


TECHNICAL MEMORANDUM

INVESTIGATION	Matarua Water Conservation Order	PROJECT	Fieldwork to assess streambed conductance
CLIENT	Environment Southland	PROJECT NO	C03993509
CLIENT CONTACT	Karen Wilson	PREPARED BY	Neil Thomas
CLIENT WORK ORDER NO/ PURCHASE ORDER		SIGNATURE	
		DATE	7 th February 2022

Introduction

Pattle Delamore Partners Limited was engaged by Environment Southland to assist with stream depletion assessments for groundwater abstractions within the area covered by the Matarua River Water Conservation Order (MWCO). Part of this work involved checks on the original stream depletion assessments and work to agree aquifer parameters with Brydon Hughes who is providing technical advice to a representative group of the consent holders. During discussions between PDP and Brydon, a number of specific areas were identified where accurate information regarding aquifer parameters was limited, particularly regarding stream bed conductance values. A program of field work was developed to help fill these information gaps. This work focussed on the following areas:

- Foxes Creek
- Unnamed springfed stream south-east of Riversdale
- Meadow Burn
- Coal Creek (north-west of Pyramid Creek)

Note that the original fieldwork plan included gauging along Pyramid Creek. However, at the time of the fieldwork, no surface water flow occurred in Pyramid Creek and therefore this site was excluded from the fieldwork.

At each of these locations, the fieldwork involved installing a piezometer into the stream bed to measure the stream stage and groundwater level directly beneath the streambed. In addition, flows were gauged at locations upstream and downstream of the piezometers to determine the rate of groundwater inflow to the stream, or seepage loss from the stream to groundwater. Combined, these measurements are used to calculate stream bed conductance based on the following formula:

$$\lambda = \frac{\Delta q}{L \cdot \Delta H}$$

Where:

λ = stream bed conductance

Δq = change in stream flow

L = length of the stream reach

ΔH = difference in groundwater levels and stream stage

In addition, test pits were excavated adjacent to each piezometer which provided information on the local strata to the depth of the water table.

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A map showing the location of each of the piezometers and stream gauging sites is provided in Figure 1. The following sections of this memo describe the results of the fieldwork, in terms of the estimates of stream bed conductance and other general information regarding stream flows collected over the course of the field days.

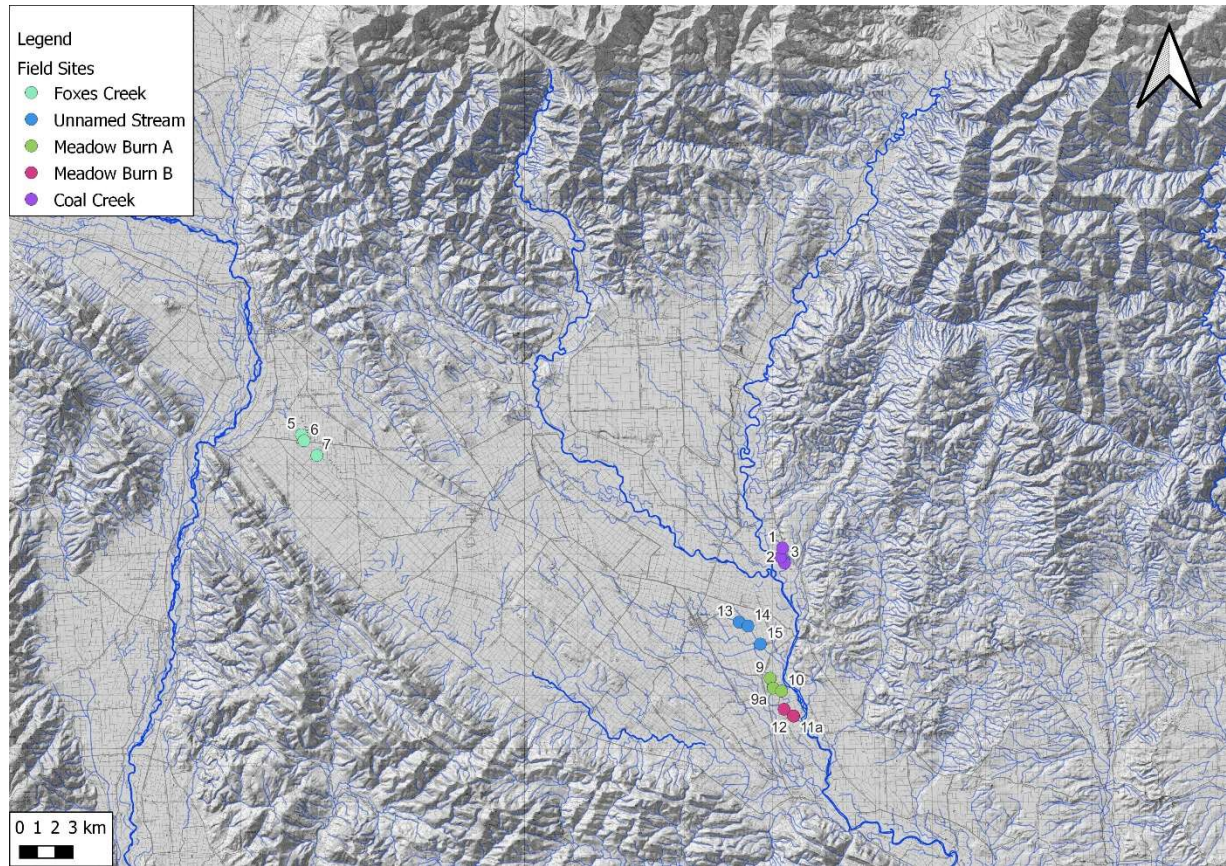


Figure 1: General location of field sites

Foxes Creek

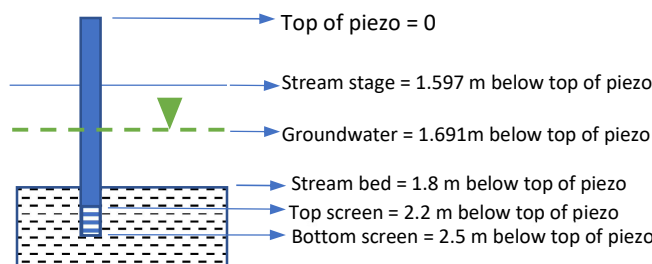
Figure 2 shows the Foxes Creek sites where groundwater levels were collected and stream flows were gauged. Stream flows in the most upstream site were very low and just above the point where a gauging measurement could be made. Further downstream, the streambed dried completely, indicating seepage of stream flow to groundwater.

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Figure 2: Location of sites on Foxes Creek

Groundwater levels were measured in a piezometer installed directly into the stream bed, with the screened interval at a depth of 0.4 m to 0.7 m below the stream bed (0.6 – 0.9 m below the water level in the stream), as per the schematic below. Groundwater levels in the piezometer were approximately 0.1 m below the stage elevation of the stream, which is consistent with the loss of stream flow along the measured reach.



The test pit excavated adjacent to the piezometer installation location indicated clays and silts to a depth of around 0.7 m. Between 0.7 and 1.2 m bgl, the strata consisted of sands, with a further 0.9 m of gravels from 1.2 m bgl to 2.1 m bgl. Groundwater was encountered in the pit at a depth of around 1.9 m bgl.

A summary of measurements made at the Foxes Creek site is provided in Table 1.

Table 1: Summary of data from Foxes Creek, based on measurements made on 3rd Feb 2022			
Site	Flow (m³/s)	Stage (m from top of piezo)	Groundwater level (m from top of piezo)
Site 5 (upstream)	0.0032	-	-

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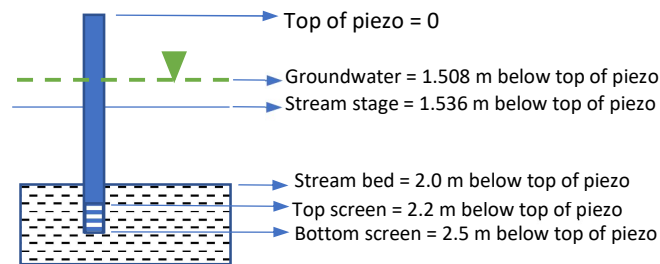
Site 6		1.597	1.691
Site 7 (downstream)	dry	-	-

Site 5 and Site 7 are approximately 1.4 km apart along Foxes Creek. Based on this information, the approximate stream bed conductance is around 2 m/d. However, there is some uncertainty around this value because identifying the exact location where the stream was dry was not clear, and the length of the reach may have been closer to around 1.1 km. Therefore, the effective reach may be shorter, which would result in a slightly higher stream bed conductance value of around 2.7 m/d.

This value of stream bed conductance is generally consistent with the strata observed in the test pit, where lower permeability clays and fine sands were encountered over more gravelly strata.

Unnamed stream

Figure 3 shows the sites on the Unnamed Stream, where groundwater levels and the stream stage were measured, as well as the stream gauging sites. Groundwater levels were measured in a piezometer installed directly into the stream bed, with the screened interval at a depth of 0.2 to 0.5 m below the stream bed (0.66 – 0.96 m below the water level in the stream) (see schematic below).



Flows in the unnamed stream were small, but there was a clear increase in flow rates between the upstream and downstream gauging sites. Groundwater levels were also slightly above the stream stage, which is consistent with a gaining reach. A summary of the data collected is shown in Table 2.

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Figure 3: Location of sites on the Unnamed Stream

Table 2: Summary of data from Unnamed Stream, based on measurements made on 3rd Feb 2022

Site	Flow (m ³ /s)	Stage (m from top of piezo)	Groundwater level (m from top of piezo)
Site 13 (upstream)	0.006	-	-
Site 14		1.536	1.508
Site 15 (downstream)	0.021	-	-

The length of the reach gauged was around 1.8 km, indicating a relatively high stream bed conductance of around 25 m/d. A test pit was also excavated adjacent to the stream and the strata encountered consisted of topsoils and clays to a depth of around 0.7 m beneath which were gravelly strata to a depth of 2 m. Groundwater was encountered at a depth of around 1.2 m. In general, these strata would be consistent with a relatively high stream bed conductance, where the stream is incised to a depth of around 1 m below the surrounding land surface.

However, an unnamed stream was also observed to flow into the main channel where gauging took place, which is likely to have influenced the estimates of stream bed conductance. Therefore, the stream bed conductance value from this site is likely to be overestimated.

Meadow Burn

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Fieldwork along the Meadow Burn included two stream reaches, with gauging at each end of the reach as well as piezometers installed into the stream bed at one location within each reach. **Figure 4** shows the location of the sites along the Meadow Burn.

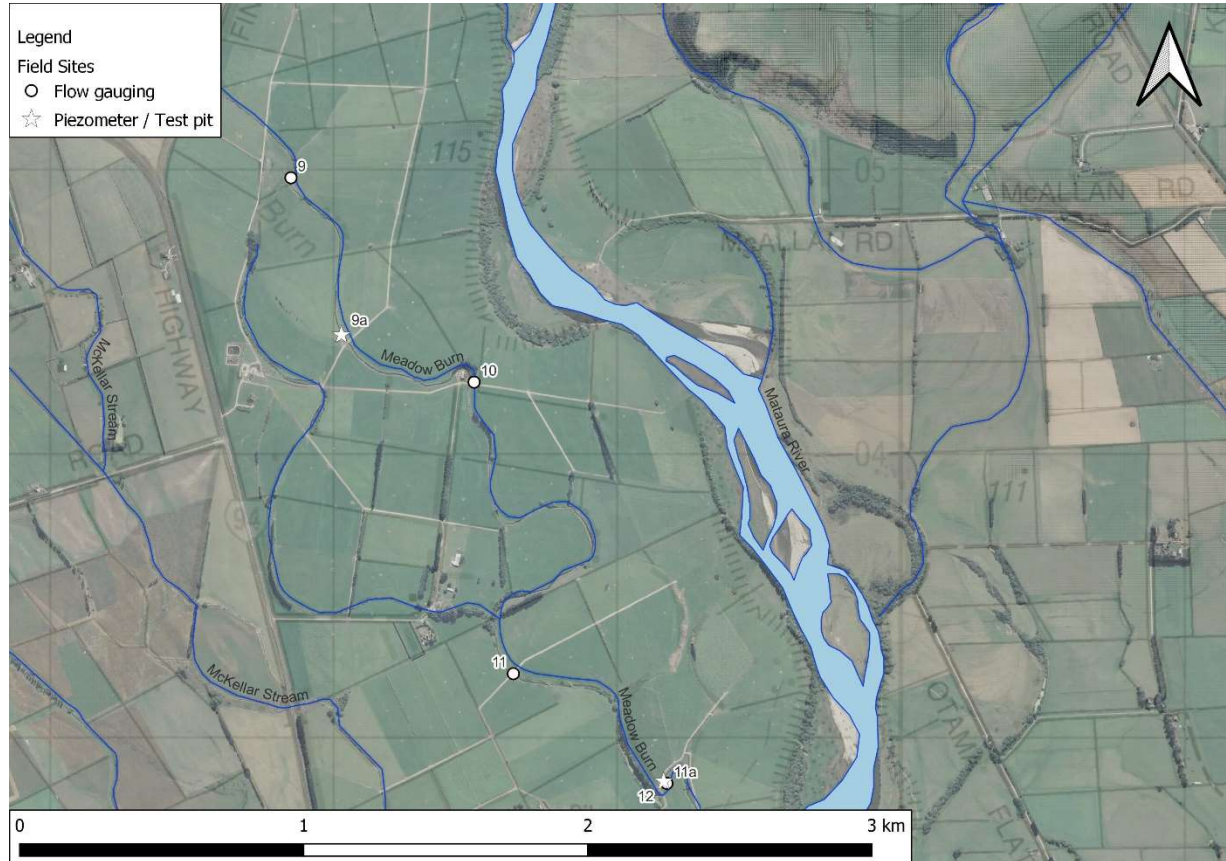
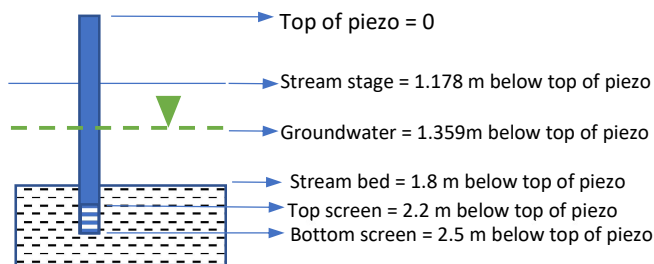
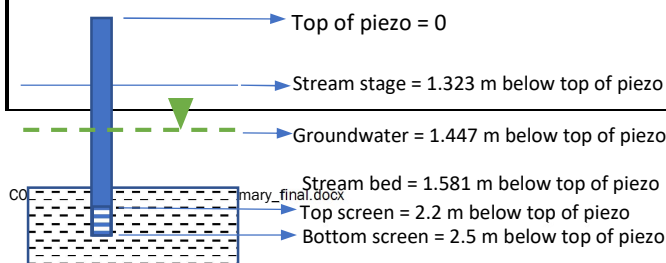


Figure 4: Location of sites along the Meadow Burn

Previous work along the Meadow Burn has shown that it gains from groundwater discharge between the source in Riversdale and its confluence with the Matakura River. Both sets of gauging carried out during the fieldwork indicated an increase in flow along the reaches that were measured. Groundwater levels were measured in piezometers installed directly into the stream bed, with the screened interval at a depth of 0.4 – 0.7 m below the stream bed (1.0 – 1.3 m below the water level in the stream) at Site 9a and a depth of 0.6 – 0.9 m below the stream bed (0.88 – 1.18 m below the water level in the stream) at Site 11a (see schematics below).



Schematic for site 9a



Schematic for site 11a

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Both the piezometers installed into the streambed showed that groundwater levels were below the elevation of the stream stage. In addition, groundwater levels measured in the test pits excavated adjacent to the river were below the stage level of the stream.

Table 3: Summary of field data from Meadow Burn, based on measurements made on 4th Feb 2022

Site	Flow (m ³ /s)	Stage (m from top of piezo)	Groundwater level (m from top of piezo)
Site 9 (upstream)	0.143		
Site 9A		1.178	1.359
Site 10 (downstream)	0.192		
Site 11 (upstream)	0.219		
Site 11A		1.323	1.447
Site 12 (downstream)	0.292		

These data are not consistent, as groundwater levels around a gaining stream would be expected to be above the stream stage level. However, it is possible that local heterogeneities mean that while the overall reaches that were measured gain flow, there are smaller sections where little groundwater – surface water exchange occurs. The test pits excavated adjacent to the streams both showed generally clay strata to a depth of 2.5 m around site 9A and clay strata to a depth of around 1.6 m around site 11A. Below the clay strata were damp gravels to a depth of around 2.3 m and 1.8 m respectively.

The clay strata may mean that this part of the stream is relatively isolated from the deeper gravel strata which are likely to carry a greater proportion of groundwater flow. Based on the depth to which the piezos were installed (see schematics above) and the description of the strata in the test pits, the piezometer may also not have fully penetrated the stream bed to the depth of the gravel strata. Together these issues may explain the lower groundwater pressures observed in the piezometers.

The discrepancies mean that a meaningful stream bed conductance value could not be calculated based on the field data collected. However, Environment Southland have previously undertaken gauging surveys on Meadow Burn, which include data that can be used to estimate stream bed conductance. The data collected by Environment Southland is from 2008 to 2009 and does not appear to have been included in the original work that was used to define stream depletion effects. Although the data is now up to 14 years old, it is still relevant and appropriate to use and we would not expect significant changes in stream bed conductance values over that time.

Details regarding the stream bed conductance calculations for the Meadow Burn based on the Environment Southland data are provided in Appendix A to this memo. In summary, 14 gauging surveys were carried out along a reach between the Fingerpost Pyramid Road Bridge and the Round Hill Road bridge, located around 3.5 to 4 km downstream (close to sites 11 and 12), with groundwater level and stream stage measurements carried out within the stream. The gauging surveys indicated a consistent gain in flow of between 200 to 300 L/s along

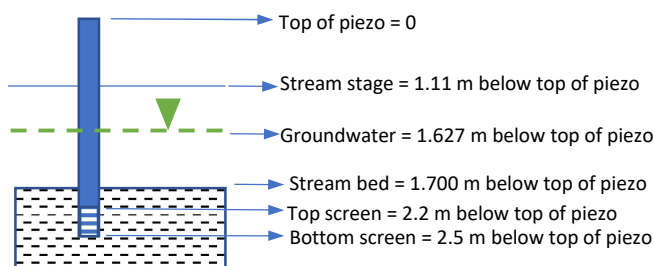
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the reach, together with groundwater levels that were consistently above the stage in the stream by around 0.1 to 0.2 m.

The results of these calculations indicate a stream bed conductance of between 18 and 92 m/d, with a median value of 48 m/d. These are relatively high values, indicating a very permeable stream bed and appear to be consistent with the values obtained from the fieldwork carried out around the unnamed stream to the north of Fingerpost Pyramid Road, as described above. The high values are also consistent with the magnitude of groundwater discharge into the Meadow Burn, despite relatively small differences in groundwater levels and stream stage elevations.

Coal Creek

Some limited flows in Coal Creek were present and a map of the gauging sites along that stream are shown in **Figure 5**. Unfortunately, the flow difference between the two sites was zero i.e., flows at both the upstream and downstream site were the same (0.001 m³/s). Groundwater levels were measured in a piezometer installed directly into the stream bed, with the screened interval at a depth of 0.5 – 0.8 m below the stream bed (1.09 – 1.39 m below the water level in the stream).



Measurements in these piezometers show that groundwater levels were notably below the elevation of the stream stage (i.e. around 0.5 m deeper), which suggests that the stream may generally lose along that reach.

The strata encountered in the test pit excavated adjacent to the piezometer indicated clay to a depth of around 0.7 m, with deeper strata consisting of gravels with some clay to a depth of around 1.9 m bgl. Groundwater was encountered in the pit at a depth of around 1.4 m bgl.

Given the scale of flows along the reach and the depth to groundwater beneath the stream, stream bed conductance is likely to be generally relatively low, although the test pits indicates that there may be some areas that are more permeable, where the clay strata are eroded by the stream to the depth of the underlying gravelly strata..

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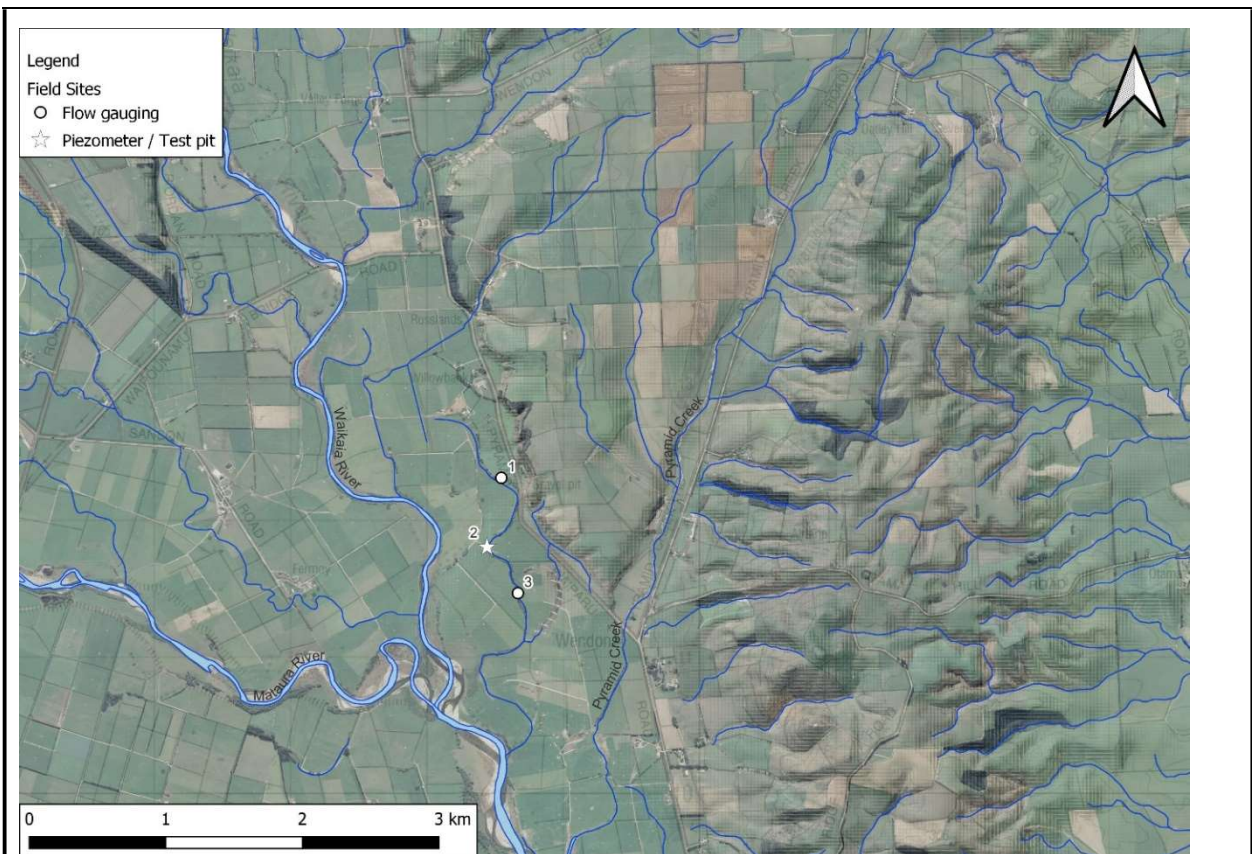


Figure 5: Location of sites along Coal Creek

Table 4: Summary of data from Coal Creek, based on measurements made on 4th Feb 2022

Site	Flow (m ³ /s)	Stage (m from top of piezo)	Groundwater level (m from top of piezo)
Site 1 (upstream)	0.001		
Site 2		1.11	1.627
Site 3 (downstream)	0.001		

Summary

Stream bed conductance values could be estimated with some confidence for the Foxes Creek and the Unnamed Stream, based on the results of the fieldwork. These indicates value of around 2 m/d for Foxes Creek and values of around 25 m/d for the Unnamed Stream.

The field data collected at the Meadow Burn sites indicates variable groundwater conditions exist beneath that waterway. Other data available for Meadow Burn collected further downstream by Environment Southland indicates that the Meadow Burn is likely to have a relatively high stream bed conductance with estimates in range of 50 m/d in that reach, although the values may vary spatially and temporally, depending on groundwater levels and the wetted width of the stream.

The data for Coal Creek and Pyramid Creek did not allow the calculation of a streambed conductance value, however the information from Coal Creek indicates that the streambed conductance is likely to be low.

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