MAC Curve Analysis at the Norske Skog Tasman Pulp and Paper Mill, Kawerau, New Zealand

Ben Scharadin

Introduction:

Norske Skog is an international pulp and paper mill that produces a majority of New Zealand's paper stock and also distributes to multiple other countries. As a result of the pulp and paper mill process, there are a large number of contaminants in the liquid effluents that are detrimental to the environment and human health. High levels of bio-chemical oxygen demand (BOD), chemical oxygen demand (COD), chlorinated organic compounds, phosphorous, and nitrogen are among the contaminants found (Pulp and Paper Mills). Numerous studies have been have been completed to show that these contaminants have adverse affects on the water system they are present in. Many of these studies analyze water samples that are collected and suggest a sustainable level of contaminants in the water that is to be reintroduced. This paper intends to build on those conclusions by proposing an economic instrument that uses the wastewater as a negative externality, which will introduce a method to coax Norske Skog Tasman to maintain safe levels of contaminants in their wastewater.

Background:

The Norske Skog Tasman plant is one of 23 mills in 15 different countries on 5 continents owned by Norske Skog (Tasman). The Tasman mill is located in Kawerau in the Bay of Plenty region on the north island of New Zealand. The mill is situated near a large water source, the Tarawera River. It is also next to a local Maori Iwi, which is the site for a majority of the solid waste material. The Iwi's land is rented out and used as a solid waste dumpsite. Precautions are said to be in place, however tests of the surface and ground water are still underway to determine if they are working. The liquid waste from the plant is treated then reintroduced to the Tarawera River. Figure 1 shows a map of the region relative to the rest of the North Island.

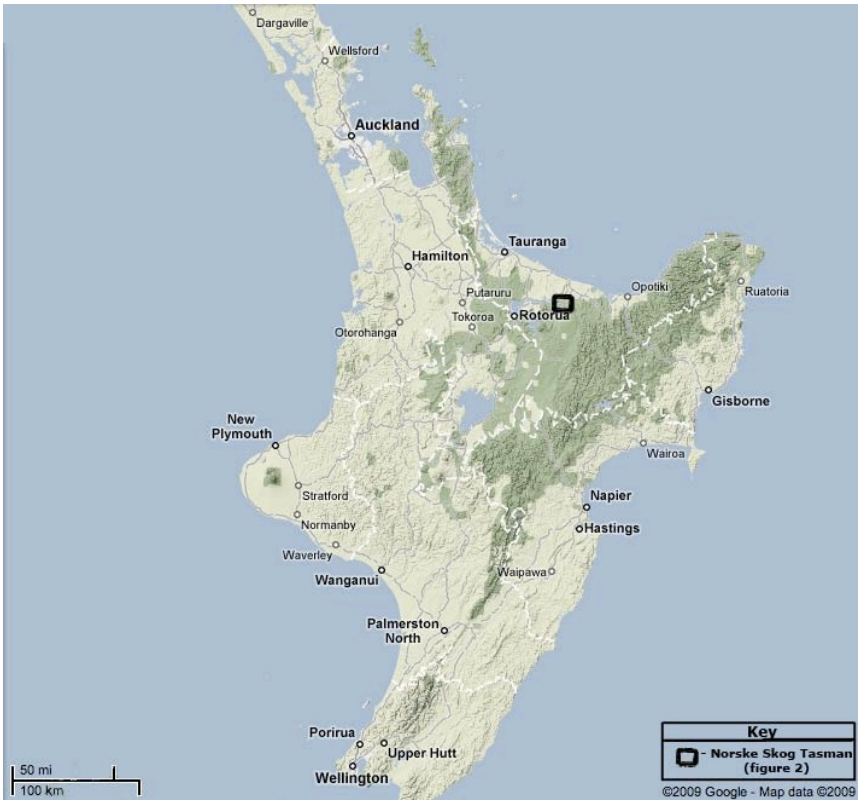

Figure 1: The north Island of New Zealand with a black box indicating the location of the Norske Skog Tasman pulp and paper mill. The boxed area is found in figure 2.

An aerial view of the Norske Skog Tasman site shows the layout of the mill. Just northeast of Kawerau along Tamarangi Drive is where the Tasman mill is located. The main production site where the paper production process, safety offices, administrative offices, and the main operation of the mill are located at the location marked by 1. With in this complex is also the Carter Holt Harvey Pulp mill, which is in a tight partnership with Tasman plant. Toward the top center of the aerial photo are the treatment ponds labeled 2. Here the wastewater is treated for the multiple contaminants that are introduced during the pulp and paper process. They are located adjacent to the natural feature labeled 3. This is the Tarawera River. The treated wastewater is re-introduced to the river and flows into the Pacific Ocean near Thorton.

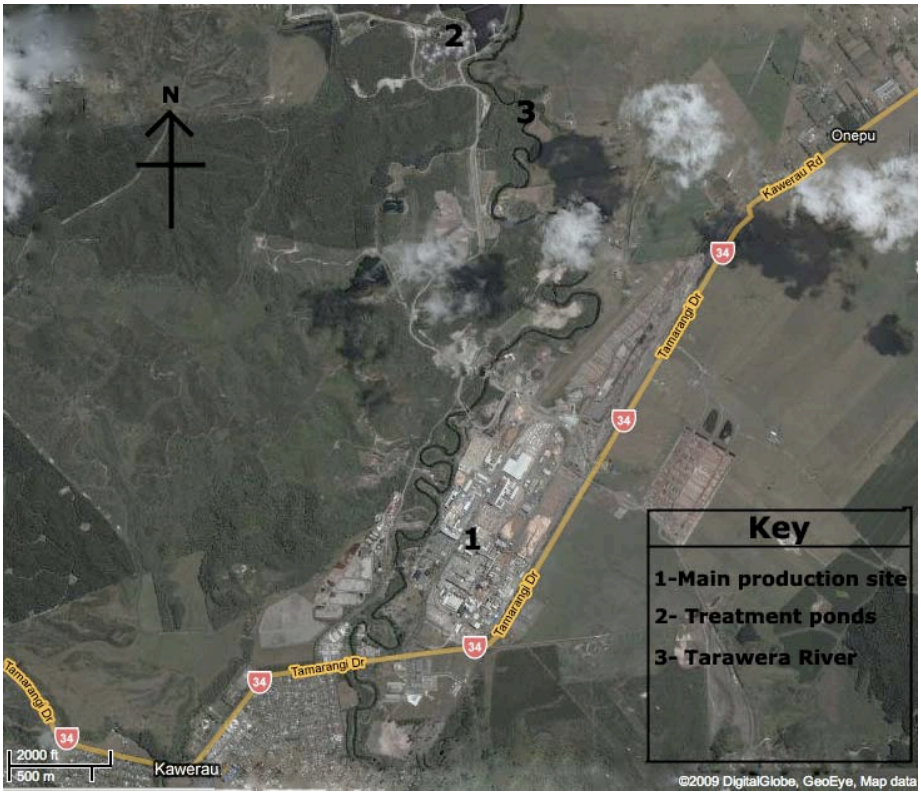

Figure 2: The Norske Skog Tasman pulp and paper mill site showing the location relative to major roadway 34 and the Tarawera River. Key sections of the image are labeled.

The plant has a production level of around 380,000 tonnes per year of newsprint, solely supplying New Zealand's demand and supplying 30% of Australia's use (Tasman). Water is on of the largest inputs to the paper making process and therefore there is a large amount of wastewater with the output. In 2005 the wastewater discharged was 30 million m^3 (Tasman). Under the assumption that Norske Skog would act as a competitive firm, without regulation the discharge water would be grossly over contaminated. This contamination would pose a social cost because it would negatively affect the people that would interact in anyway with the Tarawera River. The wastewater is therefore a negative externality, because by definition Norske Skog does not have to pay the full price of production for the paper process (Externality). For example with no regulation the pollutants in the river would increase and there would be a social cost that Norske Skog does not have to pay.

In order to solve the externality problem to find an efficient point the externality is internalized. This means that the marginal cost of the externality (MEC) is added to the marginal cost of production (MPC) to get the marginal social cost (MSC), such that MEC + MC= MSC. The MSC curve is then set equal to the marginal benefit curve (MB) and a new efficient point is found accounting for the pollutant. The new level of production is always less because MEC > 0. Figure three, using linear models, shows this relationship.

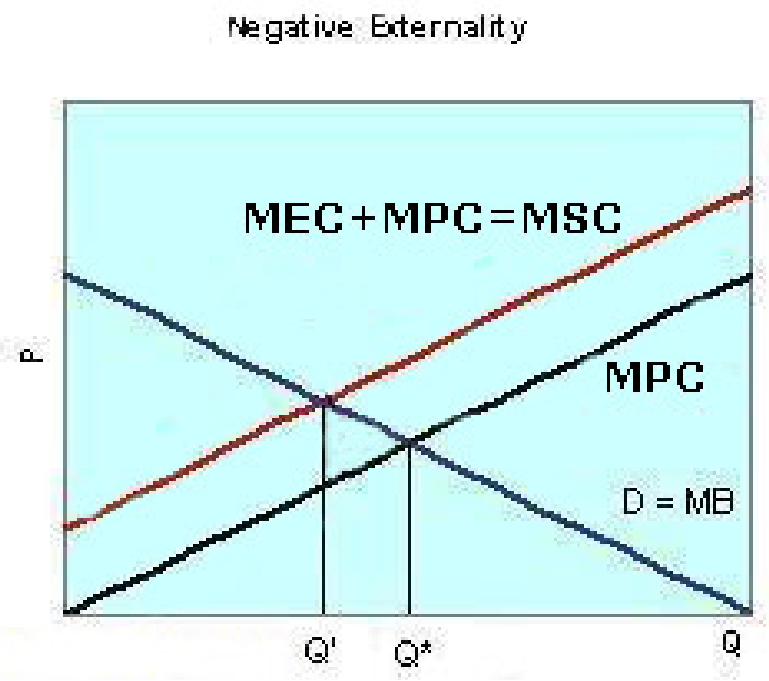

Figure 3: Internalizing and externality by adding marginal social costs to marginal private costs, then setting the sum equal to marginal benefit.

The same process can be applied specifically to a pollutant, however the terminology changes slightly. The MSC is now marginal damages (MD) and the MB is now the marginal abatement cost (MAC) (Tietenberg). With the MD being the damages to society by polluting and MAC being the cost incurred by the company to reduce pollution, the efficiency point is setting the cost incurred by society and the company equal at the margin. The efficiency point is the level of pollution that maximizes social utility. This relationship is shown in figure 4 using standard MAC and MD shaped curves.

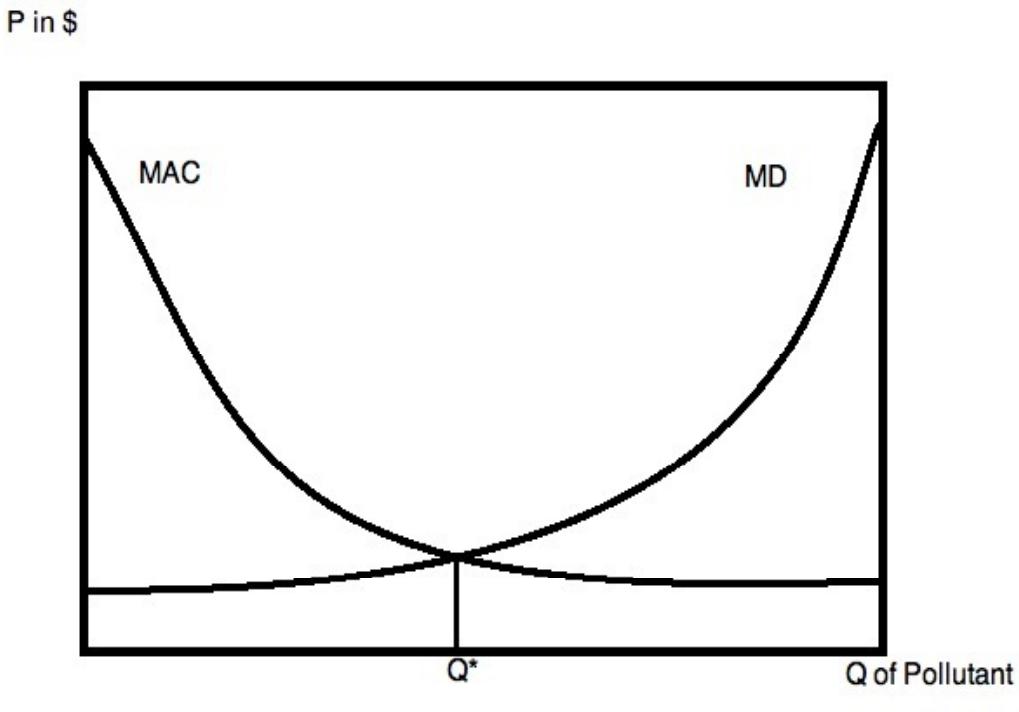

Figure 4: Efficiency point found for quantity of pollutant given marginal abatement costs and marginal damages of the pollutant.

The negative externality that this paper will be analyzing is wastewater from the Norske Skog pulp and paper mill. The specific characteristics are the COD, BOD, and turbidity of the water. In reality the marginal benefit curve is rarely well defined in a dollar metric and therefore alternative evaluation methods are adopted. This means that instead of allowing an efficiency point to decide the level of wastewater output, an arbitrary maximum level may be set. There are also other approaches including a predetermined amount of transferable credits to pollute distributed to all polluters or a set charge on every unit of pollution emitted. This study will look at Norske Skog's estimated marginal abatement costs and use the EPA maximum allowances for the three specified pollutants as an arbitrary standard in order to estimate the optimum additional cost to Norske Skog to reach the desired level of abatement.

Method:

Data must first be collected from the specific site that is being analyzed. Values of their costs of treatment for the particular contaminants are ideal; however for an estimate the total cost of wastewater treatment would be sufficient. These values should be gathered for as many years as possible. Each of the amounts must be adjusted for inflation using a numeraire dollar amount. For simplicity the earliest year should be chosen as numeraire year. Now that there is a base dollar amount the other years' values must be adjusted so that they are measured in the base dollar amount. The process for this

adjustment is the cost of treatment in current dollars x (100 + %Δ inflation index) or the cost of treatment in current dollars x the inflation index (see figure 5). The consumer price index, CPI, is the measure regularly accepted as the measure of inflation. Using the CPI for New Zealand the National Reserve Bank supplies a calculator allowing the adjustment process to be done quickly and routinely (see figure 6).

Mock Treatment Costs and Adjustments

	Treatment Cost	Adjusted Treatment Cost	NZ CPI	%Δ CPI
2000	$100.00	$100.00	842.76	0.00
2001	$110.00	$106.73	868.55	-3.00
2002	$120.00	$113.50	891.01	-5.40
2003	$130.00	$119.94	913.48	-7.70
2004	$140.00	$127.19	927.62	-9.10
2005	$150.00	$132.59	953.41	-11.60
2006	$160.00	$136.89	985.02	-14.40
2007	$170.00	$141.85	1010	-16.60

Figure 5: Mock table of values for the treatment cost compared to the adjusted cost given a percent change in consumer price index.

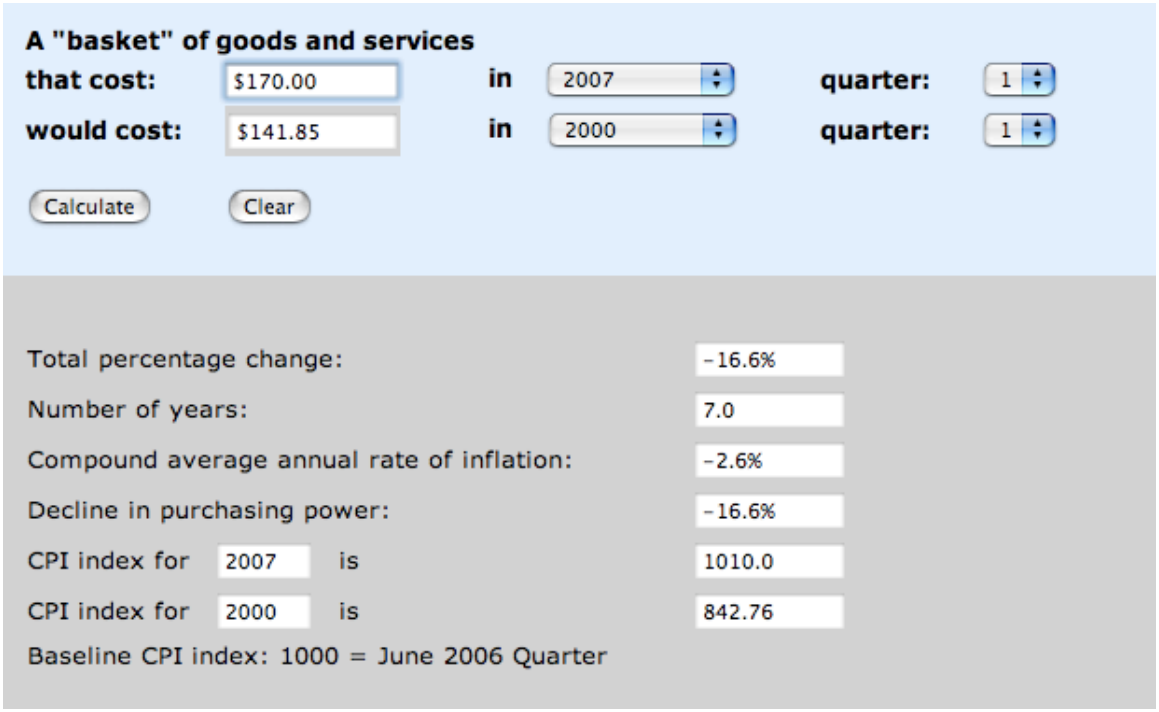

Figure 6: Image of the online inflation calculator using New Zealand consumer price index as the measurement for inflation. The New Zealand National Reserve Bank provides the calculator.

The second step to finding the MAC curve is gathering the annual average values of the contaminants. For each year that the annual expenditure on treatment is gathered, the corresponding annual average for COD, BOD, and turbidity of reintroduced water should be gathered. Once these values are gathered plots of treatment cost vs. COD, treatment cost vs. BOD, and treatment cost vs. turbidity can be drawn.

Finally, using these values a regression evaluation should be done on each plot. Multiple functional forms should be considered and the choice for best model should be based on econometric measures such as R^2, adjusted R^2, and hypothesis testing (Stock and Watson). Once the appropriate model is chosen the sample regression line will be used as the total abatement cost curve, TAC curve (figure 7). A simple derivative of the contaminant with respect to treatment cost will yield a MAC curve (figure 8).

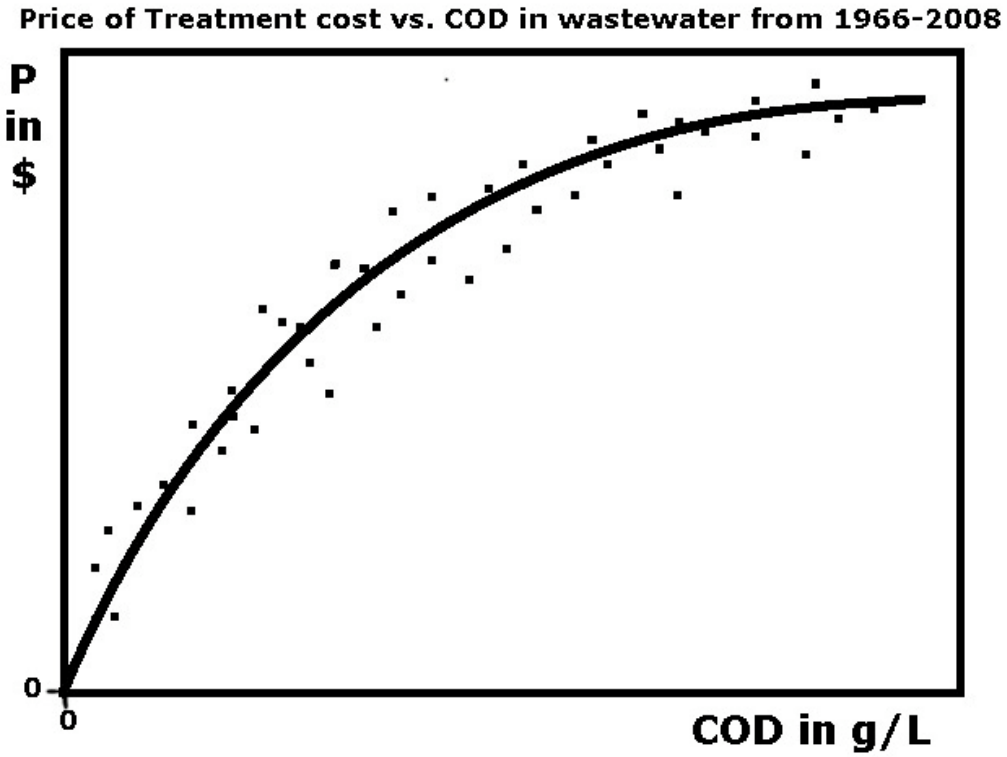

Figure 7: Example of an estimated regression line showing the individual point values for each year of observance for COD.

With a well-defined MAC curve, an arbitrary legislative standard can be set to find an evaluation point. In this case the maximum value for COD, BOD, and turbidity suggested by the United States Environmental Protection Agency (EPA) are chosen as the standard. This maximum level of allowed pollution is then substituted into the sample MAC curve to see what it would cost the company at the margin to reduce pollution to that level (figure 8). In practice this is the value of the tax that would need to be imposed to achieve the level of pollution reduction wanted (Tietenberg).

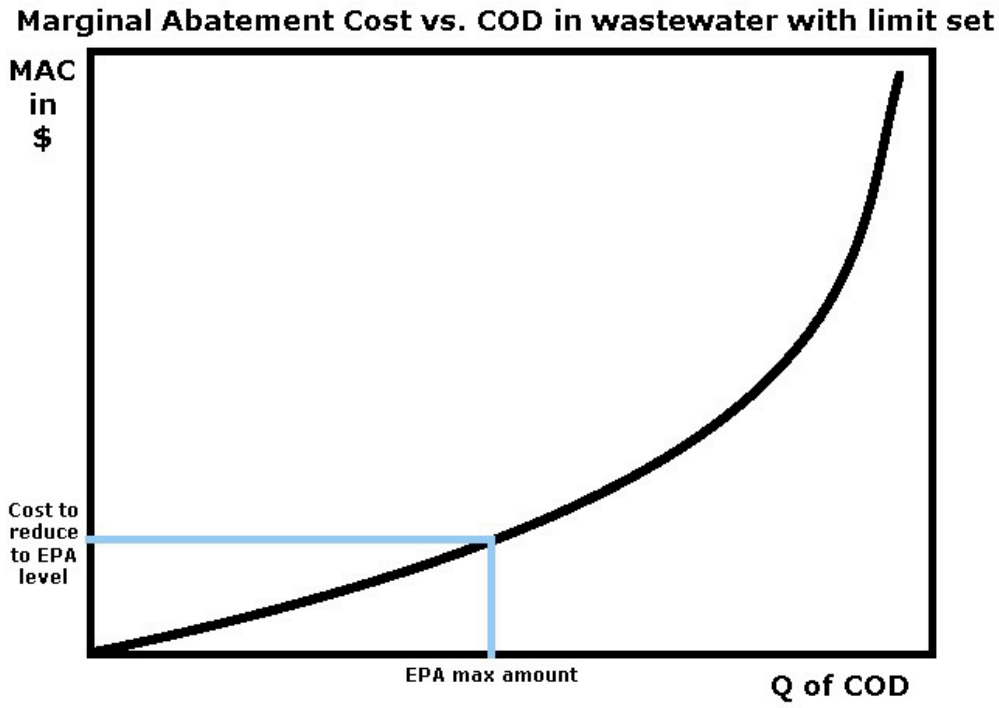

Figure 8: Graph showing the cost to reduce to Environmental Protection Agency suggested level, by setting maximum level allowed and finding the corresponding marginal abatement cost.

Discussion:

The evaluation for the appropriate tax levied against Norke Skog is a very powerful tool that can be used by legislative bodies to control effects on the environment. However, there are a few particular parts of the process that must be researched further. The first piece of the analysis that must be further reviewed is how the inflation is adjusted. In this study the New Zealand Consumer Price Index was used to account for any increase in spending dependent on inflation. The CPI is an index derived from the changes in the price urban consumers spend on a representative basket of good and services (National Reserve Bank). This index was used at the scaling factor because it is the most widely quoted and commonly used inflation statistic. Despite its popularity there are other indexes developed that may be more appropriate for this study. One alternative would be the New Zealand Employment Cost Index, which calculates indexes of labor costs and average wages over time (National Reserve Bank). This index may be more applicable because a portion of the cost of treatment is by the wastewater employees. Another possibility would be the New Zealand Producer Price Index, which develops an index using the average selling prices received by domestic producers for their output (National Reserve Bank). This may be a more applicable index because the price Norske Skog receives for their output may vary the amount the company spends on wastewater treatment. There are also other indexes that may be used, however further study is needed to determine, which is the best to adjust the abatement costs gathered from the company because although similar they can change the result of the assessment (see figure 9).

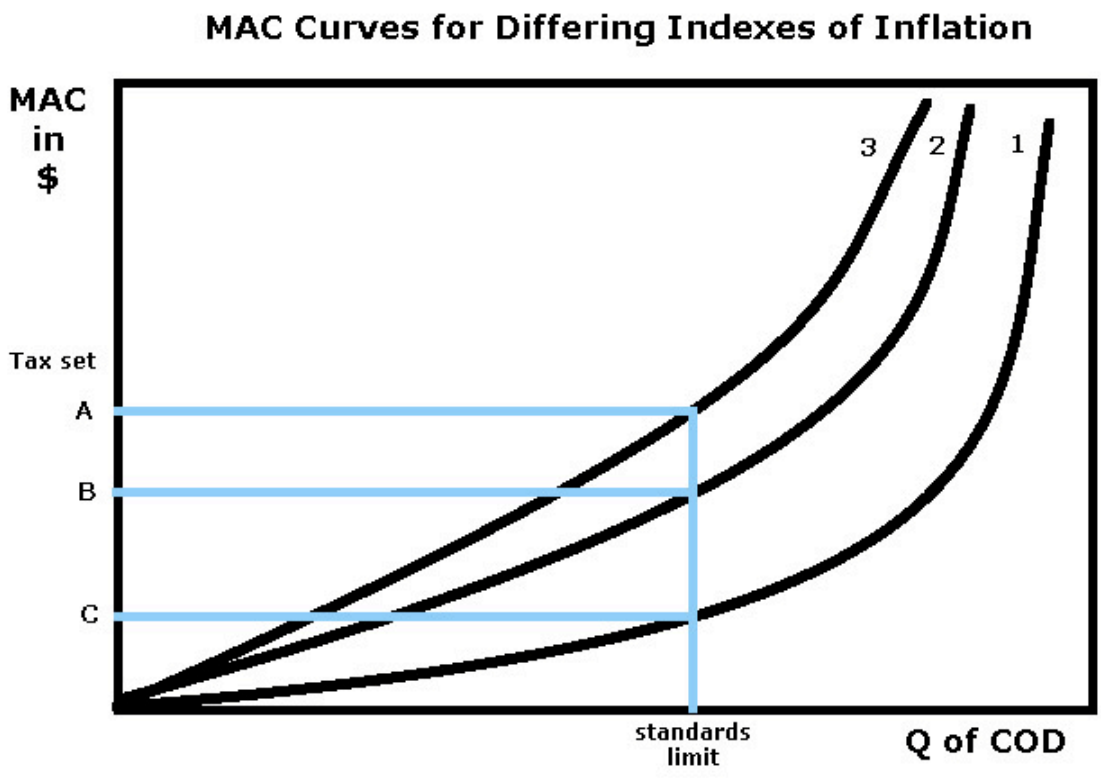

Figure 9: Chart showing the effect of the inflation index on the tax set with the same standard being met. Line 1 is using the consumer price index and corresponds to tax C. Line 2 is using New Zealand employment cost index and corresponds to tax B. Line 3 is using the New Zealand producer price index are corresponds to tax A.

During the econometric portion of the analysis there are also caveats to consider. The most fundamental is the sample size. It is necessary to have a sufficiently large sample size for the regression to be applicable for future forecast. If the sample size is not sufficiently large the analysis will still find the most appropriate line to fit the supplied data, but the data provided may not be a representative sample (Stock and Watson). For this study it means that information on enough years must be available if the behavior of the company is supposed to be accurately assessed.

Choosing a correct functional form is an important econometric issue also. Deciding whether the TAC model will be linear, quadratic, logarithmic, or a combination can have distinctly different results. There are a number of methods that can be used to assess the effectiveness of the chosen model to predict values. The most widely used is the R^2 and adjusted R^2 values (Stock and Watson). These are a measure of the predicted sum of squares over the total sum of squares, so naturally a higher value is better. As long as the dependent variable in competing models are the same these values can be used to choose the best model. Other methods such as significance tests, t-tests, and F-tests can also be used to compare differing forms (Stock and Watson). Studies should be done to testing multiple functional forms to see, which has the most forecasting power for the Norske Skog Tasman site because the effects on the decision made are largely dependent on this decision (see figure 10).

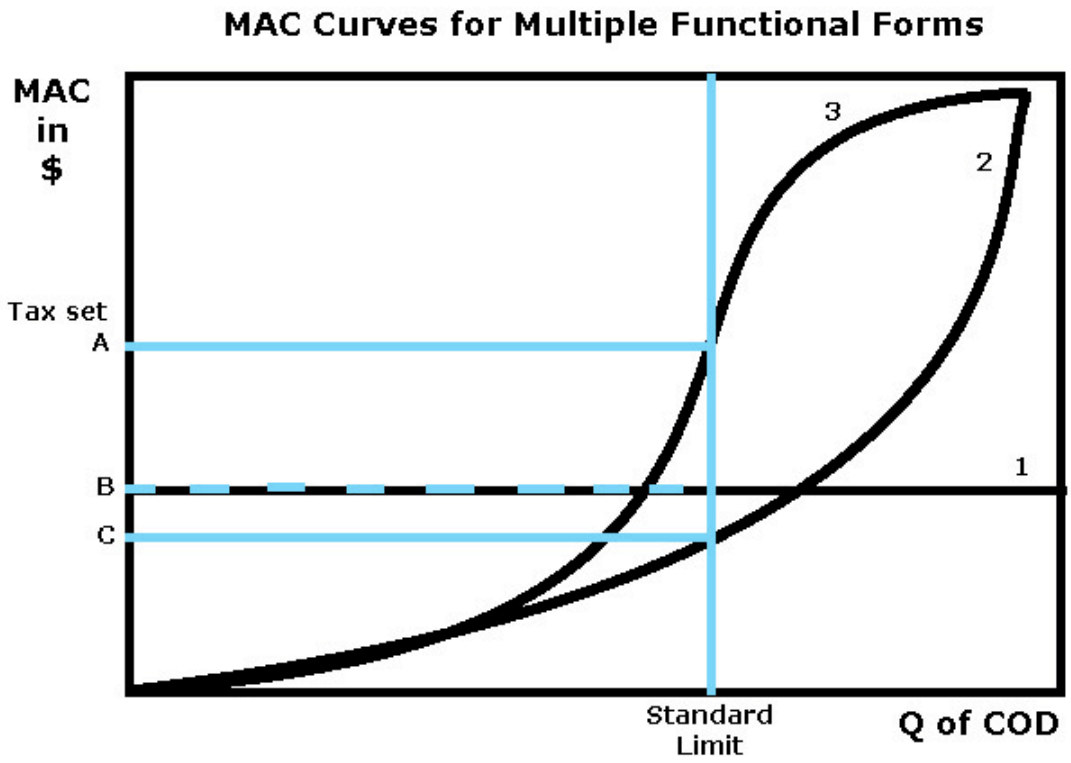

Figure 10: Graph showing the effect of functional form on the tax set with the same standard being met. Line 1 is the MAC curve for a linear model and corresponds to tax B. Line 2 is that MAC curve for a cubic model and corresponds to tax C. Line 3 is the MAC for a higher order polynomial model and corresponds to tax A.

The EPA has done numerous studies to estimate the maximum amount of pollutants from wastewater from pulp and paper sites. From these studies a suggested maximum level has been suggested as a general guideline. Despite this guideline an important suggestion is to assess the particular site at which the pollutant is being released. Depending on the flow, area surrounding, and other aspects of the river the allowances may be higher or lower then the blanket suggested amount. In this light further study should be done to see that the standard set by the EPA is applicable to the Tasman site and if not what the regularity standard should be.

Other economic instruments for reducing pollution are also available. One market-based instrument is “polluter pays”. In this mechanism the polluter would pay a set amount for each unit of pollutant that was released into the environment. This instrument provides an opportunity cost and constant incentive to seek a cleaner production method. Tradable rights is another method used to achieve an economic standard. With this method a standard is set for the whole region. For example a maximum level of BOD in the Tarawera River would be set and enforced. Then the right to pollute in the river, summing to the maximum standard, would be dispersed amongst all polluters. These rights are allowed to be traded freely amongst all polluters and in this way through the market process the standard is met and is at least cost. Both of these

methods have been used in SO_2 reducing litigation and have seen strong results (Tietenberg).

The standards approached was used for this case because of the specific characteristics of the study. Norske Skog is the sole major polluter to the Tarawera River and accurate monitoring of the site does not seem to be apparent. These factors lead the situation away from other techniques used to achieve an environmental goal and towards a standards instrument. This technique would be the cheapest to enforce and easiest to implement. The on ongoing cost would be intermittent reassessments of the environmental condition. If the standard is not being met then a reevaluation must take place and a new standard implemented.

Conclusion:

The Norske Skog Tasman pulp and paper mill is New Zealand's sole provider of newsprint and is also a major competitor on the international market. With this massive level of output comes a large level of wastewater. To ensure the wastewater is safe to be reintroduced to the Tarawera River stipulations must be placed on the site. By estimating a treatment cost vs. contaminant curve and differentiating it a MAC curve can be found. This in turn is used to find the abatement cost the company would incur for a given level of desired reduction in contaminant. This value is then set as a tax that site will be subject to if the appropriate level of reduction is not met. If the firm is competitive it will reduce the contaminants in the wastewater up and until that point, achieving an environmental goal through economic means.