THE NATURAL ENVIRONMENT OF THE MEDINA ESTUARY AND COWES HARBOUR

INTRODUCTION

Cowes Harbour is the only 'deep water' port serving the Isle of Wight and, as such, provides a vital link in sustaining the lives and livelihoods of people and businesses on the Island. In addition, it is the main gateway for the many visitors that fuel the Island's tourist economy and famously plays host to thousands of leisure mariners; it is arguably the British home to the sport of yacht racing. The harbour is run as a 'Trust Port'[1] by Cowes Harbour Commission (CHC) who is responsible for running a safe and navigable port, and for ensuring the port is passed on to future generations in its current or an improved condition. It is with this last duty in mind that the CHC has commissioned a number of scientific studies to better understand the physical environment in the harbour area and to inform future developments and maintenance activities such as dredging. This paper aims to summarize the key points of this work to date, in particular relating findings to current harbour and estuary issues.

Figure 1 Cowes Harbour & the River Medina pre-Cowes Breakwater

HISTORY

Cowes Harbour is a natural estuary formed over thousands of years where the Medina River enters the Solent. In their natural condition, estuaries tend to a state of equilibrium and any change tends to be gradual. However, several hundred years of human activity has significantly modified Cowes Harbour from its natural condition. Capital dredging, to accommodate ever larger shipping and larger marina facilities, has led to significant deepening of the harbour floor, whilst land reclamation and the building of wharves and waterside industrial facilities has caused constriction and narrowing in part of the estuary. These man-made changes have impacted the estuary hydrodynamic and sedimentation regime. The deepening by dredging of areas of the estuary to provide navigational channels and develop marinas has led to an increase in the volume of the water held in the estuary at high water to

about one and a half times its 1802 volume. The estuary is therefore far from its equilibrium state with the enhanced water exchange increasing the potential for sedimentation[2].

The shape of the estuary has been further changed by efforts to provide a more sheltered harbour. In 1937, the Shrape Breakwater was constructed, ostensibly as a tidal flow training wall and to reduce the maintenance dredging bill for keeping the fairway at navigable depth, which it achieved. However, the Shrape Breakwater construction modified the tidal flows and the feed of coarse sediment from along the coast, resulting in reduced supply to the sand/gravel Shrape Spit that used to extend to just east of the fairway[3], and flow changes in the Outer Harbour and main fairway. In more recent years, the construction of the Cowes (Outer) Breakwater to produce a considerably more sheltered harbour, has also had an effect on the tidal flows in the Outer Harbour and the sedimentation regime of the estuary.

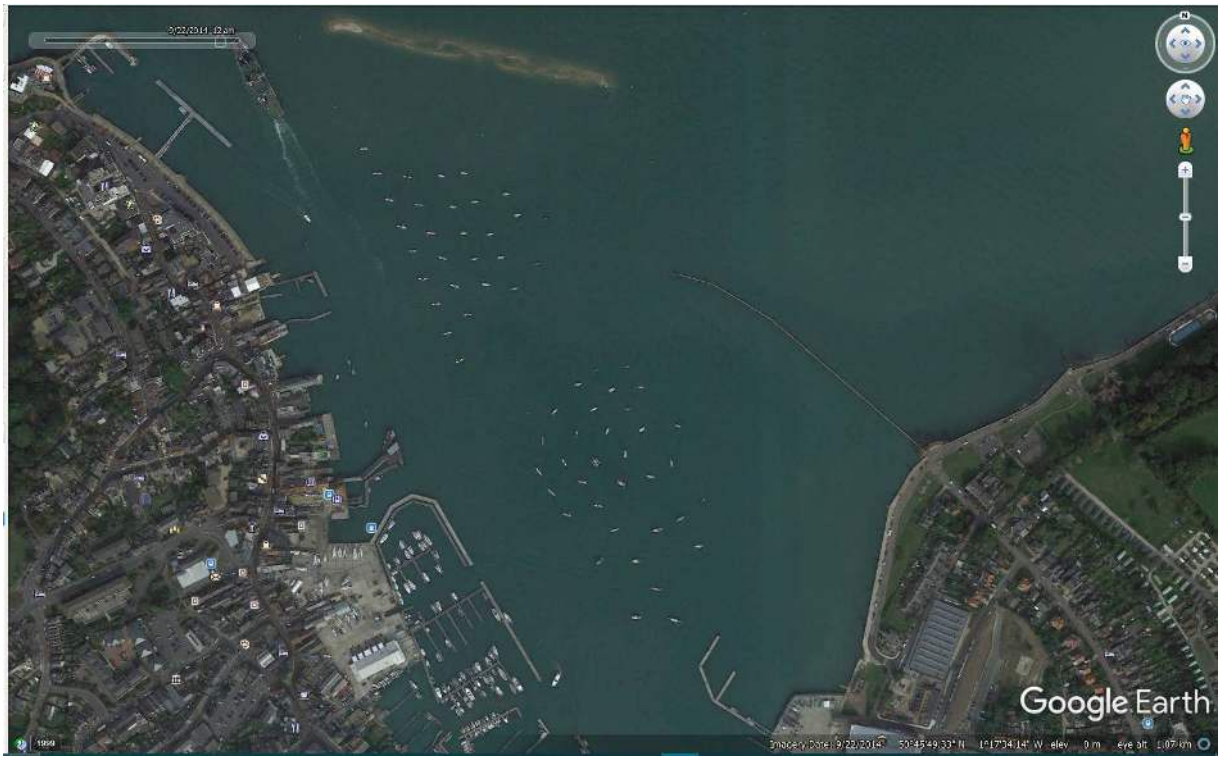

Figure 2 Aerial photograph: Note circular tidal gyre alignment of yachts in the Inner Harbour

SEDIMENTATION AND FLOW STUDY

In 2015, CHC commissioned an initial field-based study by an independent estuarine consultant scientist to provide further understanding and complementary advice to the extensive modelling studies already undertaken of how sediment is moving around the harbour. The study aimed to confirm the types of sediment present and the tidal and meteorological forces that may be controlling the processes of sedimentation. From this initial study, Cowes Harbour Commission decided to instigate a long-term project to constantly monitor the flux of fine sediment through the lower estuary. Identified by the consultants as a 'cutting edge' project that is not known to have ever been undertaken at other locations in the world, the monitoring project has been underway since 2016. The study uses two distinct techniques to measure the movement of mud within the harbour, the first being based on extensive annual bathymetric surveys of the harbour bed and the second measuring the amount of suspended sediment and a more detailed measurement of the flow patterns around the estuary. The bathymetric survey provides a clear picture of WHERE the seabed is changed by sedimentation or erosion and the sediment monitoring study provides a dynamic analysis of WHEN sedimentation occurs. The two studies are then consolidated to give a much more precise idea of how the estuary is changing with time and gives early indication of where intervention may be required.

Initial years experienced a number of issues with monitoring equipment and the environment, but the study is now producing a large amount of extremely useful data[4].

PHYSICAL ENVIRONMENT - SEDIMENTATION

As mentioned earlier, the ongoing effects of human activity in the estuary have resulted in an unnatural state as far as the processes of transport and deposition of sediment are concerned. Although naturally an estuary tends to maintain an equilibrium, human development in response to the pressures of navigation, shipbuilding, wharfage, and leisure usage, ongoing for several hundred years, has unbalanced the sedimentary system. Civil engineering works, such as dredging to accommodate larger ships and create marinas, and land reclamation to facilitate the construction of waterside industrial facilities and build breakwaters, create changed water flow regimes. Developments in shipping, such as the 'scour effect' of more powerful propulsion systems, and increased boat traffic have also had an effect. Together, these man-made changes are modifying the sedimentation processes, creating a mosaic of 'more-stable' and 'less-stable' areas of the estuary bed. Some areas are subject to significant erosion, others persistent deposition. Of the latter, the areas that have been artificially deepened and sheltered, such as the three main marinas, will naturally try to return to their pre-dredged equilibrium state. These man-made basins provide places where fine sediment will settle and accumulate, forming sediment 'sinks'. Indeed, the marina sites account for most of the annual dredging rates historically recorded.

The main source of the sediment and mud that is deposited in the harbour is from erosion of the sub-sea clay found in the wider Wight area during winter storm periods, and the amount that enters the estuary each year is widely variable. A lesser source of mud is local scouring from shipping action (indeed, studies suggest that Cowes Week leads to noticeably greater suspended sediment levels!)[5] and natural processes causing local erosion zones within the estuary itself. Maintenance dredging records (post 1986) show that typically around 10,000 dry tonnes of mud are dredged from the estuary each year (equally removed from above and below the Chain Ferry narrows) with spoil disposed of in offshore licenced areas. The amount of sediment deposited in the harbour is thus fairly constant and is generally only increased by greater than normal storm activity in the English Channel, normally in the winter season. However, as the estuary tries to regain equilibrium after 'one- off' developments or capital dredging projects, such as those conducted to deepen the Small Craft Channel in the eastern entrance to the harbour (new Eastern Channel), there are often short-term changes to the local sedimentation regime. Monitoring has currently shown no consistent adverse changes in the amount of mud and sedimentation being retained by the estuary over recent years, when compared against the records going back to 1986.

PHYSICAL ENVIRONMENT – FLOWS

In addition to sedimentation data, recent studies have also given greater understanding of the flow regime within the harbour. The strong east-west aligned tidal flow in the Solent has always led to the formation of a series of eddies or 'gyres' within the Outer Harbour area. The Cowes (Outer) and Shrape Breakwaters channel and modify these Solent flows resulting in local effects in the Outer Harbour, particularly on the flood. The northernmost gyre flowing between the breakwaters has strengthened by about 0.6 knots resulting in surface velocities peaking at around 2 knots.

The Outer and Inner harbours at Cowes are separated by the natural constriction of the estuary in the vicinity of the Chain Ferry crossing. This constriction at the Chain Ferry provides an obstacle to the volume of water entering the river on the flood or leaving on the ebb, to the point where it is the main hydrodynamic control for the river south of the Chain Ferry narrows. It can be described as the "neck of the bottle" when considering the controlling influence of this natural feature of the Medina Estuary. Flows speed-up to transit the narrow gap leading to higher current velocities here than in the main channel. The volume of water entering and leaving the harbour is totally governed by the Solent tidal

range, which defines the volume of water required to fill and empty the harbour and river on each tidal cycle. Clearly, currents through the narrows are slightly stronger on the ebb as the outgoing tidal flow is 'added to' by the river outflow, but also the ebb tide is stronger than the flood tide in Cowes due to the Central Solent double high water/stand effect that holds back the start of the ebb tide. Tidal heights in the harbour have been recorded for many years and there has been little change in tidal range over time, so it follows that current velocities at and above the narrows remain fairly constant. However, constriction of the channel by further construction or reclamation would clearly increase flow velocities.

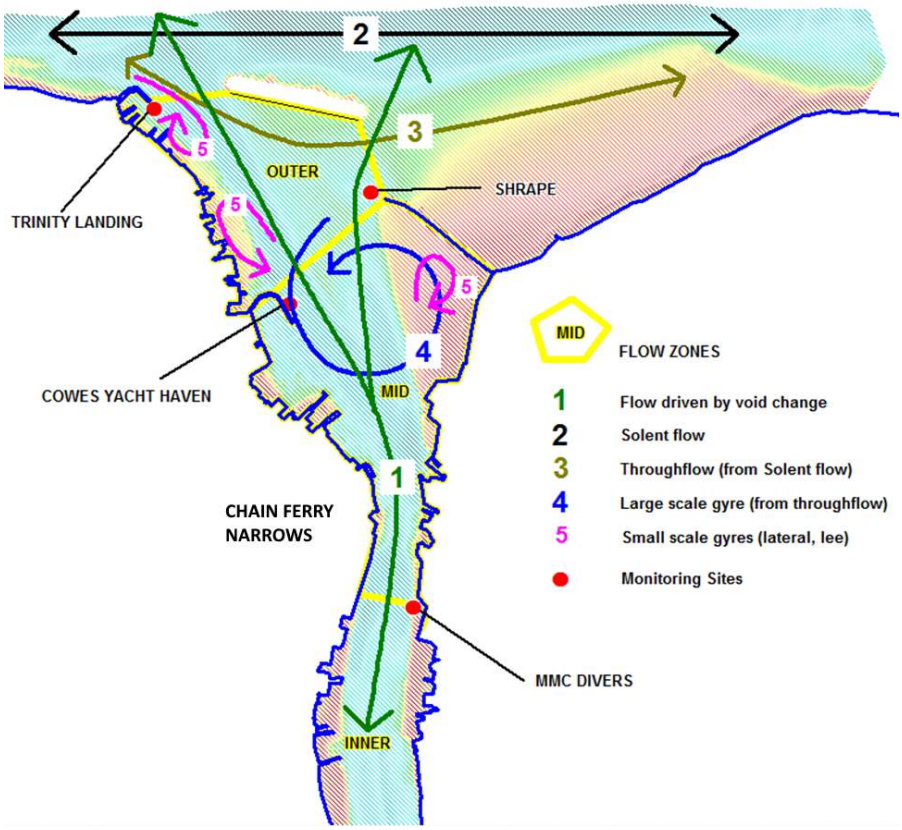

Figure 3 Flow zones

FUTURE ENVIRONMENTAL ISSUES

Protected Areas and Dredging. The River Medina contains a mosaic of Protected Areas (PAs) and is adjacent to several other PAs in the Solent region. These regions were established with the assumption that the, then current, dredging methods would prevail, and there has therefore been little concern that current estuary management processes will have an ecological effect on the PAs, particularly in terms of water quality and bed disturbance. However, some 10,000 dry tonnes of sediment has historically been dredged each year and transported to licensed offshore deposit areas; the need for a more sustainable approach to the management of bed levels in the busy Medina Estuary has been an active topic of discussion between government agencies, managing authorities and stakeholders since about 2004. As recent studies have enabled a much greater understanding of the flows and sedimentation processes in the Estuary, and as new dredging techniques have been developed, there is a possibility that a new maintenance regime could be adopted that would significantly reduce the persistent removal of sediment from the Estuary and, instead, concentrate on keeping suspended sediment moving throughout the harbour (so-called 'Keep Sediment Moving' (KSM) methods).

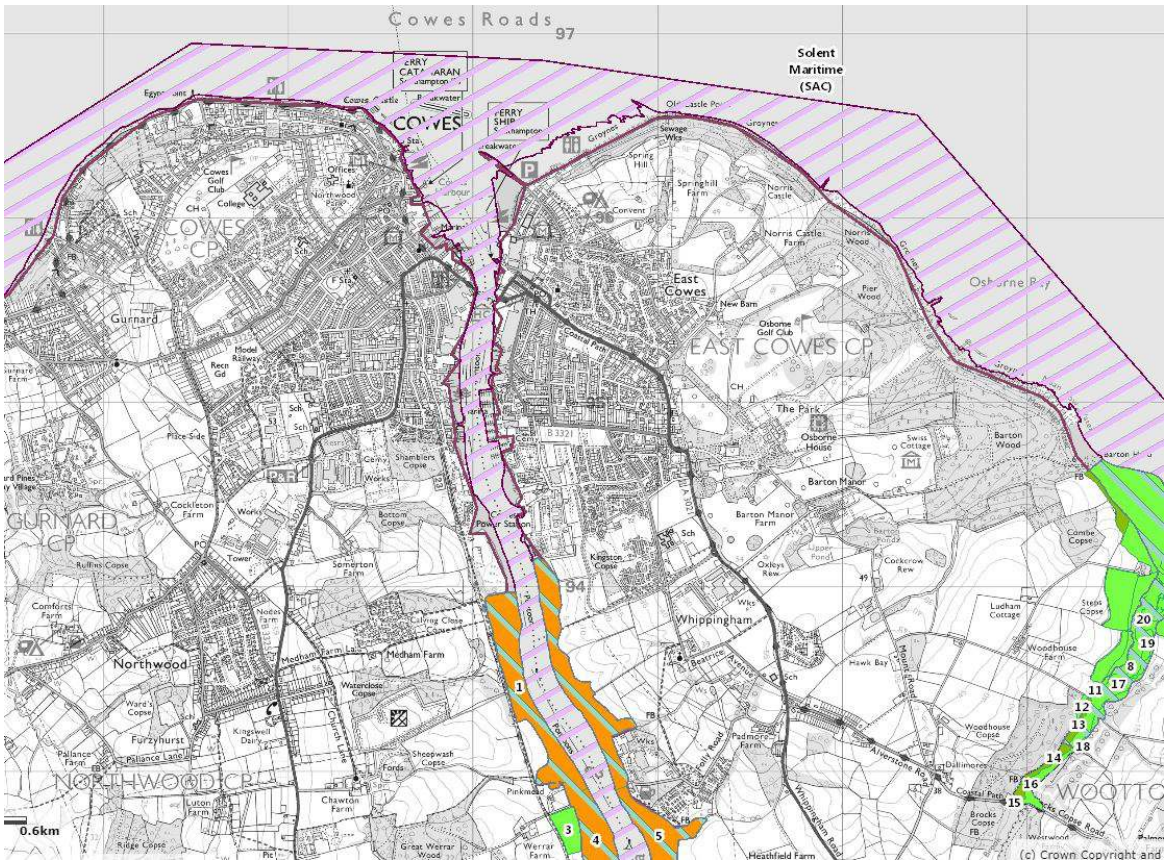

Figure 4 East Cowes Special Areas of Conservation & North Medina designations

Rather than using a traditional backhoe dredging technique, developments in Water Injection Dredging (WID) rely on smaller vessels continually disturbing the bed sediment, allowing currents to disperse the sediment plume and naturally return it back into the Solent and estuary sediment systems. This approach is being considered along with other alternative dredging techniques. Such operations would be of significantly lower impact to navigation and harbour operations but would need to be conducted on a more frequent or ideally continual basis. It would therefore be vital that the plan was fully agreed by all harbour users and stakeholders and managed to minimise the effect on their activities.

Such techniques, however, are fairly new and there are possible downsides. Sediment from the traditional 'sink' areas, such as marinas and boatyards, may contain trace metals and hydrocarbons resulting from industrial and maintenance activities. KSM techniques run the risk of transferring pollutants to currently 'pristine' areas of the Estuary. Also, there is a possibility of insensitively transferred sediment 'smothering' areas of the seabed that currently host valuable marine organisms, such as shellfish beds. So, whilst new techniques may appear to be preferable to current dredging, for both environmental and economic reasons, careful consideration will need to be given to the 'total' effect on the Estuary.

CHC has been consulting with the main dredging stakeholders in the harbour for the last few years on this project. Currently, there is not a consensus to support Water Injection Dredging but there is significant support for this important environmental and sustainability project and for the proposal to develop a carefully monitored trial programme.

Climate Change Effects. The two main predicted effects of ongoing climate change that will have the greatest impact on Cowes Harbour and the Medina Estuary are likely to be Increased severity and occurrence of storms, and sea level rise. As mentioned previously, winter storms are the main source of the mud that is deposited in the estuary, so any increase in occurrence or severity of winter storms

is likely to add significantly to any future dredging effort. Whilst Cowes is now largely a completely protected harbour in terms of onshore wave action, future storms may well induce higher storm surges that those previously experienced, with the ensuing flood risk. Flooding will also be a much increased risk if the current predicted sea level rises occur. The current rate of sea level rise is about 3.6cm per decade but is very much dependent on the rate the planet is warming[6]. Permanently higher water levels in the estuary will not only affect human and economic activity but are likely also to impinge on the natural environment, with potential effects on biodiversity and fragile areas such as the saltmarshes and sea grass beds. Ensuring that the intertidal estuary mudbanks have sufficient sedimentation supply to allow them to build, keeping up with sea level rises to maintain the estuary and river form, and associated ecosystems, is important and is an aim well served by the Water Injection Dredging methods under investigation.

CONCLUSION

Cowes Harbour is the only deep-water port on the Isle of Wight and is thus a strategic asset enabling the transport of people, goods, and vital resources. It has developed within the River Medina Estuary, which has been dredged and modified beyond its natural equilibrium condition. The Harbour is now more protected from wave effects, but the challenges of climate change, in particular storm activity and sea level rise, will likely challenge the harbour in future. Cowes Harbour Commission is dedicated to the maintenance of Cowes Harbour and takes seriously its responsibility as custodian of both the harbour and the natural environment of the Medina Estuary. The Commission is engaged in appropriate sedimentation, hydrodynamic and dredging studies, and is in continual dialogue with stakeholders and expert bodies to ensure that the utility of the Harbour can be maintained and developed economically and efficiently into the future.

ENDNOTES

[1] Definition of Trust Port - Department for Transport, 'Ports Good Governance Guidance' March 2018.

[2] Ambios Environmental Consultants Ltd., 'Sedimentary Processes in the Medina Estuary' (AmbCHC02) May 2016.

[3] Ibid.

[4] Ambios Environmental Consultants Ltd., 'Sediment Management in the Medina Estuary - Monitoring Results 2019' (AmbCHC08) April 2020.

[5] Ibid.

[6] Jones, Mackie, Shuckburgh and Vaughan, 'How Climate Change is Affecting Sea Levels'. RMetS Journal *Weather* Vol. 75 Issue 9, September 2020.