GEOLOGICAL ISSUES

1.1. This proposed development has caused great unease and concern from the very beginning. The early announcements, at times, quite often seemed to strain scientific logic.

1.2. This unease led to a detailed study of the documents submitted by the developers and their consultants.

1.3. The documents which were made available intensified my opinion that the basis on which the sea defences were proposed is flawed.

1.4. The much vaunted sea defences are based on very little local, long term data. Further, there is very little in the technical literature which covers this type of large scale development.

1.5. It is acknowledged by all the consultants and their advisors that this sandy beach has very special and unique make up. The sandy bays here are the result of man's mining activity. The sand is derived from the mining of the china clay and is a mining waste material.

1.6. The mining of china clay is a hydraulic mining operation where water is directed at the kaolinised granite surface.

1.7. The water jet disaggregates the kaolinsed granite putting the clay into suspension and the sand fraction scalped away. The make up of the granite enables the sand fraction to be freed very easily.

1.8. Before the era of environmental concerns, the surplus and unwanted waste materials were flushed away down the local water courses. A number of the local beaches are made up of various types of mining waste from a variety of sources.

1.9. The beach at Carlyon Bay is a very new beach. It was formed due to the Porth stream being diverted from its natural course into Par Bay.

1.10. The beach at Carlyon Bay was built up over a period of one hundred years from 1850 – 1950. The sand carried to the beach was course, angular and generally not ground up. It travelled about three miles and descended through about six hundred feet. It was made up of coarse quartz, mica, tourmaline, felspar and kaolin trapped in the indentation and crevices of the other minerals.

1.11. This helps to explain why the material found at the Carlyon Beach is unique in make up. It is a mine waste, not a marine sand.

1.12. It is my belief that the consultants did not realize the significance of the age or the source of the beach material. (*Reference : CE Everard)*

1.13. The developer's consultants used data furnished by Hydraulic Research, HR Wallingford's and CSMA Consultants. The final EIA was made by Wardell Armstrong International.

1.14. The very early assessment, of this area, by Hydraulic Research realized that major problems were posed here. They stated at the time, in the early 1990's, a large amount of data would accrue over a long time on this site. These studies were never undertaken.

1.15. When Wallingford's took over the project there was very little in the way of raw data. They were forced to use numerical and computer programmes with the use of many assumptions, extrapolations interpolations and data from areas that were basically unsuitable.

1.16. Carlyon Bay and its beaches are made up of china clay sand waste discharged to a river and deposited at sea via a tunnel.

1.17. The design of the sea defences suggested by Wallingford was derived from the studies of a Californian Beach which was made up of natural marine sand.

1.18. No attempt was made to show how the beach environments showed any similarity to each other.

1.19. This is why the scientific logic falls down. The status and make up of the two beaches do not show any similarities and scientifically do not compare.

1.20. The marine sand beaches, used in the studies, are from long established mature beaches which have been sorted, abraided and stabilised by the workings of the sea for at least ten thousand years and probably much longer.

1.21. Carlyon Bay is - in geological terms – a very new beach fed by mine waste and is not marine sand. It is unstable and is constantly in flux and change. It has only been established for less than two hundred years and is not in equilibrium with the sea environment.

1.22. The data on wave and tidal conditions was based on measurements from Falmouth, Mevagissey, Plymouth and various other locations. The areas used are in very sheltered estuarine localities or places well sheltered from the severe weather conditions generated from southerly direction.

1.23. In my opinion, to be able to give a true reflection of the weather and tidal conditions likely to be encountered here, a study of at least ten years would be needed. In evolving climatic conditions this should be essential.

1.24. There is sparse data on the depth and make up of the sand on such a large and complex site.

1.25. There must have been significant variations in the sand discharged here over a hundred year period. Changes would have occurred in the mining methods and there will be marked variations in the makeup of the kaolinised granite being worked.

1.26. There could have been times when the mine workings released clay- laden sand which could have formed lines of weakness within the sand. The layer between the sand and bedrock could possibly form a slip-plane.

1.27. The bearing pressures within the sand could vary widely. There is no evidence that the sand would be able to withstand the weight of the sea defences and the major development to be built behind the wall.

1.28. The ground water regime has been given scant study. There are very extensive mine workings to the north of this site. They are known to occur under the golf course and along Par Moor. The old drainage adits are very likely to be present under the beach. An old engine house is shown on Crinnis beach in one of the old photographs.

1.29. It is known that Par Moor is underlain by a buried valley which is over eighty feet deep. This was cut during the last ice age. The area south of the beach also contains buried valleys filled with sand and there are a number of shelves cut into the sea floor. *(Ref to CAMM)*

1.30. It is possible the rock shelf is more than eighty feet deep under the beach and that the sand resting on the shelf will be saturated.

1.31. Sand is often quoted as having thirty percent voids but it is known that this very angular sand can have voids of over fifty percent.

1.32. In my opinion the whole design approach is flawed because there can be no comparison of like with like. Computer and numerical modelling has been used because of a lack of usable data.

1.33. There has been an extensive modification of data from other areas to fit into the models but this data is not strictly applicable to this area.

1.34. Reservations were expressed by Royal Haskoning *(Ref 3)*, the Borough principal engineer *(Ref 4),* the Halcrow Group for the Environment Agency *(Ref 5),* and Doctor John White *(Ref 6).*

1.35. However, none of these organisations appear to realize that they were dealing with a very special material. There seems to be a lack of scientific understanding which would high light the problems posed by comparing two unlike materials.

1.36. The attempt to place Carlyon Bay sand between a shingle and a sand asks far too much of a computer programme.

1.37. To do this with any certainty it must be shown that Carlyon Bay sand is a marine material like the sand and shingle materials being used. This is not a scientifically sound logic.

1.38. There are many, many examples in the last few years where detailed computer models have been used to design engineering structures. Unfortunately, many of these have failed due to factors being omitted or ignored.

1.39. The most noted example of structural failure in the last few years is the Teams Phillips yacht. This was intensively researched using computer models and was hailed as a world beater. It failed on its first real test in true ocean conditions.

1.40. The design of the sea defence works requires nourishment to maintain the beach width and protection for the rock armour

1.41. It is abundantly self-evident that there is not the slightest prospect of the developer being able to achieve the indicated beach profile without a very substantial quantity of matching 'stent' being imported. Based upon available data, including the fact that the finished height of the new primary sea wall is to be **9.2 metres** above OS datum, and based upon my long-established knowledge of the high degree of mobility associated with the beaches at Carlyon Bay, I estimate this quantity to be at least a million tonnes but that figure does not take into account the substantial but necessary 'infills' behind the sea wall once the undercroft has been constructed.

1.42.

1.43 This point is very easily identified by reference to the above two photographs where, in order to achieve the necessary 9.2 metre height, the 'toe' of the new primary wall as seen in the first picture would need to be set at the height of the top-edge of the unauthorised steel shuttering shown in the second picture.

1.44 With the benefit of many years of close observation, I can further state that because of the angular structure of stent particles, in order to maintain the intended beach profile, frequent recharges would become essential, especially after storms.

1.45 The nourishment would require the dumping of large quantities of china clay waste sand into the sea. This material is made up of quartz, felspar, mica and tourmaline.

1.46 However, there will be a quantity of semi heavy minerals such as arsenopyrite, chalcopyride, monazite, pyrite, sphalerite, wolframite, zenotime and zircon and of course, semi kaolised felspars.

1.47 There should be a detailed study of the effects of sea water on the decomposition of these minerals. Sea water is known to be a very aggressive medium.

1.48 There is the possibility of phosphates, sulphuric and hydrochloric acid could be released. It is known that monazite, zenotime and zircon with mica can have radio-active elements in the crystals. These minerals will be concentrated over time. They are semi heavy minerals which will tend to stay in place whilst the larger light minerals such as quartz sand will be winnowed away to the east with coast wise drift.

1.49 There has been a marked movement of sand eastwards since the beach work started. I have identified coarse Carlyon Bay sand blocking the entrance to Polkerris. What is happening is the alteration of the status quo formerly found in the Bay.

1.50 Similar problems occurred at Hall Sands when large amounts of material was removed from the seabed near the village *(Ref 7)*.

1.51 The test bed results by Wallingford's have been shown to indicate there are no problems with the sea defence design. These test bed tests must be questioned. There is very little detailed information on the morphology of the Carlyon Bay area. The depths to bedrock are poorly understood as is any variation in the make up of the sand pile.

1.52 Central Cornwall is known for its concentration of sand tips. All these tips are strictly monitored and designed to very strict limits. They must be very well drained so that there is no water pressure build up which could cause structural failure.

1.53 In the granite area with its sand tips there are no major buildings on any of these waste tips. These tips are constantly monitored and water levels within them strictly controlled. These measures ensure the stability of these waste tips.

1.54 The sheet piling used on the beach will interfere with the ground water flow and could lead to loss of cohesion in the lower levels of the sand.

1.55 The levee failure in New Orleans show many similarities to the type of defence used at Carlyon Bay. The defences failed without overtopping or exposure to the surge water. The sheet piles failed due to poor ground conditions *(Ref below).*

1.56 The wave data used at Carlyon Bay is mainly made up and synthetic using extrapolated information from other areas. The flood and surge data from the most recent flooding on the beach should have been incorporated in this study. There were major tidal surges in 1987, 1989 and 2004 which caused extensive flooding on the beach.

1.57 There is no long term data of conditions in St Austell Bay. Sources used were Falmouth, a very sheltered estuary, as was the information from Plymouth. Information from Mevagissey is again from a very sheltered area which is not subjected to fierce southerly storms. The information used from Weymouth and Portland is again from an area well protected from southerly and south westerly storms.

1.58 The major draw backs and flaws in the whole design process can be summed up from two basic stand points. There is very scant local data to feed into any prepared model for the beaches at Carlyon Bay. Secondly, there is a lack of scientific understanding as to the theoretical basis for the models. They are based on marine sand. The sands at Carlyon Bay are sands from discarded mine waste.

1.59 There are no in depth studies of the behaviour of mine waste material beaches especially ones that are in constant flux and are not in equilibrium with the natural environment. The attempt to place the beach material between shingle and sand is flawed. The Carlyon Bay sand is very angular sand made up of several minerals and not marine sand worked to give a well rounded profile.

1.60 The sea wall protection and nourishment has been subjected to a very limited study. There are many flaws in this study. The source material is made up of course sand, felspar, mica, tourmaline and a series of semi heavy minerals. These semi heavy minerals will contain radio-active elements phosphorus, chlorine and sulphur.

1.61 The reaction of sea water with these minerals could release a cocktail of toxins to poison the local sea water.

1.62 It is known that potassium is slowly released from china clay waste as it has been used as a local fertilizer for many years.

1.63 The mica and china clay content of the waste sand will have a smothering effect on the near shore sea floor. Mica and kaolin have a very large aspect ratio. This ratio compares the surface area of the mineral with its thickness. The minerals are very thin but have a very large surface area. They will slowly settle to the sea floor blinding it like a coating of confetti.

1.64 Another aspect of china clay waste which could have a serious effect on the sea environment is that it is oxygen deficient. It is quite possible it would denude the local sea water of oxygen. There would then be the possibility of toxic bloom developing over the longer term.

Conclusions :

2.1. Although a lot of work and computing and numerical analysis have been undertaken on the overall design, it still does not answer all the flaws and negative aspects of the proposed development.

2.2. It looks like an experimental development. There are no detailed studies of mine waste beaches in the technical literature.

2.3. The use of a marine beach sand to compare with a new mine waste beach is scientifically flawed.

2.4. In my opinion the renowned consultants who tried to assess the validity of the sea defence design did not realize how unique the Carlyon Bay beach sands were.

2.5. Lack of basic and long term local data forced the use of computer modelling data modified from outside sources. This again questions the validity of the data produced.

2.6. There are spectacular failures of many structures based on computer generated designs. The most notable in recent years was the Team Phillips yacht.

2.7. The sand at Carlyon Bay is very mobile and ever changing so the addition of further mine waste sand to nourish the defences could cause untold damage.

2.8. The study of the disposal of mine waste in 1972 into St Austell Bay led to the conclusion that it was impossible to predict what would happen to this material on the sea floor. *(Ref 10).*

2.9. In my opinion a proper statistical sample of weather, wind, wave, flood and tidal flows would need a study lasting at least ten years.

2.10. There are so many shortcomings in the assessment of the sea defence design that I believe there is a potential for disaster for life and property on a grand scale.

Additional notes referring to radioactivity potential in China Clay Waste Sand

2.1. The extensive potential pollution of the sea environment by the addition of fresh "sand" has been highlighted. The recent worry about the radio active content in the Blackpool area raises further areas for more detailed study. The sand from the China Clay workings are known to contain many mineral inclusions.

2.2. The radio – active species include monazite, mica, thorite, illmenorutile and metamic zircon. There can be concentrations of these when the clay is recovered. The full range of radio-active radiation should be investigated.

2.3. The main source areas for these minerals should also be defined. There will be a wide range of concentration in different areas within the china clay country.

2.4. It is known that there can be high concentrations of radon gas emanating from areas within the St Austell granite which must be diluted to ensure the health of people in these areas. Therefore, no chances can be taken when dumping sand on the line of the sea defences which can continue for at least one hundred years..

Notes referring to Toxicity

3.1. The discharge of clay waste (known locally as 'Stent') to the rivers by the China Clay industry was suspended in the early 1970's. This was at the beginning of the programme to meet the new environmental requirement for
cleaning up of the local rivers and water-courses.

3.2. Measures were then investigated to see if the waste could be discharged off-shore into the sea. After much planning and investigation, it was found impossible to be certain what would happen to the waste. The cumulative make-up of the waste would have been impossible to determine.

3.3. If permission for a similar scheme, for the periodic disposal of china clay waste to the sea, were to be applied for today, it would most certainly be refused.

3.4. If for any reason there is a potential need for replacement of renourishment of the beach material this should be viewed with great caution.

3.5. The deposition of any amount of new sand on to the beach would amount to a potential for pollution in the long term.

3.6. There would have to be extensive research , for example:

A) What is the present chemical make up of this waste and what may be in the waste in future years.

B) Have the values of those toxins known to exist in some of this waste been determined?

C) What are the levels of iron, copper, lead, zinc, chromium. Arsenic, phosphorous, chlorine and any other heavy metals or chemicals remaining in the waste ?

D) Even after the proposed washing, there will remain a percentage of mica and kaolin in the waste which must also be measured, as these will blind the sea-bed very quickly.

E) Is the dumping of such waste not an infringement of E.U. regulations, and does it not go against the bathing water directives of the E.U. ?

F) Most E.U. rules and directives are changing constantly, what allowance is being, or will need to be, made for these changes and what is the manner in which the beach is to be "renourished" if the china clay waste is or becomes illegal?

It is my belief that the answers to these and many other important questions (such as the known migration of the material to other parts of the coastline) must be resolved prior to the implementation of any programme of waste discharge.

Notes Referring to Subsidence resulting from Mine Workings

4.1. I have over the years inspected over 500 mine shafts and other workings, all over Cornwall. Whilst the failure of these structures can cause a local nuisance, I have not come across any that have caused major disruption.

4.2. That is apart from Callington subsidence, which was exacerbated by occurring in made ground.

4.3. The mineralization in the South West Ore fields is in narrow vertical or near vertical veins. These do not cause the widespread subsidence which is associated with coal mining activities.

4.4. The possibility of mine workings being present under the beach highlights a potential danger to the site.

4.5. We know from past experience that the mine shafts on the golf course and at the back of Wyevale were popped open by changes in water pressure in the old mine workings. It must be assumed that this could happen to the workings under the beach.

4.6. The mine workings on Par Moor and under the golf course are very extensive and reach to (and under) the beach. These workings are all filled with fresh water and must drain to the beach.

4.7. As I have stated earlier no study has been made of this ground water flow. If there was major flooding from Par Moor then a siphon effect could well occur. If the flooding lasted for any length of time the foundations of the beach would then be destabilized.

Notes Referring to Levee Failures in Katrina Floods, August 2005

5.1. The levee designed to protect New Orleans show many similarities to the proposed sea defences at Carlyon Bay.

5.2. The levee defences failed without overtopping or exposure to surge water. The main culprits of the failure were shallow sheet piles, bad ground conditions and inconsistent construction materials.

5.3. The sea wall defence, sheet piling and sand foundation at Carlyon Bay are likely to be overtopped on a regular basis. The frequency will be dependent on the storm patterns. Further, these defences will be subjected to surge water invasion twice a day with the tides. This must destabilise the foundation sands.

5.4. There is an inherent fragility in the whole design of these defences.