Memorandum

To:	Andrew Guthrie	**Of:**	Ashburton District Council
From:	Irene Setiawan	**Date:**	13 June 2025
Reviewed by:	Ross Hector and Andrew Dark	**Job no:**	AQ25243
Subject:	**Mt Harding Creek Water Balance - Investigation**		

1 Introduction

Ashburton District Council (ADC) is considering the closure of the Pudding Hill and Methven Auxiliary intakes, which supply water to several branches of stock water races in the area and contribute to the Mt Harding Creek system. Ecological assessments have raised concerns about the potential reduction in downstream flow volume in Mt Harding Creek as a result of these closures.

The purpose of this project is to quantify, through flow gauging measurements, the inflows and outflows of Mt Harding Creek, to better understand the impacts of Pudding Hill and Methven Auxiliary intake closures on downstream flows. Additionally, the project aims to confirm or quantify flow contributions from springs along the Mt Harding Creek network.

2 Methodology

A series of concurrent flow gaugings were carried out at various points in the catchment, and the results of these were used to quantify the water balance. Details of the sites and the fieldwork are provided below.

2.1 Site Locations

The flow gauging sites and coordinates are listed in Table 1. Of the 18 proposed sites, one (Site 15) was not accessible and was not gauged (with approval from ADC). The site locations are mapped in Figure 1.

Table 1. Flow gauging sites (provided by ADC).

Location	Site No.	Waterway	Description	X (NZTM)	Y (NZTM)
Pudding Hill Intake	1	Pudding Hill Main	Immediately downstream of intake	1480919.972	5174170.726
Washpen Creek Intake	2	Washpen Creek / Mt Harding Creek	Immediately upstream of intake	1482752.023	5174533.498
	3	Pudding Hill Main	Immediately upstream of intake	1482751.496	5174512.826
Scarness Gate	4	Mt Harding Creek / Pudding Hill Main	Immediately upstream of gate	1486104.053	5173154.460
	5	Mt Harding Creek / Pudding Hill Main	Immediately downstream of gate	1486123.793	5173147.574
	6	Scarness Branch Main	Immediately downstream of gate	1486127.508	5173152.303
Methven Auxiliary Intake	7	Methven Auxiliary Main	Immediately downstream of intake	1483171.149	5168016.389
Draytons Gate	8	Mt Harding Creek / Pudding Hill Main	Immediately upstream of gate	1487993.343	5171667.085
	9	Methven Auxiliary Main	Immediately upstream of gate	1487982.986	5171649.137
	10	Mt Harding Creek / Methven Auxiliary Main	Immediately downstream of gate	1488002.643	5171637.134
	11	Methven Auxiliary East	Immediately downstream of gate	1488021.954	5171665.230
Forest Drive Gate	12	Mt Harding Creek / Methven Auxiliary Main	Immediately upstream of gate	1489844.522	5168734.825
	13	Mt Harding Creek / Methven Auxiliary Main	Immediately downstream of gate	1489884.623	5168524.187
	14	Forest Drive Main	Immediately downstream of gate	1489891.333	5168567.623
State Highway 77	15	Mt Harding Creek / Local Race	At highway culvert	Unable to access site	
End of Race	16	Mt Harding Creek / Local Race	Southern boundary Nestor Agriculture Ltd	1491302.129	5162625.255
Thompsons Track	17	Mt Harding Creek	At road culvert	1492539.150	5156354.540
State Highway 77	18	Mt Harding Creek	At highway culvert	1491711.567	5151983.841

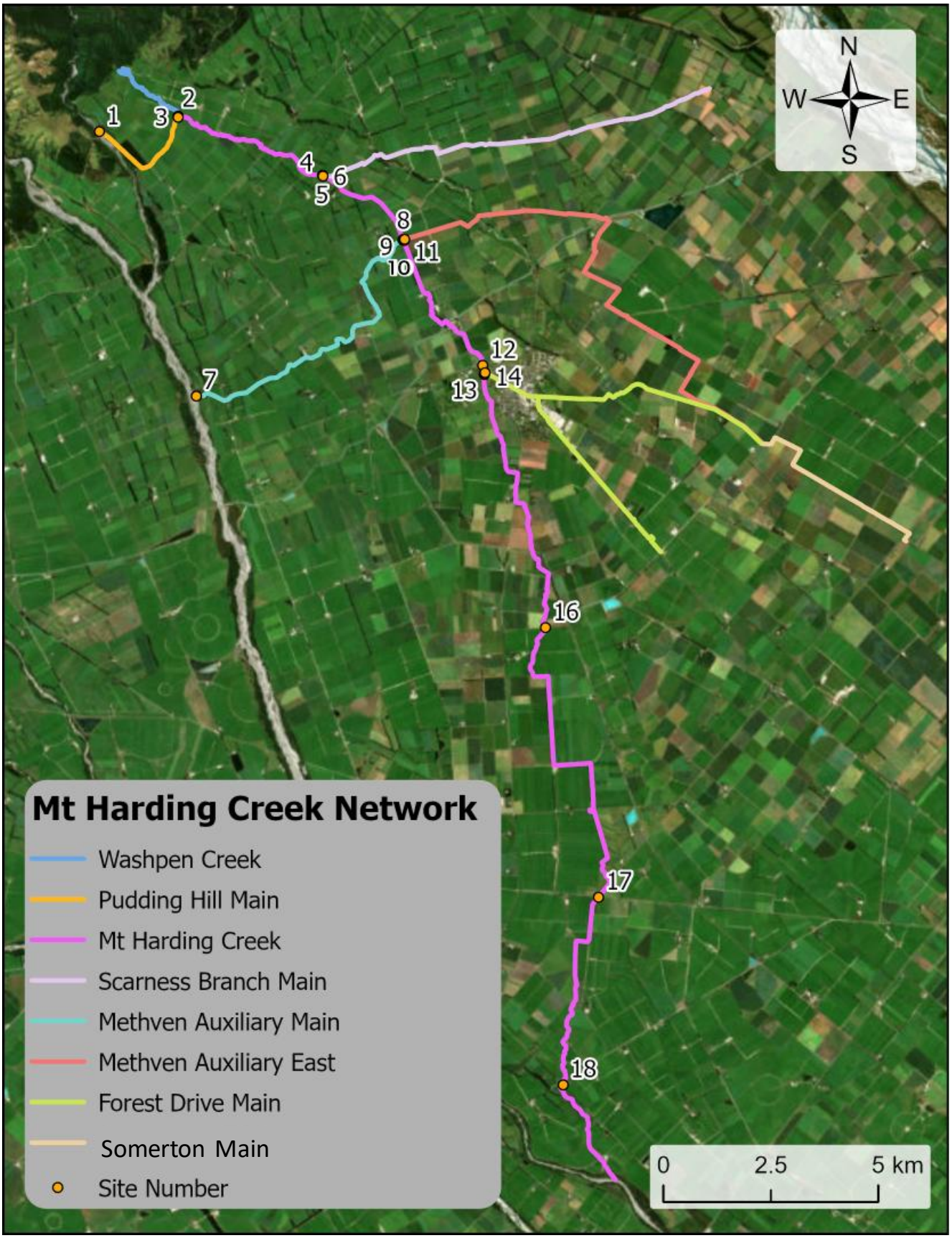

Figure 1. Site location map.

2.2 Flow Gauging Procedure

Flow gauging was carried out over three days, from 24 to 26 March 2025, during dry weather conditions. Flows were assumed to be relatively stable over this period, minimising the likelihood that timing differences between measurements would significantly affect the water balance results. Measurements were conducted in accordance with the National Environmental Monitoring Standards (NEMS Open Channel Flow Measurement V1.1, 2013) to the greatest extent practicable. Flow was measured using a SonTek FlowTracker2 handheld Acoustic Doppler Velocimeter (ADV) and calculated using the mean-section method. Site and channel preparation, including the removal of vegetation that could interfere with flow measurements, was carried out prior to gauging.

Velocity and water column depth were recorded at a minimum of 20 points across the width of the water race or at intervals of no more than 5 cm. Velocity was recorded for 40 seconds at each point. Measurements were taken at 60% of the water column depth, except at most verticals at Site 14, where most measurements were taken at 20% of the depth. This adjustment was necessary due to significant interference from vegetation rooted in the streambed, causing skewed readings at the standard 60% depth.

2.3 Method Limitations

Although the SonTek FlowTracker2 handheld ADV has a velocity accuracy of ±1%, additional sources of error can arise due to site conditions and operator-related factors.

Site-related errors may include irregular or highly turbulent flows, uneven or rocky streambeds, and vegetation interference, all of which can affect measurement accuracy. For example, at most sites, the standard error of the velocity readings exceeded the quality control thresholds of the FlowTracker2. Operator-related errors may stem from inaccuracies in reading water column depth, adjusting the wading rod, or misaligning the probe with the flow direction.

While every effort has been made to minimise these errors, some degree of uncertainty is inevitable. To account for these potential inaccuracies, a 5% error margin is allocated to our flow gauging measurements. Going forwards in this memo, this 5% has not been removed when percentages are quoted, so these values should be considered within the context of this error margin.

The flow data represent a snapshot of a low-flow period (late summer to early autumn). Springs that appear seasonally, such as in winter, were not captured in this survey. These flow measurements provide a snapshot in time.

Flow measurements were conducted following rainfall on 23 March 2025, which initially caused intake flows to rise before declining over the gauging period. This change in intake flows posed a limitation for assessing gains from and losses to groundwater, as the variability reduced the ability to isolate flow changes attributable solely to groundwater interactions. The impact of intake flow changes is considered further in Section 3.1.3.

3 Results and Discussion

3.1 Water Balance Analysis

The gauged flow measurements in the Mt Harding Creek Network are presented as a schematic diagram in Figure 2, with each colour representing a different waterway, as listed in Table 1. It is assumed that observed changes in flow are attributable to gains from or losses to groundwater. Flow changes of greater than 5% (i.e., above the estimated error margin) were identified as groundwater losses or gains (Figure 2). Detailed flow measurement data for each site can be found in Appendix A. Raw FlowTracker2 data are available upon request.

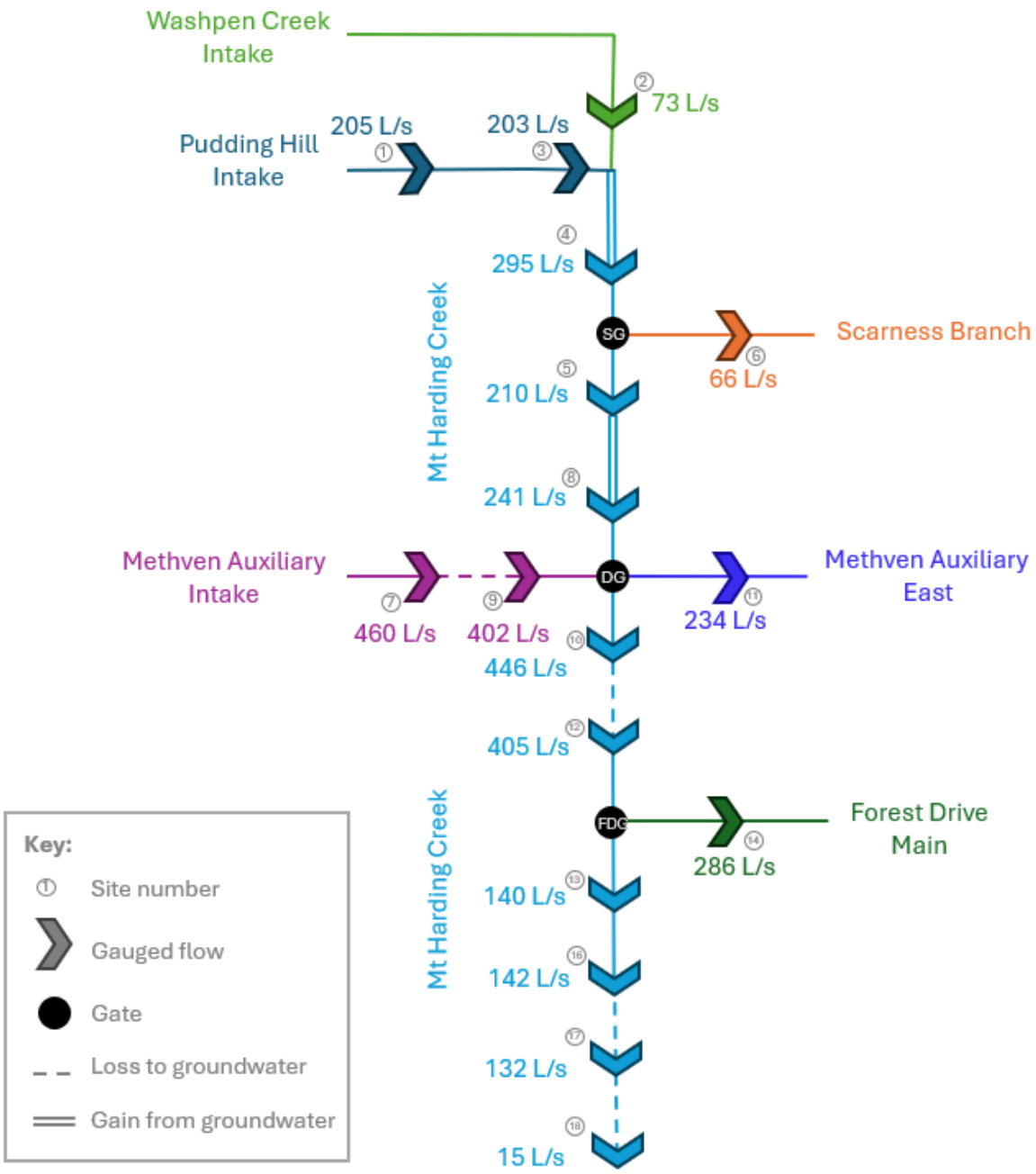

Figure 2. Flow gauging schematic diagram of the Mt Harding Creek network (SG = Scarness Gate, DG = Draytons Gate, and FDG = Forest Drive Gate).

3.1.1 Gains From and Losses to Groundwater

Flows in Pudding Hill Main between Site 1 and Site 3 were stable, with less than a 1% difference observed. As such, no significant spring inflows or groundwater losses were identified along this reach. Approximately half of this reach is concrete lined, reducing the opportunity for groundwater-surface water interaction, and potentially contributing to the lack of identified inflows or losses.

Flow increases that suggest gains from groundwater were observed at the following locations along Mt Harding Creek:

- An increase of 19 L/s (7%) between the Washpen Creek Intake (Site 3) and Scarness Gate (Site 4)
- An increase of 31 L/s (15%) between Scarness Gate (Site 5) and Draytons Gate (Site 8)

A decrease of 58 L/s (13%) in flow was observed in the Methven Auxiliary Main between the location immediately downstream of the intake (Site 7) and the point just upstream of Draytons Gate (Site 9). This reduction suggests a loss to groundwater along this reach.

Flow decreases indicating groundwater losses were observed at the following locations along Mt Harding Creek, all downstream of Draytons Gate:

- A decrease of 41 L/s (9%) between Draytons Gate (Site 10) and Forest Drive Gate (Site 12)
- A decrease of 10 L/s (7%) between the end of race at Nestor Agriculture Ltd (Site 16) and Thompsons Track (Site 17)
- A significant decrease of 117 L/s (89%) between Thompsons Track (Site 17) and State Highway 77 (Site 18), assuming no branching of the creek occurs between these sites, as this section lies beyond the ADC water race system.

At each of the three gates there are small discrepancies in flow, with the inflow not equivalent to the outflow (Table 2). When the difference is calculated as a percentage of the inflow, it is apparent that this can be primarily attributed to the 5% margin of error. Any additional difference is minor but could be attributed to further measurement error, or minor losses/gains around the gate associated with the infrastructure.

Table 2: Summary of flow differences around each gate

Flow	Scarness Gate	Draytons Gate	Forest Drive Gate
In (L/s)	295	643	405
Out (L/s)	276	680	426
Difference (L/s)	-19 (6.4%)	+37 (5.8 %)	+21 (4.6 %)

3.1.2 Intake Flows

During the flow gauging period, flows at the intakes showed a decreasing trend (see Figure 4 to Figure 6 in Appendix B) based on ADC's recorder data. While flows at the Pudding Hill and Methven Auxiliary intakes were highly turbulent, conditions at the Washpen Creek intake were comparatively smoother.

Notably, discrepancies were observed between the measured flows and the ADC recorder flows at both Pudding Hill Intake (Site 1) and Methven Auxiliary Intake (Site 7). These discrepancies are consistent with those identified in the flume re-verification assessment conducted by Aqualinc in 2024[1].

3.1.3 Impact of Intake Flow Changes During the Gauging Period

An assessment was carried out to determine whether the observed reduction in flow was attributable to declining intake flows or loss to groundwater, taking into account the travel time from the intakes to the downstream sites. The average flow velocity between sites was used to estimate the travel time from the intakes to each gauging location. Based on this travel time, the average intake flow expected to have reached the site during the gauging period was calculated based on ADC's recorder data. It is noted that this is an approximation, and the associated uncertainty or potential error in the calculation was not quantified.

As an example, the 9% flow reduction in Mt Harding Creek between Draytons Gate (Site 10) and Forest Drive Gate (Site 12) was assessed. The two sites were measured within 5 hours of each other. Taking into account the travel time from the intakes to the gates, the estimated total intake flow was approximately 660 L/s at Site 10 and 665 L/s at Site 12 at the time of gauging. This indicates a 5 L/s increase in intake flow over the period, despite the overall downward trend in flows due to fluctuations. The fact that a 9% reduction in measured flow occurred despite the estimated increase in intake flow provides greater confidence that the reduction is due to loss to groundwater along this reach.

Another example is the 15% flow increase observed in Mt Harding Creek between Scarness Gate (Site 5) and Draytons Gate (Site 8). These sites were gauged approximately 17 hours apart, during which time the total estimated intake flow decreased by 29 L/s. Despite this reduction in intake flow, an increase in measured flow was recorded between the two sites, providing stronger evidence of gain from groundwater along this reach.

3.2 Post-Closure Scenario

By adjusting components of the measured water balance, we have investigated a post-closure scenario. In this scenario, the Pudding Hill and Methven Auxiliary intakes are closed, while the Washpen Creek intake remains open. As a natural stream fed by rainfall runoff and springs, Washpen Creek becomes the sole source of flow to the Mt Harding Creek system under this configuration.

Flow contributions from the Pudding Hill and Methven Auxiliary intakes were removed from the water balance. Additionally, flows that would have been diverted into the three branches (Scarness Branch, Methven Auxiliary East, and Forest Drive Main) instead remained in Mt Harding Creek, to simulate the closure of these branches.

The modelled flow schematic under the post-closure scenario is presented alongside the measured flow gauging, in Figure 3. The results show that the Pudding Hill Main and Methven Auxiliary Main are dry, and there is reduced flow in the main Mt Harding Creek channel. However, the closure of the three branches out of Mt Harding Creek helped partially offset the impact of the intake closures by increasing flow in the main channel.

The percentage change from the measured flow gauging, that is expected under low flow conditions, after the closure of the Pudding Hill and Methven Auxiliary intakes, is displayed in Figure 3 at each gauging location along Mt Harding Creek. Within the Mt Harding Creek channel of the ADC race system (up to Site 16), the largest flow reduction was observed upstream of the Forest Drive Gate (Site 12), with a decrease of 365 L/s (90%). At the most downstream location, i.e., State Highway 77 (Site 18), the model showed a complete cessation of flow.

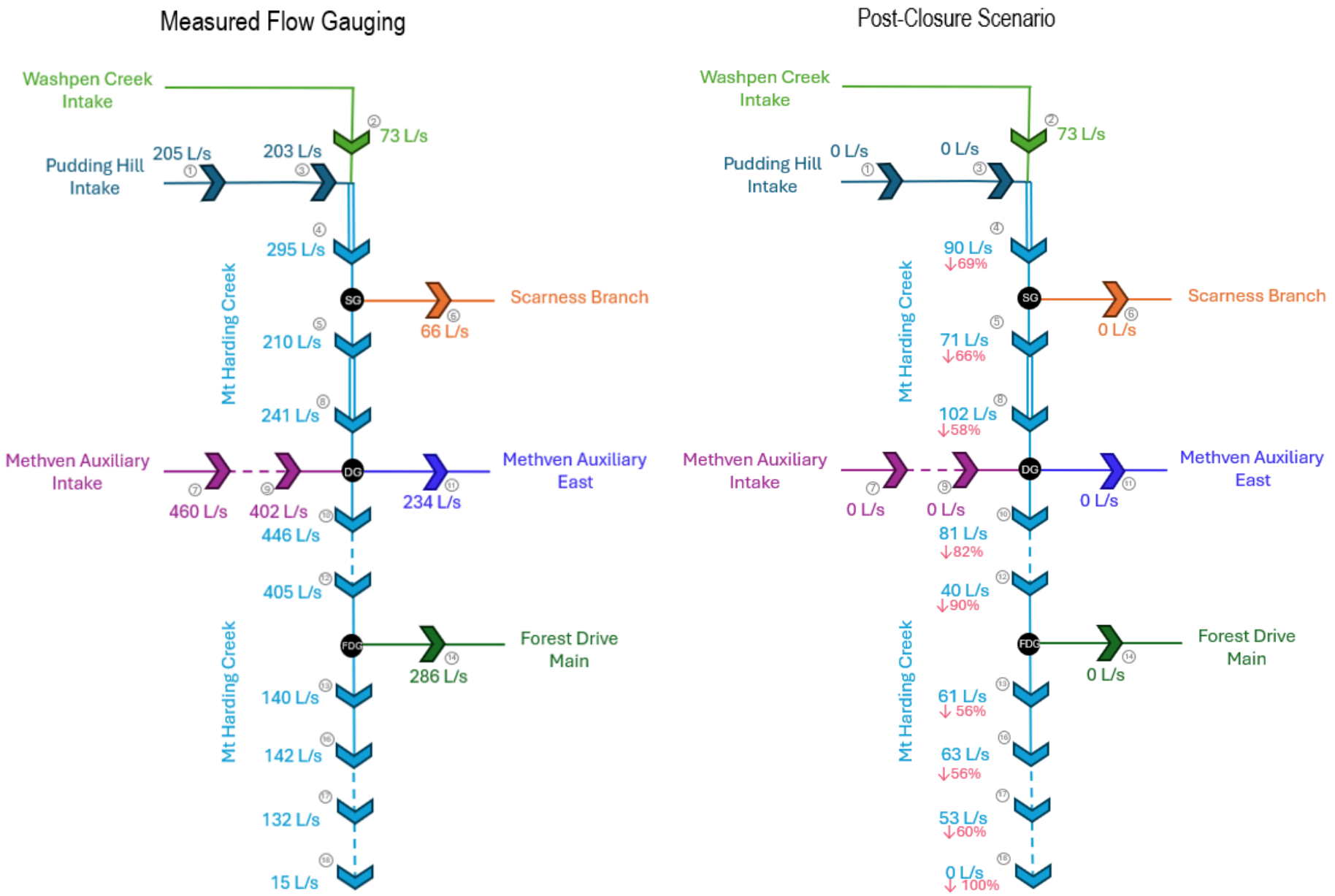

Figure 3. Measured flow gauging scematic (left) and modelled flow of the Mt Harding Creek Network under the post-closure scenario (right).

4 Conclusions

Flow gauging was conducted to assess the inflows and outflows of Mt Harding Creek, including contributions from springs to the channel, in anticipation of the closure of the Pudding Hill and Methven Auxiliary intakes. The gauging took place from 24 to 26 March 2025 at 17 sites along the Mt Harding Creek network, providing data representative of a low-flow period.

The intakes sourced from rivers provided the primary inflow to Mt Harding Creek, with Methven Auxiliary providing the largest contribution at 460 L/s, followed by Pudding Hill at 205 L/s. Washpen Creek, sourced from springs and rainfall runoff, provided the third-largest inflow at 73 L/s. It is assumed that the observed changes in flow along the waterways were caused by gains from or losses to groundwater. Gains from groundwater (springs) were detected upstream of Draytons Gate, totalling 50 L/s, while losses to groundwater were observed downstream of Draytons Gate, amounting to 168 L/s. Intake flows showed a decreasing trend throughout the gauging period.

If the Pudding Hill and Methven Auxiliary intakes are closed, Washpen Creek will become the sole source of flow into the Mt Harding Creek network, supplemented by any springs along the creek. It is assumed that the three branches (Scarness Branch, Methven Auxiliary East, and Forest Drive Main) will also be closed, with no flow directed into these branches from the main channel of Mt Harding Creek. Post-closure scenario modelling indicates a significant decrease in flow to the system, with both Pudding Hill Main and Methven Auxiliary Main becoming dry, and a flow reduction of up to 365 L/s (90%) at one location observed within the main Mt Harding Creek channel. A comprehensive post-closure scenario modelling and assessment of groundwater-stream interactions will be conducted in Phase 2 of the Mt Harding Creek Water Balance study.

Appendix A – Flow Gauging Data

Location	Site No.	Waterway	Date	Start Time (NZDT)	End Time (NZDT)	Total Discharge (L/s)	Mean Depth (m)	Mean Velocity (m/s)	Total Width (m)	Total Area (m^2)	Mean Temp (°C)
Pudding Hill Intake	1	Pudding Hill Main	24/03/25	10:31	11:32	205	0.255	0.341	2.36	0.602	10.257
Washpen Creek Intake	2	Mt Harding Creek	24/03/25	14:24	15:04	73	0.165	0.353	1.25	0.206	13.452
	3	Pudding Hill Main	24/03/25	12:41	13:39	203	0.243	0.439	1.9	0.462	11.45
Scarness Gate	4	Mt Harding Creek / Pudding Hill Main	24/03/25	15:54	16:35	295	0.282	0.312	3.35	0.945	12.725
	5	Mt Harding Creek / Pudding Hill Main	24/03/25	17:59	18:30	210	0.263	0.569	1.4	0.368	12.742
	6	Scarness Branch Main	24/03/25	16:51	17:45	66	0.095	0.501	1.39	0.133	12.658
Methven Auxiliary Intake	7	Methven Auxiliary Main	25/03/25	8:57	9:45	460	0.252	0.701	2.6	0.656	11.458
Draytons Gate	8	Mt Harding Creek / Pudding Hill Main	25/03/25	10:34	11:18	241	0.197	0.818	1.5	0.295	11.585
	9	Methven Auxiliary Main	25/03/25	11:56	12:55	402	0.496	0.285	2.85	1.413	13.207
	10	Mt Harding Creek / Methven Auxiliary Main	25/03/25	13:47	14:37	446	0.197	0.871	2.6	0.512	14.257
	11	Methven Auxiliary East	25/03/25	14:56	15:34	234	0.224	0.51	2.04	0.458	13.223
Forest Drive Gate	12	Mt Harding Creek / Methven Auxiliary Main	25/03/25	18:10	18:53	405	0.418	0.293	3.3	1.381	14.855
	13	Mt Harding Creek / Methven Auxiliary Main	26/03/25	8:39	9:20	140	0.303	0.375	1.23	0.373	12.61
	14	Forest Drive Main	25/03/25	16:27	17:40	286	0.38	0.289	2.61	0.992	15
State Highway 77	15	Mt Harding Creek / Local Race	Not recorded								
End of Race	16	Mt Harding Creek / Local Race	26/03/25	13:48	14:27	142	0.26	0.293	1.87	0.485	15.273
Thompsons Track	17	Mt Harding Creek	26/03/25	10:19	11:03	132	0.165	0.467	1.71	0.282	13.319
State Highway 77	18	Mt Harding Creek	26/03/25	11:48	12:17	15	0.126	0.127	0.95	0.12	13.878

Appendix B – Flow at Intakes

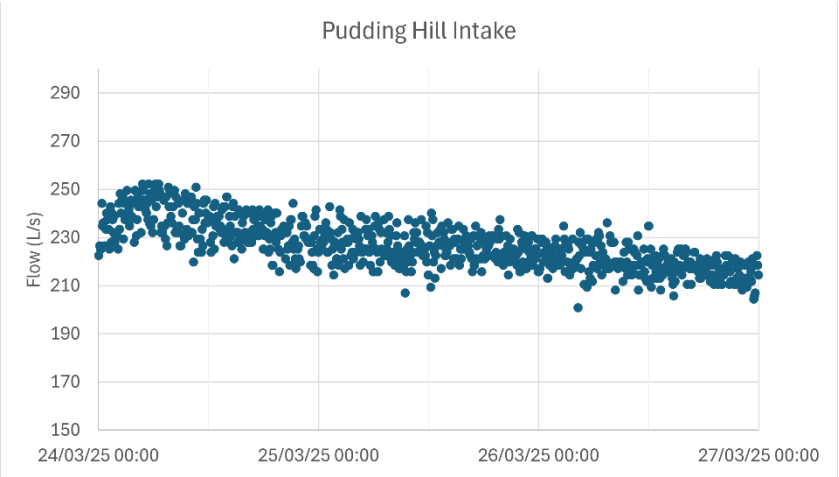

Figure 4. Flow at Pudding Hill Intake.

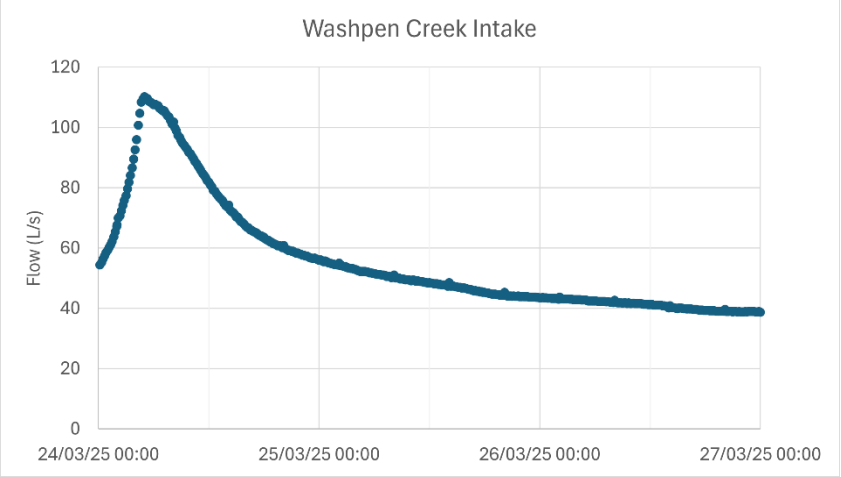

Figure 5. Flow at Washpen Creek Intake.

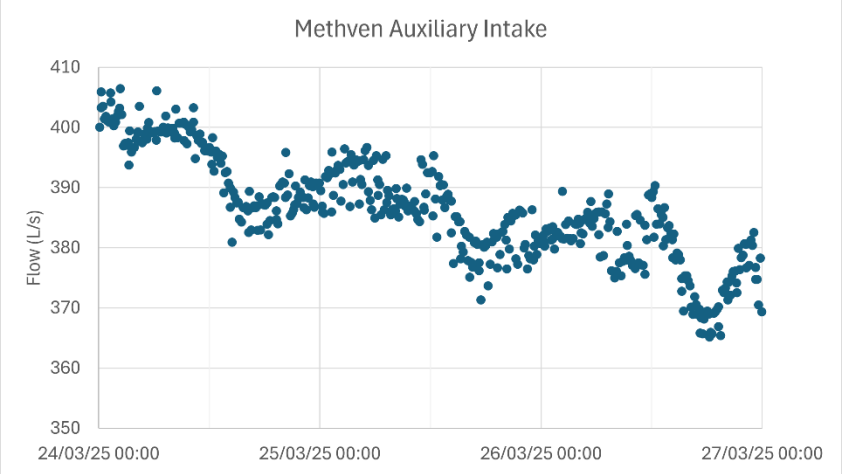

Figure 6. Flow at Methven Auxiliary Intake.