Flood Defence Levels of Service - Stage 2

Annex C: Flood Events

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R&D Note 127

NRA
National Rivers Authority

Contents

1. INTRODUCTION

This is one of five annexes which, together, provide a description of a method for applying a flood defence levels of service strategy. The overall system is described in the main report, which contains references to the other annexes where appropriate.

This particular annex deals with those aspects of the system which relate to the monitoring of actual levels of service and the way in which these levels are expressed.

2. ASSESSMENT OF ACTUAL LOS PROVIDED

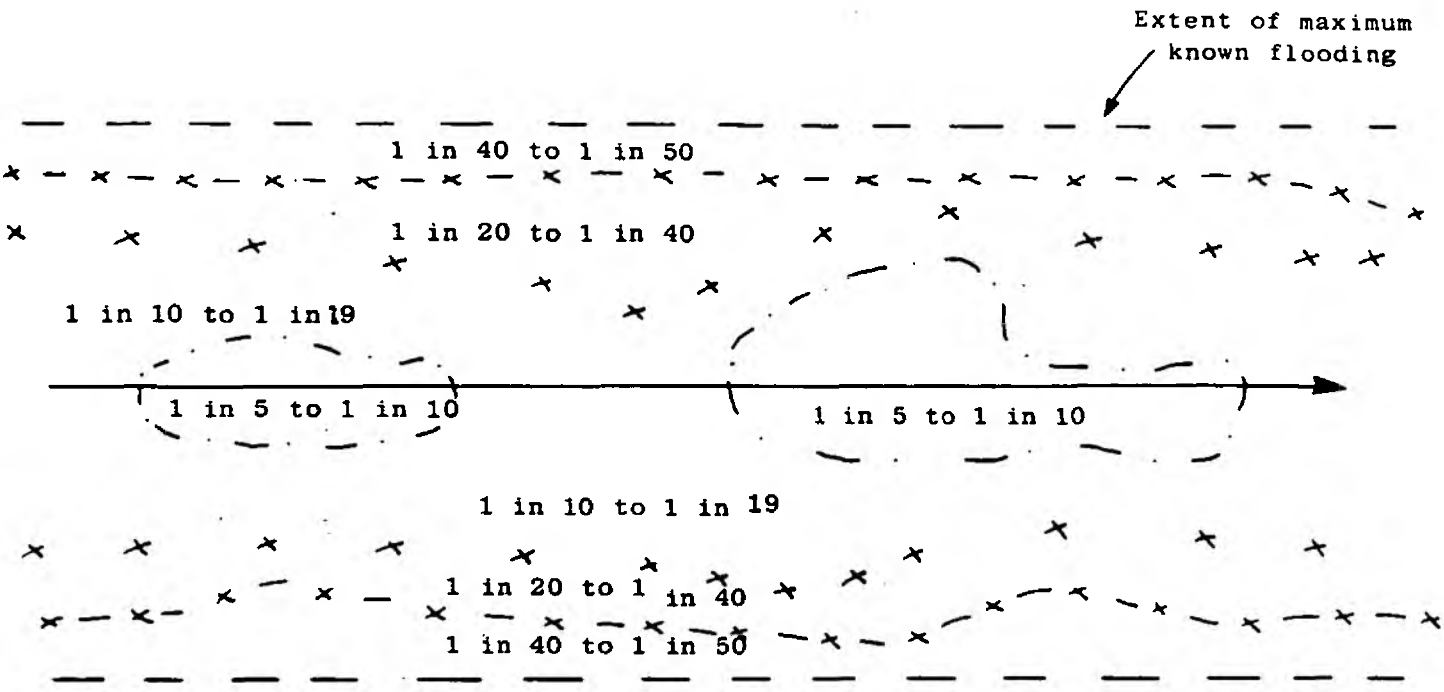
The two methods of assessing current land use which are compared in Annex B are each associated with a particular scoring method for expressing the current level of service provision. Application of these methods to the pilot areas and the consultants' earlier experience with the Thames approach highlighted the inadequacies of both techniques.

The first part of this annex describes in detail the deficiencies of the two methods proposed.

A new approach to monitoring the current level of service provision has been developed which draws from the two methods proposed as well as incorporating new ideas. The technique proposed is detailed in this report. It has not however been possible to apply this technique to all rivers in the pilot study due to insufficiency of information gathered. The consultants are confident that the proposed technique is valid and that the information required is available though not yet in an immediately accessible format.

In addition to the scoring method detailed, the current level of service provision must take into account the contribution to service adequacy due to the condition of any flood defence asset that may be present. Annex E more fully explains the data gathering and analysis method to identify the adequacy of service provided by the assets. Brief mention is made in this annex of how the asset assessment integrates with the assessment of flooding occurrence with more detailed explanation given in the main report.

Figure C.1 Example of flood return period maps for W.A.A. method.



3. DEFICIENCIES OF THE PRESENT SCORING METHODS

Under the Thames method, the scoring system, like the method of assessment, includes an element of visual assessment. Each flood event as it occurs should be monitored to identify the number of House Equivalents (HEs) affected by that event. The total number of HEs affected per year is calculated and from this the average yearly score over a rolling 5-year period is identified. This can be compared to a predetermined target score. Included in the assessment of agricultural HEs affected by events are calculations to account for the variation in damage that occurs when agricultural land is affected at different times of year and for different durations.

By contrast the W.A.A. method does not directly assess the current situation. The extent of flooding for different return period events is defined on maps. These maps are likely to be defined from historical information of flood extent as well as perceptions of local personnel. An illustration of the type of map that will be produced is given in Figure C.1. Once prepared these maps can be compared with those showing land use bands of various parcels of land. Each land use band is given a target return period of flooding which can be compared with the actual return periods. There is no differential allowance for timing and duration effects of agricultural flooding.

Both methods of scoring have deficiencies. For the Thames method this is insufficient identification of larger order events. In this method the events occurring are monitored over a rolling 5-year period. However, there is a strong possibility that only those events which occur relatively frequently will occur within this time. The higher order events, such as 1 in 20 and 1 in 50 year return periods are unlikely to occur over the 5-year period. It is possible, therefore, that the level of service provided to those interests which are only affected by the higher order events could be changing detrimentally but go unnoticed until it is too late and the inadequacy is highlighted by serious flooding.

For the W.A.A. method almost the reverse is true, with insufficient recording and definition of the lower order, more frequent events. The flood envelopes of the 1 in 20 and 1 in 50 events are likely to change relatively slowly over time. However, those for the lower order events can change almost day to day depending on the timing of river maintenance operations. Such variations cannot adequately be reported on a map based format to allow meaningful comparison with defined targets. In addition the technique takes no account of the effects of timing and duration of agricultural flooding, often the most important factors in determining the degree of damage that results. This method is also reliant on historical flooding occurrences to identify the areas that will be affected by flooding and does not directly reflect the current situation. If changes in management practice are made it is important that changes in flooding characteristics are identified and return period envelopes adjusted accordingly. This problem could in time be overcome by computer modelling. However, this is unlikely to be available for all rivers for some time.

Table C1 Reactive Method: Severity Weighting calculation

Flood Event Component	Category for Severity of Event				Weighting
	0	1	2	3	
Timing Duration	Nov-Feb ≤ 1 day	Mar or Oct >1<5 days	Apr or Sep 5-7 days	May-Aug >7 days	0.25 0.25

For each component of the flood event, timing or duration, the category of severity is identified as 0, 1, 2 or 3. This category score is then multiplied by the weighting for the particular component. Summing these scores for timing and duration of event gives the overall severity weighting for the event. This approach is illustrated in the following examples

Example (1)

Flood event in March for 4 days

Timing March (1) x weighting (0.25) = 0.25
Duration 4 days (1) x weighting (0.25) = 0.25

Severity weighting = 0.5

Example (2)

Flood event in June for 6 days

Timing June (3) x weighting (0.25) = 0.75
Duration 6 days (2) x weighting (0.25) = 0.5

Severity weighting = 1.25

4. PROPOSED APPROACH

To overcome these deficiencies and to be compatible with the land use assessment technique proposed, a dual scoring system is recommended combining both the Thames method and a modified form of the W.A.A. method. Such a system will provide an assessment of the actual incidence of flooding over a short monitoring period; a reactive assessment, as well as a more predictive assessment of the potential flooding that could occur in any year from the infrequent higher order flooding events. The two phases of this proposed method are in detail:

4.1 REACTIVE ASSESSMENT

This approach is in essence that developed by the Consultants in association with NRA Thames region. Some minor modifications have been made to bring this into line with the recommended land use assessment technique. Full details of the methodology are given in the main report but in summary the calculation of scores for each reach is as follows:

Scoring of Individual Events

Each event is scored using the following formula:

Urban HEs affected plus (Agricultural HEs affected x severity weighting).

The severity weighting is the means by which the effects of differing durations and timing of agricultural flooding is accounted for. It can be calculated for any event by using the severity weighting matrix shown in Table C.1 and the worked examples opposite.

Calculating Average Annual Scores

All the scores for individual events are summed and an average score for each year is calculated. To reduce annual variation, the sum of all events is averaged over a rolling 5-year period, to give the annual average monitoring score.

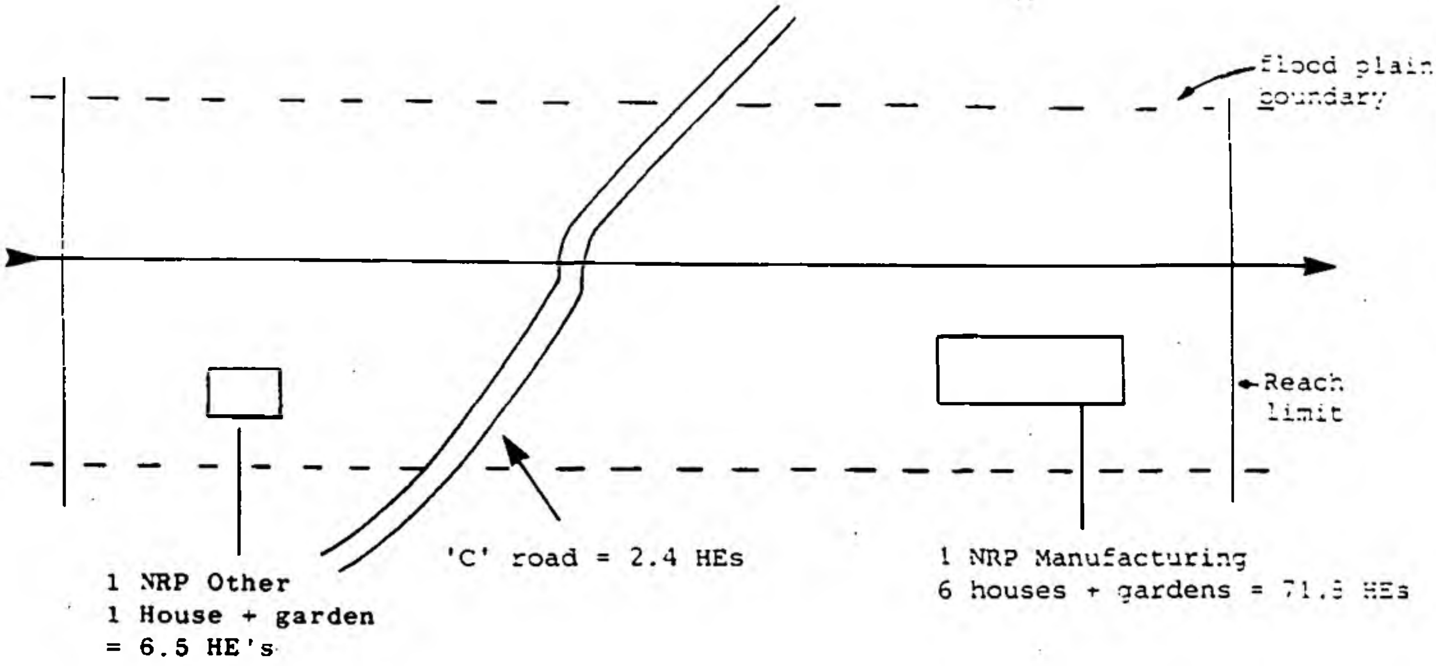
To ensure consistency of comparison of reaches the monitoring scores, like the assessment scores, are all expressed on the basis of HEs per kilometre that are affected by the event.

Worked Examples

For each of the following examples detailed in Table C.2 and Table C.3 illustrating the scoring of a reach experiencing either wholly fluvial events or wholly tidal events, the scenario indicated in Figure C.2 overleaf is used.

The score has been calculated for the right bank.

Figure C.2 - Data for Worked Examples of Scoring Methodology



<u>Assumptions for Calculations</u>

Urban HEs for the reach = 80.7 (right bank only)

Agricultural HEs for the reach (right bank only)
= 225 ha of Extensive Pasture = 2.9

Total HEs	=	83.6
Reach Length	=	5.2
HE/km	=	16.1
Land Use Band	=	C

Flooding Data

Year 1 (1) - January for 4 days, 50% of Agric Floodplain

(2) - April for 1½ days, 60% of Agric Floodplain, 'C' road
1 NRP other, 1 house + 1 garden

Year 2 - No flooding

Year 3 (1) - November for 6 days, 30% of Agric Floodplain

(2) - December for ½ days, 10% of Agric Floodplain

Year 4 - March for 3 days, 40% of Floodplain

Year 5 - No flooding

Table C2

Worked example (1) (Fluvial Flooding)

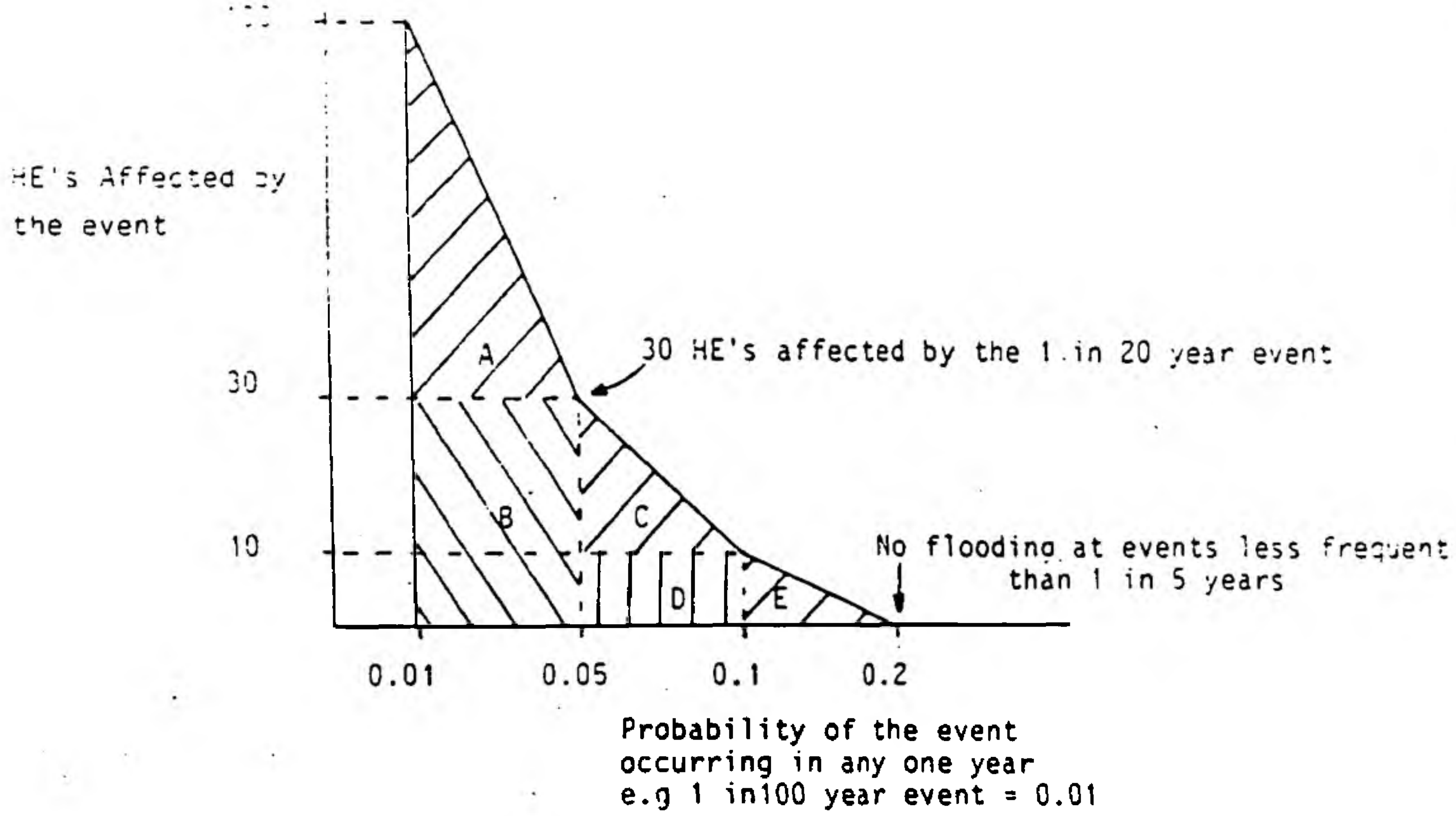
	Urban HE's affected	Agric HE's affected x severity weighting = Agric HE's	Total HE's
Year 1 event (1)	0	(2.9 x 50%) x 0.25 = 0.36	0.36
(2)	8.9	(2.9 x 60%) x 0.75 = 1.31	10.21
		Total HE Year 1	10.57
		Total HE/Km Year 1	2.03
Year 2		NO FLOODING	
		Total HE/Km Year 2	0.0
Year 3 event (1)	0	(2.9 x 30%) x 0.5 = 0.44	0.44
(2)	0	(2.9 x 10%) x 0 = 0	0
		Total HE Year 3	0.44
		Total HE/Km Year 3	0.085
Year 4	0	(2.9 x 40%) x 0.5 = 0.58	0.58
		Total HE Year 4	0.58
		Total HE/Km Year 4	0.11
Year 5		NO FLOODING	
		Total HE/Km Year 5	0
		Total HE/Km all years	2.225
		Average HE/Km per year	0.445

Worked example (2) Assumes the reach is downstream of MAFF limit of tidal dominance and upstream of the Estuary/sea defence demarcation as per schedule 4 of the 1949 Coast Protection Act.

	Urban HE's affected	Agric HE's affected x severity weighting = Agric HE's	Total HE's
Year 1 event (1)	0	(2.9 x 50%) x 0.25 x 2 * = 0.72	0.72
event (2)	8.9 x 2*=17.8	(2.9 x 60%) x 0.75 x 2 * = 2.61	20.41
		Total HE Year 1	21.13
		Total HE/Km Year 1	4.06
Year 2		NO FLOODING	
		Total HE/Km Year 2	0.0
Year 3 event (1)	0	(2.9 x 30%) x 0.5 x 2 * = 0.87	0.87
event (2)	0	(2.9 x 10%) x 0 x 2 * = 0	0
		Total HE Year 3	0.87
		Total HE/Km Year 3	0.17
Year 4	0	(2.9 x 40%) x 0.5 x 2 * = 1.16	1.16
		Total HE Year 4	1.16
		Total HE/Km Year 4	0.22
Year 5		NO FLOODING	
		Total HE/Km Year 5	0
		Total HE/Km all years	4.45
		Average HE/Km per year	0.89

* Each score is multiplied by two to account for the extra damage from tidal events.

Figure C3 Illustration of predictive scoring method



Various points are identified at which the HE's affected at particular return periods of event are known. These can be used to calculate the area under graph = HE's likely to be affected in the reach per year as follows:

Area under the graph = A+B+C+D+E

$$\frac{(0.05-0.01) \times 70}{2} + (0.05-0.01) \times 30 +$$

$$\frac{(0.1-0.05) \times 20}{2} + (0.1-0.05) \times 10 +$$

$$\frac{(0.2-0.1) \times 10}{2}$$

= <u>4.1 HE's/year in this example.</u>

Whatever the sub-division, the calculated Annual Average monitoring score can be compared with pre-determined target levels thought appropriate for the particular land use bands. This comparison is described in greater detail in the main report.

4.2 PREDICTIVE METHOD

To overcome the inadequacies of the reactive method of assessing the current level of flood protection, a more predictive technique has been developed which reflects the probability of events of differing flood return periods occurring in any particular year. In this way the long term average HEs affected per km per year can be identified with regard to the infrequent occurrence of the large events.

The basis of the technique is to identify the number of HE's that are affected by flooding in a range of events of differing return periods. By applying the probability that these HE's would be affected in any one year by the return period event, the annual average HE's per km affected by flooding is calculated. Figure C.3 opposite illustrates this calculation with the average score being calculated from the area under the graph. This score can then be compared with the appropriate targets detailed in the main report.

Provision of the information to complete this scoring method is likely to prove difficult and may be resource demanding. The level of difficulty and resource reflecting the number of points and thus accuracy of the graph is illustrated in Figure C.3. Three options of increasing resource requirement have been identified and are detailed below and illustrated in Figure C.4, using data in table C4.

Option 1

This most basic option involves very little resource input identifying only two points on the graph and extrapolating between them. Data requirements are:

i Total number of HE's in the reach, as defined by the land use assessment.

ii The return period of event at which overtopping commences.

iii The return period of event forming the maximum extent of flooding (ie on which the land use assessment was based).

The main assumption in this method is that the HE's affected increases in direct proportion to the increasing severity of event. Figure C.4 illustrates this method with data shown in table C4.

Option 2

The second option introduces greater accuracy by more precisely identifying the HE's affected by a variety of return period events. This method draws on information that is already known. Such sources of information may comprise one or more of the following:-

Table C.4

	HE's Affected under each Option		
Probability at event	Option 1*	Option 2	Option 3
0.2	0	0	0
0.1	4.75	1.1	1.1
0.05	14.25	3.3	2.5
0.04	19.0		5.4
0.03	26.6		8.2
0.02	42.75	25.6	20
0.01	100	100	100

* Allocated assuming linear relationship between increased severity at event (flood return period) and HE's affected.

i) Flood reports detailing extent of flooding for particular return period events.

ii) Studies undertaken as part of capital works projects.

iii) Knowledge of local staff identifying return periods at which particular interests become affected.

Other sources of information may also be available. Clearly the most comprehensive picture of flooding patterns will be provided by drawing on all available information. Whilst the consultants recommended that all sources should be utilised it is recognised that in the short term resources may be limited in which case the region will need to make a judgment on which source provides the greatest detail in their situation. By pooling this information with land use information the HE's affected by the following events is identified:

i Return period at which overtopping commences
ii 1 yr in 5
iii 1 yr in 10
iv 1 yr in 20
v 1 yr in 33
vi 1 yr in 50
vii 1 yr in 100

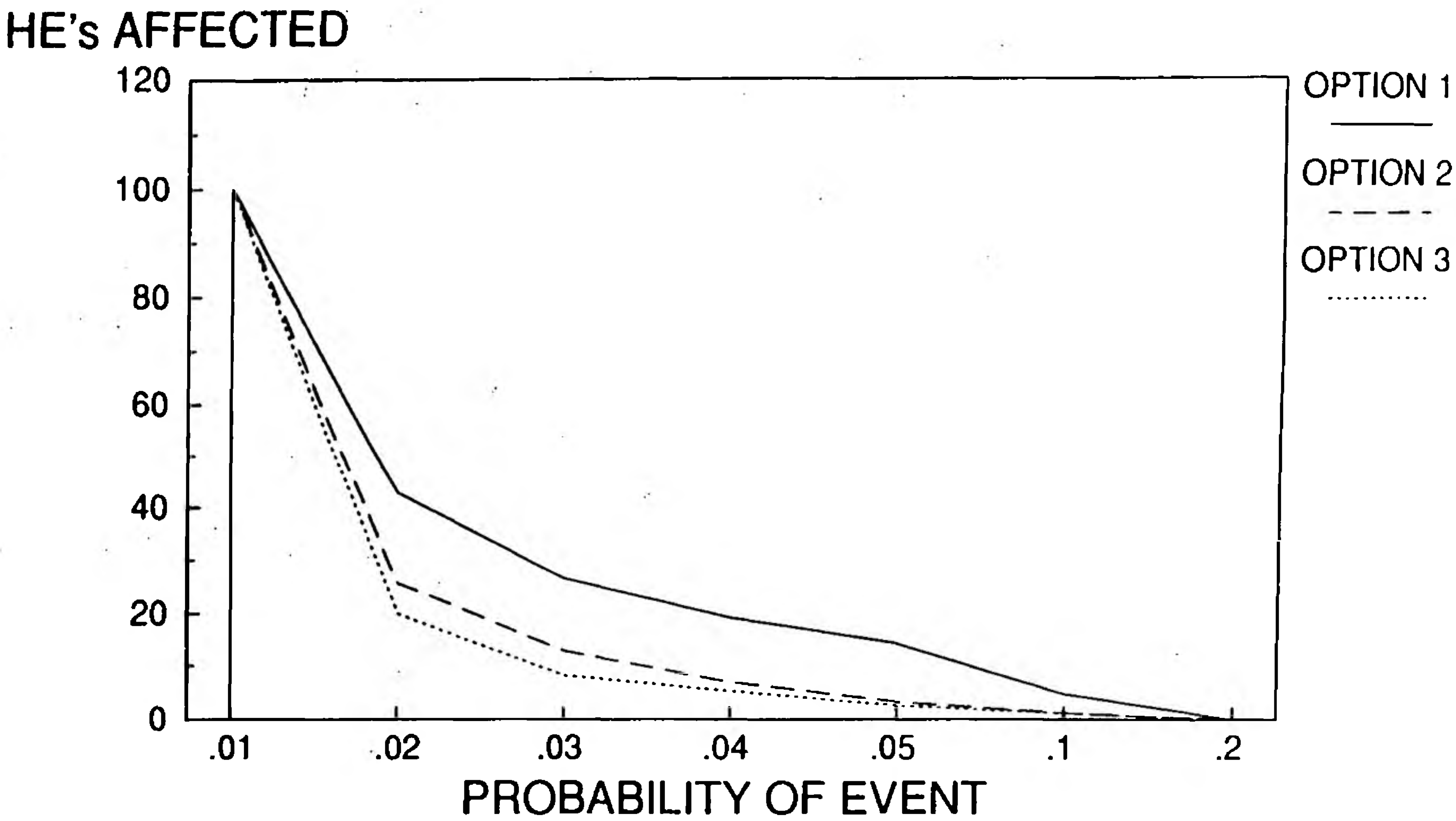
For the last category it is possible that the maximum known flooding extent is for a return period more frequent than 1 yr in 100 in which case the return period of the maximum known flooding extent is adopted. An example is illustrated in Figure C.4 with data shown in Table C.4.

Option 3

The third and most precise option is by far the most resource demanding and unlikely to be achievable in the short-term. This option would involve detailed analysis and perhaps modelling of watercourses and areas at risk from flooding to identify accurately the HE's affected at different return periods. At greatest sophistication this could identify return periods at which flooding commences for individual interests. Figure C.4 and Table C.4 illustrate the detailed information that could be provided by this method.

FIGURE C4

EXAMPLE OF THE OPTIONS FOR THE PREDICTIVE SCORING METHODOLOGY



Option 1 is the least resource demanding of the options identified. However, it is seriously flawed in its approach and the results that it produces. If it could be assumed that flooding characteristics were identical for all rivers with HE's affected being directly proportional to the event severity, then this method could be used to rank reaches in some order. Clearly however this is not the case. Reaches not only have widely differing flood characteristics but also have HE's that are unevenly distributed within the reach. In most reaches the majority of HE's notably properties, are concentrated towards the edge of the risk area, ie unaffected until the larger infrequent events occur. Option 1 assumes incorrectly that they are distributed evenly throughout the floodplain. In addition, it is necessary not just to be able to rank reaches in order of their flooding occurrence but to be able to ascertain with some accuracy the absolute level of flood protection being provided to a reach to assess the adequacy of the current service provision. Comparing the score for Option 1 as shown in Figure C.4 with that for Options 2 and 3 shows how inappropriate Option 1 is in achieving this aim.

By contrast Option 3 is very resource demanding and is likely to involve detailed analysis of flood records and modelling of flood characteristics. Such an exercise, though impossible to implement in the short term would provide the most accurate possible data for the predictive methodology and must remain as a long term aim. Progress can be made by ensuring that studies undertaken for any capital works on flows and flood characteristics are sourced as data to the predictive approach. For the majority of reaches the level of detail may also be unnecessary for those which are most rural in nature, bands D and E, the resource requirement would appear inappropriate. For the additional detail that Option 3 could provide over and above that provided by Option 2.

Option 2 is recommended by the consultants as the most appropriate means of calculating the predictive score of flood incidence in the short to medium term. This method provides a balance between resource requirement and the degree of information accuracy acceptable for the system. The information can be drawn from existing flood reports of notable events and combined with information from local operations personnel of return periods at which notable interests or groups of interests become affected by flooding. Whilst an initial assessment of the predictive scores can be made from just one source of information, the consultants strongly recommend that all possible sources of information on return periods at which interests are affected should be consulted. Experience from the pilot study areas indicates that it should be possible to make reasonable estimates of HE's affected by different return period events not by drawing up complete return period envelopes but by identifying the return periods at which key interests become affected to which other interests can be related. It is accepted that for agricultural land this may not always be possible, in which case the direct proportionality of HE's affected to severity of event would be applied as per Option 1.

Whilst the Option 2 approach is less accurate than Option 3, the difference in scores as indicated by Figure C.4 opposite is likely to be relatively small and considered acceptable within the context of the study. The score is considered accurate enough to allow the absolute standard of flood protection to be fairly reflected for rivers of different characteristics.

4.3 AGRICULTURAL FLOODING IN THE PREDICTIVE SCORING METHOD

As with the reactive scoring method, the predictive score must take account of the timing and duration effects of agricultural land flooding. This is achieved by considering the weighted probability of events occurring in particular months and for particular durations, to achieve an average severity weighting for all agricultural flooding.

Appendix 1 indicates how this could be calculated with example figures given. This indicated the average severity weighting to be 0.5 which is to be applied to all agricultural HE's in the predictive scoring methodology.

5. APPLICATION OF METHODOLOGY TO PILOT AREAS

For the pilot study areas, it became apparent that operations personnel did not have available sufficient information to identify flood return envelopes on maps to allow comparison with land use band designations as per the proposed W.A.A. method. This is by no means a situation unique to the rivers in the pilot study nor to the regions concerned having been encountered by the consultants in most of the other NRA regions. In most cases it was possible to identify a return period of event at which overtopping began but not possible to draw lines on maps to define 1 in 5, 1 in 10, 1 in 20 and 1 in 50 return period envelopes of flooding. The lack of information on this and the actual incidence of flood events is most acute in the more rural areas for the most frequent floods. Larger events tend to be better recorded as property may be affected and there may be other outside pressures such as media interest. There is also often a bias towards urban areas, not unnaturally as this is where staff efforts tend to be concentrated in the larger events. In was, however, apparent that staff could identify flood return periods at which properties or groups of property would be affected by flooding. This detail is sufficient to undertake the recommended Option 2 of the predictive assessment technique.

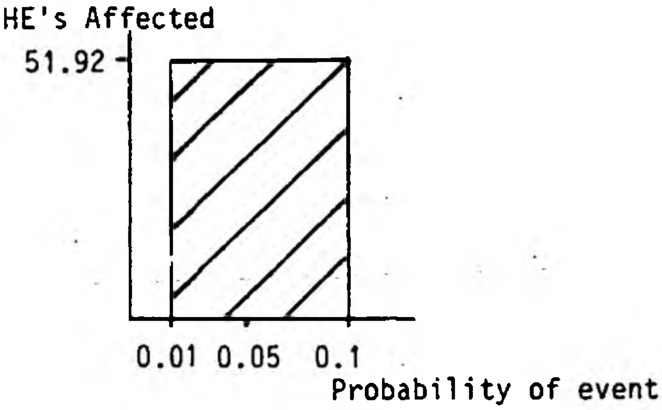
Example 1
Maltreath Marshes - Left Hand Low Level Drain Reach 1

Reactive scoring : No flooding over last 5 years.
Therefore Annual Average Monitoring Score = 0.

Predictive scoring is calculated as follows:

The assumptions made are that the flood defences provide protection to a return period of 1 in 10 up to which return period of event no flooding results. Due to the 'very' flat nature of the floodplain it is further assumed that any event exceeding this 1 in 10 magnitude would affect all the interests in the floodplain.

Graphically this information can be represented as:



Number of HEs in the reach (urban and amenity HE's plus 8.8 agric HE's x 0.5 average severity weighting)

Area under graph = 0.09 x 51.92
= 4.673

Reach length = 5.6 km

<u>HE/km/year</u> = 0.83

That is, it is predicted that on average 0.83 HE/km will be affected each year by flooding in this reach.

Both the reactive and predictive scores can be related to target levels appropriate for the land use band C that has been calculated for this reach. Even though the required standard of protection for the band C reach makes the reactive method inappropriate on it's own, it is still calculated as it may provide information to assist the interpretation of the predictive score.

Example 2 - River Spen - Reach 1 Right Bank

In contrast to the above example, Example 2 illustrates the scoring for a very urbanised area, reach 1 on the River Spen. This area has a history of flooding and a major improvement scheme is currently under construction. The figures used in this example, however, refer to the situation before any of the improvement works were undertaken. The differing magnitude of predictive scores between this reach and the earlier example is to be noted. Even though this is an urbanised area the reactive score is still calculated.

Reactive - flooding has occurred over the last 5 years.

December 1987	1 NRP (other) 'c' road closed 8 gardens

It is believed that other minor events have occurred with some overtopping, but not affecting significant interest.

The score for flood events over 5 years = 5.3 + 2.4 + 1.6

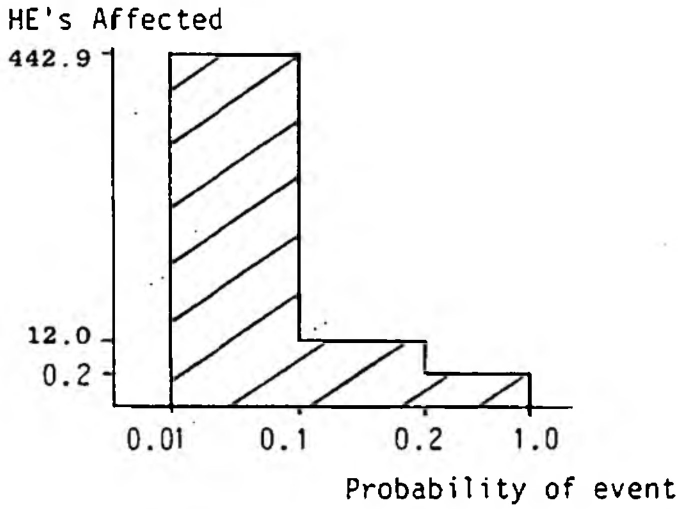
HE's affected	= 9.3
Average per year	= 1.86
Reach length	= 3.7
Reactive HE/km/year	= 0.48

The deficiencies of the reactive only scoring method can be fully appreciated when a fuller history of flooding events is noted. In 1983 a manufacturing business was affected by flooding on 3 separate occasions. This is not included in the above assessment for reactive flooding being outside the rolling 5-year monitoring period.

Predictive

Assumptions made are that overtopping commences at return periods of 1 in 1 year events at which time playing fields are affected. At return periods of 1 in 5 year events a number of properties are affected assumed for illustrative purposes to be 1 house, 1 garden and 2 NRP other. At return periods of 1 in 10 year and above all remaining interests are affected.

Graphically this can be represented as follows:



Area under graph = .8 x 0.2 +
.1 x 12.0 +
.09 x 442.9
= 41.221

Reach length = 3.7 km

HE/km/year = 11.14

That is, it is predicted that on average 11.14 HE/km will be affected per year on this reach. The target range is between 0.5 and 1.0 HE/km per year,

A programme of major capital works is underway for much of the River Spen in this area to provide flood defence to in excess of a 1 in 50 year standard. The example described above is in reference to the situation before the improvement works are carried out.

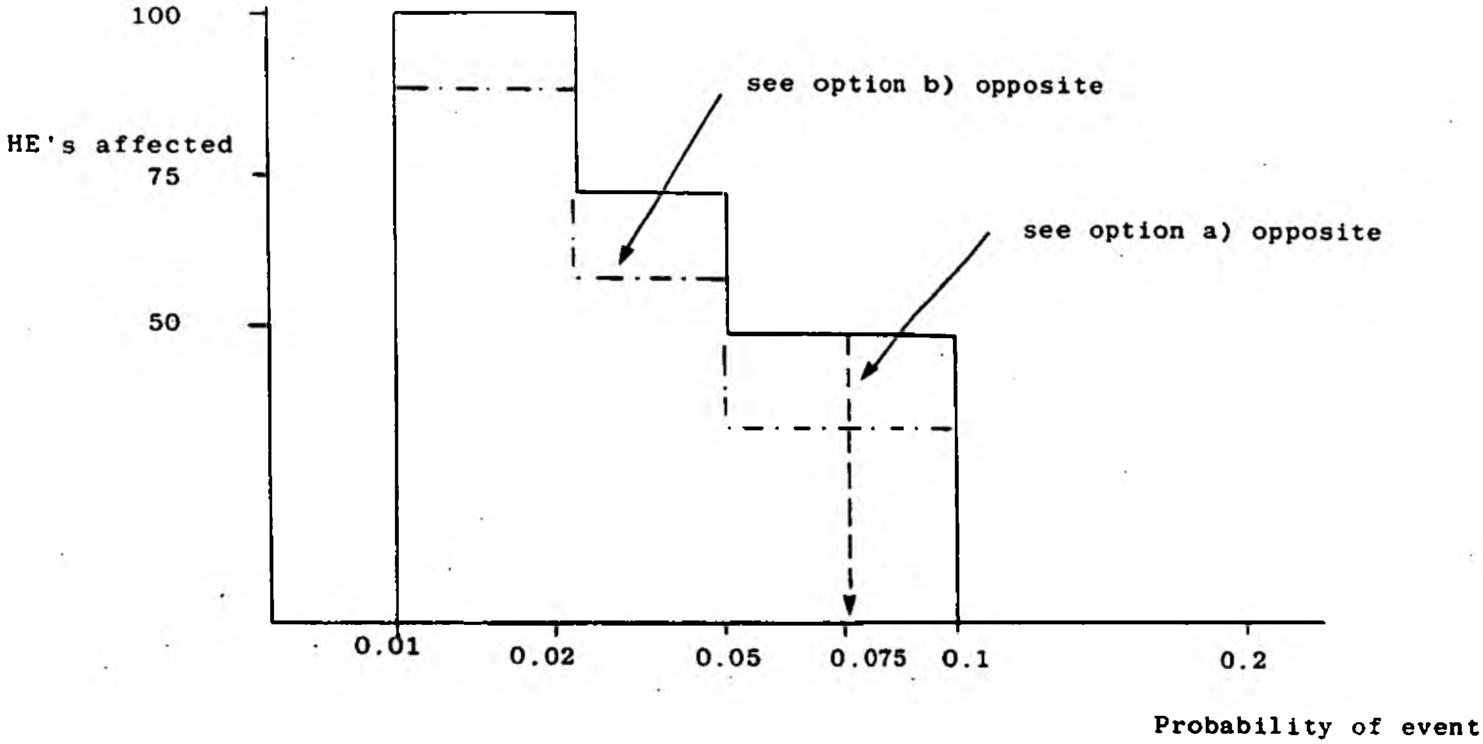
6. INTEGRATION OF REACTIVE AND PREDICTIVE SCORING WITH FLOOD DEFENCE ASSET ASSESSMENT

The actual level of service being provided to a reach is a function of both the actual and likely incidence of flooding events as well as the condition of any flood defence assets that are contributing to the provision of a particular level of service. For example, two reaches, identical in all respects, are experiencing a particular degree of flooding occurrence and would be scored with the same reactive and predictive scores. However, in one reach the flood defence asset that is present is in good condition whereas in the other the flood defence asset is in very poor condition and liable to failure in the short term.

A methodology for assessing the adequacy of provision from a flood defence asset has been developed as part of this study. This however relies on engineering judgment to allocate a number of condition factors to each asset which are then assessed on the probability that they will cause failure of the asset. Such an approach still includes an element of subjectivity and needs further refinement before data collection should proceed. A number of visual assessment and instrumental survey methods to minimise the subjectivity of asset assessments are being investigated in several independent R & D initiatives with reporting expected in approximately 1994.

In the meantime it is still important that the condition of assets is considered. It is recommended that in the interim period the assessment should be based on the considered judgment of local operations personnel of the actual standard of protection being afforded by flood defence assets. Annex E and the main report detail the method by which the judgment is incorporated.

Figure C5.



Reach length = 4.5 km

HE/km = 22.2

= Land use band C

Area under the graph = 1.28 HE/km/year

LOS provision = Inadequate

Note: In this example it is assumed that there are no flood defence assets within the reach. If there were assets present then the predictive score as modified to account for current asset condition would be taken as the starting point above.

7. ASSESSING THE EFFECT OF PROPOSED REMEDIAL ACTION FOLLOWING IDENTIFICATION OF CURRENT INADEQUACY OF LOS.

Earlier sections of this annex detail the methodology for assessing the likelihood of future flooding occurrence for each LOS reach. This method assumes that any flood defence asset present in the reach provides protection from flooding to it's design standard. This method was further developed in Annex E to allow the condition of any assets to be incorporated into the assessment. The main report details how these various scoring methods, with the reactive method, are used to identify the adequacy of current service provision.

For reaches where an inadequacy in LOS provision is identified the predictive methods can also be used to define a minimum acceptable standard of flood protection, and assess the effect of any remedial works.

In figure C5 opposite a scenario is indicated for a reach currently receiving an inadequate LOS. To remedy this action a number of options may be taken.

a) Increasing the standard of protection by altering the return period at which interests first become affected. But what standard is required?

Maximum allowable flooding = 1 HE/km/year

Current flooding occurrence = 1.28 HE/km/year

So the damage occurring on average per year must be reduced by at least 0.28 HE/km per year. For this reach of 4.5km length it means a reduction of at least (4.5 x 0.28) = 1.26 HE per year affected per year in the reach as a whole.

This can be achieved by effecting a change in the return period of event at which flooding commences. For figure C5 this requires a change from the present 1 year in 10 to 1 year in 13, as a minimum standard of protection.

b) Providing flood protection to specific interests.

The same reduction in likely incidence of flooding as detailed at a) above can be achieved by increasing the standard of protection of specific interests or groups of interests. If for example the interests in the reach includes a non Trunk A road (14.3 HE's) which is affected by flooding at events exceeding 1 in 10 year magnitude the reduction in damage due to flooding could be afforded by providing protection to the road from flooding upto the 1 in 100 year event.

Clearly combinations of measures can be considered. It is recognised that the final decision on choice of scheme will be influenced by other factors such as benefit: cost analysis.

The above approach is applicable to situations where the appropriate range of return periods is for event occurring more frequently than 1 in 100 years.

Other reaches eg band A fluvial reaches with high values of HE per km could still experience greater than 1 HE per km per year affected by flooding even if protected to a 1 in 100 year standard. The required standard of protection to reduce likely flooding incidence to 1HE per km per year equals the value of HE's per km from the land use assessment. So where HE's per km = 185 the required standard of protection is 1 in 185 years.

Provision of such standards of protection will be influenced by benefits: cost calculations and the policy of the NRA. The above approaches will merely serve as indicators of the likely standard required.

APPENDIX 1

USE OF AGRICULTURAL WEIGHTING

The predictive score assessment requires calculation of an average severity weighting for timing and duration of agricultural flooding. This can be accomplished by calculating a weighted multiplier based on probabilities of flood durations and extents for the values given in Table 3.7 of the Final Report.

This gives the following results:

For Timing

a)	Multiplier Months	0 Nov to Feb	1 Mar or Oct	2 Apr or Sep	3 May to Aug
b)	Probability of Flooding *	0.6	0.2	0.1	0.1
	Weighted Multiplier (a x b) =	0	.2	.2	.3 = 0.7

Weighting for timing is then 0.25 x 0.7 = 0.175

For Duration

a)	Multiplier Duration (days)	0 ≤1	1 >1<5	2 5-7	3 >7
b)	Assumed Probability**	0.1	0.6	0.2	0.1
	Weighted Multiplier (a x b) =	0	0.6	0.4	0.3 = 1.3

Weighting for duration = 0.25 x 1.3 = 0.325

* Approximates of figures calculated for Lincoln Flood Alleviation Scheme by LGC in 1984.
** Estimates by LGC

The severity weighting in this example would then be **0.5**.

To then calculate the agricultural HEs affected by an event of particular return period, the total agric HEs within the return period envelope would be multiplied by this weighted average severity weighting to account for average timing and duration. The figure this gives is added to the score for urban HEs to give the total HEs affected by the particular event.