



**MINISTRY OF WATER, LAND AND AIR PROTECTION
VANCOUVER ISLAND REGION**

**ENVIRONMENTAL OBJECTIVES AND BEST MANAGEMENT
PRACTICES FOR AGGREGATE EXTRACTION**

Prepared by

**Dr. Grant A. Bracher P.Ag.
Environmental Stewardship Division
Ministry of Water, Land and Air Protection**

2002

ABSTRACT

While aggregate is an essential resource for the construction of roads, schools, hospitals, houses, playgrounds and a host of other uses, its extraction can have serious impacts on the environment. This manual presents guidelines describing how sand, gravel and quarry operations should be developed, managed and reclaimed to prevent or reduce adverse environmental impacts. The planning of aggregate mines is stressed. Careful and thorough site assessments and planning are critical to identify potential adverse environmental effects and develop strategies to mitigate their impacts.

TABLE OF CONTENTS

	Page
1. INTRODUCTION.....	1
2. PLANNING PHASE AND SITE ASSESSMENT	1
2.1 Locations with Existing Biological Inventories.....	1
2.1.1 Sensitive Ecosystem Inventory	2
2.1.2 Conservation Data Centre.....	2
2.1.3 Sensitive Habitat Atlases.....	2
2.1.4 Other Inventory Information.....	3
2.2 Locations with Incomplete or without Biological Inventories	3
2.3 Water Resources	4
2.3.1 Erosion and Sediment Control	4
2.3.2 Surface Water	4
2.3.3 Groundwater.....	5
3. MINE DEVELOPMENT	6
3.1 Fish and Wildlife Habitat Protection	6
3.1.1 Birds	6
3.1.1.1 Eagles	6
3.1.1.2 Great Blue Herons.....	6
3.1.1.3 Other Birds	8
3.1.2 Sensitive Ecosystems	8
3.1.2.1 Riparian Areas.....	8
3.1.3 Instream Work.....	9
3.2 Site Clearing.....	10
3.3 Stripping and Stockpiling.....	10
3.4 Fuel Handling and Spill Containment.....	11
4. SITE REHABILITATION.....	11
4.1 Progressive Rehabilitation	11
4.2 Planting Standards.....	12
5. SUMMARY.....	12

ACKNOWLEDGEMENTS

I wish to thank my colleagues in the Environmental Stewardship Division, Ministry of Water, Land and Air Protection who provided reference material and commented on earlier drafts of the manuscript. I would like to acknowledge the special contribution made by Maggie Henigman. Her "*Environmental Objectives, Best Management Practices and Requirements for Land Developments*" was used as a template for this document.

1. INTRODUCTION

This manual was developed by the Vancouver Island Region of the Ministry of Water, Land and Air Protection (MWLAP) to assist proponents when applying for permits for sand and gravel pits and rock quarries. The Ministry of Energy and Mines and other government agencies involved in the review of such permit applications may also find it useful. The purpose of the document is to present MWLAP's environmental objectives and a series of guidelines or "best management practices" to prevent or reduce the adverse environmental impacts associated with aggregate extraction. The objective of the proponent, when following best management practices, should be environmental protection, not merely compliance with statutory and regulatory requirements.

To optimize the use of limited resources, MWLAP is shifting from the review of individual applications for new aggregate mines to providing best management practices with subsequent monitoring of aggregate mining activities and reporting of results. These reports will be used to evaluate and, where required, revise best management practices and inform the public on how well environmental values are being protected. It is the expectation of MWLAP that the appropriate best management practices will be incorporated into all aggregate extraction activities. MWLAP will continue to provide site-specific assistance on a case-by-case basis when the guidelines do not "fit" a particular situation or where there is significant risk to the environment.

Please note that the information presented in this document does not take precedence over statutory requirements imposed by other legislation. MWLAP recommends that proponents contact all appropriate agencies to confirm their requirements.

2. PLANNING PHASE AND SITE ASSESSMENT

To minimize the impact of aggregate mine development on the environment, MWLAP recommends that potential adverse effects be identified and mitigation options be considered at the planning stage. Past applications for aggregate exploration and development often contained little or no information on the environmental values of the proposed exploration or mine site. These applications lacked the necessary information to allow adequate assessment of the potential impacts of the proposed mining activities on sensitive habitats and ecosystems, rare and endangered species, fish and wildlife habitat, water quality and other environmental values. It is important that such resources be identified early in the mine planning stage to help ensure their protection. Failure to identify important environmental values early in the planning process may result in the need for plan revision resulting in loss of time, additional costs and a delay in obtaining the required permit.

2.1 Locations with Existing Biological Inventories

Biological inventories may exist for the proposed mine site. It is recommended that proponents gather all existing inventory information early in the planning process so that potential environmental impacts can be identified and mitigative measures developed.

2.1.1 Sensitive Ecosystem Inventory

The sensitive ecosystem inventory (SEI) is a joint project of Environment Canada, MWLAP and the Ministry of Sustainable Resource Management. It covers the coastal lowlands of east Vancouver Island and the adjacent Gulf Islands. The purpose of the SEI is to identify, map and evaluate remnants of rare and fragile ecosystems, and to encourage responsible land use decisions to help ensure the continued integrity of these ecosystem types. SEI information is intended to be used in a wide variety of land use planning processes. The SEI mapped nine ecosystems: coastal bluff, sparsely vegetated, terrestrial herbaceous, wetland, riparian, woodland, older forest, older second growth forest and seasonally flooded agricultural field. Volume 1 of the SEI describes the methods used (Ward *et al.*, 1998). Volume 2 explains the importance of each sensitive ecosystem and makes recommendations on how to protect them (McPhee *et al.*, 2000). SEI data is available in hardcopy or in electronic form. Further information can be obtained from the SEI website (<http://srmwww.gov.bc.ca/cdc/sei/index.htm>). MWLAP recommends that proponents use the SEI as the first stage in determining if the proposed exploration or mine site lies within or adjacent to a sensitive ecosystem. If none have been mapped, the site should be assessed for their presence.

2.1.2 Conservation Data Centre

The Conservation Data Centre (CDC) is a permanent program of the Ministry of Sustainable Resource Management. Its goal is to assist in preserving the biodiversity of the province by providing accurate information on rare species and natural plant communities. The CDC has identified British Columbia's most vulnerable vertebrate animals, vascular plants and native plant communities. They are placed on British Columbia's red (indigenous species considered to be extirpated, endangered or threatened) and blue lists (indigenous species considered to be vulnerable) according to the degree of rarity. Once identified, these rare elements of biodiversity are "tracked" in the CDC's computerized database. Information on their biology, conservation status, and the individual locations or "occurrences" for each are systematically collected and entered into the database. The CDC provides data, information and expertise on rare organisms and ecosystems on their website (<http://srmwww.gov.bc.ca/cdc/>) and by request at no cost. MWLAP encourages proponents to contact the CDC to determine if there are any reported occurrences of red or blue listed plants, animals or plant associations on the proposed mine site. If present, a protection plan should be incorporated into the mine design.

2.1.3 Sensitive Habitat Atlases

Sensitive habitat atlases have been completed for the Regional District of Comox-Strathcona, the Regional District of Nanaimo, the Cowichan Valley Regional District and the District of Saanich. Another atlas is being prepared for the Capital Regional District. These references contain environmental resource inventory information, including spatial data specific to fish and wildlife habitat and sensitive ecosystems.

2.1.4 Other Inventory Information

In addition to sensitive habitat atlases and the SEI, the Nanaimo MWLAP office also has available:

- Nest site data and annual monitoring reports for bird species identified in Section 34 of the *Wildlife Act*. On Vancouver Island this includes bald eagles, great blue herons, ospreys, peregrine falcons and goshawks.
- Freshwater fish inventories compiled from lake and stream surveys. Please see the BC Fisheries website (<http://www.bcfisheries.gov.bc.ca/fishinv/>) for the Fish Inventory Stream Summary (FISS) database.

The above mentioned inventories are not static; as new information is collected, it will be incorporated into the appropriate inventory and made available to the public.

2.2 Locations with Incomplete or without Biological Inventories

On sites without inventory information or the existing inventory data are deemed too incomplete to assess potential impacts of aggregate extraction, MWLAP recommends that the proponent commission a biological inventory of terrestrial and aquatic habitats as required to adequately describe the proposed exploration or mine site. Inventories should be done by a qualified biological consultant (Registered Professional Biologist or equivalent). Please contact MWLAP for a list of qualified consultants.

The level of biological inventory required is site specific. A site that is disturbed will require a less-detailed inventory than one for a pristine site. As a minimum, a reconnaissance level inventory should:

- provide a brief description of the major ecosystems on the proposed mine site;
- map all waterbodies including those that are ephemeral;
- provide a record of all fish species occurring in waterbodies on and adjacent to the site;
- request a search of the CDC's database for the occurrence of any red and blue listed animals, plants and ecosystems on or near the site;
- search the proposed mine site for red and blue listed species and ecosystems, as well as for the nests of bird species identified in Section 34 of the *Wildlife Act*.

The information collected should then be used to identify potential adverse environmental effects and develop ways to prevent or mitigate their impact. Further information on conducting biological inventories is available at Ministry of Water, Land and Air Protection (former Ministry of Environment, Lands and Parks, 2001a) or at <http://wlapwww.gov.bc.ca/vir/pa/index.htm> (BMP – Land Development Appendices).

2.3 Water Resources

2.3.1 Erosion and Sediment Control

Land clearing, road building, the stockpiling of soil and other activities associated with quarries and sand and gravel pits can lead to the erosion of soils into nearby watercourses. Erosion and sediment control is essential because sediment can have severe negative impacts on fish and their habitat including (Chilibeck *et al.*, 1992):

- suspended sediment can clog and abrade fish gills causing suffocation or injury;
- suspended sediment can settle on spawning beds smothering eggs and alevins in the gravel;
- sediment can infill pools and riffles reducing the availability and quality of rearing habitat for fish;
- suspended sediment can reduce water clarity impairing the ability of juvenile fish to find food items;
- settled sediment can smother and displace aquatic organisms reducing the quantity of food available to fish.

To help prevent the deposition of sediment in watercourses, MWLAP recommends that an erosion and sediment control plan be developed early in the planning process. The plan should:

- include maps of all streams, lakes, wetlands, springs and ephemeral watercourses;
- strive to minimize soil disturbance not associated with the pit opening by siting access roads, settling ponds, buildings, etc., on already disturbed sites;
- describe the intended methods of controlling erosion on all disturbed areas, including roads;
- ensure that all water draining from the pit, stock piles and roads be directed via perimeter ditches to detention ponds and to ground infiltration to help prevent the introduction of sediment and contaminants into streams, wetlands, lakes and ponds;
- make provision for the routine inspection and maintenance of silt fences and other erosion control structures after each rainfall and storm to ensure that the fence is intact and debris and sediment have not accumulated at the bottom. Remove any deposits when they reach one-half fence height;
- include monitoring activities to ensure that the discharge water does not contain more than 25 mg/L of suspended solids.

Detailed discussions of erosion and sediment control techniques and structures (e.g., interceptor ditches, silt fences, sediment traps and sediment control ponds) can be found in *Land Development Guidelines for the Protection of Aquatic Habitat* (Chilibeck *et al.*, 1992), and the *Best Management Practices for Reclaiming Surface Mines in Washington and Oregon* (Norman *et al.*, 1997) available through the Washington State website at <http://www.wa.gov/dnr/htdocs/ger/pdf/bmp.pdf>.

2.3.2 Surface Water

If the water supply for the proposed mine is to be from a surface water source such as a river, creek, lake or spring, then the long-term reliability of that supply should be certified by a qualified professional engineer or hydrologist. The engineer or hydrologist should be a member of the Association of Professional Engineers and Geoscientists of British Columbia, and have experience in surface water hydrology and water supply engineering.

It is important that the hydrology report confirm that there is an adequate water supply available for the proposed mining operation without adversely affecting downstream fish habitat or other water users. This may be critical in August and September when flow rates are low. Pump hoses must be screened to prevent impacts to small fish and other aquatic organisms. If possible, water used in the mining operation should be recycled.

A licence pursuant to the *Water Act* is required for the storage, diversion and use of surface water.

Explosives handling and utilization should be conducted in a manner, which minimizes the opportunity for nitrate and blasting residue contamination of site runoff, adjacent watercourses and groundwater.

2.3.3 Groundwater

Although a licence is not required for the use of groundwater, it is important that the long-term quality and quantity of groundwater be protected to maintain fish habitat and potable water supplies of adjacent property owners. MWLAP recommends that a hydrogeologic impact study be conducted by a qualified engineer or geoscientist to assess potential impacts of pit or quarry developments on the wells of adjacent properties or any nearby surface waterbodies. To prevent impacts to wells and streams, it is important that pits are designed and operated in a manner that does not cause or require lowering of the water table. At most sand and gravel sites, the Ministry of Energy and Mines will only permit mining to within one metre of the annual high water table to prevent unacceptable impacts to groundwater quality and availability.

2.4 ROAD DESIGN

Roads should be designed and constructed in a manner consistent with the sediment and erosion control plan. To minimize the impact of road construction on hydrology, water quality, and fish and wildlife habitat, MWLAP recommends that the road design:

- minimize new road construction by using existing roads as much as possible;
- minimize the width and total length of new road constructed;
- minimize the number of stream crossings;
- have adequate cross culverting to maintain existing surface stormwater flow patterns.

Stream crossings should be designed to protect stream function and structure, and must be in compliance with the federal *Fisheries Act* and the provincial *Water Act* and Regulation. Crossings should be avoided on flood plains, over spawning beds, meander bends or other areas where bank stability may be a concern. To help ensure that culverts and bridges do not impede fish passage or increase the risk of flood damage, clear span bridges and open bottom culverts are recommended for all road designs over fish-bearing streams. Culvert design and size selection should be made by a qualified professional engineer.

3. MINE DEVELOPMENT

3.1 Fish and Wildlife Habitat Protection

Two common techniques for protecting sensitive ecosystems and critical fish and wildlife habitat involve the use of “no disturbance” buffers and restricting the time during which mining or associated activities may take place.

3.1.1 Birds

Under Section 34(b) of the *Wildlife Act*, it is an offence to take, possess, molest or destroy the nest of an eagle, peregrine falcon, gyrfalcon, osprey, heron or burrowing owl at any time of the year. Raptors and herons are very sensitive to disturbance and may abandon their eggs or young if there is excessive human activity or noise in close proximity to the nest; consequently, it is essential that a buffer be provided around the nest of these species to reduce the risk of abandonment.

3.1.1.1 Eagles

For eagle nests, maintain a naturally vegetated no disturbance buffer of 60 metres, measured as a radius from the base of the nest tree (BC Ministry of Environment, Lands and Parks, 2001a). This distance may be reduced to 1.5 times the tree height for shorter trees, provided that the wind firmness of the tree is not compromised through grading or other ground disturbance. Buildings or other man-made structures should not be located within the buffer and all vegetation should be retained.

To reduce the risk of egg or nestling abandonment, an additional noise and no disturbance buffer of at least 100 metres in radius should be provided around the core 60 metre buffer during the breeding season (January 30 to June 30). When blasting between January 30 to June 30, it is recommended that buffers of 1,000 metres be maintained between active nest sites and blasting sites. This recommendation is consistent with the Small Business Program Forest Guidelines (BC Ministry of Forests, 2001). The recommended buffer for blasting near active urban eagle nests may be relaxed where it is demonstrated that the eagles have habituated to human disturbance. Please contact MWLAP, should a relaxation of buffer width be requested. Contact information is available in Table 1.

MWLAP is currently developing recommended buffer widths for other raptor species. In the interim, please use the buffers recommended for eagles.

3.1.1.2 Great Blue Herons

Great blue herons are currently blue listed in British Columbia and being considered for inclusion on the provincial red list. They are generally sensitive to human disturbance and may abandon their colonies in response to human disturbance (Quinn and Milner, 1999). Research has demonstrated the need for “no-disturbance” buffers to prevent abandonment of heron colonies.

A 100 metre vegetated, no disturbance buffer, measured from the most outlying nest tree in the heron colony, is needed to avoid desertion of the eggs or chicks. An additional noise and no disturbance buffer is recommended during the nesting season (January 30 to

August 15), especially for colonies not accustomed to human activity. It is recommended that this additional buffer be up to 200 metres radius around larger colonies (50 to 200 nests) and that human disturbance be restricted in this zone during the breeding season.

When blasting between January 30 to August 15, it is recommended that buffers of 1,000 metres be maintained between active nest sites and blasting sites. This recommendation is consistent with that of Butler (1991) and the Small Business Forest Enterprise Program Forest Guidelines (BC Ministry of Forests, 2001).

The recommended buffers noted for heron colonies might be reduced where the birds have colonized existing settlement areas and there is clear evidence that they have become adapted to human activities. Please contact MWLAP should a relaxation of buffer width be requested.

Table 1. Contact Information

AGENCY	CONTACT	RESPONSIBILITIES
Ministry of Water, Land and Air Protection 2080-A Labieux Rd Nanaimo, BC V9T 6J9	Grant Bracher Terrestrial Ecosystem Specialist Tel. 250 751-3221 Fax. 250 751-3103 Grant.Bracher@gems2.gov.bc.ca	<ul style="list-style-type: none"> • Answer questions on this guidebook • Provide information on wildlife species covered by Section 34 of the <i>Wildlife Act</i> • Provide information on protective buffers around important habitat features and sensitive ecosystems • Provide list of qualified environmental consultants • Guidebook revision
Ministry of Water, Land and Air Protection 2080-A Labieux Rd Nanaimo, BC V9T 6J9	Lew Carswell Fisheries Technician Tel. 250 751-3225 Fax. 250 751-3103 Lew.Carswell@gems9.gov.bc.ca	<ul style="list-style-type: none"> • Fish salvage permits
Fisheries and Oceans Canada South Vancouver Island Box 241, 5653 Club Rd Duncan, BC V9L 3X3	Tel. 250 746-6221 Fax. 250 746-8397	<ul style="list-style-type: none"> • Instream work windows
Fisheries and Oceans Canada South Central Vancouver Island 250 – 4877 Argyle St Port Alberni, BC V9Y 1V9	Tel. 250 724-0195 Fax. 250 724-2555	<ul style="list-style-type: none"> • Instream work windows
Fisheries and Oceans Canada North Central Vancouver Island 215 – 940 Alder St Campbell River, BC V9W 2P8	Tel. 250 850-5701 Fax. 250 287-4899	<ul style="list-style-type: none"> • Instream work windows
Fisheries and Oceans Canada North Vancouver Island Box 10, 8585 Wolloson Rd Port Hardy, BC V0N 2P0	Tel. 250 949-6422 Fax 250 949-6755	<ul style="list-style-type: none"> • Instream work windows

3.1.1.3 Other Birds

Section 34 of the *Wildlife Act* also affords protection to the nests of other bird species, except for Schedule C wildlife (e.g., house sparrows, European starlings and rock doves), when the nest is occupied by a bird or its egg. MWLAP recommends that land clearing activities be avoided during the peak nesting period from April 1 to August 1.

3.1.2 Sensitive Ecosystems

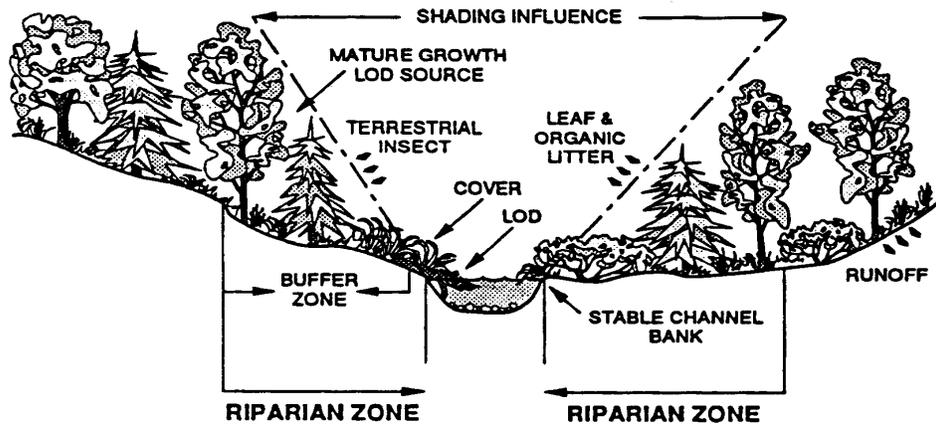
Sensitive ecosystems and habitats should be clearly flagged prior to site clearing and road construction to prevent accidental encroachment onto these areas. Temporary “hi-vis” fencing may be useful in delineating these features. In some instances, the boundaries of a sensitive ecosystem may be difficult to distinguish, due to large transition areas between ecosystems. Professional help may be required in these instances. Mine employees should be advised of the location of sensitive ecosystems and habitats and be provided with a copy of the sediment and control plan prior to the start of mine development. For coastal bluffs, sparsely vegetated, terrestrial herbaceous and other sensitive ecosystems, a 50-metre buffer zone must be provided.

3.1.2.1 Riparian Areas

Riparian areas are one class of sensitive ecosystem. They occur next to the banks of streams, lakes and wetlands, and include both the area dominated by continuous high moisture content and the adjacent upland vegetation that exerts an influence on it (Figure 1). Although they occupy a relatively small geographic area, riparian zones are of prime importance to water quality, stream stability, wildlife habitat and fish habitat. Riparian vegetation protects water quality, stabilizes streambanks, regulates stream temperatures and provides a continual source of woody debris to the stream channel (BC Ministry of Forests and BC Environment, 1995). The majority of fish food organisms drop from overhanging vegetation and bordering trees while leaves and twigs that fall into streams are the primary nutrient source that drives aquatic ecosystems. Riparian areas frequently contain the highest number of plant and animal species found in a forest, and provide critical habitats, home ranges and travel corridors for wildlife.

Because of the importance of riparian areas, all aggregate mining activities, with the possible exception of required stream crossings, are to be maintained at least 50 metres from any watercourse. This includes ephemeral streams. The 50-metre buffer should be measured from the top of the bank for streams and the highwater mark for lakes, wetlands or the ocean.

Figure 1. Riparian zone benefits to aquatic habitat (Chilibeck *et al.*, 1992).



3.1.3 Instream Work

Stream crossings should be kept to a minimum; however, should it become necessary to construct a road across a stream and work in the stream is required, the following best management practices must be adhered to in order to reduce adverse impacts on fish and fish habitat:

1. Instream reduced risk work windows
 - The general instream work window is July 1 to September 15, inclusive, for all streams, as defined under the *Water Act*, in any year.
 - If the stream channel is dry (no flow), the instream work window may be extended to September 30.
 - Fisheries and Oceans Canada (DFO) may require different instream work windows for salmon and other anadromous fish bearing streams. It is recommended that the proponent contact DFO (Table 1). Any instream work window requested by DFO supercedes the general work window stated above.
2. Minimum stream flow
 - Natural stream flows are to be maintained at all times.
3. Isolating the instream work site from streamflow
 - The work site should be isolated from water flowing in the stream channel.
 - Stream flows should be diverted around the instream work site.
4. Culvert installation, replacement or removal
 - Care should be exercised during all phases of the work to prevent silt or debris from entering the stream.
 - All work should be conducted from the stream bank.
 - Disturbed stream banks should be restored to function as in their original condition.

- All excavated material should be deposited in a stable area, above the high water mark of the stream and set back from the high water mark of the stream by a distance of at least 7.5 metres and deposited in such a way that the excavated material does not contribute sediment or debris to the stream.
5. A written contingency plan should be developed to deal with sediment control during instream work in the event that there is an increase in stream flow due to increased precipitation, an increase in local overland runoff, or saturation of the work area.
 - Work is to be suspended if the sediment control measures are ineffective.
 - In the event of an uncontrolled sediment release, proponents are directed to stabilize and correct the uncontrolled sediment release into streams as soon as possible, and to notify MWLAP and DFO.
 6. Addition of substances, sediment, debris or materials to the stream or stream channel
 - None of the above, with the exception of approved fish habitat enhancement works, are permitted to enter the stream or stream channel without the specific consent of MWLAP and DFO.
 7. Fish salvage
 - Proponents must retain a qualified environmental consultant to salvage fish that are present at the worksite or in an affected area due to instream work prior to the start of their project. A permit is required to salvage fish. Please contact the Regional Fish and Wildlife Program of MWLAP for information on how to obtain a fish salvage permit. Table 1 provides contact information.
 8. Mitigation
 - No net loss of fish habitat is authorized by this document.
 - A net loss of fish habitat may be authorized where a mitigation/compensation package can be negotiated between DFO and the proponent.

Further discussion of MWLAP requirements for instream work can be found in “*A Users Guide to Working in and around Water; Regulation under British Columbia’s Water Act*” (BC Ministry of Environment, Lands and Parks, 2001b).

3.2 Site Clearing

Before any aggregate extraction can take place, vegetation and overburden needs to be cleared. Whenever possible, stands of natural vegetation, in or near the operating area, should be retained. Priority areas for retention would include mature forest stands over poor quality sections of the deposit. Retaining these stands will preserve centers from which plants and soil microorganisms can spread into extracted areas, and help intercept and minimize noise, dust and other disturbance to people and wildlife populations on nearby lands.

3.3 Stripping and Stockpiling

Whenever possible, topsoil, subsoil, and overburden should be handled separately. Topsoil is more valuable for reestablishing natural vegetation communities than subsoil because it typically contains soil microorganisms and viable plant seeds. This enhances the potential for natural regeneration. In cases where topsoil is too thin to be removed separately,

subsoil can provide an acceptable substrate. Generally, subsoil has weathered to some extent and is, therefore, far more appropriate for establishing vegetation than the underlying parent material.

It is preferable to strip topsoil during dry periods to minimize compaction. Heavy machinery used on wet ground compresses the soil, reducing pore spaces and creating a hard, impervious surface. Drainage and root growth is inhibited, as a result. When topsoil must be stored for a long period, it should be seeded to reduce the potential for erosion and deterioration.

3.4 Fuel Handling and Spill Containment

To reduce the adverse environmental impacts associated with fuel spills, MWLAP recommends that:

- no permanent fuel storage facility be constructed on the mine site;
- tanks of limited capacity (under 600 litres) be used to refuel equipment in the pit, but should not be used for permanent storage;
- refueling of equipment not be done within or adjacent to any of the established environmental buffers or within 50 metres of any pit drainage structures;
- a spill contingency plan to deal with any spills of fuel, oil, lubricants or hydraulic fluids be developed in accordance with the BC guidelines for industrial emergency response contingency plans (BC Ministry of Environment, Lands and Parks, 1992);
- an emergency spill containment kit should be maintained on site whenever the pit is in operation;
- the operator must immediately contain, report and remediate any spill of hydrocarbon or other deleterious substances. Contaminated materials shall be disposed of in a manner acceptable to the Regional Pollution Prevention Manager;
- stationary engines and related drive mechanisms be provided with drip pans;
- stormwater from parking and service areas should be passed through an oil/water separator prior to disposal at an approved discharge.

4. SITE REHABILITATION

Before the start of aggregate extraction, the proponent must submit a site reclamation plan and receive approval from the Ministry of Energy and Mines. Consideration should be given to the most appropriate use of the site following mining. Careful and thorough site assessment and planning before extraction are critical to successful rehabilitation. Several key factors must be assessed in advance. These include deposit and overburden characteristics, water availability, adjacent land uses and local planning policies. Often the rehabilitation of the former mine site for wildlife habitat is the most appropriate use. Progressive rehabilitation may be beneficial in such cases.

4.1 Progressive Rehabilitation

Progressive rehabilitation is undertaken over the lifetime of the pit or quarry as extraction of each portion is completed, rather than all at once after the entire deposit has been excavated (Michalski *et al.*, 1987). This approach is best suited to large mines and to long-term operations. Progressive rehabilitation is especially valuable and effective when rehabilitating for wildlife as most species require plant communities in varying stages of succession, a condition more or less ensured by extracting and rehabilitating sequentially.

In addition, progressive rehabilitation reduces the visual impact of the pit or quarry, and minimizes the effect of operations on nearby wildlife populations.

4.2 Planting Standards

In many cases, natural regeneration is not appropriate because the length of time needed for successful rehabilitation will be environmentally and socially unacceptable. Preference should be given to revegetation of the site with native plants to promote biodiversity. Trees and shrubs that produce fruit help attract birds and other wildlife, which in turn aid with seed dispersal. The impact of snag/wildlife tree removal on cavity nesting birds and other wildlife during site clearing can be reduced by the erection of artificial snags and nest boxes during rehabilitation. Rather than totally regrading the pit floor, consider leaving a few small-scattered mounds as this microtopographic diversity will be reflected by the colonizing vegetation, thus enhancing the diversity of the site.

Rehabilitation plans should consider the following planting standards:

- plant large nursery stock, preferably native species, to aid survival and speed the development of ground cover;
- autumn (September to October) or spring (March to April) planting is recommended to maximize survival;
- use the spacing appropriate for each species. Use a maximum spacing of 2.0 metres between trees, and a spacing of 0.5 to 1.0 metres for shrubs and smaller species;
- fertilizers may be used where soil conditions warrant and fertilizer runoff will not be a problem;
- use native plant species adapted to local site conditions;
- plant survival can be enhanced by watering throughout the dry period, especially during the first year of rehabilitation;
- monitor plant survival; if survival is very poor, replanting in future years may be necessary for successful site rehabilitation.

5. SUMMARY

The best management practices presented are based on practical experience, common sense and extrapolations from the sometimes-sketchy scientific literature. This is an evolving document. In a sense, it will never be completely finished. As new information becomes available, the recommended management practices will be revised. MWLAP is committed to continuous improvements in environmental performance. Should you have any comments or suggestions on how the next edition of these best management practices could be improved you are invited to contact: Grant Bracher, Terrestrial Ecosystem Specialist, Ministry of Water, Land and Air Protection, 2080-A Labieux Road, Nanaimo, British Columbia, V9T 6J9, or grant.bracher@gems2.gov.bc.ca.

LITERATURE CITED

- British Columbia Ministry of Environment, Lands and Parks. 1992. *Guidelines for Industrial Emergency Response Contingency Plans*. Environmental Emergency Services Branch. Victoria, British Columbia. 17 pages.
- British Columbia Ministry of Environment, Lands and Parks. 2001a. *Environmental Objectives, Best management Practices and Requirements for Land Developments*. Vancouver Island Region, Nanaimo, British Columbia.
- British Columbia Ministry of Environment, Lands and Parks. 2001b. *A Users Guide to Working In and Around Water; Regulation under British Columbia's Water Act*; revised January 2001. Water Management Branch, Victoria, British Columbia. 31 pages.
- British Columbia Ministry of Forests. 2001. *Forest Development Plan 2000 – 2004*. South Island Forest District. Small Business Forest Enterprise Program, Cowichan Operating Area.
- British Columbia Ministry of Forests and British Columbia Environment. 1995. *Riparian Management Area Guidebook*. Forest Practices Code of British Columbia. Victoria, British Columbia. 68 pages.
- Butler, R.W. 1991. *A Review of the Biology and Conservation of the Great Blue Heron (Ardea herodias) in British Columbia*. Technical Report Number 154. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.
- Chilibeck, B., G. Chislett and G. Norris (Editors.). 1992. *Land Development Guidelines for the Protection of Aquatic Habitat*. Department of Fisheries and Oceans Canada and BC Ministry of Environment, Lands and Parks. 128 pages.
- McPhee, M.P., Ward, J. Kirkby, L. Wolfe, N. Page, K. Dunster, N.K. Dawe and I. Nykwist. 2000. *Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands, 1993 – 1997. Volume 2: Conservation Manual*. Technical Report Series 345, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 264 pages.
- Michalski, M.F.P., D.R. Gregory, and A.J. Usher. 1987. *Rehabilitation of Pits and Quarries for Fish and Wildlife*. Ontario Ministry of Natural Resources, Land Management Branch. 59 pages.
- Norman, D.K., P.J. Wampler, A.H. Throop, E. F. Schnitzer and J.M. Roloff. 1997. *Best Management Practices for Reclaiming Surface Mines in Washington and Oregon*. Open-File Report 0-96-2. Washington Division of Geology and Earth Resources and Oregon Department of Geology and Mineral Industries.
- Quinn, T., and R. Milner. 1999. *Great Blue Heron (Ardea herodias)*. In E.M. Larsen and N. Nordstrom, editors. *Management Recommendations for Washington's Priority Species, Volume IV: Birds* (<http://www.wa.gov/wdfw/hab/phs/vol4/gbheron.htm>).

Ward, P., G. Radcliffe, J. Kirkby, J. Illingworth and C. Cadrin. 1998. *Sensitive Ecosystems inventory: east Vancouver Island and Gulf Islands, 1993 – 1997. Volume 1: Methodology, Ecological Descriptions and Results*. Technical Report Series No. 320, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 146 pages.