NATIONAL RIVERS AUTHORITY

REPORT FOR WELSH REGION

ON

SELECTED FLOOD DEFENCE SCHEMES

AND

THE DEVELOPMENT OF A STANDARD METHODOLOGY

FOR RISK ASSESSMENT

NRA

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Date: JULY 1994

Project Reference: **"SPACE" - Risk Assessment**

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1. SUMMARY

S1. This report is one of a series of reports which have been prepared to cover each region of the National Rivers Authority.

S2. The first section of the report contains comments on a number of flood defence schemes, which were selected by Regional Staff. The comments and the subsequent recommendations are made with the intention of reducing or limiting the risk of failure of the scheme, or of NRA procedures. To arrive at the recommendations, consultations have been held with operational and design staff and consultants have been involved in quality checking of scheme reports. The recommendations are based on simple, practical application of collective experience (hence the Project Ref: "SPACE"). Some recommendations may currently be being actioned, but it is suggested that all should be reviewed by Flood Defence Management Teams, for action as deemed necessary.

S3 The second section of the report describes the development of a standard methodology for "risk assessment". It concludes that a measure of risk to the NRA (in monetary terms), may be arrived at by multiplying the "protected value" provided by a scheme, by a "risk factor". It is suggested that the latter can be derived by considering three separate elements:- firstly, an "inherent" risk factor which is always present when schemes are designed and constructed; secondly, a "system" risk factor which exists when schemes are operated and maintained, and finally an "associated" risk factor which is involved in monitoring, predicting and warning when scheme standards are approached or exceeded.

S4 The report contains reference to how a "rapid assessment methodology" could be developed further, and suggests uses to which it could be put.

Appendix 1 contains a suggested scoring system for derivation of the various risk factors, and Appendix 3 contains results of assessment done under this project, together with some statistical analysis.

Suggestions for future development include:-

a) the determination of "acceptable" risk levels and risk factors
b) the prioritisation of schemes for preparation of contingency plans, operational and maintenance plans
c) probabilistic design
and d) a rapid valuation methodology for land used for Environmental purposes, (see Appendix 2).

S5 In total 67 schemes were considered, of which 8 were in Welsh Region.

S6 Acknowledgment: The preparation of this report would not have been possible without the input and co-operation of staff and consultants, and the encouragement of the Project Board. Their help and assistance is gratefully acknowledged.

2. COMMENTS ON SELECTED SCHEMES AND RECOMMENDATIONS

W2 Sion Street - Pontypridd

W2.1 Sion Street is built along the left hand bank of the River Taff, immediately upstream of the Old Stone Bridge at Pontypridd. It is protected against flooding which would arise from flows reached with a storm of 1 in 100 year return period, by flood walls, gates and raised road levels.

W2.2 Data analysis, conceptual, and detailed design all appear simple, but there appears to have been no quality assurance undertaken, and the work was done totally "in-house".

Therefore, if a failure occurred as a result of "design error", the NRA would be directly liable.

No "free-board" appears to have been allowed in the calculations, - but physical constraints may have limited the scope for this.

W2.3 A relatively quick response is required for ensuring closure of gates (approximately 2 hours), and the effectiveness of this should be kept under review, with regular liaison being maintained with house occupiers (in case of changes).

W2.4 The properties are obviously still at risk of flooding if the design standard is exceeded, and this should be explained to residents, together with suggested action that they can take to reduce the extent of flood damage.

W2.5 Maintenance procedures, although limited, require further definition and documentation.

W2.6 Warning arrangements should be tested, by an exercise, involving the Police and Local Authority. (Note: see also Pontypridd F.A.S.).

Recommendations

From para		
W2.2	1)	Consider scope for "free-board" - if not already done.
W2.3	2)	Review adequacy of gate closure arrangements.
W2.4	3)	Write to residents - explaining design standard and how to reduce flood damage.
W2.5	4)	Define and document maintenance procedures.
W2.6	5)	Undertake exercise to test warning arrangements.

W3 Wentlooge Levels

W3.1 The Wentlooge Levels form a strip of flat, low lying land on the north side of the Severn Estuary, east of the city of Cardiff, extending to the western extremities of Newport. The land is protected from the sea by old, earth embankments which are inadequate in both size and construction standard.

W3.2 The land behind the defences is about 3 metres below extreme high tide level, and reports by Acer Consultants and Middlesex University Flood Hazard Research Centre, have concluded that action should be taken to improve the defence standards. The main reasons for these conclusions are:-

i) Inadequate standard of existing defence.
ii) Potential loss of life.
iii) Lack of pumping facilities to evacuate sea water entering the "Levels".
iv) Increased socio economic activity.

There are good benefit/cost ratios to justify capital investment. The NRA could be severely criticised and challenged for financial compensation, if action were not put in hand, as soon as practicable, to improve the existing situation.

W3.3 The existing banks are inspected regularly, and maintenance carried out as required. However, it appears that more work is desirable where "gouts" occur. In particular, the concrete revetment in these areas requires re-furbishment, to avoid potential weak spots.

W3.4 Recent surveys have shown that there has been considerable settlement of the banks (Note: they were 0.5m lower than previously thought) - and this tendency to settle will continue. Regular surveys are required to up-date information on levels (and on sea level rise).

W3.5 Access to some parts of the sea defences is not good, and this could cause delay in dealing with any breach, or potential breach. This issue should be reviewed to establish if easier and adequate access can be obtained.

W3.6 Maintenance of flap valves where drains pass through the embankments is particularly important, and adequacy of the activity should be reviewed.

W3.7 Monitoring, predicting and warning are extremely important, given the inadequacy of the existing defence standard, and the limited amount of maintenance that is undertaken. Indications are that the tidal prediction and warning system is not yet accurate enough. The combination of all these factors makes this scheme an extremely "high risk" scheme requiring urgent attention.

W3.8 Contingency plans should be drawn up, in consultation with the other emergency services, as a matter of priority.

Recommendations

From Para			
	W3.2	1)	Initiate capital improvement scheme as soon as possible.
	W3.3	2)	Increase maintenance at "gouts" including refurbishment of concrete revetment.
	W3.4	3)	Undertake regular (annual) surveys of embankments.
	W3.5	4)	Review and if possible, improve access facilities.
	W3.6	5)	Review maintenance arrangements for flap valves.
	W3.7 & W3.8	6)	Review existing warning arrangements and draw up contingency plans, in consultation with emergency services, as soon as possible.

W4 Whitland F A S

Whitland is mainly in the natural flood plain of the River Taf and because of its location it has suffered from serious flooding over a period of years.

The flooding is primarily attributable to high flows in the River Taf and the River Gronw.

In 1986, the banks of the River Gronw breached, north of the A 40 crossing, and the town centre, Primary School and Creamery were affected.

W4.2 As a result of the 1986 event, some improvements were carried out, and in 1991 W. A. Atkins produced a report suggesting further work to raise protection standards to 1 in 100, along the River Gronw, from its confluence with the River Taf, to a point 400 m upstream of the A 40 road bridge.

W4.3 The design suggestions appear to be appropriate, and data has been used from actual flood events, (ie levels taken from rock marks). Provision of a fixed weir and overflow channel to by-pass the existing sluice structure, should reduce risk of operational failures, and appears to be a sensible, basic concept.

W4.4 Hydrological data for the Gronw was supplied by the NRA. From the report, it is not possible to determine the reliability of the data, and the determination of the predicted peak flows for a 1 in 100 year return period is critical in the design process. If this has been underestimated, the required standard of protection may not be achieved, (although "free-board" has been allowed in the design).

W4.5 Operational involvement for the NRA is limited (mainly inspection), but the Creamery staff raise sluice gates at times of flood flows. This requirement should be fully , and formally documented in an "operational" procedure, and relative responsibilities/liabilities defined.

W4.6 Maintenance requirements also requires definition, with particular reference being made to arrangements for dealing with siltation, scour and continued stability of existing structures.

Creamery staff should be required to regularly check conditions where their building is cantilevered over the river, and where there is potential for blockage as a result of services crossing the river.

W4.7 There is no reference in the W. S. Atkins report to gauging stations on the River Gronw, or to a telemetry system.

Consideration should be given to the adequacy of monitoring, predicting and warning systems for Whitland, for occasions when design standards are exceeded.

Recommendations

From Para		
	W4.4 1)	Undertake a check on the calculation of the 1 in 100 year flows in the River Gronw and the River Taf, and their inter-relationship.
	W4.5 2)	Operational requirements for operating sluice gates should be documented, and relative responsibilities defined, (NRA and Creamery).
	W4.6 3)	Define maintenance requirements, with particular reference to dealing with siltation, checking scour and checking existing structures.
	W4.7 4)	Consider adequacy of monitoring and warning arrangements for Whitland.

W5 Carmarthen Flood Alleviation Scheme

W5.1 The River Towy, at Carmarthen, is affected by both fluvial and tidal flows. Over much of its length it has a wide, flat flood plain which has been developed at Pensarn for commercial and industrial use. Serious flooding of the area occurred in 1987, and this resulted in the design of the current defences.

W5.2 The scheme is phased, and Phase 1, consisting of channel improvements together with flood banks and walls is completed. Works in Phase 2 are dependent on the route of the proposed eastern by-pass.

W5.3 Obviously, until Phase 2 is complete, flood defence standards in parts of Carmarthen are less than desirable. If a long period is likely to be involved before construction of the Eastern by-pass, consideration should be given to the possibility of constructing temporary defence works - which, preferably, can ultimately be incorporated into the permanent works.

W5.4 As scour and siltation, historically, have been problems, regular monitoring is required to check that the scheme performs as predicted by the model tests. Sometimes reduction in scour at one location results in increased effects at another.

W5.5 Operationally, there is little involvement for NRA staff. However, probable "weak spots" in the system are the flap valves on the surface water sewers. In view of this, care should be taken to ensure that the responsible authority has adequate checking and maintenance procedures.

W5.6 The monitoring, predicting and warning systems appear to be appropriate, with adequate gauging stations, and telemetry links. Warnings are transmitted to the local NRA Depot, and to the Police, who issue public warnings.

W5.7 Adequacy of NRA response when warnings are issued depends on sufficiency of resources at the locald Depot. Care should be taken to avoid over-reduction of manpower when re-organising, or Depot response may be adversely affected.

W5.8 If pressure for development to the East of the A48 continues, special conditions may have to be placed on planning application to ensure adequate standards of protection, (ie raised floor levels, local improvement to defences etc).

W5.9 Wherever possible contributions should be sought from developers.

Recommendations

From	Para W5.3	1.	If Eastern by-pass delayed, consider possibility of temporary defences.
	Para W5.4	2.	Monitor scheme performance, compared to model test predictions, (beware of "scour").
	Para W5.5	3.	Ensure adequate checking and maintenance of flap valves on S.W. sewers.
	Para W5.7	4.	Avoid reduction of manpower resources at local Depot, to maintain adequate NRA response capability.
	Para W5.8& Para W5.9	5.	Control development in flood risk area to the East, and seek contributions for local improvements.

W6 Johnstown F A S

W6.1 The Johnstown area of Carmarthen is generally low lying, and properties south of the old A 40 Pontgarreg Culvert lie in the flood plain of the Tawelan Brook near its confluence with the River Towy. Flooding can occur as a result of high flows in the Tawelan Brook, but can also be caused by high water levels in the River Towy which is tidal. The circumstances leading to possible flooding are therefore, complex.

W6.2 Following severe flooding events in 1979 and 1987, a report was prepared in 1991, suggesting improvements by means of flood banks and walls to achieve a standard of protection of 1 in 100 year return period.

W6.3 The design allows for both maximum tidal and fluvial effects, and appears generally appropriate. However, the highway culvert under St Clears Road is thought to have insufficient capacity to deal with a 1 in 100 year event. If overflow or flooding occurred as a result of this, the main defence could possibly be outflanked.

W6.3.1 Discussions are on-going with the Highway Authority, and may lead to construction of a larger culvert. Whilst this situation exists, it would be advisable to ensure that adequate pumps exist locally which can be mobilised quickly if required.

W6.4 When the scheme concept was considered, several alternatives were investigated, including provision of a pumping station and provision of flood water storage. In view of the complexity of the design predictions, it may be necessary to review these options in the future.

W6.5 There are no screens located in front of existing culverts. They may not be required. However this situation should be kept under review, and coarse screens introduced, if necessary, to avoid blockages.

W6.6 Regular inspection/maintenance is required, of the stone clad walls, to assess how they perform when subjected to hydraulic loading.

W6.7 Warning systems for Johnstown are based on "informal" local arrangements. There is no information available from a telemetry system. Consideration should be given to either formalising the local arrangements to reduce risk, or installing gauging stations and a telemetry system to improve monitoring and predicting capabilities.

Recommendations

From Para		
W6.3	1)	Conclude discussion with Highway Authority as soon as possible regarding size of culvert under St Clears Road, and ensure pumps are available locally, until culvert size is increased.
W6.4	2)	Review design options when scheme has been subjected to significant hydraulic loadings.
W6.5	3)	Review need for coarse screens before culverts, if problems are experienced with blockages/siltation.
W6.6	4)	Ensure regular inspections of walls and banks.
W6.7	5)	Review adequacy of monitoring, predicting and warning systems, for extreme events.

W7 Bridgend F A S

W7.1 Bridgend is in the middle sub-area of a catchment approximately 168 sq km, drained by the River Ogmore.A large area of the town, including practically all the centre, is a potential flood risk area. The upper part of the catchment is mountainous, with fast, peaky flows from storms of short duration. Bridgend is moderately flat, exhibiting a marked change in river regime. The lower part of the catchment is flat, and subject to tidal influence.

W7.2 Improvements to defence standards have been carried out by construction of flood banks and walls, to heights sufficient to cater with flows from a 1 in 100 year event.

W7.3 The data analysis and conceptual design appear appropriate, but surface water drainage is adversely affected by the increased river levels. This possibility was recognised at the design stage, and cash allowed in the scheme to deal with the situation. Careful monitoring and recording should take place of any localised flooding which occurs from surcharge of the surface water drainage system and improvements undertaken if necessary, (eg localised pumping facilities provided).

W7.4 An inspection system for all flap valves on the surface water system should be agreed with the relevant drainage authority.

W7.5 A sensible feature of the scheme is construction of permanent access points for maintenance plant.

W7.6 Although the flow carrying capacity of the embanked channel has been increased, there are still restrictions to the flows at bridge abutments, and these should be regularly inspected for potential blockages.

W7.7 It is understood that some stop logging is required at times of high flows, and care should be taken to ensure that sufficient numbers of stop logs are available, locally, when needed.

W7.8 No exercises have been carried out to test warning procedures, and it appears that definition of roles and communication systems could be improved.

Recommendation

From Para		
	W7.3 1)	Monitor local surface water flooding, and, if caused by river levels, consider possible improvements in consultation with Drainage Authority.
	W7.4 2)	Ensure that inspection systems exist for all flap valves on S.W. system.
	W7.6 3)	Inspect bridge abutments regularly for possible obstructions, (and scour).
	W7.7 4)	Ensure sufficient stop logs are available, locally, for emergency situations.
	W7.8 5)	Investigate improvements to warning systems, and undertake to exercise to test.

W8 Hopkinstown F.A.S.

W8.1 The main trunk road (A4058) and some residential properties at Hopkinstown have been flooded frequently with water from the River Rhondda. A flood defence wall has been constructed to protect against flooding under flow conditions, resulting from a storm of 1 in 100 years return period.

W8.2 Data analysis and conceptual design are basic, but detailed structural design is more advanced. The design was undertaken "in house", and if a failure results from a design error, the NRA could be held accountable. There was no quality assurance undertaken at design stage. A simple check of the detailed design would be worthwhile.

W8.3 There are no manual operations involved with the defence system, but maintenance responsibilities rest with the NRA. A routine inspection and maintenance schedule should be established, and maintenance undertaken as necessary.

W8.4 The Baptist Church has not been protected by the scheme, and will still be prone to frequent flooding (1 in 10 year return frequency). This flooding is mainly in the basement, and consideration should be given to possibilities of relieving this situation, if possible.

W8.5 When road flooding does occur in the future, care should be taken to establish the cause. It may be completely localised, and not related to the River Rhondda.

Recommendations

From Para			
	W8.2	1)	Undertake a check on design calculations.
	W8.3	2)	Establish and document inspection and maintenance procedures.
	W8.4	3)	Re-consider protection of Baptist Church.
	W8.5	4)	Check cause of any future road flooding and record.

W11 Pontipridd F A S

W11.1 The town centre of Pontipridd suffers flooding both from the River Taff and from inadequate surface water drainage. Improvements have been undertaken to alleviate flooding from the river, by constructing a re-enforced concrete flood defence wall, earth embankments and blockstone armour revetments.

W11.2 As Pontipridd has been developed around the confluence of the Rivers Taff and Rhondda it is particularly susceptible to flooding. The scheme design relies on Ynysangharad Park acting as part of the flood plain, helping to reduce top water levels in extreme storms. This is not an ideal arrangement,

as the Park has a high amenity value, and damage from floods can be quite extensive. It may be worth further investigations to consider alternative schemes for overall protection of Pontipridd.

W11.3 The detailed design of the selected scheme appears to be appropriate but owners of properties in Mill Street, which will still have basements flooded regularly, will probably seek to place liability on the NRA in the future. Responsibilities for this should be clearly established, by taking appropriate legal advice, and the situation made clear to all property owners.

W11.4 Operational and maintenance requirements for this scheme will be relatively low, and limited mainly to inspection.

W11.5 When further flooding events occur, there is likely to be public debate and argument as to the course of the events ie were they caused by surface water drainage and /or river flows. There needs to be a clear understanding of the inter-relationship of the systems and of the possible causes and effects, in order to avoid litigation, or mitigate against suggestion of liability that are not warranted.

W11.6 If defence standards are exceeded, flooding in Pontipridd could cause very significant damage. It is important therefore that monitoring, predicting and warning systems are of a high standard. These should be checked for adequacy and tested by undertaking of appropriate exercises.

Recommendations

From Para			
	W11.2	1)	Review possibilities for alternative schemes for flood protection of Pontipridd, (in view of continued use of Park Area for flood storage).
	W11.3	2)	Seek legal advice (if not already sought), regarding flooding of basements in properties in Mill Street. Notifying owners accordingly.
	W11.5	3)	Ensure that inter-relationships between river flooding and flooding from surface water drainage systems is clearly understood.
	W11.6	4)	Improve monitoring, predicting and warning systems, and test by carrying out appropriate exercises.

NNW North Wales

WNW1 No scheme plans or documentation were received for North Wales, but a very useful day was spent with the Area Flood Defence Manager, and some site visits were made.

WNW2 The Western side of the Area is susceptible to, and prone to, "flash" run off from high intensity, short duration storms. This situation requires a warning system that is quick and effective, so that lowland farmers can move stock, before flooding occurs from main rivers (return frequency - probably 1 in 5).

WNW3 The warning system for the River Conway appears to be adequate.

WNW4 The Eastern side of the Area is more vulnerable when prolonged rainfall occurs. 19 Pumping Stations in the Dee and Clywd catchments have to be maintained during these situations. Some have by-passes, or overflows, some don't.

WNW5 The Area is split into zones, and operational procedures and maintenance requirements are being documented for each zone. The example seen of a "zonal plan" appeared to be very appropriate and well done. However, the production of zonal plans is being hampered by a shortage of resources, which has been increased as a result of the "client/contractor" split. Consideration should be given to increasing resources (even if on a temporary basis), to allow for rapid production of zonal plans, and to ensure adequate resources are available on the "client" side.

WNW6 Predictions of river flows are dependent on rainfall statistics, and gauged river levels. It is thought that in parts of the Area, more rainfall stations, and gauges would be helpful, and a review should be undertaken to determine need.

WNW7 A site visit was made to Llandudno junction, where completely inappropriate development has been allowed (as a result of a planning appeal), in the flood plain of the River Elwy. Property has already been flooded on 3 separate occasions, as a result of inadequate culvert size, blocked screens, and an event of probably exceptional severity (possibly 1 in 1000). Possible improvements to the flood defence system are currently being considered. However, the physical characteristics of the catchment may well preclude effective schemes to give an adequate standard of protection, at costs that can be justified. A compromise solution may have to be sought, at a reduced standard to that normally adopted for urban areas. If so, the arrangements will have to be carefully explained to all residents, who may be affected by future flooding. A letter should also be sent to the Welsh Office, placing responsibility on their Planning Inspectorate for allowing inappropriate development. Great care will have to be exercised in operating and maintaining any improved scheme.

WNW8 In some parts of the Area, consideration should be given to the preparation of contingency plans e.g. St Asaphs on the River Elwy, and Bangor on Dee where there is considerable pressure for development.

Recommendations

From Para			
	WNW5	1)	Consider increasing manpower resources, particularly to enable production of zonal plans.
	WNW6	2)	Undertake review of rain gauges and river level gauges and determine the need for adequate flood warning purposes.
	WNW7	3)	Write to all residents in Llandudno Junction who could be affected by future flooding, explaining limitations of improved scheme.
	WNW7	4)	Write to Welsh Office, Planning Inspectorate, placing responsibility on them for allowing inappropriate development.
	WNW8	5)	Consider need for contingency plan, and commence liaison with other authorities, to ensure production where required.

WFW Flood Warning

WFW1 A meeting was held with a member of staff involved in flood warning, and he explained the arrangements for the emergency control room. Some useful points came out of the discussions:-

WFW2 Manpower levels, for manning of the control room are just about adequate for a typical, regular annual event. However, if a prolonged event occurred, and shift systems were necessary, staff would be faced with working very long hours. Effectiveness may be reduced by tiredness, and it would be sensible to have more staff trained in control room duties, to cover such events.

WFW3 Monitoring and predictive systems require improvements. In particular, rainfall modelling is required for the upper reaches of the valleys, the coastal tidal system is not accurate enough, and improved weather radar is required for S. Wales.

WFW4 The "Voice Bank" arrangement in the River Wye catchment which can be interrogated by farmers, appears to be useful. Similar systems should be considered by other Regions, where appropriate.

WFW5 Trehaford and Gelli are in catchments which can reach flood conditions, very quickly. Hence the NRA have a very short response time. An exercise to test procedures in these catchments would be useful.

WFW6 At Rhymney and Ely, improved predictive capabilities would be helpful, as currently there are quite a few "false alarms". This is probably because the system is based on a "safety first principle". Better prediction would save unnecessary manpower utilisation.

WFW7 A suggestion was made that a cross-regional exchange of ideas on Flood warning systems should take place, through a meeting of a selection of Duty Officers. This suggestion is strongly endorsed, and the concept should be taken on "nationally".

Recommendations:

From Para			
	WFW2	1)	Train more people to work in the Emergency Control Centre.
	WFW3	2)	Pursue improvements to monitoring and predictive systems:- rainfall modelling in upper reaches of the valleys, coastal tidal warning, and weather radar for South Wales.
	WFW4	3)	Disseminate information on "Voice Bank" to other regions (if not already done).
	WFW5	4)	Undertake emergency exercise for Trehaford and Gelli.
	WFW6	5)	Improve predictive capability for Rhymney and Ely.
	WFW7	6)	Meeting of "Duty Officers" to be arranged nationally, to consider how Flood Warning Systems can be improved.

3. STANDARD METHODOLOGY FOR "RISK FACTORS" AND ACCOUNTABILITY ASSESSMENT

3.1 Flood defence schemes are constructed to protect people, property and the environment against the effects of flooding. Scheme standards are selected having regard to the type of area protected, and economic or benefit/cost criteria. No scheme provides absolute protection. It is a case of alleviation rather than elimination. In these circumstances, there are various aspects of "risk" involved. Adverse effects will occur if schemes fail, or if scheme standards are exceeded by extreme events. The NRA may be held accountable for financial consequences arising from failures, if these could reasonably have been avoided.

3.2 The probability of some failures occurring can be calculated, and risk quantified, but there are other "chance" events which can only be subjectively evaluated on the basis of past experience. Whatever the cause, potential NRA liability will be related to the value of what is protected. "Failures" and "effects" vary enormously. However, if the total protected value is multiplied by a factor which represents the combined "risk" and "chance" of accountable failures occurring, then an "accountability assessment" can be derived.

3.3 The assessment will give a value which is based on the assumption that the whole of the protected area is affected by flooding, following a "failure". Fortunately, this rarely occurs. A more realistic value could be arrived at by considering a proportion of the total protected value. However, this would not alter the relativity of the accountability assessments. Therefore, until more research is carried out relating "failures" to "monetary consequences", it is unnecessary to take a proportion of the protected value

3.4 The protected value provided by a scheme can be rapidly assessed by using House equivalent values as previously derived by Mott MacDonald for various types of properties, and land use. The Department of Transport has derived values for potential loss of life. However, no methods currently exist for rapid, monetary evaluation of land used for environmental purposes. As more data is collected, and evaluation techniques are developed further, this should become possible. It is certainly desirable, to ensure that environmental issues receive adequate consideration at the earliest "broad brush" stage of scheme appraisal. An "interim" method is referred to in the following paragraph.

3.5 A classification system for environmental land use is being developed by Jan Brooke of Posford Duvivier, to fit in with the NRA Standards of Service exercise. Full consultations are being held with representatives of various Environmental organisations (eg English Nature, R.S.P.B., Countryside Commission etc). The most recent consultation paper is reproduced in Appendix 2, together with a suggestion for assigning some preliminary monetary values to a limited number of the defined

classes and designated sites. It must be stressed that these values have only been derived by subjective comparison with other land use values, and they are not to be taken as being indicative of the "absolute" value of sites. These must be considered individually.

3.6 In this methodology, the basic formula used is:-

Accountability Assessment	=	Protected Value	x	"Risk Factor"
A.A. No.	=	P.V.	x	R.F.

where "Risk" factor is the combined "risk" and "chance" of accountable failures occurring.

3.7 The "A.A." number will not be a figure that could be used in economic appraisals, but it will give an indication of the relative potential monetary values that could be involved if failures occurred.

3.8 Derivation of "Risk Factors" as defined above can only be done by a subjective scoring methodology. The methodology needs to include all significant types of potential failures for which the NRA can be held accountable, and it needs to weight the various factors according to the possibility of occurrence. It also needs to include ways in which risk factors can be increased or decreased to reflect added system complexity or enhanced system security, (eg where several organisations are involved, or where there is good quality checking of a scheme).

3.9 A scoring system has been derived and is documented fully, together with definitions and explanatory notes, in Appendix 1.

The system is based around three main factors:-

a) The INHERENT "Risk" factor - that is involved in designing and constructing a scheme.

b) The SYSTEM "Risk" factor - that is involved in operating and maintaining a scheme.

and c) The ASSOCIATED "Risk" factor - that is involved in monitoring, predicting and warning processes.

3.10 The three factors combined have been taken to equal 1.00, and a weighting has been given:-

Maximum Inherent Risk	=	0.3
Maximum System Risk	=	0.5
Maximum Associated Risk	=	0.2

NOTE: For ease of calculation figures of 300, 500 and 200 have been used, and subsequently factored.

3.11 The minimum and maximum values which can be derived from the methodology are given in the following table.

	MIN	MAX	MIN	MAX	FACTORS
Design	20	150	28	300	INHERENT
Construction	8	150			
Operation	16	300	66	500	SYSTEM
Maintenance	50	200			
Monitoring, Predicting & Warning	32	200	32	200	ASSOCIATED
			126	1000	TOTAL
FACTORED VALUES			0.126	1.000	TOTAL

3.12 The methodology has been amended from the first draft, as a result of consultation with regional staff and consultants. It does not include every suggested alteration, but all comments have been considered, and many accepted.

It has been applied to over fifty selected schemes, and combined risk factors have ranged from just below 0.2 to over 0.6.

3.13 Potential "Accountability Assessments" have ranged from £11847 to 20 Billion +

4. USE OF METHODOLOGY AND FUTURE DEVELOPMENT

4.1 Although the methodology has been used to assess 50 plus schemes, this is still a relatively small sample, (see Appendix 3 for results).

If it were applied to more, then better consideration could be given to the appropriateness of the scoring system.

4.2 Also, a larger sample would enable meaningful, detailed comparisons of inherent, system and associated factors, to ascertain acceptable variations around mean values. If factors exceeded acceptable limits of variation on some schemes, then actions could be implemented to reduce them to acceptable levels.

4.3 If "accountability assessments" were carried out for all schemes, then priority ranking could be established for preparation of contingency plans. This is an area which the NRA need to work on in the near future, and resources may be scarce.

4.4 Comparison of individual factors could indicate where further resources need to be used in improvement of operational/maintenance plans and Flood Warning procedures.

4.5 Consideration of risk factors, and accountability assessments could influence scheme selection, and further development may lead to adoption of probabilistic design procedures.

4.6 As more data is collected, better monetary values could be assigned to the various environmental land use categories, as defined in Appendix 2, so that the environment gets full, appropriate recognition in any comparative assessments that are carried out.

4.7 When development is planned, and flood defence improvements are required, "accountability assessments" could be carried out for the existing and the planned circumstances. The difference in monetary value could then be used to negotiate contributions from developers, as it would be an indication of the increased "potential accountability" of the NRA.

APPENDIX No. 1

"SPACE" RISK ASSESSMENT PROJECT

FLOOD DEFENCE

STANDARD METHODOLOGY DRAFT 2

SCORING SYSTEM

DEFINITIONS AND EXPLANATORY NOTES

DESIGN

When a scheme is designed, data has to be analysed, a concept formulated, and details of structures determined.

If data is specific and adequate for the required analysis, then there is less chance of inappropriate design than if data sets are conflicting and if forecasting is required.

Simple, conceptual design, which requires basic elements only, with few or no moving parts is less likely to be prone to failure than a complex concept which relies on numerous inter-related moving elements.

Complex structural designs introduce more risk of failure, than basic simple designs. The "scale" or size of the scheme is also relevant.

If design work is carried out, totally, by NRA staff, then subsequent failure places the financial responsibility firmly with the NRA. However, if consultants have undertaken the work, the NRA may be able to recover some of the costs from them.

The chance of a design failure occurring can be reduced by undertaking Quality Assurance, and the potential effects reduced by inclusion of stand-by devices.

1.0	**Inherent Risk Design**						Score
1.1	Data analysis	specific data for design	conflicting data from different data sets		limited data -forecasting raced		
		10	20		35		
1.2	Conceptual design	Basic	Basic large scale	Advanced	Advanced large scale	Complex	
		10	20	25	30	35	
1.3	Detailed structural design	Basic	Basic large scale	Advanced	Advanced large scale	Complex	
		10	15	20	25	30	
1.4	Sub total - add figures in score column above =						
1.5	In house only					X 1.5	
	Combination of in house and consultant					X 1.5	
	Consultant only					X 1.0	
1.6	Standby devices included - limited	reduce by 10%					
1.7	Standby devices included - extensive	reduce by 20%					
1.8	No Q.A. used				reduce by 0%		
	Q.A. used - to British Standard				reduce by 10%		
	Q.A. used - independent technical audit				reduce by 20%		
1.9	**Inherent Risk - Design total** (carried forward to Grand Total) =						

1.0 **Inherent Risk** - risk associated with designing flood defence system.

1.1 Data Analysis - the level of complexity of the data to be analysed.

(i) specific data for design - whether the data analysed is historical event, gauge readings, mathematical modelling, etc, there is enough data to give accurate results.

(ii) conflicting data from different data sets - where at least two sets of data give different results.

(iii) limited data forecasting required - the data being used is unreliable for prediction purposes due to the low quantity of data.

Choose one of these categories and place in the score column.

1.2 Conceptual Design - the system selected for provision of flood defence.

(i) Basic - basic flood defence systems such as embankments, small concrete walls, etc.

(ii) Basic large scale - embankments and concrete walls but on a much larger scale to accommodate greater flows.

(iii) Advanced - design which involves several elements such as embankments/walls, pumping stations, outfalls etc.

(iv) Advanced large scale - as advanced but on a much larger scale to accommodate greater flows.

(v) Complex - design involving numerous inter-related elements.

Choose one of these categories and place in the score column.

1.3 Detailed Structural Design - concrete, steelwork calculations and drawings to enable conceptual design to be constructed.

(i) Basic - involves limited structural design eg simple floodbank.

(ii) Basic large scale - as above, but for much larger versions, increase in weighting to accommodate increase in risk.

(iii) Advanced - involves the use of concrete and steelwork calculations and drawings.

(iv) Advanced large scale - as in advanced but for much larger versions, in order to show difference in risk between say, a very small P. St. and a very large one.

(v) Complex - involves very complex calculations and drawings.

Choose one of these categories and place in score column.

1.4 Sub total - all figures derived form 1.1, 1.2 and 1.3 are to be added together and the score placed in the score column.

1.5 In house only - analysis and design completed by NRA design staff, this includes project managed schemes.

(if chosen, multiply figure in 1.4 by 1½)

Combination of in-house and consultant - analysis and design are carried out by both NRA and consultants or a number of consultants.

(if chosen, multiply figure in 1.4 by 1½)

Consultant only - a single consultant is responsible for the scheme, although some specialist parts the consultant may contract out.

(if chosen, multiply figure in 1.4 by 1.0)

Place score in score column opposite 1.5

1.6 Standby devices included - limited - if some of the likely failure modes are covered by standy devices.

(if incorporated reduce score in 1.5 by 10% and place new score in score column opposite 1.6)

1.7 Standby devices included - extensive - if standby generators, pumps, etc are included at design stage - - which cover all aspects of the system - then reduce score in 1.6 by 20%

(place score opposite 1.7 in score column)

1.8 No Q.A. used - if no systematic checking system is employed at design stage.

(reduce score in 1.7 by 0%, place in score column)

Q.A. used - to British Standard - systematic checking system employed to relevant British Standard.

(reduce score in 1.7 by 10%, place in score column)

Q.A. used - independent technical audit - design is checked independently as a technical audit.

(reduce score in 1.7 by 20%, place in score column)

1.9 **Inherent Risk - Design Total**:- score in 1.8 should be placed in this row and then carried forward to appropriate position in individual score column in the **Grand Total Summary Table.**

SEE OVER PAGE FOR

CONSTRUCTION RISK FACTORS

CONSTRUCTION

There is less chance of a "construction" failure occurring if the structure involved is basic and small scale, with very limited temporary works, than if the structure is complex with specialist processes and extensive temporary works. Construction works in a marine environment may be more susceptible to failure than works in a fluvial situation, because of the increased range of possible forces acting on the structures.

When construction work is in progress, there is an added possibility of construction failure.

Mechanical and electrical works involved in schemes increase the possibility of failures. Scale and complexity are again relevant.

If construction work is carried out directly by NRA employees inadequately, subsequent failure places responsibility firmly with the NRA. If contractors had carried out the work, they may be held liable. Chances of construction failure can be reduced by high standards of site control.

2.0	**Inherent Risk Construction**	Basic	Basic large scale	Advanced	Advanced large scale	Complex	Score
2.1	Civil Engineering (Fluvial)	5	10	14	18	20	
2.2	Civil Engineering (Marine) includes beach re-charge	15	20	25	30	35	
2.3	Work in progress	5	10	15	20	25	
2.4	Mech and electrical includes electronics	5	10	14	18	20	
2.5	Sub total - add chosen figures from above					=	
2.6	If in house					X 1.5	
2.7	Site quality control reduce scores by	Average		Good	Excellent		
		0%		10%	20%		
2.8	**Inherent Risk - Construction total** (carried forward to Grand Total) =						

2.0 **Inherent Risk - Construction** - risk associated with constructing flood defence system.

2.1 Civil Engineering Fluvial - civil engineering construction on a fluvial river (no tidal or coastal effects to consider).

(i) Basic - small embankments, walls etc with very limited temporary works.

(ii) Basic large scale - as above but on a larger scale and probably involving some temporary works.

(iii) Advanced - more advanced works on a fluvial river system which may include re-enforced concrete and steelwork and some temporary works.

(iv) Advanced large scale - as above but on a much larger scale.

(v) Complex - the use of piles, concrete, steel work, soil and rock stabilisation and other specialist processes, generally on a large scale.

Choose one category, if applicable, and place score in score column opposite 2.1.

2.2 Civil engineering (marine), includes beach re-charge - civil engineering construction in a marine environment (includes both coastal and tidal locations)

(i) Basic - simple construction process in a marine environment eg groynes, revetment etc.

(ii) Basic large scale - as above but on a much larger scale.

(iii) Advanced - civil engineering construction using advanced methods in difficult working conditions eg beach re-charge, reinforced concrete walls, step works, off shore reefs etc.

(iv) Advanced large scale - as above but on a much larger scale.

(v) Complex - civil engineering construction using difficult/complex methods in very difficult conditions eg barriers, tidal gates, etc.

Choose one category if applicable and place in score column opposite 2.2

2.3 Work in progress - when the risk analysis is assessed, the construction work is being done or is to be done.

(i) Basic - green field site with no link to an existing structure.

(ii) Basic large scale - as above but a much larger scale.

(iii) Advanced - new work is to be linked into existing structure, may involve temporary works.

(iv) Advanced large scale - as above but on a much larger scale.

(v) Complex - new structure is to be linked into several existing structures, involves a large degree of temporary works, etc.

Choose one category if applicable and place in score column opposite 2.3

2.4 Mechanical and electrical, includes electronics - construction involves the installation of electrical and mechanical systems.

(i) Basic - simple installation work such as penstocks and flaps.

(ii) Basic large scale - as above but on a much larger scale.

(iii) Advanced - more advanced installation work such as pumps, etc.

(iv) Advanced large scale - as above but on a much larger scale.

(v) Complex - more complex installation work such as electrical and electronic control systems.

Choose one category, if applicable, and place in score column opposite 2.4

2.5 Sub total - add chosen figures from above - add all figures from 2.1, 2.2, 2.3 and 2.4 and place score in score column opposite 2.5

2.6 If in house - if main works are carried out by NRA work force then multiply figure in 2.5 by 1.5 and place score in score column opposite 2.6

2.7 Site quality control - client uses resident engineer, clerk of works to ensure specification is complied with - via testing of materials, checking setting out, check temporary works.

(i) Average - minimum client input and monitoring - reduce score in 2.6 by 0%

(ii) Good - resident engineer present on site - reduce score in 2.6 by 10%

(iii) Excellent - resident engineer, clerk of works, materials and methods checked - reduce score in 2.6 by 20%

Choose one category and apply factor to score in 2.6 - place in score column opposite 2.7

2.8 **Inherent risk - Construction Total**:- score in 2.7 should be placed in this row and then carried forward to appropriate position in the individual score column in the **Grand Total Summary Table.**

SEE OVER PAGE FOR
SYSTEM RISK FACTORS

SYSTEM RISK FACTORS

OPERATION

When flood defence systems have to be operated by NRA employees, there is a relatively high "risk" of the NRA being held accountable for failures if the systems are not operated adequately.

If the acceptable response is short (ie less than 6 hours), then the chances of failure occurring are greater than they would be if the response times were longer.

The chances of NRA employees taking inappropriate or inadequate action are increased if the defence system is complex, and if it relies on sequential but co-ordinated manual actions.

The fewer the number of moving parts, the lesser the "risk" of system failures.

Stand-by devices can reduce the potential effects of systems "failures", and the chance of organisational failure can be reduced by undertaking exercises which test the procedures.

3.0	**System Risk Operation**	Allowable Response Time		Score
3.1	Type of operation system	Greater than 6 hours	Less than 6 hours	
3.2	No elements move	30	60	
3.3	No elements move but rely on manual operation (eg manually raked screen)	60	90	
3.4	Elements move independently, automatically	80	120	
3.5	Elements move independently, but only with manual operation	120	180	
3.6	Elements move, inter related, but automatically. Complex.	160	240	
3.7	Elements move, inter related but rely on manual operation. Complex.	200	300	
3.8	Choose one figure from the above and insert in box:-			
3.9	Limited standby devices included against M & E breakdown	reduce by 10%		
3.10	Extensive standby devices included against mechanical or electrical breakdown	reduce by 20%		
3.11	No exercises undertaken Reduce risk by undertaking exercises occasionally Reduce risk by undertaking exercises regularly	0% 10% 20%		
3.12	**System Risk - Operation total** (carried forward to Grand Total)		=	

3.0 **System Risk - Operation** - risk associated with the operation of a flood defence system as designed.

(a) Allowable response time - time allowed for conditions to reach flooding level based on local characteristics.

(i) greater than six hours - indicates that there is more than six hours to respond to the system

(ii) less than six hours - indicates that there is less than six hours to respond to the system

3.1 Type of operation system - what is the general arrangement of the operating system - choose one element 3.2 to 3.7 inclusive.

3.2 No elements move - a very simple operational system eg earth embankment.

3.3 No elements move but rely on manual operation - a very simple operational system but requires manual input eg debris screen on a culvert.

3.4 Elements move independently, automatically - an operational system comprising of a number of separate elements which operate independently of each other and automatically.

3.5 Elements move independently, but only with manual operation - an operational system comprising of a number of separate elements which operate independently of each other but require manual operation.

3.6 Elements move, inter related, but automatically complex - a complex moving operational system comprising of numerous inter related elements but run automatically.

3.7 Elements move, inter related but rely on manual operation, complex - a complex moving operational system comprising of numerous inter related elements which rely upon manual operation.

3.8 Choose one of the categories 3.2 to 3.7 inclusive, decide upon response time and place chosen score in score column opposite 3.8

3.9 Limited standyby devices included against mechanical or electrical breaksown - if standby generators, pumps, etc are on site permanently, (if incorporated, reduce score in 3.8 by 10% and place new score in score column opposite 3.9).

3.10 Extensive standby devices included against mechanical or electrical breakdown - if standby generators, pumps, etc are on site permanently; reduce score by 20%, (if incorporated reduce score in 3.9 by 10% and place new score in score column opposite 3.10).

3.11 (i) No exercises undertaken - if no system testing exercises in operation - reduce score by 0%

(ii) Exercises occasionally - if the system is tested but there is no regime, then reduce the figure in 3.10 by 10% and place score in the score column opposite 3.11

(iii) Exercise regularly - if system is tested regularly according to a regime then reduce the figure in 3.10 by 20% and place score in score column opposite 3.11

3.12 **System Risk - Operation Total**:- score in 3.11 should be placed in this row and then carried forward to appropriate position in the individual score column in the **Grand Total Summary Table.**

MAINTENANCE

To reduce the risk of failure from inadequate maintenance, it is important that the frequency of each maintenance task is clearly defined and adhered to, (except for variations necessitated by weather conditions).

Reactive maintenance is the most likely system to lead to "maintenance" failures, and hence warrants the highest "risk factors".

Risk may be reduced by inspection, but it will only be minimised if work is clearly defined, carried out, and quality checked independently.

4.0	**System Risk - Maintenance**	Bldgs	Hard Defences	Banks	M & E	Channel Works	Score
4.1	Not clearly defined - reactive maintenance only	20	30	45	45	60	
4.2	Not clearly defined - routine inspection but less than optimum maintenance - no checks	18	27	40	40	54	
4.3	Not clearly defined - routine inspection but less than optimum maintenance - check on work done	16	24	35	35	48	
4.4	Clearly defined - less than optimum maintenance	14	21	30	30	42	
4.5	Clearly defined - optimum maintenance carried out	12	18	25	25	36	
4.6	Clearly defined - optimum maintenance carried out - checks carried out on work done	10	15	20	20	30	
4.7	**System Risk - Maintenance** (carried forward to Grand Total)						

4.0 **System Risk - Maintenance** - risk associated with the operation of a flood defence system.

(i) Bldgs - buildings - refers to parts of the system that could be classified as buildings.

(ii) Hard Defences - refers to parts of the system that could be classified as hard defence such as revetment, concrete flood wall, piled walls, sea defence, etc.

(iii) Banks - refers to parts of the system that could be classified as banks such as earth embankments, etc.

(iv) Channel works - refers to part of the system that could be classified as channel works such as dredgers, weed control, erosion control, etc.

(v) M & E - refers to part of the system that could be classified as Mechanical and Electrical (including electronics) such as generators, pumps, barrier gates, hydraulics, etc.

NOTE All of the above components may be present in a particular scheme, so each will need to be assessed under system risk maintenance.

4.1 Not clearly defined, reactive maintenance only - the maintenance for the system is not documented and no maintenance regime exists. Maintenance is carried out when a problem is noticed. No routine inspection.

4.2 Not clearly defined, routine inspection but less than optimum maintenance - no checks -

the maintenance for the systems is not documented and relies upon routine inspection to develop the maintenance regime. The amount of maintenance on the system is less than perfect and no checks are carried out to see if programmed maintenance has been carried out and its quality.

4.3 Not clearly defined, routine inspection but less than optimum maintenance - check on work done -

as above except checks on the programmed maintenance are carried out.

4.4 Clearly defined, less than optimum maintenance -

the maintenance for the system is well documented but the amount of maintenance is less than perfect. No checks have been carried out.

4.5 Clearly defined, optimum maintenance carried out -

the maintenance for the system is well documented and carried out to the required standard. No checks on the maintenance have been carried out.

4.6 Clearly defined, optimum maintenance carried out - checks carried out on work done -

as above, but checks on work are done to ensure continuity and quality.

4.7 **System Risk - Maintenance** - all row scores in 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6 should be totalled and placed in the score column. The score column should then be totalled and this figure placed in the score column opposite 4.7 This figure should then be carried forward to the appropriate position in the individual score column in the **Grand Total Summary Table.**

MONITORING AND PREDICTING

The NRA need to be aware of the conditions to which their flood defence schemes are being subjected. To achieve this, water levels and climatic conditions must be carefully and continuously monitored.

Every scheme standard can be exceeded in extreme climatic conditions, and it is very desirable to be able to predict these situations.

If monitoring systems are only sufficient to judge conditions prevailing over relatively large areas of the country eg equal to the NRA "Areas", then the risk of being wrong with predictions at local level is increased. However, if the monitoring system is such that accurate local predictions can be made, relative to the particular flood defence scheme, then "risk" is reduced.

WARNING

When flooding is predicted, it is necessary to notify the Police, other emergency authorities, and some-times individuals or organisations.

The NRA role in the notification process is primarily to contact the Police and local authorities who in turn arrange for the general public to be notified.

However, liaison and communication systems do vary around the country, and the Police and the local authorities are not totally consistent in what they are able or willing to do. In these circumstances, it is vitally important that, at local level, there is a clear definition of roles, and efficient communication systems.

The clearer the definition of roles, the better the communication systems, and the more effective the communication to the general public, the less the risk of accountable "failure".

Exercises to test procedures and communication systems can help to reduce the possibility of mistakes, and to define system improvements.

5.0	**Associated Risk - Monitoring and Predicting**	Excellent	Good	Average	Score
5.1	AREA	40	45	50	
5.2	ZONAL	35	40	45	
5.3	LOCAL	30	35	40	
5.4	**Associated Risk - Monitoring and Predicting** (select lowest figure - carry forward to Grand Total =				

6.0	**Associated Risk - Warning**	Excellent	Good	Average	Score
6.1	Definition of roles	20	35	50	
6.2	Liaison communication systems	20	35	50	
6.3	Communication to general public	20	35	50	
6.4	Sub total - add all figures in score column =				
6.5	No exercises undertaken	reduce by 0%			
	Exercises undertaken occasionally	reduce by 10%			
	Exercises undertaken regularly	reduce by 20%			
6.6	**Associated Risk - Warning total** (carried forward to Grand Total) =				

5.0 **Associated risk** - risk of warning system failing when flood defence scheme standard is exceeded as a result of extreme climatic conditions.

(i) Monitoring - awareness of each reaction/situation with respect to water levels and climatic conditions.

(i) Predicting - ability to look ahead and forecast flood levels.

5.1 Area - areas equivalent to the NRA organisational areas.

Choose either excellent, good or average and place the score opposite in the score column.

5.2 Zonal - areas based on catchments, but less in size than NRA organisational areas.

Choose either excellent, good or average and place the score opposite in the score column.

5.3 Local - area protected by the individual flood defence system.

Choose either excellent, good or average and place the score opposite in the score column.

5.4 **Associated Risk - Monitoring and Predicting** - select the lowest score from the score column and place in the score column opposite 5.4. This figure should then be carried forward to the appropriate position in the individual score column in the **Grand Total Summary Table.**

NOTE - if none of these systems exist then assume a score of 50.

5.5 Excellent - accurate weather data, tidal data, and/or river level data sets are always available. Characteristics of a system are sufficiently well defined to enable accurate and timely predictions. No deficiencies of monitoring stations or staff trained.

5.6 Good - reasonably accurate data sets are generally available and system characteristics well known. Resource deficiencies are only marginal eg extra gauging station required.

5.7 Average - limited data sets are available, and some knowledge of system characteristics. A degree of "unpredictability" is known to exist, which could be reduced.

6.0 **Associated Risk - Warning** - the ability to give prior notification of flooding occurrences to the bodies concerned.

6.1 Definition of roles - who is responsible for what and to whom - hierarchy and procedure set up.

Choose either excellent, good or average to describe your system with regards to the above. Place score in score column opposite 6.1.

6.2 Liaison communication systems - ability for the warning system to function through the hierarchy.

Choose either excellent, good or average to describe your system with regards to the above. Place score in score column opposite 6.2

6.3 Communication to general public - ability to give information to the general public on flood situations.

Choose either excellent, good or average to describe your system with regards to the above. Place score in score column opposite 6.3

6.4 Sub-total - add all figures in score column. Place total in score column opposite 6.4

6.5 (i) No exercises undertaken - if no warning system exercises undertaken then reduce figure in 6.4 by 0%

(ii) Exercises undertaken occasionally - if warning system is exercised occasionally then reduce figure in 6.4 by 10%

(iii) Exercises undertaken regularly - if warning system is exercised regularly then reduce figure in 6.4 by 20%

6.6 **Associated Risk Warning** - score in 6.5 should be placed in this row and then carried forward to appropriate position in the individual score column in the **Grand Summary Total Table.**

6.7 Excellent - virtually no chance of confusion. Positive procedures, well documented, understood and accepted by all parties involved. Should always meet target level of service.

6.8 Good - procedures defined and generally understood. Would usually meet target level of service.

6.9 Average - procedures exist, but still require final acceptance by some parties. There may be difficulties in achieving target level of service, until further improvements are made to the system.

Grand Total Summary		Individual	Section Scores	% of Section Scores	MIN	MAX
Inherent	Design				28	300
	Construction					
System	Operation				66	500
	Maintenance					
Associated	Monitoring and Predicting				32	200
	Warning					
		TOTAL			126	1000
		RATIO				

space\table.4

APPENDIX No. 2

DRAFT CLASSIFICATION

OF LAND USED FOR ENVIRONMENTAL PURPOSES

ENVIRONMENTAL USE OF LAND - VALUATION

The assignment of monetary values to land used for environmental purposes is extremely difficult. This is partly because economic valuation methods for such land are relatively limited, and partly because the uses of such land are so different. Land of existing environmental value may be detrimentally affected by periodic flooding, or it may be enhanced. The key factors appear to be the vulnerability of the habitat to periodic flooding, and the recoverability. There is a distinct lack of information available regarding the latter.

Notwithstanding the above difficulties, it is seen as being desirable, in the interests of the environment to ensure that the NRA take into account environmental issues in their deliberations on development of standards of service and risk assessment.

The classification system outlined in the paper, by Jan Brooke of Posford Duvivier for this project, (based on the work undertaken for the Anglian Region Standard of Service Project), is a very commendable attempt to combine consideration of importance of a site, (according to its designation), with the vulnerability of the habitat, (see pages 36 to 41). Together these factors may indicate, for some sites, the importance of providing flood defence to specified standards. From the paper, class E1 would suffer Significant Damage or even irreparable damage from flood events, whilst class E2 would suffer Recoverable Damage. Classes E3, E4, E5 and E6 would be affected differently by flooding or flood defence works. Some of them would benefit, whereas others would be damaged.

Building on the work by Jan Brooke however, it is suggested that for Classes E1 and E2, house equivalent values could be established for the various categories and habitats, by the using the range of figures that exist for other land uses. It could be ensured, for instance, that the lowest rated , ESA, was higher in value than pasture land. The most valuable RAMSAR sites could be given figures which equate to low density housing sites. This would value them at considerably more than intensive agriculture. In this way, for comparative purposes only, the environmental use of land would be accounted for, and not neglected, or undervalued compared to other interests. Figures in this report are based on figures in R & D Note 187, (see page 44).

It may be possible to check the range of values allocated by reference to known, specific, replacement values, (eg saltmarsh regeneration/creation - cost approx £500/hectare), or to known contingent valuation studies.

As the methodology outlined is very subjective, it is further suggested that a range of values could be given to each class, category and habitat. Selection of the most appropriate figure could then be made by staff having adequate local knowledge.

Figures for H.E. monetary values are not currently very robust, and need checking against flood damage costs arising from actual events. However notwithstanding this limitation, a few examples of ranges of possible H.E.s for some types of environmental land are given below:-

Note: Units per hectare

		HE Values Fluvial Flooding			HE Values Saline Flooding		
RAMSAR/SPA	E1	1.8	→	9.0	9.0	→	18.0
	E2	0.6	→	0.9	1.8	→	9.0
NNR/SSSI	E1	1.35	→	6.75	6.75	→	13.5
	E2	0.45	→	0.67	1.35	→	6.75
AONB	E1	0.90	→	4.50	4.50	→	9.0
	E2	0.30	→	0.44	0.90	→	4.50
LNR	E1	0.45	→	2.25	2.25	→	4.50
	E2	0.15	→	0.22	0.45	→	2.25
ESA	E1	0.18	→	0.90	0.90	→	1.80
	E2	0.06	→	0.09	0.18	→	0.90

With further study and comparison these could be interpolated and applied to all classes given in table A, (see pages 42 & 43).
The results could then be used in the rapid assessment methodology when calculating total Protected values.

"SPACE" RISK ASSESSMENT PROJECT - FLOOD DEFENCE ENVIRONMENTAL ASSETS

FINAL REPORT
JUNE 1994

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1. Background

1.1 In parallel to developing an appreciation of the type, scale, etc. of assets for which the NRA has flood defence responsibility, various other studies are being undertaken on a more site specific basis to establish the approximate value of the assets protected within defined areas in order to determine an appropriate and consistent standard of flood defence. This work is commonly known as defining 'standards of service'.

1.2 The standards of service work currently being undertaken by Posford Duvivier for NRA Anglian Region involves developing a broad brush classification system for determining an appropriate and consistent standard of defence for hydrologically defined "compartments" throughout the Anglian Region. The completed classification system will be used to compare the existing standard of defence against that determined to be appropriate to the assets (properties, services, infrastructure, agricultural land, etc.) within the compartment. The objectives are to ensure that areas with similar assets are provided with the same standard of protection (unless there are special circumstances), and to help set priorities for more detailed investigations and any subsequent works.

2. Standards of Service Philosophy

2.1 The standards of service system works by classifying all assets according to their "house equivalent" (HE) value. An average residential property provides the base of one house equivalent and other assets are valued accordingly. For example, 100ha of extensive pasture has been determined to be equivalent to 1.3 HEs; 100ha of intensive arable to 44.1 HEs; 1m^2 of manufacturing to 0.03 HEs; a motorway to 63.5 HEs; a C Road to 2.7 HEs; etc.

2.2 Using the NRA Anglian system, in so far as it has been developed to date (June 1994), a series of land use bands have been defined according to the total number of HEs protected per kilometre of defence in each compartment. Consistent target standards of defence are then allocated to each compartment according to the land-use band. For example, where there are in excess of 50 HEs per km of defence, a minimum target defence standard is 1 in 200 years. Where there are between 1.25 and 4.99 HEs per km of defence, the minimum target defence standard is 1 in 20 years, and so on.

2.3 Although the standards of service system is designed to assist in the decision making process viz a viz defence standards, it effectively provides an inventory of the assets for which the NRA have a flood defence responsibility, and an idea of their value. The way in which environmental assets are considered within the standards of service methodology is therefore also appropriate to the "space" risk assessment project.

2.4 To date the classification system for environmental assets has been prepared as a draft document for discussion with NRA and the conservation agencies. Assuming the principles are accepted, all designated conservation sites in the Anglian Region will be reviewed and each will be placed into one or more of the five categories described in Section 4. Once this review is complete, the characteristics of the sites in each class will be assessed (eg. their vulnerability to fresh or saltwater flooding, for example), and a literature search and review will be used to help identify an appropriate standard of defence against flooding for each class.

3. Background to the Draft Environmental Classification

3.1 In order to ensure that environmental interests are given due consideration within the broad brush screening exercise to determine appropriate standards of service, a classification system similar in principle to that used for valuing other assets is required.

3.2 Within the Anglian Region there are hundreds of sites designated to protect their ecological and/or landscape interest. Although the relative importance of these sites can be determined by their designated status, the designation alone is inappropriate for use in determining an appropriate standard of flood defence. This is because the amount of damage caused by a flood event will be controlled by, *inter alia*, the type of habitat affected and the susceptibility of that habitat to flood damage

3.3 In the first instance, different types of habitat will be affected in different ways by flooding. Whether the flood is freshwater or saltwater in nature will be of particular importance in determining whether or not the habitat will recover easily. It is also acknowledged that floods of different durations, seasonality, etc. will have varying ecological effects. This level of detailed assessment is, however, too complex to be dealt with via the broad standards of service screening process.

3.4 In terms of classifying a site (and hence determining an appropriate standard of service), its designation can be used to give an initial indication of its vulnerability to flooding. In general terms, sites designated as Ramsar Sites, Special Protection Areas (SPA) or Sites of Special Scientific Interest (SSSI) are more likely to contain species or communities which are "special" (and therefore potentially vulnerable) than Local Nature Reserves (LNR). Landscapes protected by designations such as Heritage Coasts or Areas of Outstanding Natural Beauty (AONB) depend less on the survival of particular species or even communities, than on the continued integrity of the general type of habitats making up a particular landscape. Environmentally Sensitive Areas (ESA) are, similarly, designated primarily to maintain a particular type of overall landscape rather than specific species or communities.

4. Draft Classification[1]

4.1 For the purposes of a broad assessment appropriate to setting approximate standards of service, habitats can therefore be classified according to the damage which might be caused to a particular resource of a given designation. Five classes have been defined which accord to different requirements in terms of standards of service provision. The five classes are defined in the following subsections.

[1] Based on Document D8, Paper No. 7 Methodology for HE Conservation, prepared for NRA Anglian Region April 1994.

4.2 E1 Significant Damage

Some habitats are potentially vulnerable to significant or even irreparable damage from flood events. Freshwater habitats such as grazing marshes, especially those containing rare species dependent on particular physical conditions (water level, water quality, etc.), can suffer significant damage if flooded with saltwater for any length of time. Saltmarsh species, conversely, will not withstand prolonged inundation with freshwater because of competition from freshwater species. Sites designated as being of particular importance (eg. Ramsar Sites or Sites of Special Scientific Interest) are, in general, more likely to be home to rare and/or sensitive species and communities than, for example, Local Nature Reserves. The former sites therefore arguably require a higher standard of protection, being more susceptible to incomplete or non-recovery.

4.3 E2 Recoverable Damage

Several habitat types will be detrimentally affected by flooding in the short term, but will recover over a period of years, to a comparable status in terms of species, etc. This category includes, for example, the freshwater flooding of habitats such as fen woodland and the saltwater flooding of brackish grazing marshes. It also includes habitats such as unimproved grassland where the level of designation indicates few (or no) particularly sensitive species are present (ie. the site more likely to recover with time). Many of the more common freshwater grazing marsh species will eventually recover from saltwater inundation, especially if flooding occurs during the "dormant" winter period (ie. outside the growing season) or if other, unaffected, sites nearby supply a source of plants for recolonisation. The same applies to the more common saltmarsh species when affected by freshwater flooding. The habitats in this category require a standard of defence which is sufficient both to allow the community to become completely re-established, and to thrive un-hindered for some time between flood events. In other words, if it takes 10 years for a community to recover, a flood defence standard of 1 in 10 years would be too low to offer protection and a standard of, say, 1 in 25 to 1 in 50 years may be more appropriate.

4.4 E3 No Damage

For some types of habitat, flooding may not cause any damage. Freshwater grazing marsh can, in most cases, tolerate freshwater flooding. So too can standing or flowing freshwater habitats. Saltmarsh will generally withstand saltwater inundation with no damage. Such habitats would not, however, necessarily benefit from any change to the status quo situation.

4.5 E4 Benefit

In a limited number of cases, habitats may benefit from flooding (ie. the nature conservation value will be improved). Of particular importance in this respect is the winter, freshwater flooding of grazing marshes as exemplified by the Ouse Washes and by the recent initiatives to introduce winter flooding to the Somerset Levels and Moors.

4.6 E5 Dependent on Current Defence Regime

Finally, some habitats in fact depend on the current defence regime. A grazing marsh with brackish communities in its ditch system may, for example, depend on frequent but minor overtopping, or seepage through or under the defence. A coastal lagoon may be entirely dependent on a combination of saltwater overtopping or seepage and freshwater run off. In either case, raising or strengthening the flood defence could significantly affect the continued viability of the habitat and it can therefore be argued that the habitat is dependent on the maintenance of the status quo situation with respect to both the nature and the standard of the defence. It should be noted, however, that this dependence may, in some cases, be in addition to any damage which might be caused by a flood event. In other words, these habitats cannot tolerate any damage.

4.7 Susceptibility of Habitats

Table 1 identifies different habitat types according to their general susceptibility to being damaged by (or benefit from) salt or fresh water flooding. The designations shown on the table are, however, preliminary. The work required to refine the system (ie. consultation and classification of representative sites) has not yet been completed. It should also be acknowledged that, even when this refining exercise has been carried out, the table will still represent typical cases and exceptions to the general rule should therefore be anticipated. Finally, it should also be noted that Table 1 assumes flood events occur during the winter months.

5. Proposed Development of Methodology

5.1 It is proposed that, following agreement with National Rivers Authority, the draft environmental classification will be confirmed with relevant agencies. These will include English Nature, Countryside Commission, Royal Society for the Protection of Birds and MAFF. Following this consultation, a review of information presently held by National Rivers Authority on SSSI designated sites, and further information where necessary from the nature conservation agencies, will enable each site to be classified according to Table 1. As discussed in Section 4.7 the methodology may require modification once the consultation and classification exercise have been undertaken. Overall, the methodology will provide, for each site, a broad indication as to how significant the effects of flooding (or lack of flooding) might be.

5.2 Once each site has been classified (see Table 1) further discussions with National Rivers Authority will be held to ensure that the environmental classification corresponds with the HE assessment.

5.3 Valuation

The classification being devised for environmental assets will not involve the placing of an economic value on sites of conservation importance. The standard of defence identified as being required to protect such a site will depend entirely on the latter's characteristics (status, vulnerability, length of time to recover, etc.). Under the standards of service methodology, where there are various assets protected within a single compartment, the asset requiring the highest standard will generally determine the target standard for that compartment. Given that many sites of nature conservation importance are in rural areas, it is therefore possible that the presence of a site of environmental interest requiring protection against flooding will be the primary factor in determining the overall standard of defence in some compartments. Because of this, there is likely to be pressure, when detailed studies are carried out, for a money value to be placed on the resource to justify the proposed standard. At detailed investigation stage, such justification might be sought by using environmental economics techniques or via a qualitative process. It is particularly important, however, that the temptation to place a value on such an environmental resource by comparing it with an estimated economic value of the tangible assets in an equivalent standards of service class is avoided.

6. Conclusions and Recommendations

6.1 The methodology set out above has been developed for the purposes of ensuring that ecological (and landscape) resources within the National Rivers Authority Anglian Region are adequately considered within the decision making process and ultimately receive an appropriate standard of flood defence. The principle used to develop this approach could equally be applied to the protection of archaeological, heritage, recreation and amenity resources. The coverage of the evaluation could also be extended to include other sites (eg. wildlife trust reserves).

6.2 The methodology developed is not intended to be definitive, rather to provide guidance at the broad brush screening stage. Further detailed studies would be required in most instances to confirm (or otherwise) the target standard of defence for the environmental assets within a particular compartment.

6.3 Relatively little comprehensive research has been carried out to establish the rate at which different habitats/species recover after inundation. More detailed studies, either on sites prone to flooding or in controlled "laboratory" experiments, are needed to refine the methodology and define more accurately the standard of service appropriate to a particular habitat/site. Similar work (ie. on recoverability) would be needed for archaeological or recreational resources.

6.4 Great care must be taken in placing monetary values on environmental resources. In particular, the HE value for other assets (eg. property) should not be used to imply a monetary value for environmental goods.

TABLE 1 STANDARDS OF SERVICE
ECOLOGICAL CLASSIFICATION METHODOLOGY (Draft)

Habitat (1)	Designation	Freshwater Flooding					Saltwater Flooding				
	Description	SD	RE	ND	BE	DE	SD	RE	ND	BE	DE
	Classification	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
Saltmarsh	Ramsar/SPA	√	√								√
	NNR/SSSI	√	√								√
	AONB/Heritage C		√								√
	LNR		√								√
	ESA		√								√
Grazing Marsh (Vegetation)	Ramsar/SPA			√(2)	√(2)		√				
	NNR/SSSI			√(2)	√(2)		√				
	AONB/Heritage C				√(2)			√			
	LNR				√(2)			√			
	ESA				√(2)			√			
Lowland Wet Grassland	Ramsar/SPA					√(3)	√				
	NNR/SSSI					√(3)	√				
	AONB/Heritage C					√(3)		√			
	LNR					√(3)		√			
	ESA					√(3)		√			
Grazing Marsh (Freshwater Ditches)	Ramsar/SPA			√(4)			√				
	NNR/SSSI			√(4)			√				
	AONB/Heritage C			√(4)				√			
	LNR			√(4)				√			
	ESA			√(4)				√			
Grazing Marsh (Brackish Ditches)	Ramsar/SPA	√	√					√			√
	NNR/SSSI	√	√					√			√
	AONB/Heritage C		√					√			√
	LNR		√					√			√
	ESA		√					√			√
Coastal Lagoon (Brackish / Saline)	Ramsar/SPA	√					√	√			√
	NNR/SSSI	√					√	√			√
	AONB/Heritage C		√						√		√
	LNR		√					√			√
	ESA	...	...	...	...	N/A	...	...	...	...	...
Standing Water (Freshwater)	Ramsar/SPA			√			√	√			
	NNR/SSSI			√			√	√			
	AONB/Heritage C			√				√			
	LNR			√				√			
	ESA	...	...	...	...	N/A	...	...	...	...	...
Flowing Water (Freshwater)	Ramsar/SPA			√			√	√			
	NNR/SSSI			√			√	√			
	AONB/Heritage C			√				√			
	LNR			√				√			
	ESA	...	...	...	...	N/A	...	...	...	...	...
Woodland (Lowland Broadleaf	Ramsar/SPA	...	...	...	...	N/A	...	...	...	...	...
	NNR/SSSI		√				√				
	AONB/Heritage C		√					√			
	LNR		√					√			
	ESA		√					√			
Fen Woodland (Carr)	Ramsar/SPA		√				√				
	NNR/SSSI		√				√				
	AONB/Heritage C		√					√			
	LNR		√					√			
	ESA		√					√			
Fen / Reedbeds	Ramsar/SPA					√	√				
	NNR/SSSI					√	√				
	AONB/Heritage C					√		√			
	LNR					√		√			
	ESA					√		√			
Grassland (Unimproved)	Ramsar/SPA	√	√				√				
	NNR/SSSI	√	√				√				
	AONB/Heritage C		√					√			
	LNR		√					√			
	ESA		√					√			
Lowland Heathland Breckland	Ramsar/SPA	√					√				
	NNR/SSSI	√					√				
	AONB/Heritage C		√					√			
	LNR		√				√	√			
	ESA		√				√	√			

(1) Assumes that all habitats are behind existing defences.

(2) Assumes no damage or benefit from winter flooding (damage would result from summer flooding)

(3) Assumes dependance on winter flooding (summer flooding would result in recoverable damage).

(4) Assumes no damage from winter flooding (summer flooding would result in recoverable damage).

Key
SD = Significant Damage
RE = Recoverable Damage
ND = No Damage
BE = Beneficial
DE = Dependant on Present Standard of Defence

STANDARD OF SERVICE
ECOLOGICAL CLASSIFICATION METHODOLOGY
TABLE A

Habitat (1)	Designation	Freshwater Flooding		Saltwater Flooding	
	Description Classification	SD E1	RE E2	SD E1	RE E2
Saltmarsh	Ramsar/SPA	✓	✓		
	NNR/SSSI	✓	✓		
	AONB/Heritage C		✓		
	LNR		✓		
	ESA		✓		
Grazing Marsh (Vegetation)	Ramsar/SPA			✓	
	NNR/SSSI			✓	
	AONB/Heritage C				✓
	LNR				✓
	ESA				✓
Lowland Wet Grassland	Ramsar/SPA			✓	
	NNR/SSSI			✓	
	AONB/Heritage C				✓
	LNR				✓
	ESA				✓
Grazing Marsh (Freshwater Ditches)	Ramsar/SPA			✓	
	NNR/SSSI			✓	
	AONB/Heritage C				✓
	LNR				✓
	ESA				✓
Grazing Marsh (Brackish Ditches)	Ramsar/SPA	✓	✓		✓
	NNR/SSSI	✓	✓		✓
	AONB/Heritage C		✓		✓
	LNR		✓		✓
	ESA		✓		✓
Coastal Lagoon (Brackish/Saline)	Ramsar/SPA	✓		✓	✓
	NNR/SSSI	✓		✓	✓
	AONB/Heritage C		✓		
	LNR		✓		✓
	ESA	N/A	N/A	N/A	N/A

STANDARD OF SERVICE
ECOLOGICAL CLASSIFICATION METHODOLOGY
TABLE A

Standing Water (Freshwater)	Ramsar/SPA			✓	✓
	NNR/SSSI			✓	✓
	AONB/Heritage C				✓
	LNR				✓
	ESA	N/A	N/A	N/A	N/A
Flowing Water (Freshwater)	Ramsar/SPA			✓	✓
	NNR/SSSI			✓	✓
	AONB/Heritage C				✓
	LNR				✓
	ESA	N/A	N/A	N/A	N/A
Woodland (Lowland Broadleaf)	Ramsar/SPA	N/A	N/A	N/A	N/A
	NNR/SSSI		✓	✓	
	AONB/Heritage C		✓		✓
	LNR		✓		✓
	ESA		✓		✓
Fen Woodland (Carr)	Ramsar/SPA		✓	✓	
	NNR/SSSI		✓	✓	
	AONB/Heritage C		✓		✓
	LNR		✓		✓
	ESA		✓		✓
Fen/Reedbeds	Ramsar/SPA			✓	
	NNR/SSSI			✓	
	AONB/Heritage C				✓
	LNR				✓
	ESA				✓
Grassland (Unimproved)	Ramsar/SPA	✓	✓	✓	
	NNR/SSSI	✓	✓	✓	
	AONB/Heritage C		✓		✓
	LNR		✓		✓
	ESA		✓		✓
Lowland Heathland Breckland	Ramsar/SPA	✓		✓	
	NNR/SSSI	✓		✓	
	AONB/Heritage C		✓		✓
	LNR		✓	✓	✓
	ESA		✓	✓	✓

Key
SD = Significant Damage
RE = Recoverable Damage

-(1) = Assumes that all habitats are behind existing defences.

'SPACE' RISK ASSESSMENT PROJECT - FLOOD DEFENCE

House Equivalents for Fluvial and Saline Flooding

	Unit	HE Values Fluvial	HE Values Saline
House	Number	1.0	1.14
Garden/Allotment	number	0.04	0.07
NRP - Agricultural Bldgs	Per m^2	0.01	0.01
NRP - Retail	Per m^2	0.036	0.04
NRP - Office	Per m^2	0.033	0.036
NRP - Leisure	Per m^2	0.031	0.033
NRP - Distribution	Per m^2	0.054	0.06
NRP - Manufacturing	Per m^2	0.029	0.032
Railways[2]	Number	53.9	53.9
Motorways[2]	Number	53.9	53.9
B-U Trunk[2]	Number	20.4	20.4
B-U Principal[2]	Nmuber	21.0	21.0
N B-U Trunk[2]	Number	13.5	13.5
N B-U Principal [2]	Number	6.6	6.6
All Minor Roads[2]	Number	2.1	2.1
Forestry and Scrub	Per 100 ha	0.02	32
Extensive Pasture[3]	Per 100 ha	2.0	90
Intensive Pasture[3]	Per 100 ha	2.8	56
Extensive Arable[3]	Per 100ha	9.7	111
Formal Park	Number	0.6	1.9
Special Park	Number	9.3	10.1
Playing Field/Pitches	Number	0.1	0.5
Golf Course	Number	0.7	3.3

Taken from Mott MacDonald Ltd R & D Note 187 Economic Appraisal of Non-Grant Aided Work.

APPENDIX No. 3

RESULTS

AND

STATISTICAL ANALYSIS

RESULTS AND STATISTICAL ANALYSIS FOR WELSH REGION

RESULTS

Scheme Ref	Scheme Title	Protected Value	Combined Risk Factor	Accountability Assessment
W1	Emergency response manual	N/A	N/A	N/A
W2	Pontipridd - Sion Street	316,050	278	87861
W3	Cardiff (St Mellons)	909,923	374	337693
W4	Whitland	273,000	425	116025
W5	Carmarthan	8,239,000	363	2990757
W6	Johnstown FAS	379,104	280	106149
W7	Bridgend FAS	315,280	380	119806
W8	Hopkins Town	43,880	270	11847
W9	Flood Warning System	N/A	N/A	N/A
W11	Pontipridd FAS	N/A	N/A	N/A

RISK FACTORS

Scheme Ref	Scheme Title	Inherent Risk	System Risk	Associated Risk	Combined Risk Factor
W1	Emergency response manual	N/A	N/A	N/A	N/A
W2	Pontipridd - Sion Street	54.00	84.00	140.00	278.00
W3	Cardiff (St Mellons)	112.00	172.00	90.00	374.00
W4	Whitland	41.85	229.00	155.00	425.85
W5	Carmarthan	85.50	128.00	150.00	363.50
W6	Johnstown FAS	50.00	75.00	155.00	280.00
W7	Bridgend FAS	97.50	143.00	140.00	380.50
W8	Hopkins Town	55.00	75.00	140.00	270.00
W9	Flood Warning Manual	N/A	N/A	N/A	N/A
W11	Pontipridd FAS	N/A	N/A	N/A	N/A

RESULTS OF ANALYSIS

1. The number of schemes examined is not really sufficient to draw positive conclusions regarding the appropriateness of the risk factors.

2. However, the fact that results for total risk ranged from 0.2 to 0.6 indicates that the methodology has potential for differentiating between schemes and risk factors, in a significant manner.

3. More schemes need to be analysed, so that more consideration can be given to the appropriateness of the scoring system, and the weightings.

4. From the analysis undertaken, the schemes having the highest "risk factors" were generally complex schemes involving large scale mechanical and electrical installations, requiring precise operational control.

5. Schemes having the lowest "risk factors" were generally basic schemes involving small embankments and minor channel improvements, requiring little operational control.

6. No account has been taken of "known failures", which have been experienced with some schemes. A weighting factor could possibly be introduced to increase "inherent risk" and/or "system risk", related to the number and frequency of "recorded failures" and "recorded near failures".

7. It may be possible with more analysis, to establish acceptable ranges of "risk factors" for various categories of schemes. Certainly, the nature of a scheme will limit the minimum "risk factor" that can be achieved, and a "high factor" does not necessarily indicate "unacceptable risk". It depends on the type of scheme being evaluated.

8. A form of distribution analysis has been used to indicate the range of results obtained for various "risk factors", and the following points were noted:-

   a) Inherent "risk factors" were evenly distributed, and values were all well below the mid-point of the scale.

   b) System risk factors were slightly skewed towards the upper quartile, and covered a greater range than the inherent risk factors. However they also were all below the mid-point of the scale, but not so markedly as "inherent factors".

   c) Associated risk factors were strongly skewed towards the upper quartile and the majority of values were higher than the minimum point of the scale.

   d) Total risk factors had an even distribution, centred approximately around the 40% of the scale.

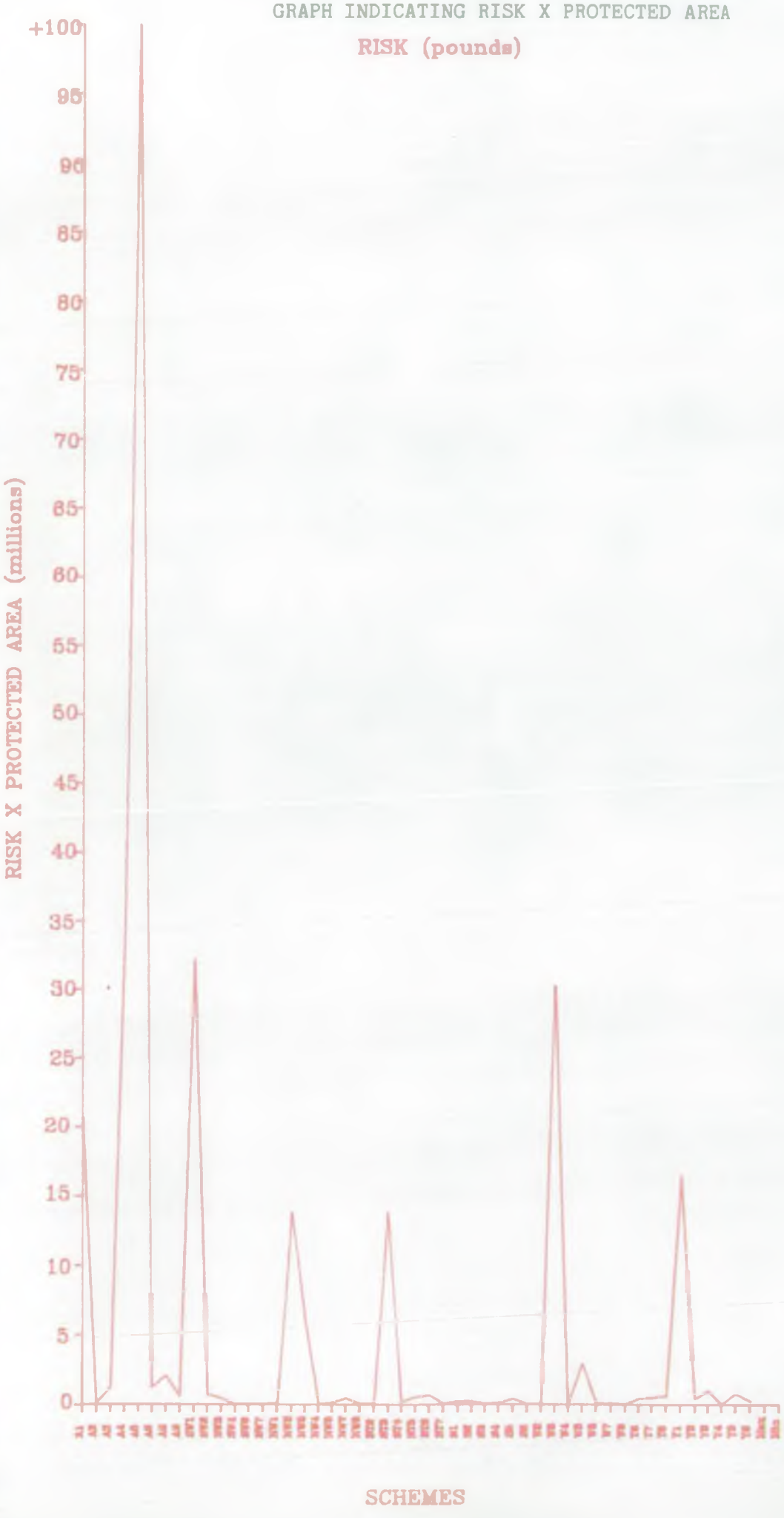
STATISTICAL ANALYSIS

The following diagrams show the range of accountability assessments that were derived for all selected schemes (ie national total - 50), and the percentile distribution of the various risk factors.

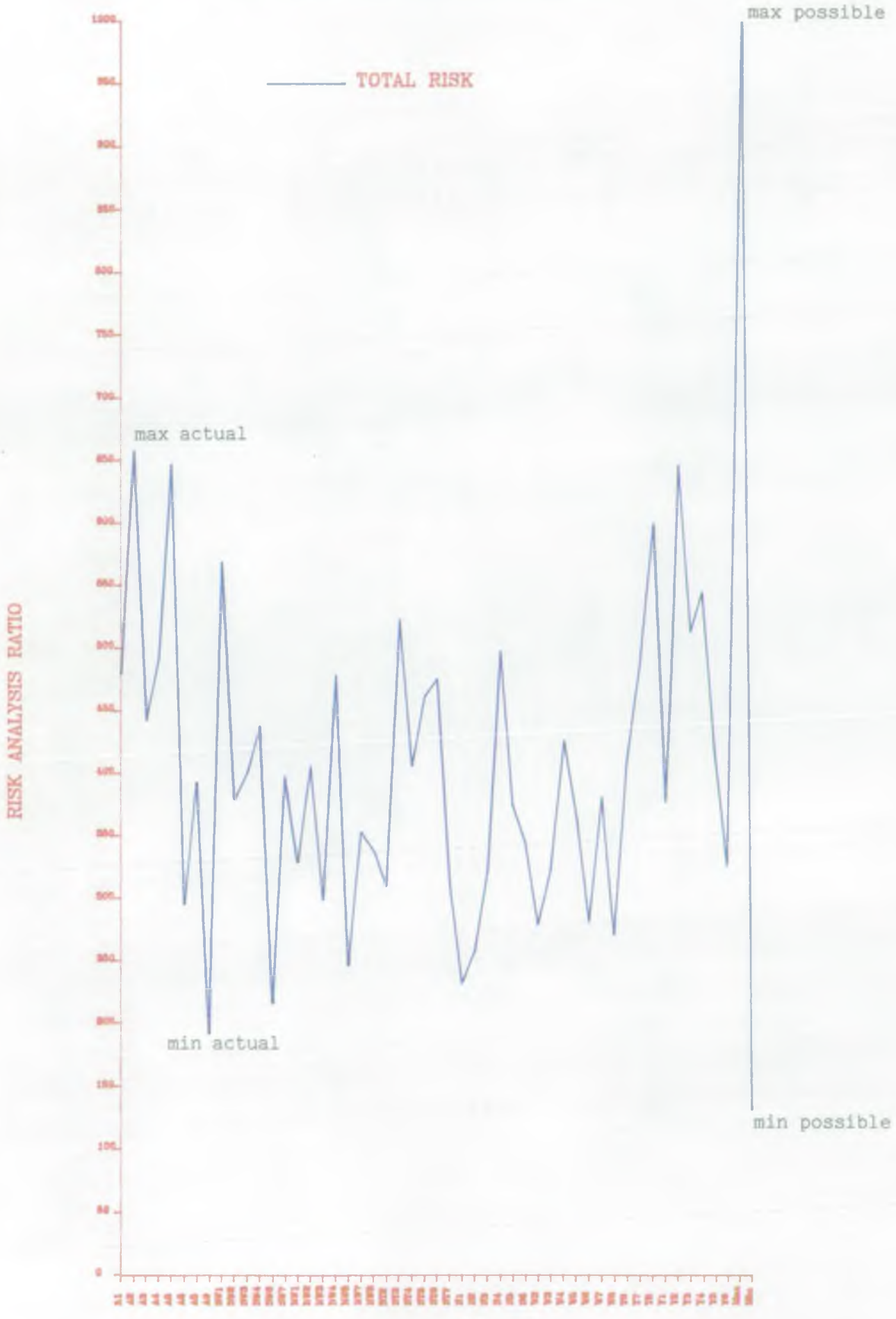
They show that:-

A.A.'s ranged from	£100 million +	to	£0.12 million
R.F.'s ranged from	just below 0.2	to	above 0.6

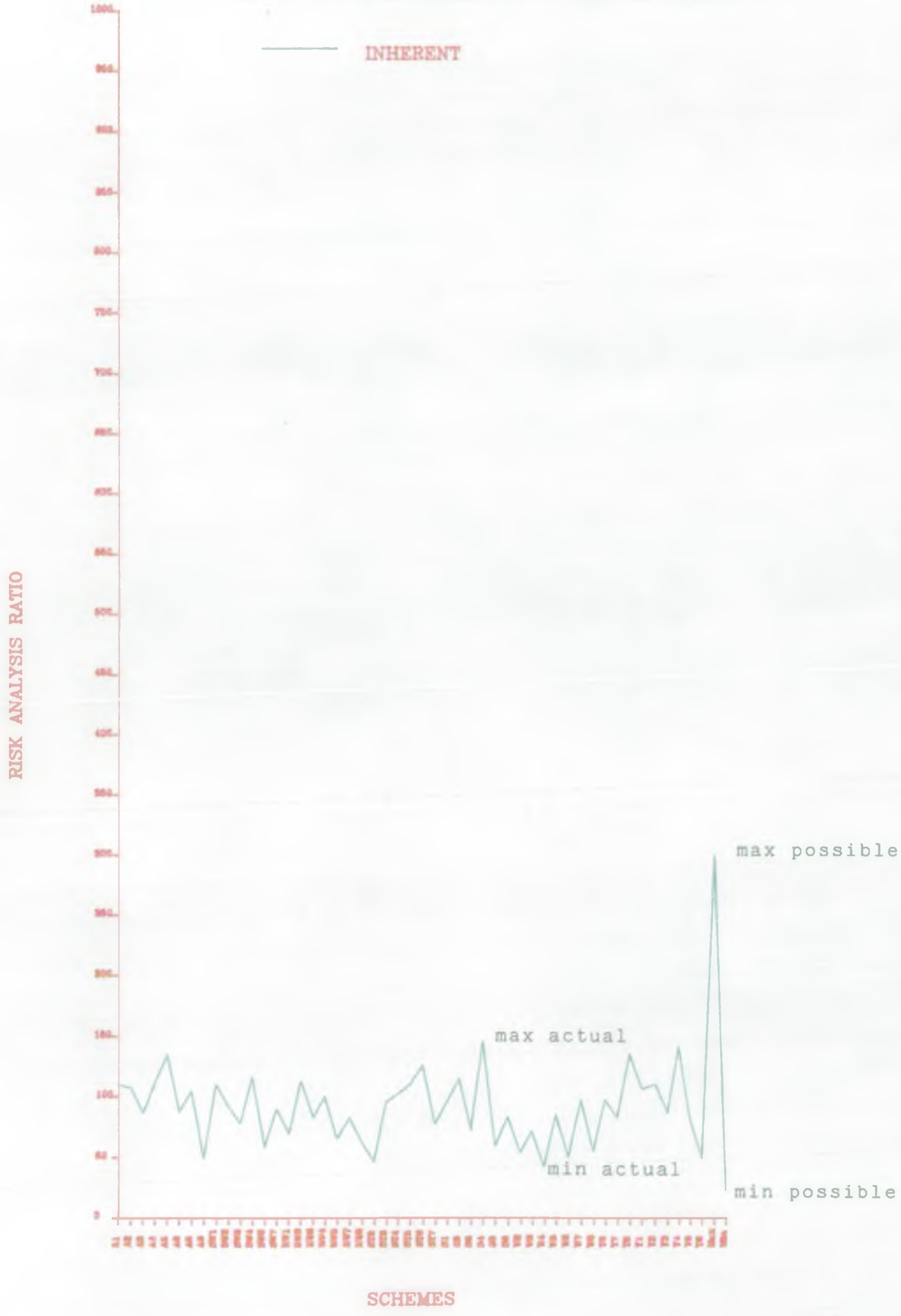
GRAPH INDICATING RISK X PROTECTED AREA



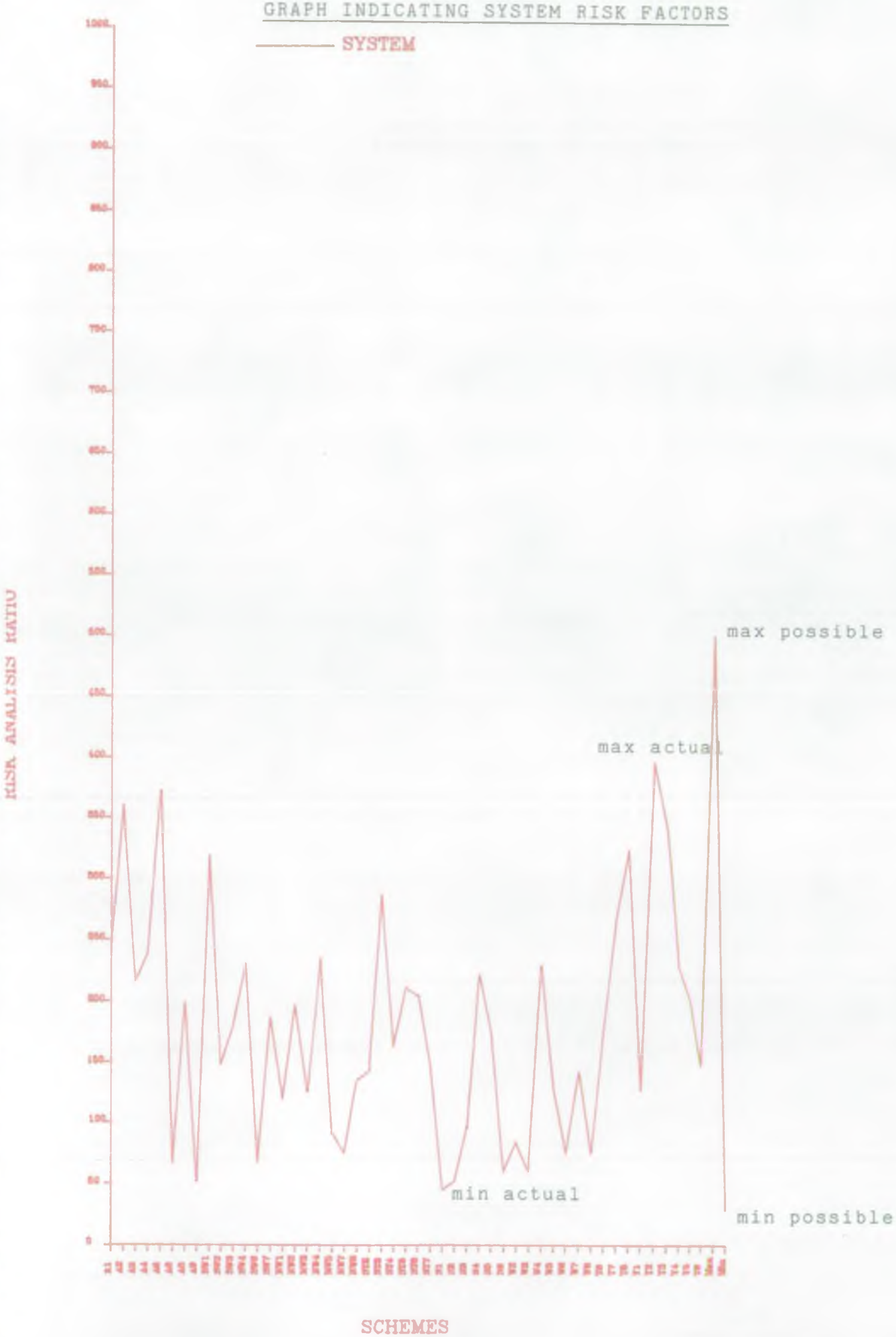
GRAPH INDICATING TOTAL RISK FACTOR



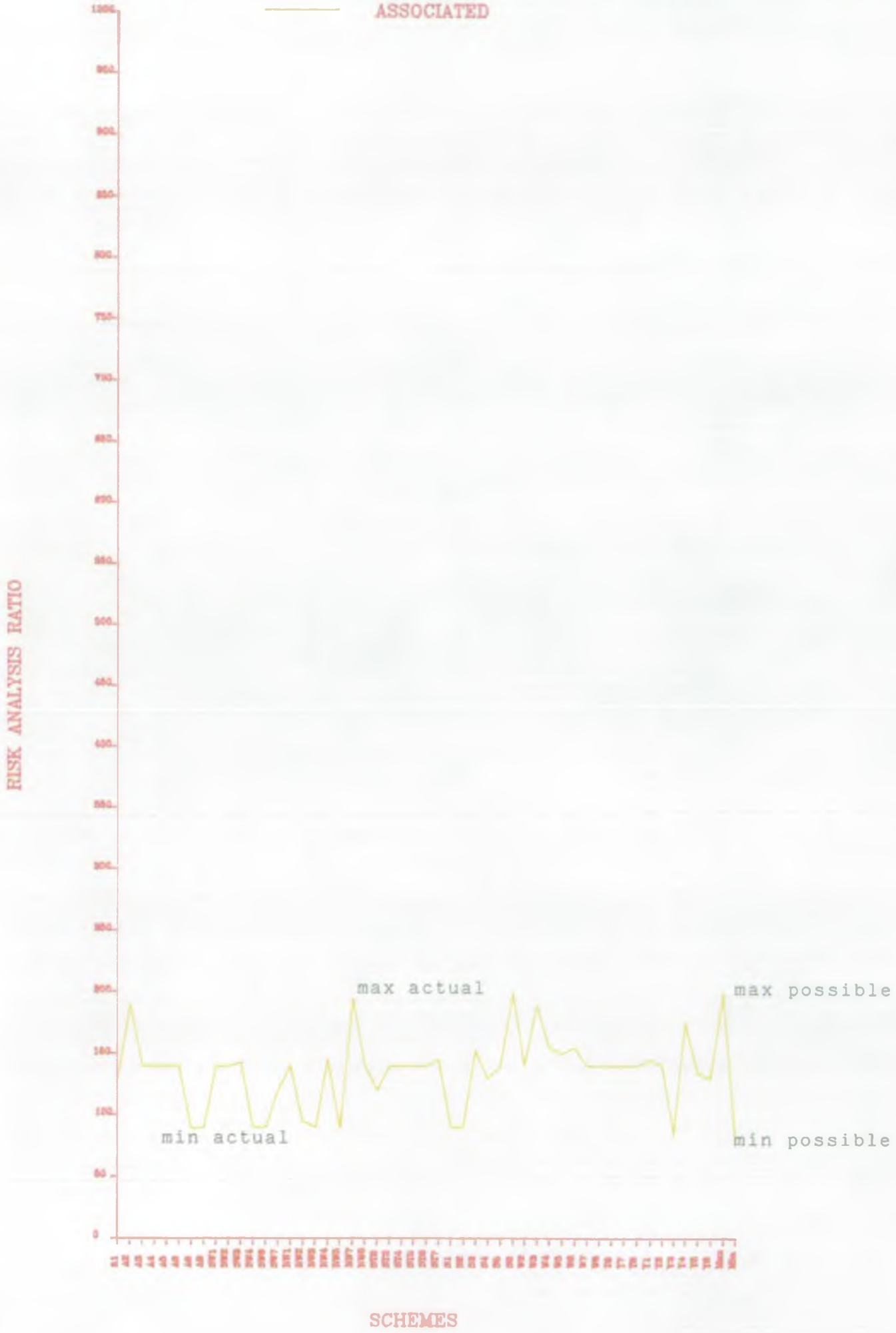
GRAPH INDICATING INHERENT RISK FACTORS



GRAPH INDICATING SYSTEM RISK FACTORS



GRAPH INDICATING ASSOCIATED RISK FACTORS



Distribution of data used in analysis–TOTAL RISK

STEM	LEAF
0	
1	91 30
2	94 15 96 46 31 78 00 80 70
3	92 79 37 97 28 52 37 09 14 21 73 44 83 80 77 28
4	79 42 90 00 04 78 05 61 75 97 25 13 90 18
5	68 22 57 99 12 44
6	57 47 46
7	
8	
9	
10	00

STEM	LEAF
0	
1	30 91
2	00 15 31 46 70 78 80 94 96
3	09 14 21 26 28 37 37 44 52 63 73 77 79 80 92 97
4	00 05 05 13 18 25 42 61 75 76 79 90 90 97
5	12 22 44 57 68 99
6	46 47 57
7	
8	
9	
10	00

$Q1 = \frac{n}{4} = \frac{51}{4} = 12.75$ round up to 13th number = 314

$Q2 = \frac{n}{2} = \frac{51}{2} = 25.5$ round up to 26th number = 392

$Q3 = n\frac{3}{4} = \frac{51x3}{4} = 38.25$ round up to 39th number = 490

Distribution of data used in analysis–INHERENT RISK

STEM	LEAF
0	23
0	49 58 69 65 62 46 59 65 41 50 55 49 54
0	66 67 92 76 90 63 99 62 95 77 96 72 64 65 97 97 63 66 62
1	09 07 12 05 10 16 13 02 10 26 15 06 10
1	35 46 35 41
1	
2	
2	
2	
3	00

STEM	LEAF
0	23
0	41 46 49 49 50 54 55 58 59 62 65 65 69
0	72 77 78 62 62 63 63 64 65 66 66 67 90 92 95 96 97 97 99
1	02 05 06 07 09 10 10 10 12 13 15 16 26
1	35 35 41 46
1	
2	
2	
2	
3	00

$Q1 = \frac{n}{4} = \frac{51}{4} = 12.75$ round up to 13th number = 69

$Q2 = \frac{n}{2} = \frac{51}{2} = 25.5$ round up to 26th number = 87

$Q3 = \frac{n3}{4} = \frac{51x3}{4} = 38.25$ round up to 39th number = 110

Distribution of data used in analysis–SYSTEM RISK

STEM	LEAF
0	45 45 29
0	67 52 67 91 75 52 98 60 84 75 75
1	47 19 25 35 42 47 28 43 26 47
1	98 79 81 97 63 74 75
2	40 18 38 31 34 11 04 21 29 28 01
2	67 67
3	18 24 42
3	60 72 96
4	
4	
5	00

STEM	LEAF
0	29 45 45
0	52 52 60 67 67 75 75 75 84 91 98
1	19 25 26 28 35 42 43 47 47 47
1	63 74 75 79 81 97 98
2	01 04 11 16 21 28 29 31 34 36 40
2	67 67
3	18 24 42
3	60 72 96
4	
4	
5	00

$Q1 = \frac{n}{4} = \frac{51}{4} = 12.75$ round up to 13th number = 91

$Q2 = \frac{n}{2} = \frac{51}{2} = 25.5$ round up to 26th number = 174

$Q3 = \frac{n3}{4} = \frac{51x3}{4} = 38.25$ round up to 39th number = 231

Distribution of data used in analysis--ASSOCIATED RISK

STEM	LEAF
0	
0	
0	89 90 90 90 95 90 90 90 90 90 90 84 78
1	29 20 20 30 34 29
1	40 40 40 40 40 40 43 40 45 40 40 40 40 45 53 40 40 55 50 55
	40 40 40 40 40 45 40
1	90 95 75
2	00 00

STEM	LEAF
0	
0	
0	78 84 89 90 90 90 90 90 90 90 90 90 95
1	20 20 29 29 30 34
1	40 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40 43
	45 45 45 50 53 55 55
1	75 90 95
2	00 00

$Q1 = \frac{n}{4} = \frac{51}{4}$ = 12.75 round up to 13th number = 95

$Q2 = \frac{n}{2} = \frac{51}{2}$ = 25.5 round up to 26th number = 140

$Q3 = \frac{n3}{4} = \frac{51x3}{4}$ =38.25 round up to 39th number = 143