NATIONAL CENTRE FOR RISK ANALYSIS AND OPTIONS APPRAISAL

Guidance Note Number 17

High Level Principles for OPRA-based Schemes: Guidance on the Development and Implementation Of Risk Rating and Regulatory Resource Planning Systems in the Environment Agency

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Management Summary

Background

In its statutory guidance on sustainable development, the Environment Agency is required to use risk assessment to assist its decisions that have to be taken about the future of the environment. The Environmental Strategy has also set out the Agency's intention to develop risk-based tools for the regulation of major industry. The National Centre for Risk Analysis and Options Appraisal was established to provide direction for this area, and are the custodians of the Agency's drive to develop risk-based tools.

This discussion document provides detailed guidance on the general principles that should be followed in the development and implementation of risk rating systems and regulatory resource planning algorithms. The guidance has been developed for certain Environmental Protection functions (Process Industries Regulation (PIR), Waste and Water Quality), but may be applied across a wider range of Agency functions in future. The guidance enables a flexible approach to risk-based resource planning, given the different conditions prevailing in different functions. However, **the guidance also specifies <u>core</u> principles and details which should be applied by all functions, in order to ensure consistency and credibility across the Agency**, and to ultimately enable comparison and resource planning across Environmental Protections functions.

The National Centre for Risk Analysis and Options Appraisal (NCRAOA) has implemented a risk-based planning approach for ICI Chemicals and Polymers. Whilst this approach is a level more complex than the current OPRA (Operator and Pollution Risk Appraisal) system, its impacts on ICI's investment programme has illustrated the benefit of such approaches.

Risk-Based Resource Planning

Risk-based resource planning requires the risk levels of regulated activities (e.g. process sites) to be determined, based on a range of factors such as type of hazard, frequency of hazardous operations, nature of receiving environment and quality of operator management systems. This information is then used to prioritise sites and allocate regulatory resources according to the risks (see Figure 1, below). If more site-specific risk factors are taken into account than in the traditional resource planning systems, then improvement is possible in both the accuracy of measuring risk and the effectiveness of resource allocation. This has the benefit of enabling risk to be reduced, or resource efficiency to be improved (see Figure 2). **Risk-based resource planning can be undertaken either by apportioning allocated resources according to risks across the Agency's remit (supply-led); or by assessing risks and delivering a case for resources accordingly (demand-led)**. Progressing from the former to the latter raises specific issues of 'read-across' within and between functions.

Risk-based resource planning may apply at a functional level, for example by allocating waste regulatory resources to higher risk waste sites, or at a strategic level, by distributing total regulatory resources between functions according to overall levels of risk. Common systems across functions are already becoming important with the harmonisation of certain functions at area level, "multi-skilling" and combined visits. This will increase with the introduction of Integrated Pollution Prevention and Control (IPPC). The summary information on key risks and issues on different sites provided by risk rating systems will support the process of harmonisation.

Figure 1: Risk-Based Resource Planning

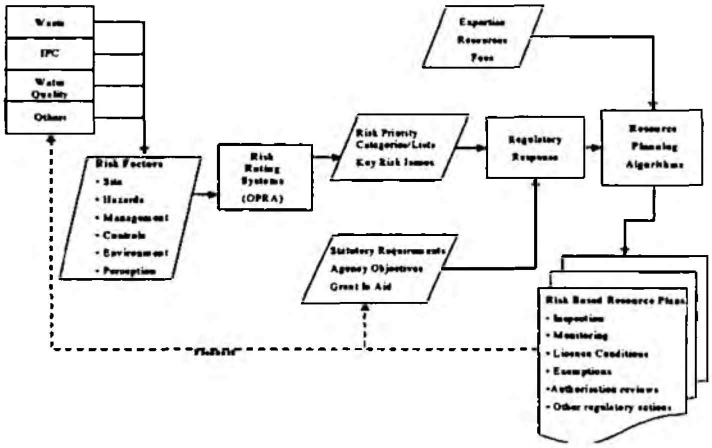
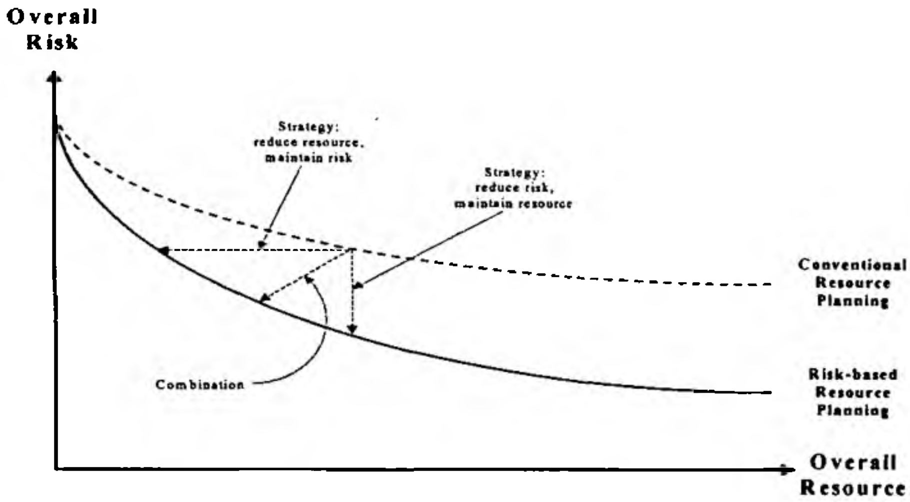


Figure 2: Reducing Risk And/Or Resources



Key Principles for Risk-Based Resource Planning Systems

The emphasis placed on various factors contributing to 'risk' in risk rating systems may be specified according to the needs of individual functions. **However it is essential that all systems incorporate the generic risk factors outlined in Table 1**. This shows that both process (i.e. the source of risk) and environment (the receptor of risk) needs to be considered to obtain a complete picture of risk. Different functions may place different emphasis on process factors vs environment factors. The way in which the factors are grouped within the risk rating system relates to the "type of factor". For example, the PIR OPRA system splits the factors into two groups: Pollution Hazard Appraisal and Operator Performance Appraisal. Grouping should be consistent but may need to be tailored for the specific functions. **In all cases it is important to identify which factors are within the control of the operator or regulator and which factors cannot be altered** ("sensitivity of factor" to operator control or regulatory intervention). The risk rating system should include all factors which can be altered. This information will affect regulatory priorities and responses to different risks.

Scoring systems need to be simple, clear, easy to follow and reproducible. Above all, they must not assume a degree of sophistication in their design above which they can realistically deliver in terms of distinguishing between risks. Where different scales are used (e.g. 1-5 vs. 1-30), these must be justified and taken into account in deciding on weighting factors. The scoring system should be appropriate to the task of providing a simple overall rating of risk which enables risk priorities to be identified; systems implying high levels of precision should not be employed given the approximate nature of risk rating. Risk rating systems can only be used for simple evaluation of the nature and relative priority of risks; other more sophisticated tools are available for when detailed evaluations of risk and operator performance are required. It is essential that risk rating systems are viewed as tools within the overall regulatory "toolkit", and used within their limits.

Guidance on how to determine scores is mostly function-specific but needs to be consistent. It is expected that scoring of operator performance should also be consistent. Frequency and nature of operations, and physical measures to reduce risk, are highly specific to functions. Scoring, weighting factors and guidance will need to evolve as experience indicates or as a result of changing conditions (e.g. the scale of available control techniques changes).

Table 1: Generic Risk Factors within Risk Rating Systems

No.	Factor description	Type of Factor	Sensitivity of Factor
1	Nature and severity of hazard posed by properties of substances present	Inherent hazard	Partially in operator's control
2	Magnitude of hazard posed by amount of substances present	Inherent hazard	Mostly within operator's control
3	Frequency and nature of hazardous operations, uncertainties in operations	Inherent frequency	Mostly within operator's control
4	Physical measures (technologies) to prevent, minimise or render harmless releases to the environment	Inherent hazard and frequency	Mostly within operator's control
5	Extent of connection between the hazard and the receiving environment – vulnerability	Inherent hazard and frequency	Partially in operator's control
6	Spatial extent of potential impact in receiving environment posed by substances present	Inherent hazard and frequency	Partially in operator's control
7	Temporal extent of potential impact in receiving environment posed by substances present	Inherent hazard and frequency	Partially in operator's control
8	Sensitivity of receiving environment	Inherent risk	Outside operator's control
9	Offensive characteristics/public perception of risk associated with site/activity	Inherent risk	Partially in operator's control
10	Recording and use of information	Management factor	Completely within operator's control
11	Knowledge of compliance requirements	Management factor	Completely within operator's control
12	Operation of process or site	Management factor	Completely within operator's control
13	Maintenance of process or site	Management factor	Completely within operator's control
14	Management and training	Management factor	Completely within operator's control
15	Historical record of incidents, complaints and non-compliance events	Management factor	Completely within operator's control
16	Recognised Environmental Management Systems	Management factor	Completely within operator's control

Similarly, the resource planning algorithm needs to be able to evolve as risk data is obtained and feedback on the effectiveness of Agency actions measured. Initially, the resource planning algorithms will be purely "Risk Targeting" – here resources will be allocated in proportion to risk levels. As the risk levels change, the Agency will be able to gauge where its resources are having an effect and where there may be resource surplus; this is related to the "sensitivity of factor". This will enable the algorithms to include an element of "Risk Reduction Targeting" – resources are allocated towards where risk reductions are possible. However it is important that the Agency continues to target appropriate resources towards high risks, in order to satisfy itself that the operator is maintaining the level of control and to address public concerns over high risks. It is also important that resource allocation reflects an appropriate balance of priorities to anticipate and avoid risk as well as priorities to reduce risk, for example in expending resource to prevent an Environmental Quality Standard being exceeded.

The priority and the nature of the risk may influence the appropriate type of regulatory activity, in which case risk-based resource planning may apply to a number of different regulatory activities, e.g. inspection, monitoring, reviews of authorisations, reviewing licence conditions, etc. Specific issues, such as setting individual conditions, cannot be based on risk rating systems as these require detailed evaluation (e.g. BATNEEC, BPEO and cost-benefit issues).

In general the risk ratings are likely to be used initially as modifiers for existing function-specific resource planning algorithms. For example, the relative risk priority of a site will be used to determine its proportion of the available resource (as in the case of Waste), or to modify the existing RSDM41 target inspection frequency (as for PIR). However, once "read-across" or comparison between risk ratings is possible through benchmarking between the different functions, it will be possible to apportion resources between functions according to risk. Furthermore it should be the aim in future to develop the resource planning systems to help determine the desired amount of resource based on risk (demand-led) considerations, rather than simply dividing the available resource according to risk (supply-led). This may be achieved by evaluating how 'sensitive' risk levels are to operator or regulatory intervention by different resource allocations.

Risk-based resource planning provides a more transparent and effective means of allocating resource to target risk. However it is likely that a risk-based approach will require more resource to explain and implement, compared with conventional techniques. **It is therefore important to consider the resource implications of introducing risk-based resource planning systems and to design and implement these with the objective of minimizing the time and effort required to run such systems.**

Proposed Way Forward

Risk-Based Resource Planning systems exist in various stages of development in EP (Environmental Protection) functions, notably PIR, Water Quality and Waste. These systems are being developed in response to differing pressures and according to varying deadlines. They are, therefore, tailored towards the specific functions but are broadly based on the forerunner PIR risk rating system, OPRA. Different legal, resourcing and charging constraints apply in the different functions. Specifically, ear-marked Grant In Aid for individual functions may constrain the resource available for wider general use. Currently, read-across within functions is relatively straightforward within known sectoral limitations and can be progressed. 'Read-across' between functions is difficult and requires more thought but will improve with time and data feedback.

The proposed way forward is that each function should continue to develop and implement its own function-specific system, using this guidance to work towards a common approach. These functional systems should be progressively harmonised based on actual experience and feedback, including development of a strategic system which supports cross-functional resource allocation. This approach is currently being developed by the National Centre. This may require statutory constraints to be reviewed based on the strategic information provided over time from the risk-based resource planning systems, regarding risks in different regulated industries and the performance of operators and regulators in managing those risks.

The development of risk-based resource planning systems should be dovetailed with other related initiatives in the Agency, notably the Priority Planning exercise and resource planning being carried out across the Agency. This guidance relates only to risk aspects of resource planning and should therefore provide a useful input to the Priority Planning exercise, but does not cover the full range of issues which need to be considered in resource planning. For example, a particular problem or issue requiring special regulatory attention could be identified through risk rating, but the risk-based resource planning system would not indicate how much extra resource is needed; this requires separate consideration.

In the short term, it may be necessary to run Risk Rating systems disengaged from resource planning, purely to gather data and test systems. Over the long-term, iteration of the resource planning system should identify areas where resource is more or less necessary. **The process of implementing full risk-based resource planning may reasonably take around 3 - 5 years. Full risk-based resource planning must consider risk to the Agency's business as well as risk to the environment.**

The strategic risk-based resource planning system will be highly challenging to develop and will need to be based on benchmarking and calibration between the functional systems. The immediate need therefore is for robust and high-quality systems to be successfully developed and implemented within individual functions. Normalisation of scores from systems of widely different architecture will be more difficult than for similar systems, which would hamper read-across between functions. However, following this guidance in advance will make the job of a strategic resource planning system more easy. **In acknowledgement of the Board's approval of NCRAOA's corporate lead in risk assessment, such systems should be developed in full consultation with the National Centre.**

Acknowledgements

The National Centre for Risk Analysis and Options Appraisal wishes to thank the following parties for their valuable contributions to this guidance note: Richard Brook, Alan Darcy, Innes Garden, Mike Harget, David Parr and Ian White.

Contents

1. Introduction

Background

1.1 The Environment Agency has a statutory duty, under the Environment Act 1995, to contribute to sustainable development. In the statutory guidance provided in support of this duty, the Government has indicated that the Agency should use risk assessment and other tools in reaching decisions which contribute to sustainable development. The Agency's Environmental Strategy sets at a commitment to implement risk-based tools in support of the regulation of major industry.

1.2 In 1995, the former Department of the Environment (DoE) published a "Guide to Risk Assessment and Risk Management for Environmental Protection", and indicated that its sponsored bodies would be expected to implement the guidance. In 1997, the Agency's Board established the National Centre for Risk Analysis and Options Appraisal (NCRAOA) to lead the organisation's efforts in implementing the requirements being placed upon it. It is against this background that the contents of this document should be seen.

1.3 The Environment Agency of England and Wales (hereafter, the Agency) is committed to extending risk-based management systems into all relevant areas of its business as part of a drive towards risk-based regulation. Such a move has far reaching implications for the structure and resourcing of the Agency and needs to be progressed in a structured fashion. However, increasingly, there are resource constraints on existing and new regulatory burdens that necessitate a new way of working. The prioritisation of regulatory activity on the basis of environmental risk provides a sound, rational and acceptable way forward. This Guidance Note sets out some core principles for risk rating and regulatory planning in the Agency, identifies where degrees of freedom exist for the development of new schemes, and provides guidance for such cases.

1.4 The Agency released its revised Operator and Pollution Risk Appraisal (OPRA) system in August 1997 for all Integrated Pollution Control (IPC), Part A processes. Regulation of IPC processes now resides within the Environmental Protection (EP) Directorate as Process Industry Regulation (PIR). Based on the success of OPRA for PIR, the Agency wishes to extend application of risk rating systems within and between all the regulatory functions of the EP Directorate. In future, consideration will be given to the development and implementation of similar schemes in other areas of the Agency's work. To progress this objective, the Agency held a workshop in June 1998, 'OPRA - Taking it Further,' hosted by the Environmental Protection National Service (EPNS) to establish the general principles, disciplines, implications and benefits of EP-wide risk rating and resource planning systems.

1.5 A clear outcome of the June workshop was the need for a set of high level principles for any risk-based resource planning systems that would ensure consistency and comparative analysis between and within the EP functions. NCRAOA has developed this Guidance in acknowledgement of its corporate lead on risk assessment work. The principles referred to here apply to the development of any risk-based resource planning system intended for Environmental Protection or Operations Directorates and, in keeping with similar best practice guidance, will be kept under review with opportunities made for continuous improvement. Where readers are considering the development of risk-based schemes beyond these Directorates, they are referred to the NCRAOA for assistance in scheme design because the assignation of hazard and performance attributes requires careful consideration to ensure compliance with the risk principles.

Purpose and Scope

1.6 The purpose of this document is to provide best practice guidance on the high level principles of risk rating and resource planning systems, in order to support the development and implementation of such systems in the Agency. The objectives are to:

- establish a coherent, robust and transferable set of guiding principles for the development of risk-rating schemes;
- facilitate the development and implementation of such schemes based on past experience and "best practice" in this developing field;
- ensure such tools are as effective and accurate as possible in differentiating and ranking sites according to environmental risk;
- ensure the resulting risk information is used, in conjunction with other relevant information, to allocate resources in a consistent and optimal manner within a given regulatory function or activity;
- enable 'read-across' (i.e. direct comparison) between regulatory functions and activities, thus allowing for "top level" planning of the total regulatory resource across all functions; and
- ultimately, collate accurate information that could inform existing and new burdens submissions to central government.

1.7 The scope of this guidance covers all risk rating systems and resource planning for Agency regulatory functions (it is not at present designed to cover financial risk rating). The guidance is based on experience gained from existing and developing risk rating and resource planning systems within the PIR, Waste and Water Quality functions and from a survey of similar schemes in external organisations. In particular, the guidance has benefited from the extensive consultation and development process undertaken for the PIR version. However, it is recognised that improvements can be made to the guiding principles contained therein, and this Guidance Note therefore represents a collation of experience to date, together with some fresh thinking on risk ranking and resource planning in general, including USEPA, HSE and industry approaches.

1.8 The NCRAOA's experience of developing and implementing a risk ranking approach for ICI Chemicals and Polymers has also been integrated within this guidance. Whilst a level more complex then OPRA-style schemes, the results provide more details regarding the risk and can be used to refine the OPRA scores. The NCRAOA's ICI work is the only example to date of risk-based scores directly affecting industries investment on environmentally-related matters.

1.9 In terms of implementation, the June '98 workshop identified the following requirements for any risk-based resource planning system being used within the Agency. Any scheme should:

- identify the level of **resource** required to effectively regulate activity in line with the Agency's targets;
- employ a **sound scientific basis** for evaluating environmental risks, operator effectiveness and be responsive to the social and political pressures;
- be a **practical tool** using simple consistent scoring systems and terminology wherever possible;
- be simple and **transparent** to both Agency staff and our customers;
- contain **quality systems** which aim to promote consistency; and
- be capable of **development**, in conjunction with our customers, through experience gained and for new legislative requirements.

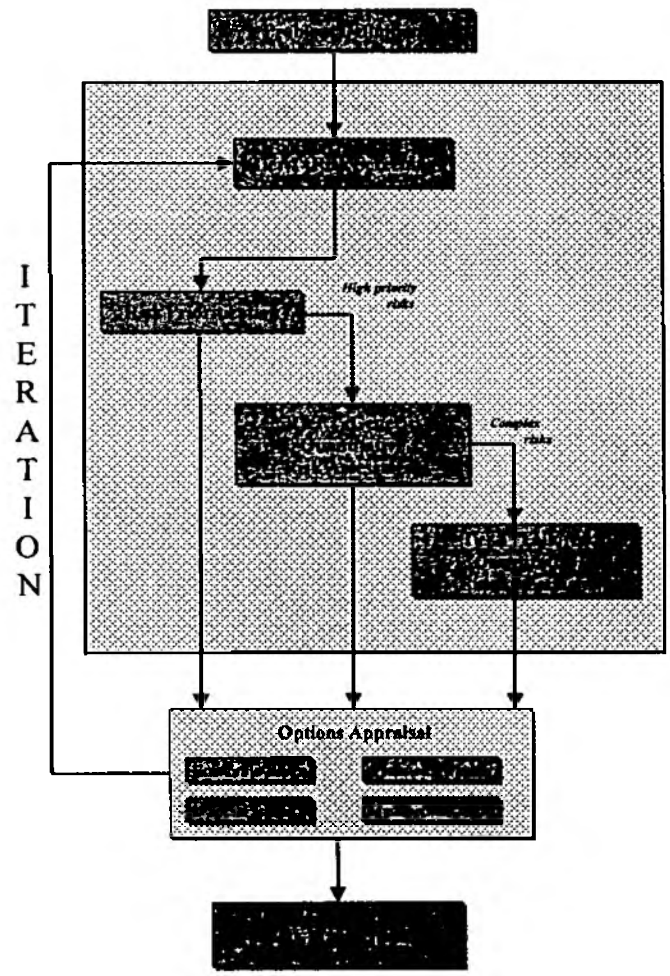
1.10 This document provides guidance on the design and implementation of risk rating and resource planning systems for the Agency. The document does not provide the detailed architecture for any particular system. Issues relating to charging and statutory requirements are not discussed in detail other than to identify where they may impinge on resource planning.

2. Basic Principles

Risk Assessment

2.1 Risk assessment can be conducted at various levels of sophistication, ranging from the initial screening of risk using a simple 'source-pathway-target' approach through to a detailed analysis of complex risks using quantitative techniques to assess consequence and frequency (Figure 3).

Figure 3: Staged, Tiered Approach to Environmental Risk Assessment



2.2 The process of risk assessment typically involves the following four stages:

- **hazard identification**: identification of the sources of the hazard and characterisation of the source and the hazard
- **exposure assessment**: evaluating the plausibility of the hazard reaching the target, and by which mechanisms, thus allowing an assessment of the probability, magnitude and duration of 'exposure';
- **risk estimation**: consideration of the consequences of exposure with reference to effects, expressed as a likelihood or probability of the effects of exposure being realised; expressed over a range of spatial and temporal fields;
- **risk characterisation**: evaluating the acceptability and significance of risk with reference to standards, targets or background risks.

2.3 For environmental risks, there is always a considerable uncertainty, particularly in the assessment of impacts from exposure. Assessment effort must therefore be targeted accordingly, where risks or uncertainties are high, or where the costs of the assessment are justified by the benefits to decision-making. The Agency has adopted a staged, tiered and iterative approach to risk assessment that facilities early risk prioritisation, avoids unnecessary detail and matches the level of approach to the needs of the problem under investigation (Figure 3). Here, a simple "screening" approach is used first to determine the key risks and priorities. If the decision cannot be made based on this approach then more detailed approaches are used, focusing on the key risks identified at screening.

Risk Rating Systems: Capabilities and Limitations

2.4 Risk rating systems are amongst the simplest screening approaches, which do not attempt to go into detail but are simple and rapid means of identifying key issues. As such, the expectations of the output of any such system should not exceed what such systems can realistically deliver. This is a critical concept in the design of scoring systems. A critical distinction for the use of risk rating systems is the distinction between the inherent, immutable aspects of a hazard and the probabilistic elements of exposure that are usually dependent on the situation in hand and, in a pollution context, often relate to operator performance. The fundamental basis of risk rating systems is that these aspects are assessed independently for the purposes of arriving at an overall risk to direct regulatory activity.

2.5 The level at which risk rating systems operate then is that of risk screening and prioritisation, whereby hazards and performance are being scored against some benchmark or reference point. Risk rating systems simply work by scoring various characteristics or 'attributes' of risk and combining the scores to provide an assessment of the overall risk. The attributes relate to aspects such as the severity of the hazard, the sensitivity of the receiving environment, the probability of accidental release and so on. Clear guidance is given on how to score over a predefined range but there are a number of over-riding capabilities and limitations of such schemes that must be recognised prior to their development and use (Table 2).

Table 2: Capabilities and Limitations of Risk Rating Schemes

Capabilities: risk rating systems **can:**	**Limitations:** risk rating systems **can not:**
Distinguish between risks posed by facilities or situations of a generic type	Provide absolute estimations of risk; scores are relative
Allow prioritisation of risks from the risk scores	Provide any degree of resolution beyond that inherent to the subjectivity of the scoring system; scores are best 'banded' in ranges
Allow comparisons between situations with similar overall risk, but with different 'driving' factors	be applied without training
Accommodate simple 'what if' questions	
Allow fast screening of numerous facilities or situations	
Establish where further risk assessment effort is best focussed	

2.6 Risk Rating systems therefore have a number of specific advantages and disadvantages which place restrictions on their use. Such systems should be used to prioritise sites and identify key risk contributors. They should not be used to assess 'absolute' levels of risk, to compare with risk criteria or to test the effectiveness of detailed risk management options. Other more detailed risk assessment systems may be applied to regulated activities, for example the "Guide to Environmental Risk Screening" developed by NCRAOA, Strategic Risk Assessment and LANDSIM. Where these have been applied, the results may be utilised as an input or check for the risk rating system. Similarly, detailed audits of management systems (such as large scale audits carried out for PIR processes) may provide information on operator performance which can be used in risk rating.

Resource Planning

2.7 Resource planning is the process of developing plans for the allocation of regulatory resources to specific tasks over a given period. Resource planning occurs primarily within individual functions but is also carried out increasingly between functions. Existing approaches to resource planning include Waste Management Paper 4 (WMP4), Regulatory Standards Memorandum 41 (RSDM41) and the National Consents Manual. These set targets for programmed activities such as inspection and monitoring. In general, regulatory functions achieve a proportion of planned activities, which may be 75% or less of the targets.

2.8 The primary aim of risk-based resource planning is to manage risks to the environment using regulatory resources in the most effective and efficient manner, taking into account the management of risk by the operator and the concerns of stakeholders such as the public. The system explicitly recognises the measures taken by industry to manage risk, and therefore both reduces unnecessary regulatory intervention and provides an incentive for operators to improve risk management.

2.9 As well as environmental risk, other forms of risk may need to be considered, for example risks to the reputation of the Agency, risks associated with various income streams, etc. Risk-based resource planning should inherently promote "reputation management" as it can be used to demonstrate that higher regulatory attention is being directed towards higher risk activities and sites.

3. Guidance on Risk Rating Systems

Overall Principles

3.1 The overall principles of risk rating systems are described in detail in the Agency's revised OPRA guide to which the reader is referred. Critical aspects of the overall approach that set the context in which such schemes are being developed internally are:

- the primary purpose of a risk rating system is to provide an objective and consistent assessment of environmental risk;
- the Agency believes risk rating systems provide greatest benefit where they are used with full openness between the operator and regulator;
- risk rating systems complement authorisations and support inspections, they do not replace them;
- overall risk levels are dictated by the balance between pollution hazard and operator performance;
- risk rating systems have wide potential application within inspection resource planning, monitoring and environmental surveillance, pollution prevention planning, strategic planning, charging and publication of environmental information.

3.2 The June '98 workshop 'OPRA-Taking it Further', identified a set of critical success factors for any risk rating system (Table 3).

Table 3: Critical success factors for Risk Rating Schemes

Factor	Description / requirement
Consistency	Within a particular regulatory function/activity, it is essential that risk rating systems work consistently, i.e. an operation in one part of the country is given a similar score to a similar operation elsewhere in the country; also, the same operation should be given the same score by different inspectors or at different times.
Range Of application	The risk rating system must be sufficiently flexible to enable evaluation of the wide range of operations and conditions within a given regulated area. Also the wide variety of types of risk on any site (different substances, media, point or diffuse sources, planned or unforeseen releases) need to be considered within the system.
Use of Sound Risk Principles	In order to be credible and to facilitate 'read-across' between different functions, each risk rating system should be based on a common philosophy and established principles of risk.
Simplicity	Systems must be simple to understand and use, with minimal resource required to operate the system in the field.
Transparency	The risk rating system should be transparent, i.e. the basis for setting a score should be possible to follow and check.
Judgement Factor	There is a degree of expert judgement involved in assessing risk, which must be incorporated within the risk rating system and clearly identified as such.
Read-across between functions	If risks from different functions are to be compared (e.g. for inter-function resource planning), it is important that the design and implementation of risk rating systems is controlled and based on common principles. It should be the presumption that systems are identical where possible and any differences in them are justified.
Adds value	Allows better decision-making (improved environmental protection and/or lower cost) than traditional approaches.

3.3 The scope of a risk rating system needs to be clearly defined. It will usually be applied to all regulated sites or activities within a particular regulatory regime. Specific issues need to be considered, such as whether unlicensed waste sites should be included, for example, particularly with reference to cost and resource implications.

What is measured by the risk rating system?

3.4 Risk rating systems measure overall risk to the environment from a regulated operation, based on information known at the time of assessment. The term 'overall risk to the environment' reflects the need to measure risk from routine and unplanned conditions, to all parts of the environment (including the human environment) affected by the operation, over the short and long term. For the regulated operation, the risk must represent the entirety of the regulated operation, e.g. the process envelope defined within the authorisation, excluding non-regulated aspects. Reliance on information known at the time of assessment reflects the fact that the risk is representative of the knowledge of the site and its environment at the time of the assessment. Changes in conditions may affect the risk level and will necessitate a reappraisal. In particular, risk ratings and the key risk factors may vary considerably from one stage of a site life-cycle to another. In the case of waste landfill sites, these stages are pre-operation, operation, closure and post-closure. For a process site there may be different phases of operation (e.g. different raw materials, throughput levels, etc.) as well as life-cycle stages to consider.

Generic Elements of Risk Rating System

3.5 Risks from an operation (which may be a site, activity or process) are determined by a combination of factors, including inherent physical or "hardware" factors (i.e. the physical nature of the operation and its environment) and "software" factors (i.e. the operator's management systems, procedures and techniques). The generic risk factors applicable to any type of operation or situation are shown in Table 4. This shows that both process (i.e. the source of risk) and environment (the receptor of risk) needs to be considered to obtain a complete picture of risk.

3.6 The generic factors represent the minimum information required to characterise risk levels. Existing resource planning systems (RSDM41, WMP4 and National Consents Manual) are based on simple considerations of risk using a limited number of factors. For example, the effluent volume and the catchment population size determine the frequency for sampling of discharge consents and the permitted proportion of non-compliances. A risk rating system incorporating a wider range of risk attributes allows the regulatory workload and type of response to be targeted more accurately at individual site risk levels.

3.7 The type of factor describes what kind of risk information is represented. Inherent hazard factors relate directly to source, pathway and receptor issues, and reflect the potential for environmental harm from the operation. Inherent frequency factors relate to the likelihood of events given the physical nature and frequency of operations. Operator performance factors relate to the operator's systems for managing risks and controlling environmental performance. The balance between inherent risk and operator performance determines the actual risk to the environment. This principle is used in the PIR OPRA system which divides attributes of risk into "hardware" (i.e. physical attributes, PHA) and "software" (i.e. management attributes, OPA) factors.

There are however several other ways to divide up attributes and express risk:

- between those within the operator's control and those outside the operator's control
- between those affecting frequency of events and those affecting consequences of events
- do not divide at all, simply provide one list and sum all factors

3.8 The sensitivity of factors relates to the ability of the operator to control each factor. This is important when determining what the regulator will seek to influence when trying to reduce risk. Some factors are completely within the operator's control, others less so. The weighting of factors is another key issue as it reflects the relative importance of different attributes. Weighting factors may vary considerably from one industry sector to another. It may also be necessary to derive weighting factors specific to each type of regulatory action. For example, nature and frequency of operations and operation procedures may be particularly important to monitoring of discharge consents, which is concerned primarily with variability of discharges against consent limits. For simplicity, no weighting factors are provided in Table 4.

Table 4: Generic Risk Factors within Risk Rating Systems

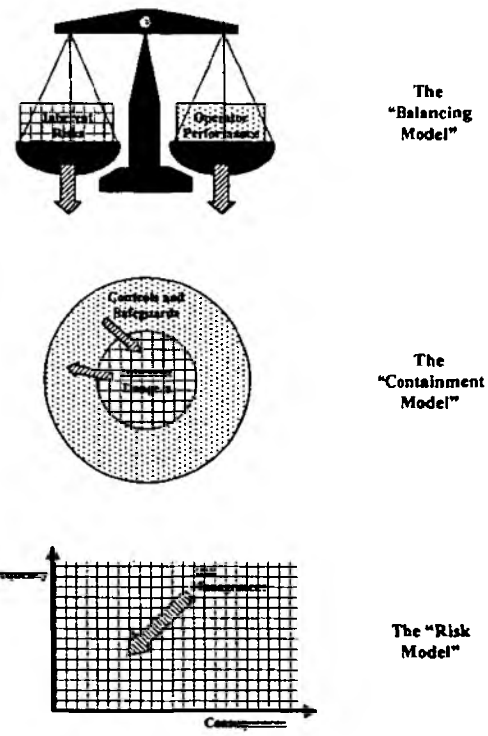
No.	Factor description	Type of Factor	Sensitivity of Factor
1	Nature and severity of hazard posed by properties of substances present	Inherent hazard	Partially in operator's control
2	Magnitude of hazard posed by amount of substances present	Inherent hazard	Mostly within operator's control
3	Frequency and nature of hazardous operations, uncertainties in operations	Inherent frequency	Mostly within operator's control
4	Physical measures (technologies) to prevent, minimise or render harmless releases to the environment	Inherent hazard and frequency	Mostly within operator's control
5	Extent of connection between the hazard and the receiving environment – vulnerability	Inherent hazard and frequency	Partially in operator's control
6	Spatial extent of potential impact in receiving environment posed by substances present	Inherent hazard and frequency	Partially in operator's control
7	Temporal extent of potential impact in receiving environment posed by substances present	Inherent hazard and frequency	Partially in operator's control
8	Sensitivity of receiving environment	Inherent risk	Outside operator's control
9	Offensive characteristics/public perception of risk associated with site/activity	Inherent risk	Partially in operator's control
10	Recording and use of information	Management factor	Completely within operator's control
11	Knowledge of compliance requirements	Management factor	Completely within operator's control
12	Operation of process or site	Management factor	Completely within operator's control
13	Maintenance of process or site	Management factor	Completely within operator's control
14	Management and training	Management factor	Completely within operator's control
15	Historical record of incidents, complaints and non-compliance events	Management factor	Completely within operator's control
16	Recognised Environmental Management Systems	Management factor	Completely within operator's control

3.9 Each system of dividing attributes and expressing risk has different advantages and disadvantages (see Table 5 below). The different approaches are illustrated in Figure 4 below. The "balancing model" implies operator performance (i.e. OPA) is desired in proportion to inherent risk (i.e. PHA). The "containment model" implies that over time, safeguards should be increased and risks decreased. The "risk model" is compatible with either of these and simply portrays risks as a product of frequency and consequence factors, where risk management may put downward pressure on either or both frequency and consequence. The "risk model" is widely established (see for example, DETR, British Standards, Health and Safety Executive, Ministry of Defence and Marine Safety and Coastguard Agency approaches in Appendix 1).

Table 5: Alternative Systems for Dividing Risk Attributes

System	Advantages	Disadvantages
Software vs Hardware (OPA vs PHA)	Allows balancing between inherent risk and management factors.	Frequency and consequence are mixed up; more complicated than other approaches.
Control vs Non-control	Facilitates distinction between factors which can be controlled and those which cannot be easily changed. Focus on improvement.	Most factors can to some extent be controlled; hence system not easily balanced. Frequency and consequence are mixed up.
Frequency vs Consequence	Most widely recognised approach. Simple.	Not sophisticated/powerful compared with above systems.

Figure 4: Alternative Models for Risk



Iteration of Risks

3.10 For any type of operation the attributes in Table 4 provide a basis for describing risk. Most regulated sites will have several, if not many, different sources of hazard. For example, an IPC process may have several well-defined point sources for releases of various substances to air and water. It may also have diffuse sources (e.g. fugitive emissions) and, for accidental releases, a potential for loss of containment in various sections of equipment. The risk rating system works by identifying (using iteration if necessary) the major source or sources of risk from the process 'as a whole' and basing the scores on these key sources. A similar degree of flexibility may be required for other regulated operations such as landfills. By 'processing' each potential risk through the same set of attributes, approximate comparison between different types of risk is possible.

3.11 Using iteration, it is possible to produce different risk rating scores for different media/ substances. However, these must be integrated into a single representative score, and it is neither practicable nor desirable within the scope of risk rating to perform a complete assessment of every possible scenario as this is more the role of a detailed exercise e.g. a BPEO assessment. The regulator's knowledge of the process and comparison with other similar processes should provide a basis for selecting a small number of candidate scenarios for iteration across the attributes. It is essential that any set of scores is based on a single scenario. Other more detailed studies should be consulted to identify and characterise scenarios.

Spatial Context

3.12 In principle, it may be necessary to evaluate different spatial scales of risk, from localised impacts (e.g. water pollution) through to national or global impacts (e.g. acidification and global warming). The same set of attributes holds for any scale of effect. However, local effects are likely to be of greater interest within risk rating systems since the contribution of any one site to a global issue is low, and increasing regulatory attention may not result in significant improvement. In principle, OPRA scores can represent any kind of release, from routine discharges to catastrophic loss of containment events (e.g. tank failure, liner failure). Proximity to receptors (particularly human dwellings) is an important spatial parameter considered in the assessment of vulnerability and sensitivity. There may be a need to normalise between different functions, as "close proximity" for a waste site and an IP site, for example, may mean different things.

onsiderations for Read-across

3.13 Likewise, the basic attributes apply equally across different regulatory functions. For example, a rating of hazardous substances is based on the properties of substances present and is independent of the operation itself. This means that a rating of say '1' for hazardous substances has the same meaning for a waste site and an IP process. Direct read-across for other attributes will be more difficult and needs to be undertaken with caution. For example, the magnitude of hazard may be difficult to calibrate for all IP and waste sites, in which case a modification or weighting factor may be required to read-across. Similarly the basis for evaluating measures to prevent or minimize releases is by reference to BATNEE or other relevant standards, which may not be easy to calibrate to a single scale for all types of regulated operation, since BATNEE is a relative standard. Such differences need careful consideration as they will determine the regulatory balance, and may need to be developed using expert elicitation processes, as discussed below for weighting factors.

3.14 Attributes can be split to clarify different issues (e.g. the PIR version has separate attributes for measures to *prevent* and measures to *minimize* releases). The nature of the surrounding environment is a complex attribute which may need to be split into further sub-attributes to facilitate proper characterisation. For example, the Waste and Water Quality (WQ) OPRA systems include several environment-related attributes, reflecting the complexity associated with any method of characterising the environment (see, for example, the DETR Comparative Environmental Index). The WQ version of Pollution Hazard Appraisal (PHA) includes "Nature of Receiving Water", "Water Quality Considerations" and "Location of Process". Waste identifies three separate attributes for three main targets: humans, groundwater and surface water. IPC on the other hand contains one "Location of Process" attribute which reflects 'overall' vulnerability and sensitivity. It is proposed that such differences are allowed, but it is important when attempting read-across between functions that the splitting of attributes is recognised and any necessary recombining or weighting is undertaken to reconcile different functional approaches.

3.15 Additional factors can be incorporated in order to capture specific issues. Similarly, non-applicable attributes can be deleted or "not scored". Deviation from the basic set of attributes in Table 4, however, needs strong justification. Examples are listed below. In most cases these attributes are actually related to the generic factors listed above; for example, operator monitoring is a part of recording and use of information. It may be necessary for the purposes of read-across to establish such relationships and where appropriate, recombine non-generic factors into generic factors. It is important to check whether additional factors will lead to any "double-counting" of issues within the generic factors. Uncertainty in specific factors (e.g. ease of detection may be an uncertainty in vulnerability) may be better expressed in higher weighting factors rather than as a separate factor.

Table 6: Additional Non-Generic Factors Proposed

Source	Non-Generic Factor	Relationship to Generic Factors
	Ease of detection of releases and impacts on the environment	Vulnerability, Nature of Hazard, Physical Measures
	Environmental exposure duration	Nature of Hazard, Vulnerability, Sensitivity
Waste	Non-compliance with licence conditions (Operator Assessment)	Historical incidents
Waste	Type of facility	Scale of process, nature of hazard, frequency of operations
PIR	Operator monitoring systems	Recording and use of information

Environmental Management Systems

3.16 Including recognized Environmental Management Systems (EMS) in the risk rating effectively provides a 'bonus' mechanism for the regulatory compliance and systematic improvement in operator performance required by EMS standards such as ISO14001 and EMAS. It also acts in support of policy objectives, as an incentive for operators to adopt recognised EMS standards.

Currently, OPRA gives credit only for ISO14001 and EMAS systems, and does not reward internal company systems or those based on other standards such as ISO9001.

3.17 The weighting factor for the EMS attribute reflects the extent to which Agency is willing to reduce regulatory attention to sites with recognised EMS, acknowledgement of the extra degree of effective management and "self-regulation" required by an EMS, plus the benefit of checking by independent certifying authorities. OPRA currently attaches a low weighting factor to this attribute, reflecting the inspectors' desire to verify for themselves the critical elements of management which dictate performance, maintenance, operation, training, etc. Thus it is the overall Operator Performance Appraisal (OPA) score which sums up the inspector's view of operator performance, and a recognised EMS is one small part of this.

3.18 Effective management and awareness of risks is evaluated in all OPA scores; presence or absence of a recognised EMS does not automatically imply high or low operator performance. The signs of an effective EMS are continuous improvement, regulatory compliance, and the demonstrative use of a management cycle (identify, evaluate, plan, implement, monitor and correct). These can occur with or without a recognised EMS, although an operator unable to demonstrate these will probably be unable to acquire or maintain ISO14001 or EMAS. Thus an operator does not have to demonstrate the effectiveness of his EMS in order to obtain the score for the recognised EMS attribute; that is something which has to be done for all other OPA attributes.

Integrating Perceived Risk

3.19 The "Offensive characteristics" adopted in PIR OPRA attribute is a requirement for all risk rating systems. It represents the public's overall perception of the operation, which can be a major factor in the amount of regulatory time spent on an operation. The weighting factor for this attribute ideally reflects the Agency's desired split between response to public perceptions and response to an objective assessment of risk. In setting the weighting factor for such concerns, the Agency needs to have regard to the inherent level of perception of different industry sectors. Consideration should also be given to the most appropriate regulatory response. For example, an inspection may be required in some situations, as it will often reassure the public and is also seen as a valuable service to the operator. In other situations, for regulatory efficiency it may be more appropriate to respond using the resources of public relations, education, R&D, operator communications or consultation processes.

3.20 Public and scientific perceptions may be quite different and therefore evaluation of "Offensive Characteristics" must be undertaken separately from the scientific evaluation of risk. Offensive characteristics are determined by two main factors: offence to human senses (e.g. visible plumes, heat and light, noise, odour, dust nuisance, etc.) and the risk perceived by the public. Risk perception may be dictated by the public image of the industry or company, the history of the site, related incidents, media and pressure group attention, whether the nature of effects are hidden or unknown, etc. In general, a new site may have a relatively high "offensive characteristics" score which would be expected to reduce as the site becomes more familiar to local communities. Public perception of risk tends to be dominated by perception of the consequences or catastrophe potential associated with a site, with less concern for frequency issues. Repeated minor incidents may, however, heighten the perception that a major risk is present on a site. Thus it is possible that an increase in perceived risk would be triggered by an actual incident, even if all measures are taken to prevent recurrence.

3.21 Operators with a high level of management, housekeeping and operational control, may minimise offence to senses and may also promote good public relations. Therefore, it is possible that operators with high OPA scores will have a low score for "offensive characteristics". However, it is acknowledged that some processes are inherently more offensive to the senses than others.

Historical Incidents

3.22 The historical record attribute enables real performance data to be included in the system, such as compliance statistics for the operation. This represents an "output" attribute, i.e. it effectively captures performance as measured by real events, rather than an "input" attribute (e.g. training or maintenance) which is a control variable available to the operator to determine performance. A combination of input and output variables gives the flexibility to recognize that even high performance systems can have faults.

3.23 The weighting factor for historical incidents is an important parameter reflecting Agency policy. A high weighting factor implies great importance is attached to actual performance with respect to compliance, incidents and prosecutions. A low weighting factor implies importance is attached to the factors within the process and the management system itself which effectively dictates performance. The WQ function may attach a higher weighting to historical incidents than PIR does, due to the different emphases on "prosecution" vs "process control", for example.

Guidance on Scoring and Weighting

3.24 The numerical expression of risk always carries with it certain difficulties. The central one is the extent to which numbers accurately distinguish between different risks. A general rule is that systems for ranking or quantifying risk need be no more complex than is required to undertake the distinction between risks. A common 'trap' is the design of over-sophisticated schemes that invoke misplaced confidence in output, usually because of aspects related to the precision of scores or risk estimates.

3.25 The existing OPRA systems use two very similar but not identical approaches to generating scores for attributes:

- **Points-based systems,** e.g. score 1,3,5,10 or 20 points for specific conditions; and
- **Relative scale systems,** e.g. 1 = lowest possible condition, 5 = highest possible condition.

In principle, it is easier to avoid skewing within and between attributes if all scales within a particular system are both simple and identical. This implies the PIR approach of using 1-5 for all attributes is more robust than other scoring systems. However it may also be less flexible. Currently, the PIR, Waste and WQ systems have total points scales of 35/105 (PHA/OPA), 300 and 130 respectively. In general it would be preferable for all risk rating systems to use the same scoring systems. However it is possible to normalise different scales. It is possible to modify scoring systems, for example by increasing the range of a relative scale system from 1-5 to say

1-10. This may provide additional statistical benefit and sensitivity of the scores. However it is more difficult to then ensure consistent scoring and may give a false sense of accuracy.

3.26 Other forms of scoring are possible. For example, the American Petroleum Institute (API) Risk-Based Inspection approach relies on an actual estimation of frequencies and consequences of releases. The frequency is calculated from a combination of generic (i.e. world-average) failure rates and site-specific modification (Mod) factors to reflect inspection regimes and management systems:

Frequency = Generic Frequency x Inspection Mod Factor x Management Mod Factor

It is unlikely that a similar approach can be developed in the near future for Agency's purposes however, because the range of industries is very wide, both accidental and routine releases need to be considered, and Agency's needs extend beyond the specific issue of inspection.

3.27 The direction of scoring also needs to be considered. The PIR OPRA scheme works on the basis that a low score corresponds to a low hazard or performance, similarly a high score is a high hazard or performance. This encourages the view that operator performance and inherent risk should ideally be in balance, and reduces the impression that all sites should strive for the best overall 'score' in management performance. WQ and Waste on the other hand score all attributes in the same direction, i.e. a low score is a low risk for all attributes. This is a more user-friendly system. From the point of view of read-across between functions, differences in scoring direction can be normalised.

3.28 Guidance on how to allocate consistent scores based on tangible attributes of the regulated operation is essential. If a scoring system of 1-5 is used, the guidance can be derived based on the notion that the lowest possible value attracts a score of 1, the highest possible value attracts a score of 5 and the median for the entire range of values attracts a score of 3. The scores of 2 and 4 are self-defining as intermediates between 1-3 and 3-5 respectively. It is important to transpose the scale of 1-5 over the entire range of values so that scores of 1 and 5 may be encountered and the 'bunching' of scores avoided. The actual distribution of all operations across the scale of 1-5 may vary considerably. Distributions may be uniform, normal or skewed. The guidance for scoring should prevent artificial bunching of scores within the range of 2-4. Such systems, notably, do not accommodate 'zero' risk scoring.

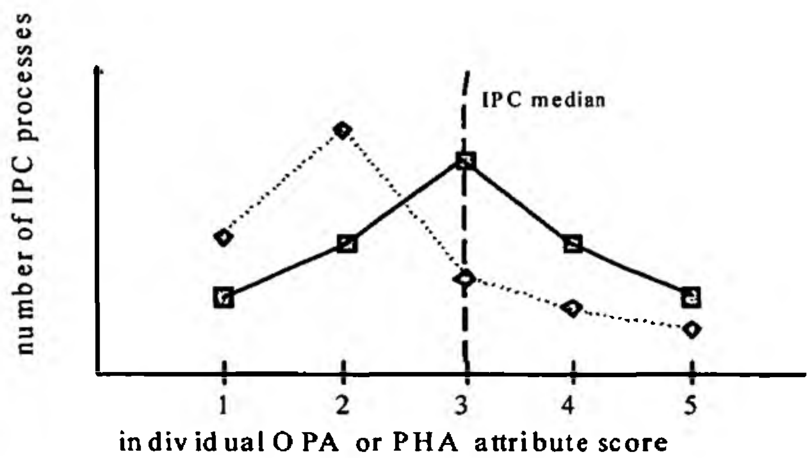
3.29 It is also possible to reflect more than one type of risk in the final score by using the main risk issue as the baseline set of scores and incrementing specific relevant attribute scores to represent other risks which the inspector is concerned about. For example, the main risk is a large release rate to air of a slightly harmful substance, but the inspector wishes to recognize a small inventory of a highly harmful substance which could accidentally spill to water. The hazard score would be based on the release to air and then incremented by 1 or 2 to allow for the spill to water. A large and complex operation can be split into subsystems and "mini" OPRAs performed, if evaluation of the total operation in one go is too difficult. It is necessary to combine the subsystem scores into an overall score for the whole operation. In essence, this represents a means of allowing for multiple inventories of hazardous substances.

3.30 As well as recording scores it is critical to record the reasoning behind a score, and in particular, a change to a score. The basis for scoring should be summarised and include information on which substance(s) and types of risk are critical for that site and why scores have been allocated. It is not the intention of OPRA systems to drive all operators to the same levels of risk and performance (particularly in relation to OPA scores). Low OPA scores may not lead to serious environmental risk, for sites with low PHA scores.

3.31 Scores and overall score distributions are likely be different for each attribute and are likely to vary with time (Figure 5). It is important to monitor these trends and to understand why changes are occurring. Scores may need to be re-evaluated when new information or technology becomes available. For example, scores may need to be re-evaluated if the BATNEEC "scale" changes. Such information provides valuable input to the assessment of specific 'sectors' in any one EP regulated function.

Figure 5: Example of Two Sectoral Distributions in OPRA-style Attribute Scores

3.32 Weighting factors represent the relative importance of different attributes with respect to the

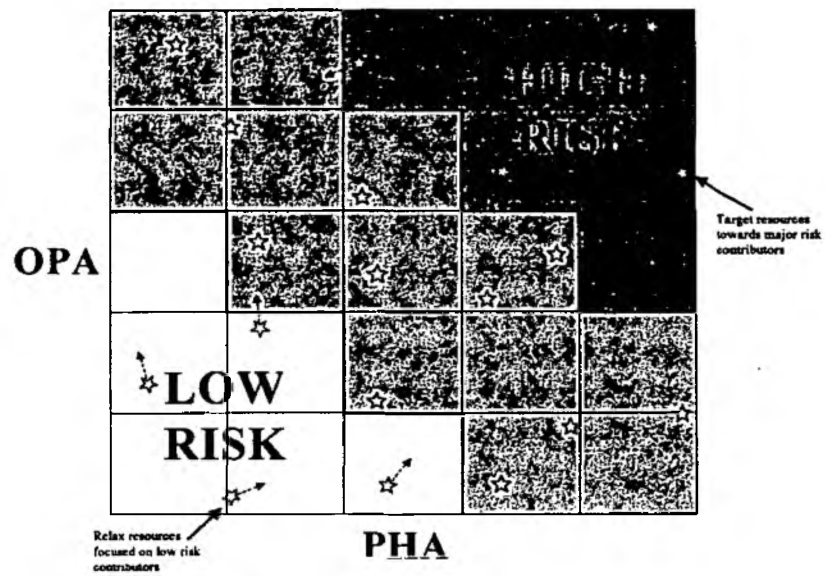


overall level of risk and the use to which the scores will be put. Weighting factors can be used as multipliers for the "raw scores". This enables a summation of scores to be performed along the following lines. Weighting factors thus dictate the overall range of scores and need careful comparison for read-across purposes.

Total Score = Σ (weighted scores) = Σ (attribute raw score * attribute weighting factor).

3.33 For the purposes of assessing and discussing risk on a specific site, weighting factors may not need to be used, because they can be controversial and are only relevant to the resource planning algorithm. In principle, it is possible to use the above equation to calculate overall PHA and OPA scores. In the Waste regulatory OPRA system, these can then be added together to obtain a total risk score for the site (given the OPA and PHA scores work in the same direction). The PIR equivalent expression for total risk would be to divide the PHA score by the OPA score (given PHA and OPA scores work in opposite directions). The Waste version is arguably more "user-friendly" but the PIR version enables a balance to be identified between OPA and PHA. In either case, combining all the risk information into a single score enables production of a list of sites ranked according to risk. An alternative approach is to not attempt to express risk by combining OPA and PHA scores but instead to present them on separate axes of a matrix (Figure 6). The relative position of a site in the matrix is then an expression of the overall risk of that site. This approach is consistent with many other methods of expressing risk and avoids the controversy which may arise over expressing risk as a single number by combining PHA and OPA scores.

Figure 6: Risk Matrix



Expert elicitation for the derivation of weighting factors

3.34 Where weighting factors are needed, experience indicates that they can be readily derived using an expert elicitation or judgement process. This is a form of group exercise where individual experts provide their views on relative importance before an overall group consensus is established. The 'Delphi technique' is an established protocol for expert elicitation: only the highest and lowest individual views need to be explained. Individuals are then allowed to recast their views of the importance and ranking. Median values are then taken to represent the group's overall view. Rules for such exercises include the following:

- a group of experts from all relevant areas participate with a facilitator;
- common understanding of the different attributes and the system is established before discussion;
- individuals determine their own views on the relative importance and ranking of attributes;
- averaging of relative importance and rankings is applied;
- all information is recorded, with explanations;
- group discussion and reconciliation of scores.

3.35 It is important to distinguish when it is appropriate to introduce another risk factor, increasing the scoring scale, or increasing the weighting factor. Each has an effect on the overall risk profile. If any adjustments are made to any aspect, it is necessary to review and adjust the overall system to maintain proper balance. In general it is recommended that scoring scales are not adjusted.

4. Guidance on Resource Planning Systems

Introduction

4.1 Corporate planning in the Environment Agency is a complex, multistage process involving the production of agreed activity lists and service levels, the collation of associated full-time equivalent inputs and financial resources, and the allocation of resources to the activity lists in a prioritised fashion. The development of a prioritised, risk-based resource programme represents a considerable shift in the manner in which this exercise is completed at present.

Overall Principles

4.2 In the initial context of guidance on the use of risk rating systems, resource planning relates primarily to setting inspection and monitoring frequencies. Other potential uses of risk rating results are dealt with in the subsequent section. Table 7 shows the critical success factors for resource planning algorithms.

Table 7: Critical success factors for Resource Planning Algorithms

Consistency – Commonality	It is essential that resource planning algorithms within different functions and activities are as consistent as possible in order to ensure rational allocation of resources both within a function (intra function planning) and between functions (inter function planning).
Cover all relevant factors	The resource planning algorithm must include all relevant factors which go into resource planning, as well as the actual risk considerations. These include available inspector resource, total number of operations, statutory requirements, hours required for visits, programmed tasks, etc.
Application range, Transparency, Judgement	As for risk rating system.

4.3 The development of resource planning systems should include consideration of the following:

- existing resource planning systems (e.g. WMP4 and RSDM41 for waste and PIR inspections respectively);
- total resource available for regulatory activity;
- total number of operations controlled within regulatory function;
- minimum statutory requirements;
- site-specific risk levels – OPA and PHA attributes;
- weighting factors between different attributes, between PHA and OPA and between different functions;
- desired rate of change of OPRA scores and inspection or monitoring frequencies;
- possible rate of change of risk following operator changes (e.g. an operator may agree to improve an aspect of management systems which requires 6 months to take effect);
- nature and duration of tasks required in regulatory activity (for example, if certain types of inspection task can only occur during certain operational phases, e.g. shutdown); and
- priorities and demands – incidents and complaints.

4.4 The purpose of resource planning is to produce ***target*** frequencies for inspection, monitoring and other regulatory activities. A wide range of issues and problems may arise which dynamically affect the available regulatory resource or the actual priority of work. For example, a major incident may occur on a site, resulting in an increase in the actual frequency of inspections compared with the resource planning target. It may be appropriate to set upper and lower limits to the target frequencies calculated in the resource planning algorithm; for example if the target inspection frequency exceeds an override level then it is reset to that level and another activity (e.g. enforcement or review) is triggered.

4.5 At the outset, risk-based resource planning should be integrated with the existing resource planning system at least in the first period of application of the new system. For example, PIR inspection frequencies may be derived using OPRA scores as modifiers for the established RSDM41 inspection frequencies. This avoids major discontinuities in resource allocation during the introduction of the new system and facilitates an acceptable progression to risk-based regulation.

4.6 Risk-based resource planning is one component of the overall resource planning process. This may take into account factors beyond the scope of risk-based considerations, for example particular problems arising in a sector or on a particular site which may require additional regulatory resource. Risk-based considerations therefore should be integrated into overall planning initiatives such as the Priority Planning exercise.

4.7 In general risk-based resource planning in simple form takes a predetermined resource budget and apportions it according to risk, i.e. a "supply-lead" model. Current risk-based resource planning is based on this model. It is intended to progress towards a "demand-lead" model where risk considerations are used to determine the total resource needed.

Specific Principles

4.8 Weighting factors provide a simple means of reflecting the different importance placed on different demands – e.g. reacting to public perceptions of risk vs objective assessments of risk. This requires a policy decision to determine the relative importance of some factors. The split between reactive and programmed inspections may depend on historical experience within the function. For example, in waste, generally 10% of inspections are reactive, whereas the proportion is much higher for PIR. It is possible to constrain OPRA to exclude reactive visits (e.g. due to complaints), effectively by setting the 'offensive characteristics' factor to 0. However, given that OPRA does measure reactive issues, it may be more sensible to retain all OPRA attributes within the resource planning algorithm, so that for example the planned inspection frequency includes a proportion for reacting to public complaints. This provides a comprehensive basis for resource planning including reactive and strategic priorities. It also reflects the reality that inspection visits may deal with both reactive and strategic issues.

4.9 The most simple technique for resource planning is based on the following equation:

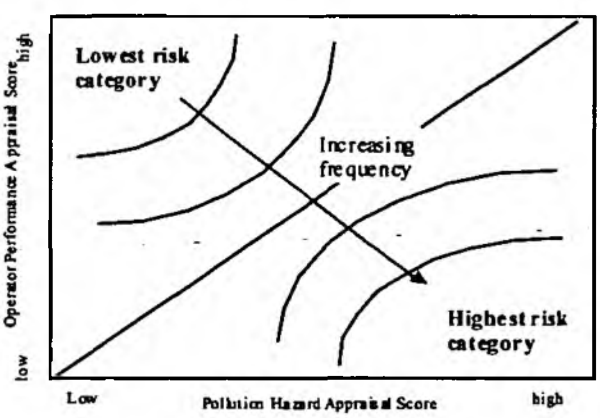
$BR_i = BR_t * (RS_i / RS_t)$

Where RS_i = Risk Score for site i (= PHA/OPA or PHA+OPA)
RS_t = Risk Score total for all sites
BR_i = Budgeted resource for site i
BR_t = Budgeted resource total for all sites

4.10 This approach may be controversial because it requires a single value to represent the risk level. A solution is to use the risk matrix approach or similarly, a banding structure, where the effective risk and corresponding resource allocation for a site are dictated by the risk band or category the site falls into according to its OPA and PHA scores (Figure 6). The banding structure needs to be sufficiently sensitive so that significant changes, e.g. serious incidents or major variations in conditions, lead to sites changing bands where appropriate.

4.11 Algorithms may work on the basis of frequencies or hours allocated to site visits. The Oxford Model and 75% WMP4 inspection frequencies are used in Waste function to define the baseline total number of hours which would be allocated to each site for a 3-month period. An average inspection time is then determined from the Oxford Model hours and the total number of sites. It is assumed that 90% of the total available hours are used for "OPRA inspections" – that is, programmed inspections. The remaining 10% is for reactive inspections. The total number of available programmed inspections is then calculated from the total hours available divided by average inspection time. An "Inspection Score per unit of Risk" is then calculated by dividing the total number of available programmed inspections by the sum of all OPRA scores over all sites considered. This is then multiplied by the individual site OPRA score to obtain the individual site risk-based number of inspections over a 3 month period. This approach is entirely consistent with the generalised approach defined above.

Figure 7: Philosophy of OPRA-style Resource Planning



4.12 Allocating resource in terms of inspection volume (hours/year) enables recognition of different durations of inspection visit and can allow total journey time to be reduced. The duration of the visit may need to be linked to specific factors such as the issues identified in the last OPRA scores. PIR has proposed a minimum inspection frequency of once/year for all processes. The minimum inspection frequency may be varied according to the potential risk of the operation, e.g. once every 4-5 years for highly benign processes. This is consistent with the HSE Inspection Rating System which automatically forces non-inspected sites up to the minimum frequency category of inspection after a designated period. The minimum inspection frequency should be set taking into account statutory inspection frequencies (e.g. in WMP4). However these may not necessarily need to be adhered to if a sound basis for reducing statutory inspection frequencies can be offered and agreed with central government. The key element of this will be to demonstrate that reducing the frequency below the statutory minimum will not significantly increase the level of risk from the operation.

4.13 The general approach to allocating resources described above has limitations. It is relative. The resource allocated to any individual site is dependent on the total budget and the performance of other sites. Therefore resource allocation to a site will go up or down even if no change occurs on the site. Another limitation is the straight-line relationship between risk score and inspection frequency implicit in the formula. It is more likely that a curved relationship is appropriate, reflecting sensitivities to change.

4.14 The simple approach defined above assumes a fixed resource budget is available and this is apportioned according to risk; this is a "supply-lead" model. It will be possible to progress towards a "demand-lead" model, i.e. where the risk levels determine the overall resource budget requirement. This could take the same form as the above equation but be based on "standard" resource requirements for particular regulatory tasks, multiplied by relative risk modification factors for each site to give the total resource required for each site. This may further evolve by replacing "relative" risk factors with "absolute" risk factors and "standard" resource requirements with risk-based resource requirements. This will require feedback from the use of the risk-based resource planning system on the effectiveness of resource allocations in reducing risk. It will also require dovetailing with the work of the Priority Planning exercise. **However it is essential that the Agency develop the capability to predict and justify the total demand for resource based on risk considerations.**

4.15 Optimising inspection and monitoring frequencies can be achieved using a risk-based resource planning process. This can be viewed in two ways. First, the inspection frequency is set according to the risk level, the higher the risk the higher the inspection frequency (Figure 8). Second, the inspection frequency affects the risk level since more inspection should result in reduced risk over time (Figure 9). In order to optimise the total cost of regulatory effort and risk, resources are shifted away from low risk activities towards high risk activities, and the particular level of inspection on a site is set according to how the risk varies as a function of inspection. There is no merit in increasing inspection if no significant reduction in risk occurs. Equally, reductions in inspection may result in some increase in risk. The aim is to set inspection frequencies for all sites so that overall reductions in risk outweigh any increases in risk. Sites where the gradient of risk vs inspection frequency is steep are in general likely to be candidates for reducing risk and increasing inspection activity, whereas sites where the gradient is shallow are likely to be candidates for increasing risk and reducing inspection activity.

Information on the sensitivity of risk to regulatory attention is not generally available immediately and may take some time to acquire. Therefore the initial phase of risk-based resource planning will be "Risk-Targeting", i.e. resources are allocated where the major risks exist (Figure 8). In time this should develop an element of "Risk-Reduction Targeting", i.e. resources are allocated where the major risk reduction opportunities exist (Figure 9)

Figure 8: Benefits of Risk-based Resource Planning

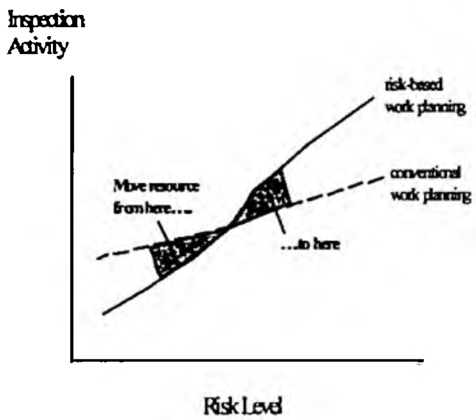
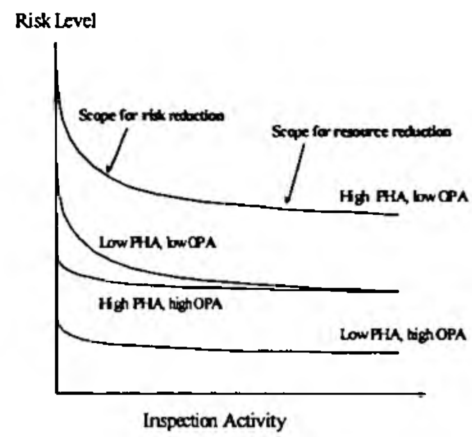


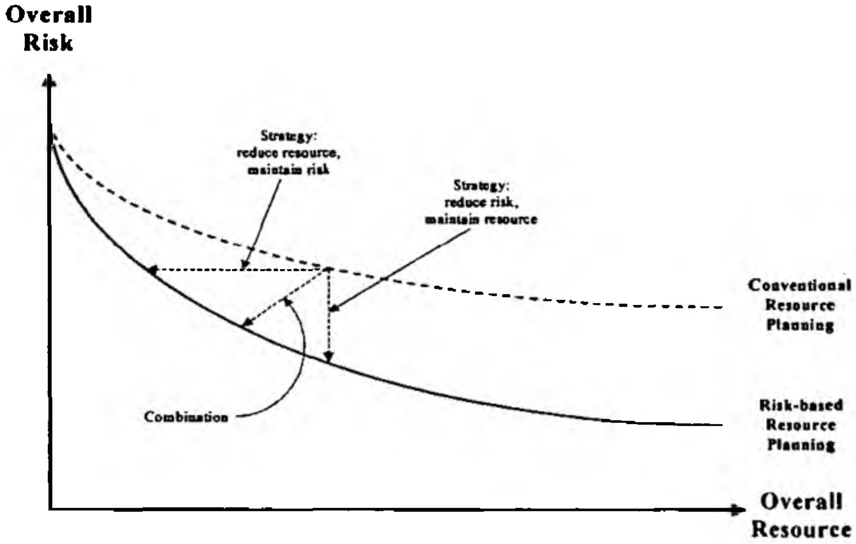
Figure 9: Response to Increased Inspection



4.16 A balance of "Risk-Targeting" and "Risk-Reduction Targeting" should be established in the long term. While opportunities to allocate resource where risk can be reduced should always be sought, it is important that the Agency continues to allocate a certain amount of resource towards high risk operations, in order to establish that the operator is maintaining the appropriate level of control and to manage the public concern towards major risk operations. It is also important that resource allocation reflects an appropriate balance of priorities to anticipate and avoid risk as well as priorities to reduce risk, for example in expending resource to prevent an Environmental Quality Standard being exceeded.

4.17 Across all sites, the move to risk-based inspection should provide scope for reducing either the overall risks or the regulatory resource requirement, or both. The available reduction depends on the difference in accuracy of risk measurement and resource allocation, between the new and existing resource planning systems (Figure 10). For example, it is recognised that some consented discharges are over-monitored given the low level of risks. The available scope for reduction may vary from function to function. The Risk-Based Inspection system developed by the API enables operators of processes to decide whether to reduce risk, or inspection cost, or both. In due course the Agency will need to establish its policy is in this respect, once the risk-based resource planning system is operational.

Figure 10: Reducing Risk and/or Resources



4.18 The required amount of inspection, and the effectiveness of varying inspection activity, for a given operation will depend on the balance between the PHA and OPA characteristics of that operation (Figure 7). Because of the design of the scoring system in this case, a site with a low PHA and high OPA will attract the lowest baseline inspection level. A site with a high PHA and low OPA will conversely attract the highest baseline inspection level. Sites with "high-high" and "low-low" are in balance and therefore fall in between.

4.19 Furthermore, sites with high OPA scores are likely to be more amenable to reduction of inspection activity than those with low OPA scores, irrespective of PHA scores (Figure 9). This is because a high OPA score implies a well-run stable level of risk where the operator's basic management cycle is functioning and the implementation and audit processes result in improvements and corrections. Increasing regulatory inspection/monitoring results in little reduction in risk and the optimum inspection level is relatively low. Low OPA operations however are more reliant on regulatory intervention to maintain performance and identify corrective action, because the internal management system is not advanced in relation to environmental performance. Increasing regulatory activity can result in significant risk reduction (or conversely, reducing regulatory activity may result in a significant upturn in risk); the optimum level of regulatory attention is therefore relatively high. Acknowledgement of the response profile (Figure 9) is critical to obtaining the optimum profile within and between functions (Figure 8).

4.20 Depending on the industry sector, regulatory inspection and monitoring may in general have more effect on OPA attributes than PHA attributes, whereas PHA attributes tend to be dealt with through authorisation and licensing. In other words, OPA attributes are likely to be more sensitive to variations in inspection and monitoring frequency than are PHA attributes. This reflects the fact that OPA covers management factors which may change relatively easily and frequently, whereas PHA covers 'hardware' factors which are generally less prone to variation. PHA attributes can be changed, but usually through variations to conditions or improvement programmes. The sensitivity of each attribute to different forms of regulatory action needs to be considered in resource planning.

4.21 Uncertainty is one of the major factors which determine the appropriateness of regulatory inspection and monitoring. Uncertainty may relate to variability (e.g. fluctuations in discharge conditions), or to knowledge limits (e.g. hidden or unknown environmental effects). Either form of uncertainty may warrant greater regulatory inspection or monitoring effort. This factor is represented in part at least by the "frequency and nature of operations" attribute. However it may need to be further incorporated in the risk rating system and/or the resource planning algorithm. Uncertainties may vary considerably in nature and scale between different industry sectors. Seasonal variations may be one form of variability which needs to be considered in resource planning. For example, summer or winter conditions, changes in wind or river flows, or particular breeding periods, may affect risk levels. These may require inspection or monitoring to be programmed for certain times of year, rather than necessarily increasing resource allocation. Uncertainty also varies according to the life-cycle stage: waste sites generally have limited licence conditions on start-up, whereas IPC processes are very tightly controlled through the authorisation process. At early operation and around closure, waste sites are subject to considerable uncertainty and may need additional regulatory resource.

4.22 In all cases, functions are initially developing risk-based approaches to inspection and monitoring. The approach may need to be extended to other elements of the regulatory system. For example, Waste Function is developing OPRA systems to cover licence conditions, financial provisions, exemptions, charging, enforcement and standard inspection sheets, as well as the inspection and audit monitoring systems. It may be necessary to do the same in other functions so that consistency within the function is achieved. In particular, OPRA may need to be considered in charging, in order to maintain the "polluter or *potential* polluter pays" principle, i.e. avoid cross-subsidy between sites for risk-based inspection and monitoring levels. In some cases all that is needed is to ensure consistency; e.g. authorisation conditions and OPRA scores should be broadly consistent. In other cases the issues are highly linked; for example in Waste, financial provisions are a "backstop" for post-closure risks. If these are strengthened then in principle other components of waste regulation may be relaxed. (There is no financial provision in IPC or IPPC.)

4.23 As well as defining target resource allocations, it is important that the resource planning process reflects the necessary quality of regulatory inspections, monitoring, etc. The use of OPRA information in determining the scope of visits and important or priority issues to address, is intended to cover the issue of quality. This also has implications to the level of expertise that may be required for different sites or visits. Currently, there is some flexibility in resource utilisation, for example WQ vary the proportion of specialist visits and routine sampling visits according to the perceived level of risk, within the existing monitoring frequency requirements given in the National Consents Manual.

4.24 The practical aspects of the availability of inspectors relative to sites needs to be considered if resource planning extends to regions and nationally. Costs of travelling to sites, and the effects of multiple-issue single-visits may then become significant. Current systems tend to work at an area level so this need not be a significant issue.

4.25 The Agency aims to take an integrated and consistent approach across regulatory functions, where possible. This may be facilitated by inter-functional resource planning, i.e. where the total resources used for regulation are divided between functions taking into account overall risks and regulatory requirements. The above approach may in principle be applied for intra-function or inter-function planning. The wider the range of applicability the greater the care needed in ensuring the scales and weighting factors are calibrated to cover the entire range of operations. This may again require the use of expert elicitation to determine suitable weighting factors in order to be able to compare say scores for an IPC process and scores for waste processes. It may be possible to use a framework similar to that being developed by NCRAOA for Strategic Risk Assessment to formulate high-level weighting factors for inter-function planning.

4.26 Compliance monitoring may be used to calibrate risk scores against “actual” environmental risks. To a certain extent this is achieved through including historical incidents in the rating system and also by triggering an update of the risk rating when a site has an incident. However it may be possible to further calibrate scores according to the results of environmental or end-of-pipe monitoring.

5. Other Uses of Rating Systems Results

Dialogue with Operator

5.1 The OPRA-style scores for an activity should be discussed openly with the developer, discharger or operator concerned, to enable the operator to bring to the attention of the inspector any information which may be pertinent to the score and to promote a focused and constructive dialogue on the factors dictating risk. This ensures the scores are as robust and up-to-date as possible and the operator can identify opportunities to improve. However it is important to establish that while operators are free to use OPRA for their own purposes (as some are now doing), the OPRA scores are the responsibility of the inspector and there is currently no scope for self-assessment by the operator as the basis for setting OPRA scores.

Publication of Risk Ratings

5.2 Publication of OPRA scores has been discussed extensively within the PIR version. Both inspectors and industry were very apprehensive that publishing such information might lead to misinterpretation, threaten credibility or inhibit open dialogue. However it is recognized that publication of performance data can provide a powerful incentive to improve performance, and is an important part of the open relationship between regulator and public. Some of the information on which OPRA scores are based is in any case already in the public domain. In the medium term, OPRA scores have therefore been given the same confidentiality status as inspection reports, which is that they are not released to the public domain unless required by legal processes. In the longer term however, it is envisaged that OPRA results may be published in one format or another, for example:

- giving sector-specific results and no site-specific results;
- showing trends in general results; or
- allocating sites to broad-band categories.

Charging

5.3 Using OPRA scores in charging is seen as a logical potential extension to the system and IPC industry at least supports this proposal. Any charging system which takes into account the number of days spent on a site will in any case automatically vary according to inspection frequency. However it is necessary to ensure that the risk rating system is robust before use in charging. The IPC review of charging is considering other methods of charging as well as an OPRA-based scheme. It is likely that linking charging to OPRA will result in greater arguments with operators over the validity of OPRA scores.

5.4 Charging is based on cost recovery for Agency resources allocated to industry sectors or specific industries. The charging basis varies from one function to another. Functions where charging is directly linked to inspection and monitoring frequencies (e.g. WQ) may not be able to fully implement a risk-based resource planning algorithm until the charging regime is updated. This depends on the rules regarding funding: revenue from some charging regimes goes to a national

Agency fund for that regulated regime (e.g. WQ C for D). Also, some funds are ring-fenced for use only within a given industry sector (e.g. waste regulation). On the other hand, the principle has been agreed with DETR that industry sites should not be expected to cross-subsidise each other.

Risk-Based Licence/Authorisation Conditions

5.5 OPRA can be used to derive risk-based conditions (e.g. discharge limits, equipment availability requirements, waste storage requirements, monitoring, etc.), by addressing conditions to the areas of concern identified in the OPRA scores. In fact it is important to ensure conditions and OPRA scores are consistent with each other. However, a link between an OPRA score and a new condition implies that the current performance in that area is unacceptable, and the implementation of that new condition should result in an improvement in the relevant OPRA score. A weak condition or set of conditions does not need to be seen as a risk attribute in its own right as it should effectively be represented in the standard OPRA scores. For example, non-compliance with a weak (i.e. high) discharge limit would constitute a severe incident and would cause a very low OPA6 (incidents and non-compliance events) score, since this addresses severity as well as frequency of events. Also if a particular aspect of an operation or a discharge or is considered to be a high risk because of a weak condition, this should be reflected in higher PHA1-6 scores.

Strategic information

5.6 The PIR OPRA system was proposed for this purpose in the original consultation document. Although industry was sceptical that such a simple system could yield useful strategic information, it is highly likely that this will be a legitimate application for OPRA results once there is enough reliable data available. OPRA scores viewed over the long-term may be seen as one of many performance indicators for industry and the Environment Agency. Furthermore it is likely that OPRA information gathered across functions will provide useful strategic information on statutory requirements and charging schemes.

Application to Other Agency Work

5.7 An OPRA style tool could be used to prioritise risks and set workloads, for example in reviewing IPC/IPPC authorizations, COMAH Safety Reports, Audits, etc. Where joint competent authority status exists, risk rating may be used to determine the division of workload, e.g. between HSE and Agency in reviewing COMAH Safety Reports. OPRA principles could also be applied in Land Quality, Flood Protection, LEAPs and IRBM. The potential exists for simple risk rating and resource planning systems in any area where risks exist and relative priorities need to be defined. Similar tools already exist in certain areas, for example the water resource management screening tool used to identify priority surface waters. Also, the “Rapid Risk Assessment Tool” was developed to assess the adequacy of measures to prevent pollution to surface waters.

6. Development and Implementation of Systems

6.1 Responsibilities for development and implementation need to be carefully defined. In general it is proposed that EPNS support national implementation of the systems and gathering and interpretation of results, with technical assistance from NCRAOA and other national centres in scheme design. A team including NCRAOA, EPNS and inspectors should develop such systems. Regional and Area managers use the results to ensure consistency across their domains. Inspectors "own" the OPRA scores for their allocated sites.

6.2 The order of development of OPRA tools for different functions can progress as parallel developments in separate functions, or sequential development using one template. For consistency the latter is preferable. However, in practice the former is required in order to make good progress. This heightens the importance of following guidance and possibly using staff with previous experience in the development of new systems.

6.3 It has become clear in the PIR version of OPRA that a stagewise process of development and implementation is advised (both by industry and inspectors), based on preliminary testing, consultation and review before extending to different application areas. It is important to develop, test and gather data from the risk rating system before applying in the Resource planning system. A controlled process of review and further improvement forms part of this stagewise process (e.g. annual review and modification of system, then freeze for one year of use). It is essential that refinement of the risk rating and resource planning system is allowed, based on a review of the results generated by the existing system. This may identify limitations in the system which require improved guidance or other refinements.

6.4 Consultation, both with industry and inspectors, was carried out exhaustively for the PIR version. The system is more robust and accepted as a result of this effort. Consultation should be built into any project to develop such a system. This is consistent with the Agency's intention to be open and consult with stakeholders. Consultation works well when it is planned and deadlines set for comments and revisions.

6.5 Training will be required for inspectors and may be desirable for operators. PIR carried out both, using outsourcing for operator training. Training should consist of both background and theory sessions, and practical sessions where inspectors work on case studies to generate OPRA scores both individually and in groups. The spread of results provides feedback on areas where guidance needs to be improved. Training should also cover the "why, when and how" aspects of employing the system, for example by demonstrating the procedures for use and indicating how long the assessment should take. Training of all inspectors should be carried out within a short timeframe and before the first official version of the system is finalised/published.

6.6 The amount of effort required of inspectors in using the system – needs to be considered and compared against the benefits of using the system. While ratings systems are inherently simple and take little time to apply, one view of inspectors has been that the insufficient resource for inspection is made worse by the additional burden of carrying out OPRA. On the other hand, inspectors have been concerned that OPRA is a "checklist" approach which potentially replaces or trivializes serious inspection. The key lessons for resource issues are shown in Table 8.

Table 8: Resourcing Issues

1	OPRA supports inspection and other regulatory activity – it does not replace these
2	Cost-benefit analysis of OPRA should indicate significant net benefit by targeting limited resource
3	Application of OPRA is always a short duration task; more comprehensive studies are separate exercises
4	Argument with operators is restricted by the procedures and review process – the inspector owns the scores
5	Frequency of updating OPRA scores is dictated by variability in site conditions and flexibility of resource planning

6.7 Regulatory Procedures define practical issues such as when and how to apply the OPRA system. Procedures have been developed for the PIR version. They contain definitions of when the inspector should consider carrying out an OPA or PHA (see below). In addition, procedures define the process for completing and passing on OPRA information, informing the operator and allowing further comments, revision of scores, etc. Different functions will specify different baseline frequencies for carrying out or updating OPRA exercises. For example, the Waste version requires scores to be updated on a quarterly basis. WQ carries out OPRA on an annual basis.

Table 9: Triggers for Attribute Re-appraisal

When to carry out an OPA?	**When to carry out a PHA?**
At least once a year	At least once every 4 years
New information comes to light potentially affecting scores	Upon reauthorization
Change of management	Major variations resulting in changes to physical process
In the event of an incident	When new technology or information becomes available
Any other reason stated by the inspector	If there is a change to the receiving environment
	Any other reason stated by the inspector

6.8 Trials and calibration should be carried out as part of the testing and development of the system. The primary purpose is to check consistency and reproducibility of scores, to eliminate abnormalities and to identify improvements to the system. Calibration is aimed primarily at ensuring consistency at a national level, although it is clear that a degree of operational calibration may occur at area or regional levels. Both for intra and inter function planning and for actual risk scores, it is worth reviewing the results of the models to see if they reflect the Agency's expectations and priorities. Calibration of results will include modification of individual scores to calibrate with other scores for similar, e.g. to avoid inconsistencies from one region to another. However it is important to check why an apparently inconsistent score has been given, because this may be due to a site-specific factor. This is where the reason for giving a score is just as important as the score itself. Calibration of risk scores against actual performance, e.g. incident records or monitoring results, may also be possible, in order to target resources towards actual low performance. This in principle may be achieved by including actual performance as an attribute (e.g. OPA6, "Incidents, Complaints and Non-Compliance Events" in the PIR version) and using a suitable weighting factor for this attribute.

7. References

IChemE
European Environment Agency Environmental Risk Assessment
HSE Landuse Planning Guide
HSE Risk In Decision-Making
DETR Guidance on Risk Assessment and Risk Management for Environmental Protection
DETR Comparative Environmental Index
MOD Standard 00-56 Safety Management Requirements
BS 8444 Part 3: Risk Management
Maritime and Coastguard Agency Health and Safety at Work Regs
Australia and New Zealand Risk Management Standard 4360
ICI Risk Screening Technique
RPS Clouston Strategic Risk Assessment
API Risk-Based Inspection
Environment Agency RSDM41
DETR WMP4
Environment Agency National Consents Manual

Appendix 1

Risk Based Inspections in other Organisations

Risk based approaches have been developed to determine the nature and frequency of inspections for different industries. The areas covered are:

- Setting of inspection frequencies by HSE
- Risk Based Inspection in process industry
- Risk based rules in Classification

HSE's Approach to Determination of Inspection Frequencies

The different Inspectorates within the HSE employ different approaches in determining the distribution and frequency of inspections. Depending on the nature of the industry the approach differs. For example, the ***Nuclear Inspectorate*** applies a risk-based approach by identifying high-risk sites and focussing inspection effort towards it. For example, a nuclear power station will have a dedicated inspector who will utilise specialist inspectors as and when required.

The ***Offshore Inspectorate*** uses the Safety Case submitted by operators as the basis for determining inspection frequency. At the New Build Stage, the operator has the option to submit a Design Safety Case (i.e. voluntary), which does not have to be accepted by the HSE. The HSE discusses the Design Safety Case with the operator and highlights potential areas of concern. 6 months before first oil an Operations Safety Case has to be submitted by the operator and this has to be accepted by the HSE before the platform can produce oil. The HSE discusses the Safety Case with the operator, in line with the goal setting approach. If the HSE Inspector is still not satisfied by aspects of the facility, they can serve different levels of Issue Notes (1 to 3 – with 1 being high and 3 low priority) detailing "issues" to be considered. If the Safety Case is not satisfactory in the Inspector's view or there are concerns regarding the operator's attitude to safety and the adequacy of the safety systems, then the facility is prioritised as requiring greater inspection effort. Each Safety Case has a nominated HSE Case Manager, and each facility has a nominated Inspector. As with the Nuclear Inspectorate specialist Inspectors are used as and when required.

The ***Field Operations Division*** is the largest division within the HSE and has over 700 inspectors and 7 regional areas to cover. The scope of application is very broad as it encompasses all the areas not covered by the other divisions (i.e. railways, nuclear, offshore and hazardous chemical industry), and includes for example, construction, agriculture, minerals/wood etc. A staged approach is employed by FOD to allocate and direct inspection activity; this involves using:

- The workload formula to allocate available inspection resource across different industry sectors (e.g. construction, agriculture etc.) and geographic regions.
- The FOCUS inspection rating system (IRS) to prioritise which facilities should be inspected.
- Sector strategic planning to identify objectives for specific industry sectors and the areas which the inspectors should focus on when inspecting specific facilities.

At a first level, the **workload formula** is used (a scheme rather than a scientific formula) to allocate resources to each of the sectors of employment for which FOD have responsibility. The scheme which is designed to show the relative priorities between the sectors takes account of:

1) accident incidence rates – corrected for under reporting;
2) ill-health incidence rates – based on a self-reported workplace ill-health survey;
3) public perception and political influence – complaints received and Parliamentary Questions and similar;
4) numbers of employers;
5) welfare standards – from inspection rating scheme; and
6) confidence in management to self-regulate – again from inspection rating scheme.

Data on the factors above are collected and evaluated by a number of working groups who assess the relative positions of the different industry groups with respect to the factors above. Inspection resources are then allocated in terms of percentages across the different industry sectors. For example, the agriculture and wood sector should be allocated nationally 17% of available resource, the construction sector 19% and so on. The scheme also gives an indication of the appropriate geographical distribution of the sector share. If one of the regions has a particular concentration of any industry or a particular problem which is of political concern, for example organo-phosphorous in Wales and the West of Scotland, it will get a greater share of the sector resource than its neighbour. In practice, some of the factors above may be weighted, for example, political and public pressures may lead to a focus on a specific industry sector although the risk level in terms of the other factors is low.

The **FOCUS Inspection Rating System** (IRS) not only feeds into the workload formula, but also guides inspectors as to which premises should be visited within the sectors. The FOCUS Inspection Rating System is for use by inspectors of all disciplines although not for the rating of construction activities. The system has the same purposes as its SHIELD-based predecessor, i.e. to enable FOD to prioritise work effectively, but the new system places extra emphasis on risk assessment enabling resources to be targeted at those employers and activities which pose the greatest risk to health and safety. The key features of the system are:

7) the addition of an objective factor based on accident incidence rates;
8) the addition of an elapsed years factor (for certain incumbents);
9) the clear distinction between risk and hazard for safety and health elements;
10) the automatic calculation of overall rating by the computer;
11) the facility to monitor trends in an incumbent's rating over time;
12) improved guidance on making hazard and risk judgements about occupational health issues;
13) the flexibility to create records which more accurately reflect employment patterns rather than ones based on the concept of a fixed establishment; and
14) the facility to group-rate blocks of incumbents automatically

The system is not intended to be a scientific risk assessment tool. It is designed to be used by, or under the supervision of, experienced HSE staff with the necessary knowledge and skills to make professional judgements of the standards at workplaces. It applies across a broad range of sectors and is not intended to address specific factors peculiar to certain types of workplaces.

The rating details contain 7 elements each of which should be rated on a scale of 1-6 (where 6 represents the worst situation). The elements are:

1) safety hazards;
2) health hazard;
3) safety risk;
4) health risk;
5) welfare;
6) public risk; and
7) confidence in management.

Inpsectors are required to enter the ratings into FOCUS and the ratings are automatically counted by FOCUS. The system will apply weighting factors to each rating element which reflect their relative significance. Greater weighting will be applied to the risk to employees, public risk and confidence in management elements with less emphasis given to hazard and welfare. FOCUS has the flexibility to allow the weighting factors to be changed centrally should this be required. The current weighting factors are:

Rating Element	Weighting
Safety hazard	6
Health hazard	6
Safety risk	9
Health risk	9
Welfare	5
Public risk	10
Confidence in Management	10

When calculating a site's overall rating, FOCUS adds one, and in some cases 2 other factors:

- **an objective weighting factor** is a figure added centrally at the start of the planning year to each rated record. It is based on accident rates for a specific type of activity (i.e. SICR92). A weighting factor is assigned to each SICR92 activity and added to the rating. The maximum addition is currently 23 and in most cases will form a relatively small proportion of the total rating.

- **an elapsed years factor** is a facility for automatically adding a factor on the basis of years elapsed since the last rating based on an inspection. But this factor will not be applied where the rating falls below and agreed threshold, currently 134.

The IRS gives a numerical "score" for each site which are grouped into A, B, and C. Group A being the most hazardous/riskiest sites and Group C being the low hazard low risk sites. The aim is to visit the Group A premises, roughly the top 9-10% of registered premises, at least once every year. Premises in Group C are low risk and FOD do not plan to inspect them at all. However, they do aim to contact them at least once every 6 years by mail-shot or a visit from a Workplace Contact Officer. They will only receive an inspection if an inspector has to visit for another reason such as following up a complaint or to investigate an accident. The premises in Group B form the bulk of the sites and these are selected for investigation on the basis of their ratings, the time since they were last visited and sector priority issues.

Sector strategic planning is the process of developing objectives for specific industry sectors, and thus identifying areas that inspectors should focus when visiting specific installations. The approach used is based on analysing broad trends in industry specific data. This sets up the basis for formal and informal liaison with tripartite industry advisory committees. It employs a risk-based approach to assign priorities within industry sectors, thus focussing on specific issues. For example if there are two similar sites with identical rating values, but one happens to carry out part of the process on equipment with known health and safety problems. If the sector strategic plan sets this as a priority for action that factory would be selected for inspection before the other.

The ***Chemical Hazardous Inspectorate (CHIDD)*** used to be a part of FOD, but split about two years ago to focus on major hazard sites. It considered the use of IRS as adopted by FOD, but due to the hazardous nature of the sites, the inherent hazard always scored highly. Initially CHIDD moved away from a risk ranking approach and relied on the information provided in the Safety Reports and the inspector's judgement to set inspection frequencies for the major hazard sites. CHIDD is obliged to inspect these sites a minimum of once a year. The less hazardous sites (i.e. lower tier) do not have to submit safety reports. Therefore the inspection frequency is based on a 5-year cyclical basis which relies on historic information (e.g. previous prosecutions) and the inspectors judgement regarding the risks of the site and the operator's systems to manage the risks. However, CHIDD have not completely moved away from a risk based approach. A simplified risk rating system is in the process of being developed and trialled for the non-major hazard sites regulated by CHIDD (approximately 8000 premises). Two main factors are rated – the intrinsic hazard associated with a site and the inspector's judgement on the standards of controls. Both factors are rated between 1 and 7, and the balance between the two determines the inspection frequency.

Risk Based Inspection in Process Industries

Risk Based Inspection (RBI) techniques have been developed for determining the optimum combination of inspection methods and frequencies for a process plant. Each available inspection method can be analysed and its relative effectiveness in reducing failure frequency can be estimated. Given this information and the cost of each inspection method, an optimisation program can be developed. The key to developing such a procedure is the ability to quantify the risk associated with each item of equipment and then to determine the most appropriate inspection techniques for that piece of equipment. The approach developed by DNV on behalf of the American Petroleum Institute (API) involves evaluating the risk for an equipment item (i) using:

$$\text{Risk}_i = \text{Consequence}_i \times \text{Likelihood of Failure}_i$$

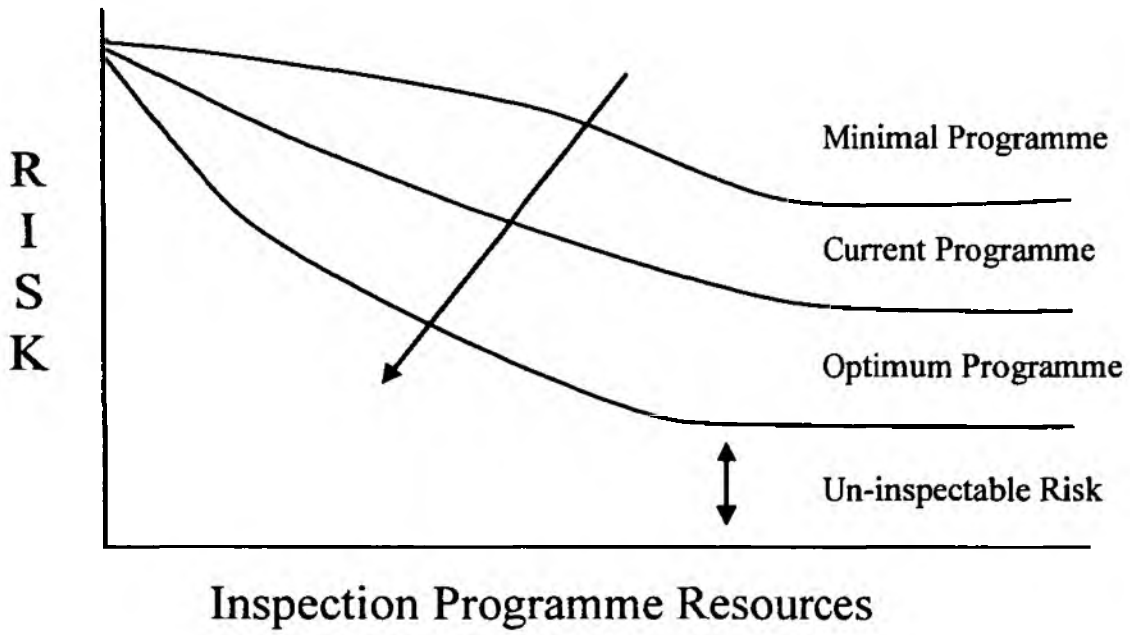
The likelihood of failure is evaluated using the failure frequency of the equipment item and applying site specific modifying factors; the latter includes:

- Technical subfactor: Damage rate, inspection effectiveness.
- Universal subfactor: Plant condition, cold weather, seismic activity.
- Mechanical subfactor: Equipment complexity, construction codes, safety factors.
- Process subfactor: Continuity, stability, relief valves.
- Management system factor.

Consequence is evaluated using discharge and dispersion models as well as flammable, toxic, environmental and financial effect models. The consequence and frequency factors evaluated are ranked (A to E for consequence and 1 to 5 for frequency) and plotted on a risk matrix. Changes to inspection regimes can only affect the frequency of an event, and not its consequences. Therefore if an item is in the high risk category primarily due to it's consequences, then no amount of additional inspection will improve it, and design changes to the system may be required instead.

A RBI study typically involves establishing the baseline scenario with regard to different equipment items. This identifies the distribution of the equipment items across the risk matrix. After establishing the baseline, sensitivity studies are conducted to consider how the risk picture would change one, five and sometimes up to ten years in the future if the organisation were to undertake a combination of different types of inspection methods. For example, the effect of "one highly effective inspection" vs. "two moderately effective inspections", etc over the specified time interval. The terms highly and moderately effective are determined by whether the method is sensitive to the active damage mechanisms in play. The inspection effectiveness is defined for different modes of failure in terms of combinations of intrusive and non-intrusive inspections. Intrusive inspection involves complex, costly and time intensive activity (as it involves opening the equipment, removing the lagging, doing the inspection, putting the equipment back together again etc.). Non-intrusive inspection does not involve entering the equipment e.g. ultrasonic scanning, and is therefore significantly less costly. Therefore by iterating around the baseline risk by varying the type and frequency of inspection for individual equipment, an optimised inspection plan can be produced. The balance between the level of risk and the utilisation of inspection resources is shown below in Figure 1.

Figure 1: Level of Risk Compared to Inspection Resources



Using the output from a RBI study, the operator can:

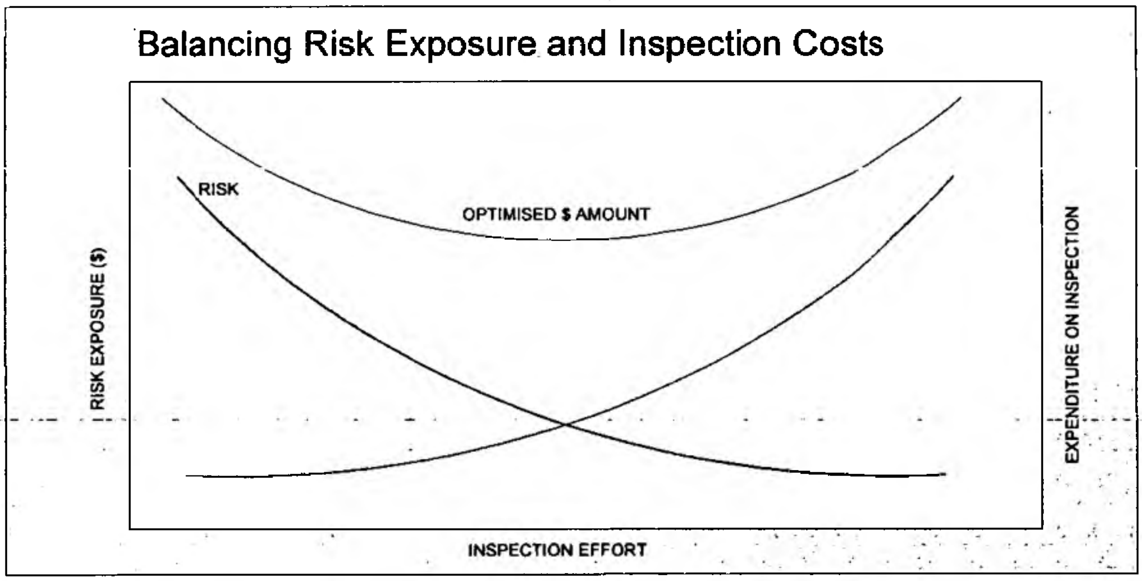
1. Allocate same level of inspection effort towards the high risk equipment items to lower the overall risk but at the same cost of inspection.
2. Allocate lower level of inspection effort but direct more to the high risk equipment items to achieve same level of overall risk but at lower costs.
3. Combination of the options above.

Studies using the RBI approach have extended the scope to include financial risk evaluation by summing the:

- cost of equipment repair and replacement
- downtime associated with equipment repair and replacement
- costs due to potential injuries associated with failure
- environmental clean-up costs

By balancing the financial risk associated with the factors above and inspection costs to evaluate an optimised inspection plan with associated costs can be developed (see Figure 2).

Figure 2: Inspection Programme Costs



Risk Based Systems for Shipping

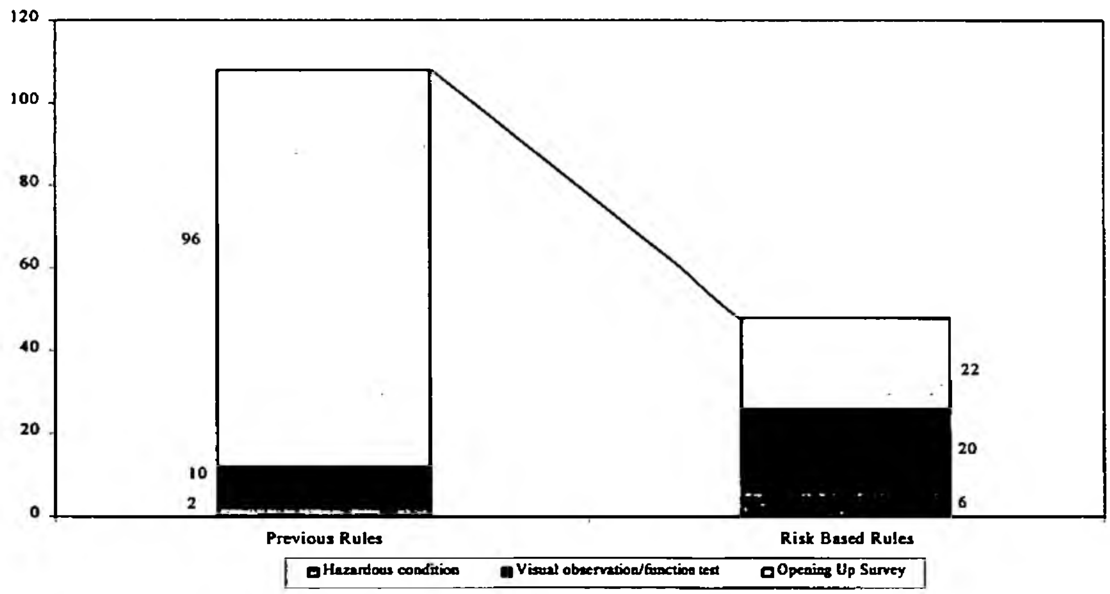
Classification

Traditionally ships have been inspected by classification bodies under blanket requirements that the ship will be inspected after the first, two/three and five years after its been in operation. For specific items of machinery, there is a move towards a risk-based rules system. DNV has developed the Nauticus Propulsion system which applies risk-based criteria for propulsion machinery based on:

- Performance evaluation based on regular checks of propulsion plant performance.
- Mechanical integrity and wear assessments are based on data from a fully implemented Planned Maintenance System. The aim of the class notation is to monitor deviations between planned and performed maintenance for specific parts of the propulsion machinery.
- Fire/explosion/leak hazards based on survey observations for detection of inflammable fluid leaks and potential fire and explosion hazards.

The approach balances the level of risk versus the need to maintain an acceptable level of functional integrity. The method is based upon failure analysis in a functional hierarchy, where each main function analysed has been assessed with respect to the consequences of failure and failure frequencies. Consequences of failure have been evaluated based on safety of personnel, ship and equipment, the environment, cargo and availability of the vessel. The results from the performance monitoring are also used to evaluate the need for "opening-up" inspection (i.e. more intrusive inspection) of vital machinery parts. As with the process industry, due to time and cost associated with intrusive inspections, as far as possible, attempts are made to reduce the number of "opening-up" surveys, unless the performance monitoring indicates a problem. Figure 3 below shows the number and type of surveys for a specific type of propulsion machinery using the traditional 1A1 rules compared to the risk based 1A1 Nauticus Propulsion scheme. This shows that the number of "opening-up" surveys have been reduced from 96 to 22 (providing no abnormal conditions are detected through performance evaluation). The number of visual observations and hazardous conditions have increased; however the time and costs associated with these surveys are lower than for opening up surveys.

Figure 3: Number of Class Surveys over a 5-year Period for Propulsion Machinery



Ship Indexing Systems

A number of ports have developed ship indexing systems for identifying substandard vessels that require inspection. For example, the Washington State Office of Marine Safety (OMS) has developed the "Screening for Acceptable Risk" program to screen cargo and passenger ships for risks posed to the marine environment. The program uses a database of risk related vessel data and a risk matrix based on the expert opinion of experienced mariners. The matrix prioritises ships for boarding and inspection. The risk matrix relies on 11 weighted risk elements such as vessel age, flag and casualty history. Each ship screened by the matrix receives a numerical score and is assigned a priority for boarding. Ships found to pose high risk are boarded by OMS personnel and examined with an emphasis on human factors. Data gathered during boarding are transferred into the OMS database. Risk predicted by the matrix will be compared to actual findings of OMS vessel examinations to facilitate continuous improvements in the process.