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ASSESSMENT OF PRESERVED WOOD DISPOSAL PRACTICES

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and

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PROPERTY OF ENVIRONMENT CANADA

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for

ADA Environment Canada Conservation and Protection

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Photo 1: 20-25 year old ties for reuse on a secondary line - CNR Orangeville, Ont.



Endty 2: Reuse of ties for tence posts on right-of-way -CER, Smith Falls, ont.



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Photo 3: Sheared ties ready for open burning - ACR, Searchmount, Unt.

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Thats it kemains of open burned ties - ACK, Searchmount, Ont.

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SPECIALS TERMS, CHEMICALS, ACRONYMS

AAC		Alkyl Ammonium Compound
ACA		Ammoniacal Copper Arsenate
ACZA		Ammoniacal copper zinc arsenate
ACB	£	Ammoniacal Copper Borate
ACR		Algoma Central Railway
AREA		American Railway Engineering Association
76		Arsenic
A=203		Arsenic Trioxide
As205		Arsenic Pentoxide
AWDA		American Wood Preservers' Association
AWDT		American Wood Preservers Institute
DCD		Britich Columbia Reilway
DUN		British Thermel Unit
DIU C		degrade Colsius
		Chromotod Coppon Arconste
CCR		Chromated Copper Alsenate
CCD		Chromated Copper Borace
CEDA		Canadian Environmental Protoction Act
CEPA		Canadian Environmental Protection Act
CNR		Canadian National Kaliway
CPR		Uanadian Pacific Railway
CPSA		U.S. ConsumerProducts Salety Act
CSA		Canadian Standards Association
Cu		Copper
CuNap		Copper naphinenale
Cr		Chromium
CWPA		Canadian wood Preservation Association
FAST		Facility for Accelerated Service Testing
EPA		U.S. Environmental Protection Agency
FDA		Federal Drug Administration
EPS		Canadian Environmental Protection Service
fbm		foot board measure
FCAP		Fluor Chrome Arsenate Dinitrophenol
FIFRA		Federal Insecticide, fungicide and
		Rodenticide Act
g		gram
HpCDD		Heptachlorodibenzo-p-dioxin
HxCDD		Hexachlorodibenzo-p-dioxin
K		dissociation constant
kg		kilogram
L		liter
m		meter
mg		milligram
MISA		Municipal Industrial Strategy for Abatement
MJ		Megajoule
MOE		Provincial Ministry of the Environment
NIBS		National Institute for Building Sciences
OWMC		Ontario Waste Management Corporation
OCDD		Octachlorodibenzo-p-dioxin
ONR		Ontario Northlands Railway

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OSHA	Occupational Safety and Health Administration					
PAH's	Polycyclic Aromatic Hydrocarbons					
PCDD	Poly chlorodibenzo-p-dioxin					
PCDF	Poly chlorodibenzofuran					
pcf	Pounds per cubic foot					
Penta i	Pentachlorophenol					
μ	negative logarithm of hydrogen ion concentration					
рК	negative logarithm of dissociation constant					
P. pine	Ponderosa pine					
dad	Parts per billion					
ppm	Parts per million					
ppt	parts per trillion					
psi	Pounds per square inch					
PWF	Preserved Wood Foundation					
RCRA	U.S. Resource Conservation and Recovery Act					
Reg.	Regulation					
RPAR	Rebuttable Presumption Against Reregistration					
RTA	Railway Tie Association					
SPF	Spruce Pine Fir					
SYP	Southern yellow pine					
TCDD	Tetrachlorodibenzo-p-dioxin					
TSCA	U.S. Toxic Substances Control Act					
ug	microgram					
USDA	United States Department of Agriculture					
W. hem	Western hemlock					
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1.0 EXECUTIVE SUMMARY

This report considers aspects of the disposal of wood treated with the heavy duty wood preservatives, creosote, pentachlorophenol (penta), chromated copper arsenate (CCA) and ammoniacal copper arsenate (ACA).

It is estimated that the creosote content of wood taken out of service is about 16,000 tonnes per year. This quantity is expected to drop with time as products no longer treated with creosote reach the end of their service lives and as the ongoing rationalization of the railways is completed. About 75 % of the creosote is in 50:50 creosote petroleum solution in changed out railway ties. The remainder is poles, posts, marine and land piling, timbers, wood floor blocking etc. Much of this wood is reused; ultimate disposal is primarily by open burning or landfill.

The amount of penta in wood removed from service is more difficult to quantify, but is estimated at 1050 tonnes per year. The amount removed should be relatively constant from year to year, and the levels are not expected to change significantly for several decades. If penta usage drops in Canada in the future as anticipated by many, this will be reflected in lower disposal amounts in 30-40 years. Most of the penta treated wood removed at this time is in poles or railway ties. Most of this wood can be recycled by the owner or sold for reuse to others. Where ultimate disposal is necessary, these products are usually placed in landfill sites.

The amount of inorganic arsenical treated wood removed from service is relatively low at this time (estimated at 36, 66, and 47 tonnes per year of Cu, Cr and As as elements). However, the use of CCA treated wood has been growing rapidly, especially in the residential construction market and the quantities requiring disposal will also rise dramatically in the future. By 2020, the amounts of inorganic preservative treated wood requiring disposal will have increased by more than 10-fold. With the exception of CCA and ACA treated poles and piling, there are few opportunities to recycle this wood.

Methods of disposal

The primary methods of disposal of treated wood are by disposal at dumps or landfills and incineration or open burning. Practices vary from country to country depending on the volumes of wood requiring disposal and the perceived health and environmental consequences of the different disposal options.

In the U.K., Australia and New Zealand, the authorities are more receptive to the burning of treated wood, including the inorganic arsenicals, than the rest of Europe, the USA

and Canada. Legislation related to the disposal of treated wood is most highly developed in the U.S.A., in response to the much greater volumes of treated wood in service. However, the solutions to the disposal problem are remarkably similar in all countries. An exception is the prohibition on burning of creosoted wood in Sweden and some other European countries.

Consequences of disposal

Studies on the depletion of preservatives from treated wood and their fate in the soil/water system, suggest that solid wood treated with all of the conventional wood preservatives can be safely disposed of in landfill sites. However, the shortage of acceptable landfill space in heavily populated areas and the rapidly escalating tipping fees make this option unacceptable in some areas, especially disposal of CCA treated lumber in residential for construction. More cost effective disposal methods must be developed for this material. Finely devided treated wood such as sawdust and planer shavings may not pass the standard leachate test and may be classifiable as "Leachate toxic wastes". Large quantities of this material should be disposed of at a hazardous waste facility.

Open burning of inorganic arsenical and pentachlorophenol treated wood can have deleterious health and environmental effects and is not recommended. Also, incineration of inorganic arsenicals without recapture and treatment of grate and fly ashes is not appropriate. Pentachlorophenol treated wood on the other hand, can be incinerated as long as sufficiently high temperatures, long dwell times and added oxygen are ensured. Appropriate incineration procedures are defined in chapter 5.

There is little evidence that burning of creosoted wood causes health or environmental problems.

Materials conservation strategies

The amounts of treated wood requiring ultimate disposal can be reduced greatly by application of a number of material conservation strategies. These approaches all have greater socio-economic benefits than the above disposal methods and should be encouraged. Appropriate strategies for treated wood are:

- Materials reuse or recycling. Railway ties and poles are particularly amenable to reuse for the origional or different purposes. As long as the intended use is appropriate, highest socio-economic benefits result.

- Materials substitution. Less toxic wood preservatives or preservative constituents can be used in place of the standard preservatives.

Reliability based design. A greater effort can be made to specify preservatives, levels of treatment and wood species that are matched to the deterioration hazard of the end use. This is done to a limited extent through CSA and AWPA treating standards that preclude unacceptable species for cartain uses and specify higher retentions of preservative for uses with high risk of deterioration and serious consequences of failure, such as wood foundations and marine piling. However, these principles can be applied to many other end uses and extended to include less toxic preservatives for low hazard uses.

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- Technological innovations. Wood products can be treated more efficiently through use of advanced incising and other pretreatment technologies and through application of improved pressure treatment technology. Alternatively, wood can be protected against moisture and biological attack through design to provide longer service lives.

- in situ treatments. The service life of some products (mainly poles) can be extended by application of treatments in service. Use of low toxicity systems ensures a net positive socio-economic benefit.

Research and study needs

In order to promote the most appropriate management of treated waste wood, the following study needs have been identified:

(i) Develop a transport model for movement and interaction of inorganic arsenicals in the soil.

(ii) Evaluate the leaching characteristics of fresh treated CCA and ACA offcuts, using the criteria for "leachate toxic waste" evaluation.

(iii) Evaluate the rate of depletion of all preservatives from aged wood (at the time of removal from service) and the fate of the preservatives in the environment.

(iv) Evaluate the service performance of low toxicity preservatives especially in above ground applications.

(v) Evaluate the effect of diffusing salt treatments and fumigants on the service life of poles and ties.

(vi) Measure the PAH emissions from burning of creosoted wood under different conditions to clarify conflicting published data. Evaluate various burner types and effects of innovative technologies such as infrasound on the efficiency of combusting pentachlorophenol treated wood.

(vii) Develop accurate statistics on the Canadian wood treating industry on an annual basis.

2.0 INTRODUCTION

Wood products that are used under conditions that expose them to attack by decay fungi and insects are usually impregnated with one of the "heavy duty" wood preservatives -creosote, pentachlorophenol-in-oil (penta), chromated copper arsenate (CCA) or ammoniacal copper arsenate (ACA). Such treatment, if applied properly, should extend the physical service life of the product by 20 to 50 years or more depending on the method of treatment and conditions of service.

However, at some future time, treated products become unserviceable, either through mechanical damage or failure, biological deterioration or obsolescence. At this point, the treated wood may be salvaged, abandoned in place or removed from active service for disposal. This decommissioned wood still contains significant quantities of wood preservative, and the fate of the wood and entrained preservative chemicals is of concern.

The purpose of the proposed work is to prepare a problem analysis on the disposal of treated wood removed potential involves estimating the It from service. environmental loading from treated wood removed from service. under present practices and to recommend, if necessary, more appropriate practices. Also, current disposal practices in Canada and abroad are summarized and relevant legislation The economic and pertaining to this problem discussed. impacts of current and proposed disposal sociological practices is evaluated. Where obvious knowledge gaps exist, recommendations for additional study and research are made. While this report emphasizes the "disposal" of treated wood, it also addresses the broader problems of materials conservation and management of waste materials.

A materials cycle for treated wood products is depicted in Figure 1 (adapted from Schlabach, 1984). This study concentrates on the portion of the process cycle involving the generation of construction wastes, removal of treated wood from service due to damage or because it has reached the end of its useful life and approaches to reducing the amounts of contaminants removed each year by improved processes and in service maintenance.

Three important strategies of materials conservation are:

- (i) Effective materials utilization
- (ii) Materials substitution
- (iii) Materials recycling

These are also reflected in the 4-R's strategy adopted by the Ontario MOE, i.e., REDUCTION, RECYCLING, REUSE and RECOVERY.

In the context of this study, "effective materials utilization" entails development, selection and design of treated wood to produce products that most efficiently meet the application requirements. For example, wood should be



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FIG 1: Total materials cycle for preservative treated wood product.

treated to an acceptable level to ensure a long service life to result in efficient use of the resource. This may be achieved through improved pretreatments, processes and quality control. Also, it may be appropriate to use low loadings or less efficacious but more chemical environmentally acceptable preservatives in applications where decay hazard is low and consequences of in service failure are not serious. These concepts are discussed in section 7.2 with regard to reliability based design. Another approach to optimizing materials utilization is to extend life through remedial or in situ physical service treatments. This approach is discussed in section 7.1.

Optimization of these approaches will require research and development to improve product design and quality of treatment and to develop appropriate in situ treatments. These requirements are discussed in chapter 9.

The strategy of "materials substitution" may be considered in two ways - use of other materials in place of treated wood and substitution of less hazardous preservative treatments. The amount of waste treated wood generated would be greatly reduced if, for example, more steel and concrete were used for poles, piling and railway ties. However, the relative costs and benefits of substituting other preservative treatments and other materials were exhaustively explored by the U.S. EPA as a part of the RPAR process (EPA, 1981, EPA, 1984, USDA, 1980). It was affirmed that products treated with the previously defined heavy duty wood preservatives are appropriate for the major uses of treated wood products and this will be assumed this in study. However, it may be feasible to reduce future disposal less toxic preservatives problems by substituting or components of preservatives while maintaining adequate efficacy for Canadian applications. Some of these options are discussed in section 7.2.

"Materials recycling" through reuse of treated wood removed from service or of derivatives of the waste wood is also a valid strategy that is discussed in chapters 4 and 5.

While effective materials conservation can reduce material and energy consumption and minimize the quantities to be disposed of, there will inevitably be treated wood waste that will have to be managed in some way. For management of hazardous wastes, there is a hierarchy of approaches (OWMC, 1982) that can also be applied to the management of treated wood taken out of service. In order of desirability, they are:

(i) Waste abatement or elimination (zero discharge)

- (ii) Waste reduction or modification
- (iii) Waste reuse
- (iv) Waste refining for recycling
- (v) Waste treatment and destruction
- (vi) Waste disposal

In this context, "disposal" refers to placement of the waste without reduction or modification in a waste disposal site such as a landfill. It is considered the least desirable option.

There are definite economic incentives for the owners of non-functional treated wood products to move up the above hierarchy.

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- The cost of wood products and especially treated wood products will continue to increase

- The cost of disposal of these materials in landfill sites is rapidly escalating.

- Environmental legislation is becoming more restrictive with regard to disposal of products perceived to be hazardous.

For preservative treated wood, the elements of this hierarchy, if relevant are considered.

3.0 ESTIMATED QUANTITIES OF TREATED WOOD AND ENTRAINED PRESERVATIVE DISPOSED OF ANNUALLY

3.1 Introduction

The environmental significance of treated wood removed from service depends on the amount of wood decommissioned, the residual amounts of preservative in the wood and the type of product and preservative. It is impossible to get a precise measure of the amount of treated wood disposed of annually, because of the lack of measurement or reporting of this information by most users of treated wood products. In this chapter, the volume of treated wood will be estimated on the basis of annual preservative consumption, quantities treated and expected service life of treated wood oſ products. Detailed and accurate statistics on the wood treating industry, such as those commissioned and published by the American Wood Preservers' Association in the USA are not available in Canada. Also, the amount of wood treated and decommissioned in a given year does not represent a steady-state situation, as the production of treated wood products is steadily growing, particularly in the area of residential construction (CCA-treated fencing, decking, siding etc.). The increased volume of wood treated now will not be reflected in increased disposal problems for many years. Also, the expected service life depends many on decay hazard factors such as type of product, end use, situation (e.g. climatic, soil, microclimate effects), wood species, preservative type and quality of treatment.

The amount of wood preservative in the wood at the time of disposal depends on the initial retention or loading in the wood and on the depletion losses in service resulting from leaching, volatilization, biological degradation or combinations of all of these factors. A modification factor is applied to the estimated preservative loadings to take these effects into account.

Where reliable information is available, estimates of wood removed from service by large users are tabulated.

3.2 Creosote

The major use of creosote is for railway ties, for which direct estimates of annual replacements are available. Other uses are bridge timbers, land piling, and marine timbers and piling. Also, in the past, substantial volumes of poles, posts and wood blocking for floors were treated with creosote and these products are still taken out of service on occasion.

The consumption of creosote and production of creosote treated products has remained relatively constant over the years. Estimates of the quantities installed annually are based on Statistics Canada figures for value of creosote used annually, estimates of service life, and correction for preservative depletion. Where possible, actual estimates of treated wood are used in the analysis.

3.2.1 Direct estimates of creosoted wood removal - ties

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The average service life of wood ties is usually governed by mechanical failure of the ties such as splitting or plate cutting and crushing. There is some evidence that this mechanical damage is affected by biological deterioration and is therefore affected by the initial quality of treatment. However, it is probably more dependent on such factors as tonnage and frequency of trains, quality of the ballast, size of plates, location (tangent vs curves) etc. In general, the average life of ties in Canada is 20-25 years on main line tracks and 25-30 years on secondary tracks.

Based on a direct survey of the major railway companies in Canada, it is estimated that there are more than 60 million ties in service and that 3.5 million are changed out annually. The number of new tie installations is lower, (about 2 million, Stats Canada, 1984-5, Brudermann, 1988) since some of the ties are reused and some of the removals Thus, future disposal decommissioned lines. for are quantities will be lower. While most of the ties are treated with a 50:50 creosote-petroleum solution, some penta, arsenate straight creosote FCAP (fluor chrome and dinitrophenol) treated ties are used. The results of the tie replacement survey are summarized in Table 3.1.

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Table 3.1 Summary of railway tie replacement data for Canadian railways

Railway	Estimated no. of	Relativ	e % of treat	tment
nullina	ties removed p.a.	50:50 creo/pet	Penta	FCAP
CNR	1.5 - 2,000,000	90	10	
CPR	1,300,000	100		
BCR	170 - 190,000	50	50	
ACR	40 - 50,000	50		50 ·
ONR	40 - 45,000	100		

Based on the above, about 2.6 - 3.1 million creosotepetroleum treated ties are removed from service each year. Each class 1 tie contains about 3.5 cubic feet (0.099 m3) vs. about 0.075 m3 for class 2 ties. Assuming 90 % class 1 ties, the volume of treated ties removed is about 0.275 million cubic meters. Assuming an average initial retention of 7.5 pcf (120 kg/m3) and creosote/petroleum losses in service of 20%, about 13,200 tonnes of creosote are entrained in railway ties removed each year in Canada.

3.2.2 Estimates based on annual usage of creosote in Canada

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Based on the reported quantities of creosote used in manufacturing in Canada, (Statistics Canada, 1962 - 1984, Table 44. Materials and Supplies Used -Manufacturing Activity) the amount used has dropped considerably in the last decade (Table 3.2). However, recent statistics do not include the quantities of creosote/petroleum, and the more recent values may be understated. An independent analysis of recent creosote use estimates that 20,000 tonnes were used in 1986 (Konesewich and Henning, 1988). Based on the above analysis of creosote content in railway ties, before depletion losses in service, the ties removed in a single year would represent origional treatment loadings of about 16,500 tonnes of creosote. This indicates that railway ties are the major single use of creosote in Canada, as confirmed by Brudermann (1988).

The other primary uses of creosote, past and present, such as marine and land piling, fence posts, poles, wood block flooring, and bridge timbers, have longer service lives than ties because mechanical damage is less of a problem. However, they have been used for these treatments for a long time at relatively constant levels. Thus, it is reasonable to assume an approximatly steady state condition with the amount of creosote entering the environment from demolition or removal of structures approximately equal to the amounts impregnated into wood in past years, corrected for depletion losses in service. For an average usage of 20,000 tonnes per year, and assumed depletion losses of 20 % over the life of the product, the total mass of creosote in wood removed from service is about 16,000 tonnes per year.

This quantity is expected to decrease modestly with time as the surplus railway lines are decommissioned and products now rarely treated with creosote, such as poles, posts and wood floor blocks are removed from service and replaced by other treated wood products or other materials. For lack of quantitative indicators of this rate of decrease, it is assumed in Table 3.3 that the amount of creosote removed will drop by 5 % per annum.

3.3 Pentachlorophenol (Penta)

The amount of wood treated with pentachlorophenol has remained relatively constant over the years; future use may decrease due to environmental concerns by users. Penta is used primarily for utility poles, railway ties, fence and guardrail posts, land piling and timbers.

3.3.1 Direct estimates of penta usage.

From Table 3.1, it is estimated that about 400,000 penta treated ties (39,000m3) are removed from service annually. At initial loadings of about 8 kg/m3 penta and depletion losses of 20 %, the amount of penta entrained in ties removed each year is about 250 tonnes.

Table	3.2	Estimated Pentachlo (Statisti	Quantities and rophenol-in-oil cs Canada)	Value of Creos used annually	sote and in Canada
	ì	,			
Year	Ŧ	Creos	ote	Pentachlor	rophenol
		Mass*	Value	Mass**	Value
		(tonnes)	(\$million)	(tonnes)	(\$million)
1987				1767 @	
1986				1653 e	
1985				2470 @	
1984		9450	3.76	2121 @	10.40
1983		9350	3.89	760**	6.17
1982		12260	4.00	1100**	8.49
1981		15020	4.52	940**	6.91
1980		12560	2.89	880**	6.14
1979		13240	2.70	900**	5.97
1978		19420	3.26	910**	5.77
1977		17250	4.21	720**	4.21
1976		16040	2.85	510**	2.85
1975		16330,	4.11	770**	4.11
1974		20660	1.93	670**	1.04
1973		16790	1.24	818**	1.21,
1972		15550	1.10	887**	1.25
1971		17900	1.29	954**	1.28
1970		19460	1.36	814**	1.04
1969		17650	1.28	830**	1.01
1968		20800	1.49	915**	1.06
1967		25240	1.78	444 @	0.49
1966		29440	2.08	867 @	0.95
1965		23150	1.63	898 @	0.91
1964		23880	1.71	1047 @	0.99
1963		26730	1.69	717 @	0.69
1962		31290	1.90	685 @	0.62

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* Assumes creosote density = 1.10 g/cm3.

** Estimates based on values of penta-in-oil and assumed inflation rate of 5%.

@ Statistics Canada estimates.

Table 3.3 Estimates of wood preservative active ingredients requiring disposal annually

Year Estimated amounts of preservatives entrained in wood removed from service (Tonnes/year)

	Inorganic elements			Creosote	Penta
	Cu	Cr	As		
1988-90	36	66	47	16,000	1050
1990-95	36	66	47	15,200	1050
1995-2000	60	110	78	14,500	1050
2000-05	110	210	145	13,800	1050
2005-10	260	48 0	340	13,200	1050
2010-15	510	950	670	12,500	1050
2015-20	530	1000	700	11,900	1050
2020-25	560	1050	734	11,400	1050
2025 +	Higher	quantities	as more	10,800	?
	poles	etc. are d	isposed of	•	

The largest single use of pentachlorophenol is for utility poles. It is difficult to predict the amount of penta removed annually from pole removals for the following reasons:

- Poles removed now include a number of untreated poles such as Northern white cedar.

- Although creosote is no longer used extensively to treat poles, some creosoted poles are still in service and make up a significant fraction of poles removed.

- Many of the poles in service are thermally butt treated (creosote or penta); thus the amount of entrained preservative is substantially lower than in full length treated poles.

- It is a common practice to saw off poles at the groundline leaving the butt portion in place when poles are changed out.

- The number of poles removed each year by a given utility may vary considerably with budgetary considerations and special factors. For example, Ontario Hydro's replacements ranged from 4,400 to 15,000 per year from 1960-1976 (Hawthorne, 1978).

- The removed poles vary considerably in size. Telephone poles, are smallest, distribution and joint use poles larger and transmission poles largest. No record is kept of the size distribution of poles removed.

It is estimated that there are currently about 8.7 million poles in service in Canada (Sugden, 1976), most of which are of treated wood. The average physical life of treated wood poles in Canada depends on many factors such as wood species, method and type of preservative treatment and geographical location of the pole in service.

The average physical life of poles, i.e., the life expectancy if poles are only removed as a result of decay, is relatively long in Canada, particularly if remedial treatments are applied to replenish the preservative lost at the surface of the pole near the groundline. Munro (1983) used a value of 43 years for poles in Manitoba. However, the actual life in service may be much shorter due to changing out of poles for road widening, upgrading of lines to larger poles or due to mechanical damage from automobiles, lightning, ice storms etc. Hawthorne (1978) estimated an actual life of 30 years for Ontario Hydro's pole population. Based on an average of 35 years for an estimated 8.7 million wood poles in Canada, an estimated 250,000 poles per vear may be removed.

Actual estimates of pole removals by individual utilities, summarized by region in Table 3.4, are consistant with this estimate.

Table 3.4 User Estimates of Pole Removals in 1988

Region

Estimated No. of Poles Removed Annually

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10,000	
15,000	
50,000	*
8,000	•
20,000	
95,000	
30,000	
	$ \begin{array}{r} 10,000\\ 15,000\\ 50,000\\ 8,000\\ 20,000\\ 95,000\\ 30,000\end{array} $

Total 228,000

 Includes about 35,000 poles per year for the next 20 years as part of a special rural underground development program.

At this time, the majority of poles placed in service treated with pentachlorophenal-in-oil, although are an increasing number of poles have been treated with the waterborne CCA and ACA treatments especially in the past 10 years. Creosote is not used appreciably at this time, but there are still many creosote treated poles in service. For the next 20 years, most of the poles removed for reasons other than mechanical damage, are expected to be creosote and penta. The exact breakdown between these two preservatives is impossible to define.

Because of the difficulties in estimating penta content of treated wood removed from service, estimates will be based on the historical penta usage in Canada.

3.3.2 Estimates based on penta consumption

As with creosote, the use of pentachlorophenol is thought to have remained relatively constant over the past 1-2 decades (e.g., de Lissa, 1983). Konesewich and Henning, (1988b) estimate the annual consumption at 1500 tonnes in 1986; Jones (1981) estimated 1536 tonnes used in 1981 and 1746 tonnes in 1976. Unfortunately, since 1967, Statistics and Canada has reported the value of penta-in-oil used, but not the amounts. These values are reproduced in Table 3.2. It is difficult to relate these values to quantities because of the volatile pricing of both penta and petroleum, especially since 1973. Assuming an annual increase in penta prices of 5% between 1966 and 1974 and an average penta concentration of 5%, the amounts of penta used are estimated (Table 3.2). Also, based on an industry estimate of penta-in-oil price at \$1.75 per imperial gallon in 1985, and assuming a 5% inflation rate between 1975 and 1985, estimates were made for these years. This analysis results in much lower estimates for penta consumption for 1981 and 1986 than those cited by Jones and Konasewich and Henning and are probably low estimates for all years reported. Since 1984, all Penta consumed in Canada has been imported. These import data are available from Stats Canada and are included in Table 3.2 for 1984 to 1987.

The annual average consumption of pentachlorophenol is taken as 1500 tonnes for the past three decades. Future the future probably drop, depending on usage will registration status of penta in Canada and the development of suitable alternative chemicals. Based on an average service life expectancy of 35 years, and a reduction factor of 30 % to take into account penta depletion and the fact that many penta treated poles are cut off at ground level for removal, leaving treated stubs in the ground, estimates for annual penta removal from service are shown in Table 3.3.

3.4 Inorganic Waterborne Wood Preservatives, CCA and ACA

While products treated with these chemicals have been available in Canada for more than 20 years, prior to about 1975, they were available on a custom treating basis only. Thus, production was relatively constant and low. In the mid 70's, the treating capacity for these preservatives, especially CCA, began to expand rapidly. The volume of CCA treated wood has grown steadily and is predicted to continue to grow at a moderate rate in the future. At present, little of this material is removed from service and there are few service records available to allow prediction of average service lives.

Most of the ACA and CCA treated wood disposed of at this time results from mechanical failure of the product, e.g., automobile collisions with poles or guardrail posts, and from offcuts generated during construction. Offcuts

resulting from levelling of posts, trimming of deck planking etc. is a minor factor since treated wood is relatively expensive and available in most common construction lengths; structures are usually designed to use the full sized uncut wood. Where offcuts are necessary, the pieces are often retained by the owner for use on odd construction projects.

However, in the future, we can anticipate significant quantities of CCA and ACA treated wood coming out of service as structures are upgraded, removed or replaced.

3.4.1 Quantities of preservative used and of wood treated

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Annual consumption of the inorganic arsenicals is estimated from data available from four sources: Statistics Canada (Anon, 1986, de Lissa, 1983); D.G. Bell and Associates,(1986); industry estimates of amounts of chemical used each year; and industry estimates of amounts of wood treated annually.

Statistics Canada publishes estimates on the value of have preservatives consumed annually, and these been converted to quantities based on current prices corrected for annual inflation by de Lissa (1983) for 1975-1981 and extended to 1984 by the authors (Table 3.5), Estimates of treated wood volumes are also presented in Table 3.6. In his calculations, de Lissa assumed an average preservative retention of 0.4 pcf (6.4 kg/m3). It is the author's opinion that 5.0 kg/m3 is a more realistic estimate of average preservative loadings and both estimates are included in Table 3.6. These estimates include all uses of CCA and ACA in addition to lumber, timbers and plywood e.g., poles, posts and piling. They are based on responses from industry and are generally thought to be conservative estimates (de Lissa, 1983).

D.G Bell and Associates, in an analysis conducted for the Alberta Forest Service, estimated the volumes of treated lumber produced in Canada between 1978 and 1986 (Table 3.6). From these data, estimates of the amounts of waterborne preservatives used these years have been made assuming an average chemical loading of 5.0 kg/m3 for all wood (Table 3.5).

Estimates from the industry on quantities of CCA and ACA consumed suggest that the Statistics Canada data are conservative. It is estimated that the consumption in 1988 is 4,950 tonnes with average annual increases from 1980 to 1988 of about 15 %/year (various industry sources). These estimates and corresponding estimates of treated wood volume are also presented in Tables 3.5 and 3.6.

Independent industry estimates on the quantities of treated lumber, timbers and plywood and waterborne treated poles produced in 1988 are 600 million board feet (0.97 million cubic meters, 2"X6"basis) lumber plywood and timbers. Applying the estimated annual increase of 15 %/year since 1980 results in higher estimates as well (Tables 3.5 and 3.6).

in Canada (Tonnes).							
Year	From Estimates of Wood Treated		From Estimates of Chemical Usage				
	I D.G.i Bell	II Industry Est.	III Industry Est.	IV Stats C deLissa	anada Cooper		
1988		4,800	4,950				
1987		4,200	4,300				
1986	3,200 (projected	1) 3,700	3,750				
1985	2,900	3,200	3,250				
1984	2,700	2,800	2,800		2,300		
1983	2,200	2,400	2,500		1,900		
1982		2,100	2,100		1,800		
1981	:	1,800	1,900	2,000			
1980	 .	1,600	1,600	1,800			
1979				1,400			
1978	1,000			890			
1977		·		830			
1976				710			
1975				820			
Notes:	(i) II and III a 15 % 1980-19 (ii) I and II as	ssume average a 88. sumes average r	nnual increases i etention of prese	n consump rvatives	tion of		

Table 3.5: Estimates of Waterborne Preservative Consumption

= 5.0 kg/m3
(iii) I and II include lumber, plywood and timbers but not poles
 posts and other products; III and IV include all treated
 products.

Year	Direct Estimates o	of Wood Treated II	From Estimates III	of Chemica IV	l Usage
	D.G. Bell	Industry Est.	Industry Est.	Stats Ca deLissa* Co	nada oper**
1988		0.97	•		
1987		0.85	0.86		
1986	0.64(projected	1) 0.74	0.75		
1985	0.58	0.64	0.65		
1984	0.53	0.56	0.57		0.46
1983	0.44	0.48	0.49		0.38
1982		0.42	0.43	÷ -	0.36
1981		0.37	0.37	0.31	0.40
1980		0.32	0.32	0.28	0.36
1979				0.22	0.28
1978	0.206	- 		0.14	0.18
1977				0.13	0.17
1,976				0.11	0.14
1975				0.13	0.17

Table 3.6 : Estimates of Waterborne Treated Wood Production in Canada (m3 X 1000).

Notes: (i)

i) II and III assume average annual increases in consumption of 15 % 1980-1988.

- (ii) Conversions from fbm on 2" X 6" basis, i.e., 1 fbm = 0.0573 cubic feet = 0.00162 cubic meters.
- (iii) I and II include lumber, plywood and timbers but not poles posts and other products; III and IV include all treated products.
 - * Assumes average CCA retention of 6.4 kg/m3.

** Assumes average CCA retention of 5.0 kg/m3.

Konasewich and Henning (1988c) estimate about 2,600 tonnes of CCA and ACA were consumed in 1984; this is reasonably consistent with the above analysis.

3.4.2 Expected service life of CCA and ACA treated *i* wood

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The expected service life depends on many factors such as end use, wood species and quality of treatment; it is estimated to range from 15 to more than 50 years.

The majority of CCA treated wood in Canada is for residential construction such as fences, decks, stairs and retaining walls. This wood is normally treated as a mixture of species such as spruce-pine-fir, (SPF), amabilis fir and western hemlock (Hem-Fir) or as a single pine species such as red pine, jack pine, lodgepole pine or ponderosa pine. While there are CSA specifications for this material, a third party inspection process is only now being instituted and lumber is often poorly treated, with retentions well below the CSA specifications for wood in ground contact (6.4 Kg/m3). Penetrations are often irregular and minimal except in sapwood and incipient decayed wood. Thus, in spite of the "limited warranty" tags affixed to much of this lumber suggesting service lives of 30 to 50 years, a more realistic expectation is 15-20 years for such wood in ground contact and 20 to 30 years for wood in above ground service.*

The actual life of the wood may be shorter, since most of this construction is associated with homes, which change hands often and may be changed out due to different tastes and preferences of new owners.

Production of CCA and ACA treated wood for use in preserved wood foundations (PWF) is under stringent control and the quality of treatment is much higher. This, in combination with the excellent drainage built into the PWF system, should ensure average service lives for these products in excess of 50 years. This use is estimated to account for about 10% of CCA and ACA treated lumber and plywood production (12-13,000 houses in 1984 at 2250. fbm/house, D.G. Bell & Associates, 1986). It may increase if the PWF system gains more popularity in Eastern Canada. Poles, pilings and round fence posts are increasingly treated with CCA and ACA as producers and users become more wary of the usual pentachlorophenol treatment. Because of the continuous sapwood band on these products and good permanence of the waterborne preservatives, deterioration will be largely limited to internal decay and carpenter ant destruction. Physical service lives of 50 years or more are

*This is based on the author's observations and analysis. It must be emphasized that field service data on Canadian species used under Canadian conditions are not available yet. It is expected that a third party inspection procedure will be introduced soon in Canada. This should extend the average service life of residential construction considerably. expected for these products (EPA, 1984). The actual service life may be shorter due to changing out of poles or posts due to road widening, upgrading of lines, automobile collisions, storm damage, etc. However, in most cases, this wood can be salvaged and re-used.

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Squared posts and timbers such as sign and guardrail posts and retaining walls, if sawn from thin sapwood species will likely have service lives of 15-25 years; thick sapwood species such as red pine should provide a longer service life. These uses are estimated to account for about 5-6% of waterborne treated wood in Canada (D.G. Bell and Associates, 1986).

3.4.3 Analysis

In order to estimate quantities of wood disposed of the quantities of wood treated or of chemicals from consumed, assumptions must be made on the relative import/export balance of treated wood products and on losses of preservative in service. Waterborne treated wood is exported in some instances while some specialty wood e.g., Southern pine treated lumber is imported from the USA. It is assumed in this study that these are approximately balanced. Leaching studies on CCA and ACA treated wood (Section 5) suggest total chemical losses from treated wood in the order of 10-30 %. These losses are heavier to Cu and As than Cr.

Based on the above estimated amounts of preservative used annually, and estimated service lives, we can expect greatly increased quantities of treated wood removals in the late 1990's. Estimates of anticipated environmntal loadings of copper, chromium and arsenic are made based on the following assumptions: replacements and changeouts of poles and preserved wood foundations will be negligible over the next 40 years; the least conservative estimates of chemical 3.5) usage for lumber and timber treatments (Table are for the period appropriate; the average consumption annum and for 1960-1970 is assumed to be 300 tonnes per 1970-5, 500 tonnes per annum; the use of inorganics will continue to increase by 5 % per year to 2000 AD; losses of the active ingredients in service amount to 20%, 10% and 30% of for Cu, Cr and As respectively; the average service life this material is 25 years; on the average, the chemical balance of the CCA in the wood is that of CCA type C, (oxides basis), i.e., the elemental composition of the preservative is 14.8 % Cu, 24.7 % Cr and 22.2 % As.

On this basis, the estimated future elemental loading from wood removed from service is projected in Table 3.3.

4.0 CURRENT DISPOSAL METHODS FOR PRESERVATIVE TREATED WOOD: CANADA, USA AND ABROAD

4.1 Railway ties.

Railway ties are removed from service when the tie inspector judges that they can no longer perform adequately in vertically supporting the rail, or transversely holding gauge. Often, ties fail mechanically from splitting, crushing under the plate or loosening of the spikes, all of which may or may not be associated with decay. The average service life then depends on many factors, including wood hardness, plate size, track loads, track location, condition of ballast and type and quality of preservative treatment. As a general rule, the average service life is 20-25 years heavily loaded mainline tracks and 25-35 years on .on secondary tracks.

A large number of the railway ties removed from service, still have some functional use; most railroad companies encourage the recycling and reuse of these ties wherever possible. Ties removed from decommissioned lines may be re-used by the railroad on secondary lines where (Photo. 1). Also, ties that have loading is less severe been removed from mainline tracks because of mechanical damage are often free of decay and, when turned over, retain enough strength to support rails on secondary lines for up to 15 more years (Burns, 1987b). This practice has been cited as one of the reasons for a decline in average tie replacements in the USA from 24.5 to 19.7 million ties per year from 1976 to 1985 (Anon, 1987e). There is also an for used but still sound ties. A11 international demand components of some decommissioned lines are sold to African and European nations (Sheepwash, 1988).

The longer switch ties and bridge ties are re-used for cribs and bulkheads. Ties that are not badly split, crushed or decayed are given or sold to private individuals, contractors or landscaping firms for use or resale for retaining walls, rustic steps, planters etc.

Also, many ties are used as fence posts along railway right-of-ways (Photo.2).

However, the majority of ties removed from service have been, and to some extent still are, burned in open fires on the track allowance (Photos. 3 & 4). This practice is particularly common where ties are extracted by a tie shear, which breaks the tie into three or more pieces for removal.

With more stringent restrictions on air quality and concerns about contaminants released by burning treated wood, this practice is becoming less acceptable and the railway companies are faced with an increasingly difficult task in disposing of the ties. In residential and other sensitive areas where open burning is restricted, both CNR and CPR pay contractors to pick up and dispose of all ties as they are removed. These ties are sorted and the high quality ones sold for re-use and the others disposed of at landfill sites. B.C. Rail is presently prohibited from open burning of all ties (Chtenko ,1988) because they use some penta treated ties.

In the U.S.A., restrictions on open burning and problems with leaving ties on the right-of-way (aesthetic, fire and safety hazard, clogged drainage, etc.) have led to research on alternative disposal methods. Burial on the railway right-of-way is only feasible for a limited number of ties and is a short term solution at best. The Environmental Affairs Committee of the Railway Tie Association (RTA) and the American Railway Engineering Association (AREA) are actively researching alternative uses of ties removed from service (Anon, 1987e).

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Attempts have been made to recycle this material by chipping and reforming it into composite ties. Cedrite Technologies Inc. manufacturers a composite tie by reconstituting used ties by a patented process (Anon, 1987d). These ties are under evaluation on various accelerated durability and performance test tracks but are reportedly having bond durability and plate cut problems.

Another possible approach is to rip substantial sized sound pieces out of failed ties and re-assemble them into a dowel laminated tie. Both approaches have serious problems with machining of rock ballast contaminated wood. Unsuccessful attempts have been made to saw ties for pallet stock, mine timbers and crib blocks (Church, 1976) and for the manufacture of charcoal briquettes (Glavin, 1982).

The most promising use of old ties in the U.S.A. is as a fuel for co-generation systems at tie treating facilities. The USDA analysed the potential of used ties as an energy source (Church, 1976) and cited the following benefits, advantages and processing considerations:

- Tie cars can deliver old ties when they pick up new ones for replacement.
- If the boiler furnace requires shredding of the wood, up to 20 tonnes per hour can be ground up using heavy duty swing hammer shredders.
- Used ties have an average heat content of 6730 BTU /# resulting in an energy value of about 1.5 million BTU's (1580 MJ) per tie.
- Stack emissions meet EPA standards.
- Burning generates 5 x the fuel required to pick up and transport used ties ... a net energy gain.
- Coal burning facilities could mix treated tie pieces with coal.
- Cost of pickup and delivery is lower than cost of disposal at most landfill sites..

This concept will be put into practice at a new Koppers Building Products Ltd. plant in Pennsylvania (Anon, 1988). Used ties from the Conrail system will be burned to generate high pressure steam which drives a steam turbine to generate electricity that is sold to Pennsylvania Power and Light Co. The low pressure exhaust steam is used in the plant for This system will consume 750,000 - 900,000 process heat. ties per year in a 10 MW plant. Conrail will deliver the used ties and pick up new ties for replacement using the same rail cars. The boiler accepts full sized split ties and burns them at about 1100 C. Stack particulates are precipitated electrostatically. The plant will generate 61 million Kilowatts of electricity per year at a capital cost of \$ 9 million.

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Similarly, Burlington Northern Railway, when faced with the need to dispose of 1 million sheared ties in Wisconsin, started a program to deliver the recovered "butts" to a local pulp mill for burning to generate steam power (Anon, 1987b).

This approach is more feasible in the USA than in Canada, since power costs are higher in the Eastern USA and local utility companies are required to accept and pay for electricity generated by others. Also, the concentration of used ties is much greater.

In the U.K., about 2 million ties are removed from service annually by British Rail (Bond and Sheils, 1980). About 300,000 are used for maintenance of minor lines, sidings and fences. Others are sold to smaller railroads, sold for landscaping or disposed of by burning or landfill.

Respondents from other countries indicated the following methods of disposing of used ties: ----- New Zealand: Landscaping, burning (Hedley, 1988).

----- Norway: Landscaping (Evans, 1988).

----- South East Asia: Reuse for landscaping, (Chan, 1988). ----- Switzerland: Garden and Landscape use, (Walchli, 1988).

4.2 Poles:

Most of the poles removed from service are re-used in part or in total. Some utilities have specifications describing criteria for reusing recovered poles, e.g., Bell Specification 621-220-980CA (Appendix A). Those removed in good condition due to road widening or upgrading of a line are re-used in other lines or cut up for stubs, braces or pole anchors. Some utilities, such as Toronto Hydro clean up and brush treat these salvaged poles. Even poles removed for mechanical breakage by storms or automobile accidents are cut into stubs or anchors. Only a small portion of the pole must be disposed of at local landfill sites.

On rural lines, removed poles are often given to farmers who recycle them for foundation piers, fence posts, corrals, lighting poles and other general construction purposes around the farm. Utility personnel are careful to

advise that the treated portions of the poles should not be used as firewood. Some utilities, especially in the USA, require that the user sign a waiver of liability. A common practice with both butt- and full length treated poles is to leave the treated butt in place. This not only reduces the cost of removal but reduces the amount of treated wood that must be disposed of. These butts are widely distributed and cause no more environmental harm than the origional pole placement.

A relatively large proportion of the poles removed at this time are butt-treated western redcedar. The above-ground portions of these poles are untreated and may be used for firewood.

Because of the high cost of replacing poles, utilities use many innovative approaches to extending their life in service. In situ remedial treatments, discussed in section 7.1 are standard practice as is the use of reinforcing stubs to support the weakened groundline portion of poles. Other less common approaches under development are plastic

reinforcement of poles in service (injection into decay cavities) and the use of pole extensions to upgrade poles where longer lengths are required.

In the U.K., about 140,000 telegraph and electricity poles are removed annually from service (mainly creosoted). About 10,000 are reused by the Post Office and others are sold locally for fences, farm buildings and firewood (Bond and Sheils, 1980). The relatively few CCA treated poles removed due to accidents etc. are stored or disposed of at a supervised landfill site.

Procedures in other countries are generally the same as above.

4.3 Marine Piling

Piles that are no longer serviceable, because of marine borer damage or mechanical failure, are usually extracted and the sound portions reused as fenders, cribs or bulkheads; the unrecyclable pieces are disposed of at landfill sites. In the USA, a significantly large number of marine piles are sold for reuse as land or fresh water piling. This has caused some concern (Keefe,1988) because the piles are not adequately inspected to determine strength loss from marine borer damage (Section 5.3).

4.4 Fenceposts, guardrail posts, sign posts etc.

Fenceposts in rural areas are usually burned on site or piled in an out-of-the-way spot and left to rot. Guardrail posts installed by the different provincial Ministries of Transportation or Highways are usually removed from service as a result of automobile accidents and occasionally from decay. In Ontario, posts installed more than 20-30 years ago are mainly untreated northern white cedar (Taylor, 1988). Thus, they do not contribute

pesticides to the environment and their method of disposal is not immportant. More recently installed posts are CCA or penta-in-oil treated. The Ministry of Transportation of Ontario (MTO) has recently obtained clarification on this material from the MOE, whereby it is classified as solid non-hagardous or industrial waste. The unsalvageable portions are disposed of at landfill sites.

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4.5 Residential lumber

There has been a rapid surge in CCA treated wood volume for residential construction since 1975 as a result of its increased availability to homeowners and increased acceptance for products that were traditionally treated with oil-borne preservatives (e.g.,fencing and decking).

Since this material has a projected service life of more than 20 years, little has been removed from service at this point. A small amount of disposable wood results from scraps and end trim that are produced during construction. This material is usally disposed of by placing in garbage or by burial as recommended by the chemical suppliers (Appendix C) although there is no doubt that small quantities are burned as well, contrary to instructions on consumer information sheets.

In the U.K., nonrecoverable CCA treated wood from the demolition of treated structures is often burned in open bonfires at the construction site (Bond and Sheils, 1980). Based on measurements of As volatilization, it is now recommended that wood treated to high retentions (Marine or cooling tower wood) only be burned in fires at least 100m from continuously occupied homes. Also, no more than 500 kg of treated wood should be charged in any one fire and not more than 1 tonne per day be burned at any one construction site (ibid, 1980). Some CCA treated wood is burned in municipal incinerators. It is recommended that it be diluted with arsenic-free material to maintain As levels below facilities. accepted concentrations for As producing Incineration with controlled stack emisions is considered an environmentally acceptable means of disposal of this wood. However, it is not recommended as a domestic fuel or for smoking food. Alternatively CCA treated wood is disposed of at a suitably liscenced landfill site.

Disposal methods employed in other countries include :

----- New Zealand: Wood from demolished buildings (mainly boron treated) is almost invariably burned (Hedley, 1988). ----- Sweden: A recent survey (Henningsson, 1980) suggests that 20,000 cubic meters of CCA treated wood is removed from service annually. This would be sufficient to produce 10,000 tonnes of particleboard per year. Blumer et al, 1978, demonstrated that CCA treated timbers could be used to produce a decay resistant particleboard with similar physical properties to that prepared from untreated wood.
5.0 HEALTH AND ENVIRONMENTAL CONSEQUENCES/IMPLICATIONS OF VARIOUS DISPOSAL PROCEDURES

5.1 Wood Left in Service or Removed to Dump or Landfill Sites.

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Treated wood left in place or buried at a dump or landfill site can adversely affect the environment if significant preservative leaves the wood and contaminates the ground water or adjacent bodies of surface water. Several physical and biological processes control the amount of pesticide reaching the water:

- (i) rate of leaching, exudation or other emission of preservative from wood (a function of preservative type and loading, wood species, relative surface area of the wood and environmental factors such as water pH and ionic strength and ambient temperature.)
- (ii) rate of breakdown or detoxification of the leached or exuded preservative as a result of u.v. degradation biological activity or chemical reaction.
- (iii) interaction of the extracted preservative with the soil (a function of preservative type, and soil properties such as pH, composition, especially organic and clay contents, and particle size).

The rate of leaching or extraction from the wood is expected to drop with time in service, as the surface zones of the wood are depleted and the more soluble constituents of the preservatives are extracted. Thus, wood disposed of after many years in service will have different leaching characteristics compared to newly treated wood. This factor was considered in chapter 3 in discussing the environmental load resulting from disposal of wood removed from service. Also, the rate of leaching is highly dependent on the relative size of the product, i.e., surface to volume ratio, and the amount of exposed end grain.

5.1.1 Loss of creosote from treated wood.

Some creosote is lost from wood in service as a result of leaching, evaporation and "bleeding". These emissions can be expected to continue in wood buried or disposed of at landfills, although at a decreased rate. Creosote is a solution of more than two hundred coal tar derivitives covering a distillation range of 200 C to >400 C. Since the water solubilities, volatilities and viscosities of individual constituents vary considerably, some components will be lost preferentially. Of most interest and concern

are the polycyclic aromatic hydrocarbon (PAH) constituents of creosote, especially naphthalene, fluorene, fluoranthene, pyrene, phenanthrene and acenaphthene. PAH's constitute 50 - 65 % of creosote depending on the grade and source. The above PAH's are included in the U.S. EPA's categories for toxic substances found in water effluents and their presence in water is rigorously monitored and regulated.

Creosote also contains phenolic compounds. Very low concentrations of phenols (< 0.001mg/L) can produce an off-taste in water, especially if chlorinated (Henningsson, 1983). Thus, limitations in water for phenols and PAH's should be considered when assessing environmental effects.

Creosoted wood used above ground or in ground contact may undergo some depletion by bleeding of free solution to the wood's surface in hot weather and dripping or absorption into the soil. Some of the low molecular weight constituents with relatively high vapour pressures evaporate from the surfaces or are solubilized and washed away. Treated wood in contact with water, such as marine piling is subjected to greater leaching effects and to exudation from the initial driving process and the swelling forces generated when dry (below fiber saturation point moisture content) piles adsorb moisture from the sea water. These effects often lead to an iridescent sheen of oil around newly installed wood that gives the impression that large amounts of creosote have been lost. In fact this layer is very thin (approximately monomolecular) and the amount of contamination is relatively law.

The total creosote losses from wood in service depends on the exposure conditions, creosote retention and grade, relative surface area of the sample, wood species etc.

Table B-1 (Appendix B) summarizes some of the available information on creosote losses under various conditions. Unfortunately, most of the studies are for the period immediately after installation and represent much more severe exposure conditions compared to landfill exposure. Rates of loss range from negligible to more than 1 kg/m2/year.

These results show the importance of initial loading, wood species, product dimensions, ambient conditions and time in service on preservative loss. Other less well-defined studies provide a better estimate of expected creosote release from landfilled wood.

Bernuth (1987) described studies conducted in Holland where initial high surface extraction of low molecular weight components occurred from water immersed wood but losses rapidly levelled off. For example, naphthalene release was as high as 1.2 g/m2/day when the wood was first installed but it had dropped to undetectable levels by 10 days. Fluoranthene levels also dropped exponentially from 35 mg/m2/day to 1 mg/m2/day after 35 days.

Bramhall and Cooper (1972) analysed the creosote content of marine piling in service for 40 years. The piles contained about 240 kg/m3 creosote compared to an estimated initial treatment of 320 kg/m3.

Becker (1977) found the loss of creosote from railway ties to be highly species dependent. The creosote content of pine ties was reduced drastically after several years, with only the high boiling fractions retained in the wood. In beech, the full spectrum of creosote components were retained. Hochman (1967) observed that creosote losses dropped exponentially with time with approximately 67% of the first year's loss of creosote in marine piling occurring in the first month of service.

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5.1.2 Interaction of creosote with the soil

Migration of creosote components in the soil and into ground and surface water depends on water solubility, soil adsorption characteristics and the rates of oxidation or biodegradation of the creosote constituents. Low molecular weight creosote constituents do not appear to have a high affinity for soils and sediments, while larger molecules have relatively large partition cefficients. For example, found partition coefficients Vowles and Mantoura (1987) between various aromatic hydrocarbons in surface sediments and in surrounding water of 34 for naphthalene, 760 for phenanthrene and 5370 for pyrene. Raven et al (1987) reported the octanol-water partitioning coefficients, which are generally correlated with soil-water partitioning coefficients, of several coal tar constituents: naphthalene: 2340; acenaphthene: 21,400; fluorene: 13,200; anthracene: and 28,800; pyrene: 75,900; 28,200; phenanthrene: crysene:407,400.

5.1.3 Biodegradation of creosote

Some creosote constituents can be metabolized by notably bacterium various micro-organisms, most the Pseudomonas creosotensis and Cladosporium, Alternaria and Lentinus fungi (Drisco and o'Neill, 1966, and Duncan and Deverall, 1964). Webb and Gjovik (1988) cite an unpublished "no movement of Mississippi state U. study that found creosote either radially or vertically from creosote treated poles". None of the major creosote components were ever isolated from soil samples collected to a depth of 30 cm or ranging from 5 to 61 cm from the pole. The authors conclude that the creosote components that enter the soil are rapidly oxidized or biodegraded.

Ingram <u>et al</u> (1982) conducted a study to evaluate the rates of depletion of specific PAH's and creosote oil from treated wood. Piling sections (fresh or 12 years in service) were placed in sea water and stirred. Water samples were collected and analysed periodically. They found the PAH's of concern in the water extract, with the low molecular weight compounds such as naphthalene preferentially extracted. More of these compounds were extracted by fresh water than by salt water. The aged sample lost considerably less of the

PAHs than the fresh sample. The concentration of PAH's extracted increased initially, then decreased, presumably as a result of biological degradation. Based on their results, they estimate the annual loss of PAH's from a 10' length of piling of surface area 15,000 cm to be 77-147 g per year with rapid breakdown of the constituents by micro-organisms etc. The authors conclude that PAH's lost from creosote treated wood have a negligible effect on the environment.

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Based on these studies, it is evident that the small amounts of creosote components that will leave treated wood in landfill sites will not adversly affect ground or surface water in the vicinity.

5.1.4 Depletion of Pentachlorophenol from Wood in Service

Pentachlorophenol is a crystalline organochloride that is dissolved in organic solvents and cosolvents for impregnation into wood. It contains a small percentage of lower chlorinated phenols, polychlorinated dibenzo-p-dioxins (PCDD's) and polychlorinated dibenzofurans (PCDF's) formed during the synthesis of penta. These PCDD's and PCDF's are a major source of concern with environmental agencies due to high acute and chronic toxicity and oncogenic properties of some isomers.

When applied in a relatively high viscosity oil solvent, penta has good longevity in treated products.

Products treated with pentachlorophenol-in-oil tend to lose preservative in the surface zones particularly if in soil or water contact. This loss results from gravitational migration, surface blooming (of penta chrystals) or bleeding of oil + penta, leaching and a minor amount of

volatilization. The amounts lost depend greatly on the properties of the solvent and co-solvents. High boiling aromatic oils retain penta in the wood better than low boiling oils (Arsenault, 1970) which are better than light organic solvents and liquid petroleum gas solvents. Also, as with the other preservatives, depletion depends on product dimensions, exposure conditions, wood species and initial penta and oil retention.

Pentachlorophenol-in-oil is rapidly depleted from the below ground area for the first few years, after which the retention tends to stabilize (Leutritz, 1965, Cooper <u>et al</u>, 1981).

Some of the available literature on penta depletion in service is summarized in Table B-2 (Appendix B).

These results show a relatively high initial rate of depletion from the surface and a levelling off with time.

Pentachlorophenol and oil extracted from wood in service or in landfill sites will be transported in relation to its water solubility and its interaction with the soil constituents. It is well known that pentachlorophenol and to

some extent the PCDD contaminants are biologically or

physically degraded in the soil so the amounts of pesticide reaching ground or surface water supplies will be reduced accordingly. Arsenault (1976) measured the amounts of penta and OCDD in soil at the base of utility poles and concluded that OCDD degraded at a slower rate than penta and that there was little movement of OCDD away from the pole. After several years, the penta and OCDD concentrations 25mm from the pole surface were 322 (658) ppm penta and 9.6 (3.4) ppm OCDD. Twelve inches (305 mm) from the pole, the concentrations were 1.6 ppm penta and 0.13 ppm OCDD. 1.5 m from the pole, the penta concentration was close to the background level (0.26 ppm). More recent studies sponsored by several Canadian utility companies (Mortimer, 1989) show a rapid attenuation of penta concentration around new poles remedially treated with penta-based groundline and poles suggest that penta is either treatments. These studies strongly held by the soil or rapidly biodegraded. However, it is also possible, especially in alkaline soils, that soluble penta is leached away in the soil water.

Rain water from penta-in-oil treated cedar shakes maintained a relatively constant concentration of pentachlorophenol (0.3 - 0.7 ppm) over a one year analysis period (Cserjesi, 1977).

5.1.5 Interaction of penta with the soil-water system.

Pentachlorophenol is relatively insoluble in water (14 ppm at normal temperatures, Leutritz, 1965), but the solubility increases exponentially with increasing pH. Penta interacts with soil in several ways. Significant amounts are irreversibly adsorbed on soil, about 20% on light loams and up to 50% on peaty soils (Lagas, 1988). It is also anion exchanged and physically adsorbed on soil particles. Since anion exchange is promoted at low pH's, penta is more mobile in alkaline soils than acidic soils. Sorption of ionic penta is essentially zero at pH of 7 or higher.

Depending on the soil type and conditions, the partition coefficient between penta in soil and penta in water solution ranges from about 10 to 1000 (Lagas, 1988).

TCDD has a strong affinity for clay, silt and alluvial soils (des Rochiers, 1983).

5.1.6 Degradation of pentachlorophenol in the soil or water.

Dilute solutions of pentachlorophenol are degraded by U.V. light and certain bacteria and fungi. The rate of degradation in soils increases with increasing organic matter content.

Some micro-organisms can methylate pentachlorophenol and completely oxidize it to CO2, H2O and HCl.

Photodegradation results in quinone formation followed by aromatic ring cleavage (Shields and Stranks, 1976). Cserjesi (1972) showed that certain fungi could convert penta to less toxic anisole and other compounds. The half life of pentachlorophenol in soil depends on soil properties, ambient temperature and initial concentration but is in the order of 20-200 days (Webb and Gjovik, 1988). In aquatic environments where significant photodegradation occurs as well, the half life is in the order of 5 days (NRC, 1982)

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Based on the above information, it is possible to compare the expected penta addition to the environment from landfill disposed wood with the objectives for penta in natural water bodies. These objectives range from a low of 0.05 ug/L as a guideline to protect aquatic life suggested of Resource and Environment by the Canadian Council Ministers to 220 ug/L the recommended maximum concentration to protect human health by the US EPA (Konasewich and Henning, 1988 b). The leaching results suggest that penta concentrations as high as 1 ppm (1000 ug/L) could occur in the leach water of newly treated wood. Values will be much lower for wood taken out of service, but have not been quantified. Further attenuation of the extracted penta will reaction with the soil and dilution, result from biodegradation. The analysis of soils around penta treated wood suggests that the chemical is rapidly broken down and insignificant quantities will reach surface water or ground However, more study is required using more water bodies. sensitive detection methods on the penta content and mobility in the soil water system around treated wood.

5.1.7 Leaching of CCA/ACA

The constituents of these preservatives react with each other and with wood to form highly insoluble compounds. Wood treated with these preservatives to recommended retentions has provided excellent service performance for more than 30 years (e.g. Gjovik and Gutzmer, 1985) under severe decay hazard conditions. However, it is known that small amounts of Cu, Cr, and As are lost from treated wood in service and similar losses will occur in wood disposed of by burial or dumping. The purpose of this section is to predict the environmental significance of these losses.

The only significant mechanism for loss of Cu, Cr and As from wood removed from service, is leaching or water extraction. Inorganic dust or sludge, occasionally found on recently treated wood contributes to respirable As when worked or handled (Saur et al, 1983). However, even on fresh treated wood, the levels are low enough to meet the U.S. OSHA standards for maximum permissable exposure levels of 10 ug/M3; on wood removed after many years in service, no significant hazard will result from this mode of exposure.

The results of several leaching studies on CCA treated wood are summarized in Table B-3 (Appendix B). Most of these studies represent leaching of freshly treated wood from test samples of large surface to volume ratios and large proportions of exposed end grain. Also, it is recognised that the efficiency of fixation of these formulations depends on the temperature and drying history of the wood during the fixation process (Arsenault, 1975). This may account for the large variation and apparent inconsistancies in the cited references.

The observed losses from large section products in soil contactionage from undetectable to <100g As/m3 wood/year. Assuming annual rainfall of 100cm falling on one cubic meter of treated wood occupying one square meter of landfill area, the average leachate concentration would be <0.1 mg/L). With an attenuation factor of 100, as assumed by the standard leachate tests, the As concentration will be well below the normal water quality objectives of 0.05 mg/L.

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The more strongly fixed Cr and Cu will be at even lower concentrations in the leach water.

In addition to the above controlled studies, there have been several evaluations of CCA loadings in treated wood in service. In these studies, the initial chemical retention some inferences can be made. was not precisely known but below less CCA in the Chin et al (1988) found about 25% New in Papua ground zone of 15 year old Araucaria poles Guinea, compared to the above ground zone. Arsenic was preferentially leached compared to copper and the chromium losses were the least. Cooper et al, (1981) found that CCA 0 - 5 years had similar CCA in service treated poles (0-5)retentions and chemical balances in the surface layer mm) above ground as below ground. However, poles in service 6 - 10 years had below ground surface retentions 19% lower on the average than above ground. These poles had higher proportions of chromium and copper both above and below ground compared to the newer poles, suggesting preferential leaching of As. In contrast, Evans et al, (1987) found levels in the groundline area than above higher Cr and As ground in 23 year old scots pine poles located in Western England.

Arsenault (1975) showed that wooden stakes treated with CCA and in service 9-12 years had retentions both above and below ground approximately identical to the origional retention.

(1977) measured the losses of several wood Cserjesi red cedar shakes preservatives from treated western installed in a high rainfall area of B.C. In all cases, the concentration of preservative in the rain water dropped rapidly over the two year evaluation period. For CCA-B shakes, the As concentration in the rain water dropped from 6-10 ppm to 2-5 ppm over two years. The As levels were consistantly lower in CCA-C treated shakes (0-5 ppm). For both treatments, Cu losses were lower than As losses and Cr losses were too low to be measured with confidence. Evans, (1987) measured the concentration of Cu, Cr and As in rain water collected from roofs covered with CCA treated roof boards. The amounts collected decreased exponentially over the two year collection period to values of 0.76 ppm Cu,

0.094 ppm Cr and 1.21 ppm As. These levels were still considered unacceptable for drinking.

Plackett <u>et al</u>, (1984) also found preferential leaching of copper and arsenic from the exposed portions of Radiata pine roofing shingles.

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In sea water, the mechanism of leaching is different and relative leaching losses are different. Gjovik, (1977) found that Cr and As were preferentially removed from CCA-C treated wood.

There have been relatively few studies on the leaching and As from ACA treated wood (Table B-4). These of Cu studies and in service evaluation of ACA treated products suggest that As is more easily extracted from ACA treated wood than CCA treated wood. Cooper <u>et al</u> (1981) found a significant difference in the ratio of Cu to As in the above and below ground portions of ACA treated poles in service 5-10 years. The ratios suggested a relatively high loss of As from the below ground area. Losses of As from ACA treated cedar shakes (Cserjesi, 1977) were higher than from CCA treated shakes; the As concentration in rain water was about 20 ppm in the first year, dropping to 5 - 10 ppm by the end of the second year. Copper losses were considerably lower.

Based on the above studies, the following conclusions may be drawn:

--- The rate of leaching is highest in freshly installed wood; it drops rapidly, i.e., exponentially at first, then levels out to a relatively steady rate.

--- The leaching performance depends on the formulation (CCA type A, B or C) but generally, arsenic is preferentially leached and chromium is most strongly retained in the wood.

5.1.8 Interaction of CCA/ACA components with the soil

As inorganic preservative constituents are leached from treated wood, they enter the soil- groundwater system, adding to the background levels of these elements. These background levels are extremely variable but in Canada are in the following ranges: Copper, 0.001 - 0.04 ppm in surface water and 2 - 100 ppm in soil; chromium 0.003 - 0.04 ppm in surface water and 5 - 1000 ppm in soil; and arsenic, 0.001 - 0.01 ppm in surface water and 1 - 50 ppm in soil (Konasewich and Henning, 1988c).

While these inorganic components cannot be completely destroyed or detoxified by physical or biological reactions, their environmental significance depends greatly on chemical interactions with the soil. For example, in CCA treating solutions, chromium is in the +6 valence state. Cr VI is water soluble, highly toxic, and much more mobile in the soil water system than Cr III (Rouse, 1988). Fortunately, Cr VI is reduced to the less toxic Cr III in wood during the fixation period following treatment. Since Cr VI is highly water soluble, any unreacted chromium will have been extracted from the wood during its exposure in service.

Similarily, the pentavalent arsenic found in treated

wood is considerably less toxic and a lower environmental hazard than trivalent arsenic.

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Once in contact with the soil, complex geological and biological reactions occur between the soil and its microorganisms and the inorganic leachates. Cu, Cr and As are all, largely immobilized by soil. Arsenates behave similarly to phosphates, reacting with Са Al, Fe and components of the soil to produce highly leach resistant complexes at normal pH's; thus, soils high in amorphous metal oxides such as weathered soils of volcanic origin have high affinities to As. Cu is cation exchanged to negatively therefore is on soil particles and charged groups immobilized by organic and high clay soils. Cr is reduced by organic matter to low solubility CrIII and is also bound by clay soils. Considering the approximate background levels shown above, it is evident that the equilibrium distribution of these elements between the soil water and the soil is heavily shifted to the soil. Brown, 1986, suggests that partition coefficients between the soil and surrounding soil water is about 5,000 for As and Cu and 10,000 for chromium. Of course, the magnitude of this coefficient depends on the sorption capacity of the soil, its permeability and pH. Sandy soils with little cation or anion exchange capacity (low clay), low organic matter, and low pH will bind less of these components.

The ability of the soil to bind components leached from treated wood depends on the degree of saturation of sites in the soil and time related effects such as diffusion into soil particles. If the soil is permeable, very little of the Cu, Cr and As constituents may be retained. For example, (1979) measured the leaching of CCA Chen and Walters components from treated plywood samples placed in sand or For the high artificial loam beds in the laboratory. measurable this study, there was no used in rainfall increase in concentration of any of the elements in either soil type, even though measurable amounts were present in the percolating leach water.

For the purpose of the leachate toxicity tests used by the U.S. EPA and by several Canadian provincial MOE's, it is assumed that the attenuation factor for Cr and As leachates from solid wastes is 100; i.e., the leachate concentration will be reduced by 100 times by dilution and extraction from the soil water before it reaches a contamination site such as a well for drinking water (e.g., Anon, 1986). This factor may be modified to incorporate site specific values when a more valid model of inorganic element transport and reaction in soil is available.

Studies on CCA movements from treated wood or from solution spills suggest high immobilization and/or high dilution of its constituents in soil.

Bellman (1972) reports that a 20,000 L spill containing arsenic did not contaminate wells 75 and 125 m away. A study on the distribution of As in the vicinity of CCA-A treated SYP poles in service 32 years (Arsenault, 1975) showed a rapid drop in As soil concentration with distance from the poles. Arsenic concentrations were 53, 36, 23, and 16 ppm in the 0-50mm, 50-100mm, 100-150mm and the 400mm zones compared to a background level of 14 ppm. Similarly, CCA-A treated SYP posts in service 26 years had As concentrations in the surrounding soil of 14, 10 and 7 ppm in the 0-50mm, 50-100mm and $100_{\overline{1}}$ -150mm zones compared to a background of 7-12 ppm (ibid, 1975).

De Groot et al, 1979 confirmed this low accumulation of As in the vicinity of 50X101 mm SYP stakes located in a fine sandy loam soil in Mississippi.

Studies on the depletion of wood preservatives from wood in service suggest that creosote, Cr and As losses from treated wood disposed of in landfill sites will not have deleterious effects on human health or the environment. The amounts of penta predicted to reach potential contamination sites following loss from aged treated wood should also be below recommended levels, but additional research on the mobility and degradability of penta in soil is recommended.

5.2 Disposal of treated wood by burning/incineration

5.2.1 Introduction

One common means of disposing of treated wood products is combustion of the wood on site or at disposal facilities. This includes open burning of whole or fragmented railway ties on right-of-ways, burning of treated wood end-cuts in residential fireplaces or wood stoves, burning of combustibles at municipal garbage dumps and disposal of waste wood in municipal incinerators.

High temperature incineration may provide an effective means of detoxifying (chemically breaking down) the organic wood preservatives and of inactivating the inorganic wood preservatives through combination into unreactive slags. Alternatively, under some conditions, some toxic constituents can be increased by burning.

One possible means of recycling or reusing treated wood is to use it as fuel for process boilers or co-generation units at treating plants or other wood burning facilities convenient to the removal sites.

Thus, it is important to evaluate the possible health and environmental implications of these processes.

5.2.2. Combustion of Creosote

There is considerable controversy about whether it is appropriate to burn creosote treated wood. Traditionally, it has been considered acceptable to dispose of creosoted crossties at railsides and many tonnes of treated wood have been disposed of in this way. Furthermore, since the oil crisis in 1973, considerable volumes of neat creosote have been burned as fuel by steel companies. Under similar combustion conditions, one expects the combustion processes and byproducts to be similar for creosote in wood and for pure creosote; combustion of creosoted wood should be 85 environmentally acceptable as burning pure creosote under likely that substantial similar conditions. It is even amounts of creosote components are generated during the normal burning of coal. Burning of solid fuels under normal conditions invariably results in oxygen poor conditions at the surface of the fuel leading to pyrolytic breakdown and the release of flammable pyrolysis gases. These conditions are not unlike the pyrolysis conditions used in the coking of coal which generates creosote as a byproduct.

With this long history of creosote and creosoted wood burning, there is insufficient evidence to prove that this practice is a hazard to health and the environment. Thus, in the U.S.A. it is considered acceptable to burn ties for generation of high pressure steam for electricity (See section 4). Open burning of creosoted wood, while still common is considered less acceptable and prohibited in certain jurisdictions.

On the other hand, it has been suggested that burning of creosote may generate polycyclic aromatic hydrocarbons (PAH's) (Greaves, 1987) some of which are of concern for their carcinogenic properties. Thus, the Swedish National Board for Environmental Protection has pronounced against the burning of creosoted wood until more is known about potential health and environmental hazards from this practice (Henningson, 1983). The U.S. EPA position (EPA. 1981) is that when creosoted wood is burned, various oncogenic or mutagenic compounds may be formed. They considered recommending against the burning of treated wood, but the hazard, if any, has not been quantified.

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The completeness of destruction of creosote by oxidation during burning depends on the burning conditions. If an adequate temperature and oxygen supply can be assured, the components are essentially completely oxidized. However, under open burning conditions, these assurances cannot be met. Considering the safe history of uncontrolled burning of creosote and the concerns noted above, it is clear that more research is required to clarify this issue.

5.2.3 Combustion/incineration of pentachlorophenol treated wood.

By use of appropriate combustion conditions, incineration is an effective way of destroying, to oxidation, penta and its associated dioxins. However, through under other conditions, the dioxin content in the effluent gas may increase due to dioxin formation from the chlorophenols or other dioxin precursors in the penta solution (Crosby et al, 1973). Also, more toxic PCDD's may be formed from the less toxic OCDD by dechlorination reactions during combustion Marklund, 1978). Unfortunately, the combustion (Rappe and often not well defined in the published parameters are literature, and one can therefore find apparently conflicting and contradictory results. Some of the results in Table 5.6. The three major parameters are summarized affecting synthesis of dioxins and oxidation of penta and dioxins are temperature, residence time of the pesticide in the high temperature flame and oxygen supply to the burner.

Heating chlorophenols for long times at higher than 200 C converts small amounts to OCDD. Heating sodium pentachlorophenate under similar conditions leads to much higher levels of OCDD formation. (Langer et al, 1973). Pentachlorophenol burned with an inadequate oxygen supply generates much greater quantities of PCDD's than when sufficient oxygen is available (Jansson et al, 1978).

The fact that dioxins can be generated during the burning of pentachlorophenol-treated wood was cited as one of the reasons for banning penta in Sweden in 1979 (Henningson, 1979).

Table 5.1 Effects of the fate of incinerator	temperature and bu PCDD and pentachles.	arner conditions on orophenol in	
Combustion conditions	Form of the contaminant	Residual PCDD and Pentachlorophenol	Ref erence
T=600 C, Dwell time 3 seconds	Penta	Penta in emissions = 50mg/kg penta burned PCDD's not detected	Ahling & Johanson (1977)
T=800 C, Dwell time 3 seconds	Penta	Penta in emissions = 15mg/kg penta burned PCDD's not detected	Ahling & Johanson (1977)
T=620 C, Dwell time 0.9 seconds	Penta	Penta in emissions =650mg/kg penta burned trace of PCDD's	Ahling & Johanson (1977)
Rotary cement kiln 1400-1450 C.	chlorophenols in waste	Penta = 0.1 mg/kg burned; trace of HpCDD and OCDD	Ahling, (1979)
Not specified, wood charred	Penta treated plywood	OCDD level doubled to 2 ng/g; traces of HpCDD & HxCDD	Crosby et al (1973)
Fluidized bed oven	Penta treated wood	No increase of PCDD's or PCDF's in fly ash	Olie et al (1983)
Conditions not specified	Penta treated wood or paper	Reduced OCDD's after combustion	Stehl et al (1973)
Open burning	Sodium tri- tetra- & penta- treated leaves or wood wool	Substantial increases in PCDD's	Rappe & Marklund (1978)
Pyrolysis of pure sodium Penta- chlorophenates 280 C for 30min.	Sodium tri- tetra- & penta- chlorphenates	Substantial increases in OCDD	Rappe & Marklund (1978)
500-600 C	Wood treated with sodium tri- & tetra- chlorophenates	Relatively high amounts of PCDD's	Jansson & Sundstrom (1978)

However, as the temperature and residence or dwell time increases, the destruction of pentachlorophenol and its PCDD and PCDF contaminants increases. For a constant dwell time under laboratory conditions the residual PCDD and PCDF drops exponentially with increasing temperature above 675 C. Typical values for both PCDD's and PCDF's are 10% remaining at 675 C, 1% aat 700 C, 0.1% at 725 C etc. (McRee & Preis 1985). Heating of pentachlorophenol contaminants at 1000 C and above with a long transit time through the burner (3-7 seconds) ensures that dioxin levels in the stack emissions and washwater circuit are below 1 ppt (Brenner et al, 1984).

The U.S. EPA has determined the following conditions to be acceptable for the destruction of pentachlorophenol treated wood:

 Two second dwell time at 1200 C with 3% excess oxygen in the stack gas.

(ii) 1.5 second dwell time at 1000 C and 2% excess oxygen (des Rosiers, 1983).

This can best be achieved in a high temperature rotary kiln, with secondary combustion chamber, such as proposed for the OWMC facility and the Alberta Special Waste Management Corp. at the Swann Hills toxic waste facility. Under these controlled conditions, incineration must be considered an acceptable means of ultimately disposing of penta treated wood.

5.2.4. Burning of inorganic arsenicals, CCA, ACA, FCAP

Combustion of inorganic arsenical treated wood results in generation of toxic constituents as gases (arsine; EPA, 1981, aerosol constituents of the flue ash (Cu, Cr and As III, Dobbs and Grant, 1976) and as particulate partially water soluble components of the ash, (McMahon et al, 1986).

The relative amount in each phase depends greatly on the burning conditions; prolonged roasting of the ashes from burned wood results in higher volatilization of the arsenic component (McMahon et al, 1986). With prolonged heating, as much as 77% of the As was in the gas or aerosol form. These authors found that the As in the ash was primarily in the less toxic pentavalent form whereas the volatilized As was trivalent in wood pyrolysed at 400 C and 86% about 50% trivalent in wood pyrolysed at 800 C. Watson (1958 a,b) found that the use of sawdust or shavings impregnated with an inorganic arsenical wood preservative to smoke meat contaminated both bacon and fish. From 9 to 22% of the arsenic in the wood particles was released as volatiles during the combustion.

Studies by Forintek Canada Corp. (Richardson, 1981) found higher concentrations of As in the smoke of CCA and ACA treated wood when burned at 450 C then when burned at 750 C. They attribute this to higher oxygen availability at

the lower temperature. At the lower temperatures, CCA and ACA treated wood had similar quantities of As in the smoke while at 750 C, ACA resulted in less As in the smoke and correspondingly more in the ash. Of the arsenic remaining in the ash, 10 - 34% was water soluble depending on the temperature and formulation.

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Dobbs and Grant (1976) concluded that burning of CCA treated wood did not add a significant amount of volatile As to the combustion gases, but that the ashes contained significant amounts of soluble Cr and As. A model has been developed from these U.K. studies to predict airborne As levels as a function of wind velocity, bonfire size, initial CCA loading and distance from the fire. This information is being used by the U.K. Department of Environment Land Wastes Division to produce recommendations on the safe burning of CCA treated wood. Recommendation have also been made on the required method of disposal of ash produced from burning treated wood. Amounts greater than 0.5 Kg as As should be disposed of under controlled conditions at a landfill site. This would involve commercial fixation in a matrix prior to disposal.

These results confirm that significant quantities of toxic and mobile arsenic are released in the smoke and ashes by the burning of wood treated with inorganic arsenicals. The significance of Cr and Cu release is thought to be less important but nevertheless an additional problem in the burning of this wood. Trivalent Cr may be converted to the more mobile and toxic hexavalent Cr (Lollar, 1986).

Technologies capable of removing and recovering most of the toxic elements from the flue gas and the ashes have been developed. For example, chromium tanned leather shavings are burned to recover heat energy and the chromium (Campbell and Glenn, 1982). Similarly, the OWMC proposed facility for solid waste disposal could incinerate inorganic arsenical treated wood in a rotary kiln with secondary combustion and advanced flue gas precipitation and treatment. Ashes containing toxic compounds would be encapsulated in concrete and disposed of in a monitored landfill area.

Clearly, such special technology must be invoked if this wood is to be safely incinerated.

At this time, users of treated wood in Canada, the U.S.A. and elsewhere are advised against burning of treated wood through instructions provided with treated wood and the voluntary labelling and information program run by the Treated Wood Industry.

In the U.K. incineration of CCA treated wood is permitted under controlled conditions (section 6).

Uncontrolled burning of arsenical preservative treated wood occurs occasionally in spite of the label and use instructions provided with the treated wood. This burned small quantities burned by homeowners wood includes in woodstoves, bonfires of fireplaces or treated scraps on building sites and burning of used ties on railway right of ways in a few isolated cases where waterborne treatments are used.

5.3 Resale or reuse of treated wood

Apart from the positive benefits of reusing treated wood products, there are some potential problems that must be considered. It is possible that recycled wood may be used for purposes for which it was not origionally intended and not appropriate. Some examples that the author become aware of in this study are:

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- the proposal of a lumber manufacturer to purchase up to 20,000 poles per year removed by Saskatchewan Power to be processed into construction lumber for use in the building industry. Incorporation of lumber containing creosote or penta would be contrary to the recommended uses of these preservatives.

- the practice of using disused marine piling for land piling in Western USA and Florida (Keefe, 1988). This material may be installed without adequate re-inspection and certification for residual strength, potentially resulting in early failure.

- the re-use of railway ties and telephone poles from the South Eastern USA is a common cause of dispersal of the Formosan termite in these areas. This is a valid concern in Southern Ontario where the Eastern subterranean termites may be spread by the same mechanism.

This suggests that an inspection, regrading and certification process may be appropriate for certain products going into some end uses.

Other possible misapplications are:

- the use of penta-treated poles for log buildings.

- the use of old ties and other creosoted treated produce for agricultural purposes where they can come in contact with the food chain.

- the use of oilborne treated ties, timbers and round stock for playground equipment.

6.0 CURRENT LEGISLATION RELEVANT TO THE DISPOSAL OF PRESERVATIVE TREATED WOOD

6.1 Canada

At this time, treated wood products are not considered toxic or hazardous wastes in Canada and so do not come under direct legislative control for these classifications of wastes. However, there are a number of legislative acts and have implications or associated regulations that do the transportation, storage and potential impacts on particularly in regard to disposal of treated wood, acceptable emissions from this material. This relevant legislation is summarized in Table 6.1 and discussed in more detail in the following sections.

6.1.1 Federal

With the Canadian Environmental Protection Act -1988 (CEPA) the federal government has established a framework within which toxic chemicals will be managed in the future. It provides for regulatory control of toxic substances through all phases of their life cycles. For a wood include its development, preservative, this would transport, distribution, storage, use, manufacture, emissions to the environment and ultimate disposal. Since many of these phases were addressed under other federal acts, it provides for consolidation of the responsibilities of Environment Canada under one act. Under this act, a Priority Substance List of 50 chemicals has been developed. These are chemicals used extensively in Canada that have highest priority for health and environmental impact chromium and arsenic are assessment. Pentachlorophenol, included on this priority list.

While wood preservatives fall under jurisdiction of this act, treated wood is not considered a pesticide nor a hazardous material and is not considered under the act.

Few of the other federal acts have direct applicability to the disposal of treated wood at this time. Acceptable levels of emissions to land or marine water are defined in the Fisheries Act. The Guidelines for Canadian Drinking Water Quality (1978) define the amounts of Cu, Cr and As permitted in drinking water. These requirements determine whether treated wood can be safely disposed of at landfill sites. The Clean Air Act limits the amounts of particulates and specific combustion products from burning of treated wood. The Food and Drug Act, identifies dioxins as food adultrants; thus, penta treated wood removed from service should not be used where it may contact the food chain.

Table 6.1 : Summary of Canadian Federal Legislation of Potential Relevance the Disposal of Treated Wood

ACT, REGULATION COMMENTS IMPACT & IMPLICATIONS OR GUIDELINE

CANADA-FEDERAL

Environmental Defines priority chemicals C. Contaminants priority chemicals priority chem

Guidelines for Defines water quality Canadian drinking objectives on aesthetic and water quality 1978 toxicology considerations: (Health and Maximum acceptable conc. Welfare Canada) As, Cr and Cu: 0.05, 0.05 and 1.0 mg/L. Objectives, As, Cr and Cu: <0.005, <0.0002 and <1.0 mg/L.

Transportation of Dangerous Goods Act (1980, (Transport Canada)

Clean Air Act (1970, Environment Canada) Defines allowable quantities or goals for various air contaminants. e.g. ambient air quality objectives.

Pest Control Products Act (1970, Agriculture Canada)

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Defines a "Pest Control Product"and registration and control criteria for pest control products.

Fisheries ActDefines acceptable discharge(Environmentto water from existingCanada)mines. e.g., As and Cu:--Existing Metal0.5 and 0.3 mg/L meanMining Liquidmonthly concentrations.Effluent Guidelines

Food and DrugIncludes dioxins as anPeAct (Healthadultrant; any foodnoand Welfare Can.)containing any residue ofco--Reg. B.01.046any dioxin is consideredfaAdulteration ofadulterated.Food.

Chlorophenols were on the priority list of 1982, but now removed.

Defines acceptable limits certain components of wood preservatives released fro disposal sites.

Exempts treated wood so hauling for disposal not affected.

Relevant to combustion of of treated wood products. Sets limits for incinerato etc. e.g., particulates: 0 - 60 ug/m3.

Wood preservatives fall under the act but not treated wood products.

Not directly applicable to treated wood, but indicatiof acceptable groundwater levels from disposal sites

Penta treated wood should not be reused where it can contact the food chain e.g farm buildings.

6.1.2 Provincial

Typical provincial legislation that is now relevant or may be relevant to treated wood disposal is summarized in Table 4.2. Where similar legislation exists in more than one province, it is only discussed once.

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As with the federal legislation, there are few direct applications to the disposal of pressure treated wood. Treated wood is specifically exempted from certain regulations such as Alberta Reg. 505 (Hazardous Chemicals Act; Table 6.2). One of the few places where waste treated wood is considered is Alberta Reg. 216 (Clean Air Act) which permits burning of used poles but defines railway ties as "Prohibited Waste" which can only be open burned with approval of the Dept. of the Environment.

One hazardous waste classification that inorganic arsenical treated wood may fall into under certain conditions is "Leachate Toxic Waste". This designation is defined and applied under Manitoba Reg. 282/87 (Clean Environment Act), Ontario Reg. 309 (Environmental Protection Act) and Quebec Reg. 1000-85 (Environmental Quality Act).

Emissions of Cu, Cr and As to the atmosphere and ground and surface water are regulated by a number of provincial regulations (Table 6.2).

6.1.3 Municipal and other levels of government

Municipalities may enact bylaws or otherwise apply incentives that affect the disposal of solid wastes. Bylaws affecting the operation of incinerators and the issuance of permits for open burning within the city boundaries may affect disposal of treated wood. Also, most landfill sites are owned and operated by municipalities and all are feeling the pressures of the escalating production of waste in our society. In Ontario, it is estimated that about 300 landfill sites will be filled by 1997 (Bradley, 1987). With the for extensive public hearings and requirements environmental assessments and the natural resistance of homeowners to have a landfill in the neighbourhood, it is becoming difficult to site these facilities.

Municipalities are seeking creative ways of reducing the burden on existing sites. Typical approaches to the solid waste disposal problem are:

- Encourage reuse and recycling through tax incentives, introduction of roadside recycling programs (blue box), and support of waste exchanges.

- Discourage landfill dumping of recyclable wastes through increased tipping fees or bylaws that allow landfill operators to turn away recyclable wastes. Tipping fees have been escalating rapidly and are likely to have an increasing impact on disposal in the future. Examples of current and former landfill fees for some Ontario regions are given in

Table 6.2 : Summary of Provincial Legislation of Potential Relevance to the Disposal of Treated Wood

ACT, REGULATION OR GUIDELINE [®]	COMMENTS	IMPACT & IMPLICATIONS
PROVINCIAL		
ALBERTATI		
Hazardous Chemicals Act (1980, Dept. of Environment)	Controls use, handling, storage & disposal of "hazardous Wastes"	Treated wood not classifie as "hazardous waste".
Reg. 505/87 Hazardous Waste Regulation	Defines specific hazardous wastes and criteria for hazardous waste definition.	Limits disposal in landfil of wastes containing > 100 mg/kg penta and liquids wi > 500mg/kg As or Cr. Specifically exempts wood preservatives and treated wood
Agricultural Chemicals Act (1980, Dept. of Environment)	Controls use, storage handling and disposal of pesticides.	Treated wood not included.
Clean Air Act (1980, Dept. of Environment)	Defines and Controls air emissions.	Limits emissions from burn treated wood.
Reg. 216/75 Clean Air (General) Regulation	Defines emission limits. Defines "Burnable Debris" vs. "Prohibited Debris" which cannot be burned in open fires without approval of the Director of Standards & Approvals, D.O.E.	Defines used power and tel communications poles, wood from demolished buildings solid waste from pole and post operations as "Burnab Debris" but includes used railway ties as "Prohibite Debris"
Reg. 218/75 Clean Air (Max.) Regulations	Defines maximum limits on particulates, CO etc.	Limits emissions from burning of treated wood.
Clean Water Act (1980, D.O.E.)	Defines & controls levels of contaminants in water	Limits contaminant effluen from landfill sites.
Litter Act (1980, D.O.E.)	Permits issuance of cleanup orders for unsightly property in view of highways.	May restrict leaving of treated wood on site after removal from service.
Special Waste Management Corp. Act	Establishment of the hazardou: waste facilities at Swann Hil Alta.	s ls

Table 6.2 cont.

BRITISH COLUMBIA

Pollution Control Act (1979, M.O.E.) --Objectives for Mining, Smelting & Related Industries

Defines objectives for discharges to air and water. e.g., ambient air objectives, As:0.1-1 ug/m3; Cr: 0.05-0.1 ug/m3; Cu: 0.25-2.5 ug/m3. Discharge to water, As: 0.1-1 mg/L;Cr: 0.05-0.3 mg/L;Cu: 0.05-0.3 mg/m3.

Defines criteria for land-

Defines effluent objectives

for discharge to marine and

fresh waters. As: 1.0 mg/L;

Cr: 0.15 mg/L; Cu: 0.1 mg/L.

fill sites for various

types of waste.

Minimum Requirements for Refuse Disposal to Land (M.O.E.)

Pollution Control Objectives Food Processing, Agricultural and other Industries (Dept. Lands, Forests, & Water Resources)

Pollution Control Objectives for Municipal Type Waste Discharges (Dept. Lands, Forests & Water Resources)

Defines criteria for landfill disposal or incineration of hazardous wastes.

Not directly applicable to treated wood, but gives indication of acceptable airborne contaminants from combustion of treated wood and water effluent from landfill sites.

At this time, treated wood is disposed of in level C sites which require soil coverage every 20 days.

Not directly applicable to treated wood, but indicativ of acceptable effluent from landfills.

Not directly applicable to treated wood.

MANITOBA

Designates materials as Clean "hazardous materials" Environment Act (Dept. of Envir. & Workplace Safety & Health)

Defines classification --Reg. 282/87 Classification criteria for substances e.g., "leachate toxic Criteria for substances" defined by Products. Substances & leaching procedure, as in Ont. and Quebec. Organisms.

No preservatives included a this time.

> Treated wood not specifically included.

Table 6.2 cont.

ONTARIO

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Environment Protection Act (1980, Ministry of Environment)

--Reg. 296 Ambient Air Quality Criteria Regulations (1980) e.g., As: 25ug/m3

--Reg. 308 Air Pollution Control (General)

--Reg. 309 Waste Management General Regulation

Defines recommended ambient air quality distant from sources 24h average.

Defines maximum conc. of various airborne contaminants at source. Regulations (1980) e.g., As: <75ug/m3; Arsine: <10ug/m3; Cr: <30 ug/m3; Cu: <100ug/m3; cresols: <230ug/m3; penta: <90ug/m3.

Limits emissions from burning of preservative treated wood at sites distant from the burner.

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Limits emissions from burning of preservative treated wood at the site of burning.

Defines "hazardous industrial waste", "acute hazardous waste chemicals" (including arsenic acid, arsenic oxides and arsine gas) and "hazardous waste chemicals" (including chromic acid, creosote and pentachlorophenol). Defines leachate quality criteria for leachate toxic waste" as a waste producing leachate containing contaminants in excess of 100X that defined in schedule $\overline{4}$ e.g., As: 0.05mg/L; Cr: 0.05mg/L; F: 2.4mg/L. If treated wood were evaluated according to the standard leachate test as described in this regulation and produce leachate with more than 5mg/L of As or Cr, it could be classified as a "leachate toxic waste" . At this time it is considered as "non-hazardous solid waste" and is exempted from the requirements of this regulation.

Ontario Water Resources Act (1980, M.O.E.) Water Management Goals, Objectives Policies and Implementation Procedures of the Ministry of the Environment.

Defines limits on certain contaminants for various uses of the water. e.g., Water Quality Objectives: As: <100ug/L; Cr: <100ug/L; Cu: $\langle 5ug/L \rangle$ Drinking Water Objectives: As: <0.05mg/L; Cr: <0.05mg/L; F: < 2.4 mg/L.

Limits contaminants from landfills and on-site disposal.

Municipal Industrial Strategy for Abatement (MISA) (Ministry of the Environment)

Table 6.2 cont.

Ontario Waste Management Corporation Act (1981, M.O.E.)

Attempts to eliminate persistent toxic chemicals in lakes and rivers. Requires monitoring of effluent and enforces limits on discharges to water.

Concerns the establishment and terms of reference of the Ontario Waste Management Corporation.

Controls the quality of leachate from disposal si to sewers and other pathw to lakes and rivers.

The OWMC facilities are or possible means of disposi of treated wood.

-QUEBEC

Environmental Quality Act (1977 Ministry of Environment??? --Regulation CQ-2 Respecting Solid Wastes (1981)

--Reg. 1158-84 Drinking Water Regulations

--Reg. 1000-85 Hazardous Waste Regulation

SASKATCHEWAN Water Resources Management Act (1972, Dept. of Environment) --Water Quality Objectives (1977)

Defines acceptable levels of Cu, Cr, phenols, etc. in leachate discharged from landfills into the groundwater supply or into storm sewers. Phenolics: <0.02mg/L; Cr: <0.5mg/L; Cu <1.0mg/L.

Defines maximum allowable concentrations of some contaminants in drinking water. e.g., As: <0.05mg/L; Cr: <0.05mg/L.

Describes a leach test procedure to determine if a solid waste has excessive contaminants in its leachate. Considered a "hazardous waste" if As and Cr >5.0mg/L aand Cu, total metals and organic contaminants > 10mg/L in the leachate.

Affects permissable emissions from treated woc placed in sanitary landfil

Limits amounts of certain effluents from disposal sites into drinking water supplies.

Defines criteria under whi treated wood products coul: be classified as hazardous wastes.

Objectives for surface water, max. conc., mg/L, As: 0.01; Cr: 0.05; Cu: 0.02. Drinking water, As: 0.01; Cr: 0.05; Cu; 1.0; phenolics: 0.001.

Relevant to leachate from landfills.

Table 6.3. It is clear that rates are increasing quickly in high population centers where the majority of solid wastes are generated; northern townships, on the other hand, generally offer their sites as a free service to the community.

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One examples of a bylaw that may impact on the disposal of treated wood is Region of Peel, Resolution 88-527-47 (Appendix D). Disposal of wood waste will be prohibited at regional landfill sites and redirected to an experimental wood processing facility. The private firm operating this proposed facility has discretion over what is "suitable" wood waste and may exclude preservative treated wood.

Table 6.3Landfill Disposal Fees in SelectedRegions in Ontario (Varangu, 1988).

Tipping Fee (\$/tonne)			
1984	1987	1988	
0	12 00		
0	12.00		
14.00	27.00		
3.00	20.00		
0	14.60	28.00	
	32.00	50.00	
18.00	36.50	53.50	
20.00	27.00	28.60	
7.95	14.43	30.80	
	13.15	15.40	
		26.00	
		37.50	
12.60	19.00	49.50	
	20.00	28.00	
0	0	0	
0	0	0	
0	0	0	
13.24	18.07	50.00	
	Tipping 1984 0 14.00 3.00 0 18.00 20.00 7.95 12.60 0 0 0 13.24	Tipping Fee (\$/tonne 1984 1987 0 12.00 14.00 27.00 3.00 20.00 0 14.60 32.00 18.00 36.50 20.00 27.00 7.95 14.43 12.60 19.00 20.00 0 0 13.24 18.07	

6.2 USA

The USA is faced with a more formidable task in the disposal of treated wood because of their significantly higher use of preservatives and of treated wood. It is estimated that in 1985, 475,000, 11,700 and 54,700 tonnes of creosote, pentachlorophenol and inorganic wood preservatives respectively were consumed in the USA (Micklewright, 1987). This compares to about 20,000, 1,500 and 3,000 tonnes for the same preservatives in Canada.

Since no pesticidal claims are made for preservative treated wood, it does not come under the stringent pesticide registration requirements under the Federal Insecticide, (FIFRA). The Fungicide and Rodenticide Act wood preservatives themselves must be registered however, and have undergone extensive analysis of the risks and benefits their use under the Rebuttable Presumption Against of Registration and Continued Registration (RPAR) process. As a result of this process, it was confirmed that the benefits treated wood are extremely high but that of using cost effective risk reduction factors could be applied to the treatment process and use of treated wood to reduce risks significantly (EPA, 1984).

The Environmental Protection Agency (EPA) Office of Solid Waste, is concerned with the disposal of preservative treated wood and in July, 1984, issued restrictions regarding the handling and use of treated wood. For disposal they specify: ""Disposal of treated wood by ordinary trash collection nor burial. Treated wood should not be burned in open fires or in stoves or fireplaces because toxic chemicals may be produced as part of the smoke and ashes. Lange quantities of treated wood from commercial or industrial use (e.g. construction sites) may be burned in commercial or industrial incinerators in accordance with state and federal regulations." (Federal Register, 1984).

Health and environmental concerns related to the use and handling of preservative treated wood would normally be addressed through the Toxic Substances Control Act. (TSCA) 1976). and the Consumer Product Safety Act (CPSA, TSCA requires labelling of a product containing toxic substances, so the user knows how to safely handle and use it. These consumer also specify instructions to the acceptable disposal procedures. However, through an agreement reached between the EPA and the American wood treating industry (represented by the American Wood Preservers Institute AWPI), the industry has undertaken to provide the consumer with all required information through Consumer Information Sheets. If this voluntary Consumer Awareness Program is deemed successful by the EPA, the mandatory requirements under TSCA will be waived. If the TSCA provisions are invoked, the treating industry could be required to provide the information on each individual piece of lumber e.g., by stamp or end tag (Hall, 1988). The legal obligations of owners of treated wood products who sell decommissioned wood for reuse are not well defined.

The Consumer Information Sheets for the three major wood preservatives are reproduced in Appendix C. They recommend that treated wood not be burned, but disposed of by trash collection.

The CPSA has authority to prevent consumer injury, illness or death by any product by creating and enforcing safety standards. At this time, no relevant regulations on preservative treated wood have been issued.

The Resource Conservation and Recovery Act (RCRA), 1976, gives the EPA authority to control the disposal of treated wood products if the EPA determines that they pose a substantial hazard to human health and the environment. At this time, treated wood is not deemed hazardous and does not fall under the RCRA regulations. In fact, on Nov. 25, 1980, arsenical treated wood temporarily excluded the EPA generated by users of treated wood, from RCRA control (EPA, 1981). EPA has recommended (1984) that if the quantity of treated wood waste exceeds 1000 Kg, disposal must comply with RCRA provisions. This prevents burning of large sources of waste wood such as dismantled logging bridges.

While solid pieces of treated wood are not considered hazardous wastes, under some circumstances, sawdust and other fine particles generated by the machining of CCA or ACA treated wood may be classed as EP (Extraction Procedure) Toxic Wastes under RCRA provisions (Hall, 1988). The EPA extraction procedure is similar to that used in Canada to define "leachate toxic wastes", (Anon, 1987). Solid wastes that pass through a 9.5 mm screen are tested by leaching directly in water. Solids that are in a single piece are subjected to a "structural integrity procedure" which involves application of a standard drop hammer for 15 cycles. Since solid wood maintains its integrity during this test, it is subjected to the leaching procedure as a piece. The maximum allowable concentration of As or Cr in the leachate is 5.0 mg/L. While solid treated material meets these requirements, fine sawdust or sanderdust, especially of fresh treated wood, may fail and be classed as an EP Toxic Waste. The EPA is also planning to add other toxicants to the list of chemicals monitored under this procedure, including pentachlorophenol (3.6 mg/L), and o-, m-, p-cresols (10mg/L) and phenol (14.4 mg/L) (Federal Register, June 13, 1986).

The above permissable levels assume a dilution/attenuation factor of 100 from the point of generation to potential locations of contamination. This factor appears to be low and may be changed once an appropriate ground water transport equation or model has been developed by the EPA (Anon, 1986).

At this time, land disposal of treated wood products is considered valid by the EPA, but not necessarily the most appropriate disposal method, in view of the high costs of landfill sites. 6.3 United Kingdom.

Since 1975, wood preservatives have been controlled under the non-statutory Pesticides Safety Precautions Scheme (1957) administered by the Ministry of Agriculture, Fisheries and Food and the Health and Safety Executive. This scheme safeguards the users of pesticides and treated products and the public and environment at large against toxic effects of the ingredients. Products containing toxic ingredients must be labelled. Label information includes recommendations on the disposal of waste materials.

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About 33,000 tonnes of creosote (ties and marine piling) are used each year in pressure treatment of wood survey). Organic solvent preservatives (based on 1970-2 including penta amounted to 1,370 tonnes and waterborne preservatives 11,000 tonnes (Bond and Sheils, 1980). Of this latter total, most of the treated wood was exported, with only 3,200 tonnes of preservative in domestic use. This 1970 amount is thought to have increased somewhat since while creosote consumption has been relatively stable. Based on recent studies on the airborne emissions from burning of CCA treated wood and established threshold limit Value (TLV) concentrations for As, a number of recommendations have been developed:

-- Wood treated to high CCA loadings (marine or cooling tower) should not be disposed of by open burning. Other materials e.g., from demolition of buildings, should only be burned in bonfires at least 100m from continuously inhabited buildings; not more than 0.5 tonne should be placed in any one fire, and no more than 1 tonne of treated wood should be burned at a single site in one day. All burning must comply with the Health and Safety at Work Act, 1974.

Burning of treated wood at municipal incinerators must comply with the HM Alkali and Clean Air Inspectorates' presumptive limits for arsenic emissions from registered arsenic works. This restricts levels to 115mg As203/m for emission rates of < 140 m3/min. (15 C, 1 atm) and 46 mg As203/m3 for emission rates > 140 m3 /min (ibid, 1980).

Disposal of ash from the burning of CCA treated wood is regulated by the Control of Pollution Act 1974 and the Control of Pollution Regulations 1976, although ashes generated on building sites are specifically exempted.

6.4 Australia

Disposal of treated wood is not considered a serious environmental problem in Australia (Norton, 1988). Levels of Cu, Cr and As permitted in marine and estuarine waters is regulated by the Environmental Protection Authority (1979): Cu: 0.01 ppm; Cr: 0.05 ppm; As: 0.01 ppm.

Occupational health limits of arsenic in the air is limited by the National Health and Medical Research Council (1978) to 0.5 mg/m. Since this limit may be exceeded during open burning of CCA treated wood, the Timber Preservers"

Association of Australia has issued leaflets warning the public to not inhale fumes from burning wood and to bury ashes from burnt offcuts. They further warn that wood should not be burned in an enclosed space or used for fuel in barbecues or cookstoves.

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6.5 New Zealand

The only Act that relates directly to the disposal of treated wood is the N.Z. Clean Air Act of 1972 (Hedley, 1988). It requires the liscencing of facilities that generate emissions. The Act limits disposal of multi-salt treated wood by burning to 100 Kg of wood waste per hour (Anon, 1973).

6.6 Sweden

It is recommended that preservative treated wood waste be buried in the ground (Henningsson, 1980). It is recognised that type of soil has a great effect on the leachate characteristics. At this time no treated wood (including creosote) is permitted to be burned (Henningsson, 1983).

6.7 Switzerland

Various aspects of wood treatment are regulated by the Federal Office for the Protection of the Environment through an Ordinance Relating to Environmentally Hazardous Substances (1986). It regulates the storage of treated wood products in areas sensitive to ground water contamination and prohibits use of preservatives containing penta or arsenic compounds. This in effect eliminates future problems with disposal of wood treated with these chemicals.

6.8 Norway

Burning of CCA treated wood is banned in Norway; sawdust and off cuts are disposed of in an official garbage heap (Evans, 1988). Creosoted wood may be burned under restricted conditions.

6.9 India

At present, there is no legislation directly pertaining to disposal of treated wood. Wood poles are recycled as building timbers and railway ties are reconditioned for reuse or sawn into joinery or construction timbers. Unuseable timber is dumped or burned.

7.0 STRATEGIES FOR REDUCING TREATED WOOD REMOVED FROM SERVICE

7.1 Extending the service life of treated wood through <u>in situ</u> remedial treatments

Any treatment that significantly increases the useful life of treated wood products will reduce the amount of wood disposed of in any given year.

For some wood products, it is technically and economically feasible to extend their useful life bv applying chemical treatments in place to stop or prevent decay or insect infestations. At this time, the utility pole owners are the only ones practicing remedial treatments, in Canada, mainly because of the high value and considerable replacement costs of poles. However, there is increased interest in the feasibility of treating railway ties in service and some interest in other products such as marine structures (Highley, 1980) foundation piles, bridge timbers and guardrail posts.

There are several options available for such <u>in situ</u> treatments, and the one selected depends on the characteristics of the products and the resulting modes of biological deterioration.

7.1.1 in situ treatment of poles.

7.1.1.1 Groundline treatments.

As discussed in chapter 5, wood preservatives may be substantially depleted from the surfaces of poles and other products by leaching, bleeding, migration and biological degradation. This is a significant problem with penta treated poles in the groundline and below ground portions, especially in thick sapwood, permeable species such as southern yellow pine. After about 20 years, the surface concentration of penta may drop below the toxic "threshold" concentration and decay fungi may deteriorate the surface shell. This decay weakens the poles substantially and if not stopped can result in pole failure or its culling by line maintenance crews.

This type of decay is treated by application of a preservative grease to the affected area, either through a hydraulic spade to the unexcavated pole (Inkis, 1976) or by digging around the pole and applying a water impervious bandage, containing the preservative paste. Studies are underway to evaluate lower toxicity formulations than conventionally used creosote, penta and FCAP based formulations. For example copper naphthenate based systems show considerable promise (Hawthorne and Ruddick, 1987).

These treatments, if applied at the optimum time will extend pole life by 10-15 years per application.

7.1.1.2 Internal treatments.

Thin sapwood poles with low durability heartwood such as Douglas-fir and jack pine are less prone to surface deterioration. However, internal decay may develop if fungi gain access to the untreated heartwood through seasoning checks.⁴

Soil fumigants such as chloropicrin and vapam have been found very effective to control internal decay (Graham, 1973). Holes are drilled into the pole and liquid or encapsulated fumigant sealed into the holes. The fungitoxic vapour then slowly diffuses through the internal void space, sterilizing the wood it contacts. Because of the slow rate of diffusion of the vapour, it persists in the pole for several years providing residual protection to the pole, and emitting only infinitesimal quantities to the surroundings.

At this time, only vapam is registered for use in Canada, although it is generally recognised that chloropicrin and methylisothiocyanate are both more effective.

Fumigant treatments have been evaluated on marine piling, glued laminated beams and bridge timbers and appear to be an efficient way to extend the service life of any large cross section wood product.

7.1.2 Treatment of railway ties.

Most of the research on remedial treatments for railway ties has been carried out in Europe (e.g. Beauford et al, 1988). The most popular treatment is by insertion of solid rods of diffusable salts such as borax or sodium bifluoride into strategically located holes drilled in suspect ties.

This concept is being extended to the treatment of window joinery and could easily be applied to other treated products such as timbers, retaining walls and guardrail posts. At this time, these systems have not been evaluated thoroughly enough to confirm that the treatment cost (\$5-10 per tie) is justified by increased service life.

7.2 Use of alternative, low toxicity preservatives reliability concepts, increased quality of treatment

The cost-benefit analysis conducted as a part of the U.S.A. EPA RPAR process, confirmed that none of the three preservative systems can be entirely replaced by another heavy duty preservative or by less toxic preservatives. However, it should be feasible to reduce the quantities of creosote, penta and inorganic arsenical treated wood through application of more targetted or specific preservatives for specific applications or through lower levels of treatment for applications where the decay hazard is low.

7.2.1 Low toxicity systems

The opportunities for applying less toxic but less efficacious preservative systems are greater in Canada than in warmer climates because of the lower decay hazards in this country. Also, a large volume of treated wood is applied[#] to relatively low hazard uses where the wood is easily replaced and the consequences of failure are not extremet (Cooper, 1985). Such wood could be treated with a less effective but more environmentally acceptable system. This targetted or focussed approach to wood protection was promoted at a recent conference of the Wood Protection Institute of Building Committee of the U.S. National Sciences (NIBS) held in Arlington VI, Oct 15, 1988. Some less broad spectrum low toxicity preservatives are discussed briefly below. Technical information is base d on several sources including a recent paper at the NIBS conference by D. Nicholas (1988) and a summary paper by Cooper, 1982).

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7.2.1.1 Residential Construction

Much of the high volume of CCA treated wood for residental construction is used in low decay hazard conditions (decks, fences, siding, lattice etc.). There are several wood preservative systems thought to be of lower environmental hazard, which should provide an adequate service life for these uses.

The arsenic content of CCA and ACA can be reduced by use of other formulations such as the origional CCA-A or new ammoniacal copper/zinc arsenate systems (ACZA). CCA-A contains a higher chromium content, which may offset the advantages of low arsenic. ACZA systems are becoming more accepted in the Standards associations and are being used in the USA. However, they are more applicable to products like wood foundations, poles and piling than to residential construction for appearance reasons.

Preservatives may be formulated without the arsenic component as in the acid copper chromate (ACC) formulation, which is recommended for above ground use only. Also, ammoniacal copper systems are capable of cation exchanging large amounts of copper in the cell wall of wood and should provide moderate protection against decay. Aternatively, the arsenate can be replaced with lower toxicity anions such as borate (CCB, ACB) or phosphate (CCP, ACP). Alkyl ammonium compounds (AAC's) are low toxicity water based preservatives with high efficacy in above ground applications. Addition of copper compounds increases their efficacy in ground contact.

Some of the relative economic and social costs or benefits of these preservatives are compared to CCA and ACA in Table 7.1.

The limited efficacy tests on these preservatives suggest that copper chrome phosphate deserves additional study and consideration as an alternative preservative for wood not in ground contact.

Borates have been evaluated extensively for temporary treatment of lumber, in situ treatments or diffusion treatment of building timbers. Recently, pressure treatment of lumber has been advocated. Borate treated lumber has promise in wood not directly in contact with soil or free water such as building sill plates. At this time, very little wood in these applications is treated with the heavy duty wood preservatives so opportunities for substitution by borates are limited.

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Preservative	Relative Chemical Cost \$US/m3 in 1979	Relative efficacy SYP in ground (Saucier, Miss.)	Rel. Toxicity of active ingredients.
CCA	15	35	HIGH
	15	35	HIGH
ACC	25	10	MOD.
AAC	?	?	LOW
ACB	· 25	10	LOW
CCB	25	10	MOD.
CCP	20	15	MOD.

Table 7.1 Comparison of waterborne wood preservatives

7.2.1.2 Railway ties

It is generally agreed that treatments for ties must provide dimensional stability and fatigue resistance in addition to protection against decay and insects. At this time, this is best met by heavy oil treatments such as penta-in-oil. Copper naphthenate creosote/petroleum or (CuNap) is one oil-based preservative that may be a suitable, low toxicity alternative. In 1979, its cost was about double that of penta-in-oil (USDA, 1980). In the presence of moisture, the solutions are corrosive. This of steaming and Boultonizing 85 use prevents the pre-conditioning treatment for ties; this restriction will increase the treating costs at some plants. When treated to the recommended retentions, CuNap is about as effective as penta although there is some concern that when copper tolerant fungi are prevalent, it may be less efficacious. Considering the fact that mechanical damage is often the mode of failure for ties, it is reasonable to assume that use of CuNap in a heavy oil will result in similar service lives to the other preservatives.

Field tests conducted by the USC have identified

several petroleum-oils that provide excellent decay resistance without addition of any active pesticide (e.g., Gjovik and Gutzmer, 1985).

Solvents identified as "Heavy gas oil - mid USA", catalytic gas base oil (West Coast), and "Texas Lube oil extract" all provided surprisingly long service lives at retentions of 64-192 Kg/m3. Such treatments should have minimal economic and social costs and warrant additional study under Canadian conditions.

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7.2.1.3 Poles, Posts etc.

Copper naphthenate, ACZA and copper ammended AAC's have potential for treatment of wood in ground contact. More field evaluation is required to determine if the benefits of reduced toxicity of the formulation warrants the added costs associated with chemical price, processing changes and possible reduced efficacy.

7.2.2 Use of Reliability Based Design Concepts.

Another aspect of targetting preservative treatments to the end use, is to consider more carefully the end use, especially the required or desired service life and the consequences of premature failure. Lower levels of treatment are adequate in uses where the decay hazard is low, especially if the wood is easily replaced or repaired, and if premature failure is unlikely to result in injury or inconvenience. For example, fence boards, trellises and decorative wood may be treated to lower retentions than wood placed in ground contact.

Wood used in above ground applications with low decay hazard potential should provide a satisfactory service life at low retentions e.g., 3.2 - 4 Kg/m. Higher loadings will result in higher quantities of Cu, Cr and As disposed of when the structure is changed out.

Wood in ground contact on the other hand must be treated to higher retentions to withstand the higher decay hazard potential. Use of low quality treated wood will result in premature failure and increased amounts of treated wood for disposal.

The treating industry could best tailor the quality of treatment to the intended end use by selecting treatable species or use incising pretreatments and prolonged treating times for wood for high decay hazard applications and reserve difficult to treat species for the other uses. The lumber would have to be marked or labelled for its intended use and the consumer educated about the two "types" of treated wood. This could be accomplished by use of different coloured plastic end tags, now used for the limited warranty programs sponsored by the chemical suppliers and through consumer information sheets.

This approach is used to some extent by railway companies when they place stronger hardwood ties on heavy traffic lines and curves where mechanical damage is a greater problem.

7.2.3 Technological innovations

The service life of many treated products may be enhanced by incorporation of novel product or process innovations. Many of these are under study at this time, but it is premature to estimate increased service life or performance.

7.2.3.1 Railway ties

Railway ties often fail mechanically, due to plate cut and crushing (related to bearing stress and moisture accumulation), full length splitting and spike loosening. Plate damage may be reduced by increasing the plate area, use of resilient pads under the plates, use of water resistant coatings or materials to protect the plate area, from moisture and use of composite ties with harder wood on the surface.

Tie checking and splitting may be controlled by kerfing ties, by use of antisplitting devices such as truss plates on the ends of ties, or by moisture protection of the tie surface. Also, composite ties such as dowel laminated ties show less tendency to split.

Spike kill may be reduced by changing fastener type e.g. tie clips vs spikes. However, all of these approaches increase the installed cost of ties and, as yet, definite benefits have not been proven.

7.2.3.2 Other products

Kerfing has also been investigated to control checking which may lead to internal decay in treated poles and timbers. Incising and other mechanical pretreatments result in more uniform treatments of wood and should extend its service life.

Since poles often rot near the groundline, use of wooden or steel reinforcing stubs will increase the pole service life at a low cost compared to the replacement cost. In 1978, a steel stub cost \$230 to install compared to a new pole cost of \$100-500 and cost of replacement of \$500-3,000 depending on the amount of conductors and equipment on the pole (Inkis, 1978).

7.2.4 Improved quality control

For applications where the decay hazard is high, poorly treated wood will deteriorate prematurely resulting in more for disposal. wood Heavier retentions and deeper penetrations can be obtained by selection of high quality white wood for treatment, proper conditioning of wood prior to treatment, incising and use of extended pressure cycles. Without a third party inspection procedure, there is little incentive for treaters to adopt these costly measures. The proposed third party inspection program under development by the industry should improve this situation in the future.

8.0 OPTIONS FOR DISPOSAL OF TREATED WOOD AND THEIR SOCIO-ECONOMIC IMPLICATIONS

8.1 Introduction

For each wood product and preservative type, there are several feasible disposal options, each with associated economic and social costs and benefits. In this section these options are discussed in the context of the waste management hierarchy discussed by the Ontario Waste Management Corporation (OWMC, 1982). Some of the best options are only feasible for a limited amount of waste wood and several approaches will have to be used in the management of a given type of waste.

The various waste management options identified in this report are summarized in Tables 8.1 to 8.3 with their estimated relative economic and social costs and benefits.

8.2 Waste abatement, elimination, reduction or modification.

8.2.1 Replacement of conventional preservatives with low toxicity alternatives.

Future environmental loadings of Cr, As, creosote and pentachlorophenol can be reduced by substituting some of these active ingredients with lower toxicity preservatives. Social benefits of reduced environmental and health effects can be anticipated. However, these will be offset to a greater or lesser extent, depending on the alternative chosen, by increased economic costs associated with more costly chemicals, higher loading requirements, equipment and plant changeovers, rewriting of specifications and increased materials and replacement costs resulting from lower efficacy of the new systems. There may also be social costs resulting from increased energy consumption and reduced conservation of the forest resource.

The relative cost/benefit ratios of the less toxic water based preservatives discussed in section 7.2 cannot be determined without additional testing of their abilities to protect wood under Canadian conditions. However, field testing to date suggests that several of the systems will provide adequate protection for residential many construction uses. The small quantity of this material requiring disposal at this time is placed in landfill sites. By 2000, the quantities for disposal will have multiplied along with tipping fees in high population areas where most of this wood is used. The costs of introducing less hazardous preservatives that could be safely burned such as ACB or AAC could be offset by this factor alone. The other formulations contain some Cr and/or As and would require similar disposal procedures as CCA and ACA. Their use would have to be justified on the basis of their superior health and environmental safety.

Table	8.1	Relative rating of economic and social costs or		
		benefits for various waste management options		
-Creosote treated products				

Waste Management Option	Railway economic	Ties social	All Other economic	Products social
Reuse as lower grade products @	BBB	BB	BB	BB
In situ treatments 🛛	BB?	BB?	BB	BB
Technological innovations	BB?	BB?	BB? @	BB?
Recycle as landscape timbers, fence posts etc. @	BB 9	cB?	BB	cB?
"Reliability" concepts @	bc?	BB	bc?	BB
Controlled incineration for energy	BB	В	В	В
Chip and reconstitute for ties and other products @	B?	B?	n.a.	n.a.
Use less "hazardous" preservative systems	CC	BB?	сс	BB?
Burn at removal site	с	CC?	с	CC?
Firewood (fireplace or wood stove)	с	CCCC	с	cccc
Leave in service or at removal site	с	CCC	с	CCC
Landfill disposal	CCC	с	CC	с
Burn at registered hazardous waste facility	CCCC*	С	*2222	С

B: Benefit (BBBB: very high benefit, etc.)

C: Cost (C: low cost, etc.)

b,c: low or zero benefit or cost.

* unacceptable cost

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@ limited applicability

? more research or study needed

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Table 8.2 Relative rating of economic and social costs or benefits for various waste management options -Pentachlorophenol treated products

Waste Management Option	Utility economic	poles social	All Other economic	Products social
Reuse as lower grade products @	BBB	BB	BB	BB
<u>In situ</u> treatments	BBB	BBB	в ?е	в ?@
Technological innovations	BB ?	BB ?	в?	в?
Recycle as landscape timbers, fence posts etc.	BB	cB?	BB	cB?
"Reliability" concepts	В	BB	cB?	BB
Controlled incineration for energy	BB	CC	В	СС
Chip and reconstitute for ties and other products	В?	. В?	B? @	B?
Use less "hazardous" preservative systems	CC	BB ?	CC	' BB ?
Burn at removal site	с	CCC'	с	ccc(
Firewood (fireplaces, wood stoves)	В	CCCC*	· b	cccc*
Leave in service or at removal site	С	CC	с	CC
Landfill disposal	ccc	c	CC	с
Burn at registered hazardous waste facility	cccc*	с	cccc*	С

B: Benefit (BBBB: very high benefit, etc.)

C: Cost (C: low cost, etc.)

b,c: low or zero benefit or cost.

* unacceptable cost

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@ limited applicability

? more research or study needed

Table 8.3 Relative rating of economic and social costs or benefits for various waste management options - CCA, ACA and FCAP treated products

Waste Management Option	Residential economic	Construction social	All Other economic	Products social
Reuse as lower grade products @	BBB	BB	BB	BB
In situ t reatments @	n.a.	n.a.	BB	BB
Technological innovations	n.a.	n.a.	BB?	BB?
Recycle as landscape timbers, fence posts etc.	B@	BB	BB	BB
"Reliability" concepts	В	BB	BB	BB
Controlled incineration for energy	BB	CC	В	СС
Chip and reconstitute for ties and other products	В?	В?	В?	B ?
Use less "hazardous" preservative systems	С	BBB	CC ? [']	В?
Leave in service or at removal site	с	CC	с	CC
Landfill disposal	ccc	c	сс	с
Open burn at site fireplace or stove	с	*3333	C	CCCC?
Burn at registered hazardous waste facility	CCCC*	С	CCCC*	С

B: Benefit (BBBB: very high benefit, etc.)

C: Cost (C: low cost, etc.)

b,c: low or zero benefit or cost.

* unacceptable cost

T

@ limited applicability

? more research or study needed

Conversion to CuNap treatment for ties would result in significant economic costs. Possible social benefits are not quantifiable at this time as they depend on the durability of CuNap treated ties and whether disposal of creosoted ties will become more difficult and costly in the future.

8.2.2 Reliability based design

Tailoring the level of treatment to the intended use of the wood can result in more efficient use of preservatives and reduced chemical content in disposed of wood. Wood used applications where removal is in low decay hazard more probable because of aesthetic and personal preference for reasons than deterioration residential (e.g., construction) can be treated to lower levels of treatment. More critical applications require a high quality of treatment to prevent changeouts from premature decay. The costs of targetting specific qualities of treated wood to applications are associated with labelling specific or identification of the seperate grades, education of the consumer and a need for increased inventories of treated wood; the social costs of misuse of wood designed for other purposes is difficult to assess. Benefits result from a more efficient use of wood preservatives and longer service life of treated products.

8.2.3 In situ or remedial treatments

useful Chemical treatments in service can extend the service life of products. The cost effectiveness of these treatments depends on the value of the product; its replacement costs, cost of treatment the and its effectiveness in extending life. Social costs may result addition of less strongly fixed from or contained preservatives to the environment.

8.2.3.1 Railway ties.

There is currently much work on the chemical treatment of the railseat and interior of ties with diffusable preservatives such as borates and fluorides (e.g. Beauford et al, 1988). Unfortunately, the relationship between decay and mechanical deterioration has not been well established and there is no conclusive proof that these treatments actually extend the service life of ties significantly. Research is required to clarify these issues.

8.2.3.2 Utility poles

It has been clearly demonstrated that pole groundline treatments (pressure spade or bandage) increase the service life of creosote and penta treated poles of species susceptible to surface depletion in the groundline.

Munro (1983) determined that, in Manitoba, groundline treatments applied to 20-30 year old full-length treated life by 15 years poles increase their service on the On this basis, in 1982, the net benefit of average. groundline treating poles over a 20 year period was about \$130 per pole (1982 dollars). The unquantifiable social costs of adding pentachlorophenol formulations to the pole surface can be reduced by using lower toxicity formulations such as those investigated by Ontario Hydro. (Hawthorne and Ruddick, 1987). Copper naphthenate based formulations are predicted to provide protection against decay for up to 10 years. Since it is a low toxicity preservative registered with Agriculture Canada as a general use wood preservative (not a restricted use preservative) the chances of adverse health or environmental effects are greatly reduced compared to penta.

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Funigant treatments to control internal decay have proven effective in stopping decay and inhibiting reinfection for many years. However, the effect of this treatment on extending the service life of poles can only be guessed at this point.

8.2.3.3 Other products

The service life of other treated products such as piling and timbers can probably be extended by in situ treatments but no reliable estimates in increased service life are available.

8.2.4 Technological innovations

Various processing, manufacturing and in service techniques can be used to ensure more durable products or to extend life in service. These include pretreatments to increase quality of treatment or reduce checking, imroved treating technology, use of attachments to reduce mechanical damage (ties), stubbing of decayed poles etc. Many of these have been proven economical and are used already. Others are under test and cannot be recommended until benefits have been proven.

8.3 Waste reuse

As discussed in chapter 4, a significant amount of decommissioned wood is reused for its defined purpose or for other functions. This may have a positive economic benefit if the product can be sold or if it reduces the need for new materials; otherwise it has the benefit of eliminating costs associated with disposal. Social benefits result from materials and energy. However, if the conservation of product is reused in an inappropriate way, unacceptable social costs may result. Generally, only a fraction of the total removal is suitable for reuse.

8.3.1 Railway ties

Many railway ties removed from rail lines taken out of service or mechanically damaged ties from main lines have adequate strength and decay resistance to be used for many additional years on secondary lines. Economic costs benefits accrue from:

- the difference in cost between collecting and transporting to the new site and disposing of the ties. This may be a net cost if the ties are normally burned on the trackside, or a benefit if the ties are collected, transported and disposed of at a landfill.

- the value of the service life of the used ties compared to the same life from new ties. In the following example, the cost of using second hand ties that require replacement every 15 years is compared to the use of new ties with an expected life of 30 years. Assumptions: the costs of transporting to the site are similar for both types of tie; the price of a new number 2 tie is \$20; the used tie has a present value of \$5.00 as a landscaping timber; the present cost of changing out a tie is \$6.00 per tie. This results in a savings of \$4.00 per tie (1988 \$).

No adverse social costs are evident.

Railway ties may also be reused as fence posts, especially along right-of-ways. Ties are usually provided free to farmers to fence off the right-of-ways. This has a value to the railway company as the net economic responsibility and cost of fencing is normally shared. otherwise benefits result from not burning or Social disposing of these ties and conservation of materials and energy that would otherwise be expended to produce alternative posts.

Many ties are sold or given to private individuals, contractors or landscapers for retaining walls, cribbing, rustic steps etc. These are generally considered acceptable applications for creosoted wood, although with increased public awareness of some of the toxicological properties of creosote, fewer homeowners are willing to use this material.

8.3.2 Utility poles

of Much of the sound portions of poles taken out service are reused by the utility as service poles to residences or as stubs, anchors or cribbing. Where the utility cannot use this wood, it is sold to given or contractors or farmers for general construction use. Most utilities make a concerted effort to warn the user that the treated portions of poles cannot be used for firewood. Appropriate reuse of these materials are clearly the most cost-effective way of managing them. Difficulties arise when the material is misused e.g., for firewood or for uses in direct contact with the food chain.

8.3.3 Other products

There are some opportunities for reuse of piling timbers and some residential construction and offcuts. Generally, however, these materials require disposal.

8.4 Waste refining for recycling

Wood products may be chipped and reconstituted for composite products or may be broken down and burned for process energy.

8.4.1 Composites

Use of treated wood for composites has costs associated with collection and transport of waste wood and machining wood that may be contaminated with rocks, dirt or metal fasteners. In the USA, it is apparently feasible to collect sufficient ties in a relatively small area to meet the raw materials requirements of a composite tie manufacturing facility. Collection and transport costs are minimal, since raw materials are supplied by the user of the new product. Rail cars can be used to bring in used ties and remove new composite ties. The economical feasibility of this approach depends on the long term performance of the composite ties, which is still under evaluation.

In Canada, the broader geographic area and reduced density of rail lines makes this approach practically infeasible. It is estimated that an assured supply of about 1.5 million ties per year is required to provide the economics of scale that would make such a facility viable (Brudermann, 1988). This would require the transport of 50% or more of the annual tie removals in Canada to a central facility resulting in uneconomical transport costs and an inadequately secure source of raw materials.

CCA treated wood may be chipped for furnish of decay resistant panel products (Henningsson, (1980). The major barrier to this approach is the collection and efficient chipping of mixed and contaminated materials. Also, much of the cross section of treated wood products is untreated. The decay resistance of a partially treated board is suspect. This approach does not have much merit at this time.

8.4.2 Recovery of Energy from Creosoted Wood

In the U.S.A., it has been shown to be economically viable to fuel cogeneration plants or partially fuel pulp and paper boilers or coal burning facilities with creosoted railway ties. There is some question about the adviseability of burning creosoted wood, even under these controlled conditions. Testing would be required to confirm that emission standards for PAH's and phenols are met at each facility. Unfortunately, there appears to be a trend away from large scale wood burning facilities in Canada at this time. However, the solid waste management crisis facing virtually every major population center in Canada has resulted in interest in "Refuse Derived Fuel" facilities. High fuel value, presegregated ties and other products would be highly desireable furnish for these facilities.

8.5 Waste Treatment and Destruction

Treated wood can be reduced in volume with or without the recovery of energy, by incineration under conditions that prevent the release of toxic gases, vapours, fly ash or grate ash into the environment., This is the disposal method of preference for organic hazardous wastes and is applicable to treated wood that is classified as a solid hazardous or toxic waste such as contaminated sawdust and sludge from treating plants and finely devided sawdust or sander dust that fails to meet the leachate test criteria for Cr and As.

The required level of emissions control can only be assured at the few hazardous waste treatment facilities in operation or under consideration in Canada. If large volumes of waste treated wood were shipped to these facilities as the ultimate method of disposal, they would typically be treated as follows:

- The wood is ground and fed into a rotary kiln with secondary combustion to consume all of the wood and organic constituents.

- Deleterious combustion byproducts are removed by electrostatic precipitators, scrubbers etc.

- Active mineral wastes in the ash are encapsulated in a concrete matrix and placed in a lined landfill cell with continuous leachate monitoring.

The cost of such treatment is extremely high, and infeasible for large volumes of treated wood products. For example, for the proposed OWMC facility, the average cost (capital cost recapture + operating costs) is estimated at \$600 per tonne of waste, excluding collection and transport (Lightowblers, 1988). For railway ties, ignoring the weight of entrained moisture, the cost of disposal would be about \$40 per hardwood tie and \$28 per softwood tie compared to current costs of \$25-30 to purchase new ties.

8.6 Waste disposal

This is generally considered the option of last resort for wastes, but may be economically and socially acceptable under certain circumstances.

8.6.1 Open burning

Because no effort is made to control combustion of the preservative treated wood or to contain contaminants during burning, this option is considered here rather than as waste treatment and destruction. Creosoted wood is still burned extensively in Canada. There are suggestions that potentially carcinogenic PAH's may be generated during burning of creosoted wood, although there is a long history of this practice without apparent adverse effects. There is insufficient evidence that hazardous of quantities deleterious compounds are generated by the combustion of creosote to recommend banning of this practice at this time. It is recommended that CCA, ACA and penta treated wood not be open burned because of the active Cr and/or As generated in the airborne emissions and ashes of inorganic treated wood and the possibility of generating dioxins from penta treated wood.

8.6.2 Landfill disposal

The cost of landfill disposal varies greatly with location. Costs in heavily populated areas are rapidly escalating, while this service is still provided free in other areas (Table 6.3). The experimental evidence on the depletion of preservatives from wood in soil contact and their fate of in the environment, while sketchy, suggests that landfill disposal is an environmentally acceptable means of disposal for all types of treated wood. However, since the largest growth of treated wood products is forseen in the residential construction area (mainly CCA), this method of disposal will soon be too costly and other options will have to be considered.

9:0 RECOMMENDATIONS AND CONCLUSIONS

9.1 Recommendations and conclusions regarding disposal practices.

(1) The quantities of creosote and pentachlorophenol treated wood that will be disposed of each year in the future will remain relatively constant or decline slightly. Volumes of inorganic arsenical treated wood on the other hand will increase dramatically over the next several decades.

(2) Landfill disposal is an environmentally acceptable disposal method for all treatments, but will become very expensive in the future, especially for residential treated wood. These costs will be borne by the home-owner or the municipality, but more cost effective disposal methods must be sought.

(3) Treated wood disposed of in landfill sites should be maintained in as large pieces as feasible. Breaking up or grinding of wood e.g. by tie shears or by cutting off treated portions should be avoided.

(4) CCA, ACA and FCAP treated wood should not be burned in open fires or uncontrolled incinerators. Only facilities with provisions for flue ash precipitation and grate and flue ash consolidation should be used.

(5) Pentachlorophenol treated wood should only be burned under controlled conditions that ensure adequate temperature, oxygen supply and dwell time of combustion products in the flame.

(6) At this time, there is little evidence of harmful effects from burning of creosote treated wood.

9.2 Recommendations regarding Environment Canada Initiatives

(1) The implementation of a third party inspection program for treated wood products will result in more efficient use of treated wood, and fewer premature failures. Since this will be a voluntary program at the individual treating company level, Environment Canada should encourage plants to join the scheme through their interactions regarding the "Code of Good Practice".

(2) It is recognised that there is a hierarchy of options available for the disposal of most types of treated wood. The most favourable options with associated economic and/or social benefits such as recycling, substitution with less toxic chemicals, use of more efficient designs, improved processing and maintenance technology can be

stimulated through information transfer and research and development as discussed below. These initiatives should be supported by Environment Canada in conjunction with the Canadian Forestry Service (conservation of resources) and Energy, Mines and Resources (conservation of energy).

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(a) Technology and information transfer.

There are several services and programs relevant to the disposal of solid wastes that producers of large volumes of treated wood may not be aware of. It is suggested that the major producers, as identified in this study, be informed by Environment Canada of the following:

(i) active or passive waste exchanges in Canada which allow generators to list their wastes in a bulletin which is circulated to potential users of waste materials. At this time, there are several waste exchanges in Canada that list identified wastes in periodical bulletins for their subscribers.

The Alberta Waste Materials Exchange, 4445 Calgary Trail S., Edmonton, Alberta T6H 5R7 (403) 450-5461

The Canadian Waste Materials Exchange, Ontario Research Foundation, Sheridan Park, Mississauga, Ontario L5K 1B3 (416) 822-4111

Manitoba Waste Exchange, 1329 Niakwa Rd., Winnipeg, Manitoba (204 257-3891

Ontario Waste Exchange, ORF Sheridan Park, Mississauga, Ontario L5K 1B3 (416) 822-4111

Peel Region Waste Exchange 10 Peel Centre Drive, Brampton, Ontario L6T 4B9 (416) 791-9400

Recently, the Ontario Waste Exchange has taken on a more active role by seeking potential users of specific waste materials. (ii) The DRECT (Development and Demonstration of Resource and Energy Conservation Technology)

This program is administered by the DRECT Secretariat of the Environmental Protection Service of Environment Canada. This program provides up to 50% of the cost to develop systems or products that help recover or conserve materials or energy.

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(b) Research Needs

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(i) Development of a transport model for themovement and interaction of inorganic arsenicals out of wood and through the soil/groundwater system. The equilibrium partitioning of these constituents with the components of various soil types should be evaluated under different temperature, leachate concentration and conditions of element balance and groundwater pH and ionic strength. Also, time dependent effects such as diffusion with chemical prediction of be evaluated to allow reaction must appropriate attenuation factors for the various leachate nature of element must be binding of the tests. The established as an indication of the permanence of the fixation. Badri (1984) describes an extraction scheme that differentiates bound Cu as "easily and freely" leachable and exchangeable (EFLE), oxidizable organic, acid reducible and residual or resistant copper.

(ii) Evaluate the leaching characteristics of fresh treated but fixed samples of CCA and ACA treated wood and aged samples from in service using the criteria of the "Leachate Extraction Procedure" referenced by the U.S. EPA and several Canadian regulatory authorities. Compare Cr and As leachate values with the criteria established for "leachate toxic wastes".

(iii) More detailed information is required on the distribution of preservatives in various treated products at the time of removal from service or failure. Certain portions of treated products may contain little or no residual preservative and can be disposed of without special concern, e.g., the tops of utility poles (Mortimer, 1989).

(iv) More data are required on the rate of leaching of all preservatives from aged wood in various locations and uses since this is most relevent to whether contamination is likely from disposal sites and will assist in disposal facility design.

Also, there is insufficient information on the rate of migration and fate of preservatives in the soil or water around treated products. In particular, there has been little work on the biodegradation of pentachlorophenol under Canadian conditions. (iv) Expand existing field tests, run by Forintek Canada Corporation to include a wider range of geographic conditions, and more above ground evaluation of low toxicity inorganic and organic wood preservatives. This work is currently supported by the Canadian Forestry Service, but would require additional support from other agencies to meet the above objectives.

(v) Develop and expand methods of increasing the service life of products by in situ treatments. There is a lack of knowledge of the effects of fumigant treatments and diffusing salt treatments on service life of poles, ties and timbers.

More study is required on emissions from (vi)burning of creosote and penta treated wood in "intermediate facilities" such as cement kilns, thermal generating plants, pellet pulp and paper mill boilers, wood waste and wood burning furnaces etc. Recent technological innovations such as infrasound generators (not previously discussed in the make less efficient burners suitable for this text) may purpose. Infrasound transducers can be retrofitted onto to generate low frequency (about 20 Hz) long furnaces wavelength sound that is claimed to increase the fuel dwell Concord. time by a factor of ten (Kiln Technologies Inc. This could allow the complete destruction of ONT.) pentachlorophenol and associated dioxins and furans and the PAH components of creosote under less than ideal combustion conditions.

(c) Development of Statistical Data.

The statistics collected by Statistics Canada on values of wood used for treatment and values of preservatives consumed are difficult to convert with confidence to quantities of preservative used. Furthermore, they are not broken down into product type or even into specific wood preservatives (CCA, ACA, FCAP, Fire retardants and possibly solid pentachlorophenol are lumped in one category).

As noted by de Lissa (1983) this absence of valid statistical data leaves the Canadian Wood Treating Industry in a vulnerable position in regard to its ability to justify the economic importance of treated wood products. It also makes it difficult to assess the environmental implications of use and disposal of treated products.

It is recommended that funding be sought to institute an annual survey of the wood treating industry, according to the model set by the American Wood Preservers' Association. This statistical survey could be supported by the CWPA and/or the CITW and the results published in the annual CWPA proceedings.

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APPENDIX A

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BELL SPECIFICATION 621-220-980CA

Reuse of recovered full length treated pine poles

Plant Series

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مت بيونج حدثه مرة الدين الارب راب .

REUSE OF RECOVERED FULL LENGTH TREATED PINE POLES

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Contents	Pag
1. General	1
2. Inspection	1
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4. Poles cut to new length	2
1. GENERAL	

1.01 This section is reissued to bring it up to date.

1.02 This section describes the inspection of full length treated pine poles after removal from plant in order to determine whether or not they are suitable for reuse.

1.03 When a pole is recovered as good, and is suitable for reuse, the Dating Nails should be removed. When a pole is reused, Dating Nails should be placed as per Section 621-200-206CA to show the year of placing.

1.04 There is no reduction in the fibre strength of wood as long as it is free from decay.

1.05 Treated pine poles removed from plant in southern Ontario after 30 years service appeared to be

				Net Ketennen	
2	f ear		Preservative	lb/cu ft	Classes
1930			Creosote	10	A 11
1931-7			P+	8	**
1938-41			**	6	**
1942				5.5	**
1943				7	**
1944-9	Red	Pine	**	5.5	7-9
		• • • • •		7	1-6
	Jack	Pine	**	4.5	ÂŇ
1949-52	Red	Pine	Greensalt	.75	**
	Jack	Pine		.50	**
1953-6	Red	Pine	Penta-Petroleum	5.0	
	Jack	Pine	Penta-Petroleum	4.0	••

free from internal and external decay and suitable for reuse. This indicates a physical life of well beyond 30 years for this type of creosoted pole which was treated with a net retention of 10 to 12 lb. The following table lists our pole preservative treatments by years, 1930-1956.

1.06 Physical Life Expectancy figures for full length treated poles in our Operating Areas with these various treatments are not yet available due to the short time in plant, but is expected to be at least 40 years.

2. INSPECTION

2.01 Make a visual check for decay over the whole length of pole and at bolt holes. A pole prod should be used in any questionable locations such as at knots, and just below the ground-line.

2.02 Sound all poles carefully on all 4 quadrants over their total length at closely spaced intervals with a hammer. A pole free from decay sounds clear and solid and the hammer usually rebounds noticeably when the pole is struck sharply and squarely. A decaying pole sounds dull or hollow and in extreme cases the wood gives under the impact of the blow. Other conditions such as a wet surface due to recent rains, a wet interior near the ground line due to high soil moisture, shakes in the pole and widd checks may change the sound of the pole. A boring should be taken in all cases where testing with a hammer indicates that decay may be present.

2.03 An increment borer or 46" wood boring bit should be used to make a check at the ground line for decay pockets in the interior of the pole. All borer and bit holes shall be plugged with standard wooden plugs.

2.04 Check pole surface for cracks or cross-breaks, and lightning burns or splits. Cracks or erossbreaks are caused by dropping or rough handling and their detection requires very close inspection. The reuse of poles with these defects would be hazardous as they break under small loads.

6	LASS	1	2	3		_ 5	6	7	8	•	ю
linimum I	Ireaking Load	4500	3700	3000	2400	1900	1500	1200	960	_	
Min. Top	Circ. (in.)	27	25	23	21	19	17	15	15	15	12
Length of pole (Feat)	Depth of Setting (Feet)		Mi	nimum Cir	cumterence (inc	e at 6 fe ihes)	et From t	Dutt			
16	3- 1/2					22.5	21.0	19.5	18.0		
18	3- 1/2			28.0	26.0	24.0	22.0	20.5	19.0		Po
20	4	33.5	31.5	29.5	27.0	25.0	23.0	21.5	20.0	ŝ	60
22	4	35.0	33.0	. 30.5	- 28.5	26.5	24.5	22.5	21.0	Ĭ	3
25	- 5	37.0	34.5	32.5	30.0	28.0	25.5	24.0	22.0	Ē	្ខ
30	5-14	40.0	37.5	35.0	32.5	30.0	28.0	26.0	24.0	c	2
35	6	42.5	40.0	37.5	34.5	32.0	30.0	27.5	25.5	Ē	f
40	6	45.0	42.5	39.5	36.5	34.0	31.5	29.5	_		Ę
45	6.14	47.5	44.5	41.5	38.5	36.0	33.0	31.0	_	le	
50	7	49.5	46,5	43.5	40.0	37.5	34.5	32.0	· -	Ē	din
55	7-1/2	51.5	48.5	45.0	42.0	3 9. 0	36.0			بد	Ę
60	8	53.5	50.0	46.5	43.5	40.0	37.0			3 u t	
65	8- 1/2	55.0	51.5	48.0	45.0	41.0	•			-	5
70	9	56. 5	53.0	49.0	46.0	43.5					Ŭ

APPENDIX B

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SUMMARY OF SOME PUBLISHED INFORMATION ON DEPLETION LOSSES OF WOOD PRESERVATIVES FROM WOOD

B-1 Creosote treated wood
B-2 Penta treated wood
B-3 CCA treated wood
B-4 ACA treated wood

Table B-1: Summary of Leaching Results for Creosote Treated Wood

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Creosote Type & Ret. (kg/m3)	Sample Descrip. and Size	Exposure and Cond	Loc. Litions	Eposure Time (y)	% Lost	Ref.	
Marine Grade (480)	D. Fir Pile Section -	Marine, Oregon	0-12.5mm	1.1	2.3	Miller (1972)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	1	*	Miller	ĩ
(480)	Section -A	Oregon	12.5-25m	m 1	*	(1977)	
Marine Grade	D. Fir Pile .	Marine,	0-12.5mm	2	*	Miller	
(480)	Section -A	Oregon	12.5-25m	m 2	*	(1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	3	*	Miller	
(480)	Section -A	Oregon	12.5-25m	m. 3	*	(1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	4	1	Miller	
(480)	Section -A	Oregon	12.5-25m	m 4	*	(1977)	
Marine Grade (480)	D. Fir Pile Section -A	Marine, Oregon	0-12.5mm 12.5-25m	8 m. 8	*	Miller (1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	1	*	Miller	
(480)	Section -B	Oregon	12.5-25m	1 1	*	(1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	a 2	*	Miller	
(480)	Section -B	Oregon	12.5-25m	am 2	*	(1977)	
Marine Grade (480)	D. Fir Pile Section -B	Marine, Oregon	0-12.5mm 12.5-25m	m 3	* *	Miller (1977)	
Marine Grade (480)	D. Fir Pile Section -B	Marine, Oregon	0-12.5mm 12.5-25m	4 m 4	1	Miller (1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	8	0.2	Miller	
(480)	Section -B	Oregon	12.5-25m	m 8	*	(1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	1	6	Miller	•
(480)	Section -C	Oregon	12.5-25m	m 1	4	(1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	2	8	Miller	
(480)	Section -C	Oregon	12.5-25m	m 2	4	(1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	3	9	Miller	
(480)	Section -C	Oregon	12.5-25m	m 3	5	(1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	4	11	Miller	
(480)	Section -C	Oregon	12.5-25m	m 4	7	(1977)	
Marine Grade	D. Fir Pile	Marine,	0-12.5mm	8	19	Miller	
(480)	Section -C	Oregon	12.5-25m	m 8	15	(1977)	
Marine Grade (???)	SYP Piling Section -	Marine, 1 West, FL	Key A	1	*	Gjovik (1977)	
Marine Grade (???)	D = 125-175mm SYP Piling Section - D = 125-175mm	Marine, I West, FL/	Key A	3	*	Gjovik (1977)	

		M	E	15	Giovik
Marine Grade (???)	SYP Piling Section - D - 125-175mm	Marine, Key West, FLA	5	10	(1977)
Marine Grade (???)	SYP Piling Section -	Marine, Key West, FLA	8	7	Gjovik (1977)
Marine Grade	D = 125-175mm SYP Pole Section -	Fresh Water	1.1	14-25	Kelso & Behr
Marine Grade	SYP Posts	N. Carolina	11.5	28-52	(1977) Colley (1972)
(???) Marine grade 448-736	SYP Blocks 19X19X19 mm	Coastal Waters	1	40-70	Colley & Burch
Marine grade 448-736	SYP Blocks 19X19X19mm	Coastal Waters	2	55-80	(1907) Colley & Burch (1967)
Marine grade	SYP Stakes	Salt Water	1.25	25-30	Leach (1960)
Marine Grade	SYP Panels 13X?X???mm	??????????????????????????????????????	1.25	33	Leach (1960)
Marine Grade	SYP Panels	??????????????????????????????????????	6.5	22	Stasse (1967)
Marine Grade Low	Redwood Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	1.5	59	Gjovik et al
(1972) Marine Grade Low	Redwood Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	5	70	Gjovik et al
(1972) Marine Grade Low	Redwood Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	10	90 /	Gjovik et al
(1972) Marine Grade Low	Doug. fir Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	1.5	12	Gjovik et al
(1972) Marine Grade Low	Doug. fir Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	5	40	Gjovik et al
(1972) Marine Grade Low	Doug. fir Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	10	58	Gjovik et al
(1972) Marine Grade Low	West. Hem Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	1.5	42	Gjovik et al
(1972) Marine Grade Low	West. Hem Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	5	45	Gjovik et al
(1972) Marine Grade Low	West. Hem Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	10	80	Gjovik et al
(1972) Marine Grade Low	P. Pine Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	1.5	54	Gjovik et al
(1972) Marine Grade Low (1972)	P. Pine Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	5	70	Gjovik et al
Marine Grade Low (1972)	P. Pine Panels 9.5X32X1816	Cooling Tower 32 C, pH 6.5-7	10	90	Gjovik et al

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Marine Grade (128)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	0.6	41	Johnson et al
(1973) Marine Grade	SYP Panels	Marine, Key	1	49	Johnson
(128)	6X38X152mm	West, FLA.			et al
Marine Grade	SYP Panels	Marine, Key	0.6	22	Johnson
(240)	6X38X152mm	West, FLA.			et.ai
(1973)	SVD Danala	Marine, Key	1	35	Johnson
Marine Grade	6X38X152mm	West, FLA.			et al
(1973)	••••••		•	24	Tohnson
Marine Grade	SYP Panels	Marine, Key	2	34	et al
(240)	6X38X152mm	West, FLA.			
(1973) Marine Grade	SYP Panels	Marine, Key	0.6	14	Johnson
(400)	6X38X152mm	West, FLA.			et al
(1973)		* 7	4	16	Johnson
Marine Grade	SYP Panels	Marine, Key	1	10	et al
(400)	6X38X152mm	West, run.			
(1973) Marine Grade	SYP Panels	Marine, Key	2	21	Johnson
(400)	6X38X152mm	West, FLA.			et al
(1973)		Man unton	0.2	28	Miller
Marine Grade	SYP Panels	Tap water 25.5 C	0.2		(1972)
(()) Marine Grade	SYP Panels	Tap water	0.4	38	Miller
(???)	3X38X130mm 2	5.5 C			(1972) Miller
Marine Grade	SYP Panels	Tap water	0.6	38	(1972)
(???)	3X38X130mm	25.5 C Ten weter	0.8	40	Miller
Marine Grade	SYP Panels 3Y38Y130mm	25.5 C			(1972)
(:::)	UNDURIOUM-	•			N'11
Marine Grade	P. Pine Panels	Estuarine Water	1.9	25	M111er (1972b)
522	3X38X130mm	Newport, Uregon.	1.3	41	Miller
Marine Grade	Joug Fir Paneis	Newport, Oregon.			(1972b)
010	UNUUNIUUL			• •	N:11-m
Marine Grade	SYP Panels	Estuarine Water	1.3	24	(1972b)
522	3X38X130mm	Newport, Oregon.			(15126)
Land Crade	Donglas fir	Test fence	0.1	19	Behr
(91)	38X89mm	Tennessee		. • *	et al
(1955)			0 1	14	Rehr
Land Grade	SYP	Test fence	0.1	14	et al
(185)	3878200	Tennessee			
(1955) Land Grade	SYP Panels	Marine, Key	0.6	61	Johnson
(128)	6X38X152mm	West, FLA.			et al .
(1973)	•	Naulus Kow	1	68	Johnson
Land Grade	SYP Panels	Warine, Key West, FLA.	*	•••	et al
(128) (1973)	0720712500	"CB0, 12			
Land Grade	SYP Panels	Marine, Key	0.6	53	Johnson
(240)	6X38X152mm	West, FLA.			et al
(1973) Land Orada	gyp Danala	Marine. Kev	1	55	Johnson
Land Grade	6X38X152mm	West, FLA.			et al
(1973)					

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Land Grade (400) (1973)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	0.6	15	Johnson et al
Land Grade (400) (1973)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	1	19	Johnson et al
Land Grade (400) (1973)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	2	26	Johnson et al
Fresh Water Grade (128) (1973)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	0.6	32	Johnson et al
Fresh Water Grade (128) (1973)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	1	30	Johnson et al
Fresh Water Grade (240)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	0.6	28	Johnson et al
Fresh Water Grade (240)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	1	35	Johnson et al
Fresh Water Grade (240)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	2	38	Johnson et al
Fresh Water Grade (400) (1973)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	0.6	15	Johnson et al
Fresh Water Grade (400) (1973)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	. 1	19	Johnson et al
Fresh Water Grade (400) (1973)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	2	26	Johnson et al

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* Exposed wood analysed higher than origional unexposed wood

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Table B-2: Summary of Leaching Results for Pentachlorphenol-in-oil Treated Wood

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Penta Ret. (kg/m3)	Sample Descrip. and Size	Exposure Loc. and Conditions	Еровиге Time (у)	% Lost	Ref.
9.3	SYP Pole Sect.	Above Ground Portion	0.5	3.4 *	Behr et al :
÷	SYP Pole Sect.	Above Ground	0.5	*	(1955) Bebr
0.0	DIT FOTE Becc.	Portion	1.5	*	et al
3.7	SYP Pole Sect.	Above Ground Portion	0.5	*	Behr et al
4 3	SVP Pole Sect	Above Ground	0.5	•	(1955) Bebr
310	SIF FOIE Sect.	Portion	1.5	*	et al
???	SYP Pole Outer 25 mm	Fresh Water Orange Park, FLA	1.7	8-20	(1955) Kelso & Behr (1977)
??	SYP Poles Outer 12.5mm	Ground Contact ??	9	44-62	(1977) Leutritz (1975)
??	SYP Poles 12.5-25mm	Ground Contact ??	9	.33-51	Leutritz (1975)
??	SYP Pole stubs Outer 12.5mm	Ground Contact ??	0.25	27	Leutritz (1975)
??	SYP Pole stubs 12.5-25mm	Ground Contact ??	0.25	10	Leutritz (1975)
??	SYP Pole stubs Outer 12.5mm	Ground Contact ??	0.5	34	Leutritz (1975)
??	SYP Pole stubs 12.5-25mm	Ground Contact ??	0.5	11	Leutritz (1975)
??	SYP Poles Outer 12.5mm	Ground Contact ??	4	6	Leutritz (1975)
??	SYP Poles 12.5-25mm	Ground Contact ??	5	23	Leutritz (1975)
5.7	SYP Posts	Ground Contact Orange Park, FLA	2	2 8	Leutritz (1965)
5.7	SYP Posts	Ground Contact Orange Park, FLA	4	41	Leutritz (1965)
5.7	SYP Posts	Ground Contact Orange Park, FLA	2	20	Leutritz (1965)
5.7	SYP Posts	Ground Contact Orange Park, FLA	4	24	Leutritz (1965)

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4.6	Douglas fir 38X89	Above Ground Test Fence- Tennessee Aromatic oil	0.08	.11.5	Behr et al (1955)
4.6	Douglas fir 38X89	Above Ground Test Fence- Tennessee Aromatic oil	1	11.9	Behr . et al (1955)
4.6	Douglas fir 38X89	Above Ground Test Fence- Tennessee 105E oil	0.08	14.3	Behr et al (1955)
4.6	Douglas fir 38X89	Above Ground Test Fence- Tennessee 105E oil	1	5.9	Behr et al (1955)
7.4	SYP 38x89	Above Ground Test Fence- Tennessee Aromatic oil	0.08	3.2	Behr et al (1955)
7.4	SYP 38X89	Above Ground Test Fence- Tennessee Aromatic oil	1	*	Behr et al (1955)
7.1	SYP 38X89	Above Ground Test Fence- Tennessee 105E oil	0.08	3.8	Behr et al (1955)
7.1	SYP 38X89	Above Ground Test Fence- Tennessee 105E oil	1	6.5	Behr et al (1955)
(1972)	Redwood Panels 9.5X32X1816	Cooling Tower 32 C, pH = 6.5	1.5	29	Gjovik et al
? (1972)	Redwood Panels 9.5X32X1816	Cooling Tower 32 C, pH = 6.5	5	43	Gjovik et al
? (1972)	Redwood Panels 9.5X32X1816	Cooling Tower 32 C, pH = 6.5	10	68	Gjovik et al
? (1972)	D. Fir Panels 9.5X32X1816	Cooling Tower 32 C, pH = 6.5	1.5	18	Gjovik et al
? (1972)	D. Fir Panels 9.5X32X1816	Cooling Tower 32 C, pH = 6.5	5	42	Gjovik et al
? (1972)	D. Fir Panels 9.5X32X1816	Cooling Tower 32 C, pH = 6.5	10	58	Gjovik et al
? (1972)	W. Hem. Panels 9.5X32X1816	Cooling Tower 32 C, pH = 6.5	1.5	50	Gjovik et al
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?	W. Hem. Panels 9.5X32X1816	Cooling Tower 32 C, pH = 6.5	5	42	Gjovik et al
(1972)					
?	W. Hem. Panels 9.5X32X1816	Cooling Tower 32 C. pH = 6.5	10	64	Gjovik et al
(1972)	010/02/1010				
?	P Pine Panels	Cooling Tower	1.5	66	Gjovik
(1972)	9.5X32X1816	32 C, pH = 6.5			et al
? ?					
•	P Pine Panels 9 573271816	Cooling Tower 32 C, pH = 6.5	5	78	Gjovik et al
(1972)	0.0x02x1010				
?			10	0.0	
	P Pine Panels 9.5X32X1816	32 C, pH = 6.5	10	SU .	et al
(1972)					

* Exposed wood analysed higher than origional unexposed wood

Table B-3: Summary of leaching results for CCA treated wood.

CCA Type & Ret. (kg/m3)	Sample Descrip. and Size	Exposure Loc. and Conditions	Eposure Time (y)	X Lost	Ref.
?	SYP Piles D = 125-175mm	Marine, Key West, FLA.	1	neg.	Gjovik (1977)
?	SYP Piles D = 125-175mm	Marine, Key West, FLA.	3	neg.	Gjovik (1977)
?	SYP Piles D = 125-175mm	Marine, Key West, FLA.	5	neg.	Gjovik (1977)
?	SYP Piles D = 125-175mm	Marine, Key West, FLA.	8	neg.	Gjovik (1977)
Туре А	Redwood Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	1.5	CCA: 33	Gjovic et al (1972)
Туре А	Redwood Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	5	CCA: 17	Gjovic et al (1972)
Туре А	Redwood Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	10	CCA: 36	Gjovic et al (1972)
Туре А	D. Fir Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	1.5	CCA: 28	Gjovic et al (1972)
Туре А	D. Fir Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	5	CCA: 42	Gjovic et al (1972)
Туре А	D. Fir Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	10	CCA: 25	Gjovic et al (1972)
Туре А	W. Hem. Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	1.5	CCA: 25	Gjovic et al (1972)
Туре А	W. Hem. Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	5	CCA: 18	Gjovic et al (1972)
Type A	W. Hem. Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	10	CCA: 14	Gjovic et al (1972)
Туре А	P. Pine Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	1.5	CCA: 18	Gjovic et al (1972)

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Туре А	P. Pine Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5 0.35-1.0 ppm	5	CCA: 9	Gjovic et al (1972)
Туре А	P. Pine Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5 0.35-1.0 ppm	-7	CCA: 18	Gjovic et al (1972)
Type A:	SY Pine Stakes	In ground,	AG 9	CCA: *	Arsenault
7.4	19X19X457 mm	Chester, N.J.	BG 9	CCA: 5	(1975)
Type A	SY Pine Stakes	In ground,	AG 12	CCA: *	Arsenault
9.4	19X19X457 mm	Chester, N.J.	BG 12	CCA: *	(1975)
Туре А	SY Pine Stakes	In ground,	AG 12	CCA: 22	Arsenault
7.7	19X19X457 mm	Chester, N.J.	BG 12	CCA: 24	(1975)
Туре А	SY Pine Stakes	In ground,	AG 12	CCA: 10	Arsenault
23.9	19X19X457 mm	Chester, N.J.	BG 12	CCA: 10	(1975)
Type A	Alstonia Blocks	Marine Water	6	Cu: 46	Leightley
3.3 @	10X20X30mm	Australia		Cr: 16	(1987)
Type A	Alstonia Blocks	Marine Water	6	Cu: 41	Leightley
7.4 @	10X20X30mm	Australia		Cr: 20	(1987)
Type A	Alstonia Blocks	Marine Water	6	Cu: 16	Leightley
11.8 @	10X20X30mm	Australia		Cr: 9	(1987)
Type A	Alstonia Blocks	Marine Water	6	Cu: 33	Leightley
3.3 @	10X20X30mm	Italy		Cr: 13	(1987)
Type A	Alstonia Blocks	Marine Water	6	Cu: 12	Leightley
7.4 @	10X20X30mm	Italy		Cr: *	(1987)
Туре А 11.8 @	Alstonia Blocks 10X20X30mm	Marine Water Italy	6	AB. 5 Cu: 16 Cr: 14	Leightley (1987)
Type A	Alstonia Blocks	Marine Water	6	Cu: 27	Leightley
3.3 €	10X20X30mm	Sweden		Cr: 9	(1987)
Type A	Alstonia Blocks	Marine Water	6	Cu: 11	Leightley
7.4 @	10X20X30mm	Sweden		Cr: 9	(1987)
Туре А	Alstonia Blocks	Marine Water	6	Cu: 1	Leightley
11.8 @	10X20X30mm	Sweden		Cr: 15	(1987)
Type A	Fagus Sylvatica	Marine Water	6	Cu: *	Leightley
3.15 e	10X20X30mm	Australia		Cr: *	(1987)
Type A	Fagus Sylvatica	Marine Water	6	Cu: 17	Leightley
7.25 €	10X20X30mm	Australia		Cr: 29	(1987)
Type A	Fagus Sylvatica	Marine Water	6	Cu: 15	Leightley
3.15 €	10X20X30mm	Italy		Cr: *	(1987)
Type A 7.25 €	Fagus Sylvatica 10X20X30mm	Marine Water Italy	6	Cu: 28 Cr: 44 As: 29	Leightley (1987)

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	Туре 1.6	A e	Fagus Sylvatica 10X20X30mm	Marine Water Sweden	6	Cu: Cr:	20 0	Leightley (1987)
	- • •	-				Δα.	4 1	(1001)
	Type	Α	Fagus Sylvatica	Marine Water	6	Cut	*	Leightley
	3,15	2	10X20X30mm	Sweden	0	Cr.	*	(1987)
		C	TONEONOOM	Breach		A.c.	*	(1507)
	Type	А	Fagus Sylvatica	Marine Water	6	Cut	25	Leightley
	7.25		10X20X30mm	Sweden	U	Cr.	23	(1987)
		-		Direden		Δα.	34	(1907)
	Туре	А	Pinus Sylvestris	a Marine Water	6	Cut	47	Leightley
	7.35	6	10X20X30mm	Australia	Ū	Cr:	9.5	(1987)
		•				Ag:	34	(100)4
	Туре	Α	Pinus Sylvestris	s Marine Water	6	Cu:	19	Leightlev
	9.6	6	10X20X30mm	Australia	•	Cr:	425	(1987)
		•				As:	45	(2007)
	Туре	Α	Pinus Sylvestris	Marine Water	6	Cu:	25	Leightlev
	7.35	6	10X20X30mm	Italv	•	Cr:	155	(1987)
						AR:	35	(100))
	Туре	А	Pinus Sylvestris	Marine Water	6	Cu:	*	Leightlev
	7.35	0	10X20X30mm	Italv	•	Cr:	*	(1987)
						As:	*	(100)
	Туре	Α	Pinus Sylvestris	Marine Water	6	Cu:	21	Leightlev
	7.35	e	10X20X30mm	Sweden		Cr:	19	(1987)
						As:	36	(,
	Туре	Α	Pinus Sylvestris	Marine Water	6	Cu:	*	Leightlev
	9.6	9	10X20X30mm	Sweden		Cr:	*	(1987)
						As:	*	, ,
	Туре	B	SYP posts	In ground, 0-12.5mm	1.2	Cu:	*	Arsenault
	4.3		D=180-230mi	Orange Park, Fla.		Cr:	6	(1975)
				- ,		AB:	13.3	
		ĸ			Total	CCA:	61	
	Туре	В	SYP posts	In ground, 0-12.5mm	1.2	Cu:	*	Arsenault
	.9.9		D=180-230mm	Orange Park, Fla.		Cr:	*	(1975)
						As:	0	
					Total	CCA:	*	
	T	п	CVD+-		~	-		
	Type	Б	SIP posts	In ground, U-12.5mm	7	Cu:	*	Arsenault
	4.0		D=180-230mm	Orange Park, Fla.		Cr:	8.1	(1975)
,		•			m ()	AS:	5.43	
					TOTAL	CCA:	24	
	Type	R	SYP nosts	In ground 0-12 5mm	7	C	A 2	Areenault
	9.9		D=180-230 mm	Orange Park Fla	1	Cri	*** *	(1075)
	0.0			orange rark, ria.			19	(19/0)
			•		Total	CCA.	*	
					10041	UUA.		
	Туре Н	В	SYP Panels	Marine, Key	6.5	Cu:	79	Johnson
	(20-4())	6X38X152mm	West, FLA.	• • •	Cr:	48	(1977)
						As:	48	(2000)
	Type H	3	SYP Panels	Marine, Key	0.6	Cu:	-	Johnson
	(4.0)		6X38X152mm	West, FLA.	-	Cr:	3	et al.
	-					As:	39	(1973)
	Type E	3	SYP Panels	Marine, Key	1	Cu:	-	Johnson
	(4.0)		6X38X152mm	West, FLA.		Cr:	4	et al
						As:	50	(1973)
	Туре Е	3	SYP Panels	Marine, Key	2	Cu:	-	Johnson
	(4.0)		6X38X152mm	West, FLA.		Cr:	12	et al
	As: 54	(1973)					
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Type B	SYP Panels	Marine, Key	0.6	Cu: -	Johnson
(40)	0X38X152mm	west, FLA.		$\begin{array}{c} \text{Cr: } 5 \\ 4 \mathbf{c} 1 3 \end{array}$	et al (1072)
Type B	SVD Danels	Marine Key	1	AB: 15	Johnson
(40)	6Y38Y152mm	West, FLA.	1	Cr: 7	et al
(40)				Δα· 17	(1973)
Туре В	SYP Panels	Marine, Kev	2	Cu: -	Johnson
(40)	6X38X152mm	West, FLA.	-	Cr: 2	et al
(,				As: 17	(1973)
Type C	SYP Panels	Marine, Key	6.5	Cu: 76	Johnson
(20-40)	6X38X152mm	West, FLA.		Cr: 45	(1977)
•				Ав: 27	• •
Туре С	SYP Panels	Marine, Key	0.6	Cu: -	Johnson
(4.0)	6X38X152mm	West, FLA.		Cr: 13	et al
				Ав: 26	(1973)
Type C	SYP Panels	Marine, Key	1	Cu: -	Johnson
(4.0)	6X38X152mm	West, FLA.		Cr: 13	et al
				Ав: 34	(1973)
Type C	SYP Panels	Marine, Key	2	Cu: -	Johnson
(4.0)	6X38X152mm	West, FLA.		Cr: 13	et al
				Ав: 34	(1973)
Туре С	SYP Panels	Marine, Key	0.6	Cu: -	Johnson
(40)	6X38X152mm	West, FLA.		Cr: 3	et al
				As: 6	(1973)
Туре С	SYP Panels	Marine, Keý	. 1	Cu: -	Johnson
(40)	6X38X152mm	West, FLA.		Cr: 8	et al
		۲		As: 8	(1973)
Type C	SYP Panels	Marine, Key	2	Cu: -	Johnson
(40)	6X38X152mm	West, FLA.		Cr: 3	et al
				As: 12	(1973)

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@ Retention expressed as w/w oxides/dry wood basis
* Exposed wood analysed higher than origional unexposed wood

Table B-4: Summary of Leaching Results for ACA Treated Wood

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ACA Re and S	et. Sample Descrip. ize and Condit	Exposure Loc. ions Time (y)	Eposure	% Lost	Ref. (kg/m3)
6.4 ?	Redwood Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	1.5	48	Gjovic et al (1972) -
6.4 ?	Redwood Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	5	58	Gjovic et al (1972)
6.4 ?	Redwood Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	10	60	Gjovic et al (1972)
6.4 ?	D. Fir Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	1.5	59	Gjovic et al (1972)
6.4 ?	D. Fir Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	5	60	Gjovic et al (1972)
6.4 ?	D. Fir Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	10	66	Gjovic et al (1972)
6.4 ?	W. Hem. Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	1.5	34	Gjovic et al (1972)
6.4 ?	W. Hem. Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	5	54	Gjovic et al (1972)
6.4 ?	W. Hem. Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	10	53	Gjovic et al (1972)
6.4 ?	P. Pine Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	1.5	53	Gjovic et al (1972)
6.4 ?	P. Pine Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	5	59	Gjovic et al (1972)
6.4 ?	P. Pine Panels 9.5X32X1816mm	Cooling Tower 32 C, pH = 6.5-7 0.35-1.0 ppm	10	66	Gjovic et al (1972)
4.0 (1973)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	0.6	Ав: 58	Johnson et al

4.0	SYP Panels 6X38X152mm	Marine, Key West, FLA.	1	As: 78	Johnson et al (1973)
4.0	SYP Panels 6X38X152mm	Marine, Key West, FLA.	2	As: 66	Johnson et al (1973)
40	SYP Panels 6X38X152mm	Marine, Key West, FLA.	0.6	As: 19	Johnson et al (1973)
40 *	SYP Panels 6X38X152mm	Marine, Key West, FLA.	1	As: 46	Johnson et al (1973)
40	SYP Panels 6X38X152mm	Marine, Key West, FLA.	2	As: 23	Johnson et al (1973)
(20-40)	SYP Panels 6X38X152mm	Marine, Key West, FLA.	6.5	Cu: 69-81 As: 24-81	Johnson (1977)

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APPENDIX C

CONSUMER INFORMATION SHEETS - TREATED WOOD

- Creosote

- Pentachlorophenol

- Inorganic Arsenicals

Consumer Information Sheet

CREOSOTE PRESSURE-TREATED WOOD

CONSUMER INFORMATION

This wood has been preserved by pressure treatment with an EPA-registered pesticide containing creosote to protect it from insect attack and decay. Wood treated with creosote should be used only where such protection is important.

Creosote penetrates deeply into and remains in the pressure-treated wood for a long time. Exposure to creosote may present certain hazards. Therefore, the following precautions should be taken both when handling the treated wood and in determining where to use the treated wood.

USE SITE PRECAUTIONS

Wood treated with creosote should not be used where it will be in frequent or prolonged contact with bare skin (for example, chairs and other outdoor furniture) unless an effective scaler has been applied.

Creosote-treated wood should not be used in residential interiors. Creosote-treated wood in interiors of industrial buildings should be used only for industrial building components which are in ground contact and are subject to decay or insect infestation and wood block flooring. For such uses, two coats of an appropriate sealer must be applied. Sealers may be applied at the installation site.

Wood treated with creosote should not be used in the interiors of farm buildings where there may be direct contact with domestic animals or livestock which may crib (bite) or lick the wood.

In interiors of farm buildings where domestic animals or livestock are unlikely to crib (bite) or lick the wood, creosote-treated wood may be used for building components which are in ground contact and are subject to decay or insect infestation if two coats of an effective sealer are applied. Sealers may be applied at the installation site.

Do not use creosote-treated wood for farrowing or brooding facilities.

Do not use treated wood under circumstances where the preservative may become a component of food or animal feed. Examples of such use would be structures or containers for storing silage or food.

Do not use treated wood for cutting-boards or countertops. Only treated wood that is visibly clean and free of surface residues should be used for patios, decks and walkways.

Do not use treated wood for construction of those portions of beehives which may come into contact with the honey.

Creosote-treated wood should not be used where it may come into direct or indirect contact with public drinking water, except for uses involving incidental contact such as docks and bridges.

Do not use creosote-treated wood where it may come into direct or indirect contact with drinking water for domestic animals or livestock, except for uses involving incidental contact such as docks and bridges.

HANDLING PRECAUTIONS

Dispose of treated wood by ordinary trash collection or burial. Treated wood should not be burned in open fires or in stoves, fireplaces, or residential boilers, because toxic chemicals may be produced as part of the smoke and ashes. Treated wood from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers in accordance with state and Federal regulations.

Avoid frequent or prolonged inhalation of sawdust from treated wood. When sawing and machining treated wood, wear a dust mask. Whenever possible, these operations should be performed outdoors to avoid indoor accumulations of airborne sawdust from treated wood.

Avoid frequent or prolonged skin contact with creosote-treated wood; when handling the treated wood, wear long-sleeved shirts and long pants and use gloves impervious to the chemicals (for example, gloves that are vinyl-coated).

When power-sawing and machining, wear goggles to protect eyes from flying particles.

After working with the wood, and before eating, drinking, and use of tobacco products, wash exposed areas thoroughly.

If oily preservatives or sawdust accumulate on clothes, launder before reuse. Wash work clothes separately from other household clothing.

Coal tar pitch and coal tar pitch emulsion are effective sealers for creosote-treated wood-block flooring. Urethane, epoxy, and shellac are acceptable sealers for all creosote-treated wood. Consumer Information Sheet

PENTACHLOROPHENOL PRESSURE-TREATED WOOD

CONSUMER INFORMATION

This wood has been preserved by pressure-treatment with an EPA-registered pesticide containing pentachlorophenol to protect it from insect attack and decay. Wood treated with pentachlorophenol should be used only where such protection is important.

Pentachlorophenol penetrates deeply into and remains in the pressure-treated wood for a long time. Exposure to pentachlorophenol may present certain hazards. Therefore, the following precautions should be taken both when handling the treated wood and in determining where to use and dispose of the treated wood.

USE SITE PRECAUTIONS

Logs treated with pentachlorophenol should not be used for log homes.

Wood treated with pentachlorophenol should not be used where it will be in frequent or prolonged contact with bare skin (for example, chairs and other outdoor furniture). unless an effective sealer has been applied.

Pentachlorophenol-treated wood should not be used in residential, industrial, or commercial interiors except for laminated beams or for building components which are in ground contact and are subject to decay or insect infestation and where two coats of an appropriate sealer are applied. Sealers may be applied at the installation site.

Wood treated with pentachlorophenol should not be used in the interiors of farm buildings where there may be direct contact with domestic animals or livestock which may crib (bite) or lick the wood.

In interiors of farm buildings where domestic animals or livestock are unlikely to crib (bite) or lick the wood, pentachlorophenol-treated wood may be used for building components which are in ground contact and are subject to decay or insect infestation and where two coats of an appropriate sealer are applied. Sealers may be applied at the installation site.

Do not use pentachlorophenol-treated wood for farrowing or brooding facilities.

Do not use treated wood under circumstances where the preservative may become a component of food or animal feed. Examples of such sites would be structures or containers for storing silage or food.

Do not use treated wood for cutting-boards or countertops. Only treated wood that is visibly clean and free of surface residue should be used for patios, decks and walkways.

Do not use treated wood for construction of those portions of beehives which may come into contact with the honey.

Pentachlorophenol-treated wood should not be used where it may come into direct or indirect contact with public drinking water, except for uses involving incidental contact such as docks and bridges.

Do not use pentachlorophenol-treated wood where it may come into direct or indirect contact with drinking water for domestic animals or livestock, except for uses involving incidental contact such as docks and bridges.

HANDLING PRECAUTIONS

Dispose of treated wood by ordinary trash collection or burial. Treated wood should not be burned in open fires or in stoves, fireplaces, or residential boilers because toxic chemicals may be produced as part of the smoke and ashes. Treated wood from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers rated at 20 million BTU/hour or greater heat input or its equivalent in accordance with state and Federal regulations.

Avoid frequent or prolonged inhalation of sawdust from treated wood. When sawing and machining treated wood, wear a dust mask. Whenever possible, these operations should be performed outdoors to avoid indoor accumulations of airborne sawdust from treated wood.

Avoid frequent or prolonged skin contact with pentachlorophenol-treated wood; when handling the treated wood, wear long-sleeved shirts and long pants and use gloves impervious to the chemicals (for example, gloves that are vinyl-coated).

When power-sawing and machining, wear goggles to protect eyes from flying particles.

After working with the wood, and before eating, drinking, and use of tobacco products, wash exposed areas thoroughly.

If oily preservatives or sawdust accumulate on clothes, launder before reuse. Wash work clothes separately from other household clothing.

Urethane, shellac, latex epoxy enamel and varnish are acceptable sealers for pentachlorophenol-treated wood.

Consumer Information Sheet

NORGANIC ARSENICAL **RESSURE-TREATED WOOD**

(Including: CCA, ACA, and ACZA)

CONSUMER INFORMATION

This wood has been preserved by pressure-treatment with an EPA-registered pesticide containing inorganic arsenic to protect it from insect attack and decay. Wood treated with inorganic arsenic should be used only where such protection is important.

Inorganic arsenic penetrates deeply into and remains in the pressure-treated wood for a long time. Exposure to inorganic arsenic may present certain hazards. Therefore, the following precautions should be taken both when handling the treated wood and in determining where to use or dispose of the treated wood.

USE SITE PRECAUTIONS

Wood pressure-treated with waterborne arsenical preservatives may be used inside residences as long as all sawdust and construction debris are cleaned up and disposed of after construction.

Do not use treated wood under circumstances where the preservative may become a component of food or animal feed. Examples of such sites would be structures or containers for storing silage or food.

Do not use treated wood for cutting-boards or countertops.

Only treated wood that is visibly clean and free of surface residue should be used for patios, decks and walkways.

Do not use treated wood for construction of those portions of beehives which may come into contact with the honey.

Treated wood should not be used where it may come into direct or indirect contact with public drinking water, except for uses involving incidental contact such as docks and bridges.

HANDLING PRECAUTIONS

Dispose of treated wood by ordinary trash collection or burial. Treated wood should not be burned in open fires or in stoves, fireplaces, or residential boilers because toxic chemicals may be produced as part of the smoke and ashes. Treated wood from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers in accordance with state and Federal regulations.

Avoid frequent or prolonged inhalation of sawdust from treated wood. When sawing and machining treated wood, wear a dust mask. Whenever possible, these operations should be performed outdoors to avoid indoor accumulations of airborne sawdust from treated wood.

When power-sawing and machining, wear goggles to protect eyes from flying particles.

After working with the wood, and before eating, drinking, and use of tobacco products, wash exposed areas thoroughly.

If preservatives or sawdust accumulate on clothes, launder before reuse. Wash work clothes separately from other household clothing.

APPENDIX D

REGION OF PEEL RESOLUTION 88-527-47 EXPERIMENTAL WOOD PROCESSING OPERATION Region of Peel

RESOLUTION 88-527-47 PASSED BY REGIONAL COUNCIL AUGUST 11, 1988

That Technitread Ltd. and WCI Waste Conversion Inc. be contracted by the Region of Peel to operate an experimental wood and tire processing operation for a period of two years at the former Derry Road Public Works Yard;

And further, that the disposal of tires at Regional landfill sites be prohibited and redirected to the Derry Road facility once Technitread Ltd. is ready to process the tires at that location;

And further, that the disposal of wood waste at Regional landfill sites be prohibited and redirected to the Derry Road facility on a phased-in basis commensurate with WCI Waste Conversion Inc.'s ability to process the wood waste;

And further, that Regional staff be committed to an extensive promotional campaign to ensure all parties involved are aware of these changes, and where necessary, non-financial assistance be provided to wood and tire waste generators to help establish recycling programs;

And further, that the Regional Clerk be directed to obtain any required approvals from the Ontario Municipal Board;

And further, that the Regional Solicitor and Regional Clerk be authorized to sign the Agreement on behalf of the Region and affix the Corporate Seal thereto, once the Ontario Municipal Board Approval has been received.

PROPERTY OF

ENVIRONMENT CANADA

CERTIFIED A TRUE COPY Regional Clerk egional Municipality of Peel J-5.

Region of Peel

RESOLUTION 88-527-47 PASSED BY REGIONAL COUNCIL AUGUST 11, 1988

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And further, that the Regional Solicitor and Regional Clerk be authorized to sign the Agreement on behalf of the Region and affix the Corporate Seal thereto, once the Ontario Municipal Board Approval has been received.

PROPERTY OF

ENVIRONMENT CANADA

CERTIFIED A TRUE COPY **Regional Clerk** gional Municipality of Peel

