



SEQUANA
PARTNERS

Goulburn Hydrometric Network Upgrades Report

Stage 1A (Feasibility Study) of the Victorian Constraints Measures
Program

Prepared for: DELWP

Date: 22 December 2022

Acknowledgement

Sequana acknowledges the Traditional Owners of Country throughout Australia and pays respect to and recognises the contribution from their Elders past and present.

Front Cover Photo Credit

Use of front cover photography is under licence from Wayne Quilliam, Aboriginal Photography.
Permission must be sought from Aboriginal Photography for hard copy publication of image.



Stage 1A (Feasibility Study) of the Victorian Constraints Measures Program

Revision control

| Issue | Author | Reviewed | Approved | Signature |
|--------------|------------------|-----------------------------------|----------------|-----------|
| Final/Issued | Stephen Campbell | Daniel Freitag Hannah Walmsley | Frank Fisseler | |

Disclaimer

This report is not intended to be used by anyone other than the DELWP. Other parties can only rely on the report if Sequana Partners is notified and agrees.

We prepared this report solely for DELWP’s use and benefit in accordance with and for the purpose set out in our contract and agreed scope of work with DELWP in December 2021. In doing so, we acted exclusively for DELWP and considered no-one else’s interests.

We accept no responsibility, duty, or liability:

- to anyone other than DELWP in connection with this report
- to DELWP for the consequences of using or relying on it for a purpose other than that referred to above.
- We make no representation concerning the appropriateness of this report for anyone other than DELWP. If anyone other than DELWP chooses to use or rely on it they do so at their own risk.

This disclaimer applies:

- to the maximum extent permitted by law and, without limitation, to liability arising in negligence or under statute; and even if we consent to anyone other than DELWP receiving or using this report. The information, statements, statistics and commentary (together the ‘Information’) contained in this Report have been prepared by Sequana Partners from publicly available material and from discussions held with stakeholders.

Sequana Partners does not express an opinion as to the accuracy or completeness of the information provided, the assumptions made by the parties that provided the information or any conclusions reached by those parties.

Sequana Partners have based this Report on information received or obtained, on the basis that such information is accurate and, where it is represented to Sequana Partners as such, complete. The Information contained in this Report has not been subject to an audit

Executive Summary

The purpose of this report is to provide an overview of the process undertaken by Sequana Partners to establish the site locations for the Hydrometric Network Upgrades as part of the Victorian Constraints Measures Program.

The site locations for the upgrade works are shown in Table 1 below.

Table 1 Final list of streamflow and rainfall gauges installed as part of Stage 1A of the Victorian CMP

| No. | Site | Type | Latitude | Longitude |
|-----|---|-----------------------------|----------|-----------|
| 1 | Goulburn River at Molesworth | Streamflow & Rainfall Gauge | -37.1651 | 145.5438 |
| 2 | Yea River confluence with Goulburn River | Streamflow & Rainfall Gauge | -37.2101 | 145.4130 |
| 3 | King Parrot Creek confluence with the Goulburn River | Streamflow & Rainfall Gauge | -37.1731 | 145.2523 |
| 4 | Major Creek upper catchment | Rainfall Gauge | -36.9708 | 144.7946 |
| 5 | Dabyminga Creek & King Parrot Creek - Upper Catchment | Rainfall Gauge | -37.2694 | 145.2108 |
| 6 | Acheron River & Murrindindi Rivers – Upper Catchment | Rainfall Gauge | -37.3766 | 145.6213 |
| 7 | Rubicon River upper catchment | Rainfall Gauge | -37.3739 | 145.8653 |
| 8 | Rubicon River lower catchment | Rainfall Gauge | -37.2906 | 145.8275 |
| 9 | Spring Creek upper catchment | Rainfall Gauge | -37.0777 | 145.7181 |
| 10 | Murrindindi upper catchment | Rainfall Gauge | -37.4722 | 145.5661 |
| 11 | Murrindindi River at Murrindindi | Telemetry Only | -37.397 | 145.564 |

Contents

| | | |
|---|--|-----------|
| 1 | Background | 1 |
| 1.1 | Workstream 5 Objectives..... | 2 |
| 1.2 | Site Finalisation Process Overview | 2 |
| 2 | Stocktake Process – Long-list of Possible Site Locations | 3 |
| 2.1 | Streamflow Gauging | 3 |
| 2.1.1 | Priority 1a: Ungauged sections of the Goulburn River between Eildon and Trawool | 4 |
| 2.1.2 | Priority 1b: Ungauged sections of partially gauged catchments in the mid-Goulburn River between Eildon and Trawool | 4 |
| 2.1.3 | Priority 2: Ungauged unregulated tributary catchments between Eildon and Trawool | 5 |
| 2.1.4 | Priority 3: Ungauged unregulated tributary catchments between Trawool and Goulburn Weir | 7 |
| 2.1.5 | Design Standards Affecting Site Selection for Streamflow Gauging Stations | 8 |
| 2.2 | Rainfall Gauging..... | 8 |
| 3 | Short-listed Sites | 10 |
| 3.1.1 | Streamflow gauging - sites for investigation..... | 10 |
| 3.1.2 | Rainfall Gauging - sites for investigation..... | 12 |
| 3.1.3 | Telemetry Sites for Investigation..... | 12 |
| 4 | Field Investigations | 14 |
| 4.1.1 | Streamflow Gauging..... | 14 |
| 4.1.2 | Rainfall Gauging | 17 |
| 4.1.3 | Telemetry-only Upgrades..... | 17 |
| 4.2 | Sites for Detailed Investigation | 21 |
| 4.2.1 | Streamflow and rainfall gauges | 21 |
| 4.2.2 | Standalone rainfall gauges | 21 |
| 5 | Final Site Locations | 23 |
| 5.1 | Streamflow & Rainfall Gauges..... | 23 |
| 5.2 | Operations & Maintenance Funding | 25 |
| 5.3 | Deliverables..... | 25 |
| 5.4 | Approvals | 26 |
| 6 | Next steps | 28 |
| 6.1 | Gauge Station Design | 28 |
| 6.1.1 | Streamflow Gauging Station | 28 |
| 6.1.2 | Rainfall Gauging Station..... | 31 |
| 6.1.3 | Commissioning & Handover | 32 |
| Appendix A: Site Locations and Imagery | | 34 |

Figures

| | | |
|----------|---|---|
| Figure 1 | Location of Streamflow Gauging Network in the mid-Goulburn River – map shows all active gauges equipped with flow monitoring and telemetry | 1 |
| Figure 2 | Location map of ungauged sections of the King Parrot Creek and the Yea River, and the ungauged section of the Goulburn River between Eildon and Trawool | 3 |
| Figure 3 | Illustrative streamflow gauging options for the Yea River, King Parrot Creek and ungauged section of the Goulburn between Eildon and Trawool | 5 |
| Figure 4 | Location map of larger ungauged unregulated tributary catchments between Eildon and Trawool | 6 |
| Figure 5 | Location map of larger ungauged unregulated tributary catchments between Trawool and Goulburn Weir | 7 |

| | |
|--|----|
| Figure 6 Location of streamflow gauges not equipped with rainfall measurement | 8 |
| Figure 7 Schematic of existing hydrometric sites in mid-Goulburn | 9 |
| Figure 8 Location map depicting streamflow gauging sites shortlisted for investigation | 11 |
| Figure 9 Location map depicting rainfall gauging sites for investigation..... | 13 |
| Figure 10 Overview map of final shortlist of streamflow and rainfall gauging sites for detailed investigations | 22 |
| Figure 11 Overview map of final streamflow and rainfall gauging sites to be installed | 24 |
| Figure 12 Schematic of a bubbler type streamflow gauging station | 28 |
| Figure 13 gauge plate with backing board | 29 |
| Figure 14 Endless Wire..... | 30 |
| Figure 15 Staff Gauges with backing plates | 31 |
| Figure 16 Rain gauge installation at Strathbogie Ranges | 32 |
| Figure 17 Location Map & Site Photo - 1. Goulburn River at Molesworth: Streamflow Gauge | 34 |
| Figure 18 Location Map & Site Photo - 2. Yea River confluence with Goulburn River: Streamflow and Rainfall gauges | 35 |
| Figure 19 Location Map & Site Photo - 3. King Parrot Creek at confluence with the Goulburn River: Streamflow and Rainfall gauges | 36 |
| Figure 20 Location Map & Site Photo - 4. Major Creek Upper Catchment: Rainfall gauge..... | 37 |
| Figure 21 Location Map & Site Photo - 5. Dabyminga and King Parrot Creek Upper Catchment: Rainfall gauge..... | 38 |
| Figure 22 Location Map & Site Photo - 6. Acheron River and Murrindindi River Upper Catchment: Rainfall gauge..... | 39 |
| Figure 23 Location Map & Aerial Map - 7. Rubicon River Upper Catchment: Rainfall gauge | 40 |
| Figure 24 Location Map - 8. Rubicon River Lower Catchment: Rainfall gauge | 41 |
| Figure 25 Location Map - 9. Spring Creek Upper Catchment: Rainfall gauge | 42 |
| Figure 26 Location Map - 10. Murrindindi Upper Catchment: Rainfall gauge..... | 43 |
| Figure 27 Location Map - 11. Murrindindi River at Murrindindi: Telemetry Only | 44 |

Tables

| | |
|---|-----|
| Table 1 Final list of streamflow and rainfall gauges installed as part of Stage 1A of the Victorian CMP..... | iii |
| Table 2 Shortlist of streamflow gauging sites, for field investigation | 10 |
| Table 3 Rainfall gauging sites for investigation | 12 |
| Table 4 Site investigation results - Streamflow Gauging | 14 |
| Table 5 Site investigation results - Rainfall Gauging | 18 |
| Table 6 Final list of streamflow and rainfall gauges to be installed as part of Stage 1A of the Victorian CMP | 23 |
| Table 7 Workstream 5 - Stage 1A Deliverables and final scope | 25 |
| Table 8 Hydrometric Network Site Approval Requirements | 26 |

1 Background

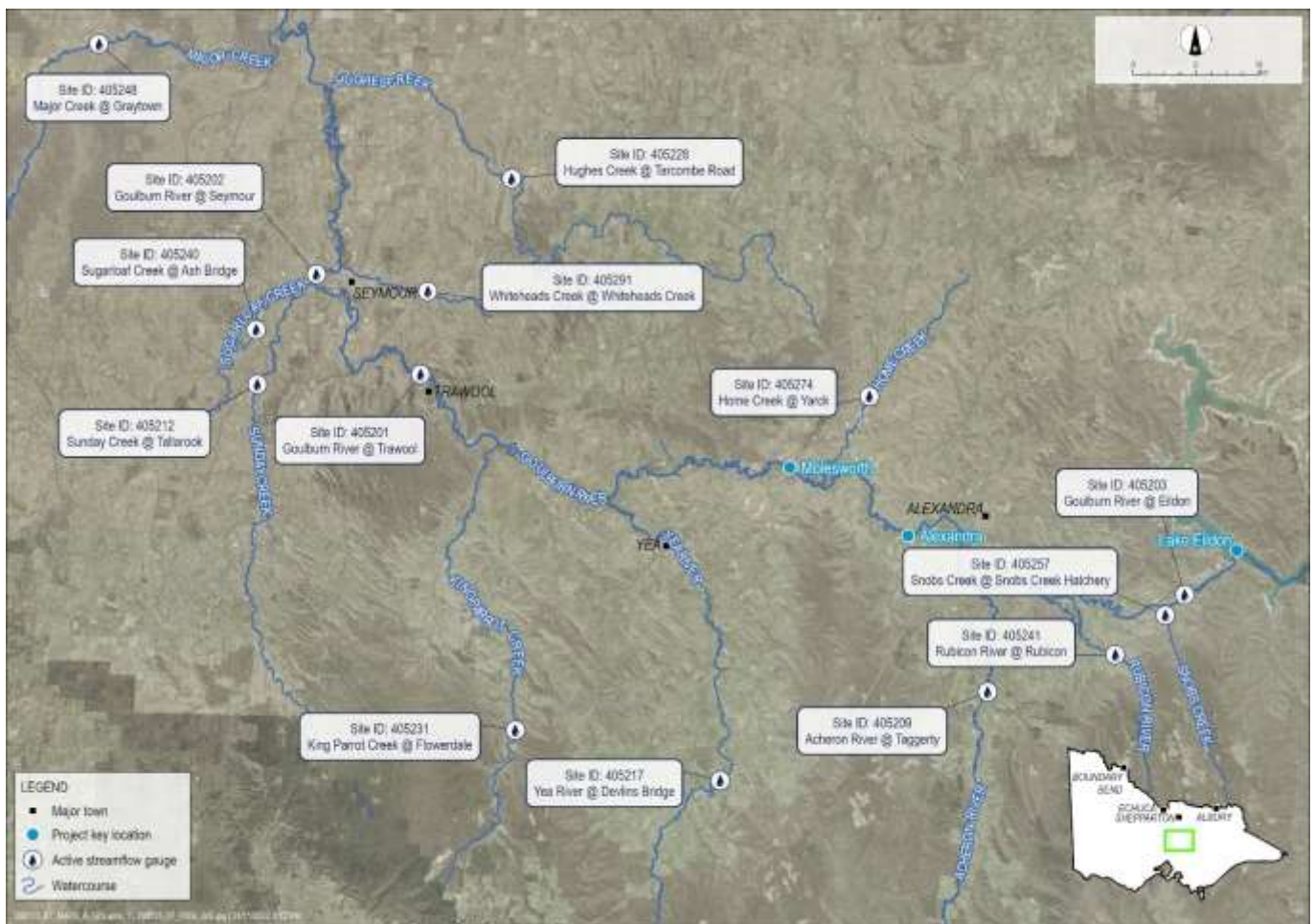
The 2017 Goulburn Constraints Measures Business Case identified a requirement for the expansion of the rainfall monitoring and stream gauging (hydrometric) network in the mid-Goulburn (from Eildon to Goulburn Weir) to provide data for decision making and operations of relaxed constraints managed environmental flows.

The business case also emphasises that the monitoring upgrades need to be installed as soon as possible to provide data to improve understanding and forecasting of tributary flows and support development of operating arrangements¹.

The relevant Commonwealth and State departments have agreed to the Stage 1A program of works to implement key elements of the Goulburn Constraints Measures project. In accordance with the business case, the program of works includes the upgrade of the hydrometric monitoring network in the mid-Goulburn.

Sequana Partners was engaged by DELWP to deliver Stage 1A of the Victorian Constraints Measures Program. One of the workstreams being delivered is the installation of new rainfall and streamflow gauges in the mid-Goulburn catchment (Workstream 5). The objective of installing new gauging sites is to assist in the operation of relaxed constraints environmental watering actions in the Goulburn system by providing an improved level of information for rainfall and streamflow data and forecasting.

Figure 1 Location of Streamflow Gauging Network in the mid-Goulburn River – map shows all active gauges equipped with flow monitoring and telemetry



¹ DELWP (2017), New Goulburn Constraints Measures Business Case

1.1 Workstream 5 Objectives

The provision of timely information on rainfall and unregulated stream flows to river operators and environmental water managers will be key to the delivery of environmental watering actions, including those which may be made possible by constraints relaxation.

Within the mid-Goulburn catchment, which generates a significant portion of the run-off into the Goulburn River downstream of Eildon, there are gaps in the coverage of the unregulated stream flow and rainfall monitoring network. Approximately 57% of the catchment is not gauged with streamflow monitoring. Additionally, the density of rainfall monitoring in the mid-Goulburn is around one monitoring site per 400 km², as compared with optimal recommendations of around one gauging site per 25 km².

This workstream aims to address the gaps in the hydrometric network within the mid-Goulburn system early in the project development. The installation of these new sites and operation over several years will provide important information for the calibration of rainfall run-off and streamflow forecasting models, as well as supporting the ongoing management of river operations.

1.2 Site Finalisation Process Overview

The below outlines the process undertaken to finalise the Hydrometric Network Site Locations:

1. Develop a long-list of possible site locations for upgrade works (Section 2 of this report).
2. Refine a short-list of sites to be further investigated (Section 3).
3. Undertake field investigations for each short-listed site (Section 4).
4. Confirm the final locations and specifications for upgrade works (Section 5).

The scope of works for Stage 1A of the Victorian Constraints Measures Program only relates to upgrading the existing network. It is important to note that the development of an improved operational management tool for river operators has been identified as a key mitigation measure needed to manage environmental water releases, including under relaxed constraint scenarios. The development of this tool is being managed separate to this project.

2 Stocktake Process – Long-list of Possible Site Locations

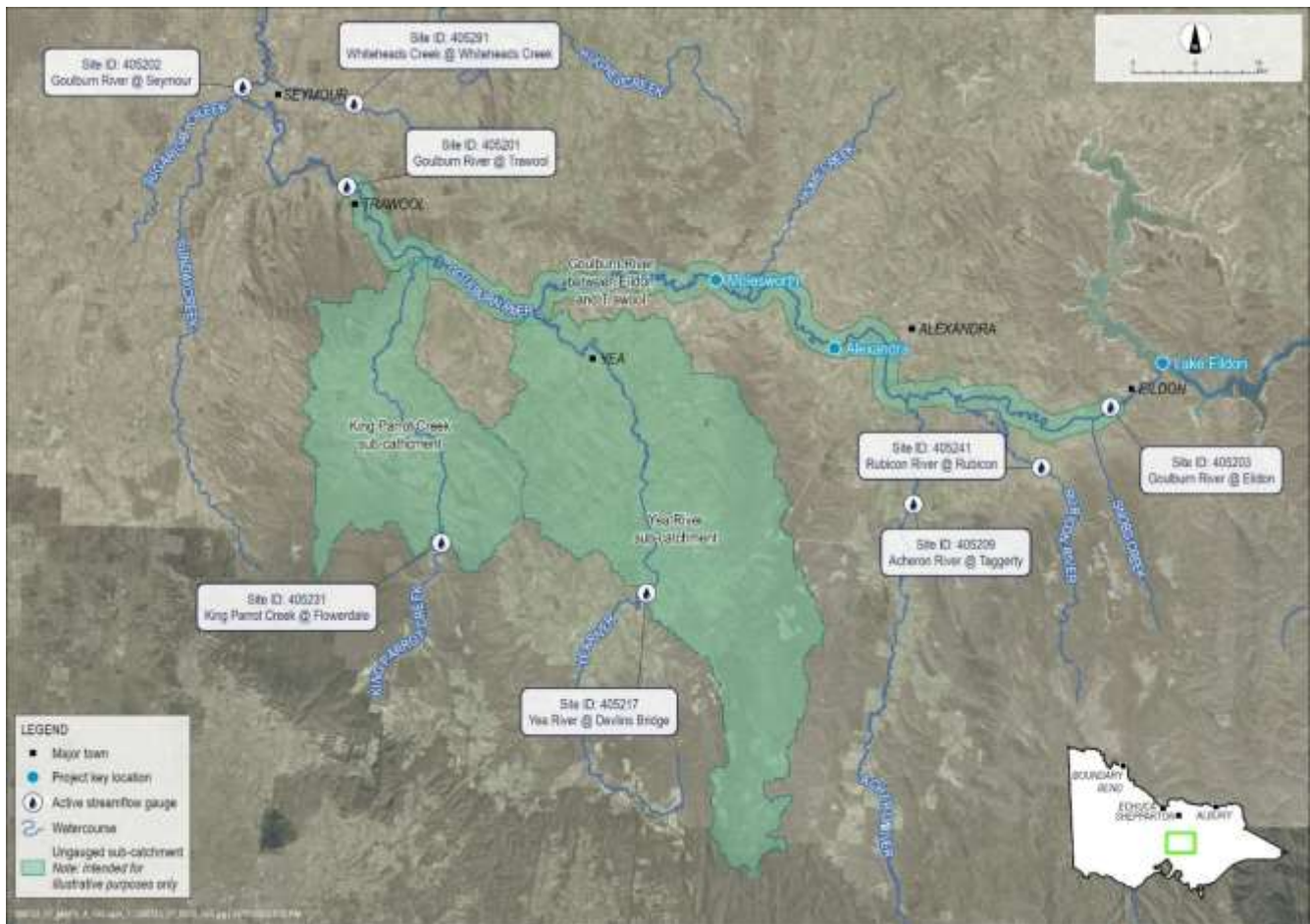
While the Goulburn constraints measures program business case identified the requirement for upgrades to the hydrometric network in the mid-Goulburn, it did not define the locations or specifications for the works. Sequana undertook a preliminary assessment of potential sites for the upgrade of the rainfall and streamflow gauging network as part of the stocktake for Stage 1A of the Victorian Constraints Program. The preliminary assessment drew upon:

- publicly available data on existing streamflow and rainfall gauges, including from the Water Measurement Information System (WMIS) website and the BOM webpages.
- recommendations for hydrometric network upgrade works as discussed in the original Goulburn business case (GBCMA, 2016), the new Goulburn business case (DELWP, 2017) and other related documentation available on the GBCMA and MDBA websites.
- discussions with relevant officers from the Goulburn Broken Catchment Management Authority (GBCMA), Goulburn-Murray Water (GMW), the Bureau of Meteorology (BOM), and the Department of Environment, Land, Water and Planning (DELWP).

2.1 Streamflow Gauging

An initial desktop assessment was undertaken to inform discussions with Government stakeholders around the existing coverage of streamflow gauges across the catchment and identify potential locations for upgrade works.

Figure 2 Location map of ungauged sections of the King Parrot Creek and the Yea River, and the ungauged section of the Goulburn River between Eildon and Trawool



2.1.1 Priority 1a: Ungauged sections of the Goulburn River between Eildon and Trawool

The south-east section of the Goulburn Valley between Eildon and Trawool is flanked by the Goulburn Gorge, characterised by mountainous terrain and steep slopes. The valley opens out downstream of Trawool where the river flows through broad alluvial plains.

According to Water Technology (2009), the unregulated tributary in the Eildon to Trawool section of the river produces a unit rate of run-off of around 2.41 ML/day/km². This is a significantly higher rate of run-off per unit area (mean daily flow (MDF) to km²) than further downstream areas due to the higher rainfall and steeper slopes and lower rates of losses of rainfall to the ground or to dams.

According to the same report, 57% of the unregulated catchment (an area of 1,948 km²) between Eildon and Trawool is ungauged.

The Goulburn River has no existing streamflow gauge for a length of 111 km between the Eildon and Trawool gauges. This is a notable gap in the streamflow gauging network, given the large area captured by the one regulated streamflow in this section of the catchment. Note that gauging the ungauged sections of the Yea River and King Parrot Creek still leaves an area of approximately 1,200 km² of ungauged catchment that could impact on streamflow within the mainstem of the Goulburn River.

The illustrative options for upgrading the network in this reach are shown in Figure 3 below. They comprise:

- **Option 1:** Install flow measurement at the existing Ghin Ghin gauge (405310). This is an active gauge and is equipped with real-time telemetry but provides water level data only. This option would upgrade the site with height vs. flow relationship (rated), including high flow measurement facilities.
- **Option 2:** Reactivate the Killingworth gauge (405329). This site last recorded data in March 2020 and is no longer active.
- **Option 3:** Install a new streamflow gauging site at Molesworth (405223). Discussions with GMW and GBCMA suggested a new site installed at Molesworth would be of significant value for river operators and water managers as storage releases are currently managed to maintain regulated flows within the banks at this location. It is noted that the 2016 business case highlighted that Molesworth is a 'choke' location in the river, where the river will break out onto the adjoining floodplain at lower flows than in other stretches of the river. Accordingly, there is community concern about the private landholder impacts in this area if constraints are relaxed. There is currently a set of gauge boards at Molesworth which are used for flood purposes only. Having a height vs. flow relationship (rating) established and real-time monitoring at Molesworth would provide more accurate data for assessing the potential impacts of relaxing constraints at this location and provide river operators and water managers with important data to inform storage releases.
- **Option 4:** Install a new flow gauging site at Alexandra. Alexandra was also identified in the business case as being an area of key community concern for constraints relaxation.

2.1.2 Priority 1b: Ungauged sections of partially gauged catchments in the mid-Goulburn River between Eildon and Trawool

The Water Technology 2009 report notes that most of the ungauged catchment area in the mid-Goulburn consists of the lower parts of the Yea and King Parrot tributaries (the area downstream of the existing gauges to the junction with the Goulburn River).

Yea River

The Yea River has a catchment area of approximately 905 km², of which 360 km² is gauged at the flow measurement point at Devlin's Bridge, leaving an area of 545 km² ungauged. The Devlin's Bridge gauge is approximately 20 km upstream of the confluence of the river with the Goulburn. A scope of works for this catchment could include either:

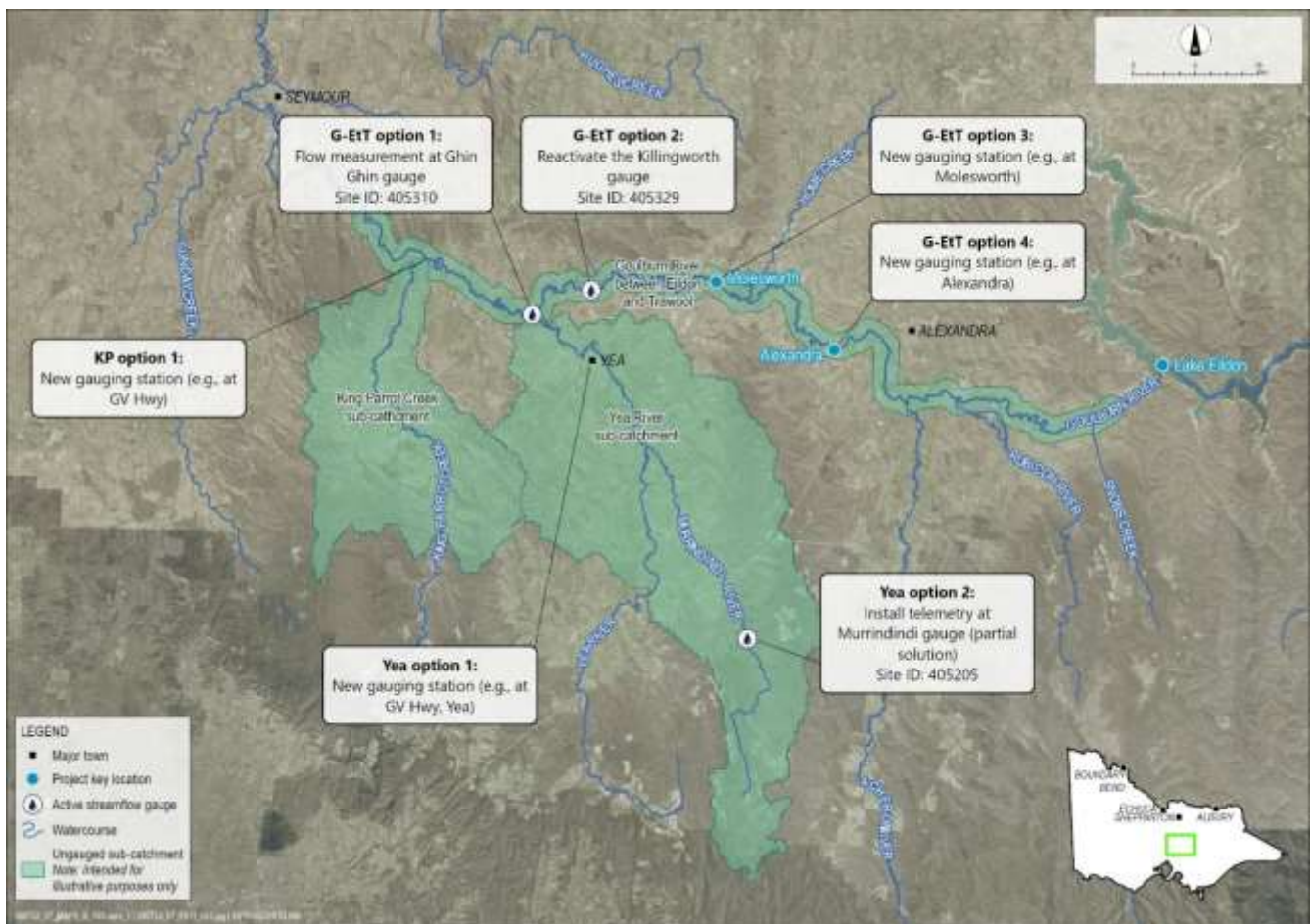
- **Option 1:** install telemetry at the existing Murrundindi gauge (405205). This gauge is active but is not equipped with telemetry and only provides data following the monthly visit. This would provide a partial solution giving real-time streamflow to the upper Murrundindi and in the river.
- **Option 2:** Install a new flow gauging site on the Yea River near the confluence with the Goulburn River. A possible site for this gauge could be downstream of the township of Yea. This would require investigations to determine if the Yea River is suitably confined downstream of the Yea township before entering the Goulburn.

King Parrot Creek

The King Parrot has a catchment area of approximately 442 km², of which 181 km² is gauged at the flow measurement point at Flowerdale, leaving an area of 261 km² ungauged. The Flowerdale gauge is approximately 25 km upstream of the confluence of the creek with the Goulburn. The potential scope of works for this catchment was to install a new flow gauging site near the confluence of the Goulburn River. A possible site this gauge could be the Goulburn Valley Highway Bridge crossing of the King Parrot Creek.

The location of the works options is illustrated in Figure 3 below.

Figure 3 Illustrative streamflow gauging options for the Yea River, King Parrot Creek and ungauged section of the Goulburn between Eildon and Trawool

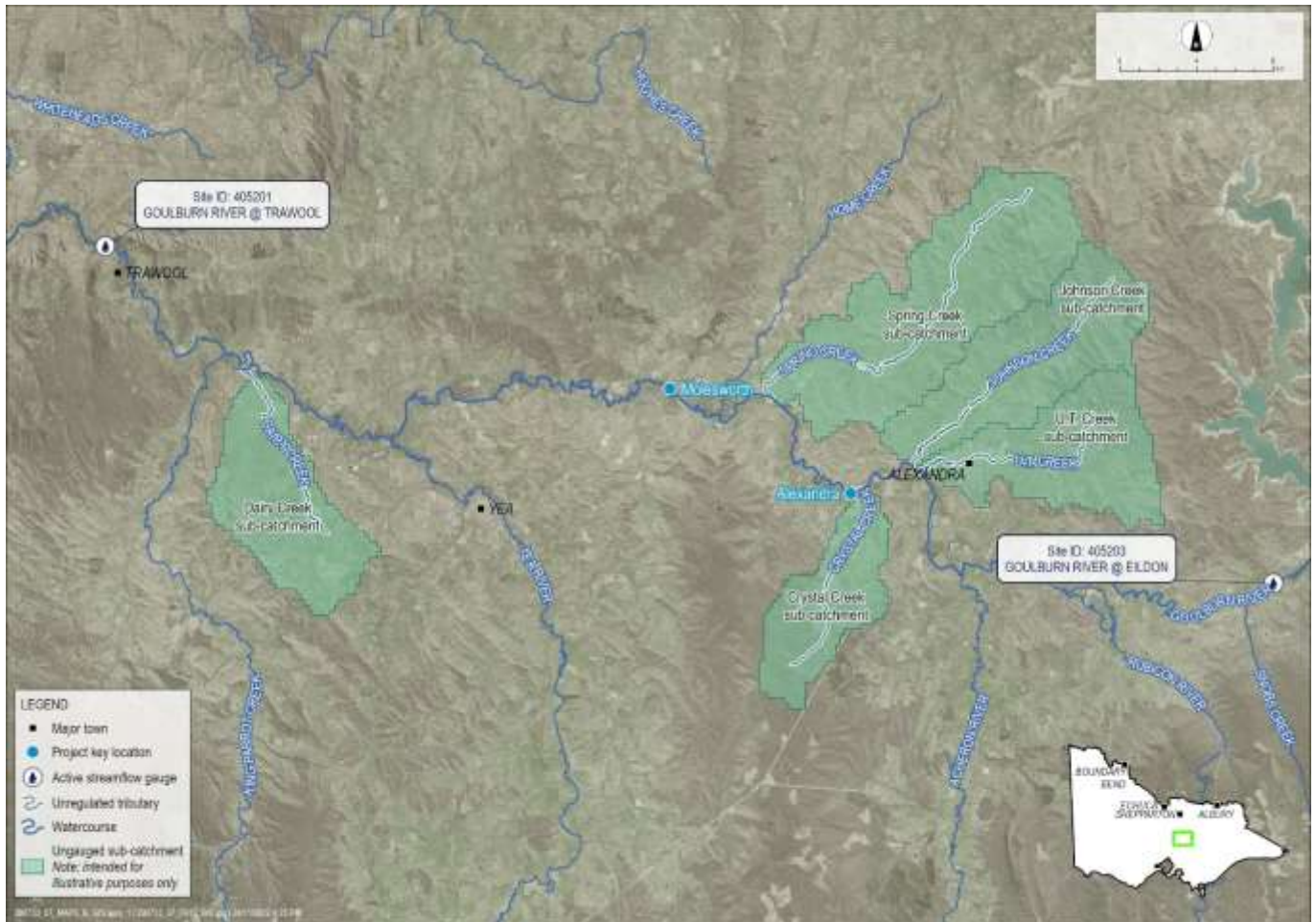


2.1.3 Priority 2: Ungauged unregulated tributary catchments between Eildon and Trawool

There are a considerable number of other tributary catchments in the Eildon to Trawool reach of the Goulburn River which are ungauged and for which there is no flow data available. The five largest of these catchments (by catchment area) are:

- Spring Creek (catchment area of 105 km²), Johnson Creek (77 km²) and UT Creek (56 km²), which flow roughly parallel to Home Creek, rising on the highly dissected Black Range to the north of the Goulburn River. All of these streams flow in a south-west direction over broad alluvial plains to their confluence with the Goulburn River.
- Crystal Creek (39 km²) is a northward flowing tributary of the Goulburn River located between the Acheron and Yea rivers and rising in mountainous forested terrain
- Dairy Creek (56 km²) is a northward flowing tributary of the Goulburn River located between the Yea River and King Parrot Creek and generally flows through broad alluvial plains.

Figure 4 Location map of larger ungauged unregulated tributary catchments between Eildon and Trawool



The potential scope of works for these catchments was the installation of streamflow gauging stations near the confluence of the various waterways with the Goulburn River. It is also noted that:

- **Spring Creek:** there are two inactive gauging sites and Spring Creek, including Spring Creek at Fawcett (405261), which last produced recorded data in 1987, and Spring Creek at Koriella (405242). The option exists to examine the reuse of these inactive sites.
- **UT Creek:** flows through the town of Alexandra near the creeks confluence with the Goulburn. An appropriate site for a hydrometric station may be found within the town.

2.1.4 Priority 3: Ungauged unregulated tributary catchments between Trawool and Goulburn Weir

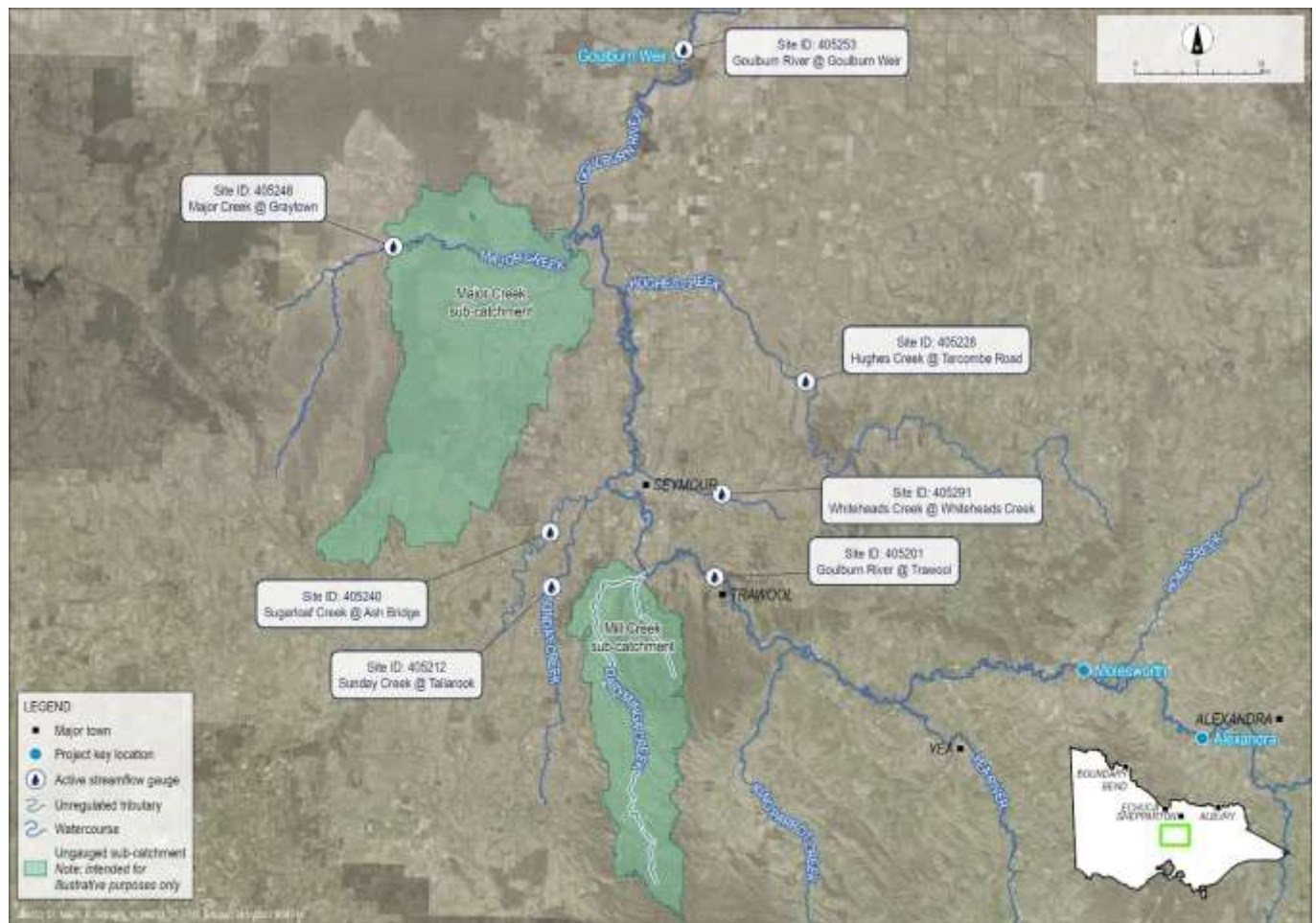
The reach of the Goulburn River between Trawool and Goulburn Weir is located in an area with relatively steep ranges to the south (Mt Disappointment – Mt Tallarook), rolling hills to the west between Kilmore and Pyalong, and the broad flat Goulburn Valley running through the centre.

According to Water Technology (2009), the unregulated tributaries in this section of the river produces a unit rate of run-off of around 0.3 ML/day/km², which is considerably lower than the tributaries further upstream (2.41 ML/day/km²). Nevertheless, the unregulated tributaries in this section do have a high mean annual maximum instantaneous flow per unit catchment area equivalent to or greater than the tributaries up further upstream. Accordingly, gauging of these tributaries is likely to be important for the operation of relaxed constraints. Two of the most significant areas of catchment that are ungauged in this section of the river are the:

- **Mill and Dabyminga Creeks (165 km²):** this Creek system rises in the Tallarook ranges and Mt Disappointment and follow steep gradients before emerging on the Goulburn floodplain. This catchment is entirely ungauged.
- **Major Creek:** this system drains substantial portion of the Puckapunyal military base and is primarily an area of forested rocky hills and ridges. The total area of the major Creek catchment is 640 km². More than half of the catchment is ungauged (349 km²).

The potential scope of works for these catchments was the installation of streamflow gauging stations near the confluence of the various Gray waterways with the Goulburn River.

Figure 5 Location map of larger ungauged unregulated tributary catchments between Trawool and Goulburn Weir



2.1.5 Design Standards Affecting Site Selection for Streamflow Gauging Stations

A key factor in determining the location for new gauging stations is the existence of a stable natural control (bedrock outcrop or stable riffle) that is effective over the range of flow rates. The flow needs to be confined to a single, well-defined, straight length of channel, with stable banks and uniform cross-section and slope. In addition, suitable sites need to be free from back water effects caused by flows in downstream waterways.

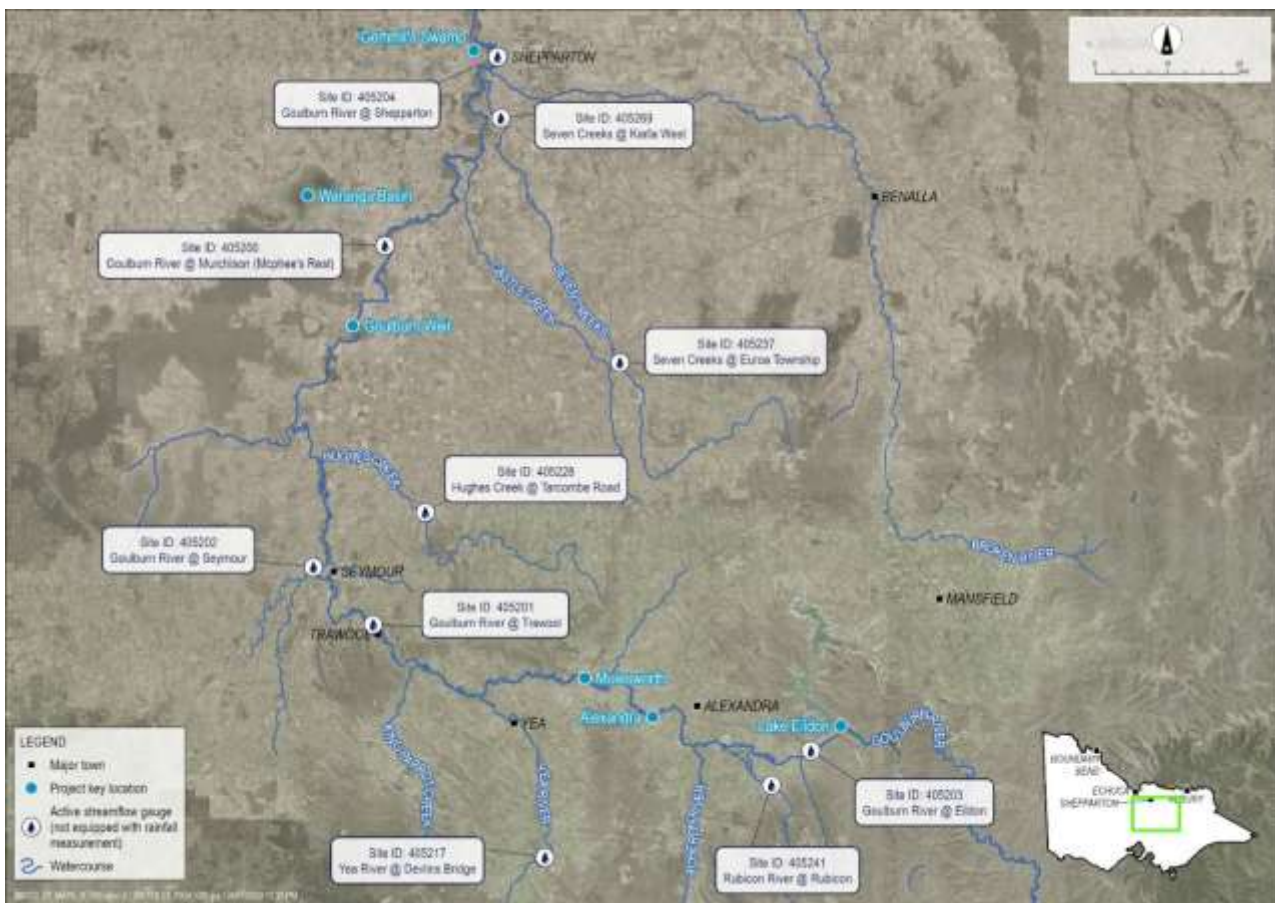
In general, broad flat sections of channel close to the confluence with a major waterway are less suitable for gauging. This became challenging for the proposed gauging sites in the Stage 1A work scope, as most sites are needed as close as possible to the confluence of the stream with the Goulburn River to best represent the catchment flows.

2.2 Rainfall Gauging

The following existing streamflow gauges are not equipped with rainfall measurement:

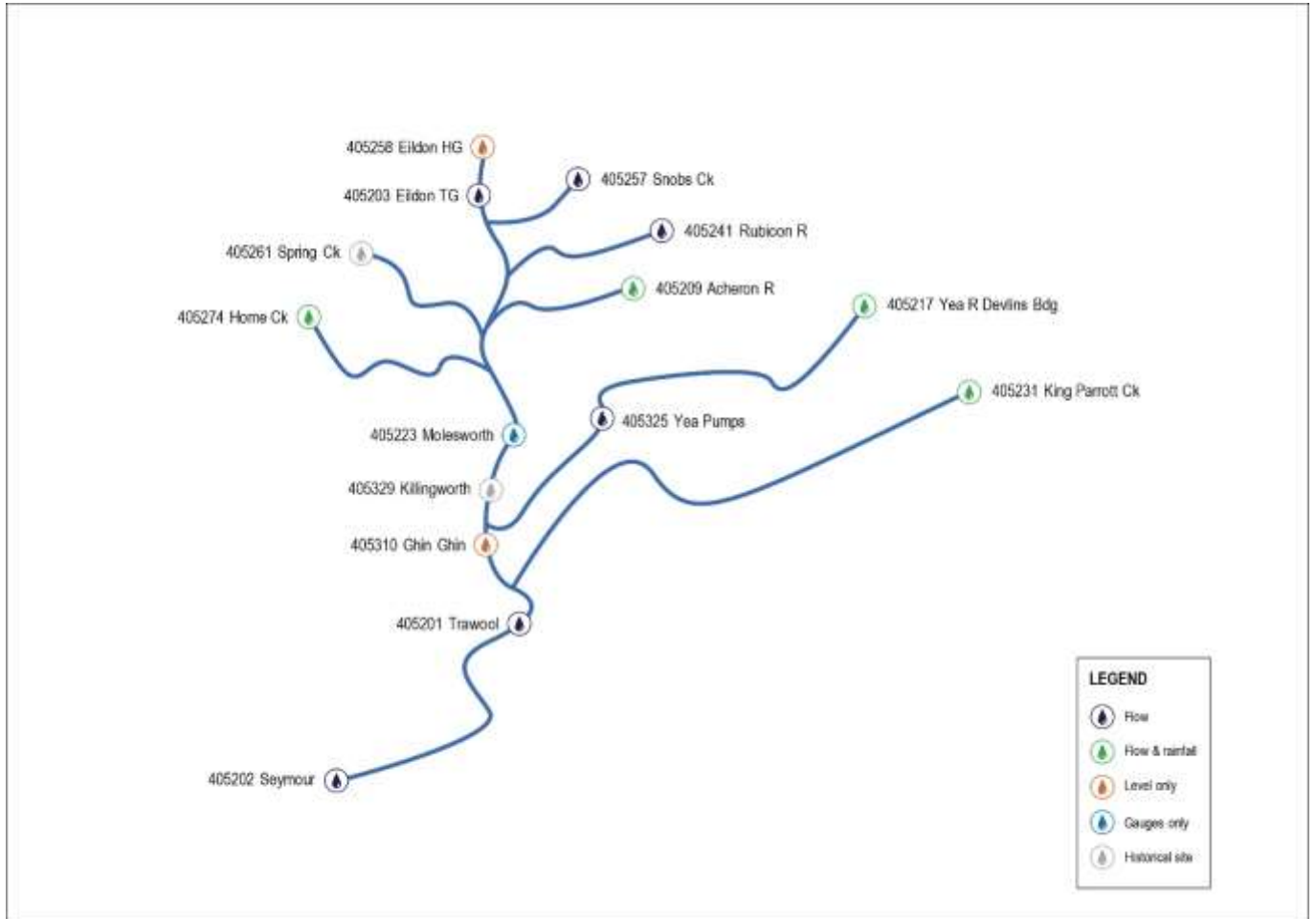
- Yea River at Devlin's Bridge: 405217
- Rubicon River at Rubicon: 405241
- Hughes Creek at Tarcombe Road: 405228
- Sevens Creek at Euroa: 405237 (noting that upstream gauges are equipped with rainfall measurement)
- Sevens Creek at Kialla West: 405269 (noting that upstream gauges are equipped with rainfall measurement)
- Goulburn River at Trawool: 405201
- Goulburn River D/S of Lake Eildon: 405203

Figure 6 Location of streamflow gauges not equipped with rainfall measurement



The location of new rainfall gauges considered both existing streamflow gauges that not equipped with rainfall measurement and new locations, typically higher in the catchments. Figure 7 shows the type of measurement available at existing sites across the mid-Goulburn.

Figure 7 Schematic of existing hydrometric sites in mid-Goulburn



3 Short-listed Sites

3.1.1 Streamflow gauging - sites for investigation

A range of potential streamflow gauging sites (long-list of sites, as set out in the section above) were identified and documented in a discussion paper circulated to GMW, GBCMA, BOM, and DELWP. Feedback and recommendations from the parties was generally consistent.

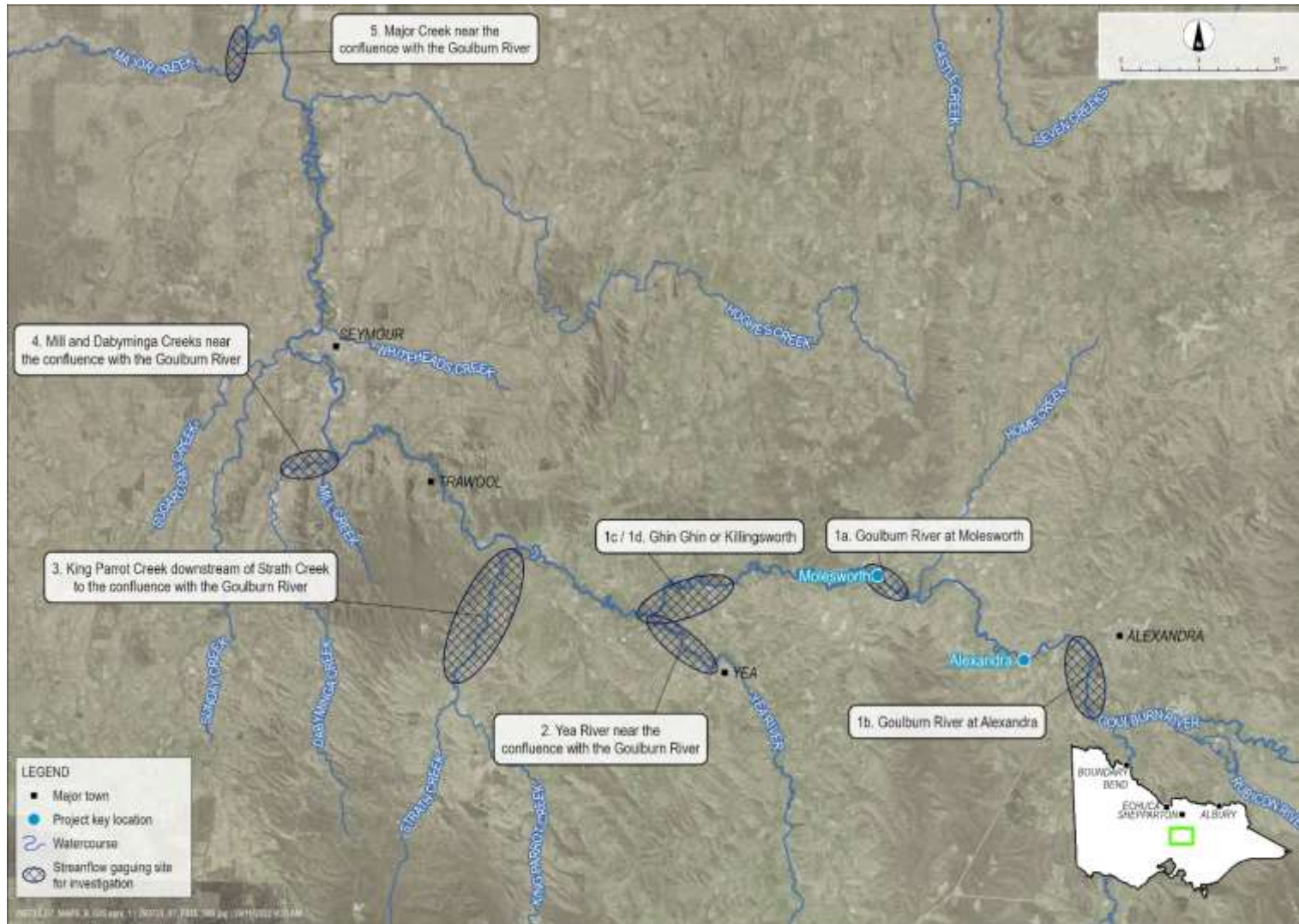
Based on this information, six streamflow gauging sites were shortlisted for investigation as detailed in Table 2 below (1a and 1b to be investigated; 1c and/or 1d only investigated if 1a and 1b were deemed unsuitable).

The location of the short-listed streamflow gauging sites is depicted in Figure 8.

Table 2 Shortlist of streamflow gauging sites, for field investigation

| Site | Site Options | Discussion |
|--|------------------------------------|--|
| 1. Ungauged section of the Goulburn River between Eildon and Trawool | 1a. Goulburn River at Molesworth | Having flow and height at this gauge would assist in addressing community concerns regarding flooding at Molesworth and support river operators with making informed decisions on storage releases. |
| | 1b. Goulburn River at Alexandra | This site is likely to be important from both the river operations and community perspective. |
| | 1c. Ghin Ghin or 1d. Killingsworth | If neither of options 1a or 1b are deemed viable, then either of these sites could be explored as alternatives for this reach of the river. |
| 2. Yea River near the confluence with the Goulburn River | | Site to be installed near the Yea township. This would be nearer to the confluence and thus complement the existing upstream gauge at 405217. |
| 3. King Parrot Creek downstream of Strath Creek to the confluence with the Goulburn River | | Site to be installed near the confluence with the Goulburn River. BOM recommended that this site should be downstream of Strath Creek. This would complement the existing upstream gauge at 405231. |
| 4. Mill and Dabyminga Creeks near the confluence with the Goulburn River | | This system is currently ungauged. Ideally the gauge should be placed close to the confluence with the Goulburn River and capturing the flow from both Creek systems. If this is not possible, then the gauge should be placed on the Dabyminga Creek. |
| 5. Major Creek near the confluence with the Goulburn River | | Site to be installed near the confluence with the Goulburn River. This would complement the existing upstream gauge at 405248 |

Figure 8 Location map depicting streamflow gauging sites shortlisted for investigation



3.1.2 Rainfall Gauging - sites for investigation

A range of potential rainfall gauging sites were identified and documented in a discussion paper circulated to GMW, GBCMA, BOM, and DELWP. Feedback and recommendations from the parties was generally consistent. BOM provided detailed advice on the preferred sites and catchments, considering factors such as coverage of existing rainfall gauges and utility of the sites for both flood warning and rainfall run-off assessments. The locations of the short-listed rainfall gauging sites are listed in Table 3 and depicted in Figure 9.

Table 3 Rainfall gauging sites for investigation

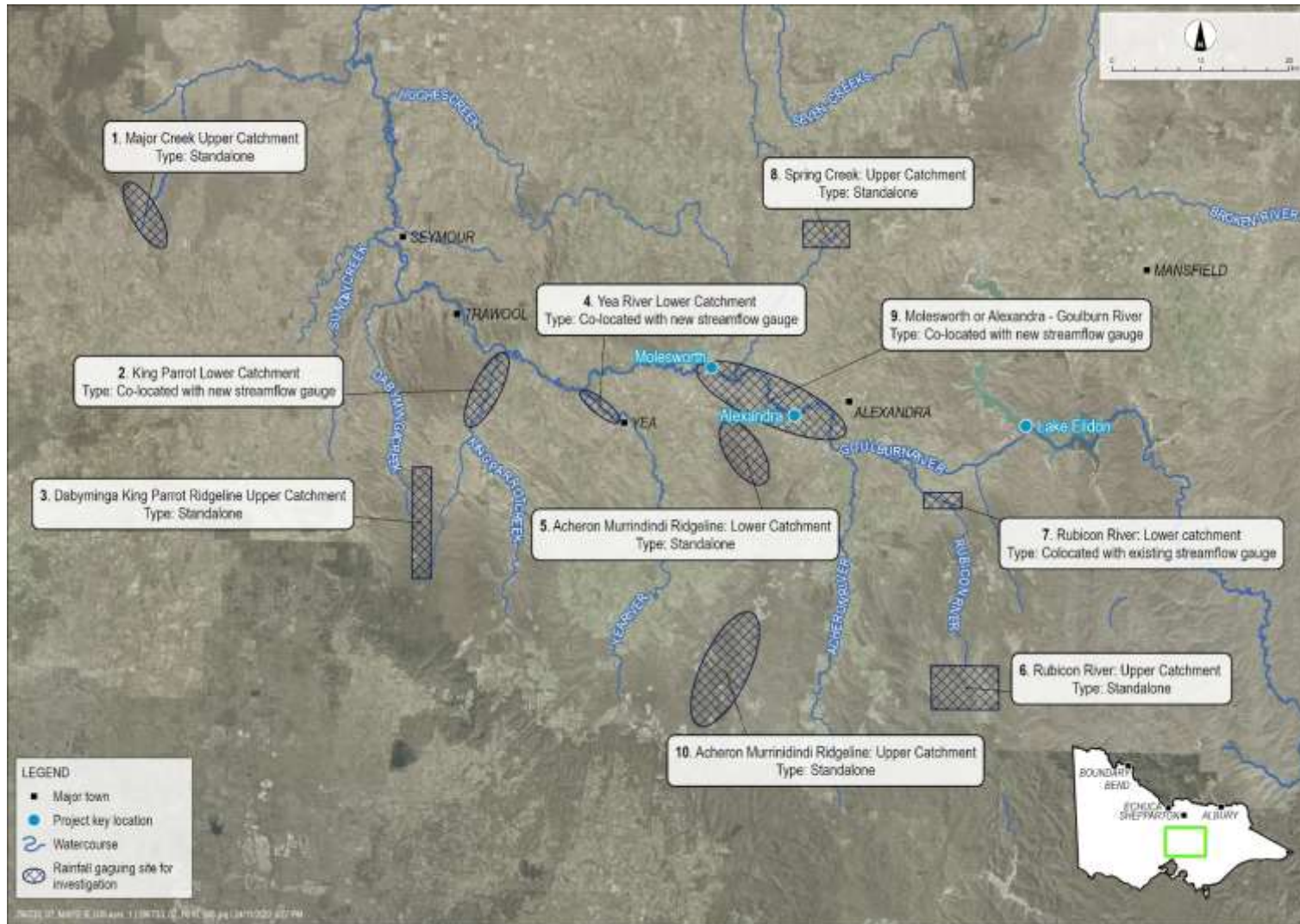
| Site | Type | Site Preference | Latitude | Longitude |
|---|---|---|----------|-----------|
| 1. Major Creek Upper Catchment | Standalone | A site at the top of the major Creek catchment, likely located outside of the Puckapunyal military base | -37.0053 | 144.8101 |
| 2. King Parrot Lower Catchment | Co-located with new streamflow gauge | Downstream of Strath Creek | -37.185 | 145.2499 |
| 3. Dabyminga King Parrot Ridgeline Upper Catchment | Standalone | A site on the ridgeline between the upper catchments | -37.3303 | 145.1656 |
| 4. Yea River Lower Catchment | Co-located with new streamflow gauge | | -37.1963 | 145.397 |
| 5. Acheron Murrindindi Ridgeline: Lower Catchment | Standalone | A site along the ridgeline of the Archeron and Murrindindi catchments | -37.2645 | 145.5845 |
| 6. Rubicon River: Upper Catchment | Standalone | A site in the upper catchment of the Rubicon River | -37.4562 | 145.8684 |
| 7. Rubicon River: Lower catchment | Co-located with existing streamflow gauge | Upgrade existing streamflow gauge with a rainfall gauge | -37.2909 | 145.8283 |
| 8. Spring Creek: Upper Catchment | Standalone | A new rainfall gauging the upper catchment of the Spring Creek | -37.0697 | 145.7325 |
| 9. Molesworth or Alexandra - Goulburn River | Co-located with new streamflow gauge | | -37.1798 | 145.6097 |
| 10. Acheron Murrindindi Ridgeline: Upper Catchment | Standalone | A site along the ridgeline of the Archeron and Murrindindi catchments | -37.4515 | 145.6198 |

3.1.3 Telemetry Sites for Investigation

The scope of works for hydrometric network upgrades included a provision for installation of telemetry at two untelemetered rainfall or streamflow sites as part of Stage 1A. The following sites were identified for investigation:

- Mollisons Creek at Pyalong: 405238
- Pine Creek at Broadford: 405290
- Marysville Golf Course: 405837

Figure 9 Location map depicting rainfall gauging sites for investigation



4 Field Investigations

4.1.1 Streamflow Gauging

Following shortlisting, field investigations were undertaken to confirm the suitability, specific location, and identify any other considerations for the shortlisted streamflow and rainfall sites. Table 4 provides the findings from the site investigations and confirms whether suitable streamflow gauging locations have been identified at each of the shortlisted sites.

The key findings from the site investigations for the streamflow gauging are:

- **Goulburn River:** all sites examined on the mainstem of the Goulburn River were found to be suitable. A new site at Molesworth was recommended as the preferred site on the basis that this is a known choke point for delivery of water through the mid-Goulburn and would best respond to community concerns regarding constraint relaxation.
- **Yea River:** a suitable site was identified on the north side of the Yea township. The site is located on private property with the landowner indicating they would be agreeable to hosting the site.
- **King Parrot Creek:** a suitable site was identified on Crown land approximately 3.8 km upstream of the Goulburn River at the Fairview Road bridge.
- **Mill and Dabyminga Creeks:** a potentially suitable site was located at the site of a historic gauge. However, examination of the historic gauge records indicates, that despite the initial assessment that this site may generate significant unregulated flows, this site had a recorded history of very low flows (<1 ML/day). It was therefore questionable whether this site would add value to the coverage of the hydrometric network and the performance of river operating in forecasting models. Accordingly, it was recommended that no works proceed for this site.
- **Major Creek:** a suitable site could not be found near the confluence with the Goulburn River outside of the boundary of the Puckapunyal army base. Sites close to the Goulburn River were found to be impacted by backwater flows from the river mainstem. Access was gained to the army reserve and, despite investigating three separate locations, no suitable area could be found for installing a new streamflow gauge.

Table 4 Site investigation results - Streamflow Gauging

| Site | Discussion | Suitability | Field Inspection Comments | Infrastructure Notes | Recommendation |
|--|---|-------------|--|--|---|
| 1. Goulburn River at Molesworth | This would be the preferred location as it is effectively the chokepoint for GMW's delivery of water through the mid-Goulburn. Having flow and heighted this gauge would also assist in addressing community concerns regarding flooding at Molesworth. Historically a streamflow gauge existed at this site (405223) | Yes | A site within the Molesworth caravan Park on crown land next to the boat launching area would be suitable. It would however require an elevated platform above flood level. The river would be confined up to bank full levels and the bed and banks would act as controlling features. Boat measurements would be required to establish ongoing height versus flow relationship. Phone reception available – 1 bar 3G. | Will require an elevated platform to raise infrastructure above future flood levels. Additionally, will require a direction antenna due to low signal coverage and larger solar panel due to impacts on solar during winter months. Will require trenching of approx. 65m for orifice line from the instrument location to the river / gauge's location. | Look to proceed with this as the primary location given community interest in previous flooding issues at the park grounds. |

| Site | Discussion | Suitability | Field Inspection Comments | Infrastructure Notes | Recommendation |
|--|---|-------------|---|---|---|
| 2. Yea River near the confluence with the Goulburn River | This would complement the existing upstream gauge at 405217. | Yes | <p>A site was identified on the North side of the Yea township where the Yea River is confined. The site is on private property of a private landholder who has indicated they are agreeable to housing the sites on their land, but subject to final confirmation. It is proposed the housing is placed above flood level, approximately 200m from the river.</p> <p>The river reach and banks will act as control feature. It should be noted that the Yea River has large amounts of tree snags across the river and following a large flood event the rating may be impacted over time.</p> <p>A cable way could be installed if requiring higher flow measurements over time, however it is expected most measurements could be waded to establish the height versus flow relationship.</p> <p>Large amounts of trees / snags extend down the reach of the river, will change the rating relationship over time and potentially following large flood events.</p> <p>A rain gauge could also be placed at the site with large areas of cleared land available, subject to the landholder confirmation.</p> <p>Phone reception available at the site.</p> | <p>The site will require trenching across approximately 150m – 200m of cleared land.</p> <p>Install cableway to capture higher flows</p> | <p>Recommend the site be considered as suitable with a note that the rating will change overtime.</p> <p>Will require formal agreement with landowner</p> |
| 3. King Parrot Creek downstream of Strath Creek to the confluence with the Goulburn River | <p>This would complement the existing upstream gauge at 405231.</p> <p>BOM suggest that this site should be downstream of Strath Creek.</p> | Yes | <p>A site was identified approximately 3.8km upstream of the Goulburn River confluence at the Fairview Road bridge. A suitable stable natural control of the stream bed and banks would create a stable relationship between height and flow.</p> <p>It is not expected that a cableway would be required here given low to medium flows.</p> <p>As the bridge is in a low traffic area (supports around 6 farms on side road) high flows would be measured using an endless wire system</p> <p>A rain gauge could also be possibly installed some 200m away to be clear of trees.</p> <p>Phone reception is available.</p> | <p>Will require short hop radio from site hut to expected location for rain gauge to be clear of trees. The site selected for the rain gauge is approximately 150m – 200m to the east.</p> <p>Install endless wire for higher measurements.</p> | <p>Confirm land ownership. Site is on the downstream side of the bridge.</p> <p>Rain gauge to go on crown land in road reserve.</p> |

| Site | Discussion | Suitability | Field Inspection Comments | Infrastructure Notes | Recommendation |
|---|---|-------------|--|---|--|
| 4. Mill and Dabyminga Creeks near the confluence with the Goulburn River | <p>This system is currently ungauged. Ideally the gauge should be placed close to the confluence with the Goulburn River and capturing the flow from both Creek systems.</p> <p>If this is not possible then the gauge should be placed on the Dabyminga Creek.</p> | No | <p>The site selected here is an old historical site that was decommissioned in 2001 (405249B). Old, galvanised pipe still on site where previous gauge boards existed.</p> <p>A ford crossing would act as a control feature with the bed and banks acting as a natural control for higher flows. A cableway would not be recommended as low to medium flows expected for majority of flow events.</p> <p>Phone reception is available here.</p> | Site is approximately 30m from the river above flood level. | Do not proceed with this site as it is a lower priority than those above |
| 5. Major Creek near the confluence with the Goulburn River | <p>This would complement the existing upstream gauge at 405248</p> | No | <p>No suitable site was available downstream of the army reserve.</p> <p>The current available river reaches available outside of the Puckapunyal Army reserve (approx. 1.2km) would be backed up during higher flows of the Goulburn and appeared to be during the site inspection.</p> <p>Inspection of three potential locations inside of the reserve failed to identify any suitable locations for a new streamflow gauge.</p> | | Do not proceed with site as no suitable location was identified |

4.1.2 Rainfall Gauging

Table 5 details the findings from the site investigations and confirms whether suitable rainfall gauging locations were identified at each of the shortlisted sites. The key findings from the site investigations were:

1. **Major Creek Upper Catchment:** a site was identified on private property with a landholder giving verbal approval to allow the rain gauge to be located on the property.
2. **King Parrot Lower Catchment:** a rainfall gauge co-located with the new streamflow gauge. A rain gauge could be installed some 200m away from the proposed streamflow location.
3. **Dabyminga and King Parrot Ridgeline Upper Catchment:** a site was identified on Crown land on the ridgeline.
4. **Yea River Lower Catchment:** a site co-located with the new streamflow gauge.
5. **Acheron and Murrindindi Ridgeline Lower Catchment:** a site was identified on the ridgeline within the proposed boundary.
6. **Rubicon River/ Upper Catchment:** a site was identified on the property boundary of the Rubicon outdoor school, within the catchment.
7. **Rubicon River Lower catchment:** a site was identified some 200m downstream of the existing site, to be within an area cleared from trees.
8. **Spring Creek Upper Catchment:** site identified on crown land with large, cleared area on road reserve.
9. **Molesworth - Goulburn River:** a suitable site was not identified nearby the Caravan Park.
10. **Acheron Murrindindi Ridgeline Upper Catchment:** a cleared area was found that could be suitable. Will require confirmation from DELWP / Parks Victoria if selected area is suitable.

4.1.3 Telemetry-only Upgrades

Correspondence from BOM confirmed that the sites initially listed for telemetry-only upgrades were in fact equipped with telemetry. It was determined that no telemetry upgrades to existing streamflow or rainfall gauges in the mid-Goulburn catchment are required.

Table 5 Site investigation results - Rainfall Gauging

| Site | Type | Discussion | Suitability | Field Inspection Comments | Infrastructure Notes | Recommendation |
|---|--------------------------------------|---|-------------|--|---|--|
| 1. Major Creek upper catchment | Standalone | A site at the top of the Major Creek catchment. | Yes | A site was selected within the proposed boundary on private property. Landholder has given verbal approval to allow a rain gauge on site pending design approval. Phone reception available – 4G 1 Bar | Site suitable for rain gauge with good, cleared land. Other than moving the site outside the catchment boundary for the rain gauge to the Tooborac football ground, there was no other suitable location due to trees. | Recommend proceeding with this site following agreement with landholder |
| 2. King Parrot Creek confluence with the Goulburn River | Co-located with new streamflow gauge | Downstream of Strath Creek | Yes | A rain gauge could be possibly installed some 100 - 200m away to be clear of trees. Confirmation if this is crownland needs to be completed. Site would require a boundary fence. Phone reception available | Site requires boundary fence on crown land and will abut to landholder's farm fence on crown land. Site will also require a short hop radio due to distance between sites and the need to cross over the bridge to housing location. | Proceed with consideration to the requirement for the rain gauge given additional infrastructure with short hop radio. Confirm road reserve suitable with local land holders. |
| 3. Dabyminga Creek and King Parrot Creek - Ridgeline | Standalone | A site on the ridgeline between the catchments | Yes | A site was selected downhill from the ridge line due to heavy tree coverage. The site is located on crown land and adjacent to the farm fence. Phone reception available – 3G 4 Bars | Will require perimeter fence around the rain gauge. | Confirm that the site selected is still within the boundary of the catchment and suitable for all authorities. Look to engage landowners before proceeding with the site. |
| 4. Yea River confluence with Goulburn River | Co-located with new streamflow gauge | | Yes | A site would be suitable with the streamflow site. Final confirmation required from landholder following design. Phone reception available. | Rain gauge will require 50m of trenching as located in cleared land area remote to housing. | Proceed with landholder approval |
| 5. Acheron River and Murrindindi Rivers – Lower Catchment: | Standalone | A site on the ridgeline between the catchments | No | A site was inspected in the lower catchment. There was no suitable site given the tree coverage in the area. Would require approval from private landholder for any preferred site. Phone coverage available. | | No sites available without seeking private landholder approval. |

| Site | Type | Discussion | Suitability | Field Inspection Comments | Infrastructure Notes | Recommendation |
|---|---|--|--|--|---|--|
| 6 Rubicon River upper catchment | Standalone | A site in the upper catchment of the Rubicon River | Yes | <p>A site is proposed within the property boundary of the Rubicon outdoor school up within the catchment. The site was unable to be visited as the bridge access leaving the Rubicon catchment was closed currently for upgrading. A representative from the Rubicon Outdoor school was enthused about having a rain gauge located at the school for students' interest.</p> <p>The site location may not be as high in the catchment as originally requested.</p> <p>Mobile coverage will require an extended mast to get communication signal.</p> <p>Limited phone coverage available</p> | Was unable to inspect site but was advised that phone communication was marginal and therefore require high mast with direction antennae. | <p>Complete site visit once bridge work upgrade complete or via alternate route.</p> <p>Seek final landholder approval</p> |
| 7. Rubicon River lower catchment | Co-located with existing streamflow gauge | Upgrade existing streamflow gauge with a rainfall gauge | Yes | <p>A rain gauge could be installed some 120m downstream of the existing site to be within an area cleared from trees. The site is next to the bridge crossing the river.</p> <p>A fence would be required around the site due to cattle within the paddock.</p> | Will require fence around rain gauge due to cattle in property. Also require trenching as the rain gauge is approx. 120m from the site | Seek landholder approval to place rain gauge on site. |
| 8. Spring Creek upper catchment | Standalone | A new rainfall gauging the upper catchment of the Spring Creek | Yes | <p>Site confirmed on crown land with large, cleared area on road reserve.</p> <p>Phone reception available. - 3G 1 Bar</p> | Directional antennae for improved phone coverage | <p>Seek approval from nearby landholders of intent to locate site.</p> <p>Site on road reserve.</p> |
| 9. Molesworth or Alexandra | Co-located with new streamflow gauge | | <p>Not at the streamflow site.</p> <p>A remote site may be identified.</p> | <p>There is no available land that is clear of trees to co-locate the site.</p> <p>Potential for a stand-alone site maybe available if further consideration was given to this. Land next to the caravan park would need to be confirmed.</p> <p>Phone reception available.</p> | If rain gauge is required, it would need to be a standalone site | Consider standalone site for rain gauge. |

| Site | Type | Discussion | Suitability | Field Inspection Comments | Infrastructure Notes | Recommendation |
|---|------------|------------|-------------|---|--|---|
| 10. Acheron River and Murrindindi Rivers – Ridgeline: Upper Catchment | Standalone | | Yes | A site was located on the ridgeline within the proposed boundary. A cleared area was found that could be suitable. Phone reception available. | Vandalism could be an issue which would require potentially a heavy-duty enclosure | Seek approval from Parks re site availability before proceeding. Consider putting it lower in the catchment if site was not available. |

4.2 Sites for Detailed Investigation

The list of sites recommended to proceed with detailed investigations because of the field investigations consisted of three streamflow gauging sites and ten rainfall gauging sites, as listed below, and shown on Figure 10.

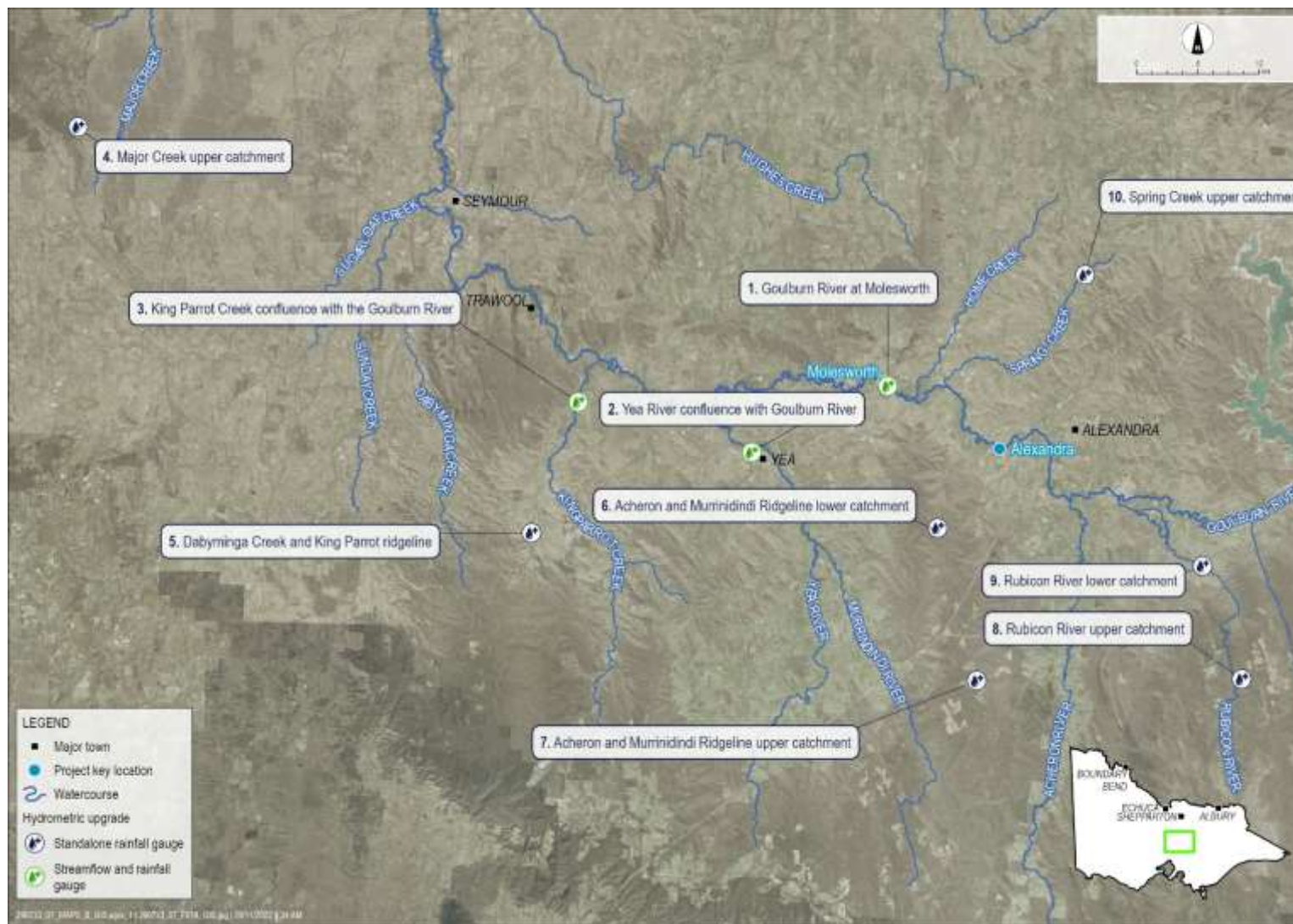
4.2.1 Streamflow and rainfall gauges

1. **Goulburn River at Molesworth:** a new streamflow and rainfall gauge on the mainstem of the Goulburn River located within the Molesworth caravan park on Crown land next to the boat launching area. Rainfall gauge site is to be separated from streamflow with site to be determined.
2. **Yea River at confluence with the Goulburn River:** a new streamflow gauge on the Yea River near the confluence with the Goulburn River. A site was identified on the north side of the Yea township where the Yea River is confined. The site is on private property and the landowner has indicated he is agreeable to having the gauges on his land. The rainfall gauge would be located next to the streamflow.
3. **King Parrot Creek at confluence with the Goulburn River:** a new streamflow gauge on the King Parrot Creek near the confluence with the Goulburn River. A site was identified approximately 3.8km upstream of the Goulburn River confluence, next to the Fairview Road bridge. A rain gauge could be installed some 200m away from the proposed streamflow location.

4.2.2 Standalone rainfall gauges

4. **Major Creek Upper Catchment:** a rainfall gauge on the upper catchment of the Major Creek. A site was selected within the proposed boundary on private property.
5. **Dabyminga and King Parrot Ridgeline:** A rainfall gauge on the ridgeline between the Dabyminga Creek and King Parrot Creek. A site was selected downhill from the ridge line due to heavy tree coverage. The site is located on crown land and adjacent to the farm fence.
6. **Acheron and Murrindindi Ridgeline Lower Catchment:** a rainfall gauge on the lower section of the ridgeline between the Acheron River and Murrindindi River. Tree cover may be an issue in this area.
7. **Acheron and Murrindindi Ridgeline Upper Catchment:** A rainfall gauge on the lower section of the ridgeline between the Acheron and Murrindindi Rivers. A cleared area on the ridgeline has been identified needs confirmation from DELWP or Parks Vic if the site is suitable or being used for logging.
8. **Rubicon River Upper Catchment: Upper Catchment:** a site is proposed within the property boundary of the Rubicon outdoor school.
9. **Rubicon River Lower Catchment Lower catchment:** a rain gauge could be installed some 120m downstream of the existing streamflow gauge, to be within an area cleared from trees.
10. **Spring Creek Upper Catchment:** a rain gauge in the upper catchment of the Spring Creek. Site confirmed on crown land with large, cleared area on road reserve.

Figure 10 Overview map of final shortlist of streamflow and rainfall gauging sites for detailed investigations



5 Final Site Locations

5.1 Streamflow & Rainfall Gauges

The following changes have been made since the field investigation were undertaken:

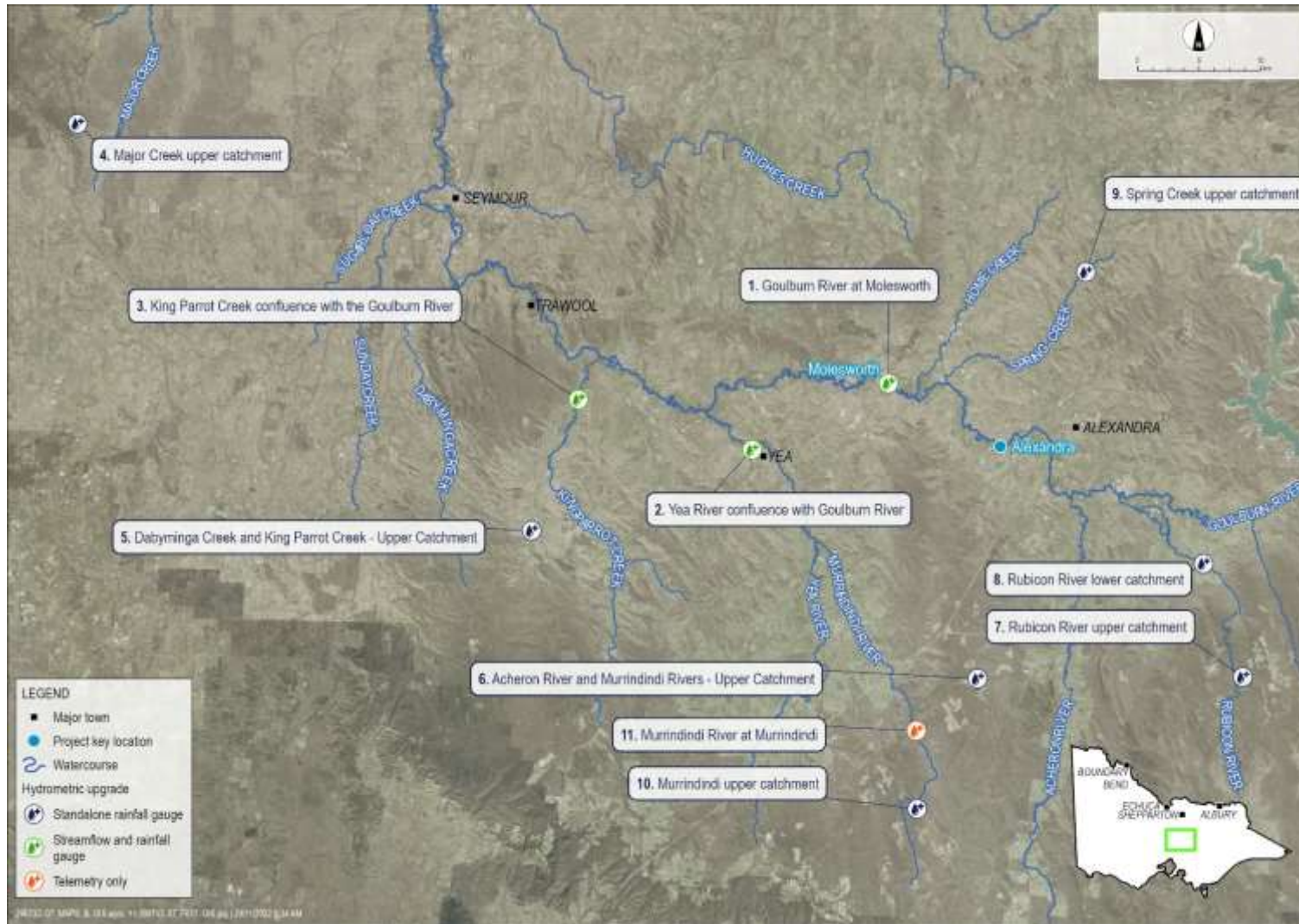
- **Goulburn River at Molesworth:** the proposed gauge on the Goulburn River at Molesworth has changed location due to recent flooding (late 2022) which showed that the originally proposed location near the Caravan Park would require a significant raised platform and would be difficult to access during high flow events. The final location for gauge installation is adjacent to the Goulburn Valley Highway, nearby the historic flood gauges (405223A).
- **Acheron & Murrindindi Ridgeline Lower Catchment rainfall gauge:** the proposed rainfall gauge on the ridgeline between the lower parts of the Acheron & Murrindindi catchments is no longer planned to be installed as no suitable site was able to be located.
- **A new rainfall gauge is proposed to be installed in the upper Murrindindi catchment:** this new site has been included in response to stakeholder feedback about being able to better attribute rainfall between the Acheron and Murrindindi catchments, as the other new gauges are being installed near the ridgeline.
- **Murrindindi at Murrindindi telemetry upgrade:** the existing streamflow gauge on the Murrindindi River will be upgraded to have telemetry installed. This upgrade work is in response to stakeholder feedback and will allow real-time data to be available for flows in the Murrindindi catchment.

Table 6 lists the final streamflow and rainfall gauge sites for installation or upgrades.

Table 6 Final list of streamflow and rainfall gauges to be installed as part of Stage 1A of the Victorian CMP

| No. | Site | Type | Latitude | Longitude |
|-----|---|-----------------------------|----------|-----------|
| 1 | Goulburn River at Molesworth | Streamflow & Rainfall Gauge | -37.1651 | 145.5438 |
| 2 | Yea River confluence with Goulburn River | Streamflow & Rainfall Gauge | -37.2101 | 145.4130 |
| 3 | King Parrot Creek confluence with the Goulburn River | Streamflow & Rainfall Gauge | -37.1731 | 145.2523 |
| 4 | Major Creek upper catchment | Rainfall Gauge | -36.9708 | 144.7946 |
| 5 | Dabyminga Creek & King Parrot Creek - Upper Catchment | Rainfall Gauge | -37.2694 | 145.2108 |
| 6 | Acheron River & Murrindindi Rivers – Upper Catchment | Rainfall Gauge | -37.3766 | 145.6213 |
| 7 | Rubicon River upper catchment | Rainfall Gauge | -37.3739 | 145.8653 |
| 8 | Rubicon River lower catchment | Rainfall Gauge ¹ | -37.2906 | 145.8275 |
| 9 | Spring Creek upper catchment | Rainfall Gauge | -37.0777 | 145.7181 |
| 10 | Murrindindi upper catchment | Rainfall Gauge | -37.4722 | 145.5661 |
| 11 | Murrindindi River at Murrindindi | Telemetry Only | -37.397 | 145.564 |

Figure 11 Overview map of final streamflow and rainfall gauging sites to be installed



5.2 Operations & Maintenance Funding

A key pre-requisite from Government departments, to be resolved prior to any installation or upgrade works on the hydrometric network, was the confirmation of the funding source to cover the operational and maintenance expenses associated with the new sites.

A briefing paper on the need for these new sites and consideration of the potential sources for O&M funding was circulated within DELWP. As these new gauges will primarily be used for planning and managing environmental flows in the Goulburn River (under current and potential future relaxed constraints scenarios), it was agreed that ongoing costs will be funded by the DELWP Environmental Water team through existing funding arrangements with the Goulburn Broken Catchment Management Authority (GBCMA).

The commitment to cover the ongoing costs of the new and upgraded hydrometric sites was approved in May 2022. A copy of the funding commitment has been circulated to the appropriate parties.

5.3 Deliverables

Table 7 below sets out the proposed deliverables as compared to the indicative scope of works envisioned by DELWP for Stage 1A.

Table 7 Workstream 5 - Stage 1A Deliverables and final scope

| Workstream Component | Indicative scope | Final scope |
|----------------------|---|---|
| Rainfall gauges | 10 x new rainfall gauges | 9 x new rainfall gauges |
| Streamflow gauges | 6 x new streamflow gauges | 3 x new streamflow gauges |
| Telemetry upgrade | 2 x telemetry upgrade to existing streamflow gauges | 1 x telemetry upgrade to existing streamflow gauges |

5.4 Approvals

Table 8 below sets out the approvals which were required to be sought at each of the site works.

Table 8 Hydrometric Network Site Approval Requirements

| No. | Site | Type | Council Planning Approval | Taungarung Land Use Activity Agreement (LUAA) | DELWP Land Manager Consent | Works Within Road Reserves | Works on Waterways | Private Landowner Agreement |
|-----|---|-----------------------------|---------------------------|---|----------------------------|----------------------------|--------------------|-----------------------------|
| 1 | Goulburn River at Molesworth ¹ | Streamflow & Rainfall Gauge | X | | | | X | |
| 2 | Yea River confluence with Goulburn River | Streamflow & Rainfall Gauge | X | X | | X | X | X |
| 3 | King Parrot Creek confluence with the Goulburn River | Streamflow & Rainfall Gauge | X | X | X | X | X | |
| 4 | Major Creek upper catchment | Rainfall Gauge | X | | | | | X |
| 5 | Dabyminga Creek & King Parrot Creek - Upper Catchment | Rainfall Gauge | X | X | X | X | | |
| 6 | Acheron River & Murrindindi Rivers – Upper Catchment | Rainfall Gauge | X | X | X | | | |
| 7 | Rubicon River upper catchment | Rainfall Gauge | X | X | X | | | |
| 8 | Rubicon River lower catchment | Rainfall Gauge | X | X | X | | | |
| 9 | Spring Creek upper catchment | Rainfall Gauge | X | | | X | | |
| 10 | Murrindindi upper catchment | Rainfall Gauge | X | X | X | | | |

| No. | Site | Type | Council Planning Approval | Taungarung Land Use Activity Agreement (LUAA) | DELWP Land Manager Consent | Works Within Road Reserves | Works on Waterways | Private Landowner Agreement |
|-----|------|------|---------------------------|---|----------------------------|----------------------------|--------------------|-----------------------------|
|-----|------|------|---------------------------|---|----------------------------|----------------------------|--------------------|-----------------------------|

| | | | | | | | | |
|----|----------------------------------|-----------------------------|--|--|--|--|--|--|
| 11 | Murrindindi River at Murrindindi | Telemetry Only ² | | | | | | |
|----|----------------------------------|-----------------------------|--|--|--|--|--|--|

¹The required approvals for this site have been updated to reflect the change in location, with the approvals currently being sought. This gauge is located on land owned by VicTrack, along the Great Victorian Rail Trail. Sequana will seek approval to locate the gauge here prior to installation.

²No statutory approvals required as works do not involve any ground disturbance.

6 Next steps

Installation is expected to commence in December 2022 and take around 2 – 3 months to complete, noting that some of the streamflow sites are currently difficult to access due to persistently high flows. The installation works will be followed by commissioning, undertaking an initial set of readings, and handover to DELWP for operation and maintenance as part of their usual program.

As noted previously in this report, the scope of works associated with Stage 1A of the Victorian Constraints Measures Program is to only upgrade the existing network. It is important to ensure that the rainfall-runoff models and improved river operations tool are progressed to ensure the benefits of upgrading the network are realised. It is understood that this work is being progressed separately through the Enhanced Environmental Water Delivery (EED) Project.

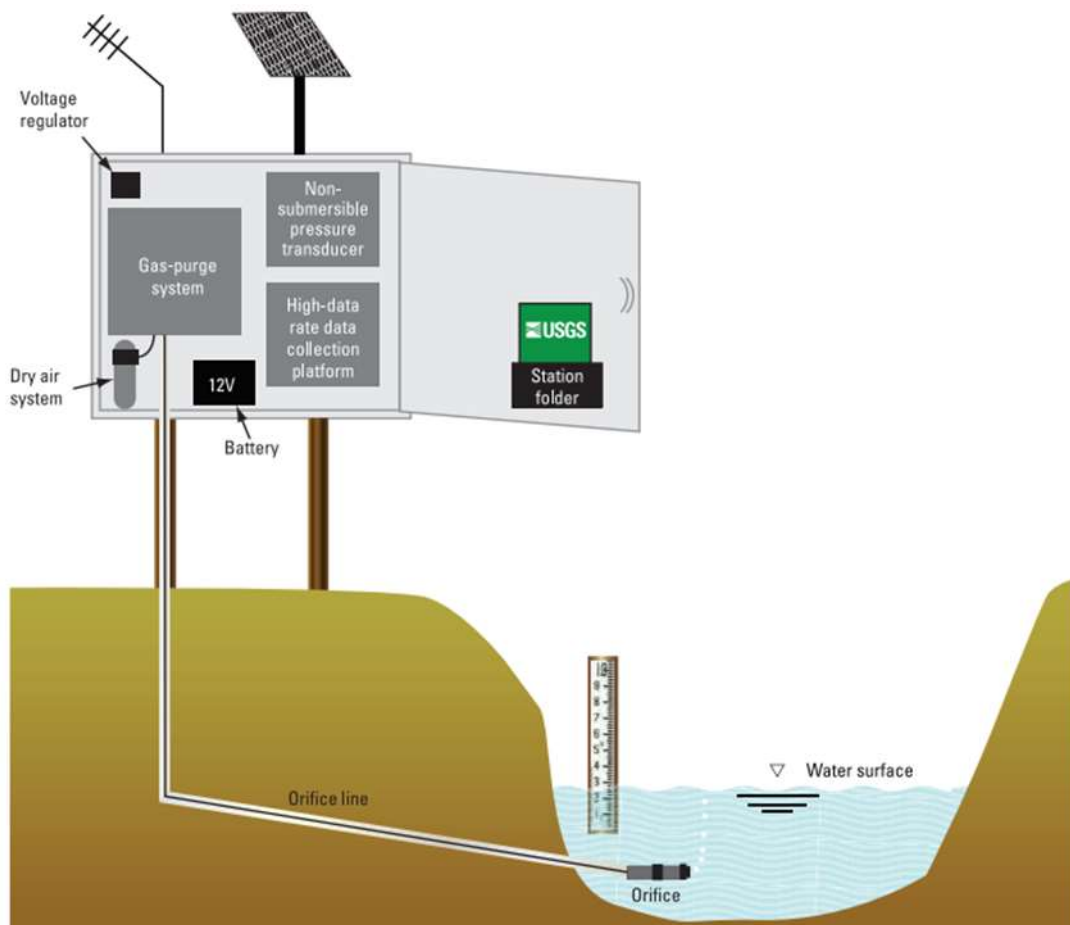
The following sections provide some additional information on what to expect at handover.

6.1 Gauge Station Design

6.1.1 Streamflow Gauging Station

Stream level will be measured using a bubbler type remote sensor with a bubble tube run into the waterway through the channel bank. Instrumentation will be installed in a post mounted cabinet located on top of the channel bank. Bubbler type streamflow gauging stations are well proven and provide a high level of accuracy.

Figure 12 Schematic of a bubbler type streamflow gauging station



Streamflow Gauge Design and Installation

Site inspections have been performed at each of the sites to ensure that they have appropriate features and will perform adequately to collect stream gauging information. During the pre-installation inspections, it was considered the sites have the following features, both for good hydrological features, ease of installation and continued operation and maintenance:

- Natural and stable control.
- Straight approach to control section.
- Contained flow to a high level.
- An appropriate location for a site cabinet to minimise vandalism and chances of inundation.
- Permitted access with approvals.

The key features of the proposed design for streamflow gauges are:

- A post mounted stainless-steel cabinet.
- Inside the cabinet there will be a secondary enclosure to house data logger.
- FTS Bubbler sensor.
- Telemetry - Intercel 4G or Unidata Satellite modem (if no mobile coverage at additional charge) and antenna.
- Fixed Mast.
- 40-Watt Solar Panel and 40Ah battery.
- Up to three-gauge boards.
- Perform a cross section to bank full.
- Perform a longitudinal survey to assist in the creation of a theoretical rating table.
- Install an Arbitrary Benchmark.
- Install endless wires where suitable (original proposal assumed 2 sites).

It is recognised that in high flow events gauge boards are easily damaged, and to mitigate damage to gauge boards, each gauge plate will be installed with a backing board as shown below in Figure 13.

Figure 13 gauge plate with backing board



Sites will be installed across a mix of catchment sizes in the area. Some sites are small and are flashy in nature. It will be difficult to capture a stream flow measurement at these sites in a high flow event due to their flashy nature. However, a cross wire will be installed at up to two sites to assist in taking stream discharge measurements and to enable the rating table to be updated and data to be collected Figure 14.

Figure 14 Endless Wire



Over the years, the requirements at environmental monitoring stations have been refined and now have a modular design. Instruments will be protected by the site hut but also an additional, waterproof logger box. This allows the instrumentation to be assembled, wired, and tested offsite to ensure that it is functional and proves field technicians with a modular system that is easily installed at site, thus cutting down on the chance of mistakes in wiring when on site, and reducing the time required to install the site.

Where a Campbells logger is selected, a logger program will be created. Programming will allow data to be transmitted to DELWP or to a desired partner location.

For site security and consistency of key to like, DELWP will provide padlocks. The cabinets will be painted green to blend with the environment and minimise the chances of being seen and vandalised.

Before and after photographs will be taken of the installation site to show that as minimal an environmental impact has been made to the site with the trenching and other works required. All rubbish will be removed from the site for responsible disposal.

At the river or creek there will be a set of staff gauges (Figure 15) installed to cover the range or water level required for this project, each gauge plate being 1m high. It is assumed it will be necessary to cover up to 4m water level change (assumed for all gauging stations), however more may be required if river levels during floods rise to a higher level.

Staff gauges will be surveyed to AHD during the survey activities for this project and a temporary benchmark established nearby so that staff gauges can be easily adjusted if required during annual maintenance. Staff gauges will be mounted to 50NB posts which are durable and can withstand most flooding conditions. A backing plate system has been designed that holds staff gauge sturdy and are built for strength and debris deflection. A site inspection will determine the number of gauges required for this.

Figure 15 Staff Gauges with backing plates



Creating New Ratings

At the new hydrometric sites, a stream vs. height relationship gauging will be conducted during installation. It is anticipated that this gauging will be at a relatively low discharge rate dependant on the current seasonal flows. To produce a full range rating, the Manning Equation will be used. The Manning Equation uses the physical characteristics of a site, such as the cross section, roughness, and slope to determine the discharge.

To create the upper end of the rating a comparison between Mannings Equation and the Slope-Area method will be conducted. Calculation methods are outlined in AS3778.3.3-2001 Measurement of water flow in open channels, Part 3.3: Velocity-area methods – Measurement by slope-area method. These methods require a cross section and a measurement of the slope of the river at the location and observations of the roughness, which is an indication of the vegetation at the site to be rated. The values are entered into the equation and a discharge is calculated.

Differences between the Manning Equation, the Slope Area method will be determined and where necessary an average value used to extend the rating. The rating will be given an appropriate quality code to indicate that it has been extrapolated.

6.1.2 Rainfall Gauging Station

Rain gauges will be installed to the Bureau of Meteorology’s Observation Specification No. 2013.1 – “Guidelines for the Siting and Exposure of Meteorological Instrumentation and Observing Facilities.” All sites will be raised approximately 600mm above ground level to overcome site conditions.

New Rain Gauge Sites

Some rain gauge sites will be installed as standalone sites. A Rimco 7499 Rain Gauge will be installed, with a BNR gauge cabinet (500mm x 500mm x 200mm). These are similar to those which have been installed around the Strathbogie Ranges, as shown below in Figure 16.

The rain gauge will be elevated on a small pipe to meet BOM 1:2 exposure ratio. Open sites were selected away from overhanging branches or close to structures that influence results. A small cabinet will be placed near the rain gauge

and the solar panel and antenna will be mounted on this. This installation method leaves a minimal footprint and disturbance. Installation at a rain gauge site will include the following:

- Rimco Rain Gauge on 1m podium.
- HydroSpider 2 Logger.
- BNR stainless steel cabinet.
- Telemetry - Intercel 4G or Unidata Satellite modem (if no mobile coverage at additional charge) and antenna.
- 20 Watt Solar Panel and 21Ah battery.
- Mast for Antenna and solar panel.

Before and after photographs of the site will be taken to demonstrate that a minimal environmental impact resulted during installation.

Figure 16 Rain gauge installation at Strathbogie Ranges



6.1.3 Commissioning & Handover

Commissioning Telemetry

Telemetry commissioning will be dependent on the logger type. Campbells will be used for the level sites and Halytech HydroSpiders for the rainfall sites. For each logger type the first step in commissioning telemetry is to ensure that a SIM card (supplied by DELWP) with a Telstra network connection is fitted. For the Campbells set up this is in a modem, with the Halytech set up, this is inside the logger itself.

The system is switched on and a check is made to ensure that all connected sensors can be measured and recorded by the logger.

With the Campbells set up, several further checks are performed to ensure that the logger and modem are communicating with each other and with the network. These checks include sending external commands and ensuring that the modem has found the server to send data to. Several program features are used to aide in identifying and

communications issues before leaving site. Once the modem and logger are commissioned, the paperwork is fill out and added to the completion report.

With the Halytech HydroSpider2 system, set up of the communication is done internally in the logger. There is an interface that allows communication with the logger and set up the Modem. A test signal is sent, usually to a mobile phone, to ensure that it is functional. Then a further test is performed to ensure the logger can connect to the FTP server. The Logger will indicate if it was successful. After a successful connection, the paperwork and completion report is filled out.

Training and Handover

All required cables and programs to operate the instrumentation will be provided as part of the handover process. Training will be provided on how to connect to the logger and download all data. Full details, including instrument serial numbers and range of operation will be provided in a final report. It is assumed that telemetry will be integrated into existing systems so that DELWP and partners will have access to the data prior to handover.

Appendix A: Site Locations and Imagery

Figure 17 Location Map & Site Photo - 1. Goulburn River at Molesworth: Streamflow Gauge



Figure 18 Location Map & Site Photo – 2. Yea River confluence with Goulburn River: Streamflow and Rainfall gauges



Figure 19 Location Map & Site Photo - 3. King Parrot Creek at confluence with the Goulburn River: Streamflow and Rainfall gauges



Figure 20 Location Map & Site Photo - 4. Major Creek Upper Catchment: Rainfall gauge



Figure 21 Location Map & Site Photo - 5. Dabyminga and King Parrot Creek Upper Catchment: Rainfall gauge



Figure 22 Location Map & Site Photo - 6. Acheron River and Murrinidindi River Upper Catchment: Rainfall gauge



Figure 23 Location Map & Aerial Map - 7. Rubicon River Upper Catchment: Rainfall gauge



Figure 24 Location Map - 8. Rubicon River Lower Catchment: Rainfall gauge



Figure 25 Location Map - 9. Spring Creek Upper Catchment: Rainfall gauge



Figure 26 Location Map - 10. Murrindindi Upper Catchment: Rainfall gauge



Figure 27 Location Map - 11. Murrindindi River at Murrindindi: Telemetry Only



SEQUANA PARTNERS

Sequana Partners Pty Ltd

E: enquiry@sequana.co

W: www.sequana.co

Sydney

Level 6, 201 Kent Street
Sydney NSW 2000

T: + 61 2 9019 1828

Melbourne

Level 35, 477 Collins Street
Melbourne VIC 3000

T: + 61 3 8688 7140

Brisbane

Level 1/1024 Ann Street
Brisbane QLD 4006

T: + 61 7 3607 6398