

## **Ecospan Environmental Ltd.**

### **Proposal for the environmental monitoring of the Salcombe-Kingsbridge estuary associated with the maintenance dredging of Batson Creek channel.**

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## **PROJECT BACKGROUND**

Salcombe Harbour Authority has a duty to maintain the depth of the Batson Creek channel to that stated on the Admiralty chart (1.0m below chart datum). Over the years this channel has become shallower due to the accumulation of silt. It is therefore now necessary to dredge the main channel of the Creek to maintain the stated depth and to dredge the channel to the lifeboat station to 2m below chart datum to enable the lifeboat to launch at all states of the tide. The total volume of sediment needed to be removed is approximately 6,000 m<sup>3</sup> which would be removed at a rate of approximately 350 m<sup>3</sup> per tide. It is estimated that similar maintenance dredging will be required every 5 years. Chemical analysis of the sediment has revealed that it does not contain any significant contamination.

Since there are no marinas, large docks or other revenue generating enterprises in the estuary, the harbour authority has limited means by which it can raise funds for such operations. For this reason and the sensitive nature of the marine ecology in the estuary, it has been proposed that Water Agitation Dredging (WAD) be used to achieve these aims. Van Oord UK Ltd has been commissioned to undertake the work.

The Salcombe – Kingsbridge estuary lies within the South Devon Area of Outstanding Natural Beauty and has been designated as a Site of Special Scientific Interest (SSSI) under section 28 of the Wildlife and Countryside Act 1981 as amended. The estuary was designated because it possesses a rich and diverse inter-tidal and sub-tidal fauna and flora. The lower estuary is partially separated from the open sea by a submerged sandbar and is characterised by rocks and sandy bays, while the upper estuary is comprised chiefly of inter-tidal mudflats. Of particular note are sea grass beds (*Zostera marina*) in the lower part of the estuary and a small number of fan shells (*Atrina fragilis*) that are also found in this part of the estuary. Both of these are the subject of UK Biodiversity Action plans. For these reasons, Natural England has proposed that monitoring of the estuary is undertaken to ensure that the dredging operation does not cause any adverse effects on the area's ecology.

The proposed works were discussed at a meeting attended by representatives of the Salcombe Harbour Authority, South Hams District Council, Van Oord, Natural England, experts from Plymouth Marine Partnership and Ecospan Environmental Ltd. It was concluded that this dredging project was necessary and the proposed method a good way of undertaking the work provided that the amount of material dredged per tide is not excessive. The primary concern centred on the possibility of the sediment creating a very dense fluid mud layer which might not disperse easily and could potentially pool and smother the fauna in the deep areas of the main channel. Given the low volume of material to be dredged, it was thought that the risk of any deleterious impact on the fauna and flora of the estuary was low and even less if fluid mud conditions could be avoided. Subsequent discussions with Van Oord have revealed that this can

be achieved by using WAD rather than Water Injection Dredging (WID) as was originally proposed. In this way, the sediment can be removed in thin layers and dispersed into the water column rather than creating a density current.

## **SCOPE OF THE ASSESSMENT**

The focus of this proposal is geared primarily towards preventing any impact from occurring in the first place rather than a raft of monitoring assessments which would merely determine the scale of any impact produced. There are five principal parts to this plan:

### **1.0 Plume dispersal modelling**

There is currently very little data on the sediment flow within the estuary and some debate into the likely fate of the sediment removed. A model would provide data on the areas most likely to be impacted, whether pooling of sediment in the deeper parts of the channel is predicted and what the ultimate fate of the majority of the sediment would be. The predictions made by the model would then be used to target the monitoring stations in the most effective manner. It is anticipated that if the model predicted low deposition rates and rapid flushing of the estuary, the reduced monitoring programme given should be appropriate. As well as providing a useful tool that could be used for subsequent projects in the estuary, modelling is predictive. If the model predictions were interpreted as unacceptable risks to the fauna and flora of the estuary, the project could be halted before any work had started and a more appropriate method of maintaining the channel determined. It would also provide part of an audit trail to demonstrate that Van Oord/ Salcombe Harbour Authority has shown due diligence.

#### **1.1 Model specifications**

The model will cover the whole of the Salcombe and Kingsbridge estuary and creek system and extend out into the coastal waters for a few kilometres to the east and west of the estuary.

The model will consist of two components:

1. A finite difference hydrodynamic model to predict the spatial and temporal distribution of depth averaged tidal currents in the whole of the Salcombe estuary system.
2. A random walk particle model to predict the movement of the disturbed sediment from the dredging operation, where material will be deposited on the seabed and the thickness of the layer, and the quantity of sediment flushed out of the estuary.

#### **1.2 Data on which the model will be based**

The models will be based on the following data:

- Depths from Admiralty charts of the area together with data from echo sounding surveys to be carried out:
  - A fine scale survey of the area to be dredged (10 – 20 m tracks)
  - And a less detailed survey (c 50 m) of Batson Creek and the main channel from 50° 13.60' N (South Sand Bay) to 50° 14.60' N (Ox Point)
- Tidal elevation data for mean neap and mean spring tides taken from the Admiralty tide tables.

- Sediment particle size distributions and density for the material to be dredged from 5 locations along the proposed area to be dredged.
- Sediment settling rates based on Stokes Law, Heathershaw's Impact Law and other literature data.
- Mixing rates to be derived from the Installoecean dye study report, 1991.

### 1.3 Model validation

Model validation will be carried out by comparing the model predictions against the following data sets:

- Tidal stream data from the Admiralty charts.
- Fixed station current profiling data. Current velocity profiling measurements using a Direct Reading Current Meter will be carried out at 3 positions within the main channel over the ebbing tide on a neap and spring tide. At each position current velocity and direction will be recorded at 0.1m, 1m, 2m, etc. until the sea bed is reached, a final measurement should be taken 0.5m above the sea bed. This will be repeated 2 hourly.
- Acoustic Doppler Current Meter (ADCP) measurements. An ADCP will be attached to a survey boat and will measure current velocity profiles as the survey boat moves along. Current velocity measurements using an ADCP will be recorded in the main channel from Snapes Point to South Sands beach at half ebb on a neap and spring tide. A differential GPS will be linked to give positional data. This work will consist of the survey vessel following transect lines within the survey area.
- Drogue tracking. Drogues set at surface and mid depth (3.0m) will be released where Batson Creek meets the Main channel and followed until the drogues leave the survey area or low water (if they are still within the estuary at that point). The first pair of drogues will be deployed 30 minutes after high water and at 2 hourly intervals until 4 hours after high water. The drogue positions will be recorded at approximately 30 minute intervals using differential GPS. Drogue tracking will be undertaken on two occasions, once over a neap tide and once on a spring tide.
- Other data in the literature:
  - Salcombe estuary tidal study: Computer modelling of tidal flows. Kinetics Ltd., 1992.
  - Salcombe dye tracing. Installoecean Limited, 1991.

### 1.4 Model confidence

Model sensitivity and uncertainty will be assessed from the validation exercises. Key parameters will be determined that significantly influence the model predictions. Predictions will be carried out, using the ranges of variability identified for the key parameters, to determine the most pessimistic and optimistic outputs from the model. In

particular the spatial coverage of sediment deposition within the estuary and the thickness of the deposits will be assessed and the quantity of material flushed out of the estuary into the coastal waters.

#### **1.4 Model outputs**

- Model outputs will be presented on spatial maps of the area and will include movement of the sediment on the ebb and subsequent flood tides, effects of dredging on subsequent tides, deposition areas and thickness of deposited sediment.
- Comparative plots for sediment movement on spring and neap tides.
- Temporal predictions of suspended sediment concentrations at a range of points in the main estuary during and after the dredging activities.
- Temporal plots of the quantity of sediment flushed out of the estuary.
- Comparative plots showing model uncertainty.

#### **2.0 Bathymetric surveys**

Bathymetric surveys will be undertaken using a dual frequency echosounder prior to and after the dredging work taking place. These will include a fine scale survey of the area to be dredged (10 – 20 m tracks) as well as less detailed survey (c 50 m) of Batson Creek and the main channel from 50° 13.60' N (South Sand Bay) to 50° 14.60' N (Ox Point). These surveys will: provide data on the dredge area for use by the dredging contractors, provide baseline data for the construction of the model, and provide bathymetric data and data on the thickness of any overlying mud layers to confirm the depth of sediment removed and quantify any significant deposition of sediment or fluid mud pools in these areas. This area includes the deepest parts of the main channel in which it is possible that some pooling of sediment could occur if a fluid mud layer was produced by the dredging process.

#### **3.0 Particle size analysis**

It is anticipated that the sediment to be dredged will be composed chiefly of silt and clay particles. Five samples will be taken from the sediment in the area to be dredged to confirm this and to provide data for the modelling using a 0.01 m<sup>2</sup> Van Veen grab. Any significant deposition of this dredged spoil in areas of the estuary with coarser sediments is therefore likely to cause an increase in the proportion of particles in this size range. For this reason, 5 replicate samples at least 10m apart should be taken from the surface of the sediment from each of the six stations marked in Fig 1 (3 upstream and 3 downstream of the entrance to Batson Creek). Since any fine sediment is likely to exert a maximum impact on the epifauna in the main channel and because it is assumed that most of the sediment will flow out through the main channel, all sample sites are located there. The degree of replication is necessary to enable the results to be statistically analysed.

#### **4.0 Turbidity monitoring**

Van Oord have proposed that they start dredging on a trial basis and that if a layer of fluid mud is detected during that time then dredging will cease. If a layer of fluid mud is created it is expected that this will have a concentration of suspended solids of at least 100 g l<sup>-1</sup>. This is a

very high concentration and will be beyond that which can typically be measured *in situ* with a turbidity meter. It is therefore proposed that a maximum reading on the turbidity meter would act as a trigger (this is typically up to 3,000 NTU). Since the creation of a layer of fluid mud is the outcome that has been identified as being most likely to have a negative impact, the focus on the turbidity monitoring is on those areas where this is most likely to be detected (i.e. in the main channel closest to Batson Creek). Two further stations on the edge of the seagrass beds are also included.

MarLIN lists *Zostera marina* beds as being sensitive to long term (> 1 month) increases in turbidity over the natural range for a particular environment, as light attenuation limits the depths to which it can grow. However, the proposed project is relatively small in size and will only take place on the ebbing tide for a ten day period. Given that the dredging project will also be taking place during the least sensitive time of year for this species, it is therefore very unlikely that there will be any impact on these beds caused by this project. It is considered that turbidity monitoring of these two stations over the trial period, coupled with the predictions from the plume modelling, will be sufficient to determine whether the operation may cause conditions that could potentially effect these beds. A nationally important population of fanshells (*Atrina fragilis*) also occur in these areas, but are not thought to be sensitive to an increase in turbidity or suspended solids according to the MarLIN website.

Seven sites will be monitored hourly immediately prior to and over the entire course of the dredging period of one tide during the first and last days of the three day trial period. As a minimum, turbidity will be recorded at half the water depth and just off the seabed. Additionally, turbidity logging at one site approximately 100m downstream of the entrance to Batson Creek will take place continually over the trial period. The position of all monitoring stations is shown in Fig 1. If a fluid mud layer is produced, it will be detected close to the seabed. For this reason this meter will be set at a depth of 10-15 cm above the seabed. A minimum of 10 water samples will be taken and analysed for suspended solids over this period to enable the turbidity readings to be subsequently converted to suspended solid concentrations. It is recommended that the trial period coincides with the smaller tides expected to be experienced over the course of the dredging project and hence be representative of the worst case scenario.

## **5.0 Ecological monitoring**

### **5.1 Seagrass (*Zostera marina*) beds**

The dredging is due to take place in late February/early March which is during the least sensitive time of year for these plants. It is not proposed that any ecological monitoring of the seagrass beds is undertaken as part of this assessment unless a potential impact in this area is predicted by the modelling. This is because it is thought that the impact of the dredging works is likely to be concentrated on those organisms living in the main channel. The seagrass beds are located in the shallow water on the margins of the estuary. Any large scale deposition of solids on the seagrass beds would be predicted by the modelling and also picked up by the turbidity monitoring during the trial dredging phase. Additionally, the leaves of the seagrass *Zostera marina* are thought to cease growing in autumn and die back over the winter (although anecdotal evidence suggests that this is not particularly marked in the Salcombe population). The leaves do not start growing again until spring when new leaves form. As mentioned in section 4.0, the seagrass is unlikely to be affected by such short term increase in turbidity.

Seagrass plants are known to stabilise sediments which results in communities adapted to silty conditions being found associated with the seagrass beds. By their nature, these communities are therefore unlikely to be affected by any short term increase in turbidity or suspended sediments although they are likely to be effected if smothering occurs.

## 5.2 Fanshells (*Atrina fragilis*)

To date only a few isolated individuals have been found in the Salcombe estuary, but nevertheless this represents a nationally important population. This large bivalve lives embedded in low inter-tidal and sub-tidal muds, sandy muds or fine gravels. As reported earlier, fanshells are not thought to be sensitive to an increase in suspended solids or to an increase in turbidity (suggested by where they live elsewhere and the MarLIN website). The biggest threat to fanshells is demersal fishing (particularly scalloping) as they are reported to be unable to survive being uprooted. Unless fluid mud pools remained undispersed over these individuals, or significant smothering occurred, these bivalves will not be affected by the dredging operations. For this reason no specific ecological monitoring aimed at this species is proposed.

## 5.3 Other marine benthic fauna and flora

Discussions with individuals from the University of Plymouth and the estuaries officer for the Salcombe estuary together with the SSSI citation have revealed that there are a number of very rich communities within the estuary which potentially could be affected by the dredging activities. Sediment plume modelling will determine which are most likely to be affected and hence enable targeted and cost effective monitoring to be undertaken.

It is envisaged that the model will not show that significant sediment deposition will occur on the inter-tidal sites lower down the estuary such as Castle Rocks. It should therefore not be necessary to conduct pre and post dredge surveys of the rich fauna and flora that occur at Castle Rocks.

Similarly, there are rich communities of benthic fauna and flora present c. 2km north of the entrance to Batson Creek around the Saltstone. This area is one of the few British localities for the red alga *Chondria coerulescens* (which lives in sheltered muddy environments) but also supports a rich invertebrate population. This includes large populations of burrowing worms and bivalves and beds of the Daisy Anemone *Cereus pedunculatus*. On the mud and gravels extensive growths of sponges such as *Hymeniacidon perleve* and *Halichondria bowerbanki* are found together with sea squirts such as *Phallusia mamillata*. Burrowing crustaceans such as the angular crab (*Goneplax rhomboides*) are also found in the mud. Unsurprisingly given the silty nature of the areas close to the Saltstone, these organisms are described by MarLIN as tolerant to increases in suspended solids or turbidity and some, such as the Proboscis Worm and the sponge *Hymeniacidon perleve*, favour silty environments. It might be expected that the Daisy Anemone would be sensitive to siltation, but this organism is adapted to silty environments and can survive smothering by up to 5cm of mud by extending its column to keep the disk above the sediment surface. Given the insensitivity of the organisms present and the distance from the dredging site, it is not proposed that this area is monitored unless results from the modelling exercise indicate significant deposition of dredging spoil in this area.

### **5.3.1 Main Channel benthic fauna and flora**

The other area that contains a very rich fauna within the estuary is the main channel which extends all the way up to the Saltstone. The sediment as far up as Ox Point is mixed containing a large proportion of shells and stones and has communities rich in algae and benthic organisms. It is expected that the model will predict that if any significant sediment deposition occurs, it is likely to be within this area. Similarly, if fluid mud is produced during the dredging operations it might possibly pool in the deeper parts of this channel. For these reasons, it is proposed that the ecological monitoring concentrates on this area.

Discussions with the Area of Outstanding Natural Beauty (AONB) Estuaries Officer, have revealed that the seabed in the main channel although mixed is very stony and might not lend itself to the sampling of the benthic infauna using traditional grabs. In addition to this, the most sensitive fauna in these areas are unlikely to be the benthic infauna (species living within the sediment), but the epifauna (organisms living on the substrate rather than in it) of the area. For these reasons it is thought that the best way of detecting any impact would be with diver surveys. Surveys using a drop down camera are unlikely to provide sufficient spatial coverage or give the quality of data that can be obtained using divers and are therefore not recommended for this task. Two surveys should be carried out, one prior to the beginning of the dredging contact and one approximately one month after the end. (One month is required to enable the estuary to stabilise and ensure that any effect has had sufficient time to cause an impact).

The exact locations of the diver survey will depend on the predictions of the model. However, it is envisaged that a minimum of 4 transects will be required. It is likely that one of these should be in the deep part of the main channel behind the bar, one either side of the entrance to Batson Creek and one across the deep water part of the channel near Scoble point. These positions are marked on Fig 1.

#### **5.3.1.1 Diving Surveys**

The surveys should be carried out using methods consistent with those described in the JNCC's Marine Monitoring Handbook (procedural guideline No.s 3-3 and 3-13. Due to the strength of the tide, these surveys should be carried out during periods of neap tides and/or over slack water periods. A 50 metre transect will be laid across the deepest part of the main channel at each location and firmly anchored at each end (these positions should be recorded accurately using differential GPS to enable precise duplication of each transect after the end of the dredging project). Once laid, the diver(s) follow each transect recording marine fauna and fauna encountered 1.5 metres either side of the transect rope. It has been found that the best results are achieved when the fauna observed and any other observations are relayed directly to the surface via the underwater communication systems rather than recorded on a slate by the diver.

The abundance of the species encountered will be determined using semi-quantitative scales (e.g. SACFOR) immediately after each dive. A video record of the transect will also be made using a high quality underwater video camera. This enables the identification of any species that the diver is unsure of to be made without necessarily requiring the removal of the organism from the seabed. It also provides a permanent record of the transect which is useful when comparing the pre and post dredge transects and enables the divers records to be modulated by one person. The modulation of the

records using the video record enables inconsistencies in identification or abundance estimates commonly found to occur between divers (or diving pairs) to be corrected.

The percentage cover of mud will be estimated at a minimum of 5 pre-determined points along the transect and any pooling or other obvious deposition of sediment recorded. The exact position of any sedimentation or pools of mud observed can be marked by alerting the diving vessel via the voice communications, pulling the SMB tight and recording the position using differential GPS.

The data recorded should then be fully analysed to determine if the dredging has had any effect on the epifauna or on the proportion of the mud visible on the seabed using traditional and multi-variate statistical techniques.

Due to the inherent risks of diving operations, all divers will be commercially qualified to dive under the Scientific code of practice (HSE IV or equivalent qualification) as well as being suitably experienced marine biologists. Risk assessments and diving operations will be carried following the Scientific ACOP. Ecospan will endeavour to use the same dive team for both pre and post dredge surveys to further reduce any potential variability.

## **REPORTING**

All data collected by Ecospan Environmental will be analysed by them prior to the production of a report which will be submitted to Van Oord, Salcombe Harbour Authority and Natural England. The results will be put into the context of the SSSI and the estuary as a whole. Any issues arising from the results of the monitoring surveys undertaken will be discussed. The results and predictions of the modelling exercise will be reported separately by AstraZeneca Brixham, although its output will be discussed within the main report.

## **TIMETABLE**

The amount of time before the proposed start of the dredging operations is relatively short for the amount of work required, both for the modelling and the monitoring. All the fieldwork for the model construction and validation will be completed by the end of January. The pre-dredge monitoring will be completed before the onset of the trial period. It is expected that predictions from the modelling exercise will be available in mid February. It is anticipated that dredging operations will begin at some point during the last week of February or the first week in March to coincide with the smallest tides to be experienced during dredging operations. Post dredging surveys will commence approximately one month after the cessation of dredging.

## **QUALITY ASSURANCE**

Ecospan Environmental Ltd was formed in 2006 as a result of a management buy out of Brixham Environmental Laboratory's (BEL) Field Survey business. The field survey team was originally established at BEL in 1965 to provide environmental support to ICI manufacturing businesses. BEL became part of Zeneca Limited following the de-merger of ICI in 1993 and subsequently AstraZeneca in 1999.

Ecospan have a comprehensive management system to ensure we work to the high standards expected by our customers in line with ISO9001. We undertake all work in accordance with standard operating procedures and recognised national/international guidelines.

## **HEALTH AND SAFETY**

Ecospan Environmental and BEL will carry out Risk Assessments for all operations that will be undertaken during the course of this project. All personnel will be suitably trained and will have

all necessary PPE and safety equipment. All fieldwork will be undertaken from Ecospan Environmental Ltd's 21ft RIB *Pagrus* (MCA coded to category 3) or from one of Salcombe Harbour Authority's licensed vessels.

**FIG 1**  
**Proposed monitoring survey locations for turbidity measurements, particle size distribution, bathymetric and ecological surveys**

