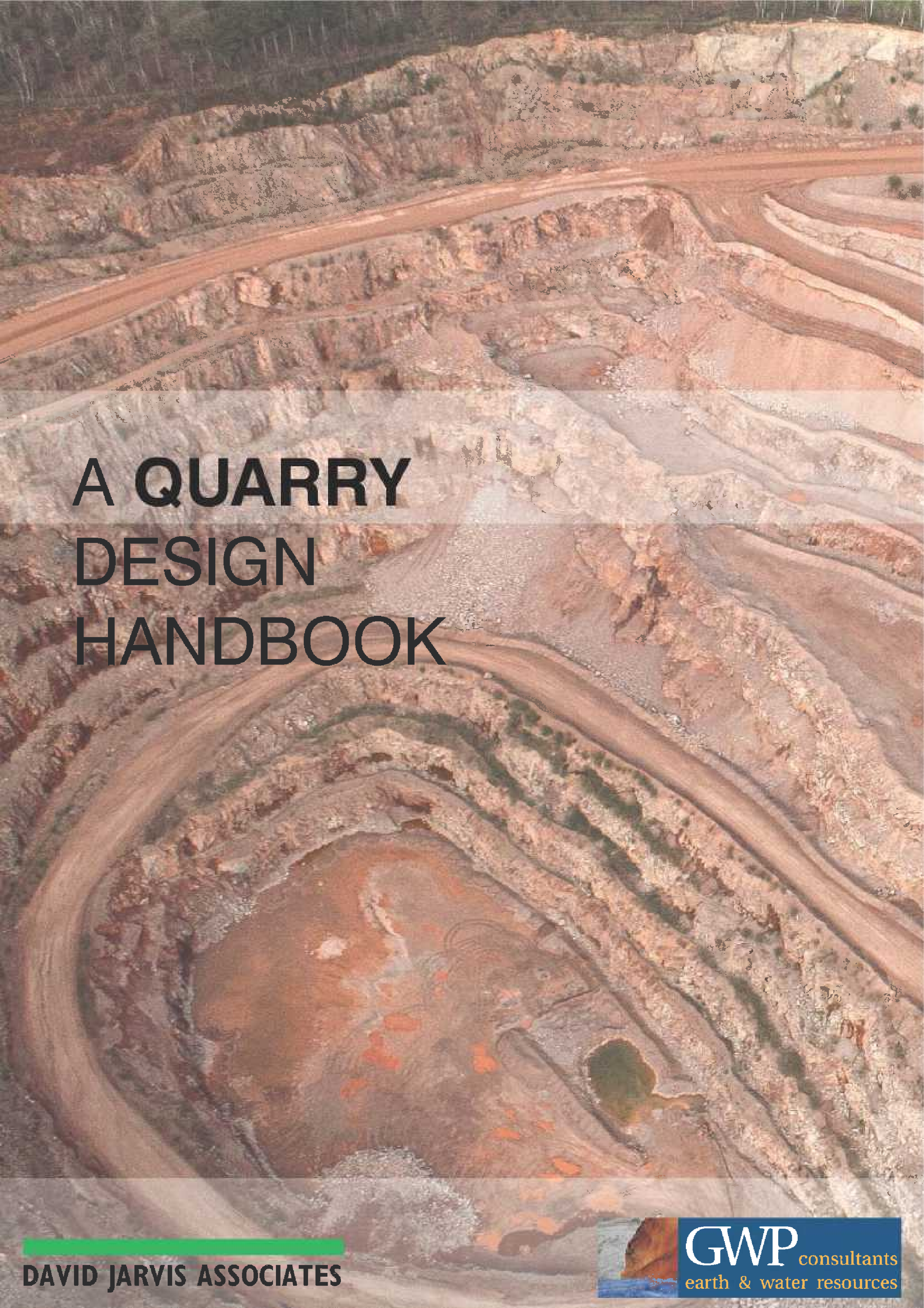

A **QUARRY** DESIGN HANDBOOK

DAVID JARVIS ASSOCIATES

GWP consultants
earth & water resources

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A QUARRY DESIGN HANDBOOK

2014 edition

An earlier version of this Handbook formed the principal output from a project supported by the Aggregates Levy Sustainability Fund (ALSF), completed in 2007[1]. The Handbook was presented in 2007 as a pre-publication draft and has now been updated and published on CD and to download from the websites of GWP Consultants LLP (www.gwp.uk.com) and David Jarvis Associates Limited (www.davidjarvis.biz). There is no charge for CDs or downloads of the Handbook, but we may make a charge for postage or for printing if hard copies are requested.

The original version of the Handbook was supported by the ALSF and was therefore necessarily targeted specifically at aggregates producers (and their stakeholders) in England and Wales. However, most of the material is relevant to the design of any quarry for the recovery of construction and industrial minerals, anywhere in the World. In this edition, specific information on the UK planning system has been removed from the main text (principally in Chapter 1) and replaced with more generic descriptions of the mineral planning processes that must be negotiated in any jurisdiction to obtain necessary permits and licences to establish and operate a quarry. An updated version of the original Chapter 1 (*Understanding the Planning and Licensing Process*) has been retained in a new Appendix 1-1. Although Regulations concerning the operation of quarries and the safety of those operations vary from jurisdiction to jurisdiction, we have retained many of the references to the UK Quarries Regulations 1999 as the authors consider that these provide a logical basis for key elements of design risk assessment (see Chapter 6) whatever the local or national legal requirements may be.

The authors

The principal authors of the Handbook are Ruth Allington of GWP Consultants and David Jarvis of David Jarvis Associates Ltd. Significant contributions were also made to the original work by other members of GWP and DJA staff, notably Dr Isobel Brown and Dr Steve Reed of GWP, and Tamsyn Howard, and Fiona Sharman of DJA. Antony Cook of DJA has updated material on the mineral planning system in England and Wales for the current edition (Appendix 1-1).

Acknowledgements

We would like to thank all those who have contributed to this work, particularly the members of our steering committee, those who attended our stakeholder consultation events during the project, and those who reviewed and commented on the consultation draft.

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[1] http://www.sustainableaggregates.com/library/links/links_onsite/L0060.htm

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FOREWORD

THE NEED FOR QUARRY DESIGN

This Handbook is about the design of new quarries, quarry extensions or revised quarry working schemes. The primary objectives of good quarry design are the safe, efficient and profitable extraction of the maximum usable material from the available land *whilst causing* the minimum environmental disturbance *and resulting in* beneficial final restoration and land-uses. The essential balance and interaction between these objectives is illustrated in Figure 1.

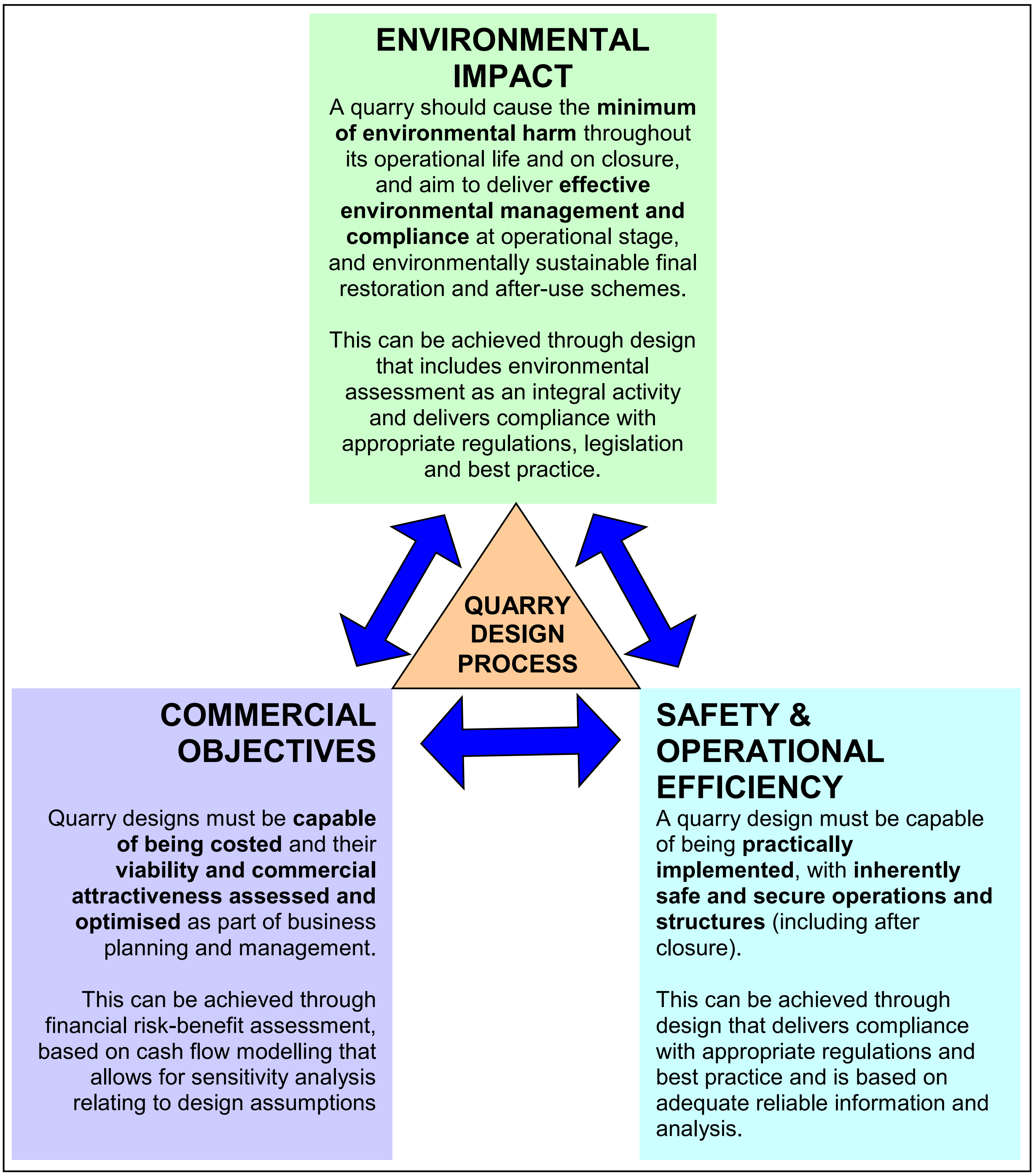

Figure 1

Quary design is not just a restricted technical process undertaken by or on behalf of a quarry operator or landowner by a few engineers, planning specialists or geologists; it is an inclusive and iterative process undertaken by a team of people covering a wide range of technical and commercial disciplines. Successful quarry designs are produced by carefully chosen and well managed teams and involve or take account of the views and requirements of all relevant interested and affected parties (stakeholders). The primary objectives of good quarry design are the safe, efficient and profitable extraction of the maximum usable material from the minimum area of land while causing the minimum environmental disturbance and resulting in beneficial final restoration and land-uses. The essential balance and interaction between these objectives is illustrated in Figure 1.

Failure to achieve a proper balance of these broad objectives, or failure to communicate this balance to stakeholders, even if it is achieved, benefits no-one. An incomplete or ill-considered design may lead to unacceptable environmental impacts, nuisance or danger to the public, danger to the workforce, or additional monitoring costs for the operator and Regulators. These all translate into cost, litigation risk, and loss of profit or asset value to the operator/landowner. Critically, quarry designs that do not achieve this balance when implemented (or are sound but poorly communicated to stakeholders) can give rise to long term damage to an operator's or landowner's reputation locally or with its customers, prejudicing its chances of success in future planning applications or in having proposed amendments to existing permissions accepted. This introduces unnecessary and distracting conflict with local and wider communities. Failure to maximise extraction from a quarry (within acceptable safety and environmental limits) leads to the need for more quarries or unnecessary pressure on other sources of minerals. Therefore good design is an essential step towards sustainability.

This Handbook is about achieving the balance depicted in Figure 1. In order to do this, it is important to understand both the context for design and the design process. These are described in Parts I and II and the delivery of successful designis described in Part III.

Quarry design begins with the selection of a site for development and typically culminates in a planning application and, if successful, support to the implementation of the permission. However, it is not a linear process. A wide range of specialist inputs is involved and the process benefits from frequent iteration through the various stages as well as effective consultation and scrutiny from stakeholders throughout.

THE PURPOSE OF THE HANDBOOK

The Handbook sets out to provide a source of reference and guidance to those involved in designing and operating quarries. In particular, it should assist them in preparing good quality mineral planning applications and quarry designs that, when implemented, will be fully compliant with environmental laws and all relevant safety and operational Regulations[2]. It also aims to assist and inform those who scrutinise planning applications (whether in an official or a private capacity) in understanding more about the process and its outcomes. It is aimed at a wide readership including members of the public, quarry operators, municipal, regional and national authorities responsible for regulating quarries and related spatial planning, landowners, environmental and health and safety regulators and consultants.

In this way, the Handbook should assist in promoting common understanding of the process of quarry design and provide support to effective communication and negotiation between all relevant stakeholder groups. In order to be accessible to a wide range of readers, it avoids, wherever possible, technical jargon and defines terms where these have to be used.

STRUCTURE AND CONTENTS

The Handbook is structured to allow it to be used in a number of ways: as a readable general introduction; as a source of guidance on specific techniques or aspects of quarry design; or as a reference source to lead the reader to other sources of information and advice.

The Handbook follows the entire design process from site selection and initial concept, through detailed development of the proposals and application for planning permission, to preparation for implementation once planning permission has been obtained. Funding for the project that has led to the production of this Handbook came from the Aggregates Levy Sustainability Fund (ALSF). Accordingly, the Handbook is specifically directed towards aggregate quarrying, both crushed rock and sand and gravel, drawing distinctions where appropriate. However, although the examples are

2 In the UK, the Quarries Regulations, 1999 (especially Regulation 33).

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drawn from the aggregates industry, all of the principles and many of the specific elements of guidance and sources of information are generally applicable to all types of open pit mineral working. The guidance is relevant to extensions to existing operations as well as to new quarries on greenfield sites.

HANDBOOK AT A GLANCE

The Handbook is presented in five parts:

PART I	THE CONTEXT FOR QUARRY DESIGN This section of the Handbook provides an introduction to planning and licensing processes that must be negotiated to obtain planning permissions, permits to work or operating licences from the appropriate public authorities **(Chapter 1),** sets out primary information requirements **(Chapter 2),** and describes how primary information is used alongside the planning process for site selection **(Chapter 3)**.
PART II	THE QUARRY DESIGN PROCESS Part II is the core section of the Handbook and examines the stages of operational design and individual design elements appropriate at each stage **(Chapter 4)** and details the information requirements and investigations to support those design stages **(Chapter 5)**. Explicit reference is made throughout these chapters as to the relevance of particular activities and stages in the process directed to achieving the essential balance between safety, commercial objectives and environmental impact. **Chapter 6** addresses the assessment, throughout the design process, of operational (especially safety), commercial and environmental risks.
PART III	DELIVERING SUCCESSFUL QUARRY DESIGN Part III provides introductions to consultation and communication and the need for management of the quarry design process. Consultation and, in particular, stakeholder consultation, is of prime importance in reducing misunderstanding between stakeholders and providing a basis for objections and questions to be considered and addressed at all stages, from pre-application consultations through the formal planning process and throughout the operational life of the site. Consultation cannot be effective unless proposals have been clearly communicated and these issues are covered together in **Chapter 7**. **Chapter 8** stresses the importance of management of the design process in delivering proposals that are likely to succeed in the planning system and deliver commercially successful operations that are safe, efficient and limit environmental harm.
PART IV	APPENDICES Appendices have been prepared to support chapters 1 and 4. They should assist with implementing the approaches described in the Handbook and provide reference material and guidance to support practitioners and therefore avoid abortive work. When used with the rest of this Handbook, it is hoped that they will provide a pathway to the safe, efficient and profitable extraction of mineral with the least environmental harm.
PART V	BIBLIOGRAPHY We have limited the number of references within the text so as not to chop it up, whilst providing 'signposts' to sources of more detailed information or guidance where relevant. Part V contains a pdf version (with operational hyperlinks to documents and websites where appropriate) of the Access database bibliography that was completed in 2007. It has been reviewed for this edition of the Handbook, and some links have been repaired where links to electronic publications are no longer operational because of relocation and concentration of UK Government websites since the original work was completed. In some cases, it has not been possible to repair specific links (usually because the document is superseded or out of date), but we have left the information in the database for reference (with associated short abstracts). There is an extensive library of ALSF funded reports and other relevant publications at www.sustainableaggregates.com; any publications that were prepared as part of ALSF funded research and are no longer directly accessible via the bibliography included with this edition of the Handbook are likely to be accessible there. The planning system in England and related guidance relevant to minerals has changed significantly since the Handbook was published as a pre-publication draft. These changes (as at 2014) are reflected in Appendix 1-1 but there are bound to be further changes in the future. Readers requiring up to date information and guidance on planning in England and Wales should refer to www.planningportal.gov.uk. Links to equivalent information for Scotland and Northern Ireland may be found at www.planningportal.gov.uk/general/glossaryandlinks/links/scotlandnireland.

FURTHER INTRODUCTORY AND OVERVIEW MATERIALS

In 2008 a series of benchmark reports was produced (*The Sustainable Aggregates Reports*) to reflect the latest information and good practice from ALSF and other contemporaneous work and to make them easily accessible to those who can put them into practice. This body of work provides a good source of introductory information for readers with no previous experience of quarrying as well as access to a large body of reference material for those who may wish to read more.

The reports were written by recognised experts in their fields (including the authors of this Handbook) and reviewed by industry representatives and other key stakeholder groups; they were designed to be easily accessible and to be widely shared. They are aimed at a wide range of industry stakeholders, including operators, planners, environmentalists, NGOs, suppliers, the archaeological community, civil servants, local authorities, academics and interested parties from local communities associated with quarrying.

12 benchmark reports were produced under 4 themes and they are all available *via* www.sustainableaggregates.com[3]:

Theme 1 Reducing the environmental effect
1. Water Environment[L0084]
2. Dust, Noise and Vibration[L0089]
3. Transport[L0073]

Theme 2 Sustainable provision of aggregates
4. Assessment and Planning[L0001]
5. Optimising the Efficiency of Primary Aggregates Production[L0022]
6. Sustainable Utilisation of Quarry By-products[L0065]

Theme 3 Creating environmental improvements
7. Biodiversity[L0093]
8. Geodiversity[L0099]
9. Restoration[L0115]

Theme 4 Heritage
10. Rich Deposits: aggregate extraction, research and the knowledge pool[L0111]
11. Sustainable Heritage: aggregate extraction and management of the historic environment[L0113]
12. The Sands of Time: aggregates extraction, heritage and the public[L0112]

A guide to these 12 reports is included in a summary report (*A Review of the Aggregates Levy Sustainability Fund Research Projects*[L0591]).

In addition, jointly authored by Ruth Allington of GWP Consultants LLP and Toby White of the University of Leeds (now at the University of Leicester), an overview report (***An overview of design and management approaches to reducing the environmental footprint of the supply chain for land-won aggregates*** [L0075]) was produced (and updated in 2012). This provides an overview of the design and management approaches available for reducing the environmental footprint of a quarry throughout its lifecycle. The overview report draws on the material in the benchmark reports. It first identifies the elements of the environmental footprint and the range of environmental effects associated with each and then how they are avoided, mitigated or incorporated in the delivery of long, medium and short term environmental benefits. Chapters covering health and safety and stakeholder engagement are also included.

[3] The superscript reference numbers relate to the library at www.sustainableaggregates.com

PART I
THE CONTEXT FOR QUARRY DESIGN

CHAPTER 1 UNDERSTANDING THE PLANNING AND LICENSING PROCESS

CHAPTER 2 PRIMARY INFORMATION REQUIREMENTS

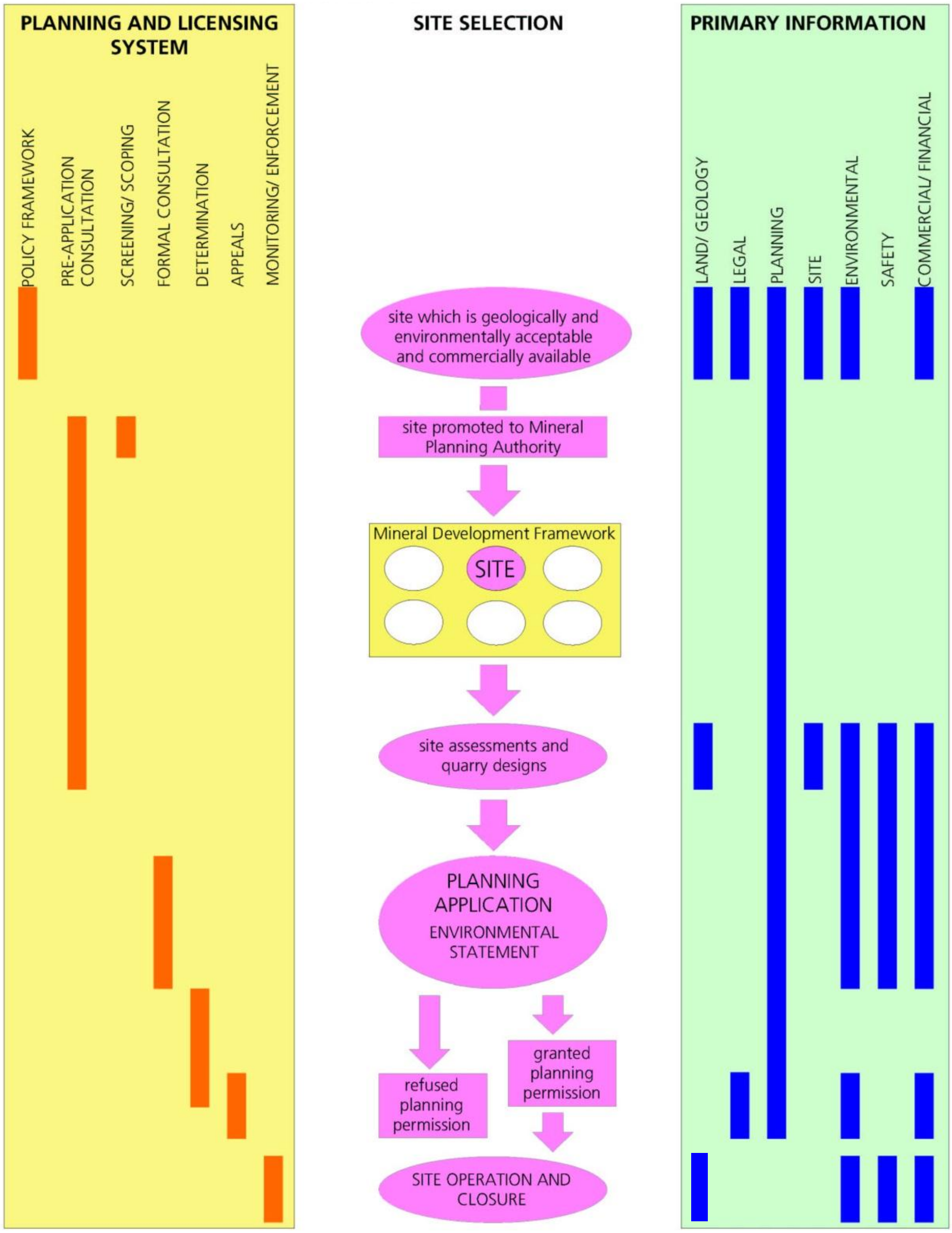
CHAPTER 3 SITE SELECTION

The Handbook begins (Part I) with three chapters setting the context for quarry design:

Chapter 1	Understanding the planning and licensing process
Chapter 2	Primary information requirements
Chapter 3	Site selection

No site may be operated without planning permission and relevant licences. The preparation of a mineral planning application provides the over-arching context for this Handbook.

THE CONTEXT FOR QUARRY DESIGN



The planning and licensing process

The planning/licensing process has three main elements:

- submission of an application for a planning permission for mineral development (often accompanied by an Environmental Statement),
- securing a planning permission and all necessary operating licences and permits, and
- operating in accordance with the planning permission, the licences and permits obtained and all relevant statutory requirements and regulations[1].

The planning process operates against a background, and within a framework, of national,, and local levels of planning policies, which may constrain or promote development of quarries in a general or specific way. At the site-specific level, the planning process relies on an effective design process to:

- Ensure that the planning application and environmental statement communicate the proposals effectively and are in the format (and contain the information) required by the responsible local or national government authority;
- Ensure that the proposals stand up to scrutiny on environmental, commercial and safety grounds; and
- Ensure that, if successful, the proposals can be implemented as designed and presented within the planning application and as regulated by planning conditions and other licences, permits, permissions and all relevant regulations and statutory requirements that apply to the site.

Key considerations during the planning process are:

- the possibility of a planning appeal against refusal;
- the range of planning conditions that may be imposed and whether they are deliverable;
- environmental licensing requirements and whether they can be achieved by the permitted development; and
- compliance with regulations and statutory requirements and whether that compliance can be achieved through implementation of the permission.

The relationship between the planning and design processes provides the focus for effective communication and iteration within the planning and design team and also for effective engagement with stakeholders, whose views arising from consultation at various stages of the process may give rise to amendments to the proposals.

Chapter 1 provides a brief introduction to the planning and licensing process, as background to the later chapters of the Handbook. For UK readers, Chapter 1 is supported by Appendix A1-1, in which the planning and licensing process relevant to quarrying in England and Wales is described as at the time of writing (2014).

Primary information requirements

The establishment of adequate primary information upon which to base first site selection and, later, the quarry design itself is vital to successful quarry design. Adequate information is also essential to the assessment (environmental, commercial and safety) of the quarry design at all stages of its evolution. If the design process commences with inadequate, outdated or missing primary information, this almost invariably leads to delays in the planning process while additional information is sought and supplied. There are seven key areas where collection and primary analysis of information is always required and increasing levels of detail are needed as the process moves from site selection to detailed design:

[1] In the UK the most important are the Health and Safety at Work Act 1974 and the Quarries Regulations 1999.

- Establishing the **minimum land requirements** – limits of recoverable mineral resources and areas required for associated activities such as processing, stocks of finished products, access, and on-site disposal of quarry or process waste.
- Establishing the **legal context** – ownership and control of the land etc.
- Establishing the **planning context** – history, status and planning cycles etc.
- **Site description** – ground surface contours, geological, geochemical, geotechnical, hydrogeological, hydrological information and the creation of reliable 3D models from primary analysis of this information.
- Identification of **environmental drivers** – matters that will have a major effect on design, such as space needed for construction of anti-pollution measures (e.g. settlement lagoons), the presence of ecology or archaeology on which there might be an impact, or proximity to sensitive receptors (i.e. residents) who may be affected by noise, dust, visual impact or other nuisance.
- Identification of **safety drivers** – identification of geotechnical or operational settings relevant to the deposit or its location that influence the creation of inherently safe designs for the workforce and third parties.
- Establishing the **commercial/financial context** – the market, competition, establishment costs etc.

Successful quarry design depends on effective identification and interpretation of primary information relevant to the project in all of these areas. It also depends upon frequent review of all of these matters as the design proceeds. Primary information requirements for quarry design are the subject of **Chapter 2**.

Site selection

The quarry design process often begins with the selection of a site as a prelude to its promotion through the planning and licensing process. In many jurisdictions, the starting point for site selection is the established 'land bank' of sites where there is a presumption in favour of exploitation of aggregates or other construction materials (*i.e.* appropriate designations in spatial plans). Once the land bank drops below the appropriate threshold for any particular mineral or material, the mineral planning authority (or responsible ministry) must identify additional potential resources of mineral to meet local or national needs. Procedures for establishing and monitoring/reviewing land banks for construction materials vary from jurisdiction to jurisdiction. It may be possible (as in the UK) for landowners and operators to be pro-active in promoting sites within their ownership or control for inclusion in the updated land bank or, where mineral bearing land is in public ownership, land may be released and made available for quarrying under licence, lease or contract.

For their part, the landowners/mineral operators must identify a commercial need for the mineral and either acquire/control sites already permitted, or investigate new sites ready for promotion into the relevant spatial planning process.

Site selection (**Chapter 3**), therefore, requires both an appreciation of what may be permitted through the planning and licensing system (and where) and sufficient primary information (**Chapter 2**) to establish what drivers and constraints exist at particular sites (resources/reserves, relationship to markets, environmental constraints and opportunities *etc*). When a site has been selected by a developer, and a decision has been taken to apply for planning permission for a new quarry or quarry extension, understanding and negotiating the planning and licensing process (**Chapter 1**) becomes an integral part of, and a key driver for, the design process, which is covered in **Part II**.

CHAPTER 1
UNDERSTANDING THE PLANNING AND LICENSING PROCESS

SIMPLIFIED PLANNING APPLICATION PROCESS

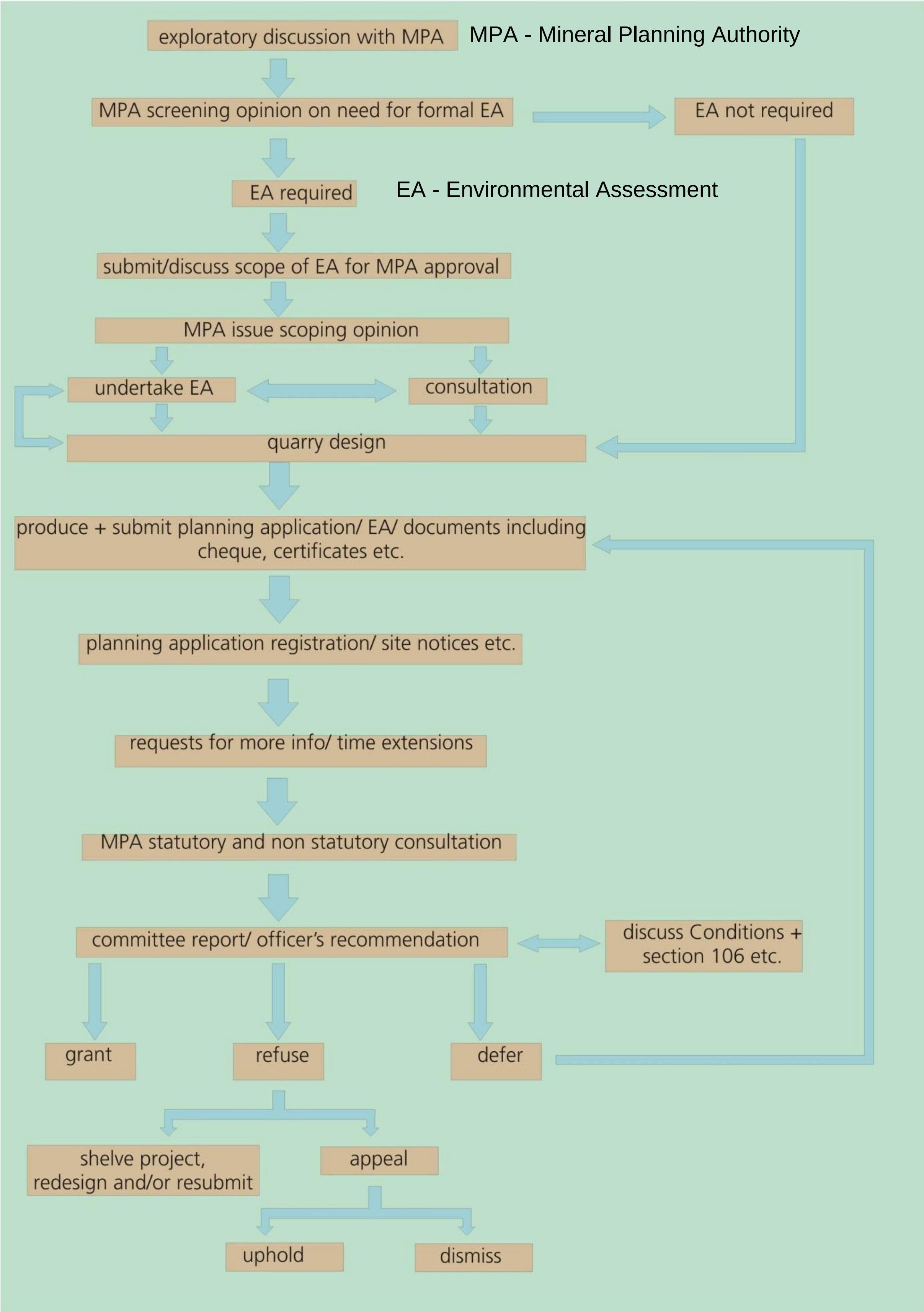


Figure 1-1 simplified flow diagram of the planning application process in England

1 UNDERSTANDING THE PLANNING AND LICENSING PROCESS

Mineral extraction, processing and transportation cannot take place typically without appropriate planning permissions and/or licences. This makes it of fundamental importance that the quarry design team understands the legal/planning context of the country in which extraction is to take place.

In particular, the team needs an awareness of:

- The role of Government, Authorities and Statutory Consultees
- The relevant Acts of Parliament and other Mineral/Planning Legislation
- Government Planning, Mineral and other Policy Guidance
- The roles and responsibilities of competent and qualified persons
- The role of the Regional or sub-Regional local authorities
- The existence of any national or regional zoning relating to or restricting mineral extraction
- The Application process including forms, costs and authorisations
- The environmental assessment rules, regulations and process including screening and scoping
- Any required stakeholder consultation process
- The determination process and timescales
- Any Appeal process
- Any Conditions, Agreements or Obligations which can be attached to a planning permission
- Any Licence, Permit and regulatory compliance required within or in addition to the planning permission
- Any Enforcement regime

For England, these matters are well covered in other texts and relevant legislation (see bibliography, Part V). Appendix 1-1 contains a general introduction to the stages of applying for a mineral planning permission in the UK (specifically England, with similar systems in Scotland, Wales and Northern Ireland). This appendix also covers the ways in which other interested parties may participate, challenge and be informed and options available for appeals and variations; the material in Appendix 1-1 is summarised in Figure 1-1.

Every jurisdiction is organised differently in relation to mineral planning and related permitting and licensing for the extraction of construction and industrial minerals, but there are key subjects and stages in the mineral planning process which are common to most. These are described in a generic way below, in a wider international context. Readers are invited to use this chapter as a checklist of subjects, stages and considerations; UK readers may find Appendix 1-1 a useful source of more detailed reference to assist in preparing applications for new or extended quarries, whilst international readers (or UK operators or consultants seeking to establish quarries outside the UK) may also find this more detailed material of interest to guide them in working out the national or local requirements in the jurisdiction of interest to them.

1.1 The role of Government, Authorities and Statutory Consultees

Understanding the structure of Government is the starting point to applying for permission to establish and operate a quarry. In particular, it is important to identify which Ministries and Departments are relevant to spatial planning and, especially, mineral-related matters. Similarly, it is necessary to understand which Authorities and Agencies cover which subject matters and which bodies must be consulted or informed on any mineral planning application.

1.2 The relevant Acts of Parliament and other Mineral/Planning Legislation

It is necessary to identify not only the extant Acts of Parliament, Regulations and Orders but also those in preparation or en-route through the parliamentary or governmental procedure.

1.3 Government Planning, Mineral and other Policy Guidance

Many governments supplement their principal legislation (Acts, Directives, Decrees *etc*) by producing Guidance or Policies; these can generally be updated without the need to amend the core legislation. Such Guidance *etc* usually provides the route-map, limitations and requirements for any mineral application.

1.4 The roles and responsibilities of competent and qualified persons

In some countries, professionals (*e.g.* geologists, engineers, landscape architects, surveyors, ecologists *etc*) are regulated and official documentation must be signed and submitted by a person or persons holding the necessary licences or appearing on a register of qualified professionals. Similarly, there are sometimes restrictions on activities companies that are not incorporated within the jurisdiction concerned. Therefore, in addition to establishing the requirements of the planning process (studies that must be undertaken, documents that must be produced, people and bodies to be notified or consulted, procedures for submitting the application *etc*), it is essential that an early check is made as to the required qualifications and status of persons or organisations who are permitted to sign the reports and other documents that make up the application. This is especially important if foreign consultants or employees of applicant organisations are retained to undertake specialist studies; it may be necessary for them to work in partnership with local counterparts with the necessary credentials.

1.5 The role of the Regional or sub-Regional local authorities

Depending on the size of the country, extent and distribution of exploitable minerals and political systems, the mineral planning application process may be devolved to a region or sub-region (*e.g.* county, province, state, territory *etc*). National legislation and policies may apply, beneath which a further level of regional or sub-regional governance pertains.

1.6 The existence of any national or regional zoning relating to or restricting mineral extraction

It is important to identify any planning zoning which may impact on any potential mineral extraction site. Such zoning may be positive (encouraging extraction) or negative (excluding or heavily restricting extraction). Planning zones relevant to mineral exploitation may have policies attached to them which will guide the quarry design process and associated application procedures.

Zones may be identified as “Areas of search” or areas of potential mineral exploration to establish or confirm the existence of exploitable mineral. In some jurisdictions, exploration permits are required for all minerals including “common minerals” such as aggregates and other construction and fill materials. In others, exploration permits are needed only for a restricted range of solid minerals (typically metals, coal, high value industrial minerals, gemstones). Where exploration permits are required, it may be necessary to submit the results to the relevant authorities and there may be restrictions on the nature and scale of exploration that is permitted at any time. Consideration of the impact of a quarry on existing and proposed uses of adjoining and nearby land is fundamental to the quarry design process and assessment of the likelihood of acquiring planning permission.

The authors have experience of reform of more than one country’s spatial planning systems through devolution to municipal and state/county authorities which exclude mineral extraction where it is already taking place or on land where permits or concessions have already been issued and where primary legislation (from the relevant government ministry) provides a mining zone within which there are established rights to extract minerals. A check should therefore be made to ensure that national (or international) designations affecting the zoning of land for mineral extraction (or excluding it) are consistent with those that may have been developed and enshrined into law or regulation locally. If they are not, it may be necessary to seek high level clarification of the position before proceeding.

1.7 The Application process including forms, costs and authorisations

At the beginning of the planning and design process it is advisable to research fully the requirements, costs and timescales involved. Invariably there are forms or templates to be completed with, perhaps, a requirement for certain drawings at certain scales. There will be costs and various stages which need to be completed in sequence. Understanding all of this, and planning for it, limits potential time delays and ensures realistic programming.

1.8 The environmental assessment rules, regulations and process including screening and scoping

Most countries require some form of environmental assessment (EA) to inform and accompany a mineral planning application. This process often begins with a 'screening' stage *i.e.* an assessment whether an EA is necessary at all and, then, a 'Scoping' stage at which the subjects to be covered in the EA are identified and agreed with the relevant Authorities. The EA provides most of the baseline information required in the quarry planning and design process (see Chapter 2) and, further, gives indications of sensitive receptors and areas/issues to be avoided or mitigated.

1.9 Any required stakeholder consultation process

Stakeholders may include Government Agencies and Departments, environmental organisations, Health and Safety bodies, local communities and a raft of other interested individuals and agencies. In most jurisdictions, there are some stakeholders who must, by law, be informed and given the opportunity to comment. As described in Chapter 7, whether it is mandatory or voluntary (or a combination of the two), the stakeholder consultation process is not just an information dissemination exercise but a genuine opportunity for positive and negative criticism which feeds into the design process. Adequate time needs to be allowed for this to be integrated properly.

1.10 The determination process and timescales

The completed planning application and associated documentation is normally considered by a committee or nominated individual. Understanding how and when the application will be determined allows for appropriate promotion of the scheme and for planning and programming its preparation.

1.11 Any Appeal process

Most jurisdictions have an Appeal process should any application be refused. Understanding the process, costs and timescales at the beginning allows for their inclusion in the project planning process.

1.12 Any Conditions, Agreements and Obligations

It is typical that the award of a planning permission is accompanied by a series of Conditions, Agreements and/or Obligations; these may be substantial in number and extent. It may be useful to offer or discuss such addenda to the permission during the application process in order to save time and to influence their content. Unless there are unique circumstances, most Authorities use standard Conditions which are amended to suit the specifics of each site.

1.13 Any Licence, Permit and regulatory compliance

Whilst Conditions, Agreements and/or Obligations are attached to the planning permission, many jurisdictions separate the planning permission from the need to also acquire certain Licences, Permits or other regulatory compliance mechanisms; these may relate to matters such as water abstraction and usage or waste handling or disposal. Establishing whether these mechanisms can be applied for during the planning application process or only following award of a permission may save time.

1.14 Any Enforcement regime

Understanding how the extraction operation will be monitored by the Authorities and any enforcement measures open to them should be established early in the quarry design process to ensure that, as far as is possible, the designs produced for the purpose of obtaining planning permission will be capable of being operated so as to comply.

CHAPTER 2
PRIMARY INFORMATION REQUIREMENTS

2 PRIMARY INFORMATION REQUIREMENTS

2.1 THE NEED FOR PRIMARY INFORMATION

Site selection (Chapter 3), quarry design and assessment (Chapter 4), and the detailed site investigation and information gathering (Chapter 5) that supports design, follows an examination and evaluation of primary information in seven key areas:

- Establishing the **minimum land requirements** – limits of recoverable mineral resources and areas required for associated activities such as processing, site access arrangements, and on-site disposal of quarry or process waste.
- Establishing the **legal context** – ownership and control of the land etc.
- Establishing the **planning context** – history, status and planning cycles etc.
- **Site description** – ground surface contours, geological, geochemical, geotechnical, hydrogeological, hydrological information and the creation of reliable 3D models from primary analysis of this information.
- Identification of **safety drivers** – identification of geotechnical or operational settings relevant to the deposit or its location that influence the creation of inherently safe designs for the workforce and third parties (e.g. identification of adverse geotechnical settings that would arise with given face alignments).
- Identification of **environmental drivers** – matters that will have a major effect on design, such as space needed for construction of anti-pollution measures (e.g. settlement lagoons), the presence of ecology or archaeology on which there might be an impact, or proximity to stakeholders who may be affected by noise, dust, visual impact or other nuisance.
- Establishing the **commercial/financial context** – the market, competition, establishment costs etc.

This information is always required for the establishment of site limits, for evaluation of the inherent suitability of the site to meet commercial and other objectives and, when the selection of the site is confirmed, as the basis for design and evaluation to proceed. These areas are interrelated and affect, and are affected by, the planning and design processes themselves. Each of the primary information requirements listed above is described in the following sections of this chapter.

It may seem obvious that one cannot begin project planning or design without having collected and collated sufficient primary information and used it to analyse and describe important aspects of the site. However, this step is often overlooked or inadequately resourced. Apart from enabling a quicker, more efficient (and therefore cheaper) design process, such information can lead to better, safer, more environmentally acceptable and more economically robust quarry proposals. These are more likely to be acceptable to Planning and Regulatory authorities and more likely to be capable of implementation without unforeseen problems arising. As a minimum, failure to collect and collate this primary information can lead to abortive work, time delays, missed opportunities, or designs with inherent risks which do not become apparent until there are further cost, time, safety, environmental or technical consequences.

As is described in Chapters 4 and 5, frequent re-appraisal and refinement of this primary information base is necessary throughout the design process, both to recognise and accommodate changes to external influences (e.g. planning, legislation) and in response to project changes (e.g. changes to extraction areas or after-use proposals):

2.2 MINIMUM LAND REQUIREMENTS

Sufficient land is required at a quarry site both to allow the efficient, safe and environmentally acceptable extraction of the mineral to be worked and to accommodate all related facilities and activities (including access arrangements and transport links). Boundaries need initially to be established at the site selection stage of a project, often to underpin a land transaction (agreement of an option, land purchase or negotiation of lease). Later, the land identified and secured at the site selection phase may be the subject of representations to the Mineral Planning Authority (MPA) in connection with local or regional spatial planning. This initial establishment of boundaries at the site selection stage may take place many years before the site is offered for consideration (or is successfully put forward) for inclusion in municipal, county, or national mineral allocation or zoning plans, and it may be many years more before a detailed design and planning application is prepared. The various influences on land take (e.g. the tonnage of recoverable mineral needed for a viable quarry, the location and sensitivity of environmental receptors, best practice, local planning policies or legislation that may affect the size of buffer zones etc) may change with the passage of time, and so review of the site boundaries and the adequacy of land holdings is an essential first and recurring step in the design process.

2.3 LEGAL

A planning permission for quarrying normally goes with the land to which it relates; i.e. is not personal to the person making the application (although in some jurisdictions, operators must also hold a licence or permit confirming that they meet established quality requirements). In the UK, it is possible to make a planning application for land outside the applicant's ownership or control. However, it would not be possible to implement such a planning permission unless ownership or occupation and control were secured, or with the permission of the owner. Therefore, from the outset, it is necessary to establish who owns or controls the surface of the land within the proposed site boundary (including buildings, structures, uses or rights). No assumptions should be made and all documentation checked and verified. Ownership may not be straightforward and may include partnerships, companies, trusts or other instruments or combinations of these. Third parties may have rights, wayleaves or access to the land; in addition, there may be restrictive covenants. Ownership, and/or control (*e.g.* a lease or public land allocation or contract) needs to be established for ALL of the land which may be required for the proposed quarry operation including, for example, the mineral extraction area, access roads, plant sites, areas for mitigation measures etc.

Similarly, from the outset, it is necessary to establish who owns or controls the mineral rights, which are sometimes owned separately from the surface. Further, different minerals may be owned or controlled by different parties.

The rights to abstract and/or discharge water from the land should be investigated as should the rights of others to discharge onto the land or into watercourses.

Where ownership and control is in the hands of third parties, there are likely to be sensitive issues to be resolved at some time during the project period in order to implement (or have the opportunity to implement) any scheme that is permitted. It is vital, therefore, that this information is not only collected (and summarised accurately on plans and in schedules available to relevant members of the project team) but also that its potential implications for the project are understood. Against this background, a strategy for exercise of options, acquisition, or negotiation of leases, licences or wayleaves can be developed.

Until the clear ownership and control of all relevant land has been unequivocally established, and options or ownership secured, it may be premature to proceed further in the planning/design process.

2.4 PLANNING

Selecting the most beneficial time to submit a planning application relies on not just an understanding of the policies affecting that site but also the planning cycles and the start and end dates of consultation periods.

It is necessary to establish the current (and emerging) planning status of the site and immediate surrounds. This involves determining which planning designations apply to the site; these may be international, national, regional or sub-regional (*e.g.* county, province, district, state, territory), municipal or other. At the highest level, such designations may include UNESCO World Heritage sites or National or State Parks. Many countries designate Green Belt surrounding urban areas (which may wash over large areas of land), and there may be specific local designations such as protected buildings, cultural sites or local nature reserves. The policies and restrictions associated with each designation must be examined and any consequences for quarrying considered.

At the site specific level, the following questions are relevant: What is the planning history of the site and immediate surrounds? What planning applications (or licence applications) have been made? Were they successful, refused or withdrawn? What planning restrictions, agreements or conditions have been placed by any earlier permission and would these restrict or interfere with any quarrying proposal?

As will be seen in Chapter 3, the planning system is constantly evolving and it is important that the implications of proposed changes and emerging policies and plans *etc* be considered at every stage, especially if there has been a significant passage of time between site selection, acquisition and preparation of a planning application.

2.5 SITE

When the location and extent of the land required and its control and planning status have been defined satisfactorily, the next stage in the establishment of adequate primary data for the project is the creation of 2D, 3D and conceptual models describing the features of the site and the mineral to be worked.

Ideally, by the time detailed design commences, the following are required:

- Accurate site location, site context and site plans accurately referenced to national grid systems, showing all relevant current boundaries (including administrative boundaries and national and local designations) of the site and surrounding physical features. (Likely sources: original site survey within the site, digital or paper based maps and plans published by government or regional survey bureaus (both current and historical), the national geological Survey, national, regional and local spatial plans)
- A 3D site survey (with a level of detail suitable for reproduction at 1:2500 or larger scale) with levels referenced to the statutory datum and grid system in the jurisdiction concerned[1]. This must have an adequate level of detail and be at a level of precision appropriate to allow reliable characterisation of the ground surface in the site area, and reliable measurement of volumes. Around the site, 3D topographic information is also required for the purpose of assessing environmental and social context, e.g. landscape and visual and traffic impact studies. Outside the site, the density and precision of topographic data may be lower than that within the site. The data may be presented as contour plans and cross sections. (Likely sources: commercially available digital terrain models, primary site survey, site specific aerial photography or LiDAR).
- An overlay to the site plan summarising surface ground conditions and previous land-uses (e.g. any suspected or recorded contaminated land, evidence of landslipping or other instability, presence of peat, evidence of underground or former surface mining activity, presence of backfill or landfill etc). (Likely sources: walkover survey, aerial photography, examination of historical OS and other maps and plans, Planning Authority records, Environment Agency etc).
- An overlay to the site plan showing all surface water features in and around the site and the limits (if any) of any flood plains. (Likely sources: walkover surveys, Environment Agency, British Geological Survey and Planning Authority registers of licensed abstractions and flood risk maps *etc*).
- 3D models (on the same grid system and level datum as the site plan and survey) representing geologically important surfaces:
    - Rockhead/top of the mineral deposit to be worked (usually at the base of any superficial material);
    - Base of the mineral deposit to be worked (if relevant);
    - Any other geologically significant surfaces (e.g. bedding planes separating mineral from waste, faults, unconformities etc); and
    - Details of any undermining activities (e.g. coal mining, metals, salt extraction.

  These essential 3D models are likely to develop and will generally increase in complexity and precision as the design process proceeds; they may be relatively simple at site selection stage. They will usually be prepared using surface modelling software, to which further or revised data can be added as design and evaluation of the site proceed. However, they could also be accurate hand drawn contour plots with grids to allow overlaying, comparison and analysis. These models, whether electronic or hand-drawn, should be based on interpretation and extrapolation of site investigation data by a suitably qualified/experienced geologist (e.g. the results of a programme of borehole drilling or trial pit excavation at surveyed locations across the site; in some

[1] In the UK, Ordnance Datum and the National Grid.

circumstances, geophysical surveys can be used with adequate 'ground truth' from boreholes or trial pits). More detailed explanation of the creation of 3D models is included in Chapter 5.

- Borehole logs, schedules and plans describing the material properties relevant to the products to be produced (e.g. aggregate strength and durability testing etc) and estimates of the volumes and percentages of waste materials that will arise from processing or selective quarrying of saleable mineral.
- A conceptual model (usually as an overlay or annotation to one or more geological cross sections derived from the geological models described above) should be produced illustrating the occurrence of groundwater at the site and its relationship with recharge and surface water. An associated 3D model (or models) is also required showing the configuration of any relevant water tables or piezometric surfaces.
- A summary plan, accompanied by cross sections and sketches identifying:
  a) geotechnical settings and domains arising from the properties of the materials to be excavated;
  b) rock mass characteristics (especially structural settings that might give rise to specific modes of failure);
  c) pre-existing geotechnical hazards (such as ancient landslipping or slumping);
  d) man-made hazards such as location of previous mining activities etc.
- Sources of data and the design of site investigations and surveys supporting the production of reliable topographic, geological, material properties, hydrogeological and geotechnical models appropriate to the particular site in question are explained more fully in Chapter 5. For some sites, obtaining representative and reliable information will be a major undertaking (*e.g.* a proposed deep hard rock aggregate quarry with complex structural settings), whilst others may require far less input (*e.g.* a flat lying site with a sand and gravel deposit of uniform thickness).

Perhaps one of the commonest mistakes comes from the use (particularly at an early stage) of out-of-date, incomplete, incompatible, extrapolated, interpolated, inferred and distorted 2D and 3D information.

Information (especially poor quality data or plans) does not become more accurate by its enlargement to a different scale, by the use of colour or by the scanning/digitisation of that information into a computer; this is false economy. In fact, such transferences and 'improvements' in presentation increase the likelihood that disproportionate or unfounded weight may be placed on the originally poor data and that its limitations will not be understood by users of the data.

It is important that an individual or body is given the responsibility to co-ordinate the collection, collation and primary analysis (i.e. the preparation of 2D, 3D and conceptual models) of the definitive base plans and models on which the planning and design team can begin work. New and better information can always be added at later stages. At the outset, the key requirement is that discrepancies, omissions and mistakes are identified and that a common grid, nomenclature and style is established for all base plans and information.

Now that vertical aerial and satellite photography is widely available electronically *via* Google Earth or national archives, it is a valuable addition at the outset for the planning and design team. It may well be used later in the illustration and communication of the scheme to others.

2.6 ENVIRONMENTAL

The environmental impact assessment process is described in detail elsewhere (see Chapters 4 and 5) but there may be environmental baseline information to be collected and surveys which need to be undertaken at the outset. Using the site information described above, the various professionals in the team can identify the key environmental topics to establish if they are relevant, restrictive or prohibitive in any way and if there are mitigation measures or alternative approaches to design which may remove or offset any problem. At this early stage, it is helpful to rank environmental topics in terms of their expected significance in the planning process and their likely importance as constraints in the design process.

Again, the planning and design team need this baseline information to avoid the production of abortive or inadequate schemes. If there is an overriding negative environmental factor which may prevent profitable quarrying (or is likely to lead to planning refusal) this needs to be established as soon as possible, before expensive detailed design and planning work get underway.

While the list of relevant environmental subjects varies from region to region and from site to site, there is a commonly accepted list (see Chapter 5) which should be examined. Many are time-sensitive and can therefore affect the length of the planning, assessment and design process. Some subjects require examination through the seasons (such as ecology or landscape), some require long periods of investigation to establish patterns or baselines (e.g. hydrology, hydrogeology or noise) and some may require comprehensive off-site investigations (such as visual impact assessment). Where a particular environmental matter could 'make or break' the project, early collection of baseline information or establishment of monitoring networks can be essential.

It is essential that there is sufficient land available on which to place waste and locate anti-pollution measures such as silt ponds together with stocking areas and room for vehicle movements.

All of this baseline environmental investigation contributes to the screening/scoping stage of the Environmental Assessment process (see Chapter 1).

2.7 SAFETY

The design of safe slopes and other structures, as well as the design of quarry layouts and working methods that promote safe operation are described in detail in Chapter 4 and its supporting appendices. As with some environmental information, there are some baseline studies relating to safety that should be progressed at the outset. In particular, by reference to the geological, geotechnical and hydrogeological models described above, and good practice, some design rules can be established. These may include:

- maximum safe excavated slope angles in each material and in each geotechnical setting or domain;
- bench widths, maximum bench heights and maximum bench face angles;
- haul road design parameters (widths, gradients, design of bends etc);
- maximum safe angles for tips and related structures such as bunds and soil mounds.

Such considerations also dictate the size and shape of the operating void as well as the likely size and location of out-of-pit waste tips etc.

Other fundamental safety issues may relate to:

- sensitive structures or receptors outside the site boundary;
- the potential influence of ancient landslips on the stability of the operation (and the potential influence of the operation on the stability of the surrounding land);
- foundation conditions for processing plant and access roads; or
- potential for inrushes of water from old mine workings or surface water courses and water bodies.

2.8 COMMERCIAL/FINANCIAL

In parallel with the work on the previous six key baseline areas, the essential/main commercial and financial parameters need to be established and the business objectives for the operation stated (e.g. to produce high PSV aggregate for x years at a rate of y tonnes per year, yielding a net profit of x% and a return on capital of y%).

This depends on addressing the following:

- What is the range of products that can be produced from this site? Is there a market? Is it evolving? What is the competition? What are their reserves? Which products/services do they offer?
- What are the establishment costs? What are the royalty/agreement costs if any and what will the operating costs be? Are there value added products or services? Are there economies of scale or break-even points? How would this operation fit into any Group network?

From these and other questions, an outline business plan can be generated to meet the business objectives, from which the general requirement in terms of volumes and production rates can be established. These, together with the planning, environmental and health and safety matters relevant to the site, provide the embryonic brief and objectives for the planning and design team.

In later chapters of the Handbook, the importance will be stressed of returning to these business objectives frequently during the quarry design process. At all times, the owner/operator of the site should be addressing the following basic questions:

- ‘given the changes that have been made to meet environmental, planning or health and safety constraints, can we still meet our business objectives at this site?’
- ‘if not, is it still worth completing the design and applying for planning permission?’
- ‘what are our revised business objectives?’

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CHAPTER 3
SITE SELECTION

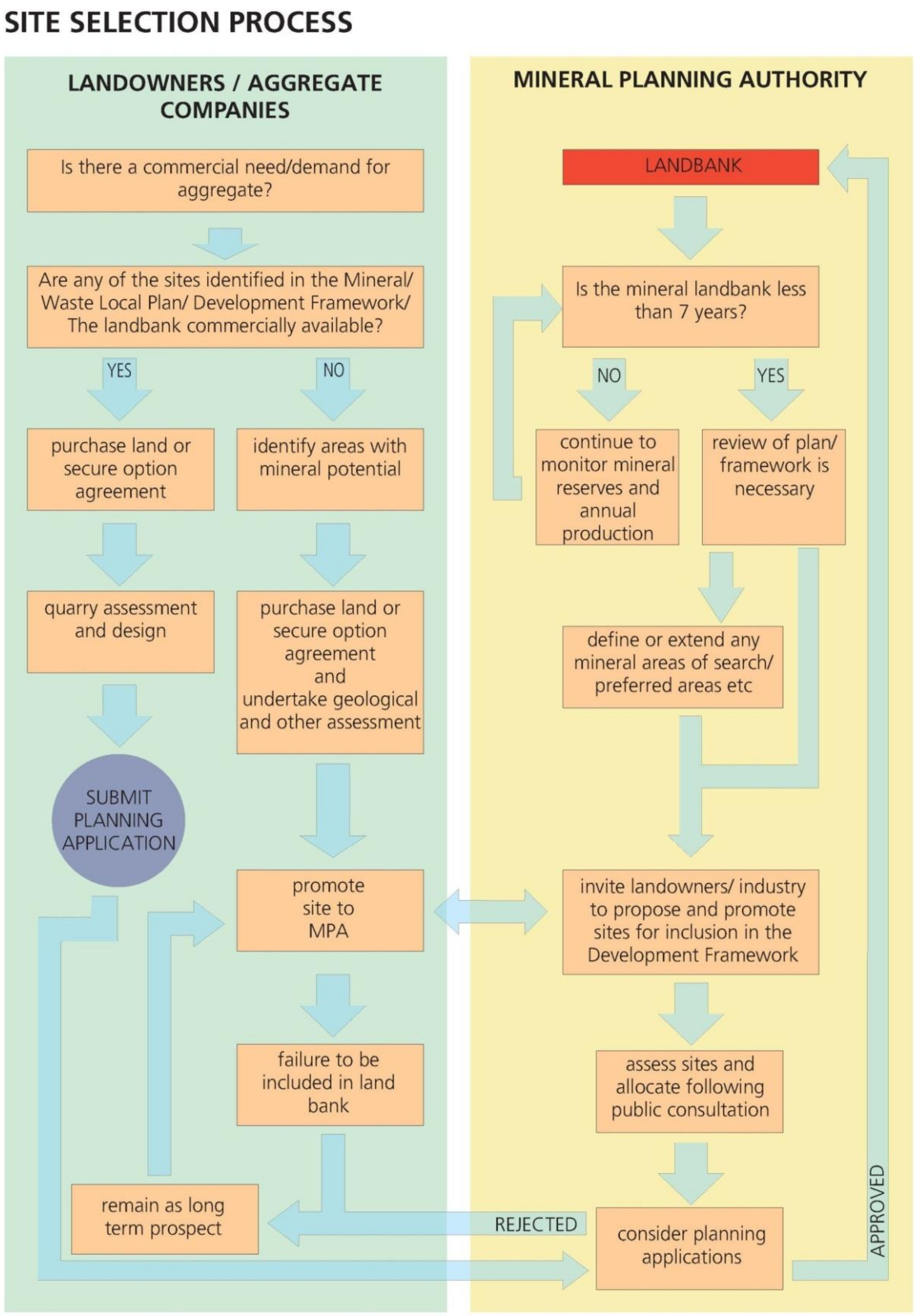


Figure 3-1 Simplified site selection process

3 SITE SELECTION AND CONSIDERATION OF ALTERNATIVES

Site selection and consideration of alternatives is described below and the process is shown schematically in Figure 3-1.

3.1 DEMAND/NEED

Mineral extraction only takes place because there is a demand/need for the material and it can be produced at a commercial profit. Mineral planning authorities (MPAs) in the UK are currently advised to maintain a land bank[1] of a minimum of 7 years' production of sand and gravel and a county-specific period for crushed rock which comes from the regional apportionment (i.e. the Government's allocation to each region). In order to achieve this, the MPA needs to monitor production rates and adjust them against any projections. If, following on-going monitoring, these thresholds are not met (*e.g.* because insufficient successful planning applications are made), the MPA may decide to define or extend any mineral areas of search/preferred areas *etc* and/or to invite landowners/industry to propose and promote sites for inclusion in the Mineral and Development Framework and, ultimately, the land bank.

Whilst time horizons and processes for managing protecting and monitoring national minerals inventory vary, land bank and/or mineral zoning systems exist in many jurisdictions and strongly influence the availability of sites with potential for achieving a planning permission.

3.2 NEW SITES/EXTENSIONS

As part of their business planning, landowners/mineral operators have to establish if there is a commercial demand for mineral (locally, nationally or internationally). If there is such a demand, they must next consider whether there are sites within their own portfolio, or which can be acquired/leased, and for which there is already a presumption in favour of mineral extraction (subject to satisfying requirements for regulating such activity). Presumption in favour of mineral extraction may be expressed by inclusion of the site in a local or national development plan; such plans may relate to minerals only and define "mining zones" or areas where particular minerals are safeguarded from development that would sterilize them, or they may be more general in nature and include all aspects of spatial planning and their interrelationships. If operators do not have access to sites within the land bank, they may need to identify new sites/extensions to which they do have access and take steps to promote their inclusion through an emerging plan consultation process so that they enter the land bank. Exceptionally (but only if this is permitted by law in a particular jurisdiction), companies may apply for permission to work outside an area included in the "land bank" – this approach clearly carries with it a higher risk that an application will be rejected.

3.3 INVESTIGATIONS & ASSESSMENTS

A site selected for further investigation and, ultimately, submission of a planning application for mineral extraction must first of all have a reasonable expectation that there will be a viable mineral resource at the site that can be recovered without causing unacceptable environmental harm. This is the case whether or not it is included in the land bank. Easily available information sources would include the local mineral plan, published memoirs and maps from the national geological survey, as well as evidence from previous or current workings or site investigations in the area. A low density of exploration boreholes or trial pits is most commonly used at a range of apparently geologically suitable sites to establish the presence or otherwise of a potentially economic horizon at more than one site before committing to more detailed investigations at the most promising location.

Part of the selection process may be initial estimates of 'ball park' volumes of *in situ* mineral and waste. These may be simply area times a conjectural thickness based on published information. In some countries, particularly those which were formerly communist demand economies, there exists valuable, publicly available site-specific geological and resource evaluation information which can significantly reduce (or avoid entirely) the need for expensive primary site investigation. Conservative

[1] Together, the areas of land where there is a legally established presumption in favour of mineral extraction are commonly referred to as the "land bank" for any given material or mineral.

estimates of excavation and processing losses are typically made and a yield estimate is made using the methodology outlined in Chapter 5. The uncertainties in the resource estimates at this stage are high, but give an indication of the potential of the site. A number of sites or excavation areas may be evaluated in this way at relatively little cost.

The range of primary information collection, survey and investigation outlined in Chapter 2 needs to be implemented; this information will be needed not only to decide if the site is commercially viable but also to determine if it is likely ultimately to be given planning permission. The MPA will need this (and other) information to consider a site, extension or area during the process which leads to inclusion of the site in any areas of search/preferred areas or, ultimately, into the land bank.

3.4 CONSIDERATION OF ALTERNATIVES

In the UK and elsewhere it is a requirement of Environmental Impact Assessment (EIA) that the environmental impacts of alternative proposals are assessed – this includes alternative sites and layouts. It is therefore important that the environmental impacts are considered right from the site selection stage so that the choice of site can be adequately justified.

Consideration of alternatives includes not just land under the control of the applicant but all other sites which could reasonably be expected to provide the same product at the same (or with less) environmental/social impact. Such sites are weighed financially against any environmental/social gain. In addition, consideration of alternatives includes not just other sites but other sources or solutions; this may include recycling, marine-dredged material, importation etc.

3.5 COMPANY STRATEGY

Notwithstanding the geology and other investigations, the company may favour a particular site over others at a particular time for one or more reason, including:

- The site fits into the company strategic plan, taking account of existing (or planned) markets and distribution network.
- The site will replace a nearby existing depleted reserve.
- Land is in the company's existing ownership or leasehold portfolio.
- The site is well placed to supply a specific local market (e.g. nearby urban regeneration or infrastructure projects or local building/restoration requiring specific local materials).
- Clear advantages are identified, such as good road and rail connections, size of site, or identification of the site as a preferred area in the relevant national, regional/sub-regional or local spatial plan.
- There is an existing planning consent covering all or part of the site.

3.6 QUARRY DESIGN PROCESS

It is often the investigations, assessments, ranking and initial layouts associated with site selection (and alternative sites), which represents the first stage in the quarry design process. This is illustrated in the flowchart at the beginning of Part II and Figure 4-1 in Chapter 4.

PART II
THE QUARRY DESIGN PROCESS

CHAPTER 4	DESIGN OF THE OPERATION AND ITS RESTORATION
CHAPTER 5	INFORMATION REQUIREMENTS AND INVESTIGATIONS
CHAPTER 6	DESIGN RISK ASSESSMENT

STRATEGIC ISSUES

A CHECKLIST OF QUESTIONS THAT REQUIRE ADDRESSING AT EVERY STAGE IN THE DESIGN OF QUARRIES

- **Control of land**
- **Mineral resources**
- **Demand for product and added value products**
- **Planning status and cycles**
- **Human & environmental constraints**
- **Technical constraints**
- **Restoration options, after use and long term asset value**

See facing page for a full list of strategic issues to be considered

SITE SELECTION

CONCEPTUAL DESIGN & FEASIBILITY STUDY

- Site investigation – reserves and identification of key geotechnical and environmental constraints and base line values
- Setting of excavation limits
- Consideration of a range of alternative concepts (working method and sequence, restoration and after-use), estimation of resources for each and identification of key technical, environmental and economic constraints.
- Initial informal discussions with MPA and research on local attitudes and sensitivities
- Initial comparative analysis of options using strategic issues checklist and design risk assessment techniques

SELECTION OF PREFERRED OPTION FOR WORKING UP INTO A PLANNING APPLICATION AND/OR DETAILED OPERATING PLAN

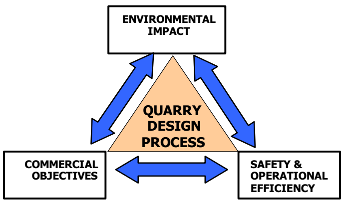
DESIGN STAGE (i): DETAILED DESIGN OF FINAL VOID AND RESTORATION SCHEME

- Preparation of detailed plans and sections showing the quarry on completion of mineral extraction and giving details of access arrangements, final working limits, final quarry slopes and benches, location of out-of pit tips, environmental screening and backfill, extent of progressive restoration achieved *etc*
- Preparation of detailed plans, sections and visualisations showing the final restoration scheme and outline details of proposed after-use
- Assessment of key aspects of environmental impact.

DECISION TO GO FORWARD WITH INVESTMENT AND THE PREPARATION OF A FULL PLANNING APPLICATION AND ES

DESIGN STAGE (ii): DESIGN OF PHASED WORKING AND RESTORATION SCHEME

- Preparation of plans and other drawings showing how the quarry will be worked and restored to achieve the final result, having regard to key environmental, economic and health and safety considerations
- Adjustment to final void and restoration design as necessary to achieve the balance:



PREPARATION AND SUBMISSION OF FULL PLANNING APPLICATION AND ES AND QUARRY DEVELOPMENT PLANS SUPPORTING THE BUSINESS PLAN AND COMPLYING WITH QUARRIES REGULATIONS

DESIGN RISK ASSESSMENT

limiting:

• ENVIRONMENTAL UNCERTAINTY • OPERATIONAL UNCERTAINTY •
• COMMERCIAL UNCERTAINTY •

SITE SELECTION AND STRATEGIC CHECKLIST

A CHECKLIST OF QUESTIONS THAT REQUIRE ADDRESSING AT ALL STAGES OF THE PLANNING AND DESIGN OF QUARRIES

- **Control of land**
  - *Lease or freehold?*
  - *Any ransom strips or similar issues (esp. in relation to access)?*
  - *Any additional land to be purchased or secured?*
- **Mineral resources and viability**
  - *Who owns the minerals?*
  - *If there is a lease, what are the terms and what royalty/rental payments are required?*
  - *What is the size of the resource and what level of risk is there attached to the estimate?*
  - *Is the resource quality, quantity, ratio and confidence of the estimates sufficient to justify investment and yield a satisfactory return? If not, what additional investigations are necessary?*
  - *What is the ratio of overburden and waste to recoverable mineral and are there any problems with scheduling, storage or disposal of these materials?*
  - *What is the downside risk relating to recoverable mineral, quarry waste and void volumes?*
- **Demand for product and added value products**
  - *Can we sell the product(s) or use it in a secondary process? Is there demand for landfill void?*
  - *At what rate and cost can we produce mineral from this site, at what selling price, for how long?*
  - *Who are our competitors and what are our relative competitive advantages and disadvantages?*
  - *Is the viability of the project sensitive to market/economic trends?*
- **Planning status and cycles**
  - *Does the site already have planning permission for the proposed development?*
  - *Is the site identified for mineral extraction and/or landfill in local or regional plans? If not, when will the next opportunity be to promote the site for inclusion?*
  - *Are there any local designations or policies that might preclude mineral extraction (AONB, SSSI, National Park, etc)?*
  - *Are there any mitigating arguments that might be successfully put forward (national need, uniqueness etc)?*
- **Human & environmental constraints**
  - *How close is the site to the nearest community, dwelling or public open space?*
  - *Is the site context rural or urban and what existing industrial, commercial or mineral extraction activities take place in the area?*
  - *What are the most important environmental issues relating to the site (visual/landscape impact, noise, dust, impact on water, blast vibrations, traffic, ecology)? Are there any that cannot be mitigated without compromising viability?*
- **Technical constraints**
  - *Are there geotechnical settings that might compromise security of third party land or the safety or practicability of the operation? If so, can these be mitigated through design (e.g. flatter slopes, larger standoffs, alterations to method or sequence of working) without compromising viability?*
  - *Is it possible to access the identified mineral resource with inherently safe haulage systems (esp. haul roads at satisfactory vertical and horizontal alignments)?*
  - *Can waste arisings be accommodated in temporary storage or backfill in the course of the operation without compromising viability (e.g. through sterilisation of resources, double handling or additional land take necessary for tips)?*
  - *Is there sufficient space on site for surface and groundwater management and control of discharges? Are there any potential difficulties with securing a discharge licence and is an abstraction licence required?*
- **Restoration options, after use and long term asset value**
  - *What restoration options would be suitable in this area and can they be implemented progressively?*
  - *What are the cost implications of the restoration options and is there any added value opportunity (e.g. landfill, recreational facilities, creation of a site suitable for development etc)?*

INTRODUCTION TO PART II: THE QUARRY DESIGN PROCESS

Part II forms the core of the Handbook and describes a process for preparing a mineral planning application in three chapters:

Chapter 4:	Information requirements and investigations
Chapter 5:	Design of the operation and its restoration
Chapter 6:	Environmental, design and commercial risk assessments

Understanding the Design Process

The vast majority of people involved in the quarry design process are not trained in design; usually, they have come from a technical or management background. An effective quarry design team will draw on and co-ordinate all relevant technical and management skills to avoid the quarry design process becoming distorted by unintentional bias. For example, without this inter-disciplinary co-operation, a solution may emerge that is technically sound but environmentally unsympathetic. Similarly, designs may be developed that are environmentally and socially sound but uncommercial. Good design is the identification of all relevant factors and the generation of the optimum solution which aims to achieve all the objectives of the brief in an environmentally sound, safe, efficient and commercial manner. It depends on assembling people who have the expertise and experience to meet the requirements of the project and on effective and informed project management to ensure that the team delivers what is required as efficiently as possible. The formation and management of effective quarry design teams is considered in more detail in Part III (Chapter 8).

Good design begins with the establishment of clear achievable objectives within a brief. The clearer and more defined the objectives, the easier the design process becomes. The design process flows from and is inter-dependent with the planning, information gathering and site selection processes described in Part I.

The next stage has already been described, in part, in Chapter 2. Data collection and primary analysis to generate working models provides the information from which the designs will be generated and against which alternative designs can be assessed against environmental, planning, commercial and safety constraints. Information requirements can be broken down into three main generic areas:

- Technical investigations and evaluations.
- Environmental investigations and evaluations.
- Commercial investigations and evaluations.

Chapter 4 describes the information and investigations required to support design of the quarry operation and its restoration (which is covered in Chapter 5). Stage 3 of the quarry design process is the development of the design of the operation at increasing levels of detail, moving from a conceptual design to establish the inherent viability and deliverability of the project to the detailed proposals that need to be submitted with a planning application; this stage is covered in **Chapter 5**.

The key to good quarry design is:

- well defined objectives;
- thorough data collection;
- comprehensive evaluation of strengths, weaknesses, opportunities and constraints;
- the weighting of these results;
- the generation of balanced, unbiased options;
- the on-going environmental testing of options;
- the on-going testing of working options that affect safety and efficiency;

- continuous design iteration and re-testing of options; and
- the inclusion of restoration and after-use objectives from the beginning.

Throughout Stage 3, the identification of strengths, weaknesses, opportunities and constraints relating to Technical, Environmental and Commercial aspects of the project provides the broad parameters for the generation of design options, and also for ongoing design risk assessment (**Chapter 6**). It is helpful to consider these aspects in the matrix format illustrated below, with the aim of developing design strategies that move issues from the 'weaknesses' or 'threats' categories into 'strengths' or 'opportunities':

	Strengths	Weaknesses	Opportunities	Threats
Technical aspects				
Environmental aspects				
Commercial aspects				

As an example, technical investigations may have shown that the rock varies considerably in quality across the site, environmental investigations may have shown the need to avoid the orientation of faces towards receptors (people or places with a view) who would suffer unacceptable visual impacts and commercial investigations may have shown the need for a particular blend of product over the course of the quarry life, requiring selective quarrying that may frustrate progressive restoration. From these three identified parameters a direction of working may be established which deals positively with these three aspects.

Some advantages of this approach are:

- A technically-biased approach may have produced a visually intrusive and uncommercial solution.
- An environmentally-biased approach may have produced a technically unsound and uncommercial solution.
- A commercially-biased approach may have produced a technically unsound and visually intrusive solution.

In the above example, it is the balancing of the three factors, while fulfilling the overall objectives, which leads to good design, an increased likelihood of planning permission being granted and, therefore, increased likelihood of commercial success.

In a complicated industry such as quarrying, there are not three but perhaps hundreds of factors to take into consideration. There will not be one obvious solution but a variety of options and possibilities. To reduce the possible total number of combinations and rule out weak solutions, which do not fulfil the brief, the matrix of factors needs to contain a weighting, ranking and hierarchy. For example, there could be overriding constraints arising from geotechnical settings, which may dictate a direction of working or limitation on working limits and other factors may, of necessity, have a lower weighting in the overall process. Similarly an international nature conservation designation would carry more weight than a local landscape designation and may override a commercially based preference for selective quarrying that would impact adversely on an area with such a designation.

In addition to the winning, processing and transportation off-site of the mineral, the quarry design needs to address the final restoration objectives and proposed after-use. By taking a holistic approach, the potential positive after-use of the quarry and surrounds can be woven into the design process.

As the options and schemes emerge throughout the operational design phase, each must be the subject of design iteration where the ideas are circulated around the team and assessed. Solutions are re-tested and adjusted to meet the over-arching objectives of quarry design described in the Foreword to this Handbook: fulfilment of the brief whilst minimising environmental impacts, optimising commercial objectives and constraints (especially costs and added value) and producing an inherently safe operational design.

We propose, in **Chapter 6**, a design risk assessment approach to achieving this balance and for checking and adjusting it throughout the design stages described in Chapter 5. The three particular areas that must be addressed within the design risk assessment are:

- The need to limit **environmental uncertainty**, particularly in relation to regulation and compliance
- The need to limit **operational uncertainty**, particularly in relation to safety and accommodation of quarry waste
- The need to limit **commercial uncertainty**, particularly in relation to costs and markets

As discussed in Part I, these areas of uncertainty are inter-related, sometimes in a complicated and potentially conflicting way. The objective of the design risk assessment is to examine all elements of the design and assess the consequences and likelihood of adverse outcomes, with respect to the three key areas of interest. When used as part of design iteration, such risk assessment can indicate the need for more investigation and analysis and/or design changes through early identification of constraints that can be addressed **as part of design** rather than as 'bolt on' mitigation after the design is complete. Design risk assessment should also be used repeatedly to assess the reliability of all of the assumptions upon which the quarry design is based.

The formal activity of Environmental Assessment, when carried out alongside design as part and parcel of the design process, is a helpful framework for the ongoing assessment of design risk relevant to **environmental matters**. Quarrying presents a multitude of opportunities for eliminating or mitigating environmental impacts through modifications to the design in an iterative way. These include:

- modifications to working limits to avoid disturbance of sensitive ecological areas;
- creation of replication natural landforms in the restoration scheme to limit landscape impact; or
- careful design of water management structures to avoid adverse impacts on receiving streams.

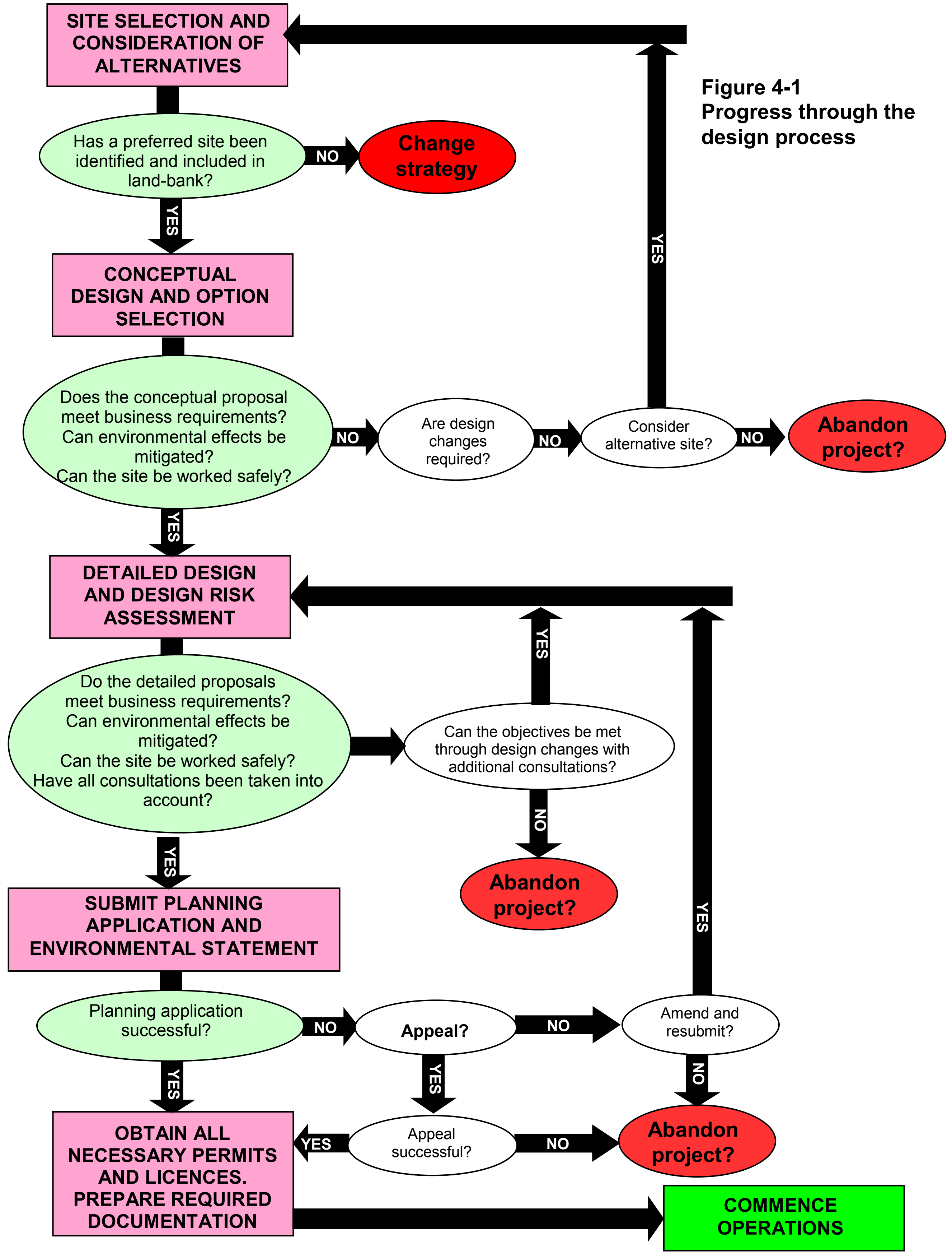
The basis for limiting **operational uncertainty** is a thorough understanding of the geological and geotechnical settings in the operation and an appreciation of the way in which these will impact on any chosen quarry and restoration design both spatially and over time. Also vital is the need for an ongoing awareness of human and mobile plant movements within the quarry. A helpful framework here is to anticipate, within the design process, the requirements of the UK Quarries Regulations 1999 and repeatedly ask the question "if we design the operation this way, have we avoided significant hazards?" If the answer is "no", then more information and analysis is required and design changes may result (*e.g.* changes in bench geometry or alignment or amendments to haulage options or working methods).

In addition to safety (and intimately related to it), it is important that the quarry design can be implemented practically without running into unforeseen difficulty. The framework for assessing this is checking, by conceptually working through the quarry phasing from beginning to end and making sure that the scheme can practically progress as envisaged throughout its life. Examples of problems which may be identified through this process are: a surplus of waste material that cannot be accommodated within the site at a particular stage of the operation, a need to relocate fixed plant, or parts of the resource that cannot be reached in a systematic and safe manner.

Limiting environmental and operational uncertainty through an evolving design incorporating design risk assessment is likely to impact on the **commercial model** for the quarry and a key element of design risk assessment is repeatedly to ask "having made these design changes to mitigate environmental and/or operational risk, are we still prepared to invest money in this operation?". A helpful framework for this ongoing commercial assessment is a business plan supported by a robust and flexible economic/cashflow model (see Appendix 4-6).

CHAPTER 4
DESIGN OF THE OPERATION AND ITS RESTORATION

Figure 4-1
Progress through the design process



4.1 INTRODUCTION

Following the selection of a site for development as a quarry (see Chapter 3) a sketch design of its layout and possibly also its restoration landform is likely to exist, together with a preliminary estimate of the mineral resource potentially available to be worked at the site. The mineral resource estimation is likely, at this stage, to have been made on the basis of area measurements and thickness estimates, with percentage allowances for geological uncertainty and the losses that will arise due to waste, areas of the site needed for essential infrastructure and environmental standoffs, and the material that can never be worked within the perimeter slopes (batters). This chapter is about moving from the site selection process to a quarry with a valid planning permission that can be implemented, as shown on Figure 4-1. This progression from site selection to a detailed design also represents increasing confidence in the resource estimate for the site (see Figure 4-2).

Once the site has been selected, the design proceeds in stages. The first stage is the establishment of a design brief (a set of commercial, operational and other objectives), against which the design can be checked and adjusted (or which may itself be adjusted) as the iterative process of operational design proceeds. Chapter 5 describes the investigations and information necessary to support the design of the operation and its restoration at each of the stages described in this chapter, and Chapter 6 covers the ongoing process of risk assessment to which the design should be subject in order to ensure that it meets its objectives.

Consultation and communication are essential throughout the design process and these aspects are covered both in general and in relation to the distinct design stages, in Chapter 7. Such a complex process, involving a range of specialist and general inputs is unlikely to succeed unless it is effectively managed, and this aspect is covered in Chapter 8.

The design of the operation itself and its restoration involves the design team in six principal stages leading to the start of quarry operations.

i. **Establishment of a design brief** – a set of business, operational and other objectives

ii. **Conceptual design, option selection and feasibility study** including initial resource evaluation and identification of working and restoration options. This stage results in a refinement of the design brief.

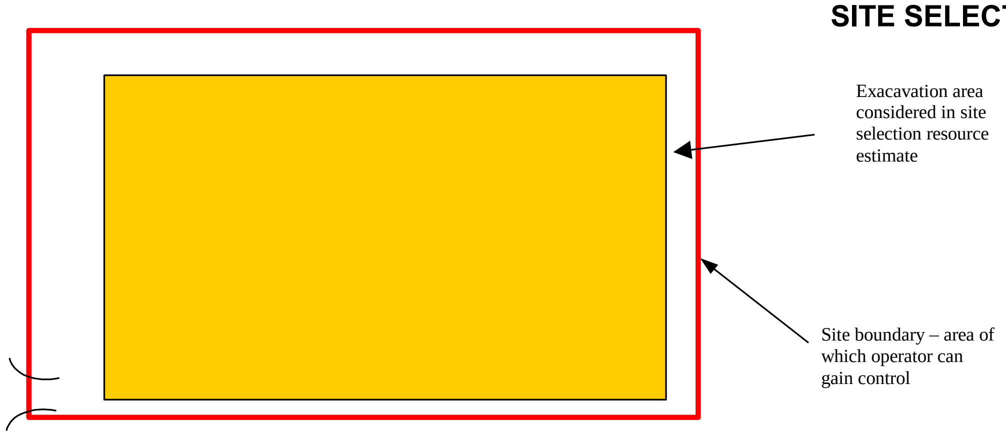
iii. **Detailed design of the final void and restoration scheme**, assessment of its environmental impact, mitigation and benefits, and updates to the initial resource evaluation based on measurement of the detailed design and more detailed 3D geological models.

iv. **Detailed design of a phased working and restoration scheme** demonstrating that the quarry can be worked and restored efficiently, safely (complying with the Quarries Regulations) and without causing environmental harm. Refinements to the stage iii design and the resource evaluation may result at this stage.

v. **Preparation and submission of documents for the Planning Application** and accompanying Environmental Statement (ES) if required. Preparation of evidence to, and participation in, a Planning Appeal if necessary.

vi. **Pre-production requirements** for operational and business plans, safety and contract documentation, implementation of planning conditions, environmental monitoring and management systems *etc*

SITE SELECTION



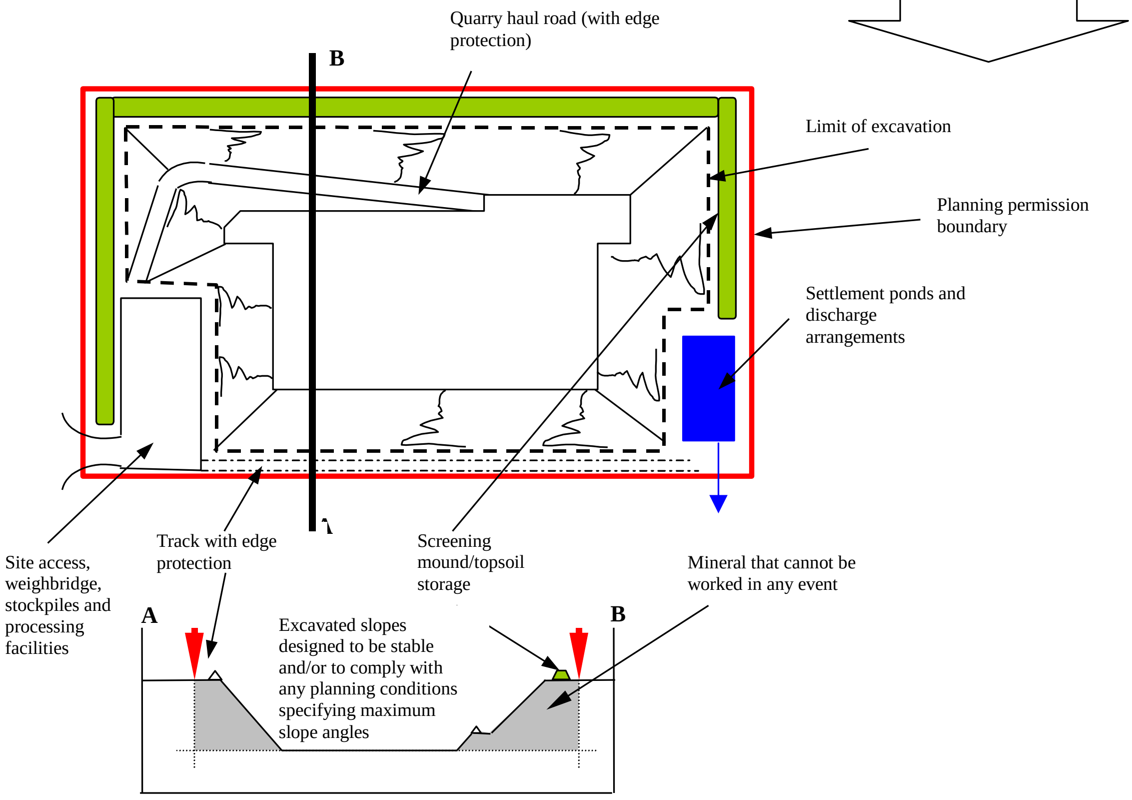
Resources estimated using the following approach:

(Excavation area x mineral thickness x *in situ* density) x F%

Where F% is a factor allowing for:
- geological uncertainty
- processing and quarrying waste
- mineral that cannot be worked beneath excavated slopes and haul roads
- Reduction in the working area to allow for establishment of infrastructure and environmental standoffs

QUARRY DESIGN PROCESS

DETAILED DESIGN



Resources estimated using the following approach:

((V – *in situ* waste) x *in situ* density) – processing waste

Where V is *in situ* volume directly measured from:
- detailed 3D site design plans depicting the final excavation geometry of the operation
- accurate surface models of all key geological surfaces (including water table, rockhead and base of mineral)

Figure 4-2 Sketches illustrating the progression from site selection to detailed design

As is indicated on the diagram in the introduction to Part II, in Figure 4-1, and mentioned throughout this Handbook, there is a need for significant feedback, iteration and overlap between these design stages, but they are listed above in generally chronological order. The information requirements and investigations described in Chapters 2 and 5 are relevant throughout the operational and restoration design stage, although most collection of information and site investigation is generally complete before design stage iii. For some operations, there may be little or no distinction between the first two stages, and items i. and ii. are often substantially completed during the site selection phase described in Chapter 3, particularly if a site has been promoted by a Developer for inclusion in the land bank. With the exception of design stage v., each of the design stages listed above is given a separate section in this chapter, generally structured as follows:

- Objectives
- Design (technical) requirements
- Information requirements
- Deliverables

The sections describing design stages ii, iii, and iv (sections 4.3 to 4.5) include examples of the design plans produced for a hard rock (crushed rock aggregate) quarry and a sand and gravel quarry; the same sites are used for all three examples to show the progression.

There are several design (or technical) requirements noted for design stages i, ii, iii, iv, and vi, which are illustrated on Figure 4-1 and described in Sections 4.2 - 4.6. There is no separate section for design stage v, since the procedures for making a planning application and the information to be included vary from jurisdiction to jurisdiction[1]. Similarly, there is abundant published guidance concerning environmental assessment and the preparation of environmental impact statements for minerals applications.

Part IV includes a number of more detailed documents describing in more detail how particular technical requirements can be met at each stage in the design process. There are six appendices relevant to Chapter 4 included in Part IV of this Handbook. These identify the principal design elements or activities required to design the operational layout, excavation geometry and restoration scheme and ensure that it meets the overarching objectives of quarry design articulated in the Foreword and Chapter 1.

The design elements selected for more detailed treatment in Appendix 4 are:

Appendix 4-1	Resource evaluation for aggregates
Appendix 4-2	Principles of design in sand and gravel quarries
Appendix 4-3	Principles of design in quarries producing crushed rock aggregate
Appendix 4-4	Slope design
Appendix 4-5	Haulage method selection and design of haul routes
Appendix 4-6	Economic modelling for feasibility studies and business planning

Whilst providing more detailed information than sections 4.2 - 4.6 on individual design elements, the documents in Appendix 4 are not intended to provide a detailed technical manual; it is not the purpose of this Handbook to replicate the wealth of practical guidance already publicly available elsewhere. However, the Handbook does set out to assist the reader to gain a good appreciation of what is required and how it can be achieved. The bibliography in Part V points the reader to sources of detailed information and guidance on techniques and methods through references to published and public access information. Where there is no readily available supporting material easily accessible in the public domain, we have incorporated in the Appendices to Chapter 4, documents and materials produced by the authors (but as yet unpublished elsewhere).

[1] Even within the UK, there is variation from County to County but the procedures are well documented on local authority websites and accessible *via* www.planningportal.gov.uk

The following design elements are also important:

- Restoration and after-use design
- Design for enhanced conservation and access opportunities
- The design of surface water management and lagoon systems
- EIA for quarries and design approaches to minimising environmental impact

These matters have been covered in considerable detail in other ALSF material, especially that summarised and described in the resources available at www.sustainableaggregates.com, which also provides links to the original reports and resources (see also links to specific review and overview documents in the Foreword to this Handbook and in the bibliography in Part V).

The specific design elements in Appendices 4-4 and 4-5 and the other design elements listed above (for which information can be obtained elsewhere) have been chosen as being those that most significantly affect operational and restoration layouts, and/or which have the greatest impact on safety, efficiency, viability and environmental impact of a quarry and/or its restoration scheme.

Appendices 4-2 and 4-3 describe, in more detail than is possible in this chapter, the particular approaches and constraints relevant to design in sand and gravel quarries and quarries producing crushed rock aggregates. Most of the design elements are relevant in varying levels of detail and complexity at all of the key design stages listed above and discussed in Sections 4.2 to 4.6 below. For example, a resource evaluation made at the site selection or conceptual design phase must be constantly refined and re-visited as more information becomes available and as the design becomes more detailed. By the end of the process, there should be high confidence in all the assumptions underlying the resource statement, and the measurements themselves will have been made from a detailed model meeting the key criteria for good quarry design. It should also be possible, by the end of the detailed design stages (iv and v) to report the resources against individual phases of working and therefore develop a 'time line' for the operation.

Appendix 4-1 addresses the key issue of resource evaluation, which is a fundamental driver for the design of quarries (Appendices 4-2 and 4-3), and is the predominant factor in economic modelling for feasibility studies and business planning for aggregates (Appendix 4-6).

4.2 ESTABLISHING THE DESIGN BRIEF (design stage i)

4.2.1 Objectives

As described in Part I and in the introduction to this chapter, the quarry design process is a complex balancing exercise between environmental, operational (including safety), commercial and planning constraints. Unsatisfactory impacts on any of these may result in the project being abandoned through refusal of planning permission or licence applications, through withdrawal of the proposals by the developer (*e.g.* if that which is permitted is uneconomic to implement) or even failure of the operation once underway if problems surface that were not recognised during the design process (*e.g.* more waste arising than anticipated and no room to accommodate it).

The final design should be such that:

- The proposed quarry operation will satisfy the financial and strategic requirements of the owner/operator.
- The site is capable of being worked safely, effectively and efficiently through all phases of the project.
- The project will stand up to environmental scrutiny, potential negative environmental impacts are appropriately prevented or mitigated, and opportunities for environmental benefits are included.
- The site can be operated in compliance with all relevant legislation and planning requirements.
- Consideration and accommodation of concerns by non-statutory consultees, including the local population and special interest groups, can be demonstrated.

Quarry design solutions should be practical to implement, appropriate to the scale and complexity of the site and present real value for money. Beneath the over-arching design objectives listed above, the financial, environmental and safety implications of design options should be clearly defined by the design team to allow informed choices to be made by the Developer. Similarly, it is important that the design team understands the Developer's objectives and requirements in four critical areas:

- Key dates for the design and application process
- The total mineral resources to be secured and the desired rate of mineral production
- Minimum required return on investment that the project must generate
- Successful negotiation of the planning and licensing system

As is illustrated in Figure 4-1, and in sections 4.3 to 4.6 below, progressive stages of design necessarily lead to increasing complexity and detail. Feedback, input of further information collected, analysis as part of an environmental assessment or geological/geotechnical site investigation, and iteration are vital components in the process. There is a danger that the process becomes solely focussed on one objective (often applying for and securing planning permission) and that other objectives are overlooked.

Example scenario:

Between the conceptual design phase and submission of a planning application, environmental assessment and comprehensive consultations have taken place. Two major design changes have been made in response to consultations following completion of the environmental assessment, which have a significant impact on the recoverable resources within the site:

- The floor level of the operation has been raised above the water table to address objections by the Environment Agency relating to protection of an aquifer.
- Final excavation slopes have been flattened, within the limit of excavation established after the conceptual design stage, to mitigate landscape impacts of the final restoration through landform replication.

Planning permission is granted and it is not until a business plan is drawn up prior to implementation of the permission that the Developer realises that the operation cannot deliver the return on investment required (and that which was assessed at conceptual design stage on the basis of the assumptions made at that time).

Agreement of clear objectives and a related design brief at an early stage is a helpful framework both for managing a quarry design project (see also Chapter 8) and for avoiding unforeseen situations arising (such as that described in the scenario) through early identification of imbalance between operational, environmental and commercial objectives and outcomes. At the end of each design stage <u>and</u> after any significant design change (especially those affecting recoverable resources), a review should be carried out of key elements of the design brief, amounting to addressing the question "are we still prepared to invest our money in this project?".

4.2.2 Technical requirements

A design risk assessment approach to ongoing checking of a design against its agreed commercial objectives is set out in Chapter 6.

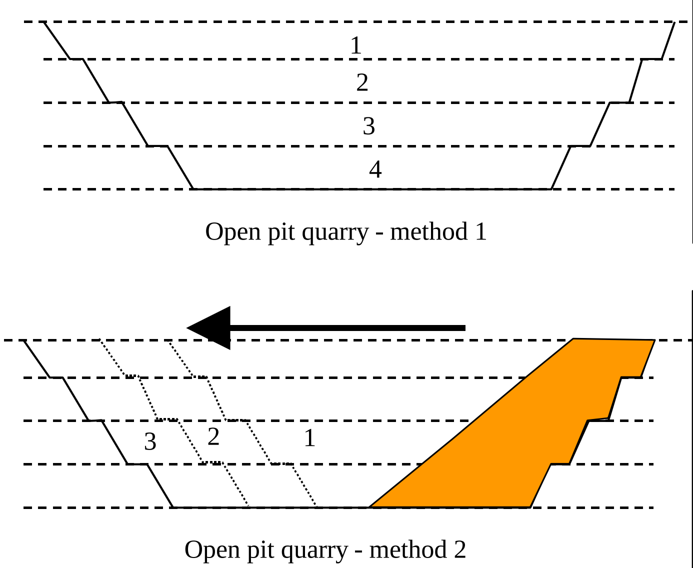
The design risk assessment approach described in Chapter 6 considers all design risks at a variety of scales and levels of importance in terms of potential impact of changes as the quarry design evolves. Monitoring of compliance with the overall design brief is likely to be best achieved through repeated updating of a discounted cash flow model created during the feasibility study phase and developed throughout the design phase so as to become the key element of a business plan.

4.2.3 Information requirements

Information required by the design team as part of a design brief is listed in Chapter 5. At this time, it is likely that the primary information described in Chapter 2, at a level of detail appropriate to conceptual design, will also be available and will inform the drawing up of the brief.

4.2.4 Deliverables

The complexity of the design brief is likely to vary, depending on the complexity of the project and internal company systems. At its simplest, it might simply state that a planning application is required for the site by a certain date and state the minimum saleable tonnage that must be produced on an annual basis for a specified number of years. For more complicated projects, especially where there is to be an EIA with wide scope, the design brief might be split into stages reflecting the design stages that form the structure for this chapter. A detailed specification of work would be provided for each design stage and decision points would be identified for checking the design against the overall commercial objectives of the project (which are unlikely to be "obtain planning permission whatever the cost"). The advantage of the latter approach is that it forms a convenient basis for building a budget and programme, and a framework for identification of appropriate specialist inputs required and for appointment and briefing of specialists. A design brief built up in this way also provides a convenient framework for monitoring performance against the budget and programme. If there is significant uncertainty in any key area (for example, whether an ES will be needed and, if so, what its scope will be), it is sensible to set out the details of the design brief in phases of work (that may reflect the quarry design stages in this chapter); early phases can be carefully planned, with full details of later phases (and detailed programmes and budgets) to be completed later as more information becomes available about what will be required. The advantage of this approach is that the phases of work provide natural points at which to re-visit the project objectives and to make positive decisions as to whether to continue or not.



Benches are worked successively, such that the entire excavation area is disturbed throughout the operation.

Overburden, soils, quarry waste and any material that cannot be sold directly must be stored outside the excavation limit, for which storage space is required.

Method is suitable for bulk minerals where there is plenty of out of pit tipping space for overburden, soils, waste and stock storage, or in small sites where method 2 is impractical.

A void is created to the full depth of the deposit (1) and then full faces are advanced (2) then (3) at multiple bench levels.

This method allows progressive replacement of overburden and soils in low level restoration or backfilling with landfill as soon as the faces have advanced sufficiently to create space for this to happen.

The overburden, soils, and quarry waste from the initial void (1) must be stored outside the excavation limit, but the space required will generally be smaller than for method 1.

Figure 4-3 Sketches showing approaches to open pit development

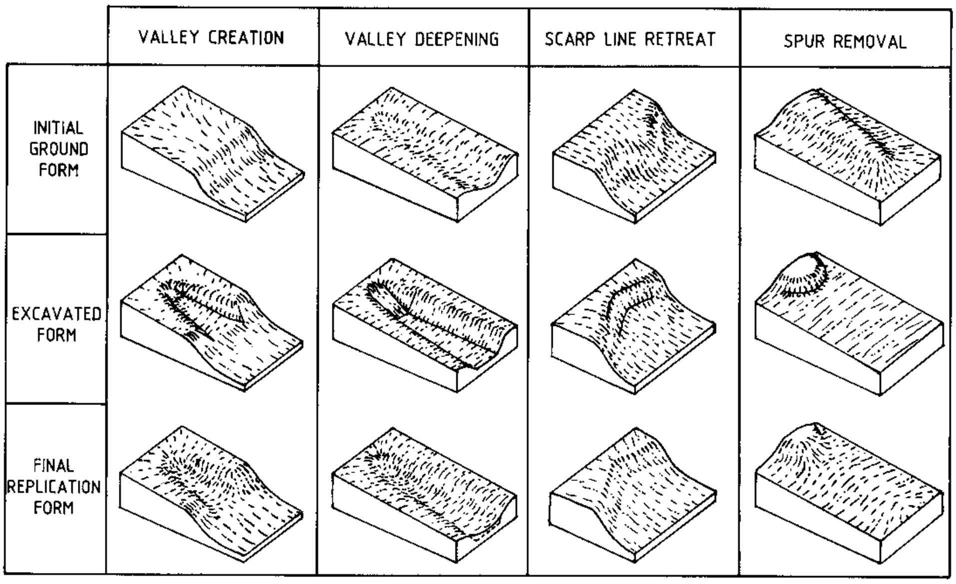


Figure 4-4 Sketches showing some approaches to restoration landform formation without landfill

4.3 CONCEPTUAL DESIGN, OPTION SELECTION AND FEASIBILITY STUDY (design stage ii)

4.3.1 Objectives

Conceptual design is undertaken once a site has been identified for development. It is directed towards:

- Identification of aims and objectives of the quarry design (*e.g.* required production rates, total reserve and reserve life required, preferred after-use or final restoration landform).
- 'Broad brush' design of one or more options for working and restoring the site at a level of detail suitable for the investigation of feasibility, identification of key environmental, geotechnical and operational constraints, and estimation of resources, waste and restoration materials.
- Option selection based on environmental scoping and 'broad brush' environmental and operational assessments.
- Developing an agreed specification for the detailed design answering the following questions or identifying further work required to allow the design to proceed:
  - Where will the final excavation limits be?
  - What are the access requirements?
  - What excavated slope angles will be stable in each geotechnical domain, and what are the design rules that should be applied to excavations?
  - What excavated slope heights will be stable in each geotechnical domain and taking into account the capabilities of proposed excavation plant to be deployed?
  - What should the design rules be for tips (overburden, soils, mineral stockpiles, lagoons *etc*) and excavations (including faces and haul roads)?
  - What will the excavated quarry floor levels be?
  - Will the workings be wet or dry?
  - If dry, will pumping of groundwater be required to keep them dry during the operation?
  - Will the quarry be worked by method 1 or method 2 depicted on Figure 4-3?
  - What will the direction(s) of working be and/or how will the operation be phased (in broad terms)?
  - How will surface water be managed and where will surplus surface water be discharged?

- What excavation and loading plant will be used at the face?
- Will there be any blasting or other ground preparation required?
- How will the mineral be hauled within the site (haul roads, conveyors)?
- If haul roads, what will be the size and number of trucks used?
- Is there a need for selective excavation to optimise quality or waste arisings?
- If so, how can that be achieved?
- What mineral processing will take place on site?
- What are the fixed plant, staff and visitor requirements (layout and size of plant, buildings, parking, and other structures)?
- How much space will the fixed plant require and where will it be located?
- What products will it produce?
- How much process waste will arise (as a percentage of run of quarry material delivered to the processing plant)?
- Will there be progressive restoration?
- Will restoration depend on the importation of material to the site (*i.e.* landfill)?
- If restoration will be progressive (see Figure 4-3, method 2), how much space will be required out of pit to accommodate quarry and process waste, overburden and soils that cannot be replaced in the working void in their permanent location in the early years?
- If restoration will not be progressive, where will the waste, overburden and soils stripped during the life of the quarry be stored? Will these storage arrangements be temporary (*i.e.* replacement of material in the void on completion of extraction) or permanent?
- What will the final restoration landform be (see Figure 4-4)?
- What after-uses will the final restoration scheme be suitable for?
- What are the key operational constraints and drivers on the operation (safety, feasibility)?
- What are the key environmental constraints and drivers on the operation (EIA scoping)?

- Specification of further geological and geotechnical site investigations and environmental baseline studies required to support detailed design phases.

4.3.2 Design requirements

The principal design requirements at this stage are:

- **Preparation of 3D surface models of all key geological surfaces** (Chapter 5 and Appendix 4-1):
  - Ground surface
  - Rockhead (the interface between the bedrock and superficial materials)
  - The top of the target mineral (if different from)
  - Significant surfaces within the target mineral (*e.g.* top, base and lateral extent of materials that comprise waste materials, water table, major faults)
  - The base of the target mineral (where relevant)
- **Definition of geotechnical domains and allocation of appropriate design rules** for each domain (Appendices 4-3 and 4-4).
- **3D design of final excavation voids and outline site layouts** based on a range of possible restoration, processing and phasing options and with varying sets of environmental and commercial assumptions.
- **Measurement of volumes and estimation of tonnages** of all materials to be excavated (mineral, top soil, sub soil, superficial material, waste within the deposit) using the 3D geological surface models and the 3D excavation design models (Appendix 4-1)
- **Provisional zoning of excavation into geotechnical domains** for each working option, within which similar potential modes of failure may occur and require particular design solutions (Appendix 4-4)
- **Provisional identification of primary environmental constraints** for each working option considered, and scoping of environmental assessment.
- **Comparative analysis of options** (Figure 4-5)

4.3.3 Information requirements

Information requirements (see Chapter 5):

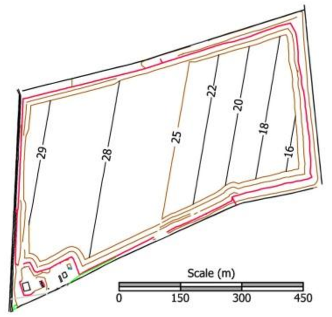
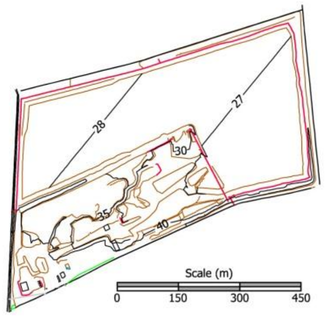
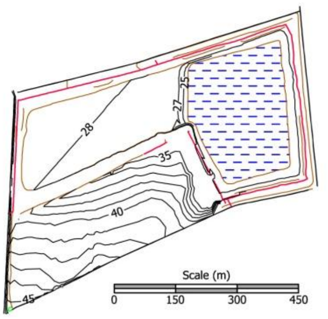
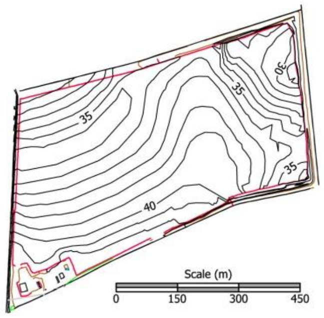
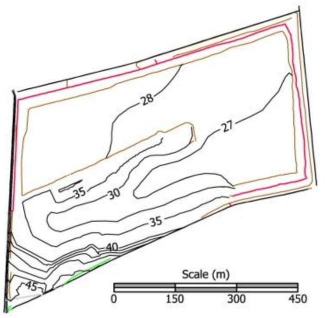
- Base mapping and geological desk studies
- Topographic survey (including site boundaries) and neighbouring land and features
- Provisional geological models and quality information
- Provisional geotechnical and operational design rules
- Results of environmental baseline studies completed to date
- Significant environmental controls and key restoration concepts (*e.g.* landform replication)

4.3.4 Deliverables

- A set of plans and resource tables identifying one or more options available for working the site
- Comparative analysis of design options produced at Stage i, and agreement of the design option that should go forward to be worked up into a planning application (see Figures 4-5 and 4-6).
- Feasibility study of the selected option including building of an economic model (Appendix 4-6)
- A design brief for the preparation of the planning application, including a set of plans, tables and descriptive material for the conceptual design option selected.
- A scoping study (or matrix) for an EIA (suitable for submission to the MPA with a request for a scoping opinion) (see Chapter 1, section 1.5).

Excavation option:______________________				Restoration option:_________________________		
Issue	**Strengths**	**Weaknesses**	**Opportunities**	**Threats**	**N/A**	**Notes**
Open pit working method						
Direction of working/overall phasing						
Final restoration geometry/landform						
After-use potential						
Accommodation of waste						
Potential for progressive restoration						
Suitability for proposed after-uses						
Environmental constraints/issues						
Visual/landscape impact						
Noise and vibration impact						
Traffic impact						
Impact on surface and groundwater						
Impact on ecology						
Impact on geodiversity						
Impact on archaeology and cultural/social heritage						
Impact on soils and land-use						
Geotechnical constraints/issues						
Excavated slope stability (including rockfall, bench and face scale failures, weak materials)						
Tip material properties and foundation conditions						
Hydrogeological setting						
Water management requirements						
Haulage proposals						
Processing proposals						
Estimated recoverable resource					**m³**	**tonnes**
Resource life						

Figure 4-5 Proforma for SWOT analysis of alternative conceptual design options

<table>
<tr>
<td><u>Excavation option 1</u>: excavation in undisturbed areas of the site only.
</td>
<td><u>Excavation option 2</u>: excavation over entire area including SW quadrant previously worked and backfilled.
</td>
<td><u>Excavation option 3</u>: excavation in undisturbed areas of the site only, above max water table.
</td>
</tr>
<tr>
<td>Restoration option 1
</td>
<td>Restoration option 2
</td>
<td>Restoration option 3
</td>
</tr>
<tr>
<td>Key quantities and issues for Option 1

<u>Extraction volume:</u>
1,050,000m³ of virgin ground, of which 157,500m³ is waste.

<u>Groundwater management requirements.</u>
The floor is below the maximum inferred groundwater levels over the whole site. Extraction of the basal bed on the eastern side will be below minimum groundwater level and there will therefore be groundwater protection issues.

<u>Blasting requirements:</u>
Blasting is required to extract the basal bed.

<u>Restoration option 1:</u>
Low level restoration and reduction of final face gradients on completion (using quarry waste) to allow establishment of vegetation. Some faces to be left exposed to provide geological conservation areas. Quarry waste to be used to re-profile the SW quadrant and build up the floor in the NW quadrant above the max water table to allow establishment of vegetation. Eastern side of quarry to remain as-excavated and will flood to form a lake</td>
<td>Key quantities and issues for Option 2

<u>Extraction volume:</u>
1,515,000m³ of which 256,300m³ is waste. The extraction area includes previously quarried ground to the south west of the site. The proportion of waste to mineral is substantially higher in this area, providing more materials for restoration, but also higher operating costs due to increased ratio.

<u>Groundwater management requirements:</u>
As Option 1

<u>Blasting requirements:</u>
Blasting is required to extract the basal bed.

<u>Restoration option 2:</u>
Restoration landform will establish a ground surface just below original ground levels by incorporating the waste volume generated as well as importation of inert waste (high groundwater table probably rules wastes other than inert and acceptability of this to be checked with EA). This restoration option would be suitable for all three extraction options.</td>
<td>Key quantities and issues for Option 3

<u>Extraction volume:</u>
532,000m³ of virgin ground, of which 79,800m³ is waste.

<u>Groundwater management requirements.</u>
No groundwater management required. The floor of the pit is above the maximum inferred water table and above the basal bed, reducing the volume of recoverable mineral.

<u>Blasting requirements:</u>
No blasting is required as it is not intended to extract the basal bed.

<u>Restoration option 3:</u>
Low level restoration and reduction of final face gradients on completion (using quarry waste). The floor level will be raised by about 0.3m to enable vegetation to be established. Given the reduced mineral volume compared with option 1 and consequential reduced quarry waste available, the previously worked area to the SW would be re-graded and the ground surface lowered slightly to realise additional fill materials to complete the in pit restoration.</td>
</tr>
</table>

Figure 4-6 Thumbnail sketches and descriptions showing range of conceptual design options for comparison

4.4 DESIGN OF THE FINAL VOID AND RESTORATION SCHEME (design stage iii)

4.4.1 Objectives

The objectives of this design stage are to refine the selected conceptual quarry design to produce a detailed scheme that will form part of the planning application and, eventually, operational plans. This refinement has the following objectives:

- Incorporation of results of further geological, geotechnical, or environmental site investigations and related modelling and assessment that may have been indicated at the conceptual design stage to address unacceptable uncertainty identified through feasibility study/option selection.
- Incorporation of design changes resulting from consultations and environmental assessment of the conceptual scheme, in particular landscape and visual impact analysis, noise, ecology and archaeology. Changes are likely to be iterative until the best safe, economic and environmental solution is agreed by the design team and relevant statutory and other consultees.
- Incorporation of changes in operating methods, haulage, processing, *etc* identified during the more detailed financial analysis of the conceptual scheme, taking account of further information.
- Preparation of more detailed design models than at conceptual design phase, suitable as the basis for detailed environmental assessment activities (*e.g.* modelling of noise or visual/landscape impacts requires the detail of benches, final roads to be shown).
- Preparation of updated resource statements and associated economic models/business plans.

4.4.2 Design requirements

- **Detailed design of final excavated slopes** (layout and profiles) based on geotechnical analysis of proposed slopes, and assessment of risks and mitigation measures with respect to specific site areas and activities (Appendix 4-4).
- **Design of out of pit tips, bunds and stockpiles** (see Appendix 4-4)
- **Detailed haul road (and/or conveyor route) design** (see Appendix 4-5).
- Detailed design of water management infrastructure (in-pit sumps, attenuation ponds, settlement lagoons, discharge arrangements, pumping arrangements and ditches)
- Detailed design of final restoration landform incorporating site derived and (if appropriate) imported fill materials and taking account of excavated slope requirements in restoration (*e.g.* flattened slopes for landscape, geoconservation, margins of water bodies, replication natural landforms *etc*).
- Iterative consideration of the results of the ongoing EIA and adjustments to elements of the design to eliminate or mitigate unacceptable impacts.
- Provision of revised assumptions and parameters for the economic/feasibility model and adjustments to design to reflect further economic appraisal and commercial risk assessment (Appendix 4-6).

4.4.3 Information requirements

- Results of further site investigations undertaken after the conceptual design phase.
- Results of ongoing EIA.
- Amended commercial assumptions that affect design (*e.g.* change in annual output, change of processing plant leading to change to amount of process waste and/or product mix *etc*)

4.4.4 Deliverables

- A detailed plan showing the final excavation geometry of the quarry on completion (including all benches and haul routes) and the layout of all site infrastructure (site access arrangements, processing plant, site offices, weighbridge, wheelwash *etc*, water management facilities, out of pit tipping areas for overburden and waste, and areas for the storage of soils)
- A schedule derived from the final excavation geometry setting out the measured volume and estimated *in situ* and recoverable tonnages of mineral to be recovered in the designed final void, and detailing volumes of:
  - soils to be stripped and stored
  - overburden to be stripped and stored
  - waste within the deposit to be excavated and discarded before processing
  - processing waste that will arise
- A detailed plan showing the final restoration geometry of the quarry on completion and the land-use(s) following closure.
- A restoration schedule setting out the total area to be disturbed and the amount of soils and other restoration materials required to deliver the proposed restoration landform.
- An updated resource statement based on measurement of volumes from the detailed design model(s) and refined economic model and incorporation of cost assumptions reflecting the operational design decisions confirmed at this stage.

Examples of final excavation and restoration design plans are shown on Figures 4-7 and 4-8.

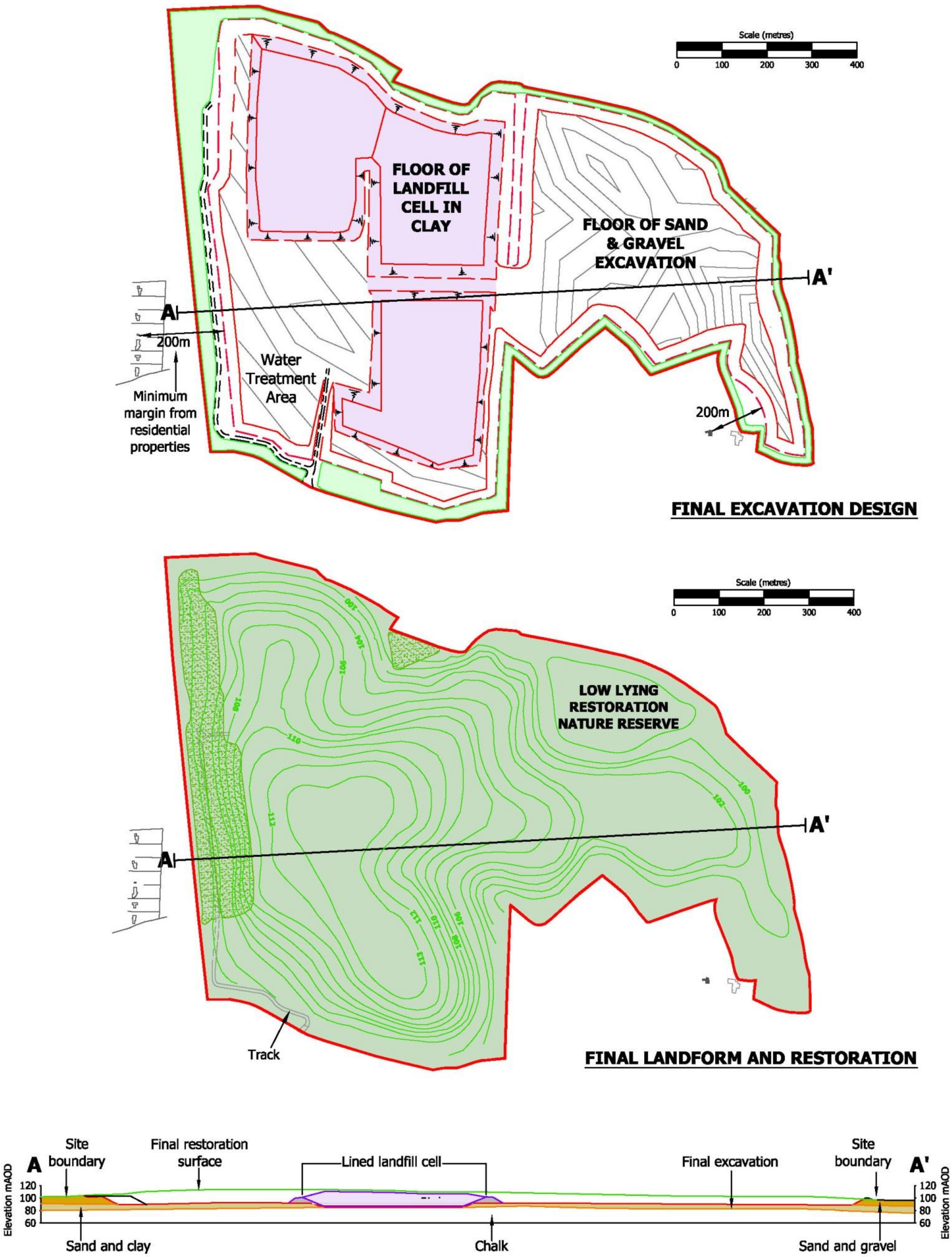


Figure 4-7 Example of a final excavation/restoration design for a sand and gravel operation

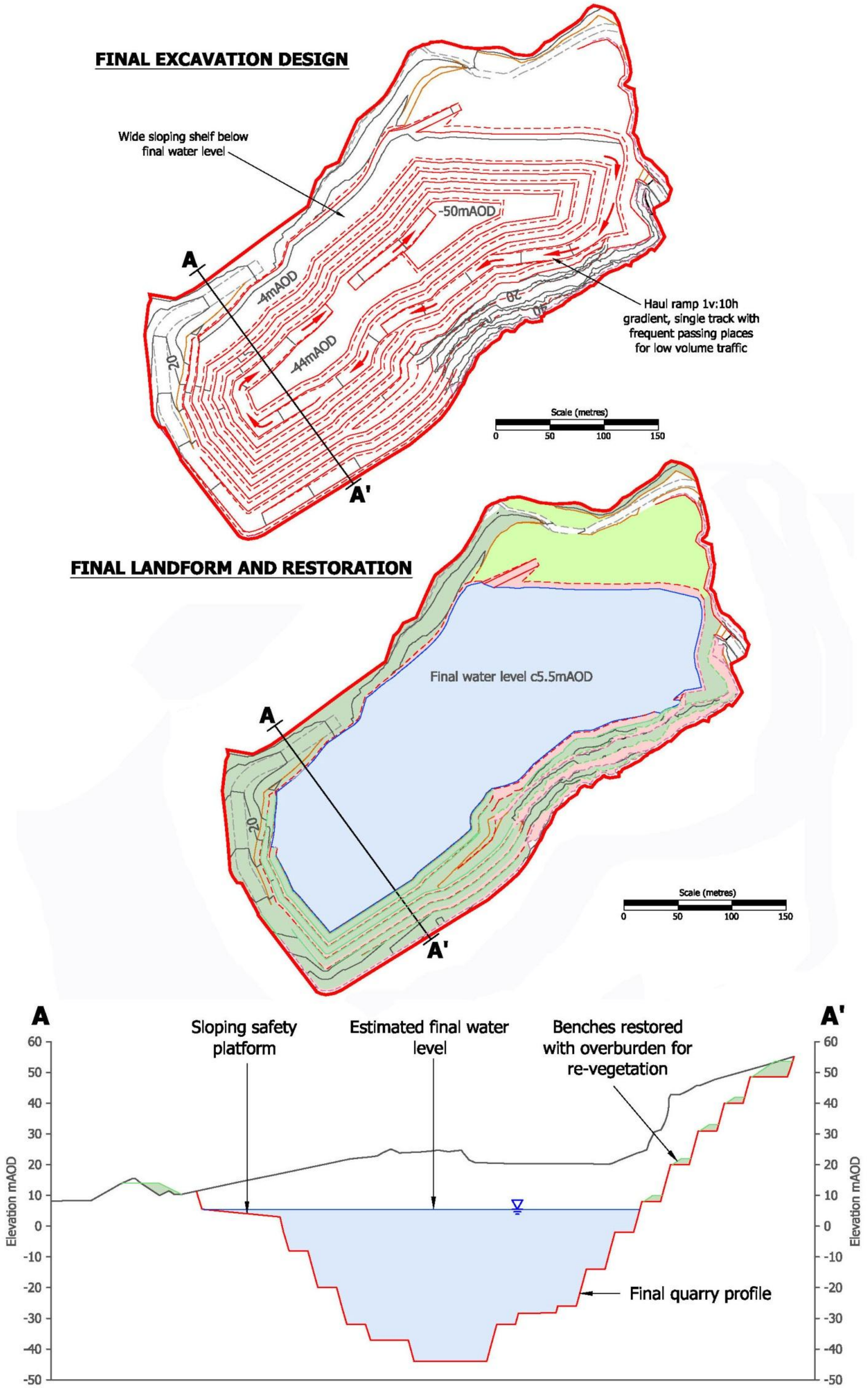


Figure 4-8 Example of a final excavation/restoration design for a crushed rock aggregate operation

4.5 DESIGN OF PHASED WORKING AND RESTORATION SCHEME (design stage iv)

4.5.1 Objectives

The objective of designing a phased working and restoration scheme is to demonstrate that the site can be taken from its current state to the proposed end state designed in stage iii (section 4.4), and describe exactly how that will be achieved. There are three reasons why this is important:

- To demonstrate to the operator that the proposed scheme is feasible and can be implemented safely and economically throughout, with 'no surprises' such as a temporary surplus of overburden or waste that cannot be accommodated in the backfill or tip space available at that time, or problems moving from one phase to another without double handling of material, loss of resources or encountering adverse geotechnical settings.
- To provide the environmental assessment team with the information they need to model impacts at critical stages throughout the operational life of the quarry, for the purposes of producing an environmental statement, to provide feedback to the design so that design changes can be considered to avoid unacceptable environmental impacts where possible, and as a basis for recommendation of mitigation measures where design amendments are not possible or will not be sufficiently effective.
- To explain to the MPA, consultees and all other stakeholders how the operation will unfold during its life and underpin environmental impact assessments, demonstrating its impacts during operation and how they are to be mitigated (or avoided through design).

Although this design stage is presented here as part of an overall design process associated with preparing a planning application for new development (including extensions), it can be an important component of operational planning where planning permissions exist but no phased operational design exists as part of the permission (only a final restoration geometry, or sometimes only a final excavation geometry).

4.5.2 Design requirements

- **Establishment of design rules for ongoing operations** These design rules will be additional to those established during the design of the final geometry of the operation (section 4.4) to reflect all activities and structures within the quarry excavation as it is worked. These are likely to include:
  - Working face and bench alignment and geometry
  - Haul route alignments and traffic flow arrangements
  - Tipping rules for waste materials and overburden placed in backfill or out of pit tips
  - Minimum standoffs between backfill/restoration and working areas of the quarry
  - Arrangements for managing surface water within the pit (sump, pump and ditch requirements)
  - Frequency of soil and overburden stripping
  - Arrangements for progressive restoration requirements

- **Preparation of detailed staged working plans** ensuring a balance at every stage between non-mineral materials (soils, overburden, quarrying waste, process waste) shown to be in storage or placed in final restoration with volumes excavated (and arising from processing). The preparation of these detailed working plans is likely to give rise to adjustments to some of the features shown on the final excavation/final restoration designs produced at stage iii (Section 4.4) either because of design changes for environmental mitigation or as a result of the process of scheduling non-mineral materials, leading to amendments to tip capacities or the amount of progressive restoration that can be achieved at any particular stage.

4.5.3 Information requirements

- Results of ongoing EIA and outcomes of ongoing public consultation and pre-application discussions with the MPA and consultees.

- Details of any amendments to commercial assumptions that affect design (*e.g.* change in projected annual output, change of processing plant leading to change to amount of process waste and/or product mix *etc*).

4.5.4 Deliverables

- Typically, plans representing the operation at given time periods (*e.g.* every 5 years for a 20 year life operation) or representing critical stages in the development would be prepared for a planning application.
- The phase plans should be accompanied by a schedule which relates to the phases shown and includes details such as total and incremental volume and tonnage of mineral recovered, volume of spoil in permanent and temporary storage, area(s) of working, area(s) available for permanent restoration.
- Description of the operation (supported by the plans and schedule) to form the basis for supporting material in the Planning Application and Environmental Statement (and/or for related PR and consultation initiatives).
- Updated resource statement and economic model incorporating all up to date volumes, tonnages and working assumptions.

Examples of phased excavation and restoration designs are shown in Figures 4-9 and 4-10.

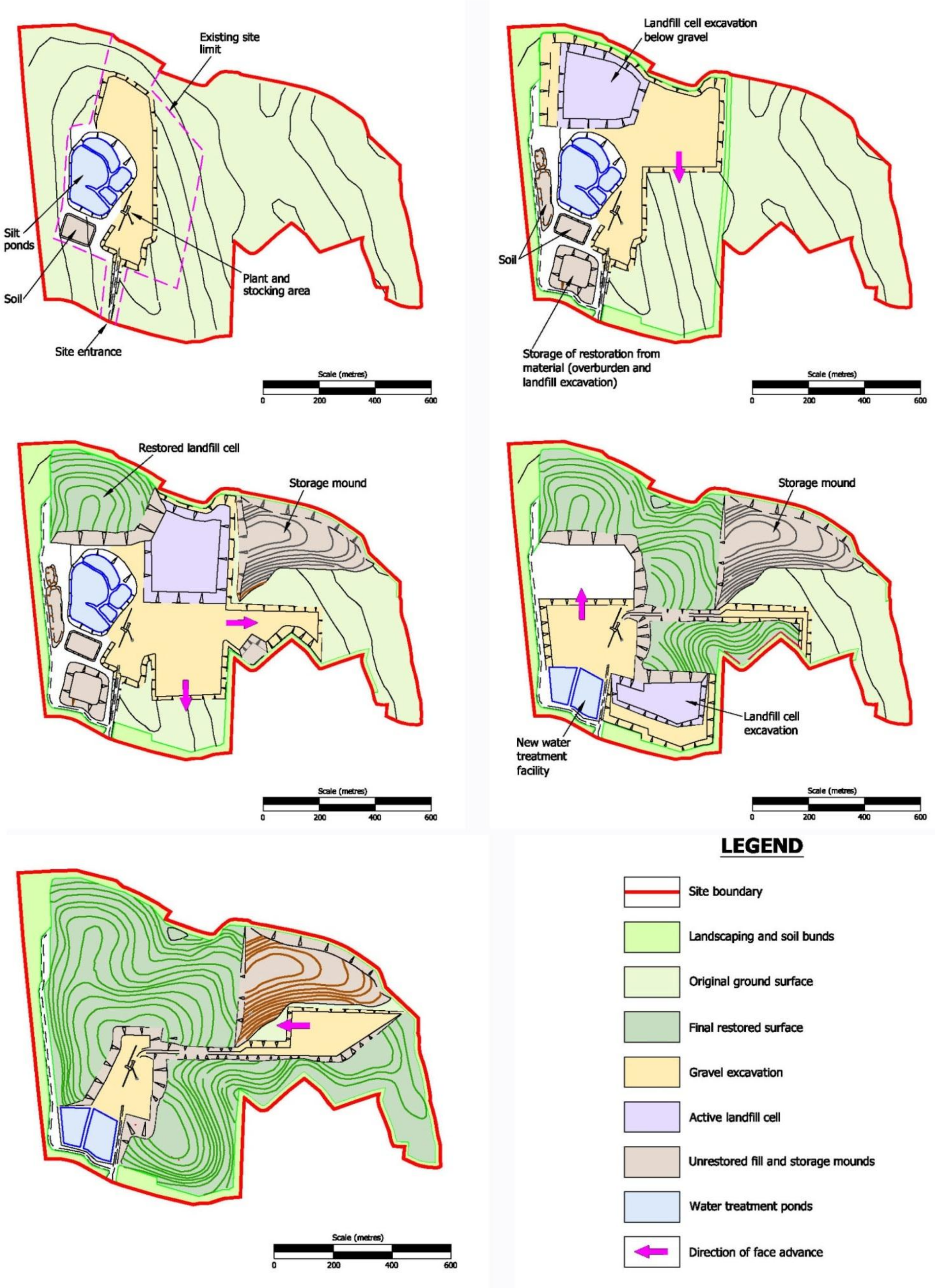


Figure 4-9 Example of phased working and restoration plans for a sand and gravel operation

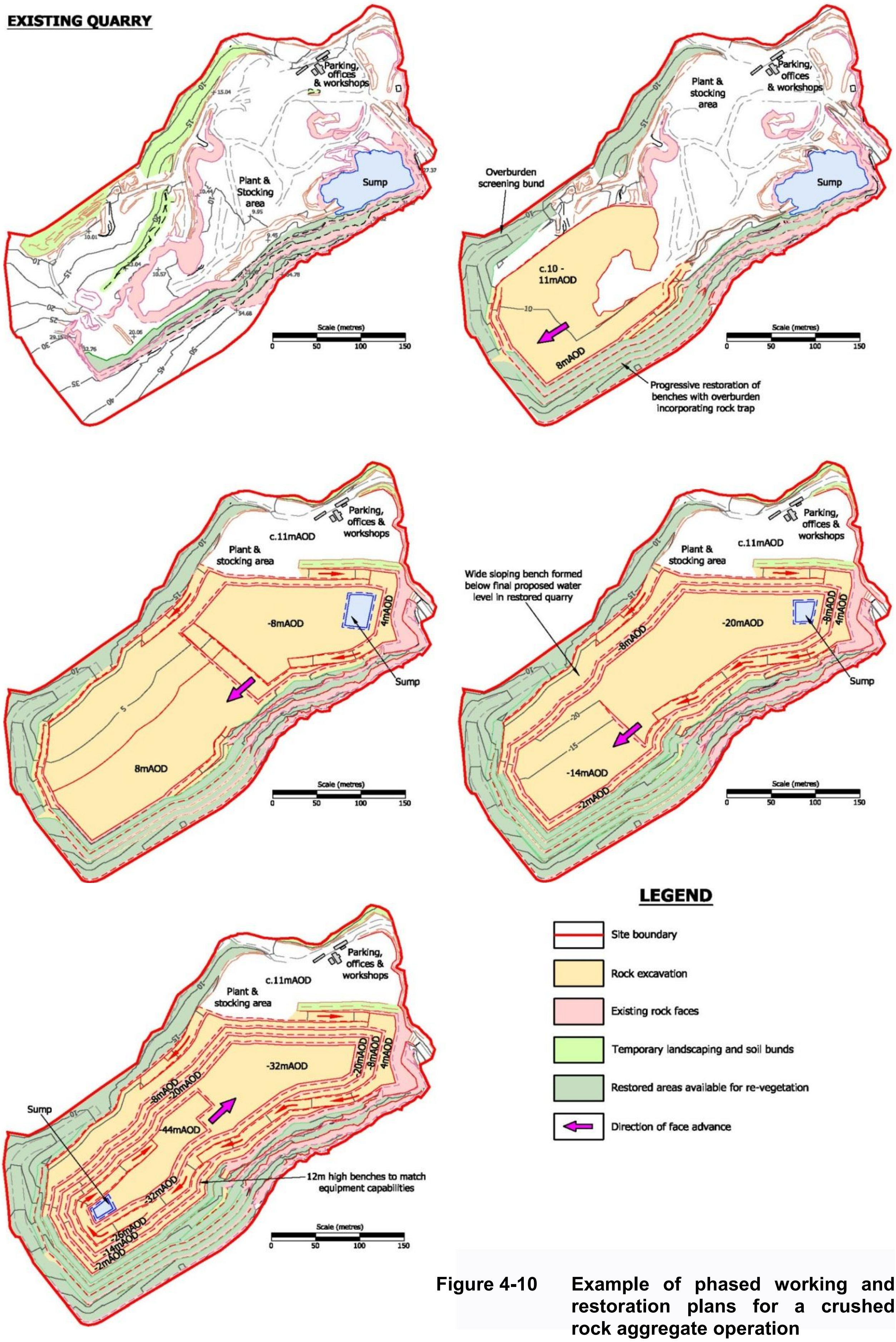


Figure 4-10 **Example of phased working and restoration plans for a crushed rock aggregate operation**

4.6 PRE-PRODUCTION REQUIREMENTS (design phase vi)

4.6.1 Objectives

Once planning permission has been granted, it cannot be implemented until certain preliminary matters are dealt with:

- All relevant permits or licences must be obtained; these may include permits or licences to:
  - discharge water from the site,
  - abstract water from groundwater or surface water bodies for use in processing or dust suppression,
  - move protected species,
  - import landfill if applicable as part of a restoration/rehabilitation scheme.
- All obligations in legal agreements (*e.g.* Section 102 in the UK) and the planning conditions must be complied with, where these relate to actions that have to be taken before operations can commence. These may include submission and approval of schemes of monitoring, details of access or offsite road improvement works, completion of purchase or access arrangements or provision of information.
- In the UK, the notice, documentation and reporting requirements of the Quarries Regulations must be complied with and similar requirements exist in other jurisdictions in relation to health and safety documentation.
- The preliminary site works (*e.g.* erection of plant and offices, construction of access arrangements, initial overburden and soil removal *etc*) must be planned and contracts may need to be drawn up and put out to tender.
- Quarry phase and final excavation/restoration plans may be supplied to the quarry management team at suitable scales and/or 3D models to support the setting out and ongoing working of the site.
- Economic models may be supplied to the quarry management team as a basis for drawing up detailed business plans and implementing management systems.

A good quality quarry design should incorporate or anticipate all of these requirements so that further design work at this stage is, where possible, limited to the abstraction of detail from the application documents (including the ES) and presentation in an appropriate format. There may be additional technical matters to cover, especially if the permitted restoration is to be achieved through importation of landfill that requires a permit – some of the risk assessments required in these circumstances will go beyond what is necessary for an EIA. Similarly, in Europe, there may be specific requirements arising from the Mining Waste Directive, but these will vary from country to country.

4.6.2 Design requirements

Members of the design team may contribute the following at the pre-production stage:

- **Geotechnical assessments and, where indicated, geotechnical appraisals** of the design, and related reporting and/or notifications to relevant authorities for the site health and safety file[2].
- **Design and related risk assessments for any imported waste** that has been permitted for inclusion in the relevant permit or licence application (often obtained from a body other than the Mineral Planning Authority).
- **Design and submission for approval of any details or schemes of working or monitoring** that may be required by the planning conditions.
- **Preparation of bills of quantity and/or working specifications** for work that may be done under contract (*e.g.* soil and/or overburden stripping, construction of lagoons and ditches *etc*).

2 In the UK, Quarries Regulations 1999, especially Regulation 7 and Part VI (Regulations 30-38)

4.6.3 Information requirements

All the information required to deliver the pre-production requirements should exist with the quarry design, either in the planning application/ES itself or in the supporting schedules, models and working papers associated with the design process. Note that not all of this information will be publicly available, especially where it relates to commercially sensitive business planning and procurement matters.

4.6.4 Deliverables

Any and all required documents to support the pre-production requirements. This will always include:

- All documentation required by health and safety authorities to be submitted and/or available at the quarry under relevant regulations (in the UK, the health and safety file required by the Quarries Regulations 1999);
- Applications for permits and licences; and
- Details required to be submitted to the MPA and others under the planning conditions.

The pre-production documentation to which the design team may contribute may also include:

- Contract documents for preliminary or ongoing works that will be put out to contract
- Operational and business planning and monitoring documents

Supporting materials in Part IV relevant to this chapter

Appendix 4-1 Resource evaluation for aggregates

Appendix 4-2 Principles of design in sand and gravel quarries

Appendix 4-3 Principles of design in quarries producing crushed rock aggregate

Appendix 4-4 Slope design

Appendix 4-5 Haulage method selection and design of haul routes

Appendix 4-6 Economic modelling for feasibility studies and business planning

CHAPTER 5
INFORMATION REQUIREMENTS AND INVESTIGATIONS TO SUPPORT DESIGN OF THE OPERATION

INTRODUCTION

This chapter describes the information required to support the quarry design, and summarises the types of investigations that may need to be undertaken to collect that information. The topics covered in this chapter have been selected as those that can have the most significant impact on the geometry and limits of quarries; they do not represent a comprehensive list of all of the topics that are considered as part of environmental assessment.

After an initial section on establishing the design brief, key elements of information/investigation that significantly influence quarry design are then presented for each topic in a common format:

- **Why** is the information/investigation required?
- **What** is required to be done/collected and **How** will this be achieved?
- **Who** is responsible for this category of information/investigation?
- **Input into the design process**, covering the importance of the information to:
  - Design of the operation and environmental assessment
  - Safety
  - Costs and benefits

Throughout this chapter (and in Chapter 4) we refer to the 'Design Team' as the group of people responsible for designing the whole operation. This team may be entirely in-house, comprised of consultants or, most commonly, a combination of in-house and consultant personnel. The selection of such teams and their management is covered in Chapter 8 (Part III). The 'Developer' is the person or company seeking to establish (or extend) a quarry at the selected site.

Chapter 5 is not intended to be a technical manual on information gathering and investigation techniques; these will only be effective if planned, supervised and undertaken by personnel suitably qualified and experienced to do so. Instead it provides an overview of what is typically required, why, and how it is used, with a brief summary only of methods. The authors hope that it will provide a useful source of reference for Developers establishing design briefs for consultants and in-house specialists when planning and co-ordinating a quarry design project. It should also provide helpful context for specialist practitioners so they can appreciate how their contribution fits into the overall, interdisciplinary, process.

Sources of further information on methods and best practice standards are included in the bibliography in Part V of the Handbook. Readers may also find the materials available at www.sustainableaggregates.com (particularly those referred to at the end of the Foreword to this Handbook) helpful for more detailed description and guidance on information requirements for quarry design and related environmental assessment.

5.1 INFORMATION TO SUPPORT ESTABLISHMENT OF THE DESIGN BRIEF

As discussed in the introduction to Part II, and in the Foreword, the primary objectives of good quarry design are the safe, efficient and profitable extraction of the maximum usable material from the minimum area of land while causing the minimum environmental disturbance and resulting in beneficial final restoration and land uses. The first of the detailed design phases described in Chapter 4 is "Establishment of the design brief".

In addition to the primary information described in Chapter 2, the initial design brief following site selection will need to take account of:

- **Proposed production rate and range of products.** What is the proposed production rate for the new development? Is it anticipated to change over the operating period and if yes, to what and why?
- **Required minimum reserve life.** A minimum reserve life may be required, for example, to justify new capital expenditure on plant?
- **Proposed markets and products.** Does the company see the markets and products changing? Are there any new market objectives that have been identified?

- **Proposed excavation method.** Current method, plant type and number of units. Bench heights, current site practices and problems. Proposed changes if any.
- **Haulage.** Existing and proposed arrangements. Plant type, model and number.
- **Proposed processing plant.** Details of type, model and specification (products produced and in what proportions?)
- **Water usage.** Processing water requirements and potential sources.
- Information and plans concerning the **location of underground and overhead services**.
- Plans showing current ownership boundaries, lease boundaries etc.
- Previous planning applications and copies of any reasons for refusal/existing planning conditions.
- All site investigation information, boreholes and monitoring locations for the site.

Where an extension is being planned, it is helpful to have all of the above information for the current operation, and to know whether (and how) conditions in the extension are expected to vary. Documents that may also exist for current operations that are to be extended include:

i. Existing operational health and safety documentation. In the UK, this would comprise the hazard appraisals and geotechnical reports (Reg. 32 and 33, Quarries Regulations 1999, and any reports prepared under superseded regulations).
ii. Site surveys including historical paper copies if available as well as 3D digital terrain models.
iii. All site investigation information, boreholes and monitoring locations for the existing site.
iv. All design reports and drawings relevant to the existing site and current planning permissions.
v. Discharge and abstraction licences.
vi. Previous resource reports, sampling and analysis.
vii. Blast Monitoring reports.
viii. Prohibition notices, stop notices past and present and relevant correspondence with the safety regulator.

Much of the information listed in i. to viii. above would normally be gathered together and included in the “Quarry Health and Safety Document” required to be maintained under the UK Quarries Regulations.

5.2 SITE PLAN

Why?

Accurate base map information at appropriate scales is fundamental to all stages of the quarry design process and Environmental Impact Assessment (EIA). Moreover, the availability of good quality mapping at the design stage provides huge benefits during the development of the site in allowing progress against the permitted development to be monitored, volumes to be accurately measured and planning boundaries and services to be safeguarded. Subsequent management of the survey information and update surveys (required under the UK Quarries Regulations 1999) is critical to making full use of the survey information as a resource in the production phase.

What & How?

Creation of base plan information, which can be used flexibly at different scales for displaying a diversity of information sets, usually requires compilation of information supplied in different digital and non-digital formats. These may include historical paper surveys and ownership plans, digital 3D surveys, 2D National Survey[1] base maps and aerial photography. Modern computer technology allows the merging of data from a variety of sources into a single model of the land surface of the site and the surrounding area, and many National Surveys now produce information in digital formats. The information should extend far enough to cover sensitive locations beyond the site boundary. It is unusual today for production of drawings for mineral planning applications to be completed without the use of computer drawing software and the use of digital data has become the norm. Production of the base map may be divided into three processes;

[1] Ordnance Survey in the UK

- Desk study – compilation of available 2D base maps (including recent and historic Ordnance survey sheets), aerial photography, commercial 3D data, previous 2D and 3D site information, service plans, planning and ownership boundaries.
- 3D ground survey of the current site including all relevant features. The special requirements of the design team and the MPA may include identification of disturbed areas, water levels, springs, public roads, bund levels, nearby residential buildings, ditches, inlet structures, footpaths, trees and tree canopies, geological and geotechnical features. Close co-operation between the surveyors and the design team is desirable. It is imperative that the survey is supplied in 3D digital format for ease of transmission between team members. 2D surveys, whether supplied on paper or digitally, are always false economy.
- Compilation of all relevant information into an easily accessible format on a common National Grid system with levels relative to a recognised national datum[2], for distribution to the design team.

Who?

The desk study is generally carried out by members of the design team. The most critical element of the base plan is the survey of the existing site, which should be carried out by an experienced survey team.

The importance of obtaining a good quality ground survey at an early stage in the design process cannot be over emphasised. A comprehensive survey, carried out by surveyors who are experienced in mineral operations, may present the owner or developer with a relatively high up-front cost. However it will invariably prove cost effective in the longer term by avoiding repeat site visits, missing or ambiguous information, and by providing reliable data on which to base the subsequent design and planning application. The owner/operator or their consultants should be rigorous in the specification of the survey and always with a view to the specialist requirements of different team members. Ideally the survey will be specified by members of the design team, although in practice the whole design team may not be in place this at this stage of the project.

Input into the design process

Design of the operation and its restoration, and environmental assessment

All the elements of the design process and environmental assessment will have requirements from the base plan.

- It will provide a common base location plan for all further site investigations.
- The 3D surface information is needed to create a geological model of the site including surface expression of the geology.
- A 3D representation of the ground surface and accurate positioning of boundaries etc is necessary for effective 3D modelling of the proposed development layout and ensuring sufficient space is available for all elements of the proposal including roads, plant, stocking areas, landscaping, water treatment and drainage arrangements.
- A good 3D representation of the ground surface is necessary for reliable measurement of excavation and fill volumes.
- Landscape assessment and visual impact is based on an analysis of the existing ground surface and generally will require details of surface features, topography and development some distance from the site boundaries.
- The MPA will require details of topography, properties, drainage, roads etc beyond the site boundary to be shown on development plans.
- Computer generated visualisation of the development is frequently used to show the effect on landscape for display to the public and planners.
- Noise, dust, traffic and transport, surface water and ecology assessments use base information for baseline studies, impact assessments and design of monitoring schemes.

2 In the UK, Ordnance Datum (mean sea level at Newlyn

- Surveys of existing drainage systems, including inlet structures, ditches and culverts, sometimes extending outside the site boundary, are usually required for design of the surface water management scheme.
- Ground water studies generally extend beyond the site boundaries and spring and well locations, catchment characteristics, source protection zones *etc* to be superimposed onto 3D base information.

Safety

The quarry survey provides a starting point for subsequent survey updates and will form a vital basis for the operational risk assessment described in Chapter 5, as well as later compliance with the inspection and reporting requirements required under health and safety regulations[3]. The quality of the survey also has implications for safety during quarry operations including:

- The accurate positioning of services.
- The accurate representation of slopes and face positions.
- The accurate positioning of hazards including old lagoons, mine workings, tips, shafts *etc* or ability to flag up areas where these may be present on the site plan.

Costs and benefits

Costs

Initial data collection, site survey and processing can represent a substantial cost, but it should not be avoided as this basic information is the foundation for the whole process. For a major development, which has the potential to affect a wide geographical area, or is perceived as a controversial development, it may be appropriate to obtain an extensive DTM (digital terrain model) extending well outside the site boundary and/or air photography, which may cost several thousand pounds, especially if LiDAR is used. Increasingly, high quality aerial surveys and associated air photography is being acquired using remotely controlled 'drone' air platforms and this is bringing the cost down for larger surveys, especially in remote or inaccessible areas.

The cost of the site survey will depend on the size and complexity of the site, the effective management of the survey, and its specification. Open greenfield sites are quickly and efficiently surveyed by GPS techniques. Where there are existing quarry faces, or extensive areas of woodland, or existing structures, or specialist requirements such as geotechnical surveys, the survey may take considerably longer and require different equipment including targetless laser equipment. It may also be necessary for the surveyor to be accompanied by a geologist or other specialist to ensure that the correct information is collected.

Benefits

- A good digital 3D base plan with relevant 2D overlays such as planning and ownership boundaries, residential properties, transport infrastucture etc, allows efficient production of application documents using shared base information among the design team.
- Accurate ground surface information made available early in the design process should prevent unnecessary and costly revisions of work which occur when partial information, for example 5m contours based on OS 1:25,000 mapping, is used for initial design work.

5.3 GEOLOGY

Why?

A good understanding of the geology and geotechnical setting of the site and the characteristics of the material types is the starting point, alongside an up to date and accurate site survey, for a safe, commercially viable and environmentally acceptable quarry design. In addition to being fundamental

[3] Geotechnical Appraisals and Assessments and Regulation 33 reporting under the UK Quarries Regulations 1999

to determining the quality and quantity of resources and reserves, the geological model (geology and structure) controls, to a greater or lesser extent, key aspects of the project including:

- site selection;
- definition of excavation boundaries and void geometry;
- the amount of waste that will be produced;
- restoration/rehabilitation that might be appropriate or practical;
- plant selection;
- geotechnical settings;
- working method; and
- economic potential.

What & How?

Desk Study

The first part of any geological investigation is a comprehensive desk study and review of existing information. The aim is to establish a provisional geological interpretation for the site as a basis for the design of a site investigation, sampling and testing programme appropriate to the material types and geological setting of the site, the nature of the potential mineral operation and its environmental impacts.

The principal sources of background geological information are:

- Geological maps, digital models, memoirs and other publications[4].
- Previous investigations – including borehole databases held by the National Geological Survey (BGS in the UK), company documents and previous planning applications relating to the site.
- Records of past mining and quarrying history.
- Published books and academic papers relevant to the site and material types
- Information on geodiversity information (*e.g.* Local Geodiversity Action Plans – LGAP in the UK).

Design and notification of site Investigation

Following the desk study, a provisional model of the geological and hydrogeological setting of the site may be constructed based on available information. Time and expense taken on the desk study will help to target the site investigation and ensure that un-necessary work is avoided, and that all information required for design is collected. For example, in a limestone sequence, it may be known from the geological survey sheet or memoir that a confined aquifer may lie beneath a clay horizon below the site. This may have an impact on the working depth in the proposed development and its presence should be verified and its thickness and geometry should be investigated by borehole investigations. The drilling programme can then be efficiently designed to reach the target depths. In superficial deposits, areas of thick overburden or absence of the mineral may be inferred from the provisional geological model (created during the desk study). The borehole or trial pit investigation may then be planned intelligently to prove the margins of workable mineral. The geological model should be continually revised as the site investigation progresses, and the design of the investigation refined.

Those undertaking borehole investigations are normally required to notify the relevant Statutory Authorities of proposed exploration drilling, and in some jurisdictions, exploration permits are required for all exploration, whereas in others construction materials are excluded from this requirement.

[4] In the UK, this type of information is available from the British Geological Survey (BGS) and the Geological Survey of Northern Ireland (GSNI). In the Republic of Ireland, it is obtained from the Geological Survey of Ireland (GSI)

Investigation

a) **Geological, hydrogeological and geotechnical site investigations, sampling and testing.** Supervision by a suitably qualified geologist will allow the geological model to be developed and for the design of the investigation to be amended as appropriate as it proceeds. Typically, a geological or geotechnical investigation would be carried out in phases, with the results of early phases used to refine the model and identify gaps to be filled. Effective sampling for material quality and geotechnical testing depends on a good understanding of the nature and potential variability of the material recovered and the selection of an appropriate investigation method. Sample recovery can be greatly increased in difficult ground by employing experienced drill operators.

b) **Analysis.** Using the information arising from site investigations, the results of geotechnical and other material testing, and monitoring (especially of groundwater), a geological model and a preliminary hydrogeological model can be produced and used as a basis for identifying geotechnical settings and determining slope design parameters and 'design rules' to be applied to design of the quarry excavations and associated structures. In circumstances where material quality is variable and selective extraction may be required or workings arranged to optimise material quality, relevant aspects of material quality may need to be modelled, either by attributing material characteristics to particular rock types or by creating block models that will allow quality and quantity release schedules to be prepared.

Reporting to support quarry design

Comprehensive factual and interpretative geological reports and resource assessments following best practice guidelines (or laws/regulations) for such reports should be prepared to support the quarry design process. These documents should include the results of the geological desk study, all raw data, borehole and trial pit logs, location plans, testing schedules and test results and should form part of the site documentation. Information may then be extracted for inclusion in the planning application supporting statement. The minimum information normally necessary for supporting an application for a planning permission (and sometimes required under national or regional legislation) is:

- A survey plan showing all borehole, trial pit and sampling locations, and other relevant information.
- General geological setting and stratigraphic sequence.
- Summary schedule of boreholes and trial pits, including records of core recovery, sampling methods, piezometer installation, groundwater and final treatment.
- Structural contour and isopachyte plans and cross sections *etc* illustrating the geological and geotechnical interpretation.
- Sample quality, testing methods.
- Discussion of the adequacy of data, reliability of geological interpretation and quality of information.

In some circumstances, where quarry design is being undertaken as part of a wider feasibility study, and a report is to be written for the purpose of raising finance, informing investors, or for public disclosure of resource and reserve information for a company quoted on an international stock exchange, reports should be prepared in accordance with the guidance and requirements of one of the CRIRSCO family of reporting codes and standards[5]. Even where this is not strictly necessary, it is prudent to ensure that the classification of resources and reserves is consistent with this widely accepted international standard so that the information in the reports may be relied upon in making future public disclosures. In Europe, the appropriate CRIRSCO standard is that produced and maintained by PERC[6] (see Appendix 4-6 for more information on codes and standards for reserves and resources reporting).

Who?

Specification, reporting and interpretation of geological site investigations and associated resource or reserve estimates should be carried out by a suitably qualified and experienced geologist.

[5] Committee for Mineral Reserves International Reporting Standards - www.CRIRSCO.com
[6] Pan European Reserves and Resources Reporting Committee – www.percstandard.eu

Geotechnical investigations are specialist and should be designed and overseen by a geotechnical specialist. The selection of a geotechnical specialist can be fundamental both to the design of the quarry and the long term performance of the design, especially if the geological and geotechnical settings are complex. The minimum qualifications for a person acting as a geotechnical specialist ('competent person') for reporting in accordance with the UK Quarries Regulations are a professional title of CEng or CGeol, and at least 5 years of relevant experience. The level of experience and expertise required in any particular setting will vary according to its complexity. In some settings, geotechnics and slope design is a relatively straightforward matter and does not represent a major constraint or driver for quarry design – 5 years of experience may be sufficient in these circumstances. In more complicated settings, the collection and analysis of data may require highly specialised skills. The geotechnical expert chosen should therefore have a proven track record of successful design and experience in similar geotechnical conditions.

If resource information is to be used in public documents, using a CRIRSCO code or standard, the reports that are to be disclosed must be prepared and signed by a 'Competent Person' (Qualified Person in Canada). A Competent Person is defined, in the PERC Standard (Clause 10) as:

> *"a minerals industry professional, defined as a corporate member, registrant or licensee of a recognised professional body (including mutually recognised international professional organisations) with enforceable disciplinary processes including the powers to suspend or expel a member.*
>
> *A Competent Person must have a minimum of five years relevant experience in the style of mineralisation or type of deposit under consideration and in the activity which that person is undertaking. Acceptable professional bodies and classes of membership under the Standard, which meet these requirements, within Europe or elsewhere (an 'RPO') are listed in Appendix 5 or in updated lists which may be published from time to time.*
>
> *This definition of 'Competent Person' is subject to any additional restrictions or conditions which may be required by the appropriate stock exchange or regulatory authority".*

The recognised international professional organisations in Europe and minimum classes of membership/professional qualifications required are as follows:

Geological Society of London	CGeol, CSci
Institute of Materials, Minerals and Mining	MIMMM
Member associations of the European Federation of Geologists (EFG)	EurGeol
Institute of Geologists of Ireland	PGeo

In some jurisdictions, it is necessary for a geologist or other professional signing or taking responsibility for technical reports concerning site investigations, quarry design, and resource/reserve evaluation to be licensed or registered in that jurisdiction.

Input into the design process

Design of the operation and its restoration and environmental assessment

The geological model for a site is relevant to a range of design elements and environmental assessment topics including:

- The geological model and geotechnical design parameters, together with the base plan, are the fundamental tools necessary for the first phase of the design of the quarry void and measurement of quantities of excavated mineral and waste materials.
- The geological interpretation forms the base model for groundwater studies and the design of groundwater investigations and monitoring and management schemes.
- Blast design (and associated predictions of ground vibration and air overpressure to be experienced at any receptor) is influenced by the strength of the rock being blasted and the

characteristics of the rock mass. The propagation of ground vibration to receptors is also influenced by the characteristics of the rock mass.

Safety

Poor site investigation and poor understanding of the results may lead to the use of erroneous information or unsound interpretation of data. The consequences of using such data in the design of slopes, in terms of the safety and quarry operations may be severe.

Costs and benefits

Costs

Geological and geotechnical investigations together with hydrogeological investigations, which may take place at the same time, represent a significant financial investment in the early stage of a quarry design project. The costs of site investigations and reporting of the results are related to the complexity of the geology and are generally carried out in one, two or even three phases. The financial risks resulting from a poor understanding of the geology should be considered by the Developer before rejecting what may appear to be expensive later stage site investigations designed to reduce the risks associated with geological (or geotechnical) uncertainty.

Benefits

- Comprehensive investigations will minimise the occurrence of unexpected variations in the geology which can lead, for example, to an underestimate of the amount of waste, unpredicted geotechnical conditions leading to failures or a need to redesign slopes, or an unanticipated change in the quality of the products that can be produced from the quarry. Loss of reserve for these reasons during the production phase of the development leads to a reduced life expectancy of the site, with direct financial consequences for the operating company.
- Efficient, safe and cost effective slope design and avoidance of conservative ‘over design’ where appropriate requires a good control on the geotechnical setting and material properties.
- Reliable and defensible information is needed to support good quality planning applications and environmental assessments and may influence the acceptance of the application.
- Poor slope design resulting from lack of understanding of the geotechnical setting may result in slope failure or risk of failure leading to loss of reserves or increased production costs.

5.4 SURFACE WATER

Why?

Quarrying on any scale will change the surface water regime in and around the site during production and after closure and restoration. Effective management of surface water in and around quarries (to prevent adverse impacts on water quality or increases in flood risk) is a key element of the design process and is beneficial to the operator in two principal areas:

i. To ensure compliance with planning and licence conditions directed to controlling environmental impact and risk to the public and property during the operating stage and after closure and restoration.

ii. To minimise the potential for surface water to adversely effect normal quarry operations, either directly or indirectly through the need to suspend operations so health and safety requirements are respected.

Design of surface water management in quarries, from routing in ditches, to storage, treatment and discharge, is often far from rigorous, however the consequences of poor provision can extend beyond the site itself and the implications for safety, the environment and the financial interests of the operator may be severe.

Within site	Outside Site
Hazards	
• Erosion of excavated or fill slopes • Failure of tips and fill slopes • Rock slope instability • Pollution of groundwater by fuel *etc*. • Flooding of pit floor or other working areas • Overflow of lagoons and sumps • Erosion and derogation of haul roads	• Flooding • Ground erosion • Pollution of watercourses • Reduction (or increase) in flow in streams and ditches • Pollution of groundwater by fuel, suspended solids*etc*.
Risks	
Health and safety	
• Accidents – in particular on haul roads, and lagoons and sumps, slope failures • Poorly maintained, eroded roads lead to increased injury to drivers (and higher maintenance costs).	
Environmental	
	• Changes in flow may affect ecological balance, fishing, licensed abstractions *etc* • Suspended sediment affects quality of water in watercourses.
Financial	
• Interruptions to site operations and production • Expensive remedial works • Damage to reputation of company with possible implications for future applications	• Permitted discharge levels exceeded may lead to stop notice and prosecution by Environment Agency. • Property damage leading to compensation claims

All these risks may be minimised through careful design and good maintenance of the surface water management system. Imaginative restoration designs to realise the potential of quarry sites for increasing biodiversity are frequently planned around surface water bodies, and there is also potential for quarry voids to contribute to rural (especially upland) flood storage as part of catchment management.

What & How?

Background desk study

The required background information for baseline reporting relating to surface water includes:

- Plan of the site and surrounding areas showing topography (incorporating a detailed site survey if available);
- Identification of watercourses, standing water bodies, springs, catchment areas;
- Details of surface water abstractions and discharge licences;
- Use of water – on site (processing) and off site e.g. fishing, irrigation etc;
- Rainfall and evaporation data (Met Office);
- Historical records of flooding, water levels;
- Existing monitoring records on active sites;
- Identification of ecologically sensitive areas (LBAP);
- Early consultation with the EA, MPA and conservation organisations.

Site Investigations

- Site walkover and identification of water bodies, springs, ditches, drainage paths, culverts and other significant structures, ecologically sensitive areas, distribution of vegetation, agricultural land and other surface types.
- Baseline monitoring – selection and specification of monitoring which may include flow rates, water chemistry and temperature, rainfall. Monitoring over a year to include periods of anticipated high and low flow rates. If flow rates are will needed then stream cross-sections will also need to be measured.
- Stream/ditch/culvert survey – to establish the cross-sections, capacities and condition of the receiving system downstream from the site
- Existing water management in active or closed sites – including condition and maintenance of silt ponds and drainage ditches, discharge and monitoring records.

Analysis and consultations

The surface water baseline report and recording of baseline information and methodology should establish:

- Interactions between surface water, groundwater and ecology
- Sensitivity of receiving water courses to additional / reduced flows
- Importance of groundwater v surface water in baseline flow

Who?

Specification of baseline investigations and the design of surface water management and monitoring schemes should be overseen by an experienced engineer or hydrologist who is a core member of the design team. It is particularly important to co-ordinate ecological, groundwater and surface water investigations. A full hydrological year (October to September) of observations and monitoring is generally needed to define the baseline conditions adequately.

Input into the design process

Design of the operation and its restoration and environmental assessment

The baseline data are used as the basis for predicting the effect of the quarrying and associated activities on the surface water flow. This in turn will determine what measures are required to mitigate the impacts on water quality and quantity discharged from the site.

There are four parts to the water management system of an active site:

i. Surface drainage on site – ditches, culverts, french drains etc.

ii. Water storage – including sumps and attenuation ponds

iii. Water treatment – settlement ponds, oil interceptors, cyclones

iv. Discharge – soakaway design, discharge structures and remedial works required downstream of discharge point.

Some of the baseline data will allow analysis of the water balance in the restoration scheme. This is vital to ensure sustainability of open water bodies, wetland etc in the scheme and ensure no longterm adverse effects e.g. flooding, from the development.

Identification of opportunities for long term additional benefits to the local community or environment, such as solutions to existing flooding through improved drainage or attenuation capacity outside the site.

Safety

Appreciation of the space requirements for water treatment structures (including silt lagoons) is an often overlooked element at both the conceptual and detailed design stage, but can have serious implication for safety and production if insufficient consideration is given to design and maintenance. An underestimate of the amount of space needed for silt ponds may lead to the need for raising of lagoon embankments to increase capacity – if not properly designed these could be unstable with serious consequences in the event of failure and escape of lagoon contents.

Lack of an effective water management system may lead to flooding of critical areas of the site and development of poor and sometimes unsafe working conditions.

Attenuation ponds, sumps and other components of the surface water drainage system should be located in such a way, and surrounded by protective bunds, to minimise risks to mobile plant operators, other vehicles and pedestrians.

Silt settlement ponds can be particularly hazardous if not correctly designed and maintained. Design should always have the safety of mobile plant operators and other workers as a priority and aim to minimise the risk at all stages of the design process.

Poor drainage management of benches and at the crest of faces may lead to erosion of faces, instability and hazardous conditions.

Costs and benefits

- Effective surface water management is required under environmental legislation to meet discharge targets for water quality. Significant financial penalties are generally incurred for breaches.
- A good understanding of the surface water regime is needed for the design of effective drainage measures and assessing pumping requirements and attenuation capacities during and after extreme rainfall events. Failure to do so may result in stoppages or access problems due to incapacity of drainage system to cope and consequent flooding.

5.5 GROUNDWATER

Why?

Hydrogeology relates to groundwater. A good understanding of the hydrogeological regime within and surrounding a quarry is necessary for a viable quarry design, both commercially and environmentally. Within the quarry hydrogeology can control or restrict the final base of working and the method of working. Outside the site, the quarry may impact local groundwater flow directions and levels as well as groundwater quality. This may consequently influence the abstraction of groundwater downstream of the site and the supply of water for vulnerable ecosystems sustained by ground waters. The hydrogeology of a site and local area is closely linked to the geology, and to the surface water surface water system. Therefore, desk studies and site investigations for geological and hydrogeological purposes should, where possible, be designed and conducted together.

What & How?

Desk study.

A comprehensive desk study should be conducted to understand the local groundwater setting, including identification of the range of rock types and whether they are aquifers, groundwater flow directions, quality of groundwater, groundwater levels, vulnerable eco-systems, groundwater abstractions *etc.* This information should then help to conceptualise the hydrogeological regime and design the site investigation. Sources of information include:

- Topographic plan at a scale of at least 1:25,000 of the site and surrounding area and identification from the plans of local wells, springs etc.
- Maps, memoirs and borehole records published or made available through the national geological survey (BGS in the UK).

- Hydrogeological maps and other publications that may be available from the national geological survey, or technical/scientific journals and books, providing information on the physical properties of major and minor aquifers in the relevant jurisdiction.
- Information on policy and regulations for the protection of groundwaters.
- Groundwater level and groundwater quality data from the municipal, regional/sub-regional or national environmental authorities.
- Details of local source protection zones and water bodies potentially at risk.
- Public registers of licensed and unlicensed groundwater abstractions (domestic, industrial and public water supply abstraction wells).
- Information on sensitive sites or sites with environmental designations which may be impacted by changes in the water balance.
- Reports of previous site investigations for geological information, groundwater monitoring installations etc. and any existing monitoring information from the proposed site or surrounding area.

Baseline investigations

Baseline investigations will normally include some or all of the following:

- Hydrogeological site investigation, testing and sampling with supervision from a suitably qualified hydrogeologist or geologist experienced in hydrogeological investigations, as the geology intercepted will influence how the investigation proceeds. The site investigation should be planned and undertaken to collect all pertinent hydrogeological features of the strata, including: thickness of the unit, the presence for example of clays within sands or fissures or karstic structures in limestone, water strike levels, rest water level, artesian flow etc.
- Sampling of hard strata when appropriate for review and/or permeability testing and sampling of sand and gravel for particle size analysis.
- Early stage site investigations may include falling head tests being conducted on different geological units to establish the permeability of relevant units.
- Piezometers should be installed to allow the monitoring of the groundwater level and quality.
- Baseline monitoring of the groundwater levels and groundwater quality should be carried out at regular intervals for a period of at least one year to gauge seasonal variability.
- At all stages of the site investigation, all applicable codes of practice and regulations should be adhered to.

Conceptual modelling

- A conceptual hydrogeological model of the area should be constructed to define the groundwater flow direction, typical groundwater level, permeability and other hydrogeological properties of the relevant geological units, areas and volumes for recharge groundwaters and discharges of groundwaters. This should identify any impact of groundwaters on the proposed quarry design and workings and any impact the quarry may have on groundwaters and related abstractions or ecosytems.
- Throughout the modelling of the hydrogeological regime, consultations with the surface water hydrologist and ecologist should take place to further refine the model.
- If a quarry is to be worked below the water table (either wet or following dewatering), consultation with geotechnical engineers will be essential to ensure that the base of the excavation and quarry faces are designed to take account of water pressures and changes to water pressures that may arise from dewatering and/or flooding following completion of excavation.
- After about one year of collecting groundwater level and groundwater quality data, this information should be added to the baseline hydrogeological model.

Further site investigations

Additional site investigations may be required at a later stage including, for example, pumping tests to determine the impacts on the surrounding area if a quarry were to consider dewatering.

Who?

Specification, supervision and factual reporting of the hydrogeological site investigations and desk study should be carried out by a suitably qualified hydrogeologist or suitable qualified geologist with experience in hydrogeological investigations. Modelling of a hydrogeological regime is specialist and should be carried out by a suitably qualified hydrogeologist who is experienced in hydrogeological issues relating to mineral extraction.

Input into the design process

Design of the operation and its restoration and environmental assessment

- Groundwater levels are necessary in some cases for the design of the excavation floor level and the determination of the method of working.
- Determination of the un-saturated zone, saturated zone, groundwater flow paths and receptors of groundwaters downstream of the quarry will influence the potential environmental impact of the quarry.
- The desk study and investigations shall determine the ability to source groundwaters, locally for processing needs.

Safety

- Poor understanding of the groundwater regime may lead to saturation and erosion of faces, instability and potentially slope failure.
- Poor understanding and interpretation of groundwater data may impact on the quarry design. Unsuitable quarry and slope designs may provide un-safe working conditions, the consequences of which could be severe.

Costs and benefits

Costs

- Preliminary hydrogeological site investigations are normally undertaken at the same time as geological site investigations at minimal or no additional cost. Piezometer installations are relatively low cost and, if positioned carefully outside the eventual limits of extraction and maintained, will provide important and necessary groundwater level and quality information for baseline monitoring before works commence, for the life of the operation, and after restoration.
- If required, pumping tests are typically expensive, but in settings where there are receptors that are particularly sensitive to groundwater flow or level changes beyond the site boundary, they are a necessity for determining reliable hydrogeological parameters for predictive modelling of groundwater flow patterns during and following the operational phase.

Benefits

- Reliable and defensible information is needed to support good quality planning applications and environmental assessments and may influence the acceptance of the application.
- A robust understanding of the hydrogeological regime will identify any locally sensitive sites and as such measures to mitigate any impacts from the quarry can be designed. Failure to understand the regime which may lead to environmental damage as a direct result of quarry workings may cause stop notices to be issued or even prosecution.
- Poor understanding of groundwater levels and seasonal variations in them may result in the loss of reserves, potentially cause slope failures and impede the chosen method of working.

5.6 LANDSCAPE AND VISUAL

Why?

Quarries (active, dormant or restored) are part of the landscape; they also sit within the wider landscape contributing to or detracting from it. Landscape is considerably more than just the visual perception of a combination of landform, vegetation and land uses. It embodies the history, culture, geology, wildlife etc in addition and is dynamic. Different people may evaluate, experience and value the same landscape differently. Landscape and visual assessments are a mixture of objective and subjective analysis. Objective baseline data is, therefore, of prime importance.

What & How

The landscape architect is one of the key professionals whose input is required from the beginning of the project. Such input may include:

- landscape and visual assessments;
- site selection on a national, regional, county or local scale;
- definition of quarry boundaries, internal configurations and directions of working;
- soil, overburden and quarry waste handling and placement;
- location and design of plant, structures and access/haul roads;
- protection/avoidance of retained landscape features;
- phasing;
- mitigation measures;
- progressive restoration;
- afteruse;
- aftercare maintenance/management.

Background desk study

The background desk study should cover the following topics:

- Plans of the site (or site search area) and surrounds with topography and drainage (with detailed site survey if available). This information is ideally available digitally as 3 dimensional digital terrain models;
- Vertical aerial photographs of the site and area ;
- Plans, descriptions and definitions of all relevant planning and environmental designations (these may include nationally or regionally protected areas, areas zoned for built development, recreational areas, sites of cultural and archaeological significance, recreational areas *etc*);
- All Rights of Way;
- All easements and restrictions created by pipelines, power lines, utilities etc.
- Any plans or GIS layers detailing landscape character covering the site and the surrounding area;
- The geology, soils and agricultural classification;
- Ownership, control and management boundaries;
- Transport network and access points;
- All buildings, villages and urban areas.

Site visits and investigations

Following the background desk study, an area is defined which encompasses or would encompass all landscape and visual impacts irrespective of the detailed quarry design/direction of workings/access points *etc*. This Study Area is typically 10km x 10km but this varies principally as a consequence of landform and intervisibility.

Within the study area, Theoretical Zone of Visual Influence (ZVI) studies are executed (visually by computer) to establish a worst-case scenario depicting the locations from which any part of the site may be seen (without mitigation). If structures or plant are proposed or likely to be proposed, the initial ZVI study is executed to take these into account, if necessary positioned in a variety of places if there is doubt about where they may ultimately be placed in the final design

Any areas within the Study Area but identified as outside of the ZVI study results cannot have sight of any proposed quarry/plant irrespective of design and internal location – later stages of investigation concentrate only on the areas within the Study Area from which the site will be visible.

Once the ZVI studies are complete, the Study Area is visited and photographs are taken to confirm, record and assess the baseline with regard to:

- Landscape.
- Intervisibility.

a) Landscape

The landscape is described by way of landform, land cover, land use elements, designated features/areas and historical/cultural association. Some of these descriptions may already be available as part of published or publicly available baseline information (*e.g.* Landscape Character Area information available in many counties of the UK). In particular, the site visit aims to establish the distribution, value, rarity, distinctiveness and sensitivity of Landscape Character Areas, elements or features.

b) Intervisibility

The site visit should cover all receptors within the ZVI area, grouping them as appropriate (*e.g.* views from places of public resort, highways, domestic properties *etc*). A representative selection of receptors and receptor types should be chosen. Their sensitivity to visual impacts (*i.e.* a qualitative assessment of negative change) should be recorded as well as potential mitigation measures. Photographs should be taken for potential use in photomontages.

Two further specific aspects need to be addressed on the site visit: the impacts of season (particularly leaf cover) and night time (lighting); it may be necessary to make further visits to particularly sensitive receptors at different seasons.

Who?

Landscape and Visual Assessments and inputs to quarry planning/design and to restoration/aftercare are usually undertaken by a landscape architect with appropriate qualifications and experience.

Input into the design process

Design of the operation and its restoration and environmental assessment

- The landscape assessment provides the team with features and areas to avoid (or acceptable standoffs). It provides restoration objectives such as typical landforms that should be incorporated or mimicked in restoration design, vegetation, landuses *etc* as well as any beneficial contributions *e.g.* flat land, biodiversity, water *etc* that may be incorporated in the quarry design.
- The visual assessment identifies the key receptors and their sensitivity. These should be taken into account when determining direction of working/orientation of operating faces, phasing of the working, plant and access locations - it is often possible to adjust one or more of these design features to mitigate visual or landscape impact.

- The landscape and visual assessments contribute to the integration of the quarry into the surrounding landscape with no or minimal negative impacts. Where this cannot be achieved, mitigation measures such as screening and/or planting (themselves integrated into the landscape) are identified.
- The assessments contribute to the landscape maintenance and management programme (including planting/agricultural schemes).

Costs and benefits

Costs

The undertaking of landscape and visual assessments together with the ongoing contribution of the landscape architect to the iterative planning and design process is a cost to the project.

Benefits

- compliance with planning;
- efficient materials handling;
- minimising the need for mitigation measures;
- good neighbour relations;
- maximisation of productive afteruse.

5.7 NOISE, DUST AND VIBRATION

Why?

Quarry excavations are sources of noise and dust and, where blasting is carried out, vibration (and air overpressure) can be experienced beyond the site boundary. Unless it can be demonstrated that these emissions can be effectively mitigated, it is unlikely that a planning application will succeed. In many settings, it is possible to mitigate noise, dust and vibration impacts through careful attention to the orientation and geometry of working faces and haul routes. Equipment selection and excavation and haulage methods can also significantly influence the noise, dust and vibration that may be emitted from a quarry site. There are, of course, other influences on the orientation and geometry of working faces and on the choice of excavation methods and equipment, the most important of these are: geology (rock mass properties and geotechnical settings); required production rates and excavation efficiency considerations; and mitigation of visual and landscape impact. It is therefore essential that noise, dust and vibration impacts are not considered in isolation but alongside geology/geotechnics and other key topics as part of the overall design process which seeks to optimise the design with respect to all relevant constraints.

What & How?

Background desk study

The objectives of a background desk study relevant to noise, dust and vibration is to identify the locations and level of sensitivity of all receptors (typically inhabited properties, structures that may be sensitive to ground vibrations, and places of public resort) around the site which may be affected by noise or dust emissions or ground vibration/air overpressure. The information relevant to the the identification of noise, dust and vibration receptors is likely already to exist in connection with desk studies described earlier in this chapter concerned with other topics.

In addition to information on sensitive receptors, it is important to understand the pathways for emissions.

- In relation to noise, topographic information and the nature of the ground surface/presence of physical barriers is highly relevant to developing a preliminary model for assessing noise impacts on sensitive receptors.

- In relation to dust, topography, presence of natural and man-made barriers and climatic information are particularly important.
- In relation to blast vibrations, the geology and the characteristics of the rock mass for propagating ground vibrations are relevant. Where there has been a history of quarrying with blasting, there may be some publicly available information that would provide regression curves that are typical of the geological setting in and around the site.

Site/surrounding investigation

Baseline investigations that may be carried out as a basis for predictive modelling of noise, dust and vibration include the following:

a) Noise

- Measurements of ambient noise levels should be taken at sensitive receptors and at the site boundary. From these, and by reference to relevant policies and regulations, it should be possible to develop thresholds for acceptable increases in noise and incorporate mitigation measures in the design to ensure that they are not exceeded.

b) Dust

- Dust monitoring locations should be established at sensitive locations and at the site boundary, so that baseline characteristics of the area with respect to nuisance dust (and PM_{10}) can be determined. The aim would normally be to ensure no, or no significant, emission of nuisance dust from a quarry site, but such baseline monitoring, together with climatic and topographic information will assist in identifying the nature of mitigation to be incorporated in the design.

c) Blast vibration

- Normally, the application of standard parameters (or ranges) appropriate to particular rock types will be appropriate for the modelling and prediction of the propagation of ground vibrations for blasting. Exceptionally, receptors will be so sensitive to vibration that field trials (trial blasts in single boreholes) will need to be carried out and monitored to establish the site specific characteristics and allow more accurate predictive models to be created.
- In areas where there are vulnerable buildings or other structures (or where there is particular local sensitivity about blasting), structural surveys may also be carried out to provide a reliable pre-operational record of condition. Such surveys are helpful following allegations of vibration induced damage to establish whether there has been a change in condition that could be attributable to blast vibration. Such surveys may also be helpful in identifying structures that may be more sensitive than others and for which a lower threshold for ground vibration ought to be set.

Who?

Collection and analysis of information relevant to noise, dust and vibration must be undertaken by suitably qualified and experienced professionals.

Input into the design process

Design of the operation and its restoration and environmental assessment

The information collection and investigations summarised above will allow identification of receptors sensitive to noise, dust and/or vibration and predictive modelling of the impact of any particular quarry design. Using the staged and iterative process described in Chapter 4, and having regard to other important impacts, face orientations, haul routes, plant selection, working methods *etc* may be adjusted to minimise noise, dust and vibration impacts.

Safety

There are some occupational health and safety issues associated with emissions of noise, dust and vibration that must be addressed as part of the management of the quarry in order to protect the workforce.

In terms of protection of the public, high levels of fugitive dust can be a health hazard and should therefore be avoided or eliminated within the quarry through good housekeeping (*e.g.* use of water sprays, enclosure of processing plant and conveyors, and placement of coverings or surface binding treatment over tips of loose, fine grained material).

The principal danger to the public from blasting is not normally ground vibration (since planning controls ensure that vibration limits are set well below the thresholds for damage to most structures), but fly rock. It is essential that blasting practices are rigorously designed and controlled to avoid incidents of fly rock. The collection of relevant geological and other information and associated modelling and blast design as part and parcel of the quarry design stage will facilitate avoidance of such incidents during the operational phase.

Costs and benefits

The costs of noise, dust and vibration studies at the quarry design and planning application stages are normally relatively modest, although long term monitoring during the operational phase can be a significant cost (especially where there are particularly sensitive structures that may be impacted by these emissions).

The benefits of addressing these matters at design stage include producing the necessary inputs to the Environmental Statement, as well as establishing models and monitoring schemes that can be refined and relied upon during the operational phase. It is particularly important to Developers that they are not blamed for impacts that their operations have not caused, and development of robust baseline models and monitoring systems at the design stage will assist with this.

5.8 TRAFFIC

Why?

Quarries generate additional traffic movements; the magnitude of the increase is determined by the production rate from the quarry. Increases come not just from the transport of the excavated materials and products for sale but also from the construction traffic, visitors, staff, maintenance and supply vehicles. The Government encourages transportation of freight by rail and water but while some quarries use rail, sea, canal, river and pipeline, the vast majority of traffic movements connected with quarrying are by road.

While the internal configurations of haul roads, car/lorry parks and circulation routes are important, it is the impact of lorries on local road networks which is one of the key interests of the general public.

Vehicle (primarily lorry) movements have a variety of impacts beyond the increased pressure on local road infrastructure which causes congestion, road safety concerns and damage. In addition, there are the impacts of noise, fumes, vibration, dust and spillages as well as the visual and psychological impacts.

What & How?

Rail, ship, barge and pipeline studies are outside of the scope of this Handbook. Road transport implications, however, are defined and evaluated by two steps: Traffic Assessments (TA) and Environmental Assessments (EA).

Background desk study

The required background information for baseline reporting includes:

- details of existing or previous TAs, EAs, planning applications/permissions, Conditions, legal agreements and traffic flow/accident reports/studies;
- details of the site, current accesses, traffic/transport network, markets;
- details of the proposed development including site boundaries, ownerships, mineral/product/waste generation by volume, rates of productions, quarry life, importation of materials, staff numbers/movements, visitor/maintenance/construction numbers/movements, lorry/vehicle types and proposed mitigation measures such as sheeting, wheelwashing, routeing etc;

- details of other permitted schemes in the area;
- average daily traffic generation broken down by vehicle type;
- existing HGV routeing and restrictions;
- daily/weekly/monthly/seasonal/annual variations in vehicle movements;
- reports from other team members on noise, dust, vibration, air quality, pollution, hydrology and socio-economic impacts.

Site/surrounding investigation

- confirmation of vehicle movements by survey;
- confirmation of access suitability (sight lines etc);
- confirmation of widths/gradients/curves/signage etc;
- confirmation of on-site provision of lorry parks, staff/visitor car parks, circulation, weighbridges, delivery points, signage, health and safety, fuelling points, maintenance areas, sheeting facilities, wheel washes, staff facilities etc;
- confirmation of cut/fill exercises.

Who?

Environmental and Traffic Assessments should be undertaken by specialists who are suitably qualified and experienced in such studies – normally highway engineers.

Input into the design process

Design of the operation and its restoration and environmental assessment

Traffic and highway assessment is incorporated into quarry design in a number of ways, including:

- Environmental Assessment (especially in relation to noise and public amenity).
- Mitigation measures.
- Operator Code of Conduct/routeing agreements.
- Negotiations with Highways Agency, Government Departments, Regional Authorities, Highways Authority, local bodies and groups.
- Specification/location of access points, circulation routes, restrictions, lorry/car parks, facilities such as weighbridges/wheelwashes that may affect the limits of excavation and the positioning of processing plant.

Safety

- Traffic and highway assessment and advice contributes to four vital areas of safety:

- public;
- off-site staff (drivers etc);
- on-site staff;
- visitors.

Costs and benefits

- Traffic represents the main interface and link between the quarry and the surrounding community; failure to address this key interface risks large costs and delays to quarry operations.
- Access roads, improvements to the Public Highway, weighbridges, vehicle Maintenance Depots etc all represent large capital outlays which are minimised by comprehensive input to the quarry design team throughout the process.

5.9 ECOLOGY

Why?

Britain has rich and diverse flora, fauna and habitats; it is also widely covered by various nature conservation and protection designations. The same is true elsewhere in the World. For obvious reasons of access to minerals and avoidance of quarrying in urban environments, quarrying often takes place near land covered by such designations. It can have negative effects *e.g.* loss of habitat, reduction in species numbers or by indirect impacts caused by dust, noise or habitat fragmentation. It can also have positive effects *e.g.* enhancement of biodiversity from restoration schemes and geoconservation by the exposure, scheduling and protection of rock and minerals together with their associated flora and fauna.

What & How?

The ecologist (and sometimes also a geologist in relation to geoconservation) provides inputs through environmental assessments and throughout the quarry design process. Nature conservation matters are covered by International, European, national and local laws, regulations, directives, policies and designations. Ecology, especially site survey and field investigation, is often subject to season and this may complicate or extend the environmental impact assessment and planning consultation/application process.

Ecologists may need to agree with environmental authorities at national, regional/sub-regional or local level, any operations (including site survey) which might be harmful to nature conservation interests in already designated or protected areas, in advance. Scheduling of ecological studies is, therefore, a key input to the design team in order to avoid lost time and abortive work.

Background desk study

- Plans of site/surrounds including watercourses, buildings, woodlands etc.
- Aerial photographs (including historic).
- Plans and schedules of protected and designated areas and descriptions of their designations and the associated restrictions.
- Rights of Way.
- Geology (including established sites of geoconservation).
- Potential areas of disturbance including off-site works, accesses, conveyor routes, temporary stockpile areas etc.
- Potential conflicts including off-site impacts from fugitive dust, surface water run-off, noise etc.
- Potential improvements to the nature conservation environment including the creation of additional areas of rare habitat e.g. chalk grassland, heathland, reedbed etc.
- Potential mitigation measures, protection areas, translocation areas, temporary refuges or protection seasons/times.

Site visits and investigations

Following the background desk study, the ecologist will have identified all relevant designated sites/species and highlighted all likely affected species. Discussions with relevant environmental authorities and local/national conservation bodies should lead to an agreed access/site survey timetable and modus operandi, taking into account preferred seasonal timings for surveys of some species.

Who?

Ecological assessments and contributions to the quarry design process should be undertaken by competent persons experienced in the necessary investigation/survey techniques, the flora/fauna and scope/opportunity for mitigation and/or enhancement.

Input into the design process

Design of the operation and its restoration and environmental assessment

- The ecological assessment provides the quarry design team with areas/features to avoid (or acceptable standoffs from sensitive features to be preserved). It provides restoration/access objectives.
- The assessment provides a phased approach including seasonal restrictions on activities.
- The ecologist provides input on mitigation measures (on-site/off-site), translocation areas, barriers and additional nature conservation benefits (such as the creation of additional rare habitat or the linking of “islands” of interest).
- The ecologist/geologist provides a maintenance and management schedule/programme to ensure that the features of importance are retained and enhanced by, for example, the removal of invasive species, damage from public access etc.

Costs and benefits

Costs

Ecological assessment and contribution to the quarry design process is an essential cost to the project. Where there are protected species involved and translocation or long term monitoring is needed, costs can be considerable, but they can be mitigated by effective forward planning and ensuring that there is adequate consultation and feedback within the design team to avoid conflicts.

Benefits

The benefits of consideration of ecology throughout the design process and early collection of all necessary representative and reliable information include:

- Avoidance of litigation from damage to designated sites and protected Species (together with statutory penalties).
- Avoidance of loss of time in the application process (and during extraction) by early identification of protected species and designated sites, together with the obtaining of any licences necessary for translocation or management of species and their habitats.
- Avoidance of loss of time by maximising use of the “windows” when surveys/disturbance is permitted.
- Avoids an automatic objection from environmental authorities if certain assessments have not been completed prior to Planning Application submission.
- Avoids bad PR.
- Adds potentially to local bio and geo diversity.
- Establishing monitoring systems to identify emerging harmful impacts at as early a stage as possible.

5.10 GEOCONSERVATION

Why?

Geoconservation is the protection (conservation) of geodiversity which includes all aspects of geological, geomorphological and soil features, the processes that formed them and the interactions between them. It includes rocks, fossils, minerals, geological structures and landforms, and the industrial and cultural heritage which were influenced by them. Inclusion of principals of geoconservation into quarry design promotes the provision of educational opportunities, tourism, and academic study, and may be a legal requirement in some jurisdictions. Incorporation, in working quarries and/or quarry restoration/rehabilitation schemes, of geological interest can present an opportunity for interaction with the wider community as part of ongoing consultation and communication activities (see Chapter 7). This may take a number of forms including: creation of a safe viewing area with explanatory information accessible to any interested member of the public; allowing access to safe geological exposures to undergraduate or school groups studying geology; or restricted access for academic geologists for research purposes.

What & How?

The potential for geological interest often emerges from the geological desk study and site investigation, or the site may already have some sort of protected status (geological SSSI in the UK) on the basis that it includes important exposures of rock or that such exposures will be created by the excavation. In an area of few exposures, drilling, and in particular core drilling, may provide a useful guide to the potential for developing a new geoconservation site, but it should be possible to combine any data collection relevant to geoconservation with geological or geotechnical site investigations.

As part of baseline studies, a geodiversity audit should be conducted, considering the relationship of geology to landscape, existing natural or manmade exposures, and cultural heritage related to past mining or quarrying. If existing exposures are present, the site may be already included in the geodiversity audit prepared for a local geodiversity action plan.

Who?

Once the type of geoconservation interest (if any) to be established or protected at a quarry has been decided, inclusion of in the design of a quarry is an integral part of design stages iii and iv described in Chapter 4 (Sections 4.4 and 4.5) and will be carried out by those responsible for these design stages. However, given the potential for reduction in recoverable material, and the long term costs and liabilities that may be related to providing an appropriate level and type of access to the operating or restored quarry, the Developer will need to be closely involved in deciding what can be provided.

Input into the design process

A stepped approach to accommodating geoconservation in quarry designs is recommended[7]. These steps in order of consideration are:

1. Avoidance: can the quarry design avoid damage to existing features of geological interest?

2. Mitigation: where adverse effects on existing sites are unavoidable, are there mitigation measures that can minimise these?

3. Compensation: if damage or destruction of a site cannot be avoided or faces cannot be safely retained (at reasonable economic cost), can another exposure be created that would provide similar quality information?

4. New Benefits: are there opportunities for creating new geological exposures or educational experiences?

The above apply not just to the final excavation and restoration scheme, but also during the life of quarrying operations. Temporary exposures during operations provide important information to the specialist geologist. Among the possible features that could be included in the design are:

- Provision for restricted public access operations to interesting or important geological features during operations and permanent viewing platforms.
- Provision for collecting areas safely accessible for the general public including school parties
- Provision for geological trails (including disabled access) in the final restoration scheme.
- Restricted access for monitoring, face logging and fossil collection by specialist geologists during operations
- Aftercare – access and provision for maintenance

[7] Based on PPS9 (ODPM, 2005) – see bibliography, Part V of the Handbook

Environmental assessment

Geodiversity is likely to be a specific topic in the EIA and resulting ES. If specific provision for geoconservation features is to be incorporated in a quarry design, it is important that the potential for conflicts with other aspects of environmental impact and proposed after-use are fully considered (*e.g.* faces retained for geological study may have an unacceptable visual or landscape impact; and an after-use that allows general public access may be incompatible with retaining steep, unprotected faces.

Safety

The safety and stability of any long term slopes left in the final restoration scheme is paramount, particularly if the final scheme includes public access to areas of geological interest. The design and treatment of all slopes must take the end use into account. The design of low stepped faces which can be easily accessed for the full height may be possible without significant loss of mineral reserves, however the long term maintenance and safety of any rock (or fill) slopes must be considered as part of the design.

Costs and benefits

Consideration of geodiversity may add a small cost to the operations and implementation of restoration scheme, however this should be weighed against the benefits, which might include a positive public image and easier progress through the planning process.

5.11 ARCHAEOLOGY/CULTURAL HERITAGE

Why?

Britain has a rich cultural past such that most of the landscape has historical associations; the same is true in other countries. Quarrying, unlike some other land uses, can remove or destroy all physical traces of these associations, and, unlike landform or ecology, they can never be reinstated or replicated. Consequently, it is a common all over the world for competent authorities to set policies and regulations for the protection, enhancement and preservation of archaeological sites and their settings. Important sites should be protected and, wherever possible, preserved *in situ*. Where this is not possible, preservation by record through excavation should be effected. Normally (as in the UK), the onus is on the developer to fund appropriate archaeological works prior to development; this can be time consuming and needs to be factored in to the planning of the design process and its associated timeline for implementation.

What & How?

Cultural heritage (physical) consists of:

- Archaeology.
- Historic Buildings and structures.
- Historic landscapes.
- Parks and Gardens.
- Scheduled monuments.

The archaeologist may provide inputs including:

- Desktop/aerial photograph assessments.
- Site walk over assessments.
- Trial trenching or pits results.
- Site attendance during soil stripping or activities close to identified features.
- Archaeological section to ES.
- Mitigation measures.

- Afteruse/aftercare/management regime.
- Public access reports.

Background desk study

- Plans of the site (surrounding area) with topography and drainage (with detailed site survey if available).
- Vertical aerial photographs of the site and area (including old photographs, military photographs).
- International/National designations and scheduling (*e.g.* UNESCO World Heritage sites).
- Local sites and designated monuments or sites of archaeological importance.
- Local Authority Development Plans and Documents.
- Published works, research, investigations etc.
- All easements and restrictions created by Rights of Way, utilities etc.
- The geology, soils and agricultural classification.
- Ownership, control and management boundaries.

Site visits and investigations

If, following the desk studies and discussions with the Mineral Planning Authority, there appears to be a likelihood that archaeological remains are likely to be directly or indirectly affected by proposed quarrying activities, fieldwork will be necessary. A programme for this work needs to be agreed with the MPA. The Confederation of British Industry (CBI) Code published in 1991 suggests that 1-2% of the affected area should be subject to trenching but the agreed figure is often higher depending on the nature of the site and the likelihood of finding archaeological remains and their potential value/rarity.

Any site visits, field walking, trenching or detailed excavation is not just undertaken to establish or help to estimate the extent and nature of any archaeological remains but also to determine the indirect effects on known scheduled ancient monuments or Listed Buildings, for example. The historical context or current setting of monument or building may require protection, avoidance or mitigation.

Fieldwork together with discussions with other professionals on the design team, such as hydrogeologists, soil specialists and ecologists, is important for establishing other indirect potential impacts. Dewatering, for example, may have an effect upon foundations or the conservation of waterlogged or palaeoenvironmental remains.

Who?

Archaeological investigations should be undertaken by competent professionals experienced in the the area where quarrying is proposed, and in the necessary investigation techniques and in the relevant periods of archaeological interest.

Input into the design process

Design of the operation and its restoration and environmental assessment

- The archaeological assessment provides the team with features and areas to avoid (or acceptable standoffs).
- The field investigations (especially trenching) both identify features and help to predict the likelihood of discovery during quarrying activities.
- An agreed programme with the MPA may include a watching brief by a competent person during key soil stripping or excavation activities.
- The archaeological assessment and team discussions should lead to a restoration scheme which avoids key elements, protects their context and, where possible, enhances such context. It also schedules Mitigation Measures where appropriate and the phasing and season of stripping and key excavation activities.

- The assessment will also contribute to the on-going maintenance and management programme.

Costs and benefits

Costs

The undertaking of archaeological assessments including all desk and field work and input to the iterative design process is a cost (often substantial) to the project.

Benefits

- avoidance of litigation and criminal proceedings if a sam, for example, is damaged;
- avoidance or minimisation of re-design and re-configuration caused by archaeological discovery during extraction;
- compliance with planning;
- efficient materials handling;
- minimisation of mitigation;
- positive PR.

CHAPTER 6
DESIGN RISK ASSESSMENTS

6 DESIGN RISK ASSESSMENT

6.1 INTRODUCTION

6.1.1 Elements of design risk assessment

This chapter deals with the identification, assessment and mitigation of design risks, focussing on environmental, operational and commercial risks associated with quarry design and operation.

Environmental risk assessment identifies the hazards in the context of their potential for damage to the environment. All quarrying activities carry environmental risks; by their nature they disturb the existing environment. The inputs to environmental risk assessment clearly arise naturally from the activity of environmental impact assessment. Avoidance or mitigation of environmental impacts (and therefore environmental risk) through design can best be achieved alongside the process of Environmental Impact Assessment (EIA).

Operational risk assessment identifies hazards arising from all aspects of the quarrying operation. The framework for operational risk assessment in the UK is the Quarries Regulations 1999 and their associated Approved Code of Practice (ACOP). The need for design of quarries is a key requirement of these Regulations and the principles behind them are the identification of hazards, the assessment of the magnitude and consequences of the associated risks and appropriate design to mitigate or avoid such risks. The risk based approach in the UK Regulations, and the role of 'Competent Persons' in assessing those risks (in contrast to more prescriptive regulations in other jurisdictions), makes them especially suitable as a framework for ensuring that the design risk assessment is undertaken effectively as part of the quarry design process (recognising of course that local regulations must always be complied with). In this chapter, therefore, there is frequent reference to the Quarries Regulations 1999 – this should be of direct value to UK readers, but we hope that overseas readers (or UK quarry designers working overseas) will also find the risk based approach in these Regulations helpful in designing safe and secure quarries, whatever the local regulatory framework.

The aspects of the design of quarry operations, which can most significantly influence (reduce) operational risks in quarries, are:

- Design of stable excavated slopes both at the final limits of working and in all intermediate faces.
- Selection of excavation plant appropriate to the ground conditions and design of working faces promoting safe use of such plant.
- Design of safe haul roads suitable for the selected mobile plant and the required intensity of use.
- Design of safe waste tips and structures such as stockpiles, lagoons and screening bunds and specification of safe methods of construction and operation.

Commercial risk assessment identifies hazards in the context of their potential to impact on the viability of the operation (profitability and asset value). Clearly, commercial risk can arise from failure to avoid or control environmental or operational risks.

Example: commercial risks arising from environmental design failure

Failure to allow sufficient space for effective water management infrastructure may make it impossible to obtain and/or comply with a discharge licence following grant of planning permission without major changes to site layouts. This could lead to one or more of a number of commercial consequences, *e.g.*:

- The need for expensive re-design work with associated EIA.
- The need to apply for a new or amended planning permission – expensive and not guaranteed to succeed.
- Delays to commencement of production leading to delays to revenue generation.
- Prosecution if the operation goes ahead without a discharge licence or the conditions are breached.

- Loss of reserves resulting from making available sufficient space to construct settlement and attenuation ponds.
- Increased pumping costs if gravity drainage cannot be arranged, given the topography.

Example: commercial risks arising from operational design failure

Failure to appreciate that bedding will dip out of the face within which the main haulage route is to be constructed until planning permission has been granted and construction has commenced, leading to unacceptably high risks of major slope failure involving the road unless major stabilisation work is carried out, or the road is re-positioned on the other side of the excavation to avoid undercutting bedding. This could lead to one or more of a number of commercial consequences *e.g.*:

- The need for the design and implementation of extensive (and expensive) engineering support works (*e.g.* rock bolting, buttressing *etc*).
- The need for expensive re-design work and, potentially, for an application to vary the planning permission and associated EIA relating especially to noise and vibration if the re-design gives rise to significant differences in the phasing and layout of the site.
- Loss of reserves if the faces have to be flattened overall for stability reasons.

Commercial risk may also arise quite independently from environmental or operational failures. For example, failure to model (or modelling with insufficient detail) quality variations within a deposit of sand and gravel could give rise to unrealistic processing, recovery or marketing assumptions during design, any or all of which could have serious consequences for profitability as and when the material of unforeseen quality is encountered.

Design risk assessment, covering the three specific risk areas described above and their interactions, allows a quarry designer to identify those aspects of quarry design where an intended course of action might result in risks that are intolerable so that amendments to the proposals can be made to mitigate the impacts. If risks are too high, the proposals should be modified and the risks reassessed until a tolerable outcome is achieved. Only when this has been done can the designer decide whether the benefits of proceeding with a development (*i.e.* income from the operation or its residual value) justify the costs involved. Common risk estimation techniques, and particularly the development and maintenance of a risk register to quantify the magnitude and possible consequences of the hazards identified are described in this chapter.

In many cases, the costs and benefits of a proposed quarry development affect only the mineral operator. However, in other circumstances, the mineral operator's actions will affect other people in ways that are not reflected in purely financial terms. This is particularly the case with environmental impacts. Risk assessment and management in regard to these aspects are crucial in the context of the possible effects on the wider environment and on human health.

6.1.2 Key terms

Risk assessment is the structured gathering of information available about risks and the forming of a judgement about them. Risk management involves using these data to make and implement decisions based on the balance of costs and benefits for a range of options that produce the desired outcome.

The vocabulary associated with risk assessment appears, on first consideration, to be non-technical because its words are often used interchangeably in everyday speech. Confusion also arises because specialists in different fields use similar definitions and terms in different ways. The following terms are used in this chapter and have the meanings ascribed to them. These are commonly used in many forms of risk assessment:

- **Hazard** – A property or situation that in particular circumstances could lead to harm;
- **Consequence** – The adverse effect or harm as the result of realising a hazard which cause the quality of human health or the environment to be impaired in the short or long term; and,
- **Probability** – The mathematical expression of chance (e.g. 1 in 5, or 20%) of a consequence arising. The definition may be applied to the occurrence of a particular event in a given period, or as one among a number of possible events. In many cases, when applied to design risk

assessment, it is not possible to express probability quantitatively, and it may only be expressed qualitatively (*e.g.* high, medium or low probability of a consequence arising).

In applying the everyday meanings of estimation and evaluation to the concept of risk, there are further terms that require definition:

- **Risk estimation** – which is concerned with the outcome (or consequence) of an action taking account of the probability of occurrence;
- **Risk evaluation** – which is concerned with determining the significance of the estimated risks for those affected (i.e. includes the element of risk perception);
- **Risk perception** – which is the overall view of risk held by an individual or group and includes both feeling and judgement;
- **Risk assessment** – consists of both risk estimation and risk evaluation; and,
- **Risk management** – the process of implementing decisions about accepting or altering risks.

The process of quarry development includes a series of actions, which are anticipated by the process of design. These actions should be the subject of the risk assessment, including a 'do nothing' action. With the assessments prepared, the quarry designer will be informed about the various benefits and costs associated with any particular action or set of actions. These will be used in preparing a risk management strategy, with certain benefits arising from a reduction in design risk. Such benefits are not necessarily financial or wholly financial. Figure 6-1 illustrates how the various stages in the risk assessment process are related.

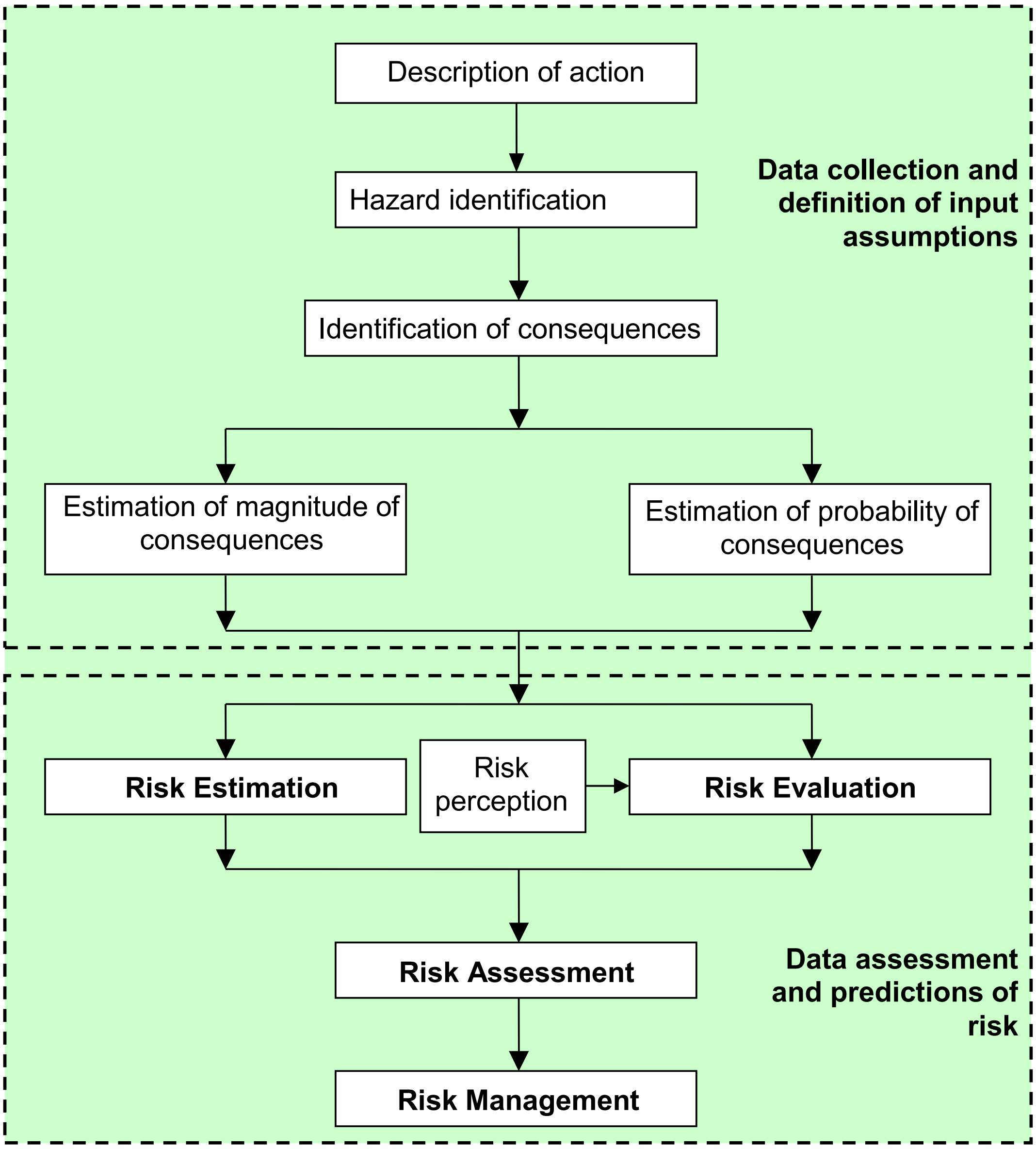


Figure 6-1 – Stages in risk assessment and preparation of management control

6.1.3 Environmental, operational and commercial risks

In the context of risk to people, it is often considered relatively simple to assess the risks and prepare management plans. There is a clear need to preserve human life and all actions and mitigation measures will address this fundamental principle. The harm that can arise is clear and apparent - loss of life or injury. By any measure, these outcomes would be considered significant. Whilst commercial risks can be readily appreciated in terms of tangible effect on profitability, unless systematically considered the ‘knock on’ effects of failures in design on the commercial viability of a quarry may be missed.

When assessing risks relating to the environment, it is often less clear what harm might be produced. Since any quarrying activity will alter the existing environment, it may always be considered that harm has been caused. This might include direct harm to an existing eco-system (*e.g.* plants removed, species disrupted, water systems modified), but equally it could be considered that environmental disturbance harms humans. Harm is often taken to include effects on a person’s property (including physical damage or financial loss) or an offence to their senses. In this context it should be realised that the concept of significance is important and this concept is fundamental to EIA. Measuring the significance of harm arising from an action in an environmental sense is only possible if suitable and sufficient baseline data is available. It is necessary to know what changes naturally occur in the environment in response to other influences (*i.e.* seasonal variations, longer term changes, effects from other land-uses, *etc*). In such cases, it may only be relevant to consider the potential harm arising from an action if this is outside normal environmental variations.

For most activities, environmental impact is not automatically reflected in the costs of carrying out the action leading to the impact. For example, for production blasting, the noise or vibration impacts arising are reflected in the costs of the blast. They arise as a one off event associated with that blast, and commercial risks associated with uncontrolled costs for this activity can be mitigated through careful planning and cost control. The visual impacts of a quarry are not reflected in the costs of working the site however. The visual impact arises as a consequence of developing the site as a whole. The methods of mitigating the impact might therefore have costs associated with them that are not directly related to any particular activity. Quarry screening bunds might be required to mitigate visual impact. This might be a direct additional cost. To mitigate the undesirable impacts of blasting, the blast size might be reduced – this could be cost neutral in overall terms (since less explosive is used in each blast, but more blasts are required), but operationally more complicated.

The assessment of risk, the accompanying assessment of cost and benefit and the decision as to whether or not to go ahead with a particular action require a judgement to be made regarding the tolerability of the harm to be experienced. Tolerability does not, however, necessarily mean acceptability:

- **Tolerability** refers to a willingness to live with a risk to secure certain benefits – provided that the risk is properly controlled and managed. The benefits might accrue to a mineral operator (in the form of profits from the operation) or may accrue to wider society (in the form of provision of necessary construction materials). Toleration of a risk does not imply it is negligible or ignored, but something that is kept under review and reduced wherever practicable.
- **Acceptability** implies that the risk is simply accepted as it is, and little further effort is expended in managing or reducing it. In many cases, acceptability is not an option. All risks should ideally be kept under review.

6.2 RISK ASSESSMENT

The following section outlines the steps required in the risk assessment process, as identified in Figure 6-1 above. Before the risk assessment can be properly undertaken, there are five stages to be considered in preparation for the process:

1	Description of action;
2	Hazard identification;
3	Identification of consequences;
4	Estimation of the magnitude of the consequences; and,
5	Estimation of the probability of the consequences.

Although the five initial stages are related to each other, some can be considered independently. These stages must be considered before risk estimation and risk evaluation can be undertaken, since these activities rely on the inputs from the five stages noted.

At every stage of the process, assumptions will need to be made and it is important that these are explicitly defined so that any further review can establish whether there have been sufficient changes to warrant modification. These assumptions should be properly recorded as a reference for the assessment and future review. Most assessments will, by their nature, be made on the basis of incomplete or uncertain information.

The keeping of proper records of the stages of the assessment process and the underlying assumptions will allow justification of the measures adopted for any proposed actions. It also allows subsequent reviews to be made in the light of new experience or knowledge, particularly for those assumptions made on incomplete or uncertain information. Many actions proposed in the quarry design (or, later in the operation of a quarry) will affect the interests of both the mineral operator and other concerned parties. The decisions on what actions are to be taken is bound to favour one party rather than another, or at least appear to do so to one party. Since any decision has the potential for criticism, it is important to keep proper records to show that due attention was paid to the various concerns and the selected decision was made in good faith and was justifiable in the context of knowledge at that time. There is also clear benefit to consultation and communication) with all relevant stakeholder groups during the assessment process (Chapter 7).

6.2.1 Description of action

The quality of any risk assessment is directly related to the extent of knowledge of what action is to be taken and the effects of that action. It must also take account of the conditions prior to undertaking the action, and what the conditions will be on completion. The process of quarry design and the information upon which it is based (described in Chapters 4 and 5) is an essential basis for meeting these requirements in design risk assessment for quarries.

There are four main groups of questions to be addressed, relating to the intrinsic characteristics of the environment that is to be affected, or the processes that will be involved:

(i) What conditions existed before undertaking the action?

(ii) What conditions will be applied in undertaking the action?

(iii) What are the intended individual steps and overall outcomes in the operation as a whole?

(iv) What conditions will exist on completion of the actions?

The description of the actions to be taken is generally detailed in the design itself and associated EIA prepared for the proposed workings. This recorded description of the proposed actions provides a summary of the proposals from which it will be possible for other parties to tell what was taken into account and what was ignored. For those intimately involved in the design process, it is often easy for them to make implicit assumptions or take account of knowledge that may not be available to others reviewing the proposals and again; good reporting will help overcome such gaps in the records.

At this first stage in the process, there should be no attempt to identify or evaluate the consequences of any action or the proposed development overall. It is the description of the actions in this first stage that is necessary to assist in identifying, in the second stage, those features that have the potential to cause environmental or other harm.

6.2.2 Hazard identification

As noted in Section 6.1, a hazard is a property or circumstance that could give rise to harm. In some circumstances, hazard identification may be relatively obvious (*e.g.* through certain intrinsic properties of materials, such as explosives, or identified through geotechnical assessments identifying certain failure modes for slopes), although in others it may not be so well recognised (*e.g.* increase in traffic on certain stretches of public roads, effects on the groundwater regime from uncontrolled escapes of diesel fuel *etc*).

Hazard is often related to location and it is not always possible therefore to draw on previous studies or research in quantifying the nature or severity of a hazard. Geotechnical or geological hazards will be totally site specific, and will also be affected by working proposals. Site investigation and data assessment is essential in identifying potential hazards. Similarly, measurements of other factors and modelling may be necessary to identify hazards associated with a quarrying operation that could arise at some remote location.

The basic question to be answered in order to derive a first order hazard identification is:

"Which of the identified properties of the proposed operation or process could lead to an adverse effect on the environment, on operational safety or on the viability of the operation?"

The properties may relate to a physical activity as part of the operation or may be a function of materials used or the way the project is organised and managed. The hazards identified will be very broad at this stage, but should be as clearly defined as possible. This will improve the final risk assessment. If there is insufficient information to assess whether a particular hazard is present or not, the assumption for the purposes of subsequent assessment should be that it is until such time as it can be ruled out. Some examples are given in Figure 6-2.

	First order design hazards	Possible Consequences
1.	Failure to write precise brief and establish clear objectives.	Abortive works, mistakes, lost time, inefficient use of land, poor mineral recovery, double handling etc.
2.	Failure to secure and define land ownership or control.	Abortive work, commercial risk from competitors.
3.	Failure to define market/demand/competition.	Poor design brief, missed opportunities, unprofitability.
4.	Failure to define timescales and key deadlines.	Slippage, missed deadlines e.g. Planning Committees, repeated work.
5.	Failure to appoint design/assessment team and leader at early stage.	Abortive work or missed inputs and delay to scoping, EA, quarry design process and application.
6.	Failure to acquire, collate and circulate base information to design team.	Abortive work or missed inputs and delay to scoping, EA, quarry design process and application.
7.	Failure to define protocols, formats, computer software etc.	Abortive work, mistakes, poor presentation.
8.	Failure to schedule baseline studies.	Missed seasons and/or delay.
9.	Failure to secure a screening opinion from the LPA/MPA.	Invalidity, legal challenge or delay.
10.	Failure to secure agreed scoping decision from LPA/MPA.	Abortive or missed work on non-relevant subjects, invalidity, legal challenge or delay.
11.	Failure to communicate and lack of input of team to quarry design iteration.	Delay, additional fees, fundamental design flaws, re-assessments of amended schemes, inefficiency of design solution and failure to maximise mineral recovery.
12.	Failure to consult statutory and non-statutory consultees.	Planning refusal, legal challenge, delay, abortive work and loss of seasons for assessment.
13.	Failure to consult public/stakeholder groups.	Poor PR, objections, lack of local knowledge or local inputs.
14.	Failure to conform to Environmental Assessment Regulations.	Rejection of EA, planning refusal.
15.	Failure to assess alternative sites, do-nothing scenario, impacts during construction, operation and on de-commissioning.	Rejection of EA, planning refusal.
16.	Failure to apply for appropriate licences, permits and approvals.	Criminal proceedings, costs, bad PR.

Figure 6-2 First order hazard identification

The set of possible hazards identified at this stage of the assessment could be very large, and some judgement may be required about which can be ignored for practical purposes until a later stage in the process. Hazards may also be inter-linked (in the way illustrated in the examples given in section 6.1).

A second question that may be asked in preparing the hazard identification, is:

"Where, and to what extent, might an operation or process (or the individual stages of an operation), by virtue of their nature and through failure, cause environmental harm, unsafe working environments or unfavourable economic impacts?"

In many cases the search for operational or process failures is likely to be appropriate only when intrinsically hazardous properties have been identified. For example, the failure of a silt lagoon retaining bund has high potential for causing harm, but this may be even greater if the lagoon is built in a sensitive location (*e.g.* by virtue of physical location or underlying foundation conditions). By contrast, the construction of a screening bund using the same materials in a suitable location has much less potential for harm even if it were to collapse.

6.2.3 Identification of consequences

The potential consequences of an operation are determined in the first instance by the hazards identified. A specific consequence only arises if the underlying hazard is realised. This can only happen if the potential receiving environment possesses the necessary characteristics and/or if the operational or process failures do indeed take place.

Identifying the potential outcome depends on the combination of the hazard and the characteristics of the receiving environment that are relevant to the particular hazard. The characteristics of the environment may be such that certain hazards will not arise (e.g. noise from a quarry in an area far from any centres of population is unlikely to generate offence (harm) to the general population, but may still be an issue for persons working at the site).

The "source – pathway – receptor" model used in EIA is a helpful context for identifying consequences, particularly for environmental consequences but also in relation to safety and economic consequences. For example, when considering the consequences of emissions from a site, the source of those emissions and the potential for exposure of the receiving environment or people to that substance should be estimated (taking account of the routes (pathways) by which they might be affected). Such estimates may well include consideration of effects far removed from the working site at points downstream, downwind or down aquifer from it. The exposure may be concentrated at a point or affect a wider local or regional area. For safety issues arising, for example, from slope instability, consequences of failure will be very different in an area where no workers are ever present as compared with an area where machinery and personnel work routinely.

The consequences arising from particular hazards may affect both the living and non-living environments. The effects on the living environment may be more apparent than those on the non-living environment, and the effects on people within the quarry are perhaps the most obvious. The clearing of a site prior to quarrying may involve the removal of existing plants, which in turn might support other forms of life (insects, birds, mammals etc.). The same action also has an effect on the non-living environment however. Ground clearance may lead to greater run-off and higher erosion rates, which in turn could add silt to local watercourses or change local drainage patterns. Higher run-off might also lead to reduced infiltration and affect underlying aquifers. These consequences may have both safety and commercial implications.

It must also be recognised when assessing consequences that the hazard identified may not cause 'physical' harm to persons, but certain activities or operations may have the potential to cause offence. This may arise in the context of loss of visual amenity, increased noise, dust or vibration or a general perception of damage. Such effects should be considered in the design risk assessment, abut may only really be relevant if they occur widely and affect significant numbers. Quarrying is often an unpopular activity and there will always be individuals who will take offence, no matter how limited the impacts are in reality.

6.2.4 Estimation of the magnitude of consequences

The consequences of a specific hazard being realised are, by definition, harm or adverse affects on people, the environment or the commercial success of the operation. In some cases, it may be possible to quantify the magnitude and even to ascribe a monetary value (*e.g.* the cost of rebuilding a house damaged by blast induced vibration). Where it is not possible to fully quantify the consequences, it may be possible to predict the order of magnitude or to adopt a semi-quantitative approach. Consequences may also be predicted by comparison with other sites or activities (where these are themselves comparable with the proposed operations).

Consideration of the magnitude of consequences may be divided into the effects on the living and non-living environment.

6.2.5 Magnitude of consequences

Magnitude of environmental consequences

For the living environment (but excluding humans), the following degrees of magnitude may be applicable:

Severe	The actions result in a significant change in the numbers of one or more species, including beneficial or endangered species, over the short or long term. The actions also have a negative effect on the functioning of the particular ecosystem and/or neighbouring ecosystems.
Moderate	The actions produce a significant change in population densities, but not a change which results in total eradication of a species or affects any endangered species.
Mild	The action causes some change in population densities, but does not cause eradication and has no negative effect on the ecosystem function.
Negligible	The action causes no significant changes in any of the populations in the environment or any changes in ecosystem function.

The above ranking depends on a broad knowledge of the species present in the receiving environment as well as the likely effects on those species produced by the proposed actions. Complete loss of a species is of prime significance, but is qualitatively different from a local eradication. However, at a local level, total eradication of a species (or its habitat, leading to migration) might have an undesirable knock-on effect in the local ecosystem.

Any significant changes in functioning of the ecosystem would be slow to recover, if indeed it ever could. The ability of the environment to recover may be related to the generation time of the species affected. If the operation (or action) causing the consequence is very short-lived, the consequences might be low if regeneration or re-colonisation from the surrounding environment could take place fairly rapidly. This might be encouraged by early and/or progressive restoration of worked areas of the site.

For the non-living environment, a similar approach may be adopted in defining orders of magnitude of consequences:

Severe	The action results in irreparable damage to natural features (*e.g.* geological type localities) or destruction of important buildings (*e.g.* historical properties, monuments, *etc*).
Moderate	The action causes damage to important structures/buildings or natural features.
Mild	The action causes damage to less important structures/building, and such damage can be repaired.
Negligible	The action causes only cosmetic damage to less important structures/buildings.

The scale of the operation must also be considered in assessing the consequences of the operation. The scale should not only be addressed in absolute terms but also in relation to the affected environment (*e.g.* a 1 million tonne per annum quarry in a previously worked area might be considered to be less damaging than a 0.1 million tonne per annum quarry in an area of virgin rainforest).

Magnitude of operational consequences

The UK Quarries Regulations 1999 require that hazards relating to excavations and tips (broadly defined to include *all* parts of a quarry site where the original ground surface is modified by excavation or accumulation of material, including haul roads and lagoons[1]) are ranked according to the magnitude

[1] Excavations and tips are defined in Regulation 2: *"excavation" means any place at the quarry where minerals are or have been extracted and includes the ground, faces or sides of the quarry and any other incline"; "tip" means an accumulation or deposit of any substance at a quarry (whether in a solid or liquid state or in solution or suspension) and includes, but is not*

of the consequences of their failure. This ranking is determined through a system of geotechnical appraisal and assessment. The procedure to be followed is explained in detail in Part VI of the Approved Code of Practice and Guidance issued in relation to Regulations 30-38, which cover:

Regulation 30	General duty to ensure safety of excavations and tips
Regulation 31	Excavations and tips rules
Regulation 32	Appraisal of excavations and tips
Regulation 33	Meaning of 'geotechnical assessment' and operator's duties in relation to geotechnical assessment
Regulation 34	Operator's duties in relation to excavations and tips which are a significant hazard ('notifiable' excavations and tips)
Regulation 35	Operator's duties in relation to excavations and tips which are not a significant hazard
Regulation 36	Duty to keep record of substances tipped
Regulation 37	Notification of excavations and tips
Regulation 38	Transitional provisions

Throughout the Regulations the obligation to design all excavations and tips (*i.e.* the whole quarry operation) and to anticipate all the hazards and assess their significance is repeatedly stressed. The relationship between appraisal and assessment and the elements involved are illustrated in Figure 5 in the guidance in the Approved Code of Practice, which is reproduced in Figure 6-3 below. The Quarries Regulations distinguish between significant hazards and other hazards as follows:

"295 The hazard should be considered significant if such a failure would, directly or indirectly, be:

(a) liable to endanger premises, roadways or other places where people are to be found off-site; or

(b) likely to kill or seriously injure anyone.

296 If the degree of hazard is not clear and the excavation or tip is not in the categories described in paragraphs 300 and 301, the advice of a geotechnical specialist should be sought."

(ACOP, paragraphs 295 and 296)

limited to, overburden dumps, backfill, spoil heaps, stock piles and lagoons, and where any wall or other structure retains or confines a tip then it shall be deemed to form part of the tip".

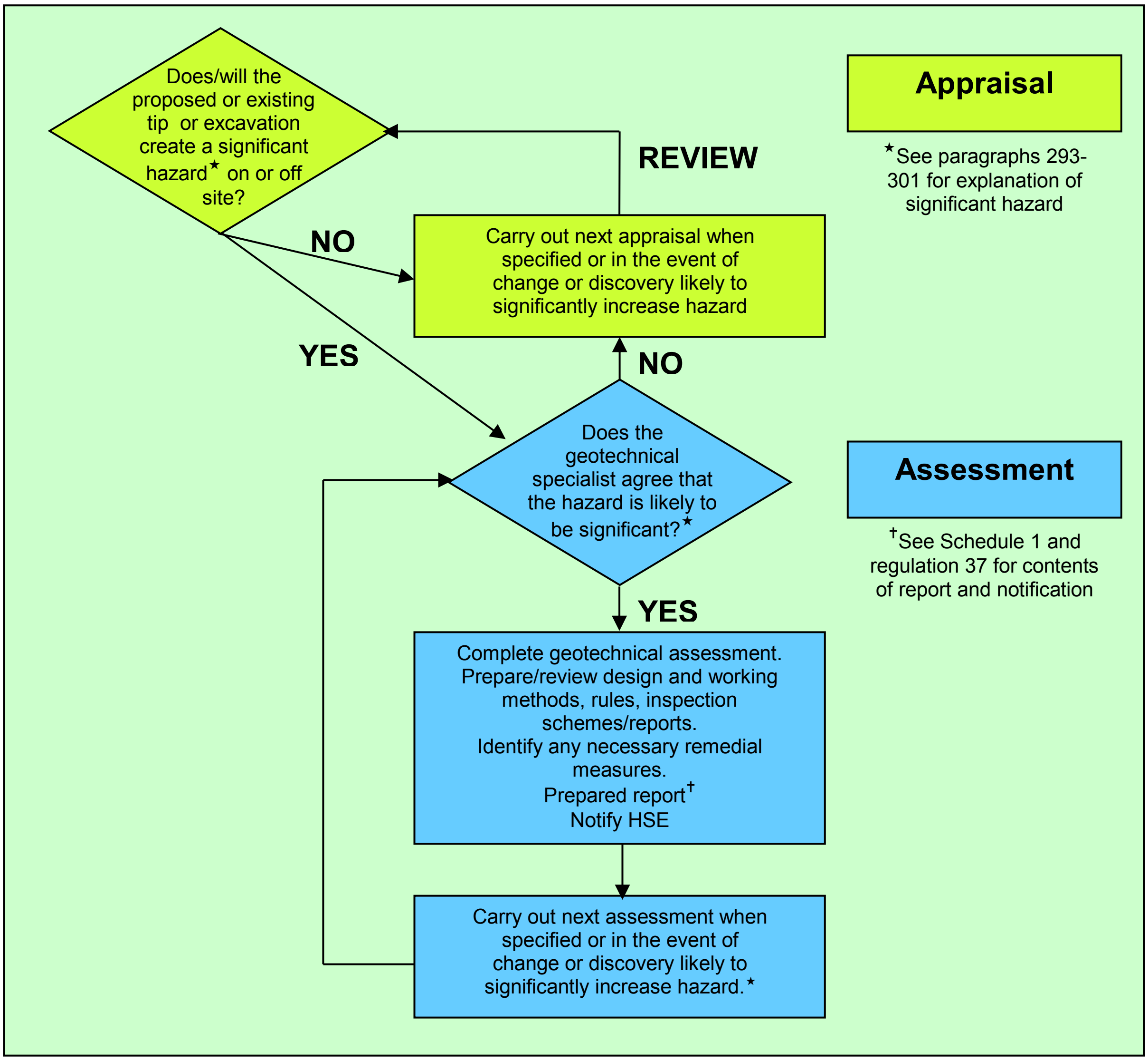


Figure 6-3 Appraisal and assessment of excavations and tips (from UK Quarries Regulations 1999, Approved Code of Practice, Figure 5)

Magnitude of commercial consequences

As noted above in relation to hazard identification (section 6.2.2), many commercial hazards (and therefore commercial consequences associated with them) arise as a direct result of environmental or operational hazards. The business plan itself will set out a number of commercial objectives, against which magnitude of commercial consequences may be assessed. Typically, the commercial objectives will include statements such as:

- Return on investment throughout the operational life of the quarry shall exceed x%;
- The operation shall have ‘paid back’ investment by the end of year y;

The framework for assessing magnitude of any commercial hazard that is identified is the business plan, and particularly the cash flow model that is likely to be included within it. Appendix 4-6 (Part IV) provides an introduction to building cash flow models and investigating the risks associated with key market, cost and revenue assumptions.

6.2.6 Estimation of the probability of consequences

The estimation of the probability or frequency of a particular hazard being realised is most likely to be semi-quantitative. The most likely approach will require an assessment of the particular operation or process and making a comparison with available information for comparable settings. In general, the aim should be to make realistic judgements that can be rationalised and recorded so as to avoid problems when other parties are reviewing the risk assessment.

As for the magnitude of the consequence, it might be appropriate to consider probability in the context of High, Medium, Low or Negligible likelihood of occurrence. These terms might be used to express the probability of a hazard being realised over a defined timescale. The timescale should overlap between categories however to prevent artificial threshold values being introduced into the assessment.

The quarry designer should note, however, that there are some consequences that will always be unacceptable, no matter what their probability (*e.g.* geotechnical hazards that would give rise to danger of death or serious injury, disruption of primary haulage routes); these hazards will represent the major constraints on design – if they cannot be mitigated through design, then the project will have to be abandoned.

In establishing ranges for particular events, it is necessary to define what event is being considered and the possible magnitude of that impact. For example, where a quarry site discharges silt into a local watercourse in excess of the permitted levels of suspended solids, the harm caused will be different in each of the following cases:

- When the receiving watercourse is in spate, the harm may be negligible. The probability may be high however, since such discharges may be expected to occur during exceptional rainfall events if the attenuation pond capacity is exceeded.
- The concentration of suspended solids in the discharge may only be harmful in the context of fish breeding or particular aquatic plant environments. The harm might be considered to be of a low magnitude out of breeding seasons, but the same discharge could have a high magnitude during the breeding season. The probability of the event should be therefore be considered for different seasons therefore.
- The duration of the event may increase suspended solids in the receiving watercourse for a prolonged period, which could affect conditions further downstream (say, at a water abstraction point). If no abstraction is in progress at the time of the incident, the harm may be minimal, but if it is required for permanent water supply, the harm might be greater.

The appropriate values for probability ranges will vary according to the event under consideration and the person making the assessment. There may be an element of risk perception in this that should be accounted for if the overall assessment is to remain valid.

6.2.7 Risk estimation

For most design elements or actions, it is likely that more than one hazard will be identified, together with a different magnitude and probability for each. Combining the magnitude and probability produces an estimation of the risk.

As noted above, in many cases the estimation of the magnitude and probability will, at best, be semi-quantitative. Each component will represent a judgement based on knowledge and experience and in this respect the estimation of the risk is no different.

A simple matrix is often the best way of determining the risk, although it may represent a gross simplification which cannot reflect the true complexity of the system and its components. However, used with care (and alongside the design process) it can be helpful in identifying those design elements or actions that present the highest risk.

An example of a typical risk matrix is given in Figure 6-4 below:

Probability/impact matrix		Magnitude			
		Catastrophic impact	*Significant impact*	*Marginal impact*	*Negligible impact*
Probability	***Very High***				
	High				
	Medium				
	Low				
	Very Low				
	Negligible				

Key to the shading used in the probability/impact matrix

	Unacceptable risk – immediate action required to improve control
	Acceptable risk – close monitoring is required and cost effective risk control measures should be considered
	Acceptable risk – no action now but review periodically and consider possible low cost control improvements

Figure 6-4 Example of a probability/impact matrix

Where there is a risk identified as potentially falling into two or more categories (*e.g.* High/medium), the decision as to which category best describes the risk is based on knowledge and experience of the operation and the potential outcomes. Published information or other comparables might assist in this determination.

The overall risk associated with a number of different identified hazards is a combination of all the risks arising from the different hazards. Although there are recognised techniques for assessing this overall risk or combinations of hazards, these generally rely on quantitative assessments of the component hazards. In most cases, quarry design risk is assessed on a semi-quantitative basis and the assessment of combined risks will usually rely on the judgement of the person undertaking the assessment, assisted with input from others experienced in the operations proposed. In such cases, the objectivity of the person making the assessment will be affected by their perception of the risks involved (as detailed further below).

6.2.8 Risk evaluation

The evaluation of the estimated risk is the second stage of the risk assessment, and requires further judgement about how significant the estimated risk is. One key factor in assessing the seriousness of the consequences is whether the risk receptor is likely to be able to withstand the effects of the actions. Many forces, arising naturally or as a result of human activity, affect the natural environment. To assess the magnitude of the outcome it is necessary to consider whether the extent of the outcome exceeds normal environmental variations. If it does, it needs to be considered whether the effects will be mitigated over time (i.e. whether recovery is likely).

Risk evaluation is the process of determining the significance of risks to the environment or persons affected. It therefore includes risk perception and a trade off between perceived risks and perceived benefits. This perception of risk and benefit will lead to different views on where the balance lies, depending on who is considering them.

Whilst in some ways it may be relatively easy to estimate the risk to the receptor, evaluating the risk may be much harder, especially if commercial consequences are ambiguous and difficult to model. Establishing a level of tolerable risk (the basis of risk evaluation) relies on knowledge and experience of the factors involved to allow a 'weighting' to be given to the estimated risk. Industry, the public, stakeholder groups and Government are likely to have different views about what is tolerable. Risk evaluation by these different parties will usually produce different levels of risks. This often arises since the risks and benefits may not fall equally on the different groups. These potential difficulties will strongly affect the selection of appropriate persons to make the judgements if the evaluation is to be seen to be fair.

General confidence in the risk assessment and evaluation process is necessary, and this is one of the key objectives of both effective consultation with external stakeholder groups and communication within and management of the team involved in the quarry design process (see Chapters 7 and 8). As noted, different parties may have different interests and agendas and these may influence the whole process. It is relatively simple to scrutinise documents to identify mistakes or untruths, but it may not be simple to identify omissions. Where a company wishes to have its proposals seen as environmentally acceptable and safe, they could seek (or appear to seek) to conceal hazards that they did not wish to have taken into account by other stakeholders.

The appointment of independent expert assessors can help to overcome this problem, but only if they are seen to be independent and not likely to be swayed by particular interests. This is very suitable for environmental and public safety matters (usually as part of EIA) but is clearly less suitable and often inappropriate where sensitive commercial matters may be involved. They must act in a way so as to maintain the confidence of all parties likely to be affected (including the mineral operator, public and government).

Evaluation of risk may change with time as more information about the consequences and probabilities becomes known. This requires that, within the risk estimation and risk evaluation process, some inclusion of alternatives are made to assess the sensitivity of assumptions. Where assumptions are identified as being particularly sensitive, caution should be taken in the evaluation of the risk overall, and further information collection or analysis (Chapter 5) may be specified to improve confidence. Small changes in circumstances could change the level of risk identified. Any alternative approach, however, should be subject to its own risk assessment; the fact that an alternative is worse than the original does not mean that the original is necessarily acceptable.

Whatever approaches are adopted, risk evaluation will ultimately guide the person or organisation responsible for making a decision whether or not to proceed with the proposed development. This might be a Government department, a regulatory authority or a development manager in a quarrying company. Whatever the position of the individual or organisation involved, they must consider the effects as widely and from as many viewpoints as possible. Although the different components of the process are likely to be guided by or weighted to reflect overall policies (corporate, legislative or accepted good practice), it is important to review the evaluation in light of other perceptions to identify the most important issues. This will allow refinement of the risk assessment in those areas that are genuinely likely to be of greatest concern.

6.2.9 Risk perception

The perception of risk may have very little to do with its significance. The former is subjective (*i.e.* depends on an individual's viewpoint) whilst the latter is objective (*i.e.*. is capable of being measured and defined by appropriate means). This is the ideal position, but as noted in earlier sections much environmental risk assessment relies on semi-quantitative techniques, which themselves rely on some subjective measures. In such cases, it may be appropriate for some consideration to be made to account for the perception of risks held by others.

There are a number of factors that are known to affect people's perception of risk:

Familiarity	People tend to underestimate the risks with activities that are familiar and to overestimate those that are unfamiliar. For example, many people drive and accept the risks involved, even though they might be quite high. Some of those drivers will also be shotfirers who regularly handle explosives and can evaluate the risks involved and find them acceptable. Non-shotfirers will be happy to drive, but would find the risks of handling explosives too high to accept.
Control	People tend to overestimate the risks associated with activities over which they have no control, but will underestimate risks related to activities in which they might engage. Again as an example, people will be happy to drive themselves

	and believe it to be safer than flying, even though published statistics show this to be otherwise. People will also tend to demand greater protection from events that are out of their control.
Proximity in space	Although the risk to an individual might be increased with proximity to a particular activity relative to a person further away, they might overestimate those risks whilst at the same time underestimating the risks associated with things happening further away.
Proximity in time	People tend to ignore the effects of risks that are going to arise much later in time, and this should be taken into account in the assessment. However, it does not imply that less account should be taken of the actual hazard itself, or its consequences if realised.
The dread factor	People exaggerate the risks associated with phenomena they do not understand. Risks associated with everyday occurrences (e.g. vibrations in the home from slamming doors) are often underestimated whilst those associated with external factors (e.g. vibrations felt in the home from blasting) are exaggerated, even when the impact of the latter may actually be less. Again, people tend to demand greater protection from events that they do not understand.
The scale factor	Large scale consequences are more apparent than numerous smaller ones, which can sum to a greater overall effect. For example, a single fatality in a car crash involving a mineral truck hauling products on a local highway may not attract the same attention as 10 people killed in a minibus in a similar incident.

The public will tend to view the risks associated with a particular activity based principally on the consequences for them or their immediate surroundings. They often ignore the probability of occurrence or base their view on an incorrect assumption regarding that probability. A person preparing a formal risk assessment will tend to focus on the probability, and may overlook public perception. As part of stakeholder engagement (Chapter 7), it will often be necessary to attempt to reach a common understanding of the relative importance of various risks as a basis for working out an optimum design solution.

Potentially serious perception issues may relate to the risk perception of members of the design team (Chapter 8); where individuals or groups are very experienced in operational or management functions in quarries, they can find it difficult to identify hazards in the first place or, if identified, to develop a realistic perception of risk (*e.g.* "I've been operating quarries for 40 years and have never had a problem with doing things that way"). The adoption of processes and techniques that formalise the process of hazard identification and risk assessment, as well as incorporation of inputs from independent persons, who are likely to be more objective will assist in ensuring that all hazards, consequences and risks are covered in the design risk assessment process; the drawing up of a risk register is a helpful framework in this regard.

A formal risk assessment is usually the best objective strategy in evaluating design risk, but the results may have to be modified to account for different perceptions of those likely to be affected by the outcome. In the longer term, it may be possible to 'educate' those affected to be more informed and less troubled by the perception of risk which has the added benefit of allaying local concern, generating goodwill and possibly support for developments.

6.2.10 Reviewing the process

The decision to proceed with a proposed action should not normally be made on a single view of the potential effects. The whole process and even the action itself should be refined in an iterative process, which has three principal elements:

- The refinement of the engineering and technological design;
- The consideration of non-monetary costs; and,
- The assessment of risk.

The refinement of engineering and technological design is entirely a matter for the quarry design team. They will be best placed to provide the optimum balance between safety, best practice and required outcome by appraising all of the site variables. Non-monetary costs may be harder to consider, but might include the effects on goodwill from the local population or the potential for impacts on the local environment. The assessment of the risks should be re-addressed after any design changes and should aim to reduce wherever practicable.

Risks from any activity are unlikely to reduce to zero because every action associated with quarry development will have an effect on the environment (either positive or negative), on the safety 'profile' of the operation and the economic model. The risks need to be considered against the costs, consequences and benefits in order to decide whether they are tolerable or not. A tolerable risk implies that further reduction in the risk may only be achieved at excessive incremental cost and that the benefits that accrue from incurring the risk are judged to outweigh the dis-benefits.

If, after completing the risk assessment, the risk is still judged to be intolerable, the proposed actions or operations should be modified (in whole or in part) so as to reduce the consequences and probabilities of occurrence. This process should be repeated until the risk is judged to be tolerable, and at this stage the costs of achieving this can be assessed to determine whether it is still worthwhile pursuing the proposals.

The iterative nature of the overall design risk assessment process is shown in Figure 6-1. The feedback loops show how judgements and decisions made at various stages are taken into account in modifying the proposals.

6.3 DEVELOPMENT AND MAINTENANCE OF A RISK REGISTER

Many organisations use risk registers as a basis for working through, recording and updating the risk assessment process depicted in Figure 6-1. Their value as part of the design process is evident, but they can then be used as a management tool at the operational phase; together with operational plans derived directly from the design, the will assist in making the transition between design and implementation.

Risk registers take many forms and are most effective when developed by the team who will use them. An example is given below.

Risk Register

Ref No	Description of the Risk	Inherent Risk Level (Impact/ Probability)	Description and Evaluation of Current Control or Mitigation methods	Residual Risk Level (Impact/ Probability	Acceptable Risk? (Impact/ Probability)[1]	Action[2]

[1] Use the probability/impact matrix (*e.g.* Figure 6-2) to guide your answer to this question which will be either "yes" it is acceptable or "no" it is unacceptable

[2] Red and Amber risks require some degree of management action. Red risks being the more pressing than amber risks

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PART III
DELIVERING SUCCESSFUL QUARRY DESIGN

CHAPTER 7 CONSULTATION & COMMUNICATION

CHAPTER 8 MANAGING THE QUARRY DESIGN PROCESS

INTRODUCTION TO PART III: DELIVERING SUCCESSFUL QUARRY DESIGN

This final part of the Handbook text is divided into two chapters:

Chapter 7	Consultation & Communication
Chapter 8	Management of the quarry design process

In addition to the other aspects discussed in Parts I and II, three fundamental activities will ensure that a quarry design is produced successfully, quickly, efficiently, economically, legally and in a socially and environmentally friendly way. These activities are consultation, communication and overall project management.

Consultation

Governments increasingly encourage business/developers to consult widely and to involve interested stakeholders in the whole quarry planning and design process and this is acknowledged good practice in the mainstream mining industry for achieving a 'social licence to operate'. Some consultees must be consulted as a statutory obligation, some are non-statutory but recommended and others, such as general public consultation, are objectives which pervade national, regional and local government policies, plans and frameworks. Consultation is not informing people or bodies of what has already been decided, it is a genuine two-way dialogue. It can speed up the design process, avoid irrelevant conflicts and misunderstandings and foster good public relations.

Communication

Consultation and public relations rely on clear communication at appropriate times with outside parties. Of equal importance is the need for clear communication within the quarry design team. This minimises the chances of abortive work, errors, lost time, poor design solutions and missed opportunities. In an age of increasing electronic communication efficiency may be lost by a lack of focused, structured and coordinated interaction. As an example, copying everything you produce to everyone on the design team every time you correspond with an individual member is not efficient communication. Key information, deadlines, requests *etc* may be lost in a mountain of seemingly irrelevant text and graphics.

Project Management

Consultation and communication (internal and external) are areas for which clear project management is essential. Proven techniques help to deliver a successful quarry design. For example, there should be a clear project leader, clear objectives, clear communication channels, clear timelines and deadlines, clear rules and procedures, specified budgets *etc*. Quarry planning, assessment and design is generally a long iterative process within an ever-changing economic, social and political context. Emerging and developing technical inputs impact on each other and on the overall design. Effective information handling and sharing is paramount. This complex interaction of people, information and process needs careful management. This section of the Handbook examines sixteen separate management systems and inputs, which range from Human Resources and Costs to Risk and Health and Safety.

The charts on the next two pages illustrate a typical configuration and composition of a quarry design team. They show the position of the project manager, an editorial board to produce the application and supporting ES, the PR consultant and the numerous professional inputs.

TYPICAL QUARRY DESIGN TEAM COMPOSITION

TEAM MEMBERS		NOTES
OPERATOR OR DEVELOPER KEY COMPANY REPRESENTATIVE OR BOARD MEMBER LEGAL REPRESENTATIVE COMMERCIAL REPRESENTATIVE OPERATIONS MANAGER PLANNING ESTATES MANAGER ENVIRONMENTAL MANAGER QUARRY MANAGER		These functions need to be provided by the landowner, the operator or the developer (or one organisation having all three roles), whichever is the initiating and commissioning organisation for the quarry design. In smaller organisations, individuals may cover several of the functions listed opposite. Normally, the Planning and Estates Manager acts as the commissioning organisation contact and is responsible for instructing external consultants. He or she may also be the project manager.
PROJECT MANAGER		Quarry design teams are general large and dispersed with differing inputs required at differing times. There are key desirable and/or essential requirements and deadlines. There must, therefore, be a clear and defined project manager (who may be from the mineral operator or from a consultancy).
REGULAR CONTRIBUTORS SOLICITOR PLANNER QUARRY DESIGNER EA COORDINATOR		Four fundamental inputs are needed on a regular basis. Together with the mineral operator representative and project manager, this group of people typically constitute the editorial committee of the Environmental Statement (ES) and Planning Application.
PR CONSULTANT		Consultation with stakeholders, management of the public release of information, political monitoring and liaison all fall to the PR Consultant who reports to the Project Manager and/or Mineral Operator representative.
EXPERT CONTRIBUTORS MINERALS/AGGREGATES GEOLOGIST GEOTECHNICAL ENG, ENG GEOLOGIST LANDSCAPE ARCHITECT HYDROLOGIST, HYDROGEOLOGIST ECOLOGIST ARCHAEOLOGIST NOISE SPECIALIST DUST AND EMISSIONS SPECIALIST VIBRATION SPECIALIST TRAFFIC AND TRANSPORT SPECIALIST AGRICULTURE AND SOILS SPECIALIST OTHER EXTERNAL EXPERTS		The number of areas of expertise requiring to be investigated and assessed varies but the eleven listed here are the most typical. Each will usually write text and provide drawings for their own section of the ES/Planning Application. They, or the editorial board, may write the Non Technical Summary. Larger mineral operators may have some of this expertise (e.g. minerals/aggregates geology or geotechnical engineering/engineering geology) in house.

TYPICAL QUARRY DESIGN TEAM INPUTS

TEAM MEMBERS	Site Selection	Design Brief	Conceptual Design, Option selection and feasibility study	Design of Final Void and Restoration	Design of Phasing and Restoration	Preparation & Submission of Planning Application	Environmental Assessment	Appeal Process	Ongoing PR & Consultation	Ongoing Project & Team Management
OPERATOR/DEVELOPER										
KEY COMPANY REPRESENTATIVE OR BOARD MEMBER	•	•				•		•	•	•
LEGAL REPRESENTATIVE	•	•				•		•	•	•
COMMERCIAL REPRESENTATIVE	•	•	•			•		•		•
OPERATIONS MANAGER	•	•	•	•	•	•	•	•		•
PLANNING ESTATES MANAGER	•	•	•	•	•	•	•	•	•	•
ENVIRONMENTAL MANAGER	•	•	•	•	•	•	•	•	•	•
QUARRY MANAGER	•	•	•	•	•				•	•
PROJECT MANAGER	•	•	•	•	•	•	•	•	•	•
REGULAR CONTRIBUTORS										
SOLICITOR	•					•		•	•	•
PLANNER	•	•	•	•	•	•	•	•	•	•
QUARRY DESIGNER	•	•	•	•	•	•	•	•		•
EA COORDINATOR			•	•	•	•	•	•		•
PR CONSULTANT									•	
EXPERT CONTRIBUTORS										
MINERALS/AGGREGATES GEOLOGIST	•		•	•	•	•	•	•		
GEOTECHNICAL ENG, ENG GEOLOGIST			•	•	•	•	•	•		
LANDSCAPE ARCHITECT			•	•	•	•	•	•		
HYDROLOGIST, HYDROGEOLOGIST			•	•	•	•	•	•		
ECOLOGIST			•	•	•	•	•	•		
ARCHAEOLOGIST			•	•	•	•	•	•		
NOISE SPECIALIST			•	•	•	•	•	•		
DUST AND EMISSIONS SPECIALIST			•	•	•	•	•	•		
VIBRATION SPECIALIST			•	•	•	•	•	•		
TRAFFIC AND TRANSPORT SPECIALIST			•	•	•	•	•	•		
AGRICULTURE AND SOILS SPECIALIST			•	•	•	•	•	•		
OTHER EXTERNAL EXPERTS			•	•	•	•	•	•		

CHAPTER 7
CONSULTATION & COMMUNICATION

7 CONSULTATION & COMMUNICATION

7.1 CONSULTATION

7.1.1 Stakeholder groups

There are four main stakeholder groups with whom consultation on quarry design should take place as part of a planning application:

1. Relevant levels of Government (national, regional/sub-regional and local).

2. Other Statutory Consultees (e.g. Agencies or Ministries responsible for environmental protection).

3 Non-statutory Consultees (e.g. environmentally focused NGOs)

4. Members of the public affected by the proposal.

There are four main reasons why stakeholder consultation should take place:

- To learn/acquire information, opinion and guidance from ‘Competent Authorities’ (*e.g.* Mineral Planning Authority, Environmental Authority or Ministry *etc*), and to seek feedback from other public bodies and specialist NGOs with an interest in the scheme and its impacts.
- To conform to legal requirements.
- To inform the authorities and public.
- As a framework for genuine engagement and dialogue with the public in an effort to understand and address their concerns and achieve a ‘social licence to operate’.

Local, Regional and National Government

There are no hard and fast rules with regard to the sequence and timing of consultation with the various parties. Individual site circumstances will dictate them. In the authors’ experience, there is no or limited statutory guidance or requirement relating to how and when consultation must take place in any jurisdiction. However, it is commonly a requirement that consultation must be demonstrated to have taken place. In general, the first approach will be made from the propositioning party (landowner, developer or operator) to the Mineral Planning Authority. This initial approach to the MPA serves two purposes:

- First, it is important to establish conformity with any current or emerging plans, frameworks or other documents as well as the current position regarding relevant land banks and other planning applications or appeals. It is recommended that all planning designations and policies be checked and updated from the relevant Municipal, Regional/sub-regional, or National Authority. Given the time required to prepare a detailed quarry design, ES and planning application, it is important that a watching brief is kept on emerging plans and policies so that appropriate inputs and consultation responses may be made and, if necessary, adjustments to the proposals can be considered in the light of changes in the policy environment.
- Second, it is often helpful to discuss and agree with the officers of the MPA a schedule of consultation, prior to that consultation taking place. If the officers of the MPA are aware of ongoing community consultation, it can assist them when fielding questions from members of the public and elected councillors.

If the quarry design involves proposed land uses or activities other than mineral extraction, processing and transportation or as part of a restoration scheme, the relevant planning or licensing authority should be approached at an early stage. Extreme examples might be the creation of an industrial complex, marina or port at the same time as developing the quarry – this is likely to require permits and/or licences from completely different Authorities, Ministries or Agencies. In such circumstances, ensuring consistency between competent authorities and full compliance with all requirements may be more complicated.

In the UK, at an early stage of the quarry design it is necessary to obtain a screening opinion from the MPA with regard to the necessity or otherwise of an Environmental Impact Assessment (EIA) – similar preliminary assessments by the relevant authorities are required in other jurisdictions. If an EIA is deemed necessary (or one is volunteered), the consultation with the competent authority on the scope of the EIA can be an excellent vehicle for initial consultations and establishing a co-operative working relationship.

The competent authorities (especially the MPA) should be involved in the various public stakeholder consultation exercises described below and will advise on the timing and requirements of their formal processes (especially scrutiny by relevant Committees and panels).

Statutory Consultees

Statutory consultees vary depending on the nature of the proposal under consideration. In England and Wales, the Planning Practice Guidance provides the following advice concerning consultations:

Statutory Consultation

Planning law prescribes circumstances where consultation must take place between a local planning authority and certain organisations, prior to a decision being made on an application. The organisations in question are under a duty to respond to the local planning authority within a set deadline and must provide a substantive response to the application in question.

Where the consultation required is specified in Article 20 of the Development Management Procedure Order and its amendment, statutory consultees are under a duty to respond to consultations within 21 days, or such longer period as may be specified in other legislation. The 21 day period does not begin until the statutory consultee in question has such information as will enable it to provide a substantive response.

It is important for statutory consultees to inform the local planning authority without delay if they require additional information, and that they have procedures in place to enable this to occur as soon as possible after they receive a consultation. It is not acceptable for a statutory consultee to wait until the 21 day period would have otherwise have come to a close to notify the local planning authority that it believes it does not have enough information to provide a substantive response.

Where a statutory consultee requests additional information it needs to set out clearly and precisely what the additional information is, and the reasons why it is required. As with local planning authorities, statutory consultees may only request information that is relevant, necessary and material to the application in question.

Statutory consultees need to provide clear, positive and transparent information to both local planning authorities and applicants about the information they require to provide a substantive response to consultations.

Early and timely engagement between developers, statutory consultees and local authorities at the pre-application phase is important in helping avoid delays occurring at the formal application stage.

Depending on the type of development, the following are the ‘Consultation Bodies’ listed in Article 16-17 of the Town and Country Planning (Development Management Procedure) Order 2010.

1.	Local Planning Authority
2.	District Planning Authority
3.	County Planning Authority
4.	The Parish Council
5.	National Park Authority

6.	Health and Safety Executive
7.	Secretary of State for Transport
8.	Operator of rail network
9.	Local Highway Authority
10.	The Coal Authority
11.	Environment Agency
12.	Secretary of State for National Heritage
13.	English Heritage
14.	The Theatres Trust
15.	Department for Environment, Food and Rural Affairs
16.	Natural England
17.	The English Sports Council
18.	The British Waterways Board

The MPA will use its discretion in deciding which of the above to consult, omitting any potential consultee wholly irrelevant or unaffected by a site specific quarry planning application.

Although the structures of government and associated legislation and regulation are entirely different from jurisdiction to jurisdiction, the list above serves to demonstrate the wide range of public/government bodies who may have an interest in a proposed quarry. In the UK, the MPA takes on a co-ordinating role in ensuring that all relevant statutory consultees are consulted on the proposals and that the promoter takes account of their responses. In contrast, in some countries there is no, or no effective, liaison and coordination within government. In these circumstances, promoters of quarry schemes need to work hard to ensure that they understand the requirements of each of the statutory consultees and competent authorities, and that the scheme that is put forward is consistent and compliant in the overlaps between different bodies (*e.g.* what is acceptable and in accordance with mining law may not be acceptable and in accordance with environmental or other laws).

Non-statutory consultees

This group can be defined as people at a strategic and local level who represent organisations with particular interests, whose support of or opposition to a development would be significant, or who have particular expertise to offer. UK examples are:

- Royal Society for the Protection of Birds (RSPB)
- Minerals Products Association (MPA)
- Campaign to Protect Rural England (CPRE)
- British Aggregates Association (BAA)
- County or local archaeological & historical societies Council for British Archaeology Wildlife Trusts
- Regionally Important Geological and Geomorphological (RIGGS) groups
- Friends of the Earth
- The Ramblers Association
- The British Horse Society
- Organisations representing the Disabled

Public consultees

This group includes individuals or organisations who are interested because they live in the community the development will affect. Examples are:

- Local residents
- Local businesses
- Representatives of residents' associations
- Clubs
- Faith groups

It is very important that every effort is made to engage with the public early in the quarry design process. Sustainable development requires meaningful engagement of all stakeholders at all levels of the planning process.

Engagement with people at a local level can bring the following benefits to the quarry design process:

- Inform the process - concerns and issues can inform the quarry design process, provide a clear audit trail and create proposals that stand up to close scrutiny and cross examination.
- Local knowledge - can be vitally important to the quality of the decision making process.
- Public relations - fosters trust in the Industry and potential support for future proposals.
- Building community - the process of working together and achieving things together creates a sense of community.
- Compliance with legislation - community involvement is often, and increasingly, a statutory requirement.
- Democratic credibility - community involvement in planning accords with people's right to participate in decisions that affect their lives. It is an important part of the trend towards democratisation of all aspects of society.
- Speedier Development - people gain a better understanding of the options realistically available and are likely to start thinking positively rather than negatively. Time-wasting conflicts can often be avoided.
- Sustainability - people feel more attached to an environment they have helped create. They will therefore manage and maintain it better, reducing the likelihood of vandalism, neglect and subsequent need for costly replacement.

The Community Planning Handbook - N Wales, Wates (2000)

7.1.2 Existing methods of Public Consultation in the quarrying industry

Consultation in relation to mineral planning for quarries (as distinct from large scale mining) generally consists of:

- One to one meetings with interested individuals or small groups
- Establishment of a Liaison Group drawn from the company and the community and regular meetings
- Public exhibitions
- Quarry open days
- Public meetings.

One to one meetings:

One to one meetings with interested parties (or meetings between company representatives and small groups), especially those concerned about the impact of a proposed quarry development on their lives, can be an extremely valuable way of engaging with the public, imparting accurate information in direct response to their questions, and fostering mutual understanding (even if that is expressed an agreement to differ). Even where they continue to oppose, and seek to stop a quarry scheme, residents who feel that they have been listened to and that their views and ideas have been heard and taken into account, are more likely to engage with the company in a constructive way rather than be locked in acrimony during the application and consultation period. Conversely, residents presented with 'glossy' information about a proposal without any warning or opportunity to discuss what is proposed, feel defensive and upset and powerless to influence the outcome other than by fighting to stop the proposals ("you've already decided what you are going to do, nothing we say will make any difference – we're going to fight you all the way"). Establishment of such a dialogue, before plans are fully formed and an application is submitted, makes it easier for residents to continue to interact with the company if their objections are not upheld and a permission is granted. Where decisions ultimately go against the objectors, the authors' experience is that the process of constructive dialogue, rooted in the company listening more and telling people things less, often leads to the identification of compromises that can be made that are not business critical, but that mean a lot to those who have been worried about the impact of the development. Participating in this type of informal consultation and engagement requires patience and listening skills – some people are instinctively good at this, whilst others might benefit from training in mediation and active listening.

Liaison groups:

Liaison groups are looked upon favourably by the Mineral Planning Authorities, and planning permissions in England and Wales often incorporate (*via* a condition or a section 106 obligation) a requirement for such a group to be established. The quarry company is able to discuss and resolve issues at a local level without involving the MPA formally (although it may be represented or invited to attend) and this maintains good public relations. Where operators have been able to establish effective dialogue with residents during the planning phase, the liaison group may have existed in an informal way for a considerable period by the time the planning permission is granted. Liaison meetings would normally be attended by the quarry manager, experts relevant to the topic of conversation and one or more community representatives (*e.g.* a member of the local Parish Council). Experience shows that such groups or committees are best chaired by a local councillor or other community representative (or sometimes a completely neutral party) rather than by a representative of the operator. Issues such as noise and operating hours can be discussed and the members can cooperate to avoid or resolve disputes. The limitation of a liaison group is that they normally involve only a small number of stakeholders, but this limitation can be very effectively overcome where local communications are strong, and where effort has been put into establishing constructive working relationships during the planning period. Operators may assist in a process of dissemination of information through, for example, funding the preparation and circulation of a bulletin or newsletter from the liaison committee reporting on its work. It may also be helpful for the liaison group to contribute a regular piece to the local parish or community magazine.

Public exhibitions:

Public exhibitions are an educational and informative method, presenting a positive face of the industry, which allows people to view proposals and ask questions of the company representatives. The limitations can be that the proposals can be perceived as a *fait accompli* if they do not engage people on a participatory level in an ongoing decision making process. The advantages of already having engaged in informal relationship building through one to one and small group meetings before mounting such an exhibition are obvious. Well planned and properly followed up, such exhibitions can provide an excellent starting point to ongoing discussion and engagement, especially if participants feel (through feedback from the operator in follow-up meetings or printed materials and/or from their experience of having been listened to in the period of scheme planning) that their views are being listened to, understood and genuinely taken into account (even if not fully agreed with).

Quarry open days:

Quarry open days are an excellent opportunity for the quarry companies to raise public awareness and interest in the quarry industry; they involve a limited amount of consultation. A visit to a quarry open day can be very valuable for residents who live in communities facing the prospect of quarrying in their local area. They can see for themselves what goes on inside the quarry and look at how effective screening and other environmental mitigation measures can be – this helps them to better articulate concrete ideas and requests that would make the quarry more tolerable if permitted.

Public meetings:

Public meetings are forums to allow everyone to attend and have their say regarding proposals that are due to be, or have been, submitted to the mineral planning authority. Whilst all stakeholders can attend, the meetings can often be dominated by a vociferous few and standing with a microphone in a crowded room can be intimidating for some. Sensitive and firm chairing of such meetings by a neutral or trusted individual can help to reduce these difficulties.

True consultation requires the inclusion of stakeholders as early as possible in the decision-making process. It is important to plan stakeholder consultation activities about new proposals (and, in the case of operating quarries, ongoing liaison) very carefully to avoid the events being (or being perceived to be) reactive rather than interactive. If it appears that decisions have already been made and the stakeholders are being invited to respond with no obvious prospect of influencing the scheme, the 'consultation' may do more harm than good.

7.1.3 Mineral planning application decisions and public consultation

The MPA can notify and consult with the public through the following methods:

- Advertisement in local newspaper and/or site notice
- Notification of a select geographical area by letter
- Multiple site notices
- Plans displayed in local community facilities
- Use of public meetings

7.1.4 Stakeholder workshops

In addition to the commonly used methods identified above, the company may wish to consider other means of consultation and engagement such as stakeholder workshops. In the context of urban design, stakeholder workshops (also known as "charrettes") are a tried and tested means of fully engaging stakeholders in the decision making process. Research has proved their potential benefits to mineral planning applications (Charrette Stakeholder Consultation for the Mineral Industry MIRO, 2006). Stakeholder workshops can be open to anyone with an interest, or be limited to selected representative stakeholders from any of the stakeholder groups identified.

Group facilitated discussion Group presentations Site visits

7.1.5 Issues and Concerns of Stakeholders

The following are issues and concerns that are, in general, likely to be raised in relation to mineral planning applications or existing operations. This list is not exhaustive but gives a flavour of typical concerns:

- Whether public access will be allowed to the restored sites.
- What the quarry after-use will be.
- Whether the quarry could be operated according to suggested alternative options
- How long the quarry operation will go on.
- Whether there is a need for the proposal in terms of market demand.
- What the access arrangements will be to the site during construction, operation and restoration.
- Whether the roads will be busier and more dangerous.
- That there will be increased toxicity/dust pollution
- What the level of monitoring of toxicity will be.

- What the impacts will be on local ecology and biodiversity.
- Whether the operator is telling the truth about what the site will really be like.
- Whether the operator may be engaging in covert activities such as removal of orchids or translocation of newts.
- Whether local property will be devalued (N.B. this is not a planning consideration)
- Whether the site will be noisy.
- What the impact of blasting (vibration and air overpressure) will be.
- What personnel changes will there be at the site to ensure the public know who to contact (good quarry neighbour)
- Whether the site will be safe.
- How the site will develop and change over time (working programme).
- What benefits are being offered to local people, (employment, investment etc.)

7.1.6 Successful consultation and engagement in the Quarry Design process

Developing a consultation strategy early on in the Quarry Design process can define:

- Motives and results required. This ensures that the right consultees are contacted in order to receive the necessary information at every appropriate stage.
- Who is responsible for consulting and with whom.
- The budget to be allocated to consultation.
- The timing and sequence of consultation. In particular, which stakeholders are consulted and when will vary according to the stage reached in the quarry design process. The Environment Council's (2004) Good Practice for Stakeholder Engagement in the Aggregates Sector contains useful advice on the type and method of consultation that should be conducted at the pre-application, application, operations, restoration and after use stages.
- The type and method of consultation. This could range from a formal letter requesting a written response, to a public meeting. Different types of consultation will suit different stages of the process and the type of consultee involved.
- The need for professional facilitators. Facilitators can be useful as mediators of conflict by their taking a neutral stance on the proposals. Facilitators also act to ensure a meeting or stakeholder workshop remains focussed.
- What will be done with the results. The results of any consultation exercise will need to be communicated to the quarry design team and incorporated into the design process.
- Evaluation of the consultation process. Evaluation is necessary throughout the quarry design process to ensure the appropriate consultation techniques and methodologies have been used. Evaluation of findings can inform the direction of future projects.

7.2 COMMUNICATION

Clear communication of aspirations, ideas, processes, timescales, physical information, financial data, environmental impacts and consequences is essential at all stages of the quarry design process. This need for clear communication is necessary both internally within the developer/mineral company and externally with third parties. Key channels of communication include:

- Within the developer body.
- Between the land/mineral owner and the developer body.
- Between the developer body and its consultants.
- Between the developer body/consultants and the local authorities.
- Between the MPA/developer body, consultants and the Statutory Consultees.
- Between the MPA/developer body and the general public.
- Between the developer/MPA and the press/media.

Concise and precise communication does not guarantee agreement between parties. It does, however, avoid or limit disagreement over misinterpretations or misrepresentations. For example, being precise about the level of costs for different options enable the client to make an informed choice. It is important to avoid communicating inaccurate information or making ill-founded or immovable statements which cannot later be amended. Good communication is cost-effective in minimising abortive work such as additional unnecessary data collection and impact analysis or the construction of unnecessary mitigation measures.

In all cases the appropriate communication techniques must be carefully chosen and rigorously applied as they will be subject to close scrutiny. Quarry development proposals are often contentious developments that may need to be explained at a Public Inquiry.

Communication is a two way process and the importance of listening is vital. Communication takes three main forms each of which needs careful attention:

- Graphic communication.
- Written communication.
- Verbal communication.

7.2.1 Graphic Communication

Quarry designs are complex technical concepts involving not only three dimensions but the passage of time. Clear, simple and consistent graphic representations of these designs are the easiest and quickest way to communicate them, especially to the lay person. Final schematic plans or representations should flow ‘up’ from detailed work not vice versa. Plans should be uncluttered and at appropriate scales. It is generally helpful for scales and layouts of plans to be consistent within, for example, the ES so as to facilitate the making of comparisons and the identification of interrelationships between features and proposals. Whatever they show, all plans used to communicate a quarry design should include:

- A grid (preferably the OS grid).
- A north point.
- Surrounding features and boundaries that help locate the site.
- Clear annotation.
- A scale bar.
- A concise key or legend.

- Consistent and precise title block information e.g. site name, unique drawing or figure number.
- Comprehensive drawing revision detail.

The same principles should be applied to all drawings including cross-sections or elevations. Consideration needs to be given to the clarity of information if the drawing is reproduced at a different scale or colour (e.g. how will a coloured plan look if it is photocopied in black and white?).

Graphical visualisation techniques

A growing range of visualization techniques is available, and computer technology and multimedia now present significant opportunities for those engaged in all aspects of Quarry Design.

The precise choice of graphical technique for a particular scheme will depend on the nature of the development, data available, timing, budget and level of accuracy required.

Use of latest computer technologies and high quality aerial and ground level images can create a very realistic rendering of the proposed development within the existing environment.

Examples of graphical presentation techniques:

- Plans, elevations, sections and exaggerated sections.
- Overlays.
- Perspective sketches, which may be constructed over computer-generated wire lines.
- Precedent images of similar projects – as long as it is made clear they are only indicative.
- Artist's impressions that are not accurately constructed are not recommended.
- Charts and tables – can permit ready comparison between different scheme options and types of effect; can be valuable in the early stages of the quarry design process. When exploring options with the quarry developer a cost benefit analysis chart may be prepared for each technique proposed.
- Photographs (ground level, oblique and vertical aerial) provide excellent and readily understandable site/surrounding information. Photomontage provides the direct comparison of the predicted change in the landscape, the precise nature of any impact is communicated clearly. Guidance on the use of cameras, lenses etc is given in the IEMA/LI Guidelines for visual and landscape impact assessment. Photomontage is the superimposition of an image onto a photograph for the purpose of creating a realistic representation of proposed or potential changes to any view. Traditionally these were created manually by hand rendering. Today most are generated using computer imagery. Physical models.
- Video and or digital video simulations – can show movement and video montages can be produced.
- Terrain modelling software.
- 3D Visualisation.
- Virtual reality model built up from OS, digital terrain maps and data from aerial photography – makes it possible to view any aspect of a development from any viewpoint contained within the boundary of the model.
- Three dimensional animation.

In general, photomontages and 3D visualisation techniques that allow a stakeholder to look at an image of the proposal from their point of view (*e.g.* from a bedroom window, street *etc*) are more effective tools for communicating proposals than aerial views, which will tend to suggest significant visual impact.

Masterplan for residential development in disused chalk pit. This image superimposes a 3D model created using 3D Visualisation software, over a perspective aerial photograph.

The Virtual Reality model can offer visualisation in the fourth dimension by demonstrating changes over time. For example, it could be used to predict the degree of screening afforded by planting over time, which is in turn useful for determining the mitigation of impacts.

To complement technical plans in CAD, computer graphics can aid the presentation. The plan can be rendered in the computer using scanned or hand drawn textures to create realistic 'aerial view' impressions.

Digitally produced drawings have the following communication advantages:

- More flexible then traditional hand rendered drawings.
- Multiple copies can be run off at various sizes , colours and scale with little change in quality.
- Alternative plans can easily be developed from a base plan.
- Revision and amendments can be carried out more easily.
- Can be supplied electronically or incorporated into presentation software such as PowerPoint or distributed on the internet.

Spatial and Geographic Information Systems (SIS & GIS)

SIS & GIS are useful in the quarry design especially when an integrated approach is needed on large scale projects. Layers of data on a variety of topics such as topography, soils, drainage catchments, archaeology can be collated, sieved, selected or superimposed and composite plans produced.

7.2.2 Written Communication

Effective written presentation as part of the Quarry Design process requires the use of a precise language that is to the point and impartial. Presentation of findings in text form needs to be clearly set out in the context of the defined methodology and supported by appropriate figures and illustrations.

Communicating through writing can be more concrete than verbal communications, with less room for error. When writing it is important to be mindful of the fact that once something is in written form, it cannot be taken back.

Written communication in the Quarry Design process includes:

- Specialist expert reports.
- Environmental Statements.
- Supporting statements with planning applications (often incorporated with the ES).
- Non technical summaries.
- Information leaflets and presentation materials produced for consultation and PR purposes.
- Correspondence.
- Agreements and contracts/tenders.
- Specification documents.
- Minutes of meetings and agenda.

All of these are important and have a role to play in communicating quarry proposals. They require a range of styles appropriate to their purpose, but a common theme is clarity and consistency within and between such documents. The most substantial document produced in relation to an individual quarry design will normally be an Environmental Statement. This will often be the source of background information for some of the other documents listed above. The requirements for such a statement (in terms of successfully communicating the proposals and their impact) include:

- Clear project scope and definition.
- Identification of methodology.
- A logical sequence of information such as site baseline data at the start of the report and findings/ recommendations towards the end. This builds a case for the development proposal.
- Knowledge of target audience. The non technical summary, for example, is intended to allow the lay person to understand and contribute to the decision making process, and should be written with this in mind. However, technical appendices in the ES do not need to be so accessible to non-specialists as the target audience is more likely to be specialist consultees.
- Acknowledgement of the limitations of the project.
- Definitions of any technical terms used and a glossary of terms.
- Careful referencing and cross referencing of information sources and a bibliography.

7.2.3 Verbal communication

Verbal communication is an excellent means of establishing a rapport between the operator and a range of stakeholders and can be a good way of reinforcing or clarifying proposals and objectives that have previously been set out on paper. Given the danger of misinterpretation associated with verbal communication, it is always wise to record or confirm any verbal agreements or the substance of important conversations in writing.

Meetings in person have the potential to gauge reactions, resolve conflict and clarify issues, provided they are handled in a professionally skilled manner. Such meetings can develop good working relationships, put a face to the project, and foster an atmosphere of trust, allowing the exploration of options and providing an opportunity to justify and promote these options. Graphical and written communication will often require verbal confirmation, discussion and justification.

Types of verbal communication relevant to quarry design include:

- Team meetings
- Project meetings
- Multidisciplinary meetings
- Managerial meetings
- Casual conversations
- Telephone calls
- In person
- One to one
- Appraisals
- On site meetings

For success in all the preceding types of verbal communication it is necessary to make statements and comments that are considered and professional. There are many courses available that offer verbal communication skills training. Examples include assertiveness training courses that deal with the common misconception that being assertive is the same as being aggressive. Presentation training courses can bring out the best in staff in terms of their presentation techniques and confidence in public speaking. Understanding the psychology of verbal communication can improve one's technique and effectiveness, for example it is worth bearing in mind that 90% of any verbal act involves non-verbal action!

CHAPTER 8
MANAGEMENT OF THE QUARRY DESIGN PROCESS

8 MANAGING THE QUARRY DESIGN PROCESS

8.1 INTRODUCTION

There is a need for effective management at all key stages of the design process (Part II of this Handbook). Management characterises the process of leading and directing all or part of an organisation, through the deployment and manipulation of resources (human, financial, material, intellectual or intangible).

The functions of management can be divided into:

- planning
- organising
- leading
- coordinating
- controlling.

The first stage of the management process is the identification of what needs to be managed, *i.e.* the quarry design process. The next stage is the appointment of a project manager or managers to progress the quarry design process from the feasibility, initial concept, stage through planning and monitoring to final restoration.

Optimum management of the whole planning and design process ensures the best results for the best balance of environmental and financial cost.

This chapter identifies key areas necessary to ensure successful quarry design project management and the associated management systems that support these key areas.

8.2 PROJECT MANAGEMENT

Project management is the application of knowledge, skills, tools and techniques to a range of activities, such as the preparation of an EIA and the design of the quarry layout and restoration scheme, in order to meet the requirements of the Quarry Design project. The Quarry Design project management process covers:

- Project **initiation**
- Project **planning**
- Project **execution**
- Project **control**
- Project **closure**.

Successful quarry design requires that the project manager incorporates the following key project management areas:

1	Scope management
2	Time management
3	Cost resource management
4	Quality management
5	Human resources management
6	Communications management
7	Risk management
8	Procurement management

8.2.1 Scope management

As with a scoping study for an EIA, Project Scope Management includes the processes required to ensure that the Quarry Design project includes all the work required, and only the work required, to complete the project successfully. Project scope management is primarily concerned with defining and controlling what is and is not included in the project.

8.2.2 Time management

By creating a schedule and sticking to it through good time management there is more chance of keeping in budget. Good time management can be achieved by creating a timetable and schedule that:

- Lists, in order, all the tasks that need to be completed.
- Assigns a duration to each task.
- Identifies interdependencies between tasks and critical paths
- Allocates the required resources.
- Is realistic.

By having prescience and experience of similar projects such as an understanding of the time taken for the production of specialist reports and the planning application system, it is usually possible to provide a realistic estimation of time frames. When all tasks are listed, resourced, and sequenced, it will be apparent that some tasks will have flexibility in their required start and finish date and some will have no flexibility. A line through all the tasks with no flexibility demonstrates the critical path whereby all tasks on this path must be completed on time if the project is to be completed on time. The Project Manager's key time management task is to manage the critical path. Tasks can be overlapped such as the timing of consultations and carrying out of various specialists' assessments.

It is unwise to develop a timetable and schedule that is rigid as this can lead to the cutting of corners in an effort to adhere to it. It is generally better to lose a few weeks or months and do things properly rather than to compromise the chances of success.

Where possible it is useful to build in some contingency time to allow for unexpected occurrences and the associated extra time and costs involved. For example an application may be refused, go to appeal or have unexpected conditions placed on it.

At a strategic level, a plan is required in order to consider costs down the line, for example life of the quarry, extent of reserves, planning for potential extensions and future applications.

8.2.3 Cost resource management

The Project Manager's job is to:

- Keep the actual cost at or below the estimated cost
- Use as little of the design allowance and contingency as possible
- Maximize the profit the company earns on the project.

By effectively managing the project resources and schedule the Project Manager is likely to complete a project within budget. The Project Manager should give priority to the management of critical cost items. Spreadsheets or proprietary project management software are an efficient system for monitoring and predicting project expenditure. The type of costs should be established at the outset of the project, costs can be divided into:

- Actual
- Estimated
- Variable

Where possible, contingencies should be incorporated to cover unexpected or unlikely occurrences.

8.2.4 Quality management

The creation of a Quality Assurance (QA) Plan is a useful tool for defining the quality goals of the quarry design project. The formulation of a QA Plan will require:

- Discussion of the approach and plans to achieve the goals
- Assessment of the risks involved
- Setting of high achievable standards.

The QA Plan and system should include procedures for:

- Auditing.
- Identifying and correcting non-conformance.
- Management review.

8.2.5 Human resources management

The quality and motivation of the workforce both internally and externally are integral to the success of the quarry design project. The project manager is responsible for the planning, formation, organisation and management of effective quarry design teams with a balance of the relevant expertise and experience (see charts in the introduction to Part III).

It is important that the Project Manager takes on a strong lead role in order to keep the project on focus and on track. This will require the coordination of personnel by regular monitoring and review of the project's progress, delegation of tasks and the setting of deadlines. The Project Manager identifies the criteria for successful team performance (outlined below) and articulates a strategy and plan for achieving team goals. The setting of short term rather than long term goals, that are achievable, are less likely to demotivate staff. Established systems and means of two way communication are essential to ensure problems are solved promptly and efficiently.

Criteria for successful team performance:

- Communication – importance of regular contact to be aware of any problems early on in the process. Provide clear advice and instruction.
- Provision of all necessary information e.g. baseline data on site.
- Resolve problems and issues quickly.
- Development and performance management – training at all levels of the organisation; appraisals, feedback, value, goals, CPD.
- National Occupational Standards – Guidance on standards of performance, knowledge and understanding.
- Organisation – delegation, clearly defined roles, skill set meets task.
- Equal opportunities awareness.
- Occupational health – understand risks and duties under relevant regulations (e.g Quarries Regulations, CDM).
- Team psychology – motivation, collaboration, responsibility, mindset, team spirit, attitude, empowerment, balanced teams. Ownership of the project: the team monitors their progress rather than project manager.
- Time management with clear deadlines

Criteria for successful performance of external employees such as Consultants and Contractors:

- Communication – importance of regular contact to be aware of any problems early on in the process. Confirmation of conversations in writing; clear advice or instructions. May need steering group to guide the consultants; named or specified lead contacts; consultants need to be aware of who is on the team.
- Provision of all necessary information e.g. baseline data on site
- Effective contracts or agreements – define deadlines; time frame and detailed requirements; establish costs and/or fees e.g. specialist reports; specification; check consultants' methodology; may need references; evidence of performance
- PR - maintain good relations; value work; build good rapport
- Resolve problems and issues quickly and ideally in partnership with the consultant or contractor
- Clear deadline for submission
- Database of consultants' skills – ensure skill set meets task
- Allow time for consultant to consider brief and prepare proposals
- Occupational health – understand risks and duties under relevant regulations (e.g. Quarries Regulations, CDM)
- Payment on time

8.2.6 Communications management

Communication management is one of the essential functions that can dramatically affect the outcome of a project. Effective project managers create and implement a communication plan that performs two principal functions:

- Collection of the right data
- Dissemination of appropriate information in a timely manner.

Effective implementation of such a plan relies particularly on:

- Identification of the appropriate audiences.
- Development of appropriate communication media.
- Establishment of a communications schedule.
- Management of the flow of information both within and to and from the project team.

A more detailed discussion of communication requirements is included in Chapter 7.

8.2.7 Risk Management

Project risk management seeks to anticipate and address uncertainties that threaten the goals and timetables of a project. The uncertainties in a quarry design project may include site geology (e.g. depth and quality of minerals); effects of delays in completing site investigations and environmental assessments; or budgetary and personnel changes. These risks can lead rapidly to delays in delivery dates and overspend that can severely undermine confidence in the project and in the project manager unless anticipated and managed.

Putting together a risk management plan can help to:

- Identify risks.
- Quantify risks.
- Plan a response to risks.
- Implement procedures to monitor and mitigate or control risks.

A methodology for design risk assessment and a framework for risk management is covered in more detail in Chapter 6

8.2.8 Procurement management

Project procurement management focuses on that part of the project's scope of work which will be bought from another organization. Such transactions are sometimes the result of company teaming arrangements, but most typically result from contracting or subcontracting. For example, the design of the quarry layout and phasing, or production of the specialist reports included in an ES may be outsourced.

The project manager is required to develop a structured approach for incorporating procurement management tasks into project plans, schedules, and budgets. Procurement issues also need to be included in risk assessment and risk management plans.

The successful performance of external employees, contractors and specialists are relevant to procurement management procedures. The establishment of project files for all contracts, specifications, and deliverables is advisable.

8.3 SYSTEMS MANAGEMENT

The application of the key project management areas to successful quarry operations requires the implementation, monitoring and review of the following systems:

- Administrative
- Data storage and retrieval
- IT
- Health & Safety
- Operational
- Quality Assurance
- Environmental

The above systems constitute one larger system but, due to their interconnectivity, changes to one component are likely to bear an impact on another. Systems management therefore requires a holistic approach and it is important to ensure that a person (or persons) is responsible for updating and maintaining the system and its component systems.

8.3.1 Administration

Administrative systems can provide a clear audit trail and means of tracking correspondence and generating periodic reports such as the annual site survey and extraction figures. The production of standard templates and proformas for environmental assessment and site surveys can avoid costly omissions and save time (staff need not reinvent the wheel). The Administrative management system should ensure a consistency of house style and strong corporate identity.

Additional requirements of the administrative system include:

- Methods of producing reports at the required stage in the project.
- Methods of recording correspondence such as complaints and the action taken.
- Methods of recording site visits and surveys.
- Meeting management such as agendas and minute taking.
- File maintenance such as the recording of company contact details and consultant database and skill sets.
- Methods of recording and managing personnel details.

8.3.2 Data Storage and retrieval

Keeping a record of a project and ensuring that information is easily accessible is important for reference on future projects or as the project progresses. The information can be used to identify areas for improvement or change in the management of the quarry design process. These records are also important for monitoring compliance with planning and licence conditions and in planning any future site extensions. In developing systems and procedures for data storage and retrieval, consideration has to be given to:

- What information is important to the company in the short and long term?
- How will information be stored and retrieved?
- What is the capacity for storage.
- Who will update the system?

For example, does the company have a library or archive, how long are records kept and who is responsible for archive control?

8.3.3 Information Technology (IT)

The Manager of the quarry design process has to weigh up the benefits in terms of need, costs and quality when considering whether to use software in house for the quarry design process or whether to outsource. Very often this decision has more to do with the availability of personnel to operate software than the choice of software or IT systems *per se*. In house systems require the capacity to meet the demand. This is a check that must be performed before the project commences in order to avoid costly delays due to the failure of parts or all of the IT system (including availability of operators). It is important that there is an IT Team (or person) responsible for the security and maintenance of the system, ensuring that a supporting network infrastructure is in place.

IT systems should also facilitate the transfer of data between the company and external contacts. It is advisable to brief all members of the quarry design team at the start of the project as to preferred file sizes and formats to be used for delivery and exchange of project information (e.g. word processor, spreadsheet, surface modelling and portable document file types).

8.3.4 Health & Safety

In order to have a chance of being implemented successfully, quarry designs need to anticipate the need for effective Health and Safety management systems. Effective Health and Safety management systems require:

- Methods of carrying out and recording H&S assessments and incidents (the health and safety document required under Regulation 7 of the Quarries Regulations 1999).
- Provision of H&S training to all staff and records of when it occurred.
- Methods of ensuring everyone is aware of their responsibilities under relevant regulations (the Quarries Regulations in quarries).
- Appointment of a Health and Safety Officer to carry out in house H&S Audits and ensure all obligations and activities are met.
- Ensuring competent appointees throughout the organisation and maintaining competency through continuing professional development (CPD).
- Occupational health system.

As discussed in Chapter 6, a key element of design risk assessment is the assessment of operational risks, many of which are concerned with safety. The quarry design process (incorporating design risk assessment) is a helpful framework within which to ensure that an effective Health and Safety management system can be implemented when the quarry is established and operating.

8.3.5 Operational management system

As with Health and Safety management, the quarry design process should result in a scheme that can be effectively managed and that provides a framework for the development and resourcing of an appropriate operational management system.

8.3.6 Quality management system

A company may consider using an internationally recognized quality management standard such as ISO9001. The ISO9001 process provides a robust framework for improving an organisation's quality system by adopting quality management principles and standards.

In accordance with ISO 9001 Standards the QM system includes:

1. Production of a Quality manual.
2. A procedures manual to support the quality manual outlining who does what and when.
3. Methods of assessing customer requirements and ensuring these results are disseminated to all staff.
4. Methods to continually improve effectiveness of the system by:
   - Carrying out regular management review to ensure the system continues to be suitable, adequate and effective.
   - Identification and implementation of preventative measures to improve levels and quality of service.
   - Review findings of internal and external audits to determine if the system still meets requirements of BS EN 9001 and is effectively maintained.
   - Reviewing quality objectives
   - Providing means for all employees to participate in management of system.
   - Setting of quality objectives which are measurable and consistent.
   - Communication of objectives in writing and verbally through team meetings and training.
   - Provide adequate resources to maintain the quality of the system and continually improve its effectiveness.
5. Provide written records as evidence of conforming to requirements.
6. Notification of verification dates from internal and external verifiers.
7. Storage of certificates, registration documents and correspondence.

8.3.7 Environmental management systems

An Environmental Management System (EMS) provides a systematic framework for an organisation to manage the environmental impacts of its operations such as the effectiveness of screening and control of noise and dust. A well-written and managed EMS can result in considerable benefits, including:

- Reduced operational costs
- Reduced waste generation
- Reduced environmental risk
- Improved sales opportunities
- Improved relations with stakeholders.

The company may wish to use an internationally accepted standard for EMS such as ISO 14001. The Quarry Products Association ran a pilot scheme at Rotherham Sand and Gravel quarry, which was designed to assist and encourage its smaller members to achieve ISO4001. This generated guidance notes that are now available to other operators. (*ref to be added*)

The ISO 14001 specifies requirements for:

- Establishing an environmental policy
- Determining environmental aspects & impacts of products/activities/services
- Planning environmental objectives and measurable targets,
- Implementation & operation of programs to meet objectives & targets
- Checking & corrective action
- Management review.

As with ISO9001, the EMS requires a planned comprehensive periodic audit to ensure that it is effective in operation, is meeting specified goals, and that the system continues to perform in accordance with relevant regulations and standards. The audits are designed to provide additional information in order to exercise effective management of the system, providing information on practices which differ from the current procedures or offer an opportunity for improvement. In addition to audit, there is a requirement for management review of the system to ensure that it is suitable (for the organization and the objectives) and effective in operation.

PART IV
APPENDICES

APPENDIX 1-1	THE PLANNING AND LICENSING PROCESS – ENGLAND
APPENDIX 4-1	RESOURCE EVALUATION FOR AGGREGATES
APPENDIX 4-2	PRINCIPLES OF DESIGN FOR SAND AND GRAVEL QUARRIES
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APPENDIX 4-6	ECONOMIC MODELLING FOR FEASIBILITY STUDIES AND BUSINESS PLANNING

APPENDIX 1-1
THE PLANNING AND LICENSING PROCESS - ENGLAND

SIMPLIFIED PLANNING APPLICATION PROCESS

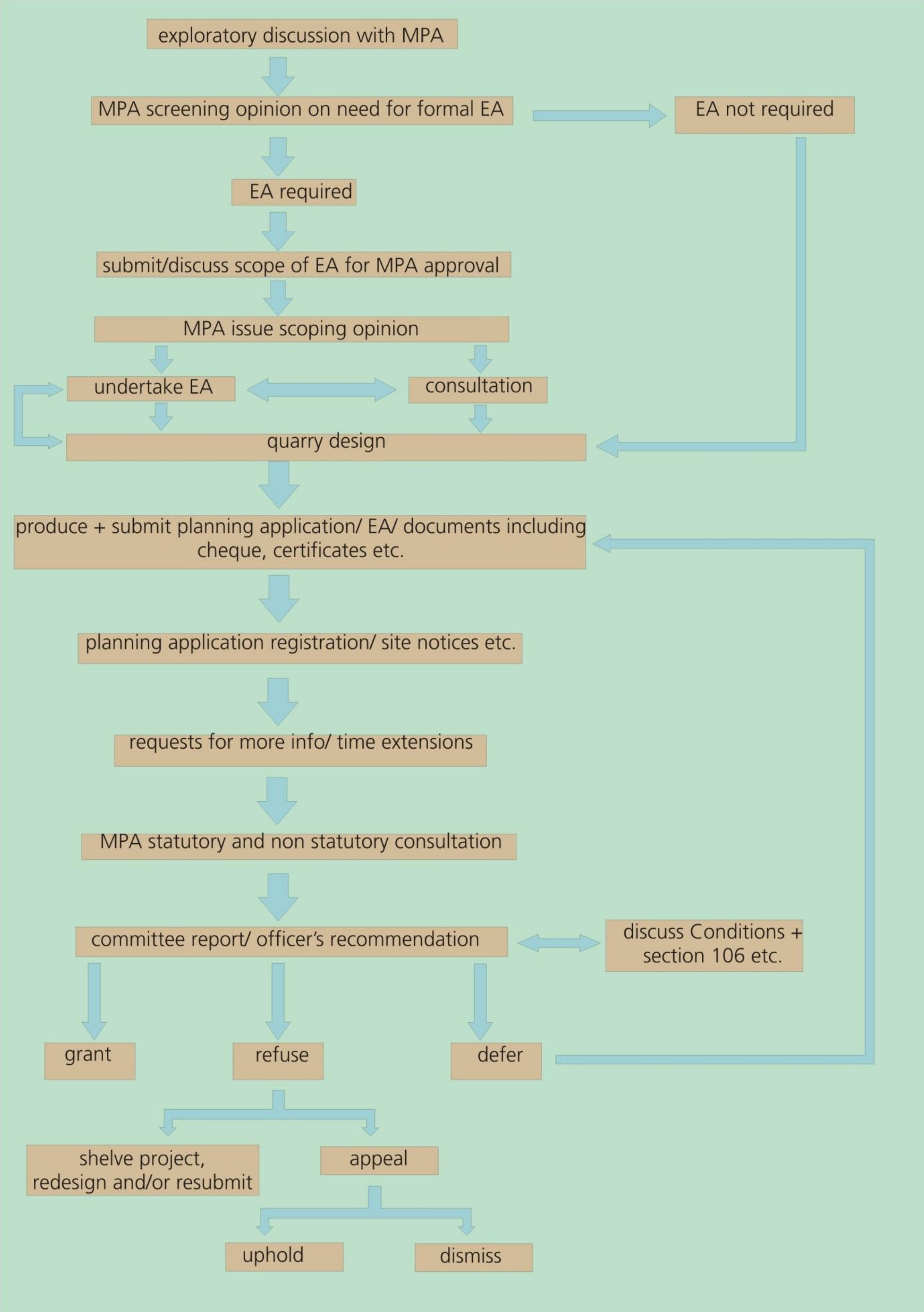

Figure 1-1 simplified flow diagram of the planning application process

1 THE PLANNING AND LICENSING PROCESS - ENGLAND

Mineral extraction, processing and transportation cannot take place typically without appropriate planning permissions and/or licences. This makes it of fundamental importance that the quarry design team understands the legal/planning context of the country in which extraction is to take place.

The important elements of a mineral planning and licensing system that need to be understood as a basis for successful quarry design anywhere in the World are described generically in Part I of the Handbook, Chapter 1. Chapter 1 is intended to provide a general introduction for a reader of the Handbook from any country. This Appendix supports Chapter 1 by giving a more detailed description of the planning and licensing system that operates in England; note that much of the material in this Appendix is also relevant in the other countries of the United Kingdom, but that there are some variations which would need to be taken into account.

Mineral extraction, processing and transportation cannot take place without appropriate planning permissions and licences. This makes it of fundamental importance that the quarry design team understands the planning context. In particular, the team needs an awareness of:

- The role of Government, Authorities and Statutory Consultees
- The relevant Acts of Parliament and other Planning Legislation
- Government Planning, Mineral and other Policy Guidance
- The role of Counties, Unitary Authorities and Districts/Boroughs etc.
- The environmental assessment rules, regulations and process
- The planning application process
- The appeal process
- The licence/permit application process

These matters are well covered in other texts and relevant legislation (see bibliography, Part V, and selected references and suggestions for further reading at the end of this Appendix). This Appendix does not seek to duplicate or summarise this body of material. Reference is made, however, to provide a general introduction to the stages in applying for a mineral planning permission in England, the ways in which other interested parties may participate, challenge and be informed and options available for appeals and variations.

When undertaking new development, an application must be made to the Local Planning Authority. For mineral related applications, *i.e.* the winning and working of minerals or ancillary operations (not those specifically located on industrial estates *e.g.* Concrete Batching Plants) the relevant Authority will be the Mineral Planning Authority (*i.e.* the County Council or the Unitary Development Authority).

The process described below is illustrated in Figure 1-1.

1.1 Who may apply for planning permission?

Anyone can apply for planning permission whether they have a legal interest in the land or not.

1.2 What are the essential elements of a planning application?

Planning Authorities provide a range of planning application forms each tailored to fit the type of development proposed. Further general information may be found *via* the Planning Portal[1] for England and Wales (there are also links on that site to equivalent information for Scotland and Northern Ireland[2]). These forms will seek to establish basic information about the development proposal. In many cases it is necessary to provide additional information in support of the application in the form of plans and drawings and a supporting statement describing the proposals in detail. Local Planning Authorities are required to provide planning application checklists which include the minimum

[1] www.planningportal.gov.uk/
[2] www.planningportal.gov.uk/general/glossaryandlinks/links/scotlandnireland

local and national requirements of plans and documents necessary for an application to be deemed valid. If a Planning Authority considers that insufficient information has been provided to it for the purpose of evaluating and determining the application, it can require further information to be made available before commencing the process. Any detail or proposal that is provided with a planning application (or subsequently in the course of the consultation and determination stages) becomes part of the planning permission if the application is granted unless it has been amended or superseded by requirements of the planning permission (conditions) or specifically withdrawn from the proposal. Thus, a phased working and restoration scheme that is approved as part of a planning application becomes the approved scheme of working and restoration against which the planning permission will be monitored in the future by the Planning Authority.

The application will need to be accompanied by the appropriate Certificates. These confirm that the applicant or its agent has served notice on those with an interest in the property:

- Landowner – where the applicant does not have the freehold interest in the whole of the application site.
- Tenant – with an unexpired term of more than 7 years
- Tenant of an agricultural holding

It will also need to be accompanied by the appropriate planning application fee. For mineral extraction applications the current scale of fees, effective from 7 April 2014 is:

10. The carrying out of any operations not coming within any of the above categories	(1) In the case of operations for the winning and working of minerals (a) where the site area does not exceed 15 hectares, £195 for each 0.1 hectare of the site area; (b) where the site area exceeds 15 hectares, £29,112, and an additional £115 for each 0.1 hectares in excess of 15 hectares subject to a maximum in total of £65,000 (2) in any other case, £195 for each 0.1 hectares of the site area, subject to a maximum in total of £1,690

In some cases the application will also need to be supported by an Environmental Statement. This is discussed in more detail below.

1.3 What are the main relevant Acts of Parliament?

1.3.1 Town and Country Planning Act 1990

The 1990 Act consolidated the various preceding pieces of legislation. The key elements of the Act from a mineral perspective are:

- The re-definition of the role of District and County Councils in the planning process. County Councils being responsible for both the forward planning and determination of mineral related developments (often referred to as the Mineral Planning Authority or MPA).
- The introduction of the requirement to prepare Development Plans (now overtaken by the 2004 Act (see below)).
- The requirement, under Section 54A of the Act, that "the determination [of the application] shall be made in accordance with the plan unless material considerations indicate otherwise." (Now superseded by Section 38(6) of the Planning and Compulsory Purchase Act 2004).
- The definition of development as being either operational development (*i.e.* the carrying out of building, engineering, mining and other operations) or change in use (*i.e.* the making of a material change in the use of any building or other land).

1.3.2 Planning and Compensation Act 1991

The Planning and Compensation Act 1991 (the 1991 Act) introduced new procedures for dealing with permissions for the winning and working of minerals or the depositing of minerals waste, originally granted under Interim Development Orders (IDOs). These were permissions granted after 21 July

1943 and before 1 July 1948, which have been preserved by successive planning Acts as valid planning permissions.

Unlike permissions issued since the Town and Country Planning Act 1947 (the 1947 Act), there was no requirement to register these permissions, so records were sparse and imprecise, with planning authorities and other interested parties not knowing where permissions existed. Because they were not registered, long dormant workings could also be re-activated without warning. In addition, existing workings could be subject to few, if any, conditions governing the operation of the quarry or its restoration. In some cases, there were large, unworked, extensions to existing workings covered by these permissions, which if worked could have significant adverse impacts on the environment and amenity.

Under the 1991 Act, holders of IDO permissions had to register them with the MPA and, subsequently, to submit a scheme of operating and restoration conditions for the Authority's approval. For dormant sites (those not substantially worked between 1 May 1989 and 30 April 1991) the scheme of conditions must be approved prior to the recommencement of operations. For active sites, the scheme of conditions was required to be submitted within 12 months of registration, unless a longer timescale had been agreed within the MPA.

At the current time most, if not, all IDO permissions will have been reviewed.

A key feature of the review provisions of the 1991 Act is that it gave opportunities for re-design of quarries to which the IDO permissions related.

1.3.3 The Environment Act 1995

The Environment Act 1995 (the 1995 Act) went a step further than the 1991 Act in considering all permissions from 1948 to the present. Under the requirements of the 1995 Act, all mineral planning permissions are required to be reviewed on a rolling 15 year programme (Review of Mineral Planning Permissions or ‘ROMP’) in order to ensure that modern conditions of working and restoration can be applied to all operations.

Under the 1995 Act, old mineral planning permissions were defined as either:

- Dormant
- Active Phase I
- Active Phase II

A site was declared dormant by the Mineral Planning Authority if there had been no substantial mineral working during the period from 22 February 1982 to 6 June 1995. No mineral development may be undertaken on dormant sites until a new scheme of conditions have been submitted to and approved by the MPA.

An Active Phase I site is a site where either the whole or the greater part of the site is subject to a planning permission granted between 30 June 1948 and 1 April 1969. For locations wholly or partially within National Parks, Sites of Special Scientific Interest, and Areas of Outstanding Natural Beauty, the definition of Active Phase I sites also included all sites with planning permissions granted since 1948. For Active Phase I sites, there was a requirement to make a submission to the MPA by 31 October 1998.

An Active Phase II site is a site where either the whole or the greater part of the site is subject to a planning permission granted between 1 April 1969 and 22 February 1982. For Active Phase II sites there was a requirement to make a submission to the MPA by 31 October 2001.

For those sites with a planning permission post-dating 22 February 1982 and the reviewed Phase I and II sites, then there is a requirement for the MPA to review the permission on a 15 year rolling programme.

The 1995 Act cites certain circumstances under which the MPA would be liable to pay compensation if the imposition of new conditions adversely affects the viability of the operation.

For further information on the ROMP process make reference to the online Planning Practice Guidance (http://planningguidance.planningportal.gov.uk/blog/guidance/).

1.3.4 Planning and Compulsory Purchase Act 2004

The Planning and Compulsory Purchase Act 2004 (the 2004 Act) reformed the planning system and aimed to improve and speed up the process.

The 2004 Act resulted in a change to the way in which "forward planning" is undertaken. Previously there was the Development Plan, to which all development had to accord. This Plan was made up of a series of documents:

- The Structure Plan
- The District or Borough Local Plan
- The Mineral Local Plan
- The Waste Local Plan

Within Unitary Authorities, where there is only one tier of local government, the above plans were incorporated into a single Unitary Development Plan.

As a result of the 2004 Act there have been a number of changes.

There was a move away from the above system towards the development of Local Development Documents (LDD), comprising the Local Development Framework (LDF). These were intended to streamline the planning process and promote a proactive, positive approach to managing development.

Under the new system, Local Authorities, at a District and Borough level, are responsible for transferring (then) regional policies and guidance to the local level. Prior to the 2004 Act this role was undertaken by County Councils through their Structure Plans. The Structure Plan was abolished under the Act.

Whilst the County Council has more limited functions under this Act, it retains responsibility for:

- The determination of mineral planning applications and their monitoring and control;
- Maintenance of the mineral landbanks; and
- Preparation of the Mineral and Waste Local Development Framework Documents.

1.3.5 Localism Act 2011

The Localism Act was introduced as a means to reform the planning system to make it clearer, more democratic and more effective. The Act sought to give members of the public increased influence over planning decisions. Arguably the biggest impact of the Act saw the eventual abolition of Regional Spatial Strategies, and with them removal of the regional tier of planning governance.

A further notable change to the planning system from the Localism Act saw the introduction of Neighbourhood Plans. Neighbourhood planning seeks to allow communities, including residents, employees and businesses to join with a Parish Council or local forum group to form a plan (in line with national planning policy) to shape development within the prescribed area.

1.3.6 Growth and Infrastructure Act 2013

Further reforms to the planning system were made through the Growth and Infrastructure Act which became law in April 2013. The Act provides an option for developers to submit major planning applications directly to the Planning Inspectorate where the local planning authority has a poor record of performance. Planning authorities are assessed by the percentage of applications determined within the required timeframe, and the quality of decisions made (*i.e.* the percentage of those overturned on appeal).

1.4 What are the different types of planning application?

In general, a range of planning applications, and therefore planning permissions, can be applied for and subsequently granted:

- Full
- Outline
- Reserve Matters
- Variation of Condition
- Retrospective
- Minor and non-material amendment

As the name would suggest, an application for full planning permission seeks permission for the development in totality. It is this form of application that is used for mineral extraction.

An outline application is only available for built development and seeks to establish the principle or acceptability of that development. The application will not be as comprehensive as a full application and will leave various matters for further consideration. This type of application is not available for mineral developments, although such an application may be made for a new or alternative use of an established minerals site (*e.g.* built after-use).

An application for the determination of reserve matters follows from the grant of outline permission and comprises the submission of further detailed information on matters such as siting, design, external appearance, means of access and landscaping. Again this only applies to built development.

An application for the variation of a planning condition or set of conditions is made under Section 73 of the 1990 Act and seeks permission for the development of land without compliance with conditions previously attached to the permission. The 2004 Act made it possible to make a Section 73 application to extend the life of a permission, this applies both to the period in which the development must be commenced and any end date for operations.

A retrospective planning application seeks permission for a development, which has already been undertaken. This is most commonly used to regularise extraction/tipping which has occurred outside of the permitted area. This is an undesirable mechanism which attempts to put right a wrong and should be used only as a last resort (see also the section on CLEUD below).

1.5 When will an environmental impact statement be required as part of a planning application?

The European Union Directive Number 85/337/EEC (as amended by Directive 97/11/EC) introduced the requirement to undertake an Environmental Impact Assessment (EIA) on a range of developments. This directive was implemented in the UK by the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 2011.

Under these regulations, thresholds are set out in terms of the area of the application site. For a mineral extraction site, Schedule 1 indicates that the threshold is 25 hectares. Mineral development exceeding this site area requires an EIA to be undertaken. However, where proposed development sites are in sensitive locations, lower thresholds may be applied. Where EIA is undertaken, its findings are reported in an Environmental Statement (ES), which is submitted with the planning application (or, if required, with an application for approval of conditions under the 1991 or 1995 Acts).

1.5.1 Screening Opinions

Where an applicant suspects that a development will require environmental assessment, or is unsure, it can ask the MPA for its opinion as to whether an EIA is necessary; this is known as a request for a **screening opinion**. In practice, such a screening opinion should be sought for all mineral-related applications. In order to secure such an opinion, the applicant must provide, as a minimum, a plan on which the site of the proposed development is identified and give a brief description of its nature and purpose and of its possible effects on the environment. If the MPA fails to issue its opinion within 3 weeks, or where an applicant disagrees with the outcome, an appeal can be made to the Secretary of State. The opinion of the MPA is just that, an opinion, and is not binding on the MPA or the applicant. However the Secretary of State has the power to require EIA and, if the MPA's opinion is that no EIA is necessary, that opinion can be challenged through Judicial Review instigated by any interested stakeholder.

Where an application is submitted without an ES, the Authority will, as part of the validation and pre-registration process, undertake an internal screening assessment with the benefit of the information in the application itself (inevitably more detailed than that which could be submitted with a pre-application screening opinion request). This happens whether or not a screening opinion has previously been given by the MPA to the effect that EIA is not required. This screening assessment leads to a decision which, unlike the pre-application screening opinion, is binding unless successfully appealed. This decision will state whether EIA should be carried out or not, and its scope if required. If an EIA is required by the MPA after the application has been submitted, the MPA will not begin the formal process of determining that application until the ES has been submitted.

1.5.2 Scoping Opinions

Where EIA is required and an ES is to be prepared as part of a planning application, the applicant can seek guidance from the MPA as to what issues should be addressed by the EIA. This is done by requesting a **scoping opinion**. As with a screening opinion, outline information in respect of the development proposed and its possible effects must be supplied to the Authority. The Authority is required to issue its opinion within 5 weeks. If this does not happen, the applicant can apply to the Secretary of State for a decision as to what must be covered by the EIA.

Whilst the scoping opinion is only guidance, it is a helpful mechanism for early dialogue with the planning authority and the statutory consultees, whose views will be sought by the MPA in the course of reaching its opinion. There is no standard format or recommended content for the supporting information to be provided with a request for a scoping opinion, and therefore a wide range of approaches is adopted. Some applicants (and/or their advisors) regard the request for a scoping opinion as an opportunity to engage in detailed early discussion with the MPA (and those it consults) as background to the preparation of a very detailed document amounting to an early draft ES. This approach tends to limit the risk that, post application, delays will be caused by the introduction of further elements that should be assessed. Other applicants will confine the supporting information to a general description of the proposed development. This is sometimes accompanied with their suggestions as to what should be covered, and what is not relevant, with a brief justification for the scope proposed.

It should be noted that the Authority is not bound in any way by the comments made in any scoping opinion issued, and may extend the scope of the ES when it undertakes its internal assessment as part of validation and pre-registration procedures. Similarly, as it develops its proposals, an applicant should vary or extend the scope of its ES if appropriate to reflect the anticipated environmental impact of the proposals that comprise the application; this often happens in consultation with the MPA and may be precipitated by receipt of detailed consultation responses from statutory and other consultees.

1.5.3 The Environmental Statement

An Environmental Statement (ES) provides a formal record of the activity of Environmental Impact Assessment. An ES sets out the applicant's own assessment of the likely environmental effects of a proposed development. It is prepared by the applicant (or a team of specialists appointed by the applicant) and submitted with the planning application to which it relates. Applicants are expected to consult those with relevant information, and public authorities which have such information in their possession are required to make it available to the developer (although charges will generally be made for its provision).

There is no statutory provision as to the form of an ES, although there is now a substantial body of guidance and recommended good practice as well as some established approaches endorsed by professional bodies. However, every ES should provide a full factual description of the development, and describe the 'main' or 'significant' environmental effects to which a development is likely to give rise. In many cases, only a few of the effects identified at the scoping stage will be significant and will need to be discussed in the ES in any great depth. Other impacts may be of little or no significance for the particular development in question and will need only very brief treatment to indicate that their possible relevance has been considered. It is necessary to state where alternative approaches to development have been considered and to give the main reasons for the choices made.

The information in the ES must be summarised in a non technical summary (NTS). This is particularly important for ensuring that the public can comment fully on the ES. The non technical summary should set out the main findings of the ES in accessible plain English. It is a requirement that developers make available copies of the ES for sale to the general public. The applicant should make clear where and how copies may be obtained.

1.6 Who is consulted on the application?

It is good practice to undertake consultation with interested parties in advance of the submission of a planning application. This includes the planning authority, the statutory consultees, and members of the general public (including communities close to the development site and Non-Governmental Organisations and non-statutory consultees with an interest in the development). Planning authorities are now able to charge for pre-application consultation exercises at locally set rates. Statutory and non-statutory consultees are defined and discussed in Chapter 7.

Once an application has been registered as valid and complete by the planning authority, it will be sent out to consultees for their comments. These are likely to include the following bodies, amongst others:

- Environment Agency
- Natural England
- District and Parish Councils
- Highways Agency/Highways Authority
- DEFRA
- English Heritage
- CPRE
- The Local Wildlife Trust
- The Health and Safety Executive

The application will also be advertised and the general public informed in order to allow them to make comments on the development proposed.

1.7 Determination of the application

Under the 1990 Act, there is a requirement that a minor planning application is determined within 8 weeks of validation. Major applications, as defined by the Town and Country Planning (Development Management Procedure) (England) Order 2010, should be determined within 13 weeks. If a planning application is accompanied by an ES, this period is extended to 16 weeks. If an authority is unable to meet these deadlines it may request agreement to an extension of time for determination of the application. Where this does not happen, the applicant may appeal against the non determination of the application (see below).

Both major and EIA planning applications will be determined by a planning committee comprising a group of elected Councillors, who are advised by planning officers *via* a report with recommendations. However, with the majority of minor applications, planning officers will have been granted delegated powers to determine an application without reference to a committee.

In advance of an application "going to committee" the planning officer will prepare his or her report. This will give details of the development proposed, together with a summary of the responses received from statutory, non-statutory and other consultees, together with public responses. The planning officer will make a recommendation as to whether the application should be approved with or without conditions (and with outline conditions as applicable) or whether it should be refused and give reasons for refusal. Planning officers' reports are typically made publicly available seven days prior to discussion and voting at committee.

While the 16 week period may be extended by agreement, it is important to maximise pre-application consultation with the authority and statutory consultees before the "official" period begins, to minimise the potential for delay.

1.7.1 The Appeal Process

An appeal can be lodged in the following circumstances:

- Against refusal of planning permission
- Against non-determination of a planning application within the statutory time period
- Against the conditions which the Planning Authority intends to attach to the permission

Only the person who made the planning permission can appeal, and an appeal must be lodged within 6 months of the decision or date on which the application was due to be determined.

An appeal can take one of three procedural routes:

- **Written Representations** – This form of appeal is used in cases which are relatively simple and where there is little public interest. This is the least costly of the appeal routes. Written evidence is exchanged by the parties and considered by a planning inspector (appointed by the Planning Inspectorate), who makes a decision which is binding on the parties (unless challenged legally).
- **Informal Hearing** – Here the inspector will lead a discussion about the points at issue in a relatively relaxed and informal atmosphere. There is an exchange of evidence before the informal hearing (similar to the written representations route), but there is no right during the hearing for any party to cross-examine the witnesses of another. Again, the Planning Inspector makes a decision which is binding on the parties (unless challenged legally).
- **Public Inquiry** – This is the most costly and formal of the appeal options, and is most applicable in complex cases attracting a great deal of public interest such as quarry applications. An Inspector will hear evidence from the appellant and the Mineral Planning Authority as well as from any other groups, bodies or individuals who wish to register an objection. A Public Inquiry is conducted to a formal structure with parties (usually) represented by legal counsel. Witnesses produce written proofs of evidence and are required to appear in person to be examined on that evidence by opposing parties and by the inspector. All witnesses are subject to rules of evidence and behaviour and there is a right for opposing parties to challenge evidence in cross examination. Members of the public may make statements to a Public Inquiry at a time set aside for this by the inspector but, unless registered as 'Rule 6 parties', they may not cross examine witnesses for the appellant. The planning inspector presides as a neutral party in the proceedings, although he or she may ask questions of any witness after they have finished giving their evidence and have been examined upon it.

1.7.2 Called in/Recovered Application

In cases where a planning authority has resolved to grant planning permission for a development which is contrary to its Development Plan, the matter has to be referred to the Secretary of State, who will consider whether to "call in the application" or "recover the application". The effect of "calling in" or "recovering" an application is to remove from the planning authority the right to determine the application and transfer the responsibility to the Secretary of State. In these circumstances, a planning inspector will consider the application (usually in a Public Inquiry) and submit a report to the Secretary of State, who will then issue a decision based on that report.

1.8 Planning Permissions

1.8.1 Planning Conditions

Most planning permissions are granted subject to a series of conditions. These will cover issues such as:

- Time limits – the time when certain activities may take place or must be completed (for example, the phasing and completion of restoration provisions).
- Restrictions on development rights – these limit or define the amount of additional development which may be permitted without planning application in the future.
- Design considerations – these cover materials, heights of structures, specifications etc.
- Highways – these Conditions cover works to the road network, access design, traffic limitations/weights/hours of usage *etc*
- Landscaping – this covers advance, sequential and restoration works including phasing and soil stripping/storage.
- Noise etc – this provides limits and times for noise generation and defines mitigation measures.

Planning conditions should be:

- Necessary
- Relevant to planning – should not seek to duplicate matters controlled under other legislation
- Relevant to the development to be permitted
- Enforceable
- Precise
- Reasonable in all other respects

Where conditions have been imposed upon a planning permission, it is likely that there will be a requirement for additional details to be submitted to the planning authority prior to any works commencing on site. Pre-commencement conditions can cover a wide range of topic areas, and work should not begin on-site until these have been 'discharged' through a formal submission to the planning authority.

1.8.2 Planning Agreements and Obligations

Section 106 agreements are separate legal agreements which are attached to the grant of planning permission. They are sometimes referred to as Planning Obligations, and cover matters that cannot be covered by planning conditions. Unlike planning permissions, which go with the land and are not personal to the applicant, the parties to these agreements are the planning authority and the landowner and they set out obligations on landowners and their successors to do certain things. In general terms, they may:

- Restrict the development of land (*e.g.* restrict the ability to undertake any alternative/additional development on the land)
- Require specific operations or activities to be carried out (*e.g.* the felling or planting of trees or the creation of particular habitats for translocated species)
- Require land to be used in a specific way (*e.g.* to implement the permitted restoration scheme after the developer has left the site and the planning permission is no longer in force)
- Require the payment of money for, say, off site improvements (*e.g.* construction of a junction or other road improvement or engineering work to a watercourse as part of flood control measures).

The Government is currently (2014) examining the subject of planning gain and the law may be revised.

1.9 Licences, permits and regulatory compliance required for the operation of a quarry

In addition to the planning permission and any Section 106 agreement that is necessary, it is likely that there will be a need to obtain licences, permits and approvals to allow the operation of the quarry to proceed. There are also regulations and other statutory requirements (especially the Quarries Regulations 1999) with which the operation of the quarry will need to comply. Examples of licences or permits that are commonly required, and the requirements of Regulations are:

- **Consent to discharge.** A consent to discharge is required for all quarries where there is to be a discharge of surface or groundwater from the site (either into a receiving water course or into a soakaway or recharge system). An application for a consent to discharge is made to the Environment Agency. It will need to be satisfied that: the proposed water management and discharge arrangements have the benefit of planning permission; that the discharge will neither cause nor exacerbate flooding in any watercourse downstream of the site; and that the discharge will not give rise to pollution of ground water or surface water. Conditions will be attached to any consent to discharge that is issued and these are likely to prescribe the amount and quality (usually in terms of suspended solids concentration) of water that may be discharged.

- **Abstraction licence.** An abstraction of groundwater from a borehole or quarry sump, solely for the purposes of dewatering that excavation does not require an abstraction licence. Abstraction of water from a borehole to supply a processing plant that also gives a dewatering benefit in the excavation may~~,~~ require an abstraction licence, subject to individual circumstances. However, when the Groundwater Directive is fully transposed into UK law, it is anticipated that abstraction licences will be required for quarries where groundwater in excess of $20m^3$ per day is to be pumped from a quarry working (either from a sump or a borehole) for any purpose including dewatering.

- **Habitats Directive/Newts Licences -** Under the Wildlife and Countyside Act 1981 certain species of flora and fauna are protected (schedule 5). The list includes, amongst others, Great Crested Newts, Badgers, and Bats. Before undertaking any operations that are likely to endanger these species, and in some cases their habitat, developers are required to obtain a licence issued by Natural England.

- **PPC Permit -** PPC (pollution, prevention and control) permits are issued by the Environment Agency to control potentially polluting activities. The activity most commonly regulated in operating quarries through a PPC permit is the importation of landfill for restoration, where this is permitted by the planning permission. In some circumstances, landfill in quarries is still covered by waste management licences but the system will eventually be entirely beneath the PPC 'umbrella'. An application for a PPC permit (or waste management licence or exemption) will only be successful if it demonstrates to the EA that the proposed development has the benefit of planning permission and, based on risk assessments, that the proposed development will not cause harm to the environment (especially but not exclusively the water environment).

- **Quarries Regulations** ~~-~~"The Quarries Regulations 1999 are intended to protect the health and safety of people working at a quarry and others who may be affected by quarrying activities. ….. They are also intended to safeguard people not working at the quarry (*e.g.* those living, passing or working nearby, or visiting, for example to buy materials)"[3]. Other health and safety legislation also applies to quarries, but it is the Quarries Regulations that provide the primary regulatory context for safety in quarries as it relates to their design, operation and closure. It is the Health and Safety Executive (HSE) that regulates health and safety in quarries. Whilst there is no need for a permit or licence to be applied for and issued, the Regulations require that, before quarrying commences, the HSE is notified and that a health and safety document (including designs for all proposed excavations, haul roads and tips, working rules and hazard appraisals and risk assessments demonstrating that the proposed workings can be carried out safely) is prepared and available for inspection at the quarry. The requirements of the Quarries Regulations are described more fully in Part II and the associated appendices.

[3] paragraph 1 of the Quarries Regulations 1999

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Each of these post permission requirements are likely to require more detailed attention once planning permission has been granted. However, the prospects of obtaining the licences and permits needed to operate the site and to satisfy the requirements of the Quarries Regulations will be significantly improved by anticipating the requirements as part and parcel of quarry design and related environmental assessment. For example, a quarry design that fails to anticipate the requirements of the Quarries Regulations may be found, when the health and safety file is being prepared, to include significant hazards that cannot be mitigated without significant changes to the quarry design. Such changes may put the operation in breach of its planning permission. Similarly, failure to allocate sufficient space for settlement and attenuation facilities for the management of surface water in a quarry design included with a planning application could severely compromise the developer's ability to obtain a discharge licence for the permitted development.

1.10 Other Planning Issues

1.10.1 Enforcement

Where operations are undertaken in breach of the description or conditions of a planning permission, or without the benefit of planning permission, the Local Planning Authority has the ability to take enforcement action. Initially the planning authority will issue a Planning Contravention Notice in order to gain information on which to take Enforcement Action.

An Enforcement Notice when issued provides information on the breach of planning, the steps to be taken to rectify the breach and the timetable for works.

As an extreme measure the planning authority may issue a Stop Notice (or a temporary Stop Notice). This places a ban on activities being carried out in breach of planning.

It is possible to appeal against an Enforcement or Stop Notice.

1.10.2 Certificate of Lawfulness for an Existing Use or Development (CLEUD)

Where a development has been undertaken without planning permission, or there has been a continuous breach of condition for more than 10 years, without the Local Planning Authority taking any action, then it is possible to apply for a CLEUD.

However, care should be taken when considering applying this theory to the extraction of mineral. Each bucket load of mineral extracted is viewed as a new development. It is therefore not possible to establish, for the extraction itself, that the operations have been ongoing continuously for in excess of ten years. It may be possible, however, to argue that an associated use of the land (such as operation of a processing plant, a waste tip or mineral stocking area) could be covered by such a certificate.

Relevant legislation and statutory guidance (for full references see Bibliography in Part V)

- Town and Country Planning Act 1990
- Planning and Compensation Act 1991
- The Environment Act 1995
- Planning and Compulsory Purchase Act 2004
- The Town and Country Planning (Development Management Procedural) (England) Order 2010
- Localism Act 2011
- Growth and Infrastructure Act 2012

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APPENDIX 4-1
RESOURCE EVALUATION FOR AGGREGATES

RESOURCE EVALUATION FOR AGGREGATES

1 INTRODUCTION

The competent evaluation and reporting of mineral resources is essential as background to investment decisions relating to the exploitation of those resources. Bankers and private investors often require reports on mineral resources and reserves to be produced by competent persons suitably qualified to prepare such reports and in accordance with recognised international reporting codes and standards. In relation to publicly quoted companies with a substantial involvement in mineral extraction (of any kind), all of their public disclosure must be made in accordance with financial market regulations, and in all the major the international exchanges, this means reporting to internationally recognised reporting codes and standards that incorporate the classifications, reporting requirements and guidance on public disclosure set out by CRIRSCO in its reporting template[1]. In many countries, applications for planning permissions and licences must be accompanied by reports classifying reserves and resources according to national standards and rules relating to criteria to be investigated, the qualifications of the persons undertaking the investigation, and the format and scope of the report itself. Whilst national requirements vary, and not all mineral extraction companies are quoted on stock exchanges (particularly in construction materials – aggregates *etc*), there is increasing awareness of the advantages of reporting mineral resources and reserves of all kinds in a consistent way and there is now wide acceptance that any of the CRIRSCO codes and standards presents a suitable framework for the collection and maintenance of resources and reserves information and its reporting (in any setting). The CRIRSCO classification illustrated in Figure 1, which is a sketch taken from the CRIRSCO international reporting template. The same sketch is included in each the CRIRSCO family of codes and standards, including the PERC code.

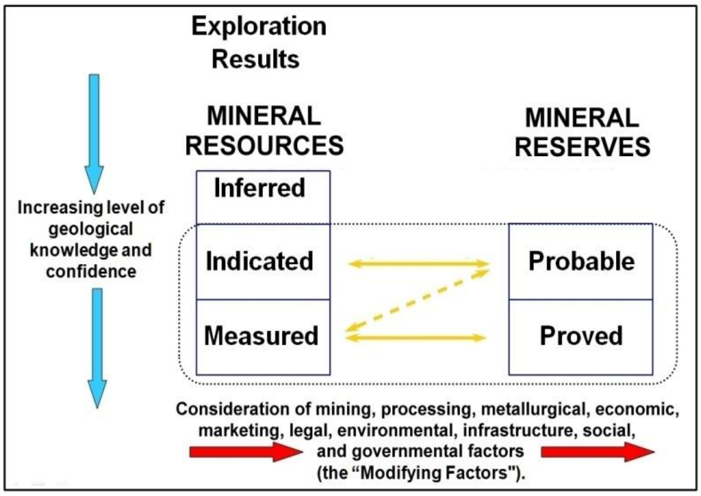

Figure 1: General relationship between exploration results, mineral resources and mineral reserves (CRIRSCO template).

Whilst essential, it is not sufficient simply to know that a resource of aggregate or other construction material that is suitable for its intended purpose exists in the ground and to have an estimate of how much will be recoverable and how much will be waste. Investors also need to be confident that a viable business can be developed from the mineral resources identified. In addition, before any working can proceed, permits and licences required by the relevant national and local authorities must be obtained, and these authorities will require supporting information as to the way in which the extraction will proceed and its impacts. Until these matters have been addressed and an appropriate level of confidence has been established in relation to the site, the minerals identified are classified as

1 Committee for Mineral Reserves International Reporting Standards (CRIRSCO; www.CRIRSCO.com). CRIRSCO codes and standards are widely recognised on international stock exchanges including the London Stock Exchange, and incorporated into national financial market regulations. The European member of the CRIRSCO family is PERC (www.percstandard.eu). Bilateral agreements between professional bodies in many countries ensure that there is mutual recognition of the professional qualifications held by persons competent to sign off resource and reserve reports in accordance with any of the CRIRSCO codes and standards.

resources[2] – the next steps are to improve the level of confidence so as to elevate these resources to the category of **reserves**[3]. For further details and guidance on the definitions of resources and reserves and the sub-categories, refer to the PERC Standard 2013 (or one of the other CRIRSCO codes or standards). Fellows of the Geological Society of London, Members of the Institute of Materials, Minerals and Mining, Members of the Institute of Geologists of Ireland and member associations of the European Federation of Geologists are required, through their codes of conduct, to undertake solid mineral resource and reserve reporting in compliance with the PERC Standard (even if the reports they write also have to conform to one of the other codes or standards such as JORC, SMAREC *etc*).

Whether the mineral in question is a metalliferous ore, an industrial mineral such as kaolin or cement feedstock, aggregate, dimension stone or building stone, the fundamental questions to be addressed in an assessment for the purposes of defining proved reserves as background to informing investment decisions or regulatory processes amount to:

- How much mineral can be recovered from the property and what are its properties (and variability in those properties) relevant to its market or use and in relation to standards and norms?
- Can the deposit be worked safely, and in accordance with local codes and laws?
- Is it possible to work the deposit in such a way as to satisfy all of the commercial objectives of the operating company and its investors (e.g. so as to release a certain production rate for a certain period within given quality or performance constraints and make a given return on investment)?
- What level of investment will be necessary, what payback period can be expected and what return on capital is likely? What is the sensitivity of the economic model to changes in key variables and how much uncertainty (risk) is associated with each of those key variables?

Taken together, these amount to ‘Would you invest your money in this mineral operation?’

The particular issues and skills relevant to addressing the key questions listed above in relation to aggregates are described in Section 2 is concerned with increasing the level of geological knowledge for construction materials recovered from quarries. Progress along the lower axis in the diagram from resources to reserves (*i.e.* consideration of the “modifying factors” is, self-evidently, achieved through the quarry design process described in detail in Parts I and II of the Handbook.

2 QUANTITY AND QUALITY OF MINERAL RESOURCES

2.1 Estimation of the recoverable tonnage of mineral

In simple terms, the tonnage of mineral that can be recovered from a particular deposit may be estimated by applying the following simple formula:

$T = (V - W) * D$	
Where:	T = recoverable tonnage of mineral
	V = recoverable volume of mineral
	D = in situ density (the number of tonnes per cubic metre of mineral in the ground)
	W = the volume of waste that will be excavated or result from primary processing

[2] **Mineral Resources** have: *Reasonable prospects for eventual economic extraction* (PERC standard 2013, Clause 20)

[3] “A **Mineral Reserve** is the economically mineable part of a Measured and/or Indicated Mineral Resource.
“It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted and is defined by studies at Pre-Feasibility or Feasibility level as appropriate that include application of Modifying Factors.
“Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified.” (Clause 29, PERC standard 2013).

Volume

Recoverable volumes may be measured in a number of ways. The simplest (and least accurate) involves the multiplication of surface area by depth of working (or depth of deposit). The most reliable method based on the definition, in three dimensions, of the following three important surfaces:

- The ground surface;
- The top of rock/base of soil or unconsolidated deposits at the surface;
- The intended working geometry; and
- The top and base of mineral where these are not coincident with the top of rock/base of soil and intended working geometry surfaces.

The volume between these surfaces can then be calculated using methods of sections or by triangulation and a method of prisms. The latter method is most commonly used when surface modelling packages are available and is described in Figure 2 below:

Volumes are measured using proprietary software, LSS (from McCarthy Taylor Systems Ltd). This is a surface modelling package in which each relevant surface (in this case the existing ground surface and a proposed excavation geometry) is represented as a continuous surface using strings of points and individual points, each of which has 3 dimensional co-ordinates. The measurement of volumes is by a method of prismatic triangulation. Each surface is triangulated, and prisms are formed between the two triangulated surfaces. The volume between the surfaces is the summation of the volumes of all the individual prisms.

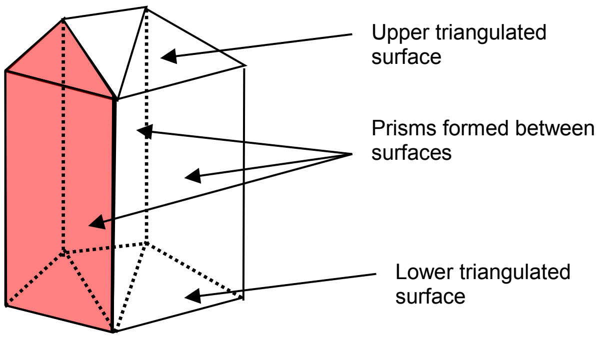

Figure 2: Volumetric measurement using the method of prisms

The ground surface model should be based on a topographic survey at a scale/point density suitable to describe the surface in detail.

The top of rock/base of soil, top of mineral and base of mineral surface models are likely to be refined as an evaluation project proceeds. Initially, an average thickness may be applied, but later, when more investigation and design have been carried out, these surfaces may be refined by contouring information from boreholes, pits and trenches or from geophysical surveys. It is essential to know the volume of overburden materials with reasonable certainty for the following reasons:

- These materials are ‘not rock’ and must not be included in the resources
- The stripping and storage of this material represents an important cost, which must be taken into account in business planning;
- They will need to be accommodated in tips during the operation, and space must be allowed for these tips to be constructed safely if the operation is not to become ‘muck bound’; and
- They form restoration materials, the volume of which must be known as the basis for designing the restoration and rehabilitation of the site.

The total volume of rock can be calculated as the volume between the ‘top of rock’ or rockhead surface and the intended working geometry, or between the top and base of mineral lying within the intended working geometry. At the initial stages of an appraisal of resources and reserves, only a conceptual design of the final void geometry is likely to be available. As the project proceeds, this will be refined as described in Section 3 below.

Conversion of volume to tonnage

The in situ density of intact rock is likely to vary between around 2.5 and 3.0 tonnes/m³; in situ densities for gravel and sand deposits would typically be lower than this, in the range 2.0-2.75 tonnes/m³. The actual density is dependent on the intact density of the material as well as the density and openness of fractures within the rock mass. For crushed rock aggregate resources, geologists generally take an intact density (which can be measured in the laboratory) and apply a factor to it relating to the rock brokenness and variability. Most accurate figures for in situ density can be calculated by excavating material, weighing it and measuring the volume that it occupied in the ground by surveying the face before and after.

Waste

The volume of waste rock depends on the quality parameters relevant to the operation. This is discussed in more detail in the following section. Initially, it is common to estimate the volumes of waste and different qualities of material to be worked from a deposit by applying a percentage for waste. Later in the evaluation process, as the assessment becomes more and more refined, it may be possible to show areas of different qualities in three dimensions (e.g. in a block model) and to apply different waste factors to each.

As with overburden materials, the volume of material that cannot be sold and remains on site (i.e. waste) is a critical item that must be taken into account in planning the operation and considering its viability. Where there is a high proportion of material that is waste or not suitable for the available aggregate markets, quarries can get into difficulties because this has been inadequately assessed and there has been a failure to design the operation to allow its accommodation without becoming ‘muck bound’ or the costs of handling and sometimes rehandling this material become crippling. The assessment of waste is intimately related to the assessment of quality variations as described below.

2.2 Modelling of quality variation

For any bulk mineral, the recoverable tonnage must fit quality criteria related to the end use of, or market for, the products.

Where quality variation is an issue (not always the case with aggregate deposits) a variety of software is available, allowing both 3D interpretation and block modelling/geostatistical analysis. There is a range of commercially available modelling software available, most of which combine the geological modelling with mine design capabilities. Some large organisations have developed in-house capabilities in this area.

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APPENDIX 4-2
PRINCIPLES OF DESIGN FOR SAND AND GRAVEL QUARRIES

PRINCIPLES OF DESIGN FOR SAND AND GRAVEL QUARRIES

1 INTRODUCTION

Many of the general principles and methods of working relating to sand and gravel operations are generally applicable to hard rock quarries and certain of the topics covered in this paper will also be relevant to hard rock sites (Appendix 4-3).

One notable difference with sand and gravel workings, however, is that these generally require a higher rate of land use. Sand and gravel deposits tend to be shallow in nature and therefore, for an equivalent volume of production, greater areas of land require disturbance. Set against that, is the opportunity for progressive restoration that arises in shallow sand and gravel operations to to ensure timely reclamation of sites and also to minimise the areas of exposed and completed workings.

Sand and gravel occurrences are usually young, unconsolidated superficial materials, which may be of glacial, fluvial (*i.e.* deposited by river or flood action) or submarine origin.

The key factor governing the composition of deposits is the nature of the source rocks from which the materials are derived.

Glacial deposits may contain a huge variety of rock types from a wide range of different *in situ* origins. Sand and gravels found in sub-glacial depositional structures (*e.g.* drumlins, eskers) and in terminal and lateral moraines will normally be extremely poorly sorted.

In fluvial deposits, the source rocks are generally upland of the occurrence. The nature of the source rocks will determine the composition and mechanical properties of the deposit (*e.g.* soft limestone will generally produce a poor quality aggregate, but harder igneous or sedimentary sources will normally produce strong aggregates). The size distribution of a fluvial deposit will generally reflect its distance from the source and way in which it has been transported - sand and gravel deposited early in a river cycle will tend to be poorly sorted and angular, whilst deposits forming in lower reaches will be better sorted and more rounded. Plate 1 illustrates a typical fluviatile exposure.

Plate 1: Sand and gravel exposure in a quarry

River deposits may also reflect local conditions, with variations occurring in the proportions of gravel, sand, silt and clay in response to bedrock contamination or inclusions of other materials deposited from crossing streams, *etc*.

Beach deposits often take the form of narrow linear occurrences parallel to coastlines. They tend to be well sorted and well rounded materials. Environmentally, these deposits may not be suitable for exploitation since they often provide natural coastal defence.

2 DEFINING THE SITE REQUIREMENTS

It is not proposed to discuss in detail the requirements for establishing that a sand and gravel resource may be considered suitable for exploitation. The following sections assume that a resource has been identified (through desk studies, site investigations, *etc*.) and that the deposit is generally considered suitable for exploitation, subject to economic, environmental and planning criteria being satisfied. The stages outlined below represent the key steps and requirements in preparing suitable designs.

2.1 Initial scoping

Prior to commencing any design work, the quarry designer should be satisfied that the deposit will fulfil certain criteria. This work may also be supplemented by reports and studies provided by other specialists and should essentially include:

- Confirmation that the deposit will be capable of producing the required type of aggregate for the proposed end-use (*e.g.* concreting aggregate, building sand, asphalt sand, *etc*.);
- An initial estimate of the potential resource available to be worked to satisfy initial economic criteria (*i.e.* is there likely to be sufficient material to support a quarry for the required life and output of the site);
- An indication of relevant development constraints (*e.g.* neighbouring land use, current status of the site, the presence of any environmentally sensitive features, existence of an established mining zone designation, services or utilities on or around the site, proximity to municipal developments, access to suitable transport networks, *etc*.). These may be obtained by considering published documents, maps, aerial photographs or other available documents as well as by site visits and discussions with land-owners, government agencies or other parties.

If it is considered that the deposit identified will not be capable of supporting development or that an application for a licence would probably be refused, the process of assessment should be terminated to avoid any further cost.

2.2 Quantitative and qualitative assessments

The quarry designer may undertake quantitative and qualitative assessments if they are suitably experienced and qualified in such areas. It is often the case in operating companies that a geologist will fulfil the role of quarry designer. In practice, such staff tend to be spatially aware and capable of conceptualising workings in three dimensions, an essential skill for anybody engaged in designing a quarry.

The quantitative assessment is primarily concerned with establishing the available resource and requires proper assessment of the available site data (mainly borehole information, topographic surveys, *etc*.). Plans of the site should be prepared, onto which geological information can be summarised as a prelude to a more complete assessment of volumes.

Contour plans for relevant surfaces (ground surface, base of soils, base of overburden and base of mineral) and thickness contour (isopachyte) plans should be produced for a deposit based on the available geological data. These can be produced by hand, but often they are generated using computer software. When working boundaries, *etc*. are added, initial volumes can be calculated (either by hand or using appropriate computerised techniques). These volumetric appraisals will become increasingly refined as the design process is advanced and boundaries, batters, *etc* are amended, but the basic data (geological surfaces) are unlikely to change unless new data is collected.

Qualitative data (*i.e.* information relating to the physical properties of the mineral) is usually assessed separately initially from a spatial consideration. If there are no significant variations in results, it may be appropriate to consider an average quality over the whole of the site. However, if there are marked differences in quality noted in samples, further consideration should be given to plotting these differences on the geological models. This will help identify trends and may require certain areas of the site to be considered separately in any design. In addition, it may identify different horizons within the deposit that should be separately modelled (*e.g.* the inclusion of large, persistent fine sand lenses within the body of the mineral that may need to be considered as waste).

2.3 Losses and allowances

It should be noted that, at an early stage of assessment, it is often necessary to make certain assumptions, particularly regarding excavation and processing losses that may arise when the site is worked.

Production losses can occur at many stages in the exploitation process. They depend largely on the nature of the deposit and may be a function of:

- The nature of the interface with the overburden (irregular interfaces can lead to complicated digging and increase losses due to an inability to cleanly separate the materials);
- The silt/clay content of the deposit (which may affect the proportion reporting as waste during processing);
- Percentage of oversize aggregate (which may be rejected during processing if no crusher is available);
- Excess sand content with respect to required end-products (*i.e.* there may be insufficient coarse material in the deposit leading to a surplus of sand for which a market may not be available)
- The presence of interburden (*i.e.* waste) within the body of the deposit (for which additional interface losses may occur); and,
- The nature of the interface with the underburden (with similar effects as the overburden interface).

The selection of excavation and processing plant should be made to reflect these factors to minimise losses. However, it must be recognised that losses can result from the selection of plant itself and the efficiency and reliability in operation. Often plant selection options may be restricted (due to availability of equipment within a company) and therefore losses may have to be accepted. Poorly trained or skilled plant operators can also affect recovery, and the nature of the workings can have a big influence (*i.e.* wet or dry operations, which are discussed further below).

Given the large number of variables, there is significant potential for inaccuracy in the volumetric assessment and care must be taken to make reasonable allowances in the designs to accommodate such factors. Without reliable estimation, there is potential to grossly inflate the recoverable quantity which can have serious consequences for the economics and logistics of the operation contemplated.

In practice, it may be possible to assess potential losses by use of comparable data from other operations. If a company is working a similar deposit, they should have sufficient data available to allow a reconciliation between predicted and actual recoveries to be made. This data can be used to adjust any allowances made for losses when designing a site.

2.4 Initial infrastructure/development issues

At an early stage, some consideration should be given to possible methods of exploitation and any associated infrastructure requirements. It should be obvious that each individual site will differ, but in essence there will be similar requirements for each and allowance should be made in the initial design.

For sand and gravel operations, consideration must be given to the following:

- Access to the site from public highways, including traffic management impacts, visual appearance of entrance and any screening, fencing or other security measures, *etc*.;
- Location of the processing plant, site offices and facilities, *etc*., having regard to avoidance of sterilisation of reserves, visual impact, noise impact, proximity to other developments, arrangements for power/water or other services, *etc*.;
- Access to processing plant and mineral stockpile areas within the site;
- Siting of water handling/treatment areas, particularly silt lagoons, surface drainage measures, processing plant water supply, *etc*.;
- General site screening and security measures; and,
- Soil, overburden and waste stockpiling.

The above elements are generally common to all sand and gravel sites, irrespective of the method of working, processing or transport arrangements.

Developmental implications can arise as a function of the proposed methods of exploitation. The most fundamental issues concern the methods of winning the sand and gravel and basically consider whether the site will be worked 'wet' or 'dry'. This matter is detailed further in Section 3.2 below. The selection of digging and haulage plant will significantly affect the development strategy and phasing. Whilst there is often an iterative process involved, it should be relatively apparent at an early stage of assessment which methods are likely to be selected (possibly due to availability of plant within a company or obvious environmental restrictions which for example may preclude de-watering of a wet site). This in turn may influence the quarry designers initial consideration as regards matters such as:

- Planning of internal haul routes and/or conveyor arrangements;
- Methods of stripping soils, overburden and digging mineral;
- Potential losses arising as a function of the intended method of working; and,
- Extraction and restoration phasing.

3 DESIGN CONSIDERATIONS

In the context of the extraction process for sand and gravel workings, there are three key stages in the operation:

- Soil and overburden handling
- Mineral excavation and loading; and,
- Haulage to the processing plant.

These elements are generally common to all types of working (wet or dry) and are considered further below.

The following sections also detail those key considerations that may affect the design of a site. They will be often closely linked and changes to one element may often affect other aspects of the operation. It is appropriate therefore to consider the total operation and to make appropriate allowances in the design as a whole.

3.1 Soil and Overburden removal

Overburden is any material that overlies the economic mineral deposit. It can comprise a variety of materials, but most commonly, for sand and gravel deposits includes topsoil, subsoil and clay material. The overburden cover to most fluvial deposits can be expected to be fairly regular and relatively thin, but this may not be the case for glacial deposits. Local variations inevitably occur (possibly as a result of secondary erosion and deposition) and these should be considered wherever possible.

The type of overburden cover does not significantly affect the economics of development, but the thickness certainly does. The depth of overburden with respect to the thickness of recoverable mineral (often referred to as the overburden stripping ratio) will significantly impact upon the costs of the operation. An acceptable stripping ratio will depend on the nature of the mineral and its local commercial significance – it is not possible to quantify an acceptable figure in isolation.

Two stripping ratios are of significance to the quarry designer:

- *Overall stripping ratio* – this is expressed as the ratio of the total overburden to the total recoverable mineral.
- *Instantaneous stripping ratio* – the amount of overburden to be stripped at any point in time to release the next available quantity of mineral.

Although the overall stripping ratio may be acceptable for a development, at any point in time, the instantaneous stripping ratio may be very high. Consideration has to be given to both figures in ensuring sufficient allowance is made for adequate provision of space for storage of waste or inclusion in any progressive restoration. Allowance must also be made to ensure that a constant supply of mineral is available for processing and sale. Forward planning is essential in achieving these goals and the preparation of phase plans for the development is an ideal tool in assessing development impacts on programme.

The consideration of overburden removal in any quarry design is therefore of great significance. In general, overburden is used for the following during development:

- The formation of landscaped bunds around working sites for screening purposes;
- Direct use in restoration of sites as backfill, or for forming amenity features (banks, marginal shallows and islands) in water filled restoration; and
- The construction of bunds around settlement ponds and water storage lagoons.

As a rule, overburden removal and handling operations should be designed to minimise the haul distance and handling required to reduce costs. In assessing the phasing of overburden stripping several factors must be considered.

Soil handling

Although often referred to as overburden, there are generally distinct layers in the upper part of the overburden layer which are typically soils. Soil handling should only be undertaken during certain seasons of the year (generally late spring, through summer to early autumn in the UK). This is to prevent unacceptable damage to the fabric of the soil. The soil profile generally comprises two layers:

- *Topsoil* – containing humic material and organisms essential in providing a suitable growing medium for plant life; and
- *Subsoil* – containing little or no organic debris, but with a developed soil structure, this lies beneath topsoil and is essential in the soil profile.

Damage to the soils can easily occur if stripping is undertaken with inappropriate plant (leading to over compaction) or if the soils are too wet. Damage can also arise from inappropriate storage in large mounds for extended periods. This can significantly reduce the fertility of the soils and may be severely detrimental to their suitability for use as agricultural soils after restoration. Successful re-use of soils previously handled depends on their remaining in suitable condition and great efforts must be given to prevention of damage to the soil fabric. Plate 2 illustrates typical soil handling operations.

In the context of a suitable quarry design, allowance must be made in the programme to handle soils only when appropriate to do so. This may require that large areas of the site are cleared of top and subsoil to give suitable working areas during periods when soil handling is not possible. Similarly, sufficient space must therefore also be made for adequate storage for these soils if they are not to be placed immediately into restoration areas.

It is often the case that soil quality may vary across the site. If this is identified during site investigation work, allowance must also be made for the separate storage of differing soil qualities prior to their eventual re-use in restoration in appropriate settings.

Plate 2 – Soil stripping by backhoe and dumptruck

Overburden handling

Overburden in its strictest sense can be considered as any economically useless material beneath the subsoil and above the recoverable sand and gravel. On certain sites, this may include sand or very sandy gravel where there is no demand for such material, the principal requirement being coarser fractions.

Where possible, it should be established early in any design how much of this material is required for any screening, bund construction *etc*. and allowances made to recover these quantities with minimum haulage/handling. The remainder should be considered as waste and removal should ideally be matched to simultaneous placement in its final restoration location. This will minimise costs associated with haulage and any double handling.

In practice, it will be difficult to place all of the topsoil, subsoil and overburden to final locations at the first pass. Sometimes it will not be achievable because of scheduling problems, but every attempt should be made during the design and preparation of a phased scheme of working to limit this.

Various methods of soil and overburden removal are available, including truck and shovel, motor scraper, or dragline casting into a void formed by recent mineral working behind the current face. It is not proposed to discuss these methods in detail in this paper. Equipment selection and operational practices may be dictated by plant availability, operating conditions or environmental/ecological restrictions. It must be noted however that no one method is 100% efficient, and some loss of mineral at the interface with the overburden, or loss of soils is to be expected and this must be allowed for when estimating total quantities (as noted in Section 2.3 above). Plate 3 illustrates overburden stripping by backhoe and truck methods.

The quarry designer must be able to quantify the volumes of soils and overburden to be handled from a site at an early stage in the design process. This is necessary to make sufficient allowance for storage/screening banks, *etc*. that may reduce the available working space within an overall site boundary. It should be borne in mind, when making such allowance, that:

- Subsoil should only be stored on subsoil (the topsoil from any subsoil storage mounds should be excavated prior to subsoil storage mounds being formed)
- Overburden should only be stored on overburden (the top and subsoil should be removed prior to overburden mounds being formed).

- Excavated mineral should only be stored on excavated mineral (the top and subsoil and overburden should be removed from mineral stocking areas, or a sacrificial 'carpet' layer of mineral should be placed on exposed overburden to prevent contamination of the as dug material.

Volumetric assessments for materials to be excavated should therefore be made for storage areas, and added to the total quantity of soil/overburden to be accommodated.

Plate 3 – Overburden stripping

3.2 Mineral recovery

Mineral recovery techniques to be employed on any particular site will be subject to a range of factors. These include:

- The type of the deposit;
- The general topography and layout of the site;
- The restoration requirements of the site;
- The scale of the operation; and
- Whether the deposit will be worked 'wet' or 'dry'.

The latter of these items is usually the primary factor and in general has the greatest impact on the design and planning for the quarry. Some techniques and processes (which will have an effect on the design and phasing) will be common to both types of working, but other methods and considerations will be required for wet or dry working separately.

Dry pit working

Dry working is usually more efficient in terms of mineral recovery, since the interfaces and can be seen when digging and operators can be more selective. It also generally offers greater flexibility in phasing of operations when being considered by the quarry designer.

Sand and gravel workings can be dry by virtue of low water tables (*i.e.* the mineral is above groundwater) or as a result of de-watering to lower the groundwater level. De-watering may raise significant issues related to environmental/ecological impacts and careful consideration needs to be given in determining its adoption on any site. The decision to de-water will essentially depend on:

- The deposit thickness;
- The permeability of the sand and gravel;
- The use of the groundwater in the local area;
- The availability of suitable de-watering pumps and equipment;
- A consideration of the available excavation and haulage plant;
- The costs of pumping;
- The availability of suitable receiving watercourses for pumped discharge; and
- The intended after-use of the site and restoration requirements.

The method of de-watering that might be selected is also dependent on many of these factors. The simplest method is to use mobile pumps in the excavation area to draw down and hold the water level below the required digging level. This may be in conjunction with cut-off walls formed around the excavation, keyed into underlying strata, limiting inflow from surrounding land. More complicated arrangements require the installation of a network of de-watering boreholes around the site which can be used to drawdown the groundwater level over a larger area.

Most sand and gravel workings are undertaken using either a dragline excavator or hydraulic 360° back acting excavator as the primary excavation plant[1]. Both of these types of excavator remove mineral from below the level of their tracks, and this is a great advantage when operating in dry deposits.

Dragline excavators, as shown in Plate 4, are ideally suited to deep, dry deposits (generally >5m) or where long reach is required (for example in casting waste aside, or tipping excavated mineral at more distant points). They do have slower cycle times than hydraulic excavators, however, and are less precise in their abilities to cleanly separate materials, which can lead to increased interface losses. They also require a skilled operator to use them to best effect and are not as versatile as other equipment. Their capital cost is generally high. Notwithstanding these apparent problems, the following are considered to be the main advantages:

- Long reach (often 8-10m vertically for moderate sized plant, which can obviate the need for benching of faces in deeper deposits and allow recovery from one face);
- Wide radius of operation from one point (since the operator can 'throw' the bucket and drag material toward the excavator);
- If used in combination with field conveyors as the primary system of in-pit haulage, the area accessible due to the wide radius of operation means that less relocation of the conveyor hopper is required if compared with other excavation equipment working with shorter reach;
- Draglines generally have a longer mechanical life than hydraulic excavators do and are less technologically complex allowing easier maintenance.

Hydraulic back-acting excavators are the most versatile excavation plant employed on dry sand and gravel sites and have significant operational advantages over draglines in shallow deposits (up to *c* 4m):

[1] Certain sites may use front end loading shovels where the deposit is particularly loose and not deep, but this is not common practice and does have greater safety implications (the method of digging at the toe of the slope and allowing material to rill down can cause stability problems).

- Hydraulic excavators have relatively fast travel times, essential if working more than one face or area regularly and are able to travel up and down inclines more readily than draglines. They are also more suited to working in soft or uneven ground conditions;
- The versatility of the plant allows it to be used for duties other than mineral production (including soil/overburden handling, drainage works, road works or bank construction);
- Precise bucket control allows better recovery of minerals at interfaces;
- Fast cycle times make hydraulic excavators ideal for loading dumptrucks when these are used for primary haulage; and,
- Hydraulic excavators typically have greater breakout forces than draglines, which allow them to work in harder or denser strata.

As noted previously, however, final equipment selection may be determined by availability of plant within a company rather than on any other technical basis. It should be apparent however, that both types of primary excavator are capable of high productivity in sand and gravel sites notwithstanding certain disadvantages of each.

Plate 4 – Dragline excavator

Wet pit working

If a pit is to be worked wet, the general principles applicable to dry working are still valid, but it is often considered that a dragline provides a better tool. Principally, this is a matter of safety; a dragline operates without digging close to the bank on which the excavator stands, whilst a back-acting excavator generally must be closer to the crest of the excavation and could undercut the ground beneath its tracks.

The excavation of mineral from a wet pit essentially requires working from the shore of a 'lake' formed in the previously worked ground. This requires that the groundwater level is below the upper surface of the sand and gravel to provide a dry working surface for the plant. Plate 5 illustrates a typical excavation in a wet pit.

Measures must be taken to allow drainage from the bucket of the excavator, and this is normally achieved by perforating the bucket with a number of holes. Bucket fill factors are significantly reduced compared with dry working and output is reduced accordingly.

When excavated, the sand and gravel will normally be stockpiled to drain Taking as much as 12 hours and then must be re-handled to the selected haulage plant. Loading is usually undertaken by hydraulic excavator or, more commonly by front end loading shovel. This requirement for re-handling and the extra plant requirements can increase the cost of such operations, but this can be offset against pumping costs if the pit is not naturally dry.

The decision to work a pit wet can become non-viable if the deposit is very sandy since this material will often be washed out of the bucket on excavation and will settle in the working area. This can contaminate material still to be recovered, or can lead to a loss of reserves if the sand is a required component of the end product.

Plate 5 – Wet gravel pit working

Other techniques for working wet pits (where the deposit is very deep or the groundwater level is above the surface of the mineral and excavators cannot stand on a suitable surface) include the use of dredging using pontoon mounted or floating plant. This is normally only justified in very large workings and the capital and operating costs are generally very high.

3.3 Mineral transport

The most common methods of mineral transport in sand and gravel quarries include conveyor and dumptruck haulage.

Conveyors

The particle sizes of excavated sand and gravel are generally small enough to justify the use of conveyors and these, as a rule, usually provide the most economic methods of transport from the excavation face to the processing plant. Conveyors are also the best option (if operating conditions permit) in areas where noise impacts may be a problem since they are quiet in use if properly maintained.

The excavated mineral is usually loaded to a feed hopper (fitted with an oversize removal grizzly) near the working face, discharging to a moveable field conveyor. This usually then discharges to a main trunk conveyor and hauls the mineral to the processing plant. Several field conveyors can discharge to one trunk conveyor, allowing working at several locations in a pit.

On level ground (and depending on the size of the belt and hence carrying capacity), conveyors may be as much as 30 to 60% cheaper to operate than dump trucks hauling at the same rate.

Field conveyors are most economic where the distances from working face to processing plant are significant and output is high. Their capital costs are high however and should only be considered for sites where greater than 3 years working is envisaged. At output rates of less than 100tph or where haul distances are less than 1,000m, dumptrucks generally provide a more economic solution overall. Plate 5 shows a field conveyor in operation, passing beneath a public road to a remote processing plant.

Conveyors are best suited to equant areas of working in relatively deep deposits and where the topography is fairly uniform. This reduces the need for frequent moving of field conveyors, which can limit pit output and increase costs. Sites where long, straight conveyor runs cannot be achieved are not normally suited to conveyor haulage.

The quarry designer, if considering the use of conveyors, should attempt to schedule mineral production from single faces and along straight lines. Attempts should be made to allow regularly sized areas of working to allow even periods between conveyor relocation. If the deposit is variable in consistency, and production is required from several areas of the site to maintain an acceptable feed to the plant, the use of conveyors will not normally be an option and the flexibility offered by dumptrucks must be considered.

Plate 6 – Field conveyor

Dumptruck haulage

Dumptrucks, although usually more expensive to operate, provide the most flexible in-pit haulage option. If all wheel drive articulated dumptrucks are used, it is not normally necessary to prepare firm haul roads and access to wider areas of the pit is possible. Internal site road maintenance can be a costly process.

The capacity of a dumptruck or fleet of trucks is determined by their maximum load, distance of haul and the time taken for loading and tipping. The quarry designer will need to assess the costs of dumptruck haulage carefully if there is the potential to use conveyors.

The flexibility of dumptruck haulage is ideally suited to deposits of irregular composition or thickness, where the site area is irregular or where the topography is variable. As noted above, such conditions would generally preclude the use of conveyors. They do have the disadvantage of offering only single load transport, and careful consideration in matching excavator and truck capacity together with numbers of trucks required is necessary to avoid problems with waiting or queuing times at either the loading or dumping point.

3.4 Siting of processing plant and quarry facilities

The siting of the processing plant can be a critical factor in the proper planning and design of sand and gravel workings. There may be conflicts between the requirements of the mineral operator and the licensing authorities in this respect, and the quarry designer should be aware of any constraints that may be imposed in determining the optimum location.

In assessing the preferred location of the plant, the quarry designer should take account of the following factors:

- The plant should be located near to the access to the public highway to minimise travel distance for customer trucks leaving the site;
- The plant should ideally be located either in a barren (*i.e.* non-mineral bearing) area of the site, or where mineral thickness are at a minimum to reduce potential loss of reserves;
- If the deposit is large, the plant should be more centrally located to minimise internal site haul distances;
- The plant area should be on good ground and should occupy the minimum area possible to reduce establishment and site preparation costs;
- Site drainage should be good around the plant site;
- The height of the plant should not be such that excessive raising of mineral in the process is required. It may be appropriate in satisfying this aspect that the plant is located in a previously worked out area of the site, with pit-run materials stockpiled at a higher level; and,
- The plant site should be suitably screened or located to minimise environmental disturbance (*e.g.* visual intrusion, noise or dust effects, *etc.*) to neighbouring land.

It is not proposed to consider the application of different processing technology in this paper, suffice to say that the selection of specific items of plant will reflect the type of deposit and the products required. Such factors will affect the size of the plant and its arrangement on site, and these issues will need to be considered by the quarry designer in preparing detailed quarry plans.

3.5 Site access

Access to the public highway will be necessary for the efficient removal of the quarry products. In general, the quarry designer should attempt to ensure that any access location is to a level area of highway, away from bends and with good visibility in either direction. This may require road improvement works in the chosen location, and discussions may be necessary with the relevant authorities to determine the appropriate standards applicable for any site.

Such consultations are a critical step in preparing a workable quarry plan; the access location may influence many factors in the quarry designer’s proposals, including plant location and phasing of operations.

3.6 Water management and lagoons

Consideration of site drainage will be necessary to avoid potential problems arising from run-off from surrounding land entering the workings, or in preventing potentially dirty water leaving the workings and entering surrounding watercourses. Ditches, banks or other drainage measures are normally required to control run-off. Depending on the quality of the water collected, it may be necessary for such water to be passed through settlement ponds to allow suspended solids to be removed prior to discharge to local drainage systems. These ponds should be sized according to the anticipated inflow and according to the principles of Stoke’s Law (governing the settlement of particles in a column of water).

In areas of high run-off, or to accommodate storm flows, it is usual to form an attenuation pond to buffer the quantity entering the settlement pond. Settling of fines from water requires long periods of slow flow and therefore the settlement pond should ideally be separate from rapid inflows. The link from the attenuation pond (which should be sized to hold the maximum storm flow predicted) will throttle the flow and allow settlement to continue unaffected.

In areas of steep terrain, or where storm flows are significant, it should be realised that pond sizes can be large and sufficient area must be allowed for their construction. Siting of the ponds will necessarily reflect the local topography (since they should generally be at low points in the site), but consideration for their security should also be allowed. Standing bodies of water are dangerous features and measures may be required to prevent unauthorised or accidental entry to the water.

There can be considerable run-off from the processing plant site (through spillage, leaking pipes, stockpile drainage, *etc.*) and the plant area should be suitable protected by drainage ditches, *etc*. It is advisable to profile the floor of the stock area to a low point to prevent uncontrolled run-off, and it is good practice to provide for sand stockpiling near the low area (since these tend to be wet and drain over long periods). Problems can be mitigated to some degree if the plant is located on exposed sand and gravel with good drainage characteristics; some run-off will then simply soak away.

Depending on the type and specification of the processing plant and the percentage of fines (undersize) material in the deposit, there may be a requirement to have processing discard lagoons formed on site. These lagoons would normally be as close to the plant site as possible to reduce pumping costs and as such may impact on the selection of plant site or phasing of excavation. The assessment of the geological data should include an appraisal of the inherent fines content in different areas of the site. These can then be reviewed when preparing the phasing plans to produce a schedule of potential waste generation during mineral recovery. On the basis of this schedule, the quarry designer can assess the need for provision of silt lagoons at different stages of the operation or can factor in the need for cleaning out of existing ponds filled in previous phases.

The quantity of silt produced should also be considered in the restoration plan for the site. Silt handling and disposal is a complicated matter and combined with the potential risks to health and safety due to the nature of the materials, the quarry designer must make due allowance for its secure and safe containment. This may include designing dedicated containment cells (polders) using suitable site won materials.

3.7 Site restoration and after-use

The restoration and site after-use requirements for a site can often have a significant influence on the design and phasing of the workings.

The quarry designer will normally have considered the after-use of the site before commencing design. The after-use may be through the operator’s choice, or may be a condition imposed by the licensing authorities.

For sand and gravel sites, restoration is usually a function of the nature of the workings. Dry and wet pits will require different approaches to restoration.

For dry pits, it is common to restore the site to agriculture, forestry or public amenity (including leisure activities such as golf, *etc.*). Landfill is another potential land-use to restore the ground to original levels, but unless significant site engineering works are contemplated, this may not be environmentally acceptable for anything other than wholly inert fill.

Where restoration to agriculture is considered, soil preservation will be a primary consideration and good handling techniques are essential. This will influence the phasing of soil stripping, handling arrangements and stockpile maintenance. To preserve agricultural quality, long term stockpiling is not recommended and progressive restoration, with soils stripped from one area of the site and placed directly to restoration in other areas is recommended.

If sites are to be restored to forest, some damage to soils may be tolerated since fertility and structure of the soil is less of an issue, but unless avoidable such damage should be minimised. Again, a phased and progressive restoration programme will limit areas of open pit and will minimise the space required for stockpiling overburden and soil.

For wet workings, restoration to water or wetland areas is commonly considered. In such circumstances, the sites are often used for recreation (*e.g.* water-sports) or as conservation/wildlife areas. Restoration of the margins of the water areas can be achieved progressively as extraction takes place. Again, specialist advice may be necessary in determining the required edge treatment to provide suitable wildlife habitats, *etc*.

Where surplus materials exist, soil or overburden may be exported from the site for use in other land reclamation projects (if it is not needed for on-site restoration). The quarry designer will be able to assess quantities required or available for restoration at any point in time based on the scheduling of production. The quantities required for restoration would probably be advised by other specialists, advising on soil depths, *etc.* required for the type of restoration considered and this can be incorporated in quarry designs and phasing plans.

4 SUMMARY OF BASIC DESIGN PRINCIPLES

To summarise, there are a number of simple 'rules' that a quarry designer must remember and consider in preparing designs and phasing plans for any particular sand and gravel site.

- The deposit is unlikely to be totally homogeneous and the quarry plan and phasing of operations must be flexible enough to account for geological variations (including variations in thickness of the soils, overburden and mineral units and variations in material quality). A proper understanding of the variability within the deposit is therefore a pre-requisite for the quarry design.
- Be aware, at the earliest possible stage, of any development constraints associated with licensing/planning conditions attached to the site or environmental concerns. These must be addressed fully in even the most conceptual of designs and can, if too restrictive, effectively signal the end of the design process.
- Ensure that the target market for the quarry products is fairly well understood and that the deposit contains sufficient material of the required type to be placed on that market for a sufficiently long period to justify site development.
- Where practicable, try to make allowances for fluctuations in market demand, including the ability to reduce production or to stockpile larger quantities without significantly affecting the overall design or phasing.
- Make sufficient allowances for material losses arising from excavation, handling and processing. These may have a big impact on the total product available for sale and on the resulting void or quantities of waste for disposal.
- Always attempt to design the most economic methods of working the quarry. This usually requires the minimum number of movements of any cubic metre of material and the selection of the minimum number of plant items necessary to achieve the required output.
- As the design progresses, always recheck assumptions or try to replace assumptions with calculated figures (particularly in relation to areas required for storage, lagoons, waste volumes, *etc*.).
- Design for restoration as a progressive activity wherever possible to avoid double handling or wastage of materials necessary for later use.

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APPENDIX 4-3
PRINCIPLES OF DESIGN FOR HARD ROCK QUARRIES

PRINCIPLES OF DESIGN FOR HARD ROCK QUARRIES

1 INTRODUCTION

Quarrying in hard rock deposits usually requires different techniques to those employed in working generally unconsolidated sand and gravel deposits. Whilst many of the overall considerations are essentially similar (*e.g.* establishing a viable resource, determining the available area for development, assessing volumes of waste, overburden and other allowances, identifying the requirements for excavation, haulage and processing plant), there are several specific areas in which different assessment and design requirements are necessary.

For the purposes of this paper, hard rock quarries can basically be defined as those where it is not possible to excavate the quarry without some degree of primary fragmentation of the rock. This primary fragmentation is necessary to reduce the rock mass to a particle size that can be dug from a loose pile. It will be achieved by drilling and blasting in most circumstances, but depending on the degree of weathering and fracturing of the rock mass, it might be achieved by 'ripping' using a dozer or a combination of ripping and blasting.

Hard rock quarries normally include excavations in sedimentary, metamorphic and igneous rock types. In each rock type the general principles will be similar in the design of the quarry, the phasing and scheduling of operations and the restoration of the workings. There may be some differences in processing arrangements, but these are normally a function of the quality of the material being quarried and the required product specification. It is beyond the scope of this paper to consider such elements in detail, but some mention will be made of the basic requirements as they may influence design considerations.

Working hard rock quarries is generally a more complicated and intensive process than quarrying sand and gravel. Typically, costs will be higher since technological issues have a greater bearing on the methods of excavation and the types of plant that can be used. Often, one of the overriding concerns in the design process is the operating cost (a function of the quarry scheduling arrangements and plant selection).

It may be relatively straightforward to assess the costs of alternative plant selections (a simple spreadsheet model is often used) and to attempt to optimise based on fleet requirements. However, if the quarry designer is unfamiliar with the geological setting and its implications for pit layout and working arrangements these costs can prove wildly unrealistic. It is therefore critical that the quarry designer has a thorough understanding of the specific site conditions and sufficient skill and experience to assess the implications for design at a very early stage. The design of the pit may then lead to alternative plant selection which may be economically sub-optimal, but allows for a greater proportion of the reserve to be recovered, thereby maximising income. There will inevitably be a balance in this process; at some point it will become uneconomic to recover any further reserves irrespective of the plant selections.

Because of the investment required in opening and operating a hard-rock quarry, they generally would be expected to have a longer life than a sand and gravel quarry. As such initial resources will often need to be greater, even though production output may be similar to sand and gravel operations.

Relative to sand and gravel operations, hard-rock quarries normally have very little waste (in the form of overburden) and typically have low overburden stripping ratios. This can lead to problems in restoration. In addition, soil storage issues may be a problem; unlike sand and gravel operations there is often very little opportunity to progressively restore workings until the quarry is exhausted. Restoration plans, prepared at the time of quarry design, can also become unrealistic over the life of the site. Where this may be several decades, changes in legislation, acceptable quality of restoration or other factors can and do make such plans inappropriate at the time of their implementation. The quarry designer should therefore be as flexible as possible in preparing such elements. Conversely, the licensing authorities must recognise the potential difficulties or undesirability of implementing any scheme prepared at the start of a quarrying operation that may not be undertaken until 20 or 30 years after any permission was given. In this context, outline schemes of restoration that are subjected to periodic reviews and approvals to take account of changing circumstances are more appropriate for hard-rock sites and should be considered by all parties.

2 DEFINING THE SITE REQUIREMENTS

Hard rock quarries generally take one of two forms:

- Hill-side quarries – characterised by a general downward haulage of excavated material from the quarry area (up slope) to the processing plant (lower down the slope); or,
- Open-pit quarries – where quarrying workings are generally below the level of the processing plant and excavated material is hauled up and out of the pit.

Hill-side quarries may often become open-pit quarries once the level of excavation has reached, and subsequently extends below, the quarry plant area. Examples of each are shown in Plates 1 and 2.

The choice of whether a hill-side or open-pit operation is contemplated is usually dictated by the site topography, ownership boundaries, geological structure and environmental considerations (hill-side quarries can be very obvious features and have a high visual impact).

It is assumed that, for the purposes of this paper, a hard-rock resource has been identified and is considered suitable for quarrying subject to the usual economic, technological, environmental and legislative matters being satisfied. The following sections detail some of the key areas of concern to the quarry designer and highlight the effects that these may have in the preparation of designs.

Plate 1 – Hill side quarry

Plate 2 – Open pit quarry

2.1 Initial scoping

Appendix 4-2, on the principles of design for sand and gravel deposits, draws attention to several key issues relating to the initial assessment of a proposed quarry site, which are summarised as:

- Confirmation of suitability of quality of quarried products for use;
- Initial estimates of resource quantities; and
- Assessment of potential development constraints.

These factors also affect the initial consideration of a hard-rock site and must be considered at the earliest stages of the design process to establish the potential viability of proceeding with designs.

Processing of material excavated from hard-rock quarries can alter its potential use (irrespective of the physical properties of the rock). Different methods of crushing can produce different shapes of material (which are typically applicable to different potential uses). The quarry designer will, at the initial stages therefore be involved in discussions with other departments within the quarrying company in determining the type of material required. This may affect decisions regarding the rate of working, the style of blasting, and the quantities of waste rock which arises.

Since geological properties (fractures, joints and bedding) may affect the breakage characteristics of the rock, it is essential that early consideration of the geotechnical properties of the rock mass be given. These may affect the type of breakage that would be expected during the quarrying operations and hence the products that may result.

2.2 Quantitative and qualitative assessments

A quantitative assessment of the volumes of material (overburden and rock) within a hard-rock site will be very similar for that undertaken for sand and gravel deposits. This requires a thorough consideration of all available site data (gathered from site investigations, topographic surveys, desk studies *etc.*) and the preparation of detailed geological models for the site.

Plans of the site should be prepared, together with structure contour plans for the rock to be quarried, isopachyte plans of the overburden and if appropriate a consideration of the ultimate floor level of the proposed pit. This may be determined by a consideration of:

- The level of any local water table;
- The quality of the rock to be worked;

- Planning restrictions; or,
- A potential limit based on an initial assessment of the overall pit slopes.

From these basic plans, the potential recoverable resource may be assessed. Again, this may be achieved by computerised methods or by hand calculation. Whichever method is adopted, it is important that this is verified or double-checked by other methods. This may be as simple as calculating volumes based on average areas and thickness of material, using a scale rule placed on the plan. This can identify any ‘order of magnitude’ errors in the initial assessment – a common mistake that, if left unchecked, can have significant consequences subsequently.

Qualitative assessments in hard rock quarry designs address the physical appraisal of the material that may be produced when quarrying (which will typically consider the results of laboratory or other tests undertaken on samples recovered during site investigations). They must also, however, consider the geotechnical setting of the proposed quarry site. Data relevant to such assessments is usually gathered through consideration of the site investigation data (which will include detailed logging of core samples) and geological/geotechnical mapping and logging undertaken on any exposures in the area.

The first paper identified some of the important factors related to quarry design that depend on consideration of geotechnical data. These are essential in establishing the design rules that will be applicable to the preparation of the quarry design and phasing plans. Such design rules include:

- Minimum allowable bench widths (both final positions and working bench widths);
- Maximum allowable bench heights, and maximum overall slopes in all materials to be excavated;
- Maximum foundation slopes as well as maximum slope angles and heights for in pit and out of pit spoil (this may vary according to the type of material to be placed);
- Minimum allowable haul road widths, maximum allowable haul road gradients, circumference of bends and other aspects of mineral haulage in pit (*e.g.* maximum gradients for in pit conveyors and widths to be allowed for such structures).

The geotechnical data will identify differing geotechnical settings within the quarry area and will allow the quarry to be ‘zoned’ accordingly. The assessment should identify the likely slope failure modes in each zone and the design rules will be prepared to reflect each area as appropriate. This may result in varying bench and slope arrangements in different areas of the pit and each must be accommodated in the design.

Plate 3 shows well developed bedding in a hard rock site. The spacing and orientation of these discontinuities, and their dip, have influenced the development of the quarry benches.

Plate 3 – Well developed bedding

The design rules may also influence such aspects as direction of working and identify face alignments to be avoided in particular settings. The direction of working can materially influence advancing face stability and will therefore be a prime consideration in the preparation of the quarry phasing plans.

The effects of weathering on rock masses can be significant and may materially affect their suitability for use as an aggregate. The quarry designer should always be alert to the presence of weathered material in the deposit since it may influence not only the acceptability of the quarried product for sale but may represent zones where stability issues can become problematic.

Weathering can be relatively shallow (where there is significant overburden cover) or can extend to some depth in the rock mass. Depending on the degree of weathering, some or all of the weathered material at or near surface may in fact represent additional overburden and its volume should be calculated in determining the extent of the resources.

Deeper weathering may also have occurred along faults, bedding planes or other discontinuities in the rock mass and these may be identified in the SI data. The presence of such material, if unacceptable as aggregate, may reduce the available resource further.

In some circumstances however, mild weathering may actually improve the rock mass when considered as a body for quarrying. The opening of joints, *etc* within the rock may lead to easier digging, with reduced need for explosives and the potential to undertake some primary fragmentation by ripping. Structurally however, this weathering may result in less stable slopes, since the rock mass is more heavily broken to begin with.

2.3 Losses and allowances

There are a number of factors that will limit the potentially recoverable resources identified in the initial stages of appraisal. As for sand and gravel operations, it is crucial to make considered allowances and assumptions at an early stage of the design process to adequately account for any losses. This is necessary to properly reflect the total quantity of rock that may be sold as product and to allow sufficient space for the tipping of wastes as they arise.

Too often quarries can become quickly 'muck-bound' due to an underestimation of the quantities of waste to be produced at various stages in the operation. In a hard-rock quarry, waste may arise from the following sources:

- Soil and overburden;

- Interface materials (weathered bedrock) at the top of the deposit;
- Unusable interbedded materials within the body of the deposit;
- Broken/weathered rock in and around faults in the deposit; and
- Wastes produced at the processing plant, including dust-sized material, and 'scalpings' – either over- or undersized material removed prior to processing.

Some of these quantities may be calculated as part of the design process (*e.g.* the soil and overburden volumes can be assessed and the presence of any interface or interbedded material can be determined from SI data). Others allowances may be simple assumptions (*e.g.* a stand-off around faults based on a review of the nature of the faulting or observation of exposed faults in the locality, the anticipated volumes of processing waste based on discussions with plant manufacturers or through operational experience, *etc*.).

Based on the measurable quantities of waste and the allowances assumed for unknowns, the requirements for waste disposal areas can be determined and accommodated in the designs. It may be necessary to arrange for both out-of-pit and in-pit spoil disposal and this will need to be addressed in the preparation of the quarry phasing to ensure that sufficient capacity for waste disposal is available at the appropriate stage of development.

It is usual in the initial stages of design to prepare a conceptual pit on the basis of overall slope angles (*i.e.* incorporating bench height and bench width), determined by the geotechnical assessment. This will often exclude any ramps, *etc.* necessary for haulage however. Such items often cannot be properly assessed until later in the design process when plant and equipment selection is more advanced and some consideration has been given to the phasing of such workings. In such circumstances, allowances (in the form of percentage reductions in quarry yield) are normally made. Such allowances generally affect only the quantity of rock to be produced and do not materially affect the calculation of waste quantities.

2.4 Initial infrastructure/development issues

Site infrastructure for hard rock quarries is generally larger and more permanent than that for sand and gravel deposits. There are also a range of other issues that affect its selection and siting (considered further in Section 3.4 below).

As for sand and gravel workings there are several items that will be common to all hard-rock workings and should be addressed early in the design process:

- Access to the site;
- Location of plant and any associated facilities;
- Access to the plant area within the site;
- Location of water management features;
- General site screening and security; and
- Soil, overburden and waste stockpiling.

The location and sizing of such features should always be carefully considered to avoid sterilisation of potentially workable reserves. Since hard-rock quarries are commonly highly visible features in the local landscape, screening at the site boundaries will be a significant matter. Screening banks constructed may be for visual amenity, but may also serve as noise baffles around sensitive locations.

The screening banks formed (commonly from soil and overburden) may represent part of the final restoration plan for the site and as such should be carefully considered in the early designs. It may not be possible to gain access to areas of the site as the quarry develops and the opportunity to re-handle such materials in the future may not exist.

3 DESIGN CONSIDERATIONS

For hard-rock workings, there are four principal stages in the extraction process:

- Soil and overburden removal;
- Primary (and secondary) fragmentation of the rock mass;

- Excavation and loading; and,
- Haulage to the processing plant.

Each should be considered as a continuation of the other in the process. Changes in proposals for one element may have consequences for the others. Many of the options will be dictated by site circumstances (*e.g.* site layout, topography, strength of the overburden and rock mass, plant selection, *etc.*) and as such there may be little flexibility in accommodating changes. Where practicable however the quarry designer will need to optimise the activities to arrive at an economically and environmentally acceptable solution.

3.1 Soil and Overburden removal

For hard-rock quarry sites, overburden may range from practically nothing (in areas of high relief) or to many tens of metres (in low lying areas or faulted ground). The thickness of overburden above a hard rock deposit can vary significantly across a site, depending on the surface topography and the nature of the underlying interface. Some typical settings are shown in Figure 1.

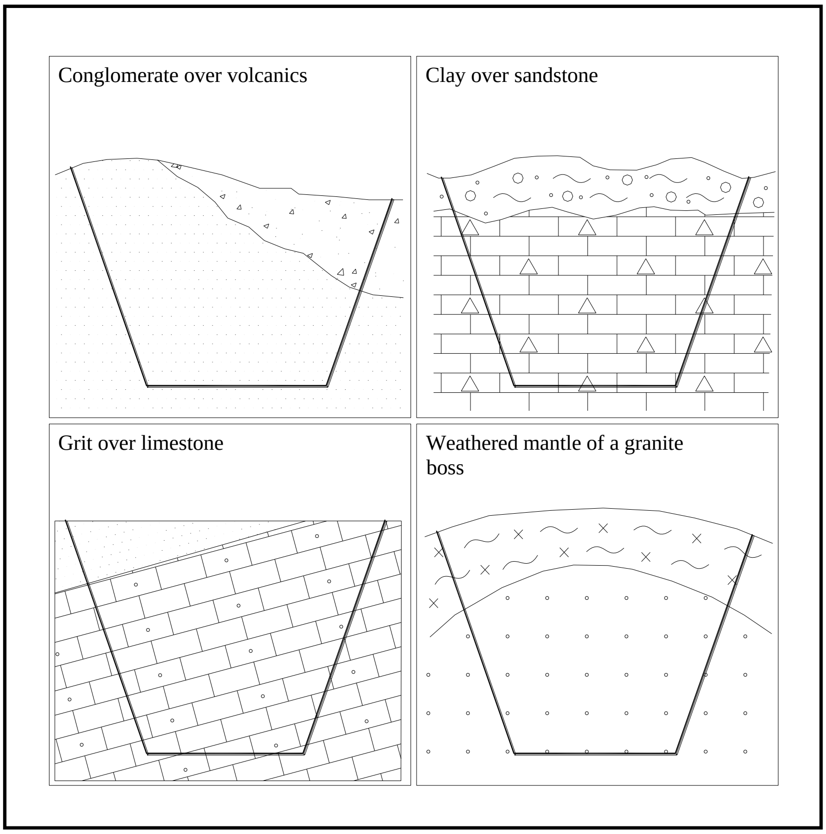


Figure 1 – Examples of overburden and weathering cover

Appendix 4-2 on sand and gravel deposits discussed the basic concepts of soil and soil handling in the context of mineral operations and it is not proposed to repeat this here. Suffice to say that, in areas where there is an appreciable soil cover, good handling techniques must be adopted to conserve as much of the soil as possible, and to retain it in a condition suitable for re-use.

Overburden in hard-rock settings may comprise a loose, unconsolidated material (clay, broken rock, gravel, *etc.*) which can be readily excavated using appropriate plant. The removal of the material away from the quarry area is normally a pre-requisite to avoid potential sterilisation of reserves. There is little potential for its removal and casting aside to storage using a single machine (*e.g.* a dragline, as might be used in a sand and gravel deposit) and typically removal of overburden requires separate digging and haulage plant.

Although a variety of excavators and trucks can normally be selected for such duties, it is normal practice to employ the plant to be used for digging and hauling the payrock from the quarry. This allows flexibility in duties, but may not be achievable economically, particularly where overburden is thick and rock production rates are high (requiring the overburden removal and quarrying activities to be undertaken as separate activities).

In some settings, the overburden can be highly indurated and requires drilling and blasting to break it prior to excavation. In such circumstances, the overburden removal is essentially the same as quarrying for payrock, and may be effectively undertaken by the same processes and plant. The broken overburden will be dug and hauled to the tipping area, rather than the processing plant.

Some overburden may be weakly cemented or thinly laminated and whilst it cannot be easily dug out, does not require drilling and blasting to break it. Ripping using a dozer with a rear mounted tooth (or tine) can effectively break the material, allowing the dozer to push it into piles that can then be dug and loaded for transport to tip.

As noted in the previous section, a common feature in humid tropical environments is a significant zone of weathering in the bedrock. In the absence of overburden (or where overburden is relatively thin), the weathered rock may be dug and tipped as waste (effectively overburden). It may be necessary to remove large quantities before acceptable payrock is exposed, and indeed in some tropical zones, there can be as much as a 1:1 ratio between the amount of weathered material and acceptable payrock on any particular site.

If the depth of overburden is significant, it may be necessary to have benched slopes in this material. Bench profiles will depend on the quality of the overburden and should be considered in the same way as quarry benches to ensure slopes remain stable and secure in the long term.

Disposal of the overburden to suitable screening banks or other areas will require careful planning and design. Given the potential long-term nature and size of such structures, there may be significant safety issues to be considered. The quarry designer will also need to prepare proper designs of tips and tipping rules should be established that will cover their construction, inspection and maintenance. This will take account of the geotechnical properties of the spoil and the physical setting in which tipping will occur.

Tips must be designed so that they are inherently stable. For this to be achieved they must have good drainage; this typically requires drainage measures to be incorporated as part of the tip design. Many major accidents and incidents at operating quarries have resulted from failures in tipped materials. Where tips may be close to the crest of an active quarry this may be of even greater concern since there is a very real potential for serious injury or fatality to any persons working on the quarry benches below. Tip design is considered in more detail in a subsequent paper.

It is good practice to leave a rockhead bench exposed at the interface with the payrock. The width of this bench will depend on a number of factors, but should ideally be wide enough to allow access to all areas of the quarry crest and accommodate suitable drainage measures to prevent flows into the quarry.

3.2 Mineral recovery

Hard-rock quarry workings may be wet or dry, depending on the depth to water table. It is not common practice to allow pits to flood during operation, and pumping may be necessary if water collects within the pit during working. This may require the formation of profiled floors and sumps to collect water prior to pumping. The precise arrangements will reflect the rate of inflow (normally a function of the porosity and permeability, mainly through joints and fissures, of the rock mass).

Most hard rock quarries (unless working in very thin rock units and achieving no significant depth) will be benched. Maximum bench heights, bench widths and face angles will be determined principally by geotechnical factors. However, operational constraints (reach of excavators, capabilities of drill rigs, quarry geometry) may dictate other arrangements that are less than those which may acceptable based on a geotechnical assessment. Similarly, there may be environmental factors that dictate bench geometry (*e.g.* the use of bench alignment and height to screen mobile plant to control noise, blast vibrations and dust, or for visual or landscape reasons). It must also be remembered that different arrangements may be required in different parts of any quarry to reflect a range of geotechnical zones or domains.

As noted in earlier sections, in undertaking any hard rock quarry design, it is essential to establish the design rules for the different areas of the quarry at an early stage. These will allow an early appraisal of the layout of the quarry, equipment selection and areas of concern to be addressed when developing phasing plans. Particular geotechnical settings may preclude development of benches in a certain orientation or may indicate areas where development should start when preparing each sinking cut for the lower levels.

Excavations of hard-rock quarries will generally require fragmentation of the rock to allow subsequent handling and digging. This is necessary to break the rock mass and produce a rock pile with lump sizes that can be handled by the excavation and haulage plant. The desired degree of fragmentation may be achieved in one or more cycles and these are considered further below.

Primary fragmentation

The major costs associated with hard rock quarrying are incurred in the loading from a rock pile and crushing of broken rock at the processing plant. Two basic techniques are commonly used in primary fragmentation:

- Drilling and blasting; and
- Mechanical breaking (ripping).

The selection of the method used will take account of:

- The degree of weathering of the rock mass;
- The nature and frequency of discontinuities in the rock mass (fractures, joints, faults, bedding, *etc.*);
- The crystallinity, nature and grain size of the rock mass; and
- The impact strength of the rock mass.

The degree of primary fragmentation required is normally geared to producing acceptable sizes for loading and crushing. Primary fragmentation should be designed therefore to optimise the distribution of particle sizes within the rock pile, compatible with the loading and crushing plant. The selection of methods and the degree of fragmentation to be achieved should therefore be assessed against the proposed plant and methods of digging for the operation.

Inappropriate particle size in the rock pile can reduce efficiency of the loading plant, resulting in slow cycle times and increased wear to buckets and teeth in the excavator. When oversize material is delivered to the crushing circuit at the processing plant, additional effort (and energy) is necessary to reduce the lump sizes in the primary crusher. If blocks that are too large are delivered, the system can be temporarily put out of action as the crusher becomes choked, leading to a loss of production. Increased wear on the crushing plates can also result.

Blasting

The degree of fragmentation achieved in the blasting cycle is dependent on a proper blast design. Each blast should be considered individually to minimise unwanted effects (over- or under-breakage of the rock, environmental problems and safety issues). Often the primary consideration in determining the size of each blast (*i.e.* the amount of rock to be broken on any one shot) is the suppression of adverse environmental impacts (vibration and noise). This, however, may be contrary to the quarry operator’s requirements and a compromise is often required. A typical quarry production blast is shown in Plate 4.

Blast design can be time consuming and expensive if considered for each and every blast in detail. Consequently, it is common practice to determine a set of rules for a typical blast in different zones of the quarry to satisfy the often contradictory requirements for production of broken rock and environmental protection. Individual blasts will still require assessment, however, and should be properly recorded.

The degree of fragmentation produced during blasting is determined by two principal factors:

- Explosive energy creating new fracture surfaces in the rock mass; and
- Exploitation of existing planes of weakness, such as joints, fractures, *etc*.

Other factors relating to the choice and amount of explosives used, the arrangement of blast holes and the sequencing of detonation will also have an effect. Variations in these aspects can also be used to limit adverse environmental effects or to improve the profile of the blast pile.

Plate 4 – Quarry production blast

Ripping

Mechanical breakage is possible where the rock mass is already fractured extensively (usually by inherent planes of weakness in the rock). Ripping, using a dozer fitted with a tooth at the rear, is the most common method.

In most quarries and deposits, ripping techniques may be used only on a limited basis if at all (for example, in areas of poor ground). They can be effective in short duration excavations (*e.g.* for construction projects) or in preparation of upper benches in a quarry (where the ground may already be fairly broken by weathering).

Where applicable, ripping has major cost advantages over drilling and blasting and avoids many of the environmental impacts associated with blasting.

Secondary fragmentation

If the primary fragmentation is inefficient and may not produce a well graded rock pile suitable for immediate loading and crushing. Geological conditions or a need to limit the amount of explosives used (in mitigating environmental impacts) may locally produce block sizes that are too great to be handled and, in such circumstances, it is often necessary to undertake secondary fragmentation.

This can be achieved using explosives, but such methods are normally unacceptable on safety grounds as the blast can be uncontrolled and result in fly rock being generated. It also produces significant environmental impacts (mainly noise). Mechanical methods are generally favoured including

- The use of a steel drop ball; and
- The use of a pneumatic/hydraulic impact breaker (rock pecker).

Drop balls are popular, effective and relatively cheap, but suffer from being slow and therefore inefficient where high production rates are required. Safety is often an issue as hazards arising from flying rock pieces are often associated with the method.

Rock peckers have a number of advantages in secondary breaking applications. They are efficient machines and can be used to accurately reduce block sizes in the rock pile (see Plate 5). In addition, they can also be used in other duties in the quarry, principally in scaling faces (to push off large hanging blocks that may pose safety hazards).

Plate 5 – Rock pecker on secondary breakage duties

Mineral loading

Once broken rock has been created in a pile (either a blast pile or pushed up by a dozer following ripping), the material is loaded to the selected haulage plant (see below). Excavation plant commonly used includes hydraulic face shovels, hydraulic back acting excavators and wheeled loading shovels. Each has advantages and disadvantages, and selection will depend on:

- Required production rate;
- Rock type;
- Geometry of quarry faces;
- Geometry of the rock pile;
- Grading of the rock pile; and
- The type of haulage plant to be used.

The quarry designer should consider the plant to be used and must carefully match its required performance with its abilities and compatibility with haulage plant. Sufficient operating space must be made available on any bench/quarry floor to allow the plant to operate safely and efficiently.

3.3 Mineral transport

As for sand and gravel operations, the basic haulage methods available within hard rock quarries include use of conveyors or dump trucks. Each has some advantages and disadvantages and design implications arising from their selection will be considered below.

Conveyors

Unlike sand and gravel deposits, where particle size distributions are usually relatively narrow, the broken rock produced within a hard rock quarry tends to have a wide range of particle sizes. This may preclude the use of conveyors as the primary transport method from the working face to the processing plant. Conveyors work best with a restricted range of sizes to allow the most economic sizing and speed of belts.

In addition, within hard rock quarries greater flexibility and access to working faces is normally required. Rock may be produced from several faces at any stage of the operation, and while it may be possible for trucks to haul to a central conveyor, it is normal practice for the excavation plant to load directly to a conveyor feed hopper to minimise costs. Conveyors therefore offer relatively little flexibility, particularly where working space is restricted and the conveyor requires frequent relocation.

Some of these problems may be overcome if the primary crusher (either semi-mobile or mobile) is located in the pit area. Under such circumstances the excavator could load directly to the crusher. A more closely sized product could then be fed to a conveyor and transported to a more remote processing plant elsewhere on the quarry site. Alternatively, the excavator could load to a truck for a short haul to the crusher station, prior to removal of material by conveyor. This would reduce the cycle time for dump trucks and could reduce the fleet required. The cost savings would then be used in providing a conveyor system. Again, however, this requires some permanence in establishing the conveyor route and may only be feasible for more developed sites with long haul distances. Unless sufficient reserves remain to justify the investment, it may not be economic to do this.

Conveyors may be a consideration in some quarries where space limitations may preclude establishing full width haul routes. Conveyors can typically operate at gradients of up to *c* 1:3 (vertical to horizontal) and hence can be used to raise the broken rock over considerably shorter distances than may be possible by hauling along roads (see below). New generations of high angle conveyors are now in use, which can be used at even steeper gradients. Capital costs are high however and careful consideration in the context of the overall economics of the operation will be a prime factor in their selection.

Dumptruck haulage

In most hard rock quarries, dumptrucks are the preferred method of haulage. Trucks may be either rigid bodied or articulated. The latter, which are ideally suited to smaller deposits with lower outputs or limited space, are more appropriate where ground conditions are poor.

Haulage can be a significant cost area and significant expenditure is incurred on fuel, tyres, engine/gearbox maintenance and wear plates in the tipper body. For all but the latter, careful design of haul routes (and their proper maintenance in operation) can help to minimise costs. Optimisation of fragmentation will play a part in reducing wear to the tipper bodies.

There is a considerable amount written about the optimum gradient of haul roads (in limiting distance of haul, breaking efficiency, engine efficiency, *etc.*). In general, gradients of 1:10 (vertical to horizontal) are usually accepted as the most acceptable trade-off between economic, technical and safety concerns. Gradients can be up to 1:8 over short distances if space or other considerations dictate.

Turns/corners on haul routes should be designed, wherever possible to be level, and all effort must be made to avoid ‘turns-into-space’ (*i.e*. where the outside of a turn is at a crest of a slope). This is essential on safety grounds and the quarry designer is best placed to ensure that such unsafe measures are avoided by careful consideration of haul route and bench layout.

Haul routes into quarries can follow a spiral, or may be in the form of switchbacks on a single face. Both forms of road have their advantages, but final selection of haul routing will be determined in the phasing of the quarry workings; it is critical to ensure access remains to all levels of the quarry, even when working on higher benches has been completed. Access may be required for maintenance work to benches, or to allow subsequent restoration.

Where dumptrucks are used for haulage, care and maintenance of haul routes are key areas in ensuring that efficiency is not compromised. Tyre wear and damage can be considerable if the running surfaces are allowed to collect debris (from blasts or falling from trucks). Braking efficiency can be compromised if the surface is covered with loose material and this can materially affect the safety of plant operators. Scrapers or sweepers should be used regularly to clear running surfaces and to ensure ruts are avoided in loose materials.

3.4 Siting of processing plant and quarry facilities

The general principles for siting the processing plant and other quarry structures are generally as described for sand and gravel deposits. However, it is not normally possible to locate the plant centrally to the area to be worked, as this could leave the plant isolated on a 'pillar' of rock as workings proceed around it. Normally processing plants in hard rock sites are located at the boundary of the working area and near the site access where practicable.

Often, processing plants for hard rock quarries will be large and may be housed in relatively tall structures. This presents problems when screening the site. Dust, noise and vibration (principally from crushers) are all sources of potential nuisance and high environmental impact and the plant layout, location and screening measures should be considered to minimise these problems.

It should be apparent that attempts need to be made to minimise the haul distances from the quarry to the processing plant. Whether the plant location is determined in advance of preparation of the phasing plans or *vice versa*, the quarry designer should always consider the location of haul routes to the pit-run stockpiles near the crusher circuit.

Sufficient space must be maintained to allow plant to operate and manoeuvre safely in such areas to prevent queuing and reductions in efficiency of the process. Where possible, haul routes to and from the working quarry should avoid crossing other roadways linking the quarry to the public road network. This minimises the amount of mud and dirt that may be dropped on surfaces used by road going vehicles and also provides for a safer environment. If at all possible, the quarry trucks and road going vehicles should be kept separate.

There has been a move in some countries to use of semi-mobile processing units within the quarry workings. These normally include primary crushers (which have already been mentioned in the context of haulage by conveyors), but increasingly include screening units and secondary crushers. This may be appropriate for smaller sites with restricted output, or in the early stages of quarry development in preparation for the installation of large fixed plant. Mobile units are also often used to supplement production from other plants when demand is high.

3.5 Site access

The site access should be located adjacent to a public road and should be properly screened and with suitable security to limit unauthorised access. As for all sites, consideration must be given to safe access and egress by laden trucks; the access should not be located where it would present a hazard to other road users.

3.6 Water management and lagoons

Site drainage measures will be required to protect local watercourses and to prevent uncontrolled run-off into the pit. Settlement and attenuation ponds may be required to clean the water prior to discharge. By appropriate design of slopes, channels and other features however, it is usually to limit the necessity for such ponds. This is a material consideration for hard rock sites in particular, where topography and space considerations often restrict the ability to form large ponds.

Pumping from the pit may be required where the workings extend below the water table or where high run-off into the pit causes standing water to accumulate. As noted earlier, it is common practice to form a sump in the lowest part of the workings as quarrying progresses from which water can be pumped to discharge.

Drainage measures may be required on benches to limit the collection of surface run off or precipitation. This may be achieved by cutting grips along the benches and channelling any run off to a suitable point to flow into the pit or for direct pumping. Alternatively bunds may be formed in certain areas to control flows.

3.7 Site restoration and after-use

Restoration of a hard rock quarry should include reclamation and rehabilitation of all areas disturbed by quarrying activities. This will include tipping areas, the quarry workings and plant areas.

For small sites, where quarrying may be completed over a relatively short period, it should be possible for the operator to define the nature of the restoration and after-use fairly precisely and to allow for this in quarry designs.

For larger sites, whilst the final restoration landform will always be defined as part of the quarry design, detailed planning of rehabilitation, reclamation and after-use may not always be possible. These operations tend to be longer in duration and it may be unrealistic (and indeed undesirable) to design the restoration scheme in detail at the outset of quarrying that may not be implemented for several decades. In such circumstances, the designs should more properly reflect the proper screening of the site and the rehabilitation of the boundaries and screens of the site at an early stage. This will then ‘hide’ the operations from persons outside of the site boundary. This screening and limited restoration at the boundaries may ultimately form part of the final restoration plan; with several decades in which to mature, it would be unreasonable to return and disturb such areas.

Typically, for deep deposits, restoration of the quarry workings may not be possible until the pit is ‘worked-out’. Access is often needed to large areas of the site, whether actively producing rock or not, depending on the benching and haul road layout. In such circumstances, no restoration will be possible until completion of the quarry workings.

Where deposits to be worked are relatively shallow (and are worked in lateral cuts), or where workings extend over larger, linear areas (*i.e.* working a ridge or similar topographic feature), some degree of progressive restoration may be possible (similar to sand and gravel operations). If quarry development takes place in discrete phases, restoration may be possible in one phase without affecting work in another.

Irrespective of the timing and nature of restoration, certain measures will always be required in the context of providing safe and secure slopes in the quarry. Intermediate benches may be designed for short term stability during operations. The stability may be compromised if they are to remain standing in the long term. As benches are formed in their final locations, further consideration may be required in assessing their design. This may require wider benches or flatter overall slopes to maintain either slope stability or to limit the effects of rockfall. Where practicable quarry operators should prepare the final benches for restoration as they are developing the pit. This particularly applies to higher benches that may be visible from outside the site and could otherwise remain unfinished for many years.

In some circumstances, it may be appropriate to return to worked out areas of the quarry and remove certain benches by blasting or other methods in an attempt to replicate natural landforms typical of the surrounding country. This has been achieved with varying degrees of success in various geological and geomorphological terrains in the UK. It relies on a thorough geomorphological survey and assessment in determining the nature of the final profiles and this should be considered when designing bench layouts.

Spoil may be re-handled and placed against some slopes to soften and flatten profiles, particularly when surplus wastes that cannot be accommodated in tips outside of the pit area. In such circumstances in-pit tipping would serve the dual function of disposal of waste material and restoration works.

In most circumstances there will never be sufficient waste generated at a site to backfill deep quarry workings. The nature of the workings and the geology may also render them unsuitable for landfilling (which would probably be uneconomic anyway since larger hard rock quarries tend to be sites way from centres of population).

Occasionally however, there may be an opportunity for filling if other quarries or industries open up in an area and need to dispose of waste materials. This can represent a good opportunity to backfill a site that could not be foreseen at the time of design and phasing. The adherence to a restoration plan prepared many years earlier can in such situations represent a missed opportunity to improve on such a plan. Operators and licensing bodies should always be aware of changing circumstances in relation to long-lived sites. Adoption of one restoration plan should not therefore prevent substitution of another at a later date.

There is a range of possible after uses of 'dry-floor' hard rock quarry workings. These include:

- Agriculture and forestry;
- Landfill;
- Industrial/built development;
- Nature conservation; and
- Geological interest.

For 'wet-floor' quarry workings (*i.e.* where pumping is required to depress groundwater during working and the pit will be partially or totally flooded once pumping ceases), restoration options may be more limited. As noted, it may not be possible to provide sufficient waste to backfill the quarry (even to a level above the local groundwater table) and a standing body of water will result. In such settings, it is unlikely that there will be much potential for any form of restoration other than nature conservation, or possibly limited public recreation (*e.g.* boating lake). Public use may not be viable though, due to remote location or access, security or safety problems.

4 SUMMARY OF BASIC DESIGN PRINCIPLES

The design of hard rock quarries is often a more complicated task than that for sand and gravel operations. All of the basic principles remain generally the same however.

Added difficulties arise in consideration of more complex geotechnical domains, typically higher capital and operating costs, extra environmental impacts and more complicated restoration requirements.

The quarry designer should attempt to reconcile each problem area before progressing designs too far. There should be regular reviews and discussions with other experts, particularly related to geotechnical issues and possible operational issues (including types of plant to be used). Restoration measures will be an area that needs much attention. Agreements will need to be reached with licensing authorities regarding the general principles to be adopted, but mechanisms need to be included to allow for changes as circumstances arise on site.

APPENDIX 4-4
QUARRY SLOPE DESIGN

QUARRY SLOPE DESIGN

1 INTRODUCTION

All quarry workings will include slopes, either in the excavations themselves or formed from placed materials (tips, stockpiles, soil storage mounds, screening bunds, *etc*.). This Appendix presents an overview of the factors that a quarry designer should consider in preparing designs and phased working plans. It does not set out to provide an exhaustive consideration of slope stability assessment and geotechnical design. This is a critical area which should be addressed by a properly qualified and experienced geotechnical engineer. The quarry designer and geotechnical engineer should work closely together in preparing safe and workable designs that result in stable and secure slopes whilst allowing recovery of the reserves at realistic cost. In relation to final quarry slopes, the quarry designer may also work closely with landscape architects and planners to achieve secure and sustainable slopes suitable to meet restoration objectives and after-use plans.

2 THE NATURE OF SLOPES

Slopes in quarries can result from a range of activities associated with the working of the site. There are three principal types of slope to be considered:

- Excavated slopes (in which *in situ* ground is exposed);
- Tipped slopes (where loose material is formed into mounds either above ground in placed in existing voids); and
- Natural slopes (which may be affected by excavations or placement of loose materials).

Every slope formed in a quarry must be properly designed to ensure that it remains (and can be managed so as to remain) in a safe and secure condition at all times from its formation to its removal or final restoration. This includes short, medium and long term slopes, examples of which include:

- *Short term slopes* – stockpiles and soil mounds, intermediate quarry faces;
- *Medium term slopes* – soil mounds, quarry faces, screening bunds, *etc*.; and
- *Long term slopes* – quarry faces, spoil mounds, lagoon embankments, screening bunds.

2.1 Excavated slopes

Excavated slopes are a feature of all quarries. They may be simple single slopes in sand and gravel deposits or overburden materials of no great height, or may comprise multi-bench slopes in hard rock quarries where the individual bench heights and the overall slope height are themselves significant.

Different design considerations will be applicable to each setting. There is no single design that will be applicable to all sites and in many cases slope geometry will change according to the location within the quarry.

2.2 Fill slopes

Accumulations of materials in quarries generally result in fill slopes. These may arise in spoil heaps, backfilled areas, stockpiles and amenity banks. They may also form the embankments to lagoons.

Spoil heaps

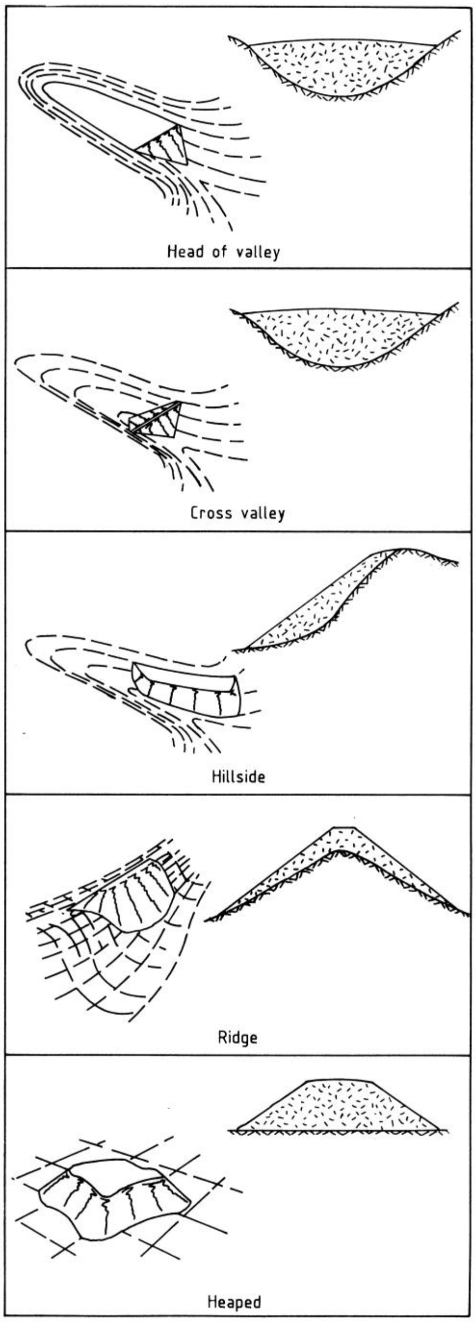
Spoil heaps are of two basic types:

- In-pit spoil dumps formed partially or wholly below ground level within the quarry workings; or,
- Out-of-pit spoil dumps formed adjacent to or some distance from the workings.

In-pit spoil dumps may be temporary structures that will be re-handled at a later date or, more commonly, are permanent structures and comprise part of a phased programme of backfilling and restoration. In pit spoil dumps may also be used to buttress insecure or unstable excavated slopes.

The generation of an initial working void usually requires some out-of-pit dumping of overburden before routine backfilling can take place. Backfilling in-pit may be phased with mineral recovery so as to optimise earthmoving operations and limit the re-handling of spoil. The backfill may be benched to assist in the operation of plant and improve stability. Backfilling may eventually restore land to approximate former levels, or to lower levels suitable for appropriate after-use. Settlement of the restored land is often common and may be particularly marked where placement and compaction have been uncontrolled.

Out-of-pit spoil dumps may also be temporary or permanent structures depending on restoration or phasing requirements. Five basic types of spoil dump are recognised as shown in Figure 1.



One spoil face, easily screened, environmentally sympathetic and very economical. Top sloped to prevent ponding. Constructed by end tipping (from upstream end) or in horizontal lifts from downstream end. Measures may be required to intercept run-off around structure. Similar principles apply with filling in former quarries.

Two spoil faces and environmentally less sympathetic. Constructed by end tipping or placement in horizontal lifts. Requires careful water management to prevent impounding of storm run-off.

Up to three spoil faces, but can be environmentally sympathetic. Good preparation of tip foundations required. Steep slopes often required to maximise volume. Up-slope drainage ditches required. Dump should be built in horizontal lifts with measures to accommodate water run-off and to prevent ponding.

Four or more spoil faces and often environmentally unsympathetic. Steep tip slopes required to maximise volume, imposing severe geotechnical and foundation problems. Tip is domed to prevent ponding and generally constructed in horizontal lifts with careful foundation preparation.

Four or more spoil faces, may be environmentally unsympathetic but often the only choice in flat or gently inclined terrain. Constructed by end tipping or in horizontal lifts with edges raised first. Final profile domed to avoid ponding.

Figure 1 – Types of waste heaps

Spoil heaps often comprise a wide variety of waste materials with variable particle sizes and physical characteristics. Deposited materials may include overburden and interburden, processing waste or substandard or unmarketable materials.

Stockpiles

Stockpiles are usually temporary dumps of processed, partly processed or as dug materials retained on site to meet future sales demand or as needed at later stages of the quarry operation. Materials retained as a buffer supply or held pending changes in the market are generally stored close to the processing plant for easy reclaim. However, materials retained for later use may be stored elsewhere or placed to provide a secondary purpose (*e.g.* screening) until required. Topsoil and subsoil dumps or temporary overburden mounds constitute such features.

Amenity banks

These structures are formed to screen the quarry from the surrounding area. They may serve to reduce noise and dust and are often landscaped on external faces. Permanent or long term screening banks may comprise waste or other materials not required for processing or restoration. Some amenity banks are commonly formed from stockpiled materials (*e.g.* top and subsoil).

3 FACTORS INFLUENCING SLOPE STABILITY

As noted in the introduction, this paper will not present a detailed appraisal of methods of slope stability analysis. It is important for the quarry designer, however, to be aware of the major factors affecting stability and the effects these may have on the designs produced.

3.1 Excavated slopes

There are three major constraints on the stability of an excavated slope:

- Properties of *in situ* material;
- Incidence and properties of discontinuities; and
- Groundwater conditions.

Apart from these principal areas, other external factors may also influence the stability of excavated slopes, such as loading by spoil and machinery, vibrations due to blasting, processing or earthquakes and the effect on slope and rock mass geometry by other engineering activities.

Considering hard rock sites, it is essential to determine the properties of the rock mass as a prelude to proper design. Two main items are considered:

- Geological structure (including discontinuities, defects, *etc.*); and
- Intact rock and soil properties.

Geological structure

There are various discontinuities of geological origin that can affect the stability of excavated rock slopes:

Bedding Planes	Arising from the deposition of sediments in layers, are distinct physical discontinuities. They may occur at the interface between different rock types at various spacings within a single rock unit. They may be persistent and generally extend over greater areas than any other type of discontinuity. In some rock types, movements along bedding planes may have developed weakened shear zones. The nature and inclination of bedding is always of prime importance when considering slope stability in sedimentary rocks.

Joint Planes	Joints are developed to some degree in most rocks. They are planar fractures formed to relieve stresses, across which there has been little or no movement. Jointing plays some part in the majority of slope failures in rock masses since intact rock is generally stronger than the discontinuities.
Fault Planes	Faults occur less frequently than joints and may have undergone substantial displacements. Faulting often produces continuous or persistent planes of weakness. Fault zones may develop in which the fault is not a single clean break, but occurs as a series of displacement surfaces in an area of distorted, crushed and often weathered material (termed 'gouge'). Faulting can occur in any rock type. Faults can provide the shearing or release surfaces for several modes of failure.
Cleavage	Cleavage is a structural property exhibited only in metamorphic rock types. Slate, crystalline metamorphic rock and tightly folded sedimentary rocks show closely spaced laminations which are not directly related to bedding features. Discontinuities associated with cleavage are likely to be smooth and continuous. Within the rocks affected, they are likely to be a major factor controlling slope stability.
Unconformities	Unconformities are surfaces representing breaks in the sedimentary process. Such breaks are only structurally significant where some erosion or tilting of rocks has occurred before the deposition of overlying material (an angular unconformity). Angular unconformities typically occur over a wide area. The surface is often irregular with sudden changes in inclination. An unconformity typically marks a change in rock properties. Where the old weathered zone has been preserved, this may also constitute a zone of weakness.
Rockhead	The rockhead marks the boundary between bedrock materials and overlying superficial materials. It is, in effect, an unconformity. Rockhead may be a sharp boundary where superficial materials have been deposited on an eroded rock surface or the boundary may be gradational where superficial materials are derived from the underlying rock, which has been weathered *in situ*. Rockhead may be planar or highly irregular, but is always extensive and usually represents a boundary between materials with contrasting engineering properties. Its location and inclination are not always easy to predict particularly where drilling data are limited. It is however an important feature since many failures in quarries are controlled by the position of the rockhead.
Margins of igneous intrusions	Within sedimentary strata, such margins may either cut across bedding (dykes and batholiths) or be parallel or sub-parallel to bedding (sills). At their margins, the surrounding 'country' rocks are commonly baked which may alter their strength and propensity to weathering. The ingress or movement of water may be altered in such zones and this may affect slope stability.
Slip planes and tension cracks	These may result from ancient or recent ground movements and can significantly affect stability, particularly if loaded or undercut by quarrying.

The importance of these features when preparing quarry designs depends on:

- Orientation with respect to both the slope and to other discontinuities within the slope;
- Resistance to movement along the surfaces or planes;
- Persistence and spacing of the features; and
- The ease with which water can penetrate, accumulate or flow along them.

In most rock masses (except where discontinuities are widely spaced or impersistent), intact material strength usually exceeds the strength of discontinuities and hence geological structure is the dominant influence on slope stability and design. Certain critical information regarding the rock mass must be recorded and available to the geotechnical engineer and quarry designer in assessing slope stability and its influence on quarry development.

The following should be considered:

Critical geometry	The location and orientation of discontinuities must be determined. These items often dictate the position of potentially unstable parts of an excavation. Combined with the slope geometry, the dip and dip direction of discontinuities frequently govern the style and extent of potential instabilities (see Figures 2 and 3).
Brokenness	The effective strength of a rock mass is influenced by the number and spacing of discontinuity sets. These features describe the degree to which rock may be broken into discrete blocks and therefore indicate the extent to which a rock mass can be deformed without involving fracture of intact material. Movement may occur along a single discontinuity set or involve several sets of parallel discontinuities in an *en echelon* type failure.
Discontinuity features	The ease with which displacement can occur along a discontinuity is affected by its openness, infilling, roughness and continuity. Openness is the separation between the faces of the intact rock blocks. In many cases where the separation is large, the void will have been infilled. Sliding resistance along a discontinuity may be increased due to mineralisation forming the infilling, or decreased where the infilling includes clay materials. Surface roughness includes irregularities on the discontinuity which may effectively increase the overall resistance to sliding. This resistance is decreased when the discontinuity is open. If wall to wall contact in the discontinuity is lost, the shear strength of the discontinuity will be that of the infilling material. Where persistence or continuity of a single feature is high (*e.g.* bedding planes, faults, shear zones and master joints), there may be potential for large movements.
Groundwater	In most cases, the presence of water reduces the resistance to sliding along a discontinuity and can have a profound effect on slope stability. Groundwater effects are considered further below.

Intact rock and soil properties

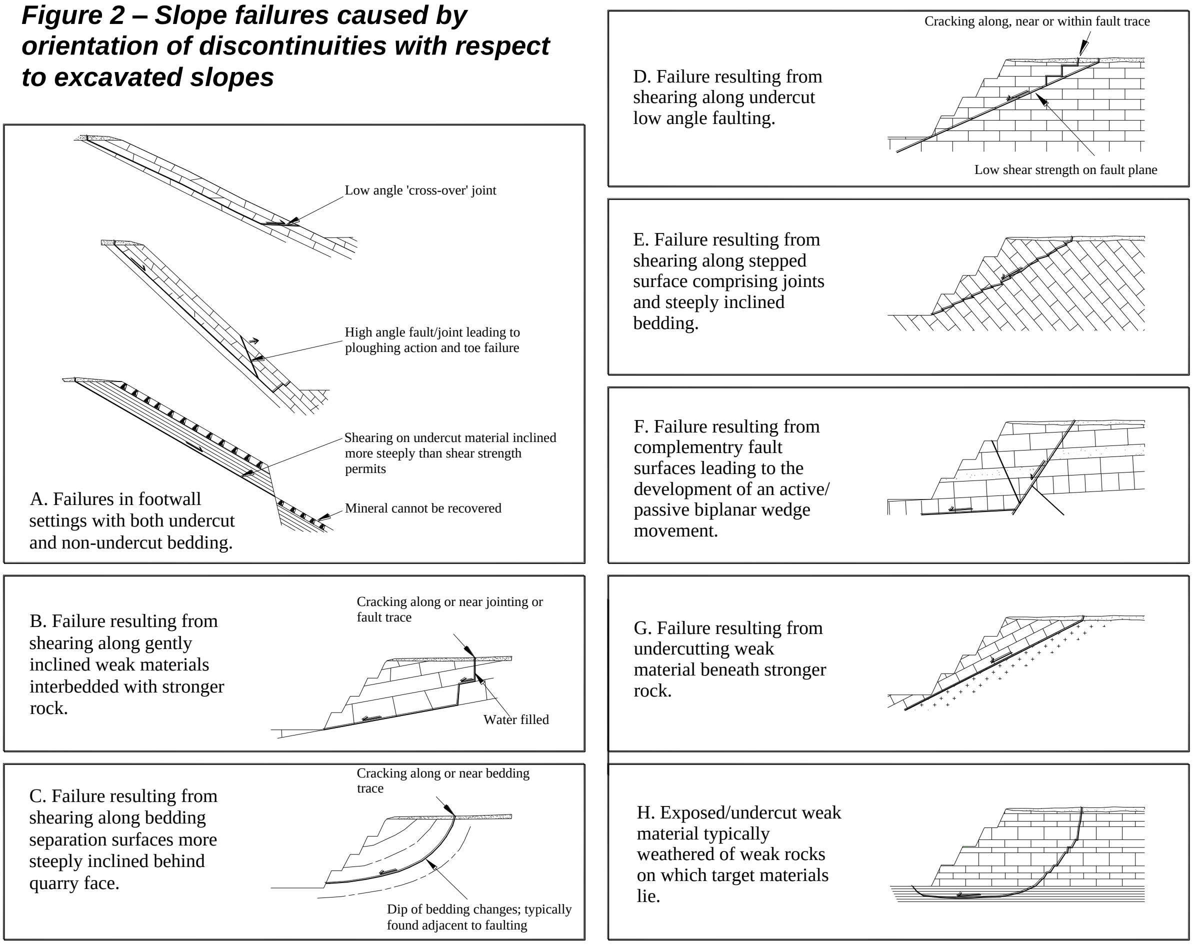
There are five main properties of an intact material that determine its mechanical character:

Lithology	The mechanical properties of intact rock depend on the physical properties of the constituent minerals and their bonding to one another. In some circumstances, petrographic analysis may identify the presence of minerals that may influence stability (including unstable weathering products or soluble cements). Unstable minerals can lead to rapid weathering of exposed rock and reduce its intact strength.
Anisotropy	This is the variation in physical properties of the rock when measured in different directions. Strength anisotropy is a common feature of rocks and may influence slope stability. It may commonly be associated with discontinuity patterns.
Moisture content	In addition to the effects of pore water pressure, many rock materials may be weakened when water is present and the materials are saturated. Strength reduction varies with rock type (*e.g.* granite and sandstone are subject only to minor strength reductions, but clay rich rocks can be much weakened).

Weathering	Rocks may be broken down by the combined effects of temperature, air, water and associated chemical activity. Wetting and drying are essentially physical effects and may only affect the outer margins of exposed rock slopes (sometimes leading to rockfall). Chemical weathering is a generally slower process, but has the potential to significantly affect rock mass strength. It often has no effect during the working life of the quarry, but may be a factor affecting the long term stability of slopes on abandonment. Weathered rock may commonly be present prior to excavation.
Strength	A number of index tests are available to assess rock and soil strengths. They range from simple field tests, to more extensive laboratory testing.

Unless there is cause to believe the rock mass properties are most strongly influenced by the properties of the intact rock, it is usual to consider the discontinuity properties as having the greatest control on slope stability and hence design.

Figure 2 – Slope failures caused by orientation of discontinuities with respect to excavated slopes



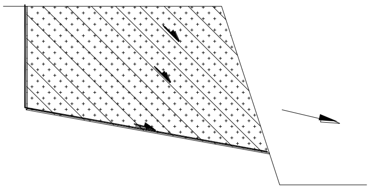
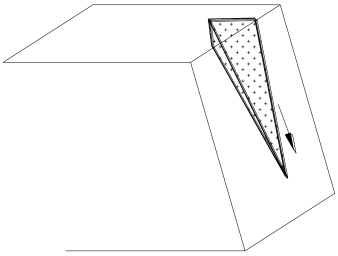
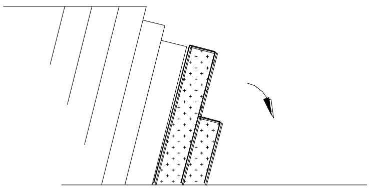
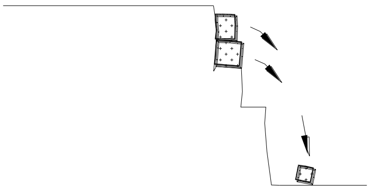
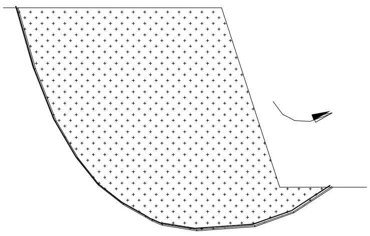
	Geotechnical setting	Critical factors promoting instability
Translational 	All rock slopes with adversely orientated planar discontinuities (i.e. faults, joints and bedding planes with a component of dip into excavation)	(i) Unfavourable face orientation (ii) Undercutting of critical discontinuities (bedding) (iii) Daylighting of critical discontinuities
Wedge 	All rock slopes where combinations of discontinuities combine to form wedges orientated such that the lie of intersection daylights on the excavated face.	(i) Unfavourable face orientation with respect to discontinuities present within the rock mass (ii) Daylighting of critical combination of discontinuity sets
Toppling 	Over steep faces with highly inclined discontinuities which act as release planes	(i) Over steep faces (ii) Overblasting (iii) High water pressures in rear discontinuities (iv) Closely spaced discontinuities steeply dipping into face
Rockfall 	Occurs in most over steep rock slopes. Individual blocks or small volumes of material based on unfavourably inclined surfaces.	(i) Over steep faces leading to undercutting of individual blocks (ii) Degradation of ground due to weathering (iii) High water pressures (iv) Freeze-thaw cycle (v) Overblasting
Rotational 	(i) High faces in weak rocks (ii) Thick superficial cover (iii) Spoil piles	(i) Crest loading (ii) Toe excavation (iii) High water pressures

Figure 3 – Typical modes of failure in slopes

Groundwater

Build-up of water pressures in the rock mass can reduce the force resisting sliding between blocks in the rock mass and enhance the disturbing forces separating blocks. In addition, the presence of water in both intact rock and discontinuities can promote weathering thus reducing shear strengths, or can erode infilling materials.

Where a rock mass has many discontinuity sets, which are closely spaced, the groundwater may behave much as it would in a soil; there is a high degree of connection of voids and groundwater levels vary only gradually over large areas. However, in tightly jointed rocks with only a few sets of discontinuities and where the discontinuity spacing is large, water pressures can vary appreciably from one fracture to the next. Seemingly erratic groundwater levels can also develop when dykes, high angle faults or steeply dipping strata act as aquicludes. Water levels may be significantly different on either side of the feature.

Surface recharge can have a marked effect on groundwater levels in rock slopes. A low porosity tightly jointed rock mass may experience a rapid rise in groundwater level of several metres from only a few centimetres of rain since infiltrating water is concentrated in relatively few tight fractures.

Where groundwater intercepts the slope face, the flow can erode material at and below the seepage level, which can contribute to slope instability.

External factors

Apart from the main constraints noted, other external factors can also affect the stability of excavated slopes. The principal elements are listed below and some examples are shown in Figure 4:

Loading of slopes	*Equipment* Where factors such as elevated water pressures and adverse structures have already reduced stability to a marginal level, equipment loading can contribute to slope failure. Where slopes are high, the increase in static loading of the overall slope due to equipment is generally very low and the effect on stability is minimal. However, on bench slopes where heavy excavating equipment or laden dumptrucks are operating, the effects can be marked and should be considered in the designs. Spoil dumps and lagoons A significant increase in loading of a slope can occur when spoil dumps or lagoons are formed near the crest of excavations. The location of such features adjacent to slopes should always be considered in detail in any design.
Slope geometry	In general, flatter slopes are more stable and in quarry excavations, the overall slope is usually reduced by the inclusion of benches. The size and nature of the benches may reflect the use of particular quarrying plant, but the designer should also be aware of the effect that particular geometry's can have in certain structural settings. These may increase or reduce the likelihood of sloe failure. Slope geometry may also be varied to reduce the volume of a potential failure mass.
Vibration	Blasting, earthquakes and the operation of heavy plant and machinery can all produce sources of vibration that might influence slope stability. In general, they would not be expected to markedly affect stability, but if certain areas of slopes appear more critical, the effects should be considered, particularly in relation to blast design and siting of plant.

Other engineering activities	These typically include other developments within or adjacent to the quarry site. They might pre-date or be contemporaneous with quarrying. Factors to consider might include: • Previous workings; • Drains and boreholes; • Previous backfill.
Time	Most of the factors affecting slope stability are to some extent time dependent. Prior to slope failure, rearrangement of blocks, dilation of joints and deformation of intact material may take place. The degree to which creep and other slow phenomena develop is related to the speed with which loading takes place. If a critical load is applied suddenly (*e.g.* earthquake), failure may occur quickly. Other time dependent controls include weathering, groundwater response to de-watering or recharge and the rate at which slope excavation proceeds relative to dissipation of adverse water pressures.

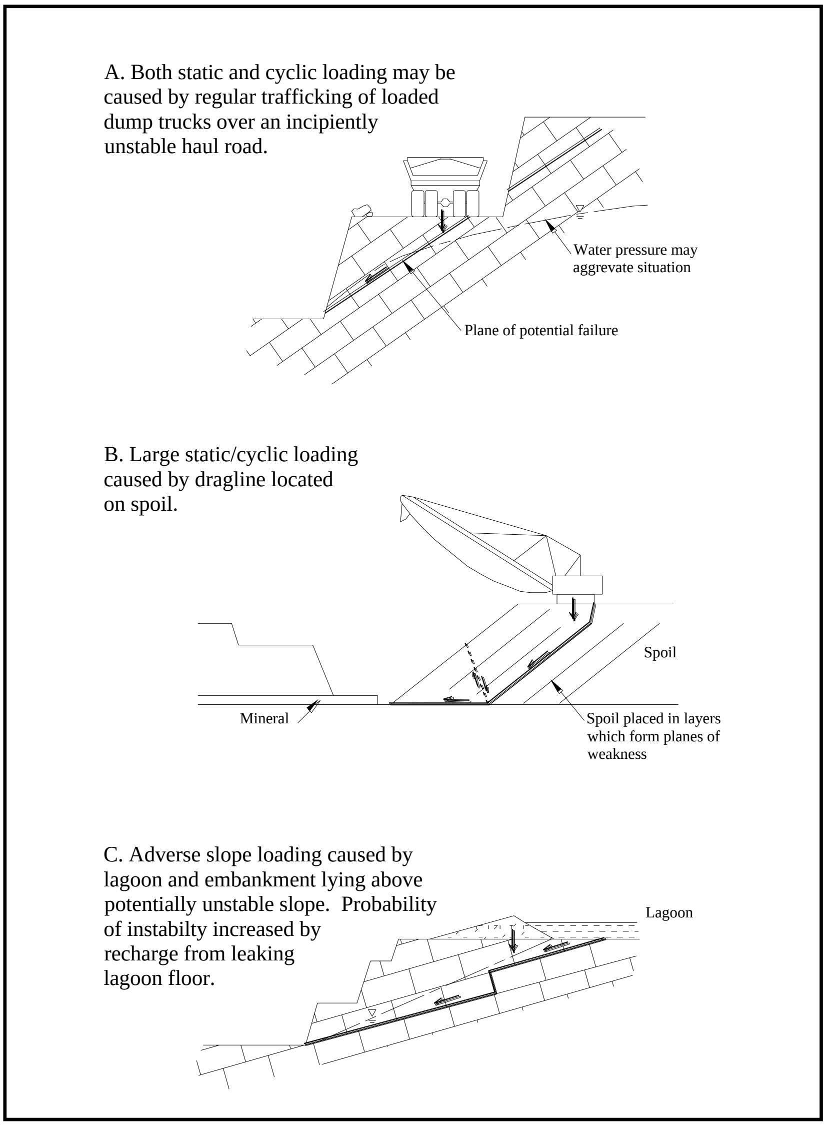


Figure 4 – Examples of adverse loading, both by equipment and super-incumbent structures

3.2 Fill slopes

All fill slopes should be regarded as structures prone to failure unless properly designed, constructed and maintained.

As for excavated slopes, there will be a range of factors that contribute to the stability or otherwise of a fill slope. The principal factors include:

- Properties of materials in and beneath the slope;
- Structure of the slope and its foundations;
- Water pressures within the slope including those arising from construction techniques; and
- External influences.

Properties of materials within and beneath fill slopes

The sizes of particles and voids influence the behaviour of any filled slope, affecting both strength and drainage characteristics. Unless formed from relatively uniform sized material (*e.g.* product stockpiles), fill slopes may be expected to contain a range of sizes, from clay to boulders.

Certain properties of both the fill and foundation materials should be understood in allowing a proper stability assessment of the slope to be made by a competent geotechnical engineer. These include:

Density	The density of the fill depends on the densities of the component materials, the number and sizes of voids and the nature of filling of the voids (whether air or water or a combination). Density can be affected by introducing or reducing the number or size of voids (as a function of the method of handling of materials).
Moisture content	Moisture can affect the behaviour and consistency of fill materials, particularly when fine grained. As the moisture content of a dry cohesive soil increases, its behaviour may change from being brittle to plastic. As moisture content increases further, it may begin to behave as a liquid. Where such materials are to be tipped, information regarding the behaviour under differing moisture contents is necessary to allow the designs to be prepared.
Permeability	Particle size and material density influence the drainage characteristics of fill materials. In gravel, the interstitial voids are generally large allowing water to pass through the material easily. By contrast, clay has small interstitial voids through which water has difficulty passing leading to poor drainage characteristics.
Shear strength	The shear strength of a fill material is the level of stress at which shear failure occurs. It is not a constant value but reflects changes in moisture content; soils generally become weaker as moisture content increases. Frictional and cohesive forces acting on particles mainly affect the strength of loose materials. Clean, coarse materials are generally most affected by frictional forces (*e.g.* slopes in stockpiles of crushed rock or clean aggregate). As the proportion of fine sizes increase, the influence of inter-particle forces increases, imparting stickiness or cohesion.

Pore pressures	Pore pressures in fill slopes may arise from loading or introduction of water into the slope. When fill is loaded, the particles within it are rearranged and the material is compressed. This leads to a reduction in void space and a consequent increase in density. Water within the voids must either drain away to allow the increase in density to take place, or since water is incompressible, the load pressure will be transmitted to the pore water. This increases water pressure in the fill and acts to force particle apart reducing strength. Pore pressures may be generated within a fill slope or beneath the slope by loading during construction (from the fill material or construction plant). When a slope is raised too quickly, pore pressures may have insufficient time to dissipate and may continue to rise during subsequent construction. Drainage measure may be needed in the fill to allow these pressures to dissipate, particularly where the rate of raising is fast (*e.g.* in a spoil dump where overburden tipping is continually occurring).

The structure of fill slopes and foundations

Fill slopes (either in the form of tips, stockpiles or other placements) should be seen as flexible structures and depend in part on secure foundations. The foundation conditions are at least as important as, and in many cases more important than, the method and materials use in slope construction. The risk of foundation failures increases as the ground slope increases or where weak materials are included in critical locations in the foundations. Reliable data is therefore necessary to characterise the foundations, in terms of topography and thickness and character of superficial materials and bedrock.

The method of slope or fill construction influences potential failure modes in the slope, together with the drainage characteristics. The amount and rate of settlement is also influenced by such factors.

Structure of fills

Fill slopes are generally constructed using one or more of three techniques by which the profile of the slope can be adjusted to suit the design and landscaping objectives where compatible with safety. Although the techniques determine the construction and management of the fill, the method of placement may have a bearing on the design of the quarry. For example, it may not be possible to access the slope to construct the fill in a particular way and an alternative may have to be considered.

End dumped structures	These are the most common form of construction (and often the cheapest) in which the fill materials are loose tipped. The slope of the tipped material forms a free face at an angle equivalent to the angle of repose of the materials (either as a function of frictional or cohesive forces). Material may be end tipped to the full design height, or tipped in lifts or benches to improve operational and slope safety. Little compaction is possible and the structure is often liable to significant settlement.
Layered structures	As the name suggests, layered structure are characterised by construction in discrete layers (varying in thickness depending on the type of material placed). Normal site traffic or specific plant may be used to compact the fill and improve its strength. This method of placement generally minimises void spaces and maximises compaction, reducing subsequent settlement, which may be important for certain after-uses.
Heaped structures	These are formed by dumping the fill in mounds of a conical or ridge form and most commonly created by dragline casting or discharge from conveyors. They are typical of stockpiles found in processing areas. As for end dumped structures, the slope of the fill is generally at the angle of repose for the material placed.

Figure 5 shows typical fill structures. With large spoil heaps, and particularly in-pit tips, a combination of these methods may be used in construction of the fill slopes. Complex structures can arise with different quality occurring vertically and laterally across the fill.

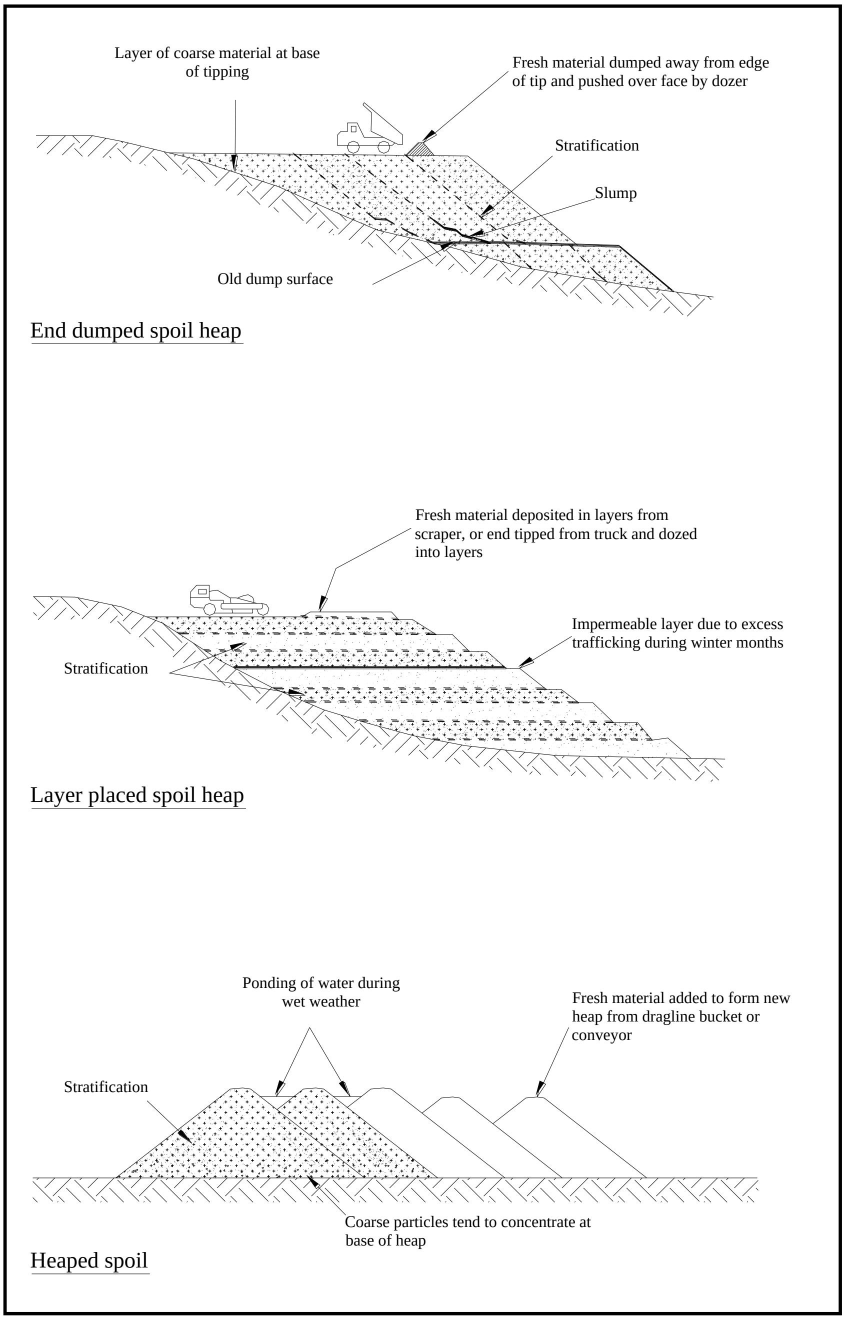


Figure 5 – Principal methods of spoil heap construction and internal structure of heaps

Foundations

Ideally, tip sites should be near horizontal, or have the ground and rockhead falling towards the structure. Such foundation arrangements help to buttress the toe of the structure and reduce the risk of slope failure through the underlying materials. Backfilling into a valley or excavation is often preferred in that the structure is largely confined by foundation surfaces dipping towards it. Where the ground surface falls away beneath a structure, there is an increased risk of failures involving weak materials or surfaces parallel or sub-parallel to the fill/foundation interface.

Foundations in superficial deposits	These comprise soils and underlying unconsolidated or partially consolidated materials (which may have been deposited by geological processes or weathered *in situ*). The behaviour of superficial deposits as foundations depends on their shear strength properties (which may be variable) and on the orientation and characteristics of major and minor structures within them, including: • Variations in rockhead level which may be steep and difficult to predict. This may lead to instability where deep pockets of weak material are present or the rockhead surface is adversely oriented with respect to the tip. • Layering and discontinuities (fissures, *etc.*) in the superficial materials. The presence of weak layers can influence stability, particularly if adversely oriented and subsequently undercut. Interbedded high and low permeability units may give rise to drainage problems or could introduce groundwater into the fill structure. • Old landslips or previous failure surfaces may be present. • Surface vegetation, when buried, may initially be quite frictional but can subsequently rot leaving voids or a weak interface. Such material should be removed from the proposed fill foundation area.
Foundations in bedrock strata	Fill slopes formed on bedrock strata can have similar foundation problems where weak layers are present in the bedrock. Problems may occur where tips are formed out-of-pit and adjacent to slopes, especially where these have undercut weak planer surfaces such as faults, bedding planes, *etc*. Foundations for in-pit structures may include silt and clay slurry remaining from quarry operations, which should be removed and replaced with more frictional material. Additional key cuts may be required to further improve friction at the fill/bedrock interface. Bedrock structure can have a major effect on the position of springlines. Such seepage can adversely affect the stability of fills constructed over springlines and should be avoided in construction. It should also be recognised that former springlines may re-establish after many years if changes in water table level occur (*e.g.* rebound of groundwater after quarrying ceases).

Water

The presence of water in a fill slope can:

- Modify the strength of fill or foundation materials;
- Increase material weight and provide additional disturbing forces;
- Generate water pressures (hydraulic uplift) reducing effective shear strength;
- Cause surface erosion; and
- Generate seepage pressures which may lead to subsurface erosion.

The key issues to be considered are:

Precipitation	Direct precipitation onto a fill slope cannot be avoided, but must be managed if the structure is to remain sound. Appropriate profiling of the upper surface and the provision of drainage channels or berms to prevent uncontrolled run-off down fill slopes must be considered. Any drainage measures included must however be capable of rapidly removing water if percolation into the fill is to be avoided.
Run-off	Removing vegetation or modifying existing drainage patterns in preparation for quarrying may significantly increase run-off from adjacent areas. The run-off pattern may also change in response to quarry development. It is therefore necessary to include suitable cut-off ditches around the fill to prevent ingress of water.
Groundwater	Changes in groundwater level can introduce water into a fill structure if not properly controlled or allowed for in designs. Groundwater may rise in response to rainfall, or changes in de-watering patterns in a quarry site.

External factors

Several external factors may affect the design and stability of fill slopes, not least of which is the influence of humans on the environment. Vibrations from heavy plant and machinery or blasting may be sufficient to initiate failures. Accidental or deliberate (*e.g.* vandalism) to drainage measures may have serious consequences.

Instability in fill slopes may also arise from the removal of material from the toe of the slope. This can arise through natural processes such as burrowing of animals, trampling by livestock or more commonly through direct excavation (*e.g.* in steepening a slope to accommodate redesigned haul route or removal of material for use elsewhere).

4 SLOPE DESIGN CONSIDERATIONS

The formation of safe and secure slopes requires three distinct stages:

- Slope design;
- Slope construction; and
- Slope management.

In the context of quarry design, the first of these is of prime consideration, but must recognise the potential effects of the latter two. The design prepared may dictate the construction arrangements or potential management regime required to ensure long term stability. The effects of slope failures on the safe operation and profitability of a quarry can be critical in determining the success or otherwise of the venture.

4.1 Excavated slopes

Successful and appropriate slope design depends on a sound understanding of the interaction between lithological, hydrogeological and structural conditions, as outline in the section above. However, the proposed face alignment will also influence stability – certain quarry arrangements may not be possible if geotechnical factors preclude a particular direction of advance.

Slope design is more generally concerned with the stability of overall slopes as local failures confined to a single bench can usually be tolerated. It is important however that the consequences of both large and small-scale failures are considered in relation to the active quarry operations. The quarry designer should always ensure that effort is concentrated on those areas of the quarry that are of particular importance (*e.g.* haul ramps, in-pit processing installations and third party land).

Two key stages are generally followed in the slope design process:

Preliminary design	At the preliminary design stage, decisions are made about general quarry slope alignments and the likely working sequence. Geological and geotechnical data will be required since these may affect considerations. The alignment and position of final quarry slopes may be determined by other constraints on development however (*e.g.* available land, topography *etc.*). The principal aim of the preliminary design is to select a working method that minimises geotechnical hazards whilst maintaining an economic and efficient operation. Several alternative methods and slope alignments should be considered and the geotechnical and operational implications of each assessed. A useful method is the preparation of a geotechnical hazard plan in which the potential mode of failure, likelihood of failure and operational implications of failure are used to classify slopes. Such plans should also be prepared for individual phases of a design, not only the final void, to allow assessments of development issues to be made. They provide a useful framework within which detailed design can proceed.
Detailed design	In order to maximise production in quarries and to minimise the overall stripping ratio, the steepest feasible overall slopes are generally required. The first step in the design of such slopes is to identify the maximum overall stable slope angle for the depth of operation projected. All materials that are to be excavated must be considered. Most quarry slopes are benched and the overall slope angle depends on the relationship between width, height and face angle of the benches (see Figure 6). The stability of benches with different combinations of height, width and face angle should be analysed for each material and each geotechnical setting identified and in combinations that do not exceed the maximum allowable overall slope angle. Bench configurations will depend on both operational and stability considerations and are considered further below. In deep workings, haul roads are commonly required, and must be formed in at least one of the quarry walls. The haul roads are usually wider than quarry benches and overall slope angles are generally lower for those faces with haul roads than those without (as shown in Figure 6). Haul roads are considered further below and in Appendix 4-5. Design of the quarry floor should also be considered, particularly where the floor is steeply dipping or where aquifers underlie the floor (which may give rise to heave). Within reason, quarry slope design should be conservative (*i.e.* appropriate Factors of Safety are considered). Once the site begins development, additional information will become available from the working faces that maybe used to revise and/or increase confidence in the designs. While detailed designs must be rigorously prepared, they must not be considered as final and must be able to accommodate changes arising from additional information or changing circumstances on site.

Quarry benches

Most quarry slopes are benched to provide:

- Access to, and advancement of, the slope at different levels; and
- A safety feature (to catch falling debris).

Benches are also critical in providing a means of adjusting overall slope angles. They may be either short-term *operational benches* (*i.e.* those from which material is being recovered and are actively advancing) or long term *permanent benches* (*i.e.* at their final position on the quarry slope).

Critical factors to consider are detailed below:

Bench width	The optimum width of a bench depends on its working status (*i.e.* operational or permanent). It is governed by the purpose of the bench and the space necessary for plant to operate safely and efficiently. In all cases, quarry benches must have suitable drainage measures included in the design. Operational benches may be many tens of metres wide, depending on the plant operating. Benches supporting haul roads used for two-way traffic may be 15-20m wide. Permanent benches can be much narrower and overall slope stability and rockfall considerations rather than operational factors dictate the width. Such benches may still require access for maintenance (ditch cleaning, debris removal) and this should be accommodated in designs.
Bench height	The height of operational benches is dictated generally by the capabilities of the excavation plant and stability issues (including rockfall and safe working arrangements for scaling the face). The height of final benches is controlled by stability considerations. For ease of working, final bench heights are often designed at the same height as, or multiples of, operational bench heights.
Bench face angle	The bench face angle, or slope, depends principally on the excavation method and stability. The slope that is generated during working often results from the excavation plant or process (blasting). These operational bench slopes must be stable in the short to medium term and may be quite steep. Permanent bench slopes must be designed for long term stability against major failures and may be required to be flatter than the operational face slope. Minor failures may be tolerable in the longer term provided they do not endanger persons in or around the quarry.

Haul roads

Haul roads in most quarries are necessary to access deeper areas of the workings and therefore are essential features in the successful operation of the site. Failure of a haul road can be costly and could potentially close some operations altogether.

To maintain a safe gradient (which should generally not exceed 1:10 (v:h)), the haul road may be longer than one quarry wall. In such cases, the haul road may have to be incorporated in the quarry design as either a spiral or as a switchback. Design of haul roads is covered in more detail in Appendix 4-5.

A spiral road winds round the quarry from top to bottom and any large slope failure on any wall will threaten the haul road. The design for the quarry must therefore account for the haul road being on all faces, and appropriate Factors of Safety must be included in the design to protect this critical feature.

Switchback roads zig-zag down one wall of the quarry excavation, and hence higher Factors of Safety are necessary for one face only. It should be apparent that a failure on the face containing the haul road can pose significant problems and attention must be focussed in this area.

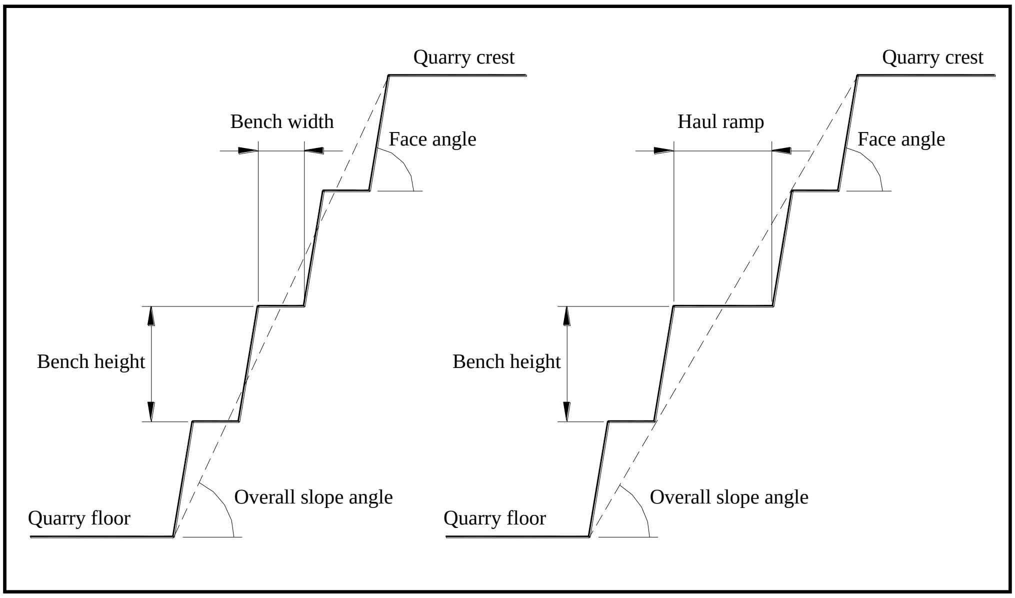


Figure 6 – Relationships between benches and overall slope angle

Slope layouts and quarry development

Slope layout is influenced strongly by geological structure as noted in earlier sections. Changes in ground conditions can lead to slope instability if benching arrangements or quarry development proceeds without taking account of differing conditions. Figure 7 indicates the potential impacts arising from changes in conditions that may be unrecognised or ignored in design. There is a particular danger, when lateral or vertical extensions to workings are planned, that having previously worked in an adjacent area, incorrect assumptions are applied to the extension area.

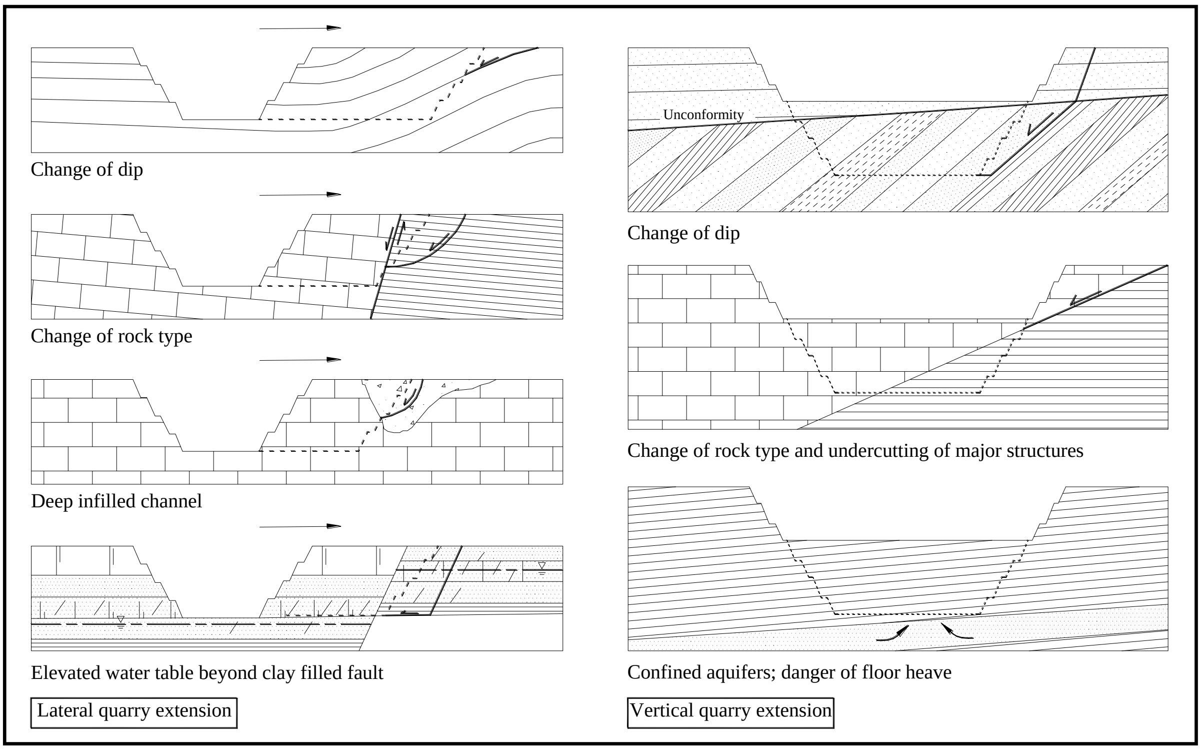


Figure 7 – Effects of unforeseen or disregarded changes in conditions on quarry expansions

Figure 8 indicates the influence of stability on faces as a function of direction of quarry advance. Alternative methods of working the rock mass can give rise to markedly different geotechnical settings during the life of a quarry and the designer should be aware of the stability implications when preparing phasing plans.

Final quarry slopes

The design criteria and requirements for terminal slopes may differ from those for working slopes, which often have a relatively short operational life. The proposed after-use of the site (including land above and below the slopes) may govern the profile of the permanent overall slope angle to be achieved during working.

Whilst the same analysis techniques applicable to consideration of the active quarry slopes are appropriate, additional factors to be considered include:

- Groundwater rebound, which may raise water pressures in a slope and flood the lower part of the excavation;
- Time dependent rock deformations that could weaken the rock mass;
- Weathering and breakdown of the rock mass arising from physical and chemical processes; and
- Inappropriate development or after-use which might overload or undercut the slopes or affect the groundwater regime.

Most deep quarries leave voids that cannot be filled with the spoil generated during working. Whatever after-use is planned, the quarry slopes will be required to stand indefinitely and a high standard of slope stability is required.

The major problem that will be experienced, assuming that slopes are stable against major failures, is rockfall. The design process should assess the potential for rockfall and the likely effects that will result. Where necessary, the designs may have to include for catch ditches and bunds on the final quarry benches.

Drainage measures should be maintained at the crests and toes of slopes to reduce problems associated with ponding water. These should be included in designs, together with suitable water management measures.

If voids are to remain water filled, a safety bench or flatter beach area should be designed at the level to which water will rise in the workings.

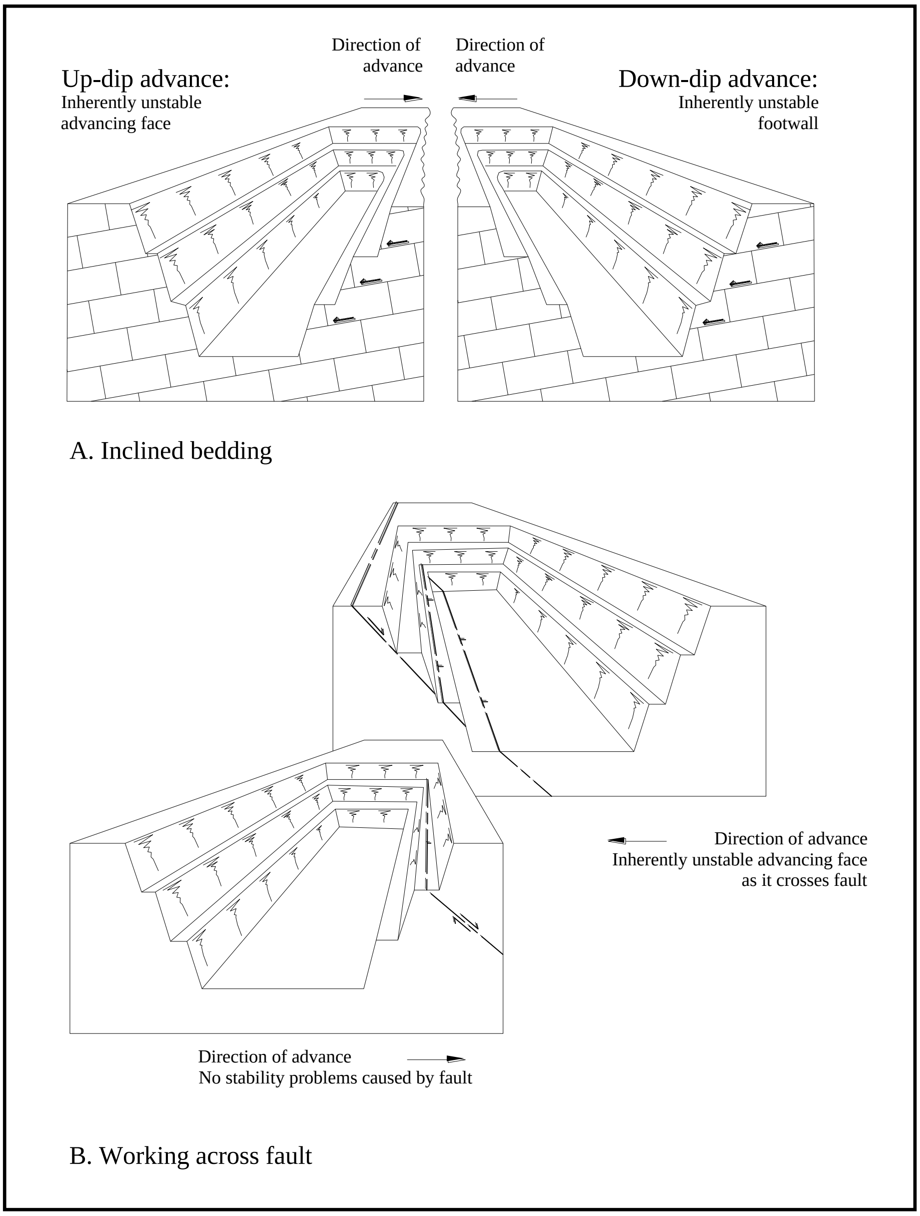


Figure 8 – Influence of geotechnical settings on working method

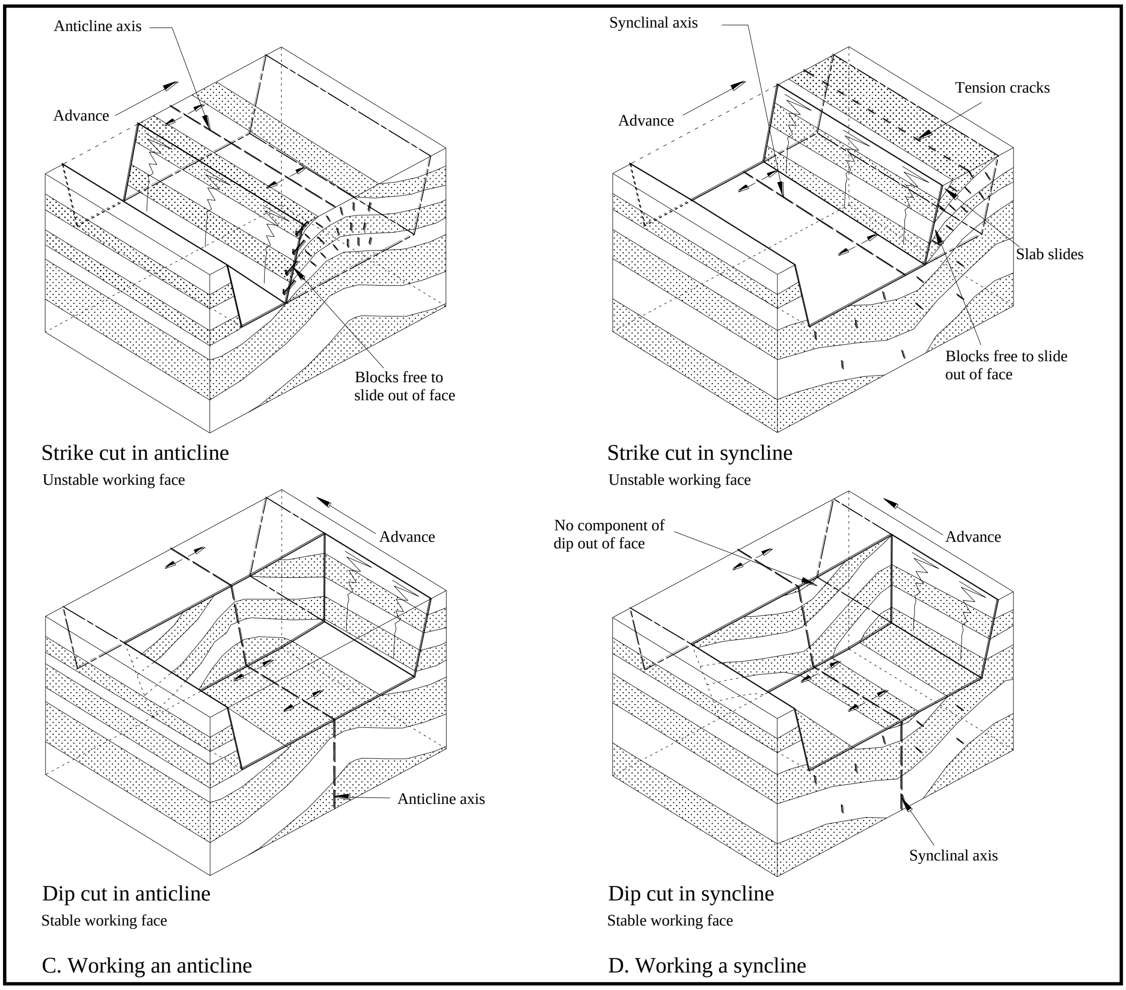


Figure 8 (continued) – Influence of geotechnical settings on working method

4.2 Fill slopes

In most circumstances, the design of fill slopes recognises the need to dispose of quantities of overburden or waste generated in the quarrying operation. Other intermediate slopes are often required (stockpiles, screening banks, *etc.*) but it is the design and construction of tips that is of particular importance. These will often be the largest structures and slopes may be significant.

Preliminary design

The principal design criteria required for assessments of fill structures at a preliminary stage include:

Availability of space	The overall quarry design will be constrained by licence and land ownership constraints. Within the area available to a quarry operator there will be a need to maximise recoverable reserves. This can lead to limited or inadequate space for tips and other fill structures unless the design prepared allows for the scheduling throughout the quarry life of all materials to be stored or disposed of in tips. Many quarry design and development problems stem from lack of attention to these issues (*i.e.* the quarry becomes ‘muck-bound’).

Assessment of likely volumes for tipping	The determination of total volumes requiring either temporary or permanent storage is critical in determining the size an necessary capacity for tips and stockpiles. This should also account for the growth and reduction in mounds as materials are either placed to tips or withdrawn for use (or sale). The assessment requires realistic determinations of production rates of various materials, and should incorporate realistic assumptions regarding the generation of processing or recovery wastes. The preliminary design for the site should allow for the correct storage of all fill materials. It may be necessary for the designs to be revised if insufficient space or capacity is available to dispose of the required quantities. This may be achieved by amending the quarry limits, or allowing in-pit tipping.
Phasing of the quarry operation	Having established the ultimate excavation limits and site layout, detailed phase drawings can be prepared by the quarry designer. These must include details of the tips and other fill structures to be constructed in each phase and is particularly important where spoil is to be placed in-pit. In all cases, sufficient capacity for out-of-pit storage must be provided to accommodate all waste before in-pit tipping is possible.
Environmental considerations	Some spoil or stockpiles can be used to mitigate environmental impacts. Materials may be used to form screening banks, to reclaim derelict land (*e.g.* areas previously affected by quarrying and essentially unrestored) or to replicate natural landforms (*e.g.* to modify excavated profiles to simulate existing features).
Method of placement	The method of placement may influence the size, shape and stability of fill structures, as noted in Section 3.2.2.1 above.
Permanence of structures	Some fill structures may be temporary or permanent, and this may affect the design as follows: • Temporary structures may not be as environmentally ‘sympathetic’ as permanent ones since they are likely to be removed and therefore may not justify the costs of extensive profiling/planting (*e.g.* mineral stockpiles); • Lower Factors of Safety may be more applicable to temporary structures, but the consequences of failures must be thoroughly addressed; • Temporary structures will require rehandling either during or after operations and their proximity to their final resting location will have an impact of the quarry economics.
Restoration objectives	Restoration in quarries may be progressive, phased, or left until completion. This depends on the nature of the deposit and methods of working. The consideration of placement of fill to restoration should be addressed in the design to minimise cost and to ensure safe structures are formed.

Detailed design

Once these factors have been considered in the context of the overall quarry design, detailed design can proceed. The following elements are to be considered by the quarry designer in preparing such designs. They are mainly applicable to larger spoil heaps, but will have an impact on smaller fill structures:

Site investigation	Earlier sections have outlined those factors that affect the stability of fill slopes and the basis for any assessment of detailed design requires a thorough understanding of site conditions where tips are to be constructed out-of-pit on *in situ* materials. Detailed understandings of tip foundation conditions are crucial in this regard. Additional site investigations may be required in selected areas of the site identified as potential fill locations.
Stability analysis	Specifications for safe slope gradients in fill materials and for benching schemes in tips depend on detailed stability analysis. These may have been considered at earlier stages in the design process, and the detailed design of fill slopes may only focus on those areas of concern or where structures are in critical locations.
Equipment selection	Decisions need to be made in the design process as to the methods of construction and plant to be employed. These can have a major influence on design and it is important that the stability of fill structures is assessed by reference to the relevant construction conditions and rates/timing of fill placement. Plant operating on fill slopes must be capable of operating in a safe and efficient manner. Where ramps are to be formed, these should be properly surfaced and protected with drainage ditches and bump banks and should have gradients of no greater than 1:10 (v:h). The provision of safe working areas and accesses may restrict the capacity of some spoil heaps.
Drainage measures	The purpose of drainage within fill structures is to reduce pore water pressure and to collect and discharge surface or groundwater. Drainage may comprise: • *Tip underdrainage* – to improve foundation conditions, to reduce pore pressures and lower the water table within the fill profile. This may be achieved by the inclusion of a drainage blanket on a flat, dished domed or inclined site, radial drains on flat or domed sites, herringbone drains on flat or inclined sites or relief wells to reduce artesian pressures in foundation materials. The choice reflects the existing ground slope, the foundation and fill characteristics and the availability of suitable drainage materials. Drainage may also be improved by including coarser fill at the base of structures during the initial construction. • *Internal drainage* – to reduce pore pressures and limit perched water tables in the fill. This may be necessary where stability analysis indicates control of pore pressures is critical to stability. Selective placement of fill and a good knowledge of the characteristics of the fill arising from quarrying may assist in this regard. • *Surface drainage* – to intercept and prevent surface water from flowing into the fill, to collect and lead water from the fill surface and to prevent infiltration and ponding. Ditches are commonly formed on or upstream of the fill surface to channel flows away. The design should ensure that temporary surfaces in the fill are graded towards suitable collector ditches. A main ditch is commonly formed around the toe of the fill to collect and lead water away from this sensitive area. Culverts beneath fill areas should be avoided in designs wherever possible. Such culverts may be difficult to inspect, maintain and repair. The failure of a culvert beneath a large, permanent fill area can have serious implications for slope stability (since it can introduce water to the base of the fill).

Stand-offs	Sufficient space must allowed for at the base of a fill slope and any adjacent third party land or quarry plant or services. This space is necessary for the provision of drainage measures, ditches and fences, amenity or screening banks, operational safety during placement of the fill, access and maintenance and inspection of the toe of the fill. The stand-offs adopted will depend on the size and geometry of the fill and the nature of the third party land. For guidance, at least 5m is appropriate between the fill and third party land and 3m from any ditch or quarry infrastructure. These distances may need to be increased where fill construction uses little or no compaction, where ground is sloping, where long term stability of the fill or foundation are uncertain, where the fill may degrade with time or where greater distances are imposed by appropriate authorities or statutory requirements.

Mineral stockpiles

For most processed materials, these will be formed by gravity discharge from conveyors and are therefore only compacted by self-loading. The outer slope of the stockpile will be the angle of repose of the materials at the relevant moisture content. A fabric and internal structure is often developed along which sliding may occur when excavation is attempted at the toe.

Provided mineral stockpiles do not comprise material with significant proportions of fine grained materials and are sited on well draining, secure, clean and level foundations, there should be little scope for failure (other than by excavation of the toe). However, all end-tipped or conveyor discharged stockpiles are poorly compacted and if disturbed can collapse to a denser state entrapping air and setting up a flow slide. Small flow sides are commonly seen on stockpiles, but if the stockpile is sufficiently large, they could overwhelm the plant working at the toe.

Stockpiles of materials more prone to collapse (*e.g.* clays, clay and silt rich scalpings, fine sands, *etc.*) should be carefully designed and loose tipping avoided if at all practicable. Such stockpiles may require storage behind secure retaining walls.

Screening banks

Where these comprise large structures they should be designed as if considering spoil tips. They are often required to screen unsightly operations (or to act as noise or dust baffles) and as such often have to meet the requirements of landscape architects or others involved in site restoration. The designer should always remember that stability issues may be paramount and there should always be a proper geotechnical assessment of such structures.

Typically, screening banks will be formed along the perimeter of quarry areas and hence the siting and security of the bunds should be carefully considered since they can have major impacts on the boundary and surrounding land if they fail.

Backfill in quarries

For design purposes, such fill should be treated in a manner similar to large spoil heaps and subject to the same level of investigation. Pit floors to be over-dumped may require preparation prior to tipping and allowance should be included in the design. Careful consideration is necessary where in-pit spoil dumping is proposed in the following settings:

- Quarry floors inclined away from the spoil toe;
- Where high water levels are likely to develop in the spoil; or,
- Where weak foundation materials are present.

In these cases, design changes may be necessary to ensure the proper security of the structures including:

- Realigning the quarry excavation and backfilling operations (*e.g.* reversing the direction of development or working dip cuts rather than strike cuts, *etc.*);
- Digging retaining keys through weak foundation materials;
- Reducing water in-flow into the quarry by sealing aquifers in quarry faces against which the spoil is to be placed;
- Selectively placing frictional free draining materials near the toe and along the base of the spoil.

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APPENDIX 4-5
HAULAGE METHODS AND HAUL ROAD DESIGN

HAULAGE METHODS AND HAUL ROAD DESIGN

1 HAULAGE METHOD SELECTION

In aggregate quarries, haulage from the face to the processing plant is generally achieved through either conveyor systems or using dump trucks travelling on haul roads (or a combination of both). Conveyors are generally more commonly found in sand and gravel quarries although, increasingly, in-pit crushing and conveying systems are being installed in hard rock quarries. The following table provides key considerations for a number of important selection criteria to assist in selection of an appropriate haulage method to incorporate in design.

SELECTION CRITERIA	CONSIDERATIONS RELEVANT TO CONVEYOR SYSTEMS	CONSIDERATIONS RELEVANT TO DUMP TRUCKS
Site characteristics		
Site Geology	Suitable for homogeneous mineral not requiring selective excavation and haulage.	Provide flexibility where there is variable geology requiring selective excavation and haulage of different grades of mineral and non-mineral from multiple faces.
Haulage distance	Suitable for sites where long haulage distances would require additional trucks to maintain production rate.	Favoured for shorter haulage distances.
Operational life of site	High capital costs and therefore operational life must be sufficiently long to recover those costs.	Favoured if short operational life.
Design		
	Efficient design and planning of operation needed to minimize conveyor realignment during the operation and optimise conveyor length.	Allows more flexible phasing and working arrangements.
	Traditional straight conveyor alignments will minimize transfer points (expensive and requiring power supplies and regular maintenance). Curved and steep (to vertical) conveyor systems are available.	Truck haulage allows a more flexible design to accommodate space limitations in many small pits.
	May reduce requirement for and maintenance of haul roads including access by dump trucks to working areas (but access roads to all parts of the excavation are still required for inspection, management and maintenance).	Dump trucks require planned and maintained haul roads to excavation area.
Operational		
	Generally suitable for material up to 300mm. Ideal for sand and gravel. A mobile primary crusher is usually located at the conveyor head in hard rock quarries.	No specific size restrictions beyond size capacity of truck.
	Life expectancy >15 years.	Life expectancy *c* 7-10 years.
	Steep (to vertical) and curved conveyor systems now available (but access roads to all parts of the excavation are still required for inspection, management and maintenance).	
	Initial capital costs may be greater than trucks but annual operating costs lower. Minimal personnel requirements.	Capital costs vary and may be as high, or sometimes higher, than conveyor. Leasing or contract hire common. Annual operating costs including labour costs, training, maintenance, fuel *etc* are high.
	Predictable maintenance requiring little space and small number of fitters.	Maintenance requirements less predictable as wear and tear not easily controlled. Requires space for maintenance. Robust operating rules and well designed and constructed haul roads can significantly reduce wear and tear.
	Electricity – vulnerable to loss of supply. Potential for local generation (*e.g.*. landfill gas).	High fuel usage – potential for biodiesel and technological developments.
	Operate in most weather conditions, although covered conveyors may be needed for material that becomes difficult to handle when wet.	Poor weather conditions may affect haul roads and interrupt production.
	Extended hours of working possible – poor light conditions/after dark when dump trucks cannot operate safely. Excavation area only needing floodlighting.	Generally unsafe to operate after dark or in poor light conditions.

SELECTION CRITERIA	CONSIDERATIONS RELEVANT TO CONVEYOR SYSTEMS	CONSIDERATIONS RELEVANT TO DUMP TRUCKS
Environmental		
	Continuous low level noise – may be reduced by housing. May argue for extended working hours since noise impact on nearby properties decreased.	Noise from trucks greater than that from conveyors and varies at any static receptor as the trucks move in relation to that receptor. Audible reversing alarms can cause intrusive noise where fitted.
	Minimal dust emissions - reduced by housing. Electrically powered – no exhaust emissions.	Dump truck movements on haul roads and loading activities are a major source of dust in quarries. Emissions from diesel fuel.
	Potentially less disturbance of ground and habitats by overland conveyors. Eliminates disturbance from regular dump truck movements.	Haul roads and large vehicles have significant ecological and visual impact, particularly on otherwise undisturbed or restored ground.
Health and safety		
	Eliminates most accidents involving mobile plant.	High proportion of quarry accidents involve dump trucks.
	Risk of injury during maintenance and blockage. Safety systems governed by regulations and legislation.	Risks from whole body vibration syndrome from driving on uneven ground.

2 DESIGN AND ROUTING OF ACCESS AND HAUL ROADS

The quarry design and site layout should consider all vehicle routing and site roads from the entrance and parking areas to the working benches and pit floor. An inadequately designed road may limit the future selection of plant on a site. The roads must be suitable for the anticipated vehicles and traffic volume at all stages of the life of the quarry. Site roads may be used by one or more of the following at the same time:

- Laden and empty dump trucks
- Other mobile plant *e.g.* excavators, dozers *etc*.
- Laden or empty road-going trucks including customers' vehicles.
- Maintenance vehicles and other smaller vehicles operated by the site, contractors or other visitors.
- Pedestrians – including site personnel, contractors and visitors.
- Mineral conveyors.

Haul roads and site roads must be designed for the three criteria of safety, cost effectiveness and environmental acceptability. Regulation 13 of the 1999 Quarries Regulations and Approved Code of Conduct requires that operators ensure, so far as is reasonably practicable that:

> *"(a) benches and haul roads are designed, constructed and maintained so as to allow vehicles and plant to be used and moved upon them safely; and*
>
> *"(b) where necessary, effective precautions are taken, by the installation of barriers or otherwise, to prevent vehicles or plant accidentally leaving any bench or haul road."*

The guidance associated with this Regulation is as follows:

> *"106 The proper design of benches and haul roads is essential. They must be suitable for the type and size of machinery and loads used on them. Vehicles must be able to move safely and without risk of accidentally leaving the bench or from any instability of the face or bench. The operator also needs to consider the effect of vibration on the bench or haul road from any use of explosives.*
>
> *"107 The minimum width of the bench and the type of machinery which can be safely used on it should be considered during the design, appraisal and, where appropriate, the geotechnical assessment of the excavation or tip. They should be reviewed as the working methods and excavation or tip develop. Benches need to be wide enough for the type and volume of traffic using them and take account of the traffic systems in force, for example one-way systems.*

"108 Benches and haul roads must be designed to avoid dangerous sharp bends and gradients. They must also be maintained so that they do not develop bumps, ruts or potholes which may make control of vehicles difficult or cause health problems due to whole-body vibration.

"109 Regulation 17 of the Workplace (Health, Safety and Welfare) Regulations 1992 (the Workplace Regulations), which applies to quarries, deals with the organisation etc of traffic routes. Operators must take the regulation and relevant sections of the Approved Code of Practice into account when making arrangements to comply with regulation 13 of the Quarries Regulations. The design and construction of traffic routes inside buildings is also covered by regulation 12 of the Workplace regulations."

Edge protection on roads is the subject of the Approved Code of Practice and related guidance associated with regulation 13 (paragraphs 110-117). The subject of edge protection is considered in more detail below.

The requirements of regulation 13 are aimed at minimizing the risk to personnel. However the design and maintenance of good quarry roads may have significant operational, and therefore financial, benefits for the operator from reduced wear and tear on plant and maintaining a smooth and efficient haulage cycle.

The principal considerations for the quarry designer are the method of construction, safe operation and environmental impacts of the haulage system.

2.1 Construction

The quarry design should reasonably aim to minimise the volume of mineral sterilised by the haul roads. In shallow or very large sites, initial temporary ramps excavated in the mineral may be replaced by ramps constructed from compacted quarry waste or other fill material during the progress of the operation so that no mineral is sterilised. In deeper, hard rock quarries, this may not be feasible (lack of sufficient fill material or insufficient space) and the pit floor may, in some cases, be accessed by a single spiral haul road.

Construction practices can be critical to the security of haul roads. For example, poor blasting practices may leave bench edges with loose or broken material unsuitable for supporting a road or edge protection, such that a road which 'on paper' might appear appropriate, is compromised by poor construction. Assessment of such risks, and recommended prevention (control) measures should be included in the design report prepared for the quarry safety file.

The stability of the slopes above and below the haul road must be included in the geotechnical analysis of the proposed quarry faces.

2.2 Safe and efficient operation

Gradient and vertical alignment

The gradient of the haul road must be appropriate for the number, size, type and load of vehicles using the road. The HSE advises that, for rigid bodied vehicles, roads should be designed no steeper than 1 vertical in 10 horizontal (ref). Steeper road gradients may be acceptable over short distances under some circumstances where suitable vehicles are in operation.

Among the hazards of steep, poorly designed (or constructed) haul roads with potentially fatal consequences are:

- The stopping distance of a vehicle travelling down a steep haul road may exceed the forward visibility such that an accident with an oncoming vehicle cannot be avoided.
- Vehicles may be travelling downhill at speeds which exceed the breaking capability of the vehicle.
- The handbrake may not be effective when parked on a steep slope.

These are exacerbated if the vehicle is laden. If the road is rutted, slippery, soft or uneven, the risks of loosing control or tipping are greater if the road is steep. Poor road design may lead to the imposition of restrictive speed limits on steep sections of roads, which may then affect the productivity of the site. Speed limits must be included in the quarry health and safety document (Mines and Quarries Regulations 1999 Regulation 14) and must be suitable for the vehicle braking capabilities, loads, road gradient and site conditions.

Steep gradients lead to reduced speed limits and slower uphill journeys, particularly if laden. As a consequence, haulage cycle times are reduced and productivity may be affected unless additional plant is used (at considerable increase in cost). Maintenance and repair costs of vehicles are increased because of greater wear and tear – particularly of breaks.

Route and layout

The principal function of the quarry roads is to get the mineral and non-mineral from the quarry floor to the processing plant, stockpiles and tips, and from there to the site entrance. The quarry operator wants to achieve the haulage cycle from the pit floor in the shortest possible time in order to maximise the production rate. Roads may also serve maintenance areas, offices and welfare facilities, employees and visitors parking areas, restored areas under maintenance. The selected road layout needs to accommodate the economic requirements alongside safety and environmental considerations. Some of the considerations when deciding on the route of the main haul roads are:

- Slope stability and rockfall risk. Avoid areas at risk, mitigate – slope design, rockfall protection measures (catch ditch, netting or rock bolts).
- Head on vehicle collisions – maintain sight lines within the stopping distance of the vehicles using that road.
- Vehicles leaving bench – minimise sharp bends
- The environmental impact of alternative routes
- The road usage and in particular potentially dangerous crossing points
- Single or 2-way routes – a one way traffic circulation system is always safer than a 2-way system but may sterilise more mineral and require more space in the pit.
- Minimise reversing – design of tips, loading and tipping areas, parking areas, plant, adequate road width
- Horizontal alignment
- Horizontal curves should be designed so that:
    - Adequate sightlines are maintained to within the vehicle stopping distances.
    - Vehicles can negotiate the bends safely at the speed limit. Curve radii should be greater than the minimum turning radius of the vehicles.
    - Hazardous bends are avoided. Where tight bends are unavoidable, for example switchback road in a quarry with limited space, the design should adequately mitigate the risks of a vehicle leaving the carriageway on the bend. Some of the design solutions are shown in Fig. *.

Road Width

HSE guidelines (ref) (ref Quarry fact file) state that the width of the carriageway should be at least 2 times the width of the largest vehicle to use the road. For a 2-way road, the running width should be 3.5 times the maximum vehicle width. This is to ensure that the vehicles can safely and confidently use the road without undue speed changes. The one-way carriageway width is not wide enough to allow two vehicles to pass in the event of breakdown. An additional width of 1.5m would allow the haul road to continue being used in the event of this happening.

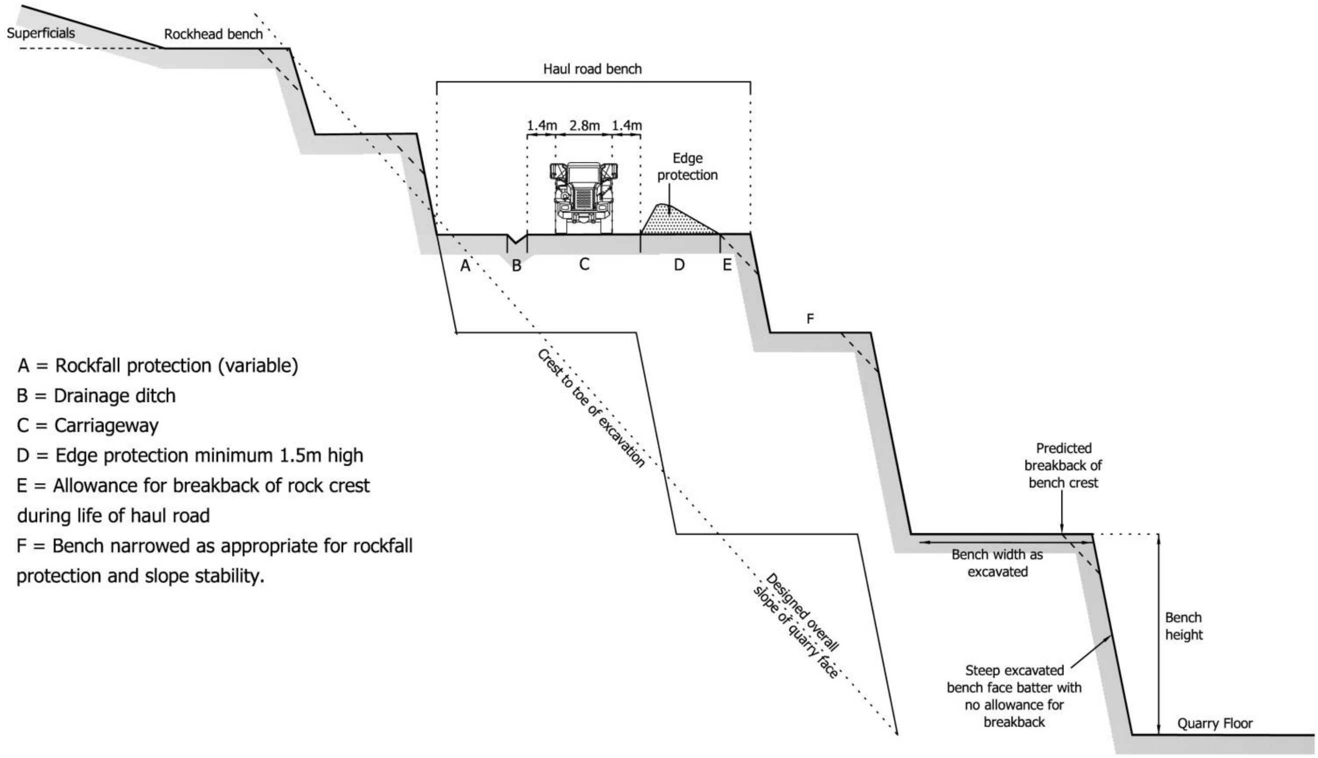

Figure 1: Design principles for haul roads incorporated in benched quarry slopes

In addition to the carriageway, the quarry road may also need to accommodate:

- Minor debris falling from the face immediately above the road and collecting at the base of the face. Rockfall protection measures may be required including a rockfall catch ditch, although risk from rockfall should be minimised by considering alternative routes.
- Drainage
- Edge protection (see below)
- Allowance for breakback of the bench crest during the life of the road. The amount of breakback will depend on the geotechnical character of the face.
- Additional width on bends to accommodate the circular clearance diameter of the vehicles.
- Additional allowance on busy roads for pedestrian routes. Pedestrians should, where possible, use different routes or be separated from the carriageway by a barrier.

Figure 1 illustrates how the width of the bench carrying a quarry haul road suitable for dump trucks might be determined as part of an overall slope design by the quarry designer.

A comprehensive design manual published by the US Bureau of Mines in 1977 (ref) includes recommendations for the design of all aspects of surface mine and quarry haul roads, much of which is still very relevant today.

Edge Protection

Regulation 13 (b) of the Quarries Regulations 1999 states that ‘where necessary, effective precautions are taken by installation of barriers or otherwise, to prevent vehicles or plant accidentally leaving any bench or haul road.’ This applies to any area of the site, including tips, areas around water bodies etc. The design of haul roads and working areas must provide sufficient space for adequate edge protection. Guidance on the design, construction and maintenance of suitable edge protection is given in the HSE Approved Code of Practice (ref). The aim of edge protection is to ‘stop the largest, fully loaded vehicle crossing it when travelling at the maximum forseeable speed’. In practice in most situations, a vehicle will impact the edge protection and be deflected back onto the road by the structure. The critical factors which must be considered during quarry design are;

- Edge protection should be constructed as continuous bank of unconsolidated quarry scalpings or similar material. Compacted material will not absorb the impact of a vehicle, which may ride over the structure. Narrow gaps may be left for drainage. Alternatively crash barriers are occasionally used where space is limited. Lines of rocks are not suitable.
- The minimum recommended height is 1.5m or half the height of the largest wheel using the area, whichever is the greater. The inside slope (impact face) should be constructed and maintained as steep as possible. A typical bank occupies 4-5m of bench width.
- Higher protection (and therefore a greater width of bench to accommodate it) may be needed in areas where a greater risk of vehicles running through the edge protection are identified – for example at bends where the vehicle may approach at a greater angle.
- The bank (or crash barrier) must be constructed on firm ground. Loose, unconsolidated fill or a broken bench crest may give way and compromise the performance of the edge protection. It is advisable that an additional allowance is made on the outside of the edge protection bank for break back. The allowance will depend on the geotechnical analysis.

Surfacing

Design and maintenance of a good haul road surface

- Reduce vehicle wear and tear
- Minimise whole body vibration syndrome
- Minimise dust emissions from the surface
- Allow the designed maximum speed limits to be maintained

The type of surface will depend on the volume and type of vehicles using the road and on the specific site conditions, the anticipated life of the road and environmental considerations including proximity to residential properties. A particular surface may be recommended as part of the design if particular conditions or users are anticipated, for example access to pit floor by customer's vehicle will require a well maintained road with a smooth surface. The monitoring, maintenance and treatment of road surfaces to minimise dust and physical injury should be included in the Environmental Statement and in the site safety file.

Drainage

Surface water run-off may damage the road surface and cause erosion of the benches if drainage measures are not well designed, maintained or of sufficient capacity. The management and treatment of surface water run-off must be considered as part of the quarry design and environmental assessment processes.

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APPENDIX 4-6
ECONOMIC MODELLING FOR FEASIBILITY STUDIES AND BUSINESS PLANNING

ECONOMIC MODELLING FOR FEASIBILITY STUDIES AND BUSINESS PLANNING

1 INTRODUCTION

This appendix presents a commonly used method of modelling predicted financial performance of a business or part of a business to support comparative analysis of different commercial courses of action and to allow expected returns on investment and commercial risks to be evaluated. As described in Chapter 6 of the Handbook, commercial risk assessment is an essential component of overall design risk assessment in the quarry design process. The method is based on the building and analysis of cash flows for a project or business as described in the following sections

2 CASH FLOWS

A cash flow is a simple arithmetic statement of predicted cash inflows (revenues) and outflows (expenditure) over increments of time. An example is given below:

	Period 0[1]	Period 1	Period 2	Totals
Cash inflows (income)	£0	£2,000,000	£2,000,000	£4,000,000
Cash outflows (Costs and Investments)	£1,000,000	£500,000	£500,000	£2,000,000
Cash flow	-£1,000,000	£1,500,000	£1,500,000	£2,000,000

The above cash flow for a notional project shows an outlay (investment) of £1,000,000 by the end of Period 0, during which no income is generated. In Periods 1 and 2, costs are £500,000 per period, giving a total outlay of £200,000,000. Also during Periods 1 and 2, there is a projected income of £2,000,000 per period, giving a total income for the project of £4,000,000. Clearly, by the end of the project period, the investment would have been paid back and a return on the investment of £1,000,000 would have been made; 100% return.

Operator's cash flow

For a quarry operator, the revenue stream will include all sources of revenue derived from the operation of the quarry. For an aggregate quarry, this will include sales of the products produced at the quarry, for which there is a market. The level and mix of sales is determined by:

- The properties of the material being quarried (its inherent suitability for various end-uses and product types);
- The rate at which the deposit can be excavated using the plant and techniques selected;
- The capacity and nature of processing plant (crushing and/or screening plant);
- The capacity of the market to accept the products produced and the market prices.

Cash outflows (costs) fall into the following categories:

- Capital investment and one-off project costs (including the cost of land);
- Fixed operating costs (incurred irrespective of production rate); and
- Variable operating costs (i.e. related to each tonne of mineral produced or to each m³ of void space filled).

[1] Period 0 is the period before the project gets underway. For each of these periods, the word 'Period n' is shorthand for 'the end of period n'.

Generally speaking the majority of capital investment and one-off project costs are incurred in "Year 0" (i.e. before the start of the project). They may include investment in equipment, land and/or other assets, site clearance costs and professional advice to get the operation up and running. Operating costs, both fixed and variable, relate to the productive period of the operation, and are entered in the cash flow in the period during which they occur. Fixed costs are such things as wages and salaries for permanent staff, rates, rent, heat, light and power etc. Variable costs are expressed in £/tonne and include items such as fuel, explosives, haulage and excavation costs, and royalties.

The total period represented by the cash flow will equate to the total operational life of the quarry (including any final restoration). The operational life of the quarry is derived from the total recoverable reserve divided by production rate with any final restoration period added at the end. With most quarrying projects, there will be a degree of uncertainty in some of the key assumptions (notably the market for the mineral and void space, but also in relation to geology and planning status). Given this uncertainty, there is normally a range of cashflows that can be generated for an operation, each of which represents an operating scenario to be considered.

Landlord's cash flow

The landlord's cash flow does not include cash outflows. The cash inflows and the total period represented by the cash flow are intimately related to the operator's cash flow in relation to the output of the quarry, the relative proportions of different quarry products, and the life of the reserves and/or void space.

3 ESTIMATION OF RETURN ON INVESTMENT IN A QUARRY FROM A CASH FLOW

3.1 Comparison of cash flows

In order to select the most commercially attractive option (and understand the risks and sensitivities attached), it is common practice in business (and particularly the minerals industry) for cash flows to be generated for each scenario and compared.

In the simple example cash flow given above, it is apparent that, for an investment of £1,000,000 a 100% return on investment was made over the project period.

The attractiveness of this return, and therefore the asset value of the business represented by that cash flow is, however, highly dependent on the length of each time period. For example, if each period in the cash flow were 6 months, then the 100% return would have been made in only a year. However, if each period were 10 years, we would have to wait 20 years to achieve the same return, by which time it could look significantly less attractive compared to a 'safe' investment such as a bank or building society.

The key question would be "how much money, received now, is equivalent to the future return that is expected to be generated?" It is clear that, given the choice, it is preferable to have £1M today than the promise of £1M in a few year's time. This is because we have the opportunity to invest the £1M if we have it today. If we decide to wait for the £1M, its real value will have diminished by the time we receive it through the effects of inflation, even before taking into account the lost opportunity to invest the money. In order to calculate how much we need now to compensate for the lost opportunity to benefit from a future income stream, we use an approach which takes into account the 'time value of money'. This involves converting all the individual future cashflows for the project to present values. The present values (PVs) are the amounts of money that would need to be invested today to yield the cashflow expected in a future year.

The following simple example illustrates how PVs are calculated.

Consider an investment (I) of £1 in a fixed interest account at a fixed rate of interest of i%, its future value (FV) at year n is:

$$FV=I(1+i)^n \qquad \text{Equation 1}$$

Clearly, an investor, knowing he will need to realise £1,000, in some years time will invest less than this now on the basis that his money will grow over the period.

Consider now a desire to have £FV in the fixed interest account at the end of year n, with a fixed interest rate i. What is the sum to be invested now to achieve that? This is simply calculated by rearranging equation 1:

$$I = \frac{FV}{(1+i)^n} \qquad \text{Equation 2}$$

I is known as the 'present value (PV)' of the investment at year n.

3.2 A discounted cash flow model for a quarry project

A quarry cash flow is far more complex than a fixed interest account because the expected returns are not simply dependent upon the rate of interest being paid; they depend upon the performance of a complicated business and on external factors (notably related to the market and regulatory environments). However, the principles are the same and are applied as follows:

i. A 'cash flow' (costs and revenues over time) is built up for the project, taking into account inflation in predicting costs and revenues.

ii. Each item in the cash flow is translated into a PV using a notional interest rate called the 'discount rate' and the formula in Equation 2. The discount rate will be chosen by the company having regard to the company cost of capital (interest on debt and dividends on equity) and the nature of the risks associated with the project. This adjusted cash flow is called a 'discounted cash flow' (DCF).

iii. By adding all the individual PVs in the DCF, we derive the 'Net Present Value' (NPV) (net inflow or outflow of cash at present values over the project period). This would be an amount that could be paid today in compensation for losing the opportunity to benefit from future cash flows (i.e. it might be the basis for a decision as to how much to offer to buy a site or how much we might accept if selling a site). An NPV of 0 indicates that a return on investment equal to the discount rate will be made (i.e. the outcome will be equivalent to making the initial investment at a rate of interest equal to the discount rate). If NPV is negative, then the expected outcome is that there will be a negative return on investment, compared with a 'safe' investment at the discount rate (or, more usually, compared with the cost of borrowing the money to invest). If the NPV is positive, then the expected outcome is that the return on investment will exceed the required threshold represented by the discount rate.

Some examples are given below; illustrating the effect of the period of the investment.

Returning to the simple cash flow given paragraph 2 above, we can calculate the present value of the return at the end of the period (known as the net present value or NPV) and vary the period to look at the effect.

Using Equation 2, and assuming a discount (interest) rate of 10%, the NPV of the project summarised in the cash flow has been calculated assuming a total duration of 20 years, 10 years, and 5 years:-

Cash flows equally spaced over 20 years

	Year 0	Year 10	Year 20	NPV
Cashflows	-£1,000,000	£1,500,000	£1,500,000	
Discount factor[2]	1	0.3855	0.1486	
Present Values (PVs)	-£1,000,000	£578,250	£222,900	-£198,850
Cumulative PV	-£1,000,000	-£421,750	-£198,850	

Cash flows equally spaced over 10 years

	Year 0	Year 5	Year 10	NPV
Cash flow	-£1,000,000	£1,500,000	£1,500,000	
Discount factor	1	0.6209	0.3855	
Present Values (PVs)	-£1,000,000	£931,350	£578,250	£509,600
Cumulative PV	£1,000,000	-£68,650	£509,600	

Cash flows equally spaced over 5 years

	Year 0	Year 2.5	Year 5	NPV
Cash flow	-£1,000,000	£1,500,000	£1,500,000	
Discount factor	1	0.7880	0.6209	
Present Values (PVs)	-£1,000,000	£1,182,000	£931,350	£1,113,350
Cumulative PV	-£1,000,000	£182,000	£1,113,350	

In the first example, if the original investment capital of £1M had been borrowed for 20 years at an interest rate of 10%, the project would lose money and the project would not appear attractive to an investor.

The second example shows that the return on investment will exceed the cost of capital over 10 years but that we have to wait for more than 5 years to start generating a positive return. The appropriate investment (or asset value) in this case would be £509,600.

In the third example, a positive return is generated before the end of the first 2.5 year period and the NPV at the conclusion of the period is £1.113M.

For a 'full blown' quarry cash flow, sensitivity analysis is an important part of this type of exercise. The sensitivity of all cost and marketing assumptions is tested as is the sensitivity to the discount rate chosen. The sensitivity of the NPV to key assumptions helps the investor to determine the risks associated with the investment opportunity and informs his decision in respect of whether those risks are acceptable or not. In general terms, the higher the risk, the greater the required return on investment. Clearly, identification of key variables and associated sensitivity analyses will be critical in assessing appropriate asset values or compensation for loss of working rights, especially in the event of a dispute.

2 See equation 2 above.

Normally, for a quarry project, the periods in the cashflow will be one year or less. They may be less at the initial stages of the project where significant investments are being made and there is a need to understand cash flows in great detail in order to plan cash requirements. Where less than a year, they are simply expressed as decimal fractions of a year (e.g. 1.25 years) and used in the formula as with whole years.

Although discounted cash flow models for rental and royalty income streams are less complex than operational models, the principles are precisely the same.

PART V
BIBLIOGRAPHY

We have limited the number of references within the text so as not to chop it up, whilst providing 'signposts' to sources of more detailed information or guidance where relevant. Part V contains a pdf version (with operational hyperlinks to documents and websites where appropriate) of the Access database bibliography that was completed in 2007. It has been reviewed for this edition of the Handbook, and some links have been repaired where links to electronic publications are no longer operational because of relocation and concentration of UK Government websites since the original work was completed. In some cases, it has not been possible to repair specific links (usually because the document is superseded or out of date), but we have left the information in the database for reference (with associated short abstracts). Any reader who would like to receive a copy of the Access database itself should apply to GWP Consultants LLP (info@gwp.uk.com) marked for the attention of Dr Stephen Reed.

There is an extensive library of ALSF funded reports and other relevant publications at www.sustainableaggregates.com; any publications that were prepared as part of ALSF funded research and are no longer directly accessible via the bibliography included with this edition of the Handbook are likely to be accessible there. The planning system in England and related guidance relevant to minerals has changed significantly since the Handbook was published as a pre-publication draft. These changes (as at 2014) are reflected in Appendix 1-1 but there are bound to be further changes in the future. Readers requiring up to date information and guidance on planning in England and Wales should refer to www.planningportal.gov.uk. Links to equivalent information for Scotland and Northern Ireland may be found at www.planningportal.gov.uk/general/glossaryandlinks/links/scotlandnireland.

QDH Bibliography (2007)

Some web links in this bibliography have been superseded. Please try the Sustainable Aggregates Library at http://www.sustainableaggregates.com/library/library_introduction.htm

Allen, D.J. et al. (1997) 'The physical properties of major aquifers in England and Wales', BGS Research Report WD/97/24, British Geological Survey.

Keywords: Environment, Water, Surface water

Allington, R. & Walton, G. (1992) 'Waste disposal, data collection and quarry design. In: Annels, A.E. (editor) Case Histories and Methods in Mineral Resource Evaluation', Geological Society Special Publication Nr.63 p.61-68.

Keywords: Design, Operations, Waste, Investigations, Surveys

Abstract: This paper explains the importance of collecting relevant data to allow accurate assessment and planning for the handling storage and disposal of waste arising during the quarry operation. The problems caused by ignoring or underestimating the amount of waste produced are considered together with design methods to avoid them.

Allington, R. & Walton, G. (1994) 'Landform Replication in Quarrying', Transactions of the Institution of Mining and Metallurgy, London Section A: Mining Industry V.103 p.55-66.

Keywords: Investigations, Surveys, Environment, Landscape, Reclamation, Restoration

Abstract: This paper reviews various techniques used in landform replication and their application in chalk and limestone quarries. The importance of an analysis of the geomorphology of the surrounding landscape is examined and the use of restoration blasting in limestone quarries as a means of replicating Daleside landforms is also described.

Andrew Herbert et al. (2002) 'Survey of Arisings and Use of Secondary Materials as Aggregates in England and Wales in 2001', Office of the Deputy Prime Minister. ISBN: 185112599X.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/archived/publications/planningandbuilding/surveyarisings3

Keywords: Operations, Waste

Abstract: The secondary materials arising from mineral extraction included in this survey are china clay waste and colliery spoil. This is a companion study to the 'Survey of arisings and use of construction and demolition waste in England and Wales in 2001'.

Anon 'A working template for increasing the public awareness and educational opportunities of archaeological investigations associated with mineral workings'.

Keywords: Environment, Archaeology, Education

Anon 'Environmental Impacts of Aggregates Recycling Equipment'.

Keywords: Operations, Environment, Processing

Anon 'AggRegain Waste Management Regulation Module'.

Anon 'Sustainable Use of Aggregates Resources in England'.

Atkinson, T. & Walton, G. 'Design and layout of haul roads for surface mines', Institute of mining and metallurgy Mining Symposium, 1986, Bristol, UK p.369-381.

Keywords: Design, Haul roads

Balmer, Les (ed) (2004) 'Aggregate grading in ultrasonically maintained suspension', Unpublished Report, MIST Project MA/2/1/005.

http://www.sustainableaggregates.com/library/docs/mist/l0027_ma_2_1_005.pdf

Keywords: Operations, Processing, Water management, Environment, Water

Abstract: Project to determine whether new or existing technologies could be utilised to provide an alternative method of washing aggregates that either requires less water or returns clean water to the start of the process.

Barrett, W.L. & Walton, G. (2002) 'An investigation of steep unstable slopes above a quarry face In: Scott, P. W. and Bristow, C. M. (eds), Industrial minerals and extractive industry geology', Combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.153-159.

Keywords: Investigations, Design, Investigation methods, Slope design, Drilling

Abstract: The paper provides an outline of the use of specially adapted drilling equipment and safe working methods that were used in the investigation of steep unstable slopes above a quarry face.

Bauer, A. M. (1970) 'A guide to site development and rehabilitation of pits and quarries', Industrial Mineral Report 33, Ontario Ministry of Natural Resources, Toronto.

Keywords: Reclamation, Environment, Restoration, After Use, Landscape

Abstract: This early report on this topic suggests possible methods for site planning and landscape improvements during operations pointing out that site plans for quarries will depend upon the prevailing conditions at the sites. Some examples of rehabilitated pits and quarries are given. The chapter titles are:

1. The mining and rehabilitation process
2. Operating practices
3. Limitations of unplanned rehabilitation
4. After-use of mined out sites

Bowen, Geoff (2002) 'A case study of the hydrological impacts of sand and gravel extraction adjacent to an internationally protected saline marsh: Efford Quarry and Landfill - Lymington to Keyhaven Marshes (abstract)', Proceedings of combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive Industry Geology Conference, Bath, England, 7th-12th May, 2000 p.353-353.

Keywords: Environment, Water, Surface water

Abstract: A paper presented at the combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000.

British Aggregates Association 'The British Aggregates Association - the Effective Association for Independent Quarry Operators', Web Site.

http://www.british-aggregates.co.uk/

Abstract: The British Aggregates Association provides essential support to the independent aggregates sector and makes sure that their voice is heard at all levels of the UK and EU administrations.

British Geological Survey 'Waterless Fines Removal', Unpublished Summary, MIST Project MA/4/5/002.

http://www.sustainableaggregates.com/library/docs/mist/l0043_ma_4_5_002.pdf

Keywords: Operations, Waste, Water management

Abstract: The aim of the project is to identify and appraise process methods for removal of quarry fines that do not use water, for example dry methods such as air classification. The project will also consider methods that are 'water conserving', for example methods that involve the recovery and re-circulation of process water.

British Geological Survey 'Quarry Fines Minimisation', Unpublished Summary, MIST Project MA/4/5/003.

http://www.sustainableaggregates.com/library/docs/mist/l0044_ma_4_5_003.pdf

Keywords: Operations, Waste

Abstract: The aim of the project is to review technologies, processes & practices that maximise the amount of saleable aggregate product and minimise quarry fines production.

British Geological Survey 'Safeguarding aggregates and the environment: Best practice for the definition of Mineral Consultation Areas for aggregates', Unpublished Summary, ALSF SAMP Project SAMP3.03.

http://www.sustainableaggregates.com/library/docs/samp/l0015_samp_3_B_3.pdf

Keywords: Environment, Feasibility

Abstract: The aim of this project is to identity an objective and consistent method for the definition of Mineral Consultation Areas (MCAs) for aggregates and to provide good practice at the local level for the delineation of areas of aggregate resources warranting safeguarding from other forms of development.

British Geological Survey 'Implementing a sustainable geodiversity framework in an area of aggregate extraction - the Northumberland national park and adjoining area', Unpublished Report, ALSF SAMP Project SAMP2.11.

http://www.sustainableaggregates.com/library/links/links_onsite/L0109a.htm

Keywords: Environment, Geoconservation

Abstract: Project objectives:

Objective 1 to undertake a geodiversity audit of the Northumberland national park and associated 'action areas'

Objective 2 to prepare and publish a booklet on the geology and landscape of the central portion of Hadrian's wall

Objective 3 to prepare a local geodivers

See also http://www.sustainableaggregates.com/library/docs/samp/l0109b_samp_2_11b.pdf

British Geological Survey 'Visualising the Past, Present and Future of Quarries in the Landscape: Tools to Aid Community Engagement', Unpublished Summary, ALSF SAMP Project SAMP2.44.

http://www.sustainableaggregates.com/library/docs/samp/l0141_samp_2_44.pdf

Keywords: Environment, Landscape

Abstract: This project aims to provide communities local to aggregate extraction operations with tools to help them better visualise and understand the impacts and context of these operations over their entire life cycle. Part of the 'toolbox' will be aimed at use by stakeholder groups such as mineral planning authorities, industry and civil society to assist the public understanding; the other part will be aimed directly at use by local communities.

The project will develop a methodology to assist stakeholders to increasing community involvement in, and understanding of, the planning issues surrounding landscape and environmental context of operational and disused aggregate quarries using a GIS-based 3-D visualisation tool.

Web link is to research poster 'Helping communities visualise restoration scenario'. Report text is not available.

This project will also provide an easy to use CD-based interactive tool which will help local communities visualize different restoration, re-use and aftercare options for aggregate quarries, including progressive restoration plans. It could be used to examine effects at different scales (from a single bench to quarries within the wider landscape) and over different timescales (through the development cycle of the quarry and well into the post-closure phase).

These tools should improve the effectiveness of consultation exercises linked to planning for provision of primary aggregates.

British Geological Survey 'Training and Information for sustainable aggregate provision', Unpublished Summary, ALSF SAMP Project SAMP2.13.

Keywords: Information Sources

Abstract: The project will provide training in key aggregate mineral issues and is aimed at Councillors and Officers in the Regional Assemblies, County Councils and Unitary Authorities. It will also be useful in disseminating information on aggregates provision to a much wider group of stakeholders, and as such the project outputs could play an important role by promoting recognition of the continuing role of the aggregates sector in a sustainable future.

The training, covering geological and resource, spatial planning, and environmental and social issues, will involve production of a web-based training pack incorporating a series of information briefs, each covering a key issue or theme. The training pack will be used as a basis for training Seminars, one of each will be given in each Region.

The research document is no longer available but see 'A Guide On Aggregates' at http://www.bgs.ac.uk/planning4minerals/assets/downloads/86210_P4M_A_Guide_On_Aggregates.pdf

British Geological Survey 'Minerals UK', Web Site.

http://www.bgs.ac.uk/mineralsuk/home.html

Keywords: Investigations, Planning, Feasibility, Information Sources

Abstract: This website contains much information on minerals from both national and global perspectives. The areas covered include mineral resources, planning, policy and legislation, sustainable development, statistics and exploration.

Information on updates are issued to subscribers two or three times a year.

British Geological Survey 'UK Minerals Information Online GIS', Web Site.

https://www.bgs.ac.uk/mineralsuk/maps/maps.html

Keywords: Information Sources

Abstract: An online GIS that links minerals information with many other types of land-use information e.g. environmental (SSSIs, SACs, NNRs), transport, landscape (AONBs) and heritage (ancient monuments).

British Geological Survey 'Minerals UK - Legislation and Policy', Web Site.

http://www.bgs.ac.uk/mineralsuk/planning/legislation/home.html

Keywords: Planning, Planning framework

Abstract: This web page provides a review of the planning system in the UK and has links to the relevant government department notes and circulars e.g. MPG notes and PPG notes. It covers much the same information as a that given in the Goodquarry planning web page.

British Geological Survey 'Minerals UK - Minerals in the Economy', Web Site.

https://www.bgs.ac.uk/mineralsuk/planning/economy.html

Keywords: Information Sources

Abstract: This web page describes and links to the report 'The Economic Importance of Minerals to the UK'. The report is intended for a non-economist audience presenting information and data on the extent, availability, production, trade and use of minerals of economic importance to the UK. It can be downloaded in low resolution format from the BGS Minerals UK web page (which contains many other free reports and presentations in pdf format). The report can also be purchased as a full colour report from BGS.

British Geological Survey 'Minerals UK - Free downloads', Web Site.

http://www.bgs.ac.uk/opengeoscience/downloads.html

Keywords: Information Sources

Abstract: This web page gives links to many pdf-format reports and presentation largely covering useful background information that can be freely downloaded. Topics covered are:

Minerals and the Economy
Mineral Matters
BGS Minerals Forum 2005 presentations
Environment
World Minerals
UK Planning
Mineral Statistics
UK Exploration

British Geological Survey 'Minerals UK - UK mineral resource maps', Web Site.

http://www.bgs.ac.uk/mineralsUK/planning/resource.html

Keywords: Information Sources

Abstract: This page lists a series of digitally generated resource maps, which support planning at national, regional and local levels. The information includes

* the geological distribution of all mineral resources;
* the location of mineral extraction sites;
* the extent of selected landscape and nature-conservation designations (National Parks, AONBs, SSSIs, NNRs and scheduled monuments).

British Geological Survey 'Minerals UK - Mineral Planning Factsheets', Web Site.

http://www.bgs.ac.uk/mineralsuk/planning/mineralPlanningFactsheets.html

Keywords: Planning

Abstract: This page lists fact sheets that can be freely downloaded that provide an overview of the supply of 21 economically important minerals that are extracted in Britain. The fact sheets are primarily intended for the land-use planning process.

British Geological Survey 'Minerals UK - Planning', Web Site.

http://www.bgs.ac.uk/mineralsuk/planning/home.html

Keywords: Planning

Abstract: This section puts minerals planning in the context of the production, ownership and sustainable development of minerals a review of the planning system in the UK. It also covers non-aggregate minerals. In its subsections it gives links to the relevant government department notes and circulars e.g. MPG notes and PPG notes.

British Geological Survey 'Minerals UK - Commodity statistics', Web Site.

http://www.bgs.ac.uk/mineralsuk/statistics/home.html

Keywords: Information Sources

Abstract: This web page provides links to free pdf downloads of reports giving statistics for the UK, Europe and the World on minerals production, consumption, imports, exports.

British Geological Survey 'Minerals UK - External Links. Links to geoscience resources across the world and the web', Web Site.

http://www.bgs.ac.uk/mineralsuk/links/home.html

Keywords: Information Sources

Abstract: Provides links to many sites of background and more direct interest in a range of sectors including Government, quarrying and the environment.

British Geological Survey (2004) 'A Geodiversity Audit for County Durham', Unpublished Report, ALSF SAMP Project SAMP1.003.

http://www.sustainableaggregates.com/library/docs/samp/l0107_samp_1_003.pdf

Keywords: Environment, Geoconservation, Landscape

Abstract: Project was 'Environmental Sustainability in local Government : A Geodiversity Audit Action Plan (LGAP), with interpretation for counties Durham and Leicestershire'. This was a review of the counties' geodiversity and its relevance to other interests, an audit of all geological exposures, and a compilation of existing information into a new dataset. The project aimed to serve as a means of informing sustainable management, planning and conservation, and as background to the Local Geodiversity Action Plan.

British Standards Institution (1999) 'Code of practice for site investigations', BS 5930:1999, BSI. ISBN: 058033059 1.

Keywords: Investigations, Surveys, Investigation methods, Drilling

Abstract: Standard relating to site investigations, construction operations, soils, soil surveys,soil sampling, soil testing, ground water, rocks, safety measures, occupational safety, field testing, excavations, soil drilling, aerial photography, Geological analysis, sampling methods.

British Standards Institution (2004) 'BS EN 1997-1:2004 Eurocode 7. Geotechnical design. General rules', CHX. ISBN: 9780580671067.

Keywords: Design

Abstract: EN 1997 - Eurocode 7: Geotechnical design, is the European Standard for the design of geotechnical structures, published in two parts; "General rules" and "Ground investigation and testing". It was approved by the European Committee for Standardization on 12 June 2006 and became mandatory in member states in March 2010.

Part 1: General rules is intended to be used as a general basis for the geotechnical aspects of the design of buildings and civil engineering works, and includes

* Basis of design
* Geotechnical data
* Supervision of construction, monitoring and maintenance
* Fill, dewatering, ground improvement and reinforcement
* Spread foundations
* Deep foundation (pile foundations)
* Anchorages
* Retaining structures
* Hydraulic failure
* Overall stability
* Embankments

EN 1997-1 is accompanied by Annexes A to J, which provide partial safety factor values and informative guidance such as internationally applied calculation methods.

British Standards Institution (2007) 'BS EN 1997-2:2007 Eurocode 7. Geotechnical design. Ground investigation', CHX. ISBN: 9780580718724.

Keywords: Design

Abstract: EN 1997 - Eurocode 7: Geotechnical design, is the European Standard for the design of geotechnical structures, published in two parts; "General rules" and "Ground investigation and testing". It was approved by the European Committee for Standardization on 12 June 2006 and became mandatory in member states in March 2010.

Part 2: Ground investigation and testing provides rules supplementary to EN 1997-1 related to, planning and reporting of ground investigations, general requirements for a number of commonly used laboratory and field tests, interpretation and evaluation of test results and derivation of values of geotechnical parameters and coefficients.

Brodkom, F. (2000) 'Good Environmental Practice in the European Extractive Industry: a Reference Guide', Centre Terre et Pierre, Tournai (Belgium).

http://www.wbcsdcement.org/pdf/tf5/2000-03-Guide-to-Good-Practices.pdf

Abstract: The Guide explains how the extractive industry operates by using a series of "real-life" case studies, which illustrate a number of "good practices" employed by the industry. These case studies show how practical and costeffective approaches to environmental protection are implemented. In most of them, the company concerned often went far beyond the regulatory requirements, simply because the option chosen was the best available under the prevailing circumstances. This attention to local conditions is a constant theme throughout the Guide. However, it is certainly not the intention of the Guide to prescribe operating standards or codes of practice. Rathe, it is to illustrate the willingness of the extractive industry to achieve sustainable development in the context of a balanced regulatory environment.

Butler, A.J. et al. (2002) 'Rock slope risk management and the Quarries Regulations 1999 In: Scott, P. W. and Bristow, C. M. (eds), Industrial minerals and extractive industry geology', Combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.263-268.

Keywords: Investigations, Design, Health and Safety, Geotechnical, Slope design

Abstract: This paper describes the determination and use of the Quarry Rock Slope Hazard Index (QHI) and the training required for its successful implementation as part of the Quarry Regulations 1999.

Calderdale Metropolitan Borough Council 'Cromwell Bottom Biodiversity Restoration Project - Elland near Halifax', ALSF Third objective 'legacy' site project 2003/286.

Keywords: Reclamation, Environment, Restoration, Ecology, Biodiversity

Camborne School of Mines 'Improving standards of health and safety management in the quarrying sector', Unpublished Summary, MIST Project MA/4/4/006.

http://www.sustainableaggregates.com/library/docs/mist/l0061_ma_4_4_006.pdf

Keywords: Health and Safety

Abstract: Project summary: the overall objective is to bring about an improvement in the health & safety performance of quarry operations in the UK

Camborne School of Mines (2006) 'An Education Strategy for the Planning and Safe Operation of Quarries', Unpublished Report, ALSF SAMP Project SAMP2.30.

http://www.sustainableaggregates.com/library/docs/samp/l0013_samp_2_30.pdf

Keywords: Health and Safety

Abstract: The principle objective of this project was to ensure that the UK has an appropriately trained and educated workforce that will drive the development of planning and delivering environmentally sustainable mineral extraction in future years. The project aimed to achieve this by:

-Raising the concerns for the need for competent persons in the quarrying & extractive industry at the highest level through a national conference aimed at policy makers, parliamentarians, government, research institutions, universities, colleges and schools, industry and business;

- Raising the national skills levels in quarry planning, design, operation & management by providing Master’s level training geared to training personnel in the workplace for leadership and managerial roles in the UK minerals extraction industry;

- Raising the profile of the industry and potential careers within the industry by developing a suite of coursework projects for use within A level courses. This would have the secondary role of helping promote interest in current relevant University courses.

Cameron, D.C. 'Directory of Mines and Quarries 2006', British Geological Survey. ISBN: 0852725272.

Keywords: Information Sources

Abstract: This book contains location data and statistical information on minerals production for each of the current mineral workings in the UK.

Camm, Thomas W (2000) 'Economics of safety at surface mine spoil piles', DHHS (NIOSH) Publication 2000 Nr.129.

Keywords: Design, Health and Safety, Design, Slope design, Fill slopes and tips

Capita Symonds Limited 'The development of geodiversity action plans for aggregates companies: a pilot study', Unpublished Report, MIST Project MA/4/2/013.

http://www.sustainableaggregates.com/library/docs/mist/l0102_ma_4_2_013.pdf

Keywords: Environment, Geoconservation, Ecology, Landscape, Archaeology, Education, Health and Safety

Abstract: Booklet provides guidance to enable quarry operators to realise the potential of their geodiversity assets. The procedures are designed specifically to allow companies to positively engage with the planning system and local communities as an affordable and integral part of their commercial operations.

For the project final report see MA/5/2/003

Capita Symonds Limited 'Mitigating the Impacts of Quarry Dewatering', Unpublished Summary, MIST Project MA/4/2/014.

http://www.sustainableaggregates.com/library/links/links_onsite/L0037.htm

Keywords: Operations, Water management

Abstract: Project objectives are to:

* Undertake more extensive and longer term field experiments than were possible in the original study, including monitoring the effectiveness of a well point recharge system

* Investigate additional methods that can be used in conjunction with recharge features to achieve enhanced levels of mitigation

* Develop evidence based guidance on good practice techniques for the construction and maintenance of recharge features, including their use with other mitigation methods and their limitations

* Produce a detailed, peer reviewed technical report giving full supporting information on both the long term and short term experiments carried out in this and the original study.

Capita Symonds Limited 'Managing the Interface between Planning and Abstraction Licensing for Quarry Dewatering - Final Report', Unpublished Summary, ALSF SAMP Project SAMP3.07.

http://www.sustainableaggregates.com/library/docs/samp/l0011_samp_2_23_samp_3_B_007.pdf

Keywords: Operations, Water management

Abstract: The principal aim of this project is to promote and raise awareness of a procedural framework (developed as part of the previous project - SAMP2.23) for managing the interface between the planning system and the new licensing regime for quarry dewatering; and also to update the final report of that project to reflect Defra's new Licensing Regulations, once they are published. The new project would build upon and add value to the existing contract by addressing the following detailed objectives, all of which are additional to the scope of the original project:

To update the Legal Review of water resources and planning legislation in the light of the new Water Resources Regulations and Transitional Regulations, when these are published by Defra for consultation this summer;

To reflect the findings of this update in our draft report and draft procedural framework, and to make these available for consultation to a wide range of stakeholders during the autumn (overlapping with Defra's formal consultation exercise);

To arrange, publicise and hold a number of dissemination workshops around the country in November 2005 to promote awareness of the draft procedural framework and the issues that it raises (and to obtain further stakeholder feedback);

To liaise with Defra as they consider any changes to the Regulations needed in response to the formal consultation exercise, so that these, as well as feedback from the workshops, can be reflected in our final report and protocol for a procedural framework; and

To publish and disseminate the findings through a higher profile launch event than had been allowed for in the original contract.

Capita Symonds Limited 'A Guide to Minerals and the Environment', Unpublished Summary, ALSF SAMP Project SAMP3.08.

Keywords: Environment, Water

Abstract: To produce an updated guide to good practice on minimising the impact of aggregate extraction on the water environment, within the wider context of sustainability, taking account of recent changes in legislation and planning, as well as new developments in technology.

Capita Symonds Limited (2007) 'Managing the Interface between Planning and Abstraction Licensing for Quarry Dewatering', Unpublished Report, ALSF SAMP Project SAMP2.23.

http://www.sustainableaggregates.com/library/docs/samp/l0011_samp_2_23_samp_3_B_007.pdf

Keywords: Operations, Water management

Abstract: The aim of the project is to develop a procedural framework for managing the interface between Planning and Licensing with respect to quarry dewatering when the present licensing exemptions on such activities are lifted in November 2005.

The need for such guidance arises directly from the Water Act 2003, which requires the Environment Agency to take on new responsibilities for controlling the impacts of quarry dewatering that previously were exerted through mineral planning conditions. The issue of refusal of new 'water transfer licences' may lead to a conflict with existing planning permissions & this may lead to a need for review of existing planning conditions in order to avoid duplication.

An overall procedural framework is needed to facilitate a smooth transition between the planning and licensing regimes & to ensure that adequate control of environmental impacts is maintained without imposing an undue burden on mineral operators. Specific project objectives, including legislative review and stakeholder consultation, in order to achieve the above overall aim are set out in more detail in the "case for support" attached.

Central Science Laboratory 'Developing an objective birdstrike risk assessment model for hazardous birds attracted to mineral extraction sites - an aid for environmental assessment policy', Unpublished Summary, ALSF SAMP Project SAMP2.29.

http://www.sustainableaggregates.com/library/docs/samp/l0012_samp_2_29.pdf

Keywords: Environment, Health and Safety, Ecology, Fauna

Centre for Sustainability at TRL (2005) 'Alternative approaches to reducing the environmental impacts of the transport of primary aggregate', Unpublished Report, MIST Project MA/4/3/007.

http://www.sustainableaggregates.com/library/docs/mist/l0074_ma_4_3_007.pdf

Keywords: Environment, Traffic

Abstract: The final report from this project has identified potential opportunities to reduce the environmental impacts of transportation over the next 10 to 15 years.

Centre for Sustainability at TRL (C4S at TRL) (2004) 'Improving environmental outcomes for the minerals industry & statutory environmental bodies - a review of barriers and opportunities', Unpublished Report, MIST Project MA/3/1/004.

http://www.sustainableaggregates.com/library/docs/mist/l0004_ma_3_1_004.pdf

Keywords: Environment, Education, Planning, Planning process

Abstract: Project aimed at examining the experiences of the minerals industry and statutory environmental bodies in relation to environmental regulation and their advice via the planning system for minerals extraction. Identification of barriers to and opportunities for improving outcomes for all parties. Provision of recommendations and proposal of frameworks for training programmes for all parties.

Centre for Sustainability at TRL (C4S at TRL) (2005) 'Improving Strategic Environmental Assessment (SEA) for Aggregates Planning - Practitioners Network', Unpublished Summary, ALSF SAMP Project SAMP3.05.

http://www.sustainableaggregates.com/library/docs/samp/l0016_samp_3_B_5.pdf

Keywords: Environment, EIA

Abstract: Strategic Environmental Assessment (SEA) is a new duty on Mineral Planning Authorities (MPAs) in England and the next two years will see a period of intense activity alongside the preparation of minerals development plan documents. As with any new process, SEA is likely to become more streamlined as time goes on with the main benefits being felt only once authorities have learnt what does and doesn't work. In the meantime, whilst this learning is taking place, SEA may have a negative effect on industry and the authorities themselves. The central aim of this project is to accelerate the learning of practitioners undertaking SEA for minerals planning. Bearing this overall aim in mind, the objectives of this study are:

* To increase the awareness and knowledge of SEA for minerals planning;
* To provide a web-based portal and e-newsletter to provide information and exchanging questions/problems/solutions on SEA of minerals plans; and
* To facilitate face to face networking to spread sound SEA practice in the minerals planning field through timely events.

Chartered Institute of Ecology and Environmental Management 'Chartered Institute of Ecology and Environmental Management', Web Site.

http://www.ieem.org.uk/

Keywords: Environment, Ecology

Abstract: The CIEEM is the professional body that represents and supports professionals in the fields of ecology and environmental management.

Charters, A.C. & Duthie, B. (2002) 'Living with the 1999 Quarries Regulations: a practical approach. In: Scott, P. W. and Bristow, C. M. (eds), Industrial minerals and extractive industry geology', Combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.269-273.

Keywords: Investigations, Geotechnical

Abstract: This paper describes an appraisal process that was applied to ensure that a full geotechnical assessment was carried out only on excavations and tips which constitute a hazard.

Coal Authority 'The Coal Authority', Web Site.

http://coal.decc.gov.uk/

Keywords: Operations

Abstract: The Coal Authority was established by Parliament in 1994 to undertake specific statutory responsibilities associated with:

* Licensing coal mining operations in Britain
* Handling subsidence damage claims which are not the responsibility of licensed coal mine operators
* Dealing with property and historic liability issues, such as treatment of minewater discharges
* Providing public access to information on past and present coal mining operations
* Provide a 24 hour call-out service for reported surface hazards

Committee for Mineral Reserves International Reporting Standards 'CRIRSCO'.

http://www.crirsco.com/

Keywords: Investigations, Feasibility

Abstract: The aim of CRIRSCO (Committee for Mineral Reserves International Reporting Standards) is to promote high standards of reporting of mineral deposit estimates (Mineral Resources and Mineral Reserves) and of exploration progress (Exploration Results).

CRIRSCO was formed in 1994 as an informal alliance of National Reporting Organisations in participating countries but has evolved to become a more rigorously constituted committee representing the mining industry on issues relating to the classification and reporting of mineral assets. Current members represent Australia, Canada, Chile, South Africa, UK & Western Europe and USA, with the prospect of other regions and countries joining in the future.

Communities and Local Government (2006) 'Environmental impact assessment (EIA)', Web Site.

Keywords: Environment, EIA

Abstract: This web page has links to guides to procedures for EIAs and notes for local planning authorities on how to avoid pitfalls in the EIA procedure as well as a very useful set of links and references for further information including links to EU and UK legislation.

Confederation of British Industry (1991) 'Archaeological Investigation - Code of Practice for Mineral Operators', CBI, London.

Keywords: Environment, Archaeology

Coppin, N. J. & Bradshaw, A. D. (1982) 'Quarry reclamation: the establishment of vegetation in quarries and open pit non-metal mines', Mining Journal Books. ISBN: 0900117311.

Keywords: Reclamation, Environment, Restoration, After Use, Ecology, Landscape

Abstract: This manual describes in considerable detail the methods and factors that must be considered for successful establishment of vegetation as part of the restoration of mineral workings. The manual brings together in one place botanical ecological and agronomic information of particular relevance to restoration that is not easily found elsewhere, e.g. tables are given that include information on factors affecting growth for a wide range of species. Aspects covered include the environmental factors that affect revegetation, after use possibilities and development of a restoration policy, as well as site preparation, appropriate species selection, seeding methods, and aftercare. The chapter titles are:

1. Quarrying and environmental quality
2. Environmental factors affecting revegetation
3. The development of a self-sustaining soil-plant system
4. After use possibilities
5. Development of a restoration policy
6. Analysis and evaluation of site and soils
7. Landforms
8. Site preparation
9. Plant species selection
10. Methods of vegetation establishment
11. Management and aftercare of restored land

Council for British Archaeology (2007) 'Council for British Archaeology - the gateway to British archaeology online', Web Site.

http://www.britarch.ac.uk/

Keywords: Environment, Archaeology

Abstract: The CBA is an educational charity working throughout the UK to involve people in archaeology and to promote the appreciation and care of the historic environment for the benefit of present and future generations.

Countryside Agency 'Involving Local Communities', ALSF Third objective 'legacy' site project.

Countryside Agency 'Nene Valley Projects', ALSF Third objective 'legacy' site project.

Countryside Agency 'North East Centre for Angling', ALSF Third objective 'legacy' site project.

Countryside Agency 'Bacup Stacksteads Greening', ALSF Third objective 'legacy' site project.

Keywords: Environment, Landscape

Countryside Agency 'Traffic Impact Reduction Scheme'.

Countryside Agency 'Churchtown Farm CNR', ALSF Third objective 'legacy' site project.

Countryside Agency 'Devon: Aggregates Twinning Pilot Project', ALSF Third objective 'legacy' site project ALSF/B/06.

Countryside Agency 'Abberley and Malvern Hills Geotourism Discovery Programme', ALSF Third objective 'legacy' site project ALSF/B/05.

Countryside Agency 'Shropshire Rocks', ALSF Third objective 'legacy' site project ALSF/B/02.

Countryside Agency 'Sandy Heath Quarry', ALSF Third objective 'legacy' site project EE/11432.

CPRE 'The Campaign to Protect Rural England', Web Site.

http://www.cpre.org.uk/

Abstract: The Campaign to Protect Rural England exists to promote the beauty, tranquillity and diversity of rural England by encouraging the sustainable use of land and other natural resources in town and country.

CPRE campaigns for a sustainable future for the English countryside. It highlights threats and promote positive solutions, supports active campaigning, and seeks to influence public opinion and decision-makers at every level.

Cranfield University (2000) 'Effectiveness of subsoiling treatments on soil structure development on mineral sites during the five year aftercare period', DEFRA Web Site.

http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=3623

Keywords: Reclamation, Environment, After Use, Soils, After care

Abstract: This report describes research carried out to evaluate the effectiveness of different methods of subsoil loosening treatments in improving soil structure and root development in five years following the reinstatement of soil. Investigations were made on a range of soils at six different restored mineral workings which also represented different climatic and soil wetness conditions. A method to determine the effectiveness of subsoiling was developed that involves the excavation of an inspection pit across the line of work at its commencement so that the soil profile can be studied to dictate if adjustments need to be made to the subsoiling operation. General guidelines are given for the depth and number of loosening operations for different soil profiles.

The report is divided into the following sections: Introduction, Research Approach, Experimental Methodology, Results, Recommendations for Management, Summary/Implications, and References.

Cranfield University (2004) 'Quarry restoration for sustainable biomass energy production', Unpublished Report, MIST Project MA/3/3/009.

http://www.sustainableaggregates.com/library/docs/mist/l0118_ma_3_3_009_ma_4_3_001.pdf

Keywords: Reclamation, Environment, Restoration, After Use, Ecology, Reclamation, Restoration, After Use, Environment, Ecology, Flora

Abstract: Project to investigate the feasibility of introducing innovative restoration techniques in quarries using energy crops to enhance socio-economic and environmental benefits and secure sustainable restoration outcomes. Includes:

* Review of existing literature on energy crop production in relation to quarry conditions.
* Investigation of socio-economic issues related to energy crop production in the quarrying industry.
* Identification of risks to the achievement of potential yields.
* Design of suitable restoration techniques.
* Identification of added value benefits and impacts.
* Definition of testing and validation techniques.
* Reporting of conclusions.

Cranfield University (2005) 'Quarry restoration for sustainable biomass energy production and Quarry Restoration: Vertical Integration: Low carbon energy production for the mineral industry.', Report, MIST Project MA/4/3/001, MIRO. ISBN: 1872440339.

http://www.sustainableaggregates.com/library/docs/mist/l0118_ma_3_3_009_ma_4_3_001.pdf

Keywords: Reclamation, Restoration, Environment, Ecology, Flora

Abstract: Restoration of quarries, especially sand and gravel, provides opportunities to return the land to a variety of end uses. Energy crops are a novel alternative end use for which the potential has not been fully established. Literature data and site data from RMC Ltd demonstrated the potential profitability of energy crops. On a purely financial assessment a subsidy is required in order for this agricultural end use to be competitive with other agricultural end uses.

Quarry restoration for sustainable biomass energy production and Quarry Restoration: Vertical Integration: Low carbon energy production for the mineral industry

Creswell Heritage Trust 'Creswell Crags, Limestone Heritage Area - Management Action Plan'.

Keywords: Environment, Geoconservation, Ecology, Landscape, Archaeology, Education

Abstract: This project is to develop an innovative, integrated archaeological, palaeontological, ecological and access Management Action Plan for the main limestone vales and gorges within the Creswell Crags Limestone Heritage Area (the southern Magnesian Limestone Natural Area).

The Management Action Plan for the Heritage Area complements the programme of Site Specific work in progress to improve heritage management and access at Creswell Crags and work in Urban Areas at Creswell (Creswell Townscape Heritage Initiative scheme) and Bolsover (Bolsover CAP scheme).

The Management Action Plan forms the second stage of a three stage programme that will result in major improvements to cultural and natural heritage conservation and access across the southern Magnesian Limestone. The project will help translate into detailed action at local level the strategic landscape character programme. The Management Action Plan responds to policies and actions set out in the Creswell Crags Conservation Plan (2001) and the Creswell Limestone Strategy (2000) which jointly form the first stage of this programme.

Darlow, E. (2002) 'Health and safety law in quarries', Institute of Quarrying, Nottingham. ISBN: 0 9538003 3 4.

Keywords: Health and Safety

Abstract: The aim of this book is to provide a description of the main points of health and safety legislation as it applies to quarrying. Where they exist Approved Codes of Practice and Guidance are referred to for the different aspects of quarry working and these aspects are covered in the order of the impact of the statutory instruments upon them. The first three chapters of this book provide an historical background to health and safety legislation. Chapter 4 reviews the legislation framework and is followed by 12 further chapters which cover the current (as of 2002) legislation.

David Jarvis Associates 'Planning and designing the restoration of quarries for the benefit of physically and mentally disabled', Unpublished Report, MIST Project MA/4/3/004.

http://www.sustainableaggregates.com/library/docs/mist/l0120_ma_4_3_004.pdf

Keywords: Reclamation, Environment, Restoration, Access, Health and Safety, Planning, Design

Abstract: Project looks at issues surrounding disabled access in relation to quarry design and restoration.

David Jarvis Associates (2006) 'Charrettes Stakeholder Consultation for the Mineral Industry', Unpublished Report, MIST Project MA/5/3/005.

http://www.sustainableaggregates.com/library/docs/mist/l0133_ma_5_3_005.pdf

Keywords: Planning, Planning process

Abstract: The Charrette is a collaborative planning workshop, coordinated by professional facilitators, that harnesses the talents and energies of all interested parties

David Jarvis Associates Limited, Professor Geoffrey Walton and Associates, and Crawford's Chartered Surveyors (2006) 'The Planning and Design of Aggregate Quarries for Non-Agricultural Afteruse', Unpublished Report, ALSF SAMP Project SAMP2.31.

http://www.sustainableaggregates.com/library/docs/samp/l0127_samp_2_31.pdf

Keywords: Reclamation, Environment, After Use, Landscape

Abstract: This work was published in a report for ALSF SAMP 3.10

David Jarvis Associates Limited, Professor Geoffrey Walton and Associates, and Crawford's Chartered Surveyors (2006) 'The planning and design of aggregate quarries for non-agricultural after use - SAMP 2.31 and Additional Work', ALSF SAMP Project SAMP3.10, Griffin House Publishing. ISBN: 0-9552346-0-3.

http://www.sustainableaggregates.com/library/docs/samp/l0127_samp_2_31.pdf

Keywords: Reclamation, Environment, After Use, Landscape

Abstract: Report looks into the planning and design of aggregate quarries for non-agricultural afteruse. Specifically looks into scope for afteruse built-development of the site (examples include; Bluewater retail park and the Eden Project).

Recommendations arising from report include: integration of mineral and built development in future planning guidance and an integrated approach at the regional level

This report covers work funded by ALSF SSAMP projects 2.31 and 3.10

David Roche Geo Cons (2005) 'Valuing Geodiversity for Conservation - Initial scoping study - Development of the Geodiversity Profile', Unpublished Report, MIST Project MA/4/2/016.

http://www.sustainableaggregates.com/library/docs/mist/l0103_ma_4_2_016.pdf

Keywords: Environment, Geoconservation, Landscape

Abstract: The project aimed to develop an objective process for the quantitative measurement of geodiversity in quarries in relation to other rock exposures, and to develop practical, safe procedures for enabling access to high quality geodiversity worthy of conservation.

See also the companion report "Valuing Geodiversity for Conservation - Report of the Scoping Study"

Derbyshire County Council 'Toothbrush Woodland Scheme, Tearsall Quarry, Bonsall Moor', ALSF Third objective 'legacy' site project 2004.12(l).

Keywords: Environment, Ecology, Flora

Derbyshire County Council 'Improvements to Stoney Wood, Wirksworth', ALSF Third objective 'legacy' site project 2004.45.

Derbyshire County Council 'Improving Access and Biodiversity on Former Aggregates Sites', ALSF Third objective 'legacy' site project 2004.24.

Keywords: Environment, Ecology, Access, Biodiversity

DETR, IEH and Environment Agency (2000) 'Guidelines for Environmental Risk Assessment and Management', Stationery Office. ISBN: 0117535516.

http://archive.defra.gov.uk/environment/quality/risk/eramguide/

Keywords: Environment, EIA

Abstract: These guidelines are primarily for the use of risk assessors and managers within Government departments and agencies, in conjunction with existing guidance. They emphasise risk assessment, management and communication and adopt a tiered approach to risk assessment. The guidelines are deliberately of a general nature and not targeted specifically at the minerals industry but are designed to be relevant to all activities that impact the environment. Risks can be minimised through correct assessment and appropriate management while achieving development that is sustainable. The guidelines are organised in chapters covering :

1. Introduction, 2. Framework, 3. Social aspects of risk, 4. Problem formulation, 5. Risk screening & prioritisation, 6. Quantification and dealing with uncertainty, 7. Evaluation of risk, 8. Options and decisions, 9.Monitoring.

The guidelines contain a useful bibliography, and addresses with URLs for sources of further information.

Produced by te Department of the Environment, Transport and the Regions (DETR), the Environment Agency and the Institute for Environment and Health (IEH)

Dominic Fairman, South Penquite Farm 'Geodiversity and ACY- Biodiversity survey for South Penquite Farm', ALSF Third objective 'legacy' site project 2004/430.

Keywords: Environment, Ecology, Biodiversity

Dorset County Council (2005) 'The Dorset Local Geodiversity Action Plan', Dorset County Council Web Site.

www.dorsetforyou.com/media/pdf/s/g/Dorset_LGAP1_1.pdf

Keywords: Environment, Geoconservation

Abstract: Relates to ongoing projects and action plan to lead to enhancement of geological resource in the county.

ECUS (2002) 'Reclamation of Limestone Quarries by Landform Simulation', HMSO. ISBN: 095422440X.

http://webarchive.nationalarchives.gov.uk/20070507015402/http://www.communities.gov.uk/index.asp?id=1145714

Keywords: Reclamation, Restoration

Abstract: This report assesses the success of trial sites on selected faces in two Peak District quarries (Hope and Tunstead Quarries) in terms of their stability, visual appearance and vegetation establishment. The objective was to consider whether the landform simulation technique can play a role in the final restoration of limestone quarries so that they resemble natural, unquarried landforms and are visually, ecologically and structurally acceptable.

This research investigated the effectiveness of using restoration blasting to create slope sequences on disused quarry faces, followed by selective plantation to produce landform/vegetation assemblages that are visually, ecologically and structurally acceptable and similar to those on natural limestone dales. Three aspects of the trial sites were studied in detail: stability, habitat reconstruction and landscape assessment. The project showed that with some development and careful consideration of how it can be applied in different quarry and landscape settings, the technique can play a major role in the restoration of limestone quarries.

English Heritage 'Biodiversity on former aggregates sites in Notts', ALSF Third objective 'legacy' site project.

Keywords: Environment, Ecology, Biodiversity

English Heritage (2007) 'ALSF OnLine', Web Site.

Keywords: Information Sources

Abstract: ALSF Projects OnLine provided access to details of all projects funded by English Heritage through its Aggregates Levy Sustainability Fund (ALSF) scheme, but is no longer active (2014)

Reports available allowed searches for information by individual project, geographical location, site type, period, research theme or year of funding. Each report generated a list of projects with access to details of each project. These in turn provided access to more detailed project summaries and external websites where they exist. Information was also available for projects funded by English Heritage through the 'Historic Environment Enabling Programme'.

English Nature 'Biodiversity Action Plan Group: Aggregates Integration for Nottinghamshire', ALSF Third objective 'legacy' site project.

Keywords: Environment, Ecology, Biodiversity

English Nature 'Derbyshire (Outside Peak District National Park) LBAP Project - Derbyshire', ALSF Third objective 'legacy' site project 2002/107.

English Nature 'Amwell Quarry - Wetland Restoration for Water Voles - Ware', ALSF Third objective 'legacy' site project 2004/419.

Keywords: Reclamation, Environment, Restoration, Ecology, Water, Fauna, Aquatic

English Nature 'Hall Marsh - Wet Grasslands for Wildlife + People - Watham Abbey', ALSF Third objective 'legacy' site project 2004/321.

English Nature 'Enhancing Gravel Pit Biodiversity - Woodstock', ALSF Third objective 'legacy' site project 2003/280.

Keywords: Environment, Ecology, Biodiversity

English Nature 'Creation of Herb-rich grassland - Much Wenlock', ALSF Third objective 'legacy' site project 2003/236.

Keywords: Environment, Ecology, Flora

English Nature 'Love Lane Quarries Earth Heritage Project - Pickering', ALSF Third objective 'legacy' site project 2004/403.

English Nature 'Geological Conservation - a guide to good practice', English Nature, Peterbrough. ISBN: 1 85716 906 9.

Keywords: Environment, Geoconservation

Abstract: Practical techniques for undertaking geoconservation with case studies.

English Nature (1999) 'Biodiversity and Minerals - Extracting the Benefits for Wildlife', Entec UK. ISBN: 0 9535400 0 6.

Keywords: Environment, Ecology, Biodiversity, Fauna

Abstract: A guide to planning, operating, restoring and managing mineral sites for biodiversity, aimed at the mineral industry. This handbook provides a guide to quarry operators on the best way to use the opportunity presented by quarrying to create new wildlife habitats.

English Nature, Quarry Products Association and Silica and Moulding Sands Association (2003) 'Geodiversity and the Minerals Industry - Conserving our geological heritage', Entec UK Ltd.. ISBN: 0 9535400 3 0.

Keywords: Environment, Geoconservation

Abstract: A guide to planning, operating, restoring and managing mineral sites for geodiversity.

Geodiversity encompasses the variety of rocks, fossils, minerals, landforms and soils, along with the natural processes that shape the landscape.

Environment Agency 'NetRegs - Mining and Quarrying Guidelines', Web Site.

http://www.netregs.org.uk/business_sectors/mining__quarrying.aspx

Keywords: Information Sources, Investigations, Design, Operations, Reclamation

Abstract: This web site provides a large resource for information and guidance via many links to different web pages on different aspects of environmental legislation. Guidance is given in ten major divisions of the information, accessed via the primary web links, viz.:

Important information
General site activities
Planning your operations
Site preparation
Site accommodation
Blasting
Mobile & static plant
Recovery of materials
Site reinstatement
Activities not covered in these guidelines

Environment Agency (2006) 'Environmental legislation', NetRegs Web Site.

http://www.netregs.org.uk/legislation.aspx

Keywords: Operations, Environment, Water management, Water

Abstract: This Netregs web page provides comprehensive links to environmental legislation, including that concerned with water.

NetRegs was originally a service of the Environment Agency, the Scottish Environment Protection Agency and the Environment and Heritage Service to provide free environmental guidance for small businesses in the UK. It now (2014) comprises environmental guidance for Northern Ireland and Scotland only.

Environment Agency (2007) 'Environment Agency home page', Web Site.

http://www.environment-agency.gov.uk/

Keywords: Environment

Abstract: the Environment Agency (EA) is the leading public body for protecting and improving the environment in England and Wales.

EPIC 'General risk assessment', Web Site.

http://www.epicltd.com/page_view.asp?InfoID=159

EPIC 'Geotechnical training for supervisors', Web Site.

http://www.epicltd.com/page_view.asp?InfoID=222

EPIC Training and Consulting Services Limited 'Address significant gaps in the education and training provision for current and prospective managers in the quarrying industry', Unpublished Report, MIST Project MA/4/4/008.

http://www.sustainableaggregates.com/library/docs/mist/l0041_ma_4_4_008.pdf

Keywords: Operations, Environment

Abstract: This project was to develop a range of education and training materials to ensure quarry and other managers in the extractives industry have the necessary knowledge to extract and transport aggregate in an environmentally friendly manner, and reduce the environmental effects of extraction through development, promotion and implementation of sustainable technologies.

Essex County Council 'Greater Thames survey of known mineral extraction sites', Historic Environment Enabling Programme 3374MAIN.

Keywords: Investigations, Surveys, Reclamation, After Use, Environment, Landscape

Abstract: This project is concerned with the establishment of up-to-date information on mineral extraction sites within the Thames Estuary area, embracing primarily the Thames Gateway sections of the historic counties of Kent and Essex (including the unitary authorities of Medway and Thurrock). It aims to inform current and future land-use proposals, and education and leisure initiatives. It will examine past, present and proposed mineral extraction sites and will identify known extraction sites, map them and, using the geological and planning records, establish what was being worked on each site. Once eligible sites have been identified, it will then assess the geological and archaeological potential of each site to inform further work in the area.

European Community 'Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds', Official Journal L 103, 25/04/1979 P. 0001 - 0018.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31979L0409:EN:HTML

Keywords: Environment, Ecology, Fauna

European Community 'Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora', Official Journal L 206, 22/07/1992 P. 0007 - 0050.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0043:EN:HTML

Keywords: Environment, Ecology, Fauna, Flora

European Community (1979) 'Council Directive 80/68/EEC of 17 December 1979 on the protection of groundwater against pollution caused by certain dangerous substances', Official Journal L 020, 26/01/1980 P. 0043 - 0048.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31980L0068:EN:HTML

Keywords: Environment, Water, Ground water

Abstract: EU "Groundwater Directive"

European Community (1992) 'Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora', Official Journal L 206, 22/07/1992 P. 0007 - 0050.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0043:EN:HTML

Keywords: Environment, Ecology, Fauna, Flora

Abstract: EU Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

European Community (1993) 'Council Regulation (EEC) No 1836/93 of 29 June 1993 allowing voluntary participation by companies in the industrial sector in a Community eco-management and audit scheme', Official Journal L 168, 10/07/1993 P. 0001 - 0018.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31993R1836:EN:HTML

Keywords: Environment, EIA

Abstract: EU Regulation

European Union (1996) 'Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control', Official Journal L 257, 10/10/1996 P. 0026 - 0040.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0061:EN:HTML

Keywords: Environment, Water, Soils, Air

Abstract: Known as "the IPC Directive", this EU Directive imposes a requirement for industrial and agricultural activities with a high pollution potential to have a permit that can only be issued if certain environmental conditions are met, so that the companies themselves bear responsibility for preventing and reducing any pollution they may cause.

European Union (1996) 'Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management', Official Journal L 296, 21/11/1996 P. 0055 - 0063.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0062:EN:HTML

Keywords: Environment, Air, Air quality

European Union (1997) 'Council Directive 97/11/EC of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment', Official Journal L 073, 14/03/1997 P. 0005 - 0015.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31997L0011:EN:HTML

Keywords: Environment, EIA

Abstract: The EIA Directive on Environmental Impact Assessment of the effects of projects on the environment was introduced in 1985 and amended in 1997.

The EIA procedure ensures that environmental consequences of projects are identified and assessed before authorisation is given. The public can give its opinion and all results are taken into account in the authorisation procedure of the project. The public is informed of the decision afterwards.

The EIA Directive outlines which project categories shall be made subject to an EIA, which procedure shall be followed and the content of the assessment.

European Union (2000) 'Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy', Official Journal L 327, 22/12/2000 P. 0001 - 0073.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0060:EN:HTML

Keywords: Environment, Water

European Union (2006) 'Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC - Statement by the European Parliament, the Council and the Commission', Official Journal L 102, 11/04/2006 P. 0015 - 0034.

http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0021

Keywords: Operations, Environment, Water management

Abstract: The Directive aims to regulate the production, treatment and storage of waste from mining and quarrying, by:

* reducing the risk of accidental spills from extractive waste facilities,
* preventing day-to-day pollution and other damage to freshwater, ecosystems from extractive waste across Europe and,
* protecting people (and property) living near or downstream from extractive waste facilities.

European Union (2006) 'Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration', Official Journal L 372, 27/12/2006 P. 0019 - 0031.

Keywords: Environment, Water management

Abstract: The "Water Framework Directive"

European Union (2006) 'Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste (Text with EEA relevance)', Official Journal L 114, 27/04/2006 P. 0009 - 0021.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0009:0021:en:PDF

Keywords: Operations, Environment, Waste, Water management

Abstract: Known as the "Waste Directive". For waste from mineral operations, see "Directive 2006/21/EC on the management of waste from the extractive industrie"s.

Farming Wildlife Advisory Group (2004) 'Maximising habitat value of non-operational and restored land around mineral extraction sites', Unpublished Report, MIST Project MA/2/3/001.

http://www.sustainableaggregates.com/library/docs/mist/l0095_ma_2_3_001.pdf

Keywords: Reclamation, Environment, After Use, Ecology, Biodiversity

Abstract: Land within and surrounding quarries is a potentially valuable habitat for wildlife. This is a pilot study examining the management of restored and non-operational land at two sites in the midlands.

Suggests there is scope to increase the value of habitat in quarries, especially where undisturbed fragments remain. Grassland can deteriorate as scrubland forms on it. Wetlands may dry up and Woodlands may require thinning. All of this suggests that afteruse management beyond the usual 5 year mark may be required to maintain important habitats.

Foster, P. J. (2003) 'Health and safety in quarrying. Part 1: Accidents - causes and effects', Quarry Management V.30 Nr.1 p.43-48.

Keywords: Health and Safety

Abstract: The first in a series of five articles, based on a CD-ROM of lecture and training material covering the fundamentals of health and safety management Prepared by the Camborne School of Mines on behalf of EPIC (NTO) Ltd and the HSE.

Foster, P. J. (2003) 'Health and safety in quarrying. Part 2: Health and safety management systems', Quarry Management V.30 Nr.3 p.43-48.

Keywords: Health and Safety

Abstract: The second in a series of five articles, based on a CD-ROM of lecture and training material covering the fundamentals of health and safety management Prepared by the Camborne School of Mines on behalf of EPIC (NTO) Ltd and the HSE.

Foster, P. J. (2003) 'Health and safety in quarrying. Part 3: Risk assessment', Quarry Management V.30 Nr.5 p.59-68.

Keywords: Health and Safety

Abstract: The third in a series of five articles, based on a CD-ROM of lecture and training material covering the fundamentals of health and safety management. Prepared by the Camborne School of Mines on behalf of EPIC (NTO) Ltd and the HSE.

Foster, P. J. (2003) 'Health and safety in quarrying. Part 4: Accident investigation and the management of contractors', Quarry Management V.30 Nr.7 p.57-65.

Keywords: Health and Safety

Abstract: The fourth in a series of five articles, based on a CD-ROM of lecture and training material covering the fundamentals of health and safety management Prepared by the Camborne School of Mines on behalf of EPIC (NTO) Ltd and the HSE.

Foster, P. J. (2003) 'Health and safety in quarrying. Part 5: Management of health risks', Quarry Management V.30 Nr.9 p.47-53.

Keywords: Health and Safety

Abstract: The last in a series of five articles, based on a CD-ROM of lecture and training material covering the fundamentals of health and safety management. Prepared by the Camborne School of Mines on behalf of EPIC (NTO) Ltd and the HSE.

Friends of the Earth 'Friends of the Earth', Web Site.

http://www.foe.co.uk/

Keywords: Environment

Abstract: Friends of the Earth campaigns for solutions to environmental problems.

Geoffrey Walton Practice 'Handbook of methods for controlling surface waters in and around aggregate quarries', Unpublished Report, MIST Project MA/2/1/003.

http://www.sustainableaggregates.com/library/docs/mist/l0026_ma_2_1_003.pdf

Keywords: Environment, Water, Surface water, Operations, Water management

Abstract: Handbook to provide guidance on good practice for dealing with surface waters in and around quarries derived from a project 'hydrological assessments in and around aggregate quarries'.

Geoffrey Walton Practice & David Jarvis Associates (2004) 'Secure and sustainable final slopes for SME aggregates quarries: a handbook prepared for the Mineral Industry Research Organisation and funded by the Office of the Deputy Prime Minister', Jon Carpenter, Charlbury. ISBN: 0897766882.

http://www.sustainableaggregates.com/library/docs/samp/l0056_samp_1_020.pdf

Keywords: Design, Environment, Slope design, Landscape, Investigations, Geotechnical

Abstract: This report describes the need and methods of obtaining secure, sustainable final slopes in quarries operated by SMEs. The chapter headings are: Introduction, Slope Issues and Interested Parties, Types of Quarries, General Approaches to Slope Treatment, Stability and Safety, Specific Techniques, Landscape Conclusions, and Geotechnical Solutions. There are in addition four appendices which contain a list of references and sources of further information, several useful survey proformas, a checklist, and a glossary.

SAMP1.020

Geoffrey Walton Practice (1986) 'Review of current geotechnical practice in British quarries and related interests and requirements of Mineral Planning Authorities and other statutory bodies', Report to the Department of the Environment.

Keywords: Investigations, Geotechnical

Geoffrey Walton Practice (1988) 'Handbook on the hydrogeology and stability of excavated slopes in quarries', HMSO. ISBN: 0117521264.

Keywords: Design, Slope design, Excavated slopes, Investigations, Geotechnical, Operations, Water management

Abstract: This handbook for the Department of the Environment provides a summary of a technical review of the stability and hydrogeology of mineral excavations. This review includes the following sections:

1. Geotechnical settings of quarries
2. Water in quarries
3. Slope stability in quarries

It also includes as Part II guidelines on the investigation, assessment and inspection of quarry slopes in bedrock quarries; sands, gravels and superficial materials are excluded.

Geoffrey Walton Practice (1988) 'Technical review of the stability and hydrogeology of mineral workings', HMSO. ISBN: 0117521337.

Keywords: Investigations, Design, Investigation methods, Geotechnical, Slope design, Environment, Water, Ground water, Surface water

Abstract: This review for the Department of the Environment was designed as a summary and reference source for the subject, of relevance to all those with an interest in planning of bedrock quarries. Sand and gravel quarries were not included in the review. It was not intended as an up-to-date review nor as an advanced textbook but to provide background information on excavated slope stability and hydrogeology. The chapter headings are:

Geotechnical and Quarry Settings
Surface Water in Quarries
Groundwater in Quarries
Factors Influencing Slope Stability
Modes of Slope Failure
Methods of Stability Analysis
Slope Design
Construction and Management
Site Investigation Practice.

References are given at the end of each chapter and there are seven appendices that include worked examples and equations.

Geoffrey Walton Practice (1991) 'Handbook on the Design of Tips and Related Structures', HMSO. ISBN: 0117525391.

Keywords: Design, Slope design, Fill slopes and tips

Abstract: This handbook was designed as a summary and a source of reference and provides a review of the practices with respect to stability of quarry tips and backfill and covers: viz., tips for the disposal of excavated waste materials and discards from related processing works, structures erected primarily or partly as amenity/baffle banks, mineral stockpiles, temporary and long term backfill within quarries and excavated ponds and lagoons. It is not intended as a specialist text book but rather a tools that will be useful to stakeholders from a wide variety of backgrounds.

The handbook is split into two parts. In Part I the chapter headings are: The Origin and Nature of Tips, Factors Influencing Tip Stability, Methods of Analysis, Tip Design, Construction and Management, and Legislation. There are also three appendices which contain a description of a 2D slope stability program which is included on a disk, records of tip instabilities in British quarries and a background to legislation. Part II contains Guidelines on the Design, Assessment and Inspection of Tips and Related Structures and References.

Geological Society 'The Geological Society of London', Web Site.

http://www.geolsoc.org.uk/

Keywords: Information Sources

Abstract: The Geological Society of London was founded in 1807. It is the UK national society for geoscience, and is the world's oldest national scientific and professional society for Earth scientists.

Geological Society (2007) 'The Geologist's Directory 2007 (17th edition)', Boundary. ISBN: 1-86239-231-5.

http://www.thegeologistsdirectory.com/

Keywords: Information Sources

Abstract: The Geologist's Directory provides an up-to-date source of information on the people, the products and the companies operating in the geoscience industries.

Geoplan Limited (2004) 'Research into the design and operational use of quarry silt lagoons to provide landscape and environmental gains', Unpublished Report, MIST Project MA/2/3/002.

http://www.sustainableaggregates.com/library/docs/mist/l0028_ma_2_3_002.pdf

Keywords: Environment, Water, Landscape, Surface water, Operations, Waste, Design, Water retention, Lagoons

Abstract: Objectives of this project are:

*Desktop study to ascertain the range of afteruses for sand and gravel silt lagoons within the study area.
*Assess designs, management and restoration techniques influencing the aftruse of silt lagoons.
*Discussion of design, restoration and management elements to maximise benefits.

The document forms a preliminary stage in developing best practice guidance.

Gloucestershire County Council 'Gloucestershire - assessment of archaeological resource in aggregate areas', Historic Environment Enabling Programme 3346.

Abstract: County wide survey of archaeological sites on areas of potential aggregate extraction

Gloucestershire Geology Trust 'RIGS Recording and Aggregates Collection'.

Abstract: The eighteen month project started in September 2002 with the aims to complete an aggregates sites recording project and to create an 'Aggregates Reference Collection' for Gloucestershire. This included researching, identification and recording of 35 new aggregate related RIGS sites and the substantial upgrading of the existing RIGS records to a cross-platform digital format. The data that is collected, correlated and recorded during this project will be stored on a cross-platform, self running electronic database which could be distributed on disk to local and national interested parties.
The geological records on the database are an extremely valuable resource for study and preservation of biodiversity and are potentially valuable scientifically, educationally and commercially. All sites given RIGS status will be notified to the county council and relevant district planning offices and added to their list of planning provisions.
The agrgregates reference collection is housed in the Collectors' Room at The Museum in the Park, Stroud and is accompanied by descriptions of the aggregates and their economic uses. Information accompanying the collection examines the role of the aggregate industries in the county. This will provide long term study and reference opportunities for products of the project and should become a valuable resource for geology in Gloucestershire. Many of the sites designated will form the basis of public awareness and geological trails in ongoing and future programmes.

Gough, K. & Stone, I (2004) 'Air Quality: Impacts, monitoring and controls', Environmmental Management, Institute of Quarrying, Nottingham.

Keywords: Environment, Air, Air quality

Great Britain (1973) 'Badgers Act 1973', HMSO. ISBN: 0105457736.

http://www.legislation.gov.uk/ukpga/1973/57/contents

Keywords: Environment, Ecology, Fauna

Abstract: Statutory Instrument, repealed and replaced by the Protections of Badgers Act 1992

Great Britain (1981) 'Wildlife and Countryside Act 1981', HMSO.

http://www.legislation.gov.uk/ukpga/1981/69/contents

Keywords: Environment, Ecology

Abstract: The Wildlife and Countryside Act remains one of the most important pieces of wildlife legislation in Great Britain, but it is important to be aware that there have been various subsequent amendments, most significantly by:

Countryside and Rights of Way Act 2000
Nature Conservation (Scotland) Act 2004

and also through other legislation including the Local Government Act 1985, the Water Act 1989, and the Environmental Protection Act 1990.

Great Britain (1986) 'Gas Act 1986', HMSO. ISBN: 0105444863.

http://www.legislation.gov.uk/ukpga/1986/44/contents

Great Britain (1989) 'Electricity Act 1989', HMSO. ISBN: 0105429899.

http://www.legislation.gov.uk/ukpga/1989/29/contents

Great Britain (1990) 'Town and Country Planning Act 1990', Stationery Office. ISBN: 0105408905.

http://www.legislation.gov.uk/ukpga/1990/8/contents

Keywords: Planning

Abstract: Statutory Instrument. Describes the statutory requirements and provisions for the planning process including the legal basis for, and responsibilities of, the Minerals Planning Authorities.

This act was passed to better regulate the way in which large and small scale developments were approved by local authorities in England and Wales, and set up rules that local authorities must follow to reach this goal.

Great Britain (1990) 'Environmental Protection Act 1990', Stationery Office. ISBN: 0105443905.

http://www.legislation.gov.uk/ukpga/1990/43/contents

Keywords: Environment

Abstract: Statutory Instrument

Great Britain (1991) 'Planning and Compensation Act 1991 (Commencement No. 3) Order 1991', Stationery Office. ISBN: 0 11 015272 7.

http://www.legislation.gov.uk/uksi/1991/2272/contents/made

Abstract: Statutory Instrument

Great Britain (1991) 'Planning and Compensation Act 1991', Stationery Office. ISBN: 0105434914.

http://www.opsi.gov.uk/acts/acts1991/Ukpga_19910034_en_1.htm

Keywords: Planning

Abstract: This act was passed to amend the law relating to town and country planning:

* to extend the powers to acquire by agreement land which may be affected by carrying out public works;
* to amend the law relating to compulsory acquisition of land, and to compensation where persons are displaced from land or the value of land or its enjoyment may be affected by public works;
* to provide, in the case of compensation payable in respect of things done in the exercise of statutory powers, for advance payments and payments in interest.

Great Britain (1991) 'Water Resource Act 1991', HMSO. ISBN: 0105457914.

http://www.legislation.gov.uk/ukpga/1991/57/contents

Keywords: Environment, Water

Great Britain (1992) 'Protections of Badgers Act 1992', HMSO. ISBN: 0105451924.

http://www.opsi.gov.uk/acts/acts1992/Ukpga_19920051_en_1.htm

Keywords: Environment, Ecology, Fauna

Abstract: Statutory Instrument, repeals and replaces by the Badgers Act 1973.

Great Britain (1994) 'The Conservation (Natural Habitats, &c.) Regulations 1994', HMSO. ISBN: 0110457161.

http://www.legislation.gov.uk/uksi/1994/2716/contents/made

Keywords: Environment, Ecology

Abstract: Legislation that transposes Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (EC Habitats Directive) into national law. The Regulations came into force on 30 October 1994 and have subsequently been amended in 1997 and (in England only) in 2000.

Great Britain (1995) 'Town and Country Planning (General Permitted Development) Order 1995', Stationery Office.

http://www.legislation.gov.uk/uksi/1995/418/contents/made

Keywords: Planning, Planning framework

Abstract: Provides a general planning permission (known as 'permitted development rights') for certain types of minor development.

Great Britain (1995) 'Environment Act 1995', Stationery Office. ISBN: 0105425958.

http://www.legislation.gov.uk/ukpga/1995/25/contents

Keywords: Environment

Abstract: This act created a number of new agencies and set new standards for environmental management. It set up the Environment Agency, the Scottish Environment Protection Agency (SEPA), and the National Park authorities.

Great Britain (1995) 'The Borehole Sites and Operations Regulations 1995', HMSO. ISBN: 0110533178.

Keywords: Investigations, Investigation methods, Drilling

Abstract: Regulations concerning the minimum requirements for improving the safety and health protection of workers in the mineral extraction industries involved with drilling.

Great Britain (1999) 'The Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999', Stationery Office. ISBN: 0 11 080474 0.

http://www.legislation.gov.uk/uksi/1999/293/contents/made

Keywords: Environment, Planning, EIA, Planning framework

Abstract: Statutory Instrument providing measures relating to the requirement for an assessment of the impact on the environment of projects likely to have significant effects on the environment.

Also known as the EIA Regulations, this document relates to a European Union Directive (Directive 85/337/EEC as amended by Directive 97/11/EC). It places a number of responsibilities on planning authorities, which relate to the different stages of the environmental impact assessment (EIA) process.

Great Britain (1999) 'Pollution Prevention and Control Act 1999'. ISBN: 0 10 542499 4.

http://www.legislation.gov.uk/ukpga/1999/24/contents

Keywords: Environment

Abstract: Statutory Instrument   Describes the statutory requirements and provisions for implementing the European Council Directive 96/61/EC concerning integrated pollution prevention and control. It also provides for regulating activities capable of causing any environmental pollution and preventing or controlling emissions capable of causing any such pollution.

Great Britain (1999) 'The Quarries Regulations 1999', Stationery Office. ISBN: 0 11 082955 7.

http://www.legislation.gov.uk/uksi/1999/2024/contents/made

Keywords: Design, Operations, Health and Safety

Abstract: These regulations cover all aspects of health and safety in quarries, including the design and maintenance of excavations and tips, the use and storage of explosives, the operation of vehicles, and the planning of health and safety management plans.

Great Britain (1999) 'Environmental Impact Assessment (Scotland) Regulations 1999', Stationery Office. ISBN: 0 11 059107.

http://www.legislation.gov.uk/ssi/2011/139/regulation/47/made

Keywords: Planning, Planning framework

Abstract: Environmental impact assessment regulations for Scotland

Great Britain (1999) 'Planning (Environmental Impact Assessment) Regulations (Northern Ireland) 1999', Stationery Office. ISBN: 0 33 793393 6.

http://www.legislation.gov.uk/nisr/1999/73/contents/made

Keywords: Planning, Planning framework

Abstract: Environmental impact assessment regulations for Northern Ireland

Great Britain (1999) 'The Management of Health and Safety at Work Regulations 1999', Stationery Office. ISBN: 0 11 085625 2.

http://www.legislation.gov.uk/uksi/1999/3242/contents/made

Keywords: Health and Safety

Great Britain (1999) 'The Control of Major Accident Hazards (Amendment) Regulations 2005', Stationery Office. ISBN: 0110727665.

http://www.legislation.gov.uk/uksi/2005/1088/contents/made

Keywords: Health and Safety

Great Britain (2000) 'The Air Quality (England) Regulations 2000', Stationery Office. ISBN: 0 11 099043 9.

http://www.legislation.gov.uk/uksi/2000/928/contents/made

Keywords: Environment, Air, Air quality

Abstract: Legislation setting out air quality objectives

Great Britain (2000) 'Countryside and Rights of Way Act 2000', Stationery Office. ISBN: 0 10 543700 X.

http://www.legislation.gov.uk/ukpga/2000/37/contents

Keywords: Environment, Ecology, Access

Abstract: Statutory Instrument

Great Britain (2000) 'The Air Quality (Wales) Regulations 2000', Stationery Office. ISBN: 0110901118.

http://www.legislation.gov.uk/wsi/2000/1940/contents/made

Keywords: Environment, Air, Air quality

Abstract: The air quality regulations as passed by the Welsh Assembly

Great Britain (2000) 'The Pollution Prevention and Control (England and Wales) Regulations 2000', Stationery Office. ISBN: 0 11 099621 6..

http://www.legislation.gov.uk/uksi/2000/1973/contents/made

Keywords: Environment

Abstract: Statutory Instrument. The regulations that implemented the Integrated Pollution Prevention and Control regime requiring UK companies to prevent or control emissions and set in place the process of adopting Best Available Techniques (BATS) for controlling emissions.

Great Britain (2000) 'The Town and Country Planning (Environmental Impact Assessment) (England and Wales) (Amendment) Regulations 2000', Stationery Office. ISBN: 0110186907.

http://www.opsi.gov.uk/si/si2000/20002867.htm

Keywords: Environment, Planning, EIA, Planning framework

Abstract: Statutory Instrument. Implements EIA for reviews of existing mineral permissions.

Great Britain (2003) 'Water Act 2003', Stationery Office. ISBN: 0 10 543703 4.

http://www.legislation.gov.uk/ukpga/2003/37/contents

Keywords: Environment, Water

Abstract: Statutory Instrument. With a few exceptions the Act applies only to England and Wales. The main provisions of interest to quarries are those that provide the Environment Agency with additional tools for managing water resources and stronger powers to take action against abstractions causing environmental damage. The Act makes information more readily available to the public on water resources so that abstractions can be planned ahead of time to minimise environmental impacts.

Great Britain (2004) 'Planning and Compulsory Purchase Act 2004', Stationery Office.

http://www.legislation.gov.uk/ukpga/2004/5/contents

Keywords: Planning, Planning framework

Abstract: An Act to make provision relating to spatial development and town and country planning, and to the compulsory acquisition of land.

The legislation was designed to pave the way for a more flexible and responsive planning system for England and Wales, introducing what the government believes is a simpler and more flexible plan-making system at regional and local level.

Explanatory notes produced to assist in the understanding of this Act are available separately.

Great Britain (2005) 'The Hazardous Waste (England and Wales) Regulations 2005', Stationery Office. ISBN: 0110726855.

http://www.legislation.gov.uk/uksi/2005/894/contents/made

Keywords: Environment

Great Britain (2007) 'Planning Portal', UK Government Web Site.

http://www.planningportal.gov.uk/

Keywords: Information Sources, Planning, Planning framework, Planning process

Abstract: The Planning Portal is the UK government's online planning and building regulations resource for England and Walse. Use this site to learn about planning and building regulations, apply for planning permission and building regulations consent, find out about development near you, appeal against a decision and research government policy.

Links for equivalent data from Scotland and Northern Ireland are located at http://www.planningportal.gov.uk/general/glossaryandlinks/links/scotlandnireland

Great Britain (2007) 'The Construction (Design and Management) Regulations 2007', Stationery Office. ISBN: 0110757890.

http://www.legislation.gov.uk/uksi/2007/320/pdfs/uksi_20070320_en.pdf

Keywords: Design, Operations, Health and Safety

Abstract: These Regulations concern occupational health, safety and welfare in construction. They place duties in relation to management arrangements and practical measures on a range of construction project participants, including clients, designers and contractors.

Great Britain (2010) 'Town and Country Planning (Development Management Procedure) (England) Order', Stationery Office. ISBN: 978-0-11-152857-0.

http://www.legislation.gov.uk/uksi/2010/2184/made/data.pdf

Keywords: Planning, Planning process

Abstract: The order, amongst other things, sets out the steps local authorities in England must take with regard to the processing and administration of planning applications.

Great Britain (2011) 'Localism Act', Stationery Office. ISBN: 978-0-11-110799-7.

http://www.legislation.gov.uk/ukpga/2011/20/contents

Keywords: Planning

Abstract: An Act to make provision about the functions and procedures of local authorities

Great Britain (2013) 'Growth and Infrastructure Act', Stationery Office.

http://www.legislation.gov.uk/ukpga/2013/27/contents/enacted/data.htm

Keywords: Planning

Abstract: Provides an option ption to make a planning application directly to the Secretary of State

Great Britain Department for Communities and Local Government 'Regional Aggregate Working Parties (RAWPs)', Web Site.

https://www.gov.uk/government/policies/improving-the-energy-efficiency-of-buildings-and-using-planning-to-protect-the-environment/supporting-pages/aggregate-working-parties

Keywords: Planning

Abstract: The Regional Aggregate Working Parties (RAWPs) were established in the mid-1970s to identify and consider likely regional problems in the supply of aggregates. They provide technical advice in relation to the supply of, and demand for construction aggregates (including for sand, gravel and crushed rock) to the Regional Assemblies/Regional Planning Bodies and the Secretary of State for Communities and Local Government. They undertake annual monitoring of aggregates production, by type and use, and levels of permitted reserves, and every fourth year an expanded survey that includes data on transportation of aggregates and which allow levels of consumption of and, thus, demand for aggregates by region to be assessed.

Great Britain Department for Communities and Local Government (2006) 'Planning and minerals: Practice Guide', DCLG Publications. ISBN: 10 1 85112 869 7.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7775/153421.pdf

Keywords: Planning

Abstract: This Guide should be read alongside Minerals Planning Statement 1: Planning and Minerals. It sets out how the policies in the Statement might best be implemented. It offers examples and principles of good practice and background information, to assist regional planning bodies in the preparation of Regional Spatial Strategies, and mineral planning authorities in the preparation of local development documents for minerals

Great Britain Department for Communities and Local Government (2006) 'Planning and Minerals', Minerals Policy Statement MPS 1, Department for Communities and Local Government. ISBN: 0 11 753971 6.

http://www.sustainableaggregates.com/library/docs/l0216_152993.pdf

Keywords: Planning

Abstract: MPS1 is the overarching planning policy document for all minerals in England. It provides advice and guidance to planning authorities and the minerals industry and it will ensure that the need by society and the economy for minerals is managed in an integrated way against its impact on the environment and communities.

This document replaces Minerals Planning Guidance (MPG1).

Great Britain Department for Environment, Food and Rural Affairs 'Middleton Hall/Middleton Lakes Feasibility Study - Near Tamworth', ALSF Third objective 'legacy' site project ALSF/B/18.

Keywords: Environment, Water, Surface water

Great Britain Department for Environment, Food and Rural Affairs 'Magic website', Web Site.

www.magic.gov.uk

Keywords: Environment, Information Sources

Abstract: Magic is a web-based interactive map that brings together geographic information on key environmental schemes and designations in one place; primarily for England although it is intended in to extend the coverage for an increasing number of datasets to Wales and Scotland. It includes data presented in map form covering an extensive range of topics including many that are of relevance for planning applications for mineral extraction, e.g. the locations of SSSIs, SPAs and other nature conservation sites, administrative boundaries and the boundaries of regional and local regulatory bodies etc

Metadata are available for all the datasets and some of the GIS data sets can be downloaded. Magic is a partnership project involving eight government organisations who have responsibilities for rural policy-making and management viz.:

DEFRA (Department for Environment, Food and Rural Affairs)
Countryside Agency - Landscape, Access and Recreation
English Heritage
English Nature
Environment Agency
Forestry Commission
ODPM (Office of the Deputy Prime Minister)
RDS (Rural Development Service)

Great Britain Department for Environment, Food and Rural Affairs (2003) 'The Air Quality Strategy for England, Scotland, Wales and Northern Ireland: Addendum', DEFRA.

Keywords: Environment, Air, Air quality

Abstract: The Government's Air Quality Strategy, issued in 2000, sets air quality standards and objectives for eight key air pollutants to be achieved between 2003 and 2008. Following a review and public consultation in 2001, this addendum introduces tighter objectives for particles, benzene and carbon monoxide and a new objective for polycyclic aromatic hydrocarbons.

Great Britain Department for Environment, Food and Rural Affairs (2003) 'Explanatory Notes to Water Act 2003', Stationery Office. ISBN: 0 10 563 703 3.

http://www.legislation.gov.uk/ukpga/2003/37/notes/contents

Keywords: Environment, Water

Abstract: These explanatory notes refer to the Water Act, which received Royal Assent on 20th November 2003. They have been prepared by the Department for Environment, Food and Rural Affairs in order to assist the reader of the Act. They do not form part of the Act and have not been endorsed by Parliament.

The four broad aims of the Act are:

(1) the sustainable use of water resources;
(2) strengthening the voice of consumers;
(3) a measured increase in competition; and
(4) the promotion of water conservation.

Great Britain Department for Environment, Food and Rural Affairs (2003) 'General guidance manual on policy and procedures for A2 and B installations: Pollution Prevention and Control Act 1999'.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/211863/env-permitting-general-guidance-a.pdf

Keywords: Environment

Abstract: Guidance for local authorities and operators on permitting industrial installations under: Local authority Integrated Pollution Prevention and Control (LA-IPPC) & Local authority Pollution Prevention and Control (LAPPC).

This is the principal guidance issued by the Secretary of State for Environment, Food and Rural Affairs on the operation of two new pollution control regulatory regimes introduced under the Pollution Prevention and Control Act 1999 (PPC Act).

Great Britain Department for Environment, Food and Rural Affairs (2004) 'Secretary of State's Guidance for Quarry Processes', Process Guidance Note 3/8 (04), DEFRA Publications.

http://archive.defra.gov.uk/environment/quality/pollution/ppc/localauth/pubs/guidance/notes/pgnotes/documents/minpg3-8.pdf

Keywords: Environment, Air, Air quality, Dust

Abstract: This note gives statutory guidance for controlling emissions into the air from quarry processes using Best Available Techniques. It falls under the Local Air Pollution Control (LAPC) established by Part I of the Environmental Protection Act 1990, and the Local Air Pollution Prevention and Control (LAPPC) regime established by the Pollution Prevention and Control Act 1999. It is directed at regulators, operators and interested members of the general public. It replaces Process Guidance Note 3/8(96) which in turn replaced PG 3/8 (91).

Other notes on processes that may occur at quarries and create emissions into the air, including cement processes, roadstone coating, mineral drying and cooling, and mobile crushing and screening are also available from the same source.

Great Britain Department for Environment, Food and Rural Affairs (2004) 'Secretary of State's guidance for mobile crushing and screening', Process Guidance Note 3/16 (04).

http://archive.defra.gov.uk/environment/quality/pollution/ppc/localauth/pubs/guidance/notes/pgnotes/documents/minpg3-16.pdf

Keywords: Environment, Air, Air quality

Abstract: This note gives best practice guidance on the conditions appropriate for the control of emissions into the air from mobile crushing and screening processes/ installations.

Great Britain Department for Environment, Food and Rural Affairs (2004) 'Secretary of State's guidance for mineral drying and cooling', Process Guidance Note 3/15B (04).

http://archive.defra.gov.uk/environment/quality/pollution/ppc/localauth/pubs/guidance/notes/pgnotes/documents/minpg3-15b.pdf

Keywords: Environment, Air, Air quality, Operations, Processing

Abstract: This note gives best practice guidance on the conditions appropriate for the control of emissions into the air from the following industrial sector: Mineral Drying and Cooling processes/ installations.

Great Britain Department for Environment, Food and Rural Affairs (2005) 'DEFRA guidance for successful reclamation of mineral and waste sites', DEFRA.

http://www.sustainableaggregates.com/library/docs/l0276_guidance-full.pdf

Keywords: Reclamation, Restoration, After Use

Abstract: This guidance is aimed at mineral planning authorities and mineral operators to promote better understanding of the agricultural issues that affect the restoration of mineral and waste sites where the long-term agricultural potential of the land is to be preserved. It provides a working tool to assess and balance the agricultural issues relating to mineral and waste proposals, by focusing on the agricultural considerations and the key issue of sustainability.

The complete guidance or individual sections are available for downloading as pdf files. The first sections comprise Introduction, How to use the guidance, Addresses, Glossary,
Abbreviations, and Contents tree. There follow checklists of the issues for consideration that are divided between four major sections viz., Application, Site Working, Restoration, and Aftercare. Each of the checklists is designed to flag up agricultural issues that must be considered and provides hyperlinks to other relevant sections and references. The guidance can also be used for quality assurance and a paper audit trail.

Great Britain Department for Transport, Local Government and the Regions (1997) 'Mitigation Measures in Environmental Impact Statements', Office of the Deputy Prime Minister. ISBN: 1851120505.

Keywords: Environment, EIA

Abstract: This report provides guidance on good practice.

Great Britain Department for Transport, Local Government and the Regions (1998) 'The Environmental Effects of Production Blasting from Surface Mineral Workings', Stationery Office. ISBN: 0117534129.

Keywords: Environment, Noise and Vibration

Abstract: DETR commissioned research by Vibrock Limited

Great Britain Department for Transport, Local Government and the Regions (2000) 'Regional Planning Guidance for East Anglia to 2016', Regional Planning Guidance Note RPG 6, Stationery Office. ISBN: 0117535613.

https://www.cambridge.gov.uk/public/ldf/coredocs/RD-NP-131.pdf

Keywords: Planning

Abstract: The Regional Planning Guidance for East Anglia covers the counties of Cambridgeshire (including Peterborough), Norfolk and Suffolk. It provides a strategy for the sustainable development of the region to meet the economic and social needs of the people, supporting urban renaissance, hi-tech growth and the housing needs of all sectors of the community, whilst protecting its distinctive environment.

Great Britain Department for Transport, Local Government and the Regions (2001) 'Development and flood risk', Planning Policy Guidance Note PPG 25, Stationery Office. ISBN: 0117536113.

Keywords: Environment, Planning, Water, Surface water

Abstract: This guidance explains how flood risk should be considered at all stages of the planning and development process in order to reduce future damage to property and loss of life. It sets out the importance that the Government attaches to the management and reduction of flood risk, acting on a precautionary basis and taking account of climate change. It summarises the responsibility of various parties in the development process. The planning system should ensure that new development is safe and that flood plains are used for their natural purpose.

Great Britain Department for Transport, Local Government and the Regions (2001) 'Transport', Planning Policy Guidance Note PPG 13, Stationery Office. ISBN: 0 11 753558 3.

http://webarchive.nationalarchives.gov.uk/20120919132719/www.communities.gov.uk/documents/planningandbuilding/pdf/1758358.pdf

Keywords: Planning

Abstract: This PPG's objectives are to integrate planning and transport at the national, regional, strategic and local level and to promote more sustainable transport choices both for carrying people and for moving freight. It also aims to promote accessibility to jobs, shopping, leisure facilities and services by public transport, walking and cycling and to reduce the need to travel, especially by car.

Great Britain Department for Transport, Local Government and the Regions (2001) 'Regional Planning Guidance for the South East', Regional Planning Guidance Note RPG 9, Stationery Office. ISBN: 0 11753562 1.

http://webarchive.nationalarchives.gov.uk/20100528142817/http:/www.gos.gov.uk/gose/planning/regionalplanning/815640/

Keywords: Planning

Abstract: This guidance provides a regional framework for the preparation of local authority development plans and a spatial framework for other strategies and programmes. It cover the period up to 2016 and supersedes the Regional Guidance for the South East issued in March 1994. This RPG should be read in conjunction with more detailed existing guidance contained in: Thames Gateway Planning Framework (RPG9a), 1995; Strategic Guidance for London Planning Authorities (RPG3), 1996 (to be superseded by the Mayor's Spatial Development Strategy); Strategic planning Guidance for the River Thames (RPG3b/9b), 1997

Great Britain Department for Transport, Local Government and the Regions (2001) ' Regional Planning Guidance for the South West', Regional Planning Guidance Note RPG 10, Stationery Office. ISBN: 0 11 753603 2.

http://www.southwest-ra.gov.uk/media/SWRA/Transport/RPG10Fulltext.pdf

Keywords: Planning

Abstract: This Regional Planning Guidance for the South West provides a regional spatial strategy, within which local authority development plans and local transport plans should be prepared. It sets out a broad development strategy for the period 2016 and beyond and provides a spatial strategy for other strategies and frameworks. It supersedes the RPG issued in 1994 and covers the period to 2011.

Great Britain Department for Transport, Local Government and the Regions, and Arup Economics and Planning (2000) 'Survey of land for mineral workings in England 2000', DTLR. ISBN: 1851125787.

Keywords: Planning

Abstract: A periodic survey of the nature and extent of mineral workings in England, undertaken by Mineral Planning Authorities (MPAs) on behalf of the relevant Government Department. Previous surveys were published in 1974, 1982, 1988 and 1994.

The report provides assessments at national and regional levels; data for individual MPAs regarding areas affected by mineral extraction and related waste tipping not yet reclaimed; the extent of permitted areas with reclamation conditions; the extent of land reclaimed since the 1994 survey; and the extent of permissions for underground mining.

Great Britain Department of the Environment (1990) 'Development on Unstable Land', Planning Policy Guidance Note PPG 14, HMSO. ISBN: 0 11 752300 3.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/publications/planningandbuilding/planningpolicyguidance16

Keywords: Design, Planning

Abstract: This PPG explains briefly the effects of land instability on development and land use. The responsibilities of the various parties to development are considered and the need for instability to be taken into account in the planning process is emphasized. Appendix A explains the causes of instability and Appendix B provides sources of information.

Separately published Annexes on Landslides and planning and Subsidence and planning develop this advice with specific reference to those areas and include background information and good practice guidance on identification and assessment of these problems and how they are can be dealt with in the planning system.

Great Britain Department of the Environment (1990) 'Archaeology and planning', Planning Policy Guidance Note PPG 16, HMSO. ISBN: 0 11 752353 4.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/archived/publications/planningandbuilding/ppg16

Keywords: Environment, Planning, Archaeology

Abstract: This guidance explains Government policy on terrestrial archaeology for English planning authorities, property owners, developers, archaeologists, amenity societies and the general public. It gives advice on the handling of archaeological remains and discoveries under the development plan and control systems, including the weight to be given to them in planning decisions and the use of planning conditions.

Local authorities, acting within the framework set by central government, in their various capacities as planning, education and recreational authorities, as well as with the owners of sites themselves are key in protecting the national archaeological heritage. Appropriate planning policies in development plans and their implementation through development control are especially important.

Great Britain Department of the Environment (1991) 'Planning and Compensation Act 1991 interim development order permissions (IDOS) - statutory provisions and procedures', Minerals planning guidance notes MPG 8. ISBN: 0 11 752531 6.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/publications/planningandbuilding/mineralsplanningguidance6

Keywords: Planning

Abstract: This MPG explains what actions need to be taken if old permissions for mineral workings and minerals waste deposits are to continue to have effect. The permissions concerned are those granted in the 1940s under Interim Development Orders (IDOs) and have remained in force even though they were granted before July 1948.

Great Britain Department of the Environment (1991) 'Provision of raw material for the cement industry', Minerals planning guidance notes MPG 10, HMSO. ISBN: 0 11 752522 7.

http://www.planningportal.gov.uk/planning/planningpolicyandlegislation/previousenglishpolicy/mmgmpsmmg/mpg10

Keywords: Planning, Planning framework, Feasibility

Abstract: This MPG provides advice to mineral planning authorities (MPAs) on the exercise of planning control over the provision of raw material for the cement industry. The notes indicate the national policy considerations which need to be taken into account in drawing up minerals policies for the industry in their development plans and some of the other factors that need to be taken into account when determining applications for planning permission. They supplement the general guidance contained in the Mineral Planning Guidance Note 1 "General Considerations and the Development Plan System" (MPG 1).

Great Britain Department of the Environment (1992) 'Simplified Planning Zones', Planning Policy Guidance Note PPG 5, HMSO. ISBN: 0 11 7527173.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/publications/planningandbuilding/planningpolicyguidance3

Keywords: Planning, Planning framework

Abstract: This PPG outlines the general nature and role of Simplified Planning Zones (SPZs). Annexes contain detailed guidance on the use, content and effect of SPZs, their relationship to other controls and planning operations, and information on SPZ procedures.

Simplified planning zones exist to promote development or redevelopment on land within the authority's area and provide an easy route for developers and landowners to secure consent with savings in money, time and effort.

Great Britain Department of the Environment (1992) 'Planning and Compensation Act 1991 - Interim development order permissions (IDOs): conditions', Minerals planning guidance notes MPG 9, HMSO. ISBN: 0 11 752629 0.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/publications/planningandbuilding/mineralsplanningguidance7

Keywords: Planning, Planning framework

Abstract: This MPG gives advice on the considerations to be taken into account by applicants and minerals planning authorities in preparing and determining the conditions to which registered IDO permissions should be subject. Permissions granted after 21 July 1943 and before 1 July 1948 had to be submitted for registration to the mineral planning authority.

Great Britain Department of the Environment (1992) 'The Town and Country Planning (Fees for Applications and Deemed Applications) (Amendment) (No 2) Regulations 1992', Planning Circular 31/92, HMSO. ISBN: 0 11 752754 8.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/index.asp?id=1144458

Keywords: Planning

Abstract: These Regulations, made under section 303 of the Town and Country Planning Act 1990 (the 1990 Act), came into force on 4 January 1993. They increased the fees payable for planning applications made on or after that date.

Great Britain Department of the Environment (1992) 'Publicity for Planning Applications', Planning Circular 92/15, HMSO. ISBN: 011752672X.

https://www.gov.uk/government/publications/publicity-for-planning-applications-circular-15-1992

Keywords: Planning, Planning process

Abstract: Describes the publicity requirements for proposed developments, including the site notices, newspaper advertisement and the application and environmental statement. Mineral extraction is classified as a major development.

Great Britain Department of the Environment (1992) 'Industrial, commercial development and small firms', Planning Policy Guidance Note PPG 4, HMSO. ISBN: 0 11 752723 8.

http://webarchive.nationalarchives.gov.uk/20120919132719/www.communities.gov.uk/archived/publications/planningandbuilding/ppg4

Keywords: Planning, Planning framework

Abstract: This PPG takes a positive approach to the location of new business developments and assisting small firms through the planning system. The main message is that economic growth and a high-quality environment have to be pursued together.

This publication has been discontinued and is no longer available to order or download. The publication record page (see web link) is retained for archive purposes only.

Great Britain Department of the Environment (1993) 'Control of noise at surface mineral workings', Minerals planning guidance notes MPG 11, HMSO. ISBN: 0 11 752779 3.

Keywords: Environment, Noise and Vibration

Abstract: This MPG acknowledges that noise from minerals workings often causes public annoyance. The guidance advises minerals planning authorities and the industry on how a mineral working's environmental performance can be improved by the control of noise.

Superseded by MPS2

Great Britain Department of the Environment (1994) 'Planning and noise', Planning Policy Guidance Note PPG 24, HMSO. ISBN: 0117529249.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/archived/publications/planningandbuilding/ppg24

Keywords: Environment, Planning, Noise and Vibration

Abstract: This PPG outlines the considerations to be taken into account in determining planning applications both for noise-sensitive developments and for those activities which generate noise.

It explains the concept of noise exposure categories for residential development and recommends appropriate levels for exposure to different sources of noise, as well as advising on the use of conditions to minimise the impact of noise.

Specific advice on the control of noise from mineral working sites is provided in Minerals Planning Guidance Note 11 - "The Control of Noise at Surface Mineral Workings" (MPG 11).

Great Britain Department of the Environment (1994) 'Guidelines for aggregates provision in England', Minerals planning guidance notes MPG 6, HMSO.

Keywords: Planning, Planning framework, Feasibility

Abstract: MPG 6 provides advice to mineral planning authorities and the minerals industry on how to ensure that the construction industry receives an adequate and steady supply of material at the best balance, of social, environmental and economic cost, whilst ensuring that extraction and development are consistent with the principles of sustainable development. It has several annexes:

Annex A: Regional Guidelines for Aggregates Provision in England
Annex B: Sub-Regional Appointment of the Guidelines
Annex C: Projections of Long Term Demand for Aggregates
Annex D: The Regional Aggregates Working Parties and National Co-ordinating Group
Annex E: Secondary Materials
Annex F: Bibliography

Great Britain Department of the Environment (1994) 'Planning and pollution control', Planning Policy Guidance Note PPG 23, HMSO. ISBN: 0117529478.

Abstract: Superseded by PPS 23

Great Britain Department of the Environment (1994) 'Planning and the historic environment', Planning Policy Guidance Note PPG 15, HMSO. ISBN: 0 11 752944 3.

http://webarchive.nationalarchives.gov.uk/+/http://www.communities.gov.uk/publications/planningandbuilding/ppg15

Keywords: Planning, Archaeology

Abstract: This PPG provides a full statement of Government policies for the identification and protection of historic buildings, conservation areas, and other elements of the historic environment. It explains the role played by the planning system in their protection. It complements the guidance on archaeology and planning given in PPG 16

Great Britain Department of the Environment (1995) 'Green Belts', Planning Policy Guidance Note PPG 2, HMSO. ISBN: 0 11 753037 9.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/archived/publications/planningandbuilding/ppg2

Keywords: Planning

Abstract: For information and confirmation that mineral extraction can be an appropriate development within green belt land.

Reprinted 2002

Great Britain Department of the Environment (1995) 'Environment Act 1995: review of mineral planning permissions', Minerals planning guidance notes MPG 14, HMSO. ISBN: 0117531758.

https://www.gov.uk/government/publications/environment-act-1995-review-of-mineral-planning-permissions-minerals-planning-guidance-14

Keywords: Planning, Planning framework

Abstract: This MPG advises minerals planning authorities and the minerals industries on the statutory procedures to be followed in the preparation of updated planning conditions on minerals planning permissions. These relate to the review of old permissions and the periodic review of all permissions, which are required by the Environment Act 1995. The advice covers initial reviews in 'first' and 'second' lists, ways of stopping an unacceptable minerals operation, special sites and periodic reviews. There are fourteen appendices covering many procedural forms etc.

Great Britain Department of the Environment (1996) 'General considerations and the development plan system', Minerals planning guidance notes MPG 1, HMSO. ISBN: 0117532894.

Keywords: Planning, Planning framework

Abstract: Rplaced by Minerals Policy Statement 1: Planning and Minerals.

Great Britain Department of the Environment (1996) 'Reclamation of mineral workings', Minerals planning guidance notes MPG 7, HMSO. ISBN: 0 11 753347 5.

http://webarchive.nationalarchives.gov.uk/+/http://www.communities.gov.uk/publications/planningandbuilding/mineralsplanningguidance5

Keywords: Reclamation

Abstract: This MPG deals with policies, consultations and conditions which are relevant to achieving effective reclamation of mineral workings. It should be read in conjunction with the general guidance in MPG1, MPG2 , MPG4, MPG9 and MPG14. It contains advice on:

the scope of information which should be provided with applications for new mineral developments, to enable relevant planning conditions to be drawn up and resulting site reclamation to be achieved; some advice on preparation of schemes of conditions for restoration, aftercare and after-use which owners/operators of older mineral sites may need to draw up for future reviews of such site; advice on financial provision in relation to securing restoration of mineral workings.

Great Britain Department of the Environment (1996) 'Provision of silica sand in England', Minerals planning guidance notes MPG 15, HMSO. ISBN: 0117533203.

http://webarchive.nationalarchives.gov.uk/+/http://www.communities.gov.uk/publications/planningandbuilding/mineralsplanningguidance11

Keywords: Feasibility, Planning

Abstract: This MPG replaces the guidance given in DOE Circular 24/85 and:

* provides advice to ensure that there is an adequate and steady supply of silica sand for the consuming industries;
* emphasises that supply must be maintained at the best balance of social, environmental and economic cost, whilst ensuring that extraction and development are consistent with the principles of sustainable development;
* sets out the policies with regard to extraction from environmentally sensitive areas;
encourages efforts to recycle, to reduce the impact of extraction on the environment.

Great Britain Department of the Environment and Ove Arup & Partners Arup Environmental (1996) 'The Environmental Effects of Dust from Surface Mineral Workings', HMSO. ISBN: 0117531863.

Keywords: Environment, Air, Dust

Abstract: Intended to provide guidance to the Department of the Environment, local authorities and the mineral industry on how best to minimise dust generation and the adverse effects of dust whilst having regard to the need to maintain minerals production in an economic and viable way.

A report on behalf of the DoE by Arup Environmental (Ove Arup & Partners)

Great Britain Department of the Environment and Roy Waller Associates Ltd (1992) 'Environmental Effects of Surface Mineral Workings', HMSO. ISBN: 0117526371.

Keywords: Environment

Abstract: Report prepared by Roy Waller Associates for the Department of the Environment

Great Britain Department of the Environment Planning Research Programme (1994) 'Evaluation of environmental information for planning projects a good practice guide', HMSO.

Keywords: Environment, EIA

Abstract: This guidance provides local planning authorities with help on how to assess an environmental statement.

Great Britain Department of the Environment Planning Research Programme (1995) 'Preparation of Environmental Statements for Planning Projects that Require Environmental Assessment', HMSO. ISBN: 011753207X.

Keywords: Environment, EIA

Abstract: A guide on how to produce an environmental statement.

Great Britain Department of the Environment, Transport and the Regions (1997) 'Revocation, modification, discontinuance, prohibition and suspension orders', Minerals planning guidance notes MPG 4, HMSO. ISBN: 0 11 753413 7.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/index.asp?id=1144169

Keywords: Planning, Planning framework

Abstract: This note gives guidance on the orders and the effects of the Town and Country Planning (Compensation for Restrictions on Mineral Working and Mineral Waste Depositing) Regulations 1997.

Supersedes MPG4 (ISBN 0117521426) issued in 1988

Great Britain Department of the Environment, Transport and the Regions (1998) 'Applications, permissions and conditions', Minerals planning guidance notes MPG 2, HMSO. ISBN: 0 11 753472 2.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/archived/publications/planningandbuilding/mineralsplanningguidance

Keywords: Planning, Planning framework

Abstract: MPG2 provides advice on those aspects of the development control system of particular relevance to minerals and on the preparation and determination of individual planning applications. It has several Appendices with useful information on:

1) the Town and Country Planning (Minerals) Regulations 1995
2) Permitted Development
3) Minerals Planning Conditions
4) Bibliography - Legislation relevant to Minerals Planning

Great Britain Department of the Environment, Transport and the Regions (1998) 'The Environmental Effects of Traffic Associated with Mineral Workings', Stationery Office. ISBN: 0117534765.

Keywords: Operations, Haulage

Abstract: Comprises report and best practice guide

Great Britain Department of the Environment, Transport and the Regions (1998) 'Applications, permissions and conditions', Minerals planning guidance notes MPG 2 (revised), Stationery Office. ISBN: 0 11 753472 2.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/documents/planningandbuilding/pdf/157995.pdf

Keywords: Planning

Abstract: Minerals Planning Guidance 2 (MPG2) provides advice on those aspects of the development control system of particular relevance to minerals and on the preparation and determination of individual planning applications.

Supersedes MPG2 (1988, ISBN 0117520527) & MPG5 "Minerals planning & the General Guidance Order" (1989, ISBN 0117521736).

Great Britain Department of the Environment, Transport and the Regions (1999) 'Planning and Waste Management', Planning Policy Guidance Note PPG 10.

Keywords: Operations, Planning, Waste

Abstract: This PPG has been superseded by Planning Policy Statement 10.

The guidance in this note replaced the parts of PPG23 (1994) which dealt specifically with waste management issues.

This guidance note provided advice about how the land-use planning system should contribute to sustainable waste management through the provision of the required waste management facilities in England and regulations under the statutory planning and waste management systems.

Great Britain Department of the Environment, Transport and the Regions (1999) 'The Town And Country Planning (Development Plans And Consultation) (Departures) Directions 1999', Planning Circular 07/99, Stationery Office. ISBN: 0117535095.

http://webarchive.nationalarchives.gov.uk/+/http://www.communities.gov.uk/publications/planningandbuilding/circulartown6

Keywords: Planning, Planning framework

Abstract: These Directions could be relevant for quarries since it requires that a development, which by reason of its scale or nature or location would significantly prejudice the implementation of a development plan's policies and proposals, must be notified to the Secretary of State if the planning authority does not oppose it.

The purpose of this version of the Directions is to provide advice to planning authorities on the implementation of the Town & Country Planning Directions and clarification, to promote consistency in the interpretation of what constitutes a departure.

Great Britain Department of the Environment, Transport and the Regions (1999) 'Environmental Impact Assessment', Planning Circular 02/1999, Stationery Office. ISBN: 0 11 753493 5.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/publications/planningandbuilding/circularenvironmentalimpact

Keywords: Environment, Planning, EIA

Abstract: This Circular gives guidance on the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulation following EEC Council Directive No. 85/337/EEC in so far as it applies to development under the Town and Country Planning Act 1990. It considers which developments always require a EIA and which may do, the scale, location and complexity of the development, EIAs and multiple and outline planning applications, the use of screening opinions, the procedure for preparing and submitting EIAs and many other aspects of EIAs.

The web site includes a useful downloadable flowsheet to assist in establishing whether a development requires an EIA.

Great Britain Department of the Environment, Transport and the Regions (1999) 'Coal mining and colliery spoil disposal', Minerals planning guidance notes MPG 3 (revised), Stationery Office. ISBN: 0 11 753498 6.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/documents/planningandbuilding/pdf/154812.pdf

Keywords: Planning

Abstract: Minerals Planning Guidance 3 (MPG3) provides a policy framework for mineral planning authorities (MPAs) and the coal industry in England to ensure that the extraction of coal and disposal of colliery spoil only takes place at the best balance of community, social, environmental and economic interests, consistent with the principles of sustainable development.

Supersedes the July 1994 ed. (ISBN 0117529508)

Great Britain Department of the Environment, Transport and the Regions (2000) 'Regional Planning', Planning Policy Guidance Note PPG 11, Stationery Office. ISBN: 0117535575.

Abstract: This PPG has been superseded by Planning Policy Statement 11.

Great Britain Department of the Environment, Transport and the Regions (2000) 'Stability in surface mineral workings and tips', Minerals planning guidance notes MPG 5, Stationery Office. ISBN: 0 11 753540 0.

http://www.planningportal.gov.uk/planning/planningpolicyandlegislation/previousenglishpolicy/mmgmpsmmg/mpg5

Keywords: Design, Planning, Slope design, Planning framework

Abstract: This MPG aims to apply guidance given in MPG14 and its Annex 1, to stability in quarries, surface mines and associated tips and related structures and should be read in conjunction with it. This guidance advises that:

- mineral planning authorities need to consider stability in relation to surface mineral workings and tips;
- local planning authorities need to consider stability in relation to development in, on or near abandoned surface mineral workings and tips; and that
- policies should outline the consideration which will be given to stability issues in considering mineral development and other development in, on or near to mineral workings and tips;
- consideration of apparently unrelated issues may require consideration of the potential effects on the stability of excavated or tipped slopes;
- where appropriate, planning applications and restoration/landscaping schemes should be accompanied by a design report prepared by a competent person which demonstrates that the perimeter slopes and any internal slopes remaining after restoration will remain stable.

Appendices outline good practice in the design, assessment and inspection of:
- excavated slopes; and
- tips and related structures

Great Britain Department of the Environment, Transport and the Regions (2000) 'The Air Quality Strategy for England, Scotland, Wales and Northern Ireland', Stationery Office.

https://www.gov.uk/government/publications/the-air-quality-strategy-for-england-scotland-wales-and-northern-ireland-volume-1

Keywords: Environment, Air, Air quality

Abstract: The Government's strategy for air quality sets out air quality standards and objectives for eight key air pollutants to be achieved between 2003 and 2008, including information on:

Legislative and policy framework
Air quality standards and objectives
The roles of organisations in delivering cleaner air
A technical annexe with details on the 8 prinicipal air pollutants
Links to useful web sites

An addendum was added in 2003

Great Britain Department of the Environment, Transport and the Regions (2000) 'Effectiveness of Aftercare Provisions for Mineral Workings', Office of the Deputy Prime Minister. ISBN: 1851124489.

Keywords: Reclamation, After Use, After care

Abstract: This reports on the statutory requirements,existing procedural arrangements and standards of reclamation being achieved in practice, and makes recommendations for improvements to the procedures.

The recommendations arising include: changes to legislation, additional guidance, better use of existing guidance, changes in practice for the MPAs which in turn will have effects on the operators.

The report inludes several useful appendices and nine restoration case studies

Great Britain Department of the Environment, Transport and the Regions (2001) 'Arrangements for handling heritage communications - notification and directions by the Secretary of State', DETR circular 01/2001, Stationery Office. ISBN: 0 11 753556 7.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7666/158304.pdf

Keywords: Environment, Planning, Archaeology

Abstract: This circular concerns the identification and protection of historic buildings, conservation areas and other aspects of the historic environment and should be read in conjunction with Planning Policy Guidance 15.

Great Britain Department of the Environment, Transport and the Regions, and The National Assembly for Wales (2000) 'Environmental Impact Assessment: A Guide to Procedures', Thomas Telford Ltd. ISBN: 0727729608.

http://webarchive.nationalarchives.gov.uk/20120919132719/www.communities.gov.uk/documents/planningandbuilding/pdf/157989.pdf

Keywords: Environment, EIA

Abstract: This guide includes general advice and guidance, applicable to all types of project, on the nature of environmental impact assessment and on the practical aspects of preparing an environmental statement.

The guide explains how EC requirements for environmental impact assessment have been incorporated into procedures in the UK. It revises the booklet 'Environmental Assessment: A Guide to the Procedures', published in 1989, to take account of the requirements of Directive 97/11/EC.

A copy can be downloaded from the Communities and Local Government web site

Great Britain Government Office for Yorkshire and the Humber (2004) 'Regional Spatial Strategy for Yorkshire and the Humber to 2016 based on Selective Review of RPG12', Regional Spatial Strategy RSS 12, Stationery Office. ISBN: 0117539333.

Keywords: Planning

Abstract: This regional spatial strategy (RSS) for Yorkshire and the Humber is based upon the selective review of RPG 12 (2001, ISBN 0117536180). The review addressed: rural regeneration; coastal communities; culture and tourism; climate change; renewable energy; flood risk; waste management and transport. The RSS has statutory status under the Planning and Compulsory Purchase Act 2003, and must be be taken into account by local authorities when preparing their development plans and local transport plans. Specific chapters cover: regional context; vision, objectives and strategy; regional spatial strategy; the economy; housing; transport; social infrastructure; built and natural environment; resource management; monitoring, implementation and review.

Great Britain Health and Safety Executive (1999) 'Health and safety at quarries: quarry regulations 1999 - approved code of practice', Legislation series, Health and Safety Commission L118, HSE Books. ISBN: 0 7176 2458 7.

http://www.hse.gov.uk/pubns/books/l118.htm

Keywords: Health and Safety

Abstract: Provides guidance on the Quarries Regulations 1999, which are intended to protect the health and safety of people working at a quarry and others who may be affected by quarrying activities. The regulations apply to both employees and the self employed. They are also intended to safeguard people not working at the quarry (eg those living, passing or working nearby, or visitors).

Great Britain Health and Safety Executive (2002) 'The Health and Safety System in Great Britain', HSE Books. ISBN: 0 7176 2243 6.

http://www.hop.uk.com/downloads/the_health_and_safety_system_in_great_britain.pdf

Keywords: Health and Safety

Abstract: A guide to the system of occupational health and safety in the UK, including the policy and legislation, the role of the Health and Safety Executive, enforcement and the control of risks in the workplace.

Great Britain Office of the Deputy Prime Minister 'Planning and pollution control. Annex 1: Pollution control, air and water quality', Planning Policy Statement PPS 23 Annexe 1, Stationery Office. ISBN: 0 11 753931 7.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/publications/planningandbuilding/pps23annex1

Keywords: Environment, Planning, Water, Air, Planning framework, Air quality

Abstract: Annex 1 explains the background to the Pollution Control legislation, its interactions with the planning system and how these interactions are dealt with in planning.

This annex contains useful reference information such as relevant Acts of Parliament and web sites

Great Britain Office of the Deputy Prime Minister (1994) 'Nature conservation', Planning Policy Guidance Note PPG 9. ISBN: 0117527874.

Abstract: This has been superseded by PPS 9

Great Britain Office of the Deputy Prime Minister (1996) 'Development on unstable land - Annex 1: landslides and planning', Planning Policy Guidance Note PPG 14 Annex 1, HMSO. ISBN: 0 11 753259 2.

Keywords: Design, Planning, Slope design

Abstract: This Annex examines the problems caused by landslides and unstable slopes and deals with planning issues arising from them.

Great Britain Office of the Deputy Prime Minister (1997) 'General policy and principles', Planning Policy Guidance Note PPG 1 (revised).

Abstract: This PPG is superseded by Planning Policy Statement 1 (2005)

Great Britain Office of the Deputy Prime Minister (1999) 'Development Plans', Planning Policy Guidance Note PPG 12, Office of the Deputy Prime Minister. ISBN: 1 85 112349 0.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/index.asp?id=1144003

Keywords: Planning, Planning framework

Abstract: This has been superseded by Planning Policy Statement 12

Great Britain Office of the Deputy Prime Minister (2002) 'Regional Planning Guidance for the North East', Regional Planning Guidance Note RPG 1, Stationery Office. ISBN: 0117536415.

http://regulations.completepicture.co.uk/pdf/Planning/Regional%20Planning%20Guidance%20for%20the%20North%20East%20(RPG1).pdf

Keywords: Planning

Abstract: This publication sets out the overall spatial strategy for the North East to the year 2016. It covers the main policy aspects to promote the sustainable development of the region based on four key themes: to accelerate the renaissance of the Tyne, Wear and Tees conurbations; to provide job opportunities and support communities in the former coalfield areas; to adapt and revitalise the region's town and city centres; and to secure rural regeneration. Topics discussed include: regional characteristics; strategic policy for regeneration, accessibility; conservation and sub-regional areas; the natural and built environment; development patterns; transport; minerals, waste and energy; implementation and monitoring.

(Unavailable as at June 2007)

Great Britain Office of the Deputy Prime Minister (2003) 'Regional Planning Guidance for the North West', Regional Planning Guidance Note RPG 13, Stationery Office. ISBN: 0 11 753648 2.

Keywords: Planning

Abstract: This document sets out guidance notes for planning policy for the North West region. It seeks to promote sustainable patterns of spatial development and secure a co-ordinated approach to a region's economic, social and environmental interests. It contains chapters on: core development principles; the spatial development framework; economic growth and competitiveness with social progress; delivering an urban renaissance for the towns and cities of the North West; enhancing coastal areas and resort towns; enhancement of the rural economy; environmental resource quality and management; and promoting an accessible region with a fully integrated transport system.

Great Britain Office of the Deputy Prime Minister (2004) 'Sustainable Development in Rural Areas', Planning Policy Statement PPS 7, Stationery Office. ISBN: 0 11 753923 6.

http://webarchive.nationalarchives.gov.uk/20120919132719/www.communities.gov.uk/archived/publications/planningandbuilding/pps7

Keywords: Planning, Planning framework

Abstract: This Statement replaces Planning Policy Guidance note (PPG)7. It sets out the Government's planning policies for rural areas, which local authorities should have regard to when preparing local development documents, and when taking planning decisions.

The key principles identified are:

* decisions on development should be based on sustainable development principles
* good quality accessible development within towns and villages should be allowed where it benefits the local community
* accessibility should be a key consideration, with emphasis on access by public transport, walking and cycling
* new building in the open countryside away from existing settlements should be strictly controlled
* priority should be given to the reuse of brownfield sites

Great Britain Office of the Deputy Prime Minister (2004) 'Planning and Pollution Control', Planning Policy Statement PPS 23, HMSO. ISBN: 0117539279.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://communities.gov.uk/planningandbuilding/planning/planningpolicyguidance/planningpolicystatements/planningpolicystatements/pps23/

Keywords: Operations, Planning, Waste

Abstract: This PPS applies in England only. It replaces the remaining extant parts of Planning Policy Guidance (PPG) Note 23 'Planning and Pollution Control' published in 1994.

Waste Planning, including operations under the Waste Management Licensing Regulations 1994 and the Pollution Prevention and Control Regulations 2000, in so far as they apply to waste management, is now dealt with in PPG10 'Planning and Waste Management' (September 1999), which is currently under review. Noise is covered by PPG24 'Planning and Noise' (1994).

Great Britain Office of the Deputy Prime Minister (2004) 'National and Regional Guidelines for Aggregates Provision in England 2001-2016: First Monitoring Report'.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/index.asp?id=1161540

Keywords: Planning, Feasibility

Abstract: The First Monitoring Report outlines the monitoring and review of the "Guidelines for Aggregates Provision" by examining recent trends with regards to the demand for aggregates including recent trends on construction activity and consumption of aggregates. Data indicate no requirement to revise the 2003 guidelines.

Monitoring reports for 2005 and 2006 are also available

Great Britain Office of the Deputy Prime Minister (2004) 'Consultation Paper on Minerals Policy Statement 1: Planning and Minerals and associated
Good Practice Guidance'.

Abstract: This consultation paper sets out the core policies and principles for minerals planning in England and provides an overview of how mineral extraction fits within the new planning system. The Good Practice Guidance provides advice on how these might be implemented.

The revised MPS will replace Mineral Planning Guidance Note 1.

Great Britain Office of the Deputy Prime Minister (2004) 'Local Development Frameworks', Planning Policy Statement PPS 12, Stationery Office. ISBN: 0117539260.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/archived/publications/planningandbuilding/pps12ldf

Keywords: Planning, Planning framework

Abstract: This statement describes the policies that should be taken into account by local planning authorities in the preparation of local development frameworks and minerals and waste development frameworks.

This document replaces Planning policy guidance note 12

Great Britain Office of the Deputy Prime Minister (2004) 'Good Practice Guidance on the Environmental Appraisal of the Provision of Aggregates', ODPM Publications. ISBN: 1 85112 689 9.

https://www.thenbs.com/PublicationIndex/DocumentSummary.aspx?PubID=428&DocID=266382

Keywords: Environment, EIA

Abstract: This document provides good practice guidance on the environmental appraisal of aggregates provision. The guidance provides details of, and an explanation of a methodology for the appraisal, and how it is applied.

Great Britain Office of the Deputy Prime Minister (2004) ' Regional Planning Guidance for the West Midlands', Regional Planning Guidance Note RPG 11, Stationery Office. ISBN: 0117539074.

http://www.wmra.gov.uk/documents/RSS%20Full%20Doc%20Jan%2008.pdf

Keywords: Planning

Great Britain Office of the Deputy Prime Minister (2005) 'Controlling and mitigating the environmental effects of mineral extraction in England', Minerals Policy Statement MPS 2, Stationery Office. ISBN: 1 85112 780 1.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/index.asp?id=1503787

Keywords: Planning, Planning framework, Environment

Abstract: Minerals Policy Statements (MPSs) set out the policies and considerations that the Government expects Mineral Planning Authorities (MPAs) to follow in preparing minerals and waste development schemes as part of local development frameworks and in considering applications for minerals development.

Minerals Policy Statement 2 (MPS2) states the principles to be followed in considering the environmental effects of mineral working and expands in appendices, on the need for community consultation and involvement and environmental management systems (EMSs). It is accompanied by separate technical Annexes on particular environmental effects, of which Annex 1 Dust and Annex 2 Noise are published alongside this MPS.

This MPS supersedes MPG11: "The control of noise at surface mineral workings"

Great Britain Office of the Deputy Prime Minister (2005) 'Controlling and mitigating the environmental effects of mineral extraction in England - Annex 1: Dust', Minerals Policy Statement MPS 2 Annexe 1, ODPM Publications. ISBN: 1 85112 781 X.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/index.asp?id=1503790

Keywords: Environment, Air, Dust

Abstract: This Annex supplements the general policies in Minerals Policy Statement 2 (MPS2) in stating the planning considerations that the Government expects to be applied by MPAs to dust emissions from surface mineral operations. It covers surface mineral extraction, including waste disposal and recycling operations that form an integral part of a mineral working operation. This Annex complements, for mineral workings, the general guidance in Planning Policy Statement 23 (PPS23) Planning and Pollution Control (2004) and its Annex 1. It covers applications for new operations and extensions to existing sites as well as the review and modernisation of conditions on older permitted operations.

Great Britain Office of the Deputy Prime Minister (2005) 'Controlling and mitigating the environmental effects of mineral extraction in England - Annex 2: Noise', Minerals Policy Statement MPS 2 Annexe 2, ODPM Publications. ISBN: 1 85112 782 8.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/index.asp?id=1503793

Keywords: Environment, Noise and Vibration

Abstract: This Annex to MPS2 is a statement of the policy considerations in relation to noise from mineral workings and associated operations, and how they should be dealt with in local development frameworks and in considering individual applications. Appendices briefly explain technical terminology and give examples of good practice in noise reduction.

This Annex supersedes MPG11 :"The control of noise at surface mineral workings"

Great Britain Office of the Deputy Prime Minister (2005) 'Changes of Use of Buildings and Land - The Town & Country Planning (Use Classes) Order 1987', ODPM circular 03/2005, Stationery Office. ISBN: 0 11 753944 9.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/index.asp?id=1500348

Keywords: Planning

Abstract: Under the Town and Country Planning Act 1990, development control extends not only to new building work but also to changes in use of buildings or land. Accordingly, planning permission is normally required for material changes of use. The Act excludes from the definition of development (and hence from planning control) any change of use where both the existing and proposed uses fall within the same single class in the order.

Great Britain Office of the Deputy Prime Minister (2005) 'Delivering Sustainable Development', Planning Policy Statement PPS 1, Stationery Office. ISBN: 0 11 753939 2.

http://webarchive.nationalarchives.gov.uk/+/http:/www.communities.gov.uk/planningandbuilding/planning/planningpolicyguidance/planningpolicystatements/planningpolicystatements/pps1/

Keywords: Planning, Planning framework

Abstract: PPS1 sets out the Government's overarching planning policies on the delivery of sustainable development through the planning system. This PPS replaces Planning Policy Guidance Note 1, General Policies and Principles, published in February 1997.

Great Britain Office of the Deputy Prime Minister (2005) 'Biodiversity and geological conservation', Planning Policy Statement PPS 9, Stationery Office. ISBN: 0117539546.

http://webarchive.nationalarchives.gov.uk/20120919132719/www.communities.gov.uk/archived/publications/planningandbuilding/pps9

Keywords: Planning, Planning framework, Environment, Geoconservation, Ecology, Biodiversity

Abstract: PPS9 sets out planning policies to be taken into account by regional planning bodies in the preparation of regional spatial strategies, on protection of biodiversity and geological conservation through the planning system. The policies may also be material to decisions on individual planning applications. It sets out planning policies on protection of biodiversity and geological conservation through the planning system. These policies complement, but do not replace or override, other national planning policies and should be read in conjunction with other relevant statements of national planning policy.

The policies set out in this PPS will needed by the Mayor of London in relation to the spatial development strategy for London, and by local planning authorities in the preparation of local development documents.

This PPS replaces Planning Policy Guidance Note 9 (PPG9) on nature conservation.

Great Britain Office of the Deputy Prime Minister (2005) 'Planning for sustainable waste management', Planning Policy Statement PPS 10, Stationery Office. ISBN: 0117539503.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11443/1876202.pdf

Keywords: Operations, Planning, Waste, Planning framework

Abstract: This statement covers key planning objectives, decision-making principles, regional spatial strategy, local development documents, the determining of planning applications (by both waste planning and other planning authorities), and monitoring and review.

The policies in this PPS are for the guidance of waste planning authorities in discharging their responsibilities; regional planning bodies in preparing regional spatial strategies; the Mayor of London in relation to the Spatial Development Strategy in London; and, in general, by local planning authorities preparing local development documents. They may also be material to decisions on individual planning applications. These policies complement other national planning policies and should be read in conjunction with Government policies for sustainable waste management, in particular those set out in the national waste strategy.

Great Britain Office of the Deputy Prime Minister (2005) 'Biodiversity and Geological Conservation', ODPM Circular 06/2005, Stationery Office. ISBN: 0 11 753951 1.

https://www.gov.uk/government/publications/biodiversity-and-geological-conservation-circular-06-2005

Keywords: Environment, Planning, Geoconservation, Ecology, Planning framework, Biodiversity

Abstract: This circular provides administrative guidance on the application of the law relating to planning and nature conservation in England. It complements the expression of national planning policy in Planning Policy Statement 9, Biodiversity and Geological Conservation (PPS9) and the accompanying Good Practice Guide.

For internationally recognised sites, under the review of outstanding permissions, minerals planning authorities are encouraged to exercise their powers under Schedule 9 to the Town and Country Planning Act 1990 to make orders prohibiting the resumption of mineral working in appropriate cases.

Great Britain Office of the Deputy Prime Minister (2005) 'Planning obligations', ODPM circular 05/2005, Stationery Office. ISBN: 0117539481.

http://www.sustainableaggregates.com/library/docs/l0386_147537.pdf

Keywords: Design, Planning

Abstract: Planning obligations are private agreements negotiated, usually in the context of planning applications, between local planning authorities and persons with an interest in a piece of land (or "developers"), and intended to make acceptable development which would otherwise be unacceptable in planning terms.

This circular supersedes Department of the Environment Circular 1/97 (ISBN 0117533653), the changes in it relate to the negotiation of planning obligations

Great Britain Office of the Deputy Prime Minister (2005) 'National and Regional Guidelines for Aggregates Provision in England 2001-2016: Second Monitoring Report'.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/16168/aggregatesprovisionletter.pdf

Keywords: Planning, Feasibility

Abstract: The Second Monitoring Report outlines the monitoring and review of these guidelines by examining recent trends with regards to the demand for aggregates including recent trends on construction activity and consumption of aggregates. Data indicate no requirement to revise the 2003 aggregates guidelines.

Great Britain Office of the Deputy Prime Minister (2005) 'Biodiversity and Geographical Conservation - Statutory Obligations and Their Impact Within the Planning System', ODPM Circular 06/2005, Stationery Office. ISBN: 0 11 753951 1.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7692/147570.pdf

Keywords: Environment, Geoconservation, Ecology

Abstract: This Circular provides administrative guidance on the application of the law relating to planning and nature conservation as it applies in England. It complements the expression of national planning policy in Planning Policy Statement 9, Biodiversity and Geological Conservation (PPS9) and the accompanying Good Practice Guide.

Part I deals with the conservation of internationally designated sites: Special Protection Areas (SPAs) classified under the EC Birds Directive, Special Areas of Conservation (SACs) designated under the EC Habitats Directive, and Ramsar sites listed under the provisions of the Ramsar convention4 on wetlands of international importance; Part II deals with Sites of Special Scientific Interest (SSSI) and the consultation and notification processes; Part III covers planning for nature conservation outside the designated sites; Part IV deals with the conservation of species and Part V provides advice on other duties and use of statutory powers.

Also referred to as Defra Circular 01/2005

Great Britain Office of the Deputy Prime Minister (2005) 'Arrangements for Handling Heritage Applications - Notification to National Amenity Societies Direction 2005', ODPM circular 09/2005, Stationery Office. ISBN: 0 11 753956 2.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7701/147534.pdf

Keywords: Environment, Planning, Archaeology

Abstract: This Circular directs that the Twentieth Century Society be added to the list of national amenity societies (the Ancient Monuments Society, the Council for British Archaeology, the Georgian Group, the Society for the Protection of Ancient Buildings and the Victorian Society) to be notified of applications for, and decisions on, works for the demolition or alteration of a listed building. To be read in conjunction with Planning Policy Guidance 15.

Great Britain Office of the Deputy Prime Minister (2005) 'The Planning System: General Principles', ODPM Publications.

http://webarchive.nationalarchives.gov.uk/20120919132719/www.communities.gov.uk/documents/planningandbuilding/pdf/147396.pdf

Keywords: Planning, Planning framework

Abstract: Published alongside PPS1, this document provides a general description of key elements of the planning system, including its structure, the determination of planning applications and the Secretary of State's role.

Great Britain Office of the Deputy Prime Minister (2005) ' Regional Spatial Strategy for the East Midlands', Regional Spatial Strategy RSS 8, Stationery Office. ISBN: 0117539414.

http://webarchive.nationalarchives.gov.uk/20100528142817/http:/www.gos.gov.uk/goem/planning/regional-planning/?a=42496

Keywords: Planning

Abstract: This Regional Spatial Strategy replaces the previous Regional Planning Guidance (RPG8) and provides a broad development strategy for the East Midlands up to 2021. The sections of the document are: core strategy, which outlines the 10 core objectives, spatial strategy, which continues the sequential approach to development outlined in RPG8; topic based priorities, which looks at five main topics such as housing; regional priorities for monitoring and review; Milton Keynes and South Midlands sub-regional strategy (which is published as a separate document ISBN 0117539422).

Great Britain Office of the Deputy Prime Minister (2006) 'EU Directive on the management of waste from extractive industries - update', Web Site.

Abstract: In 2003 the European Commission adopted a proposal for an EU Directive on the management of waste from the extractive industries. The proposal seeks to prevent or reduce, as far as possible, any adverse effects on the environment, and any resultant risks to human health, brought about as a result of the management of waste from the extractive industries.

The text of the proposed directive has now been sent to the Council and the European Parliament's Plenary for final adoption; expected to be in early 2006.

(No web link: June 2014)

Great Britain Scottish Parliament (2004) 'Nature Conservation (Scotland) Act 2004', Stationery Office. ISBN: 0 10 590067 2.

http://www.legislation.gov.uk/asp/2004/6/contents

Keywords: Environment, Ecology, Biodiversity

Abstract: An Act of the Scottish Parliament to make provision in relation to the conservation of biodiversity; to make further provision in relation to the conservation and enhancement of Scotland's natural features; to amend the law relating to the protection of certain birds, animals and plants.

Groundwork Kent Thames-side 'A walk into history: renovating the Swanscombe Skull site', ALSF Third objective 'legacy' site project.

Keywords: Environment, Historical data, Archaeology

Groundwork Rossendale 'Rossendale: Valley of Stone', Historic Environment Enabling Programme 3859MAIN.

Keywords: Environment, Landscape, Archaeology, Reclamation, After Use, Education

Abstract: 'Rossendale - Valley of Stone' is a major project to transform the negative image of Rossendale's vast quarrying remains into a positive resource of community understanding and pride, together with heritage / culture tourism. Their size - amongst the largest sandstone quarries in the UK - and the regionally unique moorland tramway routes, create a distinct heritage asset which will draw visitors to East Lancashire. Thanks to the provision of Aggregates Levy Funding from English Heritage, it is hoped that the people of Rossendale will be able to maintain a link with their industrial and social past, and that visitors gain a true appreciation of the scale of endeavours past and the need to conserve the remaining physical remnants

Need for the project:
Dereliction and landscape impact had been partly addressed by the 'Strategy for the Reclamation of Rossendale's Quarries' - for 9 quarries. But the value and scale of the industrial heritage has not been realised, nor past achievements celebrated. 'Rossendale - Valley of Stone' project has managed to take in another nineteen sites.

Main objectives and outputs:
To record and assess the large-scale heritage sites and features of Rossendale's vast quarry and tramway heritage. The human experiences of the industry and the impact on local communities will also be documented.
To physically conserve and restore sites and features as appropriate, for the benefit of local people and visitors, and for the enjoyment of future generations.
To improve and create new physical access to quarry and tramway heritage sites to encourage more local people and visitors to see and experience this heritage asset. The regionally unique moorland tramway routes will be upgraded where appropriate, and used as a major linking network.
To interpret sites and features. New information and interpretation packs and facilities will raise awareness of this rich heritage by multi-media education packs, on-site interpretation panels in quarries, and at access points, internet site, CD Rom, guide books, displays of stone products.
(By the above) to celebrate the national significance of Rossendale's quarries and tramways heritage.

GWP Consultants (2004) 'Establishment of a reliable & non-subjective measure of nuisance dust using low-cost, multi-directional dust monitoring and processing techniques', Unpublished Report, MIST Project MA/1/2/009.

http://www.sustainableaggregates.com/library/docs/mist/l0090_ma_1_2_009.pdf

Keywords: Environment, Air, Air quality, Dust

Abstract: Description of DustScan equipment and methodology for monitoring airborne dust from quarrying operations. The method can distinguish between multiple dust sources. Report includes results from field trials.

Harrison, D.J. et al. (2002) 'Development of saleable mineral products from quarry waste In: Scott, P. W. and Bristow,C.M. (eds), Industrial minerals and extractive industry geology', Combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.351-352.

Keywords: Operations, Environment, Waste

Abstract: Puts the case for recycling of the typical 20-30% of total aggregate output that is waste.

Haywood, Sheila M. (1974) 'Quarries and the landscape', British Quarrying and Slag Federation, London.

Keywords: Environment, Landscape

Abstract: This book provides an overview of the role of landscaping within the hardrock extractive industry. The main sections in the book are:

Preliminary observations - provides background and scene setting of the industry in the wider context of public concern and planning issues. It also introduces the different landscaping issues with respect to the different quarry types.

Specific considerations - discusses the objectives of a landscape plan and the importance of boundaries and contours. Major issues such as water, topsoils and overburden are also considered.

Detailed recommendations - describes the implementation of a landscape plan, measures for improving the landscape impact of a quarry at all stages and the establishment of vegetation with a brief consideration of suitable species.

General factors - describes other issues not previously covered, e.g. economics and management and quarry closure.

Health & Safety Executive for Northern Ireland 'Quarry Vehicle Safety', Web Site.

http://products.ihs.com/Ohsis-SEO/392370.html

Keywords: Operations, Haulage, Health and Safety

Abstract: A 6-page document emphasising the safe operation of quarry vehicles, maintenance and driver training, including detailed advice on vehicle brakes and braking, edge protection and vehicle visibility.

Health & Safety Executive for Northern Ireland 'Guidance Document - Face Edge Protection', Web Site.

http://products.ihs.com/Ohsis-SEO/392404.html

Keywords: Design, Operations, Health and Safety

Abstract: Under the Quarries Regulations suitable equipment or barriers must be provided where there is a risk of a person falling a distance likely to cause personal injury. This short document provides a overview of edge protection measures.

See also: Quarry Fact File No.17 (HSE Books)

Health & Safety Executive for Northern Ireland 'Safety in Sand & Gravel Quarries', Web Site.

http://products.ihs.com/Ohsis-SEO/392417.html

Keywords: Operations, Excavation, Haulage, Processing, Health and Safety

Abstract: This 3-page document highlights some of the hazards and risks that might exist in sand and gravel extraction and screening operations. Topics include faces, settlement ponds, vehicles and vehicle movements, machinery, chemicals and noise.

Health & Safety Executive for Northern Ireland 'Guidance Document - Safety In Quarry Drilling Operations', Web Site.

http://products.ihs.com/Ohsis-SEO/392420.html

Keywords: Investigations, Investigation methods, Drilling, Operations, Health and Safety

Abstract: A short document highlighting some of the hazards and risks that might exist whilst carrying out drilling operations in quarries.

Health and Safety Executive 'Hard target: quarry health and safety, cutting accidents by 50%. Vehicles and edge protection', Web Site.

http://www.hse.gov.uk/quarries/hardtarget/protection.htm

Keywords: Design, Operations, Health and Safety, Haul roads, Haulage

Abstract: According to the HSE, transport accounts for 40% of all accidents in quarries and 60% of all deaths. It has been a priority for HSE for many years but until the industry addresses safe vehicle, safe workplace, competent driver and supervision it will not improve. This web page sets out basic measures that operators can take to reduce vehicle related accidents.

Health and Safety Executive 'Hard target: quarry health and safety, cutting accidents by 50%. Vehicles and road surfaces', HSE Web Site.

http://www.hse.gov.uk/quarries/hardtarget/roadsurface.htm

Keywords: Operations, Haulage

Abstract: A brief statement of the need to keep haul roads adequately surfaced, drained and dust-free

Health and Safety Executive 'Hard target: quarry health and safety, cutting accidents by 50%. Tips and excavation', Web Site.

http://www.hse.gov.uk/quarries/hardtarget/tips.htm

Keywords: Design, Operations, Health and Safety, Slope design, Excavation, Excavated slopes, Fill slopes and tips

Abstract: HSE state "the construction of excavations, tips and lagoons should be set out in the tips and excavation rules. The rules covering tipping and excavation must be clear. Many incidents occur from falling rock off faces and from falling equipment off tips. These are all matters that should be addressed in the design of the quarry and will involve the geotechnical specialist who can advise on the strength and stability of the tip and tipping point"

The web addresses safety issues relating to layered compacted tips, advancing face tips, face heights, tips and stockpiles, tipping near tip and excavation edges, tipping and excavating the same stockpile, and working near water (draglines and long reach hydraulic excavators).

Health and Safety Executive 'Hard target: quarry health and safety, cutting accidents by 50%. Quarry design', Web Site.

http://www.hse.gov.uk/quarries/hardtarget/design.htm

Keywords: Design, Health and Safety, Slope design, Haul roads

Abstract: HSE state:" the design will set out the direction and height of the faces, the type of equipment you will use, the position and widths of haul roads, and the control measures necessary to ensure the health and safety of all who work there or are affected by the working such as the public. The quarry must be properly designed, managed and maintained to ensure health and safety." Each of these topics is developed on this web page.

Health and Safety Executive 'Health and Safety in the Quarry Industry', Web Site.

http://www.hse.gov.uk/quarries/

Keywords: Information Sources, Health and Safety

Abstract: Web pages that explain what the HSE is doing to tackle key health and safety issues in the quarry industry, and provide access to a range of information, resources and further points of contact.

Health and Safety Executive 'The Health and Safety Commission and Health and Safety Executive', Web Site.

http://www.hse.gov.uk/

Abstract: The Health and Safety Commission is responsible for health and safety regulation in Great Britain. The Health and Safety Executive and local government are the enforcing authorities who work in support of the Commission

Health and Safety Executive (1995) 'Control of noise in quarries', HSE Books. ISBN: 0717606481.

Keywords: Environment, Noise and Vibration

Abstract: Advises employers and those managing quarries on their obligations under the Noise at Work Regulations 1989 and gives practical examples of how to reduce and control noise from quarrying machinery. Quarry foremen, health and safety specialists, employees and their representatives will also find this publication useful.

Health and Safety Executive (1999) 'Health and safety at quarries: Quarries Regulations 1999 Approved Code of Practice', Health and Safety Commission legislation series L118, HSE Books. ISBN: 0717624587.

Keywords: Health and Safety

Abstract: Quarries Regulations 1999 Approved Code of Practice and Guidance

Health and Safety Executive (2000) 'The Quarries Regulations 1999', Unpublished Operational Circular OC 693/6.

Keywords: Health and Safety

Abstract: This HSE operational circular introduces the Quarries Regulations 1999 and highlights key inspection and enforcement issues for HSE inspectors

Health and Safety Executive (2005) 'Quarry Safety', Quarry fact file Nr.33.

Keywords: Health and Safety, Design, Haul roads

Abstract: Bullet point lists covering health and safety management, musculoskeletal disorders, slips and trips, transport (with haul road dimension calculator), and falls from height

Herefordshire & Worcestershire Heritage Trust 'RIGS Identification and Designation - Herefordshire and Worcestershire', ALSF Third objective 'legacy' site project 2004/364.

Keywords: Environment, Geoconservation

Heritage Trust for Lincolnshire 'Towards an understanding of the Ice Age - Welton-le-Wold', ALSF Third objective 'legacy' site project 2002/077.

Hertfordshire County Council 'Hertfordshire Mineral Local Plan Review: Historic Environment Assessment', Historic Environment Enabling Programme.

Keywords: Operations, Excavation, Environment, Ecology, Archaeology

Abstract: Project aims to produce a detailed assessment of historic environment threatened by mineral extraction

Hiller J. A. (2005) 'United Kingdom minerals yearbook 2004: statistical data to 2003', British Geological Survey. ISBN: 0 85 272515 9.

http://www.bgs.ac.uk/downloads/start.cfm?id=1397

Abstract: This publication provides comprehensive statistical data on minerals production, consumption and trade to 2003, estimates of production for major mineral commodities in 2004 and a commentary on the UK's minerals industry during 2004.

The 2005 yearbook has also been published (2006)

Historic Buildings and Monuments Commission for England 'English Heritage', Web Site.

http://www.english-heritage.org.uk/

Keywords: Environment, Archaeology

Abstract: English Heritage is a public body with responsibility for all aspects of protecting and promoting the historic environment. Officially known as the Historic Buildings and Monuments Commission for England, English Heritage is an Executive Non-departmental Public Body sponsored by the Department for Culture, Media and Sport.

Hobbs, S.L. (2002) 'The hydrogeological effect of quarrying karstified limestone: operational requirements for monitoring and mitigation In: Scott, P. W. and Bristow, C. M. (eds), Industrial minerals and extractive industry geology', Combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.161-165.

Keywords: Environment, Water, Ground water

Abstract: This paper describes two case studies which demonstrate the importance of the forward planning of mitigation methods and the operation of monitoring schemes to determine when impacts occur.

Hull University 'Understanding water table dynamics in relation to aggregate extraction sites', Historic Environment Enabling Programme 3557.

Abstract: Understanding water table dynamics in relation to aggregate extraction sites

Hull, G. & Datson, H. (2004) 'Developments in directional dust monitoring', Quarry Management V.30 Nr.5 p.15-17.

Keywords: Environment, Air, Dust

Abstract: This article describes a new low cost solution for directional monitoring of dust. After a brief survey of existing monitoring techniques the equipment, operation and data analysis of the new are described in some detail. As well as providing information on the direction of the dust source deposited dust is retained which allows further analysis.

Humphries, R. N. (1979) 'Landscaping hard rock quarry faces', Landscape Design V.127 p.34-37.

Keywords: Environment, Ecology, Landscape, Flora

Abstract: A short paper describing the application of landscaping techniques to hard rock quarry faces. It examines the provision of growing media, methods for applying these to rock slopes and benches and the appropriate vegetation to use.

Imerys Minerals Limited (2005) 'China Clay Secondary Aggregates Feasibility and Demonstration Programme (Feasibility of China Clay secondary aggregate use)', Unpublished Report, MIST Project MA/4/5/009.

http://www.sustainableaggregates.com/library/docs/mist/l0068_ma_4_5_009.pdf

Keywords: Feasibility, Operations, Waste, Haulage, Reclamation, After Use, Environment, Ecology, Landscape, Archaeology, Traffic

Abstract: This project aims to identify potential availability of aggregate resources, to assess mechanisms for transporting aggregates and to identify achievable landscape and restoration benefits. It concludes that Devon & Cornwall have a significant supply of china clay waste material that can be used as aggregates. This material could meet the demand for sands and gravels in the south east with transportation by sea being the most effective method. Removal of this waste material will have environmental benefits for the area.

Industrial Centre of Particle Science and Engineering, University of Leeds and Mineral Industry Research Organisation 'MiMeMiP - Mineral and Metals Mining and Processing', Web Site.

Abstract: A network of industrial and Academic researchers to engage material scientists and the mineral and metals mining and processing sectors in the UK.

No web site found (June 2014)

Institute of Environmental Assessment and the Landscape Institute (2002) 'Guidelines for Landscape and Visual Impact Assessment', Spon Press. ISBN: 041523185X.

Abstract: This (second) edition of these good practice guidelines provides advice on assessing the landscape and the visual impacts of development projects. Issues covered by the guidelines include: integration of landscape and visual issues into the development process; the need for a transparent approach to landscape and visual impact assessment; describing the baseline conditions; determining the magnitude and significance of impacts; and reviewing the landscape and visual components of an EIA (Environmental Impact Statement).

The guidelines will enable developers and decision-makers to be aware of the issues to be addressed by this type of assessment, as well as providing environmental consultants with a framework for good practice.

Institute of Field Archaeologists 'The Institute of Field Archaeologists', Web Site.

http://www.archaeologists.net

Keywords: Environment, Archaeology

Abstract: The Institute of Field Archaeologists (IFA) is the professional organisation for archaeologists in the United Kingdom. It promotes professional standards and ethics for conserving, managing, understanding and promoting enjoyment of heritage.

Institute of Geologists of Ireland (2007) 'Recommended Collection, Presentation and Interpretation of Geological and Hydrogeological Information for Quarry Developments', IGI Publications.

http://www.igi.ie/assets/files/Codes%20and%20Guidelines/QuarryTemplate.pdf

Keywords: Information Sources, Investigations, Design, Surveys

Abstract: A checklist of site information and data interpretations requirements for quarry developments

Institute of Highway Incorporated Engineers (2005) 'The Institute of Highway Incorporated Engineers online', Web Site.

www.theihe.org

Keywords: Environment, Traffic

Abstract: The Institute for all practitioners concerned with improving the highway environment and delivering a safe, sustainable transport system.

Institution of Mining and Metallurgy (1965) 'Opencast mining, quarrying and alluvial mining', Proceedings of a symposium held in London on 16 to 19 November 1964, Institution of Mining and Metallurgy, London.

Abstract: A collection of papers covering topics across the whole range minerals extraction within the UK and overseas. Of general and historical interest.

International Council on Mining & Metals (2006) 'ICMM - International Council on Mining and Minerals', Web Site.

http://www.icmm.com/

Keywords: Information Sources

Abstract: The council was formed to represent leading international mining and metals companies, whose vision is a "viable mining, minerals and metals industry that is widely recognized as essential for modern living and a key contributor to sustainable development."
The website gives access to a series of papers, reports and statements.

International Council on Mining and Metals 'Good Practice: Sustainable Development in the Mining and Metals Sector', Web Site.

http://www.goodpracticemining.org/

Keywords: Operations, Waste

Abstract: This web site provides an extensive resource for guidance on the implementation of good practice at mining and metals operations around the world forpeople who are directly and indirectly involved in the design, operation and regulation of mining and metals facilities. A large part of the site providesresources relating to tailings.

This website is jointly developed by the International Council on Mining and Metals (ICMM), the United Nations Conference of Trade and Development (UNCTAD), the United Nations Environment Programme (UNEP), and the UK Department for International Development (DfID) to provide access to a library of good practice guidelines, standards, case studies, legislation and other relevant material that are leading examples of their kind globally.

International Council on Mining and Metals (2005) 'Biodiversity Offsets – A Briefing Paper for the Mining Industry', Unpublished Paper.

http://www.icmm.com/document/25

Keywords: Environment, Ecology, Biodiversity

Abstract: Biodiversity offsets are sustainable conservation actions intended to compensate for the residual, unavoidable harm to biodiversity caused by development projects, so as to aspire to no net loss in biodiversity. Before developers contemplate offsets, they should have first sought to avoid and minimise harm to biodiversity.

International Institute for Environment and Development (2002) 'Breaking New Ground: Mining, Minerals, and Sustainable Development', Earthscan. ISBN: 1-85383-907-8.

http://www.iied.org/mmsd-final-report

Abstract: This study examines how the mining industry can be made sustainable, minimizing its harmful impacts and maximizing its social and economic contribution. It analyses the different needs and risks of all those affected and issues of supply and demand of minerals throughout the world.

Jones, H.K. et al. (2000) 'The physical properties of minor aquifers in England and Wales', BGS Research Report WD/00/D4, British Geological Survey.

Keywords: Environment, Water, Surface water

Kaufman, W.K. & Ault, J.C. (1977) 'Design of Surface Mine Haulage Roads - a manual', US Bureau of Mines Information Circular Nr.8758.

Keywords: Design, Haul roads

King, N (2004) 'Traffic', Environmmental Management, Institute of Quarrying, Nottingham.

Keywords: Environment, Traffic

Land Use Consultants (2003) 'Guidance on Policies for Minerals Planning', Unpublished Report for the Planning Officers Society.

Abstract: This guidance is aimed primarily to assist mineral planning authorities in the preparation of minerals development plans. It should also be of assistance to operators seeking to obtain planning permission for minerals development projects.

Latham, J. P. (ed) (1998) 'Advances in aggregates and armourstone evaluation', Engineering Geology Special Publication Nr.13, Geological Society of London. ISBN: 1862390002.

Keywords: Investigations, Quality testing

Abstract: This volume is a collection of papers dealing with the assessment of the physical properties of aggregates and armourstone and the evaluation of these for the engineering purposes for which they are employed. The last of the three sections includes papers that deal specifically with aggregates. The three sections are:

1. Marine sand and gravel geology and resources
2. Armourstone evaluation and shingle performance assessment
3. Aggregate testing and the use of alternative aggregates

Leake, C.C (2002) 'The ecological benefits of quarrying: potential for increase in biodiversity resulting from mineral extraction. In: Scott, P. W. and Bristow,C.M. (eds), Industrial minerals and extractive industry geology', Combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.321-322.

Keywords: Environment, Ecology, Biodiversity

Abstract: This brief paper examines how mineral extraction can lead to increased biodiverstiy through three disparate examples.

Leicester University (2005) 'WARM-IT - Waste minimisation by the application of integrated technology', Unpublished Report, MIST Project MA/4/2/002.

http://www.sustainableaggregates.com/library/docs/mist/l0035_ma_4_2_002.pdf

Keywords: Operations, Waste

Abstract: Project to develop an integrated methodology for sand and gravel resource evaluation which provides the tools for site evaluation and planning using a waste minimisation and resource management approach.

Leicestershire County Council 'Thurlaston Brook Nature Trail', ALSF Third objective 'legacy' site project FLAG/2004/006.

Keywords: Environment, Ecology, Education, Landscape, Access, Biodiversity, Fauna, Flora, Aquatic

Abstract: The Thurlaston Brook Nature Trail project will create disabled access, new footpaths, a viewing platform overlooking the quarry, a picnic area, and a boardwalk through a wetland area, giving visitors a chance to appreciate the variety of wildlife at the site.

Leicestershire County Council 'Cliffe Hill Quarry - Access and Geodiversity Interpretation Project', ALSF Third objective 'legacy' site project FLAG/2004/001.

Keywords: Environment, Geoconservation, Access

Leicestershire County Council 'Shawell Woodland', ALSF Third objective 'legacy' site project FLAG/2004/008.

Lenton, S. & Morgan, D. (2004) 'The Water Act 2003', Quarry Management V.31 Nr.12 p.19-20.

Keywords: Operations, Water management

Abstract: This article reviews the new licensing required and the impacts of the Water Act 2003 on abstraction and water movement in quarries. It also considers mitigation measures for minimising impacts of water abstraction which could otherwise prevent the quarry operator obtaining the necessary licences.

Littler, A. (1990) 'Sand and gravel planning and restoration', Institute of Quarrying, Nottingham.

Keywords: Investigations, Reclamation, Planning

Abstract: This book describes the planning process and the work required for restoration of sand and gravel quarries. Sand and gravel geology and exploration, and land acquisition are also described. Chapter headings are:

1. Sand and gravel output and usage
2. Sand and gravel deposits
3. Geological assessment
4. Product specification
5. The acquisition of sand and gravel deposits
6. Rates
7. Town and country planning
8. Marine gravels
9. Site after-use
10. Production costs

There are 20 references.

Littler, A. (2000) 'Sand and Gravel Production', Institute of Quarrying, Nottingham.

Keywords: Operations, Excavation, Processing, Waste

Abstract: This book describes terrestrial operations to remove overburden, win the deposit and process the minerals. The chapters titles are:

1. Overburden removal and replacement
2. Dry workings
3. Wet workings
4. Working land-based deposits
5. Gravel washing plants
6. Preparation and screening
7. Classification
8. De-sliming and dewatering
9. Removal of deleterious materials and waste treatment
10. Dredging

There are 37 references

Lucas, H. & Nice, S. (2002) 'Quarrying and reclamation at Torr Works, Frome, Somerset (abstract)', Proceedings of combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.355-355.

Keywords: Reclamation

Abstract: A paper presented at the combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, bath, England, 7th-12th May, 2000.

MAFF (2000) 'Good Practice Guide for Handling Soils (version 04/00)', FRCA, Cambridge.

http://webarchive.nationalarchives.gov.uk/20090306103114/http:/www.defra.gov.uk/farm/environment/land-use/soilguid/index.htm

Keywords: Environment, Soils, Operations, Excavation

Abstract: This guide, which was published by MAFF in 2000, provides guidance aimed at improving restoration standards and the sustainability of minerals and waste development. It comprises 19 separate guidance sheets in pdf format that cover topics associated with the mechanised handling of soils :

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Sheet 1: Soil Stripping with Excavators and Dump Trucks
Sheet 2: Building Soil Storage Mounds with Excavators and Dump Trucks
Sheet 3: Excavation of Soil Storage Mounds with Excavators and Dump Trucks
Sheet 4: Soil Replacement with Excavators and Dump Trucks
Sheet 5: Soil Stripping with Towed Earth Scrapers
Sheet 6: Building Soil Storage Mounds with Towed Earth Scrapers
Sheet 7: Excavation of Soil Storage Mounds with Towed Earth Scrapers
Sheet 8: Soil Replacement with Towed Earth Scrapers
Sheet 9: Soil Stripping with Self-Propelled Earth Scrapers
Sheet 10: Building Soil Storage Mounds with Self-Propelled Earth Scrapers
Sheet 11: Excavation of Soil Storage Mounds
Sheet 12: Soil Replacement with Self-Propelled Earth Scrapers
Sheet 13: Soil Stripping with Bulldozers and Dump Trucks
Sheet 14: Building Soil Storage Mounds with Bulldozers and Dump Trucks
Sheet 15: Soil Replacement with Bulldozers and Dump Trucks
Sheet 16: Release & Removal of Stones and Damaging Material from Excavator Replaced Soils
Sheet 17: Release & Removal of Stones and Damaging Material from Scraper & Bulldozer Replaced Soils
Sheet 18: Soil Decompaction by Excavator Bucket
Sheet 19: Soil Decompaction by Bulldozer Drawn Tines

The guide was prepared on behalf of MAFF by Humphrey Rowell Associates.

Marshalls Mono Ltd 'Demonstrating sustainable water resource management in quarries', Unpublished Report, MIST Project MA/4/2/024.

http://www.sustainableaggregates.com/library/docs/mist/l0040_ma_4_2_024.pdf

Keywords: Operations, Water management, Sustainable, Design, Environment, Water, Ground water, Surface water

Abstract: Project aims to demonstrate new approaches to environmentally sustainable water management in quarries. Concludes that it is feasible to design and implement a quarry water management scheme that delivers operational and environmental benefit.

McKie, P. (2005) 'Visible Felt Leadership', Quarry Management V.32 Nr.1 p.11-13.

Keywords: Health and Safety

Abstract: Thoughts on the importance of leadership in the management of safety in the quarrying industry

Millar, Bobbie (ed) 'Yorkshire Quarry Arts - A feasibility study to identify opportunities for regenerating new sustainable landscapes in Yorkshire', Unpublished Report, MIST Project MA/3/3/006.

http://www.sustainableaggregates.com/library/docs/mist/l0117_ma_3_3_006.pdf

Keywords: Environment, Landscape, Art, Feasibility, Reclamation, Sustainable

Abstract: A feasibility study to identify opportunities for regenerating new sustainable landscapes in Yorkshire. The primary focus of the study was to identify opportunities for proposals for projects for regenerating new sustainable landscapes in Yorkshire in partnership with selected quarry communities and academics. The project looked for sites where new and alternative technologies to environmental mitigation in the aggregate sector could be developed and applied while reflecting on the whether the model, or aspects of the model, of the Independent Quarry Project of the Portland Sculpture Quarry Trust could be adapted into a Yorkshire setting.

The project identified creative trans-domain applications of science and arts in view of the uniqueness of each environment and also explored the underlying principles that are applicable to all quarries.

Miller, Eric (1994) 'Settlement-pond design at quarry and opencast sites', Quarry Management September 1994 p.29-33.

Keywords: Design, Water retention, Lagoons

Mineral Industry Research Organisation 'Sustainable Construction in Practice: Using Recycled and Secondary Aggregates'.

Mineral Industry Research Organisation 'A Simple Guide to Planning Procedures for Recycling'.

Mineral Industry Research Organisation (2003) 'Metals and Minerals Network (MinMetNet)', Web Site.

http://www.minmetnet.org.uk/

Abstract: A network for the Metals and Mineral industrial sector in collaboration with academe, government laboratories and research organisations in order to develop and access new research findings and respond jointly to new opportunities in the areas relating to sustainable development, clean technology, zero wastes & emissions, beneficial reuse of waste products, bio- and advanced materials processing, nano-technology and modelling relevant to the network.

Mineral Industry Research Organisation (2006) 'MIST - Mineral Industry Sustainable Technology Programme', Web Site.

Abstract: The Mineral Industry Sustainable Technology Programme (MIST) provides a basis for implementation of focussed research and development activity aimed at supporting achievement of Aggregate Levy Sustainability Fund (ALSF) objectives. The programme provides funding support for R&D projects.

No website extant (June 2014)

Mineral Industry Research Organisation (2007) 'Mineral Industry Research Organisation', Web Site.

http://www.miro.co.uk/

Abstract: The Mineral Industry Research Organisation (MIRO) is a leading international collaborative research and technological development (RTD) facilitator and provider of project management services to the minerals and related industries.

Mineral Industry Research Organisation and Leeds University (2004) 'What is Planning?', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Planning

Abstract: This section of the Goodquarry website gives an overview of the planning system at all levels which are described in detail on linked web pages. It contains links to the web sites of various Government and National Assembly Departments and a link to the Planning and Compulsory Purchase Act 2004.

Goodquarry web site no longer exists: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Minerals Planning', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Planning

Abstract: This section of the Goodquarry web site describes the planning process for the development of minerals extraction, in particular for England, and explains the make up, role and responsibilities of the Minerals Planning Authorities. It has links to important guidelines such as the MPGs and MPSs.

Goodquarry web ste no longer exists: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'National and Regional Planning', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Planning, Planning framework

Abstract: This section of the Goodquarry web site describes the national and regional planning system. It lists all the Planning Policy Guidance notes, the Mineral Planning Guidance notes, the existing and proposed Planning Policy Statements and the Mineral Planning Policy Statements used within the national framework. Links to the new and important Regional Spatial Strategy documents for the nine regions are provided through a click-sensitive map. Information and links are also given, showing their relationship to the national framework, for the Regional Aggregates Working Parties (RAWPs), Strategic Environmental Assessment (SEA) and Sustainability Assessment.

Goodquarry web site no longer exists: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Planning', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Planning, Planning process

Abstract: This section provides a comprehensive reference source for information on planning at all levels and explains the way that the local and regional levels fit within the national framework. The web pages within this section contain information that is of importance to planners at all levels, major quarry operators, operators and managers of small independent quarries, and will be of interest to the general public. These pages also describe the planning process, including relevant legislation, bot hwithin the text and through the many links to other sites.

Goodquarry web site no longer exists: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Local Planning - What guides the decisions?', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Planning, Planning framework, Planning process

Abstract: This section deals with the local level of planning and reviews the old system of minerals planning before describing the new system. The new system is based upon spatial planning which is designed to optimise sustainable land use through the integration of a wide range of polices. The role of the Regional Spatial Strategy (RSS) and the Local Development Framework (Minerals & Waste Development Framework) in facilitating this goal with public participation is described. Reference is also made to the role in local planning of Strategic Environmental Assessment (SEA) and Sustainability Appraisal.

Goodquarry web site no longer exists: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Development Control - How are decisions made?', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Planning, Planning process

Abstract: This web page describes the planning application process. It includes an interactive presentation of the timetable from the minerals planning officer's viewpoint for an application submitted with an environmental statement. The application and required documents are described in detail including links to sources of guidance, procedures to be followed, consideration by the MPA (with list of typical consultees), recommendation and decision. The appeals procedure, monitoring and enforcement are also covered.

Goodquarry web site no longer exists: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Annex 3: Old Development Plans - What guided the decisions?', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Planning, Planning framework

Abstract: The Planning and Compulsory Purchase Act 2004 introduced major changes to the planning system, which are being phased in. Therefore in the period up to 2007 both old and new systems will operate. The old system, which is being phased out, is described here. This web page contains many links to other planning information sources.

Goodquarry web site no longer exists: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Annex 2: Planning Contributions', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Planning, Planning framework

Abstract: This Goodquarry web page elaborates on the legislation and processes concerning planning conditions and contributions (also mentioned in MIRO - GQDC2004) and gives examples of obligations and conditions.

Goodquarry web site no longer exists: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Annex 1: UK Authorities', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Planning, Planning framework

Abstract: The administrative areas of the UK are described in this web page with the more complicated administrative divisions in England considered in detail.

Goodquarry web site no longer exists: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Goodquarry', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Design, Operations, Reclamation, Environment, Planning, Waste, Restoration, Geoconservation, Ecology, Water, Traffic, Air, Noise and Vibration

Abstract: This web site is an important resource for all with an interest in considering how to incorporate good environmental practice into quarry design and operation. There are sections on: Air Pollution, Bio and Geodiversity, Blasting, Cultural Heritage, Ecology, Mineral Wastes, Noise, Planning, Restoration & Rehabilitation, Social and Community, Transport and Traffic, Visual and Landscape, and Water each with a variable number of sub-sections, one of which is a summary of that section.

The site is interactive providing a question board where users can post relevant questions in the hope that it will be answered by other users of the site; to date (Feb 2006) however there do not appear to be any answers posted.

There is also a comprehensive reference section with nearly 350 references listed which can be viewed by author or by title, and an extensive glossary.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Air pollution', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Environment, Air, Dust

Abstract: This section of the Goodquarry web site considers the issues connected with dust: other forms of air pollution associated with quarries are minimal in comparison. Subsections consider: the processes which create and transport dust, the effects of weather and topography, receptors and sensitivity, methods of monitoring and good practice working methods.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Bio and Geodiversity', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Environment, Geoconservation, Ecology, Biodiversity

Abstract: This part of the web site describes the various types of nature conservation sites and provides links to web sites with additional information. The potential effects of mineral extraction on bio and geo-diversity and the role of site designation and action plans on preserving and enhancing diversity are considered along with good practice at all stages of quarry operation and after use design. Many useful links are provided.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Blasting', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Operations, Environment, Health and Safety, Excavation, Noise and Vibration

Abstract: This section of the Goodquarry website gives an overview of some of the technical aspects of blasting together with the potential effects, and the acceptable levels of those effects, on people and the neighbouring environment. Health and safety issues and mitigation measures including monitoring, compliance, prediction and design and good practice are described. Many useful links to other reference sources are provided.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Cultural Heritage', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Environment, Archaeology

Abstract: These web pages deal with the interaction between minerals extraction and the archaeological environment. As well as the effects on buried archaeological remains, listed buildings, parks and gardens and battlefields are also considered. A review is given of the relevant legislation and planning issues and the mineral operators' code of practice. The potential impacts of minerals extraction, archaeological assessment methods and good practice are also reviewed. Links to references and other relevant sites are given.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Ecology', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Environment, Ecology, Fauna, Flora, Aquatic

Abstract: This section of Goodquarry gives information on the potential impacts, both adverse and beneficial, of minerals extraction and the implications of these for planning and operating quarries. The role, design and implementation of ecological impact assessment is considered in the light of legislation and the range of different species (vegetation, mammals, amphibians and reptiles, birds, fish, and invertebrates) that must be considered. Lists of the relevant Acts of Parliament and planning guidance notes are given as well as many links to other useful reference web sites. Mitigation measures and good practice which includes preservation and creation of habitat are also described. There are many links to other relevant web sites and references.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Mineral Waste', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Operations, Environment, Waste

Abstract: Waste is considered as either temporary or permanent as different issues are involved. This section of Goodquarry describes the potential impacts of both and outlines good practice for minimising and controlling waste. Links to the UK government's Waste and Resource Action Programme (WRAP) are included.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Noise', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Environment, Noise and Vibration

Abstract: This web site provides considerable technical information on the measurement of noise, noise sources and prediction, and calculation of noise from multiple and moving sources.
The potential noise effects of the different processes involved in mineral extraction are also reviewed. Acceptable noise levels and good practice for achieving them are given. There are links to references including legislation and to other useful web sites.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Restoration and Rehabilitation', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Reclamation, Restoration, After Use, After care

Abstract: This section of the Goodquarry web site describes the possible after use of quarries and the factors that will determine which after use will be chosen. Separate subsections deal with planning, handling of soil, agriculture and forestry, habitat creation, leisure and amenity, and geodiversity. Useful links to references, including a series of 19 datasheets on the handling of soil from DEFRA, and to relevant web sites are included.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Social and Community', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Operations, Environment

Abstract: This section of the Goodquarry web site deals with the important issue of maintaining good relations between the quarry operator and the quarry neighbours. It reviews the procedures for monitoring public opinion and generating good relations, and describes good practice that includes dealing with complaints, establishing community links, improving the operator's image, possible provision of compensation, providing planning gain,and restricting the duration of nuisance and working hours. Useful references and links to case studies are included.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Traffic', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Operations, Haulage

Abstract: Potential effects, acceptable levels, and monitoring of traffic, are described in this section of the Goodquarry website. Good practice is described in several subsections viz.: alternatives to road, site access, route planning, hours of operation, driving with care, parking, vehicle cleanliness, sheeting, noise reduction and vehicle identification.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Visual and Landscape', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Environment, Landscape

Abstract: The visual aspects of quarry operation is considered in this section of Goodquarry. The different aspects are considered under the headings: potential effects, design issues, planning considerations, landscape assessment, visual impact assessment and good practice. The section on visual impact assessment describes the stages and methodology under headings of desk study, field survey, baseline study, landscape impact assessment and visual impact.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Water', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Operations, Reclamation, Environment, Water management, Water, Ground water, Surface water

Abstract: This lengthy section of the Goodquarry website describes the importance of considering the interaction between water and quarries at all stages from planning through to restoration. Explanations of the components of the hydrological cycle and processes are given in the section on the water environmen. This includes sub-sections on aquifers, groundwater flow, groundwater vulnerability and source protection zones. The potential effects of ground investigation, the physical presence of the quarry, excavation dewatering and contamination are described, as are reclamation/after-use and beneficial impacts of quarrying. The importance of the hydrological impact of quarry operation on planning issues is covered in a section on planning and legislation. The roles of hydrological impact assessment and monitoring and computer modelling are explained. A very useful set of good practice guidelines is also given covering the topics mentioned above.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Industry Research Organisation and Leeds University (2004) 'Case Studies', Goodquarry Web Site.

http://www.sustainableaggregates.com/

Keywords: Operations, Reclamation, Environment, Haulage, Waste, Water management, Restoration, Geoconservation, Ecology, Landscape, Archaeology, Traffic, Air, Noise and Vibration

Abstract: This section of the Goodquarry web site provides case studies for the major topics described in the web site, viz. air pollution, blasting, cultural heritage, ecology, geodiversity, mineral wastes, restoration and rehabilitation, social and community, traffic, visual and landscape and water. The number of case studies varies between topics with a maximum of 20 for restoration and rehabilitation to one for blasting. There are no case studies given under geodiversity although three listed under restoration and rehabilitation are under the geodiversity section of the Quarry Products Association website.

Goodquarry has been superseded: see http://www.sustainableaggregates.com/

Mineral Products Qualifications Council 'MPQC Website', Web Site.

http://www.mp-qc.org/

Keywords: Health and Safety

Abstract: The MPQC awarding organisation offers a wide range of qualifications specifically designed for the quarrying, mineral products, mining and related manufacturing sector. MPQC Skills Cente provides a suite of industry-specific training courses. The organisation was previously known as EPIC

Mineral Solutions Limited (2004) 'Development of an interactive database to enhance the exploitation of quarry fines (Exploitation and use of quarry fines)', Unpublished Report, MIST Project MA/2/4/003.

http://www.sustainableaggregates.com/library/docs/mist/l0066_ma_2_4_003.pdf

Keywords: Operations, Excavation, Processing, Waste

Abstract: Study to ascertain the current state of knowledge concerning the exploitation of hard rock quarry fines and to present the information in an accessible form. Extensive review of existing reports and papers, interviews with producers of quarry fines.

Mineral Solutions Limited (2004) 'Combination of basaltic quarry fines with organic process residues for the development of novel growing media', Unpublished Report, MIST Project MA/1/3/003.

http://www.sustainableaggregates.com/library/links/links_onsite/L0025.htm

Keywords: Reclamation, Restoration, Environment, Soils

Abstract: Project aims to identify and assess potential combinations of four quarry fines with five composts for the development of growing media, aimed mainly at horticulture in the short term, and land restoration in the long term.

Concludes that most quarry fines intersct positively (at least) with composts, and vice versa, to give potential novel growing media suitable for horticultural and land restoration uses.

Mineral Solutions Ltd (2004) 'A generic model for the formulation of growing media from composts and quarry fines', Unpublished Report, MIST Project MA/3/1/003.

http://www.sustainableaggregates.com/library/docs/mist/l0067_ma_3_1_003.pdf

Keywords: Operations, Waste, Environment, Soils

Abstract: Studied the production of growing media and topsoils from blended quarry fines and compost.

Minerals Industry Research Organisation 'Sustainable Agregates: Information Gateway', Web Site.

http://www.sustainableaggregates.com/

Keywords: Information Sources

Abstract: Living within environmental limits is essential for any economic activity. Between 2002 and 2011, the Aggregates Levy Sustainability Fund (ALSF) made a significant contribution to knowledge and practice in how to produce aggregates in a sustainable way.

This web site is an information gateway, which aims to promote sustainable production and consumption of aggregates (sand, gravel and crushed rock) through better access to research and information. It has been developed to bring together through a single portal research and development funded by the Aggregates Levy Sustainability Fund in England and other relevant research and information.

Mitchell, Paul (2004) 'The protection and management of water resources', Environmmental Management, Institute of Quarrying, Nottingham.

Keywords: Environment, Water

National Assembly for Wales 'The National Assembly for Wales', Web Site.

www.wales.gov.uk

Abstract: The National Assembly for Wales is the representative body with legislative powers in devolved areas. It has sixty elected members and meets in the Senedd.

National Stone Centre 'A systems approach to geoconservation', Unpublished Summary, MIST Project MA/4/2/023.

http://www.sustainableaggregates.com/library/docs/mist/l0104_ma_4_2_023.pdf

Keywords: Environment, Geoconservation

Abstract: Project to create a model geoconservation system building upon and developing best practice.

National Stone Centre (2005) 'The Educational Use of Aggregate sites'.

http://www.sustainableaggregates.com/library/docs/mist/l0129_ma_2_4_002.pdf

Keywords: Environment, Health and Safety, Education

Abstract: Publication aimed at industry and those involved in education and looks at practical issues including health and safety in using aggregate sites in education. Includes background to both educational environments and quarrying industry. Practical examples of activities for school groups are included.

50% funded Mineral Industry Sustainable Technology Programme (MIST) of the government's Aggregates Levy Sustainability Fund (ALSF)

Natural England (2006) 'Natural England', Web Site.

http://www.naturalengland.org.uk/

Keywords: Environment

Abstract: Natural England works for people, places and nature to conserve and enhance biodiversity, landscapes and wildlife in rural, urban, coastal and marine areas.

Natural England brings together English Nature, the Countryside Agency and the Rural Development Service.

NECESI (2004) 'Environmental Management Guidance Manual for SME Aggregates Companies', Unpublished Report, ALSF SAMP Project SAMP1.027.

http://www.sustainableaggregates.com/library/docs/samp/l0082_samp_1_027.pdf

Keywords: Environment, Operations, Restoration

Abstract: Provides a practical reference to on site environmental management for smaller-sized companies in the aggregate extraction industry. Explains the planning and regulatory context governing quarry operation and describes good practice for achieving ongoing compliance with environmental controls.

Nicholson, D. T. (2002) 'Identification of deterioration hazard potential for quarried rock slopes', Quarry Management V.29 Nr.1 p.43-52.

Keywords: Investigations, Geotechnical, Health and Safety

Abstract: This paper describes the deterioration of quarried rock slopes and a classification system which allows potential rockfall hazard resulting from deterioration to be identified. It is based upon the results of an extensive investigation aimed at establishing the extent and characterising the nature of slope deterioration in UK quarries, and determining a means of identifying deterioration hazard. The paper describes the processes and an assessment of deterioration potential. Two useful appendices describe the different rock mass types (Appendix A) and the different modes of deterioration (Appendix B).

Norfolk Archaeological Unit 'Lynford Quarry, Mundford, Norfolk', ALSF Third objective 'legacy' site project 3253REC.

Keywords: Environment, Archaeology

Abstract: In late February and early March 2002, an archaeological watching brief at Lynford Quarry, Mundford, Norfolk revealed a relic Middle Devensian palaeochannel with a dark organic fill containing in situ mammoth remains and associated Mousterian stone tools and debitage buried under two to three metres of bedded sands and gravels. Well-preserved in situ Middle Palaeolithic open-air sites are exceedingly rare in Europe and very unusual within a British context. As such, the site was identified as of national and international importance, and subsequently excavated by the Norfolk Archaeological Unit from the 8th of April to the 11th of September 2002 with funding provided by English Heritage through the Aggregates Levy Sustainability Fund.

Northern Ireland Assembly 'Welcome to the website of the Northern Ireland Assembly', Web Site.

http://www.niassembly.gov.uk/

Abstract: The Northern Ireland Assembly was established as part of the Belfast Agreement and meets in Parliament Buildings. The Assembly is the prime source of authority for all devolved responsibilities and has full legislative and executive authority.

Nottinghamshire Wildlife Trust 'Grassland Biodiversity Enhancement Project - Nottinghamshire', ALSF Third objective 'legacy' site project 2004/32.

Keywords: Environment, Ecology, Biodiversity

ODPM, Defra and English Nature (2006) 'Planning for Biodiversity and Geological Conservation: A Guide to Good Practice', ODPM Publications. ISBN: 10-185 112 8522.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11481/143792.pdf

Keywords: Environment, Geoconservation, Ecology, Biodiversity

Abstract: This guide complements Planning Policy Statement 9 (PPS9) and Circular (ODPM 06/05 and DEFRA 01/05) Biodiversity and Geological Conservation: Statutory Obligations and Their Impact Within The Planning System. It provides good practice guidance using case studies and examples on how planning authorities can help deliver the policies in PPS9 and comply with the legal requirements set out in the Circular. It also suggests ways that planning decisions can positively enhance and restore biodiversity and geology.

Owen, D et al. (2005) 'Gloucestershire Cotswolds: Geodiversity Audit & Local Geodiversity Action Plan', ALSF SAMP Project SAMP2.34, Gloucestershire Geoconservation Trust. ISBN: 1904530079.

http://www.sustainableaggregates.com/library/docs/samp/l0110_samp_2_34.pdf

Keywords: Environment, Geoconservation, Geodiversity

Abstract: The Gloucestershire Cotswolds Local Geodiversity Action Plan is intended to protect and manage geodiversity and increase understanding and awareness of geodiversity. The report has the following sections:

Part 1 The Gloucestershire Cotswolds
Part 2 Geodiversity in the Gloucestershire Cotswolds
Part 3 Geodiversity Audit
Part 4 Implementing the Action Plan & Interpretation of Geodiversity
Part 5 Action Plan

Oxford Archaeology 'Coln Gravel, Fairford, Gloucestershire', Historic Environment Enabling Programme 3556ANL.

Keywords: Environment, Archaeology

Abstract: Between October and November 2003 and continuing between October and December 2004 Oxford Archaeology (OA) undertook a programme of archaeological work on part of an important Iron Age and Roman settlement at Coln Gravel, (Thornhill Farm Pit) Fairford, Gloucestershire, in the Upper Thames Valley. The excavations were the final part of a longstanding series of archaeological investigations in the area, in advance of gravel extraction by Hanson Aggregates Ltd.

All work is expected to be completed by the end of February 2006 and submitted to English Heritage. The report will be published in the Transactions of the Bristol and Gloucestershire Archaeology Society.

Oxford Archaeology North 'Kendall Fell quarry, Kendall, Cumbria', Historic Environment Enabling Programme 3895.

Abstract: To produce a Conservation Plan for a quarry.

Pan-European Reserves and Resources Reporting Committee 'PERC'.

http://www.vmine.net/PERC/

Keywords: Investigations, Feasibility

Abstract: Pan-European Reserves and Resources Reporting Committee (PERC) is the organisation responsible for setting standards for public reporting of exploration results, mineral resources, and mineral reserves by companies listed on markets in Europe.

PERC is the European equivalent of JORC in Australasia, SAMREC in South Africa, and similar reserves standards bodies in the USA, Canada, Chile, and Russia, and with them is a constituent member of the Committee For Mineral Reserves International Reporting Standards (CRIRSCO). Representation on PERC covers the major and junior mining sectors, industrial minerals, aggregates, coal, the investment and financial community and professional accreditation organisations.

Parry, M. (ed) (2004) 'Quarries and Mines 2004', McMillan and Scott.

Keywords: Information Sources

Abstract: This book contains a series of topical articles on issues affecting the extractive industry but also contains various lists that are likely to be of interest to quarry operators and other organisations with an interest in quarries and mines. The lists are of:

Products and Services
Mineral Planning Authorities
Trade Associations and Professional Organisations
Information Sources
Quarries and Mines
Suppliers

Portland Sculpture and Quarry Trust 'Independent Quarry - a new model for regeneration - promoting innovative research & opportunities for community participation with collaboration between disciplines - in the planning, implementation and after use of a new landscape for the 21st century', Unpublished Report, MIST Project MA/2/3/006.

http://www.sustainableaggregates.com/library/docs/mist/l0116_ma_2_3_006.pdf

Keywords: Reclamation, After Use, After care

Abstract: This report defines the results of a one-year research and development project to create a new landscape for the 21 Century in Independent Quarry. The project was led by the Portland Sculpture and Quarry Trust in partnership with Albion Stone Quarries Ltd. (leaseholders and operators for Independent Quarry) and nine other Consortium members: University of Brighton, University of Leeds, Royal Manor Arts College, Jurassic Coast Project - Dorset County Council, Kingston University, University of the West of England, Landscape & Arts Network and local naturalist, Bob Ford.

The research tested a new model for assessing quarry regeneration that could result in innovative designs for the sustainable after use of the quarry landscape. Research into site-specific design for the long-term preservation and interpretation of important geological features was also included. The primary focus was to examine how a new and inclusive perspective on quarry regeneration can be developed into a Master Plan for future uses, and how this process can serve as an example for the regeneration of quarry environments elsewhere.

The project ran from April 2003 to March 2004, placing inspiration through the arts at the centre of any interpretation and design of the landscape. This has encouraged a collaborative approach between people from different disciplines and brought about a creative dialogue that has made connections between people/areas that would normally appear to be separate. The collaborations that have taken place have encouraged design solutions to be developed literally from the ground up, where the community, schools, students, artists and designers have been able to integrate their ideas into a shared plan through an arts framework with an educational focus.

The project enabled people to evaluate their ideas and test their conclusions before being incorporated into the scheme. The research involved the stone working community and the younger generation who questioned the kind of landscape that could be created, what it might inspire and give to generations to come. Central to the project is the quarrying and aggregate crushing process and how the space created can assist in shaping a new landform.

Quarry Products Association 'Quarry Products Association Home Page', Web Site.

http://www.mineralproducts.org/

Keywords: Reclamation, Environment, Planning, Restoration, Geoconservation, Ecology, Archaeology, Education, Biodiversity

Abstract: Homepage of the website of the Quarry Products Association (trade association for companies in the aggregates industry). This provides useful background information with easy-to-read summaries aimed at the general public. It includes major sections on environment and heritage with the following sub-sections: the planning process, environmental management, restoration, biodiversity, conservation, working in the community, geology, history, and archaeology.

Now the Mineral Products Association

Quarry Products Association 'Safequarry', Web Site.

Keywords: Information Sources, Health and Safety

Abstract: This website contains best practice ideas, a database of incident alerts, toolbox talks and the latest on the quarrying industry's hot topics. The best practice ideas come from the Quarry Products Association's annual Health & Safety Best Practice Awards scheme.

Quarry Products Association (2006) 'Quarry Safety for Teenagers', Unpublished Report, MIST Project MA/4/4/012.

http://www.sustainableaggregates.com/library/docs/mist/l0131_ma_4_4_012.pdf

Keywords: Health and Safety, Education

Abstract: The aim of the project was to develop a communications programme that can be used to tackle the problem of teenage trespass in quarries and so save lives that are being put at risk. The project built on the QPA's successful Play Safe ... Stay Safe campaign.

Ramblers' Association 'The Ramblers', Web Site.

http://www.ramblers.org.uk/

Keywords: Environment, Access

Abstract: The Ramblers' Association is Britain's biggest walking charity, working for over 70 years to promote walking and to improve conditions for everyone who walks in England, Scotland and Wales.

Randolph, R.F. & Boldt, C.M.K. 'Safety analysis of surface haulage accidents'.

Keywords: Design, Health and Safety, Haul roads

Reeve, M.J. et al. (2000) 'Evaluation of mineral sites restored to agriculture', DEFRA.

http://webarchive.nationalarchives.gov.uk/20090306103114/http://www.defra.gov.uk/farm/environment/land-use/restore/index.htm

Keywords: Reclamation, Environment, After Use, Soils

Abstract: This report was published in 2000 by MAFF (later integrated within DEFRA) describes the results of a study designed to evaluate the effects of mineral working method, soil type and soil handling on agricultural land grade on the quality of the restoration and to improve advice to operators and regulators on the best techniques for maintaining agricultural land quality during mineral working and landfilling. The study was over a five year period and investigated 41 restorations spread across the whole of England.

Rothery, K. & Mellor, S. (2001) 'Crushing and Screening', Institute of Quarrying, Nottingham. ISBN: 0953800326.

Keywords: Operations, Processing

Abstract: This book covers the title topics in five sections, viz.:

1. Crushing
2. Screening
3. Feeding Machinery
4. System Control
5. Plant Selection and Layout

covering the principles, design and selection of the equipment. Health and safety issues and process management are covered in separate chapters in Section 4 and the final section has a chapter on recycling of waste materials for aggregates.

Royal Society for the Protection of Birds 'Understanding the Habitat Restoration Potential of Mineral Sites in England (Nature after Minerals: how mineral site restoration can benefit people and wildlife)', Unpublished Summary, ALSF SAMP Project SAMP2.38.

http://www.sustainableaggregates.com/library/docs/samp/l0128_samp_2_38.pdf

Keywords: Reclamation, Environment, Restoration, Ecology, Biodiversity, Fauna

Abstract: Project to:

1. reviiew the achievements of the minerals industry to date in re-creating UK Biodiversity Action Plan (UKBAP) priority habitats in England, and identify existing technical, economic and legislative blocks to progress as informed by the perspectives of minerals operators and planners.

2. map, using GIS, extant and closing mineral sites in England, including information on extent, (proposed) restoration type and the potential for restoring UKBAP priority habitats. Assess the gap between planned restoration and the potential for restoration to appropriate UKBAP priority habitats, and therefore the contribution the minerals industry could make to achieve UKBAP targets.

3. report on this implementation gap, and recommend strategic minerals planning measures to enable optimal delivery of UKBAP targets, to the minerals industry, planners, those in central government responsible for planning policy, as well as to organisations involved in implementing relevant habitat BAPs.

4) create an Internet-based tool enabling minerals operators, planners and consultants to access the project data, which will inform them as to the suitability of a minerals site for restoration to a nature conservation after-use, as well as access sources of further advice and best practice.

Royal Society for the Protection of Birds (2003) 'Habitat Creation Handbook for the Minerals Industry'. ISBN: 1901930378.

Keywords: Environment, Ecology, Fauna

Abstract: A practical guide to the creation of priority Biodiversity Action Plan habitats on redundant mineral workings. Covers sand and gravel, clay, soft and hard rock quarries and opencast coal. It aims to provide a reference for the process of planning habitat creation and presents the latest ideas and methodology for the creation of priority habitats appropriate for mineral extraction sites. Also shows practical management and restoration experience through case studies.

RSPB (2003) 'Habitat Creation on Mineral Sites - handbook and training', RSPB.

Abstract: see "Habitat Creation Handbook for the Minerals Industry"

Sandwell Metropolitan Borough Council 'Black Country Geodiversity Action Plan', ALSF Third objective 'legacy' site project 2004/329.

Keywords: Environment, Geoconservation, Landscape, Archaeology

Abstract: This document shows how to identify, promote and make accessible the wealth of geological and related cultural and heritage features of the sub region. Seven objectives have been agreed:

1) To ensure geodiversity is identified and included as an integral part of all Black Country sub-regional and local strategies, plans and policies.
2) To develop and maintain comprehensive geodiversity data resources integrated with other data sets.
3) To protect and enhance the geodiversity resource by appropriate designation of geological sites and features commensurate with their local, regional, national or international importance.
4) To manage existing geodiversity resources and create new features and opportunities in association with partners.
5) To increase public awareness and appreciation of the Black Country Geodiversity Heritage.
6) To maximise the opportunities for Black Country geodiversity to contribute to all levels of education including lifelong learning.
7) To establish appropriate mechanisms to secure the continuity, sustainability and effectiveness of the BCGAP process.

Scott, P. W. & Bristow, C. M. (ed) (2002) 'Industrial minerals and extractive industry geology', Geological Society of London. ISBN: 1 86239 099 1.

Abstract: This publication is based on papers presented at the combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000. The 49 papers were included on the basis of their representing useful up-to-date knowledge and research results relevant to professional geoscientists working in the industrial minerals extractive industry. The papers cover a very wide range of topics and an international perspective e.g. a paper on slope stability in a quarry in Somerset and one giving an overview of the aggregate resources of the United States are both included. The most relevant papers (9) from the conference are cited individually in the database.

Appendix 1: describes field excursions at the conference to quarries in the Bath, Bristol and Mendip Hills, Midlands and Cheshire areas.

Scottish Executive 'Scottish Executive', Web Site.

http://www.scotland.gov.uk

Abstract: The Scottish Executive is the devolved government for Scotland.

Sea-info.net 'Strategic Environmental Assessment Information Service', Quarry fact file.

http://www.sea-info.net/

Keywords: Environment

Abstract: The Strategic Environmental Assessment Information Service website.

"Minerals and Waste" is the title of home page for the SEA Minerals Network, which provides a hub for minerals practitioners to share information and practical experiences of developing Strategic Environmental Assessment/Sustainability Appraisal practice

Shropshire County Council 'Biodiversity Action - Shropshire', ALSF Third objective 'legacy' site project 2003/233, MA Creative.

Keywords: Environment, Ecology, Biodiversity,

Abstract: In 1996 Shropshire became the first county in the country to produce a Biodiversity Strategy with Biodiversity Challenge:An Agenda for Conservation in the UK – The Shropshire response. Five years later the Shropshire Biodiversity Action Plan was devised. This has provided the framework for action to protect the wild habitats and species that together make up Shropshire's rich and diverse landscape.

Shropshire Geological Survey 'Geoconservation Quarry Trails around Shropshire's classic sites - Shropshire', ALSF Third objective 'legacy' site project 2004/341.

Keywords: Environment, Geoconservation, Education

Simmons, S et al. (2006) 'Streamlining environmental impact assessments for aggregate sites through better scoping', Unpublished Report, ALSF SAMP Project SAMP2.21.

http://www.sustainableaggregates.com/library/docs/samp/l0080_samp_2_21.pdf

Keywords: Environment, EIA

Abstract: Project report contains recommendations for improving scoping practice for EIAs

Small, R.J. (2002) 'Rock slope stability: a case study at Coles Quarry, Backwell, North Somerset. In: Scott, P. W. and Bristow, C. M. (eds), Industrial minerals and extractive industry geology', Combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.147-152.

Keywords: Investigations, Geotechnical

Abstract: This paper summarises the characterisation, analysis and resolution of problems associated with the potential for planar failure at this limestone quarry.

Somerset County Council 'Somerset - assessment of archaeological resource in aggregate areas', Historic Environment Enabling Programme 3994MAIN.

Keywords: Environment, Archaeology

Abstract: The project will enhance the archaeological record of the aggregate mineral producing areas of the county by collecting and integrating information from the following sources:
• Relevant geological information.
• The Somerset County Historic Environment Record.
• The National Monuments Record.
• Published and unpublished text and map information relevant to the geology, archaeology and history of the area.
• Aerial photography and LiDAR information where available.
The Somerset Sites and Monuments Record database and Geographic Information System will be used to assimilate and present the recovered data. This will inform strategic and local management policies and act as a basis for further academic research and for strategic and development control planning advice.
The results of the project will:
• Establish a corpus of base-line data from which future archaeological research strategies in the area can be formulated.
• Enhance the existing Somerset County Historic Environment Record, equipping it to act as a proficient management tool to meet the challenges of future development in the area, and in particular, proposals for mineral extraction.
• Contribute towards a greater awareness of archaeological issues relating to aggregate extraction, and inform general and site specific management strategies.
• Contribute to initiatives for greater community involvement in the archaeology of the area through site management or research programmes.

Somerset County Council (2005) 'Effect of Quarry Water Discharges on Stream Flows in the Mendip Hills', Unpublished Report, MIST Project MA/4/2/022.

http://www.sustainableaggregates.com/library/docs/mist/l0039_ma_4_2_022.pdf

Keywords: Environment, Water, Surface water

Abstract: Project to determine the variations in quarry discharge to allow the cumulative effect on recipient watercourses to be determined.

SRK Consulting (2004) 'East Mendips strategic groundwater study', Unpublished Report, MIST Project MA/2/1/006.

http://www.sustainableaggregates.com/library/links/links_onsite/L0116.htm

Keywords: Environment, Water, Ground water, Reclamation, After Use, Ecology, Aquatic

Abstract: Report describes a GIS planning tool for collecting and collating data on both limestone quarries and groundwater resources. Also describes the potential impacts and benefits associated with the formation of quarry lakes after closure and an evaluation of the effects on the groundwater system of dewatering interaction between quarry sites.

Stead, D. et al. (2002) 'Application of hazard and risk assessment techniques to United Kingdom quarry slopes. In: Scott, P. W. and Bristow, C. M. (eds), Industrial minerals and extractive industry geology', Combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.255-261.

Keywords: Investigations, Design, Health and Safety, Geotechnical, Slope design

Abstract: A review of qualitative and quantitative risk assessment with particular attention to slope stability.

Steadman, E et al. 'Strategic Environmental Assessment (SEA) and future aggregate extraction in the East Midlands', Unpublished Report, MIST Project MA/1/1/002, BGS Commissioned Report: CR/04/003N.

https://www.bgs.ac.uk/downloads/start.cfm?id=1317

Keywords: Environment, EIA, Strategic Environmental Assessment, Aggregates

Abstract: Aggregate development, has to compete for land. However, unlike other forms of development quarrying is a temporary use of land. Quarrying is also a unique form of development because aggregates can only be extracted where they occur. This means extraction is limited to certain geological areas. Often these geological areas are in areas of inherent beauty or value because of the relationship between geology and the landscape. However, quarrying is an essential part of modern society and aggregates are a vital resource for economic growth and development.

The entire lifecycle of quarrying activity is already well regulated in the UK, given the widespread use of Environmental Impact Assessments (EIAs) to predict, prevent and manage potential environmental impacts. However, at a strategic level, there is a lack of appropriate guidance and transparency when considering the cumulative impacts of individual projects. Strategic Environmental Assessment (SEA) is designed to address this issue.

This project may help contribute to a SEA by providing a non-prescriptive tool to aid the understanding of the relationship between aggregate resources and the environmental and cultural assets that overlay them. The research aimed to achieve this through the production of a map entitled a 'future aggregates sensitivity map'. The map shows the gradation between the most and least 'sensitive' areas for future aggregate extraction based on the relative significance of environmental and cultural assets in the area. The higher the significance or value of the assets, or the higher the number of assets in the area, the higher the sensitivity score will be.

Suffolk County Council 'Flixton Quarry (Tarmac), Suffolk'.

Keywords: Operations, Excavation, Environment, Landscape, Archaeology

Abstract: The sand and gravel quarry operated by Tarmac at Flixton in north Suffolk in the Waveney valley is covered by a planning permission granted in 1958 which clearly predates any possible PPG 16 type condition. In general the local area is rich in archaeological sites with the adjacent RMC quarry having produced regionally important evidence for Neolithic, Bronze Age, Roman and Early Anglo-Saxon activity over the last few years. At the Tarmac quarry (SMR FLN 009) the final phase of working covers some 3h and this contains a cropmark of a small, square enclosure plus similar, aerial, evidence for linear boundaries. This Project Design therefore proposes the evaluation of the final quarry phase through the continuous monitoring of topsoil stripping and sampling of exposed features.
Flixton, Tarmac Quarry (TM 2990 8655; FLN 009; SCCAS Rpt. No. 2003/107) An archaeological evaluation/excavation was undertaken over a c.2.7 hectares area at Tarmac's Flixton Quarry in advance of gravel extraction. As the quarry was covered by pre-PPG16 planning consent, there was no requirement for the company to provide for a programme of archaeological works and as a result, the funding was provided by a grant from the Aggregates Levy Sustainability Fund while, the soil-stripping plant was provided by Tarmac.
The perceived high archaeological potential for the site was based on previous significant findings in both Flixton Quarry (Tarmac) and the adjacent Flixton Park Quarry (RMC Aggregates Ltd) and aerial photographs which had revealed a square ditched enclosure.

Suffolk County Council 'Suffolk - assessment of archaeological resource in aggregate areas', Historic Environment Enabling Programme 3987.

Keywords: Environment, Archaeology

Abstract: Project to assess archaeological resource in potential mineral extraction areas

Suffolk RIGS 'Making Geodiversity more accessible - Suffolk', ALSF Third objective 'legacy' site project 2003/269.

Keywords: Environment, Geoconservation

Symonds Group Ltd (2002) 'Survey of arisings and use of construction and demolition waste in England and Wales in 2001', Office of the Deputy Prime Minister. ISBN: 1851125973.

http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/archived/publications/planningandbuilding/surveyarisings3

Keywords: Operations, Waste

Abstract: This report provides central government, the minerals planning authorities and industry with data on the amount of construction and demolition waste crushed or screened for use as aggregate, and the scope for its further use as aggregate.

Three related surveys were carried out during the first six months of 2002 to establish estimates for the arisings and use of construction and demolition waste in 2001 in England and Wales, and in each of the regions covered by Regional Aggregate Working Parties.

Symonds Group Ltd (2004) 'Optimising the efficiency of groundwater recharge features associated with quarry dewatering operations', Unpublished Report, MIST Project MA/1/2/008.

http://www.sustainableaggregates.com/library/docs/mist/l0024_ma_1_2_008_ma_3_2_005.pdf

Keywords: Operations, Water management, Environment, Water, Ground water, Surface water

Abstract: The overall aims of this research were to collate existing information from literature and industrial experience, and to investigate the role of recharge features as a mechanism for mitigating the effects of quarry dewatering, including an assessment of factors associated with optimising their efficiency.

The detailed findings provide a unique source of reference for both mineral operators and the Environment Agency, and should help to promote the greater use of recharge features to mitigate the impacts of quarry dewatering. The research has not only consolidated existing knowledge on the subject; it has made substantial new advances based on empirical observations and controlled experiments.

Symonds Group Ltd, RMC Aggregates (UK) Ltd & Lafarge Aggregates Ltd (2004) 'The influence of aggregate quarrying in floodplains on flood risk and biodiversity', Unpublished Report, MIST Project MA/1/2/007.

http://www.sustainableaggregates.com/library/docs/mist/l0094_ma_1_2_007.pdf

Keywords: Environment, Ecology, Water, Biodiversity, Surface water

Symonds Travers Morgan (1998) 'Reducing the Effects of Surface Mineral Workings on the Water Environment', Symonds Group. ISBN: 0 9522345 9 9.

Keywords: Environment, Water

Abstract: A guide to good practice on minimising the impact of aggregate extraction on the water environment, within the wider context of sustainability, taking account of recent changes in legislation and planning, as well as new developments in technology.

Tarmac Ltd and Associates (2007) 'Management and Re-use of Quarry Assets', Unpublished Report, MIST Project MA/4/2/019.

http://www.sustainableaggregates.com/library/docs/mist/l0038_ma_4_2_019.pdf

Keywords: Operations, Processing, Waste, Fines

Abstract: The overall purpose of the project is to take a market-led approach in assessing potential uses for fines generated by the quarrying industry either through crushing or washing. Specific potential uses are identified based on the findings from previous work, and the aim is to take these products to market.

Tester, N. (2003) 'Rockfall: Prevention - much better than cure', Quarry Management V.30 Nr.8 p.29-31.

Keywords: Investigations, Geotechnical

Abstract: This article reviews, through a case study of a working quarry in Warwickshire, the rockfall mechanisms and assessment through visual observation and analysis of discontinuities of short, medium and long-term risks. Mitigation methods that have been employed in this case study are described.

The Environment Council (2004) 'Good Practice for Stakeholder Engagement in the Aggregates Sector', Unpublished Report, ALSF SAMP Project SAMP1.019.

http://www.sustainableaggregates.com/library/docs/samp/l0138_samp_1_019.pdf

Abstract: Project aims to promote wider understanding and implementation of good practice community engagement for those involved in all aspects of aggregates operations and planning as well as those affected by those activities.

The Environment Practice (2004) 'Environmental E-Training for the Aggregate Sector', Unpublished Report, MIST Project MA/3/4/002.

http://www.sustainableaggregates.com/library/docs/mist/l0033_ma_3_4_002.pdf

Keywords: Environment, Education

Abstract: Analysis of a research exercise to determine the existing and future environmental skills needs and an evaluation of the perceived value of e-training for the aggregates sector.

The project was in 2 phases - 1) Questionnaire approach to evaluating the environmental training activity and needs of the aggregate industry and the attitude to e-training. 2) Developing and piloting environmental e-training and seeking feedback.

The Environment Practice and North East Centre for Environmental Science and Industry (2005) 'Pocket Guide to Environmental Legislation (England and Wales) for SME Aggregate Companies', Unpublished Report, ALSF SAMP Project SAMP2.33.

http://www.sustainableaggregates.com/library/docs/samp/l0014_samp_2_33.pdf

Keywords: Operations, Environment, Water management, Geoconservation, Ecology, Water, Soils, Information Sources

Abstract: This guide provides a quick reference that summarises the requirements of relevant key environmental legislation. The Introduction includes summaries on enforcement, the role of the regulatory authorities, and environmental management systems. In the remainder it covers all the topics expected to affect aggregate SMEs in England and Wales in 14 sections viz.: pollution control, soil handling, waste and duty of care, mineral wastes, hazardous wastes, packaging waste, landfill operations, water and effluent, oil storage, contaminated land, emissions to the air, statutory nuisance, wildlife and nature conservation and development controls.

There is also a section on additional relevant legislation and another giving useful tools which includes a set of compliance checklists for each of the sections, guidelines on enforcement and prosecution, and a list of useful web addresses.

The pocket guide and the associated SAMP research report are available as downloads from the dclaggregatesfund web site.

The Friends of Ludlow Museum 'A Museum Resource Centre for Shropshire - fulfilling the potential', ALSF Third objective 'legacy' site project.

Keywords: Environment, Education

The Institution of Mining and Metallurgy (2001) 'Code for Reporting of Mineral Exploration Results, Mineral Resources and Mineral Reserves (The Reporting Code)'.

http://www.geolsoc.org.uk/~/media/shared/documents/Fellowship/UK_Euro%20Reporting%20Code.ashx

Keywords: Feasibility

Abstract: The 'Reporting Code' sets out minimum standards, recommendations and guidelines for Public Reporting of Mineral Exploration Results, Mineral Resources and Mineral Reserves in the United Kingdom, Ireland and Europe

The Landscape Institute 'Landscape Institute', Web Site.

http://www.landscapeinstitute.org/

Keywords: Environment, Landscape

Abstract: The Landscape Institute is the Royal Chartered body for landscape architects in the UK..

The Royal Society for the Protection of Birds (2007) 'The RSPB', Web Site.

http://www.rspb.org.uk/

Keywords: Environment, Ecology, Fauna

Abstract: The RSPB is the UK charity working to secure a healthy environment for birds and other wildlife

The Till-Tweed Project 'Till-Tweed Catchment Aggregates and Archaeology Project', Historic Environment Enabling Programme 3325.

http://archaeologydataservice.ac.uk/archives/view/tilltweed_eh_2010/

Keywords: Investigations, Surveys, Environment, Archaeology, Landscape, Education

Abstract: Geomorphological mapping and archaeology survey research to develop the capacity to manage the impact of aggregrate extraction.

The key aims of the project are to:
1. Acquire archaeological and geomorphological information to characterise the land-use history of the Till-Tweed catchment.
2. Set up digital maps containing all of the archaeological and geomorphological information which can then be used to assist in managing current and future aggregate extraction, thereby reducing the impact on the historic environment.
3. Provide opportunities for the public to get involved with the project and to provide archaeological interpretation and learning opportunities.

The web link provided is to a more recent (2010) document

The Wildlife Trust for Bedfordshire, Cambridgeshire, Northamptonshire and Peterborough 'Restoring Biodiversity', ALSF Third objective 'legacy' site project.

Keywords: Environment, Ecology, Biodiversity

Thomas, Ian (ed) (2004) 'Potential for educational use of aggregate sites', Unpublished Report, MIST Project MA/2/4/002.

http://www.sustainableaggregates.com/library/docs/mist/l0129_ma_2_4_002.pdf

Keywords: Environment, Education

Abstract: Study of opportunities presented by the quarrying industry for wide-ranging public education programmes. Contains a review of available information, policies and initiatives in education and industry, pertinant research findings and practical guidance.

Thompson, A et al. (2004) 'The Sustainable Use of High Specification Aggregates in England (The Sustainable Use of High Specification Aggregates forSkid-Resistant Road Surfacing in England)', Unpublished Report, ALSF SAMP Project SAMP1.039.

http://www.sustainableaggregates.com/library/docs/samp/l0057_samp_1_039.pdf

Keywords: Feasibility

Abstract: High specification aggregates used for the construction of skid-resistant road surfacing are relatively rare and can only be obtained in limited areas. They are often transported long distances for use in areas which do not have sources of suitable material. This report examines their current use in England and highlights the sustainability issues involved.

Thompson, R.J. & Visser, A.T (1999) 'Management of unpaved road networks on opencast mines', Transportation Reserch Record Nr.1652 p.217-224.

Keywords: Design, Haul roads

Thompson, R.J. & Visser, A.T (2000) 'The functional design of surface mine haul roads', Journal of the South African Institute of Mining and Metallurgy V.100 Nr.3 p.169-180.

Keywords: Design, Haul roads

Thompson, R.J. & Visser, A.T (2001) 'Mine Haul Road fugitive dust emission and exposure characterisation', Journal of the South African Institute of Mining and Metallurgy.

Keywords: Design, Haul roads

Treleven, C & Bond, D (2005) 'How does a quarry operate? Practical training on minerals operations that give rise to environmental impacts', Unpublished Report, MIST Project MA/4/4/009.

http://www.sustainableaggregates.com/library/docs/mist/l0042_ma_4_4_009.pdf

Keywords: Environment, Education

Abstract: A need was identified to help new staff of local authorities and statutory bodies to:

i) Understand how a mineral quarry works; and then
ii) Be able to learn from the experiences of quarry management and staff on how they manage these sites.

A training course was developed from October 2004 onwards with support and input from quarry industry stakeholders. Four training courses were run at 4 quarry sites in England in May 2005.

The courses consisted of a comprehensive site tour conducted by quarry staff followed by an afternoon training session jointly run by C4S and the local quarry staff. The courses covered issues such as the new Mineral Policy Statement 2 (MPS2) and changes to the environmental statutory bodies undertaken by the Government.

TRL Ltd (2004) 'Techniques for effective strategic environmental assessment for local aggregates planning. Review of predictive techniques for the aggregates planning sector', Unpublished Report, MIST Project MA/2/1/004.

http://www.sustainableaggregates.com/library/docs/mist/l0003_ma_2_1_004.pdf

Keywords: Planning, Assessment

Abstract: Review of predictive techniques that could be used at local mineral planning level with recommendations on factors that may need consideration to widen their use.

UK BAP (2006) 'UK Biodiversity Action Plan Web Site', Web Site.

http://jncc.defra.gov.uk/ukbap

Keywords: Environment, Ecology, Biodiversity, Information Sources

Abstract: This website describes the implementation of the UK Biodiversity Action Plan (UK BAP) on behalf of the UK Biodiversity Partnership and the UK Government. It is possible to examine local Biodiversity Action Plans by species, habitat or location. Further information on the geographical coverage, partner organisations and funding of BAPs is given together with much detailed information.

In March 2011, as part of the UK government's review of websites, the UK BAP site was 'closed', and the core content was migrated into the JNCC website

University College London 'Impact of Aggregate Extraction on the Historic Environment', Historic Environment Enabling Programme 3555MAIN.

Keywords: Environment, Landscape, Archaeology, Traffic, Noise and Vibration

Abstract: The expansion of aggregates extraction and transportation over the last 40 years has led to an increase in its impact on historic sites and buildings in England's villages and towns. This proposal will develop a methodology to investigate the impact and provide guidance on ways in which it can be better managed. Through a combination of desk based research, field measurement campaigns and use of geographical information systems the project will investigate the impact and range of physical factors such as noise, vibration and dust on the historic environment. The project will involve consultation with heritage managers, quarry operators and the public.

University of Bradford 'Identifying the potential and threats to the archaeology of areas of inland coversands', Historic Environment Enabling Programme 3548.

Keywords: Environment, Archaeology

Abstract: Assessment of the extent of blown sand deposits and their archaeological potential

University of Exeter, Department of Geography and Archaeology 'Aggregate Extraction Related Archaeology in England: a survey', Unpublished Summary, Historic Environment Enabling Programme Project 3350MAIN.

Keywords: Environment, Archaeology

Abstract: The report seeks to present the achievements of aggregate-related archaeology in England both before and after PPG16, assess regional variation and review environmental aspects of this work. In addition it seeks to provide a forward look at aggregate related archaeology using policies and data provided by the UK Government and Unitary Authorities, largely through County-based Local Mineral Plans.

University of Exeter, Department of Geography and Archaeology (2004) 'Archaeology and Archaeological Potential of Aggregate Deposits in SW England', Unpublished Report, ALSF Research Project.

Keywords: Environment, Archaeology

Abstract: Aggregates Levy Sustainability Fund research project (with English Heritage as the delivery partner) to re-evaluate the aggregate-based archaeological resource of SW England to move towards comparison with other parts of the UK.

No final report published as of December 2006

University of Hull 'Understanding water table dynamics & their influence on the buried archaeological resource in relation to gravel extraction', Unpublished Summary, MIST Project MA/4/2/015.

http://www.sustainableaggregates.com/library/docs/mist/l0086_ma_4_2_015.pdf

Keywords: Operations, Environment, Excavation, Water, Ground water

Abstract: Project to:

* Assess the parameters necessary for the generation of accurate data in relation to water table dynamics and the modelling of water tables in relation to aggregates extraction.
* Integrate additional information such as redox potential, pH and palaeoenvironmental assessment to determine the nature of the impacts of dewatering during extraction and quantify the likely effects over time on the buried archaeo-environmental resource.
* Synthesis of the data generated in order to provide meaningful insights into best practice approaches towards the goal of in situ preservation, mitigation and management of the historic resource in wetland/waterlogged contexts.

University of Leeds 'Feasibility project into the use of electronic detonators to control vibration from blasting', Unpublished Report, MIST Project MA/3/2/003.

http://www.sustainableaggregates.com/library/docs/mist/l0032_ma_3_2_003.pdf

Keywords: Investigations, Environment, Noise and Vibration, Blasting

Abstract: Project aimed at determining the influence that firing times have on the resulting vibration signal and to determine if it is possible to reduce said vibrations by use of very accurate delay detonators.

University of Leeds 'Development of a standard operational blasting database for use within the mineral industry', Unpublished Report, MIST Project MA/2/4/005.

http://www.sustainableaggregates.com/library/docs/mist/l0029_ma_2_4_005.pdf

Keywords: Operations, Excavation, Blasting

Abstract: Project to develop a blasting database system to meet the needs of the minerals industry with the addition (through analysis of data supplied by industrial partners) of design and inclusion of a new method for statistically quantifying blasting data variations

University of Leeds 'Yorkshire Quarry Arts: arts-science collaboration towards improved public perception', Unpublished Report, MIST Project MA/4/4/010.

http://www.sustainableaggregates.com/library/docs/mist/l0130_ma_4_4_010.pdf

Keywords: Environment, Education, Art

Abstract: A project to increase interaction with local communities during the planning, design and operation of mineral workings. The main aim of the proposed project is to use science-art interaction to improve pubic perception and knowledge of quarries and quarrying activity. This will be done through a series of activities in which teams of scientists and artists will collaborate. These activities will lead to exhibitions, performances, educational workshops and publications that will present quarries and quarrying activities in a more favourable light than that which is presently the common public perception.

University of Leeds (2003) 'Open access website for promoting good environmental practice in the UK minerals industry', Unpublished Report, MIST Project MA/2/4/004.

http://www.sustainableaggregates.com/library/docs/mist/l0077_ma_2_4_004.pdf

Keywords: Environment, Ecology, Biodiversity, Air, Air quality, Blasting, Operations, Waste, Noise and Vibration, Planning, Reclamation, Restoration, Water, Landscape, Traffic

Abstract: University of Leeds led project to develop a website which is open access and intended for all who have an interest in measures taken to minimise the environmental impact of surface mineral workings. These include quarries, gravel and clay pits and opencast coal mines.

Engineers, planners and managers in the minerals industry will find it a useful resource when considering how to incorporate good environmental practice into quarry design and operation.

This Web site should also be useful to the public who have a particular interest in quarrying, and the authorities who regulate them. Measures which can be taken to minimise the impact and the level of disturbance associated with mineral working are addressed in considerable detail.

University of Leeds (2004) 'Open Access website for promoting good environmental practice in the UK minerals industry', Unpublished Report, ALSF SAMP Project SAMP1.023.

http://www.sustainableaggregates.com/library/docs/samp/l0081_samp_1_023.pdf

Keywords: Environment, Education, Operations

Abstract: The University of Leeds led this project to develop a major new national resource for the UK aggregates sector. The project received co-funding from the Minerals Industry Sustainable Technology Programme (MIST) and the ODPM ALSF Programme and has delivered a comprehensive environmental good practice data library that is fully accessible to all organisations and individuals through an open access website. The facility provides for the first time a 'one-stop-shop' from all parties with an interest in the UK aggregates industries.

The principal deliverable is the website which can be accessed at www.goodquarry.com . This URL gives full access to the information resource. The website covers the effects of Air Pollution (Dust & Odour), Blasting, Cultural Heritage, Ecology, Mineral Wastes, Noise, Restoration & Rehabilitation, Social & Community, Traffic, Visual & Landscape Amenity, and Water. It also contains a series of case studies as well as a detailed list of references and comprehensive glossary.

University of Leicester 'Aggregate specification simulation to optimise waste utilisation', Unpublished Report, MIST Project MA/3/2/001.

http://www.sustainableaggregates.com/library/docs/mist/l0030_ma_3_2_001.pdf

Keywords: Operations, Excavation, Processing, Waste, Feasibility

Abstract: Project involved the development of new software to allow sand and gravel sites to be evaluated and planned in such a way as to minimise waste. Novel calculation methods were created to allow yields, coproduction of products and a better assessment of process sand gradings to be undertaken.

University of Leicester (2004) 'Sand and gravel aggregate deposits - improved characterisation technology (ADICT)', Unpublished Report, MIST Project MA/3/2/002.

http://www.sustainableaggregates.com/library/docs/mist/l0031_ma_3_2_002.pdf

Keywords: Geology, Investigations, Surveys, Investigation methods, Quality testing, Geotechnical, Drilling, Operations, Excavation, Waste, Feasibility

Abstract: University of Leicester, Tarmac and MIRO undertook a programme of collaborative research based on improving the characterisation of sand and gravel deposits to ensure maximum utilisation of resources and minimise waste.

University of Leicester (2004) 'Feasibility study for application of new integrated technology to the detection, delineation and characterisation of archaeological sites with potential for mineral development', Unpublished Report, MIST Project MA/3/1/001.

http://www.sustainableaggregates.com/library/docs/mist/l0114_ma_3_1_001.pdf

Keywords: Investigations, Investigation methods, Environment, Archaeology

Abstract: Project aimed to test a multi-sensor platform geophysical survey system to establish the ability of the system to collect high quality data in a fast and cost-efective manner. The system was tested by performing a deep penetration electromagnetic survey at Bull's Lodge sand and gravel deposit and by carrying out a magnetic survey of archaeological structures at the Roman town of Wroxeter.

The project demonstrated the versatility of the multi-sensor platform and its ability to acquire rapid, high-quality data in different environments.

University of Liverpool & OA North 'Aggregate extraction in the Ribble Valley', Unpublished Report, Historic Environment Enabling Programme Project 3928MAIN.

http://archaeologydataservice.ac.uk/archives/view/ribble_eh_2007/

Keywords: Environment, Landscape, Archaeology

Abstract: This report presents the results of the ALSF Ribble Valley Aggregate Extraction project, which was a study of the aggregate and archaeological potential of the Lower and Upper Ribble Valley.

The geomorphological objectives of the project were to collate evidence on all past and present aggregate extraction, produce revised estimations and mapping of suitable resources for future extraction, and produce mapping of present and future geomorphological change. The archaeological objectives were to collate evidence for all
archaeological activity and, by the means of an exhaustive survey of LiDAR, aerial
photography, field survey and other methods, find new archaeological sites and assess the potential for sites within areas of potential extraction.

The data were assimilated into a GIS system, which was integral to the project, and the archaeological data and geomorphic data were subject to spatial analysis to provide an assessment of the areas of greatest potential for each element.

University of Manchester Archaeology Unit & Groundwork Rossendale 'Rossendale Quarries & Tramways Heritage project'.

Keywords: Environment, Landscape, Archaeology, Education

Abstract: The Rossendale Quarries and Tramways project aims to encourage local people and visitors to appreciate and enjoy Rossendale's legacy of Quarries and Tramways. This heritage includes the social, environmental and economic impacts of this once great local industry.
English Heritage are funding the initial phase of this work which will record and assess Rossendale's Quarry and Tramway Heritage sites and features. Recommendations as to conservation and restoration will also be made.
The archaeological work is currently being undertaken by the University of Manchester Archaeology Unit by means of desk based assessment, field inspections and walk over surveys.
The information thus provided will allow an implementation and restoration plan to be produced and form the basis of work with local schools, interests groups and visitors.

University of Newcastle (2004) 'The hydrogeological behaviour of flooded sand and gravel pits and its implications for the functioning of enclosing aquifers', Unpublished Report, MIST Project MA/1/2/005.

http://www.sustainableaggregates.com/library/docs/mist/l0023_ma_1_2_005.pdf

Keywords: Environment, Water, Ground water

Abstract: Objectives of report: collate previous data concerning the test sites. Analyse data to determine the likely presence of blinding of the floors and walls of abandoned sand and gravel pits. Groundwater modelling of selected sites to investigate the relationship between the pits lakes and the enclosing aquifers. Measure the permeability of pit floors and walls using mini-piezometers.

University of Nottingham (2005) 'Cleaner quarries: methods to reduce the environmental impact of quarry operations', Unpublished Report, MIST Project MA/4/1/002.

http://www.sustainableaggregates.com/library/docs/mist/l0078_ma_4_1_002.pdf

Keywords: Environment, Air, Dust

Abstract: The project examined the effects of dust in the mineral industry, legislation, health issues different types of dust and approaches to studying and dealing with it including dust monitoring, dispersion modelling and practical dust suppression methods.

University of Sheffield (2004) 'Reclamation Planning in Hard Rock Quarries: A Guide to Good Practice', Unpublished Report, ALSF SAMP Project SAMP1.034.

http://www.sustainableaggregates.com/library/docs/samp/l0126_samp_1_034.pdf

Keywords: Reclamation

Abstract: Provides guidance on appropriate methodology for the planning of reclamation, including the formatiion of new landscape features, long-term stability, after-use and after-care. Based on detailed observations of landscape features and settings, vegetation and stability conditions at 25 hard rock quarries in England.

Wakes, N (2000) 'The Community Planning Handbook: How People Can Shape Their Cities, Towns and Villages in Any Part of the World', Earthscan. ISBN: 1853836540.

Keywords: Planning

Abstract: Features an accessible how-to-do-it style, with tips, checklists and sample documents to help readers get started quickly, learn from others' experience and select the approach best suited to their situation. The glossary, bibliography and contact details lead to further resources and information. This handbook is essential for all those involved in shaping their local environment - planners, architects, community workers, local authorities and residents.

Walls, Richard et al. (2004) 'Developing Policy & Best Practice in Relation to Restoration Following Minerals Extraction: Resolving Conflicts with Aviation', Unpublished Report, ALSF SAMP Project SAMP1.015.

http://www.sustainableaggregates.com/library/docs/samp/l0125_samp_1_015.pdf

Keywords: Reclamation, Restoration, Environment, Ecology, Traffic, Biodiversity, Fauna

Abstract: Literature review undertaken to assess whether information regarding a range of restoration strategies for ex-mineral sites could be compiled to identify the risk to aviation arising from the resulting bird populations present on these sites. This was followed by a radar study of avian movement at Cotswold Water Park - RAF Fairford, Glos.; an analysis of waterbody characteristics and bird populations; and finally, a modelling of bird-aircraft strikes in relation to airfield type and surrounding land use.

Walton, G et al. (2004) 'Secure and Sustainable Slopes for Quarry and Geological Conservation', Unpublished Report, ALSF SAMP Project SAMP1.020, Evenlode Books. ISBN: 0897766882.

http://www.sustainableaggregates.com/library/docs/samp/l0056_samp_1_020.pdf

Keywords: Design, Reclamation, Slope design, Restoration, Excavated slopes, Fill slopes and tips

Abstract: Handbook deals with the need for, and methods of obtaining, secure and sustainable final slopes in SME quarries. Issues and interested parties are noted, including stability, the HSE, mineral planning authorities, English Nature and local interest groups. Different quarry types and their settings are outlined. General approaches to slope treatment are discussed. Stability and safety of slopes are mentioned in regard to different quarry after-uses. A review of planning, design, construction and management of final quarry slopes is given, as is advice of slope features.

Walton, G. & Brook, D. (1987) 'Guidelines for designing and inspecting excavated quarry slopes', Planning and engineering geology (Culshaw, M.G., Bell, F.G., Cripps, J.C. and O'Hara,M. Eds) Engineering Geology Special Publication Nr.4 p.397-459, Geological Society of London.

Keywords: Design, Slope design

Abstract: These guidelines identify the steps that need to be followed when designing and examining slopes and include a template for a report form that could be used for statutory daily inspections. The guidelines focus on slope stability at quarry boundaries and the inspection of and assessment of existing quarry slopes and are intended for use by operators and MPAs.

Walton, G. (1995) 'Landform replication in quarry design', Quarry Management V.22 Nr.3 p.47-52.

Keywords: Design, Reclamation, Slope design, Restoration, Excavated slopes, Environment, Landscape

Abstract: This review of landform replication describes slope replication and the larger scale landform replication in plan. It considers the process in its application to quarries in chalk, limestone and placated areas and also discusses the issues of reserve loss, rockfall and slope stability. The article includes typical geomorphological and landform replication plans.

Wardrop, D. R. (2002) 'Landscape replication in the Welsh Valleys: the extension of Hafod Quarry. In: Scott, P. W. and Bristow,C.M. (eds), Industrial minerals and extractive industry geology', Combined 36th Forum on the Geology of Industrial Minerals and 11th Extractive industry Geology Conference, Bath, England, 7th-12th May, 2000 p.275-281.

Keywords: Reclamation, Environment, Restoration, Landscape

Abstract: Describes the application of landscape replication to a hard rock quarry in which excavation is proceeding to a replication design.

Warwickshire Wildlife Trust 'Action for Wildlife in Warwickshire - Warwickshire', ALSF Third objective 'legacy' site project 2002/118.

Keywords: Environment, Ecology, Fauna

Watkins, M. S. & Smith, M. R. (ed) (2004) 'Environmental Management', Institute of Quarrying, Nottingham.

Keywords: Environment, Geoconservation, Water, Archaeology, Air, Noise and Vibration, EIA, Operations, Waste

Abstract: This book provides an up-to-date description of all the different areas that require attention to minimise deleterious impacts of quarrying on the environment. These are dealt with in the fourteen separate chapters viz.

1. Environmental management systems
2. The protection and management of water resources
3. Air quality: impacts, monitoring and controls
4. Traffic
5. Identification, assessment and mitigation of visual impacts due to quarrying
6. Environmental impacts of quarry blasting
7. Environmental noise
8. Biodiversity
9. Geological conservation
10. Waste management
11. Energy management
12. Archaeology
13. Contaminated land
14. Recycling - aggregates from a sustainable source

Waverley Borough Council 'Farnham Biodiversity Project', ALSF Third objective 'legacy' site project.

Keywords: Environment, Ecology, Biodiversity

West Sussex County Council 'Extracting the Best: Biodiversity Handbook for quarry managers and staff - West Sussex', ALSF Third objective 'legacy' site project 2004/420.

Keywords: Environment, Ecology, Biodiversity

Abstract: Summary guidelines of West Sussex mineral sites BAP for site managers and operational staff.

Worcestershire Historic Environment and Archaeology Service, Worcestershire County Council 'Retreat Farm Quarry, Grimley, Worcestershire'.

Keywords: Environment, Landscape, Archaeology, Operations, Excavation

Abstract: Ongoing quarrying operations at Retreat Farm, Grimley (centred on NGR SO 8320 5970) form part of an extensive area of gravel workings on the western side of the River Severn, north of Worcester. Over the past thirty or so years these have led to the destruction of the large majority of a significant cropmark complex of which only a few small areas have been subject to archaeological investigation. A number of islands of the complex still survive either protected by scheduling (SAM H&W 209) or awaiting extraction under old permissions for which either no, or very limited, archaeological provision were made.
Worcestershire Historic Environment and Archaeology Service have been commissioned by English Heritage through the Aggregates Sustainability Levy to undertake a project on one of these sites, lying towards the southern extents of the cropmark complex. Here, at Retreat Farm, Tarmac Western Limited have an extant, pre-PPG16, permission for sand and gravel extraction. Much of the permitted area has already been quarried but some 20ha remains.

Worcestershire Historic Environment and Archaeology Service, Worcestershire County Council (2003) 'Land south-west of Ripple, Worcestershire'.

Keywords: Operations, Excavation, Environment, Archaeology

Abstract: This project relates to a planned programme of mineral extraction by RMC Aggregates (Western) Limited who have an outstanding, pre-PPG 16 planning permission for the extraction of sand and gravel at this site which covers some 52ha of land on the eastern side of the River Severn. This is an area of prime concern in terms of the remaining pre-PPG16 aggregate extraction permissions within Worcestershire.
The broad aims of the project are to provide sufficient information to:
Assess the potential significance of any archaeological remains and the built heritage;
Assess the impact of the proposed development on these archaeological remains and the built heritage;
Recommend mitigation measures to offset any detrimental effects of the development on the archaeological resource (in line with current development control practice as identified by PPG16 and incorporated within the Minerals Local Plan);
Inform the local population of the archaeological resource within the parish.
The desk-based assessment will lead to production of a report and updated project design. This will assess the significance and character of any archaeological site, or sites, which might be identified and present proposals for further work as appropriate.

The project will also support the development of an understanding of the overall threat which mineral extraction poses to the archaeological resource within the county and inform the development of an appropriate mitigation strategy for the development.

World Conservation Union and International Council on Mining and Metals (2004) 'Integrating Mining and Biodiversity Conservation: case studies from around the world', IUCN Publications. ISBN: 2-8317-0849-4.

http://www.icmm.com/document/4

Keywords: Environment, Ecology, Biodiversity

Abstract: This publication includes examples of work done on biodiversity conservation by Alcoa, Anglo American, BHP Billiton, Freeport McMoRan, the Mining Association of Canada, Noranda, Rio Tinto, and WMC Resources Ltd. and their experiences with biodiversity conservation in various parts of the world are well covered too, with case studies from Australia, Brazil, Canada, Chile, Indonesia, Kyrgyzstan, Madagascar, and South Africa