Review of some specific Sediment and Pollution Monitoring related issues in Seaton Channel, Holding basin, Dry Dock and Quays (dredge areas 1 to 4)

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A REPORT TO
Friends of the Earth Hartlepool

From
Tim Deere-Jones
Marine Pollution Consultant

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Introduction:
The proposed development will require a range of activities including construction and dredging in and adjacent to the TERRC (Able UK) site and the Seaton Channel and the subsequent disposal of dredged material, all of which will inevitably give rise to the disturbance and re-mobilisation of inter tidal and sub tidal sedimentary material from those areas.

The disturbance and subsequent mobilisation of the sedimentary material gives rise to a number of specific issues of concern. This Report reviews the following issues:
1: Understanding of Sedimentary regimes for Seaton Channel (and adjacent areas)
2: Baseline pollution data for Seaton Channel and adjacent areas
3: Potential impacts of construction and dredging activity on the re-mobilisation of sediments in Seaton Channel and adjacent areas
4: Potential impacts of 1, 2 and 3 (above) on the distribution and fate of sediment associated pollutants in Seaton Channel and adjacent areas

These issues are reviewed and discussed in the following pages.

1: Sedimentary regimes in Seaton Channel and adjacent areas: historical evidence
1:1 I have been unable to identify any detailed data on the sedimentary characteristics of the Seaton Channel and its adjacent areas.

However, it should be noted that the extensive reclamation of inter tidal and shallow water Tees estuary environments since the 18th century, coupled with an equally extensive programme of construction of flood embankments, sea walls, wharfs and docks means that the estuarine environment has been subject to major ongoing changes for several centuries. It is also important to remember that expected sea level rise (varying according to source), may also drive detectable changes in Tees estuary regimes and that more recent and future proposed industrial or other infrastructure developments will add to the complexity of any attempt to model or predict variations in the nature and speed of change.

1:2 The available data suggest that, in response to the construction and commissioning of the Tees Barrage in 1995, the evolution of the Tees estuary sedimentary regime has indeed become even more complex.
There appears to be a consensus that before 1995 the estuary was approximately 44 kms long from the upper tidal limit to the sea, with a saline intrusion penetrating about 28 km upstream from the estuary mouth.
Ref: "Tees Estuary Present and Future. State of the Tees estuary environment, and strategy into the millennium " Environment Agency. June 199. pages 8 and 9.

1:2 The consensus is that the Tees estuary was a partially stratified (or partially salt wedged) estuary before the commissioning of the barrage, with denser seawater flowing

upstream in a wedge, thicker towards the mouth of the estuary and thinning upstream as the channel bed rises, with the less dense river water flowing over it.
Ref : "Marine Pollution". RB Clark. Oxford University Press. 3rd Edition: 1992. page 12.

1:3: a: In a stratified, or partially stratified estuary some mixing between the fresh and salt water may take place, but the amount of mixing is dependant on the relative speeds and volumes of the two flows.
b: Above the salt wedge the seaward flow of fresh water may be of considerable velocity and the river flow may be the dominant estuarine process. In such a case the river may bring large quantities of fluvial bed load and suspended sediments down into the estuary.
c: As it meets the forward (upstream) tip of the salt wedge the fresh water rises, leaving the bed load behind in the form of a coarse sediment bar, while the fresh water suspended, finer sediment load will continue seaward.
d: When the velocity of the river currents decrease as they emerge from the channel into the wider, seaward extent of the estuary sediments will begin to settle, especially in more sheltered, low energy environments protected from major marine dynamics and the larger tidal scouring effects.
Ref: An Introduction to Coastal Morphology. John Pethick. Pub' Edward Arnold. 1984. pages 167 –191

Thus it would appear likely that prior to the construction of the barrage the low energy environments at the mouth of the Tees estuary have been the area of maximum depositional activity with finer sediment deposits increasing towards the estuary mouth.

1:4 The current consensus is that the construction of the barrage has now effectively reduced the length of the tidal estuary to approximately 18 km length and reduced the upstream limit of the saline intrusion to that distance.

The current understanding is that the differences between surface and bottom measurements suggest that the estuarine system now tends to be more definitely stratified on the ebb tide and to be relatively well mixed during the flood tide.

Consequently it is postulated that "there has been a change to the deposition of highly organic fine sediments in the upper and middle estuary and of coarser, marine derived sediments at Teesmouth, though changes in sedimentation patterns may also be influenced by changes in dredging patterns and methods".
Ref: "Tees Estuary Present and Future. State of the Tees estuary environment, and strategy into the millennium " Environment Agency. June 1999. pages 8 and 9.

1:5 The information given by the references above demonstrate that there can be no doubt that the estuarine hydrology and sedimentary regimes have not been in natural equilibrium for several centuries, that the pace of change continues to be rapid and major, and that the regimes are in a state of continuous flux.

1:6 Sedimentary regimes in Seaton Channel and adjacent areas: the current situation

In purely geographical terms the Seaton Channel/Greatham Creek/Seal Sands area is located towards the mouth of the estuary. However, as the reference given for paragraph 1:4 above explains, it is now believed that sedimentation in the Teesmouth area now consists of "coarser marine derived" material, elsewhere described as "sand" (see later paras)

However, the presence of "marshes", "salt marshes and mudflats" in the Greatham Creek, Seaton Channel area and the repeated description in many documents (e.g.*"Tees Estuary Present and Future. State of the Tees estuary environment, and strategy into the millennium " Environment Agency. June 1999)* of the adjacent Seal Sands and other nearby areas as "inter tidal mudflats" appears to confirm the presence of relatively fine sediments in the area of the proposed developments.

This implies that the Seaton Channel and adjacent areas may not be part of that Teesmouth sedimentary environment where significant deposits of "coarser marine derived" occur and that it may have characteristics which make it quite distinct from "Teesmouth" or the "mouth" of the estuary.

Empirical data derived from field studies in and around the Seaton Channel

1:7 In the late 1980s a geo-technical field-study sunk 15 boreholes in and around the Seaton Channel. 4 holes were drilled in and around the holding basin, 4 along the centre line of the Channel, and three on either side (north and south) of the channel. 12 of the boreholes were drilled through the previous dredged level within the channel.

1:8 With the exception of boreholes No 13 and No 14, the borehole records shows that at "bed level" (sea bed surface) the borehole material from within the holding basin, north and south sides of the channel and through the centre line of the channel, all consisted of "very soft dark grey clayey silt with sulphurous odour and organic material".

These records provide evidence of the presence of clays, silts, organic materials and sulphurous odour, which may be of marine origin and are consistent with sedimentary material found in estuarine fine sediment traps.

1:9 Borehole No 13 was the most seaward one of three drilled on the north side of Seaton Channel. The record for borehole No 13 shows that at "bed level" the borehole material consisted of "loose brown, shelly fine to medium sand with some coarse sand and some sub-rounded fine to coarse gravel and some organic material".

This record provides evidence of the deposition of coarse marine sediments and the material described is not characteristic of estuarine fine sediment traps.

1:10 Borehole No 14 was the most seaward one of three drilled along the centre line of the channel. The record for borehole No 14 shows that at "bed level" the borehole material consisted of "very soft dark grey slightly sandy clayey silt with sulphurous odour and organic material".

This record is somewhat inconclusive. In general the recorded material is consistent with estuarine fine sediment traps. However, the reference to "slightly sandy" material may indicate some slight evidence of coarse marine sediments in the deposition cycle.
Ref: "Tees and Hartlepool Port Authority. Proposed dredging to Seaton on Tees, Cleveland. Report on Site Investigation. Foundation and Exploration Services. March 1989. section 3 and figs 49-82.

1:11 In summary the borehole study showed that (over a decade before the construction of the Tees Barrage):
a: in and around the holding basin all seabed surface borehole material consisted of fine to very fine sediments consistent with estuarine fine sediment traps
b: along the south side of Seaton Channel all sea bed surface borehole records consisted of fine to very fine material consistent with estuarine fine sediment traps
c: along the centre line of the channel, all but the most seaward sea bed borehole material consisted of fine to very fine material consistent with estuarine fine sediment traps
d: the material from the most seaward end of the channel centre line sea bed borehole contained some "slightly sandy" material, possibly of marine derivation, but was otherwise consistent with the fine to very fine material found in estuarine fine sediment traps
e: along the north side of Seaton Channel, all but the most seaward sea bed borehole material consisted of fine to very fine material consistent with estuarine fine sediment traps
f: the sea bed material from the borehole located at the seaward end of the north side of the Channel consisted almost entirely of fine to medium sand with some coarse sand to gravel consistent with marine deposition.
g: only one site shows certain evidence of recent/current deposition of coarse marine sediments
h: one other site shows possible evidence of a slight input of coarse marine derived sediments
i: with the exception of records for boreholes 13 and 14, and given that 12 of the holes were drilled through previously dredged areas, there is no specific evidence of recent significant deposition of coarse marine material and, on the contrary, the evidence implies ongoing deposition of fine sediments which may be of both marine and/or fluvial origin and is characteristic of estuarine fine sediment traps

Durham University Study of Seal Sands

1:12 Appendix 16.1 contained a summary of fieldwork carried out by Durham University. This study concentrated on aspects of sedimentation at Seal Sands, located on the south side of the Seaton Channel.

1:13 Appendix 16.1 reported that the Durham University study showed
a: that, since 1992, inter-tidal surface sampling at 70 sites on Seal Sands showed a systematic change in grain size distribution with sampling showing a trend towards finer

sediments (possibly from dredging operations)
b: that Seal Sands had evidently been accreting sediments since the 1970s
c: analysis of six sediment cores showed net accretion since the beginning of the 20th Century, some showed “sediment disturbance events” believed to be man made
Ref: Durham University 2003.1. for the Environment Agency: summarised in Appendix 16.1 of the EIS

1:14 The Durham study data for Seal Sands appears broadly consistent with the results of the 1989 geo-technical survey borehole records for the south side of Seaton Channel, showing a trend towards deposition of “finer sediments” (an imprecise description but one apparently more consistent with those materials accumulating in estuarine fine sediment traps, than with those “sands” and sandy material normally associated with coarse marine sediment sources).

HR Wallingford reviews.
1:15 Section 6.1 of Appendix 16.1 summarises work by HR Wallingford and refers to what appears to be an estuary wide mathematical/computer modelling exercise in the early 1990s.
This exercise suggested that 90% of Tees estuary siltation was of marine origin, of which 45% was sand.

1:16 The computer study also suggested that
a: “disturbance by storms, shipping and dredging” was a driver for the upstream migration of finer particles
b: 80% of marine sediment entered the estuary during the winter months (October to April)
c: 60% of the transport occurred during 30 days of storm activity
d: most of the material originates from the North Gare Sands on rising tides during such storm events

1:17 Although generally referring to the Tees Estuary in general terms, the Appendix 16.1 summary of HR Wallingford work does make some reference to areas in, or adjacent too, Seaton Channel and reports that
a: Seal Sands is an accumulating “mud bank” (i.e. fine clay/silt/organic sediments),
b: the supply of sand into the Seal Sands area had increased,
c: the elevation of the Seal Sands continues to rise (although at a reducing rate)
d: in the long term Sea Sands may be transitioning into a salt marsh (i.e. rich in clay/silt/organic materials)
e: “at the confluence of Seaton Channel and the Tees, however, an increased rate of deposition (apparently mainly of coarser sandy material) has been noticed, possibly due to changes at the North Gare breakwater“
f: the barrage was not expected to have any significant effects in Seaton Channel, because the tidal volume and circulation would not be affected.

NB. The text of the Appendix 16.1 review of HR Wallingford work is not clear if this evidence is derived from empirical field study work or is derived from computer

modelling.
Ref: HR Wallingford 2002 as summarised in Appendix 16.1 of EIS

1:18 The summary of HR Wallingford computer modelling work suggests some coarse material marine sedimentation influence in the relevant area but fails to provide the following information:
a: percentage increase in volume or rate of supply of sand into Seal Sands or the confluence of Seaton Channel and the Tees
b: percentage of supply of estuarine fine sediments into those areas
c: details of transport and deposition regimes of estuarine fine sediments throughout the Tees estuary, especially during the summer months and non stormy periods and the impact this may have on sedimentary regimes in and around the Seaton Channel

1:19 HR Wallingford Report EX 4514 (2002)
Section 2.3.2 (para 2 page 6) of the HR Wallingford report states that the "Tees and Hartlepool Bays" combined form a "sediment sink" within which the seabed is sandy". This description makes no reference to the presence of silty or clayey material in this sediment sink.

1:20 Section 3.1.8 (para 2 page 15) notes that prior to the 1970s, sand extraction took place on the north side of the Seaton Channel using small grab dredgers and that this continues today using land based plant, in a licensed extraction area of North Gare sands.

Thus it is plain that the presence of sand in this area is not a new phenomenon generated by changes due to the construction of the barrage. Rather it is historical and long term, and may contribute to the sandy material noted in the material recorded in boreholes 13 and 14 by the geo-technical survey conducted in the late 1980s.

1.21 Section 3.1.8also states that "as and when required" dredging had taken place for 3 to 4 decades prior to 1967 in Seaton Channel and Graythorpe Basin and that post 1967 various capital and maintenance dredge works were carried out.
No description of the dredged material has been provided.

1:22 Section 3.1.9 (page 17), records further dredging activity in the Seaton Channel between 1974 and 1980. These included what may have been a capital dredge (extension to the holding basin) and maintenance dredging of the Channel.
No description of the dredged material has been provided.

1:23 A 1976 widening and straightening project in Seaton Channel removed "clay and sand", but no detail is given of the relative percentages of each material, nor of the areas of the channel from which the material was dredged.

Section 3.1.10 (page 17 para 1) reports 1989 maintenance dredging but provides no description of the materials dredged.

1:24 Section 3.1.10 (para 2) describes a "desk" and "mathematical model" study to investigate and establish more accurately the changing siltation patterns within the river Tees estuary.

The result of this mathematical and hypothetical modelling study "concluded that 90% of siltation came from the sea of which 45% was sand. In addition the study also proved that the estuary is strongly stratified which provides the mechanism whereby finer materials move upriver particularly after disturbance by storms, shipping and dredging

1:25 Unfortunately no details are provided of any of the empirical data inputs into this model, which regardless of the efficiency of its calibration, relies on a full suite of local data in order to have any opportunity to provide a fully accurate representation of Tees estuary conditions. Hopefully any future inquiry will permit clarification of this issue, but it should be noted that any reduction in empirical data inputs will mitigate against the production of fully accurate "conclusions" or "proofs".

1:26 It was also noted that 90% of siltation came from the sea of which 45% was sand. In the absence of any reference to clay/silt/organic sediments in the Tees/Hartlepool Bay sediment sink (see 1:21 above), the source and nature of the remaining 55% of siltation needs clarifying. There are several dredge disposal and other dump sites in regional inshore (near coastal) waters which have the potential to input polluted sediments to the Tees system, much near shore marine fine sediment material may also be of fluvial origin. Clarification of these issues will assist understanding of sedimentary and associated pollutant regimes in and around Seaton Channel.

1:27 Sediment data from DNV Report no 2004-1387 rev 01

This DNV report describes modelling studies to assess the impacts on Tees estuary hydrodynamics and sediment transport arising from dredging activity associated with the proposed development.

Since all modelling work requires at least some input data the DNV report offers the following information; "Based on grain size distribution provided by the EA and a previous study (Ref 2) a conclusion was made that the upper most 0 to 50mm of the sediment in Seaton Channel consists of 92% silt/clay and 8 % fine sand (Refs 2 and 12)" *Ref : page 19 of DNV and "Burt et Al : Teesmouth Sediment Study. HR Wallingford EX 4514 2002""*

1:28 The DNV Report does not provide a detailed description of the methodology of the referenced EA and HR Wallingford work, thus there is no knowledge of the number of samples taken, the spatial distribution of sample sites or the empirical justification for the choice of sample sites.

However, the presented data does make it clear that a very high percentage of fine sediment particles (92% silt/clay) appears to occur in the Channel.

1:29 The Wentworth scale, used to provide sediment size analysis classifies sediments in size classes from coarse cobbles and pebbles through to fine silts and clays. Silts are described in classes defined as “coarse”, “medium”, “fine”, “very fine” and “clays” which have a grain size of 0.002mm. Plainly those sediments lying within the clay/silt boundary are among the finest found in estuarine and marine environments.

1:30 The DNV Report also makes reference (page 8) to Chart 9 of the Tees Estuary Dredging Plan which includes Seal Sands, part of Bran Sands, part of N. Gare and Seaton Channel.

DNV (page 9) asserts that the annual average dredge volume for Chart 9 from 1991 to 2001 is found to be 1006,000 cubic metres and therefore calculates that, because the Chart 9 area covers 900,750 square metres, the average deposition rate can be expected to be “in the region of 120mm/year” (12 cms or 4.75 inches).
DNV (page 9) also states “Higher siltation rates can be expected in areas where water velocities are lower, such as the inner reaches of Seaton Channel, the holding basin, and in the dry dock when this is open.

1:31 Plainly the stated sedimentary deposition average of 120 mm per year cannot be a blanket average for the whole area. There can be little doubt that (in the main channel of the Tees and in the vicinity of the “turning circle” where relatively strong tidal and fluvial currents and velocities, combined with the impact of passing and turning vessels, will generate a degree of scouring) sedimentation rates will be notably lower than the proposed 120 mm/year.

On the other hand, in the Seaton Channel, holding basin etc, where velocities are lower, there are also the complicating factors of freshwater input from the Greatham Creek drainage.

1:32 Flocculation.
Fine grain clay and other particles are characterised by having short range attractive forces which, when the distance between them is small enough, causes them to stick together. In fresh water the grains are prevented from coming together by surface charges, which repel each other, but in saline water the effect of these surface charges is reduced. Consequently in saline water where particles are physically brought together, clay sized grains aggregate together to form large agglomerations called flocs. The process of flocculation also generates increased adsorbtion of metals and pollutants such as pesticides (scavenged from the water column) on to the flocs.

Because these flocs are so much larger than their constituent fine particles their settling velocities are increased markedly and, as a result, fine sediment deposition rates are markedly increased.

Any fine grain sediments transported into the Seaton Channel, and it’s adjacent areas, by the Greatham Creek drainage system, will undergo such flocculation and increased adsorbtion of pollutants scavenged from the water column.
Refs: Marine Pollution. R.B.Clark Clarendon Press. 1992 page 12. & An introduction to Coastal Geomorphology. John Pethick Edward Arnold 1984.

1:33 Flocculation also occurs in, and adjacent too, mudflat and marsh areas with high populations of invertebrates. This so-called "organic flocculation" is generated when organisms, which utilise any organic material on or between the grains, ingest fine clay particles. The grains are then excreted as faecal pellets, bound together into flocs, which may be as large as 5mm long. Organic flocs also have relatively high settling velocities and increase the opportunity for fine sediment clay/organic particles being deposited
Refs: Marine Pollution. R.B.Clark Clarendon Press. 1992 page 12. & An introduction to Coastal Geomorphology. John Pethick Edward Arnold 1984.

1:34 The DNV Report (page 9: third para) argues that where water velocities are lower (as in sectors of the Seaton Channel) "higher siltation rates can be expected".

Page 9 of DNV also provides Table 3:3 which offers "estimates" of "expected" siltation rates, which are derived from the outcome of a sediment transport model which is itself based on a mixture of empirical data combined with a series of hypothetical assumptions.

1:35 Despite the range of uncertainties, which have been alluded to in the various studies attempting to provide useable data, it remains evident that the areas which will be subject to dredging/construction activity (Seaton Channel/Holding Basin etc) are indeed
a: areas of fine sediment deposition, where deposition may include the products of flocculation
b: that those sediments consist of 92% silt/clay particles which are the finest to be found in suspension in the marine/estuarine water column
c: that average sedimentation across the Chart 9 area are physically significant at 120mm/12cm/4.75 inches/year and that they are probably higher (above average) in the Seaton Channel etc
d: that the Seaton Channel/Holding Basin areas are lower energy environments (reduced velocities) compared to the main channels of the Tees estuary
e: that there can be little doubt that the Seaton Channel/Holding Basin area (those areas proposed for capital and maintenance dredging) are sediment traps where relatively high volumes of fine sediments and their associated (by adsorbtion) pollutants will be re-concentrated following their deposition.

1:36 Sedimentary and Siltation Regimes in Seaton Channel and its adjacent areas: summary and conclusions
Although there is a body of reportage concerning aspects of sedimentation through the general environment of the Tees Estuary, much of this consists of "modelling", which is hypothetical work based on restricted data inputs and thus inferior to detailed, site specific empirical research.

This report notes that the reviews of sedimentation modelling work provided by the EIS and it's supporting documents, do not provide full details of the either the empirical data which was input to the model or of the methodologies used, thus the

accuracy of "modelled" results cannot be assessed.

1:39 This Report has found no evidence of specifically detailed empirical, field studies of sedimentation within the Seaton Channel/Holding Basin/Greatham Creek area. As a result of the failure to carry out such work the following issues remain unknown:
a: the source and history of fine silt/clay particles causing re-sedimentation in the Seaton Channel area
b: whether or not that material has come straight in from the sea and been rapidly deposited in the Seaton Channel, or whether it has entered the estuary via the Greatham Creek or River Tees freshwater systems
c: whether or not any of this material originate from offshore dump/disposal sites where inputs of polluted material are relatively high
d: what is the residence time of fine clay/silt suspended particles (from whatever source) in the water column and the sedimentary environments and, during that residence time, have those particles had the opportunity to scavenge, adsorb and re-concentrate those pollutants identified as being endemic to the Tees Estuary
e: whether the Seaton Channel/Holding Basin etc fine clay/silt material has been deposited elsewhere within the system, prior to re-suspension and subsequent transport into the Seaton Channel
f: what is the relationship between the Seaton Channel etc sedimentation regime and that of the wider Tees estuary system.
g: what is the effect of flocculation (both types), and it's associated increased adsorbtion of pollutants, on sedimentation regimes in the Seaton Channel and its adjacent areas.

2: Required Parameters for Devising Sediment Pollution surveys.

2:1 When devising pollution surveys in estuarine areas where construction, capital dredging and maintenance dredging activity are planned, there must be a sound justification for the methodology chosen for the survey work. The essentials are set out below.

2:2 Given the understanding that the finer grained sediments deposited in a polluted estuary will preferentially re-concentrate pollutants present in the water column, a full and adequate understanding of the grain size distribution of the development area is required.

Such work will provide a detailed description of where, within the development area, the finest and coarsest sediments are to be found and thus also indicate where higher and lower concentrations of sediment associated pollutants will be sequestered.

This will permit accurate targeting of those sediments most likely to hold both higher and lower concentrations of the pollutants in question, thus permitting the development of an accurate methodology capable of reporting the true pollution loadings of the range of sediment sample sites requiring sampling.

N.B. In the limited documentation studied, this Report finds no evidence of a thorough, area wide (Seaton Channel, Holding Basin, Dry Dock etc) survey and analysis of grain size distribution, which would facilitate such an accurate methodology. It may well be that the developers can identify such work, however, in the absence of such work, it might be assumed that any sampling points have been chosen on a spatial, or possibly random, basis, rather than on any more appropriate criteria.

2:3 In the context of a site where polluting activities are intrinsic to a proposed development (storage of decommissioned vessels, ship breaking) and where pollution may also enter the area from non-local sources (transported in the water column both dissolved in the water and adsorbed onto particles suspended in the water column) a thorough understanding and reportage of baseline pollution, generated from detailed survey, sampling and analytical work, is required.

Such work needs to be both site specific (the development area) and upstream/downstream relevant (the Tees estuary, Tees River, offshore associated sediment cell and Teesmouth).

These issues are reviewed below.

Baseline Pollution Data in Tees Estuarine sediment
Over several decades, as part of both continuous and "one off "projects, MAFF and CEFAS have conducted a series of pollution surveys of the Tees estuary and its associated marine environments. This work has included sampling of water, suspended sediments and sedimentary deposits for a wide range of industrial and municipal pollutants and a number of bioassay studies. Some of this work is summarised below.

2:4 Hydrocarbon and PAH Concentrations in Tees estuarine sediments
In June 1990, MAFF carried out a nation wide survey of UK estuarine sediments for Total Hydrocarbon Concentrations (THC). Analysis of 5 Tees estuary sediment samples showed concentrations of THCs ranging from **13 to 570** micrograms per gram.

2:5 The highest concentration found in River Tees sediments (**570** micrograms per gram) was found in a sample described as:
sample 17: (54 degrees 37.12'N : 1 degree 9.32'W) Tees/middle estuary:
visual inspection recorded this sample as "mud".
This sediment sample held the third highest concentration of the 69 samples analysed from major UK estuaries.

2:6 The second highest concentration (**96** micrograms per gram) was recorded in a sample described as "sand and mud".
The sampling results illustrate a typical tendency for hydrocarbons to preferentially associate with estuarine fine sediment deposits.

2:7 It was noted “these concentrations should be seen against the recently adopted OSPARCOM “No Observed Effect Concentrations (NOEC) for oil in sediment around offshore oil and gas installations of 10 micrograms per gram or 2 – 3 times background levels.”

Ref : Aquatic Environment Monitoring Report No 30. MAFF Directorate of Fisheries Research. Pub’ 1992. pages 31-33.

2:8 PAH in surface sediments

between 1993 and 1996 a total of 95 samples from 77 UK estuarine and marine sites were analysed for Polycyclic Aromatic Hydrocarbons.
Results for Tees sediments were as follows:
Redcar Jetty : :June 1993 : Mud : sum of 10 PAH = 15,030 micrograms per Kg (dry weight)
Bamletts Bight : June ’93 : mud ; sum of 10 PAH = 21,578 micrograms per Kg (dw)
Preston Park : August ’96 ; mud : sum of 10 PAH =581 mcg per kg (dw)
Victoria Bridge ; August ’96 : gravel and mud : sum of 10 PAH=4,035 mcg per kg (dw)
North Gare: August ’96 : mud : sum of 10 PAH=7,817 micrograms per kg (dw)

Of the 95 UK wide samples analysed for 10 PAHs, the Tees estuary, Bamletts Bight, site held the fifth highest concentrations in the UK. The discussion of results (para 9.4) noted the association between high PAH levels and “fine” and “muddy” sediments.
Ref Aquatic Environment Monitoring report No 51. CEFAS 1998 pages 39 and 44 to 46

2:9 Metal Concentrations in Tees sediments

During 1991-1992 water samples were collected from 147 UK estuaries and offshore stations and filtered. Both the water and the filtered suspended sediments were analysed for trace metals.

The Tees estuary sample results were taken from 4 sample stations including that station described as “54 degrees 37.12’N : 1degree 9.32’W (No15 Buoy)”. Samples taken from this site were described as “sediment type Mud” i.e. relatively fine sediments. Although individual site results were not given, sample result ranges were provided, as was the “mean” result.

2:10 Results from the Tees estuary were as follows :
Copper in water samples :
range =1.3 to 10.30 micrograms per litre, mean=3.80 micrograms per litre. This result was the highest concentration for copper in water from the 147 samples
The Environmental Quality Standard (EQS) for copper (5 micrograms per litre) was exceeded at one of the three stations sampled in the Tees Estuary (unfortunately the relevant table did not specify the sample station number).

Copper in suspended particulates:
Range = 60.9 to 139.1 milligrams per kg, mean =106.3 mg per kg. This result was the highest concentration for copper in suspended particulates from the 147 samples.

2:11 **Lead** in water samples:
Range = 96 to 815 nano grams per litre, mean = 460 nano grams per litre . This result was the second highest for the 147 stations.

Lead in suspended particulates:
Range= 109 to 317 milligrams per kg, mean= 203 mg per kg (third highest for the 147 stations)

2:12 **Cadmium** in water samples:
Range= 20 to 42 nano grams per litre, mean= 30 nano grams per litre (third highest concentration of 147 stations)
Cadmium in suspended particulates
Range=0.64 to 5.44 mg per kg, mean=2.29 mg per kg (second highest concentration of 147 stations)

Ref : Aquatic Environment Monitoring Report No 36. MAFF Directorate of Fisheries Research. Pub' 1993. pages 24 to 26.

2:13 Further metal sampling studies of sediments from UK east coast estuaries were carried out in 1992/93.
The AEMR No 44 did not provide full details (i.e. concentrations) of the results. However, it was reported that highest values for Copper and Chromium were recorded from the Tees estuary and attributed to industrial discharges.
Ref : Aquatic Environment Monitoring Report No 44. MAFF Directorate of Fisheries Research. Pub' 1995. pages 21 to 23.

2:14 Further analysis of metals in estuarine, intermediate and offshore sediments was carried out through 1995 and 1996. Results were not tabulated but some were provided in chart format with area proportional symbols. Precise geographical location of samples sites was not provided, nor was the number of sample sites in each estuary.

2:15 Given results for the '95/'96 survey were as follows :
Mercury : "relatively high Hg concentrations were present in sediments from the Tees, Thames and Tamar"
Cadmium : "Relatively high Cd concentrations were present in the Tyne, Tees, Thames, Tamar and Mersey."
Arsenic : "Relatively high As concentrations were present in sediments from the Tees, Humber and Tamar". The study noted that it was not possible to tell the relative significance of natural and anthropogenic sources.
Chromium : "Of particular note are the relatively high concentrations in sediments from the Tees." Figure 23 area proportional symbols indicate that the median (middle) value of Cr in the Tees sediments was 420 mg per Kg.
Copper : "Relatively high concentrations of Cu were present in sediments from the Tyne, Tees and Tamar estuaries". The study noted that it is unclear how much of this material is from anthropogenic sources and how much from geological sources.

Lead : Figure 24 area proportional symbols indicate that median value for the Tees was 43 mg per Kg
Zinc : "Relatively high concentrations of Zn in sediments were present in the Tyne, Tees and Tamar estuaries"

Ref : Aquatic Environment Monitoring Report No 51. CEFAS. Published 1998. pages 35 to 37.

2:16 Triazine herbicides in Tees estuarine water
(Simazine and Atrazine**)** have been widely used as pre-emergent and post emergent herbicides for agricultural and (in lower volume) garden use. Both were on the UK Red List of substances, inputs of which the government was committed to reduce by up to 50% by 1992. Triazines were also included in the list of determinands of the Marine Pollution Monitoring Management Group for study in marine waters.

2:17 Survey results for 1990 and 1991 showed that both determinands were present in Tees estuary water in both years, thus demonstrating the possibility that other agricultural chemicals may also be present.
Ref : Aquatic Environment Monitoring Report No 36. MAFF Directorate of Fisheries Research. Pub' 1993. pages 27 to 29..

2:18 Organochlorine and insecticide contaminants in sediments
During 1990 MAFF collected surface sediments from 122 estuarine and marine sites in the UK and carried out analysis for their chlorinated biphenyls residues. Guideline concentrations for chlorinated biphenyls in sediment were presented as follows :
Less than 0.2 micro grams per kg = contamination not detectable
0.2 to 20 micro grams per kg =slightly contaminated
21 to100 micro grams per kg = contaminated
more than 100 micro grams per kg = heavily contaminated.
This 1990 survey was considered to have provided "some preliminary information on the levels of chlorinated biphenyls in marine sediments".

2:19 Four samples taken from the Tees estuary sediments were found to contain chlorinated biphenyl residues ranging from :
2 samples showing less than 0.2 micro grams per kg (below detectability) and :
1 sample containing 0.51 micro grams per kg and 1 containing 4.6 micro grams per kg (both classed as slightly contaminated).
Once again the highest contamination loadings were identified in samples taken from sample site "54 degrees 37.12'N : 1degree 9.32'W (No15 Buoy)". Samples taken from this site were described as "sediment type Mud" i.e. relatively fine sediments.

2:20 The identification of contamination levels of these chlorinated biphenyls in Tees estuary fine sediments indicates the possibility of the presence of agricultural pesticides.
Ref : Aquatic Environment Monitoring Report No 36. MAFF Directorate of Fisheries Research. Pub' 1993. pages 37 to 41.

2:21 Through ’95 and ’96 analysis of “Organic Contaminants” (Organo chlorines) in 61 near and off shore sediment sites in UK coastal waters was carried out.
Positive (above detection levels were recorded for some compounds at the near shore site described as “Off Tees (54 degrees 44.03’N : 0 degrees52.97’ W)”.

2:22 Positive results for the Off Tees site sediments included those for:
a: Chlorobiphenyls(ICES 7 determinands), Chlorobiphenyls (11 determinands selected for National Monitoring Programme)
A positive result for Chlorobiphenyls (sum of 25 determinands) was also recorded at this site, where the concentration of 4.63 micrograms per kg was the 6th highest found among the 61 UK wide samples.
b: Hexachlorocyclohexanes (HCH), chlorinated hydrocarbon insecticides :
alpha HCH: which was present in concentration of 0.19 micrograms per kg (4th highest conc. found in 61 UK wide samples).
Gamma HCH (lindane) which was present in concentration of 0.2 micrograms per kg (6th highest conc. found in 61 UK wide samples)
c: Hexachlorobenzene (HCB) wood preservative/seed dressing was present in concentration of 0.49 micrograms per kg (highest concentration found in 61 UK wide samples)
d: Dieldrin and DDT compounds (insecticides) were also detected in the Off Tees samples
Ref : Aquatic Environment Monitoring report No 51. CEFAS 1998. pages 39 to 43.

2:23 In 1998 a study of 922 measured concentrations of a total of 25 chlorinated biphenyls in dredged sediments at various coastal, estuarine and dock sites in the UK to investigate temporal changes of 25CB concentrations in sediments, was reported

The study noted that “several sites showed an increase in median concentrations of 25CBs over the last decade”. The River Tees is positioned second in the list of such sites.

The River Tees is positioned second in the list of sites where the highest concentrations of 25CBs in dredged sediments were measured.

2:24 It is noted that “Sea disposal of dredge sediments is only acceptable for low level concentrations and therefore dredging sites that contain high and consistently high PCB levels have limited options for disposal of dredged material. In these situations, it is important to investigate whether contamination is historic or is a result of continuing practices locally”

2:25 It is also noted that the elevated concentration of CB in the Blyth estuary was “a specific case where current ship breaking practices resulted in sediments being heavily contaminated with PCBs in a particular section of the river. The area was excluded from the sea disposal license and the contaminated sediments were removed to landfill”.

2:26 It is also noted that “Further monitoring of heavily contaminated sites is required to determine the spatial distribution of PCBs, the congener profiles and changes of PCB

concentrations over time. These compounds will remain a problem for future monitoring of dredged sediments and DEFRA will need to continue to measure PCBs before a license is approved for sea disposal"
Ref: Aquatic Environment Monitoring Report 1998. No 53. CEFAS. Published 2001. pages 55 to 57.

2:27 APEO Endocrine disrupters in Tees Estuary environment
Alkyl phenol polyethoxylates (APEOs) are industrial surfactants widely used in commercial, industrial and household applications. Breakdown products of APEOs include nonylphenol and the related octylphenol. Nonylphenol has been shown to be toxic to marine and freshwater species, to induce an estrogenic response (sex change) in male fish and to bio-accumulate in aquatic organisms.
In 1993 MAFF carried out a survey of concentrations of these contaminants in water from 24 stations in 7 UK estuaries.

2:28 Results of the survey demonstrated that over 80% of the samples contained less than 0.1 micro grams per litre of total nonylphenol and that concentrations in all estuaries (except the Tees) were 2 to 3 orders of magnitude below those which produce chronic or acute toxic effects in both fish and invertebrates and the biological impact was expected to be low.

2:29 However, the Tees concentrations were described as "considerably higher and approaching chronic effect levels". (i.e. 2 to 3 orders of magnitude higher than those in other sampled estuaries).
4 stations in the Tees were sampled. Highest concentrations were found in water taken from Redcar jetty and Portrack Outfall.

2:30 These concentrations were attributed to industrial discharges from Billingham and Wilton which contribute to the fact that "the Tees probably receives one of the largest alkylphenol inputs of any estuary in the UK".

2:31 It was also reported that up to 4milligrams per gram (dry weight) of nonylphenol had been found in digested sewage sludge. This finding suggests that alkylphenols might be also be found in association with estuarine sediments, possibly in association with the organic fraction.
Ref : Aquatic Environment Monitoring Report No 44. MAFF Directorate of Fisheries Research. Pub' 1995. pages 18 to 20.

2:32 In1998, 44 sediment samples from a range of UK offshore, coastal and estuarine sites were analysed for their alkylphenol concentrations. Samples were analysed for their Nonylphenol, Octylphenol and their mono- and di- ethoxylate breakdown products.

2;33 In almost all UK samples, concentrations of Nonylphenol were below the LOD (Limit of Detection) of 0.2 micrograms per gram. The only exceptions were the 9 samples taken in, and adjacent to, the Tees estuary, where all sites exceeded the Nonylphenol LOD. Thus the Tees was demonstrated to hold far and away the highest concentrations of NP (nonylphenol) measured in a UK estuary.

2:34 The highest concentration was observed in sediments from the site "Tees – Outfalls" where the concentration was 42 micrograms per gram (i.e. 210 times greater than the LOD and at least 210 times greater than the concentrations found in any other sampled estuary).

Second highest concentration was observed at site "Tees – Ramp Outfall" where the concentration was 13 micrograms per gram (i.e. 65 times greater than the LOD and at least 65 times greater than concentrations in any other sampled estuary)

Third highest concentration was observed at site "Tees – No 23 Buoy" where the concentration was 8.6 micrograms per gram (i.e. 43 times greater than the LOD and at least 45 times greater than concentrations in any other sampled estuary)

Fourth highest concentration was observed at site "TBT Tees Transect – TE8" where the concentration was 7.1 micrograms per gram (i.e. 35.5 times greater than the LOD and at least 35.5 times greater than concentrations in any other sampled estuary)

The remaining five concentrations ranged from 2.8 micrograms per gram (14 times the LOD) down to 0.2 micrograms, just above the LOD.

2:35 The discussion section of this study noted the following :
a: "Significant concentrations of alkylphenols have been found in the Tees estuary"
b: "The Tees is an ideal candidate for examination" of alkylphenols "as it has a concentration of industrial activity"
c: NP is not detected in adjacent out estuary areas such as Tees Bay, possibly because these areas are sandy and hold little organic matter, or because transportation of NP out of the estuary is very poor and contamination is contained within the estuary
d: the Tees estuary should be further monitored
e: more sites within the estuary (high and low flow rates) should be sampled to provide a clearer picture of the transportation of contaminants.
Ref: Aquatic Environment Monitoring Report 1998. No 53. CEFAS. Published 2001. pages 12 and 13.

2:39 Further work on APEOs in UK estuarine, inshore and coastal waters was carried out by CEFAS through 1999 and 2000. 89 sites were sampled during the course of two research cruises.

Previous studies had identified the Tees estuarine environment as a significant site for APEOs (see 7.8 above). Consequently the 1999/2000 study investigated 23 sites within the estuary and a further 26 sites in the offshore zone adjacent to the estuary mouth. Nonylphenol was consistently the most significant of the APEOs detected in terms of environmental concentrations.

2:40 At the time of this study, there was no identified "safe" level of alkylphenols and

their ethoxylates in sediments.
In almost all of the UK samples nonylphenol was found to be below the 0.19 micrograms per gram LOD (Limits of Detection), except for those taken in, or adjacent to, the Tees Estuary.

2:41 Within the Tees estuary 23 sites were sampled, all of which held concentrations of Nonylphenol markedly higher than the LOD. The lowest “in-estuary” concentration (0.25micrograms per gram or 1.3 times the LOD) was found at one of the two Seal Sands sites. The highest concentration was found in the sample from the Tees outfall (30 micrograms per gram : 158 times greater than the LOD)
N.B. the second Seal Sands sample had 9.3 micrograms per gram of Nonylphenol, 49 times greater than the LOD.

2:42 In the “inshore dredge disposal” zone, 15 sites were sampled. All of the samples returned results above the LOD. Concentrations ranged from 0.36 micrograms per gram (1.9 times greater than LOD) to 3 micrograms per gram (15.8 times greater than the LOD.

2:45 In the offshore “general” zone adjacent to the Tees estuary 11 samples were tested for their APEO content. In 3 of those samples, above LOD levels of nonylphenol were detected. Above LOD levels ranged from 0.27 micrograms per gram (1.4 times greater than LOD) to 2.33 micrograms per gram (12 times greater than the LOD)

2:46 This study concluded that “Significant concentrations of alkylphenols” were found in the Tees estuary and at dredge disposal sites outside the mouth of the Tees.

A sediment core sample was taken at the dredge disposal site and analysed in 2cm sections. This demonstrated that Alkylphenols were found at concentrations above 1 micrograms per gram (5 times the LOD) at depths of up to 16cm. The study reported that the “depths of alkylphenols in this core sample would indicate that normal transport and mixing processes are being inhibited, and alkylphenols are being built up in the sediment”.
NB: Regrettably this (last) work was not carried out at an in-estuary site in order to discover whether or not similar processes were under way within the Tees estuary.
Ref : CEEFAS Aquatic Environment Monitoring Report 1999-2000. No 54. Published Lowestoft 2003.pages 11 to 18.

2:47 PBDE (Poly brominated diphenyl ether) flame retardant chemicals in the Tees estuary

PBDEs have been widely identified in marine environmental media including fish, shellfish, marine top predators (cormorants), and sediments. The Ospar Convention for the protection of the Marine Environment of the N.E. Atlantic identifies PBDEs as “chemicals of concern” described as “persistent, bio-accumulative toxicant” and points to concerns regarding the reproductive effects, developmental hazards, nervous system toxicity and carcinogenic potential.

2:48 A 1999-2000 CEFAS study investigated concentrations of residues of selected PBDE congeners in sediments and biota from the River Tees and the Tees Estuary. The CEEFAS study does not identify impacts of PBDE on the marine ecology, nor does it discuss, identify or recommend “safe level” concentrations of PBDE in any environmental medium.
However, from Tables 8 and 9 in the relevant document it appears that the LOD ranges between 0.05 micrograms per kg and 0.2 micrograms per kg (determining factors for this are uncertain).

2:49 The great majority of the 38 samples taken from the Tees estuary (between the Tees Barrage and the offshore site “NMMP 295 : Off Tees” contained detectable concentrations of at least one PBDE congener. Most samples contained detectable concentrations of several, or all, congeners.

2:50 High concentrations were reported in sediment samples from the upper, or inshore end of the estuary.
a) For the sum of the 14 PBDE congeners commonly analysed for by CEEFAS, the three highest concentrations were:
1: Bamlett’s Bight (mid channel) = 61 micrograms per kg
2: Bamlett’s Bight (north channel)= 52 “ “ “ “
3: Tees Storage Company =42 micrograms per kg

b) With regard to the congener BDE209 the three highest concentrations in this sector of the estuary were:
1: Bamlett’s Bight (mid channel) = 378 micrograms per kg
2: ICI North Tees terminal mid-channel =327 “ “ “
3: Tees Storage Company =306 “ “ “

2:51 Even higher concentrations were reported in sediment samples taken from the lower end of the estuary.
a) for the sum of the 14 PBDE congeners, the three highest concentrations were
1: Off Bran Sands mid channel =92 micrograms per kg
2: East of No 15 Buoy south bank =84 “ “ “
3: Shell Oil jetty north bank =66 micrograms per kg

b) With regard to the congener BDE209, the three highest concentrations in this sector of the estuary were:
1: Entrance to Dabholm Gut =1400 micrograms per kg
2: East of No 15 Buoy south bank =812 “ “ “
3: East of No 15 Buoy mid channel =281 “ “ “
6:6 This study reports that
a) PBDE concentrations increase markedly in the Tees estuarine environment compared to those in the Tees freshwater environment
b) BDE 209 concentrations in the estuarine environment were often (but not exclusively) higher than the sum of the 14 BDEs
c) Concentrations were highly variable (probably due to a combination of diffuse

and point source inputs, and the varied nature of estuarine sediments (gravels, sands, silts etc)

d) Outside the estuary, BDE levels generally declined quite rapidly in the coarser/sandier sediments, although there were localised pockets of elevated levels

e) There was some evidence of elevated levels of BDEs in the main Tees "dredge spoil" disposal ground

NB: It may be deduced from this material that finer sediments hold higher concentrations of PBDEs than coarse sediments.
Ref: Aquatic Environment Monitoring Report 1999-2000. No 54, CEEFAS. Lowestoft 2003. pages 21 to 31.

2:52 Dioxin and dioxin like compounds in the Tees estuary
Through 2002/2003 35 samples were collected from 7 UK estuaries in order test them for the presence of dioxin and dioxin like compounds. The sediment samples were tested by using the DR-CALUX bio-analytical technique to identify and generate a TEQ (toxic equivalent\) value relative to the most active dioxin compound TCDD.

2:53 All samples gave positive TEQ values, above the detection limit. However, the study noted that "The UK does not currently have an Environmental Quality Standard (EQS) or other formal risk evaluation for dioxins in sediments" and quoted guideline TEQ values from other jurisdictions as follows :

Canada	= 0.825 nano grams per kg	
USA	= 2.5	ng per kg
Netherlands	= 13	ng per kg

2:54 6 sites were sampled in the Tees estuary and individual results were as follows:

Site TE1 (lower estuary : closest to sea)	= 15	ng per kg
Site TE2	= 07.8	" " "
Site TE3	= 27	" " "
Site TE4	= 42	" " "
Site TE5	= 88	" " "
Site TE6(upper estuary furthest from sea)	=35	ng per kg

2:55 It will be noted that all the Tees sites exceeded the Canada, USA and Netherlands guideline TEQ values (except TE2 which did not exceed the Netherlands guideline value).
NB: The 88 ng per kg TEQ value for the TE5 sample was the second highest individual sample TEQ value recorded during the study. The mean TEQ value of the Tees estuary sites was also the second highest mean TEQ value

2:56 A further survey was conducted on the Tees estuary in order to further study the variability in a single estuary. Five replicate samples were collected at each of four sites within the estuary. Mean results were as follows:
Mean: site Tees A (upper estuary : distant from sea) = 45 ng per kg TEQ

“ : site Tees B	= 10 ng per kg TEQ
“ : site Tees C	= 38 ng per kg TEQ
Mean: site Tees D (lower estuary; nearer to sea)	= 27 ng per kg TEQ

2:57 It will be noted that each of these Tees sites also exceeded the Canada, USA and Netherlands guideline TEQ values (except Tees B which did not exceed the Netherlands guideline value).

In the context of these, and the other results of the study, it is stated that sediments from such sites

a) “could cause adverse effects in sensitive organisms” and
b) that a range of “compounds with dioxin like activity” (other than TCDD) are also contributing to the observed TEQs

Ref : Aquatic Environment Monitoring Report 2002-2003. No 57. CEEFAS. Lowestoft 2005. pages 31 and 32.

2:58 Bioassay studies on biological effects of Tees estuarine sediments

MAFF used the oyster embryo bioassay over a number of years for monitoring biological water quality in estuarine and coastal waters. Sediment test samples consist of 200ml of sediment and 500ml of water, shaken for 3 hours. Developing oyster embryos are added to the test samples and exposed for 24 hours.

2:59 Percent Net Response figures (PNR) indicate water quality. Low PNRs indicate similar responses to that of control samples and low impact on the oyster embryos. Higher PNRs indicate increasingly toxic concentrations. A PNR value of 100 occurs when the sample is highly toxic and all embryos have died or shown abnormal development.

2:60 Such bioassays were carried out in Tees estuarine sediment samples in 1990 and 1991.
The highest Tees sediment PNR for 1990 was **66.1** and the highest for 1991 was **100.0**
Both samples were taken from the same area, which was described as sample site “54 degrees 37.12’N : 1degree 9.32’W Tees/middle estuary”. Samples taken from this site were described as “sediment type Mud” i.e. relatively fine sediments.
Ref : Aquatic Environment Monitoring Report No 36. MAFF Directorate of Fisheries Research. Pub’ 1993. pages 13 and 14.

2:61 Oyster embryo sediment elutriate, quality bioassay studies were carried out between 1990 and ’94 in order to assess sediment quality at 89 intermediate, offshore and estuarine sites which were sampled once per year between May and October.
(Sediment elutriates are prepared by mixing sediments with “reference seawater” for 3 hours, filtering the slurry and bio assaying the resulting filtrate or elutriate).

Percent Net Response figures (PNR) of :
below 20 = good sediment quality elutriate
between 21 and 49= slightly impaired

between 50 and 99 substantial deterioration
PNR of 100= very poor.

2:62 Between 1990 and ’94 six Tees estuary sites were sampled.
With a PNR value of 28.8 in 1994, the Bamlett’s Bight sediment elutriate was found to be slightly impaired
With a PNR value of 85.2 in 1992, the No 25 Buoy sediment elutriate (which was not bio assayed in any other year was found to be substantially deteriorated
With PNR values of 66 (1990), 100 (1991) and 100 (1992), the Redcar Jetty elutriates were found to be substantially deteriorated in 1990 and very poor in 1991 and 92.
(The Redcar Jetty result for 1994 was below PNR 16.8. No explanation was offered for this sudden decline in PNR)
Nevertheless, through the previous years, the consistency of the results for the Tees demonstrate that, of the UK estuarine sediment elutriates studied, the Tees sediments appear to generate the greatest biological impact.

2:63 It is reported that: “The consistency of the results provides strong evidence that these sediments are probably sufficiently contaminated to be causing significant adverse biological effects.”
Ref : Aquatic Environment Monitoring Report No 51. CEFAS Lowestoft. Pub’ 1998. pages 47 to 49.

2:64 Whole sediment bioassays using Arenicola marina and Corophium volutator
In 1993 MAFF carried out two whole sediment bioassay surveys of estuarine and marine sediments (using the lugworm Arenicola marina and the amphipod Corophium volutator) taken from 41 stations around the UK coast. Both species can be found in estuarine intertidal sediments. The tests involved “whole sediment” methods using animals which were exposed for 10 days to sediments taken from the sampling stations.

2:65 Of the 41 stations, sediments from only three were found to be acutely toxic to the lugworm Arenicola marina.
Two of these were from the Tees estuary : those from Redcar Jetty generated 100% mortality of test animals, those from ICI No 4 buoy generated 33% mortality.

2:66 Of the 41 stations only two (both from the Tees estuary) were found to be acutely toxic to the amphipod Corophium volutator : those from the Redcar jetty generated 100% mortality of test animals, those from ICI No 4 Buoy generated 93% mortality.
Ref : Aquatic Environment Monitoring Report No 44. MAFF Directorate of Fisheries Research. Pub’ 1995. pages 9 and 10.

2:67 Further sediment bioassay work was carried out in 1994, using the same methodology and the same lugworm and amphipod species described above. 46 sediment stations were sampled.

2:68 Of the 46 stations only four showed acute toxicity to the amphipod Corophium volutator. Of those four, the two from the Tees estuary generated the highest mortality. Redcar Jetty showed 100% mortality and the offshore zone described as Tyne/Tees showed 60% mortality.

2:70 Of the 46 stations sampled none generated an acute lethal response to the lugworm, Arenicola marina . 18 produced a non acute, but chronic level of impact.
Of these, the Tees sampling station described as “Tees (anchor)” generated a 33% mortality of test animals (the second highest mortality percentage recorded in the survey)

The Tees sampling stations described as Tees Redcar Jetty and Tees Phillips approach buoy both generated a 27% mortality of test animals (among the third highest mortality percentage recorded)
Ref : Aquatic Environment Monitoring Report No 47. CEFAS. Published 1997. pages 7 & 8.

2:71 Other whole sediment Arenicola bioassays were carried out between 1992 and 1995. These bioassays were conducted on sediment samples from 81 UK Offshore, inshore and estuarine sampling sites.
For the Arenicola bioassay sediment samples were collected from six stations on the Tees estuary and ten samples were successfully bio assayed, two in 1992, five in 1993 and three in 1995.

2:72 At Redcar Jetty sediments were bio assayed every year and on 2 occasions (’92 and ’93) no animals survived (i.e. the sediments proved toxic to 100% of animals exposed).
On a further occasion (’95) all animals survived but feeding activity was severely impaired (56% Reduced Casting) thus “showing substantial deterioration in sediment quality”.
Feeding activity was also adversely affected in sediments taken and bio assayed from
“No 25 Buoy” = 52% Reduced Casting
“Tees anchor” = 53% RC
“ICI No 4 Buoy” =100% RC associated with 33% mortality.

These results, especially those for Redcar Jetty showed that (in the quoted years) the Tees Estuary sediments proved to be the most toxic to Arenicola (lugworm) of those UK estuaries sampled.

2:73 Other whole sediment Corophium (amphipod) bioassays were carried out between 1992 and 1995. These bioassays were also conducted on sediment samples from 81 UK Offshore, inshore and estuarine sampling sites.
For the Corophium bioassay sediment samples were collected from seven stations on the Tees estuary and fourteen samples were successfully bio assayed.

2:74 The Redcar Jetty samples from 1993 and 1994 showed 100% mortality of test animals (i.e. very poor sediment quality). These results demonstrated that the Tees estuary sediments (in the quoted years) were the most toxic to Corophium (amphipod) of

those UK estuaries sampled.
It was noted that when Redcar Jetty samples where bio assayed in ’92 and ’95 they showed good sediment quality. (It was suggested that this may have happened because the samples were not taken from identical locations and that sediment toxicity can change over very small distances i.e. less than 1.5m)

2:75 The 1993 sample from ICI No 4 Buoy showed 93% mortality of test animals (described as “a substantial deterioration” of sediment quality). These results demonstrated that the ICI No 4 Buoy sediments (in the quoted years) were the second most toxic to Corophium (amphipod) of those UK estuaries sampled.

The 1994 sample from Bamlett’s Bight showed 47% mortality (also described as “a substantial deterioration” of sediment quality), although it was noted that this result was not statistically different from the control. Nevertheless, this result showed that (in the quoted year) the Bamlett’s Bight sediments were the third most toxic to Corophium of those UK estuaries sampled.
Ref : Aquatic Environment Monitoring report No 51. CEFAS. published 1998. pages 49 to 56.

2:76 Radioactivity in the Tees Estuary
Since it’s commissioning in 1983, the nuclear power station at Hartlepool (powered by twin AGR reactors) makes direct discharges of radioactive liquid effluent and waste to Hartlepool Bay and the River Tees. Gaseous radioactive wastes are also discharged from the stations chimney stacks (some of this material may “wash out” or “fall out” from the discharge plume and also effect the estuarine environment.

The onset of these radioactive discharges initiated regular annual programmes of environmental sampling in order to monitor the distribution of radioactivity in the local environment.

2:77 The earliest results of this survey work were published in 1985 and demonstrated that a range of man made radioactive materials were present in/on estuarine and marine samples of fish, crustaceans, shellfish, seaweed, sea coal, sand and silt.

2:78 The 1985 report analysed for the presence of 6 radioactive isotopes in biological samples and confirmed the presence of Cs (Caesium) 134 (in cod alone), Cs (Caesium) 137 (in cod, plaice, shrimps, crabs, winkles, and seaweed), Plutonium 238 (in shrimps and crabs), Plutoniums 239&240 (shrimps and crabs), and Americium 241 (shrimps and crabs).

2:79 Although it did not name the sample sites, the 1985 report also analysed sand, “small coal” and silt samples for 6 isotopes and confirmed the presence of isotopes as follows:

Cs 134:	silt =1.1 Bq/kg (dry weight)	
Cs 137:	sand/coal =7.1 Bq/kg (dw)	silt=70 Bq/kg (dw)
Europium 155:	silt=1.2 Bq/kg (dw)	

2:80 It was reported that

a: the concentrations of the caesiums and the transuranics (Plutoniums and Americium) “were mainly due to discharges from Sellafield and to fallout”

b: that gamma radiation dose rates in air over intertidal sediments were indistinguishable from background at 0.089 micro Greys per hour

c: that collectors of “small coal” accounted for the highest beach occupancies but that highest exposures to man made radioactivity were likely to be to fishermen who operate in muddy areas near the mouth of the Tees

d: total beta activity in silt samples was 790 Bq/kg

e: total beta activity in sand/coal samples was 220 Bq/kg

Ref: Radioactivity in Surface and Coastal Waters of the British Isles 1985 : Aquatic Environment Monitoring Report Number 14. Published by MAFF. 1986, page 34.

2:81 By 1995 additional isotopes were being analysed for in various marine/aquatic samples including Tritium, Iodine 131, Technetium 99 and three isotopes of Curium.

However, marine/aquatic sediments were only analysed for two isotopes, results were as follows:

Mud : Greatham Creek : 2 samples : Cs 137 (mean)=12 Bq/kg (dw)
Europium (Eu) 155 (mean)=2.6Bq/kg (dw)

Mud : Paddy’s Hole : 2 samples: Cs 137 (mean)=22 Bq/Kg (dw)
Eu 155 (mean)=1 Bq.kg (dw)

Coal and sand: Little Scar: 2 samples: Cs137 (mean)=2.3 Bq/kg (dw)
Eu155 (mean)=0.69 Bq/kg(dw)

(Total beta activity was not recorded).

It is evident that, as is the case with many other pollutants, some man made radioactive materials preferentially associate with the finer sediments

2:82 It was also recorded that gamma radiation dose rates in air over intertidal sediments were as follows:

2 samples of coal and sand(Little Scar)=0.054 micro greys per hour

2 samples of sand (North Gare)=0.055 micro greys per hour

2 samples of mud and sand (Greatham Creek)=0.072 micro greys per hour

2 samples of mud (Paddy’s Hole) = 0.086 micro greys per hour

2:83 It was reported that an increase in the level of tritium was observed in seawater and attributed to the station.

Increasing levels of technetium were observed in seaweeds and attributed to increasing discharges from the Sellafield site

Concentrations of Cs and transuranics (Plutonium, Americium etc) were attributed to Sellafield and to “fall out”

“Enhanced” gamma dose rates in “mud” at Paddy’s Hole were attributed to the use of

steel works waste
Low levels of Iodine 131 were detected and attributed to local hospitals.
Ref : Radioactivity in Food and the Environment 1995 : RIFE 1: published 1996. MAFF. Pages 29 and 91.

2:84 Routine monitoring was also carried out in 2005, shortly following a decision to extend sampling and monitoring to include analysis for Polonium 210 and other naturally occurring radio nuclides (thalium, lead, bisimuth, actinium, thorium and protactinium) from waste steel work slag from the iron and steel industries which had been historically dumped along parts of the Tees bank.

2:85 Sediment results confirmed the presence of the naturally nuclides listed above, especially in the 2 sediment samples from Paddy's Hole, where they were present in concentrations of several tens of Bq/kg
E.g. lead 212=70 Bq/kg, Bisimuth 212=77 Bq/kg :
thus confirming the presence of slag derived, man made radioactive wastes in estuarine fine sediments.

Cs 137 concentrations in sediments ranged from a series of "less than" figures up to 7.9 Bq/kg in Greatham Creek

2:86 It was also reported that mean gamma dose rates over intertidal sediments ranged between 0.059 microgreys per hour and 0.17 micro greys per hour : the top three findings were as follows

2 samples : Paddy's Hole: Mud and Pebbles = 0.17 micro greys per hour
1 sample : Greatham Creek bird hide = mud and stones = 0.081 micro greys per hour
1 sample : Greatham Creek bird hide = Grass and mud = 0.069 micro greys per hour
1 sample : Old Town Basin = mud and sand = 0.069 micro greys per hour

NB ***These results demonstrate that Gamma dose rates may be rising in Tees inter tidal sediments***
The Paddy's Hole results show an elevation compared to those for 1995 (despite the inclusion in the sample of "pebbles". Similarly the highest concentration Greatham Creek sample is higher than the 1995 level despite the inclusion of "stones". Both inclusions (stones and pebbles) might be expected to lower concentrations by reducing the amount of fine material in the sample

Ref : RIFE 11: Radioactivity in Food and the Environment 2005 : Pub' CEFAS 2006. pages 122 and 123 and 138-141.

2:87 MAFF/CEFAS work :summary conclusions
There can be no doubt that the MAFF/CEFAS work demonstrates that Tees estuarine and near shore marine water and sediments hold significant concentrations of at least 10 substances or compounds known to generate toxic effects on marine and estuarine ecosystems (at concentrations up to many times

higher than detection level and at concentrations ranking amongst the highest found in UK comparative sites)
Specifically these are : THC, PAH, a number of metals, agricultural herbicides, chlorinated biphenols, HCH, HCB, APEO endocrine disrupting chemicals, PBDE, and Dioxins.

Additionally, MEFF/CEFAS work also records the presence in Tees estuary sediments of a range of radioactive isotopes derived from local sources and some (including Plutonium and Americium) from distant sources such as Sellafield

All of these substances are also chemicals of concern in terms of public health.

2:88 The MAFF/CEFAS repeated bioassay studies have reported unequivocally that
a: Tees estuary sediments range from "slightly impaired" to "substantially deteriorated" and "very poor"
b: Tees estuary sediments generate "greatest biological impact" and "significant adverse effects" of those from UK estuaries
c: up to and including 100% mortality of test species

2:89 The MAFF/CEFAS reports thus provide excellent indicators of
a: possible current baseline for the relevant determinands, in Seaton Channel and its adjacent areas, against which any additional pollution from the development (ship storage and ship breaking, construction and dredging) can be calibrated and calculated
b: potential contributions to Seaton Channel and its adjacent areas re inward transport and deposition of sediment associated pollution from other sectors of the Tees estuary (this is the material requiring post development maintenance dredging

2:90 The MAFF/CEFAS data should also enlighten discussion and deliberation of the required disposal route of Seaton Channel (and adjacent areas) dredge wastes (by sea disposal or landfill)

2:91 It is to be regretted that none of the MAFF/CEFAS work reports the analysis of samples taken specifically from the Seaton Channel/Holding Basin/Dry Dock or Quays where development activity will take place.

3: Pollution reported in association with vessels similar to those involved in the development proposals (storage and breaking of decommissioned vessels).
In 2006, the US Maritime Administration (responsible for storage, maintenance and disposal of decommissioned US Navy vessels) commissioned a Report to estimate how much polluting material had entered Suisun Bay, California, from a fleet of decommissioned vessels moored there and several decades old. The Report also estimated how much polluting material remained aboard the vessels and analysed estuarine/bay sediments below the vessels. 24 sediment samples were analysed for a range of metals.

3:1 This report was not made public, however a copy was released under Freedom of Information legislation and subsequently reported in a number of newspapers.

The general findings of the Report were reported as follows:
a: the paint on the vessels was classified as “highly toxic and hazardous waste”
b: approx’ 25% of the paint on the vessels had flaked off
c: high concentrations of metals were found in the paint on the vessels
d: high concentrations of the same metals were found in the sediment beneath the vessels
e: much of the remaining paint on the vessels was exfoliating in flakes or chips
f: sediment water contained “significantly higher” concentrations of toxic metals than commonly found
g: the bioavailability (sulfide to water ratio higher than 1) of the metals in the sediments beneath the vessels was “significantly higher than values commonly observed for contaminated sediments”
NB: thus making it highly likely to enter the food chain/webs and impact upon all levels of food chain/webs including top predators/consumers

3:2 Relatively large quantities of a range of toxic and hazardous materials were reported to have arisen from the scrapping of five vessels as follows

Vessel:	asbestos	PCB	oil/oily waste	mercury
1:	139 US tons	128 tons	285 tons	
2:	108cubic yards	108 cubic yards	287 tons	34lbs
3:	295 cubic yards	360lbs	264 tons	100lbs
4:	75 tons	150 tons	3,920 tons	
5:	195 cubic yards	240 cubic yards	453 tons	276lbs

3:3 During the course of the Maritime Administration study samples were analysed for ABLE TERRC and MAFF/CEFAS metal determinands and 1 other metal (BARIUM) **not** investigated during MAFF/CEFAS or ABLE TERRC surveys..
Barium is a soft silvery metal, with toxic impacts on the nervous system and heart, widely used in paints and the hydrocarbon industry.

3:4 The Maritime Admin’ Report is also quoted as saying that
a: “toxic material is likely to be released to the environment”
b: its clean up from the environment is “highly warranted and recommended”
c: because of potential threat to “the ecosystem, site maintenance personnel, visitors and salvage crews”

4: Sediment pollution data research reported in the EIS in support of the ABLE TERRC development.

4:1 Metals

Sampling of metals is reported in DNV Report No 2004-1387, rev 01 (section 8.6.2 page 68) where it is reported that metal concentrations “have been mapped for several metals”.

No description of the methodology for site selection, sample collection or analytical method is provided.

4:2 Since finer grain deposits re-concentrate pollutants to a greater degree than coarse sediments, the methodology for site selection is particularly relevant to the investigation of sediment adsorbed pollution.

Thus in order to ensure that the choice of sample sites will provide adequate representation of both coarse and fine sediments within the survey area, selection of sedimentary pollution sample sites must be based on a sound understanding of the nature of the sediments to be sampled. Details of the depth of the sample is also relevant to the provision of chronological deposition and re-concentration history

8.6.2 provides no detail of the sedimentary nature (grain size, organic content etc) of the sample sites, nor of the number of sample sites used.

4:3 8.6.2 lists 8 metals which have been mapped. It has been noted (in 3 above) that, in the context of other “ghost ships”, it appears that 1 other metal (BARIUM) has not been investigated during MAFF/CEFAS or ABLE TERRC surveys. This metal has been discovered in sediments beneath, and around, decommissioned vessels and appears to be derived from paint flakes and chips.

N.B. The absence of Barium analysis is a significant flaw in the sampling programme. No baseline (pre ghost ship) data was gathered against which to compare the Barium input from the fleet.

4:4 Presentation of metal concentration analysis is presented in mapped form in Appendix A. Metal concentration contours appear detailed and well defined, but again no detail is given of sample numbers or site distribution, collection or analytical methods. The metal sampling programme reported in DNV is flawed because:
a: it has failed to gather crucial information on Barium
b: and details of the sampling programme are not given

4:5 PCBs
DNVs 8.6.2 also reports that PCB concentrations for 4 congeners have been mapped in dredging areas 1 to 4. In the context of an area from which both capital and maintenance dredge waste must be removed and disposed, PCB data for those wastes must be full, accurate and precise.

4:6 Other surveys (see section 2 above) commonly analyse and report CB concentrations in various summed, congener groups (ICES : 7 congeners, NMP : 11 congeners, MAFF/CEFAS Reports : 25 congeners.

Based on the above summed congeners, results of these surveys make it evident that Tees estuary sediments have high concentrations of PCBs and that PCB contamination is a major factor in the decision making process for dredge disposal and that sites with elevated PCBs have limited options for disposal.

4:7 However, the DNV PCB concentrations for the dredging areas are presented in Appendix B in graph form. It appears that 9 samples were taken and analysed for only 4 PCB congeners with results presented for the individual congeners.

4:8 The PCB sampling programme reported in DNV is significantly flawed because:
a: The absence of a representative suite of summed CB (up to 25) congeners data, as used by other surveys, represents a significant flaw in the pollution monitoring reported in DNV
b: and plainly does not take account of all the PCB congeners known to be present in the Tees estuary.
c: Nine samples is a relatively low number for data acquisition for the whole of dredge areas 1 to 4.
d: Appendix B shows that the majority of the samples were bulked, thus further mitigating against a full understanding of the distribution of CBs through out the dredge areas
e: No details are provided of site location or grain size of sediments

5: PAHs
DNVs 8.6.2 also reports that PAH concentrations for 11 determinands have been mapped in dredging areas 1 to 4. In the context of an area from which both capital and maintenance dredge waste must be removed and disposed, PAH data for those wastes must be full, accurate and precise.
5:0 8.6.2 reports that 4 of the PAH determinands (Benzo(a)pyrene, Acenaphthylene, Anthracene and Benzo(a)anthracene) had been found in concentrations exceeding both the Canadian Probable Effect Levels and the Canadian Interim Sediment Guidelines.

5:1 No details of the methodology of the PAH survey are provided in the DNV report. However, it is evident that:
a: nine samples were analysed
b: samples were “bulked” for analysis
c: only one (bulked) result is provided for “surface” sediments
d: one (bulked) result (samples 1 to 5) are provided for 0.5 metre depths
e: one (bulked) result (samples 6 to 9) is provided for 1 metre depth
f: one (bulked) result (samples 7 to 9) is provided for 5 metre depth
g: results for the four determinands exceeding ISQG and PEL demonstrate that the highest concentrations of PAH appear either in surface samples or in those from 0.5 to 1 metre depth and that, levels were much lower at 5 metre depth,

5:2 **The available PAH data set fails to provide any information on the following issues:**
a: Since PAH concentrations are elevated in fine sediment deposits, was the

choice of sample sites informed by a thorough understanding of the location of coarse and fine sediment deposits across the survey area? From where, within the dredge areas, were the samples collected? On what basis were the sample sites selected? What percentage of the survey area is represented by the nine samples?

b: Are the reported sedimentary PAH concentrations associated with any specific grain size range? Does the data permit identification of the more contaminated dredge wastes?

c: Do the reported "bulked" PAH concentrations represent uniform (horizontal and vertical) distribution of PAHs in the sediments of dredge areas 1 to 4, or do they represent "hot spots" of contamination?

d: How can areas of elevated PAH concentration be identified?

e: Do the results of the bulked samples provide any indication of where future sedimentary PAH pollution (from the proposed development or elsewhere) might be expected to concentrate within the proposed dredge areas 1 to 4 (thus enabling targeted ongoing monitoring of pollution trends in the area?

Thus it is evident that a body of important information about the PAH pollution of dredge areas 1 to 4 is not available and thus the pollution monitoring programme for PAHs (as reported in DNV Report section 8.6. and the relevant Appendix) is seriously flawed.

6: Non-reported Pollution determinands

As section 2 (above) reports, MAFF and CEEFAS work demonstrates that Tees estuarine and near-shore waters and sediments hold significant concentrations of a number of substances/compounds known to generate toxic effects on marine and estuarine ecosystems (at concentrations up to many times higher than detection levels and at concentrations ranking among the highest in UK comparative sites.

A number of these substances have not been surveyed in the Seaton Channel and its adjacent areas (dredge areas 1 to 4). These are summarised below:

6:1 APEOs produce hydrophilic, stable and potentially more toxic metabolites with endocrine disrupting properties and the potential to bio-accumulate. Exposure is shown to increase oestrogen response in fish and mammals (sex change/fertility effects). Perceived to be chemicals of concern, APEOs are currently the subject of programmes to reduce production and use.

6:2 Nationwide surveys of APEOs are reported in section 2 (above). In almost all UK samples, concentrations of Nonylphenol were below the LOD (Limit of Detection) of 0.2 micrograms per gram. The only exceptions were the 9 samples taken in, and adjacent to, the Tees estuary, where all sites exceeded the Nonylphenol LOD. Thus the Tees was demonstrated to hold far and away the highest concentrations of NP (nonylphenol) measured in a UK estuary.

"Significant concentrations" of APEOs have been recorded in Tees estuarine sediments and the Tees dredge disposal site.

6:3 It is evident that all of the sediment samples from the "inshore dredge disposal

site" were contaminated (up to 15 times LOD) with APEOs where they were "being built up in the sediment".
The nearest sample site to the Seaton Channel and its adjacent areas was at Seal Sands (9.3 micrograms/kg of NP (49 x LOD)

6:4 In the context of their high levels and apparently unique significance to the Tees estuary, the failure to sample and analyse for APEOs represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

6:5 PBDEs are identified as "chemicals of concern" which are environmentally stable, persistent, hydrophobic, lipophilic and ubiquitous contaminants generating reproductive effects, developmental hazards, nervous system toxicity and carcinogenic potential. They are bio-accumulative and can be found throughout the marine food chain including top predators (cormorant liver, sea mammal blubber).

6:6 MAFF/CEFAS have analysed for 14 PBDE congeners at 38 sites in the Tees estuary. Most samples were found to contain detectable concentrations of several or all congeners.

The highest concentrations of 14 summed PBDE congeners were reported from sediments from the lower (seaward) area of the estuary : Bran Sands 92 micrograms/Kg, East of No 15 Buoy 84 micrograms/Kg, Shell Oil jetty N.Bank 66 microgramsKg

The highest concentrations of PBDE congener 209 were also found in the lower (seaward) end of the estuary : Dabholm Gut 1,400 micrograms/Kg, East of No 15 Buoy S.Bank 812 micrograms/Kg, East of No 15 Buoy mid channel 281 micrograms/Kg

6:7 It was reported that PBDE concentrations were highly variable (due in part to the varied nature of estuarine sediments), that concentrations appeared to decline outside the estuary and in coarser/sandier sediments and that there was some evidence of elevated levels in the "dredge spoil" disposal sites

6:8 In the context of their high levels and apparently unique significance to the Tees estuary, the failure to sample and analyse PBDEs represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

6:9 Dioxins and dioxin like compound surveys of samples from 7 UK estuaries are reported in section 2 (above)
It is reported that six samples from the Tees were analysed and that one of them held the second highest concentrations recorded in any UK estuary, 5 of the 6 samples were found to hold concentrations significantly exceeding Toxic equivalent values (TEQs) of Canada, USA and Netherlands. One of the six exceeded the Canada and USA TEQ.

6:10 Further work on Tees estuary sediments showed that at 3 of 4 sites concentrations exceeded all 3 TEQs, while 1 of the 4 sites exceeded the Canada and USA TEQs.

It was stated that sediment with such concentrations “could cause adverse effects in sensitive organisms”.

6:11 In the context of their high levels, significant breaching of TEQs, apparently ubiquitous presence through out the Tees estuary and their potential for adverse effects, the failure to sample and analyse for dioxin and dioxin like compounds in sediments from Seaton Channel and adjacent areas (dredge areas 1 to 4) represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

6:12 Agricultural herbicides and pesticides surveys of Tees estuary sediment concentrations of herbicides and pesticides, carried out by MAFF/CEFAS are reported in section 2 (above).

6:13 Positive results for herbicides (Simazine and Atrazine) are reported in Tees estuary water samples. Both were on the UK Red List at the time of analysis.

These and other herbicides will therefore be found in sediment interstitial (pore) water and therefore in inter and sub-tidal sedimentary deposits. Their association with sedimentary particles is not discussed in the MAFF/CEFAS work.

6:14 Positive results for insecticide concentrations are also reported in Tees estuary sediments. These include hexachlorocyclohexanes (alpha HCH, gamma HCH), hexachlorobenzene (HCB), concentrations of which were found to be among the highest in 61 UK wide samples, ranked as follows

a: HCB = highest concentration of 61 UK wide samples (UK 61)
b: alpha HCH =- 4^{th} highest (UK 61)
c: gamma HCH = 6^{th} highest (UK 61)

Dieldrin and DDT compounds were also identified in Tees sediments.

These, and other agricultural chemicals, are persistent in the environment, bio-accumulative, and generate a range of significant bio-toxic effects on marine wildlife.

6:15 In the context of their recorded presence in Tees estuary sediments and waters, their high levels, their apparently ubiquitous presence through out the Tees estuary and their potential for adverse effects, the failure to sample and analyse for insecticide and herbicide compounds in sediments from Seaton Channel and adjacent areas (dredge areas 1 to 4) represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

6:16 Bioassay studies to assess the toxic potential of Tees estuary sediments have been carried out and reported in MAFF/CEFAS reports since 1993, when oyster embryo bioassays were carried out on sediments from 89 UK wide estuarine, intermediate and offshore sites.

It is reported that Tees sediments were “very poor” and “substantially deteriorated”. It was reported that Tees estuary sediments appear to generate the greatest biological impact of the 89 sites.

It is stated that the "consistency of these results provides strong evidence that these sediments are probably sufficiently contaminated to be causing significant adverse biological effects".

6:17 It is reported that lugworm and amphipod bioassays on sediments from 41 UK wide sites showed that :
a: of the 41 samples only 3 proved acutely toxic to lugworm. Two of those samples were from the Tees and recorded 33% and 100% mortality of test animals
b: of the 41 samples only 2, both from the Tees proved acutely toxic to amphipod and recorded 93% and 100% mortality.

6:18 It is reported that lugworm and amphipod bioassays on sediments from 46 UK wide sites showed that:
a: of the 46 samples only 4 proved acutely toxic to amphipod. Two of these were from the Tees and were shown to be the most toxic with mortality of 60% and 100%.

6:19 Further bioassay studies of 81 UK wide offshore, inshore and estuarine sites proved that 3 Tees estuary sediment samples were the three most toxic to amphipods, of the entire group of 81 UK wide sediment samples .

6:20 In the context of
a: the extremely important implications of previous Tees estuary bioassay work,
b: the consistently high ranking of Tees estuarine sediments as among the UK's most toxic to various test animals and
c: the statement that the "consistency of these results provides strong evidence that these sediments are probably sufficiently contaminated to be causing significant adverse biological effects".

the failure to carry out bioassay study of sediments from Seaton Channel and adjacent areas (dredge areas 1 to 4) represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

7: CONCLUSIONS:

7:1 This report notes that the reviews of sedimentation modelling work provided by the EIS and it's supporting documents, do not provide full details of either the empirical data which was input to the model or of the methodologies used, thus the accuracy of "modelled" results cannot be assessed.

7:2 This Report has found no evidence of specifically detailed empirical, field studies of sedimentation within the Seaton Channel/Holding Basin/Greatham Creek area. As a result of the failure to carry out such work the following issues remain unknown:

**a:	the source and history of fine silt/clay particles causing re-sedimentation in the Seaton Channel area**
**b:	whether or not that material has come straight in from the sea and been rapidly deposited in the Seaton Channel, or whether it has entered the estuary via the Greatham Creek or River Tees freshwater systems**
**c:	whether or not any of this material originate from offshore dump/disposal sites where inputs of polluted material are relatively high**
**d:	what is the residence time of fine clay/silt suspended particles (from whatever source) in the water column and the sedimentary environments and, during that residence time, have those particles had the opportunity to scavenge, adsorb and re-concentrate those pollutants identified as being endemic to the Tees Estuary**
**e:	whether the Seaton Channel/Holding Basin etc fine clay/silt material has been deposited elsewhere within the system, prior to re-suspension and subsequent transport into the Seaton Channel**
**f:	what is the relationship between the Seaton Channel etc sedimentation regime and that of the wider Tees estuary system.**
**g:	what is the effect of flocculation (both types), and it's associated increased adsorbtion of pollutants, on sedimentation regimes in the Seaton Channel and its adjacent areas.**

**7:3	In the documentation studied, this Report finds no evidence of a thorough, area wide (Seaton Channel, Holding Basin, Dry Dock etc) survey and analysis of grain size distribution, which would facilitate and inform the choice of sample sites. It may well be that the developers can identify such work, however, if such work has not been carried out, it must be assumed that any sampling points have been chosen on a spatial, or possibly random, basis, rather than on any more appropriate criteria.**

**7:4	There can be no doubt that the MAFF/CEFAS work demonstrates that Tees estuarine and near shore marine water and sediments hold very significant (environmentally damaging) concentrations of a wide range of substances or compounds (at concentrations up to many times higher than detection level and at concentrations ranking amongst the highest found in UK comparative sites) known to generate toxic effects on marine and estuarine ecosystems.**

These include : THC, PAH, a number of metals, agricultural herbicides, chlorinated biphenols, HCH, HCB, APEO endocrine disrupting chemicals, PBDE, and Dioxins.

**7:5	Additionally, MEFF/CEFAS work also records the presence in Tees estuary sediments of a range of radioactive isotopes derived from local sources and some (including Plutonium and Americium) from distant sources such as Sellafield**

All of these substances are also chemicals of concern in terms of public health.

**7:6	The MAFF/CEFAS repeated bioassay studies have reported unequivocally that**

a: Tees estuary sediments range from "slightly impaired" to "substantially deteriorated" and "very poor"
b: Tees estuary sediments generate "greatest biological impact" and "significant adverse effects" of those from UK estuaries
c: Tees estuary sediments generate up to and including 100% mortality of test species

7:7 The MAFF/CEFAS reports thus provide excellent indicators of
a: possible current baseline for the relevant determinands, in Seaton Channel and its adjacent areas, against which any additional pollution from the development (ship storage and ship breaking, construction and dredging) can be calibrated and calculated
b: potential contributions to Seaton Channel and its adjacent areas re inward transport and deposition of sediment associated pollution from other sectors of the Tees estuary (this is the material requiring post development maintenance dredging

7:8 It is to be regretted that none of the MAFF/CEFAS work reports the analysis of samples taken specifically from the Seaton Channel/Holding Basin/Dry Dock or Quays (dredge areas 1 to 4) where development activity will take place.

7:9 Despite the MAFF/CEFAS work on pollution monitoring which has identified at least 9 significant pollutants in the Tees estuary, it is apparent that only 4 determinand groups have been analysed for in support of the EIS re the proposed development. Analysis reviews for these four determinands are poorly reported and flawed as follows:

7:10 Metals:
Presentation of metal concentration analysis is presented in mapped form in Appendix A. Metal concentration contours appear detailed and well defined, but again no detail is given of sample numbers or site distribution, collection or analytical methods. The metal sampling programme reported in DNV is flawed because:
a: it has failed to gather crucial information on Barium
b: and details of the sampling programme are not given

7:11 PCBs:
The PCB sampling programme reported in DNV is significantly flawed because:
a: Data on only 4 of a much larger group of congeners (up to 25) has been gathered, as used by other surveys, this represents a significant flaw in the pollution monitoring reported in DNV
b: and plainly does not take account of all the PCB congeners known to be present in the Tees estuary.
c: Nine sediment samples is a relatively low number for data acquisition for the whole of dredge areas 1 to 4.
d: Appendix B shows that the majority of the samples were bulked, thus further mitigating against a full understanding of the distribution of CBs through out the

dredge areas
e: No details are provided of site location or grain size of sediments

7:12 The PAH sampling programme fails to provide any information on the following issues:
a: Since PAH concentrations are elevated in fine sediment deposits, was the choice of sample sites informed by a thorough understanding of the location of coarse and fine sediment deposits across the survey area? From where, within the dredge areas, were the samples collected? On what basis were the sample sites selected? What percentage of the survey area is represented by the nine samples?
b: Are the reported sedimentary PAH concentrations associated with any specific grain size range? Does the data permit identification of the more contaminated dredge wastes?
c: Do the reported "bulked" PAH concentrations represent uniform (horizontal and vertical) distribution of PAHs in the sediments of dredge areas 1 to 4, or do they represent "hot spots" of contamination?
d: How can areas of elevated PAH concentration be identified?
e: Do the results of the bulked samples provide any indication of where future sedimentary PAH pollution (from the proposed development or elsewhere) might be expected to concentrate within the proposed dredge areas 1 to 4, thus enabling targeted ongoing monitoring of pollution trends, and of dredging activity, in the area?

Thus, it is evident that a body of important information about the PAH pollution of dredge areas 1 to 4 is not available and thus the PAH monitoring and analytical programme is flawed

7:13 Maff and Cefas have identified a wide range of high concentrations of high impact pollutants in Tees estuary most of these not been analysed/sampled for in support of the EIS for the proposed development. The following significant determinands have been ignored by pollution monitoring in support of the EIS

7:14 Endocrine disrupters:
In the context of their high levels and apparently unique significance to the Tees estuary, the failure to sample and analyse for APEO endocrine disrupting chemicals represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

PBDEs:
In the context of their high levels and apparently unique significance to the Tees estuary, the failure to sample and analyse PBDEs represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

Dioxins:
In the context of their high levels, significant breaching of TEQs, apparently ubiquitous presence through out the Tees estuary and their potential for adverse

effects, the failure to sample and analyse for dioxin and dioxin like compounds in sediments from Seaton Channel and adjacent areas (dredge areas 1 to 4) represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

Insecticides:
In the context of their recorded presence in Tees estuary sediments and waters, their high levels, their apparently ubiquitous presence through out the Tees estuary and their potential for adverse effects, the failure to sample and analyse for insecticide and herbicide compounds in sediments from Seaton Channel and adjacent areas (dredge areas 1 to 4) represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

7:15 Bioassay
Maff and Cefas have carried out a number of bioassay studies on Tees estuary sediments
In the context of
a: the extremely important implications of previous Tees estuary bioassay work,
b: the consistently high ranking of Tees estuarine sediments as among the UK's most toxic to various test animals and
c: the statement that the "consistency of these results provides strong evidence that these sediments are probably sufficiently contaminated to be causing significant adverse biological effects".

the failure to carry out bioassay study of sediments from Seaton Channel and adjacent areas (dredge areas 1 to 4) represents a significant flaw in the pollution monitoring work carried out in support of the EIS.

7:16 As a result of the failings and flaws listed above, the following issues have not, and can not be, discussed in any meaningful way because the full suite of necessary data has not been gathered and presented to regulators, decision makers, other interested stakeholders or members of the public:

1: Monitoring and mitigating potential increase of baseline pollution as a result of the presence of decommissioned vessels

2: Pollution impacts (of redistributed sediment disturbed/released by dredging activity) on wildlife and ecology

3: Source and history of polluted sediments currently found

in Seaton Channel and adjacent areas (dredge areas 1 to 4)

4: Source and history and pollution loadings of sediments contributing to re-sedimentation of dredged areas and requiring maintenance dredging

5: Pollution impacts on wildlife and ecology of disposal of dredge spoil at offshore sea dump site/or terrestrial landfill site