Appendix A

Nova Scotia Joint Stocks Record

Profile

Printer Version

Profile Info | People Info | Activites Info | Related Reg's Info

PROFILE - NORTHERN PULP NOVA SCOTIA CORPORATION - as of: 2018-11-09 09:30 AM

Business/Organization Name:	NORTHERN PULP NOVA SCOTIA CORPORATION
Registry ID:	3227808
Type:	N.S. Unlimited Liability
Nature of Business:	
Status:	Active
Jurisdiction:	Nova Scotia
Registered Office:	1969 UPPER WATER STREET, SUITE 1300 HALIFAX NS Canada B3J 3R7
Mailing Address:	P.O. BOX 730 HALIFAX NS Canada B3J 2V1

PEOPLE

Name	Position	Civic Address	Mailing Address
John Hamm	Director	112 High Street Stellarton NS B0K 1S0	
Choong Wei Tan	Director	Airport Executive Park - Bldg. 2, #95 - 10551 Shellbridge Way Richmond BC V6X 2W8	
Bruce Chapman	General Manager	132 Cardinal Court New Glasgow NS B2H 5S5	
JOHN ROBERTS	Recognized Agent	1969 UPPER WATER STREET, SUITE 1300 HALIFAX NS B3J 3N2	P.O. BOX 730 HALIFAX NS B3J 2V1

ACTIVITIES

Activity	Date
Annual Renewal	2018-03-16
Annual Statement Filed	2018-03-16
Annual Renewal	2017-05-31
Annual Statement Filed	2017-05-31

Change of Directors	2017-03-16
Special Resolution	2016-12-05
Change of Directors	2016-11-16
Annual Renewal	2016-04-01
Annual Statement Filed	2016-04-01
Annual Renewal	2015-04-27
Annual Statement Filed	2015-04-27
Change of Directors	2015-04-02
Annual Renewal	2014-05-05
Annual Statement Filed	2014-05-05
Change of Directors	2014-03-03
Change of Directors	2013-08-29
Change of Directors	2013-08-29
Change of Directors	2013-06-20
Annual Renewal	2013-05-02
Annual Statement Filed	2013-05-02
Annual Statement Filed	2012-04-20
Change of Directors	2012-04-13
Annual Renewal	2012-04-11
Change of Directors	2011-12-16
Change of Directors	2011-06-13
Annual Renewal	2011-05-31
Change of Directors	2011-02-11
Address Change	2011-02-03
Appoint an Agent	2011-02-03
Address Change	2011-02-03
Change of Directors	2011-02-03
Annual Statement Filed	2010-05-19
Annual Renewal	2010-05-19
Change of Directors	2010-02-08
Special Resolution	2010-02-08
Change of Directors	2009-12-08
Special Resolution	2009-10-23
Annual Statement Filed	2009-05-13
Annual Renewal	2009-05-13
Change of Directors	2008-11-19
Change of Directors	2008-09-12

Special Resolution	2008-09-08
Special Resolution	2008-09-08
Special Resolution	2008-06-03
Filed Document	2008-06-03
Change of Directors	2008-04-29
Appoint an Agent	2008-04-28
Address Change	2008-04-28
Special Resolution	2008-04-28
Change of Directors	2008-04-28
Incorporated and Registered	2008-04-28

Show All Collapse

RELATED REGISTRATIONS

This Company ...	
NORTHERN PULP	Registered
NORTHERN PULP NOVA SCOTIA	Registered

Appendix B

NPNS Market Profile

Global Market Profiles

NBSK, UKP and BCTMP

Prepared for:

Northern Pulp Nova Scotia Corporation

By:

BRIAN MCCLAY & ASSOCIATES INC.

January 26, 2018

Brian McClay
& ASSOCIATES INC.

Global Market Profiles: NBSK, UKP & BCTMP

Summary

Brian McClay & Associates Inc. was engaged by Northern Pulp Nova Scotia Corporation to access the viability from a future marketing/sales perspective of converting the existing Pictou Northern Bleached Softwood Kraft (NBSK) mill to produce either Unbleached Kraft Pulp (UKP) or Bleached Chemi-Thermo-Mechanical Pulp (BCTMP).

For the reasons outlined in the following report, we conclude that continuing to produce premium reinforcement NBSK is the most competitively viable option by far for the Pictou, NS mill.

Brian McClay January 26, 2018
Principal
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Montreal, Canada
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Global Market Profiles: NBSK, UKP & BCTMP

JANUARY 26, 2018

Global Market Profiles:

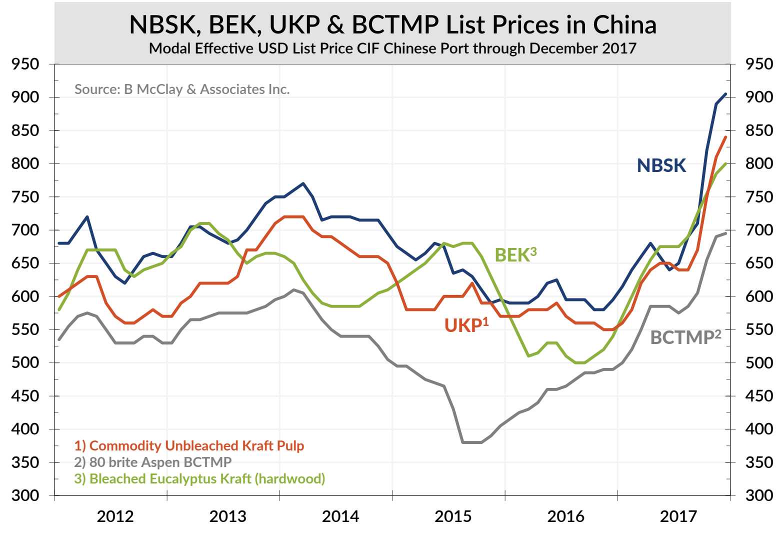
1. **Northern Bleached Softwood Kraft (NBSK)**
2. **Unbleached Kraft pulp (UKP)**
3. **Bleached Chemi-Thermo-Mechanical Pulp (BCTMP)**

Northern Bleached Softwood Kraft (NBSK)

There is a wide range of pulp qualities within the NBSK category, from commodity grades, usually from coastal or pine forests, to premium reinforcement pulp (PRP), which mainly comes from Boreal and sub-boreal forests in Canada's interior regions with their high content of spruce and balsam fir and to a much lesser extent in Finland.

PRP NBSK, such as that produced by the Pictou mill, is prized by papermakers around the world for its long, ribbon-like fibres which impart 'sheet strength' so that paper machines can run faster without the paper sheet breaking. NBSK is virtually always blended with higher percentages of other, normally lower cost and lower quality pulp grades to form fibre furnish recipes for particular end-uses and in that sense it has become a 'specialty' pulp and is priced as such (figure 1).

Fig. 1



Approximately 40% of global NBSK supply in 2015 was used in the production of tissue/toweling paper (20% in 2005), 30% for printing & writing paper (55%), 25% for specialty papers (17%) and 5% in other paper and boards (8%).

Demand

World NBSK demand in 2017 totaled just over 15 million tonnes; up 1.9% y/y with an annual average growth rate of 1.1% during 2007-2017 (figure 2) driven largely by close to 10% annual average growth in China (figure 3) more than offsetting declining demand in North America, Europe and Japan where the production of printing and writing paper, especially of the lightweight coated and uncoated mechanical paper grades for news magazines and catalogs that were the natural big users of NBSK has been contracting. However, with accelerating demand for premium tissue and toweling paper, especially in China but along with continued growth in specialty papers, global demand for NBSK could grow at a 1-2% annual average rate over the next 10 years.

Fig. 2

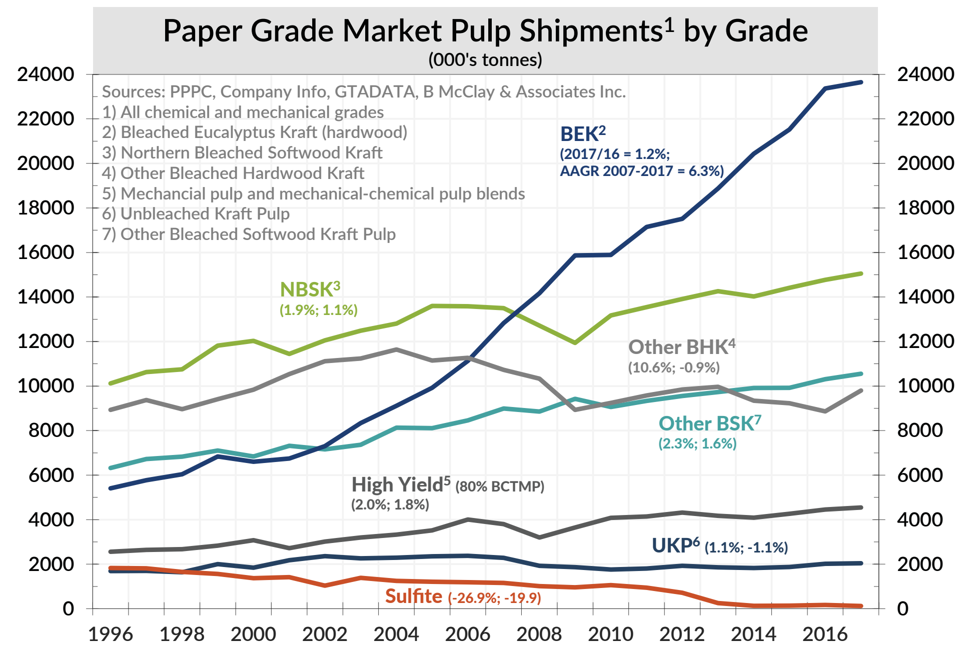
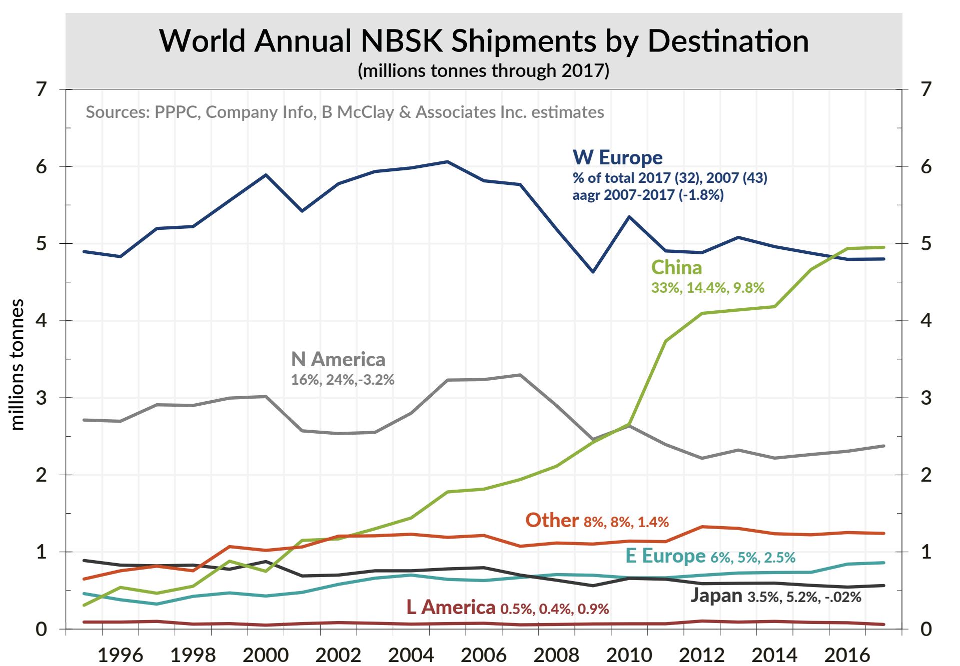


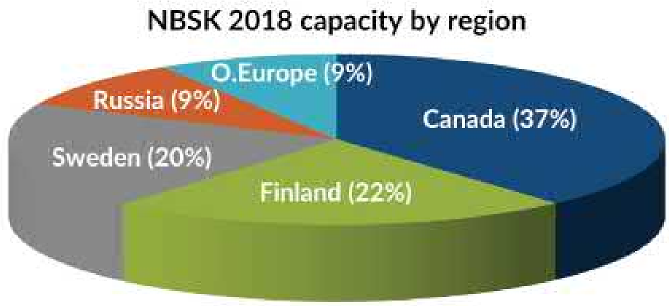
Fig. 3



Supply

Canada remains the world largest market NBSK producer by far. Its 21 mills (figure 4) account for 37% of the world's NBSK market pulp capacity. Finland, Sweden and Russia are other import producers of commodity NBSK (figure 5).

Fig. 5



The outlook for medium-to-long-term supply growth sees potential reductions in Western Canada (due mostly to wood shortages caused by the Mountain Pine beetle in the BC interior and harvesting restrictions in coastal areas) and further modest increases in Sweden and Finland. While Russia's Far East (Siberia) hosts the largest supply of softwood forests in the world and there are many projects in the works, its low forest quality (e.g. too much larch), lack of adequate logistical infrastructure and considerable political risk will likely continue to limit major investment in the sector for the foreseeable future.

Since there should be little growth (probably reductions) in PRP NBSK supply, its future demand/supply balance and prices should remain stronger than for commodity grades of NBSK.

Fig. 4

NBSK Mills in Canada 2018

Capacity: '000t/yr

Mill	Parent Co.	Country	Region	Bl. Kraft Swd	Bl. Kraft Hwd	Bl. Sulphite Swd	Bl. Sulphite Hwd	Bl. Sulphite Nes	Unbleached Kraft	Unbleached S'ite	NWP	Total Mkt	Total * All Pulp	Sel
Al-Pac	Hokuetsu Kishu Paper	Canada	N. America	70	580	0	0	0	0	0	0	**650**	**650**	
Northwood Mill	Canfor Pulp Prod.	Canada	N. America	590	0	0	0	0	0	0	0	**590**	**590**	
Celgar Pulp Mill	Mercer Intl.	Canada	N. America	520	0	0	0	0	0	0	0	**520**	**520**	
Peace River Mill	Nippon Paper Ind.	Canada	N. America	210	250	0	0	0	0	0	0	**460**	**460**	
Howe Sound	Paper Excellence	Canada	N. America	430	0	0	0	0	0	0	0	**430**	**430**	
Grande Prairie Mill	Intl. Paper	Canada	N. America	385	0	0	0	0	0	0	0	**385**	**385**	
St-Félicien Mill	Resolute Forest Prod.	Canada	N. America	375	0	0	0	0	0	0	0	**375**	**375**	
Hinton Pulp Mill	West Fraser	Canada	N. America	375	0	0	0	0	0	0	0	**375**	**375**	
Kamloops Mill	Domtar Corp.	Canada	N. America	260	0	0	0	0	110	0	0	**370**	**370**	
Cariboo Pulp	West Fraser & Daishowa	Canada	N. America	355	0	0	0	0	0	0	0	**355**	**355**	
Terrace Bay Mill	Aditya Birla	Canada	N. America	350	0	0	0	0	0	0	0	**350**	**350**	
Saint John Paper	Irving Forest Services	Canada	N. America	190	160	0	0	0	0	0	0	**350**	**820**	
Crofton Pulp & Paper	Catalyst Paper Corp.	Canada	N. America	335	0	0	0	0	0	0	0	**335**	**625**	
Harmac Pacific	Nanaimo Forest Prod.	Canada	N. America	330	0	0	0	0	0	0	0	**330**	**330**	
Dryden Mill	Domtar Corp.	Canada	N. America	330	0	0	0	0	0	0	0	**330**	**330**	
Intercontinental Mill	Canfor Pulp Prod.	Canada	N. America	315	0	0	0	0	0	0	0	**315**	**315**	
Espanola Mill	Domtar Corp.	Canada	N. America	270	40	0	0	0	0	0	0	**310**	**335**	
Thunder Bay Mill (Resolute Forest Products)	Resolute Forest Prod.	Canada	N. America	200	90	0	0	0	0	0	0	**290**	**575**	
Skookumchuck Kraft Mill	Paper Excellence	Canada	N. America	275	0	0	0	0	0	0	0	**275**	**275**	
Pictou Mill	Paper Excellence	Canada	N. America	270	0	0	0	0	0	0	0	**270**	**270**	
Mackenzie Mill (Paper Excellence)	Paper Excellence	Canada	N. America	235	0	0	0	0	0	0	0	**235**	**235**	

Unbleached Kraft Pulp (UKP)

UKP is almost always made from softwood or coniferous wood fibre but there are also very small volumes of hardwood UKP being produced at several mills.

It goes into a range of end-uses from commodity packaging applications (60%) such as linerboard for corrugated boxes, sack kraft for cement bags and kraft papers for food wrap and grocery bags to specialty products (38%) like filter papers and fibre-cement board (used in the interior walls of homes and buildings to help prevent mold and moisture damage) to higher-end 'e' grades for electrical applications such as capacitor paper. Each of these end-uses has particular performance requirements.

[It is important to note that over 95% of the world's output of commodity (brown) packaging grades is produced in fully integrated pulp/paper mills or at mills that use only recycled paper and therefore do not purchase 'market' UKP. (Integrated mills produce pulp and use that pulp to make paper in a continuous process at the same site.)]

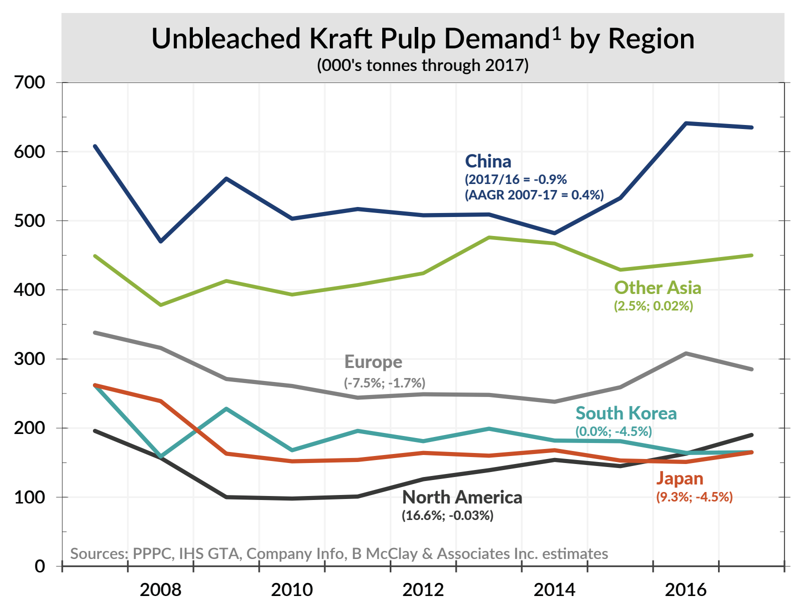
Demand

In 2017, the global market for UKP totaled just over 2 million tonnes (figure 2).

While world UKP demand has increased over the past 2 years, it had been in modest decline since its 2006 peak mostly as a result of the decreasing use of paper bags and sacks to competition from plastic and reusable alternatives. The medium-term demand outlook calls for modest growth (1-2% pa) with fibre cement board leading the way followed by specialties. (There is also a small and growing market for unbleached tissue, at least in China, but that is being fed by unbleached bamboo pulp.)

China is by far the world's largest market for UKP (figure 6) where it is used predominantly for packaging paper and some specialties. There is virtually no fibre cement board used in China whereas fibre cement board accounts for the vast majority of demand in North America.

Fig. 6



Supply

There are 25 pulp mills in the world that produce market UKP (figure 7) with the biggest (Arauco) located in very low cost Chile. Some single-line mills produce only UKP while 2-line mills can also produce other pulp grades (e.g.) NBSK.

Fig. 7

World Market UKP Mills 2018

Capacity: '000t/yr

				Bl. Kraft		Bl. Sulphite			Unbleached			Total Mkt	Total *	
Mill	**Parent Co.**	**Country**	**Region**	**Swd**	**Hwd**	**Swd**	**Hwd**	**Nes**	**Kraft**	**S'ite**	**NWP**		**All Pulp**	*Sel*
Constitución Mill	Celulosa Arauco	Chile	S. America	0	0	0	0	0	360	0	0	**360**	**360**	
Tanigawa Mill	Hyogo Pulp Ind.	Japan	Japan	0	0	0	0	0	200	0	0	**200**	**200**	
Prince George Mill	Canfor Pulp Prod.	Canada	N. America	0	0	0	0	0	150	0	0	**150**	**300**	
Tasman Mill	Oji Paper	New Zealand	Australasia	175	0	0	0	0	115	0	0	**290**	**290**	
Kamloops Mill	Domtar Corp.	Canada	N. America	260	0	0	0	0	110	0	0	**370**	**370**	
Koryazhma Pulp & Paper Mill	Ilim Group	Russia	E. Europe	0	15	0	0	0	110	0	0	**125**	**1,000**	
Vallviks Bruk	Rottneros	Sweden	W. Europe	140	0	0	0	0	100	0	0	**240**	**240**	
Pitkyaranta Pulp Mill	SFT Group	Russia	E. Europe	0	0	0	0	0	100	0	0	**100**	**100**	
Zhalantun Mill	Inner Mongolia Forestry	China	China	0	0	0	0	0	100	0	0	**100**	**100**	
Ust-Ilimsk Pulp Mill	Ilim Group	Russia	E. Europe	580	0	0	0	0	80	0	0	**660**	**660**	
Halsey Mill (International Grand Investment Corporation)	Intl. Grand Inv. Corp.	USA	N. America	90	0	0	0	0	70	0	0	**160**	**160**	
Bäckhammars Mill	Shanying International Holdings	Sweden	W. Europe	0	0	0	0	0	70	0	0	**70**	**190**	
Tacoma Kraft Mill	WestRock	USA	N. America	0	0	0	0	0	70	0	0	**70**	**440**	
Frantschach Mill	Mondi	Austria	W. Europe	0	0	0	0	0	55	0	0	**55**	**250**	
Laja Mill	CMPC	Chile	S. America	230	0	0	0	0	40	0	0	**270**	**360**	
Huaihua Paper Mill	Tiger Group	China	China	0	0	0	0	0	35	0	0	**35**	**80**	
Aspa Bruk	Ahlstrom-Munksjö	Sweden	W. Europe	170	0	0	0	0	30	0	0	**200**	**200**	
Mudanjiang Pulp Mill	Heilongjiang Sida Intl. Paper	China	China	0	0	0	0	0	30	0	0	**30**	**30**	
Pietarsaari Mill	UPM	Finland	W. Europe	505	260	0	0	0	25	0	0	**790**	**790**	
Skärblacka Mill	BillerudKorsnäs AB	Sweden	W. Europe	45	0	0	0	0	25	0	0	**70**	**435**	

UKP Options for Paper Excellence, Pictou, Nova Scotia mill

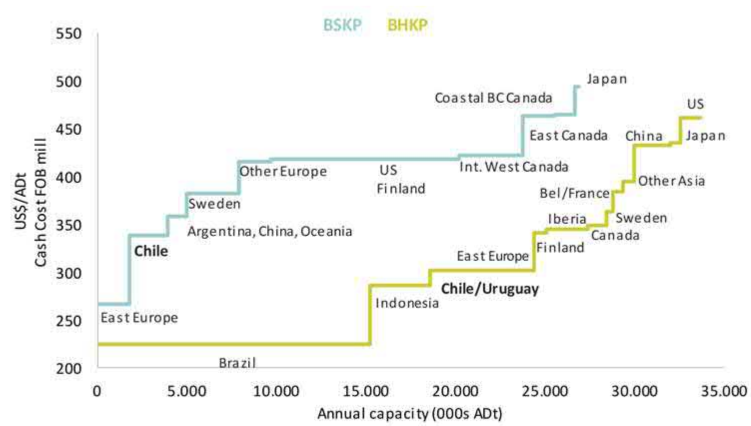
Pictou mill could technically produce 100% UKP or it could continue to make NBSK and some UKP in campaigns. (However, there is a major economic problem with UKP campaigns in that it inevitably leads to considerable volumes of much less valuable 'transition' pulp during the mill's shift from producing one grade to the other. This pulp is always sold at a discount to standard pulp.)

- UKP from Pictou mill would not be acceptable for use in the 500k t/y fibre cement board business because of its regional wood species. While the premium coniferous boreal/sub-boreal wood fibre used to make NBSK by the Pictou mill is considered the world's best for graphic papers and premium tissue, it is not long and coarse enough for fibre cement board. Major fibre cement board producers (e.g.) James Hardie (AUS, USA) and Siam Cement (Thailand) demand UKP made with long coarse softwood fibre with Radiata (Arauco, Chile; Oji Fibre Solutions, NZ) preferred followed by Douglas Fir-based UKP from Western North America (Domtar, Kamloops, BC).

- UKP from Pictou mill could potentially compete in the global specialties sector but it is only 300k tonnes annually. Moreover, supplier/buyer relationships are entrenched as one would expect in the 'specialties' sector and based on technical/product performance collaboration and long-term commercial agreements. It would require a challenging, multi-year effort to potentially win even a modest sustainable share of these global end-use markets for exceptionally high quality UKP.

- UKP from Pictou mill could try to compete in the 'brown' packaging sector but due to the Pictou mill's size (270k t/y), it would have to gain market share in the big markets in Asia, China in particular. It would have to gain share from very low cost existing producers in Chile and Russia. [While there is no UKP cash-cost curve information available, figure 8 shows the Bleached Softwood Kraft (BSK) FOB cash-cost curve (i.e. FOB cash-cost = total mill production cost per tonne including wood, energy, chemicals and labour but excluding outbound pulp freight charges) as a close estimate of UKP cash-cost, revealing the significant advantages of mills in Chile and Russia (East Europe)].

Fig. 8



- UKP from Pictou would also be at risk of future competition from new UKP mills and alternative fibres. There are currently six BSK pulp mill projects being planned in Russia and one or more of them could eventually produce packaging grade UKP. In addition, there is increasing interest around the world, including in Canada and the USA, to turn agricultural waste materials, particularly wheat straw but also bamboo, into unbleached and bleached pulp mainly for packaging materials.

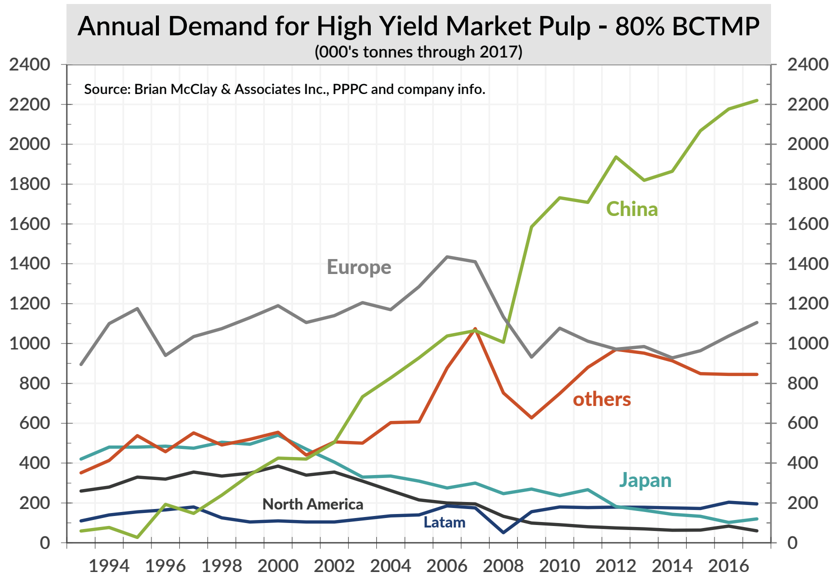
Bleached Chemi-Thermo-Mechanical Pulp (BCTMP)

Bleached chemi-thermo-mechanical pulp (BCTMP) accounts for about 80% of the world market for High Yield Pulps (HYP) - pulps produced via mechanical processes which have a pulp/wood yield of 90%+ vs. 45% for most chemical pulps, including NBSK and UKP. BCTMP – a hybrid of mechanical and chemical pulping processes - was first produced in Sweden in 1978 and it was marketed as a low-cost substitute for commodity hardwood kraft pulp. Today, BCTMP includes a range of unique grades categorized by species (softwood and hardwood), brightness and bulk.

Demand

World demand for high yield pulp (there are no publicly available statistics for BCTMP-only) totaled 4.55 million tonnes in 2017. It expanded at a 1.8% annual rate during 2007-2017 (figure 2) and the future medium-to-longer-term outlook sees that growth rate increasing to 2%+ given the accelerating demand for e-commerce and some minor fibre furnish share gains in the tissue sector in Asia.

Fig. 9



On a global basis, 50% of HYP is used in the folding boxboard (FBB) business where it is used in the middle plys of multi-layered FBB, about 40% in graphic papers, 6% in specialty papers and 4% in tissue/toweling.

China accounted for just under 50% of world high yield pulp demand in 2017 (figure 9).

Supply

There are currently 24 significant market BCTMP mills in operation worldwide (most mills in China are APMP mills which is a lower cost and quality variation of BCTMP) with an annual capacity of just under 4.5 million tonnes (figure 10, page 10). There are currently no confirmed plans to increase BCTMP capacity over the medium-term although Paper Excellence does have a 220k t/y hardwood BCTMP mill in Chetwynd, BC that was idled in September 2015 and could be restarted in the future. The key resource input for a successful BCTMP mill is low-cost electricity.

BCTMP Options for Paper Excellence, Pictou, Nova Scotia mill

Since none of the equipment needed to produce BCTMP is currently on site at Pictou, it would have to be purchased and installed at considerable expense – hundreds of $millions.

- After that, BCTMP from Pictou would very likely be relatively uncompetitive given Nova Scotia's relatively high electrical power costs vs. Quebec, Saskatchewan, Alberta and BC (figure 11, page 10) where existing BCTMP are located.

Fig. 10

Draft		Market BCTMP capacity - 2018				January 12, 2018	
Country	Company	Mill	Location	Annual Capacity ('000 tpa) Hardwood	Softwood	Wood species	Certification
Sweden	Rottneros	Rottneros	Rottneros	20	80	Aspen, spruce	FSC Mixed
	SCA	Östrand	Timrå	40	45	Birch, spruce	FSC Mixed
	Waggeryd	Waggeryds Cell	Vaggeryd	-	175	Spruce, pine	FSC Mixed/PEFC CoC[7]
Norway	Mayr-Melnhof	Folla	Follafoss		143	Spruce	FSC CoC (CW)/PEFC
Finland	Metsä Board	Kaskinen	Kaskinen	340[5]	-	Aspen, birch	FSC CoC, PEFC
Spain	Zubialde	Zubialde	Aizarnazabal		100[2]	Radiata Pine	FSC Mixed/PEFC
Canada	West Fraser	Quesnel River	BC	-	400	spf[3]	PEFC/SFI, FSC CoC (CW)[4]
	West Fraser	Slave Lake	Alberta	280	-	Aspen	PEFC/SFI, FSC CoC (CW)[4]
	Millar Western	Whitecourt	Alberta	230	100	Aspen, spf	PEFC/CSA, FSC CoC (CW)
	Paper Excel.	Meadow Lake	Saskatchewan	400	-	Aspen, spf	FSC CW[4]
	Canfor	Taylor	BC	-	209	spf	PEFC, FSC CoC (CW)
	Rayonier AM	Temiscaming	Quebec	230[9]	-	Aspen, maple	FSC Mixed
	Paper Excel.	Chetwynd	BC	240[11]	-	Aspen	FSC CW[4]
	Rayonier AM	Matane	Quebec	270	-	Aspen, maple	FSC Mixed
Estonia	Estonian Cell	Estonian Cell	Kunda	174	-	Aspen	FSC Mixed
NZ	Winstone Pulp	Karioi	Ohakune	-	205	Radiata Pine	FSC Mixed
	Pan Pac Forest	Whirinaki	Napier		200[8]	Radiata Pine	FSC Mixed
Russia	Int'l Paper	Svetogorsk[13]	NW Russia	120	40	Aspen, spruce	FSC Mixed
China	Zhongmao	Dezhou	Shandong	100[1,6]	-	Poplar	
	Chenzhou Yunong	Chenzhou city	Hunan	170		Euca	
	Fujian Tengrongda	Sanming	Fujian	40[1]	-	Poplar	
	Dongming	Dongming	Shandong	50[1*]	-	Poplar	
	Jiangsu Jinlida	Huai-an	Jiangsu	60[1*12]	-	Poplar	
	Shand'g Tianyuan	Yanzhou	Shandong	50[1*]	-	Poplar	
World				2774	1697		

1. APMP. *=wetlap
2 Bleached and Unbleached
3 SPF=Spruce, Pine, Fir
4 FSC controlled wood, pulp is a bleand of mostly aspen with some SPF
5 not all market pulp
6 Zhongmao, Dezhou mill currently closed. Likely permanent.
7 CoC is Chain-of-custody
8 Additional 100k tonnes of TMP.
9 300k total capacity and 230k for market.
10 130k total capacity but around 60k for market.
11 Idled September 11, 2015.
12 Partly integrated.
13 Total capacity is 220k with 60k on-site use.

Brian McClay & ASSOCIATES INC.

Fig. 11

General Service – Large Industrial

One Month Bill For:
Customer-Owned Transformation
Service at Transmission Voltage exceeding 100 kV
100% Power Factor

	100,000 kW / kVA 62,000,000 kWh	¢/kWh
Nova Scotia Power[1]	$ 5,619,960	9.064
NB Power	$ 4,631,000	7.469
SaskPower	$ 4,465,355	7.202
BC Hydro	$ 3,845,142	6.202
Hydro Ottawa[2]	$ 3,055,761	4.929
Hydro Quebec	$ 3,028,740	4.885
Newfoundland & Labrador Hydro[3]	$ 3,026,500	4.881
Manitoba Hydro	**$2,636,460**	**4.252**

Note:
1 An interruptible credit has been applied.
2 Includes the Class A Global Adjustment as determined by the corresponding utility and is based on the utility's contribution to Ontario's peak demand.
3 Does not include annual charges for customer plant in service that may apply to specific customers.

Brian McClay is the principal consultant at **Brian McClay & Associates Inc.**, a privately-held pulp and paper competitive intelligence consultancy based in Montreal, Canada. Its primary function is to assist subscribers and clients track global pulp market conditions and to plan for future marketplace challenges and opportunities.

Brian established the company (formerly TerraChoice Market Services Inc.) in 1997 after a long career at the Montreal-based **Canadian Pulp and Paper Association** where he was Senior Vice President, Trade and Government Affairs.

In addition, he is currently also **Chairman of Trade Tree Online**, a US-based, third-party reference price index provider and a partner in Pulp Partners s.a.r.l., a Switzerland-based private company that offers a pulp & paper industry-specific mobile application or "APP" called **PIG© (Pulp Info Global).**

Brian McClay & Associates Inc. is the publisher of the **Market Pulp Monthly** report whose current subscribers include companies that account for about 75% of global market pulp supply as well as many pulp buyers, traders, agents, banks and other financial institutions, governments and various service providers to the pulp business.

Brian McClay & Associates Inc. also provides a **strategic business consultancy service**, with the assistance of independent professional associates as needed.

The company has prepared medium to long-term (to 2030) **Global Market Pulp Outlook reports** for individual clients such as Mercer International, Metsa Fibre, Expera Specialty Solutions, Oji Fibre Solutions, CellMark Pulp, Ekman Group, Oji China, Government of Canada, Goldman Sachs and Norddeutsche Landesbank.

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Appendix C

2017 Technology Selection Report

NORTHERN PULP
NOVA SCOTIA CORPORATION
A PAPER EXCELLENCE COMPANY

DILLON
CONSULTING

Northern Pulp Nova Scotia Corporation
New Glasgow, NS

Preliminary Engineering for Effluent Treatment Plant Replacement

Technology Selection Summary

Report No.: 11 1112C
July, 2017

NORTHERN PULP
NOVA SCOTIA CORPORATION
A PAPER EXCELLENCE COMPANY

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Table of Contents

I. Background……………………………………………………...…………….……………. 6

II. Existing Conditions ………….….………….…………………………………………….. 8

III. Hydraulic Loading ……………………..…..………..…………..…….….……………………. 12

IV. Organic Loading ……………………………………..……………..…………………………. 14

V. Effluent Treatment System Technology Selection……..…………….……………………………… 92

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List of Acronyms

A	Ampere
a	annum, year
AAC	annual allowable cut
ADt	air dry metric tonne
adubmt	air dry unbleached metric tonne
AOX	absorbed organic halogens
APMP	alkaline peroxide mechanical pulp
atm	atmosphere (pressure)
avg.	average
BAT	best available technology
BCTMP	bleached chemi-thermomechanical pulp
BD	bone dry
BDt/a	bone dry tonne per year
BDt/d	bone dry tonne per day
BEKP	bleached eucalyptus kraft pulp
BHKP	bleached hardwood kraft pulp
bhp	brake horse power
BKP	bleached kraft pulp
BOD	biological oxygen demand
BSKP	bleached softwood kraft pulp
Btu	British terminal unit
c	centi (prefix)
^{O}C	degree celsius
C$	Canadian dollar
cal	Calorie
CCA	capital cost allowance
CIF	cost, insurance, freight
CIS	Commonwealth of Independent States
C.M.D.	cross machine direction
cm	centimetre
COD	chemical oxygen demand
cs	carbon steel
csf	Canadian standard freeness
c	centi (prefix)
CWF	woodfree coated paper
CPVC	chlorinated polyvinyl chloride
D	chlorine dioxide bleaching stage
d	Day
D.O.	dissolved oxygen
D/P	differential pressure
dB	Decibel
DCS	distributed control system
DG	Dissolving Grade
dia.	diametre
EUR	euro (€)
EU /EC	European Union / Community
E	alkaline extraction stage
EBITDA	earning before interests, taxes, depreciation and amortisation
ECF	elemental chlorine free
EIA	environmental impact assessment
EOP	alkaline extraction stage reinforced with oxygen and hydrogen peroxide
^{O}F	degree Fahrenheit
Ft	finished metric ton
ft	foot
ft^2	square foot
fbm	foot board measure
F.O.B.	free on board
FPC	forest products complex
g/cm^3	gram per cubic centimetre
g/m^2	gram per square metre
gal	US gallons
gdp	gross domestic products
gph	US gallons per hour
h	hour
H_2S	hydrogen sulphide
ha	hectare
hp	horse power
HVAC	heat, ventilation and air conditioning
Hz	hertz
IRR	internal rate of return
J	joule
kg	kilogram
km	kilometre
kV	kilovolt

List of Acronyms

kW	kilowatt
kWh	kilowatt hour
L	litre
LWC	lightweight coated papers
l/min	litre per minute
lb	pound
M	Mega (prefix)
m	metre
mg/L	milligram per litre
M.D.	machine direction
m/s	metre per second
m^2	square metre
MWC	medium weight coated papers
m^3	cubic metre
m^3 s.o.b.	cubic metre solid over bark
m^3 s.u.b.	cubic metre solid under bark
m^3/min	cubic metre per minute
MB	megabyte
MDF	medium density fibreboard
min	minute
MW	mega watt
µ	micro (prefix)
mm	millimetre
NA	not applicable
Nm^3	normal cubic metre
NCG	non-condensable gas
NPV	net present value
NSSC	neutral sulphite semi-chemical
O	oxygen delignification stage
OCC	old corrugated container
OSB	oriented strandboard
ONP	old newsprint
%	percent
P	hydrogen peroxide bleaching stage
Pa	pascal
ph	phase (power)
pH	hydrogen ion concentration
PLC	local control panel
PM	paper machine
ppm	parts per million
psig	pounds per square inch gauge
PGW	pressurised groundwood
P&W	printing and writing
RISI	Resources Information System Inc.
ROI	return on investment
ROE	return on equity
rpm	revolution per minute
s	second
SC	supercalandered
SGW	stone grounwood
SG&A	selling, general and administration
SOW	sorted office waste
ss	stainless steel
STD	standard
sq	square
t	tonne, metric ton
T	ton, short ton
TCF	totally chlorine free
TEF	totally effluent free
TMP	thermomechanical pulp
TRS	total reduced sulphur
TSS	total suspended solids
UHKP	unbleached hardwood kraft pulp
UKP	unbleached kraft pulp
US$	US dollar
USKP	unbleached softwood kraft pulp
UWF	woodfree uncoated paper
V	Volt
W	watt
WACC	weighted average cost of capital
Z	ozone bleaching stage

I. Background

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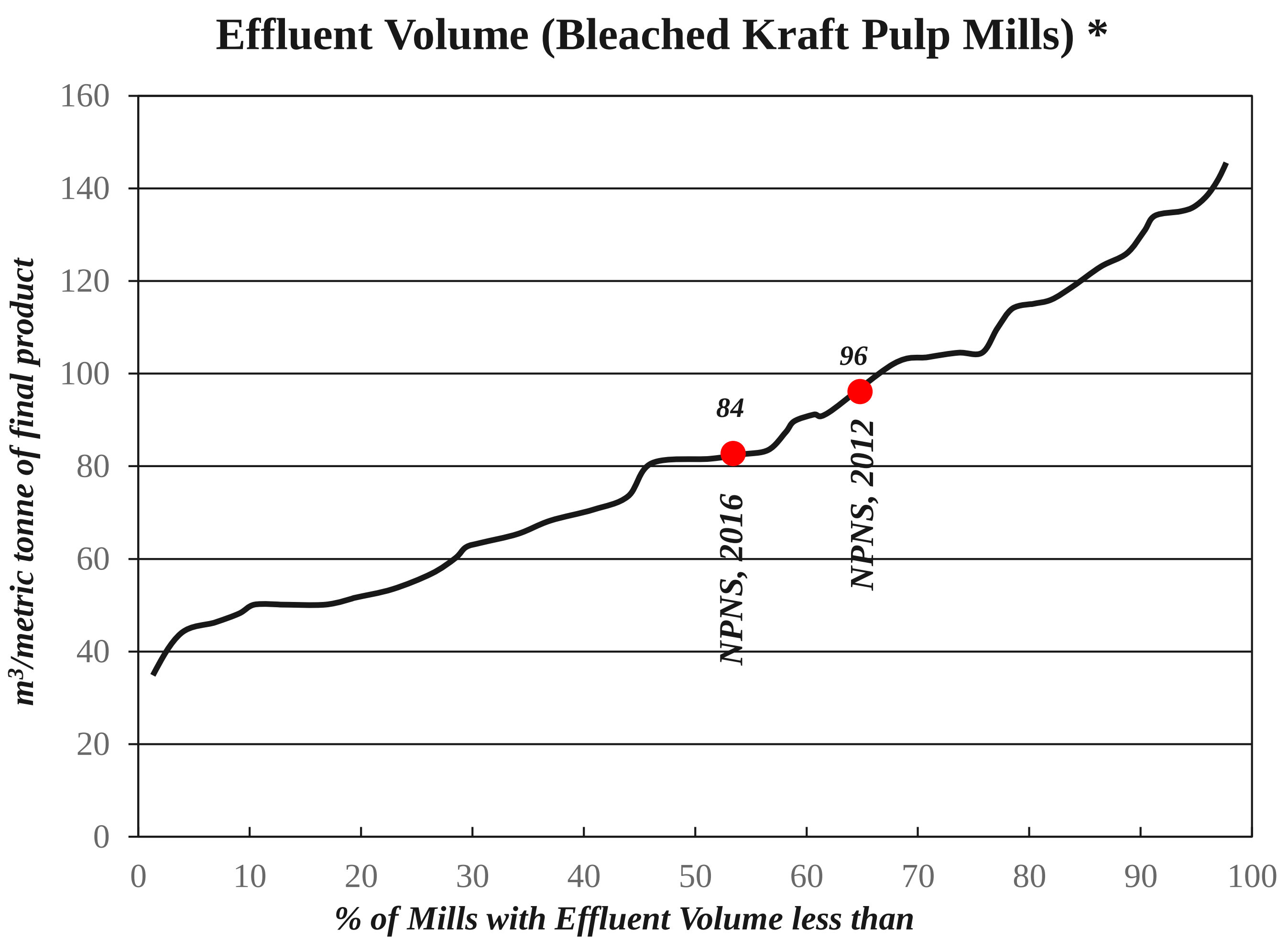
Background

- The kraft mill located on Abercrombie Point near the town of New Glasgow, NS has been in operation since 1967. Originally built by Scott Paper, the mill has seen several ownership changes until its purchase, in 2011, by Paper Excellence Canada. The mill produces bleached (ECF) kraft market pulp at a rate of 280,000 – 300,000 ADt/a;
- At the time of construction, the Government of Nova Scotia agreed to build and operate a treatment system for the mill's process effluent as well as the effluent from Canso Chemicals' chlor-alkali plant: this system was built in the western portion of an area known as Boat Harbour. The system was refurbished in 1996, at which time the mill took over the operations of the system, which is still owned by the Government of Nova Scotia;
- The current effluent treatment system is located 3.5 km east of the mill across the East River and consists of constructed sedimentation basins, followed by aeration in a natural basin equipped with baffle curtains, which direct effluent flow to prevent channelling. A large, natural final polishing/stabilization basin follows prior to release to the Northumberland Strait;
- While the system has met federal and provincial standards since 1996, there has been pressure to return some of the natural waterways to their original state. With the introduction of the Boat Harbour Act, which received Royal Assent on May 11, 2015, the use of the provincially-owned treatment facility must cease after January 30, 2020 and Boat Harbour will be returned to its natural state. This will require installation of a new wastewater treatment plant, including a new effluent outfall, before this deadline.

II. Existing Conditions

Benchmarking Water Use

- Use of water at NPNS is within the Industry average in Canada for a mill of this type, irrespective of the year of construction;
- Water use has also improved since 2012.



*: 31 mills reporting

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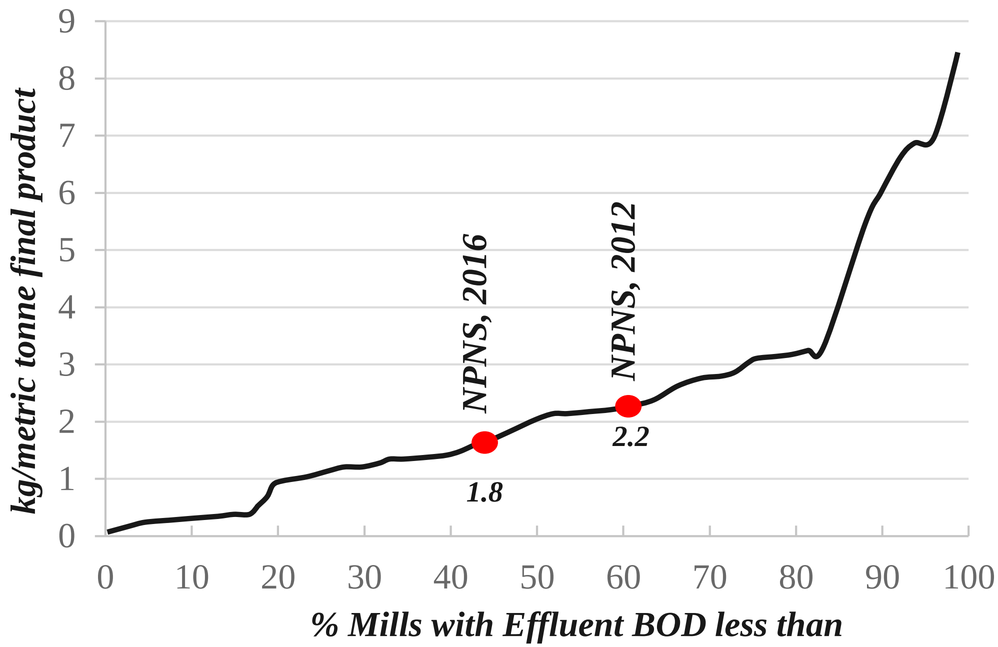
Benchmarking Organic Loading

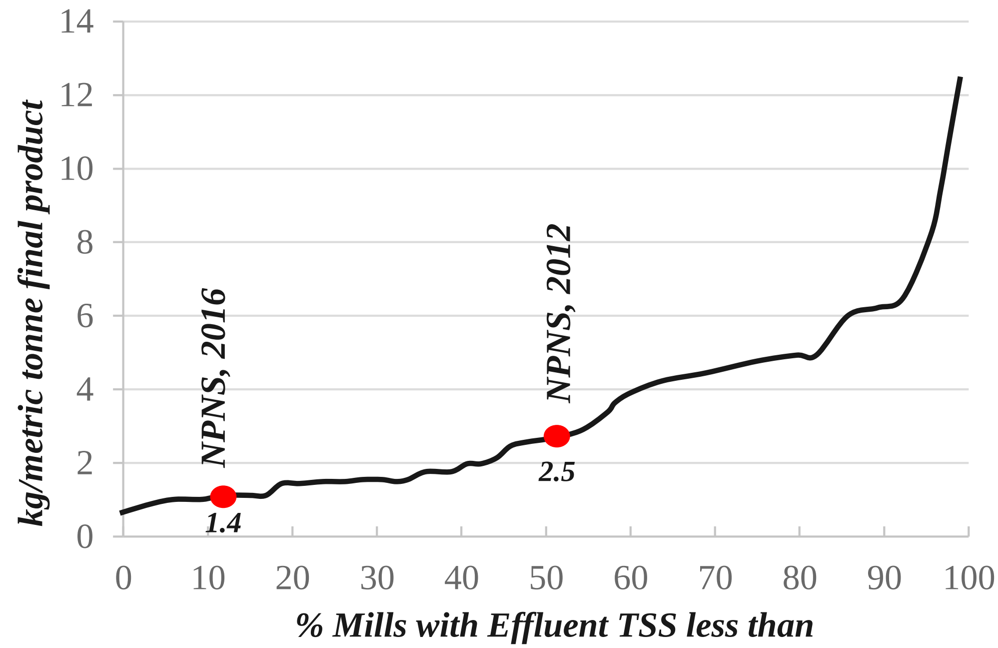
- BOD losses are within the Industry average in Canada for a mill of this type, irrespective of year of construction, and have improved since 2012;
- TSS losses have also improved and are now among the best in the Canadian Industry;
- COD, though measured at every mill, is not reported to regulated authorities and, as such, very difficult to benchmark.

Effluent BOD (Bleached Kraft Pulp Mills) *



*: 31 mills reporting

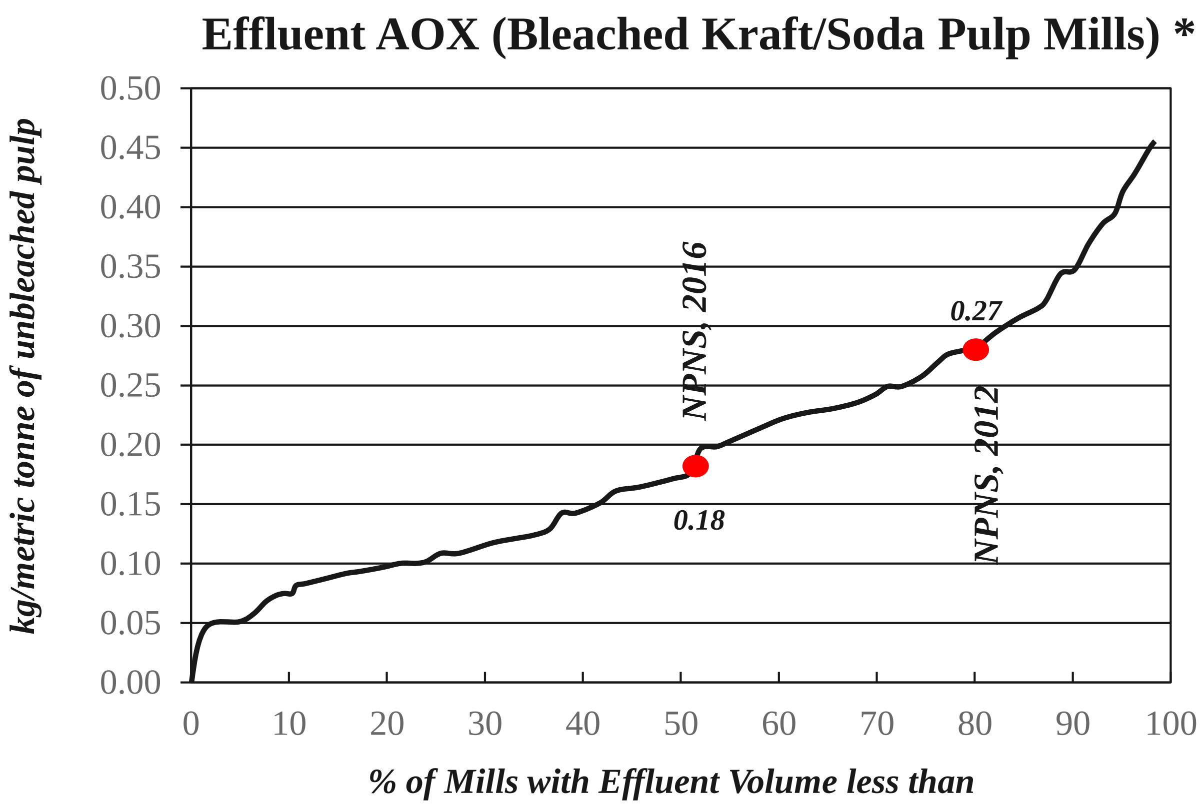
Effluent TSS (Bleached Kraft Pulp Mills) *



*: 31 mills reporting

Benchmarking Chlorinated Organic Discharges

- AOX discharges have improved significantly, with recent data showing the mill to be within the Industry average in Canada;
- This benchmarking graph does not distinguish between furnishes (hardwood/softwood) or the treatment system being used:
  - BSKP tends to yield higher AOX numbers than BHKP;
  - Activated sludge systems tend to treat AOX better than ASB's.



*: 90 mills reporting

III. Hydraulic Loading

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Mill Water Reduction Efforts

- A significant number of water reduction projects have been implemented since 2012;
- Current mill average effluent flow varies between 70,000 and 75,000 m^3/day:
  - The system will be designed to handle 85,000 m^3/day.

IV. Organic Loading

Organic Loading In a Kraft Mill Effluent

- In the design of a new wastewater treatment plant, effluent organic loading will be impacted by the following parameters:
  - Aeration requirements;
  - Nutrient requirements;
  - Sludge generation and dewatering requirements.
- The actual size of the treatment basin is mostly dictated by hydraulic loading;
- Typical organic losses from a kraft mill come from the following sources:
  - Bleach plant effluent (D_0 and E_{op} stages):
    - Continuation of delignification process, where the chloride content of the effluent makes recovery not possible.
  - Liquor losses:
    - Loss of chemicals and energy;
    - Recovery capacity issues can exacerbate these losses;
    - Equipment issues (type, metallurgy, operating efficiencies) can also affect losses.
  - System purges:
    - Necessary for control of non-process elements and final product cleanliness;
  - Brownstock carryover.

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Separate Treatment of D_0 and E_1 Filtrates

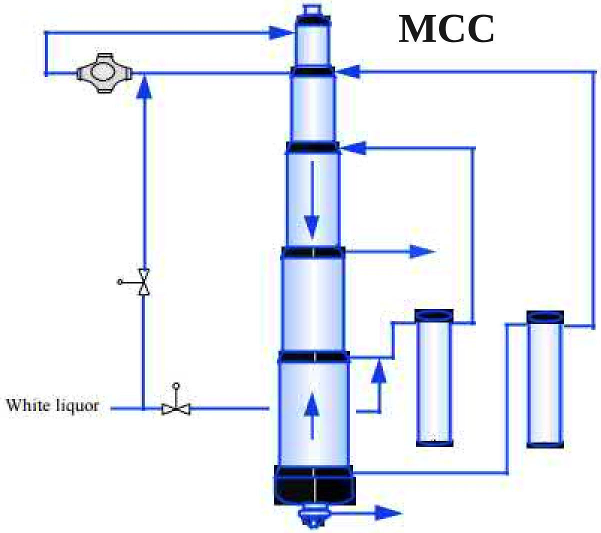
- Two options are available:
  - Biological treatment;
  - Physico-chemical treatment.
- Biological treatment is typically used to offload existing effluent treatment systems;
  - Typical removal efficiencies:
    - COD: 20 to 25%, BOD: 55 to 60%.
  - Typical issues:
    - Such systems would remove a lot of the readily biodegradable BOD, making further treatment more complex;
    - Handling of the solids generated by the process add complexity to the treatment system.
  - Because of this, biological treatment is not considered a viable treatment option.
- Physico-chemical treatment
  - Removal of trace metals (mainly calcium, manganese, magnesium) from the D_0 filtrate via filtration and cation exchange beds;
  - Removal of halogens (chlorine, potassium) from the recovery boiler precipitator catch via crystallization;
  - Results achieved at this mill:
    - Bleach plant effluent flow can be reduced by 40 to 60%;
    - Effluent colour (-25%) and AOX (-40%) can also be reduced;
    - No significant change in treated effluent BOD but a 10% increase in bleaching chemicals use.
  - Because of this, physico-chemical treatment is not considered a viable treatment option.

Extended Delignification

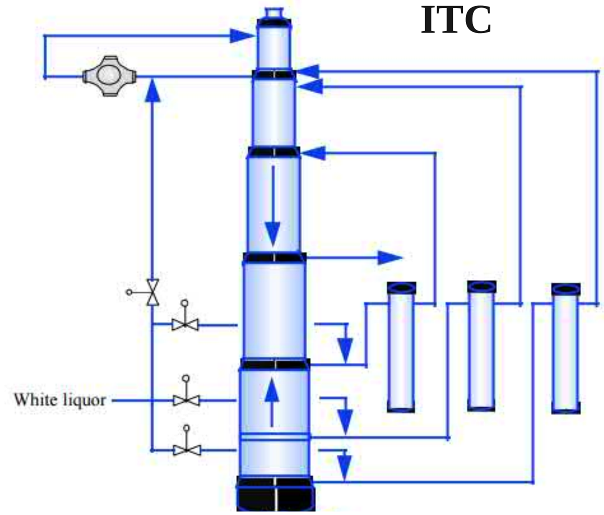
- Extended delignification allows for a more complete removal of lignin from the wood chips than conventional cooking without the detrimental effects on pulp quality;
  - The lower kappa numbers generated ultimately result in lower bleach demand and higher recovery of wood solids than traditional continuous cooking.
- Three types of processes are typically used to achieve this and rely on varying cooking chemical concentrations and contact times throughout the digester. These are:
  - Modified Continuous Cooking (MCC, sometimes referred to as *Lo-Solids* cooking), where the cook starts at a reduced concentration of effective alkali and ends at a higher concentration of effective alkali;
  - Extended Modified Continuous Cooking (EMCC) is a further development in modified cooking, where liquor is added in the digester washing zone and chemical concentrations are modified more drastically than MCC cooking;
  - Iso-Thermal cooking (ITC) expands the EMCC process with an additional circulation loop and the fifth white liquor addition point and by keeping the digester temperature nearly constant throughout cook.

Extended Delignification Flowsheets

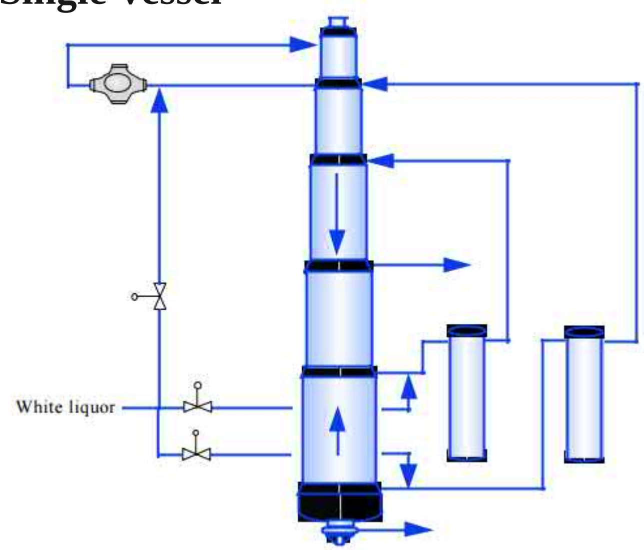
MCC



ITC

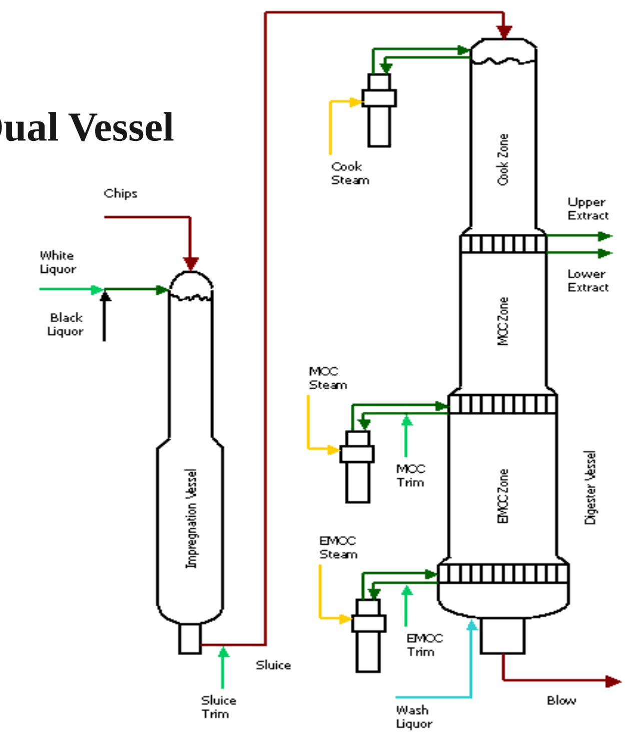


Single Vessel



EMCC

Dual Vessel



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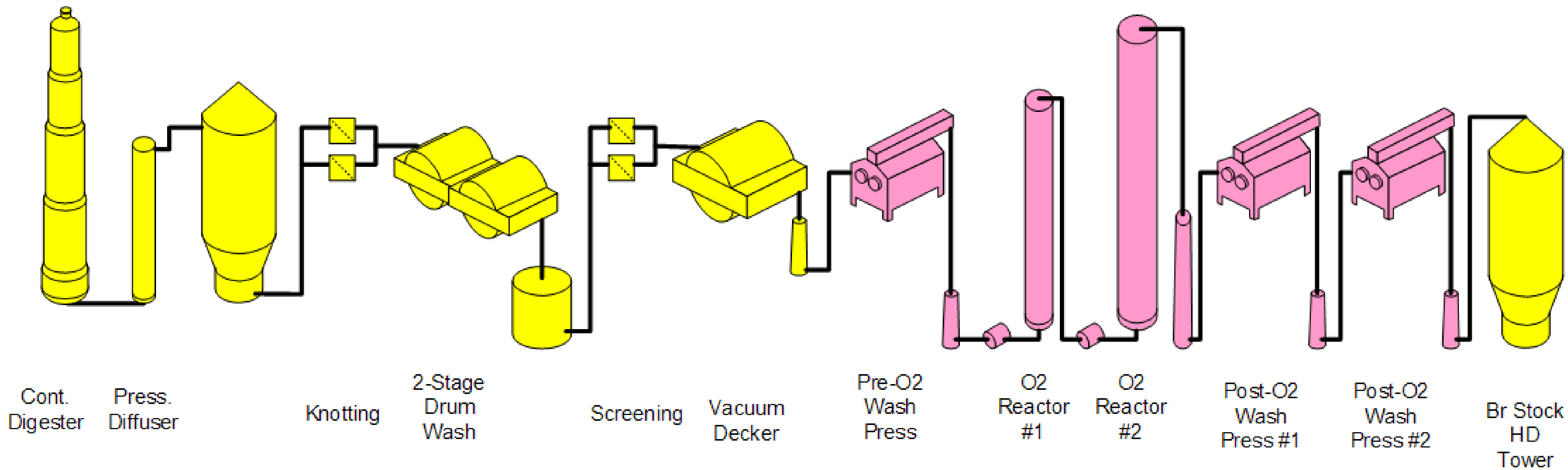
Extended Delignification Implementation

- Extended delignification systems are difficult to retrofit:
  - Significant changes to digester internals are required;
  - Changes in process conditions, such as temperatures, pressures and alkalinities can strain the structure of the digester and render some of its metallurgy incompatible with the new process conditions.
- Implementation of these systems is usually carried out as a full replacement of the existing digester system;
- Extended delignification systems would result in a 20% reduction in COD due to a decrease in bleach demand:
  - This would correspond to a 15% decrease in total COD before treatment at NPNS.
- Because of the complexity of implementation and the uncertainty of success as a retrofit technology, extended delignification, in any of its forms, is not considered a viable process option.

Oxygen Delignification (O_2 Delig)

- Oxygen delignification is a process between cooking and bleaching sequences, where part of the residual lignin left in pulp after cooking is removed using oxygen and alkali:
  - Oxygen delignification is a direct extension to delignification in cooking.
- The targeted reactions are the oxidation of lignin and breaking it down into parts that dissolve in alkali, as well as destroying the coloured groups in lignin and removal of impurities, such as resin:
  - Delignification with oxygen is a more gentle way of reducing the kappa number than extended cooking, allowing for recovery of more lignin than “conventional cooking”; and
  - Because the kappa number to the bleach plant is reduced, the demand for bleaching chemicals is also reduced, which makes for an effluent that contains less organics (BOD/COD) and halogenated compounds (AOX) prior to treatment.
- How it works:
  - Oxygen is reduced to water in reactions with the organic components, and the organic components are oxidized;
  - Oxygen in its normal state is a weak oxidizing agent, and is as such ineffective in delignification. Its oxidizing power can be promoted by raising the temperature and by alkaline conditions;
  - The most essential factor in oxygen delignification is to bring oxygen gas into contact with the fibers under alkaline conditions;
  - This means that the pulp suspension should have enough alkaline (OH- ions) to neutralize and dissolve the organic acids, which are generated in oxygen – lignin reactions.
  - The process can be carried out at medium or high consistency:
    - High consistency system are more difficult to operate and are not typically recommended.

O_2 Delignification Process Flowsheet



Legend:
Existing equipment: Yellow
Future equipment: Pink

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Impact of O_2 Delig on Remaining Mill Process and Effluent Treatment

- Increase in dry solids loading to recovery boiler of 4-6%:
- Corresponding increases in recausticizing and lime kiln capacity would also be required:
  - If this is not possible, mill throughput will have to be reduced accordingly;
- Chemical demand in the bleach plant will be reduced significantly:
  - Keeping the same kappa factor, this represents a 50% drop in ClO_2 usage at the D_0 stage;
    - Kappa number out of digester expected to be between 31 and 32;
    - Washed brownstock kappa would be around to 30 prior to O_2 Delig;
    - Kappa number to the bleach plant would drop from 24 (currently) to 12.
- O_2 Delig would bring about the following:
  - A small reduction in the size of the treatment system from the reduction in organic loading to be treated;
  - A decrease in BOD, COD and AOX loading to the treatment plan from the reduction in bleaching chemical use;
  - A reduction in effluent colour (aesthetic parameter);
  - A reduction in wood losses;
  - An increase in the recovery of lignin in the liquor cycle;
  - A reduction in nutrient addition due to organic loading reduction.

V. Effluent Treatment System Technology Selection

Technology Selection

- Treatment technologies considered in the analysis;
  - Aerated Stabilization Basins (ASB)
  - Activated Sludge Treatment (AST);
  - AST-like “high rate” systems:
    - Sequencing Batch Reactors (SBR);
    - Rotating Biological Contactors (RBC);
    - Biological Aerated Filters (BAF);
    - Moving Bed Biofilter Reactor (MBBR).
  - Anaerobic Treatment;
  - Tertiary Treatment.
- Selection of Treatment Process;

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ASB vs AST

ASB

- The aerated stabilization basin (ASB) process, also known as the aerated lagoon, effects the removal of BOD in the waste by aerated digestion with micro-organisms in a similar fashion to the activated sludge treatment;
- ABS's have no sludge recycle: the sludge is used as a food for other micro-organisms, which digest it, usually close to the bottom of the basin (facultative digestion);
- ASB's are characterized by:
  - Relatively low bacterial concentration;
  - Large residence times (in the order of 10 days); and
  - The absence of a secondary sludge clarifier.
- ASB's typically yield smaller BOD reductions (50 to 75%), when compared to AST's;
  - BOD reductions obtained at NPNS are significantly greater that what is typical of such a system.
- ASB's are typically less sensitive to process overloads and swings; and
- ASB's typically have lower capital and operating costs than AST's.

AST

- The activated sludge treatment (AST) process involves the conversion of soluble organic matter into solid biomass which, in turn, is converted to CO_2, H_2O and microbial sludge, which is separated from the liquid stream;
- The process involves two stages - an aeration stage and a clarification and recycle stage;
- Typically, from 90 to 95% removal of soluble BOD can be attained;
- Residence times in the reactor are measured in hours (6-18);
- AST's are capable of treating wastes with BOD concentrations as high as 5,000 mg/L;
- Nitrogen and phosphorus addition is usually required, in a typical mass ratio of 100:5:1 (BOD:N:P) as outside nutrients for the system;
- A dissolved oxygen concentration of 2 mg/L is usually maintained in the reactor using forced aeration;
- Reactor bacterial concentration (mixed liquor solids) are typically kept at 3,000 to 5,000 mg/L by recycling some of the waste sludge collected at the clarifier; and
- AST's usually require more protection from process upsets and spills than ASB's because of the shorter retention time and higher bacterial concentration.

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ASB's and AST's in North American Kraft Pulp and Paper Mills

- There are currently 26 kraft mills in operation in Canada at present
  - Only 8 of them operate activated sludge treatment systems (AST), which the other 17 mills have the same process currently used at Northern Pulp (aerated stabilization basin, or ASB);
  - Irving Pulp and Paper (Saint John,NB) has no treatment system, choosing to treat some streams separately within the mill prior to discharge. The mill is currently facing charges for exceeding the Pulp and Paper Effluent Regulations limits and is actively looking at potential solutions to their process issues;
- There are currently 95 kraft mills in operations in the United States
  - Of those, approximately 15 mills have AST's, with the remaining mills using ASB's.
- In both countries, no other treatment technology is used to treat kraft mill effluent.

Ruling out ASB's

- While it would cost less both to build and to operate, the implementation of an ASB to replace the existing system has been ruled out for the following reasons:
  - Not seen as a "state-of-the-art" treatment system:
    - Despite the fact that the majority of kraft mills in North America utilize this technology.
  - Lack of real estate to implement this technology on the mill site;
  - Lower BOD removal efficiencies than other, high-rate systems:
  - Large surface area makes odour control more difficult; and
  - Public and regulatory perception about the obsolescence of the existing ASB and of the technology in general.

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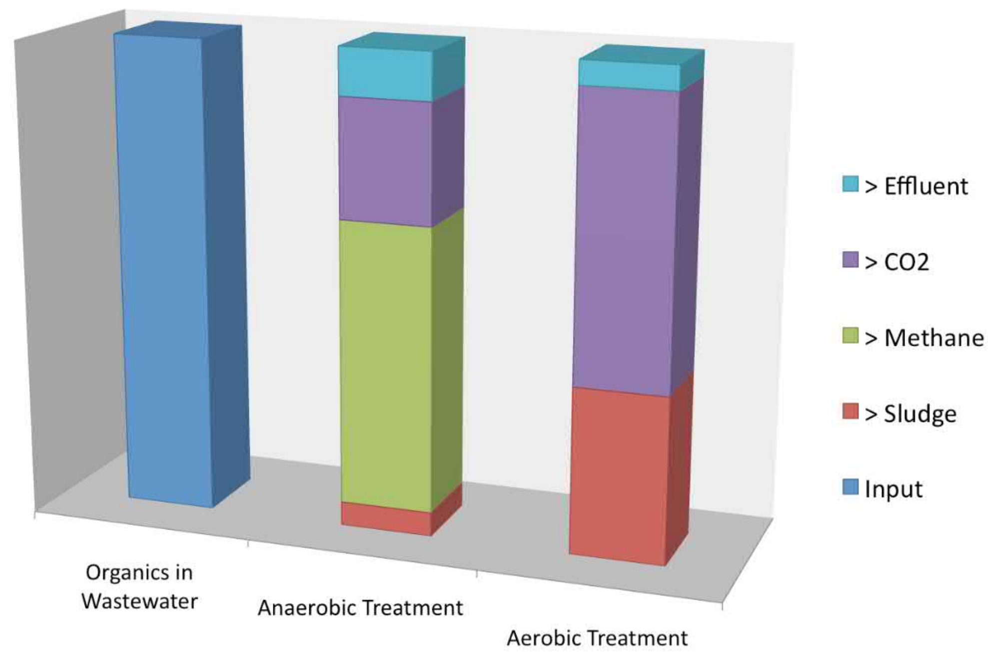
AST's vs. Other "High Rate" Aerobic Systems

- There are several different technologies that use the same operating principles as activated sludge systems. The most common are:
  - Sequencing Batch Reactors (SBR):
    - An SBR is an activated sludge process designed to operate under non-steady state conditions;
    - An SBR operates in a true batch mode with aeration and sludge settlement both occurring in the same tank.
  - Rotating Biological Contactors (RBC):
    - Also called rotating biological filters, they are fixed bed reactors consisting of stacks of rotating disks mounted on a horizontal shaft. They are partially submerged and rotated as wastewater flows through.
  - Biological Aerated Filter (BAF):
    - BAF's have a 2-3m deep bed of relatively small size filter media, to provide a high surface area, on which to grow a biomass. The filter bed is submerged and a settled wastewater is pumped either upwards or downwards through the filter. A blower sends air through a diffuser at the bottom of the bed which generates bubbles which then rise through the filter providing a steady stream of oxygen for the biomass to support the oxidation process.
  - Moving Bed Biofilm Reactors (MBBR):
    - MBBR's use thousands of polyethylene biofilm carriers operating in mixed motion within an aerated wastewater treatment basin. Each individual bio-carrier increases productivity through providing protected surface area to support the growth of heterotrophic and autotrophic bacteria within its cells. It is this high-density population of bacteria that achieves high-rate biodegradation within the system, while also offering process reliability and ease of operation.

Anaerobic Treatment

- Anaerobic digestion is a process in which microorganisms convert organic matter into biogas in the absence of oxygen;
- The anaerobic sludge contains various groups of micro organisms that work together to eventually convert organic material to biogas via hydrolysis and acidification;
- Biogas typically consists of 70% methane (CH_4) and 30% carbon dioxide (CO_2) with residual fractions of other gases (e.g. H_2 and H_2S). The methane can be used as an energy source;
- Anaerobic treatments on wastewater are normally implemented when treating more concentrated wastewater (5,000 to 30,000 ppm COD), which is not the case at NPNS;
- Anaerobic treatment of D_0 and E_1 filtrates has been implemented in one US integrated kraft pulp mill, with limited success.
- Sometimes used to treat contaminated condensates as well.
- Anaerobic always requires an aerobic polishing stage, albeit smaller.

Fate of Wastewater Organics Anaerobic vs. Aerobic Systems



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Selection of Secondary Treatment Process

Process	Advantages	Drawbacks
AST (Selected Process)	• **Process flexibility** • **Large industry experience** • **Upgradability**	• **Potential sludge settleability issues** • **Potential foaming issues** • **Higher energy use for aeration**
SBR	• Compact system • Very flexible for nutrient removal • Highly automated	• Not common at high (> 40,000m^3/day) flows • More complex design (electrical/mechanical) • Intermittent discharge
RBC	• Simple to operate • High process stability • Modularity • Low energy requirements	• High colour discharge • Limited degree of process automation • Mechanical concerns
BAF	• High loading rates • Small footprint • Modularity • Highly automated	• More complex design (electrical/mechanical) • Fine solids screening required • Potential for loss of media • Limited degree of process automation • Limited implementation
MBBR	• Simplicity of design • Small footprint	• Potential for loss of plastic media to receiving waters • Limited degree of process automation • Limited technology choices for aeration
Anaerobic	• Low sludge generation • Small footprint • Biogas generation	• Required a high strength effluent to be applicable • Aerobic treatment required to address toxicity of treated effluent • Sensitive to process upsets

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Considerations for Tertiary Treatment

- Typical processes used in tertiary treatment include:
    - Aerated or facultative polishing lagoons;
    - Chemical treatment (flocculation and clarification) systems, where chemicals (alum, bentonite or similar) will be added to the wastewater and a tertiary (chemical) sludge will be produced from the compounds removed from the effluent;
    - Sand filtration;
    - Membrane filtration (ultrafiltration or reverse osmosis);
    - Ozonation / Oxidation; and
    - Effluent evaporation or reuse.
- Tertiary treatment is used only when conventional treatment cannot remove specific contaminants that have been found harmful to the specific local ecosystem:
    - Care must be taken to look at the entire environmental footprint of tertiary treatment, since the contaminant is removed at the cost of inorganic chemical usage, large power requirements, landfilled waste in the form of sludges or uses filter media (membranes, sand, cloth, etc…) and high capital treatment systems;
    - A kraft mill followed by primary and secondary treatment is sufficient for almost all jurisdictions in the world. It is not recommended to implement tertiary treatment unless scientific analysis proves that it is required due to local receiving water conditions.

Appendix D

Veolia AnoxKaldnes Reference List

ANOXKALDNES INDUSTRIAL REFERENCE LIST - EXTERNAL USE ALLOWED

Name	Country	Year of completion	Process type	Reactor volume (m^3)	Industry category	Category specifics (type of industry etc.)	Objectives	special substances	Biomedia Tank 1	Biomedia Tank 2
Sande Paper Mill	Norway	1993	MBBR	1700	Pulp & Paper	paper board mill				
Stora Papyrus Grycksbo	Sweden	1993	MBBR	135	Pulp & Paper	fine paper mill				
Munksjö Laga Mill	Sweden	1994		200	Pulp & Paper	recycle paper mill	Post-treatment from trickling filter			
Holmen Paper Wargön Mill	Sweden	1994	MBBR	2000	Pulp & Paper	sulphite pulp, groundwood				
Shoalhaven Mill	Australia	1995	BAS™	576	Pulp & Paper	paper mill	Pre-treatment prior to AS			
SCA Hygiene Paper	Germany	1995	BAS™	380	Pulp & Paper	paper mill	Pre-treatment prior to AS			
StoraEnso Intercell SA	Poland	1995	BAS™	550	Pulp & Paper	kraft, NSSC, recycke fiber, kraft paper	Pre-treatment prior to AS			
Rottneros Rockhammar Mill	Sweden	1995	BAS™	150	Pulp & Paper	bleached CTMP mill	Pre-treatment prior to AS			
Rottneros Utansjö Mill	Sweden	1995	BAS™	550	Pulp & Paper	sulphite pulp mill	Pre-treatment prior to AS			
Alier	Spain	1996	BAS™	600	Pulp & Paper	paper mill	Pre-treatment prior to AS			
Backhammars Bruk	Sweden	1996	MBBR	2*750	Pulp & Paper	unblached kraft, kraft paper				
Metsä Tissue Nyboholms Mill	Sweden	1996	MBBR	500	Pulp & Paper	tissue from recycled fiber				
SCA Hygiene Edet Bruk	Sweden	1996	MBBR	1700	Pulp & Paper	tissue from recycled fiber				
IVEX, Chagrin Falls, Ohio	USA	1996	MBBR	166	Pulp & Paper	recycle paper mill				
Werra Papier	Germany	1997	BAS™	130	Pulp & Paper	paper mill	Pre-treatment prior to AS			
Tasman P&P	New Zealand	1997		1500	Pulp & Paper	TMP mill	Pre-treatment prior to aerated lagoon			
SCA Graphic Östrand	Sweden	1997		2375	Pulp & Paper	TCF kraft pulp mill	Anaerobic/ aerobic condensate treatment			
Munkedals AB	Sweden	1997		200	Pulp & Paper	printing paper	Post-treatment after trickling filter			
Laga Mill	Sweden	1997		200	Pulp & Paper	board from recycled fiber	Extension of existing plant			
Metsä Tissue Katrinefors Mill	Sweden	1997	MBBR	1500	Pulp & Paper	tissue from recycled fiber		toxicity		
StoraEnso Pankakoski Mill	Finland	1998	MBBR	540	Pulp & Paper	board from recycled fiber				
AssiDoman Packaging Lecoursonnoise	France	1998		350	Pulp & Paper	board, liner, fluting from recycled fiber	Post-treatment after anaerobic fluidized bed			
UPM Schongau Mill	Germany	1998	BAS™	1800	Pulp & Paper	newsprint from recycled fiber	Pre-treatment prior to AS			
Fiskeby Board	Sweden	1998	BAS™	255	Pulp & Paper	recycle paper mill	Pre-treatment prior to AS			
Thurpapier, Weinfelden	Switzerland	1998	BAS™	420	Pulp & Paper	paper mill	Pre-treatment prior to AS			
Dresden Paper, Heidenau	Germany	1999	BAS™	240	Pulp & Paper	paper mill	Pre-treatment prior to AS			
Schonfelder Paper	Germany	1999	MBBR	270	Pulp & Paper	paper mill				
Steinbeis Temming	Germany	1999	BAS™	420	Pulp & Paper	paper from recycled fiber	Pre-treatment prior to AS		F3	
Gebr. Lang GmbH, Ettringen	Germany	1999		1200	Pulp & Paper		Polishing after Ozon			
United Paper board	Malaysia	1999	BAS™	900	Pulp & Paper	paper from recycled fiber				
Irving Pulp & Paper	Canada	2000	MBBR	1700	Pulp & Paper	bleached kraft pulp	BOD-removal, thermophilic		Chip P	
Greenfield SA	France	2000	BAS™	1000	Pulp & Paper	pulp from recycled fiber				
Spezialpapierfabrik Oberschmitten GmbH	Germany	2000	MBBR	100	Pulp & Paper					
MD Albbruck Papier	Germany	2000	BAS™	780	Pulp & Paper		Pre-treatment prior to AS			
Cartiera dell'Adda	Italy				Pulp & Paper				K1	
Ripasa S.S.	Brazil	2001		1662	Pulp & Paper	bleached kraft, paper	Post-treatment after lagoon			
UPM Schauman	Finland	2001	MBBR	870	Pulp & Paper	plywood				
Papelera del Oria R1	Spain	2001	MBBR	240	Pulp & Paper					
Södra cell Mörrum	Sweden	2001	BAS™		Pulp & Paper	bleached kraft pulp (NBSK)	Pre-treatment prior to AS			
Tela, Balsthal	Switzerland	2001			Pulp & Paper					
Papierfabrik Hainsberg	Germany	2002	BAS™	150	Pulp & Paper		Pre-treatment prior to AS		K3	
Norske Skog, Walsum Mill	Germany	2002	BAS™	2500	Pulp & Paper		Pre-treatment prior to AS			

UPM Chudovo	Russia	2002	MBBR	150	Pulp & Paper	plywood				
Södra Cell Värö	Sweden	2002	BAS™	3600	Pulp & Paper	bleached TCF kraft pulp (NBSK)				
Stora Enso Hylte	Sweden	2002	BAS™	5000	Pulp & Paper	newsprint, TMP, recycle paper				
Fraser Papers, Maine	USA	2002	BAS™	6000	Pulp & Paper	fine paper			M2	
StoraEnso Langerbrugge	Belgium	2003	BAS™	2250	Pulp & Paper	recycled paper	Pre-treatment prior to AS			
Klabin Kimberly S.A.	Brazil	2003	MBBR	614	Pulp & Paper	paper mill				
Asia Kraft	Thailand	2003	BAS™	1600	Pulp & Paper	recycled paper	Pre-treatment prior to AS			
Solvay Paperboard, New York	USA	2003		1300	Pulp & Paper	recycled paper	Post-treatment after anaerobic process			
Mitsubishi Fine Paper	Germany	2004	MBBR	200	Pulp & Paper	fine paper				
Stendal Mill	Germany	2004	BAS™	6100	Pulp & Paper	bleached kraft pulp (NBSK)	EDTA removal	EDTA		
Munksjö Laga Mill	Sweden	2004	BAS™	400	Pulp & Paper	board from recycled fiber	Pre-treatment prior to AS		Chip M	
Nordic Paper	Sweden	2004	MBBR	360	Pulp & Paper	paper mill				
Nordic Paper	Sweden	2004	MBBR	360+1170+1170	Pulp & Paper	sulphite pulp	EDTA-removal in third MBBR	EDTA		Chip M
SCA Graphic Ortviken	Sweden	2004	BAS™	10000	Pulp & Paper	TMP, paper	Pre-treatment prior to AS			
Norbord	United Kingdom	2004	MBBR	1400	Pulp & Paper	MDF board				
Nexfor	United Kingdom	2004		1400	Pulp & Paper	MDF Board				
Quesnel River Pulp	Canada	2005	BAS™	3000+3000	Pulp & Paper	bleached CTMP				
CMPC Laja	Chile	2005	MBBR	7700	Pulp & Paper	bleached kraft pulp				
Stora Enso Anjalankoski	Finland	2005	BAS™	8000	Pulp & Paper	TMP, groundwood pulp, newsprint	Pre-treatment prior to AS			
SCA Puigpelat	Spain	2005	BAS™	288	Pulp & Paper	paper mill				
Munksjö Aspa Mill	Sweden	2005	MBBR	85	Pulp & Paper	bleached ECF kraft pulp	thermophilic		Chip M	
Holmen Paper Hallsta Mill	Sweden	2005	BAS™	1500	Pulp & Paper	TMP, newsprint	Pre-treatment prior to AS		Chip P	
Rottneros Utansjö	Sweden	2005	Hybas™	7350	Pulp & Paper	bleached CTMP and groundwood pulp				
CMPC Papeles Cordillera, Puento Alto	Chile	2006	BAS™	5500	Pulp & Paper	recycled paper			Chip P	
CMPC Inforsa	Chile	2006	MBBR	6000	Pulp & Paper	TMP, newsprint			Chip P	
CMPC Santa Fe	Chile	2006	BAS™	9000	Pulp & Paper	bleached kraft pulp from Eucalyptus			Chip P	
YFY Paper Mtg Yangzhou	China	2006	BAS™	2500	Pulp & Paper	board from recycled fiber			Chip P	
Inland	Sweden	2006		2.5	Pulp & Paper	recycled paper				
Billerud Gruvön Mill	Sweden	2006	BAS™	6000	Pulp & Paper	bleached kraft	Pre-treatment prior to AS			
Norske Skog Boyer	Australia	2007	BAS™	2000	Pulp & Paper	newsprint				
Bahia Sul	Brazil	2007	Lagoon Guard	15000	Pulp & Paper	bleached eucalyptus kraft	Post-treatment after aerated lagoon		Chip P	
Arjowiggins Charavines	France	2007	MBBR	250	Pulp & Paper	speciality paper				
Rhein Papier Plattling	Germany	2007	BAS™	2x1137	Pulp & Paper	publication paper	Pre-treatment prior to AS		F3	
Bhadrachalam	India	2007		6400	Pulp & Paper					
Norske Skog Follum	Norway	2007	BAS™	8000	Pulp & Paper	TMP, newsprint	Pre-treatment prior to AS			
Arkhangelsk Pulp and Paper	Russia	2007	BAS™	17400	Pulp & Paper	bleached kraft and paper	Pre-treatment prior to AS			
Papeterie de Mandeure	France	2008			Pulp & Paper	speciality paper				
SCA Drammen	Norway	2008		450	Pulp & Paper	tissue				
Swedish Tissue Kisa	Sweden	2008		115	Pulp & Paper	tissue				
Waggeryd Cell AB	Sweden	2008	BAS™	800	Pulp & Paper	bleached CTMP pulp	thermophilic MBBR			
CMPC Pacifico	Chile	2009		5500	Pulp & Paper	bleached kraft pulp				
Papelera del Oria R2	Spain	2009	MBBR	375	Pulp & Paper			no	K3	
Papelera Aralar	Spain	2009	MBBR	800	Pulp & Paper			no	K3	
SCA Packaging Munksund	Sweden	2009		11200	Pulp & Paper					

Papierfabrik Hainsberg	Germany	2009	BAS™	150	Pulp & Paper		Pre-treatment prior to AS		K3	
WWTP Georgia Pacific (ALLO)	Spain	2010	MBBR	1350	Pulp & Paper			no	K3	
Papelera Sniace	Spain	2010	MBBR	10690	Pulp & Paper			no	Chip P	
StoraEnso Fors	Sweden	2010			Pulp & Paper	CTMP consumer board			F3	
ICT	France	2011	MBBR	150	Pulp & Paper	Toilet paper and tissues	COD polishing		K3	
Paprinsa	Spain	2012	MBBR	1500	Pulp & Paper				K3	
Papelera ENCE	Spain	2013	BAS™	19408 (MBBR is 5800)	Pulp & Paper	cellulose production base from ECF eucalyptus		no	K3	
Papelera ZIKUÑAGA	Spain	2013	BAS™	8745	Pulp & Paper			no	K3	
CMPC Guaiba, Brazil	Brazil	2015	BAS™	5300	Pulp & Paper				K5	
Modern Karton PM3	Turkey	2015	MBBR	1600 m3	Pulp & Paper	recycled paper	COD removal		Chip P	
Modern Karton PM5	Turkey	2015	MBBR	1638 m3	Pulp & Paper	recycled paper	COD removal		Chip P	
SCA Graphic Östrand	Sweden	1997/2004	BAS™	1700	Pulp & Paper	bleached kraft pulp, CTMP	Pre-treatment prior to AS			
AO Kondopoga Mill	Russia	2000 / 2004	BAS™	14000	Pulp & Paper	sulfite pulp, newsprint	Pre-treatment prior to AS			
StoraEnso Kvarnsveden	Sweden	2004, 2006	BAS™	4000*2	Pulp & Paper	groundwood, newsprint				
Norske Skog Bio Bio	Chile	2007 / 2008	MBBR	1800	Pulp & Paper	PGW, newsprint			Chip P	
Rhein Papier Plattling	Germany	2011/2012	BAS™	2x1200	Pulp & Paper	publication paper	Replacement of carriers		Chip P	
Mörrum	Sweden	2013?			Pulp & Paper	bleached kraft from Softwood (NBSK)			Chip P	
Korsnäs Frövi	Sweden	2013	MBBR	2000+2000	Pulp & Paper		EDTA-removal	EDTA	K5	
SFI	Malaysia	2011	BAS™		Pulp & Paper				Chip P	
Reno de Medici	Spain		MBBR		Pulp & Paper				K3	
ITC	India	2009	BAS™		Pulp & Paper		COD 250 / TSS 100		Chip P	
Rainbow	India	2010	BAS™		Pulp & Paper				Chip P	
Winston	New Zealand		BAS™	2*850	Pulp & Paper	BCTMP			Chip P	
Hartmann	Hungary	2015	MBBR	330	Pulp & Paper		COD < 1000 ppm		K5	
Paper Mill & Converting SA	Spain	2015	MBBR		Pulp & Paper				K5	
Värö	Sweden	2016	BAS™	4000+20000	Pulp & Paper	ECF and TCF (from softwood, NBSK)	COD-removal, EDTA removal	EDTA	Chip P	
Vallvik	Sweden	2015	MBBR	2700	Pulp & Paper		Increase COD removal capacity		Chip P	
Gruvons Bruk	Sweden	2016			Pulp & Paper	NBSK			F3	
WEPA	Poland	2016	MBBR	160	Pulp & Paper				Z-200	
Vallvik Bruk	Sweden	2016			Pulp & Paper				Chip P	
M.C. Tissue SpA	Italy	2016	MBBR Pack		Pulp & Paper	Tissue paper production				
Quesnel upgrade	Canada	2017	BAS™	3000+3000	Pulp & Paper	bleached CTMP mill			F3	
Gruvöns Bruk	Sweden	2017	MBBR		Pulp & Paper	NBSK			F3	
Munksjö	Spain	2017	BAS™		Pulp & Paper				Z-400	
Stora Enso Fors	Sweden	2017	MBBR		Pulp & Paper				Chip P	
Aspa	Sweden	2017			Pulp & Paper					
Hallsta	Sweden	2017			Pulp & Paper					
Skoghall	Sweden	2017			Pulp & Paper					
Braviken	Sweden	2018			Pulp & Paper					