Nuclear Free Local Authorities

new nuclear monitor

Number 25, December 2011

SUBMISSION TO ENVIROMENT AGENCY RADIOACTIVE WASTE PERMIT FOR THE PROPOSED HINKLEY POINT NUCLEAR REACTOR, SOMERSET

SUBMISSION 1/2 – MARINE DISCHARGES

Ref: EPR/ZP3690SY

1. Introduction

The Nuclear Free Local Authorities (NFLA) has co-sponsored two submission responses with the Stop Hinkley Campaign, Friends of the Earth Cymru and CND Cymru to the Environment Agency's radioactive waste permit for the proposed Hinkley Point nuclear reactor, Somerset.

The co-sponsored submission is also supported by the following MPs and MEPs – Caroline Lucas MP, Martin Caton MP, Paul Flynn MP and Jill Evans MEP.

It has been developed for the supporting organisations by the independent marine pollution consultant, Tim Deere-Jones. A separate submission on aerial gaseous emissions from a proposed new nuclear reactor at Hinkley has also been developed for the same supporting organisations by the independent consultant on radiation in the environment, Ian Fairlie. This can be found within New Nuclear Monitor 26.

2. The Environment Agency consultation

The Environment Agency are seeking comments on **applications** it has received from EDF Energy's and Centrica's joint venture company, **NNB Generation Company Limited** (NNB GenCo), for their proposed new nuclear power station development at **Hinkley Point**.

The company has applied to:

- make disposals and discharges of radioactive wastes
- operate combustion processes (standby generators)
- discharge cooling water and liquid effluent into the Severn estuary.

The application can be found at EDF's website:
http://hinkleypoint.edfenergyconsultation.info/public-documents/nuclear-site-licence-and-environmental-permit-applications/construction/

The co-sponsored submission was emailed to the Environment Agency through the following address: NNB@environment-agency.gov.uk prior to the closing date, 15th December.

Nuclear Free Local Authorities Secretariat, c/o PO Box 532, Manchester, M60 2LA
Tel: 0161 234 3244 Fax: 0161 234 3379
Email: s.morris4@manchester.gov.uk Website: http://www.nuclearpolicy.info

PROPOSED LIQUID RADIOACTIVE WASTE DISCHARGES
From the
PRESSURISED WATER REACTORS at HINKLEY POINT: SOMERSET.

Consultation Response
To NNB Genco's
"Radioactive Substances Regulation Submission Hinkley Point C"

CONTENTS TO SUBMISSION RESPONSE

i. Executive Summary:

This Report describes Bristol Channel/Bridgwater Bay marine hydrodynamics, sedimentology and briefly reviews some of the aspects of the behaviour of radioactive wastes discharged to sea.

This Report has carried out a review of NNB Genco submissions relating to radioactive waste liquid discharges from the proposed Hinkley C reactors, and concludes that there are a number of highly significant weaknesses and flaws in aspects of NNB Genco's understanding of the behaviour and fate of those radioactive wastes, their proposed management of the discharges and their proposed sampling and monitoring programmes.

This Report further identifies a failure to address issues arising from climate change and the risks of severe flooding/inundation events

This Report concludes that, as a result of these highly significant weaknesses, there are major data gaps about near field and far field radioactivity concentrations along the entirety of the Bristol Channel coast and about the potential impact of Hinkley C (and Oldbury B) proposed radioactive waste discharges on the populations resident in English and Welsh coastal zones.

In the context of these flaws this Report concludes that the proposed development in its current form should be rejected outright.

ii. Summary of Principal Technical Conclusions:

Bristol Channel Marine Environment
The Hinkley Point Nuclear Power Station is situated on the coast of Bridgewater Bay on the southern seaboard of the Inner Bristol Channel.

Marine water enters the Bristol Channel eastwards along its southern seaboard (north coasts of Devon, Somerset and Avon), crosses the Bristol Channel near the mouth of the Severn estuary and exits the Channel in a westward direction, parallel with the south coast of Wales.

Research studies prove that seabed sediments, and sediments (and hence their associated pollutants) suspended in the marine water column travel in the same general direction.

Bridgwater Bay is a semi-enclosed embayment characterised by the presence of major fine sediment deposits, where fine sediments may be retained for up to 10 years before exchanging into the open sea of the Bristol Channel.

However, despite this long retention potential, Bridgwater Bay is also the major long term source of fine sediment to the water column along the English side of the Bristol Channel.

Suspended sediment loadings in the vicinity of Bridgewater Bay are very high and may reach levels up to 200gms per litre.

Research studies conclude that hydrodynamics may be the dominant influence on erosion, deposition and transport of sediments in the Bridgwater Bay but warn that there remain some significant and major data gaps in at least 5 areas of relevance to the Bristol Channel and Bridgewater Bay hydrodynamic and sedimentary regimes
(Sections 1, 2, 3, 4, 5 & 6)
……..

Fate and Behaviour of Radioactivity in the Sea.

The behaviour and fate of radio-nuclides in marine environments is dependant on their chemical form and their physio-chemical characteristics.

Some, such as Caesium and Tritium are soluble and can travel in the water column for extended distances and time scales.

Others such as Plutonium and Americium and other actinides are adsorbed onto the outer surface of particulate matter suspended in the water column, wherein they are available for transport over extended distances and time scales and subsequent deposition into fine sediment deposits such as estuarine and coastal mud flats and salt marshes.

Both soluble and insoluble nuclides can travel for at least several hundreds of kilometres and both are available for transport OUT of the sea area of their initial discharge.

Deposition of suspended sediments and their associated radioactivity occurs (under the influence of a range of mechanisms) into estuarine and coastal sub tidal sediments, estuarine and coastal fringing inter-tidal mud and salt flats and offshore sub-tidal sediment deposits.

Because a given volume of finer/lighter particles have a relatively greater surface area than a similar volume of coarser/heavier particles and because the fines tend to preferentially gather in the least dynamic, more low energy, sheltered and inshore environments it is usually the case that these fine sediment deposits generally contain the highest concentrations of adsorbed radioactivity and other pollutants.
(Sections 7 & 8)
……..

Re-concentration of marine radioactivity
Research demonstrates that there are a number of mechanisms by which radioactive wastes discharged to sea become re-concentrated.

Sea surface micro layers are enriched with insoluble actinides, such as Plutonium (Pu) and Americium (Am), by factors of 4 to 5 relative to concentrations measured in ambient seawater.

Marine aerosols and sea spray generated by bubble production in breaking waves are enriched with actinides by factors up 812 greater than concentrations in ambient seawater.

Algal blooms may concentrate Pu by factors up to 26,000 compared to ambient seawater.

Soluble nuclides such as Caesium137 are shown to concentrate in Bridgewater Bay sediments by factors of up to 84 compared to sea water concentrations in samples from the Hinkley Point pipelines.

Since the 1980s studies in the Irish Sea have proved that the marine originating actinides (Pu and Am) transfer across the surf line and penetrate into terrestrial environments and that the Pu and Am were found to be airborne in any coastal area where field work was carried out in onshore wind conditions.

Research demonstrates that the magnitude of the effect is dependant on wind speed and the volume of fine sediment particles (with their adsorbed radioactivity) ejected into the air in sea spray and aerosols.

The researchers agree that attempts to quantify the effect are not possible because the available tools and technology are incapable of providing quantification data.

Other studies show that sea originating Pu, Am and Caesium 137 and other radioactive wastes transferring across the surf line have been deposited on terrestrial produce and entered the human food webs in coastal regions of the Irish Sea, Inner Hebrides, and South West Wales which are distant from point sources of discharges. In some cases those doses have been comparable to those received by populations adjacent to Nuclear Power Stations.

This Report notes that no research on these mechanisms of sea to land transfer have been undertaken in the Bristol Channel and that many other potential forms of sea to land transfer are either poorly studied or completely un-researched.

This Report notes that there is a problem due to the lack of readily accessible data about sea to land transfer produced by government agencies and nuclear industry bodies. This Report specifically cites a paper produced by the DETR in 2000 entitled “Sea to Land Transfer of radio-nuclides: How much do we know?” which has been referenced by industry and regulator bodies, but which has proved un-available despite frequent requests and extensive search.

This Report notes the absence of work on sea to land transfer mechanisms in the Bristol Channel and concludes that this is highly significant because the Bristol Channel water column loadings of fine sedimentary and organic particles are reportedly much higher than those reported in the Irish Sea and that therefore the magnitude of enrichment and sea to land transfer may be much greater than those reported for the Irish Sea
(sections 9, 10 & 11)

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Hinkley C Radioactive waste Discharge Inventory:

NNB Genco have only named 14 radio-nuclides to be discharged in the liquid radio active waste streams from Hinkley C. However this Report brings forward other documentation, which implies there may be as many as 65 nuclides in the waste stream.

This Report provides additional evidence to show that, among the approximately 50 nuclides not named by NNB Genco and the Environment Agency GDA documents, there may be 12 alpha emitting actinides including 3 isotopes of Uranium, 5 of plutonium, 2 of Americium and 2 of Curium.

This Report also notes that, in addition to the radioactive wastes proposed for discharge to sea, there are a large number of radioactive wastes which will be discharged to the atmosphere in gaseous or condensate form and that, although an unknown percentage of these will enter the marine environment via fallout and washout, no attempt has been made to quantify these inputs.
(section 12)

……..

Tritium:
When the proposed new reactors at Hinkley C and Oldbury B, come on line the combined annual liquid tritium discharge limit (for existing and new stations) will increase by 50% (653 Tbq per annum to 983 TBq per annum).

When the proposed new reactors at Hinkley C and Oldbury B, come on line the combined annual ACTUAL liquid tritium discharge for existing and new stations (excluding “contingencies”) will rise by 3 times (105.4 TBq to 314.6 TBq per annum).

This Report notes that tritium in water (tritiated water) is reported to behave exactly the same as normal water and is therefore as liable to become incorporated in to sea spray and marine aerosols as does Caesium 137, but that there is no record of any research into this phenomenon as it relates to Tritium.

This Report notes that operation of the proposed Hinkley C reactors is absolutely reliant upon the discharges of large volumes of tritiated water because there are no technologies by which tritium can be removed from coolant water and discharges are therefore essential to "avoid build up of tritium in the coolant".

This Report notes that there appears to be strong support for a policy of intermittent, pulsed discharges of liquid tritium into Bridgewater Bay and that this will inevitably generate marked peaks and troughs of tritium concentration in both receiving waters and local and regional environmental media during any 12 month period.

This Report notes that there has been a long standing industry and regulator consensus that Tritium was of little biological and radiological significance based on the hypothesis that it would dilute and disperse "to infinity" in the marine environment.

This Report concludes that recent research (2000 onwards) comprehensively demonstrates that this consensus was deeply flawed and that on the contrary very large re-concentration factors can be demonstrated for tritium in marine environmental media including fin fish (especially demersal or seabed species), shellfish and wildfowl. It is shown that bio-accumulation takes place especially through predation webs.

This Report reviews a 2009 study, which concludes that:

A: "Clearly the view that tritium occurs exclusively as tritiated water and therefore dissolves to infinity should be considered cautiously.

B: Further research into the concept and nature of tritium partitioning in natural waters is required, and

C: the adoption of unit value (or sub-unit value) distribution coefficients and concentration factors that are currently recommended by the IAEA, but not supported by clearly defined measurements, may require reconsideration."

This Report additionally notes that the latest edition of the relevant IAEA recommendations is "Sediment distribution coefficients and concentration factors for biota in the marine environment." Technical Reports Series 422. International Atomic Energy Agency, Vienna, 2004.

This Report thus concludes that, to date it remains unclear whether the calculations/modelling of the behaviour and fate of tritium in the Bristol Channel environment and subsequent doses of tritium to Bristol Channel populations are based on

a: the use of models, methodologies and empirical data based on the most recent (2009) reported field and laboratory research and defined measurements

b: or on the use of models, methodologies and hypothetical data "not supported by clearly defined measurements"

c: or have taken regard to the recommendation that further research is required.

(sections 13, 14, 15, 16, 17 and 18)

……

Caesium 137

This Report notes that Cs 137 is widespread in the Hinkley local marine environment and that Cs 137 in sediments is enriched by factors of between 23 and 84 (compared to local seawater) and that low levels of Cs 137 are shown to have been transferred from the marine to the terrestrial environment by way of seaweed used as a fertiliser.

This Report concludes that about 80% of Bristol Channel environments and their associated biota, remain un-monitored and thus intermediate and far field behaviour of Cs 137 in the Bristol Channel remain unstudied and un-quantified.

This Report discusses the fact that Cs 137 has been shown to transfer from the sea to the land via sea spray / aerosol pathways in south west Wales and Hebridean environments and explains that in the latter case (200kms from discharge source), high concentrations were shown to be entered island grown produce and to generate Cs 137-alone dietary doses equivalent to (and higher than some) dietary doses received by Critical Groups identified at Nuclear Power Stations.

In this context this Report concludes that

a: a major potential impact of Cs 137 discharges to sea remains un-quantified

b: that current and historical monitoring programmes have notably failed to identify Bristol Channel fine grained sediments containing higher concentrations of Cs 137

c: and that these programmes have therefore proved incapable of delivering precise and relevant data on Cs 137 in the Bristol Channel

This Report also concludes that there is no evidence that the existing marine and coastal monitoring regimes are sufficiently stringent to detect, record and analyse the effects that proposed peaks and troughs of Cs discharge may be having on the behaviour of Cs in the environment and delivered doses of Cs to local populations via a variety of pathways.
(Sections 19 and 20)
……..

Plutonium, Americium and other Alpha emitting Actinides

While admitting that alpha emitting actinides produced by the irradiation of tramp uranium on the outer surface of fuel pins/assemblies or leaking from within pins/assemblies will be present in liquid radioactive waste streams, neither the NNB Genco nor the EDF submissions on liquid discharges offer a list of potential alpha emitting actinides and no detail of expected quantities of alpha discharge are provided.

The Environment Agency GDA Report on the proposed Hinkley C UK EPR reactors states “We will not include alpha emitters as a category for disposal limits” but provides little scientific justification for the decision.

This Report references other documentation which implies that both the Hinkley UKEPRs and the Oldbury AP1000s will give rise to liquid discharges of between 7 and 12 isotopes of alpha emitting actinides and that the list comprises isotopes of Plutonium, Americium, Curium, Uranium and Neptunium.

Westinghouse/Toshiba, the manufacturers of the AP1000, provide slightly more detail than EDF the manufacturers of the UK EPR and state that, with one exception, alpha discharges are expected to be negligible (i.e. less than 37,000Bqs per year).

Westinghouse/Toshiba’s exception is Plutonium (Pu) 241, where the annual average discharge is expected to be 80,000 Bqs p.a. and annual max discharges are expected to be 108,000Bqs p.a.

Westinghouse/Toshiba state that the Pu 241 discharges are significant because it has a long half life and may persist and accumulate in the environment.

This Report notes that this is equally true for the other alpha emitting isotopes on the “expected” list for both Hinkley C and Oldbury discharges and that the list includes all of those isotopes shown to become adsorbed to marine sediment particles, sequestered and re-concentrated in marine sediment deposits, have enrichment factors of several hundred in marine seasprays/aerosols and to transfer readily from the sea to the land in un-quantified amounts.

This Report notes, that from the figures given for Pu 241 discharge from the AP 1000 reactor, it may be calculated that over the proposed 60 year (maximum) operational life span the Oldbury B station may discharge 14,400,000 Bqs of Pu 241 and that this will generate (by decay) 450,000 Bqs of Americium 241 (more radiologically significant than Pu 241).

This Report thus proposes that (in the total absence of any information to the contrary) the Hinkley C UK EPRs may generate a similar quantity of Pu 241 and (by decay) Am 241. (I.E. a total combined output of 28,000,000 Bqs Pu 241 and 900,000 Bqs of Americium 241 from both stations over a 60 year max operational lifespan). This is in addition to the un-quantified output of the other isotopes of Plutonium, Americium, Uranium, Curium and Neptunium...

This Report concludes that, in the multi-decadal time span and in the context of the Bridgwater Bay parameters of

a: very high sediment loadings,
b: relatively poor exchange with the Bristol Channel
c: the well known proclivity of these isotopes to associate with fine sediments,
d: re-concentrate in sediment deposits,
e: enrich in marine aerosols,
f: transfer from the sea to the land and
g: the very wide consensual understanding of their potential to inflict radio biological damage via inhalation and ingestion pathways

these are not negligible quantities.
(Section 21)
……

Cobalt 60

Cobalt 60 is shown to concentrate in marine and estuarine sediments and in marine biota. It is also shown to mobilise in association with water column mobile sedimentary particles. Co 60 has been shown to transfer from the sea to the land and to enter the terrestrial food chain in a coastal region 30 to 40 miles distant from the nearest source of discharge.

The annual aggregated Cobalt 60 liquid discharges limits from all Bristol Channel NPS (existing and proposed new reactors) will be raised from 1,000,000,000 Bqs/pa at present to 5,500,000,000 Bqs pa (i.e. increased by 5.5 times) and that the future proposed ACTUAL discharges will be higher than the current limit and about 3.37 times higher than current discharges.

This Report concludes that there is a huge discrepancy (nearly ten times) between the proposed annual "expected discharges" of Cobalt 60 and the annual limit proposed by EDF/AREVA and accepted by the Environment Agency. No explanation is offered in the GDA documentation for this discrepancy.

This Report concludes that, in the absence of any further information, and given that Co60 production is linked to corrosion of stainless steel components, this discrepancy highlights uncertainties regarding the performance integrity of stainless steel reactor and cooling system components and that further consideration and review of the integrity of reactor and cooling system steel components may be relevant.
(Section 22)
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Discharge Regimes for liquid radioactive wastes

It is consensually agreed that proposed Hinkley C discharge waters will be, on average, 10 degrees C warmer than ambient sea water. This means that the temperature difference will be greater or smaller in response to seasonal conditions.

This Report notes that warm water will rise above colder water and may form a distinct mass or plume which may have a major limiting impact on the behaviour (dispersion/dilution) and fate of radioactive wastes entrained in the liquid discharge.

This Report notes that such a warm water plume or mass will have a life span dependant on a range of other ambient parameters which may contribute to mixing/turbulence processes (tidal forces, wind, sea bed roughness etc)

This Report notes that neither the NNB Genco Submission nor the Environment Agency GDA Report on the UK EPR have engaged in a review or discussion of this phenomenon.

This Report further notes that both Tritium and Caesium are to be discharged in peaks and troughs (see sections above) and that there is no review or discussion of the interaction outcomes of these intermittent concentration inputs with the behaviour and fate of warm water discharge plumes in the area adjacent to the discharge point, nor of the likely behaviour and fate of entrained radioactive wastes.
(Section 23)
…….

Sampling and monitoring programmes

NNB Genco's proposals for sampling and monitoring at the proposed Hinkley C station are based on the existing programmes for the A and B stations.

This Report identifies a number of significant weaknesses/flaws in those existing programmes that will militate against the collection of appropriate data sets required for dose and pathway calculations.

Current annual monitoring of fin fish is based on 1 sample of cod and 1 sample of sea bass from Stolford, which is not defined as either the capture site or the landing site (after capture elsewhere). Thus it is not known whether these migratory pelagic fish have been in the area for any relevant time span or that they have fed from local food webs. Furthermore, such a minute sample base cannot provide sufficient relevant information upon which to base any usefully representative fine fish dietary dose calculations.

It is noted that demersal (sea bed) fish, in closer contact with seabed sediments and food sources, would have provided a better indication of potential maximum dietary doses of radioactivity.

Similarly it is the current practice to annually sample and monitor 1 sample of limpets and 2 samples of shrimps, from Stolford. Again it is not explained whether the samples were captured elsewhere.

Limpets do not provide significant input to human diets and 1 sample cannot be geographically or seasonally representative of local or regional shellfish. Similarly 2 samples of shrimp cannot be geographically or seasonally representative of the radioactivity levels of local or regional crustaceans nor of their contribution to dietary doses of local consumers.

This Report therefore concludes that, because the flawed methodologies for fin fish and shellfish monitoring currently employed for Hinkley A and B are to be applied to Hinkley C monitoring, the Hinkley C monitoring cannot and will not provide a useful or accurate record of representative radio activity concentrations found in the entirety of locally caught marine fin fish and shellfish and crustaceans.

Therefore any subsequent dietary dose calculations will be similarly flawed, and thus the current dose models for the A and B stations are flawed, those offered in support of NNB Genco's submissions for the Hinkley C station are similarly flawed and any ongoing dose model outcomes will be similarly useless.

Current A & B station sampling and monitoring programmes take 2 samples of marine sediment (anything from pebbles down to very fine clay) from each of 9 sites across the 25 miles of Hinkley adjacent coastline per year. This policy is based on the concept of obtaining a geographical spread

of samples and is not tied in to a scientific appreciation of the radiological significance of fine sediments.

This Report explains that the presence and concentration of sediment related radio active wastes is closely linked to sediment grain size and that the current sampling regime makes no attempt to identify and collect sediment samples on the basis of their grain size.

This Report concludes that 18 samples (of un-determined grain size) from 9 sites represent a strikingly small number of samples, which cannot be verified as being at all representative of the range of sedimentary environments within the 25 mile sampling area.

This Report thus concludes that the sediment sampling and monitoring programme is further flawed because NNB Genco's Environmental Monitoring submission (NNB-OSL-REP-000137) states that the Environmental Monitoring Programme discussed in the document only takes account of routine releases from normal plant operation.

The absence of any discussion of the provision of Emergency Situation Monitoring Programmes is a matter of considerable concern since, without some degree of prior planning any emergency response is likely to be constructed and initiated under extreme pressure and without the benefit of rational analysis and discussion or the prior construction of equipment stockpiles. It is also important to note that abnormal plant operation could be both as a result of an accident, or a malevolent attack by hostile adversaries, resulting in a breach of containment in the reactor systems, or auxiliary buildings, such as fuel storage ponds. The Environment Agency should be calculating the deleterious environmental implications of a worst case scenario involving malevolent interruption. The Environment Agency may wish to consult here with the Civil Nuclear Security team within the Office for Nuclear Regulation, who have undertaken calculations based on the Design Basis Threat (DBT) for the Generic Design Assessment process in considering the EPR and the AP-1000 reactor designs.

This Report notes that it is proposed that discharges of some radio-nuclides will be intermittent, thus delivering pulsed peaks and troughs of input.

This fact is not addressed in NNB Genco's Monitoring document NNB-OSL-REP-000137. Thus it appears that there are no plans to construct the proposed marine monitoring programmes for Hinkley C in such a way as to take account of the several implications of pulsed discharges.

While of relevance to all nuclides entrained within the proposed pulsed discharges, it is particularly important in relation to Tritium because:

a: Tritium has a short life and hence peak concentrations in environmental samples (following pulsed discharges) may not be recorded by the proposed very low number/low frequency monitoring programmes based on those already in existence

b: Tritium is shown to very rapidly incorporate into marine samples (including foodstuffs) and thus the proposed low frequency/low number sampling programme will not be geared towards capturing peak tritium concentrations in foodstuffs.

c: thus, due to a: and b: (above) marine food pathway doses to exposed critical populations will not be effectively and accurately calculated each year, nor on a year on year chronological basis.

(Sections 24 and 25)

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Where should the monitoring be carried out?

Regulators and Industry alike agree that monitoring programmes "must provide representative data about the levels of radioactivity in the local area and ensure that locations where higher results might be found are sampled"

However, as shown in the preceding paragraphs, the relevance of sediments, sedimentology and grain size analysis is vital and integral to the provision of representative data.

The statement that the programme "must provide representative data about the levels of radioactivity in the local area and ensure that locations where higher results might be found are sampled." is contradicted by NNB Genco's other position statement that, "The locations should be evenly located around the station and be at appropriate distances" (Page 11 of NNB-OSL-REP-000137).

The two statements are mutually exclusive since there is absolutely no evidence that there has been any grain size analysis work, nor any other scientific work, to justify an assumption that "evenly located" and "at appropriate distances" sample sites provide an accurate (or even approximate) representation of "representative" or "higher results".

This Report concludes that, without grain size analysis, marine, coastal and estuarine sample site choice is an essentially hit or miss operation not based on scientific rigour and incapable of providing the required "representative data about the levels of radioactivity in the area" and "locations where higher levels might be found"

This Report notes that the current flawed monitoring programmes (and the proposed future programme based upon it) are strictly concerned with "near field" investigations within a 25 mile range of the Hinkley site, and that an extensive area of Somerset, Avon and Gloucestershire coast east of Weston Super Mare remains un-monitored as does virtually all of the south Wales coast other than a relatively small area around Cardiff.

This lack of monitoring is particularly significant in the case of the extensive fine sediment estuaries of the south Wales rivers, the extensive inter-tidal mud flats fringing the coasts of Gwent and Glamorgan and the extensive fine sediments of Swansea and Carmarthen Bay where sediment associating radio-nuclides (especially the long-lived alpha emitters/actinides) may have already begun to appear as a result of the current and historical discharges of the existing Hinkley and Oldbury reactors and may further concentrate if the proposed Hinkley C and Oldbury B stations begin discharges of liquid radioactive wastes.

Similarly, the surface waters, which have travelled past, and received the radioactive waste discharges of, the Hinkley and Oldbury sites, may also be of radiological significance.

This Report concludes that, given the lack of such monitoring in such areas it is legitimate to state that there is a wide swathe of ignorance concerning the radiological impact that the exiting stations may be making on those areas.

It is thus imperative that, at the very least, a wide ranging and detailed baseline survey of radioactivity in the South Wales and Avon sedimentary and water column environments be carried out prior to the initiation of discharges of radioactive waste from the proposed new reactors.

Similarly it is imperative that an ongoing sampling/monitoring programme should be maintained in order to check on the ongoing effects of those proposed new discharges of radioactive wastes in far field environments such as those of the south Wales coast.
(Section 26)

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Identification of pathways of dose delivery

This Report concludes that, because of identified failures in Bristol Channel monitoring programmes summarised above and because of the failure to take note of the unique sedimentary

and hydrodynamic regimes of the Bristol Channel, the NNB Genco submissions have failed to identify all possible pathways of dose delivery to coastal populations both in the immediate vicinity of Hinkley Point and in more distant coastal regions where “far field”/distant effects might occur as they are shown to do in other sea areas.
(Section 27)
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Flood and tsunami events

This Report briefly reviews UK and Bristol Channel meteorological flooding events and notes that recent years appear to have seen an increase in “storminess” and extreme rainfall events leading to severe flooding of low lying Bristol Channel flood plains and low lying coastal areas.

Marine originating flood events are also briefly reviewed and it is shown that academic research indicates 4 different causal factors, which have generated UK marine originating flood events. This research proposes that the 1607 Great Flood, which caused severe inundation of extensive areas of low lying Bristol Channel coastal zone, was closely linked to an earthquake occurring off the south coast of Ireland and that that area is still seismically active.

This Report notes that the academic research has concluded on a highly precautionary note and warned that, “the British tsunami risk requires a more careful evaluation”.

This Report concludes that, while it is clear that there is no scientific evidence to support any claim that a tsunami type event is likely to occur in the lifetime (40 to 60 years) of the proposed new Hinkley and Oldbury reactors, it is equally clear that there is no credible scientific evidence to support any claim that a tsunami type event is NOT likely to occur in the lifetime (40 to 60 years) of the proposed new Hinkley and Oldbury reactors.

The Fukushima experience demonstrates potential outcomes of such an event on sites, which have not been “proofed” against such events. It cannot be denied that, should such an event occur, its impact would be hugely exacerbated if it were to coincide with an extreme rainfall event.

In such a context, a strictly precautionary approach must be applied to all large engineering development proposals situated in coastal zones in respect of considering tsunami proofing. There are very good reasons for making sure that such a principle is strictly applied to nuclear power station developments.
(section 28)
……

Potential outcomes of a Fukushima type LOCA/Emergency Coolant Water use.

This Report concludes that neither the NNB Genco Submissions nor the Environment Agency’s GDA Report for the Hinkley UK EPR have addressed Loss of Coolant Accidents (LOCA) and the behaviour, fate and management of primary and secondary cooling waters in the event of a LOCA event. They fail to address the response necessary for the potentially massive Emergency Cooling Water (ECW) arisings, and have not conducted an analysis of the potential damage to site infrastructure, storage tanks or drainage systems due to unforeseen circumstances responsible for LOCA events.

They have failed to address the issues surrounding the necessity for the provision of capture/retention/treatment capacity for hundreds of thousands of cubic metres of ECW generated over prolonged time scales (at Fukushima 6 months and counting as of Nov 2011)
This Report notes that the information about site drainage is relevant to only “normal operations”, and contains no discussion of specific issues arising in the event of reactor or cooling pond LOCA events requiring the use of Fukushima type volumes of Emergency Cooling Water or severe flooding of sites (tidal bore, storm surge, tsunami, excessive rainfall).

The following extracts from the GDA for the Hinkley UK EPR are relevant:
"We have not considered at GDA other site liquid discharges such as surface water. The design of such systems will be site specific and there should be no contamination in normal operation. We will review site drainage at site specific permitting and, as a minimum, require accessible sampling points at final discharge locations for confirmation spot sampling."

This Report concludes that such an approach by NNB Genco and the Environment Agency lacks rigour, especially in the context of the coastal location of the proposed Hinkley C (and Oldbury B) NP stations and the very obvious inability to accurately predict the likely chronology or number of future meteorological and marine originating flooding events.
(Section 29)

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Climate Change effects.

This Report concludes that it is evident that there is a scientific consensus that climate change is exercising significant influences on Severn Estuary/Bristol Channel and Bridgwater Bay coastal environments, with increased storminess and ongoing sea level rise contributing to flooding and coastal erosion processes which are already shown to be making significant modifications of Bristol Channel and Bridgwater Bay low lying coastal environments.

This Report concludes that, in the context of observed historical and current modifications and ongoing future modelled losses, it is important to adopt a precautionary view of the state of knowledge of climate science and it's impacts on the marine environment because the knowledge base is constantly subject to updating as understanding and knowledge is refined by the acquisition of new data.

This Report notes that in the NNB Genco Submission there is no discussion of the effect that these climate change parameters may have on the behaviour and fate of historically discharged radioactive wastes already contained in these eroding coastal sediments, nor of the behaviour and fate of radioactive wastes proposed for discharge from proposed new reactors.
(Section 30)

……

Modelling Environmental concentrations of radioactivity and doses derived from them

This Report notes that the CREAM 98 modelling software used in the assessments of dispersion (i.e. behaviour and fate) of radio nuclides was made redundant before completion of the EDF/AREVA, NNB Genco and Environment Agency GDA assessments were completed.

It is noted that the latest PC CREAM 08 software was not used, despite being defined as "a significant improvement to CREAM 98".

This Report notes that both the CREAM 98 and its successor CREAM 08 model, are described as being suitable for assessments of continuous, uniform routine discharges, but are not stated to be suitable for the pulsed and intermittent discharges proposed for some nuclides from the Hinkley C reactors.

This Report notes that the models for Hinkley C are based on Irish Sea/Cumbrian Waters parameters but that no evidence is provided to support any assumption that there are any similarities between those waters and the Bristol Channel/Bridgwater Bay environments and that, on the contrary, there is evidence to indicate that there are identifiable dis-similarities between the two.

This Report further notes that neither PC CREAM model is informed by the latest research on the marine behaviour of radioactivity or by the ongoing research into the parameters necessary for

accurate modelling of environmental concentrations of radioactivity and the doses derived from them, and therefore concludes that their application to the modelling of proposed Hinkley C liquid discharges is highly inappropriate.
(Section 31)

Main text of consultation submission:

1. Position of Hinkley and Oldbury within the Bristol Channel.

1.1 The Bristol Channel Marine Aggregate Research Project (August 2000) identifies four separate zones within the Bristol Channel.

Outer Bristol Channel: defined by lines drawn from St Anne's Head (Pembrokeshire to Hartland Point and from Worms Head (Gower) to Bull Point and Lundy (Devon).

1.2 Central Bristol Channel: defined by lines drawn from Rhossili Point (Gower) to Bull Point (Devon) and from Nash Point (South Glamorgan coast Wales) to Minehead Bluff (Somerset).

1.3 Inner Bristol Channel: defined by lines drawn from Nash Point to Minehead Bluff and from Lavernock Point East Glamorgan coast) and Brean Down (Somerset).

1.4 Severn Estuary: (defined by lines drawn from Lavernock Point to Brean Down and across the River Severn at Newnham Gloucestershire).

1.5 Thus, the Hinkley Nuclear Power station is situated on the coast of Bridgwater Bay, in the Inner Bristol Channel and the Oldbury station is situated in the Severn Estuary. (Ref.1)

1.6 The Bristol Channel is a semi-enclosed sea area where many studies indicate that residence time of particulates and associated pollutants suspended in the water column may range from roughly 100 to 200 days landward of Minehead to 160 to 380 days in the area between Minehead and Lundy Island, after which they may be either flushed out to the Irish Sea or deposited out in regional sedimentary deposits.

2. Bristol Channel Water body movements

2.1 The MAFF Atlas of the Seas around the British Isles provides mapped generalised data for the general near surface (upper half of the water column) patterns of water movements in UK waters.

2.2 MAFF's charted evidence demonstrates that the water column enters the Bristol Channel from the south west, (Lands End, Celtic Sea) and travels in a north easterly direction parallel to the coasts of Cornwall, Devon and Somerset towards the Severn Estuary.

2.3 The water column exits the Bristol Channel in a westerly direction, parallel to the south coast of Wales and turns north into the Irish Sea as it passes the Pembrokeshire peninsula.

2.4 Supporting text explains that material in the top half of the water column will have a rate of travel of about 1.5 nautical miles per day.

2.5 This general pattern of movement is the annual norm, though tides and gales may temporarily modify rate and direction of movement. (Ref 2)

2.6 The understanding of Bristol Channel bottom water movement (lower half of the water column) is hampered by the overall weakness of systematic long term data collection. However, review of Bristol Channel seabed sediment transport provides relevant information relating to bottom water movement.

3. Sediment movements

Below a specific "grain" size, seabed sedimentary material is potentially highly mobile. However, it is important to remember that while heavier particles such as sand will generally travel at, or close

to, the seabed, finer particles (composed of clay/minerals/organic material) are highly susceptible to being lifted into the water column where they can travel as suspended particles over both extended distances and time scales.

4. Seabed sediments (sands)

4.1 A majority of studies of Bristol Channel sediment movements have investigated both the specifically local, and more generalised movement of seabed sediments with a particular focus on sand for the marine dredging industry. Such studies provide some insight into the movement of near seabed water body movements.

4.2 A 1996 Coastal Impact Study of part of the South Wales coast reports a long term and generally westward transport of sand out of the Bristol Channel and that the transport route runs roughly parallel to the south Wales coast (rather than to the Devon/Somerset coast). (Ref 3)

4.3 The Bristol Channel Marine Aggregates Research Project (August 2000) also reports a "net westerly transport of sediments through the Bristol Channel" and that the "supply of sediments along the southern flank of Helwick (south Wales coast) is from the Central Bristol Channel" (i.e. from the east). (Ref 4)

4.4 The Bristol Channel Marine Aggregates Research Project also provides a mapped, simplified conceptual model of sand transport in the Bristol Channel. This demonstrates that the seabed and close to sea bed (bottom half of the water column) material follows the broad principles set out above with major OUTFLOW of sand (relatively heavy sea bed sediments) travelling westward towards the open sea.

*4.5 However, the relevant data set also shows "a **suggested** easterly transport mechanism along the shallow coastal margins of the Bristol Channel", with relatively very small inflow movements moving towards the Severn Estuary along the coastal margins. (Ref 5)*

4.6 A "bedload parting zone" is identified toward the eastern end of the Inner Bristol Channel zone (western end of the Severn Estuary zone). From this bedload parting zone some sedimentary material is driven eastward into the Severn Estuary and some material is transported in a westerly direction through the Bristol Channel towards the Celtic Sea.

The bedload parting zone lies roughly between Bridgwater Bay on the south and Lavernock Point (Cardiff) on the north is several miles wide and may well move a few miles up or down the Bristol Channel in response to variable hydrodynamic and meteorological factors. (Ref 5)

5. Suspended sediments

5.1 There is a universal consensus that fine particle sediments are readily available for suspension in the water column under dynamic conditions such as those found in the Bristol Channel and Severn Estuary. Additionally, this is a phenomenon which is widely, and regularly visible as discoloration and/or loss of transparency of coastal waters, especially in areas of high turbidity and after storms etc have disturbed fine sediment, near coastal seabed deposits.

5.2 Many studies demonstrate that the inner sections of the Bristol Channel have very high concentrations of fine particulate materials suspended throughout the water column and that this phenomenon increases in significance with proximity to the Inner Bristol Channel and Severn Estuary zones defined in Chap 1 above.

5.3 The movement of fine sediments within the Bristol Channel is widely understood to be of particular significance in the context of contaminant/pollution behaviour because many toxic

substances tend to associate with fine sediments, which are potentially the most mobile sedimentary fraction under most conditions. (Ref 6)

5.4 It is stated that Bristol Channel/Severn Estuary fine (muddy) sediments are very mobile because of the exceptionally strong tides and currents (augmented by wind action). Tidal influence is demonstrated by the fact that research estimates that 130 million tonnes of fine sediment is suspended during spring tides, with this level reducing to about 9 million tonnes at neap tides. Thus, 70% of the sediment that is mobile at spring tides settles out during the less turbulent neap tides. (Ref 7)

5.5 Within the Bristol Channel/ Severn Estuary complex there are a number of large, fine sediment deposits, the majority of which are in association with the region's various sub estuaries including the Parrett Estuary (Bridgwater Bay). Bridgwater Bay is described as a shallow bay where the sediments are generally fine grained and "…there is a sequence of mud-sized sediment which is generally less than 5 metres thick, but which reaches up to 20 metres thick in the eastern margin of the bay." (i.e. in the vicinity of Hinkley Point). (Ref 8)

5.6 Latest reviews suggest that "despite its high mobility, the exchange of fine suspended particulate material between the estuary and the open sea occurs at relatively low rates, **with a minimum retention time of at least ten years**". This may be occurring as a result of the existence of "various gyres, which develop in Bridgwater Bay".

It is further noted that during winter "approximately double the amount of sediment is re-suspended than in the summer, presumably due to increased river flows and increased wind driven erosion". (Ref 9)

5.7 Tracer studies using "marked" fine sediments have indicated that most of the fine sediment transport occurs within the turbid water mass and it is proposed that Bridgwater Bay is "the major long term source of fine sediment" and that sediments from the Bridgwater Bay "move along the (Severn) estuary, principally on the English side, to form the turbid water mass that extends into the inner estuary".

These studies propose that the most significant sinks (areas of deposition/accretion of sediments) are probably Bridgwater Bay, the peripheral estuaries of the Parrett, and Avon (English coast), the Wye and the Usk (Welsh coast) and their associated salt marshes, and a few offshore sites such as the Newport Deep and Nash Passage (Welsh coast). (Ref 10)

5.8 Within the largely saline section of the Inner Bristol Channel there is an identifiable turbidity maximal where suspended sediment concentrations are markedly elevated. This is reported to be at its greatest in the vicinity of the Bridgwater Bay/Parrett Estuary area where suspended solids concentrations achieve between 4 to 16 grams per litre (with an observed peaks of 100 and 200 grams per litre at spring tides) are reported.

This area of turbidity maximal is reported to extend as far east as the Portishead area where suspended solid concentrations of between 132 milligrams per litre and 5 grams per litre are recorded. (Ref 11)

5.9 The extent of the turbidity maximal on the Welsh side is less well reported but appears to broadly comparable to its extent on the English side. It is relevant to note that there is a similarity to the shape and extent of the bedload (seabed sediment) parting zone described earlier.

5.10 Recent review work concludes that the strength of currents and their distribution are, ultimately, the principal drivers determining sediment deposition, erosion and transport (either in suspension or as bed load) in the Bristol Channel/Severn Estuary system and that

the “hydrodynamics also directly influence (and perhaps dominate) the dispersion of discharges”.

The review also states that:

A. “A better understanding of these features and their linkages would improve management options for the system”

and:

B. noting that flocculation (the aggregation of particles into flocs) “is a principal mechanism which controls how fine sediments, and thus contaminants, are transported” it reports that the “interpretation of the significance of this process is only just beginning to emerge. (Ref 12)

6. Data Gaps re sediment behaviour in the Bristol Channel

6.1 It is relevant to note that this recent work has highlighted a number of highly significant unknowns in the context of the statements recorded in the immediately preceding paragraphs.

6.2 The Review notes that, with respect to current understandings of the sediment dynamics and physical processes, much of the research and data collection was undertaken several decades ago and now there is a requirement to:

a: investigate how flocculation of suspended sediments responds to different degrees of turbulent mixing;

b: develop better sediment transport models to quantify settling of flocs, erodability of bed sediments and the settling of sediments during different tidal conditions;

c: examine how the mineralogical composition of muddy sediments influences their capability to both flocculate and adsorb/release pollutants;

d: Map the extent and magnitude of salinity intrusions and the turbidity maximal, including depth profile measurements in order to provide representative distributions of both suspended sedimentary matter and salinity on seasonal and neap/spring tidal cycles and time scales;

e: to determine the extent to which biological processes affect the behaviour of sediments and the bio availability of sediment associated contaminants (Ref 13).

7. Fate and behaviour of soluble and non soluble radioactivity

7.1 There is an extremely wide consensus that the fate and behaviour of radio nuclides in the sea is dependant upon their chemical form and physiochemical characteristics.

Some nuclides such as Caesium 137 or Tritium may remain in solution in the sea water after discharge to sea, and may thus travel in the water column for both extended distances and time scales.

Other radio nuclides, such as Plutonium 239 (with a half life of 24, 110 years), adsorb strongly to the outer surface of particulate matter suspended in the water column wherein they are available for transport in the water column (over extended distances and time scales) and subsequent deposition in fine sediment deposits such as estuarine and coastal mudflats and salt marshes. (Ref 14)

7.2 Water column transport

According to the International Council for the Exploration of the Seas, the fate of pollutants discharged to sea is dependant on the environmental conditions at the time of release and for a few months afterwards. (Ref 15)

7.3 The marine distribution of Caesium 137, discharged from the Sellafield sea pipes, has been widely mapped in order to study its distribution and dilution in the Irish Sea and further afield.

This work demonstrates that soluble radionuclides such as Caesium 137 discharged to sea can be detected many hundreds of kms distant from source. Furthermore, this work demonstrates that such "soluble" radioactivity spreads out of one distinct sea "area" (the Irish Sea) and into more than one other distinct sea area (e.g. the Southern North Sea). (Ref 16)

7.4 Other work has demonstrated that actinides (produced by the irradiation of uranium and other artificial elements), discharged to sea from the Sellafield site, can also travel hundreds of kms from source.

The 2009 monitoring of Irish Sea sediments, records the presence of the Sellafield derived actinides Plutonium, Americium and Curium isotopes on the Irish Sea coasts of Cumbria, Lancashire, S.W. Scotland, North Wales and Northern Ireland. (Ref 17)

7.5 Thus there is no doubt that both soluble and insoluble radio nuclides discharged to sea are physically adapted to being transported for:
a: extensive time periods and
b: over extensive distances from point of discharge.

8. Sedimentary deposits

8.1 As has been explained in the above chapters (5, 6 and 7) particulate material suspended in the water column is available for deposition into various environments under the influence of a range of parameters including flocculation and the influence of currents.

Such deposition is shown to occur in both estuarine sediments, estuary fringing mudflats and salt marshes and some more offshore sediment deposits which are usually formed under the influence of slack tide and/or gyre type phenomena.

8.2 However there is a consensus that such deposited material is subject to a number of mechanisms capable of re-suspending and re-injecting it into the water column where it is once again available for further transport. Trawling, earthquakes (surprisingly frequent in UK coastal waters), storm surge and surface waves which have an influence on shallow water sea beds.

As shown above, heavier suspended particles and/or flocs will deposit out of the water column relatively quickly. However, finer particles will travel through the marine environment for more extended periods before deposition.

8.3 Because a given volume of finer/lighter particles have a relatively greater surface area than a similar volume of coarser/heavier particles and because the fines tend to preferentially gather in the least dynamic, more low energy, sheltered and inshore environments it is usually the case that:
a: samples taken from mudflats and salt marshes in such low energy environments consist of these finer particles.
b: these fine sediment deposits are generally found to contain the highest concentrations of adsorbed radioactivity and other pollutants.

8.4 In the Wigtown Bay/Cree Estuary area of the Solway coast of Scotland, Sellafield derived radioactivity is measured at several sites.

It can be seen that the concentrations of the Sellafield derived actinides Plutonium (Pu) 238, Pu 239, Pu 240 and Americium 241 sampled at more "inner" estuary/bay (fine sediment) sites are markedly elevated over those sampled from the stony bottomed Garlieston Harbour at the mouth of the estuary/bay. (Ref 18)

9. Re-concentration mechanisms

9.1 The dominating historical justification for the discharge of liquid radioactive wastes to sea since the commencement of the UK military and civil nuclear programmes is the proposal that the wastes will inevitably be dispersed and diluted throughout the water column and the marine environment.

9.2 In 1952, when the first sea pipelines for the discharge of nuclear waste were commissioned at Windscale/Sellafield for the commencement of the UK's programme of discharge of radioactive wastes to sea, there was no knowledge of the behaviour of radioactive wastes in the marine environment. In the absence of relevant scientific data, the UK Government and the Nuclear Industry proposed an optimistic and simplistic model for the behaviour of radioactive wastes in coastal and marine environments. It was upon this proposed model that the scientific justifications for the sea disposal of radioactive wastes were based and original permission for such discharges was granted.

9.3 The model postulated that long lived, non-soluble nuclides such as the alpha emitting actinides like Plutonium (Pu) and Americium (Am), would become adsorbed to the surface of sedimentary particles in the marine water column, sink to the sea bed and remain permanently bound and immobilised in seabed sedimentary deposits close to the point of discharge. Less conservative nuclides, such as Caesium (Cs), would dilute and disperse through the water column until they reached "background" concentrations.

However, the real scientific ignorance of the subject was so great that eventually the Nuclear Industry was forced to admit that the whole issue of sea disposal, particularly in the Irish Sea, had really been an enormous research project. (Ref 19)

9.4 The evolving evidence now conclusively demonstrates that the original proposed model was certainly incorrect (with respect to non-soluble nuclides) and that there were, in fact several mechanisms by which non soluble radioactive wastes discharged to sea did not remain permanently bound and immobilised to the sea bed sediments.

9.5 Section 8:4 above provides evidence for both:

a: the transport of non soluble nuclides away from the point of discharge and into distant environments and

b: mechanisms by which non soluble nuclides become more concentrated in estuarine deposits as a result of their adsorption to fine sediment particles and subsequent deposition in fine sediment deposits.

9.6 Studies conducted in the laboratory and in the marine environment have demonstrated that Irish Sea surface micro layers (only thousandths of a millimetre thick) may become enriched with fine particle sedimentary material and their adsorbed radioactivity.
These studies have shown Irish Sea micro layers to be enriched with Plutonium and Americium (associated by adsorption to fine sediment particles) by factors of four to five (relative to concentrations found in the ambient seawater) (Ref 20)

9.7 The above referenced study also reported on investigations of the enrichment of marine aerosols (generated by bubble production in breaking waves and the surf line) with non soluble nuclides (associated by adsorption to fine sediment particles).

The study reported enrichment factors (relative to ambient seawater) of:

a: 291 for Pu 238
b: 347 for Pu 239
c: 347 for Pu 240
d: 583 for Am 241

In marine aerosols generated 10 km offshore of the Sellafield sea discharge pipelines.

9.8 Other studies report enrichment factors (relative to ambient seawater) of 812 for Am 241 in aerosols generated in the inshore surf zone along the Cumbrian coast. This evidence implies that coastally generated aerosols may produce higher enrichment factors than those produced in more open sea environments and it was estimated that about 2 curies of Pu 239 and 240 had been transferred from the sea to the land over a 14 year period. (Ref 21)

9.9 There is a marked paucity of study of other potential marine enrichment mechanisms such as fog production, evaporation from sea surfaces and evaporation from exposed mud flats.

However it has been calculated that algal blooms in the open sea may concentrate Plutonium by factors of up to 26,000 relative to concentrations in ambient sea water. (Ref 22)

9.10 It can also be demonstrated that soluble nuclides such as Caesium 137 are enriched in wet marine sediments throughout UK coastal and inshore waters (relative to concentrations in ambient marine water).

Thus, monitoring carried out in the marine environment adjacent to the Hinkley Point discharge pipeline reports:

a: seawater concentrations of Cs 137 (taken at the pipeline) of less than 0.33 Bq per kg

b: sediment concentrations of Cs 137 (at four Bridgewater Bay sites) ranging from 7.7 to 28 Bq per Kg. (max enrichment factor of 84) (Ref 23)

9.11 It is thus a very well reported and undeniable fact that there are mechanisms of re-concentration in the marine environment. In this context, the original simple hypothesis that discharged liquid radioactivity will dilute and disperse until it reaches "background" concentration is now shown to be highly simplistic.

It is plain that the behaviour and fate of sea discharged radioactive wastes is actually far more complex than previously believed and that a number of environmental parameters provide the opportunity for a range of intermediate and long term re-concentrations of radioactivity in inshore and coastal environments

10. Studies of Sea to land transfer of marine radioactivity

10.1 Since the early 1980s a number of studies have been carried out on the sea to land transfer of radioactivity. Much of the initial work was carried forward by the research division of the UKAEA, who chose the Irish Sea as their field of work (because of the presence of Sellafield and its major programme of discharge to sea of liquid radioactive wastes) and various isotopes of Plutonium (Pu) and Americium (Am) as the radio nuclides of interest.

A review of the UKAEA's work demonstrates that:

a: both Pu and Am were found to be airborne in any coastal area where the field work was carried out in onshore wind conditions and that the magnitude of the effect generally increased with wind speed;

b: the magnitude of the effect was also very closely linked to the volume of fine sediment particles ejected into the air in spray or aerosol formations and subsequently captured on muslin screens;

c: but, that the work was unable to provide accurate data on the true extent of the sea to land transfer of actinides, because the UKAEA's attempts to quantify the phenomenon were based on the use of flawed technology and methodology.

10.2 Muslin screens were deployed for the capture of airborne particles at surf line and near coastal (terrestrial) environments, while high volume air samplers (which draw air through an opening 1 metre above ground level) were sited inland of the muslin screens.

Muslin screens were originally deployed as a back up to the use of high volume air samplers, which were noted to be "not particularly suited" to sea to land transfer studies because they are "believed to be not very efficient for the relatively large particles". (Ref 24)

10.3 However it was reported that muslin screens provided inherently inaccurate data because as wind speeds increase (especially beyond Force 5) the muslin stretches and its porosity increases allowing more and more (and larger and larger) particles to pass through the material.

Attempts to estimate collection efficiency of the screens were unable to provide a definitive efficiency level for low winds but concluded that, at wind speeds of 12 metres per second (28 to 30 mph), the transmission/porosity of the screen was noted to be as high as 50% (efficiency had decreased by 50% of whatever it would be at minimum wind speeds).

It was accordingly noted that muslin screens should be used "only as a qualitative tool to compare relative concentrations of actinides in sea spray" (Ref 25)

10.4 It was also reported that the muslin screens are 5 m long, 1 metre deep and mounted vertically with their lower edges 1 metre off the ground level, but that the "enriched spray front" detected by the UKAEA at the shoreline in force five winds was about 10 metres high. N.B. At greater wind speeds it seems highly likely that an "enriched spray front" will be higher.

10.5 Despite the inability to provide usefully quantitative data on the concentrations of the actinides Pu and Am transferring from the marine to the terrestrial environments, such studies have conclusively demonstrated that the phenomenon does occur.

Subsequently a number of studies have attempted to investigate and confirm the impacts of the phenomenon on terrestrial environments.

10.6 In order to ascertain the significance of sea to land transfer of radioactivity along the Cumbrian coast, soil samples along two transects extending up to 20km inland were analysed for the insoluble nuclides Plutonium and Americium in 1982.

It was reported that: "Pu and Am deposits decrease with distance inland and correlate with deposits of marine-derived sodium. An enrichment of actinides in sea spray relative to seawater is required to account for the observed deposit." (Ref 26)

10.7 Subsequently (and still with a close focus on the Sellafield coast), there have been ongoing investigations of aspects of sea to land transfer in and around the Ravenglass Estuary. These have latterly focussed on the analysis of terrestrial foodstuffs to investigate the extent of transfer of radio nuclides from sea to land. Analysis of samples of milk, crops, fruit, livestock and other environmental indicators are collected annually and analysed for radio nuclides released in liquid effluent discharges from the Sellafield pipelines.

Thus the annual RIFE reports regularly report the detection of low levels of Technetium 99 and other artificial nuclides and also identification of (probably Sellafield derived) transuranic nuclides such as Pu 238, Pu 239 and Pu 240 in samples, thus confirming the occurrence of sea to land transfer and the entry of sea-discharged radioactivity into human terrestrial food chains. (Ref 27)

10.8 Some work on the issue of sea to land transfer via aerosol mechanisms was carried out on the north coast of Wales in 2005 and 2006. With respect to inland soil samples it was reported that the results suggested "that sea to land transfer of Pu alpha was occurring" either by "direct inundation of by deposition of marine aerosols".
NB: This study provided no hard evidence of relevant inundation events

However this study also reported that the results of sampling of coastal air using High Volume Air Samplers indicated that airborne Pu alpha and Am 241 levels were all less than the limit of detection. (Ref 28)

NB: The above study gives no indication that the 2005 version of High Volume Air Samplers were in any way improved over the 1980s version which were noted to be "not particularly suited" to sea to land transfer studies because they are "believed to be not very efficient for the relatively large particles". (see section 10:2 above)

10.9 As mentioned above, the study of the sea to land transfer of anthropogenic marine radioactivity commissioned by the nuclear industry and/or government agencies has been focussed:

a: on the coastal areas of the northern basin of the Irish Sea in the vicinity of the Sellafield sea discharge point sources

b: on the insoluble alpha actinides/transuranics.

However there is a body of independently commissioned and conducted work, which has reported on the phenomenon in other coastal areas and in respect of "soluble" radionuclides, some examples follow:

10.10 In south west Wales, Dyfed County Council commissioned a study of radioactivity in the county in the late 1980s, which among other things was asked to confirm or deny the presence of indications of sea to land transfer of Sellafield derived sea discharged material in inland environments.

This study confirmed the presence of Caesium 137 (proved to have been derived from Sellafield sea discharges) in pasture grass up to 10 Km inland of the Cardigan Bay coast of south west Wales, thus confirming:

a: an unexpectedly deep inland penetration of this isotope

b: the fact that it must therefore be entering into the regional terrestrial dairy and meat food chain

c: and strongly implying it's entry into other local produce food chains (potatoes, vegetables and fruit etc) (Ref 29)

10.11 In a study of patients from North Uist (Western Isles of Scotland) an independent medical team found excess Caesium body burdens compared to those in patients from the Scottish mainland and investigated the source of Cs in the N.Uist patients.

The immediate dose source was shown to be excess dietary intake of Cs, which was identified in all types of island grown food produce and environmental samples. Island dairy produce, meat and fish all had higher Cs concentrations than their mainland counterparts. High concentrations of Cs were also reported for N.Uist seaweed, beach sand, inland peat and both coastal and inland pasture grass.

Highest body burdens of Cs (and highest concentrations in urine samples) were found in those patients shown to be consuming the greatest dietary percentage of island produce. The average islander dietary dose, from Cs alone, was calculated at 13.7 micro Sv.
NB: This dose exceeds that, calculated for multiple nuclides, received by many officially identified coastal Critical groups ***adjacent*** *to points of discharge.*

The "fingerprint" of the analysed Cs indicated a clear Sellafield sea discharge component in the majority of samples. The study concluded that it was "important to note that an isotope discharged into the sea as waste may return to land at considerable distance from the site of discharge and enter the human food chain".
(Ref 30)

10.12 Since North Uist is shown to be saturated with Sellafield sea discharged Cs, it is not unreasonable to assume that other nuclides known to transfer from the sea to the land are also present in the islanders diet. Islander doses for total nuclides will plainly be significantly greater than the calculated dose for CS only. North Uist is approximately 200 kms by sea from the Sellafield discharge pipe.

10.13 In addition to the sea to land transfer by pathways of sea spray and marine aerosols, inundation during high winds, storm surges and tsunami type phenomena is also a recognised, though poorly studied pathway.

Similarly, sea to land transfer is referenced in the case of the use of marine based fertilisers such as sea weed

The transfer of marine fine particles, re-suspended from the drying surfaces of exposed inter-tidal sediments, during periods of onshore wind has also been alluded to in some studies but is very poorly researched.

10.14 There may be also be possibility that other pathways such as fog formation and evaporation from enriched sea surfaces and the drying out of inter tidal sediments may also make a contribution to sea to land transfer, such processes may be particularly relevant in the case of soluble nuclides such as Caesium and Tritium but such pathways remain hypothetical at the present as no studies appear to have investigated such a possibility.

11. Inferences to be drawn from Sea to Land transfer studies

11.1 There is a problem due to the lack of accessible historical data. While much information is available from peer reviewed journals, other data produced by government agencies and nuclear industry bodies can rapidly disappear from public access.

A case in point (though not the only one) is the following paper:
Ould-Dada, Z. 2000. "Sea to land transfer of radio nuclides. How much do we know?" (Proceedings 2nd Radrem-Tesc Workshop. London: Jan 21.1999. DETR/RADREM/00.001 DETR London) which has been much referenced, in recent annual RIFE reports and other documents, which state that sea to land transfer is of low radiological significance.

Regrettably, applications for a copy of this paper, made to the libraries of DETR, CEFAS, DEFRA, DECC and even the author himself (now working for the DECC) have been met with the reply that it is no longer available. Thus it is not possible to carry out an analytical review of this, or similar, papers.

11.2 However, there is plainly an evidence based consensus that:

a: man made radioactive wastes discharged to sea do transfer across the surf line from the sea to the land

b: however, the studies of some of the mechanisms reviewed in Chap 10 above make it plain that attempts to quantify the magnitude and significance of sea to land transfer via aerosol and sea spray pathways are inherently flawed because BOTH of the two tools (muslin screens and high volume air samplers) used for the task are inefficient and that, in the case of muslin screens that inefficiency has been calculated to increase markedly as sea to land wind speeds increase

c: these 2 available tools are unlikely to be able to provide appropriate sampling of "enriched spray fronts" because even in Force 5 winds such fronts are believed to be about 10 metres high (and possibly higher in stronger winds)

11.3 Sellafield marine discharged actinides (such as Pu and Am) are shown to be enriched in sea spray and marine originating aerosols, to transfer across the surf line and to be deposited in Cumbrian terrestrial environments where concentrations decrease with distance from the coast.

In Cumbrian estuarine environments sea to land transfer of actinides and Technetium 99 are regularly shown to have contaminated a wide range of terrestrial wild and cultivated foodstuffs.

11.4 Similar phenomena have been recorded in North Wales where Pu alpha, originating from Sellafield sea discharges, was detected in terrestrial soil samples, having transferred from the sea to the land either by direct inundation or by sea spray/aerosol pathways.

11.5 In south west Wales an independent study commissioned by Dyfed County Council has demonstrated the presence of Sellafield sea discharged Caesium 137 in pasture grass (at 10 Km inland of Cardigan Bay coasts) where it was shown to be entering the dairy/beef/sheep-meat food chain and therefore also available for entry into other terrestrial food stuff pathways (potatoes, vegetable, fruits etc). (Ref 31)

11.6 Independent work in the Hebrides has also demonstrated significant entry of Sellafield sea discharged Caesium 137 into almost the entirety of small island terrestrial and marine ingestion pathways, producing an average islander dietary dose (from Cs 137 alone) of 13.7 microSv, which is higher than some (multi nuclide) dietary doses received by the most exposed Critical Groups living around some UK nuclear power stations. (Ref 32)

11.7 Government agency and nuclear industry research programmes on aerosol and sea spray pathways of sea to land transfer have focussed exclusively on:

a: Sellafield derived actinides (Pu and Am etc)
b: the northern and eastern basin of the Irish Sea

11.8 However, the independent work, described above, clearly demonstrates that:

a: the “soluble” nuclides such as Caesium also transfer from the sea to the land
b: that such Cs has the potential to make significant contributions to dietary dose
c: that in the case of Cs at least, this process can occur at distances of at least 200 Kms from point of discharge.

Furthermore, in this context, the observed behaviour of Caesium strongly implies the likelihood that other, equally (or more) “soluble” nuclides will exhibit the same fate and behaviour, though their distance-from-source impact will be restricted by their half life.

11.9 The reported independent studies from south west Wales and the Hebrides also plainly indicate the fallibility of focussing solely on the northern basin of the Irish Sea as a field study area.

This is highlighted by a comparative review of other sea area parameters, which plainly demonstrates appreciable differences in various observable parameters between sea areas.

A case in point is the suspended sediment loadings of various water bodies, which are shown to be vitally important factors in the marine environmental behaviour and fate of alpha/actinides such as Plutonium, Americium and Curium (see Chap 9 above).

11.10 Thus, Irish Sea suspended sediment loadings are significantly lower than those found in much of the Bristol Channel:

Average sediment loadings in the Eastern Irish Sea are reported as being around 2.14 mg per litre (Ref 33)

Irish Sea shallow areas with faster currents (similar to conditions found close to Cumbrian and other coastlines) are reported to have suspended sediment concentrations of average 7.6 mg per litre (Ref 34)

Compare these figures to those given for the Bristol Channel suspended sediments in Chapter 5 (above) where:

a: normal suspended sediment solid loadings for the Bridgwater Bay/Parrett Estuary area are given as 4 to 16 ***grams*** *per litre*

b: peak concentrations can reach 200 ***grams*** *per litre*

c: concentrations at Portishead range from 132 mg to 5 ***grams*** *per litre*

11.11 It may therefore be postulated that, because the suspended sediment loading regime of the Bristol Channel is reported to be markedly different from that of the Irish Sea, the fate and behaviour of sediment associating radioactive wastes in Bristol Channel environments may not be a "carbon copy" of the fate and behaviour of those found in the Irish Sea, especially in respect of the range of sediment associated mechanisms such as sea surface micro layer enrichment, sediment ejection into sea sprays and marine aerosols and the sea-to-land transfer, transport and deposition of sediment associated radio nuclides.

11.12 It may also be postulated that:

a: because the organic loading of River Parret sediments (originating as they do from the very extensive vegetation and humus rich Somerset Levels) is likely to be dissimilar to the organic loading of Sellafield coastal waters,

b: the fate and behaviour of radioactive material whose action and magnitude is dependent upon an association with organic particles may not (in the Bristol Channel) be a carbon copy of their fate and behaviour as reported in the Irish Sea and Sellafield coastal waters.

11.13 There is a marked paucity (in some cases a total lack) of study of other potential marine enrichment and sea to land transfer mechanisms such as fog production, evaporation from sea surfaces and evaporation from exposed mud flats, sea to land transfer of highly actinide enriched micro organisms, transfer of marine fine particles (re-suspended from the drying surfaces of exposed inter tidal sediments), inundation etc.

11.14 **It is in the context of these "unknowns" that the current proposal for the disposal of aqueous/liquid radioactive wastes from the proposed Hinkley C reactors to the Bristol Channel has been made.**

12. Proposed Hinkley Point discharges of liquid radioactive waste

12.1 The liquid radio active waste discharges from the proposed EPR reactors are expected to consist of a cocktail of 14 named radio nuclides and an indeterminate number of others.

12.2 The Environment Agency GDA documents have identified the major components of the EPR liquid discharges as:

- *Tritium (H3)*
- *Caesium 137 (Cs137)*
- *Carbon 14 (C14)*
- *Isotopes of Iodine (I)*
- *Cobalt 60 (Co60)*

12:3 The minor components of the EPR liquid discharges consist of the following isotopes:

- *Ag (silver) 110*
- *Co (cobalt) 58*
- *Cs (caesium) 134*
- *Mn (manganese) 56*
- *Sb (antimony) 124*

- *Sb (antimony) 125*
- *Te (tellurium) 123*
- *Ni (nickel) 63*
- *Cr (chromium) 51*

12.4 The GDA also notes the presence of a number of un-named "others" in the discharge stream which appear to include some of the alpha emitting actinides as implied by para 58 (page 16) of Generic design assessment UK EPR nuclear power plant design by AREVA NP SAS and Electricite de France SA, Assessment Report Aqueous radioactive waste disposal and limits *which states that "alpha emitting radio nuclides should not be present in detectable amounts in the aqueous discharge and that in-line detectors will operate to prevent any such discharges."*

N.B. It can be inferred from this statement that SOME alpha emitters will be present in the liquid discharges from the EPR reactors

12.5 The AP1000 reactors are also expected to generate liquid radioactive wastes consisting of a large number of radio nuclides.

Table 3.4-6 of the AP1000 European Design Control Document and the Environment Report, *issued by Westinghouse, lists a total of 65 nuclides described as "expected annual release of radioactive effluent discharges".*

The Environment Agency's GDA for the AP1000 lists the major components of the liquid discharge as:
- *Tritium*
- *Carbon 14*
- *Cobalt 60*
- *Caesium 137*

12.6 The Westinghouse Table referred to in 12:5 above, lists 12 individual alpha emitters/actinides including 3 isotopes of Uranium, 5 isotopes of Plutonium, 2 isotopes of Americium and 2 isotopes of Curium as components of the "expected annual radioactive effluent discharges"

*12.7 The GDA for the AP1000 also refers to the presence of "other" nuclides and "minor radio nuclides" (*Environment Agency. GDA Assessment Report AP1000-05. page 50, Table 13).

This Table specifically lists, and quantifies, Plutonium 241 (parent of alpha emitting decay product Americium 241) as a component of the discharge, but does not list any other alpha emitters/actinides, nor attempt quantification of any other named actinide/alpha emitters.

12.8 **<u>In the context of this, and the following sections discussing the discharge of specific nuclides/isotopes, it is highly relevant to note that all of the substances likely to be found in the liquid radioactive waste discharge streams are also likely to be discharged through Hinkley C site stacks and chimneys in gaseous and atmospheric discharge streams.</u>**

It is absolutely certain that a potentially significant percentage of these gaseous/atmospheric discharges will also enter the marine environment as a result of both:

a: direct washout and fallout from atmosphere to the Bristol Channel (during both normal and temperature inversion conditions)

b: indirect washout and fallout of material onto land surfaces and subsequent transport from land surfaces into water courses and hence into the coastal environment

None of the documents studied during the course of compiling this Report have made mention of this parameter and thus it is concluded that the contribution of this mechanism to overall marine concentrations and subsequent doses remains wholly un-quantified. Thus the available data base remains deeply flawed.

13. Tritium - Volumes of discharge

13.1 The following Tables set out the basic data for liquid discharges of Tritium from:

a: existing nuclear facilities discharging into Bristol Channel waters under normal operating conditions for 2009, including any "contingencies" as taken from the annual RIFE 15 report for that year

b: proposed new stations discharging into Bristol Channel waters as set out by the EA's GDA for each reactor type

Table A: Annual Bristol Channel Tritium data for 2009

Station	Limit (TBq)	Actual Discharge(TBq)
Hinkley A	*1.8*	*0.232*
Hinkley B	650	105
Berkeley	1.0	0.00199
Oldbury	1.0	0.152
Total Limits	653	Actual discharges: 105.38599

Table B: Tritium discharges proposed for new Bristol Channel stations

Station	*Limits*	*Expected Annual Discharge (no contingencies)*
Hinkley C (EPR x 2)	150 TBq	104 TBq
Oldbury B (AP1000x3)	180 TBq	105.27 TBq
Total Limits	330TBq	Total expected actual 209.27TBq

13.2 Assuming that discharges of tritium will remain more or less steady over the next few years at existing reactors, it may be concluded that when the proposed new stations at Hinkley and Oldbury begin operational discharges, the proposal is as follows:

- The combined, annual liquid tritium discharge limit for operational discharges from all Bristol Channel nuclear power stations will rise from 653 TBq (2009) to 983 TBq (50% increase)
- The combined actual annual discharge of liquid tritium for normal operational discharges from all Bristol Channel stations will rise from 105.4 TBq (2009) to 314.6 TBq (3 fold increase)

The nature of tritium-in-water discharges

13.3 Tritium (H 3) is the heaviest isotope of hydrogen; it is beta active and has a half life of 12 years.

The EA's GDA says that the source of liquid Tritium discharges from both the EPR and the AP1000 reactors is the primary and secondary reactor coolant waters where the volume of Tritium production relates directly to the rate of power production and the coolant chemistry.

13.4 There is a very wide consensus that Tritium discharged to sea in cooling waters and as a radioactive waste product, rapidly mixes with the upper section of the water column/shallow water and that tritiated water (HTO) behaves environmentally like any other water.

Thus it follows that HTO must be equally liable to form aerosols and spray droplets during wave break in the open sea and at the surf line, as is ambient (or un-tritiated) seawater. However, there is no evidence that there has been any study of the sea to land transfer of tritium.

13.5 Tritium is widely and ubiquitously present in steam discharged atmospherically from reactors during their normal operation, in which form it behaves environmentally like any other condensed water vapour and is readily able to condense out and to enter marine and terrestrial environments as fall out or washout.

13.6 Studies have shown that "most of the tritiated water in soil is re-emitted into the atmosphere" and that during the first few hours following a deposition of tritium, the re-emission rate has been evaluated at 28% in the first hour following deposition (Ref 35)

13.7 It is also stated that "the oceans are the major global reservoir of hydrogen on earth and thus of tritium" and that "most of the tritium released into the environment by human activities finally resides in the oceans" (Ref 36)

13.8 Plainly marine environments are important sinks and reservoirs of tritium and tritiated water and thus the geo-chemical and biological behaviour of tritium and tritiated waters are of the utmost interest in the context of the more than doubled proposed rise of tritium inputs into the relatively small, enclosed sea area of the Bristol Channel

14. Managing the discharge of tritium from EPR reactors

14.1 The Environment Agency's GDA Assessment reports the manufacturers' assertion that there are no available techniques to remove tritium from the reactor coolant and agrees with the operator's statement that "to avoid the build up of tritium in the coolant (to reduce radiological hazard) a portion of the coolant must be discharged (and replaced)." (Ref 37)

14.2 The operators of the proposed Hinkley station have stated that there are different ways to safely operate the proposed Hinkley station and that these alternative strategies "can affect the timing of the liquid tritium discharges".

14.3 Subsequent text reports that some existing sites choose to discharge liquid tritium continuously, while other sites choose to discharge liquid tritium on a periodic basis, and states that "in reality the discharge profile is likely to be a combination of the two scenarios".

14.4 It is further stated that the choice of discharge practice "is normally decided by the operator of the specific site. NNB Genco has not selected yet its preferred management regime for the liquid discharges of tritium at Hinkley Point C. It may be one of the options described above or a combination of both".

14.5 NNB Genco have also stated that:

a: "it is important to provide an appropriate level of flexibility in the operational management of the plant"

b: "NNB Genco will identify their preferred management regime before the start of operations at Hinkley Point C."

c: "This decision will be based on BAT and ALAR considerations and will be assessed throughout the operating life of the plant to ensure continuing application of BAT" (Ref 38)

14.6 The above statements may interpreted as preparing the ground for a decision, that intermittent, rather than continuous, discharges of liquid tritium will be a significant aspect of the preferred management option for liquid tritium discharges.

14.7 In section 3.1 NNB Genco state that "the information presented for GDA presents the current approach adopted in France".

In their subsequent section 3.3 they report that "the monthly discharges of liquid tritium over the years considered are variable and range between 1% and 21% of the total annual site

discharge limit at Flamanville, and between 2 and 15% of the total annual site discharge limit at Paluel".

N.B. From this information it is evident that there would be significant peaks and troughs of tritium discharge throughout any given 12 month period, if this strategy was adopted.

Fate and behaviour of tritium in marine environments -

15. Historical understanding of the significance of fate and behaviour of tritium

15.1 Historically there has been a wide consensus between the nuclear industry and the regulatory agencies that Tritium was of little radio biological significance, largely based on the assumption that discharged tritium (as tritiated water) would naturally dissolve to infinity once in the marine environment and thus present no radio biological hazard. This attitude was typified by the following example:

15.2 In **1985**, liquid Tritium discharges from the Hinkley A Station were increased following work to clean the coolant circuit. The 1985 discharge was 23 TBq, compared to previous years when the annual liquid discharge of Tritium from this station was less than 1 TBq per year. (Ref 39)

15.3 Despite the observed 23 fold increase in tritium discharges in 1985, the regulatory authority stated that: "the increased discharges were of negligible radiological significance" (Ref 40)

15.4 However by **1999** this approach appears to have been under review, when a more precautionary position began to appear when reference was made to the "relatively high levels of organically bound tritium (OBT) in local fish and shellfish" from the Cardiff area of the Bristol Channel/Severn Estuary (max of 33,000 Bq/Kg in cod and 26,000Bq/Kg in mussel).

15.5 It was also reported that additional sampling of tide washed pasture and wildfowl (Curlew, Pintail, Shelduck and "duck") that feed in the Bristol Channel/Severn Estuary intertidal zone had found elevated levels of tritium in most samples with:

a: lowest wildfowl concentrations at 2,400 Bq/Kg
b: "the highest values found were in Shelduck at about 61,000Bq/Kg total tritium"
c: grass concentrations ranging from less than 3 Bq/kg to 2,000Bq/Kg
d: intertidal sediment concentrations ranging from 18Bq/Kg to 2,500Bq/Kg

While the ambient sea water concentrations of total tritium were reported to range from 9.2 Bq/Kg to 10Bq/Kg: thus representing an extremely high rate/level of biological accumulation of total tritium (assumed to be OBT + tritiated water)

15.6 In the context of these findings it was reported that research and further sampling were underway "to examine the mechanisms by which tritium becomes incorporated into biota in the marine environment" (Ref 41)

16. Revising the understanding of fate and behaviour of tritium

16.1 A follow on study (undertaken during 1999/2000) of the behaviour of Tritium (3H) in the Severn Estuary and Bristol Channel and published in **2001** found that:

Tritium concentrations in sea water from the Atlantic approaches to the Bristol Channel is estimated to be less than 0.4 Bq/Kg.

Measured Tritium concentrations in sea surface water samples at the mouth of the Bristol Channel were lower than the detection level of 2 Bq/Kg.

Measured Tritium concentrations in seawater inside the Bristol Channel were at their highest (between 2 and 10 Bq/Kg) on the English side of the Bristol Channel in the vicinity of the Hinkley Nuclear Power Station outfalls.

Measured Tritium concentrations reached their Bristol Channel second highest concentrations (between 2 and 7Bq/Kg) in the vicinity of the Cardiff outfalls.

16.2 In general, measured concentrations were at their most elevated (2 to 5Bq/Kg) in the eastern end of the sea area and at their least elevated to the west of the Hinkley discharge points. (Ref 42)

16.3 The **2001** study also reported that marine organisms incorporate Tritium, via exposure to tritiated water, very rapidly and, within a range of a few minutes to a few hours and reach concentrations close to that of the tritiated sea water in which they are immersed or from which they are acquiring their food.

16.4 **N.B. These are highly significant findings in the context of the information discussed in 14:7 above. If there were to be discrete pulses or peaks (individually consisting of as much as 21% of annual discharge limit) of liquid tritium discharge, it follows that tritium concentrations in marine organisms, with their very rapid incorporation rates, will be subject to similar time related peaks of concentrations of tritium.**

16.5 **From the information currently available it remains unclear whether the various assumptions for delivered doses of tritium have been based on steady state delivery of liquid tritium discharges to the Hinkley marine environment or whether they are based on the peaks and troughs of tritium discharges implied by NNB Genco's statements.**

16.6 The **2001** study also found that:

a: tritium becomes incorporated into the organic matter of cells and becomes Organically Bound Tritium (OBT), but at a slower rate than above and typically reaches a concentration of about half that of the ambient tritiated seawater

b: Organisms which consume tritiated food accumulate OBT at a faster rate than those exposed only to tritiated water and may reach higher concentrations by bio-accumulation

c: environmental monitoring through out UK waters demonstrates that concentrations of 3H in seafood in the Bristol Channel/Severn Estuary sea area are significantly greater than other UK marine areas

d: there was an observed disparity in the rate and degree of Tritium bioaccumulation between sediment, seaweed, benthic (seabed) organisms and fish; however this was provisionally attributed to different processes of Tritium uptake by different species

e: that bioaccumulation of tritium by benthic organisms and demersal fish occurs primarily via transfer up through a web of sediment dwelling microbes and meiofauna, which had been feeding on organic bound tritium. In this context it was observed that herbivorous species and pelagic fish had lower concentrations of tritium than carnivores and demersal (dwelling near the sea bed) fish (Ref 42)

17. Further research on the fate and behaviour of tritium discharged to sea

17.1 a more recent study (published in **2009)** reported that:

a: although tritium's reactivity with organic materials and solids in the marine environment had previously been "assumed to be limited",

and that -

b: previously, the accumulation of tritium in organic rich sediment and the food chain of the Severn Estuary "including concentration factors in excess of 100,000 for demersal fish and shellfish, were ascribed to the existence of organically bound

tritium (OBT) in local nuclear waste in the form of specific bio-chemicals, including carbohydrates, vitamins and amino-acids"

17.2 However, the 2009 research demonstrated that, contrary to this assumption, the research results "found that its distribution appears to be influenced by its affinity for organic matter" and that "Significantly, a measurable fraction of sorbed tritium associates with proteinaceous material that is potentially available to sediment-feeding organisms."

17.3 It was also noted that the discharge of tritiated water from a nuclear establishment on the Tamar estuary resulted in the immediate dilution to activities of less than 10 Bq per Kg in ambient water, "whereas corresponding activities of about 300Bq/Kg (dry weight) in sediment" where observed.

17.4 In the context of the above effect (which has been noted in this and other, estuarine waters) it was reported that the research absorption and adsorption (sorption) experiments had demonstrated that "sediment organic matter is critical to the removal of tritium from the aqueous phase" and that the effect "was greater in seawater than in river water"

17.5 The 2009 study noted that "the most remarkable aspect of our investigation is the extent of associated tritium, with both dissolved HOM (hydrophobic organic matter) and fine estuarine particles".

17.6 "Experimental results, suggest that the presence and nature of organic matter is critical to the fate of tritium in the aquatic environment, and that there is also potential for its interaction with and uptake by inorganic phases. Association of tritium with sediment organic matter was corroborated in our studies by its near complete (greater than 95%) digestion in untreated estuarine particles"

17.7 Noting that "…These characteristics have not been reported previously", the 2009 study concludes that:
"Clearly the view that tritium occurs exclusively as tritiated water and therefore dissolves to infinity should be considered cautiously. Further research into the concept and nature of tritium partitioning in natural waters is required, and the adoption of unit value (or sub-unit value) distribution coefficients and concentration factors that are currently recommended by the IAEA, but not supported by clearly defined measurements, may require reconsideration."
(Ref 43)

17.8 The latest edition of the relevant IAEA recommendations is" Sediment distribution coefficients and concentration factors for biota in the marine environment." Technical Reports Series 422. International Atomic Energy Agency. Vienna 2004.

18. Summary conclusions on Tritium:

18.1 ***Section 13:***
If the proposed new Hinkley and Oldbury reactors come on line, tritium discharge limits (for combined existing and new Bristol Channel NPSs) will rise by 50% from 653 TBq to 983 Tbq per annum.

If the proposed new Hinkley and Oldbury reactors come on line the actual annual discharge of tritium (for combined existing and new Bristol Channel NPSs) will rise from 105.4 TBq to 314.6 TBq per annum (3 fold rise)

18.2 Aqueous tritium discharged to sea rapidly mixes with surface water and behaves like any other water. Thus it is probable that it transfers from the sea to the land in marine sea sprays and aerosol droplets. (See next section: Caesium)
A search of 'Science Direct' has been unable to find any publications/references for the subject "Tritium in sea spray and marine aerosols", it is therefore concluded that there is probably no published research on this subject.

18.3 ***Section 14:***
NNB Genco say there because are no available techniques to remove tritium from reactor coolant and thus, to avoid the build up of tritium in the coolant, a portion of the coolant must be discharged to sea and replaced.

NNB Genco say that discharge strategies are normally decided by the site operator and that they will identify the preferred management strategy regime before the start of operational management of the plant.

18.4 The chosen management strategy for proposed new liquid tritium discharges at Hinkley appears likely to be based on that employed at EDF reactors in France, where discharges are pulsed rather than continuous. NNB Genco statements imply that this may be the chosen strategy at Hinkley.

18.5 If such a strategy is employed at Hinkley this could lead to as much as 21% of annual discharge being discharged in 1 month, leading to major peaks and troughs of discharge across a 12 month period. It follows that tritium concentrations in marine organisms, with their very rapid tritium incorporation rates, will be subject to similar time related peaks of concentrations of tritium.

18.6 *From the information currently available it remains unclear whether the various assumptions for delivered doses of tritium (via seafoods) have been based on steady state delivery of liquid tritium discharges to the Hinkley marine environment or whether they are based on the peaks and troughs of tritium discharges implied by NNB Genco's statements.*

18.7 ***Sections 15 & 16***
Over the last 20 years there has been a major, and ongoing, review of the behaviour and fate of aqueous discharge tritium in marine and estuarine environments.

The previous hypothesis was that tritium would disperse and dilute to infinity after discharge into the Bristol Channel marine environment and hence that tritium discharges were of negligible significance.

18:8 However, the evolving empirical research now demonstrates that, contrary to the previous view:

a: in the Bristol Channel, tritium does not disperse and dilute to infinity
b: tritium rapidly bonds with suspended organic/sedimentary particles in the receiving waters
c: tritium concentrations in Bristol Channel fine sediment deposits are significantly elevated over those found in ambient seawater
d: tritium bio-availability is much greater than expected
e: uptake through organic/sedimentary particles to marine and estuarine food webs is demonstrated to be much higher than was expected, (tritium concentration factors in demersal fish and shellfish of up to 100,000)

18.9 As a result of these and other findings, it is stated that:

a: existing IAEA recommendations are not supported by clearly defined measurements
b: the adoption of unit value (or sub-unit value) distribution coefficients and concentration factors currently recommended by the IAEA may require reconsideration
c: further research is required

18.10 N.B. It is highly relevant to note that the actual annual discharges, of Tritium from the combined Hinkley Point stations, have been markedly reduced in response to the evolution of the understanding of tritium.

Thus, in 1999, the combined Hinkley A and B station Tritium actual discharge was 355.8TBq (RIFE 5).
But by 2009 the combined Hinkley Point Tritium discharge was reduced to 105.232TBq (RIFE 15)

18.11 A Subchapter of NNB Genco's Radioactive Substances Regulation Submission Hinkley Point C: Chapter 12.2 says that

a: Initial Radiological Assessments (IRA) provided by the Environment Agency have been used to determine environmental concentrations and doses to the public

b: the general methods used in IRA are described in the EC Guidance Document Radiation Protection 72 published in 1995 (Ref 44)

c: In 1998, UK Agencies (NRPB, E.A etc) initiated use of the modelling system PC CREAM 98 as a tool for carrying out radiobiological impact assessments according to the methodology detailed in "Radiation Protection 72" and this is referenced as the modelling system for the hypothetical calculation of environmental concentrations and doses to the public arising from the proposed Hinkley C liquid discharges. (Ref 45)

18.12 To date it remains unclear whether the calculations/modelling of the behaviour and fate of tritium in the Bristol Channel environment and subsequent doses of tritium of tritium to Bristol Channel populations are based on:

a: the use of models, methodologies and empirical data based on the most recent (2009) reported field and laboratory research and defined measurements

b: or on the use of models, methodologies and hypothetical data "not supported by clearly defined measurements"

c: or have taken regard to the recommendation that further research is required.

18.13 N.B. To date, the available empirical monitoring/sampling data (as presented in RIFE reports) on the concentrations of Tritium in seawater, sediments and biota appears to be restricted to relatively small areas adjacent to points of discharge.

The Hinkley Point marine/coastal monitoring area is the largest, extending to Blue Anchor Bay (10 to 12 miles to the west) and to Weston (10 to 12 miles to the East). In total the monitoring area as 20 to 24 miles in extent.

The Oldbury and Berkeley estuarine/coastal monitoring area appears to be somewhat smaller, extending from Beachey in the west to Sharpness in the east. In total this area is about 10 miles long.

There are sites in Cardiff which also discharge large quantities of radioactive waste (of which Tritium is a significant percentage) to sea. The monitoring area for the Cardiff discharges is about the same size as the Oldbury/Berkeley area (10 miles long)

18.14 Thus, in the context that the total length of Bristol Channel coastline (Welsh and English coasts) is estimated to be about 220 miles, it can be stated that 80% of the Bristol Channel coastal environment and its associated biota is not sampled or monitored for tritium.

Therefore it is the case that the intermediate and far field behaviour-and-fate of tritium in the Bristol Channel remains unstudied and unquantified.

Similarly, the intermediate and far field environmental effects of tritium on Bristol Channel wildlife and human populations also remains unstudied and unquantified.

It should also be noted that such work is not carried out along the Irish Sea coast of west Wales.

19. Caesium (Cs) 137, half life 30 years

19.1 Caesium 137 is a fission product which arises as a result of the irradiation of uranium not cleaned off the outer surface of fuel pin/assemblies, or the irradiation of uranium leaking from within the pins/assemblies.

The presence and concentrations of Caesium are therefore a good indicator of fuel and fuel pin integrity. It is reported to be relatively mobile in the fuel, highly soluble in the reactor cooling water and easily measured at relatively low levels of detection.
The quantity of Cs 137 in liquid discharges is considered to be a good indicator of fuel and plant performance. Its relatively long half life means that it provides an indication of the longer term performance of down stream abatement systems mitigating fission product peaks.

19.2 **Volumes of discharge**
The current practice for Cs 137 discharge authorisation in France (EDF PW Reactors) is to include Cs among a category labelled "other fission and activation products".

A similar practice was initially adopted in the case of the UK's only operating PWR, Sizewell B. However, after April 2007, the Sizewell B Caesium 137 discharge authorisation was changed to a specific limit for Cs 137

19.3 Historical discharges of Cs 137 to the Bristol Channel marine environment are tabulated below:

Cs 137 limits and actual discharges for 2008 (RIFE 14)

Station	**limit**	**actual discharge**
Berkeley	0.2TBq	0.0003751TBq
Oldbury	0.7TBq	0.309
Hinkley A	1TBq	0.11 TBq
Hinkley B	0.1TBq	0.00419
Sub total	***2 TBq***	***0.4235651***

Cs 137 limits and actual discharges for 2009 (RIFE 15)

Station	**limit**	**actual discharge**
Berkeley	0.2 TBq	0.0012
Oldbury	0.7 TBq	0.199
Hinkley A	1 Tbq	0.0627
Hinkley B	0.1 TBq	0.0048
Sub total:	***2TBq***	***0.2677***

19.4 The Sizewell C (PWR) discharge limits and actual discharges (for Cs 137) are set out below for comparison:

a: 2008: limit= 0.02TBq actual discharge= 0.005 TBq (RIFE 14)
b: 2009: limit= 0.02 TBq actual discharge= 0.005 TBq (RIFE 15)

19.5 In respect of the proposed Oldbury station (AP1000 reactors) the EA's GDA has engaged in a relatively detailed discussion of issues relating to discharge authorisations of Cs137.

It would appear that this is because Westinghouse, the manufacturers of the AP1000 reactors, have themselves presented a request for authorisation for discharge limits of Cs 137 as a specific named individual isotope.

19.6 Westinghouse have offered the following detail about their proposed Cs137 discharges at Oldbury (AP1000 x 3 reactors)

a: annual limit = 0.00005TBq

b: actual annual discharge (no contingencies) = 0.000031TBq

and from the Environment Agency's GDA Assessment Report AP1000-05 (page 29 of 64) it is evident that the EA supports, and is minded to agree with, the Westinghouse proposal.

19.7 NNB Genco report that for Caesium 137, the expected BEST performance discharge from the proposed Hinkley C station will be around 9.5% of the "other fission products" or 114 MBq per year. That is 0.000114 TBq or 114,000,000 Bq per year.

19.8 NNB Genco's submission refers to an additional contribution of Caesium 137 from the normal operation of the Interim Storage Facility for Spent Fuel. It is stated that:

a: expected best performance is 114MBq per year

b: expected annual maximum is 1.9 GBq per year

c: the requested annual limit is therefore 1.9 GBq per year = 0.0019 TBq or 1,900,000,000 Bq per year. (Ref 46)

20. Fate and behaviour of liquid caesium

20.1 There is a universal consensus that Caesium isotopes 137 and 134 (both of which are proposed for discharge from Hinkley C) are highly soluble in both coolant waters and, post discharge, in marine waters.

In the marine environment close to Hinkley Point, caesium 137 is shown to be present in detectable quantities in the great majority of marine biota analysed, including shrimps, demersal and pelagic fish and seaweeds.

Shrimps and demersal (seabed dwelling) fish are shown to have higher levels than pelagics.

The concentrations in biota are only slightly elevated relative to that reported for seawater

20.2 However, it is particularly notable that detected Caesium concentrations in seawater, even samples taken very close to the pipeline, are low by comparison to those recorded in sediments. Thus Table 4.7a (page 137) of RIFE-15 records that in 2009

a: seawater concentrations (pipeline) of Cs 137 were less than 0.33Bqs per Kg

b: marine sediment concentrations of Cs 137 in the vicinity of the Hinkley Point pipeline ranged between 7.7Bq/Kg and 28Bq/Kg (dry weight)

thus demonstrating that Cs 137 is highly prone to significant factors of enrichment (EF) or re-concentration (EFs of 23 to 84) in marine and estuarine sediments.

Thus although Cs 137 does indeed dissolve and dilute in aqueous solutions, it is evident that there are powerful and significant mechanisms of re-concentration of Cs 137 operating in the marine environment adjacent to Hinkley Point.

20.3 Commencing in 2007, Tables 4.7 (a) of the annual RIFE Reports also give results for concentrations of various nuclides, including Cs 137, in soil samples from Stolford.

The 2008 Report (RIFE – 14) page 131, notes that these measurements are "used to determine sea to land transfer".

20.4 Other than reporting this sampling programme and its results, the relevant RIFE Reports offer little textual commentary on the observed concentrations of Cs 137 in the Stolford soil samples, other than to remark that:

"sea to land transfer data for vegetables and soil which had seaweed added as a compost showed no evidence for uptake of activity concentrations in foodstuffs" (RIFE – 14: page 112 para 4:6). Regrettably the relevant sections of the RIFE Reports fail to identify which foodstuffs referenced in Tables are from the Stolford soil sample site.

20.5 However the Stolford soil sample data for the years 2007, 2008 and 2009 demonstrates that concentrations of Cs 137 in (terrestrial) soil are broadly comparable with those found in marine sediments and thus that sea to land transfer by seaweed composting may indeed be occurring.

20.6 The ability of caesium to transfer from the sea to the land via microlayer enrichment, bubble burst, aerosol and/or sea spray pathways has been clearly demonstrated by the south Wales coast and Hebridean studies described above in paras 11:5 to 11:9.

However, no comparable work has been carried out anywhere in the Bristol Channel.

20.7 Since the early 1990s I have referenced the highly significant evidence derived from both of these studies many times, in many different media and fora since their publication. I have specifically used these studies to argue that there is a poor understanding of the fate and behaviour of Caesium 137 in marine and coastal environments, particularly with reference to the issue of sea to land transfer.

N.B. However, to date, the failure of both the nuclear industry and government agencies to engage with, or comment on, the issues raised by these studies and their findings means that there are still a number of significant behaviour-and-fate issues (especially with regard to the sea to land transfer of Caesium 137) that remain unresolved.

20.8 N.B. Given that the total length of Bristol Channel coastline (Welsh and English coasts) is estimated to be about 220 miles, it can be stated that 80% of the Bristol Channel coastal environment and its associated biota is not sampled or monitored for caesium.

Thus it is the case that the intermediate and far field behaviour-and-fate of caesium, and indeed all other NPS liquid radioactive wastes discharged into the Bristol Channel, remains unstudied and unquantified.

Similarly, the intermediate and far field environmental effects of caesium and all other liquid radioactive NPS wastes on Bristol Channel wildlife and human populations also remain unstudied and unquantified.

It should also be noted that such work is also not routinely carried out on the Irish Sea coasts of west Wales.

20.9 In the Irish Sea there is some uncertainty about the behaviour of Caesium 137 in sediments. RIFE-15 (2009) page 41, states that:

a: "Since the 1990s, discharges of caesium 137 ….. have remained at low levels"

b: " but there has been some variability and even a suggestion of progressive increases in the concentration in sediments (peaking in the period 2003 – 2006)"

c: "although there has been a slight increase in concentrations in 2009"

20.10 RIFE-15 hypothesises that the "likely explanation is that changes in these concentrations are due to remobilisation and subsequent accretion of fine grained sediments containing higher concentrations"

The RIFE hypothesis thus strongly implies that previous, recent monitoring has been unable to identify these "fine grained sediments containing higher concentrations" which must be somewhere in the Bristol Channel marine and estuarine environments."

On this basis it is evident that the historical and current monitoring programmes in the Bristol Channel have notably failed to identify these "fine grained sediments containing higher concentrations" and that those monitoring programmes are not delivering relevant data.

20.11 It is evident from the NNB Genco submission (sub-chapter 4.5: para 5:1, page 56) that proposed normal operational production of Caesium137 at proposed EPR stations fluctuates and produces troughs and "significant peaks" of discharges.

There is no evidence that the existing marine and coastal monitoring regimes are sufficiently stringent to detect, record and analyse the effects that peaks and troughs of Cs discharge may be having on the behaviour of Cs in the environment and delivered doses of Cs to local populations via a variety of pathways.

21. Actinides/alpha emitters:

21.1 The NNB Genco submission for the UK EPR has identified a group of "liquid fission and activation products". Among this group are various actinides and alpha emitters which, as is the case with Caesium, are produced by the irradiation of "tramp" uranium contamination on the surface of fuel pins, or leaking out from inside fuel pins, and appear in the discharge stream.

Both NNB Genco and EDF have provided only minimal detail on the constituent components of the actinides and alpha emitter liquid discharges. Their submission states that "alpha activity is not presented as a significant group of radio nuclides for GDA, and measurements carried out at PWR units do, in fact, confirm that discharges are always below detection limits". (Ref 47)

21.2 Neither the NNB Genco submission, nor the earlier EDF submission related to GDA, have offered a list of the constituent actinides and alpha emitters radio nuclides in the proposed discharge stream from the Hinkley C reactors.

However, a 1989 Table of the "Assumed Isotopic Composition of Annual Liquid Discharges from Hinkley Point "C" " from the **1989** Hinkley Point C (PWR) Public Inquiry Documents lists17 Actinides including:
6 isotopes of Plutonium, 5 of Americium, 3 of Curium, 2 of uranium and one of Neptunium.

NB: In the event the 1989 proposed Hinkley C PWR was never built, but the Sizewell B PWR (commissioned in 1995) was built to the same design as the 1989 proposed Hinkley C.

21.3 Westinghouse have provided the following information for their AP1000 reactors, which are also expected to generate liquid radioactive wastes consisting of a large number of radio nuclides.

Table 3.4-6 of the AP1000 European Design Control Document and the Environment Report, issued by Westinghouse lists 12 individual alpha emitters/actinides including 3 isotopes of Uranium, 5 isotopes of Plutonium, 2 isotopes of Americium and 2 isotopes of Curium as components of the "expected annual radioactive effluent discharges"

21.4 With one exception, Westinghouse do not provide quantifications for their listed alpha/actinide discharges and have restricted themselves to stating that the discharges of the 12 listed individual isotopes are expected to be "negligible", and defining negligible as "less than 3.7E+4 Bq" (37,000 Bq per year.)
(www.ukap1000application.com: cover page etc)

21.5 Westinghouse state that Pu 241 is "significant" because it has a long half life and may persist and/or accumulate in the environment. On this basis the Westinghouse submission to the GDAs has chosen to separate Pu 241 from the other listed actinide isotopes,

Westinghouse offer specific predictions for

a: the annual average discharge of Pu 241to sea from the AP1000 reactor and state that these will be 0.00008 Giga Bqs or 80,000 Bqs per year.
b: the annual maximum discharge of Pu 241 will be 108,000Bqs per year
c: the Westinghouse proposed annual limit for liquid discharges of Pu 241 was 0.0002Giga Bqs = 200,000 Bqs per year

21.6 In response to the Westinghouse comments, the EA's GDA Assessment Report AP1000-5 (page 30) states that the EA does not consider that a specific limit should be set for Pu 241.

In respect of NNB Genco's UK EPR, the Environment Agency's GDA Assessment Report UK EPR-05 (page 16 of 36: para 58) says "We will not include alpha-emitters as a category for disposal limits" **but provides no scientific justification for its decision in the accompanying text.**

21.7 Evidently PWR reactor liquid discharge streams must be expected to contain a number of Pu, Am, Cm and U isotopes.

There is nothing in the documentation surrounding the UK EPR reactor which demonstrates that this design of PWR is an exception.

21.8 The Westinghouse statement that Plutonium 241 is significant because it has a long half life and may persist and/or accumulate in the environment is undoubtedly correct, but the same statement is true of the other isotopes of Plutonium, Americium, Uranium and Curium.

21.9 **Other Actinide half lives:**

Uraniums : up to 4.47 billion years
Plutoniums: up to80 million years
Americiums: up to 7,370 years
Curiums: up to 30 years

21.10 Pu 241 has a half life of 14 years and decays largely by beta emissions but also emits low levels of alpha particles.

Evidently the various agencies responsible for drawing up the annual RIFE reports do not feel that Pu 241 poses any particular threat to public or environmental health in the region of Hinkley Point because the annual RIFE reports do not bother to record concentrations of Pu 241 in environmental samples within the monitoring and sampling programme for the site.

21.11 However, Plutonium 241 decays to produce Americium 241 (an alpha and beta emitter) which is produced at a ratio of about 1 unit of Americium 241 to 32 units of Pu 241. Americium 241 is assumed to be about 2.5 times more hazardous than Pu 239

N.B. Historically discharged Pu 241 (sequestered in marine sediments) is now consensually agreed by regulators and industry alike to be a major source of the production of Americium 241 in marine environments.

21:12 All of the alpha emitters listed above are consensually agreed by industry and regulators alike to preferentially attach by adsorbtion to marine and estuarine fine sediments. Some of these fine sediments are suspended in the water columns and are hence available for transport through the marine environment. Others "deposit out" in to sedimentary deposits on the seabed, coastal low energy environments or estuaries.

Those alpha emitters, which have been sampled for in surf line sea spray and marine aerosols, have been identified in those media and are shown to be capable of transfer from the sea to the land across the surf line.

21.13 Pu 241's decay product, Americium 241 is far more long lived (half life of 432 years) and emits high levels of alpha particles, beta radioactivity and intense gamma radiation. Americium 241's decay product is Neptunium 237 (half life of 2.14 million years) which also decays by alpha emission, thus presenting a significant ongoing alpha emitter presence in Bristol Channel

21.14 Several of the alpha/actinide isotopes likely to be discharged in proposed Hinkley C liquid discharge streams (other isotopes of Pu, Am 241 and isotopes of Curium) are sampled for in the regular RIFE work at Hinkley Point.

However, over the years, the annual RIFE Report's consistent failure to monitor the presence of Pu 241 in Bristol Channel samples and or to detect it in discharge streams means that there is also a total lack of data about both the location and the volume and concentration of the Pu 241 and its decay chain products sequestered in Bristol Channel sediments.

21.15 The RIFE Reports (nos 6, 13 & 15 etc) record positive (but rising!) low concentration results for several isotopes of Plutonium and one isotope of Americium in Hinkley Point C samples (shrimps only):

Hinkley 2000

Sample	**Pu238**	**Pu239/24**	**Am241**	**Cm242**	**Cm243/244**
Shrimp	0.000073	0.00034	0.00067	NA	NA

Hinkley 2007

Sample	**Pu238**	**Pu239/24**	**Am241**	**Cm242**	**Cm243/244**
Shrimp	0.000063	0.00048	0.0016	NA	NA

Hinkley 2009

Sample	**Pu238**	**Pu239/24**	**Am241**	**Cm242**	**Cm243/244**
Shrimp	0.00021	0.00091	0.00076	0.00011	NA

Similar monitoring at the Sizewell B site reports a similar positive presence for 2 isotopes of Plutonium, Americium 241, and isotopes of Curium.

21.16 In the context of the proposed 40 to 60 year life span of both the UK EPR and the AP1000 stations the environmental behaviour and fate of the long lived alpha emitters is a significant issue.

These are widely agreed to be "insoluble" and to associate and adsorb preferentially with marine and estuarine fine sediments and to re-concentrate in sedimentary deposits (see sections 8. 9 and 10 above). The areas adjacent to the discharge points for Hinkley Point C (and Oldbury B) represent sedimentary environments where conditions for such adsorbtion and deposition processes are likely to be at their most favourable due to the presence of high loads of fine sediment and the most appropriate conditions for such mechanisms as flocculation.

21.17 Despite the (potentially) 60 year life span of the stations and the evident potential for levels of alpha emitters to build up in Bristol Channel sediments neither the EDF nor the Westinghouse submissions to GDA, the EAs response to GDA submissions nor the NNB Genco submission (NNB-OSL-REP-000105) have addressed the issue of the long term

behaviour and fate in marine and estuarine environments of the long lived alpha emitting actinides and their decay products.

21.18 Equally so the issue of Americium, arising due to the decay of Pu 241 discharged from the proposed Hinkley and Oldbury stations, has been ignored by the documents listed above. Although no figures have been given by EDF, the EA or NNB Genco, with regard to the UK EPR, Westinghouse have reported that the AP1000 reactor is expected to produce 80,000 Bqs per annum of Pu 241.

21.19 For a 3 reactor AP1000 station this will be 240,000 Bqs per annum or 14,400,000 Bqs over a 60 year operational lifetime. Although no figures are provided for the 2 reactor UKEPR, station, it may be estimated that station outcomes will be (loosely) equivalent and that Hinkley outputs of Pu 241 will be roughly equivalent to Oldbury outputs.

As shown above, if 32 units of Pu 241 decay to produce 1 unit of Am 241, then the Oldbury AP1000 station will, over its 60 year life span, generate 450,000 Bqs of Am 241. Despite the lack of data for the Hinkley discharge, it may be hypothesised that its Pu discharge decay will be roughly similar.

Thus, the combined discharge of Pu241 may generate as much as 900,000 Bqs of Am241 (by decay) in the Bristol Channel. This will be in addition to the admitted (but un-quantified) discharge of non-decay product Am 241directly discharged through the pipelines at both stations.

21.20 Earlier in 2011, the NFLA in consultations with the EA over the GDA comments on the EPR submitted the following queries based on the above data.

a: what is the detection performance/threshold of the in-line detectors
b: what is the calculated quantity of alpha emitters for the UK EPR discharge
c: what is the expected isotopic content of alpha emissions for the UK EPR
d: what are the sources of the expected alpha emitters
e: what factors might lead to the presence of detectable amounts of alpha
f: if/when the in-line detectors “detect” the presence of alpha emitters, what mechanisms will “prevent” the discharge of alpha emitters

<u>To date the companies have not provided a response.</u>

22. Cobalt 60: Half life 5.27 years: beta emitter

22.1 Cobalt 60 enters the liquid discharge stream, in both dissolved and particulate form, as an activation product of stainless steel components found within the reactor and the cooling system.

Co60 is shown to concentrate in marine and estuarine sediments and in marine foodstuffs. It has been shown to mobilise in association with both the water column and mobile sedimentary particles.

Cobalt 60 has been shown to transfer from the sea to the land and to enter the terrestrial food chain via sea to land transferred material incorporated into locally grown produce in a coastal region 30 to 40 miles distant by sea from the nearest point source of discharge. (Refs 54 and 55).

22.2 EDF/AREVA have stated that they expect the annual discharge of Co60 (not including any “contingencies”), from each UK EPR reactor, will be 0.00018TBq per year or 180,000,000 Bqs per year. Thus each 2 reactor UK EPR station is expected to discharge 360,000,000 Bqs of Co 60 in its liquid radioactive wastes per year.

EDF/AREVA have proposed an annual aquatic discharge limit of Cobalt 60 per reactor, of 0.0015 TBq per year (1,500,000,000 Bq per year). The Environment Agency has accepted this proposal. Thus the annual Cobalt 60 discharge limit for the 2 reactor proposed Hinkley C PWR station will be 3,000,000,000 Bqs per year.

22.3 **NB: there is a huge discrepancy (nearly ten times) between the annual "expected discharges" of Cobalt 60 and the annual limit proposed by EDF/AREVA and accepted by the Environment Agency. No explanation is offered in the GDA documentation for this discrepancy.**

In the absence of any further information, and given that Co60 production is linked to corrosion of stainless steel components, this discrepancy highlights uncertainties regarding the performance integrity of stainless steel reactor and cooling system components and demands further consideration and review of the integrity of reactor and cooling system steel components may be relevant.

22.4 Westinghouse/Toshiba have stated that they expect the annual discharge of Co60 per AP1000 reactor (not including any contingencies) will be 230,000,000 Bqs. Thus for each 3 reactor AP1000 station the annual expected liquid discharge of Cobalt 60 will be 690,000,000 Bqs.

Westinghouse/Toshiba have proposed an annual liquid discharge limit of Cobalt 60 for each AP1000 reactor of 500,000,000 Bqs. The Environment Agency has accepted this proposal. Thus the annual limit for liquid discharges of Cobalt 60 for the proposed Oldbury three reactor AP1000 station will b 1,500,000,000 Bqs

22.5 **N.B. There is a marked discrepancy between the expected discharge performance of the AP1000 (3 reactor) stations and the limit demanded by the manufacturers and granted by the Environment Agency. As with the UK EPR this discrepancy highlights uncertainties regarding the performance integrity of stainless steel reactor and cooling system components and demands further consideration and review of the integrity of reactor and cooling system steel components.**

The proposed Co 60 limit for the UK EPR is two times higher than that proposed for the AP1000The EA has not offered any discussion of the reasoning behind its preparedness to accept such widely varying proposed limits.

In the context of the EA's willingness to accede to the requests of both EDF/AREVA and those of Westinghouse/Toshiba it appears that these limits have been set in order to comply with the potential performance of each reactor rather than in order to comply with a common understanding of best environmental requirement or most limited environmental impact.

22.6 Current monitoring regimes in the Bristol Channel only report Cobalt 60 liquid discharges from the Hinkley B (AGR) station where the annual limit is set at 0.001Tbq and the actual discharges for 2009 were 0.000383 TBq.

No Cobalt 60 figures are provided for the other Bristol Channel stations (Hinkley A and Oldbury).

22.7 The following Table compares current Hinkley B (Cobalt 60) discharge data with that proposed for Hinkley C and Oldbury:

Cobalt 60 liquid discharges: Bq per annum

Station	**discharge limit**	**actual discharge**
Hinkley B (2009)	1,000,000,000	383,000,000
Hinkley C (future)	3,000,000,000	360,000,000

Oldbury	(future)	1,500,000,000	690,000,000

From which it can be seen that:

a: the aggregated Bristol Channel NPS Cobalt 60 liquid discharge limits will be raised from 1,000,000,000 to 5,500 ,000,000 Bqs per annum: i.e. increasing by 5.5 times.

b: the aggregated Bristol Channel NPS Cobalt 60 actual discharges (excluding contingencies) are expected to rise from 383,000,000 to 1,433,000,000 Bqs per annum

c: i.e. proposed actual discharges will be higher than the current limit and

d: about 3.75 times higher than current actual discharges

23. Discharge regimes for liquid radioactive wastes

23.1 Neither the EDF nor the Westinghouse Aqueous Radioactive Waste Disposal and Limits submissions to the GDA process, nor the GDA Assessment Reports carry a discussion of proposed regimes for managing the liquid discharges from the proposed Hinkley Point C.

Similarly, the NNB Genco Radioactive Substances Regulation (Liquid Discharges) submission (NNB-OSL-REP-000105) also offers no discussion of proposed discharge regimes.

23.2 It is consensually agreed that Hinkley Point liquid discharges consist of radioactive wastes mixed with NPS cooling waters, which are (on average) 10 degrees C warmer than ambient sea water.

Presumably this implies that at some seasons the temperature difference between discharge and receiving waters will be a good deal greater, but NNB-OSL-REP-000105 does not provide any more refined detail of the temperature differences.

23.3 Seasonal temperature differences between the liquid discharges and the ambient marine water column represent a set of parameters which may have influence upon eventual behaviour and fate of radioactive wastes in the discharge streams

23.4 Having carried out at-sea field work off the Hinkley NPS liquid discharge pipelines during the summer of 1988, I can confirm from personal observation that the temperature of the discharge plume, immediately above the up-welling of the point source discharge, even in the context of August sea temperatures, was markedly elevated over the ambient water column and sea surface temperature.

This is not surprising since it is widely understood that warm water rises above cold water and that a distinct vertical plume, with horizontal attributes will form, prior to any mixing generated by dynamic current, tidal or wind effects.

23.5 The Hinkley Point raised temperature effect was readily detectable (on an ebbing tide) for some scores of yards away from the up-welling and for the duration of the approximately 2 hours I spent in the area.

It may thus be deduced that, during discharge of Hinkley Point NPS cooling water and its entrained liquid radioactive wastes, a coherent surface plume mass of warmer-than-ambient discharged water containing the liquid radioactive wastes (extending over some score of yards in several directions) had formed on and near the surface of the water column.

It may be further deduced that, in non-turbulent conditions, this plume may remain relatively coherent for some time.

23.6 With regard to the documents listed above, I have been unable to find any reference too, or discussion of, the behaviour; lifespan and fate of the coherent surface mass of warmer-

than-ambient discharged water to be found at the Hinkley NPS outfalls in the range of environmental conditions that might be expected to pertain in the relevant region of the Bridgewater Bay.

23.7 If the discharge regime is to consist of full time (non-stop 24 hour) operation of liquid discharges during all tidal phases and in non-turbulent conditions, such a regime will militate against optimum dispersal of plume contents because:

a: discharge during an ebbing tide is likely to pull the coherent warm water discharge plume offshore, possibly permitting a certain degree of water column initial mixing and dissolution/dispersion to occur under the influence of tidal/residual current mixing, before moving the mass back inshore on the subsequent flood

But -

b: discharge on a flooding tide is likely to push the coherent plume toward the shoreline. Unless the seabed below the coherent plume is particularly uneven (not the general case in fine sediment areas such as Bridgewater Bay) there is likely to be insufficient turbulence to create significant mixing/dilution of the coherent warm water plume with the ambient water mass, thus significant amounts of radioactive waste may be moved shoreward with relatively little dissolution of dispersion taking place.

23.8 Bullet points “a” and “b”, in 23:7 above, are likely to be relevant in non-turbulent conditions. However, turbulent and mixing conditions which may impact upon the coherence of a warmer than ambient surface water plume mass may include phenomena such as an uneven seabed beneath the plume, strong winds, abnormally heavy freshwater/fluvial inflows to Bridgewater Bay, storm surges, heavy seas, Tsunami and spring tides.

Again NNB-OSL-REP-000105 does not engage in discussion of these parameters

23.9 ***It is evident that both Tritium and Caesium are to be discharged in peaks and troughs (see sections above). I have found no discussion of the interaction outcomes of these intermittent concentration inputs with the behaviour and fate of warm water discharge plumes in the area adjacent to the discharge point, nor of the likely behaviour and fate of entrained radioactive wastes.***

23.10 ***N.B. Tidal and temperature parameter aspects and impacts of the discharge regime remain very poorly reviewed and discussed despite the significant influences they may exercise upon the behaviour and eventual fate of entrained radioactive wastes.***

24. **Marine Monitoring and Sampling**:

24.1 NNB Genco’s Environmental Monitoring submission (NNB-OSL-REP-000137) states that the Environmental Monitoring Programme is based on the statutory requirements consistent with the objectives of the Environment Agency and the Food Standards Agency.

The outcome of compliance with these statutory requirements is best observed by reference to the annual RIFE Reports.

24.2 Page 4 of the Monitoring document submission (NNB-OSL-REP-000137) states that: the programme outlined for Hinkley Point C “is informed by the Environmental Monitoring Programme ongoing for Hinkley Point A and B power stations” and then (page 5) states that, with reference to the atmospheric monitoring at the A and B stations:
“A common strategy for collecting terrestrial samples is to divide areas into an inner zone, which is 1 to 6km from the station and an outer zone, which is 6 to 19km from the station” and argues that “This division helps to distinguish effects that might be due to power station operations from those attributable to external effects (non-site operations).”

24.6 Page 6 of the Monitoring document, still referencing the A and B stations, but describing the marine sampling offers no comment on the zonal division, based on distance from the

site, for the collection of marine samples. Thus there appear to be no identified inner or outer zones for marine samples.
No comment is given as to why such a policy is considered useful for the terrestrial monitoring programme, but not considered useful for the marine environment.

24.4 **Fish and Shellfish**
Para 1.2.2 (page 7) of NNB-OSL-REP-000137 says that fish and shellfish are indicator species because they are foodstuffs and because "they essentially sample the local water and consume other organisms".

The annual RIFE Reports present marine sampling and monitoring outcomes for the Hinkley Point site. A review of the marine monitoring at and around Hinkley Point shows that the sample base is by no means extensive. Thus, it is the current practice to monitor only 1 or 2 samples of fish and shellfish (1 cod, 1 bass, 2 shrimp and 1 limpet) taken from just one area (Stolford).

24.5 However, the RIFE reports fail to clarify whether the cod and bass were **actually caught** at Stolford or whether they were merely landed at Stolford, having been caught elsewhere. Cod and bass are both migratory fish and the simple fact of their capture does not guarantee that any 1 individual of either species has been in the Hinkley area for any specific time period, nor to indicate that they have fed on local prey species. Therefore, the claim that the monitoring of the cod and bass samples "essentially samples" the local water and marine food chain cannot be justified, lacks scientific rigour and is false.

There is no evidence that 1 sample of each of 2 pelagic fish species (living and feeding in the water column away from the seabed) represents a legitimate sample base for regional fin fisheries. The general assumption would be that such a small sample base offers a rather poor data outcome, thus lending support to the contention set out in the previous paragraph (above).

24.6 It is widely demonstrated by water column and sediment monitoring that, in general, seabed sediments hold far greater levels of radioactivity than does the water column and wherever demersal flatfish are monitored they almost invariable show higher levels of radioactivity than pelagic species.

The failure to sample and monitor demersal fish (which reside and feed on or near the seabed) is also a notable weakness in the Hinkley sampling and monitoring programme and once again fails to fulfil the claim that the monitored fish "essentially sample the local water and consume other organisms".

24.7 ***Thus it is demonstrated that the fin fish sampling and monitoring programme for the existing Hinkley Point A and B stations does not provide a useful or accurate record of the representative radioactivity concentrations to be found in locally caught marine fin fish, hence the dietary dose calculations for locally caught fin fish are flawed.***

The same flawed methodologies for sampling and monitoring programmes are proposed for deployment in respect of Hinkley Point C and will similarly fail to provide a useful and accurate record of radioactivity concentrations from the proposed EPR reactors in locally caught finfish.

24.8 The Hinkley Point shellfish monitoring programme reported in the RIFE reports is little better than the fin fish programme. It is based on 2 samples of shrimps and 1 sample of limpets, again from Stolford. No details are provided of the constituents of a "sample".

Since limpets are widely recognised to be both sessile (immobile or at least highly localised) and very commonly distributed it can be assumed that the limpets were indeed harvested at Stolford.

Limpets are not a significant form of human dietary shellfish, favoured by few except extreme survivalists and thus have little relevance as seafood dietary indicator species. Limpets are vegetarians and hence can be said to "essentially sample" the seaweeds at Stolford and to provide some insight into the Stolford seaweed based marine food webs.

However, 1 sample is not fully representative of the entirety of the Stolford limpet population, let alone the Hinkley Point regional population. It is therefore concluded that the limpet sampling fails to provide a useful and accurate data base representative of regional shellfish.

24.9 Shrimp are a popular decapod crustacean human dietary item. 2 samples of shrimps from Stolford are taken for the Hinkley station monitoring programme. It remains unclear whether the shrimp samples were captured at Stolford or were captured elsewhere and landed at Stolford.

Shrimp tend to be relatively sessile, have a small home range and are generally omnivorous. Hence shrimp samples will be representative of conditions at their place of capture only. Additionally, 2 samples, attributed to 1 specific site (Stolford) fail to be representative of the entirety of potential crustacean/shellfish dietary items likely to be impacted by the Hinkley Point liquid radioactive wastes

24.10 ***Thus it is demonstrated that the shellfish fish sampling and monitoring programme for the existing Hinkley Point A and B stations does not provide a useful or accurate record of the representative radioactivity concentrations to be found in locally caught marine shellfish fish, hence the dietary dose calculations for locally caught shell fish are flawed.***

The same flawed methodologies for sampling and monitoring programmes are proposed for deployment in respect of Hinkley Point C and will similarly fail to provide a useful and accurate record of radioactivity concentrations from the proposed EPR reactors in locally caught shell fish.

25. Marine Water and Sediment sampling

25.1 Para 1.2.3 of NNB-OSL-REP-000137 (page 7) correctly reports that radio nuclides can become attached to silt particles and that "the smaller the particle size the greater the surface area and hence the greater adsorption capacity".

The current Hinkley Point marine monitoring takes 2 "sediment" samples from each of 9 sites spread across approximately 25 miles of coast between Blue Anchor Bay (about 11.5 miles to the west) and Weston Super Mare about 13.5 miles to the east.

25.2 The term "sediment" as used in oceanography and coastal morphology is a very broad term which is loosely refined by the use of the terms cobbles, pebbles, shingle, sand and mud and very precisely defined by use of the Wentworth Scale which defines the "grain size" of sedimentary particles by mms and fractions of mms.

Thus, the finer sediments or muds, which would be expected to hold the greatest concentrations of Hinkley Point derived marine discharged radioactive wastes, would have grain sizes at or below 0.075 mm. However the RIFE reports fail to provide individual descriptions or definitions of the nature of all but one of the sediment sample sets taken.

25.3 Only 2 sediment samples are given a definition other than “sediments” and these are the “Mud” taken from Watchet Harbour (approx 8 miles to the west of Hinkley Point). The remaining 8 sample sets are not given a more precise definition and:

a: may thus have not consisted of fine grained material
b: may not have been subjected to grain size analysis
c: may thus have generated essentially meaningless results not attached to any useful sediment descriptor

25.4 **Thus it remains unclear:**

a: exactly what type of sediment the RIFE reports have been monitoring at 8 of the 9 sample sites
b: whether those responsible for taking and monitoring the samples have a record of the sediment types sampled at those other 8 sites.

The strikingly small sample number base and the lack of data and clarity plainly militates against a precise understanding of the radioactivity concentrations across the range of “sedimentary” marine and estuarine environment types to be found across the approximately 25 miles of coastline covered by the sediment monitoring programme.

25.5 As with the fish and shellfish monitoring programmes only a maximum of 2 samples have been taken from each of the 9 sediment monitoring sites.

In addition to their failure to record the precise (grain size) nature of the “sediments” sampled, the RIFE reports fail to provide an extensive suite of highly relevant supporting data as follows:

a: are the sediment samples taken from the inter-tidal zone or the sub-tidal zone
b: in which season of the year are the sediment samples gathered (highly relevant to near shore sub-tidal and inter-tidal sediments since seasonal dynamic fluxes exercise strong influences such as accretion/erosion cycles and winnowing and sorting of grain size on such sediments)
c: what were the ambient weather and sea conditions at the time of sample collection and during the immediately preceding period: this too may exercise strong influences on sediment deposits (as described in b: above)
d: what were the ambient (high/low: spring/neap) tidal conditions at the time of sample collection and in the immediately preceding period (relevant for the same reasons as b and c above)
e: whether the same conditions (listed above) were operating at each site, each time the samples were gathered there (in order to maintain coherence across the historical annual results)

25.6 Without this supporting data the reported sample radioactivity concentrations are of relatively little relevance and represent little more than a collection of random results with geographical location the only common factor

It is possible that this supporting data has been collected and tabulated and is available to those who were engaged in the sampling programme. However it’s absence from public access absolutely militates against the effectiveness of this consultation process, which should be extended until that information has been made available to consultees.

25.7 **The strikingly small sample number base for sediments also militates against a thorough reportage and understanding of radioactivity concentrations in the Hinkley Point marine environment, because there can be no scientific justification for proposing that 2 samples from each of 9 sites (across a 25 mile stretch of coast) represent anything other than a very “brief-period” spot sampling exercise.**

Certainly such work cannot be claimed to be representative of the entirety of seasonal and annual conditions that will be experienced at those sample sites.

25.8 In addition to the issues raised above (which are relevant both to the existing Hinkley A and B monitoring programmes and to the Hinkley C monitoring programmes which are to be based on the existing work) there is a further Hinkley C specific monitoring issue as follows:

NNB Genco's Environmental Monitoring submission (NNB-OSL-REP-000137) states that the Environmental Monitoring Programme discussed in the document only takes account of routine releases from normal plant operation.

The absence of any discussion of the provision of Emergency Situation Monitoring Programmes is a matter of considerable concern since, without some degree of prior planning any emergency response is likely to be constructed and initiated under extreme pressure and without the benefit of rational analysis and discussion or the prior construction of equipment stockpiles.

If Emergency Situation Monitoring has been discussed elsewhere, then some reference to it should have been made in the Environmental Monitoring Submission.

25.9 **Pulsed discharges**
As has been discussed above, it is proposed that discharges of some radio-nuclides will be intermittent, thus delivering pulsed peaks and troughs of input.

This fact is not addressed in NNB Genco's Monitoring document NNB-OSL-REP-000137. Thus it may be concluded that there are no plans to construct the proposed marine monitoring programmes for Hinkley C in such a way as to take account of the several implications of pulsed discharges.

While of relevance to all nuclides entrained within the proposed pulsed discharges, it is particularly important in relation to Tritium because

a: Tritium has a short life and hence peak concentrations in environmental samples (following pulsed discharges) may not be recorded by the proposed very low number/low frequency monitoring programmes based on those already in existence

b: Tritium is shown to very rapidly incorporate into marine samples (including foodstuffs) and thus the proposed low frequency/low number sampling programme will not be geared towards capturing peak tritium concentrations in foodstuffs.

c: thus, due to a: and b: (above) marine food pathway doses to exposed critical populations will not be effectively and accurately calculated each year, nor on a year on year chronological basis.

26. Where should the Programme monitor?

26.1 Page 11 of NNB-OSL-REP-000137 explains that the geographical locations at which samples and radiation dose rate measurements are taken is an important part of the Environmental Monitoring programme and offers explanations for, and guidance on, the choice of sampling and monitoring sites in relation to NPS.

It is specifically stated that the programme "must provide representative data about the levels of radioactivity in the local area and ensure that locations where higher results might be found are sampled."

The principle of providing representative data has been alluded too above in the context of sediments and sedimentology.

26.2 NNB-OSL-REP-000137 states (page 10) that fine grained sediments "accumulate particle reactive nuclides present in the water". Evidently this will lead to re-concentration of various nuclides in the sediments (with higher levels in fine sediments) when compared to concentrations in ambient seawater.

This has been widely demonstrated in many studies, including the RIFE reports, and is a particularly significant factor in the relatively high concentrations (compared to ambient seawater) of alpha emitters and actinides found in sediment deposits in UK waters.

26.3 In the context of sediment accumulation of nuclides, it is evident that the optimum methodology for thoroughly examining the outcomes and extent of this particular parameter is to base the identification of sample sites on a thorough understanding of the grain size of the coastal and estuarine sediments in the vicinity of Hinkley Point. This can best be done if it is based on studies utilising Wentworth Scale grain size analyses (see 25:2 above).

Only then can "representative data about the levels of radioactivity in the area" and "locations where higher levels might be found" be accurately gathered.

26.4 The statement that the programme "must provide representative data about the levels of radioactivity in the local area and ensure that locations where higher results might be found are sampled." is contradicted by NNB Genco's other statement that "The locations should be evenly located around the station and be at appropriate distances" (Page 11 of NNB-OSL-REP-000137).

26.5 **The two statements are mutually exclusive since there is absolutely no evidence that there has been any grain size analysis work, nor any other scientific work, to justify an assumption that "evenly located" and "at appropriate distances" sample sites provide an accurate (or even approximate) representation of "representative" or "higher results".**

In fact, without grain size analysis, marine, coastal and estuarine sample site choice is an essentially hit or miss operation not based on scientific rigour and incapable of providing the required "representative data about the levels of radioactivity in the area" and "locations where higher levels might be found"

NNB-OSL-REP-000137 (page 12) explains that the sampling locations used for the current Hinkley A and B stations monitoring are relevant to the proposed Hinkley C monitoring programme. In the context of the findings above, it is evident that the proposed Hinkley C monitoring will be as inappropriate and irrelevant as the current programme.

26.6 NNB Genco's proposed sediment monitoring programme for the proposed Hinkley C liquid discharges (based on current Hinkley A and B monitoring programmes) is strictly restricted to near field observations as set out in section 25 above (maximum of about 13 miles from the site).

Thus, an extensive area between the eastern extent of Hinkley sampling (Weston Super Mare) and the Oldbury discharge point remains un-sampled and un-monitored for radioactivity from the Hinkley Point site.

In addition, virtually all the South Wales coast also remains un-sampled and unmonitored (other than the relatively small area around Cardiff where sampling is undertaken specifically to detect the impact of medical diagnostics factories operating in Cardiff).

26.7 This is particularly relevant and significant in the case of the extensive inter-tidal fine sediment deposits of:

a: the Avon Estuary;
b: the estuaries of the south Wales rivers;
c: the extensive inter-tidal mud flats fringing the Severn coast of Gwent and Glamorgan;
d: the extensive fine sediment deposits of Swansea Bay and Carmarthen Bay;

where sediment associating radio-nuclides (especially the long-lived alpha emitters/actinides) may have already begun to appear as a result of the current and historical discharges of the existing Hinkley and Oldbury reactors and may further concentrate if the proposed Hinkley C and Oldbury B stations begin discharges of liquid radioactive wastes.

Similarly, the surface waters, which have travelled past, and received the radioactive waste discharges of, the Hinkley and Oldbury sites, may also be of radiological significance.

26.8 Given the lack of such monitoring in such areas it is legitimate to state that there is a wide swathe of ignorance concerning the radiological impact that the exiting stations may be making on those areas.

It is thus imperative that, at the very least, a wide ranging and detailed baseline survey of radioactivity in the South Wales and Avon sedimentary and water column environments be carried out prior to the initiation of discharges of radioactive waste from the proposed new reactors.

Similarly it is imperative that an ongoing sampling/monitoring programme should be maintained in order to check on the ongoing effects of those proposed new discharges of radioactive wastes in far field environments such as those of the south Wales coast.

27. Identification of Pathways of delivery

27.1 NNB-OSL-REP-000137 (page 4) lists the human dose exposure pathways of greatest relevance in the context of the current, and proposed future, liquid discharges from the Hinkley Point site, and proposes that these are “the ingestion of marine fish and seafood, and external exposure from contaminated silts and sediments”.

NNB Genco offers no discussion of other potential dose pathways.

27.2 The current Hinkley monitoring regime undertakes some near-field sampling in order to determine the extent, and potential impact, of one aspect of the transfer of radioactivity from the sea to the land. A footnote to Table 4.7(a) of RIFE-16 explains that this work consists of the analysis of 1 sample each of soil, carrots and potatoes from Stolford.

The Hinkley related text in RIFE-16 provides no other information other than the statement “The use of seaweeds as fertilisers and soil conditioners was assessed to investigate transfer of radionuclides from sea to land” and, as with other samples (discussed in earlier sections) there is a marked paucity of information provided in order to support the basic data provided in the Table.

No conclusions of this research are offered by RIFE and no other studies of the dietary effect of sea to land transfer (by seaweed or any other pathway) are mentioned.

27.3 However, the outcome of studies carried out in the Hebrides and south west Wales (sections 10 and 11 above) have demonstrated that sea to land transfer does occur via these other mechanisms and

a: that it penetrates the terrestrial zone and enters agricultural, and subsequently human, diet webs;

b: in the case of Caesium 137 in the Hebrides it makes a very significant contribution to dietary dose;
c: in both cases it occurs at considerable distance (up to 200km) from the source of input.

Thus it will be the case that Caesium 137 and other soluble nuclides such as Tritium are following a similar behaviour and fate pattern in the Bristol Channel.

27.4 The ability of alpha emitting actinides to attach to sediment particles and to travel suspended in the water column prior to deposition at sites distant from the point of discharge has similarly been explained in previous sections. Re-concentration factors in fine sediment deposits have also been alluded to.

It will also be the case, that alpha emitting actinides will be following a similar behaviour and fate pattern in the Bristol Channel.

In this context and in the absence of any information to the contrary, this Report concludes that it is inevitable that coastal populations of South Wales and English coastal regions are indeed in receipt of doses of radioactivity derived from anthropogenic inputs into the Bristol Channel receiving

27.5 Section 26 above has explained the:
a: the weakness of the existing monitoring programmes
b: the absence of sampling and monitoring on the coasts of Somerset, Avon and Gloucestershire between Hinkley Point and Oldbury
c: the absence of sampling and monitoring on the entirety of the south Wales coast (other than a small area around Cardiff)

In this context it can be stated that there is no empirical evidence to confirm or deny the magnitude and concentration of the presence of these nuclides in the mid or far field environments of the English or South Wales coastal regions, their coastal and estuarine inter tidal and sub tidal fine sediment deposits, their marine water column surface water and surface micro layer environments, their sea spray or aerosol environments and agricultural/horticultural foodstuffs grown within their coastal zones.

27.6 Sections 10 and 11 (above) demonstrate that Government agency and nuclear industry research programmes on aerosol and sea spray pathways of sea to land transfer have focussed exclusively on:
a: Sellafield derived (in-soluble) alpha emitters and actinides (Pu and Am etc);
b: the northern and eastern basin of the Irish Sea;
and demonstrated that alpha emitters/actinides are proved to transfer across the surf line and to penetrate inland into the terrestrial zone;
but that independent studies also clearly demonstrate:
c: that the “soluble” nuclides such as Caesium also transfer from the sea to the land across Hebridean and South West Wales coasts;
d: that such Cs has the potential to make significant contributions to dietary dose;
e: that in the case of Cs at least, this process can occur at distances of at least 200 Kms from point of discharge.

And that, in this context, the observed behaviour of Caesium strongly implies the likelihood that other, equally (or more) “soluble” nuclides (including Tritium) will exhibit the same fate and behaviour, though their distance-from-source impact may be restricted by their half life.

27.7 It is thus evident that both soluble and in-soluble radio nuclides will transfer across the surf line and enter the terrestrial zone where they are shown to deposit out onto soil and terrestrial vegetation and hence to enter the human diet via a variety of sources ranging from vegetables and arable crops through to dairy and /meat and must therefore also be available for the delivery of inhalation doses to coastal populations.

27.8 A small number of studies, carried out by government agency and nuclear industry staff, have attempted to assess the quantities of radioactivity airborne in marine aerosol and sea spray fronts blowing across the surf line of Irish Sea coasts and penetrating the terrestrial zone.

The effectiveness of these studies has been strictly limited by the admitted fact that the tools used to measure the extent and magnitude of sea to land transfer by those pathways were deeply inefficient and fit only for qualitative measurement and NOT FOR QUANTITATIVE MEASUREMENTS.

The effectiveness of such studies is further limited by:

a: the admitted ignorance of the vertical extent of aerosol/sea spray fronts as they cross the surf line;

b: the paucity of work investigating the extent of sea to land transfer and penetration into the terrestrial zone in high wind conditions;

c: the absence of studies investigating the parameters which may influence deposition patterns of marine radioactivity in the terrestrial zone once it has crossed the surf line.

27.9 These studies have only investigated the nature of sea to land transfer derived from the production of marine aerosols and sea spray from breaking waves. Literature reviews carried out during the compilation of this review report have not found any evidence of investigation of the potential for sea to land transfer of radioactivity derived from marine and coastal evaporative processes at the sea surface and over exposed inter tidal sediment deposits (likely to be particularly relevant in the case of water soluble isotopes of Caesium and Tritium)

27.10 It should be noted that no work has been undertaken on the behaviour and fate of tritium with regard to mechanisms of sea to land transfer.

In the context of the very large quantities of proposed liquid tritium discharge, the ability of tritiated water to behave like any other water and it's apparent potential similarity of behaviour in marine environments to the behaviour of Caesium 137, it must be imperative to initiate immediate in depth research into the currently un-studied potential exposure pathways (dietary and inhalation) by which coastal populations may be exposed to doses of tritium.

27.11 Sea to land transfer studies appear to have only been carried out in the Irish Sea area and there is no evidence that any such studies have been carried out in the Bristol Channel, despite:

a: the evidence that the magnitude of the effect is closely linked to the fine sediment loading of the ambient water column;

and:

b: the additional evidence suggesting that Bristol Channel water column sediment loads may be far higher than those in the areas where the sea-to-land transfer studies were conducted.

27.12 Furthermore (as stated above) in the absence of transparent disclosure of the facts, it appears that the liquid discharge streams from the proposed Hinkley C reactors may contain around 60 radio nuclides.

Literature reviews conducted during the course of compiling this Report have not found investigations of the aerosol/sea spray sea-to- land transfer potential of nuclides other than those for 4 isotopes of Plutonium, 1 of Americium and Caesium 137 (6 nuclides)

On this basis it is evident that the aerosol/sea spray sea to land transfer potential of only 10% of the proposed isotopic content of the Hinkley C liquid radioactive wastes has been studied.

27.13 In the context of the scant information summarised herein, it is apparent that neither the nuclear industry nor government regulators have an adequate grasp of:

a: the volume and concentration of anthropogenic radio nuclides transferring across Bristol Channel surf lines and penetrating the terrestrial zone,

b: the significance of related, derived pathways of exposure delivery derived from sea to land transfer (inhalation and dietary)

c: the impact of Hinkley (and Oldbury) marine discharges on marine and terrestrial dietary and inhalation doses to mid and far field populations resident in areas adjacent to the extensive fine sediment deposits of Bristol Channel English and Welsh coasts.

28. Floods, tsunamis and storm surges

28.1 There have been a number of "severe" inundation events in the Bristol Channel region. Some of these, such as the 2007 and 2010 flooding in the Severn and Avon catchments, have been the result of unusually heavy rainfall widely attributed to climate change.

Both events were categorised by the overwhelming of land drainage systems leading to rapid build up of surface waters and fluvial floodings with river levels rising commensurately. During the 2010 event the Environment Agency reported that river levels at Gloucester Dock peaked at 4.92 metres (over 4 metres higher than normal seasonal river levels).

28.2 There have also been marine originating inundations, perhaps the most widely know being the "Great Flood" of January 1607, which inundated around 200 sq miles of land in the coastal strip of South Wales and Somerset and Avon, including wide stretches of low land around Bridgwater Bay and the estuary of the Parret.

This event has historically been believed to have been caused by a storm surge (a combination of high tides and severe storm with low pressure helping to raise the sea level and strong winds pushing water landwards.)

28.3 Since 2005, this theory has come under increasing pressure from academics, as set out by Professors Simon Haslett (Bath Spa University) and Ted Bryant (University of Wollongong) and broadcast in a 'Timewatch' Special broadcast on April 3rd2005.

Haslett and Bryant presented evidence to demonstrate that the "Great Flood" was in fact a tsunami generated by seismic events, which had occurred in the area of an ancient seismic fault off the coast of southwest Ireland. This fault is still active and a number of quakes have occurred there, including a magnitude 4.5 earthquake which was recorded in February 1980.

28.4 In 2008 Haslett and Bryant published further work reviewing historic tsunami type events in Britain since AD 1000. Their findings demonstrated that the southern UK had experienced a number of such events, and that these events originated from four distinct causal factors:

1: sea disturbance and coastal flooding linked to earthquakes in the Dover Straits;

2: far field tsunamis reaching the Atlantic coasts of the UK from seismic activity along the Azores/Gibraltar Fault Zone offshore of Portugal;

3: Tsunami associated with low magnitude near-coastal earthquakes;

4: 1 flood event linked to comet debris impact in AD 1014.

28.5 The Haslett and Bryant study described seismic events ranged from minor water disturbance, through seismic seiching, to small and "giant" waves.

Of particular note was the fact that that the study findings suggested that "near coastal, low magnitude, shallow earthquakes may be capable of triggering disturbance in relatively shallow water". Of particular relevance was the suggestion that "some of these earthquakes have shallow epicentres that may amplify their effects and so take on the characteristics of a higher magnitude event".

It was also suggested that there were implications that shallow water settings might be particularly sensitive to small near coastal earthquakes.

It was also observed that there appeared to be a seismic-tidal interaction and that "increased ocean loading associated with a rising tide, particularly in the meso-macrotidal setting of northwest Europe, may trigger an earthquake where the earth's crust is under strain" and that any tsunami thus generated would be "more likely to be more damaging." (Ref 48)

28.6 Haslett and Bryant's study specifically noted that an earlier study, conducted by DEFRA in 2005, had not acknowledged the potential risks from a number of the factors listed above.

The Haslett and Bryant study concluded on a highly precautionary note which warned that "the British tsunami risk requires a more careful evaluation". (Ref 48)

28.7 It is evident that academic research implies that there have been tsunami events and that their occurrence in the future cannot be ruled out. Plainly, precise forecasting of the precise whereabouts and timing of such events cannot be predicted.

Thus, it is clear that there is no scientific evidence to support any claim that a tsunami type event is likely to occur in the lifetime (40 to 60 years) of the proposed new Hinkley and Oldbury reactors.

28.8 However, it is equally clear that that there is no credible scientific evidence to support any claim that a tsunami type event is NOT likely to occur in the lifetime (40 to 60 years) of the proposed new Hinkley and Oldbury reactors.

The Fukushima experience demonstrates potential outcomes of such an event on sites which have not been "proofed" against such events. It cannot be denied that, should such an event occur, its impact would be hugely exacerbated if it were to coincide with an extreme rainfall event.

In such a context, a strictly precautionary approach must be applied to all large engineering development proposals situated in coastal zones in respect of considering tsunami proofing. There are very good reasons for making sure that such a principle is strictly applied to nuclear power station developments.

29. Potential outcomes of a Fukushima type LOCA/Emergency Coolant Water use at Hinkley or Oldbury

29.1 **Conclusions -**

The GDA Aqueous Radioactive Assessment Reports fail to address Loss of Coolant Accidents (LOCA) and the behaviour, fate and management of primary and secondary cooling waters in the event of a LOCA event. Furthermore it fails to address the response necessary for the potentially massive Emergency Cooling Water (ECW) arisings, and does not conduct an analysis of the potential damage to site infrastructure, storage tanks or drainage systems due to unforeseen circumstances responsible for LOCA events.

The GDA Aqueous Radioactive Assessment Reports fail to address the issues surrounding the necessity for the provision of capture/retention/treatment capacity for hundreds of thousands of cubic metres of ECW generated over prolonged time scales (at Fukushima 6 months and counting as of Nov 2011)

29.2 It is evident that the information given in the GDA's Aqueous Radioactive Assessment Reports is relevant to only "normal operations" and contains no discussion of specific issues arising in the event of reactor or cooling pond LOCA events requiring the use of Fukushima type volumes of Emergency Cooling Water or severe flooding of sites (tidal bore, storm surge, tsunami, excessive rainfall).

29.3 The following extracts from the GDA for the Hinkley type UK EPR are relevant:
"We have not considered at GDA other site liquid discharges such as surface water. The design of such systems will be site specific and there should be no contamination in normal operation. We will review site drainage at site specific permitting and, as a minimum, require accessible sampling points at final discharge locations for confirmation spot sampling." (Ref 49)

29.4 Annex 1 (Fig 1) of the same document shows collection and management of three liquid effluent streams:
A: Primary Liquid Effluent,
B: Spent Liquid Effluent,
C: Drainage Water from Turbine Hall

29.5 In their GDA for the Oldbury type AP 1000 reactor, the EA list five sources of aqueous radioactive waste (Paras 35 – 46)
A: Reactor Coolant System Effluents
B: Building floor drains and sumps
C: Detergent wastes (sinks, showers etc)
D: Aqueous chemical wastes (laboratory and other small volume sources)
E: Steam Generator blowdown wastes
(Ref 50)

29.6 And at Page 15: Para 49 of Ref 50 EA says "We consider that all sources of aqueous radioactive waste have been identified".

And at Para 57 (page 16) EA say "AP1000 has five types of tanks for collecting aqueous radioactive waste":

A:	Reactor Coolant drain tank	volume= 3.4 cubic metres
B:	Effluent Hold up tanks	volume= 2 x 106 cubic metres
C:	Waste hold up tanks	volume= 2 x 57 cubic metres
D:	Chemical waste tank	volume= 34 cubic metres
E:	Monitor tanks (42 days storage)	volume=6 x 57 cubic metre

TOTAL VOLUME……=705'4 cubic metres
(Ref 50)

29.7 It is evident that the information given in the GDA's Aqueous Radioactive Assessment Reports is relevant to only "normal operations".

The GDA Aqueous Radioactive Assessment Reports fail to address LOCA response and the potential for massive Emergency Cooling Water (ECW) arisings, and do not conduct an analysis of the potential damage to site infrastructure, storage tanks or drainage systems due to unforeseen circumstances.

29.8 The GDA Aqueous Radioactive Assessment Reports fail to address the issues surrounding the necessity for the provision of capture/retention/treatment capacity for hundreds of thousands of cubic metres of ECW generated over a 6 month (and ongoing) period.

Similarly the various submissions by the developers of both UK EPR and Westinghouse/Toshiba AP1000 also fail to consider the control and management of any ECW arisings in the event of a LOCA response

29.9 These are potentially highly significant issues. For example, at the Fukushima Daiichi complex in 2011, an unknown volume of ECW leaked into the marine environment before any attempts at quantification were attempted.

However, TEPCO press statements on September reported that,

a: since June, when filtering systems were finally installed, they have managed to decontaminate 85,000 tons of highly radioactive water (HRW);
b: 110,000 tons of HRW remains in basements of the reactor buildings 1, 2 and 3;
c: ECW still being applied daily to Reactors 1, 2 & 3;
d: Growing concern that basement HRW may be leaking into the sea via groundwater flows;
e: Concentrated nuclear waste generated by filtration treatment of 85,000 tons of HRW now occupies 70% of site dedicated, 800 cubic metre, waste storage capacity. (Waste generated so far thus equals 560 tonnes)
f: TEPCO states need to review cooling efforts in light of the continuing ECW applications and nuclear waste generation

29.10 From which the following conclusions may be drawn:

a: 85,000 tons +110,000 tons= 195,000 tons captured/retained ECW (no calculation has been offered for volume lost to the environment);
b: 85,000 tons HRW treated in 3 months = approx 1000 tons per day = thus it will require approx 110 days to clear the existing backlog (not counting ongoing applications of ECW);
c: Reactor turbine hall basements were plainly acting as storage tanks
d: Fear of leaching of HRW
e: Evident that the nuclear waste produced by filtration treatment of remaining110,000 tons of HRW (not including ongoing applications of ECW) is going to overwhelm site storage capacity.

29.10 **The Nuclear free Local Authorities (NFLA) have already submitted information to the ONR Weightman Inquiry on these issues and made the following recommendations:**

a: Site drainage (with specific relevance to emergency situations including LOCA response and inundation) should be made a GDA and major planning issue and NOT be determined on a site specific basis.

b: The GDA should review reactor basement design and construction in order to confirm that, if they are to be used for collection and storage of spilled reactor and/or cooling pond coolant and ECW, they will prevent leaching, facilitate the monitoring of the HRW and escaped coolant and be provided with appropriate equipment such as pumps, gauges etc.

c: HRW capture/retention, storage and treatment capacity should be made a GDA issue and NOT be determined on a reactor specific or site specific basis. It should be thoroughly reviewed at Hinkley Point in the context of both:

1: the Fukushima event;
2: the potential for tsunami/flood events.

d: The storage capacity for highly concentrated wastes generated by the filtration treatment of HRW should be reviewed by the GDA with a view to ensuring that, in the event of the need to filter treat high volumes of escaped coolant and contaminated ECW, there is sufficient storage capacity for the ensuing highly concentrated radioactive waste

30. Climate change impacts

30.1 There is a body of evidence to show that the coastal environments in the vicinity of Hinkley Point are experiencing climate linked change impacts leading to erosion

30.2 A 2008 paper, presents the results of an 11-year study into mudflat elevation changes within the inter-tidal zone at Steart Flats in Bridgwater Bay, Somerset. This site is located in the outer Severn Estuary/inner Bristol Channel which is a macro-hyper-tidal regime dominated by physical processes, characterized by strong tidal currents, high turbidity and a significant degree of exposure to wind generated waves.

The study reported a consistent trend of erosion, which, over the study period, suggested a strong climatic control over mudflat development on a medium-term/decadal scale. (Ref 51).

30.2 The Somerset Coastal Pathfinder website reports that the Steart Peninsula is prone to flooding and that coastal erosion, sea level rise and wave action have led to the 15km of sea defences at Steart "becoming fragile and at risk of failure".

30.3 A fifteen year study of sea level data (1993-2007), published in 2010, recorded monthly maximum and minimum sea levels at four sites in the Bristol Channel, one of which was Hinkley Point.

This research showed that:

a: rising maximum sea levels at Hinkley Point were correlated with increasing storm frequencies;
b: actual mean sea levels at Hinkley Point were significantly higher than predicted by earlier modelling;
c: and that further analysis predicted a rising Bristol Channel and Severn Estuary mean sea level trend of 2.44mm per year;
d: and a mean sea level rise of 0.370 metres by 2050.

(Ref 52)

30.4 The Severn Estuary Coastal Habitat Management Plan also reports a wide range of expected change in the Severn Estuary (which the plan recognises as including the Bridgwater Bay within its defined Area 1, outer estuary).

The Plan discusses these changes in the context of three time frames of 20, 50 and 100 years and uses modelling outputs to predict the changes in the potential distribution of specific habitat features over these time scales.

30.5 Modelling outcomes are as follows

a: Inter tidal mudflats and sand flats: a predicted net loss of these habitats over all 3 time periods;
b: salt marsh: predicted changes throughout the estuary, with a net loss of this habitat type
c: estuaries: predicted overall increase in the extent of the sub-tidal component (greater area submerged) over all three time periods
d: rock: potential increase in the relative proportion of sub-tidal to inter-tidal rock within the system
e: transitional grassland (.e. coastal grasslands very adjacent to the sea) predictions suggest net losses in the outer estuary

(Ref 53)

30.6 It is evident that there is a scientific consensus that climate change is exercising significant influences on Severn Estuary/Bristol Channel and Bridgwater Bay coastal environments with increased storminess and sea level rise contributing to flooding and coastal erosion processes which are predicted to force the significant losses set out in Ref 53 above.

30.7 In the context of these modelled losses, it is important to adopt a precautionary view of the state of knowledge of climate science and its impacts on the marine environment because

the knowledge base is constantly subject to updating as understanding and knowledge is refined by the acquisition of new data.

30.8 Neither the NNB Genco Submission, nor the Environment Agency's GDA Report on the proposed Hinkley C, have addressed the potential outcomes of climate change. Thus the behaviour and fate of historically discharged radioactive wastes sequestered in the Bridgewater Bay and Bristol Channel eroding fine sediments is not being studied and there are no indications that it will be studied.

Similarly the possible impact of ongoing climate change mechanisms on the behaviour and fate of current and proposed future discharges of radioactive waste is not to be investigated in the context of the proposed development.

31. Flawed Modelling of environmental concentrations of radioactivity and doses derived from them.

31.1 The NNB Genco Submission (NNB-OSL-REP-000147 Sub Chapter 12:2) explains that the general methodology used to calculate environmental concentrations of radioactivity and the doses derived from those concentrations is described in the EC guidance document Radiation Protection: 72 RP72.

It is explained that RP72 describes what is defined as a "comprehensive model" called the Consequences of Releases to the Environment Assessment Methodology otherwise know as CREAM. This model was developed as a tool for carrying out radiological impact assessments.

31.2 This Report can confirm that RP 72 was first published in 1995 and that the edition of the CREAM model used by the Environment Agency and the HPA's Radiation Protection Division and referenced by NNB Genco for use during the assessments of outcomes for the proposed Hinkley C UK EPR station liquid discharges is PC CREAM 98

31.3 However, the website address:
www.hpa-radiationservices.org.uk/pccream/featureoverview

introduces PC-CREAM 08 which is stated to be "a significant improvement to the PC-CREAM 98 version of the software because it takes into account feedback from users and recent model developments".

NNB-OSL-REP-000147 (page 8: sub chapter 12.2) specifically states "The PC CREAM 08 model was not available when the assessment process was undertaken"

Furthermore the HPA's Radiation Protection division is on record as stating that, as of February 28th 2010 it will no longer be committed to providing support for PC CREAM 98

31.4 This Report therefore concludes that, in this context, it is evident that the PC CREAM 98 modelling software must be considered redundant This Report also concludes that since the assessment process was evidently undertaken some time ago it may therefore not be fully informed about the latest consensually agreed advances in radiological science regarding Tritium for instance.

31.5 NNB-OSL-REP-000147 (page 8: sub chapter 12.2: fifth paragraph) states "All discharges are assumed to be continuous, uniform, routine releases". This, as is explained above, applies to the modelling conducted under PC CREAM 98.

However, as shown in earlier sections of this Report, discharges of some nuclides from the proposed Hinkley C rectors are expected to be pulsed or intermittent and thus the work

carried out under PC CREAM 98 will not be relevant to any such pulsed or intermittent discharges.

31.6 The Environment Agency's GDA Assessment report UK EPR-05 (page 25: para 119) specifically states that:
"For GDA, EDF and AREVA selected Irish Sea/Cumbrian Waters for predicting dispersion of liquid radioactive discharges using the model PC CREAM. They said this would give pessimistic results for the dose impact calculations". The Environment Agency GDA Report does not question the assumption.

However, this Report notes that neither NNB Genco, EDF/AREVA, nor the Environment Agency have offered any review, discussion or examination of the statement.

This Report has already introduced evidence to suggest that, in respect of its sediment loadings at least, the available evidence implies that there may be marked differences between the Irish Sea and the Bristol Channel.

In the context of the above, this Report concludes that there is no scientific evidence to support the assumption that the choice of Irish Sea/Cumbrian Waters is appropriate to assessments for the Bristol Channel or for claims that model outcomes will be pessimistic; in fact the available evidence tends to suggest the contrary.

31.7 This Report notes that the DORIS marine dispersion component of the CREAM model has been revised since the 2003 publication of the EC MARINA ll study into the behaviour of radioactivity in the marine environment, and thus assumes that these revisions are not encapsulated in PC CREAM 98.

31.8 This report also notes that a research study with the working title "Identifying Key Parameters which Control Coastal Dispersion Modelling" has been under way for some time and was originally supposed to be published in 2010.
Although this study has been variously attributed to the Environment Agency, the HPA and the National Dose Assessment Working group and is referenced as ongoing in several websites, inquiries to each body, while confirming that such a research project is underway, have been unable to clarify either the authors or a confirmed date of publication.

31.9 This Report is forced to conclude that the outcome of what must be highly important research input to the modelling processes and software discussed above are still not available and thus that the modelling processes and software in question are therefore not informed by the latest subject specific research.

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