NON-TECHNICAL SUMMARY

Background

In the winter of 2013/14, severe storms stripped around 0.5m of sand from Portslade Beach, exposing new localised rock outcrops. At spring low tides, dark brown tar/oil was observed seeping from the fissures and gaps in the rock. Shoreham Port instructed Arcadis (formerly Hyder), to review historical site information, existing borehole and chemical data, and investigate why the seepage was occurring. The ground investigation commenced in November 2015, with monitoring continuing over the spring low tide events of early 2016.

Part of Shoreham Port was previously occupied by the old Portslade Gas Works, which was operational between the 1870s and 1970s. The land and groundwater at the old gas works site is variously and widely contaminated by a range of substances including coal tars and other pollutants.

Investigation

Geophysical surveys were carried out to help supplement direct drilling work. Ground Penetrating Radar (GPR) targeted potential source areas, such as positions of underground tanks, located from historical plans. The GPR identified some areas of deep disturbed ground, probably where former tanks had been, but it did not indicate intact structures that might contain tars that could be pumped out.

The ground investigation comprised 6 boreholes: one just south of the area of gas works tanks (the suspected source area) and five to investigate the 3D geology, located along Basin Road South between the Port and the beach (the suspected migration route). Drilling holes into the beach was considered, but this carried a risk of making the problem worse. In this area, surface geophysics (seismic method) was used to see if it could help characterise strata conditions beneath the sand. In the out turn, differences between the strata could not be fully resolved.

The boreholes recorded the depth thickness and internal structure of the geological units (strata), and the presence of groundwater and evidence of tar/oil. Special methods were used to preserve evidence of the tar/oil, and chemical 'fingerprinting' enabled comparisons to be made.

Findings/Discussion

Chemical and physical testing of the tar/oil sample retrieved from the historic area of tanks provided strong evidence that it was a creosote-type product. This was also similar in nature to the tar/oil seeping out on the beach.

Like most oils it tends to want to stay separate from water, but in this case it is heavier than water and sinks through it. It is 'thicker' (more viscous) than water and therefore this type of pollution tends to move slowly, often for many decades following its release. The direction and speed of movement will be influenced by how 'solid' or 'open' the ground is, layering of the strata, and the way in which water moves at different states of the tide.

The geology underlying the Port and the beach comprises three main layers:

- Storm Beach Gravel Deposits (coarse gravel) over
- Lambeth Group (layered/laminated mudstone, brown coal seams and clay, overlying
- Chalk.

The layers are not level and, overall, dip slightly to the south. The Lambeth Group, in this particular area, was found to form a slightly higher, elongated 'ridge'. Until the storms, this was just buried beneath the beach sands. It is this material from which tar/oil emerges. The buried 'ridge' extends northwards under Basin Road South, and probably extends to just under the former gas works.

Within the two boreholes that encountered the ridge material, tar/oil that is a close chemical match to that emerging on the beach was found, with clear visual and malodourous evidence seen within an upper lignite layer. This was underlain by a relatively clean grey clay before more lignite layers were recorded. The top of chalk was penetrated at typical depths of around 18m.

Tar/oil contamination comprising dark brown staining and oily 'sheen', together with odours, was also encountered at the base of the Storm Beach Gravels (beneath the water table), in the lignite/mudstone fractures in the Lambeth Group, and in one location in the chalk. The most heavily contaminated locations were concentrated in and around the central 'ridge'.

Chemical evidence from the groundwater samples indicated that dissolved oxygen levels were lower in the Lambeth Group where it was contaminated with oil. The lack of oxygen will retard the natural biological breakdown processes. This is possibly part of the reason why the tar/oil emerges in a 'fresher' and particularly malodourous state on the beach.

Approximately 20cm of tar/oil has now entered the borehole located next to the historical tank locations. This is probably providing an on-going source where the possible downward slope of the upper lignite/mudstone laminations would cause the tar/oil to tend to flow under gravity, towards the beach.

Groundwater and tar/oil will be able to move in any direction in the Storm Beach Gravels. However it will tend to be confined to natural laminations and fractures in the lignite/mudstone and chalk.

Groundwater in the Lambeth Group and Chalk, is semi-isolated from the tidal rise and fall. This is due to the laminated structure and presence of clay layers. This means that at low tides, and especially spring low tide, the water (and tar/oil) is at a higher pressure than the sea level. This probably acts to bring groundwater and some tar/oil towards the surface (known as artesian conditions).

Factors that are probably favourable in mitigating the tar/oil migration are likely to include oil degradation, especially within the beach gravels, where oxygenated waters can enter, and adsorption to solid surfaces. Tar/oil seeping up through clay layers from the deeper Lambeth Group and Chalk is considered unlikely, as the clay was found to be generally clean.

Immediately following the storms, the reduction in weight of sand would have caused slight opening of fractures and laminations. This is likely to have promoted an initial release of previously semi-confined tar/oil. It is possible that as time passes that initial rate of egress may not be sustained, as replenishment along laminations from a source some 100 to 150m away is likely to be slow. At spring tide events February 2016, insufficient tar/oil was seeping to enable a sample to be obtained.

Way Forward

A source of tar/oil associated with the former gas works is present under SPA land. It is similar to that emerging at low spring tides. Special pumps are available that can recover these tars/oils from borehole sampling tubes, and this approach is recommended as a first action. Monitoring of beach outcrop seepages at spring low tides together with observations of tar/oil response in the other boreholes should continue.

In theory, methods to 'cut-through' and 'seal off' the pathway in the Lambeth Group are available, e.g. deep soil mixing or sheet piling. However whilst this would block the tar/oil (that could then be recovered) this would also block groundwater, possibly causing it to 'dam up' and then flow around the installed works. This could mobilise other (currently immobile) contamination, and possibly create other problems. The situation is complex and the effects of intervention are difficult to predict.

Thus applying intervention at the pathway is not a straightforward concept, and would carry other risks that a detailed design process would need to address. At this time, action to reduce the source can be applied, and carries little or no risks. Time should be given to enable the rate of recovery and positive effects to be evaluated before higher risk strategies are enacted.