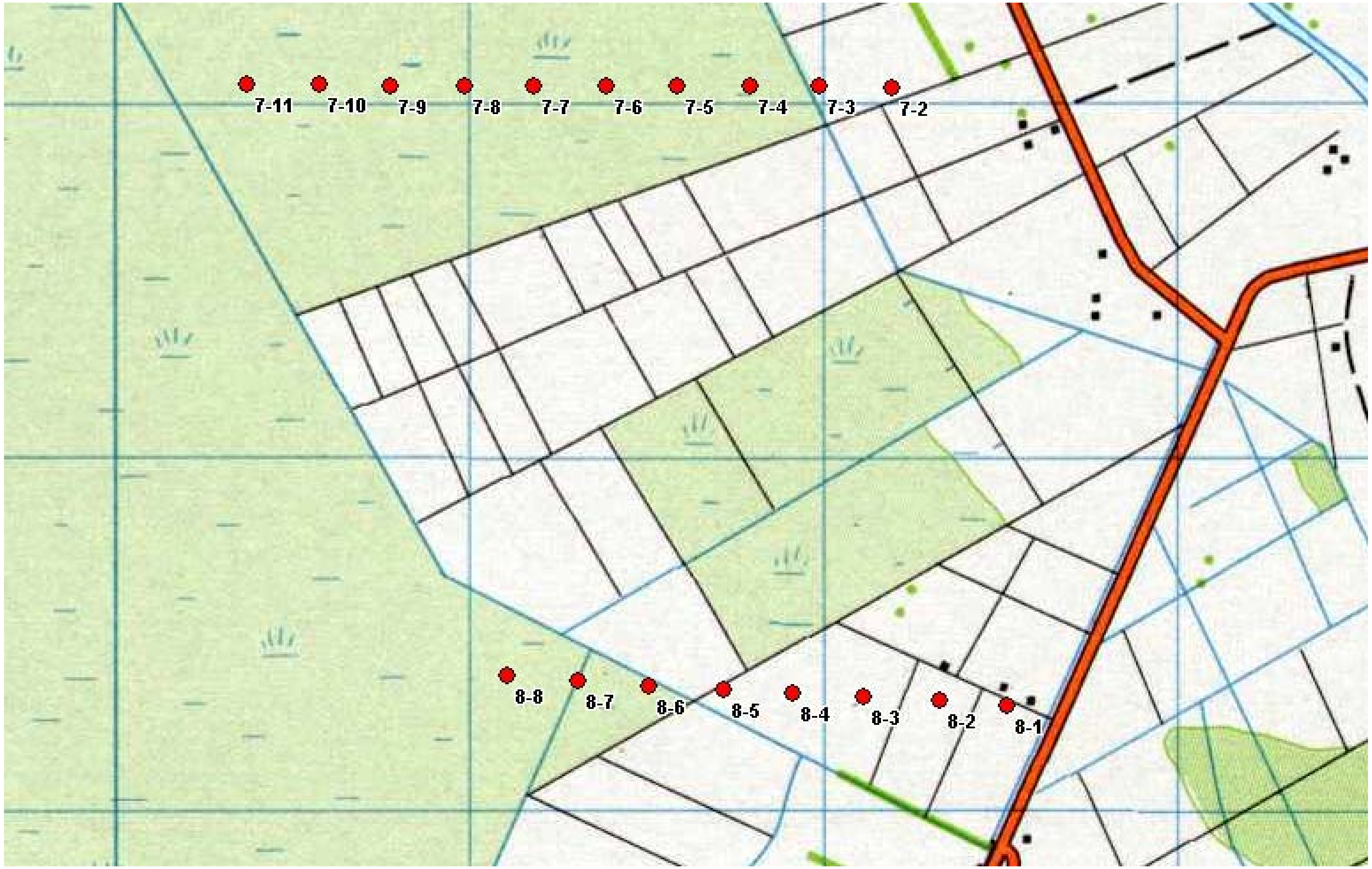


Figure 7: Location of stations along transects 7 and 8

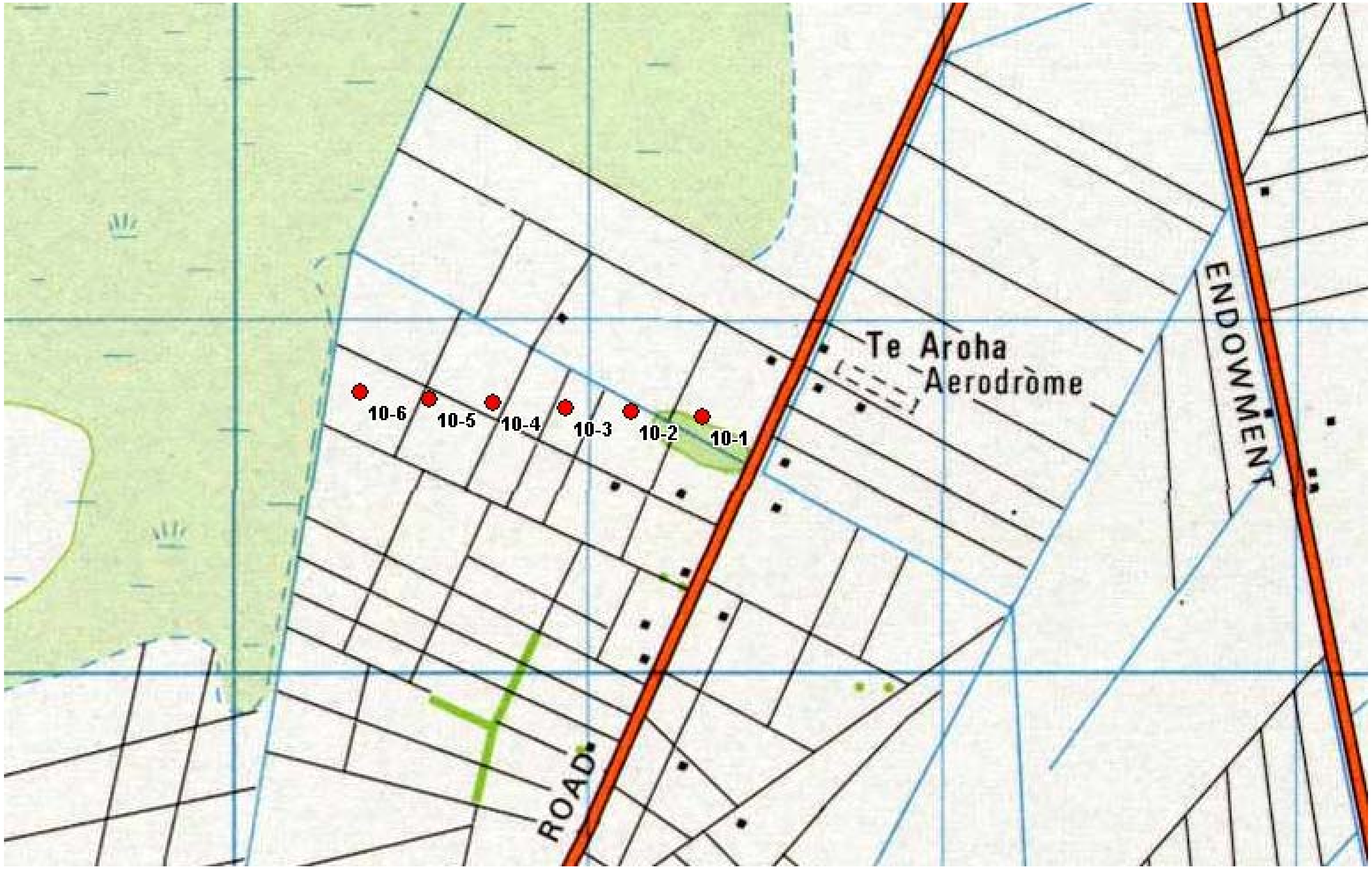


Figure 8: Location of stations along transects 10.

Figure 9: Location of stations along transects 12.

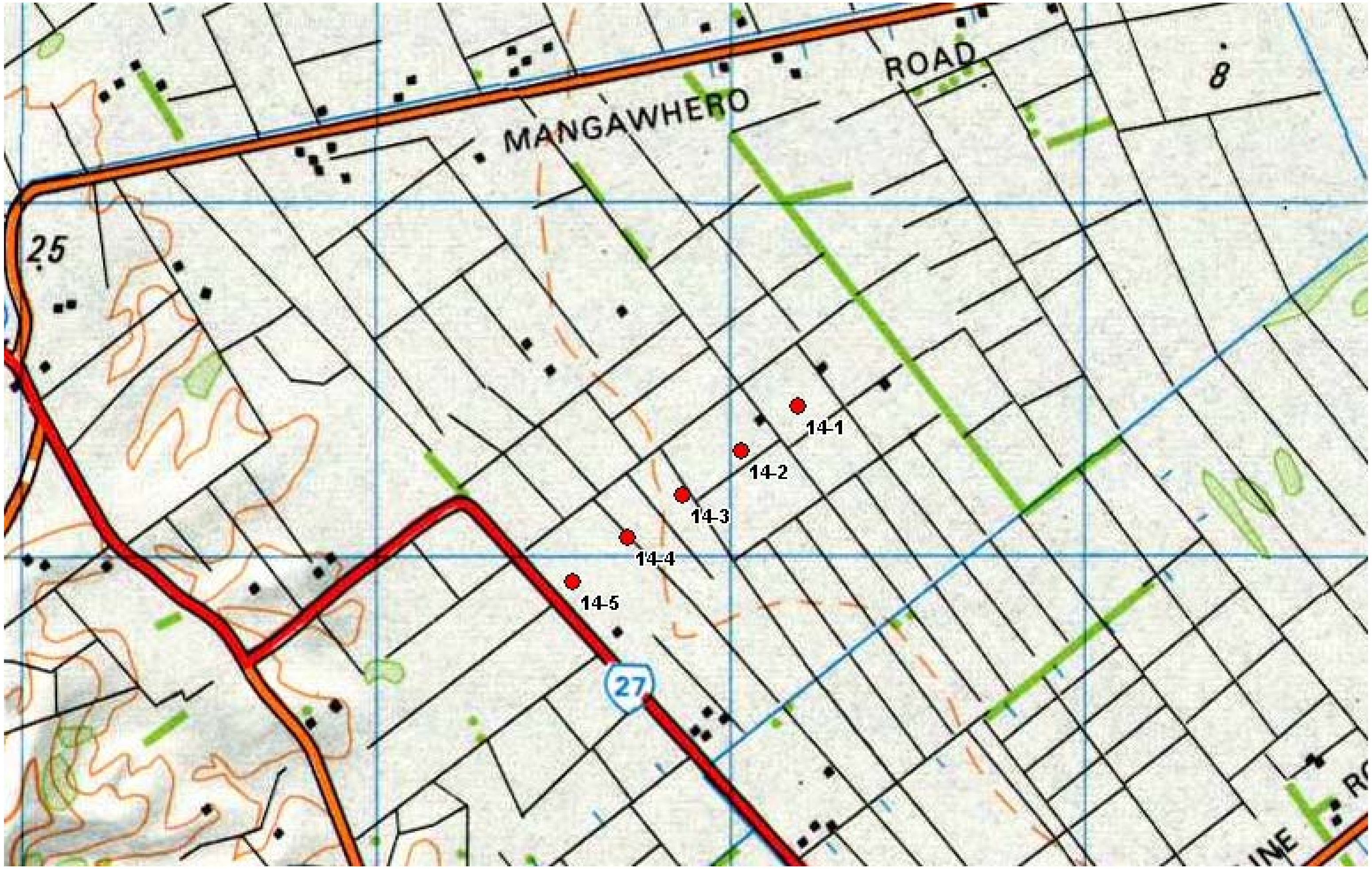


Figure 10: Location of stations along transects 14.

Figure 11: Location of stations along transects 15 and 16.

Appendix 5: Shrinkage rates at each station along transects.

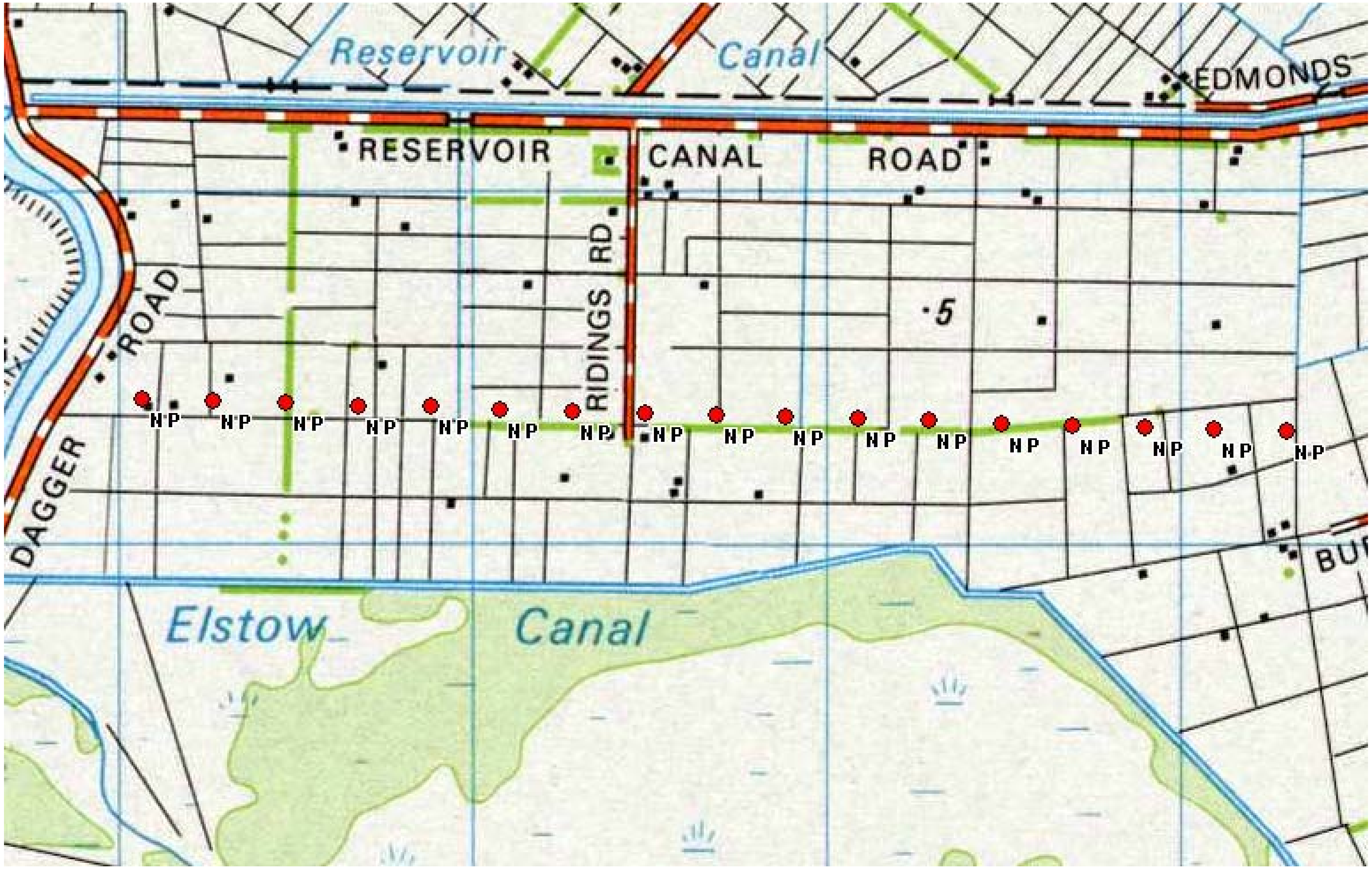


Figure 12: Shrinkage rate (cm y-1) at each station along transect 1. N P = No peat remaining

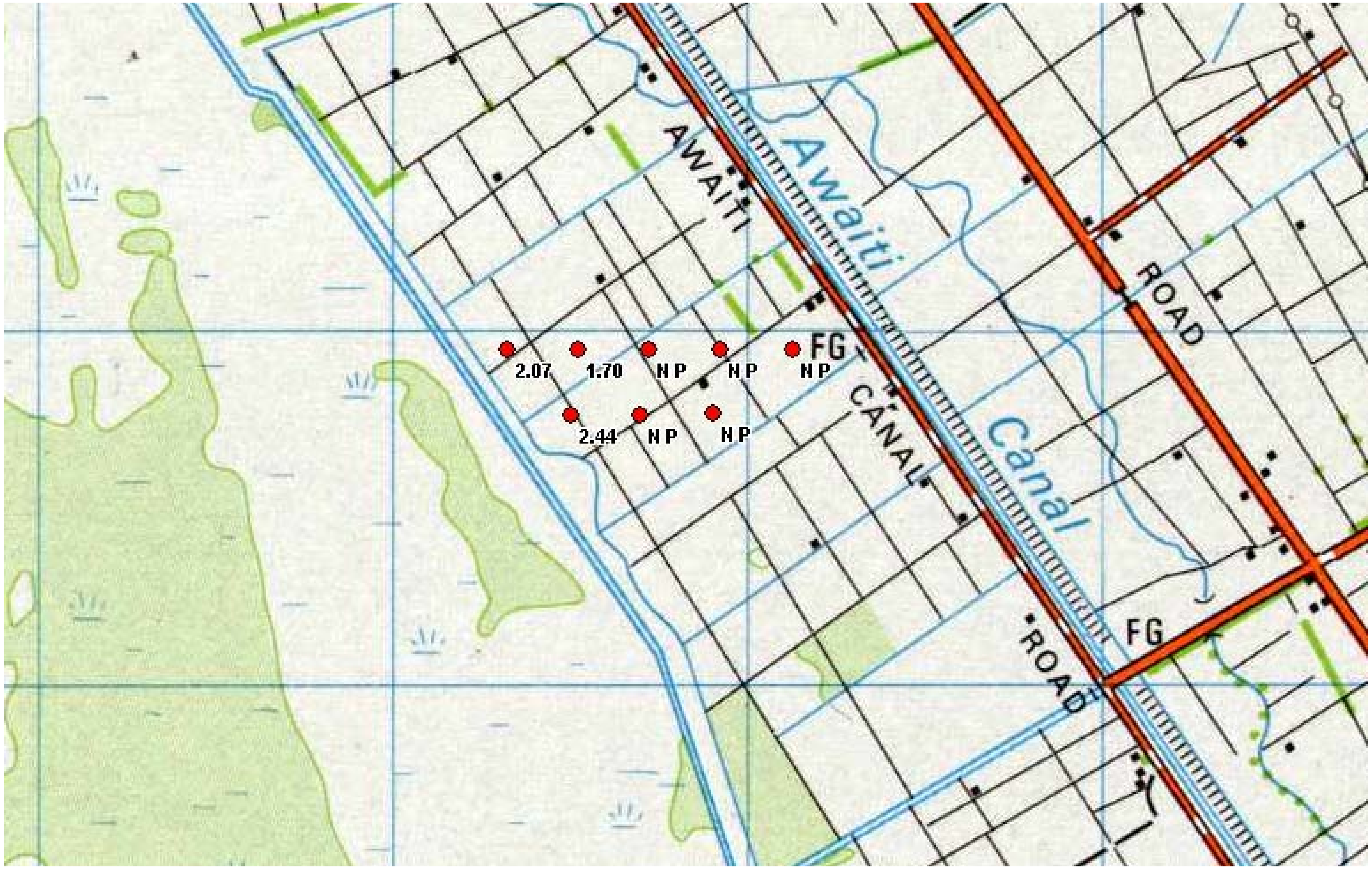


Figure 13: Shrinkage rate (cm y-1) at each station along transects 2 and 3. N P = No peat remaining.

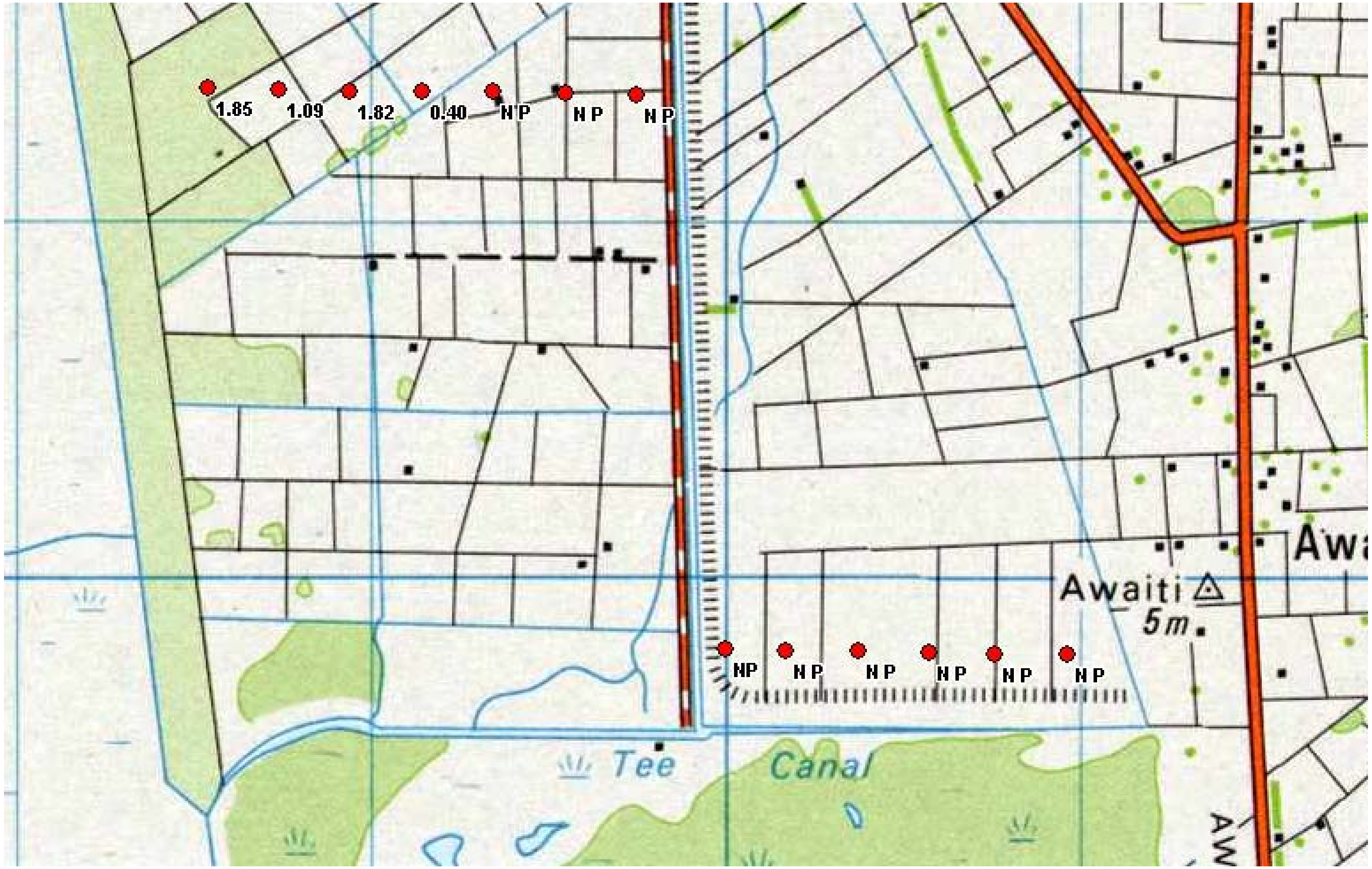


Figure 14: Shrinkage rate (cm y-1) at each station along transects 4 and 5. N P = No peat remaining

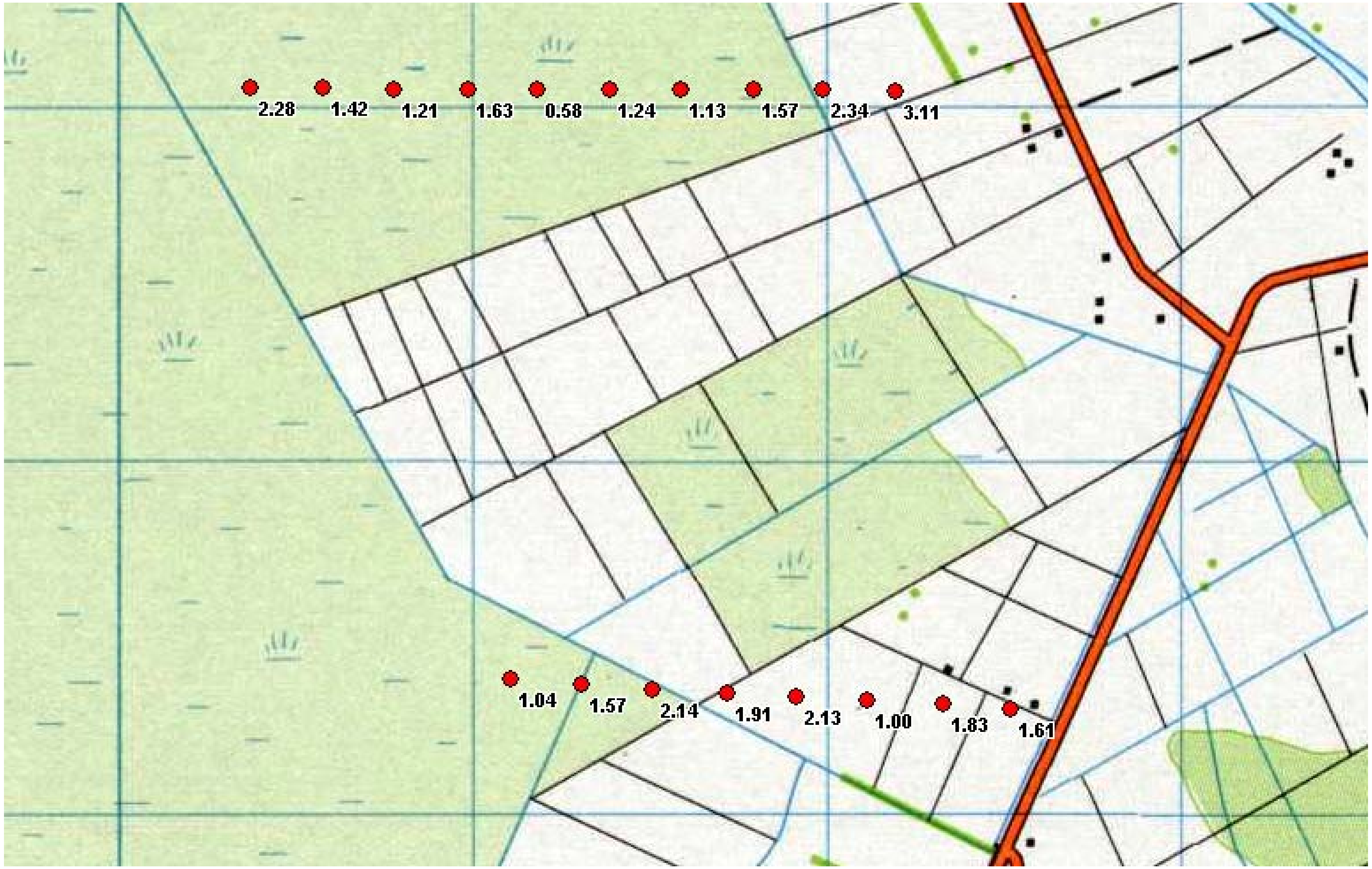


Figure 15: Shrinkage rate (cm y-1) at each station along transects 7 and 8.

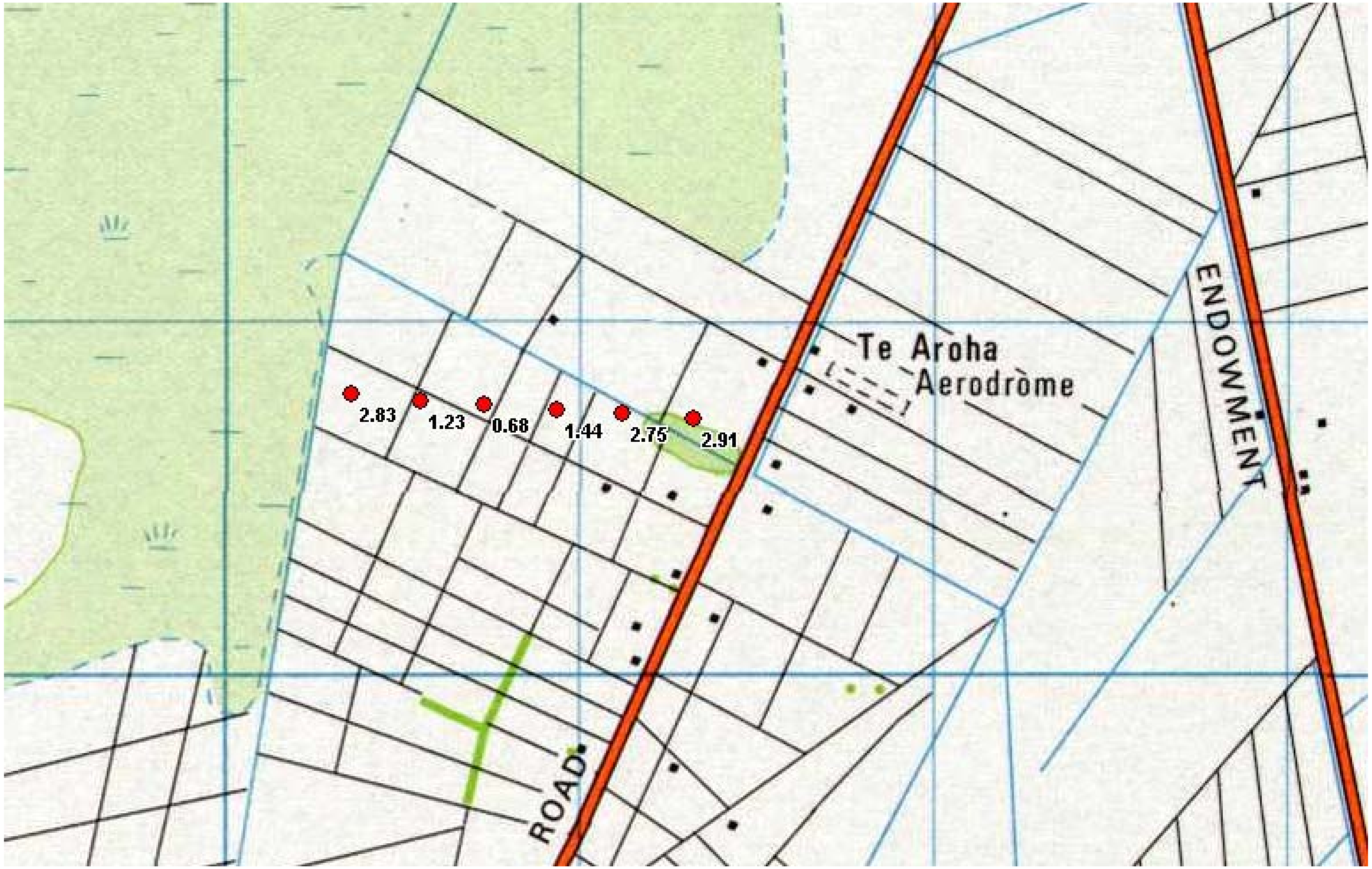


Figure 16: Shrinkage rate (cm y-1) at each station along transect 10.

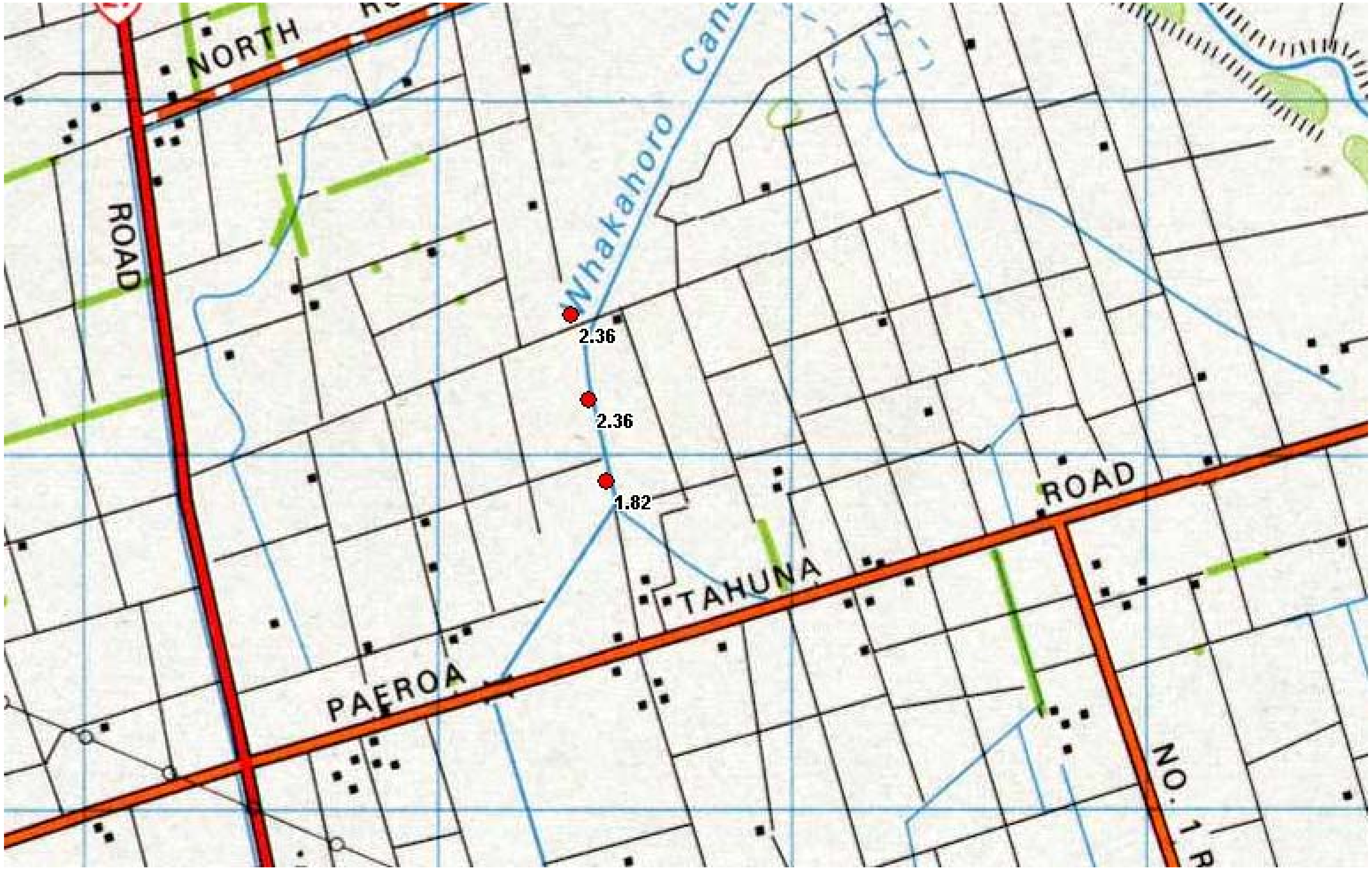


Figure 17: Shrinkage rate (cm y-1) at each station along transect 12.

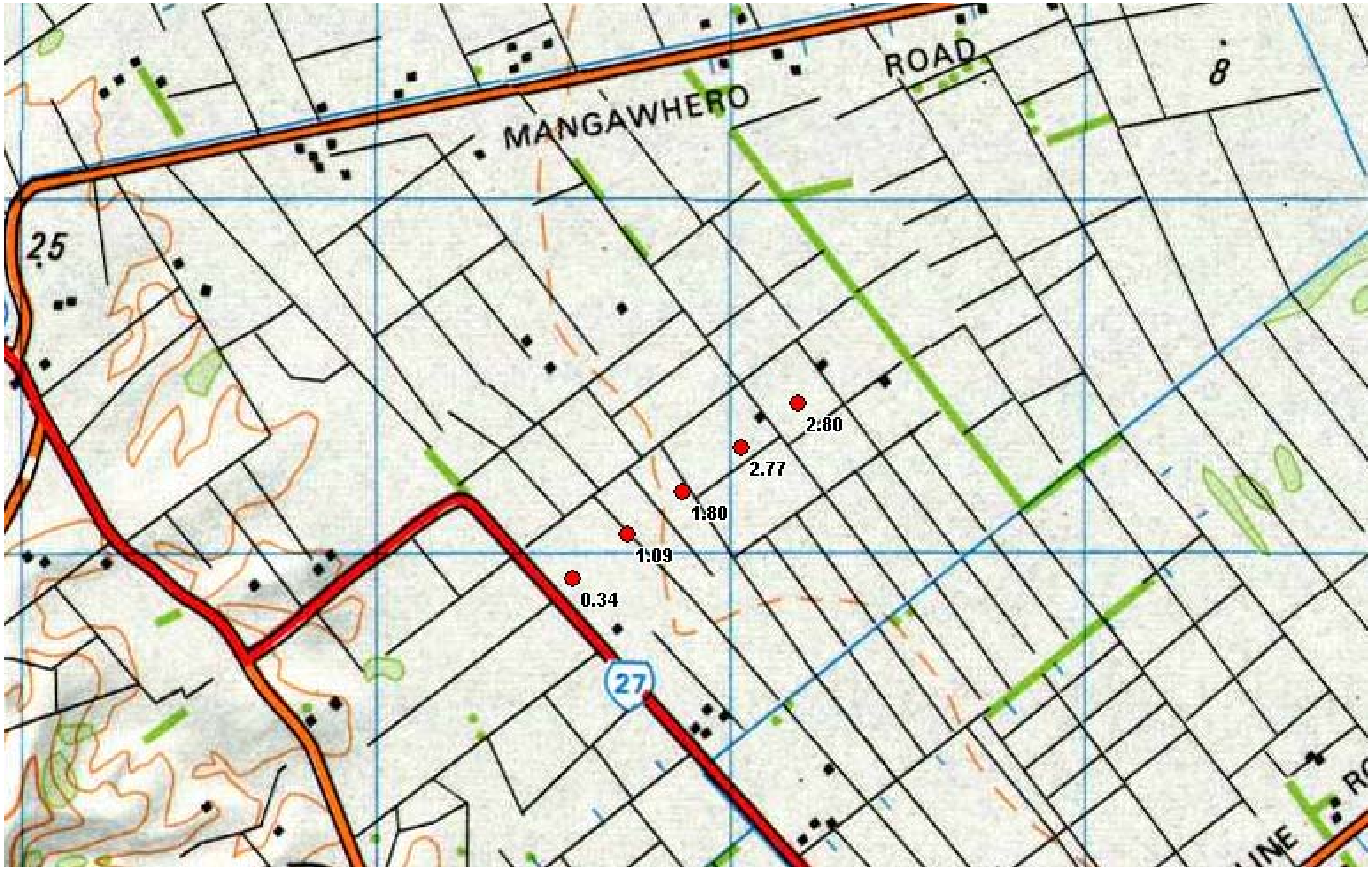


Figure 18: Shrinkage rate (cm y-1) at each station along transect 14.

Figure 19: Shrinkage rate (cm y-1) at each station along transects 15 and 16. N P = No peat remaining.