Pattle Delamore Partners Limited

TECHNICAL MEMORANDUM

INVESTIGATION	Mataura stream depletion parameters	**PROJECT**	Mataura Water Conservation Order
CLIENT	**Environment Southland**	**PROJECT NO**	C03993509
CLIENT CONTACT	Karen Wilson	**PREPARED BY**	Neil Thomas
CLIENT WORK ORDER NO/ PURCHASE ORDER		**SIGNATURE**	
		DATE	2nd Aug 2022

Introduction

Pattle Delamore Partners has been engaged by Environment Southland (ES) to assist with determining aquifer parameters to calculate stream depletion effects from bores within the Mataura River catchment upstream of Gore, within the area defined by the Mataura Water Conservation Order.

In 2018/2019, stream depletion effects were originally calculated by ES for all groundwater takes with aquifer parameters determined from the available information at the time. These calculations have since been reviewed independently by Brydon Hughes, the technical expert engaged through the consent holders steering group and generally, the parameter values used were agreed. However, there are a number of areas where concerns were raised around parameter uncertainty and whether the values used were appropriate. This memo describes those exceptions and the reasons why changes have been made to the original calculations that were presented in our memo dated 29 March 2022.

The main areas where changes have been made are:

- The Foxes Creek area, close to the catchment boundary with the Oreti River, where changes are proposed based the location of reaches that have long-term periods of flow in Foxes Creek
- The Riversdale area, where changes are proposed based on a representative value of transmissivity for takes in the area.
- The Pyramid Creek area where changes are proposed based on the location of reaches that have long-term periods of flow in the stream;
- The Meadow Burn area, where changes are proposed based on updated information on the stream bed conductance parameter
- The Gore District Council takes at Coopers Creek, where changes are proposed to better reflect the hydrogeology of the area; and
- The Garvie Aquifer, where changes are proposed based on updated modelling of the aquifer.

Each of these areas are discussed in further detail below and the general locations are shown in Figure 1.

This memo summarises the changes agreed between PDP (acting as technical experts for ES) and Brydon Hughes (acting as the technical expert for the Steering Group). One general area of uncertainty was around the value of aquifer storage (S). There is limited data to define aquifer storage and the estimates vary. After discussion, the technical experts agreed that a default value of 0.15 should be used in the absence of pumping test data.

Irrigation return flows to the local streams are considered for all bores, which offset the stream depletion effects. In all cases the offset is based on a return of 10% of the pumped volume. One update that has been made to some bores is to correct the point at which the irrigation return is simulated. In the tables detailing the changes below a comment is included where this update has been made.

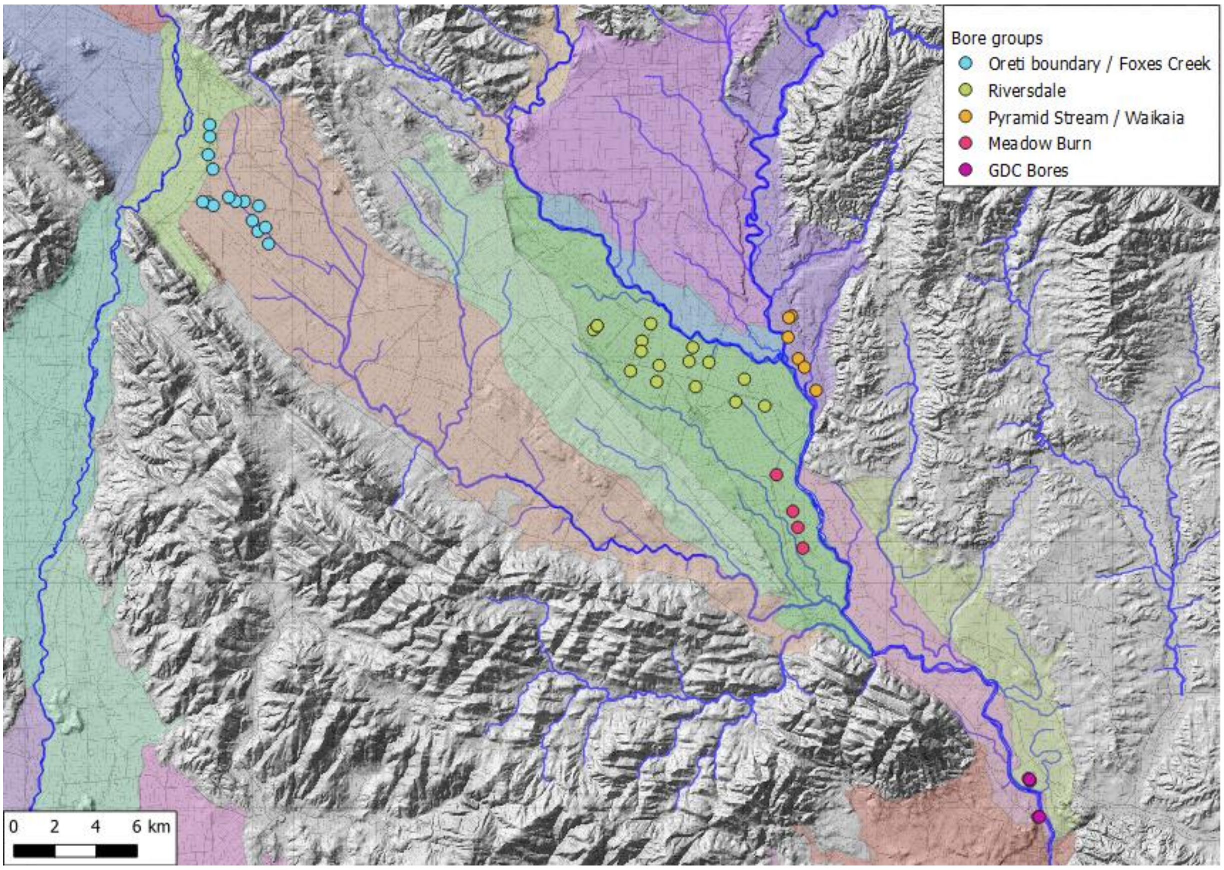

Figure 1: Location of some stream depleting bores in the Mataura Plains discussed in this memo

Foxes Creek

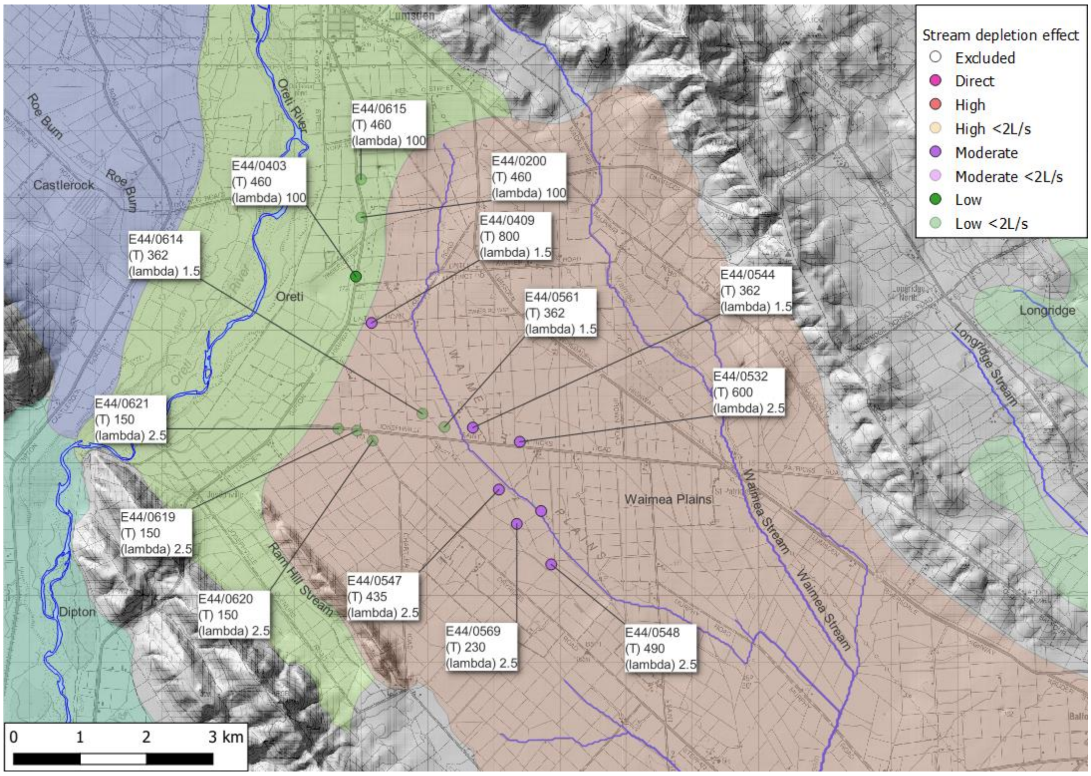

Figure 2: Location of stream depleting bores within the Foxes Creek area

Figure 2 shows the location of Foxes Creek and the current stream depletion categories for groundwater takes in the area, as determined by the ES assessment. Currently, stream depletion effects are calculated based on an assumption that the stream is permanently flowing along its full length throughout the irrigation season. The calculations are also based on a stream bed conductance value of 2.5 m/d.

Fieldwork carried out by PDP in January/February 2022 around Foxes Creek indicated a small flow of around 3 L/s upstream of Saint Patricks Road but that there was no flow downstream of Saint Patricks Road. A recent field visit by Environment Southland in March 2022 indicated that flow was observed around 1 km upstream of Glenure Road and around 3 km downstream of Saint Patrick Road. The 2021/2022 summer was relatively dry and the flow observed just upstream of Glenure Road is therefore likely to represent the point at which permanent flow in the stream generally occurs. This is not intended to account for extremely dry summers where dry conditions could extend further downstream. However, in a similar way to annual volumes on irrigation consents being set for typically 1 in 10 year dry events, the point of perennial flow relates to a typical dry year.

Table 1 summarises the changes made to the calculated stream depletion from bores around Foxes Creek and the result of that change. The key change is with respect to the distance between the bore and the stream, which is now based on the distance from the bore to the point where reaches that have long-term periods of flow are located during a typical summer season, rather than the closest point of the stream channel. That change has been made because:

- The very low flows in Foxes Creek upstream of Saint Patricks Road could not sustain the calculated stream depletion effect and the stream is dry for a distance of around 3 km downstream from St Patricks Road;

Note that Appendix L2 of the proposed Southland Water and Land Plan indicates that effects on intermittent streams must still be considered a part of an assessment of effects on surface water bodies. However, that is a separate assessment matter at the time decisions on consent applications are made, so it does not affect the surface water allocation aspect of a take and is therefore not considered in this memo.

Table 1: Foxes Creek

Consent number	Bore number	Original distance to Fox Creek (m)	Original stream depletion classification (calculated stream depletion flow in L/s)	Updated distance to Fox Creek point of permanent flow (m)	Updated stream depletion classification (calculated stream depletion flow in L/s)
20146808	E44/0547	150	Moderate (14.7)	2,049	Low <2L/s
20146808	E44/0548	270	Moderate (9.3)	740	Moderate (5.1)
20157708	E44/0569	380	Moderate (5.6)	1,504	Low <2L/s
20157708	E44/0570	65	Moderate (8.4)	1,385	Low <2L/s
20157859	E44/0544	334	Moderate (18.4)	3,008	Low <2L/s
20136291	E44/0532	390	Moderate (6.2)	2,441	Low <2L/s
205657	E44/0409	530	Moderate (8.8)	5,198	Low <2L/s

Riversdale area

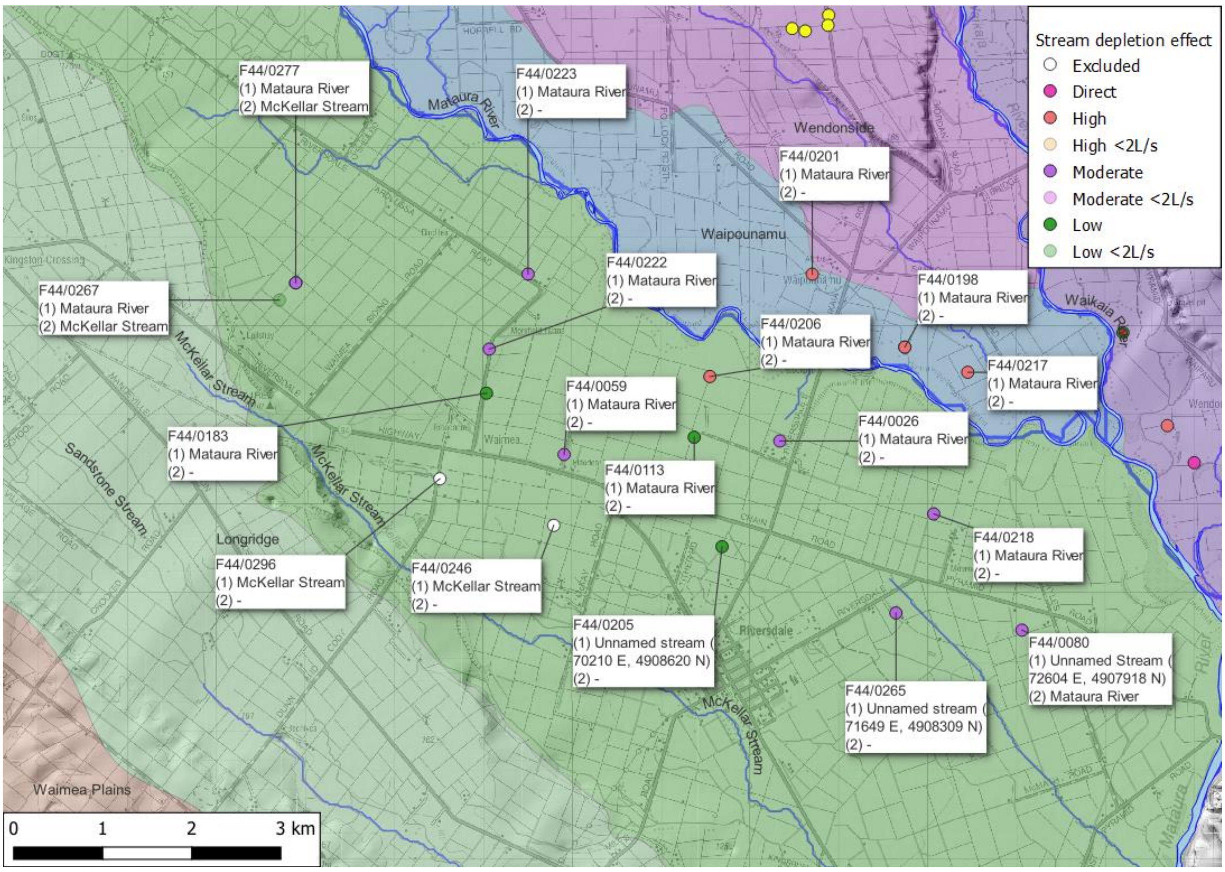

Figure 3: Location of bores in the Riversdale area

The Riversdale area includes those bores that are located between McKellar Stream and the Mataura River around Riversdale (Figure 3). In general, McKellar Stream is thought to be perched in this location (Wilson,

2011) and none of the bores in the current spreadsheet are assigned to that stream. Most bores in this area are assigned to the Mataura River, although with varying aquifer properties. 3 bores (F44/0205, F44/0265, and F44/0080) are assigned to an unnamed stream located to the east of Riversdale.

The following changes to the stream depletion calculations for bores in this area should be implemented:

- A range of aquifer properties (esp. transmissivity) have previously been used in the ES assessment which results in some highly variable calculated stream depletion effects (e.g. bore F44/0206 = high and bore F44/0113 = low). It is recommended that stream depletion for bores in this area is calculated based on a transmissivity value of 2,500 m^2/day, which is consistent with the majority of aquifer tests in the local area.
- Bores which were assigned to McKellar Stream and then excluded (i.e. F44/0246 and F44/0296) should be assigned to the Mataura River (although their stream depletion effects are likely to remain low)
- Whilst the field measurement for the stream bed conductance for the Unnamed stream indicated a value of 25 m/d, this results in stream depletion effects that Brydon Hughes has suggested are unrealistically high based on the small flow in the stream. It is possible that the gain in flow between the gauging sites may have been affected by a tributary inflow, so is not all related to groundwater inflow. Alternatively there may be lower permeability strata below the zone of conductance measured by the field work. Therefore the original streambed conductances used in the original ES review assessment have been retained. The stream depletion effects of the three bores assigned to the Unnamed stream should be updated.
- A range of possible storage values are applicable in this area and the resulting range of effects is provided in the table below.

Table 2 lists the bores and consents, showing the main changes to the stream depletion calculation (highlighted in red), compared to the assessment that was presented in Killick (2018)

Table 2: Riversdale – transmissivity changes and stream depletion effects on the Mataura River

Consent number	Bore number	Original transmissivity	Original stream depletion classification (calculated stream depletion flow in L/s)	Updated transmissivity	Updated stream depletion classification (calculated stream depletion flow in L/s)
302766	F44/0222	3,500	Moderate (24)	2,500	Moderate (19.2)
20171618-03	F44/0296	2,000	-	2,500	Low
20147001-V1	F44/0267	2,000	Low	2,500	Low
20147001-V1	F44/0277	2,000	Low	2,500	Low
300869-V1	F44/0026	650	Moderate (7.7)	2,500	Moderate (23.4)
300869-V1	F44/0113	700	Low	2,500	Moderate (8.4)
300869-V1	F44/0206	8,000	High (58.4)	2,500	High (53.1)
300942-V2	F44/0059	9,843	Moderate (21.1)	2,500	Moderate (5.5)
20146373-V1	F44/0218	2,500	Moderate (24.5)	2,500	Moderate (24.5)
20181131	F44/0246	10,000	-	2,500	Low

300781	F44/0183	1,600	Low	2,500	Moderate (6.6)
300781*	F44/0223	2,200	Moderate (15.6)	2,500	Moderate (14.8)
301359	F44/0080	1,189	Moderate (9.1)	2,500	Moderate (14)
20147520	F44/0205	2,900	Low	2,500	Low

* Updated distance between irrigation centroid and river

Pyramid Creek area

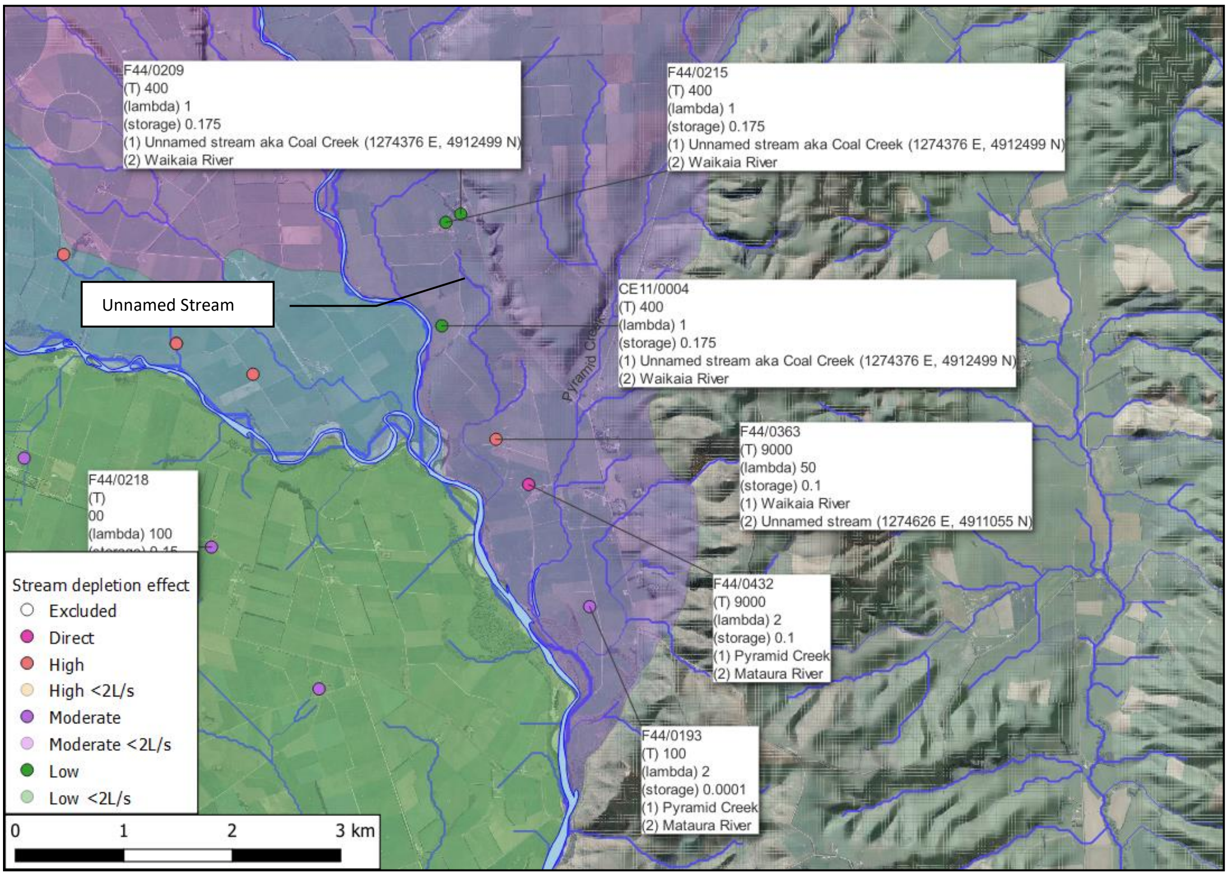

Figure 4: Location of bores in the Pyramid Creek area

There are two bores located around Pyramid Creek and the Waikaia River, close to the Mataura River confluence. Four further bores are located close to an Unnamed Stream, also known as Coal Creek (Figure 4). The stream bed conductance of Coal Creek was confirmed as around 1 m/d by fieldwork in February 2022 and the stream depletion calculations for these takes can be retained.

Fieldwork around Pyramid Creek indicated that the stream was dry in January / February 2022 and the stream reportedly goes dry upstream of Pyramid / Waiparu Road. Therefore, it would reasonable to treat Pyramind Stream as intermittent under the pSLWP (Appendix L2). The point at which Pyramid flows in a typical dry season is reportedly almost at the confluence with the Mataura River, which is therefore the point of assessment for these takes. Therefore, it is reasonable to exclude the effect of these takes on Pyramid Stream and consider the effect of the takes on Mataura River. The stream depletion effects for bores F44/0193 and F44/0432 are summarised below.

Table 3: Pyramid Creek

Consent number	Bore number	Original Pyramid Creek streambed conductance	Original stream depletion classification (calculated stream depletion flow in L/s)	Updated Pyramid Creek Stream bed conductance	Updated stream depletion classification (calculated stream depletion flow in L/s)
20136240-V1	F44/0193	-	Moderate (2.8)	-	Excluded
20136240-V1	F44/0432	-	Direct (8.3)	-	Excluded

Although effects on Pyramid Stream are excluded for these bores, bore F44/0193 has a 'Low' (2.3 L/s) effect on the Mataura River and bore F44/0432 has a direct (29 L/s) effect on the Mataura River.

Meadow Burn area

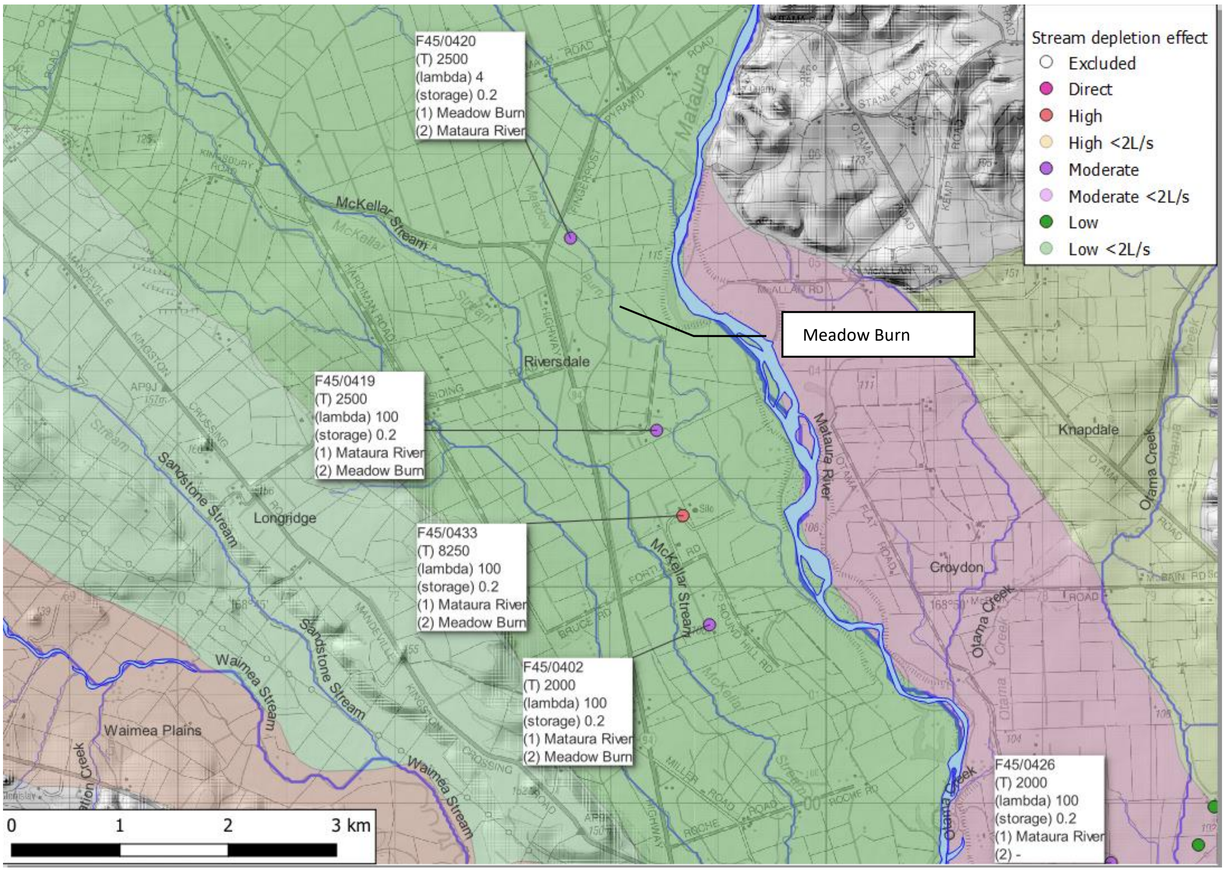

Figure 5: Location of bores along the Meadow Burn

There are four bores in this area (Figure 5), although the approach to calculating the stream depletion effect for each appears to vary slightly. It appears that the McKellar stream in this area is isolated from groundwater due to bed clogging (Wilson, 2011); there is little if any relationship between flow in the stream and groundwater level.

The Meadow Burn gains flow along its length from where it originates near Riversdale and comparisons of flow in the stream and groundwater levels indicates that the flow in the Meadow Burn is closely related to groundwater levels. Therefore, the Meadow Burn is hydraulically connected to groundwater. In the current ES stream depletion calculation, the stream bed conductance of the Meadow Burn was assumed to be much lower than the Mataura River (~4 m/d compared to >100 m/d) and on that basis, effects on the Meadow Burn are excluded for 3 of the 4 bores (i.e. F45/0402, F45/0433 and F45/0419) in this area and the stream depletion effect is calculated on the Mataura River.

In a stream depletion context, the Mataura River has a much greater stream bed conductance and effects on that river are likely to dominate over effects on the Meadow Burn in the overall stream depletion effect from pumping. This is the reason that the effects on the Meadow Burn were originally excluded, because adding the stream depletion effect from both the Meadow Burn and the Mataura River would overestimate the overall stream depletion effect. However, this calculation will depend on the stream bed conductance of the Meadow Burn, which was poorly defined. If the stream bed conductance of the Meadow Burn is more than around 1 m/d, the analytical solutions indicate that effects on the Meadow Burn could become significant.

Recent assessment of field data (ES, 2007) indicates that the stream bed conductance for the Meadow Burn is much higher than originally estimated with estimated values of between 18 m/d to 92 m/d. Therefore, the stream depletion calculation for bores F45/0420, F45/0419 and F45/0433 should be updated to allow for effects on the Meadow Burn.

Stream depletion calculations for bore F45/0402 (MCM Dairies) should only consider effects on the Mataura River because the course of the Meadow Burn is very close to the Mataura River in this area. Effects on the Meadow Burn due to pumping from bore F45/0402 are therefore not distinguishable against the effects on the Mataura River. Stream depletion effects from this bore on the Mataura River are based on the parameters derived from a particularly good quality pumping test undertaken by Liquid Earth on 12 – 14 May 2020. This results in the hydraulic connection for the currently consented quantities being classified as 'Moderate (23.1 L/s), which is unchanged from the original classification.

Revised stream depletion calculations for the three bores F45/0420, F45/0419 and F45/0433 are shown below.

Table 4: Meadow Burn

Consent number	Bore number	Original Meadow Burn streambed conductance	Original stream depletion classification (calculated stream depletion flow in L/s)	Updated Meadow Burn Stream bed conductance	Updated stream depletion classification (calculated stream depletion flow in L/s)
20146901	F45/0433	10	Excluded	25	High (38.4)
20147096	F45/0419	4	Excluded	25	High (24.1)
20147096	F45/0420	4	Moderate (23.4)	25	High (40.3)

Note that stream depletion effects on the Mataura River are no longer considered for these three bores because the Meadow Burn lies between them and the Mataura River. Given the high stream bed conductance assessed for the Meadow Burn, effects are not expected to propagate to the Mataura River.

There is uncertainty around the precise location of bore F45/0419. This may alter the absolute magnitude of the stream depletion effect, although the classification is not expected to change.

Gore District Council Bores

There are two main sources for the Gore District Council drinking water supplies.

- The Coopers bore field is on the true left (eastern) side of the river and around 1.5 km upstream from the Jacobstown bores. The Coopers bore field consists of three bores, two of which (F45/0463 and F45/0795) are currently assessed as having a 'direct' stream depletion effect. The other bore (F45/0576) is currently classified as having a low stream depletion effect as its effect is <2L/s.
- Jacobstown is located on the true right (west) bank of the Mataura River and consists of two bores (F45/0555 and F45/0806), currently assessed as having a 'high' stream depletion effect.

There are complications with both borefields in terms of their stream depletion effects. Both the consents for these takes enable emergency use of surface water to supplement the groundwater supplies, via discharges into the unused bores at each site to recharge the local aquifer. It is not clear how often these emergency surface water takes have been used, however their effect on the surface water allocation in the Mataura River needs to be considered in combination with the groundwater pumping stream depletion effects rather than independent from it to ensure there is no double counting of pumping effects on the river flow.

Coopers bore field

Based on a report from 2007 (SKM, 2007), the key complication with the Coopers borefield is that bores were drilled into an old dredge pit, which has a higher permeability than the surrounding strata. At the time the report was written in 2007, this effect is reportedly seen in the yield from one of the bores (Well 2), where the yield drops markedly at times and shows differing water level patterns to the other bore (Well 1). However, Well 1 appears to provide a consistent yield at times of low water levels. The bore numbers are not identified in the SKM (2007) report. One of the recommendations in the SKM report is that a new bore should be drilled at the Coopers town site to replace Well 2.

A technical comment (ES,2008) in support of a replacement consent for the GDC bores in 2007 and 2008 indicated that the Coopers bores included F45/0463 and F45/0395. Currently, the stream depletion effects are considered from bores F45/0463 and F45/0795. In the 2018 application, bore F45/0795 has replaced the original low yielding bore Well 2. The 2007 technical comment also notes that the take was also supplemented by a surface water take at times of low water levels, where surface water is pumped into the bores to sustain their yield, although it is not clear when this has been required. In the technical comment, a stream depletion effect was also estimated, based on a transmissivity of 50 m^2/day, a specific yield of 0.1 and a stream bed conductance value of 25 m/d, and pumping over a period of 150 days, resulting in a 'moderate' stream depletion effect. The transmissivity value was reportedly based on a pumping test from 1994.

The bores are located around 450 m from the Mataura River and the current stream depletion assessment applies a transmissivity of 1,000 m^2/day, together with a storage value of 0.1 and a stream bed conductance of 50 m/d. Based on Killick (2018), the transmissivity value of 1,000 m^2/day is based on an average of possible interpretations of the 1979 pumping test, which, based on analysis from Aquafirma in 1997 shows a possible range from 94.5 to 1,577 m^2/day. Killick (2018) notes that the transmissivity value of 50 m^2/day is not clearly referenced. The 2018 application concluded that a value of 1,200 m^2/day was reasonable and at the lower end of a possible range of values, based on a pumping test undertaken in 2018.

In general, a transmissivity value of 50 m^3/day appears unrealistically low to allow pumping from the GDC bores at rates of over 1,000 m^3/day given the shallow nature of the aquifer. A stream bed conductance value of 25 m/d also appears inconsistent with other areas of the Mataura River, where the stream bed conductance is typically taken as around 50 to 100 m/d.

Therefore, at this stage, there does not appear to be sufficient justification, in terms of new or more reliable data, to alter the stream depletion assessment for the GDC Coopers bores. It would be more appropriate to consider how the surface water take should be treated, perhaps based on more information on when, and how, it is used and considering whether the effect of that take could be pro-rata to account for the actual use of the surface water take.

Allowing for a possible range of storage values (from 0.1 to 0.2) the stream depletion effects from the Coopers bores are summarised below. A small update to the stream bed conductance value for Gold Creek was also made to allow for a narrower stream at low flows. It is important to note that the change in the classification of the takes due to the small change in parameters is because of the way the pSWLP requires that stream depletion effects across two streams are summed.

Table 5: GDC Coopers Creek – effects on Gold Creek

Consent number	Bore number	Original Gold Creek streambed conductance	Original stream depletion classification (calculated stream depletion flow in L/s)	Updated Gold Creek Stream bed conductance	Updated stream depletion classification (calculated stream depletion flow in L/s)
204330-V1	F45/0463	3	Direct (7.6)	2	Low to Direct (6.6)
204330-V1	F45/0795	3	Direct (10.7)	2	Moderate to Direct (9.3)

Table 6: GDC Coopers Creek – effects on Mataura River

Consent number	Bore number		Original stream depletion classification (calculated stream depletion flow in L/s)		Updated stream depletion classification (calculated stream depletion flow in L/s)
204330-V1	F45/0463		Direct (17.3)		High to Direct (18.320.3)
204330-V1	F45/0795		Direct (22.2)		Moderate to Direct (23.7)

Jacobstown bores

The Jacobstown bores are located around 1.5 km downstream and on the opposite (i.e. west) bank of the Mataura River. One of the bores (Well 3, F45/0555) also experiences particularly low yields at times of low water levels but in this case the cause, as described in SKM (2007), is thought be due to a basement ridge between the bores and the river, which restricts the hydraulic connection between the bores and the river at times of low flows. Low yields also affect the other Jacobstown bore (Well 1, F45/0806) at low flows, although this bore is located slightly (60 m) closer to the river compared to Well 3.

There is no dispute that the bores have a close connection to the Mataura River, however there is some evidence to suggest that their effect at lower flows is more limited. Given the purpose of the stream depletion classification system is to protect low flows in the river, there may be some justification for amending their stream depletion classification. However, this should be based on a clear relationship between flows and/or stage levels in the Mataura River and water levels in the bores, which is not currently available. Without that data, it is not clear how the stream depletion effect could be justifiably modified. A 'direct' groundwater take will have much the same impact on the allocation as a 'high' take and it is unlikely that there is justification to classify the Jacobstown bores as a 'moderate' take.

It would be more appropriate to consider how the surface water take should be treated, perhaps based on more information on when, and how, it is used and considering whether the effect of that take could be pro-rata to account for the actual use of the surface water take.

Garvie Aquifer (Wendonside)

The Garvie Aquifer is located in the Wendonside Groundwater Management Zone (GMZ), between the Mataura and Waikaia Rivers, north of Riversdale in Southland (Figure 1). Understanding the stream depletion effect of groundwater takes from this deep strata is important in ensuring that water allocation in the Mataura catchment remains within the constraints of the MCO. Calculation of stream depletion effects is typically achieved using the aquifer parameters derived from a pumping test within an analytical model that allows for the presence of a river. Many groundwater takes within the Matarua catchment fit within the assumptions of these analytical models. However, the geometry of Garvie Aquifer means that it cannot be represented in an analytical model.

Therefore, a numerical model of the Garvie Aquifer was developed that can be used for estimation of stream depletion effects arising from bore abstractions. The model has been created using the groundwater modelling software MODFLOW 6 and is intended to be a relatively simple representation of the aquifer, simulating the conceptual setting and geometry. It is intended to be used in the same way as the analytical models used for other areas of the catchment i.e. without detailed calibration to observed water levels. Further information of the technical details of the model are set out in a technical memorandum agreed between ES, PDP and Brydon Hughes as the technical representative of the consent holders steering group.

The results of the transient model used to assess stream depletion affects are presented in Table 4 below. The stream depletion category was assessed in accordance with Appendix L.2 (Table L.2) of the Proposed Southland Water and Land Plan.

Table 7: Modelled stream depletion effects in the Garvie Aquifer

Bore	**Max flow (L/s)**	**Annual volume (m^3)**	**Max pumping period (days)** [1]	**Mataura Stream depletion effect (%)**	**Matarua Stream depletion effect (L/s)**	**Waikaia Stream depletion effect (%)**	**Waikaia Stream depletion (L/s)**	**Stream depletion category** (calculated stream depletion flow in L/s)
F44/0308	58	415,800	83	6.7	3.9	4.3	2.5	Low
F44/0256	95	738,720	90	1.0	1.0	0.2	0.2	Low

F44/0415	116	650,000	65	1.1	1.3	0.1	0.2	Low
F44/0387	2	657,000	90	1.7	0.0	0.4	0.0	Low
F44/0483	56	842,400	90	2.2	1.2	0.5	0.3	Low
F44/0282	56	842,400	90	2.2	1.2	0.5	0.3	Low
F44/0075	25	194,400	90	4.4	1.1	1.4	0.4	Low
F44/0390	60	380,744	73	7.4	4.5	10.7	6.4	Moderate (6.4)
F44/0228	80	565,422	82	5.6	4.5	3.6	2.9	Low
F44/0359	70	506,000	84	7.9	5.6	10.9	7.6	Moderate (13.2)
F44/0323	10	678,400	90	8.2	0.8	11.0	1.1	Low
F44/0339	60	678,400	90	7.9	4.8	11.7	7.0	Moderate (7.0)
F44/0406 (Consent lapsed)	120	957,000	90	4.4	5.3	1.4	1.7	Moderate (5.3)
F44/0388	122	682,500	65	2.2	2.6	0.2	0.2	Low
F44/0389	424	1,993,834	54	0.2	0.8	0.0	0.0	Low

Notes

1. *The time period of pumping at the maximum instantaneous rate that it takes to use total annual volume, up to a maximum of 90 days.*

The locations of these abstraction bores are shown in Figure 6 .

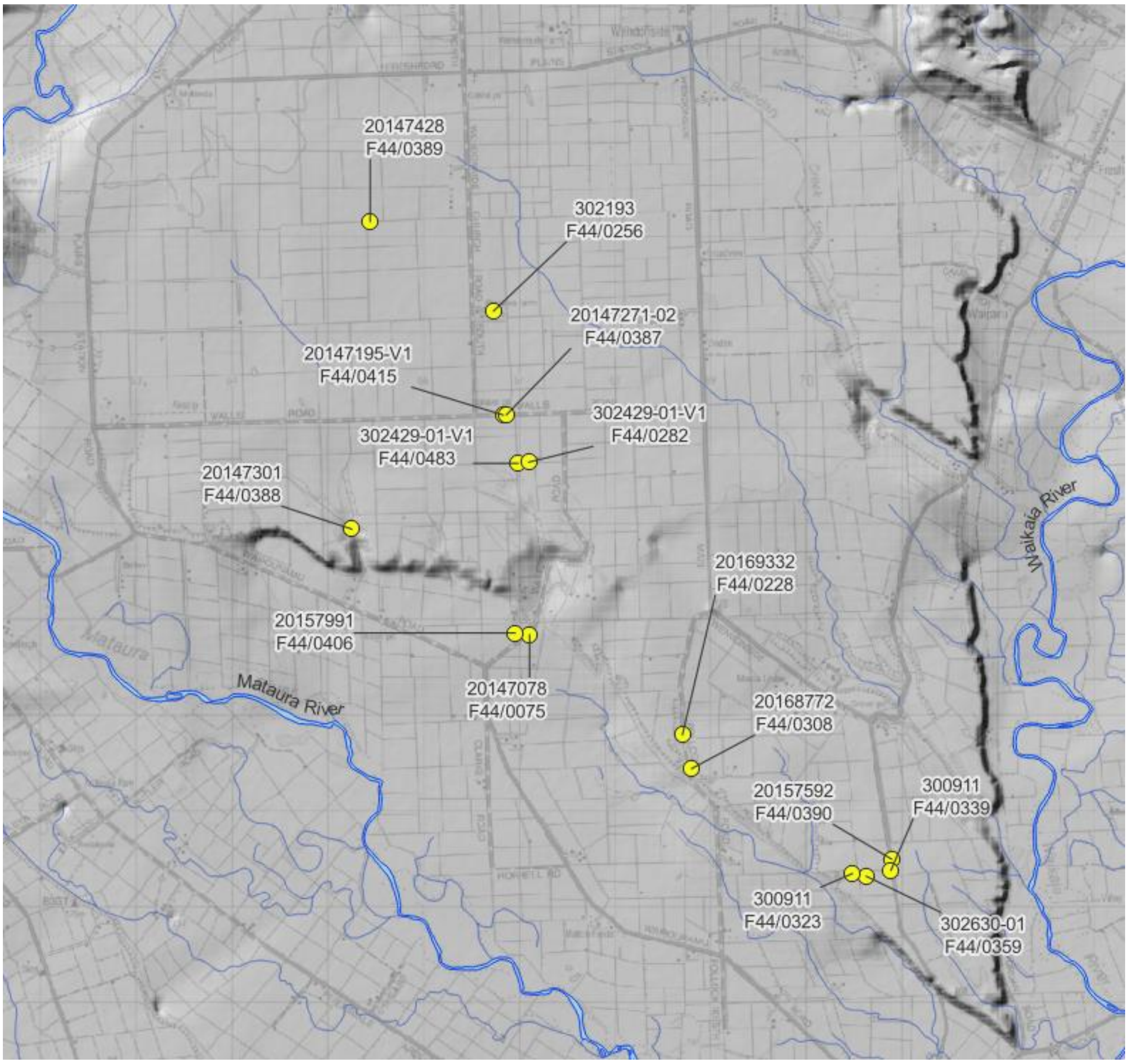

Figure 6: Location of bores within the Garvie Aquifer.

As noted above, the intent of the model is to estimate the stream depletion effect of current takes within the Garvie Aquifer whilst allowing for the geometry of the aquifer, which cannot be accurately represented in analytical models that are typically used to estimated stream depletion effects from pumping bores. All models are an approximation of real hydrogeological conditions, however the parameters chosen here are considered to be similar to the approach used for the analytical modelling of other groundwater takes.

The total stream depletion of those takes that are classified as 'Moderate' in Table 2 is 32 L/s. Under the proposed Southland Water and Land Plan, this effect should be included in the surface water allocation regime for the Mataura catchment in the no flow restriction band, which would be consistent with the use of these consents to date.

Waimea Plains

One change has been adopted for consents within the Waimea Plains which is for consent 207373. This is because the original assessment was based on the location of two duck ponds located to the south-west of the bore (E44/0441). However, based on groundwater level information as well as a site visit in February 2022 it appears that the duck ponds are perched above the local groundwater table. Therefore the assessment point for stream depletion effects has been moved to a point on the closest stream that is likely to be permanently flowing and connected to groundwater. The original assessment also used a very high stream bed conductance value for the duck ponds (25 m/d). The updated assessment uses a stream bed conductance of 2 m/d which is considered reasonable and consistent with the measured stream bed conductance for Foxes Creek, which has a generally similar setting. A summary of the changes applied is provided in the Table 8.

Table 8: Waimea Plains

Consent number	Bore number	Original distance to nearest surface waterway (duck ponds) (m)	Original stream depletion classification (calculated stream depletion flow in L/s)	Updated distance to nearest surface waterway (m)	Updated stream depletion classification (calculated stream depletion flow in L/s)
207373	E44/0441	700	Moderate	1,250	Moderate (7.6)

Croydon

There are three consents (4 bores) located in this area, within a bend of the Mataura River upstream from Gore. Aquifer properties vary widely between the consents despite the physical proximity and therefore a uniform value of transmissivity has been adopted to ensure a consistent approach to the assessment. Table 9 summarises the changes to the stream depletion effects of these takes. Where the range of storage values is used a range of stream depletion effects is shown.

Table 9: Croydon

Consent number	Bore number	Original transmissivity value (m^2/day)	Original stream depletion classification (calculated stream depletion flow in L/s)	Updated transmissivity value (m^2/day)	Updated stream depletion classification (calculated stream depletion flow in L/s)
207215	F45/0549	1,312	High (30.7)	1,500	High (31.0)
20181243[1]	F45/0529	2,000	Moderate (21.2)	1,500	Moderate (20.1)
20157812	F45/0424	3,830	High (11.4)	1,500	Moderate (8.9)
20157812	F45/0525	470	Moderate (5)	1,500	(Moderate (8.2)

1. A different distance to the Mataura River has been adopted for this bore. The original distance was to an oxbow lake which does not flow at low flows (based on evidence presented to a hearing). Therefore the distance is now set to the Mataura River mainstem.

Upper Mataura

The stream depletion effect for a number of consents in the Upper Mataura have been updated to ensure consistency between aquifer parameters applied to different bores and to ensure that the assessment point on the river is consistently applied (i.e. the point where permanent flow occurs). A summary of the changes applied is provided in Table 10. Stream bed conductance values were originally between 30 m/d and 50 m/d for these consents but recent testing in the area indicated a range of values up to 16 m/d. Therefore a value of 20 m/d has been adopted to provide an average between the original estimates and the recent testing.

Table 10: Upper Mataura

Consent number	Bore number	Original stream bed conductance (m/day)	Original stream depletion classification (calculated stream depletion flow in L/s)	Updated stream bed conductance (m/day)	Updated stream depletion classification (calculated stream depletion flow in L/s)
206312	E43/0046	30.0	High (41.9)	20	Moderate (40.1)
20171135	E43/0020	50.0	Moderate (32.1)	20	Moderate (29.1)
20171135	E43/0045	50.0	Moderate (14.6)	20	Moderate (12.3)

The stream depletion assessment for consent 20169247 has also been amended. The reach that has long-term periods of flo on the Mataura is considered to be the confluence with Diggers Creek, whereas the assessment point for this consent was set to the closest point of the river to the take. Therefore the assessment has been updated to reflect the corrected assessment point. Table 11 summarises the changes. In addition, the stream bed conductance parameter used for this consent was 44 m/d which is approximately twice the upper end of a range assumed for other nearby applications. Therefore a stream bed conductance of 22 m/d has been

Table 11: Upper Mataura

Consent number	Bore number	Original stream bed conductance and distance to river (m/day, m)	Original stream depletion classification (calculated stream depletion flow in L/s)	Updated stream bed conductance and distance to assessment point (m/day, m)	Updated stream depletion classification (calculated stream depletion flow in L/s)
20169247	F43/0032	44 m/d and 1,600 m	Moderate (20.4)	22 m/d and 2,400 m	Low

Conclusion and summary

There are a number of changes recommended in this memo that should be applied to the stream depletion calculation for the Mataura catchment above Gore. Before these changes were implemented, the total stream depletion effect was 930 L/s, of which 402 L/s was made up from 'Moderate' takes.

Applying the changes recommended above, including those for the Garvie Aquifer, reduces the overall stream depletion effect to 855.4 L/s. and the proportion of takes classified as 'Moderate' drops to 321 L/s.