Cyfoeth Naturiol Cymru
Natural Resources Wales

Merthyr Mawr
Dune Rejuvenation Works
Topographic Survey Report

Kenneth Pye & Simon J. Blott

Kenneth Pye Associates Ltd

Report No: 99

Date: March 2015

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Contents

1. Job Summary

KPAL Job No: 110315
Report Date: 28/08/2015
Client: Natural Resources Wales
Client Job Title: Merthyr Mawr Dune Rejuvenation Works

Survey conducted: 11th and 12th March 2015
Instruments used: Leica Viva NetRover controller and GS08 SmartAntenna mounted on GLS30 pole (2 m)
Leica RX900 controller and ATX900 antenna mounted on GLS30 pole (2 m)
Leica GX1230 RTK base station mounted on GST20-9 tripod
Leica RX1210T Field Controller
No. of data points: 2882
RTK Control Station: Wooden post surveyed-in using Leica Smartnet GPRS (BM1). Note that the original wooden post (BM1) had been lost/ removed since installation in May 2013:
Easting: 286099.005 m
Northing: 176259.435 m
Height: 15.223 m OD
RTK Backup Station: Wooden signpost (BM3) 56 m NNW of Control Station above. Note that second backup station (wooden post BM2) had been lost/ removed since installation in May 2013.
Fixed profiles: Eighteen existing profile lines (1-18) across the Phase 1 and Phase 2 areas, previously surveyed on 14 May 2013 and 11 March 2014, were resurveyed and compared with data surveyed on 16-29 October 2008 using airborne LiDAR. Twenty-three additional profile lines (19-41) were surveyed across the newly activated Phase 3 area and compared with the 2008 LiDAR survey. Chainages along profile lines were interpolated at positions on a theoretical straight-line between the zero and end points of the profile.

Survey undertaken by: S.J. Blott, A. Pye, K. Pye

2. Scope and purpose

This report provides a summary of the results from the topographic monitoring survey at Merthyr Mawr Warren where dune rejuvenation trials were begun in December 2012. The requirements and opportunities for sand mobility trials were identified in an initial report published in 2011 (Pye & Blott, 2011). Additional data relating to changes in bare sand area between the 1940s and 2009 were presented in Pye *et al.* (2014).

In 2013 a significant part of the former deflation corridor of the only remaining mobile parabolic dune within the Merthyr Mawr National Nature Reserve (NNR) was stripped of vegetation (referred here as 'Phase 1', see Figure 1). Sand was also excavated from a number of small ridges within the deflation corridor and placed on either side to raise the height of the 'arms' of the dune in order to achieve greater focusing of wind flow up the deflation corridor towards the mobile dune crest. Topographic changes resulting from these works, and from subsequent natural sand movement, were documented by the first monitoring survey carried out on 14 May 2013 (KPAL, 2013).

Further work to complete the removal of sand from within the deflation corridor of the Phase 1 site was undertaken in November 2013, with the excavated material being used to create an artificial sand dune (referred here as 'Phase 2'), to the south-west of the Phase 1 site. Although less sand was moved from Phase 1 than planned, the deflation trough was significantly widened and lengthened, effectively doubling the area of wet slack. The form of the western arm was also significantly modified by excavation.

A third phase of rejuvenation works (referred here as 'Phase 3') was undertaken in November 2014, to the west of the Phase 1 and Phase 2 sites. Six notches were cut in the frontal dunes, and the dunes behind stripped of vegetation, to provide a pathway for sand to migrate inland from the beach and to maximise the possibility of retaining bare mobile sand into the future (Ludlow, 2014).

At the northern half of the Phase 3 site, three notches (A, B and C) were cut through the frontal dune, with deflation corridors cut through the parallel ridges behind, in a WSW-ENE direction, approximately aligned with the prevailing winds. Approximately 130 m inland from the beach, a shore-parallel valley was partly filled with sand, and the artificial ridges created on either side of the deflation troughs behind the notches. At the eastern end of the site, shallow deflation troughs were cut through a generally flat plateau area, with a steep slip face created immediately to the west of the main bridle path and pre-existing lake. This created a largely continuous bare sand area stretching from the beach to the Phase 1 site.

At the southern half of the Phase 3 site, two shallow notches (D and E) were cut in the frontal dunes, with a short (60-70 metre) deflation corridor created behind. At the southern end, a sixth notch (Notch F) was cut through the frontal dune, and a pre-existing parabolic dune behind was stripped of vegetation, providing a 200 metre long run of bare sand, with the Phase 2 site situated immediately to the NE.

Most of the stripped turf from the inland area and notches A,B & C was deposited on the northern and southern margins of the stripped area to form new dune 'arms'. Stripped turf from notches D & E was deposited on the leeward side of the stripped / excavated areas before re-profiling with a bulldozer.

During the work care was taken to avoid sand excavation or deposition on, or within 4m of, a Welsh Water pipeline which crosses the south eastern part of the site (Ludlow, 2014).

3. Survey methods and error checking

Elevations were determined at 2882 points using Leica RTK GPS SmartRover equipment listed in the Job Summary above. Many of the survey points were on profile lines which were also surveyed in May 2013 and May 2014 (Figures 2 and 3). The limits of defined features, including areas of vegetation stripping and extent of windblown sand, were also mapped by survey points.

Average vertical and horizontal errors reported by the instrument during the March 2015 survey were well within the expected range (Table 1).

The benchmark posts 1 and 2, which were established in May 2013, had been removed by the time of the March 2014 survey. However, comparison of data for Benchmark 3 (signpost) for the previous surveys in May 2013 and March 2014 surveys, and at the start and end of the March 2015 survey, showed only small differences which are within acceptable limits (Table 2).

The locations of the survey points are shown in Figures 3 and 4.

Ground photographs were taken at a number of locations around the site; selected examples are presented in Appendix 1.

An estimate of the area of bare and substantially bare sand at the time of survey was made using the Golden Software Surfer and comparison made with the areas indicated in previous surveys. The areas defined as ‘bare’ or ‘substantially’ bare include turf stripped areas, deposited sand mounds, and areas of post-works windblown sand deposition. It should be noted that in some areas a clear distinction between ‘substantially bare’ and ‘substantially vegetated is difficult to make, since the surface comprises a mosaic of bare areas and vegetation at varying scales. A more accurate estimate of bare sand area and vegetation cover could be made using additional GIS techniques, but such analysis did not form part of the topographic survey contract.

4. Sediment particle size analysis

During the topographic survey 44 surface sand samples were collected from the dunes and beach adjacent to the dune rejuvenation area (sampling locations within the rejuvenation area are shown on Figure 5, and a full list of samples is provided in Table 3). The samples were analysed for particle size by dry sieving and the data processed using Gradistat software (Blott & Pye, 2001). The sediments have been classified using the statistical summary parameters and terminology proposed by Folk (1954), Folk & Ward (1957) and Blott & Pye (2012).

5. Results - particle size analysis

The results of the particle size analysis are summarised in Tables 4 and 5. Most of the dune sediment samples collected can be classified as well sorted or moderately sorted fine sands (Tables 3 & 4). The higher due crest and slip face samples are typically very well sorted, while some of the deflation hollow and artificial dune ridge samples are moderately well sorted or poorly sorted, with a few containing up to 6.5% gravel. Only a small number of the samples contain small quantities (<0.4% of) silt and clay '(mud'). The median size showed a narrow range of variation (188 to 216 microns). Material of fine sand size is easily moved by the wind.

The lower and mid beach adjacent to the rejuvenation area is composed mainly of well-sorted fine sand. The upper beach contains significant but spatially variable quantities of gravel and cobbles, in places overlain by well-sorted windblown fine sand.

6. Profile comparisons

The raw survey data were mathematically 'corrected' to allow direct comparison of straight line profiles derived from the October 2008 LiDAR survey and the previous ground surveys. The vertical accuracy of the LiDAR has not been quantified directly but is estimated to be better than 10-15 cm.

Forty-one profiles are compared in Figures 6-8. Profiles 1 and 2 along the central axis and slip face of the large parabolic dune in the Phase 1 area show significant sand movement since March 2014. Some lowering and eastward movement of the upper stoss (windward -facing) slope of the dune is evident, and the 20 m OD contour on the slip face (leeward side of the crest) showed an annual landward movement of 2.33 to 2.66 m between 2013 and 2015, equal to or larger than the apparent movement between 2008 and 2013 (Table 6). Most of the movement can be attributed to the greater extent of bare sand and greater wind funnelling after the works undertaken in December 2013, to the relatively windy conditions experienced in the autumn and winter of 2013-14, and to the greater wind exposure and sand supply from the Phase 3 area since November 2014.

Profiles 3 and 4 illustrate the reduction in the level of the crest of the western and eastern arms of the Phase 1 site, of 0.5 to 1.0 metre, with subsequent redistribution of surface sand by the wind. In the central Phase 1 area, where vegetation is beginning to establish, very little change is evident (Profile 5). Sand is accumulating in the bowl near the head of the dune (Profile 6), but continuing to migrate over the top of the dune down the slip face, with the top lip gradually reducing in elevation (Figure 7) by approximately 1 m since the rejuvenation works. Very little change is evident in the northwest corner of the Phase 1 area, since sediment was excavated for the Phase 2 area. Very minor sand deflation and accumulation has occurred, although no significant vegetation is becoming established (Figures 8-12).

Profiles 13 to 18 document changes to the Phase 2 area since works were undertaken. The surface level of much of the dune has dropped by 70-80 cm in the year since March 2014, with sand evidently migrating eastwards with the prevailing wind. Blown sand now extends 25 m further east than in March 2014, with a gentler slip face than was created as part of the works (see the eastern end of Profile 13).

The surveyed profiles of the Phase 3 area (Profiles 19 to 41) are compared to the October 2008 LiDAR survey, which does not quite cover the north-western extremity of the site (Figure 3). It is apparent that changes occurred in the frontal dune during the period 2008 to 2014 (i.e. between the survey and the start of the rejuvenation works in this area).

At the northern end of the site, vegetation has been stripped across the shore-parallel valley (Figure 8a: Profile 19), with sand being placed in a ‘dam’ across the valley to the north of the site. Profiles along the axes of notches A, B and C (Profiles 20-22) show that the notches were cut and re-profiled to a depth of 2-3 m through the frontal dune ridges, with the base of the deflation corridors remaining at or above 8.0 m OD (the elevation of the dune toe) for their length. At the time of survey a steep slip face was evident at the landward end of the notches where the sand is migrating eastwards into an area of trees and a pre-existing pond.

Notches D, E and F (Profiles 23-25) were cut to a shallower depth of approximately 1 m, not appreciably more than was required to strip the vegetation. At the eastern end of notches D and E, 10-15 m wide sand lobes have formed by sand migrating along the notches. The parabolic dune behind notch F has been stripped of vegetation to expose bare sand. Some sand was used to lengthen and raise the northern arm by approximately 2 m (see northern end of Profile 39). At the head of the parabolic dune sand is accumulating (Profile 41) and migrating eastwards to form a sand lobe (Profile 25).

In the north-eastern part of the Phase 3 area, crossed by Profiles 29-32, a new ridge has been created, approximately 5 m high, with a crest level reaching approximately 11-14 m OD, along the northern edge of the site. The southern boundary of this area, 100 m to the south, is formed by a pre-existing dune ridge which has not been stripped of vegetation, reaching a similar elevation of 12-14 m OD. A generally flat, vegetation-stripped plateau has been created in between, with shallow (c. 1 m deep) troughs excavated to continue the alignment of notches A, B and C in a WSW-ENE direction.

The approximate total area of bare and substantially bare sand within the rejuvenation area at the time of the March 2015 survey was 8.5 ha, comprising 3.00 ha in Phase 1, 0.56 ha in Phase 2 and 4.95 ha in Phase 3 (Table 7). The bare sand area in Phase 1 has increased by 0.26 ha since March 2014, in part due to increased blown sand spreading across the higher eastern areas, and due to sand spreading onto Phase 1 from the recently stripped Phase 3 area upwind. The bare sand area in Phase 2 has increased by 0.22 ha since March 2014, an increase of 40%, due to the formation of the large sand lobe at the eastern (downwind) end of the site. This sand is sourced largely by deflation and lowering of the dune itself, and from sand from the recently stripped adjacent Phase 3 area upwind.

7. References

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8. Tables

Table 1. Average error reported by the instrument for all 2882 data points

	1-D quality control (height)	2-D quality control (position)	3-D quality control (position and height)
Average	9.3 mm	5.9 mm	11.1 mm
StDev	1.4 mm	0.9 mm	1.6 mm

Table 2. Measured location and height of Benchmark 3 (signpost) in metres

	Easting	Northing	Height
Surveyed with Smartnet corrections (14 May 2013)	286154.133	176354.702	4.698
Surveyed with Smartnet corrections (11 March 2014)	286154.204	176354.740	4.727
Surveyed with base & rover, start of survey (11 March 2015)	286154.269	176354.695	4.685
Surveyed with base & rover, end of survey (11 March 2015)	286154.237	176354.691	4.688
Closing error for 11 March 2015 survey	-32 mm	-4 mm	+3 mm

Table 3. Locations of beach and dune sediment samples collected on 11-12 March 2015

ID	Easting	Northing	Sample type	Description
MM1	286303	176350	Dune, Phase 1	Deflation trough
MM2	286110	176275	Dune, Phase 3	Blown sand slope behind Notch C
MM3	286337	176360	Dune, Phase 1	Deflation trough
MM4	286102	176338	Dune, Phase 3	Deflation trough behind Notch A
MM5	286430	176383	Dune, Phase 1	Upper bowl
MM6	286001	176312	Dune, Phase 3	Deflation trough behind Notch A
MM7	286481	176389	Dune, Phase 1	Top of sand lobe
MM8	286061	176290	Dune, Phase 3	Deflation trough behind Notch B
MM9	286486	176402	Dune, Phase 1	Bottom of sand lobe
MM10	285879	176278	Dune, Phase 3	Mouth of Notch A
MM11	286466	176381	Dune, Phase 1	Eastern arm ridge crest
MM12	285854	176258	Beach	Upper beach, in line with Notch A
MM13	286413	176358	Dune, Phase 1	Eastern arm dune crest
MM14	285768	176200	Beach	Mid beach, in line with Notch A
MM15	286376	176413	Dune, Phase 1	Western arm vegetated dune crest
MM16	285543	176090	Beach	Lower beach, in line with Notch A
MM17	285649	175945	Beach	Lower beach, in line with Notch F
MM18	286419	176414	Dune, Phase 1	Western arm vegetated dune crest
MM19	285843	176019	Beach	Mid beach, in line with Notch F
MM20	285950	176168	Dune, Phase 3	Mouth of Notch D
MM21	286011	176196	Dune, Phase 3	Notch D, top of sand lobe
MM22	285954	176087	Beach	Upper beach, in line with Notch F
MM23	286025	176204	Dune, Phase 3	Notch D, base of sand lobe
MM24	286012	176094	Dune, Phase 3	Base of Notch F, near mouth
MM25	286040	176101	Dune, Phase 3	Base of Notch F, centre of notch
MM26	285979	176128	Dune, Phase 3	Mouth of Notch E
MM27	286095	176118	Dune, Phase 3	Deflation trough of parabolic
MM28	286026	176147	Dune, Phase 3	Notch E, centre of notch
MM29	286050	176165	Dune, Phase 3	Notch E, rear sand lobe
MM30	286139	176136	Dune, Phase 3	Deflation trough of parabolic
MM31	286002	176090	Dune, Phase 3	Mouth of Notch F
MM32	286217	176217	Dune, Phase 2	Dune crest
MM33	286175	176149	Dune, Phase 3	Crest of parabolic
MM34	286240	176286	Dune, Phase 1	Eastern arm dune crest
MM35	286036	176105	Dune, Phase 3	Base of Notch F, centre of notch
MM36	286068	176120	Dune, Phase 3	Base of Notch F, rear of notch
MM37	286122	176347	Dune, Phase 3	Deflation trough behind Notch A
MM38	286183	176373	Dune, Phase 1	Western arm dune crest
MM39	286111	176298	Dune, Phase 3	Low ridge behind Notch C
MM40	286232	176360	Dune, Phase 1	Deflation trough
MM41	286279	176392	Dune, Phase 1	Western arm base of slope
MM42	286274	176402	Dune, Phase 1	Western arm dune crest
MM43	286269	176410	Dune, Phase 1	Western arm base of slope
MM44	286195	176326	Dune, Phase 1	Beside track at W end

Table 4. Particle size characteristics of dune samples collected on 11-12 March 2015. Statistics are calculated using GRADISTAT software (Blott & Pye, 2001), mean and sorting using the formulae of Folk & Ward (1957)

ID	Mean (µm & class)		D50 (µm)	Mode (µm)	Mean (phi)	Sorting (phi & description)		Gravel (%)	Sand (%)	Mud (%)
MM1	249	FS	240	215	2.01	0.72	MS	0.0	99.8	0.2
MM2	184	FS	185	215	2.44	0.43	WS	0.0	99.9	0.1
MM3	278	MS	240	215	1.85	0.99	MS	0.0	99.9	0.1
MM4	228	FS	223	215	2.13	0.50	MWS	0.0	100.0	0.0
MM5	226	FS	223	215	2.14	0.58	MWS	0.0	100.0	0.0
MM6	203	FS	208	215	2.30	0.38	WS	0.0	100.0	0.0
MM7	216	FS	210	215	2.21	0.66	MWS	0.0	100.0	0.0
MM8	205	FS	207	215	2.29	0.43	WS	0.0	100.0	0.0
MM9	233	FS	227	215	2.10	0.59	MWS	0.0	100.0	0.0
MM10	216	FS	215	215	2.21	0.43	WS	0.0	100.0	0.0
MM11	173	FS	169	153	2.53	0.41	WS	0.0	100.0	0.0
MM12	266	MS	272	303	1.91	0.38	WS	2.7	97.3	0.0
MM13	175	FS	174	153	2.51	0.33	VWS	0.0	100.0	0.0
MM14	204	FS	204	215	2.30	0.48	WS	0.0	100.0	0.0
MM15	176	FS	175	153	2.50	0.34	VWS	0.0	100.0	0.0
MM16	150	FS	150	153	2.73	0.53	MWS	0.0	99.7	0.3
MM17	161	FS	155	153	2.64	0.41	WS	0.0	99.6	0.4
MM18	181	FS	183	215	2.47	0.36	WS	0.0	100.0	0.0
MM19	188	FS	181	153	2.41	0.53	MWS	0.0	100.0	0.0
MM20	209	FS	209	215	2.26	0.28	VWS	0.0	100.0	0.0
MM21	213	FS	212	215	2.23	0.45	WS	0.0	100.0	0.0
MM22	188	FS	194	215	2.41	0.39	WS	4.3	95.7	0.0
MM23	198	FS	204	215	2.33	0.28	VWS	0.0	100.0	0.0
MM24	231	FS	221	215	2.11	0.58	MWS	0.0	100.0	0.0
MM25	206	FS	210	215	2.28	0.38	WS	0.0	100.0	0.0
MM26	194	FS	201	215	2.37	0.35	WS	0.0	100.0	0.0
MM27	189	FS	194	215	2.40	0.41	WS	0.0	99.9	0.1
MM28	210	FS	209	215	2.25	0.48	WS	0.0	99.9	0.1
MM29	202	FS	204	215	2.31	0.44	WS	0.0	100.0	0.0
MM30	241	FS	233	215	2.05	0.63	MWS	0.0	100.0	0.0
MM31	203	FS	208	215	2.30	0.35	WS	0.0	100.0	0.0
MM32	207	FS	201	215	2.27	0.62	MWS	0.0	100.0	0.0
MM33	177	FS	178	215	2.50	0.32	VWS	0.0	100.0	0.0
MM34	240	FS	218	215	2.06	1.13	PS	6.5	93.5	0.0
MM35	206	FS	208	215	2.28	0.41	WS	0.0	100.0	0.0
MM36	195	FS	200	215	2.36	0.41	WS	0.0	100.0	0.0
MM37	206	FS	200	215	2.28	0.65	MWS	0.0	99.8	0.2
MM38	185	FS	187	215	2.43	0.42	WS	0.0	100.0	0.0
MM39	180	FS	177	153	2.48	0.41	WS	0.0	99.9	0.1
MM40	194	FS	190	215	2.36	0.55	MWS	0.0	99.8	0.2
MM41	239	FS	232	215	2.07	0.64	MWS	0.0	100.0	0.0
MM42	180	FS	181	215	2.47	0.39	WS	0.0	100.0	0.0
MM43	188	FS	192	215	2.41	0.40	WS	0.0	100.0	0.0
MM44	230	FS	224	215	2.12	0.36	WS	0.0	100.0	0.0

Mean Size Classification:
VCG (very coarse gravel)
CS (coarse sand)
MS (medium sand)
FS (fine sand)
VFS (very fine sand)

Sorting Descriptions:
VWS (very well sorted)
WS (well sorted)
MWS (moderately well sorted)
MS (moderately sorted)
PS (poorly sorted)
VPS (very poorly sorted)

Table 5. Sediment textural classifications, according to Folk (1954) and Blott & Pye (2012), from the samples collected on 11-12 March 2015

ID	Folk (1954)	Blott & Pye (2012)
MM1	Sand	Sand
MM2	Sand	Sand
MM3	Sand	Sand
MM4	Sand	Sand
MM5	Sand	Sand
MM6	Sand	Sand
MM7	Sand	Sand
MM8	Sand	Sand
MM9	Sand	Sand
MM10	Sand	Sand
MM11	Sand	Sand
MM12	Slightly gravelly sand	Very slightly gravelly sand
MM13	Sand	Sand
MM14	Sand	Sand
MM15	Sand	Sand
MM16	Sand	Sand
MM17	Sand	Sand
MM18	Sand	Sand
MM19	Sand	Sand
MM20	Sand	Sand
MM21	Sand	Sand
MM22	Slightly gravelly sand	Very slightly gravelly sand
MM23	Sand	Sand
MM24	Sand	Sand
MM25	Sand	Sand
MM26	Sand	Sand
MM27	Sand	Sand
MM28	Sand	Sand
MM29	Sand	Sand
MM30	Sand	Sand
MM31	Sand	Sand
MM32	Sand	Sand
MM33	Sand	Sand
MM34	Gravelly sand	Slightly gravelly sand
MM35	Sand	Sand
MM36	Sand	Sand
MM37	Sand	Sand
MM38	Sand	Sand
MM39	Sand	Sand
MM40	Sand	Sand
MM41	Sand	Sand
MM42	Sand	Sand
MM43	Sand	Sand
MM44	Sand	Sand

Table 6. Movement in the horizontal position of the mid-slope contour (20 m OD) of the sand lobe at the eastern end of the site (Profiles 1 and 2) indicated by LiDAR survey on 29/10/2008 and ground surveys on 14/05/2013, 11/03/2014 and 11/03/2015

	Chainage (m)				Change in chainage (m)		
	29/10/2008	14/05/2013	11/03/2014	11/03/2015	2008-2013	2013-2014	2014-2015
Profile 1	324.65	327.05	329.38	332.04	+2.40	+2.33	+2.66
Profile 2	33.38	34.28	35.96	36.71	+0.90	+1.68	+0.75

Table 7. Areas of bare sand at Merthyr Mawr, in hecatres.

Site	**May 2013**	**March 2014**	**March 2015**
Phase 1 site	2.65	2.74	3.00
Phase 2 site	n/a	0.34	0.56
Phase 3 site	n/a	n/a	4.95
Total	2.65	3.08	8.50

9. Figures

Figure 1. The three phases of dune rejuvenation at Merthyr Mawr, with works being undertaken in December 2012 (Phase 1), November 2013 (Phase 2) and November 2014 (Phase 3).

Figure 2. Locations of March 2015 data points (black dots), benchmarks (red dots) and cross-profiles (blue lines), overlaid on air photographs flown 18 April 2015 (source: Google Earth).

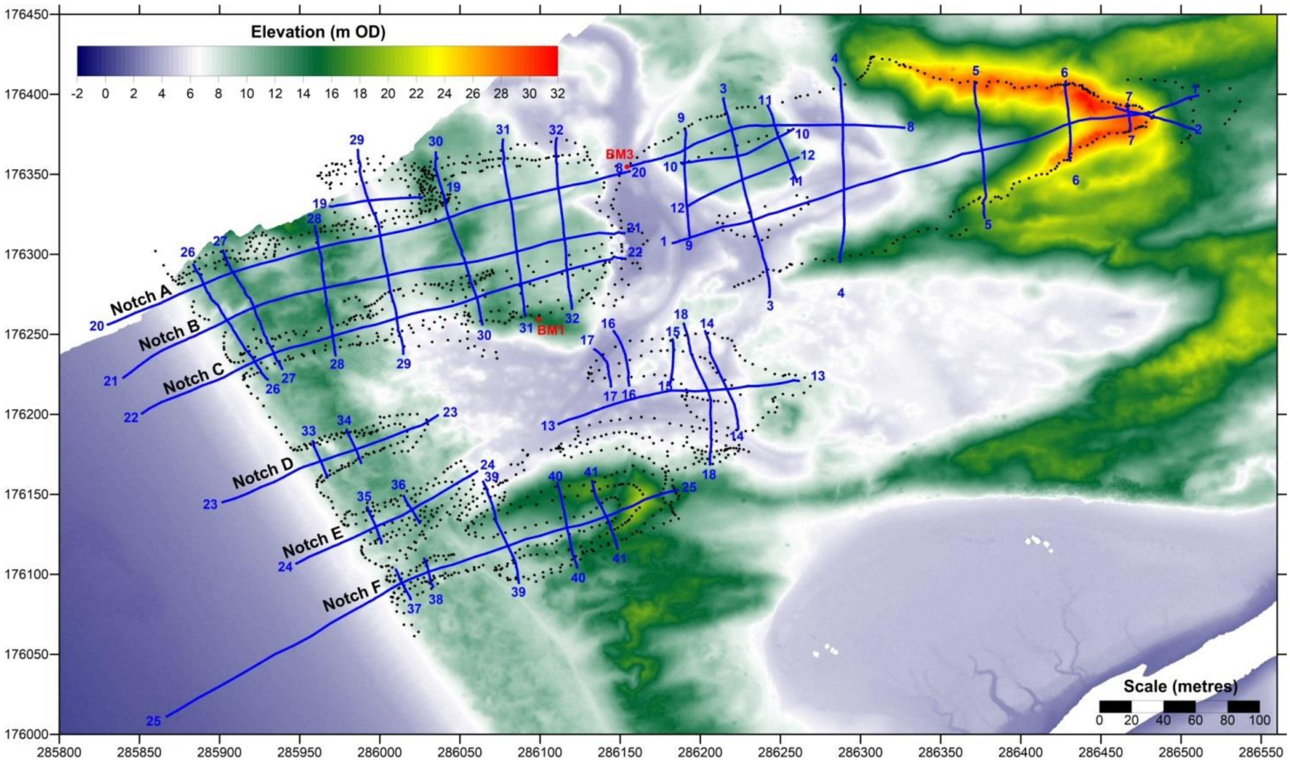


Figure 3. Locations of March 2015 data points (black dots), benchmarks (red dots) and cross-profiles (blue lines), overlaid on LiDAR DEM flown on 16-29 October 2008.

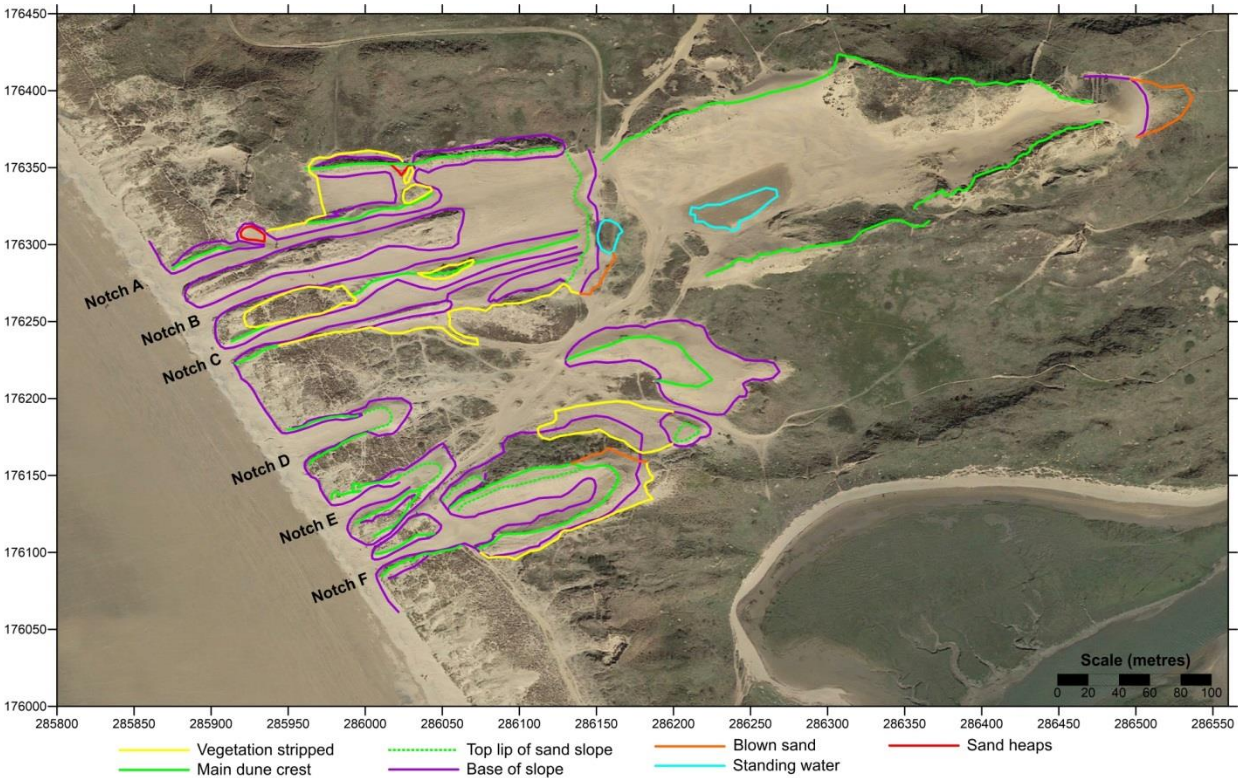


Figure 4. Locations of March 2015 data points (black dots) overlaid on air photographs flown 18 April 2015 (source: Google Earth). Areas stripped of vegetation, the main dune crests, base of slopes, and areas of blown sand, standing water and depositional sand heaps mapped in the field are also shown.

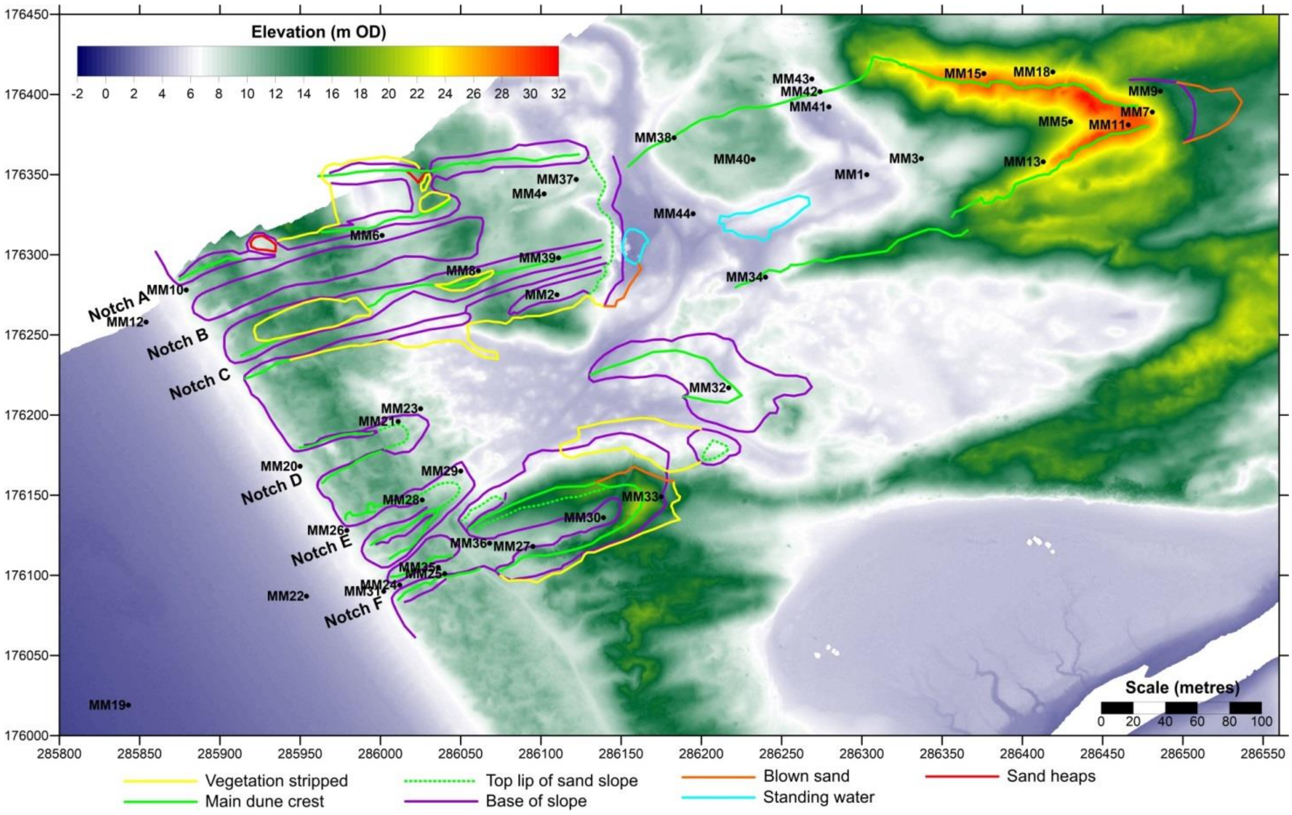


Figure 5. Locations of sediment samples collected within the dune rejuvenation area on 11-12 March 2015, overlaid on LiDAR DEM flown on 16-29 October 2008 (NB some beach sample locations not shown).

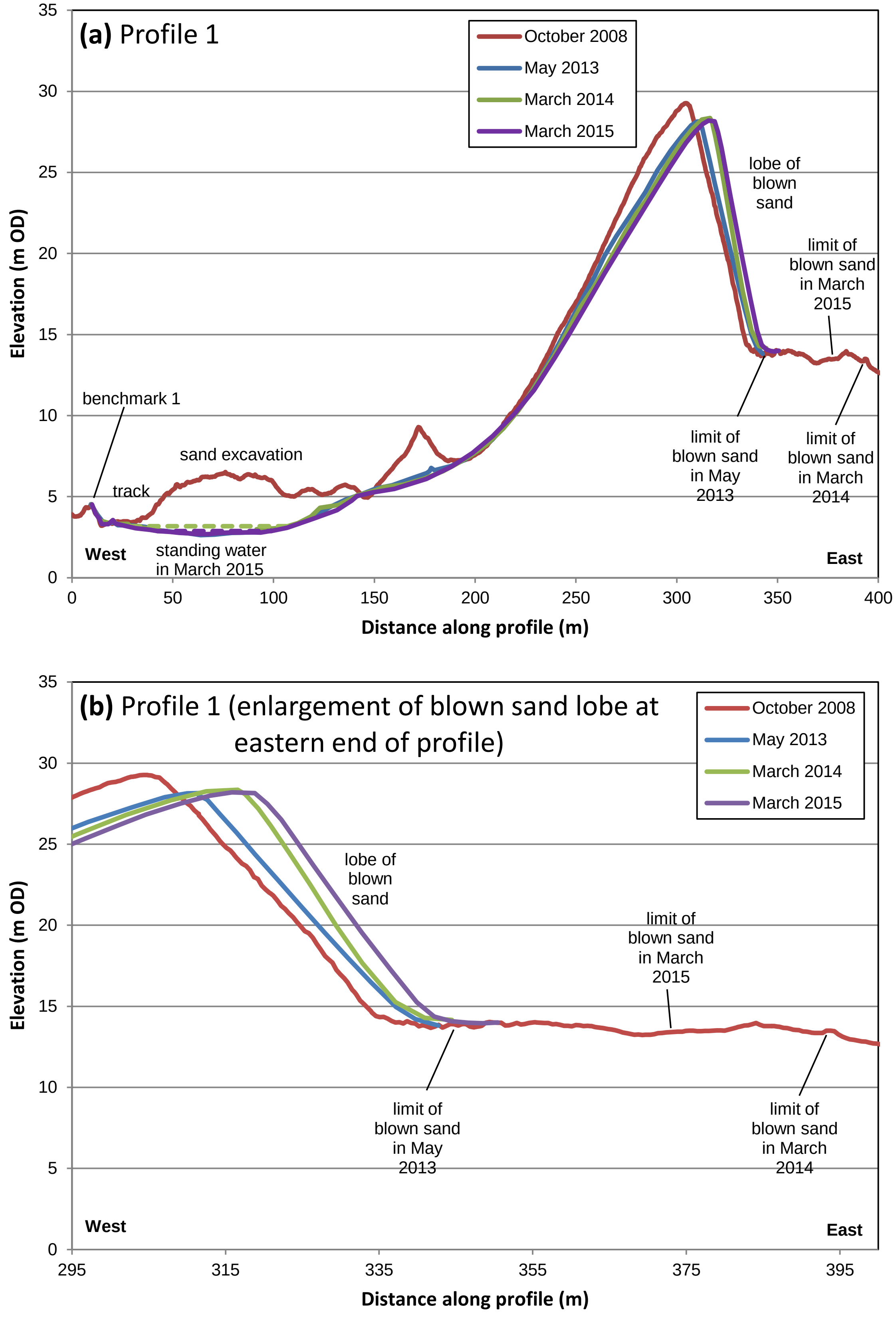
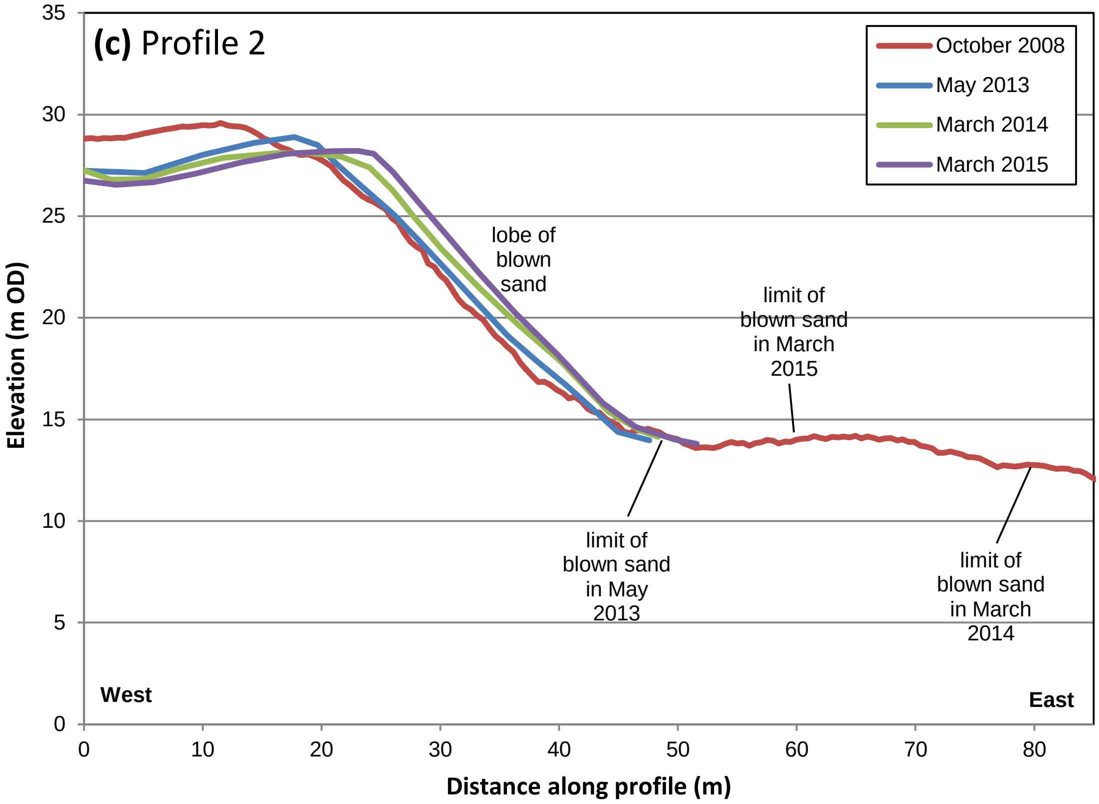


Figure 6. Comparison of surface levels at profile 1 on the Phase 1 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 14 May 2013, 11 March 2014 and 11-12 March 2015.



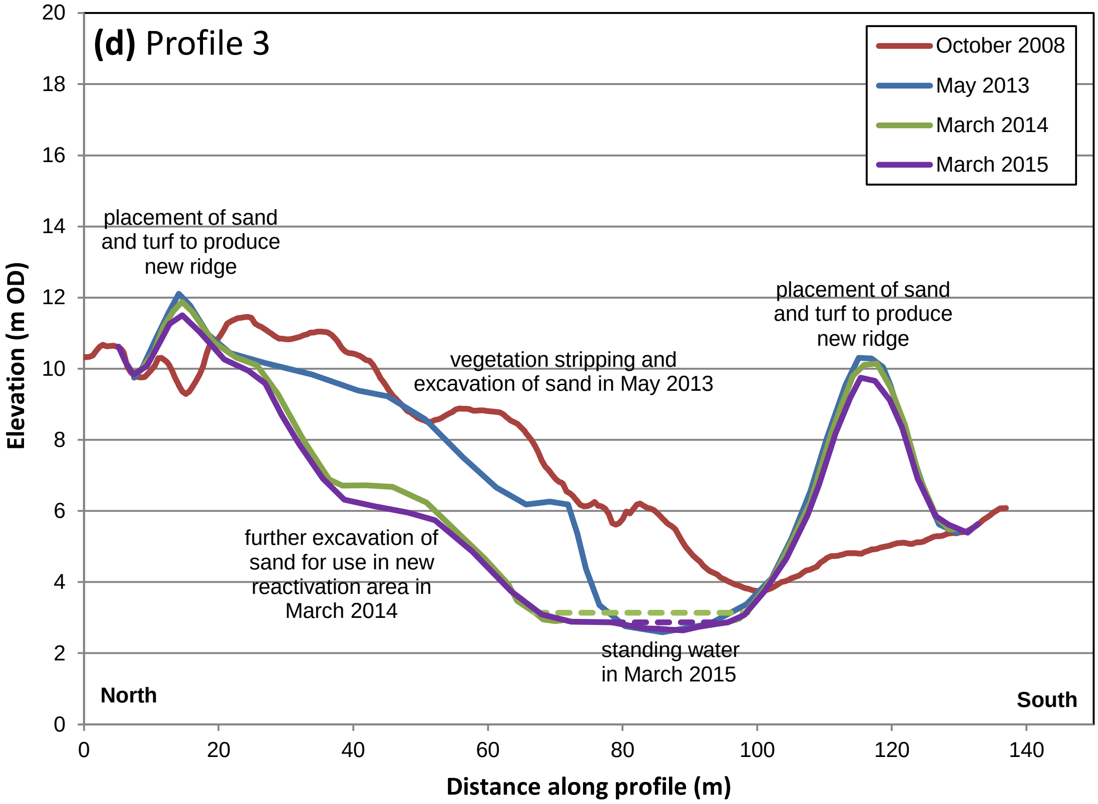
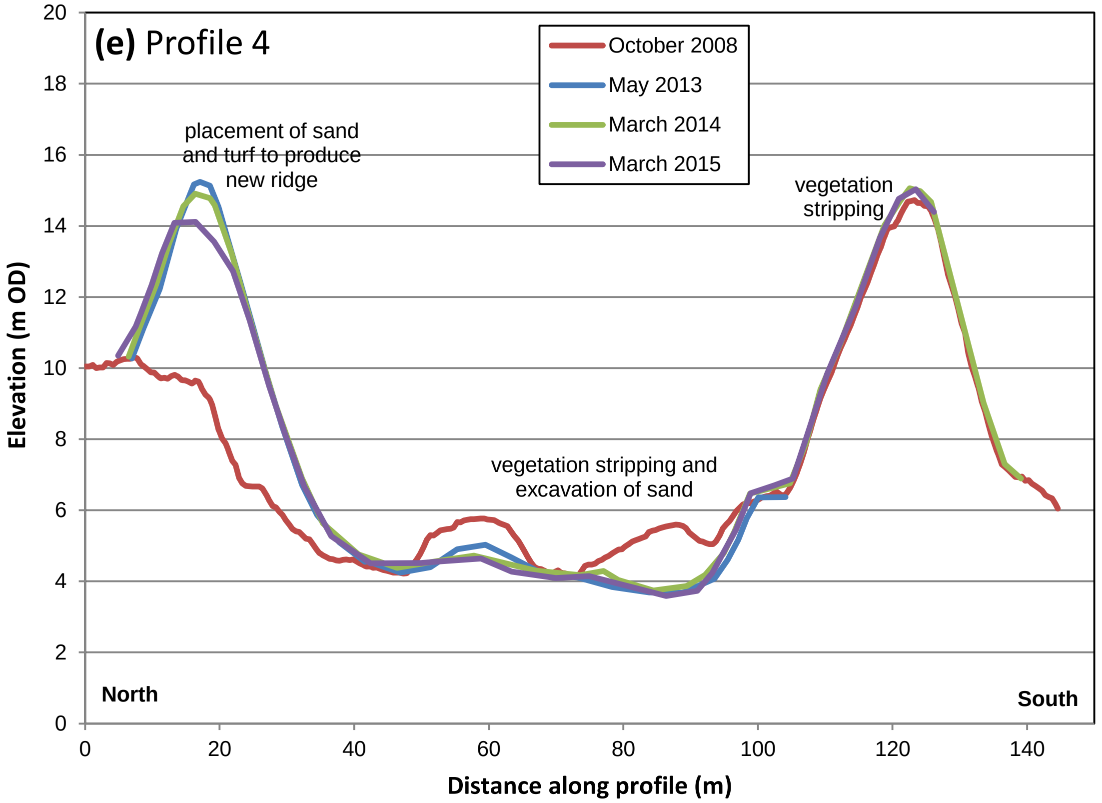


Figure 6 (continued). Comparison of surface levels at profiles 2 and 3 on the Phase 1 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 14 May 2013, 11 March 2014 and 11-12 March 2015.



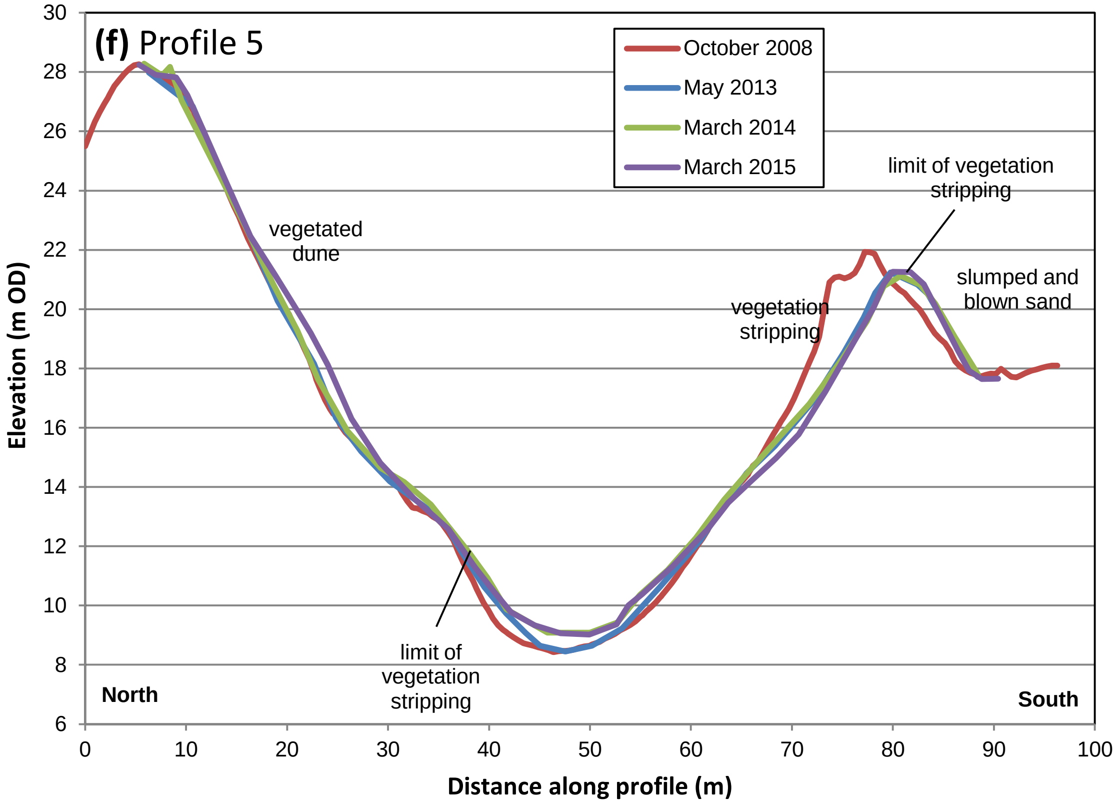
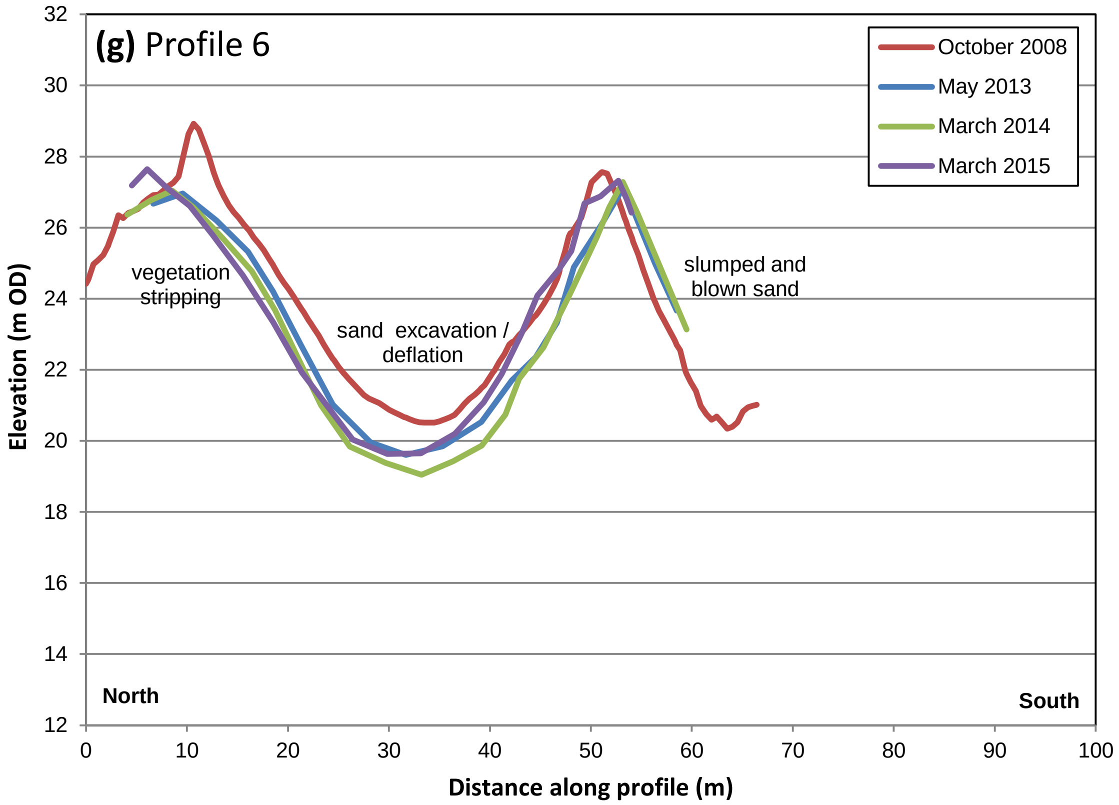


Figure 6 (continued). Comparison of surface levels at profiles 4 and 5 on the Phase 1 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 14 May 2013, 11 March 2014 and 11-12 March 2015.



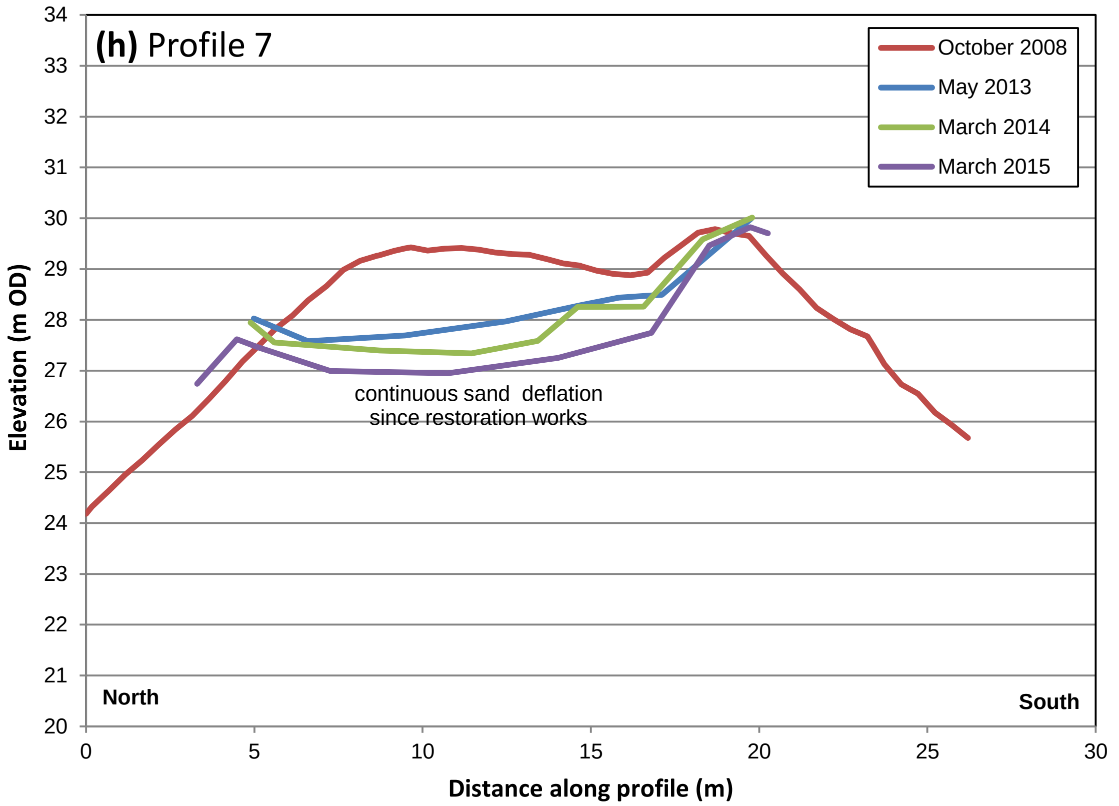
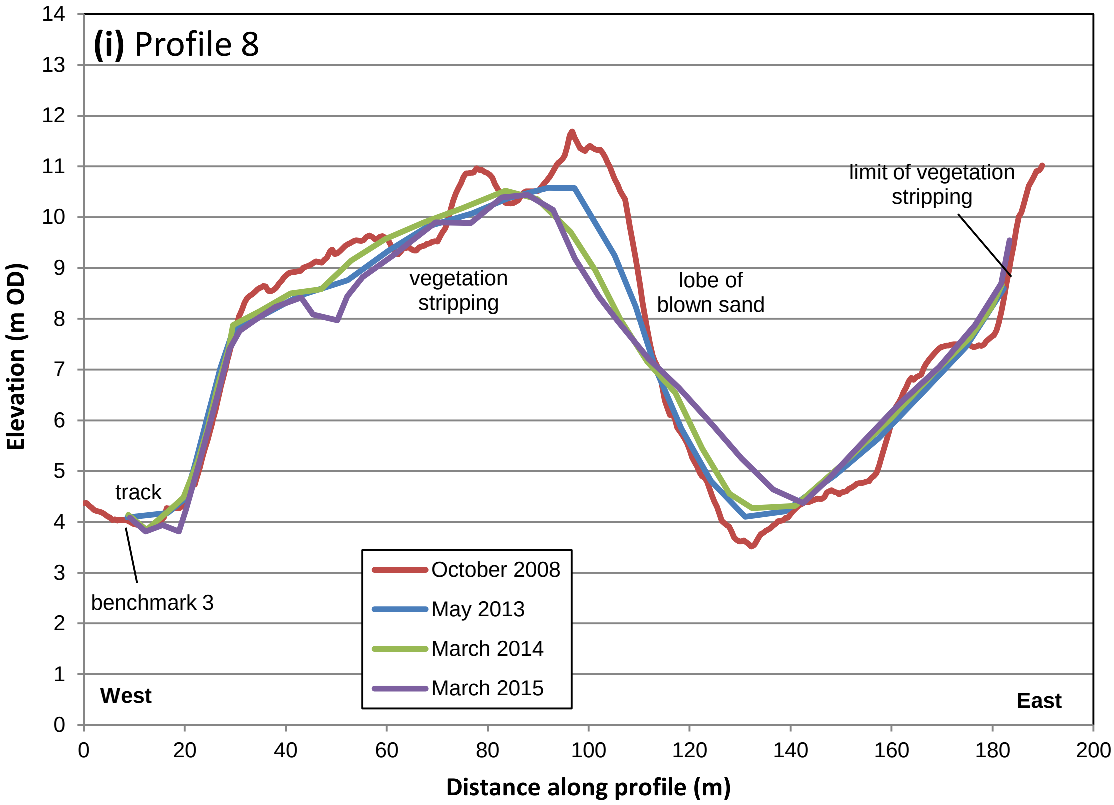


Figure 6 (continued). Comparison of surface levels at profiles 6 and 7 on the Phase 1 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 14 May 2013, 11 March 2014 and 11-12 March 2015.



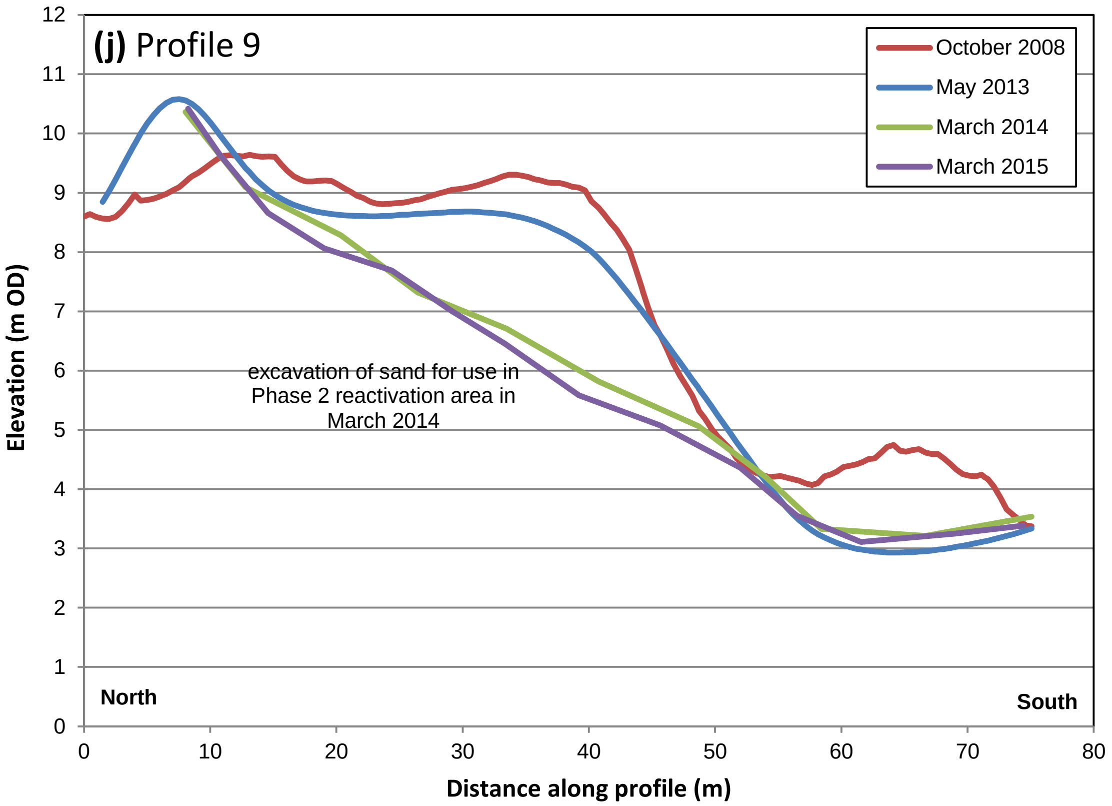
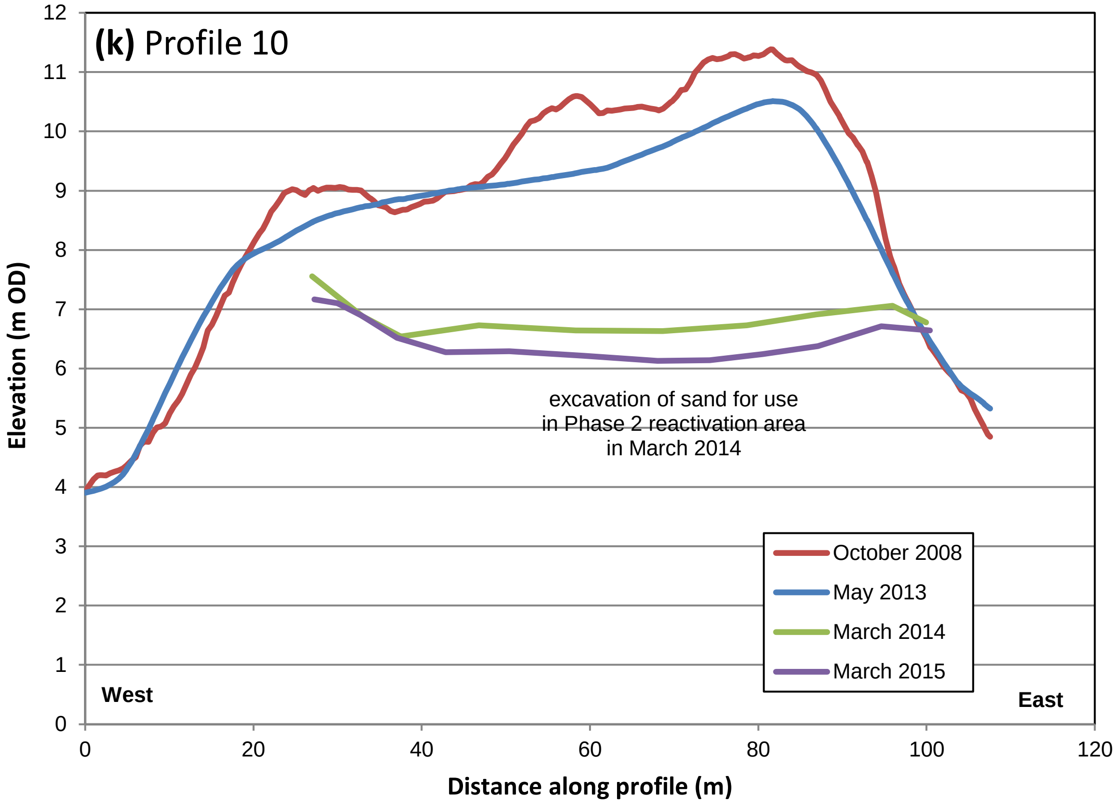


Figure 6 (continued). Comparison of surface levels at profiles 8 and 9 on the Phase 1 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 14 May 2013, 11 March 2014 and 11-12 March 2015.



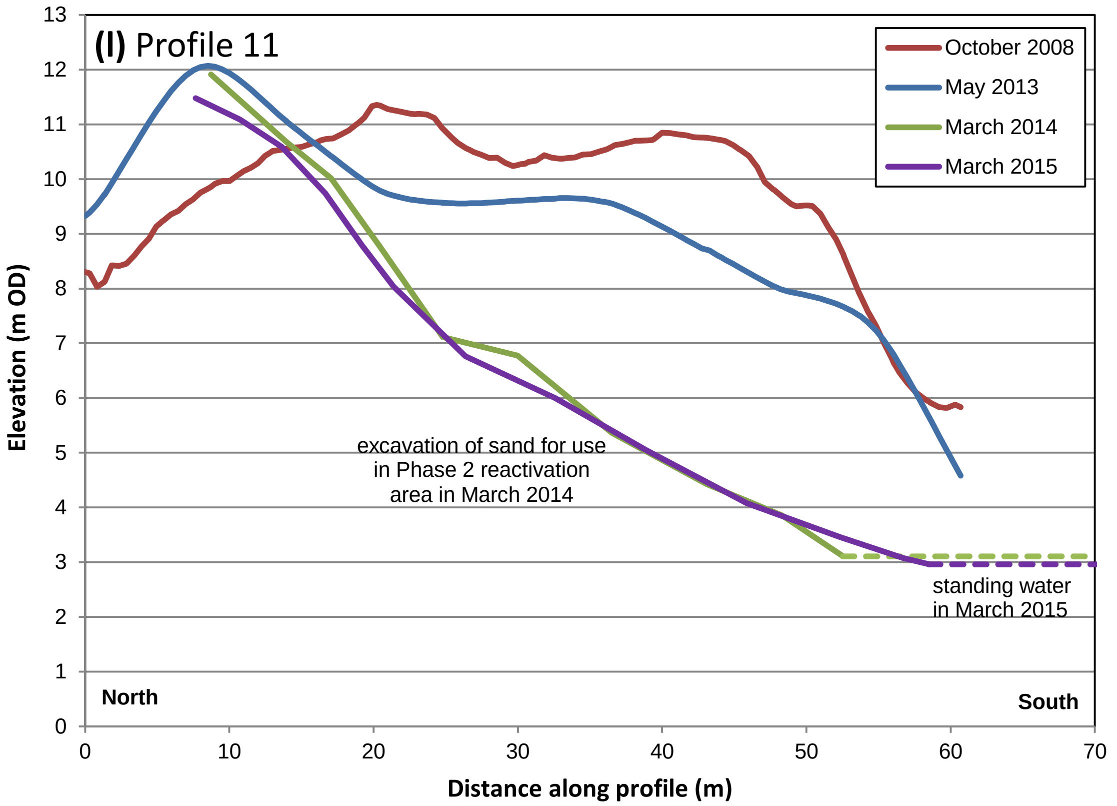


Figure 6 (continued). Comparison of surface levels at profiles 10 and 11 on the Phase 1 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 14 May 2013, 11 March 2014 and 11-12 March 2015.

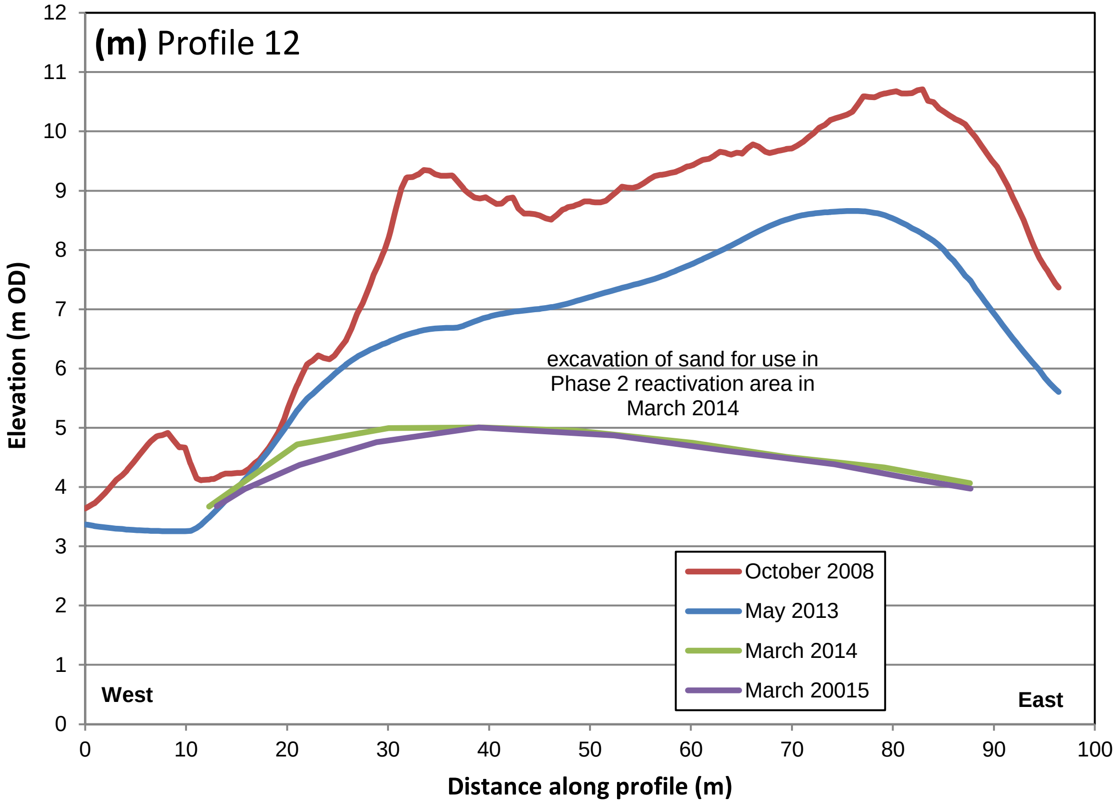
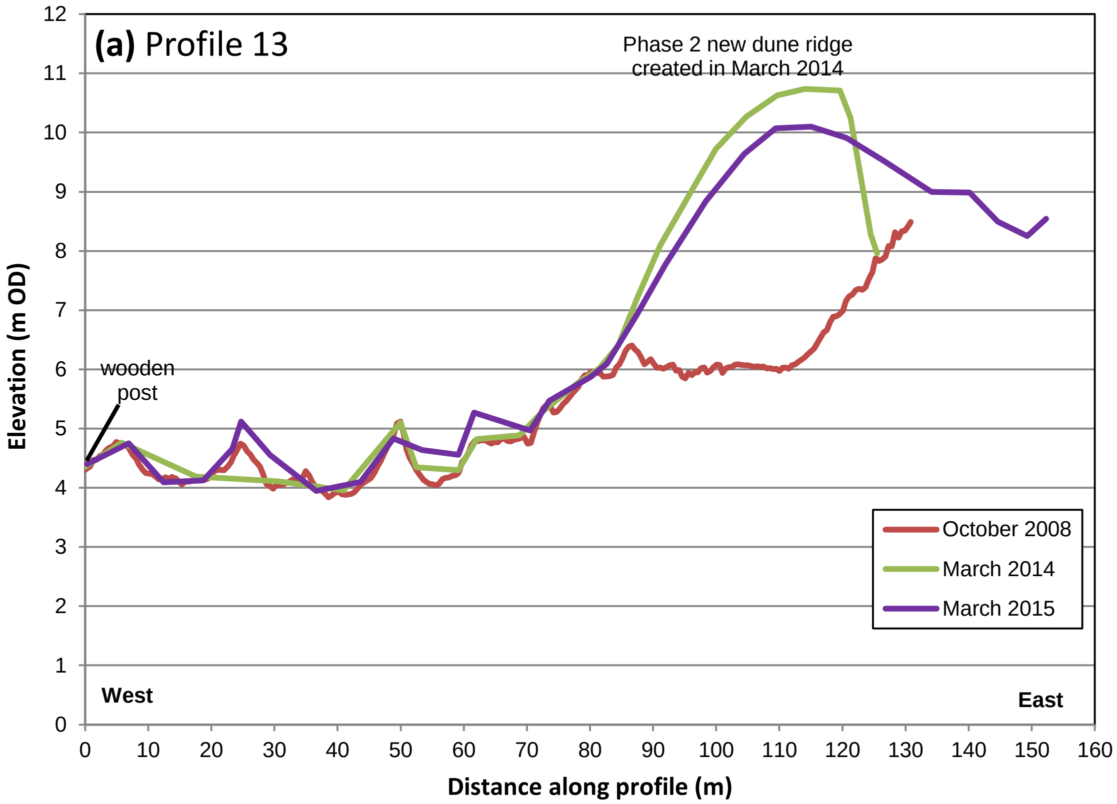


Figure 6 (continued). Comparison of surface levels at profile 12 on the Phase 1 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 14 May 2013, 11 March 2014 and 11-12 March 2015.



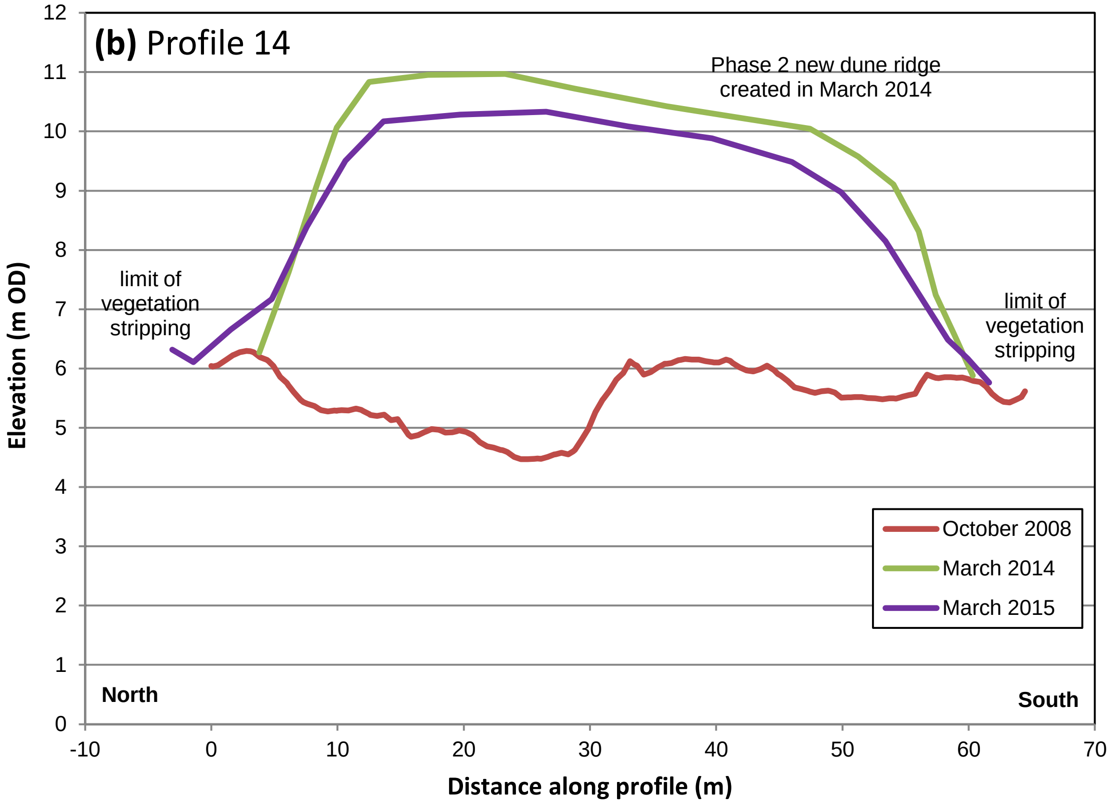
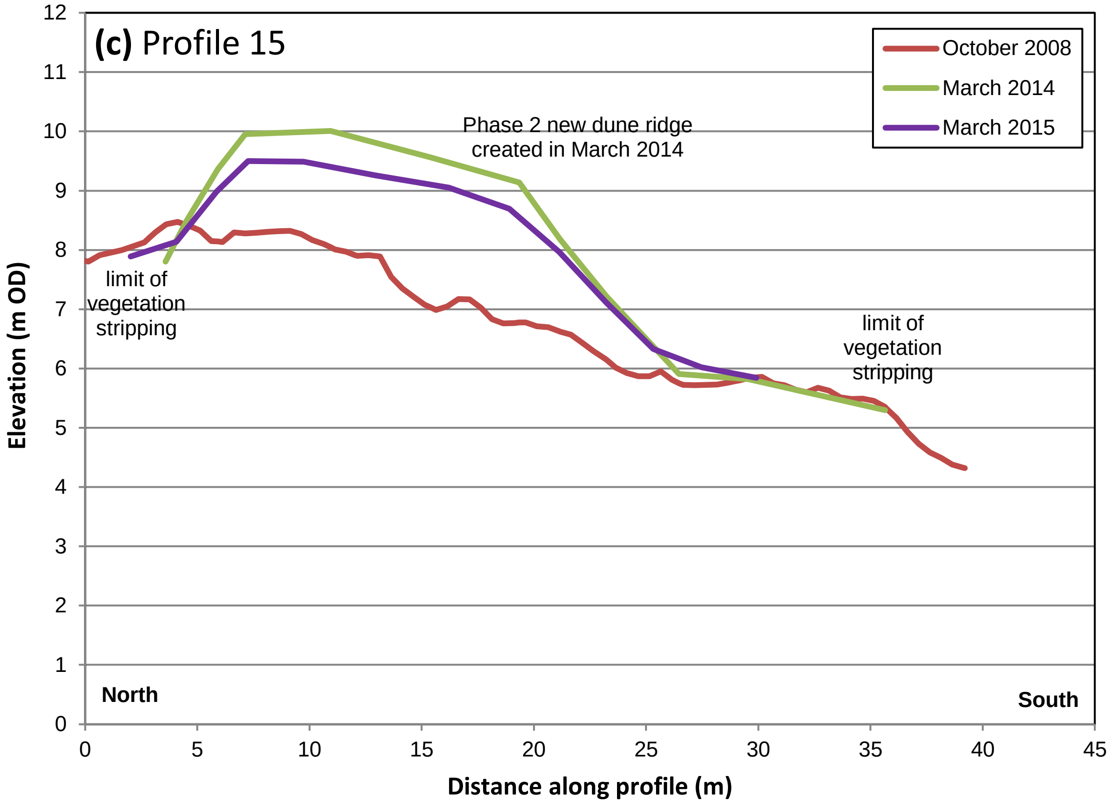


Figure 7. Comparison of surface levels at profiles 13 and 14 on the Phase 2 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 11 March 2014 and 11-12 March 2015.



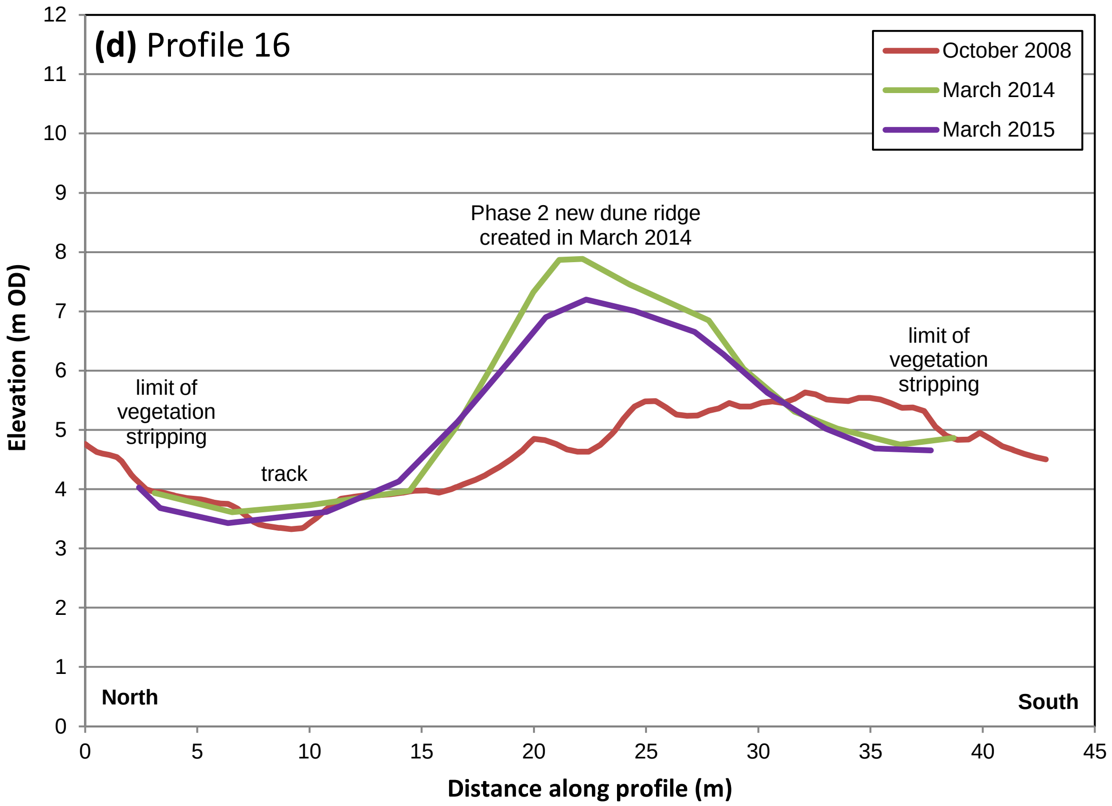
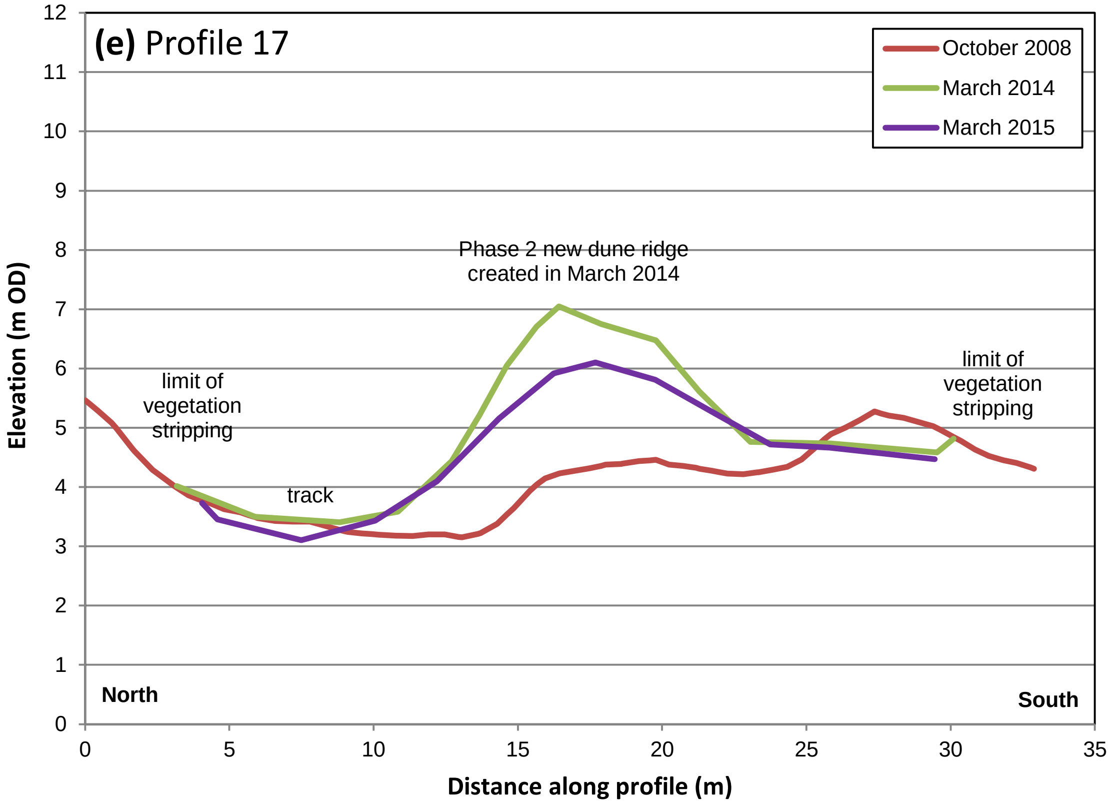


Figure 7 (continued). Comparison of surface levels at profiles 15 and 16 on the Phase 2 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 11 March 2014 and 11-12 March 2015.



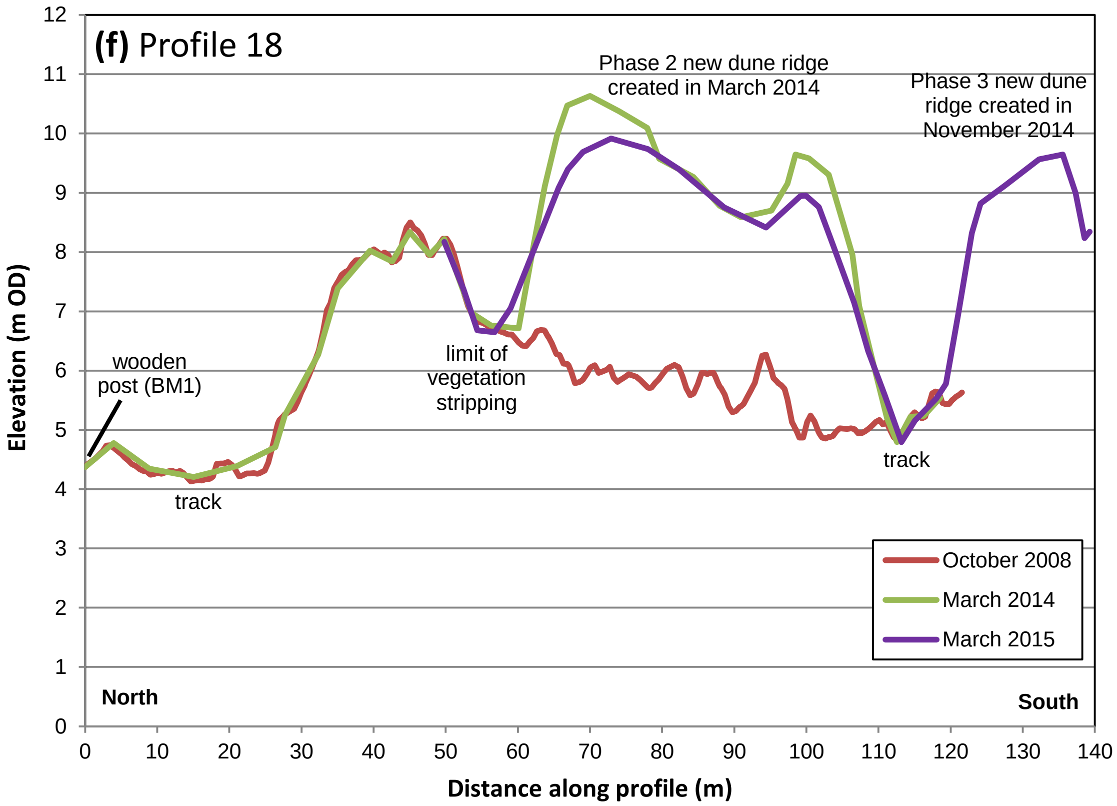
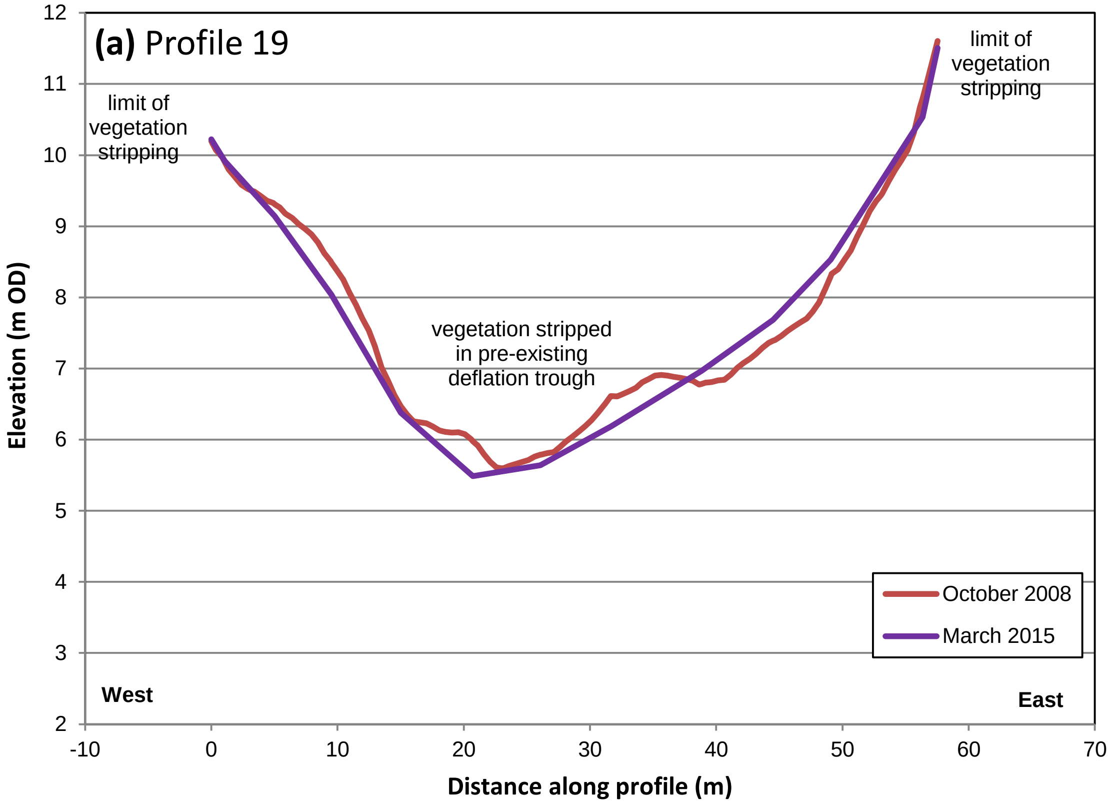


Figure 7 (continued). Comparison of surface levels at profiles 17 and 18 on the Phase 2 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground surveys on 11 March 2014 and 11-12 March 2015.



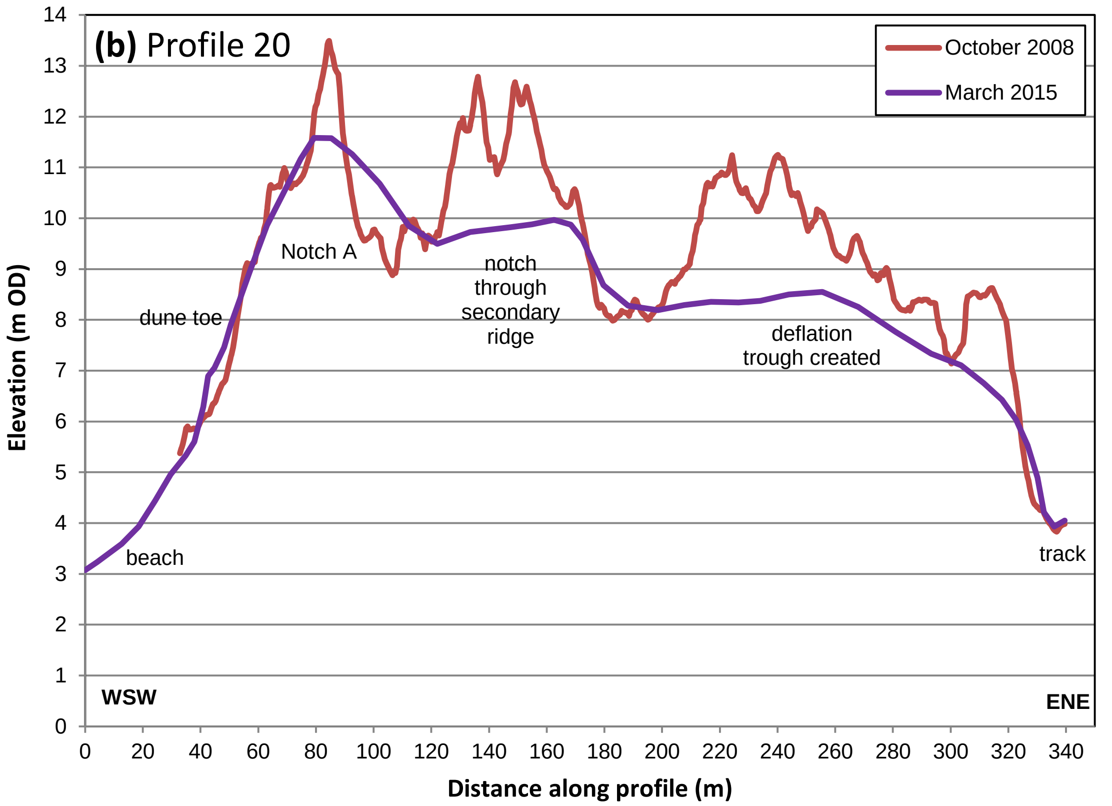
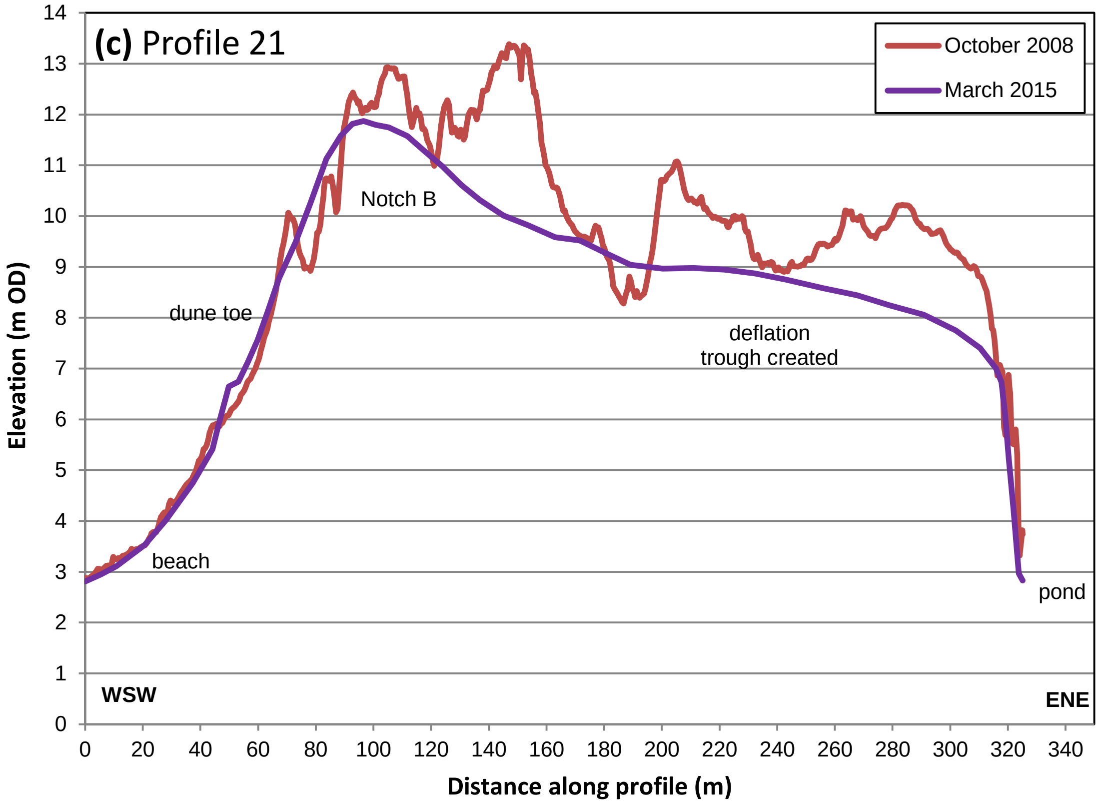


Figure 8. Comparison of surface levels at profiles 19 and 20 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.



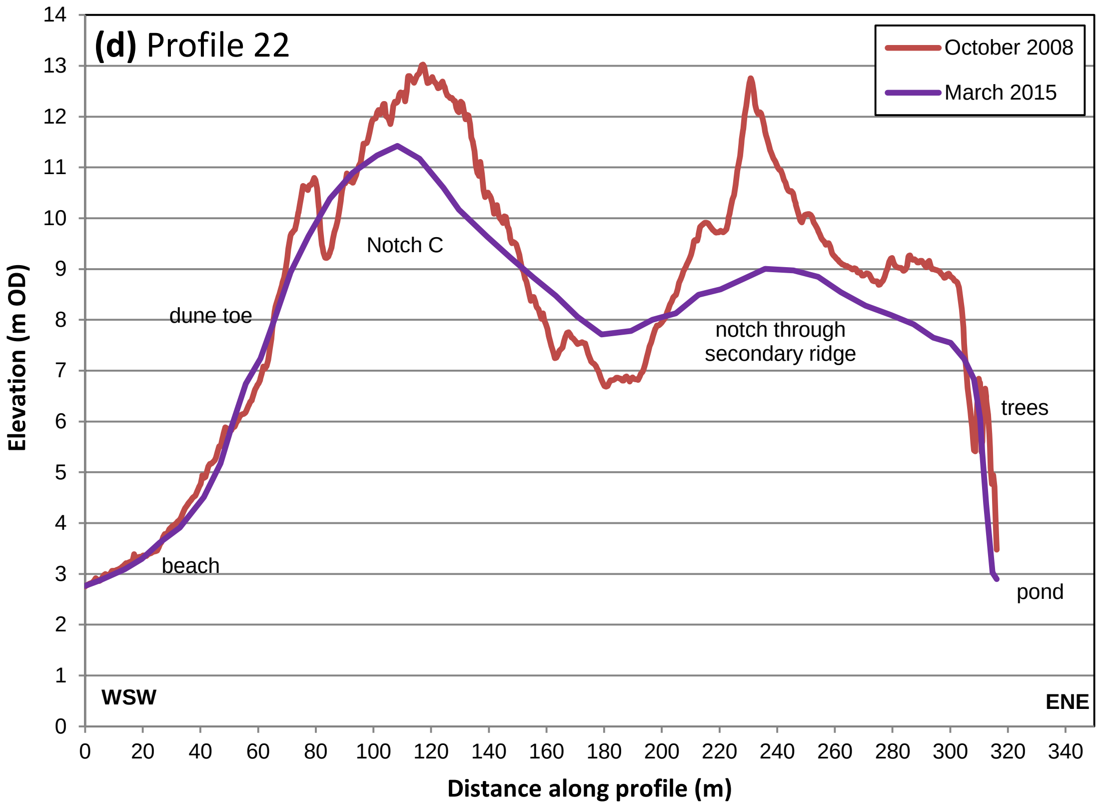
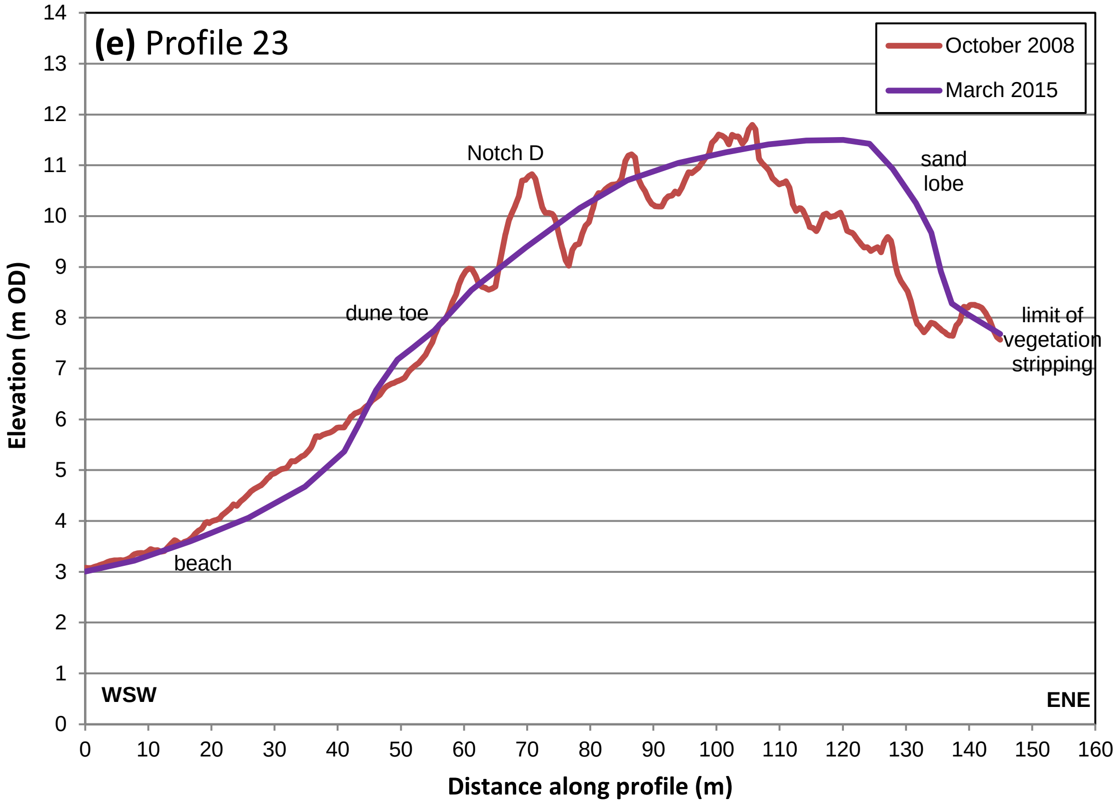


Figure 8 (continued). Comparison of surface levels at profiles 21 and 22 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.



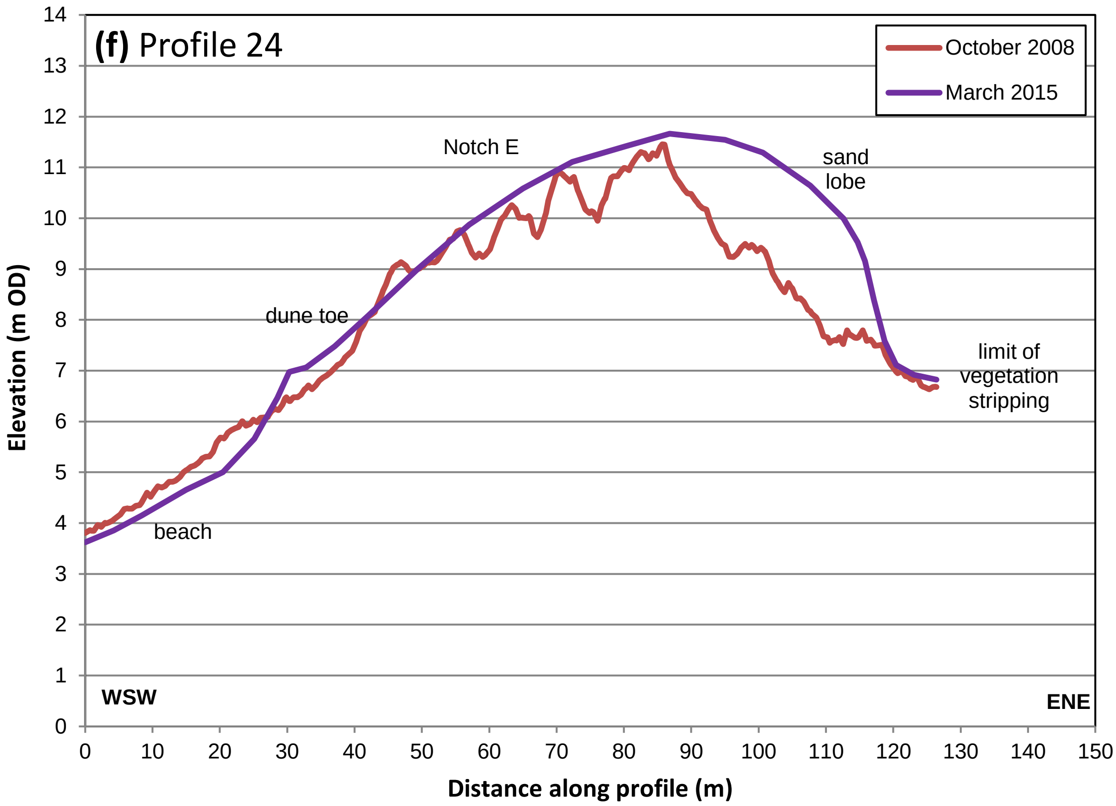


Figure 8 (continued). Comparison of surface levels at profiles 23 and 24 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.

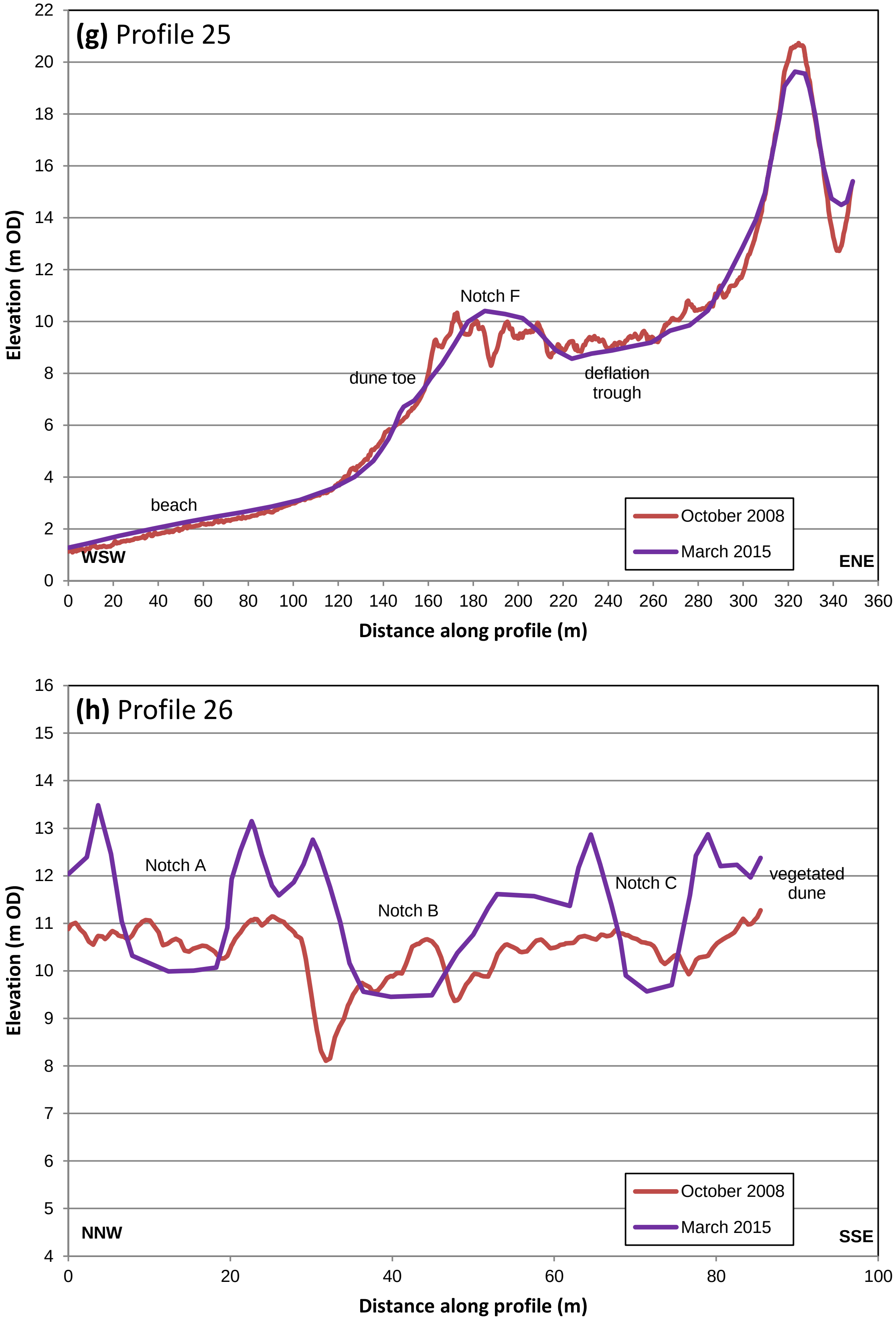


Figure 8 (continued). Comparison of surface levels at profiles 25 and 26 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.

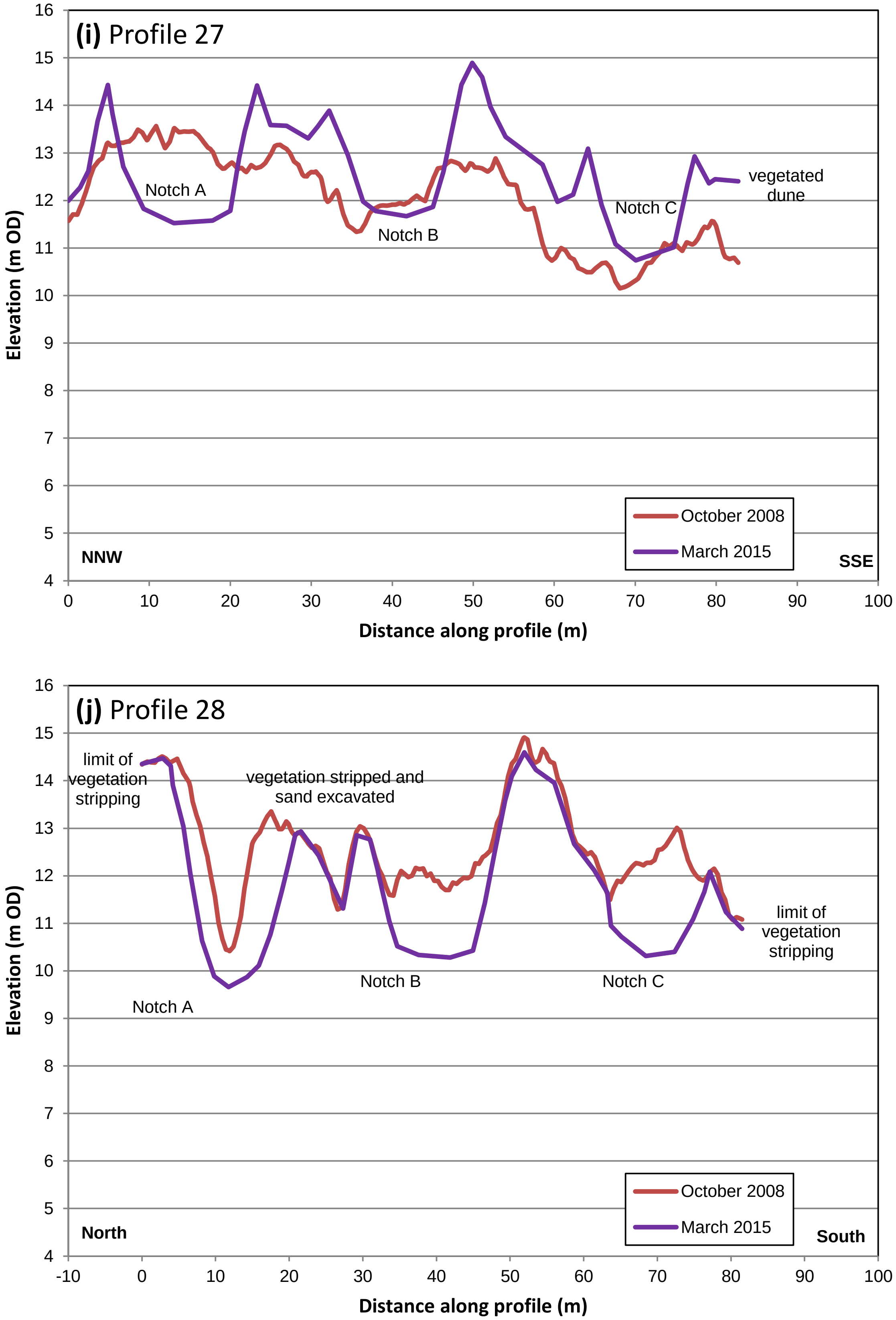
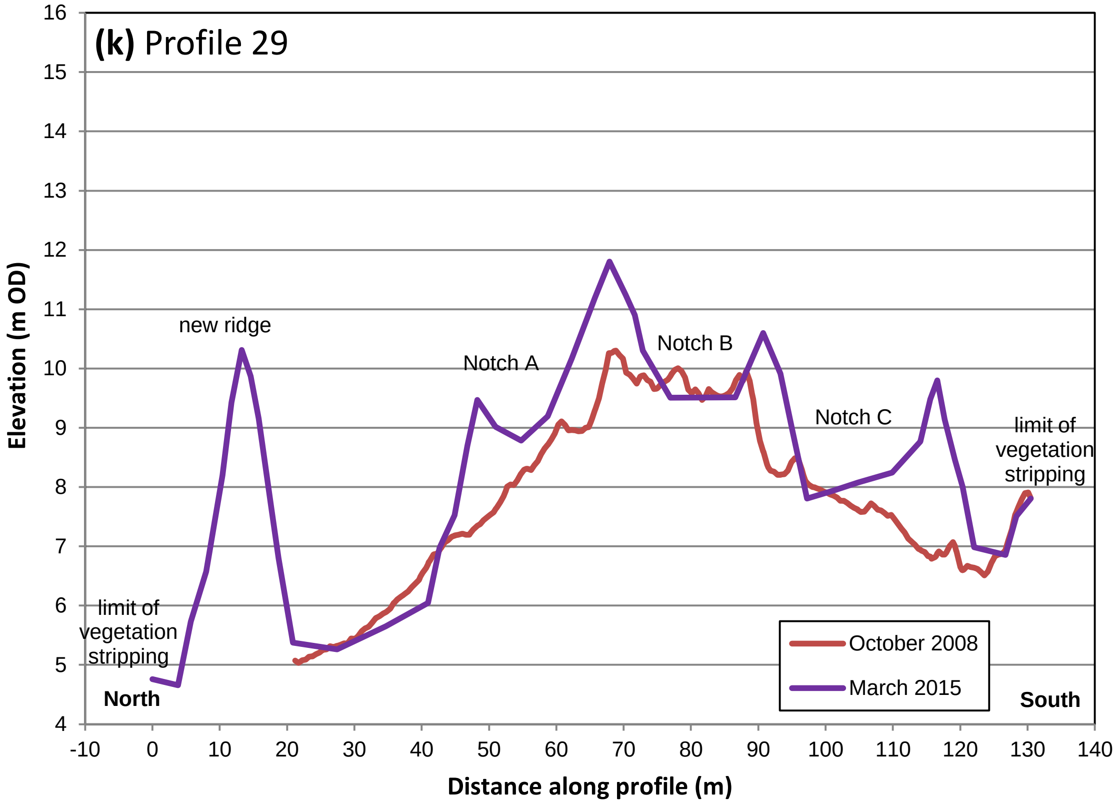


Figure 8 (continued). Comparison of surface levels at profiles 27 and 28 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.



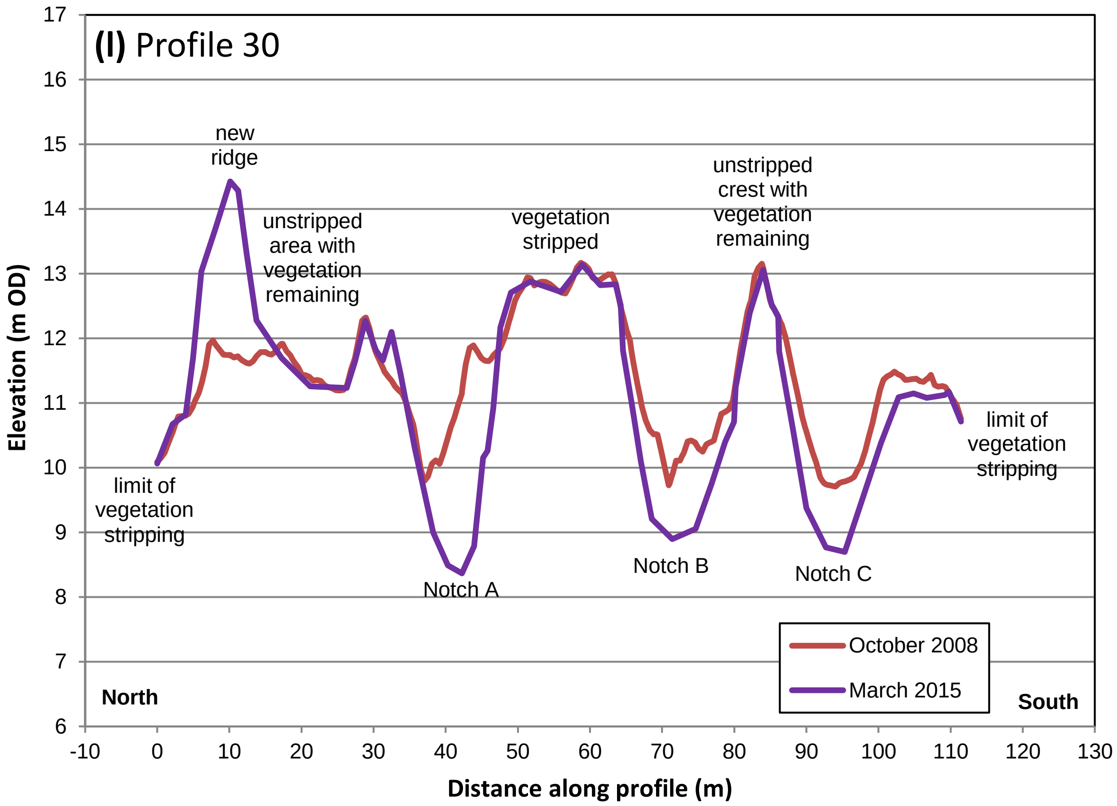
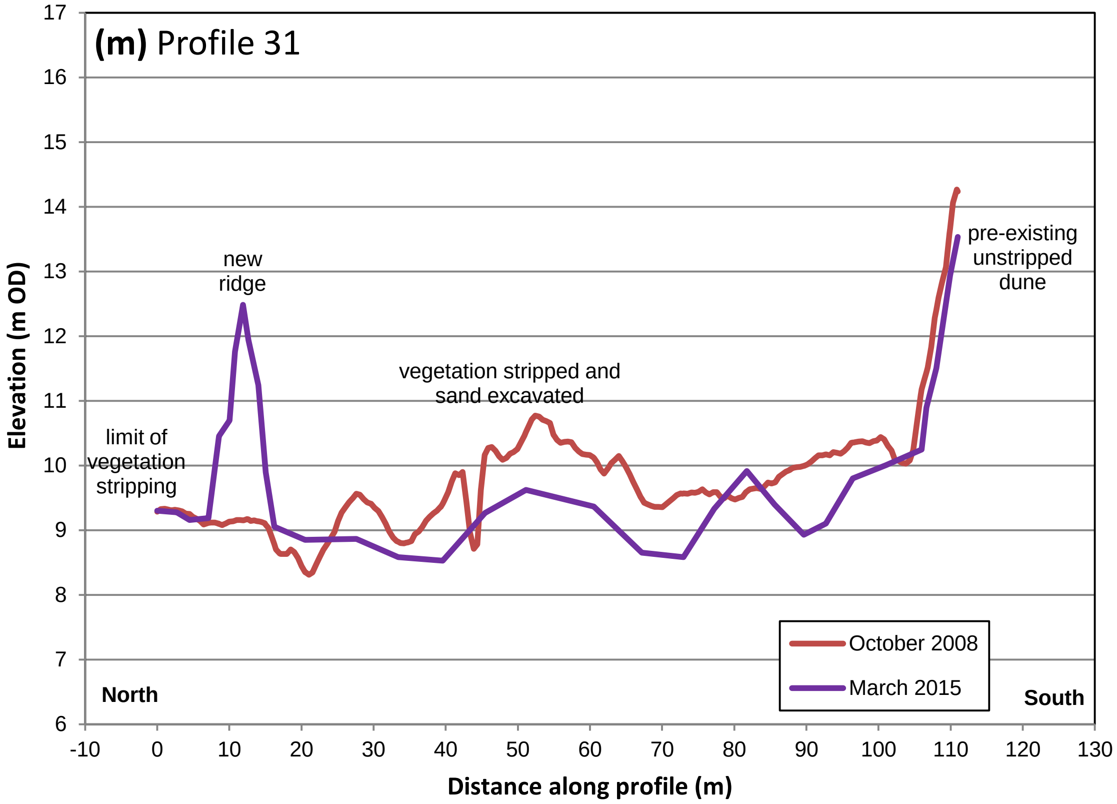


Figure 8 (continued). Comparison of surface levels at profiles 29 and 30 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.



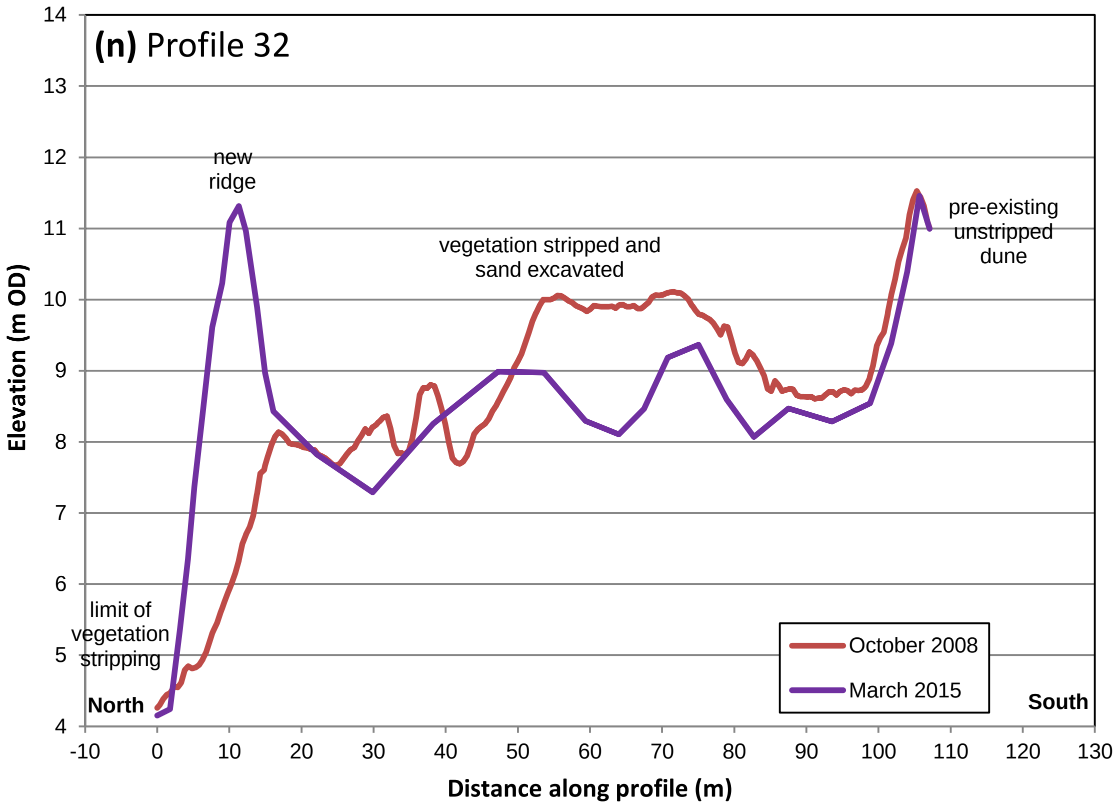
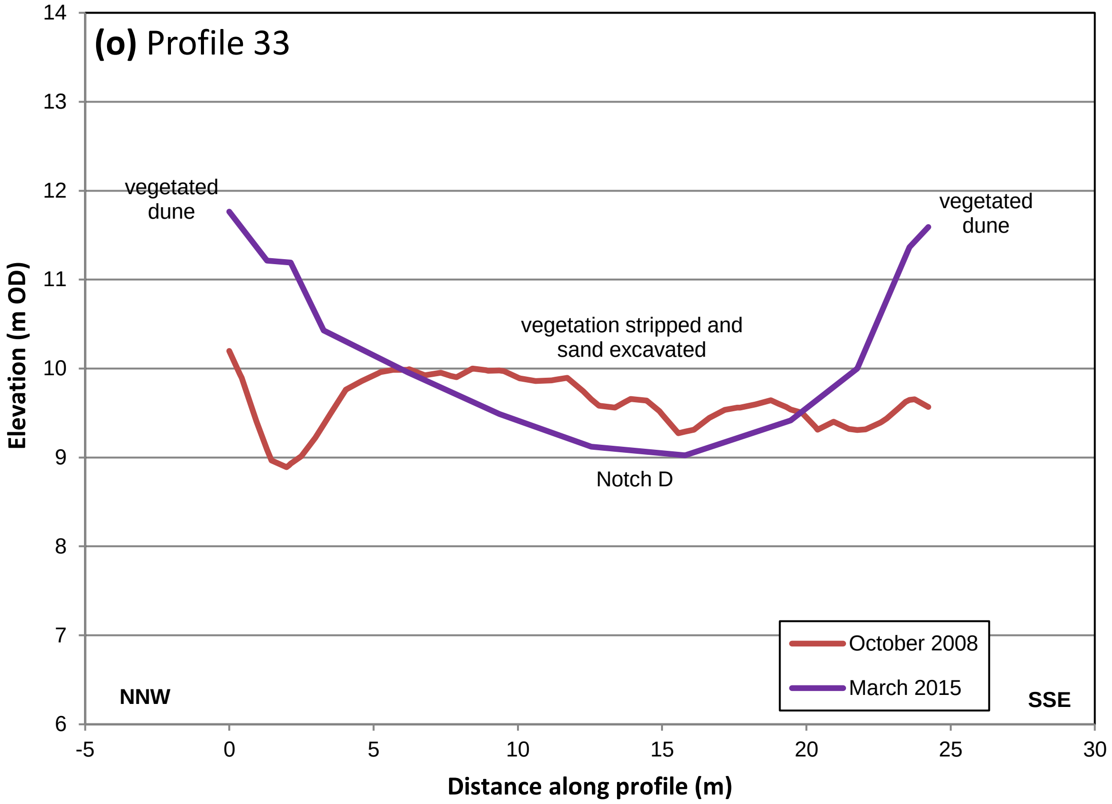


Figure 8 (continued). Comparison of surface levels at profiles 31 and 32 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.



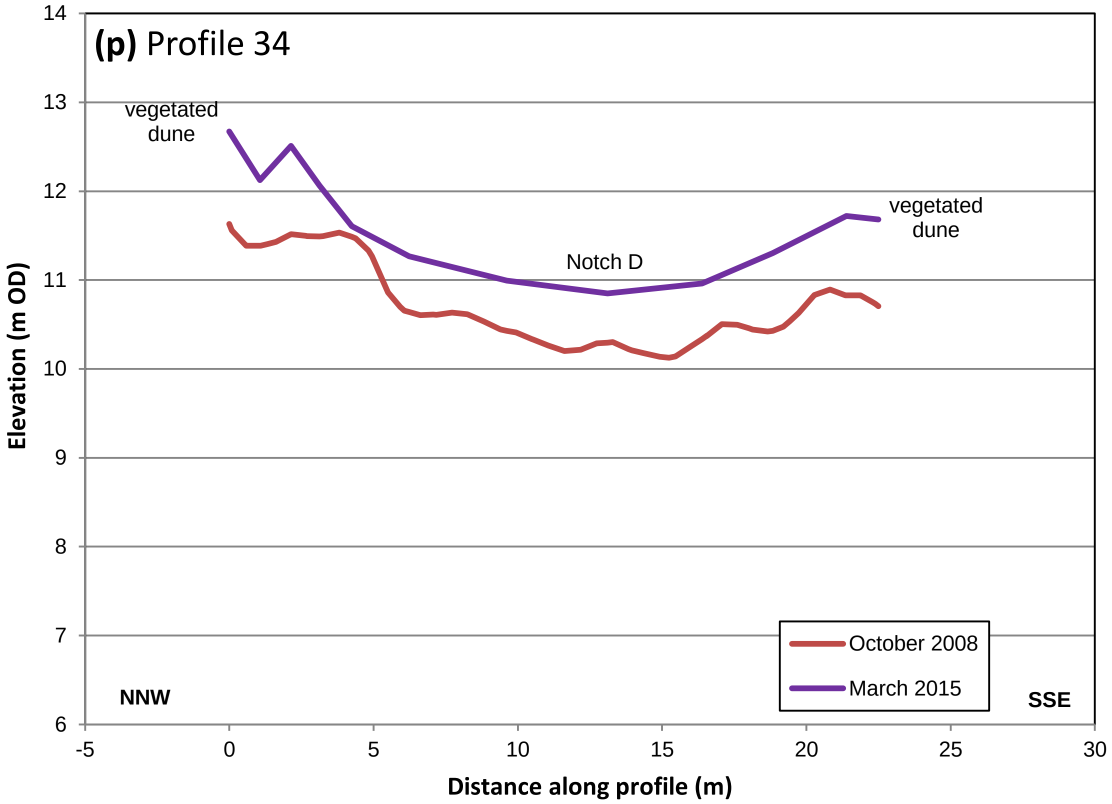
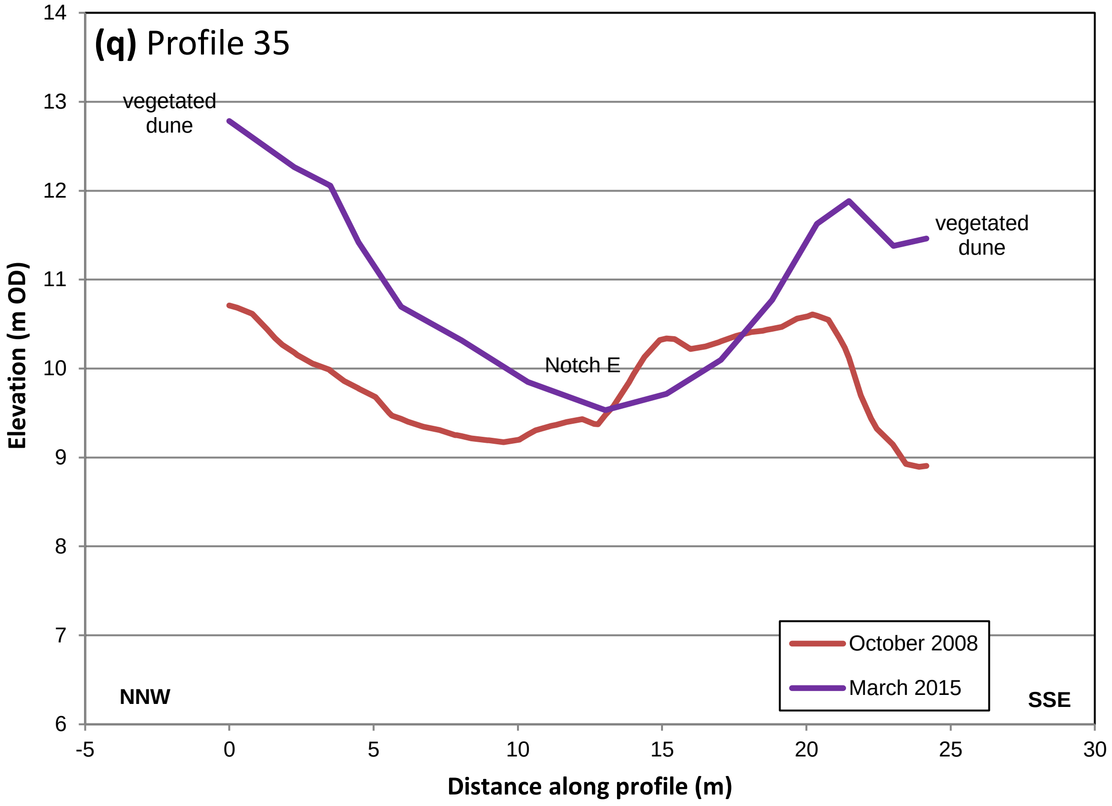


Figure 8 (continued). Comparison of surface levels at profiles 33 and 34 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.



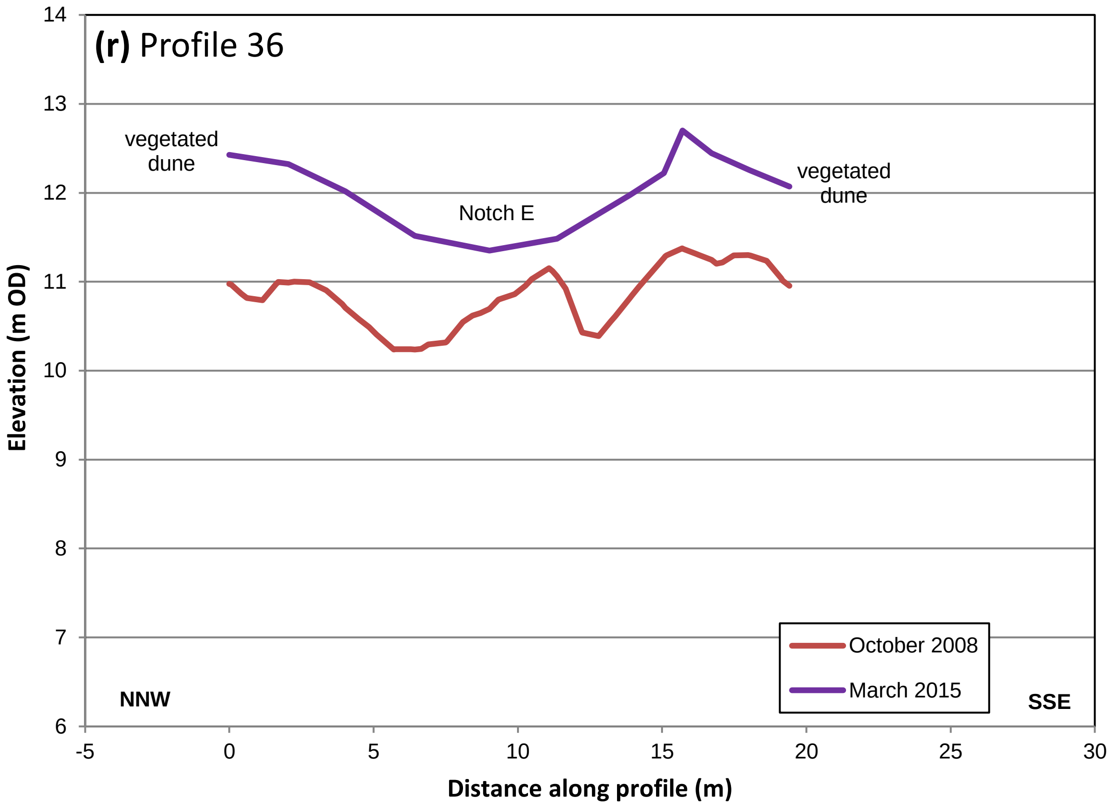
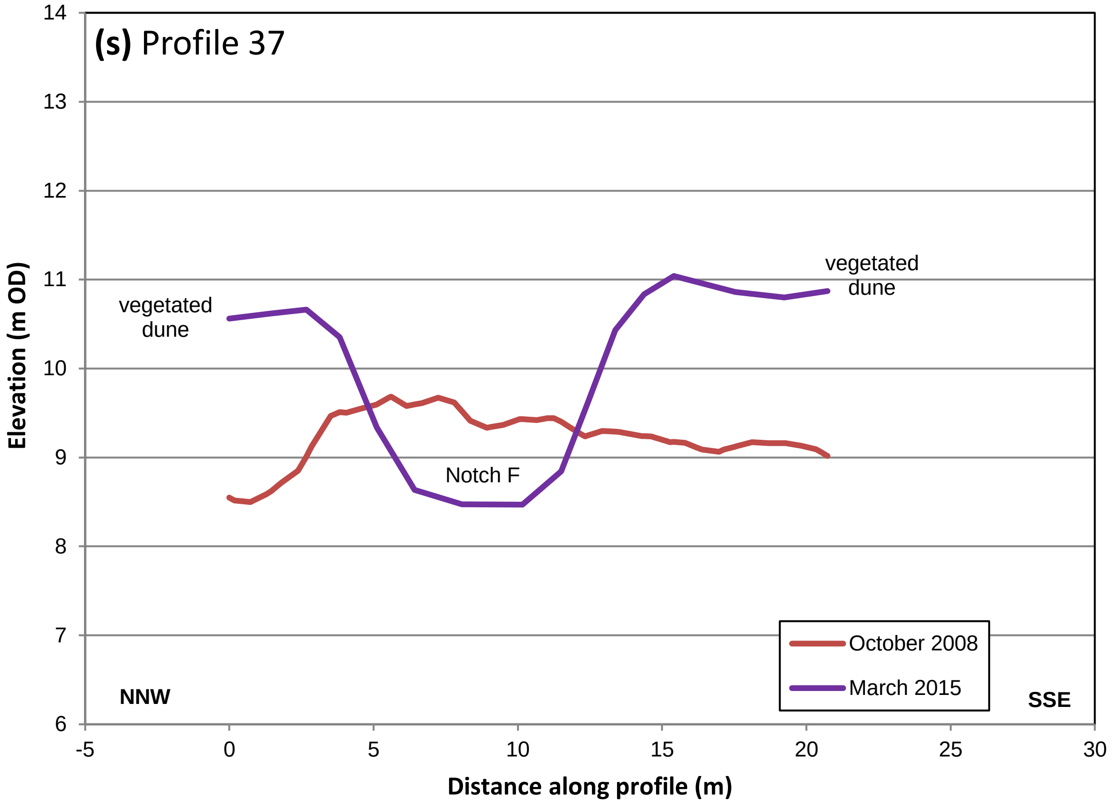


Figure 8 (continued). Comparison of surface levels at profiles 35 and 36 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.



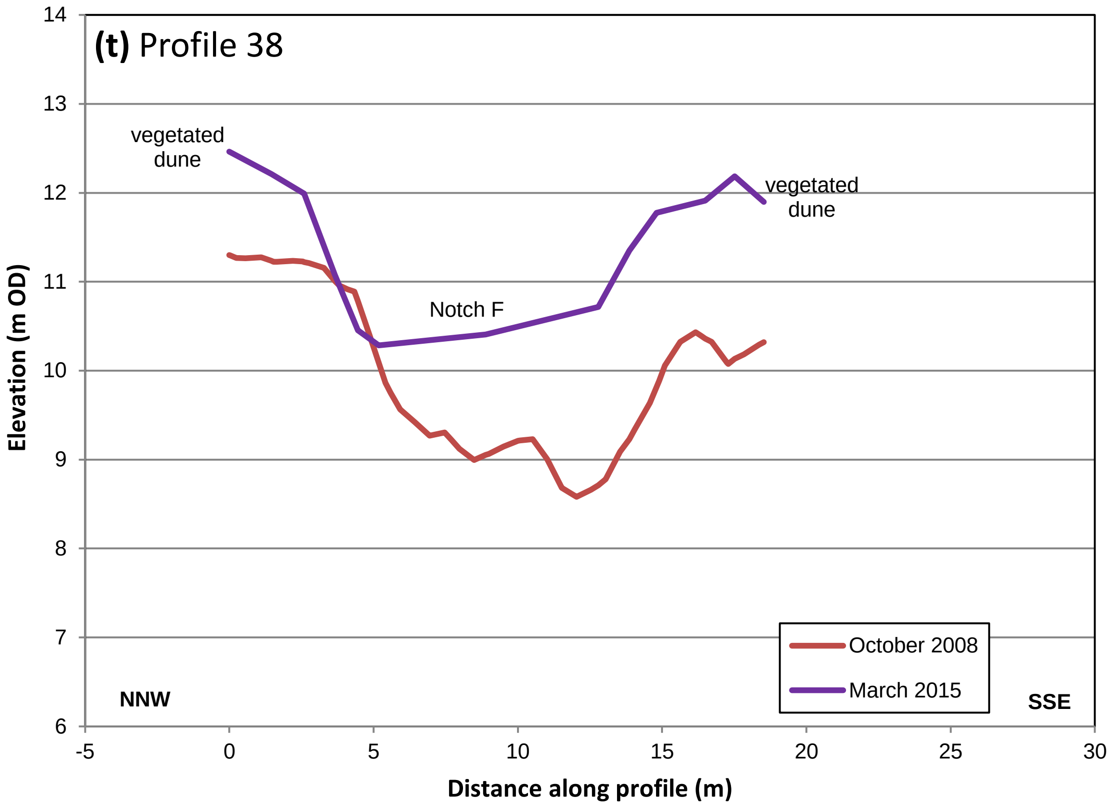
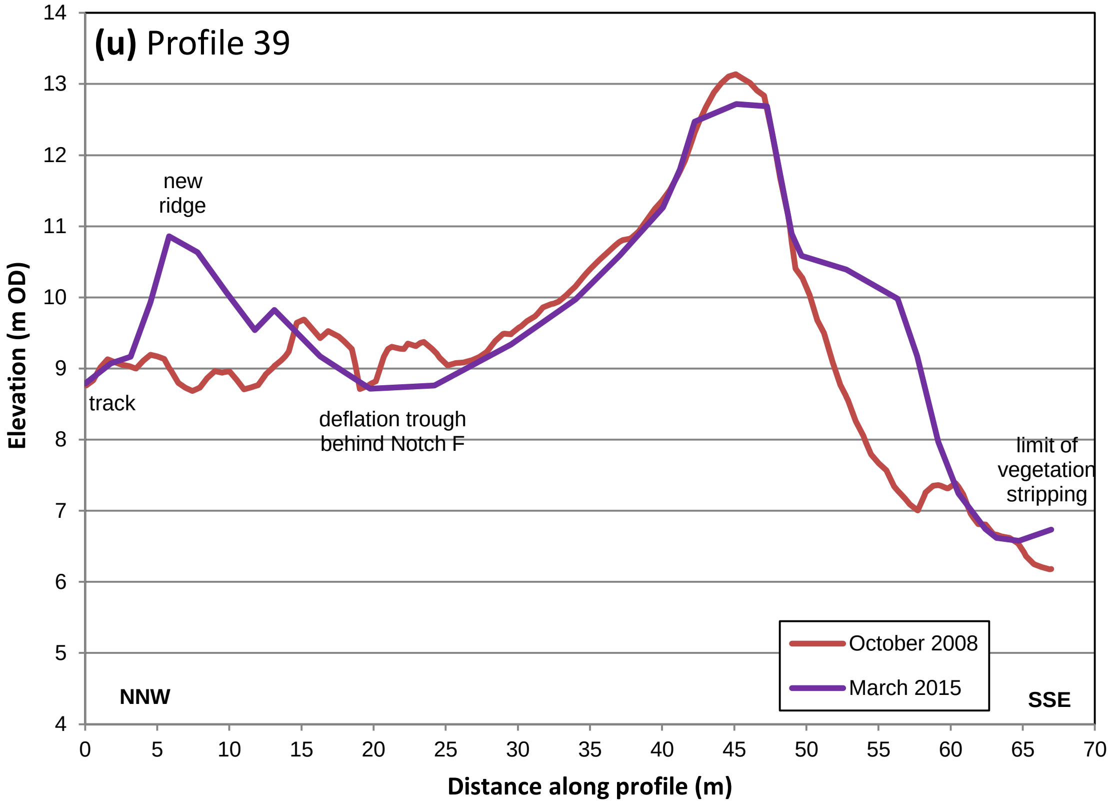


Figure 8 (continued). Comparison of surface levels at profiles 37 and 38 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.



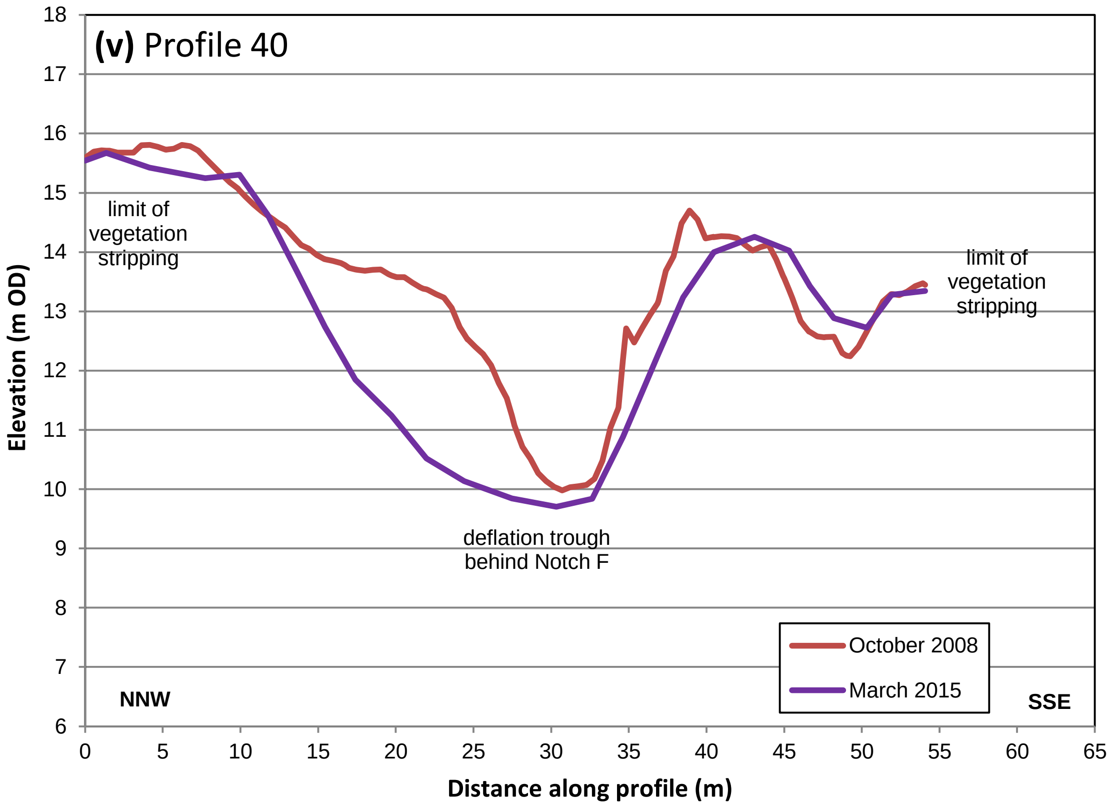


Figure 8 (continued). Comparison of surface levels at profiles 39 and 40 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015

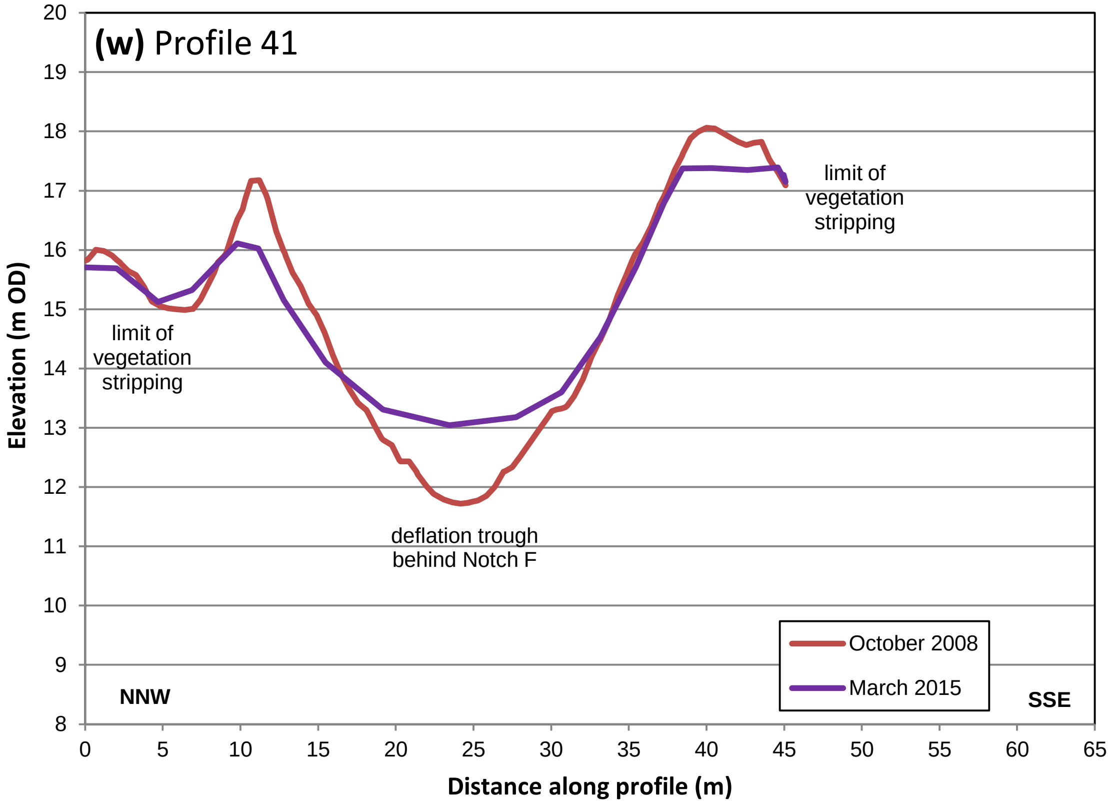


Figure 8 (continued). Comparison of surface levels at profile 41 on the Phase 3 site indicated by LiDAR survey on 16-29th October 2008 (pre-trials) and ground survey on 11-12 March 2015.

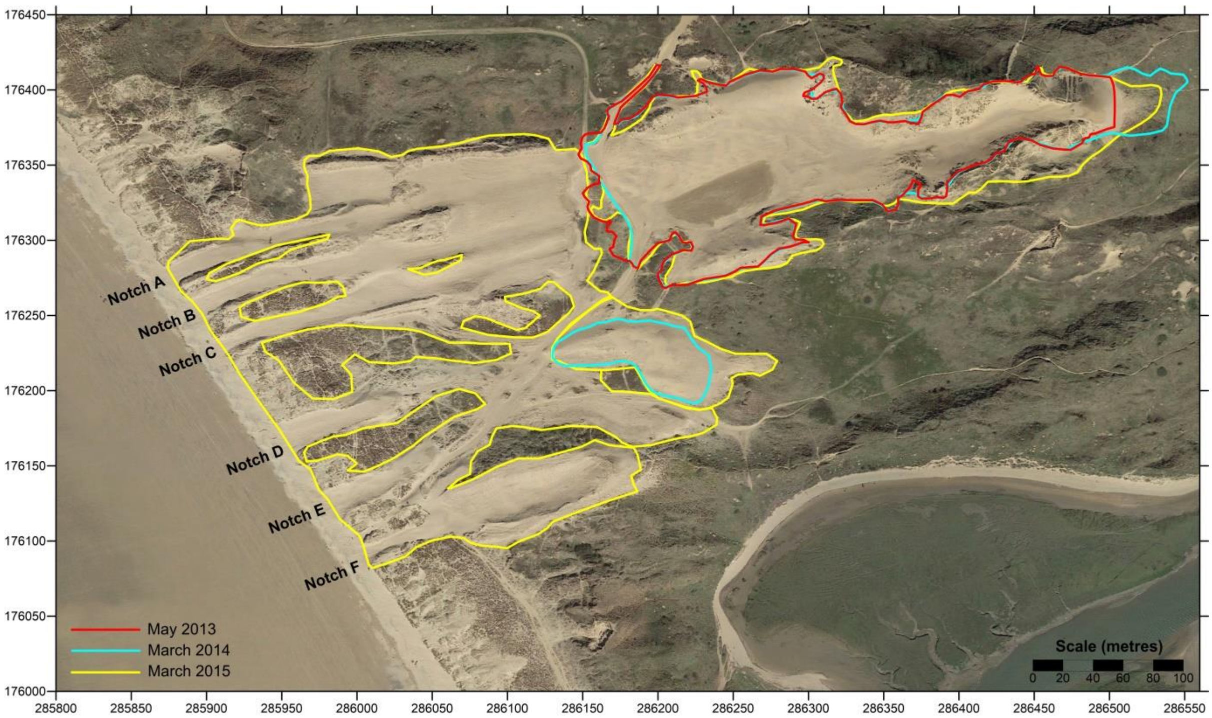


Figure 9. Digitisation of bare sand and partially vegetated areas during each of the ground surveys in May 2013, March 2014 and March 2015, overlaid on air photographs flown 18 April 2015 (source: Google Earth). The calculated areas (in hectares) are given in Table 7

10. Field photographs

Taken on 11 March 2015

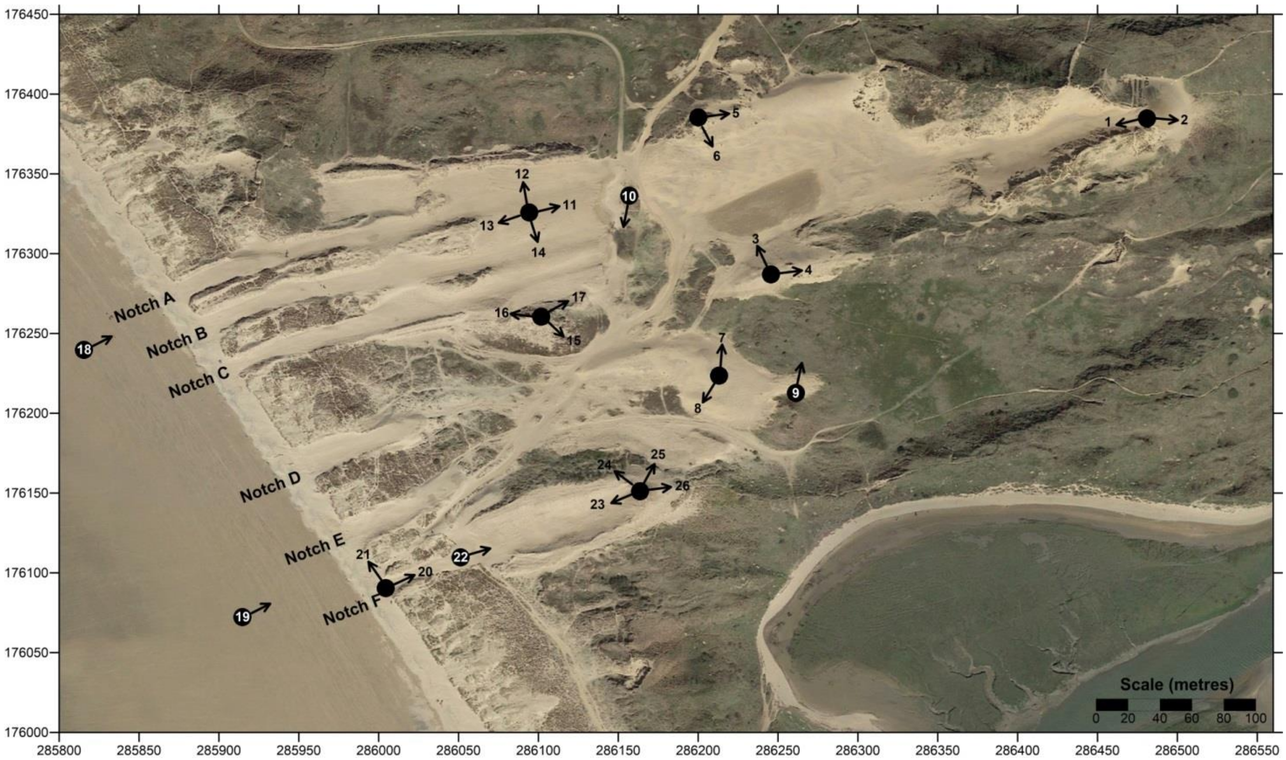
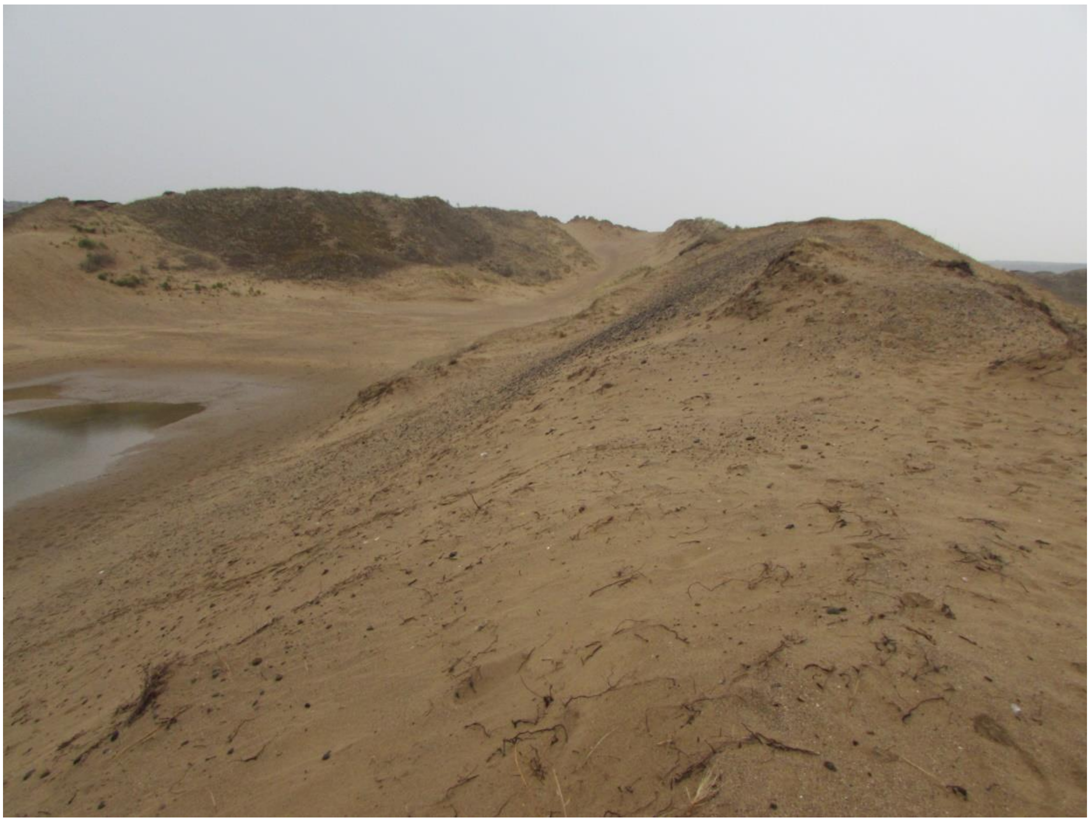


Figure A1. Locations of field photographs 1 to 26. Arrows indicate direction of view; base 2015aerial photography

Photograph 1. Central axis of the Phase 1 area, looking WSW

Photograph 2. The dune ‘nose’ at the eastern end of the Phase 1 area, with the Ogmore valley in the distance, looking east

Photograph 3. The eastern arm of the dune, looking north across the deflation trough of the Phase 1 area



Photograph 4. The eastern arm of the Phase 1 site, looking eastwards

Photograph 5. The western arm of the Phase 1 site, looking eastwards

Photograph 6. The western arm of the dune, looking south across the deflation trough of the Phase 1 area

Photograph 7. The crest of the Phase 2 site, looking north towards the Phase 1 area

Photograph 8. The crest of the Phase 2 site, looking SW towards the Phase 3 area

Photograph 9. The slip face of the Phase 2 site, looking north

Photograph 10. The slip face at the eastern end of the Phase 3 area, sand beginning to bury the trees and enter the pond, looking south

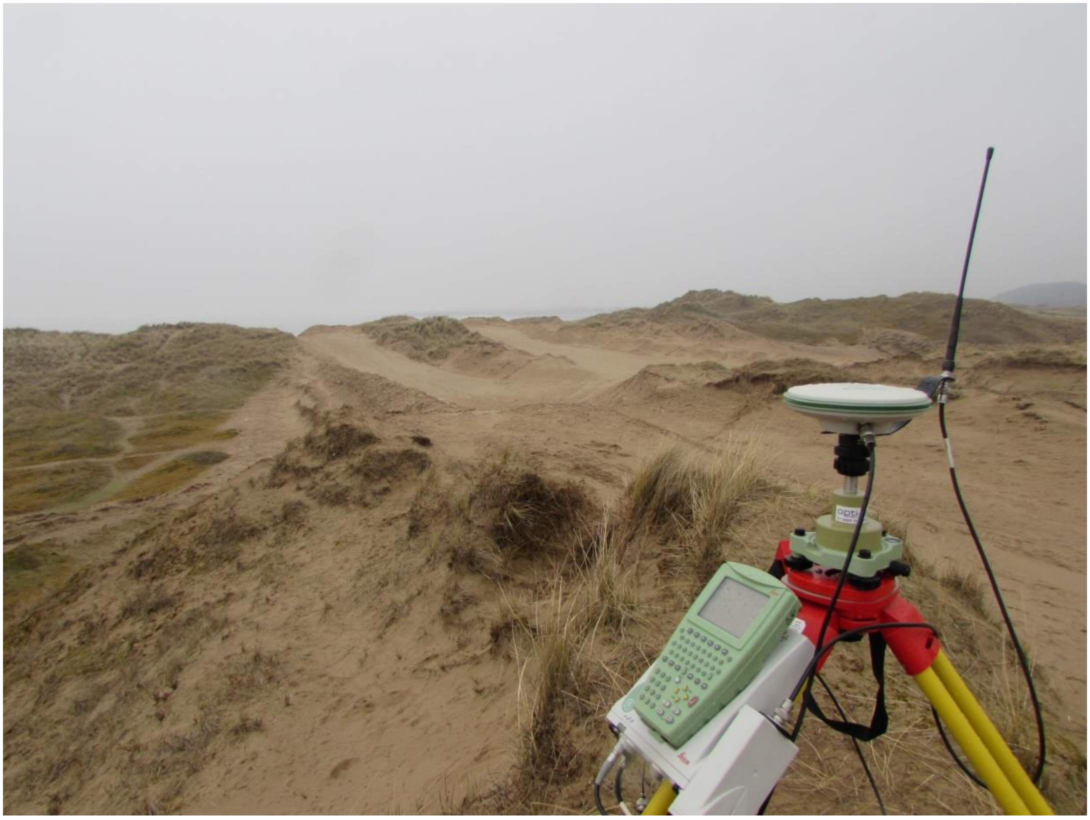
Photograph 11. Northern part of the Phase 3 site, on the small ridge separating the deflation troughs behind notches A and B, looking east

Photograph 12. Northern part of the Phase 3 site, on the small ridge separating the deflation troughs behind Notches A and B, looking north

Photograph 13. Northern part of the Phase 3 site, looking west along the deflation troughs towards notches A and B

Photograph 14. Northern part of the Phase 3 site, on the small ridge separating the deflation troughs behind Notches A and B, looking south, GPS base station in the background

Photograph 15. Centre of the Phase 3 site, beside the GPS base station, looking SE towards the Phase 2 site



Photograph 16. Centre Phase 3, beside the GPS base station, looking west towards notches A, B & C

Photograph 17. Centre of the Phase 3 site, beside the GPS base station, looking east towards the Phase 1 area

Photograph 18. Notches A and B, taken from the beach looking NE

Photograph 19. Notches E and F, taken from the beach looking NE

Photograph 20. The mouth of notch F, taken from the top of the beach, looking NE

Photograph 21. The frontal dune beside notch F, looking NW

Photograph 22. The axis of the deflation trough behind notch F, looking NE

Photograph 23. The head of the parabolic dune behind notch F, looking SW along the deflation trough

Photograph 24. The head of the parabolic dune behind notch F, looking NW across the Phase 3 area towards notches A, B and C

Photograph 25. The head of the parabolic dune behind notch F, looking NE across the Phase 2 area, with Phase 1 in the distance

Photograph 26. The head of the parabolic dune behind notch F, looking east along the Ogmore valley

Data Archive Appendix

Data outputs associated with this project are archived at 'Topographical Survey of Merthyr Mawr Dune Restoration Work project 419, media 1553' on server–based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] An Excel file named (Merthyr Mawr Survey Data 11-12 M

arch 2015.xlsx) of data points (x,y,z)

[C] A zip file named (Merthyr Mawr March 2015 Profiles.zip) containing excel files of profile data contained within the report.

[D] A zip file named (Merthyr Mawr March 2015 shapefiles.zip) containing a series of GIS layers on which the maps in the report are based.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue http://libcat.naturalresources.wales/webview/ (English Version) and http://libcat.naturalresources.wales/cnc/ (Welsh Version) by searching 'Dataset Titles'. The metadata is held as record no [115843]

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