Department for Environment, Food and Rural Affairs

Revision of the Bathing Water Directive:
Evaluation of the Draft WHO Beach Classification Methodology

Final Report

April 2002

Client: Department for Environment, Food and Rural Affairs

Project: Revision of the Bathing Water Directive:
Evaluation of the Draft WHO Beach Classification Methodology

Project No.: CC15

Status: Final Report

Date of Issue: 30th April 2002

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EXECUTIVE SUMMARY

This report was commissioned by the UK Department for Environment, Food and Rural Affairs (DEFRA) to evaluate the suitability of the draft World Health Organisation (WHO) approach to bathing water classification for regulatory application. Regulatory application may include for example the revision to the EC Bathing Water Directive.

Draft WHO Methodology

The WHO methodology comprises three main elements: categorisation on the basis of microbiological water quality (Classes A to D); sanitary inspection categorisation (using faecal contamination risk assessment) to determine risks ranging from very low to very high; and, incorporation of beach management actions. The main classification matrix uses the microbiological assessment and sanitary inspection category to arrive at a beach classification from very good to very poor, as shown in the table below:

Classification Matrix for Recreational Water Environments (WHO Table 4.8)

		Microbiological Assessment Category (Indicator Counts)			
		A <40	B 40-200	C 201-500	D >500
Sanitary Inspection Category	Very low	Very good	Very good	Follow up	Follow up
	Low	Very good	Good	Fair	Follow up
	Moderate	Follow up	Good	Fair	Poor
	High	Follow up	Follow up	Poor	Very Poor
	Very high	Follow up	Follow up	Poor	Very Poor

Note: Classes A to D are expressed as faecal streptococci (no./100ml) at 95%.

The classification matrix is informed by detailed guidelines in the WHO methodology report, together with matrices to help determine the relative risk potential for direct and indirect sources of faecal contamination.

The present study has sought to test the draft WHO methodology using data from the 471 bathing waters in England and Wales. The microbiological assessment category for each bathing water was calculated by the

Environment Agency using actual bathing water quality data from 2000. The sanitary inspection category was determined through a desk study and regional meetings with bathing water managers. All known potential sources of point and diffuse faecal contamination were identified for each of the bathing waters.

Determination of a final sanitary inspection category was often difficult to achieve, principally because of the problems associated with suitable categorisation of combine sewer overflows (CSO). In England and Wales many of the point source wastewater discharges have been or will be upgraded to high levels of treatment (secondary and/or disinfection) by 2005. They therefore represent a relatively reduced risk to bathing water quality. There are also many coastal, estuarine and lower riverine CSOs which are designed to meet the existing CSO policy that specifies an average of three or fewer spills per bathing season. Therefore these CSOs could be considered to represent a relatively low risk to human health. Nevertheless the CSOs could potentially affect bathing water quality and represent a risk to human health, and according to the WHO methodology a risk rating of high or very high would apply to these CSOs. The assessment was therefore carried out twice, using either the "high" or "low" CSO risk scenario to arrive at the overall bathing water classification.

Results of the Analysis

The results of the analysis are shown in the table below, using the "low" risk CSO scenario to illustrate the trends. All 471 bathing waters are included in the classification. Of those with a final classification, a total of 110 bathing waters are shown as very good or good, with 23 fair and the remaining 78 as poor or very poor. A total of 171 bathing waters could not be ascribed a classification as the microbiological assessment category and the sanitary inspection category did not accord, requiring an interim classification as "follow up". If used for regulatory purposes it is not likely to be acceptable to leave bathing waters in a "follow up" category, which highlights one of the potential problems with adoption of the methodology. The primary reason for discrepancy between SIC and microbiological category is the potential for variable interpretation of the SIC guidelines, leading to potential difficulties in ascribing risks consistently.

WHO Bathing Water Classification for England and Wales (assuming CSOs are "low" risk)

		Microbiological Assessment Category			
		A	**B**	**C**	**D**
Sanitary Inspection Category	**Very low**	21	23	5	2
	Low	12	53	19	7
	Moderate	5	11	4	2
	High	10	56	40	27
	Very high	9	77	51	37

56	very good
64	good
157	follow up
23	fair
93	poor
64	very poor
14	follow up

If the "high" risk CSO scenario is adopted, there is a small shift in classification to a lower status, with a fall in very good/good bathing waters from 25 to 15%, more poor/very poor waters, up from 33 to 38% and more "follow up" waters, up from 33% to 43%.

The main difficulty during the risk assessment process was achieving consistent "sanitary inspection" categorisation of the bathing waters. There were often discrepancies between bathing water managers in relation to the same bathing water, and between bathing waters that had similar characteristics. There were also problems with different regional interpretations of the guidelines.

In summary, the proportion of bathing waters in very good and good classes is between 15 and 25% (with an additional 33 to 43% of bathing waters in "follow up", but likely to be at least good), and 38 to 39% fair to very poor (and a further 3% likely to remain poor). The main driver for classification into the bathing water quality categories (very good to very poor) is the microbiological water quality (Class A to D). The classification system is relatively insensitive to the SIC rating. For example, improvement from fair to good classification (likely to be a major driver) can only made by moving from Category C to B microbiological assessment category, with the SIC having no influence.

Evaluation of the Draft WHO Methodology for Regulatory Application

It is recognised that the basic premise of the WHO methodology, to incorporate microbiological water quality, risk assessment and beach management actions, is based on an agreed set of robust elements. The WHO methodology advances the framework and guidance on implementation of such an approach, but should be regarded as a voluntary code rather than as a regulatory tool.

The difficulty in applying the methodology for regulatory purposes is that the risk assessment protocol (sanitary inspection categorisation) is given undue weight, recognising that there is an inherent probability of inconsistent application and therefore the potential for mis-classification. It is likely that

the prescriptive risk categorisation process would not be implemented evenly across the EU and would lead to variable bathing water classification. In addition, many of the hazards and pathways of pollution are site-specific and may not be covered by the methodology, leading to increased numbers of follow up cases with the potential for extensive and unnecessary investigative work. It is suggested that the sanitary inspection categorisation process (risk assessment) should be used to support the definition of beach management actions rather than be used as a primary compliance assessment tool.

A further issue is the integration of diffuse pollution effects into the risk assessment process. Although mentioned in the draft WHO methodology, no account is taken of non-wastewater derived diffuse pollution in the bathing water classification. It is generally recognised that agricultural livestock activities can adversely affect bathing water quality during and after rainfall events through transmission of faecal indicators to the bathing water site, as has been demonstrated for a number of bathing waters in the UK. Also, increased loads of faecal indicators can and do cause breaches of bathing water microbiological thresholds. For these two reasons there must be recognition of this potential source of faecal contamination in the decision-making process.

This study has not commented on the microbiological thresholds in relation to either potential health effects or their use in a potential compliance regime. The appropriateness of the various microbiological thresholds is being reviewed by others.

Discounting

Discounting is central to the draft WHO methodology, with the potential for reducing the risk category of known faecal sources (and potentially for waiving water quality samples) taken during known and predictable pollution events. No guidance is yet available from the EC on the suitability of such an approach for EU application. This has led to some difficulties in application of the methodology. However, it is likely that some form of discounting could be accommodated, which would reduce the risks of human exposure to faecal pollution incidents and limit the need for wide-scale and costly infrastructure and diffuse pollution controls.

Conclusions and Recommendations

- The draft WHO methodology is a good synthesis of existing knowledge on bathing water risk assessment.
- Application of the methodology has presented difficulties in consistently determining risk ratings for the variety of circumstances encountered.
- A relatively large proportion of the bathing waters were classified as "follow up" despite relatively detailed local knowledge.
- The draft WHO methodology was not designed for and is not currently presented in a form that could be used consistently and robustly for regulatory application.
- The risk assessment process should be used to develop suitable beach management actions and not be seen as a primary compliance assessment tool.
- The application and ramifications of discounting should be further explored.
- The processes in the WHO report should be further developed to provide useful guidance to bathing water managers.

1 INTRODUCTION

This report was commissioned by the UK Department for Environment, Food and Rural Affairs (DEFRA) to evaluate the suitability of the draft World Health Organisation (WHO) approach to bathing water classification for regulatory application. Regulatory application may include for example the revision to the EC Bathing Water Directive (BWD). The WHO methodology is contained in the document "***Bathing Water Quality and Human Health"*** (Ref: WHO/SDE/WSH/01.2) and is discussed further in Section 2 of this report.

The analysis uses data generated for bathing waters in England and Wales. However, the report does not discuss the relevance of the WHO's proposed microbiological standards and is therefore not commenting on the status of beaches in England and Wales, nor the potential health-related risks associated with bathing. The results given are intended only to be illustrative of the potential outcomes from applying such a methodology. Furthermore, the wastewater infrastructure and agricultural practices identified and the mitigation measures specified are typical of UK application. There may be differences in engineering and farming practices between the UK and other countries, for example the use of different systems of storm-water management, that have not been incorporated into the assessment process. Care should therefore be taken if using the assumptions made in this report for wider international implementation.

The report follows completion of Phases 1 and 2 of the DEFRA project to cost the revision of the EC Bating Water Directive. A companion report, ***Summary of Phases 1 and 2*** (Cascade Consulting 2002) details the findings of the wider study to date.

This report has seven Sections and one appendix:

Section 1 Introduction
Section 2 Draft WHO Methodology
Section 3 Study Methodology
Section 4 Study Findings

Section 5 Evaluation of the Draft WHO Methodology for Regulatory Application
Section 6 Conclusions and Recommendations
Section 7 References

Appendix 1 Modifications to the Draft WHO Bathing Water Classification Matrices

Appendix 2 Specimen Sheet from Bathing Water Database

2 DRAFT WHO METHODOLOGY

2.1 Introduction

The draft WHO methodology is contained in the document "***Bathing Water Quality and Human Health***" (Ref: WHO/SDE/WSH/01.2), circulated during the European Commission "Green Week", April 2001. The approach attempts to incorporate all of the elements of the beach management protocol discussed at Annapolis in 1998 and developed through the EC bathing water protocol trials in 2000. The main elements of the approach are:

- microbiological water quality analysis
- faecal contamination risk assessment (sanitary inspection categorisation)
- beach management actions.

2.2 WHO Classification Matrices

The draft WHO methodology uses the microbiological water quality results (class A to class D) and the Sanitary Inspection Category (SIC - risk rating from very high to very low) to arrive at a beach classification (see Table 2.1). If used in its present form for EC BWD purposes the methodology would have to be fit for stringent regulatory application. This study has sought to identify whether the system is appropriate for use in such a regulatory regime.

Table 2.1 Outline Contents of the Classification Matrix for Recreational Water Environments (WHO Table 4.8).

		Microbiological Assessment Category (Indicator Counts)			
		A **<40**	**B** **40-200**	**C** **201-500**	**D** **>500**
Sanitary Inspection Category	**very low**	Very good	Very good	Follow up	Follow up
	low	Very good	Good	Fair	Follow up
	moderate	Follow up	Good	Fair	Poor
	high	Follow up	Follow up	Poor	Very Poor
	very high	Follow up	Follow up	Poor	Very Poor

Note: Classes A to D are expressed as faecal streptococci (no./100ml) at 95%.

The assessment of the draft WHO methodology has required application of the guidance contained in the WHO document. The microbiological classification has been determined for each bathing water by the Environment Agency using log normal statistical calculations to arrive at the 95% value, using data from 2000.

The sanitary inspection category has been determined where possible using the guidance on estimation of SIC risks in accordance with the "Relative risk potential..." tables for direct outfalls and riverine inputs in the draft WHO methodology (WHO Table 4.9 and 4.10). The tables are reproduced below as Tables 2.2 and 2.3 respectively. These tables have required some iteration and updating to take account of circumstances in England and Wales, as discussed presently (see Section 5 and Appendix 1).

Table 2.2 Relative Risk Potential to Human Health Through Exposure to Sewage Through Outfalls (WHO Table 4.9).

Treatment		Discharge Type		
		1	2	3
		Directly on beach	Short outfall	Effective outfall
A	None	Very high	High	NA
B	Preliminary	Very high	High	Low
C	Primary (including septic tanks)	Very high	High	Low
D	Secondary	High	High	Low
E	Secondary plus disinfection	Moderate	Moderate	Very low
F	Tertiary	Moderate	Moderate	Very low
G	Tertiary plus disinfection	Very low	Very low	Very low
H	Lagoons	High	High	Low

Table 2.3 Relative Risk Potential to Human Health Through Exposure to Sewage Through Riverine Flow and Discharge (WHO Table 4.10).

Dilution Effect		Treatment Level				
		A	B	C	D	E
		None	Primary	Secondary	Secondary plus disinfection	Lagoon
1	High population with low river flow	Very high	Very high	High	High	Moderate
2	Low population with low river flow	Very high	High	Moderate	Very low	Moderate
3	Medium population with medium river flow	High	Moderate	Low	Very low	Low
4	High population with high river flow	High	Moderate	Low	Very low	Low
5	Low population with high river flow	High	Moderate	Very low	Very low	Very low

2.3 Discounting

The draft WHO methodology accepts "discounting" of samples as an integral part of the risk assessment process. Briefly, if a faecal contamination event is known to occur given certain environmental circumstances, such as a storm event, and the bathing water community are effectively warned of the risks and can therefore avoid them (for example by staying out of contaminated waters), it is possible to discount any bathing water risk or microbiological water quality sample during that period.

Discounting potentially reduces the burden of infrastructure and diffuse pollution controls that may be required, as health benefits are related to restriction of water use during adverse water quality conditions. This pre-supposes that the faecal contamination events can be routinely predicted.

The difficulty at this time is that there is no guidance from the EC as to whether discounting will be acceptable in a revision of the BWD. The studies have therefore tried to test the draft WHO methodology in consideration of the potential to use discounting (see for example the high risk/low risk scenarios for CSOs in Section 4) but with an emphasis on the actual potential for faecal contamination of the bathing waters reviewed.

3 STUDY METHODOLOGY

Phase 1 of the study involved a desk study exercise to determine an initial classification for each of the 471 bathing waters in England and Wales. The microbiological assessment category (A to D) was supplied by the Environment Agency, based on actual microbiological bathing water monitoring data (faecal streptococci) from England and Wales in 2000.

The SIC was reached through a two-stage process. The initial SIC classification was undertaken as a desk based exercise based on information provided in the Environment Agency (draft) "Stewardship Database". The Stewardship database collates microbiological, infrastructure and investigative data for each bathing water in England and Wales. The SIC was determined taking into account the location and design of wastewater infrastructure (wastewater treatment works, CSOs, sewerage etc.) and other faecal sources on a case-by-case basis. A specimen sheet from the Cascade Consulting bathing water database is given in Appendix 2 to illustrate the SIC categorisation process.

Phase 2 of the study involved a series of regional meetings with Environment Agency and Water Company personnel to verify the initial SIC, based on more detailed local knowledge. A total of 6 regional meetings were held for this purpose. The regional meetings assessed the initial analysis and iterated the classification dependant on local knowledge of the wastewater and diffuse pollution sources.

4 STUDY FINDINGS

4.1 Introduction

This section details the initial findings of Phases 1 and 2 of the study. The results shown summarise the microbiological classification and the development/verification stages of the SIC process (faecal contamination risk assessments).

4.2 Summary for England and Wales

The WHO bathing water classifications for all of the bathing waters in England and Wales, using year 2000 data, are given in Tables 4.1 and 4.2 below. The use of two tables has been necessary as there is currently a difficulty with the description of Combined Sewer Overflow (CSO) risk within the draft WHO methodology for application in England and Wales. According to the draft WHO methodology, any CSO discharging direct to a bathing water should be ascribed a "very high" or "high" risk if through a short outfall.

However, in England and Wales, CSOs to bathing waters are usually designed to current CSO policy (a statistical approach that allows an average of 3 spills per bathing season). It may be appropriate in these circumstances to consider such CSOs as having a low risk (particularly if you can predict their occurrence and limit human contact). This could be viewed as "discounting" for known CSO events.

At present therefore the project team has adopted an approach that reports the risk assessment based on CSOs as either a very high/high or a low risk according to the methodology, depending on the reviewer's perspective.

The tables detail the number of bathing waters in each category box on the left hand side, with the overall classification given in the two right hand columns.

Table 4.1 WHO Bathing Water Classification for England and Wales (assuming CSOs are *"high"* risk)

		Microbiological Assessment Category			
		A	**B**	**C**	**D**
Sanitary Inspection Category	**Very low**	21	23	5	2
	Low	8	18	5	4
	Moderate	4	3	0	0
	High	12	70	39	18
	Very high	12	106	70	51

52	very good
21	good
204	follow up
5	fair
109	poor
69	very poor
11	follow up

If all direct and indirect CSOs are considered high risk according to the methodology, the proportion of bathing water sites with a final rating (which excludes "follow up") is 54%, the remainder requiring follow up investigations according to the methodology.

A significant level of investigation has already been undertaken and in the majority of cases the sources of faecal contamination are known (although diffuse pollution may not be well defined). However, the methodology does not give guidance on a consistent approach to downgrading of effects of CSOs to lower levels taking into account attenuation, for example for more remote but still local CSOs. The Environment Agency and Water Companies expressed the view that further whole-scale investigation is not likely to be productive but would appear to be necessary according to the matrix.

Of those with a classification, 11% are very good and 4% good (with a further 43% likely to be in these categories) with 1% fair, 23% poor and 15% very poor.

Table 4.2 WHO Bathing Water Classification for England and Wales (assuming CSOs are *"low"* risk)

		Microbiological Assessment Category			
		A	**B**	**C**	**D**
Sanitary Inspection Category	**Very low**	21	23	5	2
	Low	12	53	19	7
	Moderate	5	11	4	2
	High	10	56	40	27
	Very high	9	77	51	37

56	very good
64	good
157	follow up
23	fair
93	poor
64	very poor
14	follow up

Assuming that all CSOs that have been designed to CSO policy (usually an average of 3 spills per bathing season) are low risk a slightly higher proportion of bathing waters fall into an appropriate class (64% from 54%) as shown in Table 4.2. A significant proportion would still require "follow up" investigations. These are mostly accounted for either by direct or indirect CSOs that are not designed to current CSO policy levels.

Diffuse pollution effects are not accounted for in the risk rating and the effects are often masked by the apparent over-riding influence of CSOs, although in reality poor microbiological water quality results may be from diffuse sources and not CSOs.

The shift in classification through re-specification of CSOs to low risk results in a higher proportion of very good and good bathing waters (up from 15 to 25%), with more fair (1 to 5%) and fewer poor/very poor waters (33% from 38%).

In summary, the proportion of bathing waters in very good and good classes is between 15 and 25% (with an additional 33 to 43% of bathing waters in "follow up", but likely to be at least good), and 38 to 39% fair to very poor (and a further 3% likely to remain poor). The main driver for classification into the bathing water quality categories (very good to very poor) is the microbiological water quality (Class A to D). The system is relatively insensitive to the SIC rating.

5 EVALUATION OF THE OF THE DRAFT WHO METHODOLOGY FOR REGULATORY APPLICATION

5.1 Introduction

The assessment of bathing waters in England and Wales against the draft WHO methodology has been undertaken using all available data and through meetings with key regional regulatory and water company staff that have direct experience of each of the 471 bathing waters tested.

A key difficulty at this time with evaluation of the draft WHO methodology has been the uncertainty related to the acceptability of "discounting" within the framework of the revised Bathing Water Directive. Although the benefits of properly administered and audited discounting can be acknowledged, through the safeguards accorded to human health, the difficulties of consistent implementation cannot be ignored.

The following text therefore seeks to balance the advantages that may arise from application of the draft WHO methodology with the difficulties of implementing what is intended to be a voluntary code into a regulatory framework.

5.2 Benefits of the Risk Assessment Approach

The draft WHO methodology contains many of the elements necessary to determine the risks of faecal contamination of bathing waters. The majority of the sources and pathways of faecal contamination are discussed, as are the mechanisms for potential site-specific variability. In this respect, the WHO approach provides a very good basis for guidance on undertaking a generic bathing water assessment.

However, application of the methodology for regulatory purposes, which depends on specific bathing water categorisation, is less well defined and open to inconsistent application, as discussed overleaf.

5.3 Consistency of Risk Assessments

Through application of the draft WHO risk assessment methodology it has become obvious that the framework requires a significant level of subjective input, requiring the qualified judgement of the participating personnel. This has been amplified in the national and regional meetings, where reaching a consensus view and consistent application of the WHO tables has been very difficult. Although a number of potential risk outcomes are identified and specified in the WHO methodology (see for example WHO methodology Tables 4.9 and 4.10) they do not provide sufficient guidance or cover the number of potential risk outcomes that can arise. This is particularly the case for intermittent and diffuse discharges, as discussed presently.

As a result, the risk assessment classification can vary widely both between sites and between users. This could lead to a potentially significant difference in risk assessment outcomes and thereby bathing water classification. The potential lack of consistency may have serious implications if the WHO approach is applied in its present format within the revision of the Bathing Water Directive.

5.4 Categorisation of CSOs

Many of the CSOs in England and Wales have been or are due to be upgraded to meet the existing CSO policy that specifies on average three spills per bathing season. However, in applying the draft WHO methodology a direct discharge to the bathing water must be ascribed a high risk category unless discounting is applied. Intermittent CSOs are therefore given a relatively high significance that is likely to over-emphasise their potential impacts (for England and Wales). This will particularly apply after the spending period (AMP3) to 2005, when many CSOs are to be upgraded.

In completing the Bathing Water Classification database, the project team has therefore had to develop a number of assumptions on intermittent discharges. Incorporating CSOs and storm water overflows (SWOs) into the SIC has required an increased number of columns in the classification matrix, added to the complexity of the risk assessment and multiplied the number of possible risk classification outcomes. The additional columns necessary and the added complexity are discussed in the notes in Appendix 1, with a

specimen sheet given in Appendix 2 to illustrate how the matrices have been applied.

To demonstrate these points, WHO Table 4.9 (reproduced in Section 2) includes a footnote that CSOs should be considered as treatment type 'none'. WHO Table 4.10 does not explicitly consider the risk from CSOs. The potential impacts from CSOs to rivers that affect bathing waters may be significant, as has been demonstrated for a number of bathing waters. The same rule has therefore been applied, that CSOs are included as treatment level 'none'.

Many of the CSOs in England and Wales would be categorised as discharge type: 'directly on beach' (assumed to mean into local bathing water). Following the assumption of treatment type 'none' for CSOs, this would immediately categorise a large number of English and Welsh bathing waters in sanitary inspection category "very high" risk, in terms of WHO classification. In a number of cases this would be an appropriate classification. However, there are a number of bathing waters where the effects of CSOs have been over-estimated according to the WHO methodology.

Bathing Water Example 1 has a microbiological category of A, but as there is a CSO outfall 'directly on beach' the WHO risk category is very high, as is the overall sanitary inspection category. There are no other known sources to this bathing water, but the WHO methodology would count this as a very high risk. The risk according to WHO Table 4.9 is an over-estimation of the true risk, as it is not reflected by the microbiological category. A modification of the matrix has been incorporated to attempt to address this problem. The WHO report allows for separation of 'normal' and 'event' periods. Continuous discharges would be a normal period, whereas CSO discharges are intermittent and could be classified as an event period. WHO Box 4.7, on p40 of the WHO report, classifies an event period, stormwater, as low risk because of successful management control of the event period: 'signage successfully warns users not to swim during rainfall and up to 2 days after heavy rainfall'.

Following this assumption (although it is accepted here that it is not directly related, as the CSO policy is a statistical approach related to meeting

compliance with the existing Bathing Water Directive) a revised classification of CSO discharges has been added to the risk assessment. CSOs that have been designed effectively to meet CSO policy (an average of three spills per bathing season) could potentially be classified as having a low risk, provided that successful management control was applied during CSO discharges. This would effectively "discount" these risks. All 'designed to policy' CSOs are therefore classified according to two assumptions:

i) They remain a very high or high risk according to the methodology
ii) They are a low risk ("discounted")

The following is an example of the high risk/low risk CSO assumption. **Bathing Water Example 2** has a microbiological category B. There are no riverine inputs that represent a significant source of faecal pollution. The outfall from the WwTW is an effective outfall with secondary treatment and UV treatment. There are however CSO discharges to the beach, which are designed to CSO policy. Following the assumption that all CSOs are high/very high risk, the final sanitary inspection category would be high/very high and the combined assessment would be 'follow-up'. Following the assumption of CSOs designed to policy as low risk the SIC would be low and the combined assessment would give a category of 'good' bathing water. The difference between the bathing water being classified as high or low risk will depend on the effective management control of the CSO 'event' when it discharges. At present there is no specific beach management control, which according to the draft WHO methodology would place the bathing water in the higher risk category.

Bathing Water Example 3 is another case showing the potential overestimation of the effects of a CSO discharge. The bathing water has a microbiological category of A. There is a CSO outfall direct to the beach designed to meet the CSO policy. Applying the earlier assumption, this CSO would be very high risk according to the methodology and the bathing water sanitary inspection category would be "very high" risk, as no beach management actions are ascribed at present. This clearly does not correlate with the microbiological classification. Following the assumption that the CSO would be a low risk, which would be a better representation – the combined assessment would then categorise the bathing water as "very good" (as opposed to "follow up").

There are many confounding factors when trying to define the relative impacts of direct and indirect CSOs. These include the spill frequency (design and actual), the distance from the bathing water, the dilution and dispersion afforded for a variety of environmental conditions and so on. In addition, different Member States have different policies for CSO design and implementation. The policies cover a wide range of possibilities, from Member States that prohibit CSOs direct to bathing waters (in most cases the bathing waters are remote from urban centres so this can be achieved) through to CSO arrangements that do not consider spill frequency. The UK policy would appear to be intermediate between the two. Further work would be required to identify the various Member State CSO policies and the implications for risk assessment outcomes.

Determining impacts and potential risks consistently for the range of intermittent discharges that are likely to arise within the EU would be very difficult to do in practice. This highlights the difficulties of using such an approach for compliance purposes, where intermittent discharges are likely to represent some of the greatest threats to bathing water quality at more stringent microbiological thresholds.

If using the draft WHO methodology for non-regulatory application, it is suggested that additional guidance on intermittent faecal sources would be required. This could cover the issues raised above, including how to assess the relative contribution of direct and indirect intermittent discharges and the main variables to consider when assessing the relative impacts (such as spill frequency, dilution and dispersion etc.).

5.5 Indirect Faecal Contamination

The WHO methodology identifies indirect (riverine) sources of human-derived faecal contamination as potentially significant. This supports the findings of several recent studies on the relative significance of riverine or diffuse sources on bathing water compliance.

WHO Table 4.10 (see Section 2) specifies a number of river flow conditions and wastewater treatment types that may represent a faecal contamination impact. However the guidance does not provide information on how to

categorise the population levels and river flow in order to determine the dilution effect. River dilution effect categories are broad and require a subjective assessment that could vary significantly between assessors and Member States. For the purposes of this study the general assumptions followed have been:

for river flow:

- estuaries and large rivers – high flow
- rivers – medium flow
- streams – low flow

for population:

- over 50,000 people – high population
- 5,000 – 50,000 people – medium population
- less than 5,000 people – low population

Even with these very broad assumptions it has been very difficult to ascribe a risk category. The basis of the difficulty, as recognised by the WHO team, is that the indirect impacts are likely to be very site-specific and subject to many different environmental variables. This fact alone makes consistent regulatory application of the indirect sources difficult. River dilution has had to be an estimate based on local knowledge. Further information would be required on how to categorise low, medium, high river flow and low, medium and high population levels to gain a consistent classification for river dilution effect.

Indirect risk categories also require further definition. For example, there is no category for medium population and low or high river flow, so that a less appropriate classification would have to be used. The ambiguity in terminology and lack of clear guidance, which would presumably have to be developed locally, regionally, nationally and/or internationally to ensure consistency, has hampered suitable testing of this element of the methodology.

There would also appear to be inconsistency in treatment of direct and indirect wastewater discharges, with fewer options for level of treatment in WHO Table 4.10 (discharges to rivers) than for WHO Table 4.9 (discharges to

bathing waters). As a result, wastewater treatment works that do not fit into any of the categories in WHO Table 4.10 have to be allocated to the most appropriate category available. Further specification within this table could rationalise the categories.

For the purposes of the risk assessment, the WHO approach recommends taking the potential for diffuse riverine faecal contamination when river/stream flow is at 10% (presumably of the annual average flow, ie. Q_{10}). It is not clear whether this is considered an appropriate flow condition for prediction of polluting events for all catchment types. However, the wide range of run-off and attenuation characteristics of the catchments throughout Europe would make the use of a standard flow condition for prediction of events prone to over-simplification. This may be an important consideration as any beach management actions would require knowledge of the rainfall and flow conditions likely to produce faecal contamination at each specific bathing water. The causative factors and event pathways are likely to be bathing water specific. Further work on this issue is therefore recommended.

5.6 Allowance for Attenuation

There is no clear guidance on the definition of risk from indirect discharges taking into account receiving water attenuation. Although attenuation is acknowledged to be a major factor in impact reduction within the draft WHO methodology, no clear guidance and specification of effectiveness is (or could be) given due to the many potential local interactions and environmental variables specific to each bathing water. Ascribing risks (very high vs. high vs. moderate etc.) from indirect sources therefore tends to be rather subjective and therefore inconsistent.

An example of overestimation of the impact from a river CSO is shown from **Bathing Water Example 4**, that has a microbiological category of B. The main effects are from CSOs in the adjacent river. CSOs are not designed to bathing water policy, so according to the draft WHO classification the bathing water is a high risk according to the methodology. The methodology does not allow for or take into account the distance between the CSO and the bathing water. Some type of variable risk rating taking into account attenuation dependant on distance from the source would provide a more appropriate risk assessment, or there could be consideration of the use of discounting during

event periods leading to a lower risk rating. Applying the draft WHO methodology without any such modification leads to an over-estimation of the true effect on the bathing water from the CSO. Again this highlights the problems with prescription in the methodology but insufficient guidance to determine consistently the variability of the potential impact from similar sources in different locations.

There are a number of bathing waters similar to this example, where inland CSOs are not designed to bathing water CSO policy but may be at a distance from the bathing water. The distance downstream to the bathing water may allow dilution and dispersion and mitigate the impact of the CSO, but there is no implicit allowance for this in the draft WHO methodology (other than by qualified judgement).

The methodology does not specify how far inland the risk assessment should be taken, given that each river catchment will have unique characteristics that dictate both the sources and attenuation of faecal contamination. Carrying out the risk assessment a long way inland may lead to an over-estimation of the impact to the bathing water. Alternatively, considering only the outfalls near to the end of the river may not be a complete risk assessment. For example, large estuaries with treatment works a long way upstream can still have a significant impact on the quality of the bathing water. Without any clear boundaries or guidance, the risk assessment is likely to be subjective and inconsistent.

For use in a non-regulatory capacity, further guidance on the scope (such as inputs and hydrographic factors) and geographic scale required when considering dilution and dispersion effects could enhance the methodology.

5.7 Diffuse Pollution

The draft WHO methodology acknowledges the potential for diffuse pollution from non-human sources, while stating that the approach is not appropriate for assessing the risks from certain faecal pathogens such as *Cryptosporidium spp.*. Reclassification (downgrading) of bathing water risk is allowed where diffuse sources are not thought to represent the same risk to human health as human derived sources. However, no clear guidance is given on reclassification.

Although the human health risk may not generally be as great from diffuse sources, there remains the possible presence of pathogenic micro-organisms that cannot be ignored. Additionally, there remains the potential for failing a faecal indicator microbiological standard, although the faecal indicators may not be human-derived. No risk category is given for agricultural diffuse source in the draft WHO methodology. A number of bathing waters would fail to meet more stringent microbiological standards because of the presence of diffuse sources of microbial pollution.

There are many examples where diffuse pollution can have a significant affect on bathing waters. Water Company and Environment Agency personnel have advocated the inclusion of some form of mechanism to assess the effects of diffuse pollution on bathing waters. A significant number of bathing waters in England and Wales are potentially included, particularly for more stringent microbiological thresholds.

Bathing Water Example 5 illustrates the problems that may arise because no account has been taken of diffuse pollution. A number of rural bathing waters look to be a low risk according to the sanitary inspection category - the effects of CSOs and wastewater treatment works are low. However, the Environment Agency considers diffuse pollution to be a significant potential source of contamination to these bathing waters. According to the draft WHO methodology diffuse pollution would not be taken into account and the true effect on compliance (but not necessarily human health) would be under-estimated.

Recognising the reduced influence of diffuse as opposed to human-derived wastewater on human health, any factor that can materially affect compliance, as has been demonstrated for diffuse sources, would have to be included in a regulatory approach.

5.8 Bather Shedding

Bather shedding is identified as a potentially significant effect on bathing water quality. However, the data needed to predict the influence of bather shedding on faecal contamination of bathing waters were not available for England and Wales. Doubt was expressed at the regional meetings on the use

of such a risk element for application to UK bathing waters, given the generally low density of bathers and lack of a contamination cause-effect relationship. For these reasons, bather shedding was not considered further in these studies.

However, it is understood that in some Member States there may be large numbers of bathers in very restricted areas, where consideration may be more appropriate. The risk categories, including bather densities (number/m^2), would need to be developed further to make this a useful tool in the assessment matrix.

5.9 Complexity of Guidelines

The WHO methodology should be commended for the attempt to include all possible outcomes. However, in doing so it has become rather complex and prescriptive, but does not encompass all possible bathing water pollution risks. There are several areas where recommended risk ratings would need to be given additional guidance or where users would have to use qualified judgement, which is likely to lead to inconsistent application. The draft WHO methodology was viewed as difficult to interpret systematically by the participants in England and Wales. Additional guidance, as suggested in several places within this assessment, could potentially help with (although not simplify) the procedures.

5.10 Outcome of Risk Assessments

The preliminary outcome from testing of the draft WHO methodology in England and Wales is reported in Section 2. The most striking result is the large proportion of bathing waters that are classified as "follow up", regardless of the treatment and assumptions of CSO risk. In England and Wales this equates to 33 to 44% of bathing waters in microbiological water quality categories A and B (<200/100ml FS at 95%) that do not have an SIC rating. The water quality would suggest that the bathing waters are of potentially adequate quality, but because of the wastewater infrastructure present they are viewed as requiring more study.

The Environment Agency has put significant effort into many of these bathing waters, as reported in the Agency Bathing Water Stewardship database, and considers that additional study would not in many cases be worthwhile. The

"follow up" categorisation could be reduced significantly if the effects of wastewater treatment works and CSO discharges could be more carefully classified. The draft WHO methodology suggests this possibility if sufficient warning is given to bathers of a faecal contamination event, although this is not generally practiced in England and Wales at present. Responses from the regional meetings would suggest that since the bathing waters consistently return good microbiological water quality results over a number of years it is likely that the risks of contamination are small.

For the majority of the bathing waters with good water quality the Environment Agency would usually allocate the infrastructure as at most a modest risk. However, given the specificity of the WHO matrices they do not feel sufficiently confident to allocate a low risk, as there are no conclusive data to that effect (other than the good water quality). Further work on microbiological budgets and potentially predictive modelling would be required for each bathing water (although this was thought not to be required by the participants), which would be likely in most cases to confirm the original assertions. This highlights the problems with adopting a largely qualitative risk assessment framework within a specific matrix format, where participants are often over-cautious. It may be possible to develop a more robust and easily applicable tool to support the risk assessment based on a black box predictive approach to microbiological inputs that could improve confidence and reduce the variance in qualitative risk assessment outcomes. In a relatively small number of cases, particularly where there are more complex wastewater infrastructure and/or hydrodynamic influences there will be no substitute for detailed monitoring and modelling studies to assess the sources, pathways and effects of microbiological pollution.

5.11 Use of Methodology for Regulatory Purposes

The principal difficulty when trying to adapt the draft WHO approach to a regulatory compliance regime is that the SIC/faecal contamination risk assessment would appear to be given undue weighting, recognising the inherent likelihood of inconsistent application. The intended use of risk assessment in the EC 2000 protocol was to support beach classification, through development of site-specific understanding of faecal sources and potential pathways. Through this process beach managers would then be able to develop appropriate beach management actions to protect the health of

bathers. It was not intended to be used as a primary compliance factor, principally because of the anticipated problems with consistency of application (reliance on qualified judgement) and the ability to cover all potential risk outcomes to a similar level of detail.

The use of the SIC as part of the classification process is also questioned as it does not seem to add significantly to bathing water categorisation. The differentiation between good and fair relies on the microbiological water quality (changes between B and C) and not the SIC. If a bathing water manager wants to upgrade this type of bathing water, they can only rely on changes in water quality, not an improvement in SIC. This would appear to make the risk assessment of secondary importance.

Furthermore, few bathing waters (<4%) actually fall within the middle category of fair. This reflects the relative insensitivity of the approach in this part of the matrix and mirrors the difficulties found in application of other risk assessments (see for example the intermediate "yo-yo" beaches reported in the initial EC trials of 1999). If this is the case, the added complexity that risk assessment requires is unlikely to lead to significant changes in classification and may therefore be considered inappropriate as a compliance tool.

Recent discussions with members of the WHO project team concerning these findings has confirmed that the WHO approach may be more suited to a voluntary system of beach management and classification.

On a positive note, the work undertaken to develop the risk assessment matrices will undoubtedly be of significant value if, as seems likely, some form of bathing water risk assessment protocol is incorporated into the revision of the BWD. However, it is recommended that the risk assessment is used to support the development of appropriate beach management actions rather than as a primary compliance tool.

5.12 Potential Improvements for Non-Regulatory Use

There are a number of potential additions and improvements to the methodology that could be incorporated if the methodology is to be used for

non-regulatory application. These could include further definition and guidance on:

- range of effects taking into account attenuation
- effects of intermittent discharge (CSO and SWO)
- consideration of diffuse contamination, recognising that this may be non-human derived, but that it still has the ability to cause breach of microbiological water quality thresholds.

Some additional categories have been adapted by the project team to allow progress and classification of bathing waters, as described in Appendix 1.

A number of other potential sources of contamination have been identified that could usefully be considered in the guidance. These include:

Misconnections/Leaking Sewers

Wastewater and the river risk ratings do not take into account impacts from wastewater sources such as misconnections or leaking sewers. The result can be under-estimations of the true effects on bathing water quality. This is illustrated by the **Bathing Water Example 6** that has a microbiological category of C. The main cause of the high microbiological count is from seeping sewers causing contaminated groundwaters that drain to the bathing water. This represents a high risk to the bathing water quality, although there is no allowance in the draft WHO methodology to take this into account in the risk assessment.

The footnote under WHO Table 4.8 states that the follow up category with C and D microbiological categories implies non-wastewater sources of faecal indicators. This is not necessarily the case. It may indicate wastewater sources that have not been included in the risk assessment, such as leaking sewers and misconnections. It may be necessary to include a category for diffuse wastewater sources if this effect is found to be widespread.

Storm Water Overflows (SWOs)

It is not clear from the draft WHO methodology how to classify the impacts of storm overflows. SWOs may represent a significant source of faecal contamination in urban areas. SWOs have been classified as very high risk

(1A) in the bathing water classification database. Some SWOs are contaminated by sewer misconnections or other faecal sources and are therefore accurately classified as a very high risk to bathing water compliance. However, in many cases storm water outfalls may not contain faecal materials, and a classification of 1A (very high risk) would be an overestimation of the potential effects. It is likely that consideration will have to be on a case-by-case basis, although recognition of their potential contribution may help future assessments.

Pumping Station Emergency Overflows

Emergency overflows are usually associated with wastewater treatment works and only spill in an emergency, such as during plant breakdown due to power failure. An assumption about their potential effects has had to be made for these studies. An emergency overflow is a rare event so the risk to the bathing water quality should be low. However, should an emergency overflow occur there would be a crude wastewater discharge with obvious public health consequences. The risk assessment should recognise the potential for contamination and recommend appropriate beach management actions in the event of failure, but providing that an emergency overflow is properly designed it should not form part of the classification process.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

A number of conclusions can be drawn form the studies undertaken:

- The draft WHO methodology is a good synthesis of existing knowledge on bathing water risk assessment.
- Application of the methodology to bathing waters in England and Wales presented difficulties in *consistently* determining risk ratings (SICs) for the variety of circumstances encountered.
- The relationship and relative risks (both to human health and compliance) associated with point source and diffuse faecal contamination need to be further developed.
- A relatively large proportion (~40%) of bathing waters were classified as requiring "follow up" studies despite relatively detailed local knowledge of the schemes.
- The use of the "data discounting" concept for bathing water management has not been universally accepted to date.
- The draft WHO methodology was not designed for and is not currently presented in a form that could be used consistently and robustly for regulatory application.

6.2 Recommendations

Following on from the conclusions, a number of initial recommendations are considered appropriate:

- The draft WHO methodology should not be used in its present form as the basis for a regulatory compliance framework by the EC.
- The risk assessment protocols (sanitary inspection categorisation) should not be used as primary compliance tools as they are subject to

significant levels of qualified judgement and hence potentially inconsistent application. Rather, they should be used to identify potential risks from which appropriate beach management actions can be developed.

- The draft WHO methodology should continue to be used where voluntary bathing water management practices are accepted.

- The ramifications of data discounting for compliance purposes requires further testing.

- The risk assessment processes described in the draft WHO methodology should be developed to provide useful guidance for bathing water managers.

- Consideration should be given to the development of a simple black box predictive model for microbiological pollution that could increase the confidence of risk assessors when determining the risks of faecal contamination.

7 REFERENCES

Cascade Consulting (2002). ***Revision of the Bathing Water Directive: Summary of Phases 1 and 2***. Report to DEFRA, April 2002.

APPENDIX 1

Modifications to the Draft WHO Bathing Water Classification Matrices

Modifications to the Draft WHO Bathing Water Classification Matrices :

The following tables relate to the Bathing Water Classification database for England and Wales completed as part of Phases 1 and 2 of the DEFRA contract. They are modifications to Tables 4.9 and 4.10 in the WHO report, *'Bathing Water Quality and Human Health', (WHO/SDE/WSH/01.2)*. The assessment was undertaken for two time horizons, 2000 and 2005, recognising that for England and Wales the AMP2 (2000) and AMP3 (2005) infrastructure upgrading and renewal cycles will have a potentially significant influence on bathing water quality. Significant investment in wastewater infrastructure has been allocated to increase compliance rates for the existing Bathing Water Directive.

A1 Direct Faecal Sources

A number of changes to the classification tables in the WHO methodology were necessary for application in England and Wales. Certain assumptions also had to be made to allow completion of the risk assessments. These are described below.

Table A1. Modified WHO Table 4.9 Incorporating CSOs designed to England and Wales CSO policy.

Treatment		**Discharge Type**		
		1	2	3
		Directly on beach	Short outfall	Effective outfall
A[1]	None	Very high	High	NA
B	Preliminary	Very high	High	Low
C	Primary (including septic tanks)	Very high	High	Low
D	Secondary	High	High	Low
E	Secondary plus disinfection	Moderate	Moderate	Very low
F	Tertiary	Moderate	Moderate	Very low
G	Tertiary plus disinfection	Very low	Very low	Very low
H	Lagoons	High	High	Low
A/I	**Effective**	**Very**	**High/low**	**Low**

	CSO[2]	**high/low**		

[1] Includes CSOs not designed to policy – spill frequency >3 times per bathing season on average.

[2] Includes CSOs designed to CSO policy - spill frequency <3 spills per bathing season on average.

In the classification database, CSOs discharging <3 spills per bathing season direct to bathing water have been classified as 1A (no treatment direct to beach)/1I (effective treatment direct to beach) or 2A (no treatment to short outfall)/2I (effective treatment to short outfall), depending on discharge type.

A2 Indirect Faecal Sources

As for direct sources, the assessment of indirect risks required some modification as described below.

Table A2. Modified WHO Table 4.10 Incorporating Designed to Policy CSOs.

Dilution Effect		**Treatment Level**					
		A[1]	B	C	D	E	**A/F**
		None	Primary	Secondary	Secondary plus disinfection	Lagoon	**Effective CSO[2]**
1	High population with low river flow	Very high	Very high	High	High	Moderate	**Very high/low**
2	Low population with low river flow	Very high	High	Moderate	Very low	Moderate	**Very high/low**
3	Medium population with medium river flow	High	Moderate	Low	Very low	Low	**High/low**
4	High population with high river flow	High	Moderate	Low	Very low	Low	**High/low**
5	Low population with high river flow	High	Moderate	Very low	Very low	Very low	**High/low**

[1] Includes CSOs not designed to policy – spill frequency >3 times per bathing season on average.

[2] Includes CSOs designed to CSO policy - spill frequency <3 spills per bathing season on average.

APPENDIX 2

Specimen Sheet from Bathing Water Database

Description	Microbiological Category	Category Post AMP2	Category Post Amp3	Sewage outfall - discharge type	Sewage outfall - discharge type	Discharge treatment type	Discharge treatment type	CSO	CSO	SWO	SWO	Sewage Risk	Sewage Risk	River Dilution Effect	River-ine Treat-ment Level
				2000	2005	2000	2005	2000	2005	2000	2005	2000	2005		2000
Beach A	A	3	2	0	0	0	0	0	0	0	0	very low	very low	4	C
Beach B	A	4	2	0	0	0	0	0	0	0	0	very low	very low	4	C
Beach C	A	5	4	0	0	0	0	0	0	0	0	very low	very low	4	C
Beach D	A	3	2	0	0	0	0	0	0	0	0	very low	very low	4	C
Beach E	A	2	2	0	0	0	0	2A/2I	2A/2I	0	0	high/low	high/low	0	0
Beach F	B	NI		0	0	0	0	2A/2I	2A/2I	?*	?*	high/low	high/low	0	0
Beach G	B	1	1	0	0	0	0	2A/2I	2A/2I	0	0	high/low	high/low	0	0
Beach H	C	4	3	0	0	0	0	2A/2I	2A/2I	0	0	high/low	high/low	0	0
Beach I	B	4	3	0	0	0	0	2A/2I	2A/2I	0	0	high/low	high/low	1	
Beach J	A	2	2	0	0	0	0	0	0	0	0	very low	very low	0	0
Beach K	A	NI		0	0	0	0	0	0	0	0	very low	very low	0	0
Beach L	C	NI		0	0	0	0	0	0	0	0	very low	very low	2	
Beach M	A	1	1	0	0	0	0	0	0	0	0	very low	very low	0	0
Beach N	B	2	2	0	0	0	0	2A/2I	2A/2I	0	0	high/low	high/low	0	0
Beach O	A	1	1	0	0	0	0	0	0	0	0	very low	very low	0	0
Beach P	B	4	3	1	1	D	E	1A	1A/1I	0	0	very high	MODERATE. very high/low	5	C
Beach Q	C	4	3	1	1	D	E	1A	1A/1I	0	0	very high	MODERATE. very high/low	5	C
Beach R	A	1	1	0	0	0	0	0	0	0	0	very low	very low	0	0
Beach S	B	1	1	0	0	0	0	0	0	0	0	very low	very low	0	0
Beach T	B	2	2	3	3	B	E	2A	2A/2I	0	0	high	high/low	1	0
Beach U	C	5	3	0	0	0	0	0	0	0	0	very low	very low	2	B*
Beach V	B	4	2	0	0	0	0	0	0	0	0	very low	very low	2	A
Beach W	A	1	1	0	0	0	0	0	0	0	0	very low	very low	2	C

Description	CSOs	Riverine Treatment Level	CSOs	River risk	river risk	Sanitary Inspection Category (2000)	Sanitary Inspection Category (2000)	Sanitary Inspection Category (2005)	Sanitary Inspection Category (2005)	Combined Assessment (2000)	Combined Assessment (2000)	Combined Assessment (2005)	Combined Assessment (2005)	Diffuse sources
	2000	2005	2005	2000	2005	(High risk CSO)	(Low risk CSO)	(High risk CSO)	(Low risk CSO)	(High risk CSO)	(Low risk CSO)	(High risk CSO)	(Low risk CSO)	
Beach A	A	D	A/F	high	high/low	high	high	high	low	follow up	follow up			Y*
Beach B	A	D	A/F	high	high/low	high	high	high	low	follow up	follow up			Y*
Beach C	A	D	A/F	high	high/low	high	high	high	low	follow up	follow up			Y*
Beach D	A	D	A/F	high	high/low	high	high	high	low	follow up	follow up			Y*
Beach E	0	0	0	v. low	v. low	high	low	high	low	follow up	v. good			
Beach F	0	0	0	v. low	v. low	high	low	high	low	follow up	good			
Beach G	0	0	0	v. low	v. low	high	low	high	low	follow up	good			
Beach H	0	0	0	v. low	v. low	high	low	high	low	poor	fair			
Beach I	A		A	v. high	v. high	v. high	v. high	v. high	v. high	follow up	follow up			Y*
Beach J	0	0	0	v. low	v. low	v. low	v. low	v. low	v. low	v. good	v. good			
Beach K	0	0	0	v. low	v. low	v. low	v. low	v. low	v. low	v. good	v. good			
Beach L	A*		A*	v. high	v. high	v. high	v. high	v. high	v. high	poor	poor			
Beach M	0	0	0	v. low	v. low	v. low	v. low	v. low	v. low	v. good	v. good			
Beach N	0	0	0	v. low	v. low	high	low	high	low	follow up	good			
Beach O	0	0	0	v. low	v. low	v. low	v. low	v. low	v. low	v. good	v. good			
Beach P	A	D	A/F*	high	high/low	v. high	v. high	v. high	moderate	follow up	follow up			Y
Beach Q	A	D	A/F*	high	high/low	v. high	v. high	v. high	moderate	poor	poor			Y
Beach R	0	0	0	v. low	v. low	v. low	v. low	v. low	v. low	v. good	v. good			
Beach S	0	0	0	v. low	v. low	v. low	v. low	v. low	v. low	v. good	v. good			
Beach T	A*	0	A*	v. high	v. high	v. high	v. high	v. high	v. high	follow up	follow up			Y*
Beach U	0	0*	0	high	v. low	high	high	v. low	v. low	poor	poor			Y**
Beach V	0	A	0	v. high	v. high	v. high	v. high	v. high	v. high	follow up	follow up			Y*
Beach W	0	C	0	moderate	moderate	moderate	moderate	moderate	moderate	follow up	follow up			