FRASER RIVER
ACTION PLAN

Guidelines on Storage, Use & Disposal of Wood Residue for the Protection of Fish & Fish Habitat in British Columbia

Canada

DOE FRAP 1995-18

Environment Canada   Environnement Canada

Guidelines on Storage, Use and Disposal of Wood Residue for the Protection of Fish and Fish Habitat in British Columbia

DOE/DFO FRAP REPORT 95-18

Prepared by

S.D. Liu and M.D. Nassichuk
Environment Canada
Pacific & Yukon Region
North Vancouver, B.C.

S.C. Samis
Department of Fisheries and Oceans
Pacific Region
Vancouver, B.C.

March 1996

Environment Canada

Fisheries and Oceans

ACKNOWLEDGEMENT

These guidelines were extracted from the information contained in the companion reference **Background Document** which is jointly being developed by Environment Canada and the Department of Fisheries and Oceans. During the review process for these guidelines, input was also obtained from the B.C. Ministry of Environment, Lands and Parks, industry and other government agencies. In particular, a special acknowledgement is extended to Gordon Esplin of Genesis Engineering Inc.

DISCLAIMER

This report was funded by Environment Canada under the Fraser River Action Plan through its Fraser Pollution Abatement Office. Environment Canada is not responsible for the content of this report but has made it available for public distribution.

Any comments regarding this report should be forwarded to:

Fraser Pollution Abatement Office
Environment Canada
224 West Esplanade
North Vancouver, BC V7M 3H7

Enquiries and comments on this document are welcome and maybe submitted to:

S.D. Liu
Environment Canada
224 West Esplanade
North Vancouver, B.C.
V7M 3H7

Phone: (604) 666-2104
Fax: (604) 666-7294
E-Mail: LIUS@epvan.dots. doe.ca

S.C. Samis
Department of Fisheries and Oceans
555 West Hastings Street
Vancouver, B.C.
V6B 5G3

Phone: (604) 666-0209
Fax: (604) 666-7907
E-Mail: SAMISS@mailhost.pac .dfo.ca

TABLE OF CONTENTS

1.0 INTRODUCTION

These guidelines are not to be interpreted as inflexible regulations or considered as Aall inclusive@. The information provided is intended to assist those who generate, store, use, or dispose of wood residue in understanding the scope of their responsibilities and the importance of considering the potential environmental impacts in the early stages of project planning. The objective is to protect fish and fish habitat by preventing wood residue and wood residue leachate from entering fish-bearing waters. Storage and landfilling should only be considered as a last resort after all potential alternative uses of the wood residue have been fully examined. Guidelines on alternative uses of wood residue are available from the B.C. Ministry of Environment, Lands and Parks (MELP).

In these guidelines, Section 1 briefly discusses some of the negative environmental impacts associated with wood residue and leachate, and outlines legislation designed to protect fish and fish habitat. Section 2 provides a proponent=s guide to the regulatory review process and checklists for planning a wood residue proposal. Section 3 explores some strategies for managing the use, storage and deposition of wood residue. Section 4 highlights the design considerations for a wood residue landfill site. A companion **Background Document** provides more detailed information and references on the subjects discussed in these guidelines.

1.1 Wood Residue Impacts

In the early 1990's, approximately five million bone dry tonnes of mill wood residue were disposed of annually in B.C. by burning or landfilling. This residue consisted of about 50% bark, 33% sawdust, 13% shavings, and 4% trim and yard waste. A similar quantity of wood residue resulting from dryland sorting, land and right-of-way clearing, and reservoir debris removal was also disposed of annually in B.C.

Most of the biophysical impacts of wood residue on fish and fish habitat are caused by bark and other residues being deposited in freshwater and/or marine habitats, resulting in the smothering of benthic organisms. Storage and landfilling of wood residue can also have significant negative environmental impacts. Landfilling uses potentially valuable land resources, and may result in leachate generation.

Leachate is formed when water comes into contact with saturated wood residue. Firefighting water poured onto a burning wood residue pile will also result in leachate generation. Leachate from wood residue storage and landfill sites will impact fish and fish habitat if the leachate is allowed to enter fish-bearing waters. Organic constituents leached from the wood residue can be deleterious to fish for several reasons. Leachate may be directly toxic to fish because of the phenolics, resin acids, tannins, and other organic compounds contained in it. In fish-bearing streams, the decomposition of organic constituents in the leachate may depress dissolved oxygen concentrations to levels which negatively affect fish. Leachate=s acidity may release toxic (dissolved) metals from underlying soils, and dark colouration and foam may reduce the amount of light reaching aquatic plants.

In the absence of oxygen, biological decomposition of wood residue can result in methane gas formation. Methane is not only hazardous (i.e., fire and explosion) but it is also a Agreenhouse gas@. Anoxic decomposition of submerged wood residue in seawater can result in the formation of toxic hydrogen sulphide gas.

1.2 Legislation for the Protection of Fish and Fish Habitat

The federal government has authority for coastal and inland fisheries management and research, and is responsible for the administration and enforcement of the *Fisheries Act*. Under an agreement with the Department of Fisheries and Oceans (DFO), Environment Canada has the primary responsibility for administering the pollution prevention provisions of the *Fisheries Act*, whereas DFO is responsible for the other habitat protection provisions.

Section 2 of the *Fisheries Act* defines fish to include Ashellfish, crustaceans, marine animals@, and Athe eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans, and marine animals@.

Subsection 34(1) of the *Fisheries Act* defines fish habitat as Aspawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes@. This would include freshwater, estuarine and marine environments that directly or indirectly support fish stocks or fish populations that sustain, or have the potential to sustain, subsistence to commercial or recreational fishing activities.

Subsection 35(1) states: ANo person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat.@ Deposition of wood residue directly into fish habitat, including riparian zones and nearshore marine areas, would likely contravene Subsection 35(1).

Subsection 36(3) states: Ano person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water.@ Because leachate from wood residue can be toxic to fish, its release into waters frequented by fish would likely contravene Subsection 36(3).

On summary conviction, a person who contravenes Subsections 35(1) or 36(3) may be liable to a maximum fine of $300,000 for a first offence and $300,000 and/or to imprisonment for a maximum term of six months for any subsequent offence. Alternatively, conviction on indictment may result in a maximum fine of $1,000,000 for a first offence and a maximum fine of $1,000,000 and/or imprisonment for a maximum term of three years for any subsequent offence.

In 1992, the Pulp and Paper Effluent Regulations were promulgated under the *Fisheries Act*. These regulations define effluent as including Aleachate from any site at the mill where solid residues generated by any mill are treated or disposed of or where wood chips or hogfuel is stored@. Section 4.6.3 of these guidelines provides a brief discussion on using existing pulp mill effluent treatment systems to treat wood residue leachate.

Ocean disposal of dredge spoil must be made at designated dump sites in accordance with Part VI of the *Canadian Environmental Protection Act*.

The provincial government has the authority to develop legislation concerning certain aspects of land use and pollution control (including waste management as well as the protection of water quality). The B.C. *Waste Management Act* provides the authority for MELP to require permits/approvals for the deposition or burning of wood residue. A permit, approval or exemption issued by the provincial government will not necessarily provide immunity from federal legislation. The MELP Conservation Officers are also designated as Fishery Officers and they have the full authority of Officers under the *Fisheries Act*.

It remains the responsibility of the proponent to comply with the B.C. *Waste Management Act* permit process, and to ensure that wood residue projects are located and designed to adequately protect fish and fish habitat. The responsibility to ensure that wood residue storage, use and disposal do not contravene federal and provincial legislation rests with the proponent.

2.0 PROPONENT=S GUIDE TO THE REGULATORY REVIEW PROCESS

Proponents (including government agencies and crown corporations) are entities which plan to use, store or dispose of wood residue in B.C.

2.1 Preproposal Planning

Consultation between a proponent and regulatory agencies should be conducted during the early planning stages. The preproposal consultation (e.g., meetings) should take place at least one year prior to submission of a formal proposal or application. The purposes of the informal consultation are:

C To identify the requirements and timing for proposal review by the regulatory agencies; and

C To identify the issues of potential concern to regulatory agencies and requirements for mitigating impacts.

A proponent should make two initial contacts during the preproposal stage. The first contact should be to the relevant municipal or regional district office to obtain an understanding of local requirements. The second contact should be to the Alead agency@.

2.2 Lead Agency Designation

A lead agency is one that has the lead role in coordinating the regulatory review of a proponent's proposal. Contacts for government agencies can be found in the Blue Pages section of local telephone directories.

Regulating the storage, use and disposal of waste is mainly within provincial jurisdiction. For the deposit of wood residue on private land and provincial crown land, the B.C. Ministry of Environment, Lands and Parks (MELP) is the lead agency and is responsible for referring the proposal to other agencies. Depending on the outcome of the provincial review, a permit application under the *Waste Management Act* may need to be submitted to the MELP Regional Manager. If MELP is not the lead agency, it will advise the proponent to contact the appropriate regulatory agency.

For proposals to use, store or dispose of wood residue on federal crown lands including Indian Reserves, the proponent must contact the appropriate federal authority having jurisdiction. It is not the federal government's intent to set up a permit referral process specifically to review applications to use, store or dispose of wood residue in B.C. The guidance provided in this document illustrates the general concerns and requirements of Environment Canada and the Department of Fisheries & Oceans (DFO).

2.3 Responsibilities of the Proponent

Although an exemption from the requirement to obtain provincial approval or a permit for wood residue deposition (i.e., at nurseries and equestrian centres or as construction fill) is possible, MELP must still be satisfied that pollution will not occur and the deposit will not result in a contravention of other provisions in the *Waste Management Act* or its regulations. For such utilization of wood residue, proponents are advised to contact MELP prior to the deposition of the wood residue.

The responsibility to ensure that wood residue storage, use and disposal do not contravene federal and provincial legislation rests with the proponent. The use of these guidelines for specific projects does not confer immunity from federal legislation.

Specific to the intent of this report, proponents are advised to avail themselves of the information contained herein and any other technical information/expertise as may be necessary to ensure that wood residue projects are carried out in compliance with the pollution prevention and fish habitat protection provisions of the *Fisheries Act*. Proponents are strongly encouraged to engage the services of a qualified professional to properly identify potential impacts of a project, and in designing the necessary protection and mitigation measures. Government personnel are available to discuss project issues and to provide clarification on requirements but cannot act as the project consultants.

2.4 Submitting a Proposal

The lead agency will advise the proponent of the steps required in the submission of a proposal and whether other regulatory agencies should be contacted for advice. The development of a project submission will be instructive to proponents because the extent of hidden environmental protection costs will become apparent, particularly for sensitive sites. For example, on rainy coastal sites, it may not be feasible to use wood residue as a fill material because of the difficulty in isolating the material from precipitation, runoff and groundwater.

Before submitting a proposal, a proponent should complete the relevant checklists outlined below. The checklists contain information generally requested by agencies reviewing proposals involving wood residue. The level of detail required in each submission will vary. In some cases a proponent may be requested to supply additional information (e.g., a detailed hydrogeological assessment of the site=s suitability; detailed plans for leachate control works).

2.4.1 General Site Information Checklist:

U The name of registered owners of the property (including any agents);

U Whether crown, Indian Reserve, or Agriculture Land Reserve land is involved;

U The legal description and surveyed description; site access information;

U Area of the site in square metres/hectares;

U Site plan showing adjacent roads, ditches, streams and wells;

U A location map or topographic map (at a scale of 1:50,000) showing the proposed site and its boundaries, the access to the site, surface drainage in and around the site;

U Topographical description (e.g., floodplain, swamp, bog, sidehill, gully, ravine, gravel pit, depression, bowl) and slope of land (specify % grade);

U Distance to the nearest well and to the high water mark of any adjacent water bodies (including ditches, creeks, lakes, sloughs and marshes);

U Hydrology of the site: surface water drainage pattern; depth from bottom of site to seasonal high groundwater elevation;

U Type and depth of soil (e.g., peat, gravel, clay, silt, rock, sand) to the groundwater table;

U Availability of alternate sites;

U Description of the area where wood residue is to be stockpiled, burned or deposited;

U Whether the site is new or already contains wood residue or other debris; and

U Date of commencement of the proposed operation and its estimated duration.

2.4.2 **Wood Residue Checklist**:

U Age and species of wood residue (estimate percentage of various species in mixed wood residue);

U Type of wood residue (e.g., bark, sawdust, shavings, trim ends, broken lumber, hogfuel, dredge spoil);

U Site of origin (to determine whether wood residue is likely to be contaminated with wood preservatives, antisapstain chemicals or other chemicals);

U Purpose of using wood residue (e.g., landfill operation, road construction, mulching, riding ring, berm construction, lightweight fill);

U Other refuse included with the wood residue (e.g., metals, ash, gypsum wall board and whether they will be segregated or mixed together);

U Whether leachate is being generated (if site is existing) and results of any chemical/toxicity analyses of the leachate;

U Volume (area x height) of wood residue pile(s) and rate (annual/monthly) of deposition or burning; and

U Volume of wood residue to be stored at farm, equestrian centre or nursery, including the location of storage sites with respect to fish habitat.

2.4.3 Wood Processing Facility Checklist:

- U Operational procedures to be taken to control losses, in particular wind losses, of wood residue into sloughs, stream margins and other fish habitats during storage and loading of barges and trucks; and

- U Detailed site description:

  - û locations of wood residue conveyors, truck loading facilities, jackladders and wood residue storage sites; and

  - û Structures (e.g., brow logs, bulkheads, sheet piling) for the containment of wood residue stockpiles stored near fish habitat for shipping purposes.

2.4.4 Leachate Control and Landfill Design Checklist:

- U Habitat and fishery resources description (may be available from the local offices of DFO or MELP):

  - û proximity to adjacent watercourses (e.g., fish-bearing streams); and

  - û freshwater or marine foreshore resources (e.g., fish spawning, clam beds, eelgrass beds).

- U Plans for surface water diversion around the site;

- U Types of proposed leachate control works (e.g., trench, berm, cover, cell construction; see Section 4 for details);

- U Types of leachate treatment works; and

- U Plans for leachate monitoring (e.g., visual assessments, surface flow sampling, groundwater wells).

2.4.5 Site Closure Checklist:

- U Plans for site closure and abandonment.

3.0 WOOD RESIDUE MANAGEMENT STRATEGIES

This section presents guidance on possible management strategies for the storage, use and deposition of wood residue.

3.1 Log Handling Facilities

Water handling, transportation and storage of logs often result in deposits of wood residue in aquatic habitats. Where possible, log sorting should be conducted at dryland sorting sites in order to minimize the amount of bark and other debris which can enter aquatic habitats and bury the benthos. At the same time, leachate generation and discharge will also be minimized.

Strategies to prevent impacts to aquatic habitats from the water handling, transportation and sorting of logs are described in the Department of Fisheries and Oceans report, AHandbook for Fish Habitat Protection on Forest Lands in B.C.A (1981). Additional recommendations are available from the report, AGuidelines for Log Handling Facilities@, which is being prepared by the B.C. Ministry of Environment, Lands and Parks (MELP).

3.2 Wood Processing Facilities

At facilities located adjacent to watercourses, site-specific operational procedures, including staff training, can be implemented to prevent deposits of wood residue and its leachate into watercourses. Good housekeeping should be practised by mill operators to ensure regular and frequent removal of wood residue from areas such as under jackladders, log decks and log lifts. Properly maintaining and operating wood residue handling/conveying systems will reduce wood residue deposition in foreshore areas and losses from scows. The timing of any dredging operations must be approved by the local Fishery Officer to ensure there are no fish stocks at risk in the area. Dewatering of dredge spoil must be conducted at designated sites. The ocean disposal of dredge spoil can only take place at designated dump sites in accordance with Part VI of the *Canadian Environmental Protection Act*.

Wood processing operations in water, (e.g., log bucking) should not be carried out because leachate and wood debris cannot be effectively captured. The use of hydraulic debarkers should not be encouraged unless effective treatment works are in place to deal with the debarker effluent.

3.3 Wood Residue Storage and Loading Facilities

Large piles of wood residue are commonly stored at wood processing facilities, farms and nurseries. If wood residue must be stored outdoors adjacent to a watercourse, a buffer strip is required and control structures, such as bulkheads, should be installed (with approval from the authority having jurisdiction) between the water and the wood residue pile so that erosion of the pile can be prevented. Buffer strips must be sized and control structures located so as to ensure the protection of riparian areas on streams, and to preserve the integrity of adjacent marine foreshore zones. If wood residue is stored on piled structures overhanging the water, the integrity of the structures must be checked regularly and any repairs completed immediately. If wood residue is stored in overhead bins before being hauled away on trucks, these bins should be located well away from any watercourses.

To minimize leachate generation, the base of a wood residue pile should be restricted to as small an area as possible (i.e., not spread out) and the surface should be shaped to create a moderate to steep slope (e.g., cone shaped). Surface runoff must be diverted around the piles. Leachate control works may have to be implemented if leachate occurs or if water is sprayed on wood residue piles for dust suppression or fire prevention.

Wind-blown wood residue deposited into aquatic habitat is often the result of poor scow loading practises and the overfilling of scows. Such losses can be reduced by installing enclosures for belt conveyors at critical locations and ensuring that outlet spouts are directed away from watercourses. During the loading of scows with wood residue, extra precautions should be made during windy conditions; it may be necessary to halt the loading until the windy condition has ceased. To avoid slumping of wood residue into water, care must be employed when loading scows beyond the height of the side panels. Operators of wood residue loading facilities are responsible for windblown deposits of wood residue into adjacent watercourses. Debris and wood residue should be contained (e.g., with booms) to prevent escape to open waters. The collected debris should be delivered to a proper disposal site before it becomes waterlogged and sinks to the bottom.

3.4 Use of Wood Residue for Peatland Development

Peatland is generally low lying and wet. Property values are increased if peatland can be developed for industrial, commercial, residential or recreational uses. Peatland development requires either extraction of the peat or the placement of a lightweight fill material over the peat. Large quantities of wood residue have historically been used as a lightweight fill material because this method of peatland development was considered to be the least-cost option. Although developers may be exempt from waste permitting requirements, they are advised to contact MELP prior to any wood residue utilization as construction fill material.

The implications of a change in the hydrogeologic regime should be of particular concern in areas characterized by peat soils where the weight of the overlying fill (e.g., wood residue and/or preload) may result in the compression of the underlying peat and the alteration of existing drainage patterns. In peatland areas where underground services (e.g., sewer mains, water lines) are likely to be installed later, wood residue is not a suitable fill material because, when the liner is ruptured, toxic leachate can be expected to be released, even several years after the original deposition. Penetration of liners could occur if foundation piles are used to support heavy overlying structures or if drain wicks are installed to aid fill settlement. Differential settlement may be more of a concern in peatland than in areas with mineral soil. Differential settlement exacerbates the potential for damage to the integrity of the liners and berms and other works installed to prevent contact of the wood residue with water.

The protection of adjacent fish habitat, including water quality, from degradation by wood residue and leachate must be considered as part of the project cost before peatland is filled. Peat extraction and use of more inert, lightweight materials should be considered. Strategies to protect fish habitat, including water quality, that are referenced in these guidelines are comparatively difficult and expensive to implement in peatland.

3.5. Other Uses and Storage of Wood Residue

Wood residue at loading facilities, equestrian centres, farms, nurseries, golf courses and that used in road construction is generally exposed to weather and lacks intermediate or final cover. If wood residue must be used at equestrian centres, operators are advised to only use coarse materials because finer materials like sawdust will leach more quickly. Consideration should also be given to using old wood residue that has already been weathered and will result in the generation of less toxic leachates. In addition to precipitation, water for irrigation, dust and fire control is often applied to the wood residue. At many of these sites, wood residue is deposited either directly over, or near an underground drainage system. Ditches are often placed between the fields and wood residue dykes. A portion of the leachate generated from the dykes is collected in the drainage system and ditches. Although some farmers are using the collected leachate as irrigation water during the dry seasons, research is required to determine the acceptability of using wood residue leachate as irrigation water. Presumably, the leachate acidity could be neutralized (e.g., with powdered limestone) and concentrated leachate could be diluted with makeup water. In wet seasons, or during field-flooding harvests, a much larger volume of leachate is generated than is needed for irrigation. Under such circumstances where leachate generation may be unavoidable, plans for leachate collection and treatment must be developed prior to wood residue deposition. Any leachate collected should be treated to acceptable levels prior to discharge to watercourses. Section 4 provides many applicable design criteria for the management of a wood residue site.

Environmental Guidelines for various agricultural production sectors have been produced or are under development by the B.C. Ministry of Agriculture, Fisheries and Food in cooperation with the B.C. Federation of Agriculture. Environmental considerations when using wood residue are a component of these documents.

4.0 DESIGN OF WOOD RESIDUE LANDFILLS

Many of the strategies that are used to prevent environmental impacts at municipal solid waste landfills are also applicable to wood residue landfill sites. Section 3.3 of the B.C. Ministry of Environment, Lands and Parks (MELP) document ALandfill Criteria for Municipal Solid Waste@ (1993), indicates that ASelected Waste Landfills@, such as wood residue landfills, may be exempted from some of the criteria, but that most of the criteria are considered to be relevant/mandatory and are used to evaluate a permit application. The criteria for Selected Waste Landfills call for the landfill design to be carried out by a Professional Engineer. Many of the design considerations outlined below for wood residue landfills are applicable as well to the storage/use of wood residue at farms, nurseries and construction sites.

4.1 Site Selection

Site selection is the single most important variable in preventing impacts from wood residue storage sites and landfills. On rainy coastal sites, it may not be feasible to use wood residue as a fill material because of the difficulty in isolating the material from precipitation, runoff and groundwater.

Climatologic, hydrogeologic and topographic conditions of a proposed site should be assessed by a qualified professional in order to determine its suitability for wood residue storage/disposal. Measurements to find the height of the groundwater table should be taken during the wet season or during the highest flow (i.e., freshet) of adjacent streams. The MELP criteria for siting landfills include:

< The distance between a landfill and the nearest residence, water supply well or intake, hotel, restaurant, food processing facility, school, church or public park should be greater than 300 metres;

< Depending on adjacent land use and environmental factors, buffer zones between a landfill and associated property boundary of 15 to 50 metres should be reserved for berms or vegetative screens;

< Siting should be avoided in areas within a floodplain (200-year level) or within 100 metres of an unstable area where wood residue can be carried by periodic landslides or water flows into fish habitat; and

< The distance between the landfill and the nearest surface water should be a minimum of 100 metres.

Other distances than the ones listed above may be justified, on a site-specific basis, with the approval of the regulatory agency. Where there is surface drainage from the landfill, regardless of the separation distance from a stream, leachate treatment or groundwater treatment could be required to protect water quality for fish.

4.2 Waste Segregation and Mixing

Before decisions are made to mix wood residue with other materials, discussions with regulatory agencies should take place to minimize the likelihood of unforeseen leachate and/or odour problems. Wood residue contaminated with wood preservatives or wood protection chemicals must be disposed of in accordance with the B.C. Antisapstain Chemical Waste Control Regulation and the B.C. Special Waste Regulation.

4.3 Effect of Age of Wood Residue

Where leachate control is a problem, weathered wood residue is less likely to cause a problem than fresh wood residue because deleterious leachate constituents are leached out with weathering. Old wood residue which has been subjected to degradation will generally produce a lower amount of leachable materials than will fresh wood residue. However, buried cedar debris could produce toxic leachate sometimes decades later when the deposit is disturbed and precipitation enters the fill material.

4.4 Minimizing Leachate Generation

The guiding principle for minimizing leachate generation is to keep water away from the wood residue. Leachate production can be minimized by preventing moisture from coming into contact with the wood residue. Septic tile fields should not be constructed with wood residue. Wood residue piles that are intended for prolonged storage in regions where the precipitation exceeds the evaporation rate can be covered with a tarpaulin to minimize the quantity of leachate that is generated. Some of the ways to minimize wood residue contact with water are outlined below.

4.4.1 Diversion of Surface Water and Groundwater

Diversion may be required to prevent water, including stormwater runoff, and groundwater from contacting the wood residue. The same strategies that are routinely practised at municipal landfills for the diversion of surface runoff and groundwater can be used at wood residue sites. Any strategies must include consideration for changes in the drainage pattern of a site due to the settlement and compaction of the wood residue and any overlying fill. Long-term maintenance of surface water and groundwater diversion works is necessary to prevent clogging and to ensure that water infiltration does not occur after site closure. The Water Management Branch of MELP and the Department of Fisheries and Oceans must be contacted to determine the acceptability of any proposed water diversion works, including any proposal to reroute watercourses. Installation of ditches and culverts are the two ways of diverting surface water away from a wood residue site.

Excavation of diversion ditches up-gradient and around a site is necessary to prevent infiltration and/or direct contact of the surface runoff with wood residue. A double ditch system may be required around the site - an outer ditch for runoff diversion and an inner ditch to collect leachate. A ditch=s failure to divert surface runoff can usually be traced to poor maintenance and inadequate flow capacity design.

If culverts are installed under a wood residue deposit, perforated pipes must not be used, and joints of pipe sections must have watertight seals. Failures of culverts can usually be traced to improperly sealed joints, clogged pipes, or collapsed pipes caused by the weight of overlying materials. Unrepaired, such systems act to collect large volumes of leachate. Repair of a failed culvert system will be expensive and in some cases, repair may not be feasible without first removing all the overlying wood residue.

Groundwater can be collected and diverted by installing a perforated culvert system outside the lined perimeter of a wood residue site. Trenchless technology can also be used to install underground drainage systems. Diversion of groundwater at wood residue sites is not known to be practised in B.C. because it involves extensive trench excavation and permanent pumping systems. The cost of installing such works will preclude many areas from consideration as wood residue storage and disposal sites.

4.4.2 Use of Bottom Liners

A bottom liner is a confining layer that separates wood residue from the underlying soils and groundwater at a site. A bottom liner, along with perimeter berms, can be used to prevent leachate generated within the wood residue deposit from coming into contact with groundwater. Provided that a hydrogeologic assessment shows that a natural bottom liner is continuous under the area to be filled, minimum separation distances could be waived at some wood residue sites.

Liners are impermeable barriers or membranes used to separate water from a deposit of leachable material such as wood residue. Permeability is a measure of the rate of water passage through a liner. The permeability of a liner depends on its thickness and construction. Liners are usually constructed of synthetic material or clay. The characteristics of soil and synthetic liners are outlined below.

Compacted and saturated clay with a permeability of 1×10^{-7} cm/s or less is suitable for use as a liner material. Clay must be kept moist to prevent shrinkage and cracking. Permeability of a clay liner can be increased by freeze-thaw actions, desiccative cracks and damage during its installation. A 1.2 to 1.5-metre thick clay layer may be suitable for use as a soil liner. Rip-rap, local soil and vegetation should be used to stabilize and protect a clay liner against erosion, cracking, or damage from compaction and settlement.

Synthetic liners are generally more impermeable than soil liners. A synthetic liner is made of joined sheets of flexible geomembrane which consists of plastic polymers such as high density polyethylene (HDPE) or polyvinyl chloride (PVC). Since PVC (without UV stabilizers) deteriorates in ultraviolet light, the use of PVC geomembranes must be avoided if the liners will be exposed to sunlight. No information is available on effects of wood residue leachate on geomembranes or on the anticipated life of synthetic liners in a wood residue site. Geomembranes could become useless when punctured or if the joints have been improperly sealed.

The permeability of different types of geomembranes does not differ significantly. Puncture resistance may be a factor in determining geomembrane thickness. The HDPE geomembranes are commonly used at municipal solid waste landfills. Generally, HDPE is used in a thickness of 60 - 80 mils, whereas PVC is used in a thickness of 20 - 40 mils. However, a PVC geomembrane has the advantage of being easier and being less expensive to install because it can be solvent-welded in the shop and then unfolded in the field.

Geotextile or other cushioning materials should be used on both sides of a geomembrane to protect it from puncturing and tearing. Liner integrity is most vulnerable at the seams between adjacent geomembrane sheets. Proper seam sealing methods include the use of adhesives, solvents, heat and/or extrusions. The quality of factory seals is always superior to that of seals made in the field. All field seaming should be carried out by an experienced installation contractor, based on specific instructions from the manufacturer. Sealing by merely overlapping adjacent sheets of plastic liner material would not be effective in controlling leachate.

The use of geosynthetic clay liners (GCL) is becoming more common. A GCL is a "sandwich" consisting of two geomembranes with a layer of bentonite clay between them. This system offers a quick and easy installation of a liner which is relatively impermeable and which can be self-healing if punctured. Extra bentonite clay powder is used around protrusions to seal penetrations. Joints between GCL sheets are formed simply by overlapping adjacent sheets.

The integrity of liners can be compromised by compaction and differential settlement of the wood residue and any overlying fill. In addition, the buildup of hydrostatic and/or gas pressure may possibly lead to liner rupture. It is recommended that the services of a geotechnical professional be used to design and/or to review the design of a wood residue landfill.

Because of the cost of excavating the fill to repair a ruptured liner, innovative practices such as use of a multiple liner system at wood residue sites should be considered. Guidelines for multiple liner systems are presented in the Canadian Council of Ministers of the Environment document ANational Guidelines for the Landfilling of Hazardous Waste@ (Report CCME-WM/TRE-028E, April 1991).

The MELP criteria for Selected Waste Landfills identify two types of landfills: ANatural Control Landfills@ which utilize the attributes of the site's natural setting (e.g., low permeability soils) to control leachate releases, and AEngineered Landfills@ which use engineered systems (e.g., leachate collection systems) to better protect the aquatic environment.

4.4.2.1 Liners in Natural Control Landfills

In the MELP document, the following criteria apply to Natural Control Landfills (i.e., which do not rely on engineered leachate containment/collection/disposal systems):

<   AThe bottommost solid waste cell is to be 1.2 metres above the seasonal high water table. Greater or lesser separation depths may be approved based on soil permeability and the leachate renovation capability of the soil@; and

<   AThere is to be at least a two-metre thick layer of low permeability soil with a hydraulic conductivity of 1 x 10^{-6} cm/s or less (i.e., silt or clay), below each of the bottommost waste cells. Lesser thicknesses or no layer of low permeability soil may be approved based on the potential for leachate generation, permeability and leachate renovation capability of the existing soil.@

4.4.2.2 Liners in Engineered Landfills

In the MELP document, the following criteria apply to Engineered Landfills (i.e., which have engineered leachate containment/collection/disposal systems):

<   AThe minimum liner specification for leachate containment systems is a one-metre thick, compacted soil liner with a hydraulic conductivity of 1 x 10^{-7} cm/s or less. Minimum bottom slopes of the liner are to be 2% on controlling slopes and 0.5% on the remaining slopes. Natural, in situ, low permeability soils, geomembranes, or composite liners (consisting of a geomembrane and a soil layer) which provide the same level of leachate containment are acceptable equivalents. Liners with higher hydraulic conductivities may be approved depending on the leachate generation potential and the unsaturated depth, permeability and leachate renovation capability of the existing soil@;

<   AMinimum specifications for leachate collection systems are a 0.3-metre-thick sand drainage layer having a hydraulic conductivity of 1 x 10^{-2} cm/s or greater. Synthetic drainage net which provide an equivalent hydraulic conductivity are an acceptable alternative@; and

<   AIf there is any concern for the precipitation of leachate constituents causing a plugging problem, the leachate collection system is to be designed to prevent such precipitation from occurring. The drainage layer is to be designed with appropriate grades and collection piping so that the leachate hydraulic head on the liner does not exceed 0.3 metre at any time.@

4.4.3 Use of Berms

Berms are generally installed around the perimeter of wood residue sites as part of the control works. Berms can also be used to divide a site into smaller cells. The design, construction and performance of berms may be limited by the potential instability of a site which may determine the height, extent and rate of wood residue deposition. Berms must be designed to be stable and effective under full operating conditions. The angle of side slopes is determined by the characteristics of the berm material, the precipitation rate and the availability of surface vegetation or rip-rap materials. Side slopes (rise/run) between 0.5 and 1.0 are recommended.

To be effective in preventing wood residue from contacting surface water or groundwater, a berm must be either a geomembrane or relatively impermeable soil. If a soil berm is used, it must be keyed into a bottom liner. Without a bottom liner, ground and surface waters can infiltrate the wood residue fill, or leachate can flow out, via the path of least resistance at the toe of the berm. Bentonite slurry walls can be used to retrofit existing landfills.

4.4.4 Use of Intermediate Covers

The operational phase of many wood residue fill sites in B.C. lasts for many years or decades. Water accumulation within a site during the uncovered operational phase occurs if intermediate covers are not provided. Intermediate covers can effectively reduce the exposed surface area of wood residue at a site. The frequency of applying intermediate covers depends on the amount and frequency of precipitation at a specific site. For fire protection purposes, intermediate covers may still be necessary during the dry season. Works on exposed wood residue should be scheduled during the dry period.

The MELP APollution Control Objectives for the Forest Products Industry of British Columbia@ (1977) specify that operators of sites with wood residue application rates greater than 230 m^3 per day are required to apply an intermediate cover once every week (i.e., Level A requirement). Operators of sites where wood residue is applied at rates up to and including 230 m^3 per day must apply an intermediate cover every 20 days of operation and at least once a month. Level A requirements must also be met at any site where the probability of leachate pollution is significant. The probability is considered as significant when:

< The annual excess moisture at a site exceeds 85 mm per metre of refuse depth; or

< The refuse is located near surface waters; or

< The refuse is less than 1.25 metres above the highest groundwater level at a site.

4.4.5 Use of Final Cover

When using berms and bottom liners to separate wood residue from moisture, it is essential to also install a final cover to prevent the entry of surface water. It is important that the final landfill cover has an overall, long-term permeability that is less than that of the bottom liner in order to minimize the leachate production potential of the landfill.

Although clay has relatively low permeability, it is difficult to compact clay in most situations and the tracks left by compactors cause rainfall to accumulate and infiltrate. A clay cap should always be covered with an overlying layer of native soil to protect it and to prevent the formation of desiccation cracks. Differential settling will also cause the clay layer to crack. The use of geosynthetic clay liners or properly vented geomembranes in conjunction with clay will obviate some of the problems that are inherent with the use of clay.

In the preparation of a typical wood residue fill site, the topsoil and subsoil that were stripped prior to filling should be retained as cover material to protect the final cap after site closure. Infiltration can be further minimized by planting suitable vegetation in the cover soil. To allow proper drainage, the surface of the final cap should have a slope of at least 2%. Visual assessment of damage to the final cap should be made during and well after the site closure. Vehicular movement over the final cap may have to be restricted. The MELP design criteria for covers of Selected Waste Landfills are presented below:

< AFinal cover for landfill sites is to consist of a minimum of one metre of low permeability (less than 1 x 10^{-5} cm/s) and compacted soil plus a minimum of 0.15 metre of topsoil with approved vegetation established. The depth of the topsoil layer should be related to the type of vegetation proposed (i.e., rooting depth). Soils of higher permeability may be approved based on leachate generation potential at the landfill site. Final cover is to be constructed with slopes between

4% and 33% with appropriate run on/runoff drainage and erosion controls. An assessment of the need for gas collection and recovery systems shall be made so that, in the event such systems are required, cover can be appropriately designed and constructed. Final cover is to be installed within 90 days of landfill closure or on any areas of the landfill which will not receive more refuse within the next year. Completed portions of the landfill are to progressively receive final cover during the active life of the landfill@; and

< AAdditional layers of natural materials, including earth and aggregate, and/or synthetic materials, may be necessary for inclusion in the final cover design due to site-specific conditions and the presence of management systems for leachate and landfill gas.@

4.5 Containment and Collection of Wood Residue Leachate

Although implementation of the techniques described in the previous sections will minimize leachate generation, there is no guarantee that leachate production can be eliminated during filling or following site closure. A proposal to minimize leachate production does not necessarily make a site suitable for wood residue deposition. If there is a potential for leachate generation then a plan is required to contain and collect the leachate. The cost of implementing the necessary leachate control works for a site should be factored into a development decision which involves the storage, use or disposal of wood residue.

Liners, ditches and culverts are effective in containing and collecting leachate that is generated. Leachate collection can be a simple matter of installing, over the bottom liner, a collection tile field system, consisting of perforated collection pipes, culverts, cleanouts/manholes, and pumps. If granted, approvals to deposit wood residue in environmentally sensitive areas (e.g., adjacent to fish habitat) will require the total containment of leachate; which dictates the use of a double bottom liner system as a minimum design. Primary leachate collection capacity is provided with the first layer of the liner, but there is also a secondary collection capacity between the liners. The second system can act as a leachate monitoring network or as a Awitness drain@ of liner integrity. Down-gradient monitoring is required to determine if leachate seepage is occurring and if further containment, collection and treatment works are needed.

The control works should be designed to ensure that only leachate is collected and uncontaminated surface water or groundwater will not add unnecessary volume to the leachate. The effects of settlement on the elevation and slope of the control works must be taken into account when deciding on the location for their installation. Failures of leachate collection systems can be traced to clogging and under-capacity designs. Geotextiles, filters, rockpits or other drainage materials may need to be installed around the collection pipes to reduce clogging, and access should be provided for back flushing or clean-outs. Trenchless technology can be used to install leachate collection works at locations where disturbance of surface soil layers is undesirable.

The capacity of the collection system must be designed to handle the largest expected leachate volume. Large volumes of leachate can be generated during the working phase of an open wood residue deposit before intermediate covers and a final cap have been installed. In such circumstances it may be necessary to utilize a temporary leachate recovery system that has a higher capacity than the system that will be required over the long term. In any case, some form of surge capacity should be installed in order to accommodate seasonal variations in flow and any sudden increases generated during storm events. **Regardless of the mitigation measures designed into a site, failures can occur and legal liability can result if leachate is discharged into fish habitat.**

4.6 Leachate Treatment and Discharge

Wood residue deposition may result in leachate generation unless the deposit is completely sealed and properly vented. The discharge of wood residue leachate may cause toxic impacts on aquatic life or otherwise degrade habitat for fish. In determining the economic viability of a project involving the storage, use or disposal of wood residue, proponents are advised to include the capital, operational and maintenance cost of leachate treatment works. Proposals for leachate treatment must be accompanied by laboratory and field trial data to show that treatment can be expected to be effective over the long-term. Field trials or testing of experimental technologies must be coordinated with the relevant agencies but will not be acceptable in a sensitive locations. The discharge of treated leachate must be approved through application to MELP. In the case of discharge to municipal sewerage systems, application must be made to the appropriate municipal authority. Surface water, and possibly groundwater, monitoring should be conducted at sites in sensitive locations. If the treatment systems do not perform adequately, removal of the deposited wood residue could be the only remedy.

There can be considerable variability in leachate volume and in the concentration of its chemical constituents at a wood residue site and between different wood residue sites. More concentrated leachate may have to be dealt with during the initial phase of wood residue deposition. Seasonal variations in leachate volume may require a retention pond or treatment system that is over-designed for most of the year. A treatment system may still be required years after site closure.

Wood residue leachate treatment technologies are derived mainly from treatment processes for pulp mill effluent and municipal landfill leachate. Little or no research is currently being conducted on the treatability of specific constituents in wood residue leachate. Ideally, a treatment process should produce a treated leachate with quality similar to that of the unpolluted receiving water body.

Dilution and dispersion of leachate in a watercourse are not considered a form of treatment. Dilution does not immobilize or reduce the load of toxicants and other leachate constituents. The amount of dilution depends on the hydrology of the site and it varies greatly between different sites and during different times of the year.

Four leachate treatment processes are discussed below.

4.6.1 Natural Attenuation

Natural attenuation may be defined as a process where the load of toxicants and other leachate constituents is reduced by natural processes as the leachate permeates the soil. Dilution of leachate by groundwater or surface water is not considered to be a natural attenuation process. Adsorption is probably the main attenuation mechanism for immobilizing the constituents of wood residue leachate. There is a limit on the attenuation capacity of a given volume of soil. The effectiveness of natural attenuation is also site/soil-specific. The adsorptive force of mineral soils is very limited while organic matter, such as peat, is capable of strongly adsorbing dissolved organics in leachate. The adsorptive capacity of a given volume of soil is reached when all the available surface contact area is saturated with leachate. Until the adsorptive capacity of that volume of soil is renewed through biological decomposition of the fixated organic constituents on the soil surfaces, no further reduction in leachate constituents will take place. Natural biological activity occurs mainly in the soil layer above the water table. Biodegradation processes may eventually refresh leachate-saturated soil for further attenuation. However, such processes likely occur too slowly for the treatment of continuously produced wood residue leachate.

Natural attenuation of leachate occurs to some extent at existing wood residue sites in B.C., but the attenuation capacity of soils can be easily exceeded. At many of the natural attenuation sites in B.C., dark coloured, anoxic and toxic leachate is observed. This problem is compounded when fresh wood residue is added continuously. Approval for use of natural attenuation leachate treatment at wood residue sites must be based on a demonstration by the proponent that the surrounding soils will be effective and have adequate capacity to attenuate and contain all the leachate that could be generated. Otherwise, natural attenuation should only be accepted as a viable form of leachate management in situations where a small volume of wood residue is stored, used or disposed of in dry areas of B.C. that are not adjacent to fish-bearing waters.

4.6.2 Recirculation

Recirculation involves the collection and pumping of leachate onto the surface of a wood residue pile. The wood residue will absorb some of the recycled leachate, if it is not already saturated, and evaporation will occur on the surface during dry weather. The other portion of the recycled leachate seeps through the underlying wood residue and is repeatedly collected and recirculated. If a wood residue pile is not covered and it is located in an area where precipitation exceeds evaporation, a net increase of leachate volume with time can be expected with recirculation. Recirculation systems generally fail during periods of heavy rain and cause overflow of inadequate leachate containment works.

Little leachate treatment is provided in the recirculation process unless microbial decomposition of the organic constituents in the leachate is enhanced by the addition of nutrients. Without the addition of nutrients, biological action occurring within a wood residue pile will usually be inadequate to properly treat the leachate. Nutrient addition to recirculating leachate is usually necessary to promote microbial activity. Spray irrigation of recirculated leachate will increase its oxygen content and aid in the aerobic decomposition in the upper portion of a wood residue deposit. Neutralization of recirculated leachate may be necessary to maintain anaerobic microbial activity. A large leachate retention pond may be needed to supply a steady flow of leachate throughout the year. Temperature extremes may terminate microbial activity. Once terminated, such activity requires considerable time to be reinitiated.

At B.C. wood residue sites where natural attenuation is being used, recirculation is generally the first option implemented when a leachate problem becomes apparent. Recirculation requires inexpensive pumping equipment, but passage of the leachate through the wood residue can be blocked by a buildup of fines, silt or microbial mats. Recirculation is generally considered to be ineffective at natural attenuation wood residue sites in B.C. because of the following three problems:

- Such sites do not typically have adequate leachate containment/collection works;

- Leachate pumping capacity is quickly overwhelmed during storm events and in wet regions/seasons; and

- The rate of microbial activity is inadequate to effectively treat the leachate.

If a leachate recirculation system is used, it must be designed to prevent these problems. Leachate generation must be minimized using the methods previously discussed. The resulting leachate must be collected and stored in a tank or pond with adequate capacity for all leachate from the wet season. The stored leachate should be aerated to prevent it from becoming anoxic, and its acidity should be neutralized. During the dry season the leachate can be sprinkled over a large area of the landfill site so as to promote water evaporation and to retain the organic material within the deposit.

4.6.3 Biological Treatment

Although some organic constituents in the wood residue leachate are toxic to microorganisms and fungi, much of the leachate can be readily biodegraded, especially in a diluted form. True biological leachate treatment systems require control of leachate volume, temperature, pH and nutrients, to maintain a stable environment for the microorganisms. Nutrients, such as nitrogen and phosphorus, may need to be added to leachate treatment facilities to promote microbial growth. Oxygenation of the leachate undergoing treatment is required so that aerobic microorganisms will survive. A surge pond may be needed to reduce fluctuation in effluent volumes entering a biological treatment system. Biological treatment is ideally operated at 35^{o}C, but it will proceed more slowly at lower temperatures. This implies that biological treatment in cold regions may not be effective unless the leachate is pre-heated.

Most of the biological treatment processes proposed for wood residue leachate treatment are derived from pulp mill effluent treatment technology. Biological treatment systems for wood residue leachate, including aeration lagoons, activated sludge systems and artificial wetlands have demonstrated their potential value through various laboratory studies. Provisions for sludge removal and disposal must be included in the plans for a biological treatment system. Further developmental work is required to enable the design and testing of small, self-contained biological treatment systems suitable for wood residue disposal sites.

The use of a wood residue deposit as a crude anaerobic filter in leachate recirculation is a form of biological treatment. Methane generation can be used to monitor microbial activity.

Natural and artificial wetlands can be used as biofilters to remove organic and inorganic constituents from wood residue leachate. The effectiveness of such a treatment system can be enhanced by using mature plants and relatively long retention times. An Aengineered marsh@ was used to treat leachate that emerged along roads constructed over a wood residue fill site in Richmond. Based on analyses of treated and untreated leachate, the engineered marsh was reported to be successful in treating leachate over a two-year period. Natural wetlands with a surface flow directly into fish habitat, including fish food production areas, are not acceptable for use in leachate treatment.

Since most forms of biological treatment are expensive, a proponent may wish to explore the acceptability of directing the leachate into existing municipal or pulp mill secondary effluent treatment systems. In some cases it may be feasible to use the barges/scows that are being used to transport hogfuel to pulp mills to also transport a relatively small volume of leachate, either by simply adding the leachate directly to the hogfuel or by pumping it into the barge's bilge and then pumping the leachate into the mill's effluent treatment system.

4.6.4 Physical/Chemical Treatment

Various carbonaceous materials have been used for treatment of pulp mill effluent. Ash from burned bark was found to be effective for detoxification of hydraulic debarker effluent. Activated carbon has been used in the treatment of industrial effluent. Lignite or soft coal has been used in a large bed of filter media to treat municipal effluent. Wood ash and activated carbon have been used in treating log pond and hydraulic debarker effluent in B.C. forest products operations but their effectiveness is not known since monitoring data are not readily available.

The effectiveness of other physical/chemical treatment processes on wood residue leachate is less well understood than carbon adsorption. Before implementing any such process, proponents should be prepared to conduct laboratory, pilot and field studies. There are indications that physical/chemical processes will be costly to install and operate and they may only be cost-effective in situations where a small volume of leachate has to be dealt with for a short period of time.

4.7 Control of Decomposition Gases

Biological decomposition of wood residue will result in gas formation. Some of these gases have an unpleasant odour. Anaerobic decomposition could result in the formation of toxic or explosive gases such as hydrogen sulphide or methane. Aerobic decomposition will result in the formation of carbon dioxide gas. Gases generated in the decomposition processes can be dissolved in the leachate/water or the gases can be directly released into the atmosphere. The control and safe venting of gases must be taken into consideration (see Section 4.4.5) during design of the landfill site and leachate containment works. This is particularly important where low-permeability liners, foundations, slabs or large paved areas are constructed over wood residue and the gases can migrate off-site and present a hazard if allowed to accumulate within an enclosed space.

The design of leachate control works should also include measures to prevent the passage of methane into underground services (e.g., sewer lines). A few small vents connected to above ground stacks should be installed at regular intervals in liners encasing the wood residue in order to prevent the buildup of carbon dioxide and methane which could lead to the eventual rupture of the liner, and fire or explosion hazards. These vents should be situated well above the groundwater table. Alternatively, the vents could be connected to riser pipes which penetrate the surface of road bed margins. Consideration could also be given to the collection and use of methane gas from wood residue disposal sites.

Landfill gas monitoring and control are outlined in the following two documents:

< Governmental Refuse Control and Disposal Association (now called the Solid Waste Association of North America) 1988 document AA compilation of landfill gas laboratory and field practices and procedures@; and

< B.C. Environment 1993 document ALandfill criteria for municipal solid waste@.

Another document titled: AGuidance Document for Landfill Gas Management@ is being prepared by Environment Canada in 1996.

4.8 Leachate Monitoring

The only way to determine if leachate is being generated or migrating outside of containment and collection structures is by leachate and groundwater monitoring. Leachate monitoring could include the sampling of leachate, surface runoff, groundwater and receiving waters at and adjacent to a wood residue site. Leachate collection systems could act as witness drains for liner integrity or as monitoring tools. Locations for installation of groundwater monitoring wells must be determined after an evaluation of the local hydrogeology. Monitoring parameters will be site-specific, and advice on the design of a monitoring program should be obtained from MELP. Leachate monitoring may be a requirement for receiving a permit or approval from MELP to deposit wood residue. Recommended procedures for design and implementation of a leachate monitoring program can be found in a 1977 Environment Canada publication: ARecommended procedures for landfill monitoring programme design and implementation@. Monitoring may be a significant part of landfill operating and post-closure costs.