UNIVERSITY OF ALBERTA

FACTORS INFLUENCING PULP MILL EFFLUENT TREATMENT IN ALBERTA

BY

KATE LINDSAY

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of **Master of Science**

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DEDICATION

Humbly I dedicate this thesis to the Bahai Faith, which has inspired me to pursue environmental studies:

"Every man of discernment while walking upon the earth, feeleth indeed abashed, inasmuch as he is fully aware that the thing which is the source of his prosperity, his wealth, his might, his exaltation, his advancement and power is, as ordained by God, the very earth which is trodden beneath the feet of all men. There can be no doubt that whoever is cognizant of this truth, is cleansed and sanctified from all pride, arrogance, and vainglory."

(Baha'u'llah - Epistle to the Son of the Wolf, page 44)

ABSTRACT

Factors influencing in-plant and external effluent treatment systems in six Alberta pulp mills were investigated. These factors included environmental impacts of pulp mill effluent, pulp mill technology development, government incentives and control of pulp mills, market influences, and public concerns. It was determined that public concern and awareness was instrumental in influencing government to approve mills with the best available technology and to implement high effluent discharge standards for the mills.

Between 1988-1991, four new pulp mills were constructed in Alberta, and the existing two pulp mills were upgraded as part of the provincial government's economic diversification program. This increased level of activity, especially the ALPAC hearing process, and global environmental concerns, enhanced public awareness of forestry development in the province. The public was concerned with harvesting practices and mill pollution as down-stream users of receiving waters.

The process by which the pulp mill industry responded to the public concerns about the environment is complex. A systems approach was used to identify the basic pathways and interactions between the sector's influencing factors. Defining the response process depends on the observer's point of view since environmental issues have become, to a large extent, a matter of perception. Fully understanding these concepts is crucial for government to establish constructive policy and for industry to cost-effectively address public concerns.

ACKNOWLEDGEMENT

Many people in industry, the government and the public contributed information for the completion of this report. I would like to thank all of them and in particular the company representatives who were patient with my many inquiries and the Hopwoods, who were patient when finalizing this report with me.

I would also like to thank

Professor Hrudey for allowing me to think differently,
Professor Higgs for allowing me to feel differently,
Professor Smith for allowing me to act differently,

because together these are the roots of innovation and the dynamics of the human spirit.

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LIST OF ACRONYMS

AAC	Annual Allowable Cut
AEPEA	Alberta Environmental Protection and Enhancement Act
AFL	Alberta Federal of Labour
ALPAC	Alberta Pacific Forest Industries Inc.
AOX	Absorbable Organic Halogens
ASWQO	Alberta Surface Water Quality Objectives
BCTMP	Bleached Chemi-Thermo-Mechanical Pulp
CCEM	Canadian Council of Environmental Ministers
CEAA	Canadian Environmental Assessment Act
CEPA	Canadian Environmental Protection Act
CWQG	Canadian Water Quality Guidelines
DC	Daishowa Canada Ltd.
DEMR	Department of Mines and Resources
DOE	Department of Environment
EARP	Environmental Assessment Review Process
EIA	Environmental Impact Assessment
EPS	Environmental Protection Service of Environment Canada
FEARO	Federal Environmental Assessment Review Office
FMA	Forest Management Agreement
FOC	Fisheries and Oceans Canada
MWP	Millar Western Pulp Ltd.
NEPA	National Environmental Policy Act (U.S.)
NRCB	Natural Resources Conservation Board
PNGC	Procter and Gamble Cellulose Ltd.
SLPC	Slave Lake Pulp Corporation
U.S. EPA	United States Environmental Protection Agency
WC	Weldwood Canada Ltd.

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

The purpose of this report is to investigate the factors which influenced the choice of in-plant and external effluent treatment systems in Alberta's six pulp mills. The report provides an overview of environmental programs operated by Alberta pulp mills and other information about effluent treatment, i.e., water licence parameters. The information was collected from a literature review of available reports on Alberta mills as well as from interviews with involved government, industry and public officials. Each mill was visited and the owners have approved the information presented in APPENDIX A.

The economy of Alberta has always relied heavily on the development of natural resources. With down-turns in the energy and agricultural sectors in the early 1980s, the provincial government investigated ways to diversify the economy by enhancing the then minor forest industry. Establishing pulp mills, especially those using hardwoods, was recognized as a means of meeting this objective. The Forest Industry Development Division of Alberta Forestry, Lands, and Wildlife was created to promote the Province's forest resources to major forest businesses. The increased demand for high quality paper products coupled with the development of technology to utilize aspen as pulp feedstock for those high quality products (as well as for board products) made development of the predominantly aspen boreal forests attractive and financially viable (Edwards, 1990).

As a result of the government's promotional and business development efforts, a number of proposals were received for the construction of pulp, lumber and fibreboard mills. Prior to these efforts, there were only two pulp mills in the Province, Weldwood (WC) of Canada Ltd. at Hinton (1956) and Proctor and Gamble Cellulose Ltd. (PNGC) at Grande Prairie (1972). Between 1988 and 1992, there were four pulp mills and one pulp/paper mill constructed in the Province and both the existing mills were upgraded/expanded. Associated with these processing developments were the allocations of timber resources, usually in the form of Forest Management Agreements (FMA).

This increased level of forest industrial activity, especially the hearing process of the most recently built mill, Alberta Pacific Forest Industries Inc. (ALPAC), and global environment concerns enhanced public awareness of forestry development in the Province. Public attention has focused on the impact of harvesting practices and on mill pollution (drinking water, downstream of receiving waters) (Fuller, 1990; Cancik, 1990). Alberta regulates pulp mill effluent levels by issuing licenses that outline effluent parameter limits and tests.

Today in Alberta's pulp mills, levels of technology and government effluent control standards are the highest in Canada if not the world (See FIGURE 1.1). In 1991, total mill discharges were substantially less than combined provincial and federal licence standards' allowances (See FIGURE 1.2). This performance level has been reached through the employment of state-of-the-art processing systems in the newly constructed mills and through effluent treatment improvements in the older mills.

The premise of this investigation is that public concern was the primary factor influencing the pulp producing industry in Alberta to reach this high performance level.

FIGURE 1.1: Jurisdiction Standards Comparison
(Monthly Ave kg/ADMT) (AFPA, 1991)

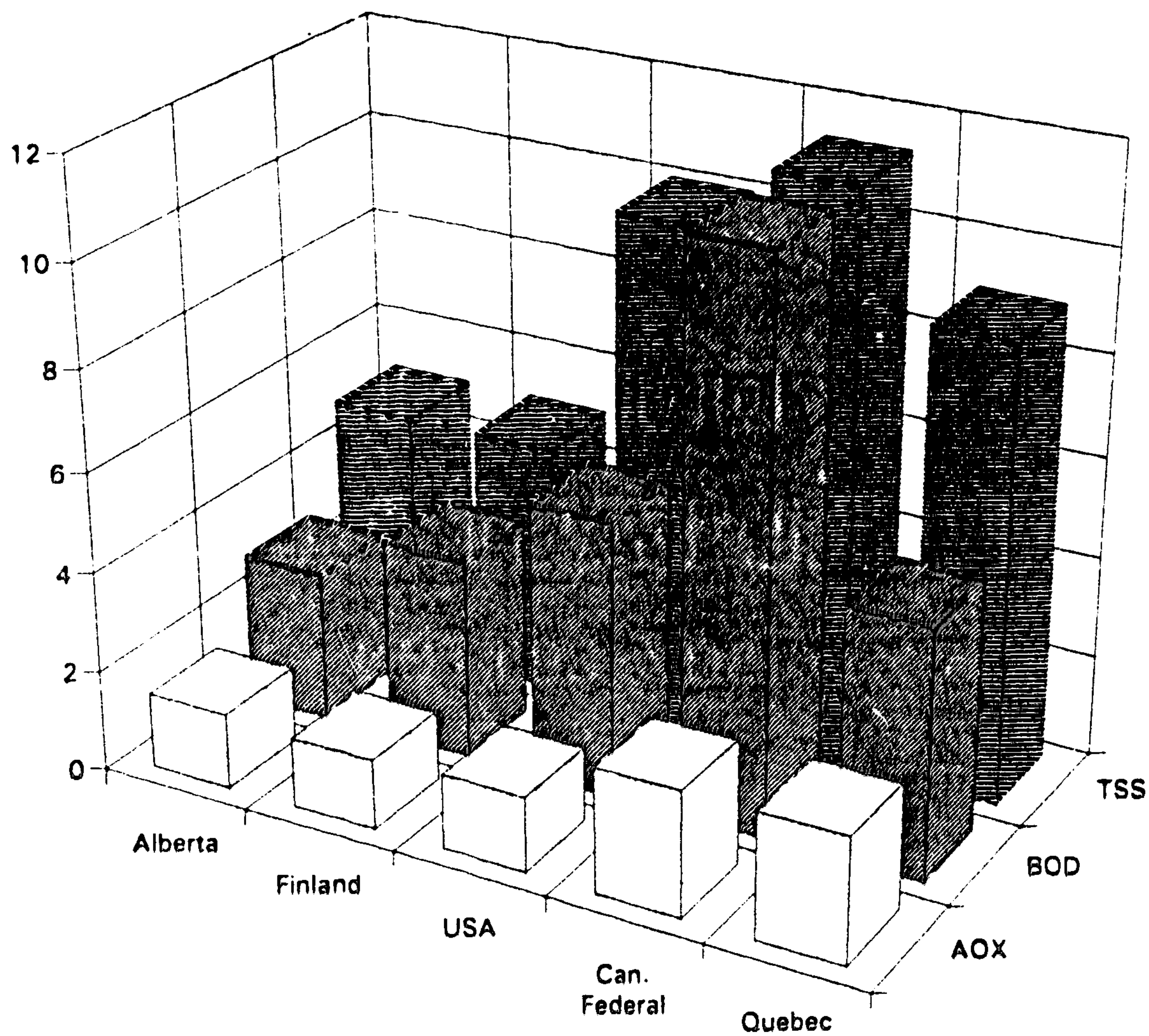
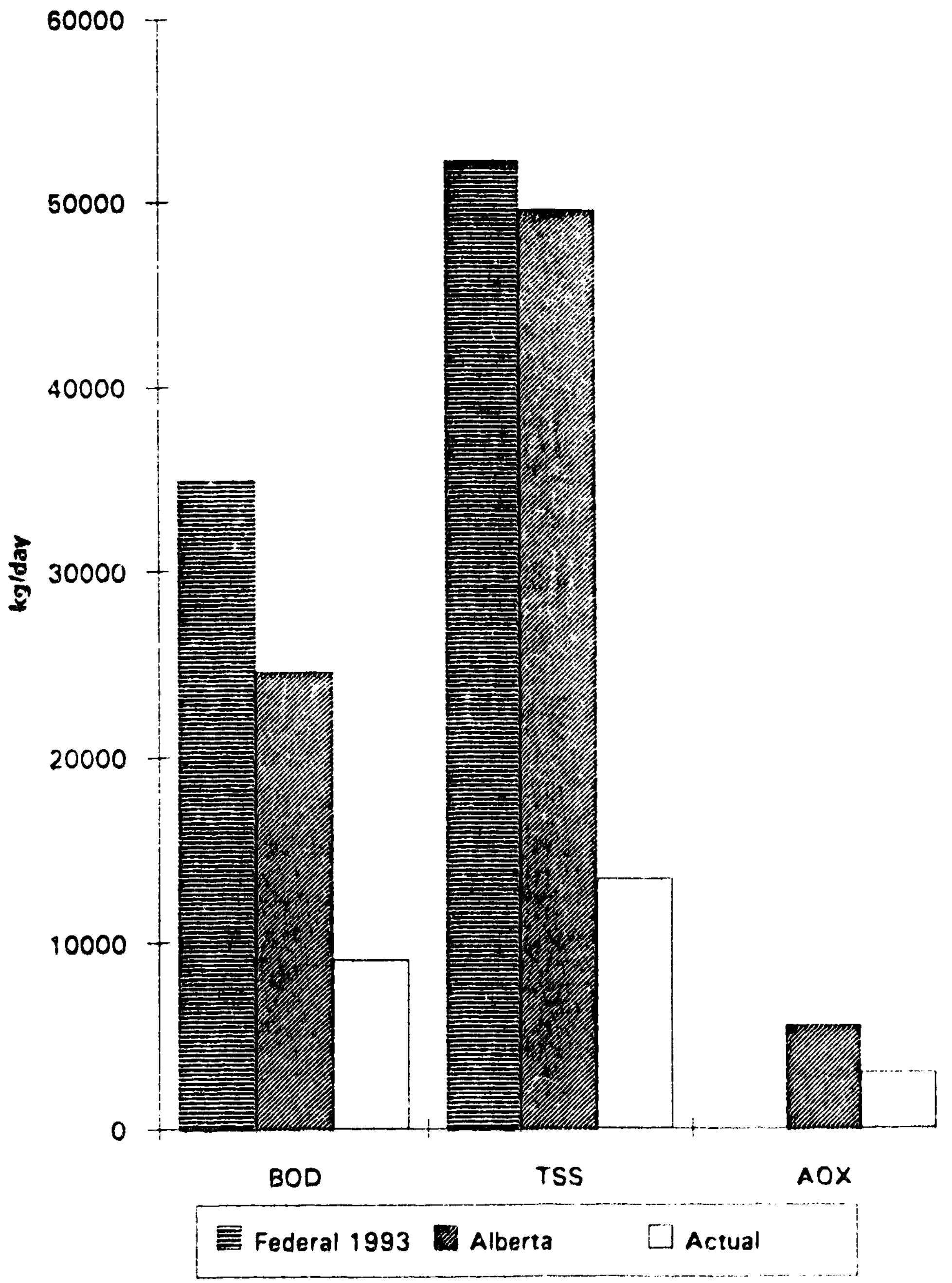


FIGURE 1.2: Total Discharges for Six Alberta Mills 1991 (AFPA, 1991)



1.2 DESCRIPTION OF MILLS IN ALBERTA

Today, there are six pulp mills in Alberta, four kraft and two Bleach Chem-Thermo-Mechanical Pulping (BCTMP). Detailed descriptions of these mills are provided in APPENDIX A.

The kraft mill in Hinton, currently owned by WC, was the first pulp mill in the Province, construction completed in 1957. The mill resulted from a government initiative to increase utilization of the Province's forests. Although the original mill was considered state-of-the-art, exterior effluent treatment processes were not installed until 1967, one of the first systems in Canada. The next major mill modification occurred in 1989.

The second mill to be established was the kraft mill located in Grande Prairie by PNGC. In 1966 and 1967, the government advertised, in pulp industry and financial journals, the availability of forest lands suitable for a pulp mill development. In compliance with 1965 policy for pulp mill development, a public hearing was held in late 1967 to review two proposals received in response to the government advertisements. PNGC was selected to establish the mill and the first pulp shipment from the mill was made in August 1973. The original mill was built with both primary and secondary exterior effluent treatment processes. The mill completed minor improvements as part of an upgrade in 1990.

In August 1988, the third pulp mill was constructed. Millar Western Pulp Ltd. (MWP) initiated operation of a BCTMP mill, the first of the type in the Province. Although the original system consisted of both primary and secondary effluent treatment systems, the resulting effluent did not meet provincial water licence limits when both production lines were first operated together. Modifications, conversion from an Aerated Stabilization Basin (ASB) to an Activated Sludge (AS) process, were completed within the first year of operation and provincial licence standards were met.

The fourth mill (third kraft mill) was built by Daishowa Canada Ltd. (DC) in 1990. Both primary and secondary effluent treatment processes were included in the original mill construction.

Slave Lake Pulp Corporation (SLPC) completed construction of their pulp mill in late 1990. This mill was the fifth pulp mill and second BCTMP. Both primary and secondary effluent treatment processes were included in the original mill construction.

Construction of the Alberta Pacific Forest Industries Inc. (ALPAC) kraft pulp mill in Athabasca will be completed in 1992/93. This mill is considered to be state-of-the-art with the most modern in-plant and out-of-plant effluent treatment technology.

Each of these mills, even within its own type, is unique. Thus, a combination of factors must be considered in evaluating their environmental impacts. These factors, listed by mill in TABLES 1.1 - 1.6, include:

- pulp production levels and wood consumption
- water consumption
- receiving environment characteristics
- in-plant processes
- external effluent treatment and discharge equipment.

TABLE 1.1: Alberta Pulp Mill Pulp Production and Wood Supply

MILL	OPEN DATE	MILL TYPE[1]	PRODUCTION ADMT[2]				FMA AAC[3]		% WOOD SOURCE	
			PER DAY	ANNUAL[4]			million m³		FMA	OTHER[5]
				hard wood	soft wood	Total	soft wood	hard wood		
ALPAC	1992	BKP	1500	396000	99000	495000	0.39	2.44	90	10
DC	1990	BKP	1000	272000	68000	340000	0.03	1.09	61	39
MWP	1988	BCTMP	680	90000	130000	220000	0.08	0.73	41[6]	59
PNGC	1972	BKP	820		300000	300000	1.36	0.15	33	67
SLPC	1991	BCTMP	350	110000		110000	0	0.17	55	45
WC	1957	BKP	1100		395000	395000	1.70	0.20	68	32
TOTAL			5450	868000	992000	1860000	3.56	4.78		

TABLE 1.2: Alberta Pulp Mill and Receiving Environment Flow Rates

MILL	EFFLUENT DESIGN FLOW RATE			RIVER FLOW RATE		% EFFL. TO RIVER FLOW	
				Winter low	Summer high	Winter low	Summer high
	m³/day	m³/ADMT	m³/s	m³/s	m³/s	%	%
ALPAC	82080	55	0.95	42	1075	2.26	0.09
DC	75000	75	0.90	550	5570	0.16	0.02
MWP	15000	22	0.17	19	720	0.89	0.02
PNGC	60000	73	0.69	13	341	5.30	0.20
SLPC	7000	15	0.08	30	60	0.30	0.10
WC	100000	90	1.16	33	530	3.52	0.22

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1 BKP = Bleached Kraft Pulping; BCTMP = Bleached Chemi-Thermochemical Pulping

2 ADMT = Air Dried Metric Tonne

3 AAC = Annual Allowable Cut - the volume of timber that a company can cut to maintain a sustained yield in perpetuity. AAC allotments are used by forest owners, i.e., provincial government, as a means of controlling cutting practices.

4 Figures confirmed by Mr. B. Demulder, Forest Industry Development Division, Alberta Forestry, Lands and Wildlife, September 1992 as well as by companies during interviews.

5 Mills also obtain wood by purchasing chips form nearby sawmills and logs from other smaller logging companies holding timber rights (quota). Some mills utilize chips from sawmills owned indirectly by the company. Some mills with FMAs also have other harvesting rights (quota).

6 Millar Western does not hold an FMA; logs are received from quota holding rights and chips from Millar Western sawmill.

TABLE 1.3: Summary of In-plant Processes Influencing Effluent Quality in Alberta Pulp and Paper Mills

MILL[7]	T	BSW	ED[8]	OD	$HClO_2S$	BLEACH SEQUENCE[9]
ALPAC	no	yes	yes	yes	yes	$D_oE_{op}D_nD$
DC	yes	yes	no	yes	yes	$C_DE_o(DN)D$
MWP	n/a	n/a	n/a	n/a	n/a	Hydrogen Peroxide
PNGC	yes	yes	no	no	100%	$DE_{op}DED$
SLPC	n/a	n/a	n/a	n/a	n/a	Hydrogen Peroxide
WC	yes	yes	no	yes	25%	$DE_o(DE_sD)$
					75%	$D/C\ E_o(DE_sD)$

TABLE 1.4: Summary of Out-of-Plant Effluent Treatment Processes in Alberta Pulp Mills

MILL	1° CLARIFIER	SLUDGE TREAT-MENT	2° CLARIFIER	ASB	EMERGENCY SPILL SYSTEM	AS	RIVER DIFFUSER
ALPAC	settling	pressed burned	yes	no	yes	yes	yes
DC	settling	pressed burned	no	yes	yes	no	yes
MWP	settling	pressed burned	yes	no	yes	yes	yes
PNGC	settling	pressed landfill	no	yes	yes	no	yes
SLPC	flotation	pressed burned	yes	no	yes	yes	yes
WC	settling	pressed landfill	no	yes	yes	no	yes

---

7 BSW = Improved Brown Stock Washing; ED = Extended Delignification; OD = Oxygen Delignification; $HCLO_2S$ = High ClO_2 Substitution; T = Turpentine and other by-product production.

8 Although Weldwood and Daishowa have the capacity to employ extended delignification, the mills do not use the process due to decreased product quality and unchanged effluent loading. Also, in Weldwood, although turpentine products can be extracted, due to extremely poor market conditions, these compounds are remaining in the process.

9 BLEACHING SEQUENCE (numbers denote %): C = Chlorine stage; D = Chlorine dioxide (ClO_2) stage; E = Caustic Extraction; E_{op} = Extraction with hydrogen peroxide; E_sN = NaOH.

TABLE 1.5: Alberta Pulp and Mills Actual Effluent Annual Averages

MILL	BOD_5 kg/d	BOD_5 kg/ADMT	TSS kg/d	TSS kg/ADMT	AOX kg/d	AOX kg/ADMT	COLOR kg/d	TOXIC 96hr LC50
ALPAC	2250	1.5	4500	3.0	436	0.29	55900	
DC	1900	1.9	6668	6.7	650	0.68	70973	10/10
MWP	604	0.9	1837	2.7	0	0	8515	9/9
PNGC	1812	2.2	1696	2.1	508	0.62	102960	7/8
SLPC	739	2.1	708	2.0	0	0	12062	7/14
WC	2372	2.2	5084	4.0	943	0.86	109472	9/9

TABLE 1.6: Alberta Pulp and Mills Current Effluent Licence Standards (Monthly Averages)

MILL	BOD_5 kg/d	BOD_5 kg/ ADMT	TSS kg/d	TSS kg/ ADMT	AOX kg/d	AOX kg/ ADMT	COLOR kg/d	TOXIC 96hr LC50	LIC EXP DATE
ALPAC	2250	1.5	4500	3.0	436	0.29	55900	100%	PC only
DC	5500	5.5	14500	14.5	1400	1.4	182000	100%	May 93
MWP	2040	3.0	3400	5.0	0	0	30600	100%	Dec 93
PNGC	5330	6.5	7380	9.0	2050	2.5	185000	100%	Dec 92
SLPC	1050	3.0	1750	5.0	0	0	15750	100%	Nov 93
WC	3300	3.0	15950	14.5	1650	1.5	200000	100%	Dec 92

For All Mills: RESINS AND FATTY ACIDS $\leq$ 2 mg/L; pH 6.5 - 9.5.

CHAPTER 2 ENVIRONMENTAL IMPACTS OF PULP MILL EFFLUENT

2.1 DESCRIPTION OF THE AFFECTED ENVIRONMENT

2.1.1 Natural History

The landforms present today in Alberta have resulted from a series of events occurring over a long period of time. At the end of the Cretaceous era 65 million years ago, the Rocky Mountains were formed by the buckling of thick sedimentary rocks originating in the Devonian, Mississippian and Cretaceous eras. About 500,000 years ago during the Pleistocene Ice Age, glaciers moved across the Canadian shield and central plains from the northeast to join glaciers flowing from the Rocky Mountains. These combined ice flows moved southward into the USA. The melting of these glaciers about 10,000 years ago modified the landscape. The large amount of released water formed the lakes and rivers which are present today. During this melting process, solid material, ranging from fine mud to huge boulders, was deposited into various landforms. Depending on the underlying bedrock geology, these landforms in Alberta are classed into four general regions: Rocky Mountain ranges, foothills belt, the plains and forested lowlands, and Precambrian Shield.

This geological history, along with moisture, temperature, latitude and elevation, contributed to a variety of biotic zones or ecosystems in Alberta: Prairie, Aspen Parkland, Alpine, Foothills and Boreal Forest.

The Prairie Zone is the warmest and driest part of Alberta located in the south eastern corner. Predominated by grasslands, it includes the Short Grass, Mixed Grass, and Fescue Grass Prairies. Restricted by moisture, trees grow only along streams. However, in the Cypress Hills, an area with higher elevation located within the prairie zone, pine forests have developed on the cooler, moister north slopes.

North of the prairies is the Aspen Parkland Zone. This area is a mixture of aspen groves, located in depressions with gray soils and fescue prairie or agricultural areas with dark brown soils. Associated with the aspen groves are well developed shrub communities.

The Alpine Zone is located above the treeline in mountainous areas. Typically, meadows and heaths develop where soil has accumulated, fens where soil is water-logged, lichens where soil is absent. The forests located between the alpine and the lower more productive forests is called Subalpine Forest and characterized by severe conditions. Englemann spruce and subalpine fir predominate with lodgepole pine on burned areas.

The Foothill Zone is located west of the Aspen Parkland Zone and on the lower slopes of the Rocky Mountains. This area is characterized by a transition from grassland to forest. Douglas-fir grows on warmer, drier slopes; white spruce grows on more northern wetter areas. Lodgepole pine tends to be found in areas that have been burned, especially at higher elevations. Aspen groves and small, open grassland areas are also present at lower elevations.

In the north, the Boreal Forest Zone is located in areas wetter and colder than the Aspen Parkland Zone. Although small areas of prairie are present, this zone is characterized by substantial forest cover. In the north, aspen predominates over conifers and in the south, coniferous forest is more common. Typically, white spruce grows on moister areas with black spruce and tamarack on muskeg sites and jack pine on dry, sandy ridges.

2.1.2 Description of Forests Resources

The Boreal Forests and western Foothill Zones as well as portions of the Subalpine Zones are considered to be the productive forest areas in Alberta, approximately two thirds of the province or 21 million hectares.

The provincial government recognized the potential of forests as early as 1906 when the first forest reserve was established in what is now Elk Island Park. In 1910, the Forest Reserve and Parks Act was passed, setting aside about 4.7 million hectares in the Rocky Mountains. More forestry reserves were created during the early 1900s and ranger stations were established to reduce losses from forest fires. Control of natural resources was transferred from the federal to provincial government in 1930 and eventually these reserves became Forest Districts.

Inherent in sustained yield forest management are the establishment of a secure land base and maintenance of current inventories. In 1948, Alberta set aside the Green Area, northern forested lands (53% of province), for forest management and prohibited settlements and land sales. Land could be withdrawn only after review if a use higher than forestry could be demonstrated. The first forest inventory, called Phase 1, was initiated in 1949, in response to concerns meeting future timber demands. This inventory was completed in 1956 and covered forests on publicly owned lands in the Green Area. To provide more detailed data, the Phase 2 Inventory was initiated in 1956 and completed in 1966. The most recent and intensive inventory, Phase 3, was initiated in 1970 and completed in 1984. This latest work provided more detailed information and updated the previous inventories.

The provincial government in Alberta controls utilization of timber and the level of forest management through a licencing quota system. In 1954, Forest Management Agreements (FMA) were created to secure timber resources for renewable 20 year terms thereby providing stability for companies to invest substantial capital in pulp mills. The FMAs incorporated concepts of sustained yield, harvesting and management of forested areas over entire rotations (80 years for conifers).

The amount of timber available for harvesting within each FMA, called the Annual Allowable Cut (AAC), depends on the type and quality of the forests, with the intent that timber can be cut in perpetuity, on a sustained yield basis. In 1990, the total provincial AAC potential, combining coniferous and deciduous trees, was estimated to be 24.7 million m^3 (See TABLE 2.1). Of the 14.3 million m^3 potential coniferous

AAC, 58% was actually cut, an additional 28% was committed, and 14% was uncommitted. Of the available 10.4 million m³ deciduous AAC, 13% was actually cut, and an additional 30% was committed, and 57% was uncommitted (Alberta Forestry, Lands and Wildlife, 1992).

TABLE 2.1: Area and Volume Summary by Land Classification and Forest Type (Alberta Forestry, Lands and Wildlife, 1985 & 1992; D. Price personal communication, 1992)

FOREST TYPE	PRODUCTIVE AREA[10]		VOLUME million m^3	POTENTIAL AAC	
	HA	% of prov. total land area		% allo-cated	million m^3
Coniferous pure & mixed	11,021,213	17	1,512.2	86	14.3
Deciduous pure & mixed	9,138,245	14	842.6	43	10.4
Total	20,159,458	31	2,354.8	68	24.7

Environmental protection within each FMA is administered through the Harvest Planning and Operating Ground Rules. These guidelines are a subset of the actual FMA document and negotiated separately with each company, within overall provincial standards. The rules include details on quality of road construction, protection of wildlife habitat, and maintenance of water quality. Renewal of an FMA depends on the company's compliance with the Harvest Planning and Operating Ground Rules.

Reforestation of harvested areas has been required by law since 1966 and all FMAs require complete reforestation to provincial standards. Harvested areas must be restocked with specific tree species to certain tree sizes within 14 years of cutting. In areas where conifers are harvested, tree planting is usually carried out within two

10 Productive forest land is defined as land capable of producing 50 m³ or more of wood per hectare within 120 years. Other area classes include potentially productive, i.e., burned areas; insect killed areas; forested non-productive, i.e., scrub & muskeg; and non-forested non-productive, i.e., grassland, rock, cultivated land, water.

years of harvesting. Deciduous areas are usually restocked naturally. Within the 14 years, the areas are surveyed and treated appropriately to ensure restocking. The number of trees planted in Alberta between 1962 and 1972 increased from 173,000 to 2,168,000 seedlings. In the 1990s, it is anticipated that 100 million seedlings will be planted. In 1990, of the 46,000 hectares harvested, 80% will be scarified and planted with the remaining areas left to restock naturally (Phase 3 Inventory Alberta Forestry, Lands and Wildlife 1992).

Integrated resource management plans are used to coordinate the multiple use of the various resources associated with forest lands, including recreation, agriculture, wildlife, energy, and watershed integrity. These plans have been particularly popular since the early 1970s on the eastern slopes of the Rocky Mountains where activity levels are high.

There has been considerable debate regarding the environmental impact of current forest management practices. Clear cutting with sustained yield concepts and heavy reliance on planting for reforestation in Alberta is considered by some to have disastrous effects on local and world environments. It is important to note that under the FMA system, companies practice forest management at a level considered to be one of the highest in Canada. These practices may not be as high as in Europe or the USA, but are considered by professional foresters to be above "standard practices".

The public's concern about forestry practices by FMA holders is probably one of the most important aspects of pulp mill development and difficult to separate from concerns about direct environmental impacts from the mills. As of 1992, the provincial government requires companies with FMAs to solicit public input, on a formal, ongoing basis. Some companies have recognized the need to integrate the two aspects of the industry and combine forestry and mill issues either in the FMA Public Involvement Process (WC, 1987) or through Environmental Advisory Committees (Personal Communication PNGC).

Determining the validity of the forest management impacts by FMA holders, however, is beyond the scope of this study. Public concern about development of forested wilderness areas will be discussed along with other public concerns about pulp mills in Chapter 6.

2.1.3 Description of Water Resources

Alberta Environment has described water to be one of the province's most important natural resources (Environment Council of Alberta, 1985). The natural water systems have supported human settlements and influenced their distribution. Water has been withdrawn, used, and returned by both settlements and industry. As populations and settlements grew, infrastructures for controlling water supply and sewage disposal became important and as a result municipal sewage systems were developed. Industry used water for cooling, lubricating and cleaning; as a result, water treatment became necessary to minimize impact on the receiving environment. Most of the province's major population (75%) in cities and towns utilize surface water sources and the remaining rural population (25%) utilizes ground water sources.

Each natural water system is unique in ecological characteristics (Environment Council of Alberta, 1985). Ecosystems are influenced by water flow patterns and volumes, temperature, sediment loads, nutrient levels and metal/salt concentrations. These factors determine the occurrence and abundance of plant, invertebrate, and fish populations within the water system. Although ecosystems can be characterized by indicators, generally a water system is in a constant state of flux, adapting to changing conditions such as flows.

In Alberta, the two main watersheds are the Saskatchewan-Nelson and the Mackenzie River systems; both originate in the eastern slopes of the Rocky Mountains (Alberta Industry and Resources, 1992). Generally, these surface water systems experience seasonal flow variations with maximums resulting from snow melt in late summer and minimums occurring usually under ice cover in late winter.

The total mean annual flow is comprised of 67.7 billion m^3 originating in the province and 67.3 billion m^3 from British Columbia, Saskatchewan and the United States. Less approximately 10% withdrawn for local use, the total mean annual discharge is 121.5 billion m^3, approximately 2% of Canada's total stream flow.

TABLE 2.2: Summary of Watershed Area and Discharges by River System in Alberta (Alberta Industry and Resources, 1992)

RIVER SYSTEM	LAND & WATER AREA		MEAN ANNUAL DISCHARGES	
	billion ha	%	billion m^3	%
Sask.-Nelson	26.1	35	15.8	13
Mackenzie	48.5	65	105.7	87
TOTAL	74.6		121.5	

The Saskatchewan-Nelson River system drains into Hudson Bay and in Alberta, consists of the Beaver, North Saskatchewan, Battle, Red Deer, Bow, Oldman, and South Saskatchewan rivers. This system covers 35% of the province's land area, primarily in the south and contributes to 13% of the mean annual river discharges (See TABLE 2.2). These rivers provide water for hydroelectric power developments plus domestic, urban, industrial, irrigation, and recreational purposes.

The Mackenzie River system drains into the Arctic Ocean and is comprised of the Athabasca, Peace, Slave, and Hay Rivers. This system, located in the northern portion of the province, covers 64% of the land area and accounts for 87% of the mean annual river discharges leaving the province. All six pulp mills in Alberta are located on these northern rivers.

The Athabasca River contributes about 25% of the flow of the Slave River, with the remaining portion contributed by the Peace River (MacNichol, 1989). Alberta's Peace and Athabasca Rivers constitute 25% of the flow of the MacKenzie River at its mouth. The Athabasca, fed by the Columbia Icefields at the headwaters in the Rocky Mountains near Jasper, falls 750m, and travels over 1280 km to the Peace-

Athabasca Delta and Lake Athabasca. Although most of the Athabasca River is ice-covered for about three months of the year, ice is broken at warm water pulp mill discharge sites and at the Grand Rapids upstream of Fort McMurray. The Athabasca River in the upper foothill reaches, tends to have high alkalinity/hardness, relatively low suspended solids, and low dissolved oxygen in winter. The intermediate reach, Fort Assiniboine to Fort McMurray, is lower in alkalinity/hardness and moderate in suspended solids. The downstream reach, Fort McMurray to Lake Athabasca, is slower moving, lower in alkalinity/hardness, and higher in suspended solids.

The Peace River flows 1650 km from its headwaters in the Rocky Mountain Trench to its confluence with the Slave River (MacNichol, 1989). Except below the Bennett Dam and the Vermilion chutes, most of the river is ice covered for about three months of the year. The Bennett Dam influences the river flows: spring floods have been 50% lower than natural levels; winter flows have been 300% higher. The Peace River tends to be well oxygenated along its entire length, slightly alkaline, and very turbid during high flows.

The Peace/Athabasca Delta, between Fort Chipewyan and Fort Smith, is considered to be the most biologically productive area in the province and a world heritage site (MacNichol, 1989). The delta water flow is complex, being mixed from Lake Athabasca and the Peace and Athabasca Rivers. The basic flow pattern is determined by the Peace River's water level.

The Slave River flows from the confluence of the Peace River (contributing 60%) and Riviere des Rochers (originating in Lake Athabasca and contributing 40%) for 420 km into Great Slave Lake in the Northwest Territories. Only 200 km are located in Alberta (MacNichol, 1989). The Slave River tends to be turbid and relatively alkaline.

2.2 IMPACTS OF EFFLUENT ON THE AQUATIC ENVIRONMENT

2.2.1 Effluent Sources

For a long time, rivers have been used for waste disposal by agricultural, domestic and industrial users. Concern over the impact by pulp and paper mill effluent on the receiving environment has been realized since the industry started in Canada in the early twentieth century. Oxygen depletion and total solids were the primary concerns, and to a lesser degree colour and turbidity. The concern about impacts has been present in Alberta since 1966, when one of the first major effluent treatment systems for pulp mills in Canada was installed at Hinton. In the 1970s, effluent toxicity became an important aspect of effluent monitoring when fish bioassays were introduced. With the development of improved analytical techniques with gas chemotography/mass spectrometry equipment, specific chlorinated compounds, primarily phenolics, were being identified. Continuing this type of research in the 1980s, bleach liquors from pulp mills came under investigation. It became apparent that bleach liquor toxicity depended upon both the chosen bleach sequence within the plant and external effluent treatment (Folke, 1989).

Wood is composed of cellulose (fibre), lignin, hemicellulose and extractives, and each of these produces different types of waste (See TABLE 2.3). Pulp is formed from the cellulose fibres. The type of pulping process used, chemical or mechanical, determines the amount and type of waste produced. Chemical pulping separates lignin and hemicellulose from wood fibres, whereas mechanical pulp does not. Therefore, in chemical processes, effluent is composed of lignin, hemicellulose and extractives. In mechanical processes, most of the lignin and hemicellulose remains with the fibres.

TABLE 2.3: Summary of Wood Resulting Waste Component (Hall, 1992)

WOOD COMPONENT	% COMPOSITION	PRIMARY WASTE COMPOSITION
cellulose (fibres)	45	suspended solids
lignin	25	chomophores
hemicellulose	25	BOD
extractives	5	Toxicity

In chemical pulping processes without chemical recovery systems, the higher the yield, i.e., pulp production to wood used, the lower the effluent organic loading, i.e., BOD. In kraft plants with chemical recovery, effluent quality depends on the efficiency of the recovery system. For a typical modern kraft mill with a chemical recovery system, the sources of effluent entering the exterior treatment system include:

- bleach plant and ancillary mill areas' acid streams;
- bleach plant and ancillary mill areas' alkaline streams;
- miscellaneous discharges from general mill sewer;
- brownstock, bleach plant, and machine room sewer discharges; and
- mill sanitary waste discharges.

In a state-of-the-art kraft pulp mill, effluent entering the exterior treatment systems is handled by three separate sewers. The general sewer collects discharges from the brownstock, bleach plant and machine room areas. The alkaline sewer effluent is mixed into the general mill sewer, which are both processed by the primary treatment system. After being neutralized, the acid sewer, being low in suspended solids, is released into the secondary biological treatment system. TABLE 2.4 lists typical effluent characteristics of the three sewers.

TABLE 2.4: Predicted Characteristics of Modern Kraft Sewer Streams (Adapted from ALPAC, 1989)

PARAMETER & UNIT		ACID SEWER		ALKALINE SEWER		GENERAL SEWER	
		soft wood	hard wood	soft wood	hard wood	soft wood	hard wood
Volume	m^3/ADMT	11.0	11.0	15.0	15.0	26.0	26.0
Temp	°C	60.0	60.0	70.0	70.0	50.0	50.0
TSS	kg/ADMT	-	-	-	-	11.0	13.0
BOD	kg/ADMT	3.5	2.2	3.5	2.2	13.0	12.0
Colour	kg/ADMT	7.0	2.2	26.0	11.0	40.0	17.0
TOCL	kg/ADMT	1.2	3.0	0.3	0.5	-	-
pH		4.0	4.0	9.0	9.0	7.0	7

In the mechanical pulping processes, chlorinated organics are not generated because the pulp is brightened with hydrogen peroxide. Generally, since this process does not have a chemical recovery system, BOD and TSS effluent loading is higher than the kraft process. Effluent loading from CTMP is higher than from TMP. Typically, the main source for effluent TSS is from the tertiary cleaner and chip washer reject streams and consists mostly of fibre. This can be reduced by additional centrifugal cleaning and by effective fibre recycling systems. The resulting sludge can be dewatered and landfilled either directly or through the primary effluent treatment system. Adequate design and efficiency of the saveall/pulp thickener reduces fibre and white water loss.

2.2.2 Effluent Parameters

The aim of pollution control is to minimize the impact of effluent on the receiving environment. This can be done by three different approaches (US EPA, 1991). Water quality objectives or limits can be set for individual parameters. The toxicity of effluent being discharged can be set to a certain limit. The impact of the effluent in the receiving environment can be assessed. The US EPA suggests that all three methods should be utilized. Ideally, the effluent returning to the environment, should have the same or higher water quality levels as source. In practice, effluent treatment has been aimed at reducing negative impacts, implying that each receiving environment has an assimilative capacity to handle some deleterious substances without lowering the habitat quality of the water.

Assimilative capacity levels are set by government regulating agencies and based on river monitoring data measuring natural water quality data and effluent impacts on a particular river system. Pollutants are defined as factors that exceed these buffering limits and cause negative impacts on the carrying capacity of the receiving water. Pollution parameters, commonly used by the government to regulate the pulp industry in Alberta, are detailed in APPENDIX B.

Liquid pulp mill effluent is a slurry comprised of solids, and other chemicals occurring in various phases/states. Organic solids are a major problem with pulp mill effluents due to their potential for depleting dissolved oxygen in the receiving water. In water, biodegradable organic material utilizes dissolved oxygen during the biodegradation process, depleting the amount available for aquatic life. This biochemical oxygen demand (BOD) has been used to estimate the amount of organic material in pulp mill effluent and the resulting oxygen demand in the receiving waters. Other important components of effluent solids are those that can settle out of solution. These particles settle and form a sludge in the receiving water disrupting the ecosystem. The sludge smothers bottom dwelling invertebrates and destroys spawning areas for fish. Effluent colour, caused by the presence of dissolved organic solids, is considered to be a major aesthetic problem, particularly for kraft mills.

Pulp mill effluents tend to be low in nitrogen, phosphorus, and trace metals. These elements, essential for microorganism metabolism, are often added to the waste stream to ensure optimization of the biological waste treatment processes. These elements are removed by the same biological treatments so that the levels in effluent are low.

Chlorinated organics are produced by pulp mills using chlorine in their bleaching process. In kraft mills, about 95% of the wood resins are removed during the brown stock washing and directed into the chemical recovery and effluent treatment streams. The remaining 5% are removed from the fibres by a chemical bleaching process, usually with chlorine. Chlorine combines with the organic compounds to produce chlorinated organics. The amount formed and contained in the effluent is measured in Alberta as AOX (Absorbable Organic Halogens). (AOX is an arbitrary fraction of the chlorinated compounds in the effluent, i.e., portion readily adsorbed to activated carbon). It is important to note that this test is not a measure of toxicity. It determines the amount of organic compounds with chlorine or other halogens, each with a different level of toxicity.

Toxicity of pulp mill effluent is considered to be a major problem which can be caused by a number of compounds derived from the wood and process chemicals (See TABLES 2.5 and 2.6), including resins and fatty acids as well as some chlorinated organic compounds. The basic pulping process involves separating the polysaccharide fibrous material (60% of wood) from the polyphenolic macromolecules or lignin (30% of wood). There are numerous possible lignin derivatives available from these polymers, and they constitute the main source of waste from the kraft pulping process. Potentially, for every 2 tonnes of pulp produced, approximately 1 tonne of lignin waste results (US EPA, 1971).

TABLE 2.5: Principal Toxic Compounds Formed in Pulping and Bleaching Processes (Casey, 1980)

PROCESS	CONSTITUENTS THAT MAY BE TOXIC
Debarking	Resin acids; Unsaturated fatty acids; Diterpene alcohols
Kraft pulping	Resin acids; Unsaturated fatty acids
Mechanical pulping	Resin acids; Unsaturated fatty acids; Diterpene alcohols; Javabiones
Bleaching and caustic extraction	Chlorinated resin acids; Unsaturated fatty acid derivatives

TABLE 2.6: Known Organic Compounds in Pulp Mill Effluent Toxic to Fish (Eddy, 1984)

Type of Organic Compounds (non-volatile toxicants)	Toxic Contribution[11]		
	High	Med	Low
RESIN ACIDS : Abietic, dehydroabietic, isopimaric, palustric, pimaric, sandaraco-pimaric, neoabietic	KP,D, M,S		
UNSATURATED FATTY ACIDS: Oleic, linoleic, linolenic, palmitoleic		KP	S, D,M
DITERPENE ALCOHOLS: Pimarol, isopimarol, abienol, 12E-abienol, 13-epimanool		M	D
JUVABIONES: Juvabiones, juvabiol, todomatuic acid, 3'-deoxy-3'hydroxytodomatuic acid, dehydrojuvabione, dehydrojuvabiol		S	M
LIGNIN DEGRADATION PRODUCTS : Eugenol, isoeugenol, 3,3'-dimeth -4,4'-dihydroxystilbene			S
CHLORINATED RESIN ACIDS: Mono & dichloro dehydroabietic		K,C	
UNSATURATED FATTY ACID DERIVATIVES: Epoxy & dichlorostearic		K,C	
CHLORINATED PHENOLICS: Tri & tetrachloro guaiacol		K,C	
MISCELLANEOUS: Non-ionic dispersants			K,C

Depending on the process used, acidity, alkalinity, and heavy metals may form major problems from pulp effluent (Casey, 1980). Both kraft and BCTMP pulp mill effluents tend to be high in alkalinity. Prior to biological treatment and to discharge into receiving waters, the pH in all mills has to be adjusted to neutral conditions (pH=6 to 8) to minimize the shock on the invertebrate and fish communities. The heavy metals of principal concern in pulp mill effluent are aluminum, chromium, copper, nickel, titanium, iron, mercury and zinc. These heavy metals originate from the chemicals used in the pulping process, and from corrosion.

11 K = kraft, P = pulping, C = caustic extraction, S = sulphite pulping, D = debarking, M = mechanical pulping.

Pulp mill waste is a potential source of thermal pollution. Pulp processes involve high temperatures and produce high raw effluent temperatures. These high temperatures are of benefit to biological treatment, which requires high temperatures for optimization (35°C), but can have detrimental effect, on aquatic life in the receiving waters.

2.3 RIVER MONITORING

2.3.1 General

In the discussion about pulp effluent environmental impacts, there is a growing trend in pulp mill monitoring programs toward testing for long term effects. Short term testing, i.e., LC_{50} fish toxicity, determines immediate impacts, but long term monitoring is aimed at measuring changes in stream biota and chemical-physical cycles caused by effluent discharges (Mischuk, et al., 1989). The benthic organisms, being sedentary with a long life cycle, are subject to local environmental changes, which allows for both temporal and spatial analysis. Species richness, kind and number of taxa can change in response to organic pollution (Hynes, 1960) and communities of organisms tolerant to the input will be established.

As part of the most recent Fisheries Act amendments, the federal government required pulp mills throughout Canada to meet long term monitoring standards identified in the Environmental Effects Monitoring (EEM) program. In Alberta, the provincial government has required mills to conduct river monitoring as part of the Licence to Operate issued under the Clean Water Act. The requirements of these programs vary depending on mill site and are modified as the licences are renewed. The requirements for the most recent mill, ALPAC, are similar to the EEM program and include:

- benthic invertebrate monitoring surveys twice per year during spring and fall;
- a water quality and sediment chemistry monitoring survey each year during low flow under ice cover;
- water quality and quantity monitoring of local water courses once per year in the spring; and
- fisheries resources' creel survey, fish tissue analysis, and fish taste testing once per year.

Within the water quality standards, dissolved oxygen (DO), is considered important to protect fish habitat. For example, in the Athabasca River, six salmonidae species (including whitefish, trout, and grayling) inhabit various reaches. In order to protect habitat for these species and overall aquatic quality from regulated pollution sources, knowledge about the receiving environment in regards to the spread of pollutants and the river's flow characteristics is necessary to form the basis for models which assist government agencies in determining licensing parameter levels for all users of the system.

2.3.2 Alberta Dissolved Oxygen River Models

The study of fluid and river mechanics has been developing over the last 35 years and has recently become popular as a modeling tool. Numerous physical processes affect discharges into rivers and should be incorporated into river modeling and monitoring: advection, molecular and turbulent diffusion, differential advection, and secondary circulation. Advection refers to transport by the river current in the same direction as the river flow and depends on the substance concentration and the river flow velocity. Molecular diffusion accounts for the spread of substances due to the random motion of molecules, usually occurring on the interface between the plume and the surrounding body of water. The eddying motion of the river causes turbulent diffusion of substances in all directions. Differential advection results from the variation in flow within the river cross section in both the vertical and horizontal directions. Secondary circulation contributes to transport when the concentration is not uniform over the cross section and is caused by secondary currents when turbulence is not identical in all directions.

Based on surveys conducted in 1970, 1975, and 1989 for PNGC, a dissolved oxygen model for the Wapiti/Smoky River watershed was calibrated for seasonal flow levels, river velocity of various reaches, BOD decay and reaeration processes, and model parameters. In this study, Hodgson and Barth (1989) found, firstly, that the critical low-flow period for DO in northern Alberta Rivers occurs during the winter months under ice-cover. This contrasts with data used by other popular DO river models developed on southern systems where low flows occur during the summer months. Secondly, slug injection tests proved sufficient to quantify river velocities while covered in ice. Thirdly, while 1-component BOD decay models provided the best laboratory results for BOD exerted, 1-component model underestimated a 2-component model for ultimate BOD. Fourthly, Wink DO analysis showed negative bias due to reducing agents in the effluent. In-situ DO meter measurements were more accurate in determining winter DO levels in river systems. Fifthly, the DO model was calibrated to actual field measurements within 4%. Finally, BOD decay rates in the field at 0°C were 60% of the laboratory BOD decay rates at 20°C (Hodgson and Barth, 1989).

In 1986, a report (Fonstad, et al., 1986) aimed at river mixing analysis problems and developing guidelines for the 1985 Alberta Environment Water Quality Task Force for future pulp mill submissions recommended that detailed analysis be completed with each application for releasing pulp mill effluent. The study recognized that limited data were available and recommended that Alberta Environment:

- collect information regarding toxicity levels to fish by species, as well as allowable exposure and concentration levels;
- prepare a list of trace elements considered harmful to the public and the environment, with allowable concentration levels;
- require applicants to identify individual effluent constituent concentrations at water intake sites within the mixing zone;
- require applicants to determine distance downstream from the source where Canadian Water Quality Standards (or others) would be met;
- require applicants to determine the required dilution to meet standards prior to discharge ;
- require applicants to determine subsequent treatments needed by down-stream users as a result of the concentrations determined above;
- require applicants to address emergency notification for downstream users under plant failure or abnormal situations; and

- require applicants to determine the extent of the possible zone non-compliance with respect to some allowable reference concentration.

The provincial government completed synoptic surveys of 25 stations in February and March 1988, and extensive surveys were conducted at 70 stations during the winter of 1988-89. This information (NAQUADAT data base) formed the foundation for a mid-winter under-ice water quality model, which has played a significant role in establishing effluent BOD standards for pulp mills on the Athabasca River. This modeling identified a critical dissolved oxygen depletion period between December and March during low flows and ice-cover conditions. The oxygen deficit was due to low effluent dilution and almost no reaeration potential due to the ice cover (Hodgson, et al., 1989).

After the 1987-88 winter season and calibration for the Athabasca oxygen model, several items were identified as requiring further research (McKenzie, et al., 1989) and included in the 1988-89 winter study:

- effluent quality for ultimate BOD, and the proportion subject to fast versus slow decay (conducted by Alberta Environment Centre at Vegerville);
- length of open-water zones that will develop below the mills and provide a zone of reaeration (conducted by HydroQual using direct tracer gas measurements with propane and aerial photography);
- degree of sediment oxygen demand that will develop below the new mills (conducted by Alberta Environment's Environmental Assessment Division downstream from WC and MWP);
- refined estimates of tributary oxygen level (conducted by Alberta Environment's Environmental Assessment Division); and
- confirmation of BOD decay rates under low temperatures.

In 1989, the DO concentrations standard was 5 mg/L during 7Q10 flow conditions, which corresponds to the Prairie Provinces Water Board and Alberta Surface Water Quality Objectives (ASWQO). In response to questions at the ALPAC EIA Review

Board hearings, Alberta Environment prepared information (TABLE 2.7) regarding BOD loading limits on the Athabasca River (MacNichol, 1990).

TABLE 2.7: Athabasca BOD Loading (monthly averages) from all existing and proposed Pulp Mills (MacNichol, 1990)

Mill	1990		1991		1992		1993	
	kg/ ADMT	kg/ day	kg/ ADMT	kg/ day	kg/ ADMT	kg/ day	kg/ ADMT	kg/ day
WC	7.0	7700	7.0	7700	3.0	3300	3.0	3300
ANC[12]	3.0	2100	3.0	2100	3.0	2100	3.0	2100
MWP	7.5	5100	3.0	2040	3.0	2040	3.0	2040
SLPC			5.0	1750	5.0	1750	3.0	1050
ALPAC							1.5	2250
TOTAL		14900		13590		9190		10740

2.3.3 Alberta River Monitoring Surveys

As part of ongoing water quality studies, Alberta Environment collects water quality data from existing effluent, rivers, and sediment. The surveys conducted include the 1975-85 Alberta Oil Sands Environmental Research Program, 1984-85 Water Quality Overview, and the 1987-88 Delta Survey, as well as numerous surveys on the Peace, Slave, Athabasca, and Wapiti-Smoky River systems. Pulp mill companies also have collected similar data from the receiving environments.

a) **Peace River Surveys**

In 1988, Alberta Environment began an extensive water quality study of the Peace River (Shaw, 1990). River monitoring data were collected in 1988 and 1989 at ten sites along the Peace River and its tributary rivers. The purpose was to:

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- characterize water quality patterns over several seasons and years
- identify factors affecting water quality
- assess mixing of the Smoky and Peace Rivers
- describe the aquatic invertebrate animal communities
- compare water quality with the Alberta Surface Water Quality Objectives (ASWQO) and the Canadian Water Quality Guidelines (CWQG).

The results of the survey indicated that the water quality of the Peace River had changed only slightly since 1977. While levels of fecal streptococci bacteria and boron increased, levels of eight other substances decreased. Dissolved oxygen increased slightly. These changes were attributed to the Williston Reservoir on the Peace River in British Columbia. In the intermediate reach, between the Smoky River and Fort Vermilion, concentrations of most constituents increased gradually as a result of tributary inputs, particularly from the Smoky River. Increases in sodium and chloride were attributed to the PNGC pulp mill on the Smoky River and the abandoned Peace River Oils well. Increased bacteria were attributed to the municipal sewage effluent from the Town of Peace River.

The composition of invertebrate animal communities in the upstream portion above the Smoky River confluence was high in number and in variety. In the intermediate section, the total number of invertebrate animals was lower and the variety was higher. In the downstream reach, below Fort Vermilion, both total numbers and diversity were low due to the river bottom becoming naturally more silty and less conducive to invertebrate communities.

The report indicated that water quality in the Peace River did not always comply with the ASWQO or the CWQG. At times, several metals, nutrients and phenolics exceeded guideline levels. Being associated with increases in suspended solids, these changes resulted from natural processes rather than from human activity in the watershed. The report concluded that because the Peace River has high water quality in the headwaters, relatively high volume flows, and continuous natural scouring processes, effluent discharges have little effect.

Other major baseline surveys have been conducted on the Peace River. Discharge sources upstream from the DC mill include the municipality of Peace River, PNGC's kraft pulp mill (via the Wapiti and Smoky Rivers) and a CMTP mill in Taylor, B.C. The Peace River water flow is controlled by the W.A.C. Bennet Dam in B.C. (250 km upstream). A water quality monitoring program was conducted between 1970 and 1983 during the construction of the dam. Data from this and other studies (See TABLE 2.8) were used to determine water quality prior to construction of the DC mill.

Subsequent river monitoring studies provided additional information about the parameters (See TABLE 2.8). Peak values for TSS typically occured in April and May during high water flows. The TSS values tended to be higher on the right side of the river, the same side as the Smoky River confluence. The dissolved oxygen values ranged from 9.0 to 14.9 mg/L and were considered to be relatively high. Apparent colour ranged from less than 5 to 240 relative units.

TABLE 2.8: **Peace River Water Quality Measured at the Town of Peace River (Daishowa, 1987) and Downstream of Mill (HBT AGRA Ltd., 1992)**

PARAMETER	No	BASE LINE DATA[13]		BELOW MILL SITE 4L	
		SURVEY YR	May 1992	April 1990[14]	May 1992
TSS	59	1968-76, 1983	339 mg/L	870 mg/L	30 mg/L
BOD	41	1970-71, 1973-76 1983	0.7 mg/L	1.4 mg/L	1.4 mg/L
DO	29	1970-73, 1973-75	12.0 mg/L	9.9 mg/L	11.4 mg/L
%O_2 Sat.	29	1970-71, 1973-75	96%	82%	96.1%
Aprt. Colour	75	1968-74	37.6 RUn.	60 Co.Un	25 Co.Un
AOX				0.025 mg/L	<0.025 mg/L
Total Coliform Density	30	1971, 1973-76, 1983	2,223 CFU/100 ml		
Fecal Coliform Density	28	1971, 1973-76, 1983	5.6 CFU/100 ml		

As part of the provincial Licence to Operate, DC has recently released results from surveys completed on the Peace River (HBT AGRA Ltd., 1992). The surveys, conducted in May 1992, consisted of 12 water quality and 15 benthic invertebrate sample sites. The 1992 survey results, when compared to the 1990 surveys in 63 different parameters, found no appreciable differences, apart from natural river quality variations. Analyses of the benthic samples did not indicate any differences between upstream and downstream sites or between the 1990 and 1992 surveys.

The water quality near the mill was most influenced by the influent of the Smoky River. Chemical analyses of water samples showed detectable concentrations of AOX in the Smoky River and along the right side of the Peace River channel, the side influenced by the

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13 Data collected prior to mill start up.

14 Data collected prior to mill start up.

Smoky River. AOX was not detected on the left side of the Peace River channel, the side receiving the DC mill effluent.

b) **Wapiti-Smoky River Surveys**

Surveys have been conducted on the Wapiti-Smoky River system by PNGC since 1970 and by Alberta Environment since 1983. Recently, PNGC annual water quality surveys have measured parameters such as temperature, pH, dissolved oxygen, nitrogen, phosphate, sodium, colour and others. The biological surveys of bottom dwelling aquatic insects (benthic macro-invertebrates) measured changes in numbers, species, and community structures. The results showed some enrichment by nitrogen and phosphorus and increases in colour, sodium ion concentrations and BOD levels from both the mill and Grande Prairie sewage effluents. Although the absolute number of benthic organisms increased downstream, the number of different species sensitive to effluent decreased, especially at stations where the effluent stream had not yet completely mixed with the river flows. In general, the company report indicated effects of exposure to the mill and sewage effluents, but these changes, did not impair the water quality and biological life of the river.

The results of PNGC's river ecosystem survey program, initiated in 1989, indicated the health status of fish in the river. Longnose sucker and mountain whitefish were examined for growth, age distribution, fertility, blood chemistry and sex hormone levels. as health indicators. The study showed that some compounds from the mill effluent, i.e., dioxins and furans, were transported in suspended sediment. Bottom dwelling aquatic insects, feeding by filtering water and suspended sediment through their gills, had higher body levels of these compounds. Fish, (mountain whitefish) feeding on these aquatic insects also showed higher levels of dioxins and furans than other species.

The study concluded that fish populations (over at least two generations) have no discernible negative effects from sixteen years' exposure to treated mill effluent at least at the population level. Individual whitefish had higher levels of dioxins and furans than longnose suckers, reflecting the diet differences between the two species. The study also suggested that previous conclusions linking organochlorines with environmental impact should not be generalized to all bleached kraft mill sites. Mill effluent impacts occur in some instances, but not in others. Impacts depend on the quality and quantity of the mill effluent relative to the physical, chemical, and biological characteristics of the particular receiving waters. In the future, these studies will investigate the cause of increased higher dioxin/furan levels, as well as fish migration and degree of exposure to effluent.

Over the years the Alberta Environment surveys have concentrated on low flow periods (November to March) when dilution of effluent is lowest. Winter sampling on the Wapiti-Smoky River system included measuring for hydraulic parameters and sampling for winter water quality, BOD, and continuous oxygen data similar to the Athabasca River surveys. Other information collected included samples of the benthic community, dioxin/furan levels, sediment content, and fish populations (Alberta Environment, 1989).

Detailed results from 1983 fish toxicity study (Alberta Environment, 1987) on the Wapiti-Smoky River system indicated that out of 47 water quality parameters, 30 were elevated in downstream water and 15 of these parameters showed an increase of five-fold or greater (See TABLE 2.9).

TABLE 2.9: Summary of 15 (1982) Water Parameters > 5 Fold Upstream Levels in Wapiti near PNGC Mill in mg/L except as specified (Alberta Environment, 1987).

PARAMETER	UPSTREAM LEVEL	EFFLUENT LEVEL	DOWNSTREAM LEVELS	INCREASE FROM UP TO DOWN STREAM
conductivity (umohs)	265.0	5025.0	2152.0	812%
total dissolved solids	145.0	2619.0	1124.0	775%
filterable residue	262.0	4245.0	1520.0	580%
dissolved organic carbon	ND	258.0	125.0	>2000%
BOD	1.6	80.0	35.8	2225%
COD	29.9	982.0	432.6	1417%
total nitrogen	0.8	7.2	3.3	415%
surfactants	0.1	11.1	4.5	4500%
aluminum	ND	1.4	4.5	4500%
total mercury	<0.000 1	<0.0001	0.0059	5900%
potassium	0.8	11.9	5.4	675%
sodium	7.0	785.0	308.0	4400%
chloride	1.6	943.0	422.0	2637%
sulphate	19.3	468.0	155.6	806%
phenols	0.004	1.0	0.1	2500%

Of the compounds listed in TABLE 2.9, the increases in sodium, potassium and chloride were contributed by the pulp mill process chemicals, while the others were lignin by-products. The mercury increases were caused by physical disturbance of river sediments and not from the chemical composition of the effluent. In general, the parameters which increased downstream corresponded to increases in the same effluent parameters. The study concluded that the mill effluent was not acutely toxic to resident fish populations. Although no long term (subacute or chronic) studies were conducted, typical chronic exposure symptoms were not found, i.e., presence of young-of-the-year in vicinity of effluent discharge, no grossly visible evidence of abnormalities. However, it would be beneficial to measure effects from chronic exposure by investigating non-migratory fish downstream of the mill.

Noton (Alberta Environment, 1992) reported survey results (1987-1991) on the Wapiti-Smoky River system, were in "non-compliance" with ASWQO for certain parameters. These included odour, colour, sulphide, aluminum, chromium, manganese, total nitrogen, total phosphorus, total phenolics, dichlorophenol and total coliforms as well as dioxin/furan in fish. Benthic biota (algae, invertebrates) display evidence of enrichment, but no distinct indications of toxicity. These alterations were attributed mainly to the PNGC mill and to a lesser extent to Grande Prairie sewage and urban runoff.

In response to the "non-compliance" study, PNGC initiated a two-phase study to investigate the effluent effects on the river. The company was notified of the survey results in April 1992. Analysis of 11 of the 12 parameters used by Alberta Environment showed that the PNGC mill effluent directly affected five parameters: true colour, odour, TDS, manganese, and sulphide. The effluent had incremental effects on downstream levels of total phosphorus, total nitrogen, and total phenolics. Typically, these increased levels occur in winter during low flows.

The company completed a review of the Alberta Environment "non-compliance" report and indicated a number of concerns (Stanley, 1992). The samples, used by the government, were limited and taken at infrequent points in time. The company suggested that judgments about water quality should be based on a more extensive sampling program and/or a mass balance assessment of an historical period.

The Stanley report indicated that using the water quality objectives was not an appropriate evaluation of increased parameters levels. The ASWQO, issued 15 years ago, indicate minimum water quality for sensitive use, i.e., public water supply, recreation involving direct water contact, and wildlife/aquatic life protection. The CWQG were developed by a government task force to provide information on the effects of water quality parameters on specific water resource uses, i.e., drinking water, aquatic life.

The ASWQO and CWQG, different from water licence standards, are aimed at maintaining a designated water use at a specified site and as a tool for management of an aquatic ecosystem. Standards are enforceable environmental control laws but the objectives and guidelines are not. Prior to the "non-compliance" report, company performance had been measured against the Licence to Operate standards and not ASWQO. Indicating non-compliance with these previously unapplicable targets was of considerable concern to the company.

The Stanley report indicated that there was no evidence that biological productivity of the river was impaired. Of the twelve parameters studied only two, chromium and some forms of nitrogen (ammonia), were related to toxicity. For example, increased levels above the objectives of sulphide, do not necessarily equate to toxicity. Also, some drinking water sources in the province have naturally high TDS and manganese levels above the objectives. The objective levels for chromium are set for aquatic and human health rather than for aesthetics. Background chromium levels in the river fluctuate seasonally to exceed the objectives upstream and downstream of the mill. The mill and Grande Prairie sewage effluent show relatively low levels of chromium. The company agreed that observed and potential impacts on water quality in the river from the mill discharge are primarily affecting river uses like recreation. Additional studies are required to determine toxic, bioavailable-form concentrations of parameters, i.e., nitrogen, phosphorus, and phenolics, as well as the tainting properties of chlorophenol compounds present in the mill effluent.

c) **Lesser Slave River Surveys**

On the Lesser Slave River, baseline studies were initiated in 1989 and completed in late 1991 to collect data gaps identified by the SLPC EIA process (SLPC, 1991). These studies included examinations of water chemistry, periphyton, bacteria, benthos and fish populations as well as hydrological features of the river system. PISCES (population indicators of sublethal contaminant effects on sucker), a sentinel monitoring framework, was established to assess the impact of the pulp mill on water quality.

Comparison of baseline data collected in 1989 with data collected after startup indicates no measurable impact on river water quality (See TABLE 2.10). River modeling indicates that DO levels would decrease by 0.3 mg/L across the effluent outfall, but the actual change has been measured to be less than a 0.2 mg/L decrease.

TABLE 2.10: Baseline River Data After Startup Data (Firth, et al., 1991)

PARAMETER	UPSTREAM	DOWNSTREAM
pH	6.98-7.07	7.18-7.67
TKN, mg/L	0.96-2.28	0.52-0.80
Ammonia-N, mg/L	0.08-0.09	0.01-0.06
BOD, mg/L	2.3-2.6	1.2-2.0

d) **Athabasca River Surveys**

On the Athabasca River, effluents are discharged from two pulp mills, one oil sands plant, and several municipalities. In the past, monitoring included three long term sites near Jasper, Athabasca, and Embarra/Old Fort. In 1987-89 extensive water quality surveys were conducted on the river to improve the hydraulic and water quality data base used for modeling. These surveys included river geometry and time-of-travel, effluent characterization, monthly key site samples, continuous winter oxygen monitoring data, winter reaeration rates, and data on riverbed BOD.

In early 1990, the Alberta Environment reported on nitrogen and phosphorus levels in the Athabasca River as requested by the ALPAC EIA Review Board (MacNichol, 1990). Concerns had been raised about the increased levels of phosphorus relative to nitrogen loading and the potential shift in the direction of blue-green algae populations in the river. Although the nitrogen/phosphorus ratio was at the level required by aquatic plants, the bio-availability of the particular fractions had not been investigated. Because the ratio of the two nutrients in the pulp mill effluents was approximately 7 (N/P), and even though in higher concentrations than the river, the pulp mill effluent discharges may not alter the river ratio. It was concluded that the total phosphorus would not increase relative to nitrogen as a result of pulp mill effluents. However, since the forms of the nutrient in the pulp mill effluents were more assimilative than the naturally occuring forms in the river, there was a potential for changes in the river nutrient ratios which should be addressed in future monitoring programs.

The results from the Athabasca River surveys indicate that pulp mill effluents had negative impacts on dissolved oxygen, phenolic compounds, trace organic compounds, colour, odour, phosphorus, and manganese and were in "non-compliance" with ASWQO and/or CWQG for oxygen, phenols, colour, odour, and phosphorus (Alberta Environment, 1990). Other parameters that were increased by the pulp mill effluent were: sodium, chloride, sulphate, sulphide, suspended solids, tannin/lignin, organic carbon, nitrogen, and bacteria, as well as a high load of zinc. These results are consistent with previous surveys on the Athabasca River and other surveys from the Wapiti-Smoky River system.

In the spring of 1992, WC completed river monitoring surveys at nine stations above and below the mill outfall to document water chemistry and benthic macroinvertebrate communities (WC, 1992). Consistent with previous surveys, the survey indicated complete mixing at the station 9 km downstream of the mill. Dissolved oxygen remained high at all stations. Temperature was not modified by the effluent. The pH was marginally modified. Total phosphorus and total dissolved phosphorus levels remained below detectable limits. BOD, total and dissolved organic carbon, total Kjeldahl nitrogen and ammonia, and indicative nutrient enrichment, increased below the effluent outfall. Other parameters concentrations, i.e., true colour and sodium ion, had elevated levels at stations below the mill effluent outfall.

The WC report indicated, consistent with previous surveys, that mill effluent showed some influence on the benthic macroinvertebrate communities. Below the effluent outfall, an increased number of organisms indicated nutrient enrichment. The number of taxa remained high, indicating that the effluent was not toxic. The benthic community had a reduced level of diversity below the outfall for several kilometres. At Station 7 located 22 km downstream, diverse community structure was present.

In 1992, MWP reported results of a benthic invertebrate monitoring study on the McLeod and Athabasca Rivers (Sentar, 1992). Data were collected in 1987 and 1988 prior to the mill startup and in 1988 and 1991 subsequent to startup, to document any differences in the benthic communities. The results indicated that most parameter concentrations measured were below ASWQO or CWQG at all sites. In the Athabasca River downstream from the MWP pulp mill and Whitecourt sewage treatment plant, benthic community structure demonstrated organic enrichment by shifting to increased proportions of tolerant taxa.

e) **AOX Surveys**

Surveys on the Athabasca and Wapiti-Smoky Rivers 1989-90 (See TABLE 2.11) indicated that AOX concentrations in rivers increased markedly just below both pulp mills at Grande Prairie and Hinton (Alberta, 1990). Although AOX concentrations declined downstream from the sources primarily due to dilution from tributary inflow, total mass of AOX remain constant. During the winter surveys there were no substantial loss of AOX at 240 km (4.5 days) downstream in the Wapiti-Smoky River system and at 1250 km (35 days) downstream in the Athabasca River. AOX persisted farther downstream into the Peace and Slave Rivers. These levels cannot be considered as "non-compliance" since no surface water quality objectives had been set at the time of the report submission.

TABLE 2.11: Summary of AOX River Survey Data (Alberta Environment, 1990)

SITE	DOWN STREAM DISTANCE km	FLOW	AOX	
		m^3/s	mg/L	kg/d[15]
Wapiti @ Hwy 40	0	14.3	0	0
Grande Prairie mill effluent	12	0.516	33	1500
Wapiti d/s mill	14	14.5	1.3	1600
Smoky River d/s Wapiti	61	61.1	0.34	1800
Peace River d/s Smoky	354	1061	0.016	1500
Ft. Vermilion-Peace River	682	1264	0.030	3600
Athabasca u/s Hinton	0	33.0	0	0
Hinton combined effluent	1.9	0.784	3.3	220
Athabasca d/s mill	7.5	33.1	0.077	220
Athabasca u/s Whitecourt	210	50.7	0.047	210
Millar Western mill	212	0.136	0.12	1.4
Athabasca d/s Millar Western	221	61.8	0.037	200
Athabasca u/s Slave Lake mill	438	73.3	0.047	300
Slave Lake mill effluent		0.033	0.20	0.57
Lesser Slave R. @ mouth on Athabasca	449	43.7	0.007	26
Athabasca R. @ Athabasca	556	117	0.030	300
Athabasca R. @ Lake Athabasca	1239	247	0.013	280

15 Mass transport or load = mg/L x m^3/s x 86400s/d kg/1000g = kg/d.

In the fall of 1990, Alberta Environment released an advisory to limit consumption of some freshwater fish in specific areas of the province. Based on fish samples over three years (See TABLE 2.12) and on human health risk assessed by Health and Welfare Canada, the government decided to adopt a stringent interpretation of the available information. It recommended that the public restrict fish consumption for burbot, Dolly Varden and Mountain whitefish in the Athabasca River drainage and Mountain whitefish in the Wapiti/Smoky River drainage.

Between 1987 and 1990, the Alberta Government conducted over forty fish samplings near the WC pulp mill on the Athabasca River and PNGC pulp mill on the Wapiti River. The fish were tested as whole fish and/or fillets as individuals and composites of four or five fish. Unacceptably high levels were measured in several of these samples, i.e., greater than 20 parts per trillion (pptr) for dioxin and furans.

It is interesting to note that although the government advised restrictions of fish consumption to reduce human health risk, it also included a disclaimer on dioxin/furans as a cause of fish cancer.

> "While dioxins are sometimes implicated in fish cancers in heavily industrialized eastern lakes and rivers, there is no information or reason to conclude this occurs in Alberta. Skin lesions and cancers also occur in pike and walleye in rivers not affected by pulp mills." (Alberta Environment Press Release Kit July 1990)

TABLE 2.12: Summary of Dioxin Furan Data for Alberta Fish (Alberta Environment Press Release Kit July 1990)

RIVER	SAMPLING SITE	SPECIES	NUMBER & FISH PART TESTED	DIOXIN[16] (pptr)	FURAN (pptr)
Athabasca	Below Weldwood mill fall 1987	longnose sucker	5 whole	12.6	49.4
	15-20 km below Weldwood mill fall 1989	longnose suckers	5 whole 10 fillet	2.6 1.6	8.0 4.3
		whitefish	15 whole 15 fillet	18.1 10.2	41.1 26.7
		burbot	1 whole 9 fillet	21.2 2.0	66.8 7.7
		Dolly Varden	5 whole 5 fillet	21.9 12.1	20.9 12.7
		rainbow	3 fillet	6.7	5.2
Wapiti	Below PG mill fall 1987	longnose sucker	5 whole	11.4	203.4
	1-10 km below PG mill fall 1989	white sucker	5 whole 10 fillet	5.5 4.0	23.2 9.8
		whitefish	10 fillet	18.7	156.8
		walleye	5 fillet	1.8	4.3
		northern pike	8 fillet	1.5	9.5
Peace	Below & above Daishowa mill site fall 1988	goldeye	10 fillet	ND	4.1
		walleye	10 fillet	ND	<1.6
		northern pike	5 fillet	ND	<1.6
Rock Lake	Control fall 1989	whitefish	5 whole 5 fillet	<2.3 <1.9	<1.9 <2.2

16 Dioxin=2,3,7,8 T4CDD; Furan=2,3,7,8 T4CDF.

CHAPTER 3 TECHNICAL CONTROL OF EFFLUENT IMPACTS

3.1 GENERAL PULPING TECHNOLOGY

The two basic pulping processes, chemical and mechanical, are aimed at separating wood cellulose fibres held together by lignin for later use in paper making. Most of the related pollution problems result from the dissolved wood organics and lignins detached from the pulp fibres by the various chemical or mechanical systems.

In kraft mills, a chemical pulping process, the operating factors are liquor composition, cooking time, and pH, as well as digester operating pressure and temperature. Generally, kraft pulp is produced in a slurry after removing spent cooking chemicals and dissolved wood organics. After further refining, cleaning and addition of other pulps and chemicals, the pulp is dried and shipped to market (Environment Canada, 1983).

Combining mechanical and chemical processes, the Bleached Chemi-Thermo-Mechanical Pulping (BCTMP) process is aimed at treating wood without removing the lignin to form a pulp product. The BCTMP process differs from kraft pulping by removing less lignin, as well as having generally higher yields, higher BOD effluent loading and lower pulp brightness.

When determining the required mill modification to minimize environmental impacts, in-plant and out of plant design must be evaluated (McCubbin, 1992). In-plant control modifications are aimed at improving efficiencies through fibre, energy, and chemical savings. Indirect benefits are reduced heating requirements and reduced external effluent treatment costs than are improved out of plant effluent treatment systems.

3.2 KRAFT PULPING ENVIRONMENTAL TECHNOLOGY

In chemical pulping, chips are separated into fibres by cooking in a pressure vessel with chemicals and steam (Environment Canada, 1983). Approximately 60% of the debarked wood is recovered. The two major chemical pulping processes, sulphite and kraft, produce a dark pulp requiring bleaching. Depending on the process, the form of the basic chemicals, sulphur, oxygen and alkali, varies.

The sulphite process, under acidic conditions, solubilizes lignin by using a solution of sulphur dioxide and alkaline oxides, i.e., sodium, magnesium, ammonium, or calcium. This process operates best with wood with low resin content. Recovery processes are less common in sulphite pulping due to economic and technical factors and resultant effluent streams tend to be high in BOD (Environment Canada, 1983). There are no sulphite mills in Alberta.

Although the first kraft pulp mill in North America was constructed in 1907, the first kraft mill with a black liquor chemical recovery system was not built until 1933. This process greatly reduced the cost of pulp production and contributed to it becoming popular. Costs of operating kraft mills without chemical recovery were considered prohibitive. In kraft pulping, lignin is dissolved, in an alkaline medium and cellulose fibres released in a caustic solution of sodium hydroxide and sodium sulphide. This process is well suited to wood with high resin and fatty acid content. Since most of the organic material is recovered and burned along with spent cooking chemicals, the effluent from the kraft mill consists of fibres lost from the pulping/recovery cycles and is lower in BOD than the sulphite process (Environment Canada, 1983). There are four kraft pulp mills in Alberta: WC, PNGC, DC, and ALPAC.

Usually after the initial kraft pulping process, a bleaching process is used to remove the minor amounts of remaining lignin and is considered to be an extension of the cooking or delignification process initiated in the pulping stage. Pulp from the chemical processes is usually bleached with chlorine based chemicals and produces chlorinated organics by-products. The toxicity of the resulting spent liquors depends on the amount of chlorine and the bleaching sequence used.

In kraft systems, the amount of chlorine required depends on the timber species used, pulping and bleaching processes employed, and final product grade desired. A number of processes have recently been employed to reduce the required amount of elemental chlorine (Cl_2) and the resulting chlorinated organic by-products. These pollution control steps include:

- extended/oxygen delignification;
- improved washing techniques;
- improved countercurrent bleaching processes with water recycle;
- high consistency gas-phase chlorination;
- high chlorine dioxide substitution;
- oxygen or ozone to replace chlorine bleaching;
- hydrogen peroxide replacement; and
- recovery of spent bleaching liquors.

There are a number plant kraft pulping in-plant processes, considered best achievable technology, that can minimize effluent impacts. TABLE 3.1 list those currently being installed in the ALPAC mill.

TABLE 3.1: Best Available In-plant Technology to Minimize Effluent Impacts (Modified from ALPAC, 1989)

PROCESS	PARAMETERS REDUCED			
	BOD/COD	COLOUR	TOCL	DIOXIN
Dry debarking	X			
Modified continuous cooking			X	X
Steam stripping condensate				X
Brown Stock Pre-bleach Washing	X	X	X	X
Oxygen Delignification	X	X	X	X
Multiple chemical addition			X	X
High Chlorine Dioxide Substitution		X	X	X
Medium Consistency Chlorination			X	X
Minimum water consumption				

3.2.1 Pre-Pulping Treatments - Dry Debarking

a) History

The essential first step in pulp production with wood is bark removal, due to it being non-fibrous and detrimental to quality paper production. Typically, bark can be 15% by weight of the wood entering the mill.

The solids produced from the debarking process, in the past, were handled in the most convenient low cost method, being sent to landfills or released into an aquatic-receiving environment. As energy costs increased, mills justified investments into waste wood boilers, thereby utilizing solids generated from the debarking process. High moisture content of bark from a wet debarking process contributed to boiler inefficiencies.

In the past wet drum debarkers were the common debarking process in pulp mills. Wet debarkers consumed large amounts of water, produced effluent high in TSS and BOD, and contributed substantially to plant effluent. The three sources of wood yard effluent were hydraulic log conveyors, log washing, and drum wastewater.

Recently, to reduce loadings on the effluent system and the subsequent high treatment cost, dry debarkers and mechanical log conveyers have been installed. The incorporation of waste-wood boilers helped to decrease the need for outside power, and boiler operations have been enhanced by the use of dry debarkers.

All six pulp mills in Alberta use dry ring or drum debarkers. Most of the mills have eliminated using wash water in their wood handling in an attempt to minimize water usage. PNGC uses water to wash logs and this water is treated in the effluent treatment system. All mills process leachate from the wood yard in the effluent treatment system.

b) **Process description**

Wet drum debarkers consist of a slotted drum equipped with internal staves to knock off bark as logs rotate in water (Casey, 1980). Usually spent process water and the water recycled within the process were fed into the system with the logs to loosen bark and flush the drum. Bark left the process through the slots (along with the overflow water), collected in a flume or conveyors, passed through a dewatering system, and was pressed for burning. Characteristically, the process effluent contained 700 mg/L of BOD_5 and 2700 mg/L of suspended solids (Casey, 1980).

Prior to joining the plant effluent stream, wet debarker effluent underwent preliminary treatment as part of the water recycling system, decreasing water requirements and effluent loading. This effluent tended to have a high silt content which settled rapidly. After coarse filtration, a clarifier was used to remove 70 to 90% of the TSS with a 2 hour retention time to remove the silt. These clarifiers were equipped to remove floatable material and dense silt sludge. This sludge was often dewatered and burned with the hog fuel.

In dry drum debarkers, bark is removed by friction created from the drum action, rotating at speeds higher than wet drum debrakers, and logs rubbing together. In sawmills adjacent to pulp mill operations, dry mechanical debarkers strip bark with rotating knives. The bark waste, called hogfuel, exits these systems through slots and is later burned.

Bark burners require several days storage for efficient operation. Bark storage areas require runoff design to minimize impacts from leachate. Bark is burned in specially designed furnaces with varying thermal efficiencies. Hogfuel is burned, sometimes with clarifier sludge, in combination with auxiliary fuels. Boiler design parameters are aimed at maximizing hog fuel heat potential and minimizing the amount of auxiliary fuel required; and this depends on the wood species, moisture and ash contents, and boiler size. The most efficient are those utilizing hog fuel from dry burners. The energy released nearly doubles when hog fuel moisture content was reduced from 60% produced from wet drum debarkers to 30% produced from dry debarkers (Casey, 1980). Fluidized bed combustion systems have occasionally been used to produce hot water by direct scrubbing of the hot flue gases, but have limited thermal efficiency.

c) **Advantages**

Essentially, no effluent is produced from dry debarking. The bark wastes from dry debarking can be more easily and inexpensively utilized to generate power (not requiring dewatering processes) than in wet debarking. Dry debarking contributes to a major reduction in phosphorus in the effluent discharge (Vuoriranta, et al., 1989) because up to 15% of the effluent phosphorus can originate from both wet and dry debarking processes (Palenius, 1988).

TABLE 3.2: **Comparison of Debarking Processes (McCubbin, 1992)**

PARAMETER	UNITS	WET DRUM	DRY DRUM	MECHANICAL RING
effluent flow	m^3/ADMT	3 to 20	0 to 5	0 to 2
suspended solids	kg/ADMT	15 to 50	0 to 10	0 to 3
BOD	kg/ADMT	5 to 10	0 to 3	1
energy used	kWh/ADMT	20	21	3
bark dryness	% OD	40 to 55	50 to 55	50 to 55
residual bark	% wt	0.5 to 1.0	0.5 to 4.0	0.2 to 0.5

d) Disadvantages

Wet debarking produces cleaner logs, removing sand, grit, and bark fines. This is important to the mechanical and sulphite processes. Dry woodrooms have to be complemented with chip washing and pulp cleaning processes to remove coarse particles from the pulp.

3.2.2 Modified Continuous Cooking

a) History

Part of the fibre separation process involves a chip treatment or cooking stage, which can be either batch or continuous. In the past, kraft pulp mills utilized batch digesters. In 1955, the first continuous digester in Canada was installed in Hinton, Alberta. Aimed at increased pulp strength and yields, continuous cooking reduced chemical reaction shocks and had less aggressive cooking conditions than the batch process. Also, the continuous cooking system was easier to operate, had fewer pollutant spills, and was more desirable environmentally.

Today, Modified Continuous Cooking (MCC) is considered to be a kraft industry standard, as all new digesters sold in the last six years have been equipped with MCC (McCubbin, 1992). Associated with MCC, the concept of extended delignification was introduced in the late 1970s and aimed at reducing the lignin content of unbleached pulp without reducing the production quality. This allowed a reduction in the amount of bleaching chemicals required. The first trials were completed on a converted two-vessel digester in 1983. Later in the 1980s, the MCC system, developed by Hartler, was made available on a practical and commercial basis from vendors of both batch and continuous digester systems.

All the kraft mills in Alberta, except for PNGC, have modified continuous digesters. The newer kraft mills, ALPAC and DC, were built with MCC digesters. WC converted the continuous digester (installed when the mill was constructed) to a MCC during the 1989 expansion. PNGC was built with a continuous digester but has not converted to a MCC system.

b) **Process Description**

The modified continuous digester system consists of a Kamyr continuous cooking process, involving single impregnation vessel and hydraulic type digester. The chips are preheated with steam before entering the digester to remove air, non-condensible gases, and volatile constituents (terpenes). In the continuous digester, the chips are impregnated with cooking liquor at a constant temperature to ensure uniform liquor penetration. The cooking mixture consists of an alkaline solution of sodium hydroxide (NaOH) and sodium sulphide (Na_2S). The temperature is then raised to 165°C by indirect heating of circulated cooking liquor for about one hour. During cooking, lignin and other non-cellulosic material are dissolved and cellulosic fibres are liberated. The pulp is then quenched to 125°C with wash liquor.

Spent chemicals are removed from the lower zone of the digester by diffusion washing at 80°C.

MCC is aimed at minimizing the variability of cooking chemicals within the digester. High concentration of active chemicals in conventional, continuous cooking, decreases during the digestion process, which causes uneven chip processing. MCC levels off alkali concentration throughout the cook, reducing the aggressive action of the chemicals in the initial stages of digestion and increasing the amount of lignin removed in the latter stages. Diffusion washing is carried out in the lower region of the digester, removing a considerable proportion of the spent chemicals. Extended MCC lengthens the cooking time by adding white liquor in the existing wash circulation phase to improve the pulp viscosity.

c) **Advantages**

Modified Continuous Cooking (MCC) extends the cooking process while maintaining pulp quality. MCC is aimed at removing higher amounts of lignin prior to bleaching while lowering the effluent organic loading and colour levels. As a result, less bleach chemicals are required, producing lower AOX effluent levels.

Extended delignification was designed in association with the MCC process. In theory, extended delignification facilitated cooking to lower Kappa levels than conventional kraft cooking by adding white liquor into the base of the digester. This meant more organic material was removed through the recovery cycle and less bleaching chemicals was required (Mannisto, et al., 1989). Some suggested that the digester Kappa number could be reduced by up to 5 to 8 units without sacrificing pulp quality.

None of the kraft mills in the province currently use extended delignification on an operational basis, but all, except for PNGC, have the capacity of implementing extended delignification, with minor digester modifications. Although tests have been made on an operational basis (WC, 1987), extended delignification caused operational problems, limiting yield and pulp strength. Many engineers felt that reduction in the Kappa level could be optimized better with subsequent oxygen delignification and that both extended and oxygen delignification on the same production line were not necessary. Optimization of extended delignification technology can be expected to be developed in the near future (McCubbin, 1992).

d) **Disadvantages**

Reduced overall pulping yield, increased loading of the recovery processes, and increased white liquor use are associated with the extended delignification process.

3.2.3 Oxygen Delignification

a) **History**

Oxygen delignification was originally developed in the late 1960s. In the early 1970s, in Europe, if mills installed oxygen delignification, biological treatment systems were not required and as a result many European mills installed the system (McCubbin, 1992). At the same time in North America, regulations for new mills required biological effluent treatment systems. Since the environmental advantage of using oxygen delignification was limited to a marginal reduction in effluent treatment costs, many mills did not install the process. Up until 1990, there was only one mill in Canada using oxygen delignification (McCubbin, 1992). Today, with increased pressure to reduce chlorine bleaching, oxygen delignification has become more popular for North American kraft mills.

Out of the six kraft mills in Canada with oxygen delignification installed or proposed, three (WC, DC, ALPAC) are located in Alberta. PNGC does not have oxygen delignification equipment.

Although there are no published surveys justifying the use of oxygen delignification, environmental pressure, from regulation and public/consumer opinion, have been most influential in the installations (McCubbin, 1992). Government personnel have indicated that new or expansion plans of existing kraft mills would probably not be approved without oxygen delignification.

b) **Process description**

Oxygen delignification applies gaseous oxygen to dissolve lignin prior to bleaching stages. Although early installations, in the 1970s, operated at high consistency units (25 to 30%), the trend is towards medium consistency units (10 to 12%) (McDonough, 1985). At these lower degrees of delignification, strength properties are not reduced. The environmental aspects of the two processes do not differ.

In high consistency oxygen delignification, the washed, unbleached pulp is dewatered to 25 to 30% consistency in a press and then pressurized in the presence of gaseous oxygen (McCubbin, 1992). Sodium hydroxide is added to control pH and magnesium salt is added to reduce the oxygen's tendency to attack the fibres. Operating at medium consistencies (10 to 12%) reduces capital costs by utilizing conventional brown stock washers. For both consistencies, good pulp washing is essential for the oxygen delignification system to minimize the amount of chlorine bleaching required.

In ozone delignification, reactants are applied in the gas phase to pulp at 20 to 40% consistency with no free draining water (Casey, 1980). This reduces the amount of chlorine and chlorine dioxide required in subsequent bleaching stages to achieve the same brightness level.

c) **Advantages**

Oxygen delignification is used as a pre-bleaching step, removing lignin prior to bleaching. It involves replacing the first two conventional, highly polluting, bleaching stages (chlorination and caustic extraction) by treating the pulp with oxygen under pressure in an alkaline medium. To optimize pollution reduction, oxygen delignification should be followed by an efficient washing system and complete reuse of effluent.

TABLE 3.3: Effect of Oxygen Bleaching on Kraft Bleach Plant Effluents (Eddy, 1984)

PARAMETER	CEHDED	OCEDED	OCEDED	% EFFICIENCY	
	kg/tonne bleach pulp			recovery level	
		80% recovery	100% recovery	80%	100%
Colour	232	206	58	68	87
BOD	21	35	10	41	77
COD	168	236	79	25	76
Chloride	70	21	42	64	70

Oxygen delignification reduces the amount of chlorine required in two ways. Firstly, oxygen delignification can be used to lower the Kappa level of the pulp entering the bleaching stage; lower Kappa numbers mean less required bleaching chemicals. Secondly, because the liquor dissolved in the oxygen stage is recovered and burned, less organic material is discharged with the bleach plant effluent. Depending on the degree of oxygen delignification and chemical recovery efficiency, about half of the COD, BOD, and colour is produced (Environment Canada, 1983).

With lignin being removed prior to bleaching, requiring less bleach chemicals means lower AOX effluent levels. In bleached kraft mills, 80% of the total phosphorus effluent is derived from the bleaching process, 15% from debarking processes, and 5% from other sources (Palenius, 1988). Oxygen delignification reduces phosphorus production and can also reduce toxicity (toxic units/ADMT) by 50% (McCubbin, 1992).

McCubbin (1992) found that oxygen delignification can offer a $8/ADMT savings in mills using 100% chlorine dioxide substitution. If market and regulatory pressure for chlorine dioxide substitution are low, then the low cost of chlorine will eliminate the cost advantage of oxygen delignification.

d) **Disadvantages**

Oxygen delignification decreases pulp strength and pulp uniformity. Other economic and engineering problems are (Casey, 1980):

- no oxygen recovery mechanism; oxygen consumption contributes to the cost of operation;

- reduction in tall oil and turpentine recovery due to oxidation of these compounds;
- reduced fuel value of spent liquor due to long exposure to oxidative conditions;
- high corrosion rates where metal surfaces are wetted and dried in the presence of oxygen;
- increased explosive hazard when dealing with oxygen systems;
- increased toxic hazard from carbon monoxide production during pulping stages; and
- dissipation of surplus heat from the exothermic reaction of oxygen pulping.

Oxygen delignification increases (4 to 7%) loading of the recovery processes, i.e., evaporators, recovery boiler, lime kiln and recausticizing (Mannisto, et al., 1989). Also, the process usually produces effluent with higher colour and BOD levels than chlorine bleached pulp processes (McCubbin, 1992). In order to maximize environmental benefits, the filtrate from the oxygen stage must be recycled to the chemical recovery system.

3.2.4 Improved Brown Stock Washing

a) History

Brown stock washing has been in use for over forty years in kraft mills as part of the chemical/fibre recovery system, and in the last fifteen years, equipment has been substantially improved (McCubbin, 1992). The theory of optimized brown stock washing was developed in 1960, but the operational information was not available until the late 1970s when computer based process simulation technology was developed. In the past, some mills added fresh water to the pulp after washing and discharged the excess to the sewer from the decker. This caused increased effluent BOD levels. In the 1970s, this was considered environmentally undesirable since BOD was the principal criterion for defining effluent quality. Mills began to recirculate some of this wash liquid to reduce BOD, but ended up with higher organic content in the pulp entering the bleaching stages and increased levels of chlorinated organics.

Today, it may be better to have the organics released into the effluent treatment system prior to bleaching rather than remaining in the pulp during the bleaching stages. A general trend toward increasing the efficiency of existing brown stock washer systems involves installing additional washing stages, better washing equipment, and improving instrumentation. This has the potential of reducing soda loss from 50 kg/tonne, common 20 years ago, to 7 kg/tonne (McCubbin, 1992), a major economic improvement. Traditionally, kraft pulp was washed on a series of countercurrent vacuum drum washers, using large liquor/fibre flows and a high potential for spills. Mills built after the early 1970s were installed with continuous diffusion washers operated at atmospheric pressure. In the 1980s, these diffusion washers were installed to operate under pressure. All of the kraft mills in Alberta have improved brown stock washing systems.

b) **Process description**

In kraft pulp mills, when leaving the digester and prior to bleaching, fibres are separated from black liquor solids. Any increase in washing efficiency transfers organic material and chemicals from the sewers and the subsequent receiving environment to the recovery furnace (Environment Canada, 1983). Secondarily, this reduces the mill's energy requirements.

During this brown stock washing, about 97 to 99% of material dissolved in the cooking process is extracted. Washing efficiency depends on the number of washing stages, the quality of the equipment and the amount of water added to the process. The amount of water used is expressed as a dilution factor consisting of the ratio of water mass flow remaining to the pulp mass flow.

The efficiency of brown stock washers is measured by the amount of soda loss and expressed as Na_2SO_4/ODT. To make the washer loss appear lower, Na_2O/ODT is sometimes used. Soda loss is the concentration of sodium sulphate remaining with the pulp as it leaves the last washing stage. This salt is bound with fibres by sorption and cannot be removed by washing with water. If sufficient washing equipment is installed, the remaining unbound soda can be removed. Modern mills are designed for a soda loss of 5 kg/tonne of unbound soda and 3 kg/tonne as bound soda (Environment Canada, 1983). Soda loss is inversely proportional to the dilution factor. This factor also related to the recovery plant evaporation and a balance between the two must be achieved.

The organic material attached to the pulp leaving the washers is of particular concern. A portion is eventually discharged to the effluent system after passing through the screen room. This organic material, with high molecular structure, is transformed in either secondary treatment lagoons or in the receiving environment into often more toxic and persistent low molecular mass compounds (Environment Canada, 1991). The remaining portion of organic material that is not removed in the screening room is removed in the bleaching stages by reacting with chlorine. This material is discharged to the effluent as chlorinated organics. In unbleached plants this remaining black liquor is removed in the paper machine or pulp dryer and discharged to the mill effluent in the excess white water.

The organic material discharged to the effluent system is directly proportional to the soda loss and inversely proportional to the dilution factor. The equipment used determines these relationships. Four stage washing with a closed screen room discharges less than a three stage washing with an open screen room (Environment Canada, 1983). Scandinavian mills have added an "open" washer to the brown stock or post-oxygen stage washing system (Mannisto, et al., 1989).

Improved brownstock washing usually consists of cooked pulp being discharged into an atmospheric two-stage diffusion washer and then into blow tanks. The pulp is then pumped through pressure knotters and pressure screens and onto washers, usually two in parallel. Knots removed are returned to the digester for cooking. The sludge resulting from the brown stock washing is evaporated and burned in the recovery boiler.

c) **Advantages**

This process of brown stock washing lowers: chlorine use in the subsequent bleaching stages; the amount of chlorinated organics produced; and the risks of dioxin/furan formation.

d) **Disadvantages**

Brown stock washing tends to increase the process effluent BOD content. Black liquor is toxic to fish and high losses from the washing area have negative impacts on effluent quality (McCubbin, 1992).

3.2.5 Bleaching - Improved Water Recycling Processes

a) History

The chlorination stage in pulping has become a focal point for pollution control due to the potential effluent toxicity and high volumes of water required. In the 1960s, bleach plant effluent flow was typically 100 m^3/tonne (McCubbin, 1992). The highest effluent loading results from the first two bleaching stages. Recycling chlorination stage process water from a countercurrent washing system has been a popular approach because it drastically reduces effluent volumes. However, since 1977, pulp mills have been slow to employ countercurrent systems of all the bleach stages due to corrosion problems (Casey, 1980). Most modern mills have countercurrent systems for the first two bleaching stages, with water requirements as low as 25 m^3/tonne (McCubbin, 1992).

Effluent from a traditional kraft bleach sequence CEHDED[17] and (C_{85}+D_{15})EDED for softwood kraft pulp have shown negative impacts on fish despite treatment with an aerated lagoon (Folke, 1989). The bleaching sequence, O(C_{52}+D_{48})EDED, had low environmental effect, even without secondary biological effluent treatment (Folke, 1989).

Dynamic or displacement bleaching is another method of water recycling and reducing the number of stages in the bleaching sequence. The principles of displacement bleaching were developed in the 1920s (Eddy, 1984). These involve adjusting the rate of bleaching by varying the chemical concentrations, temperature and

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17 C= Chlorine Stage (number indicates % of this stage)
D= Chlorine dioxide stage
E= Extraction Stage
H= Hypochlorination
O= Oxygen Bleaching Stage.

transfer conditions, with the overall rate being diffusion-controlled. The incorporation of displacement bleaching has increased from 100 ADMTPD in 1972 to 6500 ADMTPD in 1982, but is still considered to be a "new" technology (Eddy, 1984).

Other techniques to reduce water consumption in the bleaching phase include (Casey, 1980):

- intermittent washer showers;
- using white water from other sources in-plant;
- replacing the chlorination stage with oxygen; and
- substitution of a buffer hypochlorite stage for the normal hot caustic extraction stage.

b) **Process description**

The three types of countercurrent process are direct, split-flow, and jump-stage. In displacement bleaching, conventional chlorination stages ($E_1D_1E_2D_2$) occur in a single tower with four displacement diffusion washers bleaching with high reaction rates, with bleaching chemicals being displaced through a pulp mat rather than being mixed in a conventional manner. As the pulp moves upward through the tower, liquor moves in a countercurrent manner and the filtrate withdrawn at each stage is fortified with makeup chemical and reused.

c) **Advantages**

Countercurrent recycling of shower and seal-box water will reduce effluent loading. Direct countercurrent bleaching can reduce effluent levels to 16.7 m^3/tonne.

The displacement bleaching process uses less water, consumes less power, and discharges lower BOD_5 levels than the conventional system. Also, the process equipment is more compact, requiring less land area and building volume.

d) **Disadvantages**

The main disadvantage of the direct countercurrent process is serious corrosion where equipment contacts chlorine dioxide filtrates, especially at chloride concentrations above 1700 ppm (Casey, 1980). Split-flow and jump-stage countercurrent processes were developed to minimize the corrosion problems.

The countercurrent system accumulates temperature during the process. Lower reaction time modifies temperature problems; with 40 to 70% chlorine dioxide substitution, excessive loss of viscosity can be avoided (Casey, 1980). The disadvantages of displacement bleaching involve corrosion, scaling, and reaction rate control.

3.2.6 Bleaching - High ClO_2 Substitution

a) History

The concept of replacing chlorine with chlorine dioxide was first proposed in 1946 by two Canadians for a Quebec mill. This process allowed kraft pulp to be bleached to extreme whiteness, increasing the kraft product popularity. In 1986, a survey conducted by the University of Toronto indicated that the majority of mills reported substitution levels of 20 to 50% and an overall reduction in equivalent chlorine and caustic consumption. Recently, chlorine dioxide substitution has increased at some mills to 50 to 70% and in some hardwood pulp mills up to 100%. Pryke (1989) reported increased consumption of bleaching chemicals for substitutions above 50%. High ClO_2 substitution has become the alternative for reducing effluent AOX throughout the world. Canadian mills have adopted high ClO_2 to a greater extent than mills in other countries, including Sweden (McCubbin, 1992).

PNGC and the proposed ALPAC mill use 100% chlorine dioxide continuously. WC employs 100% chlorine dioxide 25% of the time to produce an Elemental Chlorine Free product for sale in Europe. For the remaining 75% of the production time, WC uses 25% chlorine dioxide substitution. The resulting pulp is sold to the U.S. markets and to the U.S parent company. At this time, DC uses 25% chlorine dioxide substitution on a continuous basis.

b) **Process description**

Chlorine dioxide can be used instead of molecular chlorine in the first stage of the bleach plant and is defined as the level of substitution of equivalent chlorine. The amount of molecular chlorine needed is reduced by the percentage of chlorine dioxide designated. Since 1 kg of chlorine dioxide replaces 2.63 kg molecular chlorine, there is a net reduction in the amount of chlorine used (McCubbin, 1992). Chlorine dioxide is produced in R8 generators by electrolysis of sodium chlorate and rock salt in a water solution.

c) **Advantages**

High chlorine dioxide substitution results in lower chlorinated organics and colour in the effluent. Although dependent on degrees of substitution, the AOX formation with high chlorine dioxide substitution can be reduced by 5 times through chlorine bleaching. High chlorine dioxide substitution is used to improve hardwood pulp quality.

d) **Disadvantages**

Although many mills can operate at 100% substitution for a few days, few have the capacity to operate continuously at this rate. In Alberta, only PNGC and ALPAC can operate at 100% substitution on a continuous basis. Another main deterrent is the change in chlorine/caustic balance and the resulting increased chemical costs. The cost of operating at 100% is higher than conventional bleaching operations (~$6 to 8/tonne).

3.2.7 Water/Chemical Recovery and Recycling

a) **History**

In the past, enormous amounts of water have been used in kraft pulp production, i.e., in-plant wood transport, power generation, fibre processing. When wood and energy were inexpensive, water was used once in the processes and this contributed to large chemical, fibre and heat losses. In the 1930s, it was believed that water removed from the pulp washing process, called white water, could not be reused without sacrificing product quality (Casey, 1980).

In kraft mills, effluent is generated from three sources: decker filtrate, condensates, and intermittent losses (Casey, 1980). In earlier mills, pulp was diluted after brown stock washing, sent through a series of screens to remove slivers and knots, and then thickened on a decker for later storage. The filtrate from these deckers was sewered and comprised a major portion of the plant effluent, about 30% of BOD_5 loading (Casey, 1980). In time, the system was designed to recycle this filtrate to dilute incoming pulp, utilizing closed pressurized and non-pressurized screen rooms.

Hot stock screening was also employed to decrease the amount of decker filtrate. After cooking, pulp was fiberized and passed through a hot stock screen to remove slivers prior to washing. This eliminated the need for pulp dilution and decreased loading on the effluent stream.

Condensates from the digester and evaporators, along with decanted water, contribute about 30% of the plant BOD_5 loading, being comprised of low-molecular weight organic matter. This is comprised of 80% methanol and 20% other substances, i.e., alcohol, ketones, phenolic and sulphur compounds, as well as terpenes. This condensate mixture in older mills was recycled in brown stock wash, caustizing makeup, lime kiln stack scrubbers and dissolving tank makeup. These recycling procedures increased problems with resin wet-strength brown stock washing and odour. Steam stripping the condensate prior to recycling reduced odour problems and eliminate 90% of effluent BOD_5 loading.

In older mills, intermittent losses contributed 30 to 50% of BOD_5 effluent loading from equipment breakdown spills, overflows, and routine mill closure maintenance washups. These were minimized by adequate spill collection systems.

Today, large amounts of water are still utilized, but intensive recycling facilities reduce both fresh water requirements and effluent loading of fibres, chemicals and heat. TABLE 1.2, listing the water design flow for each of the mills, indicates that water usage by the four kraft mills range from 75,000 m³/day to 100,000 m³/day.

b) **Process description**

Although varying among mills, the solid content of white water usually consists of fibre debris, soluble matter and nonfibrous suspended matter (pigments, starches, etc.) (Casey, 1980). An important aspect of white water recycling is efficient saveall operation to remove suspended solids. In kraft mill chemical recovery, the spent liquor from the washing stages contains most of the original cooking chemicals and the wood's organic content.

Many mills have installed spill collection systems to handle periodic equipment failure. These effluent contributions can be minimized by (Casey, 1980):

- recycling liquid from periodic evaporator bailouts;
- sizing facilities to avoid overflow and accommodate weak and strong black liquor, as well as recovery plant chemicals;
- adjusting production to avoid overflows;
- utilizing conductivity probes to monitor for mill sewer leaks;
- training of personnel to avoid and respond to spills; and
- installing surge lagoons prior to biological treatment.

c) **Advantages**

Chemical recovery in kraft mills is economically and environmentally essential. Improvements to recovery boilers have indirect benefits on effluent treatment. Functioning properly, a recovery boiler ensures fewer shutdowns (which have great impact on effluent system).

Spills in a kraft pulping area are sometimes the highest effluent source, significantly contributing to the total effluent BOD. Efficient recovery reduces effluent loading and minimizes shocking of biological treatment systems.

d) **Disadvantage**

The problems associated with water recycling include build-up of suspended and dissolved solids, as well as retention of thermal energy (Casey, 1980). Suspended solid accumulations (long fibres) plug equipment and contribute to biological slime formations. Dissolved and colloidal materials present leads to scale and corrosion problems.

3.2.8 Other

a) **Turpentine Production**

Some pulp mills (WC, PNGC, DC) have installed equipment to extract other wood products released during the pulping process. Turpentine is discharged in vapour form from the digester. Although these vapours are normally condensed as part of the odour control system, turpentine recovery can reduce effluent BOD and toxicity. A typical recovery system is designed to decant pure turpentine off condensed water using the density difference principle (turpentine specific gravity = 0.8). The system underflow effluent is toxic with about 4 kg/t pulp of BOD and consists of terpene, terpinol and methanol. The recovered turpentine is either sold to refining companies or used as fuel in the mill, i.e., in the lime kiln.

b) **Effluent Free Kraft Mills**

Effluent free kraft pulp mills have been a topic of discussion for a long time (Mannisto, et al., 1989), but some feel that technology is not yet available to attain effluent free operation while producing quality pulp.

Drs. Rapson and Reeve developed a closed-cycle bleached kraft mill. The design was incorporated in 1977 into a pulp mill at Thunder Bay, and was the first in the world. The modification costs were equivalent to secondary biological treatment installation costs. Additional savings were attributed to decreased heat/steam/water/chemical consumption, fibre savings, and yield increases (Eddy, 1984).

The Rapson Reeve design involved the following features (Environment Canada, 1983):

- Seventy per cent chlorine dioxide substitution at the first bleaching stage. This decreased the amount of chloride ion produced and sodium ion (from sodium hydroxide) required to produce sodium chloride. Lower input of sodium chloride into the recovery cycle and salt recovery plant resulted.
- Countercurrent washing in the bleach plant from the second chlorine dioxide stage to the first extraction stage. No external wash water was supplied to any of the pulp washers. This minimizes external water input to the bleach plant which can be reclaimed in the recovery cycle.
- A salt recovery process removed sodium chloride from the white liquor. The salt by-product was used by the chlorine dioxide generator and not released into the sewer.
- An ERCO R-3 uses sodium chlorate, sulphuric acid and sodium chloride to produce chlorine dioxide. The gases produced pass through a cold water absorber to dissolve

chlorine dioxide and chlorine, with most of this material being utilized (and the remainder being sewered).

- Black liquor condensates significantly contribute to BOD, reduced sulphur, and toxicity effluent loading. Since not all these condensates can be recycled, a stream stripper treats evaporated condensates to lower effluent levels.

New zero-effluent designs for kraft mills may result from the development of oxygen or ozone bleaching, as mentioned below. The operational development of this technology will probably follow within 5 years of the acceptance and implementation of oxygen bleaching.

c) **Oxygen and Ozone Bleaching**

Oxygen and ozone bleaching are considered by some to have tremendous potential to replace chlorine and chlorine dioxide bleaching. In the literature, oxygen and ozone delignification (a pre-bleach treatment), is sometimes improperly called oxygen and ozone bleaching (a new bleaching technology). Today, there are no mills in North America utilizing oxygen bleaching. Although currently being researched, oxygen bleaching technology may not be operational for another two years. The only mill utilizing ozone bleaching, owned by Union Camp, began operation in the fall of 1992, after 10 years of research and equipment development.

The advantage of oxygen bleaching is that it allows the bleach wastewaters to be evaporated and burned along with the black liquor. This will eventually encourage the development of zero-effluent technologies involving combustion. The numerous combinations of oxygen and conventional stages have shown reductions of 30% to 90% in BOD, COD, colour, and AOX. Oxygen bleaching has shown savings in chemical and heat costs over conventional bleaching

(Eddy, 1984). The advantages of ozone bleaching are similar to oxygen bleaching.

Oxygen reactors are more expensive than conventional bleaching equipment (Eddy, 1984). Additional evaporation and recovery furnace capacity (4 to 6%) is required in plants using oxygen bleaching. Oxygen bleaching technology development has been limited by loss of pulp strength and high modification costs.

d) **Caustic/Chlorine Balance**

McCubbin (1992) has indicated that until recently kraft mill chemicals, caustic (sodium hydroxide) and molecular chlorine, were produced in a fixed ratio as part of the same process. The pulp industry in the past has been required to purchase amounts of the two chemicals in balance with a stoichiometric ratio. The amount of caustic required has increased with employment of oxygen delignification and the amount of molecular chlorine has decreased with increased use of high chlorine dioxide substitution. In 1985, the pulp industry purchased about 45% of the chlorine manufactured in Canada for industrial use, compared to 100% in 1970 (McCubbin, 1992). McCubbin (1992) estimates today that the pulp industry consumes 33% of the Canadian chlorine production and 66% of the caustic production. It is well known that some chemical suppliers have charged the pulp industry a premium for caustic when purchased out of balance with molecular chlorine. These changes in chemical demands are an important problem facing the kraft pulping industry and the associated chemical production industries.

The demand for caustic can be met by mills using oxygen delignification. This is done by oxidizing white liquor as an alkali supply to the oxygen supply but it imposes increased loading on the recausticizing/lime kiln cycle. The Papricycle process, another alternative, involves installing an additional washer in the bleaching cycle and recovering caustic from the extraction washer. Some suggest that sodium carbonate can replace sodium hydroxide in the pulping cycle. Chemical suppliers are investigating processes of producing caustic from sodium carbonate, similar to the recausticizing/lime kiln kraft methods.

3.3 MECHANICAL PULPING ENVIRONMENTAL TECHNOLOGY

a) History

In the two basic mechanical pulping methods, groundwood and thermo-mechanical systems, heat and mechanical forces reduce the lignin and produce a light-coloured pulp. Groundwood pulping was invented by Keller in Germany in 1844, but was not used commercially until 1870 due to the resulting poor quality pulp. Based on groundwood mechanical technology, the first commercial chemi-thermo-mechanical pulp (CTMP) mill was built in the early 1970s.

Further developments made the viability of bleached chemi-thermo-mechanical pulp (BCTMP) mills more popular. In 1978, Rockhammer started up the first market BCTMP mill. Today, there are two BCTMP mills in Alberta: SLPC and MWP.

b) Process description

In groundwood mechanical pulping, the pulp fibres are released either by grinding logs with rotating stones or by forcing chips between grooved rotating steel plates in refiners. There is about 80 to 90% recovery from debarked wood. The quality of the resulting pulp is dependent on the amount of specific energy input, i.e., higher operating pressures and energy inputs produce higher quality pulps. In thermo-mechanical pulping (TMP) chips are softened by steam and defibred in a disc refiner with both processes under pressure. The raw pulp is further mechanically refined and later screened/cleaned to remove fines.

The CTMP process involves the addition of sodium sulphite and heat to the steaming vessel to increase chip softening. This process improves pulp quality but decreases yield and increases effluent organic loading. CTMP differs from traditional sulphite processes by having lower digester retention time and pressures. BCTMP uses hydrogen peroxide, sodium hydroxide, and magnesium sulphate to brighten the pulp by oxidation and solubilization of impurities in lignin and cellulose.

The process used at the MWP mill in Whitecourt differs from a typical BCTMP mill in that it does not use sulphur dioxide in the chip softening process and should be considered an alkaline peroxide pulp (APP/BCTMP) instead of a BCTMP. The standard BCTMP pulp process uses sodium sulphite and temperature to soften and separate fibres plus additional refining steps to increase pulp quality (Reis, 1992). In APP/BCTMP processes, especially for hardwood, chips are treated with both sodium hydroxide and peroxide to develop higher pulp strengths and brightness. Employing more impregnation stages than a typical BCTMP mill, APP/BCTMP can eliminate the environmental impact of sulphurous compounds, reduce energy requirements, and produce a higher quality pulp. The major chemicals used are hydrogen peroxide, caustic, sulphuric acid, sodium silicate, and magnesium sulphate. However, the overall inorganic chemical feed demand is higher and the moisture consistency reduction is lower during the final pulp presses, making the water consumption and effluent flows higher. Effluents in BCTMP mills originate from chip washing, plug screw filtrates, wash press water, and contaminated reboiler effluent.

c) **Advantages**

BCTMP technology is often compared to kraft pulping methods for environmental impacts (See TABLE 3.4). BCTMP typically has higher yields, converting about 80% of round wood supplies into pulp compared to kraft which converts about 40%. This means that one half the forested area is required to supply the mill.

Whereas kraft processes remove lignin, the primary cause of effluent toxicity, BCTMP methods are aimed at forming pulp from both the lignin and fibres together. Also, BCTMP requires less process water and does not employ chlorine for bleaching, thereby eliminating dioxin and AOX problems.

The low water consumption of BCTMP has allowed for the development of zero effluent designs: Louisiana Pacific in B.C. and MWP in Saskatchewan. The Louisiana Pacific mill, utilizing a freeze crystallization process. This partially freezes the waste stream to form ice crystals that when separated, washed and melted, form clean water. MWP in Saskatchewan concentrates effluent with an evaporation process, returning distillate to the mill and treating the remaining portion with steam stripping or in an aerated holding basin.

TABLE 3.4: Typical Characteristics of the Processes and Effluents of Various Pulping Processes (McCubbin, 1992; Reis, 1992; Hall, 1992)

	PULP YIELD %	TOXICITY		PLANT BOD LOADING kg/ADMT	COLOR kg/ ADMT	FLOW 1000 m³ /ADMT	ENERGY (KWH/ADMT)	
		RFA* mg/L	tu/ADMT				TOTAL	% SELF SUFF
APP BCTMP	90	26 to 500	100 to 6000	60 to 80	35 to 50	8 to 25	1700	0
BCTMP	88			80 to 100			3250	
new bleach kraft	50	1 to 21	100 to 1100	15 to 20	150	50 to 100	8750	85 to 95
old bleach kraft				30 to 60	350	100 to 200		

* RFA: Resin Fatty Acid; tu/ADMT: toxic units per air dried metric tonne.

d) **Disadvantages**

Although lignin loading from BCTMP is lower than kraft, BOD levels (~30 kg/tonne softwood to 80 kg/tonne hardwood) are substantially higher than typical kraft mills (~20 kg/tonne). This BOD loading problem is reduced by 97 to 99% with the installation (at greater cost) of activated sludge effluent treatment systems. MWP effluent system reduces BOD from 90 kg/adt to 2.5 kg/adt and the final effluent TSS levels are 5 to 7 kg/adt (Reis, 1992).

The newness of BCTMP technology and the resulting concentrated effluent with high BOD loading has generated research interest to improve water treatment methods, i.e., ultrafiltration, anaerobic treatment, freeze crystallization, and evaporation (McCubbin, 1992).

BCTMP effluents are the most toxic of the various pulping processes (McCubbin, 1992). This is due to increased resin fatty acid levels depending on the wood species used: BCTMP 26 to 500 mg/L compared to kraft 1 to 21 mg/L. Reis (1992) has indicated that BCTMP toxicity tests have failed due to ammonia concentrations. Usually, the effluent sample pH of 8.2 increases to 9.2 during the actual fish bioassay test. The pH shift is caused by bicarbonate changing into carbon dioxide and water with the stripping of carbon dioxide during the sample aeration, thereby increasing the sample toxicity.

Energy requirements for BCTMP mills are higher than kraft mills. Typically, kraft mills can be 85 to 95% energy self-sufficient with the chemical recovery process, whereas BCTMP mills are required to purchase energy from other sources. MWP will be installing a new power plant, designed to burn sludge and sawmill waste, to offset its current outside energy needs.

As yet, there is no proven sulphur chemical recovery system for BCTMP mills (unlike kraft mills). In the past, BCTMP mills used less chemicals and more energy and today, BCTMP mills have reduced their input levels of both energy and chemicals (Reis, 1992). However, comparing APP/BCTMP with BCTMP mills, APP/BCTMP mills tend to use less energy but higher amount of chemicals (Firth-personal communication).

Pulp brightness, a primary marketing characteristic, is lower in BCTMP mills (~85 ISO) than in kraft softwood high-brite (90 ISO). Recent changes in paper technology involve combining lower quality BCTMP with high quality kraft pulp. This has increased the popularity of BCTMP and reduced the direct competition with high-brite kraft.

3.4 EFFLUENT TECHNOLOGY DEVELOPMENTS

3.4.1 General

Pulpmill effluent treatment usually consists of primary and secondary treatments. Primary treatment removes suspended solids through screening and settling. Secondary treatment involves the decomposition of organic components by contact with naturally occurring aquatic micro-organisms. All six pulp mills in Alberta have both primary and secondary effluent treatment systems.

In general, there is an improving trend in the Canadian pulp mill discharges as illustrated in FIGURE 3.1 from 1959 to 1989 for BOD and TSS (Casey, 1980). This same trend can be seen in the two older Alberta mills (See FIGURE 3.2). The efficiency of effluent treatment systems has improved (Casey, 1980) between 1960 to 1989 (See TABLE 3.5). In Canada, AOX levels can be, with no effluent treatment, between 3.0 to 10.0 kg/ADMT; with only primary treatment, about 1.0 kg/ADMT; and with secondary treatment, as low as 0.5 kg/ADMT (Environment Canada, 1991).

TABLE 3.5: Overview of effluent treatment efficiency in Canada from 1960 to 1989, (CPPA, 1991)

PARAMETER	% REDUCTION
effluents produced (per-tonne)	52
total suspended solids	92
BOD	78
use of chlorine	50
dioxins and furans	90
AOX	70

FIGURE 3.1: Canadian Pulp Mill Effluent Abatement by Parameter (CPPA, 1991)

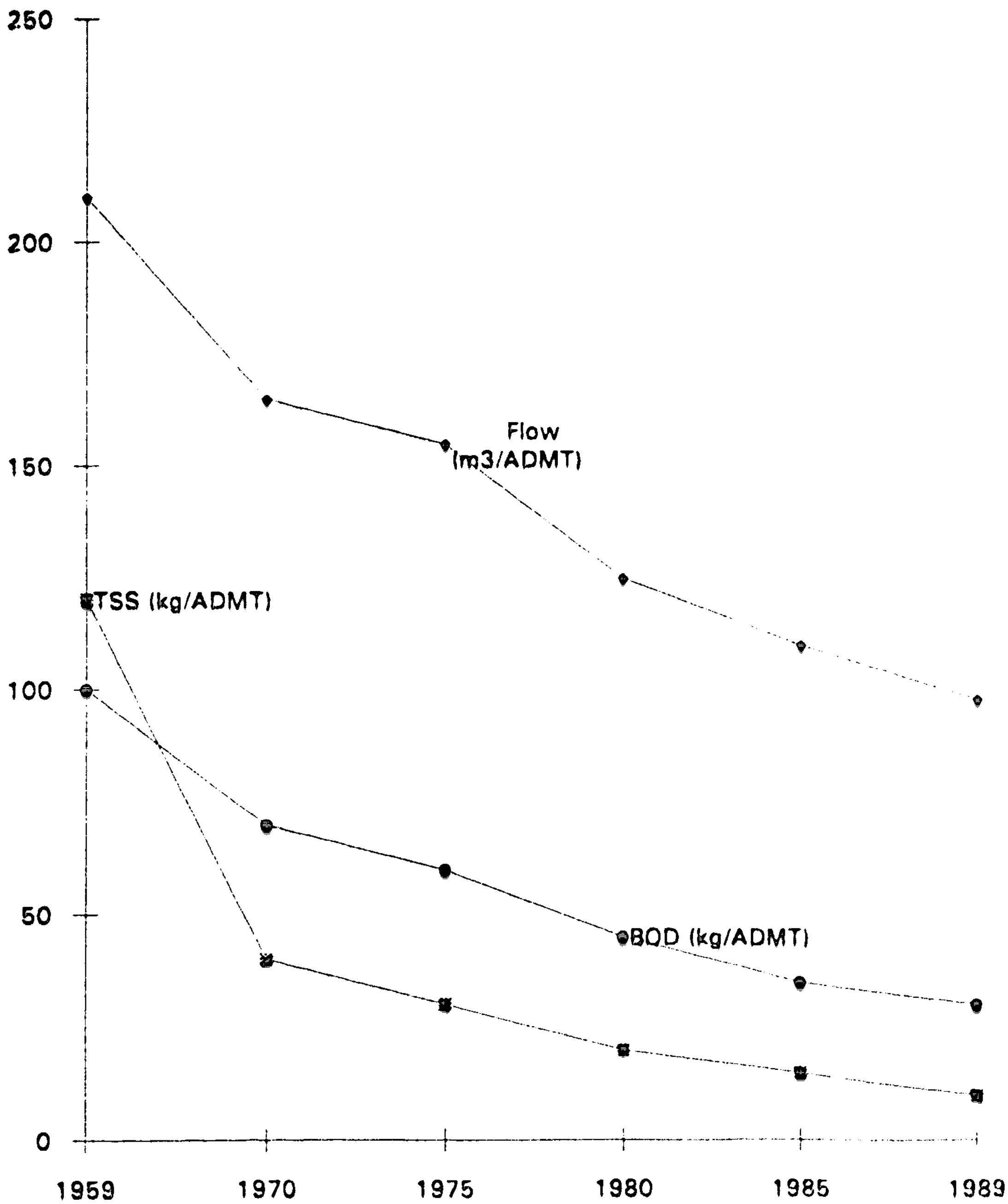
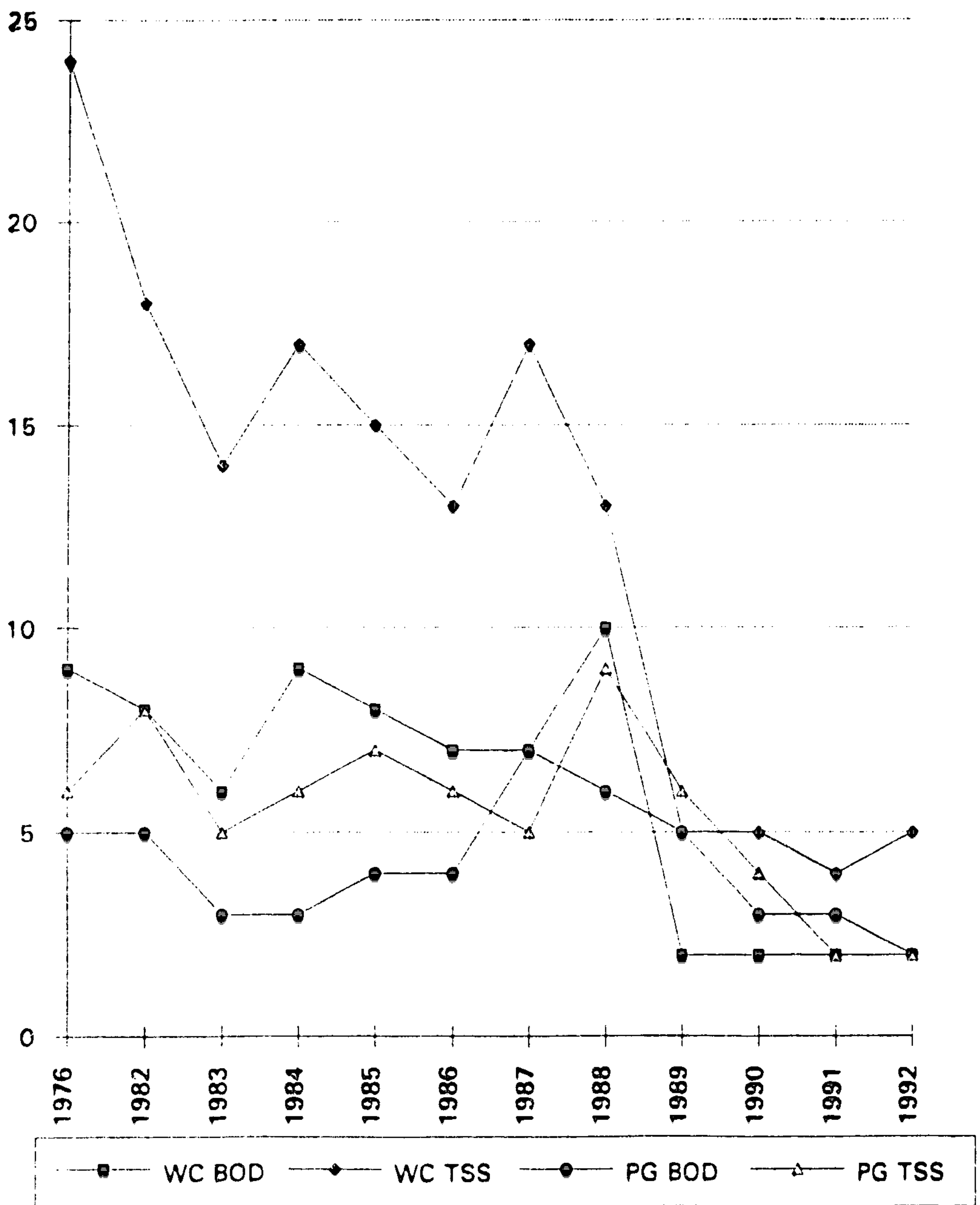


FIGURE 3.2: Alberta Pulp Mill Effluent Abatement by Parameter for Weldwood and Procter and Gamble 1976 to 1992 (Alberta Environment Summary, 1992)



3.4.2 Primary Treatment

a) History

The main purpose of pretreatment and primary treatment is the removal of suspended solids from the effluent. A report produced by Jones (1973) indicated that technology for pretreatment and primary treatment has existed for the pulp industry since the 1950s, but did not become popular, i.e., in more than 75% of US mills, until the early 1970s. Popular pretreatment consisted of grit removal, bar screens, and neutralization. Popular primary treatment consisted of gravity clarifiers. Except for the pulp mill in Hinton, all the pulp mills in Alberta were constructed with primary treatment. Primary treatment was installed in the Hinton mill in 1967.

b) Process Description

Prior to primary treatment, the effluent passes through a pretreatment process, i.e., grit chambers, bar screens, to remove coarse material to reduce equipment abrasion and pump damage. Typically, inorganic ash, grit, sand and gravel are removed at this stage. Fine screens, microstrainers, and pressure filters are avoided due to the blinding and plugging propensities of pulp wastes.

The grit chamber is a gravity settling tank with mechanical or automated grit removal. It is designed to separate the organics from the inorganics (Casey, 1980). Grit larger than 65 mesh (>0.15 mm diameter) is removed by maintaining an average velocity of less than 0.76 m/min. Bar screens remove large debris greater than 10 to 30 mm that may clog overflow weirs and sludge withdrawal lines.

Neutralization is an important component of pretreatment The mill effluent pH can cause severe corrosion, upset the biological treatment, and negatively impact the receiving stream Kraft mill effluent can be neutralized by mixing with waste chemicals and other effluents. Sludge from the lime kiln scrubber adjusts the acid sewer stream pH. Subsequent mixing with the alkaline sewer and additions of acid and caustic prior to the secondary treatment provides final pH adjustments.

Typically, primary treatment is a physical process allowing effluent to settle solids, removing 10% of total BOD and 75 to 95% suspended solids. The unsettleable portion of solids, consisting of colloidal and very fine material, pass through the system. If this fraction is substantial, subsequent treatment with chemical additions, i.e., alum, ferric chloride, polyelectrolyte, may be required to promote settling.

In gravity clarifiers, the effluent is fed into the circular clarifiers through the centre and flows radially to peripheral overflow weirs. Skimming devices, screens, and savealls have been used to reclaim floating fibres from the effluent and return them to the pulping process The clarifiers are equipped with rotating sludge removal rakes. The sludge is usually dehydrated and burned or disposed in a landfill.

Clarifier overflow rates range from 800 to 60,000 L/d·m² with common design practice to be 24,450 to 32,000 L/d·m² A typical mill would have 0.36 to 6.0 kg/m³ of suspended solids flowing in and 0.036 to 0.06 kg/m³ flowing out of the primary clarifier (with 90% efficiency) (Casey, 1980).

Clay lined settling basins have been used for primary settling. Normally a 6 to 24 hour retention time is used. The sludge is removed by earth moving equipment. Initially, reliable and inexpensive, maintenance costs are high. Basins tend to be used for spill effluent storage and as back-up systems for circular clarifier tanks.

In some mills, flotation (instead of settling) clarifiers are used. The Slave Lake BCTMP mill is the only mill in Alberta using a flotation clarifier. It was installed when the mill was built, based on research that indicated flotation clarifiers to be more efficient than gravity clarifiers for BCTMP effluent (Firth-Personal Communication). In flotation clarifiers, air is introduced under pressure as the effluent enters the bottom of the tank through an upflow unit. From the super-saturated liquid, air bubbles attach to suspended solids and carry the particles to the surface. A scraper or saveall separates the particles from the effluent overflowing from the unit. Alum, with or without polyelectrolyte, can be added as a flocculant to achieve acceptable efficiency.

c) **Advantages**

Primary sedimentation cuts 40% to 50% of influent phosphorus from a pulp and paper mill (Vuoriranta, et al., 1989). Flotation clarifiers can remove up to 98% TSS (Casey, 1980).

d) **Disadvantages**

Clarifiers are sensitive to surges and temperature differentials, which cause convection currents and entrained air (Casey, 1980). Flotation clarifiers are affected by large flow and solid loading fluctuations. This is minimized by over-sizing the system or operating at a fixed flow by utilizing a by-pass system leading back to the clarifier inlet. Flotation clarifiers are limited to removing particles with specific gravity greater than 1. Except when space is at a premium, flotation clarifiers are limited by equipment expense, the use of flocculation chemicals, high power requirements, and more equipment maintenance.

3.4.3 **Secondary Treatment**

Secondary treatment is a biological process simulating the natural oxidation process by encouraging bacteria and other microorganisms to consume organic wastes in the effluent. This process is aimed at reducing total BOD by 70 to 95% of influent BOD and reducing effluent toxicity.

In the biological treatment process, naturally occurring microorganisms convert dissolved organic materials into benign matter, i.e., water, carbon dioxide and organic suspended solids. Most systems are aerobic and consist of populations of bacteria, algae, fungi, and protozoa. Since bacteria predominate, treatment performance is based on the bacteria population characteristics. The populations continually adapt to the effluent characteristics, but at approximately 1 to 3 orders of magnitude slower than the chemical and physical processes (Environment Canada, 1983). Pulp mill effluent characteristics tend to fluctuate more quickly than the microorganisms can react, and abrupt reductions in populations result in subsequent inefficiencies.

Biological systems tend to be more effective in removing low molecular weight pollutants, i.e., methanol, than high molecular weight materials, i.e., resin acids and chlorinated lignins.

Like municipal systems, pulp mill secondary design control parameters for biological systems are pH, temperatures, nutrient supplies, and retention times. Some failures in pulp mill systems have been attributed to the use of municipal design levels inappropriate for pulp mill effluent. Although most biological systems have some assimilative capacity, optimum pH is neutral. Optimum temperature is approximately 35°C. Due to pulp mill effluent's high temperature and characteristic foam layer, winter failures in severe cold climates are uncommon. In plants with extensive recycling systems and with short secondary retention times, cooling water is required to ensure optimum temperature.

Limiting nutrients (oxygen, nitrogen and phosphorus) are added as required to optimize the system. Nutrient addition for pulp mills was first tested in the 1950s, but did not become popular (>80% US mills) until the late 1970s. The most common retention time for pulp mill biological treatment in Canada is 4 to 10 days, depending on the system used. Retention time can reduce the impact from effluent quality fluctuations, i.e., the assimilative capacity tends to increase with retention times. Since toxic components of pulp mill effluent tend to be slow to degrade, longer retention times provide better toxicity removal than short retention times.

Aerated lagoons are the most popular system in Canadian pulp mills. Newer mills (particularly BCTMP) utilizing activated sludge. Other systems, i.e., holding ponds, rotating biological contactors and trickling filters, have been used on a limited basis, by the pulp industry in North America.

3.4.3.1 Naturalization or Long Retention Time Lagoons

a) **History**

Naturalization Stabilization Lagoons, also called long retention time lagoons, were created for pulp mills in the southern U.S. For these mills, land was inexpensive and effluent discharge into streams had to be limited during low summer flows. The least expensive and most common system of such secondary treatments is a series of holding ponds.

b) **Process Description**

The process in long retention time lagoons involved building basins large enough to encourage organisms to grow and establish biological treatment. These ponds had to be large enough to retain effluent until natural decomposition processes dissolved wastes. BOD could be reduced 50 to 90% with a retention time of 20 to 60 days and loading of about 5×10^{-5} $kg/m^2/day$ (Casey, 1980).

c) **Advantages**

Although it could take several months for treatment, operating costs were low and no special equipment was required. Also, long retention time lagoons provided a buffering from accidental spills of strong wastes with a minimum of upset.

d) **Disadvantages**

Long retention time lagoons required extensive acreage. This added to costs where land prices were high and land availability was limited. Another problem resulted from stratification of warm waste across the pond surface. This was minimized with barriers forcing waste to enter at the pond bottom. Since these systems did not often meet legislative requirements, higher functioning systems had to be employed to enhance pond efficiencies. Due to these and other problems, long retention time lagoons have generally been replaced with Aerated Stabilization Basin systems in the pulp industry.

3.4.3.2 Aerated Stabilization Lagoons

a) **History**

The Aerated Stabilization Basin (ASB) increased efficiencies of long retention time lagoons by incorporating aeration. The first surface aerated system in the pulp and paper industry was developed by Reigel Paper Company in a North Carolina kraft mill in 1964, achieving a State Wildlife Federation Award (Council on Economic Priorities, 1972). Regulation changes for suspended solids spelled the end for the single (surface) stage ASB system (Reeser, et al., 1989).

Today, ASB consists of multiple stages with high levels of aeration. This type of system has become common in western Canada (McAllen, et al., 1989). WC, PNGC, and DC have this type of ASB. Whereas the first two mills use floating aeration systems based on a plug flow design, DC uses submerged jet aeration systems based on a mixed design.

b) **Process Description**

In aerated ponds or lagoons, biological oxidation is accelerated by adding nutrients and supplying air or oxygen (with aeration devises) to the effluent. Nutrients (BOD:N:P=100:5:1) are added in the form of urea or ammonia, and phosphoric acid. The longer the retention time the less nutrients are required. Retention times vary from 3 to 15 days with BOD reduction efficiency of 80 to 95%.

The required dissolved oxygen is supplied by surface aerators or bottom diffusers through a piping system. The diffusers supply oxygen, keep solids completely mixed and minimize settling.

Optimum efficiency is reached at 0.5 mg/L dissolved oxygen or 0.5 kg oxygen per kg BOD removed (Casey, 1980). Effluent quality has been found to be directly related to the power level applied. To reduce short circuiting and minimize traces of toxic contaminants in the discharge, mixing velocities are critical. Typically, floating mechanical aerators (50 to 75 Hp) ensure oxygen transfer and mixing (McAllen et al, 1989). In the industry, there is a trend towards fewer higher powered units rather than a large number of smaller powered units (Casey, 1980).

Temperature has a significant influence on the BOD removal efficiency of ASB and as a result discharge quality varies between winter and summer (McAllen, et al., 1989). A large portion of suspended solid produced by the lagoon reactions settle and are consumed by auto-oxidation. This auto-oxidation is critical for minimizing sludge removal.

c) **Advantages**

An ASB can treat up to 20 times more effluent than a long retention time lagoon, and absorb shock loads without changes in treatment efficiencies. The effect of strong waste slugs are minimized by the large liquid volume and adequate/rapid mixing of the basin (McAllen, et al., 1989). The systems have high reliability due to simple mechanical equipment. Due to nutrient recycling within the lagoon, minor amounts of nutrients, except at startup, are required. This also contributes to minor nutrient discharge levels.

There are fewer problems with the waste sludge because a high proportion of biological solids are discharged as suspended solids in the effluent. Subsequent clarification and sludge disposal are minimized. This results in lower energy consumption.

ASB tend to have better toxicity removal than other systems. Total resins can be reduced to as low as 1.30 mg/L in the final effluent by an ASB in a cold climate (McAllen, et al., 1989). Odour from the lagoon is not a problem if adequate aeration is applied to maintain oxygen residual above the demand of the wastewater.

d) **Disadvantages**

In ASB, a minor amount of biologically active material leaves with the effluent in systems that do not have secondary clarification or recycling. In the lagoon design for potentially low effluent temperatures (below 20°C), organic loading must be kept below 0.002 kg/m²/day to maintain biological solids production in the range of 0.045 to 0.09 kg/kg BOD removed (Casey, 1980). In temperatures between 20 to 45°C, biological solids are digested by autolysis. During lower temperatures, detritus production increases, causing settling problems. Additional chemical and physical treatments are required to reduce this problem.

A major disadvantage of ASB, is that BOD removal efficiency decreases with decreasing temperatures. At temperatures less than 20°C, BOD removal can be as low as 70% and a 10°C temperature drop requires a 35% detention time increase (Casey, 1980). Staging the ASB to keep high temperatures in the first stage, reduces the effect of temperatures. Although effective in reducing BOD, ASB has limited effectiveness in removing: colour, foaming agents, odourous compounds, complex forms of BOD and chlorinated organics (Mohamed, et al., 1989).

3.4.3.3 Activated Sludge

a) History

Activated Sludge (AS) technology was borrowed from sanitation waste treatment methods. In 1955, the first AS technology was used by the pulp and paper industry in a kraft mill by Westvaco in Virginia (Council on Economic Priorities, 1972). It was installed primarily to reduce BOD (<4.5kg/ADMTPD) and minimize impacts on the receiving river water during low summer flows.

Pure oxygen activated sludge (UNOX) was developed in the late 1960s. In 1974, Weyerhaeuser Company in Washington successfully installed an UNOX system. The development of the pressure swing absorption system (molecular sieve), for economical pure oxygen production in small quantities, has renewed interest in UNOX (Casey, 1980). Today, there are 17 UNOX installations operating in the pulp industry (McCubbin, 1992).

AS systems differ from ASB by having higher biological active material concentrations contacting effluent during shorter retention times. Essentially an AS design extends an ASB by increasing solids concentrations from 50 to 200 mg/L to 2000 to 5000 mg/L and by the addition of a secondary clarifier (Casey, 1980).

In Alberta, both BCTMP mills, MWP and SLPC, as well as the ALPAC kraft mill have activated sludge systems. Although the original design for the MWP system was an ASB, this system had to be modified into an activated sludge due to failures during the first year of operation.

b) **Process Description**

AS technology controls oxidation with a mixed bacteria culture. The process involves neutralizing the effluent, adding nutrients and aerating the effluent in the presence of bacteria culture. In high rate systems, bacteria are recovered and recycled, with high levels of biological solids concentrations (2000 to 5000 mg/L mixed liquor suspended solids [MLSS]) and detention times ranging from 3 to 6 to 8 hours (Casey, 1980). Low-rate activated sludge systems (1500 to 2500 mg/L MLSS) have retention times between 48 to 72 hours.

AS systems can be designed with air or pure oxygen (McAllen, et al., 1989). AS follows a primary settling treatment, reducing suspended solids, and a neutralization mixing step where nutrients are often added. The effluent is then biologically oxidized and biological solids are separated from effluent with secondary clarifiers. The resulting sludge is returned to the aeration basin to maintain desired solids concentrations. The required oxygen is supplied with air mechanically through surface or diffused aerators.

Operating at high MLSS (5000 to 7000 mg/L) and high dissolved oxygen concentrations (>5 ppm), pure oxygen system design involves recirculating the aeration tank, with 90% oxygen utilization (Casey, 1980). Temperature for the UNOX systems is also critical. When it exceeds 37°C, sludge bulking occurs in the secondary clarifier, causing increased levels of suspended solids in the effluent.

c) **Advantages**

When inexpensive land is available, a low rate mixed activated sludge tends to be the most viable cost effective system. In a AS system, BOD removal can be 90 to 95% with substantial toxicity and COD removal (McAllen, et al., 1989). The BOD reduction rates are higher than ASB.

UNOX is a well proven pulp and paper mill effluent treatment system and can remove toxicity to meet an LC_{50} at 100% effluent (McAllen, et al., 1989) at levels higher than ASB. BOD removal rate ranges from 87% to 97% (Casey, 1980). This system is less susceptible to shock, has lower aeration tank volume, improved sludge settling, and using less land than the ABS system.

For both AS systems, capital costs are equal, but operational costs for UNOX can be substantially higher depending on the location of the oxygen supply (McAllen, et al., 1989). AOX removal by both activated sludge systems is higher than the ASB (See TABLE 3.6). Due to the smaller volume, AS are less susceptible to winter operating conditions than ASB.

TABLE 3.6: AOX Removals (McAllen, et al., 1989)

SOURCE	AS	ASB
Cook (1968)	-	49%
Skogman (1989)	39 %	14 %
Gergov (1988)	48 to 65 %	33 %

d) **Disadvantages**

One major disadvantage of the AS process is high production of biological solids, i.e., waste activated sludge ranging up to 0.5 kg solids per kg BOD removed (McAllen, et al., 1989). This requires subsequent clarification and elaborate sludge handing. Recycling of these biological solids is critical to the process.

Due to past disappointing experiences in the pulp and paper industry, incorporation of AS systems has been slow. Short retention times and small system volumes make the AS system more sensitive to effluent quality fluctuations than ASB. Also, effluent entering an AS must be below 38°C to avoid system disruptions.

One of the operational problems of an extended aeration activated sludge is bulking due to growth of filamentous organisms in the mixed liquor biomass (Reeser, et al., 1989). The filamentous organisms can be eliminated by passing the mixed liquor through an anoxic chamber immediately after the raw effluent has been added to the return activated sludge. A second anoxic chamber between the aeration tank and the secondary clarifier can reduce ammonia, toxic to fish.

3.4.3.4 Anaerobic Treatment

a) **History**

Although popular for treating municipal sewage and food industry wastes, anaerobic treatment systems are limited in the pulp industry. In 1979, the first pulp and paper industry anaerobic system was installed in a waste paper boxboard plant (upstream of an aerated stabilization basin) to reduce BOD levels increased by a mill expansion. Although research into anaerobic systems is as high as into aerobic systems, anaerobic applications in the pulp industry are limited in both Canada and the U.S.

Nagendran, et al. (1988) indicated that lower water use in BCTMP mills than in kraft mills and the resulting high strength wastewater prompted anaerobic treatment investigations. Although anaerobic treatment between primary and secondary treatments has been promising, Alberta mills have not installed this technology.

Nagendran attributes this to low energy costs of existing aerobic systems and the possibility of additional upsets from peroxides used in BCTMP mills.

Since aerobic systems have been treating effluent sufficiently to meet current government licensing parameters, the installation of anaerobic systems has not been seen as necessary. However, with licensing limits becoming more stringent, anaerobic treatment has recently become more attractive to the pulp industry.

b) **Process description**

Basically, anaerobic treatment is conducted in closed vessels with no aeration and good agitation relative to an aerobic system (McCubbin, 1992). Ideally, anaerobic treatment is most effective in the pulp industry where effluent BOD is over 1000 mg/L and 35°C. The system is usually preceded by a primary clarifier to reduce suspended solids concentration to below 200 mg/L; pH is controlled to near neutral range and sufficient nutrients are added.

The process within the reactor consists of three stages (McCubbin, 1992). First, in the hydrolysis stage, fines and other insoluble matter are solubilized by enzymes secreted by acid forming bacteria. Second, in the fermentation stage, soluble organic material is converted into a variety of organic acids, i.e., acetic and propionic acid. Finally, in the methanogenesis stage, a major portion of the organic matter produced in the two preceding stages, is converted into methane gas and carbon dioxide.

Systems can be rated as high or low rate (McCubbin, 1992). High rate systems, loaded to 5 to 20 kg COD/(m^3·day), require design capacities for agitation and gas removal. Made of steel or concrete tanks, the high systems are more expensive than low rate systems, but are also more resistant to shock. Low rate systems, loaded tc 1 kg COD/(m^3·day), are less expensive to construct, sometimes being made of earthen basins with a plastic cover, but are susceptible to temperature changes.

c) **Advantages**

The application of anaerobic systems in mills having high effluent concentrations includes (McCubbin, 1992):

- less biosludge production than an activated sludge system (reduced by 50%) and improved sludge characteristics for dewatering;
- lower power consumption than both activated sludge and aerated stabilization basin;
- less space required than an aerated stabilization basin
- significant value of biogas produced;
- some systems have lower capital costs than activated sludge; and
- potentially high AOX removal (up to 60%).

d) **Disadvantages**

Hydrogen sulphide, a lethal gas, is produced even in non-sulphur pulping mills. Safety precautions in the design and operation are important to mitigate this problem.

Anaerobic treatment may be limited in reducing BOD and toxicity levels to meet Canadian regulations as determined by pilot tests on pulp mill effluent (McCubbin, 1992). Although an anaerobic system alone did not reduce BOD by 80%, the system followed by an ASB (3 to 5 day retention time) exceeded 95% BOD reduction. For toxicity, an anaerobic system had a minor effect on toxicity but with an ASB (retention times of 6 to 7 days) non-lethal effluent limits were achievable.

3.4.4 Tertiary Treatment

a) History

Tertiary treatment involves processes following secondary treatment and aimed at reducing residual suspended solids BOD, colour and toxicity. In the pulp and paper industry, this involves removal of colour and organic salts with activated carbon adsorption, lime treatments and foam separation.

Research into an economical colour removal system for the pulp and paper industry started in the 1940s and 1950s. This research resulted from complaints of colour from pulp mills and not by governmental regulations (Nebel, et al., 1974). Although colour can be removed by a wide variety of coagulants[18], high chemical costs have made the technology prohibitive. Lime treatments were considered to be the least expensive and most attractive to kraft mills, already utilizing lime.

The first full-scale colour removal system using lime was installed before 1970 by Interstate Paper Corporation in a kraft mill in Georgia (Council on Economic Priorities, 1972). In 1974, ozone treatment for colour was considered to be effective on pulp and paper mill effluent

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18 Alum, ferric sulphate, lime, sulphuric acid, char, clay, activated carbon, activated silica, ferric chloride, phosphoric acid, waste pickle liquor, and barium alumina silicate compound (Casey, 1980).

(Nebel, et al., 1974). There are no tertiary systems used by pulp mills in Alberta.

b) **Process Description**

On a large scale operational basis, colour can be removed by chemical co-precipitation, adsorption, and chemical oxidation. The most common chemical co-precipitation is massive lime treatments, although alum and ferric chloride can also be used. Colour treatment with lime usually involves massive doses (20,000 mg/L) to reduce the fraction of colour bodies in the process sludge. Slaked lime is mixed with the highly coloured stream, i.e., sewered bleach plant caustic. Then the lime is settled, dewatered and used for caustizing green liquor. The colour bodies dissolve in the white liquor and then are removed in the recovery furnace. Additional lime is removed by precipitation from the effluent when passing through a carbonation clarifier. This process can remove 95% of the colour bodies and produce 70% colour reduction from all mill effluent streams (Casey, 1980).

Lower dose (100 mg/L) lime processes were used to improve the massive dose treatments. This involves adding lime to the effluent prior to primary settling, designed to double conventional capacity. In the clarifier, 60% of the lime, colour bodies and suspended solids settle out of the effluent. The resulting sludge is thickened by centrifuges. The overflow is treated with carbon dioxide from the lime kiln stack gas for insoluble lime conversion. Both are burned in the lime kiln. The lime kiln is oversized usually by 25% to accommodate the sludge. This system can be 85 to 93% effective in colour removal (Casey, 1980).

Adsorption methods involve using activated carbon when the flow rate is large and carbon regeneration is feasible (Nebel, et al., 1974).

Chemical oxidation involves altering the coloured organic molecules in the effluent (Nebel, et al., 1974). Ozone, chlorine, hydrogen peroxide, and potassium permanganate have been used. The chemical oxidation potential or efficiencies of these depend on the thermodynamic values. Although chlorine is considered to be the most inexpensive, environmental problems resulting from chlorine use have encouraged the use of ozone as next least expensive chemical.

c) **Advantages**

Tertiary treatment of pulp and paper effluent can reduce phosphorus in the effluent. About 50 to 70% of phosphorus discharged in effluent is insoluble solid matter. Chemical, filtration or flotation treatments (particularly flotation filtration) are proposed as phosphorus control (Vuoriranta, et al., 1989).

Ozone treatments are effective in removing colour, odour and foaming characteristics. Ozone treatments (Mohamed, et al., 1989):

- are simple and compatible with existing systems as pre- or post treatments without major modifications;
- do not produce by-products and subsequent sludge handling problems like lime and coagulation;
- being a strong oxidizing agent, fragment larger molecules for more easy biodegradation; and
- leave effluent with high oxygen content, i.e., as high as 30 to 40 mg/L.

Powder activated carbon requires little capital expenditure, and utilizes small clarifiers due to high settling rates (Nebel, et al., 1974).

Ozone treatments substantially reduce COD and turbidity, and provide disinfection (Nebel, et al., 1974). Ozone treated effluents are saturated with dissolved oxygen and no sludge results, eliminating secondary clarification.

d) **Disadvantages**

In Canada, costs of tertiary treatment are considered to be prohibitive and this treatment is uncommon.

The sludge from a lime colour treatment process is difficult to dewater. The massive lime dosage process evolved to overcome this problem. Not being able to treat all the mill effluent is a shortcoming of the process and dilution of the cooking liquors increases pressure on the recovery and chemical preparation equipment (Casey, 1980).

Powdered activated carbon treatments are expensive because the carbon cannot be reclaimed; and sludge disposal is a problem (Nebel, et al., 1974).

3.4.5 Effluent Discharge Systems

The characteristics of the receiving environment also play a role in determining effluent impacts. During low flows or during the winter, these water systems have reduced dilution capacity and effluent concentrations increase. All the pulp and paper mills in Alberta discharge into rivers and all have submerged diffusers, except DC. DC has a high rate vertical jet diffuser.

Typically, effluent can be discharged two ways (Fonstad, et al., 1986). Firstly, point source is considered to be discharge from a pipe as an outfall on a river bank, or placed within the stream flow at some distance across the river cross section. Secondly, linear or diffuser source is a pipe laid on the river bed slit along its length, or comprised of number of point sources equally closely spaced.

These discharge systems affect the river differently (Fonstad, et al., 1986). Point sources located at midstream generate mixing lengths about one quarter of those for bank sources, due to increased turbulence scales. Midstream discharges are diffused and mixed in two directions by both the mainstream flow and discharge turbulence, effectively halving the initial maximum concentrations. The mixing length for the single diffuser is between the source mixing length for the bank and midstream point sources. A number of physical processes affect discharges into rivers: advection, molecular and turbulent diffusion, differential advection, and secondary circulation (See CHAPTER 2 - SECTION 2.3.2).

A vertical jet diffuser with a high velocity outfall configuration, as installed by DC, is considered to have better mixing characteristics than other low velocity mixers. Typically, the structure is comprised of multiple jets discharging from a height of 0.3 to 0.8 m above the river bed. The height accommodates irregularities in the bottom profile and prevents river sediments from covering the outlets. The top of the diffuser should be low enough to avoid ice levels. The diffuser piping should be buried to a depth of 2 m to prevent scouring. This type of diffuser is capable of providing 20:1 dilution ratio within 50 m downstream of the structure.

CHAPTER 4 GOVERNMENT INFLUENCES ON ALBERTA PULP MILL EFFLUENT TREATMENT

4.1 INTRODUCTION

Sinclair (1990) attempted to define the economic and social trade-offs involved in government intervention. The pulp industry has always had a direct obligation to its shareholders. Society has benefited from industrial development through creation of income, employment and wealth. Industry has shared with society, in varying degrees, a concern for environmental protection. Government intervention has been viewed as the means of setting the level of environmental protection required. Environmentally disruptive waste discharges have not necessarily been associated with production costs or product prices. The amount of pollution society has been willing to accept in return for benefits has been difficult to determine. On the one hand industry points out the economic importance of pulp production to local, provincial, and federal tax bases, and on the other hand those concerned about pollution point out the negative impacts and their willingness forgo economic benefits. Governments have the responsibility of determining the trade-offs appropriate to both society and industry through legislating pollution controls.

In Canada, the relationship between government and the pulp and paper industry has been strongly interactive. Numerous technologies to decrease environmental impact have been developed independently by industry and in cooperation with government agencies. This relationship has been influenced by the industry's importance to the tax base and to Canada's trade balance. Government's role in regulating pulp and paper wastes has evolved over time; the industry for the most part harvests wood from publicly owned lands and the potential for environmental damage of those resources has been well recognized (Sinclair, 1990).

Legislative developments in the United States have influenced Canadian law regarding pulp mill effluent treatment systems. Up to 1965, most pollution control legislation was developed by individual states, resulting in varying standards and criteria. The 1899 Refuse Act (Rivers and Harbours Section) empowered the U.S. Federal Government to bring suit against anyone dumping materials into navigable waters without authorization. This act was invoked as recently as the mid-1970s to bring action against industries discharging mercury into Lake Superior and Puget Sound.

The 1965, U.S. Federal Water Quality Act and 1967 Air Quality Act established national air and water pollution control standards and the mechanism for abating interstate pollution. The Water Quality Act approved state laws which became federal regulations. If state standards were below federal standards, the federal government had the authority to dictate standards to the state's industries. The Water Quality Criteria (Green Book) released in April 1968 established standards necessary for preservation of various types of aquatic life.

A famous 1966 court case (Scenic Hudson Preservation Conference vs Federal Power Commission) determined environmental protection to be a public right. Subsequent to this confrontation, numerous court decisions and law reviews recognized that all federal agencies were responsible for public rights. In response to such situations/needs and overall increased public awareness, the United States enacted the National Environmental Policy Act (NEPA) in 1969 (McNeill et al., 1975). This legislation provided broad national policy on environmental quality, previously limited to single agencies. It identified necessary procedures for Environmental Impact Statements.

In 1970, the Environmental Protection Agency (EPA) was formed to consolidate and co-ordinate fifteen environmental programs administered by the Departments of Interior, Agriculture, Health, Education and Welfare as well as the Atomic Energy Commission and the Federal Radiation Council (McNeill, et al., 1975). The U.S. EPA was also made responsible for problems of air and water pollution, solid waste management, pesticides, radiation and noise. It began to review Environmental Impact Statements on projects concerned with those areas.

In 1970, the NEPA was used to deny federal funds for projects planned without explicit provisions for environmental protection. In 1972, the U.S. Federal Water Pollution Control Act Amendments were passed to restore and maintain the chemical, physical, and biological integrity of national waters. Water quality for the protection of fish, shellfish, wildlife and recreation was to have been assured and all pollutant discharges eliminated by 1985. Monetary and penal penalties were established. By 1977, the Best Practical Control Technology Currently Available (BPCTCA) was to be installed. Most pulp mills choose to install external treatment equipment, considered at that time to have a lower risk than non-proven, in-plant process modifications (Eddy, 1984). By 1983, the Best Available Treatment Economically Achievable (BATEA) was to have been implemented, involving both internal and external modifications.

The effluent standards in the 1983 legislation were more stringent that those in the 1977 legislation. This provided a transition period in which the pulp industry could adjust. Also, these new effluent guidelines were supplemented with information in policy development documents regarding new processes. In the 1970s, many states first enacted State Environmental Policy Acts (SEPA) which underwent major reviews in the early 1980s.

International environmental policy development has had an influence on Canadian federal and provincial attitudes. The World Conservation Strategy, published in 1980 by the International Union for the Conservation of Nature and Natural Resources (IUCNNR), the United Nations Environment Programme (UNEP) and the World Wildlife Fund (WWF), was one of the first attempts to integrate conservation and economic concerns in the policy making process (CEARC, 1990). This report recognized three important components in resource development decisions:

- maintain essential ecological processes;
- preserve genetic diversity; and
- sustainable utilization of species and ecosystems.

Over 40 national and regional strategies resulted from the report, including the Canadian government's endorsation of the Strategy in 1981.

In 1983, the United Nations General Assembly established the World Commission on Environment and Development to study the relationship between economic development and the global environment (Canada, 1990). Dr. G.H. Brundtland, Norway's Minister of Environment, as chairperson of a 23 member commission, conducted meetings throughout the world investigating economic and environmental problems. The resulting report, Our Common Future, released in 1987, clarified the concept of sustainable development. Other subsequent reports have called for integration of economic and environmental decisions (CEARC, 1990). In Canada, the concept of sustainable development was confirmed by the 1985 MacDonald Commission on Economic Union and Development Prospects. These reports indicate that national and international policies for sustainable development must include ecological dimensions as well as economic, trade, energy, agricultural, industrial and other facets.

In October 1986, in response to the Brundtland report, Canada established a National Task Force on Environment and Economy. It was comprised of seven environmental resource ministers, industry executives and environmental organization representatives. The resulting report recommended that:

- government economic development directives demonstrate economically and environmentally sound and sustainable policy;
- government processes screening, reviewing and evaluating economic development projects include socio-economic and environmental criteria; and
- industry meet environmental standards prior to receiving government funding or loan guarantees.

The report was endorsed by Canada's First Ministers in November 1987.

In October 1988, Finland established a Water Protection Programme. This directive gave special attention to the pulp sector to reducing risks from toxic wastewaters, i.e., load of chlorinated organics, and to improving effluent treatment equipment (Hynninen, et al., 1989). In-plant processes for water protection were considered most important and target levels for 1992 were set by the government for chlorinated organics.

In February 1988, the Declaration on the Protection of the Marine Environment of the Baltic Sea states was established by the Ministers of Environment of the Baltic Sea Area. It stated regulations for industrial/municipal discharges of toxic compounds, heavy metals, hydrocarbons, and limiting nutrients.

At the same time (February 1988), recommendations by the Baltic Marine Environment Protection Commission (Helsinki) were released for reduction of pulp and paper mill effluent, i.e., reducing toxic slow-degradable substances and nutrients. These compounds were to be reduced by 50% by 1995 using the latest available technology. Some proposed limits included 1 to 2 kg chlorine/ADMT of bleached pulp, 65 kg/ADMT for mean annual value of COD, 60 g/ADMT for phosphorus, and 160 tonnes per day for BOD. Pulp mills built after January 1, 1989 were to comply immediately; older factories were to meet these objectives by 2000.

In Alberta, the provincial government has been responsible for the management of water quality under the Clean Water Act administered by Alberta Environment (Environment Council of Alberta, 1985). Where there was significant national interest, the federal government had jurisdiction under the British North American Act (now the Constitution Act). These national interests include the management of boundaries, international and interprovincial waters and federal resources, i.e., fisheries or navigation. The Fish and Wildlife Division of the Department of Energy and Natural Resources has been mandated to enforce certain aspects of the Fisheries Act in Alberta.

The distribution of responsibilities between the two senior levels of government and the jurisdictional overlaps have often made industry/government planning difficult and confusing. Pulp industry technology, knowledge about pollution, and processes necessary for successful control of waste discharges have changed with the passage of time (Sinclair, 1990). Regulatory controls have not been uniform for either the pulp industry or other polluters. Sinclair (1990) indicated the level of frustration in industry in meeting government regulations by quoting one industry representative:

> "If government wants industry to reduce waste discharges we will do it, but tell us what is required, treat everybody the same, and don't change the rules every ten minutes."

4.2 BRITISH NORTH AMERICA ACT

Historically, both the federal and provincial government have had jurisdiction over water pollution control due to the nature of Canada's original constitution, formally the British North America (BNA) Act 1867. The BNA was vague in determining the ultimate level of government responsible thereby for water pollution control. The legislation gave the provinces' jurisdiction over water through proprietary interest in natural resources – the provinces have become responsible for municipal water quality. The federal government has been concerned with water quality through its responsibility for navigation, northern development, fisheries, and peace-order-and-good government authority as well as for industrial pollution. Under the Dominion Public Health legislation and the peace-order-and-good government BNA clause, it has been assumed that Parliament should assert authority in regards to controlling pollution in the interests of general human health.

Resulting from rising concern in the late 1950s and 1960s, numerous federal and provincial agencies along with crown corporations, i.e., International Pacific Salmon Commission, have worked under 80 different pieces of legislation dealing with effluent. Industry and the public both want greater coordination for more effective control. Despite early controls of water pollution, overlapping jurisdiction, inconsistency of application and poor coordination have led to the need for a more structured legislation/policy framework (Sinclair, 1990).

4.3 FEDERAL FISHERIES ACT

The federal government was initially involved in industrial pollution abatement around 1901, when the Department of Marine and Fisheries conducted regular experiments on pulp mill discharge impacts on fish habitat. On the east coast these experiments resulted in systematic monitoring of individual mills and negotiation for effluent treatment installations. Although the first pulp mill in B.C. began operation in 1894, effluent discharge limits were not imposed until 1949. These limits resulted from investigations by the Fisheries Research Board of Canada in cooperation with the Water Resources Branch of B.C. between 1939 and 1946. Negotiations for biological treatment at this same mill began in 1965.

In 1970, the Federal Department of the Environment (DOE) was created under the Government Organization Act. This legislation provided DOE with the mandate of protecting and enhancing the quality of the natural environment, including water, air, and soil. DOE initially administered through the Fisheries Act and the Canada Water Act (1970) and later through the Clean Air Act (1971), Ocean Dumping Control Act (1975), and Environmental Contaminants Act (1975). In 1973, a Cabinet directive and additional legislation established DOE's responsibility for solid waste management. Although other departments, i.e., Agriculture, Indian and Northern Affairs, Transport, shared authority for the environment, the main responsibility for industrial waste control was handled by DOE, now known as Environment Canada.

Environment Canada, through Environmental Protection Services (EPS), administers regulations and guidelines addressing industrial pollution under the legislative authority of the Fisheries Act. Although regulations and guidelines exist for six industries, those for the pulp and paper industry were the oldest and most extensive in terms of economic importance and overall impact (Sinclair, 1990).

There have been a number of administrative agreements among the federal departments for controlling industrial wastes. While the Fisheries Act is the responsibility of Fisheries and Oceans Canada (FOC), the administration of the Pulp and Paper Effluent Regulations were transferred to Environment Canada in 1978. In 1978, the "Lucas Weir Memorandum of Understanding" moved the fisheries mandate to DOE. It allowed the EPS to adopt national baseline effluent regulations for industry, negotiate solutions to pollution problems, enforce federal legislation, and act as the single point of contact for problems relating to the enhancement and protection of the natural environment (Sinclair, 1990). In 1985, a Memorandum of Understanding between DOE and FOC reaffirmed the 1971 agreement and also specified the need for better cooperation. It developed a number of changes to the Lucas Weir agreement. Even today, Environment Canada has the authority to administer pulp and paper regulations.

4.3.1 History of 1971 Pulp and Paper Mill Effluent Regulation

In the early 1960s, many felt that although the Fisheries Act (Sections 33 & 34) could regulate industrial pollution, the act was limited – even when penalty fines were increased as in 1960 (Parlour, 1981). Even though the British North American Act had provided the federal government with exclusive jurisdiction over fisheries, this power was limited by interpretations involving provincial/federal overlaps.

Prior to 1966, water pollution was dealt with on an ad hoc basis. The Fisheries Act was considered limited and inflexible and the actual definition of "pollution" within the act was ambiguous. There was negligible information about the extent of water pollution. As a result, in 1966, FOC recognized the need for a comprehensive interdepartmental approach and this was outlined in a report in August 1967 called "Proposed Program of Pollution Control and Anti-Pollution Research in the Fisheries Environment". This report indicated efforts needed to strengthen pollution control under the Fisheries Act and the need for a detailed assessment of current water pollution control programs operated by the various federal departments. As a result, FOC joined with the Department of Energy Mines and Resources (DEMR) and National Health and Welfare to establish an ad hoc working group aimed at developing an overall policy framework. FOC supported research into fisheries environment on an ad hoc or single spot management approach. On the other hand, DEMR supported a comprehensive river basin approach as it developed the foundation for the Canada Water Act. These conflicts set a caustic tone on developments in this field. The inability of this working group to resolve basic policy differences and bring about program consolidation resulted in the federal Cabinet creating the Interdepartmental Committee on Water in March 1968.

In 1966, Canadian Pulp and Paper Association President D. Jones, publicly suggested to the Canadian Council of Resource Ministers' Conference several ways of controlling water pollution (Palour, 1981). These included the creation of a water quality data collection/retrieval system, development of national water policy aimed at greater coordination between government and industry, and methods of financial assistance to industry for pollution control. This suggested assistance involved public/private cost-sharing, accelerated depreciation allowances for pollution control equipment, interest free loans, and research and development assistance. Jones suggested that flexible, economically and technically feasible government policies should be developed in consultation with industry. These suggestions were incorporated into legislative changes four years later. This initiative demonstrated the industry's concern for pollution control prior to government policy.

The economic situation of the same time period was onerous for the older, more inefficient mills in eastern Canada. Investment in modernization, let alone external pollution treatment systems, was not possible. The industry felt, in 1972, that government funds should be supplied to ease this burden in meeting public demands for increased controls, after understanding that employment losses and community impairment would result (Parlour, 1981).

The industry eventually became involved in the 1971 Fisheries Act amendments by participating in the revision of the regulations' first draft. The final regulations, in line with then current US and provincial standards, were a compromise that met government and industrial concerns. Industry felt a partial victory in having the older mills exempt on the grounds that in-plant modification costs were prohibitive. This was important since external treatment facilities could have been incorporated in old or new mills without modifying in-plant processes. The government was pleased that the industry would cooperate in complying with the regulations on new mills. The federal government had been concerned about being too severe without sufficient data upon which to base the regulations. It was better to be more lenient and get industry compliance than to be too severe and meet resistance.

The view that pollution was a public expense was not shared by some federal government agencies who held a "polluter pays" attitude. The principle of pollution control being a cost of doing business was enhanced by the Environment Committee of the Organization for Economic Co-operation and Development 1971 to 1973, especially by Canadian and U.K. members. It was believed that this approach would minimize the advantage of government subsidies for the industry in international markets.

The government realized during the summer of 1971 when the amendments had been approved that they would face resistance from industry if financial assistance was not forthcoming. Financial arrangements were made through amendments to the Tax Act, even though the previous public message had been "the polluter pays". Companies investing in pollution control equipment could claim accelerated capital cost allowances against corporation tax. Special arrangements were made for other companies not having sufficient profits to cover the available tax allowances.

The first step toward the eventual 1971 amendments was a memorandum from the Minister of FOC (January 1968) to Cabinet implying that pollution control would be better handled with extensions to the Fisheries Act rather than through the creation of other devices involving the Canada Water Act, as proposed by DEMR. This memorandum requested amendments to extend powers of the Fisheries Act to control developments constituting threats to fish habitat. The Interdepartmental Committee on Water, upon receipt and review of the proposed amendments and in light of opposition from other departments, decided to postpone any action on this matter until the draft Canada Water Act had been completed. This opposition came from DEMR and Northern and Indian Affairs, both concerned about legislative powers on this matter implied in the Canada Water Act and Northern Waters Rights Act.

During this debate in the spring of 1969, two public events with significant impact occurred (Parlour, 1981). Firstly, at public meetings held by the House of Commons Standing Committee for FOC on water pollution in B.C., the public condemned the federal government for failing to control water pollution in the province and demanded that the Fisheries Act be used more aggressively to control pollution. The Standing Committee agreed and recommended that the Fisheries Act be amended. Secondly, riding mass media coverage of environmental issues, the Fisheries Minister publicly recommended using the Fisheries Act to control pollution, especially for individual mill pollution where the proposed Canada Water Act would be limited.

The first draft of the amendments were released to the Canadian Pulp and Paper Association and provincial authorities in late October 1970 and critical reviews were returned. There was concern about using U.S. data to formulate the regulations. More current and complete data were needed on effluent levels and production technologies from the Canadian pulp and paper industry. A regulation development team comprised of federal, provincial, and industrial representatives was created to revise the first draft. The mandate of this team was to establish a philosophy of national effluent standards based upon the best practical technology, not exempting any mills discharging directly into the ocean, and avoiding compliance schedules for older mills (which would be negotiated after approval).

After much debate and confusion regarding the two Acts, the Cabinet decided to limit the Fisheries Act amendments to fish habitat protection so as to minimize conflict with the Canada Water Act. Due to the high level of public concern, both legislative documents were drafted and submitted jointly to parliament for approval (Parlour, 1981). The Fisheries Act amendments received final approval in June 1971. These amendments expanded power to protect fish environment, and set national effluent standards based on technical feasibility (especially for pulp and paper industry effluent).

At about the same time, the creation of the Department of Environment was announced in the House October 1970.

4.3.2 Contents of 1971 Pulp and Paper Regulations

The Fisheries Act regulations addressed conventional pollutants, total suspended solids, oxygen demanding decomposable material. In 1970, an amendment to the Act allowed industrial pollution control regulation to be developed and regulations for the pulp and paper industry were the first to be issued. The Pulp and Paper Effluent Regulations of the Fisheries Act regulated mills built, expanded or modified after 1971. The regulations were based on cooperation and coordination with industry and provincial governments. New mills were required to immediately incorporate standards based on best available technology. Standards for existing mills, with expansions and modifications, were negotiated and phased in over time (accounting for technical feasibility, financial burdens, and local implications).

4.3.3 1992 Fisheries Act Amendments

Sinclair (1990) conducted a review of pollution control in Canadian pulp and paper manufacturers from a federal perspective. The report's recommendations include:

- All mills should be required to meet federal regulations over a period of 5 to 7 years.
- Regulations should specify the legal authority for federal officials to enter into compliance agreements with individual mills and to enforce the negotiated provisions.
- The in-place BOD, TSS, and toxicity limits are considered to be appropriate and should be maintained. Toxicity test requirements across the industry and among provinces should be reviewed.

- Biological impact assessments should be used selectively to set criteria for validating and negotiating exceptions to regulations. Unless discharged waste detrimentally affects fish habitat, discharge limits more stringent than the federal regulations should be left to the provincial authorities.
- Federal government should avoid choosing the control system to be used by industry.
- Industry should not be permitted to determine when environmental assessments or treatability studies are necessary, unless the companies pay the full costs of such assessments and commit themselves to additional control measures if indicated in the studies.
- After all mills are in compliance with federal regulations, additional time concessions should be based on the financial circumstances at each individual mill.
- When companies claim government standards cannot be met for financial reasons, independent audits should be required.
- Government assistance for environment controls should be provided through research incentive programs or a fixed fund reserve system to encourage the industry to spend its own funds on controls.
- The single window approach for industry to deal with one government should allow the federal government to deal with individual mills when necessary.
- To ensure the availability of the most current information to the Canadian industry, government and industry should work with other nations.
- The federal government should establish regulations to control organo-chlorines at source.
- The Fisheries Act should be maintained as the applicable federal legislative process until other legislation becomes effective.
- The Federal Pulp and Paper Effluent Regulations should apply immediately to expanded or altered mills.
- Environment Canada's information on the pulp and paper industry should be upgraded.

Difficulties arising from implementing the 1971 Fisheries Act regulations were (Canada, 1991 & Halliburton, et al., 1989):

- Regulations did not apply to all mills, resulting in less than 10% of pulp mills in Canada being covered.
- When applying toxicity testing, it was difficult to determine if the effluent originated from the expanded or original portions of the mill.
- Regulations did not reflect technologies developed since 1971.
- Toxicity testing methodology was overly complicated and based on a pass/fail test. (This did not provide quantitative information on the degree of toxicity and the effectiveness of actions taken.)
- Reporting frequencies were not specified.

The Pulp and Paper Regulatory Package, put forward on December 4, 1991 by Environment Canada, Fisheries and Oceans, and Health and Welfare Canada, proposed changes to the Fisheries Act and Canadian Environmental Protection Act (CEPA). Proposed amendments to regulations under the Fisheries Act included setting new limits on effluent discharges, establishing new monitoring procedures and extending regulations to all mills in Canada. Within these revised regulations, specific clauses apply to stricter enforcement policies.

The Pulp and Paper Industry Regulation Package was developed from extensive consultations with the Canadian Pulp and Paper Association, other federal departments, non-governmental environmental organizations, and 14 public meetings across Canada (Canada, 1991). The industry representatives recognized the need for improved regulations, but were concerned about the required capital investment, especially during the depressed economic climate. They were concerned about a potential shortage of consulting engineering expertise required for the process changes. Industry representatives requested a joint provincial/federal regulatory "window" aimed at simplifying the enforcement and implementation of these regulations.

During the same process, environmental groups, supportive of the government's efforts to regulate pulp and paper mill effluent, made a number of comments. They considered the current limits for BOD, TSS, and toxicity as not sufficiently stringent and the time allowed to implement the new regulations as too long. Another concern was that no guarantee that monitoring would reflect actual discharges.

Fisheries Act Regulations amendments come into effect July 1, 1992. These regulations apply to all pulp and paper mills discharging effluent to receiving water and to off-site treatment facilities[19]. Mills requiring more time to install modifications must apply for authorization to discharge effluent while necessary process changes are being implemented. These changes must be completed by December 31, 1993. Extensions will be granted until December 31, 1995, if extraordinary circumstances can be demonstrated to government and the public. Technical, financial and competing environmental priorities will be taken into account by the government before granting extensions.

Mills will be required to submit an Environmental Effect Monitoring (EEM) report to Environment Canada every three years in accordance with the monitoring regulations. The EEM will measure the amount of deleterious substances in waters and the resulting impacts on fish habitat. The EEM procedures should be in accordance with the Aquatic Environmental Effects Monitoring requirements, which may be amended occasionally. The evaluation of this information will determine the need for further controls and improved monitoring procedures.

The new regulations apply to the discharge of deleterious substances defined by three classes: BOD, TSS, and acutely lethal effluent. Monitoring will consist of taking a grab sample at each effluent outfall for acute lethality testing, daily and monthly duplicate samples for BOD and TSS testing and daily and monthly measurements of the effluent volume at the outfall. Testing for acute lethal toxicity will be weekly and

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19 Applies where off-site facilities have BOD $\geq$ 5,000 kg/day or represents more than 20% of the total quantity of BOD from all sources treated by the off-site facility. (Canada, 1991).

monthly, for BOD tri-weekly, and for TSS daily. The maximum allowable levels of BOD and TSS are determined by:

a) during any 24 hour period[20]: $Q_d = F \times 2.5 \times RPR$;

b) during any month: $Q_m = F \times D \times 1.5 \times RPR$.

Capital costs to comply with the 1991 Federal CEPA changes are estimated at $560 million and Fisheries Act changes will cost $2.3 billion (Canada, 1991).

Federal regulations for BCTMP mills are ambiguous. The recent amendments, effective 1994, will include BCTMP mills.

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20 Q_d= max BOD or TSS in kilograms/day
Q_m= max BOD or TSS in kilograms/month
F = factor of 5 for BOD; 7.5 for TSS in kilograms/tonne of finished product
D = number of days in a month
RPR= reference production rate for dissolving grad sulphite pulp.

4.4 CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA)

CEPA regulations play a role in controlling both toxic chemicals used by and by-products emanating from the pulp and paper industry, i.e., dioxins and furans. Toxic substances (chemicals, groups of chemicals, effluent and wastes) are defined as being harmful to the environment or constituting a danger to human health. Enacted June 30, 1988, CEPA (Section 34) allows for the development of regulations restricting substances deemed toxic under the Act. It consolidated some earlier federal environmental legislation, including the Environmental Contaminants Act, Canada Water Act, Clean Air Act, Ocean Dumping Control Act, and Department of Environment Act (Phillips, 1990).

Under the Act, the Ministers of Environment and National Health and Welfare are required to prepare and publish a Priority Substances List (Schedule I of Act) identifying toxic substances. Regulations for these substances control any aspect of their life cycle, from the research and development stage through manufacture, use storage, transport and ultimate disposal (Environment Canada, 1990). Up to 1991, two Priority Substance List Assessment Reports have been completed and published: one on dioxins/furans, the other on effluent from pulp mills using bleaching. Both groups of substances were considered to be toxic under the Act.

Although federal and provincial governments were moving toward state-of-the-art processes and treatment technology to control pulp mill effluent, certain pulp mill wastes were not regulated as of 1991. These include (Environment Canada, 1991):

- Disposal of chlorinated organic contaminated sludge from the secondary treatment lagoons. Current disposal methods are incineration, suspected of source of dioxins at low temperatures, and dumping at landfills.
- Emissions into the atmosphere.
- Chlorine consumption by the bleaching pulp mills.
- Safe chlorinated organics levels in fish for human consumption.
- Long term studies of aquatic biota.

The 1991 Pulp and Paper Regulatory Package contained new regulations under CEPA. These established new standards for dioxin/furan levels. An immediate ban on the use of contaminated defoamers and on woodchips containing pentachlorophenol were to be regulated under CEPA. Pulp mills operating prior to June 1, 1990 are required to implement process changes by January 1, 1994 to prevent the formation of dioxins/furans. Mills built after June 1, 1990 must comply by July 1, 1992. Any measurable amount of dioxins/furans is considered a violation.

Within both the Fisheries Act and CEPA, there is provision for joint agreements between the two levels of government regarding the administration of the regulations. Currently, no agreements exist, but there have been memoranda of understanding for cooperation, i.e., Environmental Accords 1985. One of the major concerns expressed by industry during the developments of the most recent federal legislative changes was to have one reporting window. Until this is brought about, pulp and paper mills report monitoring data to both governments.

Currently, the federal and provincial governments are negotiating these administrative accords and Alberta may have an agreement by mid-1993. The intent of the federal legislation is to establish national baseline standards for pulp and paper mill effluent. Where provinces meet or exceed federal legislation, the federal government will not actively legislate the industry and the province will be responsible for collection and verification of monitoring data. If there are discrepancies, the federal government will be actively involved. Details for these agreements are found in CEPA Enforcement Compliance Policy for Administrative Agreements and in the Fisheries Act in designation of the Authorization Officer.

4.5 CLEAN WATER ACTS

In 1970, the Canada Water Act was proclaimed to respond to trends in the 1960s towards large scale, multipurpose water resource developments which crossed jurisdictional boundaries, as well as to the need for federal-provincial arrangements (Environment Council of Alberta, 1985). This legislation allowed the Federal Minister of Environment to enter into agreements with the provincial government for water management. No water quality management agreements were ever established under the Canada Act, but some national standards were set, i.e., phosphorus content in detergents. Existing inter-provincial agreements, i.e., Prairie Provinces Water Board, addressed basin specific water quality requirements and apportionment of similative capacity between provinces. Other water quality objectives, Surface Water Quality Criteria and Interim Water Quality Requirements, were adopted by Alberta Health Department in 1970 and by Environment Canada in 1973.

In Alberta, the Minister of Environment had primary responsibility for the management of water through the 1971 Clean Water Act (Environment Council of Alberta, 1985). The responsibility involved balancing resource management, environmental protection and the quality of life. This implied that the economic and social benefits of resource development had to be weighed against the environmental and social costs.

In the early 1980s, the Alberta Minister of Environment requested that the Environmental Council of Alberta review the Clean Water Act and its role in the management of water quality in Alberta. This was in response to growing public doubt about the government's effectiveness in regulating and enforcing environmental protection. The resulting Environment Council of Alberta report (1985) indicated the balance between judgments by water resource managers and the political process could be found in a number of provincial policy statements. The Water Resources Management Principles for Alberta recognized that a plentiful supply of good quality water, widely distributed, was a fundamental requirement for balanced economic growth and an expanding population. Water resources were to be managed in support of the overall economic and social objectives of the province. These principles included:

- To be effective, pollution was to be controlled at its source.
- The polluter was to generally pay for the clean up costs.
- Preventing pollution was the direct responsibility of the polluter and the government will not pay for industrial pollution control equipment.
- Government aimed at being preventative, working with industry in pollution control and natural resource management, and enhancing the livable environment.
- To control pollution at the source, enterprises were to adequately monitor and report their pollution streams.
- Government policy aimed at setting pollution standards initially severe enough so as to prevent the need for revision at frequent intervals.
- Each industry would be assigned individual standards.
- Alberta standards would be set as high if not higher than the federal government nationally and by U.S. EPA.
- Identify the need for green belts and dispersing polluting industries to reduce pressure of existing industries so as to maintain ambient standards.

The Clean Water Act was the primary licencing statute whereby these principles could be implemented and water quality protected (by permitting, licensing, monitoring, and enforcing the release of contaminants into surface waters). Standards and Approvals Division of Alberta Environment was responsible for setting effluent standards and issuing licenses. River monitoring and control of emissions were implemented by the Pollution Control Division.

Originally, the Clean Water Act contained a provision also found in the federal Fisheries Act prohibiting deposition of deleterious substances. Proving a substance to be deleterious was difficult in court and the Clean Water Act was revised in 1980 to improve the definition. The Clean Water Act amendment defined a water contaminant as any solid, liquid, or gas, or heat in water, resulting in a temperature change in surface or underground fresh water. Water pollution occurred when a water contaminant was in excess of the permissible concentration prescribed by the regulations. If the allowed maximum contaminant concentration was contravened, water quality control orders were issued. The Act prohibited disposal of a water contaminant into a watercourse, surface water, or underground fresh water sources if it was likely to degrade or alter chemical or biological water quality or to be harmful to human, fish, wildlife, livestock or plant life (Environment Council of Alberta, 1985).

Discharge limits were set specifically for individual pulp mills to incorporate the uniqueness of the mill technology and of the receiving environment. APPENDIX A provides standards for each mill in Alberta, actual discharges reported, provincial licence limits and the federal parameter limits. It is interesting to note that in all cases industry-reported monthly average discharge levels have been below the provincial limits. Both the actual industry discharges and provincial limits are substantially lower than the national limits set under the Fisheries Act. APPENDIX B summarizes parameter limits included in a typical provincial Licence to Operate.

Approval to discharge pulp mill effluent under the provincial Clean Water Act consisted of two phases: Permit to Construct and Licence to Operate. A Permit to Construct, issued by Alberta Environment, stipulated the design basis of the approval. It was issued after the Environmental Impact Assessment (EIA) was approved and prior to start of construction. The Permit to Construct contained effluent standards based on the EIA information generated from monitoring and modeling programs.

A Licence to Operate, valid usually for five years (may vary), was issued upon completion of mill construction and prior to start up. It identified detailed liquid effluent standards, monitoring/reporting requirements and specific treatment studies. Typically, mills were required to conduct groundwater monitoring, biological and water quality river surveys, and routine wastewater sampling (on monthly and annual bases). The Licence required studies aimed at optimizing performance of wastewater treatment systems. When licences were renewed, new concerns and standards were to be addressed.

The Clean Water Act was enforced through control ord~ , s:op orders, and certificates of variance (Environment Council of Alberta, 1985). Water quality control orders were issued if a water contaminant concentration in the receiving environment exceeded the maximum prescribed by regulations. For the pulp industry, a control order was issued if a discharged water contaminant exceeded the maximum licenced limit. Control orders directed companies to limit or halt the discharge of the water contaminant, to install equipment to control discharge, to measure rate and amount of discharge, and to report actions taken. A stop order was issued if the company was contravening the Act, regulation, or order, or was operating a plant considered to be immediately dangerous to human life or property. Stop orders required the company to cease the contravention and/or stop operations. Failure to comply was an offense and liable to fines of $50,000/day or term of imprisonment of up to 12 months or both.

Two fundamental approaches to water quality management involve protecting the resource or licencing allowable contamination (Environment Council of Alberta, 1987). The Clean Water Act was aimed at regulating the release of substances rather than protecting environmental quality by preventing additional contaminants loadings. This has had a major influence on the administration and enforcement of the Act. It fostered the attitude of "will this extra contamination cause a noticeable deterioration in water quality", rather than "what steps can be taken to maintain or improve water quality". Environment Council of Alberta (1987) determined Alberta Environments approach to water quality management to be based on what technology could achieve, not on what was necessary to protect the environment.

Instead of regulating ambient standards under the Clean Water Act, the Director of Standards and Approvals published the Alberta Surface Water Quality Objectives (ASWQO) in 1977. These provided a set of criteria by which the government could measure if the protection of water quality had been achieved (Environment Council of Alberta, 1985). The 1977 Surface Water Quality Objectives replaced the 1970 Surface Water Quality Criteria established by the Water Pollution Control Section of the Department of Health.

When released, the ASWQO did not reach standards established by Environment Canada in 1972 or by the U.S. EPA in 1976 (Environment Council of Alberta, 1985). The ASWQO covered a limited number of parameters, did not contain parameters[21] set by other provinces and provided general pesticide levels rather than specific objectives for individual pesticides (Environment Council of Alberta, 1985). The ASWQO were aimed at establishing minimum water quality guidelines for the most sensitive uses, i.e., public water supply, recreation involving direct water contact, and wildlife/aquatic life protection. Alberta Environment recognized that although water quality assessment was complicated, partially subjective, and limited by current knowledge, a minimum level of quality was needed beyond which no water body should be allowed to deteriorate.

Environment Council of Alberta (1985) indicated that the report publishing ASWQO did not state how the objective would be applied. Where natural water quality fell below the ASWQO, the report suggested that it would be unwise to permit further deterioration by unlimited or uncontrolled introduction of pollutants. The ASWQO were not to be applied to the area immediately around discharge outfalls. The numerical objectives provided a basis for determining the receiving water's capacity to assimilate water contaminants. The report indicated that effluent discharge limits should be budgeted upon implementation of best practicable control technology and industrial performance in conjunction with the ambient ASWQO. This implied that the objectives provided protection of the aquatic environment and that the licensing discharges should be related to the ASWQO and ambient quality. The ASWQO report was unclear about what would result if the ASWQO were achieved/maintained, and about how the province could achieve the objectives

21 Beryllium, magnesium, nickel, chloride, chlorine, total dissolved solids, chlorine residuals, or sulphate (Environment Council of Alberta, 1985).

The lack of explicit direction about the implementation of ASWQO led to different views within Alberta Environment and reflected the different attitudes and approaches toward water quality management (Environment Council, 1987). Where ASWQO applied to all surface waters for the most sensitive use, other basin-specific and reach-specific objectives were being developed for existing water quality and uses. Calgary was required to reduce phosphate loadings with tertiary treatment, whereas phosphorus levels 100 kilometers downstream of Edmonton routinely exceed ASWQO. The Environment Council recommended that the effectiveness of the Clean Water Act could be substantially enhanced by the addition of clearly stated water quality goals and a statement of policies/guidelines to obtain the goals.

Some pulp mill proposals have been vehicles for legislative changes and guideline development. One such proposal was submitted by Makin Pulp and Paper Company for the development of the O'Chisse Block of the Brazeau Timber Development Area (1982). This proposal consisted initially of a 200 ADMTPD Chemi-Mechanical Pulp Mill, with a second phase expansion of 200 ADMTPD, discharging effluent on the North Saskatchewan upstream from a number of communities including Edmonton. Water quality was of major public concern during hearings held following the submission. As a result, the mill application was not approved. An Alberta Environment Water Quality Task Force was ordered by the Deputy Minister of Alberta Environment in 1985 to investigate water quality issues as they related to a subsequent submission by the same company. This task force concluded that government guidelines to address water quality concerns did not exist. In response, a report was released (March 1986), aimed at river mixing analysis problems and developing guidelines for assessing for future pulp mill submissions (Fonstad, et al., 1986). The Makin proposal, i.e., design factors, was used as an example indicating how future proposals should be submitted.

This report recommended that similar analysis be conducted for all discharge applications under the Clean Water Act. Where other uses, i.e., drinking water, fish habitat, were identified in the receiving water, more rigorous analysis should be conducted as suggested by Krishnappan and Lau (1982) with the RIVMIX Model.

The study recognized limited data were available and recommended that Alberta Environment adopt an effective river monitoring program.

Technology based and water quality based approaches have been used to establish effluent standards. The water quality approach considered knowledge of existing conditions, water quality objectives for sensitive areas, and the ability to predict changing river water quality for the development scenario (MacKenzie, et al., 1989).

The technology based approach required mills to meet the equivalent of the New Source Performance Standards of the U.S. Environmental Protection Agency, involving good in-plant collection and recycling with primary clarification and secondary biological treatment. For biological treatment of pulp mill effluent in cold climates, there has been a trend away from aerated stabilization basins (ASB) to activated sludge (AS), because AS has superior performance in reducing BOD, TSS, and chlorinated organics. Anaerobic treatments, (especially for mechanical pulp mills between the primary and secondary stages) have been investigated but not accepted in Alberta due to low energy costs for high energy-using technology, and to concern about toxicity of anaerobically treated peroxides.

In Alberta under the Water Quality Act, both technology and water quality based approaches were used to regulate pulp mills. Alberta Environment appeared to be the first regulatory agency in North America to control production of chlorinated organics (McKenzie, et al., 1989). In addition to setting licence standards, three in-plant processes, based on worldwide research/progress, were required for all kraft mills: extended delignification, oxygen delignification, and high chlorine dioxide substitution.

On December 2, 1988 the provincial government announced new standards for pulp mill developments, based on a review of standards throughout the world. Pulp and paper mills in Alberta, as in the USA, were required to apply state-of-the-art technologies as well as primary and secondary effluent treatments for new and expanded bleached kraft pulp mills. Only about one half of Canadian mills using bleaching have both primary and secondary treatments.

Prior to the 1988 directive, mechanical and chemical pulp mills were expected to employ the Best Practicable Technology, which included inplant spill collection and recycle as well as primary and secondary effluent treatment (Nagendran, et al., 1988). In 1988 a state-of-the-art technology directive was sent to companies operating kraft mills by the Minister of Alberta Environment indicating that Modified Continuous Cooking (MCC) with Extended Delignification (ED), Oxygen Delignification (OD), and High Chlorine Substitution (HCS) were required. WC and the DC mills complied by installing MCC, OD, and HCS. PNGC originally agreed to install the required or equivalent technology, but eventually only installed HCS to a 100% capacity. It is interesting to note that of the three operating kraft mills, PNGC presently records some of the lowest AOX (kg/tonne) levels.

In the early 1980s, the Environment Council (1987), with Alberta Environment staff input, identified disadvantages of using technology based effluent guidelines. Implicit allowance was made for the inability of technology to be in 100% compliance, allowing for uncontrolled releases, controlled but unlicensed releases, and accidental spills. This approach did not account for the environmental impacts of releases, nor foster an attitude that violations were serious matters. New guidelines were slow to develop, in part because many felt the existing guidelines adequately protected water quality. Preventative or improvement action was not encouraged. Instead, further contaminant additions were permitted until deteriorating quality warranted improved response. The public, expecting environmental legislation to protect water quality and all offenses to be serious offenses, perceived the government to be ineffective. In essence, the Environment Council found that the public expected the government to measure performance against some set of ambient water quality standards, if not the ASWQO, and not allow industries, unable to meet the ambient conditions, to develop.

Another concept that the Environment Council (1987) reported to be misunderstood was the concept of assimilative capacity. The concept of assimilative capacity assumed that aquatic systems eliminated organic materials through a biodegradation, oxygen consuming process and that at some point downstream the water body returns to its previous dissolved oxygen levels. Sometimes this concept had been used for other contaminants, i.e., metals, that do not assimilate but accumulate with adverse impacts. The definition of assimilative capacity had changed to mean the difference between the natural water quality and an arbitrary maximum acceptable level for a particular contaminant. This modified meaning was no longer a measure of a river's capacity to purify itself, but an acceptable level of quality lower than natural quality. The long term consequence would be a deteriorated level of water quality across the province. The Environment Council recommended that the Clean Water Act, the associated regulations, and Licences to Operate be modified to control, reduce and eliminate contamination in order to meet the natural water quality standards expected by the public.

A 1987 national survey indicated that 98% of the pulp and paper representatives felt that the federal government could make the greatest effort to help industry protect the environment by incorporating assimilative capacity into regulations (Sinclair, 1990). Edwards (1990) indicated in a report on the ALPAC Hearings that an ecosystem approach to water quality regulation in Alberta had been recommended in 1988 by a Review Panel investigating Environmental Law Enforcement. The ALPAC Review Board recommended that this approach be adopted not only for EIA reviews but also for ongoing management and regulation of river systems. Based on carrying capacity, this approach required detailed knowledge of watersheds. This recommendation facilitated the Northern Rivers Basin Study.

The Clean Water Act, along with other legislation regulating substance discharge[22], will be consolidated into the proposed Alberta Environmental Protection and

22 Clean Water Act, Clean Water (General) Regulation, Clean Water (Municipal Plants) Regulations, and Water Resources Act (permits and Licences).

Enhancement Act. This consolidation, also done at the federal level for CEPA, was aimed at more effective regulation of pollution.

4.6 FEDERAL ENVIRONMENTAL IMPACT ASSESSMENT (EIA) PROCEDURES

In 1974, the federal government released Environmental Assessment Review Process (EARP) Guidelines, formulated pursuant to subsection 6(2) of the Government Organization Act (1979). EARP was formally established by order-in-council in 1984, by the Environmental Assessment and Review Process Guidelines Order, pursuant to the Department of Environment Act (Kansky, 1991). EARP set out the policy and procedures to determine environmental impacts of projects (Edwards, 1990). EARP's stated its purpose was to ensure environmental implications were considered as early in the planning process as possible and before irrevocable decisions were made. EARP applied to all proposals where the federal government had a decision making responsibility. The Federal Environmental Assessment Review Office (FEARO) was made responsible for the administration of EARP.

Basically, EARP consisted of two phases: initial assessment and review by a panel. The initial assessment determined the potential adverse environmental impacts and recommends either approval or a public panel review. EARP panels, administered by FEARO, were selected to hold public hearings and review project EIAs within predetermined terms of reference. Each panel submitted to the Ministers of Environment a report containing conclusions and recommendations about the project

In order to avoid duplication of EIA reviews, in May 1986, the Alberta and Canadian governments established an agreement concerning EIA procedures for projects in Alberta, (Moen, 1992). This Agreement Concerning EIA of Projects in Alberta with implications for Canada and Alberta was a subsidiary agreement under the Canada-Alberta Accord for the Protection and Enhancement of Environmental Quality. This unpublished document encouraged cooperation and coordination between the two governments and set out the principles and basic procedures to review projects with environmental impacts. It indicated that EIA procedures of the government with primary jurisdiction for approval would apply and where governmental jurisdiction overlapped, a consultative process would determine review procedures. The

FEARO ALPAC Review Board was negotiated by Alberta Environment and FEARO under this agreement. This agreement expired in May 1989.

The EARP guidelines were considered discretionary until a Federal Court Decision on the Rafferty Alameda Dam Case (1989) and the Oldman River Dam Case (1992) determined that the guidelines were law of general application and therefore binding on the federal Crown. The EARP had to be complied with prior to the issuance of federal permits and approvals for projects with potential environmental impacts (Kansky, 1991). The Federal Court of Canada ruled that EARP bound the government to assess all its activities for their environmental effects, including policies and programs (FEARO, 1991). This decision influenced the creation of the Canadian Environmental Assessment Act (CEAA), legislation to clarify the policy assessment process.

In 1987, the federal Minister of Environment was directed by the government to initiate consultation with the public on the need for reforming EARP. A Green Paper was released for discussion (FEARO, 1991). Over a six month period ending in March 1988, meetings were held with governments, the private sector, native peoples, environmental and special interest groups, the legal profession, EIA professionals and the general public. As part of this process, the Environmental Planning and Assessment Caucus of the Canadian Environmental Network reported core elements essential for an effective environmental protection process (Kansky, 1991). Among the many comments by the participants, an accountable and administratively simple process based in law was endorsed. This consultative process formed the basis for new legislation.

In June 1990, the federal government initiated Bill C-78, an Act to establish a Federal Environmental Assessment Process, namely to improve and strengthen the EARP guidelines. The resulting Canadian Environmental Assessment Act Bill C-13 was given Third Reading by the federal Parliament in March 1992.

CEAA proposes a number of key reforms over EARP (FEARO, 1991). In the new Act the Minister of Environment will make decisions on public reviews; previously the responsible authority had decided. All major projects will undergo a mandatory assessment; previously this was discretionary. Assessments of major projects will be required to include accumulative effects relative to other projects within and outside Canada, project justification, alternative project methods, effects on resource sustainability, and formalized public consultation. These are not required under EARP. Public registries will be maintained for all assessed projects; where previously registries were ad hoc and voluntary. Public review panels, including the chair, will be fully independent of the government and be issued subpoena powers. Previously, review panels were chaired by public servants from the FEARO and had to rely on the goodwill of participants. There is provision in CEAA for mediation of environmental disputes and follow up and monitoring plans of major projects, both of which are unique internationally. Special provisions are available for lands claimed by native peoples and for Crown corporations. Intervener funding will be formally and consistently provided for participants. Finally, CEAA will be separate from Environment Canada.

4.7 ALBERTA ENVIRONMENTAL IMPACT ASSESSMENT (EIA) PROCEDURES

In 1965, the Alberta government modified policy regarding pulp mill developments. Prior to this time, the government had granted sole exploratory rights for a reasonable time to one company interested in developing a pulp mill in the province (Alberta Lands and Forests, 1967). This action appeared to eliminate other investigations and delay pulp mill developments. In January 1965, interested parties were required to indicate financial and management abilities to operate pulp mill facilities and market the resulting product.

Any proposals would be subject to public hearings. The purpose of the hearings was to allow the public to review proposals and express views on the advisability of the development and any other aspect pertaining to use of the forest resources of the area (Alberta Lands and Forests, 1967). The hearings were not intended to be competitions between the interested companies or to allow discussions not directly relevant to the proposals. The meetings were chaired by the Minister of Lands and Forests.

In 1966 and 1967 the government advertised in pulp and paper and financial journals the availability of forest lands suitable for pulp mill development in the Grande Prairie area. Two proposals were received by July 1, 1967, one from McIntyre Porcupine Mines Ltd. and PNGC. In October 1967, the Alberta Department of Lands and Forests held public meetings on the two proposals (Alberta Lands and Forests, 1967).

The public hearing summary presented by McIntyre Porcupine Mines Ltd. specifically mentioned minimizing air and water pollution by meeting the Public Health Act. This Act regulated BOD to standards determined by the Department of Health. It was noted that the pulp mill sites near Grande Prairie (where odours would be obnoxious) would require high construction costs to reduce air pollution. However, the company was prepared to spend a reasonable amount for pollution control (estimated at $1.5 to 3.5 million).

In its presentation to the hearing, PNGC mentioned that a site with land adequate for necessary ponding areas for effluent treatment would be required. The company promised to comply with the Public Health Act's air and water pollution standards and to spend up to $4 million for control and disposal facilities. This pollution would be treated with modern abatement techniques, methods and devices.

Questions were received from Grande Prairie council and chamber of commerce representatives as well as members of the forest industry, i.e., North Canadian Forest Industries already operating in the area. The discussion dealt primarily with the pulp mill being compatible with existing lumber mill operations and the capacity of Grande Prairie to develop further. It is interesting to note that although the meetings were intended for the public, most questions were offered by representatives of involved organizations.

In 1977-78, the provincial government solicited proposals for unallocated timber adjacent to the WC FMA. WC applied for the timber rights along with a number of other companies. At that time, after an EIA process, a proposal from BCFP/Grand-cash joint venture was accepted. The timber would be granted on condition that milling facilities be constructed. This mill was never constructed. WC was granted the extra timber rights and the Hinton mill was expanded in 1989 as a result.

Originally, the Environmental Conservation Authority of Alberta held the power to conduct public hearings regarding environmental protection under its own initiative or direction by the Lieutenant Governor (Edwards, 1990). In 1977, the Authority lost this power when it was reconstituted as the Environmental Council of Alberta, which did not have the authority to initiate hearings. The Cabinet could still constitute a panel for the purpose of holding specific public hearings. Today, the Council plays no regular role in reviewing EIAs. The power to conduct public hearings ended up in Section 6 of the Department of the Environment Act (1980) under the direction of its

Minister. There was no guidance regarding the procedure for conducting public hearings.

Prior to 1992, EIAs were reviewed by the Environmental Assessment Division of Alberta Environment under the Conservation and Reclamation Act (1980). The authority for requiring an EIA was contained in Section 8 of the Act. Technically, an EIA could be invoked when the proposed project would result in a surface disturbance. Specifically, an EIA could be requested for projects affecting the conservation management and utilization of natural resources, as well as for the prevention and control of pollution and the protection of aesthetic values of natural resources. Companies proposing projects with potentially significant environmental impacts sought clarification from Alberta Environment on the requirement of an EIA. As indicated by a set of guidelines, the company was then ordered to submit a document based on a consultative process including the company, public and Alberta Environment.

It is important to note that these guidelines were not legislation, even though the Act provided for the promulgation of regulations for EIAs by the Minister. In December 1985, the government published a booklet called "EIA Guidelines". Although not legally binding, the guidelines were heavily used by government staff administering the process (Tingley, 1991). The guideline objectives were achieved through an interactive process involving public and government review of draft stages of the EIA document. The Guidelines provided a list of projects requiring EIAs. Although pulp mills were not on this list, pulp mill proponents were submitting EIAs as a matter of policy by 1988.

In 1988, these guidelines indicated a number of main objectives:

- describe the proposed mill facilities, infrastructure and manufacturing process and the environmental management of these systems;
- identify the main environmental, community and economic impacts of construction and operation of the proposed mill;

- identify the environmental, community and economic issues that concern municipal and provincial governments;
- identify issues that concern members of the affected communities by a public consultation program; and
- describe measures to address these concerns, minimize negative impacts and enhance favourable effects of the project.

Between October 1986 and September 1989 Alberta Environment received five EIA proposals for new mills and expansions of existing mills (See TABLE 4.1).

TABLE 4.1: Summary of Alberta Pulp Mill EIA Reports

COMPANY	LOCATION	DATE	PURPOSE
MWP	Whitecourt	October 1986	new mill
WC	Hinton	September 1987	existing mill expansion
DC	Peace River	December 1987	new mill
ALPAC	Athabasca	May 1989	new mill
SLPC	Slave Lake	June 1989	new mill

In December 1989, in response to concerns about legislating EIA procedures, the Environment Minister appointed an EIA Task Force representing all interests involved in EIAs to investigate the EIA process. In a report submitted March 1990, the EIA Task Force indicated that the existing EIA process was inadequate for both the proponent and the (concerned) public. It recommended that there be binding and enforceable EIA legislation. Other recommendations included an active public involvement process and intervener funding. These concepts later became part of the concurrently developed environmental legislation revisions.

In June 1990, the government initiated legislation, the Alberta Environmental Protection and Enhancement Act (AEPEA), to replace all of the province's existing environmental laws. These included the Clean Air and Water Act, Land Surface Conservation and Reclamation Act, Agriculture Chemicals Act, Beverage Container Act, Ground Water Development Act, Hazardous Chemicals Act, Litter Act, and some sections of the Department of Environment Act. The new legislation was aimed at modernizing environmental legislation and establishing a basis for the government's environmental platform (Tingley, 1991). The Act codified Alberta Environment practices, making the process clear to industry and assuring consideration of environmental impacts (Moen, 1992).

This legislation contains sections formalizing the EIA process. The Director determines the requirement of an EIA report, which depends upon the location, size and nature of the project, complexity of the project technology, and potential public concerns (Moen, 1992). When the submitted EIA report meets the required standards, the Director refers the project, in the case of a pulp mill, to the Natural Resources Conservation Board (NRCB) for review. The NRCB, enacted June 1991 and similar to the Energy Resources Conservation Board, was formed to formalize the process for reviewing and assessing EIA proposals for renewable resources, i.e., projects by the forest industry, for recreation/tourism, and others. The NRCB Board reviews projects for approval and can conduct hearings to ensure public input. The proponent must receive NRCB approval prior to requesting other required licences and permits.

The AEPEA was formulated through a public process beginning in 1990 with the release of an Alberta Environment Mission Statement, "Alberta's Environment Towards the 21st Century" (Tingley, 1991). The people of Alberta were invited to review and comment on the principles and policies in the document. The government received 4,000 responses. Next, the draft act was released for Albertans to review in writing or in person before the Environmental Legislation Review Panel. The panel held hearings in twelve communities, heard 151 oral presentations and received 198 written submissions. The panel submitted a report to the government in January 1991. This public process permitted a review of the development of both governmental and public positions on environmental issues.

Where the Land Conservation and Reclamation Act did not directly provide for public involvement, the new AEPEA EIA requires the proponent to include people directly affected by the proposed project. This approach to public involvement is aimed at exchanging information between the proponent and the public in order to identify impacts and concerns. Public input is required in a number of places during the formal EIA process.

In the past five years, EIA procedures have undergone major changes by both the Canadian and Alberta governments (Moen, 1992). These modifications resulted from EIA requirements being unclear and confusing to both industry and the public Some anticipate that the public, through this new legislation, will push for deeper assessments of industrial projects in the future. In particular, some of these challenges will be aimed at the line between federal and provincial jurisdiction over resources and EIA procedures.

4.8 GOVERNMENT INCENTIVES AND ECONOMIC POLICY

Environment Canada has been directly involved in financial assistance programs to encourage industry to develop and install less environmentally disruptive equipment (Sinclair, 1990). The Accelerated Capital Cost Allowance, initiated in 1965, granted rebates of federal sales tax on pollution abatement equipment and allowed business to depreciate installation costs over a two year period. The 1971 Co-operative Pollution Abatement Research program (encouraging the pulp and paper industry to research pollution abatement technology), received over 900 applications and issued $10.6 million during the eight years of the program. The Development and Demonstration of Pollution Abatement Technology was a cost-share program with industry initiated in 1975 and aimed at demonstrating the feasibility of using the new technology. The government share of the total $14 million spent under the program was $3 million. The 1979 Demonstration of Resource and Energy Conservation Technology was aimed at demonstrating energy-saving industrial systems. The 1979 Pulp and Paper Modernization Program, a federal/provincial/industry cost share program investing $3.1 billion, encouraged pulp mill modernization by reducing production costs and installing energy saving and environment protecting equipment.

The Northern Alberta Development Council (1985) together with the Alberta Economic Development, and Alberta Energy and Natural Resource, established a steering committee to investigate the utilization of the province's hardwood resources. Although the potential for the hardwood resources had been recognized for a number of years, actual harvesting levels had been limited. In the early 1980s, the government considered these resources to be under-utilized. In the period between 1975 to 1985, global timber supply deficits of economically accessible soft and hardwood timber was evident. Alberta's uncommitted resources and their potential in meeting this world demand were acknowledged.

The use of aspen in Alberta at the time was limited. There were two facilities utilizing aspen in an oriented strand board process, both installed during the five previous years. About 25 sawmills cut aspen on a limited basis, supplying a small local market. PNGC had experimented with aspen in pulp production on a limited basis.

A report completed for the Northern Alberta Development Council identified a number of economically feasible uses for the aspen resources of the province. The most promising uses of aspen were aspen/softwood CTMP, lightweight coated paper, bleached aspen kraft pulp, and specialty lumber.

Barriers to developing the northern aspen resource were also identified by the report. Adequate transportation infrastructures, both rail and trucking services, were absent. A good business climate and strong promotion were recognized as essential for the required investment. External economies of forest products would influence investment in and development of the aspen processing facilities.

In 1984, the Alberta Government circulated the white paper, "Proposals for an Industrial and Science Strategy for Albertans 1985 to 1990" in order to obtain input on industrial strategy and economic development from individuals, organizations and interest groups. A series of public hearings was held in major centres.

The main emphasis in the white paper was the recognition of a need for economic diversification. Within this, utilization of resources was recognized as a significant component of the strategy. The oil and gas sector along with agriculture were identified to be the major resources to develop in the province. Significant growth in the forest products industry, i.e., softwood lumber and long-fibred bleached kraft pulp, was recognized. The white paper indicated that a surplus of sufficient softwood fibre existed to twice the current high quality bleached kraft pulp production (500,000 ADMTPY) and, with improved wood chipping capacities in sawmills, two additional kraft pulp mills. In total, four new kraft mills could be developed. It is interesting to note that the type of mill identified with potential was bleached kraft. Proven commercial BCTMP technology was limited. Hardwood resources were also identified and the potential for pulp mentioned.

A list of key economic events and developments between 1971 and 1982, was provided with the white paper. TABLE 4.2 is a summary of these events. Investment in environment-related initiatives included the construction of the Alberta Environmental Centre at Vegerville (1977), land reclamation program (1976 to 1987), and weather modification program (1973). To enhance future pulp production, the white paper indicated that research was required into the economical use of aspen, financial assistance to defray infrastructure costs, i.e., transportation, financial assistance to integrate lumber/pulp mills by increasing chip production, and continued government pressure to obtain forest products' freight rate adjustments.

TABLE 4.2: A Summary of Key Provincial Economic Events 1971 to 1982 by Resource Category (Government Alberta White Paper, 1984)

CATEGORY	NUMBER OF EVENTS	% OF TOTAL
Forestry - Lumber	2	2
Forestry - Pulp mill	0	-
Forestry - Reforestation	2	2
Environment	3	3
Agriculture	19	22
Oil and Gas	10	12
Mining	2	2
Transportation	6	7
Other	42	50
TOTAL	86	100

In October 1987, the Alberta Minister of Environment publicly addressed the need to prepare for future pulp and paper developments and announced a 10 point program (MacNichol, 1989). These points included:

- testing dioxins downstream of Alberta's two kraft mills;
- ambient data collection of dioxins;
- a risk assessment of human and environmental health from dioxins within the pulp mill context;
- develop multi-media standards for dioxins from all pathways;

- monitor dioxin : ›arch in US and Ontario;
- Athabasca Riv 3asin studies aimed at establishing the total assimilative capacity;
- report on the city of kraft pulp mill effluent on fish was released and indicating not ε e toxicity to fish;
- assessment of ›rnative treatment technologies for pulp mill effluent;
- environmental ·act study of the Athabasca River as the receiving water for present and fu ; pulp and paper mills;
- a literature rev of pulping and wastewater treatment technology.

In December 1988, th rovincial government, i.e., Minister of Environment, through a press release and lε ·s to companies, set pulp mill technology standards. These standards required e nded delignification, oxygen delignification, and chlorine dioxide substitution in › first stage bleaching for all new mills or for mills expanding production. These st. 〈ards were aimed at reducing production/release of dioxins and other organic co ›unds and developed from European and North American technology evaluatior. The standards were to be unique for each mill and reflect the best technology a ›vable when permits/licences are issued.

CHAPTER 5 MARKET INFLUENCES ON EFFLUENT TREATMENT

5.1 BASIC ECONOMIC CONSIDERATIONS

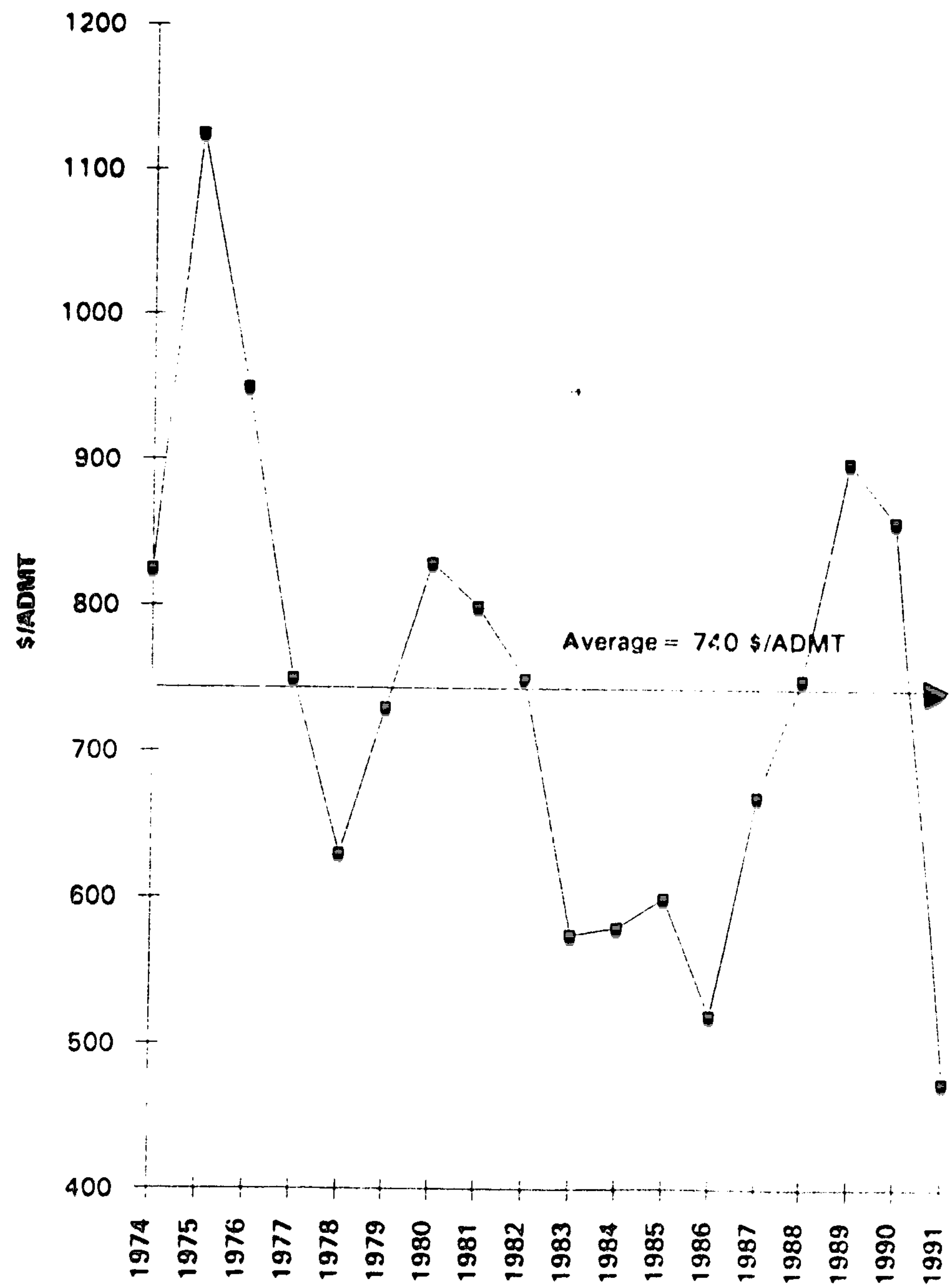
Profitability of pulp mills depends on the quantity of output and cost of production, assuming stable market conditions. Pulp markets are typically cyclical (See FIGURE 5.1). During periods of higher prices, pulp mills typically concentrate on high production rates and during periods of lower prices, cost controls become the focus. The major operating cost factors are wood, energy, chemicals, labour and transportation (of wood supply and product to markets) (see Table 5.1). Due to economies of scale, large operating units are more profitable with respect to relative capital cost per tonne of product and to operating costs.

TABLE 5.1: Pulp Mill Profit Margin Comparison Between Baseline and Incremental Production (Smook, 1982)

<table>
<tr><th>BASELINE PRODUCTION</th><th>INCREMENTAL PRODUCTION</th><th>SELLING PRICE</th></tr>
<tr><td>Profit
(15%)</td><td rowspan="2">Profit
(52%)</td><td rowspan="5">Market
Value
(100%)</td></tr>
<tr><td>Fibre
Costs
(37%)</td></tr>
<tr><td>Chemical & Energy
Costs
(20%)</td><td rowspan="2">Fibre
Costs
(33%)</td></tr>
<tr><td>Labour
(13%)</td></tr>
<tr><td>Fixed Costs
(15%)</td><td>Chemical & Energy
Costs (15%)</td></tr>
</table>

Production costs incurred are direct and periodic (Smook, 1982). Direct or variable costs include wood chips, chemicals and steam and are associated with each ton of

FIGURE 5.1: Northern Softwood Kraft Pricing History 1974 to 1991 (PNGC, 1992)

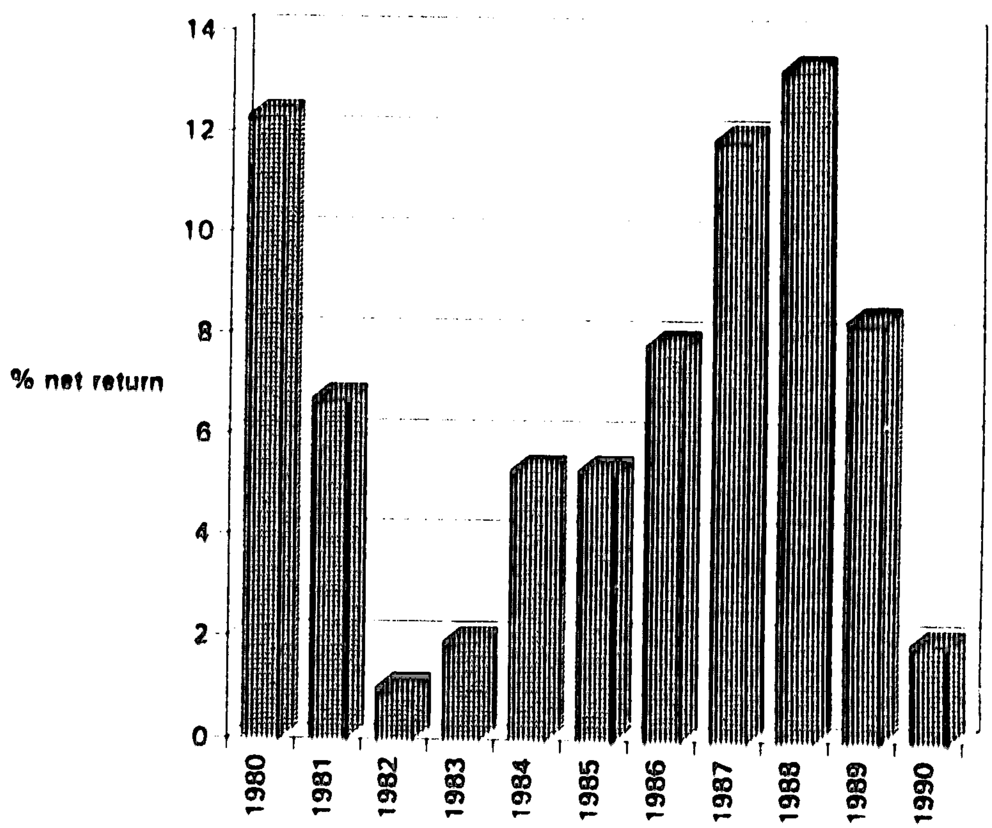


production. Period or fixed costs include operating labour, maintenance, management salaries, taxes, depreciation of capital plant costs and are incurred over a period of time, independent of tonnage produced. Although production costs depend on both direct and periodic costs, when production levels are above an established base line, costs are a function of only direct costs. This incremental production, i.e., above baseline, is extremely profitable and forms the basis for increased mill productivity.

Pulp mill obsolescence depends on a number of relative factors including energy efficiency, raw material costs, person-hours per tonne of pulp, overhead costs, and capital costs. Costs for environmental protection also directly affect mill efficiency and profitability and have to be balanced with the need to invest in modernization and maintenance. One of the main drives for modernizing mills has been to improve profitability by incorporating cost-saving techniques. Typically though, industry is cautious due to high capital investment in relation to profit margins. Also, there is a certain amount of risk involved in adapting pilot plant developments to operational levels. Generally, technology is tried by a few mills and if successful, the new methods are incorporated by the rest of the industry. It is important to note though that it can take up to three years to alter plant processes (design investigations, public/government approvals, and finally construction).

Another important factor influencing mill modernizing is the availability of investment capital. Capital plays an important role as a catalyst in generating and enhancing the productivity of labour and material resources employed. Economic growth has been related to availability and efficient use of capital and the ability of management and labour to increase total productivity with investment capital (Ondro, et al., 1982). Net return on investment in the pulp industry fluctuates with market prices and can influence the investment climate. Note that in FIGURE 5.2 during a period of high return on investment (8 to 13%) between 1986 to 1989, most of the decisions to invest in new or upgrade existing pulp mills in Alberta occurred. High interest and inflation rates tends to inhibit capital investments. Typically, pulp and paper industry requires more units of capital per unit worker than other forest industries.

FIGURE 5.2: Return on Investment for Major Pulp Producers (CPPA, 1991)



5.2 SAWMILL WASTE UTILIZATION

In November 1968, a study was conducted to investigate the potential of using sawmill residues for pulp in Alberta (Bums, et al., 1968). In general, the province's forest resources were considered to be utilized below their potential. Using sawmill chips in pulp production, in the future, was considered to be a way to increase utilization. In Alberta, the average delivered cost of pulp wood in 1964 was $\$8.83/m^3$ and the cost of debarking and chipping at the mill was $\$0.70/m^3$ for a total cost to the chip stage of ~$\$9.50/m^3$. Chips made from sawmill residues could be delivered for approximately the same.

In 1968, three factors influencing the economics of the pulp industry in Alberta were distance to markets, sawmill/pulp mill industry structure and problems with water supply and pollution. Although B.C. and eastern Canada had better transportation connections with markets, their raw material supplies were becoming progressively more remote from advantageous shipping points. With a growing demand for wood products, Alberta's timber resources would become attractive despite transportation disadvantages.

The location of sawmills relative to pulp mills influences the use of sawmill residue chips in pulp production. At the 1968 market conditions and mill locations, utilization of sawmill chips in pulp production was not feasible. Incorporating the two milling industries into future developments, i.e., having a sawmill headrig added to pulp mill structure, could greatly increase the raw resource values by utilizing inexpensive sawmill residue chips by producing lumber instead of pulp from saw logs with higher values.

Today, this concept of sawmills and pulp mills has been exemplified in Alberta. All six pulp mills purchase some portion of their wood supply in the form of chips. Four of the six pulp mills[23] have sawmilling operations associated with (operated by) the owning company.

23 MWP, PGNC, SLPC, and WC.

5.3 MARKETS

The Canadian pulp and paper industry is closely linked with international market conditions. The fastest growth in wood pulp consumption has been in the industrialized nations, i.e., Japan, USA, western Europe. Factors that influence the wood pulp markets are general economic growth, wastepaper recycling, raw material supply, and the development of other products such as synthetic paper. Over the long term, growth in the world market will depend on population growth, literacy and income levels.

The pulp industry is one of the oldest in Canada, the first mill starting in 1803. World consumption of wood pulp increased from 38.4 million tons in 1950 to 114.9 million tons in 1970, representing 5.7% growth per year (Manning, G.H., 1974). This increase included a shift toward the consumption of chemical pulp. During the period between 1955 to 1965, Canadian production increased 30% in response to world demand (Parlour, 1981). At the same time profits declined. The world demand sharply increased in 1963 and Canada responded by significant expansion in order to compete with new US mills in the southern states and price discounting by other producers. Prior to 1966, Canada was a price maker. By the end of 1966, the US firms had taken over. Between 1966 and 1972, a "rising consumption-increased capacity-oversupply" cycle occurred, adversely affecting Canadian producers, especially older inefficient mills in eastern Canada.

In 1970, Canada exported 5.58 million tons of wood pulp, which was 5.5% of the total world requirements (Manning, G.H., 1974). Of the United States wood pulp imports, Canada provided 72% in 1950 and 96% in 1970. About 62% of the total Canadian production (2 million tons) in 1970 was bleached sulphate (kraft) pulp.

The worldwide recession in 1973 resulting from the oil crisis drastically reduced pulp product consumption and increased inflation rates. As a result, the industry suffered from increased energy and labour costs and decreased prices, especially for hardwood pulp products. World market pulp inventories increased (AENR, 1977).

A report by Ondro (1989) stated that the potential for aspen utilization for pulp in Alberta was recognized in the early 1980s. In comparison with other producers internationally, Alberta producers would be competitive with those in the southern U.S. and Scandinavia due to lower wood costs (stumpage rates) and 60% lower energy costs In 1983, pulp mills in Alberta using aspen would be in a position to sell poplar bleached kraft pulp to Japan and South Korea, which import 42% of total supply from Brazil. Technology proven in the northeastern U.S. and eastern Canada was refined to utilize aspen and other short fibre species for papers not requiring high strength, i.e., tissues, sanitary products, fine papers.

In approximately 1986, the kraft process produced 70% of the world's pulp production, of which 29% was made from hardwoods (DC, 1987). One third of this hardwood kraft pulp was sold internationally. Hardwood kraft pulp accounted for about 30% of all market pulps and was the fastest growing grade of market pulp. At that time, there were approximately 173 kraft pulp mills operating in North America, of which 47 were in Canada. Northern Softwood Kraft (NSK) had been traditional the premium product in the pulp market, having high strength and brightness. During the decline from the last cyclical peak in pulp prices, NSK producers attempted to maintain their high price levels. As the spread grew between the NSK and other standard quality pulp producers, paper makers began to modify technology to incorporate more "lower" grade pulp, i.e., hardwood and BCTMP, to keep costs down. This paper technology shift weakened the influence of NSK producers on market prices.

In 1989, the printing and writing paper sector, with high quality requirements, was the fastest growing segment of the pulp and paper industry. It was considered necessary to have kraft pulp at least 90 ISO to be competitive in the international market (McCubbin, 1992). Brightness has been the key to determining the marketability of pulp. Kraft pulp off the target 90 ISO, i.e., 89 ISO, is reportedly sold at reduced prices.

Due to extensive technology developments in the forest products industry between 1986 and 1989 and higher capital costs, investment interest shifted from capital-intensive pulp industries, i.e., kraft mills, toward lower capital cost BCTMP mills (Ondro, 1989). BCTMP technologies can now utilize aspen to competitively produce quality high brightness pulp (AEC, 1989). The BCTMP market demand increased by 3% annually from 1981 to 1989 (Ondro, 1989). At the same time, newsprint markets declined. The demand for Canadian newsprint first declined in the late 1970s when newsprint mill capacity in Sweden was substantially increased and again in the early 1980s when Scandinavian currencies were sizably devalued. This competitive newsprint market limited the potential for Alberta newsprint mill development and augmented the development of whiter, stronger pulp products (Ondro, 1989).

During the first twelve years after the first BCTMP mill was established in 1978, market BCTMP production increased to about one million tonnes per year. Between 1987 and 1992, the annual growth rate for CMP/BCTMP was 8.4% per year (Reis, 1992).

Between 1984 and 1992, BCTMP consumption for printing and writing paper grades grew from 10% to 50% and consumption for newsprint decreased from 50% to 10% (Reis, 1992). In the past, BCTMP pulps were not of sufficient quality to compete in the printing and writing sector, but it was expected that, considering increased quality characteristics and cost advantages, BCTMP pulps would eventually compete directly with bleached hardwood chemical pulp grades (Reis, 1992).

The main barriers to APP/BCTMP, produced by MWP, in printing and writing grades have been (Reis, 1992):

- the wood free definition, i.e., 10% maximum mechanical pulp content;
- maximum brightness levels of 85 to 86 pts. ISO;
- brightness shade (more yellow);
- brightness stability; and
- too high a coarse fibre content.

Future changes in the market place will accommodate an increased consumption of BCTMP. Non-integrated paper makers will develop specific intermediate BCTMP based paper grades and paper grade will be priced according to functional properties rather than by the woodfree classification.

Sinclair (1990) indicated that, in the world markets in 1989, Canadian companies sold 59% of the newsprint, 33% of the wood pulp, and 50% of the softwood lumber. The pulp industry, comprised of 149 mills in 1990, was the most important in Canada for value of production and total wages paid (ranked second to the steel industry in exports and first in terms of consumed electrical power and goods and services). The Canadian pulp and paper industry sold in every major world market and could influence newsprint prices during certain market conditions (although there has been considerable debate regarding the role of the Canadian pulp and paper industry in setting world market prices).

In 1991, Canada was the largest exporter of pulp, paper and other forest products - a position maintained for 70 years -producing 26% worth $18.4 billion (CPPA, 1991). Export of all forest products was larger than that of mining energy, fisheries, and agriculture combined. In 1991, Canadian companies produced 24.9 million tonnes of products, of which 20.5 million tonnes (82%) were exported. For Canada as a whole and for Alberta TABLES 5.2 and 5.3 indicate distribution in the world market by basic pulping process grouping. The pulp and paper industry is Canada's largest in terms of valued added, export, and employment. The industry employed 179,000 people in the mills and associated harvesting operations and supports some one million jobs in Canada (CPPA, 1991).

TABLE 5.2: Canadian and Alberta Shipments by Area (CPPA, 1991)

MARKET	CANADIAN TOTAL % DISTRIBUTION	EST. ALBERTA % DISTRIBUTION					
		ALPAC	DC	MWP	PNGC	SLPC	WC
Canada	18		35	25			65
United States	51	n/a			98	50	
Asia	5		40	20			25
Europe	15		25	45	2	50	10
Others	11			10			

TABLE 5.3: Summary of Wood Pulp Production Capacity in Canada and Alberta by Process (CPPA, 1991)

PROCESS		CANADA 1989 million ADMTPY	% OF TOTAL PROD.	ALBERTA[24] million ADMTPY	% of ALBERT A Prod	% OF TOTAL CAN. PROD
Chemical	kraft	10.850	45	1.53	82	14
	other	2.332	10	0	0	0
Mechanical	TMP & CTMP	5.279	23	0.33	18	6
	other	5.227	22			
Total		23.688		1.86		8

The CPPA (1991) reported that production capacity in the fall of 1991 exceeded demand for both hardwood and softwood pulps. The world capacity for bleached hardwood pulp increased from 6.7 million tonnes in 1981 to 10.6 million tonnes in 1990, a 58% absolute increase and 5.3% annual growth rate. Demand increased by 5% per year during the same period. Canada's share of 1990 world hardwood pulp capacity was 10%. The world capacity for bleached softwood pulp increased from 11.3 million tonnes in 1981 to 14.8 million tonnes in 1990, 31% absolute increase and a 3.1% annual growth rate. Demand increased by 1.6% per year during the same period.

24 Includes six Alberta pulp mills

In the same report, the CPPA reported that bleached NSK producers' operating rates were under pressure from lower cost southern softwood and hardwood pulp producers. Canadian pulp producers had increasingly higher overall costs. Typically, the NSK held a higher demand than pulp produced in the southeastern United States (the main competitor) up until the early 1980's. The cost difference between the two producers was approximately $50/tonne. When the market price difference increased to $100/tonne, paper makers began to employ new technology which could utilize weaker pulps produced from the southern States as well as hardwood kraft and BCTMP. The market share for NSK shifted. Today, with governments becoming more stable, competition comes from South American producers of lower cost radiata pine pulp with only 15% less strength than the NSK. Tough environmental regulations in developed countries may shift production to less developed third world countries with more relaxed environmental regulations (Reis, 1992).

In the past in Germany (since television advertising was not practiced), the advertising departments of the intensively competitive magazine industry demanded exceptionally high brightness in kraft pulps (McCubbin, 1992). All the required kraft pulp was imported because the German government prohibits the manufacture of bleached kraft pulp in the country. The European market, primarily Germany, currently represents 50% of the world pulp market. Of that amount today, 50% of the demand is for Elemental Chlorine Free pulp. It has been projected that by 1996/7, this same demand will be for Total Chlorine Free pulp.

Recently the Canadian pulp industry's growth has faced several threats. Substantial areas of forest land have become allocated to other uses. Claims of excessive and poor harvesting practices and inadequate reforestation have tarnished the industry's image. Increased environmental concern (especially about pulp and paper mill effluent toxicity – chlorinated organics) as well as increased competition for water resources have influenced the industry's practices. "As far as a chlorine free pulp is concerned, North American markets have shown little interest. That may change with new regulations in response to 'green movement'" (Stevenson, 1992). The future of the industry will depend on: wood supply, economic efficiency of mills, and influences in the world market for Canadian pulp and paper products (Sinclair, 1990).

The Canadian Pulp and Paper Association anticipated world consumption of paper and board to grow by 54 million tonnes between 1989 and the year 2000. With access to fibre and capital for modernization, Canadian companies should reach 32 million tonnes by the year 2000. Total Canadian capacity of paper, paperboard, and market pulp is anticipated to expand by 2.2 million tonnes (7.5%) between 1991 to 1994. Capacity to produce mechanical market pulp will rise by 42% and the supply of chemical paper grade market pulp will increase by 10%. This future growth will provide the pulp industry an opportunity to maintain its importance in the world economy.

5.4 PULP TECHNOLOGY

With its impressive tradition and economic importance, the Canadian pulp and paper industry is recognized world wide for innovation. The attitude of innovation and adoption of new approaches carried the industry through difficult economic conditions and provided improvements for continual growth over the years. Sinclair (1990) has reviewed the Canadian industry and feels that product demands for stronger and whiter pulp along with pressure to reduce production costs have significantly influenced technology development/adoption in the industry.

When the industry started, wood, energy, inexpensive chemicals and cheap labour were abundant. As these decreased, new technologies were developed to offset production costs. As a result, increased product quality and the resulting increased value were also investigated. In 1922, the Canadian Pulp and Paper Association formed a Committee on Industrial Wastes to investigate techniques of reducing losses of raw material during production. This innovative attitude has been ongoing.

Stone groundwood mechanical processes of the mid-1800s, the first widespread pulping techniques, were replaced by the chemical processes due to low product strength and high labour/energy requirements. Soda processes were the first chemical pulp methods used in Canada during the mid to late 1800s. The more cost effective and less environmentally harmful sulphite pulping process replaced the soda processes and dominated the Canadian industry until the 1940s. This technology became unpopular primarily due to the high cost of the spent liquor recovery systems and advances in the kraft process. The development of a black liquor recovery furnace, chemical recycling and improved steam technology rapidly increased the use of the kraft process. Subsequent bleaching technology development, reducing the cost of additional bleaching required by the kraft process, also contributed to the popularity. Consumer demand and the high value for the strong, bright pulp produced by the kraft process increased the popularity of the method. Kraft pulp exports in 1944 accounted for 13% and in 1984, 85%.

The kraft process was popular for a number of reasons (DC, 1987). Firstly, hardwoods and softwoods could be used in the process. Secondly, the process produced strong pulp that could be bleached economically to a high degree of brightness. Thirdly, cooking chemicals could be regenerated through an integrated chemical recovery process. Fourthly, the mill could be essentially self-sufficient in energy through combustion of wood and chemical waste. Finally, effluent from the mill could be treated to reduce BOD 90% and minimize environmental impacts.

Concern about increased labour, energy, and raw material costs in the 1950s, forced producers to investigate methods of reducing fibre and bark losses. This also lead to decreases in water pollution. Eventually, this lead to the development of thermo-mechanical pulping in the 1970s. Chemi-thermo-mechanical and closed-cycle bleached kraft pulping processes are recent innovations and meet future trends by offering low energy/water consumption, higher fibre yields, and reduced chemical use. Although the main motivation was cost reduction (reduction in solid waste discharges was incidental), these developments occurred long before the federal government became actively interested in water pollution control (Parlour, 1981).

5.5 COSTS OF EFFLUENT TREATMENT

During the late 1960s and early 1970s, capital had been invested at an increasing rate in water treatment for in and out of plant processes, despite poor economic conditions. From 1970 onward, the rate of expenditure on external treatments increased from $2.3 million per year prior to 1970 to $16.9 million in 1970 and $22.7 million in 1971 (Parlour, 1981). In 1972, external expenditures were about 50% of all money spent in the preceding 12 years on these treatments. Industry is most likely to invest limited capital in the greatest potential for profits. In-plant investments helped to increase profits where external processes were considered to be no-return on profit. The increases in external water treatment were probably a result of the regulation amendments at both the provincial and federal levels.

The economic feasibility of treatment systems is an important factor. It has been estimated that water and air pollution controls represent 12 to 15% of the total capital cost of a new mill (Sinclair, 1990). Retrofitting pollution control costs are higher than new mill installation costs; the older the mill, the higher the costs. Many in the industry think that, although technology may be available to control wastes, it is seldom economically possible to employ the technology.

Sinclair (1990) suggests that pollution control should be tailored to individual mills and not necessarily mandated to automatically require the installation of the best technical solutions across the whole industry. This approach is also accepted among pulp and paper industry representatives, as confirmed by a survey by Sinclair (1990). The pollution control system should not only be tailored to each mill but also to each pollutant. TSS is most effectively removed by settling. BOD can be effectively reduced with efficient chemical recovery systems and biological treatments. This approach to issuing permits would articulate the pollution protection needs for individual mills and the differences in receiving environments.

Colour, resulting from lignin compounds not easily biodegradable, may be enhanced by biological treatment rather than reducing it. Although a number of different treatments (carbon, membrane, electrochemical, and biological) has been used to reduce toxicity, no one treatment has consistently solved pulp mill toxicity problems.

Inherent in the installation of new plant or effluent treatment technology is the cost or risk of the unproven methods not being effective. A process may function sufficiently at the bench or pilot project levels, but fail at the operational level. Although theoretical advantages may be evident for a system such as using anaerobic treatment over aerobic treatmant for BCTMP mills, reliable operational data are required to ensure that the effluent standards can be met. Guarantees of process performance depend on goodwill, reputation, and ethical standard of the vendor involved.

In 1991, the CPPA surveyed Canadian pulp and paper producers for information regarding capital expenditures for the period 1989 to 1994. Overall, expenditures in 1991 declined from 1990 by 43%. Environmental expenditures are projected to be on average $865 million per year for the next three years. This would bring the total spent for pollution abatement for the five year period to $4.7 billion.

5.6 MARKET INFLUENCES IN ALBERTA

The expansion plans of WC in the late 1980s were based on the assessment that the demand for fully bleached northern softwood kraft pulp would remain strong or increase (WC, 1987). The pulp produced at the mill (known as "Alberta Hibrite") had been marketed primarily in the US (90%) and to a lesser extent in Asia (10%). About 65% of the product sold in the U.S. has been purchased by the parent company Champion International, a large consumer of bleached softwood pulp. Other markets have been promoted in order to provide the Hinton mill with a broad market place, good average freight rates, and flexibility during recessionary markets. With the expansion, the US/Asia product split was aimed at 75%/25%.

MWP mill, constructed in 1988, is part of the BCTMP product growth. Although the EIA submission proposed a standard BCTMP mill, the final mill was modified to an alkaline peroxide BCTMP. This approach, newly developed by Scott Paper, was aimed at increasing product quality from BCTMP mills for use in tissue and towel production by lowering the fines levels in the resulting pulp. Being a two-line mill (unique to this design) allows the company to transfer fibres between the lines to optimize flexibility in product characteristics. These two mill design components allow the company to maintain consistency and improve flexibility, viewed to be important in establishing a niche in an expanding market. With the BCTMP market following the NSK market, product flexibility is important.

MWP felt it was important to have a sound environmental program to minimize impacts to meet public concerns locally and internationally. The company installed an effluent treatment system to maintain local community credibility (established since 1920s by other local ventures) and to meet provincial licence limits. The company noticed a dramatic shift in public opinion about pulp mills in Alberta between 1985 and 1990, primarily due to rapid development of five pulp and paper mills. This concern influenced the company to install a zero effluent system in its second pulp mill in Saskatchewan. This decision was made to a lesser extent to mitigate the potential impacts on a sensitive river system, supplying water to a number of communities. The major factor influencing the decision was the ever increasing environmental concerns of the public and licence parameter limits over the long term. The cost difference between an acceptable effluent treatment system and a zero effluent system became narrow enough for the company to justify, with government assistance, a zero effluent system. In the market place, particularly from European customers, the company has received an increased number of questionnaires on the environmental standards practiced in the plant and woodland divisions. Maintaining a "green" image in the market place was determined to be important.

The expansion in the late 1980s by PNGC was heavily influenced by the growing public concerns over chlorine in effluent as well as the growing market trends for Total Chlorine Free (TCF) or Elemental Chlorine Free (ECF) pulp (D. Myers PG-personal communication). PNGC has always produced a high quality product with high strength characteristics, known as NSK, and it was important to the company to maintain this product quality when considering technology modifications. Looking ahead for expansion plans, PNGC felt that capital expenditures for effluent improvement should be evaluated on the basis of degree of improvement versus cost (PNGC Inc. 1992). This influenced the company to only installing a generator with the capacity for 100% chlorine dioxide substitution and not to install the 1988 government required technology, (MCC,extended delignification, and oxygen delignification) to achieve required effluent targets.

Today, WC and DC, having installed the government required technology, can only use 100% chlorine substitution for a short time period. To maintain 100% chlorine dioxide substitution full time these two mills would have to invest in major equipment modifications. It is important to note however, that the level of AOX produced by the three mills are all comparably low, i.e., between 0.9 to 0.62 kg/ADMT (See TABLE 1.4).

In comparing U.S. with Canadian legislation, PNGC found environmental legislation in the U.S. to be more stringent but clearer, especially the relationship between state and federal governments. This is important to companies for security of investment. It may take pulp companies 3 to 5 years to design, approve and install plant modification at a substantial investment ($40 to 200 million). Knowing where "the goal posts" are is important to industry. In Alberta, the lines of authority/requirements between provincial and federal governments on the environment were not clear in the late 1980s. The company recognized wilderness protection to be an important cultural value in Canada and higher than in the U.S. PNGC felt that the provincial government proceeded too quickly in diversifying the economy by promoting rapid and massive pulp developments. The public, with high wilderness values and concerned about the rapid pulp mill development, expressed concerns so strongly through the ALPAC hearings that governments responded by increasing licence limits.

The controversy resulting from the ALPAC hearings was another major factor influencing PNGC to stop expansion plans in 1989. As a producer of primary consumer products, i.e., soaps, diapers, PNGC did not want to be exposed to the risk of a consumer boycott. The company attributed part of the controversy of the ALPAC hearing to unclear guidelines/legislation regarding environmental protection.

This threat contributed to the company selling the entire pulp division in 1992, i.e., both the U.S. and Canadian plants. Recognizing that new product markets were opening in Russia and Asia, the company felt it would be better to buy pulp for paper products from other companies throughout the world and not just in Canada. The main reason PNGC invested in a Canadian mill in 1970s was to assure a NSK pulp supply. At that time, the main NSK suppliers (located in BC) were susceptible to production interruptions resulting from strikes by unionized labour, i.e., inside plant workers and outside woods workers. Changes in the market place, more pulp capacity and new paper making technology, allowed PNGC the freedom to purchase pulp from other producers. It is also important to note the difference in return between the secondary paper products and primary pulp products. Return on equity for pulp was 4 to 6% and for PNGC's secondary products was 16 to 18%.

In short then, PNGC did not expand production in 1989 and eventually sold its pulp division because of: the lack of clarity of environmental legislation for approvals; potential consumer boycotts of other more profitable company products; shifts in paper technology and pulp sources; and recognition of higher returns from the company's other paper products.

CHAPTER 6 PUBLIC CONCERNS ABOUT CONTROL OF EFFLUENT IMPACTS

6.1 INTRODUCTION

As the forest industry in Alberta has evolved to diversify the economy, there has been a shift in attitude to recognize forest uses other than timber. This shift in attitude has resulted in part from societal lifestyle changes, i.e., increased leisure time, greater affluence, accelerating technology, greater public awareness and altering value systems (Zuzak, 1972). The public, aware of basic ecological principles, i.e., interconnectedness of living systems, changed attitude toward forest resource use from a perception of infinite supply to the need to manage and preserve for future generations. The concept of multiple use management resulted in an attempt to meet the complex problem of satisfying the various forest users' needs. Public pressure to protect clean water and air has in part influenced changes in pollution control methods in pulp mills (Zuzak, 1972).

For example, in the past, water supplies in northern Alberta were considered abundant for pulp mills' use and, since the area was remote and largely uninhabited, pulp production was considered suitable. However, values of unpolluted water and air (to agriculture and human needs) south of Edmonton were considered so high that the pulp industry and the resulting pollution were considered unacceptable (Burns, 1968).

A March 1992 USA Today poll, by G. S. Black Corp. attempted to determine how the U.S. public feels about the environment. About 63% of the people said they would accept a lower standard of living for a cleaner environment. Approximately 69% agreed with the statement, "We should protect the environment, even if that means some people will lose their jobs and the government will have to spend a lot of money". About 60% would pay an additional 15% in taxes to significantly reduce pollution. Another 52% have stopped buying products made by a company they thought was polluting the environment.

In a survey (Adams, 1989), Canadians perceived that the greatest current threat to humanity, greater than AIDS and nuclear exposure, was environmental pollution. Public values for remote forested areas or wilderness, where Alberta pulp mills are located, include recreational, spiritual, cultural, therapeutic, aesthetic, ecological/scientific and ethical concerns as well as wildlife/fish habitat protection (Manning, R.E., 1989). The existence value, knowing that the resources will be available in the future for others, is an important value in itself to many people who may not ever go to "use" the remote resources. The degree of importance of these values varies depending upon where the individual lives.

Tingley (1991), in discussing environmental law, indicated that were more than 200 organizations listed in the Alberta Environmental directory, many formed in the past few years. The recent ALPAC EIA controversy fueled the development of a number of effective, articulate environmental organizations. Many of the organizations formed around local issues and then continued to deal with larger issues once the local issue had been resolved. Recently, many individuals and groups appear more willing to use legal processes than in the past. A few examples for forestry/pulp mill litigation include Edmonton Friends of the North et. al. vs. Minister of Western Economic diversification; Peter Reese vs. Her Majesty the Queen; Sierra Club of Western Canada et. al. vs. Federal Minister of Transport (Moen, 1992). Tingley stated that this increasing trend of environmentalists using legal processes would continue. Understanding public environmental concerns and how to effectively negotiate with the public has become an essential skill for the pulp industry.

6.2 INDUSTRY/PUBLIC INTERFACE

Another facet in the dynamics of the communication interface between industry and the public is the accessibility of information for the public. One fundamental purpose in conducting EIAs is indicated in the Alberta Environment Guidelines (Edwards, 1990):

> "The purpose of an EIA is to provide information to the public and the government of Alberta to enable the early identification and resolution of significant adverse effects on the environment."

This statement implies that information regarding negative impacts will be available to the government and public in order to make decisions regarding the acceptability of a proposed project. The key to successful or effective EIAs is that this information be accessible, i.e., in a form easily assimilated by the public, and be presented as early as possible in the project proposal. Members of the public who may be directly affected by the project have rights not only to being informed, but also to have their concerns incorporated into the decision making process (Edwards, 1990). Public hearings are held in an attempt to help meet this need.

Accessibility depends on the format and the credibility of the presenters, in this case pulp mill representatives. Although presenting project information is one of the inherent EIA objectives, EIA proponents tend to present data in such a way that the public, lacking the required technical skills, must rely on other scientists to interpret and help evaluate the data. In essence, EIA data often tends to be presented for peer review, instead of public review and as a result, the information is not accessible to the public. For example, during the ALPAC EIA hearings, native groups brought scientists to verify their point of view and Friends of the Athabasca relied on members who were scientists. This gap between scientific terminology and public understanding is not unique to EIAs, but can be found throughout the world in science/public interfaces.

A case study in northern England on the effects of damage from the Chernobyl accident illustrated the lack of credibility of scientists in transferring technical knowledge about risks to the public (Wynne, 1989). The public mistrust resulted more from the cultural differences in problem solving between the local farmers and the government-appointed experts than from the public's inability to assimilate technical information.

> "...critical to the scientific experts' lack of credibility was their inability to recognize that the farmers held extensive informal knowledge about sheep habits, the local physical environment, and farming practices and decision making, all of which needed to be integrated with more abstract and formal scientific knowledge to create an effective response frame work to the Chernobyl fallout...experts did not appreciate that science may also be parochial (the assumption about cesium immobilization by clay soils, for example) and that it may need to be supplemented by special knowledge, perhaps expressed in a nonscientific idiom." (Wynne, 1989)

In this situation, the gap between the farmers and the experts was created by: the farmers operating from a highly flexible, adaptive and informal decision making style developed to account for the unexpected and the experts operating from a rigid bureaucratic method based on a belief in control and certainty. The actual transfer of information to the farmers was facilitated by other local officials (who were considered plain speaking, open about uncertainty, independent and trustworthy) and not by the appointed experts (who were perceived as scientifically arrogant, unrealistic, secretive, and unwilling to admit to unknowns). One attitude most important to the farmer was to have the experts admit to uncertainty and error. Technical communication with the public was more effective when the experts

In Alberta, during the 1980 Public Hearings on Hazardous Waste Management, the Environment Council (1987) found that 55% of the presenters expressed concerns about the government's credibility in the environmental regulatory field. The presenters felt that both the regulations and enforcement were inadequate. These views were supported by a survey conducted for the Council (MIR Information Research Ltd. 1981). In 1980, 67% of Albertans believed greater emphasis on environmental protection was needed, even if it meant spending more money. This attitude was also found in a study conducted by M. Kelly (1982) for the Alberta Environment Council.

In Canada, Environics, a public opinion research group, polled Canadians in March 1989 to determine public attitudes toward the pulp industry and environmental concerns (See TABLE 6.1). About 37% of those polled felt that pulp companies were poor corporate citizens primarily because of environmental pollution and poor forest management practices. It is interesting to note the forestry workers have more credibility than industry associations, corporate executives or government officials. Keeping university scientists informed about industry activities by accepting speaking invitations, receiving groups in the mills, or providing data for research are ways for industry to indirectly reach the public (McCubbin, 1992).

TABLE 6.1: Credibility of Sources "How credible is each source in providing information on the Industry?" (Environics, 1989)

SOURCES	% OF TOTAL
University Scientists	46
Environmental Groups	41
Forest Industry Workers	26
Magazines/Newspaper Articles	20
TV/Radio Programs	20
Pulp & Paper Associations	16
Pulp & Paper Industry Executives	10
Governmental Officials	6

A social survey conducted in Poland to measure public attitudes towards scientific knowledge indicated a disparity between what scientists and the public feel is important about technology (Koptas, et al., 1987). These results confirmed observations by T.S. Kuhn (1977):

> "...laymen...are interested rather in the end-product of creation...Apart from very particular circumstances, which indeed arouse public interest, what really interests the public in science is of secondary importance for the scientist".

This survey indicated that certain types of knowledge function well in society and are closely connected with one another, particularly in relation to everyday life. A strong relationship between science and religion, provided, at the same time, the public answers about the meaning of human life while knowledge from art and literature were considered to be less important. This indicated that religious and scientific knowledge were complimentary and not competitive. As stated by the Shoghi Effendi (1974):

> "...the fundamental purpose of religion is to promote concord and harmony, that it must go hand-in-hand with science, and that it constitutes the sole and ultimate basis of a peaceful, an ordered, and progressive society"

Scientists negating these other types of knowledge contribute to the gap between the public and scientists.

Foucault (1982) indicated the "modern state" has replaced the pastoral power of Christianity. Pastoral power obtained from confessional influence cannot be exercised without knowing the inside of people's minds, without exploring their souls, without making them reveal their innermost secrets. It implies a knowledge of the conscience and an ability to control it. The "modern state" propagates this pastoral power by integrating the individual into the state under one condition, that this individuality would be shaped in a new form and submitted to a set of very specific factors. Ashforth (1990) applies Foucault concepts in analyzing commissions of inquiry, i.e., ALPAC hearings, as mere regimens of power, extending the state's knowledge/power into the innermost consciousness of environmentalists as a form of control.

Scientists have been taught to be and view themselves as "priests" of the religion of western culture, science. Having a responsibility to interpret science for the public, scientists retain control and power through the guise of scientific method. The scientific method according to Land (1990) has been based on a causal paradigm (as in cause-and-effect...having been caused in the past) where management meant taking a path, projecting it into the future, and controlling it. Land goes onto suggest that in this transitional age when we can count only on things changing, scientists must shift to a new paradigm called a creative world view, in which certain patterns are going to occur, but can't be tracked from their past. The major force is the future. By journeying to a new point of organization, Land proposes that we shift from prejudging the connection and the environment, which creates a screen, keeping us from connecting with things different from us, to a system where we are accessible to all the possible connections and the environment. He states:

> "It does not make any difference what the objective reality is around us; the issue is how we relate to it, because we create ourselves from moment to moment in our choice of how we relate."

Land proposes to replace the old scientific method with a management model, a new paradigm of creativity, that is based on unconditional love. It is critical that scientists today reevaluate and modify the scientific method. They must also realize their ethical responsibility to choose a field of study that will contribute to the betterment of mankind and in making information accessible to the public.

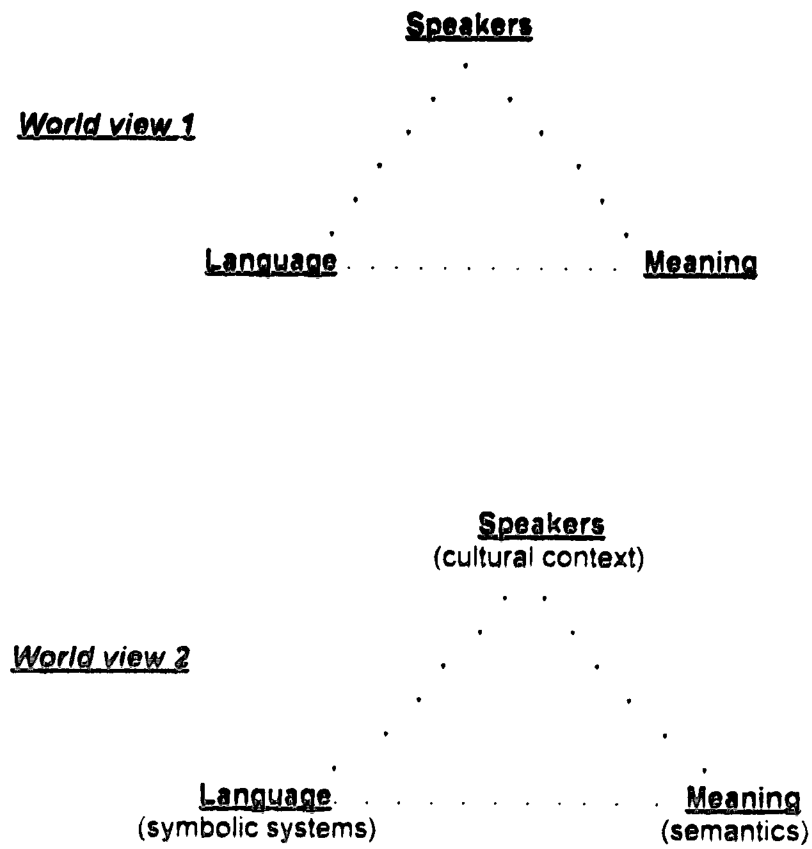
Martin Luther King, Jr. (1986) also professed unconditional love to be essential for modern society. This love does not refer to sentimental or affectionate emotion. The Greek language, used for many biblical writings, has three words for love. Eros, an aesthetic love, has come to mean romantic love. Philia, a reciprocal love, implies a level of vital or valuable love between two friends. The third word to describe love is agape, an understanding, creative, redemptive goodwill for all men which forms the basis for unconditional love. At this level, people can love men not because they are likable, not because they do things that attract us, but because God loves them. Agape springs from the need of people to belong and is manifested through action in seeking to preserve and create community.

In accepting that scientists and the public actually come from different cultures, the gap between them can be illustrated by the relationship between different languages and cultures or world views (see Figure 6.1). Fantini (1989), with the linguistic notion of language determinism and relativity, suggested that:

> "Lack of awareness of our own language and language use arises from the fact that as we master our native tongue, it in turn masters us...the language we acquire influences the way we construct our vision of the world...(an) individual exposed to a second language may develop a differing or an expanded vision of the world inherent in each language system but also by the differing interactional strategies used by speakers of each system."

Fantini goes on to say that "if you want to know about water, don't ask a goldfish", meaning those who have not experienced a different language or culture may take for granted the milieu in which they have always existed.

FIGURE 6.1: Language/Cultural Components of Differing World Views (Fantini, 1989)



The gap between scientists and the public may be caused by both groups operating from different world views, not only with a unique language (terminology), but with different cultural contexts, symbolic systems and semantics. For example, it is imperative to the public that scientists be open to uncertainty and error, while scientists are trained to value the exact opposite. A number of cultural/language misunderstandings occurred during the ALPAC EIA and were documented and discussed by Gismondi, et al (1991). (See APPENDIX D).

Lincoln (1989), in Discourse and the Construction of Society, indicated the power of discourse:

> "Discourse supplements force in several important ways, among the most important of which is ideological persuasion. In the hands of elites and of those professionals who serve them (either in mediated fashion or directly), discourse of all forms - not only verbal, but also the symbolic discourses of spectacle, gesture, costume, edifice, icon, musical performance, and the like - may be strategically employed to mystify the inevitable inequalities of any social order and to win consent of those over whom power is exercised, thereby obviating the need for the direct coercive use of force and transforming simple power into legitimate authority."

Awareness of these differences in language and culture, allows industrial scientists to understand that communicating with the public is not diluting technical terms, but transcending cultural differences. Understanding the importance of transcending other world views is paramount to the greatest revolution in the world; the one which occurs within the mind reflecting the environmental world paradigm shift (Ferguson, 1980).

Authors such as Dunlap and Van Liere (1984) explain changes in worldwide values toward wild remote areas by a paradigm shift from the Dominant Social Paradigm to a New Environmental Paradigm. The New Environmental Paradigm believes strongly in man, science, and technology to solve problems plus in an abundance of natural resources. The Dominant Social Paradigm shows man being part of nature, accepting limits to growth, and the need to protect ecosystem integrity.

This shift has been manifested in the public wielding power on environmental movement. Dearden (1989) indicates that recent wilderness "victories" in Canada (Moresby) and Australia (Franklin) show this paradigm shift and that society has chosen to recognize wilderness protection over the relative merits of industrial development. Everywhere, the public that heard the message of the World Commission on the Environment and Development (Bruntland, 1987) expressed deep concern for the environment, concern that has led not just to protests but often to changed behaviour, documenting increased values of wilderness worldwide.

Wilson (1990) identified the growth of the anti-science movement and the importance of popularization of science. In the report summarizing a symposium on science culture in North America, he stated that scientists, educators, governments, industry and the media have a role to play in increasing the public's awareness of science, science literacy, and science appreciation. In the future as public exposure to science increases (which will not necessarily be welcomed by scientists), so too will anti-science activities increase (which will likely result in threats, risks and alienation). With the popularization of science, direct control may be lost by scientists, but dialogue among decision-makers, the informed public, and the scientific communities will ultimately be enhanced resulting in better scientific policy.

6.3 PUBLIC ENVIRONMENTAL VALUES

6.3.1 Public Response To Change

Responses of communities to change, i.e., pulp mill installation, are complex. Zeiss and Atwater (1991) found some people can be threatened by change to experiencing physical stress and shifting into a fight or flight mode of opposition. High stress reactions to change limit balanced decision making processes. Avoidance of triggering this response depends probably as much on acknowledging and understanding host communities' beliefs and values as on presenting factual impact information about the proposed development. Concerns have to be addressed on a human level not on a technical level. This is done by "connecting" on an emotional level to establish credibility, thereby opening the "window" for information exchange.

A belief is a statement made about a fact that a person thinks is true. A value judgment is an opinion on whether something is good or bad. Beliefs about a project may differ (positive for the proponent and negative for the stakeholder) and can be influenced by background beliefs. These are salient beliefs, "off the top of your head", and underlying beliefs, developed through discussions and exposure to the project information. All of this results in people having different perspectives on issues.

Through a waste disposal facility siting case study, Zeiss (1991) attempted to explain how apparently insignificant physical impacts from waste facilities can generate strong opposition. The proposed facility represented a threat of change in the host community by introducing physical impacts, i.e., increased emissions and pollution risks, and nonphysical impacts, i.e., decreased property loss and community self-determination. Assuming that attitude was the basic indicator to community opposition, a mathematical model was devised, from the work of others, to test belief-attitudes of the community. In this work, Zeiss and Atwater (1991) found that physical impacts and beliefs about physical impacts were not consistently associated. Apparently, minor physical impacts (nuisances) triggered more serious concerns (negative beliefs) about non-physical impacts. Residents may mask their own range of concerns with common concerns about physical impacts by the proposed facility.

Zeiss and Atwater (1991) recommended that managers, in this case for waste facilities, be sensitive to the underlying significance of changes in host communities by establishing a impact-belief-attitude pathway. Physical and non-physical impacts must be identified within the context of the communities' characteristics and values, especially those underlying seemingly irrational beliefs. This is done by the proponent acknowledging or validating public concerns rather than rationalizing physical impacts. This helps to reduce fear and stress, to determine underlying trigger beliefs, and to identify the basic cause of opposition as well as effective mitigation measures. This process transfers tangible control and power over impacts to the community, reducing stress and fears about change.

6.3.2 Wilderness Values

In attempting to define public opinion on the environment, four extreme perspectives can be defined. Firstly, extreme utilitarians view nature as resources to be used for the short term as long as benefits exceed the cost. This attitude has been attributed by many in describing multinational capitalistic corporations. Secondly, an ecological system group operates from the view point that development should be in balance with nature. This group is typified by the scientific community that developed the concepts of Environmental Impact Assessments. Thirdly, extreme protectionists perceive the environment as having rights equal in status to human rights, and their resulting role is stopping all development. This category can be typified by groups such as Greenpeace. The fourth perspective operates from a moral-spiritual approach, valuing nature on a level other than factual or emotional and can be found among aboriginal peoples. In reality, agencies involved in the environmental field (as well as individual people within and outside) would describe themselves as operating from a combination of these four perspectives, each with its own set of values and beliefs.

Inherent in the public's concern about resource use is the concept and value of wilderness. Worldwide, it has become a highly valued resource and this worldwide trend has been influenced by wilderness concepts developed in the U.S. Some believe that the public's concept of wilderness came from deeply rooted religious and cultural beliefs. In religious scriptures, wilderness often denoted wasteland or desert where human survival was difficult. Living in such places of hardship provided an opportunity for people to prove themselves and become spiritually strengthened. In the 18th century, romantic and primitivist traditions of civilized society developed the thought that spirituality in the wilderness could be found free of the contaminating influence of civilization and the city (Stankey, 1989).

Contrasting these concepts were other views developed by pioneers trying to survive in remote areas by capturing other monetary values from timber, minerals and oil. The development of natural resources provided a standard of living that allowed the new world to compete on world markets. National parks where established in the USA initially to prevent natural benefits such as hot springs, watersheds, and beauty "from being taken up in private ownership" (Stankey, 1989). Eventually, a shift in social values ensured that the purpose of these parks was to protect wilderness.

The difference between values held by people in the cities from those living in remote areas provides a contrast which appeared to be related to the distance the public was from wilderness.

> "As the distance between society and wilderness grew, the ability of society to hold an appreciative attitude toward wild nature expanded" (Stankey, 1989).

In comparison even today, rural residents display a more utilitarian disposition toward nature than do their urban counterparts (Hendee, 1969). This is an important concept when trying to explain the differences in values between local rural residents directly influenced by pulp mill developments and the urban public interested in the preservation of remote wilderness.

Nelson (1989) indicated that in Canada, little or no reference to wilderness was made until after the turn of the 20th century, and never attained the mythical status it did in the U.S. He states:

> "One searches the journals of the Northwest or Hudson's Bay company traders long and hard for any fulsome reference to the wilderness idea in the United States' sense...Canadians were and remain a rather utilitarian people whose national consciousness found expression in standards such as the maple leaf and the beaver rather than the wilderness and the bald eagle as in the States."

Uniquely different in Canada's park system is the understanding or acknowledgment of the native peoples' right to use areas set aside as parks and wilderness areas. The protectionist view of unmanaged wilderness in the U.S. is being questioned by the ecosystem concept of everything being interconnected, which suggests that wilderness should be managed.

However, in the last three decades, Canadian literature shows a wilderness concept similar to the U.S. protectionist idea. Nelson (1989) states:

> "Since the ecology decade of the 1960s, United States environmental thought has spread into Canada as part of what can best be viewed as a growing worldwide concern about human effects on the environment...many young Americans migrated to Canada where they often began to push vigorously their image of wilderness as a basis for making judgments about land use activities and planning

> proposals...Although it is gradually changing, this protectionist philosophy, with relatively little foundation in management based on scientific research and environmental monitoring, is still very much with us and is surely a major challenge for the future."

Within Canada, Heritage for Tomorrow reported that perceptions of wilderness varied between regions (Nelson, 1989). The strongest support for protectionism was found in British Columbia, the Prairies and Ontario. Land claims and native involvement were prominent in the Yukon and Northwest Territories. Specific concerns for rivers, forests, caves and human history were more significant in Quebec than for the concept of wilderness. There was a strong interest in tourism in the Atlantic provinces, Quebec and Ontario.

These differences at various levels within Canada influence wilderness decisions along with the media. Adams (1989) found that one in five Canadians watched national news sources, which routinely covered resource management conflicts. For example, the decision to establish the South Moresby National Park in British Columbia was influenced not only by B.C.-based environmental groups, but also by public concern all across Canada (Sewell, et al., 1989). Many resource managers in B.C. at the time felt that inaccurate and biased coverage by prominent media personalities like Dr. Suzuke was powerful enough to stir support, particularly among the eastern urban public (thereby influencing the decision on the park establishment).

Public values are deeply rooted in beliefs developed over several generations and are not easily changed. The apparent difference between local and urban values poses important questions when deciding what segment of the public should be included in an EIA or FMA participation process.

RECREATIONAL VALUES

One of the more easily understood wilderness values is recreation. Although users in unregulated areas have been difficult to observe, recreational users in established wilderness parks have been monitored for a number of years. Other studies have evaluated hunting and fishing records to provide information about recreationalists. Values for enjoying remote areas include appreciating nature, physical fitness, reduction of tensions, escaping noise/crowds, outdoor learning, independence, introspection and risk taking (Manning, 1989). Visiting wild areas provides therapeutic psychological benefits by releasing constraints and playing out emotion and instincts as found in Outward Bound type programs (Manning, 1989).

Roggenbuck and Lucas (1987) found that typically, people using wilderness parks were younger than the general population. The majority had high education levels and were either in mostly professional-technical occupations or were students. Different again from the general population, most of these visitors were working with people, ideas, or abstractions rather than working with things. These working environments had a strong contrast with wilderness. This supports the theory mentioned above that the greater the distance from wilderness, the higher the value.

Lucas (1989) found that wilderness use in parks leveled off or declined recently after many years of rapid growth. Rapid growth had been used as the basis for designating wilderness areas. Lucas suggests with the reduced growth in recreation use and use of other values, i.e., scientific, will have to be used to form the arguments for the need for more wilderness designations.

SPIRITUAL VALUES

As mentioned previously, some people value remote untouched areas as places to develop spirituality. Emerson (1883) said that nature is the symbol of the spirit. Transcendentalist interpretation of nature indicated that the wilder and purer the nature, the better the spiritual benefit (Manning, 1989). Graber (1976) and Driver et al. (1987) indicate personal introspection was often cited as an important motive for people who visit wilderness areas. They also suggested that wilderness preservation might be justified on the constitutional basis of maintaining religious freedom and spiritual values.

AESTHETIC VALUES

Manning (1989) reported that aesthetic values are not only important to people who use remote areas (however briefly, like driving along a remote highway), but also to people who only see nature's beauty in paintings and photographs. He went on to state:

> "...nature possesses unique aesthetic characteristics: detached from all imperial relationships...not rooted in any one period of human history; ...encompassing physical ambiance in that we can be literally surrounded by its beauty;...a dynamic beauty...always changing;...the potential to gratify all the senses...seen, heard, smelled tasted, and felt; and...provides the best opportunity for pure or perfectly objective aesthetic enjoyment...not created or affected by man."

ECOLOGICAL/SCIENTIFIC VALUES

Today, significant concerns for environmental groups involve the ecological and scientific importance of remote wild areas.

> "Establishing wilderness areas is viewed as a way to protect everyone's future well-being...If certain types of scientific knowledge can be obtained only from natural ecosystems, then wilderness holds special value for

developing scientific theory and knowledge" (Manning, 1989).

These groups are interested not only in how the environment will be altered by pulp mill operation, but also the impacts from the resulting forest harvesting practices. Some feal that timber harvesting and pulp mills have the potential for eliminating the ability of studying natural terrestrial and aquatic ecosystems.

ETHICAL VALUES

Land use ethics is a new concept held by the environmental community; nature has intrinsic rights. To those believing that nature has intrinsic rights, preservation of wilderness is an expression of man's moral and ethical obligation to the environment (Manning, 1989). Complementary to this concept is the belief that society owes wilderness preservation to future generations and that this value alone, in some surveys, outweighs more tangible wilderness benefits. Walsh, et al, (1984) found that an average family would pay $14 per year to preserve recreation areas, but $19 per year to know that these areas would be preserved for future generations. This leads into another existence value held by people who are satisfied knowing that wilderness is "out there" but have no interest in using it.

WILDLIFE PROTECTION

Generally, protection of wildlife/fish habitat is an important wilderness value held by the public. Almost like a barometer, many people feel that if wildlife and fish are protected then the environment is also being protected. More than likely, if wildlife/fish habitat is negatively impacted by an activity, little support will be provided by the public.

6.4 DIOXIN/FURAN INVESTIGATIONS

Public concern about dioxin/furan is one of the major forces underlying interfaces between the pulp industry and the public. A case study, presented in APPENDIX C, summarizes the process by which dioxin/furan became prominent and how industry reacted to the situation.

The dioxin/furan concerns grew within a larger context of the public slowly learning about disastrous impacts of certain chemicals resulting from agricultural and industrial development. Widespread chemophobia (fear of chemicals) resulted. Winner (1986) indicated that after World War II, there was a series of events, viewed to be biological and social experiments. In the 1950s, hexachlorophene was used in soap as an antibacterial agent and effective treatment for acne. In the 1970s, after high concentrations of hexachlorophene were linked to human infant mortality and brain abnormalities in monkeys, the U.S. Food and Drug Administration made the chemical available only by prescription. Preservatives, colouring agents and other food additives were linked to human health problems. Atmospheric nuclear bomb testing increased human radiation exposure. Pesticides, herbicides, chemical fertilizers and industrial pollutants were released into the environment to be found later in food and water supplies. The bioaccumulative nature of DDT alone greatly increased levels of chemophobia within the public.

Public chemophobia was enhanced by statements linking dioxin with Agent Orange (a defoliant used in the Vietnam War) and about dioxin being "the most deadly poison known to man". Concern was generated about dioxin being a compound that would bioaccumulate in the environment like DDT and being a hazard to human and animal health at low doses. Greenpeace reported that the U.S. EPA determined that no safe level of dioxin exposure could be demonstrated on the basis of available information (Van Strum, 1987). The difficulty in establishing a complete cause and effect relationship between dioxin and health also contributed to the public perceiving limitations in the scientific method. Once dioxins were found to be present in chlorine bleaching pulp mill effluent, the public became concerned about the other chlorinated organics produced by the same mills. People were alarmed at the amount of chlorinated organics, measured by AOX, and at the undetermined environmental and health risks from these numerous compounds. Environment Canada (1990, 1991) determined dioxin/furans and bleached pulp mill effluent to be toxic substances, hazardous to the environment and public health.

This heightened public concern, forcing the pulp and paper industry in Canada and in particular in Alberta, to respond quickly to reports on the presence of dioxin/furans in effluent. Technology changes included using alternate oil defoamers, increasing chlorine dioxide substitution, and treating effluent with biological systems. These industry changes were not only aimed at reducing dioxins/furans but also at decreasing AOX levels in the effluent.

It is important to note that these substantial changes were made without actually knowing the health and environmental impacts of dioxin/furans. Most industry managers, being trained in the scientific method, tend to base decisions on sound facts or data. Once the pulp industry collected data on the occurrence of dioxin/furans in chlorine bleaching pulp mill effluent, process changes were made. These changes were made not because the health risks of dioxin/furans were known or completely proven, but because the public was extremely concerned about the potential health risks yet to be proven. While responding with process changes, many in the industry and government interviewed for this thesis felt that the finances invested into dioxin/furan research could be better spent in improving the existing effluent treatment systems or developing new technology like zero effluent systems.

6.5 CANADIAN ENVIRONMENTAL VALUES AND OPINIONS

The Canadian Council of Environmental Ministers (CCEM) (1991) determined that the sustained public concern, along with continuing deterioration of environmental quality, international issues, and costs of traditional environmental management were factors influencing Canadian environmental policy. Increased public concern about the environment since the mid-1980s (See FIGURE 6.2) was attributed to the fear of pollution adversely affecting human health. Others believed that the very survival of human species was at stake. The high cost of environmental protection and rehabilitation will require increased attention to costs and benefits of environmental objectives. This may force a policy shift from remedial approaches to anticipatory and preventive strategies. The rising public concern (See FIGURE 6.3) over a deteriorating environment, coupled with the declining trust of Canadians in their governments, set a volatile arena in which to develop environmental policy.

The CCEM report indicated that the demand for greater accountability, the need to integrate environmental considerations with economic decisions, the greater use of economic instruments, and extensive environmental reporting will influence future environmental policy. Low public confidence in governments and large corporations was at the root of the demand for greater accountability. Within the EIA process, environmental groups lobbied for rigorous application of procedures; industry worried about uncertainty and costly delays; governments tried to protect jurisdiction and control. Public expectations about consultation have been rising faster than the governments' ability or willingness to deliver.

In the 1990s it is essential that the pulp mill industry recognize the importance of non-technical communication with the public, labour, and media (McCubbin, 1992). The rapid growth of environmental activist groups and their effect on the general public opinion about the pulp industry has changed the way the industry responds to the public. Some of the allegations on technology and economics by environmental groups, even though misleading and factually incorrect, influence the way governments and customers treat the pulp industry.

FIGURE 6.2: Environmental Concern Fall 1990
(Environmental Monitor cited in CCEM, 1991)

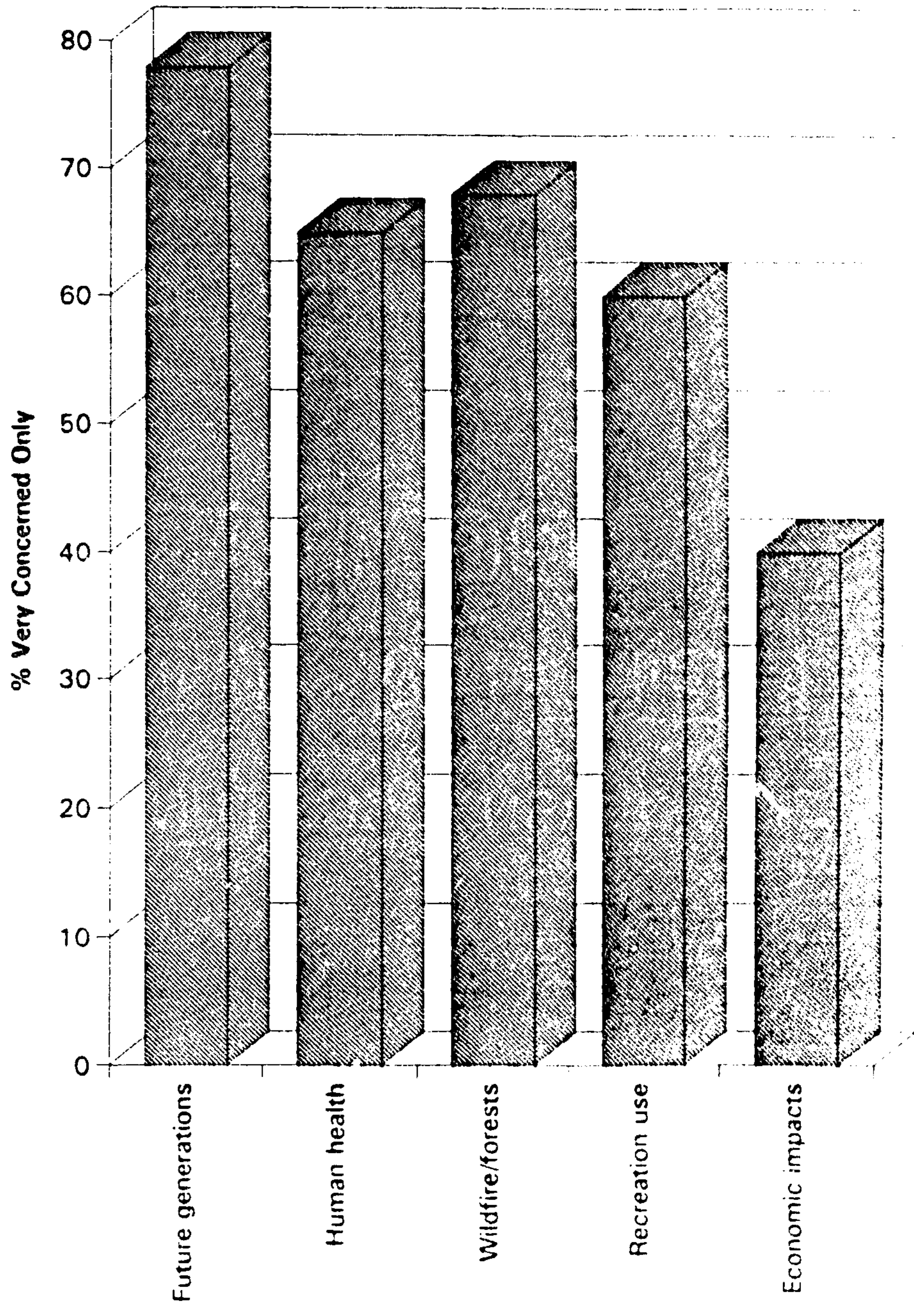
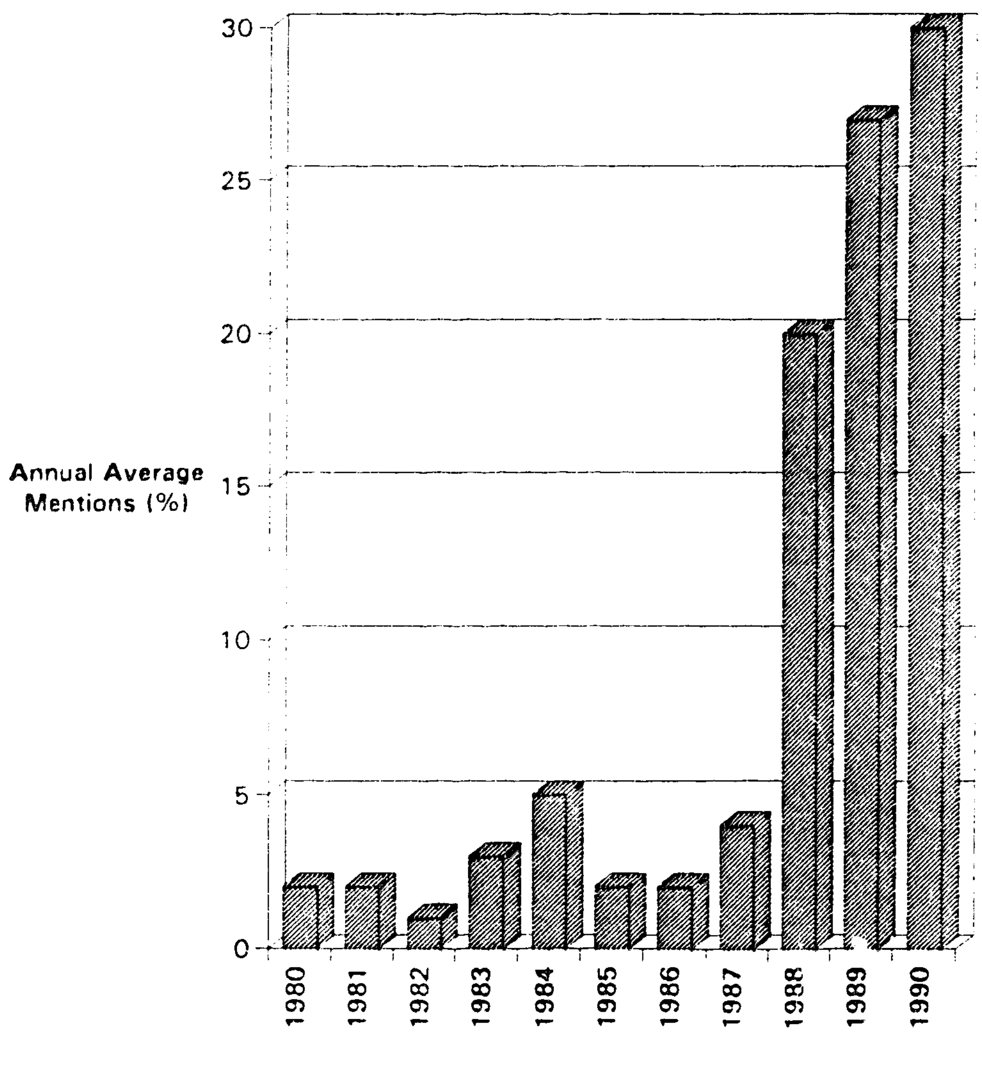


FIGURE 6.3: Growth of Public Environmental Concern (Angus Reid Group cited in CCEM, 1991)



Public opinion surveys have been used to present information about environmental concerns. In Canada, a recent poll summarized in TABLE 6.2 identified seven mindsets on public attitudes about environmental change (Angus Reid Group, 1992). This mosaic within the Canadian public is important to consider when evaluating opinion surveys. Members of some of the mindsets, i.e., fatalist, apathetic, and hostile, may be reluctant to respond to surveys on the environment, thereby producing biased results. Whereas modern public surveys attempt to sample across stratified groups within the general population, eg., income levels and regional locations, it would be very difficult to ensure adequate sampling across mindsets.

TABLE 6.2: Public Attitude in Canada about Environmental Change (Angus Reid Group, 1992)

MINDSET NAME	% OF PUBLIC	DEFINITION
activist	18	young well educated; willing to oppose and very active
enthusiast	9	real concerned with environment; believe that science and technology can serve public; somewhat active
anxious	15	older predominantly female; feels helpless, vulnerable; concerned with environment; supports tough issues with little activity
privilege optimist	20	high income and education levels; predominantly powerful conservative males; not seriously concerned; believe hope for future
fatalist	13	believe environmental situation is hopeless and will not take any action
apathetic	14	low income and education levels; typical older females; disinterested; not concerned about the environment; more concerned about meeting basic needs
hostile	11	predominantly older males; believe that environmental problems are media based and over played

In recent surveys completed in 1988 and 1990, Angus Reid Group polled Canadians to determine perceptions of which industries cause the most environmental damage. Across Canada, the number of people believing forestry/pulp and paper was the worst polluter almost doubled from 27% in 1988 to 50 % in 1990. In the Prairies, during the same period, the number increased from 20% to 56%, almost a three fold increase.

In another similar poll (summarized in TABLE 6.3), the forestry/pulp and paper companies continue to be seen as less friendly towards the environment than other industries (Angus Reid Group, 1992). About two thirds of Canadians depicted the forestry/pulp and paper industry to be careless, producing a Concern Index of -28. This however, is an improvement on the 1990 Concern Index of -49. (The Concern Index is obtained by subtracting response to "careless" from response to "careful". A negative number implies that the public views the sector as more "careless" than "careful"). In the same survey, policy initiatives were examined and people were asked if resource companies' access to Canada's wilderness lands should be sharply curtailed, even though it would mean losses of jobs in some areas. A strong majority, 61% of Canadians, favourably supported placing greater restrictions on resource companies. One third of the total surveyed were staunch proponents (strongly in favour) of environmental protection initiatives. However, only 44% of the same group would favourably support a complete ban on logging in old growth forest, knowing many loggers would lose their jobs.

TABLE 6.3: Selected Industries' Public Image for Environmental Conscience (Angus Reid Group, 1992)

INDUSTRY	% Very Careful	% A Little Careful	% A Little Careless	% Very Careless	% Unsure	Concern Index
chemicals	5	16	31	36	12	-46
mining	4	21	31	26	18	-32
forestry /pulp & paper	9	24	25	36	6	-28
oil & gas	7	24	31	28	10	-28
ag chemical	6	25	30	26	13	-25
fast food rest.	7	34	30	25	5	-14
auto manuf.	8	31	29	21	11	-11
food processing	9	31	31	14	15	-5
retail sector	7	37	31	14	11	-1
nuclear energy	23	23	19	19	17	8
tourism	20	35	22	9	14	24
electricity utilities	20	37	21	10	11	26
ag. producers	21	38	25	7	9	27
natural gas	20	38	17	6	21	35

In the 1990 survey, "Canadians and the Environment", Angus Reid Group attempted to determine if consumers would be willing to pay a premium for protection of the environment (See TABLE 6.4). This involved asking questions about seven different scenarios, all except the first one required higher spending. The results are summarized in TABLE 6.4 It is interesting to note that an overwhelming majority of Canadian consumers (86% in 1989; 94% in 1990), across all socio-demographic groupings, expressed a willingness to substitute bleached paper with the unbleached variety.

TABLE 6.4: Canadian Willingness to Make Financial Sacrifices in the Interest of Environmental Protection in 1989 & 1990 (Angus Reid Group, 1992)

PROPOSED	1989 %	1990 %
Buy unbleached paper products such as toilet paper and paper towels which are kind of brown in colour, in place of bleached white paper products	86	94
Pay 10% more for groceries packaged and produced in an environmentally safe way	66	73
Pay 10% more for farm produce grown completely organically, that is, without any chemical pesticides	n/a	73
Pay $1000 more for a smog free car	63	71
Pay 5 cents a litre more for gasoline to decrease air pollution	63	69
Pay 50% more for garbage collection to pay for safe long term disposal	67	68
Pay $250 a year more taxes to clean up your communities sewage system	58	63

6.6 PUBLIC WILDERNESS VALUES IN ALBERTA

It wou'd be interesting to determine what part of the Canadian population (urban/rural) and in what region has experienced the New Environmental Paradigm Shift. The results of a survey conducted by Jackson (1989) on urban population in Alberta supports this shift (See TABLES 6.5 & 6.6). This split between Dominant Social Paradigm and New Environmental Paradigm appears to parallel the distance from wilderness theory mentioned previously. Jackson concluded from the survey that preservationist views have been widely adopted by urban residents in Alberta. The majority of respondents disagreed with pro-development statements and agreed with restrictions on recreation land use due to environmental impacts. Jackson also concluded that these findings could be applied across social strata not just to an elitist minority.

TABLE 6.5: Evaluation of Land Management Purpose (Jackson, 1989)

CONCERN	% by level of importance			
	not at all	not too	somewhat	very
To protect plants/animals native to Alberta	0.9	2.7	19.0	77.4
To protect typical examples of Alberta's natural regions	1.2	5.0	21.6	72.1
To set aside wilderness areas from resource development	3.4	10.1	19.8	66.8
To protect areas of historical interest	1.5	4.9	33.7	59.8
To provide opportunities for wilderness recreation activities	4.3	12.1	32.7	50.9
To provide camping facilities	7.4	10.3	28.9	53.4
To provide opportunities for outdoor recreation activities that require a high level of development	5.8	16.9	33.3	44.0

TABLE 6.6. Responses to Recreation-Resources Statement (Jackson, 1989)

CONCERNS	% by level of importance				
	strongly disagree	disagree	neutral	agree	strongly agree
In any public park or forest, people should be allowed to enjoy their own kind of recreation	25.2	36.4	14.6	18.1	5.6
Some recreational activities should not be permitted in certain areas if they disturb other recreationists	2.0	2.1	6.5	38.4	51.0
Some recreational activities should not be permitted in certain areas because of their effects on the natural environment	2.1	2.9	3.6	36.1	55.2
Setting aside wilderness areas is not worthwhile if it means keeping out motorized transportation	43.3	27.1	9.9	13.0	6.7
'Multiple use' in regard to our public lands means that every possible use should be made of every acre of public land	26.4	35.0	14.8	15.0	8.9
Potential energy and mineral deposits should be developed even if they occur in wilderness areas	22.7	28.0	23.1	18.6	7.6

Other reports have indicated that non-respondents are more tolerant of resource development and less purist in their attitudes toward wilderness than respondents (Peterson, et al., 1973). Perhaps there is some middle ground held by the "silent majority" between the two paradigms that combines the "best" of both to provide sustainable development while protecting wilderness areas. Although Jackson (1989) explained that this did not apply, since differences between the first and second wave of returns were negligible. While the study may be statistically sound, the large number of non-respondents could have been more passive in their views causing skewed results.

In 1990, the Environmental Legislation Review Panel held public meetings to obtain views on the proposed Alberta Environmental Protection and Enhancement legislation. Evans (1990) indicates that many participants criticized the use of the term "enhancement", perceiving that the environment cannot be enhanced and indicating a misunderstanding of the environment by government. Many participants supported the concept of sustainable development, meaning a wise use of resources while maintaining a healthy economy. This balancing of considerations was summarized in statements like:

> "Governments, the private sector and the public must assess the economic, social, and environmental costs of all environmental initiatives, and balance the costs and benefits when making plans for environmental protection." (Evans, 1990)

Many of the participants asserted the public's right be directly involved in a meaningful process in all aspects of both the government's operations and development, affecting the environment. This would involve having Alberta Environment maintain more direct contact with the public, offering timely and adequate consultations and follow-up reporting. Regulations and standards should be clarified so that all members of the public, including industry, know where they stand in relation to the laws.

The report indicated the need for environmental education, public access to information, and the necessity of public consultation during the EIA process. Many critical comments concerned the release of contaminants; the public perception being that releases were not prohibited. The public wanted the polluters to be accountable at all costs, but environmental costs must be borne by both polluter and collective society. Legislation should allow environmental costs to be recognized, levied and distributed appropriately. Many participants recognized the need for stricter enforcement of legislation. Many of these and other public concerns were incorporated into the proposed legislation.

6.7 PUBLIC INVOLVEMENT IN THE EIA PROCESS IN ALBERTA

FOREST MANAGEMENT AGREEMENTS

It is important to note, although of prime importance to most in the public, companies proposing a pulp mill are not required to include forest harvesting activities in the EIA process. These are handled separately under Forest Management Agreements (FMA) and subsequent forest management plans. The FMA is not issued formally until the EIA process has been completed and approved, but conditional FMAs are granted to ensure a wood supply to the mill proponent. The FMA is referenced in EIA reports to provide clarification about wood supply and forest management procedures for mitigating negative impacts of harvesting practices.

Although in a different format, a forest management plan of a major forest tenure like a FMA is similar to an EIA report. Baseline data are presented as forest inventories. Potential impacts and mitigating measures are indicated by the companies objectives and polices. Although generally the plan is aimed at maintaining environmental quality, rather than predicting and mitigating individual impacts as in an EIA report, there are exceptions for protecting particularly important animal species within the FMA area. Detailed methods of mitigating damaging impacts are presented in the companies' operation plans on an annual basis and harvesting plans a day-to-day activities. These plans are prepared in consultation with representatives of the Alberta Ministry of Forests, Lands and Wildlife. Even though the standards set by the province are high, the degree to which the standards are actually met depends on the company's attitude, their foresters' abilities, economic conditions, and enforcement by government.

Some people believe that the public can act as a watchdog to ensure that the standards set by the government are high enough and that the standards are met or surpassed by the companies. A recent survey indicated that on the one hand the public may be the best arbitrator of conflicting values between a resource agency and public interest groups, on the other hand the public is becoming suspicious of decisions made "in a black box", concealing how trade-offs are made (Knopp, et al 1990).

Although companies reference FMA documents in the EIA report, as mentioned earlier, forestry issues are handled as a separate issue at EIA public meetings. The EIA report for DC stated clearly that specific environmental and land use impacts of the forestry operations were not included.

> "...the impacts of the forest operations will be dealt with by Daishowa Canada in accordance with the terms and conditions of the FMA (to be negotiated between the company and government); Alberta Timber Harvest Planning and Operating Ground Rules; the provincial Forest Act, Timber Management Regulations" (Daishowa Canada Co. Ltd., 1987).

More specifically in regards to the FMA, the report indicates that the FMA

> "...will deal with matters relating to environmental issues covered under the Province of Alberta's standard FMA's. Reforestation and silvicultural practices appropriate for hardwood species in northern Alberta will also be an important part of Daishowa Canada's forest management plans."

The DC EIA report briefly mentioned wood quality and quantity as well as log transportation routes.

Opposition to and debate on the DC pulp mill continued from 1988 (when constructed) through to 1992. A boycott group asked businesses to refuse to buy or stock any DC paper products, cardboard or wood chips. The group claimed the company refused to honour a 1988 pledge to the Lubicon Indians to refrain from logging on land claim areas and has been logging irresponsibly in Wood Buffalo National Park. Some of the group's activities include involuntary and voluntary compliance of retailers in Ontario and Alberta, and demonstrations in both provinces, and negative media stories.

The boycott group is being coordinated by Friends of the Lubicon in Toronto, the Alberta Environmental Alliance Action Canada Network in Edmonton and the DC Boycott Coalition in Calgary. The boycott has been supported by the chief of the Lubicon Indian Band, the Assembly of First Nations and other native rights activists in Edmonton.

The objectives of the boycott include (DC, 1992):

- pressuring the federal and provincial governments to settle the Lubicon monetary demands included in land claims (the land claim negotiations between the Lubicon and the federal government have been ongoing for a number of years. The provincial government issued a FMA to DC covering territory claimed by the Lubicon Band to be under the band's jurisdiction.);
- forcing third parties like DC to make a commitment not to carry out any business activities in an area that the Lubicon claim as their own; and
- pressuring DC to change its forestry practices in the FMA allocated by the Alberta government.

Concerns have been expressed by Lubicon Indians land claim interests within the DC FMA and by environmental groups in Toronto and Tokyo Japan (Edmonton Journal Nov 24-29, Dec 3, 1992). In Japan, environmental groups were initially informed about the situation by Canadian English teachers working in Tokyo and later by Lubicon Chief Bernard Ominayak, who was unsuccessful in presenting his case to Japanese DC officials. The Japan Christian Council launched one of the first nation wide boycotts targeting DC, the country's second largest paper maker and parent company of the Canadian mill in Peace River. Other Japanese environmental groups and DC opponents, i.e., Japan Tropical Forest Action Network, became more active in the product boycott.

DC has felt unjustly implicated and caught in the middle, having met all provincial EIA and FMA requirements (Mr. Morrison, DC Personal Communication). Tom Hamaoka, DC General Manager indicated (Edmonton Journal Nov 24-29, Dec 3, 1992) that the boycott was a well-orchestrated media campaign to discredit the company in hopes that the company would pressure governments to negotiate a settlement. DC views itself as environmentally responsible, responsive to aboriginal interests, concerned about employees and the Peace River community, and respectful of its commercial and legal commitments to governments and customers (DC, 1992). The company believes it honoured its 1988 commitment to not harvest on the proposed Lubicon "Reserve Area" and to consult with the Band prior to harvesting close the reserve. As yet no logging has been conducted in the area. DC recently acquired High Level Forest Products Ltd. as a subsidiary, which has traditionally logged in Wood Buffalo National Park. The company has ceased logging in the park pending negotiations with the Federal government for a harvesting alternative. It is also important to note that DC paper bags and cardboard products are manufactured from other commercially available pulp fibre and not from pulp made at Peace River.

Once a settlement is reached, the implications to the province's ability to control forest harvesting levels and indirectly to the company's FMA remain to be seen. Having the FMA included in the EIA process may not have alleviated the controversy due to the sensitive and long standing land claim issue. However, it does demonstrate the vulnerability of pulping operations to boycotts by those opposing forestry practices.

The Alberta government has made several attempts to address public concerns about forest management. In 1977, the Environment Council of Alberta conducted public hearings in 15 locations over a two year period on the environmental effects of forestry operations (MacNichol, 1989). In 1990, a report (Dancik, 1990) by the

Expert Panel on Forest Management summarizing public concerns was submitted to Alberta Forestry, Lands and Wildlife.

In June 1990, the provincial government released new policy on public involvement in forest management planning. In the past, the avenue for the public to comment on FMAs has not been clear. Public involvement was not specifically mentioned in the FMA plans, except briefly in the ground rules. The DC ground rule document states that:

> "...the company will consider the interests and concerns of the general public and other resource users in a manner consistent with the terms and conditions of the FMA." (Alberta, 1989)

Under the new policy, companies are required to develop a public involvement plan, outlining how the public can participate with both the government and company during the forest management planning process. Public concerns expressed at company sponsored public meetings, workshops, and field tours must be recorded and addressed in the FMA plan. Drafts of the FMA plan must be made available for public review. Forestry Environmental Liaison Committees, comprised of representatives of local public groups and the company, should be formed to provide advice to the company on forestry issues on an on going basis.

This policy extensively covers public review of FMA plans, but may not be sufficient to mitigate public concern. Comments of one environmentalist (Keith, 1992) on the Interim Timber Harvesting Guidelines included concerns about:

- poor advertising of public meetings, being in small print and vaguely worded;
- the public meeting process being intimidating for many members of the public;
- the difficulty of obtaining in-depth understanding of community concerns from a one-night meeting;

- the public commenting on guidelines already drafted instead of being a part of the decision making process;
- adequate integration of all forest resources;
- the guidelines not being specific enough for the public to approve, and often contradictory in nature; and
- recognizing and accepting emotions as well as science when dealing with environmental issues.

Knopp and Caldbeck (1990) report that public values are not necessarily represented by volunteer organizations or public interest groups (see previous discussion on public values). Also, listening to the public is different from having them participate in the decision making process (which involves a transfer of power). Knopp and Caldbeck suggested four steps for participatory democracy in resource management. First, resource management alternatives or mitigating measures must be clear and well defined. Secondly, companies and the public must understand that the tradeoff decisions of the various alternatives are made by individuals by choice, not by cost/benefit analysis. Thirdly, the outcome or consequences of the various alternatives must be available and easily understood. Finally, selectivity by the company of the choices for a public process should be avoided. Although this suggested approach may mean the company and government must consider less attractive alternatives, the public has the opportunity to be a responsible part of the decision making process, which may provide the benefit of public acceptance over the long term.

WC EXPANSION EIA

For approval of the 1987 expansion plans, the mill at Hinton submitted an EIA as required by the provincial government (WC, 1987). As part of the process, the company conducted a public consultation program to solicit comments on the proposed expansion. This program consisted of holding 18 advertised meetings in 10 downstream communities with 22 individual groups, i.e., improvement districts, health units, reserve and métis natives, industries, and other related parties. At each meeting, participants received a general oral overview and printed material indicating the past, present and projected performance of the environmental equipment. These formal presentations were followed by question and answer sessions.

In general, the questions focused on clarification of the material presented in regards to chemicals used by the mill, river monitoring programs, and impacts on the water and fish, as well as the fate of effluent compounds in the river. Most questions were answered to the satisfaction of the participants; some, requiring additional information, were recorded and the company forwarded information to the individual who had asked the question.

The transcripts from the meeting held with native representatives at Fort Chipewyan indicated a high level of concern about the water and fish quality in nearby lakes. These included mercury levels, quality of fish, spills in the mill, amount of water being used and returned to the river, and general concerns about water pollution. More specifically, the participants were upset because: they felt they were being notified about the project after it had been approved; and more industrial/municipal waste would be released into the river. A general mood of distrust of both industry and government prevailed.

ALPAC EIA

In December of 1988 the approval in principle of the ALPAC pulp mill was announced by the provincial government. There were a number of concerns expressed by the public regarding the installation of the ALPAC mill. It would be foreign owned. It would be one of the largest pulp mills in the world, annually consuming 2.4 million m^3 of timber from a designated FMA area of 74,000 square kilometres, about 12% of the province. Concern was expressed about BOD loading in the Athabasca River, especially since there were already four mills discharging into the river system. Another significant concern centred on chlorinated organics and dioxin/furans, particularly by downstream communities such as Fort McMurray.

Fishermen raised concerns about effluent toxicity and fish tainting. Local residents were concerned about contamination of surface water by site run-off and groundwater by landfill leachate and lagoon leakage. Water usage during low flow conditions was also a concern.

During the first half of 1989, an EIA hearing process was conducted by the provincial government. Rising public concerns and the threat of litigation compelled the federal and provincial governments to jointly establish the ALPAC FEARO Review Board. This group consisted of four provincial appointees (a local farmer, airline owner, school superintendent, the Chief of the Ft. McKay Indian Band); two federally appointed scientists (a reknowned water quality scientist and an environmental science professor with EIA experience) (Gismondi, 1991). The head of the Alberta Energy Resources Conservation Board was designated chairman. The resulting hearings, held in 12 communities in northern Alberta and the NWT, formed one of the most comprehensive investigations of a pulp mill in Canada.

TABLE 6.7: Summary of Registration List for Documents for the ALPAC EIA Review Board (provided by V. MacNichol Alberta Environment, 1992)

SESSION	NO.	DATE	PLACE	TYPE
A	51	30,31/10/89	Fort McMurray	Hearing submission
B	4	01/11/89	Janvier	Hearing submission
C	22	3,4/11/89	Lac La Biche	Hearing submission
D	1	08/11/89	Beaver Lake	Hearing submission
E	10	9,10/11/89	Fort Chipewyan	Hearing submission
F	27	15,16/11/89	Fort Smith	Hearing submission
G	70	17-21/11/89	Athabasca	Hearing submission
H	18	22/11/89	Fort Resolution	Hearing submission
I	15	23-24/11/89	Prosperity	Hearing submission
J	108	1-2/12-89	Edmonton	Hearing submission
K	6	5/12/89	Wabasca-Demarais	Hearing submission
L	48	7,8/12/89	Grassland	Hearing submission
M	87	14/12/89	Prosperity	Hearing submission
N-1	40	17/11/89	EIA Review Board	Letters received
N-2	46	15/12/89	EIA Review Board	Letters received
O	191	11/89-2/90	EIA Review Board	Reports received
P	6	n/a	Other	Letters received
TOTAL	750			

Within its terms of reference, the Board was requested to examine all environmental impacts of the proposed mill (Moen, 1992) including:

- the biophysical impacts, i.e., air emissions and discharges into the Athabasca River;
- socio-economic impact, i.e., resulting from an increased workforce in the region during mill construction and operation; and
- impacts relating to federal government jurisdiction, i.e., parks, fisheries, navigable waters and NWT water quality.

The Board did not consider so-called non-environmental aspects, i.e., financial feasibility, potential kraft pulp markets, kraft mill technology, or forestry operations associated with the mill.

In March 1990, the ALPAC Review Board recommended that the mill not be approved, even though the mill would be one of the least polluting pulp mills in the world and offer many economic benefits. The Review Board stated that additional data were required to determine if the mill would pose a serious hazard to the river and downstream users and recommended further scientific studies be conducted over the next three to five years to obtain the necessary information. The Northern Rivers Study, currently in process, was initiated to obtained the required information.

The scientific aspects of effluent were presented to the public by the proponents through various meetings. Some people were satisfied with ALPAC's responses to their concerns; others were not. From those meetings, Gismondi et. al. (1991) documented examples of gaps between the scientific experts and the concerned public, demonstrating cultural and language differences. They saw the ALPAC hearings as a process that undermined the powers of state and capital by providing opportunities for differing values to be expressed, for the public to present counter-arguments that could disrupt the previously persuasive discourse of the ALPAC proposal. This was confirmed by many Athabascans becoming opposed to the mill only after the ALPAC Review Board came to town (Gismondi, et al, 1991). Examining the ALPAC hearing transcripts, Gismondi investigated incidents when less powerful groups undermined the discourses empowered by the dominant groups and interjected highly political counter discourses in the midst of complex sociological and historical processes. Gismondi states:

> "Some of these are the expansion of the forest industry into previously unused hardwood resource areas; high prices for premium pulp; the globalization of markets; the Canada-US Free Trade Agreement; the Alberta Government open invitation to offshore capitalists such as Mitsubishi to develop the northern boreal forest; the personalities and political aspirations of the receptive Environment Ministers, the paramilitary nature of the forestry department and its "general"; Federal-Provincial

relations and the Canadian Constitutional crisis. These are counterpointed by a growing global concern about environmental problems; the green house effect; global deforestation; dioxin and furan contamination from pulp mills; the closing of shellfish fisheries in B.C. and a rise in the number of people in organized environmental and public advocacy groups. In the midst of this is the coincidence of a university in Athabasca, the retirement of a couple of scientists from the impact areas, and a well organized New Democratic Party association in the riding where ALPAC built."

ONGOING PUBIC/COMPANY INTERACTION

Most of the pulp mill companies are aware of the importance of public education and have ongoing programs to address this need. All the mills host tours for interested individuals and groups. The staff involved with these tours find them to be extremely effective in showing people the various environmental protection programs operated by the mill. Many visitors comment that they assumed that the pulp mills were not doing anything in this regard and were surprised at the level of activity.

PNGC established a Environmental Advisory Committee in 1990 comprised of representatives from the company and active local groups. The South Peace Environmental Association, one of the more active local environmental groups, declined to participate in the process. Committee meetings are held every 4-6 weeks. In the beginning, the process was aimed at an education program about the pulp mill industry. Later, issues ranging from forestry to specific effluent problems were generated by members of the committee and discussed.

PUBLIC MEETINGS FOR WATER LICENCE RENEWALS

As indicated early in Chapter 4, the Environment Council (1987) reviewed the effectiveness of the Clean Water Act. In recognizing the important role of the public in setting water quality standards, the resulting report recommended that Alberta Environment improve communications with the public, thereby increasing awareness of, interest in, involvement with and support of water management activities.

The report recommended that the public guide water quality managers and the government with respect to value judgments inherent in environmental protection. Technical expertise was considered to be limited in balancing value judgments between resource development and environmental protection. Sound policy decisions depended on the incorporation of a broad range of points of view. The public should be involved in the development of water quality objectives for the province and in the process of setting effluent standards.

The proposed provincial environmental legislation will require pulp mill companies to conduct public reviews for Licence to Operate renewals. Although not as yet approved, PNGC followed these proposed procedural changes and solicited public approval for the renewal of its Licence to Operate. The public meetings in the town of Grande Prairie (September 1992) were open to the general public and approximately 100 people attended. The meetings, in a workshop format with sessions, were held in the morning and repeated in the afternoon. The information presented by the company included public input obtained throughout the summer while displaying information in booths in the local shopping mall.

The topics included landfills/ground water sampling program, air pollution control, and water pollution control. At each session, a company representative presented an oral and written overview of the proposed changes in the Licence. The subsequent discussion was facilitated by a consultant chosen by both Alberta Environment and the company. This consultant summarized the workshops for Alberta Environment to review as part of the application for the Licence.

It is interesting to note that the local environmental groups formally boycotted the public meetings. The workshop report (Western Environmental, 1992) noted that some community members had asked for a town hall type meeting. The environmentalists wanted Alberta Environment to be responsible for the workshop and not PNGC. The format chosen resulted in the environmentalists not participating in the workshop. One participant felt that the workshop did not provide the opportunity to exchange objective information. While a company representative was given 25 minutes to present the mill's opinion, environmentalists, who might have different views, were given no time. Another person suggested that a broader review of the mill with those responsible for forestry issues and environmental protection should be conducted. Other priorities included protection of human life, as well as concerns about odour and colour.

MEDIA AND THE INDUSTRY

M. Voisin, Alberta Forest Products Association (McCubbin, 1992), has reported that the relationship between industry and media is poor. Some industry representatives have viewed reporters with animosity, indifference, irrelevance, and/or fear, resulting from past "biased" reporting as well as "poor" past industry performance. The media is often viewed by industry as being in conflict between making a profit and providing the truth. In reality, journalists work under stressful and demanding situations with few resources. Organizations that do not invite scrutiny, like the pulp industry, are viewed with suspicion by journalists. An improved relationship between the media and the pulp industry is essential to increase public confidence and support. This involves having a designated media contact person at each mill to provide consistent liaison and by responding to media investigations. Also, mills must be proactive in providing press releases/conferences and attending speaking engagements.

6.8 LABOUR AND INDUSTRY

Another component of the public is organized labour. In Alberta, the Alberta Federation of Labour (AFL) and one of its member unions, the Canadian Paperworkers Union (CPU), have been the most active labour groups on pulp mill developments, taking direct and indirect action. Direct action has involved workers reporting environmentally harmful spills and accidents to Alberta Environment. Indirect action involves increasing awareness about environmental problems by presenting papers at EIA hearings, participating in environmental round tables, and forming local-provincial-national-international committees on the environment.

Direct action is taken by workers in mills around the province. Only one mill in the province is unionized (WC -Hinton) and workers in that mill are protected against loss of employment if caught reporting spills. Workers in other mills do not have the same protection and if caught may be dismissed[25].

The unions are trying to make employers responsible for environmental protection. In general, workers are encouraged to protect the environment by ensuring government regulations are followed within the plants. The union is working on protecting employees who bring the information to the employers' attention as well as inform the authorities about regulation violations. The union also establishes committees, comprised of workers and management, to work on specific issues, eg., safe use of wood stain chemicals. Although the union approached employers with concerns on effluent treatment systems, as yet only inside committees have been effective. Unions have been vocal during hearings on legislative changes.

In 1991 contract negotiations, the CPU and the Pulp and Paper Workers of Canada requested several clauses to empower workers in environmental protection. These include:

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25 Personal Communication, Dave Cole, CPU Edmonton, October 21, 1992.

- having no disciplinary action taken against an employee who fulfills duties under the Environmental Laws of Canada;
- establishing joint company/union environmental protection committees to solve environmental concerns and problems; and
- encouraging the company to have open and jointly conducted investigations into plant spills.

Ideally, the union would like to have employees able to shut down equipment when an environmental threat is imminent. Presently, only union workers in B.C. and Saskatchewan can shut down equipment if worker safety is threatened. In Alberta, workers cannot shut down equipment if an environmental accident occurs.

Pulp mill unions, aware of the pollution problems in the industry, have developed environmental policy statements to support the reduction of both air and water pollution. An environment document released by the CPU stated interest in maintaining pressure on the industry to clean up operations inside plants for worker safety and outside for environmental protection. In addition to recommendations regarding other environmental concerns, i.e., ozone depletions, tailpipe emissions, the CPU made several specific recommendations concern pulp mill pollution.

The CPU recommended that:

- Federal and provincial governments strictly enforce all existing laws on air pollution and enact new standards requiring best available pollution control technologies.
- The provinces implement the zero discharge philosophy, based on the Great Lakes Water Quality Agreement.
- Governments establish water pricing policies reflecting clean up costs and water conservation standards.
- Pulp and paper companies be required to develop nonpolluting technologies.
- Future Forest Resource Development Agreements be based on ecologically sustainable principles.

The Alberta Federation of Labour (AFL)(1991) has been active politically since the early 1980's to influence pulp mill pollution and environment protection. In 1980, AFL policy (80/D8) was aimed at passing "strict legislation prohibiting all pollution of our rivers and lakes". In 1984, AFL policy (84/603) "demand(ed) that uniform environmental standards and regulations be put in place and enforced" (Alberta Federation of Labour, 1991). In 1985, AFL policy (85/803) was aimed at "ensuring rights to a pollution-free environment".

At the 1988 AFL Annual Convention, a policy paper was adopted summarizing concerns regarding the environmental situation partly in response to the Brundtland report released in 1987 (Alberta Federation of Labour, 1990). This paper indicated interest in joining with environmental groups and networks. This alliance was aimed at organizing to focus public opinion on environmental issues. This paper moved environmental protection to the top of labour's agenda. Other policies adopted at the 1988 convention included (Alberta Federation of Labour, 1991): educate Albertans about the state of the environment; promote public participation in environmental standard setting and enforcement; publish a list of environmental violators; establish clearly defined enforcement response procedures (88/110); and reject the proposition that workers must accept trade-offs which sacrifice the environment and endanger their health in return for jobs (88/208).

In Alberta in 1989, the Alberta Federation of Labour, along with the Alberta Environmental Network and Pro-Canada Network, conducted regional meetings to discuss "A People's Agenda for Alberta". Environmental concerns was one of four major topics discussed. In the written material supporting the meetings, negative impacts on the environment were acknowledged. Federal election polling results indicated that environmental concerns was number one for Canadians. The Brundtland report was cited and Canada-Alberta agreement with the report was mentioned, as was their poor response so far.

Pulp mill development was indicated as one of the front line issues for 1989 at the regional meetings. Concerns were expressed about the lack of public hearings and environmental impact assessments prior to decisions being announced. The 1989 AFL Policy 107 "Demand(ed) that approval of Alberta pulp and paper development be denied when using damaging bleaching agents, processes or harvesting methods" (Alberta Federation of Labour, 1991). Policy 89/721 "Promote(d) legislation for stringent Environmental Impact Assessments" (Alberta Federation of Labour, 1991).

At the 1990 AFL Annual Convention, the AFL stated that "the labour movement will assume a leadership role to halt the environmental degradation which has taken place, and restructure economic and social development on a sustainable environmentally friendly basis" (Alberta Federation Labour, 1990). The position of labour included taking an active role in the decision making process on the assumption that corporate and government approaches have been irresponsible and environmental damage has resulted. Policy 90/808 "support(ed) a freeze on the DC Pulp Mill until proper federal environmental assessments have been performed" (Alberta Federation of Labour, 1991).

At the 1991 AFL Annual Convention (Alberta Federation of Labour, 1992), the Environmental Committee reported national, international and provincial activities. Nationally, the committee joined with the new Canadian Labour Congress Environmental Committee at meetings across Canada. Discussion at the meetings included the establishment of Environment Committees in every province, sustainable development, and action plans for "Sustainable Prosperity". Internationally, the AFL solicited the Canadian Labour Congress to encourage the International Confederation of Free Trade Unions in Geneva to be involved with environmental issues and participate at the United Nations Conference on the Environment in 1992. In Alberta, the AFL worked toward including workers in determining and implementing "Sustainable Prosperity". Action included participating in both the round table on sustainable development and the federal

Green Plan, and as a member of a coalition with non-labour groups on development[26].

Forming an alliance with environmental groups was another way that the AFL/CPU worked toward influencing pulp mill development. The alliance formed for the ALPAC hearings met an organizational need which had been building for a number of years. Prior to the MWP mill, AFL/CPU activity concentrated on organizing the PNGC mill and reporting spills. Concern within the AFL/CPU resulted from the rapidity of pulp mill development (the SLPC and DC mills were approved almost without public input or opposition). As these developments were occurring, the AFL/CPU began to organize and join with the environmental groups for the ALPAC hearings. The ALPAC hearing presentations were not just concerns about the ALPAC mill but also an accumulation of concerns about the rapid approval and construction of the three previous mills[27].

In late 1989, the AFL and CPU submitted papers to the ALPAC Environmental Impact Assessment Review Board. The written briefs indicated concerns about the inadequacies in the hearing process, and concerns about toxic discharges, recycling, forest management, resource use/exploitation, and research and development. Issues about workers included health and safety, employment, and affirmative action. Concerns about toxic discharges included remarks about the poor quality of the EIA report on chlorinated organics, effects on aquatic life, and the companies' assumption of their right to pollute.

On the one hand labour joined with environmental groups for environmental protection, on the other hand unions are hesitant in supporting environmental actions that threaten employment. In July 1991, in New Directions, Jack Munro, then President of IWA-Canada, expressed concerns regarding a pulp product

26 Included Friends of the Athabasca, Friends of the Lubicon, Friends of the North, Friends of the Earth, Mother Earth Society, Environmental Resource Centre, Alberta Wilderness Association, Canadian Parks and Wilderness Society, Friends of the Oldman River, and the Toxic Watch Society.

27 Personal communication, Dave Cole, CPU Edmonton, October 21, 1992.

boycott in Europe launched by environmental groups. His comments were directed to a comparison of forests in B.C. and Brazil by the Federal NDP environmental critic, Mr. Fulton. Mr. Munro indicated that these comparisons supported the environmental groups' boycott and could "hurt Canada's working men and women".

CHAPTER 7 FACTORS INFLUENCING PULP MILL EFFLUENT TREATMENT IN ALBERTA

7.1 INTRODUCTION

One of the basic goals of scientific research is exploring and exposing the structure of natural and social systems. A system can be defined as a group of parts operating together toward a common purpose. In primitive society, humans merely adjusted to natural systems, considering them to be beyond comprehension or control and without feeling compelled to understand them. As industrial societies emerged, systems involving families, social groups, business enterprises, countries, national economics, and international relationships began to evolve and dominate in economic cycles, political turmoil, fluctuating employment, and changing social fabric. To function in this more complex and "unnatural" world humans found it necessary to define and understand systems. The scientific method was developed, in part, to determine the cause-effect relationships between various components of extremely complex systems. Economics identified basic relationships in our industrial system; psychology and religion in human interaction systems; medicine and ecology in biological systems; political science in governmental systems. The understanding of system structure provided the means to effectively interrelate and interpret observations made in different fields of knowledge.

Systems can be classified as either open or closed (Forrester, 1968). Open systems have outputs that respond to inputs, but do not influence inputs. Typically, open systems have a low awareness of performance or of the feedback process; past action tends not to control future action. Closed systems are influenced by past behaviour or feedback, have a looped structure and are more aware of performance than open systems. Feedback, as a consequence of failing to achieve goals or as a measurement of performance, can cause fluctuation and instability and/or generate growth processes. Some of the most important systems for humans to understand are those which incorporate both social and physical elements. Forrester (1968) suggested that the interaction between social and physical systems are multi-loop, nonlinear feedback systems.

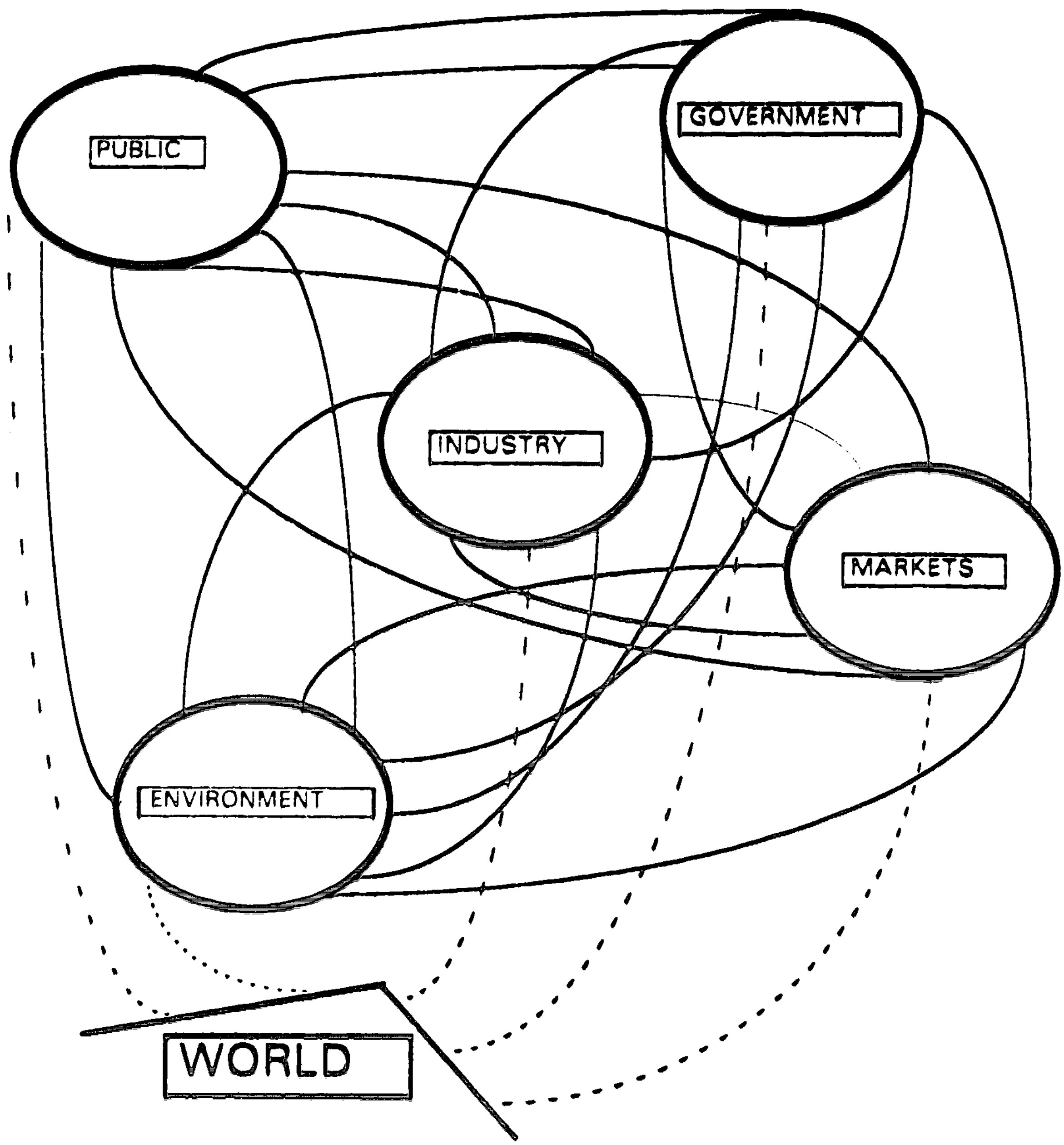
Determining if a system is open or closed is not intrinsic to the assembly of the component parts, but depends on the observer's viewpoint in defining the purpose of the system. Inherently essential in understanding of any system and making decisions within a system is the quantity and quality of available information. As research is often aimed at extrapolating data collected from a portion of a population to characterize the entire population, available information about a system is used to depict the entire system through what is commonly known as modelling. Establishing and maintaining information about a system is then paramount to understanding how it functions. Behaviour and function of systems can be influenced by and in a sense depend upon the amount of information available.

7.2 ALBERTA PULP MILLS SYSTEM

This thesis, by documenting the history of pulp mill effluent treatments in Alberta, suggests a system with both physical and social elements (See Figure 7.1). Viewed independently, as a snap shot, this system can be considered an extremely complex multi-loop open system. Although developed in relative isolation, it has been influenced by components of an even larger, more complex systems played out at the world level. This document, is essentially the first stage of a model process. It has identified most of major influence centres and to a certain extent, the development of each sector. To create a functioning model, clearly defining the system and identifying units of interaction among the various influence centres, would require additional extensive analysis and is beyond the scope of this thesis.

The following presents an overview of the information presented in the document and portrayed in Figure 7.1. This diagram is an over simplification of an extremely complex and intricate system. It consists of social sectors, i.e., industry, public, governments, and markets, as well as a physical sector, i.e., the environment. There are boundless pathways of influence running among the sectors. As a system on its own, each sector influences the others through numerous pathways, directly and indirectly, contributing pressure or leverage for change. As a system within a more complex world system, each sector has external influences, which again affects the internal interactions. Internal and external influences are played out on the interfaces between and among the sectors. Although there are countless interfaces, the four major interfaces which apply major influence on the system include: industry - environment, government - industry, market - industry, and public- government.

FIGURE 7.1: System Diagram of Pathways Influencing Alberta Pulp Mill Effluent Treatment



INDUSTRY-ENVIRONMENT INFLUENCE

Pulp mills in Alberta, have some of the best in-plant and external effluent treatments and the lowest effluent parameters in Canada, perhaps the world. Some say this can be attributed to most of the mills being new, but, even the two older mills have effluent parameters within the range of the newer mills. Industry has consistently met or bettered the effluent parameters set by the provincial government.

Industry's impact on the environment directly by releasing treated effluent wastes into rivers. It is extremely difficult to compare the environmental impact of a group of pulp mills. Each mill, even within its own class, i.e., softwood kraft, hardwood kraft, BCTMP, has unique pulping processes. The response to the effluent or the assimilative capacity of each of the receiving waters also varies.

River monitoring surveys are aimed at determining pulp mill impacts on the receiving environment. Surveys have been conducted by both government and industry for a number of years. Increased levels of some compounds were observed down-stream of the mills (see Chapter 2, Section 2.3.3). Reported shifts in benthic populations below pulp mills indicated increased levels of nutrients. Shifts in benthic communities, indicating responses to toxicity, have not been documented. Long term detrimental effects on fish populations have not been reported.

Two river monitoring surveys that have greatly influenced effluent treatment by industry are those for DO and dioxin/furans. Synoptic surveys and improved modelling techniques indicated critical DO depletions during low flows and under ice conditions in the Athabasca River. This information provided support for setting parameters for the four subsequently approved mills as part of whole watershed management rather than on a point source basis. Unacceptably high levels of dioxin/furans, i.e., greater than 20 parts per trillion (Health and Welfare Canada limit), were found in fish collected over a three year period from the Athabasca and Wapiti-Smoky Rivers. The government issued fish consumption limits for certain fish on these rivers. The industry has changed processes to minimize dioxin/furan production by decreasing the amount of bleaching chemicals, increasing chlorine dioxide substitution, reformulating the additives used in pulp washing, and replacing dioxin/furan forming defoaming agents.

Throughout its history of implementing technology, the Alberta pulping industry has been considered innovative and leaders in the industry. WC at Hinton was one of the first mills in Canada to install a continuous digester (1955) and later, an aerated lagoon (1967). Currently, PNGC is probably one of the first mills in Canada to operate a continuous 100% chlorine dioxide process. Half of the six kraft mills in Canada operating oxygen delignification processes are located in Alberta. The pulping processes developed by MWP in Whitecourt are considered by the industry throughout the country to be on the leading edge of BCTMP technology.

As the pulp industry evolved, the drive behind technical improvement changed. Typically in the past, technology developed primarily to improve plant efficiencies and profitability. For example, the kraft processes improved chemical-fibre recovery and reduced costs to such an extent that they quickly became an industry standard. Recently, technology has been developed to meet tightening government standards and reduce environmental impact, while at the same time improve profitability. This can be seen in the rapid implementation of in-plant processes like MCC and oxygen delignification. These were developed in part to reduce effluent loading, but were accepted swiftly by industry because of improved pulping processes. Other less cost-effective technologies, like aerobic digesters and zero effluent treatments, will probably not be implemented rapidly even though environmental impacts would be reduced. Technology that increases industry competitiveness, like replacing chlorine bleaching with oxygen processes (thereby addressing a growing market trend of Total Chlorine Free pulp), will be more readily accepted by industry.

In many cases, in-plant and exterior effluent treatment technologies, which reduce environmental impact, existed for a number of years before industry installed the equipment. Generally, the technology, especially for external treatments, was installed only after increased awareness of the environmental problems, i.e., DO Athabasca River case, or more stringent government regulations were imposed.

Another factor in the slow adoption of effluent treatment technology is the high financial risk involved. Considering the high capital costs involved, high risk is associated with proving operational feasibility on a pilot basis. Typically, one company will determine a process need, i.e., improved efficiency, pay for technology development and then install the equipment. Other companies will observe the performance and competitive advantages in the original mill. When a competitive advantage has been proven, the technology is rapidly incorporated throughout the industry. For example, a Union Camp mill in the U.S. has developed ozone bleaching technology for the last ten years and installed the equipment in 1992. Although finding bleaching technology to replace chlorine is considered paramount, many in the industry are sceptical of the ozone technology developed by Union Camp. Industry wants to make sure they install the most cost effective environmental technology and will closely examine all potential solutions prior to making the financial commitment. BCTMP technology was recognized by investors as a solution to the chlorine bleaching problems when considering new mill development. However, recent developments by industry research agencies like PAPRICAN in using oxygen as a bleaching agent may provide a solution within two years. Oxygen bleaching will eliminate the use of all forms of chlorine and the AOX component of the effluent.

GOVERNMENT-INDUSTRY INFLUENCE

In Alberta, the provincial government has greatly influenced/improved pulp mill effluent treatment standards primarily by reducing parameter limits and encouraging the implementation of appropriate treatment technology. Licensing parameter limits, typically below federal and other provincial levels, were negotiated with each mill based on the technology existing in the mills. New mills were required to have the latest form of effluent technology. This attitude can be traced back to when the first mill in Alberta was constructed. The first mill (WC) was constructed in 1957 with a facultative pond, considered to be the best available technology at the time. In 1967, to meet lower parameters limits set by the government and current technology levels, the mill upgraded its effluent treatment system by installing a primary clarifier and aerating the lagoon. All subsequent pulp mills built in the province were constructed with both primary and secondary equipment at standards considered to be the best available technology.

Government in the 1980s recognized that industry could be influenced by setting technology standards as a means of controlling pollution using best available technology. The hazard in specifying environmental technology (especially for in-plant processes), is that governments must accept some responsibility and risk of the technology being inappropriate. In the case of requiring extended delignification, industry determined that oxygen delignification alone was just if not more effective. This was contrary to the government directive. Although the mills in Alberta did not install all the equipment for extended delignification, some did incur the expense of incorporating the capacity to install the process in the future. Recognizing these hazards, the provincial government has lately avoided specifying technology and has concentrated on setting effective effluent quality objectives, allowing industry to determine the technology required to achieve the parameter levels.

Environmental policy of both the federal and provincial governments is aimed at balancing pressures of economic development and environmental protection. Within both the federal and provincial governments, there are differing views on how pulp mill pollution should be controlled. One example of this is demonstrated in the application of the assimilative capacity concept. The currently dominant philosophy is that the balance between development and environmental protection can be best achieved by controlling industry on a point source basis, allowing mills to release substances up to set maximums. This is based on the understanding that rivers have the capacity to receive a certain load of material without harming their ability to sustain aquatic life. The federal Fisheries Act Pulp Mill Regulations and Alberta Clean Water Act Licence to Operate, the main pulp mill control legislation, have been based on this philosophy. Others in government believe that the original water quality should be maintained and rivers should be managed as watersheds rather than on a point source basis. This was the approach proposed but not implemented in the Canada Water Act. It is also demonstrated by the federal government's determination that both dioxin/furans and bleached pulp mill effluent are toxic substances and by the provincial government declaration that certain pulp mills have been above the Alberta Surface Water Quality Standards (ASWQO). These two mandates appear to contradict the policy established in the previously mentioned pollution control systems. It appears that through the licensing system, the government is permitting industry to release substances the government, itself has determined to be toxic to the environment. If the ASWQO are indicative of acceptable natural levels, the government is permitting industry to exceed those levels in the receiving environment.

The struggle between the two philosophical approaches at the federal level is presented in the documentation of the 1971 Fisheries Act amendments. Some felt that pulp mills could be best controlled through legislation of the Canada Water Act and others supported control through the Fisheries Act. The government decided to accept the Fisheries Act philosophy, that all receiving environments could assimilate effluent. It is interesting to note that, in the end, this was only enforced on new mills. Existing, older mills were not made to comply, due to the threat of closers resulting from prohibitive capital requirements. This situation continued until 1992 Fisheries Act Amendments called for all mills to conform to set parameter levels.

In Alberta, the federal government did not influence effluent treatment development through parameters limits because provincial parameter levels have always been more stringent. The Alberta government enforced controls on all mills, based on the concept of assimilative capacity and remoteness of the rivers. One reason Alberta pulp mills were located on the northern Mackenzie River system was because the general area was relatively uninhabited. The 1982 Makin pulp mill proposal on the southern Saskatchewan-Nelson River system was deemed inappropriate when a number of down-stream communities, including Edmonton, expressed concerns about resulting water quality. At the same time, an Alberta Environment Water

Quality Task Force determined that the government guidelines to address water quality concerns, i.e., analysis of mixing and dilution problems, were non-existent. If parameter limits for the northern pulp mills would mitigate negative impacts on the northern rivers, how is it that these same limits would not suffice to mitigate impacts for pulp mills on southern, more populated rivers.

Government can also influence industry by providing incentives. The federal government has made funding available under a number of programs for the pulp industry to improve effluent treatment systems and to research technology for environmental protection. While the provincial government offered one third of all incentives between 1971 to 1984 to the oil and agriculture sectors, no provincial incentives were provided to the pulp industry. In the late 1980s, the provincial government offered infrastructure incentives to companies to establish mills in Alberta, but these incentives were not directed at pulp mill effluent treatment systems. It is interesting to note that the Saskatchewan government provided incentives for Millar Western Pulp to develop a zero effluent technology for their most recently constructed plant in the Meadow Lake area.

Pulp mill companies provide significant stable economic benefits to the federal and provincial governments from, among other things, taxes and employment. As mentioned earlier, eastern mills, contributing substantially to government revenues, threatened closures rather than meet effluent treatment requirements. Some of the people in the pulp industry suggested that because the Alberta pulp industry provided a smaller share of total revenues behind the oil industry, the industry had limited influence in resisting governments enforcement of effluent treatment. Others suggest that the oil industry has probably been more tightly regulated by government than the pulp industry and the presence of a bias against pulp mills can not be supported.

MARKET-INDUSTRY INFLUENCE

Maintaining markets, of course, is an important component of profitability for the pulp industry. The main pulp markets are in Europe, Asia, and the United States and prices are determined by a number of international factors. In the past, as one of the major world pulp producers, the Canadian NSK pulp companies, offering a large amount of premium product, held some influence in the market place. Paper makers required the strength and brightness of NSK pulp to produce high quality and valued paper. During the most recent decline in cyclical pulp prices, NSK producers attempted to maintain high prices. As the price differential widened between NSK and lower quality pulps, i.e., BCTMP and southern kraft, paper makers investigated new paper making technology and paper products that could use more of the lower quality pulp. Today, although still considered a premium quality product, NSK has less price setting influence in the market place.

The German pulp market has become and likely will continue to be one of the major influences in the pulp market. Up to one half of world consumption is attributable to the advertising business in Germany. Today, one half of this demand (one quarter of world consumption) is for Elemental Chlorine Free pulp, i.e., kraft pulp made with 100% chlorine dioxide substitution. It is expected that within five years, this preference will shift to Total Chlorine Free pulp, i.e., BCTMP, NSK bleached without chlorine dioxide substitution.

Available investment capital fluctuating with market demand and prices along with alternate investment opportunities limits plant upgrades and new plant installation. The intensive pulp mill development between 1986-1990 coincided with a parallel upswing in market profitability. Some believe that this industrial development may not have taken place without the corresponding market support. Following with this assumption, during the next market upswing, one could anticipate existing kraft mills incorporating alternative bleaching technology such as oxygen to eliminate chlorine.

MWP, being a new mill and interested in carving a niche in the market place, felt it was important to disassociate the company's name from any environmental pollution controversy even though targeting U.S. buyers, who are considered to be less environmentally concerned than European buyers. This demonstrates how environmental concerns have indirectly influenced the market and industry.

PUBLIC-GOVERNMENT INFLUENCE

The public is probably the most difficult of the influence sectors to define and as a result understand because of the level of diversity within the public and of the difficulties in assessing public opinion. At the core of the public's environmental concerns are values about the importance of wilderness and nature. These are developed directly by the individual from experience in nature, i.e., recreation, hunting, and indirectly by a society from available information, i.e., media, speakers.

Within the public sector various groups influence governmental environmental policy to control pulp mill pollution. One of the most active voices against pulp mill development have been environmental groups. Comprised of individuals with strong, if not extreme, environmental values, these groups become concerned about a specific local issue, organize to focus influence on government and industry, and carry on to support other groups as new issues arise, i.e., Friends of the Athabasca, Friends of the Lubicon, and Friends of the Peace. Members of these groups can be based locally, across the country or throughout the world. These groups hold protests and promote product boycotts, often orchestrated to gain media coverage, i.e., the national boycott of DC and Greenpeace boycott campaign in Germany against Canadian pulp and lumber producers.

Organized labour is another public sector group voices environmental concerns in Alberta, but on a more confined basis. With only one unionized mill, labour wields substantially less power in Alberta than in other provinces. One reason PNGC chose to build in Alberta was because pulp supply was often interrupted from B.C., where most mills were unionized and strikes/shut downs were not uncommon.

Without having many unionized mills, the Alberta Federation of Labour and the Canadian Pulpworkers Union work to raise awareness through position papers and by joining environmental groups via coalitions as with the ALPAC hearings.

The remaining portion of the public sector in Alberta, the general public, can be broadly categorized into urban (75%) and rural (25%) groups. A large portion of the urban group is highly concerned about environmental quality with well defined wilderness values. In comparison with urban groups, rural people tend to have higher interest in resource economic development. Within both of these groups is another subgroup called the "silent majority". These people tend to be reluctant to express their opinions, hesitant about getting involved, or too busy maintaining basic living requirements to contribute to environmental conflicts.

It is important to note that many members of the public sector, with different levels of interest, are concerned about the impact of development on human health and the vitality of the environment to sustain future generations. In short the public sector "buys into" the concept of sustainable development, without providing a vision of how to achieve this objective. For example, although the public basically agrees that both the polluter and society should pay for environmental protection, agreement within the public as a whole, on the actual split of the burden, would be difficult to achieve.

A number of people, both in environmental groups and industry, recognized a build up of environmental concern as a result of the rapid development of pulp mills in the province. Most agree that opposition climaxed during the ALPAC EIA Review Board hearings and through the news media. The approval of the ALPAC mill, in contravention of Review Board recommendations, was considered by environmentalists to be a major defeat. Subsequently, the level of focused opposition by environmentalists dissipated. Industry, on the other hand, still recognized the ALPAC opposition as a potential threat in the market place, i.e., boycotts, even though the environmental groups were no longer functioning at full capacity. Seeing the public controversy involving ALPAC, subsequent DC product boycotts, and ambiguous government legislation, PNGC declined the opportunity to expand mill production and took action to sell its pulp production division.

CHAPTER 8 CONCLUSIONS

This thesis provides a comprehensive overview of the establishment of the current advanced effluent treatment practices in the Alberta pulp industry. This is the first step toward understanding this development processes as an extremely intricate and complex system influenced, not only by factors in Alberta, but also by other systems played out on the world level. Detailed analysis would be required to create a model that would clearly define the major sectors and the countless influence pathways.

During the process of documenting the Alberta pulp mills' effluent treatment system, it became evident that each of the influence sectors viewed the system differently. Understanding that these sectors are paradigms or separate cultures with different world views is paramount in determining how these influence centres interacted and will continue to interact. Designing a model that would present the complex system from one point of view would be difficult. Creating a model that could observe the same system from different points of view would be enigmatic.

From interviews with the people involved in industry, government and public, it became apparent that the truth for them depended upon how they viewed the situation. It was evident that the engineer, by trying to alleviate an effluent toxicity problem through 18 hour days for weeks on end, really did care about environmental on public attitudes about environmental change (Angus Reid Group, 1992).impacts. It was true for the government worker that substances discharged by mills at levels below licensed parameter limits should not be considered pollution. It was true for the organized labour leader that multinational corporations move capital around the world to optimize profit with no consideration of local employment. It was true for the environmentalist that the increased level of pulping industry development was unleashed without adequate forethought and environmental planning. All of these people, these human beings with great integrity, have been deeply concerned about the series of events that took place in Alberta and the resulting environmental impacts. In that sense everyone was "right" or perhaps it would be better to say that they perceived themselves to be "right".

The foundations of the world as we know it are in a constant state of change; the only thing we can count on is that things will change. Old world order systems, i.e., the scientific method, are being shaken at the roots to be either transformed or replaced. This is reflected in recent EIA tragedies where scientific method was inadequately applied to extremely complex and intricate interfaces between natural and social systems. The communication/credibility gap between industry, scientists and the public, as demonstrated in the recent ALPAC EIA, resulted in part by differences in culture and language. As Land (1990) states:

> "It does not make any difference what the objective reality is around us; the issue is how we relate to it, because we create ourselves from moment to moment in our choice of how we relate."

Today, in the province, the pulping industry employs state-of-the-art effluent treatment technology and is considered a world leader in the field. The parameter levels set by the provincial government are as low as any in the world and the industry consistently discharges below these limits. By these standards, the Alberta "system" has operated successfully.

Within a climate of increasing environmental awareness, the rapid pulp industry growth between 1988 and 1991, when four pulp mills were approved for construction caused a public outcry against the industry. The EIA hearings for the ALPAC mill became the vehicle in which many of these concerns were manifested by local environmental groups, distant environmental groups, organized labour, and the scientific community. The government tightened standards in response to the resulting political tension. Indirectly, industry implemented effluent treatment systems to meet these modified standards, to mitigate negative impacts during the same time period, to be more competitive in the environmentally conscious European markets, and to avoid worsening its collective public image.

The history of the evolution of the pulp effluent treatment systems in Alberta documented in this report, indicates that public concern about the environment was a major influence. Viewing the major factors all at once as a system moving toward equilibrium, indicates that industry did not respond directly to public concerns but indirectly through other factors enforced by government regulations. Public concerns helped to make Alberta's pulp industry one of the cleanest in the world. The public's involvement has been somewhat troublesome, but it got the job done.

The "polluter pays" concept has been presented in the literature and legislation affecting the pulp industry, but has not been played out to the extent as in other industries; i.e., the oil and gas industry set aside, in financial statements, amounts for complete clean-up of well sites and gas station sites. This "polluter pays" attitude, established by the government, is based on the premise that the environment does not have a tolerance or assimilative capacity for the changes incurred from drilling activities.

The current pulp mill licensing system accepts that each receiving environment has an assimilative capacity, an ability to assimilate certain levels of pollution. The extent of the "polluter pays" concept in the pulp industry has been confined to the cost of in-plant and out-of-plant effluent treatment systems. As public pressure increased, the acceptable levels of pollution were reduced through more stringent effluent parameters in the licensing system. To meet these parameter changes, industry invested in plant modifications.

However, during the same time period, the receiving environment's "assimilative capacity" did not change. If the parameter limits in the early 1960s were environmentally safe, then why has industry been made to subsequently reduce effluent? If today's standards actually reflect the assimilative capacity of the rivers, yet the parameters permitted in the early 1960s in Alberta were above the then determined carrying capacities, the effects on the river systems from then to today have not been determined, i.e., recreation, health, fishing. Who then will be able to specify and determine the "damage"?

The public, in electing the government, assumes that the government will protect the environment and provide economic direction for the public's well being. Inherent in the current licensing system, the government assumes the liability of determining pollution limits and the industry, meeting those limits are, in a sense, absolved of accountability.

To establish a balance between the environmental economics, the government defined pollution as levels above set parameters. Environmentalists and even some people within government feel that pollution should be defined as levels above what is naturally found within the river system. Thus, it is difficult to technically and legally determine pulp mill effluent impacts. The assumption that damage does not occur if impacts cannot be measured is no longer ethically responsible for natural resource users. Morally, we must return the environment to its natural state. To the pulp industry, this means that if water is being used for in-plant processes, sufficient out-of-plant treatment should be employed to return the water to its original condition. The other alternative for the pulp industry is to design closed loop, effluent-free, in-plant processes to eliminate all discharges.

In the future, the controversy over pollution will not be about the impacts, but about whether or not the environment has been returned to its natural (original) state. Sound governmental policy must consider how the entire system will respond over the long-term and not just react to immediate concerns. Industry, genuinely wanting to address public concerns, must learn to transcend cultural language differences when interacting with the public.

Values for wilderness are evolving. As society changes and as the perception grows, particularly among urban people, that wild areas are becoming more scarce, wilderness values will become more important. The concept of preservation of wilderness has become a commonly held belief in our society, especially and ironically by those who live in urban centres some distance from wilderness. Canadians, in different parts of the country and with different perceptions of wilderness, can influence resource management decisions, especially in highly publicized situations regardless of the remoteness of the conflict as demonstrated during the ALPAC hearings and the DC boycott.

It is most important to understand that environmental disputes today are compounded by differences in perception of the same situations. Application of the scientific method alone is inadequate for fully expressing and understanding the enigma of paradigms. One way for full expression and understanding of these paradigms and the resolution of conflict over the disparate perceptions of them, may be achieved through adoption of agape love in day-to-day interactions with people. Agape love includes the understanding that the human spirit can be exemplified in three components: reason, emotion and will. The combined expression of these components by all the influence sectors may provide an opportunity to establish collaborative, not antagonistic, relationships and to manifest sound and integrated environmental action.

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APPENDIX A – DETAILED HISTORY OF ALBERTA PULP MILLS

A.1 ALBERTA PACIFIC FOREST INDUSTRIES INC. (Athabasca)

A.1.1 Descriptive Overview

a) Location

Alberta Pacific Forest Industries Inc. (ALPAC) is constructing a large kraft mill 50 km downstream of the city of Athabasca on the Athabasca River. It is located 150 km north of Edmonton.

b) Plant Processes -Production Levels, Species, Wood Supply

This single line bleached kraft mill will process both hardwood and softwood to produce 1500 ADMTPD of hardwood pulp (260 days) and 1250 ADMTPD of softwood pulp (85 days). The total annual mill production will be about 495,000 ADMT operating for 345 days.

The hardwood and softwood supply will be obtained by harvesting (90%) logs from the FMA and by purchasing (10%) local logs and chips. The approximate AAC for the FMA is 2.8 million m^3.

The mill was designed, according to the principle of Best Achievable Technology. The pulping processes include modified continuous cooking (extended delignification), oxygen delignification, high chlorine substitution, multistage pre-bleach brown stock washing and minimum water consumption as well as other steps to minimize environmental impacts. The effluent system includes primary and secondary treatments, an emergency spill pond and a surface drainage pond for control of runoff water.

c) Adjacent Sawmill Operation

The mill will not be directly associated with a sawmill. Softwood chips will be purchased from local sawmills.

d) Other

Several new infrastructures will be built to support the mill. A CNR rail extension from Boyle, new roads connecting the mill with main highways (#55 & #63), additional power line (25 kV), and a new bridge across the Athabasca River will be required.

A.1.2 Mill History and Ownership

ALPAC is a wholly-owned subsidiary of Crestbrook Forest Industries Ltd., a public company with stocks listed in Vancouver and Toronto exchanges. Two major share holders of Crestbrook are Honshu Paper Company and Mitsubishi Corporation, both of Japan, each holding approximately 32%. Crestbrook Forest Industries Ltd. operates a bleached kraft pulp mill and lumber/plywood plants in B.C. Honshu Paper Company operates high quality, value added printing paper mills in Japan.

In July 1988, Crestbrook Forest Industries Inc. submitted an application to the provincial government to construct a bleached kraft pulp mill utilizing un-allocated timber resources in east central Alberta (ALPAC, 1989). Preliminary resources, environmental market and feasibility studies formed the basis of the application. Subsequent investigation on project definition formed the basis of an EIA submitted in 1989.

A number of factors influenced ALPAC to decide to build a kraft pulping process over other alternatives. The parent companies predicted that future paper markets will continue to rise, especially for high quality printing and writing paper. Kraft process produces pulp that can be used as stock for paper production to meet international market specifications.

A.1.3 Environmental Impact Assessments

On May 8, 1989, ALPAC submitted a detailed EIA package, consisting of an Executive Summary, a Main Technical Report, and a Public Consultation Report, to Alberta Environment. This was in compliance with the Alberta Environmental Impact Assessment Guidelines.

A.1.4 Regulatory and Licence Status - Performance Data

ALPAC was granted a Permit to Construct on January 10, 1991.

River monitoring will be conducted to ensure proper operation of the effluent treatment system as required in the Licence to Operate. Monitoring obligations require effluent discharged to the river to continuously record pH, temperature, conductivity, dissolved oxygen and flow rate. Daily (24 hour) composite sampling is required for TSS, BOD_5, pH, TOC, COD, TON, conductivity and colour. Composite samples (24 hour) for NH_3-N and total solids is required on a weekly basis.

A.1.5 River Monitoring

The mean annual flow for the Athabasca River at the mill site is 436 m^3/s and ranges between a low winter flow of 42 m^3/s to a high summer flow of 1075 m^3/s. The river is covered with ice between October and mid April.

An aquatic monitoring program will be conducted by ALPAC starting two years prior to start up. The program includes:

- water quality monitoring in Athabasca River;
- regular effluent quality monitoring required by the province;

- dioxin baseline study and monitoring of dioxin concentrations in edible fish in cooperation with Alberta Environment and Environment Canada;
- benthic monitoring program to detect long term chronic effects;
- water quantity and quality monitoring in local watercourses;
- groundwater quality and quantity monitoring, separate from river monitoring.

A.1.6 In-plant Technology and Effluent Treatment

a) Water Treatment, Debarking, Chipping

The Athabasca River will be used to supply the mill with process water (design rate of 0.95 m^3/s) and the receiving water for the mill's treated effluent. About 90% of this amount will be returned to the river. Water intake structures will be installed in the Athabasca River.

A dry mechanical debarker will be used to remove bark from the wood. Bark and other wood wastes will be burned in a power boiler.

b) Cooking

The pulping process includes modified continuous cooking, steam stripping of condensate, multistage pre-bleach washing, and oxygen delignification. The digester will have the capacity for extended delignification. An oxygen delignification stage with pressure washer will be used. The complete unbleached fibre line will be operated fully counter current.

c) Bleaching and Pulp formation

Bleaching is multi-staged with medium consistency (100%) chlorine dioxide substitution. The extraction process is reinforced with oxygen as well as hydrogen peroxide. The target Kappa number, measuring the organic level from the digester will be 10 for hardwoods and 18 for softwood. The lower the K number, the higher the amount of organics that are removed prior to bleaching, eventually reducing the amount of organic material to be treated in the effluent system. Softwood pulp will be bleached to 90% ISO brightness and hardwoods to 91% ISO brightness.

d) Chemical Recovery

Chemical recovery system consists of multiple effect evaporator and concentrator train, a low odour recovery boiler and lime kiln with precipitator, and a recausticizing plant.

The required process steam will be provided by the chemical recovery boiler and power boiler. Electrical power will be generated with two steam driven turbo-generators and provided by local utility during start up and shut down.

All water is routed to the secondary treatment plant. A boiler is situated at the river pumphouse which may be used to prevent frazzle ice build up on the intake.

A.1.7 Out of Plant Effluent Treatment

a) Primary

Effluent leaving the mill will pass through a mechanical screening system and enter two settling clarifiers. From the primary clarifier, effluent will flow to the equalization/cooling pond which is designed for 24 hour detention of the total mill effluent flow. This serves to equalize process loadings and hydraulic loadings from the mill prior to the secondary treatment. The pond will use mechanical surface aerators for mixing and some cooling. Additional cooling of the primary effluent can be achieved by flow through a conventional cross flow cooling towers.

b) Secondary

The cooled primary effluent will be supplemented with nutrients, phosphorus as phosphorus acid and nitrogen as anhydrous ammonia. The secondary biological treatment is an air activated sludge system consisting of two bioreactors. The retention time for the AS is 34 hours. The MLSS will be clarified in two parallel secondary reactors producing clear treated effluent and sludge. Sanitary waste from the mill will be treated in this system.

c) Discharge

Predicted effluent treatment parameter levels are listed in TABLE A.1.

TABLE A.1: Predicted effluent treatment parameters for ALPAC (ALPAC, 1989)

PARAMETER	MILL EFFLUENT	TREATED EFFLUENT		% EFFICIENCY
	kg/ADMT	kg/ADMT	mg/L	
BOD_5	17.0	1.5	20.0	92
TSS	11.5	3.0	30.0	74
TOCL	1.4	1.0	10.0	40

The effluent will be discharged into the river through a submerged diffuser outfall. It is designed to provide 20:1 dilution ratio within 50 m downstream of the structure at 7Q10 flow. Full transverse mixing occurs by Grand Rapids, approximately 200 km downstream.

d) Sludge Treatment

Sludge from the primary clarifier will be dewatered with a screw press and then burned in the plant boiler. Most of the secondary sludge will be returned to the bioreactor to maintain a balanced activated biological system. The remaining sludge will be collected, thickened and dewatered either separately or with the primary sludge, and then burned in the power boiler.

A.2 DAISHOWA CANADA LTD. (Peace River)

A.2.1 Descriptive Overview

a) Location

DC operates a kraft pulp mill near Peace River, 500 km northwest of Edmonton. The mill is located on the west bank of the Peace River about 18 km downstream of the town of Peace River. Water for mill processes is drawn from and discharged into the Peace River. Of the 75,000 m^3/day used by the mill, 65,000 m^3/day is used as process water and the remaining 10,000 m^3/day, is used for cooling purposes.

b) Plant Processes -Production Levels, Species, Wood Supply

The wood supply for the mill comes from a variety of sources; FMA, quota, private land, and purchasing from other suppliers. All of the softwood is purchased as chips (approximately 30 loads/day) from local sawmills (within 300 km radius). The FMA was formalized in 1989 and a revised AAC of the FMA is 1.09 million m^3. About 50 loads of hardwood logs are delivered daily over the summer months and about 400 loads during the winter season. The mill requires a total of 2.4 million m^3.

The mill produces a total of 340,000 ADMT (1,000 ADMTPD): 272,000 ADMT hardwood and 68,000 ADMT softwood pulp. Although operating on a single line pulping system, the design included plans for expansion with a second line.

c) Adjacent Sawmill Operation

Sawmill facilities associated and owned by the mill were not constructed.

d) Other

Both federal and provincial governments provided incentives for improvements to regional transportation infrastructures. A new rail line from Peace River, connecting to the existing CNR line, was constructed to the mill for pulp shipments. A new bridge was constructed across the Peace River. New and upgraded roads linking the mill to existing main highways and forest lands were constructed. Also, a new 144 kV power line was required.

About 95% of the mill's energy requirements is generated internally by hog fuel and chemical waste incineration. The remaining portion of the energy requirements is derived from purchased electricity and natural gas.

A.2.2 Mill History and Ownership

DC was incorporated as a company, first in British Columbia, in 1977. Later, the company was extra-provincially registered in Alberta, as a subsidiary of Daishowa Paper Manufacturing Co. Ltd. (DPM) of Japan. In 1969, Daishowa-Marubeni International Ltd. (DMI) was incorporated first in British Columbia and later extra-provincially in Alberta, to design and construct a bleached kraft pulp mill in Quesnel, B.C. This mill was built in 1972 in a joint venture with WC, DMI is owned 50% by DPM and 50% by Marubeni Corporation of Japan. In 1981, DC also in joint venture with West Fraser Timber Co. Ltd., constructed a thermomechanical pulp mill in Quesnel. In 1988, DC acquired a newsprint mill in Quebec City.

The Peace River Pulp Company is a division of DC which is 100% owned by Daishowa Paper Mfg. Co. Ltd. of Japan. In September 1992, DC entered into an agreement to sell the Peace River mill to Daishowa-Marubeni International Limited (DMI). The sale is expected to be completed by November 30, 1992.

The provincial government recognized the potential for locating a hardwood kraft mill in northern Alberta before DC's interest in the project. Over a five year period before

1987, several studies were conducted to identify to potential for a mill utilizing under-utilized hardwood resources in northern Alberta. In particular, two studies prepared for Northern Alberta Development Council, recognized the potential of a hardwood kraft mill in the area between Peace River and Manning[28].

DC completed a feasibility study in May 1987. This lead to discussions with the province about availability of timber and infrastructure development for the proposed project. A project definition study was completed by the company in late 1987.

A.2.3 Environmental Impact Assessments

DC submitted a mill EIA report to Alberta Environment originally in December 1987 and a revised version on January 4, 1988. The Land Surface Conservation and Reclamation Act of Alberta authorizes the Environment Minister to order an EIA report in accordance with the provincial guidelines. Alberta Environment requested an EIA report from DC in August 1987. This report provided details on the proposed mill regarding environmental design and environmental economic and social impact assessment as well as an overview of the public consultation program conducted by the company.

A.2.4 Regulatory and Licence Status - Performance Data

A Permit to Construct was issued on June 22, 1988. A Licence to Operate was issued May 22, 1990, which expires May 1, 1993.

Monitoring has been conducted to ensure proper operation of the effluent treatment system as required in the Licence to Operate. Monitoring obligations requires effluent discharged to the river to continuously record pH, temperature, conductivity, dissolved oxygen and flow rate. Daily (24 hour) composite sampling is required for

28 Woodbridge, Reed and Associates, "Utilization of Hardwoods in Northern Alberta", February 1985; Currie, Coppers and Lybrand Management Consultants "Economic Development Opportunities in Northern Alberta" December 1985.

TSS, BOD_5, COD, conductivity and colour. Composite samples (24 hour) for NH_3-N, NO_2-N, NO_3-N, total phosphorous, and dissolved phosphorous, are required on a weekly basis.

TABLE A.2: DC Performance Data and Licence Limits (Alberta Environment Personal Communication, 1992)

YEAR	PROD ADMTPD	EFFL FLOW '000 m^3/D	REAL BOD_5 KG/ ADMT	FED[29] BOD_5 KG/ ADMT	PROV BOD_5 KG/ ADMT	REAL TSS KG/ ADMT	FED[30] TSS KG/ ADMT	PROV TSS KG/ ADMT	TOXI-CITY[31] tests pass/ total
1990	1000	57. 9	2.1	33. 0	5.5	2.9	10. 0	14.5	7/8
1991	1000	61. 4	1.7	33. 0	5.5	4.4	10. 0	14.5	15/16
1992	1000	63. 7	1.9	7.5	5.5	6.7	11. 3	14.5	10/10

A.2.5 River Monitoring

As required by the Licence to Operate, the company conducted a river monitoring program, consisting of a total of 15 benthic macroinvertebrate sampling sites. These are located on the Peace River from 14 km upstream to 30 km downstream. Also, chemical analyses were conducted on water samples collected at 12 locations during the survey.

Future monitoring will be designed to meet the requirements set out in the revised Federal Fisheries Act and Canadian Environmental Protection Act for the EEM program.

29 Based on filtered sample.

30 Based on samples collected after the primary treatment and before the secondary treatment.

31 Effluent toxicity testing failure is defined as a 96 hr LC_{50} of less than 100% effluent concentration.

A.2.6 In-plant Technology and Effluent treatment

a) Water Treatment, Debarking, Chipping

Water, intake rate from the Peace River at 0.9 m^3/s, is treated prior to use in the mill. The water intake is a submerged low profile concrete structure located in the river channel and connected to a pumphouse by horizontal buried pipes. Travelling screens and trash racks at the pumphouse remove solids and debris. The effluent is treated in a clarifier with alum addition and sand filtration to reduce turbidity and remove coarse particles. The clarifier sludge, sand and gravel is returned to the river. The ability to soften is provided.

The logs used by the mill are debarked with a dry debarking system. The wood wastes are utilized as hog fuel. The logs are chipped with slotted rotating discs with knife blades on each slot. These hardwood chips are screened and stored. Softwood chips, purchased locally, arrive by truck and are stored.

b) Cooking

The cooking process begins with the chips passing through two steaming vessels to open wood pores to enhance cooking liquid absorption. The cooking liquor (water, NaOH, Na_2S) is forced into the chips under pressure in the impregnation vessel. These chips enter a continuous digester under controlled high pressure and temperature, where chemicals dissolve lignin. The pulp is then screened for knots and oversized chips to be recycled through the cooking process. After digestion and before brown stock washing, the pulp enters an atmospheric diffusion vessel aimed at removing lignin. The counter-current washing system begins with a single-stage rotating vacuum brown stock washer which removes spent chemicals and liquid. This black liquor is used to rinse the bottom portion of the digester and then removed by the recovery system.

The washed fibres are mixed with oxygenated white liquor and oxygen gas and then are passed into oxygen delignification reactor where additional lignin is removed under controlled pressure and temperature. The oxygen delignification reactor is followed by two washers arranged in series.

c) Bleaching and Pulp formation

With oxygen delignification, only four bleaching stages are used instead of the conventional six stages. The bleaching sequence involves: ClO_2+Cl_2; NaOH+O_2; ClO_2+(NaOH); ClO_2. After each stage, a compact baffle washer removes spent solution which is sent to the exterior effluent treatment processes. The bleached pulp is cleaned in centrifugal cleaners and sheets are formed on a pulp machine. The pulp is dried and packaged for shipping.

d) Chemical Recovery

Black liquor containing water, spent chemicals and fibres, is thickened with a steam heat evaporation process. This concentrated liquor is burned in a boiler as a low grade fuel producing energy for the mill. The burner molten ash, containing sodium carbonate (Na_2CO_3) and sodium sulphide (Na_2S), is dissolved in a tank. The resulting green liquor is settled in a clarifier. The sludge is filtered and shipped to a landfill. The clarified green liquor is mixed with lime in a slaker, producing sodium hydroxide (NaOH) and calcium carbonate ($CaCO_3$). The $CaCO_3$ is settled out of the mixture and fired in the kiln to produce lime for reuse in the green liquor process. The resulting white liquor, sodium hydroxide (NaOH) and sodium sulphide (Na_2S), is reused in the impregnation vessel. White liquor is used for oxygen delignification process after being combined with oxygen in a reactor vessel.

Steam, produced by both the chemical recovery and power boilers, is passed through turbines to produce electricity. Electricity for startup procedures is acquired from outside power grids.

Emergency spill basins collect overflow from the various plant processes during upset or process malfunctions. This material is metered into the primary clarifier stream at low rates to ensure minimum impact on the exterior treatment process.

As for a typical modern kraft mill, the sources of effluent entering the exterior treatment system of this mill include:

- non-contact cooling water:
  - discharged back to the river or recycled in the raw water influent system;
- general sewer stream (sent to the primary clarifier):
  - alkaline streams, from bleach plant and ancillary mill areas;
  - brownstock, bleach plant, and machine room sewer discharges first pass through a fibre recovery system (sump, drainer, and chest) and then are added to the general mill sewer;
  - miscellaneous discharges;
- acid sewer stream (to the aeration lagoon inlet):
  - bleach plant, chemical preparation plant and ancillary mill areas acid streams, being low in suspended solids;
  - mill sanitary waste to ensure destruction of pathogens.

A.2.7 Out of Plant Effluent Treatment

a) Primary

Effluent from the general mill sewer is mixed with effluent metered from the spill pond before entering the primary clarifier. The treated water is mixed with the acidic streams for neutralization prior to entry into the lagoon system.

b) Secondary

Secondary treatment consists of an ASB with a ten day hydraulic retention time. Air to the lagoon is supplied with a submerged jet aeration system. The basin (600,000 m^3 capacity) consists of (DC, 1987):

- an active biological treatment zone equivalent to six day retention, employing submerged jet aerators to reduce BOD (these aerators minimize heat loss in winter and ensure maximum transfer of air to the lagoon to facilitate BOD and toxicity reductions);
- a quiescent zone prior to discharge to minimize the TSS levels.

A back-up aerated stabilization basin was constructed in 1991 to provide additional treatment capacity if needed.

c) Discharge

The treated effluent is released in the Peace River through a high-rate vertical jet diffuser. The outfall structure is comprised of fourteen 150 mm diameter jets located 2 m apart and 0.5 m above the river bed. The structure discharges effluent over a width of about 40 m at a rate of 5 m/s. It is designed to rapidly dilute the effluent to mitigate any localized effects of the discharge in the river. Effluent dilution in the river at 7Q10, 10 metres below the discharge is 40:1 and 100 metres below is 70:1. The length of mixing zone is about 25-40 km.

Several techniques are used to minimize thermal impacts of the warm water released from the cooling system. In the winter, some of the clean warm water from the cooling process, is returned to the intake structure to prevent frazzle ice formation on the travelling water intake screens.

The storm water system collects runoff from parking lots, roofs of non-process buildings, and cooling water from the air-conditioning units and directs the flow into a retention pond. This water is discharged (130-500 m^3/d) after being monitored for flow, COD, TSS, pH, and oil/grease.

Non-contact cooling water outfall returns excess cooling water to the river after monitoring. During the summer the cooling water is discharged at 10,000 m^3/d and in the winter the water is recycled through the raw water intake.

d) Sludge Disposal

Sludge from the primary settling basin is dewatered, pressed, and burned in the power boiler.

The company operates a Class II landfill with a 1 m clay liner and a leachate collection system. The collected leachate will be treated in the effluent treatment system. Currently, the landfill is used for deposition of boiler ash, chemical recovery grits/dregs, and the off-spec lime mud from the kiln. The woodyard wastes are being reclaimed, i.e., separated into rocks, burnables, and fines, by a local contractor. The contractor recently purchased the equipment and will be soliciting business from other mills to reclaim yard wastes.

MILL DESCRIPTION[32] – DAISHOWA CANADA CO. LTD.

PRODUCTION: Bleached Kraft pulp 340,000 adt/y
: hardwood 1000 adt/d softwood 950 adt/d

TRANSPORTATION: Rail

WOOD HANDLING EQUIPMENT:

Log yard Max Storage: 400,000 m^3
Chip Storage Capacity: 160,000 BDU
Debarkers: 1 Nicholson ring A-5 type
Chippers: 1 Nicholson 1500 Hp
Chip screens: 3 stage screen, 1st V=screen, 2nd,3rd Liwell screen

PULPING EQUIPMENT

Digesters: 1, Kamyer MCC 2 vessel with Kamyr Atmospheric Diffusion Washer
Knotters: 2 stage, Hi-Q, 10 mm hole
Primary screens: 5, Centrisorter
Secondary screens: 2 Centrisorter
Thickeners: CCB - 4065 vacuum
Presses: 2, Sunds
Bleach stages: 4, O_2 - D/C E_O(DN)D
Pulp dryers: 1, Flakt
Evaporators: 1, HPD 5-effect & conc
Process control systems: 1, Honeywell TDC 3000

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RECOVERY PLANT

Slakers: 1
Lime kilns: 1, F.L. Smidth
Clarifiers: 1, Eimco green liquor
Mud washers: 1, Eimco pressure
Recausticizers: 1, Eimco
Lime kilns: 1, F.L. Smidth
Evaporators: 1, HPD
Recovery boilers: 1, Babcock & Wilcox
Precipitators: Flakt
Kiln precipitator: 1 Flakt
Process control systems: 1, Honeywell TDC 3000

BLEACH PLANT

Oxygen delignification: Sunds
Bleaching sequence: O_2 - D/C E_O(DN)D
Washers: 4 I.R. C.B.
Towers: 4
Mixers: 2, D/C, O_2
Chlorine dioxide plant: R8 (Albright & Wilson)

PULP FINISHING PLANT

Pulp Machine: Black-Clawson
Pulp Dryer: Flakt
Cutter layboys: 1, Lamb Gray
Baling presses: 2
Wire tying machines: 2
Scales: 2
Unitizers: 2

EFFLUENT SYSTEM

Primary clarification
Neutralization
Sludge thickening
Spill pond
Aeration lagoon
High rate diffuser

A.3 MILLAR WESTERN PULP LTD. (Whitecourt)

A.3.1 Descriptive Overview

a) Location

MWP operates a Bleached Chemical-thermomechanical pulp mill (BCTMP) in Whitecourt, 180 km northwest of Edmonton. The mill is situated on a flood plain at the junction of the McLeod and Athabasca Rivers.

b) Plant Processes -Production levels, species, wood Supply

Optimum mill production is 220,000 ADMTPY (680 ADMTPD). The mill process design is considered to be a alkaline peroxide process, a specialized BCTMP mill and not a alkaline-sulphite process of standard BCTMP mills. Being the first of its kind, the system differs from BCTMP mill by being more cost effective, producing a higher quality pulp, by not using sulphurous chemicals, and having lower energy requirements. The effluent problems occurring in the first year of production resulted from the effluent system being design with limited available data.

The mill produces two products in separate pulping and bleaching lines in the mill. Line 1 High freeness pulp (400 ADMTPD), low in fines is used in absorbent type paper such as tissue and towelling grades. This pulp is made from softwood chips. Line 2 low freeness pulp (300 ADMTPD), short in fibre, is used primarily in coated grades of printing and writing paper. This pulp is made primarily from aspen chips. Fibre transfer between lines allows for the optimization of quality and grades.

Wood supply is composed of hardwood (aspen) and softwood (pine & spruce) chips. Although the company does not hold an FMA, wood is obtained from other timber cutting (quota-0.81 million m^3), and chips from the sawmill.

c) Adjacent Sawmill Operation

The forest product division of the company operates a lumber mill and is associated with the company.

d) Other

MWP will be constructing a power plant (21.5 MegaWatts) in 1994 under the Small Energy Producers Act. This government program is aimed at increasing the amount of energy available from non-traditional sources. Due to public concerns and operational problems (limited sludge dewatering capacity), the sawmill bee hive burner located adjacent to both the sawmill and pulp mill, was relocated 23 kilometres north. Hog fuel, woodyard wastes, effluent sludge is dewatered and shipped to the burner for burning. When the power plant construction is completed, this waste will be utilized and power will be sold to the provincial power grid.

A.3.2 Mill History and Ownership

MWP operations began in August 1988 and was the first mill of this type in Alberta and the third pulp mill in the province to be constructed. MWP is owned by Millar Western Industries Ltd., founded by J.W. Millar. The latter company has three operating divisions. The heavy construction division, formed in the 1920s, builds railroad grade, highways and bridges in western Canada. The chemical division has produced sodium sulphate in Saskatchewan since the 1930s. The forest products division has produced kiln dried lumber since 1923 in a Whitecourt plant and is associated with the pulp mill. The company has also commenced construction of a 240,000 ADMTPY zero-effluent APP/BCTMP mill in Meadow Lake, Saskatchewan.

A.3.3 Environmental Impact Assessments

An Environmental Impact Assessment (EIA) for the MWP was submitted to the government in October 1986 according to the requirements specified in Section 8 of the Land Surface Conservation and Reclamation Act (Millar). This report had been requested by the Minister of Environment following a preliminary submission on May 22, 1986.

A.3.4 Regulatory and Licence Status - Performance Data

MWP received a Permit to Construct in January 1987. The current Licence to Operate was issued on June 28, 1991 and expires on December 31, 1993.

During the first six months of operations, with only one line functioning, the original effluent treatment system adequately treated the effluent. When the second line became functional, the effluent system could not keep the parameters below the licence limits. The company had initiated immediate response to the effluent problems by limiting production in January 1989 and modifying the effluent system by the end of 1989.

Monitoring has been conducted to ensure proper operation of the effluent treatment system as required in the Licence to Operate. Monitoring obligations require effluent discharged to the river to continuously record pH, temperature, conductivity, dissolved oxygen and flow rate. Daily (24 hour) composite sampling is required for TSS, BOD_5, pH, TOC, COD, TON, conductivity and colour. Composite samples (24 hour) for NH_3-N and total solids is required on a weekly basis.

TABLE A.3: Miller Western Performance Data and Licence Limits (Alberta Environment personal communication, 1992)

YEAR	PROD ADMTPD	EFFL FLOW '000 m^3/D	REAL BOD_5 KG/ ADMT	FED[33] BOD_5 KG/ ADMT	PROV BOD_5 KG/ ADMT	REAL TSS KG/ ADMT	FED TSS KG/ ADMT	PROV TSS KG/ ADMT	TOXICITY[34] tests pass/ total
1988	680	11. 0	3.6	n/a	7.5	12.1	n/a	30. 0	4/4
1989	680	12. 9	5.6	n/a	7.5	17.1	n/a	30. 0	3/15
1990	680	13. 4	1.5	n/a	7.5	6.1	n/a	30. 0	7/12
1991	680	12. 6	1.7	n/a	3.0	4.4	n/a	5.0	11/1 2
1992	680	11. 7	0.9	7.5	3.0	2.7	11.3	5.0	9/9

A.3.5 River Monitoring

As specified in the Provincial Licence to Operate, the company is required to conduct river surveys during the winter months upstream of the plant and downstream of the confluence of the Lesser Slave and Athabasca Rivers. Data is collected for dissolved oxygen, BOD, TSS, resin acids, colour, extent of ice-free zones, flow, phenols, total organic carbon, nitrate/nitrite/nitrogen, total nitrogen, ammonia-nitrogen, phosphorus, dissolved phosphorus, sulphate, chloride, sodium silicate, manganese, zinc, Klebsiella, HEDTA, DTPA, and pH.

A.3.6 In-plant Technology and effluent treatment

a) Water Treatment, Debarking, Chipping

Prior to use in the mill, aspen logs are debarked by a mechanical ring debarker. These logs are chipped by a gravity feed disc chipper with an overhead discharge system. The aspen chips are stored for up to three days in piles. Also stored in piles, the softwood chips are obtained from the sawmill operating on site and trucked from other sawmill sites within a 80

33 Federal regulations did not have a category for APP BCTMP mills and as a result BOD and TSS levels were not issued prior to the 1992 Fisheries Act amendments.

34 Effluent toxicity testing failure is defined as a 96 hr LC_{50} of less than 100% effluent concentration.

kilometre radius to the pulp mill. Bark and waste fines are trucked to a burner located approximately 23 kilometres north of the bill to be burned in the beehive burner.

b) Chip preparation and Refining

The mill consists of two lines as mentioned before. Each operates in parallel. The chips, after screening, are held in 90 minute presteaming bins and then washed and fed to a second presteaming surge bin. These chips are fed into a vertical chemical treatment vessel with chemicals and continue into a atmospheric pressure reaction bin for 15 minutes. Then the chips undergo more stages of chemical impregnation in steaming vessels. The resulting fibres are washed and eventually pressed for a second treatment with chemicals.

c) Bleaching and Pulp formation

The system has a peroxide application operating at medium consistency (10-15%) and acidification occurs after bleaching. The pulp is mechanically dewatered before it is fluffed and dried.

d) Heat Recovery

Steam is recovered from the refiners and pressurized cyclones for the chip preheating, steam vessel and heat recovery systems. Wash water and strong bleach liquor pressate are separated for reuse.

Effluent is comprised of spent recycled waters from the pulping and bleaching area flows, chip wash waters, and washdown water from the chemical preparation area as well as small cooling streams.

A.3.7 Out of Plant Effluent Treatment

a) Primary

The mill effluent system was designed for 15,000 m^3/day and based on other CTMP mills designs. The effluent passes first through a self-cleaning bar screen in the main effluent pumped on the way into a primary clarifier (27.5 m EIMCO reactor). Suspended solids were comprised of dirt and grit from the pulp cleaning operations and reject pulp fibres.

In the first year the primary clarifier had poor solids removal due to residual hydrogen peroxide. As part of the 1989 modifications, a secondary 46 m EIMCO suction tube clarifier was installed.

b) Secondary

Ammonia and phosphoric acid are added to the primary clarified effluent for the subsequent secondary biological treatment in an aerated lagoon. The nutrients are monitored to minimize excess nutrients in the effluent discharge. During the first year, toxicity failures were attributed to ammonia in ASB basin. The ammonia is controlled by reducing the amounts added as nutrients. Due to high alkalinity in the final effluent, carbon dioxide stripping occurs during the bioassay test. This causes pH to increase from 8.4 to 9.2. Any nitrogen present at a pH below 9.0 exists in the form of NH_4 and is non-toxic. As the pH rises, the nitrogen equilibrium shifts to NH_3 which is toxic to fish. The pH of the final effluent would not climb to 9.0 when entering the receiving environment. Due to the test conditions, MWP must run the system nutrient deficient (zero ammonia residual) in order to pass the bioassay test. The wastewater treatment system would run more efficiently if it was not operated under nutrient deficient conditions.

Aeration equipment consisted of sub-surface jet aeration with 3-900 Hp Hoffman Blowers. This level of power required for oxygen transfer and jet aeration mixing pumps assured complete mixing. Retention time is 6-8 days.

By December 1989, MWP had completed a conversion of the aerated basin to an activated sludge system in order to lower both the BOD and TSS discharges (Nielsen, 1989). Short term solutions involved curtailing production in early 1989 and one cell of existing lagoon was converted to function as a settling zone by shutting down the air supply and mixing pump.

In addition a 30 minute Anoxic Selector tank and a 10 minute mix tank were installed. With these modifications, the effluent treatment system meets or exceeds all licence requirements.

Recycling sludge from the secondary clarifier was part of the 1989 improvements. The suction tubes of the new secondary clarifier draws only the return activated sludge. The waste activated sludge consistencies have been 1.4 - 2.0 % while return activated sludge are 0.6 - 0.9%.

TABLE A.4 : MWP Activated Sludge Operating Parameters (Nielsen et al, 1989)

OPERATING PARAMETER	LEVEL
Hydraulic Retention Time.	8 Days
Sludge Retention Time	15-20 days
BOD:N:P	100:2.0:0.4
Mixed Liquor Suspended Solids	3500 mg/L
Food to Microorganism Ratio (F/M)	0.1 to 0.2

c) Discharge

After final clarification, the effluent is be discharged into the Athabasca River through a submerged diffuser outfall. The plant sanitary sewage was pumped to the sewage treatment operated by the town of Whitecourt.

d) Sludge Treatment

The primary clarified underflow sludge is pumped to two twin wire presses for dewatering and hauled for incineration. The secondary sludge is dewatered also with the two Phoenix belt presses.

MILL DESCRIPTION[35] – MILLAR WESTERN PULP LTD.

PRODUCTION: Alkaline peroxide pulp 210,000 adt/y

TRANSPORTATION: Rail

WOOD HANDLING EQUIPMENT

Chip consumption: 120,000 t/y
Roundwood consumption: 100,000 t/y Aspen
Debarkers: 1 Nicholson ring
Chippers: 1 Carthage
Rechippers: 1
Chip screens: 3, 1200 t/d Radar Disc.

PULPING EQUIPMENT

Primary screens: 8, 400 t/d Hooper pressure
Secondary screens: 4, 400 t/d Hooper pressure
Thickeners: 2, 400 t/d Celleco disc filters
Centricleaners: 2, 400 t/d 6-stage Celleco centricleaners & FRVs
Presses: 14, 400 t/d Thune screw press & IR twin roll press
Shredders: 4, 400 t/d Sunds Fluffers
Chip washers: 2, 400 t/d Hymac
Bleach stages: 2, 400 t/d
Bleaching sequence: 2, 400 t/d Alkaline peroxide pulp
Pulp dryers: 2, 400 t/d Flakt flash dryers
Refiners: 7, 12,000 hp Hymac 60"
Process control systems: 1, Bailey Net 90 DCS

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PULP FINISHING PLANT

Baling presses: 2, 400 t/d Sunds
Wire tying machines: 2, 400 t/d Gerrard Ovalstrapping
Scales: 2, 400 t/d Sunds
Unitizers: 2, 400 t/d Gerrard Ovalstrapping

POWER PLANT

Gas: Package boiler
Electricity: purchased
Water consumption: 15,000 m^3/d
Water source: river water, Eimco clarification

EFFLUENT/POLLUTION SYSTEM

Clarifiers: 2, 15,000 m^3/d primary Eimco gravity;
secondary Eimco suction tube
Sludge disposal: 2, 46 BDNTD Phoenix belt presses
Aerators 7, mixing systems jet
Blowers: 3, 900 hp each Hoffman

A.4 PROCTER AND GAMBLE CELLULOSE LTD. (Grande Prairie)

A.4.1 Descriptive Overview

a) Location

Proctor and Gamble Cellulose Ltd. (PNGC) operates a kraft process pulp mill near Grand Prairie 450 km northwest of Edmonton. The mill is located on the bank of the Wapiti River approximately 30 kilometres upstream from its union with the Smoky River.

b) Plant processes

The PG mill was constructed during 1971/1972 and the first pulp shipment was in August 1973. The plant was designed as a kraft pulp mill for softwood (spruce and pine) chips. When built, the plant had both primary and secondary water treatment.

Today, the mill harvests logs from an FMA covering 1.1 million hectares of crown provincial forests. This FMA contains 0.2 million hectares in Saddle Hills, and 0.9 million hectares south of Grande Prairie. When the mill was first constructed, the FMA granted had provision for future expansion containing 2.2 million hectares north and south of Grande Prairie. When the FMA was renewed in 1988, the provincial government stipulated that the northern expansion area (1.1 million hectares) could no longer be provisional. The company was given the choice of modifying the mill to increase production capacity (1740 ADMTPD) and utilize the wood currently not being used or lose the northern portion of the original FMA to another company. Although PNGC proposed an extensive refit, the company decided not to follow through, completed less intensive upgrade modifications, and lost rights to the northern FMA. The production level has from the original 680 ADMTPD to 820 ADMTPD as a result of a number of plant modifications.

The plant underwent several modifications over the years. In 1986, oxygen bleaching equipment was installed. In 1990, as part of the upgrade, the effluent system was modified, the boiler reliability was improved, and chlorine dioxide generation equipment was installed.

c) Adjacent Sawmill Operation

In 1979, a sawmill was constructed adjacent to the pulp mill and began operations in 1980. The mill produces kiln dried dimensional lumber (130 MBF/yr) from 500,000 tonnes spruce/pine/fir logs. Chips are utilized in the mill process and waste is burned in the power boilers.

d) Other

In 1990, equipment for turpentine production was installed.

A.4.2 Mill History and Ownership

PNGC (1976) established a headquarters in 1969 in Grande Prairie to manage the pulp mill and the associated woodlands activities under contract to PNGC of Canada Ltd. The official opening ceremonies were held May 27, 1971. The first train load of pulp was shipped from Grande Prairie on August 13, 1973. The cost of the mill was estimated to be approximately $110 million.

Recently, PNGC has sold the mill to Weyerhaeuser Canada Ltd., assuming operational control on December 1, 1992.

A.4.3 Environmental Impact Assessments

The decision to construct the mill was conducted on a strictly confidential basis with information supplied by government and community leaders. In 1966, Grande Prairie civic and business leaders began a search for a suitable industry for the region. In 1967, PG announced intentions to seek pulp rights south of the Wapiti River. In 1967, the provincial government announced that PG was to be chosen to negotiate the Grande Prairie pulp mill project and an FMA for 1.4 million hectares of crown forest lands was signed between the two parties in early 1969.

Public hearings were held in Grande Prairie in October 1967 to review the proposed pulp mill development. These were required by policy modified in 1965. Two proposals had been submitted in response to the provincial government advertising in 1966-67 regarding the availability of forest lands suitable for pulp mill development. Both companies made presentations including financial and management abilities as well as explanations of the proposed pulp mill developments.

A draft EIA report was prepared in 1989 for proposed mill expansion. For a number of reasons, PG decided not to complete the proposed changes and conducted a mill upgrade instead. The company was not required to complete an EIA process for this upgrade.

A.4.4 Regulatory and Licence Status - Performance Data

The current Licence to Operate expired December 1, 1992. For renewal, PNGC followed the proposed provincial legislation procedures and held public meetings to review the new Licence to Operate. It is important to note that the provincial legislation has yet to be approved, and the company was not obligated to follow the new procedures.

Monitoring has been conducted to ensure proper operation of the effluent treatment system as required in the Licence to Operate. Monitoring obligations require effluent discharged to the river to continuously record pH, temperature, conductivity, dissolved oxygen and flow rate. Daily (24 hour) composite sampling is required for TSS, BOD_5, pH, COD, conductivity and colour. Composite samples (24 hour) for NH_3-N and total solids is required on a weekly basis. Effluent discharged to the secondary treatment requires the same monitoring. Up until 1985, the company operated a water quality station in the Wapiti River, measuring flow, DO, pH, temperature and conductivity daily. Since then, the company has been required to measure DO once per week if the river flow drops below 17 m^3/sec. and once per day below 7 m^3/day.

During the fall of 1991 after modification in the bleaching and mill processes, the treated effluent began to fail toxicity tests a six week period. The company responded immediately by increasing dilution with non-contact cooling water, eliminating nutrient additions to the lagoon, and increasing aeration. Consultants were hired to complete toxicity identification and impose a reduction evaluation program (TIE & TRE) developed by the U.S. EPA. The results indicated that the ammonia levels in the effluent were influenced by a secondary toxicant. It is important to note that during the process, tests on identical samples conducted by two different laboratories, were being passed in one but not the other. PNGC came to realize that the increased number of toxicity tests led to the laboratories being overloaded, i.e., running out of trout to complete the tests, and lower quality of tests were being completed. In the end, the company changed laboratories and recognized the need for standardization of laboratories through a certification process as practiced in the US.

PNGC, as a result of switching to 100% chlorine dioxide substitution, reported drop in AOX monthly average values from 2.1 kg/adt in 1990 to 0.6 kg/adt in 1992. In 1991 the provincial effluent standard was 3.0 kg/adt and in 1992 it was 2.5 kg/adt.

TABLE A.5: PNGC Performance Data and Licence Limits 1976-1993 (Alberta Environment personal communication, 1992)

YEAR	PROD ADMTPD	EFFL FLOW '000 m^3/D	REAL BOD_5 KG/ ADMT	FED BOD_5 KG/ ADMT	PROV BOD_5 KG/ ADMT	REAL TSS KG/ ADMT	FED TSS KG/ ADMT	PROV TSS KG/ ADMT	TOX-CITY[36] tests pass/ total
1982	778	54.0	4.6	31.2	11.3	7.5	8.0	13.9	1/1
1983	809	53.4	3.2	31.2	11.3	5.4	8.0	13.9	5/5
1984	851	56.6	3.3	31.2	8.7	5.8	8.0	10.7	4/5
1985	851	55.4	4.2	31.2	8.7	7.2	8.0	10.7	4/4
1986	794	58.3	3.6	31.2	8.7	6.4	8.0	10.7	4/4
1987	729	55.8	7.1	31.2	8.7	4.6	8.0	10.7	5/5
1988	796	62.2	5.5	31.2	8.7	9.3	8.0	10.7	4/4
1989	796	55.0	4.8	31.2	8.5	6.2	8.0	10.0	4/5
1990	820	48.5	3.1	31.2	7.5	4.2	8.0	9.5	14/16
1991	820	59.1	2.8	31.2	6.5	2.3	8.0	9.0	13/15
1992	820	65.5	2.2	7.5	6.5	2.1	11.3	8.5	7/8

36 Effluent toxicity testing failure is defined as a 96 hr LC_{50} of less than 100% effluent concentration.

A.4.5 River Monitoring

The company started a three year environmental monitoring program in 1990, consisting of two phases. Phase I involved initial assessment of the river system by determining fish habitat/biology, sampling sites/controls, salmonoid spawn sites, and fish/invertebrate biomarker variety. This phase was aimed at understanding the trends in water quality parameters by developing a daily mass balance to predict concentrations in the river.

Phase II will be based on the results in Phase I and detailed assessment reporting is due in the summer of 1992. The parameters will be evaluated for chemical, biological, and sediment interactions in the river system by utilizing a computer simulation model. In 1992/93, the monitoring will continue and include monitoring for dioxin/furan level trends, and organochloride discharges.

A.4.6 In-plant Technology and effluent treatment

a) Water Treatment, Debarking, Chipping

Logs entered the mill through the thawing chamber where the bark was washed in the summer and thawed with alkaline effluent in the winter. The logs cut to 5 meter lengths were debarked with a drum debarker and the bark was ground up and burned in the power boiler with natural gas. Debarked logs are chipped and piled.

b) Cooking

When the mill was first built, chips were digested under high temperatures and pressures (170°C,~165 psi), with liquor (mainly caustic (NaOH) and sodium sulphide (Na_2S) to dissolve lignin and release cellulose fibres. When the chips leave the digester, the rapid reduction in pressure caused individual fibres to be released. The fibres were washed on the Brownstock Washers to remove the black liquor. In 1989, a pressure diffusion system was installed between the digester and blow tank to increase washing efficiency. Dirt was removed from the fibres by pressure screens and three stage centrifugal cleaners. Deckers remove dirt specks and excess water from the fibres.

c) Bleaching and Pulp formation

When the mill was first built, the fibres were bleached with a six stage process (chlorine, caustic, hypochlorite, chlorine dioxide, caustic, chlorine dioxide). At each stage, steam was added to control temperatures and the pulp was washed to remove chemicals and residues. This waste water was added to the effluent stream. The resulting pulp was again cleaned with centrifugal cleaners and dewatered with deckers. The slurry was formed into mats by a Fourdriner type pulp machine and cut into sheets forming bales to be later shipped to markets.

In 1989, the bleaching sequence (CEDHED) was modified to include 25% chlorine dioxide substitution ($C_{D_{25}}E_oDHED$). In 1990, the bleaching sequence was modified by the upgrade work to included higher chlorine dioxide substitution ($DC_{30}E_oDHED$) with the installation of a improved chlorine dioxide generator. Prior to the upgrade, chlorine dioxide was substituted at rate of 13%; after the upgrade the rate was 75%. This decreased the use of chlorine by 75% and the amount of effluent AOX by 25-40%. In 1991, the bleaching sequence was modified to eliminate the hypochlorite stage ($D_{C_{30}}E_{op}DED$) with the addition of hydrogen peroxide to the first extraction stage. As of July 1992, the mill has operated with 100% chlorine dioxide ($DE_{op}DED$) and AOX monthly maximum been 0.6 kg/adt.

d) Chemical Recovery

The active chemicals in the black liquor, a combined solution of cooking liquor and dissolved chemicals, are recovered with a counter current flow. This involves using hot water from the evaporators on the second washer. The resulting weak liquor is used to wash the first washer. This intermediate liquor is removed and used to wash the digester floor. Strong black liquor is drained from the digester and stored as a supply for the evaporators. The evaporators use steam to drive water out of the black liquor in a six-stage counter current system, where liquor solids reach 60% and can be burned in the recovery boiler.

In 1990, the recovery boiler was improved by replacing the bottom third, installing new tubes and economizer bundles. This was aimed at increasing reliability, i.e., fewer shut downs, and decreasing impacts on the effluent system.

During the 1990 improvements, special basins and tanks were installed to intercept spills and unusual waste loads resulting from unexpected process changes and equipment failures.

A.4.7 Out of Plant Effluent Treatment

a) Primary

The first primary treatment consisted of a large circular clarifier which removed 95% TSS and some BOD. This effluent was mixed with wastewater from the acid sewer and neutralized, with nutrients (phosphorus and ammonia) (Hodgson).

Non-contact cooling water flow ranges from 13,000 m^3/day (0.32 m^3/s) in the winter to 65,000 m^3/day (0.76 m^3/s). In the summer, this flow is combined with storm runoff and discharged directly into the river. In the winter, the non-contact cooling water and the storm water runoff is discharged into the lagoons for treatment.

b) Secondary

Secondary treatment involved two biological aerated lagoons which were designed to remove 90% BOD in a 8-10 day retention time, and an additional settling basin (1 day retention time) which collected solids produced by the lagoons prior to release into the Wapiti River. In addition there were acid and alkaline neutralization and foam retention panel processes.

In 1978, an accidental PCB transformer spill was contained and isolated in the north settling basins which is clay lined. Today, average PCB concentrations in the sludge are less than 25 mg/L. The company is proposing in 1985 to either clean out the basin or cap it.

In 1990, the lagoon capacity was increased to treat effluent for 10-14 days. The sludge was removed from the first cell and stored in a decantation pond to increase efficiencies. Aeration was increased with 3 more aerators making 20 total. This lagoon improvement dropped BOD by 40% and TSS by 11%.

Today, the first portion of the lagoon consists of the north and south basin. The north basin described above is currently not functioning. The south basin (12 hour retention time) receives effluent from the primary clarifier and, being without aeration, acts as a quiescent or settling pond. The second main portion of the lagoon, Cell 1, has a high level of aeration (18 75 Hp) and as a result reduces approximately 85% BOD levels. The final main portion of the lagoon, Cell 2, has a lower level of aeration (9 x 75 Hp) and also contains a section without aeration which acts as a second quiescent zone immediately prior to discharge into a foam pond. Each cell has a 6 day retention time with a 430,000 m^3 capacity.

c) Discharge

After leaving the lagoon, the treated effluent flows through an hydraulic jump aerator into a foam pond to increase the level of dissolved oxygen and dissipate foam. The effluent then flows into a discharge pipe buried approximately 1.8 metres in the river bed. The effluent percolates coarse and fine gravel up into the river stream.

d) Sludge Treatment

Sludge from the primary clarifier is dewatered with a screw press and hauled by truck to a landfill for disposal.

The company currently operates two landfills: Class II & III. The Class II is a clay-lined sanitary landfill with a leachate collections system for deposition of green liquor dregs and human garbage. The leachate from the landfill is processed in the effluent treatment system. The Class III is operated for deposition of wood yard wastes, ash from the boiler, and sludge from the primary clarifier.

MILL DESCRIPTION[37] – PNGC

PRODUCTION: Bleached Kraft pulp 850 adt/d

TRANSPORTATION: Rail C.N.R.

WOOD HANDLING EQUIPMENT

Roundwood storage capacity: 300,000 cds.
Chip storage capacity: 54,000 cds.
Barkers: 1 drum 85 cds/h
Chippers: 1

PULPING EQUIPMENT

Digesters: 1, Kamyer continuous
Washers: Impco.
Knotters: 2, Hi-Q
Screens: Centrisorter
Brown stock cleaners: Bauer
Bleach stages: 5-stage $DE_{op}DED$
Pulp dryers: 1, Flakt
Bleached stock screen: Black Clawson selectifier
Bleach stock cleaners: Bauer
Decker: Impco
Evaporators: 1, Unitech 5-effect with concentrator high solids c r y s ta l l i z e r H P D
Recovery boilers: 1 low Combustion Engineering solids 3.45 mlb/d
Lime kilns: 1 300tpd

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POWER PLANT/WATER & WASTE DATA

Fuel: Gas and hog
Power boilers: Combustion Engineering
Turbines:Stal-Laval
Effluent system: clarifier and lagoon
Boiler feed water treatment: degremont
Raw water treatment: river, cold lime softening, sand filtration

EFFLUENT SYSTEM

Primary clarification
Neutralization
Sludge dewatering: screw press
Spill pond
Aeration lagoon

A.5 SLAVE LAKE PULP CORPORATION (Slave Lake)

A.5.1 Descriptive Overview

a) Location

Slave Lake Pulp Corporation (SLPC), operates a BCTMP 17 km east of Lesser Slave Lake and 250 km north of Edmonton. The Lesser Slave River, which flows into the Athabasca River, is used as both water supply and receiving environment for the mills treated effluent.

b) Plant Processes -Production Levels, Species, Wood Supply

The mill was designed for 350 ADMTPD (110,000 ADMTPY) with an effluent flow rate of 15,000 m^3/d and planned expansions within three years. The effluent system has both primary and secondary treatment.

The mill uses BCTMP technology to produce low-freeness high-brightness hardwood (aspen) pulp for high value printing and writing grade paper markets in Europe, Asia and North America. The process includes a chemical pre-treatment, three-stage pressurized refining, and two-stage hydrogen peroxide bleaching, as well as low-temperature flash drying, pressing and baling phases.

Aspen used by the mill will be supplied primarily from harvesting activities on the FMA (170,500 m^3 AAC). Softwood chips will be purchased from local sawmill operators and the associated sawmill.

c) Adjacent Sawmill Operation

Blue ridge Lumber (1981) Ltd., in Whitecourt, is a wholly owned subsidiary of Alberta Energy Corporation and supplies softwood chips to the pulp mill.

A.5.2 Mill History and Ownership

The mill initiated production in December 1990. Alberta Energy Company owns 75% of SLPC and holds the provincial licences. The remaining 25% is owned by MoDo Canada Inc.

A.5.3 Environmental Impact Assessments (EIA)

As required by the Alberta government, a complete EIA was submitted June 23, 1989 for the Slave Lake pulp mill. Western Research, on behalf of AEC, conducted a detailed assessment of environmental, social and economic impacts resulting from the proposed mill. The mill design criteria included (Firth):

- hydrogen peroxide bleaching to satisfy environmental responsibility, and meet market demand for high brightness (85%+ ISO) high yield pulp;
- process flexibility to customize BCTMP property profiles to specific market demands;
- use of proven, stat-of-the-art equipment only;
- meeting of Alberta Environmental regulations;
- consistency of product quality;
- processes which are simple to operate.

This assessment commenced in July 1988 and completed in mid-February 1989 and involved biophysical analyses and public consultation with individuals and organizations in the vicinity of the mill.

A.5.4 Regulatory and Licence Status - Performance Data

A Permit to Construct was issued August 15, 1989, and Licence to Operate on November 23, 1990. Due to toxicity violations, on March 20, 1992, Alberta Environment issued a water quality control order to increase effluent testing and reporting of plans for compliance.

Monitoring has been conducted to ensure proper operation of the effluent treatment system as required in the Licence to Operate. Monitoring obligations require effluent discharged to the river to continuously record pH, temperature, conductivity, dissolved oxygen and flow rate. Daily (24 hour) composite sampling is required for TSS, BOD_5, pH, TOC, COD, TON, conductivity and colour. Composite samples (24 hour) for NH_3-N and total solids is required on a weekly basis.

TABLE A.6: SLPC Performance Data and Licence Limits (Alberta Environment personal communication, 1992)

YEAR	PROD ADMTPD	EFFL FLOW '000 m^3/D	REAL BOD_5 KG/ ADMT	FED[38] BOD_5 KG/ ADMT	PROV BOD_5 KG/ ADMT	REAL TSS KG/ ADMT	FED TSS KG/ ADMT	PROV TSS KG/ ADMT	TOX-CITY[39] tests pass/ total
1991	350	3.9	2.5	n/a	5.0	3.0	n/a	5.0	10/12
1992	350	4.7	2.1	7.5	3.0	2.0	11. 3	5.0	7/14

A.5.5 River Monitoring

As indicated in the EIA, SLPC operates a comprehensive environmental monitoring program in addition to effluent monitoring. This aquatic bio-monitoring and toxicological testing program is aimed at establishing a baseline and monitoring program for seasonal variation in water quality, DO hydrology, benthic communities, sediment oxygen demand and fisheries.

38 Federal regulations did not have a category for BCTMP mills and as a result BOD and TSS levels were not issued prior to the 1992 Fisheries Act amendments.

39 Effluent toxicity testing failure is defined as a 96 hr LC_{50} of less than 100% effluent concentration.

A.5.6 In-plant Technology and effluent treatment

a) Water Treatment, Debarking, Chipping

Water from Lesser Slave Lake is treated to remove turbidity, colour, iron, manganese, odour, and bacteria as well as adjust pH (AEC). This completed by a reactor-clarifier (13.7 m) and two filter tanks (4.9 m) with anthracite and sand. Water purification chemicals (potassium permanganate, alum, polymer, caustic soda) are used in coagulation, flocculation and sedimentation in the reactor-clarifier. Chlorine is used as a disinfectant in the potable water treatment. Sludge and filter back wash is stored in a holding pond adjacent to the aerated lagoon.

Aspen logs from the storage area are prepared, debarked, and chipped. These chips and softwood chips (lodgepole pine and spruce) are metered, blended and screened to remove metal, oversized and undersized chips and stored in separate piles. The rejects are sent to the waste wood burner.

b) Pretreatment

To provide uniform heating and air removal prior to chemical treatment, chips are pre-steamed for 30 minutes and then washed to remove coarse dirt/fines and thickened to 50% bone dryness (BD) by draining the slurry. The chips are impregnated in a sodium sulphite solution for three to five minutes and then steamed prior to refining. The chips undergo three pressurized refining stages, each consisting of plug screw feeder, a pressurized refiner, and a discharge blow line to a pressurized pulp cyclone (AEC). When the chips are compressed by the plug screw feeders, resinous material is removed. Extractives are also removed in the transfer chest and subsequent pressing a twin wire press. The pulp is fed to the bleaching system.

c) Bleaching and Pulp Formation

A two-stage bleach plant with an interstate configuration proved by extensive pilot testing to be most efficient with respect to peroxide consumption and energy requirements. Brightness levels of 85%-90% ISO could be achieved with P1 and P2 bleach stages operating at 12-14% (MC) and 30% (HC) consistencies. Bleaching efficiency includes pulp washing prior to and following the second (HC) bleach stage and removes 88%-95% of contaminants.

The bleaching process begins with the pulp entering an inter-stage bleaching tower and being diluted with recycled chemicals from the second-stage bleaching. The pulp undergoes additional refining to minimize fibre cutting and ensure low-freeness. The cleaned refined pulp is thickened and held in a semi-bleached high-density storage tank and later in high-density bleach tower after further thickening. The treated pulp is dewatered and dried into slabs forming 250 kg bales for later shipment.

The interstate bleaching configuration softens and swells refined fires to reduce energy requirement during the subsequent refining (Firth).

d) Chemical Recovery

The required bleaching levels of 100% aspen can be achieved with less than 45 kg/t of hydrogen peroxide (Firth). The residual peroxide is collected in a 300 m^3 chest and redistributed. The key flow returns the active peroxide at concentration of about 3g/l H_2O_2, to the P1 interstate bleach mixer. This results in no fresh peroxide being required when operating continuously. This same stream also carries sufficient sodium silicate to the P1 stage.

The mill is equipped with a spill handling system designed to 6000 l/min maximum hydraulic surge from process upset and the mill floor trench. A bar screen removes coarse material and rejects are sent to the bunker and then the incinerator. The spill effluent is stored in a transfer/equalization tank (1370 m^3) and then pumped through a dewatering process sending effluent to the primary clarifier and rejects to the sludge storage tank.

Strong and weak pressate are collected and recycled during all washing stages to minimize water consumption.

A.5.7 Out of Plant Effluent Treatment

a) Primary

Mill waste water consists of excess process water from pulp and chip washing, all floor trench wastes (sewered seal water, pulp spills, chemical spills, and raw water filter backwash) and non-contact cooling water used on electric motors (Firth).

Effluent from the mill and white water processes is combined and passed through a heat exchanger prior to primary treatment. Waste-activated sludge from the AS is combined with polymer and added to the effluent stream prior to the clarifier.

The primary treatment consists of flotation rather than a settling system. In a 8 metre diameter tank, pressurized air creates bubbles causing solids to rise to surface and a skimmer removes solids. Solids and sludge are removed and stored for later processing. Cooling water, phosphoric acid, aqueous ammonia, and return activated sludge are mixed with the primary effluent and forwarded to the secondary treatment.

Floor trench wastewater passes through a trash screen and collected in an equalization basin (1,100 m^3), which reduces hydraulic spill surges. The solids removed are stored and the wastewater component either flows to the primary clarifier or is bypassed to the AS system.

b) Secondary

The secondary treatment consists of an extended aeration activated sludge system. Wastewater from the primary clarifier and floor trench screens is combined with nutrients from the mill sanitary waste, non-contact cooling water and return activated sludge. The AS system consists of four 7000 m^3 bioreactors, each sized for a 6-8 day retention time that can operate in series or parallel. Wood yard waste is added directly to the aerobic portion of the basin. Air from three 28,000 CAM Turblex blowers enters the bioreactors via a coarse air bubble diffusion system. The extended aeration activated sludge system was reported to remove 99% BOD (Frith, 1991)

TABLE A.7: SLPC Activated Sludge Operating Parameters (Firth, 1991)

OPERATING PARAMETER	LEVEL
Hydraulic Retention Time,	7.8 days
Sludge Retention Time	16 days
BOD:N:P	100:5.0:1.0
Mixed Liquor Suspended Solids	5000 mg/L
Food to Microorganism Ratio (F/M)	0.01-0.02

The effluent from the AS is settled in two final clarifiers (26m diameter). The treated effluent is aerated with bubbled air to increase dissolved oxygen levels above required legislative limits (greater than 2 mg/L). Cooling water can be added to the reaeration basin to reduce the treated effluent temperatures.

c) Discharge

The treated effluent is piped 3 km to be discharged through a diffuser, ensuring efficient mixing of effluent with river water.

d) Sludge Treatment

Sludge from the primary clarifier, floor trench screens, and waste-activated sludge are collected in a 235 m^3 basin and mixed with air. A polymer floc is added to the sludge (2% solids concentration) as it is pumped to a floc tank to aid in dewatering. The sludge flows onto a rotary screen thickener, increasing solids concentration to 5%. The sludge, passing through a screw press, is then pressed to 20-35% solids. This cake is fed by loader into a burner for incineration.

MILL DESCRIPTION[40] – SLAVE LAKE PULP CORPORATION

PRODUCTION: BCTMP 110,000 t/y

TRANSPORTATION: Rail C.N.R.

WOOD HANDLING EQUIPMENT

Log deck: 1,700 t/y
Chip unloaders: 1,988
Chip storage capacity: 4 weeks
Roundwood consumption: 330 m^3 y
Debarkers: 1 Nicholson
Chippers: 1
Chip screens: 1, Acrowood

PULPING EQUIPMENT

Washers: 10 Andritz
Primary screens: 2
Secondary screens: 2
Thickeners: 1
Centricleaners: 4 stages
Presses: 10 Andritz
Shredders: 10 Andritz
Chip washers: 1, Sunds
Bleach stages: 2
Bleaching sequence: Peroxide
Pulp dryers: 2
Refiners: 3
Process control systems: Fisher
Clarifiers: 2 Krofta

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PULP FINISHING PLANT

Baling presses: 1 Sunds
Wire tying machines: 2
Scales: 1
Unitizers: 1

POWER PLANT

Fuel: Gas
Electricity: purchased 20-40 MW
Steam generated: 2 boilers
Water consumption: 10 M^3 t
Water source: river

EFFLUENT/POLLUTION SYSTEM

Clarifiers: 2
Screens: 2
Sludge disposal: Burner
Sludge press: 1

A.6 WELDWOOD OF CANADA (Hinton)

A.6.1 Descriptive Overview

a) Location

The Weldwood of Canada (WC) pulp mill is located in Hinton 300 kilometres west of Edmonton, Alberta.

b) Wood supply and Plant Processes

The FMA, 1 million hectares of crown provincial forests, extends for 20 years intervals with automatic renewals depending upon performance involving multiple use, sustainable cutting levels and reforestation. In 1987, the FMA area was increased from 783,000 hectares to the current size as a result of the approved expansion plans.

The current mill production is 1100 ADMTPD and the resulting fibre demand is approximately 2.4 million tonnes of chips (60% lodgepole pine, 36% white/black spruce, and 4% balsam fir). This demand is met by utilizing purchased softwood chips (28%), harvesting from the FMA (68%), and purchasing roundwood (4%).

In 1967, the mill installed the first primary and secondary effluent treatment systems in Canada.

Mill expansion was completed in 1990 doubling production from 550 ADMTPD to 1100 ADMTPD. This work involved processes improvements, i.e., oxygen and extended delignification, high chlorine substitution. Also, the effluent treatment system was modified to include increased aeration in the secondary treatment lagoons.

c) Adjacent Sawmill

A stud mill, built in 1972, is associated with the pulp operations. The original production rate of 50 million FBM was expanded in 1980 to 75 million FBM annually. Suitable logs are sawn into 2 x 4 studs, kiln dried, trimmed, and shipped by rail to markets in US and Canada. The sawmill hog fuel is utilized by the pulp mill power boilers and wood waste is chipped, supplying 15% of the total chip demand.

d) Other

The mill supplies chlorinated and fluorinated drinking water to Hinton and processes the town's sewage, as part of the mills treatment processes.

Tall oil, comprised of rosin and fatty acids can be recovered as a pulping by-product (5,000 tonnes/year) and marketed in the U.S. and Canada as a flotation agent and is also marketed in emulsified asphalt. This plant was put into operation in 1964. Turpentine was also produced (75,000 litres per year) and marketed in US. Since 1991, the extraction of these components was discontinued due to poor market conditions of the products. These compounds are treated with other liquid waste in the mill.

The steam from the power boiler and the chemical recovery boiler produces 66% of the mill energy requirements.

A.6.2 Mill History and Ownership

The mill was originally owned by North Western Pulp and Power Ltd. (1965) and St. Regis Paper Co. In 1954, the provincial government granted the FMA. The first production was shipped in 1957.

The pulp mill was considered a third major project in the development of the town of Hinton (North Western Pulp and Power, 1977). Around the turn of the century, Hinton was an important outfitting centre on the Great North Trail originating in Montana and leading to Dawson Creek in the Peace River region. The town was named after W.D. Hinton, Vice-president of the Grand Trunk Pacific Railroad. The second boom was in 1912 when Hinton was headquarters for Foley, Welsh and Stuart, the builders of the Grand Trunk Railroad grade to Jasper. At this same time, a coal mine was opened and operated in the area.

In 1978, St. Regis (Alberta) Ltd. bought out Northwestern and became the principal owner. In 1985, the mill was bought by Champion International Corporation and WC purchased the mill in 1988.

A.6.3 Environmental Impact Assessments

In 1977-78, the provincial government solicited proposals for unallocated timber adjacent to the WC FMA. WC applied for the timber rights along with a number of other companies. At that time, after an EIA process, a proposal from BCFP/Grand-cash joint venture. The timber would be granted on the condition that milling facilities be constructed by the company. This mill was never constructed. The WC was granted the extra timber rights from the area proposed by the government in 1977 and the mill was expanded in 1989 as a result.

In September 1987, WC submitted an expansion proposal, through an EIA process, to the government to increasing the FMA area and cutting rights as well as mill expansion plans (WC). In the initial stages of the EIA process, the company held discussions with communities downstream of the mill on the Athabasca River, including 22 groups from health units, improvement districts, and native bands. One of the primary reasons for expansion was improved competitiveness on the world market by increasing total production to decrease unit cost.

A.6.4 Regulatory and Licence Status

The provincial Clean Water Act did not exist when the mill was constructed. The Most recent Licence was issued in April 30, 1990 and will expire in December 1, 1992. Monitoring consists of daily measurements for TSS, BOD_5, and colour.

Three times a week, AOX is sampled (1.5 kg/ADMT). Nutrients are tested weekly and monthly. Chlorinated phenolics, total phenolics, sulphide, acute toxicity, dioxin/furans, and resin/fatty acids are tested monthly.

TABLE A.8: Weldwood Canada Performance Data and Licence Limits 1976-1992 (Alberta Environment personal communication, 1992)

YEAR	PROD ADMTPD	EFFL FLOW '000 m^3/D	REAL BOD_5 KG/ ADMT	FED BOD_5 KG/ ADMT	PROV BOD_5 KG/ ADMT	REAL TSS KG/ ADMT	FED TSS KG/ ADMT	PROV TSS KG/ ADMT	TOX-CITY[41] tests pass/ total
1976	474. 0	96. 4	9. 1	49	11.9	24.1	25	19	
1982	479. 3	90. 1	7. 9	49	11.9	18.0	25	19	4/8
1983	502. 0	96. 4	5. 7	49	11.9	13.9	25	19	4/5
1984	512. 9	97. 7	8. 6	49	11.9	16.7	25	19	4/11
1985	525. 0	92. 9	8. 1	49	11.9	14.5	25	19	6/11
1986	537. 3	98. 7	7. 5	49	11.9	12.5	25	19	5/5
1987	539. 0	88. 3	7. 3	49	11.9	17.4	25	19	2/6
1988	532. 0	84. 7	10 .1	30	9.0	13.4	11. 8	19	2/4
1989	532. 0	90. 1	2. 3	30	9.0	4.63	11. 8	14.5	6/9
1990	1100	102	2. 2	30	7.0	4.9	11. 8	14.5	12/12
1991	1100	101	2. 3	30	7.0	4.0	11. 8	14.5	12/12
1992	1100	98. 6	2. 2	7.5	3.0	4.6	11. 8	14.5	9/9

41 Effluent toxicity testing failure is defined as a 96 hr LC_{50} of less than 100% effluent concentration.

A.6.5 River Monitoring

Monitoring the benthic invertebrates in the Athabasca River has been conducted since 1962. All studies (1962-86) found significant changes in the community and the greatest impact occurred about 0.32 km from the outfall where the effluent concentration is the highest. Between 1972-1976, populations of pollution-sensitive species increased showing water quality improvement due to effluent treatment modifications (Beak 1980, IEC 1979). The studies show that there has been high degree of recovery by the benthic community 43 km downstream.

The company conducts water quality river sampling as requested by the water licence. This program will be expanded to include the new federal EEM sampling requirements when finalized.

A.6.6 In-plant Technology and Effluent Treatment

a) Water Treatment, Debarking and Chipping

The mill utilizes water from the Athabasca River. The water is treated prior to use. The mill supplies chlorinated/fluorinated drinking water to the town of Hinton. In 1989, mixed media bed filters were installed.

As of 1975 pulp logs were debarked with a wet drum debarker and chipped with the bark and sawdust being burned in the power boiler. Also a woodroom effluent screen was installed along with a system to collect and direct run-off waters from the bark pile. During the 1989 expansion, a FMP-Rauma dry debarker and a 28 centimetre Carthage chipper was installed. The dry debarker reduced the effluent organic loading and the new chipper increased utilization.

b) Cooking

As of 1976, all chips were cooked in two Kamyr continuous digesters with caustic soda and sodium sulphide, separating fibres from the lignin. These fibres were then washed in three (Jonsson Knotters) brownstock washers to remove residual cooking chemicals for recycling through the liquor recovery process. The fibres were screened in centrifugal pulp screens.

During 1989 expansion, Modified Continuous Cooking (MCC) and oxygen delignification equipment (two-vessel hydraulic MCC Kamyr digester) was installed as a pre-bleaching step, removing 45% lignin which was used as fuel. This step was aimed at reducing the organic loading and colour levels in the effluent and reducing the amount of bleaching chemical required which results in lower AOX effluent levels. During the 1988 expansion the brown stock washers were improved.

c) Bleaching and Pulp Formation

As of 1976 the fibres were bleached in with a six stage continuous process (chlorination, caustic extraction, sodium hypochlorite, chlorine dioxide, second caustic extraction, second chlorine dioxide) to produce Hi-Brite kraft pulp. In each of the bleach stages, residual bleaches were removed by washing with circulating hot water, minimizing heat losses and water wastage. The bleached fibres were rescreened and then pumped unto wire screens for drying with heat and pressure. This pulp was cooled, cut into sheets, and baled for later shipping to markets in the US.

After the 1989 expansion, the bleach plant consisted of a 5-stage sequence involving 3 washing stages; C_DE_O(DED) and provisions for higher chlorine dioxide substitution were also installed (R-8 generator). Prior to this modification, chlorine dioxide substitution was approximately 5-10%. The expansion increased this capacity to 100% substitution. The ability to use hydrogen peroxide was also installed.

Today, the mill produces pulp by two methods. About 75% of the monthly production is produced with 45% ClO_2 substitution, which has AOX readings of about 1.3 kg/ADMT. The remaining 25% of production is made with 100% ClO_2 substitution and this product is sold to European markets.

d) Chemical Recovery

As of 1975, the spent chemicals used in the cooking of chips (black liquor) was washed from the pulp, evaporated and incinerated in the chemical recovery boiler. After further treatment, the chemicals from the boiler were reused. The company installed a spill collection system and a bleach plant water recycling system.

In 1979 a recovery boiler, electrostatic precipitator and black liquor evaporators, was installed and operational. In 1986, a white liquor clarifier was installed.

During the 1989 expansion, extensive in-mill spill collection was installed to recover chemicals and fibre during upset operations for brownstock washing, bleach plant, evaporator, recausticizing. A 6 million litre weak bleach liquor storage was installed as a buffer to accept spill flows. This reduces loading on the effluent system and recovers chemicals and fibres. Also, a recovery boiler was installed as well as a new lime kiln along with HPD black liquor evaporation equipment. Clean condenser cooling water bypass was installed to reduce hydraulic loading.

A.6.7 Out of Plant Effluent Treatment

a) Primary Clarification

In 1967 (North-b), an effluent clarifier (60 meter diameter), one of the first in Canada, was installed. Effluent from the bleach plant alkali sewer, mill general sewer and portions of the bleach plant acid sewer were first clarified to remove TSS (80%). Sludge handling equipment was also installed.

b) Secondary

From the mill start up in 1957 to 1967, the mill effluent was treated in a facultative pond (8.5 hectare 2.4 m deep) without primary treatment. BOD removal efficiency was 50-60%.

In 1967 (North-b), an aerated lagoon was installed, one of the first in Canada. The facultative pond was expanded and converted into an aerated lagoon by installing 11-50 Hp surface aerators. These changes occurred to meet Board of Health limits.

In 1975, the mill modified the aerated lagoon into two cells in series with a total retention time of 7 days (3.3 + 1.7 days). The aeration system was also increased to 1475 Hp (Cell 1=7-75Hp + 11-50Hp; Cell 2=7-50Hp). The lagoon was also deepened to 7.6 metres. This expansion was done to meet the 1976 regulation changes.

In 1985, sludge from the lagoon was removed and placed in a decantation pond with the filtrate returning to the lagoon for treatment. In 1989, the aeration of the lagoon system was increased to 3000 Hp capacity with a 6.5 day retention time. The current regulatory requirement for aeration is 2100 Hp. The amount of nutrients added to the lagoon system was also increased.

The mill processes the sewage produced in the town of Hinton. Sufficient phosphate exists in the sewage for adequate operation of the aerated lagoon. Nitrogen is currently added in the form of urea to ensure sufficient nutrients.

c) Discharge

In the past, portions of the untreated acid sewer, low in TSS and BOD, were not treated. With clean cooling water, this was discharged with the treated effluent, down a rock bed into the Athabasca River. Between 1965-1967, a sparger diffuser discharge pipe (1200 mm diameter) was installed, extending halfway across the river, to improve effluent mixing and assimilation. Six diffuser ports each 400 mm diameter are located 3.05 m apart and approximately 2.7 m below the top of the ice in winter conditions (WC).

d) Sludge Treatment

During the 1989 expansion, a twin sludge press was installed to replace the vertical disc vacuum filter. This equipment increased clarifier reliability and decreased water content in the land fill sludge.

Recently the mill has constructed a new 7 year capacity land fill consisting of a clay liner (1m) over bedrock, leachate collection system, and ground water monitoring program including local creek sampling procedures. The leachate will be collected and trucked back to the effluent system for treatment. In the past, the waste land filled consisted of 60% woodyard wastes and 40% sludge and ash. This new landfill will only be used for the sludge/ash wastes. The woodyard wastes will be reclaimed with a filtering equipment.

MILL DESCRIPTION[42] – WELDWOOD OF CANADA LTD.

PRODUCTION: Bleached Kraft pulp 1100 adt/d

TRANSPORTATION: Rail C.N.R.

WOOD HANDLING EQUIPMENT

Barkers: wet drum - Horton chain suspended; drum FMP
Chippers: #1 110" Murray 10-knife; #2 112" Carthage

PULPING EQUIPMENT

Digesters: 2 vessel, Kamyer hydraulic MCC
Blow tanks: 250 adt
Knotters: 2 Ingersoll-Rand HiQ primary, 2 Jonsson sec.
Washers: 4-stage brownstock, 2-stage Ingersoll-Rand vacuum filters, 2-stages Sunds wash press
Screens: 3-stage brownstock screening, Ingersoll-Rand model 212D centrisorters
Oxygen delignification: Sunds MC system
Brown stock storage: 450 adt
Bleach stages: D/C EO(DESD, 3-stages of washing)
ClO_2 plant: 25 t/d R-8 Albright & Wilson
Bleach storage: 300 adt
Bleach cleaning: 2 systems, 5-stage Noss AM 80 centrifugal cleaners
Pulp machines: 2, 1-Dominion Engineering fourdrinier, press section and vacuum dryer, 160" dry trim;1-Black Clawson fourdrinier and press section, Blakt dryer 160" dry trim
Recovery boilers: 2,2.4 and 2.7 Mlb dry solid CE low odour

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Evaporators: 2, 1 Envirotech 6 effect plus 2 concentrators; 1 HPD 5 effect falling film plus crystallizer

Lime kilns: Ahlstrom 12' 6" dia. z 374'

Recausticizing: Eimco, green liquor reactor clarifiers, pressure filters for white liquor clarification and mud washing

POWER PLANT/WATER & WASTE DATA

Fuel: self sufficient, 20 & 30 MW 600/180/80 truogenerators CE

Power boilers: 2, Foster Wheeler gas boilers, 1 CE hog fuel boiler, converted recovery boiler

Raw water treatment: Athabasca river, Eimco reactor clarifier, softening, mixed bed filtration

Primary treatment: 200' clarifier

Secondary treatment: 6.5 Day ASAB with 2475 hp floating aerators

APPENDIX B - EFFLUENT PARAMETER TESTING INFORMATION

TABLE B.1: Alberta Kraft Mill Licences Effluent Parameters McCubbin, 1992)

PARAMETER	FREQUENCY	SAMPLE TYPE	# SAMPLES
BOD_5	1/day	composite	1,2
BOD_u	4/year	composite	1
COD; TSS; flow	1/day	composite	1,2
	1/week	grab	3
	1/month	grab	4
AOX	3/week	composite	1
colour	1/day	composite	1
resin/fatty acid	with bioassay	with bioassay	1
bioassay	see licence	grab/composite	1
pH	continuous	recorder	1
	1/week	grab	3
	1/month	grab	4
dissolved oxygen	1/day	grab	1
chlorate/chlorite	1/week	grab	1
chlorinated phenolics	with bioassay	grab/with bioassay	1
heavy metals	1/year	composite	1
organic priority pollutants	2/year	grab	1
nutrients	1/week	composite	1
dioxin/furans	1/month	composite	1
oil/grease	1/week &/month	grab	3 & 4
temperature	continuous	recorder	1
specific conductance	1/day	grab	3
sulphide	1/month	grab	1

APPENDIX B – EFFLUENT PARAMETER TESTING INFORMATION

B.1 DISSOLVED OXYGEN

B.1.1 Definition

Dissolved oxygen (DO) is required in aquatic environments and is influenced by BOD and the in-plant processes. The amount of dissolved oxygen in a natural system is a function of periphyton communities which depend on water quality, substrate, and seasonal patterns in temperature and solar illumination.

B.1.2 Test

As indicated in Standard Methods Section 10300 D (10-31), there are several methods of measuring dissolved oxygen. These include biomass accumulation, standing water productivity measured by oxygen method, standing water productivity measured by carbon 14, and flowing water productivity measured by oxygen method. These tests quantify dissolved oxygen in a natural system as a function of periphyton community activity.

B.1.3 Environmental Impact

Each river system has the ability to adjust to loading of biodegradable material to a threshold level. The environmental impact of removing dissolved oxygen is more critical in winter where river systems freeze over and when the river cannot absorb oxygen from the air to replenish depletions.

Government regulations establish a threshold level below which will cause negative impacts. The threshold dissolved oxygen value (in river-diluted) of the Alberta water quality objective is 5 mg/L and in some river systems with salmonoid species BOD is 9.5 mg/L by the Canadian federal water quality guidelines. It is important to note that a river's ability to adjust has to be based on extensive measurements on the aquatic ecosystem before and after effluent discharges and that each river is different. Computer programs, designed to measure the river's response, should be based on data from that particular river.

B.1.4 Discussion

In licences previous to ALPAC, the DO limit (>5 mg/L in the river-diluted) has been identified in the text and not as a specific water contaminant. In the ALPAC permit, DO is recognized as a water contaminant and the parameter limit is set at >2 mg/L for pure undiluted, but treated effluent.

3.2 BOD (Biochemical Oxygen Demand)

B.2.1 Definition

BOD measures the amount of oxygen required to oxidize organic matter or food available for degradation (digestion, consumption) by natural occurring microorganisms, affectionately called "bugs". It implies an indirect measure of the effluent solids fraction that is biodegradable. In the first of two BOD process stages, saprophytic bacteria oxidize carbonaceous organic matter. During the second-stage, autotrophic bacteria oxidize non-carbonaceous matter, i.e., ammonia produced from protein hydrolysis, to nitrites and nitrates, taking up to 6-10 days to exert significant BOD. This delayed or secondary nitrification stage can be eliminated by adding inhibitory agents.

Biochemical oxidation, being a slow process, can theoretically take an infinite time for completion, but 20 and 5 days have become standard times for the BOD tests.

B.2.2 Test

The test consists of placing an effluent sample in a jar with bugs suited to that particular waste long enough for the bugs to consume all the food, oxygen, and eventually expire. The temperature is held constant, usually at 20°C, simulating summer receiving water temperatures. The test usually takes 20 days to oxidize 95-99% of the sample and this is called BOD_u or ultimate BOD. For expediency, measurements of BOD_u test are taken at a shorter time period, usually 5 days as a standard (oxidizing 60-70%), hence BOD_5, and the results extrapolated to BOD_u. The rate of oxidation is usually formulated with first order reaction kinetics by the following equations:

- the total or ultimate first stage BOD initially present or the amount remaining, L at time t=0: $L_t = L\, e^{-kt}$

- the amount of BOD expended at any time t equals y: $= L - L_t = L(1-e^{-k't})$
  the 5 day BOD equals: $y_5 = L(1-e^{-k'5})$
  k values at different temperatures determined by:
  $k'_T = k'_{20}\, \Theta^{(T-20)}$ where Θ = 1.056 (20-30°C), 1.135 (4-20°C)

The reaction rate constant, k, depends on the type of effluent and temperature. Values range from 0.02 day^{-1} to 0.15 day^{-1}. This constant is used in conjunction with BOD_5 to determine BOD_U. The k values can be determined by a number of methods including: least squares, methods of moments, daily difference, rapid ratio, and the Thomas method.

This 5 day minimum is often considered to be too long to be useful in estimating plant parameters. As a result, plants often correlate the BOD_5 test with other tests, such as COD (Chemical Oxygen Demand) and TOC (Total Organic Carbon). The required times for these tests are shorter, i.e., 1-4 hours, but measure more material than the digestible food measured in BOD. As a result COD and TOC provide higher results and are completed as a supplement to BOD_5 tests. See Standard Methods Section 5210 (5-1) for detailed procedures.

B.2.3 Environmental Impact

BOD measures the oxygen to be depleted by the effluent in the receiving environment, i.e., river, and is used as a test to design and regulate plant performance. BOD levels infer an impact on the environment, and are considered to be negative after passing a threshold level set by government regulations.

B.2.4 Discussion

The actual BOD test is delicate and susceptible to errors. Strict procedures must be followed. The tests are based on certain assumptions:

- The bugs should have a high concentration and be acclimated or adjusted to the type of effluent involved. If bugs developed from sewer treatment are used on pulp and paper effluent, the test results will indicate a delayed reaction and the BOD_5 values will be below actual amounts.
- The bugs should have sufficient nutrients and oxygen and that no additional oxygen is added after the test begins.
- More than one test should be done on the same sample to ensure consistent results.
- All substances, i.e., heavy metals, alkali, acids, toxins, fatal to the microorganisms, should be eliminated.
- The tests cannot be validated stoichiometrically after soluble organic matter is utilized.
- The test time required is arbitrary and long.

BOD values can be represented in different units depending on where the measurements are taken as the effluent is treated.

TABLE B.2: BOD Ranges Depending on Measurement Location

INDUSTRY	EFFLUENT TYPE	UNITS	LIMITS
Pulp	pure treated	kg/ADMT or kg/day	ALPAC 1.5 kg/ADMT
Pulp	diluted in river	mg/L	ALPAC 5 mg/L
sewage treatment	pure treated	mg/L	GOLDBAR 20 mg/L

B.3 COD (Chemical Oxygen Demand)

B.3.1 Definition

COD measures the amount of organic matter that can be chemically and biologically consumed by a waste sample. Included in these estimates is the amount of waste toxic to microorganisms.

B.3.2 Test

In the test for COD, a waste sample is oxidized with strong agents, i.e., potassium permanganate or dichromate. The test is performed at high temperatures in the presence of a catalyst (silver sulphate). See Standard Methods Section 5220 (5-6) for detailed procedures.

B.3.3 Environmental Impact

Same as BOD

B.3.4 Discussion

Because COD measures compounds that can be chemically and biologically oxidized, COD measurements are higher than BOD. However, COD takes a short time period to complete and once correlated to BOD, COD is used for treatment plant control and operations.

B.4 TSS (Total Suspended Solids)

B.4.1 Definition

Solids in a sample are classified as total solids, dissolved solids, and suspended solids. Total solids is the material remaining as residue after evaporation at 103°C. Suspended (filterable) solids are larger than 1 um in diameter and retained on a filter medium. Suspended solids are classed as settleable and non-settleable material. Dissolved solids, comprised of material less than 1 um which passes though the filter medium, consists of colloidal (1 to 10^{-3} um) and dissolved material (< 10^{-3} um). These categories are often further classified by volatility into organic and inorganic components (Casey).

B.4.2 Test

TSS (nonfilterable) are the solids remaining after evaporation of the sample which are usually larger than 1.2 um in size and collected on a filter. See Standard Methods Section 2540 C (2-55) for detailed procedures. TSS are comprised of algae, bacteria, debris (wood particles), sediment etc. TSS is the amount of material settling in a cone-shaped Imhoff container after 60 minutes. TSS is an estimate of the quantity of sludge that can be removed by sedimentation.

Samples are often classed further into organic and inorganic fractions. Organic material is vaporized at high temperatures (600°C) and the residue is considered to be inorganic.

B.4.3 Environmental Impact

TSS infers a measure of turbidity, even though the term turbidity is used in the industry to represent another test. In rivers under flood condition, most of the turbidity will be the result of relatively coarse material, primarily clay and silt. In lakes or other quite water, most of the turbidity during summer and fall periods is caused by algae and bacteria.

TSS may reduce photosynthesis rates and th capacity to assimilate/process wastes in the receiving environment. The sludge resulting from the settling solids:

- alters the benthic community composition by covering the stream bottoms;
- exerts an oxygen demand, depleting the dissolved oxygen;
- undergoes anaerobic decomposition causing odour problems gases to float solids to the surface.

B.4.4 Discussion

TSS was a major concern in the past when pulp mills did not have any effluent treatment facilities. Today, TSS levels are not considered to be a concern in most mills, where primary effluent treatment processes are in place.

B.5 COLOUR

B.5.1 Definition

Colour is defined as either true or apparent colour (Casey). True colour is the water colour after the removal of turbidity. Apparent colour is caused by both substances in solution and suspended matter. "Natural" water is never colourless; colour in naturally occurring waters ranges from blue to dark brown and is caused by negatively charged colloidal particles, suspended particles and organic matter content.

The term "condition" is used to describe odour and colour of water in a treatment process. Fresh waste water is typically light brownish-grey colour; with time and the lack of oxygen combined with metal, the waste water becomes dark grey or black and is called septic. Primarily though, organic matter content accounts for the dark brown colour of untreated effluent and when diluted in the environment or treated by biological sewage treatments, the colour becomes yellow-brown, typical of natural water colour. Organic matter is better tested by other means as mentioned above.

The main source of colour in the kraft pulp effluent originates generally from the caustic extraction of the bleach plant process, assuming effective brown stock washing and black liquor recovery systems (McCubbin 1984). A typical kraft pulp mill can produce 150 kg of colour per tonne pulp produced (Casey). Of this total amount, 22% comes from the cooking stages, 67% from the bleaching processes, and remaining 11% from the wood yard, recovery and caustizing portions of the plant. The colour indicates the presence of lignin, tarmins, and other resins. The amount of colour in the effluent depends on the recovery system efficiency.

B.5.2 Test

Colour is determined by visual comparison of a sample with known concentrations of coloured solutions. In the platinum-cobalt method, one unit of colour is produced by

1 mg/L platinum in the potassium chloroplatinate ion form. The Licence to Operate recognizes the Canadian Pulp and Paper Association H.5P Spectrophotometric Method. See Standard Methods Section 2120 B (2-2) for detailed procedures.

B.5.3 Environmental Impact

Coloured effluents affect the receiving waters as follows (Casey):

- potentially retards sunlight transmission essential for photosynthesis by aquatic life;
- lowers recreational potential because of darker-than-natural receiving waters;
- increases downstream users treatment costs because of colour;
- disrupts metabolic processes in the lower food chain since colour bodies can complex with toxic metal ions, i.e., iron, copper;
- disrupts the lower food chain processes because of colour from lignin;
- affects fish movement and productivity because of colour bodies;
- exerts long term BOD (20-100 days) not measured in BOD_5 due to colour bodies.

B.5.4 Discussion

Public opinion has a strong influence on the water treatment industry in regards to colour. Because of the public's concerns, influenced by the aesthetic qualities, especially for drinking water, colourless water is considered to be pure. Authorities know this is not necessarily the case, but have incorporated a colour test into licensing and monitoring programs primarily due to public concern.

B.6 NUTRIENTS: TOTAL PHOSPHORUS, NITROGEN AND TRACE METAL IONS

B.6.1 Definition

Bugs in the biological treatment (aerated lagoons), to function properly, require a certain amount of nutrients, i.e., nitrogen and phosphorus. Because pulp mill wastes tend to be low in these required nutrients, these chemicals are added to facilitate the process and the amount added is related to the amount of BOD_5 removed. Generally, the accepted ratio of BOD_5:nitrogen:phosphorous is 100:5:1. Control of this nutrient feed system is based on testing the effluent daily and adjusting the chemical additions to keep the effluent concentrations below 0.3-0.5 mg/L P (as orthophosphate).

Nitrogen in samples can occur in several oxidation states: nitrate, nitrite, ammonia, and organic nitrogen. All forms, along with nitrogen gas, are part of the nitrogen cycle.

B.6.2 Test

The test selected to measure phosphorus depends on the sample to be measured. Basically, the process involves first converting the phosphorus form to dissolved orthophosphate and then determining the colorimetric characteristics of orthophosphate. See Standard Methods Section 4500-P A (4-108).

Testing procedures for nitrogen depend on the oxidized form present. See Standard Methods Section 4500 A (4-94) for detailed procedures.

B.6.3 Environmental Impact

Eutrophication describes an enrichment of aquatic system. Unlike terrestrial systems, aquatic systems optimize habitat under low nutrient conditions. Sources of nitrogen and phosphorous increase the level of nutrients and set aquatic system off balance through prolific weed growths, nuisance algal blooms, deteriorating fisheries, and lower water quality. These processes would be most prevalent in lakes that have low flow trough volumes. Critical nutrient concentrations should be evaluated during the spring overturn or before the beginning of the productive season. These processes influence river ecosystems less because of the amount of water flowing through the system but may be a concern during the season low water flows.

Total phosphorus is a measure of a number of different forms of phosphorus and phosphorus as orthophosphate is considered to be the most usable form. Total phosphorus values in lake surface water are ~0.02 mg/L, in agricultural runoff are ~0.75 mg/L and in raw untreated domestic waste water are 9 mg/L. Phosphorus, in the form of phosphate, influences the chemical and biological processes in aquatic ecosystems. Phosphate is a required nutrient for the growth for all living tissues; in short supply, it limits growth and in high concentrations, it can contribute to a major change in the aquatic ecosystem.

Ammonia toxicity can result and is related to pH and temperature of the nutrient system as well as bicarbonate alkalinity, hardness, and carbon dioxide content. Mills using chlorine bleach may also have problems with mono and dichloramines.

B.6.4 Discussion

Monitoring for total phosphorous in Alberta has not been a part of pulp mill licensing prior to the ALPAC permit to construct was issued. As yet, standards for this component have yet to be established in the ALPAC licence.

Concentrations of 0.3 to 0.4 mg/L of undissociated ammonia is the threshold safety level for ammonia toxicity and 7-8 mg/L of undissociated ammonia or 700-800 mg/L of ammonium chloride killed fish in one hour (Environment Canada-d).

B.7 FECAL COLIFORM

B.7.1 Definition

The operational definition of total coliform is bacteria that ferment lactose to produce gas within 48 h at 35°C. These pathogenic organisms, i.e., bacteria, fungi, viruses that cause human diseases, have traditionally been a parameter of water quality, especially for municipal treatments. Since these organisms are isolated and difficult to measure, coliform organisms resulting from the presence of fecal matter are used as an indicator, being numerous and easily estimated. The coliform bacteria include Escherichia and Aerobacter.

B.7.2 Test

Since Aerobacter and certain strains of Escherichia coli, are not necessarily of fecal origin, a high incubation temperature test has been developed to differentiate this group (Casey). The elevated-temperature (45°C) coliform test is a more appropriate name than fecal coliform test. See Standard Methods Section 9221 E (9-52) for detailed procedures.

The probable number (MPN) and the membrane-filter techniques are two accepted methods of obtaining the number of coliform organisms. The MPN statistically analizes the negative/positive results. In the membrane-filter technique, bacteria is filtered from samples, grown on algae and then counted. The membrane technique is faster than MPN and provides a direct coliform count.

B.7.3 Environmental Impact

These bacteria occur naturally in the environment and in the gut of living organisms. Diseases in humans and animals result when the population combinations and size increases beyond the naturally occurring threshold amounts.

B.7.4 Discussion

Klegsiella pneumoniae, present in surface waters and pulp effluents, has responded positively to the test and provide misleading results.

B.8 AOX (Adsorbable Organic Halogens)

B.8.1 Definition

When used by the pulp industry, AOX is aimed at quantifying the amount of adsorbable chlorinated organics. Essentially AOX in bleached kraft mill effluent consists of 80% high molecular mass material, 19% relatively hydrophillic (water soluble) low molecular mass compounds, and 0.09% relatively lipophilic (fat soluble). It is this latter group that has the highest potential of bio-accumulating, being toxic and persistent (McCubbin). This fraction includes polychlorinated dibenzo p dioxins (PCDD), polychlorinated dibenzo p furans, (PCDF) and polychlorinated phenolics compounds (PCPC).

AOX is usually 30% higher than TOCL (Total Organic Chlorine, also called TOX). The levels of AOX are directly related to the amount of pure chlorine added in the pulp bleaching stage, the amount released in the effluent after secondary treatment, and depending on plant process is approximately 10% of the chlorine used.

B.8.2 Tests

In the test for AOX, a water sample is passed through activated (highly absorptive) carbon, which is washed to remove inorganic chlorine. The material remaining on the carbon is combusted and the gaseous products measured for total chlorines. See Standard Methods Section 5320 B (5-16) for detailed procedures.

B.8.3 Environmental Impact

Chlorinated organic compounds, produced by any industry that treats organic material, i.e., wood fibres, with chlorine have caused public concern in regard to toxicity and environmental persistence. In kraft pulp mill effluent, 95% of the AOX is chlorinated lignin, which is fairly soluble and resistant to decay. Although several researchers consider high molecular chlorinated lignin non-toxic because it cannot penetrate cell membranes, other toxic low molecular chlorinated organics may result as the chlorinated lignins decay (Alberta-b). Also, chlorinated lignin imparts colour to the water, reducing light penetration and aesthetic qualities.

It is important to note that there is a potential of producing thousands of chlorinated compounds, of which less than 50 have been studied for toxicity and other properties. It is generally accepted that chlorine molecules attached to organic compounds tend to make some of the resulting combinations toxic by altering the genetic structure of tissues and, in the environment are to be persistent and accumulate in the food chain.

B.8.4 Discussion

AOX can be reduced by several in-plant processes such as: modifications to continuous cooking, multi-stage prebleach washing, oxygen delignification, multiple chemical additions, medium consistency chlorination, and chlorine dioxide substitution. Up to 50% can be eliminated by secondary treatment (aerated lagoons), where the chlorinated organics are converted into a harmless salt (chloride). ALPAC suggested extended delignification, 100% chlorine dioxide substitution and peroxide bleaching which can achieve an AOX loading of less than 1 kilogram per Air Dried Tonne of pulp (kg/ADMT). No commercially proven method, however, is available to bleach pulp to the level of brightness currently demanded by the market without the use of chlorine-containing bleaching agents (Environment Canada b).

It is important to note that AOX is not a measure of toxicity. The science community assumes that not all chlorinated organics are toxic, even though only a small percentage of chlorinated organics have been analyzed and tested. In dealing with toxicity, especially with the current scientific methods, scientists have accepted the attitude that chemicals can be proven to harmful but not proven to be safe. This means until proven "guilty" or toxic, a chemical is considered to "innocent" or safe.

This contrasts with the public's intuitive knowledge, leading them to believe the opposite. Generally, the lower the exposure to any of these compounds, the better.

B.9 CHLORATE AND CHLORITE

B.9.1 Definition

These chemicals are by-products of bleaching methods involving chlorine dioxide. A certain amount of chlorine dioxide is transformed back into chlorate, which is later converted into chlorite in effluent treatment systems (McCubbin).

B.9.2 Tests

Tests for these compounds have been included by Alberta Environment in the ALPAC licence to quantify these potential by-products and the eventual effect on down stream users.

B.9.3 Environmental Impact

Chlorate is considered to be a human health concern, especially in drinking water. Environmental affects of these chemicals are not well known. Chlorate has been reported to be used as a herbicide in the 1970s and destroyed algae populations and serious ecological impacts below a pulp mill outfall in Sweden in the 1980s (McCubbin). Fresh water systems, not limited by nitrogen nutrients, appear to be less susceptible to chlorate than brackish waters. It has been reported that plants do not differentiate between nitrate and chlorate which have similar molecular structures. Lethal effects result in systems deficient in nitrates.

B.9.4 Discussion

Chlorate is converted to harmless chloride in aerated stabilization basins if an anoxic zone is provided. Some concerns have been expressed about the suspected inefficiencies of activated sludge systems in controlling chlorate, if they have not been designed for denitrification.

B.10 RESINS AND FATTY ACIDS

B.10.1 Definition

This group of pulp mill by-products is formed from the resin and fatty acids found in the wood fibres.

B.10.2 Tests

The procedure for measuring these chemicals is delicate. Through a chemical process, the resins and fatty acids are extracted from effluent samples and concentrated. Once in this form, the concentrate molecules are analyzed through sophisticated equipment (GC-MS Gas Chromatogram-Mass Spectrometer) which provides a graph indicating abundance of the molecules with time. These profiles are fingerprints, unique to the compound, and can be compared with fingerprints of other known substances in the pure form. See Standard Methods Section 6000 (6-1) for detailed procedures.

B.10.3 Environmental Impact

Resins and fatty acids are toxic to aquatic life and can cause effluent toxicity limits to be exceeded if not destroyed in the treatment system. Resin acids have been shown to be toxic to fish at levels as low as 0.2 mg/L and resin acids are normally responsible for most of the toxicity, particularly for softwood pulp (leach). Apart from their own tendency to be toxic, resins and fatty acids can add to the solubility of other toxic substances, compounding the toxic effect.

B.10.4 Discussion

It is important to know that the GC-MS process is extremely specialized. In reputable laboratories, identification of the compound profiles is done by two experienced scientists, usually holding Ph.D.s in the field. It is so complicated that often engineers working in the field cannot interpret the data and rely on the labs for analysis. To reduce errors in interpretation, it is highly recommended that more than one lab should be used to analyze data and that engineers become familiar with the GS-MS data. It is also important to know that there are a possible 13 million organic compounds that can be produced; only about 125,000 compounds have had fingerprints identified and logged for use by the GS-MS method.

It is also important to know that as chemical analysis improves and toxicants are identified, industry responds and reduces the level of chemicals. For example, dioxins were only found to be in pulp mill effluent in 1986. Since that time, industry has lowered the levels produced by changes in plant processes. The more the public knows about the results produced by the sophisticated chemical processes, the more pressure there will be to reduce the levels in the effluent.

These GS-MS tests are used to determine the concentrations of Priority Pollutants in effluent. The federal government established a list of pollutants that were considered to be highly toxic and as result, a priority was set for testing in effluent. The disadvantage with using an individual contaminant testing is that unidentified contaminants are not included. A sample may be rated as non-toxic according to the Priority Pollutants list, but may be toxic to the environment because of other pollutants in the sample and not on the list or because of the synergistic effect of the combined concentrations of the priority pollutants. A shift toward whole effluent toxicity testing will help resolve this problem.

B.11 TOXICITY

B.11.1 Definition

Toxicity tests are aimed at measuring the effects of pollution on aquatic biota. Typically, pulp mill effluent is tested for short term lethal effect (acute toxicity) with the LC_{50} (bioassay). The effects of chronic toxicity measures long time effects of reduced growth, reduced reproduction and other physical abnormalities and are quantified.

B.11.2 Tests

For pulp mill effluent, acute toxicity is measured by the LC_{50} (bioassay) test which involves exposing juvenile fish or other aquatic species to effluent collected at the end of the discharge pipe and monitoring the response of a set time (usually 96 hours). The effluent is considered to be non-toxic if more than 50% of tne fish survive after 96 hours. The higher the LC_{50} number of lab standards, i.e., temperature, pre-test condition of the fish. See Standard Methods Section 8000 (8-1) for detailed procedures.

B.11.3 Environmental Impact

Toxic substances in surface water can damage food chains in aquatic ecosystems, reduce the waste assimilative capacity, cause fish kills, and contaminate fish tissues. Toxicity is dependent on the concentrations of the chemical and length of exposure. It is important to measure effects from short-term exposure at high concentrations (tests by LC_{50}) and to measure effects from long-term exposure to low concentrations (as part of a monitoring program). Different chemicals act differently in the environment. Chemicals with low water solubility remain in water for short time periods and tend to collect in sediment and fish tissues. Monitoring programs for toxicants should include multi-media sampling, i.e., sampling sediment, of fish and plant materials in addition to water samples.

B.11.4 Discussion

The current trend in effluent testing for toxicity is aimed at whole effluent testing as opposed to testing for specific priority pollutants. The tests mentioned above will be used for this purpose. The changes to the Federal Fisheries Act have provisions for environmental monitoring, aimed at long term-exposures of the environment to low concentrations of toxins.

In a recent case with PNGC, the effluent was passing in one lab and failing in another, primarily because of these various conditions. ALPAC will be required to combe the trout LC_{50} with a 48 hour LC_{50} Daphnia magna bioassay and a chronic toxicity bioassay, standards for which will be set by the end of 1992.

There are several other tests that could be used for toxicity, but have not been accepted as regulations. Firstly, the microtox test which measures acute toxicity, is an alternative to the LC_{50} tests, taking only a few minutes instead of a few days. It involves rehydrating bacteria which naturally emit light. When impaired by toxins, the bacteria produce a corresponding decrease in light emissions. Secondly, another alternative is to conduct the bioassay test with the effluent flowing through the tank past the fish rather than with static flows as is currently practiced. This would allow testers to see behaviour changes in the fish, eg., schooling (the control or healthy response to flowing water). Thirdly, a 7 day chronic bioassay, in keeping with the whole effluent testing approach, has been suggested to cover the longer term affects on fish, considering that most pulp mill discharges may not be acutely toxic. This test involves exposing fish in the early life stages, i.e., larvae and not adults, to effluent for 7 days instead of 48 or 96 hours.

Another aspect of toxicity testing problems is that bioassay tests usually increase pH. If the sample tested has a high in pH, i.e., approximately 8.5, the increase in pH from the test will change the form of nitrogen to increase the level of ammonia. This increases the toxicity of the sample. The test can actually measure a higher level of toxicity from the sample than is present in the effluent. This is a problem for especially BCTMP mills which tends to have alkaline effluent.

B.12 ACIDITY, ALKALINITY, AND HEAVY METALS

B.12.1 Definition

The pH test (level of acidity of the effluent) is aimed at measuring the ability of water to react with a strong base. Values range from 1 (extremely acidic) to 14 (extremely basic) with pH 7 being neutral.

Alkalinity of water is a measure of properties that neutralize acidity and is a function of carbonate, bicarbonate, and hydroxide content of the sample as well as borates, phosphates, silicates and other bases if present.

Heavy metals, with a toxic concentration threshold are considered toxic in biological oxidation systems. These include arsenic, barium, cadmium, copper, fluorides, iron, lead, manganese, mercury, nickel, selenium, silver and zinc.

B.12.2 Test

The pH parameter is monitored mechanically on a continuous basis. Alkalinity is usually measured by the titration method. Methods for estimating heavy metals depends on the process compounds and involve polarography and atomic absorption spectroscopy (Casey). The toxicity testing will reflect the presence and harmful effects of heavy metals. See Standard Methods Section 2310 (2-23) for pH, 2320 (2-25) for alkalinity, and 3000 (3-1) for heavy metal detailed procedures.

B.12.3 Environmental Impact

Natural waters range from pH 6 to pH 9. Each water system has an ability to buffer changes in pH, but passed that threshold level, the natural balance of aquatic ecosystems will be negatively affected.

The effects of metals ranging from beneficial to toxic depends on concentrations and types. While some are essential, heavy metals are considered to be toxic.

B.12.4 Discussion

Alkalinity and heavy metals are a minor component of pulp mill waste and negative impacts on the receiving environment are minor. Although damage from high pH can result from pulping processes used in kraft mills, in-plant and effluent treatment systems adjust the pH sufficiently to minimize impacts. Frequent evaluations of continuous monitoring data ensures that pH adjustment features of the mills are functioning properly.

B.13 TEMPERATURE

B.13.1 Definition

Pulp processes involve high temperatures and as a result raw effluent temperatures are usually high. Biological treatment requires high temperatures for optimization (35°C).

B.13.2 Test

Effluent temperatures are monitored constantly by mechanical methods.

B.13.3 Environmental Impact

Effluent with high temperatures can cause negative environmental impacts. Aquatic animals have no mechanism to cool body temperature below ambient water. By increasing the receiving water temperatures, the metabolic rate of aquatic life increases. Increased oxygen demand results. In receiving environments without complete mixing, fish may experience thermal shock entering the warmer areas. The aquatic community structure may shift to accommodate the changes.

B.13.4 Discussion

The effects of temperature on the aquatic community structure should be part of any long term monitoring program.

APPENDIX C – DIOXIN/FURAN CASE STUDY

AGENT ORANGE AND DIOXINS

The term "dioxin" has come to mean more than a common name for 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). It is a major factor influencing industrial management and in particular the pulp and paper industry. This broader association with toxins in Canada has developed over the past 25-30 years from situations occurring in the USA and Europe. This background concern over health impacts of dioxins influenced the Canadian pulp and paper industry to act independently of government regulations to take steps to eliminate dioxin and the associated furans, once it was determined to be present in pulp mill effluent.

Some feel (Boddington, 1984) that the dioxin sensation originated from the turbulent times and numerous causes in the 1960s. It was a decade of causes when universal protest was at its height. One of the crusades within this era of social change was environmental protection which included a number of important issues, i.e., DDT, phosphates, mercury. Governments throughout the world responded to the depth of environmental concern by establishing environmental departments and industrial regulations. The formation of the U.S. EPA in 1970 coincided with the recognition of a dioxin problem, Agent Orange (2,4,5-T and 2,4-D) and it's association with the cause against the Vietnam War and of peace in general (Barnes, 1985). During the scientific investigation into the chloracegenic nature of 2,4,5-T, dioxin was found to be an impurity and this knowledge provided a foundation for dioxin research.

Growing concern arose, principally from potential dioxin toxicity and widespread distribution in the environment, as noted by numerous studies[43] conducted in the early 1970's and 1980's. For a number of years, the public was bombarded with

43 Moore 1973, Blair 1973, IARC 1977, Cattabeni 1978, Esposito 1980, Kinbrough 1984, Hutzinger 1981 & 1983, NRCC 1981a, 1981b, & 1984, Stalling 1983, FRG 1985, US.EPA 1985 & 1988, McNelis 1989.

intense publicity regarding the public health threats of these chemicals (Kleopfer, 1984). Chemophobia, fear from unknown impacts of chemicals on health and the environment, was a major consideration in dealing with the dioxin problem (Kay, 1989). Subsequent industrial accidents and improper handling of the 2,4,5-T and the dioxin impurities, contributed further to public concern.

CONTAMINATION WITH DIOXINS

The contamination with dioxin in Missouri (Kleopfer, 1984) originated from one particular plant producing Agent Orange between 1968 to 1969 and later, in 1972, producing hexachlorophene. Prior to the 1976 Resource Recovery Conservation Act regulating industrial wastes, the disposal of the still bottom sludges from this plant was haphazard and widely distributed. About 12,000 gallons of the sludge were shipped to Baton Rouge for incineration and 21,500 gallons were dispersed to over 40 Missouri sites. These included spraying roads and a number of stock yards, resulting in cases of human chloracne and animal deaths. The actual cause of these occurrences was not investigated until 1974 when it was attributed to the dioxin contaminated wastes. Site remedial actions have occurred in the late 1970 and into the 1980s.

In the late 1970s, large amounts of chemical wastes (including 2,3,7,8-TCDD), in Hyde Park dump site and the Love Canal near the Niagara River, New York State, were found to be leaking into the environment. In Europe and the U.S., dioxins were found in emissions from municipal waste incinerators. Dioxins were released from fires involving certain types of electrical equipment containing polychlorinated biphenyls and chlorinated benzenes. In 1974, the first discussions occurred regarding the possibility that the pulp industry might be a source of dioxin/furans by Sandermann (Swanson, et al., 1988).

In 1976, a well known and documented industrial accident near Milan Italy, occurred in a plant producing 2,4,5-trichlorophenol (Fortunati, 1984). A cloud of toxic gases containing 2,3,7,8-TCDD as a by-product was released during this incident. This accident greatly contributed to dioxin awareness throughout the world.

In Britain, shortly after the Milan accident, knowledge about a 1968 dioxin accident became known. The incident exposed 70 workers to dioxin from the Coalite Chemicals plant in Bolsove, Derbyshire, which manufactured trichlorophenol. The resulting journalist documentation led to the phrase "the most deadly poison known to man" (Cox, 1986).

In Canada, dioxin was found in fish and herring gull eggs around the Great Lakes in the late 1970s by both Canadian and US agencies (Norstrom, 1983; Hallett, 1984). Dioxin was measured in human adipose tissue in people living east of the Great Lakes (Boddington, et al., 1983). Shared by both countries, the Great Lakes solution to reduce the release of dioxin resulted in a multi/agency/government hazard assessment and management effort. In the mid-1980s, whale kills were associated with dioxins and although this may not have been the cause, the resulting political pressure and ensuing attention to the controlling of industrial wastes provided an avenue for improved policy for chemical spells (Boddington, 1984). The major source of dioxins in Canada was attributed to the production of pentachlorophenol, used primarily as a wood preservative. Dioxin was found in chicken livers from flocks housed on wood shavings previously treated with pentachlorophenol (Boddington, et al., 1983).

Discussions on dioxin/furans in Canada began in 1979 and were formulated under the National Research Council of Canada (NRCC, 1981), investigating both the analytical developments and environmental/human health effects (NRCC, 1981). Increased interest by various agencies and the public can be attributed to confusion with 2,4-D herbicide issue (Maybury, et al., 1982), dioxin findings by Agriculture Canada (Cochrane, et al., 1981), and the noted environmental of dioxins (Jones, P.A., 1981), as well as a number of facts (Boddington, 1984):

- the majority of research in Canada was completed in government laboratories or paid for by government contracts;
- the release of each new finding caused great interest in the Canadian news media, necessitating response where the scientific data describing the problem did not provide the solutions;
- the expanding analytical capabilities and interest in isomers other than just 2,3,7,8-TCDD suggested that there may be an increasing necessity to respond to the entire issue in the future; and
- the complexity of the legislative mandate in Canada with respect to different entry routes and environmental compartments required considerable cooperation in order to agree on solutions which often had considerable sociological, political and economic implications.

In 1983, early federal government initiatives, based on the Minister's Expert Advisory Committee Report recommendations, were aimed at controlling contamination with dioxin/furans and federal waste combustion operations (Canada, 1983; Muller, 1990). In response to public concern, the federal government responded with two directives. Firstly, the National Sampling Program was established to determine scope and extent of dioxin/furans in fish and sediments around pulp and paper mills and to take appropriated action where public health was at risk. Secondly, measures were developed to control the release of dioxin/furans by pulp and paper mills and federal incinerators.

DIOXIN AND FURAN ASSOCIATED WITH PULP MILL INDUSTRY

Dioxins and furans were not factually attributed to the pulp mill industry until 1986. Although many studies indicated high levels of dioxins and furans in indicator wildlife populations near pulp mills using bleaching, establishing a cause and effect relationship with pulp mills was difficult due to other industrial sources. With improved analytical equipment, i.e, gas chemotography/mass spectrometers, levels of dioxins and furans were more easily detected. Concern had been expressed in May 1986, in the U.S. regarding the possibility that dioxins may be present in pulp and paper mill sludges which may impact the industry's land application programs (Swanson, et al., 1988). The U.S. National Dioxin Study (established in 1983) conducted in April 1986 and reported in February 1987 that previously undetected levels of dioxin/furans had been found in fish downstream of pulp and paper mills, where no other known source existed (Amendola, 1989). In late 1987, the Swedish Forestry Industries Waster and Air Pollution Research Foundation found similar results. These reports were significant in that subsequent research on dioxin shifted from primarily studying incinerators as a main source of dioxin to investigating the bleached pulp and paper industry.

In June 1986, the U.S. EPA and the pulp and paper industry agreed to conduct a joint screening of a small groups of mills (The 5 Mill Study) aimed at determining the source of dioxin/furans and quantifying untreated/treated waste water effluent and sludge concentrations (Amendola, 1989). With data collected between June 1986 to January 1987 by National council of Paper Industry for Air and Stream Improvement (NCASI), the study concluded that 2,3,7,8-TCDD and 2,3,7,8-TCDF were the principal dioxin/furans formed as trace contaminants during bleaching kraft hardwood and softwood pulps using chlorine and chlorine derivatives. Also, it concluded that amounts varied between mills, but were consistent within each mill in bleached pulp, effluent, and sludge.

In Canada, May 7-8, 1987, the Council of Resource and Environment Ministers (CCREM) sponsored a workshop on dioxins, in which senior scientific and policy-making staff of both federal and provincial government met to review the issues concerning environmental and health. A dioxin sub-committee, reporting to the Toxic Substance Advisory Committee was formed to provide overall coordination for four dioxin working groups on communication, regional, regulatory and scientific priorities.

In August 1987, a Greenpeace report, "No Margin of Safety" linking the pulp industry with dioxins, was widely publicized in the media across North America (Van Strum, 1987). Greenpeace based the report on U.S. EPA findings on dioxins in paper products leaked to Greenpeace and other documents obtained from the agency through a Freedom of Information Act lawsuit. The Greenpeace report documented the "leisurely" U.S. EPA investigation during the early 1980s of dioxin formation in the chlorine-based pulping processes and apparent "lack" of control regulations. Subsequent to the release of "No Margin of Safety" in 1987 and in 1988, Greenpeace called for a Congressional investigation into the U.S. EPA delays, held protests at MacMillan-Bloedel's Harmac mill in B.C., and released other industry reports indicating dioxin in paper products.

In April another investigation, the 104 Mill Study, was initiated (See TABLE C.1) to provide the EPA with more complete data on the release of dioxins. This new screening study further characterized all the U.S. mills (104 total) that practice chlorine bleaching of chemically produced pulps (Whittemore, et al., 1990). Bleached pulp, sludge, and effluent were measured for dioxins/furans. This study, developed jointly by EPA and the industry, was implemented by the NCASI.

TABLE C.1: Distribution of 2378-TCDD/F Concentrations in Pulp (Whittemore, et al., 1990)

Parameter	Mean ng/kg		maximum ng/kg	
	2378-TCDD	2378-TCDF	2378-TCDD	2378-TCDF
Hardwood Kraft Pulp	5	48	33	661
Softwood Kraft Pulp	12	137	116	262
Sulphite Pulps	1	44	15	409
Kraft Mill effluent	0.059	0.50	0.57	8.4
Sulphite effluent	0.0006	0.122	0.023	0.84
Kraft Mill sludge	95	806	1,390	17,100
Sulphite sludge	16	130	58	584

This study found that bleached softwood kraft pulps had higher concentrations of dioxin/furans than bleached hardwood pulps. Both bleached kraft pulps generally had higher concentrations than bleached sulphite pulps. Furans tended to be in higher concentrations in bleached kraft mills effluent and sludges than in sulphite effluent and sludges. Data varied from mill to mill. The estimated amount formed in the U.S. bleached kraft industry in 1988 was 0.64kg/yr of dioxin and 5.1 kg/yr furans.

In a Swedish study conducted by Ryan (1988), milk cartons were reported to be a source of furans. This surprised the pulp and paper industry and as a result extensive studies were initiated in several countries. In Sweden, dairy production was considered to be one of two major sources of human exposure to dioxins/furans; the other was fatty fish and seafood (Rappe, et al., 1990). In a study conducted in that country, dioxin/furan levels in pulp used for milk cartons increased dioxin/furan levels in milk. The levels found in milk were influenced less by unbleached or low chlorine pulp cartons and more by different geographical locations. In the U.S., investigations into milk cartons and other food packages determined that contamination by dioxins/furans was dependent upon food fat content, storage temperature, contact time, and container barrier coating (LaFleur, et al., 1990).

In August 1988, the Pulp and Paper Institute of Canada reported in Umea Sweden, evidence that oil-based additives were a source of dioxin/furans produced in kraft bleach plants (Allen, 1989). Since only low levels had been found by the 1988 USEPA/NCASI and Swanson studies, the additives to the brown stock system were suspected as the source. Three brown stock defoamers tested positive only after chlorination. The oil base for these defoamers was suspected to be the contributor. It was also found that defoamers made from oils with aromatic compounds removed, contained undetectable levels dioxin/furan before and after chlorination.

In 1988, eight NATO countries accepted a standard set of International Toxicity Equivalency Factors rating the toxicity of dioxins and furans (NATO, 1988). Chlorine bleaching has been shown as the major source of dioxins in pulp and paper mills (Berry, et al., 1989; Rappe, et al., 1989) and that chlorine substitution with chlorine dioxide effectively prevents the formation of dioxin/furans (Axegard, et al., 1989; Berry, et al., 1989; Kitunen, et al., 1989).

The Ontario Ministry of Environment reported 2,3,7,8-TCDD in 17 of 47 samples of fish downstream of kraft operations in levels greater than the Ontario consumption guideline of 20 parts per trillion (Clement, et al., 1989). This study also showed that dioxin/furans were in sludges from nine bleached kraft pulp mills. In 1988 and 1989, the Government of Canada released results from a Fisheries and Oceans dioxin and furan National Sampling Program conducted in cooperation with the provinces, and later with extended sampling programs conducted by industry as requested by the government (Canada, 1989). In November 1988, Environment Canada issued notices under Section 18, CEPA to all 47 bleached kraft mills requiring the mill to supply all data regarding dioxin/furan and chlorinated organic levels in effluent, pulp, sludges, and process streams and the mills plans to control them. The response to all of the information was fisheries closures and health advisories to limit consumption. The shellfish industry near coastal pulp mills (Woodfibre, Port Mellon, Prince Rupert), and seven other coastal areas in B.C. was closed in 1988 and 1989. Also, Health and Welfare Canada (May 1989) issued health advisories for nine recreational and native shellfish coastal sites, for four inland B.C. locations and for one Quebec (La Tuque mill) inland location. In March 1989, Environment Canada developed draft regulations under CEPA to control chlorinated dioxin/furans in pulp and paper mill wastes, which became the foundation for the 1992 CEPA and Fisheries Act changes.

One of the first studies investigating effluent treatment for dioxin/furans was reported in 1990 (Barton, et al., 1990). This study conducted a screening of physicochemical treatment effectiveness. Out of eight technologies applied[44], only precipitation by alum or lime was effective in reducing dioxins (98% reduction at

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44 Alum and Lime Precipitation, cationic polymer, activated carbon, synthetic resin, ozonation, solvent extraction, and acid precipitation.

dosage of 9000 mg/L) in bleach plant filtrates. To final effluents, lime and alum precipitation achieved 50% dioxin reduction at low doses (200 mg/L), but a portion of this reduction can be attributed to TSS reduction.

In Canada, McCubbin (1992) has reported that between 1989 and 1991 highly significant advances were made by the Canadian kraft pulping industry in reducing dioxin/furan levels. This was attributed mainly to industry associations, which conducted four surveys to provide information of dioxins in kraft mill effluent. In 1989, the Pulp and Paper Research Institute of Canada (PAPRICAN) surveyed kraft pulp mills and conducted extensive research to determine the cause of dioxin/furan formation in pulp and paper mill effluent. Mills were asked to define their 1988 baseline operational parameters for brownstock kappa no., active chlorine multiple, and per cent chlorine dioxide substitution before any preventative action had been implemented. In the same year, the CPPA organized a national dioxin study, conducted over a 3-5 day period, at all mills using chlorine as a bleaching chemical. In late 1990, PAPRICAN conducted a third survey to update the information procured in the national survey In July 1991, a fourth survey of Canadian kraft pulp mills was completed by PAPRICAN to obtain TCDD/TCDF and AOX effluent discharge levels.

From the information, a relationship was established between the active chlorine multiple and dioxin formation. As a result, reducing the amount of bleaching chemicals, increasing chlorine dioxide substitution, especially in the first stage of bleaching, reformulating the additives used in pulp washing, and removing anti-foaming agents, were found to minimize the production of dioxin/furans. Biological treatment of effluents was also indicated to be effective in reducing dioxin levels in the final effluent. Mills began to implement these process changes. By July 1991, 60% of the kraft bleach lines operated with the new techniques, compared to 33% in 1989 having the equipment available to implement these processes. Even these 33% non-compliance mills reduced their dioxin discharges since 1989 by 75%. The data summarized in TABLE C.2 indicates that average discharge of dioxin/furans in toxicity equivalents is reduced by over 98% with the dioxin reduction technology and

20-25% by biological treatment. For AOX, bleach plant changes accounted for 50-60 % reduction and biological treatment reduced AOX levels by 40-55%.

TABLE C.2: Effects of Dioxin Reduction Technology and Biological Treatment on Effluent Discharges by Canadian Bleached Kraft Mills (McCubbin, 1992)

MILL CLASS	AVG CHLORINE USE kg/ADMT	AVG TOXICITY EQUIVug/ADMT	AVG AOX kg/ADMT
dioxin tech-biotreat	22.1	0.3	1.5
dioxin tech-no biotreat	24.8	0.4	2.7
1988 pre-dioxin tech-biotreat	56.5	22.3	3.1
1988 pre-dioxin tech-no biotreat	57.2	28.4	6.7

During the process of determining the rate of dioxin/furan production relationship between active chlorine multiple and per cent chlorine dioxide substitution, the quantities were so small as to became non-measurable. The term measurable, to be used in the new federal dioxin regulations, is a set level, i.e., that level below which samples are considered non-measurable due to the equipment inaccuracies and background levels of dioxin/furans. An effluent sample may have a detectable level of 2-5 ppq, but is not considered measurable because it is below the set 15 ppq limit.

Variation of results occurred among the mills. In mills employing the dioxin/furan reducing methods, some still had high levels of dioxin/furan formation. Within the group that had not yet employed the techniques, some mills observed low levels. In early 1991, a questionnaire was sent to bleached chemical pulp mills to determine the unexplained appearance of the dioxin/furans. The following summarizes the events affecting the effluent levels (McCubbin, 1992):

- unstable mill operations at the time of sampling resulted in elevated chemical charges in the first stage of bleaching;

- degree of mixing of pulp and chemical in the first stage of bleaching varied and pockets of excess chemical remained at the end of stage;
- dredging sludge formed during the aerated stabilization basin sampling period had disturbed deposition laid down prior to the implementation of the dioxin reduction technology;
- during bleach plant modifications, contaminated deformer remaining at the bottom of an old storage tank had been washed out during the sampling period; and
- dioxins were being leached from an old creosote-lined effluent pipe and once replaced with steel piping reduced 2378-TCDF levels in final effluent from 3000 ppq to under 50 ppq.

In 1990, the American Paper Institute published an article in Pulp and Paper Journal summarizing dioxin sources (McCubbin, 1992). In observing the results (See TABLE C.3), McCubbin questioned why the pulp industry is under so much more pressure than other higher sources. Information about the pulp industry reducing dioxin levels since 1988 has not been promoted in the media, even though it has been published in professional journals.

TABLE C.3: U.S. Annual Releases of Dioxin in 1990 by the American Paper Institute (McCubbin, 1992)

SOURCES	% TOTAL ANNUAL RELEASES OF TOXIC EQUIVALENTS (dioxins+furans)=39309 grams
Municipal Incineration	60.3
Fuel Combustion	15.4
Secondary Copper Furnaces	11.2
Forest Fires	4.5
Public Treatment Works	2.6
Magnesium Production	2.4
Hospital Incineration	1.4
Ind. & Haz. Waste Incineration	0.8
Pulp and Paper Industry	0.8
Other	0.6

DIOXIN IN ALBERTA

As part of a larger 10 point program announcement, the Alberta Minister stated several directives regarding dioxins (MacNichol, 1989). The points pertaining to dioxins included:

- testing dioxins downstream of Alberta's two kraft mills;
- ambient data collection of dioxins;
- doing a risk assessment of human and environmental health from dioxins within the pulp mill context;
- development of multi-media standards for dioxins from all pathways;
- monitoring of dioxin research in US and Ontario.

In the fall of 1990, Alberta Environment released an advisory to limit consumption of some freshwater fish in limited areas of the province. Based on fish samples over three years (See TABLE C.4) and on human health risk assessed by Health and Welfare Canada, the government decided to adopt a stringent interpretation of the available information. It recommended that the public restrict fish consumption for burbot, Dolly Varden, Mountain whitefish in the Athabasca River drainage and Mountain whitefish in the Wapiti and Smoky River drainage.

Between 1987 and 1990, the Alberta Government conducted over forty fish samples near the WC Pulp Mill on the Athabasca River and PNGC Pulp Mill on the Wapiti River. The fish were tested as whole fish and/or fillets in individual and composites of four or five fish. Unacceptably high levels were measured in several of these samples, i.e., greater than 20 ppt for dioxin and furans.

It is interesting to note that although the government advised restrictions of fish consumptions to reduce human health risk, it also included a disclaimer that dioxin/furans were a cause of fish cancer.

"While dioxins are sometimes implicated in fish cancers in heavily industrialized eastern lakes and rivers, there is no information or reason to conclude this occurs in Alberta. Skin lesions and cancers also occur in pike and walleye in rivers not affected by pulp mills." (Alberta Environment Press Release Kit July 1990)

TABLE C.4: Summary of Dioxin Furan Data for Alberta Fish (Alberta Environment Press Release Kit July 1990)

RIVER	SAMPLING SITE	SPECIES	NUMBER & FISH PART TESTED	DIOXIN (ppt) 2,3,7,8 T4CDD	FURAN (ppt) 2,3,7,8 T4CDF
Athabasca	Below Weldwood mill fall 1987	longnose sucker	5 whole	12.6	49.4
	15-20 km below Weldwood mill fall 1989	longnose suckers	5 whole 10 fillet	2.6 1.6	8.0 4.3
		whitefish	15 whole 15 fillet	18.1 10.2	41.1 26.7
		burbot	1 whole 9 fillet	21.2 2.0	66.8 7.7
		Dolly Varden	5 whole 5 fillet	21.9 12.1	20.9 12.7
		rainbow	3 fillet	6.7	5.2
Wapiti	Below PG mill fall 1987	longnose sucker	5 whole	11.4	203.4
	1-10 km below PG mill fall 1989	white sucker	5 whole 10 fillet	5.5 4.0	23.2 9.8
		whitefish	10 fillet	18.7	156.8
		walleye	5 fillet	1.8	4.3
		northern pike	8 fillet	1.5	9.5
Peace	Below & above Daishowa mill site fall 1988	goldeye	10 fillet	ND	4.1
		walleye	10 fillet	ND	<1.6
		northern pike	5 fillet	ND	<1.6
Rock Lake	Control fall 1989	whitefish	5 whole 5 fillet	<2.3 <1.9	<1.9 <2.2

APPENDIX D – EXCERPTS FROM DISCOURSE AND POWER

The following are direct quotes from "Discourse and Power in Environmental Politics: Public Hearings on a Bleached Kraft Pulp Mill in Alberta, Canada" written by M. Gismondi and M. Richardson. These excerpts are presented here in detail to emphasize the importance of discourse between industry and public.

THE MARKET MADE ME DO IT

ALPAC maintained throughout that they were responding to impersonal market forces. Because their clients wanted bright white paper with strong fibres, they were forced to bleach their pulp with chlorine. Likewise, market requirements for strong white fibres explained why, though ALPAC was supportive of recycling in principle, they could not mix in recycled fibres – because this could lower the whiteness of pulp made from the Alberta's virgin hardwood fibre.

Ms. Peruniak (housewife): What do you base your market research on?

Mr. Fenner (ALPAC):...the market itself.

Ms. Peruniak: ...I put it to you that within the next decade, you are going to see major changes in the bleached kraft pulp market. And I think my estimations are probably as good as yours...

Dr. Schindler (Board Member): Mr. Fenner to what extent does the pulp and paper industry determine that these markets can be driven rather than predicted. They push the markets in the directions they want them to go. It is my experience from soap and detergent companies and the power industry that these markets can be driven rather than predicted. They push the markets in the directions they want them to go. I once overheard one, admittedly drunken, detergent executive brag to one of his colleagues that

> they could package horse shit in a yellow and orange box and housewives would still buy it.
>
> Ms. Peruniak: Not this housewife.

ALPAC's "Mr. Fenner" does not define the complex word "market". But the word "market" empowers his discourse...is persuasive because ALPAC appears subordinated to market laws and market rules carved in stone...(implying) it is consumers who actually forced ALPAC to pollute because "the market is you not me", the consumers of shiny white paper.

...Schindler ... breaks through this dominant discourse...he will not accept economic rationales as a justification for evading responsibility for environmental damage...By unmasking the myth of an impersonal market, he reasserts that corporate salesmen create markets, that they can and do manipulate consumers.

...Ms. Peruniak's retort ... asserts sovereignty of the thinking consumer...1990s of environmentally conscious persons who refuse to be victims of the market or corporate decision makers.

THE LC_{50} TEST: THE MAN WHO LOVED FISH

To this point in the review of the project, the public had accepted without question a "technologist" understanding of scientific tests. The LC_{50} appeared in the EIA as simply a set of procedures agreed upon and set out in a government policy manual. The government technologist who reviewed the ALPAC data checked to see that they followed the procedures. The scientist's job was to report the results of the test on the stand to the panel. Either the effluent passes or fails the test and the theatricality of it is much like that of a coroner at a murder trial. ALPAC's data suggested they would routinely pass this test, unlike many B.C. mills. Alberta Environment agreed. But Dr. Birtwell, Fisheries and Oceans Canada, drawing his research on fish downstream from kraft pulp mills on the Fraser River alters the discourse.

> Dr. Birtwell: My main area of research is on the sub-lethal effects of contaminants, that is, levels that don't inherently kill fish outright, but perhaps have may have an affect at a level below that, that would have killed them...many times an animal may be debilitated and essentially ecologically dead by conditions far below those which kill it in four days, and kill 50% of them in four days. Surely what we are trying to do is protect that level of populations, the zero to 50% that is sensitive. In regulatory bioassays where effluents are exposed to fish, typically one may consider the effluent as being acceptable if it does not kill 50% of the test fish within four days. Well, from my perspective, it's those zero to 50% which are equally important. For biological purposes, we've typically used the 50% response level, but I think we also have to consider response at the 1%, the 5% and the 10% level. Those fish, or whatever animal, we are studying and testing, is also of relevance in the environmental context.

Here Birtwell questions...the underlying assumptions of the test...His "love of fish" reveals a subjective aspect of science which is stunning after months of dry, passive discussions of whether the mill's effluent would pass the LC_{50} and cause no harm... Birtwell breaks us free from this timeless, object-object way of seeing science...Birtwell's subject-object intervention enlarges human agency and responsibility...when local people showed emotion their points were devalued as non-rational appraisals of the project. Dr. Birtwell, a representative of the Government of Canada, and a scientist studying the effects of pulp mill effluent on fish, made his emotional expression of the love of fish and changed all that.

UNIONS AND CHLORINE BLEACHING

The CPU ...read a prepared text questioning the appropriateness of chlorine bleaching in the ALPAC's proposed mill...chlorine bleaching should be phased out in existing plants and that no new plants using this process should be built.

> Dr. Schindler: So is this not tantamount to endorsing that the occupation that your members hold be rendered extinct?
>
> Mr. Coles (CPU): Well, I guess we have to face the realities of life. I'll use for an example when people worked in asbestos mines and were assured it was good for their health, they ended up with problems and had to make changes. We as a union and us as a society, are having to wrestle with a lot of these environmental issues brought to fruition in the last years. There are problems with pulp and paper, and we appreciate that.
>
> Mr. Fenner: ...are you going to not try to organize this mill because of your concern about the environment?
>
> Mr. Coles: ...we'd never disassociate ourselves from any class of worker, whether it's in this pulp mill or any other.
>
> Mr. Neuman (CPU): We believe that workers should be represented by unions everywhere, no matter whether we think the project that they are working on is ideal or not. So that's kind of an irrelevant question.

The CPU's intervention arrested two broad public discourses often heard since the mill was announce. The first was that industrial workers were anti-environmentalists because environmentalists threatened their jobs. The CPU spoke at the invitation of Friends of the Athabasca and their intervention indicated that pulp mill workers are willing to work with environmentalists to promote environmentally sound developments.

The CPU speakers also undermined the powerful argument that the proposed jobs would solve the employment problems of northern Albertans... By linking the jobs directly to a potential health hazard for mill workers, the CPU added a sobering dimension to these potential jobs - a potential health hazard for the youth of Athabasca and northern Alberta.

...Finally, Mr. Fenner's query as to whether the CPU would refrain from organizing the ALPAC plant based on environmental grounds confirmed in an ironic way how labour-capital struggles play themselves out even within this discursive field of the environmental hearing. The responsible comebacks of the CPU speakers laid bare some fundamental opposition of labour and capital within the debate on the environment in the 1990s.