Cuckmere Estuary Community Forum

Seven Options: Joint Report for the Working Group by the Options, Landscape, Geomorphology and Tourism Groups

1. INTRODUCTION

1.1 The purpose of this paper is to examine seven options for the estuary's future, laying out in each case the benefits and disbenefits, uncertainties and areas requiring further information. It is hoped that these observations will help the Working Group and the Forum to arrive at a fair and objective evaluation of the seven options.

1.2 This document is presented in thirteen sections:

1. Introduction
2. Option A: Partial breach managed realignment (EA)
3. Option B: Full breach managed realignment (EA)
4. Option C: Engineered reactivation of meanders & meandering creeks
5. Option D: Maintain the existing defences (EA Option 2a)
6. Option E: Sustain the existing defences (EA Option 2b)
7. Option F: Sustain the existing defences (Nigel Newton scheme)
8. Option G: Tidal flood barrier
9. Option H: West Beach revetment
10. Issues relating to sea level
11. Why hold the line?
12. Why managed realignment?
13. Concluding note on Tourism

2. OPTION A: PARTIAL BREACH MANAGED REALIGNMENT (Environment Agency)

2.1 Description

2.1.1 Partial breach realignment involves the admission of tidal water into cells B & C through artificially created breaches in the existing embankments, which are otherwise to be left intact. The four arrows on the EA's map indicate possible locations for the breaches in the embankments, though they could be in different places. The purpose of this scheme is to encourage saltmarsh development in cells B & C and allow siltation in an upwarping saltmarsh environment; this will keep the land level building up at the same rate as the rising sea level.

2.1.2 An additional embankment 200m long would connect the current east bank of the river to the eastern valley side, to stop the tidal water that enters cell C from flooding cell A and also give flood protection to the Foxhole valley. The existing east bank of the Cuckmere would require raising and strengthening twice – once at the start and once after 50 years; it would also

require annual maintenance. The area of the canoe barn and meanders, cell A, would be left entirely unchanged, including the footpath access.

2.2 Benefits

2.2.1. It sets aside an area where re-creating an interesting historic saltmarsh would be possible.
2.2.2. It would be ecologically more diverse than the present landscape. The present semi-improved neutral grassland in cells B and C is regarded as species-poor by ecologists, partly because of saline influence. This would be converted (reverted) to intertidal habitat, which would benefit the already saline-influenced species. Retention of grassland in cell A and the SSSI north of Exceat Bridge would ensure that the freshwater interest of the SSSI is maintained and that favourable condition of this habitat is maintained; this is important as the government has a Public Service Agreement target for 95% of SSSIs to be in favourable or recovering condition by 2010. The birds for which the SSSI is designated will benefit from this option as the intertidal habitat will support a greater range of overwintering species. The current breeding bird assemblage has declined – breeding lapwings have been lost due to the grassland drying out. Reversion to intertidal habitat will give new opportunities for breeding wetland birds, eg redshank. As well as the statutory protection of the SSSI, the Cuckmere habitats receive policy protection as Biodiversity Action Plan (BAP) habitats. This option would result in the loss of 40 ha of grazing land and 5.6 ha of saline lagoon (Jacobs Babtie 2007). But 64 ha of intertidal habitat would be created. Therefore, to comply with BAP targets, 40 ha of grazing marsh and 5.6 ha of saline lagoons should be created in more sustainable locations. If this happens, there will be a net gain in BAP habitats. There would be a change in the overall mix of the wildlife, a change that would make the landscape more attractive.
2.2.3. EA monitoring shows that the Cuckmere estuary currently supports fish nurseries for sand-smelt, bass and sprat in the main river channel below the A259. This existing interest could be increased by the creation of saltmarsh habitat. The value of saltmarsh is well-recognized in biodiversity terms, but its function as a fish nursery has only recently emerged. Recent work (Colclough et al 2005) demonstrates how important UK saltmarshes are as fish nursery sites; new MR flood risk management options delivered as a response to sea level rise can be designed to yield valuable additional marine fish nursery grounds.
2.2.4. It would increase the tidal scour on the falling tide by enlarging the tidal compartment, and could help keep the mouth of the river open.
2.2.5. The land levels are high enough for saltmarsh vegetation to grow across most of the area of the floodplain.
2.2.6. Inundation would be controlled (according to Babtie), to manage flood risk, though this control seems to amount only to breaching the embankments in selected places. [cost]
2.2.7. Given the experimental nature of the project, this halfway-house stage might be seen as a cautious, inexpensive first step.

2.2.8. It would preserve the meanders in the lower valley, constrained but clearly visible. This will have a significant resonance with local people and visitors (but see 2.3.5).
2.2.9. It would preserve the concrete road and the most used area of the floodplain as far as tourism is concerned; the canoe barn and lake would be preserved. Canoeing could continue as at present.
2.2.10. It increases the saltmarsh area, which is being reduced nationally.
2.2.11. It allows some of the floodplain to operate effectively to reduce upstream flooding, by allowing lateral spillage of excess discharges.
2.2.12. The present view across the lower valley from the Golden Galleon would be maintained.
2.2.13. The loss of the river bank walks would be beneficial to bird life. Currently the wildlife in Chyngton Brooks is fairly closely encircled by people walking dogs. Birds are seen to congregate in the centre. Removing the dog-walkers from one edge would significantly improve the environment for birds. The man-made saltmarsh could be improved by creating roosting/ nesting sites within it.
2.2.14. Natural England currently assesses the vegetated shingle habitat on the beaches as being in unfavourable condition, due to the EA's beach management operations, which disturb the shingle and prevent the growth of vegetation. This option would enable shingle recycling to be reduced, though some may still be needed to maintain an open river mouth. Therefore some restoration of the shingle vegetation would occur, though it could be periodically damaged by continued, though less frequent, shingle recycling.

2.3 Disbenefits

2.3.1. Only 64ha of additional intertidal habitat would be created. This may not be enough to function as a viable ecosystem [expert eco-opinion needed here].
2.3.2. The river remains confined in the cut, an unnatural channel: in nature rivers 'prefer' sinuous channels.
2.3.3. The speed and energy of waves arriving in the embryonic saltmarsh landscape would need to be kept low to avoid destroying the new vegetation. The area would need to be protected from high-energy wave action (this is why long stretches of the nineteenth century embankment would be left in place), while the saltmarsh vegetation is becoming established. The earth embankment on the east side of river might need to be strengthened to cope with lateral outflows of water from the saltmarsh on the west side. [cost] (=why EA rejected this scenario in 2006)
2.3.4. A lot of ongoing engineering maintenance would be needed [cost], so little money would be saved.
2.3.5. Although it appears to conserve the meanders, in the form of the existing canoe lake, they will if left as they are silt up and disappear within 100 years.
2.3.6. An additional 200m embankment would be needed to separate cells A and C. [cost]

2.3.7. Significant disruption to rights of way. The current road access to the beach down the eastern side of the valley would be lost, unless built up by 2.5m; new paths above water level would need to be added down both sides of the valley [cost]. Other rights of way would be compromised. South of Foxhole, the route would be diverted eastwards, up the valley side, to descend again near the beach – a 900m wheelchair-unfriendly detour, and a very unsatisfactory main access route to the beach. There is a problem with allowing flooding of Foxhole Bottom, as this cuts off footpath and vehicle access to Foxhole Cottages. The EA map provides no visible alternative for this lost access; presumably a track would have to be created along the northern valley side. The Vanguard Way would be diverted to a more conspicuous location, 50m up the western valley side, where it would need to be terraced into the hillside, creating an unsightly scar. The rights of way along the river banks would be interrupted by the breaches. The breaches might be fitted with footbridges, but the bridge abutments would have to be stoutly revetted to stop the tidal flows of water from widening the breaches and undermining the bridge supports. Significant cost would be added by the need for regular safety checks and maintenance [cost]. On the other hand, without the revetted footbridges, the riverbank walk will be lost.
2.3.8. The lower valley contains significant archaeological and historical resources, on both valley sides and valley floor. Some of these are known and documented (East Sussex Historical Environmental Record), but not all. There is a danger that medieval fossil creeks and any associated archaeology may be lost through erosion or silting. New survey work undertaken by Oxford Archaeological Unit may help to identify new resources that should be either conserved or examined and recorded before any landscape change. The County Archaeologist has prepared briefs for a geophysical survey and the development of a Heritage Assets Plan for Cuckmere Haven, incorporating features of archaeological, historical, architectural and artistic interest. The outputs of these pieces of work will provide an essential baseline against which to evaluate all the various options and identify any need for safeguarding, interpretation, mitigation or rescue.
2.3.9. 'Controlled inundation' is an ambiguous phrase but appears to mean sluices, which would let water through but little sediment, so warping-up would be impeded. If no sluices are intended, it is hard to see how the inundation could be described as controlled.
2.3.10. It is a complex mixed solution that is difficult to envisage working hydrologically (eg the river is treated asymmetrically, with a continuous embankment on one side, and a perforated embankment on the other).
2.3.11. The river outfall would continue to need artificial clearing. The small area of tidal saltmarsh would probably generate only a small increase in tidal prism, so the mouth would not be self-scouring.
2.3.12. It only partially takes up the opportunity to develop an upwarping saltmarsh landscape; if sea level rises significantly in the medium term, the land surface in cell A may be left at a disadvantageously low altitude for future managed realignment.

2.3.13. Leaving substantial lengths of embankment in place may mean that tidal water gets ponded behind them. Areas could develop into stagnant pools rarely refreshed in the tidal cycle. This would require monitoring.
2.3.14. Tidal flooding of almost completely contained cells in this way is untested in the area, and it does not reflect what happens in nature.
2.3.15. No provision is made for stopping the sea from breaking through at the western end of the West Beach, by-passing the western end of the tank wall and inundating Chyngton Brooks.

2.4 Questions & uncertainties

2.4.1. Conflicting expert information has been released about the likely rate of upwarp of saltmarsh.
A) Binnie, Black & Veatch (1999) states that the prospects for developing saltmarsh in Chyngton Brooks are poor. This is based on two lines of evidence: a) That land level is too low (below 2.6m OD, though no more than 0.3m below) and would be subject to too many inundations per year to allow saltmarsh plants to grow. The lower threshold for lower saltmarsh in the Cuckmere Estuary is said by them to be **2.6m OD**, based on an observed threshold of 2.1m OD at Tollesbury in Essex, modified by tidal data from Shoreham. b) That there would be very low rates of siltation from the Cuckmere, based on a measurement of suspended load at Sherman Bridge. The measurement (240mg/litre) was taken in the top layer of the water body. A different figure was arrived at by calculation (962mg/litre). These were then used to estimate the rate of siltation in the lower floodplain. The low rates arrived at in this way (1.7mm or 6.7mm/ year) indicate that it will take either 40 or 180 years for the land surface to rise high enough for saltmarsh plants to colonize. The authors of the report do not adjudicate between the two widely differing figures for suspended load and timescale, but offer them both as possibilities. One is clearly wrong, perhaps both. Either way, the figures cannot be used to indicate rates of siltation in Chyngton Brooks. The rate of siltation in a saltmarsh is not dependent on external inputs of silt. Pagham Harbour receives no external input of silt – no river empties into it – yet the rate of upwarp there has been of the order of 8-10mm/ year.
B) James Mumford of EAS (2003) comments on the Binnie, Black & Veatch report that a vital point was missed. Sea level is predicted to rise at 6mm/year, so warping-up (at the rate inferred from BBV, 1.7mm/year) would never catch up with rising sea. From this Mumford predicts that increasing areas of floodplain would turn into mudflats. This is a highly selective commentary, which makes no mention of the higher rate of 6.7mm/year which BBV also cite, and which would keep just ahead of the 6mm of sea level rise. Nor does it challenge, as it might have done, the methodology used or the measurements arrived at by BBV, but merely accepts (some of) the BBV figures.
C) The geomorphology report (Posford 2003) rejects BBV's calculation of land level requirement for saltmarsh vegetation, partly because of field observation of saltmarsh plants presently growing in a fairly hostile

environment in the open Cuckmere channel at lower levels than those given by BBV. Posford gives **2.36m OD** as the lower limit for saltmarsh vegetation in the Cuckmere estuary, which because of the methodology is more likely to be true than the BBV figure. The LiDAR map of land levels included in the Posford Report shows that most of the lower floodplain is *above* 2.36m OD. Only an area 250m x 300m in the middle of Chyngton Brooks would be mudflats, and that only just below the critical height for vegetation. Building the topography up by 10cm would bring the whole area up to saltmarsh level. The Posford report ignores BBV's rates of accretion in favour of comparison with other saltmarshes, pointing to the Sussex examples of Chichester Harbour and Pagham Harbour. It is reasonable to assume the rate would be at least as high on the Cuckmere.

D) There is an apparent conflict in expert opinion, but the more reliable of these views is that the land level *is* going to be high enough, that the rate of upwarp *will* be more than enough to keep pace with sea level rise. The only reasonable conclusion is that, even without any sediment input from the river, the lower Cuckmere floodplain could be expected to warp up at **8-10mm/year**. It is reasonable to expect that the Cuckmere saltmarshes would warp up at a higher rate than this, perhaps **10-15mm/year,** because some additional silt is arriving downriver. If SL rise accelerates to 6mm, accretion would outstrip it by 4-9mm.

2.4.2. It is difficult to acquire reliable data on the speed at which saltmarsh develops. Comparison of historic maps of saltmarshes in estuaries round Morecambe Bay shows that saltmarsh vegetation can spread laterally across mudflats quickly, at mean speeds up to 20m/ year (Adam 1990, 30-1). So, such documentary evidence as we have implies that saltmarsh could develop with impressive speed.

2.4.3. How well will saltmarsh develop in conditions of global warming? Will familiar English saltmarsh species thrive in a warmer climate?

2.4.4. More needs to be known about the archaeology of the floodplain before it undergoes change. The medieval fossil creeks and inning banks should be investigated and if possible dated before they are damaged by engineering works or lost to erosion or deposition. Results of the geophysical survey undertaken by the Oxford Archaeological Unit are needed to identify sensitive areas.

2.4.5. How will the river mouth behave with a slightly increased discharge? Will it become to any extent self-scouring? Will it be better able to maintain its present position? The likelihood is that an increase in discharge will help to keep the mouth clear, but not prevent drifting shingle from moving the mouth gradually eastwards to Haven Brow, as it has done historically.

2.4.6. It is uncertain whether people will like the appearance of the new saltmarsh landscape more than that of the existing semi-improved pasture.

2.4.7. We await reports from the Visitor, Geoarchaeological, Landscape Character Assessment and Economic Surveys. The results of these surveys may affect our views on appropriate action.

2.4.8. We believe that local people and visitors will wish, above all else, to see the meanders retained in the landscape, but an attempt should be made to confirm this through visitor survey. Similarly it is unlikely that the shift in

landscape and vegetation towards saltmarsh would have a negative impact on overall visitor numbers, provided care is taken over access; this too might emerge from visitor survey.

3. OPTION B: FULL BREACH MANAGED REALIGNMENT (Environment Agency)

3.1 Description

3.1.1. Full breach realignment involves the admission of tidal water into cells B & C as above but also cell A (the area of the floodplain containing the canoe barn and canoe lake). Tidal water would be admitted by way of restricted breach points in the embankments. Otherwise, the embankments will be left intact; it is envisaged that the embankments will create a more sheltered environment for saltmarsh to develop. The breach point for cell A would be at the southern end of the canoe lake, admitting water into the meanders and flanking floodplain, with the aim of fostering saltmarsh development there. Arrows on the EA's map are suggested locations for breaches, not finally decided.

3.1.2. It also involves the creation of a major new embankment running across the floodplain from approximately 30m south of Exceat Bridge to the eastern valley side about 100m SE of the Visitor Centre. The intention is to prevent tidal water from reaching the A259, form a northern boundary for cell A and (perhaps incidentally) leave a small segment of the meanders as a truncated canoe lake. A second new bank would be created to separate cells A and C, following a different route from the bank in Option 1 and allowing inundation of the Foxhole valley.

3.1.3. An area at the western edge of cell C will be excavated to create a reservoir that will enlarge the Cuckmere's tidal compartment [volume of water stored at high tide] and help to increase flow at the river mouth on a falling neap tide. It is envisaged by the EA that the river mouth would maintain itself in its present position, because of the larger volume of water flowing through it.

3.1.4. Diversions of valley-side rights of way would be necessary, as in Option A. Short footbridges could ensure continuing access along the two valley-centre rights of way.

3.2 Benefits

3.2.1. It sets aside an area (larger than in Option A) where re-creating an interesting historic saltmarsh would be possible.
3.2.2. It would be ecologically more diverse and more attractive than the present landscape. The semi-improved neutral grassland is regarded as species-poor by ecologists. This would be converted (reverted) to intertidal

habitat, which would benefit the already saline-influenced species. As in Option A, reversion to intertidal habitat will give new opportunities for breeding wetland birds; because the area is larger, this option is likely to be more beneficial to wetland birds than Option A.
3.2.3. Comments made under Option A about fish nurseries also apply to Options B and C. This option would provide valuable additional marine fish nurseries.
3.2.4. It would further increase the tidal scour on the falling tide by enlarging the tidal compartment, and be more likely to keep the river mouth open. This would entail a reduction in the need for human interference in the outfall and therefore a financial saving.
3.2.5. A reduction in artificial shingle recycling would mean that there is a greater chance that the vegetated shingle habitat on the crests of the beaches will be restored to favourable condition.
3.2.6. The land levels are high enough for saltmarsh vegetation to grow across most of the area of the floodplain, in fact rather higher in cell A than elsewhere.
3.2.7. A larger area of extra intertidal habitat (108 or 112ha acc to report, but about 1.1 sq km compared with 3 sq km at Pagham Harbour) would be created than in Option A. This would probably be ecologically and geomorphologically sounder (the larger the area of saltmarsh the better).
3.2.8. Development of saltmarsh would be a way of harnessing natural processes to adjust the level of the land to a changing sea level. Saltmarsh is a dynamic environment that induces sedimentation and can therefore build up to keep pace with rising sea level.
3.2.9. There is little risk of harbouring a mosquito population (high salinity, tidal flushing effect). According to the SEA (environmental report).
3.2.10. The new 600m bank would provide some protection for the A259 causeway and the low-lying upper valley behind it from incursion by the sea under sea level rise conditions or storm surges. As the (unmanaged?) beach barrier increasingly fails under wave attack, an artifical barrier will become increasingly necessary as a seawall.
3.2.11. The new bank could be designed to carry a footpath, which would provide improved pedestrian access across the valley, separated from the road. It would connect the visitor centre and canoe barn car park with the Golden Galleon and the northern end of the Vanguard Way.
3.2.12. A (smaller) canoe lake is preserved, so novice canoeing can continue (but see 2.3.5). Similarly, the canoe barn and adjacent car park will be preserved.
3.2.13. The agricultural value of the land lost is low (Grade 4).
3.2.14. The view from the Golden Galleon across saltmarsh would be more interesting.

3.3 Disbenefits

3.3.1. There will be a greater loss of neutral grassland SSSI habitat than in Option A. 75 ha of grazing marsh and 13 ha of saline lagoon will be lost, though there is the possibility of replacing this to the north of the A259,

where there is already an SSSI grazing marsh. There would be a need to compensate for the lost Biodiversity Action Plan Habitats by creating them elsewhere in the SSSI, north of the A259. If that could be achieved, then this option is to be preferred to Option A as there will be a larger net gain in area of priority BAP habitat. On the other hand, the creation of areas of intertidal habitat will increase the *diversity* of habitats in the SSSI, and freshwater interest will be retained in the part of the SSSI north of Exceat Bridge. We are not aware of any particular freshwater/ brackish wildlife interest in cell A that would be lost by realignment.

3.3.2. The presentation of this option presumes that historic creeks 'are likely to be reactivated, becoming more defined features within the floodplain.' (SEA 7.2.16) But this needs to be deliberately engineered if an integrated hydrological system is to develop [cost]. 'This is especially the case for the old meander. The meander is likely to become a tidal limb to the main channel.' But left as a backwater, the meanders will probably silt up progressively from the landward end and disappear within 100 years (=loss of a classic landform).

3.3.3. What was said under Option A (2.3.7) about the breaches in the embankment applies equally to this option.

3.3.4. The new 'shallow-gradient closing bank' running across the floodplain south of the hairpin meander [substantial cost]. It would make a poor visual impression on visitors arriving at either end of the A259 causeway; it would spoil the classic view of the meandering reach from the northern end of the estuary, cutting the meandering reach in two. This would be an inappropriate and unwelcome new man-made addition to the landscape, when the overall intention of managed realignment is to return it to nature. Possibly its appearance could be improved by planting some shrubs and hawthorn trees on it. The negative visual impact might be evaluated more objectively by means of a visitor survey (to identify key elements in the landscape that vistors want to see) and a landscape character assessment. In a similar way the short new closing bank separating cells A and C may impact on views within the estuary and this issue too should be included in an objective assessment exercise.

3.3.5. Too few breaches are allocated to allow water freely in and out of the saltmarsh areas: one in each of Cells A and C and two in Cell B (though two are shown in Cell A on Fig 10). This restriction of flow would not lead to a naturally functioning saltmarsh.

3.3.6. The increase in tidal compartment could lead to increased erosion at the outfall and therefore increased maintenance costs relating to training groynes (= objection from EA in 2006)

3.3.7. The greater discharge of the river at the outfall could mean that the training groynes, set rather close together, could be undermined by the flow. The increased risk of collapse means a higher maintenance cost – unless a decision is made to abandon the groynes and allow them to collapse.

3.3.8. Comments about 'controlled inundation' and 'flow control structures' under Option A apply here too.

3.3.9. Similar problems with footpath changes as in Option A, with similar hillside-scarring.

3.3.10. The increased volume of the river accompanying the enlargement of its tidal prism may create problems at Exceat Bridge. There is a risk of damage to the abutments at times of high flow, a risk that might necessitate building a new a larger bridge. [cost]

3.4 Questions & uncertainties

3.4.1. Although the greater discharge on a falling tide will be more likely to create a river outfall that will be self-cleansing, there is no certainty that it will stay in the same place. Once the training groynes are removed or allowed to disintegrate, longshore drift will probably cause the outfall to migrate slowly towards the east. The greater flow may mean that the eastward drift is slower. But it is not possible to predict accurately what will happen.
3.4.2. Recurring problems with the MR options are the small size of Exceat Bridge and the low altitude of the surface of the A259 on the adjacent causeway. If the causeway has to be raised 2m or more and the bridge has to be rebuilt to a new specification, considerable costs are added to the project. This is not to say that these works are not required, but rather that they put the MR schemes into a higher price bracket.
3.4.3. Questions have been raised about the possible penetration of salt water into the chalk aquifer, especially along the eastern valley side, which could contaminate the fresh water abstracted at Friston. SE Water expressed concern about this in 2006, but concluded from their borehole measurements that this option would have no effect on salinity of water abstracted at Friston (salt water already passes up the Cuckmere to Alfriston). They concluded that even the penetration of sea water onto the floodplain *above* the A259 would have no effect on the quality of abstracted drinking water.
3.4.4. It is presumed that in time, through withdrawal of maintenance, the embankments on each side of the cut will disintegrate and that water will flow in a less controlled way into the three cells. All the river bank walks would be lost. This would turn the scheme (halfway) into Option C. If on the other hand maintenance of the river banks is to continue there is an added cost.
3.4.5. It has been suggested that tidal inundation of cell A would mean the loss of informal picnic sites out on the floodplain; this is not a substantial objection, as no-one has been seen doing this.
3.4.6. The success of the scheme will depend on a certain amount of topography-creation before the floodplain is exposed to tidal inundation, to ensure that a sufficient area remains exposed at high tide to provide high tide roost sites for birds.

4. OPTION C: ENGINEERED REACTIVATION OF MEANDERS AND SALTMARSH CREEKS

4.1 Description

4.1.1 The valley floor would be restored as a fully functioning tidal estuary, complete with active tidal river meanders and branching networks of tidal creeks with flanking saltmarshes. The landscape would retain much of its present visual appeal (meanders crossing a vegetated floodplain), together with branching networks of small meandering creeks nested within the larger meanders of the tidal river channel. It would be geomorphologically, hydrologically and ecologically diverse – and therefore of great tourist and educational interest. There would be improved access along both sides of the valley to the beach, though the two valley-centre rights of way would be lost.

4.1.2 The scheme goes further than other MR schemes in reconnecting and restoring remnants of the historic creek system. Micro-engineering the floodplain, would re-create a landscape that was (and can again be) an integrated and fully working hydrological system.

4.1.3 The following engineering works would be needed:
1. Raise the A259 causeway by 2m (to 5.7mOD). Revet the causeway's seaward slope.
2. Raise the concrete road on the east side of the valley by 2.5m and continue it along the floodplain edge to the beach.
3. Raise the middle section of the Vanguard Way by 2.5m (to 5-5.5m OD), to ensure that it is above flood level. Make its surface usable by wheelchairs, pushchairs and emergency service vehicles.
4. Dredge the canoe lake of accumulated silt down to current river bed level.
5. Reconnect the meandering reach at upper and lower ends, re-establishing river flow round the meanders.
6. Revet the outer bank of the river bend at Exceat Bridge to ensure flow is diverted into the meandering reach.
7. Backfill the 1846 cut using material from the embankments on each side.
8. Topography creation. Excavate the floors of silted 'fossil' creeks and reconnect the creeks to the river. Create artificial creeks where the original creeks have been effaced. Raise selected areas between the creeks, creating subdued local relief where lower saltmarsh, upper saltmarsh and safe higher nesting sites can be generated.

4.2 Benefits

4.2.1. High initial set-up costs give way to minimal costs in the long term, as the system should in time become entirely self-running.
4.2.2. The scheme follows the concept of managed realignment to a logical conclusion.
4.2.3. It creates a self-regulating system that benefits from the knowledge that such a system once functioned there in the past.
4.2.4. It restores the meandering reach as an active tidal feature, resuming its pre-1846 function as the main river channel. This will work hydrologically, because the original natural channel geometry has remained unchanged since the reach was by-passed, apart from becoming half-filled with silt; the silt would need to be dredged out before the segment of channel is

reconnected [cost]. The reactivation of the meanders will work in terms of tourist attraction too; water flowing round the meanders and at different tidal levels will be more exciting to look at, animating the landscape.
4.2.5. It similarly restores and reactivates the fossil tidal creeks, creating flows of water that will be interesting to watch.
4.2.6. Because of the comprehensive engineering of the land surface and the channels, the scheme returns the landscape **rapidly** to a fully-functioning natural tidal estuary system with flanking saltmarsh, rather than waiting for natural processes to do the engineering. The RSPB's experience at managed realignment projects in East Anglia is that it is cheaper and easier to create the desired topography when realigning over a flat site before a breach occurs. This ensures the swift colonization by, particularly, birds.
4.2.7. The transition period should be short. This is likely to be more acceptable to both the local community and visitors. Long transition would probably lead to restlessness and hostility.
4.2.8. The greater variation in topography that is possible with comprehensive engineering will generate more saltmarsh and bring greater benefits as a fish nursery ground.
4.2.9. It creates a mainly vegetated landscape, which we believe is what most people want to see, though a visitor survey may show otherwise.
4.2.10. It creates improved access along both sides of the valley. The Vanguard Way, being raised and given a more level surface, would become drivable by emergency vehicles, though it is envisaged that this would be principally a footpath, with locked gates, and used by emergency vehicles only. Regular vehicle use would be detrimental to the tranquillity of the adjacent saltmarsh environment. A small number of additional spur walkways is proposed into the saltmarsh as it establishes, providing visitors with exciting close contact with the saltmarsh environment.
4.2.11. It re-creates a now-rare ancient landscape, a wetland as it was before medieval draining and land reclamation. This has an important heritage resonance, with major tourist and educational implications.
4.2.12. By removing the central rights of way, it creates more remote saltmarsh areas, which would be attractive to many wetland bird species.
4.2.13. It maintains an upwarping land level in an environment of rising sea level.
4.2.14. It creates a whole tidal saltmarsh environment (not divided artificially into cells) that would be of major interest, to bird-watchers and tourists.
4.2.15. It will help, marginally, in flood alleviation. Because embankments would be entirely removed south of Exceat Bridge any excess discharge flowing down the river after storms would be able to spill laterally onto the floodplain instead of remaining trapped in the river channel. This should reduce river flood levels and reduce the likelihood of ponding back.
4.2.16. All three managed realignment options would benefit wildlife in the SSSI and be preferable to the current situation. Similarly, all three options would achieve a net gain in priority BAP habitats, provided that the grazing marsh and saline lagoons were to be re-created elsewhere. Options B and C are preferable to Option A, as they bring greater benefits to the SSSI and

BAP habitats. Option C may bring further benefits in terms of certainty and speed in the creation of habitats.

4.3 Disbenefits

4.3.1. Significant set-up costs.
4.3.2. Sturdy revetments would be required immediately below Exceat Bridge, and about halfway to the sea, to ensure water flow round the meanders.
4.3.3. Substantial engineering works would be needed to raise the A259 causeway by about 2 metres, though this will eventually prove to be necessary with other schemes.
4.3.4. There would be a need for monitoring and aftercare (though probably no more than other MR schemes).
4.3.5. Two rights of way down the centre of the valley, created in 1846, would be lost.
4.3.6. The still-water novice canoeing facility would be lost.
4.3.7. The canoe barn would be lost, though it could be rebuilt on the foot of the valley side, close to the road.
4.3.8. The canoe barn car park would be lost. On the other hand, it is visually unsightly, occupies a focal point in the landscape and the lost parking could be replaced by extending the woodland car park further to the north; this would be a significant net gain in landscape aesthetics. On the other hand, it would mean more pedestrians crossing the A259.
4.3.9. Several major elements of the 19th-20th century landscape would be removed, including the Victorian cut and embankments.
4.3.10. This option has similar ecological consequences to Option B in terms of its impacts on the SSSI and BAP habitats. However, this scheme may bring greater certainty over the diversity of intertidal micro-habitats created. The meanders and tidal creeks – and the land surface between them - will be engineered to ensure that the topography is there to guarantee a gradation from higher to lower saltmarsh through to mudflat and creek.
4.3.11. There is a need for an assessment of the likely impact on known and unknown archaeological resource for this option – and for the other options as well.
4.3.12. The West Beach would need to be maintained in the short term, while the new hydrological and ecological system becomes established. The embryonic saltmarshes need to be protected from high-energy wave action. The outfall would similarly need to be maintained and monitored as the new system stabilizes. Increased tidal prism would mean increased discharges on ebbing tides, and the effects on the river mouth would need monitoring. This disbenefit is shared with Options A and B.

4.4 Questions & uncertainties

4.4.1. Because of its radical nature and the amount of landscape change involved at the outset, this scheme may provoke a negative response from some people. It is uncertain whether the naturalness and historical and

cultural values implicit in this recreation of a former landscape would bring widespread public endorsement. Does the existing mix of landscape elements possibly have too strong a hold on public affection? This point may be elucidated by the visitor survey and the landscape character assessment.

4.4.2. When a commitment to preserving the status quo is expressed, 'saving the meanders' is often mentioned, but nothing is said about the cut. Would the loss of the cut in fact be popular? Some people see the removal of the cut as a major improvement to landscape aesthetics (a jarring straight line in a landscape of elaborately developed meanders), while others may see it as a loss of Victorian heritage. This point too may be elucidated for us by visitor survey and landscape character assessment.

4.4.3. This option has not been costed. Costings for Options A and B are available (EA 2008) but they are in question and seem to be incomplete. Ongoing, continuing costs for monitoring, maintenance and modification would exist, but they would be likely to be on a scale similar to or less than those required for Options A and B.

4.4.4. It has been suggested by some that allowing tidal water to flow round the meanders may have (adverse?) ecological consequences. It has, on the other hand, been pointed out by others that there is no vegetation to speak of in the canoe lake, and that the lake is dying, so it is hard to see what would be lost in the reactivation process.

4.4.5. Some local opinion maintains that the river 'needs' the cut to aid its flow, the idea being that because the cut was made it must have been necessary. Documents from the early nineteenth century indicate that discussions preceding the creation of the cut had improving drainage from the upper valley as their focus, not improving navigation (Longstaff-Tyrrell, 11-14). Against this, the following points; a) The prevailing culture in England at the time was the improvement of rivers for navigation, canalization, and it is known that the lower Cuckmere was in regular commercial use for transporting coal from Newhaven to Alfriston. To judge from scrutiny of historic maps, the bypassing of the two small but very tight meanders at Brockhole Bottom (GR 512000 and 514002) was carried out in around 1815, well before the big cut below Exceat Bridge. Bypassing these little meanders could have made no difference to flooding either here or upstream, but a great deal of difference to the manoeuvring of barges. b) Even if the river was straightened with the intention of alleviating flooding, the perception of those who concluded this may have been mistaken. Interference with natural river channels has frequently proved to be misguided. In the mid-twentieth century, many of the Mississippi's meanders were artificially cut off (mainly to improve navigation), but that river quickly re-asserted its meandering habit, so the costly interference was misconceived. c) It is not the case that rivers flow more efficiently in straight channels. Artificial straight channels frequently show high levels of turbulence, and reaches of alternating faster and slower flow – sure signs of uneven and inefficient expenditure of energy. There are no straight river channels in nature. Conversely, rivers with meandering channels commonly display very smooth flow. d) The idea that meandering rivers are senile and consequently need assistance is itself 120 years old and in need of

pensioning off. Modern work on meandering lower-course rivers shows that they have high energy levels and are well able to create their own channel geometry. The lower Cuckmere created its preferred geometry, which is plain to see in the canoe lake.

4.4.6. A related piece of local lore asserts that below Exceat Bridge oxbow lakes were likely to form as the river sought to take a more direct route; the bend at the Golden Galleon was critically tight. This entirely unfounded idea has been used to promote the idea that the cut was made to relieve the river of this problem. Historic map evidence shows that the Cuckmere made this abrupt bend freely and naturally, and maintained it for at least 250 years before the cut was made.

5. OPTION D: MAINTAIN THE EXISTING DEFENCES (Environment Agency 2007 Option 2a)

5.1 Description

5.1.1 The existing flood embankments along the river would be maintained at their present height by carrying on maintenance work as at present [cost]. Beach sediment would be regularly artificially recycled from the river mouth to the West Beach as at present to keep the river mouth clear of shingle and nourish the West Beach [cost]. Beach nourishment would be required in the future on the East Beach [cost]. The training groynes at the river mouth and the groynes on the West Beach would be maintained as at present [cost], though long-term the training walls at the river mouth will need to be replaced [cost]. In 2008, the Environment Agency estimated the total present-value cost over the next 100 years as £6,290,000 (EA 2008), though this sounds very high and maybe should be recalculated.

5.1.2 According to the Environment Agency, continuing maintenance as at present can only be short-term. As a result of climate change there will be increased numbers of storms and sea level will rise, so the risk of overtopping will increase; in time, even if maintained, the present defences will become inadequate to prevent flooding.

5.1.3 An addendum to this option by Richard Mann (the Working Group Chairman) deals with the pragmatic maintenance of the flood defences. The proposal is to achieve the continuing maintenance of river embankments by spreading the financial responsibility for the task. It would require riparian landowners to meet their customary obligations; it would similarly require statutory bodies to meet their statutory obligations. This means less public funding, maintains the status quo in landscape terms and keeps options open while we wait and see what happens to sea level, about which there is uncertainty.

Recent observation indicates that there has been a significant period of neglect of the flood embankments. In places the soil and rubble surface of the bank crest has been both worn down vertically and broken away at the

edges by pedestrians walking along the bank-crest footpaths and by livestock trampling. At these weak points in the banks overtopping could occur on a very high tide accompanied by very low atmospheric pressure or a south wind. Once overtopped, such points would quickly erode, allowing large volumes of water out onto the floodplain. They could easily be repaired, and relatively cheaply. The concrete revetments reinforcing the channel have similarly been allowed to break up in some places: these would be more expensive to repair. In some places the soil and rubble bank has become eroded behind and underneath the revetment, leaving the revetment suspended and weakened: these could easily be repaired.

5.2 Benefits

5.2.1. No new technology is needed. All that is required is to continue environmental management as at present, though more conscientiously and systematically. This means no change of strategy, no risk with experimental new techniques, no uncertainty.
5.2.2. There is a consequent high level of predictability.
5.2.3. There will be little change to the appearance of the landscape.
5.2.4. It would give a 20-year pause for thought and further planning – allowing us to wait and see what happens to sea level. (NB See section 5 on sea level change below.)
5.2.5. It retains the canoe lake as a novice canoeing facility (but see 5.3.4 below).
5.2.6. There would be no change to the current usage of the landscape for agriculture, wildlife and recreation.
5.2.7. It has a strong appeal to the natural conservatism of the community. (but see 12.8).
5.2.8. It retains all the existing rights of way in the lower valley.
5.2.9. It is an economical, low-cost option.

5.3 Disbenefits

5.3.1. The Environment Agency states that water nearly fills the artificially embanked channel now, so the situation may not be sustainable in the future, in the context of a rising sea level. The success of this option is to a considerable extent dependent on there being little or no future rise in sea level. Predictions of future sea level vary substantially, but most entail a rise on some scale (see below, section 10).

On the other hand, the Environment Agency's description of the water level situation could be challenged. On the highest tides seen recently (7.2m) the water level in the river was observed to be about 0.4m below the crest of the banks, so there is still some spare channel capacity that would allow for a small amount of sea level rise.
5.3.2. This 'wait and see' approach may be a short-term approach that in the long-term could prove to be a waste of resources. If the summary forecasts published by the Inter-governmental Panel on Climate Change are on the

right lines and serious sea level rise is on the way, an interim hold-the-line measure could prove to be a waste of money.
5.3.3. It could similarly waste valuable time. If sea level does rise, then the relative levels of floodplain surface and sea will become increasingly inimical to saltmarsh development. Time lost in maintaining the flood defences now could wreck the prospects of successful managed realignment later.
5.3.4. In this scenario, the meanders, a key element in the landscape, would be lost through silting. As the lake gets shallower and the flow of water in and out reduces, oxygen content will reduce and temperature will increase, causing fish deaths – unpleasant for the fish and for the tourists. The canoe lake is already unusable in hot weather, already unsafe for swimming, and is likely to become an increasing health hazard. Preservation of the meanders as a lake will depend on a programme of dredging and the installation of a second sluice, so that water can flow through periodically.
5.3.5. If people supported this option on the understanding that the canoe lake would be preserved, they would feel short-changed if the lake disappeared and/or became unusable.
5.3.5. It entails continuing maintenance cost, which the EA has declared that it does not wish to bear.
5.3.6. There would be increasing frequency of over-topping with time, with associated risks; the possibility of eventual failure of the defences makes this option less than safe and predictable. It would also lead to changes in the vegetation, which would change gradually from grassland to marsh.
5.3.7. Rectification to make up for the backlog of unperformed maintenance is likely to have visual impact, as well as some impacts on wildlife and access.
5.3.8. Many will see the short-termism of this option as a cop-out, based on an impractical desire to keep an older generation comfortable with a familiar landscape, but without regard for the longer-term consequences.

5.4 Questions & uncertainties

5.4.1. How would riparian landowners be made to repair the river banks? Who will be the source or threat of any legal challenge to non-compliance? Local authorities are experienced in non-compliance or half-hearted compliance with statutory obligations when funds are short.

5.4.2. Of the 'statutory bodies', the Environment Agency would be unlikely to want to find extra resources to pursue maintenance to a higher standard. This seems to disadvantage the proposal.

5.4.3. It seems unlikely that the National Trust would be interested in funding bank repairs, given its interest in managed realignment.

6. OPTION E: SUSTAIN THE EXISTING DEFENCES (Environment Agency Option 2b)

6.1 Description

6.1.1 The river embankments would be built up to accommodate the expected future sea level rise. Raising the height and increasing the bulk of the existing defences would counteract the increasing flood risk as sea level rises. River embankments would be made higher and wider. They would be raised by 300mm at the beginning, with the addition of stone or concrete revetments in places vulnerable to erosion [cost]. In the medium term (20-50 years) the channel would be reinforced with concrete walls or sheet piling to support the second phase of bank-raising, a further 300mm to make 600mm in all, to meet the expected rise in sea level indicated in Defra guidelines [cost]. Sea defences would be added, such as a rock revetment to reinforce the West Beach [cost]. Substantial and repeated engineering works would be needed and the groynes would have to be replaced [cost]. The landscape of the floodplain could be kept looking much the same as now, except that the meanders would gradually be lost through silting (though the silt could be dredged from them in order to ensure their survival [cost]), and after rain there would be pools of standing water on the floodplain. Confining the river between flood banks as sea level rises will lead to an increase in river volume and the erosion and destruction of the saltmarsh areas developing in the channel.

The estimated 100-year present-value cost of this option according to the Environment Agency is £6,947,000 (EA 2008). Once again, a recalculation would appear to be called for, as this figure is only slightly higher than the figure quoted for Option D, yet Option E requires a great deal more in the way of engineering works.

6.2 Benefits

6.2.1. There would be limited physical intrusion in terms of engineering works while the banks are being raised (but see 6.3.2).
6.2.2. It would be initially relatively inexpensive, because of the low-technology required, though continuing sea level rise could multiply the cost so that by 2100 a great deal could be spent in total.
6.2.3. It would leave a familiar and much-loved landscape visually unchanged and preserve its archaeological features, such as the WW2 remains (but see 6.3.2.).
6.2.4. It retains the canoe lake as a novice canoeing facility (but see 6.3.1).
6.2.5. There would be no change to the current usage of the landscape for agriculture or recreation, though the section of the Vanguard Way that descends onto the floodplain, already muddy in winter, would become even wetter.
6.2.6. It has a strong appeal to the natural conservatism of the community.
6.2.7. It allows continuing easy, level access to the beach along the concrete road, and so is good for all-round, all-ages tourism, including access for wheelchairs and pushchairs.

6.2.8. It allows for huge savings in the non-development of infrastructure. There would be no need under this scheme to alter or divert any footpaths or do any engineering works on roads.
6.2.9. The banks would be widened as they are raised, giving them greater stability and strength; the present crest width would be maintained so the banks would continue to have their present recreational function as walkways.

6.3 Disbenefits

6.3.1. The meanders would become shallower and eventually be lost through silting. As the lake gets shallower and the flow of water in and out reduces, oxygen content will reduce and temperature will increase, causing fish deaths (see 5.3.4 above).
6.3.2. Raising the banks repeatedly in response to repeated or continuing sea level rise commits us to making the flood banks ever-higher and ever more massive. The height of the banks may eventually become unsustainable in engineering terms. Then managed realignment would be the alternative; all the money spent building the banks would have been wasted, and valuable time would have been lost when saltmarsh development could have been raising the land level to keep pace with the rising sea. It is therefore questionable whether this is a genuinely sustainable option in the long term.
6.3.3. The impact of successive major engineering operations suggests that continuity in terms of landscape, wildlife and access may be modest. The requirement to build defences up, in height and breadth, on a continuing basis suggests a steady change over time in the appearance of the estuary. If sea level should rise significantly, and if the banks should be raised in parallel, they will take on an ever-increasing appearance of an engineered solution.
6.3.4. It will increase the likelihood of serious flooding in the Cuckmere valley by confining more water in the channel between embankments. The Environment Agency's Scoping Report states that there would be an 'increase in flood risk upstream' (Babtie, Brown and Root 2005, p 47). Increased overbank flow will reduce access and create problems for walkers.
6.3.5. The eventual overtopping (or indeed breaching) of the raised river banks under storm conditions would be more severe, more damaging, more dangerous.
6.3.6. The consequent raised water levels in the Cuckmere would put a slightly greater water pressure on the lower parts of the embankment structure, increasing the risk of leaking, seepage and consequent embankment failure. In this scheme, too much depends on the strength of the construction of the original embankments. It seems unlikely that the internal structure of the existing embankments is fully understood, and if they consist of randomly dumped rubble of varying density there are likely to be (currently undetected) places where permeability is high. Today when river level is high (as on a 7.2m tide), there is evidence of seepage at the base of the outer face of the embankments. This has been seen both below Exceat Bridge (eg at O.S. Grid Reference 514979) and at locations above the

bridge, in the form of pools of standing water adjacent to the embankments when there has been no recent rainfall and no overbank flow; the standing water can only have come from seepage through the embankment. Given that water is evidently percolating through the embankments under *present* conditions, it is likely that this problem would become worse as water levels rise.

6.3.8. Raising the banks would necessitate widening them to give them stability and maintain crest width, as the Environment Agency states. The engineering work would entail building out the ramps facing the floodplain. This would make a significant visual impact on the landscape (see below, Option F).

6.3.9. The cumulative cost of this work, spread over a century, has been calculated at £6,947,000 by the Environment Agency, then revised to £18 million. The basis of the revised figure is unknown and the costings – for all the options - should be independently reviewed.

6.3.10. In the short term, when the banks are to be raised by 300mm and sea level is still close to its present altitude, the engineering work might be confined to the lowest reach, below Exceat Bridge. But by 2060, when the sea may be 300mm higher, there would be increased overtopping in the reach between Exceat Bridge and Alfriston, with associated impacts on pedestrian access. If sea level were to go on rising as predicted to 600mm above its present level, there would then be frequent and large-scale overtopping of the river banks in that reach of the valley, on a scale that could seriously impact land use, ecology and health and safety. The banks would at that stage have to be systematically raised all the way up to Milton Lock – unless managed realignment in that reach were to be considered an option.

It is not clear whether the costing quoted by the Environment Agency includes this upvalley expansion of the engineering work [cost] (and see below). The detailed scenario description table in the Environment Agency's Strategic Environmental Assessment (May 2006) makes no mention of extending the work up to Milton Lock. Raising the banks that distance upstream will have a considerable visual impact on the landscape, and involve considerable added cost.

6.3.11. As the sea level rises, the floodplain will be left at a progressively lower altitude in relation to the sea and to the water table in the chalk hills to east and west. The level of the water table in the coastal chalk is partly controlled by sea level; if sea level rises, the water table too will rise. This means that, although the floodplain might be defended from flooding by the river, it would become more and more frequently flooded by water leaking out of the chalk valley sides. There would be standing water on the floodplain far more frequently. There would be waterlogging, gradual degradation of grazing land and colonization by marsh vegetation. Springs could appear in the floodplain as the water table rises underneath.

6.3.12. Confining the river between flood banks as sea level rises will lead to an increase in river volume and the erosion and destruction of the saltmarsh areas currently developing in the channel. This would mean a reduction in biodiversity.

6.3.13. The progressively developed hard engineering, becoming more massive as sea level rises, will become more conspicuous as a landscape feature. This will detract from the area's visitor appeal.
6.3.14. This strategy involves a separation from a sustainable natural system that increases with time. It would be likely to lead eventually to the hydrological system reorganizing itself in a catastrophic (ie sudden and unpredictable) behavioural switch.
6.3.15. It seems to display fewer of the apparent benefits of Option D (in terms of keeping change to a minimum) and more of the disadvantages (more intervention, more risk).

6.4 Questions & uncertainties

6.4.1. Where would the material for raising the banks come from?

6.4.2. What line is being held here? As the amount of engineering increases, the landscape changes. Is too little being gained at too great a cost?

7. OPTION F: SUSTAIN EXISTING DEFENCES (Nigel Newton Scheme)

7.1 Description

7.1.1 This scheme differs from Option E in envisaging a single raising of the river's flood banks by 300mm at the outset, to cater for predicted sea level rise during the next 50 years. The engineering aspects have been worked out in detail by EAS, engineering consultants commissioned by Mr Newton. Surveys of river bank level, computer modelling and flood risk assessment have been carried out as well. The existing banks are seen as sound enough to accept being raised by 300mm, to cope with the raised water levels in 50 years' time as envisaged in current climate change predictions. The proposed design (EAS 2004) involves raising the river's flood embankments by 300mm while maintaining a minimum crest width of 1.5m.

7.1.2 To achieve a minimum crest width of 1.5m, EAS acknowledge that the banks would need to be widened locally: specifically, they mention the short stretch of bank running along the southern edge of the old boating pool near the Golden Galleon. An impermeable core to the banks would need to be created (EAS 2004, p 3, 3.5), but it is not clear how that will be done. It is not considered by EAS that piping failure due to increased hydraulic pressure would be very likely to happen (p 4, 3.6). There would be some construction and maintenance difficulties, resulting from the narrowness of the bank crest. In spite of the narrowing of the bank crest, EAS believe that armouring will not be necessary, except 'where the main flow of the river is adjacent to the bank and where the width for flow is narrow. . . principally at the north end of the eastern bank.' (p 4, 3.7). The raised banks are thought capable of accommodating a 1 in 200 years flood event.

7.2 Benefits

7.2.1. There would be limited physical intrusion: one episode of engineering works while the banks are being raised (but see 7.3.13).
7.2.2. The bank height of the reach between Exceat Bridge and the sea is already close to adequate, according to the EAS report. Although the bank crests have been reported to be as low as 4.2m OD, a levelled survey shows that this is a minimum height; generally the bank crest stands a little higher, at 4.4-4.5m OD at the northern end, near Exceat Bridge, falling gently to 4.2-4.3m OD towards the outfall. The banks are regarded by EAS as being generally sound, though it is not clear on what information this confidence is based (see above 3.3, point 5). Raising the banks to accommodate sea level rise by 2060 would therefore be relatively inexpensive, using low-technology. Alan Edgar's current [autumn 2010; pers com] estimate is a cost of around £1.2 million, which compares favourably with the Environment Agency's 2008 estimate of £2,564,000 for its full-breach managed realignment option.
7.2.3. In broad terms it would leave a familiar landscape visually unchanged.
7.2.4. It satisfies the precautionary principle. The 300mm increase in riverbank height should suffice until 2060. This allows time for a review of alternative options in the light of actual environmental changes that are at present uncertain, eg climate change, sea level change. The engineering involved is said to be reversible. On the other hand it is only reversible in the narrow sense that banks built can be taken down again; if this option were to be abandoned in favour of managed realignment after two or three decades, managed realignment would fail because of the intervening change in the relative levels of land and sea.
7.2.5. It avoids the potentially catastrophic scenario (in Option E) of ever-rising, ever-widening river banks bringing the threat of structural failure.
7.2.6. It retains the canoe lake as a novice canoeing facility (but see 7.3.1).
7.2.7. There would be no changes at all to current usage of the landscape for agriculture or recreation, though the section of the Vanguard Way that descends onto the floodplain, already muddy in winter, would become even wetter.
7.2.8. It has a strong appeal to the natural conservatism of the community.

7.3 Disbenefits

7.3.1. The meanders would eventually be lost through silting. As the lake gets shallower and the flow of water in and out reduces, oxygen content will reduce and temperature will increase, causing fish deaths (see 5.3.4 above).
7.3.2. This is a short-term solution only. If IPCC forecasts are on the right lines and serious sea level rise is on the way, this interim measure could prove to be a waste of money.
7.3.3. Raising the banks by 300mm will accommodate sea level rise at a rate of 6mm/ year over the next 50 years, but it will not accommodate any rise in excess of that figure. Some predictions include not only continuing sea level rise after 2060, but at an even higher rate, 9mm/ year. This scheme would

not cater for any additional increase in sea level. It would evidently not satisfy Defra's 100-year time-scale requirement.

7.3.4. It may increase the likelihood of serious flooding in the Cuckmere valley by confining more water in the channel between the raised embankments.

The banks would not be raised upstream from Exceat Bridge, only downstream (EAS 2004, p. 2, 2 and map 'Plan showing construction types'). This is likely to pass on the flooding problem from the reach of the river below Exceat Bridge to the reach upstream. Even if, as hoped, the bank raising below Exceat Bridge does not aggravate overtopping upstream, the bank crest heights are such that rising sea level, irrespective of the raising of the banks, will lead to overtopping. The bank crest heights were surveyed upstream all the way to Milton Lock to ascertain whether the banks are high enough to cater for sea level rise. The still water level on a 7.2m high tide in 2060 will be at 3.9m OD, according to Defra guidelines. This means that there are 70 places along the river banks above Exceat Bridge where the water would rise to within 100mm of the bank crest. This provides a minimal margin for the coincidence of a 7.2m tide with heavy rain in the upper catchment area, low atmospheric pressure or a strong onshore wind.

The bank top survey data also shows that there are some points on the crests of the river bank between Exceat Bridge and Alfriston that are only 3.4-3.8m OD.

It looks as though, for safety, the banks between Exceat Bridge and Milton Lock need to be raised. If the bank-raising does indeed need to continue up to Milton Lock, about 8km in all, compared with the 1.5km below Exceat Bridge, the cost of the project would rise accordingly. If the cost 'per metre of river channel' is the same, the overall cost would rise from £1.2 million to £6.4 million, making this a significantly more expensive project.

On the other hand, other options dealing only with the area of the floodplain south of the A259 will leave the valley above the A259 exposed to overtopping in exactly the same way, so the additional cost being discussed here in relation to this option must in fairness and for the sake of comparison be applied to other options – in fact all of the other options except the tidal barrier, Option G.

7.3.5. Because of the containment of larger volumes of water between the embankments, the eventual overtopping of the banks under storm conditions would be more severe, more damaging, more dangerous.

7.3.6. Confining the river between flood banks as sea level rises will lead to an increase in river volume and the erosion and destruction of the saltmarsh areas currently developing in the channel. This would mean a reduction in biodiversity.

7.3.7. Raised water levels in the Cuckmere would put slightly greater water pressure on the lower parts of the embankment structure, increasing the risk of leaking, seepage and consequent embankment failure. Too much depends on the (uncertain) strength of the construction of the original embankments. The engineering design at the heart of this proposal does not appear to add any structural reinforcement to deal with the increased pressure. Although it has been asserted in EAS 2004 that the existing embankments are sound,

when river level is high (as on a 7.2m tide), there is evidence of seepage at the base of the outer face of the embankments. This has been seen both below Exceat Bridge (eg at 514979) and at locations above the bridge, in the form of pools of standing water adjacent to the embankments when there has been no recent rainfall and no overbank flow; the standing water can only have come from seepage through the embankment. Given that water is passing right through the embankments under present conditions, it is likely that the problem of water penetration would become worse as water levels rise.

7.3.8. Raising the embankments by 300mm entails widening them as well to conserve both the crest width and the gradient of the embankments. Where the embankment is currently 3 metres wide, a crest width of 1.5-1.7m can be maintained comfortably, but there are several places along the embankments south of Exceat Bridge where the existing crest width is less than 3 metres. In these places even the minimum crest width of 1.5m could not be achieved and the bank would have to be widened. This widening would destroy the pasture and a significant amount of shrub vegetation on the floodplain face of the embankments - along substantial stretches.

If, as we believe to be the case, the raising of the banks would need to continue up the valley to Milton Lock, there could be, for perhaps two years, a double scar running down the Cuckmere valley as much as 8 km long. The ramp down onto the floodplain is commonly 4m wide. With the bank raised 300mm, this would become 5m wide. If the decision was made to widen the entire length of flood embankments to maintain a crest width of 2.5m or 3m instead of the 1.5m envisaged by EAS, the area of visible new land surface in addition to the raised crest would be of the order of 80,000 m^2; because tilted from the horizontal it would be a conspicuous landscape feature, plainly visible from ground level on the valley floor and even more so from the valley sides. The bank widening would also occupy an additional 24,000 m^2 of the floodplain surface. These are significant landscape impacts.

7.3.9. A raised bank crest 3m wide with associated bank-widening was shown in the Powerpoint presentation by James Mumford of EAS in 2010, but it seems that this will not be realized. The formal proposal still envisages the narrower-than-existing crest described in the original EAS proposal of 2004. A width of 1.5m is mentioned as the minimum acceptable width in the 2004 report (p 3, 3.1). The bank crest is commonly 3m wide at present, and nowhere less than 2.2m. On each side of Exceat Bridge the bank crest is 4m wide. The tarmac footpath on the low causeway running along the side of the A259 is 1.5m wide, and it allows only single-file traffic. Walking along the causeway footpath gives a fair impression of what it would be like walking along the raised flood banks. Narrowing to this width would be a significant reduction in the amenity value of the embankments. It would also make them harder to maintain, as EAS acknowledge (2004, 3.2, 3.4 and 3.6); only small equipment would be manageable on a narrow bank-top.

7.3.10. EAS argue that the remade surface would 'provide all-weather pedestrian and disabled access' (2004, p. 5, 4.3). It is hard to see how an unguarded bank crest only 1.5m wide, next to a fast-flowing river, could be presented as wheelchair-friendly. The Countryside Agency guide requires

'inclusive access to the outdoors for disabled people'. The Countryside and Rights of Way Act (2000) requires 'consideration of the needs of disabled people when authorizing works on footpaths'.
7.3.11. As the sea level rises, the floodplain will be left at a progressively lower altitude in relation to the sea - and also to the water table in the chalk hills to east and west. This means that, although the floodplain might be defended from flooding by the river, it would become more and more frequently flooded by water leaking out of the chalk valley sides. There would be standing water on the floodplain far more frequently, waterlogging, a gradual degradation of grazing land and an increase in marsh vegetation. Springs could appear in the floodplain, in response to the water table rising underneath the valley floor.
7.3.12. This strategy involves a separation from a sustainable natural system that (because of sea level rise) will increase with time. It would be likely to lead eventually to the hydrological system reorganizing itself in a catastrophic (ie sudden and unpredictable) behavioural switch.
7.3.13. Although the engineering operation would be a single operation, it would be major, with significant visual impact while under way and afterwards and a high number of lorry movements; if these related to a proposed landfill operation, there would be a major outcry, and may not appeal to those who fundamentally want no change to the landscape.

7.4. Questions & uncertainties

7.4.1. Where would the material for raising banks come from?

8. OPTION G: TIDAL FLOOD BARRIER

8.1 Description

8.1.1. A tidal barrier would be installed near the mouth of the Cuckmere. Two alternative designs have been put forward, each providing a dual waterway. Providing two gates separated by a concrete pier would make routine maintenance work easier: one channel can be shut for maintenance, while the river continues to use the other. It is assumed that the current gap between the training walls is the required/ desired width of channel, but the gap could be wider: the EA would need to specify a width in line with the long term goals.

Initially John Foxley proposed locating the tidal barrier at the inner end of the training works; later he proposed moving it to a location 100m upstream. The position of the barrier is critical because, if placed 100m upstream from the inner end of the present training walls, it would necessitate raising the banks and sea defences downstream of the barrier to the altitude of the highest tide level [additional cost].

8.1.2. The first design offered by Mr Foxley is a tidal tilting gate, consisting of two bottom-hinged gates normally resting flat on the riverbed. The gates would be open most of the time, allowing water in on rising tides and out on

falling tides as at present. On very high tides threatening flooding, the barrier could be raised from the river bed, removing the flood danger. With predicted climate change and associated sea level rise, the number of occasions when the barrier would need to be closed to keep the sea out will increase.

8.1.3. The second design is a tidal V lock gate, a vertically-hinged gate system that is regularly used in dry docks and entry into marinas. A tidal V lock gate has been installed at Sovereign Harbour. The gates in both designs would be operated by electrically-powered hydraulic rams.

8.1.4. The principle is the same as for the Thames Barrier, the scale is much smaller. The purpose is to allow the entire floodplain floor behind the flood barrier to remain in its present state and continue to be used exactly as at present.

8.2 Benefits

8.2.1. No new technology is needed, other than the installation of the barrier itself. The rest of the lower valley can continue to be managed as at present.
8.2.2. There would be no change at all to the appearance of the landscape, apart from the installation itself, making this a very non-intrusive (probably the least intrusive) option. The top of the concrete structure could be flat and no higher than the crest of the shingle barriers on each side; the height would be designed according to the specified future sea level.
8.2.3. It would give a 20- or 50-year pause for thought and further planning – and allow us to see what happens in the way of climate and sea level change.
8.2.4. Everything north of the barrier could continue as now.
8.2.5. It retains all the existing rights of way.
8.2.6. It retains the novice canoeing facility (but see 8.3.10 below)
8.2.7. There would be no change to current usage of the landscape for agriculture or recreation, though the section of the Vanguard Way that descends onto the floodplain, already muddy in winter, would become even wetter.
8.2.8. It has a strong appeal to the natural conservatism of the community.
8.2.9. As an example of old-style hard-engineering sea defence, it appeals to many people.
8.2.10. The Environment Agency engineered a new set of gates for Polperro harbour in 2010 at a cost of £350,000. This is to be paid for by a levy on 80 residential and commercial properties defended by the gates.
8.2.11. It would not necessitate bank-raising in any reach of the valley.
8.2.12. The solid abutments on each side and the concrete pier in the middle could be used as (free) foundations for a footbridge, which would be a great asset in terms of access and improving footpath routes. A bridge close to the mouth of the Cuckmere would become a key element in the proposed Sussex Coast Path, as well as allowing a satisfying round walk to be accomplished

right round the Estuary. A bridge, whether part of this scheme or not, would undoubtedly be a major benefit to tourism.

8.3 Disbenefits

8.3.1. There would be a high and continuing running and maintenance cost after the initial installation. On the 100-year timescale it could prove to be prohibitively expensive.
8.3.2. As a permanent visual landscape feature in its own right, at a key location in the landscape, the barrier could (depending on its design) be an intrusive structure and prove aesthetically inappropriate. John Foxley's drawings show a fairly discreet, flat-topped structure, rising very little higher than the water level that it is designed to dam. It would probably disappear into the landscape when viewed from floodplain level. It would on the other hand be conspicuous when viewed obliquely from the valley sides, for example from the track down from South Hill Barn and from Haven Brow.
8.3.3. This is a type of project that is more appropriate to high land-value urban locations, places where there is a substantial amount of built property to protect, like Sovereign Harbour.
8.3.4. In storms, the sea could breach the shingle barrier (as we saw in 1999) and so by-pass the tidal gate. When the shingle barrier is breached the tide gate would be totally ineffective, and it would be during storm surges that the tide gate would be most needed.

The only alternative is to continue the impermeable concrete barrier all the way to the valley sides to east and west. The Polperro Harbour tidal gate (which is on a similar scale) occupies a narrow space between two massive impermeable harbour quays. The Cuckmere outfall is very different, with permeable and, in the case of the West Beach, fragile and vulnerable shingle barriers on each hand.
8.3.5. In a rising sea level scenario, this breaching and by-passing (and percolation) would be likely to happen more often. The only way it could be stopped is by building a solid dam right across the valley, which would be hugely expensive (a huge cost over and above the beguilingly low capital cost of the gates themselves). It is questionable whether the high financial and environmental costs could be justified.
8.3.6. It would require a power supply; currently there is no permanent electricity supply to the Coastguard Cottages or anywhere in the vicinity of the river outfall. John Foxley has proposed that a turbine could be incorporated into the design to generate tidal power; this, he argues, could be fed into the National Grid to fund the running of the gate (Foxley 2010). But very small quantities of power would be generated, probably insufficient to offset the cost of installation. This is not a project that we believe could ever be self-funding.
8.3.7. The selected site is an exposed and vulnerable location, close to the open sea. In storms, the tidal gate would be subjected to high-energy waves and pelted with shingle. The nearest comparable tide gate is Rye Harbour, where the location is well upstream, in a low-energy environment where there is no wave action, no danger of being machine-gunned with shingle.

John Foxley has responded to this point by proposing that the gate might be located a little further upstream from the training works, in a protected position round the bend in the river, 100m upstream from the inner end of the training works (Foxley 2010). This would entail building 'wings', further impermeable barriers leading from each side of the gate seaward to the training works – a significant additional disbenefit in visual terms and in terms of cost.

8.3.8. There are technical problems with the tilting gate or flap gate design. The submerged hinges would be more difficult to maintain. Shingle driven in from the seaward side would get underneath the gates and prevent them from lowering onto the riverbed properly; shingle could also foul the hinge mechanisms. The continual movement of shingle into and through the tidal gate is likely to cause considerable wear and tear and cause malfunction. The Rye Harbour gate, well back from the sea, is in a friendlier silt environment. John Foxley has responded to this point by proposing the alternative design, the V lock gate.

8.3.9. Whether the Environment Agency or other authorities favour gates depends to a great extent on an assesment of the value of the properties to be defended. The Agency put in flood gates and barriers at Rye, to defend some 600 houses on low ground. The Thames Barrier cost £534 million in 1984, equivalent to about £1.3 billion now; the capital cost was huge but, when in 1997 a vessel sank on the barrier and prevented it from closing, the flood damage that could have occurred as a result of barrier-incapacity was estimated at £13 billion. The very high investment on the Thames was to prevent flood damage that would have been an order of magnitude greater; it was cost-effective. Very few properties in the Cuckmere valley are going to benefit from this kind of flood protection, and no future property development is anticipated, so it is hard to see how it could ever be cost-effective.

8.3.10 The meanders would eventually be lost through silting. As the lake gets shallower and the flow of water in and out reduces, oxygen content will reduce and temperature will increase, causing fish deaths (see 5.3.4.)

8.4 Questions & uncertainties

8.4.1. Could this proposal perhaps be adapted and combined with one of the other schemes? The outfall location that has been proposed is evidently unsuitable (see points 2, 4, 5, 6, 7, and 8 above), but a location further upstream might work better.

8.4.2. An alternative possibility is to place the tidal gates much further upstream, at Exceat Bridge, associating them with a seawall supporting the A259, which would create the necessary impermeable cross-valley barrier. This could allow managed realignment to take place south of the A259 under rising sea level conditions, while protecting the valley upstream. The gates would then be in a more protected place, and accessible for maintenance and electricity supply. This option looks more viable as a bolt-on to options A, B, C, D, E or F than as a freestanding option in its own right. In fact it could be considered as part of the long-term plan to cater for a sea level rising from

+300mm to +600mm (50-100 years' time), ensuring that the valley floor north of the A259 remains free from overtopping, and save the intrusive raising of the river banks by perhaps 600mm all the way up to Milton Lock.

9. OPTION H: WEST BEACH REVETMENT

9.1 Cuckmere Haven: the dynamics of the shoreline processes

9.1.1. Full managed realignment in the lower Cuckmere valley would (over a 100 year period) result in an enlargement of the tidal prism that will almost double the river's discharge at the outfall on an ebbing spring tide. The channel geometry will change accordingly; the cross section area of the channel at the mouth will become over 50% larger, occupying as much as one-quarter of the width of the valley (Posford Haskoning 2003; Dangerfield et al 2005).

9.1.2. Some consultants' reports (eg Dangerfield et al 2005) assess that the West Beach is currently incorrectly graded (too steep) and that its crest should be 20m further landward to acquire the correct gradient and stability. The Dangerfield report goes so far as to describe the West Beach as 'unsustainable in its present position and prone to catastrophic failure', continuing 'it is logical that this is allowed to roll over landward to establish a new crest position approximately 20m inland of the present crest front' (p 31). Even with the sea remaining at its present level, both East and West Beaches at Cuckmere Haven would be likely to roll back in a northerly direction, in line with the retreating cliffs to east and west.

9.1.3. But the historic rate of roll back since the late nineteenth century is faster than expected; the coastline of Cuckmere Haven has retreated faster than Seaford Head or the Seven Sisters. These are the approximate retreat rates in metres/year, as measured from maps:

Period	*Coastguard Cottages*	*West Beach*	*East Beach*
1874-1908	0.7	0.7	1.5
1908-1920	1.2	6.7	2.0
1920-1938	0.8	1.1	2.7
1938-1955	0.3	1.1	1.1
1955-1997	0.2	0.0	-0.3 (building out)
Mean rate	0.57	**0.85**	**1.0**

The average rate of retreat of the chalk cliffs at Seaford Head and the Seven Sisters over that period was 0.5 metres a year (Castleden 1996). The beaches at Cuckmere Haven have been going back twice as fast. These rapid rates of retreat are considered by some to be due to the dramatic reduction in sediment supply from the west (Posford Haskoning 2003, p 26). These are starved beaches.

9.1.4. The East Beach is broader than the West Beach, containing a larger volume of beach sediment, and although it has a history of rolling back it does not have a known history of breaching. The East Beach may be regarded as stable and capable of self-management.

9.1.5. Long-term, the future of the West Beach will be to roll back to the north. On the other hand the present position and condition of the beach are not natural. This is a beach that has been starved by the insertion of two major breakwaters, the Western Breakwater at Newhaven and the Splash Point Groyne at Seaford, which have intercepted large quantities of shingle that naturally would have travelled eastwards by longshore drift. The beach has also become depleted by commercial extraction, which only ceased in the mid-twentieth century. No figures are available for the amount of shingle that was removed, but any programme to return the beach to nature should take account of these man-made depletions; indeed returning it to nature should involve a significant level of making-good by beach replenishment.

9.1.6. The regrading and the 20-metre landward shift of the beach's crest described by Dangerfield could be the first steps in a process by which the sea outflanks the eastern end of the seawall. A consequence of this would be that vehicles would no longer be able to pass between the Coastguard Cottages and the Cable House to reach the beach. This would create problems for the Environment Agency, making it difficult for them to get plant down to manage the West Beach and the outfall. Even in the context of the managed realignment schemes currently being discussed, some level of management of the beach and outfall would need to continue in the short term.

9.2 Rationale for the revetment proposal

9.2.1. It is clearly desirable to maintain access for machinery onto the West Beach from the South Hill Barn track. This would enable the Environment Agency to continue routine maintenance to the beach and the outfall if necessary, and respond to unforeseen emergencies like the collapse of the western training wall.

9.2.2. Cuckmere Haven is a focus for summer visitors, many of whom are not local and not aware of the dangers surrounding the Cuckmere outfall, where conditions can change significantly according to the weather and the state of the tide. It is essential that emergency service vehicles can reach the West Beach quickly in the event of a bathing or boating accident. The chalk hillside route via the South Hill track is the one all-weather, all-states-of-the-tide, all-known-options access to the beach. Health and safety considerations demand that it is maintained to ensure that emergency services such as Police, Ambulance and Coastguards have fast and efficient vehicle access down onto the storm beach under all conditions. It should be regarded as a key element in the infrastructure for which ESCC is ultimately responsible.

9.2.3. The Cuckmere is a Main River under the terms of the Environment Act of 1995. This Act states that the Environment Agency has a duty 'to secure an adequate outfall for a main river'. This means that the Agency has a legal obligation to maintain the outfall of the Cuckmere. In any of the hold-the-line options under consideration, the Agency will need to continue clearing shingle from the river mouth as at present, and access to the beach will be necessary in order to do this.

9.2.4. In the managed realignment scenarios, there is an expectation that the enlargement of the Cuckmere's tidal prism will substantially increase the volume of water flowing out on the ebb tide (see above, 1.1), and that this increased discharge will keep the mouth of the river clear. But the efficacy of this self-cleansing is not known and will not be known until the managed realignment has taken place, and it may be that occasional human interference will be seen as desirable to adjust the channel's changing profile. In any case in the short term the mouth will continue to require clearing as at present. Under managed realignment, it may be that the outfall will become self-cleansing but not remain in its near-central position in the haven. It could remain open while gradually shifting towards the east under the influence of longshore drift. If for any reason it is seen as desirable to keep the outfall central, rather than allowing it to move towards Haven Brow, again the Agency would require access to the West Beach for its plant.

9.3 Proposal for a West Beach rock revetment

9.3.1. The proposal is to construct a rock revetment to support the West Beach. The revetment would be about 150 metres long, if straight, running from the eastern end of the private seawall east-northeast to the western training wall, 200 metres long if curved. A problem with the short revetment already under consideration by the EA, running northwards from the eastern end of the seawall towards the tank trap, is that it would create a vulnerable corner where it leads away from the seawall. Corners like this concentrate wave energy as waves are refracted round them; as a result of this concentration of energy erosion is accelerated. A virtue of the new design is that it continues the line of the seawall, or bends seawards rather than landwards; this would have the effect of stretching the waves rather than compressing them, and so slightly reducing wave energy. The structure would have the character of a freestanding rock groyne, mainly buried within the beach, providing it with a spine. Beach sediment would accumulate on its seaward face.

9.4 Benefits

9.4.1. It would stop the sea from encroaching northwards, outflanking the seawall and truncating the vehicle access to the West Beach from South Hill. It would preserve the current vehicle access from the west onto the beach both for the Environment Agency's plant and for emergency services.

9.4.2. It would fix the crest of the storm beach, give it spinal strength and prevent (or substantially delay) its migration northwards. This would create a stable shingle surface both on and behind it on which a vegetated shingle environment could become established. The scheme would therefore contribute to biodiversity.
9.4.3. It would allow the extraction of a large volume of shingle behind the revetment that is at present piled high against the western training wall and is believed to be putting a great deal of pressure on it. Removing this shingle would relieve the training wall of a considerable tonnage of shingle and extend its working life.
9.4.4. The excavated shingle could be spread across the shore platform to the southwest, in front of the seawall and in front of the seaward face of the West Beach, to allow the waves to create a gentler seaward-facing slope to the beach.
9.4.5. It would prevent the tank trap from being engulfed in beach sediment and lost to view.
9.4.6. It would prevent a major storm-breach like the one that occurred in October 1999 from happening again. Under all three of the managed realignment options that are being considered, the western area of the floodplain, Chyngton Brooks, is to be subjected to controlled tidal inundation so that a saltmarsh environment will be re-created. During the early stages of this transition, the saltmarsh plants need to be protected from major wave action; it is only when a fully developed mat of saltmarsh vegetation is established that it has any resistance to wave action. So, in the short term, during the transition, it is vital that Chyngton Brooks be defended against a storm breach in the West Beach.
9.4.7. It would be relatively unobtrusive in terms of landscape aesthetics, once the beach shingle and pebbles have been pushed back in place against and among the revetment boulders. The revetment would not adversely affect the recreational use of the West Beach.
9.4.8. It would not compromise the eventual managed realignment of the river mouth, as this would in any case be likely to evolve to the east of the rock revetment, whether the western and eastern training groynes are left in place, removed, or allowed to disintegrate. The existence of the rock revetment would in fact help to stabilize the position of the outfall, which, on historic map evidence, has undergone frequent changes over the past 400 years but only within the eastern two-thirds of the haven.
9.4.9. The option is reversible. The boulders can be removed once they are no longer needed.

9.5 Disbenefits

9.5.1. Access for tourists down onto the lower beach across the revetment could be a problem if the boulders are exposed after storms. On the other hand, if beach shingle is sloped up against the seaward face of the revetment, movement up and down the beach may be easier than at present.

9.5.2. The feature is alien to the nature of the landscape, so much will depend on how much of the revetment can be buried within the beach.

9.4. A bolt-on proposal

The emplacement of a rock revetment in the West Beach would remove several areas of uncertainty and jeopardy. Importantly, it entails no commitment to any particular option for the Cuckmere Estuary as a whole and does not pre-empt the discussion about options, as it can be combined with any of them equally. A decision about the proposal can therefore be made independently of the discussion of the main options. Given that the western training wall is in danger of imminent collapse, the proposal should be given urgent consideration.

10. ISSUES RELATING TO SEA LEVEL

10.1 The starting-point for these discussions about the future of the Cuckmere Estuary, was the assertion that its management could not continue as at present if sea level is set to rise. How much is really known about sea level dynamics?

10.2. Sea level change in the twentieth century

Records from tide gauges supply the data on twentieth century sea level changes. They form the basis of the figure often quoted for general global sea level rise, an average rate of 1.7 or 1.8mm/ year through the twentieth century, though that is not agreed; some researchers quote lower figures.

Assessment of future sea level rise must be rooted in past trends, so uncertainties about what happened in the twentieth century give cause for concern (IPCC 2010). Predictions can only have limited reliability, when the facts (and the physical mechanisms) relating to past sea level are incompletely understood.

10.3. Sea level change in the future

The Environment Agency works to Defra's guidelines in designing projects that will accommodate 6mm/ year of sea level rise during the next 50 years (MAFF 1999). But what is the evidence for the predicted sea level rise?

The evidence for current sea level rise is based mainly on tide gauges. A new source of data, satellite altimetry, shows a different (faster) rate of sea level rise.

A common perception is that the rate of sea level rise should have accelerated in the second half of the twentieth century, in line with accelerated increase in CO_2 concentration in the atmosphere. CO_2 concentration increased as follows:

1800 - 1850 + 3% on the 1800 value
1850 - 1900 + 2% on the 1850 value

1900 - 1950 + 6% on the 1900 value
1950 - 2000 + **18%** on the 1950 value

The marked increase in CO_2 concentration in the second half of the twentieth century might be expected to be reflected in a marked acceleration in the rate of sea level rise. But the tide gauge data instead show a fairly constant overall rate of rise.

Initially there were high hopes for satellite altimetry as a way of measuring sea level everywhere in the world, but the level of accuracy is not fine enough to measure the small year-by-year changes. Sea level is changing by only a few mm/year, so GPS measurement must be accurate to less than 1mm/year, which up to now has not been achieved.

Other problems with sea level measurements include the possibility that the piers to which the gauges are attached are sinking, and some of the historic sea level rise that has been measured is really a measurement of the subsidence of harbour structures.

Satellite altimetry shows a faster rate of sea level rise for 1993-2003 than the tide gauges. The could be explained in a number of ways; a recent acceleration in sea level rise, or genuine real-world differences between satellite and tide gauge data, or problems in satellite data calibration. Satellites suffer gradual orbit decay and it could be that they are measuring their own decreasing altitude rather than a rise in the surface of the ocean. This is new technology and it would be unwise to place too much confidence in the measurements it yields, at least until the problem of calibration is addressed (Leuliette 2004).

Regional variations in sea level have been known about for some time, but it is emerging that they are increasing (IPCC 2010). This means that attempts such as Defra's to apply global rates of change to specific locations will become increasingly unrealistic. Another point emerging is the lack of any physical basis for the recent high estimates for future sea level rise (IPCC 2010).

It is widely assumed that an element in sea level rise in south-east England is the tectonic subsidence of the region, but this subsidence does not seem to be consistent or universal. Some places are subsiding, others are not. It is important that we establish if we can whether Cuckmere Haven and the lower Cuckmere valley are areas of tectonic subsidence or tectonic upwarping; upwarping could mitigate and perhaps cancel out the effects of global sea level rise.

London and the Thames estuary show significant local variation in rates of subsidence. The fastest rates are along the banks of the estuary (where the land is sinking at 1.25-2.5mm/year). The rates are less on each side, in Kent and Essex. There is a very slight uplift of London itself, up to 0.5mm/year.

The tidal gauging station at Newhaven shows the sea **falling** around 50mm between 2000 and 2009 (Permanent Service for Mean Sea Level).

10.4 Implications

Those working on the design of the Cuckmere Estuary project with an eye on planning consent or funding will need to accept as a specification a

projected sea level in line with Defra guidelines, a rise of 300mm over 50 years. But those working pragmatically, on the evidence of local processes, will note that the Newhaven gauge shows that during the first decade of the twenty-first century sea level has not risen, and infer that that may be either a temporary blip or a local trend that could continue.

This has implications for the options we are considering.

a) If the sea is not rising in relation to the land, perhaps because of local tectonic uplift, there is no practical reason why the estuary cannot continue to be maintained as it is. If the sea is not rising, it is not necessary to do anything new; continuing maintenance as at present (or as it ought to be at present) becomes a real option in practical terms, if not in terms of planning, strategy or funding.

b) The uncertainties may support an argument for waiting to see whether the level of the sea, as measured at Newhaven, really does begin to rise again.

c) If there is a temporary remission in sea level rise (the sea remaining at its present level for, say, 20 years before rising), then Option F looks like better value in comparison with Option E. If that remission were to last for 30 years, better value still.

The situation is to an extent simplified by the non-negotiability of the official sea level guidelines. We will ultimately have to support options that qualify for planning consent and funding, or the authorities will not listen to what we have to say. Even so, exploring alternative scenarios for future sea level may help us to understand what is going on when something unexpected happens in the Cuckmere estuary – such as sea level not rising after all. We need above all to appreciate the complexity of the situation in which we find ourselves.

11. WHY HOLD THE LINE?

11.1. Bonding with places

Options D, E, F and G have a common aim: to keep the landscape substantially in its present state. Why should this be seen as desirable?

People develop strong feelings about places that are important to them. The concept of home is universal, whether applied to the house one lives in, the street, the town, the region or the country. People also develop affinities with special places that they adopt, places they regularly return to for holidays, which are sometimes places associated with a happier time in their lives, especially with their childhood. For many of us this kind of geographical bonding is important and deep-seated. The special place has to remain unchanged in order that we can recapture the pieces of the past that we want to relive or remember. The act of revisiting the place where we grew up can revive pleasant memories of parents, relatives and friends who are perhaps no longer living, and it allows for a kind of reunion with as well as commemoration of that personal past.

Changing the special place can therefore upset, disturb and disorientate the people for whom it is special.

11.2. Englishness, rurality and 'unchange'

For a century or more, the English have seen themselves as fundamentally rural. It may be a largely mistaken perception, but the perception is there. If we change the Cuckmere valley, especially if we change it unsympathetically, we may find that we are treading on toes, not just locally but in towns and cities far afield.

The United Kingdom underwent a social transformation in the nineteenth and twentieth centuries. The population increased from 17 million in 1851 to 60 million in 2001. Now, many more are living in towns and cities. The proportion increased from 50% in 1851 to 89% in 2001. The urban population grew enormously, from 8.5 million to 53 million (Anon 1999). Many towns have had large areas rebuilt to accommodate expanding populations and changing commercial and social needs. In some towns and cities swathes of cityscape have been comprehensively redeveloped to a point where people have difficulty in recognizing once-familiar neighbourhoods.

In the nineteenth century, a nostalgia for rural roots was already developing. Now the nostalgia is more acute than ever. People turn to the countryside for continuity, stability and solace. It is important to show sensitivity in managing the countryside, so that whenever possible it can satisfy this deep-seated need for 'unchange'.

11.3 Archaeology and history

Some elements of the floodplain landscape have an historical and archaeological value that is hard to evaluate. Do they merit preservation and conservation or not? Two reports commissioned by the National Trust explore the archaeological and historic significance of the western half of the floodplain, the Chyngton Brooks (Bannister 1999 and James 2004). The remains are of three broad periods: medieval and post-medieval, nineteenth century, Second World War.

The medieval and post-medieval remains are of innings, land claimed from the tidal estuary for agriculture or grazing. This was an important historical episode in the Cuckmere valley, and what can be seen, in one panoramic sweep, is a largely unaltered example of medieval land reclamation: it has a visual integrity that has been lost in other valleys because of later developments.

The geomorphological evidence suggests that the inning in Chyngton Brooks took place in three phases, and it is desirable to establish the dates of inning of the three areas before the landscape is altered as part of the Cuckmere Estuary Project. Test pits dug into the banks might yield phase dates and palaeoenvironmental evidence.

The site is unique in South-East England in that later activity has been small-scale and left the ditches and banks more or less intact, though degraded by weathering and animal trampling. The estuarine deposits may contain remains associated with the two small medieval ports of Chyngton and Exceat. The geo-archaeological survey may tell us more.

The innings, especially the Chyngton Brooks, are of high local significance, but the National Trust's surveyors did not see the area as being of more than moderate significance in the region.

Nineteenth century remains include the fragmentary footings of a Napoleonic barracks, the intact and picturesque coastguard watch-houses, livestock drinking ponds, the cut of 1846 and its associated embankments.

Second World War remains reflect the site's vulnerability as a target landing-place in Operation Sealion in 1940-41. There are pill-boxes (mostly on the lower valley sides), anti-tank defences (a concrete wall, blocks and a ditch), a telegraph cable station and at least one concrete base for the decoy lighting system that was intended to deceive German pilots into believing that this was the port of Newhaven. A case could be made for regarding this vestigial wartime landscape as being of high local and regional historical importance and potentially of very high educational importance. It has been suggested that the defensive system should be considered of national importance and that it should be interpreted accordingly for visitors.

11.4 Biodiversity

One major argument advanced against hold-the-line options and in favour of managed realignment is that the estuary would be ecologically richer if turned back into a tidal saltmarsh. The present grassland environment of much of the estuary landscape looks rather empty. Is it really ecologically impoverished?

When Thomson Ecology undertook a habitat survey in 2004, 25 bird species were seen (Thomson Ecology 2004, p 13). The SDCB survey, 1998-2003, recorded 59 species (Babtie, Brown & Root 2005).

The vegetation cover too is richer than at first appears, though large areas are admittedly species-poor. The Cuckmere's meanders have no obvious aquatic or marginal vegetation and are 'of no botanical interest' (Thomson Ecology 2004, pp 11, 17). The grassland, which covers a large area of the Estuary, is species-poor.

The survey notes that the quality of the semi-improved grassland that covers most of the estuary landscape falls below what would normally be expected within an SSSI (Thomson 2004, p 15, 3.4.4).

A good indication of the changes that managed realignment might bring is the vegetation that has colonized the mudflats within the Cuckmere's present channel. This saltmarsh area is dominated by sea purslane with occasional glassworts on bare mud areas as well as sea-spurrey. On the higher areas flanking the embankments there are sea wormwood and rock samphire. On the eastern side of the flood bank is a saltmarsh area that is floristically distinct. This has a continuous carpet of glasswort. In places a grass sward has developed, comprising sea couch and red fescue with some sea aster.

One area of grassland merits protection, the chalk grassland growing on the steep foot slopes of the eastern valley side, from Foxhole northwards to the visitor centre. Because of its topographic location, on the valley side above high water mark, this need not be adversely affected by any of the

options under consideration, whether managed realignment or hold-the-line. This unimproved calcareous grassland is of high botanical interest, supporting a number of Nationally Scarce species. It is a foraging area for badgers and bats. It also offers interesting exposures of slopewash representing ploughsoil eroded further up the slope by ploughing during the bronze age (Bell 2010); the steep slope itself is a late iron age sea-cliff. The educational value of this valley-side area is considerable, but its preservation does not depend on holding the line.

The vegetated shingle barrier has been colonized by sea kale and yellow-horned poppy; there are occasional sea mayweed, creeping thistle, scarlet pimpernel. Further from the sea and away from its influence are increasing amounts of cover, from sheep's fescue, buck's horn plantain, English stonecrop, common nettle and teasel. This is considered by Thomson to be a good example of a restricted habitat, and should be conserved.

One argument repeatedly advanced for changing the landscape under a managed realignment scheme is that doing so will enhance biodiversity. Will a realigned landscape really be more diverse than the present landscape? It may well be so, but it would be useful if the scale of that improvement could be demonstrated and quantified in some way. Has any attempt been made to calculate the biomass of the future saltmarsh ecosystem and compare it with the biomass of the present landscape? Has any comparison been made between the numbers of plant, bird and reptile species in the two systems?

11.5 Conserving the meanders

A major underpinning argument for hold-the-line is the preservation of the canoe lake, partly as a striking visual element in the landscape, partly for its recreational value. But the canoe lake is filling with silt, and will eventually, if left, become a marshy depression. Canoeing as an activity will disappear under all three hold-the-line options because of the ecological deterioration of the lake; it is already unsafe to swim in the lake because of the algae. The only way canoeing can continue is for the lake to be dredged and for periodic flow to and from the river to be introduced.

11.6 Conservation

Finally, it should be borne in mind in any scheme to alter the landscape that the Cuckmere estuary has been identified several times over as a locality deserving of conservation and protection. The area falls, either wholly or in part, within the following formally designated areas:

1) Seaford to Beachy Head Site of Special Scientific Interest (SSSI)
2) Seven Sisters Country Park
3) National Trust (Chyngton Farm)
4) Local Nature Reserve (LNR)
5) Environmentally Sensitive Area (ESA)
6) Voluntary Marine Conservation Area (VMCA)
7) Cuckmere Haven Regionally Important Geological/Geomorphological Site (RIGS)

8) Sussex Heritage Coast (HC)
9) Sussex Downs Area of Outstanding Natural Beauty (AONB)
10) South Downs National Park (NP)

With this level of investment in protection, or attempted protection, we should think very seriously before instigating changes to the landscape.

12. WHY MANAGED REALIGNMENT?

12.1. The Environment Agency works to Defra's policy guidance. Defra expects the EA to withdraw maintenance where there is insufficient economic justification for continuing to maintain sea defences. There is no legal right to sea defence (EA's *Information for owners and occupiers of land adjacent to sea defences in England)*. Managed realignment is in part a response to the ever-increasing cost of providing hard river-flood defences and coastal defences. For many years it has been UK government policy to assess proposals for hard defences by cost-benefit analysis: the property being defended must be worth at least as much as the cost of the proposed defences. Budget constraints have led to prioritization; coastal towns like Brighton and Eastbourne are such valuable assets that almost any investment in hard coastal defences will be considered worthwhile. Conversely, coastal areas with few houses or commercial premises will inevitably be seen as failing to qualify for coastal defences. Cuckmere Haven has naturally been identified as such a coastline.

12.2. Schemes for coastal defence also have to be technically workable and sustainable. In a context of rising sea level, schemes have to demonstrate that they are going to continue to work effectively for up to 100 years.

12.3. Realignment strategy may entail converting a coastal landscape into a buffer zone that will absorb the impact of coastal processes. Established coastal saltmarshes are effective in absorbing wave energy, which spreads across a large area instead of being concentrated onto a seawall. Creating new saltmarshes in these buffer zones helps to mitigate the loss of intertidal habitat. In the past, land reclamation (as in Chyngton Brooks) was a major factor in the loss of saltmarsh; today, most saltmarsh losses are due to erosion.

12.4. Saltmarsh is a favoured habitat under the EU Habitats Directive. It provides habitat for a number of species protected by the EU Birds Directive. It has become a legal requirement that net losses in the area of saltmarsh in existence in 1992 will be prevented, so losses in marsh since then must be compensated by replacement habitat. In the UK, there is a need to create 1.4 sq km of saltmarsh every year to meet this requirement, though so far only 6 sq km have been created by managed realignment schemes. Turning the lower Cuckmere valley into saltmarsh would add 1 sq km. It is claimed that the variety of intertidal habitats that could be generated under managed realignment in the Cuckmere estuary would greatly add to the area's biodiversity.

12.5. If in the long term sea level continues to rise, hold-the-line options will prove unsustainable. The artificial embankments along the river cannot be raised again and again, without becoming extremely massive and expensive. Nor can the beach be kept in its present location indefinitely. At some point the beach will be breached and the river banks will be overtopped. There would then be a catastrophic switch in landscape processes, a sudden 'unmanaged' realignment. If landscape change is going to happen, the outcome would be more predictable (and safer) if managed and controlled.

12.6. Sea level rise will induce water table rise. If hard engineering is introduced to reinforce the beach and river banks, flooding by the incusrison of the sea might be prevented and overbank flow by the river might be prevented. But a *rising water table* means that the floor of the Cuckmere will become increasingly waterlogged as a result of water seeping out of the chalk valley sides or even from springs in the floodplain itself; nothing could be done to prevent this. The floodplain will become increasingly marshy and a fen vegetation cover will develop, with pools of standing water. In the longer term, none of the hold-the-line schemes can prevent the floodplain from being flooded.

12.7. There will be many who will see the short-termism of hold-the-line options as a kind of cop-out, based on an impractical desire to keep an older generation comfortable with a familiar landscape, but without regard for the longer-term consequences. This may or may not be a fair or accurate perspective on the conservative view, but it would need to be overcome if any of the hold-the-line options were to be selected.

12.8. Although hold-the-line options may attract support from people who want to keep the landscape as it is, holding the line in fact entails some considerable changes to the landscape. If there is a significant local population preferring to see **no change** to the Cuckmere estuary, the Forum will need to be clear that this is not really an option at all.

13. CONCLUDING NOTE ON TOURISM

13.1. Tourism is unlikely to be affected adversely by any of the options, so long as care is taken to provide appropriate footpath access down to the beach; that access is crucial. Other sites suggest that managed realignment might attract very substantial increases in visitor numbers (Fenn and Ash 2005, 6). Without visitor survey results, it is not possible to say more. Although personal views vary, there is a general feeling that the overall attractiveness of the Estuary to visitors should not be allowed to be reduced (as measured by visitor numbers) by any action that might be taken.

13.2. Car park provision. One option involves the loss of the canoe barn car park to saltmarsh. This would need to be replaced. Two possibilities are suggested; a northward extension of the woodland car park at the visitor

centre, and a southward extension of the valley-side car park (suitably screened with trees) at the Golden Galleon. The latter would be on the right (south) side of the A259; pedestrians would not have to cross the road. If the river mouth migrates eastwards, more visitors would target the West Beach as their destination, and the Golden Galleon car park would be the right starting-point for a walk along the Vanguard Way to the West Beach.

Provision of alternative or additional parking will have to be considered in relation to other options as well, if visitor numbers increase. Indications are that managed realignment would be likely to lead to an increase in visitor numbers, and many visitors arrive by car. Expanding or even publicizing the South Hill car park would be detrimental to the adjacent residential area of south-east Seaford, where the road system is not designed to cater for this type of traffic.

13.3. Survey results. A visitor survey is needed in order to prioritize valued visual and other assets. At the time this report was drafted, no results had been passed to the Working Group from the Visitor Survey, Archaeological Survey, Landscape Survey or Economic Survey. Views might change once those results are made known. All three managed realignment options entail changing the landscape. There is a need for an assessment of the likely impact on known and unknown archaeological resource under each option. The more that can be recorded and conserved of the estuary's heritage the better. The Oxford Archaeological Unit's survey should supply much of the evidence needed to supplement what is already known. Existing or planned landscape character assessments should be used to identify the key landscape components and then the impact of any proposed change should be assessed.

To an extent guesses are being made about public responses and values. We may expect, though, that the familiar is what people will prefer, and that there will be some hostility to a landscape that looks very different. On the other hand, the experience at Freiston in Lincolnshire shows that a managed realignment scheme can attract enormous positive interest as measured by visitor numbers (Fenn and Ash 2005). There is also the possibility that, while some people may be nervous about the prospect of the landscape changing, and be unsettled by the process of change, they will be pleasantly surprised, and like the new landscape once it has been established.

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