Sand removal from the West Sands for use on the Links Golf Courses from June 2018 to October 2019

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Introduction

This report follows on from previous reports concerning beach changes along the West Sands at St Andrews and the possible influence of sand removal from the beach by the Links Trust in order to recharge bunkers on its Golf Courses. During 2018-2019 the Links Trust removed about 750 tonnes (288.5 cubic metres) of sand from an area of about 30metres by 50metres at a location comparable to that reported in previous years.

The concerns associated with sand removal are that the disruption of natural processes by excavations will adversely affect beach processes and cause erosion of the upper beach that provides protection of the backshore areas. The backshore area above the High Water Mark (HWM) was used as a waste disposal site for many years by St Andrews Council and its erosion could expose waste at the shore. The beach is important in that it absorbs wave energy and protects the ground above the high water mark from erosion and the release of potential spoil.

One can monitor this protection by measuring the movements of the high water mark and the sand elevations that front the high water mark.

Wave Activity 2018-2019

The Wave Rider Bouy deployed in the Firth of Forth by CEFAS allows one to infer wave conditions along the West Sands at St-Andrews. This data is recorded in a depth of 62metres and clearly the shallow water of St Andrews Bay will affect wave heights at the shoreline. Principally wave heights at the shore will be less than offshore as wave energy is lost through its interaction with the seabed in St Andrews Bay. In the Firth of Forth as along the West Sands maximum wave heights are recorded by waves entering the area from the eastern sector and one might expect that the largest waves on the shore will come from the east. This is evident from the plot of wave height against wave direction in Figure 1 – maximum wave heights during the year were from due east and all waves exceeding 2m originated from between 30 and 150 degrees- most waves exceeding 4metres during the year originated from a narrow sector between 80E and 110E

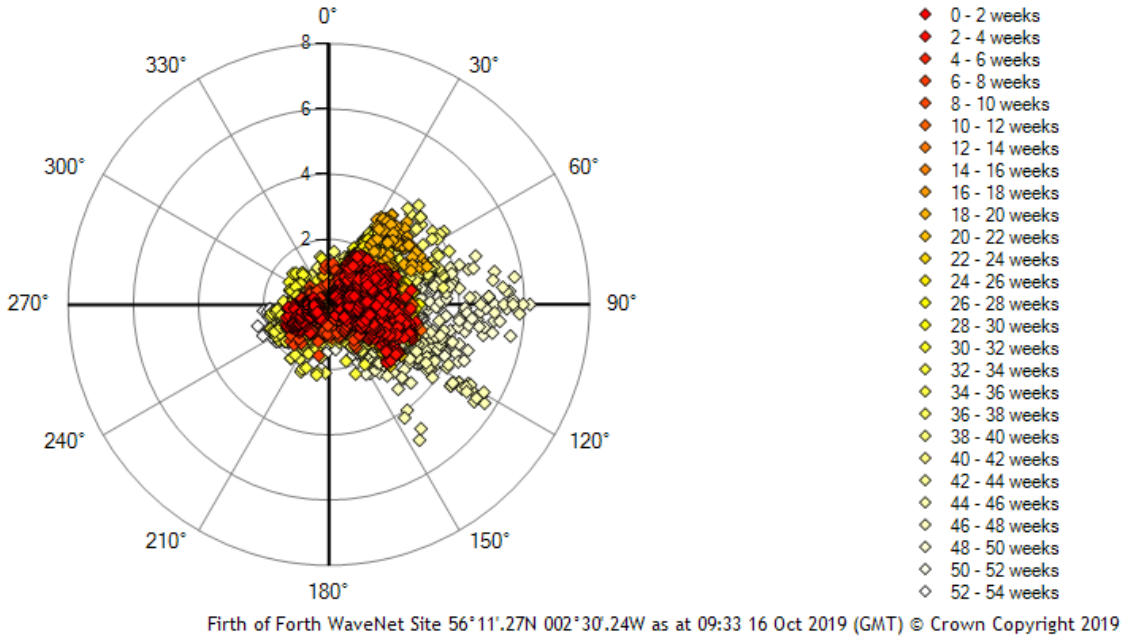

Figure 1 Wave height (metres) and wave direction east of May Island - October 2018-October 2019

The beach is modified by both wind and wave activity. In general, wind action results in slow changes to the beach profile although persistent on-shore winds can drive volumes of sand to the upper beach and potentially remove it from the beach by building sand dunes above the high water mark. The more frequent south- westerly winds at St Andrews tend to move sand down the beach although this can be returned to the upper beach by wave activity. The low gradient of the West Sands together with its fine grain size means that much of the beach below about 1.5m OD remains wet throughout low tide and surface sand is not easily mobilised by wind action.

The nature of wave activity tends to have a different impact on beach profiles during summer and winter. Winter waves are frequently short steep waves whereas summer waves tend to be lower profile swell waves. Winter waves driven by strong winds tend to lower beach profiles while gentle summer wave activity tends to be constructive and move material onshore. Wave activity is more effective in changing beach profiles especially at the HWM if they occur on spring tides and at or near high water when the water level reaches the upper beach

In the area adjacent to the extraction site sand on the upper beach is thus influenced by wave activity and wind action. Sand movement can be both onshore and offshore by wind and wave but the long term development of the beach at the northern end of the West Sands demonstrates that alongshore movement is also important in determining coastal change. This movement is significant and much progradation of the shoreline north of the area of survey results from sand moving north along the West Sands.

Coastal Change adjacent to the Links Trust extraction Site

During late 2018 and much of 2019 the beach close to the links Trust extraction site slowly recovered from the impact of the north-easterly storms of March 2018 and sand levels rose on the upper beach as modest wave activity pushed sand towards the HWM. From March 2019 the former spoil associated with the previous use of the back shore area as a rubbish tip for St Andrews became buried by fresh sand and a drape of windblown sand accumulated below the cliff line. These charges are recorded in the movements of the 2.5m OD contour during the year with movement onshore indicating positive accumulation near the HWM (Figure 3).

Figure 2 December 2018

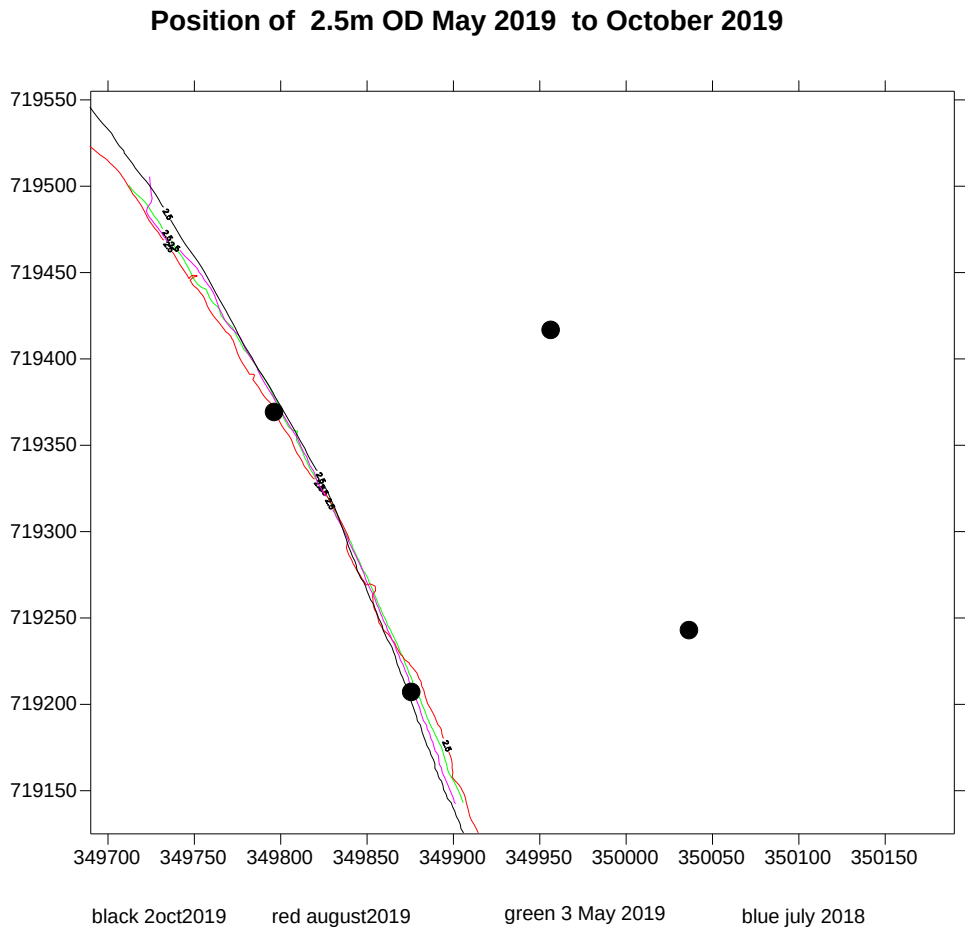

Figure 3 The end points of the beach normal surveys are marked.

Survey work in 2018-9

Topographic surveys of the beach adjacent to the sand removal site have been carried out in September and December 2018. In 2019 surveys were carried out in May, August, and October Surveys were carried out on Spring tides and were taken to at least -1m OD - an elevation that should be well below the impact of sand removal from the extraction site that is at (1 to 1.5m OD).

Survey practice of previous years has been replicated in this survey. The highest point of the ramp that defines the intercept of the beach with the cliffline is surveyed at 3-5metre intervals along the ramp. Parallel surveys are carried out at the mid-point and base of the ramp and thence at 5 -10metre intervals across the upper beach, with parallel surveys carried down the

beach to below 1mO.D. Survey points on these parallel lines are recorded at about 5 metre spacing.

Beach profiles normal to the parallel surveys are carried out from the crest of the ramp to low water with elevations recorded at 6 metre separations and at any change in the break of slope (crest and base of ridge and runnel features). These beach profiles are taken along the beach at 30 metre intervals (surveyed to -1.5m O.D.) .The surveys thus define beach height well on the upper beach where beach change has been noted and less well on the lower beach where change is less variable. –

It is not possible to replicate profile locations between surveys so in order to investigate changes that have taken place on the beach between surveys the observed data are interpolated on to a consistent matrix of data points. Using the computer program *Surfer 12* a rectangular grid of data points is computed that cover the survey area with a 255 x 183 grid of points at 2.5m intervals- this grid is less extensive than the total survey area. Subsequent calculations are carried out on the gridded data. This data is used to display contours and compute beach profiles and also to compute sand volumes in the survey area. Beach profiles are thus drawn from data points that have the same coordinates in each survey and volumes are computed by summation of the individual grid volumes in the 2.5m cells that comprise the area under study.

Changes of sand volume in the survey area.

Figure 4 shows the computed volume of sand in the survey area above a horizontal surface at an elevation of 1m OD. It is considered that this represents the volume of the sand stored in the upper beach area and reflects the protection available to the backshore areas. During 2019 beach volumes have tended to increase. However, for much of 2019 this increase in volume has resulted in accumulation between about 1mOD and 2.0mOD and only after March 2019 did the accumulation affect the HWM and a drape of sand formed at the junction between the beach and backshore cliff.

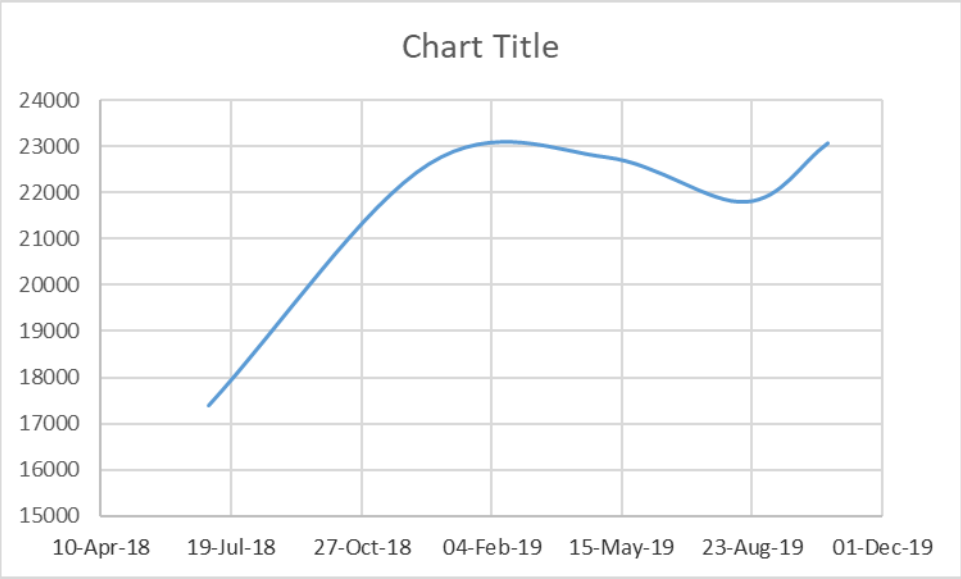

Figure 4 Sand volumes (cubic metres) above 1m OD in the area of survey

Beach profiles (Figures 5,6) amplify the changes that have taken place on the beach since September 2018.

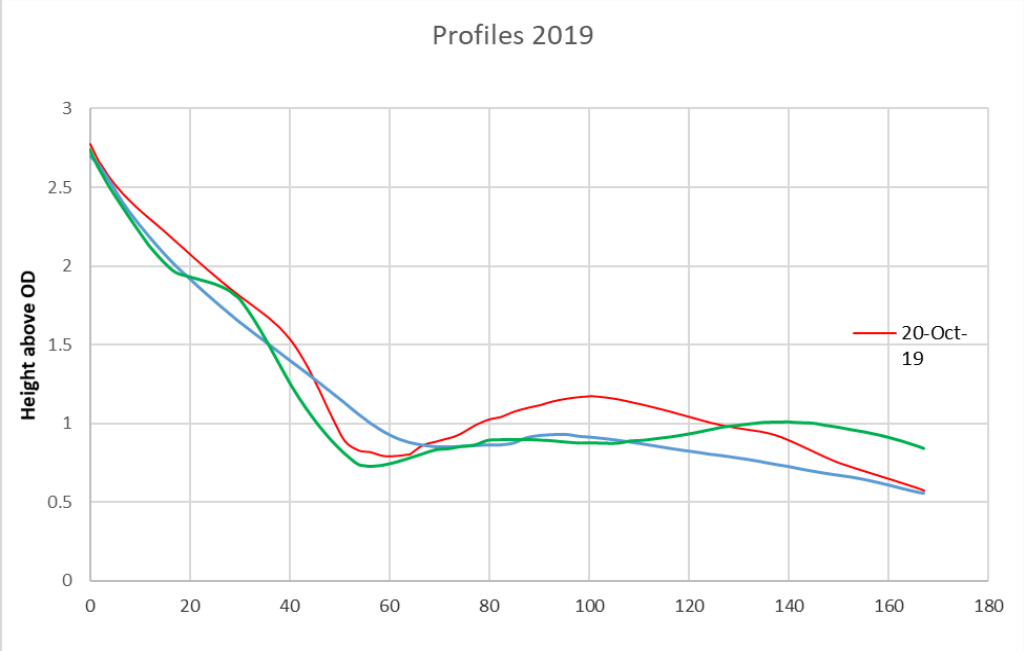

Figure 8 Beach Profiles (Northern location)

Figure 9 Beach Profile (Southern profiles)

Photographic record of changing Cliff line 2019

Coastal Changes adjacent to the extraction site 2019

March 2019

May 2019

August 2019

October 2019

Conclusion

Despite erosion of the backing cliff some 4,500 cubic metres of sand have accumulated in the survey area since July 2018. This compares with 100 cubic metres of sand removed by the Links Trust during that same period of time. It is not possible to attribute a causal relationship between these processes of sand removal and deposition. It is noteworthy that the surveys of the beach reveals that the site is one where wave energy is focussed. In the northern part of the survey area accumulation at the HWM has continued while erosion is concentrated to south of the survey area. 200m further to the south one again enters a zone where accumulation takes place and the shoreline is prograding. In particular, one notes that the erosion at the cliffline observed in October 2019 has not caused a reduction of computed beach volumes (Figure 4). Sand appears to have moved from the HWM to the upper beach (Figures 8, 9) and levels have increased in this part of the beach profile.

The role of the former area of landfill dumping may be affecting coastal change here. Landward movement of the HWM is impeded by the more resistant material released from the dump and thus cannot supply sand to the beach. However, this does not fully explain why wave energy is focussed here and It is possible that energy is concentrated here because of the role of the offshore bathymetry

One concludes that sand movements reported above are the result of natural changes resulting from both wave and tidal activity. The West Sands is a dynamic environment and although it's overall appearance is that of a single coastal unit. However, considerable variations within the small survey area around the extraction site have taken place in both space and time.