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Technical solutions for mining and processing of aggregates and the mining sites after-use

A Cleaner Production Guideline for Vietnam

MAREX Publication Series – Issue 3

IMPRINT

Technical solutions for mining and processing of aggregates and the mining sites after-use –
A Cleaner Production Guideline for Vietnam

Results of the project MAREX: Management of Mineral Resource Extraction in
Hoa Binh Province – a Contribution to Sustainable Development in Vietnam (2015-2018)

Supported by BMBF, Grant Code FKZ 033R122A

Issue 3

Internet: www.marex-project.de

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Editorial deadline August 2018

ISBN 978-3-933053-39-8

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A Cleaner Production Guideline for Vietnam

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1. Introduction

1.1 Objective of the Guideline

The formulation of Cleaner Production Concepts (CPC) is based on ideas discussed at the 1992 Conference on Environment and Development in Rio de Janeiro. The basis of CPC is the approach of a sustainable, integrated and systematic environmental protection strategy that focuses on processes, products and services. The aim is not only to improve environmental protection but also to raise sustainability by reducing ecological risks through positive economic and social factors while mitigating production factors with a negative environmental impact. CP is an important method for the development of cycle management at the level of strategic company positioning, and includes measures for product-integrated environmental protection (i.e., resource efficiency) and production-integrated environmental protection (i.e., the production process, including health and safety issues).

CP means: "… the continuous application of measures for design improvement, utilization of clean energy and raw materials, the implementation of advanced processes, technologies and equipment, improvement of management and comprehensive utilization of resources to reduce pollution at source, enhance the rates of resource utilization efficiency, reduce or avoid pollution generation and discharge in the course of production, provision of services and product use, so as to decrease harm to the health of human beings and the environment." (UNEP, 1993). CP is considered as an important method at the level of strategic business positioning for the development of the circular economy.

1.2 Flow Scheme of Building Material Production in Vietnam

The flow scheme of building material production in Vietnam is given in figure 1. The guidance document is structured following the steps of the flow scheme.

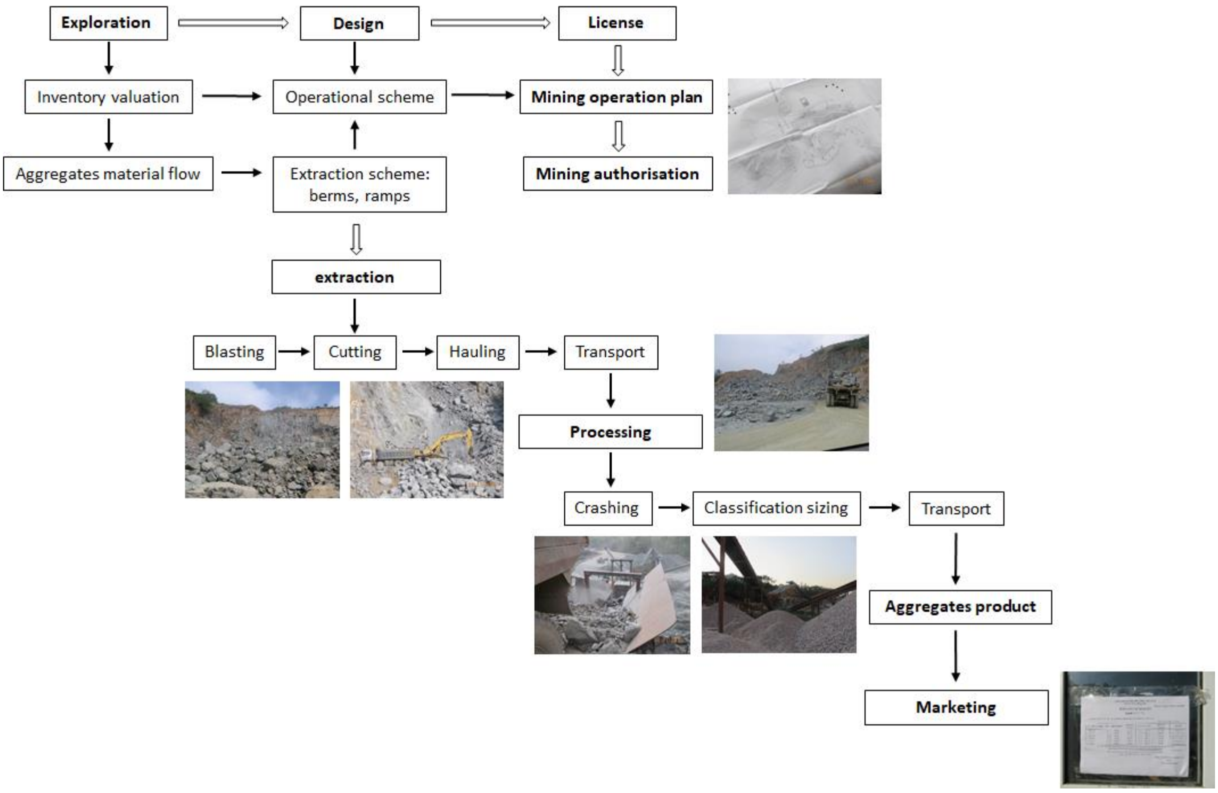

Figure 1: Overview on the flow scheme of building material production in Vietnam (source P. Schneider et al. 2018)

Currently, Vietnamese mining companies focus on occupational health and safety. The need for improvement requires practicable approaches for the environmental assessment along the value-added chain "building material mining – transport – distribution – construction site – buildings".

1.3 Structure of the Guideline

Following the flow scheme in Figure 1 the Guideline has the following parts:

Issue	Objectives	Guideline reference
Quarry Design	Checklist for site design and planning.	3.1
Operational Management		
Preparatory Works	To prepare the quarry site in a safe and resource efficient way.	4.1
Drilling and Blasting	To perform drilling and blasting of the quarry site in a safe and resource efficient way.	4.2
Extraction	To perform extraction works of the quarry site in a safe and resource efficient way.	4.3
Processing	To perform processing works of the quarry site in a safe and resource efficient way.	4.4
Environmental Management		
Topsoil management	To protect the regenerative capacity of the natural topsoil.	5.1
Landform design	All landforms on the site should be safe and stable.	5.2
Control of noxious weeds, pest animals and plant disease (Invasive species)	To ensure that the working of the quarry does not lead to the spread or proliferation of noxious weeds, plant disease and pest animals.	5.3
Drainage and erosion control	To minimise erosion and turbid water impacts offsite.	5.4
Water storage and discharge control	To ensure that all discharges from the site are free of sediment and other pollutants.	5.5
Groundwater	To meet groundwater quality objectives and to minimise any environmental impact on the quality of groundwater.	5.6
Slimes management	To manage the disposal and rehabilitation of slimes in order to minimise the risk to public safety and the environment.	5.7
Fire management	To ensure that the quarrying activities do not contribute to, or exacerbate, fire hazards.	5.8
Hazardous materials management	To manage the storage, use and handling of hazardous materials to minimise the risk of environmental harm.	5.9
Noise	To avoid the quarry being a source of nuisance noise to surrounding land users and people.	5.10
Dust control	To avoid dust impacting on surrounding land users and people.	5.11
Visual management	To ensure that the quarry is not visually intrusive.	5.12
Community	To inform and engage the community regarding the operation of the quarry.	5.13
Rehabilitation		
Progressive rehabilitation	To efficiently and effectively rehabilitate the quarry.	6.1
Earthworks	To reconstruct the landform to be compatible with the surrounding landscape and to prepare the ground for revegetation.	6.2

Issue	Objectives	Guideline reference
Erosion prevention	To minimise erosion of final landforms.	6.3
Revegetation	To provide a stable self-sustaining cover through revegetation that protects the rehabilitation asset and is consistent with the final land use.	6.4
Monitoring and maintenance	To monitor and maintain the site until the rehabilitation is stable, safe and self-sustaining.	6.5
Decommissioning and Closure		
Final land use of a site	To evaluate final land use options.	7.1
Site clean up	To have a clean site ready for the final land use.	7.2
Final rehabilitation	To implement final rehabilitation measures.	7.3

2. Approval Requirements

2.1 Regulatory Framework

The Mineral Law of 2010 constitutes the main regulatory framework for mineral extraction in the country. The regulatory framework for environmental assessment is the obligation to conduct an Environmental Impact Assessment (EIA) and environmental monitoring.

In Vietnam, aggregates production is governed by the Ministry of Natural Resources and the Environment, under following legal framework:

No.: 45/2016/TT-BTNMT: Regulations on exploration of mineral resources and mining projects, as well as reports on mineral activities and the necessary documents contained in the application for authorization for mineral reserves and demolition procedures, last amended on 26.12.2016 as well as

No.: 26/2016/TT-BCT: Circular letter for the formulation, evaluation and approval of mining investment projects as well as construction programs and cost estimates, as last amended on 30.11.2016.

No. 51/2001/QH10: The Mineral Law of 2010 constitutes the main regulatory framework for mineral extraction in the country. The law requires the preparation of Mineral strategies and master plans.

2.2 Environmental and Other Standards, Recommendations and Directives

Environmental assessment is a method that ensures that environmental effects of decisions are taken into account before the decisions are made. Different environmental assessment approaches are applied in practice, depending if the environmental implications of a plan, project or product shall be considered. Figure 2 gives a general overview on the existing environmental assessment approaches with respect to mining. The respective terms are explained below.

Strategic Environmental Assessment (SEA) is a legal instrument for the environmental assessment of plans and programs. With SEA, potential environmental impacts of a planning can be recognized and taken into account before the plan or program is accepted.

Environmental Impact Assessment (EIA) is an environmental policy instrument of environmental protection with the aim of verifying environmentally relevant projects prior to their approval for possible environmental impacts.

Environmental Management Systems (EMS) is that part of the overall overarching management system, which includes the organizational structure, responsibilities, formal procedures, and means for the implementation of the environmental policy of a company. ISO 14001:2015 specifies the conditions for an EMS that an organization can use to enhance its environmental performance.

Life Cycle Assessment (LCA) is a systematic analysis of environmental effects of products throughout the life cycle. The preparation procedure is laid down in ISO 14040:2006.

Environmental Monitoring (EM) refers to the observation of scientifically relevant areas of the environment and the documentation of ecological parameters. The scientific fields include biology, soil science, chemistry, geography, geology, hydrology, meteorology and physics.

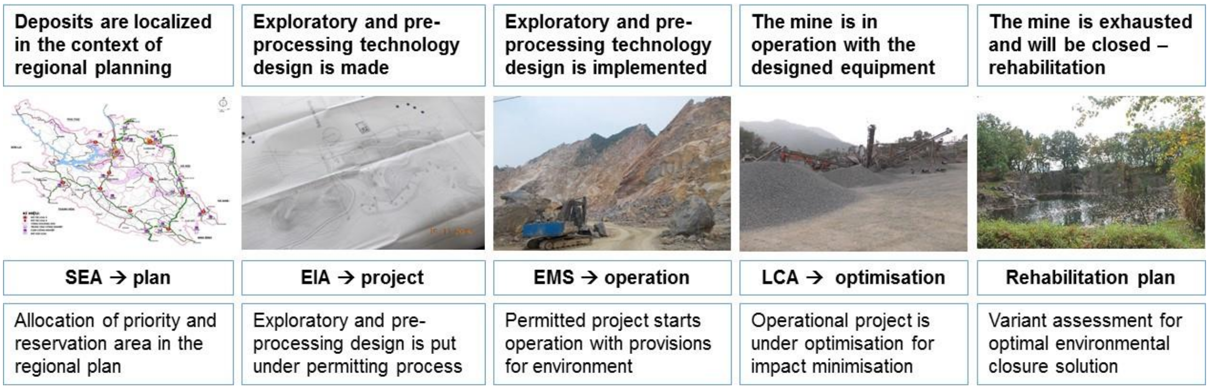

Figure 2: Overview on the existing environmental assessment approaches related to mining activities (source: P. Schneider et al., 2017)

In 1993, with the Decree 175/CP on Providing Guidance for the Implementation of the Law on Environmental Protection (LEP), general requirements for EIA were established. In the Circular letter 490/1998/TT-BKHCNMT on Guidance on Setting Up and Appraising the EIA Report for Investment Projects the specific requirements for EIA have been laid down. Since 2005, with the passing of the revised LEP (current version as of 2014), also SEA is mandatory for a range of national, regional and provincial strategies and plans.

The applicable environmental standards are: QCVN 05: 2013 / BTNMT, QCVN 6649: 2000 AA8800, TCVN 27: 2010 / BTNMT, TC.3733 / 2002 / QD.BYT, QVCN 27: 2010 / BTNMT, QCVN 08: 2008 / BTNMT, QCVN 14: 2008 / BTNMT, QCVN 19: 2009 / BTNMT and QCVN 40: 2011 / BTNMT.

3. Quarry Design

Background

Taking into account the layout of a quarry operation before starting work or opening up new areas the effort required to meet environmental and safety requirements will be significantly reduced in the future.

3.1 Checklist for the organisation and planning of the quarry

Selection of Quarry site

- To ensure that sufficient resources are available in the proposed quarry to make the quarrying site financially viable; including rehabilitation costs.
- To locate a site sufficiently remoted from watercourses to ensure that the cloudy waters are kept out of the watercourse.
- To identify the land use conditions, local planning rules and legislative responsibilities of the promoter and / or land manager; this also includes responsibilities for pests, plant and animal management, heritage, catchment area and environmental protection.

- To analyse of the potential visual impact of a quarry from surrounding and frequently used roads or viewpoints.
- To ensure that all easements are identified and, if necessary, protected.

Minimising disturbance/staging of operations

- To control the erosion by rainwater run-off, increased dust and weed infestation; to minimize the area of disturbed soil at any time during operation of a quarry.

Access roads and road traffic

- To locate the access roads and the quarry access as well as the weighing stations so that they are located away from sensitive land uses.
- To locate the entrance to the quarry so that its function is not visible from public roads (see Figure 3).
- To minimize the track inclines to reduce noise from the use of brakes and / or increased engine power to negotiate inclines, especially when they are fully loaded. A maximum gradient of 1:10 (vertical: horizontal) is generally recommended for transport roads.

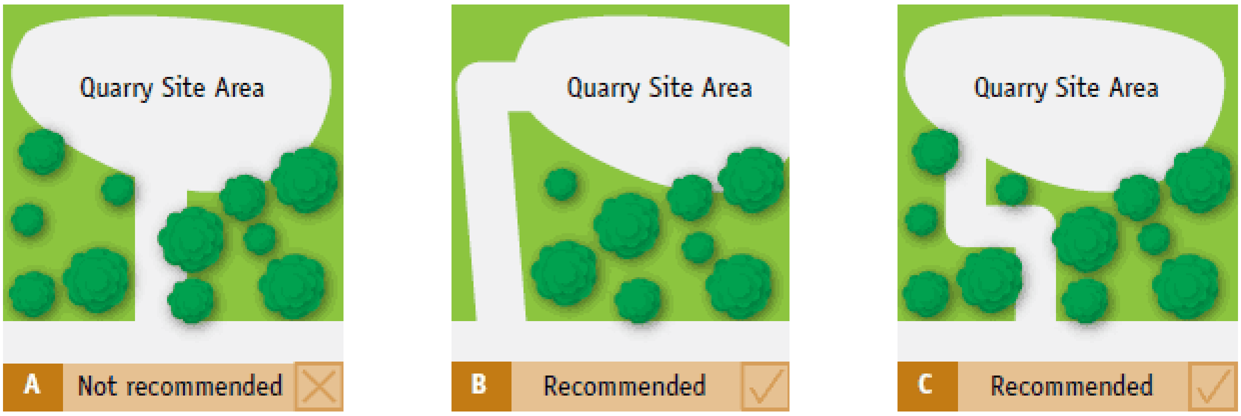

Figure 3: Preferred location of access roads to reduce visual impact (source: Department of Economic Development, Jobs, Transport and Resources. Code of Practice for Small Quarries, 2010)

Drainage

- To construct the roads with sufficient diversion drains and culverts to ensure that clean rainwater is drained from roads.

Weeds

- To identify the harmful weeds and to develop a control plan.

Safety

- Access tracks must be of adequate width.

Plant location

- To ensure that the proposed site of the plant complies with industry standards, municipal planning schemes and legislative requirements.
- To locate a fixed plant with consideration for surrounding sensitive land uses and land use conditions.

- To locate a quarry with consideration of the direction of predominant wind direction. Prevention of the installation of machines that could cause dust nuisance in the case of sensitive land use.
- To consider the constructing bunds to provide barriers to shield from noise, visual impacts and dust.

Planning of the final land use

- To determine the intended future use and final landform of a site at an early stage.
- To ensure that topsoil is stockpiled and appropriately managed so it is suitable for rehabilitation works.
- A plan for drainage works and the final drainage pattern should generally be determined before beginning of the work (see Figure 4).

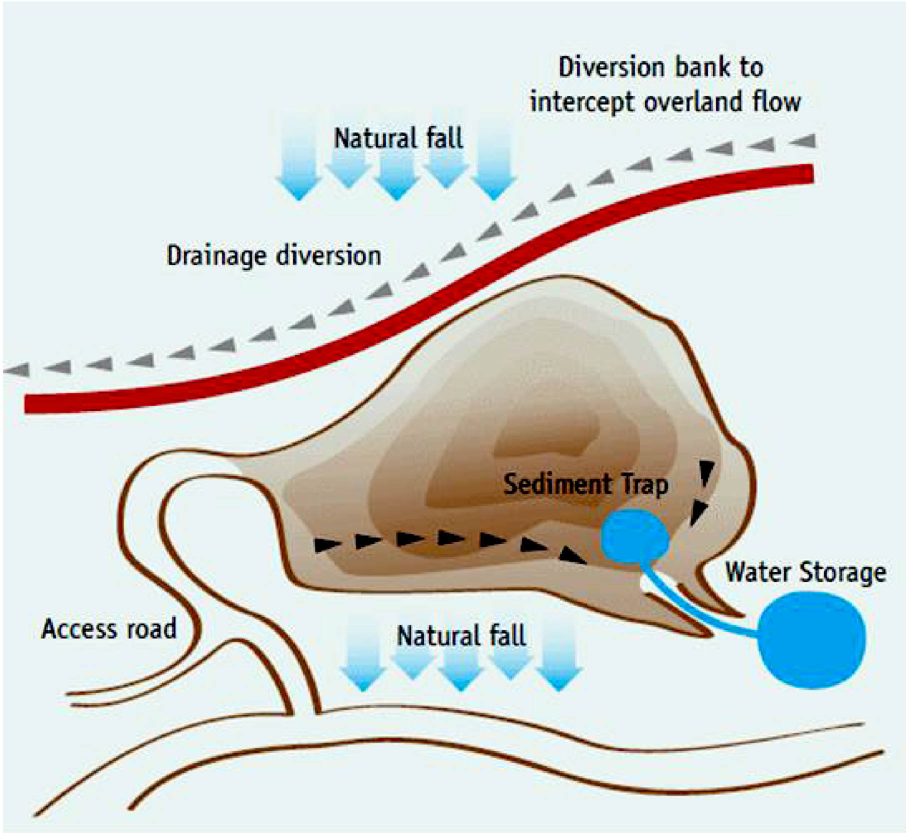

Figure 4: Typical Drainage Plan to Manage Water across the Work Site (source: Department of Economic Development, Jobs, Transport and Resources. Code of Practice for Small Quarries, 2010; Adapted from Quarry Code of Practice, Department of Environment and Primary Industries Water and Environment, Tasmania 1999)

3.2 Design of the quarry, including design of Berms and Benches

It will be necessary to establish the extraction scheme in order to find a sustainable and recultivable form of deposit exploitation. Subsequently, the excavation work is carried out with stock calculation and orientation of the deposit (base, directions, mining methods, extraction, processing). Based on this, the device of access to the work locations and the establishment of the extraction operation can be made. For this purpose, the ancillary operations (workshops, storage areas, transportations, subsidies, ventilation, de-dusting, electrical energy supply, etc.) must also be optimized. The classic process of extracting and processing the raw materials consists of the following steps:

1. drilling and blasting,
2. loading and conveying,
3. crushing by breaking and grinding,
4. moisten or dry,
5. screening by sieving, electro-optical sorting, sedimentation, flotation or electrostatic methods,
6. enrichment by classifying and pelleting.

Berms and benches serve the functionality, the safety, and the manageability of the quarry. On the one hand, they serve as buffer for rockfall to not go down directly to the ground, further they serve the internal traffic and operational management. The design of berms and benches depends on the shape and form of the aggregates resource, and the size of the operational area.

The principal way of progressing the extraction front over a longer period of time is defined as degradation.

Design Aspects of Open Pit Mining:

1. Ultimate pit depth:

This is the maximum depth of the mine that it will reach at the end of its life. This is decided by economic reasons and a breakeven point is decided beyond which it is not economic to continue production.

2. Berm Height:

The height of the berm has to be chosen according to the location of the mine and depends on the drilling and blasting technology to be used. The thickness of the raw material body and its inclination as well as the thickness of the overburden also play a decisive role in the height of the berm. The height of the berm and of the slope depends on:

a) Deposit character and geology: selectivity

b) Production strategy: ore/waste ratios, blending requirements, required work force, operating / capital costs, etc.

c) Slope stability

3. Slope Inclination:

The angles of the slopes and berms are determined by the geological and geotechnical conditions of the over-burden and the raw material body.

4. Overall Inclination of Quarry:

This is also determined by the geotechnical stability of the rocks in the quarry, the height of the berm and inclination of the slopes. The overall inclination of the quarry is always less than the inclination of the slope.

5. Bench Width:

This is usually decided based on the space needed for the operation of the equipment on it.

6. Loading Width & Inclination:

This depends on the operation parameters of the trucks and other transport equipment used in the mine.

3.3 Preparatory Works

Background

Deforestation and preparation works are necessary in order to gain access to raw material sites and / or to reduce raw materials that are stored under forests. For the alignment and device (development) basically two variants are distinguished:

- slope development (slope deposit and mountain deposit)
- plateau development.

Figure 5: Pre-processing and bypassing as well as mining process of a hill deposit (left) (photo source: K.-D. Oswald et al., 2018) and of a slope deposit (right) (photo source: © BAG Basalt-Actien-Gesellschaft)

Objective

To prepare the quarry site in a safe and resource efficient way.

Requirements

The decision to dismantling depends on the concrete deposit content, hence the creditworthiness of the deposit and the future benefit concept in compliance with all environmental laws, determinations and regulations.

Recommended Practice

- exploration of the stockpile stock
- evaluation of raw material-economical aspects
- creation of deposit model (e.g. with data mine)
  - determination of the mining regime
  - setting up a framework operation plan
  - submit for approval
- development concept
- completion operation plan
- decommissioning

3.4 Drilling and Blasting

Recommended Practice

In addition to the direct influence on the operating result by achieving a largely continuous piece of the pile results in an optimum

- borehole diameter and specification (borehole distance) as well
- specific explosives consumption.

Minimizing the consumption of drilling and explosives results in time-consuming and expensive secondary reduction, an increase in drilling effort and the consumption of aerosol means a negative operating result. In principle, the following relationship is shown:

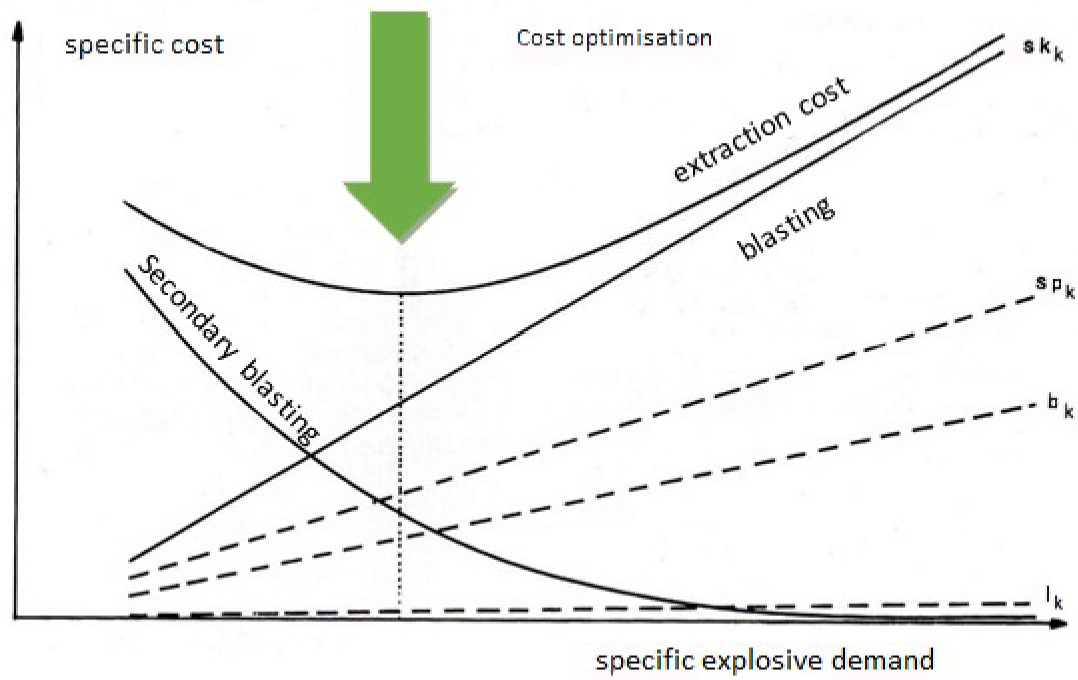

Figure 6: Optimization of the mining costs using the example of the specific explosives expenditures (source: H. Heinze, 1993)

Technically and technologically, the following principal possibilities are distinguished in order to enable an optimal blasting result:

Possible blasting methods with drilling works:

- borehole blasting (drilling depth >12 m)
- single-row or berm blasting (Borehole row by setting parallel to the wall with stope holes)
- multi-row blasting (max. 3 rows in parallel to the berm)
- surface blasting (multi-row blasting)
- (bottom blasting, no longer applied)
- gentle blasting, compaction of the distances, use of powder explosives.

The blasting work is geared to the specific deposit conditions (e.g. avoidance of mixing with adjacent rock, production of an already usable grain size without costly subsequent cost-intensive depositor blasts, environmental requirements such as single-row blasting to avoid larger blast vibrations, etc.).

Transport

Decisive in the design of the transport is the use of the means of transport. Typically, discontinuous resources are used, this means Load Haul Dump Techniques with excavator and removal via heavy trucks to the first crushing plant, then the continuation by means of conveyor belts to the processing (crushing / classification) and production of the saleable end product.

3.5 Excavations Works

Background

Before final determination of the exploration method, it must be decided whether the deposit has the potential to do the extraction works as a surface mining or as a underground mining. Sand and gravel deposits as well as deposits of the stone and earth industry are generally mined in open-pit mining.

Objective

To perform extraction works of the quarry site in a safe and resource efficient way.

Requirements

- The existence of appropriate exploration data (horizontal and vertical extent of the deposit or deposit body)
- The requirements for the required daily, monthly and annual production quantities
- The Clarification of the technical possibilities, the exploration and mining methods for the realization of a "feasibility study" with the determination of the cut-off content and break-even calculation including profitability calculation

Recommended Practice

- After provision of the feasibility study and financial calculation, start of planning stages (preliminary design, detailed design, approval planning)
- Submission of the approval planning to the governmental institutions and approval authorities
- Upon completion of all permits, completion of the planning documents (detailed design)
- Setting up a business plan
- Start of exploration works

3.6 Processing

Background

The effectiveness of the processing depends crucially on the quality of mining extraction. This has to be designed in such a way that a low-loss end product can be produced almost without increased effort.

Objective

Production of saleable end products at maximum minimization of processing losses.

Requirements

To perform processing works of the quarry site in a safe and resource efficient way.

Recommended Practice

- interface mining extraction / processing is the transfer to the crushers (first processing stage of the treatment)
- classifying
- sorting
- provision of end products

4. Environmental Management

4.1 Top soil management

Background

The subsoil and the excavation material have a less value for the greening than the topsoil. The contamination of the topsoil with these materials can reduce their value. They have to be stored separately in order to be able to use them later for the recultivation.

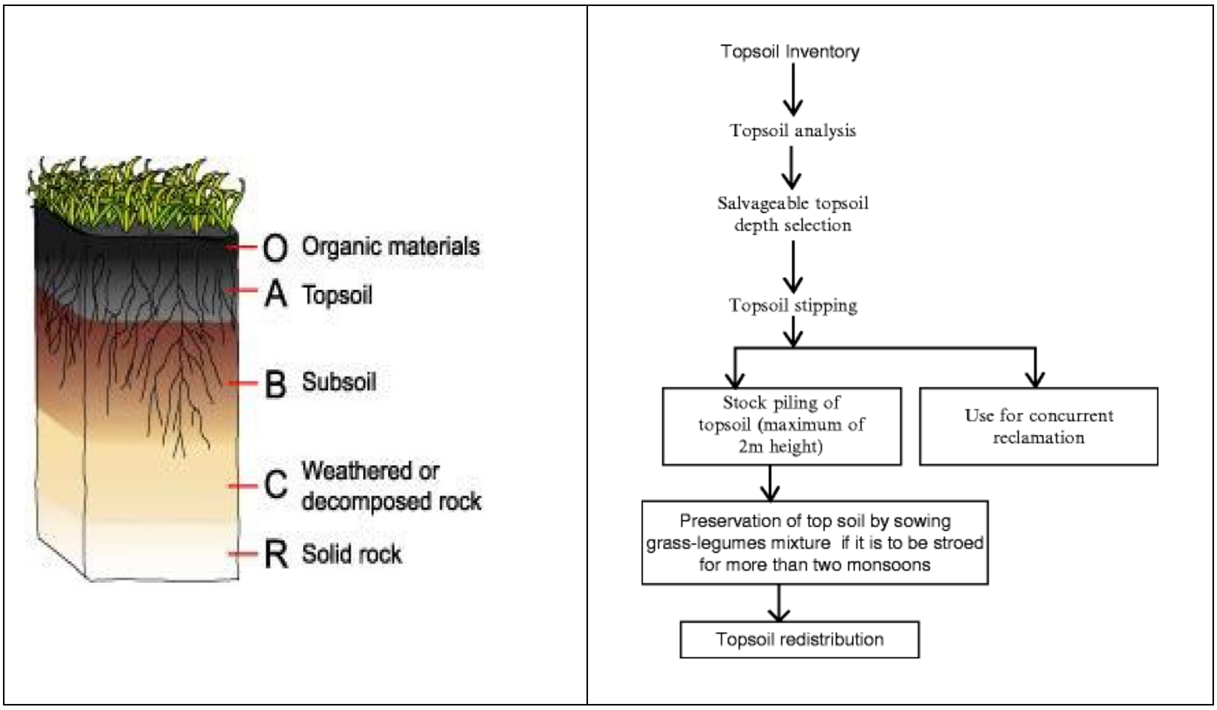

Figure 7: Top soil characterisation (left: Government of Western Australia, cited in New Hope Group Australia, 2014) and management (right: S. K. Maiti 2013)

Objective

To protect the regenerative capacity of the natural topsoil.

Requirements

- At the beginning of excavation works, the mine operator must ensure that topsoil to a depth of 150 millimetres below the natural surface is removed and placed in stockpiles not exceeding two metres in height.

Recommended Practice

- To avoid topsoil removal in case of saturation or dryness
- To minimise the topsoil loss
- To keep topsoils separated from overburden, gravel and other materials
- To protect topsoil stockpiles from erosion
- To avoid the driving of soil stockpiling
- Strategically us of the long-term stockpiles as noise or visual barriers (see figure 7).

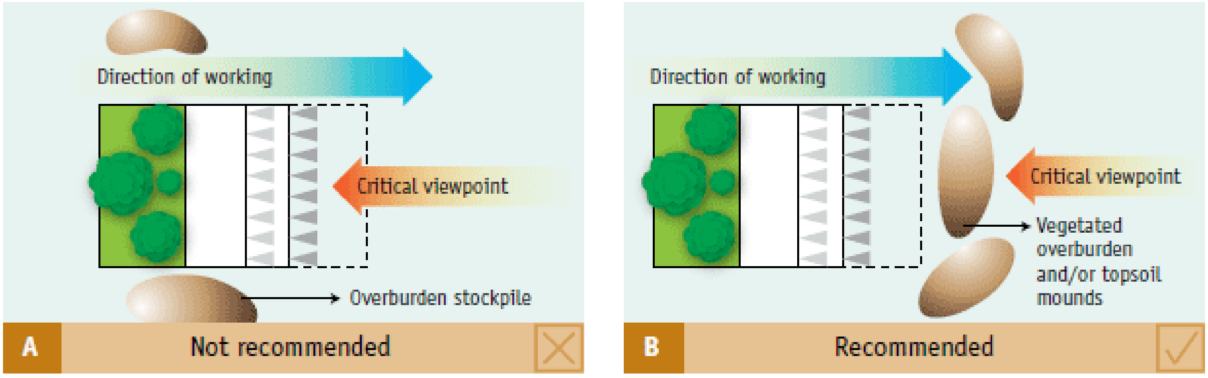

Figure 8: Placement of Overburden for Visual, Noise and Dust Screening (source: Department of Economic Development, Jobs, Transport and Resources. Code of Practice for Small Quarries, 2010, Adapted from Mine Rehabilitation Handbook, Australian Mining Industry Council 1989)

4.2 Quarry landform design

Background

A quarry should be carefully constructed so that the landform poses no slope failure, slumping or collapse risk to employees, the public, or the viability of the operation.

Figure 9: Sample of a quarry design with slopes and berms (source: GWP Consultants Earth and Water Resources, 2018)

Objective

All landforms on a site should be safe and stable.

Requirements

The Mine Operator must ensure that all slopes/ berms including excavations, roads, stockpiles and dumps are designed, constructed and maintained in such a way that the stability is guaranteed for a long time. If there is a significant slope failure event, the Mine Operator must inform this to the regulatory authority.

Recommended practice

- To construct the self-draining berms
- To ensure that the inclinations of the intermediate storage facilities have suitable angles of repose
- The angle of the work surfaces is determined by the nature of material, in general:
    - Clay should have an overall slope no more than 1:1 (vertical:horizontal).
    - Sand should have an overall slope no more than 1:1.5 (vertical:horizontal), and
    - Vertical faces should be less than two metres.

4.3 Control of harmful weeds, pest animals and plant disease (Invasive species)

Background

The establishment of a quarry site may provide the opportunity for invasion or spread of harmful weeds. A quarry should be managed so that:

- it does not become a source of harmful weeds, plant diseases and pest animals; and
- to prevent their penetration during the construction, operation and rehabilitation of the quarry.

Objective

To ensure that operations of a quarry do not lead to the spread or spreading of harmful weeds, plant disease and pest animals.

Requirements

- The Mine Operator must take measures to prevent the spread of declared harmful weeds, pest animals and plant diseases within working area.
- The Mine Operator must ensure that all soil that is imported into and exported out of the working area is free of disease and harmful weeds.

Recommended Practice

- Development and implementation of a plan to control harmful weeds and pests.
- To take appropriate control or eradication measures.

4.4 Drainage and erosion control

Background

To avoid and control erosion, vegetation clearance should be kept to a minimum as it mitigates high volume of run-off occurring at high speed which increases the rate of erosion. Drainage control measures should be used to control the rain water flow as much as possible. Measures should maximise infiltration and minimise the speed that water flows over a site.

Objective

To minimise offsite erosion and turbidity water impacts from small quarry operations.

Requirements

- The Mine Operator must minimise the area of ground disturbance throughout the life cycle of the quarry operation.
- The Mine Operator must design, install and maintain erosion and sediment controls to prevent erosion of areas of disturbed land and sedimentation of waterways.

Recommended Practice

Minimise disturbed area

- To stabilise disturbed land as soon as possible to minimise erosion

Drainage

- To use drains or walls to keep rainwater out of disturbed areas, work areas, and inventory.
- Drains should discharge clean rainwater into vegetated natural drainage lines, or via horizontal brinks that distributes run-off across a stable area or to water storage dams.

Access Road

- To minimise gradients of access tracks.
- To maintain surface runoff and to install regular cross drains or culverts.

4.5 Water storage and discharge control

Background

Any water that passes through a site should be handled either to avoid areas where it becomes muddy or to be treated adequately to ensure that no contaminants remain when released from a site. Sediment ponds must be of sufficient size to retain water until all sediment has fallen out of suspension.

Objective

To ensure that all discharges from a site are free of sediment and other pollutants.

Requirements

The Mine Operator must prevent that contaminated runoff enters in the receiving water bodies.

Recommended Practice

- To design a drainage system to take into account seasonal factors, high precipitation events, exposed area and soil type.
- Regular removal of sediment from sediment traps and ponds to ensure sufficient capacity is available to capture all contaminated runoff in flood situations.
- Disposal of sediments that have been removed from ponds to avoid contamination of the waterways.

Construction of sediment ponds

- To calculate drainage capacity and water balance in the design stage.
- To design of storage ponds and other drainage measures to contain and control rainfall for a one in ten year storm event. In sensitive areas a higher storm event such as a one in 100 year may be required.

Discharge

- It should be a direct discharge of all treated rainwater to the vegetated areas.

Reuse

- To design rainwater management system to ensure that rainwater is reused and does not cause flooding.
- To use of water from sedimentation tanks on site for dust control or for irrigation of the vegetation.

4.6 Groundwater

Background

Extractive sites can alter the groundwater level either by removal or discharge into the groundwater. When a quarry cuts groundwater, the competent rural authority must authorize the collection and extraction of groundwater as part of a mining operation.

Objective

To meet groundwater quality objectives and to minimise any environmental impact on the quality of groundwater.

Requirements

Appropriate permits must be obtained from a groundwater licensing authority before extracting groundwater from a labour authority.

Recommended Practice

- To comply with all requirements of the Water Act, and the Water Authority Approvals.
- To install surface, bounded facilities in preference to underground fuel tanks.

4.7 Sludge Management

Background

The majority of sandstone quarries wash sand to produce a marketable product. The waste product of this process is a fine, clayey slurry. Dried up fine sludge can be a source of increased dust levels.

Objective

To manage the disposal and rehabilitation of sludge to minimise the risk to public safety and to the environment.

Requirements

- The Mine operator must take all reasonable measures to minimize the formation of fine sludge material.
- The Mine operator must ensure that the location, planning, construction, operation and safe management of the sludge ponds are designed to prevent the release of sludge into the environment and be inaccessible to the public.

Recommended Practice

- Planning and ensuring that a quarry has sufficient storage capacity for any produced sludge
- To design desiccant zones to promote fast drying and consolidation.
- To minimize the dumping of sludge in dams wherever possible
- Monitoring the stability of sludge dams
- To control of the dust from dried sludge

4.8 Fire Management

Background

Many human activities like excavation works can increase the risk of fire in an area and pose a hazard to the population and environment in the surrounding.

Objective

To ensure that the excavation works does not contribute to or aggravate the risk of fire.

Requirements

- The Mine Operator must take all reasonable measures to prevent the ignition and spread of the fire.
- The Mine Operator must ensure that all buildings, fixed installations and mobile facilities are equipped with fire extinguishers, such as: fire extinguishers, fire blankets and backpack sprayers.

Recommended Practice

- To develop a fire management plan
- To maintain an appropriate firefighting equipment at a working site

4.9 Hazardous materials management

Background

The management of hazardous materials must include appropriate storage of these materials and preparation for leaks to ensure that the risk of release of hazardous materials into the environment is minimized.

Objective

Targeted management of storage, use and handling of hazardous materials to minimize the risk of environmental damage.

Requirements

- The Mine Operator must prevent contamination of the environment through the release of fuels, lubricants and / or hazardous materials.
- The Mine Operator must ensure that all fuels, lubricants and / or hazardous substances are stored in accordance with the relevant requirements for storage and handling of flammable and combustible liquids.
- The Mine Operator must ensure that appropriate facilities are available and accessible in the vicinity of all equipment, including mobile and solid fuel storage facilities, for protection against spillage and disposal.

Recommended Practice

Hazardous material storage areas

- Planning and installation of tank farms and surface sealing of tank farms.
- Provision of the high-performance grease separators and oil separators in the vicinity of workshops and locations where vehicles and machines are parked.
- Placement of the bundled intermediate bearings with impermeable material.

Reaction to hazardous substance loss

- Minimization of the amount of hazardous substances on site
- Development of emergency plans

4.10 Noise

Background

Quarrying activities can cause significant noise pollution. The precautions should be taken to reduce the effects of noise in case the residential buildings or other sensitive land users are in the surrounding of quarries.

Objective

Prevent a quarry from causing noise pollution to surrounding land users.

Requirements

The Mine Operator must avoid causing unacceptable noise.

Recommended Practice

Quarry layout

- To provide an adequate buffer distance between a quarry and sensitive land users.
- To locate crushing and screening equipment in appropriate locations to reduce existing and potential noise impacts. Where possible, take advantage of natural topographical features when planning a site.
- To provide noise barriers such as earthen bunds to shield residential or other sensitive land users.

Operation planning

- To limit operating hours where necessary to comply with the noise control regulation.

- To maintain the access and transport roads in a good condition to prevent corrugations which can contribute to traffic noise.
- To identify the roads to/from quarry that minimise nuisance noise and direct trucks to use these roads.

4.11 Dust pollution

Background

Dust can affect neighbouring residential buildings and sensitive land users. Dust control and monitoring for quarries is defined in the environmental management plan. Some dust mitigation measures include:

- To minimize the area of disturbance and progressive greening to avoid dust formation.
- To minimize the movement of trucks and vehicles on the working site and on the public roads with a high dust source.

Objectives

To avoid dust impacting on surrounding land users.

Requirements

The Mine Operator must prevent dust release that causes adverse impacts to the surrounding area and people.

Recommended Practice

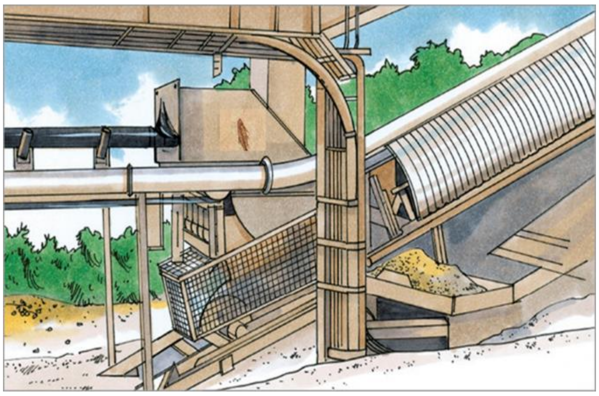

Figure 10: Dust in quarries. Left: not recommended (photo source: P. Schneider, 2018), right: recommended (source: Berufsgenossenschaft Rohstoffe und Chemische Industrie, 2018)

Quarry

- To consider the prevailing winds while planning the work area, facilities, work surfaces, and heap layouts to minimize the dust nuisance.
- To use the windbreak plant trees or topography and slopes to protect stocks and working areas from the prevailing winds.

Overburden or topsoil stocks

- To green the stocks that will not be used for some time

Vehicle movements

- To minimize vehicle movement and speed
- Dust control by watering

Plant operation

- To maintenan and to care the equipment in order to keep them in a perfect working conditions
- To equip the plants and equipment with suitable dust protection devices such as water sprays

Dry, windy conditions contribute to disturbing dust

- Stopping crushing plants.
- Increase the use of irrigation systems

4.12 Visual Management

Background

The visible impact of quarries on the landscape may be significant despite their size. High visual impact could be due to: the location or design of a site, its inconsistencies with surrounding areas; or its proximity to sensitive land uses.

Objective

To ensure that a quarry is not visually intrusive to neighbours or other sensitive land users.

Requirements

- The Mine Operator must take all reasonable measures to reduce visual impact on the surrounding area.

Recommended Practice

Site layout of quarry

- To select carefully the method of pre-processing and bypassing works, so that the operating surface is protected from critical view (see Figure 8).
- To use the topographic barriers to reduce the visual impact of a quarry

Operations

- To minimise the exposure of open surfaces
- To ensure that the vegetation used for rehabilitation or for vegetation cover is compatible with the surrounding vegetation or originates from indigenous native plant stocks.
- To develop the size and shape of berms adapted to existing landforms.
- To paint all exterior surfaces of buildings and fixed structures with matt, non-reflective colours to blend with the environment.
- Fastest possible remediation of the top slope.

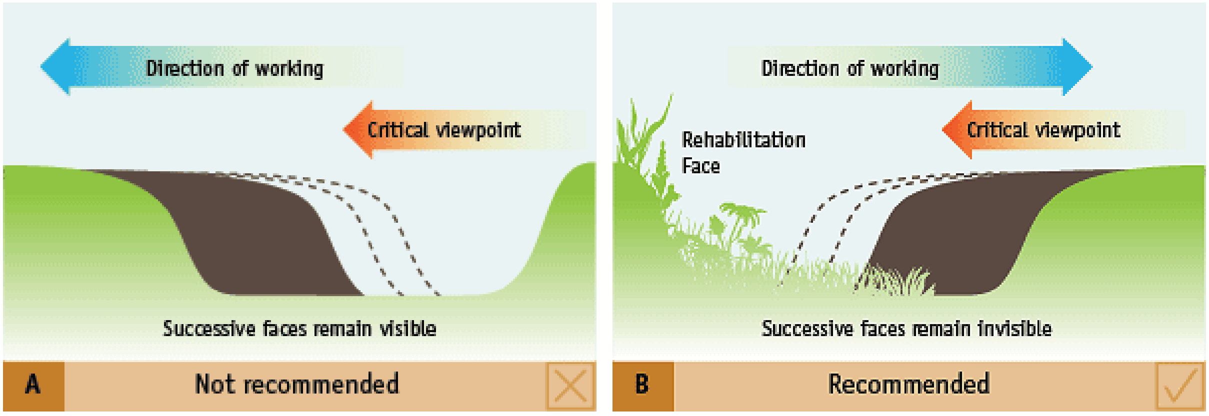

Figure 11: Design of the Quarry to Minimise Visual Impact (source: Department of Economic Development, Jobs, Transport and Resources. Code of Practice for Small Quarries, 2010, Adapted from Quarry Code of Practice, Department of Primary Industries Water and Environment, Tasmania 1999)

4.13 Municipality

Background

In accordance with the requirements of the Mining Law, the Mine Operator is required to consult with the municipality throughout the term of the labour authority. Good communication is essential for good cooperation with the community and will help to effectively manage the effects of a quarry.

Objective

Information and involvement of the municipality in relation to the operation of a quarry.

Requirements

- The Mine Operator must maintain a complaints register.
- As a response to a complaint, the Mine Operator must record the following information in the complaints register:

a) the date and time of the complaint;

b) who complains;

c) the specific issue/s raised in the complaint; and

d) the actions taken to address the specific issue/s raised in the complaint.

Recommended Practice

- To identify how the operations on a site may impact on the local environment, people and their surroundings and take measures to reduce the risks.
- Establish good working relationships early in the project's development to better understand community expectations and possible issues.
- Listen to all community concerns and facilitate a reasoned response to all issues raised.

5. Rehabilitation

The term rehabilitation encompasses any measures taken to repair disturbed or degraded land and return it to a stable and non-polluting state; suited to the proposed future use of the land.

5.1 Activities for Preparation of the Mining Site

Background

Progressive recovery refers to the rehabilitation of already exploited sections as the mining operation continues. When new quarry sections are opened, developed areas should be progressively rehabilitated to avoid increasing the total disturbed area of a quarry.

Objective

To efficiently and effectively rehabilitate a quarry.

Requirement

- The Mine Operator must ensure that progressive rehabilitation of disturbed land will be carried out as soon as possible.

Recommended Practice

- Rehabilitation in accordance with the intended final use of the land.
- Develop work areas systematically, as a series of benches or bays.
- Complete development of each section of a quarry and rapid start with ongoing restoration work.
- Once the final landscape model is created, areas are recultivated to stabilize the landform and provide maximum time for vegetation while the quarry is still in operation.

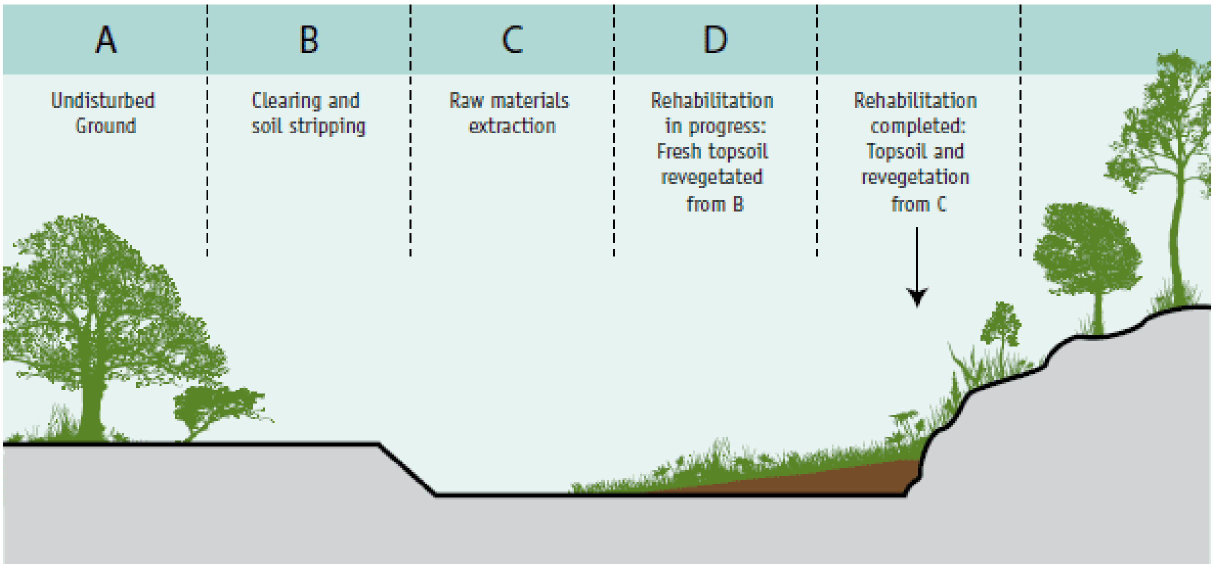

Figure 12: Progressive Rehabilitation to Maximise Visual Improvement (source: Department of Economic Development, Jobs, Transport and Resources. Code of Practice for Small Quarries, 2010, Adapted from Quarry Code of Practice, Department of Primary Industries Water and Environment, Tasmania 1999).

5.2 Earthworks

Background

The area should be redesigned to blend in with the landscape as much as possible. A location should remain in a stable, free drainage condition.

Objective

To reconstruct the landform to be compatible with the surrounding landscape and to prepare the ground for revegetation.

Requirement

The Mine Operator must ensure that the site is left in a safe and stable condition.

Recommended Practice

- To reduce all slopes to a gradient of 1:3 (vertical:horizontal) or less, or apply an artificial means of stabilising the slope such as with the use of geotextiles, mulch mats or benching to break up the slope.
- Once a stable landform has been created, respreads topsoil uniformly over the area at a suitable depth to support revegetation.
- Leave topsoil with a rough surface.

5.3 Erosion Protection

Background

The best erosion prevention at a site is the establishment of vegetation on a stable landform. However, as vegetation establishes, it may be necessary to use other erosion prevention techniques.

Objective

To minimise erosion of final landforms and transportation of sediment offsite.

Recommended Practice

- In order to slow the runoff, drainage controls, such as troughs, contour banks and rock filters, must be maintained above the area to be rehabilitated.
- Covering growing seedlings with surface mulch on steep slopes to reduce erosion, weed formation and soil moisture retention, and to add nutrients to the soil.

5.4 Vegetation

Background

Establishing a self-sustaining cover of vegetation is the best way to stabilise disturbed sites in the long term. Vegetation also minimises the visual impact of quarries. Generally, the vegetation type which existed before the disturbance, or a similar vegetation type will be regenerated most successfully.

Objective

To provide a stable, self-supporting cover that protects the object of rehabilitation and is compatible with final land use.

Recommended Practice

Steps of successful vegetation

- To use the native vegetation originating from the local area; and is selected according to the ecological vegetation class of a location.
- Sow seed or plant tubestock.
- Use high quality seeds free from harmful weeds.

Time of restoration

- To carry out the preparatory earthworks in the drier months.
- To plant the plants at a time when growth is most likely (usually autumn or spring). In species susceptible to frost, however, seeds should be sown after the last frosts.

5.5 Monitoring and Maintenance

Background

Revegetation may take several years to produce a stable, safe and self-sustaining ecosystem. Any damage to rehabilitation should be quickly rectified.

Objective

To monitor and to maintain a site until the rehabilitation is stable, safe and self-sustaining.

Recommended Practice

- To inspect rehabilitated areas regularly to assess the health of the vegetation and to check for erosion, pest animal browsing damage and weed infestation.
- In areas where germination has failed, to carry out enrichment planting of seedlings into unstocked areas or spot sowing by hand sowing of seed into small cultivated patches.
- Apply fertiliser if poor growth and yellow leaves indicate nutrient deficiencies.
- Planting a variety of species in the vegetation with native vegetation to increase the probability of success.

6. Decommissioning and closure

Quarrying activities create changes to topography with ongoing potential to impact the environment long after a quarrying activity has ceased. The restored landscape can be designed as:

- agricultural land, field or meadow
- forest
- biotope
- wetland
- backfill site
- left to natural succession without further treatment.

Figure 13: Reuse of abandoned quarries (photo source: P. Schneider, 2017)

6.1 Reuse of a quarry and criteria for completion of rehabilitation

Background

A local agreement may also be required if the proposed final land use changes the land use currently in force for the area or if the area is subject to planning overlaps. Once the final land use has been agreed, the completion criteria can be set.

Requirement

The Mine Operator must ensure that:

a) the rehabilitated area is left in a stable, safe, nonpolluting state;

b) the area is suitable for the planned final use or rehabilitation objective;

c) rehabilitated areas are not excessively affected by erosion;

d) vegetation is consistent with the final land use.

Recommended Practice

- To consult the environmental department regarding any proposed final land use and rehabilitation of a site that was agreed to by the landowner/ manager prior to commencing works.
- Carry out progressive rehabilitation in order to maximise the efficiency of the rehabilitation and to ensure that the majority of the rehabilitation liability is addressed prior to the closure of a site.

6.2 Remediation of Quarry

Background

After the end of the productive life of a quarry, the Mine Operator is responsible to clear the site from any remains of a quarry operation.

Objective

To provide a clean quarry for final land use.

Requirement

The operator must ensure that all obsolete and superfluous installations, vehicles, machinery and equipment are removed from the working area.

Recommended Practice

- Removal of all fixed and mobile equipment
- Removal of all temporary and permanent structures, unless they are required for future use
- Removal of any noise barriers and waste dumps or their adaptation for final land use requirements

6.3 Final Rehabilitation and Long Term Monitoring

Background

While most part of the rehabilitation works should take place during the working phase of a quarry operation, some areas will need to be rehabilitated after completion of the works. All rehabilitation activities must comply with the principles described in Section 6. Monitoring the rehabilitation works may take some time before it is determined that the works are safe, stable and environmentally friendly. The required level of surveillance may vary depending on site characteristics and the proposed final land use.

Proposed reclamation, as included in a mining plan, describes a concept for the final reuse of the site. The potential reclamation uses are highly variable, ranging from simple slope stabilization to habitat for wildlife or even to residential development on the lake shore, see also Figures 11 and 12.

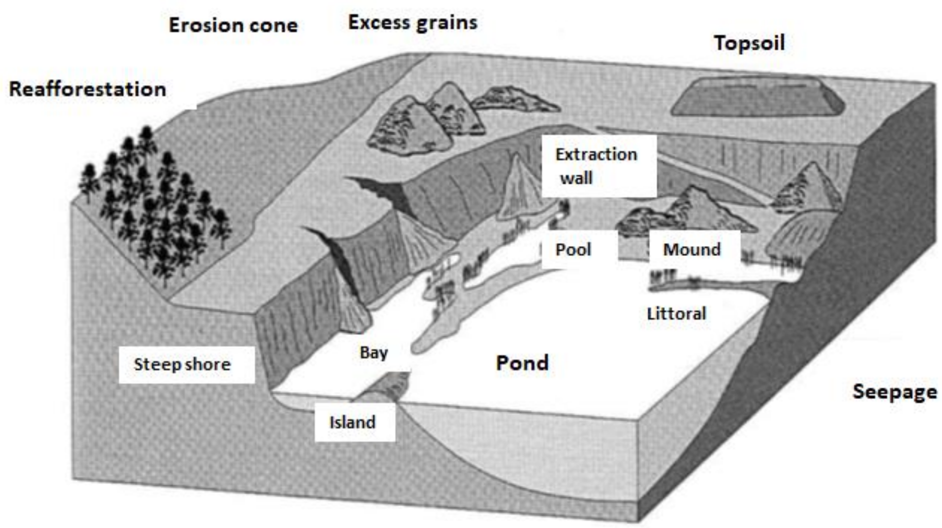

Figure 14: Potential habitats in gravel, sand, clay and clay pits (source: Trautner & Bruns, 1988, modified)

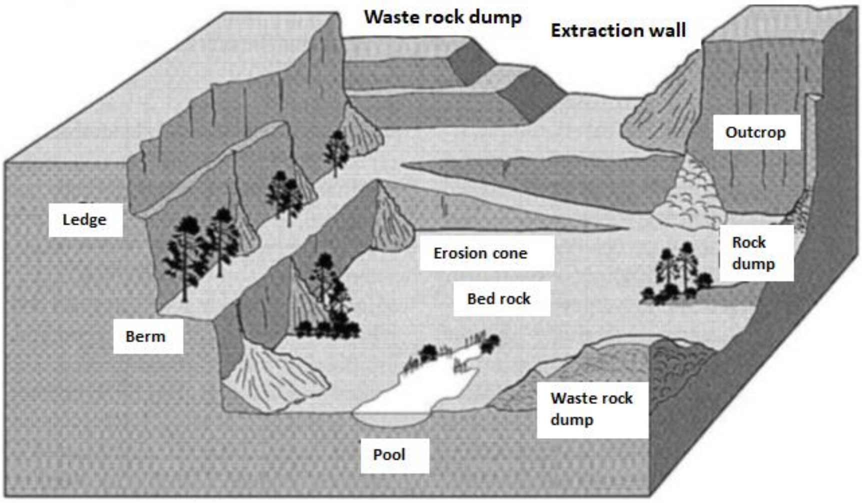

Figure 15: Potential habitats in quarries (source: Trautner & Bruns, 1988, modified)

Objective

Implementation of final rehabilitation measures.

Requirement

The Mine Operator must ensure that the negligible quarry area is prepared for adequate reuse in accordance with regional planning.

Recommended practice

In the event that a species habitat is developed, the following points are to be applied:

- Is the site within the range of any species at risk or rare habitats? It is reasonable to target a species for which there are recent records within about 20 km of the site.
- Does the site contain suitable biological, hydrological, and geophysical conditions to create the desired habitat?
- What is the condition of existing habitat features on the site?
- What are the surrounding land uses? Is the site connected to an adjacent natural area and, if so, what kinds of vegetation are found in the intact/reference habitat?
- How much land is available to restore?
- Are there local genetic stocks of the species at risk readily available?
- Translocation of any animals is strongly discouraged, unless under very exceptional circumstances.

Constructed ponds and wetlands

Many ponds and wetlands, which originate from the mining industry, have rectangular shorelines, steeply sloping sides and uniform depths. Wetlands with these characteristics have limited value for fish and wildlife. Following are guidelines for the construction of ponds and wetlands that could be incorporated into mining plans and implemented during active mining.

- Shorelines should be irregular with as many bays, peninsulas and sandbanks as possible, like at the figure 15.

- The bottom of the ponds should be undulating to provide a variety of water depths. Ponds larger than 1.2 ha should be built with a wave pattern.
- In general, a water depth of 0.15 to 0.9 m will lead to shallow water areas that promote the growth of emerging vegetation. Depths between 0.9 and 1.5 m result in open water.
- Whenever possible, 0.15 to 0.2 m of topsoil should be replaced on shorelines, wetland bottoms, and on islands to promote the growth of vegetation and aquatic invertebrates.
- Placement of vegetative debris (from clearing activities) in the wetland may provide habitat for water-fowl and promote habitat for invertebrates.
- In order to supply adequate food, cover and space for wildlife, wetlands should be a minimum of 0.2 ha in size.
- A buffer strip of undisturbed vegetation along the shores is important for wildlife and for reducing erosion. The bigger the buffer, the more productive the wildlife, especially for the nesting of waterfowl.
- Nest boxes may be placed on trees or posts near the wetland for use by wood ducks.
- Gradual inclines of 10: 1 to 20: 1 in about half of wetlands are recommended to provide tidal flats, growing vegetation, feeding and wildlife coverage, and to minimize soil erosion and slope subsidence.
- Where practicable, large tree species on the south and west sides of wetlands should be avoided to allow more exposure to the wetlands.

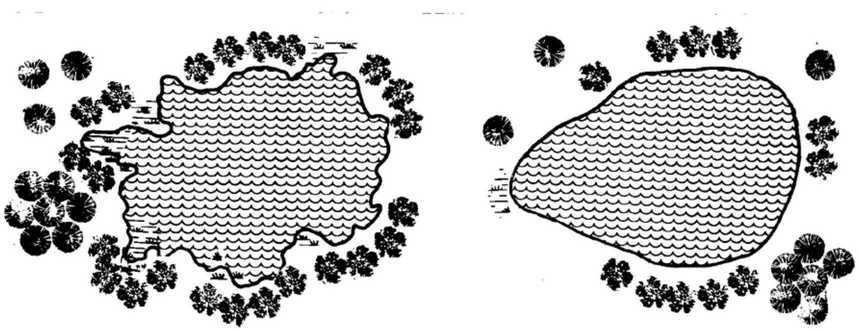

Figure 16: The pond illustrated on the left provides greater potential for wildlife due to increased shoreline development (source: after R. E. Szafoni, 1982)

Island construction

- Islands provide nesting and loafing sites for wildlife and add value to a wetland.
- Islands built during active mining begin as peninsulas (see Figure 16), which are graded to have the appropriate shapes and slopes. The canals are then dredged to separate them from the mainland when the final water levels are known. Material from the channel excision can also be used to construct islands.
- To provide both loafing and nesting habitats and to minimize shore erosion from wave action, islands should be 0.2 to 1.2 m in size and have rock riprap on those shorelines facing large expanses of water.
- Nesting islands can be any size and shape, however, they should be constructed in deeper water to provide protection from predators.
- Irregularly shaped islands are more advantageous for wildlife than round islands.

- Whenever possible, islands should be covered with topsoil to promote growth of vegetation.
- Floating, anchored rafts can provide waterfowl nesting sites in deeper water.

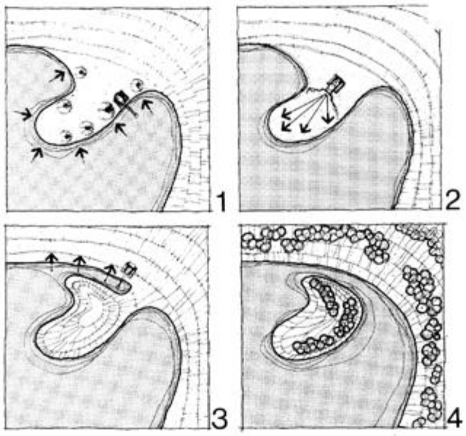

Figure 17: Island construction during active mining (source: M. F. P. Michalski, 1987, Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources)

- Horseshoe-shaped islands are ideal for waterfowl. The mouth of the horseshoe should be in the lee of the prevailing wind to protect waterfowl spawns. The inner banks should be more gentle than the outer banks to enhance the protective effect (see Figure 15).

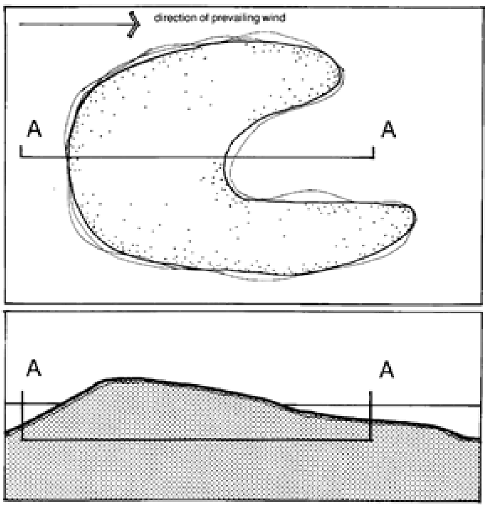

Figure 18: Horseshoe island construction (source: M. F. P. Michalski, 1987, Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources)

Fisheries

Most ponds resulting from the mining activities are too shallow to support a viable fish population. If plans are to produce a deep body of water with substantial area, it is to contact the competent fisheries authority for advice on species and habitat improvements. Stocking of fish requires a permit. Following are suggestions for improving fish habitat.

- Fish habitat can be quickly improved after mining is completed by adding structures which duplicate the habitat requirements of the desired species. Brush piles and submerged tree crowns provide excellent cover (see Figure 16).

- Materials such as boulders can be disposed of in ponds to provide cover for fish and a substrate for invertebrates.

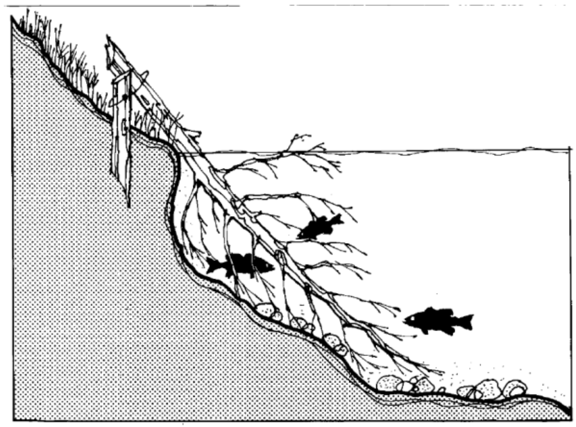

Figure 19: Submerged tree crowns provide cover where banks drop off steeply (source: M. F. P. Michalski, 1987, Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources)

- Protected spawning and nursery habitat can be provided by laying tiles, culverts, crib structures, and rock piles on the pit floor (see Figure 19).

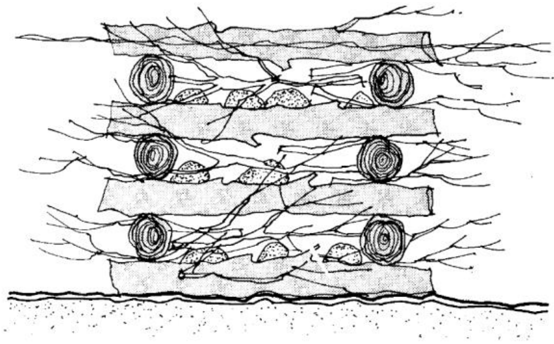

Figure 20: Crib structures can provide feeding and cover for fish (source: M. F. P. Michalski, 1987, Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources)

- Stream spawners usually only reproduce successfully in ponds that have gravel bottoms and inflowing springfed streams or upwellings. Sites without these characteristics are unlikely to support natural reproduction and will require restocking.
- Shadow is important for some species. Pools near shores of 1.5m depth provide shelter when spanned by vegetation.

Examples

Below are three shoreline plans designed to enhance wildlife habitat. Figure 18 is a shoreline plan that features a shallow bench with islands that provide food, cover, and nesting areas. Emergent vegetation will grow in the shallow water areas both along the bank and around the islands on the bench.

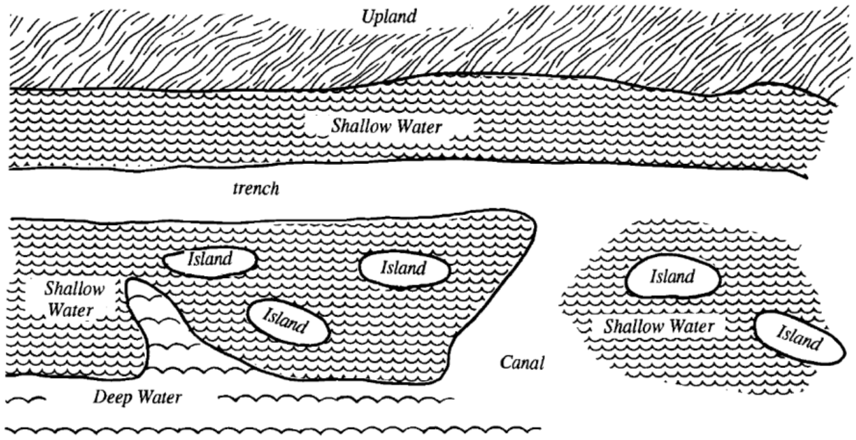

Figure 21: Shallow bench with islands (source: acc. to Washington DNR, 1989, Gravel mine reclamation guidelines)

Figure 21 and 22 is a shoreline plan that produces habitat for fish and waterfowl. The highly irregular shoreline is easily adapted to irregularly shaped gravel deposits. Such a shoreline can also be created through backfilling with non-commercial material or unwanted fill.

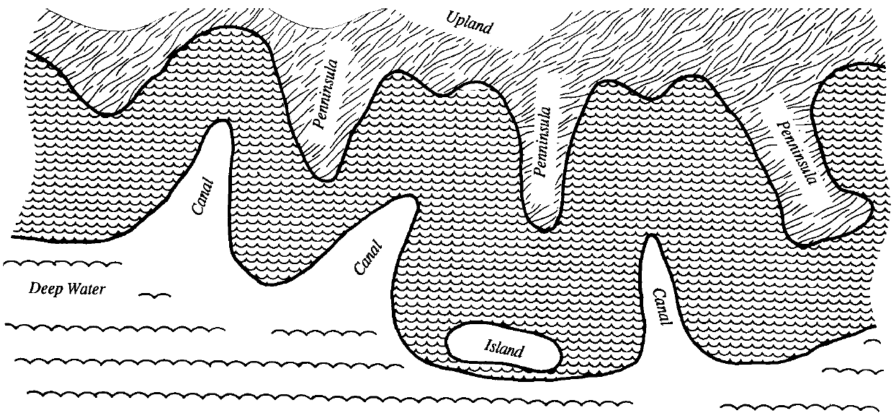

Figure 22: Bays and peninsulas (source: acc. to Washington DNR, 1989, Gravel mine reclamation guidelines)

Figure 23 shows a steep shoreline that will minimize the growth of emergent vegetation which may be desired in areas planned for residential development.

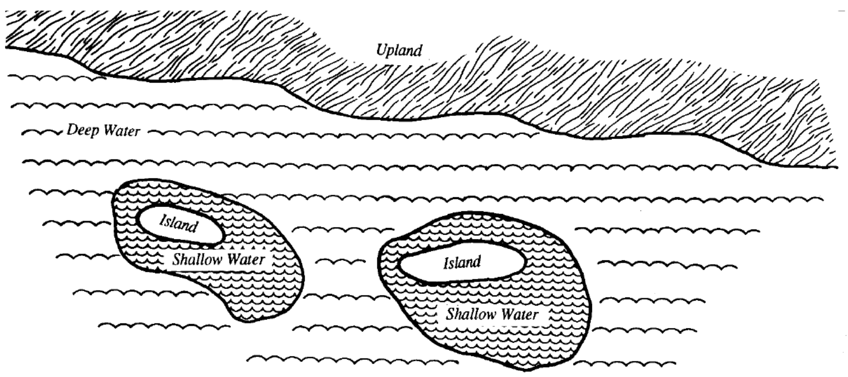

Figure 23: Scattered islands (source: acc. to Washington DNR, 1989, Gravel mine reclamation guidelines)

All implemented measures must be documented and monitored in a comprehensive way.

6.4 Nature Protection Measures

Although quarries change nature and landscape, mining areas can also become ecologically valuable secondary sites for many animal and plant species. Sometimes important sites for species and nature conservation develop during the operation. A mosaic of partial and micro habitats of sun-exposed screes, precipices, niches and ledges, old lanes and ponds promotes a high biodiversity and offers space for plants and animals with different survival strategies. Important during the mining operation are suitable accompanying measures that promote biodiversity.

Although quarries change nature and landscape from the ground up and are therefore often wounds in the landscape, mining areas can also become ecologically valuable secondary sites for many animal and plant species. Sometimes important sites for species and nature conservation develop during the operation. A mosaic of partial and micro habitats of sun-exposed rockfalls, steep broken rocks, niches and ledges, old lanes and ponds promotes a high biodiversity and offers space for plants and animals with different survival strategies. Important during the mining operation are suitable accompanying measures that promote biodiversity.

Measures during the exploitation

Numerous measures important for nature conservation as well as for protection of species can already be carried out in quarries during the mining operation. Which care measures are suitable in detail must be adapted to the local circumstances and the target species. In general:

- Early creation of resting zones immediately after beginning of the mining activities, in which a primary colonization can take place. These areas offer opportunities for retreat for the animal and plant inhabitants of the quarry and serve after decommissioning as a reservoir for the settlement of the rest of the terrain.
- Rock face and edges of varying size and exposure, depressions, cracks and crevices of different dimensions on the demolition wall provide habitats for animals and plants.
- Amphibians, especially yellow-bellied toads, as well as aquatic insect larvae and aquatic insects, benefit from small-scale, nutrient-poor waters. Timewise drying does not hurt, as long as the small bodies of water for oviposition and development of the larvae carry sufficient water.

- From small-scale, nutrient-poor waters benefit amphibians, especially the yellow-bellied toad, as well as aquatic insect larvae and aquatic insects. The temporary drying does not hurt, but is even more desirable in the case of the yellow-bellied toad and the natterjack toad, as long as the small water supplies enough water for oviposition and larvae development.

Figure 24: Sample for a rehabilitated quarry with nature protection after-use: Quarry Garden in Shanghai Botanical Garden (source: American Society of Landscape Architects, 2012)

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This booklet is a result of MAREX project:
Management of Mineral Ressource Extraction in Hoa Binh Province –
A Contribution to Sustainable Development in Vietnam

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ISBN 978-3-933053-39-8