2014

2013 Crop Bentley Pilot Malting and Brewing Trials

CMBTC

4/2/2014

2013 Crop Bentley Pilot Malting and Brewing Trials

Summary

CMBTC conducted pilot malting and brewing trials with 2013 crop barley samples of Bentley, AC Metcalfe and CDC Copeland. These barley samples were provided to the CMBTC by Canada Malting, Calgary, Alberta. The objective of this study was to examine Bentley barley quality and process performance in malting and brewing against the controls, CDC Copeland and AC Metcalfe.

The trial results obtained in this study indicated that there were some significant quality differences between Bentley and control AC Metcalfe and CDC Copeland. Some of the important quality differences recorded in this study are summarized in the table below:

Bentley quality compared to AC Metcalfe and CDC Copeland

Parameter	Compared to AC Metcalfe	Compared to CDC Copeland
Barley Analysis		
Grain protein	Higher than Metcalfe	Higher than Copeland
Germination energy	Higher than Metcalfe	Higher than Copeland
Water sensitivity	Comparable to Metcalfe	Stronger than Copeland
Water-uptake	Comparable to Metcalfe	Faster than Copeland
Chitting	Higher than Metcalfe	Comparable to Copeland
Acrospire growth	Faster than Metcalfe	Comparable to Copeland
Malting Performance		
Modification	Better than Metcalfe	Comparable to Copeland
Extract	Lower than Metcalfe	Higher than Copeland
α-amylase	Lower than Metcalfe	Higher than Copeland
Diastatic power	Comparable to Metcalfe	Higher than Copeland
Beta-glucan	Lower than Metcalfe	Lower than Copeland
FAN level	Higher than Metcalfe	Higher than Copeland
Brewing Performance		
Conversion time	Comparable to Metcalfe	Comparable to Copeland
Lautering time	Slower than Metcalfe	Slower than Copeland
Brew. Efficiency	Comparable to Metcalfe	Comparable to Copeland
Fermentability	Comparable to Metcalfe	Comparable to Copeland
Final beer color	Higher than Metcalfe	Higher than Copeland
Final beer foam	Comparable to Metcalfe	Lower than Copeland
Green = better; Red = poorer; Yellow= comparable results		

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

1. Barley Analysis

When the barley samples of Bentley, AC Metcalfe and CDC Copeland arrived at CMBTC, their quality was examined immediately, and the test results are given in Table 1. Please note that except for the germination testing all the test results reported in Table 1 were generated from a single test only. The barley testing results indicated that there were significant varietal differences in barley quality among samples included in this study.

Table 1. Analysis of 2013 crop barley samples of Bentley and control AC Metcalfe and CDC Copeland

Sample ID	Variety	Moisture, %	Protein, %	Germination, % (4ml, n=2)	Germination, % (8ml, n=2)	1000 Kernel wt, g	Sizing, %		RVA
							>6/64 sieve	>5/64 sieve	
B-13-162	Bentley	12.0	12.7	100	81.0	49.5	93.89	4.37	7
Control									
B-13-159/ B-13-163	AC Metcalfe	13.0	11.6	97.0	83.5	48.6	91.84	5.66	150
B-13-161	Copeland	11.5	12.2	100	95	45.3	85.39	11.77	140

The 2013 crop Bentley barley sample (Table 1) showed acceptable grain moisture for safe storage (<13.5%), acceptable protein content, very good thousand kernel weight and excellent plumpness. Its germination energy was excellent with strong water sensitivity. In comparison with the AC Metcalfe and CDC Copeland controls, this Bentley barley sample showed better overall quality. However, the extremely low RVA value indicated that this Bentley sample experienced significant pre-harvest sprouting damage. It is suggested that this barley should be processed ASAP to avoid potential germination loss during storage.

2. Pilot Malting Trial

At CMBTC three pilot malting trials were conducted on the Bentley barley sample. These pilot malting trials were carried out under the malting conditions given in Box 1, which were similar to those used for evaluation of 2013 new crop barley quality at CMBTC.

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

CMBTC™
CANADIAN MALTING BARLEY TECHNICAL CENTRE

Box 1. Details of pilot-malting conditions employed in this study

STEEPING CYCLES **Total 46 hrs (8 hrs Wet- 14 hrs Dry- 8 hrs Wet- 14 hrs Dry- 2 hr Wet) at 14°C** **GERMINATION CONDITIONS** **Day 1 @ 15°C; Day 2@ 15°C; Day 3 @ 15°C; Day 4 @ 15°C** **KILNING CONDITIONS** **A 21 hour cycle with a 4-hour curing phase at 82° C**

Steep-out moisture, chitting rate and acrospire growth

Under the given malting trial conditions in the pilot malting trails, this Bentley barley sample did not exhibited any process abnormalities. At steep, normal water-uptake and normal chitting were observed. Bentley barley obtained satisfactory steep-out moisture content and excellent chitting rate at the end of steep (Table 2). During germination this Bentley sample showed good growth of acrospires. In comparison with the control CDC Copeland and AC Metcalfe, Bentley barley showed slightly slower water-uptake than CDC Copeland but faster than AC Metcalfe. Its chitting rate was similar to Copeland but higher than Metcalfe. Its acrospire growth was also slower than CDC Copeland but more advanced than AC Metcalfe.

Table 2. Steep-out moisture, chitting rate and acrospire growth profile of 2013 crop barley samples

Variety	Pilot-malting #	Steep-out Moisture,%	Chitting rate,%	Acrospire length @96 hrs				
		(%)	(%)	0-¼ (%)	¼-½ (%)	½-¾ (%)	¾-1 (%)	>1 (%)
Bentley	PM-13-064	43.22	100	0	0	65	30	5
	PM-13-070	44.91	100	0	0	5	70	25
	PM-13-073	44.09	100	0	0	5	70	25
	Mean	44.07	100	0.0	0.0	25.0	56.7	18.3
Control								
CDC Copeland	PM-13-057	44.4	100	0	0	0	80	20
AC Metcalfe	PM-13-054	43.30	90	0	0	20	60	10

Complete analysis was conducted on the malts generated from the pilot malting trials of Bentley 2013 crop and the analytical results are given in Tables 3. The table also includes the malt analysis of 2013 crop AC Metcalfe and CDC Copeland trials for comparison.

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

CANADIAN MALTING BARLEY TECHNICAL CENTRE

Table 3. Analysis of malt generated from the pilot -malting trials with Bentley

Variety	Bentley				Copeland	Metcalfe
	PM-13-064	PM-13-070	PM-13-073	Mean n=3	PM-13-057	PM-13-054
Malt Yield, %	75.71	73.68	76.28	75.2	80.04	71.96
Moisture, %	3.7	3.5	3.9	3.7	4.2	3.9
Friability, %	71.4	80.1	80.1	77.2	84.3	74.3
Fine-extract, %	80.6	80.5	81.1	80.7	80.1	81.4
Coarse –Extract, %	80.0	79.8	79.9	79.9	79.3	81.2
F/C Difference, %	0.6	0.7	1.2	0.8	0.8	0.2
Soluble protein, %	5.76	5.55	5.73	5.68	4.84	5.49
Total protein, %	12.7	12.1	12.4	12.40	12.0	12.8
Kolbach Index, %	45.5	45.7	46.1	45.8	40.2	43.1
Beta-glucan, ppm	137	93	128	119	136	240
Viscosity, cps	1.46	1.47	1.48	1.47	1.47	1.57
Diastatic power, °L	130	147	135	137	115	136
a-Amylase, D.U.	59.2	59.7	54.1	57.7	50.2	64.6
Wort colour, ASBC	3.26	2.53	2.44	2.74	1.87	2.54
Wort pH	5.82	5.78	5.92	5.84	5.84	5.92
FAN, mg/L	248	227	217	231	190	221

Malt analysis/limit dextrinase/RVA test/arabinoxylans analysis/other analyses performed by the Grain Research Laboratory (GRL), Canadian Grain Commission

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

Malting summary

- ***General modification:*** The values for friability, F/C difference, soluble protein and beta-glucan content all suggested that under the given malting conditions, this 2013 crop Bentley barley sample produced malts with very good modification.

- ***Extract yield and enzyme levels:*** The malts produced from this 2013 crop Bentley barley sample exhibited good average extract yield which was higher than the control CDC Copeland but lower than the control AC Metcalfe. Bentley malts developed very good levels of enzymes. On average, its diastatic power was significantly higher than the control CDC Copeland but was comparable to the control AC Metcalfe. Its α-amylase was significantly higher than Copeland but lower than Metcalfe.

- ***Soluble protein, free amino nitrogen (FAN) and malt colour:*** Bentley malts exhibited good protein modification. On average, its soluble protein content was higher than both Copeland and Metcalfe. Also, its KI was higher than the control Copeland and Metcalfe. Bentley malts developed adequate levels of FAN, which were higher than the control Copeland and Metcalfe. The malt developed good malt color which was on average higher than the controls.

- ***Malting yield:*** Under the given malting conditions, this Bentley barley sample displayed malting yield lower than CDC Copeland but higher than AC Metcalfe.

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

CMBTC™
CANADIAN MALTING BARLEY TECHNICAL CENTRE

3. Pilot Brewing trials

A Bentley malt blend (PM-13-070 & PM-13-073) from the pilot malting trials was brewed in CMBTCs 300L Pilot Brewery and was compared against CDC Copeland and AC Metcalfe malts which were used as the controls (Figures 6 through 13 in the Appendix detail the brewing trial with CDC Copeland and AC Metcalfe malts). The following are the brewing and fermentation conditions for the pilot brewing trials.

PILOT BREWING PARAMETERS (300L):

Mash Tun

- 100% malt blend brew - 40 kg of malt and 105 L of water added to mash tun (Grist: water ratio of 3.75:1)
- Mash in at 48°C, hold for 30 min
- Raise to 65°C, hold for 30 min
- Raise to 77°C, hold for 1 min
- Pump over to Lauter Tun

Lauter Tun

- Rest for 10 minutes, vorlauf for 10 minutes
- Rakes at 20 cm above bottom, on slow for entire lautering
- 25L underlet
- 125L sparge water at 75°C
- Last running at 1.5 Plato

Brew Kettle

- First hop (Nugget) boiled for 90 min – 45g
- Second Hop (Mt. Hood) boiled for 5 min – 85g
- Whirlpool rest of 150 min before cooling

Fermentation, aging, filtering and bottling conditions for the brewing trials

- Cooled to 12ºC, pitched with lager yeast at 12 million cells per mL
- Free rise to 13.5ºC
- Fermented for 7 days (4 days at 13.5ºC and 3 days at 15ºC)
- Cooled and stored at -1 ºC for 7 days
- Filtered through a 1 µm pad filter system, carbonated to 2.5 volumes CO_2
- Stored 2 days at -2°C, and packaged
- Pasteurized to 15 PU

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

PILOT BREWING TRIAL WITH BENTLEY

Figures 1 through 4 detail the brewing trial with the Bentley malt blend.

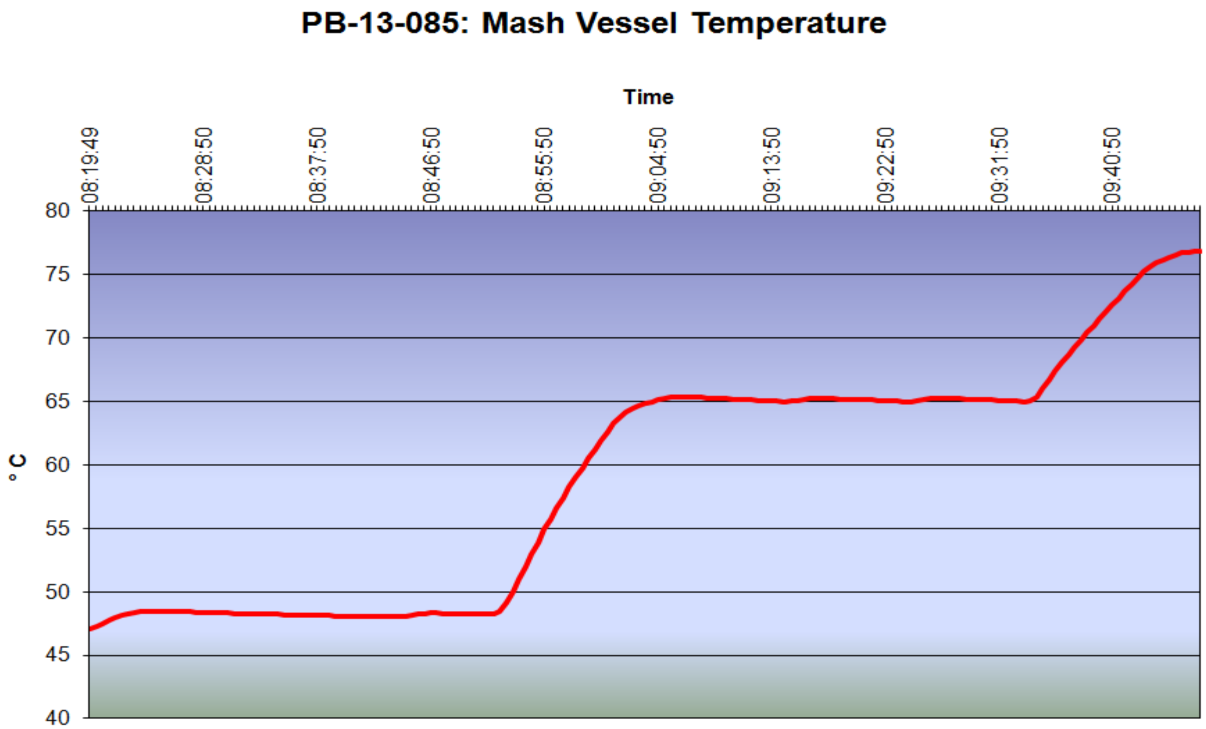


Figure 1: Mash Temperature Profile for Bentley (temperature versus time)

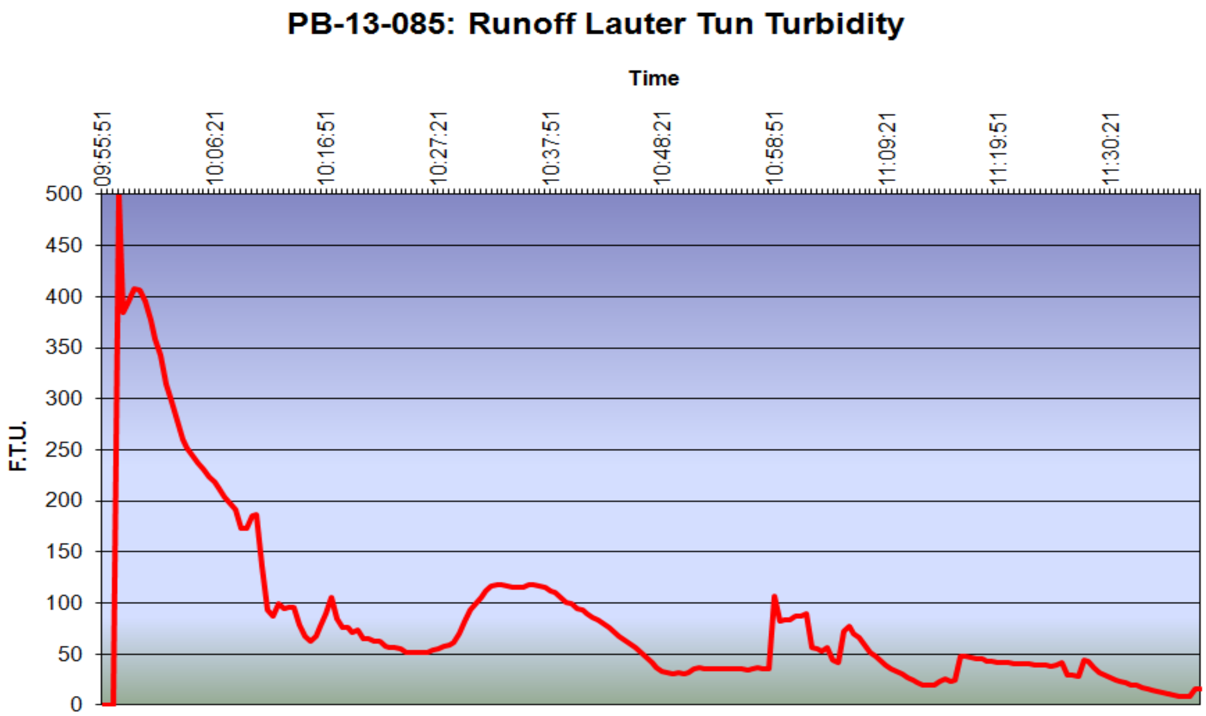


Figure 2: Runoff Turbidity for Bentley (turbidity FTU versus time)

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

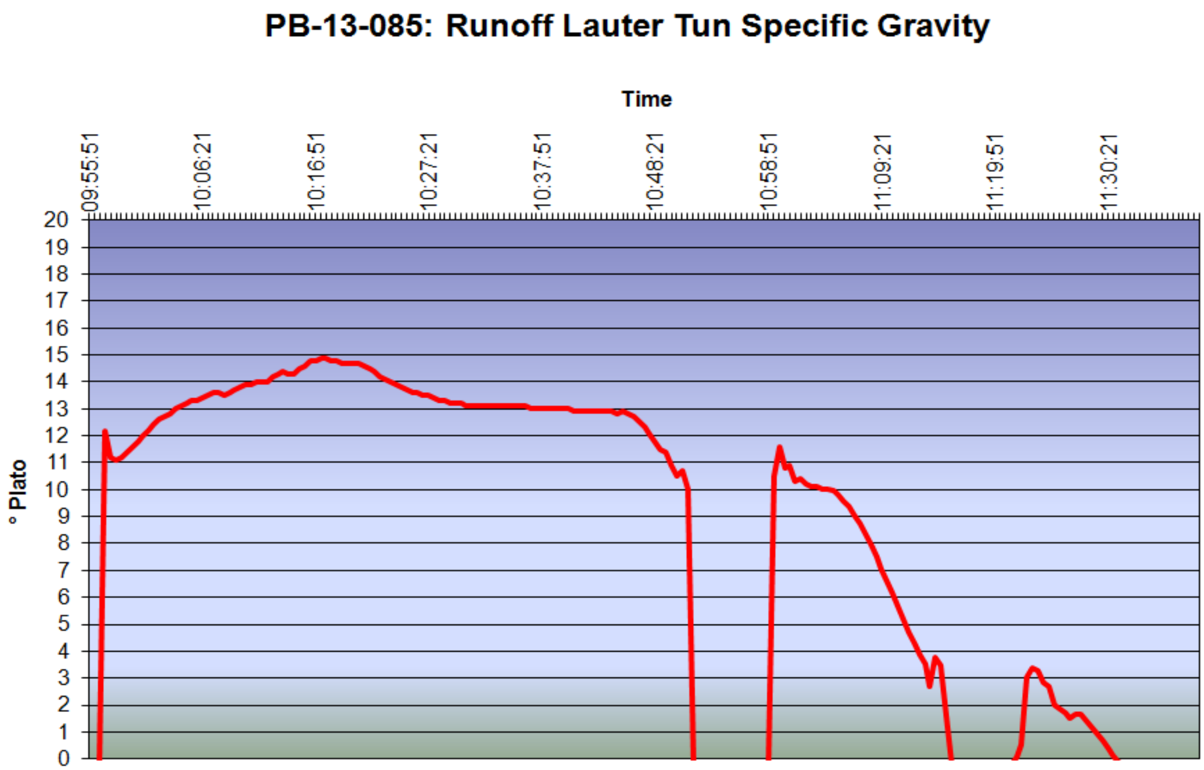


Figure 3: Runoff Specific Gravity for Bentley (°Plato vs time)

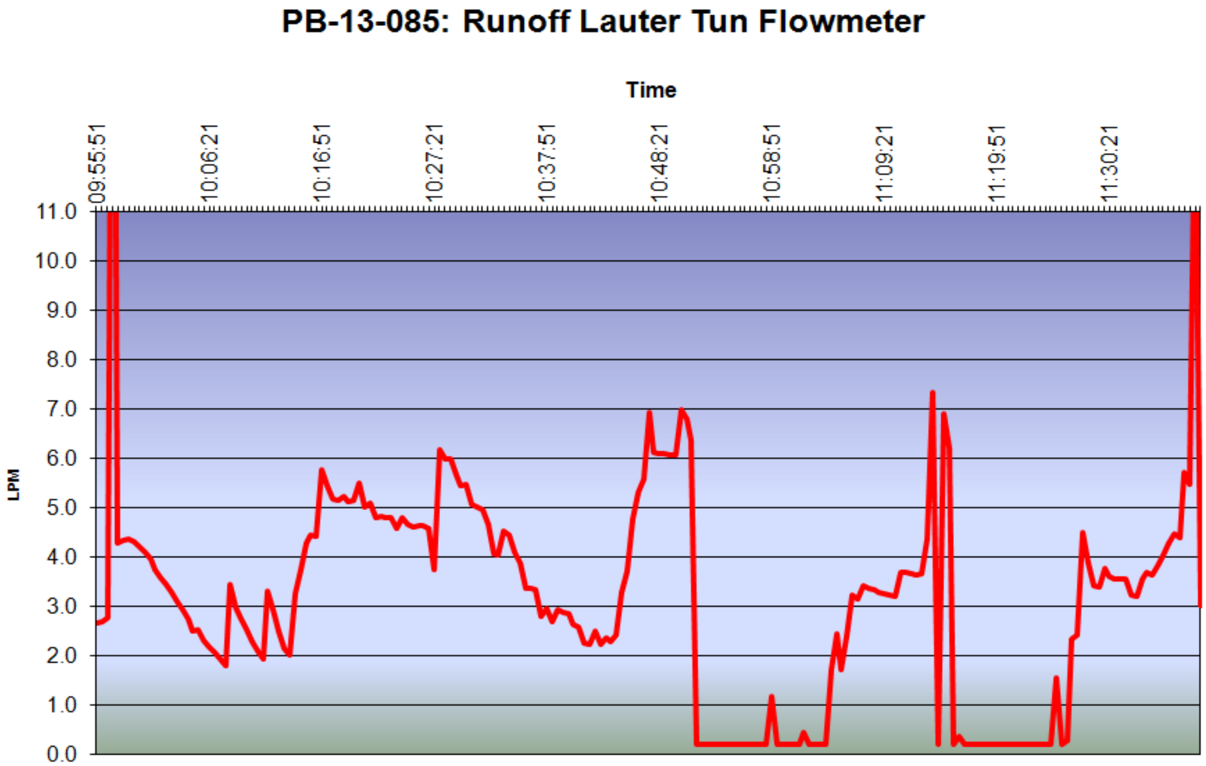


Figure 4: Runoff Flowrate for Bentley (l/minute vs time)

Bentley brewing results are given in Tables 4, 5, 6, 7 and 8.

Table 4. Main Brewhouse observations for Bentley pilot brewing trial

Parameter	Bentley PB-13-085	CDC Copeland PB-13-066	AC Metcalfe PB-13-064
Conversion time (min.)	**12**	**9**	**8**
Time to clear (min.)	**14**	**5**	**6**
Lautering time (min.)	**81**	**41**	**42**
Brewhouse Yield (%)	**70.7**	**71.0**	**71.6**
Wort pH	**5.32**	**5.32**	**5.28**
Wort Colour (SRM)	**6.84**	**4.42**	**4.56**

In the brewhouse, the Bentley sample recorded a slightly longer conversion time (12 minutes) then both CDC Copeland and AC Metcalfe, although this was still acceptable. Conversion time is a metric that is important for the brewer in regards to the economics of his brewhouse. Longer conversion times could translate into higher operating costs in more energy requirement, higher labour costs or decreased capacity. Conversion time is related to the enzyme content of the malt, and can be manipulated by changing malt: water ratio and temperature.

Time for wort to clear to less than 100 FTU in lautering was 14 minutes for Bentley malt blend. That was significantly longer than both CDC Copeland and AC Metcalfe who took 5 and 6 minutes respectively to clear. Therefore, Vorlauf time had to be extended from regular 10 minutes to 15 minutes for Bentley malt blend. Time required for the wort to clear is a metric that is important for the brewer in regards to the economics of his brewhouse as well as the quality of the finished beer. Most brewers want clear wort, it provides better quality beer and also allows for better capacity utilization in fermentation. The time to obtain wort that is clear (less than 100 FTU) is therefore related to capacity and manpower utilization.

The lautering time for Bentley malt (81 minutes) was significantly longer than for both CDC Copeland and AC Metcalfe sample. Due to extremely poor runoff the Bentley sample had to be re-vorlaufed twice in the second part of the runoff (Figures 3 and 4). The reason for this anomaly is unknown, beat-glucan levels in the malt as well as the wort viscosity was very low, much lower than the AC Metcalfe control and the CDC Copeland control, which both lautered in a normal fashion. This lautering problem has been noted in Bentley before and again the reason for it is not clear. Time to complete the runoff is a metric that is important for the brewer in regards to the economics of his brewhouse. Longer times could translate into higher operating costs in more energy requirement, higher labour costs or decreased capacity. Runoff time is related to the beta-glucan content of the malt as well as the friability and milling of the malt.

Bentley malt had a similar Brewhouse Yield to both CDC Copeland and AC Metcalfe malt samples. Brewhouse Yield shows the percentage of the extract that was recovered into the cast wort. It is a measure of how easily the extract is recovered from the malt.

Wort clarity and break in the wort kettle was marginally acceptable for Bentley malt blend. Bentley samples showed somewhat increased runoff turbidity. Wort clarity and good protein precipitation is related to improved colloidal stability of the final product.

The wort pH values for both the sample and the controls were typical for the wort derived from barley malts. Bentley sample showed comparable pH value to CDC Copeland and AC Metcalfe wort. Wort pH is related to beer flavour stability, the higher the pH the more flavour stable the beer is through time. However, the pH cannot be too high or else the possibility of flavour changes and microbiological infection can occur.

Bentley recorded somewhat higher wort colour than both CDC Copeland and AC Metcalfe wort samples. Wort colour is positively correlated to the barley protein content, as well as malt colour and malting processing conditions. Most international brewers are looking for a lower pale colour to be derived from the malt, so the lower the better.

Wort taste was acceptable. This is a quick test to look for off-flavours. The wort should be malty, sweet with no off-flavours.

Table 5. Wort sugar concentration for the brewing trials (mg/L)

Carbohydrate	Bentley PB-13-085	CDC Copeland PB-13-066	AC Metcalfe PB-13-064
Maltotetrose	**3.98**	**2.12**	**1.56**
Maltotriose	**16.75**	**12.80**	**13.66**
Maltose	**64.17**	**64.75**	**63.36**
Glucose	**14.13**	**13.59**	**13.07**
Fructose	**2.32**	**2.54**	**1.97**

Normal and generally comparable wort sugar spectra were recorded for all the samples (Table 5). Bentley recorded slightly higher levels of Maltotriose and Glucose fermentable sugars than the CDC Copeland and AC Metcalfe wort samples.

Table 6. Fermentation observations for Bentley brewing trial

Parameter	Bentley PB-13-085	CDC Copeland PB-13-066	AC Metcalfe PB-13-064
Attenuation Limit (%)	**89.6**	**89.4**	**89.6**

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

Fermentabilty for both the sample and the controls were good and comparable (Table 6). Fermentability is important in that it is a measure of the amount of beer that can be produced from the original malt. The higher the fermentability the better.

Table 7. Final beer analysis for Bentley brewing trial

Parameter	Bentley PB-13-085	CDC Copeland PB-13-066	AC Metcalfe PB-13-064
Apparent Ext. (Plato)	**1.92**	**1.34**	**1.35**
Real Ext. (Plato)	**3.91**	**3.71**	**3.22**
Alcohol (v/v %)	**5.52**	**5.01**	**5.13**
Color (ASBC)	**5.49**	**3.82**	**4.07**
pH	**4.39**	**4.29**	**4.22**
Foam (Nibem)	**161**	**180**	**161**
Initial Turbidity (FTU)	**28.1**	**24.8**	**33.8**
Chill Turbidity (FTU) 24 Hr	**31.3**	**25.2**	**34.0**

The Bentley sample was bottled and it produced beer with good quality. Apparent, real extract and final alcohols were all slightly higher than CDC Copeland and AC Metcalfe controls. Final beer colour for Bentley sample was higher than both CDC Copeland and AC Metcalfe beer colour reading. CDC Copeland and AC Metcalfe beer had somewhat lover pH readings than Bentley product. Bentley foam stability was comparable to AC Metcalfe and lower than CDC Copeland beer. The initial and chill turbidity for Bentley beer indicated acceptable physical and colloidal stability, which were lower than AC Metcalfe and slightly higher than CDC Copeland controls.

In terms of sensory, the Bentley beer received slightly lower overall quality rating than CDC Copeland and was comparable to AC Metcalfe. It was rated as typical slightly aged market beer. Beer sensory data is presented in Table 8 and Figure 5 in more details.

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

Table 8. Final Bentley and CDC Copeland and AC Metcalfe beer organoleptic property data

Parameter	Bentley PB-13-085	CDC Copeland PB-13-066	AC Metcalfe PB-13-064
Freshness	2.50	2.61	2.14
Body	2.00	1.43	1.82
Flavour	2.00	1.86	1.91
Smoothness	2.00	2.36	2.23
Hop Aroma	1.00	1.07	1.27
Hop Bitterness	2.00	1.00	1.41
Estery	1.00	1.64	2.00
Cereal	2.00	1.71	1.91
Turbidity	4.00	1.07	1.09
Sour	0.00	1.14	1.77
Sweet	1.00	1.14	1.41
Sulphury	1.00	0.96	1.59
Overall Quality	2.20	2.56	2.25

Quality scale
0 – Undrinkable
1 – Defects at high level (consumer would notice)
2 – Slight defects (expert would object, typical slightly aged market beer)
3 – Normal good beer (nothing really good or bad, reasonably fresh)
4 – Excellent (no real defects and many good characters)

Additional Terms Rating Scale
0 – Non existent
1 – Light, faint
2 – Mild
3 – Very noticeable
4 – Very strong

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

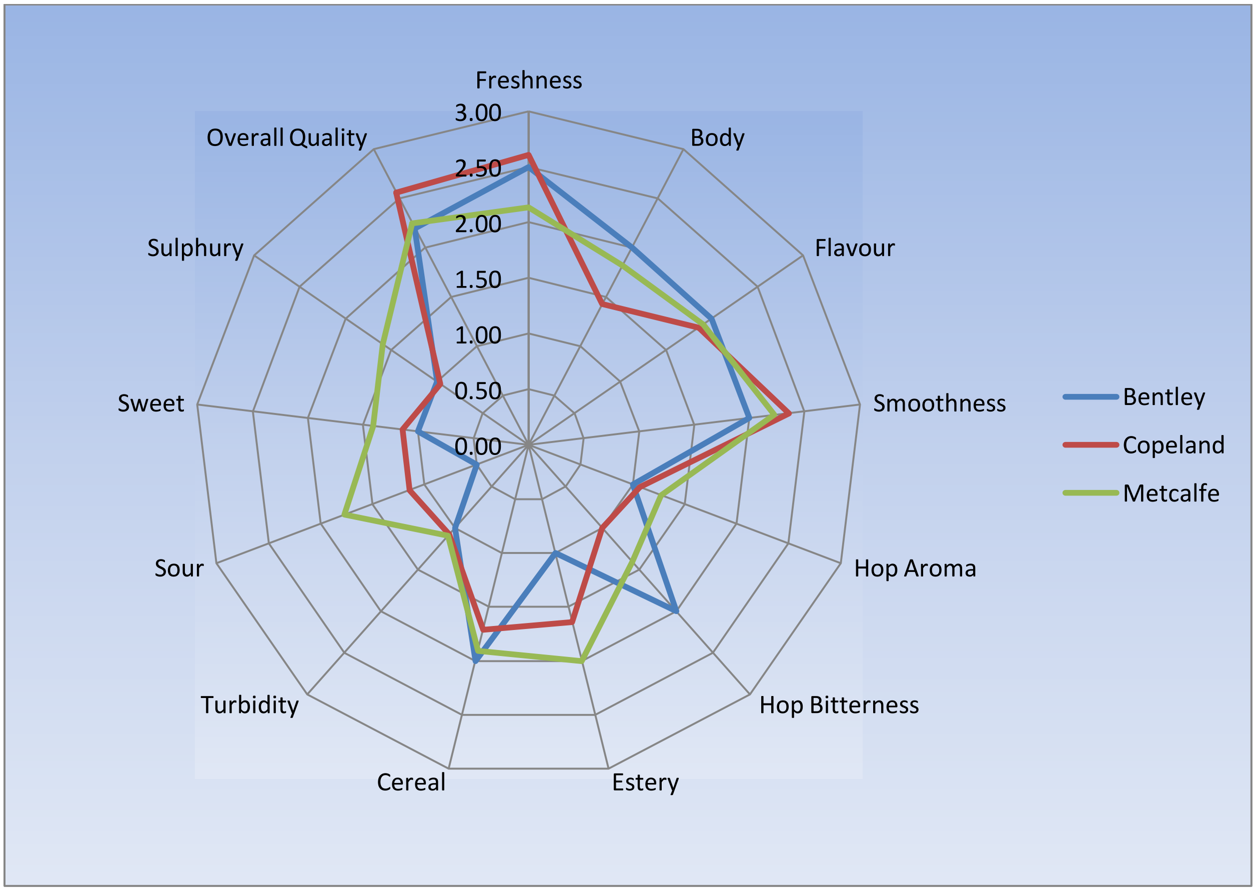


Figure 5. Final Bentley and CDC Copeland and AC Metcalfe beer organoleptic property

For more information, please contact CMBTC:

Rob McCaig, Managing Director and Director of Brewing
Tel: (204) 983-1981
Email: rmccaig@cmbtc.com

Yueshu Li, Director of Malting Technology
Tel: (204) 984-0561
Email: yli@cmbtc.com
Fax: (204) 984-5843

APPENDIX: PILOT BREWING TRIAL WITH CDC COPELAND AND AC METCALFE

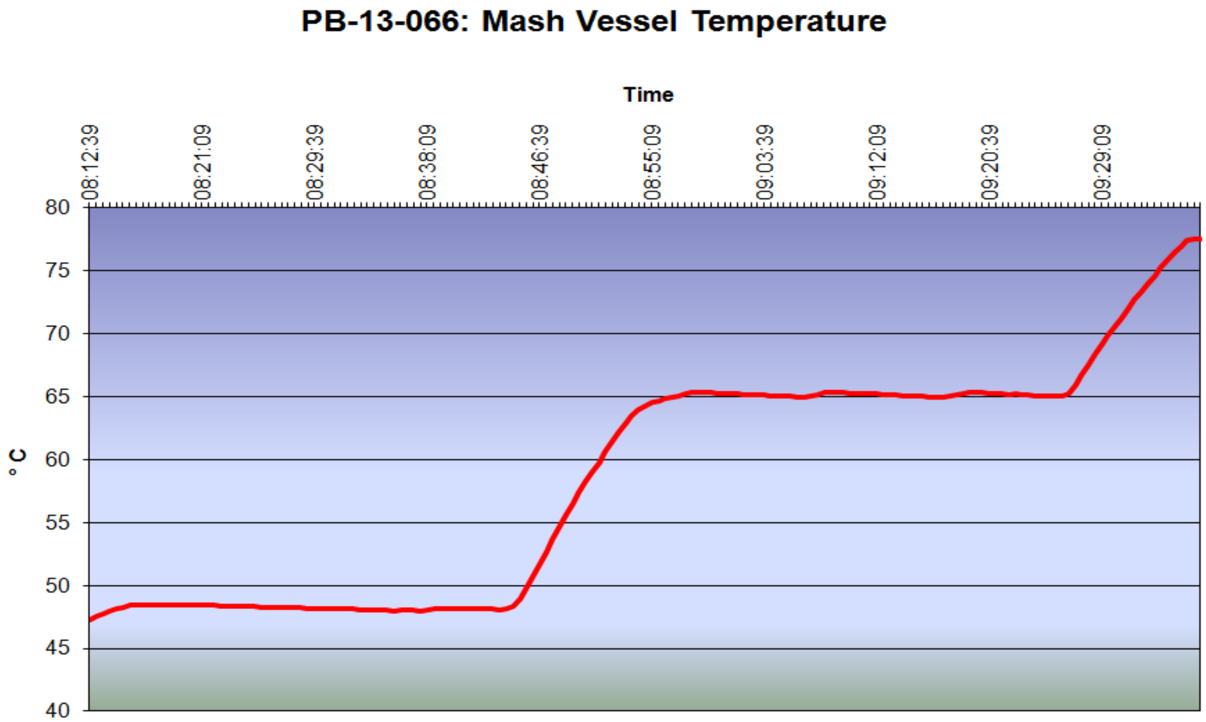
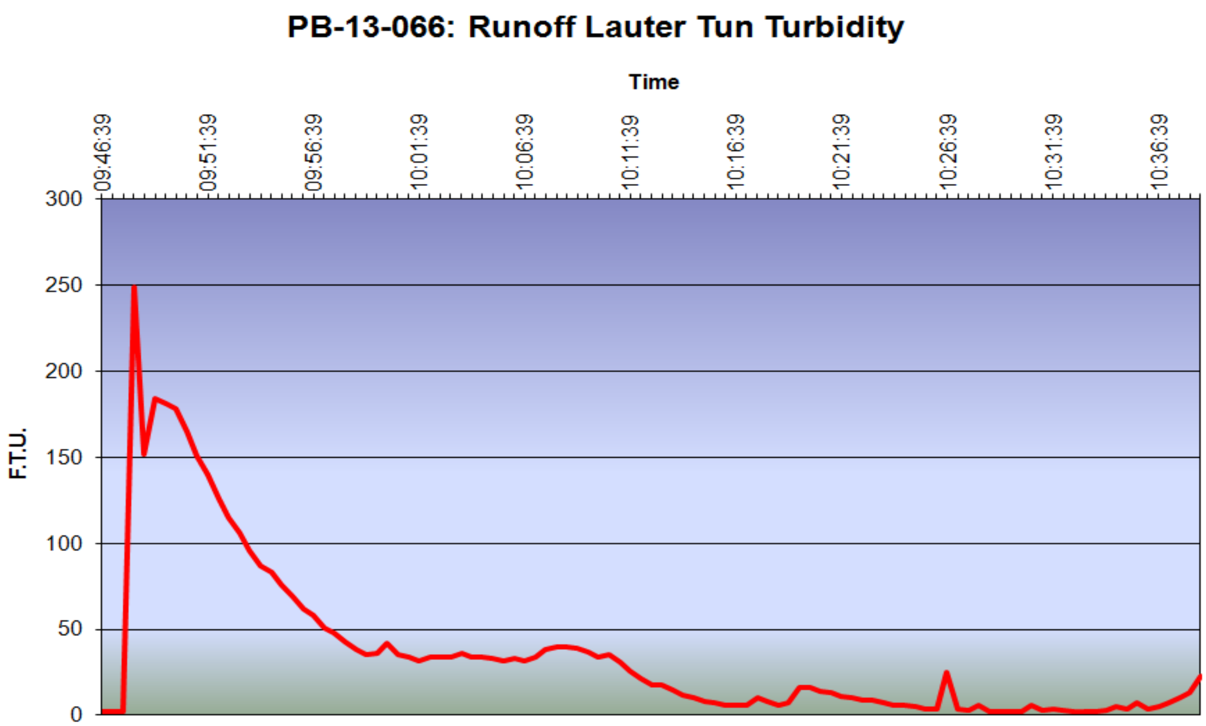


Figure 6: Mash Temperature Profile for CDC Copeland (temperature versus time)



1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

Figure 7: Runoff Turbidity for CDC Copeland (turbidity FTU versus time)

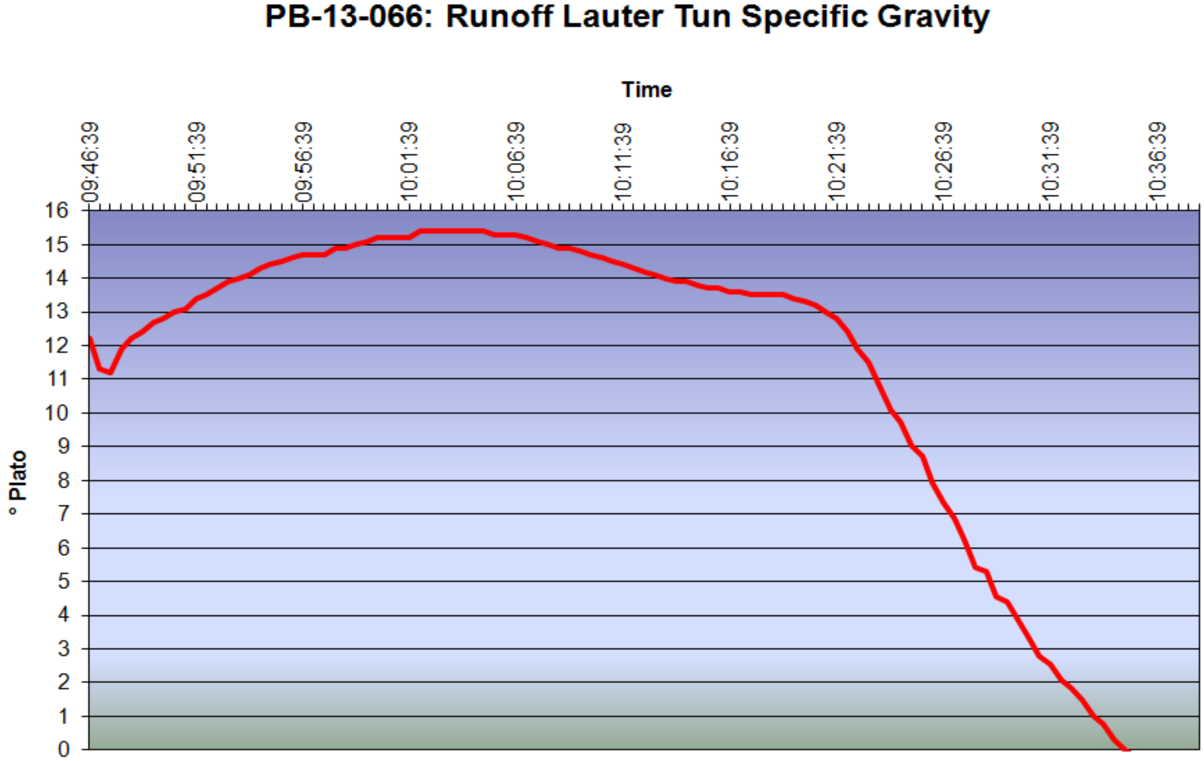


Figure 8: Runoff Specific Gravity for CDC Copeland (°Plato vs time)

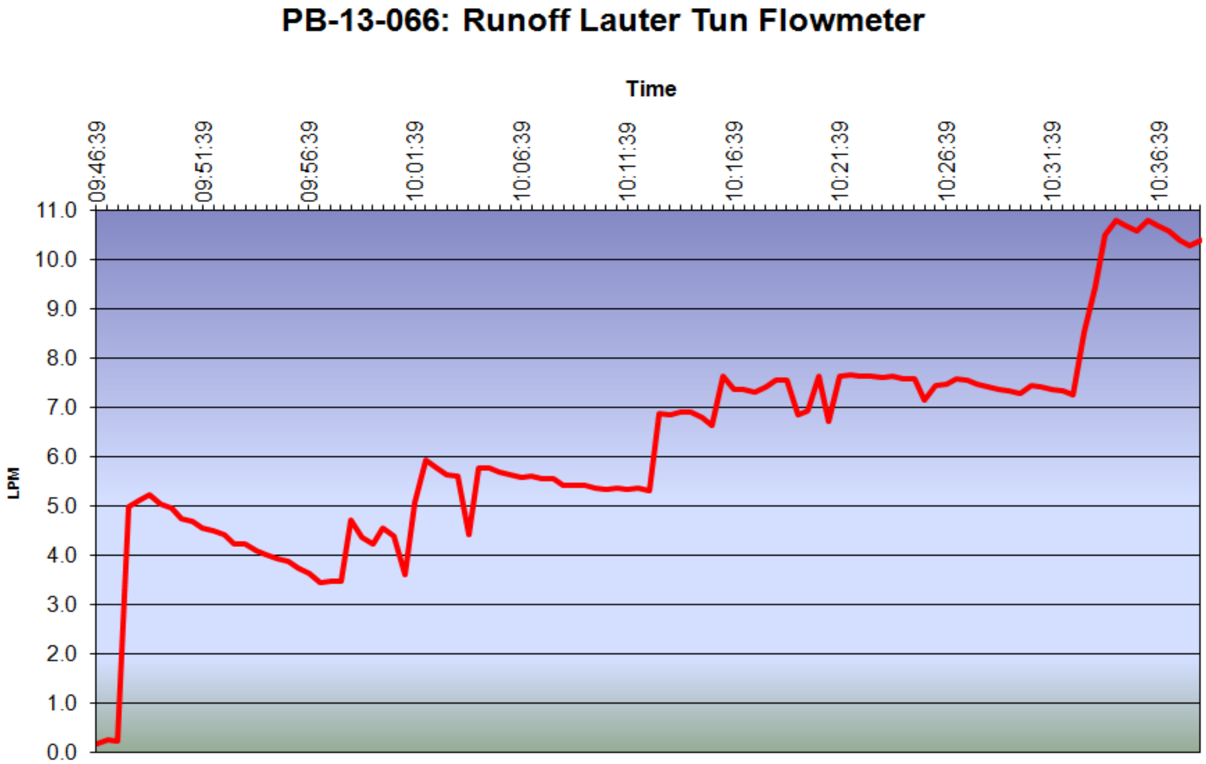


Figure 9: Runoff Flowrate for CDC Copeland (l/minute vs time)

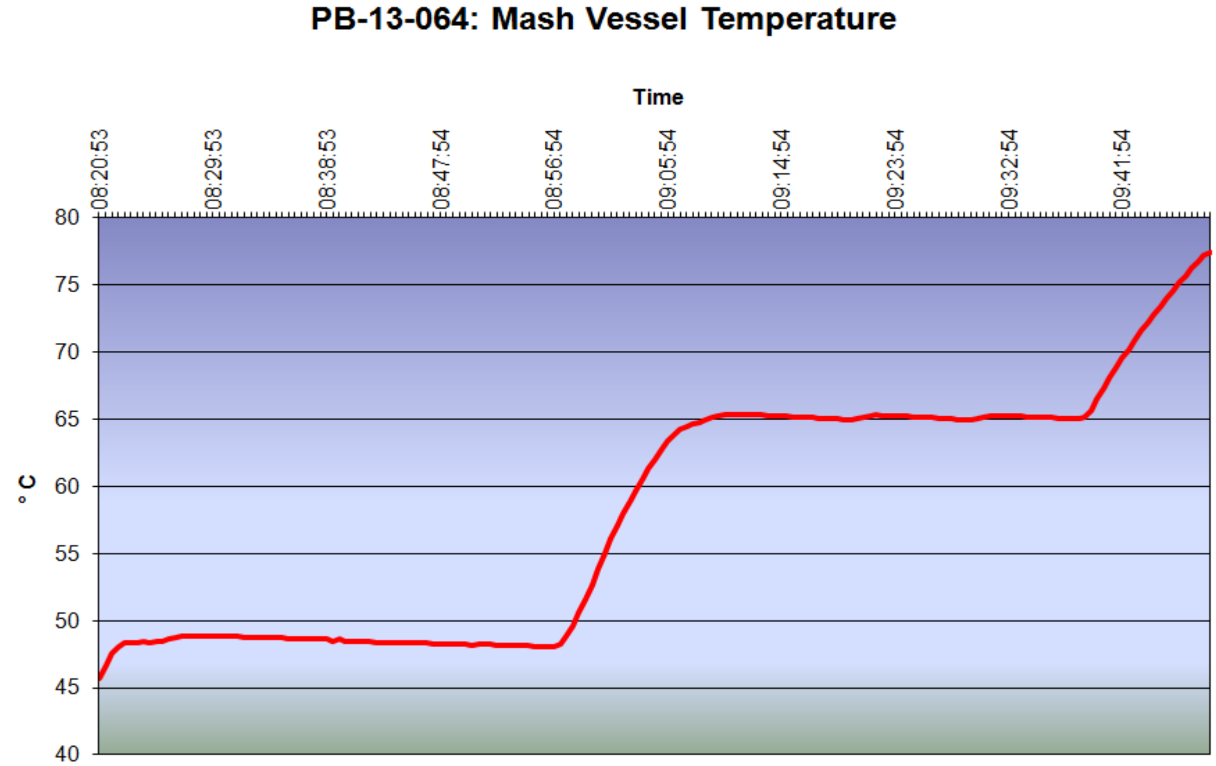
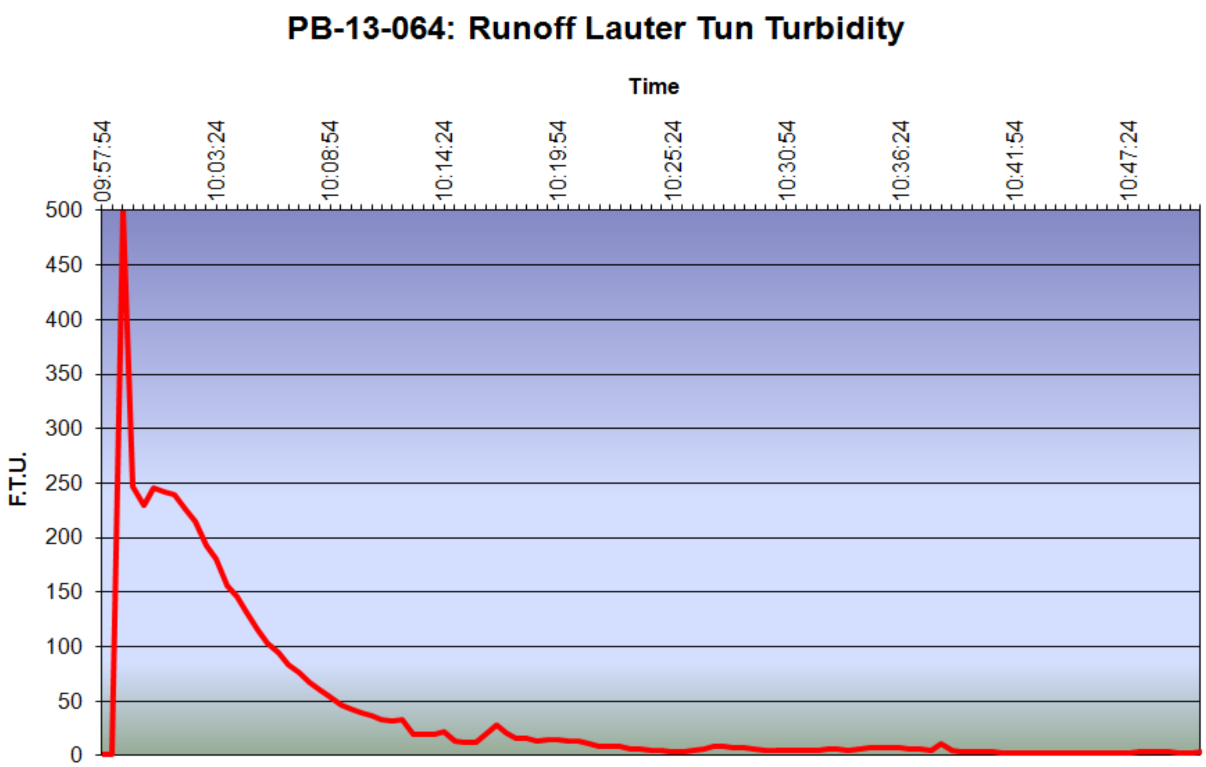


Figure 10: Mash Temperature Profile for AC Metcalfe (temperature versus time)



1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

Figure 11: Runoff Turbidity for AC Metcalfe (turbidity FTU versus time)

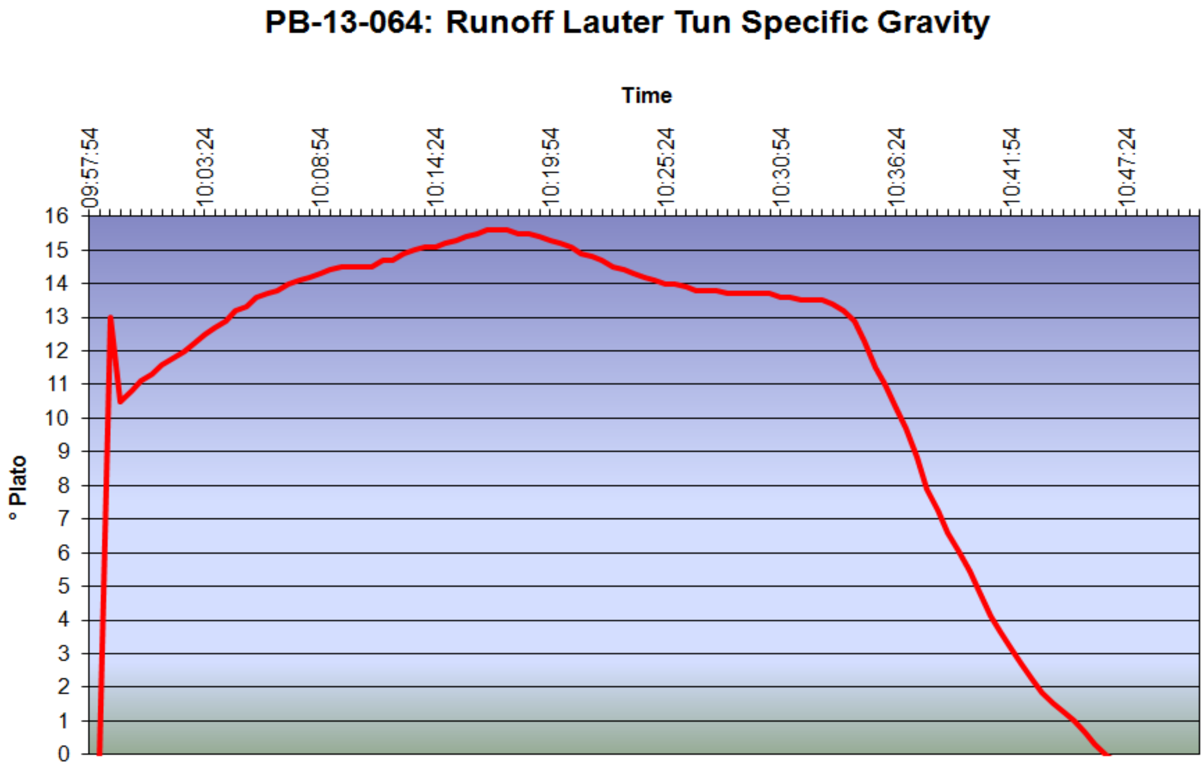
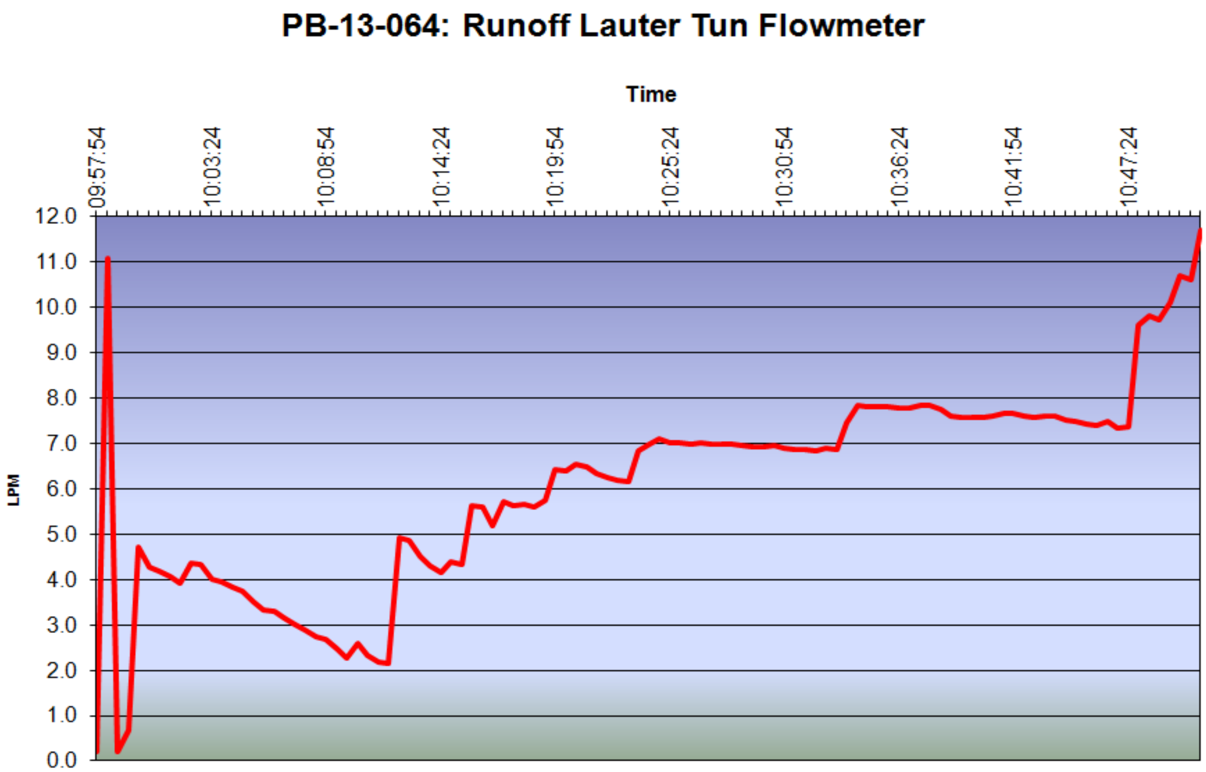


Figure 12: Runoff Specific Gravity for AC Metcalfe (^{o}Plato vs time)



1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com

Figure 13: Runoff Flowrate for AC Metcalfe (l/minute vs time)

1365-303 Main Street • Winnipeg, Manitoba, Canada R3C 3G7 • Telephone 204-984-4399 • Fax 204-984-5843
Email cmbtc@cmbtc.com • Website www.cmbtc.com