AMURI IRRIGATION CO

MEMORANDUM

From	Peter Brown
Reviewer(s)	
To	Andrew Barton
Date	4 December 2017
Subject	On-farm impact of irrigation restrictions
Status	DRAFT

Overview

- I have modelled how changing from AIC's current minimum flows, to HWRRP minimum flows would affect restrictions and soil moisture on-farm.
- These results have been used by Mr Mark Everest to estimate the on-farm economic impacts of changing minimum flows.
- I have compared Mr Everest's production loss estimates to my 2012 HWRRP hearing estimates, and have found the two models are producing similar results.
- The main difference with the 2012 work is with the 'status quo' scenario for the Waiau Irrigation Scheme. My 2012 evidence presented a generic A-Block reliability and did not model the specifics of Amuri Irrigation's Waiau Irrigation Scheme consent, which has higher reliability.

River flow and restriction modelling

River flow modelling and reliability given AIC's current consents and HWRRP minimum flows, are described in my memorandum titled "Hydrological change from implementing HWRRP minimum flows" and dated 25 September 2017. These calculations have been reviewed by Environment Canterbury.

Soil moisture modelling

I modelled soil moisture using a FAO 56 soil water balance model. This is an internationally accepted method for estimating irrigation water requirements and soil moisture levels. The model was calibrated to align with previous AusFarm soil water balance modelling. I modelled two rainfall stations, and two soils (a total of four scenarios) to capture a range of climate and soil conditions. The two climate scenarios were Culverden (mean annual rainfall = 640mm/y) and the average of Riverside and Waiau township (mean annual rainfall = 730mm/y). Potential evapotranspiration data was from Culverden (annual average = 850mm/y). The period of simulation was 1 June 1960 to 31 May 2017. Key parameters are summarised in Table 1. The soil moisture for every day of the 57 years of simulation were provided to Mr Everest. Mr Everest used these estimates to predict the production loss due to soil moisture stress.

Table 1. Key soil water balance model parameters

Parameter	Soil 1	Soil 2
PAW (mm)	65	80
Crop coefficient	0.95	0.95
Water stress point (% PAW)	50%	50%
Application depth	20.8	20.8
Trigger soil moisture level (% PAW)	0.54	0.57
Application efficiency	80%	80%
System capacity (mm/d)	5.20	5.20
Effective application depth	16.64	16.64

HWRRP Hurunui River hearing evidence

In my supplementary evidence presented at the hearing on 5 December[1], Scenarios 1 represents Amuri Irrigation's current consent (CRC951326.1), while Scenario 4 is very close to the current Hurunui A-Block. These scenarios are summarised in Table 2.

Table 2: Hurunui scenarios modelled

ID	2012 Scenario		HWRRP Table
	1	4	1
Name	Amuri	HWRRP post-storage	Hurunui A-Block
Block size	5.00	6.20	6.47
Flow sharing	No	No	No
Minimum flow by month			
Jan	12.0	15.0	15.0
Feb	12.0	15.0	15.0
Mar	12.0	15.0	15.0
Apr	12.0	15.0	15.0
May	12.0	12.0	12.0
Jun	12.0	12.0	12.0
Jul	12.0	12.0	12.0
Aug	13.0	12.0	12.0
Sep	15.0	15.0	15.0
Oct	19.0	15.0	15.0
Nov	18.0	15.0	15.0
Dec	13.5	15.0	15.0

I have extended reliability modelling to include the last 5 years. River flows, and consequently reliability over the last 5 years has been below the long-term average. This means the average reliability for the period 1960 to 2017 (Table 3) is slightly lower than my 2012 estimates, which were for the period 1960 to 2012. Table 3 illustrates that reliability for Scenario 4 (2012) and the current HWRRP Hurunui A-Block, are almost identical[2].

Table 3: Hurunui A-Block reliability (expressed as % available) from 1 June 1960 to May 2017

Scenario	Average year		1 yr in 10		Worst year	
	Sept-Apr	Oct-Mar	Sept-Apr	Oct-Mar	Sept-Apr	Oct-Mar
2012 Scenario 1 (Amuri)	95.8%	96.0%	88.3%	88.5%	60.5%	63.4%
2012 Scenario 4 (HWRRP post-storage)	90.8%	91.0%	78.5%	77.8%	55.8%	57.7%
HWRRP final	90.8%	91.0%	78.5%	77.8%	55.8%	57.7%

[1] Brown (2012). "Statement of evidence of Peter Derek Brown for Canterbury Regional Council dated 5 December 2012. Supplementary evidence for the Hurunui and Waiau Regional Plan". 65pp. Refer Paragraph 6.
[2] The difference between the two scenarios is 0.01%.

When HWRRP minimum flows are applied to AIC's Balmoral consent, average supply reliability will reduce from 96.0% to 91.0% (Oct-Mar)

In my 2012 evidence I estimated the production loss due to water stress as a percentage of average *annual* production. Key results are reproduced in Table 4. To convert from this metric to kg-DM/ha, the percentages should be multiplied by the annual production. Mr Everest has estimated that average annual pasture growth will range from 12.5 t-N/ha to 15.2 t-N/ha, depending on the amount of nitrogen applied. Table 5Table 4 and Table 6 present the production impacts in kg-DM/ha, using these annual production estimates.

Most of this loss will occur during, and shortly after, the period of restriction. So, while on an annual basis the percentage lost production may appear quite low, the reduction in growth during the period of restriction will be significantly greater.

My 2012 production loss estimates are similar to Mr Everest's 2017 estimates. Generally, my modelling indicated a greater impact in areas with low rainfall and light soils (particularly during dry years), but a lesser impact on heavier soils. Overall however the two modelling approaches are indicating a similar scheme level impact.

Table 4: Hurunui production impacts (from Brown 2012, paragraph 18)

Scenario	Farm 1			Farm 2		
	Average	1 yr in 10	3 worst years	Average	1 yr in 10	3 worst years
AIC CRC951326.1 (2012 Scenario 1)	1.3%	2%	15%	0.90%	1%	13%
HWRRP (2012 Scenario 4)	3.6%	11%	19%	1.30%	3%	23%

Table 5: Hurunui production impacts in kg-DM/y (Farm 1 – light soil, low rainfall)

	Average		1 yr in 10		3 worst years	
Annual growth (kg-DM/ha)	12500	15200	12500	15200	12500	15200
AIC current (2012 Scenario 1)	163	198	250	304	1875	2280
HWRRP (2012 Scenario 4)	450	547	1375	1672	2375	2888
Change	**288**	**350**	**1125**	**1368**	**500**	**608**

Table 6: Hurunui production impacts in kg-DM/y (Farm 2 – heavier soil, higher rainfall)

	Average		1 yr in 10		3 worst years	
Annual growth (kg-DM/ha)	12,500	15,200	12,500	15,200	12,500	15,200
AIC current (2012 Scenario 1)	113	137	125	152	1625	1976
HWRRP (2012 Scenario 4)	163	198	375	456	2875	3496
Change	**50**	**61**	**250**	**304**	**1250**	**1520**

HWRRP Waiau River hearing evidence

In my 2012 hearing evidence, Scenarios 1 (status quo) is the closest to represents Amuri Irrigation's current consent (CRC951304), while Scenario 3 (HWRRP 18cu) is very close to the current Waiau A-Block.

Scenario "status quo" approximately describes the average reliability of the Waiau Bands 1-7 that existed in 2012. Bands 1-7 together had a total allocation of about 18 m^3/s. Bands 1-7 consents all share the same minimum flows, but because of variations in consent conditions there are a range of different reliability levels within this "A-Block". AIC's consent CRC951304 conditions can be interpreted in different ways. In analysis I have used the interpretation from ECan's compliance department (refer Brown 2011[3]). I have rerun the reliability analysis for the period 1960 to 2017 (refer Table 7). In my 2012 evidence the period of analysis was 1968 to 2012. These two periods have slightly different long-term reliability.

Table 7: Waiau A-Block reliability (expressed as % available) from 1 June 1960 to May 2017

Scenario	Average year		1 yr in 10		Worst year	
	Sept-Apr	Oct-Mar	Sept-Apr	Oct-Mar	Sept-Apr	Oct-Mar
2012 Scenario 1 (status quo)	95.7%	96.9%	88.7%	90.6%	73.2%	82.4%
2012 Scenario 3 (HWRRP 18cu	94.7%	94.8%	85.6%	85.6%	69.5%	73.9%
HWRRP final (Waiau A-Block)	94.8%	94.9%	85.7%	85.8%	69.7%	74.0%
AIC (CRC951304)	97.8%	98.8%	93.7%	96.6%	80.2%	90.1%

Table 7 illustrates that there is a reasonable difference between my 2012 Scenario 1 (status quo) and AIC's consent CRC951304, with the latter have higher reliability.

When HWRRP minimum flows are applied to AIC's Waiau consent, average supply reliability will reduce from 98.8% to 94.9% (Oct-Mar)

Production loss estimates from my 2012 evidence are not directly comparable, because of the differences between Scenario 1 and AIC's consent CRC951304. Indicatively, production losses for CRC951304 [due to restrictions] will be one third of Scenario 1. Results are presented below. As with the Hurunui, the results align reasonably closely with Mr Everest's production modelling.

[3] Brown (2011). "Waiau River Irrigation Reliability". Report prepared for Environment Canterbury by Aqualinc Research Ltd. April 2011.

Table 8: Waiau production impacts (from Brown 2012, paragraph 29)

Scenario	Farm 1			Farm 2		
	Average	1 yr in 10	3 worst years	Average	1 yr in 10	3 worst years
2012 Scenario 1 (status quo)	1.1%	4%	6%	0.20%	1%	1%
AIC CRC951326.1[4]	0.4%	1.3%	2.0%	0.1%	0.3%	0.3%
HWRRP & 2012 Scenario 3	2.1%	6%	14%	1.00%	3%	9%

Table 9: Hurunui production impacts in kg-DM/y (Farm 1 – light soil low rainfall)

	Average		1 yr in 10		3 worst years	
Annual growth (kg-DM/ha)	12500	15200	12500	15200	12500	15200
AIC CRC951326.1	46	56	167	203	250	304
HWRRP & 2012 Scenario 3	263	319	750	912	1750	2128
Change	**217**	**263**	**583**	**709**	**1500**	**1824**

Table 10: Hurunui production impacts in kg-DM/y (Farm 2 – heavier soil, higher rainfall)

	Average		1 yr in 10		3 worst years	
Annual growth (kg-DM/ha)	12,500	15,200	12,500	15,200	12,500	15,200
AIC CRC951326.1	8	10	42	51	42	51
HWRRP & 2012 Scenario 3	125	152	375	456	1125	1368
Change	**117**	**142**	**333**	**405**	**1083**	**1317**

[4] Not in 2012 evidence. Assumed to be 1/3 of Scenario 1