Appendix 19: Kinleith Discharge

1. Introduction

The Kinleith pulp and paper mill, south of Tokoroa, is operated by Carter Holt Harvey Limited (CHH). The mill is consented to discharge treated wastewaters into Lake Maraetai. The discharge causes a discernable change in water colour of the lake and for some distance downstream, and this discolouration has been identified by river iwi and the wider community as being a cause for concern (NIWA et al., 2009).

As part of their resource consent, Carter Holt Harvey Kinleith is required to monitor the mill's wastewater discharge into the Waikato River and report the results to Environment Waikato (EW). They are also required to investigate and report on the feasibility and costs associated with improving the quality of the discharge (Environment Waikato, 2006).

Colour is a property of the effluent and is defined as the absorption of light at a specific wavelength in a filtered effluent sample. It is commonly expressed as platinum cobalt units (PCU) either as a concentration (grams per cubic metre) or a mass load (kilograms per day). Davies-Colley and Nagels (1991) estimate the optical cross-section of Kinleith effluent to be 0.1 square metres per gram PCU (at 440 nanometres) and this figure enables conversion of PCU to absorbance at 440 nanometres as required by the Waikato Catchment Model (see Appendix 13: Water Quality).

The colour of pulp and paper mill effluents originate in the wood handling, chemical pulping and bleaching, and papermaking processes and is due to tannin and lignin compounds in the wood. The majority of colour is produced in the chemical pulping and bleaching stages where the lignin in the wood is separated from the cellulose fibre. In the kraft pulping process, under alkaline conditions at high temperature and pressure, the lignin is solubilised and removed from the wood chips. These dissolved solids form highly coloured spent liquor called black liquor. This black liquor is washed from the pulp in subsequent washing stages and is collected and returned to the recovery cycle. The majority of the black liquor is typically recovered and reused in the process and does not enter the effluent system, although a small quantity is lost routinely. In addition, intermittent discharges and spills can occur.

Some residual black liquor remains with the pulp entering the bleach plant along with residual lignin inside the fibres that has not been removed in pulping. In the bleach plant the pulp is treated in a series of stages, called a bleach sequence. The dominant colour discharged from the bleach plant is the caustic extraction stage. Because of the chloride content of the caustic extraction and its corrosive nature this stream is generally not recovered.

Table 1 summarises the trends in the quality of the discharge from the Kinleith Mill from 2001 to 2008 and planned future improvements for discharge quality.

Carter Holt Harvey state that a 50 percent reduction in colour discharged from Kinleith was achieved in the late 1990s prior to the granting of their current consent. Much of the improvement was achieved by the introduction of oxygen delignification and improved post-oxygen washing.

Table 1: Summary of Kinleith wastewater discharge characteristics from 2001–2008, based on Carter Holt Harvey (2009).

Parameter	Monitoring results	Consent conditions	Consent compliance	Improvements during 2001-2008	Planned improvements
Flow (m^3/day)	Mean - 87,600 Max - 151,000	Mean - None Max - 165,000	Consent conditions have never been exceeded. Very slight downward trend in discharge over the period.	A 20% reduction in discharge flow has been achieved when compared to production of the plant. A 50% reduction in discharge flow volume (not linked to production) has been achieved since 1990. These improvements have been achieved through reclaiming various process waters and other process improvements. This has increased the hydraulic retention time of the treatment and led to improvements in the levels of BOD, TSS and nutrients discharged.	Investigating future projects which would further decrease wastewater volumes by approx 5 million L/day (involve reuse of water). The more feasible gains have already been achieved.
Biological Oxygen Demand (BOD) (tonnes/day)	Mean - 2.8 Max - 12.1	Mean - 2.5 Max - 6.0	The mean BOD reading exceeds the consent limit. Significant improvements have been made to BOD discharge over the period and BOD has reduced accordingly. Latest rolling mean shows consent compliance.	Addition of phosphorus and oxygen to the treatment process has addressed the nutrient imbalance and improved removal of BOD. CHH identified BOD as one area where significant improvements could be made easily. Process changes are aimed at directing flows with high organic loads to the recovery circuit. CHH has undertaken a number of process changes and improvements to the treatment process to improve BOD removal.	Future projects will focus on improving mill discharge to the treatment process.
Total Suspended Solids (TSS) (tonnes/day)	Mean - 5.9 Max - 16.6	Mean - 7.0 Max - 14.0	The mean consent limit has not been exceeded since 2004. The extreme limit has been exceeded 4 times, but not since 2003 and the consent conditions have never actually been violated.	Addition of phosphorus and oxygen to the treatment process has addressed the nutrient imbalance and improved removal of TSS. Process changes and improvements have been made to improve TSS removal.	Ongoing improvements to hydraulic retention time and monitoring are expected to yield some improvements.

Table 1 (cont):

Parameter	Monitoring Results	Consent Conditions	Consent compliance	Improvements During 2001-2008	Planned Improvements
Colour (tonnes/day)	Mean - 35 Max - 75	Mean - 75 Max - 140	Consent conditions have never been exceeded. No significant improvement has been made in the period, however CHH state that they have managed to reduce colour significantly prior to 2001.	No improvement has been made in the monitoring period, but between 1996 and 2001 an approx 50% reduction of colour load was achieved (while mill output increased significantly). Projects undertaken to reduce colour load relate to the mill processes and include pulp washing improvements, black liquor improvements and improvements to bleaching.	CHH is keeping abreast of emerging technologies to reduce colour loads. It is also expected that improvements could be achieved through reducing black liquor discharge to the treatment process.
Total Nitrogen (TN) (kg/day)	Mean - 431 Max - 728	Mean - 600 Max - 750	Consent conditions have never been exceeded. There has been a downward trend in TN discharged over the period.	No significant improvements to total nitrogen have been achieved, due to the need to maintain a nutrient balance in the treatment process.	Ongoing improvements to hydraulic retention time and monitoring are expected to yield some improvements.
Total Phosphorus (TP) (kg/day)	Mean - 52 Max - 97	Mean - 62 Max - 75	The mean consent limit has never been exceeded. The extreme limit has been exceeded three times, most recently in 2005. There has been a steady increase in the discharge of TP since 2004.	The amount of phosphorus has increased. This is due to the addition of phosphorus to the treatment process that has brought about improvements in the removal of BOD and TSS.	Ongoing improvements to hydraulic retention time and monitoring are expected to yield some improvements.

The composition and concentration of colour in the effluent stream of a pulp and paper mill is affected by differences in raw materials, wood type, process water characteristics, process lines and operating regimes. The colour of effluent produced by a particular mill will be specific to their production line or processing technology, or an interaction of several processes. The exact nature of the discharge and cause of the colour is therefore likely to be unique to a particular mill and one treatment process is unlikely to provide a solution for all mill discharges.

Recently the Carter Holt Harvey and Norkse Skog Tasman mills[1] at Kawerau renewed their wastewater discharge consents. As part of that process, extensive reviews of colour removal technologies, costs and feasibility were undertaken. The capital and operating costs were calculated as was the likely colour reduction that would be achieved.

In assessing the probable cost to reduce Kinleith's colour load to the river, reference has been made to reports and evidence presented in the Environment Court relating to the appeal against the Carter Holt Harvey and Norske Skog Tasman mill discharges. Key references included Beca AMEC (2008), Beca AMEC (2009), and Johnson (2009 and 2010).

The Kinleith mill will have differences in the process configuration, the raw material inputs and the nature of the colour and the volume of wastewater compared to the Tasman mills (e.g., see Table 2 comparing flow and colour). However the costs generated for Tasman may be used to give an approximate order of magnitude of costs to treat Kinleith's colour (assuming similarities in production and mill age). More accurate cost estimates for the Kinleith plant would require a highly detailed study, undertaken in collaboration with Carter Holt Harvey.

Table 2: Comparison of Kinleith and Tasman discharges.

Item	Tasman	Kinleith
Flow (million L/day)	Typical 127 – 137	Mean 87.6 Max 151
Colour (t/day)	Typical 20 – 27	Mean 35 Max 75

[1] Norske Skog operate the paper mill while Carter Holt Harvey operate the pulp mill.

Effluent colour reduction technologies that are not currently used by Tasman were investigated and then ranked to identify the best viable technologies for implementation. The top-five technologies are summarised in Table 3. Carter Holt Harvey provided commentary as to which treatment technologies identified for Tasman may or may not be applicable to Kinleith. Capital cost estimates are indicative only.

Table 3: Tasman colour reduction options and suitability for adoption at Kinleith.

Treatment	Description and comment	Expected colour reduction (t/d)	% of Tasman colour load[1]	Estimated capital cost $Million	Suitability for Kinleith[2]
Spill collection	Reducing spills by monitoring, prevention and recycling within the liquor system is proven technology widely implemented in all major jurisdictions as well as an integral part of all new kraft pulp mill designs. Tasman monitors spills and recovers evaporator washings, but does not have a spill recovery system in place for all areas.	1–2	4–9%	0.5–1.5	Spill control systems at Kinleith are already advanced and do not provide significant scope for enhancement.
Improved brownstock washing	Good brown stock washing is a fundamental requirement in any fibreline. Washing should remove most of the organics from the pulp in the fibreline so that they can be sent to the chemical recovery cycle. Any improvement that can be made in washing efficiency will reduce the organic loading in the effluent stream. This option has high capital costs and has implications for the quality of specialty pulps.	0.3–1.6	1–7%	4–7	The opportunities for improved washing are less at Kinleith than at Tasman, because the washing efficiency of the Kinleith washers is already high and because the plant configuration does not give a ready upgrade path.
EOP filtrate recycle	Filtrate from the caustic extraction stage (termed EOP filtrate) of the bleach plant is the largest contributor to effluent colour. The recycling of this filtrate is a proven technology although it has limited acceptance by the pulp and paper industry, but can be limited by evaporator capacity. Tasman does not currently have the evaporator capacity to recycle more than a small portion of the EOP filtrate.	0.9–1.4	4–6%	5–8	Filtrate recycling faces the same barriers at Kinleith as at Tasman.

Table 3 (cont):

Treatment	Description and comment	Expected colour reduction (t/d)	% of Tasman colour load[1]	Estimated capital cost $Million	Suitability for Kinleith[2]
Advanced oxidation processes	Recent research has focused on use of advanced oxidation processes to treat various mill effluents. Although there are several processes in an experimental stage, the current viable oxidation processes use hydrogen peroxide, ozone or chlorine. Hydrogen peroxide treatment requires minimal capital investment but has been shown in some cases to exhibit a colour reversion in subsequent ASB treatment. The ozone treatment involves large capital investment and a large operating cost. Both peroxide and ozone have large chemical operating costs. Reducing effluent colour with chlorine has shown to be very effective, but chloroform generation can occur under certain conditions. The downside of this option is the increased generation of other contaminants.	0.7–1.6	3–7%	0.3–4	The options for advanced oxidative treatment at Kinleith are similar to those at Kawerau.
End-of-pipe treatment	A broad category that includes tertiary clarification activated sludge treatment (AST), membrane filtration and chemically enhanced primary clarification. Each is a proven technology with the exception of membrane filtration. The use of membranes for effluent treatment is still under development. Chemically enhanced primary clarification is not favoured because it is expensive to operate and sludge characteristics make it very difficult to handle. Activated sludge plants have high operating costs due to the aeration demand and the costs associated with sludge dewatering and disposal. The chemicals in the sludge make disposal particularly problematic. This option has very high capital and operating costs.	7–12	30–50%	25–50	The end-of-pipe options for Kinleith are similar to those at Kawerau.

[1] Based on 23.5 t/d which is the midpoint of the typical Tasman colour range of 20–27 t/d.
[2] Comment provided by CHH Kinleith mill.

No viable colour reduction technologies were identified for the Norske Skog Tasman Mill. Of the options considered for Carter Holt Harvey Tasman, spill recovery and brownstock washing measures were the most reasonable methods of reducing the mill effluent discharge colour, however neither of these are considered to be suitable options for Kinleith. The Kinleith mill already has spill recovery systems and the brownstock washing already has a high washing efficiency. Also, the Kinleith mill has limited evaporator capacity so that implementation of any treatment process which increases evaporator loading will require either significant capital investment to increase capacity or will impact on total plant throughput.

2. Goals

The colour change in the Waikato River produced by the mill discharge at Kinleith is regarded by river iwi and the wider community as being an issue which needs to be addressed. While the goal can be simply stated as wanting to reduce the colour load of the mill discharge, the challenge is to ensure that the mill remains economically viable.

3. Actions

Only three treatment options emerge as being suitable for adoption at Kinleith (see Table 3). Although based on options for Tasman, it has been assumed that implementation of any one of these processes could produce the same order of magnitude in colour reduction at Kinleith and would have similar capital and operational costs. Implementation of a combination of processes would not necessarily have an additive effect on colour reduction but some further reduction is likely.

The three actions, their potential costs (capital and operational), and the possible benefit in terms of colour reduction are summarised in Table 4.

Table 4: Colour reduction and indicative costs for the three Kinleith options.

Action	Scenario	% Colour reduction	Capital cost ($ million)	Annual operating cost ($100,000)
A	End-of-pipe activated sludge treatment	30–50%	25–50	20–50
B	Advanced oxidation processes - chlorine, peroxide or ozone	3–7%	0.3–4.0	2–40[1]
C	EOP filtrate recycle (partial recycle of bleach plant effluent)	4–6%	5–8	5–7

[1] Chlorine has a relatively low to neutral supply cost. Peroxide has a high chemical supply cost and ozone has an extremely high chemical supply cost..

4. Outcomes

Action A involving end-of-pipe treatment could possibly achieve up to 50 percent colour reduction. However it would require significant capital expenditure and has a high associated operating cost. Implementation of any these three options would result in some reduction of colour load to the Waikato River, with increase in water clarity and light transmissivity in the vicinity of the discharge. Environment benefits would however have to be considered against the higher costs of production to cover the associated capital investment and operating costs (associated with process chemicals, energy, labour). There would also be flow-on regional social and economic effects as a consequence of lower net revenues if these higher costs cannot be recovered from mill product sales.

5. Risks and probability of success

To achieve even a modest colour load reduction at the Kinleith mill would require significant capital investment and depending on the process may also have significant ongoing operating costs. For significant colour load reductions, end-of-pipe activated sludge treatment is required, which requires large capital expenditure and has high on-going operating costs. Advanced oxidation with chlorine has the lowest capital and operating cost but only achieves a modest colour reduction. It also has the potential disadvantage of forming chloroform. Bleach plant EOP filtrate recycling only achieves a modest colour reduction for a relatively high capital cost. This cost could be even higher if evaporator capacity has to be increased.

Implementing large capital works for effluent treatment may impact on the commercial viability of the mill. The mill produces commodity products that are subject to global supply and demand forces. This dictates the returns the mill receives. Although the Kinleith mill is the largest of its type in New Zealand it is relatively small by modern international standards and so it is important that any investment decision is economically sound.

6. References

Carter Holt Harvey (2009). Kinleith pulp and paper mill wastewater discharge monitoring report – Conditions 22B and 23, Resource Consent 961348, January 2009.

Beca AMEC (2008). Literature review of colour reduction technologies for kraft pulp mill effluent. Prepared for Norske Skog Tasman and Carter Holt Harvey Tasman by Beca AMEC Ltd, September 2008.

Beca AMEC (2009). Colour reduction technology report. Prepared for Norske Skog Tasman and Carter Holt Harvey Tasman by Beca AMEC Ltd, June 2009.

Davies-Colley, R.J.; Nagels, J.W. (1991). Effects of effluent from NZ Forest Products pulp and paper mill at Kinleith on the optical quality of the Waikato River. *DSIR Consultancy Report 6210/1*. October 1991.

Environment Waikato (2006). Review of science relating to discharges from the Kinleith pulp and paper mill. *Environment Waikato Technical Report 2005/58.*

Johnson, A.P. (2009). Statement of evidence of Anthony Peter Johnson (Beca AMEC Ltd). Presented to the Environment Court, 3 August 2009.

Johnson, A.P. (2010). Statement of evidence of Anthony Peter Johnson (Beca AMEC Ltd). Presented to the Environment Court, 5 March 2010.