Mr D. Stock,
P.O. Box 29443,
Fendalton,
Christchurch.
1/03/2011
Dear Mr Stock,

You have asked me to provide an independent expert review in relation to various colour physics and wool colour testing issues, together with a view on possible wool colour improvements which might be achieved in scouring. You have also asked me to comment on the economic benefits which might result for the industry, should these be achieved. The background to your request are the sections of the Cavalier Bremworth application to the Commerce Commission concerned with possible wool colour improvements and the economic benefit which might result for the industry, should the NZWSI scours be reconfigured as described in the application. Whilst I am not in a position to provide a direct comparison between the outcome from scouring the same wool on the two scouring systems employed by these two companies, the purpose of this review is to assist the Commerce Commission to understand and evaluate this aspect of the application. The views I express below are my own views as an independent expert in this field. A summary of my relevant qualifications is attached.

My opinion is as follows.

1. The Colour Test and the Tristimulus Values X, Y and Z.

The colour of wool is routinely measured using the internationally accepted colour test, IWTO -56. The measured colour is described by three tristimulus values X, Y and Z. These are widely used in colour physics.

In the case of wool, the Y value is often associated with the brightness of the wool. It indicates the amount of incident light reflected. The higher the value, then the more versatile the wool and the wider range of shades to which it may be dyed. The colour test measures the clean or base colour. This is essentially the best value that can be achieved with perfect scouring.

The same wool sample scoured in different ways will have a different appearance depending on how much residual dirt and grease remains. However the underlying clean colour of the fibres, the base colour does not vary much. Indeed a given lot of wool will essentially have the same base Y value both in the greasy form and after it has been scoured. In preparing wool for the colour test, the fibres are presented as short snippets to a very thorough scouring followed by vigorous mechanical

9 Edward Street, Lincoln,
Canterbury, New Zealand
T: +64 3 325 2969
F: +64 3 325 2964
M: +64 21 644 232
E: carnaby@xtra.co.nz

opening in a special machine which also removes the vegetable matter particles aerodynamically. This effectively strips the maximum possible grease and dirt leaving just the clean fibre to be tested.

It is generally not possible to significantly affect the base colour, Y by carrying out more or less agitation in the scour or indeed by more effective scouring and rinsing. This can only affect the appearance of the wool before it enters the preparation step for base colour determination.

The "as is" colour is sometimes measured by omitting the cleaning steps from the colour test preparation. Y values in the "as is" test, do vary according to the scouring quality. For commercially scoured wool the measured "as is" Y may be up to 10 units below the base colour tested on the same lot. However improvements to "as is" Y values are of temporary significance and little economic value as wool is usually subjected to further vigorous mechanical agitation during carding and prolonged wet treatments associated with dyeing. It is the base value of Y which carries the economic significance of substance.

What might constitute a significant improvement in Y? The various sampling errors and other sources of imprecision associated with testing create the result that the wool colour test has a retest precision of 3 units of Y at the 95% confidence level[1]. It has been reported that most observers cannot distinguish two different wools by eye if they are within 1.8 units[2] of Y each other.

2. Public Domain Knowhow relating to Possible Scouring Technology Improvements.

It is relatively straightforward to carry out more vigorous agitation, use cleaner wash liquors or achieve more effective rinsing during scouring. A number of these steps were proposed by WRONZ when the industry funded joint research programs. These additional steps are likely to result in a cleaner, brighter looking product leaving the scour, and a higher "as is" Y value. Even though this doesn't alter the fundamental value of the wool, which is determined by base Y, there was a WRONZ project aimed at closing the gap between the "as is" Y value of wool and its base Y value.

But there is no reason to suppose that any of these steps might greatly improve the base colour of the fibres as this is always measured only after the even more vigorous agitation and cleaning which occurs during sample preparation for the colour test IWTO 56.

It is relatively common in scouring to add small amounts of bleaching agent. This practice generally lifts both the base Y value and reduces the yellowness of the wool. Yellowness is often characterized from the difference between the Y and Z tristimulus values, viz, Y-Z. Whilst small amounts of bleach are relatively harmless, excessive bleaching leads to loss of mechanical performance of the wool fibres.

It is also common to use pH adjustment in the final rinse bowl. Dilute formic acid is sometimes used. Changes to the pH can affect 'as is' Y values significantly but these are temporary and largely reversible on further pH adjustment, unless iron staining is reduced by the acidity.

Equally, higher processing temperatures are known to adversely affect the base colour.

Staining of the fibre with iron ions sourced from soil particles depresses the Y value[3]. It is possible that extra mechanical action prior to wetting may reduce the amount of iron staining and consequent dulling of the wool by removing more soil before wetting the wool. Ion staining is not reversed by the cleaning steps used in the colour test IWTO 56.

3. The Scouring Technology Improvements Described in the Application.

These all appear to fall into the category of more vigorous agitation, cleaner wash liquors or better rinsing. As such they are likely to result in a cleaner, brighter looking product leaving the scour, and a higher "as is" Y value. But there is no reason to expect that any of these steps would be likely to greatly improve the base colour of the fibres as this is always measured only after the even more vigorous agitation and cleaning which occurs during sample preparation for the colour test IWTO 56.

4. The reported Improvements in Colour Achieved by Cavalier.

The Cavalier application says that whilst the base colour of greasy wool produced in the North Island over a ten year period has risen by only 0.2 units of Y, the base colour of the scoured product produced by Cavalier has improved on average by 1 unit of Y. This needs to be considered in the light of the test imprecision of 3 units, results taken over many samples and averaging effects of the central limit theorem. Bearing these in mind, it is possible that a small real improvement of say 0.8 of a unit of Y has been achieved. Whilst the possible effect of changes in bleaching practice have been considered and excluded, there are other aspects of processing, as described above, which are known to affect the Y value obtained. No information is provided in the application on trends in the use of acid or whether processing conditions of time and temperature during scouring and drying have changed. These would need to be considered to properly understand and evaluate Cavalier's suggested Y improvement.

It is possible that the new processes introduced by Cavalier have reduced the amount of iron staining and consequent dulling of the wool by removing more soil before wetting the wool. But NZWSI also employ very vigorous triple drum openers in opening their greasy wool and no supporting information is provided to support the suggestion that the Cavalier processes are more effective in this regard.

However more significantly when it comes to evaluating the information provided by Cavalier, I note that the two populations of wool used in the comparison are not the same. Figure 5 which relates to greasy wool in the North Island includes all wool produced and has a mean Y value of about 62.2 units. Figure 6 which relates to Cavalier's scoured output has an average Y value of about 65.2. The three unit difference implies that Cavalier uses an above average subset of the NI production. The small shift of 1 unit or less over 10 years could just reflect the progressive purchase of a slightly whiter subset of North Island wools over that 10 year period. (For example fewer oddments may now be included in blends)

Therefore it is my opinion that no relevant information has been provided in the application to support the contention that the Cavalier scours can achieve a base colour result, Y different from that achieved with the NZWSI scours as they are presently configured. I consider that there are sound scientific grounds for doubting that this is the case.

5. Proprietary Know-How Controlled by NZWSI in Relation to Y Enhancement.

It is public knowledge that NZWSI offers a commercial scoured product under the trademark Glacial™. [redacted] The details of the process are confidential to AgResearch (which acquired the WRONZ IP assets) and exclusive to NZWSI under the terms of a license agreement. [redacted]

The process has been used to launch very bright white carpets by leading overseas carpet makers using wool processed in the Kaputone scour of NZWSI. [redacted]. Some competitors have tried to emulate the Glacial™ process by double scouring the wool. This inevitably lifts the "as is" colour, but does not necessarily lift the base colour.

6. The Value of Y and the Public Benefit

There have been various studies of the economic value of colour in NZ wools. Many of the studies were carried out by my students (e.g. Maddever and Aryal). It is clear from these studies that the wool auction market has consistently rewarded suppliers for improved colour in wool. It is my opinion that a long term average value of 4c/kg per unit increase in base Y is a conservative figure and could be used to reliably calculate economic value.

I consider that the arguments presented in sections 18.31 to 18.37 of the Cavalier application relating to the economic value of Y, should improvements be achieved, may be broadly accepted.

However as noted above the Cavalier application does not in my opinion provide any reliable information to support the suggestion that changing the NZWSI scour configurations would improve the base colour of the wool which NZWSI currently produce. Equally, in my opinion, no basis has been identified for expecting benefits in terms of improved Y values to result from the proposed acquisition and reconfiguration of NZWSI assets.

7. Final Remarks

[redacted]

8. References

1. "Stability of wool colour", Peter Baxter, SGS Wool Testing Services, Wellington, 2001 Massey Wool Association Conference

2. "Changes in unscourable discolouration of Romney wool samples during storage for one month." Bray, A. R., D. O'Connell, et al. (1999).Proceedings of the New Zealand Society of Animal Production 5 9: 49-51.

3. "Relationship Between the Whiteness of Scoured Wool and the Level of Residual Nitrogen Containing Contaminants", B.O. Bateup, Textile Research Journal, 1984, 54, 299-307.

G.A. Carnaby,
MNZM, DSc., FRSNZ.
19/02/2011

Profile - Dr G.A. Carnaby

Garth Carnaby runs his own company providing consultancy, research, governance, and strategic advice services, in the science, agriculture, and wool fields.

Garth, a New Zealander, had his initial training, in textile physics, graduating from UNSW with first class honours and the university medal in 1971. After gaining his PhD at Leeds University in 1976, he returned to NZ to spend 20 years at WRONZ (Inc.) involved in personally conducting and leading a very wide range of research projects all involving in some way the application of mathematics and physics to the industrial utilisation of the New Zealand wool clip. He produced over 200 publications and patents during this period and was subsequently awarded a DSc from UNSW and Fellowship of RSNZ in recognition of this research work. During this period he invented and commercialised the WRONZ Needle.

In 1992 Garth became Managing Director of WRONZ (Inc). He retired from his CEO roles in 2004 and set up his own research business after successfully creating Canesis Network Ltd from merging WRONZ (Inc) and Wools of New Zealand Ltd.

His other current external appointments include; President of the Royal Society of New Zealand, Chair of the NZ Synchrotron Co Ltd, Director of the Australian Synchrotron Company Ltd and of the Australian Synchrotron Holding Co Ltd, Chair of the Canterbury Development Corporation and the Canterbury Economic Development Fund Trustee Ltd, and Director of CORE Education Ltd. He was World President of the Manchester based Textile Institute in 2000-2002 and chaired the Marsden Fund Council from 2004-2009. He has also been awarded two further honorary Doctorates by De Montfort and Lincoln Universities. He was made a Member of NZ Order of Merit, (MNZM) in the 2006 Queen's Birthday Honours for services to the wool industry.

3 Edward Street, Lincoln,
Canterbury, New Zealand
T: +64 3 325 2969
F: +64 3 325 2964
M: +64 21 644 232
E: carnaby@xtra.co.nz