EARTH & ENVIRONMENTAL SCIENCE

abigail@eescience.co.nz
021 2800 750
www.eescience.co.nz

Resource Consent Application Review II: Castlerock Farming Company Ltd. (revised)

To:	Rebecca Robertson	Southern Land and Water Planning	(SLWP)
From:	Abigail Lovett	Earth & Environmental Science	(E&E Science)
Date:	08.01.2021	**Revised:** 14.01.2021	

1. Background

E&E Science was engaged to undertake a review of hydrogeological information submitted in resource consent application (APP-20181676) by Castlerock Farming Company Limited (CFCL) in May, 2020. The applicant proposed a new groundwater abstraction from the Lumsden Aquifer for the purposes of irrigation. The review was limited to consideration of the environmental effects of the proposed groundwater take for irrigation, including well interference effects and stream depletion effects (Lovett, 2020). Based on information presented, the initial review concluded aquifer testing results were of low reliability and therefore results of the modelling for bore interference effects were not deemed to be reliable. Stream depletion effects were demonstrated to be negligible based on a combined take of 25.5 L/s from bore 1 and 3.

The applicant subsequently undertook drilling and aquifer testing of an additional bore (new Bore 1; CE10/0001) in December 2020. The results of the second aquifer testing were presented in Liquid Earth (2020) and the results of the bore interference effects were presented in emails from Tim Muller (December, 2020). No further stream depletion assessment was undertaken.

The total volume of groundwater abstraction sought by the consent application remained at 122,178 m^3/year. Changes to the original application are that the rate of take has been reduced from 50 L/s to 30.6 L/s and that the duration of pumping has been increased from 28 days to 46 days (assuming continuous pumping). The applicant proposes for the groundwater to be used for the purposes of irrigation of 234 ha of pasture. The assessment presented in this report includes a review of the physical aquifer testing on new Bore 1 (CE10/0001), analysis of aquifer test results, and consideration of modelled interference effects and stream depletion effects. Comment on whether the applicant has addressed Appendix L pSWLP (2018) is provided.

2. Review of Aquifer Testing (Liquid Earth, 2020)

A review of the 'CE10/0001 Hydraulic Testing Report' was undertaken to assess the reliability of the hydraulic properties used to undertake well interference effects modelling.

Overall, the hydrogeological setting was clearly and suitably described using information obtained from existing resources and hydrogeological information from the local area (e.g., bore logs; water levels; aquifer test results). The hydrogeology at the site consists of the Castlerock unconfined aquifer and a deeper confined/semi-confined Lumsden Aquifer. Groundwater levels in the Lumsden Aquifer are influenced by seasonal pumping with no obvious decline in water level over time. The aquifer is close to full primary allocation. Sufficient bore location, geology, and well construction details were provided (Pg. 6; Liquid Earth, 2020).

2.1 Variable rate Aquifer Test (CE10/0001)

A sufficient description of the variable rate aquifer testing method was provided. Details included the purpose of the test, commencement date/time, pumping rates, and method and frequency of water level measurements. Summary tables of the test data and plots of drawdown and recovery were clearly presented in the report and Attachments (Liquid Earth, 2020). Limitations of the step test are also presented, in particular that groundwater levels were not static over the period of testing (e.g., effects of other pumping have influenced the test results); testing was subject to human error (e.g., displacement of a logger); and that ideal test conditions were not obtained (e.g., time constraints did not allow for full recovery to be monitored).

2.2 Constant rate Aquifer Test (CE10/0001)

A sufficient description of the 48-hour constant rate aquifer testing method was provided. Details included dates and timing, pumping rate and measurement method, the method and frequency of water level measurements in the pumping bore and observation bores, and monitoring of antecedent conditions. A discussion of the limitations associated with undertaking the aquifer test following commencement of the irrigation season was provided, primarily that the test data was influenced to an extent (and unable to be corrected) by nearby pumping from the aquifer. As a result, only data from the pumped bore and the closest observation bore (E44/0370) was used for analysis. Other limitations of the constant rate aquifer test are also presented, including instrument/human error (e.g., loss of automatic data from CE10/0002). Summary tables of the test data and plots of drawdown and recovery were clearly presented (e.g., Figures 8 – 12; Liquid Earth, 2020), including groundwater levels for three shallow observation bores (CE10/0019, CE10/0020, CE10/0032). Factors which require consideration and/or likely reduced the reliability of the aquifer test results include: loss of automatic water level data; the aquifer was not in a state of equilibrium prior to the aquifer test and that background groundwater levels were declining. Furthermore, due to the timing of the aquifer testing (following onset of the irrigations season), the aquifer test was influenced by nearby pumping, which reduced the availability of data from observation bores.

2.3 Aquifer hydraulic properties

The analysis of aquifer test results was limited to the pumping bore and nearby observation bore (E44/0370). The Theis (drawdown and recovery) analysis of the step test results indicated a transmissivity of 360 – 370 m^2/day (Pg. 25; Liquid Earth, 2020). Values of transmissivity and storativity for the constant rate test were relatively consistent, ranging from 350 – 640 m^2/day and 2 x 10^{-7} to 5 x 10^{-5}, respectively (Table 1). It is unclear why there was minor inconsistency in presentation of values in Table 1 (e.g., rounding). Analysis plots generally showed a good fit to the analysis methods (Attachment A; Liquid earth, 2020). The aquifer testing results were discussed in the context of current knowledge of the Lumsden Aquifer, in particular that the results are representative of the local area where testing was undertaken. A discussion on the hydraulic properties of the wider aquifer was presented, including a prediction of potential drawdown over the wider Lumsden Aquifer. The assessment concluded that "… *the source aquifer* (Lumsden) *is semi-confined with a moderate to low transmissivity (350 – 500 m^2/day) …".*

Table 1: Aquifer hydraulic properties calculated from CE10/0001 aquifer test (Liquid earth, 2020).

Observation Bore	Analysis Method	T (m^2/day)	S	L	K'/B' (day^{-1})
E44/0370	Theis	642	0.0000002		
	Theis recovery	519			
	Hantush	352	0.00005		
	Boulton	360	0.00007	1950	
	Hunt and Scott	350	0.00008		0.0001
CE01/0001	Theis Recovery	400			

2.4 Assessment against policy: well interference

Appendix L.1 of the pSWLP (2018) addresses minimum aquifer test requirements for groundwater consent applications. Based on the application to abstract groundwater from a Confined Aquifer (Lumsden) at 30.6 L/s (2,644 m^3/day) the applicant is required to address the criteria presented in Table 2. When assessed against the entirety of information presented in the consent application, the applicant has suitably addressed the criteria for aquifer testing descried in the pSWLP (2018) for Bores 1 and 3 (CE10/0001 and CE10/0002).

Table 2: Summary of the pSWLP (2018) criteria for aquifer testing in Bore 3 (May, 2020) and new Bore 1 (December, 2020).

Criteria from pSLWP (2018) Table L.1	Bore 3 CE10/0002	Bore 1# CE10/0001	Description
Step-drawdown aquifer testing			
A step-drawdown aquifer test comprising a minimum of 3, 1-hour pumping steps…	Yes	Yes	Bore 3: May 2020 Bore 1: December 2020
… followed by measurement of water level recovery.	Yes	Yes	
The maximum pumping rate utilised should be equal to or greater than the maximum proposed abstraction rate.	Yes (6-17 L/s)	Yes (8-22 L/s)	Pumping rates were consistent with the maximum rate of abstraction for each bore, but less than the total proposed abstraction rate.
24-hour constant rate aquifer testing (+ recovery)			
A 24-hour constant-rate aquifer test undertaken…	Yes (72-hr)	Yes (48-hr)	Bore 3: May 2020 Bore 1: December 2020
… at the maximum proposed abstraction rate	Yes (12 L/s)	Yes (18.4 L/s)	Pumping rates were consistent with the maximum rate of abstraction for each bore, but less than the total proposed abstraction rate
Water level monitoring should include drawdown and recovery (to within 10% of the initial static water level) in the pumped bore …	Yes^	Yes	
(to within 10% of the initial static water level) … and in at least two observation bores in the source aquifer …	Yes^	Yes	
(to within 10% of the initial static water level) … and one observation bore in the overlying aquifer within the area of localised drawdown.	Yes^	Yes	
The pump rate should be kept constant within +/- 5%	Yes^	Yes	

A new Bore 1 was drilled in November, 2020 and information presented here is for that bore (not previous/original Bore 1)

^These requirements were not suitably addressed by the applicant in the initial application. Considerable additional information was presented by the applicant which largely addressed some of these issues.

2.5 Stream depletion

The applicant had previously presented a stream depletion assessment based on pumping from original Bore 1 and Bore 3 using a pumping duration of 28 days and a combined abstraction of 25.5 L/s. The initial results indicated that "*… total modelled stream depletion effects are less than 0.5 L/s for pumping from the 2 existing wells. Stream depletion in this order of magnitude is highly unlikely to be discernible or to result in adverse environmental effects*"

(Landpro, 2020). The following conclusion was made by the applicant based on updated aquifer testing results "*Given that the three shallow (Castlerock GMZ) wells near Bore 1 showed no drawdown during the pump test there, discernible stream depletion is also considered highly unlikely.*" (Tim Muller, December 2020). A lack of drawdown in the observation bores is not sufficient enough information to determine that there will be negligible stream depletion effects. It is suggested that insufficient information is presented to confirm the status of the abstraction to suitably address Appendix L.2.

The original stream depletion assessment does not reflect changes to the application have been subsequently made. Changes include an increase in the proposed duration of groundwater abstraction from 28 days to 46 days, a reduction in the combined take from 50 L/s to 30.6 L/s, and confirmation of proposed maximum abstraction volumes from each bore. For completeness, a revised steam depletion analysis should be presented to reflect the changed duration in proposed abstraction and the actual pumping rates of the proposed abstraction to address Appendix L.2 (pSWLP, 2018)

3. Assessment of Effects: well interference

The applicant presented an updated summary of well interference effects in an email. Hydrogeological properties used for the bore interference assessment are presented in Table 3. The results of aquifer testing from Bore 1 (CE10/0001) are considered to be much more reliable than those obtained from Bore 3. The reviewer maintains that the results of aquifer testing undertaken in May 2020 are of low reliability as described "*The report is lacking a suitable description of the design and execution of the aquifer test and in many instances standard procedures are not described or followed*" (Lovett, 2020). Therefore, results of bore interference effects modelling (based on these results) would also be considered less reliable. Reasons for this assessment have been clearly detailed previously (e.g., Lovett 2020).

Table 3: Summary of hydraulic properties used for the well interference assessment.

Bore	Transmissivity (T)	Storativity (S)	Conductance (K'/B')	Information source
CE10/0001 (Bore 1)	350 m^2/day	0.00008	0.0001 day^{-1}	December 2020 aquifer test; Hunt & Scott
CE10/0002 (Bore 3)	1,300 m^2/day	0.00018	0.000083 day^{-1}	May 2020 aquifer test;

Information has been collated from the excel sheet of interference effects assessment and email communication (Table 4). The assessment estimates that abstraction of 30.6 L/s from CFCL bores is likely to generate a drawdown of 0.52 m in the Menlove bore (E44/0256); and 0.72 m (E44/0623) and 0.41 m (E44/0012) in the English bores. Maximum allowable drawdown (MAD) was estimated in the original application (Table 2 and Table 4; Landpro, 2019a), but was not addressed in light of the revised drawdown assessment (Table A.1). In addition, MAD has not been calculated for E44/0012. Limitations of the MAD calculation include reliance on the accuracy of information presented in bore logs and that verification of groundwater levels in nearby bores has not been undertaken for the purposes of the application and/or is not clearly presented. For completeness, it would be beneficial for a succinct summary of MAD values and the revised drawdown information to be presented.

Table 4: Summary of estimated drawdown in nearby bores (Menlove and English), as a result of simultaneous abstraction of 18.4 L/s from Bore 1 (CE10/0001) and 12.2 L/s from Bore 3 (CE10/0002) for up to 46 days.

Drawdown (46 days pumping)	Estimated drawdown effect Bore 1 (m)	Estimated drawdown effect Bore 3 (m)	Total estimated drawdown (m)	Remaining available drawdown (m)
Menlove (E44/0256)	0.39	0.13	0.52	7.4
English (E44/0623)	0.59	0.13	0.72	1.9
English (E44/0012)	0.24	0.17	0.41	?

4. Conclusions

4.1 Stream depletion

Changes to the application have been made since the original stream depletion assessment was undertaken. Changes include an increase in the proposed duration of groundwater abstraction from 28 days to 46 days, a reduction in the combined take from 50 L/s to 30.6 L/s, and confirmation of proposed maximum abstraction volumes from each bore. For completeness, it is recommended that a revised steam depletion analysis should be undertaken to reflect the changed duration in proposed abstraction and the actual pumping rates of the proposed abstraction, and to address Appendix L.2 (pSWLP, 2018).

4.2 Well interference effects

Information presented over the entirety of the application is used to support the following statement regarding well interference effects (Tim Muller, December 2020):

> *" These values compare with max. acceptable drawdown of 1.9 m for E44/0623 and 7.4 m for E44/0256 (see Table 4 of Hydrogeological Assessment included in original application). I.e. the modelled drawdown is less than half of the remaining available drawdown for the closest well, even with inputs considered conservative as discussed above. Modelling drawdown from Bore 1 using the Boulton solution gave essentially identical drawdown outputs. The pump test data is therefore considered to give strong evidence that no unacceptable drawdown effects will occur."*

For completeness, it would be beneficial for a succinct summary of MAD values and the revised drawdown information to be presented. Based on information presented in the entirety of the consent application, well interference effects on Menlove (E44/0256) and English (E44/0623, E44/0012) bores are expected to be within the range of acceptable interference identified in the application, and therefore suitably addresses Appendix L.3 (pSWLP, 2018). This conclusion is based on the assumption that MAD values are sufficiently reliable.

5. Limitations

This report has been prepared by E&E Science on the basis of information provided by the applicant and their consultants, in formal reports, meetings, and email communications. Where possible, datasets have been checked and validated for consistency against standard practices. E&E Science has ultimately relied upon the information provided by the applicant as being accurate and sufficient to prepare this report and as such accepts no responsibility for any errors or omission, or inaccuracy of information provided by the applicant.

Please do not hesitate to contact me if you require any further information.

Kind regards,

Abigail Lovett 13/01/2021
Lead Scientist / Director

Zeb Etheridge 08/01/2021
Peer Reviewer

References

Landpro, 2019a. Castlerock Farming Company Ltd., Resource Consent Application to Environment Southland For consent to install bores and take and use groundwater. Dated 2 August, 2019. Landpro, 13 Pinot Noir Drive, Cromwell, 413 p.

Landpro, 2019b. Request for Further Information under Section 92(1) of the Resource Management Act 1991 – Application Insert details from s92 request. Dated 3 March, 2019. Landpro, 13 Pinot Noir Drive, Cromwell, 12p.

Landpro, 2020. Updated hydrogeological calculations for Castlerock Farming Company Ltd groundwater take application. Landpro Reference: 18180 Council Reference: APP-20191827. 18 July, 2020. 59 p.

Lovett, A., 2020. Review of Resource Consent Application submitted by Castlerock Farming Company (Revised). Earth & Environmental Science Report 2020/05, prepared for Environment Southland Regional Council 29p.

Liquid Earth, 2020. Castlerock Dairies Hydraulic Testing Report. Liquid Earth. No author. No Date. Appended to Landpro (2020).

Liquid Earth, 2020. Castlerock Dairies - Request for further information. Prepared by Liquid Earth for Landpro. 13p.

pSWLP 2018. Proposed Southland Water and Land Plan, Decisions Version, 4 April 2018. Environment Southland Regional Council Corner North Rd &, Price St, Waikiwi, Invercargill, 9810. www.es.govt.nz/Document%20Library/Plans,%20policies%20and%20strategies/Regional%20plans/Southland%20Water%20and%20Land%20Plan/Proposed%20Southland%20Water%20and%20Land%20Plan%20-%20Part%20A%20-%20Decisions%20Version%20(4%20April%202018)%20PDF.pdf

Appendix

Table A.1: Table 2 - Available drawdown and other key details of relevant nearby wells (Landpro, 2019a).

Well	Date drilled	Static water depth (mbgl)	Base of aquitard (mbgl)	Poten-tiometric head (m)	Notes/sources
E44/0300	10/2/2005	5.5 *	34	28.5	Beacon/ ES Enviro Data/ SKM (2005)
E44/0256	July 2004	4.12	27	22.9	ES data
E44/0263	5/2/2004	18.84	63.5	44.7	Aqualinc bore log
E44/0264	-	-	-	-	No bore log – assumed same as closest well (0263).
E44/0339	3/12/2014	7.1	19.6	12.5	Southdrill bore log
E44/0623	18/4/2016	4.68	15.5	10.8	McNeill bore log

** Note: E44/0300 surface RL of 213.97 m, and static water level of ~ 208 5 m.*