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memorandum

TO	Brent Walton, Onno Mulder	FROM	Bas Veendrick
	Waimakariri Irrigation Ltd	DATE	29/4/2021
RE	Wrights Road Storage Pond – Irrigation Supply- Demand Modelling		

1.0 Introduction

WIL has obtained consent for an 8.2 Mm^3 storage pond at Wrights Road. As part of the next stage of work for the project WIL are keen to quantify the improvement in reliability of supply as a result of the proposed 8.2 Mm^3 of on plains storage.

WIL have engaged PDP to develop a comprehensive irrigation supply and demand model which enables quantifying the reliability of supply based on a number of current and future scenarios. The model developed by PDP builds on previous reliability of supply modelling undertaken for WIL and is developed in PDP's Python-based modelling framework.

WIL has asked for the improvement to reliability to be quantified for four scenarios:

1. The current reliability based on the current minimum flow[1] (41 m^3/s) and no on-plains storage at Wrights Road (Scenario: Current no OPS).
2. The reliability based on the current minimum flow with 8.2 Mm^3 of storage at Wright's Road (Scenario: Current with OPS).
3. The reliability based on a future increased minimum flow of 50 m^3/s and no on-plains storage at Wrights Road (Scenario: Increase MF no OPS).
4. The reliability based on a future increased minimum flow of 50 m^3/s with 8.2 Mm^3 of storage at Wright's Road (Scenario: Increased MF with OPS).

For each scenario the reliability was quantified for five individual farms as well as the average reliability for the entire WIL command area. For the WIL scheme two sets of reliability outputs were produced. The first set of reliability outputs provides the average reliability for all farms without on-plains storage and the second set of outputs provides the average reliability for farmers with on-plains storage.

With the On-Plains storage in place it is likely that in some years surplus water is available from on-farm storage which can be traded to farmers without on-farm storage. Therefore, in addition to the four scenarios' outlined above one additional scenario was modelled for farmers without on-farm storage

[1] Minimum flows referred to in this memo are unmodified flows estimated by Environment Canterbury in the Waimakariri River at the Old Highway Bridge.

which assumes that 30% of the total current on-farm storage volume is available for farmers that currently don't have on-farm storage.

In addition to the potential future changes in reliability as a result of an increase in minimum flow it can be expected that the future reliability of the WIL scheme will be affected by climate change and water requirements for environmental enhancement activities such as Managed Aquifer Recharge (MAR) and Targeted Stream Augmentation(TSA).

This memorandum provides a summary of the key model results along with a brief description of the model development, input parameters and calibration.

The PDP report '*Wrights Road Storage Pond Business Case – Irrigation Supply-and Demand Modelling*' provides a more in-depth description of the model and model results.

2.0 Model Development, Input Parameters and Calibration

Irrigation water demand was modelled using a daily water-balance approach which tracks the change in water content within the root zone of a representative soil profile. Water inputs to the soil profile include rainfall and irrigation, while losses include runoff, evapotranspiration, and drainage to groundwater. The WIL command area has been modelled as 266 individual demand zones, each with a daily water balance being carried out on a representative soil profile. The supply component of the model incorporates the water available to WIL from the Waimakariri River and/or from on-farm storage or the proposed on-plains storage on each day, with an allowance for water race seepage losses, as indicated by WIL. The model determines the amount of water available to WIL on each day based on the flow in the Waimakariri River and the minimum flow and allocation as detailed in the WIL take and use consent. The simulation period for the model was 1972-2020 (48 years) which was determined based on the available amount of climate and Waimakariri river flow data.

The water WIL takes from the Waimakariri River is used for irrigation as well as stored in numerous on-farm ponds. There are 25 on farm ponds throughout the scheme with a total combined storage capacity of 5.7 Mm^3. These ponds supply a total irrigable area of approximately 8,033 ha (average storage volume of 710 m^3/ha). This compares to a total scheme area of 20,807 ha and as such the irrigable area supplied from on-farm storage ponds accounts for approximately 39% of the total irrigable area. The proposed Wrights Road On-Plains storage has a storage capacity of 8.2 Mm^3.

Water use data from the WIL intake (at Browns Rock) and from the five individual farms was used to calibrate the supply-demand model.

3.0 Model Results

Scheme wide model results for each of the four scenarios are included in Table 1 and Table 2 below. Table 1 shows the long-term average volumetric reliability over the full 48 year modelling period (1972- 2020) as well as the reliability for a 1 in 5 and 1 in 10 year dry year and for the driest year on record for shareholders with on farm storage and shareholders without on farm storage. Table 2 shows the years in which demand is fully satisfied for the four model scenarios. Note that the scenarios in the Tables below are labelled in accordance with the scenario abbreviations detailed in section 1.0 above. For example, the scenario 'Current no OPS' means 'The current reliability based on the current minimum flow (41 m^3/s) and no on-plains storage at Wrights Road'.

Table 1: Scheme Wide Model Results (volumetric reliabilities)

Scenario		Long term average reliability (1972-2020) (%)	1 in 5 year dry year reliability (%)	1 in 10 year dry year reliability (%)	Reliability in driest year (%)
No on farm storage	1. Current no OPS	**85.2%**	76.4%	68.5%	51.1%
	2. Current with OPS	**93.6%**	90.4%	80.4%	65.2%
	3. Increased MF no OPS	**77.1%**	67.5%	61.8%	44.1%
	4. Increase MF with OPS	**88.0%**	78.8%	71.7%	57.2%
With on farm storage	1. Current no OPS	**96.7%**	98.6%	86.3%	82.9%
	2. Current with OPS	**98.4%**	100.0%	99.1%	89.7%
	3. Increased MF no OPS	**92.7%**	87.0%	79.9%	65.9%
	4. Increased MF with OPS	**96.7%**	98.3%	87.6%	84.3%

Note: Volumetric reliability is defined as the ratio of the total volume of water supplied over the full simulation period, relative to the water demand during that same period. The reliability for individual irrigation seasons (for example the 1 in 5 dry year) is the volumetric demand ratio for the individual season.

Table 2: Scheme Wide Model Results (number of years demand is fully met)		
Scenario		**Number of years demand is fully met over 48 years (1972-2020)**
No on farm storage	1. Current no OPS	**0**
	2. Current with OPS	**27**
	3. Increased MF no OPS	**0**
	4. Increase MF with OPS	**16**
With on farm storage	1. Current no OPS	**29**
	2. Current with OPS	**41**
	3. Increased MF no OPS	**22**
	4. Increased MF with OPS	**32**

The scheme wide model results for shareholders with and without on-farm storage are summarised below.

Key model results for shareholders without on farm storage

Under the current minimum flow (41 m^3/s) construction of 8.2 Mm^3 of storage at Wrights Road will result in:

- An increase in the long term average reliability from 85.2 to 93.6 % (refer to Table 1).
- 27 years out of the 48 year modelling period being fully reliable. Without Wrights Road Storage farmers experience demand deficits in all 48 irrigation seasons (refer to Table 2). In the remaining 21 years the demand deficits will be less than that experienced without the Wright's Road storage pond.

Under a scenario with increased minimum flow (50 m^3/s) construction of 8.2 Mm^3 of storage at Wrights Road will result in:

- An increase in the long term average reliability from 77.1 to 88 % (refer to Table 1).
- 16 years out of the 48 year modelling period being fully reliable. Without Wrights Road Storage farmers experience demand deficits in all 48 irrigation seasons that were modelled (refer to Table 2). In the remaining 32 years the demand deficits will be less than that experienced without the Wrights Road storage pond.

Key model results for shareholders with on farm storage

Under the current minimum flow (41 m^3/s) construction of 8.2 Mm^3 of storage at Wrights Road will result in:

- An increase in the long term average reliability from 96.7 to 98.4 % (refer to Table 1).
- 41 years out of the 48 year modelling period being fully reliable (refer to Table 2). In the remaining 7 years the demand deficits will be less than that experienced without the

Wright's Road storage pond in place. Without Wrights Road Storage farmers are fully reliable for 29 out of the 48 year modelling period. In other words, Wrights Road Storage Pond provides a further 12 years of full reliability.

Under a scenario with increased minimum flow (50 m^3/s) construction of 8.2 Mm^3 of storage at Wrights Road will result in:

- An increase in the long term average reliability from 92.7 to 96.7 % (refer to Table 1).
- 32 years out of the 48 year modelling period being fully reliable (refer to Table 2). In the remaining 16 years the demand deficits will be less than that experienced without the Wright's Road storage pond in place. Without Wrights Road storage farmers are fully reliable for 22 out of the 48 year modelling period. In other words, Wrights Road Storage Pond provides a further 10 years of full reliability.

The results for the five individual farms modelled are similar to those for the overall scheme.

Potential for shareholders with on-farm storage to trade water

With the On-Plains storage in place it is likely that in some years surplus water is available from on-farm storage which can be traded to farmers without on-farm storage. Reliability modelling (assuming that 30% of the total on-farm storage volume in the WIL scheme is available for water trading) indicates that trading water from on-farm storage ponds will increase the reliability for shareholders without on-farm storage when the Wrights Road storage pond is built. The likely periods that shareholder with on-farm storage can trade water will be during relatively dry years when On Plains Storage is depleted and shareholders without on-farm storage experience a deficit in the supply of water. Under the scenario with current minimum flows there are likely to be opportunities to trade water from on-farm storage in 26 years out of the 48 year modelling period.

MAR, TSA, IPO and Climate Change

In addition to a potential increase in the minimum flow for the WIL abstraction from the Waimakariri River it can be expected that other factors influence the reliability of supply in the future. Climate change, negative cycles of the Interdecadal Pacific Oscillation(IPO) and water requirements for Targeted Stream Augmentation (TSA) are likely to adversely affect the reliability of supply for WIL shareholders in the future, as they coincide with the peak irrigation requirements. Water requirements for Managed Aquifer Recharge (MAR) are less likely to have an impact on the future reliability of supply for WIL, as they can occur outside of the peak irrigation season.

The proposed Wrights Road storage pond will assist with offsetting the effects of climate change, negative IPO periods and future TSA requirements on the reliability of supply for the scheme.

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Reviewed and approved by

Peter Callander
Director

Limitations

This memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Waimakariri Irrigation Ltd and others (not directly contracted by PDP for the work), including Water Strategies, National Institute of Water and Atmospheric Research (NIWA), Environment Canterbury, Damwatch and Landcare Research. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the memorandum. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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