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ENVIRONMENT CANADA
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PACIFIC AND YUKON REGION

87-15

SUMMARY REPORT

ASSESSMENT OF STORM WATER RELATED
CHLOROPHENOL RELEASES FROM WOOD PROTECTION FACILITIES
IN BRITISH COLUMBIA

Regional Program Report 87-15

By

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ABSTRACT

This report documents the contamination of storm water runoff with chlorophenols leached from surface treated lumber in British Columbia. Storm water runoff from sawmills and lumber export terminals was suspected as a significant source of chlorophenols to adjacent water courses based on a 1978 Environment Canada Study. During 1986 and 1987, a four month field study was conducted at five sawmills and two lumber export terminals. The sites represented typical lumber handling and treatment methods including dip tanks, low pressure and high pressure spray systems. Leachate dripping directly from the wood and yard runoff was analyzed for 2,3,4,6-tetrachlorophenol and pentachlorophenol using a gas chromatography method.

It was found that leaching from treated lumber began after 1.0 to 1.5 mm of continuous rainfall. Dip treated lumber leached up to 158 000 parts per billion (ppb) and generated runoff with up to 6 600 ppb total chlorophenols. Low pressure sprayed lumber leached up to 576 000 ppb total chlorophenols. High pressure sprayed lumber leached up to 9 800 ppb and generated average yard runoff up to 1 968 ppb total chlorophenols. Chlorophenols were found to leach from treated lumber under all conditions of exposure to rainfall. Conditions studied included up to eight days of drying, 13 consecutive days of rainfall and 18 days of alternating wet and dry periods.

Most lumber storage yards have their own drainage systems which discharge directly to fresh or marine waters. Acute lethal static bioassay tests (LT₅₀'s) using rainbow trout underyearling were performed on two pure stormwater samples discharging from such yards. The fish became excited upon introduction to the effluent, exhibited coughing and erratic swimming within 10 minutes and mortality in all fish occurred within 40 to 120 minutes. The acute lethal toxicity for salmonids of 32 to 130 ppb total chlorophenols was exceeded virtually 100% of the time at all the storage yards monitored.

RÉSUMÉ

Ce rapport documente la contamination d'écoulement d'eau pluviale avec des chlorophénols lessivés de la surface de bois traité en Colombie-Britannique. L'écoulement des eaux pluviales provenant des scieries et des terminaux d'exportation de bois était une source significative suspectée de chlorophénols dans les cours d'eau adjacents basé sur une étude d'Environnement Canada en 1978. Pendant 1986 et 1987, une étude de quatre mois sur le terrain fut entreprise à cinq scieries et deux terminaux d'exportation de bois. Les sites représentaient une manutention typique du bois et des méthodes de traitement incluant des bassins de trempage de même que des systèmes de vaporisation à basse et haute pression. L'écoulement du lessivage dégouttant directement du bois et du site fut analysé pour le 2,3,4,6-tétrachlorophénol et pentachlorophénol utilisant une méthode de gaz chromatographique.

Il fut découvert que le lessivage du bois traité commencerait après une pluie continue de 1.0 à 1.5 mm. Le bois traité par trempage a lessivé jusqu'à 158 000 parties par milliard et a généré des eaux d'écoulement jusqu'à 6 600 parties par milliard en chlorophénols totaux. Le bois vaporisé à basse pression a lessivé jusqu'à 576 000 parties par milliard en chlorophénols totaux. Le bois vaporisé à haute pression a lessivé jusqu'à 9 800 parties par milliard et a généré un écoulement moyen du site jusqu'à 1 968 parties par milliard en chlorophénols totaux. Il fut découvert que les chlorophénols se lessivent du bois traité sous toutes les conditions d'exposition à la pluie. Les conditions étudiées comprennent jusqu'à huit jours sans précipitations, 13 jours consécutifs de pluie et 18 jours de périodes alternant entre sèches et mouillées.

Les dépôts d'entreposage de bois ont souvent leurs propres systèmes de drainage lesquels déversent directement dans les eaux fraîches ou marines. Des tests de bio-essai statique de toxicité aiguë létale (TL₅₀) utilisant des truites arc-en-ciel de moins d'un an furent conduits sur deux échantillons purs d'eaux d'écoulement provenant de tels dépôts. Les poissons devinrent excités à l'introduction de l'effluent, commencèrent à tousser et à nager erratiquement en moins de 10 minutes et tous les poissons furent morts entre 40 et 120 minutes. La toxicité létale aiguë pour les salmonidés de 32 à 130 parties par milliard en chlorophénols totaux fut dépassée pratiquement 100% du temps à tous les dépôts d'entreposage échantillonnés.

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	i
RÉSUMÉ	ii
TABLE OF CONTENTS	iii
List of Figures	iv
CONCLUSIONS	v
1 INTRODUCTION	1
1.1 Background	1
2 DIP TREATED LUMBER	4
3 LOW PRESSURE SPRAYED LUMBER	7
4 HIGH PRESSURE SPRAYED LUMBER	10
5 TOTAL RUNOFF AND LOADING ESTIMATES	12
6 FISH BIOASSAYS	13

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	LOCATION OF SAWMILLS AND LUMBER EXPORT TERMINALS IN LOWER MAINLAND USING CHLOROPHENATE ANTI-SAPSTAIN CHEMICALS	2
2	CHLOROPHENOL CONCENTRATIONS IN LEACHATE FROM DIP TREATED LUMBER	5
3	CHLOROPHENOL CONCENTRATIONS IN YARD RUNOFF FROM DIP TREATED LUMBER	6
4	CHLOROPHENOL CONCENTRATIONS IN YARD RUNOFF FROM LOW PRESSURE SPRAYED LUMBER (ZERO DRYING TIME)	8
5	CHLOROPHENOL CONCENTRATIONS IN YARD RUNOFF FROM LOW PRESSURE SPRAYED LUMBER (EIGHT DAYS DRYING TIME)	9
6	CHLOROPHENOL CONCENTRATIONS IN YARD RUNOFF FROM HIGH PRESSURE SPRAYED LUMBER (MIXED DRYING TIMES)	11

CONCLUSIONS

Based on the data collected and the observations made during the 1986/1987 study of storm water runoff from five saw mills and two lumber export terminals it can be concluded that:

1. The levels of chlorophenols in mill runoff is dependent upon the following parameters:
 1. Initial chemical formulation;
 2. Treatment application method;
 3. Lumber cut (rough vs planed);
 4. Lumber packaging and stacking;
 5. Lumber drying time;
 6. Rainfall intensity and duration;
 7. Amount of treated lumber on site;
 8. Normal vs abnormal operations (i.e. has the lumber been cut or treated properly); and
 9. General housekeeping practices.

2. Chlorophenols will leach from treated lumber under all conditions of exposure to rainfall. This includes up to eight days of drying, 13 consecutive days of rainfall and 18 days of alternating wet and dry periods. The highest concentrations were measured in rainwater dripping directly from the lumber packages before further dilution occurred on the paved storage yard. The wood exposed to rainfall for the first time, ranged from 8 816 ppb to 576 000 ppb. The average concentrations in surface runoff draining from the lumber storage yards was found to range from 180 to 27 500 ppb total chlorophenols. These concentrations were in the same order of magnitude as those found in simulated rainfall studies conducted by Forintek Canada Corporation.

3. Total annual loading of chlorophenols to the environment can be

estimated using the local average total precipitation, storage yard area and average concentration of chlorophenols in yard runoff for the specific lumber storage conditions.

4. Stormwater runoff from storage yards containing chlorophenolate treated lumber can be acutely toxic to fish. Acute lethal static fish bioassays of pure stormwater runoff resulted in 100% mortality within 40 to 120 minutes.
5. The acute lethal toxicity (96 hr LC₅₀) range of 32 to 130 ppb for salmonids was exceeded virtually 100% of the time at all the storage yards monitored.
6. Storm water runoff from wood protection mills contains a complex mixture of contaminants. The concentrations of the majority of these contaminants lie within acceptable ranges and would not be expected to pose a threat to the receiving environment. Elevated concentrations of specific metals occurred infrequently and therefore do not constitute cause for concern. The chlorophenol component of the wood protection stormwater effluent is of primary concern.
7. The alkaline buffers used to maintain the chlorophenolate in solution before application to lumber may buffer the acidic reaction at the lumber interface after application thereby inhibiting the fixation of the chlorophenols to the wood surface.
8. The leaching of chlorophenols may be reduced by alternate or additional forms of protection which include:
 - wrapping of treated lumber with water resistant papers or plastic;
 - total coverage of treated lumber;
 - use of kiln drying in place of chlorophenols;
 - coating with wax or polymer sealing films;
 - alternative chemicals with low leachability;
 - treatment of contaminated runoff;
 - combinations of the above.

1 INTRODUCTION

This report summarizes the main technical report of the same title. Chlorophenol wood protection chemicals are a high priority for assessment and control in British Columbia because of their heavy usage, potential for release, high toxicity and persistence in the environment. Controlled laboratory studies of chlorophenols have established that acute toxicity (death within 96 hours) occurs at concentrations of 32 to 130 parts per billion (ppb) for juvenile salmon species. This is equivalent to 1 drop of pure chemical in 10 barrels (360 gallons) of water.

1.1 Background

Stormwater runoff from sawmills and lumber export terminals was suspected as a significant source of contamination based on findings in a 1978 Environment Canada study. In 1983 a joint government/industry report was developed to improve chemical handling, worker safety and environmental protection. The report recommended an interim storage time of 2 $\frac{1}{2}$ hours that would be reviewed after further leaching studies were completed.

In late 1986 a field study was initiated by Environment Canada which measured the extent to which rainfall could be contaminated with chlorophenols leached from treated lumber. The objectives of the study were to undertake a sampling program of stormwater and conduct chemical analysis to determine concentrations of 2,3,4,6-tetrachlorophenol (TTCP) and pentachlorophenol (PCP) in the runoff. Five sawmills and two lumber export terminals were chosen from 29 facilities in the lower Fraser Valley and they were monitored over a four month period from the end of October 1986 to the end of January 1987 (Figure 1).

The sample sites were chosen to cover the full range of chemical application technology which included diptank treatment, low pressure spray (old technology) and high pressure spray (new technology). The effect of drying times was measured by monitoring lumber which was freshly treated and exposed directly to rainfall to lumber which had up to eight days of dry storage before exposure. The mills were located in areas where annual

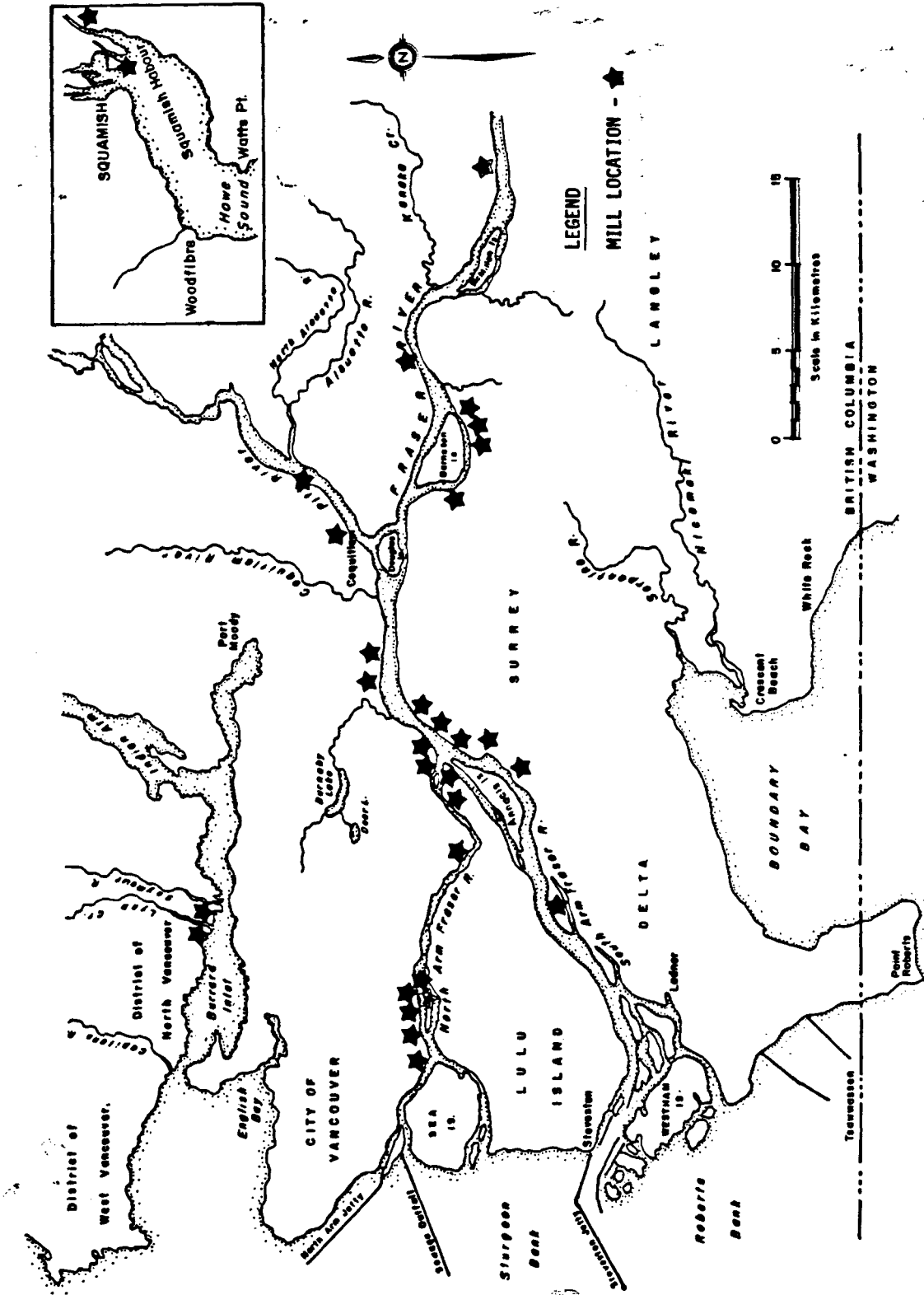


FIGURE 1 LOCATION OF SAWMILLS AND LUMBER EXPORT TERMINALS IN THE LOWER MAINLAND USING CHLOROPHENATE ANTI-SAPSTAIN CHEMICALS

rainfall varied from 1094 mm (Vancouver Airport) to 1800 mm (Whronnock) and daily accumulation ranged from 3 mm to 60 mm.

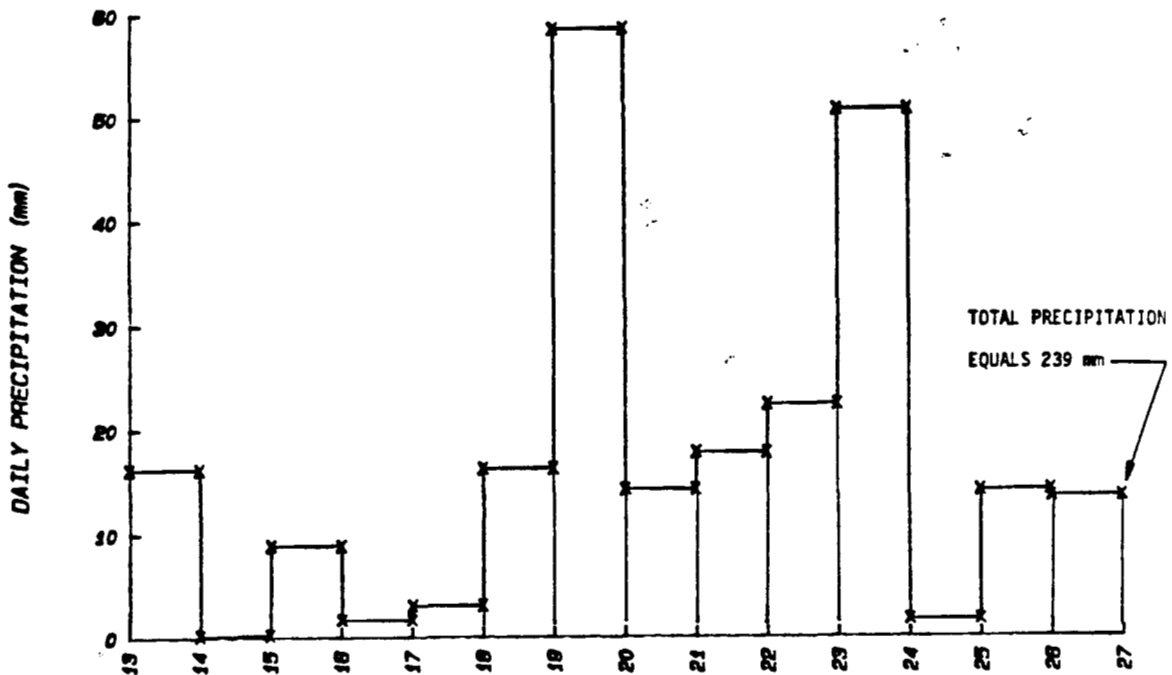
Contaminated rainwater was collected in two types of samples; as leachate dripping from the lumber stacks before it reaches the paved yard surface, and as diluted yard runoff discharging to the storm sewer. The leachate was collected continuously in heat treated pyrex glass trays and transferred to amber glass bottles (to protect from ultraviolet light) while the yard runoff was collected directly as grab samples in amber glass bottles. All samples were stored at 4°C prior to analysis by a gas chromatography method.

At six of the sites water quality parameters including total and suspended solids, total organic carbon, oil and grease, nitrogen, phosphorus and total metals were measured. During each sampling run, the temperature, dissolved oxygen content, pH and electrical conductivity of the runoff was continuously monitored. At two of the sites, static LT₅₀ fish bioassays using rainbow trout were performed. The LT₅₀ is the lethal toxicity time at which 50% of the test organisms die after continuous exposure to the undiluted effluent.

2 DIP TREATED LUMBER

Undiluted leachate from a stack of dip treated lumber was monitored for eight rainfall events over 13 days with a total precipitation of 239 mm (Figure 2). Samples were collected of leachate dripping from the exterior of the packages as well as percolating through the interior. Total chlorophenol concentrations reached 90 000 ppb on exterior drippings and 158 748 ppb on the interior drippings. After 12 days of continuous rainfall the concentrations were still above 8 000 ppb. Three drainage basins which stored dip treated lumber were monitored for one rain event and each site had already experienced from 7 mm to 23 mm of rainfall prior to the test. In these cases a significant proportion of the chemical may have already been washed off and the average total chlorophenol concentrations in yard runoff ranged from 258 ppb to 528 ppb with peaks as high as 6 624 ppb (Figure 3).

MILL #2 NOV 13-26/86 TOTAL DAILY PRECIPITATION



MILL #2 NOV/13-21/86 CHLOROPHENOL CONC. FROM WOOD EXT. & INT

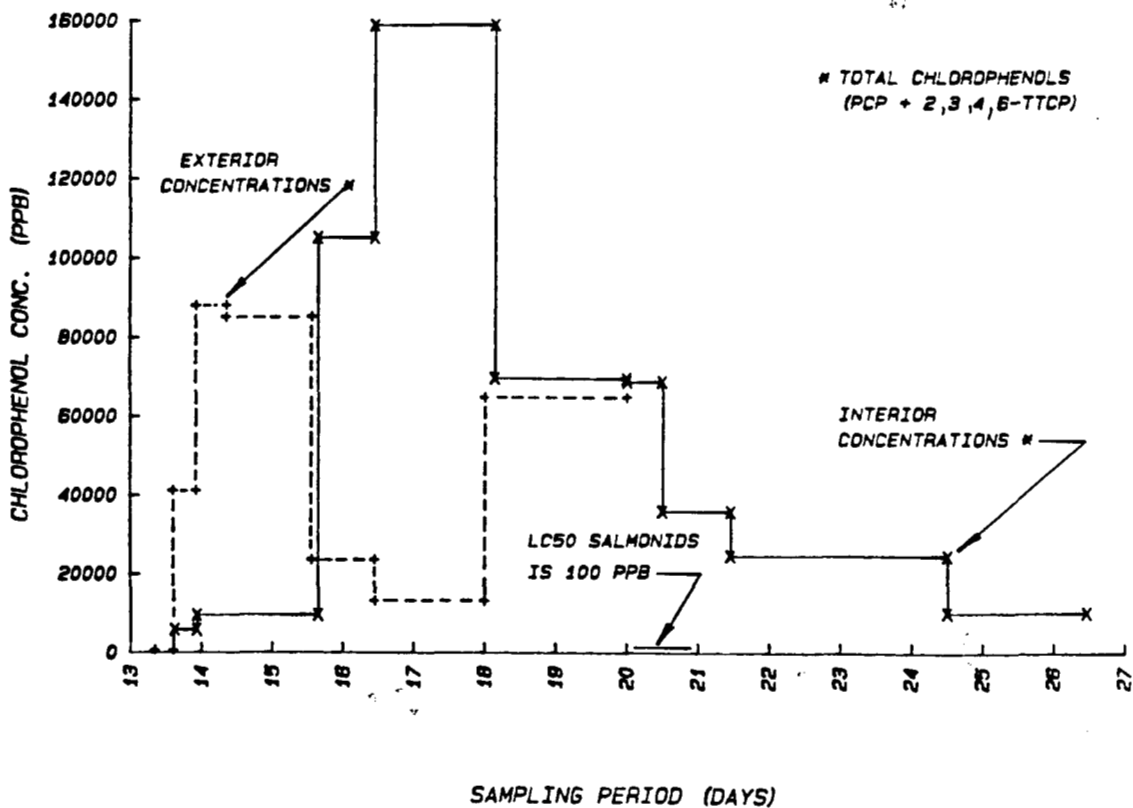
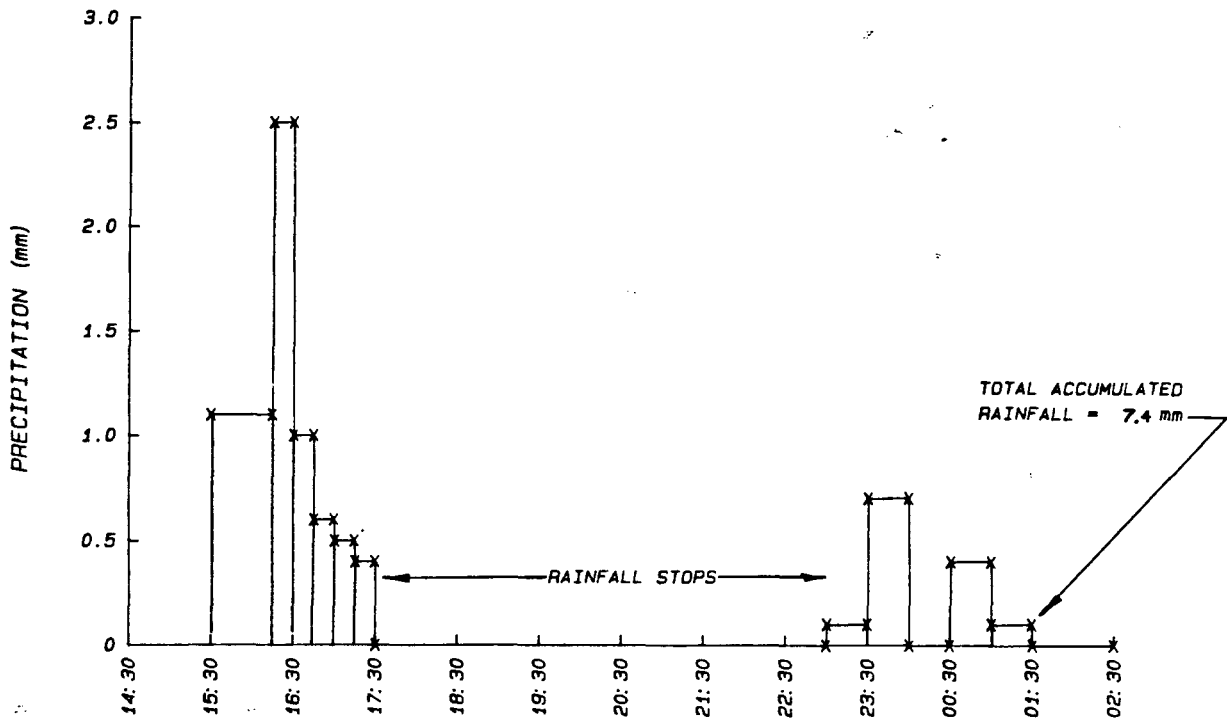


FIGURE 2 CHLOROPHENOL CONCENTRATIONS IN LEACHATE FROM DIP TREATED LUMBER

MILL #2 OCT 29-30/86 PRECIPITATION



MILL #2 OCT 29-30/86 CHLOROPHENOL CONCENTRATIONS

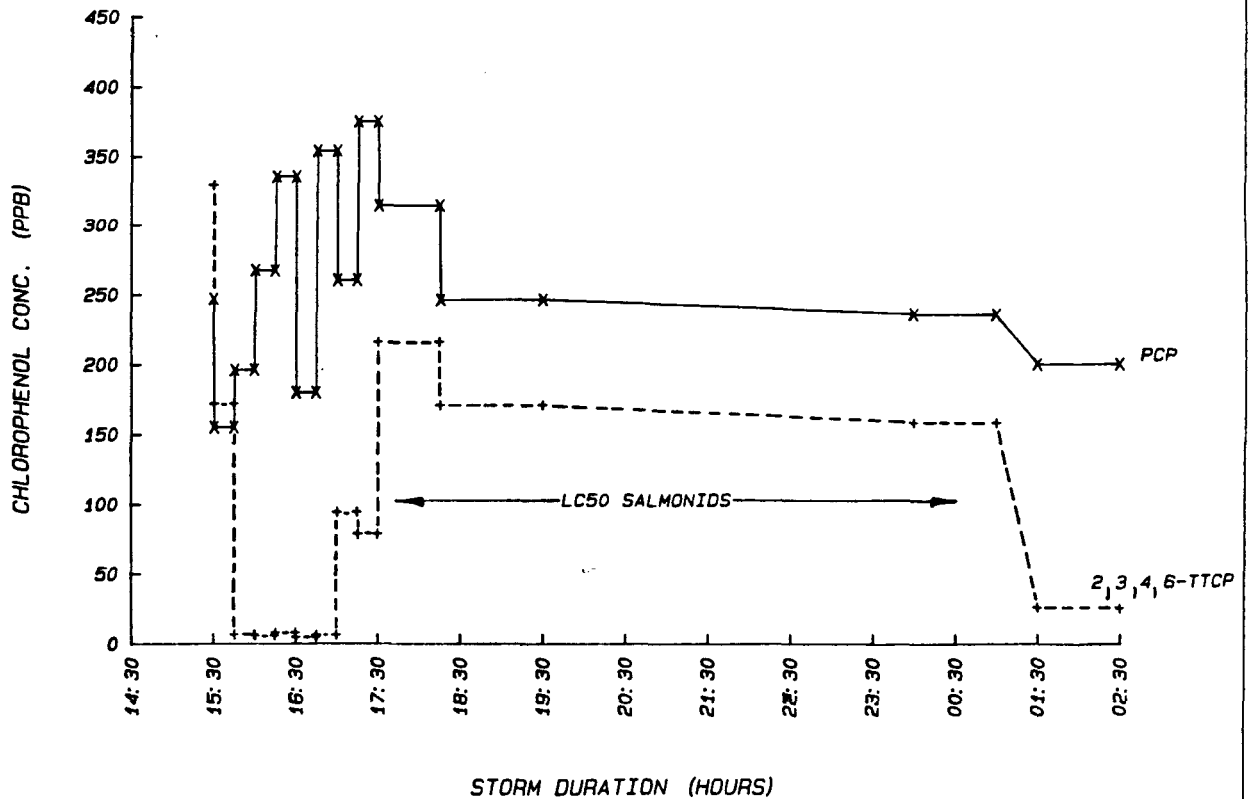


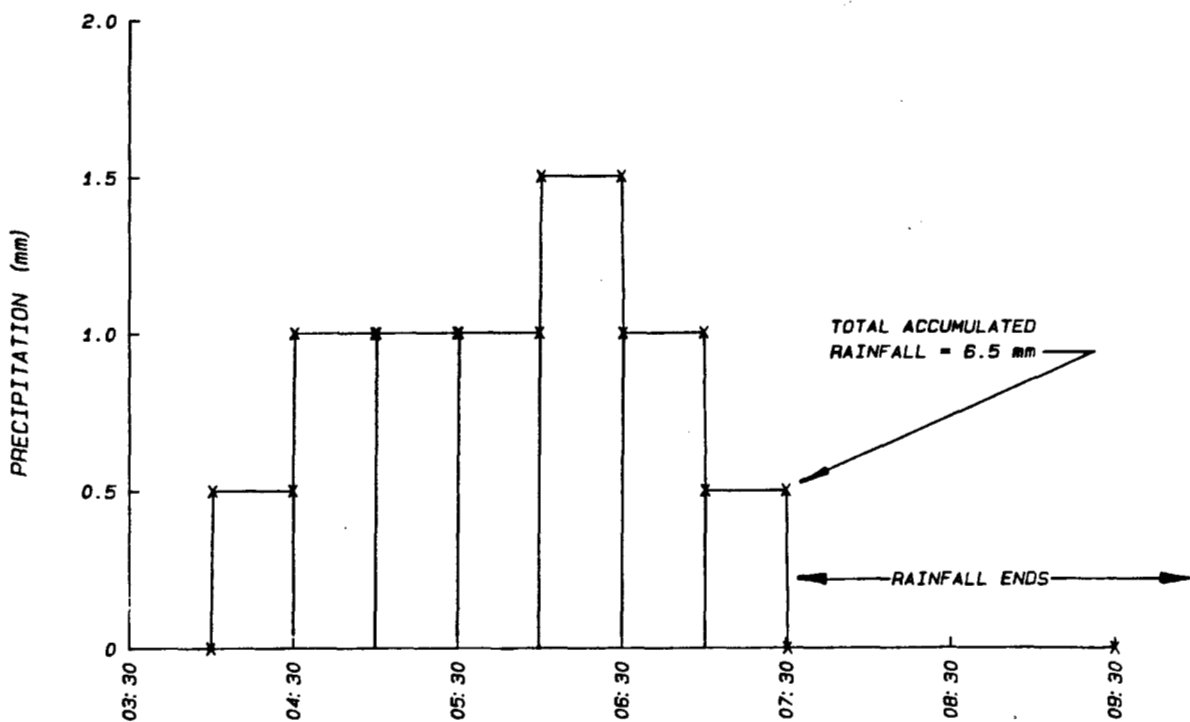
FIGURE 3 CHLOROPHENOL CONCENTRATIONS IN YARD RUNOFF FROM DIP TREATED LUMBER

3 LOW PRESSURE SPRAYED LUMBER

Lumber which was treated by low pressure spray systems (old spray technology) was monitored over various drying times ranging from zero to eight days after treatment. Lumber which had zero fixation time experienced direct washoff and total chlorophenol concentrations of up to 576 000 ppb were found in water dripping from the wood. Direct washoff would occur at the green chain sorting line where the lumber was pulled from the covered conveyor and piled in stacks outside the roofed area. In some cases there were no rain gutters so that roof runoff was directed onto the freshly treated wood in addition to direct rainfall. The yard runoff from such sites had average total chlorophenol concentrations of up to 27 542 ppb which were the highest of any situation monitored (Figure 4). The three mills where this type of runoff was observed were situated on the shores of the Fraser River and discharged their runoff directly to near shore surface zones.

Low pressure spray treated lumber which had up to eight days of drying after treatment had total chlorophenol concentrations of up to 15 910 ppb dripping from the wood. Yard runoff from the sites averaged up to 545 ppb total chlorophenols (Figure 5). These samples were taken from a yard which had 1/3 to 1/2 of the total lumber capacity in it and higher lumber loading would likely increase the concentrations in the runoff.

MILL #3 NOV/18/86 PRECIPITATION



MILL #3 NOV/18/86 CHLOROPHENOL CONCENTRATIONS

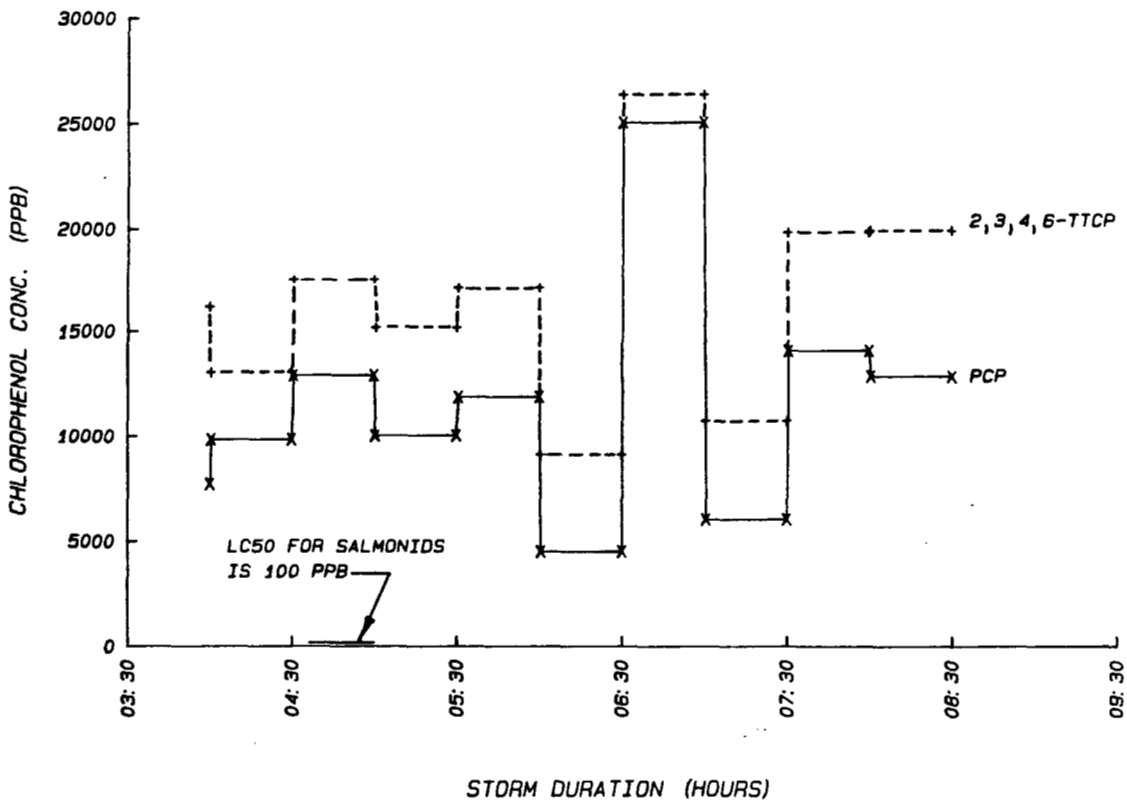
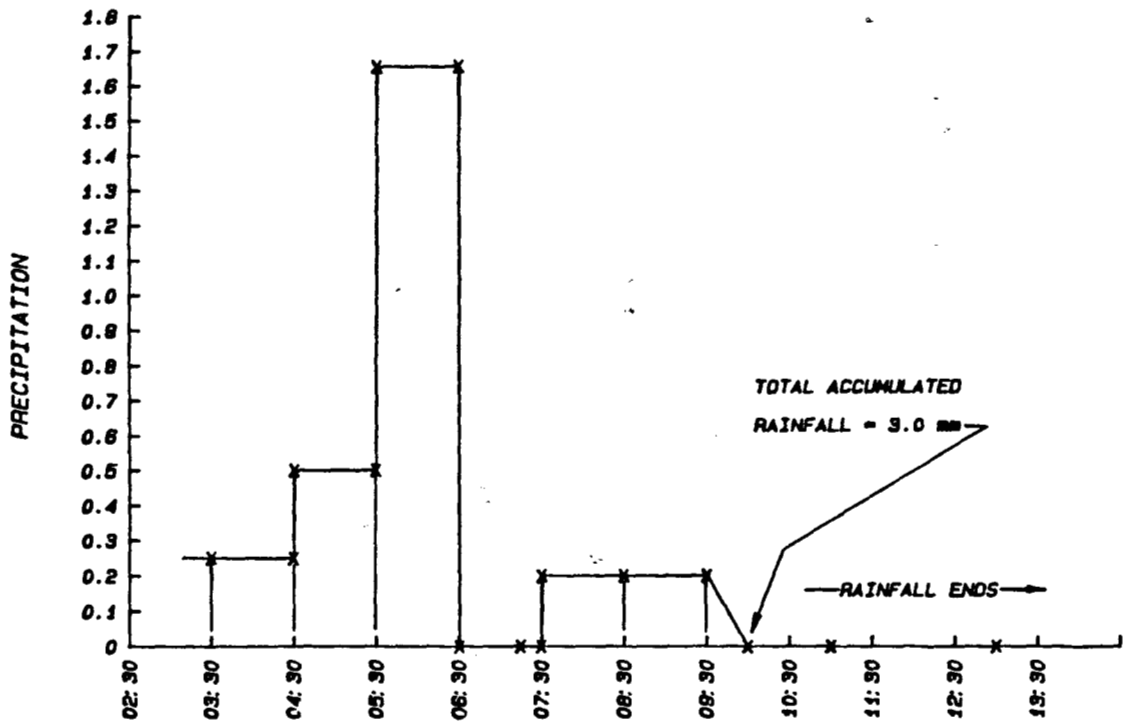


FIGURE 4 CHLOROPHENOL CONCENTRATIONS IN YARD RUNOFF FROM LOW PRESSURE SPRAYED LUMBER (ZERO DRYING TIME)

MILL #1 OCT/25/86 PRECIPITATION



OCT/25/86 CHLOROPHENOL CONCENTRATIONS

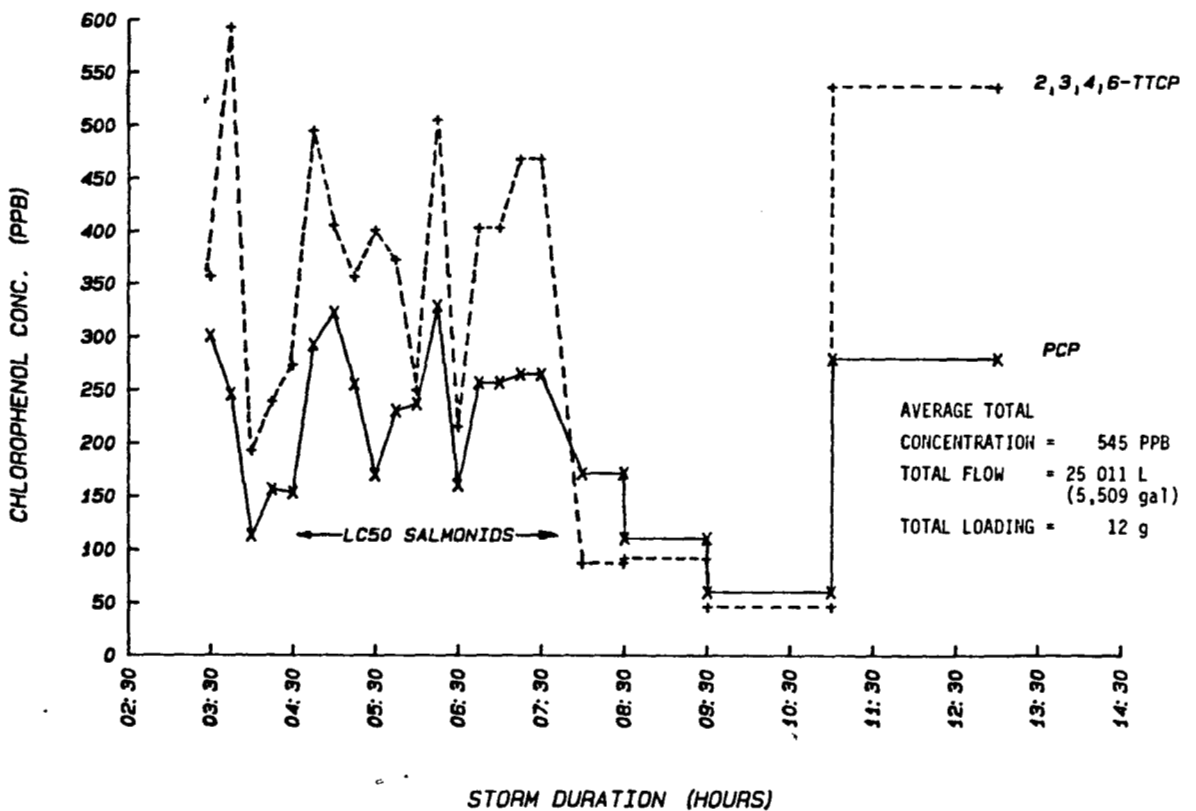
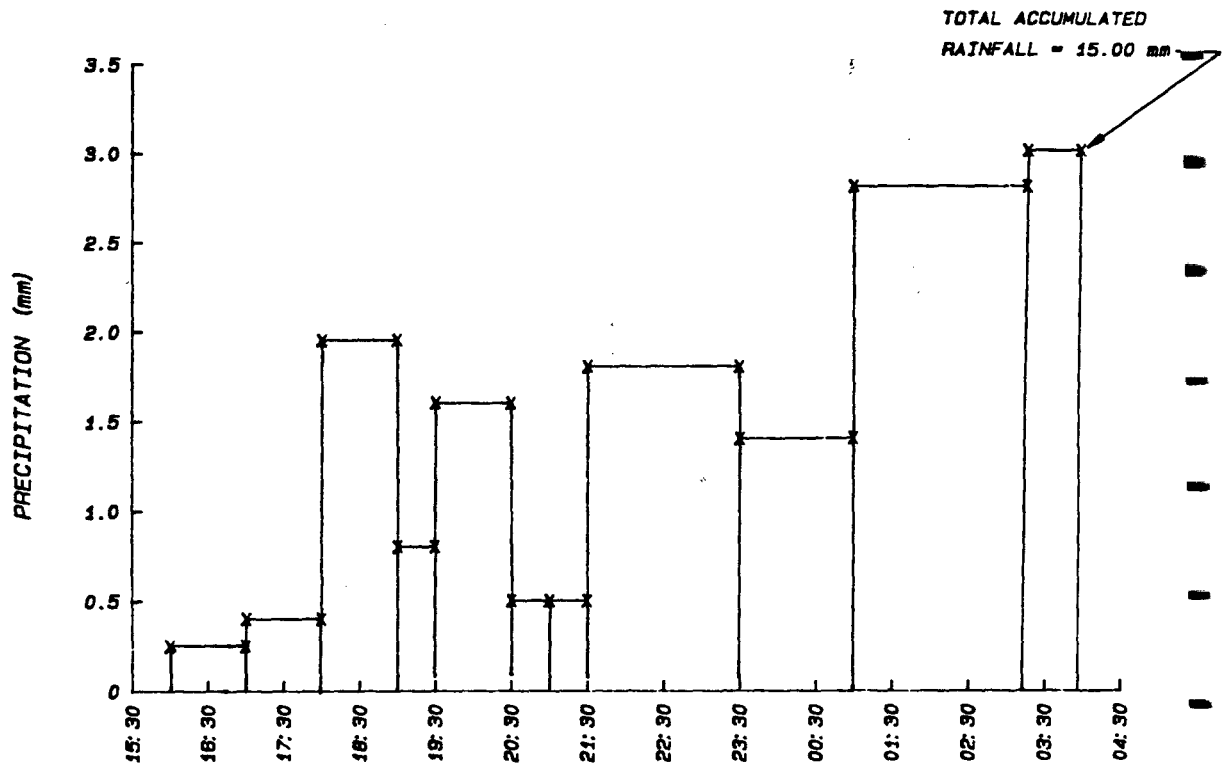


FIGURE 5 CHLOROPHENOL CONCENTRATIONS IN YARD RUNOFF FROM LOW PRESSURE SPRAYED LUMBER (EIGHT DAYS DRYING TIME)

4 HIGH PRESSURE SPRAYED LUMBER

High pressure spray systems (new spray technology) operate at over two atmospheres of pressure and produce lumber which is almost dry to the touch immediately after treatment. All the sites monitored contained lumber which was rough cut and unplaned which resulted in a much higher surface area per board than in any of the other situations. The average total chlorophenol concentration in water dripping from this type of wood was 9 829 ppb and storage yard runoff from these sites averaged up to 1 968 ppb (Figure 6).

MILL #4 DEC 20-21/86 PRECIPITATION (CENTRE DRAIN)



MILL #4 DEC 20-21/86 CHLOROPHENOL CONCENTRATIONS (CTR. DRAIN)

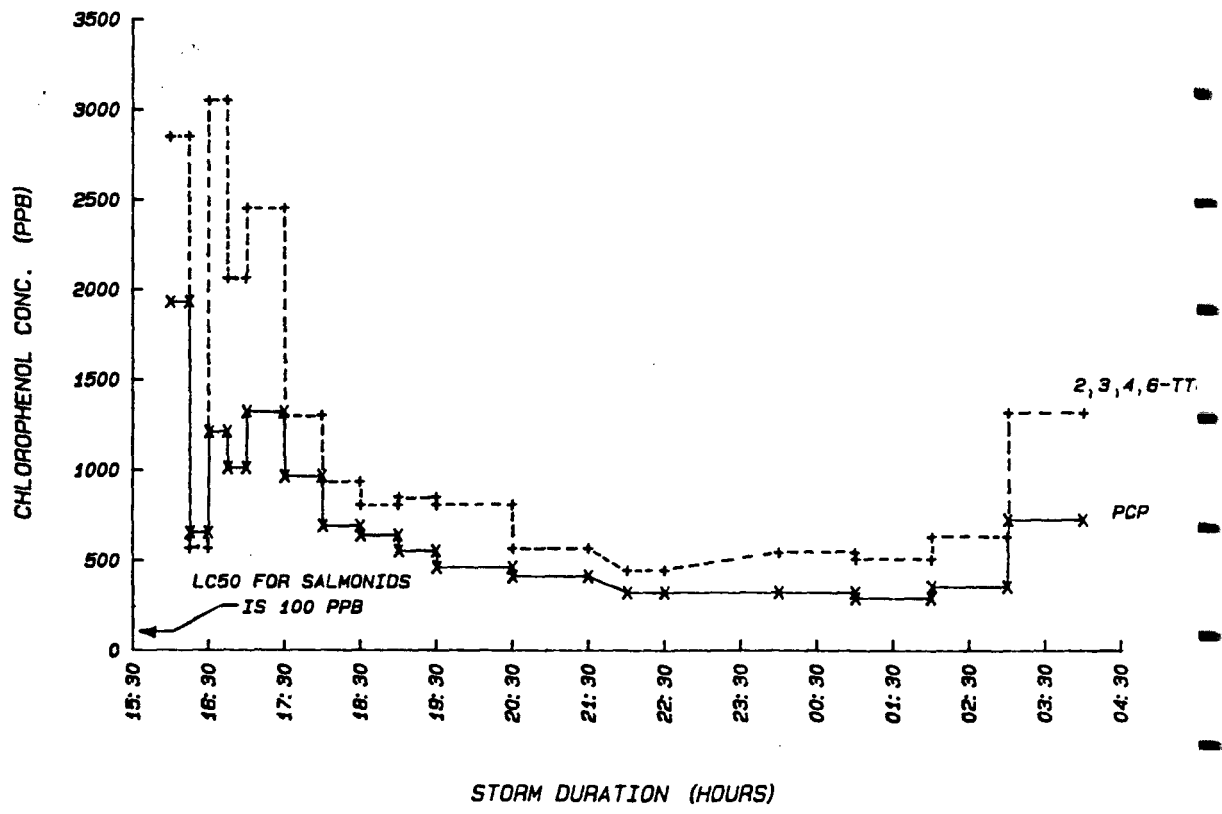


FIGURE 6 CHLOROPHENOL CONCENTRATIONS IN YARD RUNOFF FROM HIGH PRESSURE SPRAYED LUMBER (MIXED DRYING TIMES)

5 TOTAL RUNOFF AND LOADING ESTIMATES

Whenever there was measurable rainfall at a treated lumber storage yard there were measurable chlorophenols in the runoff. Rainfall intensities and durations were a significant factor with higher intensities and longer durations increasing the quantities of chlorophenols leached. It was found that rainwater dripping from the wood after the end of a rain event would dry on the yard surface and then be washed in a concentrated form down the storm drain at the start of the next storm. The way the lumber is cut, strapped and stacked on the yard also affected the quantity of chemical leached, and it was found that leaching from the tops and sides of the packages occurs within 1.0 to 1.5 mm of continuous rainfall.

The annual total runoff generated at lumber storage yards on the lower Fraser River from Kanaka Creek to the mouth was estimated at 490 000 to 775 800 m³/year with total chemical loading up to 916 kg of pure chlorophenol. The annual runoff volume to Burrard Inlet was estimated at 511 000 to 850 000 m³/yr which contains up to 523 kg/yr of pure chlorophenols. Runoff to Howe Sound at Squamish was estimated at 165 000 to 261 000 m³/yr with up to 85 kg/yr of pure chemical.

Many of the treated lumber storage yards drainage systems are not cross connected with other systems and will discharge directly to the surface and near shore areas of rivers and marine waters. The lower Fraser River is affected by tidal action which will block these drains for up to 12 hours and cause rainwater to back up in the drainage systems and sometimes pool on the yard. The discharge of a pool of rainwater (contaminated with 1 200 ppb of chlorophenols) to the Fraser River during an ebb tide was simulated using a computer generated model. The simulation estimated that a plume at a concentration of 100 ppb (which is toxic to fish) could extend up to 12 m from shore and up to 60 m downstream. Elevated shoreline chlorophenol concentrations of 10.0 - 15.0 ppb in Fraser River water was measured approximately 200 m downstream of a large outfall after a storm event such as the one simulated.

6 FISH BIOASSAYS

Acute lethal static bioassays (LT₅₀'s) were performed at the Environmental Protection Bioassay Laboratory by placing juvenile rainbow trout in tanks filled with pure stormwater effluent. The fish became excited upon introduction to the effluent, were exhibiting coughing responses within 5 minutes, followed by erratic swimming after 10 minutes. After 20 minutes they had lost equilibrium, exhibited irregular gill movement and were unresponsive to touch. The test is designed to last for up to 96 hours, however death of all the test specimens occurred within 40 to 120 minutes. General water quality analysis performed on the bioassay samples and other samples indicate that the majority of the parameters were within acceptable levels. Aluminum, iron and silicon were elevated in one of the bioassay samples and may have had a minor contribution to its toxicity.

Rainfall occurs year round in the British Columbia coastal regions with 6-7 days of precipitation averaging 6 mm/day occurring during July which is the driest month. This is sufficient rainfall to produce the type of runoff discussed earlier. The direct affect such discharges have on resident, migratory fish, and other aquatic organisms has not been documented. Migratory juveniles such as salmon, steelhead trout and eulachons are most likely to be affected during the downstream migration in late February through June which occurs in most of the coastal rivers, especially the Fraser. Resident fish species are likely to receive a continuous input of chlorophenols. It is conceivable that fish kills of juveniles could occur in the aftermath of a significant storm event and that these kills would go undetected because the small fish are not highly visible and could be washed away or eaten by other fish and birds.