WAMBO COAL PTY LTD
2021 ANNUAL REVIEW

1 January – 31 December 2021

Name of operation	Wambo Coal Mine
Name of operator	Wambo Coal Pty Ltd
Development consent /Project Approval #	DA305-7-2003, DA177-8-2004, EPBC 2003/1138, EPBC 2016/7636, EPBC 2016/7816
Name of holder of development consent	Wambo Coal Pty Ltd
Title/Mining lease #	CL365, CL374, CL397, CCL743, ML1402, ML1572, ML1594, ML 1806, A444, EL7211
Name of holder of mining lease	Wambo Coal Pty Ltd
Water licence #	As per **Table 3**
Name of holder of water licence	Wambo Coal Pty Ltd
MOP/RMP start date	1 December 2020
MOP/RMP end date	31 December 2023
Annual Review start date	1 January 2021
Annual Review end date	31 December 2021

I, Peter Jaeger, certify that this audit report is a true and accurate record of the compliance status of Wambo Coal Mine for the period 1 January 2021 to 31 December 2021 and that I am authorised to make this statement on behalf of Wambo Coal Pty Ltd.

Note:

a) *The Annual Review is an 'environmental audit' for the purposes of section 122B(2) of the Environmental Planning and Assessment Act 1979. Section 122E provides that a person must not include false or misleading information (or provide information for inclusion in) an audit report produced to the Minister in connection with an environmental audit if the person knows that the information is false or misleading in a material respect. The maximum penalty is, in the case of a corporation, $1 million and for an individual, $250,000.*

b) *The Crimes Act 1900 contains other offences relating to false and misleading information: section 192G (Intention to defraud by false or misleading statement—maximum penalty 5 years imprisonment); sections 307A, 307B and 307C (False or misleading applications/information/documents—maximum penalty 2 years imprisonment or $22,000, or both).*

Name of authorised reporting officer	Peter Jaeger
Title of authorised reporting officer	Manager: Environment & Community
Signature of authorised reporting officer	
Date	31/3/22

Statement of Compliance

Were all conditions of the relevant approval(s) complied with?	
EPL529	No
DA305-7-2003	No
DA177-8-2004	Yes
EPBC 2003/1138	Yes
EPBC 2016/7636	Yes
EPBC 2016/7816	Yes
CL365	Yes
CL374	Yes
CL397	Yes
CCL743	Yes
ML1402	Yes
ML1572	Yes
ML1594	Yes
ML1806	Yes
A444	Yes
EL7211	Yes
Water licences (as per **Table 3**)	Yes

Compliance Status Key

Risk Level	Colour Code	Description
High	Non-compliant	Non-compliance with potential for significant environmental consequences, regardless of the likelihood of occurrence.
Medium	Non-compliant	Non-compliance with: • potential for serious environmental consequences, but is unlikely to occur; or • potential for moderate environmental consequences, but is likely to occur.
Low	Non-compliant	Non-compliance with: • potential for moderate environmental consequences, but is unlikely to occur; or • potential for low environmental consequences, but is likely to occur.
Administrative non-compliance	Non-compliant	Only to be applied where the non-compliance does not result in any risk of environmental harm (e.g. submitting a report to government later than required under approval conditions).

Non-Compliances

Relevant Approval	Condition #	Condition Description (summary)	Compliance Status	Comment	Where addressed in Annual Review
DA305-7-2003	B45	Air Quality Operating Conditions	Non-compliant	Continuous air quality data was not recorded due to technical and environmental factors that resulted in a loss of power or data.	Section 10.1
Environment Protection Licence 529	M2.2	Air Monitoring Requirements			
Environment Protection Licence 529	M2.3	Surface Water Sampling Requirements	Non-compliant	Representative surface water samples were not collected monthly due to dry conditions or unsafe access.	Section 10.2
DA305-7-2003	B66	Performance Indicators	Non-compliant	Exceedance of groundwater performance indicators at one location.	Section 10.3
DA305-7-2003	B55	Discharge Limits	Non-Compliant	TSS levels exceeded the HRSTS discharge limit.	Section 10.4
Environment Protection Licence 529	L2.1	Concentration Limits at Discharge Point			
DA305-7-2003	B54	Pollution of Waters	Non-Complaint	Floodwaters from Wollombi Brook inundated a sediment control sump at Hales Crossing resulting in release from the Hales Crossing Sump.	Section 10.5
Environment Protection Licence 529	L1.1				

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FIGURES

APPENDICES

1.0 Introduction

The Wambo Coal Mine (the Mine) is situated approximately 15 kilometres (km) west of Singleton, near the village of Warkworth, New South Wales (NSW) (**Figure 1**). The Mine is owned and operated by Wambo Coal Pty Limited (WCPL), a subsidiary of Peabody Energy Australia Pty Limited.

A range of open cut and underground mine operations have been conducted at the Mine since mining operations commenced in 1969. Mining under the current Development Consent (DA305-7-2003) commenced in 2004 and permitted both open cut and underground operations and associated activities to be conducted. The approved run-of-mine (ROM) coal production rate is 14.7 million tonnes per annum and all product coal is transported from the Mine by rail.

Operations at the Mine also include a rail spur and loop, coal reclaim and rail loading facility for the Wambo Coal Terminal under Development Consent (DA177-8-2004) which was granted in 2004.

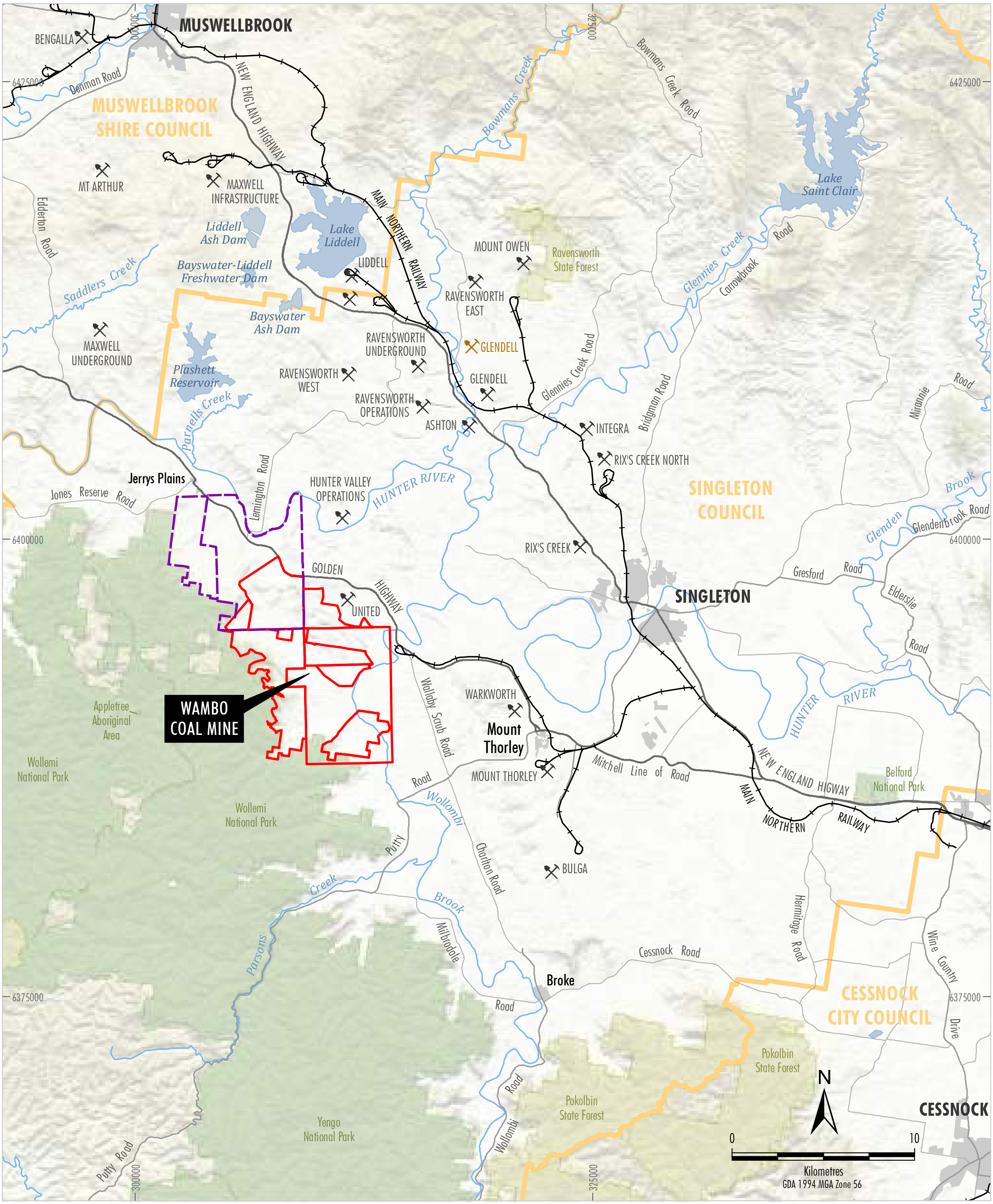
MOD 16 to (DA305-7-2003) was approved by the Independent Planning Commission of NSW on 29 August 2019 and required development at the Mine to be undertaken in the following stages:

- Phase 1 – open cut mining operations at Wambo open cut mine, underground mining operations at Wambo underground mine and the operation of Wambo mine infrastructure (including minor upgrades to this infrastructure) under DA305-7-2003.
- Phase 2 – underground mining operations at Wambo underground mine, the operation of Wambo mine infrastructure under DA305-7-2003 and associated surface infrastructure.
- Phase 3 – following the cessation of underground mining operations that includes mine closure.

Phase 2 commenced on 1 December 2020, and open cut operations are now covered under SSD 7142. Operations under Development Consent DA177-8-2004 have not changed following the commencement of Phase 2.

Upon the commencement of Phase 2 under DA305-7-2003 (MOD 16), WCPL and United Collieries Pty Limited (United) (owned 95 per cent by Abelshore Pty Limited, a wholly owned subsidiary of Glencore Coal Pty Limited [Glencore] and 5 per cent by the Construction, Forestry, Mining and Energy Union [CFMEU]) entered into a 50:50 Joint Venture at the open cut mine. United manages Joint Venture tenements (i.e. open cut operations), and WCPL continues to operate underground mining operations.

Figure 2 shows the approved Mine layout including mining lease boundaries, current operational disturbance footprint and Remnant Woodland Enhancement Areas (RWEAs) for Phase 2. **Figure 3** shows the approved Mine longwall layout for Phase 2.



LEGEND
- Mining and Coal Lease Boundary (ML, CL, CCL)
- Exploration Licence Boundary (AUTH, EL)
- Local Government Area
- National Parks and Wildlife Estate
- State Forest
- Mining Operation
- Proposed Mining Operations (Application Lodged)

Source: NSW Spatial Services (2021)

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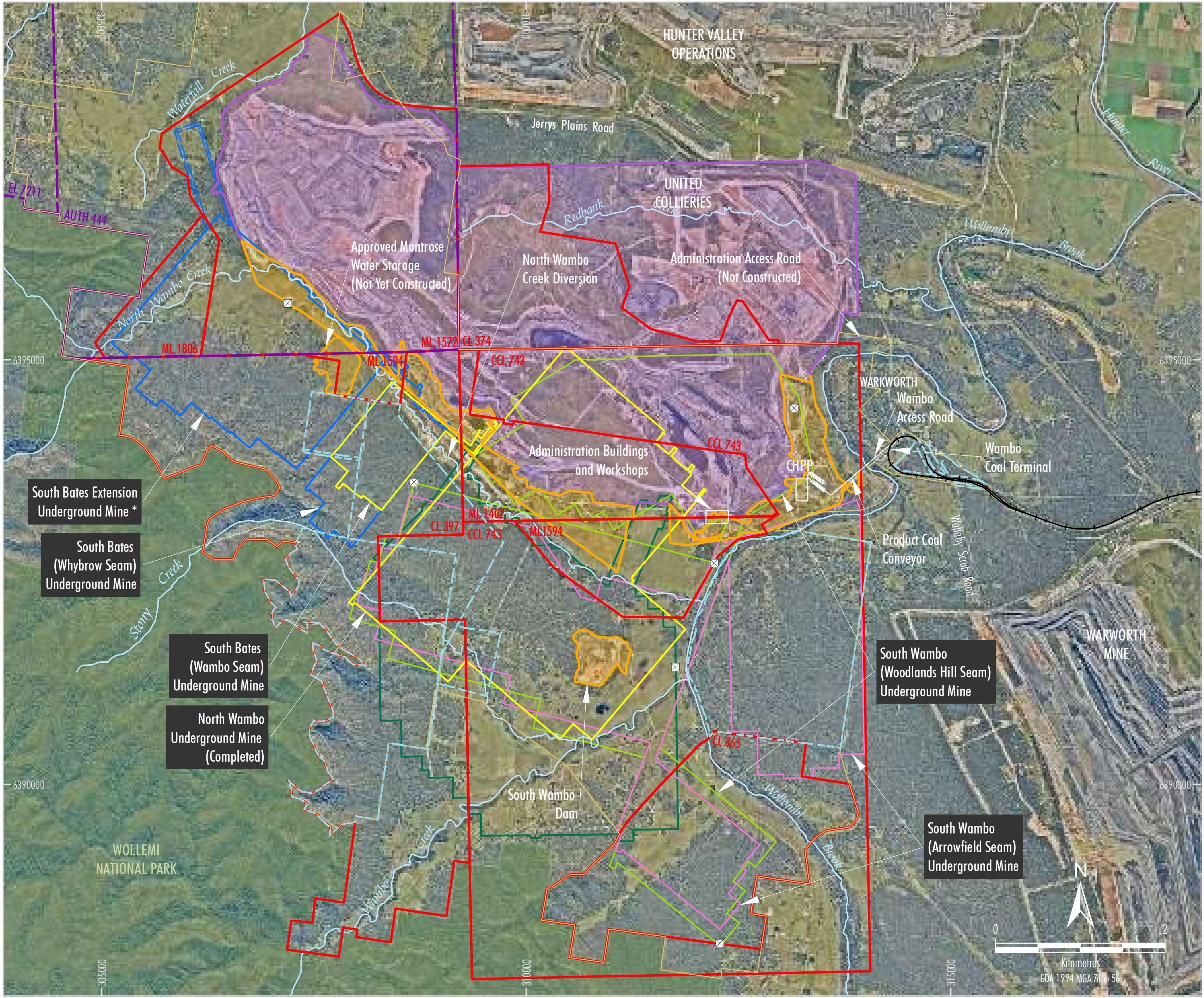
WAMBO COAL MINE
Regional Location

Figure 1



WAM-09-15 AR 2021_204B

LEGEND

- National Park
- WCPL Owned Land
- Exploration Licence Boundary (AUTH, EL)
- Mining and Coal Lease Boundary (ML, CL, CCL)
- Remnant Woodland Enhancement Program (RWEP) Area
- SSD 7142 Operational Area #
- Existing/Approved Surface Development Area (Phase 2)
- Ventilation Shaft

Approved Underground Mining Areas

- Whybrow Seam*
- Whybrow Seam (First Workings only)
- Wambo Seam
- Woodlands Hill
- Arrowfield Seam
- Previous Underground Workings in Whybrow Seam

Under Phase 2 of mining at Wambo Coal Mine (commenced 1 December 2020), this area is operated by United Colleries Pty Ltd under the United Wambo Joint Venture Project.

* Approved underground development as per South Bates Extension Underground Mine Modification Environmental Assessment. The actual longwall layouts may include minor revisions but are contained within this boundary.

Source: WCPL (2022); NSW Spatial Services (2022)
Orthophoto: WCPL (April 2021)

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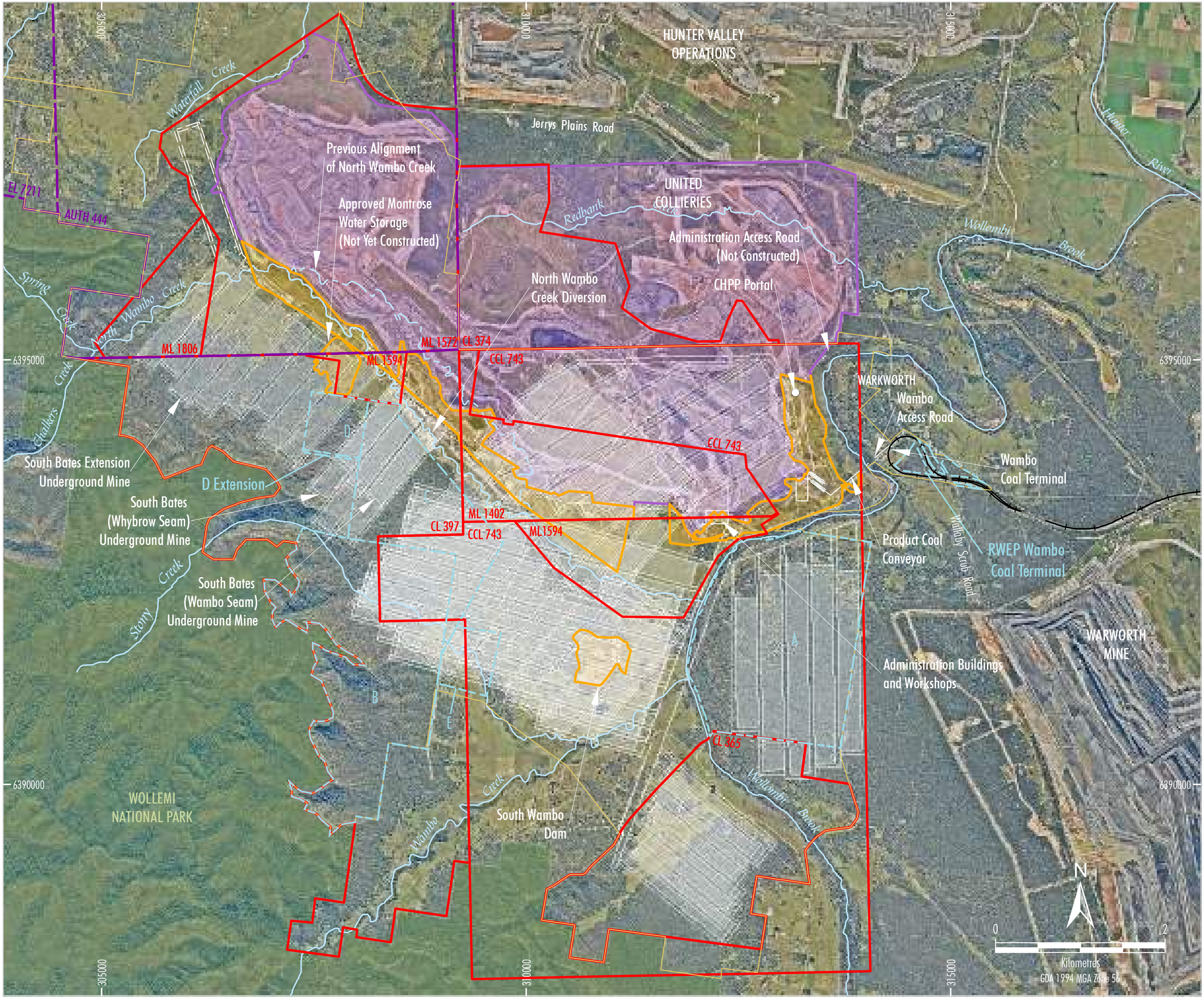
WAMBO COAL MINE

Approved Wambo Coal Mine General Arrangement

Figure 2



LEGEND

- National Park
- WCPL Owned Land
- Exploration Licence Boundary (AUTH, EL)
- Mining and Coal Lease Boundary (ML, CL, CCL)
- Remnant Woodland Enhancement Program (RWEP) Area
- SSD 7142 Operational Area #
- Existing/Approved Surface Development Area (Phase 2)
- Approved Underground Mining Area
- Approved Underground Mining Area (First Workings only)

Under Phase 2 of mining at Wambo Coal Mine (commenced 1 December 2020), this area is operated by United Colleries Pty Ltd under the United Wambo Joint Venture Project.

Source: WCPL (2022); NSW Spatial Services (2022)
Orthophoto: WCPL (April 2021))

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W A M B O   C O A L   M I N E

Approved Wambo Coal Mine Layout

Figure 3

WAM-09-15 AR 2021_205A

This Annual Review details WCPL's environmental and community performance for the reporting period 1 January 2021 – 31 December 2021. This Annual Review has been prepared in accordance with the NSW Department of Planning and Environment's (DPE) *Post-approval requirements for State significant mining developments – Annual Review Guideline – October 2015* (DPE 2015) and WCPL's statutory approvals (**Section 2.1**).

The Annual Review is not intended to be an exhaustive description of WCPL's operations, approvals and activities rather it is a summary of WCPL's compliance status with respect to WCPL's statutory approvals.

This Annual Review is distributed to a range of stakeholders including government authorities, Singleton Council and members of the WCPL Community Consultative Committee (CCC). A copy of the Annual Review will be made available on the Peabody Energy website (www.peabodyenergy.com).

1.1 Mine Contacts

The contact details of key WCPL personnel who are responsible for the environmental management of the Mine are listed in **Table 1**.

Table 1: Contact Details of Key WCPL Personnel

Name	Role	Phone No.
Michael Alexander	Director Projects & Portfolio Management	(02) 6570 2361
Peter Jaeger	Manager: Environment and Community	(02) 6570 2209

2.0 Approvals

2.1 Current Approvals

WCPL has a number of statutory approvals, leases and licences that regulate activities at the Mine (**Table 2** and **Table 3**). Conditions from WCPL's approvals that specifically relate to this Annual Review are detailed in **Appendix A.**

Table 2: WCPL's Statutory Approvals

Type	Description	Issued By[1]	Issue Date	Expiry Date
Development Consent	DA305-7-2003[2]	DPE	4/02/2004	31/12/2042
Development Consent	DA177-8-2004[3]	DPE	16/12/2004	16/12/2025
EPBC Approval[4]	EPBC 2003/1138	DAWE	23/11/2004	31/12/2029
EPBC Approval[4]	EPBC 2016/7636	DAWE	30/4/2017	1/3/2037
EPBC Approval[4]	EPBC 2016/7816	DAWE	4/5/2018	31/12/2039
Mining Lease	ML1402[5]	MEG	23/09/1996	14/08/2022
Mining Lease	ML1572	MEG	21/12/2005	20/12/2026
Mining Lease	ML1594	MEG	1/05/2007	30/04/2028
Mining Lease	ML1806	MEG	11/08/2020	11/08/2041
Consolidated Coal Lease	CCL743[5]	MEG	9/03/1990	14/08/2022
Coal Lease	CL365	MEG	19/09/1990	19/09/2032
Coal Lease	CL374	MEG	6/12/1991	21/03/2026
Coal Lease	CL397	MEG	4/06/1992	4/06/2034
Exploration Licence	A444[5, 6, 7]	MEG	4/10/2007	16/05/2021
Exploration Licence	EL7211[8]	MEG	29/09/2008	29/09/2026
Environment Protection Licence	EPL529	EPA	4/02/2021	-
S101 Approval[9]	Approval to discontinue use of the North East Tailings Dam (NETD)	MEG	3/09/2009	-

1. DAWE = Commonwealth Department of Agriculture, Water and the Environment, MEG = Mining, Exploration and Geosciences, EPA = NSW Environment Protection Authority.
2. DA305-7-2003 has been modified 17 times since the original approval was granted in 2004. One modification application was withdrawn subsequent to WCPL submitting the application. The latest modification (MOD18), for the South Bates Extension Underground Mine First Workings was granted approval in January 2022.
3. DA177-8-2004 has been modified three times since the original approval was granted in 2004. The last modification (MOD3), for the United Wambo Joint Venture (UWJV), was granted approval in August 2019.
4. EPBC = *Environment Protection and Biodiversity Conservation Act 1999.*
5. At the time of preparing this Annual Review, a renewal application was still pending.
6. A444 is an Authority to Prospect granted under the *Coal Mining Act 1973* and is deemed to be an Exploration Licence for the purposes of the *Mining Act 1992*.
7. A444 is managed by United.
8. EL7211 is managed by United.
9. Section 101 of the *Coal Mine Health and Safety Act 2002.*

Table 3: WCPL's Water Licences

Licence Number[1]	Description	Expiry Date	Entitlement	Category	Access Licence	Nominated Water Supply Work Approval	Expiry Date
Hunter Regulated River Water Source							
WAL 718 (20SL060212)	Hunter River Pump	Perpetuity	1,000 unit shares (high security)	Regulated River (high security)	20AL200631	20WA200632	30/06/2027
WAL 8599 (20SL061206)	Hunter River Pump	Perpetuity	6 unit shares (high security)	Regulated River (high security)	20AL201457	20CA201459	25/09/2028
WAL 8600 (20SL061206)	Hunter River Pump	Perpetuity	868 unit shares (general security)	Regulated River (general security)	20AL201458	20CA201459	25/09/2028
WAL 43299	TBC (extraction via Hunter River pump)	Perpetuity	80 units (general security)	Regulated River (general security)	20AL220689	-	-
WAL 8604 (20BL061206)	Hunter River Pump	Perpetuity	240 unit shares (supplementary water)	Supplementary Water	20AL203044	20CA201459	25/09/2028
Hunter Regulated River Water Source – Shared with United Colliery							
WAL 929 (20SL050661)	Other Pump	Perpetuity	3 unit shares	Domestic and Stock	20AL201147 (NOW Reference Number)	20WA201148	06/12/2027
WAL 1369 (20SL060416)	80 mm CP	Perpetuity	15 unit shares (supplementary water)	Supplementary Water	20AL203071 20AL204246 20AL204247	20CA201654	30/11/2028
WAL 15459 (20SL204246)	80 mm CP	Perpetuity	21 unit shares (general security)	Regulated River (general security)	20AL204246	20CA201654	30/11/2028
Hunter Unregulated and Alluvial Water Sources (Lower Wollombi Brook Water Source)							
WAL 18437 (20SL033872)	Wollombi Brook Pump	Perpetuity	350 unit shares	Unregulated River	20AL208641	20WA208642	31/07/2022
WAL 23897 (20BL167737)	Well No. 2	Perpetuity	70 unit shares	Aquifer	20AL211371	20WA211372	31/07/2022

Licence Number[1]	Description	Expiry Date	Entitlement	Category	Access Licence	Nominated Water Supply Work Approval	Expiry Date
North Coast Fractured and Porous Rock Groundwater Sources (Sydney Basin – North Coast Groundwater Source)							
WAL 42373[2]	-	Perpetuity	1,549 unit shares	Aquifer	20AL219997	20MW065010	-
WAL 41532 (20BL172156)	Dewatering	Perpetuity	98 unit shares	Aquifer	20AL218994	20MW065010	-
20BL168997	Piezometer	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL168998	Piezometer	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL168999	Piezometer	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL169000	Piezometer	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL170638	Piezometer	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL172237	Monitoring Bore (GW14, GW18, GW21)	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL172238	Monitoring Bore (GW12)	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL172240	Monitoring Bore (GW15)	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL172242	Monitoring Bore (GW16, GW17)	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL172244	Monitoring Bore (GW20)	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL172255	Monitoring Bore (GW22)	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL172256	Monitoring Bore (GW13)	Perpetuity	Groundwater monitoring	NA	-	-	-

Licence Number[1]	Description	Expiry Date	Entitlement	Category	Access Licence	Nominated Water Supply Work Approval	Expiry Date
20BL172257	Monitoring Bore (GW19)	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL172332	Piezometer	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL173290	Monitoring Bore	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL173291	Monitoring Bore	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL173292	Monitoring Bore	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL173293	Monitoring Bore	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL173946	Monitoring	Perpetuity	Groundwater monitoring	NA	-	-	-
20BL173999	Monitoring Bore	Perpetuity	Groundwater monitoring	NA	-	-	5/12/2023
-	Bore	Perpetuity	Stock	Basic Rights	-	20WA214848	-
-	Bore	Perpetuity	Stock	Basic Rights	-	20WA214849	-
-	Bore	Perpetuity	Stock	Basic Rights	-	20WA214850	-
-	Bore	Perpetuity	Stock	Basic Rights	-	20WA214851	-
-	Spearpoints	Perpetuity	Stock/Domestic	Basic Rights	-	20WA215574	-

WAL = water access licence; mm = millimetres.

1. 20BL prefix bore licences with allocations have been replaced with WALs.
2. WAL 42373 was issued in 2019 to consolidate six of WCPL's previous WALs under the North Coast Fractured and Porous Rock groundwater Sources (Sydney Basin – North Coast Groundwater Source) including WAL 39735, WAL 39738, WAL 39803, WAL 41494, WAL 41528 and WAL 41520.

2.2 Changes to Approvals

During the reporting period, the following changes were made to WCPL's approvals:

- DA305-7-2003 – WCPL lodged an application to modify DA305-7-2003 under section 4.55(1A) of the EP&A Act to allow for development of first workings associated with a reoriented Longwall 24 within Mining ML1572 and ML1806 with the DPE on 26 November 2021. This modification application was determined on 25 January 2022.
- Environmental Protection Licence (EPL) 529 – was varied on 4 February 2021 and 30 September 2021.
- Extraction Plan for South Bates Extension Underground Mine Longwalls 21 to 24 – was submitted to the DPE in July 2020 and was approved in April 2021. In June 2021, WCPL advised DPIE that longwalls 22 to 24 were to be shortened in accordance with Schedule 2, Condition A2 of DA305-7-2003 due to the presence of faulting. DPE approved the shortened longwalls on 2 September 2021. The main report and figures of the Extraction Plan have been revised to reflect the shortened longwall panels (Version D, January 2022).
- EL 7211 – was renewed on 3 December 2021 with an extended expiry date on 29 September 2026.
- ML1402 and CCL743 – applications were made to renew ML1402 and CCL743 in July 2021. At the time of preparing this Annual Review, the applications are still pending.

2.3 Environmental Management System

WCPL operates an Environmental Management System to manage compliance and advance continual improvement across the Mine. A summary of the status of required management plans is presented in **Table 4**.

In accordance with Schedule 2, Condition D15(a) of DA305-7-2003, copies of these management plans have been made available to the public on the Peabody Energy website https://www.peabodyenergy.com/Operations/Australia-Mining/New-South-Wales-Mining/Wambo-Approvals,-Plans-Reports.

In accordance with Schedule 2, Condition D6 of DA305-7-2003, WCPL will review the strategies, plans and programs required under DA305-7-2003 within three months of the submission of this Annual Review to relevant government regulators. If necessary, the strategies, plans and programs required under this consent must be revised, and submitted to the Planning Secretary for approval within six weeks of the review in accordance with Schedule 2, Condition D7 of DA305-7-2003

Table 4: Status of WCPL's Environmental Management Plans

Management Plan	Status	Approved Version[1]
North Wambo Underground Extraction Plan for Longwalls 8 to 10A (and associated component plans)	Approved – 2015	April 2015
South Bates Underground Mine Extraction Plan for Longwalls 11 to 16 (and associated component plans)	Approved – 2017	July 2017[2]
South Bates Extension Underground Mine Extraction Plan for Longwalls 17 to 20 (and associated component plans)	Approved – 2019	Revision C (June 2019)[3]
South Bates Extension Underground Mine Extraction Plan for Longwalls 21 to 24 (and associated component plans)	Approved – 2022	Revision B (January 2021)
MOP/RMP	Approved – 2020	MOP December 2020-December 2023 (Nov 2020)
Environmental Management Strategy	Approved – 2020	Version 7 (Nov 2020)
Air Quality & Greenhouse Gas Management Plan	Approved – 2020	Version 8 (Nov 2020)
Noise Management Plan	Approved – 2020	Version 11 (Nov 2020)
Water Management Plan	Approved – 2020	Version 2 (Nov 2020)
Groundwater Management Plan	Approved – 2022	Version 4 (Dec 2021)
Surface Water Management Plan	Approved – 2020	Version 2 (Nov 2020)
United Wambo and Wambo Site Water Balance	Approved – 2020	Version 2 (Aug 2020)
United Wambo and Wambo Water Monitoring Plan	Approved – 2022	Version 4 (Dec 2021)
Erosion and Sediment Control Plan	Approved – 2021	Version 4 (Nov 2021)
Biodiversity Management Plan (previously the Flora and Fauna Management Plan)	Approved – 2021	Version 4 (Dec 2021)
Heritage Management Plan	Approved – 2018	Version 5 (July 2018)
Wambo Homestead Complex Conservation Management Plan	Approved – 2019	Version 6 (May 2019)
Pollution and Incident Response Management Plan	Current	Version 5 (May 2021)

1. Approved version as at the end of the reporting period.
2. On 11 October 2017, DPE approved the South Bates Underground Mine Longwalls 11 to 16 Extraction Plan with the exception of the Site Water Management Plan (and associated component plans), which were unable to be approved until they were updated in consultation with Department of Industry – Water (DI-Water) (now Department of Primary Industries and Environment – Water [DPIE-Water]). In 2018, the South Bates Extension Underground Mine Longwalls 17 to 20 Extraction Plan (including the Site Water Management Plan which had been updated in consultation with DPIE-Water was approved by DPE.
3. On 4 September 2018, WCPL provided DPE with correspondence explaining that geological structures had been encountered that may require changes to the main headings and finishing ends of Longwalls 18, 19 and 20. Accordingly, WCPL requested that DPE approve the Extraction Plan for Longwalls 17 to 20 for extraction of Longwall 17 only. On 7 September 2018, DPE approved the extraction of Longwall 17 only, on the basis that WCPL would prepare an amended Extraction Plan for Longwalls 18, 19 and 20. On 1 March 2019, WCPL submitted an amended Extraction Plan for Longwalls 17 to 20. DPE approved the amended Extraction Plan on 4 June 2019.

3.0 Operations Summary

3.1 2021 Mining Operations

The Mine operates seven days a week, 24 hours a day on a rotating shift basis.

During the reporting period, the following mining operations were undertaken at the South Bates Extension Underground Mine (current longwall mining area):

- Longwall 20 (completed March 2021); and
- Longwall 21 (commenced April 2021).

Table 5 shows the production summary for 2021, compared to the production for 2020 and the forecast production for 2021 and 2022.

Following the commencement of Phase 2 operations on 1 December 2020, production material (including waste rock/overburden, ROM coal/ore, coarse/fine reject and saleable product) from open-cut operations is covered under SSD 7142.

Table 5: Production Summary

<table>
<tr><th>Material</th><th>Unit</th><th>Approved limit</th><th>2020 reporting period (actual)</th><th>2021 reporting period (forecast)[3]</th><th>2021 reporting period (actual)[3]</th><th>2022 reporting period (forecast)[3]</th></tr>
<tr><td colspan="7">Wambo Coal Mine</td></tr>
<tr><td>Waste Rock/ Overburden</td><td>bcm</td><td>-</td><td>33,313,464</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>ROM Coal/ Ore</td><td>Mt</td><td>14.7[1]</td><td>7.0</td><td>1.9</td><td>2.1</td><td>1.7</td></tr>
<tr><td>Coarse Reject</td><td>Mt</td><td>-</td><td>1.37</td><td>1.20</td><td>1.49</td><td>1.21</td></tr>
<tr><td>Fine Reject (Tailings)</td><td>Mt</td><td>-</td><td>0.97</td><td>0.91</td><td>0.60</td><td>0.55</td></tr>
<tr><td colspan="7">Wambo Coal Terminal</td></tr>
<tr><td>Saleable Product – Mine</td><td rowspan="2">Mt</td><td rowspan="2">15[2]</td><td rowspan="2">4.6</td><td>1.4</td><td>1.5</td><td rowspan="2">6.5</td></tr>
<tr><td>Saleable Product – UWJV</td><td>Not Provided</td><td>4.1</td></tr>
</table>

Note: bcm = bank cubic metres, Mt = million tonnes.

1 DA305-7-2003, Condition A16, Schedule 2.

2 DA177-8-2004, Condition A8, Schedule 1. Refers to product coal transported off-site.

3 Under Phase 2 of the UWJV, open cut operations are undertaken by United.

During the reporting period, the ROM coal production at the Mine (2.1 Mt) was slightly higher than the forecast ROM coal production (1.9 Mt). Saleable product coal from the Mine (1.5 Mt) was similarly slightly higher than forecast (1.4 Mt).

No overburden production occurred at the Mine as forecast.

During the reporting period, a total of 5.6 Mt of product coal was transported off-site via rail (no coal was hauled off-site by trucks). A summary of 2021 daily train movements, required by Schedule 2, Condition B29(b) of DA177-8-2004 is provided in **Appendix B**.

The maximum daily train movements on any one day was eight or less in accordance with Condition A12, Schedule 2 of DA177-8-2004A9 (**Appendix B**).

Figure 4 shows the amount of saleable product coal transported off-site on a weekly basis.

Figure 4: Coal Transported Off-site during the Reporting Period

A total of 633 trains were loaded during the reporting period with 69 trains loaded on Friday evening (between 6 pm to 9 pm) and Sunday morning (between 9 am to 12 am). In accordance with Schedule 2, Condition A12 of DA177-8-2004, WCPL took all reasonable steps to minimise train movements within these hours.

3.2 Next Reporting Period

Operations during the next reporting period will be undertaken in accordance with the approved relevant Extraction Plan and will include continued mining at the South Bates Extension Underground Mine, including:

- Longwall 21 (commenced April 2021); and
- Longwall 22 (anticipated to commence in April 2022).

4.0 Actions Required from Previous Annual Review

A number of actions and improvements have been identified in the 2020 Annual Review undertaken by WCPL. Actions and improvements recommended in the 2020 Annual Review and their current status are summarised in **Table 6**. In addition, further information/actions requested by DPE in relation to the 2020 Annual Review are also addressed in **Table 6**.

Table 6: Actions from Previous Annual Review

Action/Improvement required from previous Annual Review	Requested by	Action taken by the Operator	Where Discussed in Annual Review
Undertake scheduled remediation and rehabilitation works on the Kharlibe property would be undertaken during the reporting period.	WCPL	Complete Remediation and rehabilitation works completed across the Kharlibe property in March 2021.	Section 5.9.3
Re-erection/replacement of the fallen three nest boxes would undertake during the reporting period.	WCPL	Ongoing Nest boxes scheduled to be replaced during the next reporting period.	Section 5.6.4
Review of blast data and assess cracking of concrete water tank on neighbouring property by Structural Engineer during the reporting period.	WCPL	Complete Report provided to the landowner of the neighbouring property on the 4 March 2021.	Section 5.2.2
Conduct a preliminary investigation in to the surface water quality (pH) results recorded at SW02.	WCPL	Complete Investigation concluded the natural variation was the cause of the pH levels at SW02.	Section 6.1.2
Review flows observed at FM13 and FM15.	WCPL	Complete Investigation concluded that the discrepancies between the flows were largely attributed to the influence of sub--daily rainfall patterns not captured in the site rainfall gauge and were not attributed to the mining operations.	Section 6.1.2
Investigate a better method for capturing extraordinary events impacting air quality during the reporting period.	WCPL	Complete WCPL investigated methods for capturing extraordinary events impacting air quality this with an air quality specialist and it was determined that the current industry practice implemented at site will continue.	Section 5.3
Undertake planned 2021 NWCD rehabilitation and maintenance works.	WCPL	Ongoing Repair and maintenance work conducted in 2021 and will continue in next reporting period.	Sections 5.6.4 and 7.2
Implement ongoing groundwater model updates.	WCPL	Ongoing SLR has been commissioned to update the existing groundwater model.	Section 6.2.3

Table 6: Actions from Previous Annual Review (continued)

Action/Improvement required from previous Annual Review	Requested by	Action taken by the Operator	Where discussed in Annual Review
Investigate GW15 in order to determine whether the accurate groundwater level of the bores in the surrounding aquifers and whether the low groundwater level noted are related to the Mine.	WCPL	Ongoing WCPL is continuing an investigation into the observed groundwater levels at GW15 (including consideration of revised trigger levels based on the updated groundwater model).	Section 6.2.3
A HRSTS system audit will be undertaken if discharges through the HRSTS occur during the next reporting period.	WCPL	Complete Discharges through the HRSTS system occurred during the reporting period and an audit completed.	Section 6.3
Report the maximum daily train loading in the Annual Review.	DPE	Complete. Daily train movements from 1 January to 31 December 2021 are included in this Annual Review.	Section 3.1 and Appendix B
Evaluate and report on the effectiveness of the noise and air quality management systems in the Annual Review.	DPE	Complete An evaluation on the effectiveness of the noise and air quality management systems in included in this Annual Review.	Sections 5.1.2 and 5.3.2
Report on the variance from the EIS predictions for greenhouse gas emissions from diesel and electrical power sources in the Annual Review.	DPE	Complete The variance from the EIS predictions for greenhouse gas emissions from diesel and electrical power sources explained in this Annual Review.	Sections 5.4.2 and 5.4.3
Report on greenhouse gas monitoring and abatement measures in the Annual Review.	DPE	Complete Greenhouse gas monitoring and abatement measures are reported in this Annual Review.	Section 5.4.4
Report on the effectiveness of waste minimisation in the Annual Review.	DPE	Complete The effectiveness of waste minimisation is reported in this Annual Review.	Section 5.11
Report on compliance with water performance measures in the Annual Review.	DPE	Complete Compliance with water performance measures is reported in this Annual Review.	Section 6.1 and 6.2
Report trends of surface water monitoring results and predictions to identify any discrepancies between the predicted and actual impacts of the development and analyse the potential cause of any significance discrepancies in the Annual Review.	DPE	Complete Trends of surface water monitoring results and predictions to identify any discrepancies between the predicted and actual impacts of the development and analyse the potential cause of any significance discrepancies are reported in this Annual Review.	Section 6.1.3
Report on compliance with volumetric and water quality limits.	DPE	Complete Compliance with water volumetric and water quality limits is reported in this Annual Review.	Section 6.3.1

5.0 Environmental Performance

5.1 Noise

Noise Impact Assessment Criteria for the Mine are defined in Table 4 of DA305-7-2003 (Schedule 2, Condition B13 and B14) and in EPL529 (Condition L5). Additional noise conditions relating to land acquisition, operating hours, rail noise, noise monitoring and the WCPL Noise Management Plan (NMP) are also detailed in these approval documents.

Global Acoustics (2022) prepared an annual noise monitoring report for the Mine and is presented in **Appendix C**.

5.1.1 Approval Criteria/EIS Predictions and Management Plan Requirements

A summary of the relevant approval criteria for noise in relation to sensitive receivers is included in **Table 7**.

Table 7: Impact Assessment Criteria for Noise DA305-7-2003 (Phase 2 Operations)

Noise Assessment Area	Receiver	Applicable Noise Impact Assessment Criteria			
		Day $L_{Aeq,15minute}$ (dB)	Evening/Night $L_{Aeq,15minute}$ (dB)	Night $L_{Aeq,15minute}$ (dB)	Night $L_{A1,1minute}$ (dB)
Area 1 – North Bulga	R003	38	38	38	48
	R007	37	37	37	47
	R379 (previously 91)	37	37	37	47
	All other privately-owned residences	35	35	35	5
Area 2 – South Wambo	R025	39	39	39	49
	R035a	37	37	37	47
	All other privately-owned residences	35	35	35	45
Area 3 Warkworth Village	R019	59	59	59	69
	All other privately-owned residences	44	44	43	53
All other areas	All other privately-owned residences	35	35	35	45

The noise impact assessment criteria in DA305-7-2003 did not apply under meteorological conditions of:

1. *The noise criteria in condition B12 are to apply under all meteorological conditions except the following:*
    a. *where 3°C/100 metres (m) lapse rates have been assessed, then:*
        i. *wind speeds greater than 3 metres per second (m/s) measured at 10 m above ground level;*
        ii. *temperature inversion conditions between 1.5°C/100 m and 3°C/100 m and wind speeds greater than 2m/s measured at 10 m above ground level; or*
        iii. *temperature inversion conditions greater than 3°C/100 m.*

b. where Pasquill Stability Classes have been assessed, then:

i. wind speeds greater than 3m/s at 10m above ground level;

ii. stability category F temperature inversion conditions and wind speeds greater than 2m/s at 10m above ground level;

iii. stability category G temperature inversion conditions.

Condition L5.1 of EPL529 includes similar noise emission limits to those identified in DA305-7-2003 for Phase 1 operations. Conditions L5.5 and L5.6 of EPL529 specify that the noise emission limits identified in Condition L5.1 do not apply under meteorological conditions of:

- wind speeds greater than 3 m/s at 10 m above the ground level; and/or
- temperature inversion conditions of greater than 3°C/100 m and wind speeds greater than 2 m/s at 10 m above the ground.

Note, the noise criteria in EPL529 have not been updated to reflect Phase 2 of operations, therefore, the noise criteria in the Development Consent (DA305-7-2003) (which is now more conservative than those in EPL529) have been used to assess compliance in 2021.

As lapse rates were not measured directly, meteorological conditions have been assessed against the Pasquill Stability Classes detailed in Condition 1(b), Appendix 5 of DA305-7-2003.

In addition to the statutory requirements detailed in DA305-7-2003, WCPL is also required to meet additional requirements detailed within the WCPL NMP. These requirements include reporting of monthly attended monitoring results on WCPL's website (or when there is an exceedance of criteria) and provision of results to the WCPL CCC.

5.1.2 Performance during the Reporting Period

The noise monitoring network during the reporting period consisted of five attended noise monitoring locations (two of which were coincident with real time noise monitors). During 2021, attended noise monitoring was undertaken monthly at N01, N16, N20A, N21 and N26. For further detail, refer to the WCPL NMP (**Appendix C**).

Noise levels from the Mine were inaudible at all receivers and WCPL complied with relevant noise criteria during all monitoring conducted during the reporting period (**Appendix C**). More detail is provided in **Appendix C**.

Results of monitoring were published on the WCPL website and details were provided to the WCPL CCC during meetings, in accordance with the WCPL NMP.

In addition, WCPL complied with all operational requirements detailed in the WCPL NMP.

No complaints were received relating to noise during the reporting period (**Section 8**).

WCPL did not receive any written requests for acquisition from the landowners of the land listed in Table 11 of DA305-7-2003 (under former Condition C1, Schedule 2).

Based on the performance of the noise management system outlined above, it is considered that the noise management system is effective.

5.1.2.1 Comparison with UWJV EIS Predictions

Phase 2 operations commenced on 1 December 2020, the Mine now only includes underground mining operations at Wambo underground mine, the operation of Wambo mine infrastructure under DA305-7-2003 and associated surface infrastructure. Open cut operations are now managed by United under SSD 7142.

Subsequently, comparison of measured Mine noise levels against the UWJV EIS noise model predictions (which includes open operations) was not possible (**Appendix C**).

5.1.3 Trends and Key Management Implications

Global Acoustics (2022) considered that noise levels at most monitoring locations increased from 2016 to 2018 as mining operations progressed to the northwest and were initially less shielded. From 2018 to 2020, site noise levels decreased at most monitoring locations, likely due to mining activity being deeper in pit and therefore more shielded from receptors (**Appendix C**).

From 1 December 2020, open-cut mining is no longer undertaken by WCPL; hence noise emissions decreased significantly compared to the previous reporting period (**Appendix C**).

5.1.4 Implemented or Proposed Management Actions

WCPL will continue to implement the noise management measures detailed in the WCPL NMP, including documenting the timing and scale of any operational changes made in response to adverse conditions or noise alarms from monitoring units.

5.2 Blasting

Since the commencement of Phase 2, no blasting associated with open cut operations is allowed at the Mine in accordance with Condition B21 of DA305-7-2003. Blasting activities associated with the UWJV open cut operations are managed by United.

5.2.1 Approval Criteria/EIS Predictions and Management Plan Requirements

DA305-7-2003 and Condition L6 of EPL529 includes blast criteria associated with Phase 1 operations.

5.2.2 Performance during the Reporting Period

No blasting was undertaken at the Mine during the reporting period.

During the previous reporting period (November 2020), a neighbouring landowner requested assistance to repair a cracked concrete water tank. The landowner believed that the water tank had cracked as a result of blasting at the Mine. WCPL engaged a structural engineer to assess damage to the water tank and review relevant blast data. WCPL provided a report to the landowner of the neighbouring property on the 4 March 2021 that concluded that the cracking was not related to the Mine.

5.2.3 Trends and Key Management Implications

No blast-related trends were identified during the reporting period.

5.2.4 Implemented or Proposed Management Actions

No blast-related management actions are proposed in the next reporting period.

5.3 Air Quality

Air quality criteria for the Mine are defined in Table 6 of DA305-7-2003 (Condition B42, Schedule 2) and EPL529 (Condition M2.2). Additional conditions relating to air quality, odour and greenhouse gas emissions, land acquisition, operating conditions and the WCPL Air Quality and Greenhouse Gas Management Plan (AQGGMP) are also detailed in these approval documents.

Jacobs (2022) prepared an annual air quality monitoring report for the Mine and is presented in **Appendix D**.

5.3.1 Approval Criteria/EIS Predictions and Management Plan Requirements

A summary of the approval criteria for air quality applicable during the reporting period is included in **Table 8.**

Table 8: Approval Criteria for Air Quality

Pollutant	Averaging Period	Criterion
Particulate Matter <10 µm (PM_{10})	Annual	[a,c] 25µg/m³
	24 hour	[b] 50 µg/m³
Particulate Matter < 2.5 µm ($PM_{2.5}$)	Annual	[a,c] 8 µg/m³
	24 hour	[b] 25 µg/m³
TSP matter	Annual	[a,c] 90 µg/m³

Note: TSP = total suspended particles, PM_{10} = particulate matter with a diameter less than 10 micrometers, $PM_{2.5}$ = particulate matter with a diameter less than 2.5 micrometers, µg/m³ = micrograms per cubic metre, g/m²/month = grams per square metre per month.

a. Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources).

b. Incremental impact (i.e. incremental increase in concentrations due to the development on its own).

c. Excludes extraordinary events such as bushfires, prescribed burning, dust storms, fire incidents or any other activity agreed by the Planning Secretary.

Following the determination of the UWJV, the appropriate EIS documentation to refer to is the UWJV EIS (Umwelt 2016) in regard to air quality predictions.

A summary of the UWJV EIS predictions for air quality is included in **Section 5.3.2.1**, along with WCPL's performance against these predictions during the reporting period. For more information on the UWJV EIS predictions, refer to the UWJV EIS (Umwelt 2016).

In addition to the statutory requirements detailed in **Table 8**, WCPL is also required to meet additional requirements outlined in the WCPL AQGGMP. These requirements include reporting of greenhouse gas monitoring data in the Annual Review (**Section 5.4**).

5.3.2 Performance during the Reporting Period

Air quality monitoring was undertaken during the reporting period, in accordance with the WCPL AQGGMP.

During the reporting period, WCPL complied with all statutory conditions relating to air quality, excluding continuous data monitoring at AQ04 due to technical and environmental factors that resulted in a loss of power or data. The lapse in continuous monitoring resulted in a non-compliance with Condition B45 of DA305-7-2003 and Condition M2.2 of EPL529 (**Section 10.1**). Notwithstanding, data capturing for the reporting period was above 98%, generally considered acceptable for air quality monitoring networks (**Appendix D**). No known adverse impacts resulted due to the non-compliance.

WCPL complied with all additional air quality requirements detailed in the WCPL AQGGMP.

Noted in DA305-7-2003, determination of compliance against the impact assessment criteria is to exclude "extraordinary events such as bushfires, prescribed burning, dust storms, fire incidents or any other activity agreed by the Planning Secretary". Notwithstanding the above, as no extraordinary events were identified during the reporting period and therefore, the results with and without extraordinary events are the same.

Jacobs (2022) concluded that:

- In relation to PM_{10}:
  - The 24-hour average PM_{10} concentration did not exceed 50 µg/m^3 at any monitoring locations.
  - The annual average PM_{10} concentration did not exceed the 25 µg/m^3 criterion.
  - The monitoring demonstrates compliance with DA 305-7-2003 in terms of particulate matter as PM_{10}.
- In relation to $PM_{2.5}$:
  - The 24-hour average $PM_{2.5}$ concentration did not exceed 25 µg/m^3 at any monitoring locations.
  - The annual average $PM_{2.5}$ concentration did not exceed the 8 µg/m^3 criterion.
  - The monitoring demonstrates compliance with DA 305-7-2003 in terms of particulate matter as $PM_{2.5}$.

No complaints were received regarding air quality, odour or greenhouse gases from the Mine during the reporting period (**Section 8.3**).

WCPL did not receive any written requests for acquisition from the landowners of the land listed in Table 11 of DA305-7-2003 (under former Condition C1, Schedule 2).

There were no other incidents relating to air quality, odour or greenhouse gases during the reporting period.

Based on the performance of the air quality management system outlined above, it is considered that the air quality management system is effective.

5.3.2.1 Comparison with UWJV EIS Predictions

The UWJV EIS (Umwelt 2016) included predicted cumulative TSP, PM_{10} and dust deposition levels for four operational scenarios (Years 2, 6, 11 and 16). These years approximately translate to 2022, 2026, 2031 and 2036. Accordingly, the Year 2 scenario best represents current operations at the Mine.

A summary of the predicted cumulative annual average TSP, PM_{10} and $PM_{2.5}$ levels for the Year 2 and six scenarios at the WCPL air quality monitoring sites assessed in the UWJV EIS (Umwelt 2016) air quality assessment, is provided in **Table 9**. The annual average TSP, PM_{10} and $PM_{2.5}$ levels recorded during the reporting period are also provided in **Table 9**.

Table 9: Comparison of UWJV EIS Predictions and 2021 Monitoring Data – Air Quality

Parameter	UWJV EIS Predictions			2021 Monitoring
	Site	Year 2 (2022)	Year 6 (2026)	
Annual Average TSP ($\mu g/m^3$)[1]	HV01	66	63	62.1
	HV02	51	51	37.9
	HV03	52	51	25.5
	HV04	57	54	40.0
Annual Average PM_{10} ($\mu g/m^3$)	AQ01 (PM01)	34	33	20.5
	AQ02 (PM02)	16	16	12.5
	AQ03 (PM03)	17	16	8.4
	AQ04 (PM04)	22	21	13.2
Annual Average $PM_{2.5}$ ($\mu g/m^3$)	AQ01 (PM06)	6	7	5.5
	AQ03 (PM07)	4	3	3.9

Source: After Umwelt (2016) and Jacobs (2022).

1. TSP is estimated from PM_{10} monitoring data based on the relationship that 33% of TSP is PM_{10}.

The annual average $PM_{2.5}$, PM_{10} and TSP concentrations were below than the relevant predicted cumulative annual average concentrations at all monitoring locations.

5.3.3 Trends and Key Management Implications

There were no air quality, odour or greenhouse gas management implications arising from WCPL's operations for the reporting period.

5.3.3.1 TSP

A study on co-located TSP and PM_{10} monitors conducted in the Hunter Valley by the NSW Minerals Council (2010) indicated that dust generated from predominately coal mining sources has long-term average PM_{10} concentrations that are approximately 40% of the corresponding TSP concentration (or equivalently, TSP concentrations are approximately three times PM_{10} concentrations). This ratio was found to be reasonably accurate for long-term averages (e.g. annual averages).

The long-term average ratio of PM_{10} to TSP over the four co-located monitoring sites at the Mine over a six year period was 33% (or equivalently, TSP concentrations are approximately three times PM_{10} concentrations). Using this ratio, TSP levels during the reporting period were generally lower that those recorded in 2020 with the exception of HV01, as shown in **Table 10** and **Figure 5**. The data shows there was a general increase in recorded TSP levels from 2011 to 2014, with a dip in 2015 and 2016, before increasing again in 2017 and 2018 and then decreasing again in 2019 to 2021.

Table 10: TSP Annual Averages (µg/m3) (2011-2021)

HVAS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
HV01	56.7	64.8	61.0	66.0	54.8	47.8	68.8	77.1	60.0	46.3	62.1
HV02	48.8	61.4	62.0	58.0	51.5	47.7	61.6	70.8	62.5	46.0	37.9
HV03	49.0	38.9	41.0	48.0	40.6	39.5	50.0	55.8	45.0	40.5	25.5
HV04	41.0	58.6	49.0	63.0	60.6	56.6	64.1	75.3	62.5	46.8	40.0

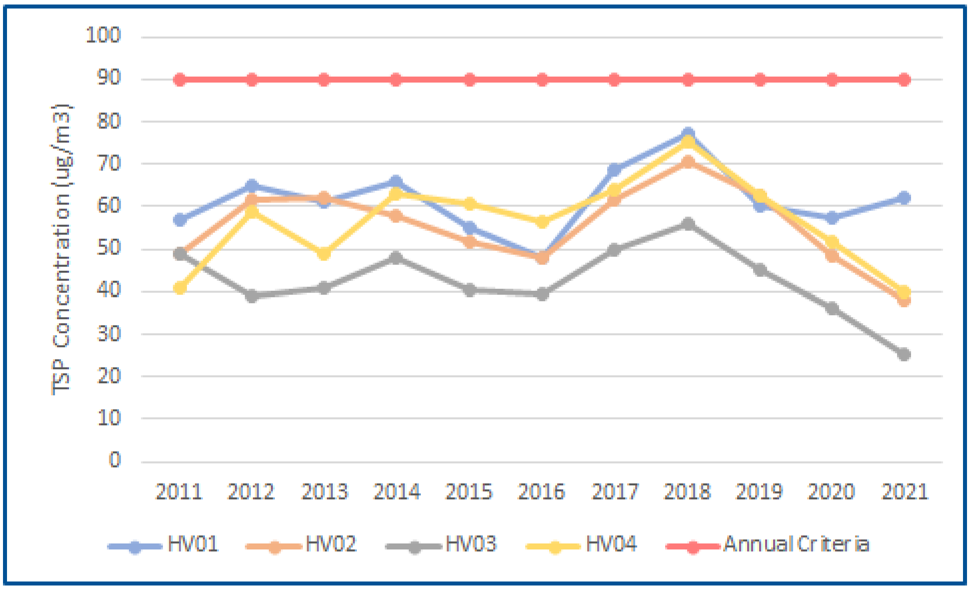


Figure 5: TSP Annual Averages (2011-2021)

5.3.3.2 PM10

PM_{10} concentrations recorded by WCPL's four Tapered Element Oscillating Microbalance Analyser (TEOMs) during the reporting period are shown in **Table 11** and **Figure 6**.

The data shows that PM_{10} concentrations remained relatively consistent from 2011 to 2017, with the highest concentrations recorded to date observed in 2018. This is considered to be due to open cut mining moving to a more exposed location in the Montrose Open Cut Pit during 2018.

Table 11: PM10 Monitoring Results (2011-2021)

TEOM	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020[2]	2021
Annual Average in µg/m³											
AQ01 (PM01)	16.8	21.0	19.3	18.0	15.7	15.6	20.6	25.7	24.1	21.6	20.5
AQ02 (PM02)	17.2	21.1	22.3	19.0	16.0	17.5	19.1	23.6	18.8	19.2	12.5
AQ03 (PM03)	16.7	16.6	16.5	15.3	12.9	14.1	14.6	18.6	25.1	14.7	8.4
AQ04 (PM04)	16.2	18.3	16.8	17.7	16.5	16.3	17.2	25.1	25.1	19.8	13.2
Maximum 24-hour Average in µg/m³											
AQ01 (PM01)	49	47	65	55	52	49	66	151.9[1]	59	106.1	66
AQ02 (PM02)	83	76	97	70	55	49	52	163.5[1]	54	132.5	35
AQ03 (PM03)	43	47	71	51	43	39	39	143.8[1]	64	137.8	36
AQ04 (PM04)	43	45	65	56	71	44	49	125.0[1]	73	131.4	99
Number of Days Above 24-hour Average Criteria											
AQ01 (PM01)	0	0	4	2	1	0	5	15	9	13	0
AQ02 (PM02)	2	7	20	2	3	0	2	9	1	13	0
AQ03 (PM03)	0	0	1	1	0	0	0	6	9	9	0
AQ04 (PM04)	0	0	3	1	2	0	0	12	6	9	0

1. If the results on 22 and 23 November 2018 are discounted as they were the result of a state-wide dust storm, the maximum 24-hour averages are; 80.6 µg/m³ at AQ01, 66.0 µg/m³ at AQ02, 58.70 µg/m³ at AQ03 and 70.9 µg/m³ at AQ04.
2. Results shown are inclusive of "extraordinary days".

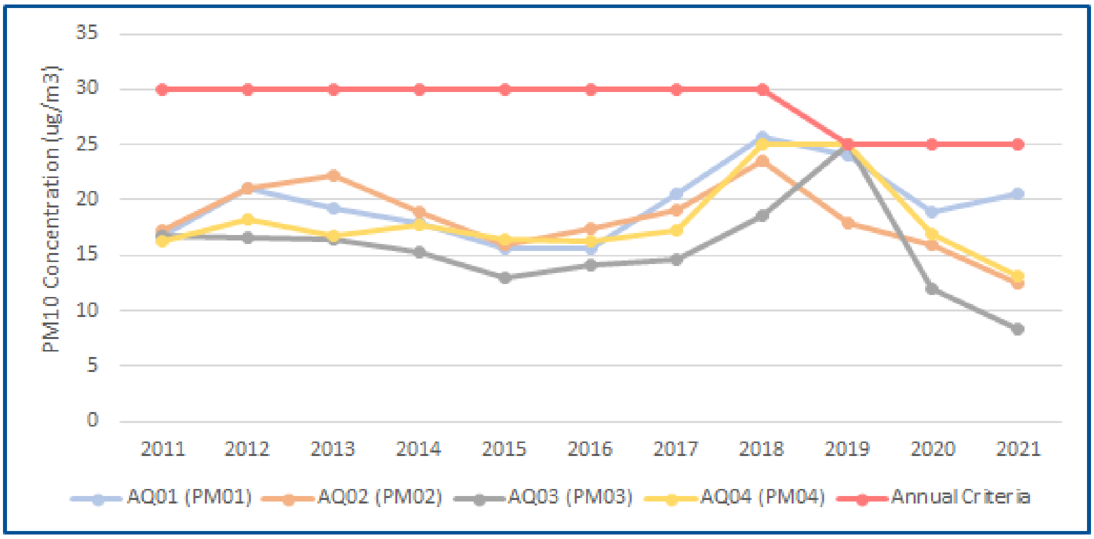


Figure 6: PM_{10} Annual Averages (2011-2021)

5.3.3.3 PM$_{2.5}$

On-site PM$_{2.5}$ data was available from late June 2020 onwards, following installation of the monitors. Results of monitoring during the reporting period are presented in **Table 12.** The data shows that PM$_{2.5}$ concentrations remained relatively consistent between 2020 and 2021.

Table 12: PM2.5 Monitoring Results (2020-2021)

TEOM	2020[1, 2]	2021
Annual Average in µg/m^3		
AQ01 (PM06)	5.2	5.5
AQ03 (PM07)	4.2	3.9
Maximum 24-hour Average in µg/m^3		
AQ01 (PM06)	15	14.9
AQ03 (PM07)	17	28.9
Number of Days Above 24-hour Average Criteria		
AQ01 (PM06)	0	0
AQ03 (PM07)	0	0

1. Results available from June 2020 onwards.
2. Results shown are exclusive of “extraordinary days”.

5.3.4 Implemented or Proposed Management Actions

During the reporting period, WCPL continued to conduct training sessions with the workforce on real-time dust monitoring and in particular, for the operators responsible for on-shift monitoring of noise and dust.

WCPL investigated methods for capturing extraordinary events impacting air quality this with an air quality specialist and it was determined that the current industry practice implemented at site will continue.

WCPL will continue to implement the WCPL AQGGMP during the next reporting period.

5.4 Greenhouse Gas Emissions

There are no approval criteria for greenhouse gas emissions in WCPL’s statutory approvals.

5.4.1 Approval Criteria/EIS Predictions and Management Plan Requirements

A summary of the EIS predictions for carbon dioxide (CO_2) emissions is included in **Section 5.4.2**, along with WCPL’s performance against these predictions from 2014 to 2020. For more information on the EIS predictions refer to the EIS (Resource Strategies 2003).

WCPL is required to report greenhouse gas monitoring data in the Annual Review, in accordance with the WCPL AQGGMP.

5.4.2 Performance during the Reporting Period

WCPL calculates and reports on greenhouse gas emissions at the end of every financial year, hence the summary data provided in **Table 13** below is for the period 1 July 2020 to 30 June 2021. Data for the second half of the 2021 reporting period will be included in the 2022 Annual Review.

A total of 124,307 tonnes of carbon dioxide equivalent (CO_2-e) was emitted by the Mine's ventilation systems in 2021 which is lower than the predicted 2,644,503 tonnes CO_2-e. The emissions predictions in the 2003 EIS were based on the assumption that there would be simultaneous mining of two longwalls at the South Wambo Underground Mine (Arrowfield and Bowfield Seams) in conjunction with South Wambo Underground Mine gas drainage occurring during 2021 compared to one mining of one longwall at the South Bates Extension Underground Mine (Whybrow Seam) during the reporting period. In addition, the Whybrow Seam is less gas rich compared to the Arrowfield and Bowfield Seams. For these reasons, the actual emissions are much lower (approximately 5%) than the predicted volumes.

The total greenhouse gas emissions from the Mine's ventilation systems (124,307 tonnes of CO2-e) were lower than predicted ventilation emissions from the South Bates Extension Mine in 2021 (200,000 tonnes of CO2-e) (Todoroski Air Sciences, 2016).

It is also noted that ventilation emissions have been gradually decreasing over the years due to the change from methane rich coal seam gas to CO_2 rich coal seam gas, as the Mine has progressed from the North Wambo Underground Mine to the South Bates (Whybrow and Wambo Seam) Underground Mine. This change is part of a regional gas change that happens to occur across the Wambo lease.

A total of 450,987 tonnes of CO2-e was emitted from the other operations (fuel and electricity consumption) compared to predicted 120,393 tonnes CO_2-e. This is principally higher than the predicted 120,393 tonnes of CO2-e due to inclusion of 206,602 tonnes of CO_2-e from the decommissioned North Wambo Underground Mine that was not considered in the EIS.

The 2020-2021 financial year was the fifth National Greenhouse and Energy Reporting (NGER) year that the Mine had emissions from a decommissioned mine due to North Wambo Underground Mine closing in April 2016. The total emissions emitted from the Mine during the reporting period (575,294 tonnes CO_2-e) is less than in previous reporting periods and the predicted emissions in the EIS (**Table 13**).

5.4.3 Trends and Key Management Implications

Levels of total CO_2 emissions monitored from the main ventilation shafts in 2014 to mid-2016 were indicative of the active mining at the North Wambo Underground Mine.

Following the closing of the North Wambo Underground Mine in 2016, a significant proportion of the methane (CH_4) emissions previously recorded at the main ventilation shaft shifted to being presented under a 'closed mine calculation'. The overall annual emissions from the Mine during the last five reporting periods have remained relatively consistent.

During the reporting period, annual emissions from diesel and other sources (44,661 tonnes CO_2-e) for production related electrical generation significantly reduced from the emissions in 2020 (108,850 tonnes CO_2-e). The relative reduction in emissions is due to transition from open-cut mining operations to underground mining operations. Electricity use during the reporting period remained consistent with the previous years.

5.4.4 Implemented or Proposed Management Actions

WCPL did not undertake any targeted energy saving projects during 2021, however energy efficiency is considered during mine planning.

Table 13: Comparison of EIS Predictions and Monitoring Data – Greenhouse Gas

Parameter	Monitoring Point	Monitoring Frequency	Emissions Calculated	Calculated CO_2-e tonnes for 2014 – 2015	Calculated CO_2-e tonnes for 2015 – 2016	Calculated CO_2-e tonnes for 2016 – 2017	Calculated CO_2-e tonnes for 2017 – 2018	Calculated CO_2-e tonnes for 2018–2019	Calculated CO_2-e tonnes for 2019–2020	Calculated CO_2-e tonnes for 2019–2021	EIS predicted CO_2-e tonnes for 2021[1]
Ventilation Systems											
Methane (CH4)	Main Ventilation Shaft	Real-time continuous	Emission factor to convert from tonnes of CH4 to tonnes of CO_2-e	703,596	618,127	137,521	227,824	145,110	82,427	96,017	**2,644,503**
Carbon Dioxide (CO_2)	Main Ventilation Shaft	Real-time continuous	Tonnes of CO_2-e	26,750	30,552	33,184	43,471	41,007	26,004	28,290	
Sub-Total				**730,346**	**648,679**	**170,705**	**270,295**	**186,117**	**156,883**	**124,307**	
Other (Fuel, Electrical Power and Other Fugitive Emissions)											
Diesel Use	Calculated from invoices	Annually	Emission factor to convert from kL use to tonnes of CO_2-e	92,935	97,983	97,274	92,034	101,556	108,790	44,451	**120,393**
Oil Use	Calculated from invoices	Annually	Emission factor to convert from kL use to tonnes of CO_2-e	280 (plus 321 kL not combusted)	339 (plus 104 kL not combusted)	44 (plus 206 kL not combusted)	163 (plus 643.5 kL not combusted)	23	15	210	
Grease Use	Calculated from invoices	Annually	Emission factor to convert from kL use to tonnes of CO_2-e	0 (plus 63 kL not combusted)	0 (plus 42 kL not combusted)	0 (plus 26 kL not combusted)	0 (plus 67.1 kL not combusted)	0	0	0	
Electricity Use	Calculated from invoices	Annually	Emission factor to convert from kWh use to tonnes of CO_2-e	78,576	76,506	63,435	64,185	63,213	59,017	55,358	
ROM Coal Production	Calculated from weight meter and survey	Monthly	Fugitive emissions factor based on ROM production[3]	59,124 (UG Stockpile residual emissions) 31,899 (OC Fugitives)	80,543 (UG Stockpile residual emissions) 24,634 (OC Fugitives)	69,202 (UG Stockpile residual emissions) 518,263 (closed mine calculation) 45,227 (OC Fugitives)	45,880 (UG Stockpile residual emissions) 472,331 (closed mine calculation) 18,231 (OC Fugitives)	46,992 (UG stockpile residual) 355,759 (closed mine calculation) 6,212 (OC Fugitives)	48,402 (UG stockpile residual emissions) 270,118 (closed mine calculation) 25,942 (OC Fugitives)	124,307 (UG stockpile residual emissions) 206,026 (closed mine calculation) 20,635 (OC Fugitives)	
Gas Drainage[4]	-	Annually	Tonnes of CO_2-e	-	-	-	145	0	0	0	
Sub-Total				**262,814**	**280,005**	**793,445**	**692,969**	**573,755**	**512,284**	**450,987**	
Total				**993,160**	**928,684**	**964,150**	**963,264**	**759,872**	**669,167**	**575,294**	**2,764,896**

Note: kL = kilolitres, OC = Open Cut, UG = Underground, kWh = kilowatt hours.

1. Refer to Tables 16 and 17 of Appendix B of the WCPL EIS (Resource Strategies 2003).
2. Anomalous results recorded during 2014 for non-combustible grease and oil use are believed to be due to human error in internal accounting procedures.
3. Wambo Open Cut uses Method 2 in situ measured emissions calculations for fugitive emissions. This involves the application of a gas model to as-mined pit shells for the year to generate the measured emissions number.
4. Financial Year 17/18 was the first time that a gas drainage plant was used. The plant was used intermittently.

5.5 Meteorology

WCPL is required to maintain a meteorological monitoring station at the Mine and monitor the parameters specified in Condition B50, Schedule 2 (DA305-7-2003) and EPL529 (Condition M4), using the specified units of measure, averaging period, frequency and sampling method described in the tables.

WCPL maintains the meteorological monitoring station in accordance with AS 2923-1987. The following parameters are monitored by the meteorological monitoring station, in accordance with WCPL's statutory conditions:

- temperature (at 2 m and 10 m);
- rainfall;
- lapse rate[1];
- wind speed (at 10 m);
- wind direction (at 10 m);
- solar radiation (at 10 m);
- humidity; and
- sigma theta.

Table 14 summarises the annual rainfall, temperature and wind direction data for 2021, compared to previous reporting periods.

Table 14: Environmental Performance – Meteorology (2014-2021)

Parameter	2014	2015	2016	2017	2018	2019	2020	2021
Rainfall (mm)	556.44	789.49	721.18	442.50	536.2	387.4	966.6	1,188.6
Maximum Temperature (°C)[1]	45.3 (Nov)	40.8 (Nov)	41.6 (Dec)	46.8 (Feb)	43.8 (Jan)	44 (Jan)	45 (Jan)	38.4 (Jan)
Minimum Temperature (°C)[1]	-1.7 (June)	-0.85 (June)	-3.4 (July)	-3.5 (July)	-5.5 (July)	-2.9 (Aug)	-1.5 (July)	-2.7 (July)
Mean Temperature (°C)[1]	18.1	19.2	18.4	18.5	18.7	19.2	17.9	17.1
Predominant Wind Direction	E/SE (summer) W/NW (winter)	S/SE (summer) W/SW (winter)[2]	S/SE (summer) SW (winter)	S/SE (summer) W/SW (winter)	S/SE/E (summer) NW (winter)	E/SE (summer) WNW/NW (winter)	SE (summer) NW (winter)	SE (summer) NW (winter

Note: °C = degrees Celsius, E = East, SE = South-east, W = West, NW = North-west, S = South, SW = South-west, mm = millimetres.

1. Measured at 2 m above ground.
2. The winter data (2015) was influenced by the use of the Charlton Ridge weather station which may explain the change in weather direction as WCPL's weather station was experiencing software issues.

[1] WCPL calculates the lapse rate from measurements made at 2 m and 10 m, in accordance with DA305-7-2003.

5.6 Biodiversity

WCPL implemented Biodiversity Management Plan (BMP) during the reporting period. The BMP encompasses the extraction of Longwalls 17 to 20 and Longwalls 21 to 24. It also addresses the requirements within the Voluntary Conservation Agreements (VCA) prepared under Condition B75 (g), Schedule 2 of DA305-7-2003, and the requirements of the EPBC Act 1999 approvals (EPBC 2003/1138, EPBC 2016/7636 and EPBC 2016/7816).

The BMP applies to all activities undertaken within WCPL's mining authorisations and approved mining areas that may impact on biodiversity, as well as biodiversity in WCPL's RWEAs and Open Cut Revegetation Areas. The BMP has been developed to:

- identify lands to be managed in accordance with this BMP;
- provide a framework for the management of biodiversity in the RWEAs and Open Cut Revegetation Areas;
- provide a clear, concise set of management actions and a schedule for the coordinated and effective delivery of biodiversity enhancement;
- define realistic Completion Criteria for RWEAs and Open Cut Revegetation Areas that can be quantitatively evaluated through a seasonally based monitoring program;
- define a seasonally based monitoring program suitable for determining management success (or otherwise);
- provide suitable contingency measures and associated Trigger Action Response Plans (TARPs) that adequately address any deviation from the Completion Criteria; and
- define the responsibilities for implementing, reviewing and reporting on the BMP.

The BMP also meets the requirement for a Biodiversity Management Plan under Condition B7(f), Schedule 2 of DA305-7-2003 in support of the Extraction Plan for the South Bates Extension Underground Mine Longwalls 17 to 20 and the Extraction Plan for the South Bates Extension Underground Mine Longwalls 21 to 24.

5.6.1 Approval Criteria/EIS Predictions and Management Plan Requirements

Performance measures for subsidence impacts on biodiversity are detailed in Condition B1, Schedule 2 of DA305-7-2003 (**Section 5.9.2**). In addition, performance measures for aquatic ecosystems are detailed in Condition B62, Schedule 2 of DA305-7-2003 (**Section 6.1.1**).

WCPL is required to monitor and report on biodiversity in accordance with the conditions of DA305-7-2003, DA177-8-2004, EPBC 2003/1138, EPBC 2016/7636, EPBC 2016/7816 and the approved BMP.

The BMP includes a combined Landscape Function Analysis (LFA) and biometric monitoring methodology. The LFA target scores and floristic performance criteria are provided in **Table 15** and **Table 16**, respectively.

Table 15: LFA Target Scores

Site Type	LOI[1]	SI[1]	INFI[1]	NI[1]
Woodland Rehabilitation	>0.87	>59	>43	>36
Pasture Rehabilitation	>0.93	>61	>29	>25
North Wambo Creek Diversion	>0.84	>62	>41	>37
Wambo Creek	>0.84	>62	>41	>37

2. LOI = landscape organisation index, SI = stability index, INFI =infiltration, NI = nutrient index.

Table 16: Floristic Performance Criteria for Plant Community Types in RWEAs and Performance Targets for Older Woodland Areas and Rehabilitation Sites

	Attribute[1]									
	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Rehabilitation										
Older Woodland Areas with a canopy of Sugar Gum	>15	15-40	5-40	5-15	5-10	5-15	<20	1	-	5
Areas of Narrow-leaved Ironbark – Bull Oak – Grey Box open forest	>20	10-40	5-10	15-50	5-10	5-40	<20	1	-	-
RWEAs										
PCT42[2]	>20	10-50	10-50	20-60	1-5	5-30	<10	1	-	-
PCT1658[2]	>20	10-40	10-50	4-20	5-30	5-35	<10	1	-	-
PCT1603[2]	>25	10-40	5-10	15-50	5-10	5-40	<5	1	-	-
PCT1604[2]	>35	15-40	5-20	30-50	5-15	5-40	<5	1	-	-
PCT1176[2]	>21	15-40	5-30	5-30	0-25	2-10	<5	1	-	-
PCT1584[2]	>45	15-45	5-40	5-40	10-20	5-20	0	1	-	-

1. NPS = the number of native plant species (native to NSW), NOS (%) (including *E.cladocalyx*) = projected native foliage cover of canopy, NMS (%) (including *A.saligna*) = projected native midstorey cover, NGCG = native groundcover of grasses, NGCS = native groundcover of shrubs, NGCO = native groundcover of other plant types (sedges, herbs etc.), EPC = exotic plant cover, OR = overstorey regeneration over the whole vegetation zone, HBT = hollow bearing trees, FL= length of fallen logs >10 cm diameter within the vegetation plot, PCT = plant community type.
2. PCT42: River Red Gum/River Oak riparian woodland wetland in the Hunter Valley.

   PCT1658: Rough-barked Apple – Narrow-leaved Ironbark – Blakely's Red Gum – Bull Oak – Coast Banksia woodland on sands of the Warkworth area.

   PCT1603: Narrow-leaved Ironbark – Bull Oak – Grey Box shrub – grass open forest of the central and lower Hunter.

   PCT1604: Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter.

   PCT1176: Slaty Box – Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion.

   PCT1584: White Mahogany – Spotted Gum – Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley.

5.6.2 Performance during the Reporting Period

During the reporting period, WCPL commissioned Eco Logical to monitor the fauna and vegetation structure within the RWEAs and rehabilitation areas. Floristic surveys, bird surveys, LFA and riparian condition surveys were all conducted during October 2021 across both RWEAs and rehabilitation areas. A copy of the Annual Flora and Fauna Monitoring Report prepared by Eco Logical (in prep) is included in **Appendix E**.

Remnant woodland sites within the RWEAs are generally performing well. High diversity of native flora species and an increase in native ground cover was recorded, likely in response to the above average rainfall recorded over the last two years. Fauna habitat features such as fallen logs and hollow bearing trees remain present (**Appendix E**).

High exotic cover was recorded in RWEA A and RWEA Rail Loop within the River Red Gum/River Oak riparian woodland wetland in the Hunter Valley (PCT 42) and Rough-barked Apple – Narrow-leaved Ironbark – Blakely's Red Gum – Bull Oak – Coast Banksia woodland on sands of the Warkworth area (PCT 1658). The recorded exotic cover levels failed to meet the performance criteria and VCA targets at several sites. Increased weed management is recommended in this area control exotic cover and allow native diversity and cover to increase (**Appendix E**).

Bird survey results from remnant woodland sites reflected the good condition of these woodland areas with RWEA areas continuing to support a large diversity of birds including several threatened species. Bird diversity and communities were largely consistent with the data available from previous monitoring years and the monitoring data does not indicate any declines in local bird communities (**Appendix E**).

The North Wambo Creek Diversion (NWCD) has continued to not meet completion criteria for landscape function and this area will require continued active management actions to ensure that all completion criteria and other commitments are met in the near future. Gully erosion and areas of bare soil exceeding completion criteria were observed. Major remediation works are currently underway in the NWCD to improve drainage, erosion and establishment of native plant communities (**Appendix E**).

Floristic monitoring in the NWCD recorded acceptable native species diversity and native ground cover. Cover of shrubs and canopy were low however this is expected during establishment phase. Significant growth in Eucalypt and Acacia trees and shrubs was observed, including several areas where trees have naturally established along the creek channel. A large proportion of the NWCD remains as grassland and will require additional revegetation efforts to establish the target vegetation communities. An increased number of floristic sites is required to monitor this area (**Appendix E**).

Riparian condition scores for North Wambo Creek, Wambo Creek and Stony Creek were similar to 2020 when an increase was following drought years and in response to the reduction/exclusion of grazing. Understorey vegetation cover remains high following the increase in 2020 resulting from higher rainfall, although a high proportion of ground cover contribution is from exotic species, owing to the agricultural disturbance history within these systems. Cattle should continue to be excluded from riparian areas, including fencing of the lower reaches of Stony Creek, and control of feral pigs is also recommended. Planting native trees in over-cleared areas to facilitate more rapid regeneration is also recommended (**Appendix E**).

The Melaleuca decora low forest GDE community along North Wambo Creek was recorded to be in good condition with scores for most attributes increasing since 2019. This community was undermined during 2019 and 2020, and data collected to date may serve as suitable baseline for this community noting that 2019 was a dry year followed by wetter conditions in 2020 and 2021. The River Oak riparian tall woodland GDE recorded strong growth and monitored trees appeared in healthy condition, likely in response to the higher rainfall in 2020 and 2021. High exotic ground cover is present in some areas of this community due to historical clearing and agricultural activities. The extent of the community remains unchanged since originally mapped in 2019, however recruitment of trees and shrubs was observed following two wetter years, and this may translate into expansion of the community in coming years (**Appendix E**).

Floristic and bird monitoring sites established in 2020 in the South Bates Extension Underground Mine area, including reference sites outside of the mining area, were monitored for the first time. Vegetation and bird communities were recorded in good condition and no significant impacts to floristic attributes or bird communities were recorded at sites within areas impacted by undermining to date (**Appendix E**).

Subsidence was observed in several locations across the site including RWEA C and RWEA D and the NWCD, however no significant effects on flora and fauna or performance criteria exceedances were recorded. Repairs to tracks and subsidence cracks are required in RWEA C. No other significant management issues were recorded during walk through inspections of RWEAs (**Appendix E**).

Aquatic ecosystem monitoring was conducted by Niche Environment and Heritage during the reporting period along North Wambo Creek, South Wambo Creek, Waterfall Creek and Wollombi Brook. A copy of the Annual Aquatic Ecosystem Monitoring Report (Niche Environment and Heritage 2021) is included in **Appendix F**.

The aquatic monitoring indicated that the Wollombi Brook (Bands A to C) exhibited good to poor stream health and no ecological impacts were observed at Licence Discharpge Point (Site 11). Consistent with previous monitoring, South Wambo Creek (Band B) and Waterfall Creek (Band C) exhibited poor stream health (**Appendix F**).

That North Wambo Creek realignment remains severely to extremely impaired at some sites Bands B to D). There were however some signs of improved habitat complexity and macroinvertebrate diversity with crustaceans (yabbies and shrimp) and sensitive aquatic macroinvertebrates (Leptoceridae and Leptophlebiidae) present at one site. Erosion and sediment control measures and rehabilitation works in North Wambo Creek realignment are having some localised improvements to stream condition and habitat (**Appendix F**).

It is noted that ephemeral streams (e.g. North Wambo, South Wambo and Waterfall Creeks) are particularly susceptible to variations in water availability, which in turn affect the availability of aquatic habitat and lead to changes to water quality associated with a drying system (**Appendix F**).

5.6.3 Trends and Key Management Implications

The majority of RWEAs remain in good condition with high numbers of native species, few exotic species present and with low cover and abundance. No major issues were identified that require urgent management (**Appendix E**).

The number of native species generally increased from the previous year and was the highest to date in several PCTs. The 2021 results appear to confirm that some lower scores for native species diversity recorded in recent years were a result of the dry conditions, with the increase this year in response to higher rainfall (**Appendix E**).

However, as reported in previous years, exotic species cover remains relatively high in riparian and floodplain areas (V1 and V2 plots of RWEA A) and continues to exceed performance criteria and also VCA targets in certain locations. Several weed species listed under the NSW *Biosecurity Act 2015* were observed in these areas that have potential to become problematic in the wider region (e.g. *Olea europaea* subsp. *cuspidata* [African Olive]). WCPL will continue to implement weed management (particularly species listed under the NSW *Biosecurity Act 2015*) to achieve performance criteria in these riparian and floodplain areas.

The Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland (PCT 1658) in RWEA A appears to be suffering from Banksia integrifolia die-off in the mid-storey, first observed in 2019 and continuing this year. This community recorded a higher average number of native species in 2021, compared to 2020 results decreased from previous years. Higher exotic covers were also recorded at some locations. This community occurs on sandy soils, and it is possible the soils suffered more significant drying during the recent dry years than other areas and the rainfall to date has not been sufficient to recharge the soil (**Appendix E**). Future monitoring will continue to record the condition of this community and increased weed control will be applied.

Although the average number of bird species per site was lower in 2021 than the previous three years, the diversity remains within levels previously recorded, and overall diversity across all sites within RWEAs also remains high and was higher than the previous two years. Number of birds per survey returned to levels similar to previous years after a lower score was recorded in 2020 (**Appendix E**). Future surveys will continue to monitor abundance to ensure the lower abundance recorded in 2021 is not the beginning of a decline.

As vegetation and habitat attributes in RWEAs have remained relatively stable over time, variability in diversity and abundance between years is likely explained by a combination of factors such as varying numbers of nomadic and migratory bird species, weather and climate, sampling methods, differences in the skill of observers, the timing of surveys and surveys coinciding with the flowering of trees and also broader landscape scale and seasonal changes across the Hunter Valley. The total number of bird species detected each year has varied over time and the 87 species recorded during 2021 is within the range of previous years. Threatened species appear to be persisting well within the RWEAs, with Grey-crowned Babbler continuing an increasing trend (after low abundance in 2019) and Speckled Warbler, Little Lorikeet and Varied Sittella all recorded at more sites and in similar or higher numbers than the previous year (**Appendix E**).

The aquatic monitoring report (**Appendix F**) found that comparison with previous survey data showed no significant temporal trends attributable to current catchment management.

5.6.4 Implemented or Proposed Management Actions

In 2018, 50 nest boxes were installed in five clusters within RWEAs B, C and D. The first inspections were undertaken during the 2020 monitoring. These next boxes were occupied by Brushtail Possum (Trichosurus vulpecula) or showed signs of use. Three nest boxes had fallen to the ground and will be re-erected/replaced during the next reporting period.

WCPL will continue to give priority to managing weed species listed under the *Biosecurity Act 2015* that have the potential to become problematic in the wider region (e.g. *Olea europaea* subsp. *cuspidata* [African Olive]).

Rehabilitation work for the NWCD continued during the reporting period and included (**Figure 7**):

- quarterly vegetation monitoring and maintenance in existing remediation areas;
- dismantling and reconstruction of Chutes 3 and 7;
- construction of Chute 10;
- stabilisation works and construction of a drop structure above Longwall 16; and
- amelioration and revegetation.

The NWCD Rehabilitation and Maintenance Plan is updated annually, based on the results of the annual monitoring conducted by Alluvium. WCPL will continue to implement the NWCD Rehabilitation and Maintenance Plan during the next reporting period.

Soil Conservation Services was commissioned by WCPL to prepare the NWCD Plan 2022 to 2023 which will guide the Stage 3 works in 2022. Based upon the current condition of the NWCD from Longwall 18 to the confluence of North Wambo Creek and Wollombi Brook, the Plan provides a priority assessment for the remediation of remaining areas of instability on the NWCD. Work proposed for the next reporting period is currently being finalised, however will likely include (**Figure 7**):

- quarterly vegetation monitoring and maintenance in the existing remediation areas;
- amelioration and revegetation;
- re-building of rock chutes; and
- remediation of subsidence impacted areas.

Legend

- Stage 2 Chute/Cascade Constructs
- Stage 1 Chute/Cascade Constructs
- Stage 2 Amelioration/Rip Areas
- Stage 1 Amelioration/Rip Areas
- Stage 1 Stabilisation Areas (*log deflectors, bed control and riffle*)
- Stage 2 Amelioration/Rip Areas (*additional treatment from Stage 1*)
- Stage 2 Amelioration/Rip Areas (*remaining March 2022 – additional treatment from Stage 1*)

NWCD Remediation Works: Stage 1 (*2020*) & Stage 2 (*2021/2022*)

Date: 14/03/2022
Version: 1
Author: Nick Scanlan

SOIL CONSERVATION SERVICE SINCE 1938

Projection: MGA 94 Zone 56

Figure 7: North Wambo Creek Remediation Works

5.7 Heritage

WCPL manages Aboriginal heritage on-site in accordance with the relevant conditions of DA305-7-2003 and the conditions of Aboriginal Heritage Impact Permits (AHIPs) #2222, #C0001474, #C0002000 and #C0003213. These AHIPs allow for the disturbance and/or salvage of all known and unknown Aboriginal objects within the extent of the relevant AHIP boundaries. Any Aboriginal objects salvaged under these permits are managed in accordance with a Care Agreement.

In 2016, WCPL developed a Heritage Management Plan (HMP) for the Mine, to consolidate all statutory requirements into one document and assist in the management of Aboriginal cultural heritage on-site. The HMP was approved in June 2018 with the Extraction Plan for Longwalls 17 to 20 at the South Bates Extension Underground Mine. The HMP was updated in July 2020 for inclusion with the Extraction Plan for Longwalls 21-24 at the South Bates Underground Mine and was approved by DPE in April 2021.

Consistent with the requirements of the HMP, WCPL has implemented a Surface Disturbance Permit (SDP) procedure and checklist, applicable to all surface works at Wambo Coal Mine. During the SDP assessment process, WCPL undertake a due diligence assessment to ensure that no artefacts that may have been identified in the area are damaged South East Archaeology (2021) conducted Aboriginal Heritage Due Diligence Investigations on proposed drilling locations in November 2021. No salvage operations were conducted by WCPL during the reporting period.

5.8 Non-Aboriginal Heritage

WCPL is required to prepare a Conservation Management Plan (CMP) for the Wambo Homestead Complex (WHC) in accordance with Condition B90, Schedule 2 of DA305-7-2003. The current CMP (Version 6) was approved in May 2019.

Maintenance work continued during the reporting period was guided by the Preventative and Cyclic Maintenance Program outlined in Table 15 of the WHC CMP. In April 2020, an application was made to Heritage NSW under section 60 of the NSW *Heritage Act 1977* for approval to undertake stabilisation works to the Servant's Wing building. Heritage NSW issued the approval on 23 September 2020 and the necessary work was undertaken.

Other maintenance activities conducted at the WCH during the reporting period included general clean-up of the site; weed and pest control; erosion and drainage control maintenance; and visual inspections.

An annual photographic record of the elevations of all structures at the WHC was completed during the reporting period and lodged with the Heritage Branch, Singleton Council and DPE on 29 December 2021, in accordance with Condition B92, Schedule 2 of DA305-7-2003.

During the reporting period, WCPL undertook no blasting that was within 2 km of the WHC.

In an effort to improve access to studies, reports, plans and surveys that have been prepared for the Wambo Homestead, WCPL created a platform on the Peabody website, specific to the WHC. Content includes '*Wambo Homestead-an artist's impression'* by Vivian Dwyer 2007, an outline of the history of the WHC, a drone fly-over video and black and white archive photographs. The website can be accessed at:
https://www.peabodyenergy.com/Operations/Australia-Mining/New-South-Wales-Mining/Wambo-Homestead

In May 2021, an application was made to Heritage NSW under section 60 of the NSW *Heritage Act 1977* for approval to undertake a preliminary Archaeological Assessment within the Wambo Homestead site. Heritage NSW issued the approval on 15 July 2021 and the assessment was undertaken. The purpose of the archaeological testing is to confirm the presence, absence and nature of historical archaeological remains within the Homestead site, with the results of the test excavations to be used to inform a Revised Archaeological Assessment and Archaeological Management Plan (historical heritage only) for the Homestead site.

5.9 Subsidence

During the reporting period, underground mining occurred at Longwalls 20 and 21 of the South Bates Extension Underground Mine. Subsidence monitoring was undertaken in the reporting period for Longwalls 18, 19, 20 and 21.

5.9.1 Relevant Extraction Plans

Longwall mining during the reporting periods was undertaken in accordance with the relevant Extraction Plans, in accordance with Condition B9, Schedule 2 of DA 3095-7-2033. A summary of the Extraction Plan reporting requirements related to subsidence is provided in the subsection below.

5.9.1.1 Extraction Plan for South Bates Extension Underground Mine Longwalls 17 to 20

The following reporting is required to be undertaken as part of the Extraction Plan for South Bates Extension Underground Mine Longwalls 17 to 20:

- Incident Report – to be prepared as required and submitted (by email) to DPIE (Manager, Mining Projects), NSW Resources Regulator (Subsidence Executive Officer), Subsidence Advisory NSW (District Manager) and other regulators as specified in management plans.
- Subsidence Management Status Reports – to be updated fortnightly and submitted (by email) if new impacts are identified or upon request, to DPIE (Manager, Mining Projects) and NSW Resources Regulator (Subsidence Executive Officer).
- Six Monthly Report – to be updated annually for the period 1 January to 30 June and submitted (by email) to DPIE (Manager, Mining Projects) and NSW Resources Regulator (Subsidence Executive Officer).

  Annual Review – to be updated annually for the period 1 January to 31 December and submitted (by email and/or post) to DPE (Manager, Mining Projects), NSW Resources Regulator (Subsidence Executive Officer), NSW Resources Regulator (Manager Environmental Sustainability), Subsidence Advisory NSW (District Manager), BCD/EPA (General Contact), DPE-Water (Water Regulation), Singleton Council (General Manager) and WCPL CCC Members.

5.9.1.2 Extraction Plan for South Bates Extension Underground Mine Longwalls 21 to 24

During the reporting period, an Extraction Plan for Longwalls 21 to 24 was granted approval by DPE in April 2021.

The reporting requirements for Longwalls 21 to 24 Extraction Plan are the same the Extraction Plan for South Bates Extension Underground Mine Longwalls 17 to 20 (**Section 5.9.1.1**).

5.9.2 Approval Criteria/EIS Predictions and Management Plan Requirements

In accordance with Conditions B1 and B4, Schedule 2 of the Development Consent (DA305-7-2003), WCPL must ensure that there are no exceedances of the Subsidence Impact Performance Measures detailed in Tables 1 and 2 of the Development Consent (**Table 17**).

Table 17: Subsidence Impact Performance Measures

Aspect	Performance Measures[1]
Water – Wollombi Brook	Negligible subsidence impacts and environmental consequences. Release of water from the site only in accordance with EPL requirements.
Land – Low level cliffs within the South Bates Extension Area	Minor environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing that in total do not impact more than 5% of the total face area of such features).
Biodiversity – Wollemi National Park	Negligible subsidence impacts and environmental consequence.
Biodiversity – Warkworth Sands Woodland Community	Minor cracking and ponding of the land surface or other subsidence impacts. Negligible environmental consequences.
Biodiversity – White Box, Yellow Box, Blakely's Red Gum Woodland/ Grassy White Box Woodland Community	Minor cracking and ponding of the land surface or other subsidence impacts. Negligible environmental consequences.
Biodiversity – Central Hunter Valley Eucalypt Forest and Woodland Ecological Community	Minor cracking and ponding of the land surface or other subsidence impacts. Negligible environmental consequences.
Biodiversity – Conservation Areas (including the proposed Wambo offset area under SSD 7142)	Negligible reduction to previously identified biodiversity credits.
Heritage – Wambo Homestead Complex	Negligible impact on heritage values, unless approval has been granted by the Heritage NSW and/or the Minister.
All Built Features (including public infrastructure and all structures on privately-owned land)	Always safe. Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensate.
Public Safety	Negligible additional risk.

1. Note, the requirements of this condition only apply to the impacts and consequences of mining operations undertaken following the date of approval of Modification 9.

Underground mining was undertaken at South Bates Extension Underground Mine Longwalls 20 and 21 during the reporting period. Longwall 21 (completed in February 2022) will be inspected during the next reporting period hence is not considered in this Annual Review.

No longwall panels encroached upon the Wollombi Brook, Warkworth Sands Woodland Community or the White Box, Yellow Box, Blakely's Red Gum Woodland/Grassy White Box Woodland Community.

South Bates Extension Underground Mine Longwalls 20 and 21 did not undermine the NWCD.

Longwalls 20 and 21 are offset from the base of the Wollemi National Park escarpment by a minimum 26.5 degree angle of draw. No impacts to the escarpment were observed during the reporting period (**Section 5.9.3**).

WCPL does not have approval for undermining of the WHC and as such no evidence of subsidence related impacts were identified during the reporting period. No impacts to non-Mine built features or threats to public safety resulting from the discussed mining activities were identified during the reporting period.

5.9.3 Performance during the Reporting Period

5.9.3.1 Subsidence Surveys

During the reporting period, WCPL undertook longwall mining in the South Bates Extension Underground Mine Longwalls 20 and 21 (**Section 3.1**). Subsidence monitoring was undertaken in accordance with the South Bates Extension Underground Mine Longwalls 21 to 24 Extraction Plan. Subsidence monitoring was undertaken for Longwalls 18, 19 and 20 (within 10 months of the longwalls being competed). Results for Longwall 21 will be reported in the next Annual Review.

Table 18 summarises the actual versus predicted subsidence results for Longwall 17 and 20 at the South Bates Extension Underground Mine. The monitoring shows that the actual maximum subsidence recorded across Longwall 17 to 20 are generally similar but less than the predicted values. This could be partly attributed to the average mining height of Longwalls 19 (2.4 m) and 20 (2.35 m) being less than the subsidence model of 2.8 m and 3.0 m (Mine Subsidence Engineering Consultants [MSEC] 2021).

Table 18: Subsidence Monitoring – Actual versus Predicted for South Bates Underground Mine Longwalls 17 and 20 (8XL-Line)

Parameter	Predicted[1]	Actual[1]	Consistent with Predicted Range
Maximum Vertical Subsidence (mm)	1800	1332	Y
Maximum Tilt (mm/m)	50	31	Y
Maximum Hogging Curvature (km^{-1})	3.0	1.4	Y
Maximum Sagging Curvature (km^{-1})	2.0	1.2	Y

1. *South Bates Extension Underground Mine Subsidence Review Report for the South Bate Extension Underground Mine WYLW19* and *WYLW20* (MSEC 2021).

5.9.3.2 LiDAR Surveys

The changes in surface level due to mining at the South Bates Extension Underground Mine have been measured using Light Detection and Ranging (LiDAR) surveys. The changes in surface level due to the mining of Longwalls 17 to 21 have been determined by taking the differences between the surface levels measured in the LiDAR surveys carried out in May 2018 (before the commencement of Longwall 17) and July 2021 (approximately 550 m extraction of Longwall 21)

It should be noted that LiDAR surveys have an accuracy in the order of ±50 to ±150 mm. The accuracy of the observed changes in surface levels (i.e. the difference between the two surveys), therefore is in the order of ±100 to ±300 mm.

LiDAR survey results for Longwalls 17 to 21 are as follows (MSEC, 2021):

- The measures changes in surface level are greater than the predicted above the south western ends of Longwalls 20 and 21 and above the face of Longwall 21 partially due to the effects of the steep slopes beneath the escapement on the LiDAR surveys.
- The measured changes in the surface level are also slightly greater than the predicted above north-eastern ends of Longwall 20.
- The measured profile is slightly flatter than the predicted.
- It is considered that the ground movements measured using the LiDAR surveys are consistent with the prediction provided in the South Bates Extension Underground Mine Longwalls 21 to 24 Extraction Plan.
- The subsidence model appears to be providing conservative predictions based on the single-seam mining conditions.
- No changes to the subsidence model are recommended based on the measured subsidence effects from the LiDAR survey.

5.9.3.3 Visual Inspections

Visual inspections were carried out by WCPL during and after the extraction of Longwalls 17 to 20 at the South Bates Extension Underground Mine (WCPL, 2021). The surface cracks were mapped and added to the WCPL's subsidence impacts register.

The largest surface deformations occurred adjacent to the maingates and tailgates, towards the finishing (i.e. north-eastern) ends of each longwall, due to the shallower depths of cover. Less extensive cracking was recorded towards the commencing (i.e. south-western) end of the longwalls due to the higher depths of cover and less accessible terrain limiting mapping of the surface (MSEC, 2021).

The recorded surface crack widths above Longwall 20 typically ranges between 10 mm to 50 mm (i.e 68% of cases) which is less than the predicted surface deformation and the majority of the recorded crack width are less than 200 mm (97% of cases), the maximum crack width is approximately 400 mm where localised potholing occurred adjacent to the tailgate of Longwall 20 (MSEC, 2021).

It is considered that the recorded surface deformations above Longwall 20 are typically within the range assessed. While surface cracking up to approximately 400 mm occurred in isolated locations, these impacts represent less than 1% of the total length of mapped surface cracking above the mining area (MSEC, 2021).

5.9.3.4 Bi-annual Audits of Subsidence Impacts

Bi-annual audits (May and November) of subsidence impacts were undertaken by SLR during the reporting period to identify new subsidence impacts over the South Bates Extension Underground Mine and to determine the status of known subsidence impacts (e.g. have they self-repaired, are they stable but pose a risk to long-term sustainable land use, or are they deteriorating in condition).

During the reporting period, subsidence monitoring and remediation focused on the South Bates Underground Mine in the vicinity of Longwalls 17, 18, 19 and 20. Of the 48 subsidence sites rehabilitated in 2021, this included 16 sites in and adjacent to the North Wambo Creek diversion. The remediation of sites occurred throughout the year and consisted of a combination of targeted subsidence campaigns and reactive subsidence remediation. The sites ranged from small potholes to cracks several meters in length.

The methodology used continues to be fine-tuned with remediation of sites primarily including:

- Excavate the subsided area using an excavator. Store topsoil and subsoil in separate piles for later use.
- Excavate site until no subsurface void is identified or to the limit of the excavator.
- Insert geofabric to line the floor of the excavated pit.
- Backfill the pit using the excavated material mixed with gypsum at 2%.
- Compact the excavated material in layers using the back of the excavator bucket up to surface level.
- Topsoil and seed the disturbed area.

Bi-annual detailed subsidence monitoring will continue to monitor further subsidence, vegetation coverage and weeds in the next reporting period.

5.9.3.5 Remediation of Subsidence Impacts to 'Kharlibe'

In 2018, a Subsidence Remediation Plan (SRP) was developed for the 'Kharlibe' property located in Bulga, approximately 20 km west-southwest of Singleton in the Upper Hunter Valley of NSW.

Between 1991 and 2000, the property was undermined by the former Homestead Mine (owned by WCPL, now a subsidiary of Peabody Energy Australia Pty Ltd). The mining occurred within CL 397 and CCL 743 held by WCPL. The longwall mining resulted in the surface of the ground being lowered, and the formation of subsidence cracks – some of which took time to migrate through the alluvium to reach the surface.

Historical subsidence remediation works have been undertaken across the property by various contractors and consultants since the late 1990's. The success of these works was mixed and, in some instances, require remedial works.

In February 2018, the Resources Regulator issued a Notice under Section 240 (1)(b) and (c) of the *Mining Act 1992* (Mining Act) that required WCPL to prepare a SRP for Kharlibe. SLR and SCT Operations Pty Ltd (SCT) were approved as suitably qualified experts to prepare the SRP in consultation with the landholder and the Resources Regulator.

A second Section 240 Notice was issued by the Resources Regulator on 19 September 2019, requiring WCPL to:

- implement subsidence remediation works and associated works in accordance with the Subsidence Remediation Plan (with timing of works and associated monitoring bound by the Project Gantt Chart); and
- to provide quarterly Subsidence Remediation Reports including field observations, remediation works methodologies and results of any monitoring.

Initial (Phase 1) remediation works were undertaken at two sites on 21 and 22 May 2019. These features included an isolated sinkhole, a close spaced row of sink holes and five small depressions. The purpose of this initial remediation works was to identify constraints and opportunities to guide future remediation works.

The Phase 2 remediation works were undertaken from 17 – 21 June 2019 as they were considered high priority works. These works included the remediation of 20 sites.

Phase 3 remediation works were undertaken from 15 July – 20 December 2019 and included landform design and remediation works. Phase 3 works in 2019 included the remediation of 51 sites, with 33 completed in October to December 2019.

Phase 4 remediation works were undertaken across the Kharlibe property within Stony Creek (Site 99) between 3 – 24 March 2020. Further Phase 4 remediation works were undertaken throughout each quarter of 2020 with both newly treated areas and maintenance works on previously remediated sites occurring.

During the reporting period, Phase 4 works continued across the Kharlibe property. Throughout the reporting period ongoing care and maintenance works and monitoring was conducted across rehabilitated sites. Care and maintenance works included further remediation works in Quarter 2 and 3 with both newly treated areas and maintenance works on previously remediated sites occurring.

5.9.3.6 Visual Inspections of Wollemi Escarpment (via Drone)

Baseline cliff top mapping of the Wollemi National Park escarpment in the vicinity of the South Bates Underground Mine was undertaken during 2015 utilising an Unmanned Aerial Vehicle (Microdrone MD4-1000) and a high-resolution camera along a designated route. Photos were taken of the cliff top at designated intervals and stitched to form a high-resolution panoramic image which can be used to assess subsidence. The route has been recorded and programmed to be repeatable from year to year.

The Cliffs Associated with the Wollemi Escarpment were visually inspected using drones. The cliffs were inspected in October 2018 (before the extraction of Longwall 17), August 2019 (after the extraction of Longwall 17), January 2020 (after the extraction of Longwall 18), August 2020 (after extraction of Longwall 19) and April 2021 (after extraction of Longwall 20). There were no cliff instabilities identified along the escarpment from these surveys.

5.9.4 Trends and Key Management Implications

It is considered by MSEC (2021) that the observed ground movements for South Bates Extension Underground Mine Longwalls 17 to 20 were consistent with predictions. It is also considered that the impacts on the natural and built environment are similar to those assessed and predicted.

Given the above, WCPL will continue to implement the approved Extraction Plans for South Bates Extension Underground Mine Longwalls 21 to 24 in the next reporting period.

5.9.5 Implemented or Proposed Management Actions

During the next reporting period, WCPL will continue to implement the approved Extraction Plans for South Bates Extension Underground Mine Longwalls 21 to 24.

WCPL will also continue with the program of works for the remediation of the subsidence impacts identified by the bi-annual subsidence audits in areas away from active subsidence (**Section 5.9.3**).

5.10 Exploration

During the reporting period, 11 drill holes (10 non-core and one fully-cored) were drilled in WCPL's exploration licence and mining lease areas. Of these drill holes, 10 were groundwater monitoring boreholes and remaining drill hole (fully-cored) was for geotechnical investigation for a ventilation shaft.

No boreholes were drilled within EL7211 and A444. The UWJV (operated by Glencore) drilled one hole in A444 during the reporting period. All boreholes completed during the reporting period were drilled within WCPL's mining leases and were managed under WCPL's Surface Disturbance Permit system consistent with the MOP/ROM.

Rehabilitation of exploration sites is undertaken continuously throughout the exploration program and begins immediately after holes are geophysically logged. Of the 11 drill holes drilled, one drill hole has been grouted to the surface, with open standpipe groundwater monitoring installed at the remaining 10 sites. Removal of drilling waste from all the site has commenced as a part of preliminary rehabilitation.

To date, none of the drill holes have been signed off as completely rehabilitated, however rehabilitation is planned to continue in the next reporting period. The immediate area around the fully-cored geotechnical investigation drill hole is still subject to ongoing surface-based geotechnical assessment and as such, final rehabilitation of the drill site has been delayed until all activity in the area has been completed. Final rehabilitation of the 10 groundwater monitoring bores cannot be completed until the groundwater monitoring bores are decommissioned and surface infrastructure is removed.

Overall, 20 boreholes from the previous drilling programs have been rehabilitated, however, WCPL's final sign-off on drill site rehabilitation is yet to be completed. Significant delays to the ongoing boreholes rehabilitation project have been incurred due to ongoing weather events and COVID-19 related impacts to operations. Outstanding boreholes rehabilitation will continue when access conditions are suitable.

5.11 Waste

Waste management at WCPL is undertaken by a licensed waste management company under the basic principles of the Total Waste Management System (TWMS). Significant benefits of the TWMS include:

- segregation of waste at the source;
- expansion of recycling capabilities;
- reduction in the risk of contaminating non-hazardous waste;
- comprehensive monthly reports detailing volumes, recycling, disposal and transportation of waste; and
- improved data capture to increase the efficiency and accuracy when reporting.

During the reporting period, a total of 2,251,671 kilograms (kg) of waste was generated by the Mine. Of this, 2,045,171 kg was taken off-site for disposal or recycling (i.e. 90.8%). Of the waste disposed off-site, 81.7% was recycled.

The total waste sent off-site by the Mine in 2021 (2,045,171 kg) was less than half the amount of was sent off-site in 2020 (4,552,262 kg) and the recycling rate for 2021 (81.7%) was similar to 2020 (84.7%) (**Figure 8**).

As the amount of waste generated during the reporting period was significantly lower than the previous reporting period, it is considered that waste minimisation program at the Mine has been effective during the reporting period.

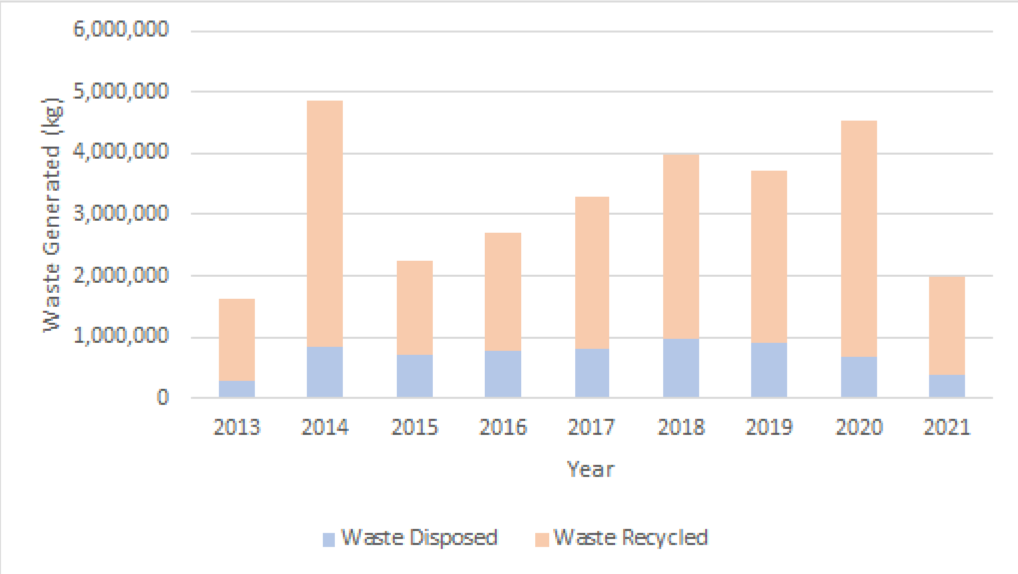


Figure 8: Waste Volumes (2013-2021)

5.12 Visual Amenity and Lighting

All mobile lighting plants are strategically positioned to avoid light being directed towards WCPL's neighbours and other identified potential sensitive receptors.

There were no complaints received during the reporting period relating to lighting impacts from WCPL's mining operations (**Section 8**).

5.13 Contaminated Land

No contaminated land event, that posed a threat of potential or material harm to the environment, occurred during the reporting period. Where possible, any contaminated material is managed on-site in the site bio-remediation area.

5.14 Topsoil Management

During Phase 2 operations at the Mine (i.e. from 1 December 2020), WCPL will no longer undertake topsoil management. It will be managed by United as a component of the UWJV.

5.15 Weed and Pest Management

WCPL commissioned REM to undertake management and control of weed species within the operational and offset areas at the Mine during 2021. Weed management techniques included spraying and manual removal (cut and paint). During the reporting period, a total of 40.5 days of weed control work at the Mine was undertaken by a two-person crew (REM 2021a).

Weed management was undertaken in RWEA A, RWEA B, RWEA E, rail loop area and Warkworth village. A summary of the total areas of specific weeds treated by REM (2021a) is provided in **Table 19** and shown in **Figure 9**.

Table 19: Approximate Area of Weeds Treated at the Mine during 2021

Weeds Treated	Area (ha)
African boxthorn (cut & painted)	1.11
African boxthorn and bridal creeper	0.01
African olive (5 individuals)	-
Bridal keeper	0.07
Fireweed and various weeds	0.27
Galenia	0.41
Galenia and various weeds	2.18
Mother of millions	24.99
Prickly pear	16.79
Prickly pear and African boxthorn (scattered)	8.68
Prickly pear and various weeds	9.61
Total	**64.12**

Note: ha = hectares.

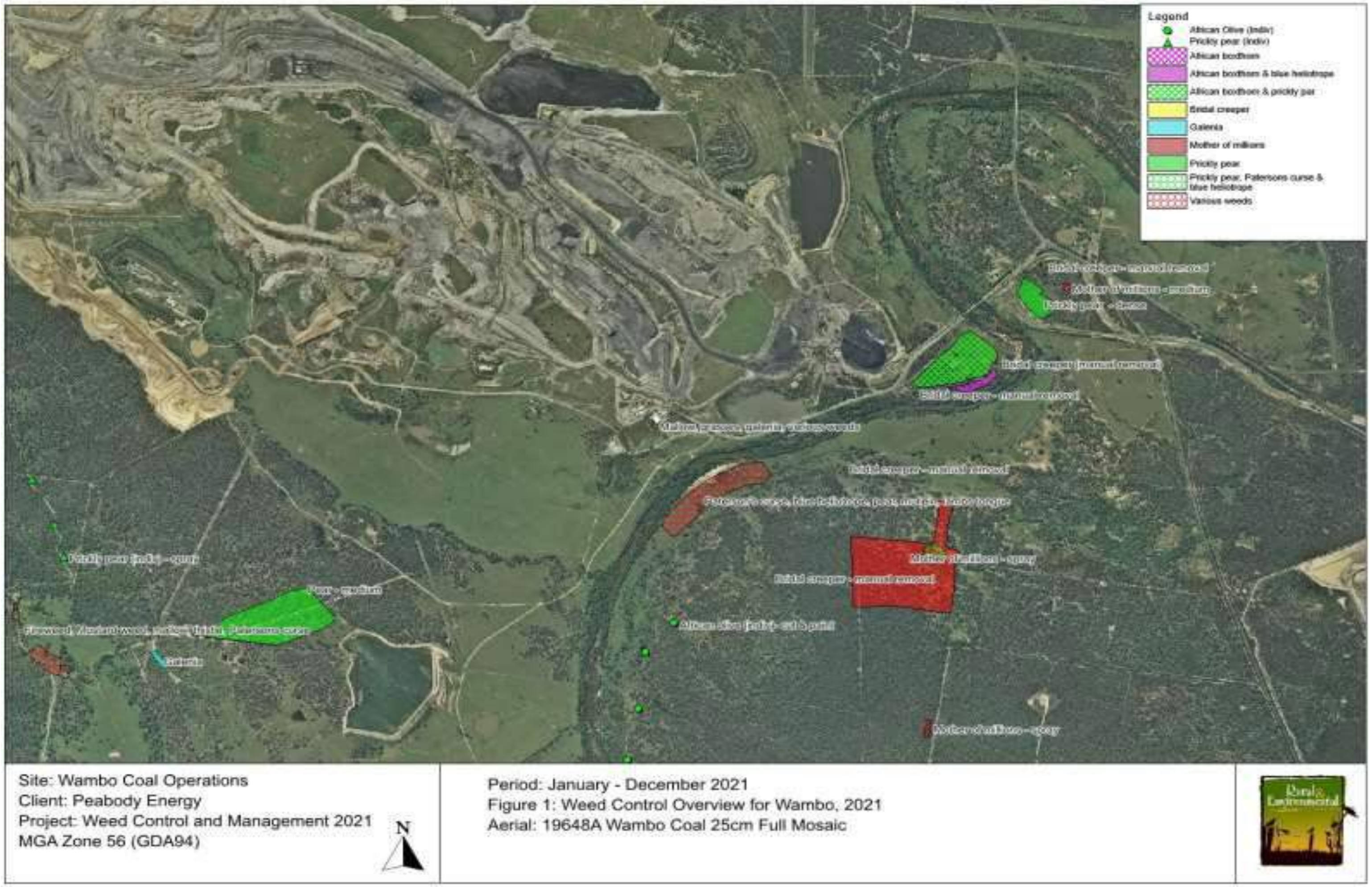


Figure 9: Weed Control Overview for the Mine (REM 2021)

During the reporting period, WCPL undertook a vertebrate pest management program as part of the Hunter Local Land Services Pest Species Management program, along with other mines in the area, in Autumn (May and June) and Spring (October and November), targeting wild dogs and foxes. A combination of ground and ejector baiting was used (REM 2021b and 2021c).

The results of the baiting program were considered to be positive due to the high rate of baits being taken by the target species. A total of 55 (in Autumn) and 60 (in Spring) bait locations were set up with a baiting efficiency of 53% and 68%. The baiting efficiency decreased in Autumn compared to the previous year. This trend may reflect decreased targeted populations in the area and may be from bait shy population avoiding taking meat baits (REM 2021b and 2021c).

Fox takes have increased significantly from 5% and 12% for the preceding two baiting programs respectively to almost 28% in this program. Again, the increase may reflect increasing fox populations or a change in foraging patters relating to season (REM 2021b and 2021c).

In addition, opportunistic feral pig trapping was undertaken in June 2021 and five feral pigs were trapped in steel cages.

During the next reporting period, WCPL intends to continue to work with Local Land Services and neighbouring landowners and participate in coordinated pest control programs.

WCPL prepared an Annual Weed Treatment Plan in 2019 which guided weed management activities in 2021, and will continue to do so into the future. Pest and weed management will continue as required on-site and on agistment managed properties throughout the next reporting period.

5.16 Bushfire Management

No grassfires or bushfires were reported within the Mine during the reporting period. WCPL undertakes proactive grass slashing and maintenance around all site infrastructure and boundary fences where practical.

Although Development Consents DA305-7-2003 and DA177-8-2004 no longer require a Bushfire Management Plan, hazard reduction and maintenance of fire trails will continue to be conducted as required.

5.17 Spontaneous Combustion Management

Inspections for spontaneous combustion form part of daily WCPL inspections across the two main operating areas (i.e., Underground and CHPP).

No spontaneous combustion events were identified by WCPL during the reporting period.

6.0 Water Management

Water management performance measures for the Mine are defined in Table 8 of Condition B62, Schedule 2 DA305-7-2003 and Condition L2 of EPL529. Additional conditions relating to water supply, water and salt balances, discharge volume, effluent application to land, monitoring and recording requirements (including for the HRSTS), the NWCD, Chitter Dump Dam, South Wambo Dam, WCPL's Water Management Plan and independent water audits are also detailed in these documents.

WCPL must also operate in accordance with the conditions of various water licences issued under the *Water Management Act 2000* as well as conditions of DA177-8-2004.

6.1 Surface Water Monitoring

WCPL undertakes surface water monitoring at the Mine in accordance with the approved Surface Water Management Plan (SWMP), which is a component of the WCPL Water Management Plan. The SWMP has been developed to ensure WCPL complies with its statutory conditions relating to surface water monitoring at the Mine.

6.1.1 Approval Criteria/EIS Predictions and Management Plan Requirements

WCPL's EPL529 details the approval criteria for off-site water discharges (**Section 6.3.1**). WCPL has developed impact assessment criteria for surface water quality and stream flow as part of the SWMP.

For the surface water quality criteria (**Table 20**), where actual site-specific water quality monitoring data is available, the criteria have been set based on the 20th and 80th percentile for the available dataset. Where insufficient data is available, WCPL has adopted the applicable Australian and New Zealand Environment and Conservation Council (ANZECC) default guidelines values for slightly to moderately disturbed ecosystems (ANZECC 2000) or the Water Quality Objectives for the Hunter River.

Triggers for the local ephemeral creeks in the SWMP are based on the unexpected absence of flow in climatic situations when flows would be expected. The triggers would be met if there was no flow recorded at the flow monitoring site either on the day or the day after the recorded rainfall was equal to or greater than the nominated amount. Applicable criteria for stream flow are included and **Table 21.**

Table 20: Surface Water Quality Impact Criteria1,2

Sampling Site	Parameter[3]	Lower Limit	Upper Limit
SW02 – Wollombi Brook	pH	7.4	8.1
	EC (µS/cm)	599	1,947
	TSS (mg/L)	17 (low flow) to 308 (high flow)[4]	
SW05 – North Wambo Creek	pH	7.3	8.0
	EC (µS/cm)	1,155	2,350
	TSS (mg/L)	53 (low flow) to 1,110 (high flow)[4]	
SW07 – Wambo Creek	pH	7.4	7.9
	EC (µS/cm)	360	724
	TSS (mg/L)	29 (low flow) to 331 (high flow)[4]	
SW08 – Stony Creek	pH	6.8	7.4
	EC (µS/cm)	288	416
	TSS (mg/L)	5 (low flow) to 15 (high flow)[4]	
SW39 – Waterfall Creek	pH	7.3	7.8
	EC (µS/cm)	159	429
	TSS (mg/L)	582 (low flow) to 1,922 (high flow)[4]	

1. From Table 15 of the SWMP.
2. An exceedance occurs when water quality results exceed the impact criteria on three consecutive sampling events.
3. EC = electrical conductivity, TSS = total suspended solids, µS/cm = microSiemens per centimetre, mg/L = milligrams per litre.
4. Low flow condition based on 80th percentile of recorded concentrations and high flow criteria based on maximum recorded concentrations.

Table 21: Surface Water Flow Impact Assessment Condition

Watercourse and Flow Monitoring Site	Daily Rainfall when Flow Commenced on 80% of Recorded Occasions[1]
North Wambo Creek (FM1)	100 mm[2]
Stony Creek (FM13)	20 mm
South Wambo Creek (FM15)	20 mm

1. From Table 14 of the SWMP.
2. Streamflow measurements in North Wambo Creek daily rainfall data from stations adjacent to the catchment have been analysed and indicated a total depth of continuous rainfall depth of approximately 100 mm (can occur over more than one day) is required to generate surface flow in North Wambo Creek upstream of the diversion.

Condition B62 of DA305-7-2003 and Condition B9 of 177-8-2004 require WCPL to comply with general water management performance measures. Performance indicators relevant to surface water are outlined in **Table 22**.

In addition**,** WCPL is also required to meet additional requirements, in accordance with the SWMP. These requirements include annual reporting on performance against the performance indicators detailed within the SWMP (**Table 23**).

Table 22: Surface Water Performance Measures

Aspect	Performance measure	Performance Indicator/Trigger
Downstream Surface Water Quality	Negligible change in surface water quality (compared to predicted impacts	Surface water quality monitored is outside of the adopted trigger values for at least one parameter for more than two monitoring rounds.
Channel Stability	No increase in areas of instability within watercourses	Channel stability monitoring indicates one or more areas of decreasing stability in watercourses.
Downstream Flooding Impacts	Negligible change in downstream flood access (compared to predicted impacts)	No change to flood inundation of downstream properties in major flood events.
Stream and Riparian Health	Riparian Health	No evidence of significant weed growth or death of vegetation
	Condition of channel	No evidence of significant rill erosion, undercutting or slumping
	Deposition of sediment and debris	No evidence of significant accumulation or deposition, large blockages in channel
	General conditions	No evidence of significant hazards presented to the public, poor aesthetics or feral animals, or geomorphic instability
Surface Water User Supplies	Negligible impact to downstream surface water users (compared to predicted impacts)	• Mining extents / disturbance areas lie within approved boundaries. • Surface water take associated with baseflow impacts is licensed. • No complaints from downstream water users regarding loss of surface water (quality and/or quantity).
Post-mining Water Pollution from Rehabilitated Areas of the Site	Water discharged from the site is suitable for receiving waters and fit for aquatic ecology and riparian vegetation	• Runoff water quality from rehabilitation areas is within the range of water quality data recorded from analogue sites and/or baseline data and does not pose a threat to downstream water quality. • Drainage structures (including drainage lines established in the final landform) are stable and there is no evidence of overtopping or significant scouring as a result of runoff

Table 23: Surface Water Performance Indicators

Performance Indicator
Number of complaints received relating to surface water.
Number of non-compliances received relating to surface water.
Number of exceedances of surface water impact assessment criteria[1].
Number of reportable environmental incidents relating to surface water.

1. An exceedance occurs when water quality results exceed the 80th Percentile Trigger Value (**Table 20**) after three consecutive sampling events.

6.1.2 Performance during the Reporting Period

Surface Water Quality

An exceedance of the surface water quality triggers is considered to have occurred when water quality results exceed the impact criteria (**Table 20**) for three consecutive sampling events.

WCPL recorded exceedances of the surface water quality impact criteria on during the reporting period, at SW02 (for pH), SW05 (for pH), SW07 (for pH) and SW08 for (EC) (**Table 24**).

Table 24: Summary of Exceedances of the Surface Water Quality Impact Criteria

Site	pH	EC
SW02	January to May, September and December	-
SW05	March, November and December	-
SW07	February, April and July to November	-
SW08	-	April to November

In accordance with the TARP for Impacts on Surface Water Quality in the SWMP, WCPL will undertake a preliminary investigation to determine contributing factors for the recorded exceedances of the surface water quality impact criteria (**Table 24**). If the results of the preliminary investigation indicate further works are necessary, WCPL will:

- engage a suitably qualified ecologist or similar to investigate the aquatic environment (where appropriate);
- increase monitoring frequency (where relevant); and
- develop corrective/preventative actions based on the outcomes of the investigation and/or additional monitoring.

WCPL engaged Umwelt (in prep) to undertake a preliminary investigation of the recorded pH exceedances of the surface water quality impact criteria at SW02 and SW07. Umwelt (in prep) concluded, that as all of the results except for one were within the historical and *Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand*, Canberra, 2018 Default Guideline Value (DGV) ranges, it is highly unlikely that operations at the Mine are related to the pH exceedances and that the exceedances are a result of natural variation.

WCPL will undertake an investigation into SW05 in the next reporting period.

With regards to the EC exceedance at SW08, WCPL engaged SLR Consulting to undertake a preliminary investigation at the Stony Creek (SW08) monitoring location. The report concluded that the large magnitude recharge event in March 2021 (following 301 mm of rainfall), may have resulted in sufficient recharge to the shallow groundwater system to enable the migration of surface and shallow groundwater through fractures in bedrock or dilated bedding planes within the Newcastle Coal Measures underlying the creek. This has resulted in the observed change in water quality at SW08 when compared with historical data. Further monitoring and investigations will continue in the next reporting period.

WCPL reported to the EPA that, due to dry conditions or unsafe access, monthly water quality samples were unable to be collected at the required frequencies at monitoring locations, SW03, SW04, SW05, SW07, SW08, SW27a, SW32a, SW39, and SW41 during the reporting period, resulting in a non-compliance with Condition M2.3 of EPL529 (**Section 10.2**). No known adverse impacts resulted due to the non-compliance.

No complaints relating to surface water quality were received during the reporting period.

A summary of the surface water quality monitoring data is included in **Appendix G.**

Surface Water Flows

AECOM (2022) prepared an annual stream flow monitoring report for the Mine and is presented in **Appendix H**.

The WCPL stream flow monitoring system consists of (**Figure 10**):

- five monitoring stations on North Wambo Creek (US-FM1, FM1, FM2, FM3 and FM4);
- three monitoring stations on South Wambo Creek (FM9, FM15 and FM16);
- two monitoring stations on Stony Creek (FM12 and FM13); and
- one monitoring station on a major tributary to Stony Creek (FM14).

During the reporting period, no issues were encountered with the stream monitoring network except for at site FM13 which was destroyed during March 2021 as a result of a significant rainfall. An alternative site for relocation of FM13 has been proposed by AECOM (2022) and will be re-established during the next reporting period.

Table 25 presents a summary of flow events observed at the relevant streamflow monitoring stations on the days during the reporting period when 20 mm or greater rainfall was recorded at the WCPL meteorological station.

There were 17 days during the reporting period that recorded 20 mm or greater of rainfall. FM15 recorded ten (10) flow events throughout the year. Flow events were recorded at FM13 after all of the eight rainfall events that occurred before FM13 was destroyed in March 2021. Flow events were recorded at FM15 after all of the 17 rainfall events recorded during the reporting period.

Umwelt (in prep) investigated the discrepancies between the flows observed at FM13 and FM15 after rainfall during the last reporting period and concluded that the discrepancies between the flows were largely attributed to the influence of sub--daily rainfall patterns not captured in the site rainfall gauge and were not attributed to the mining operations.

Table 25: Surface Water Flow Results

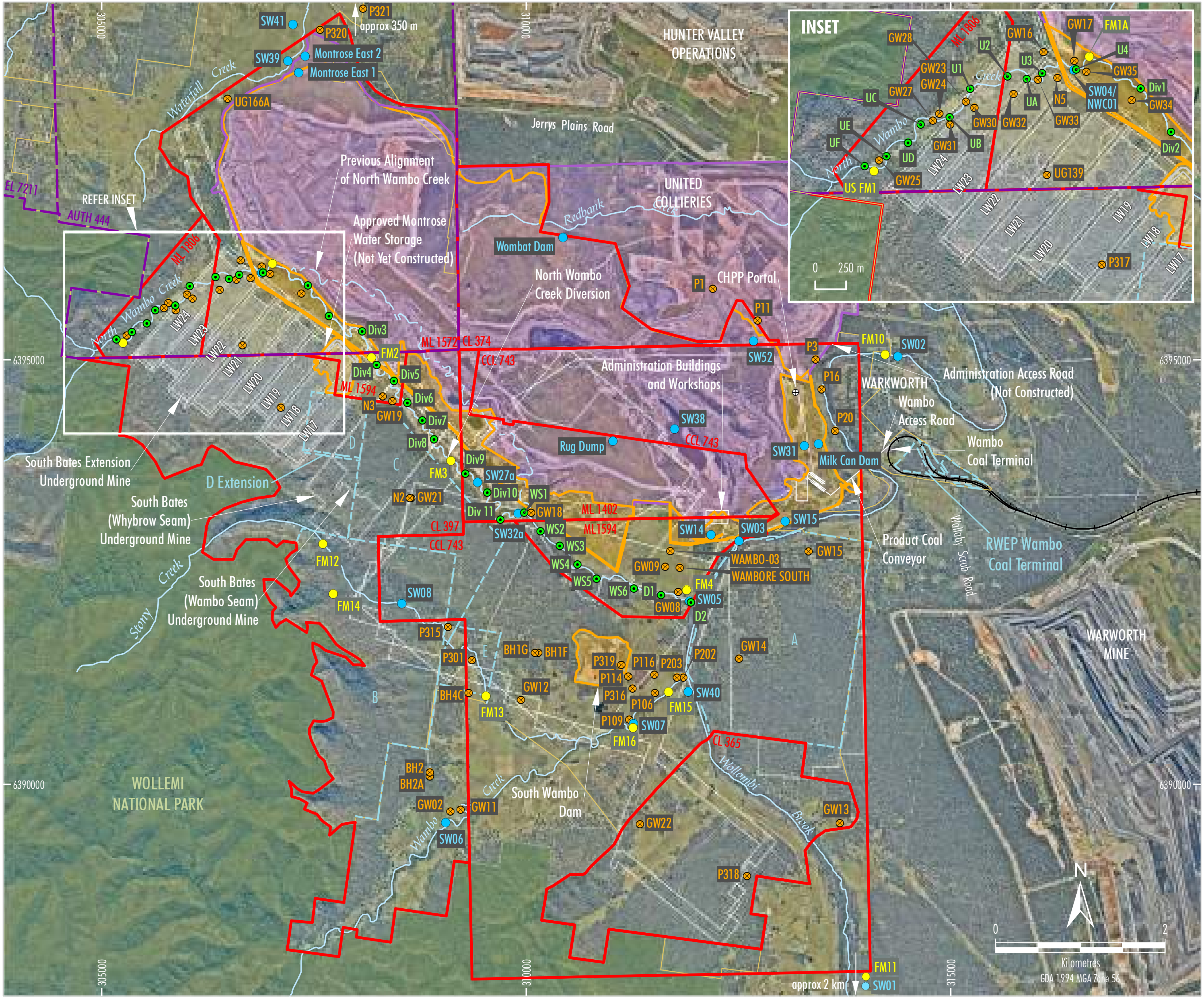
<table>
<tr><th>Date of Rainfall Event</th><th>Rainfall at WCPL Station (mm)</th><th>FM13</th><th>FM15</th></tr>
<tr><td>4/01/2021</td><td>84</td><td>Flow event 4/01/2021 16:47 to 14/01/2021 7:27</td><td rowspan="3">Flow event 2/01/2021 10:20 to 2/03/2021 10:50</td></tr>
<tr><td>0/02/2021</td><td>39.6</td><td>Flow event 1/02/2021 20:27 to 2/02/2021 11:27</td></tr>
<tr><td>13/03/2021</td><td>35.6</td><td>Flow event 14/02/2021 5:17 to 14/02/2021 11:07</td></tr>
<tr><td>14/03/2021</td><td>56.2</td><td>Flow event 14/03/2021 11:07 to14/03/2021 19:07</td><td rowspan="6">Flow event 14/03/2021 19:50 to 8/08/2021 14:00</td></tr>
<tr><td>18/03/2021</td><td>47</td><td rowspan="4">Flow event 18/03/2021 8:47 to 25/03/2021 14:17</td></tr>
<tr><td>19/03/2021</td><td>49</td></tr>
<tr><td>20/3/2021</td><td>36.6</td></tr>
<tr><td>22/03/2021</td><td>47.8</td></tr>
<tr><td>8/06/2021</td><td>24</td><td rowspan="10">This flow station was destroyed during March 2021 and as a result no flow data was recorded from April to December 2021</td></tr>
<tr><td>24/08/2021</td><td>38.4</td><td>Flow event 24/08/2021 9:50 to 4/09/2021 17:00</td></tr>
<tr><td>12/10/2021</td><td>28</td><td>Flow event 13/10/2021 2:00 to16/10/2021 17:00</td></tr>
<tr><td>10/11/2021</td><td>58.6</td><td rowspan="6">Flow event 10/11/2021 20:40 to 31/12/2021 23:50</td></tr>
<tr><td>11/11/2021</td><td>32.8</td></tr>
<tr><td>12/11/2021</td><td>43</td></tr>
<tr><td>21/11/2021</td><td>28.2</td></tr>
<tr><td>26/11/2021</td><td>47.4</td></tr>
<tr><td>8/12/2021</td><td>35.4</td></tr>
</table>

6.1.3 Trends and Key Management Implications

WCPL recorded exceedances of the surface water quality impact criteria on during the reporting period, at SW02 (for pH), SW05 (for pH), SW07 (for pH) and SW08 for (EC) (**Table 24**). As Umwelt (in prep) undertook a preliminary investigation of the recorded exceedances at SW02 and SW07 and concluded that it is highly unlikely that operations at the Mine are related to the pH exceedances at SW02 and SW07 and that the exceedances are a result of natural variation, no additional specific measures are proposed.

WCPL will undertake a preliminary investigation of the surface water quality results recorded at SW05 and additional monitoring and further investigations will continue at SW08 during the next reporting period.

To minimise the potential for the recurrence of not being able to collect monthly waters samples, where samples cannot be collected due to dry conditions, the monitoring site will be revisited for sample collection by WCPL in the event of rainfall of more than 20 mm.



LEGEND

- National Park
- WCPL Owned Land
- Exploration Licence Boundary (AUTH, EL)
- Mining and Coal Lease Boundary (ML, CL, CCL)
- Remnant Woodland Enhancement Program (RWEP) Area
- SSD 7142 Operational Area #
- Existing/Approved Surface Development Area (Phase 2)
- Approved Underground Mining Area
- Approved Underground Mining Area (First Workings only)
- Groundwater Monitoring Site
- Surface Water Quality Monitoring Site
- Surface Water Flow Monitoring Site
- Diversion and Subsidence Monitoring Site

Source: WCPL (2022); NSW Spatial Services (2022)
Orthophoto: WCPL (April 2021)

Peabody

WAMBO COAL MINE

Locations of Surface Water and Groundwater Monitoring Sites

Figure 10

WAM-09-15 AR 2021_206B

6.1.4 Implemented or Proposed Management Actions

During the next reporting period, WCPL will continue to implement the SWMP. If management actions are required as a result of the required preliminary investigations, WCPL will implement the actions accordingly.

6.2 Groundwater Monitoring

WCPL undertakes groundwater monitoring at the Mine in accordance with the approved Groundwater Management Plan (GWMP), which is a component of the WCPL Water Management Plan. The GWMP has been developed to ensure WCPL complies with its statutory conditions relating to groundwater monitoring at the Mine.

In 2019, the Wambo groundwater model was updated to include greater temporal variability to better capture groundwater conditions along North Wambo Creek. This was further refined in the South Bates Extension LW21-24 Extraction Plan modelling undertaken by SLR (2020). The modelling noted that the alluvium and shallow weathered rock are less broadly saturated following the construction of the NWCD and interception of alluvial material by the Montrose open cut.

During the reporting period, WCPL commissioned SLR to update the groundwater model for the Longwalls 24-26 Modification Groundwater Assessment (SLR, in prep).

6.2.1 Approval Criteria/EIS Predictions and Management Plan Requirements

The GWMP includes triggers for groundwater levels and quality in shallow bores. These triggers have been developed using statistical analysis of baseline monitoring data and data acquired to 2014 (from a number of monitoring bores on and around the Mine) and the predicted effects presented in the EIS (Resource Strategies 2003) and subsequent Environmental Assessments.

The trigger values are not assessment criteria but are used to initiate investigations into the groundwater levels or groundwater quality as reported by the groundwater monitoring program. A summary of the groundwater triggers for shallow bores, as detailed in WCPL's approved GWMP is included in **Table 26**. In order to avoid false triggering, as a trigger would be initiated 20% of the time due to natural causes, triggers for groundwater level are defined to occur when two consecutive bi-monthly observations (over a 2-month interval) exceed or fall below the specified depth to groundwater.

In addition to the groundwater monitoring triggers detailed in **Table 26,** WCPL is also required to meet additional requirements, in accordance with the GWMP, Extraction Plan for North Wambo Underground Mine Longwalls 8 to 10A, Extraction Plan for the South Bates Underground Mine Longwalls 11 to 16, Extraction Plan for the South Bates Extension Underground Mine Longwalls 17 to 20, and Extraction Plan for the South Bates Extension Underground Mine Longwalls 21 to 24. These requirements include annual reporting on performance against the performance indicators detailed within the GWMP (**Table 27**).

Table 26: Water Quality and Level Trigger Values – Shallow Bores

Bore	Depth to Groundwater (mBTOC[1]) Min (10th percentile)	Depth to Groundwater (mBTOC[1]) Max (90th percentile)	Conductivity (µS/cm) Maximum (Three Consecutive Bi-Monthly Exceedances)	pH Minimum (Two Consecutive Bi-Monthly Exceedances)	pH Maximum (Two Consecutive Bi-Monthly Exceedances)
P109	4.6	6.7	595	6.5	7.6
P202	7.8	9.6	8,172	6.7	7.7
P206	16.1	21.6	2,630	7.3	8.1
P315	NA[5]	NA	552	6.0	7.4
GW08.2[2]	ND[4]	ND[3]	NA	NA	NA
GW09.2[2]	ND[4]	ND[3]	NA	NA	NA
GW15	10.4	11.1	730	6.7	7.2
GW16[3]	NA	NA	NA	NA	NA
GW17[3]	NA	NA	NA	NA	NA
P16	7.1	7.8	10,832	7.0	7.7
P20	7.1	8.2	10,625	7.0	7.6

1. mBTOC = metres below top of casing.
2. GW08.2, GW09.2 and GW10.2 have been installed within unconsolidated strata near North Wambo Creek to serve as replacement bores to GW08 and GW09. Trigger levels for these bores will be established following the collection of baseline data and based on predicted drawdown from the revised groundwater model.
3. GW16 and GW17 are located upstream of the NWCD and in close proximity to the approved open cut. There are no groundwater users located in the vicinity of North Wambo Creek upstream of the NWCD. Therefore, a trigger level for these two bores is not considered warranted. Monitoring data will be reviewed annually at these bores.
4. Insufficient baseline data to develop meaningful trigger level.
5. NA – trigger level not appropriate for assessing Wambo mining impact at this location.

Table 27: Groundwater Performance Indicators

Performance Indicator
The performance indicators will be considered to have been exceeded if Wambo receives complaints from groundwater users.
The performance indicators will be considered to have been exceeded if monitoring data suggests significant divergences away from the modelled groundwater.
The performance indicators will be considered to have been exceeded if the groundwater levels in alluvial bores exceed the groundwater level criteria listed in the GWMP (**Table 26)**.
The performance indicators will be considered to have been exceeded if the groundwater quality in alluvial bores exceeds the groundwater quality criteria listed in the GWMP (**Table 26**).
Wollombi Brook
The performance indicators will be considered to have been exceeded if the groundwater levels in alluvial bores exceed the groundwater level criteria in the GWMP (**Table 26**).
The performance indicators will be considered to have been exceeded if the impacts observed on riparian, aquatic or groundwater dependent ecosystems are beyond negligible.

Groundwater monitoring data from the Permian monitoring bores is assessed and reviewed as part of the Annual Review. Data is also used to validate the groundwater model.

6.2.2 Performance during the Reporting Period

Monitoring of groundwater levels and quality in alluvial and Permian bores was undertaken in accordance with the GWMP.

SLR (2022) prepared an annual groundwater monitoring report for the Mine and is presented in **Appendix I**.

Above average rainfall conditions occurred at the Mine during the reporting period resulting in flow events in ephemeral watercourses across site, and broad-scale recharge to shallow groundwater systems (**Appendix I**).

The following GWMP trigger value exceedances were recorded during the reporting period (**Appendix I**):

- P315 (Stony Creek Alluvium) – exceedance of EC trigger level.
- GW15 and P16 (Wollombi Brook Alluvium) – minimum groundwater level trigger breach.

Consistent with the GWMP, an investigation was commenced (**Section 6.2.3** and **Appendix I**).

No complaints from groundwater users were received during the reporting period.

Groundwater model performance is consistent with previous Annual Review assessments, with generally good matches to absolute observed groundwater levels (**Appendix I**).

SLR (2022) reviewed compliance against the groundwater performance indicators (**Table 27**) and concluded that WCPL was compliant with the exception of the performance indicators for P315. SLR (2022) recommended further investigation prior to a determination of compliance with the Performance Indicators for GW15 and P16. This investigation will be undertaken during the next reporting period (**Section 6.2.3**).

6.2.3 Trends and Key Management Implications

Groundwater monitoring data collected during the reporting period has been reviewed and assessed against the triggers in the approved GWMP (**Table 26**) by SLR (2022).

During the reporting period exceedances of the EC trigger level were recorded at P315 (Stony Creek Alluvium). The EC increased above the trigger level of 552 µS/cm in June and reached a maximum of 1,275 µS/cm in October before falling back to 568 µS/cm in December. This breach of the EC trigger level was the subject of an investigation that concluded that the high rainfall in March 2021 may have resulted in sufficient recharge to the shallow groundwater system to enable the “flushing” of shallow groundwater through fractures in bedrock or dilated bedding planes within the Newcastle Coal Measures resulting from NWU undermining.

Based on this conclusion, and the data gaps and limitations identified, if the EC breach continues, the following recommendations are made to inform the nature and extent of the water quality change in the Stony Creek alluvium (**Appendix I**):

- Continued monitoring of shallow groundwater sites adjacent to Stony Creek, including periodic monitoring of Fenwick Well 4 downstream. This could be incorporated into the current bi-monthly monitoring program.
- Routine monitoring at a location upstream of NWU LW1 where water quality is currently fresh.
- Survey/ measure height of stickup at all viable Stony Creek monitoring sites.
- Installation of water level and quality loggers within a monitoring bore near the Stony Creek channel (P316, P319), and one within Stony Creek itself to improve the understanding of surface water-groundwater interactions.

Exceedances of the minimum groundwater level trigger at GW15 (Wollombi Brook Alluvium) were recorded during the reporting period. Since early 2018 through to mid-2021, groundwater levels at GW15 have been below the 90th percentile trigger level. From mid-2021, with the ongoing higher than average rainfall, the groundwater level has recovered above the low-level trigger. However, full recovery to levels seen prior to the 2017-20 drought has not occurred although it is possible that the last reading in 2021 just preceded the high rainfall at the end of 2021 which would have generated further recovery at this location. The following is noted / recommended with regard to the minimum groundwater level breach at GW15 (**Appendix I**):

- The trigger levels were defined in a period of prolonged higher than average rainfall and as such the low-level trigger is may be set too high and could be reviewed. The “normal” response to a long period of below average rainfall (as occurred from 2017 to late 2019) had not been observed at this location when the trigger levels were set.
- Groundwater levels have recovered significantly in 2021. The groundwater level response at GW15 may be normal for this location following a period of drought, rather than due to a mining related impact from Wambo or Warkworth operations.
- It is possible that the approaching Warkworth Open Cut may be responsible for some decline in groundwater levels at GW15 although, given its distance from the bore and the changes in geology, impacts from this development would be expected to be limited.
- As part of the 2022 numerical modelling work contributing to the Longwalls 24 to 26 Modification Groundwater Assessment – the model setup should be reviewed in this area. The predicted impacts at GW15 (including any potential impact from Warkworth Open Cut) should be reassessed, and if necessary, the trigger levels revised to reflect refined model predictions and the effect of drought periods.

During the reporting period exceedances of the minimum groundwater level trigger at P16 (Wollombi Brook Alluvium) were recorded. The amount of drawdown in P16 is consistent with the groundwater assessment for the South Wambo Boxcut by HydroSimulations (2016) which predicted a small amount of additional drawdown in Permian strata at P16 due to the excavation of the boxcut, on top of broader regional depressurisation from mining activity including NWU, United Underground and the United Wambo Joint Venture (**Appendix I**).

As part of the groundwater model update, the model setup in this area and the potential controls on levels at P16 will be reviewed (alluvial properties, Wollombi Brook flow etc.). A reassessment of the predicted impacts on P16 will help revise trigger levels to reflect model predictions and the effect of drought periods (**Appendix I**).

WCPL will continue to monitor the bores in accordance with the approved GWMP.

6.2.4 Implemented or Proposed Management Actions

SLR (2022) recommended:

- Replacement of P106 due to an obstruction.
- Removal of GW02 and GW11 from future revisions of the GWMP if pumping is proposed to continue for both bores. A replacement monitoring bore may be useful in a nearby location.
- VWP locations identified with persistent poor-quality data should be removed from the monitoring network.
- Top of casing and ground elevation should be surveyed at recently installed standpipe monitoring bores (GW08.2, GW09.2, GW10.2(a), P316(a,b,c), SW30) in order to convert dipped groundwater levels to mAHD.
- The GWMP should be updated to consider P316a a Wambo Creek Alluvium bore, and P325a (SW30) a Wollombi Brook Alluvium bore.
- Investigate observed impacts at P315, GW15 and P16 (**Section 6.2.3**).

During the next reporting period, WCPL will continue to implement the GWMP.

6.3 HRSTS Discharges

WCPL is permitted to discharge water to the Hunter River in accordance with the conditions of EPL529 and the Hunter River Salinity Trading Scheme (HRSTS) guidelines. These guidelines include the following conditions:

- notification from DPE-Water of discharge opportunity must be received;
- flow of water in Wollombi Brook at the DPE-Water Bulga Gauging Station (FM11) needs to be more than 500 megalitres per day (ML/day);
- pH will be measured continuously throughout the discharge with an inline instrument;
- EC will be measured continuously in µS/cm throughout the discharge with an instrument designed to measure between 0 and 10,000 µS/cm; and
- TSS will be measured once a day during discharge.

A representative sample will be collected every day during discharge and sent to the lab for analysis.

WCPL held 30 credits under the HRSTS at the end of the last reporting period. No credits were retained nor gained by WCPL during the reporting period and therefore WCPL still maintains 30 credits under the HRSTS.

6.3.1 Approval Criteria/EIS Predictions and Management Plan Requirements

A summary of the approval criteria for off-site discharges (from EPL529) is included in **Table 28** in accordance with the Schedule 2, Condition B55 of DA305-7-003.

Table 28: EPL529 Approval Criteria for Off-site Discharge

Parameter	Criteria[1]
pH	6.5-9.5[2]
TSS	120 mg/L[2]
EC	N/A
Volume	250 ML/day

1. Criteria as per EPL529 and DA 305-7-2003.
2. 100^{th} percentile concentration limit.

6.3.2 Performance during the Reporting Period

During the reporting period, discharged a total of 75.1 ML from Licensed Discharge Point (LDP) No.4 to the Hunter River in accordance with the conditions of EPL529 and the HRSTS guidelines. The releases occurred between 22 March 2021 to 25 March 2021.

During the discharges, WCPL undertook continuous in-line monitoring (EC, pH, turbidity and volume) and collected a grab sample at SW15 to measure TSS every day.

WCPL complied with all approval criteria for off-site discharges during the reporting period with the exception of TSS levels at EPL ID Point 4 on 24 March 2021 and 25 March 2021. On these days, the grab sample laboratory analysis results exceeded the TSS approval criterion (120 mg/L) which was inconsistent with the in-line turbidity monitoring system that did not detect any significant change in turbidity during this period.

An investigation determined that the continuous in-line turbidity monitoring was correctly calibrated and that the difference between the results was likely due to the different location of the continuous in-line turbidity monitoring probe and the grab sample location (SW15). The distance between the two monitoring points is approximately 100 m and the samples are taken at varying water depths.

Notification of the non-compliance was reported to DPE and EPA by WCPL as required by EPL 529 and DA 305-07-2003.

There were no adverse effects from the non-compliance. However, to minimise the recurrence of the non-compliance, a new inline grab location was established to better reflect the discharged water location.

6.3.3 Trends and Key Management Implications

An overview of HRSTS releases over time is provided in **Table 29**.

Table 29: Summary of HRSTS Releases

Year	Number of Releases	Release Volume (ML)
2014	1	9.6
2015	6	140.1
2016	11	416
2017	0	0
2018	0	0
2019	0	0
2020	0	0
2021	4	75.1

6.3.4 Implemented or Proposed Management Actions

A written report of the activities undertaken by WCPL under the HRSTS (for the period 1 July 2020 to 30 June 2021) was submitted to the EPA on 18 August 2021 in accordance with Condition R4 of EPL529.

The HRSTS discharge system was reviewed during 2016. This review consisted of updating the communication hardware in consultation with WaterNSW, continued regular calibration of instrumentation and development of operating procedures. A guideline for a HRSTS system audit was completed in 2018. The audit was unable to be completed as WCPL was unable to discharge through the HRSTS in 2018, 2019 or 2020. As discharges occurred during the reporting period, WCPL undertook the HRSTS system audit in 2021.

During the next reporting period, WCPL forecasts compliance with the HRSTS requirements, and predicts that, if the opportunity arises, it will use all of its HRSTS credits, as dictated by River Register releases.

6.4 North Wambo Creek Diversion Discharge Flows

The NWCD Plan was approved by the then NSW Department of Planning (now DPE) in April 2008. A requirement of the approval was to comply with the requirements of the then Department of Water and Energy (now DPE-Water). These requirements included reporting on the performance of the NWCD annually in the Annual Review.

During the reporting period, WCPL monitored flow within the North Wambo Creek at five locations:

- US-FM1, approximately 1 km upstream of FM1 (installed in December 2017);
- FM1, upstream of the NWCD;
- FM2, middle of the NWCD, downstream of FM1;
- FM3, middle of the NWCD, downstream of FM2; and
- FM4, downstream of the NWCD.

A review of the flow events at each monitoring site during the reporting period was undertaken by AECOM (2021) and a summary is provided in **Table 30**. Flow monitoring data is included in the AECOM report (**Appendix H**).

Table 30: NWCD Discharge Flow Monitoring – 2021

Flow Monitoring Station	No. of Flow Events Recorded	Maximum Stream Height Recorded (m)	Maximum Theoretical Flow Rate Recorded (ML/day)
US-FM1	1	0.993	822
FM1*	6	0.811	554
FM2	6	1.37	2,020
FM3	20	1.3	712
FM4	6	2.12	89,500#

* Flow at FM1 was detected through the back-up sensor FM1BU.
# Result influenced by water backing up from Wollombi Brook flood flow.

6.5 Water Take

WCPL maintains a variety of WALs under the *Water Management Act 2000* which consist of High, General and Supplementary securities, as detailed in **Table 31**.

During the 1 July 2020 to 30 June 2021 water year, WCPL extracted a total 134 ML of water from the Hunter River (under WAL 718), 207 ML of water from Wollombi Brook (under WAL 18437), 70 ML of groundwater from Wollombi Brook alluvium (under WAL 23897), and 735 ML from porous rock groundwater sources (under WAL 42373). As shown in **Table 31**, all water take during the 2020-2021 water year was less than the allowable limits under the relevant WALs.

No water was used for irrigation purposes between 1 July 2020 to 30 June 2021 (from licence 20WA200632).

6.6 Compensatory Water

WCPL did not provide any compensatory water to any water users during the reporting period.

Table 31: Environmental Performance – Water Take (1 July 2020 to 30 June 2021)

Licence Number[1]	Description	Expiry Date	Entitlement	Category	Passive take/ inflows (ML)	Active pumping (ML)	Total (ML)
Hunter Regulated River Water Source							
WAL 718 (20SL060212)	Hunter River Pump	Perpetuity	1,000 unit shares (high security)	Regulated River (high security)	0	134	134
WAL 8599 (20SL061206)	Hunter River Pump	Perpetuity	6 unit shares (high security)	Regulated River (high security)	0	0	0
WAL 8600 (20SL061206)	Hunter River Pump	Perpetuity	868 unit shares (general security)	Regulated River (general security)	0	0	0
WAL 8604 (20BL061206)	Hunter River Pump	Perpetuity	240 unit shares (supplementary water)	Supplementary Water	0	0	0
Hunter Regulated River Water Source – Shared with United Colliery							
WAL 929 (20SL050661)	Other Pump	Perpetuity	3 unit shares	Domestic and Stock	0	0	0
WAL 1369 (20SL060416)	80 mm CP	Perpetuity	15 unit shares (supplementary water)	Supplementary Water	0	0	0
WAL 15459 (20SL204246)	80 mm CP	Perpetuity	21 unit shares (general security)	Regulated River (general security)	0	0	0
Hunter Unregulated and Alluvial Water Sources (Lower Wollombi Brook Water Source)							
WAL 18437 (20SL033872)	Wollombi Brook Pump	Perpetuity	350 unit shares	Unregulated River	0	207	207
WAL 23897 (20BL167737)	Well No. 2	Perpetuity	70 unit shares	Aquifer	70 (open cut seepage)	0	70
North Coast Fractured and Porous Rock Groundwater Sources (Sydney Basin - North Coast Groundwater Source)							
WAL 42373[2]	-	Perpetuity	1,549 unit shares	Aquifer	174	561 (Dewatering Bores 2A and 2C)	735
WAL 41532 (20BL172156)	Dewatering	Perpetuity	98 unit shares	Aquifer	0	0	0

1. 20BL prefix bore licences with allocations have been replaced with WALs.
2. WAL 42373 was issued in 2019 to consolidate six of WCPL's previous WALs under the North Coast Fractured and Porous Rock groundwater Sources (Sydney Basin – North Coast Groundwater Source) including WAL 39735, WAL 39738, WAL 39803, WAL 41494, WAL 41528 and WAL 41520.

6.7 Site Water Balance

WCPL reviewed the Site Water Balance at the end of the reporting period, in accordance with the requirements of the Water Management Plan. A summary of the WCPL site water balance for the period 1 January to 31 December 2021 is provided in **Table 32.**

Table 32: Site Water Balance (1 January to 31 December 2021)

Water Sources	Volume (ML)
Hunter River	313
Wollombi Brook	24
United Collieries	1,274
Rainfall/Runoff	2,644
Underground Seepage	90
Dewatering Bores 2A and 4C	70
Total Water Inputs	**4,633**
Water Usage	**Volume (ML)**
Dust Suppression	55
CHPP Consumption	2,455
Underground	97
United Collieries	593
CHPP/UG Potable Water	11
Domestic Usage	0
Total Water Usage	**3,211**
Water Loss	**Volume (ML)**
Evaporation – Mine Water & Tailings Dam	469
HRSTS Discharge	76
Seepage	0
CHPP Process (washdown)	217
Total Losses	**761**
Change in storages	**Volume (ML)**
Initial (January 2021)	486
Final (January 2022)	1,440
Change in Storage	**+954**
Water Balance (ML)	**-294**

A total of 313 ML was extracted from the Hunter River and 24 ML was extracted from the Wollombi Brook during the reporting period. This total is above the EIS forecast annual average extraction volume of 106 ML (Resource Strategies 2003).

As 1,274 ML of water was sourced from the United Collieries during the reporting period, this brings the total volume of water imported to approximately 35% of the total water input. This is considerably higher than the EIS forecast of an average of 2.6% (Resource Strategies 2003).

A total of 2,189 ML of runoff from rainfall was intercepted during the reporting period, 155 ML more than intercepted during 2020 (2,034 ML).

Underground seepage represented 1.9% of total supply compared to the 2003 forecast of 13.8% (Resource Strategies 2003), this is consistent with seepage in 2020. The MOD17 Groundwater Assessment (HydroSimulations 2017) predicted that there would be an average seepage of 212 ML per annum (ML/a) and a maximum seepage of 376 ML/a from the combined sources of the South Bates Underground Mine and South Bates Extension Underground Mine. The underground seepage recorded during the reporting period (90 ML) is similar to seepage recorded in 2020 (90) but it is considerably lower than these predictions.

No water was exported off-site during the reporting period. No water was discharged during the reporting period.

6.7.1 Salt Balance

WCPL reviewed the Salt Balance at the end of the reporting period, in accordance with the requirements of the Water Management Plan. A summary of the WCPL salt balance for the period 1 January to 31 December 2021 is provided in **Table 33.**

Table 33: Salt Balance (1 January to 31 December 2021)

Inputs	Salt (t)
Raw water- Hunter	128
Raw water- Wollombi	10
Runoff	3,133
Groundwater (ROM coal)	1,103
Groundwater (Bores)	1,385
Groundwater (Seepage)	1,021
Total	**6779**
Outputs	**Salt (t)**
Product Coal	719
Dust suppression	192
Release to HRSTS	271
Total	**1,183**
Balance	**5596**

6.8 Erosion and Sediment Control

WCPL has developed an ESCP to address the relevant consent conditions and regulatory requirements.

6.8.1 Performance during the Reporting Period

During the reporting period, WCPL complied with all requirements ESCP under DA 305-7-2003 from 1 January 2021 to 31 December 2021.

Notwithstanding the above, the sediment control sump that collects runoff from the Wambo Rail Load Out Facility (i.e. Hales Crossing Sump) was inundated by floodwaters from the Wollombi Brook on 22 March 2021 after significant rainfall.

The Hales Crossing Sump was subsequently inspected for structural integrity and pumping infrastructure reinstated and flood water remaining in Hales Crossing Sump was pumped back into the Mine water system on 26 March 2021.

WCPL notified the DPE and EPA of the incident in accordance with Condition R 2.2 of EPL 529 and the DA 305-7-2003.

No complaints were received relating to erosion and sediment control.

6.8.2 Trends and Key Management Implications

No trends or key management implications for erosion and sediment control were identified during the reporting period.

6.8.3 Implemented or Proposed Management Actions

During the next reporting period, WCPL will continue to implement the approved ESCP.

7.0 Rehabilitation

7.1 Rehabilitation Performance during the Reporting Period

Proposed rehabilitation and disturbance activities for the reporting period are detailed in WCPL's approved RMP/MOP (December 2020 to December 2023).

7.1.1 Status of Disturbance and Rehabilitation

WCPL is responsible for rehabilitating the remaining surface area and activities related to the Mine's approved underground activities. Due to the nature of this disturbance, there will be minimal progressive rehabilitation reported by WCPL over the coming years (i.e. as the disturbed surface area will be required for the life of the underground mine).

A summary of the proposed and actual rehabilitation activities undertaken in 2021 is provided in **Table 34**.

Table 34: Actual versus Proposed Rehabilitation Activities (2021)

	2021 Proposed	2021 Actual (at 31 December)	2022 Proposed
Total Disturbance (ha)	0	0	0
Total Rehabilitation (ha)	0	0	0
Cumulative Rehabilitation (ha)	121.9	121.9	121.9

During the reporting period, subsidence remediation focused on the South Bates Underground Mine in the vicinity of Longwalls 17, 18, 19 and 20. Of the 48 subsidence sites rehabilitated in 2021, this included 16 sites in and adjacent to the North Wambo Creek diversion. The remediation of sites occurred throughout the year and consisted of a combination of targeted subsidence campaigns and reactive subsidence remediation. The sites ranged from small potholes to cracks several meters in length.

7.1.2 Agreed Post Rehabilitation Land Use

The agreed post rehabilitation land use for the Mine is detailed in WCPL's EIS (Resource Strategies 2003), DA305-7-2003 and MOP/RMP (December 2020 – December 2023). The final landform for WCPL proposes a balanced rehabilitation outcome which recognises the alternative land uses that exist in the region, and therefore aims to establish the potential for both sustainable agriculture and endemic woodland habitat. The proposed design of final landforms and the revegetation strategy are described in the MOP/RMP (December 2020 – December 2023) and in United's RMP.

All rehabilitation activities completed at the Mine are undertaken with consideration to the agreed post rehabilitation land use goals.

7.1.3 Key Rehabilitation Performance Indicators

Table 35 summarises WCPL's rehabilitation status at the end of the reporting period, compared to the previous reporting period.

As outlined above, WCPL is responsible for rehabilitating the remaining surface area and activities related to the Mine's approved underground activities. As such, there will be minimal progressive rehabilitation reported by WCPL over the coming years.

Table 35: 2021 Rehabilitation Status and Forecast

Mine Area Type	2021 (Forecast) (ha))	2021 Actual (at 31 December) (ha)	2022 (Forecast) (ha)
A. Total mine footprint[1]	323.21	323.21	323.21
B. Total active disturbance[2]	201.31	201.31	201.31
C. Land being prepared for rehabilitation[3]	0	0	0
D. Land under active rehabilitation[4]	121.9	121.9	121.9
E. Completed rehabilitation[5]	0	0	0

1. Total mine footprint includes all areas within a mining lease that either have at some point in time or continue to pose a rehabilitation liability due to mining and associated activities. As such it is the sum of total active disturbance, decommissioning, landform establishment, growth medium development, ecosystem establishment, ecosystem development and relinquished lands (as defined in DRE (now DPE) MOP/RMP Guidelines). Please note that subsidence remediation areas are excluded.
2. Total active disturbance includes all areas ultimately requiring rehabilitation such as: on-lease exploration areas, stripped areas ahead of mining, infrastructure areas, water management infrastructure, sewage treatment facilities, topsoil stockpile areas, access tracks and haul roads, active mining areas, waste emplacements (active/unshaped/in or out-of-pit), and tailings dams (active/unshaped/uncapped).
3. Land being prepared for rehabilitation – includes the sum of mine disturbed land that is under the following rehabilitation phases – decommissioning, landform establishment and growth medium development (as defined in DRE (now DPE) MOP/RMP Guidelines).
4. Land under active rehabilitation – includes areas under rehabilitation and being managed to achieve relinquishment – includes the following rehabilitation phases as described in the DRE (now DPE) MOP/RMP Guidelines – "ecosystem and land use establishment" (area seeded OR surface developed in accordance with final land use) and "ecosystem and land use sustainability" (revegetation assessed as showing signs of trending towards relinquishment OR infrastructure development).
5. Completed rehabilitation – requires formal sign-off by DRE (now DPE) that the area has successfully met the rehabilitation land use objectives and completion criteria.

7.1.4 Renovation or Removal of Buildings

No buildings were renovated or removed during the reporting period.

7.1.5 Other Rehabilitation Activities

In consultation with DRE (now MEG), an extensive audit of historical exploration works commenced during 2015. The scope of the audit was to identify all historical exploration sites, rehabilitate as required and relinquish the sites to DRE (now MEG). Of the identified sites:

- 9 sites were rehabilitated;
- 21 sites were inspected;
- 8 sites were identified as suitable for relinquishment; and
- 13 sites were identified as mined through.

In 2016, the scope of the audit was finalised and a total of 222 sites associated with historical exploration were identified in A444 and 17 in EL7211. The sites were identified as requiring inspection, possible rehabilitation and eventual relinquishment.

Both the EL7211 and A444 audits were completed during 2017. Copies of these reports were provided to DRG (now RR) on 17 April 2017. In December 2017, DRG (now RR) requested an ESF2 Form (Rehabilitation Completion and/or Review of Rehabilitation Cost Estimate) be completed to accompany the Audit Reports. The ESF2 form was submitted to DRG (now RR) on 14 December 2017. Follow up inspections required for the remaining holes associated with this audit were delayed. These bores will be inspected as part of the ongoing exploration rehabilitation program (refer to **Section 5.10**).

7.1.6 Trials, Research Projects and Other Initiatives

The following rehabilitation trials were undertaken during the reporting period:

- Subsidence repair trials.
- Remediation of approximately 1 km of the NWCD, as guided by the NWCD Rehabilitation and Maintenance Plan, including the application of gypsum to improve soil sodicity and structure beneath newly constructed rock chutes.

Subsidence remediation trials were previously conducted on areas of historical subsidence. Trials were conducted in several areas using different methodologies dependent on the identified surface impact. Continued monitoring of subsidence remediation will identify any further subsidence or requirement for reworks. As of the end of the reporting period, remediated sites remained sound.

7.1.7 Variations in Activities Proposed in the MOP/RMP

During the reporting period, rehabilitation was undertaken in accordance with the activities proposed in the approved MOP/RMP (December 2020 - December 2023).

7.1.8 Key Issues That May Impact Successful Rehabilitation

WCPL is responsible for rehabilitating the remaining surface area and activities related to the Mine’s approved underground activities.

Due to the nature of this disturbance, there will be minimal progressive rehabilitation reported by WCPL over the coming years (i.e. as the disturbed surface area will be required for the life of the underground mine).

7.2 Actions for the Next Reporting Period

7.2.1 Rehabilitation Trials, Research Projects and Other Initiatives

The following rehabilitation trials, research projects and other initiatives are proposed over the next reporting period:

- Continuation of subsidence repair trials.
- Continuation of NWCD remediation works, as guided by the NWCD Rehabilitation and Maintenance Plan.

7.2.2 Proposed Rehabilitation in the Next Reporting Period

Following the commencement of Phase 2 of the UWJV, rehabilitation activities for open cut operations is managed by United. Rehabilitation work proposed during the next reporting period includes:

Work proposed for the next reporting period is currently being finalised, however will likely include:

- Continuation of subsidence remediation works in the vicinity of South Bates and South Bates Extension Underground Mines.
- Continuation of NWCD remediation works, as guided by the NWCD Rehabilitation and Maintenance Plan.
- Continuation of the historical exploration works rehabilitation program.

8.0 Community

WCPL operates a 24 hour Community Enquiry Line (02 6570 2245), and a dedicated community email account (wambocommunity@peabodyenergy.com), to enable community members to make enquiries or lodge complaints regarding the operation of the Mine.

8.1 Community Engagement Activities and Initiatives

8.1.1 Community Consultative Committee

The WCPL CCC is made up of residents from the surrounding district, a representative of Singleton Council and WCPL management. The CCC representatives act as the point of contact between the mine and the community. The CCC is chaired by an independent chairperson.

During the reporting period WCPL held four CCC meetings:

- Tuesday 9 February 2021;
- Tuesday 4 May 2021;
- Tuesday 28 September 2021; and
- Tuesday 9 November 2021.

Minutes of these meetings are available on the Peabody Energy website https://www.peabodyenergy.com/Operations/Australia-Mining/New-South-Wales-Mining/Wambo-Approvals,-Plans-Reports.

8.1.2 Newsletters

No community Newsletter was published during the reporting period.

8.1.3 Other Community Engagement Activities

No community information sessions were held during the reporting period.

8.2 Community Contributions

During the reporting period, WCPL contributed to the community through the following:

- Singleton PCYC Youth Boxing Program
- Singleton Business Chambers – Men's Health;
- Singleton Business Chambers – International Women's Day;
- Singleton Business Chambers- Annual Business Awards;
- Wildlife Aid;
- Jenny's Place- Women's Domestic Violence & Homelessness Support; and
- Wambo Singleton Hall of Fame.

8.3 Community Complaints

WCPL received no community complaints during the reporting period (**Figure 11**). This is a significant reduction compared to eighty-three (83) in 2020, compared to forty-six (46) in 2019 and forty-four (44) in 2018. The reduction in complaints associated with the Mine is expected to be due to the commencement of Phase 2 operations which do not include open cut mining operations.

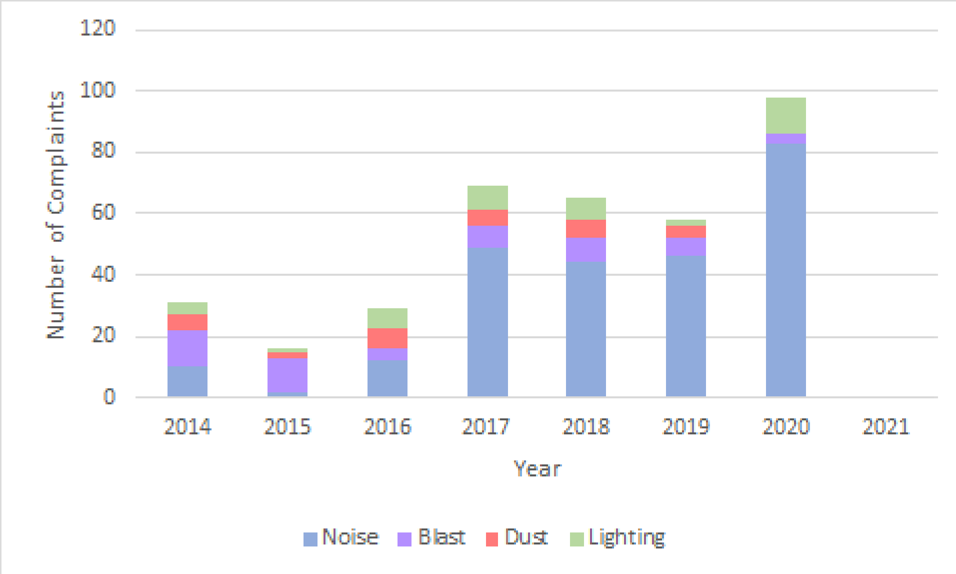


Figure 11: Community Complaints (2014-2021)

9.0 Independent Audits

9.1 2015 Independent Environmental Audit for South Bates Underground Mine Extraction Plan

In 2015, WCPL commissioned an independent audit of subsidence, surface water and groundwater impacts prior to the submission of an Extraction Plan for Longwalls 11 to 13, in accordance with Condition 37, Schedule 4 of DA305-7-2003 (no longer required by the Development Consent). The report was finalised in June 2015 and submitted to DPE.

All actions from the independent audit were reported as complete in previous Annual Review.

9.2 2016 Independent Rehabilitation Audit for Annual Environment Management Report

In 2015, WCPL commissioned GHD to undertake an independent audit (GHD 2016) of the rehabilitation at the Mine to identify any potential deficiencies of the rehabilitation and improvement strategies. The audit report was finalised in June 2016 and submitted to MEG.

All actions from the independent rehabilitation audit were reported as complete in previous Annual Review.

9.3 2017 Independent Environmental Audit

An IEA was undertaken by Hansen Bailey (2017) in November and December 2017 to assess compliance against DA305-7-2003 and DA177-8-2004).

The audit also assessed compliance against EPL529 and ML1572. The audit report was finalised in December 2017 and submitted to DPE in accordance with Condition 7, Schedule 6 (now Condition D11, Schedule 2) of DA305-7-2003. Following review of the IEA, DPE advised their agency requirements had not been addressed in the audit and requested the IEA be revised to include them. The revised IEA was submitted to DPE on 19 September 2018 and approved 31 January 2019. A copy of the audit report is available on the Peabody Energy website (www.peabodyenergy.com).

Thirty-six (36) non-compliances, comprised of 25 issues, were identified during the audit, including thirteen (13) which were classed as “administrative”. The non-compliances were risk ranked. No high risks were identified during the audit. Eleven issues were identified as low risk and one issue as medium risk. The report also included numerous recommendations for improvement. **Table 36** summarises WCPL’s actions taken to address the remaining continual improvement recommendations.

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Table 36: Continual Improvement Recommendations Made by the 2017 IEA for DA305-7-2003 and DA177-8-2004

<table>
<tr><th>Ref</th><th>Description</th><th>WCPL Response</th><th>Timing</th></tr>
<tr><td colspan="4">DA305-7-2003 Continual Improvement Recommendations</td></tr>
<tr><td colspan="4">Other</td></tr>
<tr><td>N/A</td><td>• The diversion management program should be implemented to improve the operation of the diversion;</td><td rowspan="3">Agreed. The revised NWCD Plan contains a detailed rehabilitation plan including:
• Table 13: 5 Year NWCD Rehabilitation and Maintenance Plan.
• Appendix C – Detailed Rehabilitation Plan.</td><td rowspan="3">Stage 2 works completed in 2021.
Stage 3 works in 2022 will be guided by the North Wambo Creek Diversion Remediation Plan 2022-2023.</td></tr>
<tr><td>N/A</td><td>• Ongoing management is required in order to ensure that soil erosion is minimised and ground cover is given adequate opportunity to become established; and</td></tr>
<tr><td>N/A</td><td>• Rehabilitation of subsided areas of the diversion is required in accordance with an Extraction Plan (or SMP), including repairing surface subsidence cracks and undertaking subsidence remediation where necessary in areas where the diversion has been subsided.</td></tr>
<tr><td>N/A</td><td>The area in RWEA B is rehabilitated to prevent further damage and reduce risks to the surrounding Central Hunter Grey Box-Ironbark Woodland Endangered Ecological Community (EEC) as per Ecological Australia’s recommendations.</td><td>Most appropriate method of rehabilitation to be determined, in order to reduce impacts if rehabilitation is undertaken with machinery.</td><td>Ongoing.</td></tr>
<tr><td>N/A</td><td>Subsidence affected sites identified as ‘intolerable’ by SLR Consulting should be remediated to an acceptable standard as per SLR’s recommendations. Photos of completion should be kept within the database along with a report checklist with date and signature demonstrating works were completed.</td><td>Most appropriate method of rehabilitation to be determined, in order to reduce impacts if rehabilitation is undertaken with machinery.</td><td>Ongoing.</td></tr>
</table>

9.4 2019 Independent Environmental Audit for EPBC 2003/1138 and Biodiversity Management Plan

An IEA was undertaken by Cumberland Ecology in 2019 to assess compliance against EPBC Approval 2003/1138, the Biodiversity Offset Strategy (BOS), and the commitments made in WCPL's BMP. The audit report was finalised in January 2020 and submitted to DPE in accordance with Condition 4 of EPBC 2003/1138 and Condition 50, Schedule 4 of DA305-7-2003 (no longer a requirement under the Development Consent following approval of MOD 16). A copy of the audit report is available on the Peabody Energy website (www.peabodyenergy.com).

Seven (7) non-compliances and three (3) items that were unable to be verified were identified during the audit. All recommendations from this audit have been addressed.

There is no longer a requirement for WCPL to undertake an IEA for EPBC 2003/1138 under DA305-7-2003. As required by Condition 4 of EPBC 2003/1138 future audits will be undertaken every five years.

9.5 2020 Independent Environmental Audit

An IEA was undertaken by GHD in November of 2020 to assess compliance against DA305-7-2003 and DA177-8-2004 and other relevant environmental approvals and licences. The audit was conducted for the period beginning September 2017 to end of November 2020. The audit report was finalised in December 2020 and submitted to DPE in accordance with Condition D11, Schedule 2 of DA305-7-2003 and was approved on 1 December 2021. A copy of the audit report is available on the Peabody Energy website (www.peabodyenergy.com).

There were no medium or high risk non-compliances identified during the audit. Thirty-one (31) non-compliances were identified, including ten (10) which were classified as "administrative", the remaining twenty-one (21) were classified as "low". The report also included recommendations for improvements. **Table 37** and **Table 38** summarise WCPL's proposed actions to address the outstanding non-compliances and continual improvement recommendations, respectively.

9.6 2020 Pollution Monitoring Data EPA Desktop Audit

As part of the EPA state wide compliance audit program focusing on the requirements for licensees to publish pollution monitoring data, a desktop audit was conducted by the EPA on 11 May 2020. A copy of the audit report is available on the Peabody Energy website (www.peabodyenergy.com).

A number of administrative non-compliances were identified for EPL529 regarding pollution monitoring data. All non-compliances identified by the audit have been addressed.

Table 37: Non-Compliances Requiring Action Identified by the 2020 IEA for DA305-7-2003 and DA177-8-2004

Ref	Audit Finding / Risk	Description	WCPL Response	Timing
B105 of DA305-7-2003 and B26 of DA177-8-2004	Low	The method for assessing rehabilitation performance using LFA monitoring should be reassessed in line with Tongway and Hindley (2005). TARP and Completion Criteria should be updated in the MOP.	Section 8.1.1 of the RMP (approved 25 November 2020) states 'Over the RMP term, WCPL will review the use of LFA as a monitoring method and transition to alternative monitoring methods for rehabilitated landscape establishment which may include soil monitoring. Biometric Vegetation Assessment and visual assessments. The TARP and Completion criteria will be updated accordingly.	During next MOP/RMP review (current MOP/RMP approved to 31 December 2023).
B108 of DA305-7-2003	Administrative	The MOP should be updated to include relevant programs and activities to address care and maintenance and mine closure requirements.	Agreed.	During next MOP/RMP review (current MOP/RMP approved to 31 December 2023).
C4 of DA305-7-2003 and C2 of DA177-8-2004	Administrative	Provide copies of relevant resident tenancy agreements to the Planning Secretary to confirm satisfaction that the intents of this condition of been met.	Agreed.	By 31 March 2021.
EPL529 Condition M2.3	Administrative	When PM_{10} samplers (TEOM) stop logging data, report the duration and the 24 hour average concentration to see if the downtime would likely of resulted in an exceedance.	Agreed.	As required.

Table 38: Continual Improvement Recommendations Made by the 2020 IEA for DA305-7-2003 and DA177-8-2004

Ref	Description	WCPL Response	Timing
B42 of DA305-7-2003	Calculation of the site incremental impact, and contributions during extraordinary events such as bushfires is undertaken as required for elevated 24 hour concentrations and on an ad-hoc basis for annual averaged concentrations. The site can investigate a method to better capture extraordinary events such as bushfires and exclude this from the data on a regular basis. Increase in site annual averages shows this may be an issue moving forward with climate related events such as bushfires and droughts.	This matter will be discussed with WCPL's appointed air quality expert and an appropriate method to better capture extraordinary events and exclude this from the data will be determined.	Complete
B66 of DA305-7-2003	Figure 10 of the ESCP would benefit from flow direction arrows indicating is satisfaction of detailed plans for water run-off diversions and catch drains and any reinstated drainage networks on rehabilitated areas of the site.	Agreed.	Complete
B90 of DA305-7-2003	The CMP should be resubmitted to the Heritage Branch for endorsement/verification of satisfaction, to ensure compliance with the modified requirements of DA305-7-2003.	Agreed.	Complete – re-submitted to Heritage NSW on 21 April 2021.

9.7 2021 Audit of the Wambo Conservation Agreements

On 25 May 2021, representatives from the NSW Biodiversity Conservation Trust (BCT) conducted a site visit and inspection of the Wambo offset areas subject to Conservation Agreements. A number of recommendations were made following the visit, generally relating to weed and pest management, fencing requirements, and suggested improvements to the annual reporting format. These recommendations will be implemented by WCPL.

10.0 Incidents and Non-compliances during the Reporting Period

The following incidents and non-compliances were identified during the reporting period (refer **Statement of Compliance** at the front of this document):

- Continuous air quality data was not recorded due to technical and environmental factors that resulted in a loss of power or data (**Section 10.1**).
- Representative surface water samples were not collected monthly due to dry conditions or unsafe access (**Section 10.2**).
- Exceedances of groundwater performance indicators (**Section 10.3**).
- TSS levels exceeded the HRSTS discharge limit (**Section 10.4**).
- Floodwaters from Wollombi Brook inundated a sediment control sump at Hales Crossing resulting in release from the Hales Crossing Sump (**Section 10.5**).

10.1 PM_{10} Monitoring

During the reporting period, PM10 readings were not obtained on 23 occasions at AQ04. The lapse in continuous monitoring resulted in a non-compliance with Schedule 2, Condition B45 of DA 305-7-2003 and Condition M2.2 of EPL529.

The PM10 monitors ceased logging for varying lengths of time. These breaks in continuous monitoring were a result of technical and environmental factors that resulted in a loss of power or data storms (e.g. equipment malfunction/failure, water ingress, loss of power supply, electrical fault, and lightning/storm). These issues were addressed as quickly as possible following identification of the issue. It is noted that data capture for the reporting period was above 98%, which is generally considered acceptable for air quality monitoring networks (**Appendix D**).

All monitoring stations are remotely controlled by internal contractor equipment minimising the likelihood of data being lost as a result of faults/communication errors/ power outages. Regular preventative maintenance will continue on all four PM_{10} monitors during the next reporting period.

No known adverse impacts resulted due to the non-compliance.

10.2 Surface Water Sampling

Condition M2.3 of EPL529 requires surface water quality samples to be collected at a number of locations, however, due to dry conditions or unsafe access in some locations, samples were unable to be collected at the required frequency at monitoring locations SW03, SW04, SW05, SW07, SW08, SW27a, SW32a, SW39, and SW41.

WCPL will continue to implement the SWMP and monitoring on a monthly basis. Where samples cannot be collected due to dry conditions, the monitoring site will be revisited for sample collection by WCPL in the event of rainfall of more than 20 mm.

No known adverse impacts resulted due to the non-compliance.

10.3 Groundwater Performance Indicators

SLR (2022) reviewed compliance against the groundwater performance indicators (**Table 27**) and concluded that WCPL was compliant with the exception of the performance indicators related to the following:

- P315 (Stony Creek Alluvium) – exceedance of EC trigger level.

SLR (2022) recommended further investigation prior to a determination of compliance with the Performance Indicator for GW15 and P16. This investigation will be undertaken during the next reporting period.

Notification of the non-compliance was reported to DPE as required by DA 305-07-2003.

10.4 HRSTS Monitoring

Schedule 2, Condition B55 of DA 305-7-2003 and EPL 529 provides discharges water quality limits for the HRSTS. WCPL complied with all approval criteria for HRSTS discharges during the reporting period with the exception of TSS levels at EPL ID Point 4 on 24 March 2021 and 25 March 2021. On these days, the grab sample laboratory analysis results exceeded the TSS approval criterion (120 mg/L) which was inconsistent with the in-line turbidity monitoring system that did not detect any significant change in turbidity during this period.

An investigation determined that the continuous in-line turbidity monitoring was correctly calibrated and that the difference between the results was likely due to the different location of the continuous in-line turbidity monitoring probe and the grab sample location (SW15). The distance between the two monitoring points is approximately 100 m and the samples are taken at varying water depths.

To minimise the recurrence of the non-compliance, a new inline grab location was established to better reflect the discharged water location.

Notification of the non-compliance was reported to DPE and EPA by WCPL as required by EPL 529 and DA 305-07-2003.

There were no adverse effects from the non-compliance.

10.5 Hales Crossing Sump Inundation

The sediment control sump that collects runoff from the Wambo Rail Load Out Facility (i.e. Hales Crossing Sump) was inundated by floodwaters from the Wollombi Brook on 22 March 2021 after significant rainfall. The contents of the Hales Crossing Sump were therefore released not in accordance with Condition L1.1 of EPL 529.

The Hales Crossing Sump was subsequently inspected for structural integrity and pumping infrastructure reinstated and flood water remaining in Hales Crossing Sump was pumped back into the Mine water system on 26 March 2021.

WCPL notified the DPE and EPA of the incident in accordance with Condition R 2.2 of EPL 529 and the DA 305-7-2003.

11.0 Regulator Requests for Information

During the reporting period the DPE and EPA made a number of requests for information relating to WCPL operations. On each occasion, WCPL conducted a review of relevant monitoring data and operational activities and provided a summary to DPE and/or EPA.

An overview of the information requested and actions taken is provided in **Table 39**.

Table 39: Regulator Requests for Information

Date of Request	Relevant Agency	Comment
27 January 2021	EPA	The EPA requested information and records in response to the noise exceedance that occurred on 8 September 2020. WCPL provided response on 12 January 2021
19 February 2021	EPA	The EPA invited Wambo to 'Show Cause' and provide reasons why the EPA should take no further actions relating to the noise exceedance that occurred on 8 September 2020. WCPL provided response on 5 March 2021
3 November 2021	DPE	The DPE requested additional information to be included in the Annual Review. WCPL has incorporated this additional information in this Annual Review (Table 6).

12.0 Activities to be Reported in the next Reporting Period

The following activities will be undertaken and reported on by WCPL during the next reporting period:

- re-erect/reconstruct three (3) fallen nest box;
- investigate observed impacts at P315, GW15 and P16;
- preliminary investigations of the surface water quality results (pH) recorded at SW05;
- Further investigation into increased EC recorded at SW08;
- continuation of subsidence repair trials;
- repair subsidence damage to tracks;
- continue planned 2022 NWCD rehabilitation and maintenance works; and
- review of P16 as the part of underground model update.

Where required, updated management plans and strategies will be submitted to relevant government authorities for approval and uploaded to the WCPL website.

13.0 References

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- GHD, 2016. *Wambo Coal Rehabilitation Audit – Audit Report.* June 2016.
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- Mine Subsidence Engineering Consultants, 2020. *South Bates Extension Underground Mine Subsidence Review Report for the South Bate Extension Underground Mine WYLW18 and WYLW19.*
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- New South Wales Department of Planning and Environment, 2015. *Post-approval requirements for State significant mining developments – Annual Review Guideline – October 2015.*
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- Rural & Environmental Management Pty Ltd, 2021c. Wambo Coal Spring Vertebrate Pest Management Report (14 October – 5 November 2021).
- SouthEast Archaeology Pty Ltd, 2021. Wambo Coal Mine-Aboriginal Heritage Due Diligence Investigation Of Drilling Locations, November 2021.
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- Todoroski Air Sciences, 2016. *Air Quality and Greenhouse Gas Review – South Bates Extension Modification*.
- Tongway and Hindley, 2005. *Landscape Function Analysis: A System for Monitoring Rangeland Function.*
- Umwelt, 2016. *United Wambo Open Cut Coal Mine Project Environmental Impact Statement*. August 2016.
- Umwelt, In preparation. *Stream Flow and Water Quality Impact Assessment Criteria Exceedance Investigation. Wambo Coal Mine.* March 2022.
- Wambo Coal Pty Ltd, 2021. *South bates Extension Underground Mine Extraction Plan Longwalls 21 to 24*.

APPENDIX A

APPROVAL CONDITIONS SPECIFICALLY RELATING TO THE ANNUAL REVIEW

Approval	Condition	Description	Where Addressed
DA305-7-2003	Condition B49, Schedule 2	For the life of the development, the Applicant must: (a) monitor the greenhouse gas emissions generated by the development; (b) investigate ways to reduce greenhouse gas emissions generated by the development; and (c) report on greenhouse gas monitoring and abatement measures in the Annual Review. to the satisfaction of the Planning Secretary.	Section 5.4
DA305-7-2003	Condition B53, Schedule 2	The Applicant must report on water extracted or discharged from the site each year (direct and indirect) in the Annual Review, including water taken under each licence. *Note: under the water Act 1912 and/or the Water Management Act 2000, the Applicant is required to obtain all necessary water licences for the development, including during rehabilitation and post mine closure*.	Sections 6.3 to 6.7
DA305-7-2003	Condition B66, Schedule 2	The applicant must prepare a Water Management Plan for the Wambo Mining Complex to the satisfaction of the Planning Secretary. This Plan must: (a) be prepared by a suitably qualifies and experiences person/s whose appointment has been endorsed by the Planning Secretary; (b) be prepared in consultation with DPIE Water and the EPA; (c) describe the measures to be implemented to ensure that the Applicant complies with the water management performance measures: … (vi) a protocol to report on the measures, monitoring results and performance criteria identified above, in the Annual Review referred to in condition D10.	Section 6
DA305-7-2003	Condition B100, Schedule 2	The Applicant must: (a) take all reasonable steps to minimise the water (including coals rejects and tailings) generated by the development; (b) dispose of all waste at appropriately licensed waste facilities; (c) manage on-site sewage treatment and disposal in accordance with the requirements of Council; and (d) monitor and report of the effectiveness of the water minimisation and management measures in the Annual Review referred to in condition D10.	Section 6
DA305-7-2003	Condition B111, Schedule 2	The Applicant must: (a) keep accurate records of the amount of coal transported from the site (on a daily basis); and (b) include these records in the Annual Review.	Section 3

Approval	Condition	Description	Where Addressed
DA305-7-2003	Condition D10, Schedule 2	By the end of March each year or other timeframe agreed by the Planning Secretary, a report must be submitted to the Department reviewing the environmental performance of the development, to the satisfaction of the Planning Secretary. This review must: (a) describe the development (including any rehabilitation) that was carried out in the previous calendar year, and the development that is proposed to be carried out over the current calendar year; (b) include a comprehensive review of the monitoring results and complaints records of the development over the previous calendar year, including a comparison of these results against the: (i) relevant statutory requirements, limits or performance measures/ criteria; (ii) requirements of any plan or program required under this consent; (iii) monitoring results of previous years; and (iv) relevant predictions in the documents listed in condition A2(c); (c) identify any non-compliance or incident which occurred in the previous calendar year, and describe what actions were (or are being) taken to rectify the non-compliance and avoid reoccurrence; (d) evaluate and report on: (i) The effectiveness of the noise and air quality management systems; and (ii) Compliance with the performance measures, criteria and operating conditions in this consent; (e) identify any trends in the monitoring of data over the life of the development; (f) identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and (g) describe what measures will be implemented over the next calendar year to improve the environmental performance of the development.	This Annual Review
EPBC 2016/7636	Condition 5	The person taking the action must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plan, program, strategy and review required by condition 1. The reporting period and report publication must comply with conditions D10 and D15 of schedule 2 of the **state development consent**. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the **Department** at the same time as the compliance report is published. The person taking the action must continue to publish the report until such time as agreed in writing by the **Minister**.	Appendix J

Approval	Condition	Description	Where Addressed
EPBC 2016/7816	Condition 5	By 31 March of each year after the commencement of the action, the person taking the action must: publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans and strategies required by conditions D10 and D15 of schedule 2 of the state development consent over the previous calendar year; and provide documentary evidence providing proof of the date of publication to the Department, by email to EPBCMonitoring@environment.gov.au (or another email address as stipulated by the Department). The person taking the action must continue publishing annual compliance reports and make all reports available on their website for the life of the approval, unless agreed in writing by the Minister.	Appendix J
S101 Approval (NETD)	Condition (h)	The North East Tailings Dam shall be reported on within the Annual Environmental Management Report for Wambo Coal. Consideration shall also be given to the rehabilitation performance for this site.	Sections 7.1.6 and 7.2.1
CL365, CL397 ML1806	Condition 3(f)	(f) The lease holder must prepare a Rehabilitation Report to the satisfaction of the Minister. The report must: (i) provide a detailed review of the progress of rehabilitation against the performance measures and criteria established in the approved MOP/RMP; (ii) be submitted annually on the grant anniversary date (or at such other times as agreed by the Minister); (iii) be prepared in accordance with any relevant annual reporting guidelines published on the Department's website at www.resources.nsw.gov.au/environment. Note. The Rehabilitation Report replaces the Annual Environmental Management Report.	This Annual Review
CCL743, ML1402	Conditions 4-5	The lease holder must lodge Environmental Management Reports (EMR) with the Director-General annually or at dates otherwise directed by the Director-General. The EMR must: a) report against compliance with the MOP/RMP; b) report on progress in respect of rehabilitation completion criteria; c) report on the extent of compliance with regulatory requirements; and d) have regard to any relevant guidelines adopted by the Director-General.	This Annual Review

Approval	Condition	Description	Where Addressed
CL374	Condition 3	(1) Within 12 months of the commencement of mining operations and thereafter annually or, at such other times as may be allowed by the Director-General, the lease holder must lodge an Annual Environmental Management Report (AEMR) with the Director-General. (2) The AEMR must be prepared in accordance with the Director-General's guidelines current at the time of reporting and contain a review and forecast of performance for the preceding and ensuing twelve months in terms of: a) the accepted Mining Operations Plan; b) development consent requirements and conditions; c) Department of Environment and Conservation and Department of Planning licences and approvals; d) any other statutory environmental requirements; e) details of any variations to environmental approvals applicable to the lease area; and f) where relevant, progress towards final rehabilitation objectives. (3) After considering the AEMR the Director-General may, by notice in writing, direct the lease holder to undertake operations, remedial actions or supplementary studies in the manner and within the period specified in the notice to ensure that operations on the lease area are conducted in accordance with sound mining and environmental practice. (4) The lease holder shall, as and when directed by the Minister, co-operate with the Director-General to conduct and facilitate review of the AEMR involving other government agencies and the local council.	This Annual Review
Water Licence 20AL200631, 20AL203044, 20AL201457	Condition 1	The licence holder must provide the Minister with figures recording the quantity of water taken via the nominated water supply works approval, when required to do so, and in the form specified by the Minister.	Section 6.5

Approval	Condition	Description	Where Addressed
Water Licence 20WA200632	Condition 9	The account holder must provide the Minister, in the approved form, with the following information when requested: A) A report detailing the quantity of water taken through the authorised work(s) and recorded by the approved measuring device, or where the work does not have a measuring device fitted to it, advise the Minister of the duration of any pumping, and B) Where the water is used for irrigation, the area of land irrigated, the planting date, area and yield of all crops grown on the property for each season. These details must include: i) The volume of water taken from the water source and applied directly to crops and/or pasture; ii) The volume of water taken from the water source and held in on-farm storages; iii) The volume of water taken from on-farm storages and applied to crops (including pasture); iv) The type and area of each crop (including pasture) irrigated; v) The method of irrigation for each class of crop and/or pasture; and vi) The volume of water applied to each individual class of crop and/or pasture.	Section 6.5

APPENDIX B

DAILY TRAIN MOVEMENT SUMMARY

Table B1: Daily Train Movements

Date	Trains per Day	Date	Trains per Day	Date	Trains per Day
1/01/2021	5	27/02/2021	2	25/04/2021	1
02/01/2021	5	28/02/2021	1	26/04/2021	2
03/01/2021	3	01/03/2021	2	29/04/2021	1
04/01/2021	2	02/03/2021	5	01/05/2021	3
05/01/2021	4	03/03/2021	4	02/05/2021	1
06/01/2021	4	04/03/2021	3	03/05/2021	1
07/01/2021	2	05/03/2021	2	07/05/2021	2
08/01/2021	3	06/03/2021	1	08/05/2021	1
09/01/2021	4	07/03/2021	3	12/05/2021	1
14/01/2021	1	08/03/2021	2	13/05/2021	1
15/01/2021	2	09/03/2021	1	14/05/2021	4
18/01/2021	2	10/03/2021	4	15/05/2021	2
19/01/2021	1	11/03/2021	3	16/05/2021	1
20/01/2021	2	12/03/2021	1	17/05/2021	4
21/01/2021	1	13/03/2021	4	18/05/2021	1
22/01/2021	2	14/03/2021	4	19/05/2021	2
24/01/2021	1	15/03/2021	2	20/05/2021	4
25/01/2021	3	16/03/2021	3	21/05/2021	3
26/01/2021	2	17/03/2021	1	22/05/2021	1
28/01/2021	4	18/03/2021	1	23/05/2021	2
29/01/2021	3	24/03/2021	1	28/05/2021	1
31/01/2021	1	25/03/2021	1	29/05/2021	3
01/02/2021	2	26/03/2021	2	30/05/2021	2
02/02/2021	1	29/03/2021	1	04/06/2021	2
03/02/2021	2	30/03/2021	2	06/06/2021	2
04/02/2021	4	31/03/2021	2	07/06/2021	1
05/02/2021	2	01/04/2021	3	08/06/2021	5
06/02/2021	3	02/04/2021	1	09/06/2021	1
07/02/2021	2	03/04/2021	2	11/06/2021	2
08/02/2021	3	04/04/2021	1	12/06/2021	3
12/02/2021	3	06/04/2021	3	13/06/2021	2
14/02/2021	3	07/04/2021	1	14/06/2021	5
15/02/2021	5	10/04/2021	2	15/06/2021	3
16/02/2021	1	11/04/2021	1	16/06/2021	1
17/02/2021	1	12/04/2021	2	19/06/2021	2
18/02/2021	1	16/04/2021	1	20/06/2021	3
19/02/2021	2	18/04/2021	1	21/06/2021	2
20/02/2021	1	19/04/2021	1	22/06/2021	1
21/02/2021	2	20/04/2021	1	23/06/2021	1
23/02/2021	1	21/04/2021	2	24/06/2021	2
24/02/2021	1	22/04/2021	2	25/06/2021	3
25/02/2021	1	23/04/2021	3	26/06/2021	4
26/02/2021	2	24/04/2021	3	27/06/2021	2

Date	Trains per Day	Date	Trains per Day	Date	Trains per Day
02/07/2021	1	30/08/2021	2	16/10/2021	4
03/07/2021	2	31/08/2021	5	17/10/2021	2
04/07/2021	3	01/09/2021	2	18/10/2021	2
05/07/2021	3	02/09/2021	2	19/10/2021	3
07/07/2021	2	03/09/2021	2	20/10/2021	1
08/07/2021	1	04/09/2021	1	21/10/2021	2
09/07/2021	1	05/09/2021	2	22/10/2021	1
10/07/2021	1	06/09/2021	2	23/10/2021	2
11/07/2021	2	07/09/2021	1	24/10/2021	3
12/07/2021	1	08/09/2021	3	25/10/2021	1
13/07/2021	1	09/09/2021	4	26/10/2021	1
16/07/2021	5	10/09/2021	3	27/10/2021	2
18/07/2021	2	11/09/2021	3	28/10/2021	4
19/07/2021	2	12/09/2021	1	29/10/2021	3
20/07/2021	3	13/09/2021	1	31/10/2021	1
21/07/2021	1	14/09/2021	4	01/11/2021	2
23/07/2021	2	15/09/2021	3	02/11/2021	2
24/07/2021	3	16/09/2021	1	03/11/2021	2
25/07/2021	6	17/09/2021	1	04/11/2021	2
26/07/2021	4	18/09/2021	6	05/11/2021	1
27/07/2021	1	19/09/2021	2	06/11/2021	2
28/07/2021	5	20/09/2021	1	07/11/2021	3
29/07/2021	4	22/09/2021	1	08/11/2021	5
30/07/2021	3	23/09/2021	2	09/11/2021	2
31/07/2021	2	24/09/2021	1	10/11/2021	3
01/08/2021	7	25/09/2021	2	11/11/2021	2
02/08/2021	5	26/09/2021	1	13/11/2021	1
03/08/2021	3	27/09/2021	2	14/11/2021	3
05/08/2021	1	28/09/2021	3	15/11/2021	2
07/08/2021	2	29/09/2021	2	16/11/2021	1
08/08/2021	2	30/09/2021	1	17/11/2021	2
09/08/2021	2	01/10/2021	4	18/11/2021	4
12/08/2021	1	02/10/2021	3	19/11/2021	1
13/08/2021	1	03/10/2021	3	20/11/2021	5
14/08/2021	2	07/10/2021	4	21/11/2021	4
15/08/2021	2	08/10/2021	3	25/11/2021	2
16/08/2021	1	09/10/2021	5	26/11/2021	2
23/08/2021	3	10/10/2021	2	27/11/2021	3
24/08/2021	1	11/10/2021	3	28/11/2021	1
25/08/2021	2	12/10/2021	3	01/12/2021	1
26/08/2021	1	13/10/2021	2	02/12/2021	4
28/08/2021	1	14/10/2021	4	03/12/2021	2
29/08/2021	5	15/10/2021	1	04/12/2021	4

Date	Trains per Day
05/12/2021	4
06/12/2021	3
07/12/2021	3
08/12/2021	3
09/12/2021	4
10/12/2021	5
11/12/2021	1
12/12/2021	2
15/12/2021	1
16/12/2021	2
17/12/2021	3
20/12/2021	2
21/12/2021	2
22/12/2021	2
23/12/2021	2
26/12/2021	1
27/12/2021	1
28/12/2021	3
29/12/2021	1
30/12/2021	1
31/12/2021	1

Peabody

Table B2: Train Movements within Sensitive Service Hours

(Friday 6pm-9pm & Sunday 9am-12am)

Date	Time	Date	Time
Sunday, 3 January 2021	12:43 PM	Sunday, 15 August 2021	1:21 PM
Friday, 22 January 2021	8:35 PM	Sunday, 29 August 2021	11:12 AM
Sunday, 24 January 2021	12:54 PM	Sunday, 29 August 2021	2:46 PM
Friday, 29 January 2021	8:00 PM	Sunday, 29 August 2021	6:32 PM
Sunday, 31 January 2021	6:08 PM	Sunday, 5 September 2021	8:58 PM
Sunday, 7 February 2021	10:45 AM	Friday, 10 September 2021	8:31 PM
Friday, 12 February 2021	8:57 PM	Sunday, 12 September 2021	4:06 PM
Sunday, 14 February 2021	6:05 PM	Sunday, 19 September 2021	12:19 PM
Friday, 19 February 2021	6:13 PM	Sunday, 26 September 2021	12:46 PM
Sunday, 21 February 2021	6:03 PM	Sunday, 3 October 2021	10:22 AM
Sunday, 28 February 2021	11:39 AM	Sunday, 3 October 2021	1:20 PM
Sunday, 7 March 2021	7:28 PM	Sunday, 10 October 2021	11:19 PM
Sunday, 7 March 2021	11:34 PM	Sunday, 10 October 2021	5:39 PM
Sunday, 14 March 2021	9:06 PM	Sunday, 17 October 2021	11:38 AM
Sunday, 14 March 2021	12:01 PM	Sunday, 24 October 2021	12:39 PM
Sunday, 4 April 2021	8:40 PM	Sunday, 24 October 2021	3:37 PM
Sunday, 11 April 2021	4:09 PM	Sunday, 31 October 2021	8:34 AM
Friday, 23 April 2021	8:28 PM	Sunday, 7 November 2021	10:03 PM
Sunday, 2 May 2021	4:44 PM	Sunday, 7 November 2021	11:07 AM
Friday, 7 May 2021	8:48 PM	Sunday, 14 November 2021	10:08 PM
Sunday, 16 May 2021	11:47 AM	Sunday, 21 November 2021	11:54 AM
Sunday, 23 May 2021	10:06 PM	Sunday, 21 November 2021	3:13 PM
Sunday, 30 May 2021	5:00 PM	Sunday, 21 November 2021	5:43 PM
Sunday, 6 June 2021	10:10 AM	Sunday, 28 November 2021	3:11 PM
Sunday, 13 June 2021	2:00 PM	Sunday, 5 December 2021	11:35 PM
Sunday, 20 June 2021	7:54 PM	Sunday, 5 December 2021	5:51 PM
Sunday, 20 June 2021	10:21 PM	Friday, 10 December 2021	7:59 PM
Friday, 25 June 2021	7:18 PM	Sunday, 12 December 2021	10:29 AM
Sunday, 27 June 2021	5:01 PM	Sunday, 12 December 2021	12:56 PM
Sunday, 4 July 2021	5:54 PM	**Total**	**69**
Sunday, 11 July 2021	4:49 PM		
Sunday, 18 July 2021	8:06 PM		
Sunday, 25 July 2021	8:21 PM		
Sunday, 25 July 2021	11:17 PM		
Sunday, 25 July 2021	11:18 AM		
Sunday, 25 July 2021	3:12 AM		
Sunday, 1 August 2021	9:46 AM		
Sunday, 1 August 2021	11:30 AM		
Sunday, 1 August 2021	5:50 PM		
Sunday, 8 August 2021	2:18 PM		

APPENDIX C

ANNUAL NOISE MONITORING REPORT

Wambo Coal Mine

Annual Environmental Monitoring Report 2021

Prepared for

Wambo Coal Pty Ltd

Noise and Vibration Analysis and Solutions

Global Acoustics Pty Ltd
PO Box 3115 | Thornton NSW 2322
Telephone +61 2 4966 4333
Email global@globalacoustics.com.au
ABN 94 094 985 734

Wambo Coal Mine

Annual Environmental Monitoring Report 2021

Reference: 21304_R01
Report date: 22 February 2022

Prepared for

Wambo Coal Pty Limited
PMB 1
Singleton NSW 2330

Prepared by

Global Acoustics Pty Ltd
PO Box 3115
Thornton NSW 2322

Prepared:	Jesse Tribby Consultant	QA Review:	Robert Kirwan Consultant

Global Acoustics Pty Ltd ~ Environmental noise modelling and impact assessment ~ Sound power testing ~ Noise control advice ~ Noise and vibration monitoring ~ OHS noise monitoring and advice ~ Expert evidence in Land and Environment and Compensation Courts ~ Architectural acoustics ~ Blasting assessments and monitoring ~ Noise management plans (NMP) ~ Sound level meter and noise logger sales and hire

EXECUTIVE SUMMARY

Global Acoustics was engaged by Wambo Coal Pty Ltd to provide an Annual Environmental Monitoring Report for 2021, in order to compare noise monitoring results against relevant criteria.

This report summarises monthly attended noise monitoring surveys conducted at five monitoring locations around Wambo Coal Mine (WCM) during the reporting period 1 January to 31 December 2021. The purpose of the surveys was to quantify and describe the acoustic environment around the site and compare results with specified limits.

Attended noise monitoring described in this report was conducted on a monthly basis in accordance with the relevant development consents, Environment Protection Licence (EPL), and the WCM Noise Management Plan (NMP).

January to December 2021 Compliance

Noise levels from WCM were inaudible at all receivers during 2021 noise monitoring. No modifying factors were applicable to WCM operations. WCM complied with relevant noise criteria during all measurements during 2021 noise monitoring.

Long-Term Noise Trends

During the 5-year period analysed, WCM noise levels at most monitoring locations increased from 2017 to 2018 as mining operations progressed to the northwest and were initially less shielded. From 2019 to 2020, site noise levels decreased at most monitoring locations, likely due to mining activity being deeper in pit and therefore more shielded from receptors. From 1 December 2020, open cut mining was no longer undertaken by WCM and noise emissions decreased significantly.

EIS Comparison

WCM commenced Phase 2 on 1 December 2020, wherein WCM only manages underground operations and associated plant. Open cut operations are managed by United Wambo (UW) as part of the United Wambo Joint Venture (UWJV). UW was solely responsible for noise emissions from UWJV during 2021.

Noise levels from WCM were inaudible at all receivers during all of 2021 noise monitoring. Subsequently, comparison of measured WCM noise levels against EIS noise model predictions was not possible. Additional information is provided in Section 3.5 of this report.

Global Acoustics Pty Ltd

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Appendices

1 INTRODUCTION

1.1 Background

Global Acoustics was engaged by Wambo Coal Pty Ltd to provide an Annual Environmental Monitoring Report (AEMR) for 2021, in order to compare noise monitoring results against noise modelling predictions and relevant noise criteria.

This report summarises monthly attended noise monitoring surveys conducted at five monitoring locations around WCM during the reporting period 1 January to 31 December 2021. The purpose of the surveys was to quantify and describe the acoustic environment around the site and compare results with specified limits.

1.2 Monitoring Locations & Frequency

Attended monitoring locations are detailed in Table 1.1 and shown in Figure 1. It should be noted that Figure 1 shows the actual monitoring position, not the location of residences.

Table 1.1: WAMBO COAL ATTENDED MONITORING LOCATIONS[1]

Site Reference	EPL 529 ID	Description	Representative Addresses[2]
N01	N/A	North Bulga	3, 7, 379
N16	20	Jerrys Plains Road	Privately owned residences near Jerry's Plains
N20A	21	Redmanvale Road Central	Privately owned residences near Jerry's Plains
N21	22	South Wambo	25, 35a
N26	23	Redmanvale Road South	Privately owned residences near Jerry's Plains

Notes:

1. *Sourced from the NMP – WA-ENV-MNP-503, November 2020; and*
2. *Representative address numbering is from Appendix 4 of DA 305-7-2003.*

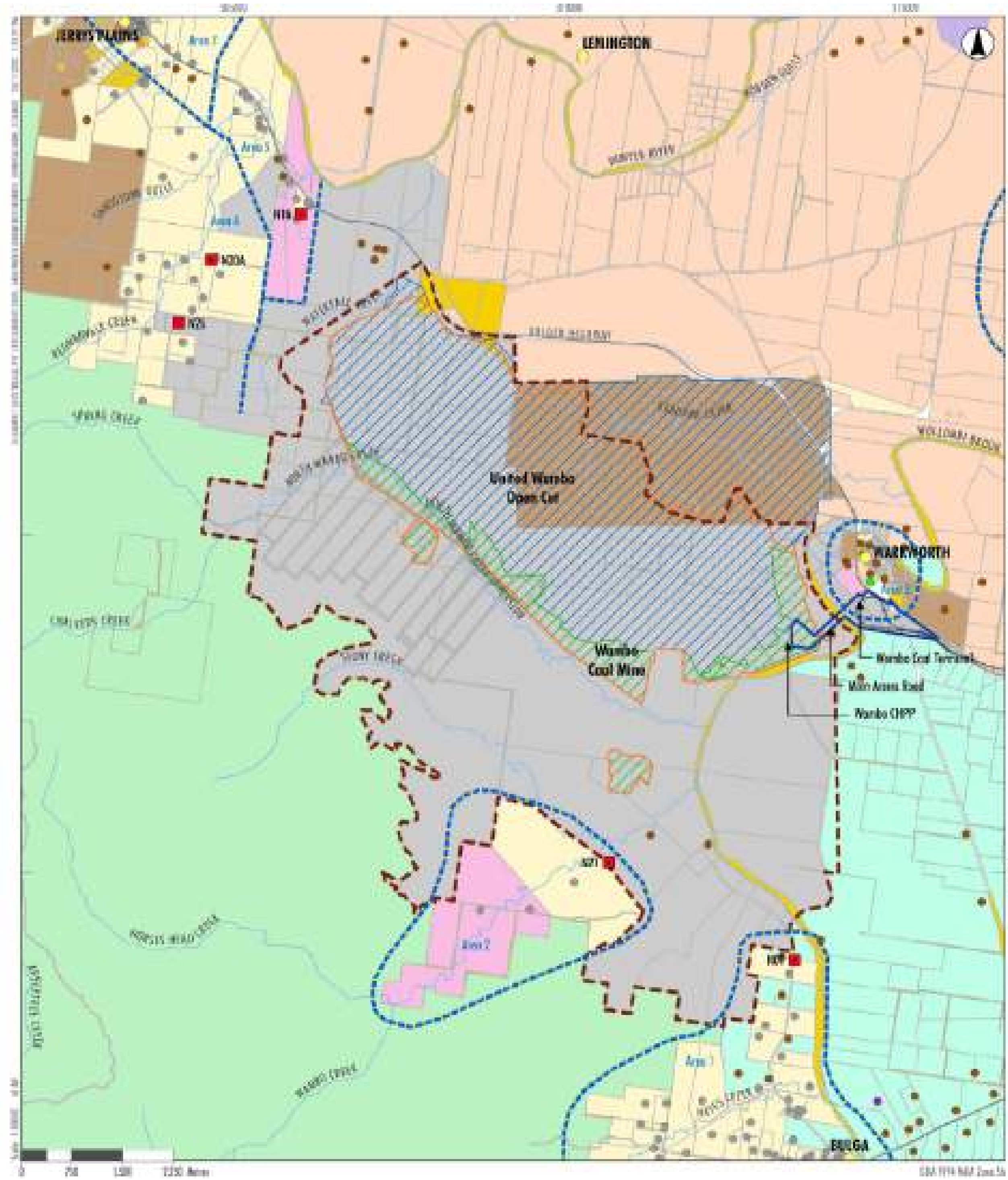

Figure 1: WCM Attended Noise Monitoring Locations

1.3 Terminology & Abbreviations

Definitions of terms and abbreviations which may be used in this report are provided in Table 1.2.

Table 1.2: TERMINOLOGY & ABBREVIATIONS

Descriptor	Definition
dB(A)	Noise level measurement units are decibels (dB). The "A" weighting scale is used to describe human response to noise.
L_{Amax}	The maximum A-weighted noise level over a time period.
L_{A1}	The noise level which is exceeded for 1 per cent of the time.
$L_{A1,1minute}$	The noise level which is exceeded for 1 per cent of the specified time period of 1 minute.
L_{A10}	The noise level which is exceeded for 10 percent of the time.
L_{Aeq}	The average noise A-weighted energy during a measurement period.
L_{A50}	The noise level which is exceeded for 50 per cent of the time and the median noise level during a measurement period.
L_{A90}	The level exceeded for 90 percent of the time. The L_{A90} level is often referred to as the "background" noise level and is commonly used to determine noise criteria for assessment purposes.
L_{Amin}	The minimum A-weighted noise level over a time period.
L_{Ceq}	The average C-weighted noise energy during a measurement period. The "C" weighting scale is used to take into account low-frequency components of noise within the audibility range of humans.
SPL	Sound pressure level. Fluctuations in pressure measured as 10 times a logarithmic scale, with the reference pressure being 20 micropascals.
Hertz (Hz)	The frequency of fluctuations in pressure, measured in cycles per second. Most sounds are a combination of many frequencies together.
AWS	Automatic weather station used to collect meteorological data, typically at an altitude of 10 metres
VTG	Vertical temperature gradient in degrees Celsius per 100 metres altitude.
Sigma-theta	The standard deviation of the horizontal wind direction over a period of time.
SC	Stability class (or category) is determined from measured wind speed and either sigma-theta or VTG.
IA	Inaudible. When site noise is noted as IA then there was no site noise at the monitoring location.
NM	Not Measurable. If site noise is noted as NM, this means some noise was audible but could not be quantified.
Day	This is the period 7:00am to 6:00pm.
Evening	This is the period 6:00pm to 10:00pm.
Night	This is the period 10:00pm to 7:00am.

2 REGULATOR REQUIREMENTS AND NOISE CRITERIA

2.1 WCM Development Consent

The most current development consent for WCM is DA 305-7-2003 (MOD 16, 29 August 2019). Schedule 2, Part B of the WCM consent details specific conditions relating to noise generated by WCM.

2.2 Environment Protection Licence

WCM holds Environment Protection Licence (EPL) No. 529 issued by the Environment Protection Authority (EPA) most recently on 30 September 2021.

2.3 Noise Management Plan

Noise monitoring requirements are detailed in the *Wambo Coal Noise Management Plan WA-ENV-MNP-503* (NMP, November 2020), prepared in accordance with the WCM consent.

2.4 Noise Criteria

Noise criteria detailed in Table 2.1 have been adopted for each monitoring location based on Phase 2 and 3 of the development consent (MOD 16) and the NMP.

Table 2.1: WCM NOISE CRITERIA, dB(A)

Location	Day $L_{Aeq,15minute}$	Evening/Night $L_{Aeq,15minute}$	Night $L_{A1,1minute}$
N01[1]	38	38	48
N16	35	35	45
N20A	35	35	45
N21[2]	39	39	49
N26	35	35	45

Notes:

1. *Noise criteria for the nearest privately-owned property (R003) have been adopted; and*
2. *Noise criteria for the nearest privately-owned property (R025) have been adopted.*

EPL noise criteria have not been updated for Phase 2 and 3 of operations. As noise criteria in the development consent and NMP are now more conservative than those in the EPL, they have been adopted in Table 2.1.

2.5 Meteorological Conditions

Meteorological conditions required for noise criteria to apply are consistent between the consent and EPL.

2.5.1 Development Consent

Appendix 5 of MOD 16 details specific meteorological conditions required for noise criteria to be applicable:

APPENDIX 5 NOISE COMPLIANCE ASSESSMENT

Applicable Meteorological Conditions

1. The noise criteria in condition B12 are to apply under all meteorological conditions except the following:
   (a) where 3°C/100 metres (m) lapse rates have been assessed, then:
   (i) wind speeds greater than 3 metres/second (m/s) measured at 10m above ground level;
   (ii) temperature inversion conditions between 1.5°C and 3°C/100m and wind speeds greater than 2m/s measured at 10m above ground level; or
   (iii) temperature inversion conditions greater than 3°C/100m.
   (b) where Pasquill Stability Classes have been assessed, then:
   (i) wind speeds greater than 3m/s at 10m above ground level;
   (ii) stability category F temperature inversion conditions and wind speeds greater than 2m/s at 10m above ground level;
   (iii) stability category G temperature inversion conditions.

As lapse rates (VTG) were not measured directly, meteorological conditions have been assessed against Pasquill stability classes detailed in 1.(b).

2.5.2 Environment Protection Licence

Condition L5.5 of the EPL details meteorological conditions required for noise limits to apply:

L5.5 The noise limits set out in condition L5.1 apply under all meteorological conditions except for the following:

a) Wind speeds greater than 3 metres/second at 10 metres above the ground level;
b) Stability category F temperature inversion conditions and wind speeds greater than 2 metres/second at 10 metres above ground level; or
c) Stability category G temperature inversion conditions.

Condition L5.5 is consistent with stability category conditions outlined in Appendix 5, 1.(b) of MOD 16.

2.6 Modifying Factors

The EPA 'Noise Policy for Industry' (NPfI, 2017) was approved for use in NSW in October 2017. For assessment of modifying factors, the NPfI immediately superseded the 'Industrial Noise Policy' (INP, 2000), as outlined in the EPA document 'Implementation and transitional arrangements for the Noise Policy for Industry' (2017). Assessment and reporting of modifying factors has been undertaken in accordance with Fact Sheet C of the NPfI.

3 METHODOLOGY

3.1 Overview

Attended environmental noise monitoring was conducted in general accordance with Australian Standard AS1055 'Acoustics, Description and Measurement of Environmental Noise', relevant NSW EPA requirements, and the NMP. Meteorological data was obtained from the WCM automatic weather station (AWS) which allowed correlation of atmospheric parameters with measured noise levels.

3.2 Attended Noise Monitoring

During this survey, monthly attended monitoring was undertaken during the night period at each location. The duration of each measurement was 15 minutes. Atmospheric condition measurement was also undertaken at each monitoring location.

This survey presents noise levels gathered during attended monitoring that are the result of many sounds reaching the sound level meter microphone during monitoring. Received levels from various noise sources were noted during attended monitoring and particular attention was paid to the extent of WCM's contribution, if any, to measured levels. At each receptor location, WCM's $L_{Aeq,15minute}$ and $L_{A1,1minute}$ (in the absence of any other noise) was measured directly, where possible, or, determined by frequency analysis.

If the exact contribution of the source of interest (in this case WCM) cannot be established, due to masking by other noise sources in a similar frequency range, but site noise levels are observed to be well below (more than 5 dB lower than) any relevant criterion, a maximum estimate of the potential contribution of the site might be made based on other measured site-only noise descriptors in accordance with Section 7.1 of the NPfI. This is generally expressed as a 'less than' quantity, such as <20 dB or <30 dB.

The terms 'Inaudible' (IA) or 'Not Measurable' (NM) may also be used in this report. When site noise is noted as IA, no site noise was audible at the monitoring location. When site noise is noted as NM, this means some noise was audible but could not be quantified. If site noise was NM due to masking but estimated to be significant in relation to a relevant criterion, we would employ methods (e.g. measure closer and back calculate) to determine a value for reporting.

All sites noted as NM in this report are due to one or more of the following reasons:

- Site noise levels were extremely low and unlikely, in many cases, to be even noticed;
- Site noise levels were masked by another relatively loud noise source that is characteristic of the environment (e.g. breeze in foliage or continuous road traffic noise) that cannot be eliminated by moving closer; and/or
- It was not feasible, nor reasonable to employ methods such as move closer and back calculate. Cases may include, but are not limited to, rough terrain preventing closer measurement, addition/removal

of significant source to receiver shielding caused by moving closer, and meteorological conditions where back calculation may not be accurate.

A measurement of $L_{A1,1minute}$ corresponds to the highest noise level generated for 0.6 second during one minute. In practical terms this is the highest noise level, or L_{Amax}, received from the site during the entire measurement period (i.e. the highest level of the worst minute during the 15 minute measurement).

Often extraneous noise events (for example, road traffic pass-bys and dogs) interfere with the measurement of site noise levels in the frequency range of interest. Where required, the sound level meter is paused during these occurrences to aid in quantification of the site only $L_{Aeq,15minute}$ level.

3.3 Modifying Factors

All measurements were evaluated for potential modifying factors in accordance with the NPfI. Specific methodology for assessment of each modifying factor is outlined in Fact Sheet C of the NPfI.

Assessment of modifying factors is undertaken at the time of measurement if the site was audible and directly quantifiable, such that the site-only L_{Aeq} was not "NM" or less than a maximum cut off value (e.g. "<20 dB" or "<30dB").

If applicable, modifying factors have been reported and added to measured site-only L_{Aeq} noise levels when meteorological conditions satisfied requirements for site noise criteria to be applicable. Low-frequency modifying factors have only been applied to site-only L_{Aeq} levels if WCM was the only contributing low-frequency noise source.

3.4 Meteorological Data

Meteorological data was obtained from the WCM meteorological station; this was logged at 10-minute intervals. Atmospheric parameters include wind speed, wind direction, rainfall and sigma theta. When meteorological data is provided in less than 15 minute intervals, an analysis must be conducted to determine the meteorological conditions present for the majority of each measurement period and whether those conditions result in noise criteria being applicable or not.

3.5 Comparison with United Wambo EIS Model Predictions

The MOD 17 environmental assessment (EA) and MOD 16 EIS both make reference to the noise impact assessment (NIA) prepared in July 2016 to support application for the UWJV project. The NIA includes noise impacts associated with ongoing operations from both WCM and UW.

WCM commenced Phase 2 on 1 December 2020, wherein WCM only manages underground operations and associated plant. Open cut operations are managed by United Wambo (UW) as part of the United Wambo Joint Venture (UWJV). UW was solely responsible for noise emissions from UWJV during 2021.

Noise levels from WCM were inaudible at all receivers during all of 2021 noise monitoring. Subsequently, comparison of measured WCM noise levels against EIS noise model predictions was not possible.

It is feasible for noise emissions from WCM ventilation fans, conveyors, coal preparation plant, and/or rail loop to contribute to total UWJV noise levels, but this did not occur during the reporting period 1 January to 31 December 2021. Unless this occurs, it is recommended that UW noise emissions be compared against model predictions, as it is the primary source of noise emissions for the UWJV.

4 RESULTS

4.1 January 2021

4.1.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in January 2021 are provided in Table 4.1.

Table 4.1: MEASURED NOISE LEVELS – JANUARY 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	21/01/2021 00:05	50	47	46	45	44	43	40
N16	20/01/2021 23:34	47	42	39	38	37	36	34
N20A	20/01/2021 22:32	49	41	38	35	34	32	29
N21	20/01/2021 23:35	47	43	41	39	39	37	34
N26	20/01/2021 22:01	54	43	39	38	38	36	34

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.1.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.1.3 Attended Noise Monitoring

Table 4.2 to Table 4.3 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.2: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – JANUARY 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	21/01/2021 00:05	0.8	F	38	Yes	IA	Nil
N16	20/01/2021 23:34	0.8	F	35	Yes	IA	Nil
N20A	20/01/2021 22:32	1.4	F	35	Yes	IA	Nil
N21	20/01/2021 23:35	0.8	F	39	Yes	IA	Nil
N26	20/01/2021 22:01	1.5	F	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.3: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – JANUARY 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	21/01/2021 00:05	0.8	F	48	Yes	IA	Nil
N16	20/01/2021 23:34	0.8	F	45	Yes	IA	Nil
N20A	20/01/2021 22:32	1.4	F	45	Yes	IA	Nil
N21	20/01/2021 23:35	0.8	F	49	Yes	IA	Nil
N26	20/01/2021 22:01	1.5	F	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.2 February 2021

4.2.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in February 2021 are provided in Table 4.4.

Table 4.4: MEASURED NOISE LEVELS – FEBRUARY 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	23/02/2021 23:51	52	46	45	44	44	42	40
N16	23/02/2021 23:32	51	47	44	41	41	37	34
N20A	23/02/2021 22:57	62	48	44	41	39	37	34
N21	23/02/2021 23:26	52	40	38	36	35	33	31
N26	23/02/2021 22:24	58	42	40	38	37	35	33

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.2.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.2.3 Attended Noise Monitoring

Table 4.5 to Table 4.6 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.5: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – FEBRUARY 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	23/02/2021 23:51	2.0	F	38	Yes	IA	Nil
N16	23/02/2021 23:32	1.7	F	35	Yes	IA	Nil
N20A	23/02/2021 22:57	2.1	F	35	No	IA	NA
N21	23/02/2021 23:26	2.0	F	39	Yes	IA	Nil
N26	23/02/2021 22:24	1.5	F	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.6: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – FEBRUARY 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	23/02/2021 23:51	2.0	F	48	Yes	IA	Nil
N16	23/02/2021 23:32	1.7	F	45	Yes	IA	Nil
N20A	23/02/2021 22:57	2.1	F	45	No	IA	NA
N21	23/02/2021 23:26	2.0	F	49	Yes	IA	Nil
N26	23/02/2021 22:24	1.5	F	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.3 March 2021

4.3.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in March 2021 are provided in Table 4.7.

Table 4.7: MEASURED NOISE LEVELS – MARCH 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	15/03/2021 23:11	57	45	44	43	43	42	41
N16	15/03/2021 23:31	54	51	47	43	41	37	35
N20A	15/03/2021 22:57	45	40	39	37	37	36	35
N21	15/03/2021 22:44	54	44	42	40	40	38	35
N26	15/03/2021 22:19	48	39	38	37	37	35	33

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.3.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.3.3 Attended Noise Monitoring

Table 4.8 to Table 4.9 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.8: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – MARCH 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	15/03/2021 23:11	0.4	F	38	Yes	IA	Nil
N16	15/03/2021 23:31	0.3	F	35	Yes	IA	Nil
N20A	15/03/2021 22:57	0.5	D	35	Yes	IA	Nil
N21	15/03/2021 22:44	0.4	F	39	Yes	IA	Nil
N26	15/03/2021 22:19	1.0	E	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.9: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – MARCH 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	15/03/2021 23:11	0.4	F	48	Yes	IA	Nil
N16	15/03/2021 23:31	0.3	F	45	Yes	IA	Nil
N20A	15/03/2021 22:57	0.5	D	45	Yes	IA	Nil
N21	15/03/2021 22:44	0.4	F	49	Yes	IA	Nil
N26	15/03/2021 22:19	1.0	E	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.4 April 2021

4.4.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in April 2021 are provided in Table 4.10.

Table 4.10: MEASURED NOISE LEVELS – APRIL 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	27/04/2021 00:14	46	41	38	37	36	35	33
N16	26/04/2021 23:13	46	40	38	36	35	34	32
N20A	26/04/2021 22:43	43	37	34	33	32	31	29
N21	26/04/2021 23:48	48	38	36	34	34	33	30
N26	26/04/2021 22:17	44	39	36	34	33	32	29

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.4.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.4.3 Attended Noise Monitoring

Table 4.11 to Table 4.12 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.11: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – APRIL 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	27/04/2021 00:14	0.5	F	38	Yes	IA	Nil
N16	26/04/2021 23:13	0.7	D	35	Yes	IA	Nil
N20A	26/04/2021 22:43	0.3	F	35	Yes	IA	Nil
N21	26/04/2021 23:48	0.3	F	39	Yes	IA	Nil
N26	26/04/2021 22:17	0.9	D	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.12: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – APRIL 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	27/04/2021 00:14	0.5	F	48	Yes	IA	Nil
N16	26/04/2021 23:13	0.7	D	45	Yes	IA	Nil
N20A	26/04/2021 22:43	0.3	F	45	Yes	IA	Nil
N21	26/04/2021 23:48	0.3	F	49	Yes	IA	Nil
N26	26/04/2021 22:17	0.9	D	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.5 May 2021

4.5.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in May 2021 are provided in Table 4.13.

Table 4.13: MEASURED NOISE LEVELS – MAY 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	17/05/2021 22:53	47	36	32	30	29	27	25
N16	17/05/2021 23:50	65	52	43	42	37	35	32
N20A	17/05/2021 22:50	41	35	33	31	31	29	26
N21	17/05/2021 22:25	57	46	35	35	32	29	27
N26	17/05/2021 22:21	39	33	32	31	30	29	27

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.5.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.5.3 Attended Noise Monitoring

Table 4.14 to Table 4.15 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.14: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – MAY 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	17/05/2021 22:53	0.5	F	38	Yes	IA	Nil
N16	17/05/2021 23:50	0.7	F	35	Yes	IA	Nil
N20A	17/05/2021 22:50	0.5	F	35	Yes	IA	Nil
N21	17/05/2021 22:25	0.6	F	39	Yes	IA	Nil
N26	17/05/2021 22:21	0.7	E	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.15: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – MAY 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	17/05/2021 22:53	0.5	F	48	Yes	IA	Nil
N16	17/05/2021 23:50	0.7	F	45	Yes	IA	Nil
N20A	17/05/2021 22:50	0.5	F	45	Yes	IA	Nil
N21	17/05/2021 22:25	0.6	F	49	Yes	IA	Nil
N26	17/05/2021 22:21	0.7	E	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.6 June 2021

4.6.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in June 2021 are provided in Table 4.16.

Table 4.16: MEASURED NOISE LEVELS – JUNE 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	16/06/2021 00:12	43	37	36	34	34	33	30
N16	15/06/2021 23:31	54	41	38	37	36	34	33
N20A	15/06/2021 23:01	47	39	34	32	31	29	26
N21	15/06/2021 23:43	44	40	38	36	36	34	32
N26	15/06/2021 22:32	46	39	36	34	33	31	28

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.6.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.6.3 Attended Noise Monitoring

Table 4.17 to Table 4.18 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.17: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – JUNE 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	16/06/2021 00:12	0.4	F	38	Yes	IA	Nil
N16	15/06/2021 23:31	0.6	E	35	Yes	IA	Nil
N20A	15/06/2021 23:01	0.5	E	35	Yes	IA	Nil
N21	15/06/2021 23:43	0.3	F	39	Yes	IA	Nil
N26	15/06/2021 22:32	1.0	D	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.18: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – JUNE 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	16/06/2021 00:12	0.4	F	48	Yes	IA	Nil
N16	15/06/2021 23:31	0.6	E	45	Yes	IA	Nil
N20A	15/06/2021 23:01	0.5	E	45	Yes	IA	Nil
N21	15/06/2021 23:43	0.3	F	49	Yes	IA	Nil
N26	15/06/2021 22:32	1.0	D	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.7 July 2021

4.7.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in July 2021 are provided in Table 4.19.

Table 4.19: MEASURED NOISE LEVELS – JULY 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	22/07/2021 23:18	42	39	37	36	36	34	33
N16	22/07/2021 23:43	52	48	45	43	42	40	38
N20A	22/07/2021 22:44	46	42	38	36	36	34	31
N21	22/07/2021 22:38	47	42	40	39	38	37	35
N26	22/07/2021 22:17	42	36	34	32	32	29	26

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.7.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.7.3 Attended Noise Monitoring

Table 4.20 to Table 4.21 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.20: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – JULY 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	22/07/2021 23:18	0.8	F	38	Yes	IA	Nil
N16	22/07/2021 23:43	0.7	E	35	Yes	IA	Nil
N20A	22/07/2021 22:44	0.7	F	35	Yes	IA	Nil
N21	22/07/2021 22:38	0.3	F	39	Yes	IA	Nil
N26	22/07/2021 22:17	0.2	F	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.21: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – JULY 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	22/07/2021 23:18	0.8	F	48	Yes	IA	Nil
N16	22/07/2021 23:43	0.7	E	45	Yes	IA	Nil
N20A	22/07/2021 22:44	0.7	F	45	Yes	IA	Nil
N21	22/07/2021 22:38	0.3	F	49	Yes	IA	Nil
N26	22/07/2021 22:17	0.2	F	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.8 August 2021

4.8.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in August 2021 are provided in Table 4.22.

Table 4.22: MEASURED NOISE LEVELS – AUGUST 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	10/08/2021 22:54	50	41	39	37	36	34	32
N16	05/08/2021 23:09	64	56	41	43	29	22	20
N20A	06/08/2021 00:13	40	31	24	21	18	17	16
N21	10/08/2021 22:15	49	45	41	39	38	36	34
N26	05/08/2021 23:46	43	32	26	23	19	17	16

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.8.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.8.3 Attended Noise Monitoring

Table 4.23 to Table 4.24 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.23: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – AUGUST 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	10/08/2021 22:54	0.6	E	38	Yes	IA	Nil
N16	05/08/2021 23:09	0.7	E	35	Yes	IA	Nil
N20A	06/08/2021 00:13	0.3	F	35	Yes	IA	Nil
N21	10/08/2021 22:15	0.6	F	39	Yes	IA	Nil
N26	05/08/2021 23:46	1.0	D	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.24: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – AUGUST 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	10/08/2021 22:54	0.6	E	48	Yes	IA	Nil
N16	05/08/2021 23:09	0.7	E	45	Yes	IA	Nil
N20A	06/08/2021 00:13	0.3	F	45	Yes	IA	Nil
N21	10/08/2021 22:15	0.6	F	49	Yes	IA	Nil
N26	05/08/2021 23:46	1.0	D	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.9 September 2021

4.9.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in September 2021 are provided in Table 4.25.

Table 4.25: MEASURED NOISE LEVELS – SEPTEMBER 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	07/09/2021 00:07	47	39	35	33	33	31	29
N16	06/09/2021 23:14	48	45	39	37	36	34	32
N20A	06/09/2021 22:45	43	40	34	32	32	29	27
N21	06/09/2021 23:39	45	39	36	34	34	32	29
N26	06/09/2021 22:15	45	40	36	33	32	30	27

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.9.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.9.3 Attended Noise Monitoring

Table 4.26 to Table 4.27 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.26: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – SEPTEMBER 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	07/09/2021 00:07	0.1	F	38	Yes	IA	Nil
N16	06/09/2021 23:14	1.0	D	35	Yes	IA	Nil
N20A	06/09/2021 22:45	0.5	F	35	Yes	IA	Nil
N21	06/09/2021 23:39	0.2	F	39	Yes	IA	Nil
N26	06/09/2021 22:15	0.8	E	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.27: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – SEPTEMBER 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	07/09/2021 00:07	0.1	F	48	Yes	IA	Nil
N16	06/09/2021 23:14	1.0	D	45	Yes	IA	Nil
N20A	06/09/2021 22:45	0.5	F	45	Yes	IA	Nil
N21	06/09/2021 23:39	0.2	F	49	Yes	IA	Nil
N26	06/09/2021 22:15	0.8	E	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.10 October 2021

4.10.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in October 2021 are provided in Table 4.28.

Table 4.28: MEASURED NOISE LEVELS – OCTOBER 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	28/10/2021 00:02	55	52	50	47	47	43	40
N16	27/10/2021 23:20	48	43	40	36	34	32	31
N20A	27/10/2021 22:27	48	44	41	39	38	35	32
N21	27/10/2021 23:38	54	51	48	45	44	39	35
N26	27/10/2021 22:00	49	46	45	42	42	40	37

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.10.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.10.3 Attended Noise Monitoring

Table 4.29 to Table 4.30 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.29: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – OCTOBER 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	28/10/2021 00:02	0.6	F	38	Yes	IA	Nil
N16	27/10/2021 23:20	0.3	F	35	Yes	IA	Nil
N20A	27/10/2021 22:27	0.8	F	35	Yes	IA	Nil
N21	27/10/2021 23:38	0.7	F	39	Yes	IA	Nil
N26	27/10/2021 22:00	0.8	E	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.30: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – OCTOBER 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	28/10/2021 00:02	0.6	F	48	Yes	IA	Nil
N16	27/10/2021 23:20	0.3	F	45	Yes	IA	Nil
N20A	27/10/2021 22:27	0.8	F	45	Yes	IA	Nil
N21	27/10/2021 23:38	0.7	F	49	Yes	IA	Nil
N26	27/10/2021 22:00	0.8	E	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.11 November 2021

4.11.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in November 2021 are provided in Table 4.31.

Table 4.31: MEASURED NOISE LEVELS – NOVEMBER 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	29/11/2021 23:59	59	54	53	52	52	51	49
N16	29/11/2021 23:20	59	57	55	54	54	52	49
N20A	29/11/2021 22:28	64	44	42	42	41	40	39
N21	29/11/2021 23:34	61	60	59	57	57	54	48
N26	29/11/2021 22:00	51	45	43	42	42	40	38

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.11.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.11.3 Attended Noise Monitoring

Table 4.32 to Table 4.33 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.32: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – NOVEMBER 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	29/11/2021 23:59	0.6	F	38	Yes	IA	Nil
N16	29/11/2021 23:20	0.6	E	35	Yes	IA	Nil
N20A	29/11/2021 22:28	1.2	E	35	Yes	IA	Nil
N21	29/11/2021 23:34	1.2	D	39	Yes	IA	Nil
N26	29/11/2021 22:00	1.0	D	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.33: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – NOVEMBER 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	29/11/2021 23:59	0.6	F	48	Yes	IA	Nil
N16	29/11/2021 23:20	0.6	E	45	Yes	IA	Nil
N20A	29/11/2021 22:28	1.2	E	45	Yes	IA	Nil
N21	29/11/2021 23:34	1.2	D	49	Yes	IA	Nil
N26	29/11/2021 22:00	1.0	D	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

4.12 December 2021

4.12.1 Total Measured Noise Levels

Overall noise levels measured at each location during attended measurement in December 2021 are provided in Table 4.34.

Table 4.34: MEASURED NOISE LEVELS – DECEMBER 2021 [1]

Location	Start Date and Time	L_{Amax} dB	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A50} dB	L_{A90} dB	L_{Amin} dB
N01	14/12/2021 00:04	56	54	53	51	51	48	45
N16	13/12/2021 23:14	62	55	53	51	50	48	46
N20A	13/12/2021 22:25	58	50	40	40	39	38	36
N21	13/12/2021 23:38	58	56	55	53	52	50	48
N26	13/12/2021 22:00	53	51	49	46	44	40	38

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.12.2 Modifying Factors

Measured site-only levels were assessed for the applicability of modifying factors in accordance with the NPfI and methodology described in Section 3.3.

There were no modifying factors, as defined in the NPfI, applicable during the survey.

4.12.3 Attended Noise Monitoring

Table 4.35 to Table 4.36 detail noise levels from WCM in the absence of other noise sources. Noise criteria are applicable if weather conditions during the measurement were within parameters outlined in the WCM development consent.

Table 4.35: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – DECEMBER 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{Aeq,15min}$ dB	Criterion Applies?[2]	WCM $L_{Aeq,15min}$ dB [3,4]	Exceedance [4,5]
N01	14/12/2021 00:04	0.9	E	38	Yes	IA	Nil
N16	13/12/2021 23:14	1.0	E	35	Yes	IA	Nil
N20A	13/12/2021 22:25	2.6	E	35	Yes	IA	Nil
N21	13/12/2021 23:38	1.3	E	39	Yes	IA	Nil
N26	13/12/2021 22:00	2.4	D	35	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{Aeq,15minute}$ attributed to WCM, including modifying factors if applicable;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

Table 4.36: $L_{A1,1minute}$ GENERATED BY WCM AGAINST PROJECT APPROVAL METEOROLOGICAL CONDITIONS – DECEMBER 2021

Location	Start Date and Time	Wind Speed m/s	Stability Category[1]	Criterion $L_{A1,1min}$ dB	Criterion Applies?[2]	WCM $L_{A1,1min}$ dB [3,4]	Exceedance [4,5]
N01	14/12/2021 00:04	0.9	E	48	Yes	IA	Nil
N16	13/12/2021 23:14	1.0	E	45	Yes	IA	Nil
N20A	13/12/2021 22:25	2.6	E	45	Yes	IA	Nil
N21	13/12/2021 23:38	1.3	E	49	Yes	IA	Nil
N26	13/12/2021 22:00	2.4	D	45	Yes	IA	Nil

Notes:

1. *Stability Class calculated using sigma theta method provided by NPfI;*
2. *Noise emission limits identified in the above table apply under all meteorological conditions except wind speeds greater than 3 m/s at 10 metres above ground level; or stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level, or stability category G temperature inversion conditions;*
3. *Site-only $L_{A1,1minute}$ attributed to WCM;*
4. *Bold results in red indicate an exceedance of relevant criterion; and*
5. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent, therefore criterion was not applicable, or there is no applicable criterion.*

5 LONG TERM NOISE TRENDS

Site-only L_{Aeq} noise levels measured during monthly attended environmental noise monitoring over a 5-year period from January 2017 to December 2021 have been collated and graphed to summarise WCM long-term noise performance. Less than five years of data was available at three locations due to monitoring commencing at those locations during the 5-year period.

Due to the qualitative nature of some attended noise monitoring descriptors, calculation of site noise statistics such as mean, median, and standard deviation is not always possible. Subsequently, site-only L_{Aeq} noise levels for each monitoring event have been grouped into one of three categories:

1. WCM-only L_{Aeq} was either inaudible (IA), not measurable (NM), or less than 30 dB, which together are represented by green bars;
2. WCM-only L_{Aeq} was between 30 dB and 40 dB (inclusive) represented by blue bars; or
3. WCP-only L_{Aeq} was greater than 40 dB for that location, represented by red bars.

For each calendar year, the percentage of occurrence for each of these categories is shown, as well as annual trend lines over the entire five-year period. Figures show site-only L_{Aeq} noise levels, including adjustments due to modifying factors, as defined by the EPA NPfI.

Meteorological conditions and applicability of noise criteria have not been considered.

5.1 Noise Trend Graphs

Site-only L_{Aeq} noise levels measured during attended environmental noise monitoring over a 5-year period have been collated and graphed to summarise long-term noise trends. Figure 2 to Figure 6 provide percentage occurrence information for WCM noise levels at eight monitoring locations.

As meteorological conditions and applicability of noise criteria have not been considered in long-term trend analysis, potential exceedances indicated in the following graphs may not have been applicable depending on weather conditions at the time of monitoring.

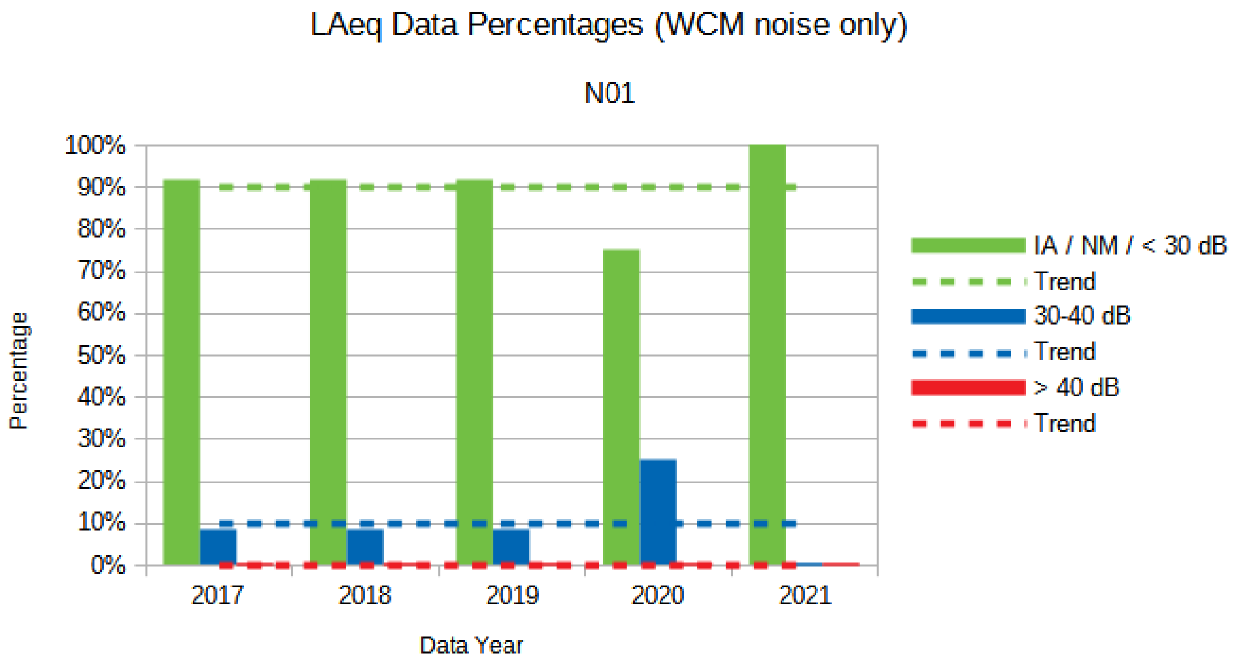

Figure 2: Attended noise monitoring data, N01

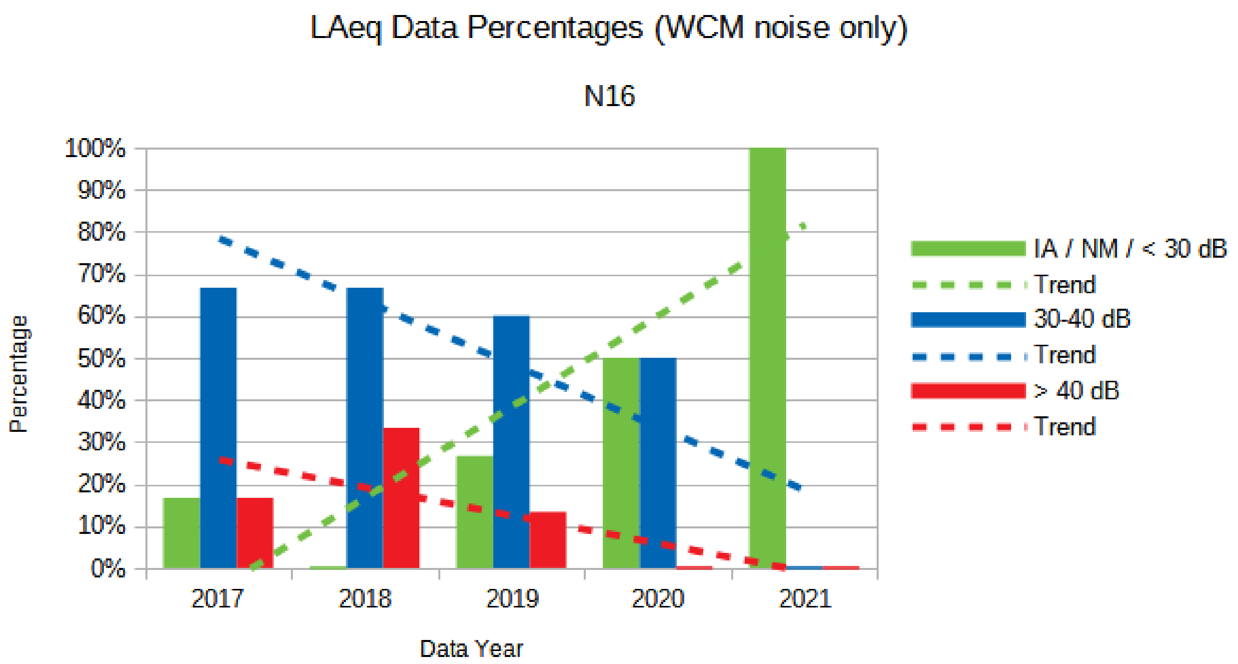

Figure 3: Attended noise monitoring data, N16

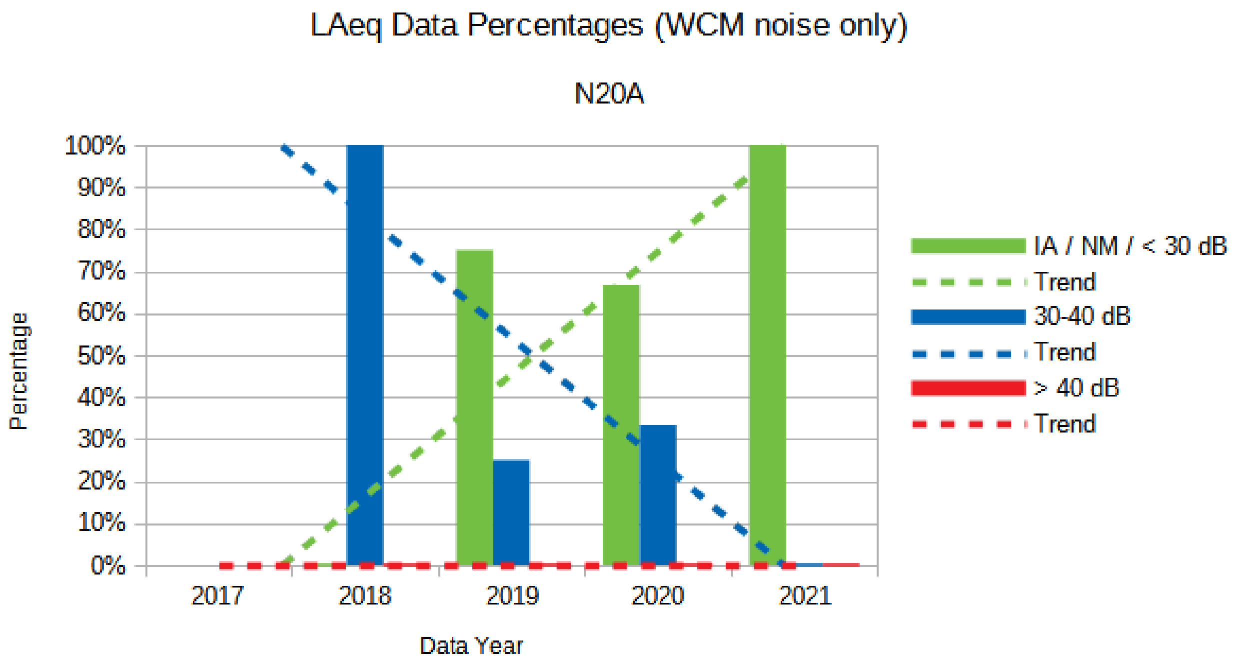

Figure 4: Attended noise monitoring data, N20A

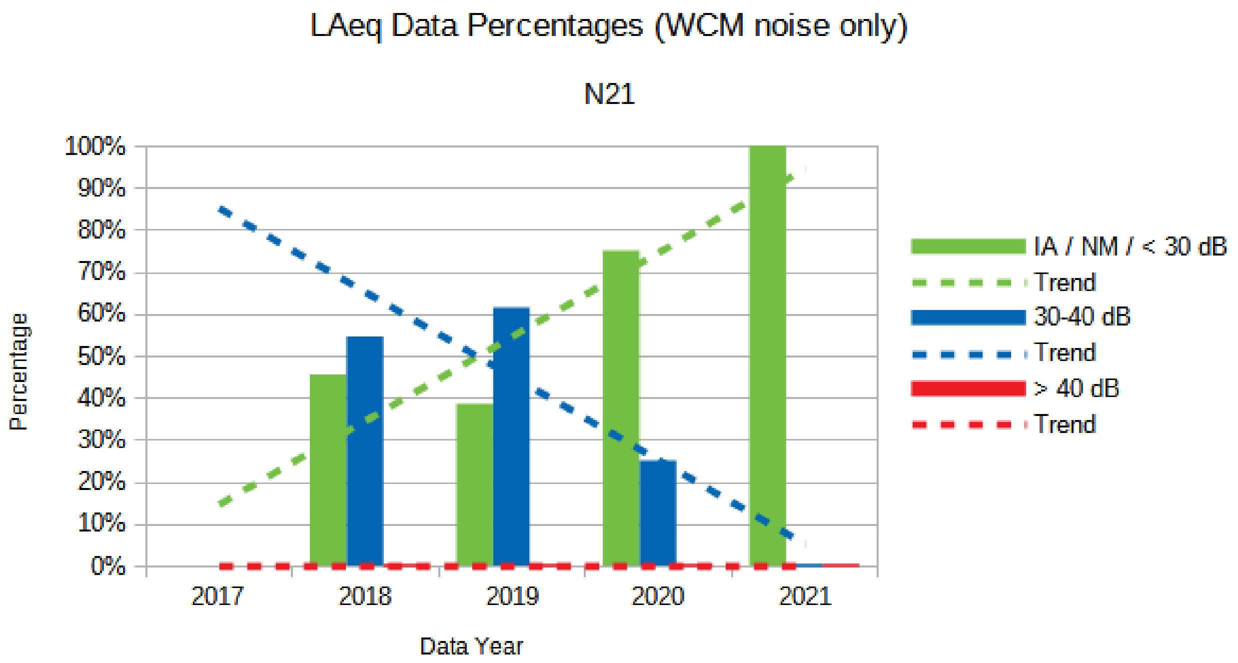

Figure 5: Attended noise monitoring data, N21

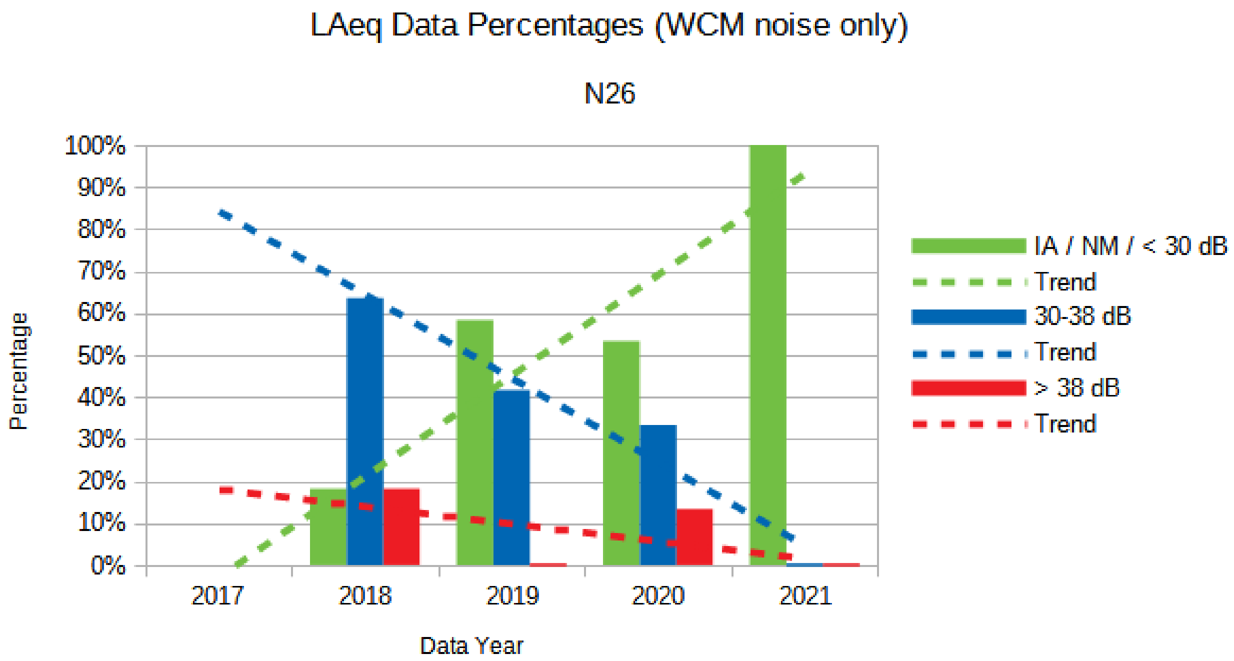

Figure 6: Attended noise monitoring data, N26

5.2 Discussion

During the 5-year period analysed, WCM noise levels at most monitoring locations increased from 2017 to 2018 as mining operations progressed to the northwest and were initially less shielded. From 2019 to 2020, site noise levels decreased at most monitoring locations, likely due to mining activity being deeper in pit and therefore more shielded from receptors.

From 1 December 2020, open cut mining was no longer undertaken by WCM and noise emissions decreased significantly.

6 SUMMARY

Global Acoustics was engaged by WCM to provide an AEMR for 2021, in order to compare noise monitoring results against relevant criteria.

This report summarises monthly attended noise monitoring surveys conducted around WCM during the reporting period 1 January to 31 December 2021. The purpose of the surveys was to quantify and describe the acoustic environment around the site and compare results with specified limits.

Attended noise monitoring described in this report was conducted on a monthly basis in accordance with DA 305-7-2003 (MOD 16), EPL No. 529, and the WCM NMP.

6.1 January to December 2021 Compliance

Noise levels from WCM were inaudible at all receivers during 2021 noise monitoring. No modifying factors were applicable to WCM operations. WCM complied with relevant noise criteria during all measurements during 2021 noise monitoring.

6.2 Long-Term Noise Trends

During the 5-year period analysed, WCM noise levels at most monitoring locations increased from 2017 to 2018 as mining operations progressed to the northwest and were initially less shielded. From 2019 to 2020, site noise levels decreased at most monitoring locations, likely due to mining activity being deeper in pit and therefore more shielded from receptors. From 1 December 2020, open cut mining was no longer undertaken by WCM and noise emissions decreased significantly.

6.3 EIS Comparison

WCM commenced Phase 2 on 1 December 2020, wherein WCM only manages underground operations and associated plant. Open cut operations are managed by United Wambo (UW) as part of the United Wambo Joint Venture (UWJV). UW was solely responsible for noise emissions from UWJV during 2021.

Noise levels from WCM were inaudible at all receivers during all of 2021 noise monitoring. Subsequently, comparison of measured WCM noise levels against EIS noise model predictions was not possible. Additional information is provided in Section 3.5 of this report.

Global Acoustics Pty Ltd

Peabody

APPENDIX D

ANNUAL AIR QUALITY MONITORING REPORT

Level 4, 12 Stewart Avenue
Newcastle West NSW 2302 Australia
PO Box 2147 Dangar NSW 2309
Australia
T +61 2 4979 2600
F +61 2 4979 2666
www.jacobs.com

10 February 2022

Attention: James Benson
Wambo Coal Pty Ltd
PMB 1, Singleton NSW 2330

Project Name: Wambo Coal
Project Number: IA230800

Dear James

Wambo Mine 2021 Air Quality Monitoring Review

I have completed a review of Wambo Coal's air quality monitoring data for 2021. Please see attached for the outcomes of the analysis. In summary, it has been concluded that Wambo Coal was in compliance with its development consent in terms of particulate matter as PM_{10} and $PM_{2.5}$ based on data collected in 2021.

Yours sincerely

Shane Lakmaker
Principal (Air Quality)
0419 239 687
shane.lakmaker@jacobs.com

1. Background

The Wambo Mine is owned and operated by Wambo Coal Pty Limited (Wambo Coal), a subsidiary of Peabody Energy Australia Pty Limited (Peabody). Mining is carried out under Development Consent DA 305-7-2003. The latest modification to DA 305-7-2003 (Mod 16) permits underground mining, operation of Wambo Mine infrastructure and associated surface development; collectively referred to as Phase 2 under DA 305-7-2003.

Wambo Coal has a network of air quality and meteorological monitoring equipment around Wambo Mine which is designed to meet the relevant conditions of DA 305-7-2003.

Figure 1 shows the meteorological and air quality monitoring network. This network includes:

- One (1) meteorological station, referred to as M6.
- Four (4) tapered element oscillating microbalance (TEOM) instruments measuring PM_{10}. Compliance is determined at AQ01 (D3 Coralie), AQ02 (D2 Caban), AQ03 (D4 Thelander) and AQ04 (D1 Muller).
- Two (2) TEOMs measuring $PM_{2.5}$. Compliance is determined at AQ01 (D5 Kelly) and AQ03 (D4 Thelander).

A review of the air quality monitoring data collected in 2021 has been carried out. The main purpose of the review was to determine whether Wambo Coal had complied with the PM_{10} and $PM_{2.5}$ criteria specified in the development consent (DA 305-7-2003). Table 1 shows the relevant development consent criteria.

Table 1 Development consent criteria from DA 305-7-2003 Modification 16

Substance	Averaging time	Impact assessment criteria (applicable from 29 Aug 2019)
Particulate matter (PM_{10})	Annual	[a, c] 25 μg/m^3
	24 hour	[b] 50 μg/m^3
Particulate matter ($PM_{2.5}$)	Annual	[a, c] 8 μg/m^3
	24 hour	[b] 25 μg/m^3

[a] *Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources).*
[b] *Incremental impact (i.e. incremental increase in concentrations due to the development on its own).*
[c] *Excludes extraordinary events such as bushfires, prescribed burning, dust storms, fire incidents or any other activity agreed by the Planning Secretary.*

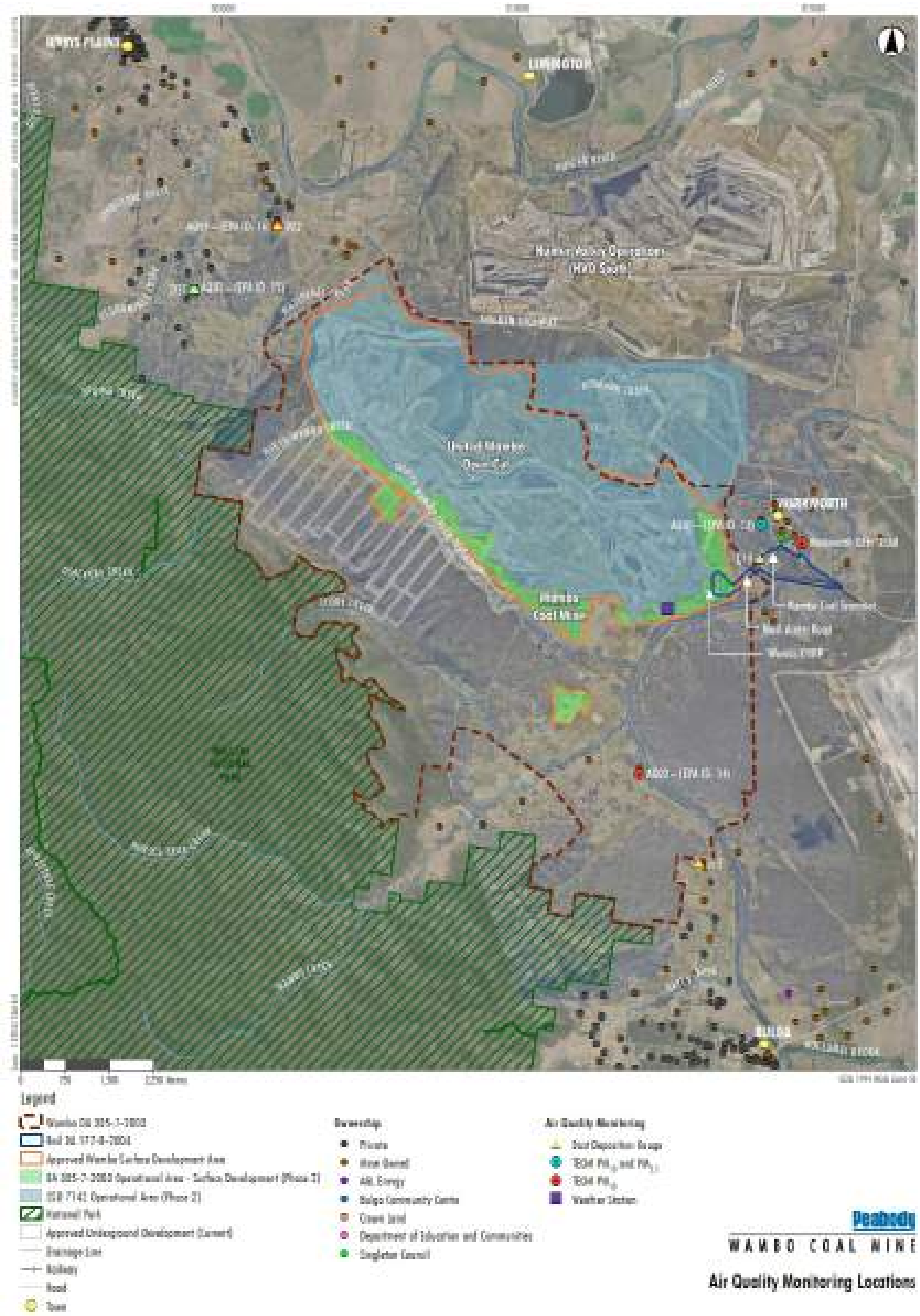

Figure 1 Location of monitoring stations around Wambo Mine

2. Approach to Review

2.1 Extraordinary Events

Historically the Department of Planning Industry (DPIE) has identified extraordinary events that are relevant to the Hunter Valley based on the Upper Hunter Air Quality Monitoring Network (UHAQMN) as well as other factors such as bushfires and dust storms. For example, in 2020 the DPIE identified 24 days as extraordinary events. The DPIE did not identify any “extraordinary event” days in 2021.

Extraordinary events are also identified using Wambo Coal’s monitoring data in combination with the data collected by the DPIE as part of the UHAQMN. For a particular day, this involves:

- Checking if 24-hour average PM_{10} concentrations exceeded 50 µg/m^3 at more than one of Wambo Coal’s monitoring stations. Specifically, at least one upwind and one downwind monitoring station.
- Checking if 24-hour average PM_{10} concentrations exceeded 50 µg/m^3 at either of the DPIE’s Singleton or Muswellbrook compliance monitoring stations.

The checks above show whether elevated PM_{10} concentrations were not unique to the monitors around Wambo mine, therefore indicating an extraordinary event. Wambo Coal also seeks confirmation from the DPIE on any days proposed to be declared as extraordinary events.

2.2 Particulate Matter (as PM_{10})

Evaluation of PM_{10} involved:

- Obtaining hourly average PM_{10} concentration data from all monitoring sites for 2021 and determining the 24-hour and annual averages.
- Obtaining hourly meteorological data from the Wambo Mine weather station for 2021 and calculating the contributions from the direction of Wambo Mine to each hourly PM_{10} concentration result.
- Summarising all monitored PM_{10} concentration data and estimated contributions from the direction of Wambo Mine, and making comparisons to the consent criteria.

There is no standard prescribed methodology for determining contributions to air quality from mining operations. The methodology described below is based on the use of concurrent hourly meteorological and air quality monitoring data from suitably located monitoring stations around the mine site to estimate the potential contribution from the direction of the mining operations. This method is referred to as an “upwind / downwind” calculation approach. In this context, “upwind” is a location that collects data representative of background conditions, not influenced by the source of interest, and does not necessarily need to be upwind of the source of interest.

The maximum contributions from the direction of Wambo Mine to each measured hourly average result was calculated by first determining the wind direction ranges which represented a wind from the direction of Wambo Mine towards the monitor. Table 2 shows the wind direction ranges that represented the direction to Wambo Mine from each monitor.

Table 2 Wind directions to Wambo Mine activities for PM_{10} contribution calculations

Monitoring site	Directions to Wambo Mine
D1 Muller	Between 130 and 180 degrees from true north
D2 Caban	Between 320 and 10 degrees from true north
D3 Coralie / Kelly	Between 255 and 300 degrees from true north
D4 Thelander	Between 110 and 140 degrees from true north

The potential contribution from the direction of Wambo Mine to each monitor was calculated for every 1-hour average record for every day based on the concurrent wind direction and from a "monitor" concentration minus "background" concentration calculation. Table 3 shows the data representing "monitor" and "background" conditions for each monitoring site. The "monitor" concentration minus "background" concentration result was only calculated for hours with wind speeds greater than 0 m/s.

Table 3 Data for monitor and background PM_{10} calculations

Monitoring site	Data representing "background" conditions
D1 Muller	D2 Caban
D2 Caban	D1 Muller
D3 Coralie / Kelly	D4 Thelander
D4 Thelander	D3 Coralie / Kelly

The potential contribution to each monitor was then calculated as 24-hour and annual averages (not including negative values) from the 8,760 hourly records.

The main limitation with this method is that the calculated contribution may not consider dust that is generated by the mining activities but transported towards a monitor at an earlier or later time under different wind conditions (that is, re-suspended dust). In addition, this procedure does not account for any dust generating activities which may have been located between the mine and the monitor. These factors mean that the calculated site contribution will have some embedded uncertainty.

2.3 Particulate Matter (as $PM_{2.5}$)

Evaluation of $PM_{2.5}$ involved:

- Obtaining hourly average $PM_{2.5}$ concentration data from all monitoring sites for 2021 and determining the 24-hour and annual averages.
- Obtaining hourly meteorological data from the Wambo Mine weather station for 2021 and calculating the contributions from the direction of Wambo Mine to each hourly $PM_{2.5}$ concentration result.
- Summarising all monitored $PM_{2.5}$ concentration data and estimated contributions from the direction of Wambo Mine, and making comparisons to the consent criteria.

The maximum contributions from the direction of the Wambo to each measured hourly average result was calculated in the same manner as for the calculated $PM_{2.5}$ contributions, as described in Section 2.2. Table 4 shows the wind direction ranges that represented the direction to Wambo Mine from each monitor.

Table 4 Wind directions to Wambo Mine activities for $PM_{2.5}$ contribution calculations

Monitoring site	Directions to Wambo Mine
D5 Kelly	Between 255 and 300 degrees from true north
D4 Thelander	Between 110 and 140 degrees from true north

The potential contribution from the direction of Wambo Mine to each monitor was calculated for every 1-hour average record for every day based on the concurrent wind direction and from a “monitor” concentration minus “background” concentration calculation. Table 5 shows the data representing “monitor” and “background” conditions for each monitoring site. The “monitor” concentration minus “background” concentration result was only calculated for hours with wind speeds greater than 0 m/s.

Table 5 Data for monitor and background $PM_{2.5}$ calculations

Monitoring site	Data representing “background” conditions
D5 Kelly	D4 Thelander
D4 Thelander	D5 Kelly

The potential contribution to each monitor was then calculated as 24-hour and annual averages (not including negative values) from the 8,760 hourly records.

3. Monitored Results

3.1 Meteorology

Meteorological conditions are important for determining the transport of emissions, and the potential influences on air quality. Rainfall can influence air quality conditions, particularly dust. Figure 2 shows the rainfall data collected by Wambo Coal in the past seven years. Rainfall was well below the long-term average (currently around 688 mm) in 2017, 2018 and 2019, coinciding with the drought, but exceeded the long term average in 2020 and 2021.

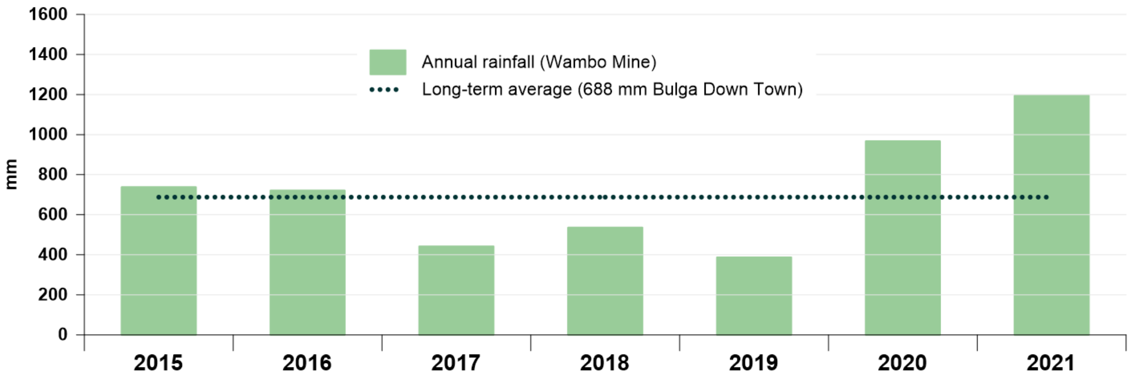

Figure 2 Annual rainfall from the Wambo Mine meteorological station

Wind-roses have been prepared to summarise the wind data that were collected in 2021. The wind-roses (Figure 3) show the frequency of wind speeds and wind directions based on hourly records for each location. The circular format of the wind rose shows the direction from which the wind blew and the length of each "spoke" around the circle shows how often the wind blew from that direction. The different colours of each spoke provide details on the speed of the wind from each direction.

It can be seen from Figure 3 that the winds in 2021 were predominantly from the southeast and northwest. This pattern of winds is common for many parts of the Hunter Valley and reflects the northwest-southeast alignment of the valley.

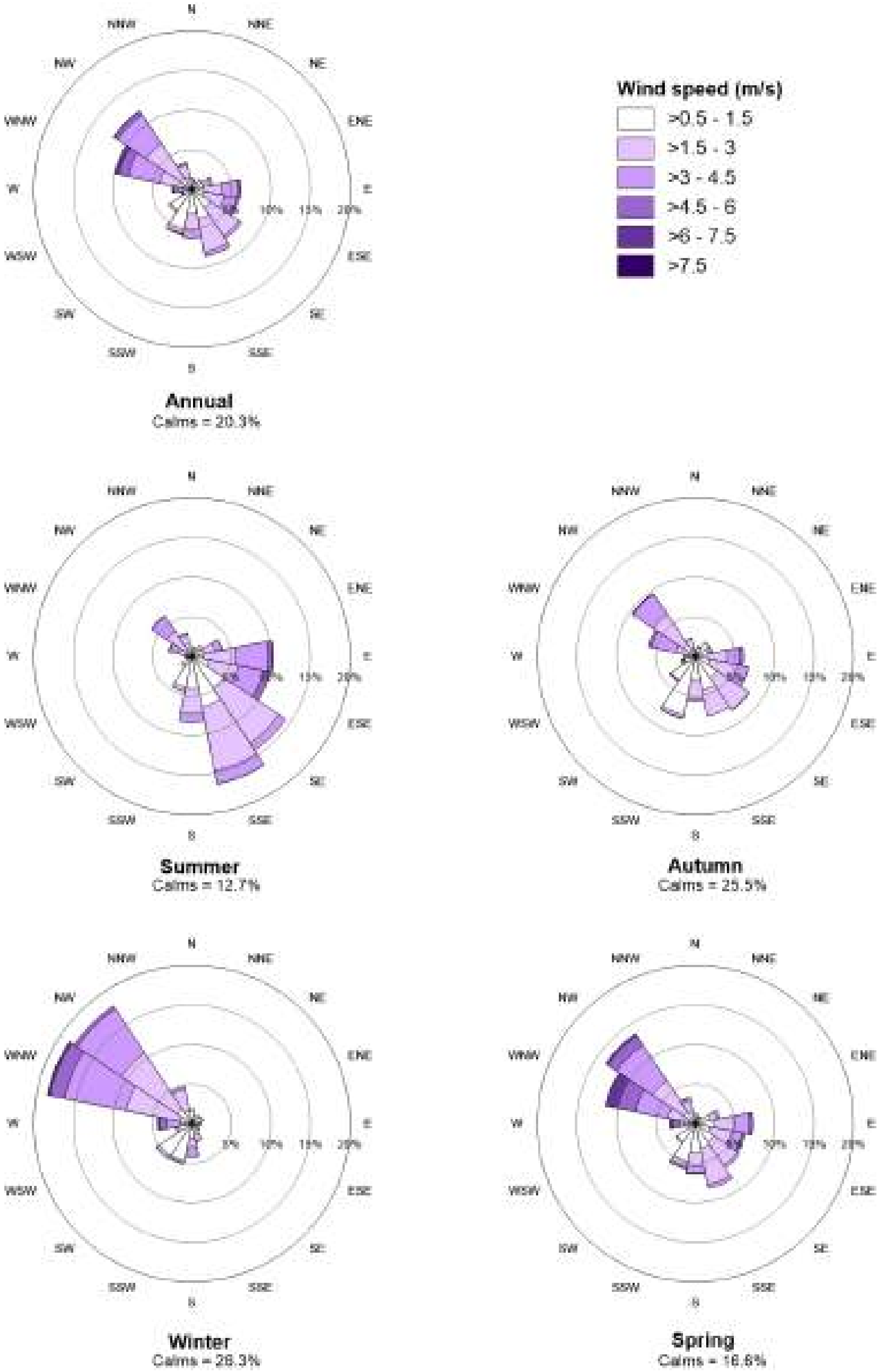

Figure 3 Annual and seasonal wind-roses from data collected at Wambo Mine in 2021

3.2 Particulate Matter (as PM_{10})

The PM_{10} data capture rates are shown in Table 6. Generally, a data capture rate of 90% or more is considered acceptable for air quality monitoring networks as this takes into account downtime from servicing, maintenance, calibrations and reasonable periods to deal with breakdowns. All sites achieved greater than 90% data capture.

Table 6 Data capture rates for PM_{10}

Year	D1 Muller	D2 Caban	D3 Coralie / Kelly	D4 Thelander
2021	99.7%	99.7%	99.7%	98.4%

Figure 4 shows the measured 24-hour average PM_{10} concentrations in 2021 from data collected at each compliance monitoring site. Table 7 summarises the measured PM_{10} concentrations. As noted in DA 305-7-2003, and reproduced in Table 1, determination of compliance against the impact assessment criteria is to exclude *"extraordinary events such as bushfires, prescribed burning, dust storms, fire incidents or any other activity agreed by the Planning Secretary"*. Therefore the results have also been reported without extraordinary events, where relevant.

The data in Table 7 show that, without extraordinary events, the PM_{10} concentrations at all four monitors were below the 24-hour criterion (50 µg/m^3 as a development increment) and annual average criterion (25 µg/m^3 as a total). Consequently the monitoring demonstrates compliance with DA 305-7-2003 in terms of particulate matter as PM_{10}.

Table 7 Summary of PM_{10} concentrations from Wambo Coal monitors in 2021

Statistic	D1 Muller	D2 Caban	D3 Coralie / Kelly	D4 Thelander	Criterion
Maximum 24-hour average in µg/m^3					
Measurement (all data)	99	35	66	36	NA
Measurement (without extraordinary events)	99	35	66	36	NA
Calculated maximum contribution from direction of Wambo Mine (without extraordinary events)	7.7	11.6	25.2	4.3	50
Annual average in µg/m^3					
Measurement (all data)	13.2	12.5	20.5	8.4	NA
Measurement (without extraordinary events)	13.2	12.5	20.5	8.4	25
Calculated contribution from direction of Wambo Mine (without extraordinary events)	0.9	0.3	1.9	0.1	NA

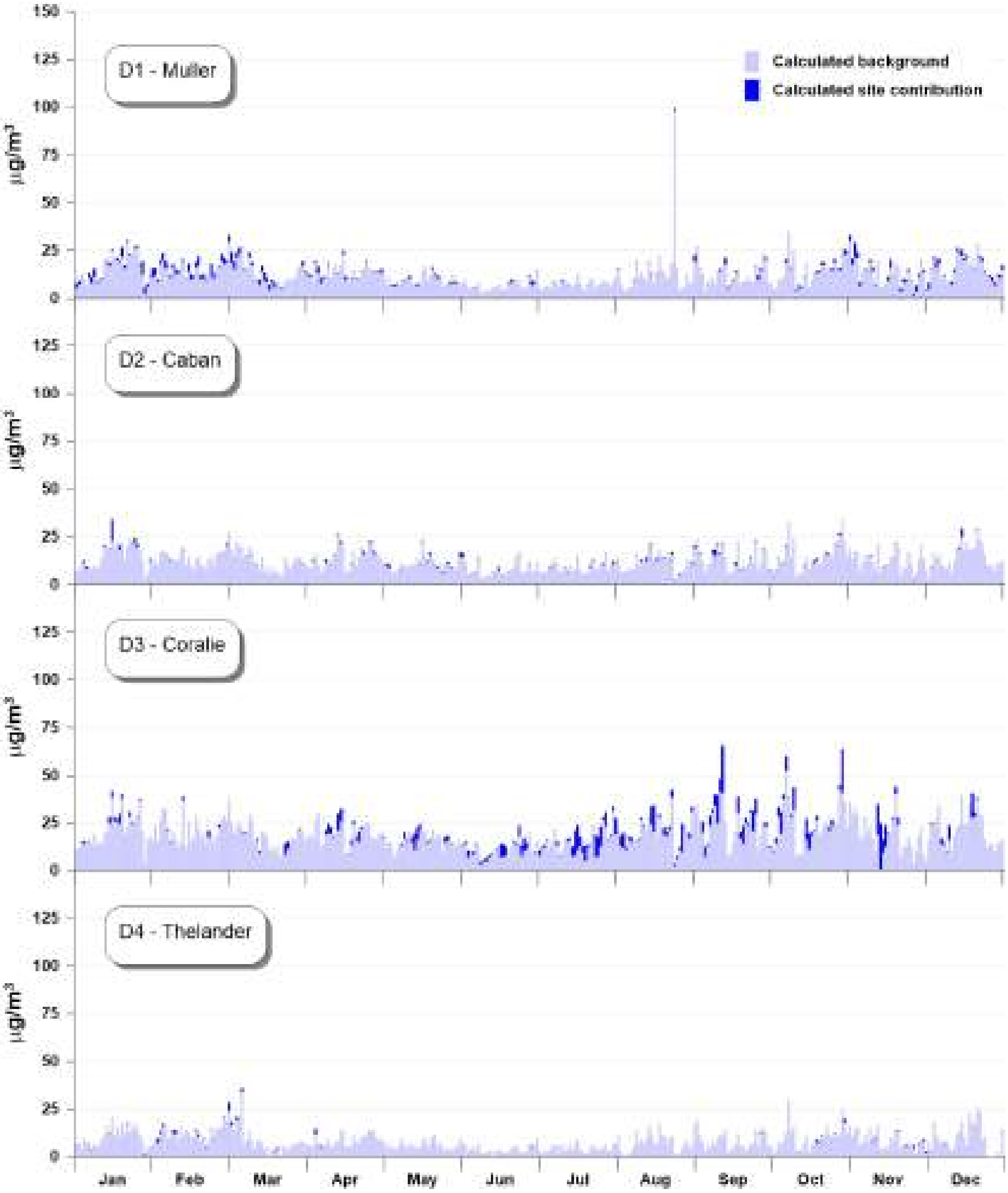

Figure 4 Measured 24-hour average PM_{10} concentrations in 2021

3.3 Particulate Matter (as $PM_{2.5}$)

The $PM_{2.5}$ data capture rates are shown in Table 8. Both sites achieved greater than 90% data capture.

Table 8 Data capture rates for $PM_{2.5}$

Year	D5 Coralie / Kelly	D4 Thelander
2021	99.7%	98.4%

Figure 5 shows the measured 24-hour average $PM_{2.5}$ concentrations in 2021 from data collected at each compliance monitoring site. Table 9 summarises the measured $PM_{2.5}$ concentrations from each monitor. As noted in DA 305-7-2003, and reproduced in Table 1, determination of compliance against the impact assessment criteria is to exclude *""extraordinary events such as bushfires, prescribed burning, dust storms, fire incidents or any other activity agreed by the Planning Secretary"*. Therefore the results have also been reported without extraordinary events.

The data in Table 9 show that, without extraordinary events, the $PM_{2.5}$ concentrations were below the 24-hour criterion (25 µg/m^3 as a development increment) and annual average criterion (8 µg/m^3 as a total). The monitoring data therefore demonstrates compliance with DA 305-7-2003 in terms of particulate matter as $PM_{2.5}$.

Table 9 Summary of $PM_{2.5}$ concentrations from Wambo Coal monitors in 2021

Statistic	D5 Kelly	D4 Thelander	Criterion
Maximum 24-hour average in µg/m^3			
Measurement (all data)	14.9	28.9	NA
Measurement (without extraordinary events)	14.9	28.9	NA
Calculated maximum contribution from direction of Wambo Mine (without extraordinary events)	4.8	4.4	25
Annual average in µg/m^3			
Measurement (all data)	5.5	3.9	NA
Measurement (without extraordinary events)	5.5	3.9	8
Calculated contribution from direction of Wambo Mine (without extraordinary events)	0.4	0.3	NA

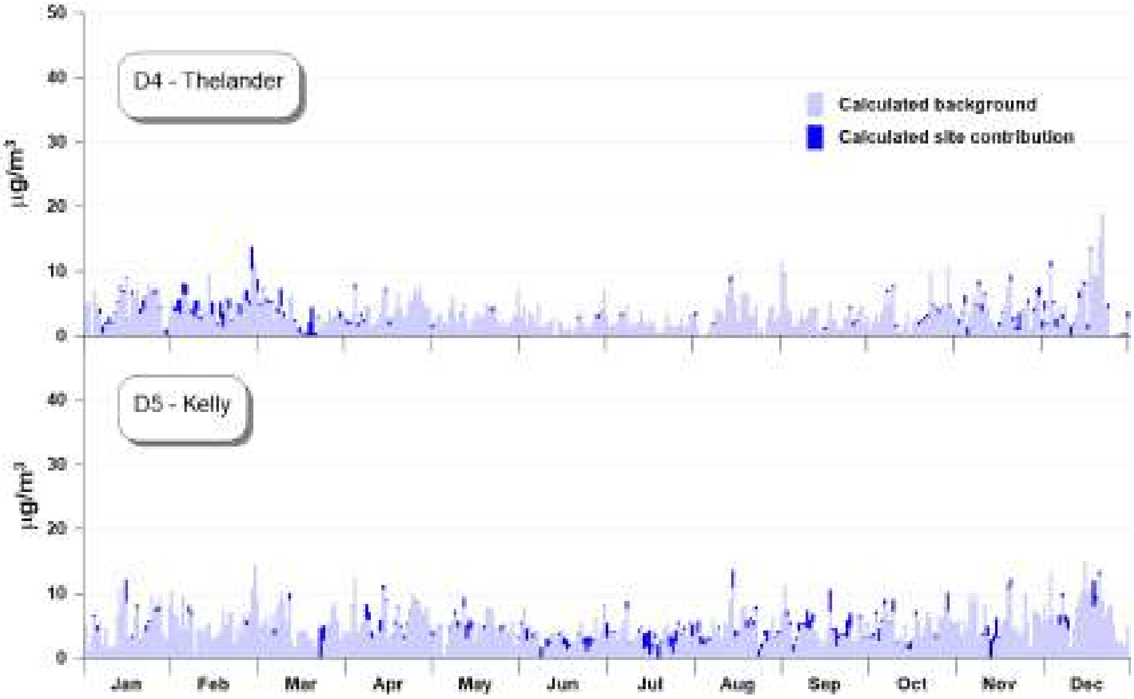

Figure 5 Measured 24-hour average $PM_{2.5}$ concentrations in 2021

4. Conclusions

Based on the analysis and it has been concluded that Wambo Coal was in compliance with its development consent (DA 305-7-2003) in terms of PM_{10} and $PM_{2.5}$ impacts at all reportable monitoring sites for data collected in 2021.

APPENDIX E

ANNUAL FLORA AND FAUNA MONITORING REPORT

Wambo Coal Mine Annual Flora and Fauna Monitoring Report 2021 – Volume 1

Wambo Coal Pty Ltd






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A TETRA TECH COMPANY

1300 646 131
www.ecoaus.com.au

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Abbreviations

Abbreviation	Description
AEMR	Annual Environmental Management Report
BC Act	NSW Biodiversity Conservation Act 2016
BS	Bare soil cover
BOA	Biodiversity Offset Area
BMP	Biodiversity Management Plan
BVT	Biometric Vegetation Type
CEEC	Critically Endangered Ecological Community
DBH	Diameter at Breast Height
DPI	NSW Department of Primary Industries
EEC	Endangered Ecological Community
ELA	Eco Logical Australia Pty Ltd
EPBC Act	Federal Environment Protection and Biodiversity Conservation Act 1999
EPC	Exotic Plant Cover
FL	The length of Fallen Logs >10 cm diameter
GDE	Groundwater Dependent Ecosystem
HBT	Hollow-bearing Tree
INFI	Infiltration Index
LFA	Landscape Function Analysis
LI	Leaf litter cover
LOI	Landscape Organisation Index
NGCG	Native Ground Cover - Grasses
NGCO	Native Ground Cover - Other
NGCS	Native Ground Cover - Shrubs
NI	Nutrient Index
NMS	Native Mid-storey Cover – the projected native foliage cover of mid-storey (%)
NOS	Native Overstorey – the projected native foliage cover of canopy (%)
NPS	The number of Native Plant Species
OEH	NSW Office of Environment and Heritage
OR	Overstorey Regeneration
PCT	Plant Community Type
RWEA	Remnant Woodland Enhancement Area

Abbreviation	Description
RWEP	Remnant Woodland Enhancement Program
SI	Stability Index
SSA	Soil Surface Assessment
TEC	Threatened Ecological Community
VCA	Voluntary Conservation Area
WCPL	Wambo Coal Pty Ltd
WONS	Weed of National Significance

Executive summary

The Wambo Coal Mine annual flora and fauna monitoring program was undertaken by Eco Logical Australia (ELA) in 2021. Several different components make up this monitoring program. Floristic surveys, bird surveys, Landscape Function Analysis and riparian condition surveys were conducted during Spring across both remnant woodland, general surface and rehabilitation areas. Floristic and bird survey sites in the South Bates Extension underground mine area were monitored for the first time since their establishment in 2020. Nest box monitoring and targeted winter bird survey were not required in 2021.

Remnant woodland sites within Remnant Woodland Enhancement Area (RWEA) areas are generally performing well. High diversity of native flora species and native ground cover was again recorded, likely in response to the above average rainfall in the past two years. Fauna habitat features such as fallen logs and hollow bearing trees remain present.

High exotic cover was recorded in RWEA A and RWEA Rail Loop within the Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland on sands of the Warkworth area community and in the River Red Gum / River Oak riparian woodland community. The recorded levels failed to meet the performance criteria and voluntary conservation area (VCA) targets at several sites. Increased weed management is recommended in this area control exotic cover and allow native diversity and cover to increase. Future surveys should continue to monitor for high exotic cover and low ground cover scores (shrubs and other). Plantings of canopy species could be considered in the open grassland areas of on the Wollombi Brook floodplain in RWEA A, where natural regeneration is unlikely to occur in a reasonable timeframe. Plantings may also assist weed control through establishment of a shading canopy.

Bird survey results from remnant woodland sites reflected the good condition of these woodland areas with RWEA areas continuing to support a large diversity of birds including several threatened species. Bird diversity and communities were largely consistent with the data available from previous monitoring years and the monitoring data does not indicate any declines in local bird communities.

The North Wambo Creek Diversion (NWCD) has not yet met completion criteria for landscape function and this area will require continued active management actions to ensure that all completion criteria and other commitments are met in the near future. Gully erosion and areas of bare soil exceeding completion criteria were observed. Major remediation works are currently underway in the NWCD to improve drainage, erosion and establishment of native plant communities. Floristic monitoring recorded acceptable native species diversity and native ground cover. Cover of shrubs and canopy were low however this is expected during establishment phase. A increased number of floristic sites is required to monitor this area. Significant growth in Eucalypt and Acacia trees and shrubs was observed, including several areas where trees have naturally establishing along the creek channel. A large proportion of the NWCD remains as grassland and will require additional revegetation efforts to establish the target vegetation communities.

The use of LFA for future monitoring of rehabilitation areas is currently under review following recommendations made by the Biodiversity Conservation Division (BCD) of the NSW Department of Planning, Industry, and Environment (DPIE) on the Wambo Coal Mine Phase 2 Rehabilitation

Management Plan (RMP). Any changes to the proposed monitoring methodology for rehabilitation at the Wambo mine will be incorporated into an updated Biodiversity Management Plan (BMP) for approval prior to implementation.

Riparian condition scores for North Wambo Creek, Wambo Creek and Stony Creek were similar to 2020 when an increase was following drought years and in response to the reduction/exclusion of grazing. Understorey vegetation cover remains high following the increase in 2020 resulting from higher rainfall, although a high proportion of ground cover contribution is from exotic species, owing to the agricultural disturbance history within these systems. Cattle should continue to be excluded from riparian areas, including fencing of the lower reaches of Stony Creek, and control of feral pigs is also recommended. Planting native trees in over-cleared areas to facilitate more rapid regeneration is also recommended.

Floristic and bird monitoring sites established in 2020 in the South Bates Extension underground mine area, including reference sites outside of the mining area, were monitored for the first time. Vegetation and bird communities were recorded in good condition and no significant impacts to floristic attributes or bird communities were recorded at sites within areas impacted by undermining to date. Continued monitoring in these areas is required to assess for impacts of ongoing operations in this area.

The *Melaleuca decora* low forest GDE community was recorded to be in good condition with scores for most attributes increasing since 2019. This community was undermined during 2019 and 2020, and data collected to date may serve as suitable baseline for this community noting that 2019 was a dry year followed by wetter conditions in 2020 and 2021. The River Oak riparian tall woodland GDE recorded strong growth and monitored trees appeared in healthy condition, likely in response to the higher rainfall in 2020 and 2021. High exotic ground cover is present in some areas of this community due to historical clearing and agricultural activities. The extent of the community remains unchanged since originally mapped in 2019, however recruitment of trees and shrubs was observed following two wetter years, and this may translate into expansion of the community in coming years. Ongoing monitoring of these GDE areas is required to assess whether any impacts are occurring from underground mining activities.

Subsidence was observed in several locations across the site including RWEA C and RWEA D and the NWCD, however no significant effects on flora and fauna or performance criteria exceedances were recorded. Repairs to tracks and subsidence cracks are required in RWEA C. Monitoring should continue to document and assess subsidence impacts across the site. No other significant management issues were recorded during walk through inspections of RWEAs.

1. Introduction

Wambo Coal Pty Limited (WCPL) is situated approximately 15 kilometres (km) west of Singleton, near the village of Warkworth, New South Wales (NSW). A range of open cut and underground mine operations have been conducted at WCPL since mining operations commenced in 1969. Mining under the current Development Consent (DA 305-7-2003) commenced in 2004 and permits both open cut, underground operations and associated activities to be conducted. As part of the development consent, a Remnant Woodland Enhancement Program (RWEP) has been established as a biodiversity offset for lands disturbed by open cut coal mining activities. The RWEP aims to conserve local and regional biodiversity by protecting and enhancing the habitat for flora and fauna within these areas through a conservation agreement.

HLA - Envirosciences Pty Ltd initially established a program to monitor the fauna and vegetation structure within the RWEP areas, as well as to monitor stream and riparian condition within North Wambo, Wambo and Stony Creeks, with the aim of measuring and documenting the status and change in ecological condition. Eco Logical Australia (ELA) was commissioned by WCPL to undertake this monitoring program during spring 2021. This monitoring program is conducted in response to the 2004 Development Consent condition (DA 305-7-2003 Schedule 4 Condition 48) and informs WCPL's Annual Environmental Management Report (AEMR).

ELA's scope of works was to:

- collect floristic and fauna habitat data from established monitoring locations throughout land owned by WCPL, including remnant woodland enhancement areas (RWEA) (otherwise known as Biodiversity Offset Areas (BOA) or Voluntary Conservation Areas (VCA))
- conduct Landscape Function Analysis (LFA) at established sites along the North Wambo Creek Diversion
- conduct riparian condition monitoring at North Wambo, South Wambo and Stony Creeks
- conduct bird monitoring at established monitoring locations throughout land owned by WCPL, primarily in land set aside as part of the RWEP
- monitor Groundwater Dependent Ecosystems above the in South Bates Underground Extension area
- report on any mine subsidence observations
- document results and compare to performance criteria or past results (where relevant) and identify what and where management actions may be required.
- provide a summary of management actions.

1.1 Report structure

This report has been set out in the following manner:

- **Executive summary –** summary of the key findings of the monitoring works
- **Introduction –** provides background information to the current report
- **Remnant woodland enhancement areas (RWEAs) –** provides methods, results and interpretation of data, as well as recommendations from flora and bird surveys primarily within RWEA areas.
- **Rehabilitation areas –** provides methods, results and interpretation of data from LFA and biometric flora survey plots from the North Wambo Creek Diversion
- **Riparian condition assessment –** provides methods, results and interpretation of data, as well as management recommendations for riparian transects at North Wambo, Wambo and Stony Creeks
- **South Bates Underground Extension area –** provides methods, results and interpretation of data from monitoring of Groundwater Dependent Ecosystems, flora and birds in the area above the South Bates Underground Extension.
- **Mine subsidence observations and other management issues –** provides observations of mine subsidence and other management issues on land owned by WCPL
- **Summary of management actions –** provides a summary of required and recommended actions.

Raw data and photographs from monitoring site surveys are included in **Volume 2**.

1. Remnant Woodland Enhancement Areas (RWEAs)

1.1 Floristic monitoring

1.1.1 Introduction

The aim of floristic and fauna habitat monitoring is to measure the current condition of vegetation within the RWEAs in terms of floristics and habitat complexity. The results aim to provide direction to management of these areas and for the monitoring program in the future.

1.1.2 Methods

Data was collected by ELA ecologists Shawn Ryan and Liam Scanlan from 18-22 and 25-27 October 2021. A standard biometric plot 50 x 20 m (Figure 1) was used to measure the following parameters and collect data following the BioBanking methodology (DECC 2008a):

- full floristic species list (including cover abundance scores) in a nested 0.04 ha plot (20 m x 20 m)
- canopy regeneration over whole vegetation zone
- estimation of projected native foliage cover of ground cover from 50 points and canopy and mid-storey layer from 10 points along the 50 m transect
- occurrence and abundance of weed species in 0.04 ha plot (20 m x 20 m)
- number of hollow-bearing trees and length of logs (>10cm diameter) in the plot
- photograph of each plot (at start of 50 m transect).

The abundance of each species in the 0.04 ha plot was estimated, using a modified Braun-Blanquet scale, as used in previous floristic monitoring at WCPL. These are listed below:

- 1 = few, small cover (<5%)
- 2 = numerous (<5%)
- 3 = 5 – 25%
- 4 = 25 – 50%
- 5 = 50 – 75%
- 6 = >75%.

All vascular plants species were recorded and identified to the lowest taxonomic level possible, with samples of unknown species collected for further identification where possible. Nomenclature followed the Flora of New South Wales (Harden 1992; 1993; 2000; 2002), and any subsequent recent taxonomic changes as presented on PlantNet (RBGDT 2015).

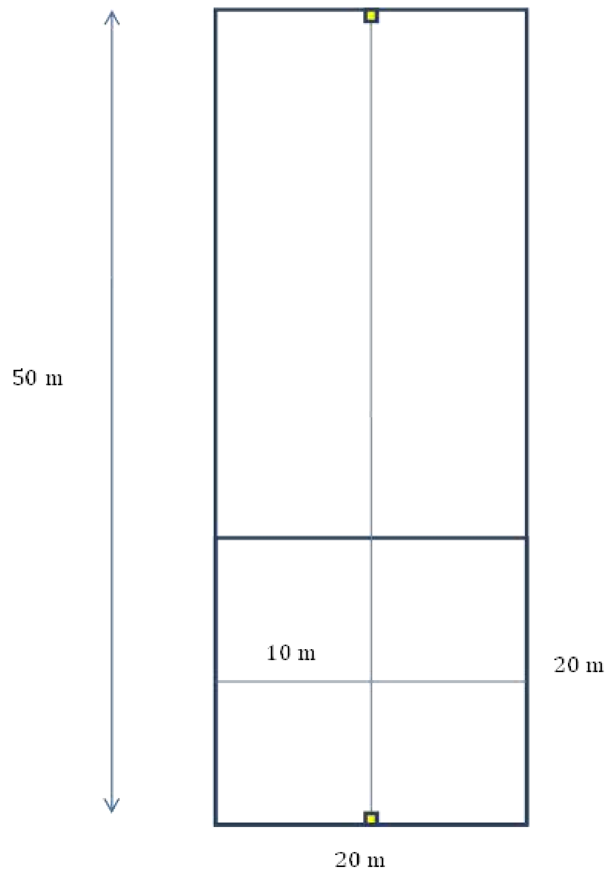

Figure 1: Biometric vegetation plot dimensions

Flora monitoring plots were located within the ten vegetation communities originally mapped and described by Orchid Research (2003). Since this time, a number of changes in vegetation mapping standards in NSW have occurred. Previously a set list of plant communities known as Biometric Vegetation Types (BVT) were used as a state-wide standard by the NSW Office of Environment and Heritage (OEH). These BVTs have now been modified and are now known as Plant Community Types (PCT's). As such, the ten vegetation communities originally mapped and described by Orchid Research (2003) have been converted to their equivalent PCT within this report. Several of these communities are also listed under both State and Federal legislation as Threatened Ecological Communities (TECs) under different nomenclature. Table 1 clarifies the conversion of vegetation communities.

Data was collected from the 34 locations previously surveyed as part of the RWEP monitoring program. Floristic data was also collected from an additional four sites in woodland rehabilitation areas to measure biometric attributes in addition to LFA. The results from these plots are included in Section 2. During 2019 and 2020, several additional floristic monitoring plots were added outside of RWEAs in the North Wambo Creek Diversion and South Bates Extension Underground Mine area as part of the broader Wambo Coal Mine biodiversity monitoring program. These sites are monitored using the same methods described here, with results presented in the relevant sections later in this report. All floristic plot locations are shown in Figure 2.

Table 1: Original vegetation classification, plant community type classification and TEC status for each monitoring plot in remnant vegetation

<table>
<tr><th>Vegetation Community (Orchid Research 2003)</th><th>Plant Community Type (PCT)</th><th>TEC</th><th>Plot name</th></tr>
<tr><td rowspan="5">River Oak / Rough-barked Apple Forest</td><td rowspan="9">PCT 42: River Red Gum / River Oak riparian woodland wetland in the Hunter Valley</td><td rowspan="9">Listed NSW Biodiversity Conservation Act 2016 (BC Act), E: Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions</td><td>V1-A1</td></tr>
<tr><td>V1-A2</td></tr>
<tr><td>V1-B1</td></tr>
<tr><td>V1-B2</td></tr>
<tr><td>V1-B3</td></tr>
<tr><td rowspan="3">River Red Gum Woodland</td><td>V2-A1</td></tr>
<tr><td>V2-B1</td></tr>
<tr><td>V2-B2</td></tr>
<tr><td>Yellow Box / Blakely's Red Gum / Rough-barked Apple Forest</td><td>V3-B1</td></tr>
<tr><td rowspan="4">Coast Banksia / Rough-barked Apple / Blakely's Red Gum Forest</td><td rowspan="4">PCT 1653: Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland on sands of the Warkworth area</td><td rowspan="4">Listed BC Act, E: Warkworth Sands Woodland in the Sydney Basin Bioregion, also listed as CE under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) as Warkworth Sands Woodland of the Hunter Valley</td><td>V5-B1</td></tr>
<tr><td>V5-B2</td></tr>
<tr><td>V5-B3</td></tr>
<tr><td>V5-B4</td></tr>
<tr><td rowspan="8">Narrow-leaf Ironbark/Grey Box/Bulloak/Honeymyrtle Forest</td><td rowspan="10">PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter</td><td rowspan="10">Listed BC Act, E: Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions, may also be listed as CE under the EPBC Act as Central Hunter Valley eucalypt forest and woodland, dependant on condition and landscape position</td><td>V6-A1c</td></tr>
<tr><td>V6-A3</td></tr>
<tr><td>V6-B1</td></tr>
<tr><td>V6-B1c</td></tr>
<tr><td>V6-B2</td></tr>
<tr><td>V6-B2c</td></tr>
<tr><td>V6-B3</td></tr>
<tr><td>V6-B4</td></tr>
<tr><td rowspan="2">Grey Gum/Narrow-leaf/ Ironbark/Bulloak/Honeymyrtle Forest</td><td>V11-B1</td></tr>
<tr><td>V11-B2</td></tr>
<tr><td rowspan="2">Spotted Gum/Narrow-leaf Ironbark/Bulloak/Paperbark Forest</td><td rowspan="2">PCT 1604: Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter</td><td rowspan="2">Listed BC Act, E: Central Hunter Ironbark - Spotted Gum - Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions, may also be listed as CE under the EPBC Act as Central</td><td>V9-A1</td></tr>
<tr><td>V9-B1</td></tr>
</table>

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	TEC	Plot name
		Hunter Valley eucalypt forest and woodland, dependant on condition and landscape position	V9-B2
			V10-B1
Slaty Gum/Narrow-leaf Ironbark/Bulloak/Paperbark Forest	PCT 1176: Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion	Listed BC Act, V: Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion, may also be listed as CE under the EPBC Act as Central Hunter Valley eucalypt forest and woodland, dependant on condition and landscape position	V10-A1
			V10-A2
			V10-B3
White Mahogany/Rough-barked Apple Forest	PCT 1584: White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	-	V13-B1
Brush Wilga/Native Olive Shrubland	PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	Listed BC Act, E: Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions	V14-A1
			V14-B1
			V14-B2

*CE – Critically Endangered, E – Endangered, V- Vulnerable

Cover/abundance scores for each species within each plot in the RWEAs was provided by WCPL from 2010 onwards, with the exception of woodland rehabilitation sites, which were only sampled for the first time by ELA during monitoring undertaken in 2015. Biometric plot data using the current method was collected for the first-time during monitoring undertaken in 2014.

Data was examined for changes in native species richness within each sampled plant community over eleven monitoring periods from 2010 to 2021 and cover of exotic species over the last six monitoring periods (2016 to 2021). Monitoring point photographs were also compared where possible to determine if major structural elements of each community had changed since the earliest photos available were taken (generally in 2013). Data from each vegetation community was compared to established performance criteria, biometric benchmarks and compared with reference sites outside of the RWEA areas where possible.

Vegetation community condition benchmarks (developed by OEH for each PCT) have been modified to provide realistic, ambitious but achievable performance criteria for each PCT. Monitoring results can then be compared to these criteria to determine if management actions are likely to be required.

A green, yellow, amber and red colour system has been developed to rank each measured attribute according to performance and management actions required (Table 2). The structure of this table has been derived from (DECC 2008b). The number of hollow-bearing trees and length of fallen logs have been presented as a measure of fauna habitat attributes. However, no performance criteria have been set for these attributes in remnant vegetation, as in situations where historical logging or clearing has been intensive, it may take many years for a suitable density of hollows and logs to form naturally.

Table 2: Colour ranking system for floristic attributes and performance targets

Attribute	Red (needs greater improvement)	Orange (in need of improvement)	Yellow (not meeting target but values still acceptable)	Green (excellent – within target range)
Native species richness	0–10%	>10 – <50% of target range	50 – <100% of target range	≥ target range
Native overstorey cover % (*pfc)	0 – 10% or >200% of target range	> 10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range
Native mid-storey cover %(*pfc)	0 – 10% or >200% of target range	>10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range
Native ground cover – grasses %	0 – 10% or >200% of target range	>10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range
Native ground cover – shrubs %	0 – 10% or >200% of target range	>10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range
Native ground cover – other %	0 – 10% or >200% of target range	>10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range
Proportion of native overstorey species regenerating	0	0-0.5	0.5-1	1
Exotic cover	>66%	33-66	5-33	0-5%

Several abbreviations for measured attributes are used in tables throughout the following section. An explanation of these is provided below.

- NPS– the number of native plant species
- NOS (%) - projected native foliage cover of canopy
- NMS (%) – projected native mid-storey cover
- NGCG (%) – native groundcover of grasses
- NGCS (%) – native groundcover of shrubs
- NGCO (%) – native groundcover of other plant types (sedges, herbs etc.)

- EPC (%) – exotic plant cover
- OR – proportion of overstorey species regenerating over the whole vegetation zone
- HBT – number of hollow-bearing trees present in the 20 x 50 m vegetation plot
- FL – length of fallen logs >10 cm diameter.

In addition to those performance criteria listed above, Annexure C of the VCAs for the RWEA areas requires that WCPL aim for an exotic plant cover within the Conservation Areas that does not exceed the percentages detailed in Table 3. Photo-monitoring points established as part of the VCAs in 2013 were compared to photos at the same location during the current vegetation monitoring.

Table 3: Exotic plant cover criteria for VCA areas

RWEA	Aim	Timing
Coal Terminal	Exotic plant cover within the Conservation Area must not be permitted to exceed: - 5% of the foliage cover at monitoring site CT1* - 15% of the foliage cover at monitoring site CT2*.	In Year 1 and at the end of Year 5
RWEAs A, B, C and D	Exotic plant cover within the Conservation Area must not be permitted to exceed: - 70% of the foliage cover at monitoring site A1 within Area A - 20% of the foliage cover at monitoring site A2 within Area A - 30% of the foliage cover at monitoring site A3 within Area A - 10% of the foliage cover at monitoring site A4 within Area A - 5% of the foliage cover at monitoring site B1 within Area B - 5% of the foliage cover at monitoring site B2 within Area B - 5% of the foliage cover at monitoring site C1 within Area C - 5% of the foliage cover at monitoring site D1 within Area D.	In Year 1
	Exotic plant cover within the Conservation Area must not be permitted to exceed: - 60% of the foliage cover at monitoring site A1 within Area A - 15% of the foliage cover at monitoring site A2 within Area A - 20% of the foliage cover at monitoring site A3 within Area A - 5% of the foliage cover at monitoring site A4 within Area A - 5% of the foliage cover at monitoring site B1 within Area B - 5% of the foliage cover at monitoring site B2 within Area B - 5% of the foliage cover at monitoring site C1 within Area C - 5% of the foliage cover at monitoring site D1 within Area D.	Years 2-5

Figure 2: Floristic and habitat monitoring sites and RWEAs

1.1.3 Results

The floristic and biometric data collected during floristic and fauna habitat monitoring is summarised below, with the full floristic plot data and other data including plot photographs provided in **Volume 2**.

1.1.4 *River Red Gum / River Oak riparian woodland wetland in the Hunter Valley*

This community is one of the most disturbed vegetation communities on WCPL land, as it occurs on more fertile soils on the banks and floodplains of Wollombi Brook, is naturally disturbed by flood events and has been historically used more intensively for agricultural purposes.

River Red Gum / River Oak riparian woodland is distinguished by an overstorey of *Eucalyptus camaldulensis* (River Red Gum), *Casuarina cunninghamiana* subsp. *cunninghamiana* (River Oak), *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus melliodora* (Yellow Box) on floodplains and riparian areas. This PCT conforms to the BC Act listed Endangered Ecological Community (EEC) *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions.* This community also contains the endangered Hunter Valley population of *Eucalyptus camaldulensis* listed under the BC Act.

The River Red Gum / River Oak riparian woodland at WCPL is typical of other remaining stands throughout the Hunter Valley, with generally a high cover of weed species and a reduced number of native species (Photograph 1).

Photograph 1: River Red Gum / River Oak riparian woodland wetland on North Wambo Creek in 2021 (Site V1-A1 within the Wollombi Brook channel)

Nine monitoring plots are located within this PCT. V1 monitoring sites are located within *Casuarina cunninghamiana* dominated forest along the banks of Wollombi Brook. V2 monitoring sites are located on the partially cleared red gum dominated floodplains of Wollombi Brook and the V3 monitoring site is located in a slightly wetter site on the boundary of the floodplain and sand dunes supporting Warkworth Sands type vegetation.

Three sites (V1-A1, V1-A2 and V2-A1) appear to have been originally intended as reference sites at the commencement of the monitoring program, as they are located outside of the RWEP areas. However, cattle have been fenced out of the immediate riparian zone on Wollombi Brook (including sites V1-A1, V1-A2) and thus treatments for both reference sites and management sites are similar.

Floristic results for this vegetation zone in relation to performance criteria are presented in Table 5.

NMS and EPC did not meet targets. Targets were met or acceptable for the other performance criteria.

The average number of NPS recorded per monitoring plot in River Red Gum / River Oak riparian woodland within RWEAs increased from 2020 and was above the average over the past eleven years (Figure 3). The average number of NPS at the three reference sites also increased from the previous year and 2021 is the highest recorded for those sites. Although the RWEA sites scores are still higher than for the reference sites, they had been significantly above the reference sites during 2016-2018.

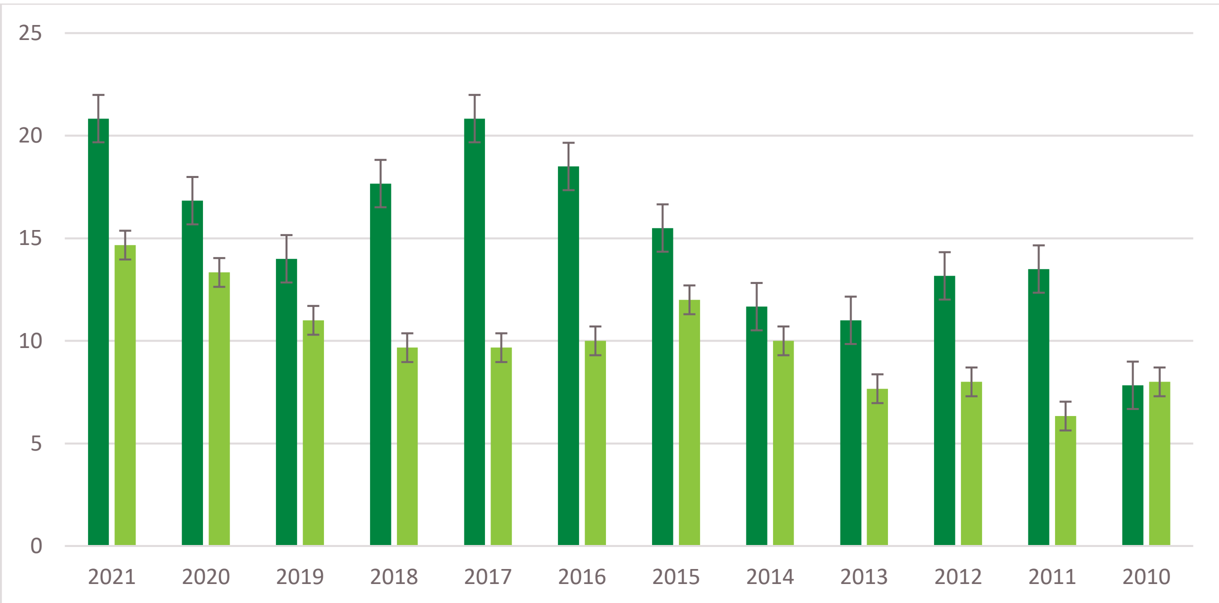

Figure 3: Average number of NPS per plot in monitoring sites within riparian woodland in RWEA A (light green) and from three reference sites outside the boundary of RWEAs (dark green). Error bars represent standard error

Total EPC has been recorded since 2014 and results are quite variable over time (Figure 4), even within each site. Total EPC, although lower than in 2020, was still significantly higher than all other years except 2016, which was notably also a year with higher-than-average rainfall. The trends suggest EPC is strongly correlated to rainfall. Floristic plot data suggests total exotic plant cover is a result of a combination of both annual and perennial species.

Several priority weeds are present within this PCT, these are listed in Table 4 below, along with their biosecurity duty according to NSW Department of Primary Industries (DPI 2017). Priority weed distribution and abundance was generally similar to previous years, although the annual *Senecio madagascariensis* (Fireweed) was recorded at all sites and has likely responded to the wetter conditions. All plants listed under the NSW *Biosecurity Act 2015* are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.

Photo monitoring points in this PCT, show no obvious changes within this PCT between years 2015 and 2021 (Photograph 2 and Photograph 3), and 2013 and 2021 monitoring (Photograph 4 and Photograph 5), although evidence of recent wetter seasonal conditions is evident in the understorey of some 2021 photos.

Overall, the performance of this PCT is considered acceptable, although continued weed management should be undertaken.

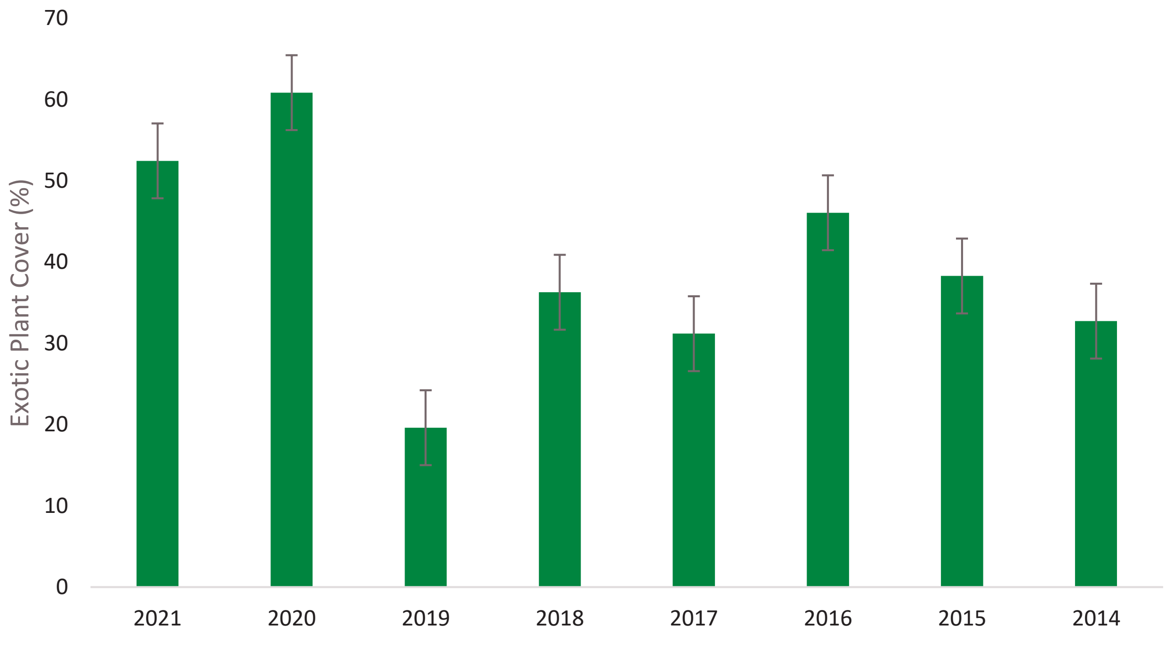

Figure 4: Average EPC (%) within all riparian woodland monitoring sites per year

Table 4: Declared weeds observed within the River Red Gum / River Oak riparian woodland PCT plots in 2021

Scientific Name	Common Name	Site	Biosecurity duty (NSW Biosecurity Act 2015)
Asparagus asparagoides	Bridal Creeper	V2-B1, V2-B2	**Prohibition on dealings** - Must not be imported into the State or sold
Echium plantagineum	Patterson's Curse	V1-A2, V1-B3	**Regional Recommended Measure** - Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. The plant should not be bought, sold, grown, carried or released into the environment.
Lycium ferocissimum	African Boxthorn	V1-A2, V1-B2, V2-B2	**Prohibition on dealings** - Must not be imported into the State or sold
Olea europaea subsp. *cuspidata*	African Olive	V1-B3	**Regional Recommended Measure** - Land Area 1: Singleton and Maitland. Land Area 2: outbreaks in Hunter region except Singleton and Maitland. Land Area 1: Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. Land Area 2: Land managers should mitigate spread from their land. Land managers should mitigate the risk of new weeds being introduced to their land. Plant should not be bought, sold, grown, carried or released into the environment.
Opuntia aurantiaca	Tiger Pear	V1-A2, V2-B1	**Regional Recommended Measure** - Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land.
Opuntia stricta	Prickly Pear	V1-B2, V1-B3, V2-B1, V2-B2	**Prohibition on dealings** - Must not be imported into the State or sold
Salix species	Willows	V1-A1, V1-B1	**Prohibition on dealings** - Must not be imported into the State or sold
Senecio madagascariensis	Fireweed	All sites	**Prohibition on dealings** - Must not be imported into the State or sold

Photograph 2: Flora monitoring site V3-B1 during 2015

Photograph 3: Flora monitoring site V3-B1 during 2021

Photograph 4: Monitoring site A3 during 2013

Photograph 5: Monitoring site A3 during 2021

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL (m)
River Oak / Rough-barked Apple Forest	PCT 42: River Red Gum / River Oak riparian woodland wetland in the Hunter Valley	Outside of RWEP	V1-A1	13	6.2	0	14	0	2	42	1	1	80
		Outside of RWEP	V1-A2	11	11	5.1	0	0	0	98		1	28
		A	V1-B1	25	9.2	0	52	2	60	10		0	12
		A	V1-B2	20	22.2	8	16	0	32	54		0	13
		A	V1-B3	17	12.9	0.2	16	24	0	80		0	10
River Red Gum Woodland		Outside of RWEP	V2-A1	20	18.5	1	58	8	2	18		1	0
		A	V2-B1	15	17.7	4	0	4	0	90		1	6
		A	V2-B2	18	9.7	8	0	14	12	80		1	18
Yellow Box / Blakely's Red Gum / Rough-barked Apple Forest		A	V3-B1	30	16.2	0	42	0	48	0		1	30
Average values for RWEA monitoring sites				20.8	14.7	3.4	21.0	7.3	25.3	52.3	1	0.5	14.8
Performance criteria				>20	10-50	10-50	20-60	1-5	5-30	<10	1	-	-

Table 5: Floristic results and performance criteria for River Red Gum / River Oak riparian woodland wetland

1.1.5 *Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland on sands of the Warkworth area*

Within WCPL owned land, this community is mostly restricted to the eastern side of Wollombi Brook, primarily within the RWEP area A (Photograph 6). This PCT corresponds to the *EPBC Act* listed Critically Endangered Ecological Community (CEEC) *Warkworth Sands Woodland of the Sydney Basin Bioregion* and is also listed under the BC Act. This PCT occurs on aeolian sand deposits and is restricted to the Warkworth area.

Photograph 6: Warkworth Sands Woodland within RWEA A in 2021 (Site V5-B2)

The average number of NPS met the performance criteria in 2021 (Table 6) and has been relatively consistent over the past four years after lower diversity was recorded in 2017 (Figure 5).

Results for other performance criteria were mixed (Table 6). NOS and OR met the performance indicating a healthy canopy. NGCG was high above the target, however this is not considered to be a major concern, with the higher grassy cover likely to be caused by strong growth as a result of continued higher rainfall in 2021. EPC was higher than the target, driven by sites V5-B1 with and V5-B4. At V5-B1, *Richardia humistrata* and *Tagetes minuta* (Stinking Roger) are still the dominant exotics, and at V5-B4, *Melinis repens* (Red Natal Grass) contributed strongly to the high EPC. NMS was just below target, although diversity and cover of species from this group were recorded in the floristic data and are visible in plot photographs.

In recent years, the environmental weed *Bryophyllum* sp. (Mother of Millions) was observed to be abundant in certain locations within this vegetation community, both within RWEA A and inside the Rail Loop area. *Bryophyllum* sp. is listed as a priority weed in the Hunter under the *Biosecurity Act 2015*. It is understood that this species is currently the focus of a weed management program. This is evident in 2021 results, with *Bryophyllum* sp. occurring in V5-B1 only.

Photo-monitoring point A2 within this PCT shows a minor change in vegetation between the 2013 and 2021 monitoring periods, with a reduction in cover of *Pteridium esculentum* (Bracken) apparent (Photograph 7 and Photograph 8). NOS and NMS collected by ELA from the 2015 to 2021 monitoring periods have remained generally similar between years.

Banksia integrifolia (Coast Banksia) has been observed to suffer die-off over the past few years, and continued to not be recorded as live in any plots in 2021. Live individuals were observed more broadly within this PCT during 2021. Monitoring should continue to note the health of this species within the PCT.

Overall this community is performing acceptably, although surveys should continue to monitor the high EPC and low NMS.

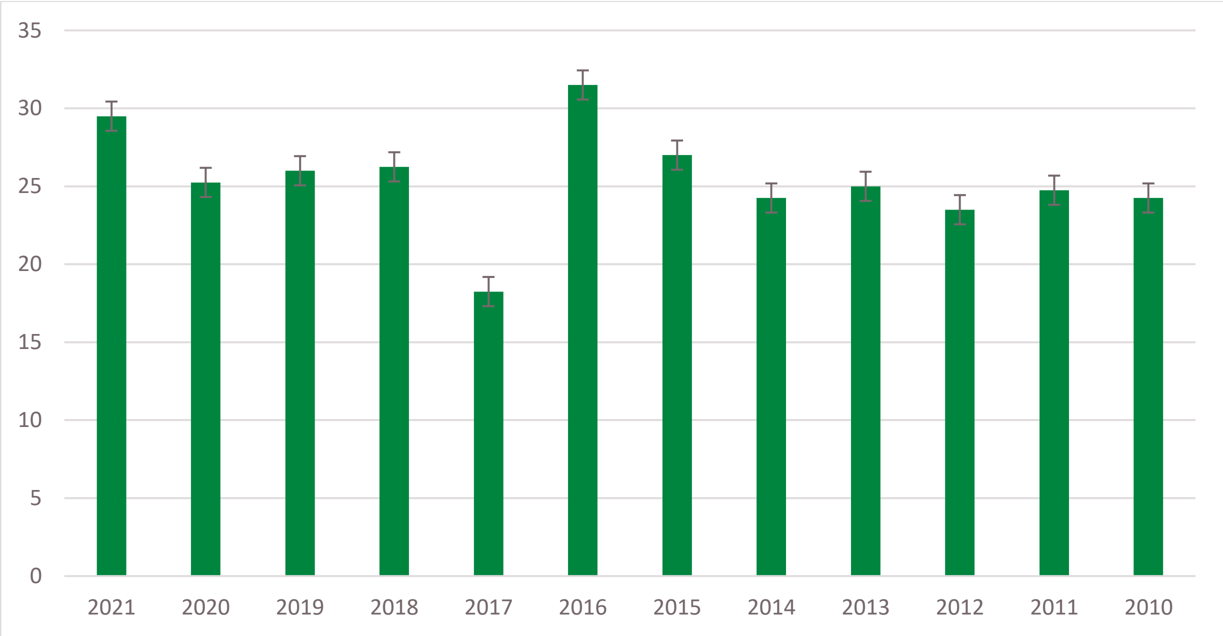

Figure 5: The average number of NPS recorded within Warkworth Sands Woodland monitoring plots over time.

Photograph 7: Photo monitoring point A2 during 2013

Photograph 8: Photo monitoring point A2 during 2021

Table 6: Floristic results in regards to performance criteria for Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Coast Banksia / Rough-barked Apple / Blakely's Red Gum Forest	PCT 1658: Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland on sands of the Warkworth area	A	V5-B1	35	13.4	8.2	52	6	8	20	1	1	11
		A	V5-B2	24	10.3	13.7	60	0	42	6		1	4
		A	V5-B3	33	4	14.1	70	24	4	2		1	12
		Rail Loop	V5-B4	26	17	0	10	12	2	82		1	8
Average values for RWEP and Rail Loop monitoring sites				29.5	11.2	9	48	10.5	14	27.5	1	1	8.75
Performance criteria				>20	10-40	10-50	4-20	5-30	5-35	<10	1	-	-

1.1.6 *Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter*

This community on land owned by WCPL is generally dominated by the canopy species *Eucalyptus crebra* (Narrow-leaved Ironbark) and occasionally *Eucalyptus moluccana* (Grey Box) (Photograph 9). A sparse *mid-storey* or shrub layer of *Allocasuarina luehmannii* (Bull Oak), *Bursaria spinosa* subsp. *spinosa (Blackthorn) and Notelaea microcarpa var. microcarpa (Mock Olive), with a grassy understorey is often present. Eucalyptus punctata (Grey Gum) and Melaleuca decora* also occur in some areas.

Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest forms the BC Act listed EEC C*entral Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions. Sections of this community in good condition with a Eucalypt canopy are also likely to be the Central Hunter Valley eucalypt forest and woodland* CEEC listed under the EPBC Act.

This community appears to be performing well with generally very low cover of exotic species and high diversity of native species present at each monitoring plot. The number of native species recorded in 2021 was the highest on record (Figure 6) and achieved the performance target (Table 7). Performance criterion were met for all other attributes. A notable increase in ground cover (grass) was recorded at several sites which mirrors and the increase in diversity and suggests many grasses have responded to the higher rainfall in 2021. Photo monitoring point A4 (Photograph 10 and Photograph 11) samples this community, and no major changes are visible between the 2013 and 2021 monitoring periods.

Subsidence cracking is present at four of the eight monitoring plots within this PCT. However, no significant vegetation damage has been observed. Very large cracks are present at site V11-B1 in RWEA C and this plot may not be safe to survey in the future. ELA recommends WCPL inspect this area and undertake remediation of large subsidence cracks if possible.

Photograph 9: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest at WCPL (site V6-A3 in 2021)

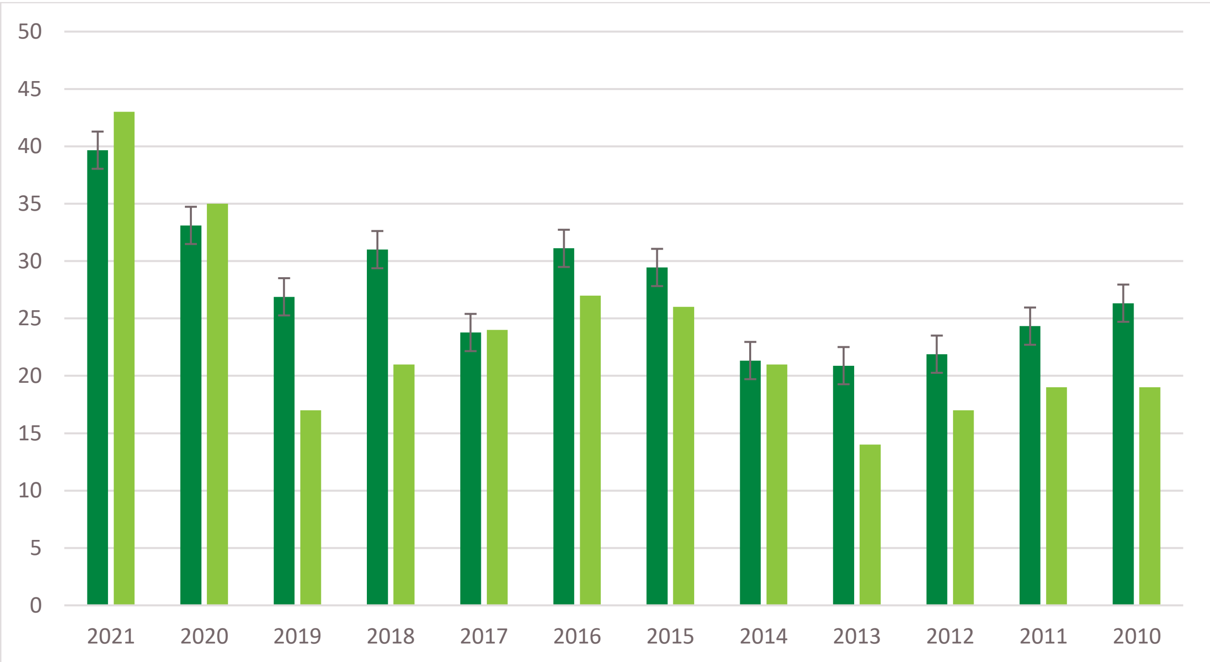

Figure 6: Average number of NPS recorded in Narrow-leaved Ironbark - Bull Oak - Grey Box open forest within RWEAs (light green) compared to reference site V6-A3 (dark green). Error bars represent the standard error of the mean

Photograph 10: Photo-monitoring point A4 during 2013

Photograph 11: Photo-monitoring point A4 during 2021

Table 7 : Floristic results and performance criteria for Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Narrow-leaf Ironbark / Grey Box / Bulloak / Honeymyrtle Forest	PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	C	V6-A1c	49	17.5	5.5	86	12	12	4	1	1	22
		Outside of RWEP	V6-A3	4	19.3	7	56	6	10	0		1	8
		A	V6-B1	33	12.3	14.2	48	0	8	0		1	30
		C	V6-B1c	40	9.3	10.2	84	38	4	0		1	28
		A	V6-B2	33	7	8	72	16	10	2		0	50
		C	V6-B2c	49	9	5.5	58	10	12	0		1	20
		A	V6-B3	42	11	11.5	78	18	18	0		1	35
		Rail Loop	V6-B4	17	14.3	0	16	2	2	0		1	5
Grey Gum / Narrow-leaf Ironbark / Bulloak / Honeymyrtle Forest		C	V11-B1	41	7.1	12.2	82	40	2	0		1	55
		C	V11-B2	53	6.5	4.7	94	14	16	0		1	27
Average values for RWEP and Rail loop monitoring sites				39.7	10.4	8	68.7	16.7	9.3	0.7	1	0.9	30.2
Performance criteria				>25	10-40	5-10	15-50	5-10	5-40	<5	1	-	-

1.1.7 *Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter*

Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter at WCPL is characterised by an overstorey of *Eucalyptus crebra, Corymbia maculata* (Spotted Gum) and *E. moluccana. E. punctata and E. dawsonii* (Slaty Gum) are also occasionally present. The mid-storey or shrub layer often includes *Melaleuca decora, Bursaria spinosa subsp. spinosa, Allocasuarina luehmannii* and *Olearia elliptica* (Sticky Daisy Bush). This community corresponds to the EEC Central *Hunter Ironbark -Spotted Gum – Grey Box Forest* listed under the BC Act. Sections of this community in good condition with a Eucalypt canopy are also likely to be the *Central Hunter Valley eucalypt forest and woodland* CEEC, listed under the EPBC Act.

This PCT is performing well meeting all performance criteria in 2021, except ground cover (shrubs) with all performance criteria slightly above target (Table 8). The average number of native species in both RWEA and reference sites was the highest recorded to date (Figure 7). No weed species were recorded at any sites in 2021. Ground cover (grasses) significantly increased from 2020 and is likely a result of increased growth in response to higher rainfall in 2021.

Photo-monitoring points in this community show little change in vegetation structure between the 2013 and 2021 monitoring periods (Photograph 12 and Photograph 13). Overall, this PCT is performing well and no additional management actions are required at this stage.

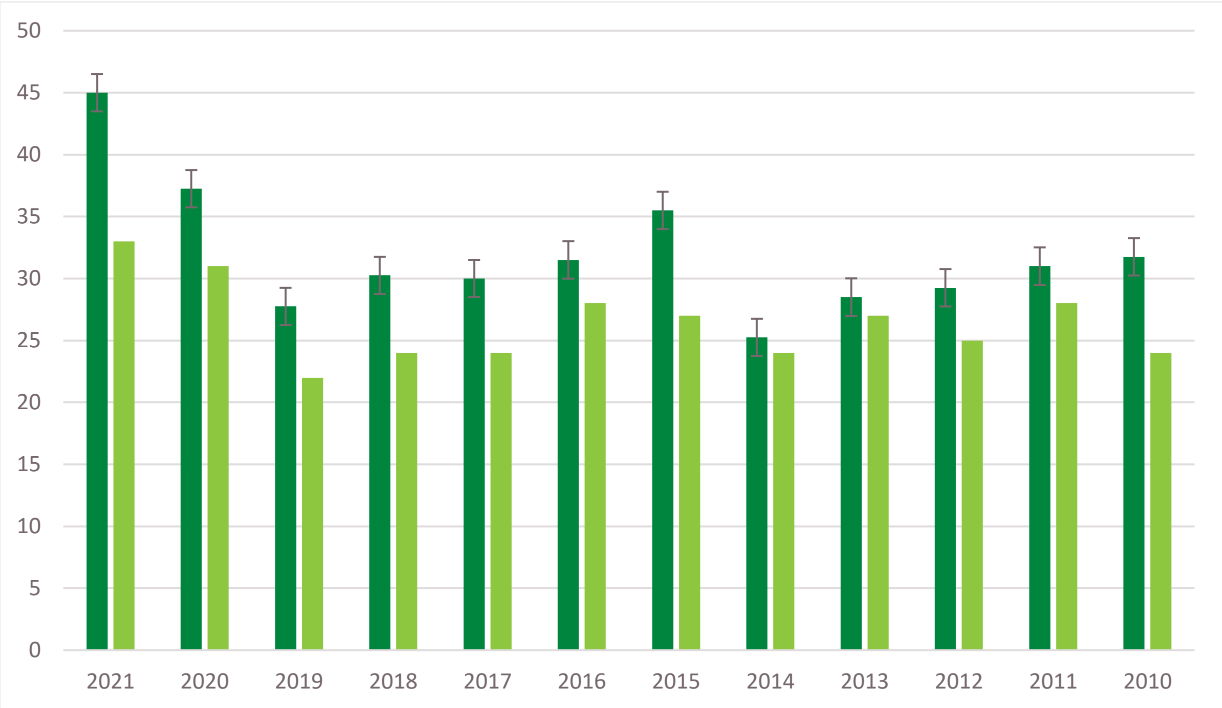

Figure 7: The average number of NPS in Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland within RWEAs (light green) compared to the recorded number at reference site V9-A1 (dark green). Error bars represent the standard error of the mean

Photograph 12: Photo-monitoring point B2 during 2013

Photograph 13: Photo-monitoring point B2 during 2021

Table 8: Floristic results, performance criteria for Narrow-leaved Ironbark - Grey Box - Spotted Gum woodland at Wambo

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Spotted Gum / Narrow-leaf Ironbark/ Bulloak / Paperbark Forest	PCT1604: Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass of the central and lower Hunter	Outside of RWEP	V9-A1	33	15.2	11.5	52	10	0	0	1	1	17
		B	V9-B1	50	9.7	13.5	80	54	8	0		1	25
		B	V9-B2	41	18	7	64	30	16	0		1	17
		B	V10-B1	56	19	13.5	84	38	2	0		1	36
Average values for RWEP monitoring sites				49	15.56	11.33	76	40.66	8.66	0	1	1	26
Performance criteria				>35	15-40	5-20	30-50	5-15	5-40	< 5	1	-	-

1.1.8 *Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion*

The canopy of Slaty Box - Grey Gum shrubby woodland is typically dominated by *Eucalyptus dawsonii* and several other species including *E. punctata*, *E. moluccana* and *E. crebra. Acacia salicina* (Cooba) and *Allocasuarina luehmannii* may form a small tree layer or be part of the upper-most canopy. The shrub layer includes species such as *Olearia elliptica*, *Acacia cultriformis* (Knife-leaved Wattle), *Canthium odoratum* (Shiny-leaved Canthium), *Notelaea microcarpa var. microcarpa* and *Dodonaea viscosa* subsp. *cuneata* (Wedge-leaf Hopbush). The groundcover is generally sparse to very sparse and is can be species poor during drier years (Photograph 14). This community is listed under the BC Act as the EEC *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion*. Sections of this community in good condition with a Eucalypt canopy are also likely to be the *Central Hunter Valley eucalypt forest and woodland* CEEC under the EPBC Act.

At WCPL, this PCT primarily occurs on the smaller ridge tops and slopes and is patchily distributed at lower elevations. *E. crebra* is often present and may co-dominate the canopy with *E. dawsonii*.

This PCT is generally in good condition, particularly on the slopes and ridgetops where historical disturbance from forestry and grazing has been minimal. A large number of native species, few weed species and a sparse weed cover was recorded. Occasional occurrences of the priority weed *Opuntia* spp. were observed at low densities, similar to other woodland areas at WCPL. Very minor changes in exotic species cover values has occurred between 2014 and the present, with exotic cover zero in 2021.

The monitoring sites in this community are located in or near RWEA D. All performance criteria were met in 2021, except for NGCG which was again very high above the target range (Table 9). This not considered a management concern. The average NPS recorded in 2021 was the highest to date (Figure 8), suggesting a number of species have responded to the wetter conditions.

Overall, this PCT is considered to be performing well and no additional management actions are required at this stage.

Photograph 14: A typical example of Slaty Box woodland at WCPL during 2021 (Site V10-B3)

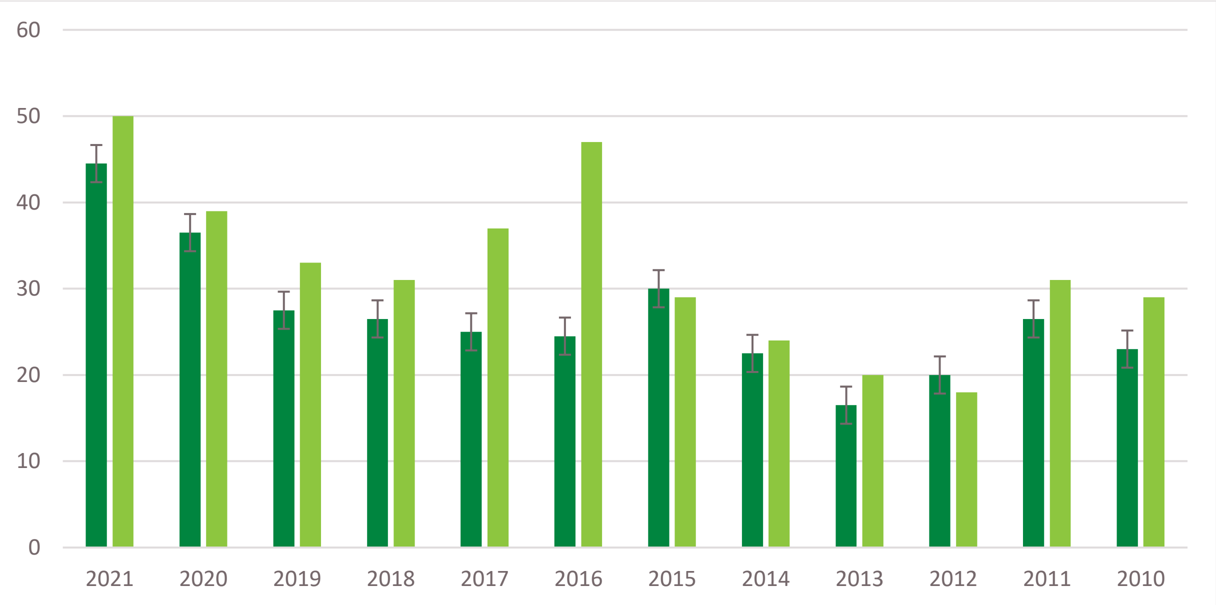

Figure 8: The average number of NPS recorded in Slaty Box shrubby woodland within RWEAs (light grey) compared to reference site V10-A2 (dark grey). Error bars represent the standard error of the mean

Table 9: Floristic results, performance criteria for Slaty Box - Grey Gum shrubby woodland

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Slaty Gum / Narrow-leaf Ironbark / Bulloak / Paperbark Forest	1176: Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion	D	V10-A1	45	8.8	4.5	84	2	10	0		1	27
		Outside of RWEP	V10-A2	50	6.1	7.5	34	30	2	0		1	12
		D	V10-B3	44	15.2	2	52	38	10	0		1	40
Average values for RWEP monitoring sites				44.5	12	3.25	68	20	10	0	1	1	33.5
Performance criteria				21	15-40	5-30	5-30	0-25	2-10	<5	1	-	-

1.1.9 *White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley*

At WCPL, this community occurs along Stony Creek and is sheltered by steep sandstone escarpments to the south and a large ridgeline to the north. This PCT is in good condition with many native species and occasional large remnant trees with hollows. One monitoring plot (V13-B1) samples this PCT (Photograph 15).

This monitoring site met all performance targets, except NGCG which was very high above the target range (Table 10), though not considered a management concern. Grass cover was previously low with zero recorded for the transect in 2019, as such the high result in 2021 is considered to reflect the upper range of natural fluctuation in relation to environmental conditions. NPS was the highest recorded, showing recovery from the recent dry conditions when the equal lowest NPS was recorded in 2019 (Figure 9). EPC is very low with no species recorded in the floristic plots and no EPC recorded along the biometric transect.

Overall, this PCT is considered to be performing well and no additional management actions are required at this stage.

Photograph 15: White Mahogany - Spotted Gum - Grey Myrtle forest at V13-B1 in 2021

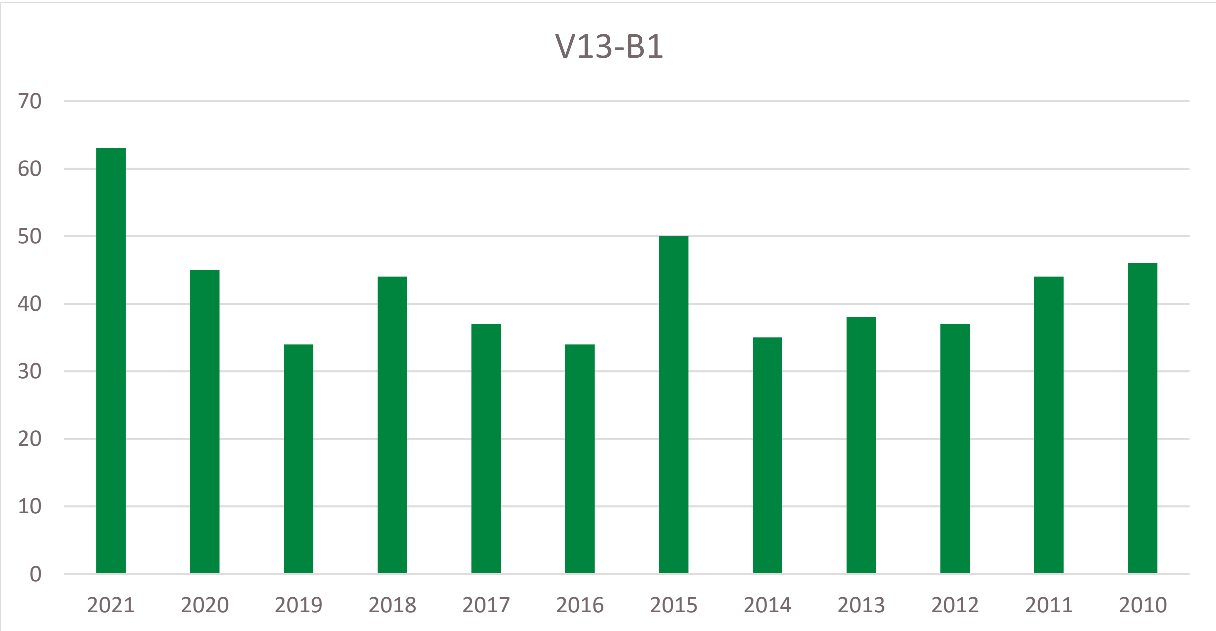

Figure 9: The number of NPS recorded in White Mahogany - Spotted Gum - Grey Myrtle forest at V13-B1 each year

Table 10: Biometric scores and performance citeria for White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest at Wambo

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
White Mahogany / Rough-barked Apple Forest	PCT 1584: White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	B	V13-B1	63	20.3	24.6	94	50	24	0	1	1	34
Performance criteria				>45	15-45	5-40	5-40	10-20	5-20	0	1	-	-

1.1.10 *Brush Wilga/Native Olive Shrubland*

The monitoring plots within this PCT are dominated by the shrubs *Notelaea microcarpa var. microcarpa*, *Geijera salicifolia* (Brush Wilga), *Olearia elliptica* and the small tree *Brachychiton populneus* (Kurrajong) (Photograph 16). Occasional *Eucalyptus crebra* or *E. moluccana* are present as canopy species. The PCT sampled by floristic monitoring may be partially a derived community, resulting from the historic removal of overstorey species in Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest combined with a south facing aspect. These areas are in good condition, with a large number of native species and few exotic species. EPC has remained consistently very low over time at these monitoring plots.

This monitoring site met all performance targets, except native ground cover (grasses) which was slightly above the target range (Table 11). High grass cover is not considered a management concern, likely the high score reflects the upper range of natural fluctuation in relation to environmental conditions such a rainfall. The average number of native species recorded within this PCT was above the performance criteria again, similar to 2020 (Figure 10). Overall, this PCT is considered to be performing well and no additional management actions are required at this stage.

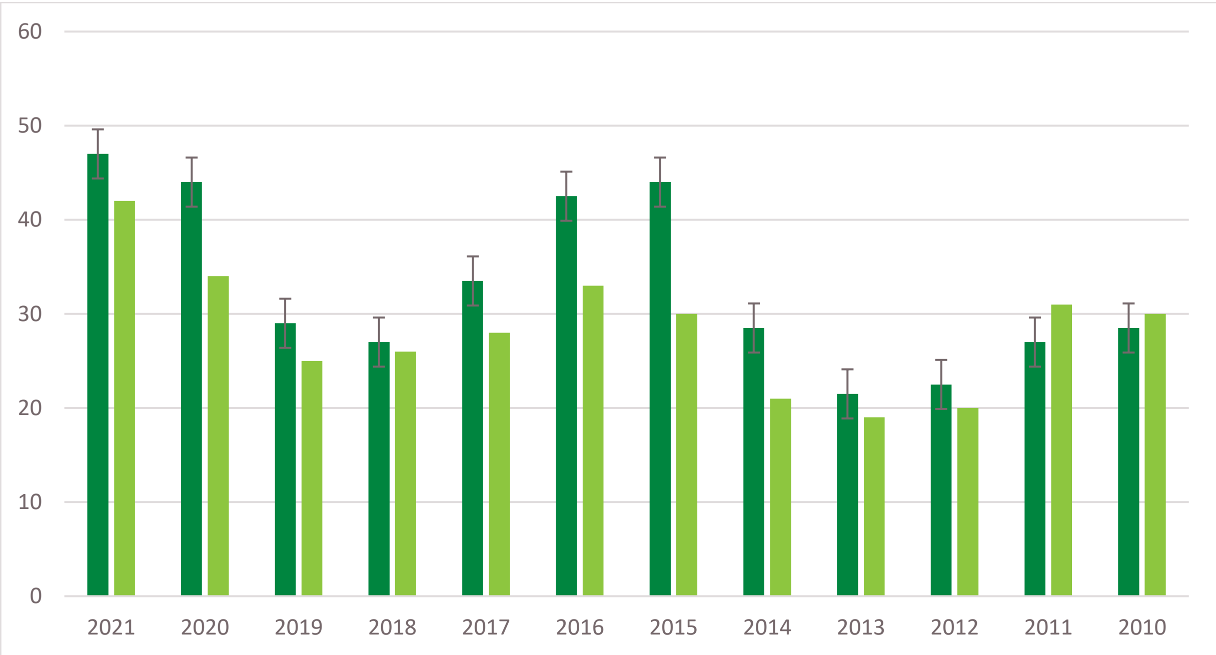

Figure 10: The average number of NPS recorded in Brush Wilga/Native Olive shrubland within RWEAs (light green) compared to reference site V14-A1 (dark green)

Photograph 16: Brush Wilga/Native Olive Shrubland at V14-B2 in 2021

Table 11: Biometric scores and performance citeria for Brush Wilga/Native Olive Shrubland at WCPL

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Brush Wilga/Native Olive Shrubland	PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter *	Reference site/ now within RWEA E	V14-A1	50	3	47.5	48	2	42	2		1	7
		B	V14-B1	42	13.1	26	64	10	8	0	0	1	29
		B	V14-B2	44	15.7	41	88	42	20	2		0	7
Average values for RWEP monitoring sites				43	14.4	33.5	76	26	14	1	0	0.5	18
Performance criteria				>30	5-40	5-40	30-50	5-10	10-40	<5	1	-	-

*considered a variant of this PCT

1.1.11 Conservation agreement requirements and photo monitoring points

Annexure C of the VCAs requires that WCPL aim for an exotic plant cover within the Conservation Areas that does not exceed the exotic cover percentages detailed in Table 3. Target limits for Years 2-5 are used for the ongoing targets as no further limits are presented.

Four of the ten monitoring plots exceeded the exotic cover limits for the 2-5 year targets (Table 12). The sites exceeding limits are located within RWEA A and RWEA Rail Loop.

At Site A1, within the riparian zone of Wollombi Brook in RWEA A, very high exotic cover (90%) was recorded. *Ehrharta erecta* (Panic Veldtgrass) and *Heliotropium amplexicaule* (Blue Heliotrope) are dominant, with twelve other common exotic flora species also recorded. Exotic cover at this site has fluctuated over time, previously being as high as 84% in 2016. The high cover in 2021 is a result of strong growth of ground cover vegetation in response to rainfall and surface water flows in the Wollombi Brook channel.

At Site CT2 within the Rail Loop, major fluctuations in exotic cover over time has also occurred. High exotic cover (82%) was recorded in 2021, no exotic cover was recorded from 2017-2019, and very high exotic cover (52%) was recorded in 2016. The exotic cover at this site is dominated by *Melinis repens* (Red Natal Grass). It is suspected that the variation in cover of *Melinis repens* is driven by rainfall, with 2016 and 2020 both being higher than average rainfall years, and 2017-2019 being relatively dry years. The data from floristic plot V5-B4 is used as a reference for CT2 results. Plot V5-B4 is technically outside of the RWEA Loop Area although the area receives the same management treatment. Photo monitoring from CT2 indicates actual exotic cover at the site is lower than at V5-B4, nevertheless weed management is required in this general area.

At Site A1, a high exotic cover limit is set (64%), reflecting the disturbed condition of the site. The limit was exceeded in 2021 with exotic cover of 90% recorded. This site has previously had exotic cover as high as 95% in 2014. Exotic cover at this site is dominated by *Heliotropium amplexicaule*, *Bidens subalternans* and *Galenia pubescens* (Galenia). Tree planting is recommended in this area with the strategy to shade out the exotic ground covers over time and improve fauna habitat.

Site A2 recorded total exotic cover of 20% with dominant exotic species of *Heliotropium amplexicaule* and *Bidens pilosa* (Cobbler's Pegs). Total exotic cover at this site has varied over time. The result in 2021 represents the second highest exotic cover recorded to date (since 2014), however it is a decrease from 2020.

Exotic cover is very low or zero at the remaining sites and all these fell below the exotic cover limits.

Comparison of photo-monitoring sites between 2013 and 2021 monitoring show no major changes in vegetation over this time period. Wetter conditions during the 2021 are apparent in some photographs, with more green vegetative growth visible in the understorey, but in general, no major changes in species composition or structure are apparent. Dry conditions were observed and reported in previous years (2017-2019). These observations correspond to the floristic data collected within biometric plots with higher ground cover scores recorded across most PCTs this year.

Table 12: Exotic plant cover at monitoring sites in regard to VCA targets

RWEA	Site Code for VCA	Corresponding flora monitoring plot	Exotic cover limits yr 1	Exotic cover limits yrs 2-5	Total exotic cover from biometric plots in 2021
Coal Terminal (Rail Loop)	CT1	V6-B4	5	5	0
Coal Terminal (Rail Loop)	CT2	V5-B4	15	15	82
A	A1	V2-B1	70	60	90
A	A2	V5-B1	20	15	20
A	A3	V1-B2	30	20	54
A	A4	V6-B1	10	5	0
B	B1	V13-B1	5	5	0
B	B2	V9-B1	5	5	0
C	C1	V11-B1	5	5	0
D	D1	V10 -B3	5	5	0

1.1.12 Discussion and recommendations

The majority of remnant woodland areas remain in good condition with high numbers of native species, few exotic species present and with low cover and abundance. No major issues were identified that require urgent management. However, as reported in previous years, exotic species cover remains relatively high in riparian and floodplain areas (V1 and V2 plots of RWEA A) and continues to exceed performance criteria and also VCA targets in certain locations. Continued weed management will be required to achieve performance criteria in these riparian and floodplain areas.

The number of native species generally increased from the previous year and was the highest to date in several PCTs. The 2021 results appear to confirm that some lower scores for native species diversity recorded in recent years were a result of the dry conditions, with the increase this year in response to higher rainfall.

Several weed species listed under the *Biosecurity Act 2015* were observed in these areas that have potential to become problematic in the wider region e.g. *Olea europaea* subsp. *cuspidata* (African Olive). It is recommended to give priority to species such as this in the mine's weed control program. As discussed in previous monitoring reports, planting of canopy species should be considered in RWEA 'A', where natural regeneration is unlikely to occur in a reasonable timeframe (i.e. the open grassland areas of on the Wollombi Brook floodplain). Once established, these plantings may also reduce issues with exotic flora species in these areas.

Climatic conditions are considered to be a major factor in the fluctuation of results observed over time. Monthly rainfall data from 2021 from Bulga (Down Town) (BOM 2021) reveals that above average rainfall was recorded in summer, winter and spring. This follows below average rainfall for 2017, 2018 and 2019. This data corresponds to the generally higher diversity and cover of native flora species observed in 2021, and the lower scores reported in the previous few dry years. Similar increased in native diversity and exotic cover were reported in 2016 which was also a year of above average rainfall.

The Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland (in RWEA A) appears to be suffering from *Banksia integrifolia* die-off in the mid-storey, first observed in 2019 and continuing this year. This community recorded a higher average number of native species in 2021, compared to 2020 results decreased from previous years. Higher exotic covers were also recorded at some locations. This community occurs on sandy soils, and it is possible the soils suffered more significant drying during the recent dry years than other areas and the rainfall to date has not been sufficient to recharge the soil. This community is listed as a CEEC under the EPBC Act, future monitoring should continue to record the condition of this community; increased weed control is also recommended.

1.2 Bird monitoring within RWEAs

1.2.1 Introduction

The bird monitoring program is a requirement of the current Development Consent conditions and has been designed in an effort to measure the performance of the WCPL RWEP. The consent conditions (DA 305-7-2003) specify that "Terrestrial fauna surveys should be conducted to monitor the usage of enhancement areas by vertebrate fauna. Monitoring may include fauna species diversity and abundance or, alternatively, the use of indicator species to measure the effectiveness of enhancement measures".

Methods, results (including a comparison with previous monitoring), and interpretation of results, are included below.

Data from previous year's bird surveys was limited to:

- RPS Australia East (RPS) 2009. Annual Ecological Monitoring Report. Remnant Woodland Enhancement Monitoring Program Riparian and Bed and Bank Stability Monitoring, Stoney Creek, South Wambo Creek and North Wambo Creek. Prepared for Wambo Coal Pty Limited.
- Niche 2014b. EMP010 Monitoring 2014 – Indicator Species (birds). Prepared for Wambo Coal Pty Limited.
- Eco Logical Australia (ELA) 2015-2020. Wambo Coal Mine Flora and Fauna Monitoring Reports Prepared for Wambo Coal Pty Ltd.

1.2.2 Methods

1.2.2.1 Bird monitoring surveys

Bird monitoring during spring 2021 was consistent with the six previous monitoring events in methods and general timing of surveys. During the survey, two observers spent 10 minutes recording birds seen and heard within 50 m radius (0.8 ha) of a central point, followed by an additional 10 minutes searching the balance of a 2 ha plot, and recording the total numbers of birds detected (seen and heard). One morning and one afternoon survey was conducted per site.

The thirty (30) sites (Figure 11) were surveyed by ELA ecologists Daniel McKenzie and Dee Ryder between 18-22 October and 26-28 October 2021.

The total number of bird species recorded each year 2007-2021, average number of bird species per 20-minute bird survey, average number of birds per survey, bird density and the distribution and relative abundance of threatened species were examined. Broad comparisons between the bird species recorded in previous years and the current year were also made.

1.2.2.2 Targeted winter bird survey

Winter bird survey targeting Swift Parrot and Regent Honeyeater is undertaken every second year and was not required or undertaken in 2021. The winter bird survey will be next undertaken in 2022.

Figure 11: Bird monitoring locations and remnant woodland enhancement areas

1.2.3 Results

1.2.3.1 Bird monitoring surveys

The 2021 monitoring recorded a total of 87 bird species from 26 monitoring sites during formal bird surveys of RWEAs. This number is higher than the median from all 26 sites in previous monitoring periods (2007-2020) (Figure 12).

One hundred and twenty-six bird species have been recorded during timed bird surveys over the last six years, with 87 of these recorded in 2021, including five species not previously recorded during bird monitoring surveys.

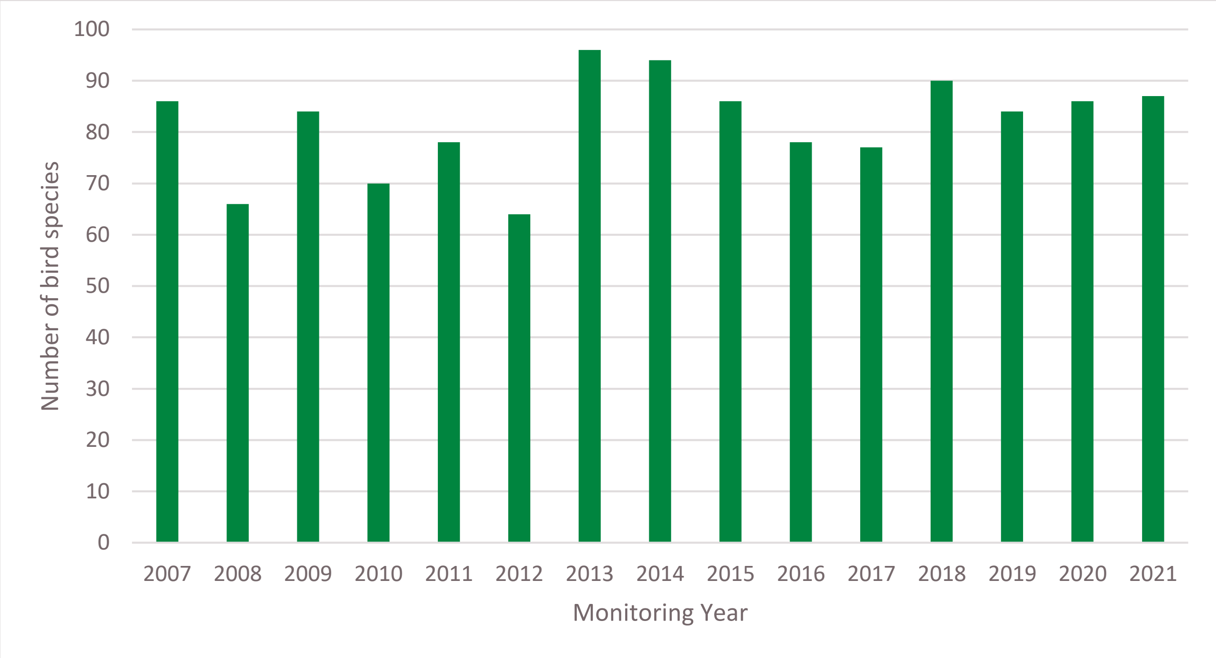

Figure 12: Number of bird species recorded at monitoring plots 2007 - 2021

In 2021, the average number of bird species per 20-minute bird survey (11.8) and bird species per site (18.1) (Figure 13), was slightly lower than the previous two years, but similar to the previous years with available data (2015-2018).

The average number of birds recorded per survey was 27.4 in 2021, translating to a bird density of 13.7 birds/ha/20 mins. This represents an increase from the previous year (22.7 birds per survey), and is similar to the other years before 2020, with records ranging from 25.5 to 27.9 (Figure 14). Numbers of birds were not presented in RPS (2009) and it is assumed only bird species were recorded.

The most species-diverse site during 2021 was BP7, BP8 and BP 26 all recording 26 species over the two surveys. Other species-diverse sites included BP24 (25 species) and BP15 (23 species)., BP15 and BP26 (19 species). BP2 had the lowest species diversity in 2021, with 11 species recorded.

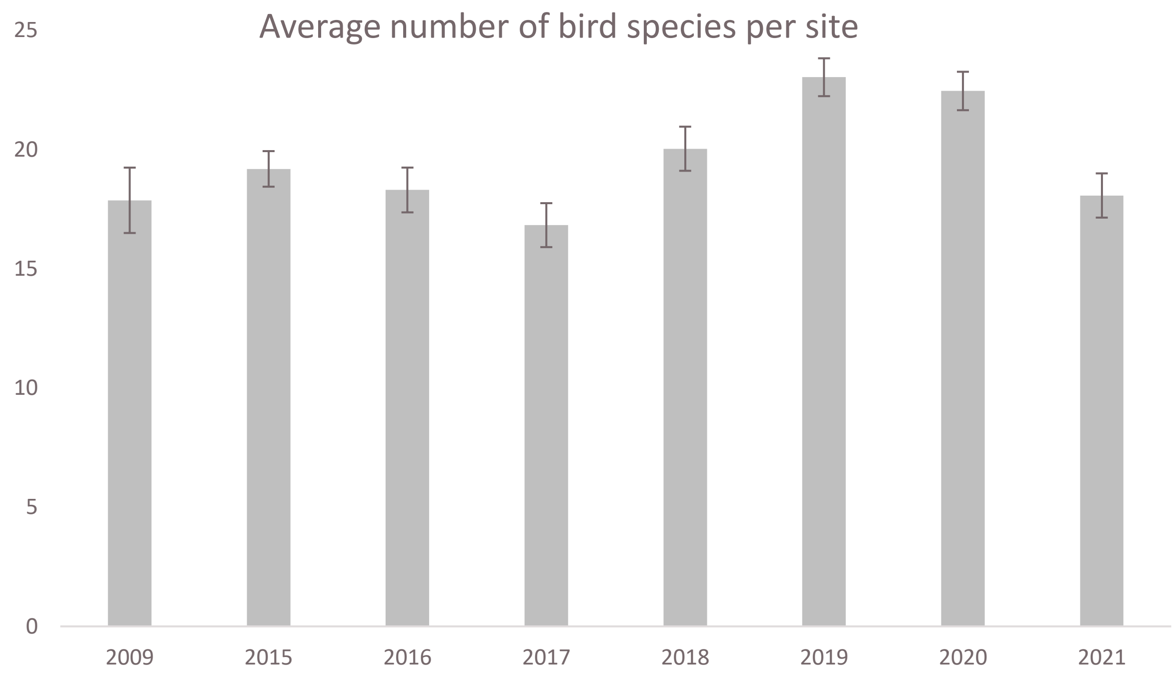

Figure 13: Average number of bird species recorded per monitoring site during 2009 and 2015-2021

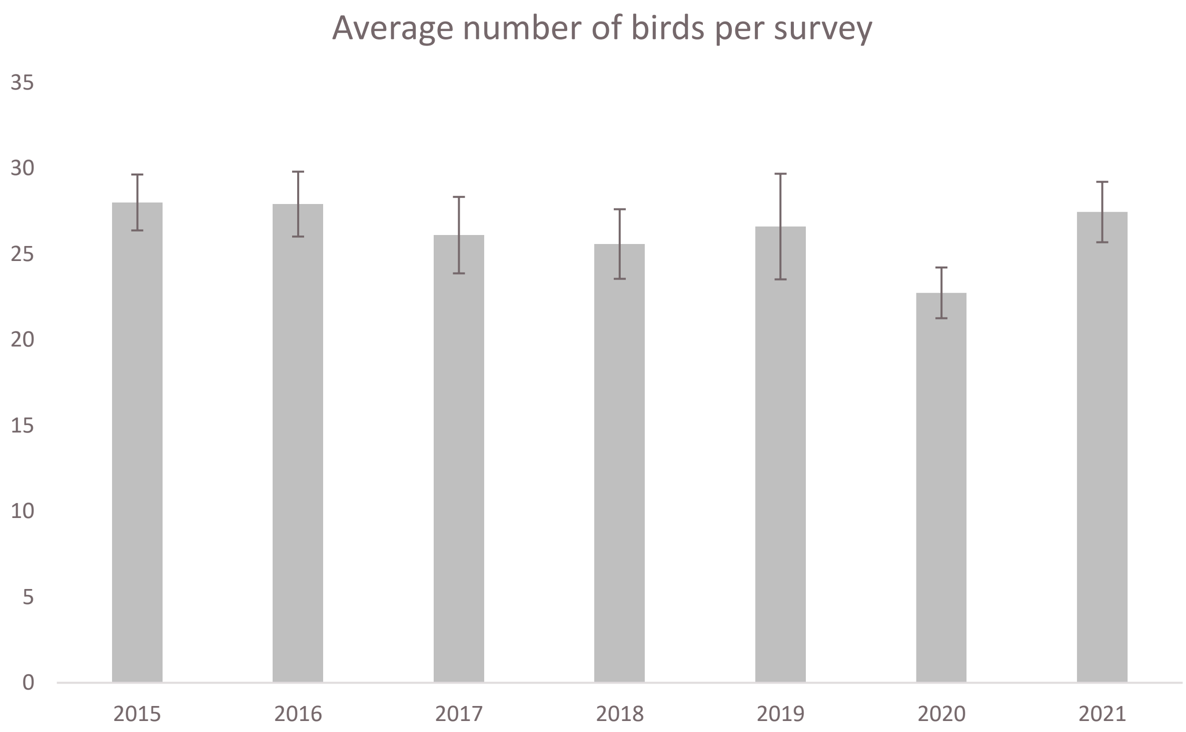

Figure 14: Average number of birds recorded per survey (2015-2021)

Bird assemblages over time were not compared statistically, however, assemblages appear broadly similar to the previous six years and also to data from 2009 monitoring. When comparing the 20 most widely recorded species from each year, the results from 2021 contain an average of 12.6 of the same species recorded in the top 20 for previous years. The most widely recorded species in 2020 were Yellow-faced Honeyeater (*Lichenostomus chrysops*), Rufous Whistler (*Pachycephala rufiventris*), and

Superb Fairy-wren (*Malurus cyaneus*) all of which were also widely recorded in previous years. Two species were recorded in the top 20 widely recorded species for the first time; Channel-billed Cuckoo (*Scythrops novaehollandiae*) and Sulphur-crested Cockatoo (*Cacatua galerita*).

Six threatened species listed under the BC Act were recorded during 2021 surveys; Dusky Woodswallow (*Artamus cyanopterus*), Grey-crowned Babbler (*Pomatostomus temporalis temporalis*), Varied Sittella (*Daphoenositta chrysoptera*), Speckled Warbler (*Chthonicola sagittata*), Little Lorikeet (*Glossopsita pusilla*) and Brown Treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*). These threatened species are part of a group that are regularly recorded during the monitoring surveys, with between five and eight threatened bird species annually recorded between 2014 to 2020.

Comparison of numbers of individuals of threatened species during the 2015-2021 monitoring periods and the number of sites they were recorded at during the 2009 and 2014 to 2019 monitoring periods was undertaken. Grey-Crowned Babbler was recorded from the most sites ever (8) and also the highest number of individuals (34). This species appears to be increasing in total number and distribution within the RWEAs. Speckled Warbler was recorded from 10 sites, an increase from the previous year, and a total of 11 individuals were recorded which is the same as in 2020 which was the lowest for the species. Varied Sittella was recorded from six sites with 21 individuals recorded, which an improvement to normal levels after lower recordings in 2020. Little Lorikeet was recorded from three sites with a total of 12 individuals, which a return to more usual levels after the species was not recorded in 2020. Results for Dusky Woodswallow and Brown Treecreeper are within the range of previously recorded values.

1.2.3.2 Targeted winter bird survey

No survey required or undertaken in 2021. The winter bird survey is conducted every second year and will be completed in 2022.

1.2.4 Discussion

RWEA and other remnant woodland sites at WCPL continue to support a large diversity of bird species and no introduced bird species were detected within RWEA areas.

Although the average number of bird species per site was lower in 2021 than the previous three years, the diversity remains within levels previously recorded, and overall diversity across all sites within RWEAs also remains high and was higher than the previous two years. Number of birds per survey returned to levels similar to previous years after a lower score was recorded in 2020 and it was recommended to continue monitoring this statistic. Future surveys should continue to monitor average diversity per site to ensure the lower scores recorded in 2021 is not the beginning of a decline.

As vegetation and habitat attributes in RWEA areas have remained relatively stable over time (see previous section), variability in diversity and abundance between years is likely explained by a combination of factors such as varying numbers of nomadic and migratory bird species, weather and climate, sampling methods, differences in the skill of observers, the timing of surveys and surveys coinciding with the flowering of trees and also broader landscape scale and seasonal changes across the Hunter Valley. The total number of bird species detected each year has varied over time and the 87 species recorded during 2021 is within the range of previous years.

Threatened species appear to be persisting well within the RWEAs, with Grey-crowned Babbler continuing an increasing trend (after low abundance in 2019) and Speckled Warbler, Little Lorikeet and Varied Sittella all recorded at more sites and in similar or higher numbers than the previous year.

2. Rehabilitation areas

2.1 Introduction

Rehabilitation areas are monitored using a combination of LFA and biometric plots (woodland rehabilitation areas and North Wambo Creek Diversion).

LFA is currently used to monitor the progress of the North Wambo Creek diversion, woodland rehabilitation and pasture rehabilitation towards achieving a suitable condition for their intended land use post-mining. The rehabilitation objectives for the North Wambo Creek Diversion (WCPL 2015) include:

- To establish pasture species consistent with revegetation strategy
- Tree species established along creek lines consistent with the riparian zone
- Creek diversion stable and will not present a greater safety hazard than surrounding land
- Creek diversion able to shed water safely without causing excessive erosion, jeopardising landform integrity or increasing pollution of downstream watercourses
- All watercourses subject to subsidence impacts shall be hydraulically and geomorphologically stable, with riparian vegetation established that is the same or better than prior to commencement of mining.

Completion criteria for the North Wambo Creek diversion, mixed woodland/pasture areas and woodland corridors for LFA have been developed using previous monitoring results from relatively undisturbed and natural landscapes surrounding the mine. These are listed in each results table below.

Additional completion criteria for these rehabilitation areas are listed in the Mining Operations Plan (WCPL, 2015) and include ensuring that:

- Minimum 70% of area has a vegetative cover
- No single bare area >20m^2
- Biometric monitoring confirms exotic cover <33%
- No tunnel or gully erosion is to be present
- Rill erosion is to be limited to <200 mm deep and/or <200 mm wide.

Woodland rehabilitation monitoring sites currently occur within plantings of *Eucalyptus cladocalyx* (Sugar Gum) that do not match up with the species composition of natural vegetation communities surrounding the mine and completion criteria based for biometric monitoring has also been developed for these areas. As existing woodland rehabilitation areas have been designed and implemented applying old techniques that do not reflect the current best practice of utilising species of local provenance, performance criteria for these older rehabilitation areas have been developed by modifying condition benchmarks for *Grey Box –Slaty Box shrub – grass woodland*, which is expected to have a similar vegetation structure, albeit different species composition, to the mature rehabilitated woodland community.

LFA monitoring at WCPL focusses on scores for Landscape Organisation, Stability, Infiltration/Runoff and Nutrient Cycling. **Landscape organisation** relates to the proportion of the transect occupied by patches - patches being landscape elements that are relatively permanent and provide stable, resource accumulating structures, such as grassy tussocks and other ground cover, leaf litter and logs. Therefore, a larger Landscape Organisation Index (LOI) number implies a more stable transect that traps water and nutrients and is less prone to soil erosion.

A Soil Surface Assessment (SSA) is completed for each patch type on each LFA transect. Five 'query zones' are selected for each patch type where possible. Scores are recorded for rain splash protection, vegetation cover, plant litter cover, cryptogam cover (cover of algae, mosses and liverworts, lichen and fungi), crust brokenness, erosion type and severity, deposited materials, surface roughness, surface nature and the stability and texture of the soil. These soil surface indicators are then used to give Stability, Infiltration/Runoff and Nutrient Cycling scores for each transect.

Stability is defined as the ability of the soil to withstand erosive forces, and to reform after disturbance. The stability index is derived from data collected during the SSA's, such as crust broken-ness, surface resistance, slake tests, erosion type and severity, deposited materials, cryptogam cover, rain splash protection and leaf litter cover.

Infiltration concerns the way water interacts with soil to become soil water (and becomes available for plants) or runoff water where water is lost from the system or transports materials (such as soil, nutrients and seed) away. Scores for vegetation cover, surface roughness, slake tests, litter cover, origin and decomposition, surface resistance to disturbance and soil texture contribute to the infiltration index.

Nutrient cycling is defined as how efficiently organic matter is cycled back into the soil. Scores for vegetation cover, litter cover, origin and decomposition, cryptogam cover and surface roughness contribute to nutrient cycling values.

2.2 Methods

2.2.1 Landscape Function Analysis

LFA data was collected from a total of nine monitoring sites, including eight in the riparian rehabilitation areas at the North Wambo Creek Diversion and one reference site in riparian pasture near South Wambo Creek (site 14R) (Figure 15)**Error! Reference source not found.**. LFA methods followed the method for Landscape organisation and SSA, as provided in Tongway and Hindley (2004). LFA data was collected between 26-28 October by ELA ecologists Dan McKenzie and Dee Ryder.

Previously monitored woodland and pasture rehabilitation sites are located on land no longer managed by WCPL and have now been excluded from the monitoring program. As such, these sites were not monitored by ELA in 2021.

Raw numerical values from previous years were available for Landscape organisation, Stability, Infiltration and Nutrient cycling indices. Creek diversion sites were first sampled at the completion of the creek diversion construction and subsequent seeding in 2008, with additional sites added in 2015 after an extension to the creek diversion. Trends in these values over time along with general field observations were used to inform management recommendations.

Performance criteria have previously been developed from a range of scores from previous monitoring years from nearby sites with relatively undisturbed riparian habitat. The following colour system is used to highlight the performance of each LFA site as shown below in Table 13.

Table 13: Colour system devised to highlight the performance of each LFA site

Green	Yellow	Orange	Red
Area generally meets or exceeds target values and values do not show trend of decline over time – where monitoring sites are meeting targets and values are relatively consistent, reduce monitoring to infrequent LFA when changes in landscape or management practices occur i.e. fire or grazing)	Area generally falls below target values but within 75% of targets or appears to be on a trajectory of improvement without the need for management intervention – further monitoring required	Area generally falls between 75% and 50% of target values or shows little sign of improvement over several monitoring events – further monitoring and possibly management actions required	Area falls below 50% of target and is unlikely to improve without management actions or shows trend of decline which is unlikely to improve without management actions

2.2.1.1 Future use of Landscape Function Analysis

The use of LFA for future monitoring of rehabilitation areas is currently under review following recommendations made by the Biodiversity Conservation Division (BCD) of the NSW Department of Planning, Industry, and Environment (DPIE) on the Wambo Coal Mine Phase 2 Rehabilitation Management Plan (RMP). BCD suggested the use of LFA should be reconsidered as recent peer reviewed articles have indicated LFA may not be appropriate for monitoring post mining landscapes (Erskine et al. 2013).

Any changes to the proposed monitoring methodology for rehabilitation at the Wambo mine will be incorporated into an updated Biodiversity Management Plan (BMP) for approval prior to implementation. As LFA is the currently approved monitoring methodology it has been continued in 2021.

2.2.2 Floristic monitoring

Floristic monitoring is undertaken using the BioMetric plots as described in Section 1.1.2. Two new sites were established within the North Wambo Creek Diversion (NWCD) in 2020 (Figure 2).

Floristic monitoring targets for the NWCD have been derived from the NWCD Revegetation Management Plan (Cumberland Plains Seeds 2019) and are based on combination of Benchmark Values for River Red Gum/ River Oak riparian woodland wetland in the Hunter Valley and Narrow-leaved Ironbark– Grey Box – spotted gum shrub grass open forest of the central and lower hunter. The exotic plant cover target has been modified to match the performance criteria for the NWCD from the Wambo Mining Operation Plan (WCPL, 2015).

Refinement of floristic monitoring locations and target values within the NWCD may be appropriate following additional remediation and revegetation works planned during 2020-2025 under the NWCD Management Plan (WCPL, 2020). The original intention of the NWCD was to establish riparian vegetation, however analysis of soils and water flows has indicated that a combination of woodland and riparian vegetation is more appropriate (WCPL, 2020). Additional monitoring to assist in identifying success or issues with early-stage revegetation was recommended in the NWCD Revegetation

Management Plan (Cumberland Plains Seeds, 2019). This monitoring was undertaken by Cumberland Plains Seeds in 2021 and is reported separately in the NWCD Monitoring Report (Cumberland plains Seeds, 2021).

Figure 15: Landscape Function Analysis monitoring sites

2.3 Results

2.3.1 North Wambo Creek Diversion

2.3.1.1 Landscape Function Analysis

Monitoring sites within the NWCD area are variable in condition (Table 14), with monitoring sites described in Table 15. Most monitoring sites are open pasture areas and generally have low diversity of native plant species and consist of predominantly low grass, primarily *Cynodon dactylon* (Common Couch), with tussocks of *Chloris gayana* (Rhodes Grass) and *Setaria* sp.. Native *Acacia* sp. and *Eucalyptus* sp. saplings, shrubs and small continue to develop in the south of the diversion area as a result of direct seeding works and are present in some transects, particularly sites 25R, 26R and 27R, and some trees are now up to 7 m tall. Natural establishment of *Casuarina cunninghamiana* and *Eucalyptus* sp. in the creek bed, particularly in the north of the creek diversion, also continues (Photograph 17). Erosion was observed in some areas of the creek channel, including gully erosion (Photograph 18).

It is important to note that significant soil remediation works have been undertaken at the NWCD during 2020 and 2021 by the NSW Soil Conservation Service (Photograph 19).

Photograph 17: North Wambo Creek Diversion during 2021 showing canopy regeneration in near the channel (downstream of site 23R)

Photograph 18: Gully erosion within the North Wambo Creek Diversion (near site 23R) in 2021

Photograph 19: Example of active landscape management work in the North Wambo Creek Diversion area in 2021

Table 14: North Wambo Creek Diversion LFA results in 2020 (Transects are listed by location - upstream to downstream)

Monitoring Plot	LOI	ST	INFI	NI
17R	1.00	56.1	38.7	30.5
19R	0.61	58.3	34.5	31.3
21R	0.87	57.5	38.5	30.5
23R	0.43	50.4	30.7	22.2
28R	0.78	41.1	20.6	19.0
27R	0.71	59.7	29.1	25.2
26R	0.85	59.0	34.0	26.3
25R	0.74	64.2	36.2	32.7
Average score	0.75	55.79	32.79	27.21
Target score	>0.84	>62	>41	>37
14R (reference site)	1	57.5	45.6	36.6

The average **LOI** score was 0.75 and was just below the performance target (>0.84). The scores were similar to the previous two years, and significantly higher than the four years before that (2015-2018).

Site 23R continues to have the lowest LOI score, resulting from a bare slope in the middle of the transect, which is a lower slope of the broader creek diversion channel. Site 23R and adjacent areas have issues with erosion (also noted in previous reports), with rills, scalds and eroding creek banks recorded close by. Several rills and areas of gully erosion exceed the depth specified in the completion criteria in regard to erosion control (WCPL 2015). In 2020 and 2021, soil remediation works were being undertaken in the vicinity of these areas.

Site 17R recorded an LOI score of 1, the maximum score, reflecting that the entire transect was covered in resource accumulating patches – in this case grassy patches and tussocks. This site had previously had relatively high LOI scores, and the increase this year is likely a result of expansion of existing ground covers over small patches of bare soil.

The reference site 14R recorded an LOI score of 1 for the second year in a row, indicating no bare soil is present. This site has had regular fluctuations in LOI score with changes in ground cover vegetation occurring in response to rainfall due to the dominance of exotic annual species.

LOI scores were mixed compared to the previous year with some sites increasing slightly and some decreasing, with the overall average steady for the past three years. The addition of four sites in the more recently constructed southern portion of the diversion during 2015 is observable in the data via a drop in LOI scores and the very low scores reported, and the low score from the first monitoring year in 2008 may reflect the bare soil of the newly created diversion followed by the establishment of a cover crop in the following years (Figure 16).

The average **stability** index at creek diversion sites in 2021 was 56% and did not meet the performance target (62%), however the score is very close to the target and has remained similar over time (Figure 17). The overall average stability index increased very slightly, but this not considered to represent any significant change in conditions at the sites. The lowest stability score was at site 28R and this site recorded a notable reduction in its stability index score. This is due to the increased area of bare soil recorded at the top of the transect. Other sites have remained relatively stable in their stability index scores in recent years. The average stability index across the NWCD sites (56%) is similar to the score recorded at the analogue site 14R (57.5%).

The average **infiltration** index was 33% and fell below the performance target of 41%. This is a slight increase from the previous year (Figure 18). The majority of sites recorded similar infiltration index scores to recent years, with notable changes occurring at site 17R which increased due to the higher cover of grasses, and 28R which decreased due to the increase in bare soil. The changes in infiltration score at these sites reflect the relative propensity for water to run-off from the site rather than enter the system as soil-water. Analogue site 14R achieved the target score.

The average **nutrient** index was 27% and fell below the performance target of 37%. This result is slight increase from the previous year (Figure 19). All sites recorded higher or similar nutrient index scores than in 2020, except for site 26R which recorded a slightly lower score. The decrease in nutrient index at this site suggests the system is less efficient at cycling organic matter back into the soil. This result is caused by changes in nutrient indicators such as litter and cryptogam cover, perennial basal cover and surface roughness. Analogue site 14R achieved the target score.

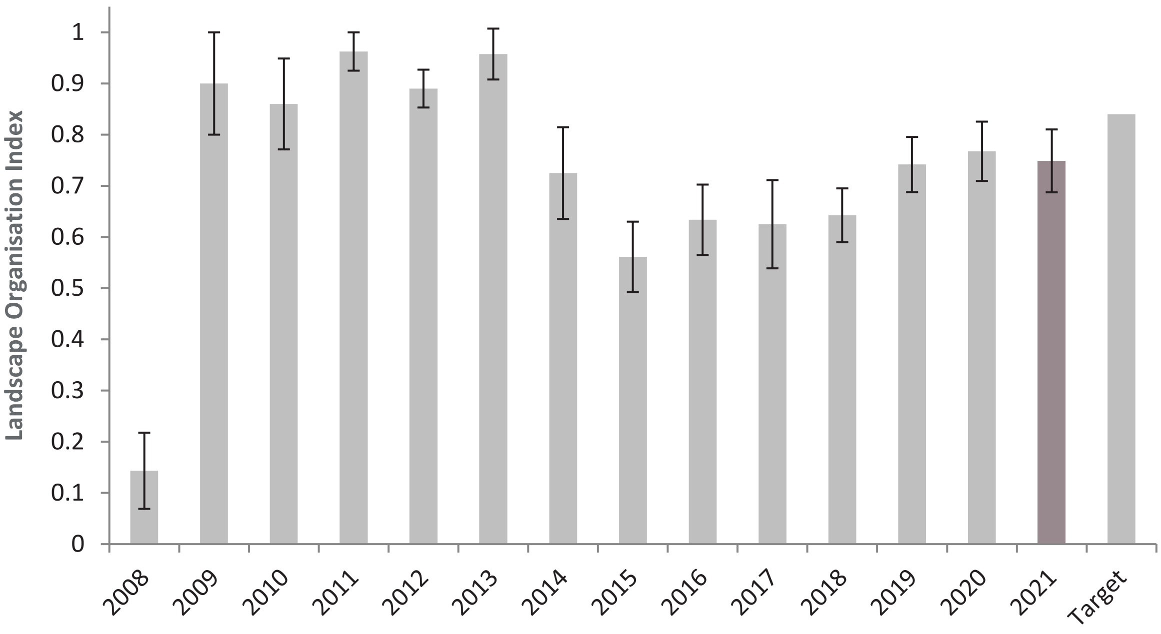

Figure 16: Average landscape organisation scores from the creek diversion sites. Average scores onwards from 2015 incorporate four additional sites (25r, 26R, 27R and 28R). Error bars represent standard error of the mean. Only 3 sites 19R, 21R and 23R were sampled in 2008. The target bar represents completion criteria for the Landscape Organisation Index.

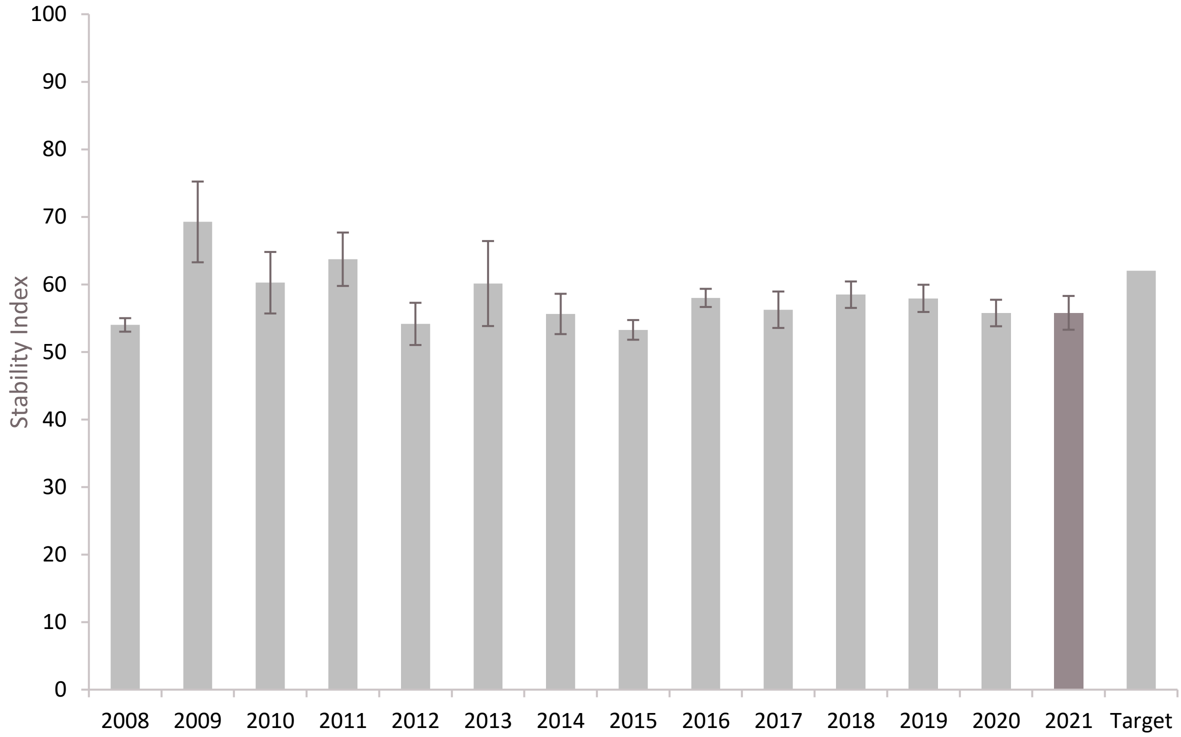

Figure 17: Average stability index values from the creek diversion sites. Values are derived from sites 17r, 19r, 21r and 23r each year since 2009-2014. Average scores from 2015 onwards incorporate four additional sites (25r-28r). Error bars represent standard error of the mean. Only sites 19R, 21R and 23R were sampled in 2008. The target bar represents completion criteria for the Stability Index.

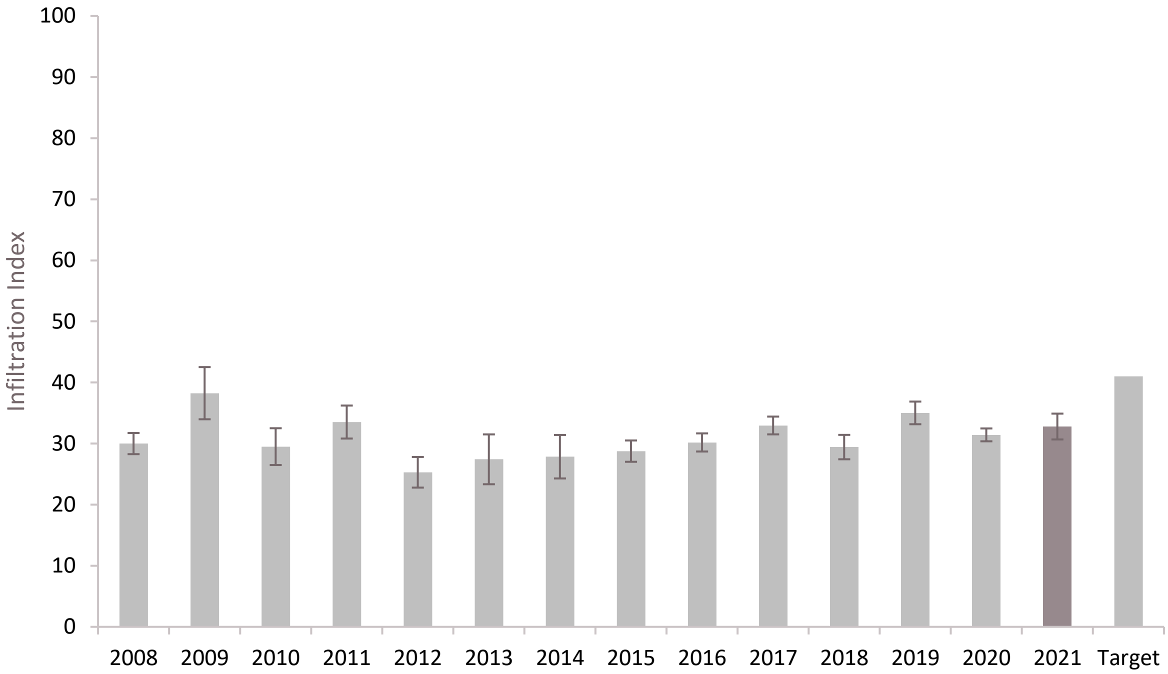

Figure 18 : Mean infiltration index values from the creek diversion sites. Values are derived from sites 17r, 19r, 21r and 23r each year between 2009 -2014. Average scores from 2015 onwards incorporate four additional sites (25r-28r). Error bars represent standard error of the mean. Only sites 19R, 21R and 23R were sampled in 2008. The target bar represents completion criteria for the Infiltration Index.

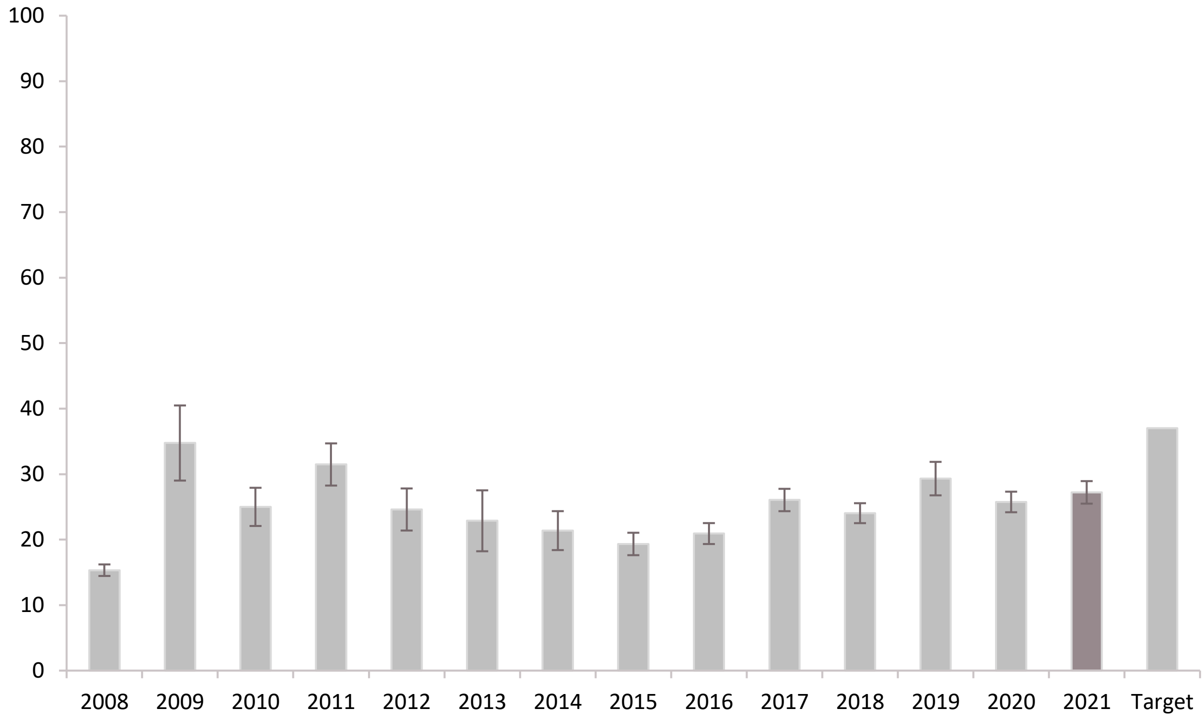

Figure 19: Mean nutrient index values from the creek diversion sites. Values are derived from sites 17r, 19r, 21r and 23r each year between 2009 -2014. Average scores from 2015 onwards incorporate four additional sites (25r-28r). Error bars represent standard error of the mean. Only sites 19R, 21R and 23R were sampled in 2008. The target bar represents completion criteria for the Nutrient Index.

Table 15: Site description of each creek diversion LFA transect

Transect	Notes	Photograph
17R	This transect consists of relatively flat ground covered in pasture with a combination of grassy patches (primarily *Cynodon dactylon*) and grass tussocks (primarily exotic *Chloris* gayana), together the entire transect. This is an increase from 2020 when 14% bare soil was recorded. This result is likely a result of two wetter years and the flat nature of this site.	
19R	Transect relatively flat and comprised primarily of low grass (*Chloris gayana*) (55%) and Galenia (6%), dispersed with patches of bare soil (39%). The appearance is similar to the previous year, although a higher proportion of bare ground was recorded in the transect but is not observable in the photo. The bare ground was present as numerous small interpatch areas. Young *Eucalyptus* and *Acacia* species continue to develop on creek banks downstream.	
21R	Transect relatively flat grassland dominated by annual exotics and low grass (96%) with bare soil (4%). An increase in annual cover and decrease in bare ground was recorded from the previous year.	

Transect	Notes	Photograph
23R	Low grass occurs over 38% of the transect, similar to recent years, with shrubs also covering 5%. Large bare patches of stony soil occur towards the middle and end of transect where there is a slope (not visible in photo). Bare soil patches cover 57% of the area. Some areas of active erosion including some 30cm deep rills occur in the surrounding area. The creek bank is in this area has been undercut and there is slumping on western bank. Regenerating *Casuarina cunninghamiana* (up to 8m) and some Eucalypts and *Acacia* sp. are present in and near the channel.	
28R	Transect primarily samples the relatively steep eastern creek bank. The majority of this transect was ripped to control *Galenia pubescens* and erosion prior to the 2017 monitoring. The dominant patches were low grass 49% and tussocks 29%, with tussocks present on the lower slopes and flat at the end of the transect. Bare soil (22%) increased from previous year and the upper slope is unstable and requires works to establish vegetation and limit erosion.	
27R	Transect samples the relatively steep western bank of the NWCD. The majority of this transect was ripped to control *Galenia pubescens* and erosion prior to the 2017 monitoring. Low sparse grasses and logs dominate the flat area adjacent to the creek channel. The transect is dominated by low grass (49%), tussocks (14%) and logs (8%). Bare soil (29%) has decreased from 2019 and 2020, which corresponds to an increase in low grass cover over previous bare soil/woodchips.	

Transect	Notes	Photograph
26R	Transect samples the relatively steep eastern bank to the edge of the creek channel. Low grass (46%) and tussocks (15%) dominated this transect in 2020. Bare soil areas (15%) and logs (19%) make up the remainder. The transect remained similar to previous years, although log patches increased likely due to changes in interpretation by the assessor. *Acacia* sp. shrubs are continuing to establish on some sections of the bank near this transect.	
25R	This slope is relatively steep with low grass dominating 58% of the transect and having the highest contribution to soil stability. Shrubs (15%), tussocks (8%) and logs (8%) are also present, with tussocks and logs dominant on the lower bank. Bare soil is most prevalent at the top of transect where some minor erosion is occurring and makes up 11% of the transect, a reduction from the previous year due to an increase in shrubs and tussocks. *Acacia* sp. and Eucalyptus shrubs and small trees are continuing to develop in and near this transect.	

2.3.1.2 Floristic monitoring

Two floristic monitoring sites were established within the NWCD area in 2020 (Figure 2**;** Photograph 20 and Photograph 21). 2021 results of the floristic monitoring are presented in Table 16.

Results in relation to the performance criteria were mixed. NGCG met the target and OR was recorded at both sites which is a positive result. An increase in diversity of native species was recorded, although the target still not reached. EPC was for the first time below the target, largely due to an increase in native annual and grass species within NWCD1. Interrogation of floristic plot data suggests a significant proportion of the EPC is attributable to annual species such as *Centaurium tenuiflorum* and *Lysimachia arvensis*, which is of lower concern than weed cover from perennials. NOS and NMS targets were not met however these are likely to take longer to reach for rehabilitation.

These results represent the first floristic monitoring undertaken within the NWCD since the sites were established in 2020. Ongoing monitoring will provide further insights into the vegetation condition and trajectory. Inclusion of additional monitoring sites and methods is likely to assist assessment of the vegetation condition and performance.

Table 16: Biometric scores for NWCD moniotring sites and performance criteria

Plant Community Type (PCT)	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Target: PCT 42: River Red Gum / River Oak riparian woodland wetland in the Hunter Valley	NWCD1	17	0.3	0.1	23.4	0	0	17.1	1	0	75
	NWCD2	21	0.2	0.7	45.8	0.1	0.3	40.2	1	0	2
Average value		19	0.25	0.4	34.6	0.05	0.15	28.65	1	0	38.5
Performance criteria		>20	10-50	10-50	20-60	1-5	5-30	<33	1	-	-

Photograph 20: NWCD Biometric Plot 1 in 2021

Photograph 21: NWCD Biometric Plot 2 in 2021

2.4 Conclusion and recommendations

2.4.1 North Wambo Creek Diversion

The NWCD did not meet the completion targets for any LFA index based on average scores across all sites. However, the scores were above 75% of the target values for all indices except nutrient index which was 74% of the target. Generally, areas of bare soil associated with the steeper slopes of the creek diversion are contributing to the lower scores.

Casuarina and *Eucalyptus* sp. have continued to develop within the creek channel and patches of *Acacia* and *Eucalyptus* shrubs are present in places, particularly in the downstream reaches of the NWCD, and appear to have grown significantly in the past two years of higher rainfall. Nevertheless, a large proportion of the creek diversion remains primarily open pasture with high cover of exotic species. Riparian vegetation is considered unlikely to be 'better' than prior to the diversion and the proposed net increase in riparian vegetation (which included establishing *Angophora floribunda*, *Casuarina cunninghamiana* and a selection of native grasses in the riparian zone) (Resource Strategies, 2003) is yet to be achieved.

Floristic monitoring resampled the two plots established in 2020 for the first time. Sites achieved targets for native ground cover of grasses and exotic plant cover and are showing good signs of native species diversity. Sites did not meet targets for shrub and canopy cover, however these are expected to take longer to achieve.

Some areas of erosion that exceed completion criteria targets are present, with some gully erosion, deeper rills and large areas of bare soil observed. Significant soil remediation works have been undertaken within the North Wambo Creek Diversion in 2020 and 2021 by the Soil Conservation Service and works are continuing. The works include several new rock chutes manage drainage and erosion and ripping to stabilise soil and are likely to lead to significant improvement to the condition of the NWCD over time.

Monitoring should continue, although it is noted that LFA monitoring is proposed to be replaced by the monitoring undertaken by Cumberland Plains Seeds to assess vegetation establishment following recommendations from DPIE. This change in methodology should be incorporated into the next update of the site Biodiversity Management Plan.

Additional floristic monitoring sites are likely to be required to fully characterise the vegetation performance along the NWCD. Floristic monitoring sites should be established across the full range of revegetation areas, i.e. if the final revegetation plan includes multiple target communities such as woodland and riparian areas. In areas of newly established revegetation additional monitoring methods may also assist in assessing success and provide data to guide future works, if required. This early stage monitoring should be undertaken using the tailored vegetation establishment monitoring methods (Cumberland Plains Seeds 2020), before transitioning to BioMetric plot monitoring once vegetation has established.

In light of the currently active management works, no further management actions are currently recommended, however ongoing active management including soil stabilisation, planting native species and weed control will be required following completion of the current works.

3. Riparian condition assessment

3.1 Introduction

The riparian EFA monitoring program is a requirement of the 2004 Development Consent conditions. The objective of the monitoring program is to evaluate how the riparian environment is responding to management initiatives (such as cattle exclusion) and document any impacts arising from mine subsidence.

North Wambo Creek drains the mid and eastern sections of the North Wambo Underground Mine development area and flows south-east into Wollombi Brook, approximately 600 m south of the Mine. North Wambo Creek has been highly disturbed both by historic and present grazing activities and by the North Wambo Creek Diversion. The diversion channels the creek around the open-cut mining operation.

Stony Creek drains from Mount Wambo in a north-east direction and meanders across the western boundary of coal lease (CL) 397 near the south-western boundary of the North Wambo Underground Mine and passes in a south-easterly direction through the existing underground development area of WCPL to join Wambo Creek. Wambo Creek then runs east to join Wollombi Brook. Much of the riparian zone along Wambo Creek has been disturbed by historic agricultural activities.

3.2 Methods

Field sampling for the riparian monitoring was undertaken between 18 and 22 October 2021. The *Rapid Appraisal of Riparian Condition* method (RARC), developed by Jansen et. al. (2005) and used during the 2016 to 2020 monitoring, was utilised during the 2021 survey period. Using this method, an overall score is obtained at each monitoring site by examining the width of riparian vegetation, proximity to large patches of native vegetation, vegetation cover, debris (leaf litter, standing dead trees and fallen logs) and other features (native canopy and understory regeneration, tussock grasses and reeds on creek banks). Areas monitored were:

- North Wambo Creek
- (South) Wambo Creek
- Stony Creek.

Methods followed Jansen et. al. (2005) with four 40 m long cross-section transects sampled at each monitoring site (an approximate 500 m length of riparian zone). Three monitoring sites were measured along each creek. The location of monitoring sites and transects is illustrated in Error! Reference source not found. with photographs presented in **Volume 2**.

The three creeks and sample sites were compared in regard to the following sub-indices:

- *Habitat* - longitudinal continuity of canopy vegetation (> 5 m wide); width of riparian canopy vegetation; and proximity to nearest patch of native vegetation > 10 ha
- *Cover* - vegetation cover and structural complexity
- *Native* - dominance of native species versus exotic species
- *Debris* - leaf litter; standing dead trees; hollow-bearing trees; and fallen logs

- *Features* - other indicative features such as regeneration, presence of large native tussock grasses (e.g. *Austrostipa* spp.) and reeds.

The five sub-indices were assessed across the three separate reaches of each creek and were combined to create a *Total Score.* Site photos and scores from previous monitoring reports (ELA (2016 to 2020) were compared. Although not directly comparable due to differing site locations and methodologies, data and photos from Niche (2014d) and RPS (2009)) were also reviewed.

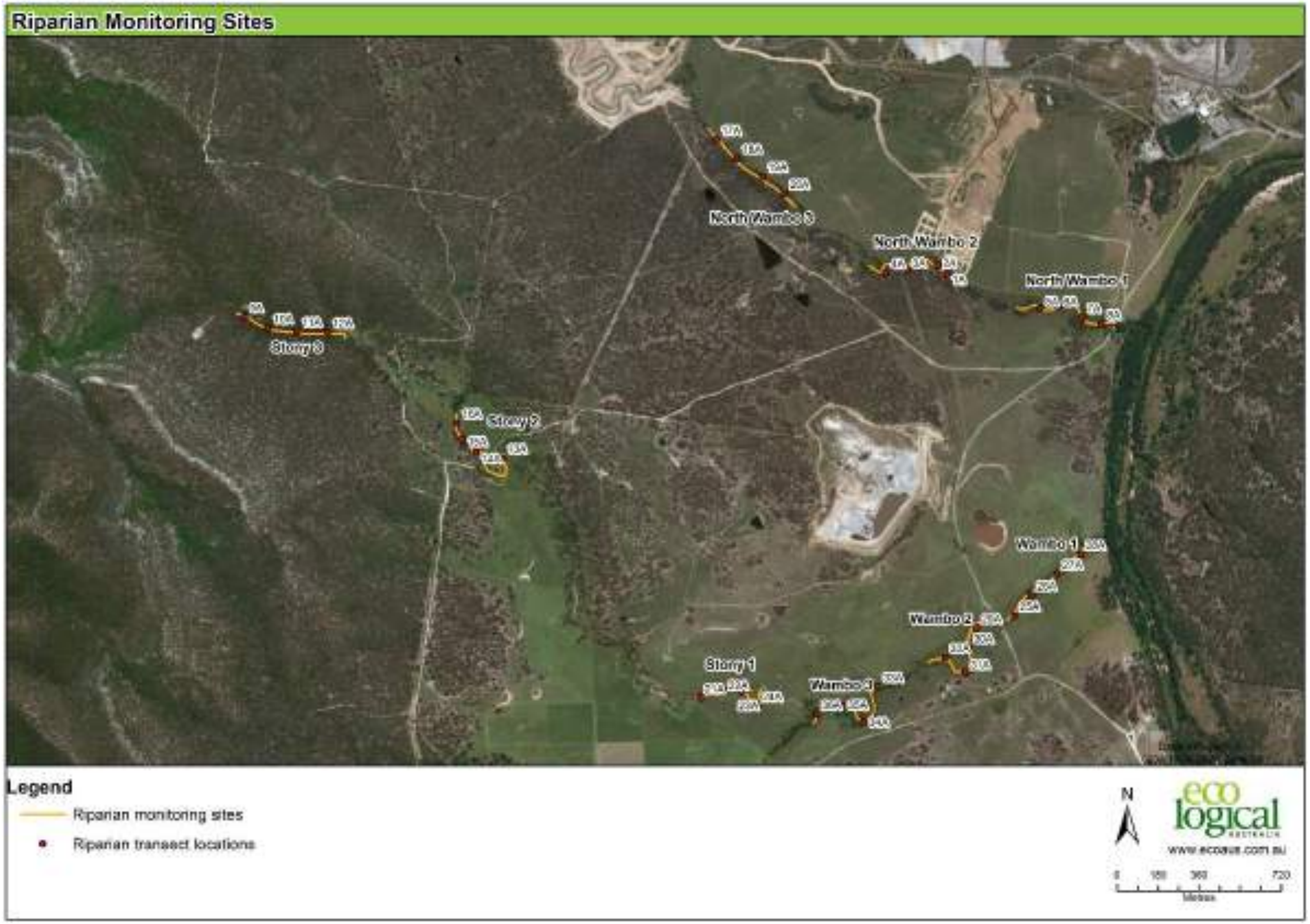

Figure 20: Location of riparian monitoring cross-sections and transects

3.3 Results

The results of the riparian condition monitoring are presented below, with raw data included in **Volume 2**.

The average total score for Stony Creek and North Wambo Creek were similar to the 2020 records. South Wambo Creek recorded a decline in the average total score compared to 2020 and 2019 when it recorded its highest score (**Figure 21**).

South Wambo Creek remains the lowest scoring creek system based on the sub-indices measured.

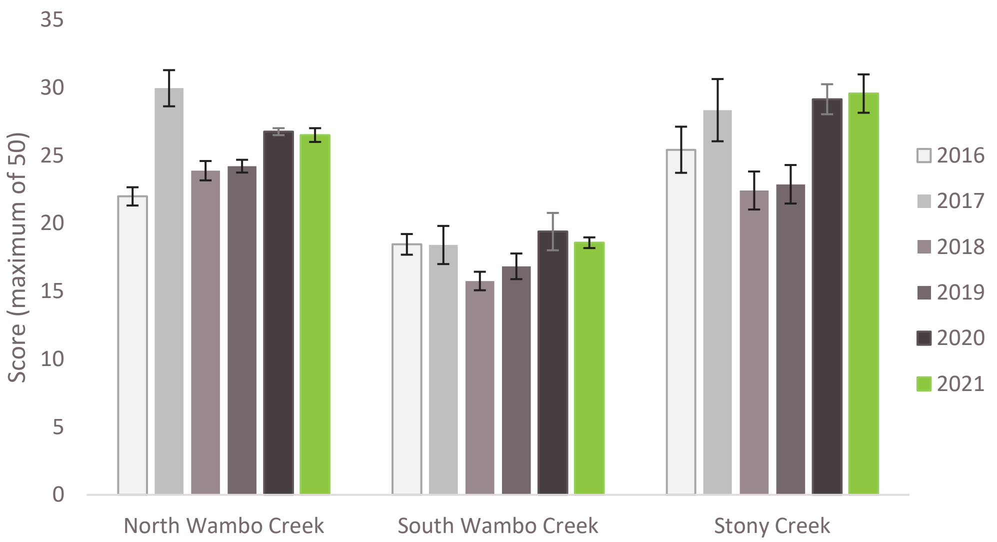

Figure 21: Average "Total Score" for North Wambo Creek, South Wambo Creek, and Stony Creek, from surveys in 2016 - 2021

3.3.1 North Wambo Creek

North Wambo Creek recorded similar scores for all sub-indices to previous years. This site has relatively good scores for habitat, cover and debris. However, lower scores were recorded for natives and features.

Natives score dropped slightly from 2020, driven by a reduction in the score at the North Wambo 1 transect, where higher exotic cover was recorded. There was a slight increase in debris score due to an increase in leaf litter.

3.3.2 South Wambo Creek

South Wambo Creek has consistently been the lowest scoring site. In 2021 South Wambo Creek recorded similar scores to 2020 for *cover, natives*, *habitat* and a slight drop in scores for *features* and *debris.*

Evidence of feral pigs was observed within the site 3 of South Wambo Creek for the second consecutive year. Pig disturbance reduces the ground cover, regeneration and destabilises the soils leaving these areas more prone to erosion, this may attribute to the low scoring.

Casuarina cunninghamiana (River Oak) regeneration was recorded within South Wambo Creek which is a positive sign for canopy recruitment for riparian habitat.

Site 3 recorded a decline in features, natives and cover scores. Evidence of significant disturbance from pigs was recorded at site 3 of South Wambo Creek (Photograph 22).

No evidence of recent cattle grazing was recorded in this area. Grazing pressure reduces the ground cover and destabilises the soils leaving these areas more prone to erosion. In previous years cattle grazing had impacted riparian condition scores along South Wambo Creek.

Photograph 22 Evidence of pig disturbance within site 3 of South Wambo Creek from in October 2021.

3.3.3 Stony Creek

Stony Creek recorded increases for cover, natives and features. These results may reflect the gradual regeneration of riparian vegetation in the lower reaches and an increase in ground cover vegetation following the wetter years in 2020 and 2021.

The habitat score remained the same as in 2019 and 2020. The habitat score is controlled by features which change over longer periods of time such as canopy connectivity and proximity to large patches of native vegetation and has always remained at the maximum score at Stony Creek 3 where the site is within high condition native vegetation.

There remains large variability in the habitat sub-index between longitudinal transects at Stony Creek which reflects the differences in vegetation and habitat features between the cleared lower reaches at

Stony Creek 1 (Photograph 23) and the heavily forested upper reaches observed at Stony Creek 3 (Photograph 24).

It is unclear whether cattle have been excluded from the lower reaches of Stony Creek at Stony Creek 1. No evidence of recent cattle grazing was recorded, however there was no fencing that would prevent cattle accessing the riparian area. In previous years cattle grazing had impacted riparian condition scores along lower reaches of Stony Creek.

Photograph 23 Stony Creek 1 predominately cleared vegetation

Photograph 24 Stony Creek 3 heavily forested vegetation

3.3.4 General observations

Overall scores at all creeks were similar to previous years and conditions were similar to 2020 which had also received higher rainfall than previous years. Higher ground cover, containing a mix of native and exotic species remains present, particularly due to an increase in ground cover following drought in the previous two years. The change in ground cover from 2019 to 2021 can be seen in Photograph 25 and Photograph 26. 2020 was also similar to 2021.

No evidence of recent subsidence impacts was observed at North Wambo Creek, South Wambo Creek, or Stony Creek during the 2021 riparian condition survey.

Site scores from available past monitoring reports (Niche (2014) and RPS (2009)) show similar results with Stony Creek (particularly the upper reaches) being regarded as in good condition, North Wambo Creek as being either in good or moderate condition and South Wambo creek being in moderate condition. General comparison of riparian area photos from 2021 with those from 2014 show that the riparian vegetation remains similar, with seasonal variation in ground cover in response to rainfall the most obvious change over time.

Photograph 25: Transect 14 at stony Creek 2 in 2021 showing high ground cover following higher rainfall

Photograph 26: Transect 14 at stony Creek 2 in 2019 showing drought impacted ground cover

3.4 Conclusions and recommendations

Similar scores to the previous year for all creeks reflect the ongoing wetter conditions following previous drought and the reduction/exclusion of grazing. Understorey vegetation cover remains high following higher rainfall in 2020 and 2021, although a high proportion of ground cover contribution is from exotic species.

Sub-indices relating to more permanent features such as habitat connectivity, tree canopy and logs and hollows remained similar.

Exclusion of cattle from riparian areas has been recommended in previous monitoring reports and no evidence of cattle grazing was recorded in 2021. Cattle should continue to be excluded from riparian areas to encourage tree regeneration and prevent erosion.

Plantings of trees in over-cleared riparian areas (that are unlikely to regenerate naturally with cattle exclusion) will also be beneficial to riparian area and the surrounding environment.

4. South Bates Extension Underground Mine area

4.1 Floristic Monitoring

4.1.1 Introduction

Floristic monitoring of the South Bates Extension underground mine area was added to the annual biodiversity monitoring program in 2020 and was continued in 2021. The purpose of this monitoring is to measure the current condition of vegetation in terms of floristics and habitat complexity and identify whether any adverse impacts from undermining are occurring through comparison with previous years (2020). The results aim to provide direction to management of these areas and for the monitoring program in the future.

4.1.2 Methods

Floristic monitoring is undertaken using the BioMetric plots as described in **Section 1.1.2**. The monitoring was undertaken on by ELA ecologist Shawn Ryan and Liam Scanlan on 25 October 2021.

Four new sites were established in 2020 to sample the two dominant PCTs in the South Bates Extension area. Data from two existing monitoring plots that are also within the South Bates Extension area were also used for analysis. Of the new sites, two were established outside of the approved mining area and are intended as reference sites. A summary of the monitoring sites is presented in Table 17 and site locations are shown on Figure 2.

Table 17: Floristic monitoring sites for the South Bates Extension Underground Mine

Plant Community Type (PCT)	TEC	Plot name	Type	Site age
PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	Listed BC Act, E: Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions, may also be listed as CE under the EPBC Act as Central Hunter Valley eucalypt forest and woodland, dependant on condition and landscape position	SBX2-GB-I	Impact	1 year
		SBX4-GB-C	Reference	1 year
PCT 1176: Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion	Listed BC Act, V: Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion, may also be listed as CE under the EPBC Act as Central Hunter Valley eucalypt forest and woodland, dependant on condition and landscape position	V10-A1	Impact	Existing
		V10-A2	Impact	Existing
		SBX1-SG-I	Impact	1 year
		SBX3-SG-C	Reference	1 year

Performance targets for the same communities within the RWEP areas have been adopted as an indication of good condition vegetation for reference. Reference sites outside of the approved mining area are used as a comparison for assessing seasonal variation factors.

4.1.3 Results

Floristic data from sites added in 2020 and existing monitoring sites within the South Bates Extension Underground Mine area indicate the vegetation and habitat features are in good condition with most attributes meeting the performance criteria (Table 18).

Both sites within Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest have not been undermined to date and therefore data collected in 2020 is considered to be baseline data. NMS was slightly below target at both sites, however had still increased from 2020. NGCS which was below target in 2020 is now within target. These results are likely to represent natural variation within the community and climatic conditions between .

Of the four sites within the Slaty Box - Grey Gum shrubby woodland, two (V10-A1 and V10-A2) have been undermined and two (SBX1-SG-I and SBX3-SG-C) are acting as current reference sites. NOS was still slightly below target at both impact sites and grass cover high at V10-A1. NOS has fluctuated over time with most sites across the monitoring program scoring higher in 2021 than the previous year. Site V10-A2 scored slightly lower for canopy cover, however review of plot photographs (Photograph 36) shows canopy in good condition, with all trees healthy and no observable impacts to the canopy from undermining. The two current reference sites within this community met the performance criteria for most attributes. At one site, SBX1-SG-I, NMS was below target although this is considered likely to representing natural variation within the community.

Photograph 27: Site V10-A2 in 2021 with canopy in good condition

4.1.4 Conclusions and recommendations

Floristic monitoring results for vegetation communities within the South Bates Extension underground reveal vegetation is in good condition, generally meeting performance targets. No evidence of mine subsidence impacting native vegetation condition were detected.

It is recommended monitoring continue in this area, including the use of reference sites to allow comparison including impacts of seasonal variation.

Table 18: BioMetric scores from South Bates Extension floristic monitoring sites in 2021

Plant Community Type (PCT)	Plot Name	Site type	Mining status	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	SBX2-GB-I	Impact	Not yet mined	40	27.5	4.5	50	10	30	0	0	1	12
	SBX4-GB-C	Reference	Outside mining area	42	19.5	1.5	38	10	12	4	2	1	48
	Performance criteria			>25	10-40	5-10	15-50	5-10	5-40	<5	1	-	-
1176: Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion	V10-A1	Impact	Undermining has occurred	45	8.8	4.5	84	2	10	0	0	1	27
	V10-A2	Impact	Undermining has occurred	50	6.1	7.5	34	30	2	0	0	1	12
	SBX1-SG-I	Impact	Not yet mined	31	21	0.5	20	2	8	0	0	1	35
	SBX3-SG-C	Reference	Outside mining area	35	23	11	28	18	8	0	0	1	20
	Performance criteria			21	15-40	5-30	5-30	0-25	2-10	<5	1	-	-

4.2 Bird monitoring

4.2.1 Introduction

Bird monitoring of the South Bates Extension underground mine area was added to the annual biodiversity monitoring program in 2020 and continued in 2021. The purpose of this monitoring is to use bird diversity and abundance as an indicator of health of the local fauna populations and identify whether any adverse impacts from undermining are occurring. The results aim to provide direction to management of these areas and for the monitoring program in the future.

4.2.2 Methods

Bird monitoring survey methods are the same as described in **Section 1.2.2.** Surveys were undertaken by ELA ecologists Daniel McKenzie and Dee Ryder between 18-22 October and 26-28 October 2021.

Four new bird monitoring sites (BP27-BP30) in the South Bates Extension Underground Mine area were established in 2020, and one existing bird survey site (BP26) is within the South Bates Extension Underground Mine area. Of the new sites, two were established outside of the approved mining area and are intended as reference sites. Bird survey site locations are shown on Figure 11. The current progress of mining in the South Bates Extension area means that of the five sites only BP26 is currently in an area that has been undermined (Table 19). As such, current data from all four new sites can be considered baseline data for comparison after mining occurs.

Table 19: Bird monitoring sites within the South Bate Extension underground mine area

Site	Mining status	PCT
BP26	Undermining has occurred	1176: Slaty Box - Grey Gum shrubby woodland
BP27	Reference site (outside mining area)	1176: Slaty Box - Grey Gum shrubby woodland
BP28	Reference site (outside of mining area)	1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest
BP29	Not yet undermined	1176: Slaty Box - Grey Gum shrubby woodland
BP30	Not yet undermined	1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest

4.2.3 Results

The highest diversity and abundance of birds was recorded at BP26 (Figure 22), which is currently the only impact site. This site also recorded the highest diversity and abundance of species in 2020.

Two threatened bird species were recorded at the monitoring sites, with two species recorded at sites BP26 and one species recorded at site BP30 (Table 20).

Table 20: Threatened bird species recorded at South Bates Extension underground mine bird survey sites

Species	BP26	BP27	BP28	BP29	BP30
Dusky Woodswallow	2	-	-	-	-
Grey-crowned Babbler	5	-	-	-	2

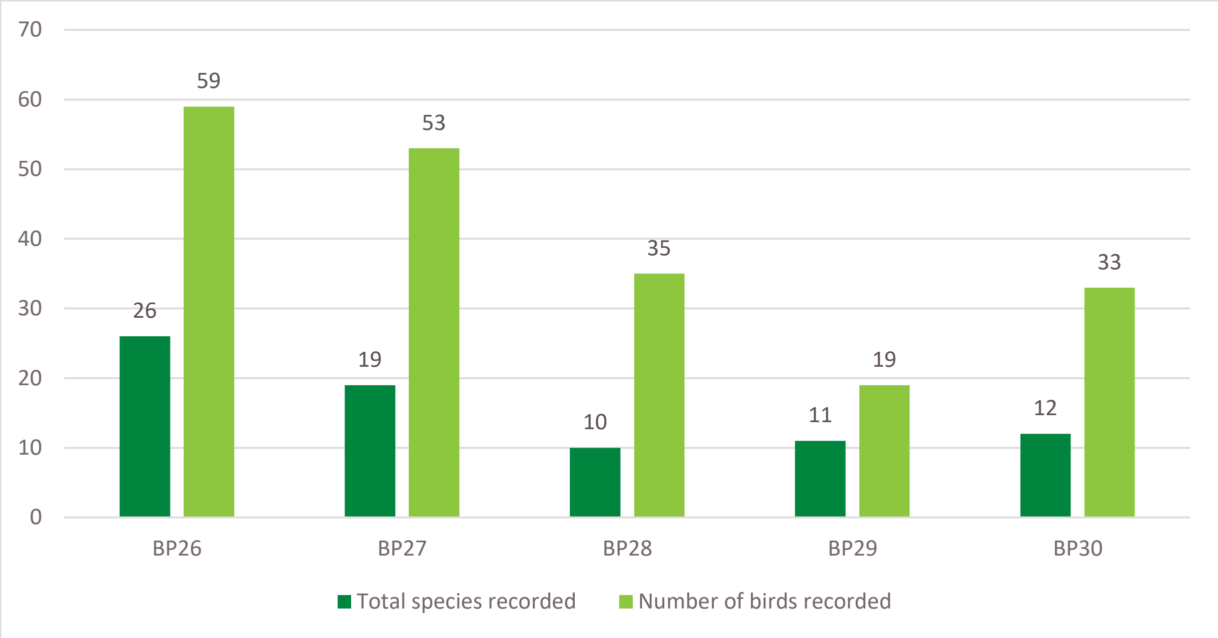

Figure 22: Bird monitoring results for sites in the South Bates Extension underground mine area

4.2.4 Conclusions and recommendations

Bird surveys recorded data at four sites established in 2020 and one existing site associated with the South Bates Extension underground mine area. One of the five sites was located above an area which had been undermined to date in 2021. This site recorded the highest diversity and abundance of bird species and also had the most threatened bird species recorded. As such, there is no indication that the undermining is having a detectable impact on bird species within this area.

Continued monitoring is recommended in this area, including the use of reference sites to allow comparison including impacts of seasonal variation. Progress of underground mining activities should be corelated to site locations annually to ensure results are appropriately analysed as baseline, or impact once undermining progresses.

4.3 Groundwater Dependent Ecosystem monitoring

4.3.1 Introduction

Monitoring of Groundwater Dependent Ecosystems (GDEs) is a new component to the annual biodiversity monitoring program initiated in 2019. The GDE Vegetative Assessment Report (Hunter Eco, 2019) identified two likely GDEs in the area above the South Bates Underground Extension:

- River Oak riparian tall woodland
- M*elaleuca decora* low forest.

The South Bates Underground Extension has the potential to impact groundwater in the vicinity of the two GDEs. Hunter Eco (2019) recommended the establishment of a GDE monitoring program including:

- Vegetation condition and extent assessed by aerial imagery and on-ground inspection over time
- Document tree height and diameter at breast height (DBH) of selected River Oak saplings and mature trees.

4.3.2 Methods

GDE monitoring was undertaken by ELA ecologist Shawn Ryan and Liam Scanlan 26 and 27 October 2021. Several methods were used to monitor GDEs, as described below.

4.3.2.1 Vegetation survey plots

Two vegetation monitoring plots (standard biometric plot 50 x 20 m - refer to (**Section 1.1.2**)), previously surveyed in 2019 and 2020, were surveyed in each GDE (Figure 26). Vegetation structure and function data compliant with the Biodiversity Assessment Method (BAM) plot method (current standard method for ecological impact assessment) was also collected.

4.3.2.2 Photo monitoring points

At each photo monitoring plot, images were captured at 0, 90, 180, and 270 degrees, as well as one at the ground. A total of eight photo monitoring points were surveyed (Figure 26).

4.3.2.3 Tree measurements

Thirty *Casuarina cunninghamiana* trees (15 mature trees and 15 saplings) were selected for monitoring across the River Oak riparian tall forest GDE area along North Wambo Creek in 2019 (Figure 28). Each tree was permanently marked with a numbered metal tree tag and the DBH was measured. The point of DBH measurement (1.3m above the ground) was sprayed with paint so that the measurement location can be replicated during subsequent monitoring. In 2020 and 2021 the DBH for each tree was re-measured.

Crown extent was assessed for each of the 30 tagged trees. Crown extent was assessed as the percentage of the assessable crown (all live and dead branches on the tree) in which there are live leaves. Two observers each recorded a crown extent estimate from opposite sides of the tree to the nearest 5%, and the average of the two scores was recorded.

4.3.2.4 Mapping of vegetation extent

Mapping the extent of the River Oak riparian tall woodland community along the upper reach of North Wambo Creek was completed in a GIS at 1:1000 scale using georeferenced aerial imagery (NearMap, 2021). Polygons were drawn with reference to Rapid Data Points (RDPs) and photos collected during the monitoring survey and using comparison to aerial imagery from 2019 (NearMap) when the community extent was first mapped in detail.

4.3.3 Results

The results of the GDE monitoring are presented below, with raw data and all photographs included in **Volume 2**.

4.3.3.1 Vegetation survey plots

Two monitoring plots were surveyed in each GDE (Figure 26). BioMetric data from each plot is presented in Table 21.

The BioMeteric results from the *Melaleuca decora* low forest GDE indicated the community is in good condition, with the majority of scores increasing from 2021, likely as a result of the increased rainfall in 2020. The average number of native species recorded increased by 9 (Figure 23), and all other attributes similar to 2020. EPC was zero along the BioMetric transect at GDE1, however GDE2 and increased from zero in 2020 to 16 in 2021.

The River Oak riparian tall woodland GDE also recorded increased scores for most categories. NPS increased by 11 from 2020 (Figure 23), NGCG increased by 10%. NGCO and NOS has decreased by 25% and 17.5% respectively. EPC decreased by 41%, which is still mostly driven the presence of *Galenia pubescens* at site GDE3.

Table 21. BioMetric data for GDE monitoring plots in 2021

GDE	Plot Name	NPS	NOS (%)	NMS (%)	NG CG	NGC S	NGC O	EPC	OR	HBT	FL	LI	BS
***Melaleuca decora* low forest**	GDE1	47	8.1	13.5	58	8	0	0	0	1	30	70	0
	GDE2	41	5	16.5	68	14	16	4	0	1	20	63	0
	Average	44	6.55	15	63	11	8	2	0	1	25	66.5	0
River Oak riparian tall woodland	GDE3	36	15	0	24	4	14	42	0	1	25	20	7
	GDE4	52	18	0.5	20	8	12	0	0	1	38	38	0
	Average	44	16.5	0.25	22	6	13	21	0	1	31.5	29	3.5

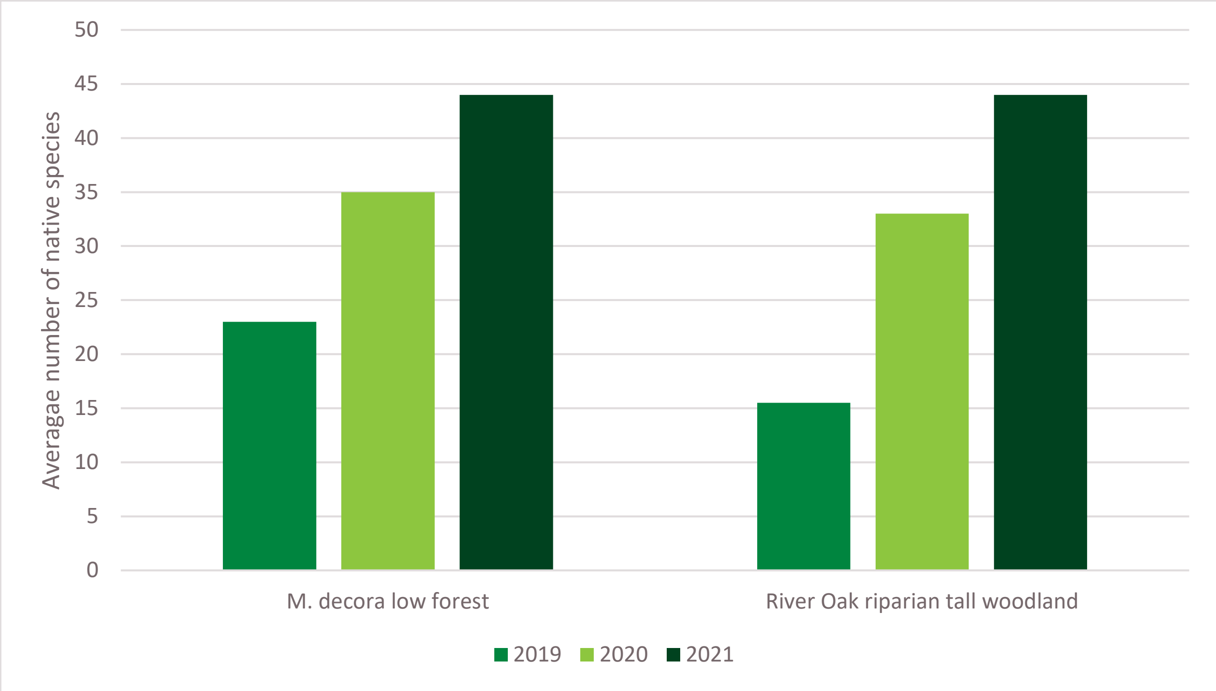

Figure 23: Average number of native species within each GDE over time from 2019-2021

4.3.3.2 Photo monitoring points

Review of images from photo monitoring points show GDE vegetation in good condition in 2021. A noticeable increase in ground cover vegetation is visible in both *Melaleuca decora low forest* and *River Oak riparian tall woodland* GDE communities since site establishment in 2019 (Photograph 37 to 40).

Photograph 28: GDE Photo monitoring point M2 (facing south) in *Melaleuca decora* low forest in 2019

Photograph 29: GDE Photo monitoring point M2 (facing south) in *Melaleuca decora* low forest in 2021

Photograph 30: GDE Photo monitoring point M7 (facing north) in River Oak riparian tall woodland in 2019

Photograph 31: GDE Photo monitoring point M7 (facing south) in River Oak riparian tall woodland in 2021

4.3.3.3 Tree measurements

Individual tree measurements from 2021 are presented in Table 22. The average DBH for River Oak trees increased in the saplings (1 cm), however there was no change in mature trees (Figure 24). This indicates tree growth and suggests the trees have received good access to water over the past year. Sapling growth is expected to be greater than mature trees. Two individual adult trees (Trees 13, 18, 26, 28 and 30) recorded smaller DBH in 2021 than the previous year, this was a result of a portion of bark falling away; in all cases trees appear healthy, with the exception of tree 18 which had some signs of crown dieback.

The average canopy extent increased by 7% for mature River Oak trees and decreased by 1% for saplings (Figure 25). This result indicates that tree health has generally improved or maintained from the previous year.

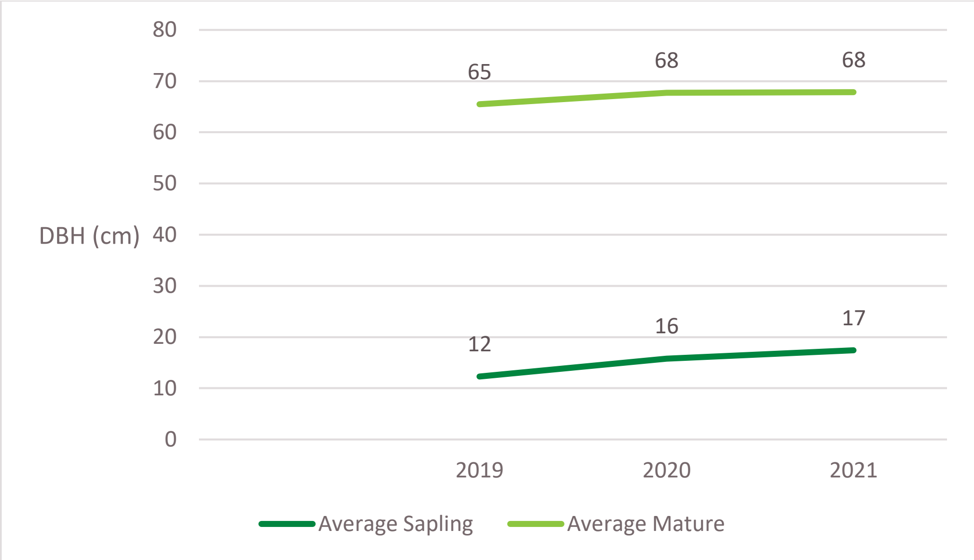

Figure 24: Change in DBH over time of measured trees within the GDE River Oak riparian tall woodland GDE

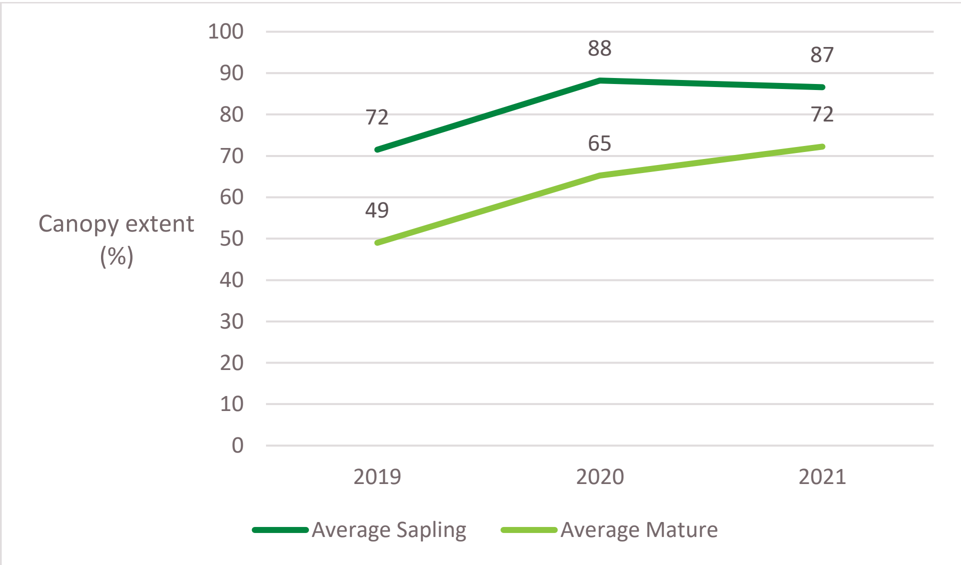

Figure 25: Change in canopy extent over time of measured trees within the GDE River Oak riparian tall woodland GDE

Table 22. River Oak tree monitoring results in 2021

Tree Tag No.	Age class	DBH (cm)	Canopy Extent (%)	Easting	Northing
1	Mature	73.4	75	306275	6395900
2	Mature	39.8	85	306164	6395894
3	Sapling	26.4	100	306090	6395881
4	Mature	83.4	87.5	306050	6395868
5	Mature	32.9	32.5	305952	6395693
6	Mature	102	72.5	305964	6395705
7	Sapling	25.2	96.5	305811	6395612
8	Sapling	16	96.5	305753	6395618
9	Mature	61.2	75	305785	6395619
10	Sapling	17	96.5	305529	6395440
11	Sapling	27.6	97	305470	6395438
12	Mature	65.5	92.5	305442	6395439
13	Sapling	5.6	92.5	305380	6395409
14	Mature	58	75	305379	6395410
15	Sapling	9	80	305573	6395454
16	Sapling	13.2	95	305587	6395457
17	Sapling	13.4	67.5	305593	6395493
18	Mature	104.5	62.5	305566	6395521
19	Mature	75.9	82.5	305571	6395591
20	Sapling	20.3	97	305607	6395612
21	Mature	113	82.5	305338	6395325
22	Mature	60.5	85	305307	6395248
23	Sapling	22.3	67.5	305264	6395213
24	Mature	52	52.5	305218	6395224
25	Sapling	24	90	305202	6395237
26	Mature	48.8	67.5	305171	6395235
27	Sapling	20.6	90	305038	6395194
28	Mature	46.7	77.5	305035	6395190
29	Sapling	12	77.5	305021	6395183
30	Sapling	8.8	55	305004	6395173

4.3.3.4 Mapping of River Oak riparian tall woodland vegetation extent

No change in extent of River Oak riparian tall woodland was observed in the field or observable in the aerial imagery. The total area of the GDE remains 5.07 ha (Figure 27).

4.3.4 Conclusions and recommendations

Ongoing monitoring of these sites is required to assess whether any impacts to GDEs occurs as a result of planned mining activities in this area.

Floristic monitoring recorded generally increased scores for both GDEs surveyed. Similar to 2020, high rainfall in 2021 is likely to be the major factor in these results and photo monitoring clearly shows increased vegetation cover, particularly in the understorey of both areas.

For the *Melaleuca decora* low forest GDE, it may be appropriate to use data collected during 2019, 2020 and 2021 as the baseline conditions for the community. This area was undermined during 2019 and 2020 and no obvious impacts have occurred, and any adverse effects to vegetation are unlikely to have been detectable yet. As such future monitoring surveys may be considered as post impact surveys and compared to the 2019, 2020 and 2021 results.

GDE tree monitoring within River Oak riparian tall woodland recorded tree growth and increased or similar canopy extent, suggesting continued good health of the trees following ongoing high rainfall in 2021.

The River Oak riparian tall woodland remains approximately 1km from the closest mined portion of the South Bates Underground Extension mining area. As such, there may be no current impacts from undermining and the current data will serve as a baseline for reference once mining activities occur in the vicinity of the community. Variation in results between the dry year in 2019 and wetter years in 2020 and 2021 is likely to be useful to understand the natural changes which occur in the community when attempting to determine whether any future changes observed are the result of mining impacts or natural variation.

No discernible change in the extent of the River Oak riparian tall woodland GDE was recorded. Changes to the extent of the community are likely to take place over the course of several years. The wetter years in 2020 and 2021 may have provided suitable conditions for the spread and germination of canopy and mid storey species which in the coming years may result in an increase in the extent of the community.

Monitoring should continue to assess for impacts to the *Melaleuca decora* low forest GDE and to continue collecting baseline and future impact data for the River Oak riparian tall woodland GDE. Several groundwater monitoring wells have been established in the vicinity of the GDE along North Wambo Creek and the data from these is also likely to assist with determining whether any impacts to GDEs are likely to occur.

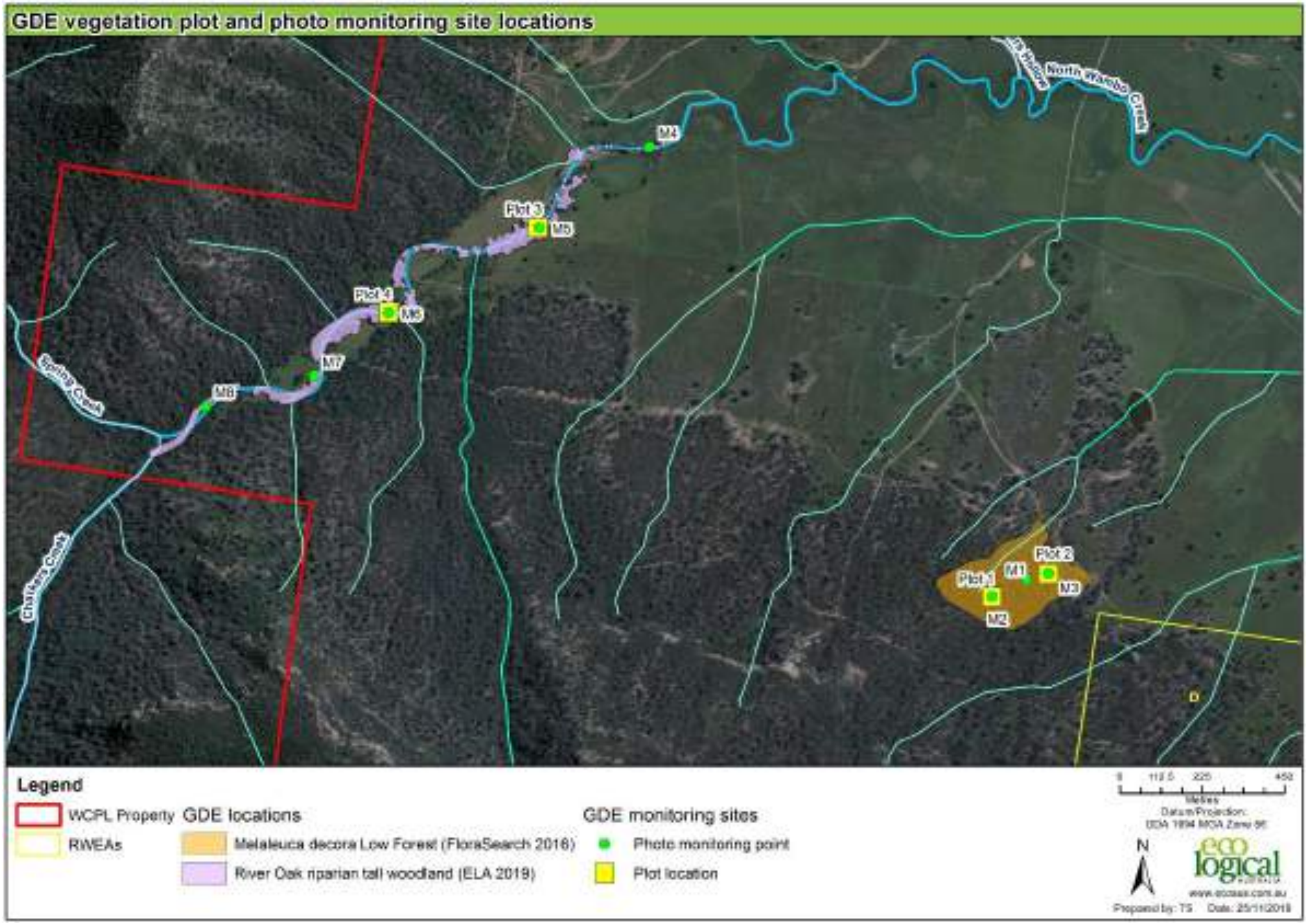

Figure 26. GDE monitoring site locations

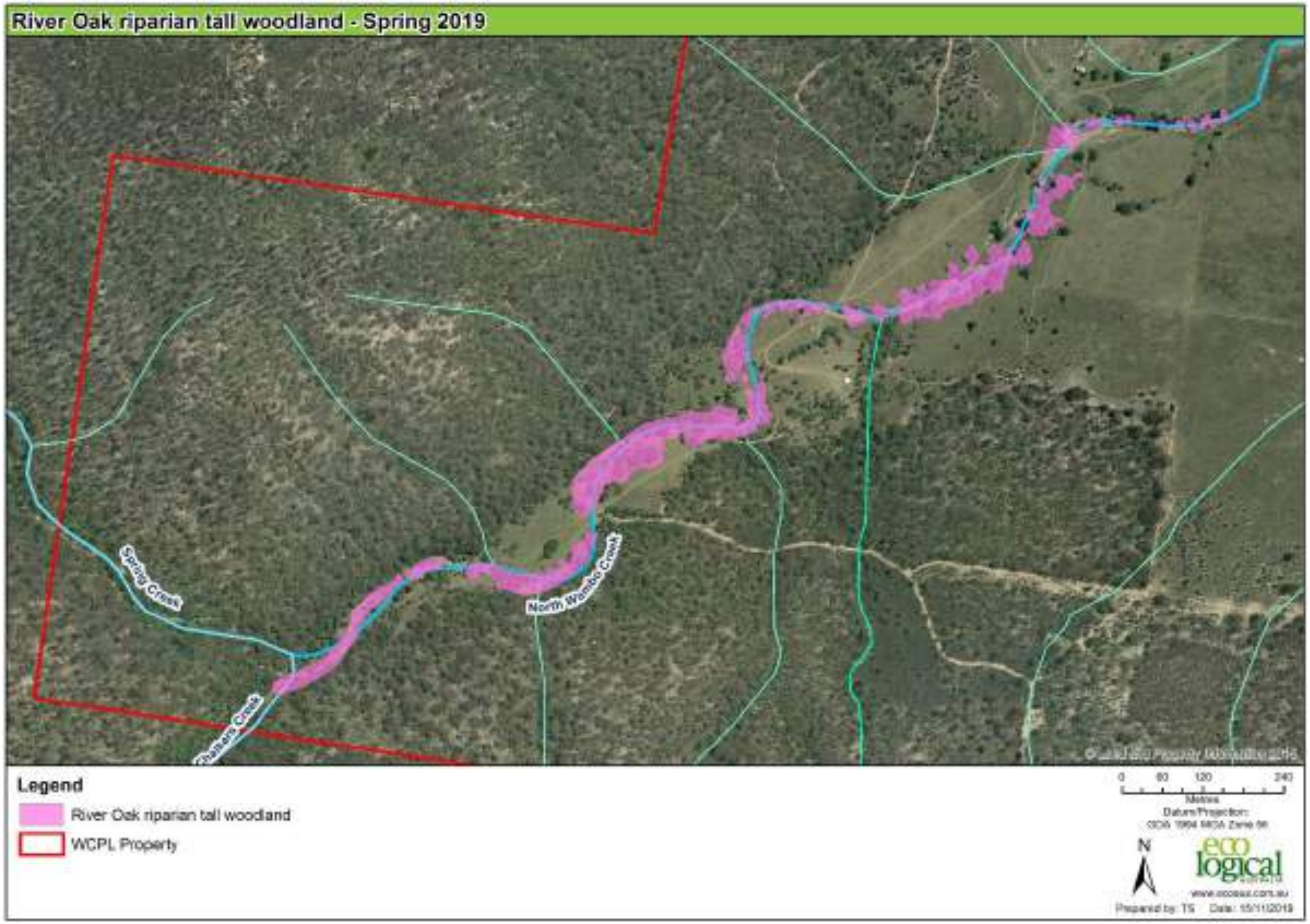

Figure 27. Extent of River Oak riparian tall woodland mapped in spring 2021, largely unchanged from spring 2019

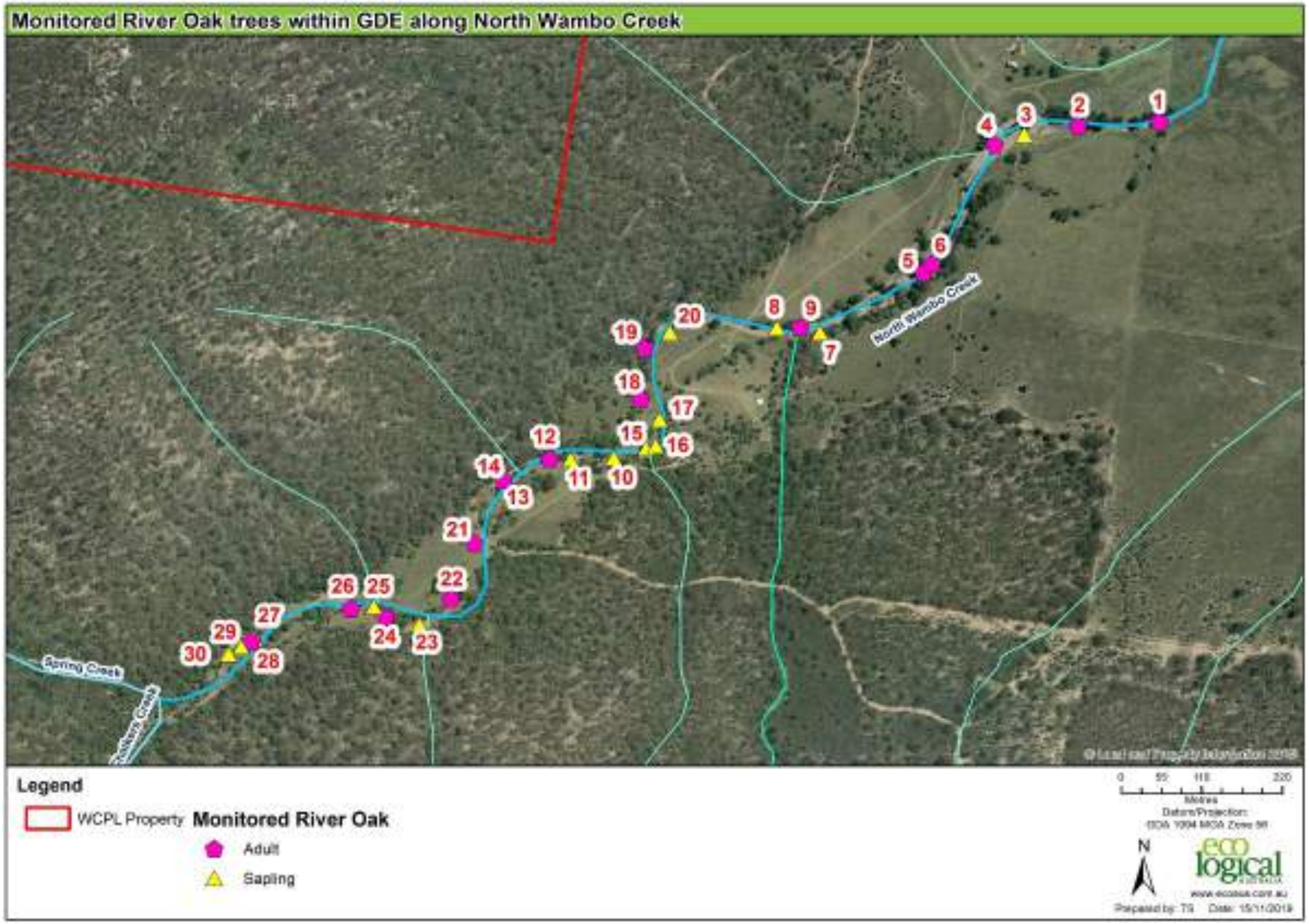

Figure 28. Monitored River Oak trees along North Wambo Creek

5. Mine subsidence observations and other management considerations

Mine subsidence and land management issues observed during the 2021 monitoring surveys across the RWEAs and rehabilitated landforms are summarised in Table 23 and mapped on Figure 29.

Table 23. Mine subsidence and other land management observations recorded during 2021 Spring monitoring (# corresponds to the labels on Figure 29)

#	Type	Location	Notes
1	Subsidence cracking	RWEA C	Crack width 0.5 m, length undetermined
2	Subsidence cracking	RWEA D	Crack width 25 cm, length 10 m. On edge of dam wall.
3	Subsidence cracking	RWEA C	Crack width 40 cm, length 10 m. Crack parallel to road, depth 50 cm
4	Subsidence cracking	RWEA C	80 cm wide, 50 cm deep hole in road. Risk to vehicles.
5	Subsidence cracking	RWEA C	Crack width 1 m, road undercut length 5 m. Drainage line impeded.
6	Subsidence cracking	RWEA C	Sinkhole on track, 30 cm deep, 50 cm wide. Cracks on side of track
7	Subsidence cracking	General surface area	Crack width 5-10 cm, length undetermined
8	Subsidence cracking	General surface area	Crack width 2 cm, length undetermined
9	Pest species	General surface area	Pigs observed

Figure 29. Subsidence and other land management observations from Spring 2021 biodiversity monitoring surveys

5.1 Remnant woodland enhancement areas

5.1.1 Subsidence observations

Subsidence cracks were noted during flora field work within RWEA C and RWEA D, within the Narrow-leaved Ironbark and Slaty Gum communities. The largest subsidence cracks were noted near flora site V11-B1, as per recent years (Photograph 32 and Photograph 33 from 2019). These cracks appeared larger in 2021, however the cracking was not having any observable significant impacts on vegetation at the current time, with the adjacent trees and shrubs surviving. A large hole was present on the edge of the track within RWEA C with undercutting of the track, and large subsidence cracks observed nearby (Photograph 34 and Photograph 35).

Photograph 32: Large subsidence cracks near flora monitoring site V11-B1 (in 2019)

Photograph 33: Large subsidence cracks near flora monitoring site V11-B1 (in 2019)

Photograph 34: Large hole on edge of track within RWEA C

Photograph 35: Large subsidence crack in RWEA C

5.1.2 Other management observations

No other significant management observations were recorded within the RWEAs.

5.1.3 Performance criteria and results

Performance criteria and findings during the 2021 monitoring for subsidence impacts are presented in Table 24, which is based on Table 20 in the *Wambo Coal Biodiversity Management Plan* (WCPL 2017). These performance criteria exclude any impacts and consequences of mining that occurred prior to February 2011 in accordance with Condition 22, Schedule 4, of Development Consent DA 305-7-2003.

Table 24: Subsidence performance measures, indicators and 2021 findings

Biodiversity feature	Performance measure	Performance indicator (WCPL 2017)	2021 findings
Wollemi National Park	Negligible subsidence impacts and environmental consequences	The performance indicators will be considered to have been exceeded if conventional vertical subsidence exceeds 20 millimetres (mm) or the limit of survey accuracy (whichever is greater) at the base of the Wollemi National Park escarpment. The performance indicators will be considered to have been exceeded if visual inspections identify cliff or rock face instability at the Wollemi National Park escarpment.	N/A - Vertical subsidence as the base of escarpment or cliff or rock face instability not inspected as part of the flora and fauna monitoring program in 2021.
Other species, populations or communities listed under the Biodiversity Conservation Act 2016 or Environmental Protection and Biodiversity Conservation Act 1999	Minor cracking and ponding of the land surface or other impact. Negligible environmental consequences.	The performance indicator will be considered to have been exceeded if annual monitoring at flora monitoring sites V6-B1c and V11-B1 or bird monitoring sites (BP14, BP16, BP20, BP21) above Longwalls 11 to 16 indicate a statistically significant downward trend or change between monitoring periods not observed at analogue/reference sites.	Bird monitoring sites above longwalls do not show a downward trend or a decrease not observed at other reference sites (Figure 30). Subsidence cracks were recorded at both sites V6-B1c and V11-B1. No significant vegetation damage was observed at these sites. Flora monitoring sites V6-B1c and V11-B1 showed an increase in the number of native species recorded, with a similar increase recorded at the reference site (Figure 31), indicating no significant effect of undermining was recorded. The same trend was also recorded across the majority of flora sites in 2021. Vegetation at these sites and in the wider area remains in relatively good condition.
Warkworth Sands Woodland Community		The Warkworth Sands Woodland Community is absent from the South Bates Underground Mine area. Monitoring and performance indicators relevant to mine subsidence in the	Area not currently undermined – no subsidence observations.

Biodiversity feature	Performance measure	Performance indicator (WCPL 2017)	2021 findings
		Warkworth Sands Woodland Community will be addressed in future revisions of the BMP prior to any extraction under the Warkworth Sands Woodland Community	
White Box, Yellow Box, Blakely's Red Gum Woodland/Grassy White Box Woodland Community		The White Box, Yellow Box, Blakely's Red Gum Woodland/Grassy White Box Woodland Community is absent from the South Bates Underground Mine area. Monitoring and performance indicators relevant to mine subsidence in the White Box, Yellow Box, Blakely's Red Gum Woodland/Grassy White Box Woodland Community will be addressed in future revisions of the BMP prior to any extraction under the White Box, Yellow Box, Blakely's Red Gum Woodland/Grassy White Box Woodland Community.	Area not currently undermined – no subsidence observations.
Central Hunter Valley Eucalypt Forest and Woodland Ecological Community		Minor cracking and ponding of the land surface or other impact. Negligible environmental consequences.	No additional observations of damage to this community beyond that described in the 2016 flora and fauna monitoring report (ELA 2016). Predominantly minor surface cracks observed.

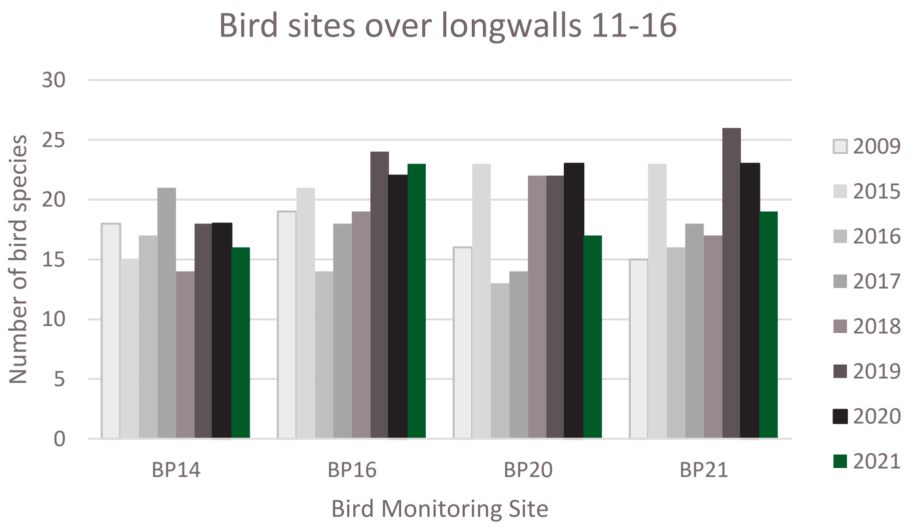

Figure 30: Total number of bird species recorded at sites located over longwalls 11 to 16 in 2009 and 2015-21

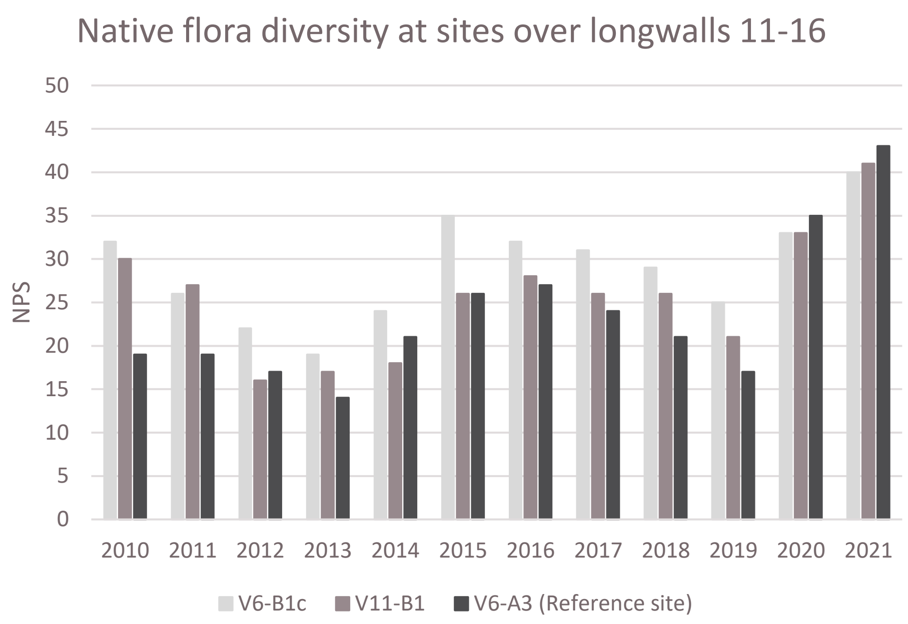

Figure 31. Average number of native flora species recorded at sites located over longwalls 11-16 and reference site 2010-2021

5.1.4 Conclusion and recommendations

Subsidence was observed in the RWEA C above Longwalls 11 to 16. Monitoring data or general observations do not indicate any exceedance of the performance criteria or any significant effects on biodiversity values at this stage, however future monitoring should continue to document and assess subsidence impacts across the site.

5.2 Rehabilitation areas and other land

The condition of rehabilitated land has been discussed in **Section 3**, however, some relevant opportunistic observations relating to land management and biodiversity were made while traversing the mine site.

Two Feral Pigs (*Sus scrofa*) were observed in the general surface area (Figure 29) and evidence of feral pig activity was recorded along Wambo Creek during the riparian assessments.

Along the North Wambo Creek Diversion erosion and subsidence issues were observed in the same or similar locations to previous years. These issues/areas are under current active management by the NSW Soil Conservation Service.

5.3 Weed issues

Environmental weeds have largely been discussed in previous sections. Exotic annual species have increased in abundance in 2021 following higher than average rainfall. Management of weeds across WCPL land should continue, particularly for priority weeds and Weeds of National Significance (WONS), to prevent their spread.

A targeted weed survey and update to Annual Weed Treatment Plan is scheduled for 2022, which will record weed issues, incorporating the results of this monitoring program, and outline proposed strategy for weed treatment in 2022 in detail.

6. Summary of management actions required

A summary of the management actions required and recommended to be undertaken by WCPL based on the results of the 2021 annual biodiversity monitoring program is provided in Table 25.

Table 25: Summary of management actions required

Area/Feature	Performance criteria	Result	Action required
RWEA A and Rail Loop	VCA Target: Exotic plant cover limits within RWEA A and Rail Loop **Targets** Rail Loop CT2: 15% RWEA A A1: 60% RWEA A A2: 15% RWEA A A3: 20%	Exotic plant cover at CT2 (Rail Loop), and A1, A2, and A3 (RWEA A) exceeded targets **Results** Rail Loop CT2: 82% RWEA A A1: 90% RWEA A A2: 20% RWEA A A3: 54%	Conduct annual weed survey and review of weed management activities success. Update Annual Weed Treatment Plan. Continue weed management in RWEA A and Rail Loop in accordance with Updated Weed Treatment Plan – increased weed management effort is recommended. Consider planting native trees in over-cleared riparian areas
RWEA A and Rail Loop	Performance target: Exotic Plant Cover (<10)	Average exotic plant cover: PCT 42 sites within RWEA A was 52.3. PCT 1658 within Rail Loop was 82.	Continue weed management in RWEA A and Rail Loop in accordance with Updated Weed Treatment Plan – increased weed management effort is recommended.
North Wambo Creek Diversion	Mining Operations Plan: No tunnel or gully erosion is to be present	Gully erosion observed in creek diversion near 23R	Current active management in progress by NSW Soil Conservation Service. Continue active management of creek diversion to encourage establishment of native species and address erosion issues.
North Wambo Creek Diversion	Mining Operations Plan: No single bare area >20m^2	Several areas of bare soil larger than 20m^2 observed along creek diversion	

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APPENDIX F

ANNUAL AQUATIC ECOSYSTEM MONITORING REPORT

Excellence in your environment

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Aquatic Ecosystem Monitoring - Spring 2021
Wambo Coal Mine

Prepared for Peabody Energy - Wambo Coal Pty Ltd | 13 December 2021

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Document control

Project number	Client	Project manager	LGA
6688	Peabody Energy/Wambo Coal Mine	Matthew Russell	Singleton

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Enquiries should be addressed to:

Sydney Head Office
Niche Environment and Heritage
02 9630 5658
info@niche-eh.com
PO Box 2443 North Parramatta
NSW 1750 Australia

Executive summary

Project outline

This report documents findings for the Spring 2021 aquatic ecosystem monitoring in relation to Wambo Coal operations in accordance with Conditions B62 and B66 of Development Application (DA) 305-7-2003 and the Biodiversity Management Plan.

The aim of the aquatic monitoring program is to assess river health of drainages occurring within the Underground Mining Lease Areas, historical open cut operations and associated infrastructure areas. The drainages include North Wambo Creek, South Wambo Creek, Waterfall Creek and Wollombi Brook.

Methods

The aquatic ecological monitoring is primarily focused on macroinvertebrate monitoring including the Australian Rivers Assessment System (AUSRIVAS). AUSRIVAS is a rapid assessment based on presence/absence of invertebrates, where macroinvertebrate samples from impact sites are compared to modelled Reference sites. AUSRIVAS was used in conjunction with SIGNAL analysis (a measure of pollution tolerance of macroinvertebrates), water quality and habitat observations to assess stream health. Overall methods consisted of:

- Aquatic habitat assessment
- Macroinvertebrate survey
- Fish sampling
- Physiochemical water quality measurements.

Results and conclusions

Although there was some variability in data, the results showed similar results to aquatic monitoring conducted in 2016. The results showed that:

- North Wambo Creek realignment remains severely to extremely impaired at some sites, however Site 13 shows signs of improved habitat complexity and macroinvertebrate diversity. Fish have not yet recruited to the pools within the stream realignment, however, crustaceans (yabbies and shrimp) and sensitive aquatic macroinvertebrates (Leptoceridae and Leptophlebiidae) were present at the site.
- South Wambo, Wollombi Brook and Waterfall Creek results were similar to 2016 monitoring results indicating there has been no substantial long term change in stream health over this time period.
- Site 11 at the Licence Discharge Point (LDP) had the highest stream health scores in Wollombi Brook and no ecological impacts from discharges were observed at this location.
- Comparison to previous survey data found no significant temporal trends that could be attributed to current catchment management. Ephemeral streams (North Wambo, South Wambo and Waterfall creeks) are particularly susceptible to variations in water availability, which in turn affect the availability of aquatic habitat and lead to changes to water quality associated with a drying system. This is exacerbated in the catchment which has been historically modified and influenced by a range of land use activities including mining and agriculture. Erosion and sediment control measures and rehabilitation works in North Wambo Creek realignment are having some localised improvements to stream condition and habitat.

Recommendations

The following recommendations are provided for the consideration of future management activity:

- Continue monitoring in accordance with the Biodiversity Management Plan.
- Continue with erosion and sedimentation control within North Wambo Creek stream realignment.
- Continue riparian revegetation and bank stabilisation works.
- Where possible, continue wider riparian management involving the revegetation of the North Wambo riparian zone using industry standard techniques and guidelines and restriction of cattle movement in the riparian zone and waterway.

Glossary and list of abbreviations

Term or abbreviation	Definition
SIGNAL	Stream Invertebrate Grade Number Average Level
DTV	Default Trigger Level
AUSRIVAS	Australian Rivers Assessment System
RCE	Riparian Channel and Environment Inventory Assessment
FM Act	*Fisheries Management Act 1994* (NSW)
DPI	The NSW Department of Primary Industries
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
Modal Width	The width which appears most often in a specified length of stream channel

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1. Introduction

1.1 Context

In November 2014, Glencore and Peabody agreed to form a 50:50 Joint Venture to develop an open cut coal mine project that combined the extraction and exploration rights for a number of mining tenements held by United Collieries Pty Limited (United) (a subsidiary of Glencore) and Wambo Coal Pty Limited (WCPL). An application to modify the Development Consent (DA 305 7 2003 MOD 16) was lodged in November 2016 to support the Joint Venture and was approved on 28 August 2019. The Mine (Wambo Coal Mine) is currently in Phase 2 operations which commenced 1 December 2020 and no longer includes open cut mining operations. Phase 2 comprises the underground mining operations at Wambo underground mine and the operation of Wambo mine infrastructure (coal processing and handling activities) within the green operational area identified in Figure 1.

The Mine includes the three following approved underground mining operations:

- North Wambo Underground (NWU) Mine (commenced in 2005 and now completed)
- South Bates Underground (SBU) Mine, including the South Bates Underground Extension (SBUE) Mine (commenced in 2014 and currently operational)
- South Wambo Underground (SWU) Mine (not yet commenced).

To satisfy relevant conditions of the DA305-7-2003, aquatic ecosystem monitoring is included in the various components of WCPL's Water Management Plan. Details of the aquatic ecosystem monitoring program are also included in the Biodiversity Management Plan (BMP), to satisfy the requirements of Conditions B62 and B66 of DA305-7-2003.

1.2 Required aquatic ecosystem monitoring

The BMP requires:

"Freshwater macro-invertebrate monitoring, including an assessment of SIGNAL A values and water quality (e.g. temperature, pH, and salinity)."

The aquatic monitoring program for Wambo Coal Mine commenced in 2016 and is to be conducted every five years in spring. The program is based on AUSRIVAS (Australian River Assessment System), a prediction system used to assess the biological health of Australian rivers. These models predict the aquatic macroinvertebrate fauna expected to occur at a site in the absence of environmental stress, such as pollution or habitat degradation, to which the fauna collected at a site can be compared. AUSRIVAS produces a biological assessment that can be used to indicate the overall ecological health of the site. AUSRIVAS is used in conjunction with SIGNAL (a measure of pollution tolerance of macroinvertebrates), water quality and habitat observations to assess stream health.

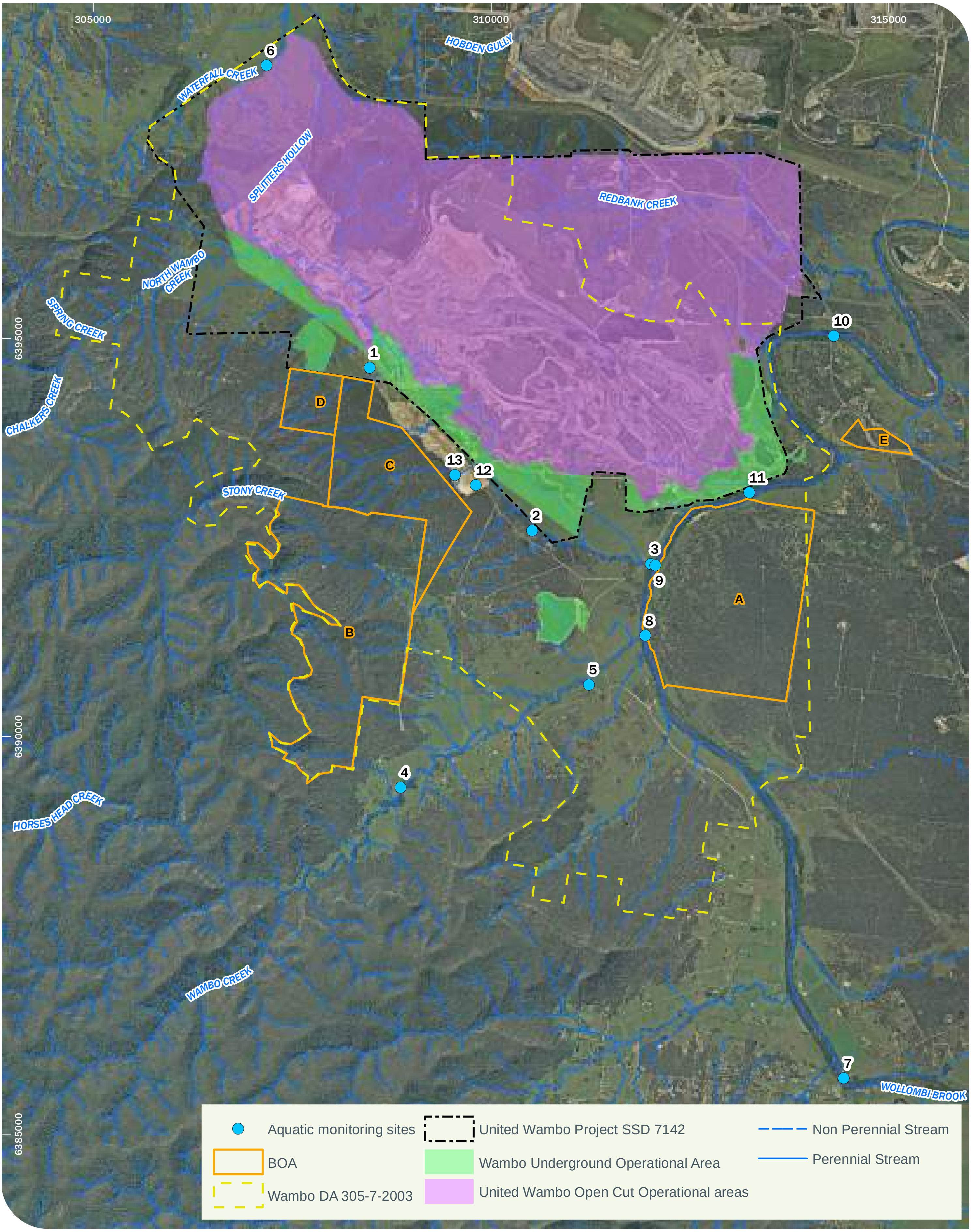
The waterways monitored include the ephemeral/intermittent streams of: North Wambo Creek, South Wambo Creek, Waterfall Creek and the perennial stream Wollombi Brook. These waterways have been potentially affected by a range of mining and agriculture activities including:

- Stream realignment (North Wambo Creek)
- Subsidence (North Wambo Creek)
- Mine water discharge (Wollombi Brook)
- Agriculture (cattle) (all water ways).

1.3 Objectives of this report

The aim of the aquatic monitoring program is to assess river health of drainages occurring within the Underground Mining Lease Areas, historical open cut operations, and associated infrastructure areas. The objectives of the monitoring program are to:

- Assess aquatic habitat
- Assess water quality against ANZG default trigger values
- Assess stream health using the AUSRIVAS model, SIGNAL and water quality results
- Discuss the results in context of the various land management impacts and the environment
- Specifically examine the condition of aquatic environs within the North Wambo Creek diversion
- Collect baseline data for future mining activities
- Suggest management actions designed to improve the condition of the aquatic environments.



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Wambo Coal operational area and aquatic monitoring sites

Wambo aquatic ecosystem monitoring

Niche PM: Matt Russell
Niche Proj. #: 6688
Client: Wambo Coal

Figure 1

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2. Methods

2.1 Study area

The Study Area and monitoring sites are shown in Figure 1. The Study Area comprises North Wambo Creek, South Wambo Creek, Waterfall Creek and Wollombi Brook.

2.2 Sampling locations

The location of monitoring sites (sampling locations) are shown in Figure 1. A total of 13 sites were sampled: five sites were in pool habitats on North Wambo Creek; one site on Waterfall Creek; two sites on South Wambo Creek, and five sites on Wollombi Brook (Table 1, Figure 1). Effort was made to ensure site independence and appropriate representation of habitat types observed within the catchment. The locations selected were constrained by access and water availability.

Table 1: Location of monitoring sites

Site number	Stream	Location	Easting	Northing
1	North Wambo	Stage 2 North Wambo	308470	6394637
2	North Wambo	Below diversion at subsidence pool	310513	6392590
3	North Wambo	At pool before confluence with Wollombi Brook	312008	6392169
4	South Wambo	Upstream Wambo site	308206	6389177
5	South Wambo	At gauge	311227	6390652
6	Waterfall Creek	Downstream pool	307175	6398438
7	Wollombi Brook	At Bulga bridge	314433	6385703
8	Wollombi Brook	At South Wambo confluence	311939	6391268
9	Wollombi Brook	At North Wambo confluence	312063	6392151
10	Wollombi Brook	Downstream bridge on Golden Highway	314308	6395036
11	Wollombi Brook	At discharge point	313248	6393066
12	North Wambo	Stage 3 diversion	309808	6393160
13*	North Wambo	Stage 3 diversion	309543	6393289

*Commenced monitoring in 2021

2.3 Aquatic habitat assessment

Visual assessment of aquatic habitat was conducted using the AUSRIVAS method. The survey is a rapid assessment to describe habitat based on the following parameters:

- Geomorphology
- Channel diversity

- Bank stability
- Riparian vegetation and adjacent land use
- Water quality
- Macrophytes
- Local impacts and land use practices.

2.4 Macroinvertebrate survey

2.4.1 AUSRIVAS

The AUSRIVAS method of sampling both pools and riffles was modified to suit site conditions, as no suitable in-stream riffle features were present. Samples were collected from pool edges for a length of 10 metres (m) either side of the pool as a continuous line or in disconnected segments. Sampling in segments was undertaken to ensure the sampling of all sub-habitats such as macrophyte beds, bank overhangs, submerged branches and root mats. Segmented sampling was also employed where pool length was short and it was logistically difficult to sample in a continuous line (e.g. due to the presence of in-stream logs). A 250 micrometre (µ/m) dip net was drawn through the water with short sweeps towards the bank to dislodge benthic fauna while scraping submerged rocks and debris, sides of the stream bank and the bed substrate. Further sweeps in the water column targeted suspended fauna.

Each sample was rinsed from the net onto a white sorting tray from which animals were picked using forceps, pipettes and/or paint brushes. Each tray was picked for a minimum period of forty minutes, after which time they were picked at ten-minute intervals for either a total of one hour or until no new specimens were found. Care was taken to collect cryptic and fast-moving animals in addition to those that were conspicuous or slow. The animals collected at each site were placed into a labelled jar containing 70% ethanol.

The chemical and physical variables required for running the AUSRIVAS predictive model were also recorded. This included: alkalinity, modal depth and width of the stream, percentage bedrock, boulder or cobble, along with latitude and longitude. Distance from stream source, altitude, land-slope and rainfall were also recorded.

2.4.2 Laboratory methods - invertebrate identification

Macroinvertebrate samples were identified to family level with the exception of Oligochaeta (to class), Polychaeta (to class), Ostracoda (to subclass), Nematoda (to phylum), Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Small crustaceans Ostrocoda, Copapoda and Cladocera were not included as part of the analysis. Identification keys used included:

- Dean, J., Rosalind, M., St Clair, M., and Cartwright, D. (2004). *Identification keys to Australian families and genera of caddis-fly larvae (Trichoptera).* Cooperative Research Centre for Freshwater Ecology.
- Gooderham, J. and Tsyrlin, E. (2002). *The Waterbug Book: A guide to the Freshwater Macroinvertebrates of Temperate Australia*. CSIRO Publishing.
- Hawking and Theischinger (1999). *A guide to the identification of larvae of Australian families and to the identification of ecology of larvae from NSW*. Cooperative Research Centre for Freshwater Ecology (Australia).
- Madden, C. (2010). *Key to genera of Australian Chironomidae.* Museum Victoria Science Reports 12,1-31.
- Madden, C. (2011). *Draft identification key to families of Diptera larvae of Australian inland waters.* La Trobe University.
- Smith, B. (1996). *Identification keys to the families and genera of bivalve and gastropod molluscs found in Australian inland waters.* Murray Darling Freshwater Research Centre.

- Murray Darling Freshwater research – Centre for freshwater research: Identification and ecology of Australian invertebrate. Website - http://www.mdfrc.org.au/bugguide/.

2.4.3 Data analysis

AUSRIVAS

Samples collected using AUSRIVAS protocol were analysed using the predictive models for NSW pool edge habitats (Turak *et al*., 2004). The AUSRIVAS model predicts the aquatic macroinvertebrate fauna expected to occur at a site in the absence of environmental stress, such as pollution or habitat degradation. The AUSRIVAS NSW autumn and spring models were used for the data collected. Observed to Expected ratio (OE50), SIGNAL (Stream Invertebrate Grade Number Average Level) and number of taxa were the indices used to interpret stream health.

OE50

The OE50 is the ratio of the number of invertebrate families observed at a site (NTC50) to the number of families expected (NTE50) at that site. Only macroinvertebrate families with a greater than 50% predicted probability of occurrence are used by the model. OE50 provides a measure of biological impairment at the test site. The OE50 ratios are divided into bands representing different levels of biological impairment (Table 2).

Table 2: AUSRIVAS band interpretation

Band	Interpretation
Band X	Represents a more biologically diverse community than reference
Band A	Is considered similar to reference condition
Band B	Represents sites significantly impaired
Band C	Represents sites in a severely impaired condition
Band D	Represents sites that are extremely impaired

SIGNAL (Stream Invertebrate Grade Number Average Level) scores

The revised SIGNAL2 biotic index developed by Chessman (2003) was also used to determine the "environmental quality" of sites. This method assigns grade numbers to each macroinvertebrate family or taxa found based largely on their response to a range of environmental conditions (Table 3). The sum of all grade numbers for that habitat is then divided by the total number of families recorded in each habitat to calculate the SIGNAL2 index. The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site. Table 4 provides a broad guide for interpreting the health of the site according to the SIGNAL2 score of the site.

Table 3: SIGNAL Grade and the Level of Pollution Tolerance

SIGNAL Grade	Pollution tolerance
10-8	Indicates a greater sensitivity to pollution
7-5	Indicates a sensitivity to pollution
4-3	Indicates a tolerance to pollution
2-1	Indicates a greater tolerance to pollution

Table 4: Guide to interpreting the SIGNAL2 scores

SIGNAL2 Score	Habitat quality
Greater than 6	Healthy habitat
Between 5 and 6	Mild pollution
Between 4 and 5	Moderate pollution
Less than 4	Severe pollution

Note: SIGNAL2 scores are indicative only and pollution does not refer to just anthropogenic pollution. Environmental stress may result in poor water quality occurring naturally in waterways. Low family richness and the occurrence of pollution-tolerant invertebrates can give a low SIGNAL score even though they are in a natural condition state.

Taxa Richness

The richness of macroinvertebrate families (or class/orders if not identified to family level) was calculated as an indicator of stream health. The higher the number, the healthier the aquatic ecosystem.

2.5 Water quality

Surface water quality was measured *in situ* using a Yeokal 611 water quality probe at each site. The following variables were measured:

- Temperature (°C)
- Conductivity (µS/cm)
- pH
- Alkalinity measured with a standard titration kit (mg $CaCO_3$/L)
- Dissolved Oxygen (DO) (% saturation L)
- Turbidity (NTU).

2.6 Fish

Fish collected by dip net sampling techniques as part of the macroinvertebrate sampling were separated from the sample *in situ* and recorded. To further sample the fish assemblage, four concertina type baitfish traps (Plate 1) were set at each site. The main aim was to detect if fish have recruited into the North Wambo stream realignment. The fish were identified and counted and returned to the water. Fish and macroinvertebrate sampling was conducted under Section 37 *Fisheries Management Act 1994*- scientific collection permit number P13/0008-1.1

Plate 1. Concertina baitfish trap

3. Results

3.1 Aquatic habitat

3.1.1 Rainfall

Field survey was conducted from 6 October 2021 to 8 October 2021. There was no rainfall during surveys however there was total of 22 millimetres (mm) rainfall the week prior to surveys. Rainfal was low during the month preceeding the surveys (a total of 27 mm in September).

In general, the presence of aquatic habitat was similar at most sites when compared to previous surveys, with perennial aquatic habitat in Wollombi Brook and intermittant and ephemeral aquatic habitat in South Wambo, North Wambo and Waterfall Creeks.

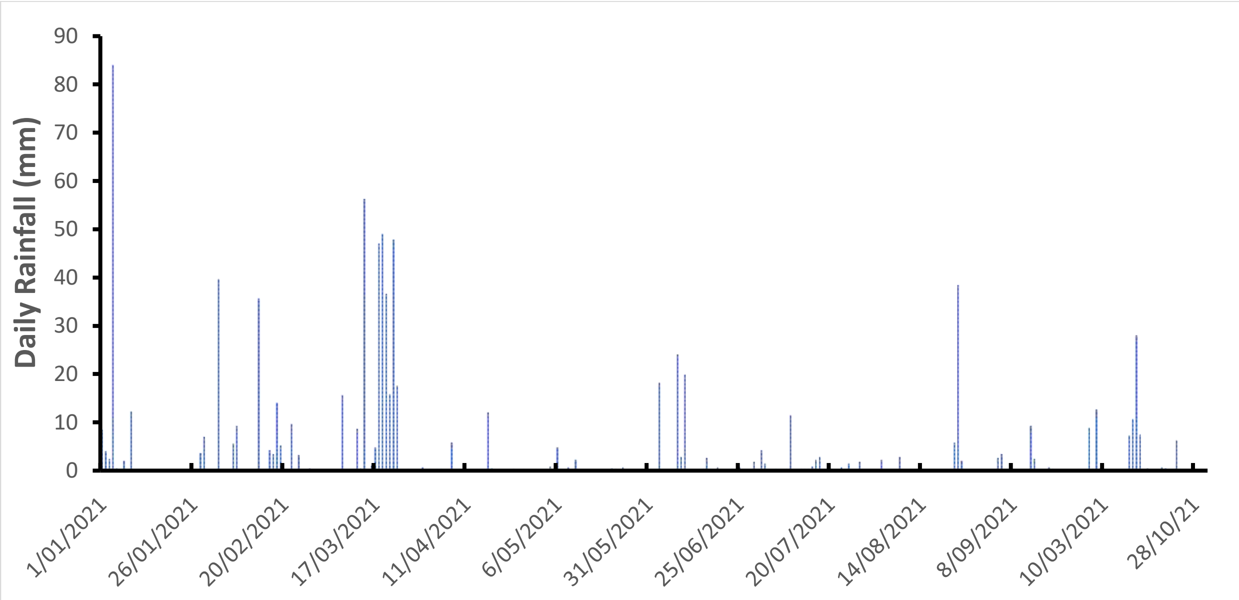

Figure 2: Daily rainfall January 2021-October 2021 (source – WCPL)

3.1.2 North Wambo Creek

North Wambo Creek sites within the stream realignment (Site 1, Site 12 and Site 13) (Plate 2A, D and E) had increased riparian vegetation and improved bank stability with areas susceptible to erosion being reshaped and lined and banks protected as part of the stream remediation works. There was limited water in the stream alignment, however pool aquatic habitat was evident in some sections of the waterway. These pools generally were shallow and turbid with limited aquatic vegetation and shading. Site 13 provided the best aquatic habitat within the stream realignment with a deeper pool and some aquatic vegetation (*Juncus* sp. and *Cyperus* sp.) and evidence of yabbies using the location. Site 2 downstream of the alignment also provided limited aquatic habitat, however, in general had healthier riparian vegetation and aquatic habitat compared to the stream alignment. Site 3 had relatively good riparian vegetation cover and provided a large pool habitat with a broad range of habitat types including undercut banks, fine sediment and rocky substrate, and aquatic vegetation including *Phragmites australis.*

A

B

C

D

E

Plate 2. North Wambo Creek. A- Site 1, B- Site 2, C- Site 3, D- Site 12, E- Site 13

3.1.3 South Wambo Creek

South Wambo Creek at Site 4 (upstream) (Plate 3A) was similar to previous surveys and provided a range of aquatic habitat (bank over hangs, fine sediment, cobbles, pebbles boulders, large woody debris, organic matter and aquatic macrophytes). The water was clear however there were high loads of organic matter and filamentous algae was also present in the benthos. Although there were several weeds (herbs and shrubs) present, the Casuarina (*Casuarina cunninghamiana*) dominated riparian vegetation was in moderate condition and provided shading to the waterway.

Site 5 (downstream) (Plate 3B) had limited aquatic habitat, with only one large pool present. The aquatic habitat there was dominated by fine sediment and coarse-grained sand. There was riparian vegetation present, however, this was limited and provided only partial shading to the waterway. The pool was clear and was up to 0.5 m deep.

A

B

Plate 3. South Wambo Creek. A- Site 4, B- Site 5

3.1.4 Waterfall Creek

Waterfall Creek is considered an ephemeral stream and has very limited aquatic habitat (Plate 4). There was one pool present at Site 6, which consisted of shallow, muddy aquatic habitat. While there were some canopy riparian vegetation trees present (Casuarina and Acacia species) these provided limited stream-bank protection and shading. There were also signs of bed and bank erosion in the waterway and evidence of cattle use.

Plate 4. Waterfall Creek. Site 6

3.1.5 Wollombi Brook

Site 7 could not be sampled as there was bridge construction at Bulga and the site could not be accessed. Of the sites that were surveyed (Site 8-11) all showed very similar aquatic habitat types. The waterway provided large pool habitat which was relatively deep in places (>1 m) and wide (approximately 15 m). The benthos was dominated by sand-sized sediment with few gravels, cobbles or boulders.

The riparian zones were in fair condition showing moderate disturbance such as the presence of weeds. The canopy was dominated by River Sheoak (*C. cunninghamiana*), with the midstory consisting of Willow (*Salix* sp) and smaller River Sheoak. Tall groundcover species included Common Rush (*Phragmites australis)* and Marsh Club-rush (*Bolboschoenus fluviatilis*). Exotic weeds were present. Vegetation cover provided a low to moderate shading of the river.

A B

C D

Plate 5. Wollombi Brook. A- Site 8, B- Site 9, C – Site 10, D – Site 11.

3.2 Water quality

Water quality results are shown in Table 5. Results showed that temperature ranged from 12.8.– 17.6°C across all the sites. Conductivity was elevated at most sites ranging from 258-1009 µ/cm, exceeding Australian and New Zealand water quality Guidelines (ANZG) Default Trigger Values (DTVs) at all but one site (Site 2). Site 3 has the highest conductivity (1009 µS/cm) (Table 5).

Turbidity exceeded DTVs at all sites except for Site 5 in South Wambo Creek and Site 11 in Wollombi Brook. However, Site 3, Site 4, Site 8 and Site 9 only marginally exceeded DTVs for turbidity (Table 5). Turbidity was highest at Site 1 and Site 6 (500 NTU) (Table 5).

Dissolved oxygen (DO) was mostly low and ranged between 40.3 - 101.2% saturation with Site 6 having the lowest results. Only Wollombi Brook (Site 10, Site 11 and Site 12) were within DTV for DO (Table 5). The pH ranged from 7.42-8.15 and most sites were within the DTVs. Site 1 and Site 12 were slightly elevated above DTVs for pH. Alkalinity was generally moderate with sites recording between 40 - 100 mg$CaCO_3$/L.

Overall, the water quality was generally consistent with values recorded on previous monitoring occasions.

Table 5: Water quality results spring 2021

Site number	Stream	Temperature (C°)	Conductivity(µS/cm)	Turbidity (NTU)	Dissolved Oxygen (% sat)	pH	Alkalinity (mg $CaCO_3$/L)
1	North Wambo	12.8	**550**	**500**	**84.5**	**8.15**	80
2	North Wambo	14.6	258	**497**	**67.6**	7.89	40
3	North Wambo	17.6	**1009**	**27.2**	**91.2**	7.45	80
4	South Wambo	14.9	**400**	**30.2**	**85.2**	7.52	40
5	South Wambo	15.1	**716**	19.3	**81.5**	7.43	40
6	Waterfall Creek	15.6	**400**	**500**	**40.3**	7.57	100
7	Wollombi Brook	*	*	*	*	*	*
8	Wollombi Brook	17.6	**715**	**26.5**	**81.8**	7.45	80
9	Wollombi Brook	17.19	**709**	**31.8**	**79.8**	7.42	80
10	Wollombi Brook	19.48	**685**	13.9	101.2	7.63	60
11	Wollombi Brook	18.91	**732**	**155.3**	100.2	7.67	100
12	North Wambo	17.25	**828**	**293.1**	100.7	**8.14**	100
13	North Wambo	15.3	**1023**	**302**	**78.9**	7.87	100

NOTES: ANZG Default Trigger Values (DTVs) for upland streams: Electrical conductivity (30-350µS/cm), Turbidity (2-25 NTU), pH (6.5-8.0), Dissolved Oxygen (90-110%). Text in bold indicates those variables that exceed the DTVs.

* Not sampled.

3.3 AUSRIVAS and SIGNAL

AUSRIVAS results for spring 2021 are presented in Table 6, with raw data provided in Annex 1.

The number of taxa observed was generally low, with most sites having fewer than 12 different taxa. The lowest was at North Wambo Creek (Site 1) however Site 2 downstream within North Wambo Creek had the highest (23). AUSRIVAS results were variable with sites scoring in Band A (similar to reference condition) to Band D (extremely impaired) (Table 6, Table 2). Sites within the North Wambo Creek (Site 1, Site 12) had the lowest OE50 scores and scored in Band C and Band D indicating poor stream health. Low scores included Waterfall Creek (Site 6) and Wollombi Brook (Site 10) which also scored in Band C. Wollombi Brook at Site 11 returned the highest score (Band A) close to reference condition, with remaining sites in Band B (significantly impaired), including Site 13 (OE50 0.59) which is in the North Wambo stream realignment.

The SIGNAL scores for all sites and seasons varied but were low and ranged between 2.4-4.33 which may indicate severe pollution or extreme environmental stress (Table 6). The low scores in general reflect the dominance of pollution-tolerant macroinvertebrates and presence of few pollution-sensitive taxa.

Despite low SIGNAL and AUSRIVAS scores indicating impaired stream health, five pollution sensitive families (SIGNAL ≥ 6) (refer to Table 3) were observed in spring 2021. These were Leptoceridae (SIGNAL 6) observed at all sites except for Site 1 (North Wambo Creek) and Site 6 (Waterfall Creek); Calamoceridae (SIGNAL 7) at North Wambo Creek (Site 4) and all Wollombi Creek sites; beetles Scirtidae (SIGNAL 6) and Elmidae (SIGNAL 8) observed at Wollombi Brook (Site 11); mayfly Leptophlebiidae (SIGNAL 8); and Leptophlebiidae present at Wambo Creek (Site 2, Site 3 and Site 13), South Wambo (Site 5), and Wollombi Brook (Site 11) (Annex 1).

Table 6: AUSRIVAS results spring 2021

Site	Stream	No of taxa	OE50	SIGNAL	Band
1	North Wambo	5	0.19	2.40	D
2	North Wambo	23	0.77	3.41	B
3	North Wambo	14	0.59	4.25	B
4	South Wambo	8	0.53	3.63	B
5	South Wambo	12	0.58	4.33	B
6	Waterfall Creek	6	0.29	3.08	C
7	Wollombi Brook	*	*	*	*
8	Wollombi Brook	12	0.53	4.00	B
9	Wollombi Brook	11	0.60	3.91	B
10	Wollombi Brook	8	0.42	4.00	C
11	Wollombi Brook	18	0.83	4.17	A
12	North Wambo	10	0.49	2.40	C
13	North Wambo	13	0.49	3.75	B
Average		11.67	0.53	3.61	

3.4 Fish

The fish sampling results are provided in Table 7. No fish were recorded in Site 1, 2, 6 and 12. Waterfall Creek (Site 6). The most dominant fish recorded was Fire Tailed Gudgeon (*Hypseleotris galii*) which was observed at Site 3, Site 5, Site 8, Site 9 and Site 12. Other fish included Flathead Gudgeon (*Philypnodon grandiceps*) and Cox's Gudgeon (*Gobiomorphus coxii*) (Site 3), Australian Smelt (*Retropinna semoni*) (Site 5) and introduced Mosquito Fish (*Gambusia holbrooki*) Site 3 and Site 5. No fish were observed in the North Wambo stream realignment; however, two large yabbies (*Cherax destructor*) were trapped at Site 13.

Table 7: Fish result from traps and dip net

Species	Sites												
	North Wambo Creek			South Wambo Creek		Waterfall Creek	Wollombi Brook					North Wambo Creek	
	1	2	3	4	5	6	7	8	9	10	11	12	13
Firetail Gudgeon *Hypseleotris galii*			74		36			2	5		2		
Flathead Gudgeon *Philypnodon grandiceps*			2										
Cox's Gudgeon *Gobiomorphus coxii*			1										
Australian Smelt *Retropinna semoni*					4								
Mosquito Fish *Gamubusia holbrooki*			1		1								

4. Discussion

4.1 Comparison to previous monitoring

There appears to have been little change in vegetation communities at all sites since when monitoring was last conducted in spring 2016. There was some regrowth of riparian vegetation in North Wambo Creek realignment, however no distinct change in communities or shading of the river was apparent. An increase in the establishment of aquatic vegetation within the stream realignment since 2016 shows some further, although limited, stream channel rehabilitation. The bank erosion that was present in spring 2016 has been reduced by the erosion control works that are underway which appear to have stabilised some areas vulnerable to erosion. Riparian vegetation in South Wambo Creek (Site 4) appears to have increased. However, this included mostly grasses and shrubs that have grown since cattle were fenced from the area.

Water quality results were consistent with ephemeral stream physicochemical characteristics and similar to past monitoring (Niche 2013, Niche 2014, Niche 2016). There were exceedances of ANZG DTVs, however this was also observed from past monitoring and unlikely the result of recent mining activity.

Overall, there appears to be a slight change in stream health based on AUSRIVAS indices that have slightly increased since the spring 2016 sampling period (Table 8). This included slight increases in average OE50 and SIGNAL score but a small decrease in average number of taxa. Sites in North Wambo Creek that had low stream health (Site 1 and Site 12) scores also showed poor stream health in 2021 indicating ongoing anthropogenic or environmental stress. Notable changes include a reduction of Site 4 (South Wambo Creek) from Band A to Band B, and an increase at Site 11 (Wollombi Brook) from Band B to Band A. However, this is likely the result of natural variation as opposed to any direct impacts from mining or improvements in catchment condition.

Table 8: Previous stream health monitoring results

		Spring 2016			Spring 2014			Spring 2013		
Site number	Stream	Band	SIGNAL	Number of taxa	Band	SIGNAL	Number of taxa	Band	SIGNAL	Number of taxa
1	North Wambo	D	2.50	4	dry	dry	dry	D	2	5
2	North Wambo	C	3.44	18	B	2.94	16	B	3.3	17
3	North Wambo	B	3.92	13	C	3.89	9	B	4.1	13
4	South Wambo	A	4.10	20	A	3.11	19	A	4.5	24
5	South Wambo	B	4.00	17	B	3.25	16	A	4.1	28
6	Waterfall Creek	C	2.67	9	dry	dry	dry	C	2	9
7	Wollombi Brook	C	4.00	8	C	4.4	5	B	4.3	12
8	Wollombi Brook	B	3.67	12	B	3.5	16	B	4.1	11
9	Wollombi Brook	B	4.18	11	C	3.36	11	B	4.2	13

		Spring 2016			Spring 2014			Spring 2013		
Site number	Stream	Band	SIGNAL	Number of taxa	Band	SIGNAL	Number of taxa	Band	SIGNAL	Number of taxa
10	Wollombi Brook	C	4.33	9	B	3.31	13	B	4.4	13
11	Wollombi Brook	B	3.94	16	C	3	9	-	-	-
12	North Wambo	D	2.33	3	B	2.7	15	-	-	-
Average		Average O/E50: 0.5	3.59	11.7	Average O/E50 0.548	3.34	12.9	Average O/E50 0.654	3.7	14.4

Low SIGNAL scores may indicate severe pollution of the waterway (Gooderham J and Tsyrlin E 2002); however, this index is based upon the pollution tolerance of invertebrate communities, which may naturally (or pre-mining) inhabit these streams. Therefore 'pollution' to some extent is likely to be natural (e.g. the natural drying cycles and water quality changes associated with ephemeral streams) as discussed in Niche (2013, 2014) as opposed to pollution caused by a specific management action/activity.

Fish communities in general were similar to past surveys however there was one Cox's Gudgeon found at Site 3 and Australian Smelt observed at Site 5. Surveys conducted in 2013 (Niche 2013) found that North Wambo Creek below the stream alignment (Site 2) contained Firetail Gudgeon and Flathead Gudgeon however no fish were observed in monitoring conducted in 2016 (Niche 2016). There were no fish observed in this location in spring 2021. This could be the result of persistent lack of habitat in this area that has been previously impacted by subsidence.

4.2 North Wambo Creek

The ephemeral nature of this stream (i.e. the natural variation in flow) is the controlling factor determining the invertebrates found at this location, however sedimentation from previous land use and input from the stream diversion, is likely to exert some influence on community composition. North Wambo sites below the diversion scored in Band B, while within the diversion, Site 1 and Site 12 scored in Band C and D respectively and Site 13 scored in Band B. Site 13 may show an increasing complexity in aquatic community. While Site 1 and Site 12 had mostly pollution-tolerant worms, beetles (Coleoptera), bugs (Hemiptera) and flies (Diptera), Site 13 included several large yabbies (*Cherax destructor*), freshwater shrimp (Atyidae), and the pollution-sensitive caddis fly (Leptoceridae- SIGNAL 6), as well as mayflies Baetidae, Caenidae and pollution-sensitive (Leptophlebiidae- SIGNAL 8).

Niche (2016) predicted that with pool retention, successional changes of associated flora and fauna are likely to progress as the creek system matures following revegetation and increased aquatic habitat complexity. This will likely result in increases in the number of macroinvertebrate families, at different stages of their lifecycle in the long term. This succession may potentially include native fish (Firetail Gudgeon) that potentially could recruit from downstream pool refugia to long-standing pool habitat once habitat is suitable. Niche (2016) also considered that in light of the catchment condition, it is reasonable to expect a stream health below reference quality (particularly within the stream diversion), with realistic long-term expectations of aquatic health likely to be aligned with Band B.

Macrophyte habitat improvement was limited, and no fish has yet been detected in the realignment, however the spring 2021 Site 13 results show that this level of stream health (Band B) can be achieved. It is expected that recovery of stream health will be a slow process and take a minimum of ten years to recover to a level comparable to pre- realignment condition and will require ongoing retention of pool habitat to facilitate long term improvement in-stream health.

4.3 South Wambo Creek

Upstream South Wambo Creek (Site 4) AUSRIVAS results showed impairment to stream health (Band B). This was a decrease from the 2016 monitoring results (Band A – close to reference condition). This change could be the result of natural or sampling variation and is not considered indicative of a major long-term change in stream health. Downstream at the gauge (Site 5) the site was restricted to an isolated pool with limited aquatic habitat. In 2013 the site was flowing and scored in Band A (Niche 2016) and was not flowing in 2016 and scored in Band B. The latter observation and result were similarly observed in 2021 monitoring. Despite there being an isolated pool at the site, several native Firetail Gudgeon and Australian Smelt were observed, indicating the ability of an isolated pool to support and provide refuge to a higher trophic level of aquatic fauna.

4.4 Waterfall Creek

The site within Waterfall Creek scored in Band D indicating severe impairment at the site, which is consistent with the obvious dry and poor channel condition of the waterway. This site is affected by having little to no flow, erosion, limited riparian vegetation and cattle which use the waterway.

4.5 Wollombi Brook

Wollombi Brook stream health is variable between sites and within sites over time. In 2021 Wollombi Brook has shown signs of good stream health (comparable to reference condition) and of impairment (i.e. not close to reference condition) scoring in either Band A to Band C. These results are expected considering the historical long-term agricultural land-use impacts to its catchment and natural variability. Wambo Coal Mine is unlikely the cause of this stream's poor or variable condition particularly since the upstream site, Site 7, has historically had similar impaired AUSRIVAS scores (Niche 2013, 2016). Site 11 showed an increase in stream health which scored in Band A. This may indicate that discharge from the LDP (75 ML discharged 23 March 21 to 25 March 2021 into Wollombi Brook) has not impacted the aquatic fauna at this location.

5. Conclusion

Although there is some variability in data, the results showed similar results to aquatic monitoring conducted in 2016. The results showed that:

- The North Wambo Creek realignment remains severely to extremely impaired at some sites, however Site 13 shows signs of improved habitat complexity and macroinvertebrate diversity. Fish have not yet recruited to the pools within the stream realignment; however, crustaceans (yabbies and shrimp) and sensitive aquatic macroinvertebrates (Leptoceridae and Leptophlebiidae) were present at the site.
- South Wambo, Wollombi Brook and Waterfall Creek results were similar to 2016 monitoring results indicating there has been no substantial long term change in stream health over this time period.
- Site 11 at the LDP had the highest stream health scores in Wollombi Brook and no ecological impacts were observed at this location.
- Comparison to previous survey data found no notable temporal trends that may be attributed to current catchment management. Ephemeral streams (North Wambo, South Wambo and Waterfall Creeks) are particularly susceptible to variations in water availability, which in turn affect the availability of aquatic habitat and lead to changes to water quality associated with a drying system. This is exacerbated in the catchment which has been historically modified and influenced by a range of land-use activities from mining and agriculture. Erosion and sediment control measures and rehabilitation works in North Wambo Creek realignment are having some localised improvements to stream condition and habitat.

It is recommended to:

- Continue monitoring in accordance with the Biodiversity Management Plan.
- Continue with erosion and sedimentation control within North Wambo stream realignment.
- Continue riparian revegetation and bank stabilisation works.
- Continue wider riparian management involving the revegetation of the North Wambo riparian zone using industry standard techniques and guidelines, and restriction of cattle movement in the riparian zone and waterway.

6. References

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Websites:

http://ausrivas.ewater.com.au/

http://www.mdfrc.org.au/bugguide/

Annex 1: Macroinvertebrates results

AUSRIVAS Spring 2021

SITE	1	2	3	4	5	6	7	8	9	10	11	12	13
Taxa													
Nematoda	0	1	0	0	0	0	0	0	0	0	0	0	0
Lymnaeidae	0	1	0	0	0	0	0	0	0	0	0	0	0
Pyralidae	0	1	0	0	0	0	0	0	0	0	0	0	0
Oligochaeta	0	0	1	0	0	7	0	0	0	1	0	3	1
Acarina	0	0	3	0	0	0	0	3	10	5	8	0	0
Cladocera	0	9	2	0	0	16	0	0	0	0	0	0	0
Atyidae	0	2	9	4	3	0	0	6	14	11	8	0	14
Parastacidae	0	2	0	0	0	0	0	0	0	0	0	2	1
Dytiscidae	6	19	0	5	5	9	0	4	0	2	1	3	15
Gyrinidae	0	0	0	1	4	0	0	2	0	0	0	0	0
Elmidae	0	0	0	0	0	0	0	0	0	0	1	0	0
Hydrophilidae	0	2	0	0	0	0	0	0	1	0	0	4	0
Hydraenidae	2	3	0	2	0	0	0	0	0	0	4	4	3
Scirtidae	0	0	0	0	0	0	0	0	0	0	1	0	0
Tipulidae	0	1	0	0	0	0	0	0	0	0	0	0	0
Stratiomiyidae	0	0	0	0	0	0	0	0	0	0	1	0	0
Culicidae	19	3	0	0	0	0	0	0	0	0	2	30	0
Ceratopogonidae	0	0	0	0	1	0	0	2	0	0	0	0	0
Tanypodinae	0	1	1	5	16	3	0	2	3	0	6	1	3
Orthocladiinae	0	1	0	2	0	0	0	0	0	0	0	0	0
Chironominae	0	0	18	48	11	8	0	8	4	0	2	2	1
Baetidae	0	1	0	0	1	0	0	0	0	0	1	0	2

SITE	1	2	3	4	5	6	7	8	9	10	11	12	13
Leptophlebiidae	0	5	2	0	14	0	0	0	0	0	1	0	7
Caenidae	1	7	18	0	20	0	0	5	27	8	7	0	3
Veliidae	0	2	0	0	0	0	0	0	0	0	2	0	0
Corixidae	1	13	1	0	0	0	0	0	6	0	0	1	0
Notonectidae	0	11	0	0	0	0	0	0	0	0	0	3	13
Pleidae	0	1	0	0	0	0	0	0	0	0	0	0	0
Coenagrionidae	0	4	9	0	0	1	0	7	4	2	5	0	0
Isostictidae	0	0	2	0	0	0	0	2	0	0	1	0	0
Hemicorduliidae	0	4	0	0	2	0	0	0	0	0	0	0	1
Ecnomidae	0	0	1	0	1	0	0	0	3	0	0	0	0
Calamoceratidae	0	0	4	0	0	0	0	4	1	1	1	0	0
Leptoceridae	0	1	25	3	12	0	0	14	2	12	32	0	4

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Contact Us

Niche Environment and Heritage
02 9630 5658
info@niche-eh.com

NSW Head Office – Sydney
PO Box 2443 North Parramatta
NSW 1750 Australia

QLD Head Office – Brisbane
PO Box 540 Sandgate
QLD 4017 Australia

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Terrestrial
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Research and monitoring
Wildlife Schools and training

Heritage management
Aboriginal heritage
Historical heritage
Conservation management
Community consultation
Archaeological, built and landscape values

Environmental management and approvals
Impact assessments
Development and activity approvals
Rehabilitation
Stakeholder consultation and facilitation
Project management

Environmental offsetting
Offset strategy and assessment (NSW, QLD, Commonwealth)
Accredited BAM assessors (NSW)
Biodiversity Stewardship Site Agreements (NSW)
Offset site establishment and management
Offset brokerage
Advanced Offset establishment (QLD)

APPENDIX G

SURFACE WATER MONITORING DATA SUMMARY

Site	Date	pH	EC (µS/cm)	TSS (mg/L)	Comments
SW01	5 Jan	6.86	163	37	-
SW01	3 Feb	7.08	570	<5	-
SW01	15 Feb	7.28	409	6	-
SW01	19 Mar	7.29	386	8	-
SW01	27 April	7.17	518	8	-
SW01	25 May	7.19	594	<5	-
SW01	9 June	7.07	640	34	-
SW01	30 July	7.17	608	7	-
SW01	25 Aug	7.2	720	<5	Slow flow
SW01	24 Sep	7.2	638	7	-
SW01	13 Oct	7.29	737	<5	-
SW01	11 Nov	7.18	847	9	Suspended fines
SW01	22 Nov	7.15	527	6	Suspended fines
SW01	29 Nov	6.87	392	7	Suspended fines
SW01	9 Dec	7.05	174	25	-
SW02	5 Jan	6.8	187	43	-
SW02	15 Jan	7.2	355	<5	-
SW02	29 Jan	7.37	501	<5	-
SW02	3 Feb	7.3	518	<5	-
SW02	15 Feb	7.35	490	<5	-
SW02	15 Mar	7.28	395	<5	-
SW02	19 Mar	7.25	386	8	-
SW02	27 Apr	7.1	526	6	-
SW02	25 May	7.26	578	<5	-
SW02	9 June	7.36	627	9	-
SW02	23 June	-	597	-	-
SW02	8 July	-	635	-	-
SW02	30 July	7.4	643	<5	-
SW02	25 Aug	7.4	666	<5	Slow flow
SW02	9 Sep	-	507	-	Moderate flow
SW02	24 Sep	7.36	593	7	-
SW02	8 Oct	-	651	-	-
SW02	13 Oct	7.4	654	<5	Trickle
SW02	11 Nov	7.4	700	15	-
SW02	22 Nov	7.25	502	8	-
SW02	29 Nov	6.9	321	6	-
SW02	9 Dec	7.18	308	19	-
SW03	05 Jan	6.8	204	42	-
SW03	03 Feb	7.2	528	<5	-
SW03	15 Feb	7.28	466	5	-
SW03	15 Mar	7.2	390	12	-
SW03	19 Mar	7.1	294	16	-
SW03	27 Apr	7.2	520	<5	-
SW03	25 May	7.25	580	<5	-

Site	Date	pH	EC (µS/cm)	TSS (mg/L)	Comments
SW03	09 Jun	7.3	630	10	-
SW03	30 Jul	7.29	650	6	-
SW03	25 Aug	7.3	677	<5	Slow flow
SW03	24 Sep	7.35	610	10	-
SW03	13 Oct	7.38	668	<5	-
SW03	11 Nov	7.26	704	14	-
SW03	22 Nov	7.2	487	8	Suspended fines
SW03	29 Nov	6.98	388	7	-
SW03	09 Dec	7.08	263	28	suspended solids and fines
SW04	05 Jan	7.1	217	<5	-
SW04	03 Feb	-	-	-	No flow (pool)
SW04	15 Feb	-	-	-	No flow (dry)
SW04	15 Mar	-	-	-	No flow
SW04	19 Mar	-	-	-	Unsafe access
SW04	27 Apr	-	-	-	No flow
SW04	25 May	-	-	-	Dry
SW04	09 Jun	-	-	-	Pool - No Flow
SW04	30 Jul	-	-	-	Dry
SW04	25 Aug	-	-	-	Dry
SW04	24 Sep	-	-	-	Dry
SW04	13 Oct	-	-	-	No flow
SW04	11 Nov	-	-	-	No flow
SW04	22 Nov	-	-	-	No flow
SW04	29 Nov	7.19	256	<5	-
SW04	09 Dec	7.46	246	9	Suspended fines
SW05	05 Jan	6.98	195	97	-
SW05	03 Feb	-	-	-	No flow (pool)
SW05	15 Feb	-	-	-	No flow (pool)
SW05	15 Mar	-	-	-	No flow
SW05	19 Mar	7.1	186	285	-
SW05	27 Apr	-	-	-	No flow
SW05	25 May	-	-	-	Dry
SW05	09 Jun	-	-	-	Pool - No Flow
SW05	30 Jul	-	-	-	Dry
SW05	25 Aug	-	-	-	Dry
SW05	24 Sep	-	-	-	Dry
SW05	13 Oct	-	-	-	No flow
SW05	11 Nov	-	-	-	No flow
SW05	22 Nov	-	-	-	No flow
SW05	29 Nov	6.9	377	14	-
SW05	09 Dec	7.36	178	118	-
SW06	05 Jan	6.67	184	62	-
SW06	03 Feb	6.8	496	5	-
SW06	15 Feb	7	475	<5	-
SW06	15 Mar	7	316	<5	-

Site	Date	pH	EC (µS/cm)	TSS (mg/L)	Comments
SW06	19 Mar	6.86	180	20	-
SW06	27 Apr	6.95	429	<5	-
SW06	25 May	7	448	<5	Suspended fines
SW06	09 Jun	7.1	444	12	-
SW06	30 Jul	7.2	428	<5	-
SW06	25 Aug	7.2	402	<5	Slow flow
SW06	24 Sep	7.29	440	<5	-
SW06	13 Oct	7.3	408	<5	-
SW06	11 Nov	6.9	169	6	-
SW06	22 Nov	6.87	152	7	Suspended fines
SW06	29 Nov	6.73	160	<5	-
SW06	09 Dec	6.97	127	15	Suspended fines
SW07	05 Jan	6.7	191	50	-
SW07	03 Feb	7.28	540	<5	-
SW07	15 Feb	7.58	578	<5	-
SW07	15 Mar	7.4	524	<5	-
SW07	19 Mar	6.92	183	22	-
SW07	27 Apr	7.4	509	<5	-
SW07	25 May	7.4	560	<5	Suspended fines
SW07	09 Jun	7.4	567	7	-
SW07	23 Jun	-	567	-	-
SW07	08 Jul	-	598	-	-
SW07	30 Jul	7.29	612	<5	-
SW07	25 Aug	7.36	583	8	Slow flow
SW07	09 Sep	-	655	-	Slow flow
SW07	24 Sep	7.2	671	<5	-
SW07	08 Oct	-	665	-	Slow flow
SW07	13 Oct	7.3	515	10	Trickle
SW07	11 Nov	7.26	387	20	-
SW07	22 Nov	7.18	266	20	Suspended fines
SW07	29 Nov	7	205	<5	-
SW07	09 Dec	-	-	-	Unsafe access
SW08	05 Jan	6.7	199	25	-
SW08	15 Jan	7.19	304	<5	-
SW08	29 Jan	7	370	<5	-
SW08	03 Feb	7	377	<5	-
SW08	15 Feb	7.07	431	<5	-
SW08	15 Mar	6.9	590	<5	-
SW08	19 Mar	-	-	-	Unsafe access
SW08	27 Apr	7.6	2240	<5	EC checked
SW08	25 May	7.5	4240	<5	EC checked
SW08	09 Jun	7.66	4530	11	-
SW08	23 Jun	-	4720	-	-
SW08	08 Jul	-	4800	-	-

Site	Date	pH	EC (µS/cm)	TSS (mg/L)	Comments
SW08	30 Jul	7.4	4970	7	-
SW08	25 Aug	7.47	5100	<5	Slow flow
SW08	09 Sep		5320		Trickle, suspended solids
SW08	24 Sep	-	-	-	Dry
SW08	08 Oct	-	-	-	Dry
SW08	13 Oct	7.6	5080	<5	Trickle
SW08	11 Nov	7.66	3670	<5	pH and EC checked
SW08	22 Nov	7.2	472	<5	Suspended solids
SW08	29 Nov	7.09	324	<5	-
SW08	09 Dec	7.27	265	12	Suspended fines
SW12	18 Jan	8.8	2510	32	-
SW12	22 Feb	8.87	2820	38	-
SW12	31 Mar	8.46	1343	31	-
SW12	19 Apr	8.6	4530	11	-
SW12	18 May	8.8	6520	10	-
SW12	23 Jun	8.68	3490	18	-
SW12	21 Jul	8.87	4850	20	-
SW12	17 Aug	8.77	6660	<5	-
SW12	14 Sep	8.8	6430	14	-
SW12	20 Oct	8.8	5950	30	-
SW12	16 Nov	8.7	1894	20	-
SW12	15 Dec	8.8	3300	18	-
SW27a	05 Jan	7.3	202	62	-
SW14	18 Jan	9.3	531	6	-
SW14	22 Feb	8.94	515	6	-
SW14	31 Mar	9.0	446	64	-
SW14	19 Apr	7.87	454	9	-
SW14	18 May	8.2	690	<5	-
SW14	23 Jun	8.5	665	<5	-
SW14	21 Jul	8.57	672	<5	-
SW14	17 Aug	8.6	708	<5	-
SW14	14 Sep	8.8	697	7	-
SW14	20 Oct	8.65	738	<5	-
SW14	16 Nov	8.56	610	5	-
SW14	15 Dec	7.96	548	10	-
SW14	18 Jan	9.3	531	6	-
SW14	22 Feb	8.9	515	6	-
SW14	31 Mar	9	446	64	-
SW14	19 Apr	7.87	454	9	-
SW14	18 May	8.2	690	<5	-
SW14	23 Jun	8.5	665	<5	-
SW15	18 Jan	8.96	5650	8	-
SW15	22 Feb	8.77	5960	15	-
SW15	31 Mar	9.06	2360	44	-
SW15	19 Apr	8.69	4360	20	-

Site	Date	pH	EC (µS/cm)	TSS (mg/L)	Comments
SW15	18 May	8.68	5210	<5	-
SW15	23 Jun	8.7	5450	9	-
SW15	21 Jul	8.75	6190	14	-
SW15	17 Aug	8.7	5810	9	-
SW15	14 Sep	8.79	5150	15	-
SW15	20 Oct	8.8	6130	10	-
SW15	16 Nov	8.88	5120	54	-
SW15	15 Dec	8.68	4670	26	-
SW15	05 Jan	8.96	4320	80	-
SW15	03 Feb	8.87	6610	38	-
SW15	15 Feb	8.79	5460	16	-
SW15	15 Mar	8.65	5470	55	-
SW15	19 Mar	8.69	5110	69	-
SW15	31 Mar	8.69	2360	44	-
SW15	19 Apr	8.68	4360	20	-
SW15	18 May	8.7	5210	<5	-
SW15	09 Jun	8.8	4790	333	-
SW15	23 Jun	8.75	5450	9	-
SW15	25 Aug	8.75	5750	41	-
SW15	13 Oct	8.7	6190	31	-
SW15	11 Nov	8.8	5770	52	-
SW15	22 Nov	8.69	4970	39	-
SW15	29 Nov	8.66	4180	29	-
SW15	09 Dec	7.56	4550	14	-
SW15	23 Jun	8.7	5450	25	-
SW15	21 Jul	8.68	6090	13	-
SW15	17 Aug	8.79	5810	12	-
SW15	14 Sep	8.8	5160	16	-
SW15	20 Oct	8.87	6140	9	-
SW15	16 Nov	8.69	5040	75	-
SW15	15 Dec	8.8	4700	76	-
SW15	23 Jun	8.7	5460	15	-
SW15	21 Jul	8.68	6130	14	-
SW15	17 Aug	8.79	5810	10	-
SW15	14 Sep	8.8	5150	17	-
SW15	20 Oct	8.87	6150	12	-
SW15	16 Nov	8.67	5030	2440	-
SW15	15 Dec	8.76	4700	30	-
SW27a	05 Jan	7.3	202	25	-
SW27a	03 Feb	-	-	-	No flow (pool)
SW27a	15 Feb	-	-	-	No flow (pool)
SW27a	15 Mar	7.98	801	91	-
SW27a	19 Mar	-	-	-	Unsafe access
SW27a	27 Apr	-	-	-	Dry / pool
SW27a	25 May	-	-	-	Dry

Site	Date	pH	EC (µS/cm)	TSS (mg/L)	Comments
SW27a	09 Jun	7.8	573	210	-
SW27a	30 Jul	-	-	-	Dry
SW27a	25 Aug	7.9	825	34	Trickle
SW27a	24 Sep	-	-	-	Unable to access due to construction
SW27a	13 Oct	7.9	756	46	-
SW27a	11 Nov	7.8	565	134	-
SW27a	22 Nov	7.86	765	71	-
SW27a	29 Nov	7.58	278	12	-
SW27a	09 Dec	7.48	246	61	Suspended fines
SW31	18 Jan	9.0	3510	50	-
SW31	22 Feb	8.78	5790	22	-
SW31	31 Mar	8.7	1039	13	-
SW31	19 Apr	9	4350	36	-
SW31	18 May	9.1	5700	10	-
SW31	23 Jun	8.97	5780	26	-
SW31	21 Jul	8.8	4580	14	-
SW31	17 Aug	8.9	3880	30	-
SW31	14 Sep	8.96	4030	89	-
SW31	20 Oct	9.0	6200	46	-
SW31	16 Nov	8.99	3710	320	-
SW31	15 Dec	8.91	3460	1380	-
SW31	18 Jan	9.0	3510	50	-
SW31	22 Feb	8.78	5790	22	-
SW31	31 Mar	8.7	1039	13	-
SW31	19 Apr	9.0	4350	36	-
SW31	18 May	9.1	5700	10	-
SW31	23 Jun	8.97	4780	26	-
SW32a	05 Jan	7.2	202	110	-
SW32a	03 Feb	-	-	-	No flow (pool)
SW32a	15 Feb	-	-	-	No flow (pool)
SW32a	15 Mar	7.68	566	172	-
SW32a	19 Mar	-	-	-	Unsafe access
SW32a	27 Apr	-	-	-	Dry
SW32a	25 May	-	-	-	Dry
SW32a	09 Jun	-	-	-	Dry
SW32a	30 Jul	-	-	-	Dry
SW32a	25 Aug	7.88	727	38	Trickle
SW32a	24 Sep	-	-	-	Dry
SW32a	13 Oct	7.9	683	45	-
SW32a	11 Nov	7.66	461	393	-
SW32a	22 Nov	7.8	836	80	-
SW32a	29 Nov	7.5	279	12	-
SW32a	09 Dec	7.57	246	70	-
SW38	18 Jan	9.1	5230	7	-

Site	Date	pH	EC (µS/cm)	TSS (mg/L)	Comments
SW38	22 Feb	8.98	5650	<5	-
SW38	31 Mar	8.86	2060	35	-
SW38	19 Apr	8.7	2230	19	-
SW38	18 May	8.	3700	<5	-
SW38	23 Jun	8.79	4090	17	-
SW38	21 Jul	8.8	4640	15	-
SW38	17 Aug	8.87	5120	16	-
SW38	14 Sep	9	5700	28	-
SW38	20 Oct	8.99	5630	15	-
SW38	16 Nov	8.9	2210	32	-
SW38	15 Dec	8.67	1492	22	-
SW39	05 Jan	-	-	-	Pool - no flow
SW39	03 Feb	-	-	-	No flow (pool)
SW39	15 Feb	-	-	-	No flow (pool)
SW39	15 Mar	-	-	-	No flow
SW39	19 Mar	7.3	139	382	-
SW39	27 Apr	-	-	-	Dry
SW39	25 May	-	-	-	Dry
SW39	09 Jun	-	-	-	Pool - No Flow
SW39	30 Jul	-	-	-	Dry
SW39	25 Aug	-	-	-	Dry
SW39	24 Sep	-	-	-	Dry
SW39	13 Oct	-	-	-	No flow
SW39	11 Nov	-	-	-	No flow
SW39	22 Nov	-	-	-	No flow
SW39	29 Nov	-	-	-	No flow
SW39	09 Dec	7.48	119	20	-
SW40	05 Jan	6.89	180	42	-
SW40	03 Feb	7.25	516	<5	-
SW40	15 Feb	7.2	463	<5	-
SW40	15 Mar	7.28	385	<5	-
SW40	19 Mar	6.65	66	76	-
SW40	27 Apr	7.28	511	5	-
SW40	25 May	7.3	570	<5	-
SW40	09 Jun	7.39	625	9	-
SW40	30 Jul	7.4	640	8	-
SW40	25 Aug	7.36	542	10	Slow flow
SW40	24 Sep	7.3	611	6	-
SW40	13 Oct	7.28	356	8	-
SW40	11 Nov	7.2	426	26	-
SW40	22 Nov	7.1	404	9	-
SW40	29 Nov	6.97	414	8	-
SW40	09 Dec	7.08	237	24	-
SW41	05 Jan	7.38	139	35	-
SW41	03 Feb	7.16	178	36	-

Site	Date	pH	EC (µS/cm)	TSS (mg/L)	Comments
SW41	15 Feb	-	-	-	No flow (pool)
SW41	15 Mar	-	-	-	No flow
SW41	19 Mar	7.4	173	30	-
SW41	27 Apr	-	-	-	No flow
SW41	25 May	-	-	-	Dry
SW41	09 Jun	-	-	-	Pool - No Flow
SW41	30 Jul	-	-	-	Pool - No Flow
SW41	25 Aug	7.33	185	22	Slow flow
SW41	24 Sep	-	-	-	Pool, no flow
SW41	13 Oct	-	-	-	No flow
SW41	11 Nov	-	-	-	No flow
SW41	22 Nov	-	-	-	No flow
SW41	29 Nov	-	-	-	No flow
SW41	09 Dec	-	-	-	Unsafe access
SW51	18 Jan	7.84	368	101	-
SW51	22 Feb	8.36	511	169	-
SW51	31 Mar	7.69	193	142	-
SW51	19 Apr	8.08	278	50	-
SW51	18 May	8.1	396	42	-
SW51	23 Jun	8.27	409	78	-
SW51	21 Jul	8.3	478	40	-
SW51	17 Aug	8.28	529	44	-
SW51	14 Sep	8.4	546	89	Brown
SW51	20 Oct	8.1	533	112	-
SW51	16 Nov	8	180	609	-
SW51	15 Dec	8.2	286	138	-
US FM1	05 Jan	7.2	218	15	-
US FM1	03 Feb	7.4	380	<5	-
US FM1	15 Feb	7.39	419	<5	-
US FM1	15 Mar	7.48	426	<5	-
US FM1	19 Mar	-	-	-	Unsafe access
US FM1	27 Apr	7.4	417	<5	-
US FM1	25 May	7.4	497	<5	-
US FM1	09 Jun	7.4	513	8	-
US FM1	30 Jul	7.16	622	<5	-
US FM1	25 Aug	7.1	636	<5	Slow flow
US FM1	24 Sep	7.07	696	<5	-
US FM1	13 Oct	6.85	688	<5	-
US FM1	11 Nov	6.88	740	<5	-
US FM1	22 Nov	7.47	334	<5	-
US FM1	29 Nov	7.34	222	<5	Suspended fines
US FM1	09 Dec	7.36	189	12	-

APPENDIX H

ANNUAL STREAM FLOW MONITORING REPORT

AECOM Australia Pty Ltd
17 Warabrook Boulevard
Warabrook NSW 2304
PO Box 73
Hunter Region MC NSW 2310
Australia
www.aecom.com

+61 2 4911 4900 tel
+61 2 4911 4999 fax
ABN 20 093 846 925

25 March 2022

Commercial-in-Confidence

Nicole Dobbins
Environmental Advisor
Wambo Coal Pty Ltd.
ABN: 13 000 668 057
PMB 1
Singleton NSW 2330

Dear Nicole,

Report on stream flow events along North Wambo, South Wambo and Stoney Creeks for the period 1 January to 31 December 2021.

Please find contained within this report a summary of probable flow events which occurred along North Wambo, South Wambo and Stony Creeks from and inclusive of 1 January to 31 December 2021.

1.0 Locations, Configurations and Observations

The flow monitoring network now comprises of eleven flow monitoring stations. These flow monitoring stations are distributed along the following creeks: -

- North Wambo Creek has five flow monitoring stations;
- South Wambo Creek has three flow monitoring stations, and;
- Stony Creek has two monitoring stations with an additional flow monitoring station located on a major tributary to Stony Creek.

Details of the location (**Table 1, Table 2, Figure 1** and **Figure 2**), configuration (**Table 3**) and observations (**Table 4**) for each flow monitoring station are provided below.

Table 1 Flow Station Locations

Station ID	Location	Easting	Northing
FM1	North Wambo Creek adjacent to the mine	307014	6396139
USFM1	North Wambo Creek upstream of mine	305257	6395201
FM2	Midway along old North Wambo Creek diversion	308217	6395056
FM3	Midway along new North Wambo Creek diversion	309226	6393663
FM4	North Wambo Creek upstream of the confluence of Wollombi Brook	311906	6392160
FM15	South Wambo Creek upstream of the confluence of Wollombi Brook	311814	6391224
FM16	South Wambo Creek upstream of washout of Wambo Mine Road	311279	6390673
FM9	South Wambo Creek downstream	308666	6389176
FM12	Stony Creek upstream of proposed area to be mined	307711	6392744
FM14	Major tributary of Stony Creek upstream of proposed area to be mined	307723	6392242
FM13	Stony Creek downstream of proposed area to be mined	309537	6391090

Table 2 Atmospheric Pressure Correcting Station Locations

Station ID	Location	Easting	Northing
PM2	Midway along old North Wambo Creek diversion at Flow Station FM2 data logging housing	308196	6395042
PM6	South Wambo Creek upstream of washout of Wambo Mine Road inside the data logger housing for old Flow Station FM6	311253	6390711
PM8	Stony Creek upstream on the old Flow Station FM8 infrastructure	307996	6392278
PM7	Stony Creek downstream on the old Flow Station FM7 infrastructure	309400	6391443

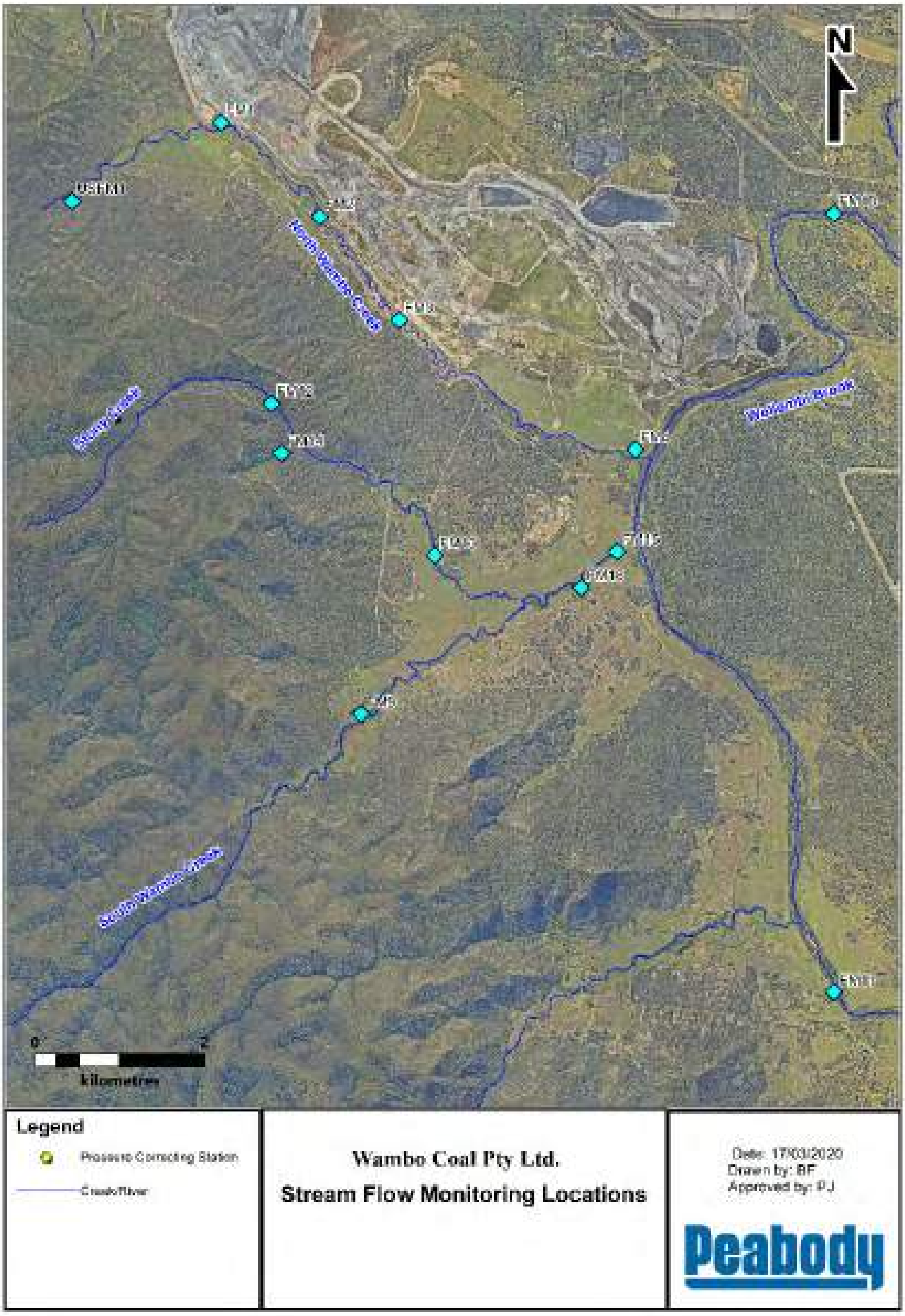

Figure 1 **Stream Flow Locations**

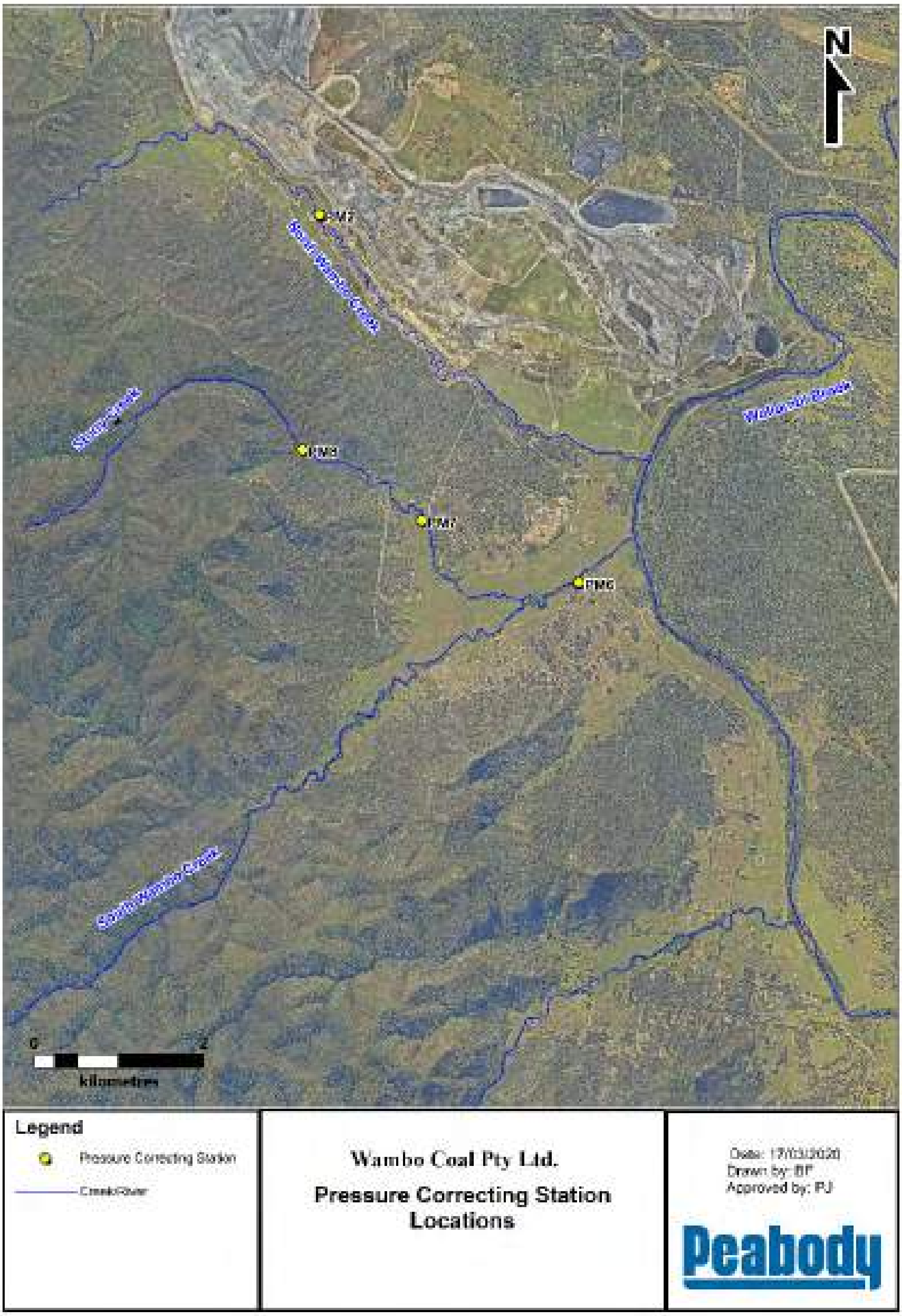

Figure 2 Pressure Correcting Station Locations

Table 3 Monitoring Location Equipment Configurations

Station ID	Equipment	Corresponding Correction Station
FM1	Campbell Scientific (CSA) CS451 SDI-12 pressure transducer connected to a CSA CR800 series data logger, powered by a 12-volt lead acid battery with solar charging. Data is logged hourly. A backup Insitu Rugged TROLL 100 absolute pressure sensor logging data at 10-minute intervals is also installed.	**PM2**
USFM1	Insitu Rugged TROLL 100 absolute pressure sensor. Data is logged at 10-minute intervals	**PM2**
FM2	CSA CS450 SDI 12 pressure transducer connected to a CSA CR200X series data logger, powered by a 12-volt lead acid battery with solar charging. Data is logged at 10-minute intervals. A backup Insitu Rugged TROLL 100 absolute pressure sensor logging data at 10-minute intervals is also installed.	**PM2**
FM3	CSA CS450 SDI 12 pressure transducer connected to a CSA CR200X series data logger, powered by a 12-volt lead acid battery with solar charging. Data is logged at 10-minute intervals. A backup Insitu Rugged TROLL 100 absolute pressure sensor logging data at 10-minute intervals is also installed.	**PM2**
FM4	CSA CS450 SDI 12 pressure transducer connected to a CSA CR200X series data logger, powered by a 12-volt lead acid battery with solar charging. Data is logged at 10-minute intervals. A backup Insitu Rugged TROLL 100 absolute pressure sensor logging data at 10-minute intervals is also installed.	**PM2**
FM15	Insitu Rugged TROLL100 absolute pressure sensor which has been configured to record data at 10-minute intervals.	**PM6**
FM16	Insitu Rugged TROLL100 absolute pressure sensor which has been configured to record data at 10-minute intervals.	**PM6**
FM9	Insitu Rugged TROLL100 absolute pressure sensor which has been configured to record data at 10-minute intervals.	**PM6**
FM12	Insitu Rugged TROLL100 absolute pressure sensor which has been configured to record data at 10-minute intervals	**PM8**
FM14	Insitu Rugged TROLL100 absolute pressure sensor which has been configured to record data at 10-minute intervals	**PM8**
FM13	Insitu Rugged TROLL100 absolute pressure sensor which has been configured to record data at 10-minute intervals	**PM7**
PM2	Insitu Rugged BaroTROLL. Data is logged at 10-minute intervals	N/A
PM6	Insitu Rugged BaroTROLL. Data is logged at 10-minute intervals	N/A
PM8	Insitu Rugged BaroTROLL. Data is logged at 10-minute intervals	N/A
PM7	Insitu Rugged BaroTROLL. Data is logged at 10-minute intervals	N/A

Table 4 Monitoring Location General Observations

Station ID	Observations
FM1	Originally located at the top of North Wambo Creek upstream of surface water monitoring site SW04; re-located approximately 300 to 400m further downstream in December 2017 – downstream of surface water monitoring site SW04
USFM1	New station installed on North Wambo Creek during December 2017; located approximately 1 kilometre upstream of the original site of FM1
FM2	Located downstream from relocated Flow Station FM1 approximately midway along the old North Wambo Creek diversion. A backup pressure sensor was installed at this location in August 2020.
FM3	Originally located on North Wambo Creek between the old Wambo Underground Surface Infrastructure and the Open Cut Overburden: relocated in May 2013 to approximately midway along the new diversion of North Wambo Creek downstream of Flow Station FM2. A backup pressure sensor was installed at this location in August 2020.
FM4	Located at the Wambo Mine Road culvert which crosses North Wambo Creek upstream of the confluence of North Wambo Creek and Wollombi Brook
FM15	Located on South Wambo Creek just upstream of the confluence of South Wambo Creek and Wollombi Brook; relocated to approximately 100 to 200m downstream in December 2016
FM16	Located on South Wambo Creek approximately 200 to 300 metres up stream of the washout on Wambo Mine Road
FM 9	Located approximately 2 kilometres upstream from its original location following a recommendation from Environmental Instrument Solutions' hydrographer
FM12	Re-located during September 2018 approximately 50 metres downstream from its original location following a recommendation from Environmental Instrument Solutions' hydrographer
FM14	Installed in December 2015
FM13	Re-located during September 2018 approximately 50 metres upstream from its original location following a recommendation from Environmental Instrument Solutions' hydrographer.
PM2	In November 2018 data collection it was identified that this BaroTROLL failed during October 2018. A replacement sensor was installed on 24 January 2019
PM6	N/A
PM8	N/A
PM7	N/A

2.0 Methodology

The results represent a theoretical flow and have been calculated using polynomial equations derived from theoretical flow rating curves. These theoretical flow curves were constructed from data received by AECOM from Wambo Coal and Environmental Instrument Solutions with the exception of the relocated Stony Creek flow monitoring station and the new monitoring station FM9 on South Wambo Creek. Theoretical flow curves generated by AECOM were utilised to calculate theoretical flow along Stony Creek and its tributary when probable flow events occurred.

The data for each theoretical flow rating curve has been generated from cross and long section surveys. From the surveys a cross sectional area and the wetted perimeter for various theoretical stream heights were derived.

From these derived values the hydraulic radius was calculated for each theoretical stream height. The hydraulic radius is calculated as follows:

Rh = A/P

Where:-

Rh = Hydraulic Radius

A = Calculated cross section area for a give stream height

P = Calculated wetted perimeter for a given stream height

The stream slope was calculated from the long section surveys and the Manning's coefficient of rugosity was determined from the conditions observed in the stream bed and surrounding flood plain.

These values were then entered into the Manning's equation and a theoretical stream velocity was calculated. The Manning's equation is as follows: -

$V = (Rh^{2/3} \times Sw^{1/2})/n$

Where: -

Rh = Hydraulic radius for a given stream height

Sw = Stream slope derived from the long section survey

n = Manning's coefficient of rugosity

The Manning's coefficient of rugosity was sourced from AS 3778.3.3 - 2001 *"Measurement of water flow in open channels, part 3.3: Velocity - area methods – Measurement by slope – area methods".*

The theoretical velocity, derived from the Manning's equation, was then multiplied by the calculated cross-sectional area for a given stream height to give a theoretical flow rate Q. The resultant theoretical flow rates were calculated for a series of stream heights and graphed to generate theoretical flow rating curves. **Appendix B** contains these theoretical flow rating curves for each Flow Monitoring Stations.

The data collected from each Flow Station was presented as a pressure reading in kPa. This pressure was converted to a stream height in metres using the following equation: -

Stream Height (m) = Stream Height (kPa) X 0.101972 (m/kPa)

The calculated stream height was then compared to the cease to flow point at each site. The cease to flow point was identified in conjunction with the long section surveys and represents a point in the reach/stream which the height of the stream must attain before it starts to flow.

The relative level of the cease to flow point was compared to the relative level of the sensor at each station. The difference in height between the cease to flow point and the sensor was calculated. This difference was used to screen the data collected from each station for probable flow events.

Once a flow event had been recognised at a flow monitoring station the resultant stream height was applied to the polynomial equation derived from theoretical flow rating curve, for that flow station, to give a theoretical stream flow rate for the identified flow event at the station. In some instances, more than one polynomial equation was required; see flow rating curves in **Appendix B**.

3.0 Results

Probable flow events for the period 1 January to 31 December 2021 for each flow station (including backup sensors) are presented in the following tables. All results displayed in respect to stream flow are theoretical and should be treated as such.

- Upper North Wambo Creek – Flow Monitoring Station USFM1 (**Table 5)**;
- North Wambo Creek adjacent to the mine – Flow Monitoring Station FM1BU (**Table 6)** – note that probable flow events were detected by the backup sensor only;
- North Wambo Creek midway along old diversion – Flow Monitoring Stations FM2 (**Table 7**) and FM2BU (**Table 8**) – note that FM2's main pressure sensor failed during March 2021, a replacement sensor is on order;
- North Wambo Creek midway along new diversion – Flow Monitoring Stations FM3 (**Table 9**) and FM3BU (**Table 10**);
- North Wambo Creek upstream of Wollombi Brook – Flow Monitoring Stations FM4 (

- **Table** 11) and FM4BU (**Table 12**);
- South Wambo Creek upstream of Wollombi Brook – Flow Monitoring Station FM15 (**Table 13**);
- South Wambo Creek upstream of washout of Wambo Mine Road – Flow Monitoring Station FM16 (**Table 14**);
- South Wambo Creek downstream – Flow Monitoring Station FM9 (**Table 15**);
- Stony Creek upstream of proposed area to be mined – Flow Monitoring Station FM12 (**Table 16**);
- Major tributary of Stony Creek upstream of proposed area to be mined – Flow Monitoring Station FM14 (**Table 17**) – note that the sensor at this location failed from 22 January until 11 November 2021; and
- Stony Creek downstream of proposed area to be mined – Flow Monitoring Station FM13 (**Table 18**) – note that the sensor at this location failed from 25 March 2021 until the end of the reporting period.

Table 5 Flow Monitoring Station USFM1 Upper North Wambo Creek – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						0.119	10.3	9.51	822
1	1/01/2021 0:02	31/12/2021 23:52	365	0.139	0.993	0.119	10.3	9.51	822

Table 6 Flow Monitoring Station FM1BU North Wambo Creek – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	4/01/2021 22:19	12/01/2021 20:29	7.92	0.12	0.284	0.188	16.2	0.817	70.6
2	19/03/2021 10:49	16/04/2021 17:39	28.3	0.194	0.811	0.667	57.6	6.41	554
3	17/04/2021 10:29	18/04/2021 3:19	0.701	0.0196	0.0384	0.00804	0.695	0.0206	1.78
4	12/11/2021 10:49	13/11/2021 10:29	0.986	0.189	0.311	0.286	24.7	0.736	63.6
5	26/11/2021 11:39	25/12/2021 4:39	28.7	0.246	0.463	0.502	43.4	1.84	159
6	26/12/2021 23:19	28/12/2021 0:29	1.05	0.0781	0.15	0.0159	1.37	0.0974	8.41

Table 7 Flow Monitoring Station FM2 North Wambo Creek Mid Old Diversion – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	1/01/2021 0:00	11/01/2021 5:40	10.2	0.122	0.532	0.226	19.5	1.67	145
2	2/02/2021 6:10	2/02/2021 18:20	0.507	0.0151	0.044	0.051	4.41	0.11	9.49
3	13/02/2021 11:40	15/02/2021 9:00	1.89	0.02	0.0858	0.0563	4.86	0.119	10.3
4	18/02/2021 15:00	20/02/2021 15:20	2.01	0.0121	0.0347	0.044	3.81	0.0983	8.49
5	8/03/2021 13:30	8/03/2021 23:00	0.396	0.0124	0.0505	0.0424	3.66	0.115	9.95
6	14/03/2021 10:10	5/04/2021 9:00	22	0.353	1.37	2.18	188	23.3	2020

Note: FM2's main pressure sensor failed during March 2021, a replacement sensor is on order.

Table 8 Flow Monitoring Station FM2BU North Wambo Creek Mid Old Diversion – Summary of Results – 4 August to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	1/01/2021 0:07	11/01/2021 4:47	10.2	0.121	0.55	0.228	19.7	1.79	154
2	2/02/2021 6:47	2/02/2021 19:17	0.521	0.0171	0.0461	0.00579	0.5	0.022	1.9
3	13/02/2021 12:07	15/02/2021 6:57	1.78	0.0223	0.089	0.00962	0.831	0.0633	5.47
4	18/02/2021 15:37	20/02/2021 15:37	2	0.0136	0.0403	0.00428	0.369	0.0179	1.55
5	8/03/2021 13:57	9/03/2021 2:57	0.542	0.0141	0.0565	0.00487	0.42	0.0301	2.6
6	14/03/2021 10:47	5/04/2021 3:07	21.7	0.357	1.36	1.37	119	10.5	910
7	24/08/2021 21:57	28/08/2021 18:07	3.84	0.0334	0.11	0.0828	7.15	0.119	10.3
8	1/10/2021 17:47	3/10/2021 21:07	2.14	0.028	0.0591	0.0776	6.71	0.119	10.3
9	12/10/2021 18:27	17/10/2021 15:17	4.87	0.0446	0.141	0.0886	7.66	0.119	10.3
10	10/11/2021 16:37	17/11/2021 22:27	7.24	0.085	0.384	0.123	10.6	0.674	58.3
11	21/11/2021 15:17	18/12/2021 19:27	27.2	0.234	0.594	0.41	35.4	3.06	265
12	27/12/2021 0:57	31/12/2021 0:27	3.98	0.0552	0.137	0.0929	8.03	0.119	10.3

Table 9 Flow Monitoring Station FM3 North Wambo Creek Mid New Diversion – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	4/01/2021 15:20	7/01/2021 0:20	2.38	0.129	0.359	0.185	16	1.02	87.8
2	2/02/2021 6:10	2/02/2021 7:50	0.0694	0.0199	0.0376	0.0102	0.882	0.0206	1.78
3	13/02/2021 11:40	13/02/2021 13:10	0.0625	0.0191	0.0369	0.00964	0.833	0.0201	1.74
4	13/02/2021 14:30	13/02/2021 16:10	0.0694	0.00436	0.00849	0.00188	0.163	0.00374	0.323
5	8/03/2021 13:30	8/03/2021 15:00	0.0625	0.0161	0.0325	0.00802	0.693	0.0172	1.48
6	14/03/2021 10:20	14/03/2021 13:10	0.118	0.0391	0.0802	0.0246	2.12	0.0596	5.15
7	18/03/2021 7:50	18/03/2021 15:50	0.333	0.0628	0.169	0.0525	4.54	0.216	18.7
8	19/03/2021 7:00	30/03/2021 12:20	11.2	0.383	1.3	1.75	151	8.24	712
9	24/08/2021 22:30	24/08/2021 23:40	0.0486	0.00335	0.00524	0.00143	0.123	0.00225	0.195
10	1/10/2021 18:10	1/10/2021 19:10	0.0417	0.00451	0.00626	0.00194	0.167	0.00271	0.234
11	12/10/2021 15:40	12/10/2021 17:30	0.0764	0.00877	0.015	0.00394	0.34	0.00692	0.598
12	12/10/2021 19:00	12/10/2021 21:50	0.118	0.0148	0.0273	0.00708	0.612	0.0139	1.2
13	13/10/2021 3:00	13/10/2021 5:00	0.0833	0.00628	0.00991	0.00275	0.237	0.00441	0.381
14	10/11/2021 16:00	10/11/2021 17:40	0.0694	0.00813	0.019	0.0163	1.41	0.0353	3.05
15	10/11/2021 18:20	10/11/2021 22:30	0.174	0.027	0.0857	0.0402	3.47	0.101	8.69
16	11/11/2021 20:10	12/11/2021 17:30	0.889	0.167	0.654	0.116	10	0.292	25.2
17	26/11/2021 4:00	26/11/2021 20:10	0.674	0.0324	0.0987	0.0471	4.07	0.109	9.45
18	26/11/2021 22:30	29/11/2021 19:40	2.88	0.113	0.357	0.103	8.91	0.218	18.9
19	4/12/2021 13:00	5/12/2021 15:50	1.12	0.0501	0.238	0.0605	5.23	0.178	15.4
20	8/12/2021 18:20	12/12/2021 22:00	4.15	0.161	0.659	0.119	10.3	0.293	25.3

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Table 10 Flow Monitoring Station FM3BU North Wambo Creek Mid New Diversion – Summary of Results – 4 August to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	4/01/2021 15:29	7/01/2021 6:29	2.63	0.145	0.403	0.228	19.7	1.31	113
2	2/02/2021 0:49	2/02/2021 15:29	0.611	0.0237	0.0581	0.0126	1.09	0.037	3.2
3	13/02/2021 11:49	13/02/2021 18:29	0.278	0.0266	0.0553	0.0143	1.24	0.0345	2.98
4	14/02/2021 11:09	14/02/2021 16:49	0.236	0.019	0.0599	0.00972	0.84	0.0387	3.34
5	8/03/2021 13:59	8/03/2021 16:09	0.0903	0.0218	0.0561	0.0117	1.01	0.0353	3.05
6	14/03/2021 10:39	14/03/2021 20:09	0.396	0.0309	0.103	0.0197	1.7	0.0887	7.66
7	18/03/2021 2:59	18/03/2021 19:39	0.694	0.0467	0.197	0.0415	3.59	0.292	25.3
8	19/03/2021 2:09	30/03/2021 14:59	11.5	0.381	1.31	1.77	153	8.24	712
9	8/06/2021 20:19	8/06/2021 22:59	0.111	0.0149	0.0306	0.00726	0.628	0.0159	1.38
10	10/06/2021 12:59	10/06/2021 21:09	0.34	0.00904	0.0197	0.00411	0.355	0.00946	0.817
11	24/08/2021 20:49	24/08/2021 23:29	0.111	0.00693	0.0173	0.00311	0.269	0.00813	0.703
12	1/10/2021 17:19	1/10/2021 19:09	0.0764	0.00976	0.0167	0.00445	0.385	0.00781	0.675
13	12/10/2021 15:29	13/10/2021 0:29	0.375	0.0174	0.0419	0.0086	0.743	0.0237	2.05
14	13/10/2021 2:09	13/10/2021 7:29	0.222	0.0105	0.0234	0.00483	0.418	0.0115	0.996
15	13/10/2021 10:49	13/10/2021 12:39	0.0764	0.00678	0.0141	0.00299	0.258	0.00649	0.561
16	14/10/2021 10:29	14/10/2021 14:49	0.181	0.0181	0.0374	0.0089	0.769	0.0205	1.77
17	10/11/2021 16:19	10/11/2021 23:59	0.319	0.0346	0.111	0.0228	1.97	0.101	8.73
18	11/11/2021 20:09	12/11/2021 18:39	0.938	0.116	0.302	0.17	14.7	0.7	60.5
19	21/11/2021 20:39	22/11/2021 5:49	0.382	0.00671	0.0169	0.00298	0.258	0.00792	0.684
20	26/11/2021 3:39	29/11/2021 23:09	3.81	0.101	0.242	0.113	9.74	0.442	38.2
21	3/12/2021 17:49	3/12/2021 19:49	0.0833	0.0125	0.0257	0.00592	0.512	0.0129	1.12
22	4/12/2021 13:19	5/12/2021 19:39	1.26	0.0684	0.189	0.0596	5.15	0.267	23.1
23	7/12/2021 22:49	8/12/2021 1:59	0.132	0.00655	0.0181	0.00294	0.254	0.00857	0.74
24	8/12/2021 18:19	13/12/2021 1:59	4.32	0.128	0.31	0.182	15.7	0.74	64
25	22/12/2021 16:39	22/12/2021 17:59	0.0556	0.00697	0.0161	0.00311	0.269	0.00749	0.647
26	26/12/2021 20:39	26/12/2021 23:29	0.118	0.0136	0.0361	0.00653	0.564	0.0195	1.69
27	27/12/2021 9:19	27/12/2021 15:09	0.243	0.0191	0.0355	0.00949	0.82	0.0192	1.66

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Table 11 Flow Monitoring Station FM4 North Wambo Creek upstream of the confluence of Wollombi Brook – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	4/01/2021 16:20	8/01/2021 7:20	3.63	0.151	1.62	3.28	284	240	20800
2	18/03/2021 15:20	31/03/2021 1:20	12.4	0.585	2.12	107	9210	1040	89500
3	11/11/2021 23:00	13/11/2021 12:20	1.56	1.34	17.9	0.194	16.8	1.01	87.6
4	26/11/2021 6:50	30/11/2021 5:20	3.94	0.31	0.941	0.0992	8.58	0.236	20.4
5	4/12/2021 20:30	6/12/2021 0:50	1.18	0.0885	0.265	0.0404	3.49	0.0976	8.43
6	8/12/2021 19:10	13/12/2021 4:20	4.38	0.382	1.46	0.111	9.63	0.337	29.1

Table 12 Flow Monitoring Station FM4BU North Wambo Creek upstream of the confluence of Wollombi Brook – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	4/01/2021 16:15	8/01/2021 10:25	3.76	0.156	1.64	3.28	283	253	21800
2	18/03/2021 15:25	30/03/2021 9:15	11.7	0.591	2.09	103	8930	959	82900
3	11/11/2021 22:55	13/11/2021 21:05	1.92	0.168	1.02	1.12	97.1	18.7	1620
4	26/11/2021 6:25	1/12/2021 8:25	5.08	0.0909	0.256	0.292	25.2	1.05	90.5
5	1/12/2021 16:35	1/12/2021 19:05	0.104	0.00432	0.0106	0.00536	0.463	0.014	1.21
6	4/12/2021 20:15	6/12/2021 7:35	1.47	0.0514	0.128	0.122	10.6	0.397	34.3
7	8/12/2021 17:55	13/12/2021 10:55	4.71	0.117	0.346	0.404	34.9	1.5	129
8	13/12/2021 16:35	13/12/2021 22:45	0.257	0.00495	0.0151	0.00617	0.533	0.0212	1.83
1	4/01/2021 16:15	8/01/2021 10:25	3.76	0.156	1.64	3.28	283	253	21800

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Table 13 Flow Monitoring Station FM15 South Wambo Creek upstream of the confluence of Wollombi Brook – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	1/01/2021 0:00	1/01/2021 18:40	0.78	0.0184	0.0398	0.00311	0.269	0.0166	1.44
2	2/01/2021 10:20	2/03/2021 10:50	59.0	0.109	1.4	3.53	305	174	15000
3	14/03/2021 19:50	18/08/2021 14:00	157	0.478	4.88	82.9	7160	1760	152000
4	18/08/2021 23:20	19/08/2021 10:00	0.44	0.0292	0.0603	0.0166	1.44	0.0725	6.26
5	20/08/2021 5:40	20/08/2021 9:00	0.14	0.0105	0.0217	0.000577	0.0499	0.00249	0.215
6	24/08/2021 9:50	4/09/2021 17:00	11.3	0.0814	0.173	0.263	22.7	1.83	158
7	4/09/2021 18:10	4/09/2021 22:00	0.16	0.00602	0.0136	0.000106	0.00917	0.000561	0.0485
8	5/09/2021 2:50	5/09/2021 6:40	0.16	0.00345	0.00993	0.0000207	0.00179	0.000205	0.0177
9	13/10/2021 2:00	16/10/2021 17:00	3.63	0.0846	0.142	0.323	27.9	1.02	88.3
10	10/11/2021 20:40	31/12/2021 23:50	51.1	0.254	0.995	5.76	498	87.7	7580

Table 14 Flow Monitoring Station FM16 South Wambo Creek upstream of the washout of Wambo Mine Road – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	1/01/2021 0:04	31/12/2021 23:54	365	0.11	1.17	4.03	349	857	74000

Table 15 Flow Monitoring Station FM9 South Wambo Creek downstream – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	1/01/2021 0:01	27/06/2021 23:21	178	0.195	2.29	0.786	67.9	51.2	4430
2	28/06/2021 7:31	4/07/2021 2:01	5.77	0.0112	0.0262	0.0146	1.27	0.0329	2.84
3	4/07/2021 10:41	4/07/2021 21:41	0.46	0.00487	0.0126	0.00652	0.563	0.0165	1.43
4	5/07/2021 9:31	5/07/2021 20:51	0.47	0.00534	0.0124	0.00713	0.616	0.0163	1.4
5	6/07/2021 10:01	6/07/2021 19:51	0.41	0.00273	0.00922	0.00367	0.317	0.0122	1.06
6	7/07/2021 11:41	7/07/2021 13:51	0.09	0.00243	0.00514	0.00329	0.284	0.00691	0.597
7	7/07/2021 17:21	7/07/2021 19:41	0.10	0.00381	0.00759	0.00513	0.443	0.0101	0.874
8	8/07/2021 15:11	9/07/2021 0:51	0.40	0.0026	0.00749	0.00351	0.303	0.00999	0.863
9	9/07/2021 2:21	11/07/2021 9:21	2.29	0.00601	0.0159	0.008	0.691	0.0206	1.78
10	11/07/2021 10:41	11/07/2021 13:51	0.13	0.0021	0.00667	0.00284	0.245	0.00892	0.771
11	11/07/2021 17:21	11/07/2021 23:01	0.24	0.00329	0.00963	0.00442	0.382	0.0128	1.1
12	12/07/2021 17:21	12/07/2021 19:51	0.10	0.0029	0.00698	0.00391	0.338	0.00932	0.805
13	12/07/2021 21:41	13/07/2021 3:51	0.26	0.00356	0.00922	0.00479	0.413	0.0122	1.06
14	13/07/2021 8:01	31/12/2021 23:51	172	0.118	1.44	0.163	14.1	16.4	1420

Table 16 Flow Monitoring Station FM12 Stony Creek upstream of the proposed area to be mined – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	1/01/2021 0:03	18/01/2021 13:23	17.6	0.0867	1.08	0.401	34.6	19.7	1700
2	18/01/2021 18:13	19/01/2021 9:13	0.63	0.0043	0.0125	0.00535	0.462	0.0156	1.34
3	19/01/2021 15:33	20/01/2021 9:23	0.74	0.00241	0.00934	0.003	0.259	0.0116	1
4	20/01/2021 18:33	21/01/2021 1:53	0.31	0.00192	0.00486	0.00239	0.206	0.00604	0.522
5	21/01/2021 4:23	21/01/2021 6:53	0.10	0.00241	0.00588	0.003	0.259	0.00731	0.632
6	2/02/2021 1:33	2/02/2021 4:43	0.13	0.00455	0.0105	0.00566	0.489	0.013	1.12
7	18/03/2021 8:53	5/04/2021 11:23	18.1	0.19	0.933	1.36	118	14.9	1280
8	5/04/2021 16:13	6/04/2021 8:03	0.66	0.00238	0.00639	0.00297	0.257	0.00794	0.686
9	6/04/2021 21:03	7/04/2021 9:13	0.51	0.00187	0.00608	0.00234	0.202	0.00756	0.654
10	7/04/2021 15:43	8/04/2021 8:03	0.68	0.0023	0.00863	0.00287	0.248	0.0107	0.927
11	8/04/2021 21:03	8/04/2021 23:33	0.10	0.00211	0.007	0.00262	0.227	0.0087	0.752
12	9/04/2021 2:13	9/04/2021 9:43	0.31	0.00279	0.00975	0.00347	0.3	0.0121	1.05
13	10/04/2021 4:03	10/04/2021 8:13	0.17	0.00191	0.00414	0.00238	0.206	0.00516	0.446
14	10/04/2021 21:53	14/04/2021 15:23	3.73	0.0259	0.0631	0.0337	2.91	0.0884	7.64
15	14/04/2021 17:53	15/04/2021 12:13	0.76	0.00809	0.0249	0.0101	0.871	0.0314	2.71
16	16/04/2021 4:43	16/04/2021 10:33	0.24	0.00558	0.0103	0.00694	0.6	0.0128	1.1
17	17/04/2021 20:43	28/04/2021 12:13	10.6	0.052	0.145	0.0787	6.8	0.311	26.9
18	28/04/2021 23:23	29/04/2021 13:03	0.57	0.0183	0.031	0.023	1.99	0.0393	3.4
19	29/04/2021 22:13	30/04/2021 12:43	0.60	0.0129	0.0304	0.0162	1.4	0.0385	3.33
20	11/11/2021 23:08	18/11/2021 13:38	6.60	0.0854	0.581	0.307	26.5	5.94	513
21	18/11/2021 15:08	19/11/2021 12:08	0.88	0.00409	0.0109	0.00509	0.44	0.0135	1.17
22	20/11/2021 2:38	20/11/2021 9:58	0.31	0.00195	0.00506	0.00243	0.21	0.0063	0.544
23	21/11/2021 5:28	19/12/2021 10:18	28.2	0.0513	0.211	0.0857	7.41	0.647	55.9
24	19/12/2021 17:18	20/12/2021 8:08	0.62	0.00467	0.0124	0.00581	0.502	0.0154	1.33
25	21/12/2021 3:58	21/12/2021 6:38	0.11	0.002	0.00414	0.0025	0.216	0.00516	0.446
26	22/12/2021 16:28	22/12/2021 22:08	0.24	0.00176	0.00822	0.00219	0.189	0.0102	0.883
27	23/12/2021 17:28	24/12/2021 8:58	0.65	0.00422	0.0101	0.00525	0.454	0.0125	1.08
28	24/12/2021 17:28	25/12/2021 8:38	0.63	0.00307	0.00802	0.00383	0.331	0.00997	0.862
29	25/12/2021 22:48	26/12/2021 8:18	0.40	0.00209	0.00679	0.00261	0.225	0.00845	0.73
30	26/12/2021 20:18	31/12/2021 11:58	4.65	0.0141	0.0297	0.0176	1.52	0.0377	3.26
31	31/12/2021 14:08	31/12/2021 23:58	0.41	0.00301	0.0071	0.00375	0.324	0.00883	0.763

Table 17 Flow Monitoring Station FM14 Major tributary of Stony Creek upstream of the proposed area to be mined – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	2/01/2021 19:58	3/01/2021 11:08	0.63	0.00316	0.0103	0.0000256	0.00222	0.0000561	0.00485
2	3/01/2021 18:28	21/01/2021 9:48	17.6	0.0617	0.472	0.0198	1.71	1.74	151
3	21/01/2021 20:18	22/01/2021 8:08	0.49	0.00262	0.00698	0.0000227	0.00196	0.0000476	0.00411
4	12/11/2021 0:03	24/12/2021 8:13	42.3	0.0572	0.279	0.00573	0.495	0.355	30.7
5	25/12/2021 1:03	25/12/2021 7:33	0.27	0.00216	0.00738	0.0000189	0.00163	0.0000489	0.00423
6	25/12/2021 22:33	26/12/2021 8:23	0.41	0.00291	0.0081	0.0000245	0.00211	0.0000511	0.00442
7	26/12/2021 18:43	31/12/2021 23:53	5.22	0.031	0.0519	0.000244	0.0211	0.00107	0.0921

Table 18 Flow Monitoring Station FM13 Stony Creek downstream of the proposed area to be mined – Summary of Results – 1 January to 31 December 2021.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	4/01/2021 16:47	14/01/2021 7:27	9.61	0.112	0.882	0.779	67.3	50.5	4360
2	14/01/2021 8:47	14/01/2021 18:07	0.39	0.0109	0.0367	0.0255	2.21	0.0553	4.78
3	14/01/2021 21:57	15/01/2021 9:27	0.48	0.00704	0.0153	0.0186	1.61	0.0359	3.1
4	15/01/2021 13:27	15/01/2021 15:57	0.10	0.0101	0.0243	0.0243	2.1	0.0475	4.1
5	16/01/2021 10:37	16/01/2021 17:17	0.28	0.00883	0.028	0.0221	1.91	0.0508	4.39
6	20/01/2021 3:57	20/01/2021 11:17	0.31	0.0174	0.0396	0.035	3.02	0.0561	4.84
7	26/01/2021 4:27	26/01/2021 7:37	0.13	0.00438	0.0111	0.0122	1.05	0.0283	2.44
8	29/01/2021 12:47	30/01/2021 10:57	0.92	0.00594	0.0174	0.0159	1.38	0.0392	3.39
9	30/01/2021 20:07	31/01/2021 9:57	0.58	0.00521	0.0186	0.0141	1.22	0.0408	3.52
10	1/02/2021 1:17	1/02/2021 6:47	0.23	0.0042	0.0169	0.0116	0.999	0.0384	3.32
11	1/02/2021 20:27	2/02/2021 11:27	0.63	0.00814	0.0252	0.0205	1.77	0.0484	4.18
12	3/02/2021 1:57	3/02/2021 6:57	0.21	0.00529	0.0147	0.0144	1.24	0.0348	3.01
13	4/02/2021 1:17	4/02/2021 7:37	0.26	0.00975	0.0316	0.0228	1.97	0.0531	4.59
14	7/02/2021 0:07	7/02/2021 7:27	0.31	0.00493	0.0131	0.0136	1.18	0.032	2.76
15	11/02/2021 7:47	11/02/2021 11:07	0.14	0.0161	0.0347	0.0337	2.92	0.0546	4.72
16	14/02/2021 5:17	14/02/2021 11:07	0.24	0.016	0.0343	0.0332	2.87	0.0544	4.7
17	15/02/2021 7:27	15/02/2021 10:27	0.13	0.0195	0.0328	0.0407	3.52	0.0537	4.64
18	16/02/2021 1:57	16/02/2021 10:37	0.36	0.0198	0.0409	0.0398	3.44	0.0563	4.86
19	18/02/2021 5:47	18/02/2021 8:57	0.13	0.0199	0.0346	0.0388	3.36	0.0545	4.71
20	22/02/2021 17:17	22/02/2021 19:37	0.10	0.005	0.0106	0.0139	1.2	0.0272	2.35
21	23/02/2021 23:47	24/02/2021 8:17	0.35	0.0196	0.0447	0.038	3.29	0.0567	4.89
22	24/02/2021 10:07	24/02/2021 12:17	0.09	0.0241	0.036	0.0453	3.91	0.0551	4.76
23	25/02/2021 3:17	25/02/2021 11:27	0.34	0.0157	0.0491	0.0321	2.77	0.0565	4.88
24	26/02/2021 2:17	26/02/2021 10:07	0.33	0.0138	0.04	0.03	2.59	0.0561	4.85
25	4/03/2021 22:37	5/03/2021 8:17	0.40	0.0102	0.0384	0.0243	2.1	0.0558	4.82
26	14/03/2021 11:07	14/03/2021 19:07	0.33	0.0127	0.0315	0.0291	2.51	0.053	4.58
27	18/03/2021 8:47	25/03/2021 14:17	7.23	0.266	0.852	3.15	272	45.5	3930

A summary of total monthly rain fall data presented in **Table 19** below was derived from the Wambo Coal's Meteorological Station located next to the helicopter pad near the Mine Infrastructure Area.

Table 19 Monthly Total Rainfall Data at Wambo Coal Meteorological Station – 1 January to 31 December 2021.

Month	Wambo Coal's Meteorological Station Total Rainfall (mm)	Number of Days Rain Fell in the Month
January	124.0	9
February	130.4	13
March	301.2	14
April	20.0	12
May	10.4	11
June	71.6	14
July	27.8	15
August	51.8	8
September	27.6	9
October	74.0	11
November	259.6	21
December	90.2	13

A second rainfall monitoring station was installed at location FM2 during April 2021. Rainfall data for this monitoring location for the period May to December 2021 is presented in **Table 20** below.

Table 20 Monthly Total Rainfall Data at FM2 location – 1 May to 31 December 2021

Month	FM2 Monitoring Location Total Rainfall (mm)	Number of Days Rain Fell in the Month
May	8.8	7
June	61.0	11
July	25.8	14
August	45.6	7
September	27.0	7
October	77.8	9
November	220.4	18
December	87.2	12

Daily rainfall data was used to cross reference the raw data collected from the Flow Monitoring Stations to help identify periods where a flow event may have occurred.

Appendix C contains, where theoretical flow events were recognised, annual graphical depictions of stream height and theoretical flow in conjunction with daily and cumulative rainfall.

The results presented in the above tables should be read with the following qualifying statements in mind: -

- All flow events represent a theoretical flow and have been derived from stream height data. The stream height data was then applied to polynomial equations derived from theoretical flow rating curves to give a theoretical flow. These theoretical flow rating curves were generated using cross and long section surveys in conjunction with the Manning's equation. These theoretical flow rating curves were constructed by AECOM in 2019 on data provided by Environmental Instrument Solutions;
- North Wambo, South Wambo and Stony Creeks are ephemeral and as such only flow after significant rainfall events, therefore the theoretical flow rating curves in **Appendix B** have not been calibrated/checked against actual physical measurements of flow using a current meter;
- Some flow events may have been overlooked due to, but not limited to, poor data quality, data missing, inconsistent data, sensor failure or loss, logger failure, power supply problems and changes to stream bed characteristics, and;
- The three flow monitoring stations installed on Stony Creek and its associated tributary have been positioned such as to be outside a proposed underground mine area and designed to monitor stream flow and any associated effect of underground mining on stream flow. These stations were installed by AECOM on 7 December 2016 and replace flow monitoring stations 7 and 8.

4.0 Recommendations

During the period 1 January to 31 December 2021 the following issues were encountered with the stream monitoring network as a result of the significant rain which fell during January, February and especially March 2021 and the subsequent flows which occurred across the whole flow monitoring network.

- Flow Station FM1:-
  - Both the main and backup pressure sensors were displaced. The anchor/protection concrete pad was also displaced. Upon inspection it was found that both sensors did not sustain any damage. The anchor/protection concrete pad was re-anchored to the stream bed and both sensors were then anchored to this pad.
  - The stream bed flow characteristics were changed, and a re-survey of the stream bed was undertaken. From the re-survey new theoretical flow curves were constructed and used to calculate theoretical flow post April 2021.
- Flow Station FM2:-
  - The stream bed flow characteristics were changed, and a re-survey of the stream bed was undertaken. From the re-survey new theoretical flow curves were constructed and used to calculate theoretical flow post April 2021.
- Flow Station FM13:-
  - This flow station was destroyed during March 2021 as a result no flow data was recorded post April 2021.
  - Several alternate sites were identified for the relocation of FM13 and submitted to the Wambo's Environment Team for consideration. Wambo's Environment Team supplied AECOM with the preferred alternate site with the relocation of FM13 completed during January 2022.

Subsequent visual inspections of the other flow station in the flow monitoring network did not indicate any significant damage to the station hardware or stream bed flow characteristics.

It is recommended that over the coming reporting period, 1 January 2022 to 31 December 2022, that the remaining flow stations be re-surveyed to account for any changes in the stream bed flow characteristics.

Due to the failure of the Barometric correction sensor associated the absolute pressure sensor along North Wambo Creek resulting in unusable data from October 2018 to 24 January 2020 AECOM recommends that the percentage battery used in the remaining Insitu sensors at the flow stations along Stony and South Wambo Creek be closely monitored. Once the percentage battery used is great than 50% and as delivery lead times are unpredictable (estimated 4 to 6 weeks) consideration should be given to obtaining replacement loggers.

If you have any questions or require any clarification of aspects in this report, please contact us in the Singleton office.

Yours faithfully

Paul Wenta

Paul Wenta
Principal Scientist - Air Quality
paul.wenta@aecom.com

Mobile: +61 438 670 281

Scott McDonald
Senior Environmental Chemist
scott.mcdonald@aecom.com

Mobile: +61 414 493 642

encl: Appendix A - Flow Station Field Sheets and Station Data Logger Status Sheets.
Appendix B - Theoretical Flow Rating Curves.
Appendix C - Stream Height, Theoretical Flow, Daily and Cumulative Rainfall Charts.

Addendum: Comparison of Flow Monitoring Data with the Surface Water Monitoring Plan (SWMPV2)

SWMPV2 states:

"Flow impact assessment criteria for the local mine site ephemeral creeks are based on the unexpected absence of flow in climatic situations when flows would be expected. The impact assessment criteria would be met if there was no flow recorded at the flow monitoring site either on the day or the day after the recorded rainfall was equal to or greater than the nominated amount. The resulting runoff generating rainfall values are given in Table 14" of the SWMPV2 which has been reproduced as **Table 21** below.

Table 21 Surface Water Flow Impact Assessment Condition

Watercourse and flow monitoring site	Daily rainfall when flow commenced on 80% of recorded occasions
North Wambo Creek – FM1*	100mm
South Wambo Creek – FM15	20mm
Stony Creek – FM13	20mm

*Revised Wambo SWMP V2 (approved 20 November 2020) removed North Wambo Creek performance indicator of 20mm daily rainfall at location FM4 replacing with performance indicator of rain event total of 100mm at location FM1 effective 21 November 2020.

Table 22 below lists the dates from 1 January to 31 December 2021 when 20mm or greater of 24 hour rainfall was recorded at the Wambo Coal's Meteorological Station located next to the helicopter pad near the Mine Infrastructure Area and corresponding flow events at flow monitoring sites FM15 and FM13.

Table 22 Dates of Daily Rainfall Greater than 20mm and Corresponding Flow Events

<table>
<tr><th>Date</th><th>24 hour Rainfall (mm)</th><th>Site FM15</th><th>Site FM13</th></tr>
<tr><td>4/01/2021</td><td>84.0</td><td rowspan="3">Flow event 2/01/2021 10:20 to 2/03/2021 10:50</td><td>Flow event 4/01/2021 16:47 to 14/01/2021 7:27</td></tr>
<tr><td>2/02/2021</td><td>39.6</td><td>Flow event 1/02/2021 20:27 to 2/02/2021 11:27</td></tr>
<tr><td>13/02/2021</td><td>35.6</td><td>Flow event 14/02/2021 5:17 to 14/02/2021 11:07</td></tr>
<tr><td>14/03/2021</td><td>56.2</td><td rowspan="6">Flow event 14/03/2021 19:50 to 18/08/2021 14:00</td><td>Flow event 14/03/2021 11:07 to 14/03/2021 19:07</td></tr>
<tr><td>18/03/2021</td><td>47.0</td><td rowspan="4">Flow event 18/03/2021 8:47 to 25/03/2021 14:17</td></tr>
<tr><td>19/03/2021</td><td>49.0</td></tr>
<tr><td>20/03/2021</td><td>36.6</td></tr>
<tr><td>22/03/2021</td><td>47.8</td></tr>
<tr><td>8/06/2021</td><td>24.0</td><td rowspan="9">This flow station was destroyed during March 2021 and as a result no flow data was recorded from April to December 2021</td></tr>
<tr><td>24/08/2021</td><td>38.4</td><td>Flow event 24/08/2021 9:50 to 4/09/2021 17:00</td></tr>
<tr><td>12/10/2021</td><td>28.0</td><td>Flow event 13/10/2021 2:00 to 16/10/2021 17:00</td></tr>
<tr><td>10/11/2021</td><td>58.6</td><td rowspan="6">Flow event 10/11/2021 20:40 to 31/12/2021 23:50</td></tr>
<tr><td>11/11/2021</td><td>32.8</td></tr>
<tr><td>12/11/2021</td><td>43.0</td></tr>
<tr><td>21/11/2021</td><td>28.2</td></tr>
<tr><td>26/11/2021</td><td>47.4</td></tr>
<tr><td>8/12/2021</td><td>35.4</td></tr>
</table>

Table 23 below lists the periods from 1 January to 31 December 2021 when accumulated rainfall greater than 100mm was recorded at the Wambo Coal's Meteorological Station located next to the helicopter pad near the Mine Infrastructure Area and corresponding flow events at flow monitoring site FM1.

Table 23 Dates of Rain Event Rainfall Greater than 100mm and Corresponding Flow Events

Dates	Total Rainfall (mm)	Site FM1
26/12/2020 to 5/01/2021	158.8	Flow event 4/01/2021 22:19 to 12/01/2021 20:29
17/03/2021 to 23/03/2021	218.6	Flow event 19/03/2021 10:49 to 16/04/2021 17:39
10/12/2021 to 12/12/2021	134.4	Flow event 12/11/2021 10:49 to 13/11/2021 10:29
21/11/2021 to 23/11/2021	108.4	Flow event 26/11/2021 11:39 to 25/12/2021 4:39

Appendix A

Flow Station Field Sheets & Data Logger Status Sheets

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60248386 – Flow Station 1 North Wambo Creek Data Logger Status Summary 20/04/2021 10:31:29 AM

Datalogger Information

Reported Station Name: 6722
OS Version: CR800.Std.27
OS Date: 131010
OS Signature: 6757
PakBus Address: 801
Security Settings(1): 0
Security Settings(2): 0
Security Settings(3): 0
Panel Temperature: 22.95 °C
Memory: 4194304 bytes
CPU Drive Free: 442368 bytes
USR Drive Free: 0 bytes
Watchdog Errors: 0

Program Information

Current Program: CPU:WaterLevel_V2_1A_10.CR8
Start Time: 4/08/2020 10:27:53 AM
Run Signature: 52401
Program Signature: 58453
Results for Last Program Compiled: CPU:WaterLevel_V2_1A_10.CR8 -- Compiled in SequentialMode.
Memory Free: 21644 bytes

Program Errors

Program Errors: 0
Skipped Scans: 0
Skipped Slow Scans: 0
Skipped System Scans: 0
Skipped Records in Hourly: 0
Skipped Records in Daily: 0
Skipped Records in BatteryData: 0
Variable Out of Bounds: 0

Battery Information

Battery Voltage: 13.98
Lithium Battery: 3.31
Number of times the datalogger's 12V supply has dropped below operating threshold: 0
Number of times voltage has dropped below 5V: 0

60248386 – Flow Station 2 North Wambo Creek Data Logger Status Summary 20/04/2021 11:19:56 AM

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 2
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.54

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 3 North Wambo Creek Data Logger Status Summary
20/04/2021 8:56:48 AM

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 3
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.54

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 4 North Wambo Creek Data Logger Status Summary
20/04/2021 8:27:07 AM

Datalogger Information
OS Version: CR200X.Std.01
OS Date: 100810
PakBus Address: 4
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA_V2a.CR2

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.62

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 2 North Wambo Creek Data Logger Status Summary 13/07/2021 10:43:17 AM

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 2
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.57

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 1 North Wambo Creek Data Logger Status Summary 13/07/2021 10:19:13 AM

Datalogger Information

Reported Station Name: 6722
OS Version: CR800.Std.27
OS Date: 131010
OS Signature: 6757
PakBus Address: 801
Security Settings(1): 0
Security Settings(2): 0
Security Settings(3): 0
Panel Temperature: 17.34 °C
Memory: 4194304 bytes
CPU Drive Free: 425984 bytes
USR Drive Free: 0 bytes
Watchdog Errors: 0

Program Information

Current Program: CPU:WaterLevel_V2_10min.CR8
Start Time: 20/04/2021 10:53:46 AM
Run Signature: 26077
Program Signature: 44714
Results for Last Program Compiled: Warning: Variable WaterLvlRaw out of bounds.
Memory Free: 19720 bytes

Program Errors

Program Errors: 0
Skipped Scans: 0
Skipped Slow Scans: 0
Skipped System Scans: 0
Skipped Records in Tenmin: 0
Skipped Records in Hourly: 0
Skipped Records in Daily: 0
Skipped Records in BatteryData: 0
Variable Out of Bounds: 725567 - There is a program error.

Battery Information

Battery Voltage: 14.11
Lithium Battery: 3.27
Number of times the datalogger's 12V supply has dropped below operating threshold: 0
Number of times voltage has dropped below 5V: 0

60248386 – Flow Station 3 North Wambo Creek Data Logger Status Summary
13/07/2021 9:00:56 AM

Datalogger Information

OS Version: v07
OS Date: 090723
PakBus Address: 3
Watchdog Errors: 0

Program Information

Current Program: WaterLevel_CSA.

Program Errors

Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information

Battery Voltage: 13.73

RF Information

Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 4 North Wambo Creek Data Logger Status Summary 13/07/2021 8:34:30 AM

Datalogger Information

OS Version: CR200X.Std.01
OS Date: 100810
PakBus Address: 4
Watchdog Errors: 0

Program Information

Current Program: WaterLevel_CSA_V2a.CR2

Program Errors

Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information

Battery Voltage: 12.90

RF Information

Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 1 North Wambo Creek Data Logger Status Summary 29/10/2021 1:05:12 PM

Datalogger Information

Reported Station Name: 6722
OS Version: CR800.Std.27
OS Date: 131010
OS Signature: 6757
PakBus Address: 801
Security Settings(1): 0
Security Settings(2): 0
Security Settings(3): 0
Panel Temperature: 30.71 °C
Memory: 4194304 bytes
CPU Drive Free: 425984 bytes
USR Drive Free: 0 bytes
Watchdog Errors: 0

Program Information

Current Program: CPU:WaterLevel_V2_10min.CR8
Start Time: 20/04/2021 10:53:46 AM
Run Signature: 26077
Program Signature: 44714
Results for Last Program Compiled: Warning: Variable WaterLvlRaw out of bounds.
Memory Free: 19720 bytes

Program Errors

Program Errors: 0
Skipped Scans: 0
Skipped Slow Scans: 0
Skipped System Scans: 0
Skipped Records in Tenmin: 0
Skipped Records in Hourly: 0
Skipped Records in Daily: 0
Skipped Records in BatteryData: 0
Variable Out of Bounds: 0

Battery Information

Battery Voltage: 13.77
Lithium Battery: 3.36
Number of times the datalogger's 12V supply has dropped below operating threshold: 0
Number of times voltage has dropped below 5V: 0

60248386 – Flow Station 2 North Wambo Creek Data Logger Status Summary
29/10/2021 1:41:41 PM

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 2
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.28

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 3 North Wambo Creek Data Logger Status Summary 29/10/2021 11:42:01 AM

Datalogger Information

OS Version: v07
OS Date: 090723
PakBus Address: 3
Watchdog Errors: 0

Program Information

Current Program: WaterLevel_CSA.

Program Errors

Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information

Battery Voltage: 13.31

RF Information

Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 1 North Wambo Creek Data Logger Status Summary 28/01/2022 1:22:28 PM

Datalogger Information

Reported Station Name: 6722
OS Version: CR800.Std.27
OS Date: 131010
OS Signature: 6757
PakBus Address: 801
Security Settings(1): 0
Security Settings(2): 0
Security Settings(3): 0
Panel Temperature: 40.44 °C
Memory: 4194304 bytes
CPU Drive Free: 425984 bytes
USR Drive Free: 0 bytes
Watchdog Errors: 0

Program Information

Current Program: CPU:WaterLevel_V2_10min.CR8
Start Time: 20/04/2021 10:53:46 AM
Run Signature: 26077
Program Signature: 44714
Results for Last Program Compiled: Warning: Variable WaterLvlRaw out of bounds.
Memory Free: 19720 bytes

Program Errors

Program Errors: 0
Skipped Scans: 0
Skipped Slow Scans: 0
Skipped System Scans: 0
Skipped Records in Tenmin: 0
Skipped Records in Hourly: 0
Skipped Records in Daily: 0
Skipped Records in BatteryData: 0
Variable Out of Bounds: 786346 - There is a program error.

Battery Information

Battery Voltage: 13.70
Lithium Battery: 3.40
Number of times the datalogger's 12V supply has dropped below operating threshold: 0
Number of times voltage has dropped below 5V: 0

60248386 – Flow Station 4 North Wambo Creek Data Logger Status Summary 29/10/2021 8:08:09 AM

Datalogger Information
OS Version: CR200X.Std.01
OS Date: 100810
PakBus Address: 4
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA_V2a.CR2

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.39

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 2 North Wambo Creek Data Logger Status Summary
28/01/2022 2:05:30 PM

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 2
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.21

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 3 North Wambo Creek Data Logger Status Summary 28/01/2022 10:39:39 AM

Datalogger Information

OS Version: v07
OS Date: 090723
PakBus Address: 3
Watchdog Errors: 0

Program Information

Current Program: WaterLevel_CSA.

Program Errors

Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information

Battery Voltage: 13.23

RF Information

Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 – Flow Station 4 North Wambo Creek Data Logger Status Summary
24/01/2022 8:30:14 AM

Datalogger Information
OS Version: CR200X.Std.01
OS Date: 100810
PakBus Address: 4
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA_V2a.CR2

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.39

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

AECOM

60248386 - Wambo Coal - Quarterly Flow Station Field Sheet

Flow Station No.	Location (Creek)	Date	Time	Logger Type	Solar Panel Output (V)	Battery(V)	Solar Panel Cleaned	Battery Replaced	Memory Used (%)	Battery Used (%)	Data Collected	Sensor Operating	Logger Operating	Stream Observations	Height of Water Above Sensor (mm)	Comments
Upstream old FM1	North Wambo	20-04-21	0930	RuggedTroll	-	-	-	-	100%	26%	Y	Y	Y	Flowing	0.260	Data wrap on - Needs Re Surveying
Old FM1	North Wambo	20-04-21	1000	RuggedTroll	-	-	-	-	93%	17%	Y	Y	Y	Flowing	0.323	Data wrap on New logger
FM1 New Location	North Wambo	20-04-21	1030	CS-CR800	Cycling	14.03	Y	N	-	-	Y	Y	Y	DRY	0	Program updated 10 min data table added
FM1 New Location BU	North Wambo	20-04-21	1026	RuggedTroll	-	-	-	-	100%	26%	Y	Y	Y	DRY	0	Data wrap on New logger - Needs Re Survey *
FM2	North Wambo	20-04-21	1115	CS-CR200	21.3	13.34	Y	N	-	-	Y	Y	Y	Pool ~~DRY~~	0	Sensor not in water
FM2 BU	North Wambo	20-04-21	1120	RuggedTroll	-	-	-	-	34%	5%	Y	Y	Y	Pool ~~DRY~~	0	Needs Re Surveying
BarroLogger NWC	North Wambo	20-04-21	1125	BaroTroll	-	-	-	-	93%	17%				-	-	Data wrap on New barrologger
FM3	North Wambo	20-04-21	0845	CS-CR200	20.70	13.49	Y	N	-	-	Y	Y	Y	DRY	0	
FM3 BU	North Wambo	20-04-21	0855	RuggedTroll	-	-	-	N	34%	5%	Y	Y	Y	DRY	0	
FM4	North Wambo	20-04-21	0820	CS-CR200	17.67	13.57	Y	N	-	-	Y	Y	Y	DRY	0	
FM4 BU	North Wambo	20-04-21	0830	RuggedTroll	-	-	-	-	56%	17%	Y	Y	Y	DRY	0	Data wrap on New logger
FM12 SCUP	Stoney	7-5-21	1015	RuggedTroll	-	-	-	-	100%	45%	Y	Y	Y	Flowing	0.358	Data wrap on
FM14 SCtrib	Stoney Ck Trubutary	7-5-21	0920	RuggedTroll	-	-	-	-	100%	46%	N*	Y	Y	pool	0	Data wrap on station time updated
Stoney Ck Up Barro	Stoney	7-5-21	1055	BaroTroll	-	-	-	-	100%	44%	Y	Y	Y	-	-	Data wrap on
FM13 SCDown	Stoney	7-6-21	1130	RuggedTroll	-	-	-	-	100%	46%	Y	Y	Y	Flowing	0.20	Data wrap on
Stoney Ck Down Barro	Stoney	7-5-21	1145	BaroTroll	-	-	-	-	100%	44%	Y	Y	Y	-	-	Data wrap on
FM9 Brossi	South Wambo	21-04-21	1130	RuggedTroll	-	-	-	-	100%	31%	Y	Y	Y	Flowing	0.245	Data wrap on Needs Resurveying
FM15 (FM5)	South Wambo			RuggedTroll	-	-	-	-							0	Data wrap on
FM16 (FM6)	South Wambo	21-04-21	1250	RuggedTroll	-	-	-	-	100%	34%	Y	Y	Y	Flowing	0.285	Data wrap on
Barro Logger SWC	South Wambo	21-04-21	1305	BaroTroll	-	-	-	-	100%	34%	Y	Y	Y	-	-	Data wrap on
Upstream old FM1	North Wambo	[illegible]	09:30	RuggedTroll	-	-	-	-	100	28	Y	Y	Y	Flowing	0.215	Data wrap on
Old FM1	North Wambo	13.07.21	09:55	RuggedTroll	-	-	-	-	100	19	Y	Y	Y	DRY	0	Data wrap on
FM1 New Location	North Wambo	13.07.21	10:15	CS-CR800	[illegible]	14.15	Y	N	-	-	Y	Y	Y	DRY	0	
FM1 New Location BU	North Wambo	13.07.21	10:40	RuggedTroll	-	-	-	-	100	28	Y	Y	Y	DRY	0	Data wrap on
FM2	North Wambo	13.07.21	10:35	CS-CR200	22.00	13.50	Y	N	-	-	Y	Y	Y	~~Pool~~ DRY	0	
FM2 BU	North Wambo	13.07.21	10:45	RuggedTroll	-	-	-	-	43	7	Y	Y	Y	Pool	0	
BarroLogger NWC	North Wambo	13.07.21	10:50	BaroTroll	-	-	-	-	100	19	Y	Y	Y	-	-	Data wrap on
FM3	North Wambo	13.07.21	09:55	CS-CR200	13.72	12.27	Y	N	-	-	Y	Y	Y	DRY	0	
FM3 BU	North Wambo	13.07.21	09:00	RuggedTroll	-	-	-	N	43	7	Y	Y	Y	DRY	0	
FM4	North Wambo	13.07.21	0820	CS-CR200	13.25	12.78	Y	N	-	-	Y	Y	Y	DRY	0	
FM4 BU	North Wambo	13.07.21	09:50	RuggedTroll	-	-	-	-	65	19	Y	Y	Y	DRY	0	Data wrap on
FM12 SCUP	Stoney	15.07.21	0930	RuggedTroll	-	-	-	-	100	46	Y	Y	Y	Flowing	0.335	Data wrap on
FM14 SCtrib	Stoney Ck Trubutary	15.07.21	0845	RuggedTroll	-	-	-	-	72	16140	N	N	N	DRY	0	Data wrap on
Stoney Ck Up Barro	Stoney	15.07.21	1000	BaroTroll	-	-	-	-	100	46	Y	Y	Y	-	-	Data wrap on
FM13SCDown	Stoney	15.07.21	1030	RuggedTroll	-	-	-	-	100	47	Y	Y	Y	DRY	0	Data wrap on
Stoney Ck Down Barro	Stoney	15.07.21	1055	BaroTroll	-	-	-	-	100	46	Y	Y	Y	-	-	Data wrap on
FM9 Brossi	South Wambo	13.07.21	12:30	RuggedTroll	-	-	-	-	100	32	Y	Y	Y	FLOWING	0.195	Data wrap on
FM15 (FM5)	South Wambo	13.07.21	11:30	RuggedTroll	-	-	-	-	100	36	Y	Y	Y	FLOWING	0.340	Data wrap on
FM16 (FM6)	South Wambo	13.07.21	13:00	RuggedTroll	-	-	-	-	100	36	Y	Y	Y	FLOWING	0.250	Data wrap on
BarroLogger SWC	South Wambo	13.07.21	13.10	BaroTroll	-	-	-	-	100	36	Y	Y	Y	-	-	Data wrap on

[redacted]

FM2 Cable 32 m

* Extensive damage to FM1 BU New due to heavy rainfall & flow

* FM14: Logger date was 26.2.21. logger was not functioning but the sensor was working. logger reset. No data since last download.

60248386 - Wambo Coal - Quarterly Flow Station Field Sheet

...on No.	Location (Creek)	Date	Time	Logger Type	Solar Panel Output (V)	Battery (V)	Solar Panel Cleaned	Battery Replaced	Memory Used (%)	Battery Used (%)	Data Collected	Sensor Operating	Logger Operating	Stream Observations	Height of Water Above Sensor (mm)	Comments
...stream old FM1	North Wambo	29.10.21	1217	RuggedTroll	-	-	-	-	100%	31%	yes	yes	yes	Slow flow	0.18	Data wrap on
...ld FM1	North Wambo	29.10.21	1244	RuggedTroll	-	-	-	-	100%	22%	yes	yes	yes	DRY	0	Data wrap on New logger
FM1 New Location	North Wambo	29.10.21	1259	CS-CR800	Cycling	13.87V	yes	No	-	-	yes	yes	yes	Dry	0 N/A	
FM1 New Location BU	North Wambo	29.10.21	1311	RuggedTroll	-	-	-	-	100%	31%	yes	yes	yes	Dry	0 N/A	Data wrap on New logger
FM2	North Wambo	29.10.21	1332	CS-CR200	21.2V	12.08V	yes	No	-	-	yes	yes	yes	Pool	0	
FM2 BU	North Wambo	29.10.21	1345	RuggedTroll	-	-	-	-	53%	9%	yes	yes	yes	Pool	0	
BarroLogger NWC	North Wambo	29.10.21	1350	BaroTroll	-	-	-	-	100%	22%				-	-	Data wrap on New barrologger
FM3	North Wambo	29.10.21	1135	CS-CR200	19.19V	13.30V	yes	No	-	-	yes	yes	yes	Dry	0 N/A	
FM3 BU	North Wambo	29.10.21	1150	RuggedTroll	-	-			53%	9%	yes	yes	yes	Dry	0 N/A	
FM4	North Wambo	29.10.21	0800	CS-CR200	*17.43V	12.34V	yes	No	-	-	yes	yes	yes	Dry	0 N/A	
FM4 BU	North Wambo	29.10.21	0810	RuggedTroll	-	-	-	-	75%	22%	yes	yes	yes	Dry	0 N/A	Data wrap on New logger installed
FM12 SCUP	Stoney	29.10.21	0945	RuggedTroll	-	-	-	-	100%	48%	yes	yes	yes	Slow flow	0	Data wrap on - no logger on arrival
FM14 SCtrib	Stoney Ck Trubutary	29.10.21	0910	RuggedTroll	-	-	-	-	-	-	-	-	-	-	0	Data wrap on ← Installed new logger
Stoney Ck Up Barro	Stoney	29.10.21	1017	BaroTroll	-	-	-	-	100%	48%	yes	yes	yes	-	-	Data wrap on - new logger installed
FM13 SCDown	Stoney	29.10.21	1046	RuggedTroll	-	-	-	-	100%	50%	yes	yes	yes	Dry	0 N/A	Data wrap on - new logger installed
Stoney Ck Down Barro	Stoney	29.10.21	1105	BaroTroll	-	-	-	-	100%	48%	yes	yes	yes	-	-	Data wrap on - new logger installed
FM9 Brossi	South Wambo	29.10.21	1115	RuggedTroll	-	-	-	-	100%	35%	yes	yes	yes	Slow flow *	0.21	Data wrap on
FM15 (FM5)	South Wambo	28.10.21	1212	RuggedTroll	-	-	-	-	100%	39%	yes	yes	yes	Dry	0 N/A	Data wrap on
FM16 (FM6)	South Wambo	28.10.21	1244	RuggedTroll	-	-	-	-	100%	39%	yes	yes	yes	Slow flow	0.21	Data wrap on
Barro Logger SWC	South Wambo	28.10.21	1255	BaroTroll	-	-	-	-	100%	39%	yes	yes	yes	-	-	Data wrap on
Upstream old FM1	North Wambo	28.1.22	1225	RuggedTroll	-	-	-	-	100%	33%	yes	yes	yes	Slow flow	0.240	Data wrap on
Old FM1	North Wambo	28.1.22	1255	RuggedTroll	-	-	-	-	100%	24%	yes	yes	yes	Slow flow	0.325	Data wrap on
FM1 New Location	North Wambo	28.1.22	1320	CS-CR800	Cycling	13.64V	yes	No	-	-	yes	yes	yes	Dry	0 N/A	
FM1 New Location BU	North Wambo	28.1.22	1330	RuggedTroll	-	-	-	-	100%	33%	yes	yes	yes	Dry	0 N/A	Data wrap on
FM2	North Wambo	28.1.22	1355	CS-CR200	-	13.21	yes	NO	-	-	yes	yes	yes	pool	0.095	
FM2 BU	North Wambo	28.1.22	1350	RuggedTroll	-	-	-	-	65%	11%	yes	yes	yes	pool	0.095	
BarroLogger NWC	North Wambo	28.1.22	1405	BaroTroll	-	-	-	-	100%	24%	yes	yes	yes	-	-	Data wrap on
FM3	North Wambo	28.1.22		CS-CR200	19.85V	13.25V	yes	NO	-	-	yes	yes	yes		0	
FM3 BU	North Wambo	28.1.22	1110	RuggedTroll	-	-	-	NO	65%	11%	yes	yes	yes	Dry	0 N/A	
FM4	North Wambo	24.1.22	0830	CS-CR200	14.20V	13.35V	Yes	No	-	-	yes	yes	yes	Dry	0 N/A	
FM4 BU	North Wambo	24.1.22	0840	RuggedTroll	-	-	-	-	84%	24%	yes	yes	yes	Dry	0 N/A	Data wrap on
FM12 SCUP	Stoney	24.1.22	1055	RuggedTroll	-	-	-	-	15%	1%	yes	yes	yes	Slow flow	0.350	Data wrap on
FM14 SCtrib	Stoney Ck Trubutary	24.1.22	0945	RuggedTroll	-	-	-	-	15%	1%	yes	yes	yes	Slow flow	0.205	Data wrap on
Stoney Ck Up Barro	Stoney	24.1.22	1140	BaroTroll	-	-	-	-	15%	1%	yes	yes	yes	-	-	Data wrap on
FM13 SCDown	Stoney			RuggedTroll	-	-	-	-							0	Data wrap on
Stoney Ck Down Barro	Stoney			BaroTroll	-	-	-	-						-	-	Data wrap on
FM9 Brossi	South Wambo	27.1.22	~~0845~~ 0940	RuggedTroll	-	-	-	-	100%	37%	~~yes~~ yes	~~yes~~ yes	~~yes~~ yes	Slow flow	0.280	Data wrap on
FM15 (FM5)	South Wambo	28.1.22	0910	RuggedTroll	-	-	-	-	100%	41%	yes	yes	yes	Slow flow	0.400	Data wrap on
FM16 (FM6)	South Wambo	28.1.22	0940	RuggedTroll	-	-	-	-	100%	41%	yes	yes	yes	moderate flow	0.370	Data wrap on
Barro Logger SWC	South Wambo	28.1.22	0950	BaroTroll	-	-	-	-	100%	41%	yes	yes	yes	-	-	Data wrap on

* FM9 - lots of weed

Appendix B

Stream Theoretical Flow Rating and Profile Curves

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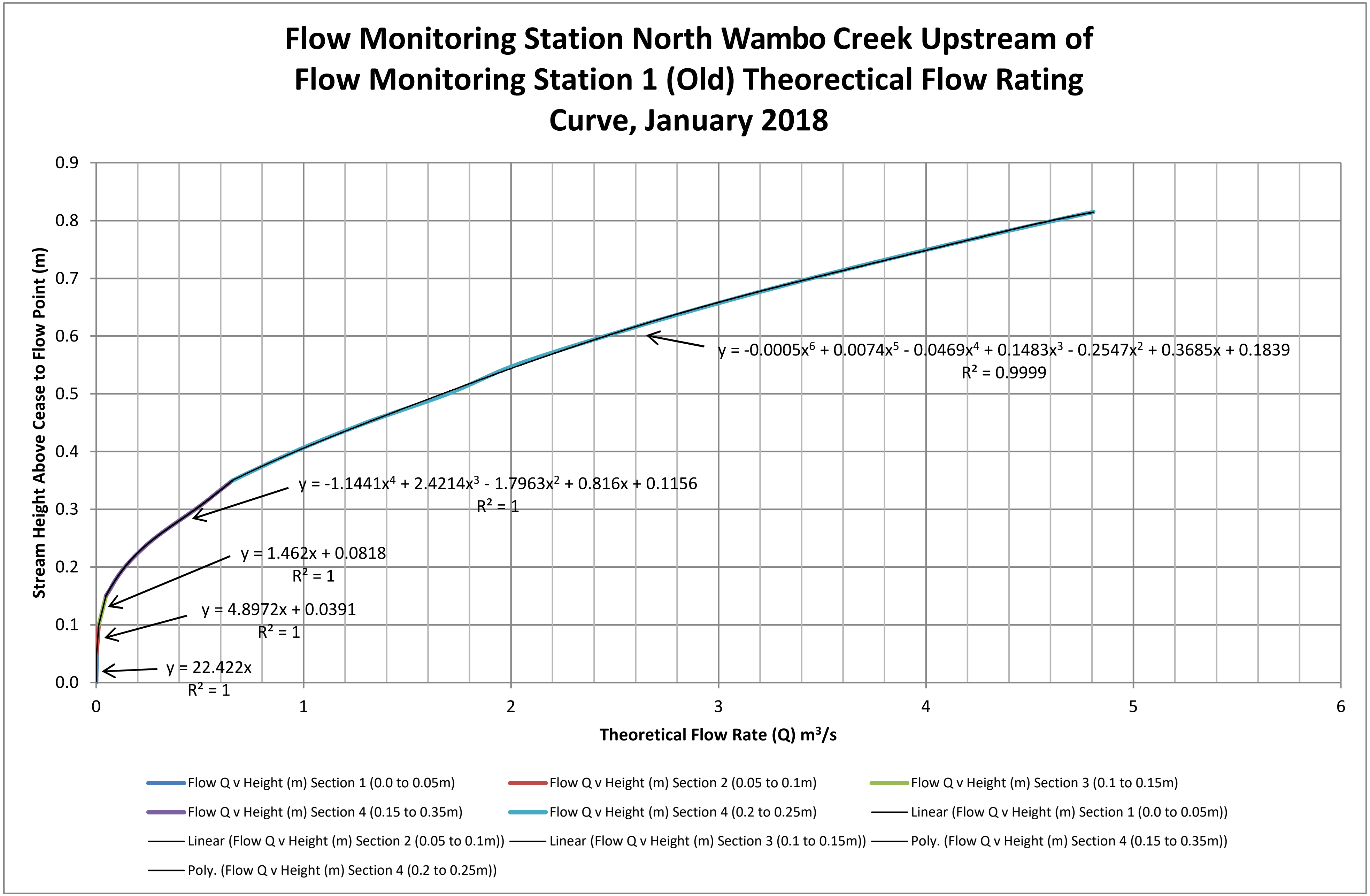
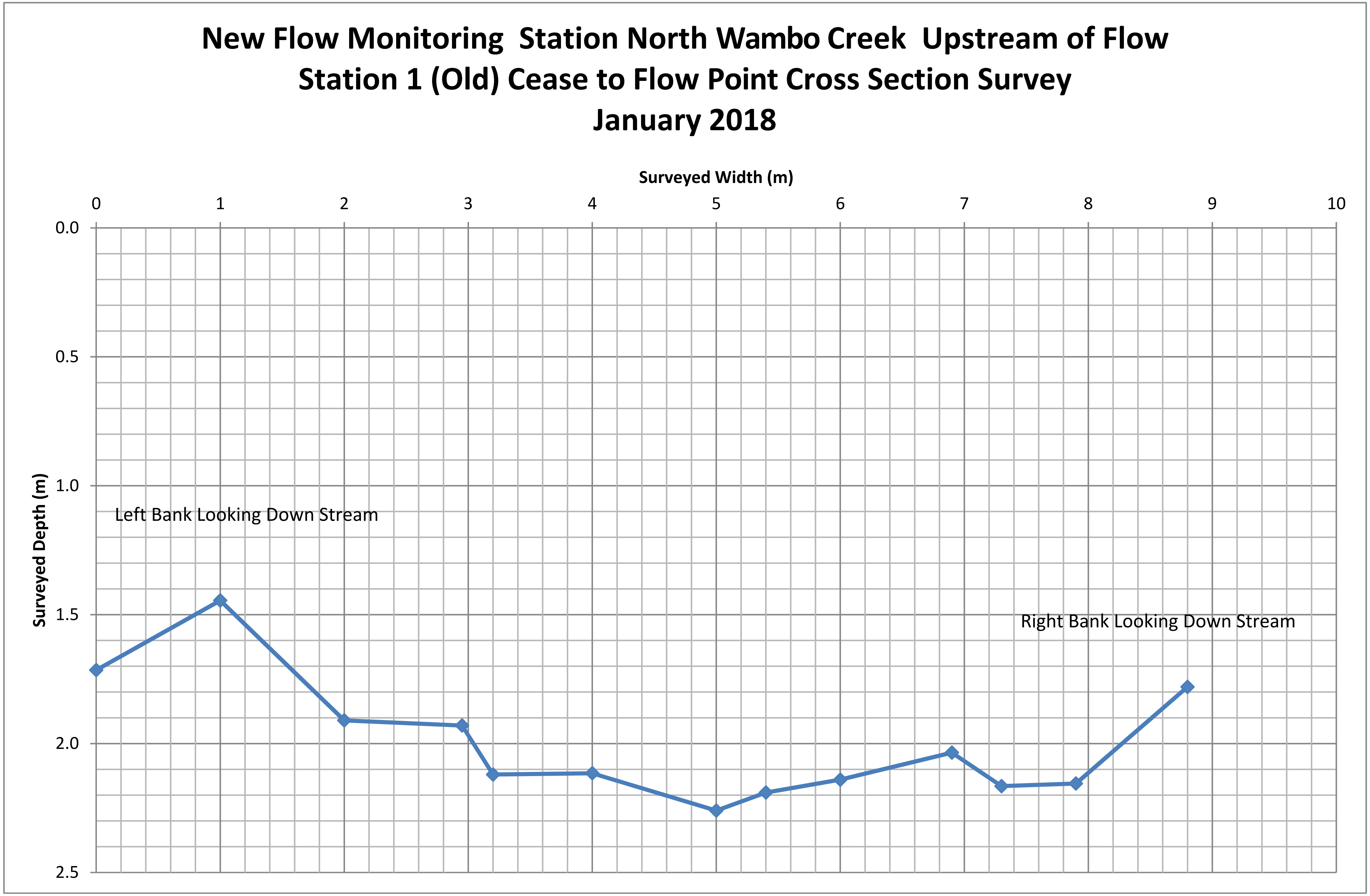
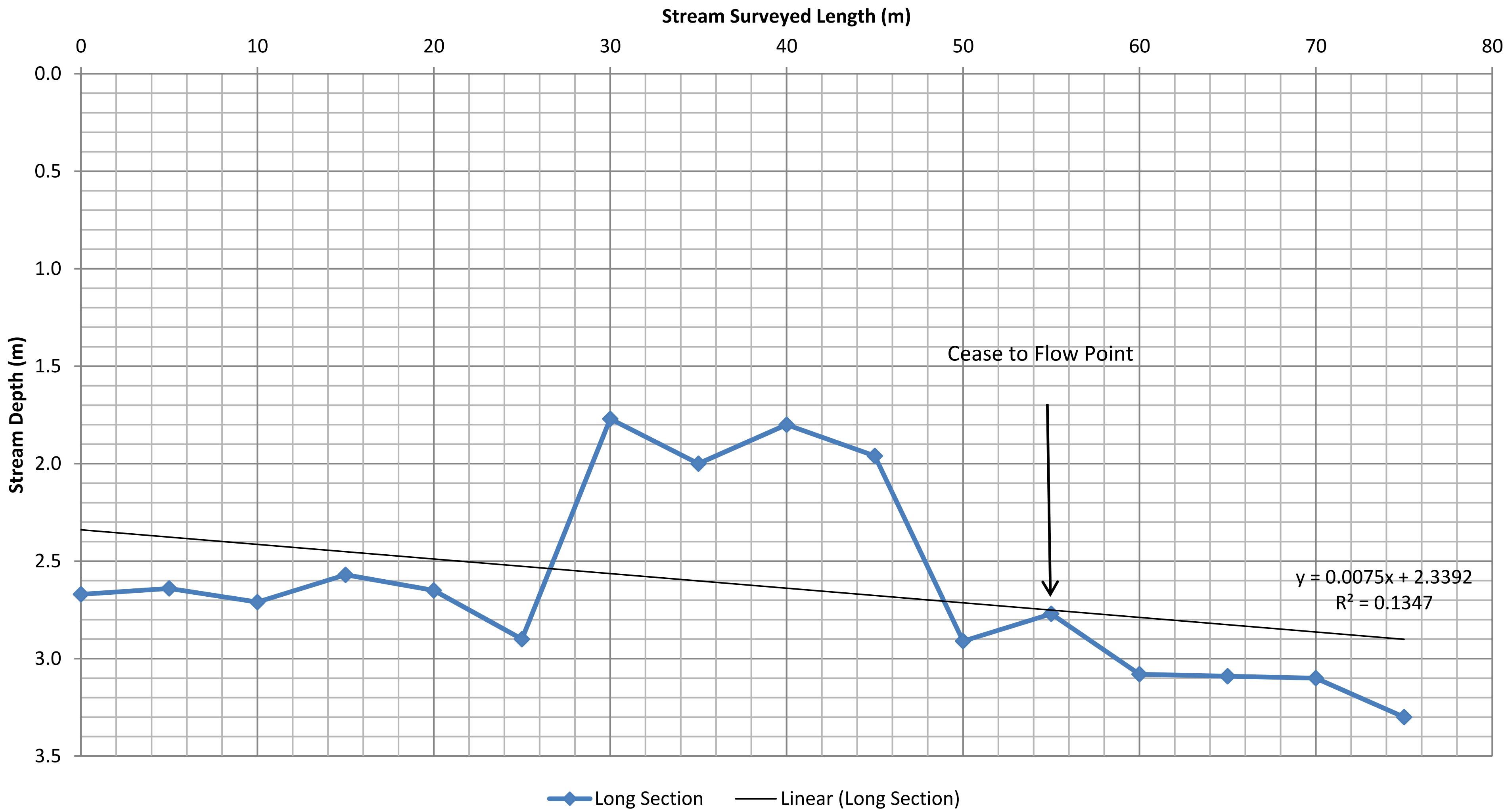
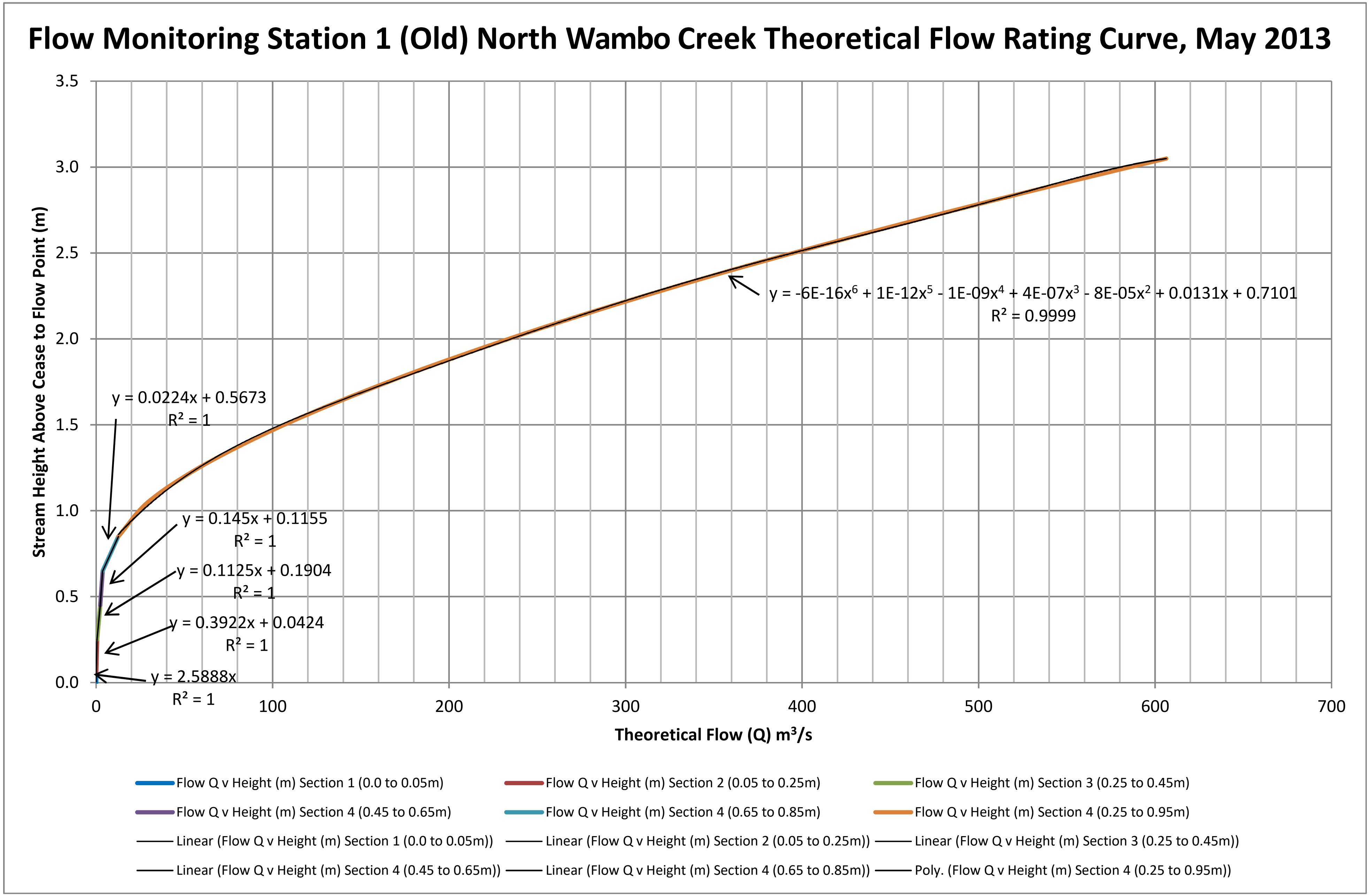

Flow Monitoring Station North Wambo Creek Upstream of Flow Monitoring Station 1 (Old) Theorectical Flow Rating Curve, January 2018
Stream Height Above Cease to Flow Point (m)
Theoretical Flow Rate (Q) m³/s
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1
2
3
4
5
6
y = -0.0005x⁶ + 0.0074x⁵ - 0.0469x⁴ + 0.1483x³ - 0.2547x² + 0.3685x + 0.1839
R² = 0.9999
y = -1.1441x⁴ + 2.4214x³ - 1.7963x² + 0.816x + 0.1156
R² = 1
y = 1.462x + 0.0818
R² = 1
y = 4.8972x + 0.0391
R² = 1
y = 22.422x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.05m)
Flow Q v Height (m) Section 2 (0.05 to 0.1m)
Flow Q v Height (m) Section 3 (0.1 to 0.15m)
Flow Q v Height (m) Section 4 (0.15 to 0.35m)
Flow Q v Height (m) Section 4 (0.2 to 0.25m)
Linear (Flow Q v Height (m) Section 1 (0.0 to 0.05m))
Linear (Flow Q v Height (m) Section 2 (0.05 to 0.1m))
Linear (Flow Q v Height (m) Section 3 (0.1 to 0.15m))
Poly. (Flow Q v Height (m) Section 4 (0.15 to 0.35m))
Poly. (Flow Q v Height (m) Section 4 (0.2 to 0.25m))

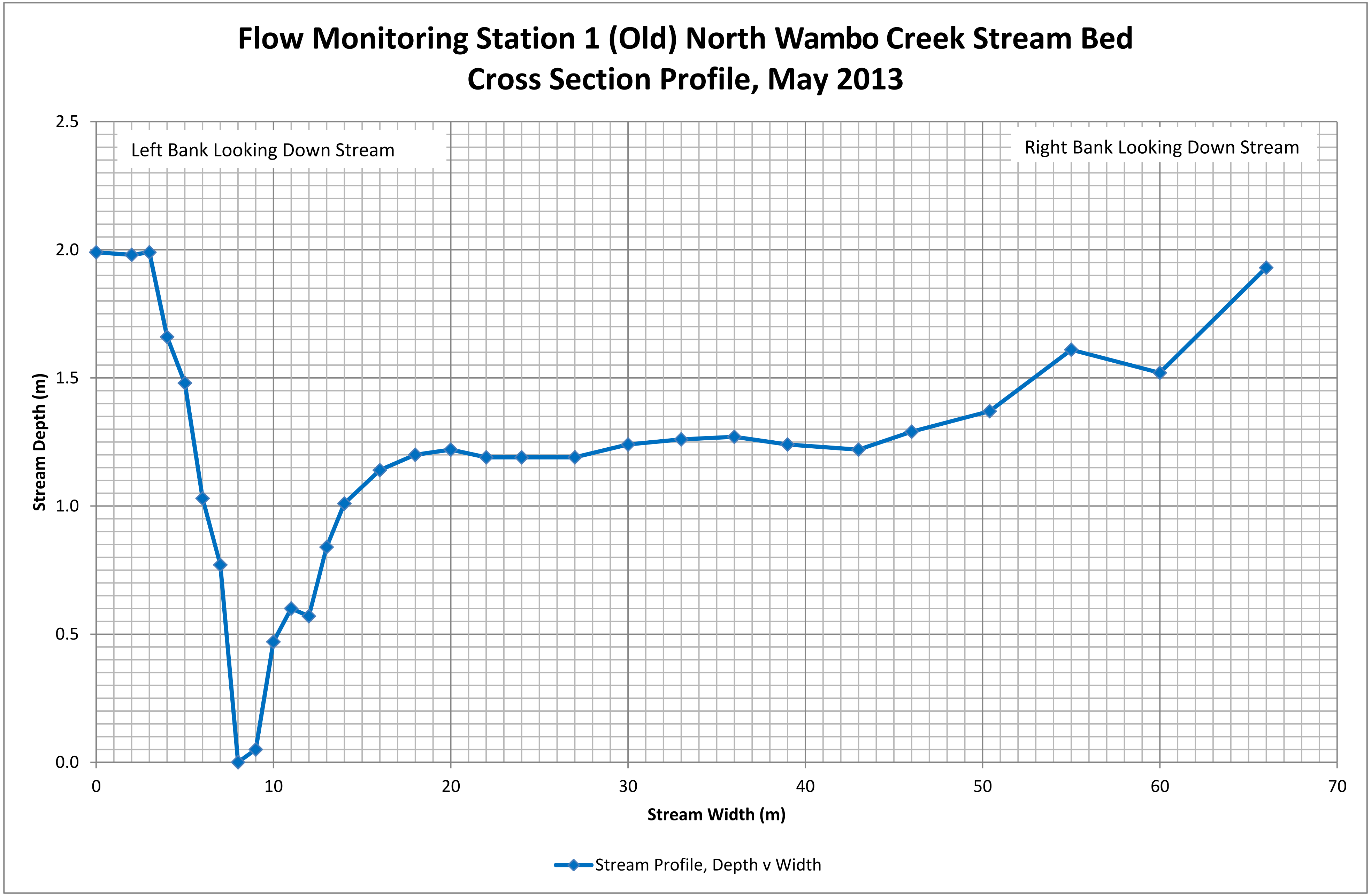

New Flow Monitoring Station North Wambo Creek Upstream of Flow
Station 1 (Old) Cease to Flow Point Cross Section Survey
January 2018
Surveyed Width (m)
0
1
2
3
4
5
6
7
8
9
10
0.0
0.5
1.0
1.5
2.0
2.5
Surveyed Depth (m)
Left Bank Looking Down Stream
Right Bank Looking Down Stream

New Flow Monitoring Station North Wambo Creek Upstream of Flow Station 1 (Old) Long Section Profile Through Cease to Flow Point January 2018



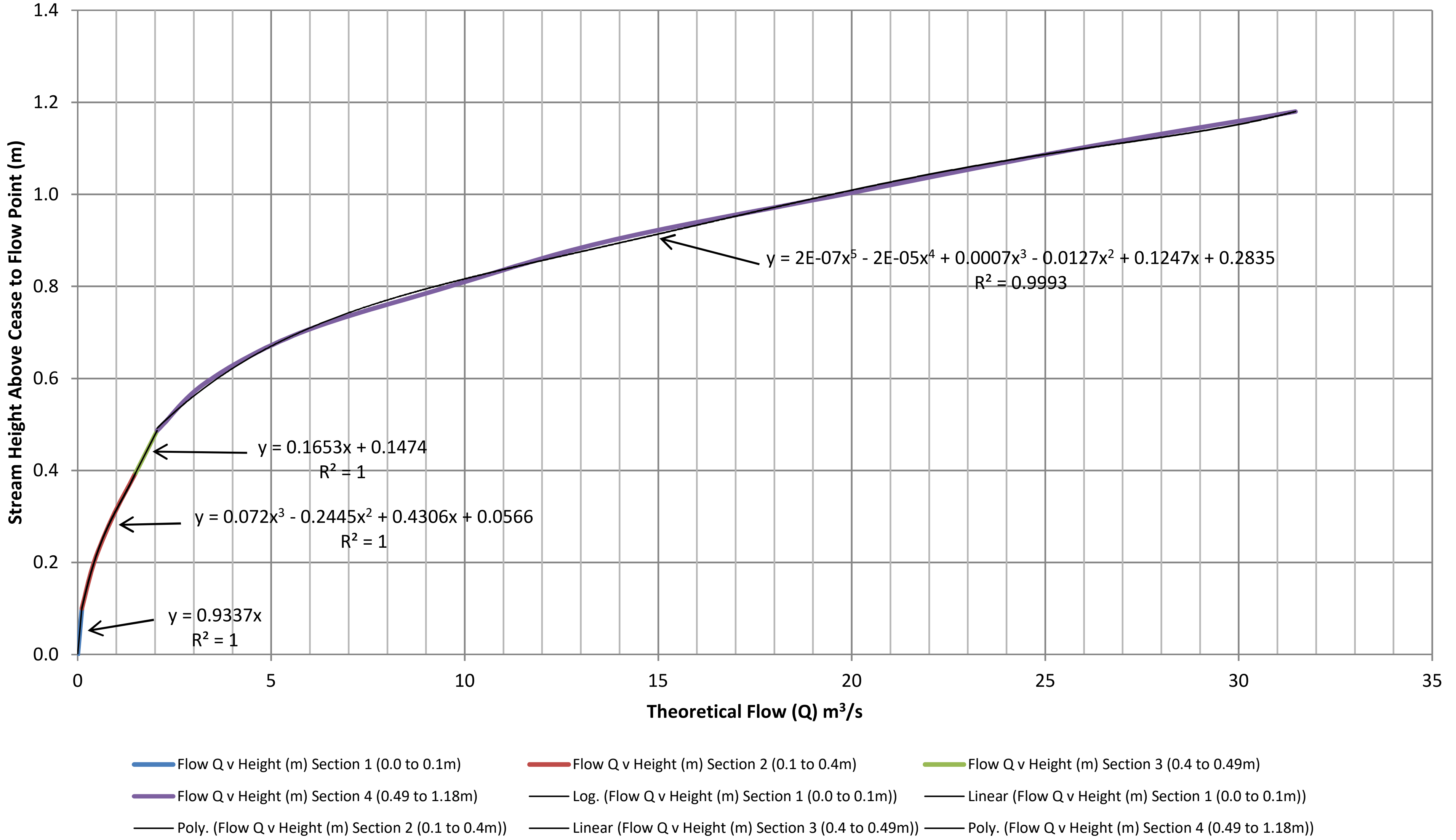


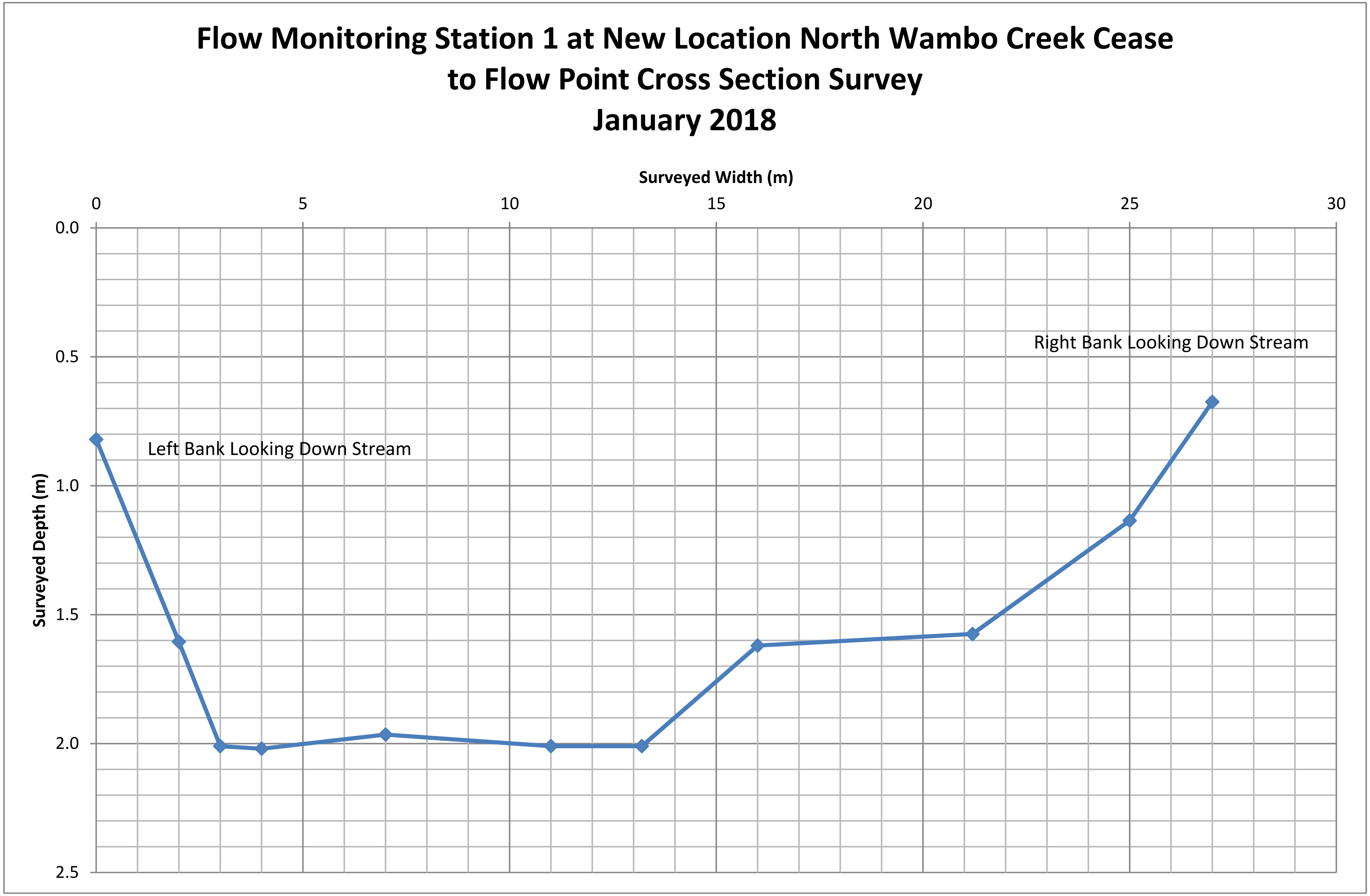
Flow Monitoring Station 1 (Old) North Wambo Creek Theoretical Flow Rating Curve, May 2013
Stream Height Above Cease to Flow Point (m)
Theoretical Flow (Q) m³/s
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
100
200
300
400
500
600
700
y = -6E-16x⁶ + 1E-12x⁵ - 1E-09x⁴ + 4E-07x³ - 8E-05x² + 0.0131x + 0.7101
R² = 0.9999
y = 0.0224x + 0.5673
R² = 1
y = 0.145x + 0.1155
R² = 1
y = 0.1125x + 0.1904
R² = 1
y = 0.3922x + 0.0424
R² = 1
y = 2.5888x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.05m)
Flow Q v Height (m) Section 2 (0.05 to 0.25m)
Flow Q v Height (m) Section 3 (0.25 to 0.45m)
Flow Q v Height (m) Section 4 (0.45 to 0.65m)
Flow Q v Height (m) Section 4 (0.65 to 0.85m)
Flow Q v Height (m) Section 4 (0.25 to 0.95m)
Linear (Flow Q v Height (m) Section 1 (0.0 to 0.05m))
Linear (Flow Q v Height (m) Section 2 (0.05 to 0.25m))
Linear (Flow Q v Height (m) Section 3 (0.25 to 0.45m))
Linear (Flow Q v Height (m) Section 4 (0.45 to 0.65m))
Linear (Flow Q v Height (m) Section 4 (0.65 to 0.85m))
Poly. (Flow Q v Height (m) Section 4 (0.25 to 0.95m))



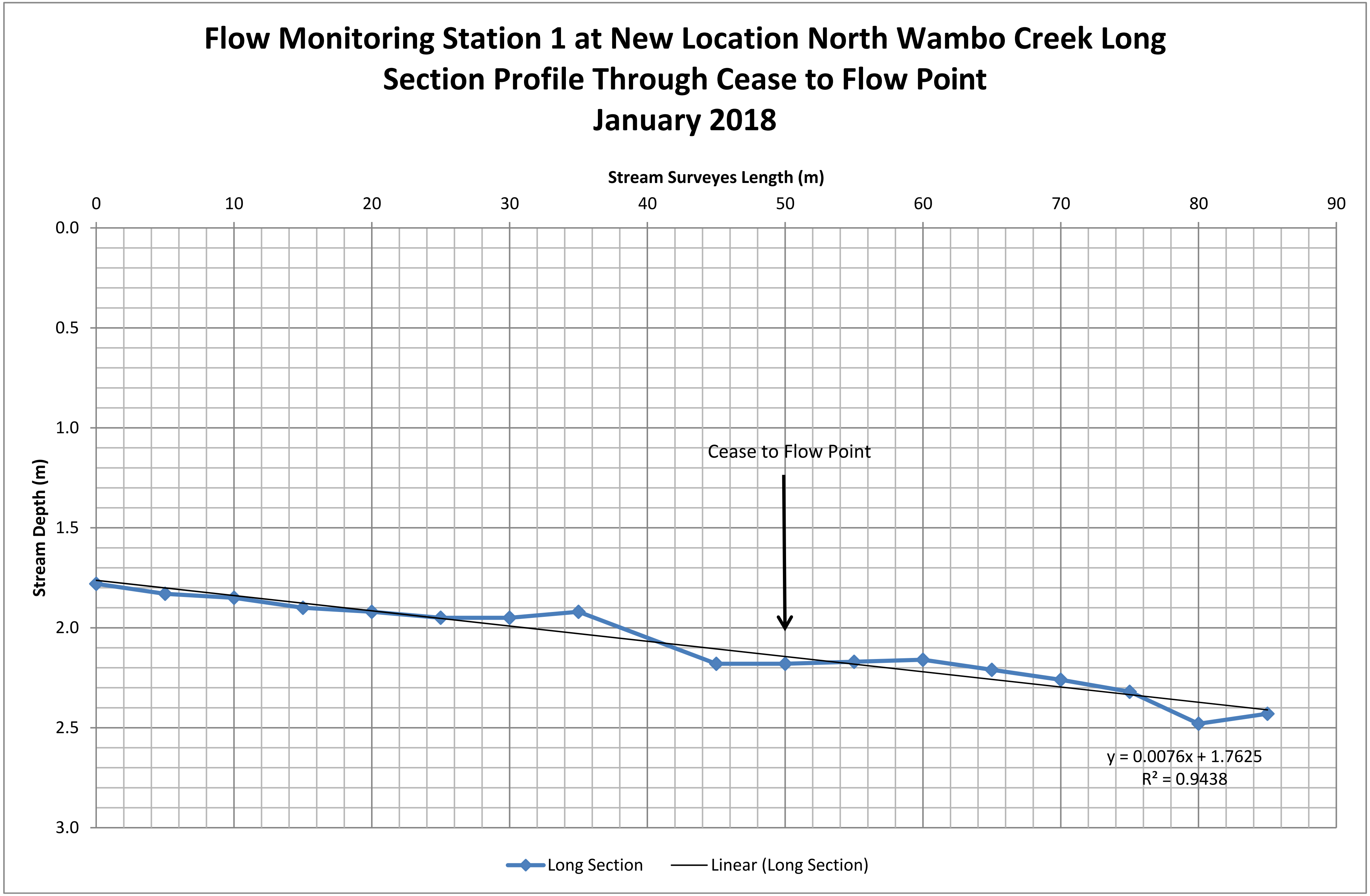
Flow Monitoring Station 1 (Old) North Wambo Creek Stream Bed
Cross Section Profile, May 2013
Left Bank Looking Down Stream
Right Bank Looking Down Stream
Stream Depth (m)
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
Stream Width (m)
Stream Profile, Depth v Width

Flow Monitoring Station 1 at New Location North Wambo Creek Theoretical Flow Rating Curve, January2018

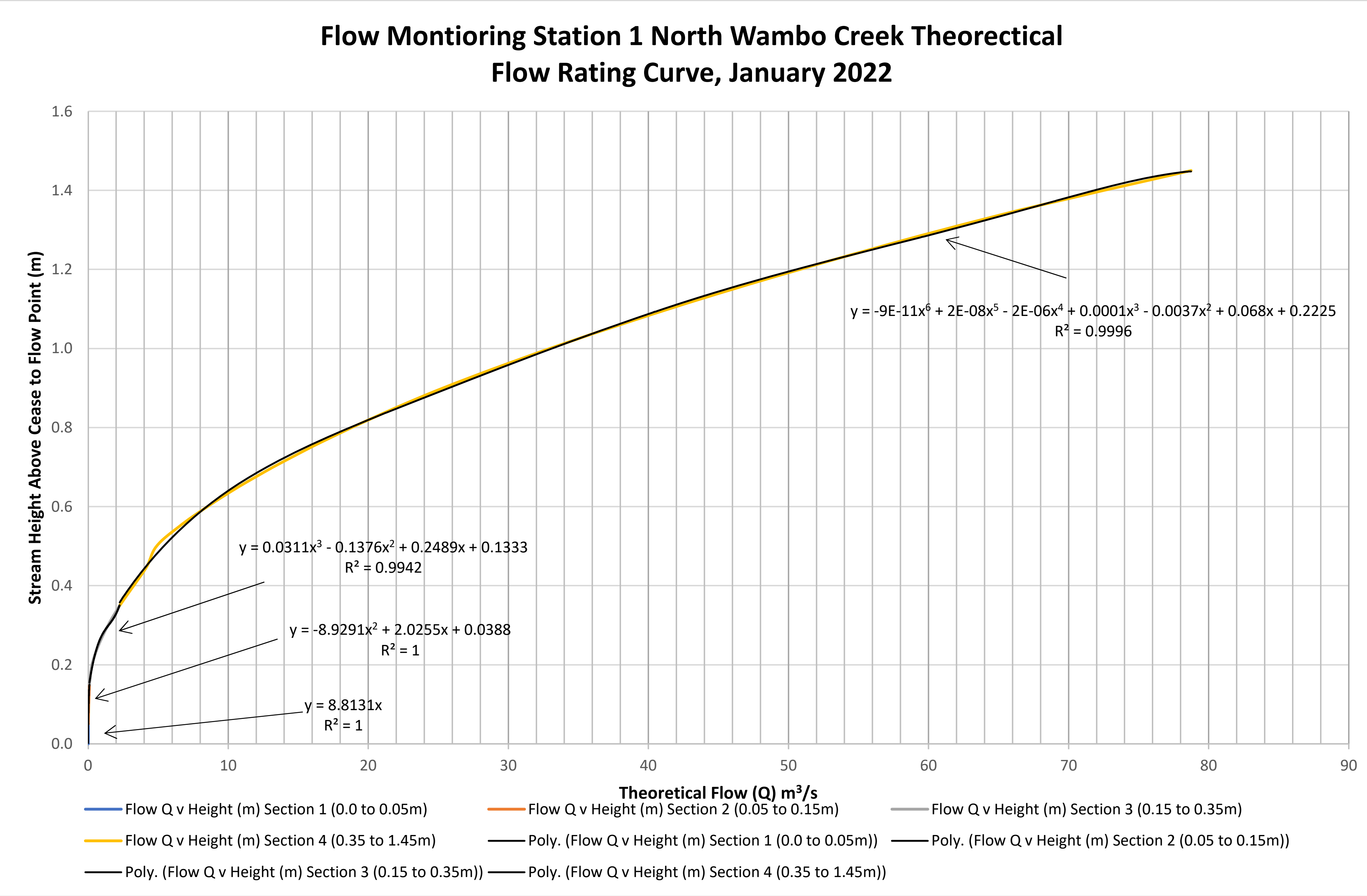




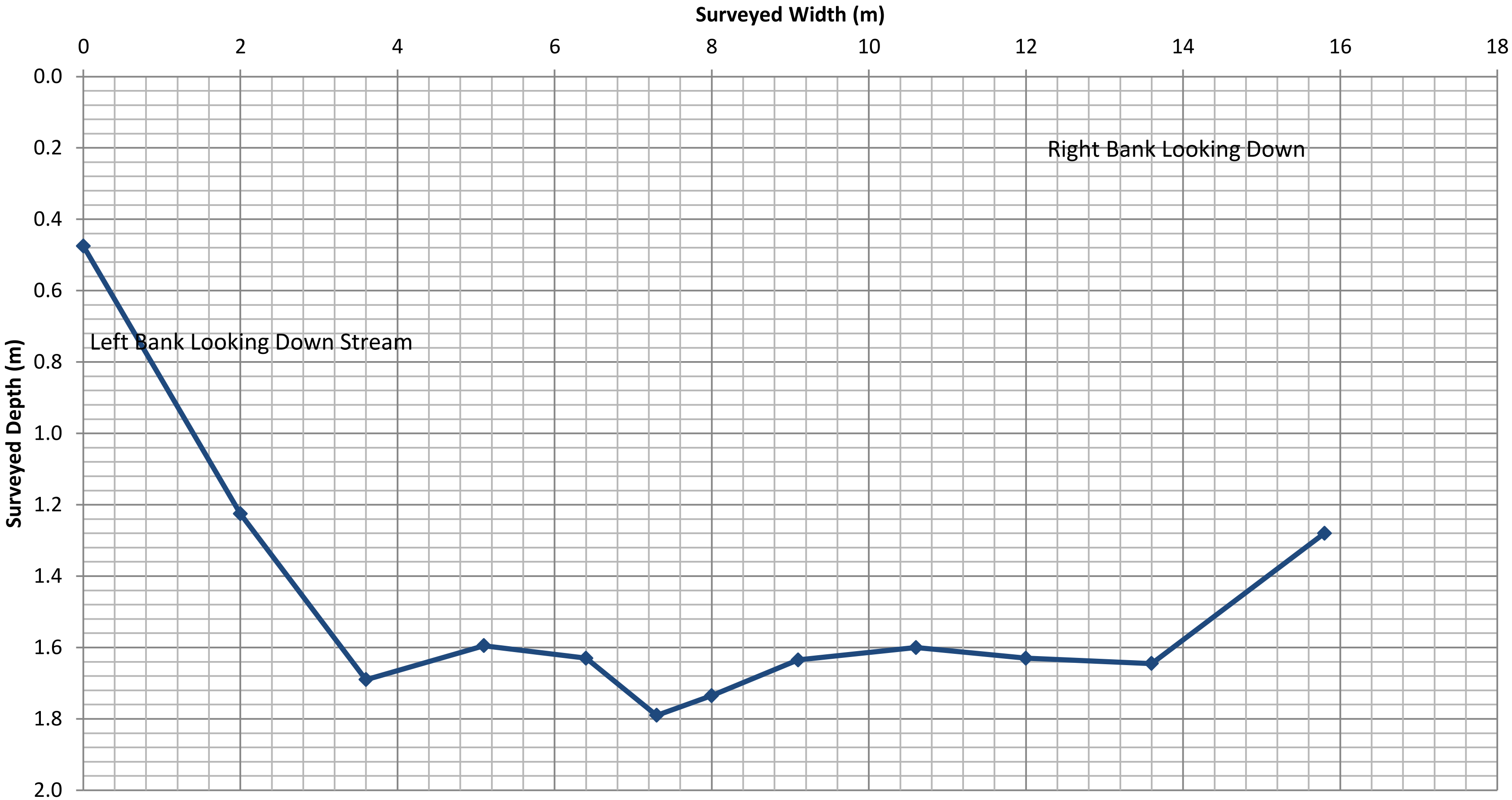
Flow Monitoring Station 1 at New Location North Wambo Creek Cease
to Flow Point Cross Section Survey
January 2018
Surveyed Width (m)
0
5
10
15
20
25
30
Surveyed Depth (m)
0.0
0.5
1.0
1.5
2.0
2.5
Left Bank Looking Down Stream
Right Bank Looking Down Stream

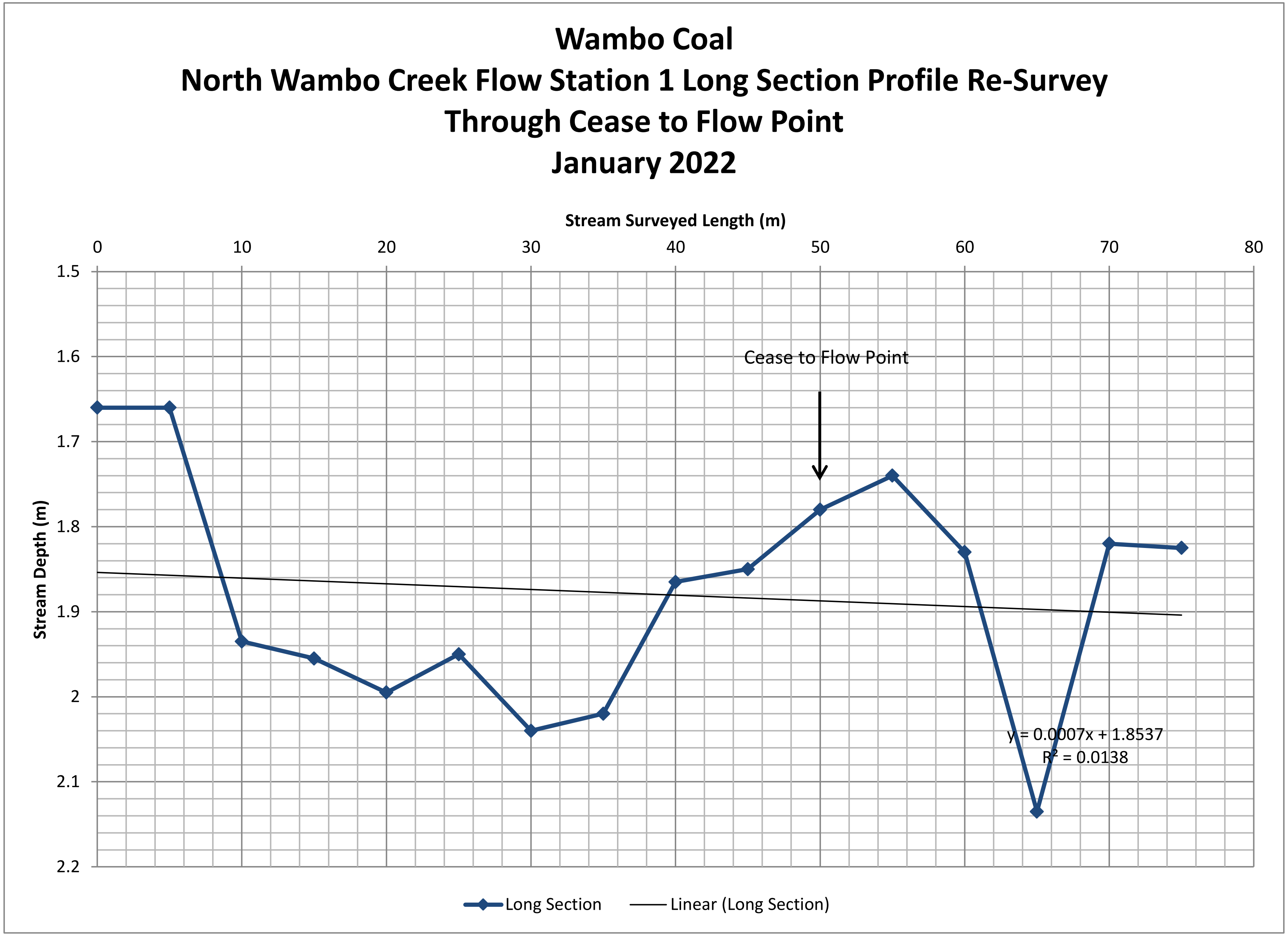


Flow Monitoring Station 1 at New Location North Wambo Creek Long Section Profile Through Cease to Flow Point
January 2018
Stream Surveyes Length (m)
0
10
20
30
40
50
60
70
80
90
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Stream Depth (m)
Cease to Flow Point
y = 0.0076x + 1.7625
R² = 0.9438
Long Section
Linear (Long Section)


Flow Montioring Station 1 North Wambo Creek Theorectical
Flow Rating Curve, January 2022
Stream Height Above Cease to Flow Point (m)
Theoretical Flow (Q) m³/s
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
10
20
30
40
50
60
70
80
90
y = -9E-11x⁶ + 2E-08x⁵ - 2E-06x⁴ + 0.0001x³ - 0.0037x² + 0.068x + 0.2225
R² = 0.9996
y = 0.0311x³ - 0.1376x² + 0.2489x + 0.1333
R² = 0.9942
y = -8.9291x² + 2.0255x + 0.0388
R² = 1
y = 8.8131x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.05m)
Flow Q v Height (m) Section 2 (0.05 to 0.15m)
Flow Q v Height (m) Section 3 (0.15 to 0.35m)
Flow Q v Height (m) Section 4 (0.35 to 1.45m)
Poly. (Flow Q v Height (m) Section 1 (0.0 to 0.05m))
Poly. (Flow Q v Height (m) Section 2 (0.05 to 0.15m))
Poly. (Flow Q v Height (m) Section 3 (0.15 to 0.35m))
Poly. (Flow Q v Height (m) Section 4 (0.35 to 1.45m))

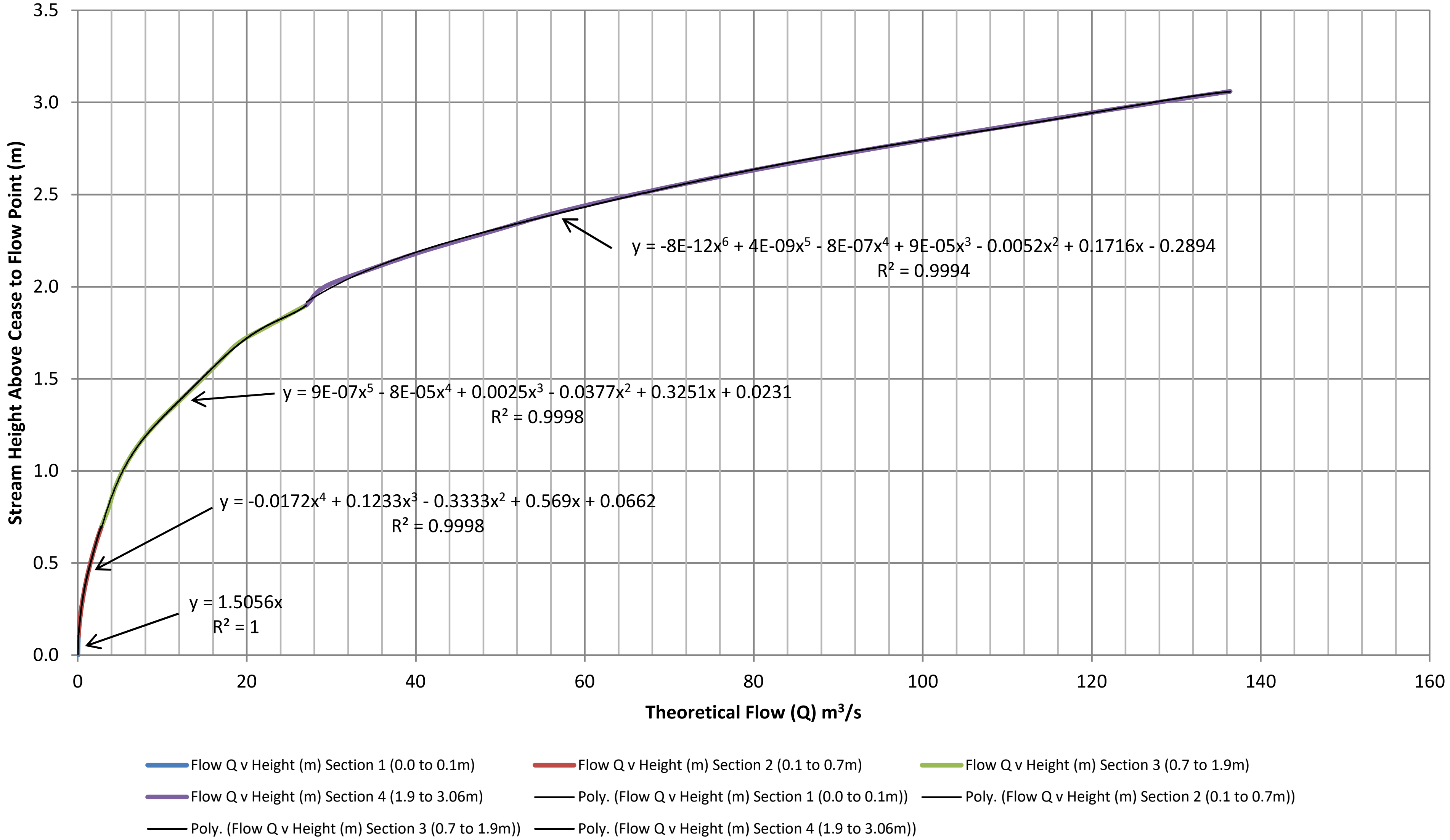
Wambo Coal
North Wambo Creek Flow Station 1 Cease to Flow Point Cross Section
Re-Survey
January 2022

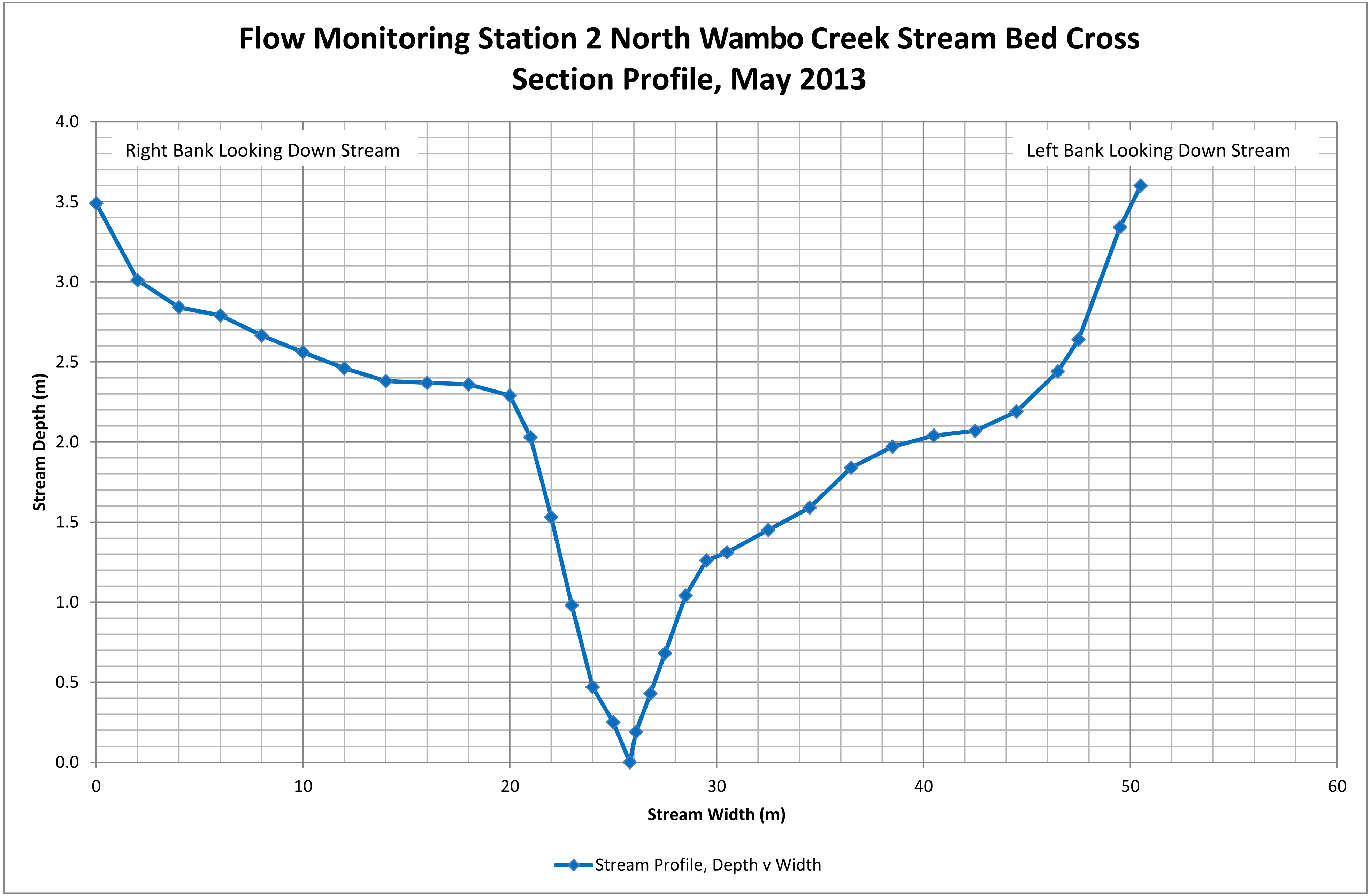




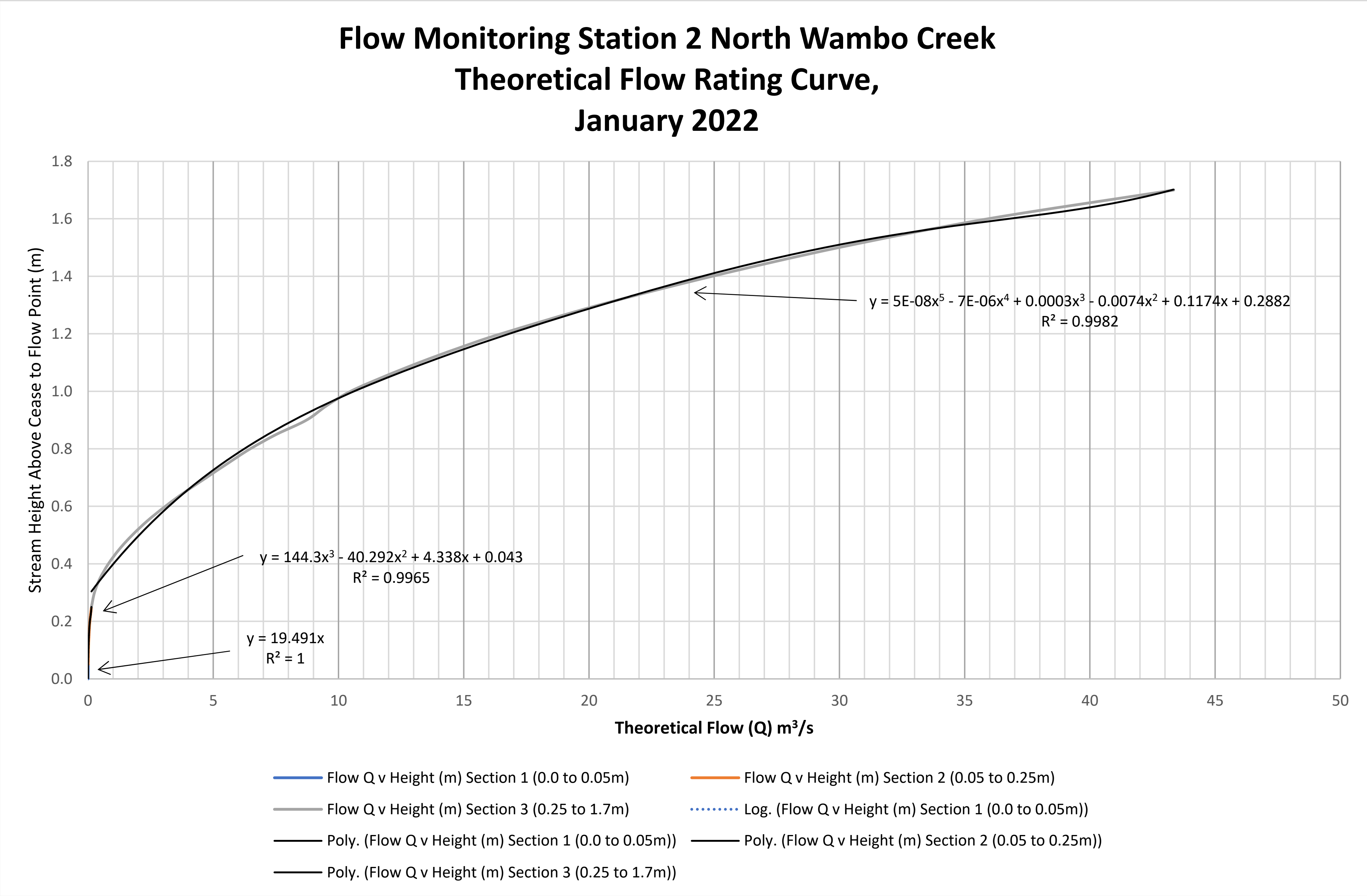
Wambo Coal
North Wambo Creek Flow Station 1 Long Section Profile Re-Survey
Through Cease to Flow Point
January 2022
Stream Surveyed Length (m)
0
10
20
30
40
50
60
70
80
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
Stream Depth (m)
Cease to Flow Point
y = 0.0007x + 1.8537
R² = 0.0138
Long Section
Linear (Long Section)

Flow Monitoring Station 2 North Wambo Creek Theoretical Flow Rating Curve, January 2018

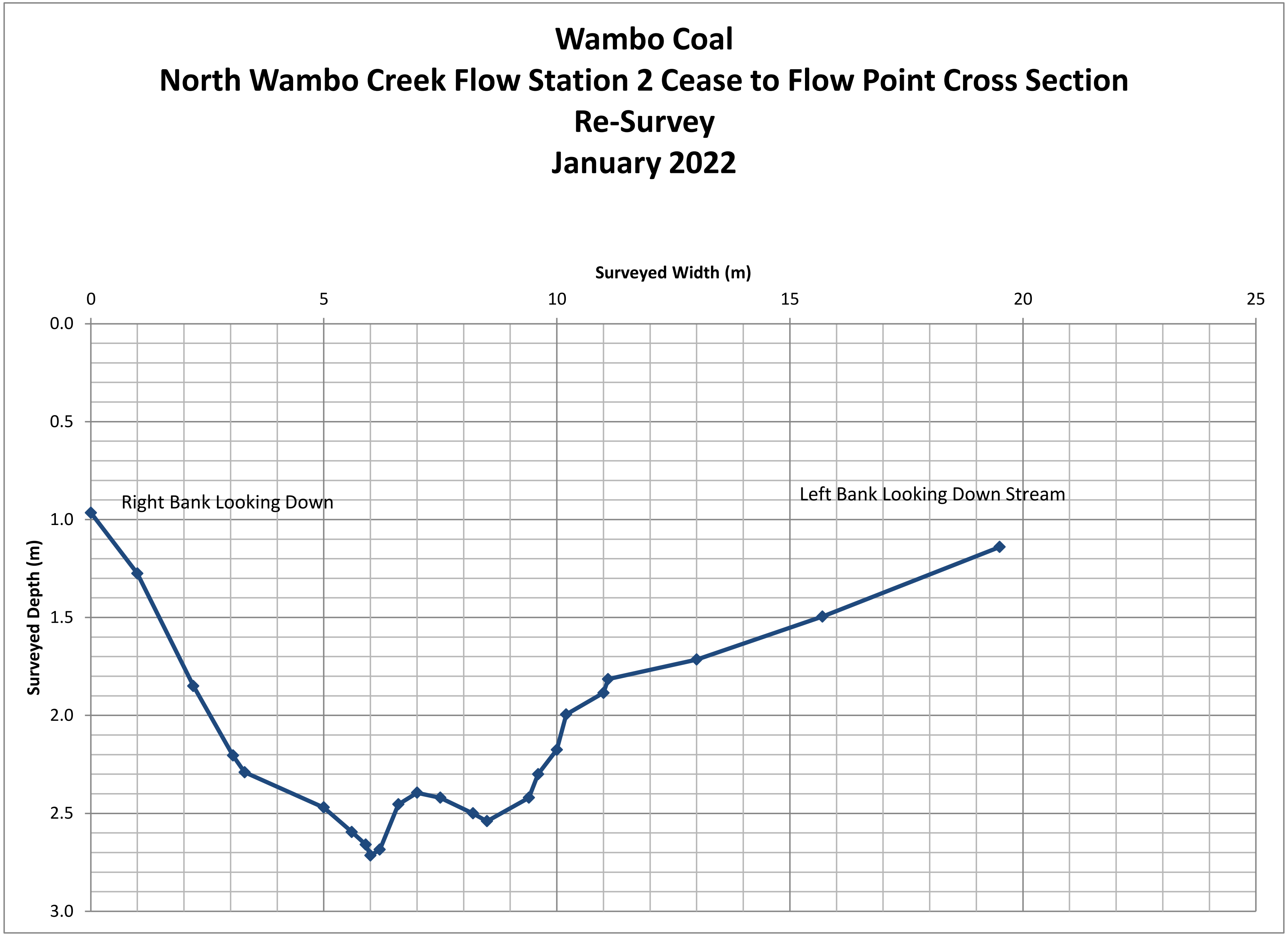




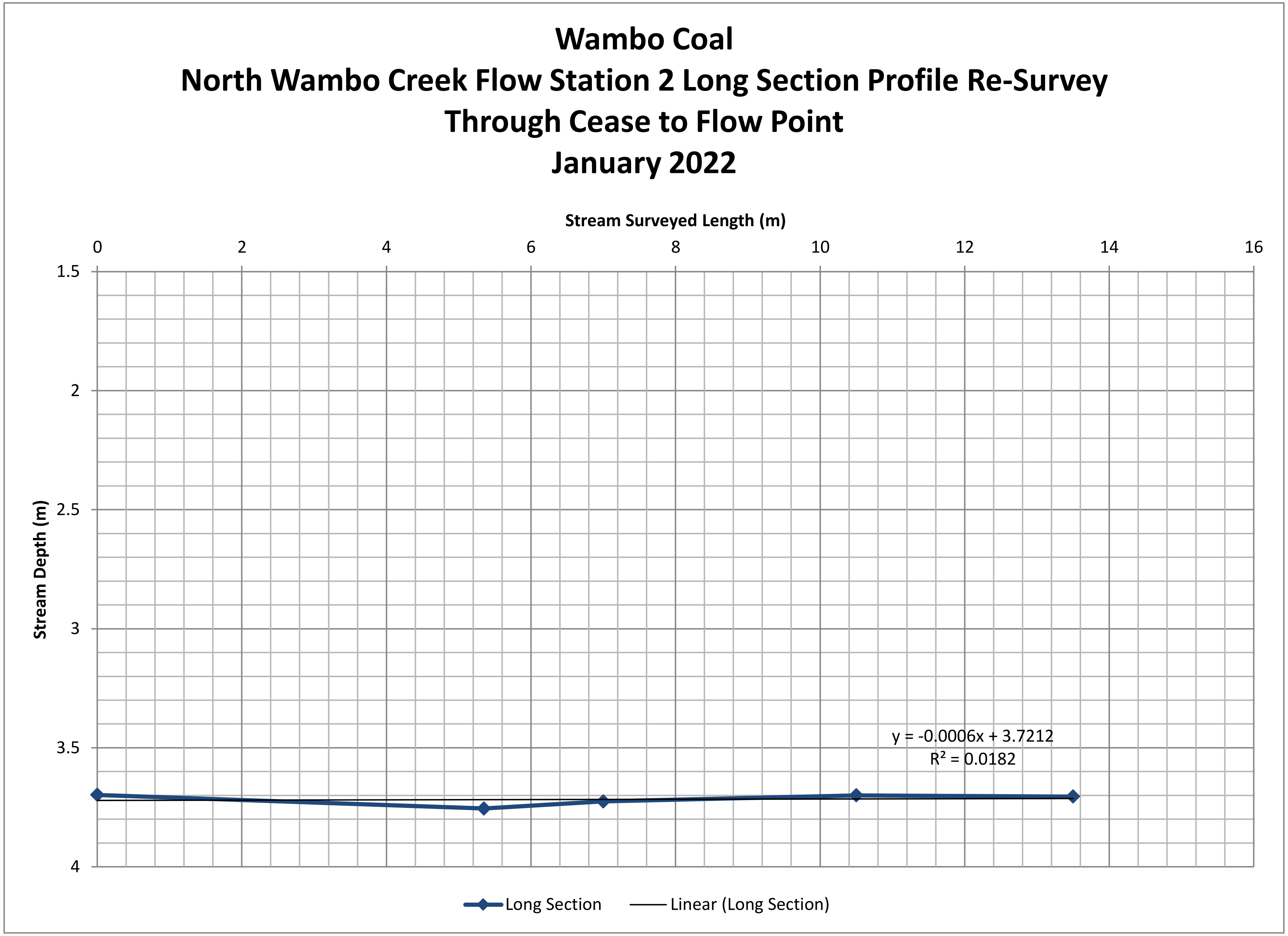
Flow Monitoring Station 2 North Wambo Creek Stream Bed Cross Section Profile, May 2013
Right Bank Looking Down Stream
Left Bank Looking Down Stream
Stream Depth (m)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
Stream Width (m)
Stream Profile, Depth v Width



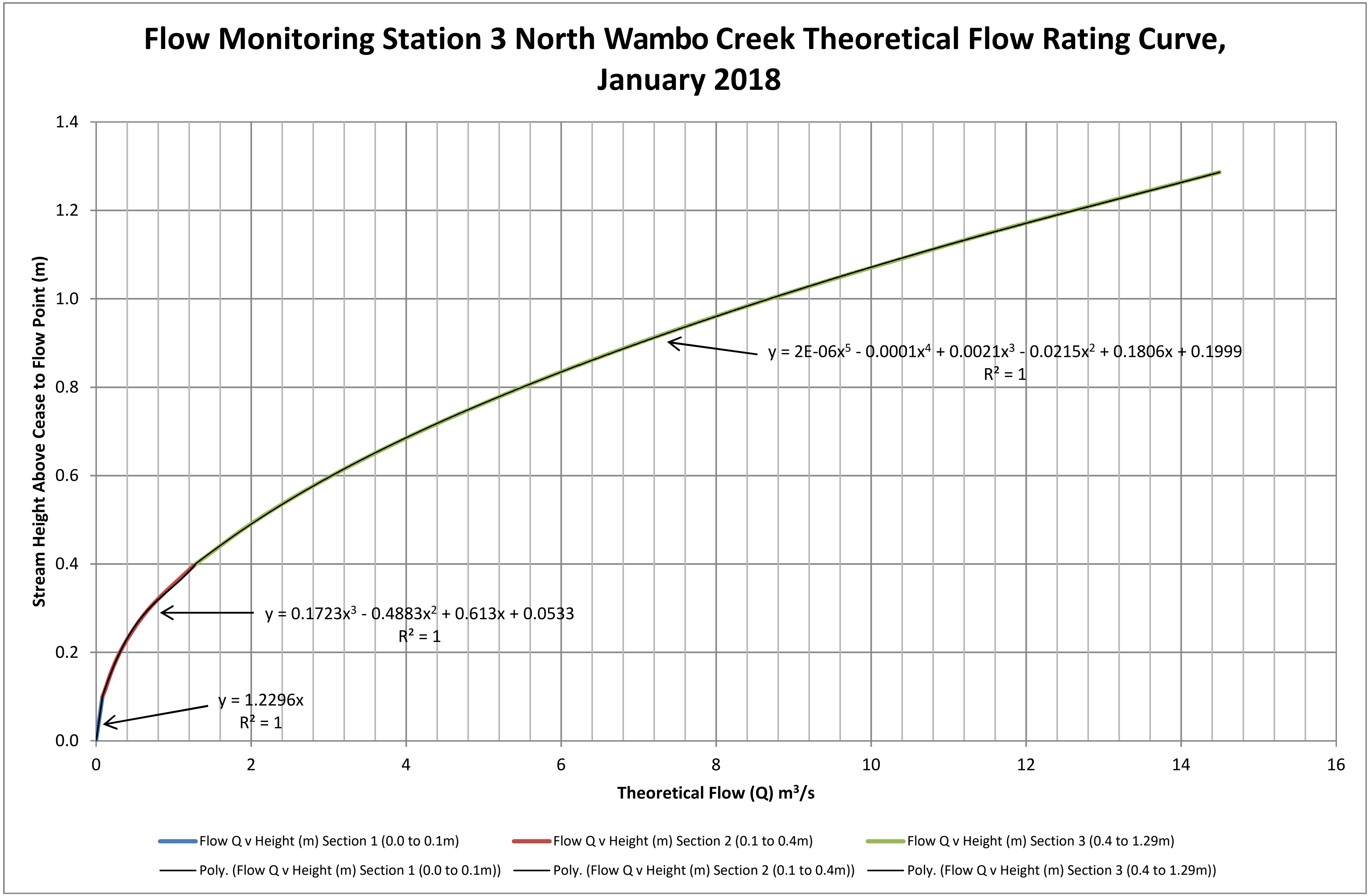
Flow Monitoring Station 2 North Wambo Creek
Theoretical Flow Rating Curve,
January 2022
Stream Height Above Cease to Flow Point (m)
Theoretical Flow (Q) m³/s
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0
5
10
15
20
25
30
35
40
45
50
y = 5E-08x⁵ - 7E-06x⁴ + 0.0003x³ - 0.0074x² + 0.1174x + 0.2882
R² = 0.9982
y = 144.3x³ - 40.292x² + 4.338x + 0.043
R² = 0.9965
y = 19.491x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.05m)
Flow Q v Height (m) Section 2 (0.05 to 0.25m)
Flow Q v Height (m) Section 3 (0.25 to 1.7m)
Log. (Flow Q v Height (m) Section 1 (0.0 to 0.05m))
Poly. (Flow Q v Height (m) Section 1 (0.0 to 0.05m))
Poly. (Flow Q v Height (m) Section 2 (0.05 to 0.25m))
Poly. (Flow Q v Height (m) Section 3 (0.25 to 1.7m))



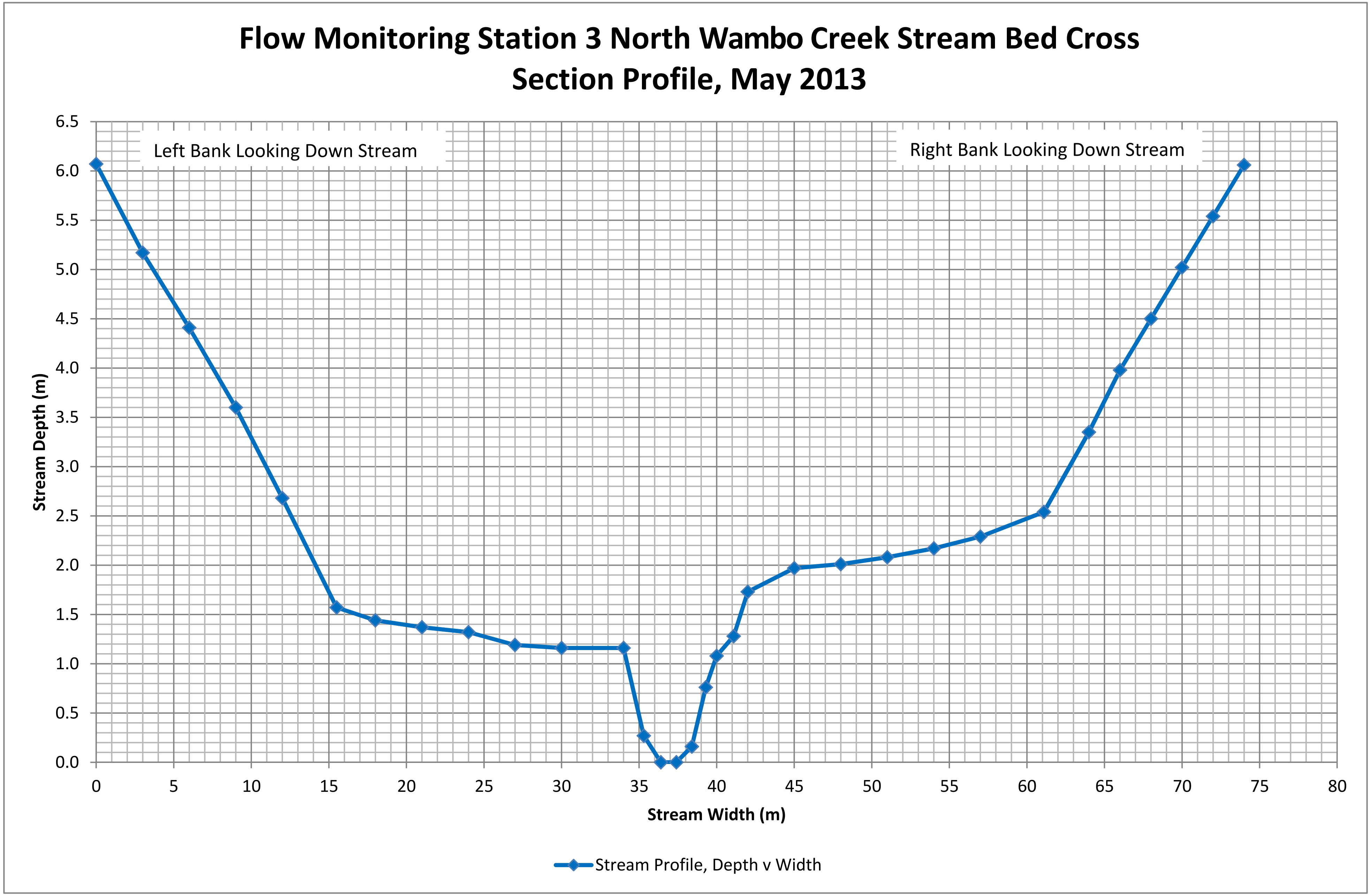
Wambo Coal
North Wambo Creek Flow Station 2 Cease to Flow Point Cross Section
Re-Survey
January 2022
Surveyed Width (m)
0
5
10
15
20
25
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Surveyed Depth (m)
Right Bank Looking Down
Left Bank Looking Down Stream



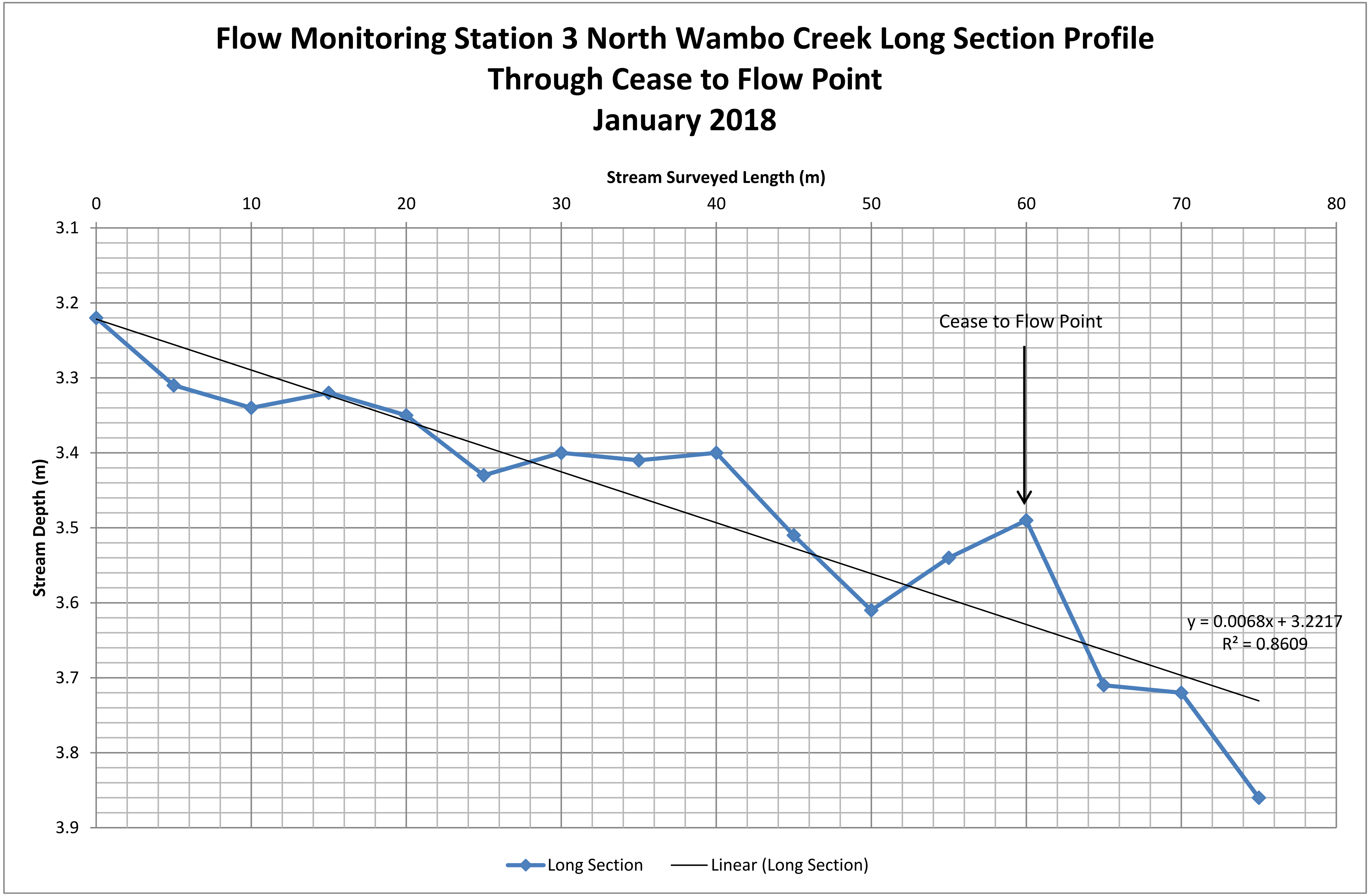
Wambo Coal
North Wambo Creek Flow Station 2 Long Section Profile Re-Survey
Through Cease to Flow Point
January 2022
Stream Surveyed Length (m)
0
2
4
6
8
10
12
14
16
Stream Depth (m)
1.5
2
2.5
3
3.5
4
y = -0.0006x + 3.7212
R² = 0.0182
Long Section
Linear (Long Section)

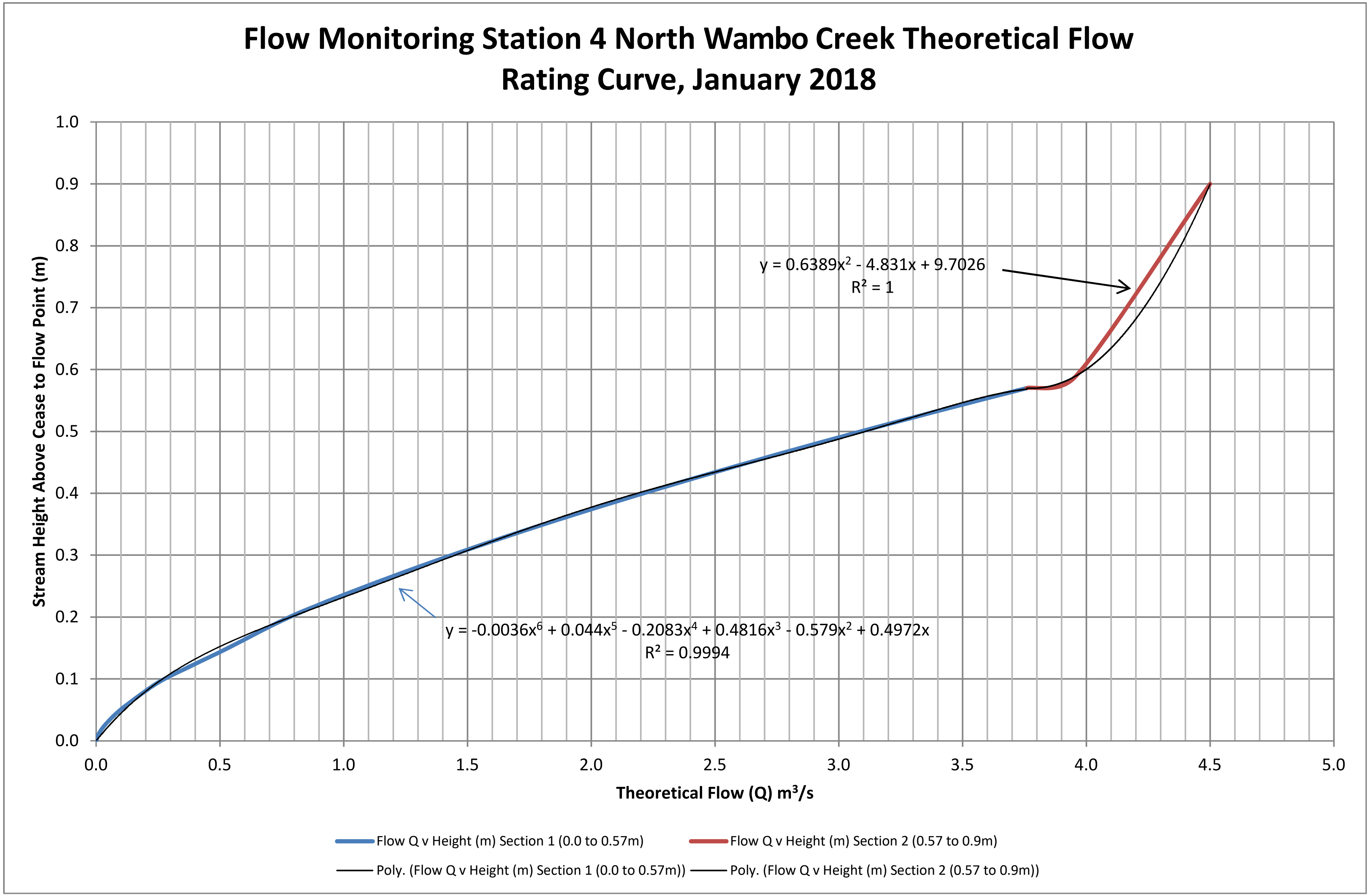


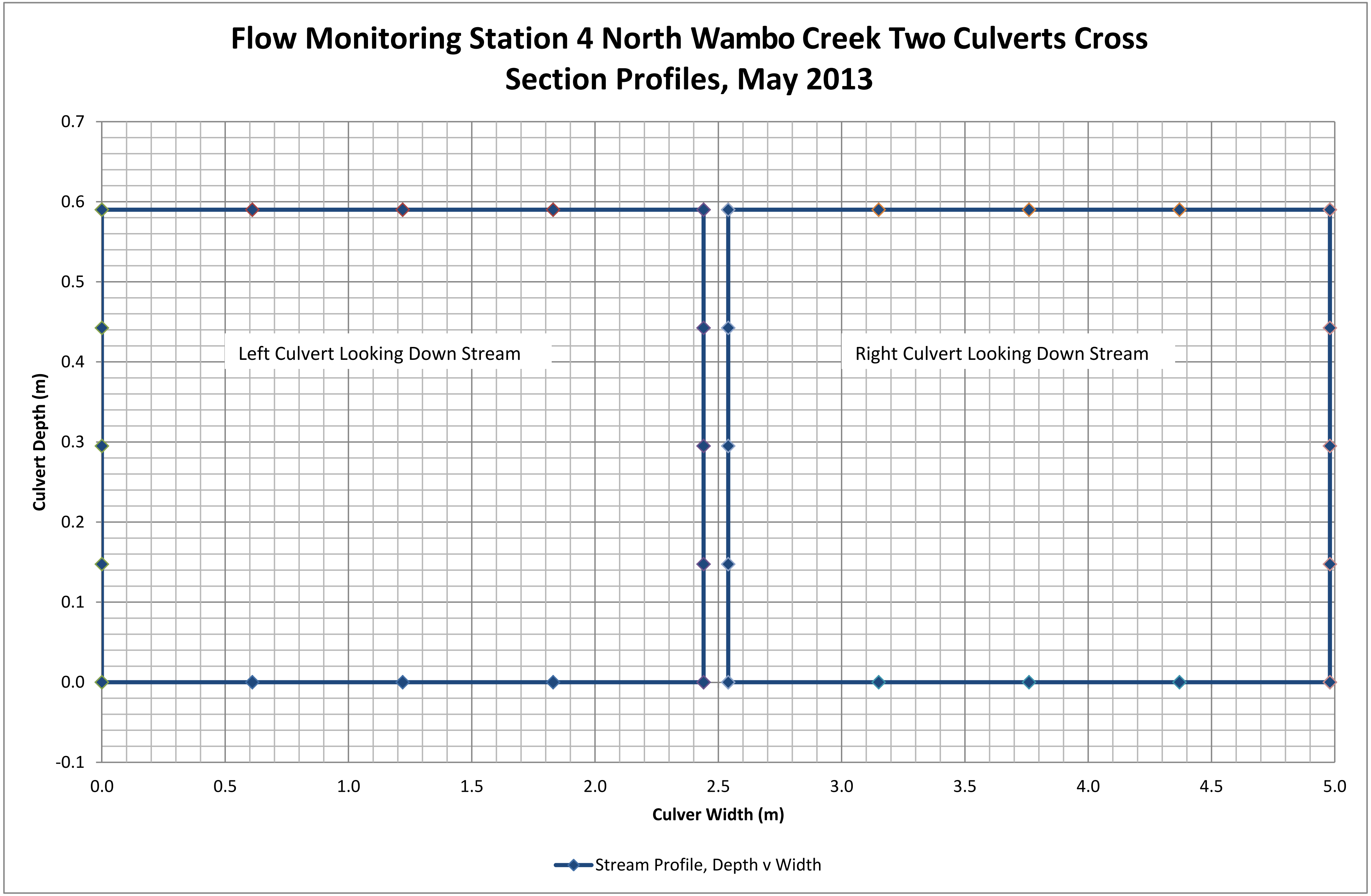
Flow Monitoring Station 3 North Wambo Creek Theoretical Flow Rating Curve, January 2018
Stream Height Above Cease to Flow Point (m)
Theoretical Flow (Q) m³/s
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
y = 2E-06x⁵ - 0.0001x⁴ + 0.0021x³ - 0.0215x² + 0.1806x + 0.1999
R² = 1
y = 0.1723x³ - 0.4883x² + 0.613x + 0.0533
R² = 1
y = 1.2296x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.1m)
Flow Q v Height (m) Section 2 (0.1 to 0.4m)
Flow Q v Height (m) Section 3 (0.4 to 1.29m)
Poly. (Flow Q v Height (m) Section 1 (0.0 to 0.1m))
Poly. (Flow Q v Height (m) Section 2 (0.1 to 0.4m))
Poly. (Flow Q v Height (m) Section 3 (0.4 to 1.29m))

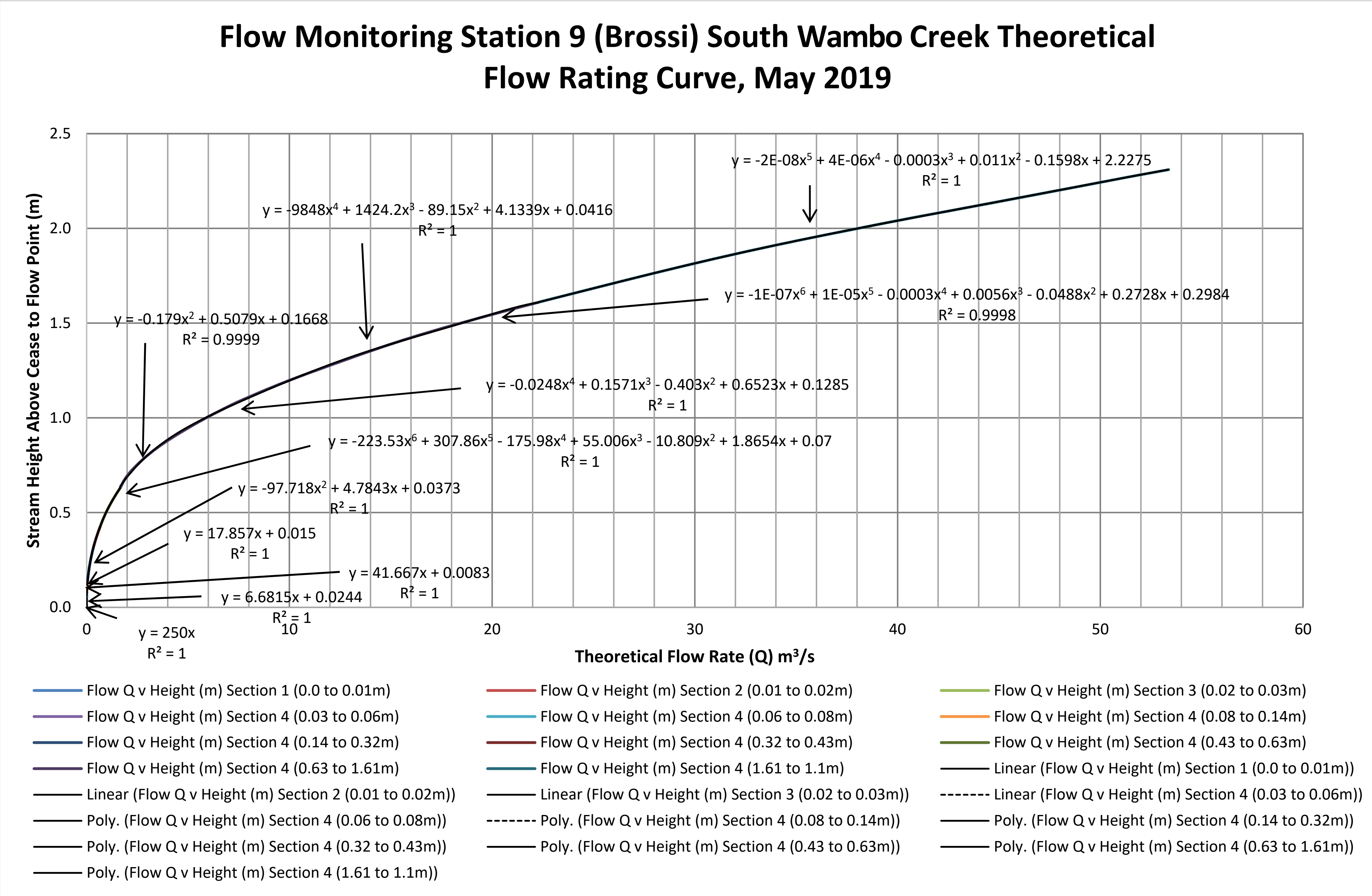


Flow Monitoring Station 3 North Wambo Creek Stream Bed Cross Section Profile, May 2013
Left Bank Looking Down Stream
Right Bank Looking Down Stream
Stream Depth (m)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Stream Width (m)
Stream Profile, Depth v Width

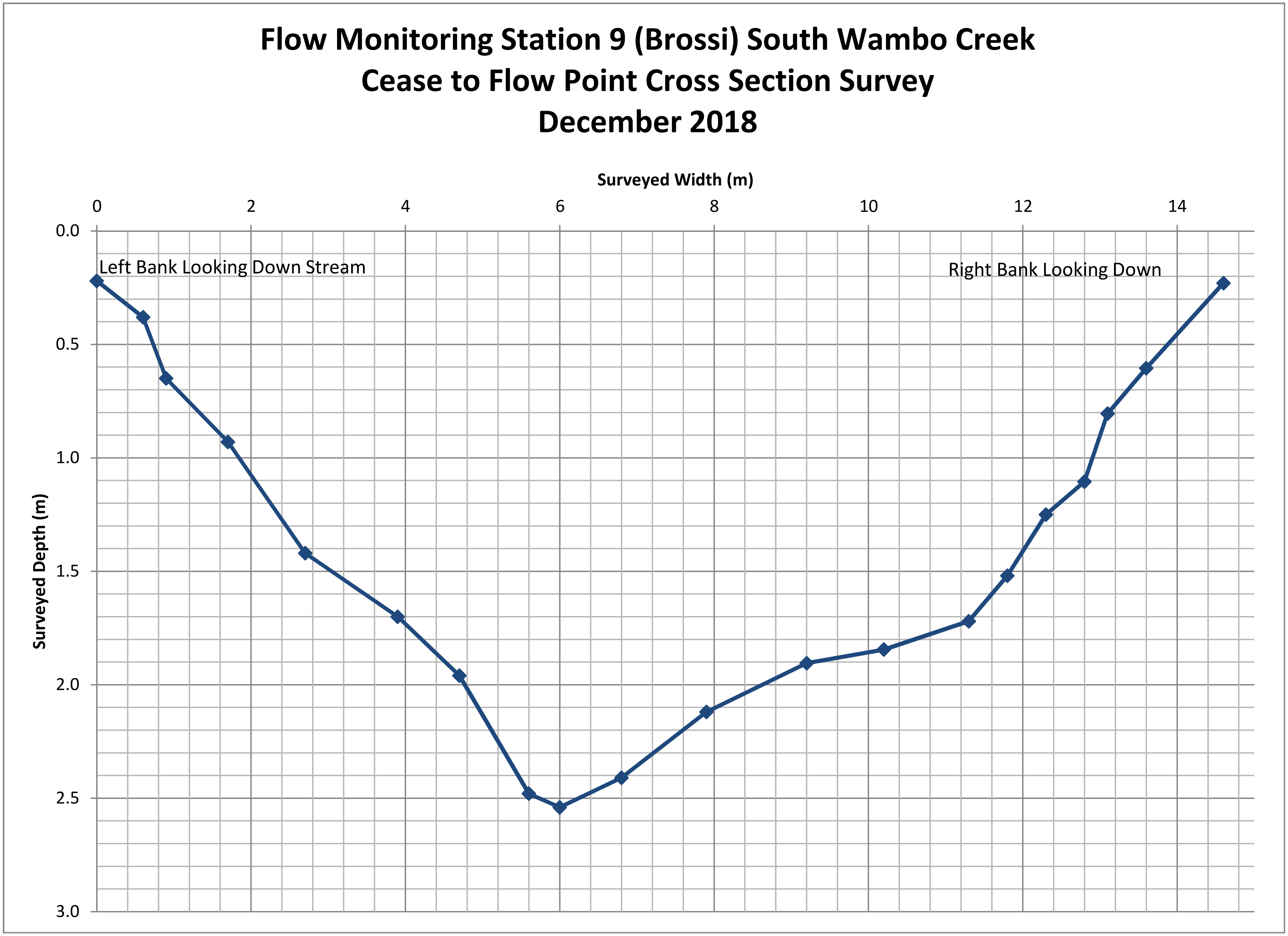

Flow Monitoring Station 3 North Wambo Creek Long Section Profile
Through Cease to Flow Point
January 2018
Stream Surveyed Length (m)
0
10
20
30
40
50
60
70
80
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
Stream Depth (m)
Cease to Flow Point
y = 0.0068x + 3.2217
R² = 0.8609
Long Section
Linear (Long Section)


Flow Monitoring Station 4 North Wambo Creek Theoretical Flow
Rating Curve, January 2018
Stream Height Above Cease to Flow Point (m)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Theoretical Flow (Q) m^3/s
$y = 0.6389x^2 - 4.831x + 9.7026$
$R^2 = 1$
$y = -0.0036x^6 + 0.044x^5 - 0.2083x^4 + 0.4816x^3 - 0.579x^2 + 0.4972x$
$R^2 = 0.9994$
Flow Q v Height (m) Section 1 (0.0 to 0.57m)
Flow Q v Height (m) Section 2 (0.57 to 0.9m)
Poly. (Flow Q v Height (m) Section 1 (0.0 to 0.57m))
Poly. (Flow Q v Height (m) Section 2 (0.57 to 0.9m))


Flow Monitoring Station 4 North Wambo Creek Two Culverts Cross Section Profiles, May 2013
Culvert Depth (m)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Culver Width (m)
Left Culvert Looking Down Stream
Right Culvert Looking Down Stream
Stream Profile, Depth v Width

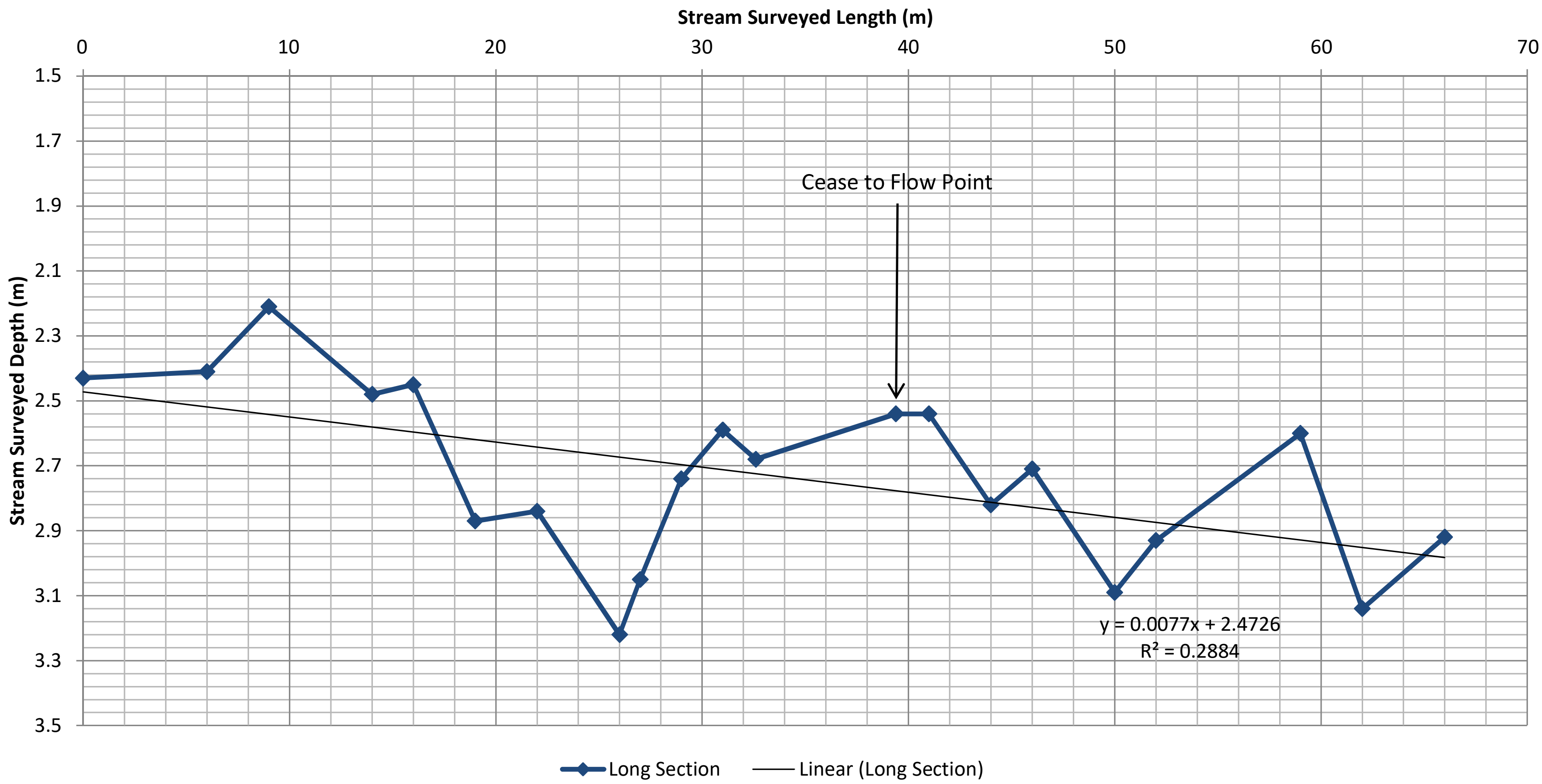


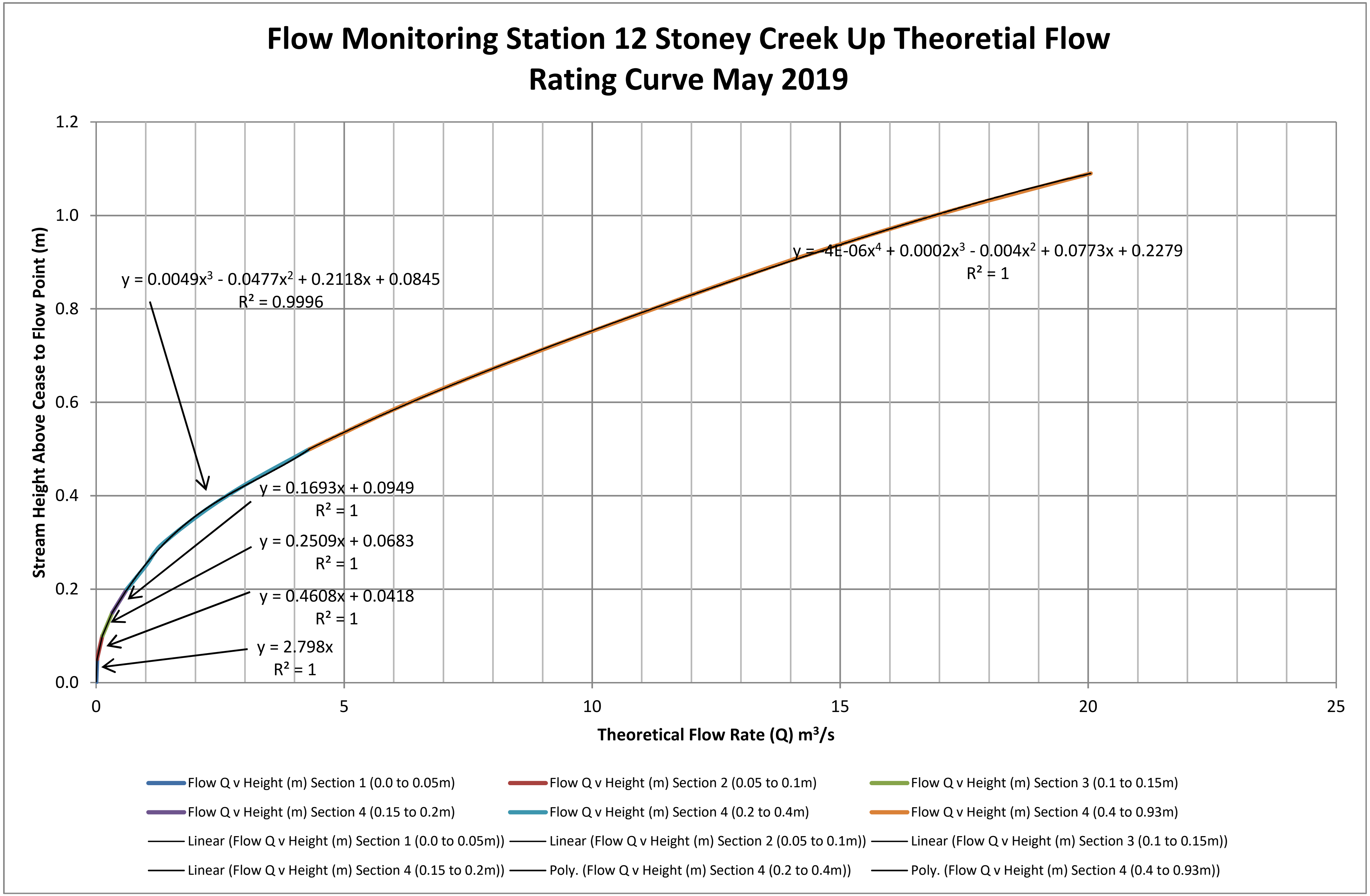
Flow Monitoring Station 9 (Brossi) South Wambo Creek Theoretical Flow Rating Curve, May 2019
Stream Height Above Cease to Flow Point (m)
Theoretical Flow Rate (Q) m³/s
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
y = -2E-08x⁵ + 4E-06x⁴ - 0.0003x³ + 0.011x² - 0.1598x + 2.2275
R² = 1
y = -9848x⁴ + 1424.2x³ - 89.15x² + 4.1339x + 0.0416
R² = 1
y = -1E-07x⁶ + 1E-05x⁵ - 0.0003x⁴ + 0.0056x³ - 0.0488x² + 0.2728x + 0.2984
R² = 0.9998
y = -0.179x² + 0.5079x + 0.1668
R² = 0.9999
y = -0.0248x⁴ + 0.1571x³ - 0.403x² + 0.6523x + 0.1285
R² = 1
y = -223.53x⁶ + 307.86x⁵ - 175.98x⁴ + 55.006x³ - 10.809x² + 1.8654x + 0.07
R² = 1
y = -97.718x² + 4.7843x + 0.0373
R² = 1
y = 17.857x + 0.015
R² = 1
y = 41.667x + 0.0083
R² = 1
y = 6.6815x + 0.0244
R² = 1
y = 250x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.01m)
Flow Q v Height (m) Section 2 (0.01 to 0.02m)
Flow Q v Height (m) Section 3 (0.02 to 0.03m)
Flow Q v Height (m) Section 4 (0.03 to 0.06m)
Flow Q v Height (m) Section 4 (0.06 to 0.08m)
Flow Q v Height (m) Section 4 (0.08 to 0.14m)
Flow Q v Height (m) Section 4 (0.14 to 0.32m)
Flow Q v Height (m) Section 4 (0.32 to 0.43m)
Flow Q v Height (m) Section 4 (0.43 to 0.63m)
Flow Q v Height (m) Section 4 (0.63 to 1.61m)
Flow Q v Height (m) Section 4 (1.61 to 1.1m)
Linear (Flow Q v Height (m) Section 1 (0.0 to 0.01m))
Linear (Flow Q v Height (m) Section 2 (0.01 to 0.02m))
Linear (Flow Q v Height (m) Section 3 (0.02 to 0.03m))
Linear (Flow Q v Height (m) Section 4 (0.03 to 0.06m))
Poly. (Flow Q v Height (m) Section 4 (0.06 to 0.08m))
Poly. (Flow Q v Height (m) Section 4 (0.08 to 0.14m))
Poly. (Flow Q v Height (m) Section 4 (0.14 to 0.32m))
Poly. (Flow Q v Height (m) Section 4 (0.32 to 0.43m))
Poly. (Flow Q v Height (m) Section 4 (0.43 to 0.63m))
Poly. (Flow Q v Height (m) Section 4 (0.63 to 1.61m))
Poly. (Flow Q v Height (m) Section 4 (1.61 to 1.1m))

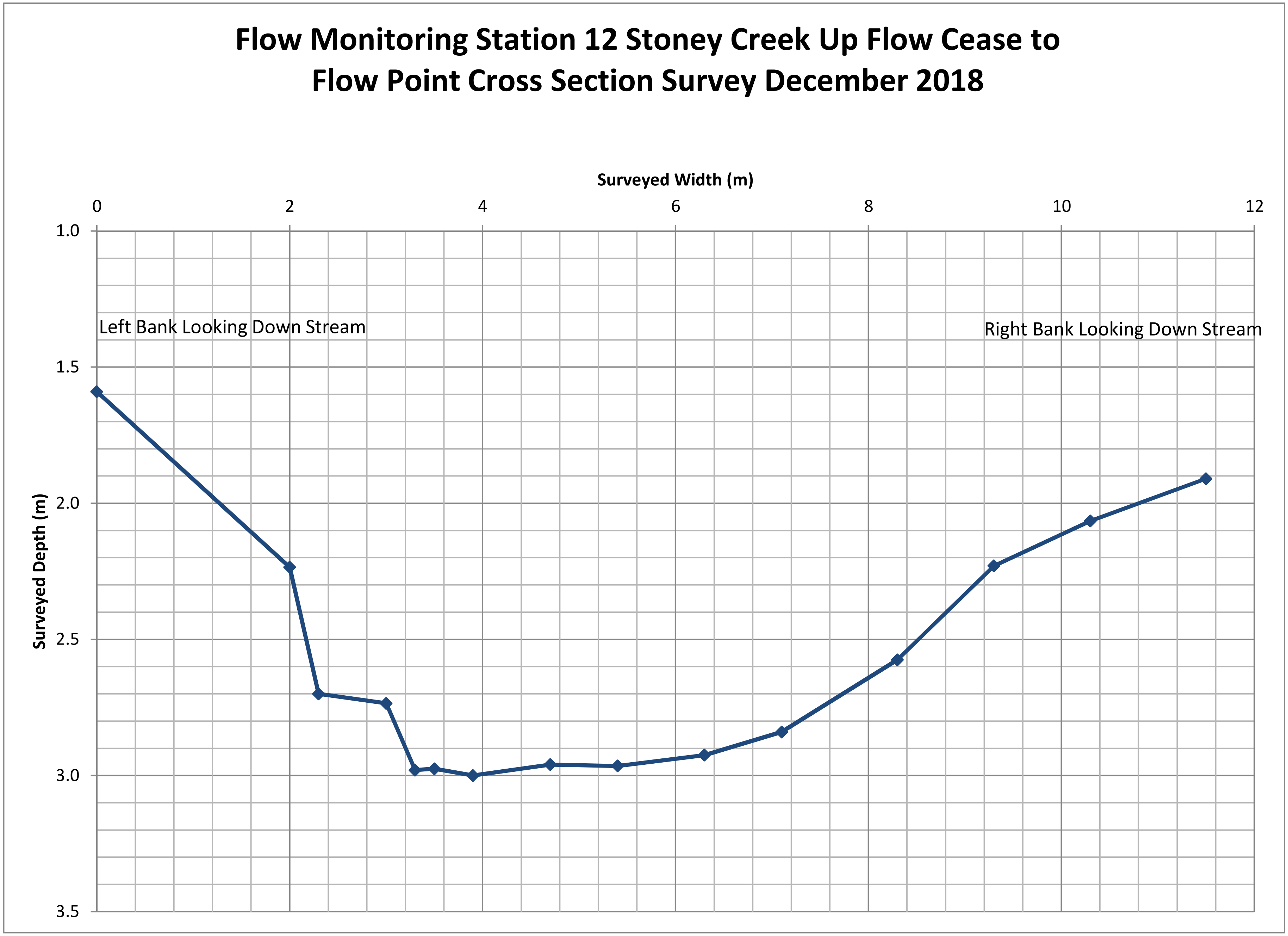


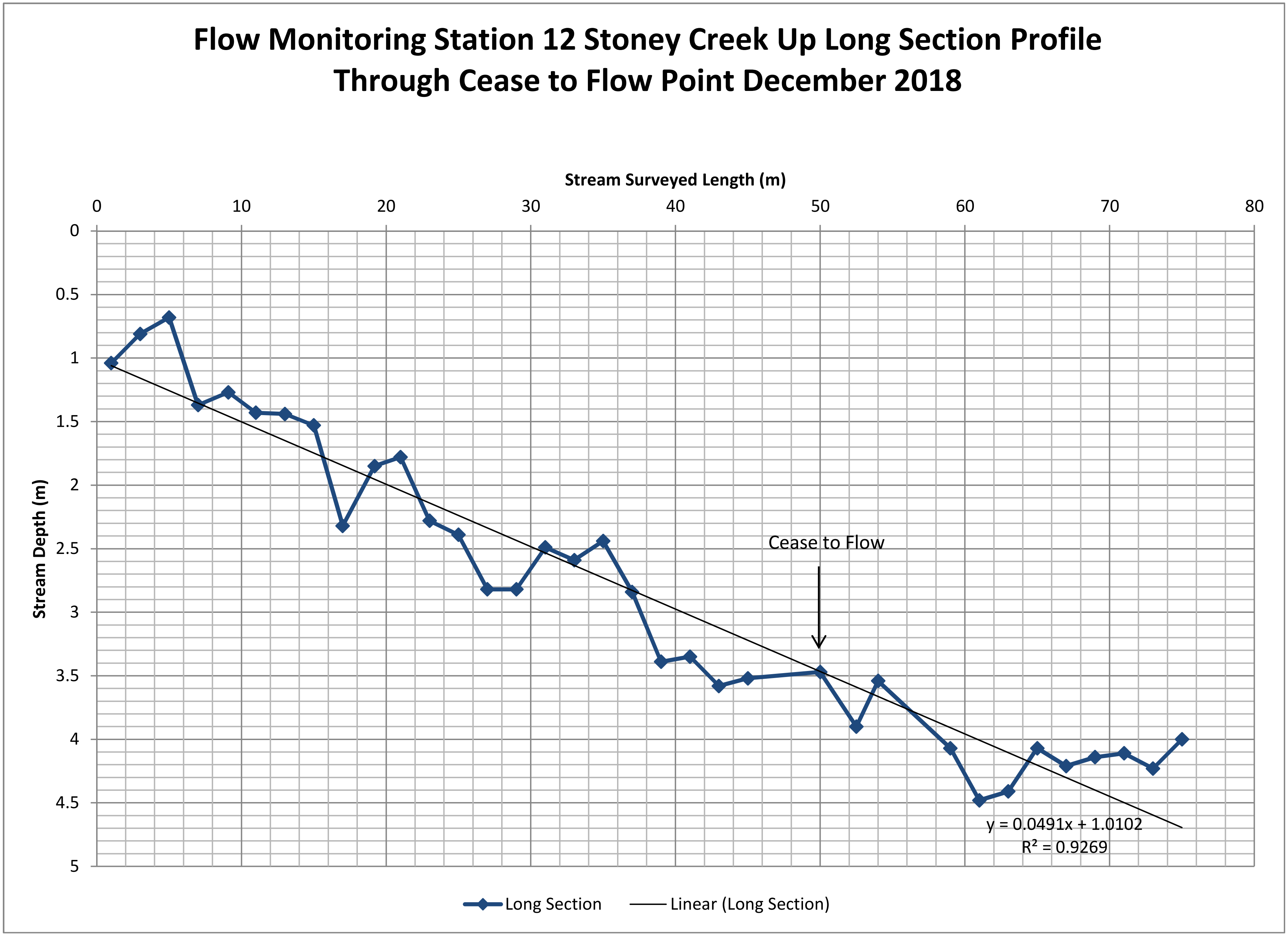
Flow Monitoring Station 9 (Brossi) South Wambo Creek
Cease to Flow Point Cross Section Survey
December 2018
Surveyed Width (m)
0
2
4
6
8
10
12
14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Surveyed Depth (m)
Left Bank Looking Down Stream
Right Bank Looking Down

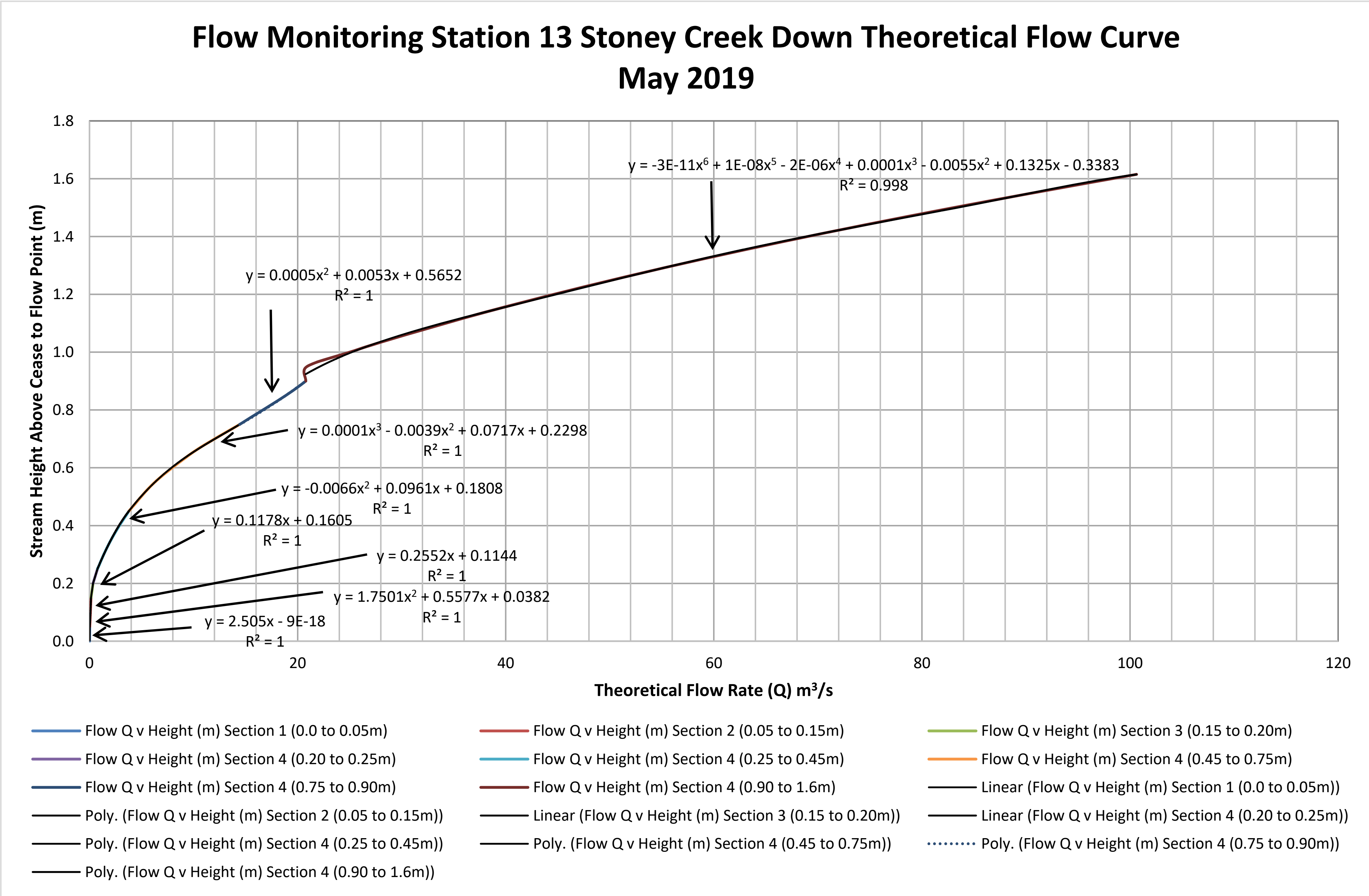
Flow Monitoring Station 9 (Brossi) South Wambo Creek Long Section Profile Through Cease to Flow Point December 2018




Flow Monitoring Station 12 Stoney Creek Up Theoretial Flow Rating Curve May 2019
Stream Height Above Cease to Flow Point (m)
Theoretical Flow Rate (Q) m³/s
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
25
y = 0.0049x³ - 0.0477x² + 0.2118x + 0.0845
R² = 0.9996
y = -4E-06x⁴ + 0.0002x³ - 0.004x² + 0.0773x + 0.2279
R² = 1
y = 0.1693x + 0.0949
R² = 1
y = 0.2509x + 0.0683
R² = 1
y = 0.4608x + 0.0418
R² = 1
y = 2.798x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.05m)
Flow Q v Height (m) Section 2 (0.05 to 0.1m)
Flow Q v Height (m) Section 3 (0.1 to 0.15m)
Flow Q v Height (m) Section 4 (0.15 to 0.2m)
Flow Q v Height (m) Section 4 (0.2 to 0.4m)
Flow Q v Height (m) Section 4 (0.4 to 0.93m)
Linear (Flow Q v Height (m) Section 1 (0.0 to 0.05m))
Linear (Flow Q v Height (m) Section 2 (0.05 to 0.1m))
Linear (Flow Q v Height (m) Section 3 (0.1 to 0.15m))
Linear (Flow Q v Height (m) Section 4 (0.15 to 0.2m))
Poly. (Flow Q v Height (m) Section 4 (0.2 to 0.4m))
Poly. (Flow Q v Height (m) Section 4 (0.4 to 0.93m))

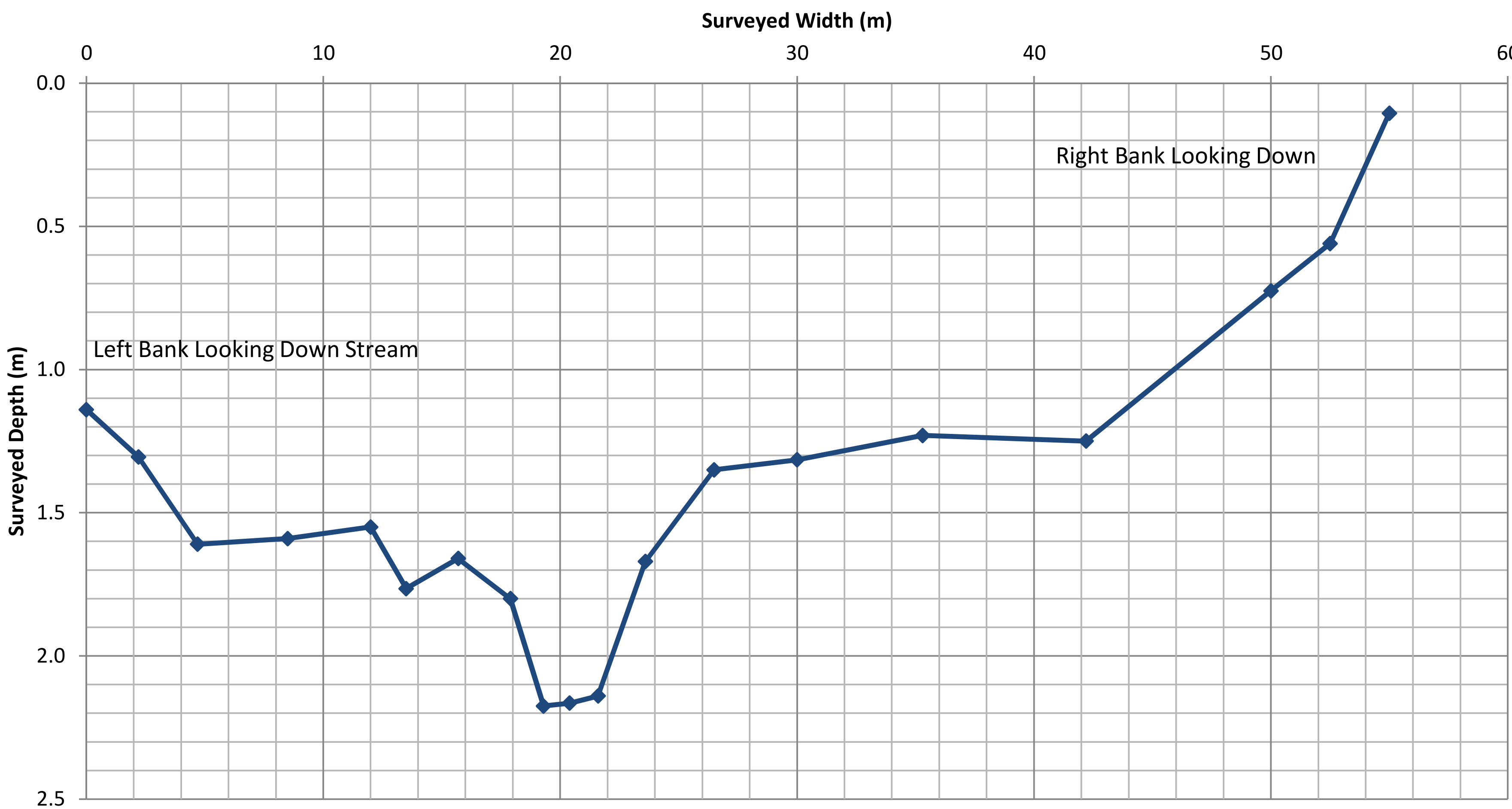

Flow Monitoring Station 12 Stoney Creek Up Flow Cease to
Flow Point Cross Section Survey December 2018
Surveyed Width (m)
0
2
4
6
8
10
12
1.0
1.5
2.0
2.5
3.0
3.5
Surveyed Depth (m)
Left Bank Looking Down Stream
Right Bank Looking Down Stream

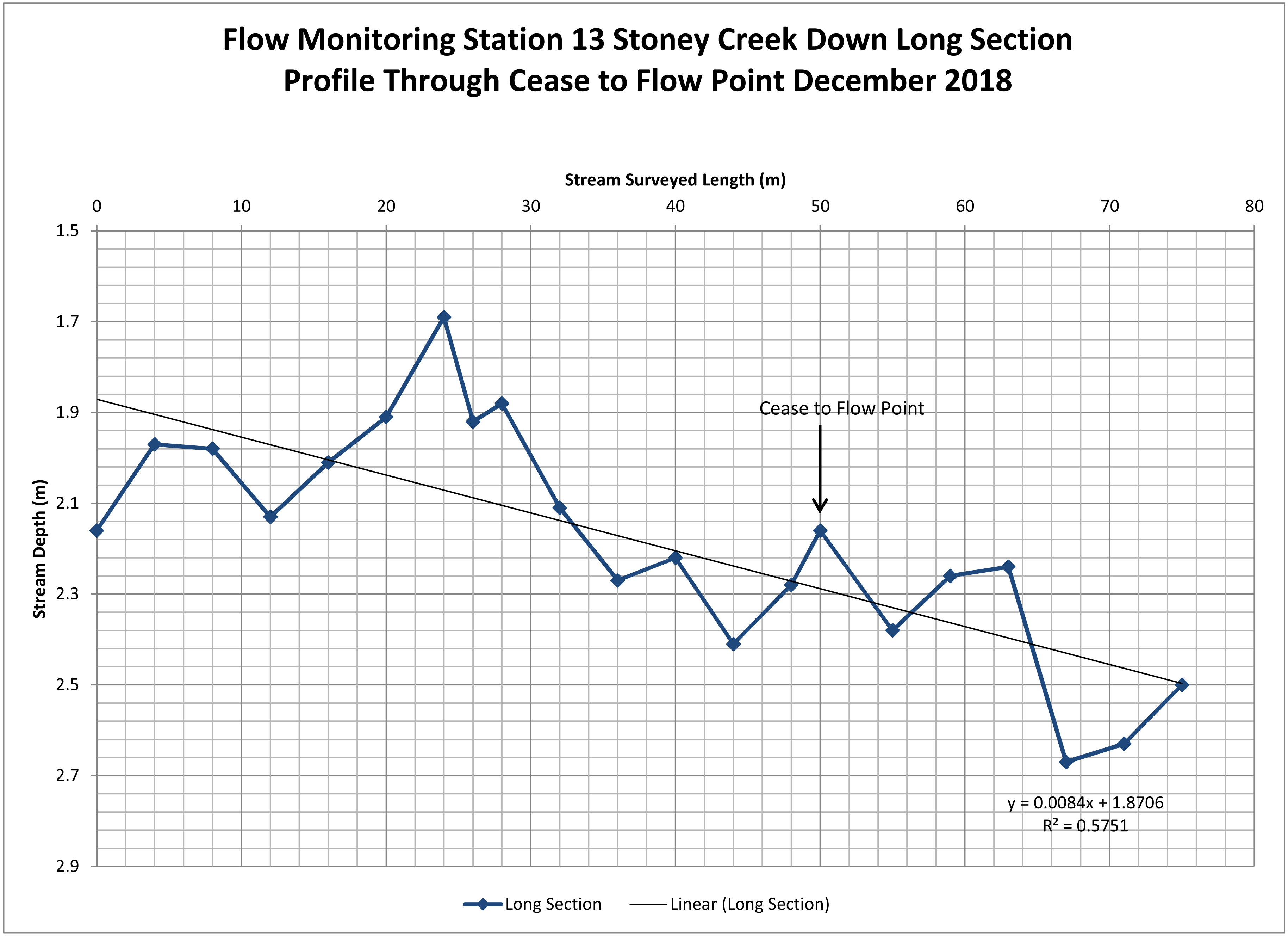

Flow Monitoring Station 12 Stoney Creek Up Long Section Profile
Through Cease to Flow Point December 2018
Stream Surveyed Length (m)
0
10
20
30
40
50
60
70
80
Stream Depth (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Cease to Flow
y = 0.0491x + 1.0102
R² = 0.9269
Long Section
Linear (Long Section)



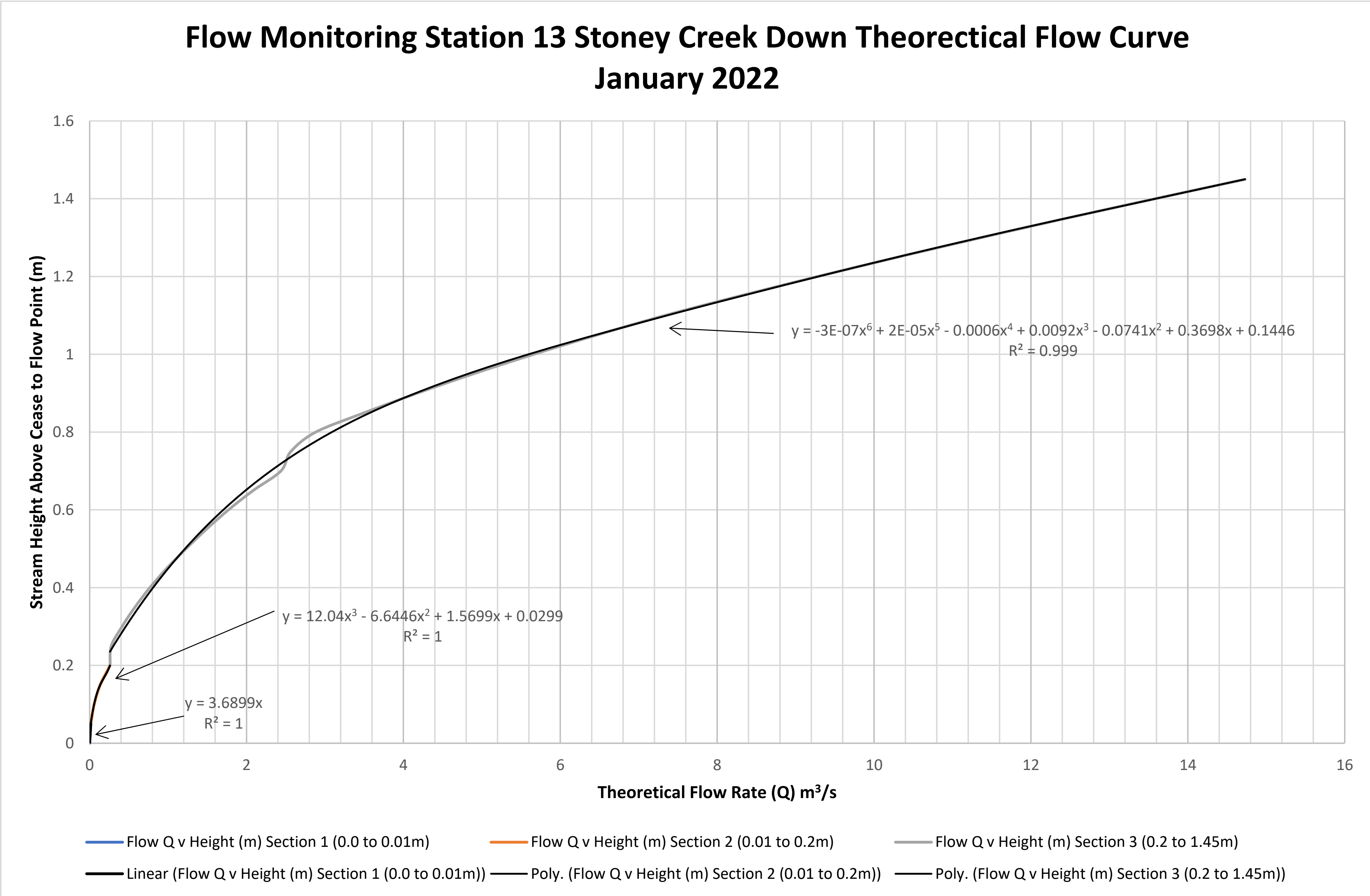
Flow Monitoring Station 13 Stoney Creek Down Theoretical Flow Curve
May 2019
Stream Height Above Cease to Flow Point (m)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
Theoretical Flow Rate (Q) m³/s
y = -3E-11x⁶ + 1E-08x⁵ - 2E-06x⁴ + 0.0001x³ - 0.0055x² + 0.1325x - 0.3383
R² = 0.998
y = 0.0005x² + 0.0053x + 0.5652
R² = 1
y = 0.0001x³ - 0.0039x² + 0.0717x + 0.2298
R² = 1
y = -0.0066x² + 0.0961x + 0.1808
R² = 1
y = 0.1178x + 0.1605
R² = 1
y = 0.2552x + 0.1144
R² = 1
y = 1.7501x² + 0.5577x + 0.0382
R² = 1
y = 2.505x - 9E-18
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.05m)
Flow Q v Height (m) Section 2 (0.05 to 0.15m)
Flow Q v Height (m) Section 3 (0.15 to 0.20m)
Flow Q v Height (m) Section 4 (0.20 to 0.25m)
Flow Q v Height (m) Section 4 (0.25 to 0.45m)
Flow Q v Height (m) Section 4 (0.45 to 0.75m)
Flow Q v Height (m) Section 4 (0.75 to 0.90m)
Flow Q v Height (m) Section 4 (0.90 to 1.6m)
Linear (Flow Q v Height (m) Section 1 (0.0 to 0.05m))
Poly. (Flow Q v Height (m) Section 2 (0.05 to 0.15m))
Linear (Flow Q v Height (m) Section 3 (0.15 to 0.20m))
Linear (Flow Q v Height (m) Section 4 (0.20 to 0.25m))
Poly. (Flow Q v Height (m) Section 4 (0.25 to 0.45m))
Poly. (Flow Q v Height (m) Section 4 (0.45 to 0.75m))
Poly. (Flow Q v Height (m) Section 4 (0.75 to 0.90m))
Poly. (Flow Q v Height (m) Section 4 (0.90 to 1.6m))

Flow Monitoring Station 13 Stoney Creek Down Cease to Flow Point Cross Section Survey December 2018



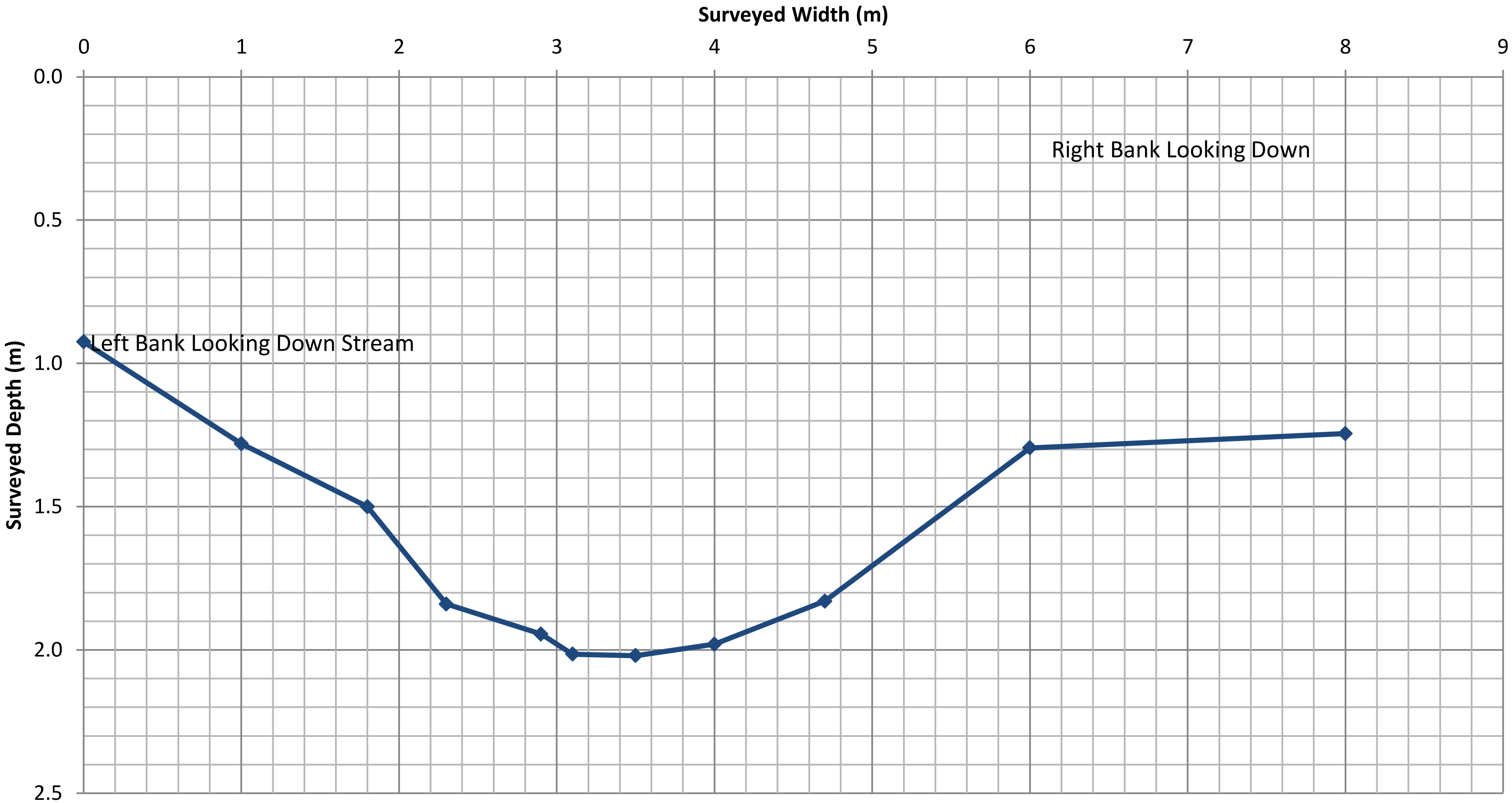


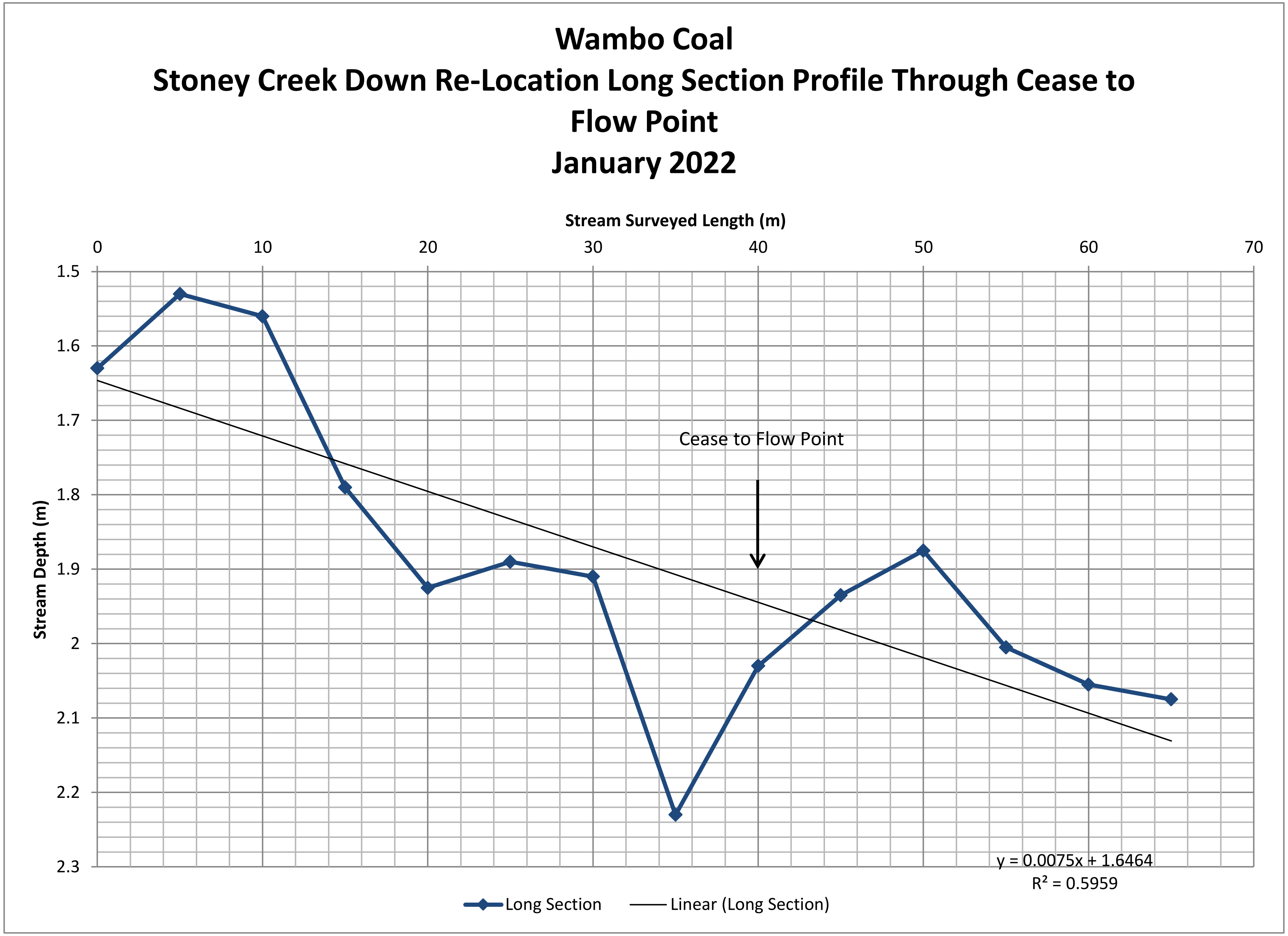
Flow Monitoring Station 13 Stoney Creek Down Long Section
Profile Through Cease to Flow Point December 2018
Stream Surveyed Length (m)
0
10
20
30
40
50
60
70
80
Stream Depth (m)
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
Cease to Flow Point
y = 0.0084x + 1.8706
R² = 0.5751
Long Section
Linear (Long Section)



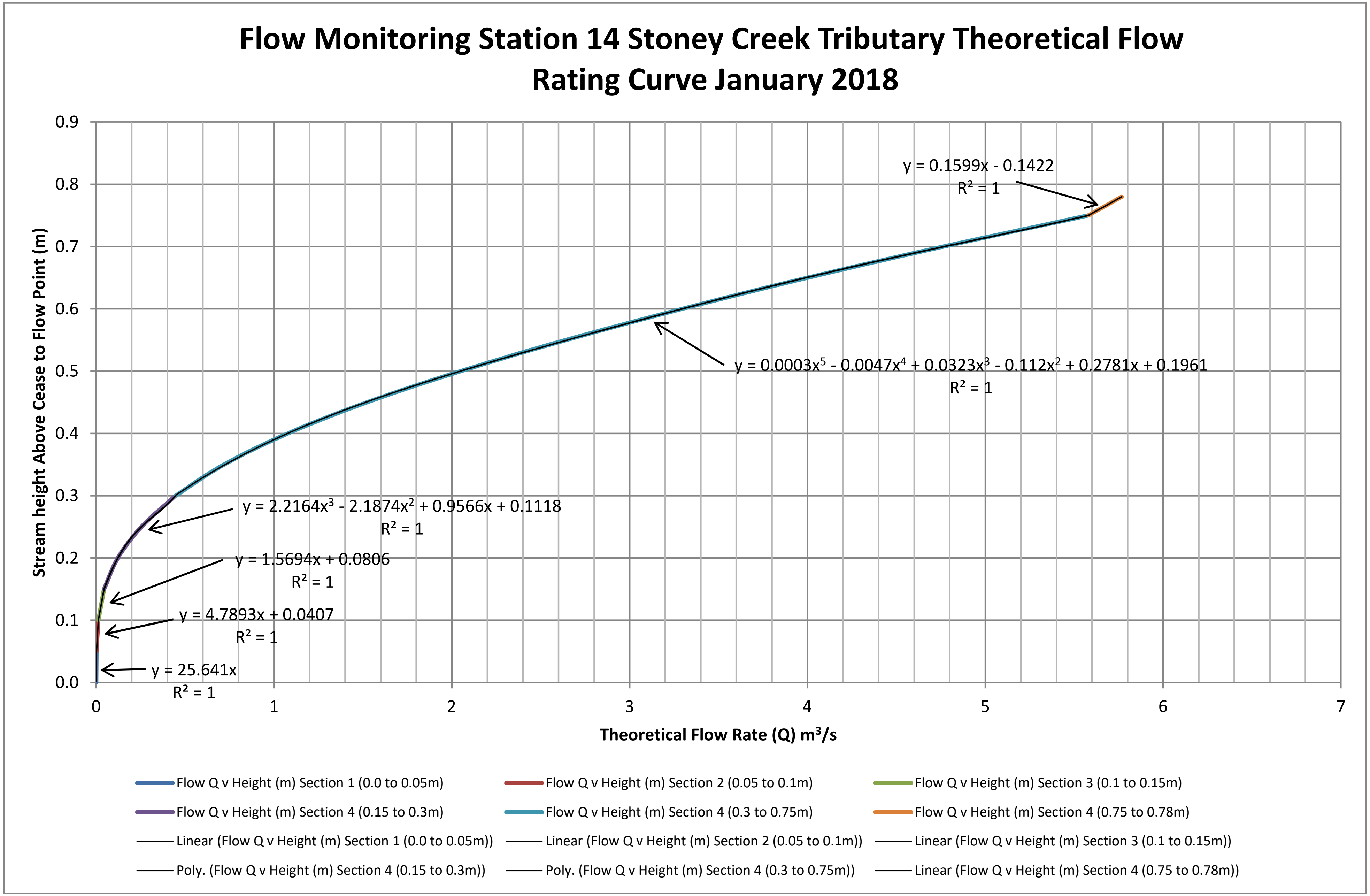
Flow Monitoring Station 13 Stoney Creek Down Theorectical Flow Curve
January 2022
Stream Height Above Cease to Flow Point (m)
Theoretical Flow Rate (Q) m³/s
y = -3E-07x⁶ + 2E-05x⁵ - 0.0006x⁴ + 0.0092x³ - 0.0741x² + 0.3698x + 0.1446
R² = 0.999
y = 12.04x³ - 6.6446x² + 1.5699x + 0.0299
R² = 1
y = 3.6899x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.01m)
Flow Q v Height (m) Section 2 (0.01 to 0.2m)
Flow Q v Height (m) Section 3 (0.2 to 1.45m)
Linear (Flow Q v Height (m) Section 1 (0.0 to 0.01m))
Poly. (Flow Q v Height (m) Section 2 (0.01 to 0.2m))
Poly. (Flow Q v Height (m) Section 3 (0.2 to 1.45m))

Wambo Coal
Stoney Creek Down Flow Station Re-Location Cease to Flow Point Cross Section Survey
January 2022

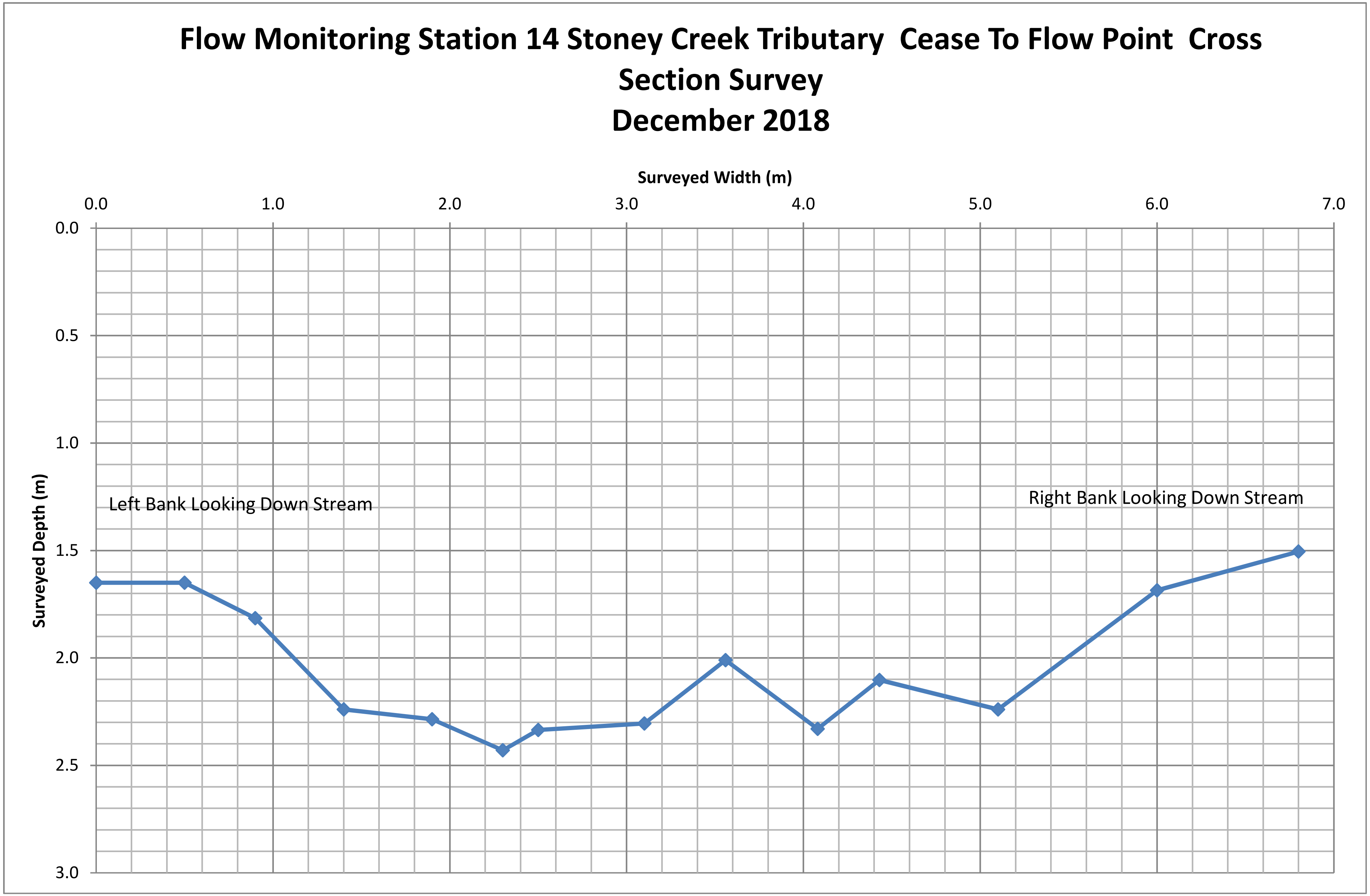


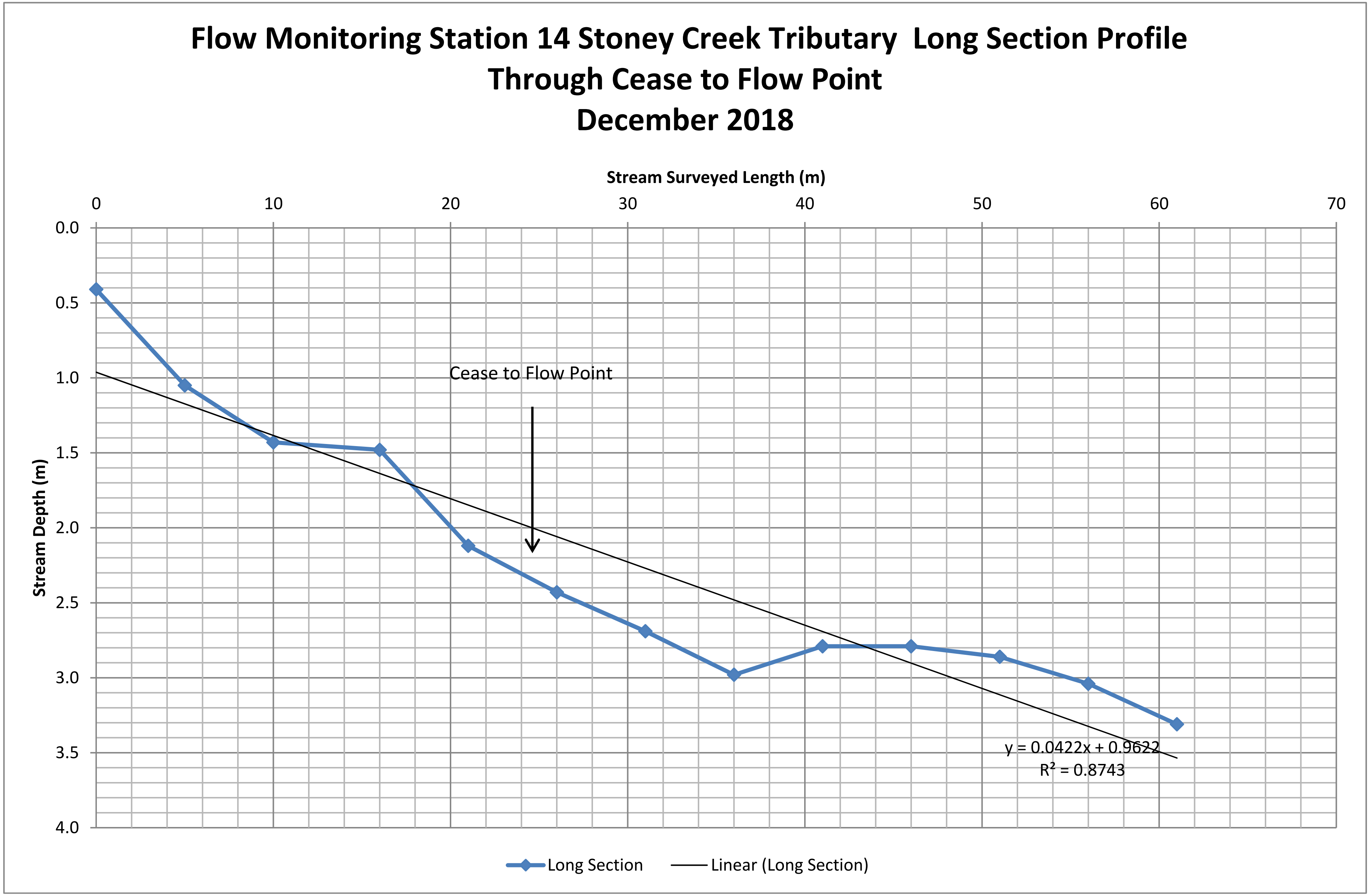


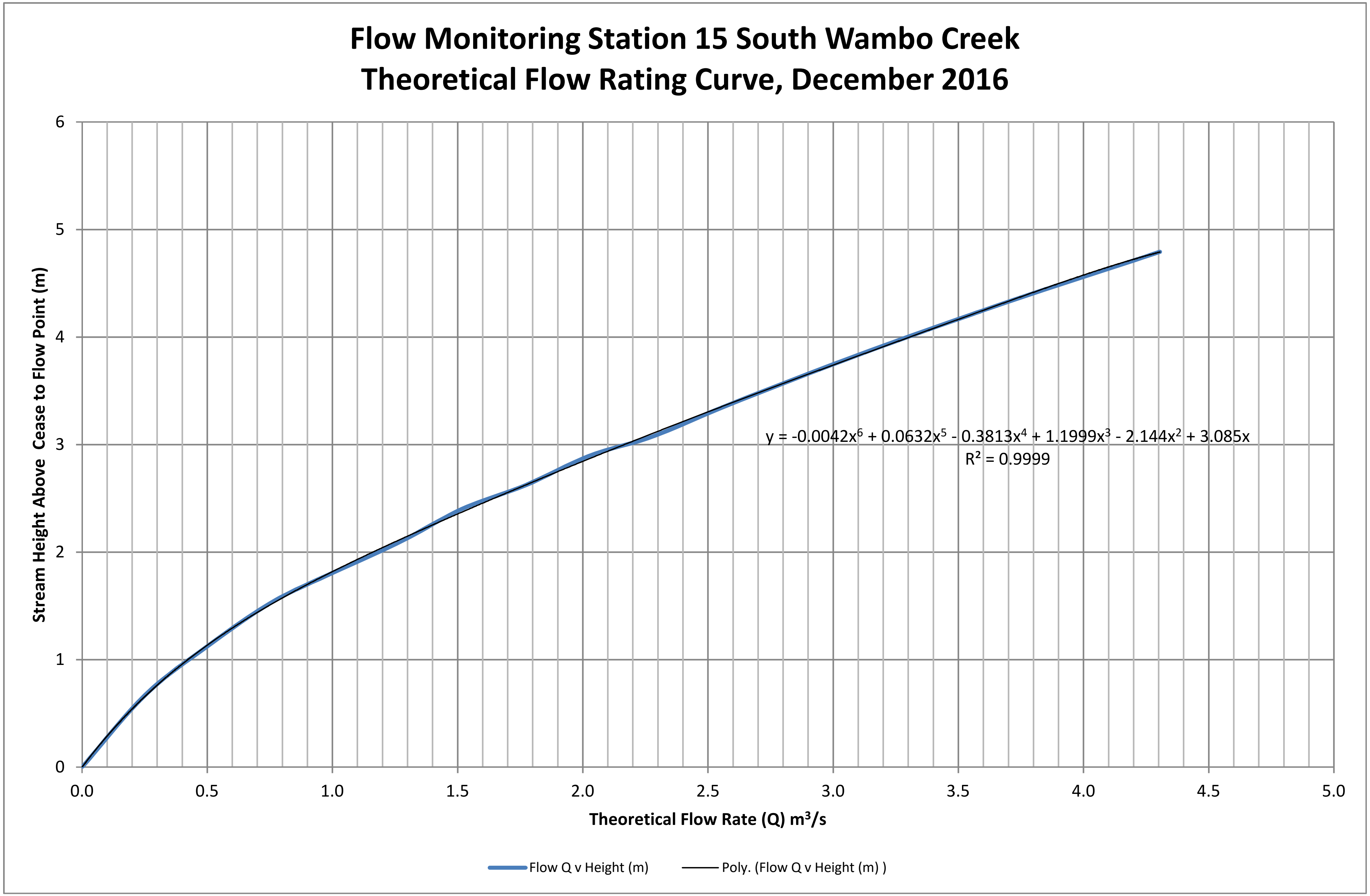
Wambo Coal
Stoney Creek Down Re-Location Long Section Profile Through Cease to Flow Point
January 2022
Stream Surveyed Length (m)
0
10
20
30
40
50
60
70
Stream Depth (m)
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
Cease to Flow Point
y = 0.0075x + 1.6464
R² = 0.5959
Long Section
Linear (Long Section)

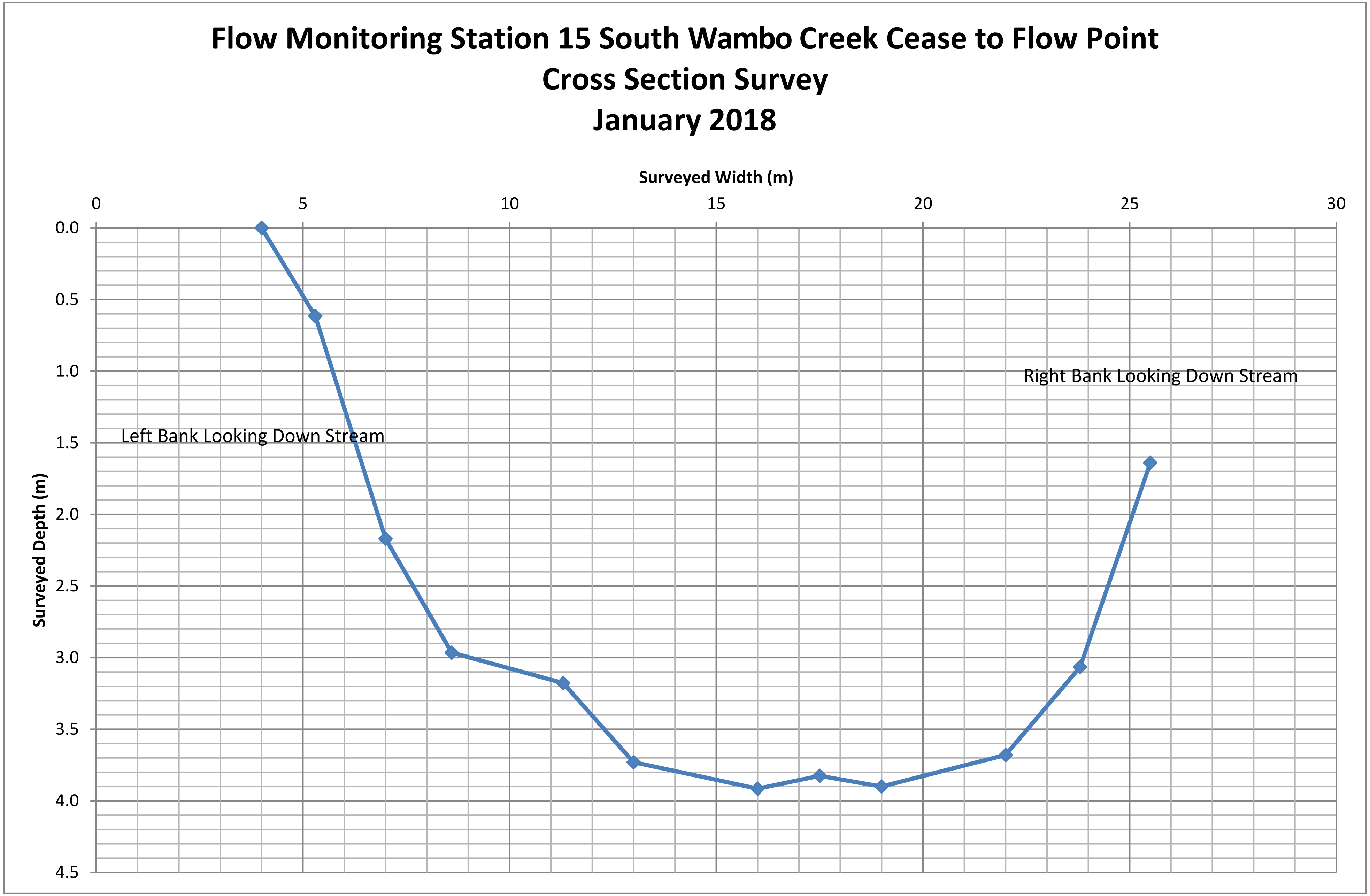


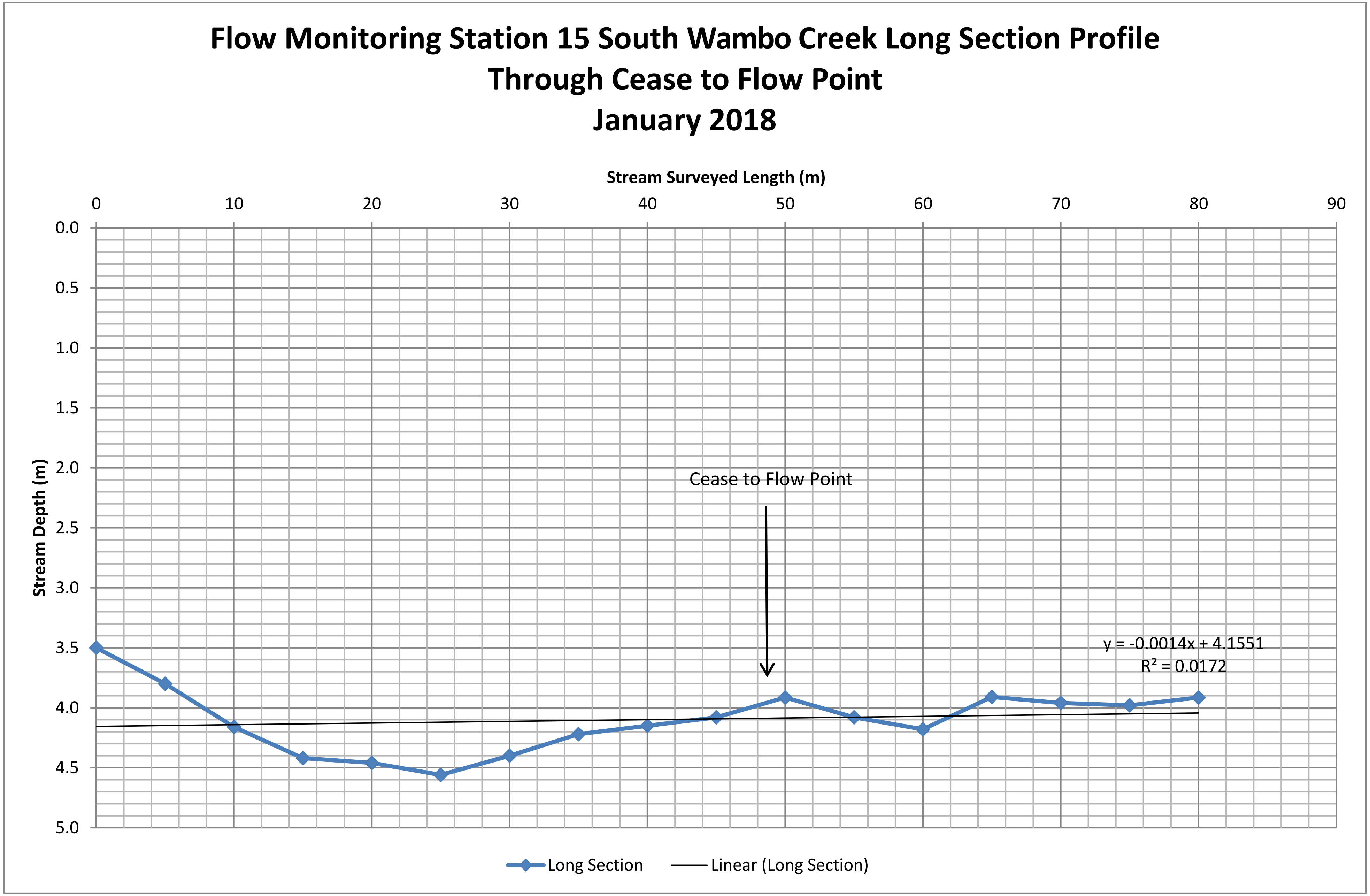
Flow Monitoring Station 14 Stoney Creek Tributary Theoretical Flow Rating Curve January 2018
Stream height Above Cease to Flow Point (m)
Theoretical Flow Rate (Q) m³/s
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
1
2
3
4
5
6
7
y = 0.1599x - 0.1422
R² = 1
y = 0.0003x⁵ - 0.0047x⁴ + 0.0323x³ - 0.112x² + 0.2781x + 0.1961
R² = 1
y = 2.2164x³ - 2.1874x² + 0.9566x + 0.1118
R² = 1
y = 1.5694x + 0.0806
R² = 1
y = 4.7893x + 0.0407
R² = 1
y = 25.641x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.05m)
Flow Q v Height (m) Section 2 (0.05 to 0.1m)
Flow Q v Height (m) Section 3 (0.1 to 0.15m)
Flow Q v Height (m) Section 4 (0.15 to 0.3m)
Flow Q v Height (m) Section 4 (0.3 to 0.75m)
Flow Q v Height (m) Section 4 (0.75 to 0.78m)
Linear (Flow Q v Height (m) Section 1 (0.0 to 0.05m))
Linear (Flow Q v Height (m) Section 2 (0.05 to 0.1m))
Linear (Flow Q v Height (m) Section 3 (0.1 to 0.15m))
Poly. (Flow Q v Height (m) Section 4 (0.15 to 0.3m))
Poly. (Flow Q v Height (m) Section 4 (0.3 to 0.75m))
Linear (Flow Q v Height (m) Section 4 (0.75 to 0.78m))


Flow Monitoring Station 14 Stoney Creek Tributary Cease To Flow Point Cross Section Survey
December 2018
Surveyed Width (m)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Surveyed Depth (m)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Left Bank Looking Down Stream
Right Bank Looking Down Stream

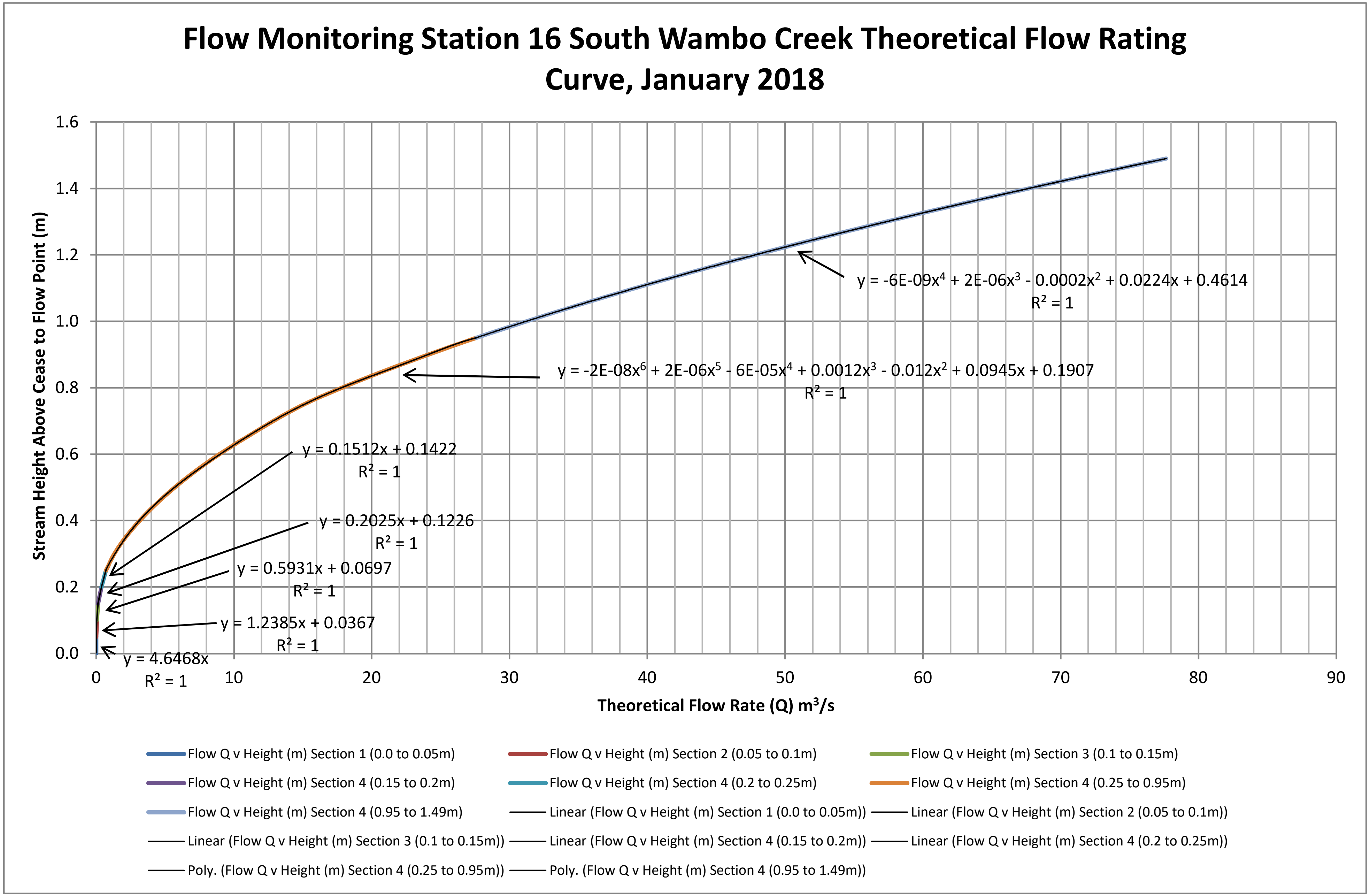

Flow Monitoring Station 14 Stoney Creek Tributary Long Section Profile
Through Cease to Flow Point
December 2018
Stream Surveyed Length (m)
0
10
20
30
40
50
60
70
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Stream Depth (m)
Cease to Flow Point
y = 0.0422x + 0.9622
R² = 0.8743
Long Section
Linear (Long Section)

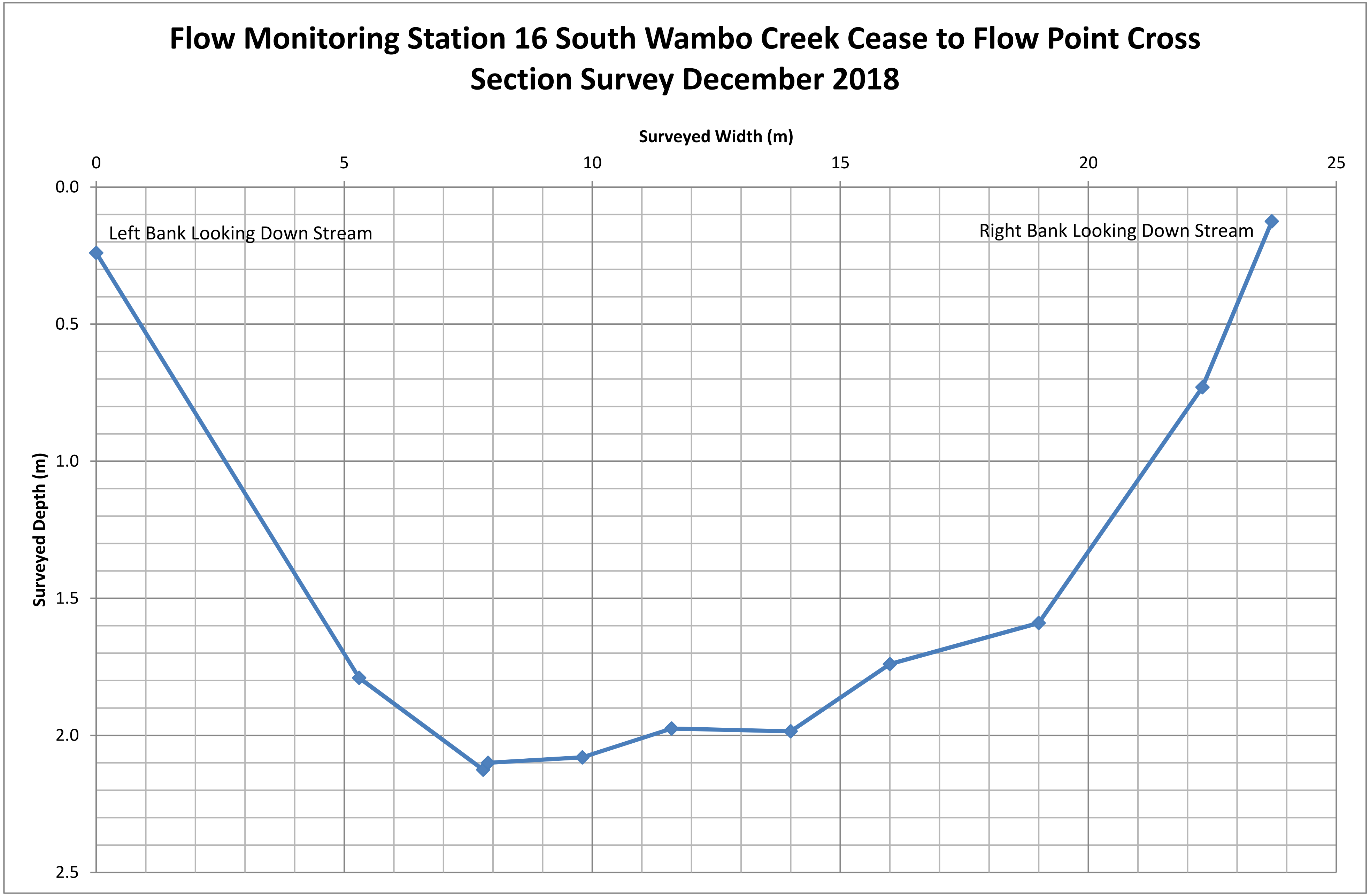

Flow Monitoring Station 15 South Wambo Creek
Theoretical Flow Rating Curve, December 2016
Stream Height Above Cease to Flow Point (m)
Theoretical Flow Rate (Q) m3/s
0
1
2
3
4
5
6
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
y = -0.0042x6 + 0.0632x5 - 0.3813x4 + 1.1999x3 - 2.144x2 + 3.085x
R2 = 0.9999
Flow Q v Height (m)
Poly. (Flow Q v Height (m))


Flow Monitoring Station 15 South Wambo Creek Cease to Flow Point
Cross Section Survey
January 2018
Surveyed Width (m)
0
5
10
15
20
25
30
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Surveyed Depth (m)
Left Bank Looking Down Stream
Right Bank Looking Down Stream

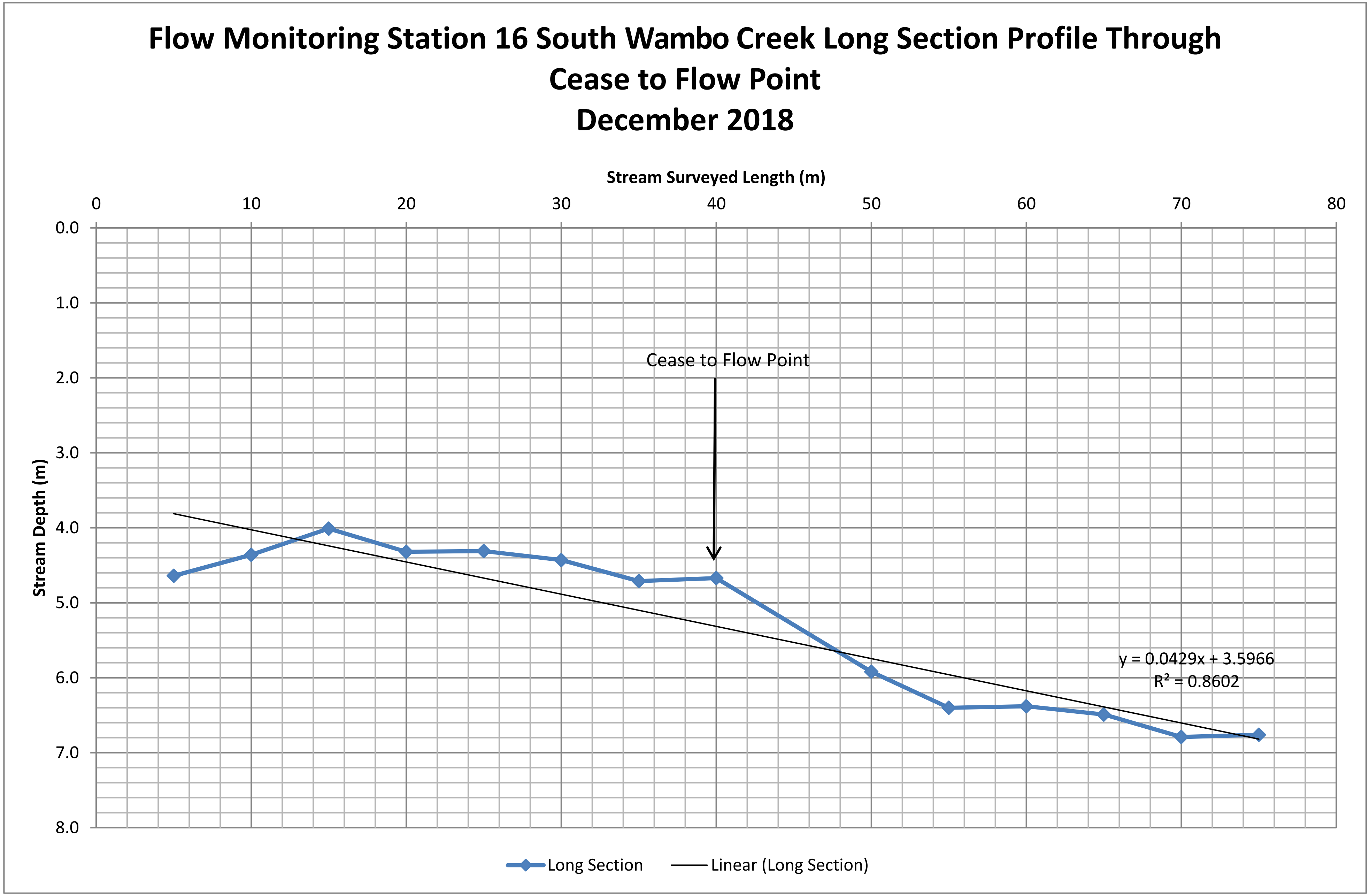


Flow Monitoring Station 15 South Wambo Creek Long Section Profile
Through Cease to Flow Point
January 2018
Stream Surveyed Length (m)
0
10
20
30
40
50
60
70
80
90
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Stream Depth (m)
Cease to Flow Point
y = -0.0014x + 4.1551
R² = 0.0172
Long Section
Linear (Long Section)


Flow Monitoring Station 16 South Wambo Creek Theoretical Flow Rating Curve, January 2018
Stream Height Above Cease to Flow Point (m)
Theoretical Flow Rate (Q) m³/s
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
10
20
30
40
50
60
70
80
90
y = -6E-09x⁴ + 2E-06x³ - 0.0002x² + 0.0224x + 0.4614
R² = 1
y = -2E-08x⁶ + 2E-06x⁵ - 6E-05x⁴ + 0.0012x³ - 0.012x² + 0.0945x + 0.1907
R² = 1
y = 0.1512x + 0.1422
R² = 1
y = 0.2025x + 0.1226
R² = 1
y = 0.5931x + 0.0697
R² = 1
y = 1.2385x + 0.0367
R² = 1
y = 4.6468x
R² = 1
Flow Q v Height (m) Section 1 (0.0 to 0.05m)
Flow Q v Height (m) Section 2 (0.05 to 0.1m)
Flow Q v Height (m) Section 3 (0.1 to 0.15m)
Flow Q v Height (m) Section 4 (0.15 to 0.2m)
Flow Q v Height (m) Section 4 (0.2 to 0.25m)
Flow Q v Height (m) Section 4 (0.25 to 0.95m)
Flow Q v Height (m) Section 4 (0.95 to 1.49m)
Linear (Flow Q v Height (m) Section 1 (0.0 to 0.05m))
Linear (Flow Q v Height (m) Section 2 (0.05 to 0.1m))
Linear (Flow Q v Height (m) Section 3 (0.1 to 0.15m))
Linear (Flow Q v Height (m) Section 4 (0.15 to 0.2m))
Linear (Flow Q v Height (m) Section 4 (0.2 to 0.25m))
Poly. (Flow Q v Height (m) Section 4 (0.25 to 0.95m))
Poly. (Flow Q v Height (m) Section 4 (0.95 to 1.49m))



Flow Monitoring Station 16 South Wambo Creek Cease to Flow Point Cross Section Survey December 2018
Surveyed Width (m)
0
5
10
15
20
25
0.0
0.5
1.0
1.5
2.0
2.5
Surveyed Depth (m)
Left Bank Looking Down Stream
Right Bank Looking Down Stream


Flow Monitoring Station 16 South Wambo Creek Long Section Profile Through
Cease to Flow Point
December 2018
Stream Surveyed Length (m)
0
10
20
30
40
50
60
70
80
Stream Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Cease to Flow Point
y = 0.0429x + 3.5966
R² = 0.8602
Long Section
Linear (Long Section)

Appendix C

Stream Height, Theoretical Flow, Daily and Cumulative Rainfall Charts

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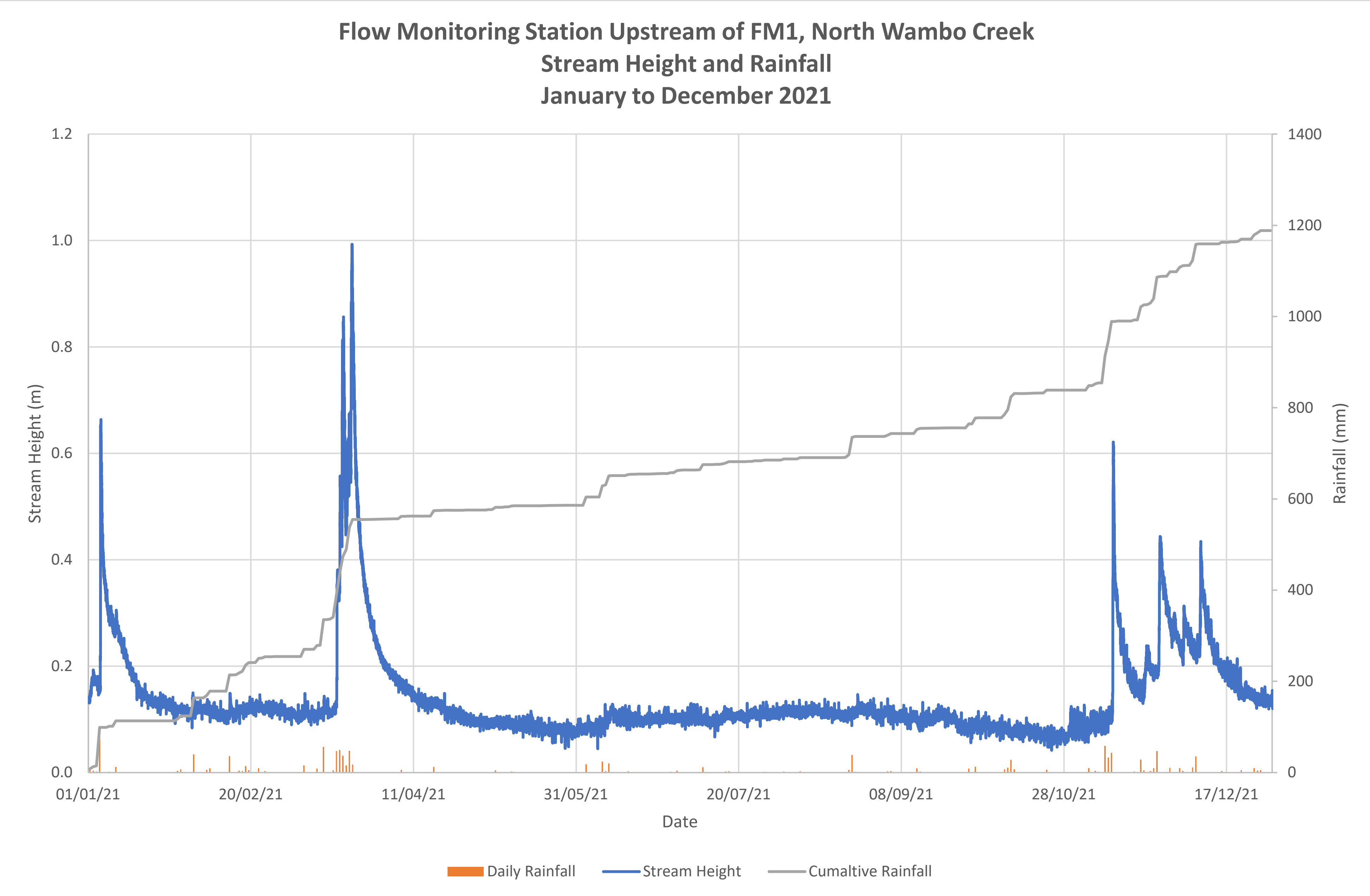
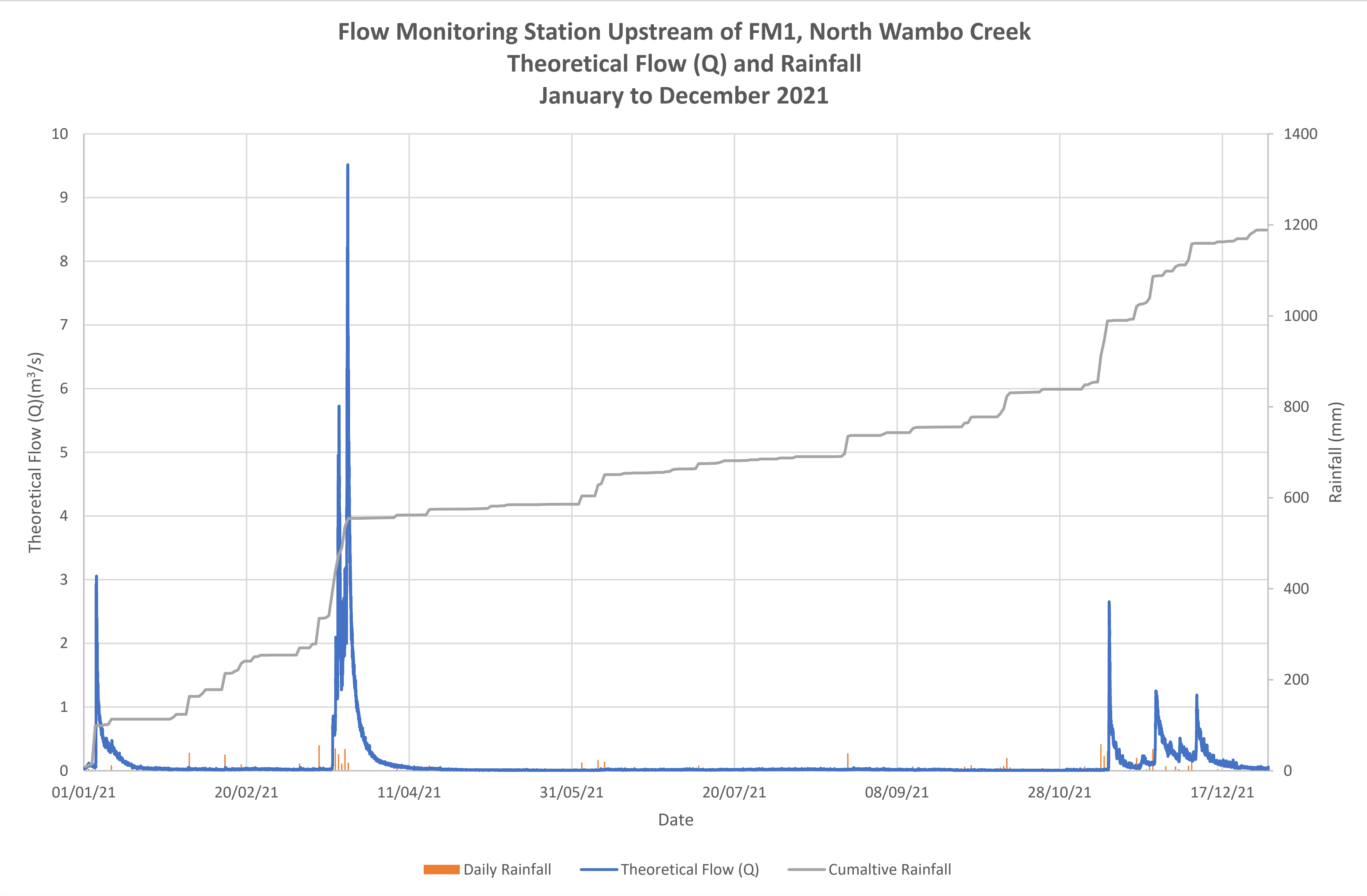
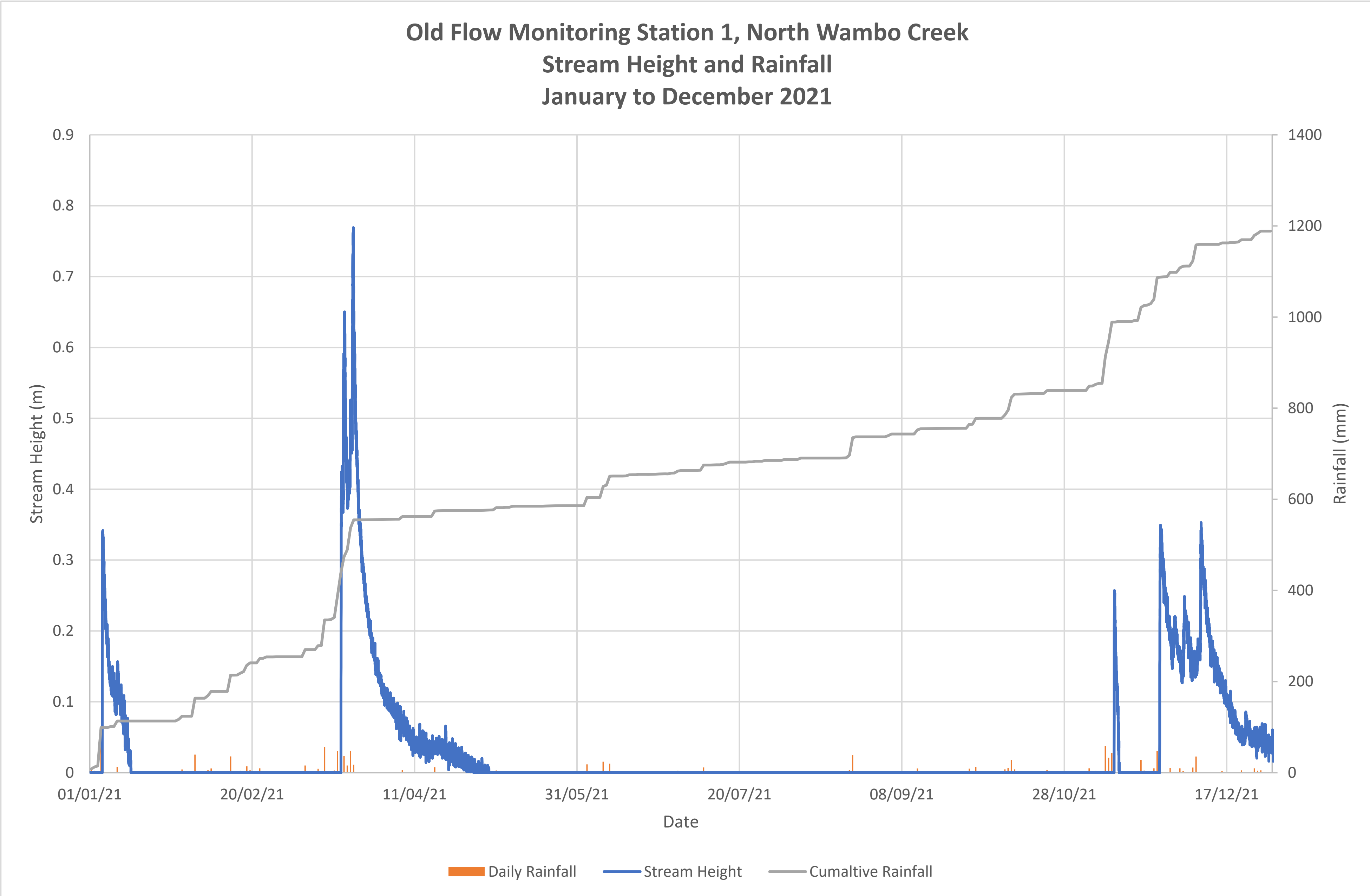
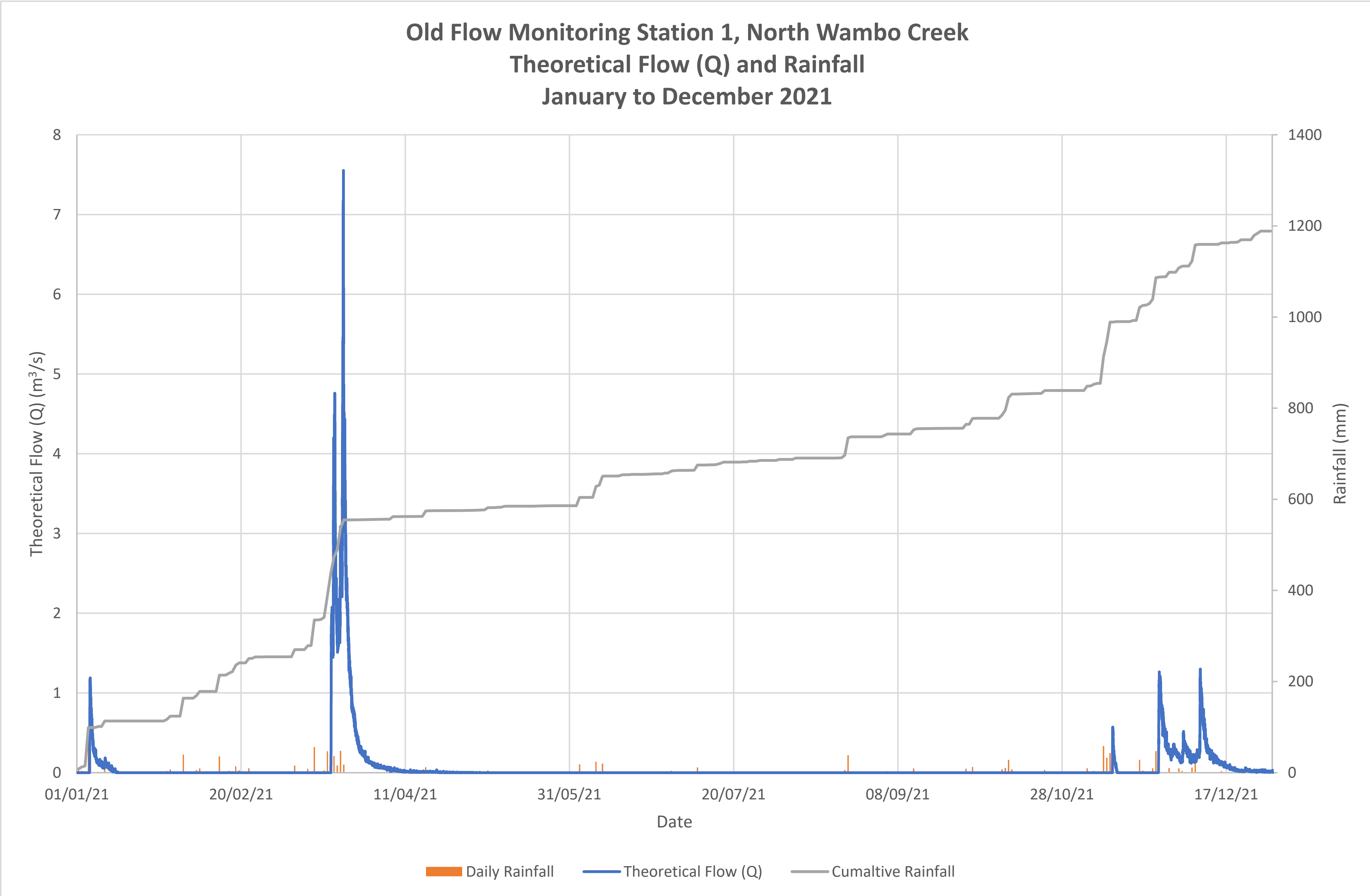

Flow Monitoring Station Upstream of FM1, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall



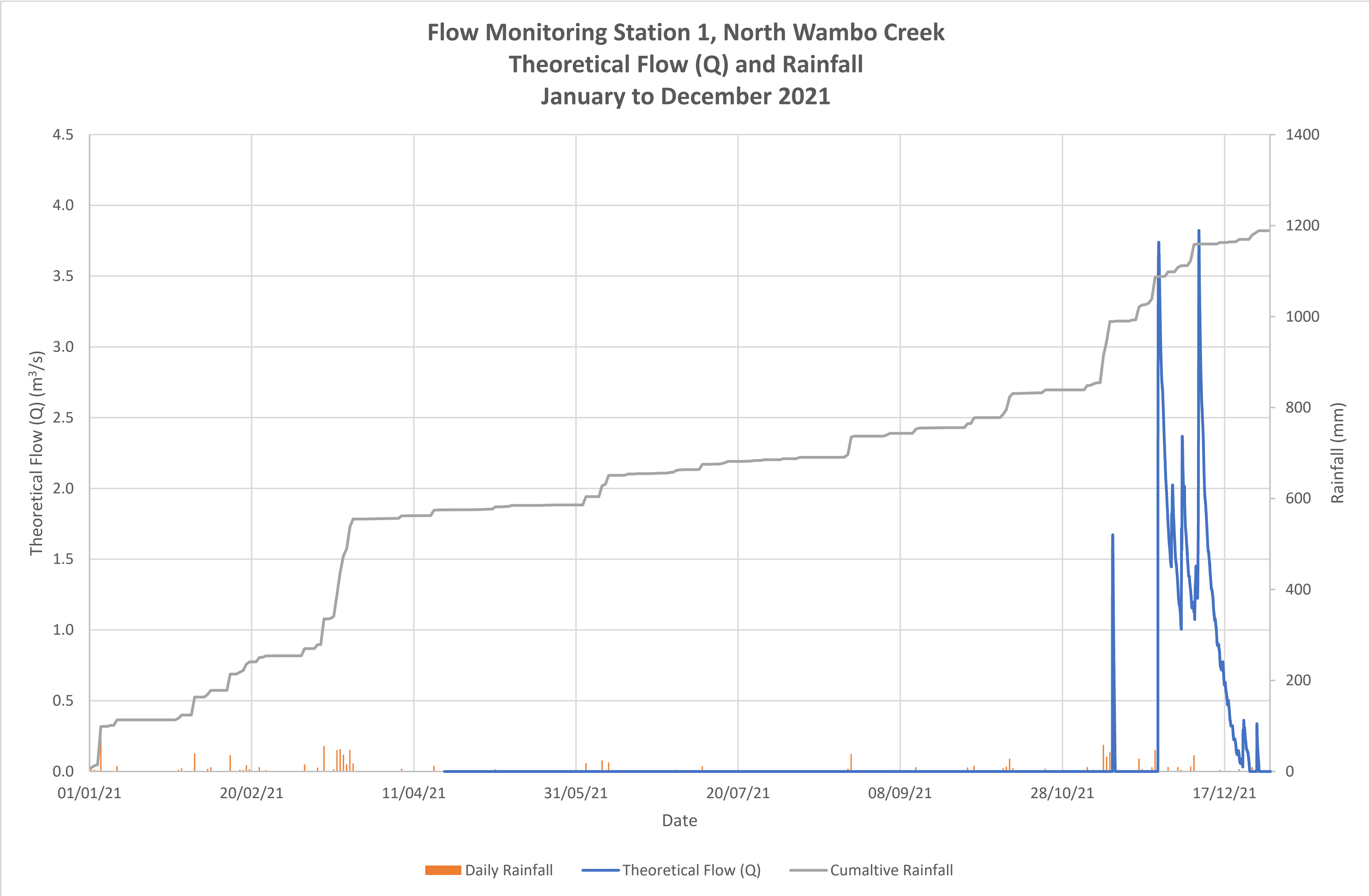
Flow Monitoring Station Upstream of FM1, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q)(m³/s)
Rainfall (mm)
0
1
2
3
4
5
6
7
8
9
10
0
200
400
600
800
1000
1200
1400
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall



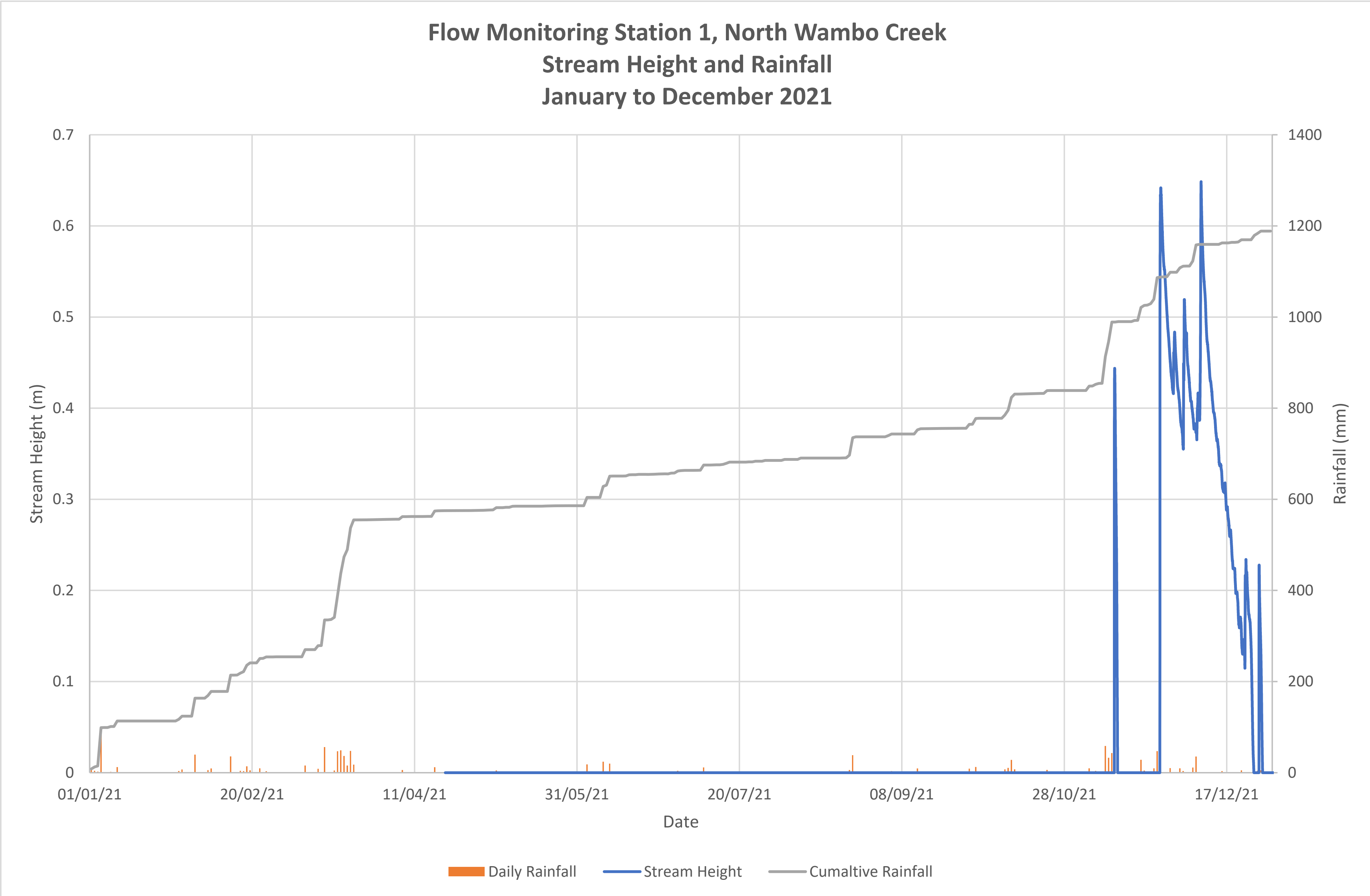
Old Flow Monitoring Station 1, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rainfall (mm)
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall



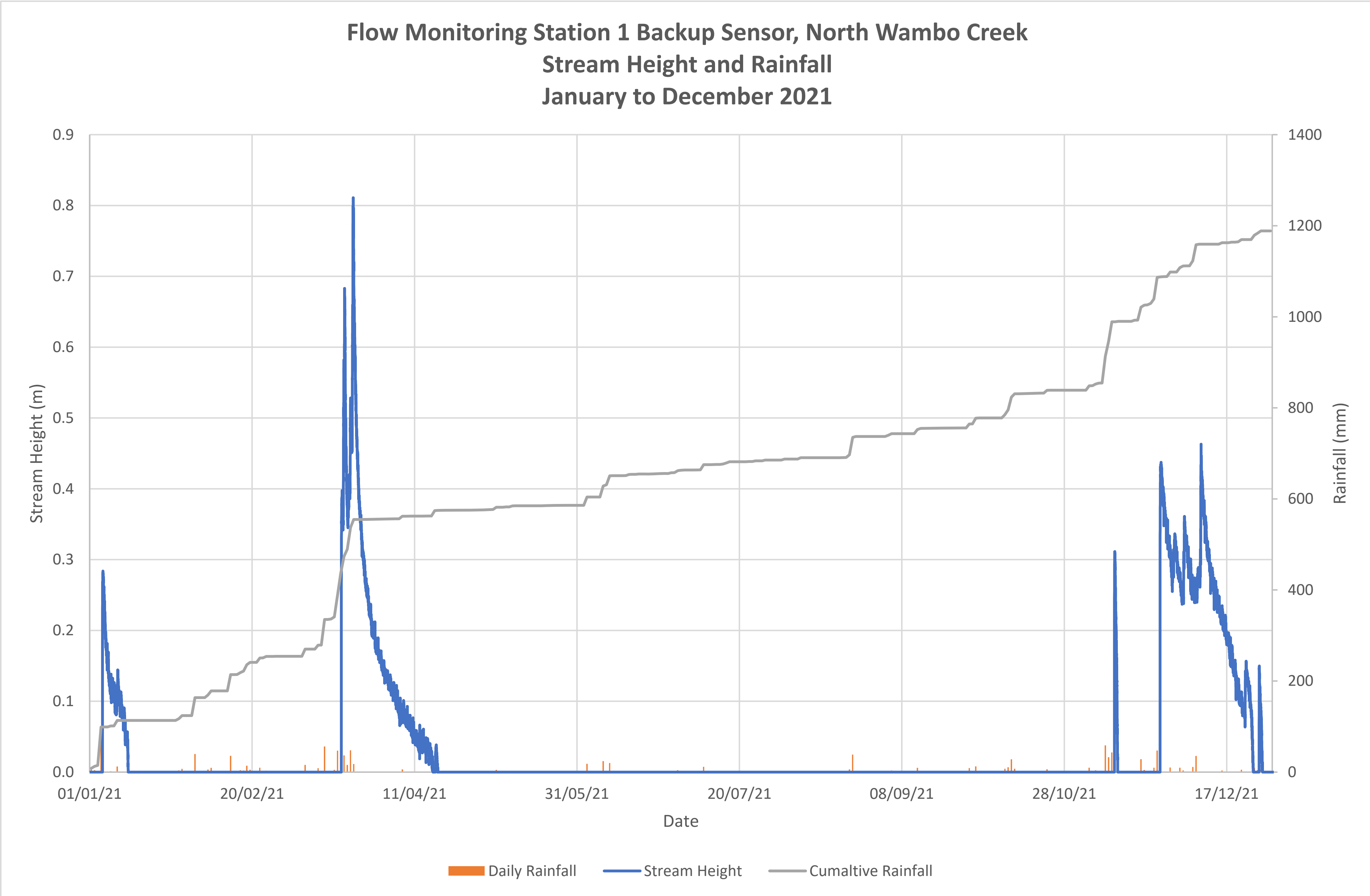
Old Flow Monitoring Station 1, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
Rainfall (mm)
0
1
2
3
4
5
6
7
8
0
200
400
600
800
1000
1200
1400
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall



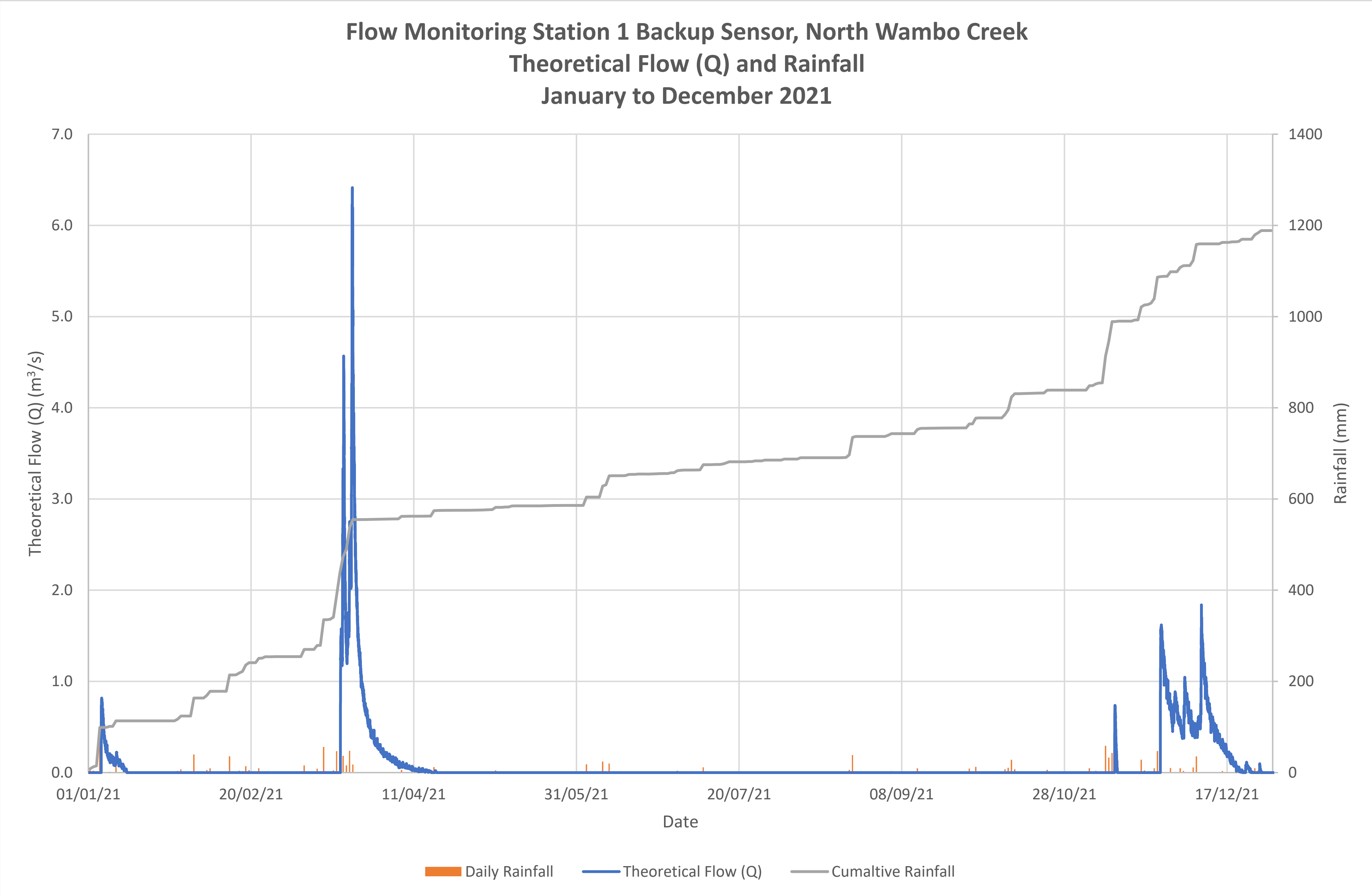
Flow Monitoring Station 1, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
Rainfall (mm)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
0
200
400
600
800
1000
1200
1400
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall



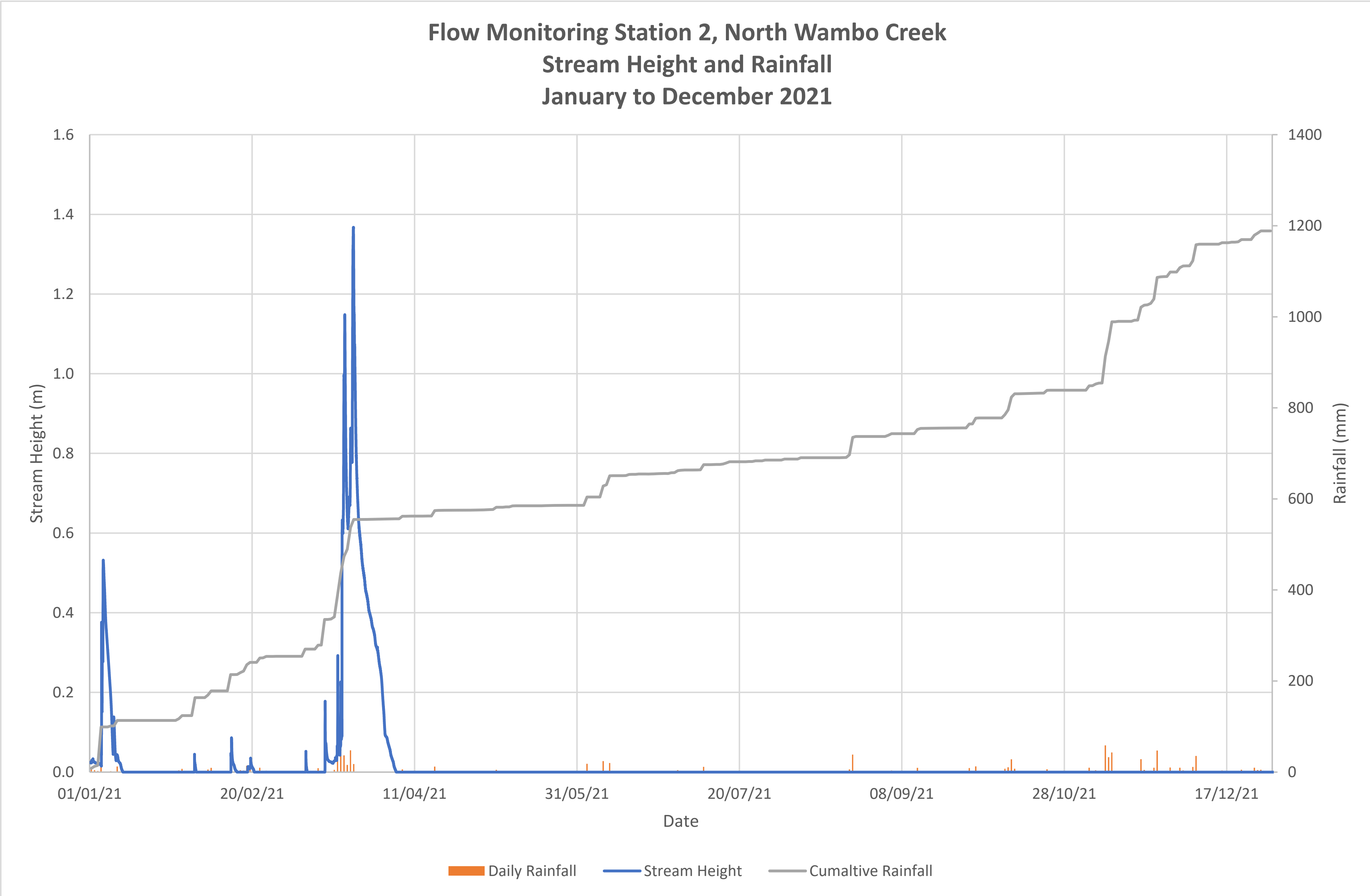
Flow Monitoring Station 1, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rainfall (mm)
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

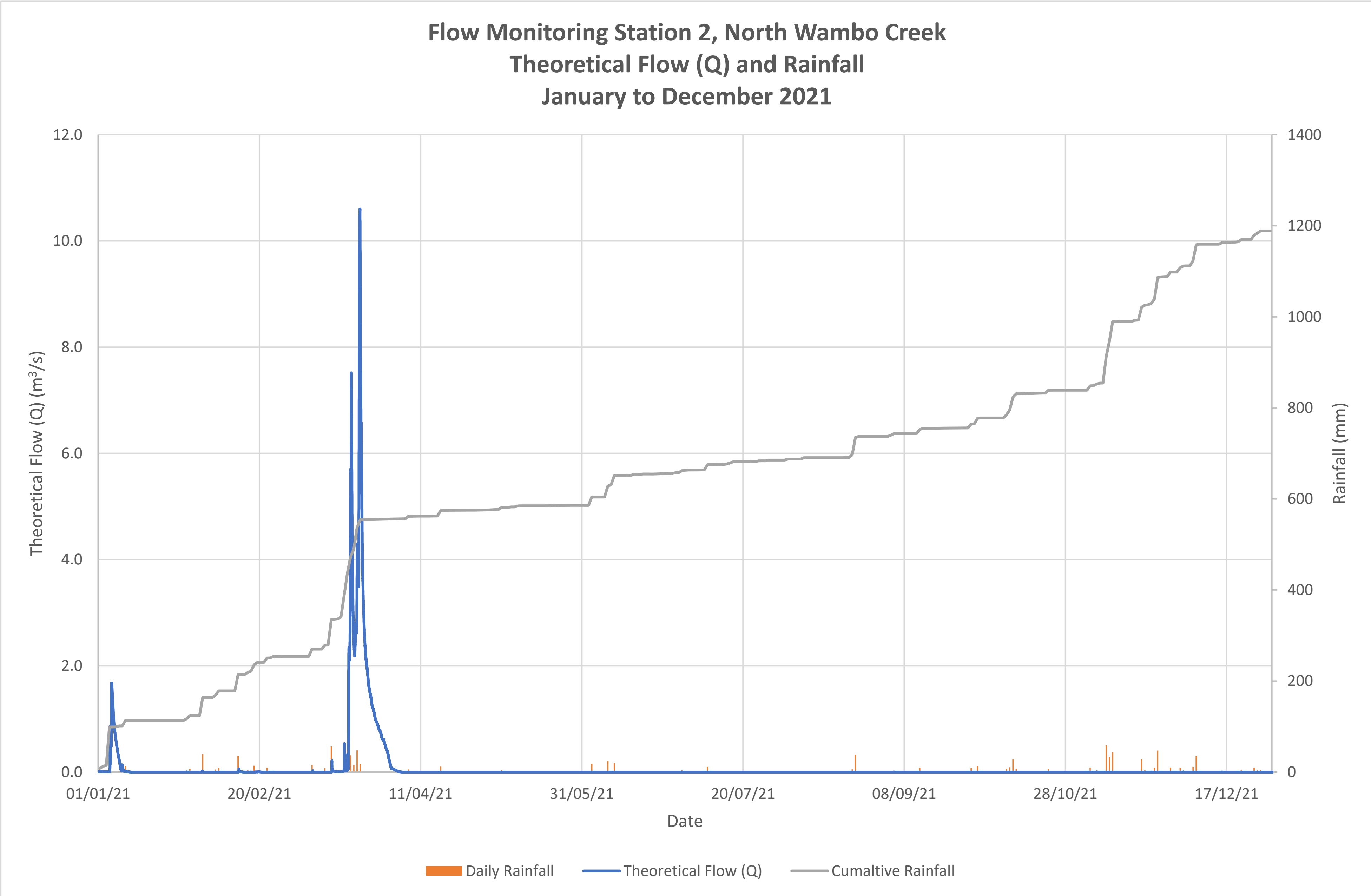


Flow Monitoring Station 1 Backup Sensor, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
Date
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
200
400
600
800
1000
1200
1400
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Daily Rainfall
Stream Height
Cumaltive Rainfall

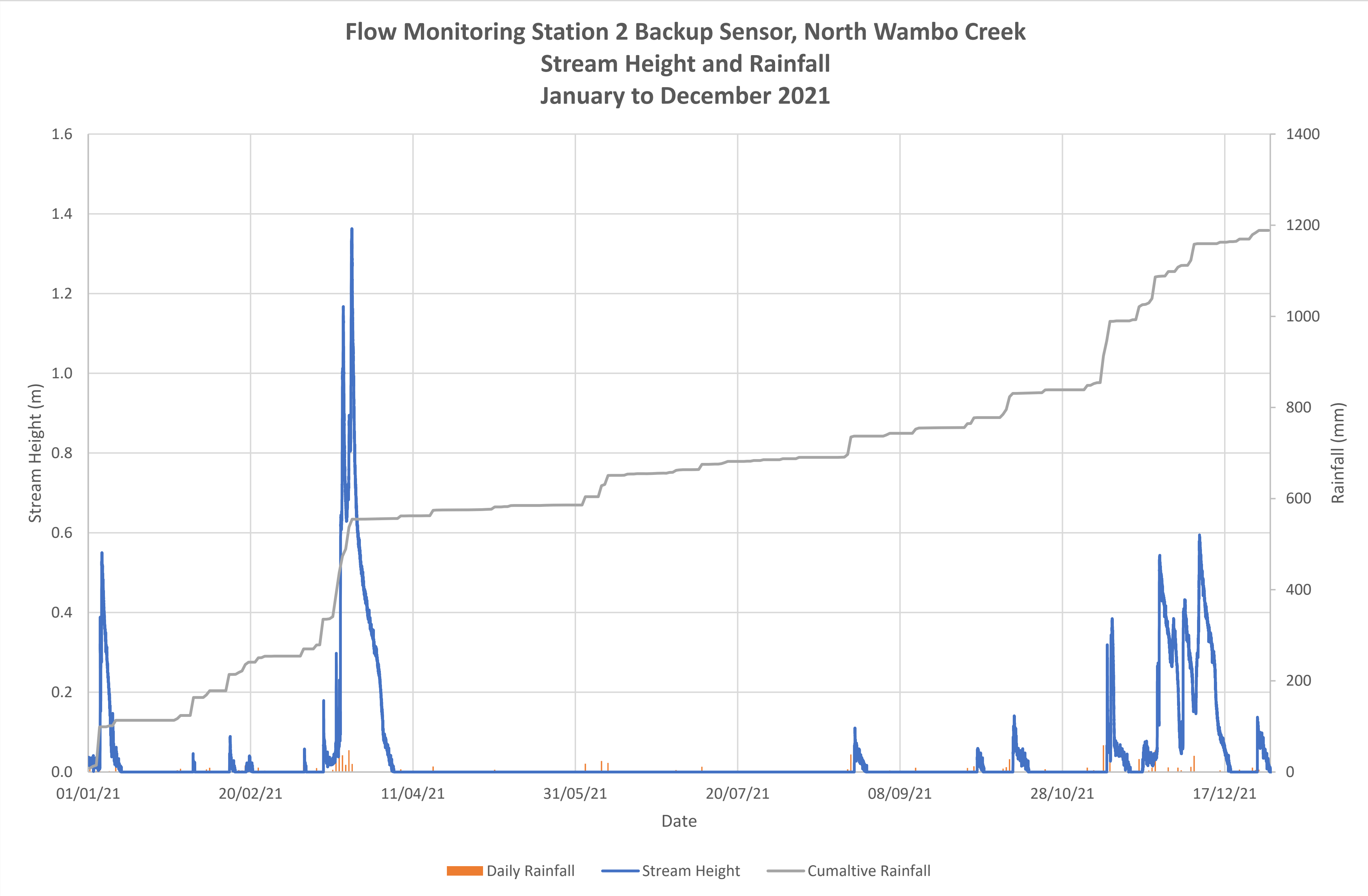


Flow Monitoring Station 1 Backup Sensor, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
Rainfall (mm)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

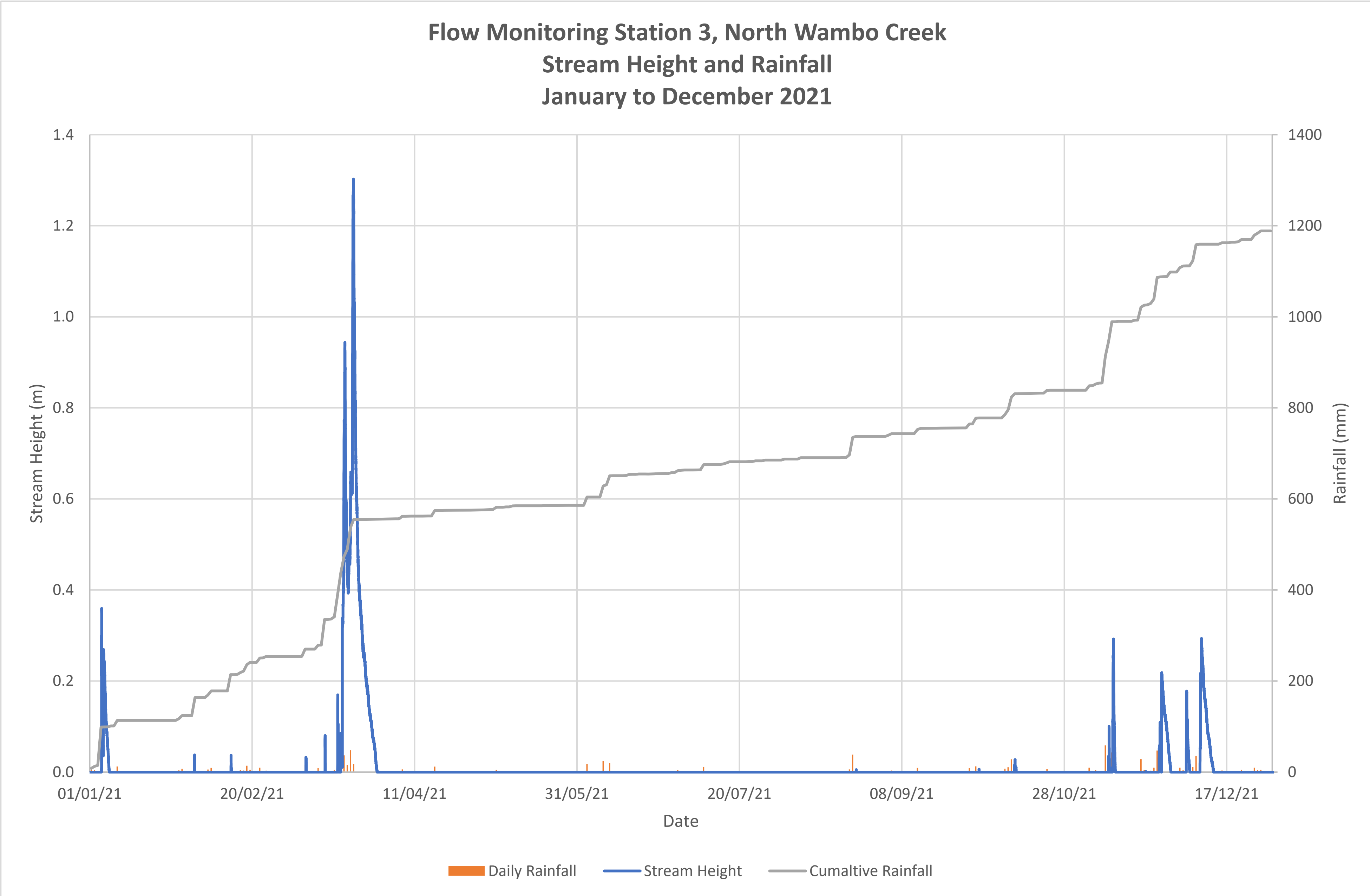

Flow Monitoring Station 2, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall



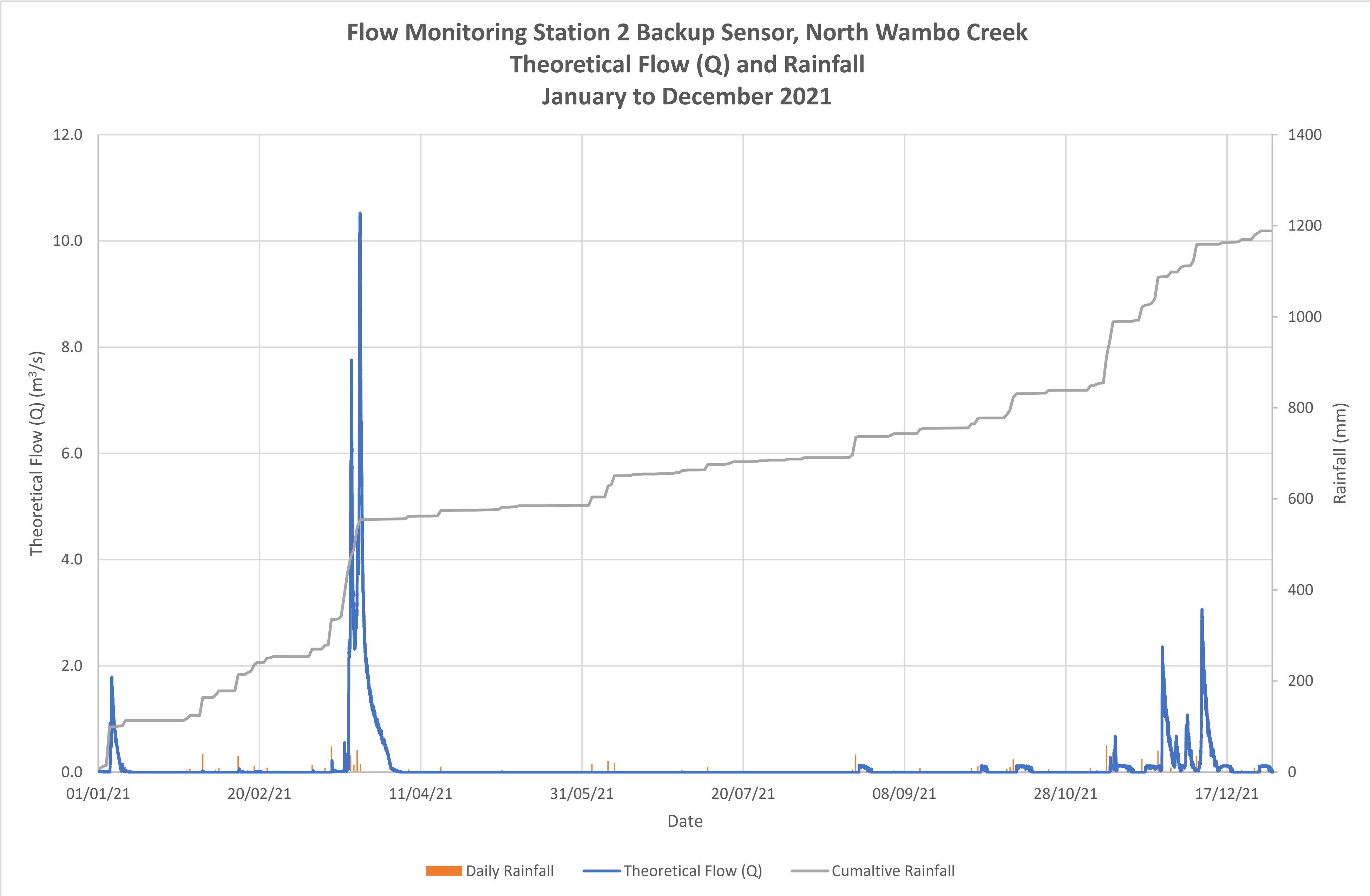
Flow Monitoring Station 2, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Rainfall (mm)
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall



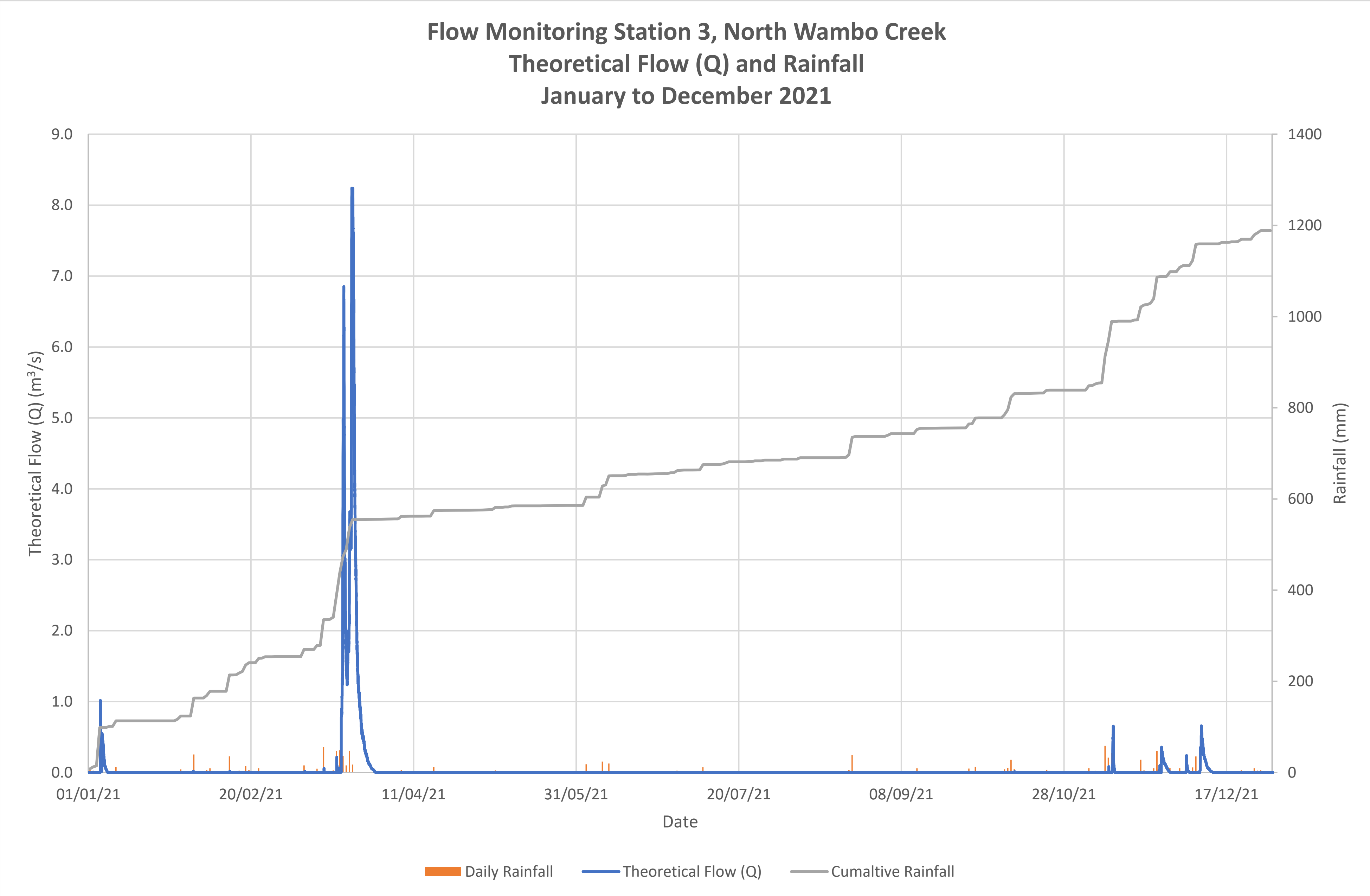
Flow Monitoring Station 2 Backup Sensor, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

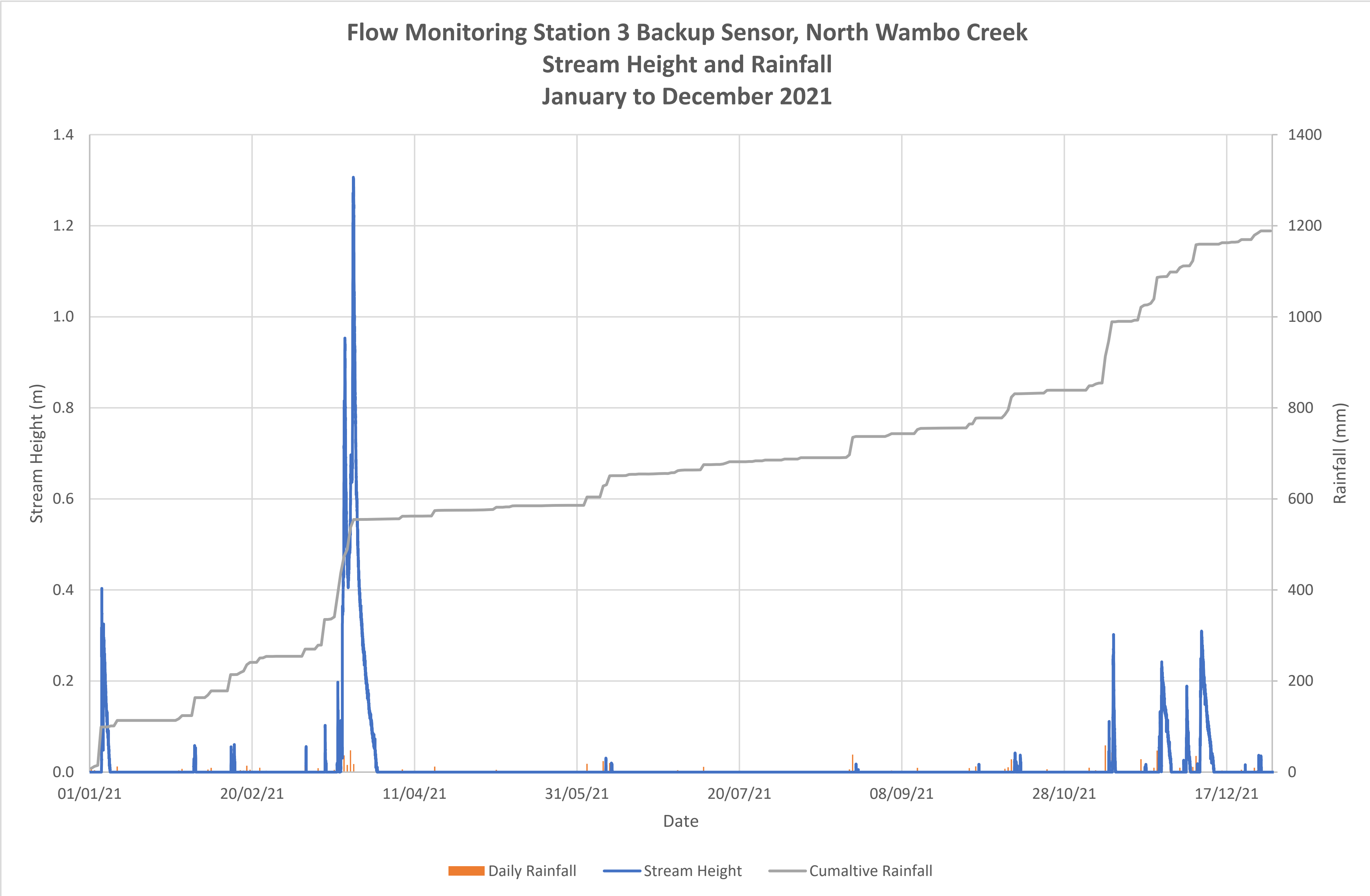


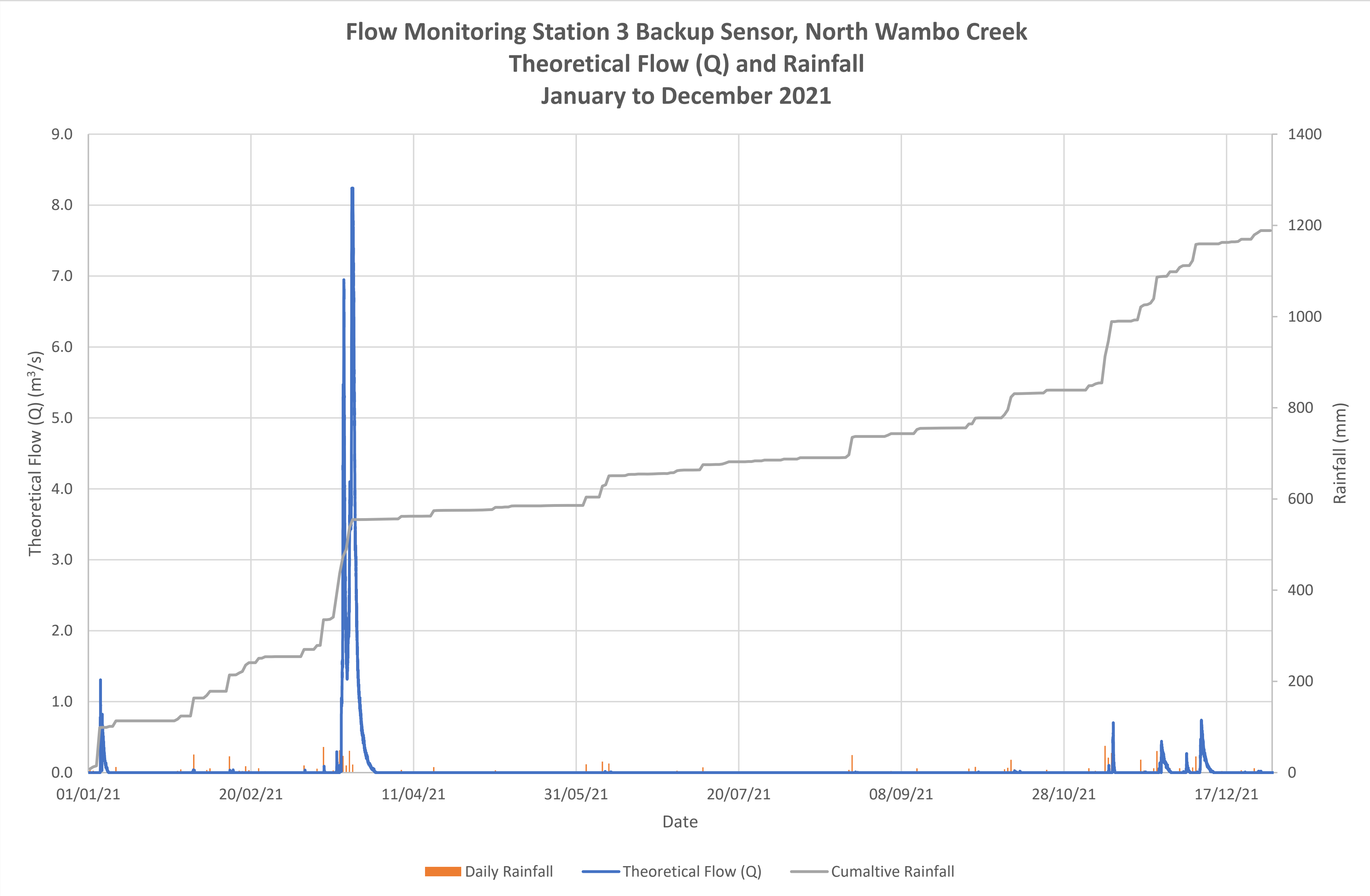
Flow Monitoring Station 3, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
Date
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Daily Rainfall
Stream Height
Cumaltive Rainfall



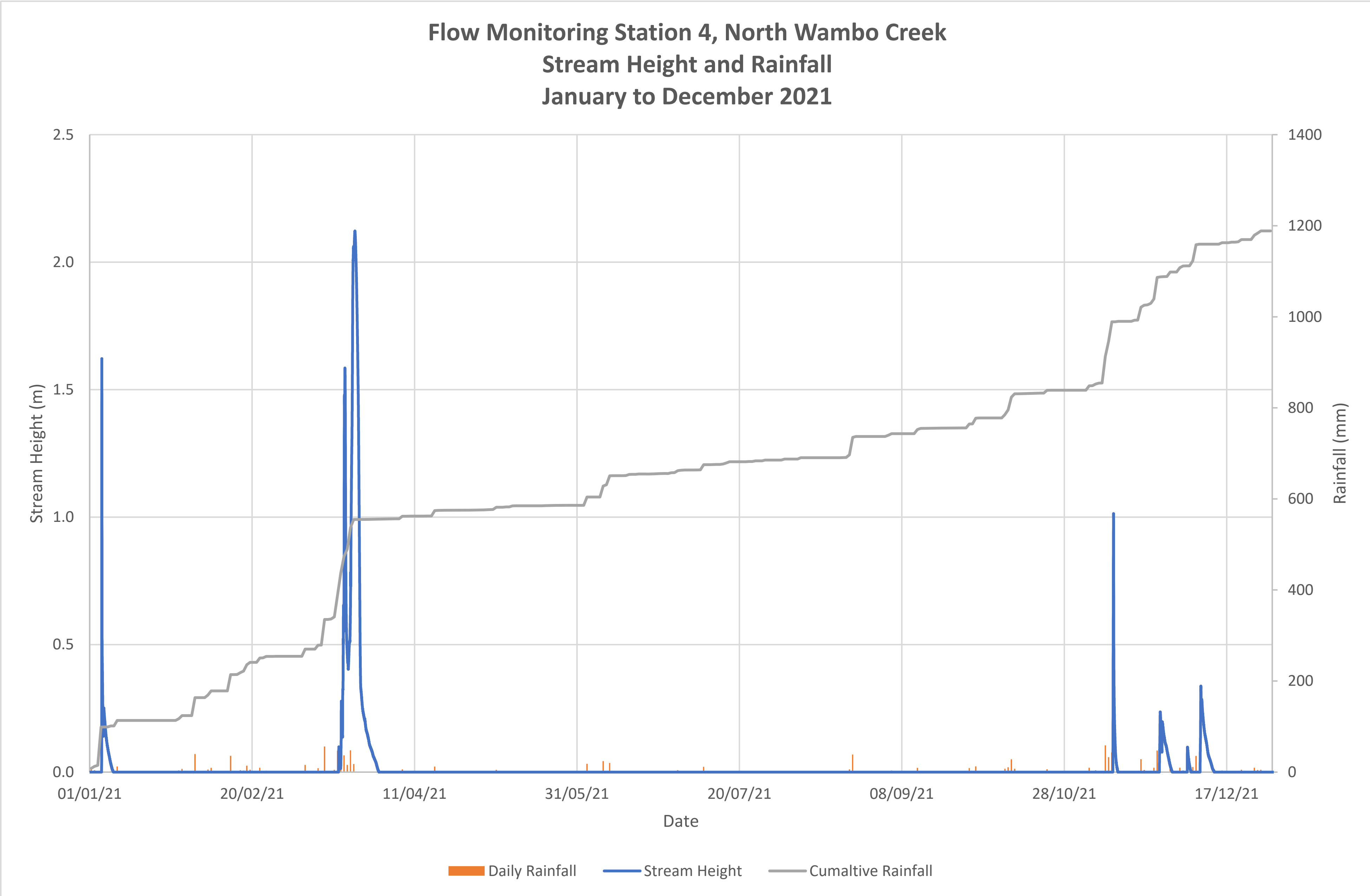
Flow Monitoring Station 2 Backup Sensor, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m^3/s)
Rainfall (mm)
Date
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall


Flow Monitoring Station 3, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m³/s)
Rainfall (mm)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

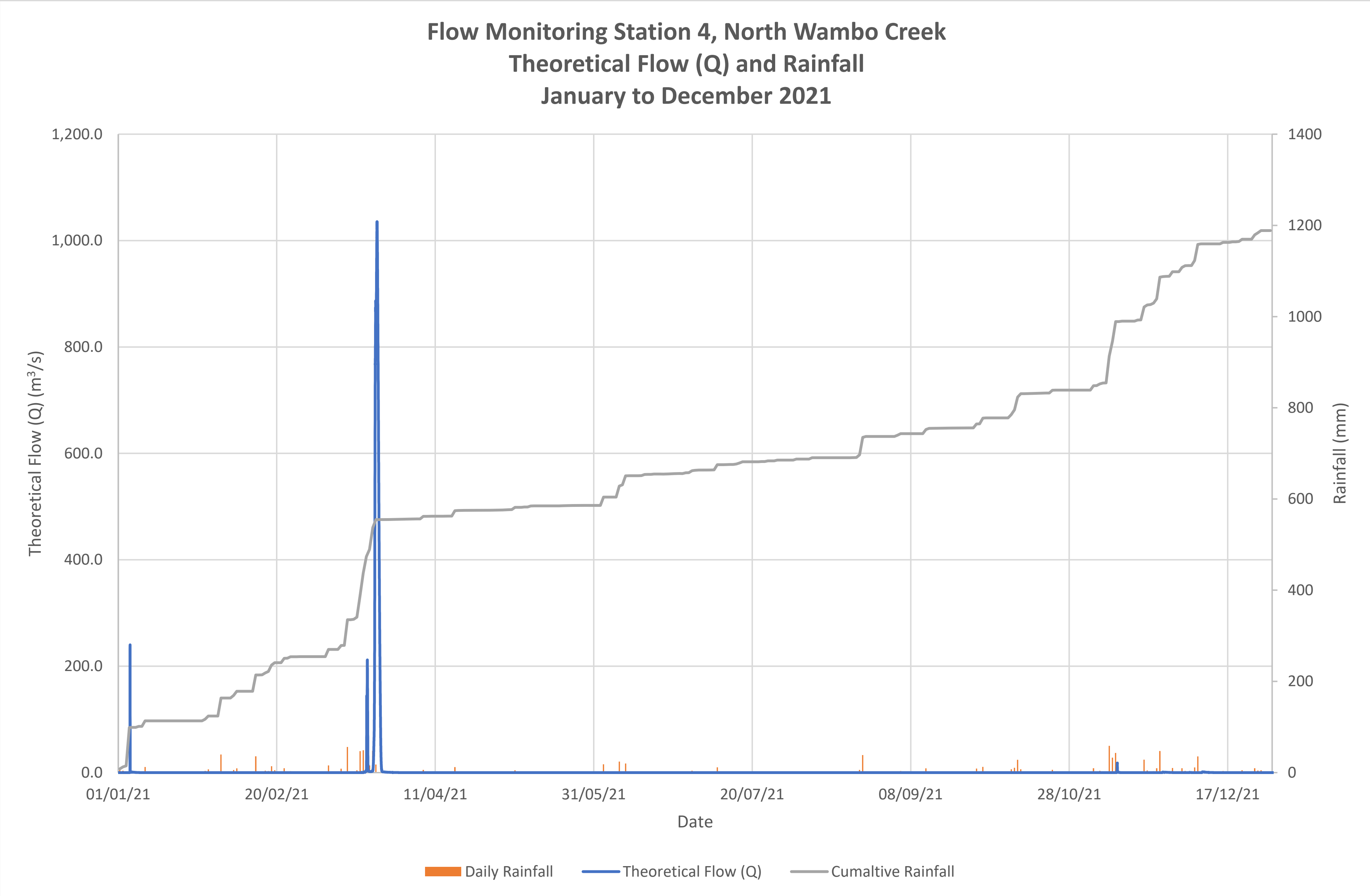

Flow Monitoring Station 3 Backup Sensor, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall



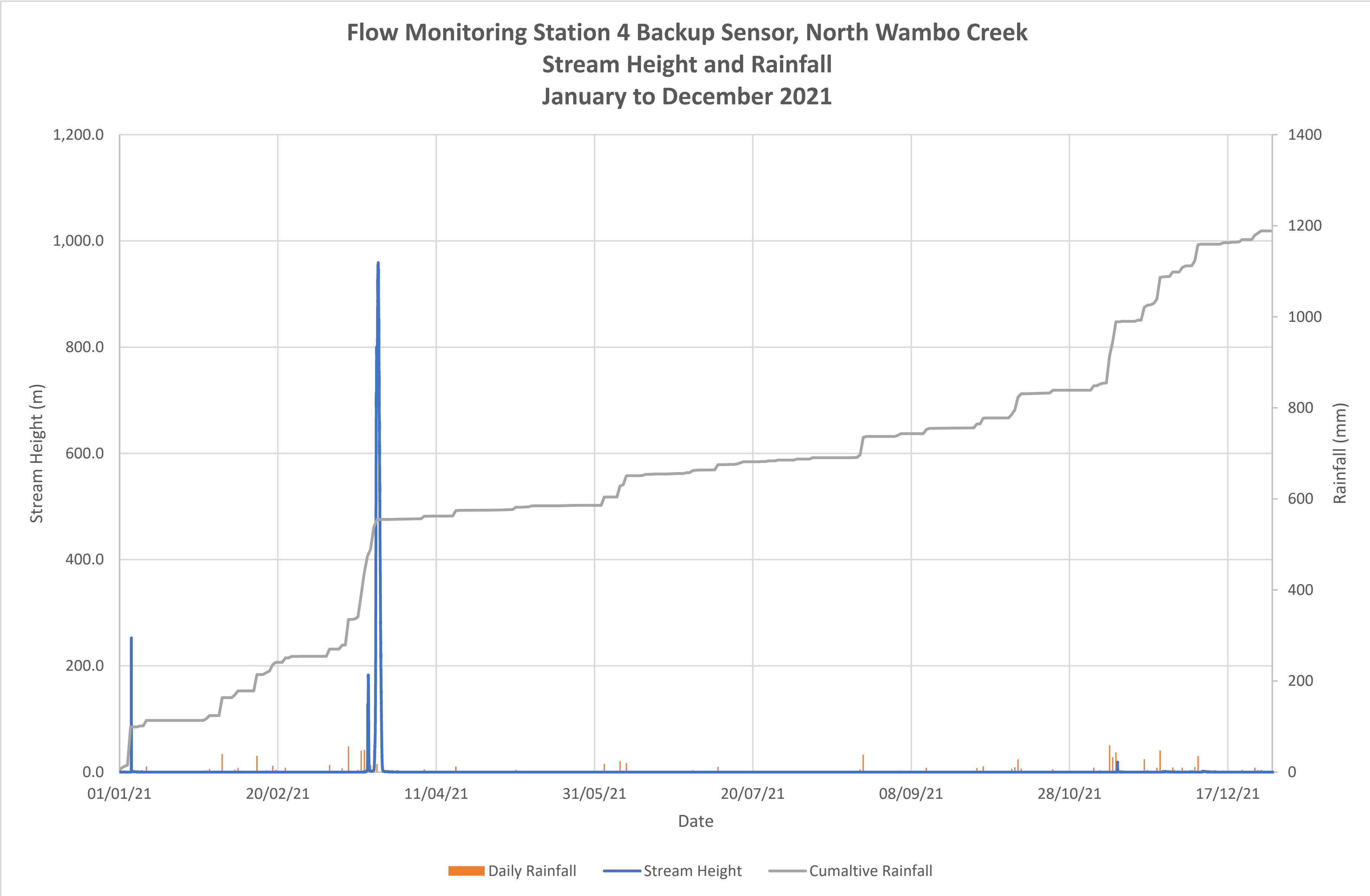
Flow Monitoring Station 3 Backup Sensor, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
Rainfall (mm)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

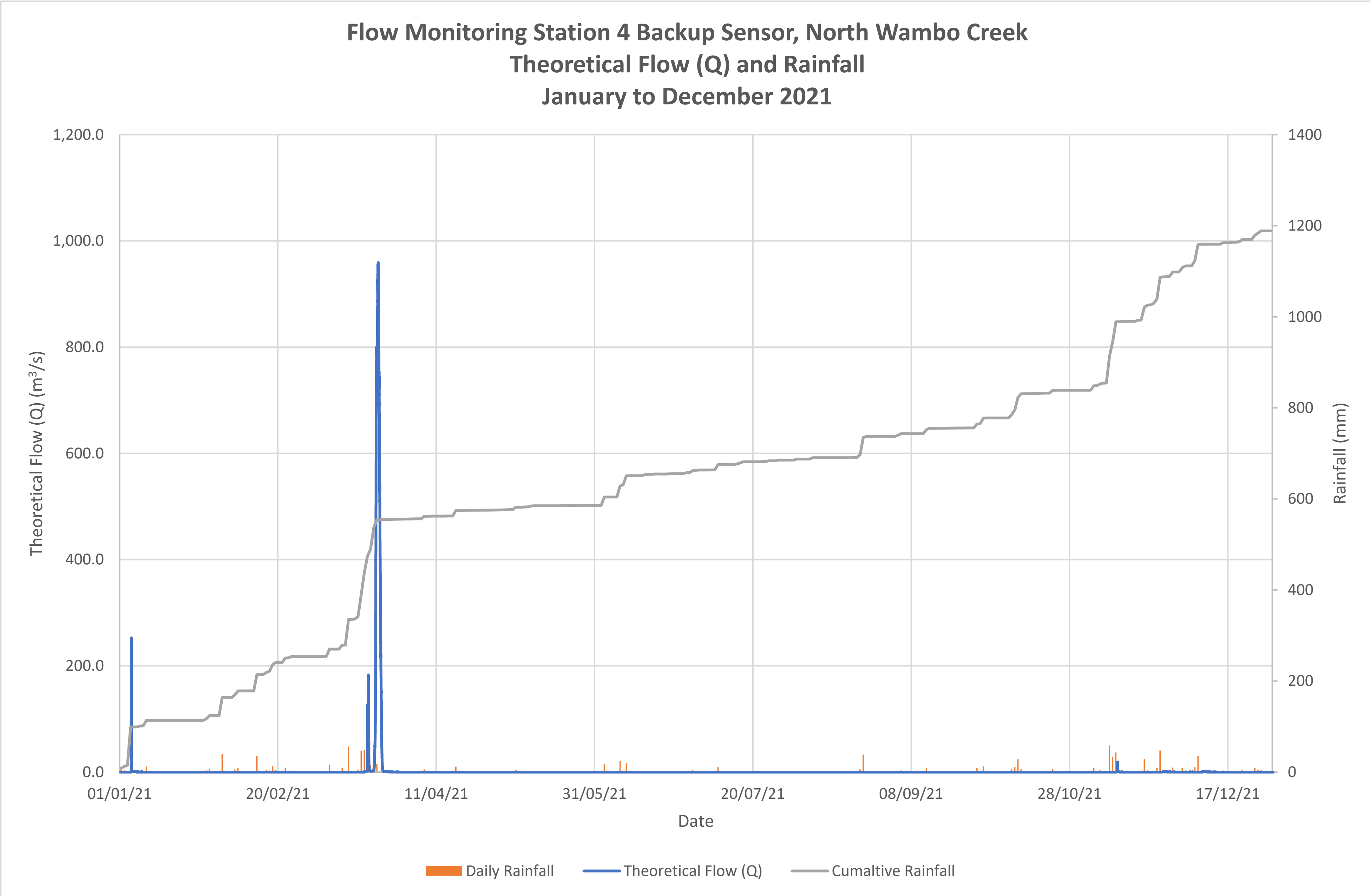


Flow Monitoring Station 4, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
2.5
2.0
1.5
1.0
0.5
0.0
Rainfall (mm)
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

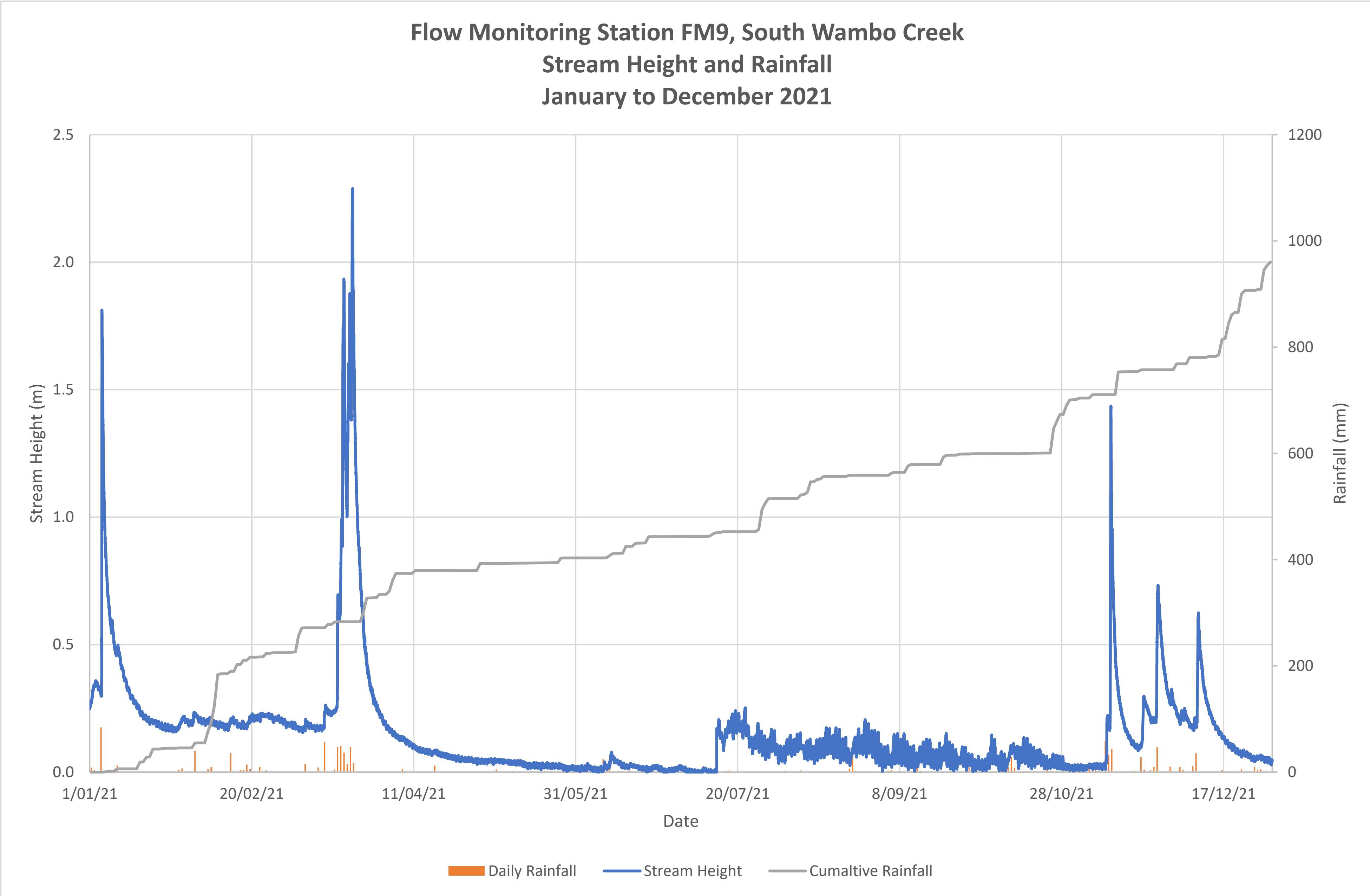


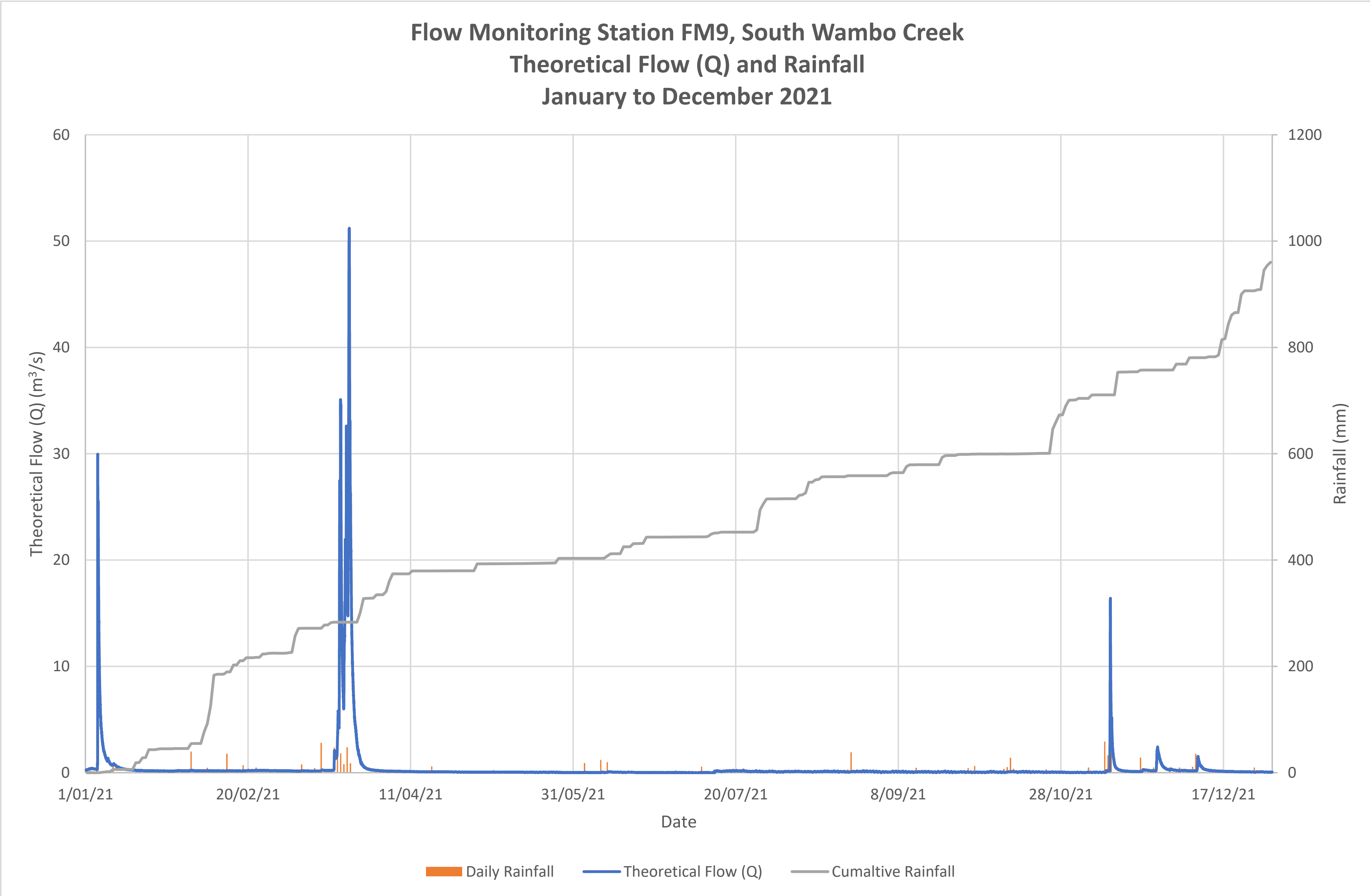
Flow Monitoring Station 4, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
1,200.0
1,000.0
800.0
600.0
400.0
200.0
0.0
Rainfall (mm)
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

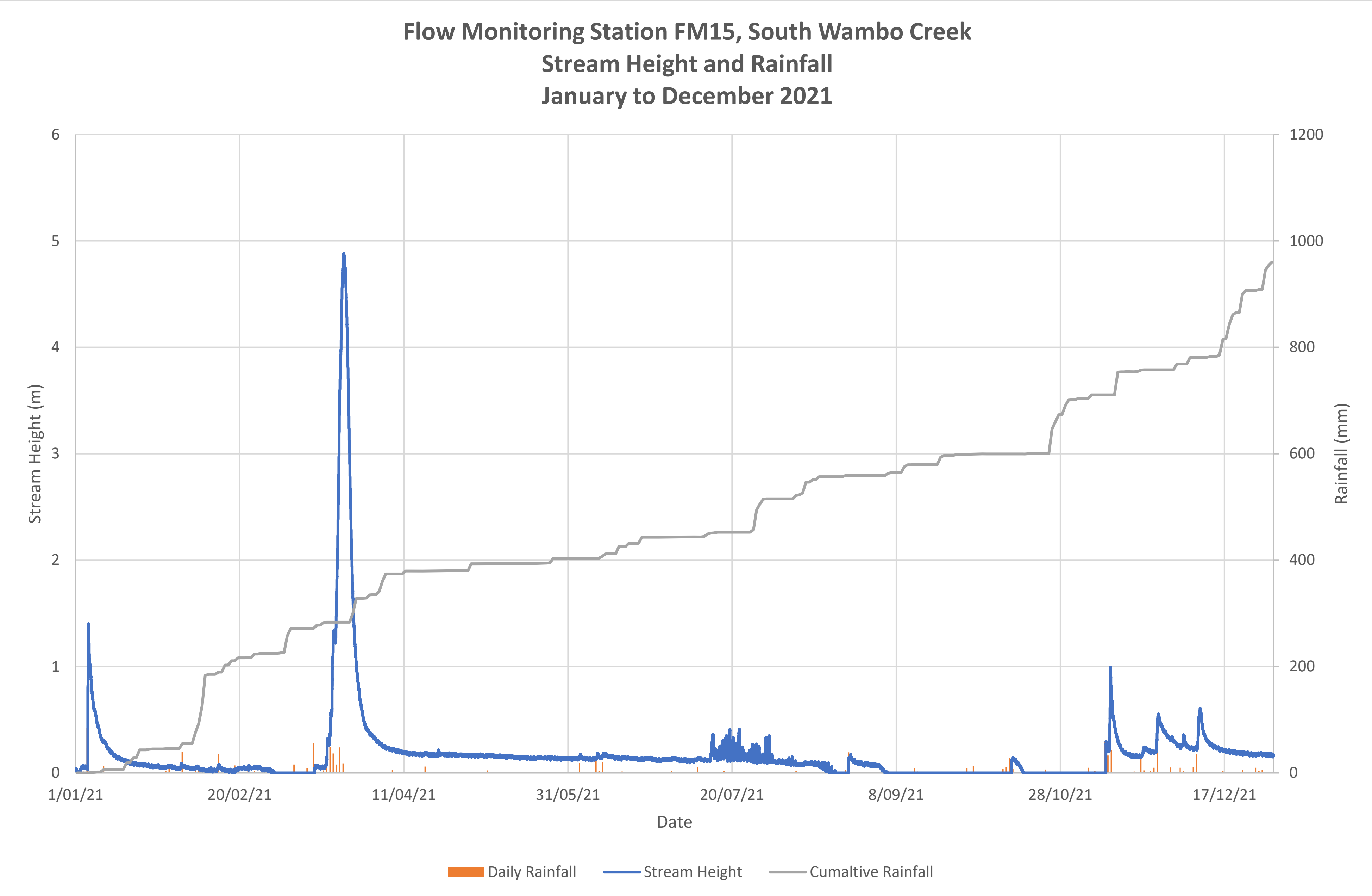

Flow Monitoring Station 4 Backup Sensor, North Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
1,200.0
1,000.0
800.0
600.0
400.0
200.0
0.0
Rainfall (mm)
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall



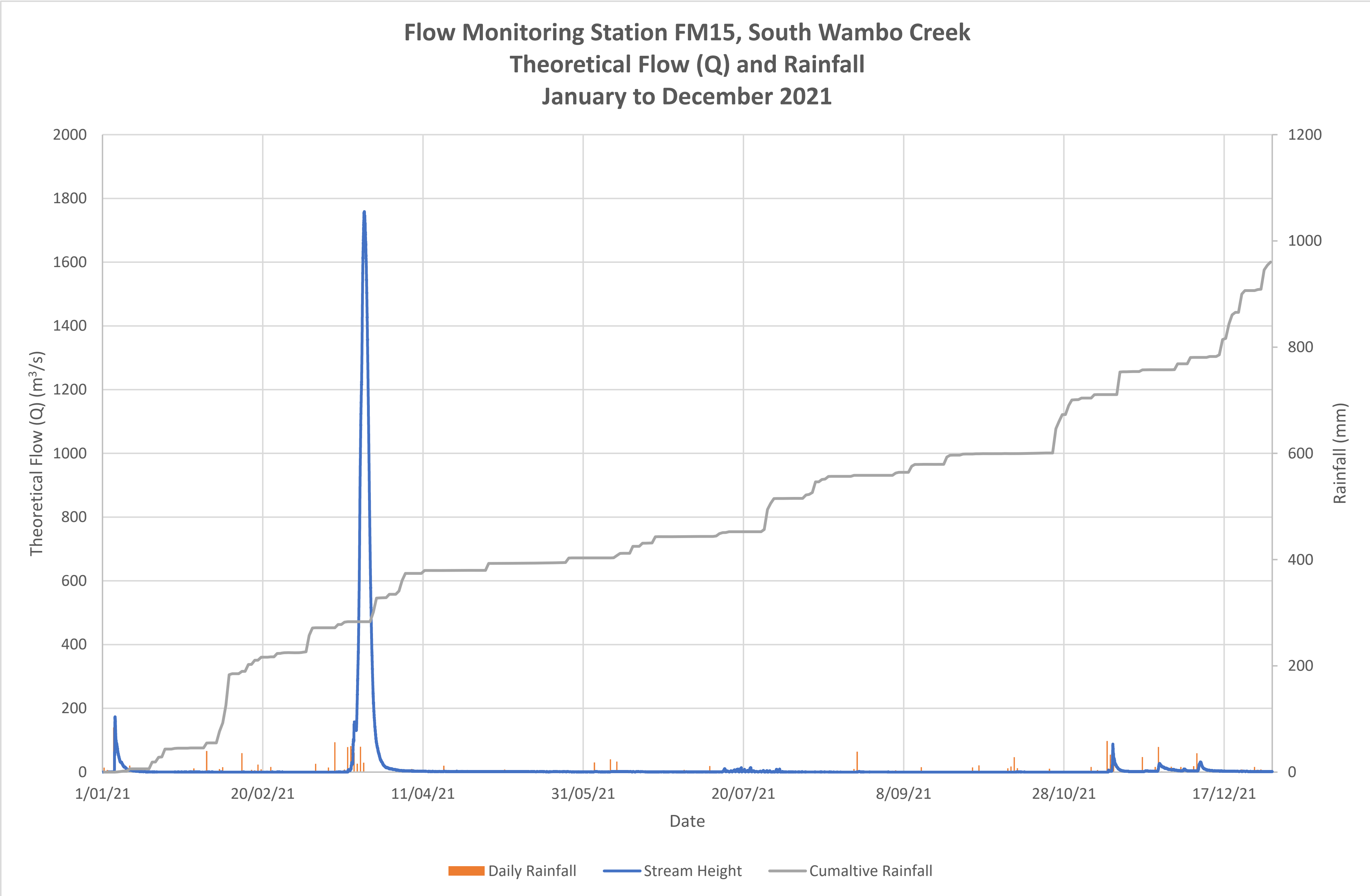
Flow Monitoring Station 4 Backup Sensor, North Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
Rainfall (mm)
1,200.0
1,000.0
800.0
600.0
400.0
200.0
0.0
1400
1200
1000
800
600
400
200
0
01/01/21
20/02/21
11/04/21
31/05/21
20/07/21
08/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall


Flow Monitoring Station FM9, South Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
2.5
2.0
1.5
1.0
0.5
0.0
1200
1000
800
600
400
200
0
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

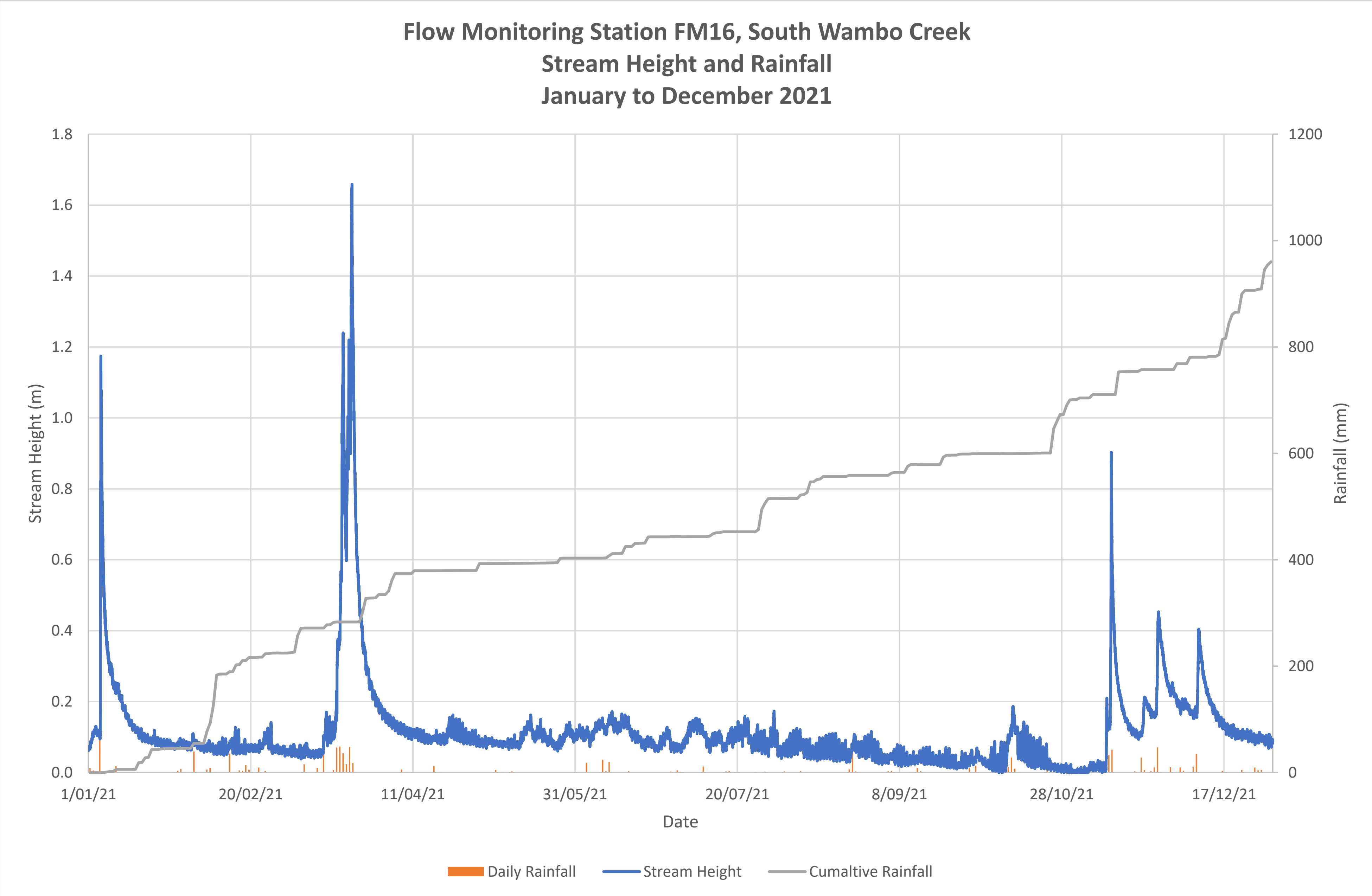

Flow Monitoring Station FM9, South Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
Rainfall (mm)
Date
0
10
20
30
40
50
60
0
200
400
600
800
1000
1200
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall



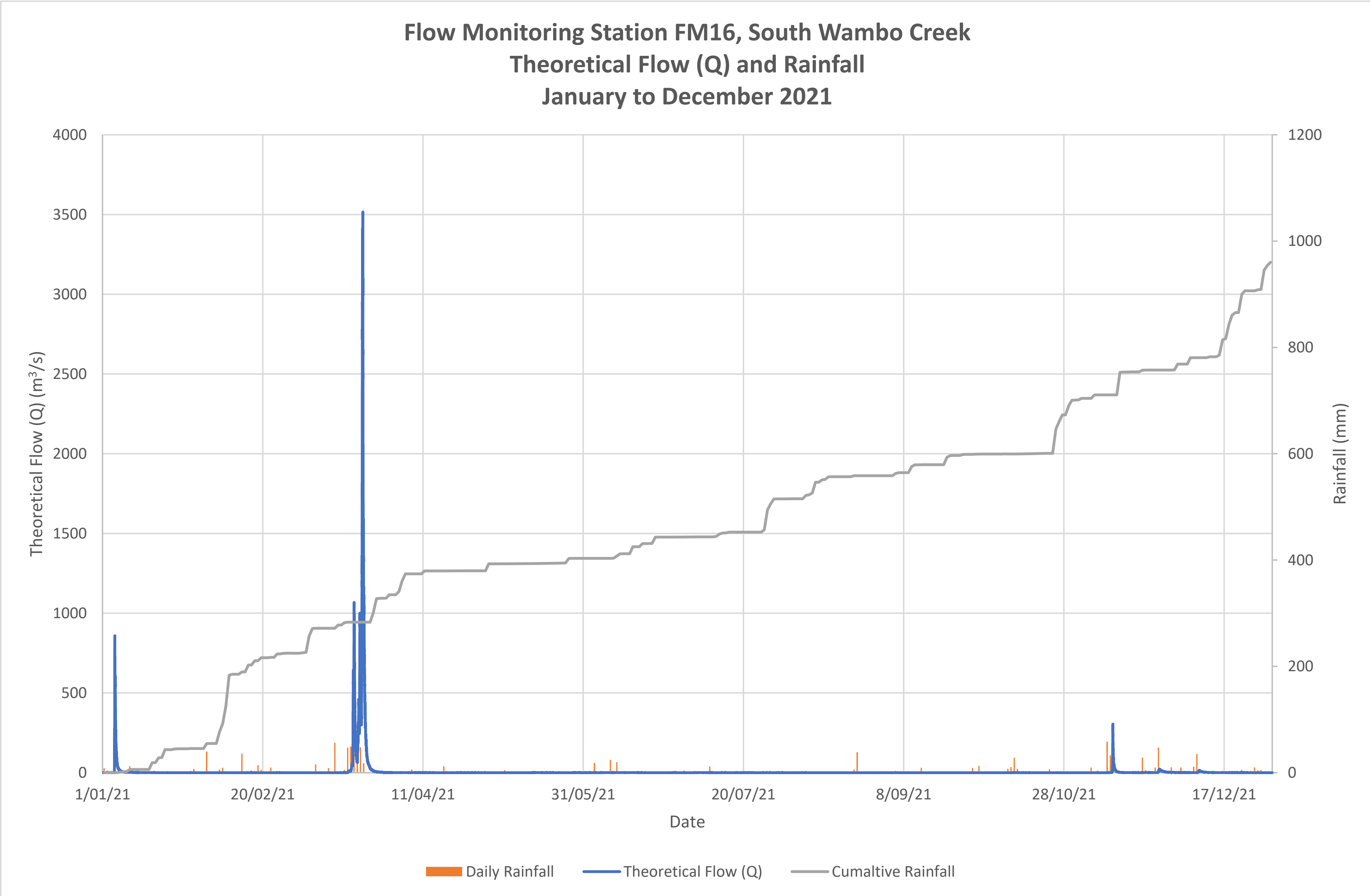
Flow Monitoring Station FM15, South Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
Date
0
1
2
3
4
5
6
0
200
400
600
800
1000
1200
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Daily Rainfall
Stream Height
Cumaltive Rainfall

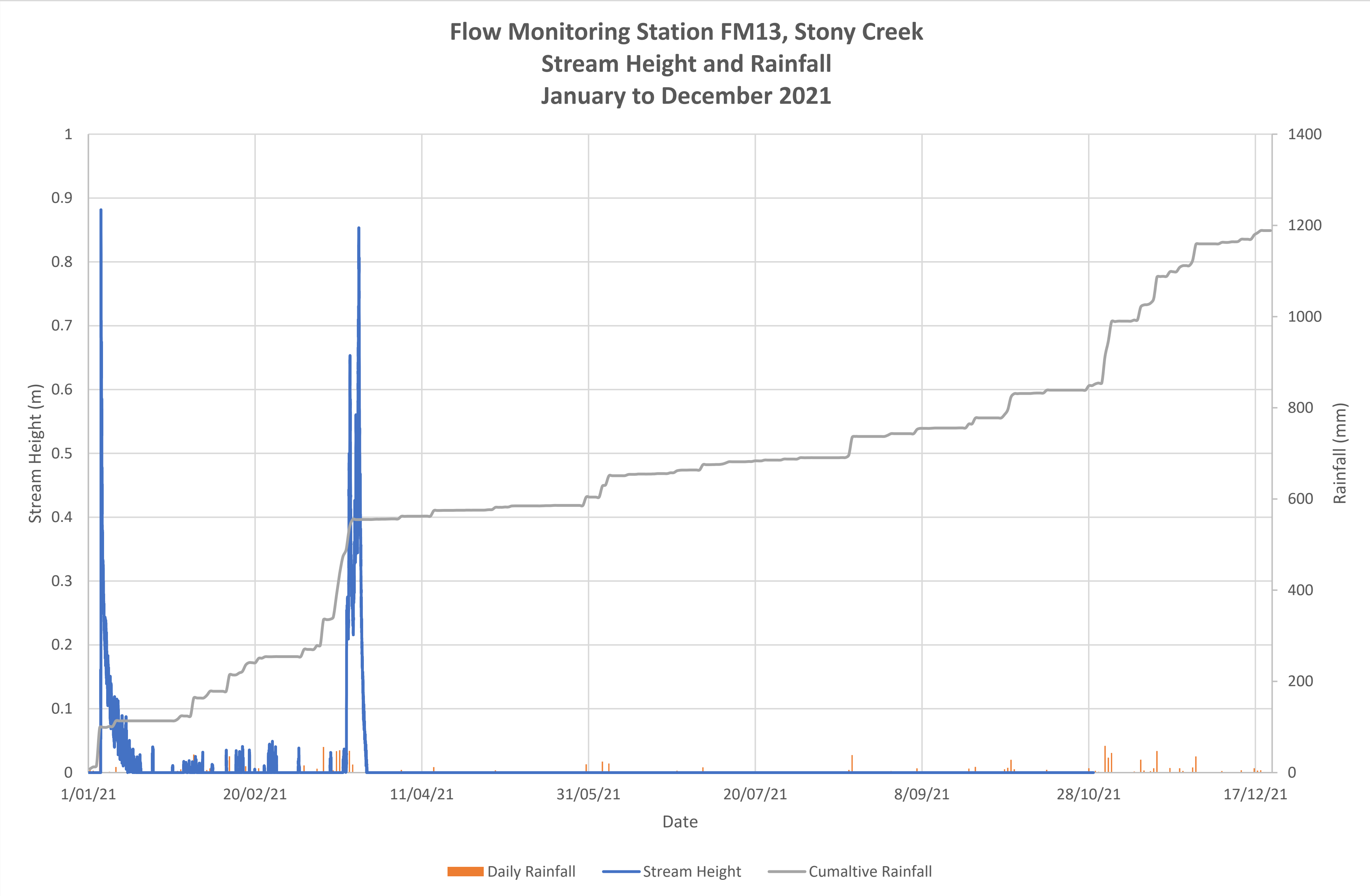


Flow Monitoring Station FM15, South Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
Rainfall (mm)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1200
1000
800
600
400
200
0
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

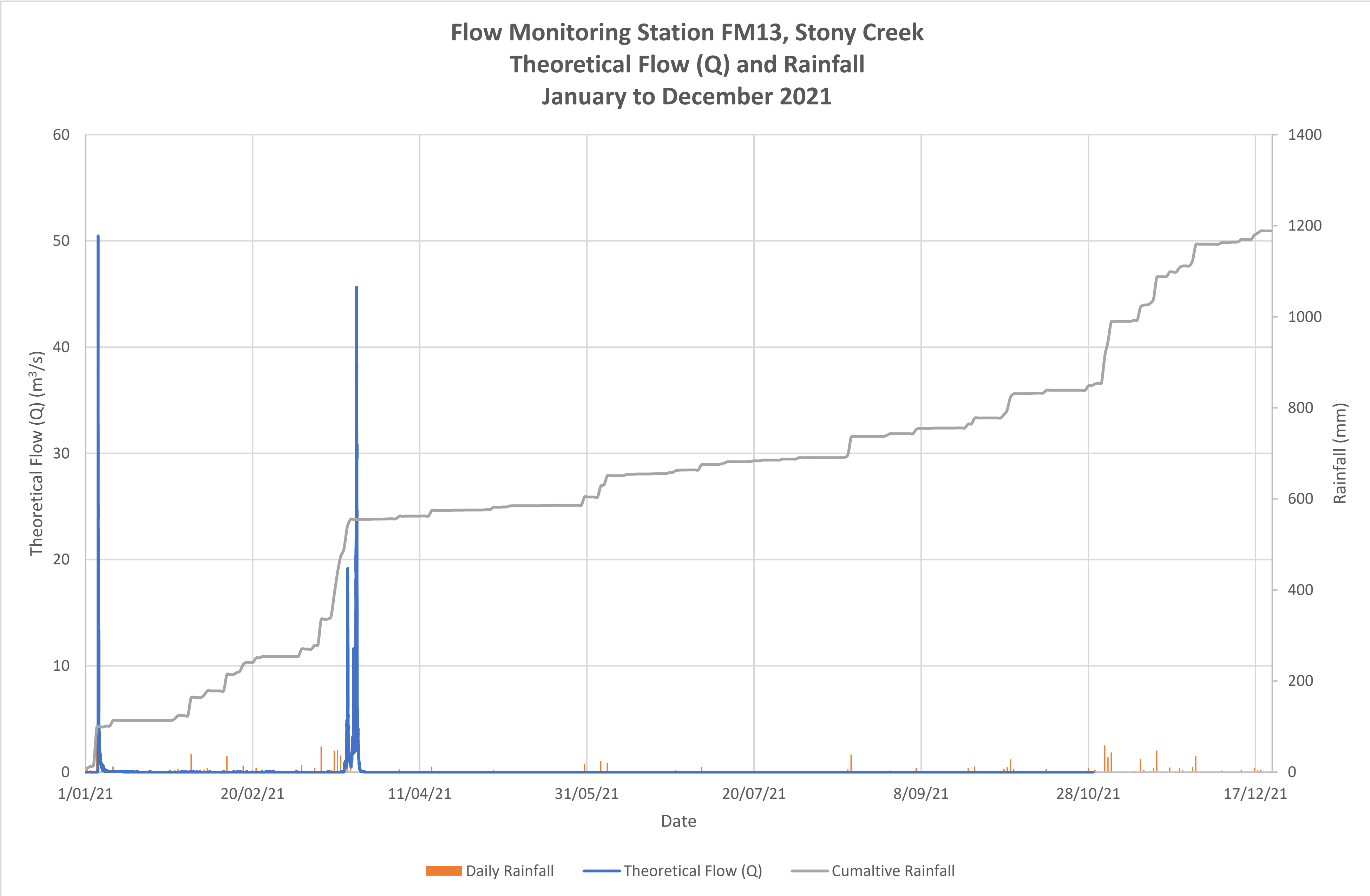


Flow Monitoring Station FM16, South Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1200
1000
800
600
400
200
0
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

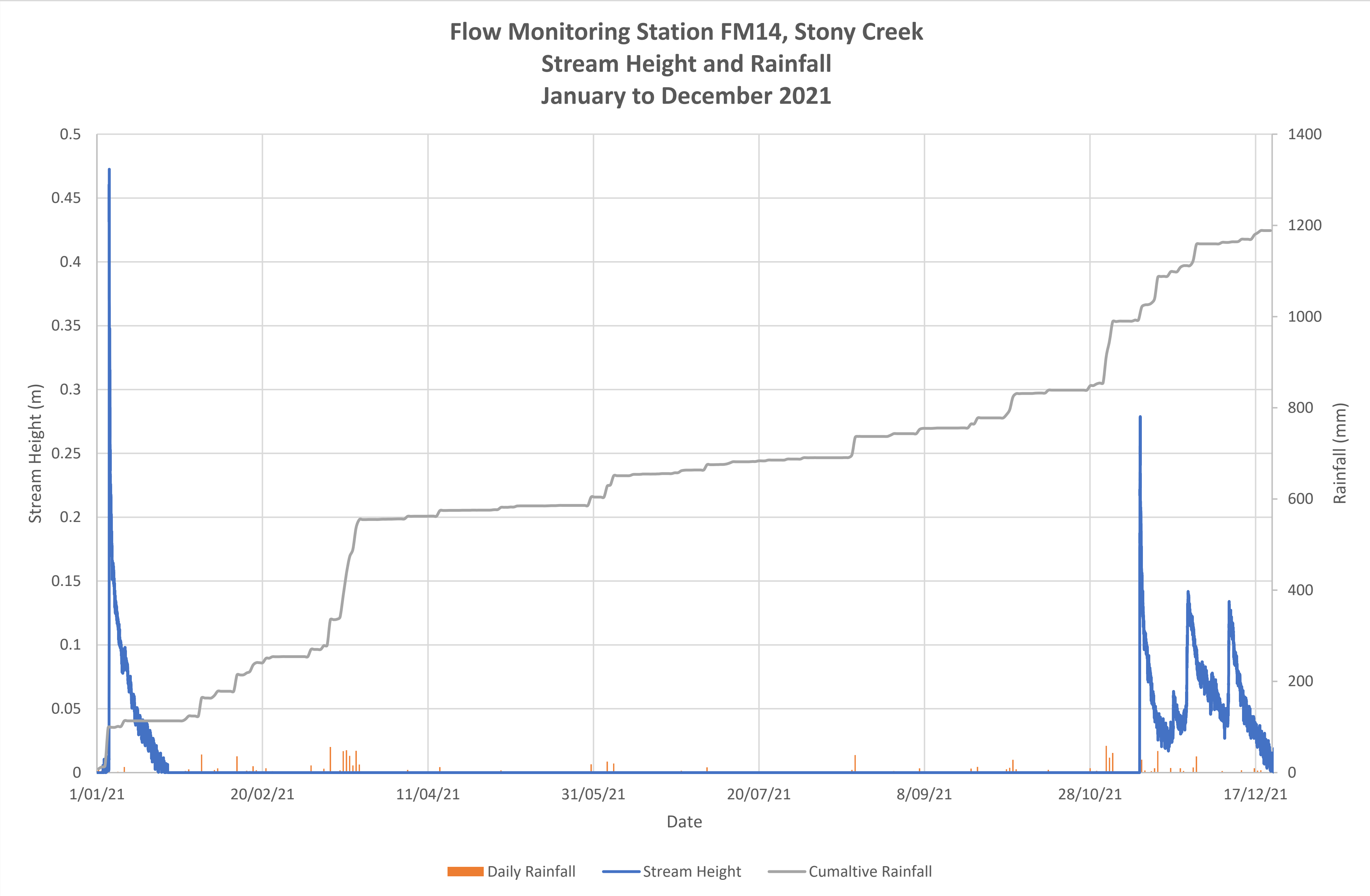

Flow Monitoring Station FM16, South Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m³/s)
4000
3500
3000
2500
2000
1500
1000
500
0
Rainfall (mm)
1200
1000
800
600
400
200
0
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

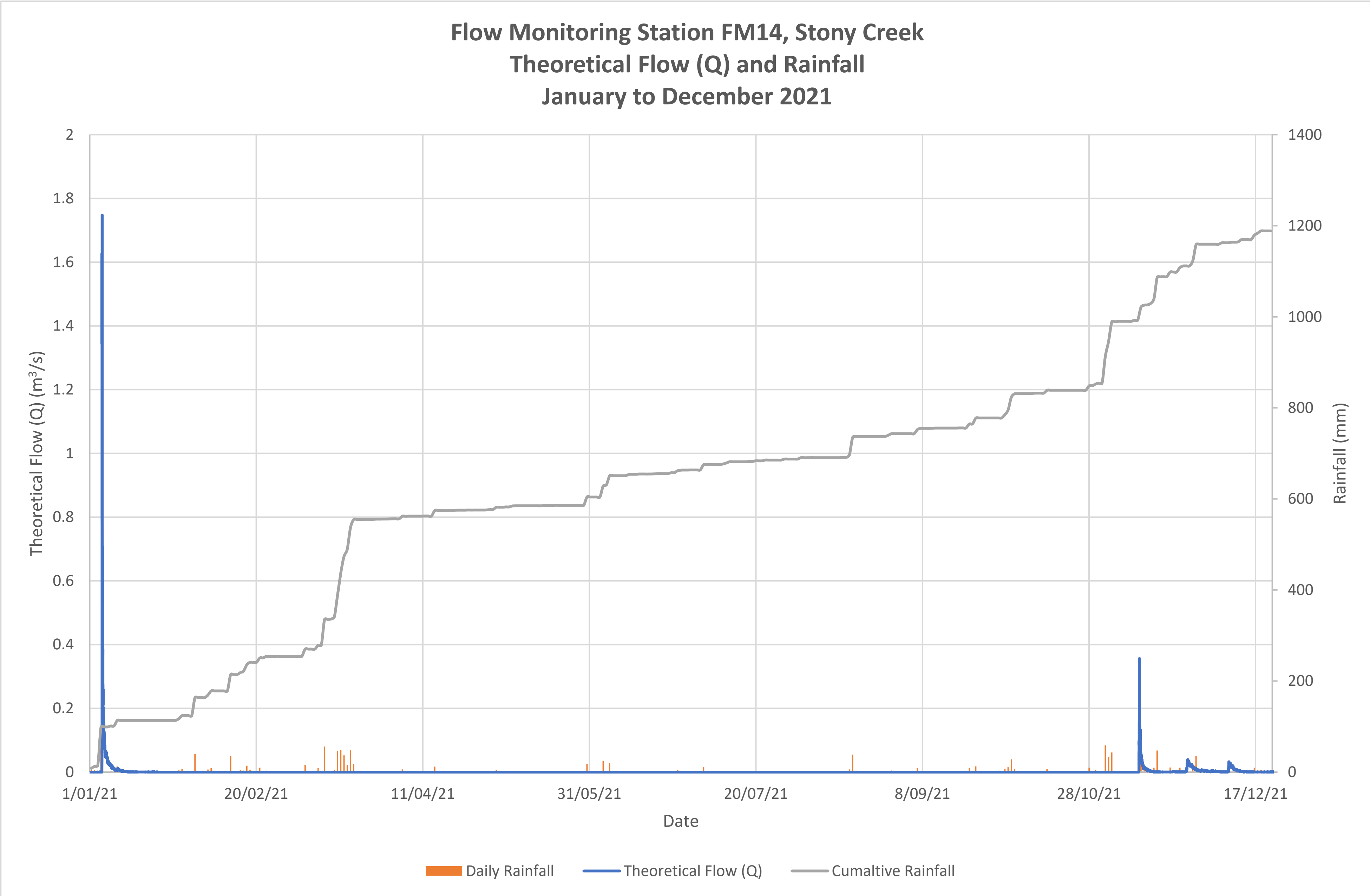


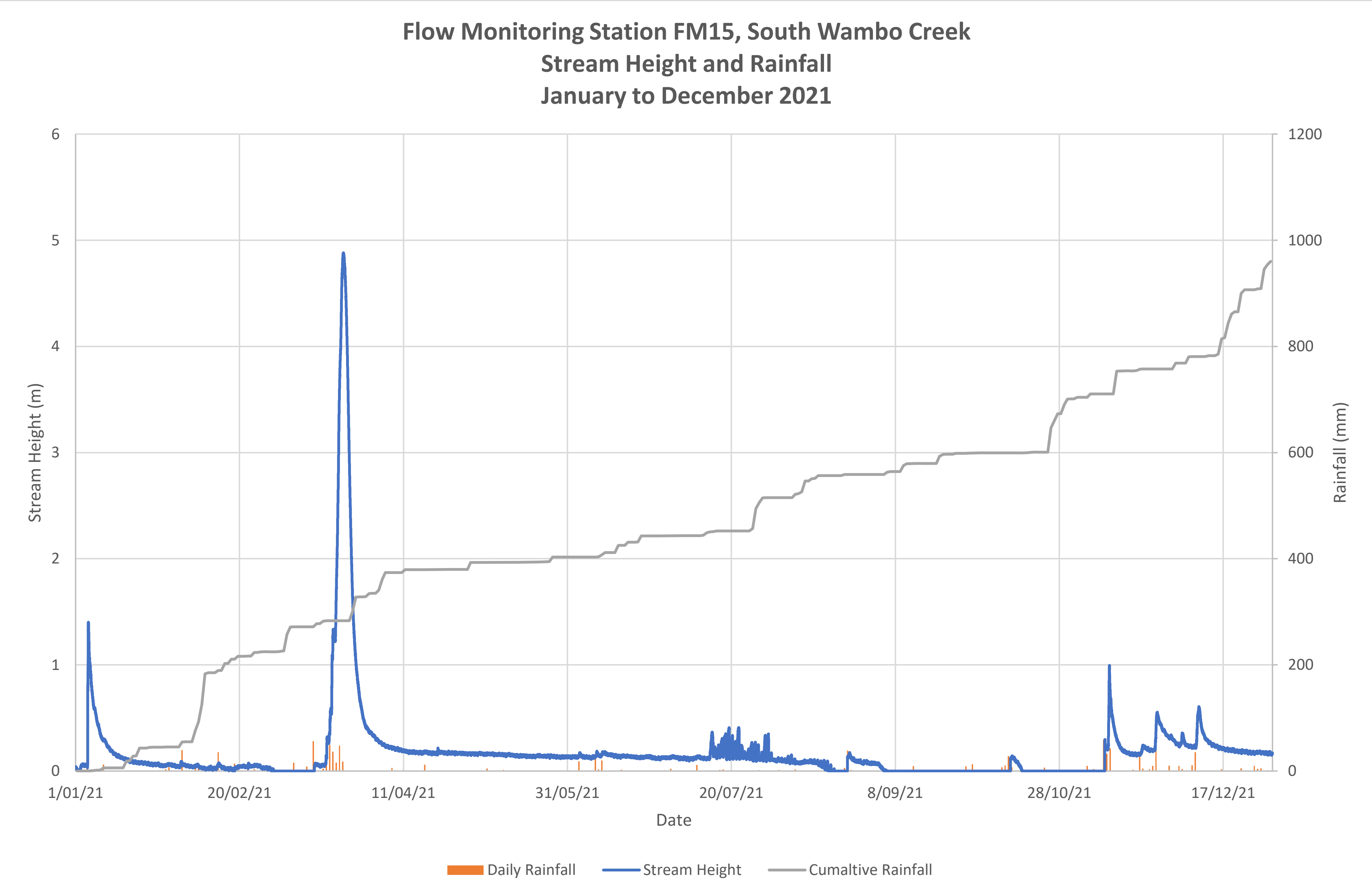
Flow Monitoring Station FM13, Stony Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1400
1200
1000
800
600
400
200
0
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

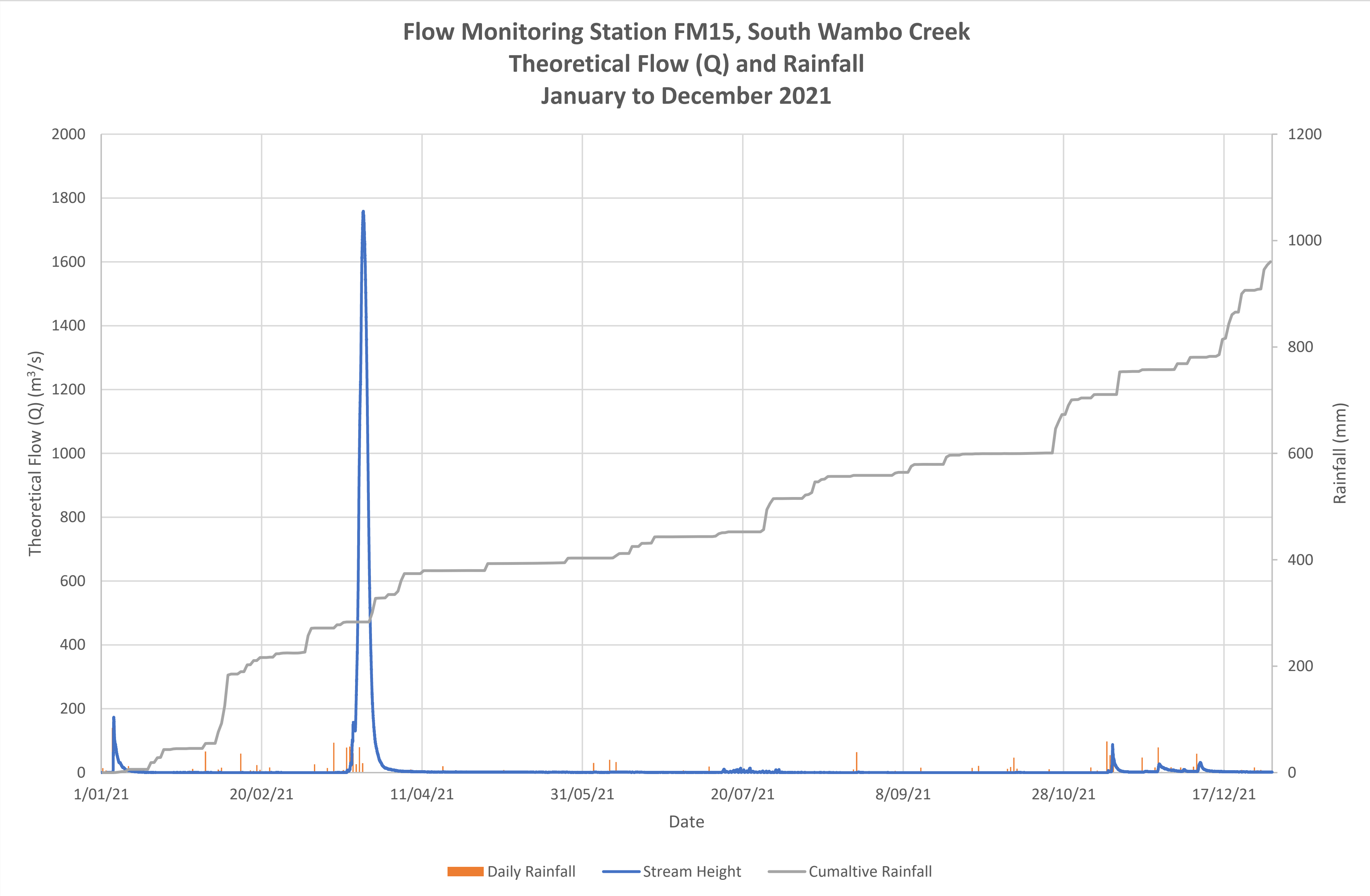


Flow Monitoring Station FM13, Stony Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m³/s)
Rainfall (mm)
Date
60
50
40
30
20
10
0
1400
1200
1000
800
600
400
200
0
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall


Flow Monitoring Station FM14, Stony Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1400
1200
1000
800
600
400
200
0
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall


Flow Monitoring Station FM14, Stony Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m3/s)
Rainfall (mm)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1400
1200
1000
800
600
400
200
0
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall


Flow Monitoring Station FM15, South Wambo Creek
Stream Height and Rainfall
January to December 2021
Stream Height (m)
Rainfall (mm)
0
1
2
3
4
5
6
0
200
400
600
800
1000
1200
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall



Flow Monitoring Station FM15, South Wambo Creek
Theoretical Flow (Q) and Rainfall
January to December 2021
Theoretical Flow (Q) (m³/s)
Rainfall (mm)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1200
1000
800
600
400
200
0
1/01/21
20/02/21
11/04/21
31/05/21
20/07/21
8/09/21
28/10/21
17/12/21
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

APPENDIX I

ANNUAL GROUNDWATER MONITORING REPORT

WAMBO - 2021 ANNUAL REVIEW

Groundwater

Prepared for:

Wambo Coal Pty Ltd
Peabody Energy Australia
PMB 1, Singleton NSW, 2330

SLR Ref: 665.10008.00915-R01
Version No: -v3.0
March 2022

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 1, The Central Building, UoW Innovation Campus
North Wollongong NSW 2500 Australia

T: +61 2 4249 1000
E: wollongong@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Wambo Coal Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
665.10008.00915-R01-v2.0	25 March 2022	John Barlow	Adam Skorulis	John Barlow
665.10008.00915-R01-v1.0	22 March 2022	John Barlow	Adam Skorulis	

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1 Introduction

1.1 Overview

The Wambo Coal Pty Ltd (WCPL) mining complex is located approximately 20 kilometres (km) north-west of Singleton, New South Wales (NSW). As part of compliance with mine approval conditions, routine groundwater monitoring is conducted across WCPL, and the data reviewed and analysed on an annual basis. This report presents the annual groundwater review for WCPL, developed in accordance with the approval conditions and requirements outlined within the GWMP (Peabody, 2020). The annual groundwater review is required to:

1. Compare groundwater levels and quality to trigger levels. Groundwater levels are also compared to rainfall to identify trends. Simulated groundwater levels will also be compared to observed levels with model revisions recommended if necessary (Sections 4.1 and 4.2 of the WCPL Groundwater Management Plan (GWMP) (Peabody, 2020)).
2. Assess the volume and quality of groundwater inflow to Open Cut Pits and Underground Workings (Section 6.1.2 GWMP). Inflow volumes to underground workings will be compared to model predictions.
3. Report against specific performance indicators developed for the subsidence impact performance measures relating to groundwater for North Wambo Underground (NWU), South Wambo Underground (SWU), and South Bates Extension (SBX) mine areas (Sections 4.3 and 4.4 GWMP).

1.2 Scope

This report contains the analysis and information required to address the following components of the Annual Environmental Management Review (AEMR) for WCPL for the 2021 calendar year:

1. Review hydrographs for relevant groundwater monitoring bores and VWPs and assess whether trends are due to climate variations, mining, or other influences. (**Sections 5.1 to 5.3**)
2. Assess Vibrating Wire Piezometer (VWP) data quality to assist with optimization of the monitoring network. (**Section 5.6**)
3. Assess shallow monitoring bores for compliance against the groundwater level and quality performance indicators (Tables 11 and 13 of the GWMP (Peabody, 2020)). (**Section 5.4**)
4. Assess bores against relevant groundwater performance indicators defined for MOD16, and South Bates Extension (SBX) (Tables 14, and 16 of the GWMP (Peabody, 2020)). (**Section 5.5**)
5. Assess compliance with groundwater licencing limits for both hard rock and alluvial aquifers.
6. Address comments and recommendations from the following sources:
   - The 2017 Independent Environmental Audit in line with commitments made in the GWMP;
   - Letters from regulatory agencies to WCPL (OUT19/14134 and OUT19/8833); and
   - Previous Annual Reviews and compliance reporting, including the 2020 Annual Review (SLR,2021), the 2021 Periodic Groundwater Review (SLR, 2021), and the Stony Creek Water Quality Trigger Investigation (SLR, 2022).
7. Provision of recommendations (as required).

2 Wambo Complex

The following section provides a description of the WCPL Complex relevant to this annual groundwater review. The general site layout is presented in **Figure 1**.

2.1 Mine operations

Table 1 presents a summary of mine areas across WCPL, approved mining timeframes and activities conducted during 2021. Mining was only active at South Bates Extension Underground during 2021.

Table 1 Summary of WCPL Activities

Mine Area	Seam Mined To	Approved Life of Mining	2021 Activities
North Wambo Underground (NWU)	Wambo Seam	2007 to 2015	Mining complete
South Bates Underground (SBU)	Wambo Seam and Whybrow Seam	2016 to 2018	Mining complete
South Bates Extension (SBX)	Whybrow Seam	2018 to 2024[1]	Mining of SBX LW20 completed16/02/2021 LW21: Start 10/04/2021, Expected Finish February 2022.
South Wambo Underground	Arrowfield and Bowfield Seam	To 2042	Not yet active

[1] based on current Extraction Plan approvals.

WCPL was granted development consent in February 2004 (DA 305-7-2003). The approved development described in the Project EIS and subsequent sixteen modifications extend the underground mine life until 31 August 2042. Under the most recent modification (Modification 16, determined 28 August 2019) current operations at the Wambo Mine include underground mining and coal processing and handling activities. Open cut mining activities are managed by the United Wambo Joint Venture. The approved operations are summarised **Table 1**.

2.2 Groundwater Impacts

Groundwater impacts associated with the approved operations at WCPL have been progressively assessed for each mining area, including:

- Wambo Development Project Groundwater Impact Assessment (AGE, 2003);
- North Wambo Underground Mine Modification Groundwater Assessment (Heritage Computing, 2012);
- North Wambo Underground – Longwall 10A – Modification Assessment (HydroSimulations, 2014a);
- Wambo Coal Mine Open Cut Modification Groundwater Assessment (HydroSimulations, 2014b);
- South Bates Underground Mine Modification – Groundwater Assessment (HydroSimulations, 2015);
- South Wambo Underground Mine Modification Groundwater Assessment (HydroSimulations, 2016a):
- South Wambo Box Cut – Groundwater Assessment (HydroSimulations, 2016b);

- South Bates Extension Modification Groundwater Assessment (HydroSimulations, 2017); and
- Wambo Knowledge to inform NWC GDE Study (HydroSimulations, 2019).

The most recent groundwater assessment that captures operations across Wambo is the Groundwater Assessment in Support of South Bates Extension LW21-24 Extraction Plan (SBX LW21-24 EP). The groundwater assessment for SBX LW21-24 EP was completed by SLR (2020) and included an updated version of the HydroSimulations (2017a) and HydroSimulations (2019b) numerical groundwater model to assess groundwater response to approved mine activities. Mining is expected to commence in Longwall 21 around April 2021.

The key findings of this groundwater assessment review were:

- The alluvium adjacent to the SBX footprint has been disconnected from the regional alluvial system due to the removal of alluvium downstream of the longwalls by the approved open cut mining operations (and associated construction of the NWC diversion).
- The alluvium adjacent to the SBX footprint has been affected by open cut mining activities. with several metres of drawdown in the alluvium and regolith predicted by the numerical model.
- There is expected to be negligible impact on the highly productive alluvium associated with the Wollombi Brook and Hunter River as a result of extraction of Longwalls 21 to 24.
- Extraction of Longwalls 21 to 24 would not result in reduced beneficial uses of the alluvium (from a water quality perspective).
- There are no bores above the SBX footprint that are used for irrigation, domestic or stock use. There are no private registered bores that would be likely to be affected by 2 m drawdown or more if Longwalls 21 to 24 were to occur in isolation.
- Site monitoring bores have the potential to be impacted during mining, therefore review of the condition of the monitoring network will be undertaken during each sampling event, and bores remediated/replaced as required, to maintain a long-term monitoring network.
- Depressurisation of up to 200 m, due to extraction of Longwalls 21 to 24, are expected in the Whybrow Seam in accordance with the depth of cover.
- Extraction of Longwalls 21 to 24 would not have a significant impact on water levels in the Permian coal measures from a regional perspective due to the regional zone of depressurisation within the Permian coal measures created by historical and ongoing open cut and underground mining.
- Extraction of Longwalls 21 to 24 would not lower the beneficial use category of the groundwater within the Permian aquifers, as there would be no migration of groundwater away from the underground mining areas in the Permian aquifers either during mining or following completion of mining activities.
- There is an expectation of enhanced leakage from the NWC if the creek happens to flow during the period of extraction of Longwalls 21 to 24 underneath the diversion.
- Negligible loss of baseflow to the natural NWC is expected due to extraction of Longwalls 21 to 24, however, surface remediation may be required to maintain the long-term flow regime along NWC (MSEC 2020).

The groundwater data analysis, based on currently available records, has shown that there are no observed material impacts from longwall mining beyond what was foreseen for the cumulative impacts described in the South Bates Extension Modification – Groundwater Assessment (HydroSimulations, 2017a).

2.3 Groundwater Licensing

Under the *Water Act 1912* and *Water Management Act 2000*, adequate water licences are required for approval of the mine developments. Groundwater licenses held for WCPL are outlined in **Table 2**.

Table 2 WCPL Groundwater Entitlement and Licenses

Licence Number	Description	Expiry Date	Entitlement	Category	Access Licence	Nominated Water Supply Work Approval	Expiry date	Comment
Hunter Unregulated and Alluvial Water Sources (Lower Wollombi Brook Water Source)								
WAL18437 (20SL033872)	Wollombi Brook Pump	Perpetuity	350 unit shares	Unregulated River	20AL208641	20WA208642	31/07/2022	
WAL 23897 (20BL167737)	Well No. 2	Perpetuity	70 unit shares	Aquifer	20AL211371	20WA211372	31/7/2022	
North Coast Fractured and Porous Rock Groundwater Sources (Sydney Basin - North Coast Groundwater Source)								
WAL42373	Dewatering	Perpetuity	1549 unit shares	Aquifer	20AL219997	20MW065010	-	6 x WALs consolidated 20/12/18.
WAL41532 (20BL172156)[1]	Dewatering	Perpetuity	98 unit shares	Aquifer	20AL218994	20MW065010	-	
20BL168997	Piezometer	Perpetuity	Groundwater monitoring	NA		-	-	
20BL168998	Piezometer	Perpetuity	Groundwater monitoring	NA		-	-	
20BL168999	Piezometer	Perpetuity	Groundwater monitoring	NA		-	-	
20BL169000	Piezometer	Perpetuity	Groundwater monitoring	NA		-	-	
20BL170638	Piezometer	Perpetuity	Groundwater monitoring	NA		-	-	
20BL172237	Monitoring Bore (GW14, GW18, GW21)	Perpetuity	Groundwater monitoring	NA		-	-	
20BL172238	Monitoring Bore (GW12)	Perpetuity	Groundwater monitoring	NA		-	-	
20BL172240	Monitoring Bore (GW15)	Perpetuity	Groundwater monitoring	NA		-	-	

Licence Number	Description	Expiry Date	Entitlement	Category	Access Licence	Nominated Water Supply Work Approval	Expiry date	Comment
20BL172242	Monitoring Bore (GW16, GW17)	Perpetuity	Groundwater monitoring	NA		-	-	
20BL172244	Monitoring Bore (GW20)	Perpetuity	Groundwater monitoring	NA		-	-	
20BL172255	Monitoring Bore (GW22)	Perpetuity	Groundwater monitoring	NA		-	-	
20BL172256	Monitoring Bore (GW13)	Perpetuity	Groundwater monitoring	NA		-	-	
20BL172257	Monitoring Bore (GW19)	Perpetuity	Groundwater monitoring	NA		-	-	
20BL172332	Piezometer	Perpetuity	Groundwater monitoring	NA		-	-	
20BL173032	Monitoring		Groundwater monitoring	NA			-	
20BL173290	Monitoring Bore	Perpetuity	Groundwater monitoring	NA		-	-	
20BL173291	Monitoring Bore	Perpetuity	Groundwater monitoring	NA		-	-	
20BL173292	Monitoring Bore	Perpetuity	Groundwater monitoring	NA		-	-	
20BL173293	Monitoring Bore	Perpetuity	Groundwater monitoring	NA		-	-	
20BL173946	Monitoring	Perpetuity		NA				
20BL173999	Monitoring Bore	Perpetuity	Groundwater monitoring	NA		-	-	
20BL009818	Bore	Perpetuity	Stock	NA		-	-	
20BL009819	Bore	Perpetuity	Stock	NA		-	-	
20BL009820	Bore	Perpetuity	Stock	NA		-	-	
20BL009821	Bore	Perpetuity	Stock	NA		-	-	
20BL143779	Bore	Perpetuity	Stock/Domestic	NA		-	-	

WAL = water access licence, ML/year = megalitres per year.

2.4 Groundwater Conditions

In accordance with the development consent approval requirements of DA305-7-2003 (as modified) and various groundwater licences, WCPL are required to prepare and implement a Groundwater Management Plan (GWMP). **Table 3** presents a summary of the relevant groundwater conditions from the development consent and Version 2 of the GWMP (Peabody, 2020) approved on 20 November 2020.

Table 3 DA305-7-2003 Requirements for the GWMP

Condition	Condition Details*	GWMP Section
B66	(v) Groundwater Management Plan, which is consistent with Groundwater Monitoring and Modelling Plans – Introduction for prospective mining and petroleum activities (DPI Water, 2014) and includes:	Entire Document
	detailed baseline data of groundwater levels, yield quality for groundwater resources and groundwater dependent ecosystems potentially impacted by the development, including groundwater supply for other water users;	Section 3.4
	a detailed description of the groundwater management system;	Section 5.1
	groundwater performance criteria including trigger levels for identifying and investigating any potentially adverse groundwater impacts associated with the development, on: • Regional and local aquifers (alluvial and hardrock); • Groundwater supply for other water users such as privately-owned licensed groundwater bores; and • Groundwater dependent ecosystems	Section 4.0
	program to monitor and evaluate: • compliance with the relevant performance measures listed in Table 8, and the performance criteria established above, including monitoring of regional groundwater levels and quality during the life of the development and at least 10 years post-mining; • water loss/seepage from water storages into the groundwater system (particularly from South Wambo Dam and Montrose East Dam); • groundwater inflows, outflows, and storage volumes to inform the Site Water Balance; • any hydraulic connectivity between the alluvial and hardrock aquifers; • impacts on groundwater dependent ecosystems; • impacts on groundwater supply for other water users; and • the effectiveness of the groundwater management systems;	Sections 6.0 and 9.2
	reporting procedures for the results of the monitoring program;	Section 9.2
	a plan to respond to any exceedances of the groundwater performance criteria, and repair, mitigate, compensate and/or offset any adverse groundwater impacts of the development; and	Section 7.0
	a program to periodically validate the groundwater model for the development, including an independent review of the model every 3 years, and comparison of monitoring results with modelled predictions; and	Sections 5.3 and 9.1.2
D5	**Management Plan Requirements** The Applicant must ensure that the management plans required under this consent are prepared in accordance with any relevant guidelines, and include where relevant: Section 2.1	Section 2.1
	(a) summary of relevant background or baseline data;	Section 2.4
	(b) details of:	Section 2.0 / Section 4.0

Condition	Condition Details*	GWMP Section
	• the relevant statutory requirements (including any relevant approval, licence, or lease conditions); • any relevant limits or performance measures and criteria; • the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	
	(c) any relevant commitments or recommendations identified in the document/s listed in condition A2(c);	Section 2.0
	(d) a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;	Sections 5.0 and 6.0
	(e) a program to monitor and report on the: • impacts and environmental performance of the development; and • effectiveness of any management measures set out pursuant to paragraph (d)	Monitoring – Section 6.0 Reporting - Section 9.0
	(f) a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 7.0
	(g) a program to investigate and implement ways to improve the environmental performance of the development over time;	Section 9.0
	(h) a protocol for managing and reporting any: • incident, non-compliance or exceedance of any impact assessment criterion and performance criterion; • complaint; or • failure to comply with other statutory requirements; and	Managing – Section 7.0 Reporting – Section 9.0 / Section 8.0 / Section 7.4
	(i) a protocol for periodic review of the plan.	Section 9.1.3

Groundwater monitoring is conducted in accordance with the United Wambo and Wambo Water Monitoring Program (WMonProg), a component of the WCPL Water Management Plan. The program outlines groundwater monitoring frequency, parameters to be tested, as well as groundwater triggers for electrical conductivity (EC) and pH. The WMonProg and GWMP were updated in November 2020, including updates and upgrades to the monitoring network, and development of performance indicators for alluvial aquifers and GDE's. This annual review is based upon the monitoring and reporting requirements documented within the November 2020 version of the GWMP. Further discussion on the groundwater monitoring program and triggers is included in **Section 4**.

2.5 Independent Environmental Audit Recommendations

An Independent Environmental Audit (IEA) conducted by Hansen Bailey in 2017 (in accordance with the requirements of DA305-7-2003 and DA177-8-2004) made recommendations relating to the GWMP. These recommendations and where they are addressed in the GWMP are presented in Table 3 of the GWMP (Peabody, 2020). GHD conducted the following IEA in 2020 and made no recommendations in relation to groundwater.

3 Hydrogeological Setting

This section presents a brief summary of the hydrogeological setting for WCPL. This includes discussion on climate, terrain, drainage, geology, and groundwater bearing units.

3.1 Climate, Terrain and Drainage

3.1.1 Climate

The climate of the Wambo region is temperate and characterised by hot summers and mild dry winters. Rainfall data is available from the Bureau of Meteorology (BoM), Bulga-South Wambo Station (Station: 0611191), through the Scientific Information for Landowners (SILO) database. The SILO database provides the most complete long-term dataset and is therefore useful for assessing long term rainfall trends. **Table 4** provides the long term historical monthly average compared to the 2021 monthly rainfall data. Based on the SILO dataset, the long-term average annual rainfall is 640.7 mm. In 2021, the total rainfall was 1083.3 mm indicating that the year was very wet compared to average, with the substantial majority of the excess rainfall falling in March and November. The Wambo weather station recorded 1188.6 mm of rain in 2021, approximately 10% more than the SILO dataset for the site in 2021.

Table 4 Long Term Average and 2021 Climate Data

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Historical[1]	76.6	75.0	64.7	46.3	37.8	46.6	39.0	34.2	39.9	50.2	60.5	69.9	640.7
2021 Rainfall	132.4	96.4	256.3	19.8	5.5	67.6	30.8	46.0	24.8	78.5	229.0	96.2	1083.3
Excess/deficit	55.8	21.4	191.6	-26.5	-32.3	21.0	-8.2	11.8	-15.1	28.3	168.5	26.3	442.6

[1] Based on SILO dataset January 1900 to December 2021

The cumulative rainfall departure (CRD) (**Figure 1**) graphically shows the rainfall trend relative to the long-term average. A positive (upward) slope in the CRD indicates periods of above average rainfall, while a negative (downward) slope indicates periods of below average rainfall. The CRD shows that since the start of 2020 rainfall has been significantly above average. The wet conditions recorded in 2021 continued the widespread recovery from the 2017-2020 drought event. The CRD also shows a prolonged period of above average rainfall from late 2007 to the end of 2016.

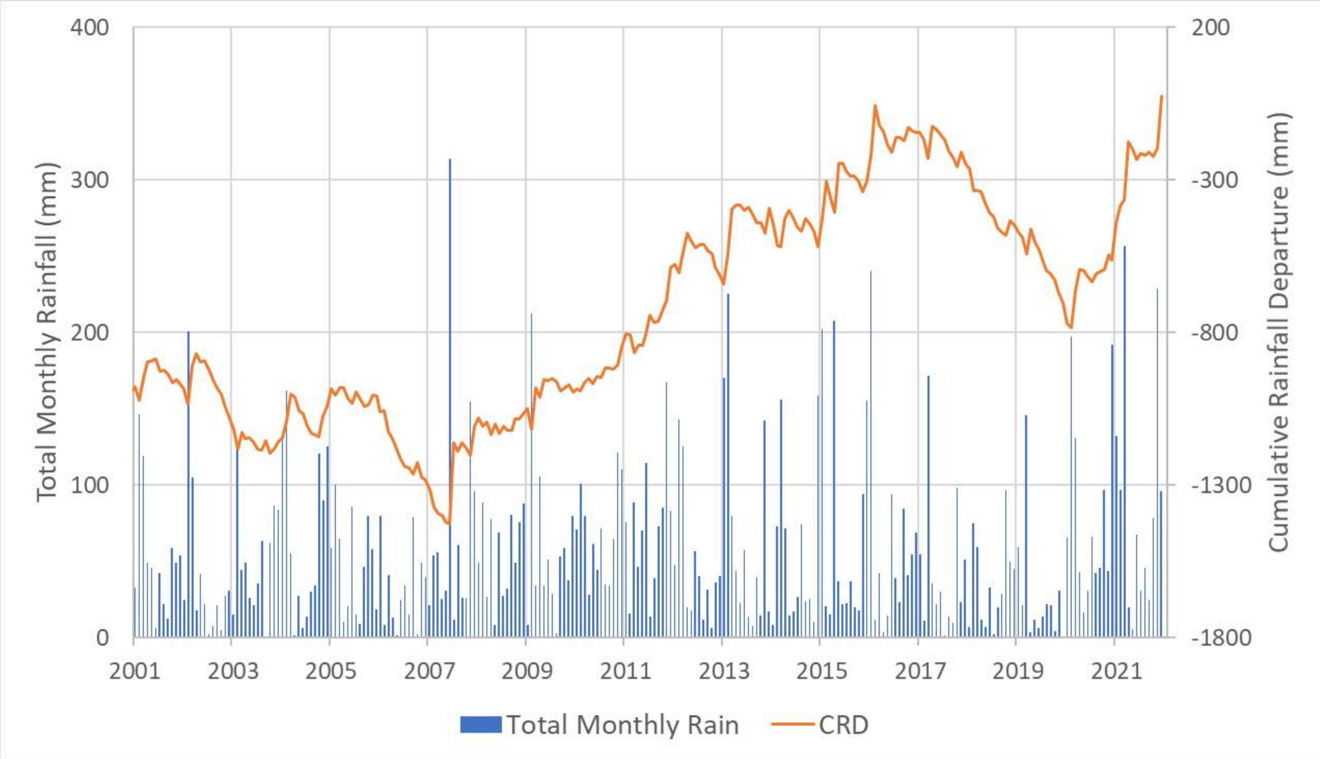


Figure 1 Monthly Rainfall and CRD

3.1.2 Terrain and Drainage

WCPL is located in the Upper Hunter Valley region where landforms are characterised by gently sloping floodplains associated with the Hunter River and the undulating foothills, ridges and escarpments of the Mount Royal Range and Great Dividing Range. Elevations in the vicinity of WCPL range from approximately 60 metres Australian Height Datum (mAHD) at Wollombi Brook to approximately 400 mAHD on the nearest ridges of the hills immediately to the south west of WCPL.

Wollombi Brook, situated immediately south-west of WCPL, flows north-east to its confluence with the Hunter River (**Figure 1**). Wollombi Brook drains an area of approximately 1,950 square kilometres (km^2) and joins the Hunter River some 4 km east of Wambo. The Wollombi Brook sub-catchment is bound by the Myall Range to the south-east, Doyles Range to the west, the Hunter Range to the south-west and Broken Back Range to the north-east (Hunter Catchment Management Trust, 2002).

The majority of lands within WCPL mining tenements drain via Wambo, Stony, North Wambo and Redbank Creeks to Wollombi Brook, while Waterfall Creek drains to the north-east directly to the Hunter River. These watercourses are generally characterised by ephemeral and semi-perennial flow regimes (Gilbert and Associates, 2003).

3.2 Geology

WCPL is situated within the Hunter Coalfield subdivision of the Sydney Basin, which forms the southern part of the Sydney-Gunnedah-Bowen Basin. The stratigraphy in the Wambo area comprises the Triassic Narrabeen Group, Permian coal measures, and more recent (Quaternary) alluvial deposits associated with major drainage pathways. Folding, faulting and igneous intrusions have affected the Permian sediments after deposition. The target Seams for WCPL underground mining lie within the Jerrys Plains Subgroup of the Wittingham Coal Measures.

Along the Wollombi Brook, Wambo Creek, North Wambo Creek (NWC), and Stony Creek thin Quaternary alluvial deposits unconformably overlie the Permian strata. The alluvial deposits comprise surficial fine-grained sediments (i.e. sands, silts, and clays). Along major watercourses (i.e. Wollombi Brook) the surficial sediments overly basal sands and gravels that are between 7 m to 20 m thick. **Table 5** presents a summary of site geology.

Table 5 Wambo Generalised Stratigraphy

Age	Stratigraphic Unit		Description
Cainozoic	Quaternary sediments -alluvium (Qa)	Surficial alluvium (Qhb)	Shallow sequences of clay, silty sand, and sand.
		Productive basal sands/gravel (Qha)	Basal sands and gravels along major watercourses (i.e. Hunter River).
	Silicified weathering profile (Czas)		Silcrete
	Alluvial terraces (Cza)		Silt, sand, and gravel
Jurassic	Volcanics (Jv)		Flows, sills, and dykes
Permian	Whittingham Coal Measures	Jerrys Plains Sub-group (Pswj)	Coal bearing sequences interbedded with sandstone and siltstone. Coal seams (youngest to oldest) include Whybrow Seam, Redbank Creek Seam, Wambo Seam, Whynot Seam, Blakefield Seam, Glen Munro Seam, Woodlands Hill Seam, Arrowfield Seam, Bowfield Seam, Warkworth Seam, Mt Arthur Seam, Piercefield Seam, Vaux Seam, Broonie Seam and Bayswater Seam.

3.2.1 Groundwater Units

The hydrogeological regime of the Wambo area and surrounds comprises two main systems:

- Quaternary alluvial aquifers associated with Wollombi Brook, NWC, Wambo Creek, and Stony Creek; and
- Underlying Permian strata of generally low permeability and hence very low yielding to dry sandstone and lesser siltstone, with low to moderately permeable coal seams which are the prime water-bearing strata within the Permian coal measures. Triassic strata, namely the Narrabeen Group, are present to the south-west of the North Wambo Underground Mine and underlie some areas of alluvium.

3.2.2 Alluvium

Groundwater flow within the shallow alluvial aquifers reflect local topography and the containment of alluvium within the low-lying drainage pathways. Evidence from temporal groundwater monitoring hydrographs (**Appendix B**) within the alluvium indicates that the shallow aquifer is responsive to rainfall recharge and it is likely that the alluvium plays an important role in supplying recharge to the underlying Permian strata as well as, in places, contributing to baseflow of the perennial surface water features. In some areas upward or lateral flow may occur from the Permian and Triassic rock, but downward leakage seems to be the more common behaviour.

3.2.3 Permian Coal Measures

Prior to the commencement of mining operations in the region, the piezometric surface across the Wambo area most probably reflected the topography, with elevated water levels/pressures in areas distant from the major drainages and reduced levels in areas adjacent to the alluvial lands. Historical and ongoing open cut and underground mining within the Wambo area and adjoining mining operations have significantly altered the natural regime with a regional zone of depressurisation within the Permian coal measures.

The inter/overburden sediments have low permeability due to their fine-grained nature, the cemented lithic mature of the sandstones and the common occurrence of a clayey matrix in the sandstones and conglomerates. The permeability of the groundwater system is related to the joint spacing and aperture width. Permeability of the rock units generally decreases with depth of burial as the joints tighten and become less frequent.

The laminated fabric of the interbedded sandstone/siltstone/mudstone strata suggests that vertical hydraulic conductivities are significantly lower than horizontal hydraulic conductivities. Due to the laminar nature of the coal measures, groundwater flow generally occurs within or along the boundaries between stratigraphic layers.

The permeability of the coal measures is generally low, with rock mass permeabilities typically more than two orders of magnitude lower than the unconsolidated alluvial aquifers. The most permeable horizons are the coal seams, which commonly have hydraulic conductivity one to three orders of magnitude higher than the interburden of siltstones, shales, and sandstone units.

The coal seams are generally more brittle and therefore more densely fractured than the overburden and interburden strata, which causes the higher permeability. Within the coal seams, groundwater flows predominantly through cleat fractures, although there is some evidence of structure-related fracturing and this may play an important role in groundwater flow paths.

The impact of fault structures such as the Redmanvale Fault is not known with certainty. However, it is likely that groundwater flow dynamics are complex in the vicinity of these structures.

4 Groundwater Monitoring

4.1 Groundwater Monitoring Program

Groundwater monitoring is conducted at WCPL in accordance with the GWMP (Peabody, 2020). The purpose of the GWMP is to monitor and manage groundwater quality and levels to detect potential impacts on surrounding groundwater users, assess the performance of the mine against the performance indicators, and to ensure that relevant legislative and policy requirements are met.

The overall objectives of the GWMP are to establish baseline groundwater quality and water level data and implement a program of data collection that can be utilised to assess potential impacts of mining activities on the area's groundwater resources. From a hydrogeological perspective, the Wambo region is relatively complex. This is due to the various areas of alluvium, proximity to Wollemi National Park and number of historical and current mining developments.

Standing Water Levels (SWL) are monitored at WCPL and compared to background data, EIS predictions, and historical trends as a means of assessing any WCPL related impacts to the quantity of groundwater in the various aquifers.

Ongoing groundwater monitoring requirements at WCPL are as follows:

- Groundwater monitoring bores to monitor groundwater sources above and in close proximity to mine workings;
- Monitoring of potential groundwater leakage from Wollombi Brook and associated alluvial aquifers;
- Monitoring of groundwater inflows to underground and open cut mining operations; and

The monitoring programme at WCPL also assesses the quality of groundwater against background data and historical trends. Bi-monthly monitoring of groundwater levels, pH, and EC is undertaken at all standpipe bores included in the groundwater monitoring program. Comprehensive analysis of major ions is conducted at each standpipe bore annually.

From 2017 to 2019 a total of 13 bores were drilled into the NWC Alluvium to gain a better understanding of the nature of the alluvial groundwater system in this area (SLR, 2017; AGE, 2019a; AGE, 2019b). Four to five bores from each drilling investigation were converted into monitoring bores to allow assessment of whether alluvial groundwater levels are affected by mining activity occurring in the South Bates Extension underground mine and Montrose Open Cut. In addition to the existing monitoring network, between 2017 and 2020, WCPL installed a series of standpipes (nested and single) and VWPs in the following areas:

- Adjacent to South Wambo Dam (P316, P316 a,b,c, P319);
- To the north-west of the mining area (P320, P321, P327, P328, P329, P330, P408, and UG166A); and
- To the south of Wambo Creek (P318 and P325) – to estbalish baseline groundwater conditions prior the commencement of South Wambo Underground.

In 2020 the following additional monitoring was installed (further details provided in **Table 6** and **Table 7**:

- Two additional bores in the upstream channel of NWC (GW36a: alluvium, GW36b: weathered Permian underlying the alluvium).

- Two VWPs and one standpipe, were installed above South Bates extension workings to provide operational groundwater information across an identified structure, while the standpipe will help inform the presence and magnitude of groundwater impacts to shallow overburden.
- At NWC, GW08.2, GW09.2, GW10.2 and GW10.2a were installed within the unconsolidated strata as replacements for bores GW08 and GW09.
- Nested standpipe P316(a, b, c) was constructed in the Wambo Creek alluvium to serve as a replacement for bores in the area screened across multiple strata (e.g. P114, P116). While P325a was installed further south adjacent to P325 (VWP) to monitor shallow strata overlying the approved South Wambo Project footprint.

Survey data is still required for these bores in order to convert dipped groundwater levels to mAHD and consider these new monitoring locations in the context of the wider monitoring network.

Refer to **Figure 2** for the location of these bores.

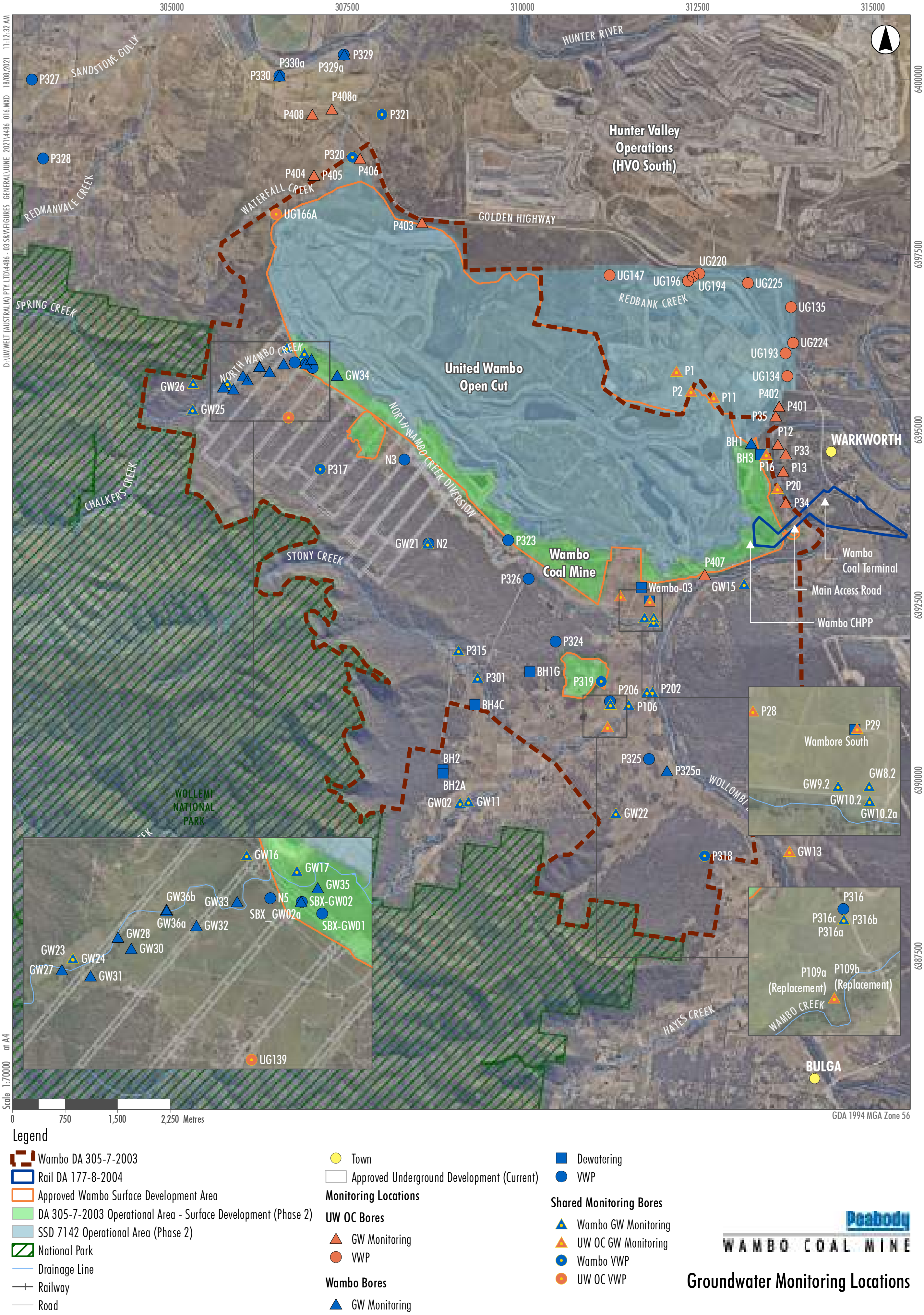
Table 6 2020 Installed Standpipe Monitoring Sites

Bore ID (Installation Report)	Wambo ID	Easting (m)	Northing (m)	Ground Elevation (mAHD)	Screen Interval (mbgl)	Target Geology	Data Collected
GW08.2	GW08.2	311869	6392326	N/A[1]	2 - 3	NWC Alluvium	manual
GW09.2	GW09.2	311743	6392326	N/A[1]	4.5 - 7.4	NWC Alluvium	manual
GW10.2a	GW10.2a	311872	6392264	N/A[1]	2 - 3	NWC Alluvium	manual
GW10.2a	GW10.2a				22 - 25	Permian	
P316a	P316a	311255	6391087	N/A[1]	4 - 7	NWC Alluvium	manual
P316b	P316b				10 - 13	Weathered Permian	
P316c	P316c				23 - 26	Permian	
SW30	P325a	312062	6390137	65.2	5 - 8	Wollombi Bk Alluvium	N/A
SBX-GW02	SBX-GW02	306905	6395946	108.92	10 - 20	Weathered Permian	Y (logger + manual)
In-Stream 4 (shallow)	GW36a	306247	6395906	113	4.9 - 7.9	NWC Alluvium	Y (logger + manual)
In-Stream 4 (deep)	GW36b	306248	6395901	113.05	13.6 - 16.4	Weathered Permian	Y (logger + manual)

[1]Top of casing elevation at these sites should be collected to enable conversion of depth-to-water measurement to mAHD groundwater levels for comparison with nearby sites.

Table 7 2020 Installed VWP Monitoring Sites

Bore ID (Installation Report)	Wambo ID	Easting (m)	Northing (m)	Ground Elevation (mAHD)	Sensor depth (mbgl)	Target Geology	Data Collected
SBX_20_GW01 VWP		307010	6395886	107.95	43	Whybrow Overburden	N/A
SBX_20_GW02 VWP		306910	6395943	108.88	65.8	Whybrow Seam	N/A
					61.7	Whybrow Overburden	
					53.7	Whybrow Overburden	



Groundwater Monitoring Locations

Image Source: Nearmap (June 2021), ESRI Basemap Data source: DFSI (2020), Peabody (2021)

4.1.1 Groundwater Monitoring Methodology

Groundwater monitoring considers the following document: *Murray-Darling Basin Groundwater Quality. Sampling Guidelines. Technical Report No 3 (Murray-Darling Basin Commission [MDBC, 1997]).*

In general, the groundwater monitoring methodology at the standpipe bores comprises:

- Measurement of groundwater levels;
- Grab sampling of groundwater using a bailer in accordance with WCPL instructions;
- Measurement of groundwater pH and EC in the field using a calibrated water quality meter;
- Groundwater samples are collected into appropriate laboratory supplied sample containers;
- All sample containers are clearly labelled with sample number, sample location, and sample date. The samples are stored in a chilled esky immediately following collection for shipment to the testing laboratory. A Chain-of-Custody (CoC) form is forwarded with the samples to the testing laboratory; and
- Decontamination of all non-bore dedicated sampling equipment between monitoring locations.

4.2 Groundwater Monitoring Compliance Criteria

The annual groundwater monitoring data review is undertaken with reference to specific compliance criteria (trigger levels - **Table 8**), and an assessment of the data against specific performance criteria set out in groundwater (**Table 9** and **Table 10**).

4.2.1 Groundwater Trigger Levels

Trigger levels are used to initiate investigations into shallow (primarily alluvium) groundwater levels or groundwater quality at WCPL when they stray beyond anticipated bounds. The trigger levels specified in the WCPL Groundwater Monitoring Program (Peabody 2020), are based on statistical analysis on pre-mining baseline monitoring data.

Trigger levels for groundwater level, EC and pH are presented in **Table 8**. The trigger for groundwater levels occurs when two consecutive bi-monthly observations exceed or fall below the maximum / minimum values specified. Triggers for EC occur when three consecutive bi-monthly observations (a 6-month period) exceed the specified trigger value. Triggers for pH occur when two consecutive bi-monthly observations (a 4-month period) exceed or fall below the specified values.

As per the GWMP, several the bores (presented in Table 12 of the GWMP) are no longer assessed against groundwater trigger levels, namely: P106, P114, P116, P202, P206, P301, GW02, GW11, GW12, and GW13. Detailed justification for this is provided in Table 12 of the GWMP (Peabody, 2020).

Trigger exceedances and analysis for the 2021 monitoring period are presented in **Section 5.4.**

Table 8 Groundwater Level and Groundwater Quality Trigger Levels (Peabody, 2020)

Bore	Monitoring Area	Lithology	Groundwater Level (mAHD)		Groundwater Quality		
			Maximum (10th %ile level)	Minimum (90th %ile level)	EC (µS/cm)	pH Min	pH Max
P301	Stony Creek	Alluvium	N/A	N/A	9200	6.1	7.2
P315[1]	Stony Creek	Shallow Permian	N/A	N/A	552	6.0	7.4
GW08.2[2]	NWC (downstream)	Alluvium	ND	ND	ND	ND	ND
GW09.2[2]	NWC (downstream)	Alluvium	ND	ND	ND	ND	ND
GW10.2[2]	NWC (downstream)	Alluvium	ND	ND	ND	ND	ND
P109	South Wambo Creek	Alluvium	57.8	55.7	695	6.5	7.6
GW15	Wollombi Brook	Shallow Permian	52.0	51.3	730	6.7	7.2
P16	Wollombi Brook	Alluvium	50.4	49.7	10832	7.0	7.7
P20	Wollombi Brook	Alluvium	50.3	49.2	10625	7.0	7.6

N/A = Not applicable
ND = Not defined, due to Insufficient data at present
[1]P315 was dry prior to NWU mining activity. Therefore, a specific depth to water trigger is not appropriate to indicate Wambo mining impacts. Data will be reviewed as part of the Annual Review to determine whether there are changes in groundwater level that can be attributed to Wambo mining activity.
[2]GW08.2, GW09.2 and GW10.2 have been installed as replacement bores to GW08 and GW09. Establishing trigger levels for these bores will be considered following the collection of baseline data and also informed by model predictions.

4.2.2 Groundwater Performance Criteria

Version 2 of the GWMP, published in November 2020 (Peabody, 2020) includes three sets of performance indicators relevant to groundwater (**Table 9** and **Table 10**), the first set are performance indicators relevant to general water management performance (GWMP – Table 14). The second and third sets are specific performance indicators to monitor the subsidence impact for North Wambo Underground (GWMP – Table 15) and South Bates Underground and Extension longwalls (GWMP – Table 16) respectively.

An assessment of compliance with performance indicators relevant to groundwater (**Table 9** and **Table 10**) is presented in **Section 5.5**.

Table 9 Performance Indicators

Feature	Performance Indicator
Groundwater Management Performance Indicators	
Alluvial aquifers (including Wollombi Brook alluvium and excluding the NWC alluvium)	The performance indicators will be considered to have been exceeded if impacts exceed those predicted in the documents listed in condition A2c) (of DA305-7-2003), including: A greater than negligible change in groundwater levels; A greater than negligible change in groundwater quality; and A greater than negligible impact to other groundwater users.
Groundwater dependent ecosystems	The performance indicators will be considered to have been exceeded if impacts exceed those predicted in the documents listed in condition A2c) (of DA305-7-2003), including: Greater than negligible environmental consequences, beyond those predicted in the documents listed in condition A2c); and Channel stability is not maintained or improved

Table 10 Subsidence Performance Indicators for Groundwater

North Wambo Underground Performance Indicators
- The performance indicators will be considered to have been exceeded if Wambo receive complaints from groundwater users. - The performance indicators will be considered to have been exceeded if monitoring data suggests significant divergences away from the modelled groundwater. - The performance indicators will be considered to have been exceeded if pumping of water from the North Wambo Underground Mine roadways requires regular pumping at rates higher than normal. - The performance indicators will be considered to have been exceeded if the groundwater levels in alluvial bores exceed the groundwater level criteria listed in Table 11 of the GWMP. - The performance indicators will be considered to have been exceeded if the groundwater quality in alluvial bores exceeds the groundwater quality criteria listed in Table 13 of the GWMP.
South Bates Underground and South Bates Extension Underground Performance Indicators
- The performance indicators will be considered to have been exceeded if the groundwater levels in alluvial bores exceed the groundwater level criteria in the GWMP (Table 11 of the GWMP). - The performance indicators will be considered to have been exceeded if the groundwater quality in alluvial bores exceeds the groundwater quality criteria in the GWMP (Table 13 of the GWMP). - The performance indicators will be considered to have been exceeded if the impacts observed on riparian, aquatic or groundwater dependent ecosystems are beyond negligible.

5 Monitoring Results

A summary of the groundwater level data for each of the main water bearing units is provided below together with a review of electrical conductivity (EC) and pH (see **Appendix B** for plots). Performance against trigger levels prescribed in the GWMP (Peabody, 2020), is presented in Section 5.4.

Data from monitoring bores at key sites has been reviewed to identify potential impacts from mining areas:

- North Wambo Underground (completed in 2016);
- Montrose Open Cut;
- South Bates Underground;
- South Bates Extension - LW19 and LW20 extracted in 2020.

5.1 Alluvium

5.1.1 Wambo Creek Alluvium

Wambo Creek is a north-east flowing tributary of Wollombi Brook located just to the south of the NWU workings and directly above the Wollemi and Homestead workings. The upper reach of the Wambo Creek alluvium is monitored at GW02 and GW11, and adjacent to the south-east end of the NWU mine footprint area at P106 and P109.

GW02 and GW11 on the upper reach of the Wambo Creek alluvium showed a sharp recovery of groundwater levels (approximately 4 m) due to above average rainfall in 2020, following a period of below average rainfall from 2017 to early 2020. During 2021, despite continued above average rainfall, groundwater levels have stabilised to some degree with near maximum levels seen at both locations. This suggests the current maximum levels at this bore may be somewhat controlled by outflow from the alluvium via creek flows following continued above average rainfall in 2021. Groundwater levels within the Wambo Creek alluvium have shown a strong correlation with rainfall trends since monitoring began in 2005, with no evidence of a WCPL mining impact. As these are active landholder bores with occasional groundwater extraction noticeable in the hydrographs it is suggested that logging of water extraction from these bores, or replacement with dedicated monitoring bores, is considered for ongoing monitoring.

P106 and P109 are situated on the downstream reach of the alluvium, within 250m of NWU longwall 10A, which commenced extraction in July 2015. They show similar behaviour to GW02 and GW11 during 2021 with levels continuing to increase at the start of the year before stabilising against a background of above average rainfall in 2021. As with the upstream monitoring, near maximum levels are seen in 2021 with outflow from the alluvium via streamflow being the likely control on these high groundwater levels.

An obstruction has been identified in P106, and a replacement bore is recommended. P109 is also due to be replaced as it is screened across both alluvial and Permian strata (Groundsearch, 1998). It is recommended that it is replaced with two bores: one in the alluvium, and the other in the in the underlying weathered Permian (Peabody, 2020), as a replacement for both P109 and P106.

Groundwater within the Wambo Creek alluvium is generally fresh (<1,000 µS/cm) with minor fluctuations observed in response to climatic trends.

5.1.2 North Wambo Creek Alluvium

5.1.2.1 Upstream monitoring

Upstream of the NWC diversion, there is limited historical groundwater level data within the alluvium. With dedicated alluvial bores were only installed from 2017 to mid-2019. This limits the assessment of long-term groundwater trends against climatic conditions or identify historical mining impacts although the available data starts prior to undermining by the South Bates Extension. Data loggers were installed in four bores (alluvium and Permian strata), upstream of the NWC diversion to assist in the assessment of groundwater levels.

Most of the monitoring bores installed in the upstream reaches of the NWC alluvium from 2017 to early 2020 were dry. This has been attributed to a lack of rainfall and flow in NWC associated with the NSW drought. Since the start of 2020, above average rainfall has resulted in several flow events in NWC with recharge to the alluvium occurring as a result of creek flow losses and direct infiltration. The hydrographs in the upstream NWC monitoring area of show a range of responses described below.

On the uppermost reach of the NWC alluvium (GW23, 24, 25, 26, 27) the hydrographs generally show a similar trend with a significant increase in water levels at the start of 2020 following the end of the three-year drought period with higher-than-average rainfall through 2020. Since the sharp rise at the start of 2020, levels then fluctuate by between 1-3m in response to rainfall events through to the end of 2021. Despite the continued higher than average rainfall through this period there is generally not an overall increasing trend and it’s likely that the highest groundwater levels recorded over this period reflect close to maximum levels at these locations, with creek discharge being a control.

In the central area of the upper NWC closer to the NWC diversion or Montrose Open Cut (GW28, 30,32, 33, 35, 36a, 36b and SBX-GW02), both the alluvial bores and the shallow Permian bores show large rises and falls of 4-7m in response to the high rainfall events seen through 2020-21. The very “flashy” saturation response to high rainfall events appears linked closely to flow and flow recession in NWC.

Continuous monitoring logger data from GW35 is displayed in comparison to NWC flow events, monthly rainfall, and shallow Permian groundwater level (**Figure 3**). Rapid increases in groundwater level (up to 6 m) are observed to correlate with periods of flow observed at the NWC FM1BU surface water monitoring site. Under average rainfall conditions ,and without a subsequent flow events, saturation in the alluvium declines to <0.5 m over a period of approximately 6 months. Similar trends are observed in underlying Permian strata (SBX_GW02 Standpipe), although peak groundwater levels are around 1 m lower and occur ~2-3 weeks after peak levels are observed in the alluvium. This is consistent with delayed infiltration into the lower conductivity weathered coal measures underlying the NWC alluvium.

Response to rainfall and flow events, and the relationship between alluvial and Permian strata provides useful baseline data to assess potential impacts caused by approaching South Bates Extension underground mining.

EC within the NWC Alluvium, upstream of the NWC Creek diversion is generally fresh with observations <1000 µS/cm.

Ongoing data collection will serve as a useful dataset prior to SBX undermining of NWC, with no obvious impacts from SBX mining currently apparent at NWC monitoring sites.

5.1.2.2 Downstream Monitoring

Newly installed monitoring bores GW08.2, GW09.2, GW10.2a monitor groundwater level in the alluvium downstream of the NWC diversion close to its confluence with Wollombi Brook and where the mapped alluvium is up to 1km wide. These sites were installed in 2019 as replacement bores to GW08 and GW09, which are historical concrete lined wells without construction/ geology information. Observations at GW08 in 2020 showed some minor response to rainfall in 2020 (0.5 m) but remained near-dry until further heavy rainfall at the end of 2020 into the start of 2021 when a 1.5m rise was recorded before monitoring of this bore ceased. GW09 has been dry since early 2017 and remained dry to February 2021 when monitoring ceased at both GW08 and GW09.

The replacement bores GW08.2 and GW09.2 need to be surveyed so the measured groundwater levels can be converted to mAHD although GW08.2. However, GW09.2 has shown approximately 2m recovery since December 2020 while GW08.2 remained dry for most of 2021 with water levels recorded in October and December only. Reduced catchment area for this section of the NWC alluvium has been caused by open cut operations, the impact of nearby underground mining operations, and the performance of the NWC Diversion and may all be contributing the lack of recovery observed within this section of the NWC alluvium.

The delayed response and lower levels of saturation seen in downstream monitoring bores may be related to the underlying weathered Permian strata recharging following the 2017-2020 drought, before recovery is seen in the overlying alluvium. The delayed response may also relate to the larger storage volume within the aquifer as the alluvial plain broadens downstream of the Wollemi NP escarpment, requiring larger volumes of water to cause the same increase in observed groundwater level.

Limited observations of EC within the downstream NWC alluvium ranged from 2000 µS/cm at GW09.2 to 4650 µS/cm at GW08.2.

5.1.3 Wollombi Brook Alluvium

Groundwater within the alluvium/unconsolidated material along Wollombi Brook is monitored at P12, P16, P13, P15, P20, GW15 and P325a.

Alluvial groundwater levels on the western bank of Wollombi Brook are monitored at P20, P16, and P15. Both sites are observed to respond to rainfall recharge events / flow in Wollombi Brook and correspond to the CRD. However, at P16 following the above average rainfall at the end of the 2017-19 drought period, groundwater levels remain approximately 1-1.5 m below pre drought levels and are currently tracking below the minimum groundwater level trigger value. P15, is located 150 m further downstream of P16 and has been sampled in December 2021, after the bore reported dry from December 2018 to February 2020 and was not monitored from April 2020 to October 2021. The observation similarly indicates groundwater levels remain 1-1.5 m below pre-drought levels despite above average rainfall conditions. Observations at these sites suggest some mining impact from the Glen Munro Pit in the alluvium west of Wollombi Brook.

At P20, which is a little further east of Glen Munro, levels have fully recovered with 2020-21 seeing levels at the high end of the range observed at this bore since 2004. A similar full recovery of groundwater levels in the alluvium through 2020-21 is seen on the east side of Wollombi Brook to the east of Glen Munro Pit at P12 and P13.

Further upstream (south) on the east side of Wollombi Brook at GW15, whist there has been a significant recovery in groundwater level since the start of 2020 it appears that levels have not fully recovered (by about 0.5m) to those seen prior to the 2017-19 drought during periods of similar higher than average rainfall. It is noted however that the last reading of 2021 may have preceded the high rainfall at the end of 2021 which could have resulted in further recovery in this bore. Given the location of this bore on the opposite bank of Wollombi Brook to WCPL mining operations, a WCPL mining impact is considered unlikely at this location. It is possible that the approaching Warkworth Open Cut may be responsible for some decline in groundwater levels at GW15.

P325a was installed in the alluvium in 2020 and is located 1.2 km south (upstream) of NWU longwalls and 175 m west of Wollombi Brook. Limited data is currently available for this bore, with only four water level measurements between late 2020 and early 2021 which show a ~1 m increase in response to much higher than average rainfall over this period.

East of Wollombi Brook, alluvial groundwater is fresh generally ranging between 500 to 1200 µS/cm (P12, P13 and GW15) with no strong correlation to CRD. On the western bank, monitoring bores (P16, P20 and P325a) yield brackish to saline groundwater (3,000 to 10,000 µS/cm) suggesting, some contribution of Permian groundwater to the alluvium. P16 and P20 have recorded a general long term decline in EC since monitoring began at the end of 2004 with EC falling from around 11,000 µS/cm to around 2,500 µS/cm at the end of 2021. It is possible that regional drawdown in the Permian induced by mining may have reduced the discharge of more saline Permian groundwater to the alluvium, increasing the proportion of fresher surface water from Wollombi Brook in the alluvium at these locations. From the start of 2020 to the end of 2021, groundwater at P16 and P20 has freshened significantly from around 7,000 µS/cm and 5,000 µS/cm respectively to around 2,500 µS/cm at both locations.

Groundwater pH in the Wollombi Brook alluvium is generally near neutral to slightly acidic (pH 6.5 to 7.5). Through 2021, pH generally fell within the typical ranges for each bore. At P12 pH appears to have declined from 7.15 to as low as 5.80 before increasing a little through 2021 to around 6.4.

5.1.4 Stony Creek Alluvium/ Colluvium

The steep gradient and narrow catchment at Stony Creek results in different groundwater responses in the unconsolidated deposits here compared to the lower gradient, broader alluvial plains of Wambo and North Wambo Creeks. Groundwater associated with the Stony Creek alluvium/ colluvium is monitored at P315 (alluvium), and P301 (alluvium and shallow Permian), located between 60 m and 70 m from Stony Creek and above NWU LW4 and LW6. GW12, located 300 m downstream to the east of the creek, was removed from the network due to the screen placement straddling both alluvial and Permian strata (Peabody, 2020).

There is a strong relationship between rainfall and groundwater levels at P315 and P301, with large fluctuations in groundwater levels during periods of above average rainfall. Groundwater level observations at both sites declined during the NSW drought by 3 m to 5 m, with P315 dry during 2018 and 2019. Above average rainfall conditions from the start of 2020 to the end of 2021 have seen groundwater levels in P301 recover sharply with a 10m increase at the start of 2020 and 2.5 m seasonal fluctuations to the end of 2021 with levels over the last 2 years reaching the upper end of the range recorded since 2004. P315 shows a very flashy response to high rainfall events rather that closely following the CRD although the effect of the drought from 2017-19 is clear. At the start of 2020 levels increase by 5.5 m followed by seasonal fluctuations of around 3m to the end of 2021. The seasonal highs and lows recorded between the start of 2020 and the end of 2021 are amongst the highest recorded since monitoring began in 2004.

EC at P301 decreased dramatically from around 9000 µS/cm during the first 3 years of monitoring to around 3000 µS/cm 2007 before trending up to 7000 µS/cm at the end of 2019 and then falling to 500 µS/cm during 2020. In 2021 EC spiked to 2000 µS/cm before falling back to 500 µS/cm in December. The step falls in EC align with conditions changing from lower than average rainfall to higher than average rainfall in 2007 and 2020. At P315 EC has been more consistent (ignoring one anomalous reading in 2018), and much lower at around 250-500 µS/cm since 2004. During 2021 EC spiked to around 1,300 µS/cm before falling to around 550 µS/cm in December.

Groundwater samples recorded pH that were slightly acidic in both P315 and P301 during 2021. The pH of the groundwater in P315 fluctuated a little at the low end of the historic range just above 6. During 2021 pH recorded at P301 fluctuated between 6.0 and 6.5.

5.2 Regolith – Shallow Weathered Sandstone

5.2.1 Wambo Creek

Groundwater associated with the weathered sandstone underlying the Wambo Creek alluvium has been monitored at P114, P116, and P109 since 1998. Monitoring in bores P114 and P116 ceased at the start of 2021 and P316a was installed in 2020 in the weathered sandstone to replace P114. Groundwater levels versus cumulative rainfall deficit are presented in **Appendix B**. Several of the bores referred to in this section were previously considered to be screened in alluvium due to their depth and location. A review of construction logs identified that the bores had been installed across both Permian and alluvial strata, meaning that it is not appropriate to consider the bores as representative of alluvium. Work is underway to decommission sites screened across multiple aquifers, consistent with the *Minimum Construction Requirements for Water Bores in Australia* (NUDLC, 2020), and replace them with sites only screened in one aquifer.

Sites within shallow Permian strata overlying and adjacent to WCPL and historical longwall mining activity show drawdown associated with mining. Mining related drawdown and an ongoing impact is observed at P114 which is located over NWU longwall 10A, which commenced extraction in July 2015. Groundwater levels at P116 located 100m from NWU longwall 10A show quite a different character to P114 with lower correlation to the CRD and a more subdued and delayed impact from mining activity. P109 located 210 m from longwall 10A shows limited mining impacts and much more closely follows the CRD with levels in 2021 at the top of the range observed since 2004. Any impacts from mining activities at P109 are likely to be subdued by the effect of surface water leakage from Wambo Creek.

EC at P109 has remained relatively stable and fresh over the monitoring record, likely dur to the leakage / recharge from Wambo Creek with EC levels in 2021 varying between ~600-750 µS/cm. EC at P114 and P116 away from the influence of Wambo Creek has generally shown an increasing trend over time with EC at P114 increasing to 8-10,000 µS/cm since 2011 after a long period of stable EC around 500-1000 µS/cm from 2004-2011, and EC at P116 trending up from 500 µS/cm in late 2007 to 4500 µS/cm in early 2021 (following a substantial sharp fall from a high variable range of 3000-6500 µS/cm). The increasing salinity in these bores is considered likely to be controlled by low groundwater levels in each bore intercepting saline Permian groundwater below the base of the Wambo Creek Alluvium. This relationship between groundwater levels and salinity is consistent with assessments regarding the mechanisms of saline water observed at the mine conducted by HydroSimulations (2016, 2017b, 2019) and SLR (2020b).

pH in groundwater sampled from these bores remains relatively stable with levels staying at similar levels during 2020 as to those in 2019, fluctuating around a neutral pH (7.0).

5.2.2 North Wambo Creek

Groundwater in the shallow overburden near NWC is monitored upstream of the NWC diversion at GW23, GW25, GW36a, GW16, GW17 and SBX-GW02. Downstream of the NWC Diversion this unit will be monitored at GW10.2 which was recently installed.

Despite relatively shallow construction depths (<20 m), nearby mining at SBX and Montrose Open, and the NSW drought from 2017-2020, the sites upstream of the NWC diversion maintained some level of saturation and provide useful baseline data prior to SBX undermining in the future. Groundwater levels at GW16 and GW17 match the rainfall trends, as they also appear to for the much shorter monitoring records at GW23, GW25 with a “flashy” increase and recession in the very limited record for GW36a starting in late 2021.

EC is variable across these monitoring sites (from <1000 µS/cm to 5500 µS/cm) but generally showed a sharp reduction at the start of 2021 in response to the high rainfall following the 2017-19 drought with all locations recording <1000 µS/cm in 2021 with the exception of P16 which has only showed a reduction from 5500 µS/cm to 4250 µS/cm from the start of 2020 to the end of 2021. The freshening of groundwater since the start of 2020 indicates the influx of fresher water from overlying unconsolidated strata during this period of higher than average rainfall. Observations at the paired site GW36a and GW36b show this downward vertical hydraulic gradient from the alluvium to the shallow Permian.

pH in groundwater samples collected from these bores is generally near-neutral (6.5-7.5) with no departure from normal trends in 2021. At GW36s a slightly basic pH was observed in 2021 (~7.8-8.4), following neutral pH in late 2020 when monitoring started.

Downstream of the NWC diversion, GW10.2 is constructed to a depth of 25 m and has been dry since observations started in November 2020.

5.2.3 Wollombi Brook

Groundwater level and quality associated with shallow weathered strata present below the Wollombi Brook alluvial/unconsolidated material is monitored at GW13. GW13 is located 380 m west of Wollombi Brook, around 2.8 km east of the Warkworth Open Cut and ~1.2 km of WCPL mining activity.

At GW13, groundwater level trends are somewhat like those observed at GW15 in the shallower strata, although the magnitude of groundwater level change in response to climate or streamflow is less. Groundwater levels show a general declining trend of ~1m from the start of monitoring in 2010 to mid-2017 against a rising CRD. At the start of the 2017-2020 drought the declining groundwater level trend steepens in line with the rainfall deficit through to the start of 2020. The significant rainfall excess through 2020-21 only results in a ~0.75m increase compared to the 2.75m decline to the start of 2020. Groundwater levels at this location could be influenced by the advancing Warkworth Open Cut.

EC at GW13 has slowly declined from ~4,500 µS/cm in 2010 to 2,000-2,400 µS/cm in 2021. This long-term decline may relate to a reduced component of more saline Permian groundwater associated with regional depressurisation and downward migration of fresher water.

pH in groundwater samples collected from GW13 remains stable with pH recorded through 2021 just below 7.0, in line with the historic record.

5.3 Permian Coal Measures

Monitoring locations within the Permian coal measures (both over/ interburden and coal seams) provide information on the timing, magnitude, and extent of mining impacts. Discussion of these monitoring sites is based on creek catchment area, with specific reference to WCPL mine areas that may be influencing groundwater observations at these sites.

5.3.1 Wambo Creek Catchment

In the Wambo Creek catchment the Permian Coal Measures is monitored at P202, P206 and P316c. There are also some recently installed VWPs in this area that will be included in future analysis once data quality has been assessed.

Bores P202 and P206 are located directly south-east of the North Wambo UG, and immediately east of the Homestead-Wollemi UG close to the confluence of Wambo Creek and Wollombi Brook. The shallow Permian (P202) and Permian (P206) show some evidence of a WCPL mining impact in recent years. P206 was previously impacted by historical Homestead-Wollemi underground mining, with current observations ~15 m lower than those in the late 1990's. From 2015 to early 2020, groundwater level declined at P206 by about ~10 m and did not respond to above average rainfall in 2015/16, indicating a NWU mining impact and later, the effect of below average rainfall from 2017-2020. Since the start of 2020 and significantly higher than average rainfall conditions groundwater levels have been somewhat erratic with a ~12.5 m rise through 2020 before a ~7.5 m fall at the end of 2020 and a net fall of 2.5 m through 2021. P202 in the shallow Permian appears to follow the CRD more closely over the historic record, probably under greater influence from the overlying alluvium. Groundwater levels responded sharply at the start of 2020 to the high rainfall at the end of the 2017-20 drought, but since then have fluctuated by ~0.75 m rather than increase in response to the much higher than average rainfall over this period.

No data is currently available for P316c.

EC through 2021 broadly follows historical ranges. At P206 pH has been slowly trending up since 2016 and in early 2021 was recorded at around 8.2, just above the upper trigger level, before falling back below this trigger in the second half of 2021. At P202, pH was within the historic range through 2021.

5.3.2 North Wambo Creek Catchment

In the NWC catchment, groundwater associated with Permian Coal Measures, overlying NWU, SBU and SBX and adjacent to Montrose Open Cut is monitored at N2, N3 and N5 VWPs.

Data at the VWPs has been recorded since July 2015. N3 overlies the gate road to the north side of SBU Whybrow LW11, while N2 lies south-east of SBU Whybrow LW14 and is separated from SBU workings by a fault. N5 is located 2 km north of current mining in the South Bates Extension Underground Mine (SBX).

N5 has four vibrating wire piezometer sensors installed at depths of 30 m (N5-4: Permian Overburden), 73 m (N5-3: Whybrow Seam), 89.5 m (N5-2: Whybrow–Wambo Seam Interburden) and 133 m (N5-1: Wambo Seam) that have been recording since July 2015.

The shallowest Permian sensor (N5-4) has recorded generally consistent groundwater levels that show a good correlation with the CRD until early 2019 (**Figure 4**). Following this time groundwater level has shown a gradual decline. In 2021 there has been a delayed response to the above average rainfall since early 2020 with a ~3.5 increase seen during 2021. It is likely that this sensor is showing some impact from the approaching SBX mining. The middle two sensors (N5-3 and N5-2) similarly show gradual impacts from SBX mining, but have also responded strongly to recent higher than average rainfall with ~9 m increases since late 2020. The lowest sensor, N5-1, declined by ~20 m from 2015 to the end of 2019, likely associated with SBU mining in the Wambo Seam or SBX mining, although it has recovered by ~20m to late 2015 levels since the end of 2019 coincident with the much higher than average rainfall over this period. This rise may also partly result from recovery in the Wambo Seam following the completion of SBU mining.

VWP N2 (**Figure 6**) is located between NWU and SBU (**Figure 2**), at an elevation of 122.5 mAHD. It is a multi-piezometer grouted array with six VWPs installed at depths of 40 m (N2-6: Permian overburden), 70 m (N2-5: Permian overburden), 100 m (N2-4: Permian overburden) and 140 m (N2-3: Whybrow Seam), 173 m (N2-2: Whybrow to Wambo Seam interburden), and 204 m (N2-1: Wambo Seam). These WVPs commenced recording in July 2015.

The upper two sensors N2-6, N2-5 appear to show groundwater levels at or near the sensor elevation (essentially, they appear to be “dry”). N2-4 reported groundwater levels near the sensor elevation from late 2017 to early 2020 but showed some response to above average rainfall in early 2020 although since this time, pressures have slowly declined despite high rainfall in late 2020 /early 2021 and in late 2021. Sensors N2-3 (Whybrow Seam) and N2-2 (Whybrow-Wambo Interburden) have both shown a gradual decline in groundwater levels since recording began in 2015 to the end of 2020 (~10 m and ~15 m respectively). These declines do not show an obvious response to individual SBU longwall extraction and may be somewhat protected by the fault between NWU and SBU. An upward hydraulic gradient from the Whybrow-Wambo seam interburden to the Whybrow seam is evident in the N2-2 and N2-3 data. No clear evidence of a mining impact is present in the Wambo Seam sensor (N2-1), however, the large fluctuations in the pressure data (5-15 m), and more erratic data in 2021 suggest the sensor is unreliable.

VWP N3, located above the northern edge of SBU LW11, has a ground elevation of 104.9 mAHD. It is a multi-piezometer grouted array with six sensors installed at depths of 30 m (N3-6: Permian overburden), 55 m (N3-5: Permian overburden), 75 m (N3-4: Permian overburden), 109 m (N3-3: Whybrow Seam), 142 m (N3-2: Whybrow to Wambo Seam interburden) and 190 m (N3-1: Wambo Seam). Recording commenced in July 2015. Sensors at N3 are no longer recording accurate groundwater level data (generally since May 2016) (**Figure 5**).

5.3.3 Wollombi Brook Catchment

In the Wollombi Brook Catchment, groundwater associated with Permian Coal measures is currently monitored up hydraulic gradient of NWU longwalls at GW22. There are also some recently installed VWPs in this area that will be included in future analysis once data quality has been reviewed. Permian monitoring in this area will provide baseline data for the approved South Wambo Project.

At GW22, up hydraulic gradient of NWU mining operations, groundwater levels associated with the Whybrow Seam interburden show a good correlation to the CRD. During the NSW drought, water levels declined by just over 1 m before recovering slightly in 2020 and then fully in 2021 to pre drought levels. This response suggests vertical connectivity between the Wollombi Brook alluvium/unconsolidated aquifer and the underlying Permian aquifer.

EC in this bore has fluctuated over the monitoring record but shows an overall increasing trend from ~6,400 µS/cm in 2010 to 7,100 µS/cm at the end of 2021 with occasional spike values outside of this range. pH is stable, though slightly basic at ~8.4.

5.4 Trigger Level Exceedances

Triggers for EC occur when three consecutive bi-monthly observations (a 6-month period) exceed the specified trigger level. Triggers for pH occur when two consecutive bi-monthly observations (a 4-month period) exceed or fall below the specified trigger level (Peabody, 2020). The trigger level exceedances for groundwater level and groundwater quality in 2021 are shown in **Table 11**.

Table 11 2021 Trigger Level Exceedances

Bore (Aquifer#)	Trigger Exceedances				
	Min Depth to Water 2 Consecutive (10th percentile) *	Max Depth to Water 2 Consecutive (90th percentile) **	EC 3 Consecutive	pH min 2 Consecutive	pH max 2 Consecutive
P109 (WCA, SP)	No (2 separate exceedances)	No	No (3 separate exceedances)	No	No
GW02 (WCA)	N/A	N/A	No	No (2 separate exceedances	No
P315 (SCA)	N/A	N/A	Yes (4, Jun to Dec)	No	No
P301 (SP)	N/A	N/A	No	No (1 exceedance)	No
GW15 (WBA)	No	Yes (Feb, Apr)	No (1 exceedance)	No	No
P16 (WBA)	No	Yes (5 of 6 readings)	No	No	No
P20 (WBA)	No (1 exceedance)	No	No	No	No
GW08.2 (NWCA)	ND				
GW09.2 (NWCA)	ND				
GW10.2 (NWCA)	ND				

Aquifer: WCA = Wambo Ck alluvium; SCA = Stony Ck alluvium; WBA = Wollombi Brook alluvium; NWCA = North Wambo Ck alluvium; SP = shallow Permian;

ND = Not Defined – currently there is insufficient baseline data to develop appropriate trigger levels

*Minimum depth-to-water is equivalent to maximum groundwater level (mAHD)

**Maximum depth-to-water is equivalent to minimum groundwater level (mAHD)

Over 2021, groundwater levels in bores GW15 and P16 exceeded the trigger level for the 90th percentile (maximum) depth to water. Bore P315 exceeded the EC trigger during 2021. There were no breaches of the trigger levels for pH during 2021.

5.4.1 P315 – Stony Creek Alluvium - EC

EC increased above the trigger level of 552 µS/cm in June and reached a maximum of 1275 µS/cm in October before falling back to 568 µS/cm in December. This breach of the EC trigger level was the subject of an investigation by SLR (SLR, 2022). The investigation concluded that the high rainfall in March 2021 may have resulted in sufficient recharge to the shallow groundwater system to enable the “flushing” of shallow groundwater through fractures in bedrock or dilated bedding planes within the Newcastle Coal Measures resulting from NWU undermining. Based on this conclusion, and the data gaps and limitations identified, if the EC breach continues the following recommendations are made to inform the nature and extent of the water quality change in the Stony Creek alluvium:

- Continued monitoring of shallow groundwater sites adjacent to Stony Creek, including periodic monitoring of Fenwick Well 4 downstream. This could be incorporated into the current bi-monthly monitoring program.
- Routine monitoring at a location upstream of NWU LW1 where water quality is currently fresh.
- Survey/ measure height of stickup at all viable Stony Creek monitoring sites.
- Installation of water level and quality loggers within a monitoring bore near the Stony Creek channel (P316, P319), and one within Stony Creek itself to improve the understanding of surface water-groundwater interactions.
- Further review of the following:
    - Historical surface water, groundwater, and subsidence reporting (Wollemi-Homestead reports by Coffey, NWU End of Panel reports).
    - Observed water quality changes following subsidence specific to the Hunter Coalfield (if available).
    - Any literature on water quality changes following flood/ erosive events not related to subsidence.

5.4.2 GW15 – Wollombi Brook Alluvium - Minimum Groundwater Level

GW15 is located 275 m east of the channel of Wollombi Brook and 1.5 km west of the advancing Warkworth Open Cut. Since early 2018 through to mid-2021, groundwater levels at bore GW15 have been below the 90th percentile trigger level. From mid-2021, with the ongoing higher than average rainfall, the groundwater level has recovered above the low level trigger. However, full recovery to levels seen prior to the 2017-20 drought has not occurred although it is possible that the last reading in 2021 just preceded the high rainfall at the end of 2021 which would have generated further recovery at this location. The following is noted / recommended with regard to the minimum groundwater level breach at GW15:

- The trigger levels were defined in a period of prolonged higher than average rainfall and as such the low-level trigger is may be set too high and could be reviewed. The “normal” response to a long period of below average rainfall (as occurred from 2017 to late 2019) had not been observed at this location when the trigger levels were set.
- The last reading of 2021 may have occurred before the high rainfall at the end of 2021. As such, further recovery may be seen in GW15 in to 2022.
- It is possible that the approaching Warkworth Open Cut may be responsible for some decline in groundwater levels at GW15 although, given its distance from the bore and the changes in geology, impacts from this development would be expected to be limited.
- Groundwater levels have recovered significantly in 2021. The groundwater level response at GW15 may be normal for this location following a period of drought, rather than due to a mining related impact from Wambo or Warkworth operations.

5.4.3 P16 – Wollombi Brook Alluvium - Minimum Groundwater Level

Bore P16 is located approximately 4.5 km from LW11, adjacent to Wollombi Brook and downstream (north) of underground mining at WCPL (**Figure 2**), and less than 200 m east of the South Wambo Boxcut, now known as Glen Munro Pit, which was completed in July 2017. Bore P16 was constructed as part of an assessment to identify whether the alluvial aquifer associated with Wollombi Brook extended west of the channel, and over the United Underground longwalls (GeoTerra, 2003). The study found that colluvial and silty alluvial material ranging in thickness from 1.9 m to 11.5 m existed at sites to the west of Wollombi Brook in this area, but that this material is not part of the Wollombi Brook Alluvial Aquifer. The colluvial and silty alluvial material in P16 is 11 m thick.

The CRD from 2015 to 2020 indicates decreased recharge, with the lowest groundwater level on record at P16 occurring in late 2019 (approximately 1.4 m below the minimum observation recorded from 2005 to 2015). While some of the decline in groundwater level at P16 could be attributed to the low rainfall conditions as part of the 2017 to early 2020 NSW drought, excavation at Glen Munro Pit appears to have caused additional drawdown in the order of 1.2 m. Groundwater levels increased at the start of 2020 and by a total of ~1.5m through 2020 but despite continued high rainfall through 2021 a recovery to the levels seen prior to the 2017-20 drought has not occurred. However, at P12 and P13 to the east of Wollombi Brook a full recovery has been observed in 2021. This lack of recovery in P16 indicating an ongoing mining impact in the alluvium at this location.

The amount of drawdown in P16 is consistent with the groundwater assessment for the South Wambo Boxcut by HydroSimulations (2016) which predicted a small amount of additional drawdown in Permian strata at P16 due to the excavation of the boxcut, on top of broader regional depressurisation from mining activity including NWU, United Underground and the United Wambo Joint Venture.

The representation of unconsolidated strata and the potential controls on shallow groundwater levels across the Wambo Complex will be reviewed as part of the numerical modelling work being undertaken for the Modification 19 Groundwater Assessment in 2022. The results from the updated model may help revise trigger levels at P16 to reflect the influence of both approved impacts and climatic conditions.

5.5 Compliance with Groundwater Performance Criteria

The 2021 groundwater monitoring has been evaluated against the performance criteria, defined within the Version 2 GWMP (Peabody, 2020). **Table 12**.

Table 12 Performance Indicators

Feature	Performance Indicator	2021 Performance Indicator Observations	Overall Compliance
Groundwater Management Performance Indicators			
Alluvial aquifers (including Wollombi Brook alluvium and excluding the NWC alluvium)	The performance indicators will be considered to have been exceeded if impacts exceed those predicted in the documents listed in condition A2c) (of DA305-7-2003), including: A greater than negligible change in groundwater levels;	There is continued exceedance of the low groundwater level trigger at P16 in the Wollombi Brook alluvium/ colluvium. However, the drawdown in P16 is consistent with predicted impacts for the South Wambo Boxcut (HydroSimulations, 2016b) and is not considered an exceedance of performance indicator. There has been a long-term exceedance of the low groundwater level trigger at GW15 with only partial recovery in 2021 suggesting ongoing impacts due to WCPL mining or possibly the approaching Warkworth Open Cut. However it is also likely that the low level trigger is inappropriate and requires revision. Further investigation is recommended prior to a determination of compliance with the Performance Indicator. See **Section 5.4.1** for more details on these trigger level breaches, and the recommendations set out in **Section 10**.	**Compliant** **(subject to further investigations)**
	A greater than negligible change in groundwater quality	EC trigger exceedances were observed at P315 in 2021 (up to 1,275 µS/cm vs a trigger level of 552 µS/cm) and investigated with several recommendations being made for further investigations. The last reading at the end of 2021 was just above the trigger level. See **Section 5.4.1** for more details on this trigger level breach and the recommendations set out in **Section 10**.	**Not Compliant (investigation ongoing)**
	A greater than negligible impact to other groundwater users.	Previous groundwater assessments for Wambo Coal predicted that some privately-owned bores may experience more than 2 m cumulative drawdown as a result of the approved operations (HydroSimulations, 2017a, 2019b and SLR, 2020). No complaints have been made to Wambo Coal during the 2021 AR period in respect to groundwater or water (WCPL, 2022).	**Compliant**

Feature	Performance Indicator	2021 Performance Indicator Observations	Overall Compliance
Groundwater dependent ecosystems	The performance indicators will be considered to have been exceeded if impacts exceed those predicted in the documents listed in condition A2c) (of DA305-7-2003), including: Greater than negligible environmental consequences, beyond those predicted in the documents listed in condition A2c)	GW36a and GW36b were drilled in 2020 to monitor impacts at the River Oak GDE. To date, limited data has been gathered. However, observed depths to groundwater are <3 mbgl and therefore accessible by the River Oak GDE, and groundwater is fresh (EC is in the range 300-550 µS/cm); and pH of 6.25-8.4. Continued monitoring will allow trends / ranges to be established for these bores and determine whether SBX mining is impacting groundwater close to this GDE.	**Compliant**

Table 13, and **Table 14** below provide an assessment of compliance with the performance criteria defined for general water management performance, and subsidence impacts for North Wambo Underground and South Bates Underground and Extension longwalls.

Table 13 North Wambo Underground Performance Indicators

North Wambo Underground Performance Indicators		Overall Compliance
The performance indicators will be considered to have been exceeded if Wambo receive complaints from groundwater users.	Previous groundwater assessments for Wambo Coal predict that some privately-owned bores may experience more than 2 m cumulative drawdown as a result of the approved operations. These drawdowns are due to the cumulative effects of all mining in the Wambo district. No additional impacts are predicted to third-party groundwater users from the underground mining operations (HydroSimulations, 2017a, 2019b and SLR, 2020). No complaints on the Wambo Coal Community Complaints Register 2021 (Wambo Coal, 2022) with respect to groundwater or water.	**Compliant**

North Wambo Underground Performance Indicators		Overall Compliance
The performance indicators will be considered to have been exceeded if monitoring data suggests significant divergence from modelling predictions.	GW09 within the NWC alluvium, close to historical underground mine areas exhibits greater drawdown than predicted in the latest groundwater modelling (SLR, 2020a) indicating a possible exceedance of the performance indicator. However, GW09 has been investigated previously for potential impacts in the NWC alluvium and potential licencing implications (HydroSimulations, 2015b and SLR 2020b, 2020c). The 2019 trigger investigation (SLR, 2020c) identified that the HydroSimulations (2019b) modelling captures the timing of drawdown and desaturation of the alluvium at GW09 (**Figure 18**). The groundwater modelling for the approved South Bates Extension Modification (HydroSimulations, 2017a) similarly replicates the timing of drawdown at GW09. Rather than an exceedance of the performance indicator, this indicates that a review of the SLR (2020a) model assumptions near GW09 should be undertaken. This will be done as part of the numerical modelling work being undertaken for the Modification 19 Groundwater Assessment in 2022, which will review of the representation of unconsolidated strata and the potential controls on shallow groundwater levels across the Wambo Complex. Data from replacement bores GW08.2 and GW09.2 will be reviewed against model predictions once valid data is being collected Note that calibration quality at nearby GW08 and at other NWC monitoring locations has remained consistent between the model versions. See recommendations set out in **Section 10**.	**Compliant** **(further reviewed in MOD19 numerical modelling - See recommendations set out in Section 10.)**
The performance indicators will be considered to have been exceeded if pumping of water from the North Wambo Underground Mine roadways requires regular pumping at rates higher than normal.	No longer applicable – Mining of NWU longwalls was completed in December 2015. Since then, the workings have been sealed and there has been no ongoing pumping.	**Compliant**
The performance indicators will be considered to have been exceeded if the groundwater levels in alluvial bores exceed the groundwater level criteria listed in Table 11 of the GWMP.	There is continued exceedance of the low groundwater level trigger at P16 in the Wollombi Brook alluvium/ colluvium. However, the drawdown in P16 is consistent with predicted impacts for the South Wambo Boxcut (HydroSimulations, 2016b) and is not considered an exceedance of performance indicator. There has been a long-term exceedance of the low groundwater level trigger at GW15 with only partial recovery in 2021 suggesting ongoing impacts due to WCPL mining or possibly the approaching Warkworth Open Cut. However it is also likely that the low level trigger is inappropriate and requires revision. Further investigation is recommended prior to a determination of compliance with the Performance Indicator. See **Section 5.4.1** for more details on these trigger level breaches and the recommendations set out in **Section 10**.	**Compliant** **(subject to further investigations)**
The performance indicators will be considered to have been exceeded if the groundwater quality in alluvial bores exceeds the groundwater quality criteria listed in Table 13 of the GWMP.	EC trigger exceedances were observed at P315 in 2021. See **Section 5.4.1** for more details on this trigger level breach and the recommendations set out in **Section 10**.	**Not Compliant (see Table 12)**

Table 14 South Bates Underground and South Bates Extension Underground Performance Indicators

South Bates Underground and South Bates Extension Underground Performance Indicators		
The performance indicators will be considered to have been exceeded if groundwater levels in alluvial bores exceed the groundwater level criteria in the GWMP (Table 11 of the GWMP).	There are exceedances of the low groundwater level trigger at P16 and GW15 in the Wollombi Brook alluvium/ colluvium. As both these sites are >4 km from South Bates Underground and South Bates Extension mining, these sites are not considered relevant to this performance indicator, and are captured in the Groundwater Management Performance Indicators (**Table 12**). No sites near South Bates operations are exceeding groundwater level performance indicators in 2021.	**Compliant**
The performance indicators will be considered to have been exceeded if the groundwater quality in alluvial bores exceeds the groundwater quality criteria in the GWMP (Table 13 of the GWMP).	EC trigger exceedances were observed at P315 in 2021 Although South Bates Underground longwalls are within the Stony Creek catchment, initial investigation indicates the trigger exceedance is likely related to historical NWU operations. This trigger exceedance is therefore captured in **Table 13** No sites near South Bates operations are exceeding groundwater quality performance indicators in 2021.	**Compliant**
The performance indicators will be considered to have been exceeded if the impacts observed on riparian, aquatic or groundwater dependent ecosystems are beyond negligible.	GW36a and GW36b were drilled in 2020 to monitor impacts at the River Oak GDE. To date, limited data has been gathered. However, observed depths to groundwater are <3 mbgl and therefore accessible by the River Oak GDE, and groundwater is fresh (EC is in the range 300-550 µS/cm); and pH of 6.25-8.4. Continued monitoring will allow trends / ranges to be established for these bores and determine whether SBX mining is impacting groundwater close to this GDE.	**Compliant**

5.6 Vibrating Wire Piezometer Data Review

In late 2020, SLR undertook work to rationalise the data collected at WCPL VWP locations, including a number that have been installed recently following exploratory drilling across site. The table included in **Appendix C** provides details on each of the VWP locations, and also provides a preliminary assessment of data quality collected at each of the sites. Key findings from the data quality assessment include:

- Unreliable data at VWP sites where sensors are within shallow overburden, Whybrow or Wambo seams. Sensors are dry or near-dry, likely associated with WCPL or regional mining activity. It is worth continuing to download these while at least one of the sensors is collecting reliable data, and where recovery / re-saturation is possible.
- As recommended in 2020, older sites and unlabelled sites (MG06, MG08, MG09, GW20, U/Fenwick) which are no longer collecting reliable data should be removed from monitoring network.

Discussion and assessment of VWP data has not been undertaken or presented in this report but will be included in future reporting where the data quality is found to be good. A summary of groundwater level observations from site VWPs are provided below:

- Most shallow VWP sensors (~10 m depth) are dry indicating greater depths to water table.
- Depressurisation associated with Wambo mining activity is observed within the Wambo and Whybrow seams and adjacent Permian Coal Measures in sites close to historical and current mining activity. This observed depressurisation is broadly consistent with current model predictions (SLR, 2020a) and will be assessed against predictions from the revised modelling.
- Deeper sensors, installed to monitor impacts of the Approved South Wambo Project, maintain significant pressure head in the absence of South Wambo Project mining activity.

6 Verification of Model Predictions

In February 2020, SLR undertook groundwater modelling as part of the Groundwater Assessment in Support of the South Bates Extension LW21-24 Extraction Plan. Detailed hydrographs of the modelled groundwater levels versus observed groundwater levels at key sites are presented in **Figure 7** to **Figure 18** located in **Appendix A**.

The model predictions used in this report are from HydroSimulations (2017a and 2019b) which has been used as part of the South Bates Extension LW21-24 Extraction Management Plan (SLR, 2020). Key updates to this groundwater model since the HydroSimulations (2017a) include:

- Refined alluvial thickness and extent at NWC;
- Revision of topography within the model using site LiDAR data for the NWC area;
- Quadtree refinement within the NWC alluvial zone to improve representation of alluvial and channel topography; and
- A revision to the stress period timing within the model to include more temporal detail and better capture seasonal trends:
    - Transient historical period from January 2003 to December 2019 with monthly stress periods;
    - Transient predictive period from January 2020 to December 2029 with monthly stress periods; and
    - Transient predictive period from December 2029 to December 2040, with quarterly stress periods.

The following sections contain an assessment of the SLR (2020) modelled groundwater levels compared to observed mining impacts.

A key consideration for assessing modelled and observed groundwater levels during 2021 is that the transient historical period for the SLR (2020) groundwater modelling ended in December 2019, prior to the above average rainfall experienced in the region since March 2020. As this wet period is not included in the SLR (2020) model, a response in predicted groundwater levels is not expected.

6.1 Montrose Open Cut

The elevation of modelled heads at GW16 (**Figure 7**) and GW17 (**Figure 8**) are reasonably close to the overall observed groundwater levels at these locations. However, the variability in the observed data is not replicated by the model. The predicted impacts at GW16 and GW17 are also conservative, with the predicted mine impact being greater than observed. Both locations have observed groundwater level recovery in response to 2020-21 rainfall and have not continued to decline as predicted. This overestimation of groundwater level decline is likely to be a function of simplified model layer discretisation at these locations not fully capturing local scale geology such as a weathered Permian layer.

The groundwater model is currently being revised for the Modification 19 Groundwater Assessment (SLR, in prep). Revision of alluvial aquifer properties, infiltration rates and layer discretisation across the Wambo Complex is being undertaken as part of groundwater model revision for this groundwater assessment and will aim to improving improve calibration quality at GW16 and GW17 and other bores at North Wambo Creek.

Modelled heads at VWP N5 compared to observations (**Figure 9**) are poor. Modelled heads are much higher than observed to the end of 2020, before large drawdown is predicted in all sensors in 2021. Observed groundwater level remain stable or recover in response to above average rainfall conditions through 2020-21. The timing and magnitude of the observed drawdown due to the open cut is accurate, as is the timing of drawdown due to longwall 21 extraction, but the vertical hydraulic head gradients are not accurately reproduced by the model. As reported in the previous AEMR reports (HydroSimulations, 2019a and SLR, 2020b), the model requires lower vertical hydraulic conductivities in this area, which if implemented may result in lower predicted impacts in the alluvium from underground mining.

The groundwater model currently being revised for the Longwalls 24-26 Modification Groundwater Assessment (SLR, in prep) will focus on improving calibration to observed data near South Bates Underground mining. This will include review the hydraulic properties and layer discretisation adjacent to Montrose Open Cut mining to better reproduce observed hydraulic gradients and the observed magnitude of mining impacts.

6.2 North Wambo Underground

Modelled heads at six bores in **Figure 11** to **Figure 15** (P114, P116, GW08, GW09, P106 and P109) where historical North Wambo Underground (NWU) mining activity was predicted to impact groundwater levels, have been compared to observed data.

Previous reporting for P114 (HydroSimulations, 2016) had underestimated the drawdown associated with NWU LW10a extraction. However, the currently presented modelled heads for P114 (**Figure 10**) are a weighted average from layer 1 and layer 2 heads according to the degree of partial penetration of the bore through both alluvial and Permian strata. The resulting calibration is a good representation of the observed magnitude and timing of the NWU mining effect. Re-saturation was observed in P114 to levels consistent with predictions in 2020 after being dry throughout 2019. Monitoring was ceased at P114 after February 2021, with bores P316a and P316b, to serve as a replacement sites into the future. These sites respectively target Wambo Creek alluvium and underlying Permian strata.

Modelled heads for P116 (**Figure 11**) generally compare well with observations. However, the predicted magnitude of the gradual decline is less than the gradient of observed data. The same magnitude of climatic variation is also not as apparent in the modelled heads as it is in the observed heads. The lack of variation in the modelled data may be occurring for the flowing reasons:

- As in previous assessments, the SLR (2020) groundwater model simulates a constant long-term average stage height in Wambo Creek. This may suppress variation within the shallow groundwater system near Wambo Creek; and
- An overestimation of simulated specific yield may also be responsible for the overestimation of groundwater head elevation in the model, due to the location of the bore within the official alluvial extent but outside the limits determined by geophysics. Accordingly, it should be attributed to regolith instead of alluvium in future updates to the groundwater model.
- Like P114, P116 partially intersects weathered Permian strata below intersected Wambo Creek alluvium. Mining effects from NWU to these strata may not be replicated in predictions for model layer 1.

As P116 does not lie directly over NWU workings, predicted drawdown as a result of mining activity is limited compared with P114. Only a minor drawdown response in both simulated and observed heads following the extraction of NWU LW10a is shown. As with P114, monitoring was ceased at P116 after February 2021, with bores P316a and P316b, to serve as a replacement sites into the future.

Modelled heads at GW08 (**Figure 12**) show a good match with the overall trends seen in the observed data. The timing of mining related drawdown in both modelled and observed heads, following the extraction of NWU LW5 is well correlated despite simulated heads being lower than observed. The faster rate of decline in observed data at GW08 may be related an underprediction of impacts, but may also be related to the below average rainfall conditions from 2017 to early 2020. Recovery in 2020 to February 2021 in response to above average rainfall is not captured in the model as the rainfall recharge and stream flow from January 2020 reflects long-term averages rather than high rainfall climatic conditions.

Calibration performance at GW09 (**Figure 13**) in SLR (2020) is poorer than previously reported in HydroSimulations (2017a). Simulated groundwater levels at GW09 show a response to climatic inputs of a similar magnitude to the observed data but do not show any drawdown associated with NWU LW5 mining. GW09 observations show drawdown in the order of 3 m at GW09 prior to going dry in December 2014 in response to NWU with no observed recovery. Further investigation is required to ensure the interaction between NWU and the overlying historical Homestead Underground Mine has been sufficiently captured within the model (refer to **Table 13** and **Table 14**).

The revision of fracture zone parameters and extents associated with longwall extraction is being tested within the groundwater modelling work being undertaken for the Modification 19 Groundwater Assessment (SLR, in prep) in effort to better calibrate the model to observed impacts.

Simulated groundwater levels at P106 (**Figure 14**) follow the general observed trends, however, the magnitude of water level change is not reproduced by the model. This may be due to the absence of streamflow dynamics in the model, or specific yield values within the alluvium/regolith being too high. An obstruction has been identified in P106, limiting the observation of groundwater levels in lower parts of the bore, and comparisons between modelled and observed data with a replacement bore are recommended.

There is a good correlation between simulated groundwater levels and observed groundwater levels at P109 (**Figure 15**) from 2003 to 2007. However, the model has a declining trend in contrast to generally higher and more dynamic observations. The model is probably missing a component of enhanced recharge from intermittent streamflow along Wambo Creek. As a result, the model underestimates observed heads in this area. During the 2021 monitoring period, simulated groundwater level stabilises in response to the modelled average climatic conditions but does not match the observed increase in groundwater level related to observed above average rainfall as it has occurred after the historical (calibration) period of the SLR (2020) model.

6.3 South Bates Underground

The performance of modelled heads at N2 VWP (**Figure 16**), and N3 VWP (**Figure 17**) have been assessed against observed data where South Bates Underground (SBU) mining activity is predicted to impact groundwater levels. Permian overburden sensors in N2 and N3 each include three sensors within one model layer. In addition, all sensors at N3 are either dry or have failed, and therefore ongoing assessment against model predictions is not practical.

Prior to sensor failure, predictions matched observed hydraulic gradients at N3 well, with near-dry conditions in the Whybrow Seam and higher heads in the underlying interburden and Wambo seam sensors. The 70 m sensor at N2 (N2-5) shows a good match with the predicted level and magnitude of decline until the end of 2017 after which the sensor went dry. The modelled groundwater levels lower sensors in N2 overestimate impacts but are accurate in indicating an ongoing mining effect from NWU that continues through the beginning of SBU mining. The modelled head in the Wambo Seam (N2-1) does not match the stable groundwater level observations to the end of 2021. This may be due to inherent difficulties in representing the fault that divides NWU and SBU, as well as conceptualising its hydrogeological influence. It may also be related to an inaccurate representation of the end of dewatering at NWU, which would limit the recovery of modelled heads to match observed data.

Improving model calibration at South Bates underground monitoring locations is an objective of the groundwater model revision work being undertaken for the Modification 19 Groundwater Assessment (SLR, In Prep). This will include review the hydraulic properties and layer discretisation adjacent to South Bates mining to better replicate observed hydraulic gradients, groundwater levels and the observed magnitude of mining impacts.

6.4 Assessment

The groundwater levels, as predicted by SLR (2020), generally show a good match with the magnitude and timing of impacts associated with mining at WCPL. Areas where the model is not accurately simulating observations can be attributed to:

- Difficulties in understanding the hydrogeological influence of and accurately simulating complex geological features, such as the fault between SBU and NWU;
- Multiple VWP sensors being simulated in a single model layer;
- Model parameters in surficial layers not configured to match the variations in observed data;
- Long-term average stage heights used in some watercourses within the model domain; or
- Issues related to the simplification of local geology within the groundwater model layering.

Overall, the groundwater model performs well and remains fit for purpose to predict the timing and magnitude of impacts to groundwater caused by mining at WCPL. Model updates undertaken for the Modification 19 Groundwater Assessment aim to keep the model predictions current and.

7 Inflow to WCPL workings

Section 4.1 in the GWMP (Peabody, 2020) requires quantification of the volume and quality of groundwater inflows to both open cut and underground mine workings at WCPL. This section assesses compliance of WCPL against the requirements and measurement criteria in the GWMP (Peabody, 2020).

The assessment of licence compliance regarding the interception of groundwater is undertaken in **Section 6.5** of the main WCPL Annual Review document.

7.1 Inflows to Open-Cut pits

Under the most recent modification (Modification 16, determined 28 August 2019) current operations at the Wambo Mine include underground mining and coal processing and handling activities. Open cut mining activities have been managed by the United Wambo Joint Venture since the commencement of development *Phase 2* on 1 December 2020.

Inflows to open cut pits with respect to groundwater licencing entitlements and water quality will be quantified by the United Wambo Joint Venture.

7.2 Inflows to Underground Workings

Active SBX and SBU workings in the Whybrow and Wambo Seams are currently being dewatered, with dewatering volumes and underground water levels required to be recorded daily during pumping according to **Section 4.1.5** of the GWMP (Peabody, 2020). Annual assessments for mine inflows are assessed against the peak simulated mine inflow from HydroSimulations (2017) of 316 ML/yr (Peabody, 2018). An exceedance of this predicted inflow by greater than 50% (i.e. an annual inflow of > 474 ML/yr) will require WCPL to:

- Investigate if there is a change in the predicted take of water from the Lower Wollombi Brook Water Source from mining related activities;
- Where there is an increased take from the Lower Wollombi Brook Water Source, investigate any influence on low flow cease-to-pump criteria specified in the HUA WSP;
- Define the Mine inflow volume value triggering this response procedure; and Groundwater Monitoring Program WA-ENV-MNP-509.1 Version: 12 Uncontrolled when printed 45
- Submit a report summarising the assessment to DoI Water. WCPL must notify DoI Water as soon as practicable on becoming aware of any take of water in excess of its licensed entitlement.

Predictions of annual inflows based on the actual mine progression for 2019 and anticipated mine progression after this was captured in modelling for the South Bates Extension LW21-24 Extraction Plan (SLR, 2020). This modelling predicted up to 68.5 ML/year inflows to the South Bates Extension and South Bates Underground mine areas over 2021.

This is significantly lower than the previously predicted inflows of 316 ML/year and may be due to a reduction in the actual mined extent and below average rainfall conditions from 2017-early 2020 simulated in SLR (2020). Revised groundwater modelling being undertaken as part of the Modification 19 Groundwater Assessment (SLR, in prep), is currently being undertaken by SLR. This modelling incorporates environmental observations to the end of 2020 (including observed creek flow and rainfall) and should assist in providing more robust estimates of inflow under wetter conditions.

The water quality of inflows to the underground workings are generally measured indirectly through monthly water quality monitoring of groundwater bores and mine water storages. During 2021, WCPL staff were unable to take water quality samples directly from the underground workings, due to insufficient observed seepage. Despite above average rainfall conditions throughout 2020 and 2021, WCPL staff confirmed there continued to be no observable seepage in South Bates Underground.

7.2.1 Underground Inflow Assessment

Modelled inflow values have been provided for 2021 based on the South Bates Extension LW21-24 Extraction Plan groundwater modelling (SLR, 2020). This groundwater model was revised to represent rainfall recharge for 2017-2019 that considers observed below average rainfall conditions, before returning to long-term average values for future predictions. These predictions are suitable for average climatic conditions. However, revised modelling for the Modification 19 Groundwater Assessment (SLR, in prep) may provide more informative predictions for above average rainfall conditions, as observed in 2020 and 2021.

As was described in the 2018 Annual Review (HydroSimulations, 2019), the modelled underground seepage values are calculated for the combined sources of SBU and SBX. This is done by calculating the volume of water intercepted by the MODFLOW Drain package, which is used within the model to represent areas of active mining/ dewatering in our groundwater models. In 2021, drain cells active in all historical SBU workings in the Whybrow, as well as all mined areas in the Whybrow Seam workings at SBX. The current conceptualisation of South Bates mining is that the mains at the north-eastern end of South Bates panels are required to be dry while any South Bates mining is progressing. This effectively limits the ability for groundwater to recover across the whole South Bates area, and justifies keeping the drain cells active across the whole mine area.

Total inflow from the Whybrow Seam for 2021 (SLR, 2020) is predicted at 68.5 ML. This value is indicative of inflows to the South Bates underground associated with long-term average rainfall conditions. This predicted inflow to the underground is well below the 474 ML/yr required to trigger further investigation.

The managed water source for this groundwater is the Sydney Basin - North Coast Groundwater Source of the North Coast Fractured and Porous Rock Groundwater Sources. Under the Water Sharing Plan for this groundwater source, WCPL hold 1,647 units.

8 Independent Environmental Audit

In September 2017 an Independent Environmental Audit against Development Consents DA 305-7-2003 and DA 177-8-2004 was conducted for the Department of Planning & Environment (DP&E). Two recommendations relating to groundwater inflows and seepage were made as follows:

- Schedule 4, Condition 25: Improvements could be made in terms of the overall site water management if specific groundwater inflows to the open cut via alluvium and Permian could be pumped and/or metered.
- Schedule 4, Condition 34: Consideration should be made to directly monitor the quality of groundwater seepage reporting to the underground and open cut workings.

Both recommendations were considered in the 2021 review.

8.1 Schedule 4, Condition 25

Due to the location of a spoil dump at the high wall near NWC, the physical observation of seepage from the alluvium and Permian strata to the open cut is not feasible. Scheduled model updates for the Modification 19 Groundwater Assessment (to be completed in 2022) will be tailored to replicating groundwater conditions within and underlying the NWC alluvium. This will improve the reliability of estimates of localised groundwater interception to the open cut.

8.2 Schedule 4, Condition 34

Attempts were made throughout 2021 to sample seepage from the active workings of SBU and SBX mine areas, in line with the Schedule 4, Condition 34 recommendation. However, samples could not be collected due to generally dry conditions within the underground. Regional depressurisation associated with historical and ongoing mining in the Wambo region, low rainfall from 2017 to 2019, and a lack of vertical connectivity between underground mine workings and strata recharged by above average rainfall in 2021 may be responsible for the dry underground conditions.

9 Summary

A summary of key findings from the review and analysis of WCPL groundwater data collected during 2020 is presented below:

- 2020-21 saw above average rainfall conditions at Wambo and across most of NSW. This resulted in flow events occurring in ephemeral watercourses across site, and broad-scale recharge to shallow groundwater systems (**Section 3.1** and **Section 5**).
  - Only bores GW15 and P16 continued to breach the minimum groundwater trigger level in 2021, with other sites recovering to within the limits of baseline observations during 2020.
- Data collection has started at new groundwater monitoring sites installed in key locations for the following purposes (**Section 4.1**):
  - Provide baseline/ pre-mining data in areas to be approached by WCPL mining activity.
  - Replace sites not constructed consistent with the *Minimum Construction Requirements for Water Bores in Australia (*ADIA, 2020), i.e. those screened across multiple aquifer units.
  - Replacement for monitoring sites as recommended in previous assessments.
- Further investigation is required to assess overall compliance with Performance Indicators and recommendations are made in Section 10 to further investigate the following:
  - P315 – Stony Creek Alluvium – exceedance of EC trigger level.
  - GW15 and P16 – Wollombi Brook Alluvium – minimum groundwater level trigger breach.
  - Observed vs modelled predictions in the downstream reaches of the North Wambo Creek Alluvium, utilising data from replacement monitoring bores where suitable.
- The data quality assessment undertaken on WCPL VWPs identifies arrays with failed sensors/ poor quality data which can be excluded from the monitoring program (**Appendix C**).
- Groundwater model performance is consistent with previous Annual Review assessments, with generally good matches to absolute observed groundwater levels. Future modelling, as is being completed in 2022 for the Modification 19 Groundwater Assessment, will focus on improving in the model's ability to capture vertical hydraulic gradients in deeper bores, and seasonality in shallower monitoring sites (**Section 6**).
- Predicted and inferred groundwater inflow volumes within limits of alluvial and rock water licences. Groundwater model updates will verify these predicted volumes under wetter climatic conditions for 2020 (**Section 7**).

10 Recommendations

Following the 2021 annual review of groundwater data several general recommendations are made in relation to ongoing groundwater monitoring, together with specific recommendations in relation to identified breaches of trigger levels at specific bores.

10.1 General Recommendations

- An obstruction has been identified in P106, and a replacement bore is recommended. P109 is due to be replaced as it is screened across both alluvial and Permian strata. It is recommended that P109 is replaced with two bores: one in the alluvium, and the other in the in the underlying weathered Permian, as a replacement for both P109 and P106.
- If pumping continues at GW02 and GW11 they should be removed from the GWMP and a single replacement alluvium monitoring bore installed in a nearby location (keeping in mind the potential influence of pumping from GW02 and GW11). Alternatively, flow meters could be installed on GW02 and GW11 to quantify the extraction of groundwater from these bores.
- VWP locations identified with persistent poor-quality data should be removed from the monitoring network (see **Appendix C**).
- Top of Casing and ground elevation should be surveyed at recently installed standpipe monitoring bores (GW08.2, GW09.2, GW10.2(a), P316(a,b,c), SW30) in order to convert dipped groundwater levels to mAHD.
- The GWMP should be updated to consider P316a a Wambo Creek Alluvium bore, and P325a (SW30) a Wollombi Brook Alluvium bore.

10.2 P315 – Stony Creek Alluvium – EC Trigger Level

EC increased above the trigger level of 552 µS/cm in June and reached a maximum of 1275 µS/cm in October before falling back to 568 µS/cm in December. This breach of the EC trigger level was the subject of an investigation by SLR (SLR, 2022). The investigation concluded that the high rainfall in March 2021 may have resulted in sufficient recharge to the shallow groundwater system to enable the “flushing” of shallow groundwater through fractures in bedrock or dilated bedding planes within the Newcastle Coal Measures resulting from NWU undermining. Based on this conclusion, and the data gaps and limitations identified, if the EC breach continues the following recommendations are made to inform the nature and extent of the water quality change in the Stony Creek alluvium:

- Continued monitoring of shallow groundwater sites adjacent to Stony Creek, including periodic monitoring of Fenwick Well 4 downstream. This could be incorporated into the current bi-monthly monitoring program.
- Routine monitoring at a location upstream of NWU LW1 where water quality is currently fresh.
- Survey/ measure height of stickup at all viable Stony Creek monitoring sites.
- Installation of water level and quality loggers within a monitoring bore near the Stony Creek channel (P316, P319), and one within Stony Creek itself to improve the understanding of surface water-groundwater interactions.
- Further review of the following:

- Historical surface water, groundwater, and subsidence reporting (Wollemi-Homestead reports by Coffey, NWU End of Panel reports).
- Observed water quality changes following subsidence specific to the Hunter Coalfield (if available).
- Any literature on water quality changes following flood/ erosive events not related to subsidence.

10.3 GW15 – Wollombi Brook Alluvium - Minimum Groundwater Level

Groundwater levels at GW15 in the Wollombi Brook Alluvium have been below the minimum groundwater level trigger since early 2018. Whilst levels recovered above the lower trigger in the second half of 2021, recovery to levels seen prior to the 2017-20 drought, as seen at other locations in the Wollombi Brook Alluvium has not occurred. It should be noted that the last reading of 2021 may have occurred before the high rainfall at the end of 2021 and as such, further recovery may be seen in GW15. In addition, the trigger levels were defined in a period of prolonged higher than average rainfall and the low-level trigger is likely set too high. It is also possible that the approaching Warkworth Open Cut may be responsible for some decline in groundwater levels at GW15 although, given its distance from the bore and the changes in geology, impacts from this development would be expected to be limited. The following recommendation is made with regard to the minimum groundwater level breach at GW15:

- Further review and investigation into the minimum groundwater level breach at GW15 should be considered. Based on the findings of this investigation, it may be suitable to revise the trigger level to capture groundwater level response over a broader range of climatic conditions.

10.4 P16 – Wollombi Brook Alluvium - Minimum Groundwater Level

Groundwater levels at P16 in the Wollombi Brook Alluvium have been below the minimum trigger level since early 2017. Levels increased at the start of 2020 and by a total of ~1.5m through 2020 but despite continued high rainfall through 2021 a recovery to the levels seen prior to the 2017-20 drought has not occurred. However, at P12 and P13 located near P16 to the east of Wollombi Brook a full recovery has been observed in 2021. The lack of recovery in P16 indicates an ongoing mining impact in the alluvium at this location adjacent to the South Wambo Boxcut. However, the degree of impact is broadly consistent with the HydroSimulations (2016) groundwater assessment. We would therefore recommend the following actions with regard to this (likely ongoing) trigger level breach:

- Check for seepage into the South Wambo boxcut from the alluvium on the eastern face – is this obvious following heavy rainfall. This potential outflow from the alluvium at this location just west of P16 is likely to be a control on maximum groundwater levels at P16

- The representation of unconsolidated strata and the potential controls on shallow groundwater levels across the Wambo Complex will be reviewed as part of the numerical modelling work being undertaken for the Modification 19 Groundwater Assessment in 2022. The results from the updated model may help revise trigger levels at P16 to reflect the influence of both approved impacts and climatic conditions.

10.5 North Wambo Creek Alluvium – Observed vs Modelled Predictions

Historical monitoring sites within the NWC alluvium have exhibited greater drawdown than predicted in the most recent groundwater modelling. This has been investigated previously and it was determined that the modelling (HydroSimulations, 2017a, 2019b) accurately captures the timing of drawdown and desaturation of the alluvium at GW09.

Limited data for replacement bore GW09.2 (and GW08.2) shows evidence of recovery in 2021 at this location in response to above average rainfall conditions.

Whilst there is not strictly a breach of the associated performance indicator, a review of the numerical model assumptions within alluvium and unconsolidated strata across the Wambo Complex is being undertaken as part of the modelling work contributing to the Modification 19 Groundwater Assessment be completed in 2022. Where possible, the new data from GW09.2 and GW08.2, should be considered in this or future reviews and compared to model predictions.

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FIGURES

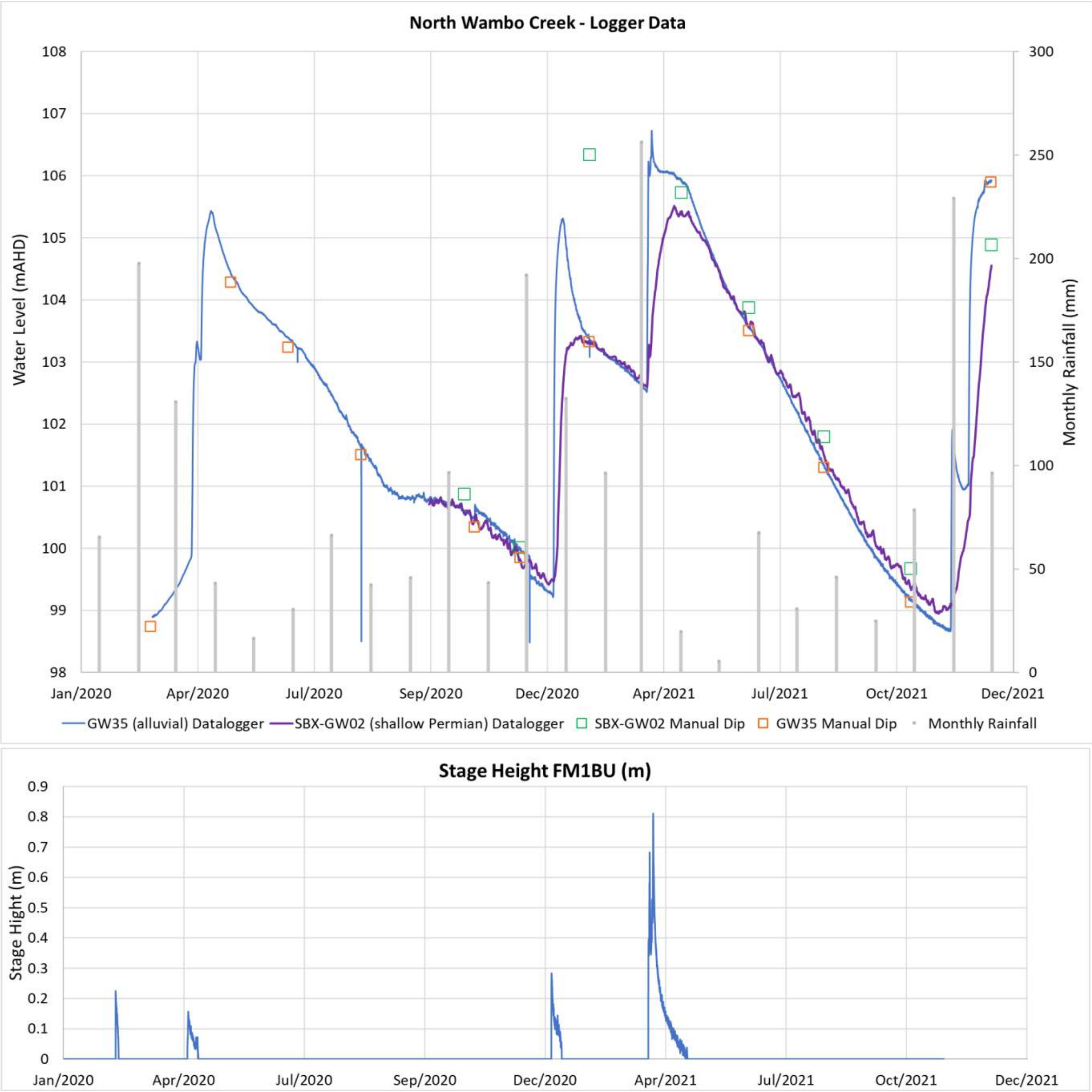


Figure 3 GW35 (Alluvial) and SBGW02_Standpipe (Shallow Permian) Hydrographs

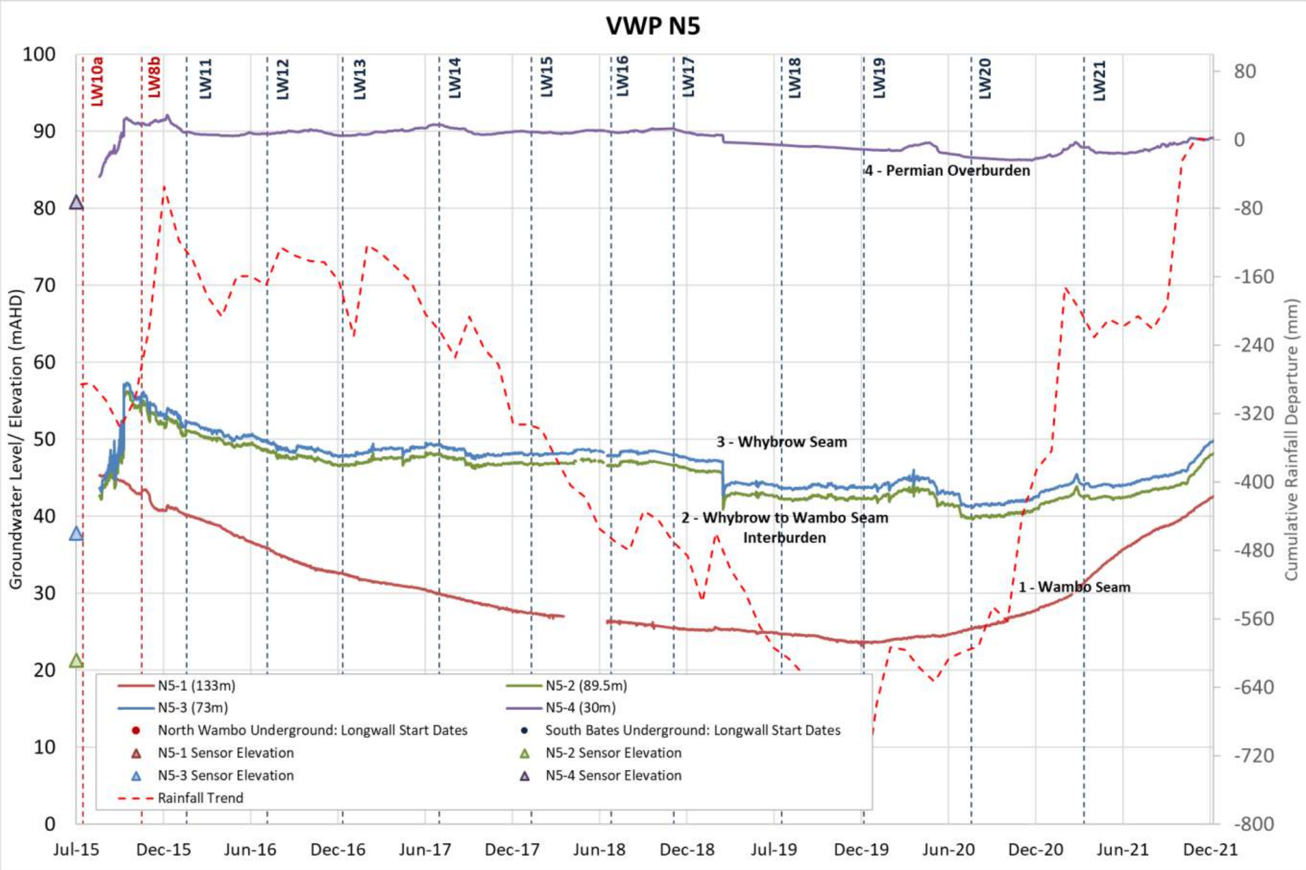


Figure 4 N5 VWP hydrograph

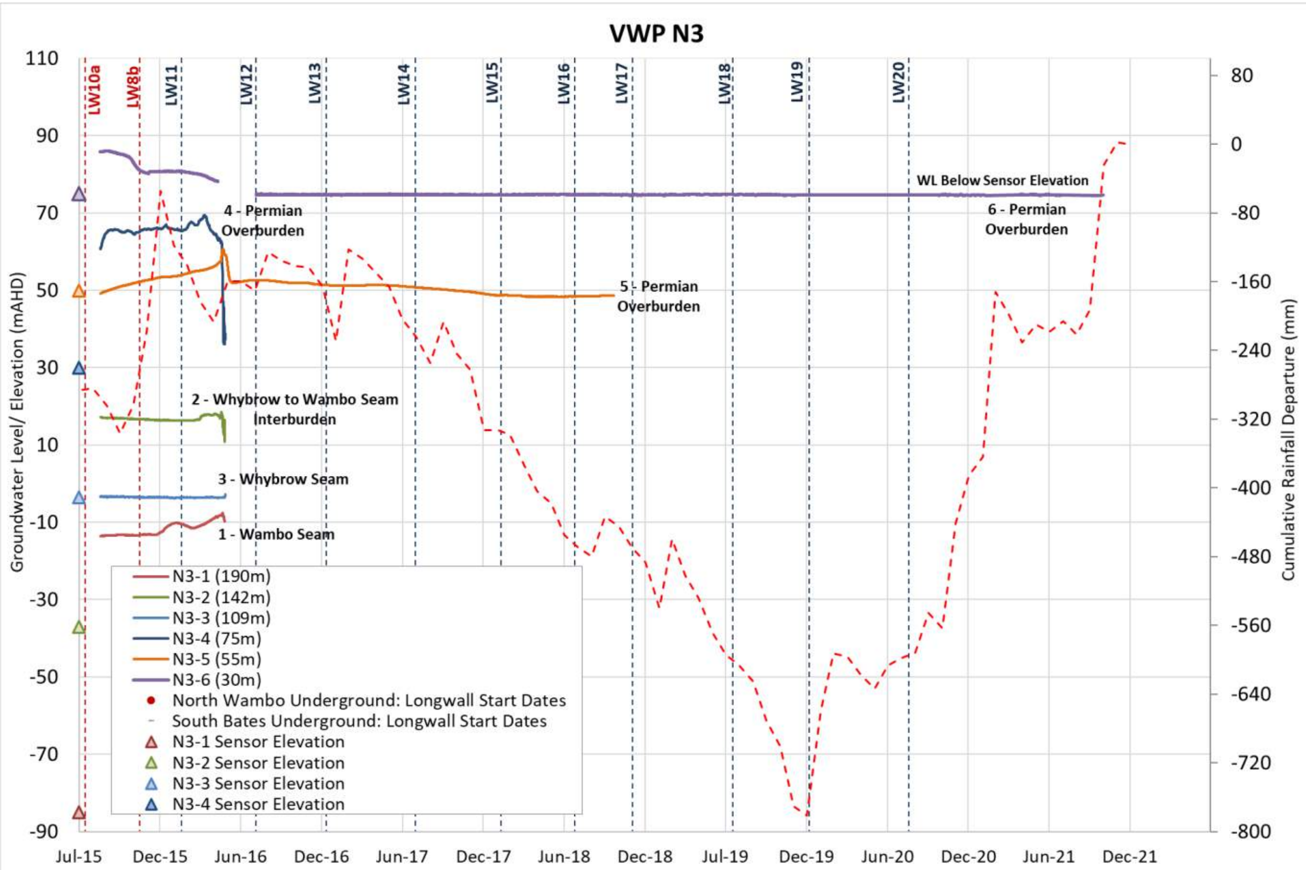


Figure 5 N3 VWP hydrograph

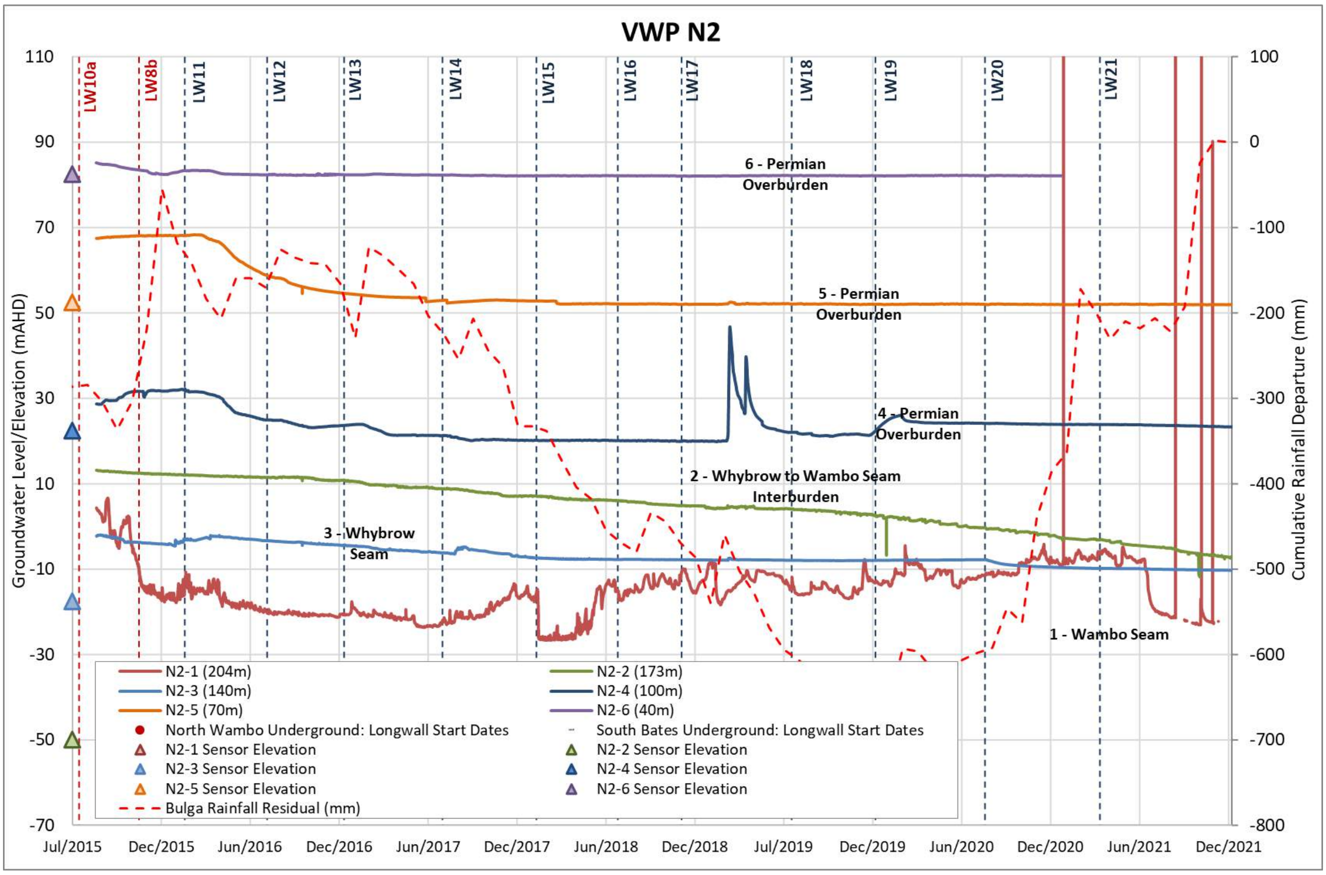


Figure 6 N2 VWP hydrograph

APPENDIX A

Calibration Hydrographs

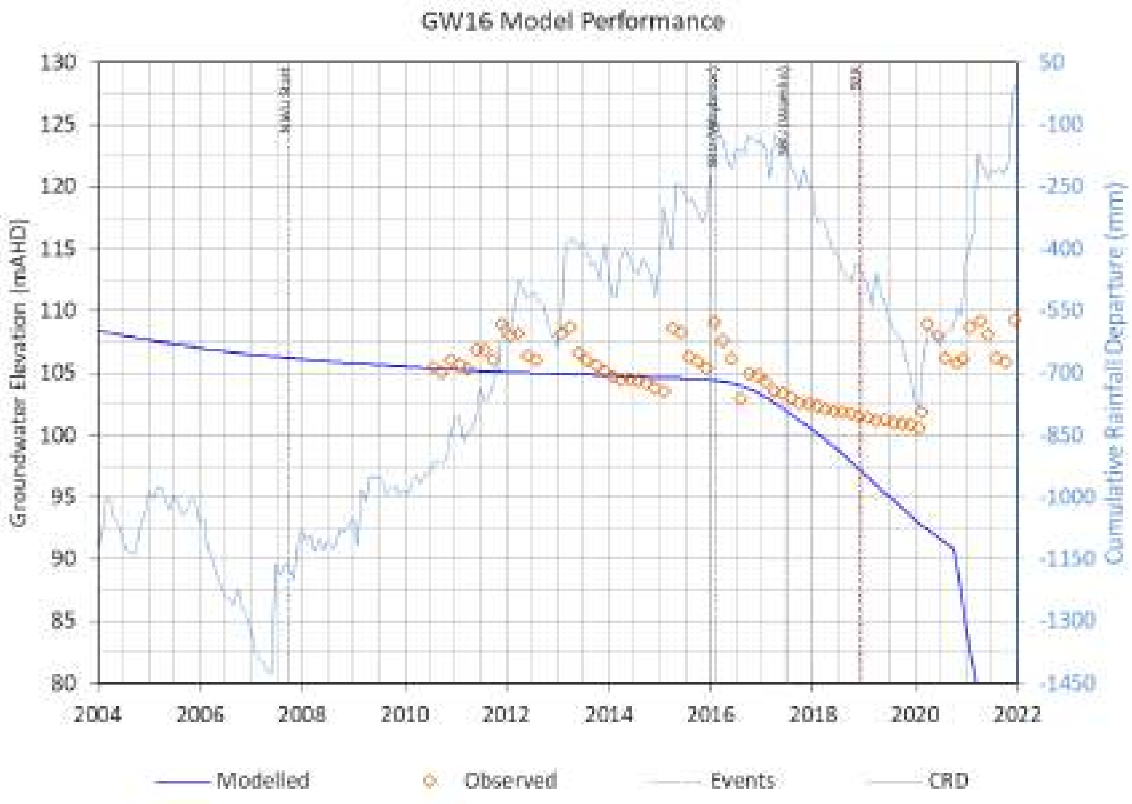


Figure 7 GW16 Calibration Hydrographs

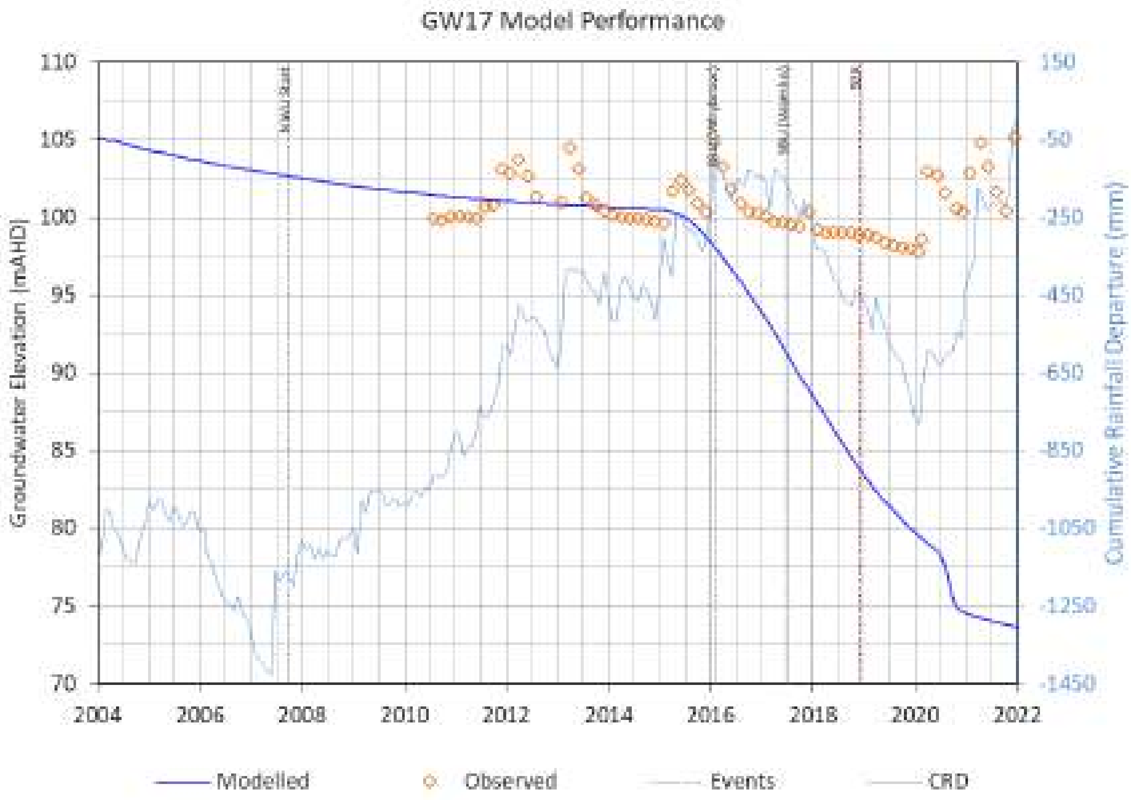


Figure 8 GW17 Calibration Hydrographs

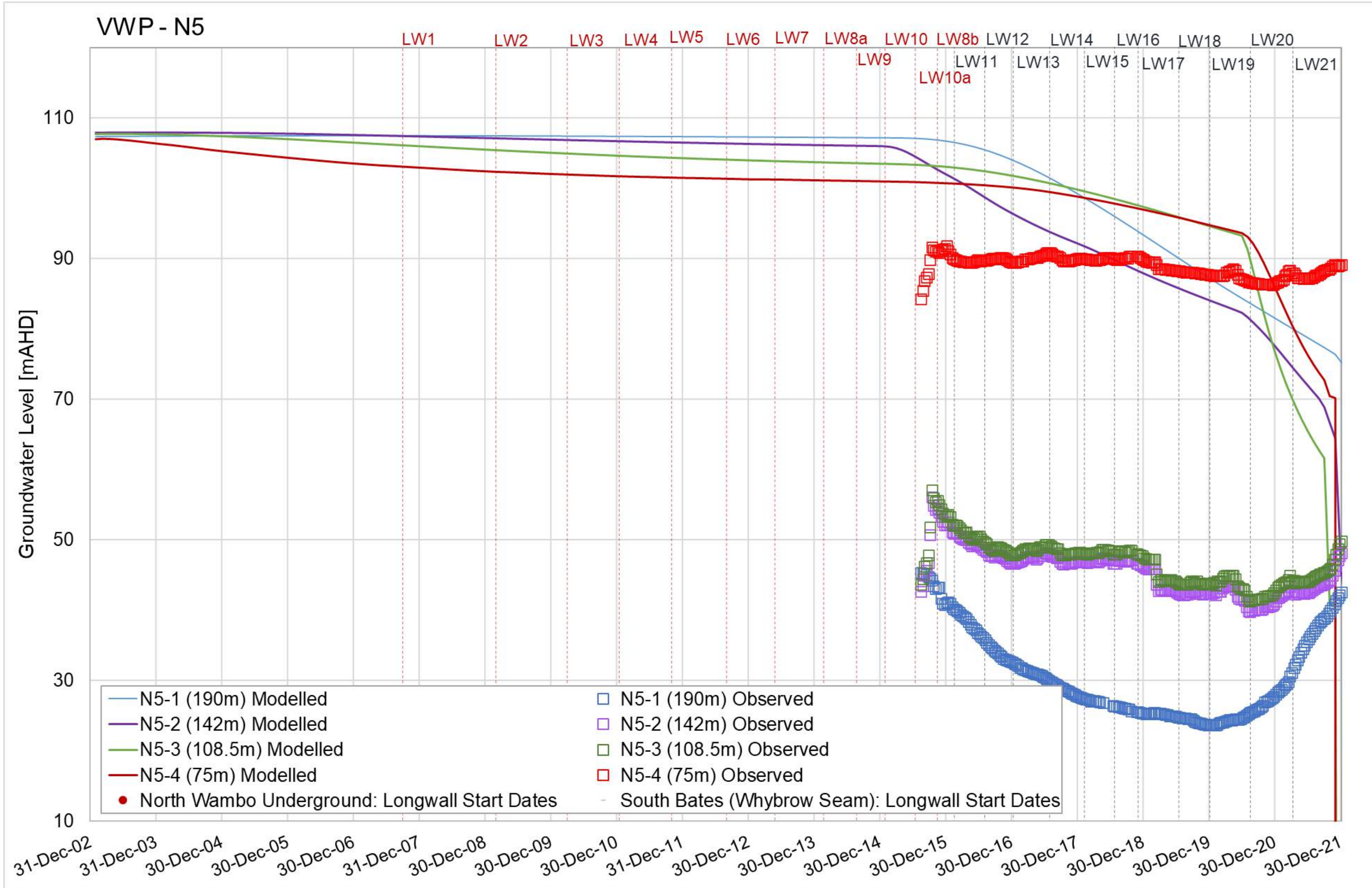


Figure 9 N5 Calibration Hydrographs

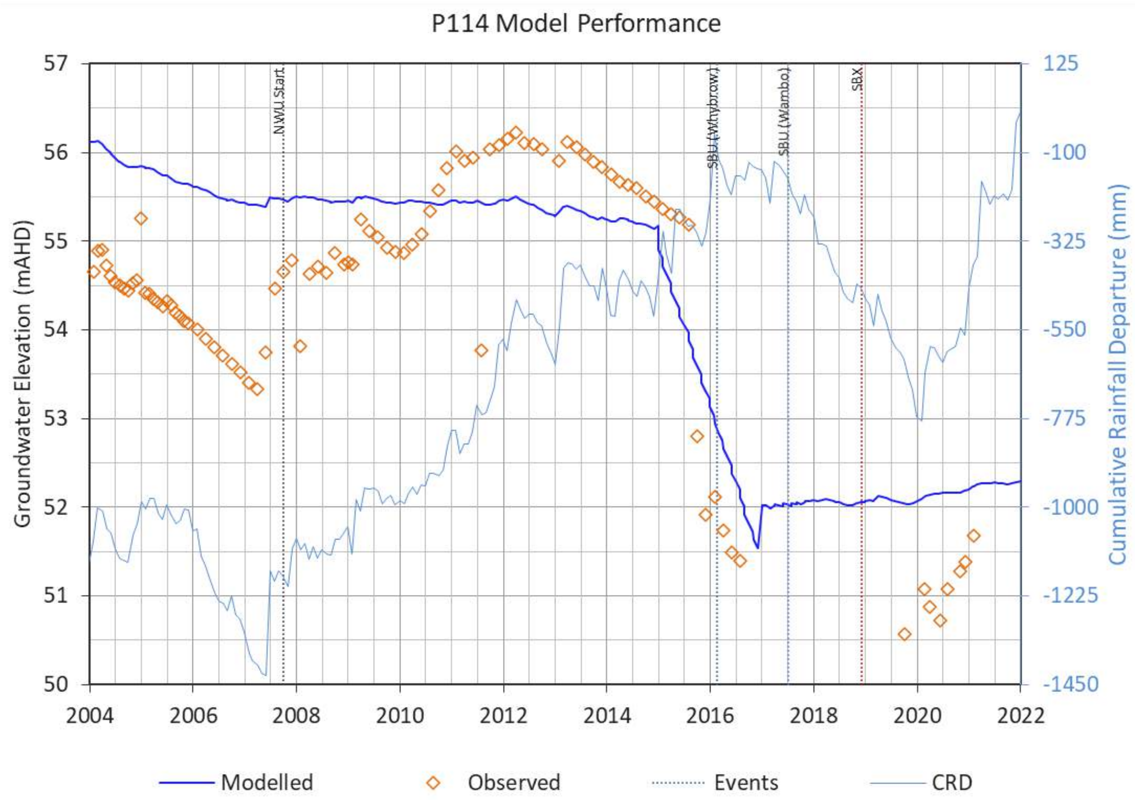


Figure 10 P114 Calibration Hydrographs

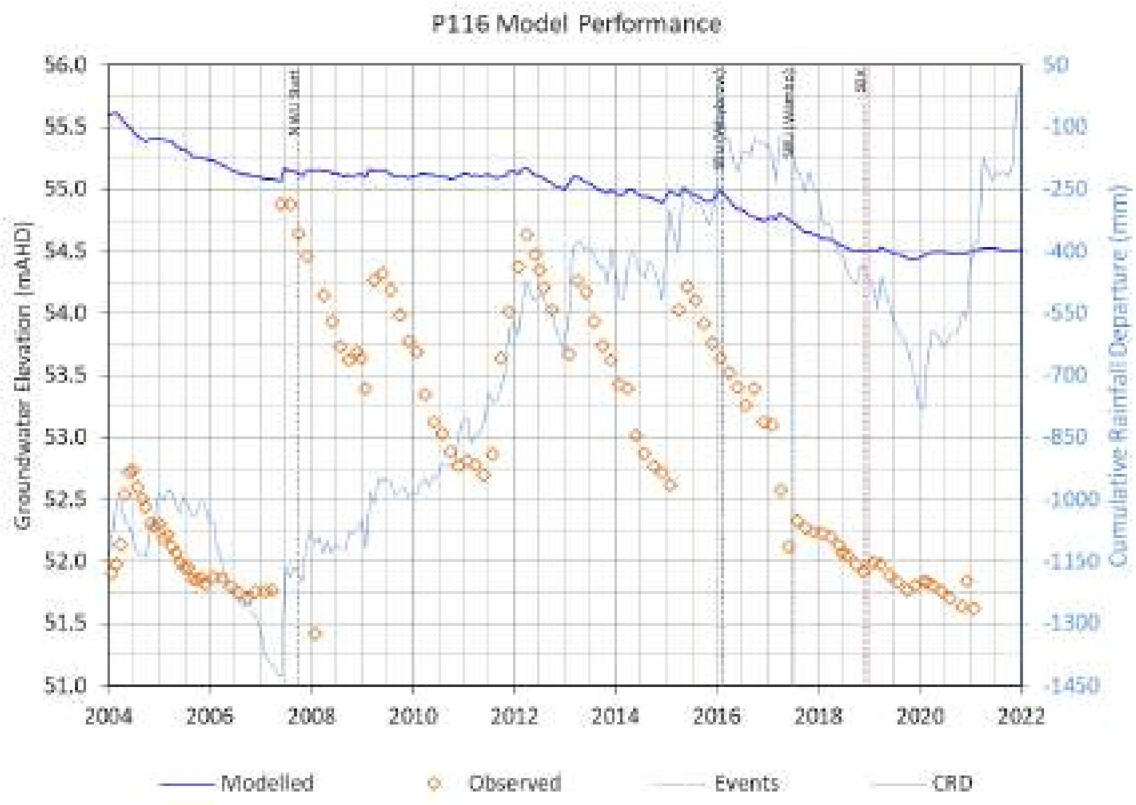


Figure 11 P116 Calibration Hydrographs

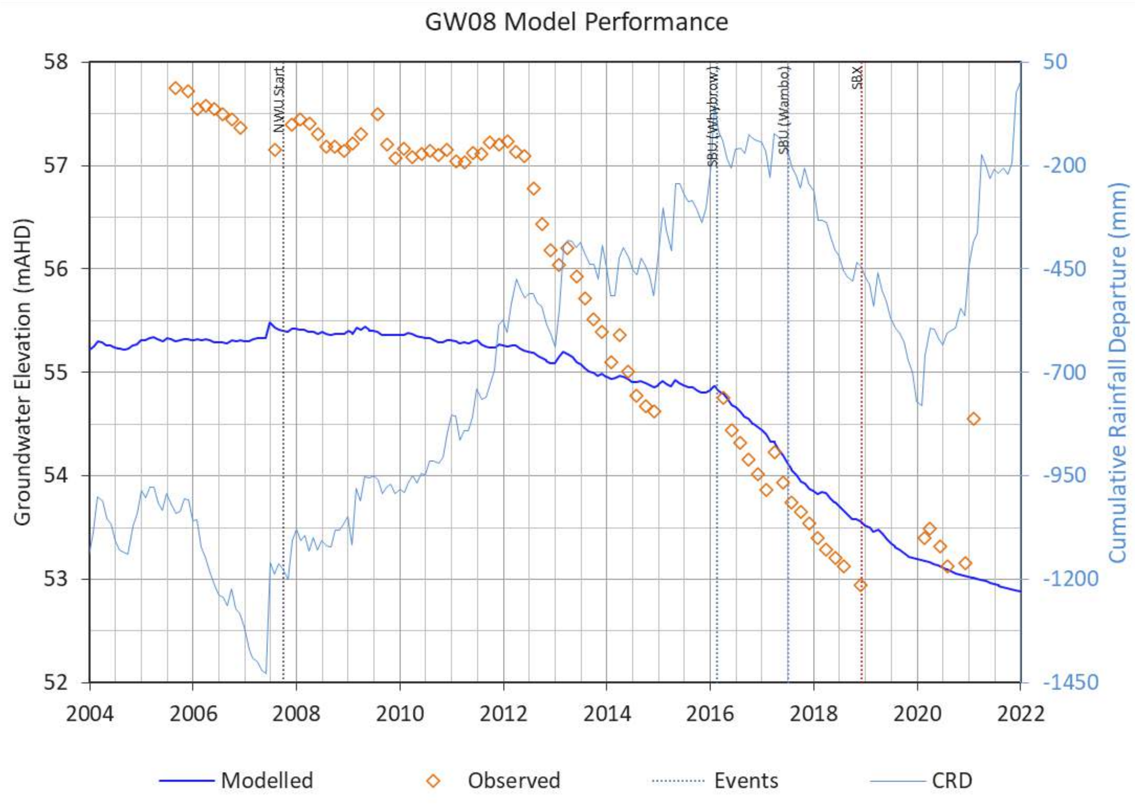


Figure 12 GW08 Calibration Hydrographs

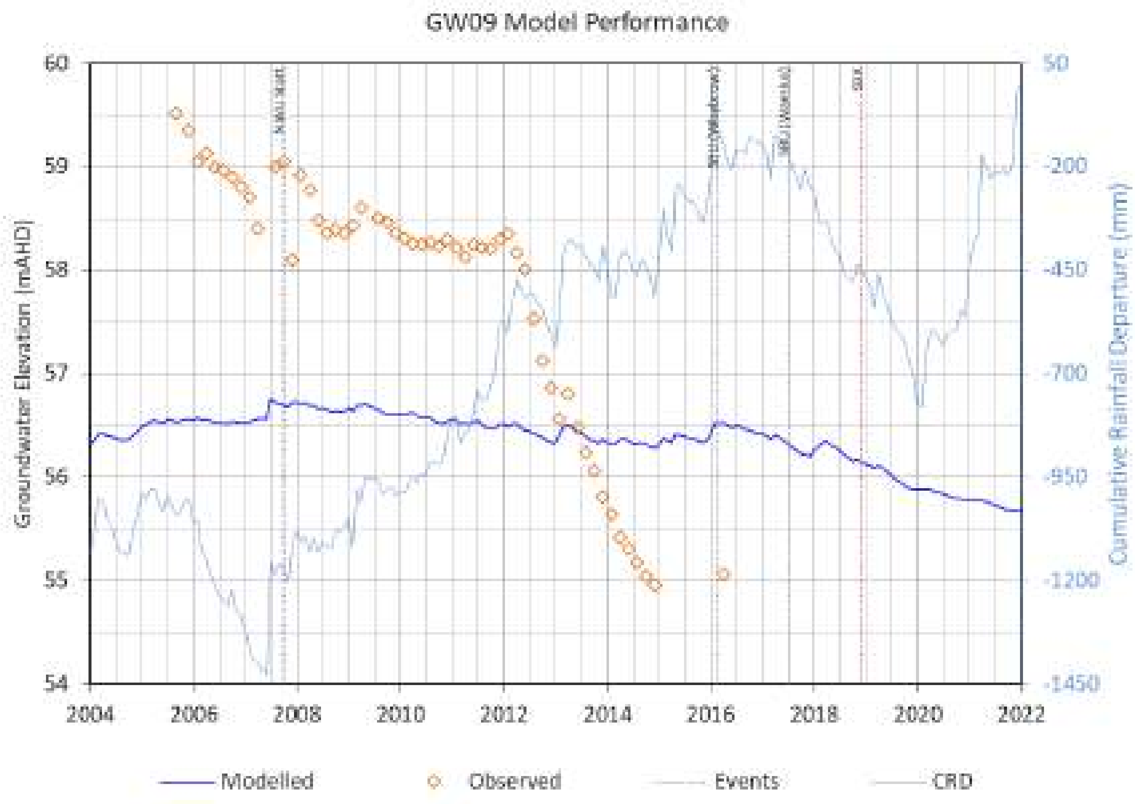


Figure 13 GW09 Calibration Hydrographs

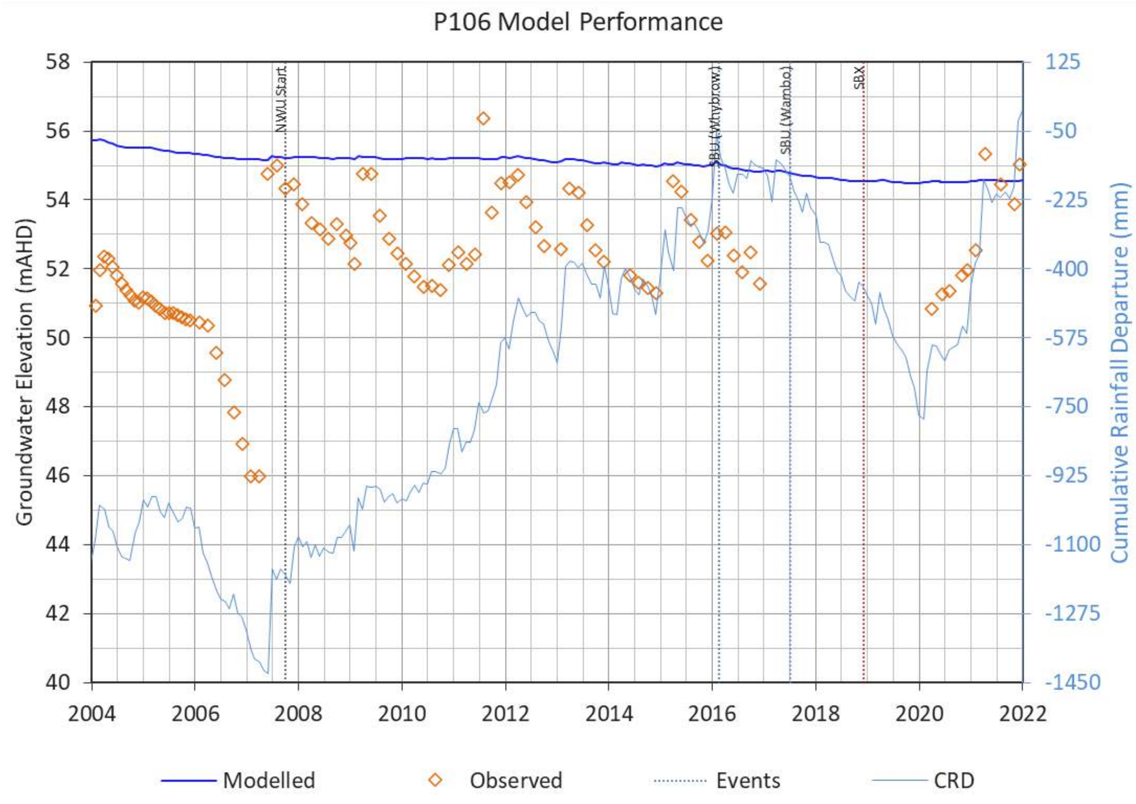


Figure 14 P106 Calibration Hydrographs

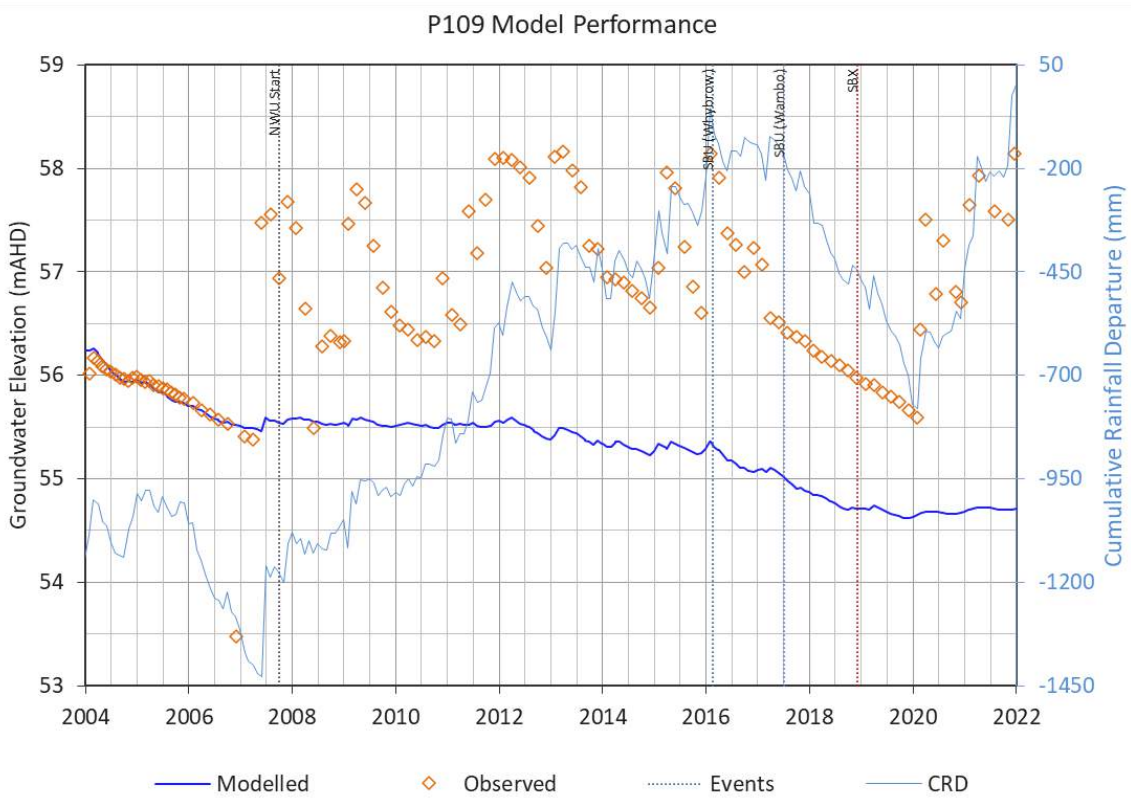


Figure 15 P109 Calibration Hydrographs

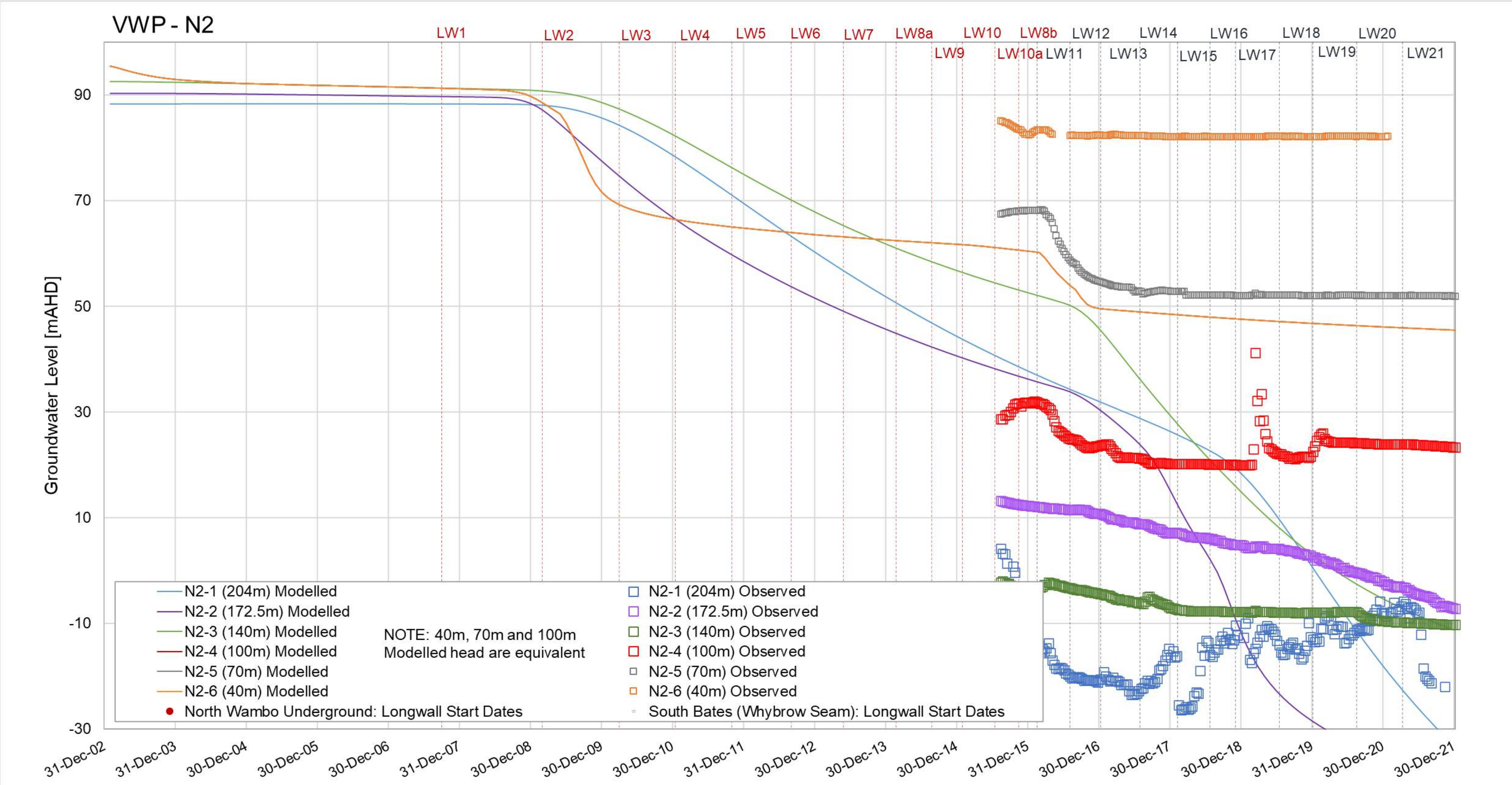


Figure 16 N2 Calibration Hydrographs

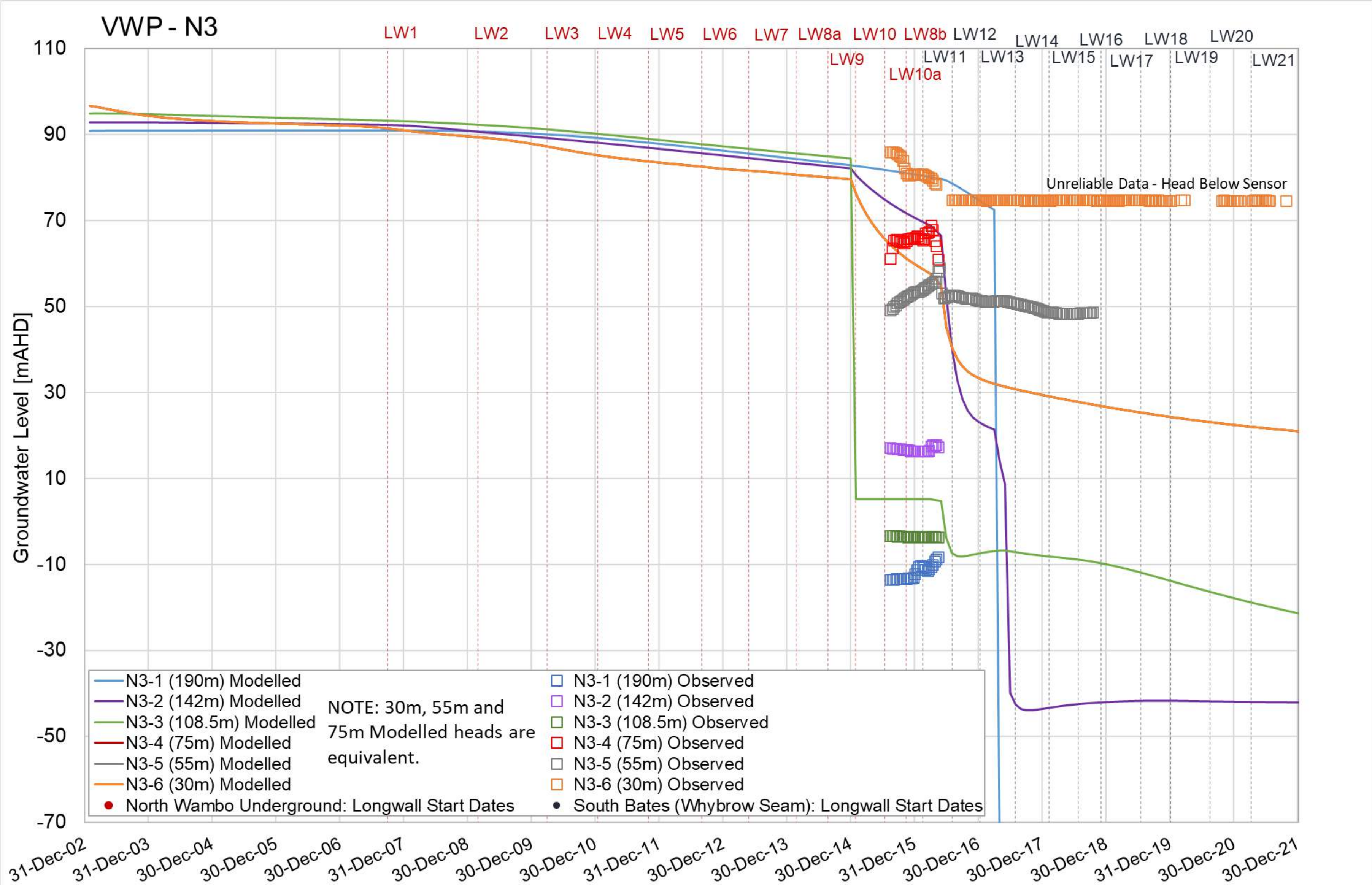


Figure 17 N3 Calibration Hydrographs

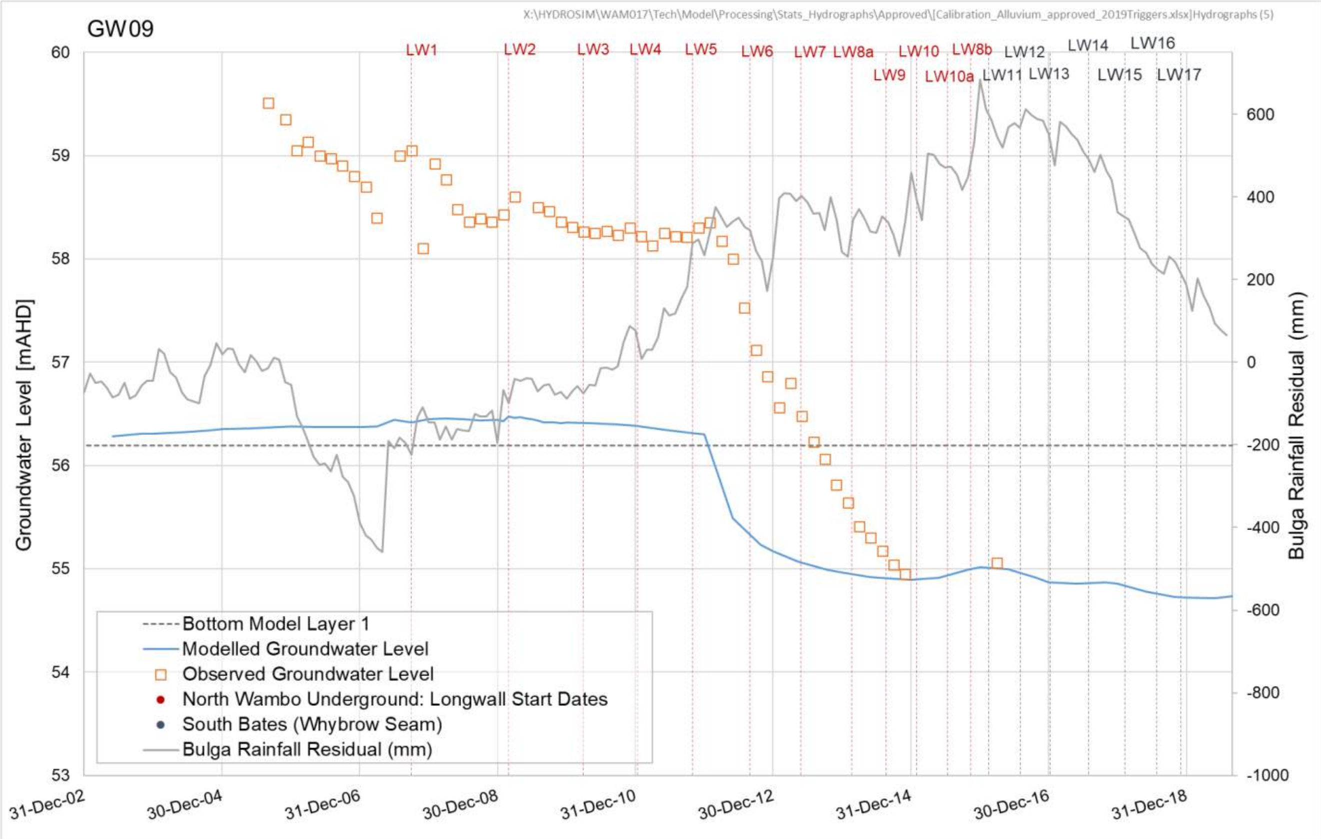
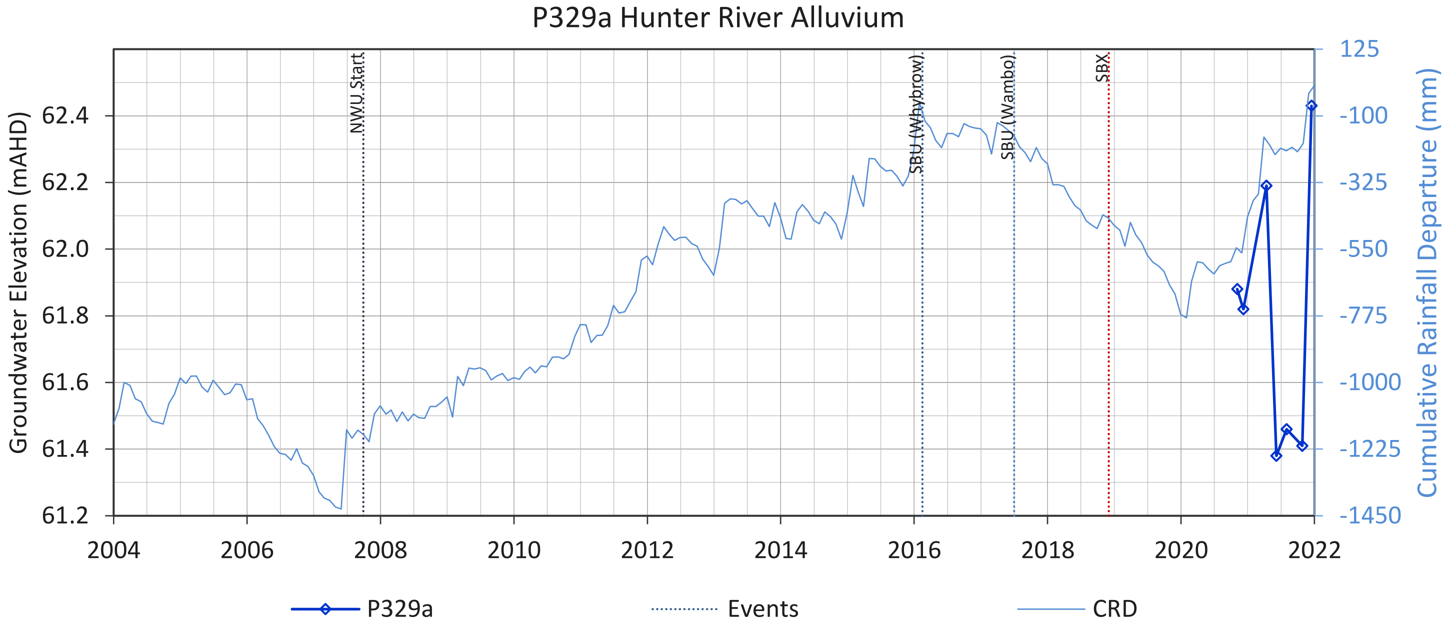
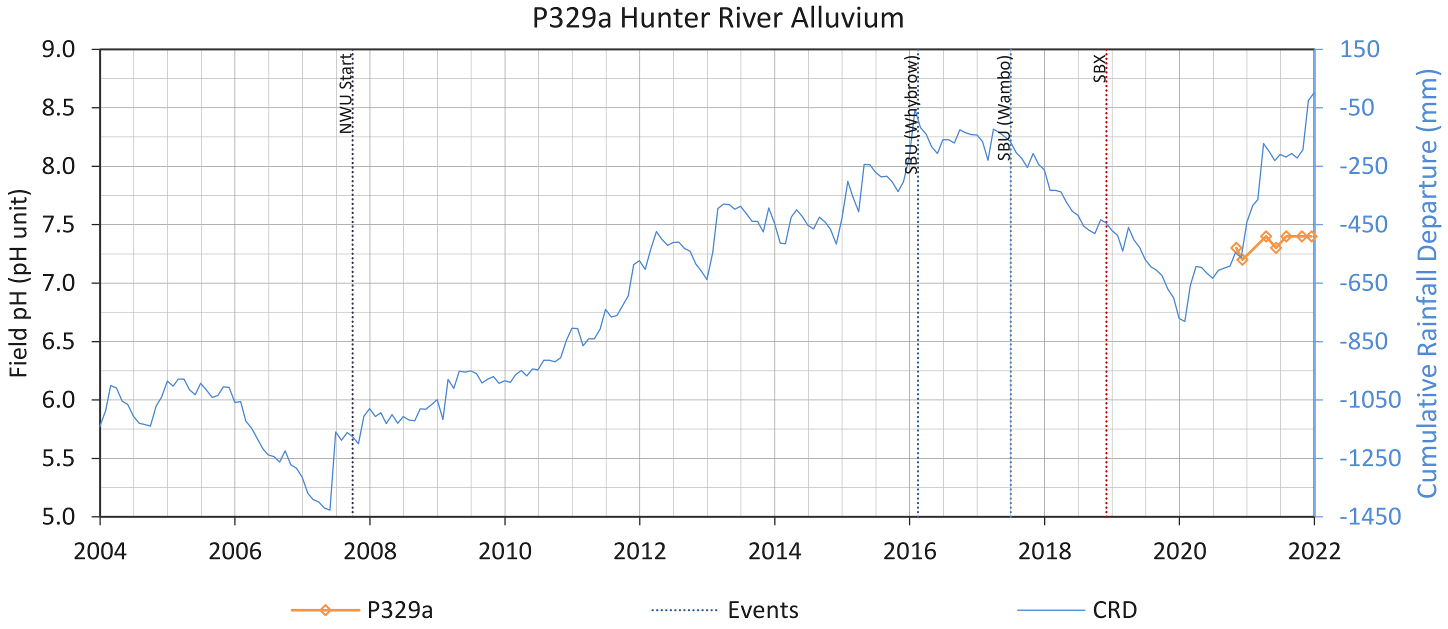


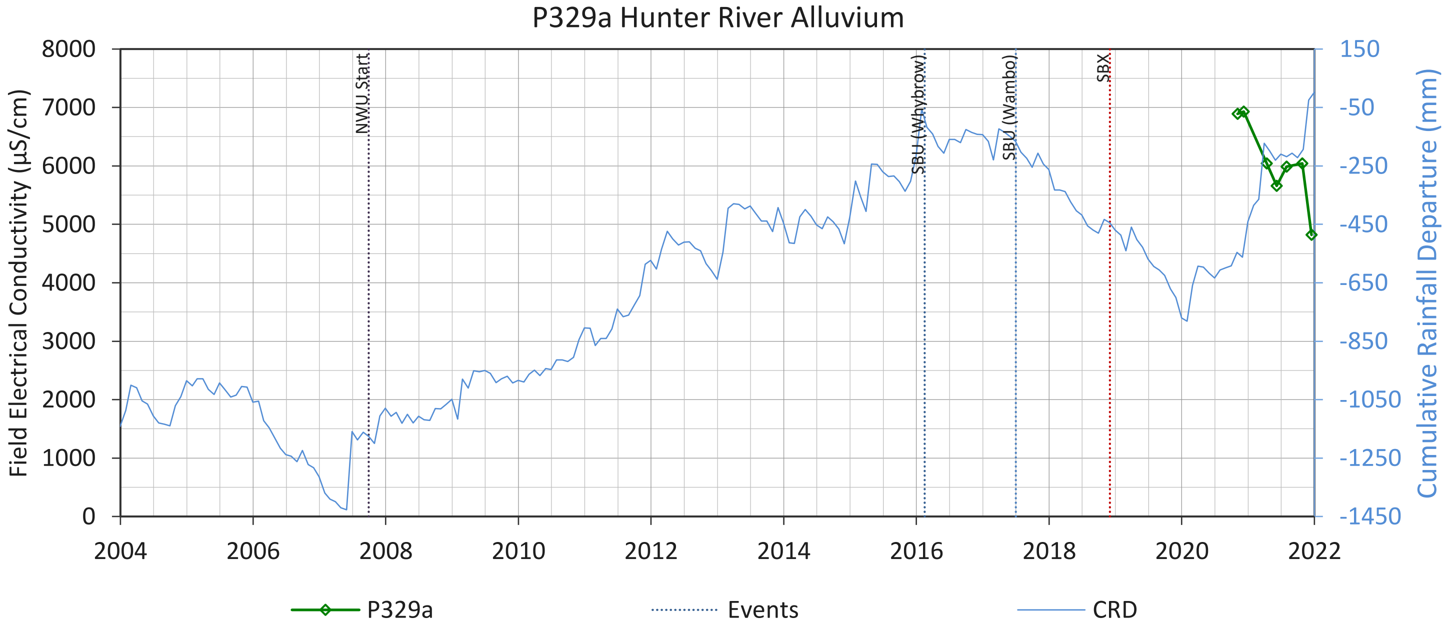
Figure 18 Simulated vs observed groundwater level at GW09 from previous model (Hydrosimulations, 2019b)

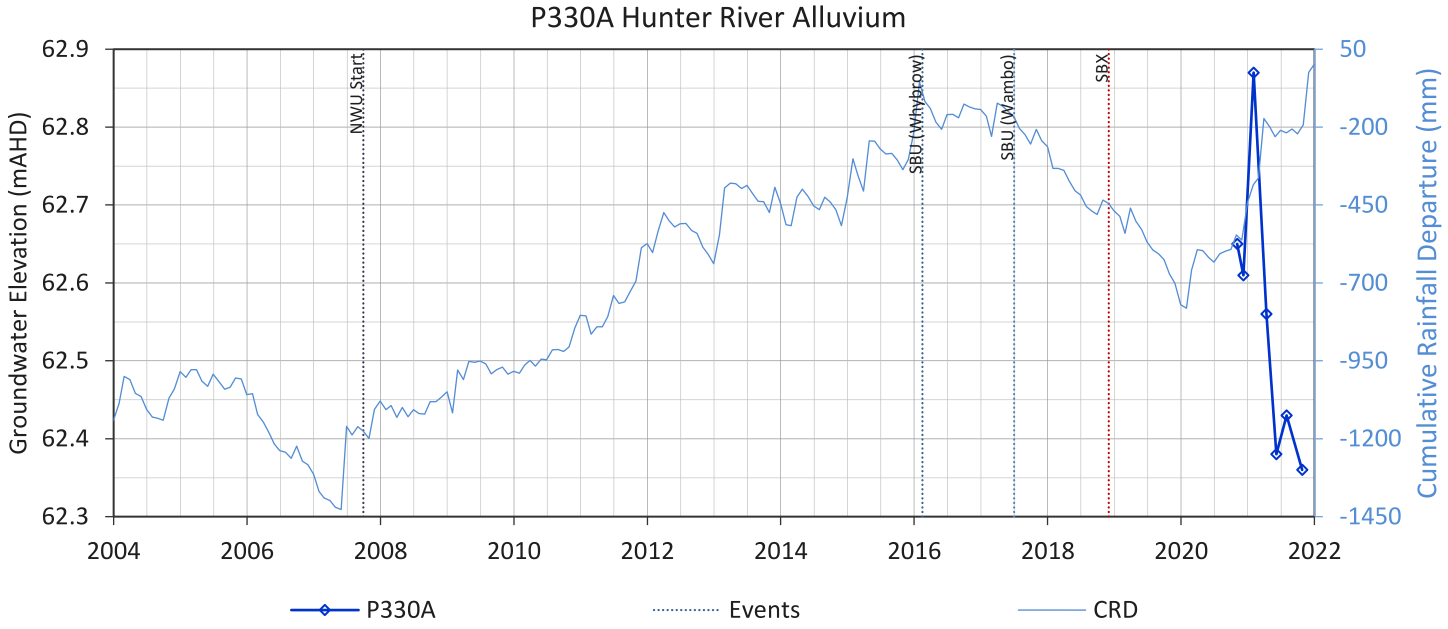
APPENDIX B

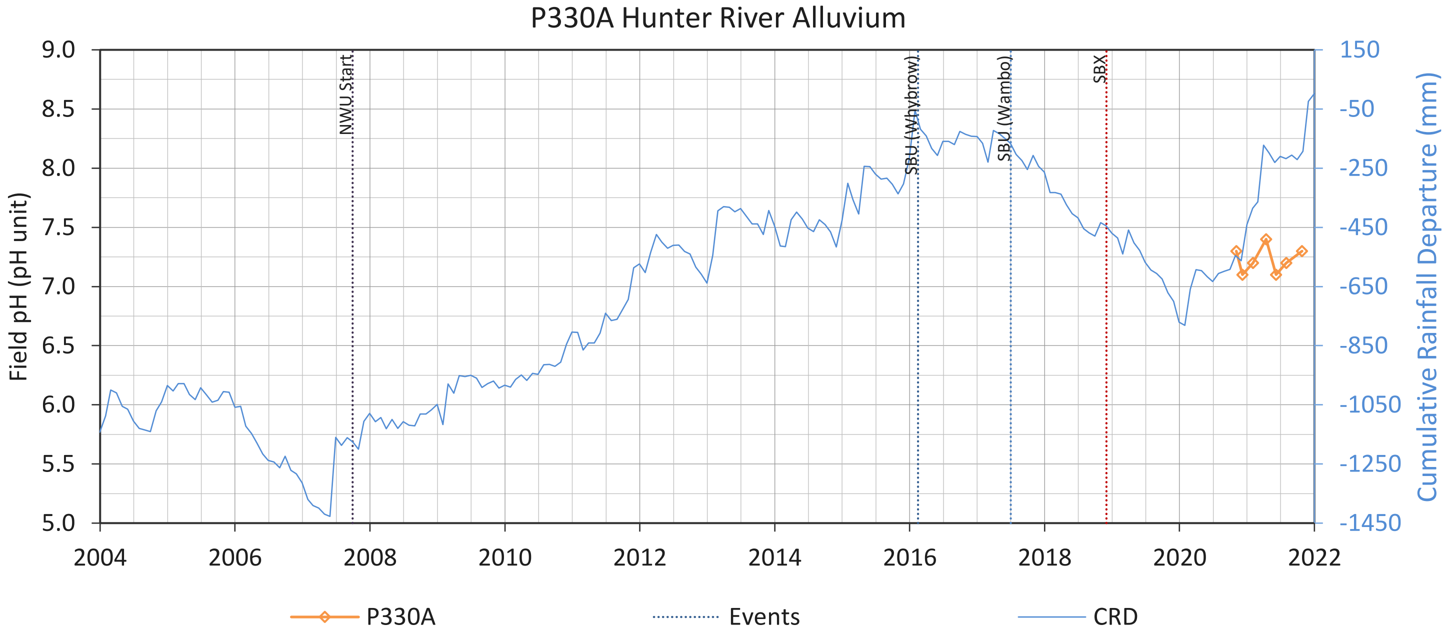
Groundwater Level and Groundwater Quality Graphs

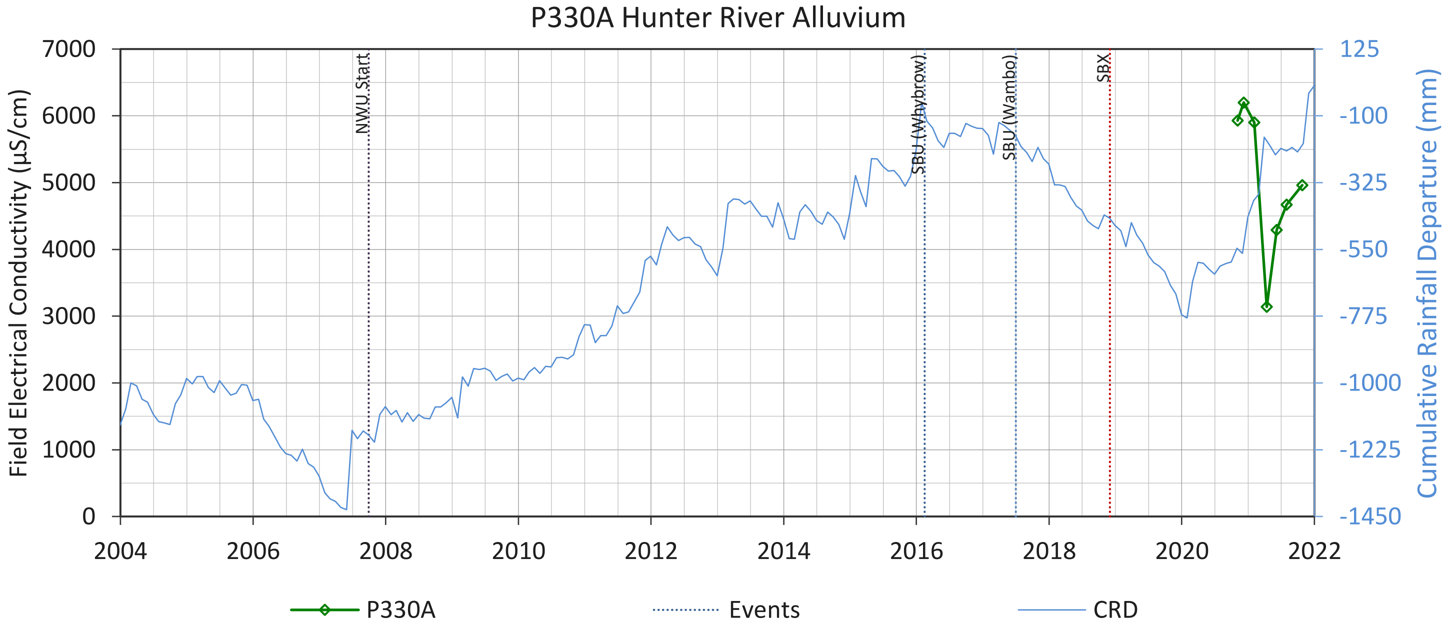

P329a Hunter River Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P329a
Events
CRD

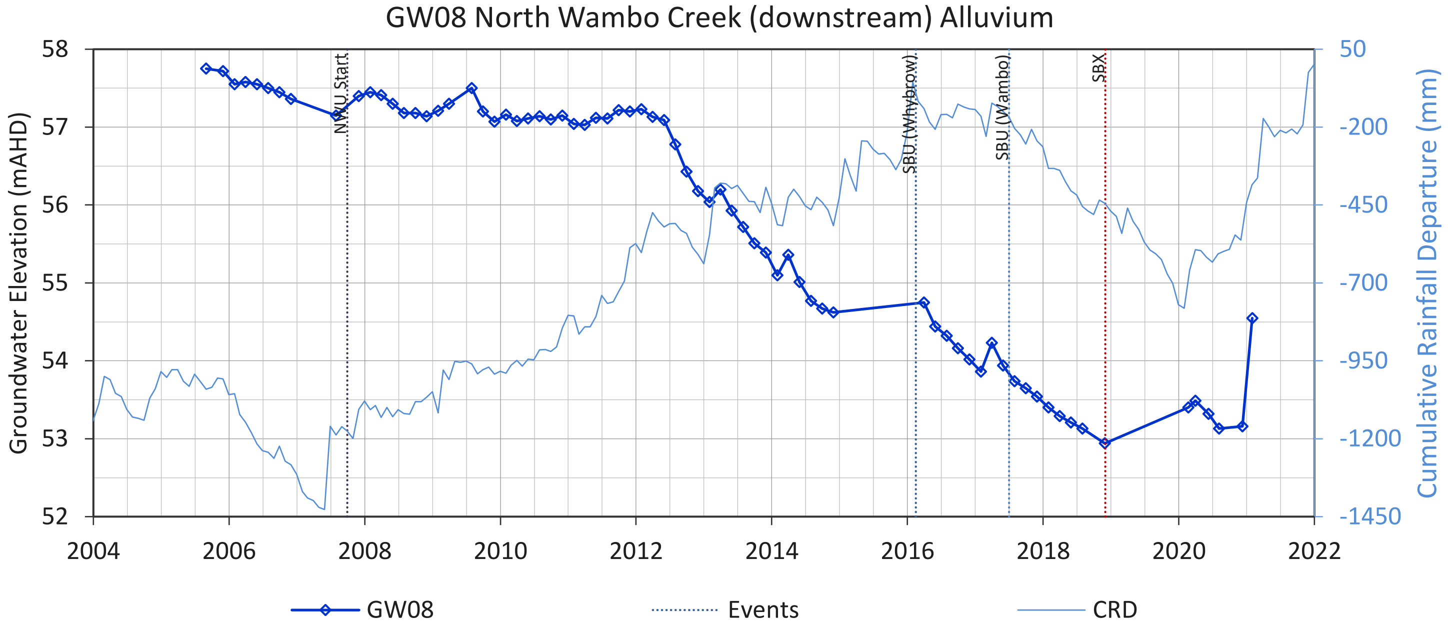

P329a Hunter River Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P329a
Events
CRD

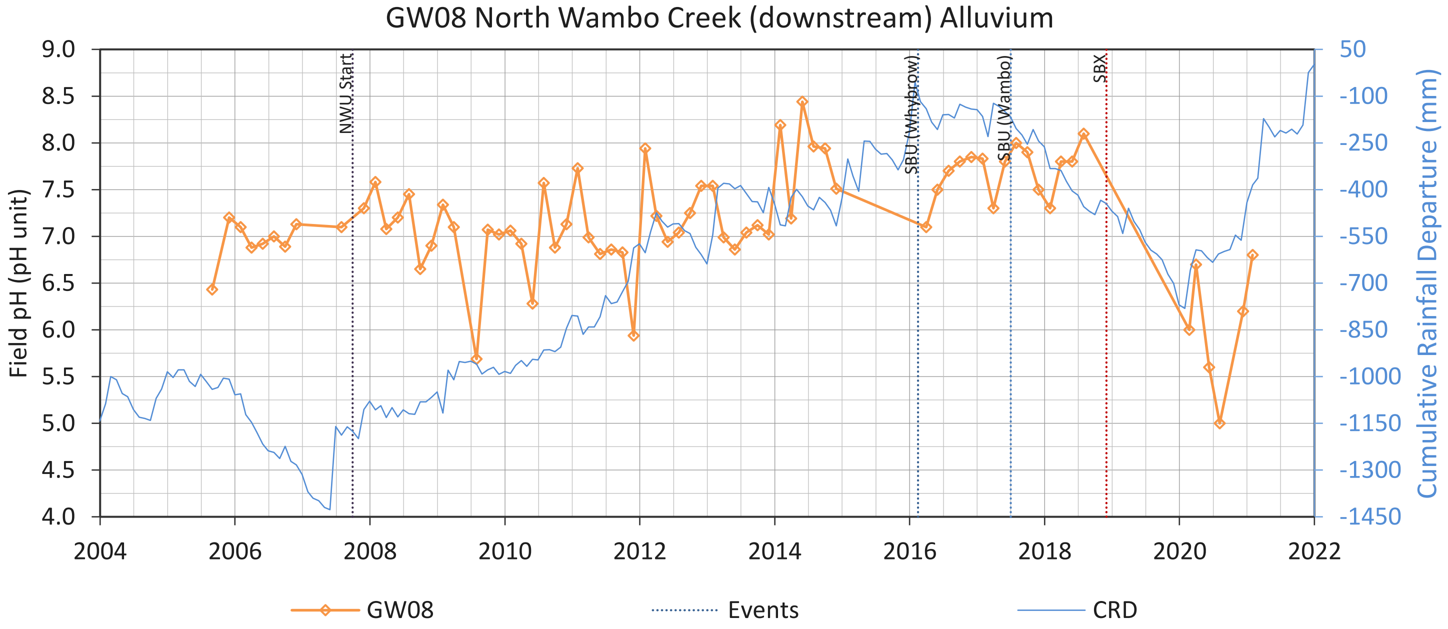

P329a Hunter River Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P329a
Events
CRD

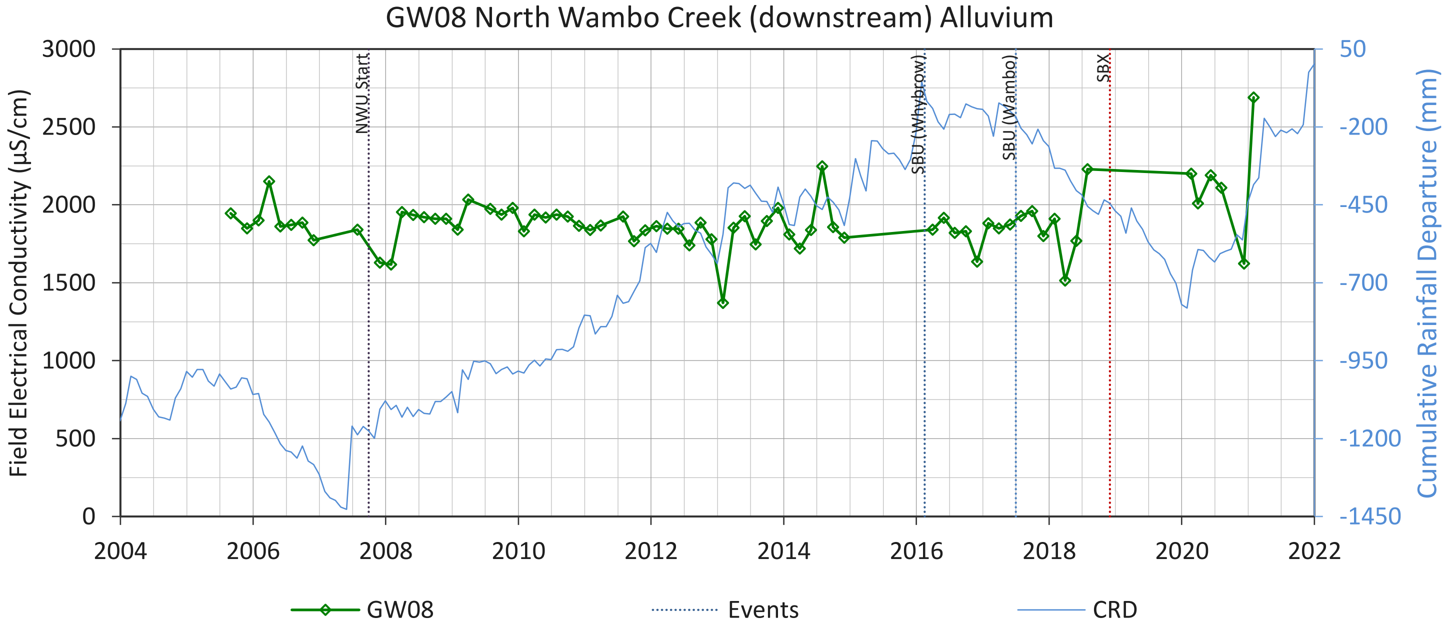

P330A Hunter River Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P330A
Events
CRD

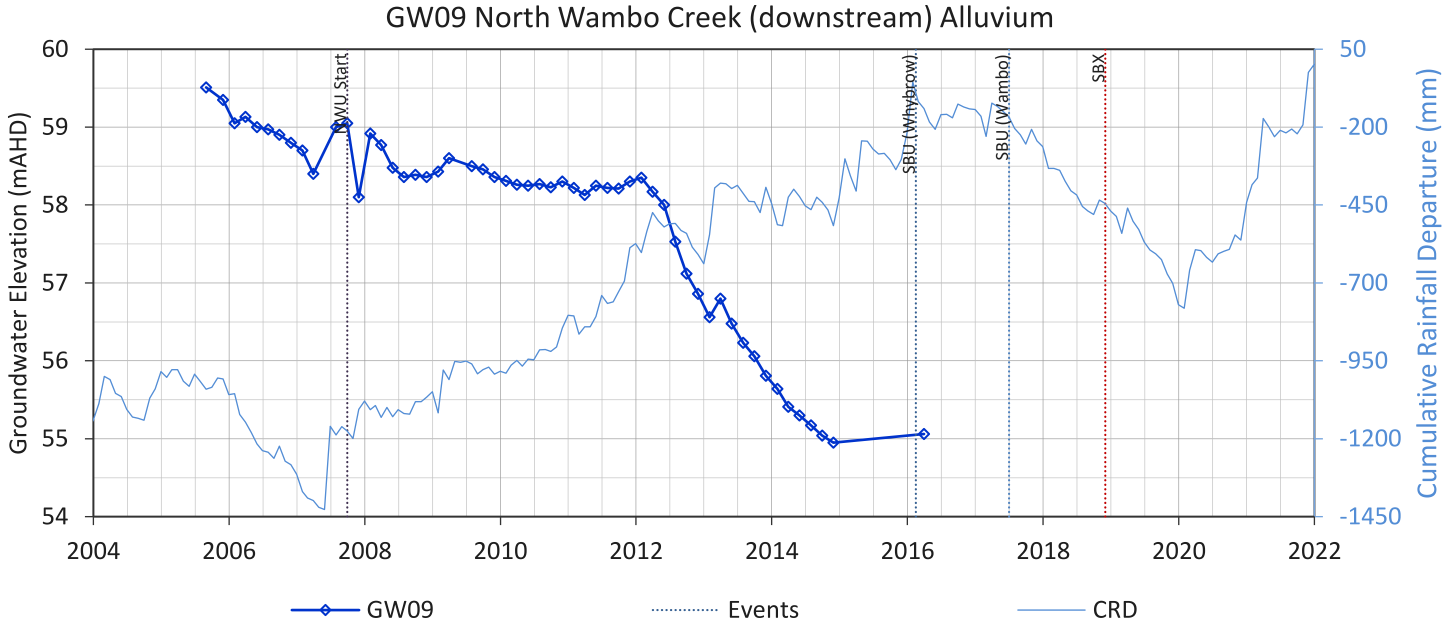

P330A Hunter River Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P330A
Events
CRD

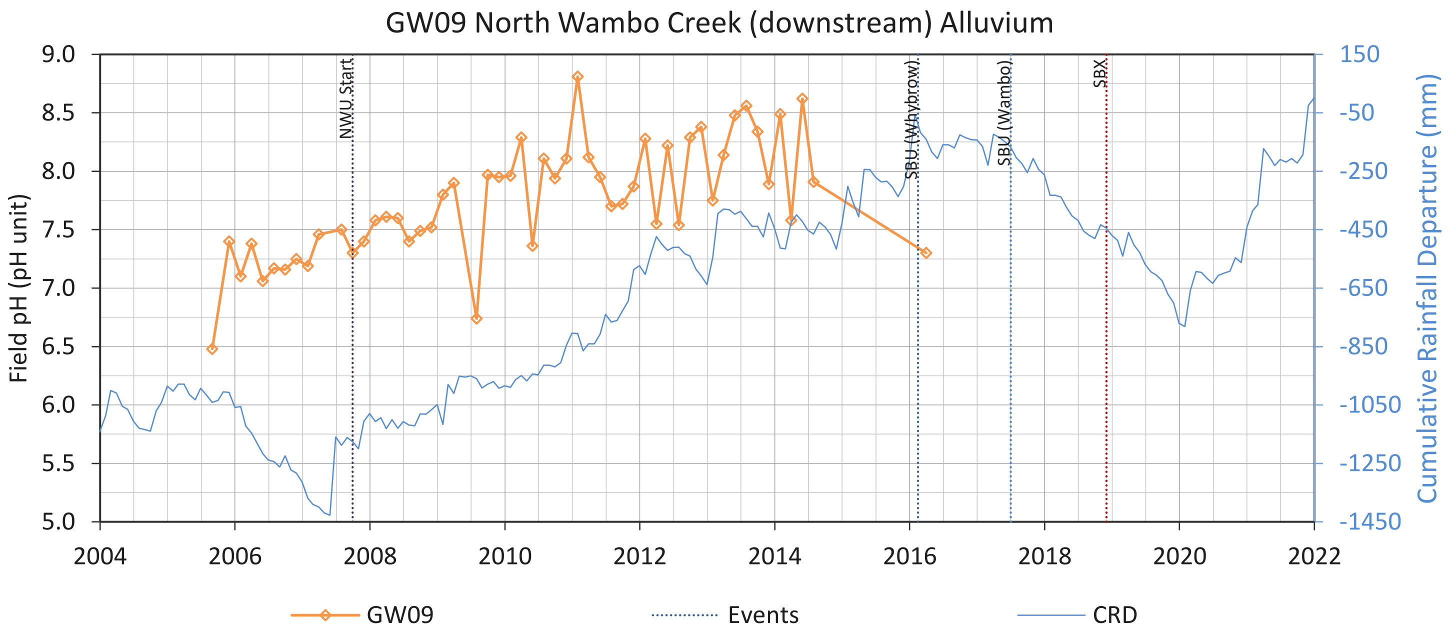

P330A Hunter River Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P330A
Events
CRD

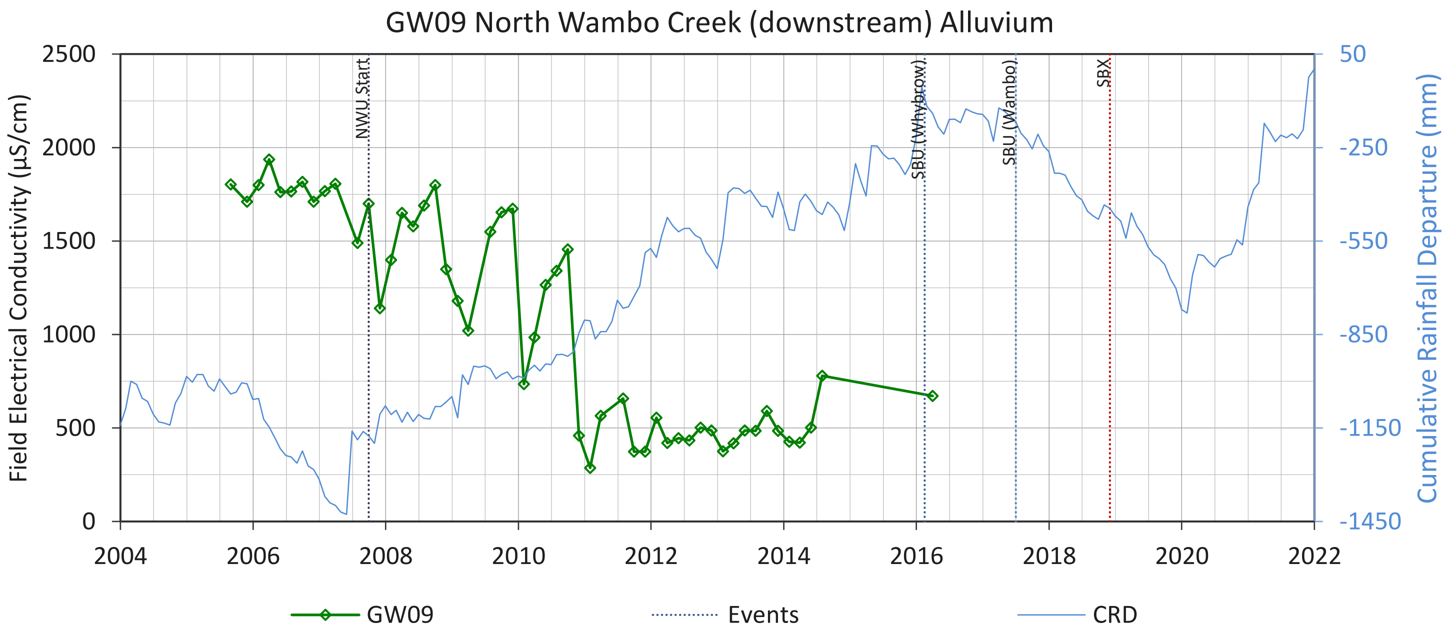

GW08 North Wambo Creek (downstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW08
Events
CRD

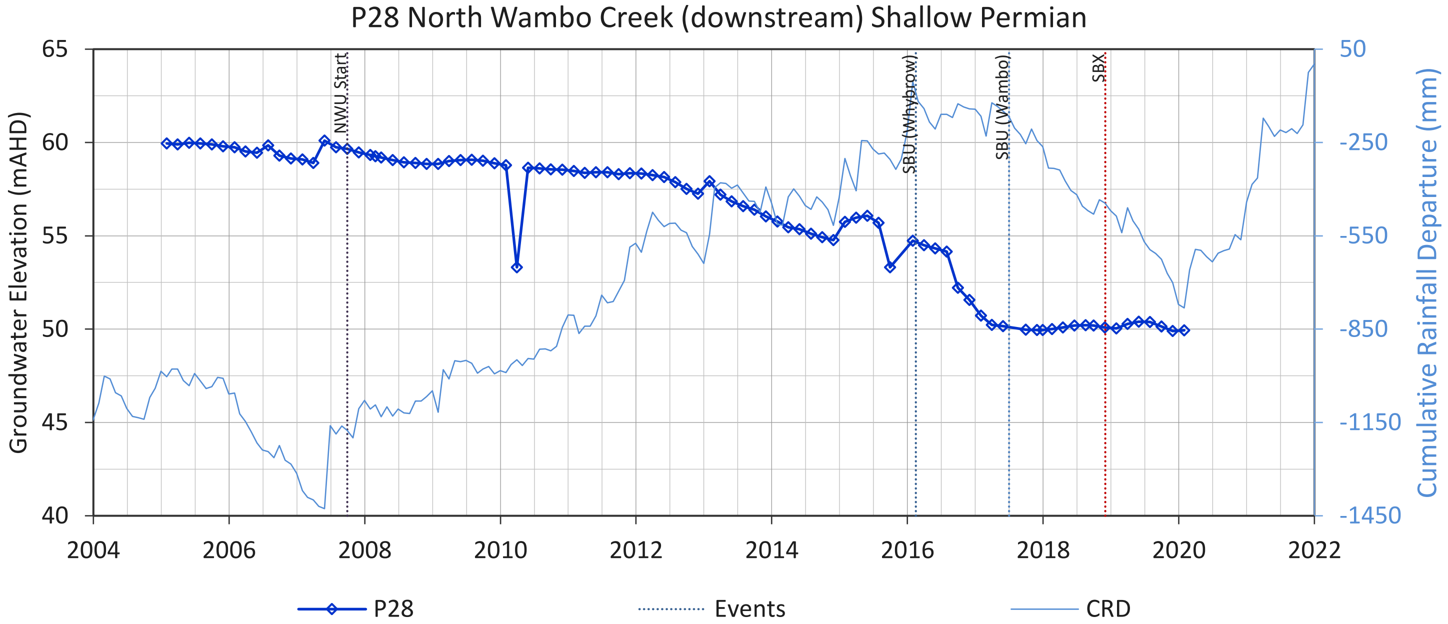

GW08 North Wambo Creek (downstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW08
Events
CRD

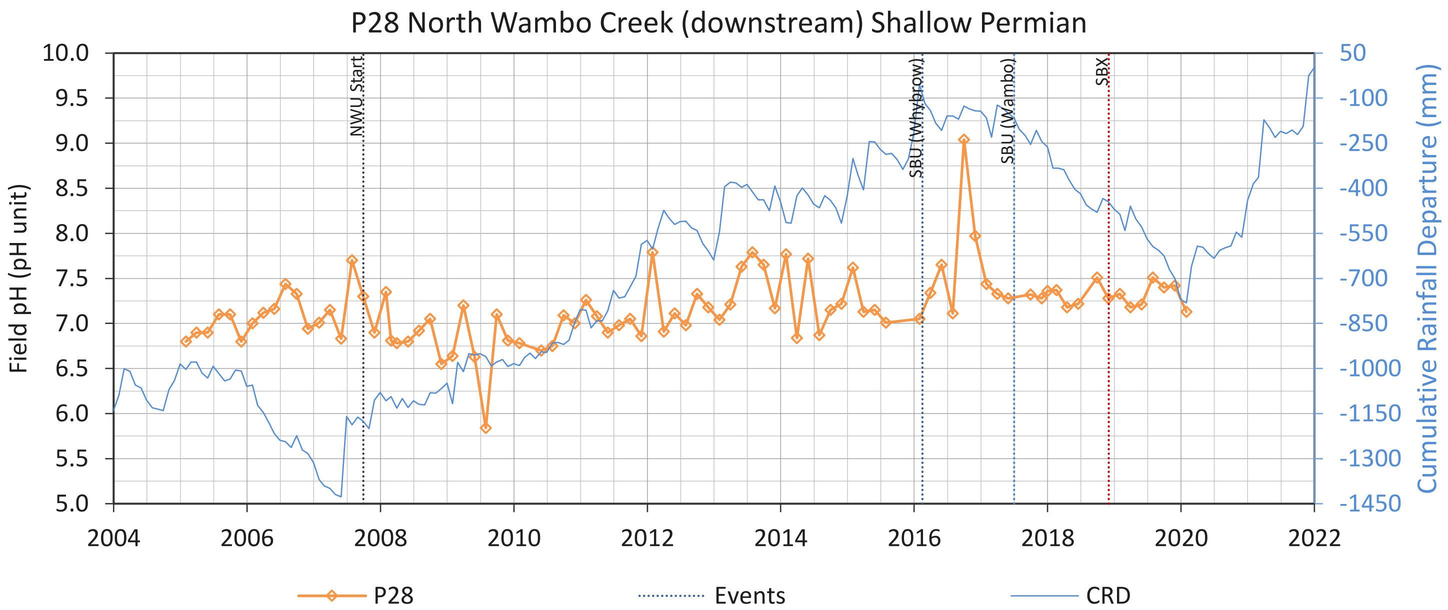

GW08 North Wambo Creek (downstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW08
Events
CRD

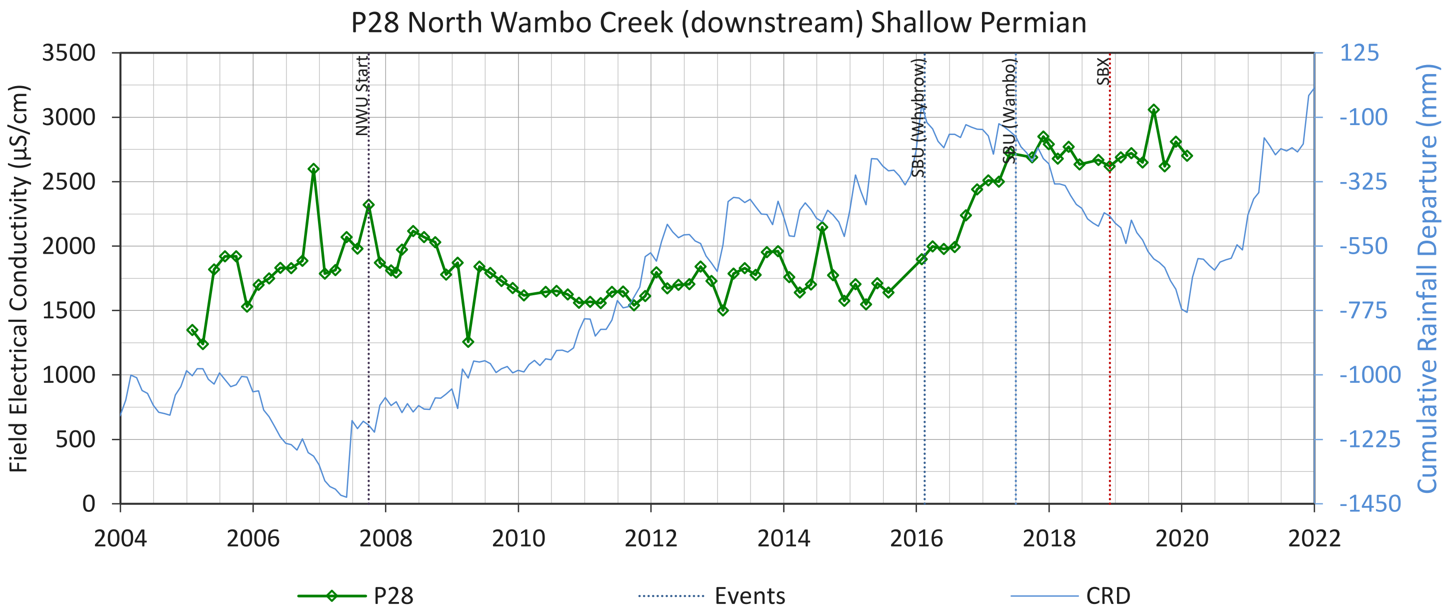

GW09 North Wambo Creek (downstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
60
59
58
57
56
55
54
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW09
Events
CRD

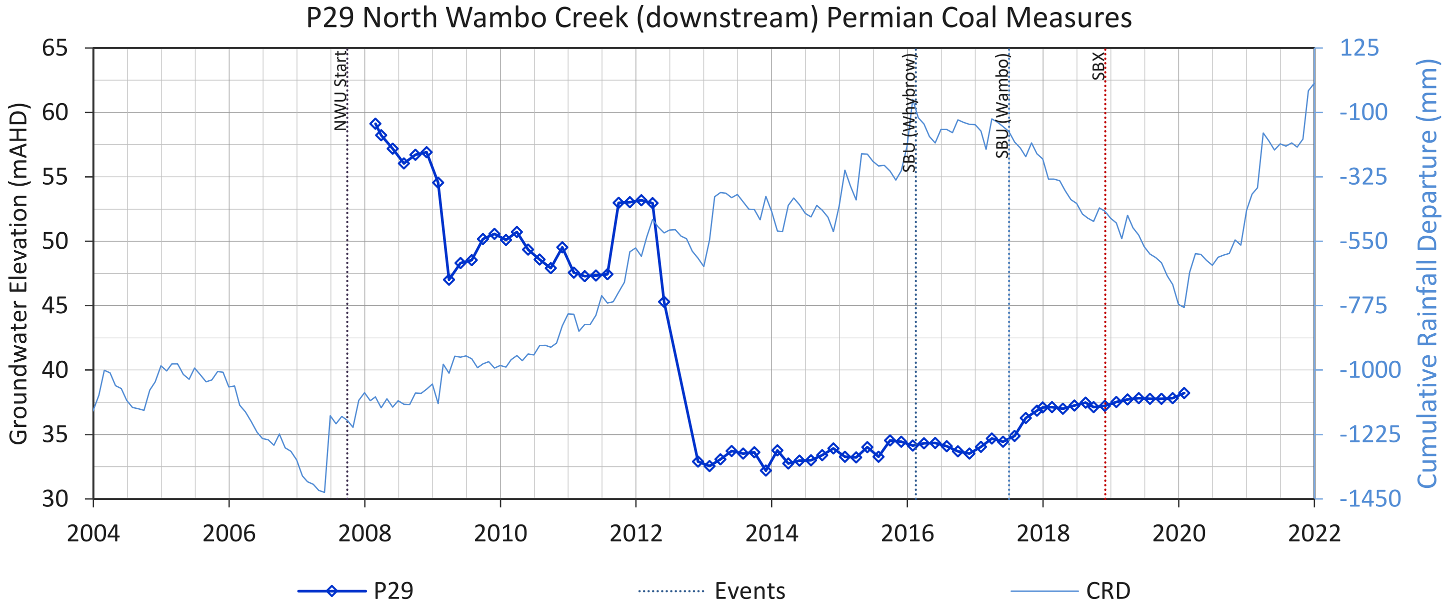

GW09 North Wambo Creek (downstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW09
Events
CRD

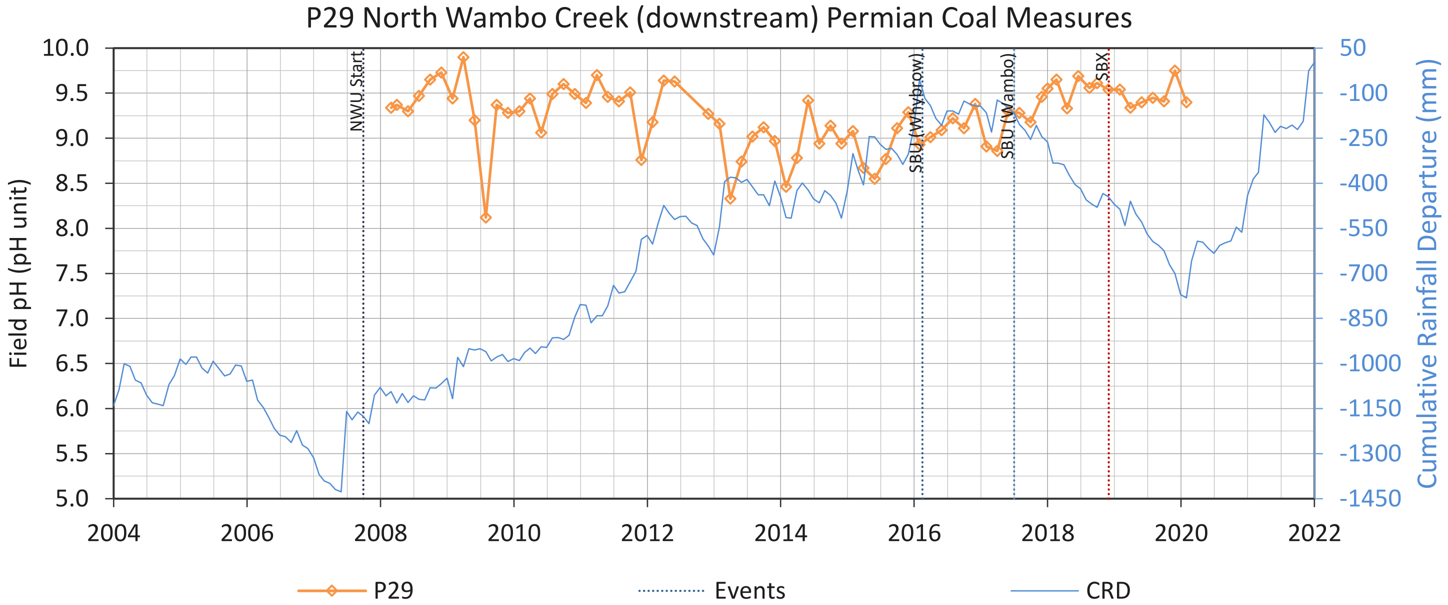

GW09 North Wambo Creek (downstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
2500
2000
1500
1000
500
0
50
-250
-550
-850
-1150
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW09
Events
CRD

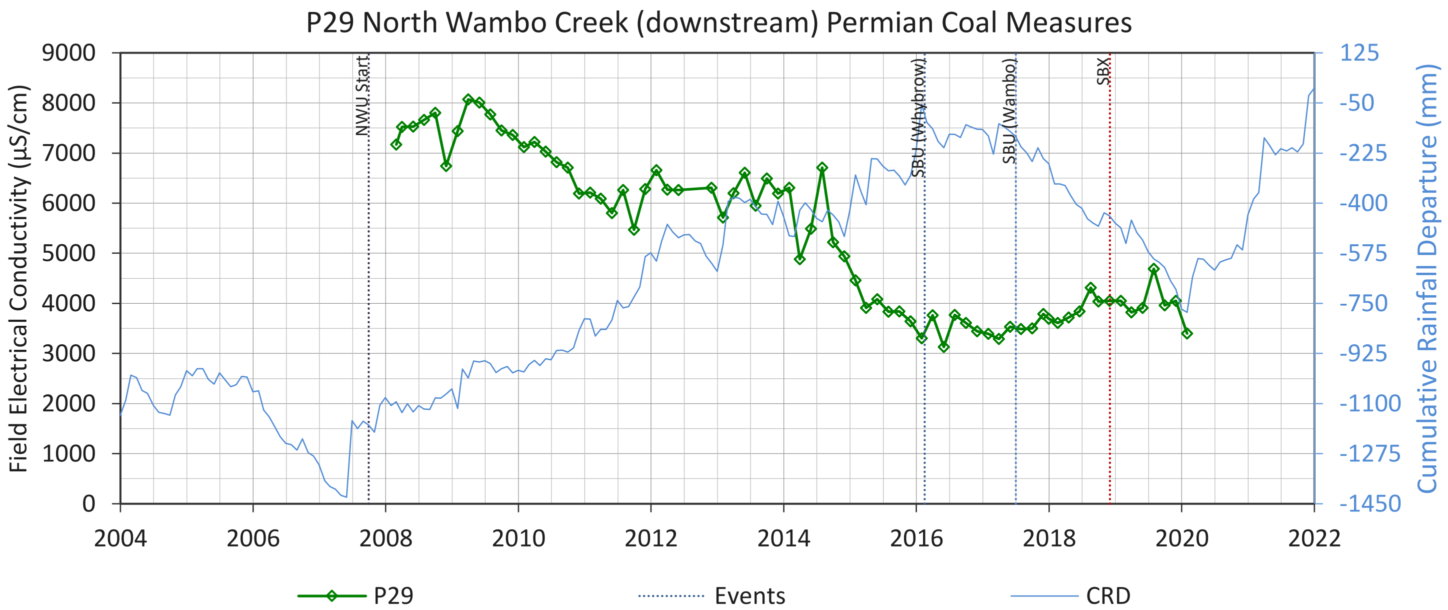

P28 North Wambo Creek (downstream) Shallow Permian
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P28
Events
CRD

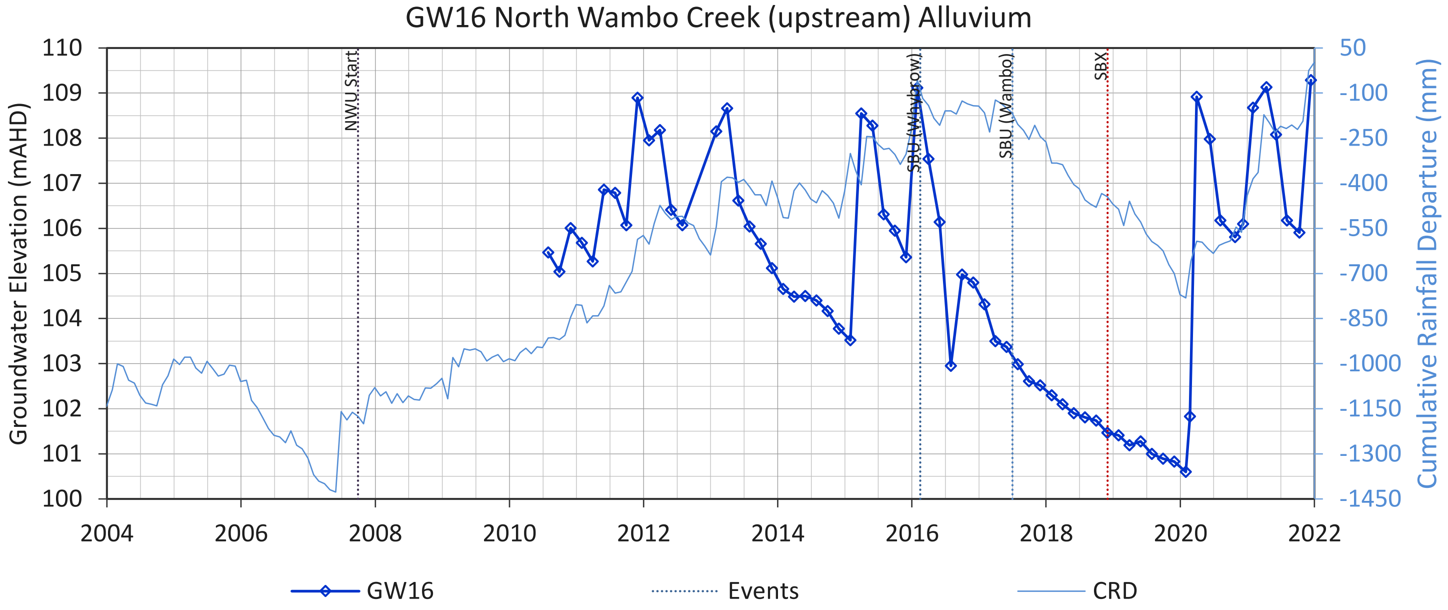

P28 North Wambo Creek (downstream) Shallow Permian
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P28
Events
CRD

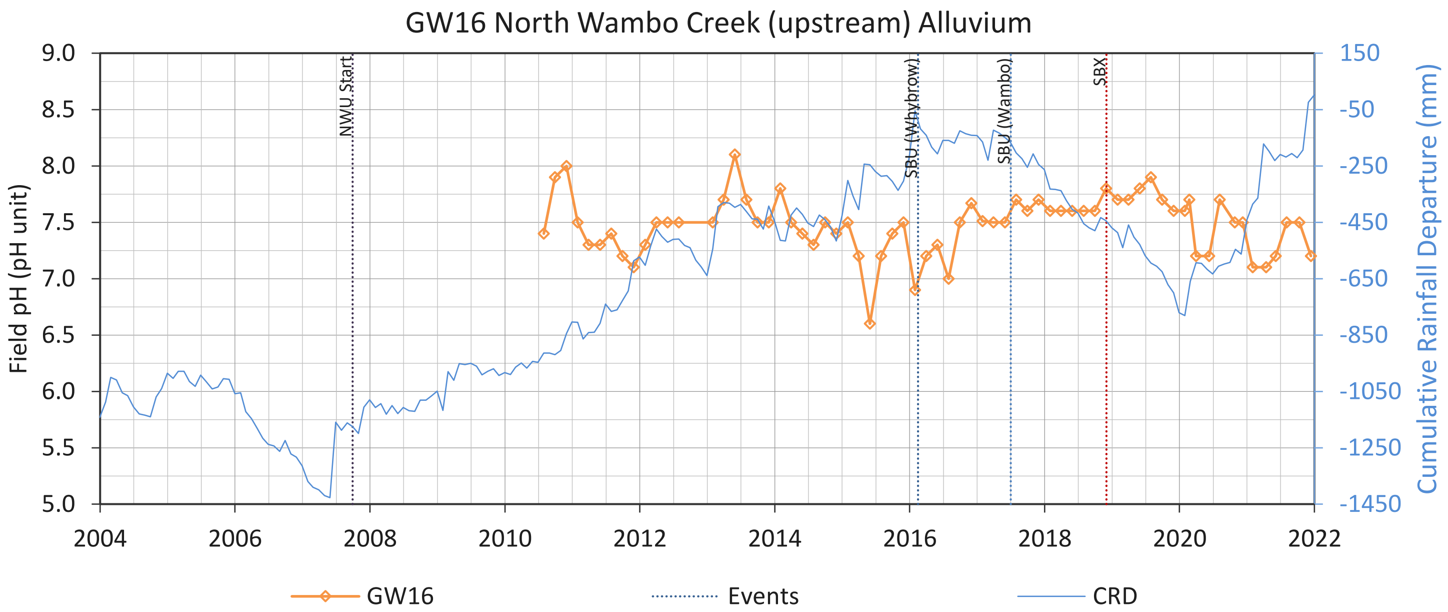

P28 North Wambo Creek (downstream) Shallow Permian
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P28
Events
CRD

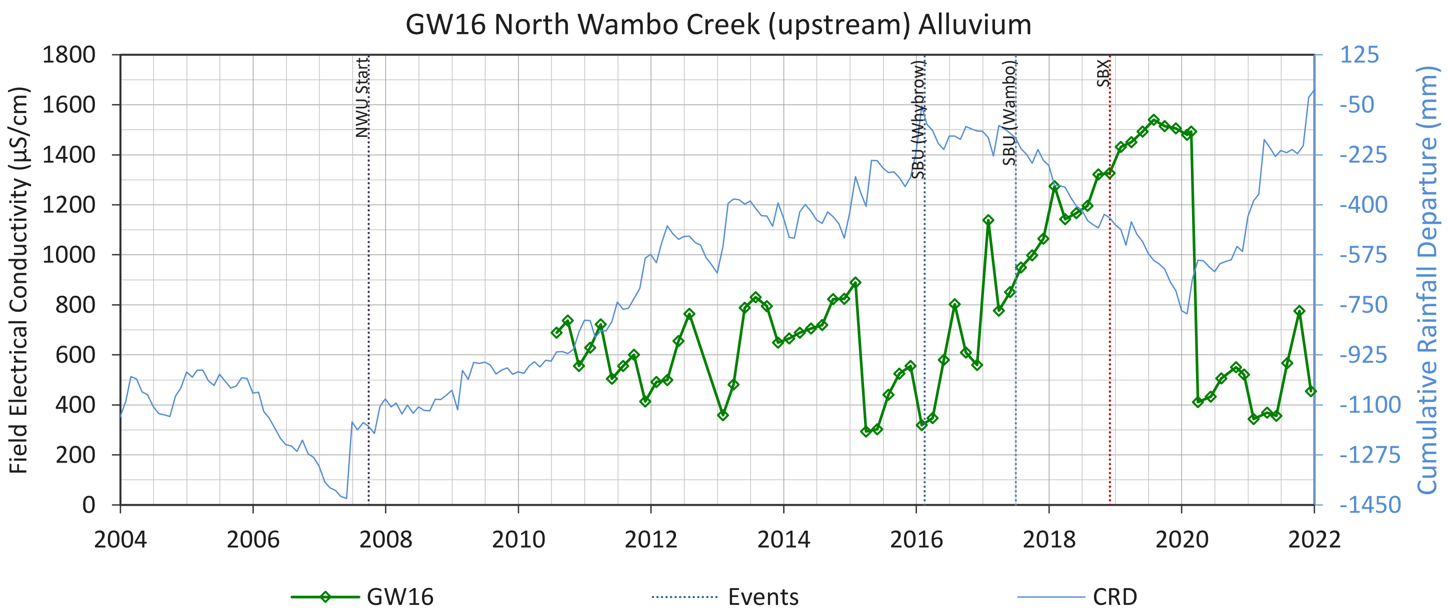

P29 North Wambo Creek (downstream) Permian Coal Measures
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P29
Events
CRD

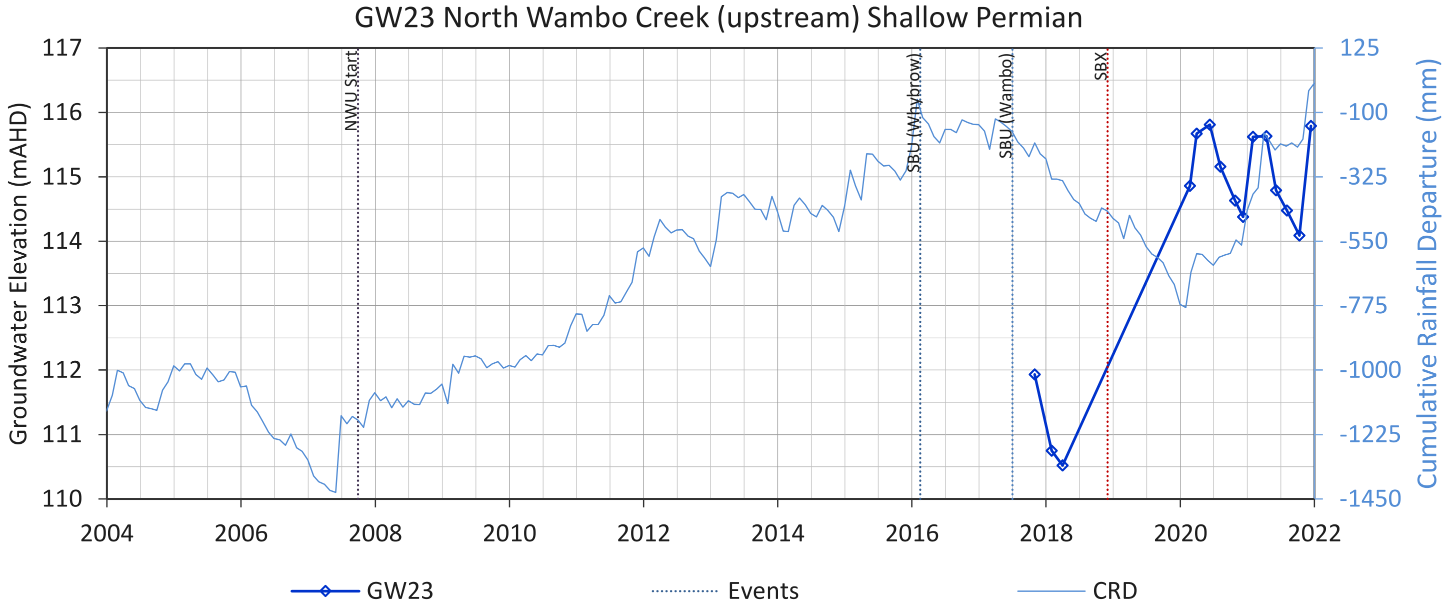

P29 North Wambo Creek (downstream) Permian Coal Measures
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P29
Events
CRD

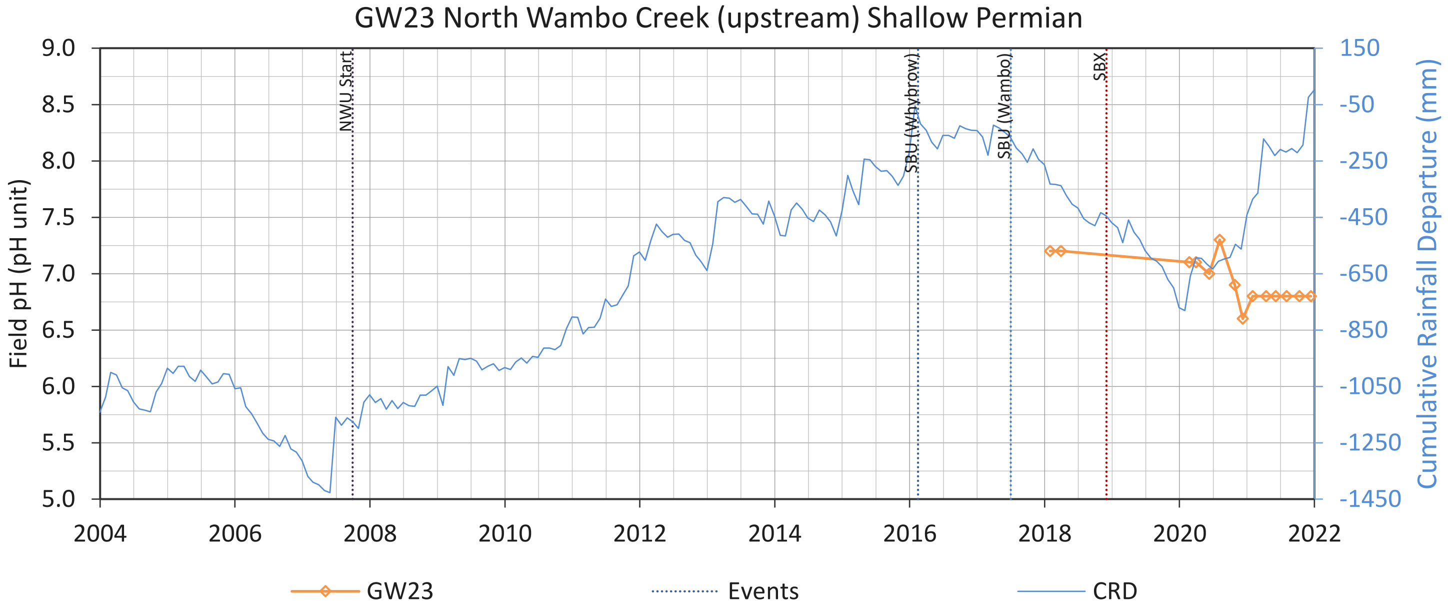

P29 North Wambo Creek (downstream) Permian Coal Measures
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P29
Events
CRD

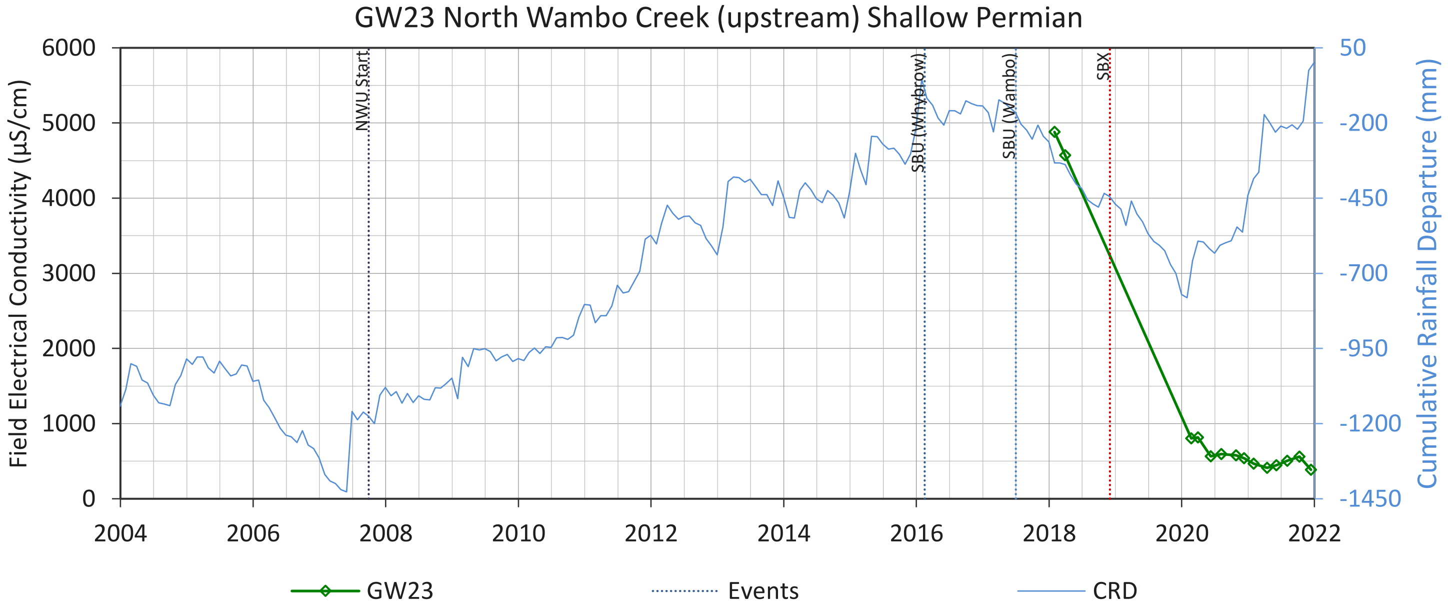

GW16 North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW16
Events
CRD

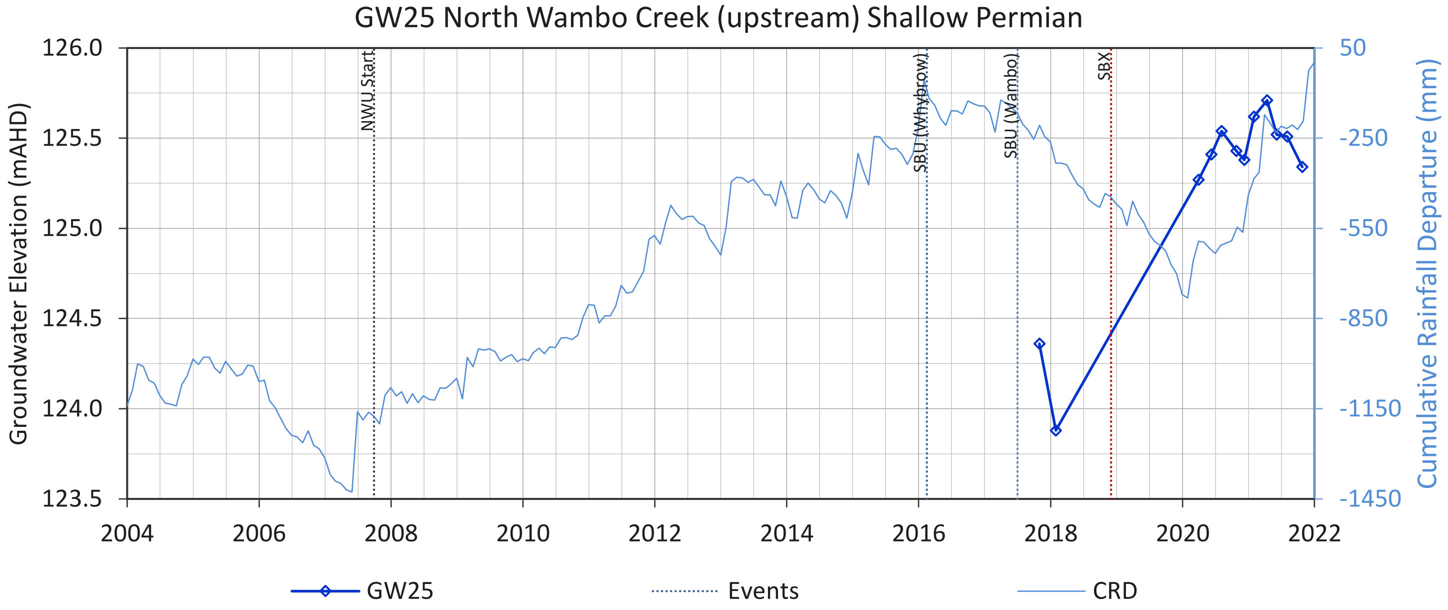

GW16 North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW16
Events
CRD

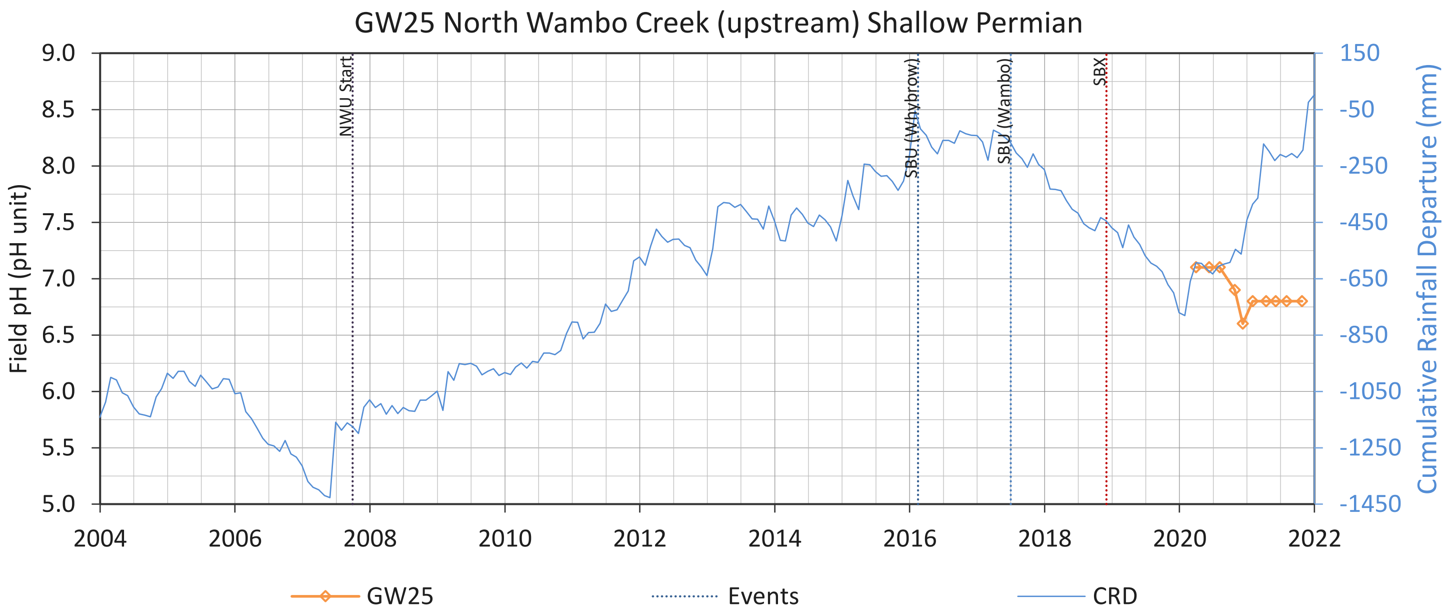

GW16 North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW16
Events
CRD

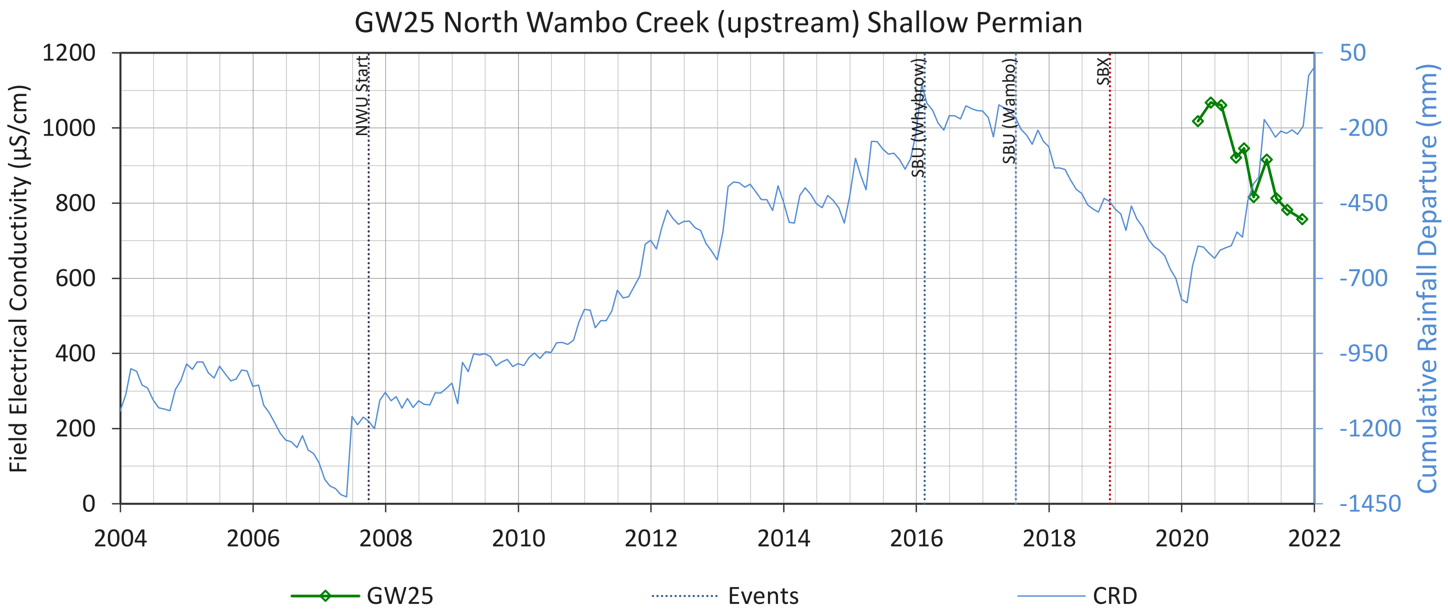

GW23 North Wambo Creek (upstream) Shallow Permian
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW23
Events
CRD

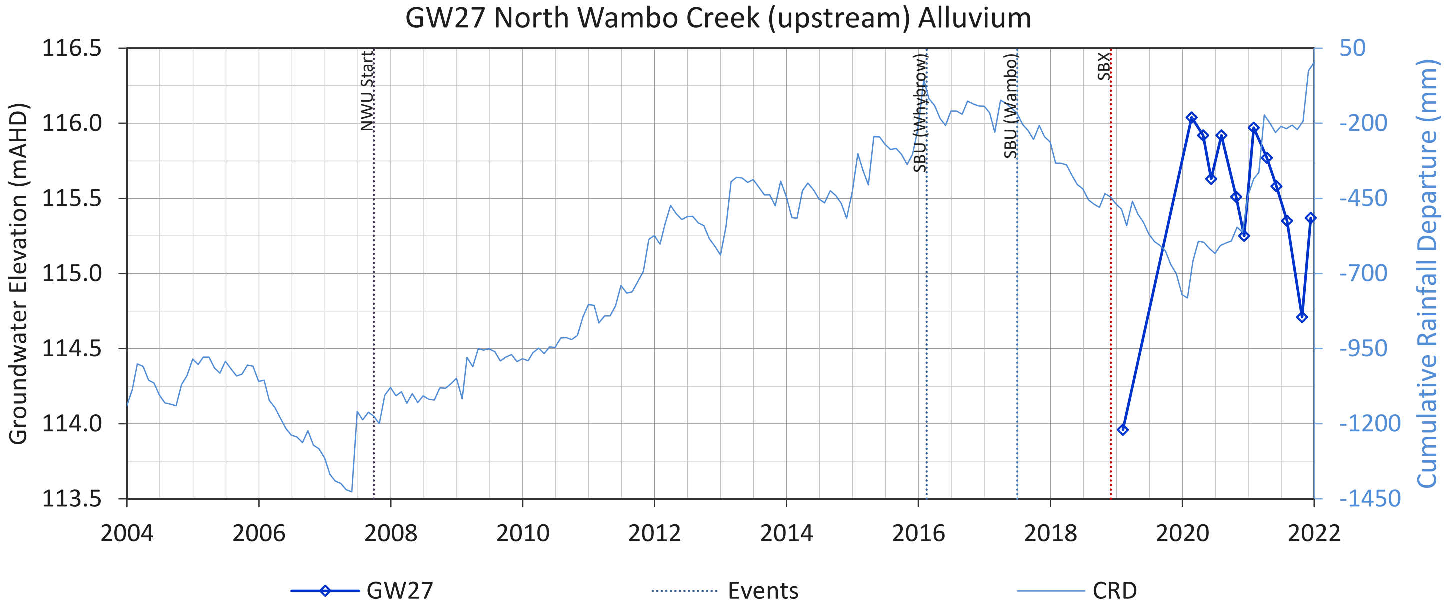

GW23 North Wambo Creek (upstream) Shallow Permian
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW23
Events
CRD

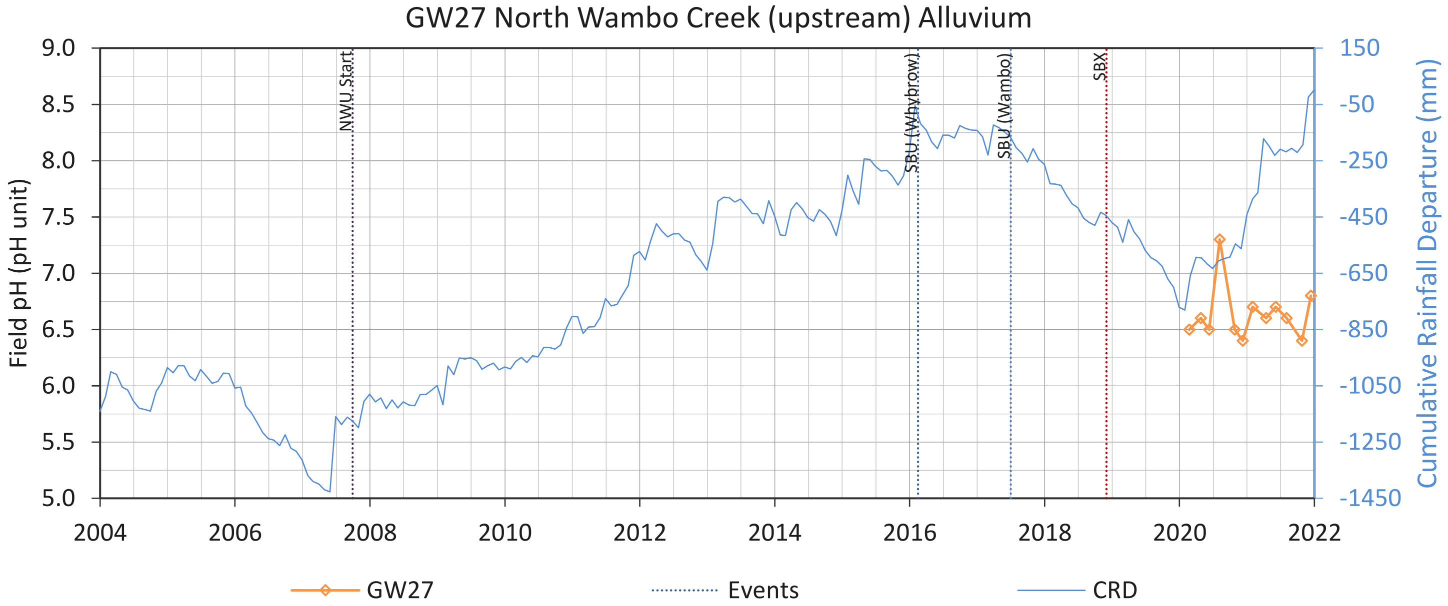

GW23 North Wambo Creek (upstream) Shallow Permian
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW23
Events
CRD

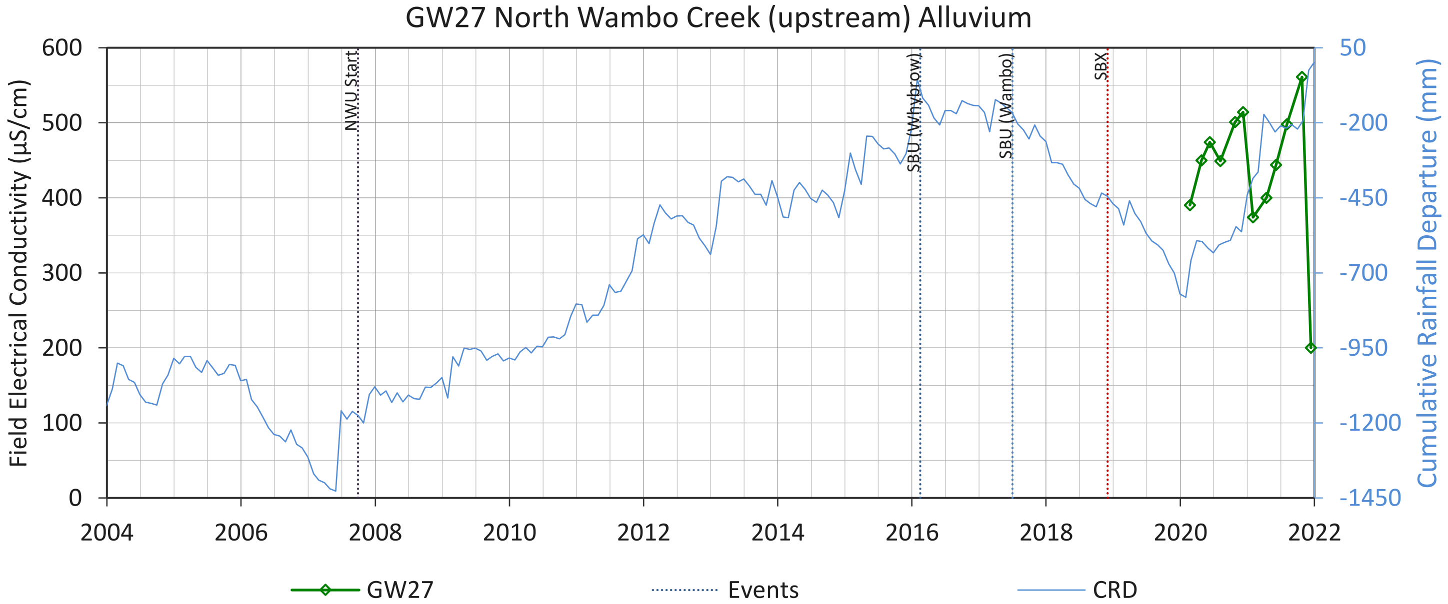

GW25 North Wambo Creek (upstream) Shallow Permian
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
126.0
125.5
125.0
124.5
124.0
123.5
50
-250
-550
-850
-1150
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW25
Events
CRD

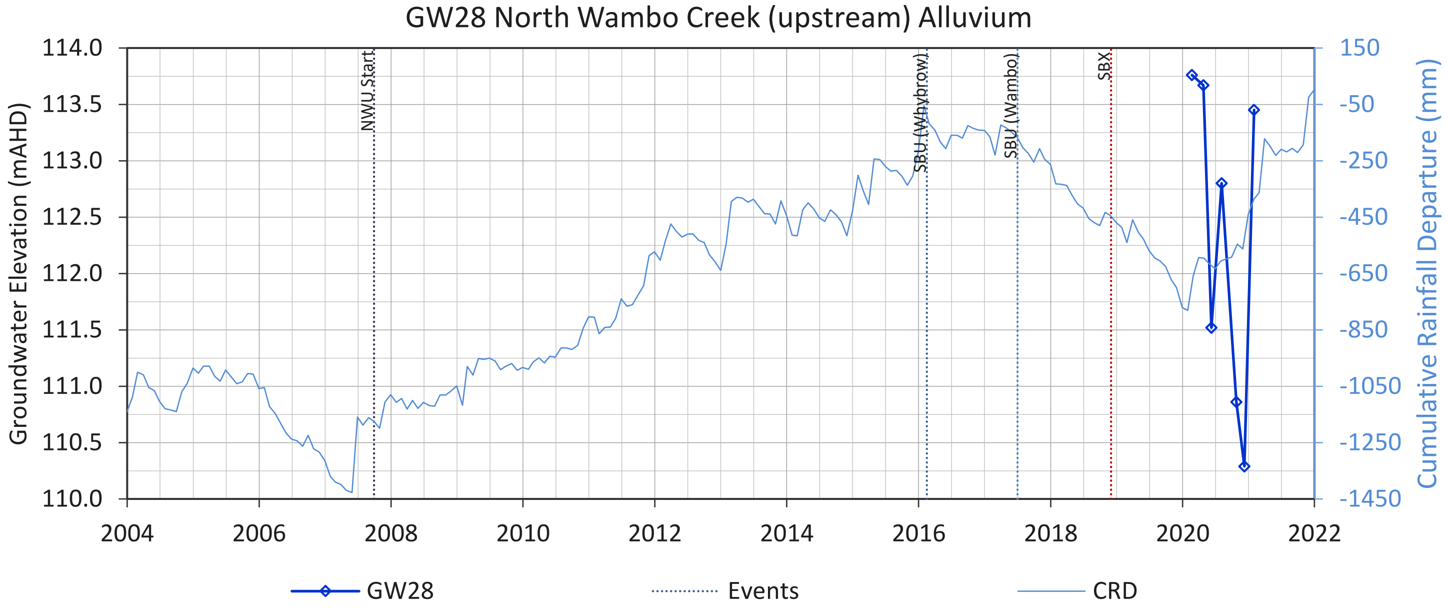

GW25 North Wambo Creek (upstream) Shallow Permian
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW25
Events
CRD

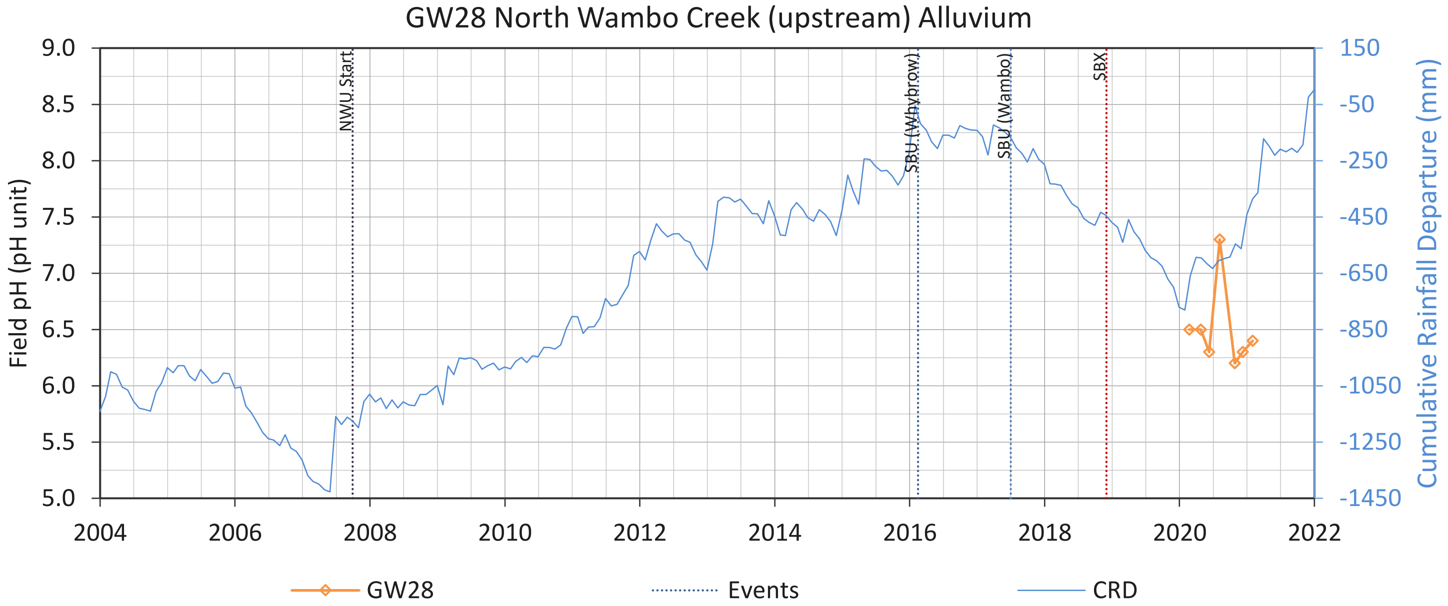

GW25 North Wambo Creek (upstream) Shallow Permian
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
1200
1000
800
600
400
200
0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW25
Events
CRD

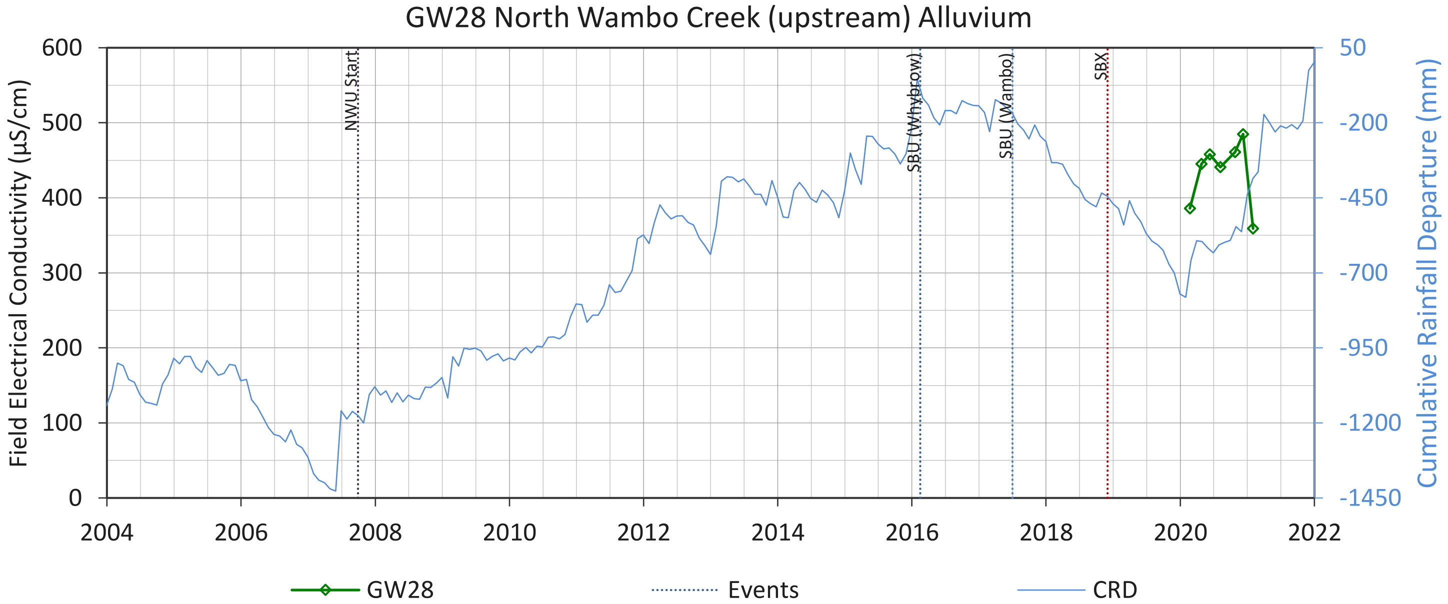

GW27 North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
116.5
116.0
115.5
115.0
114.5
114.0
113.5
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW27
Events
CRD

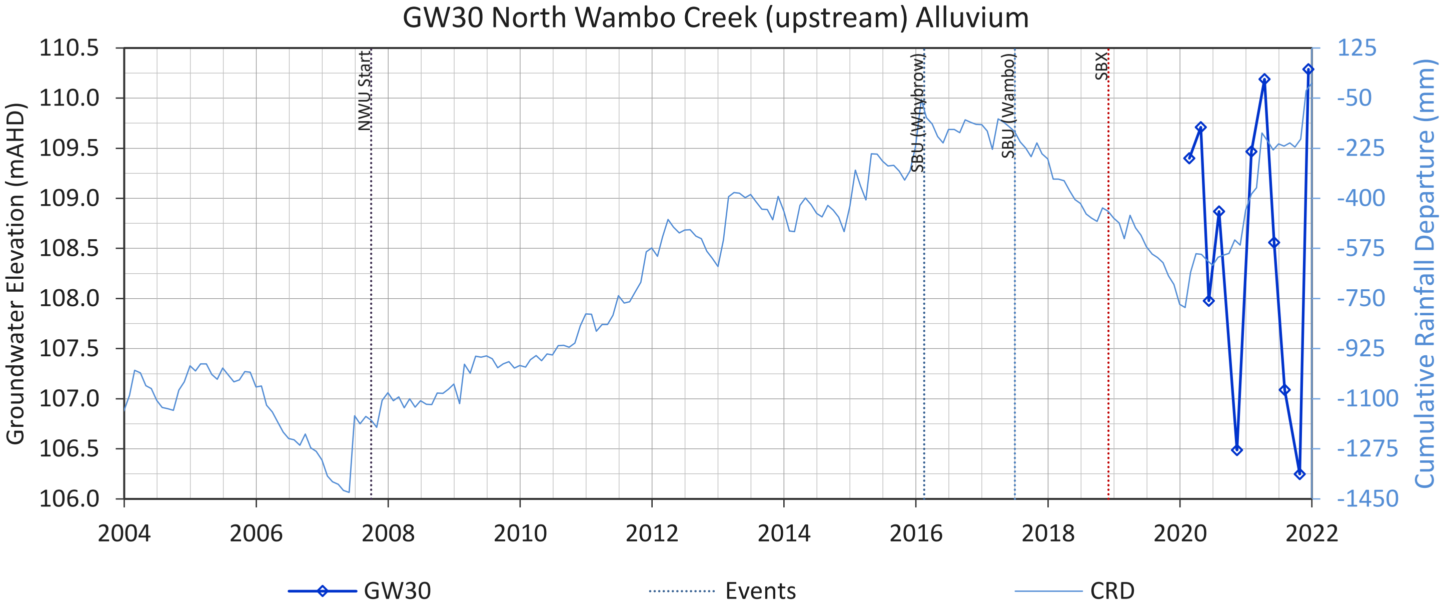

GW27 North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW27
Events
CRD

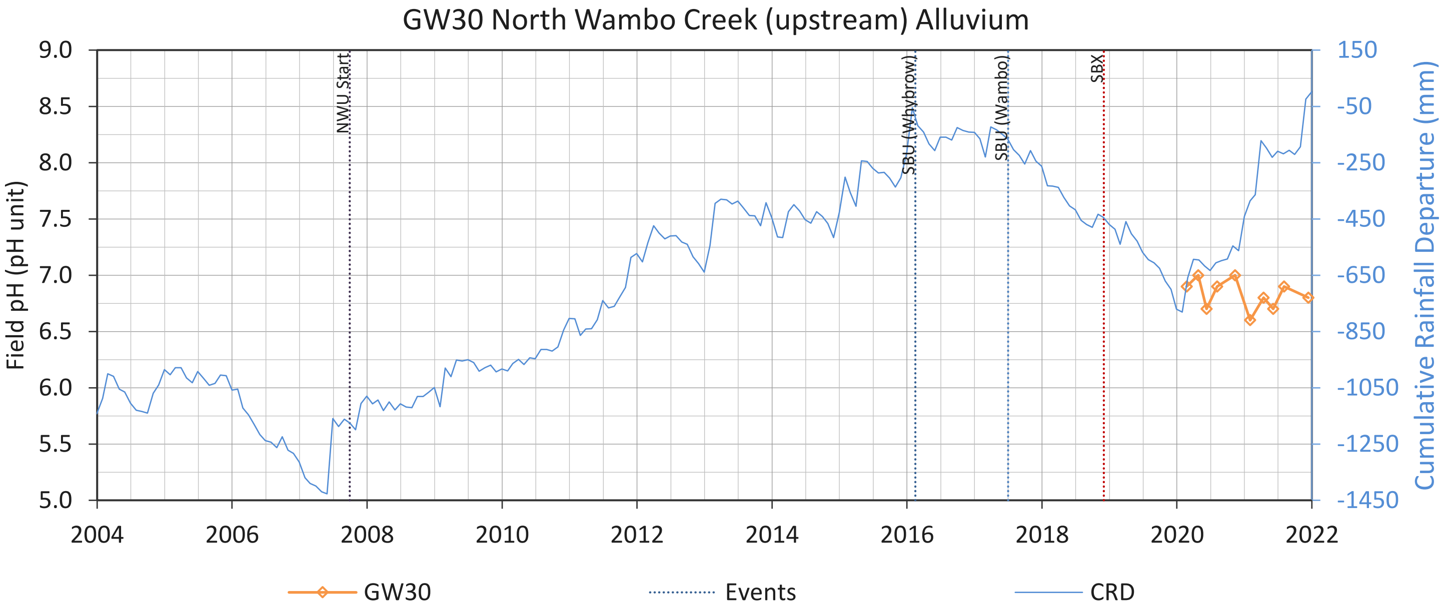

GW27 North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
600
500
400
300
200
100
0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW27
Events
CRD

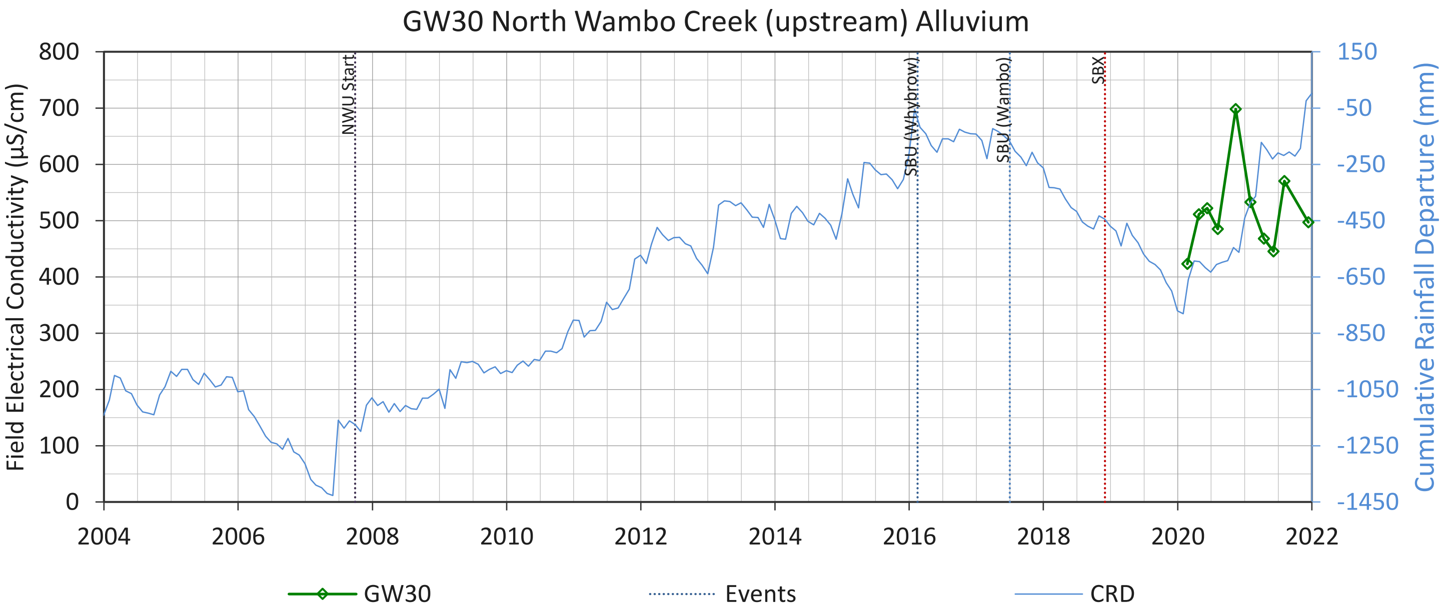

GW28 North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW28
Events
CRD

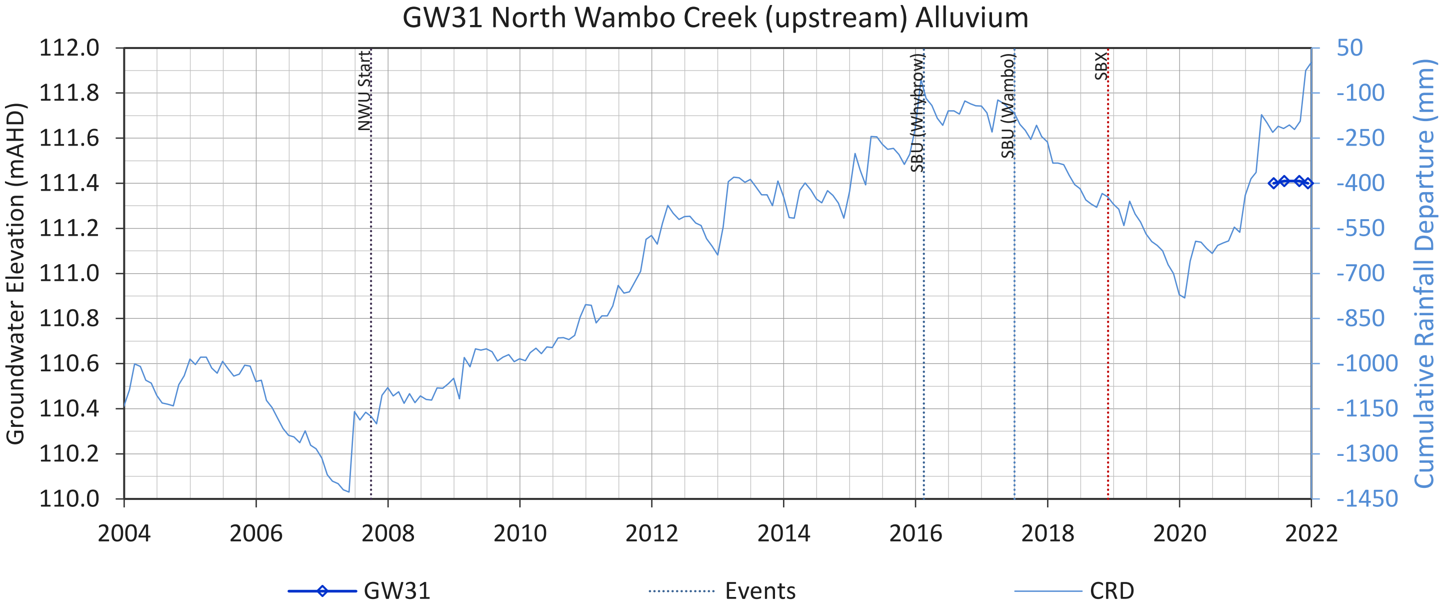

GW28 North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW28
Events
CRD


GW28 North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW28
Events
CRD


GW30 North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
110.5
110.0
109.5
109.0
108.5
108.0
107.5
107.0
106.5
106.0
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW30
Events
CRD

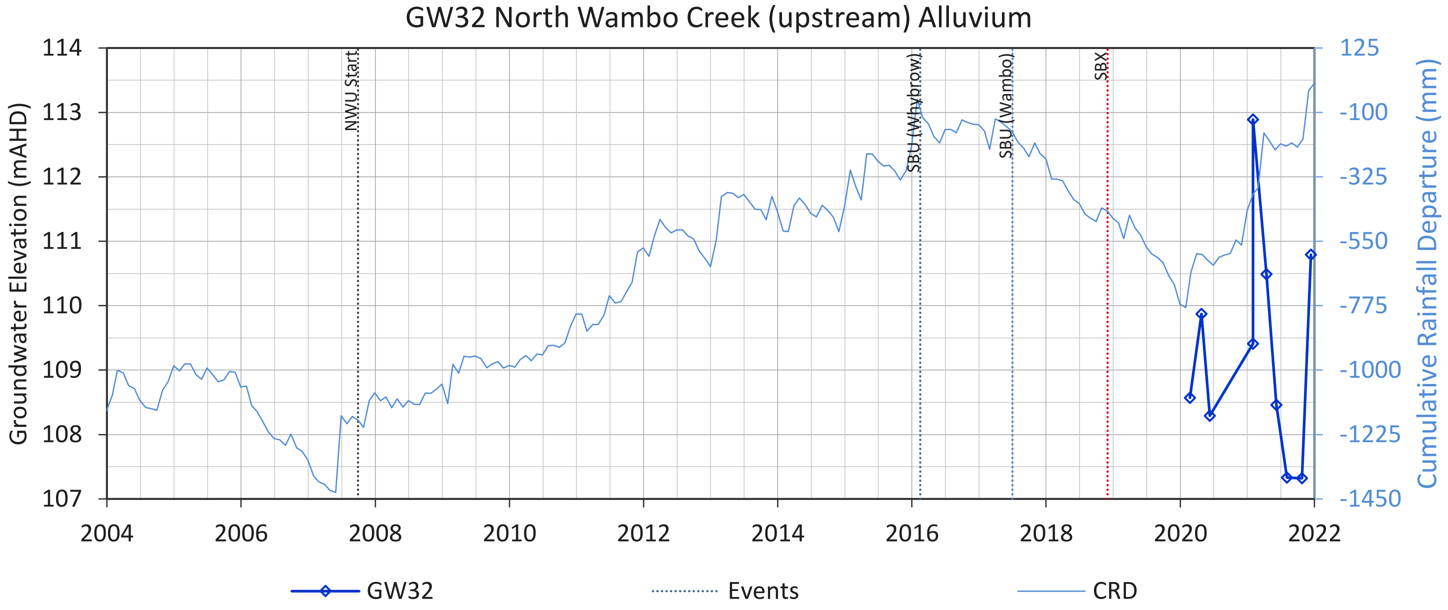

GW30 North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW30
Events
CRD

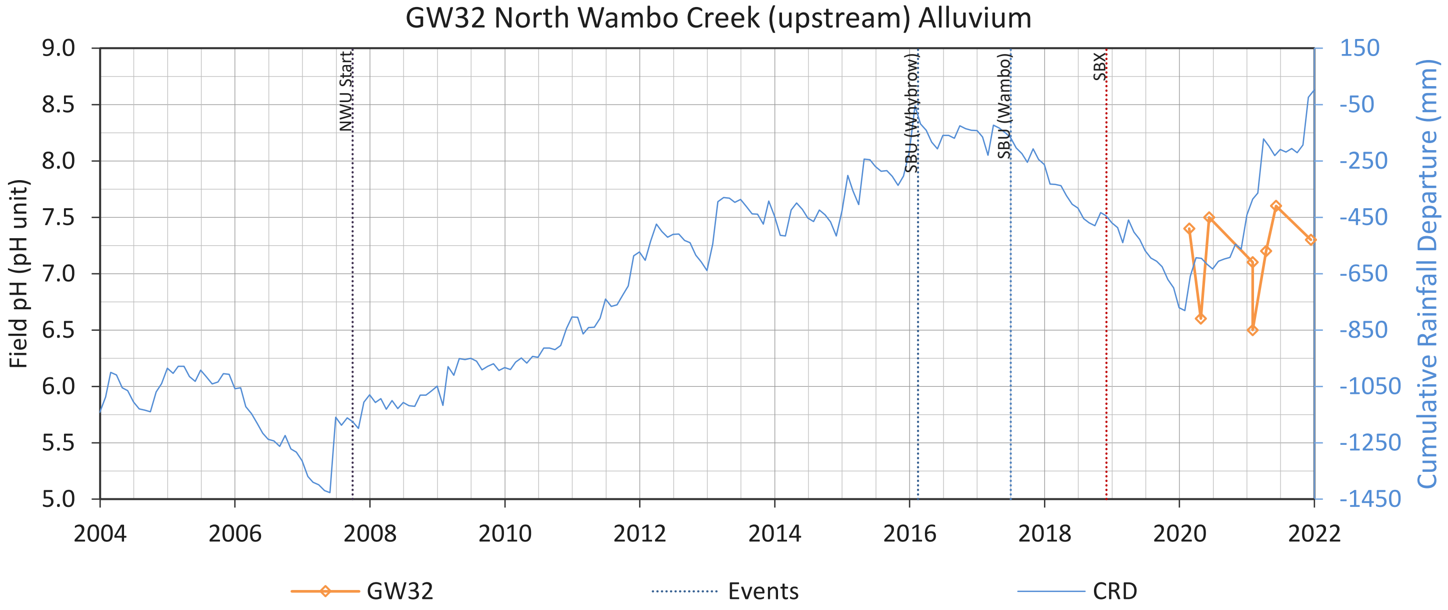

GW30 North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
800
700
600
500
400
300
200
100
0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW30
Events
CRD

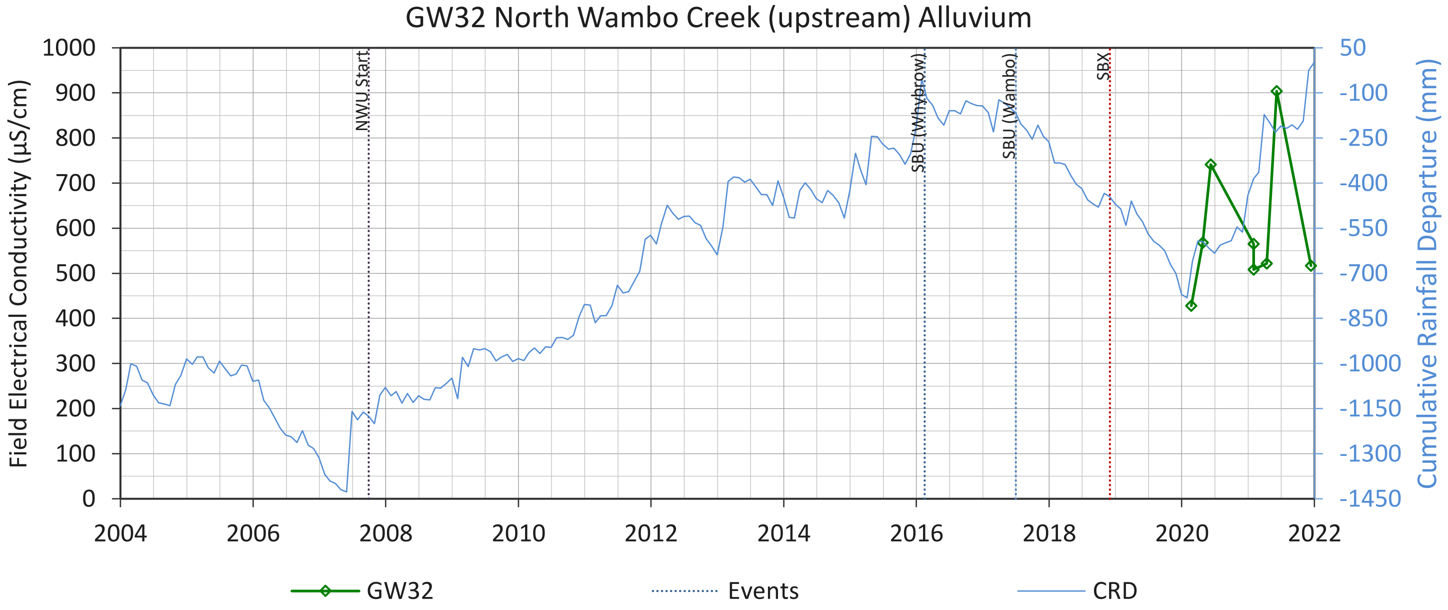


No Data Available for Field pH (pH unit)

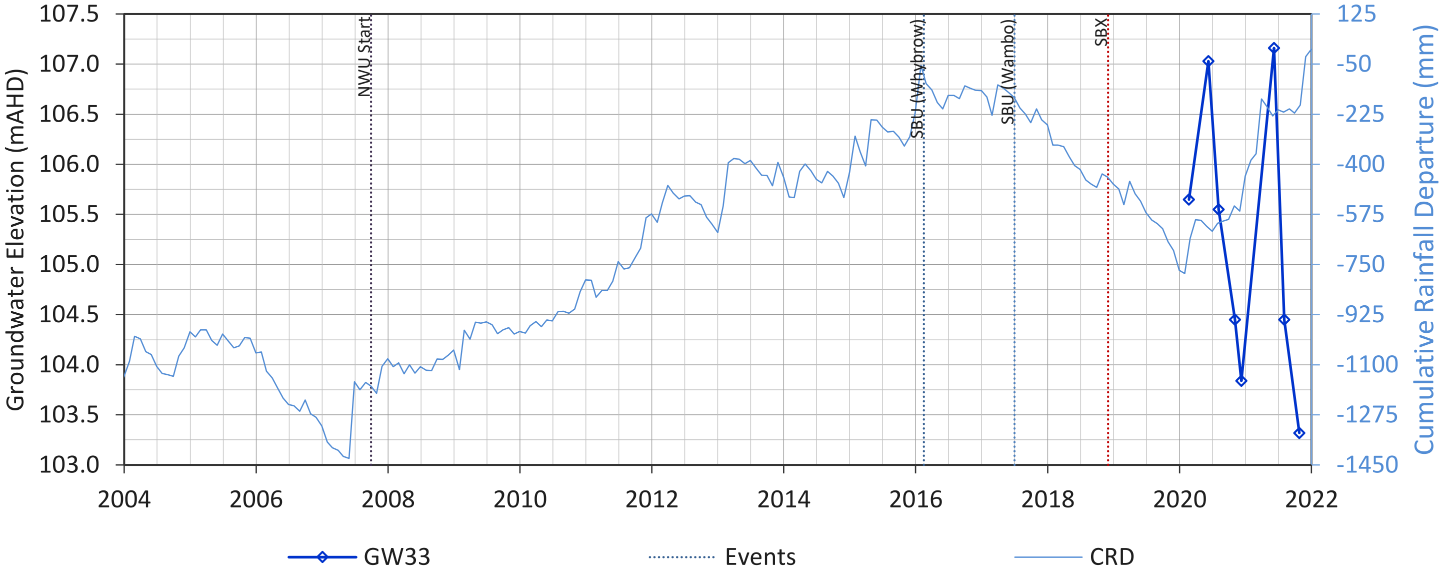
No Data Available for Field Electrical Conductivity (µS/cm)


GW32 North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWLI Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW32
Events
CRD

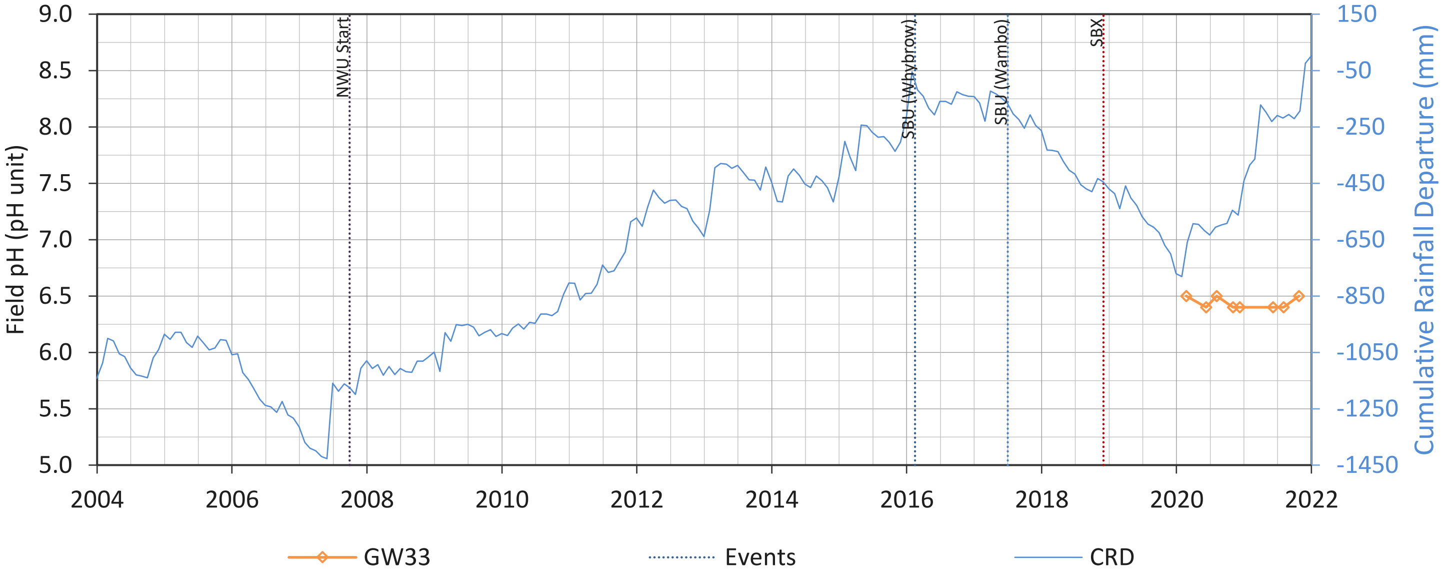

GW32 North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWLI Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW32
Events
CRD


GW32 North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWLI Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW32
Events
CRD

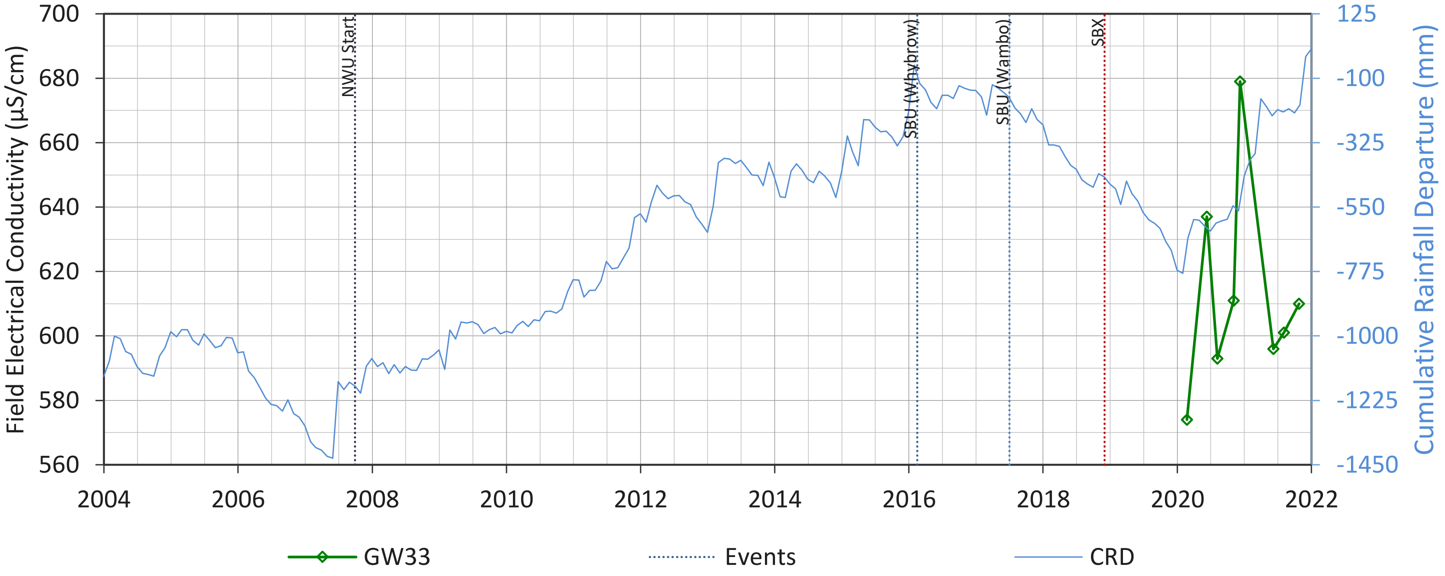
GW33 North Wambo Creek (upstream) Alluvium

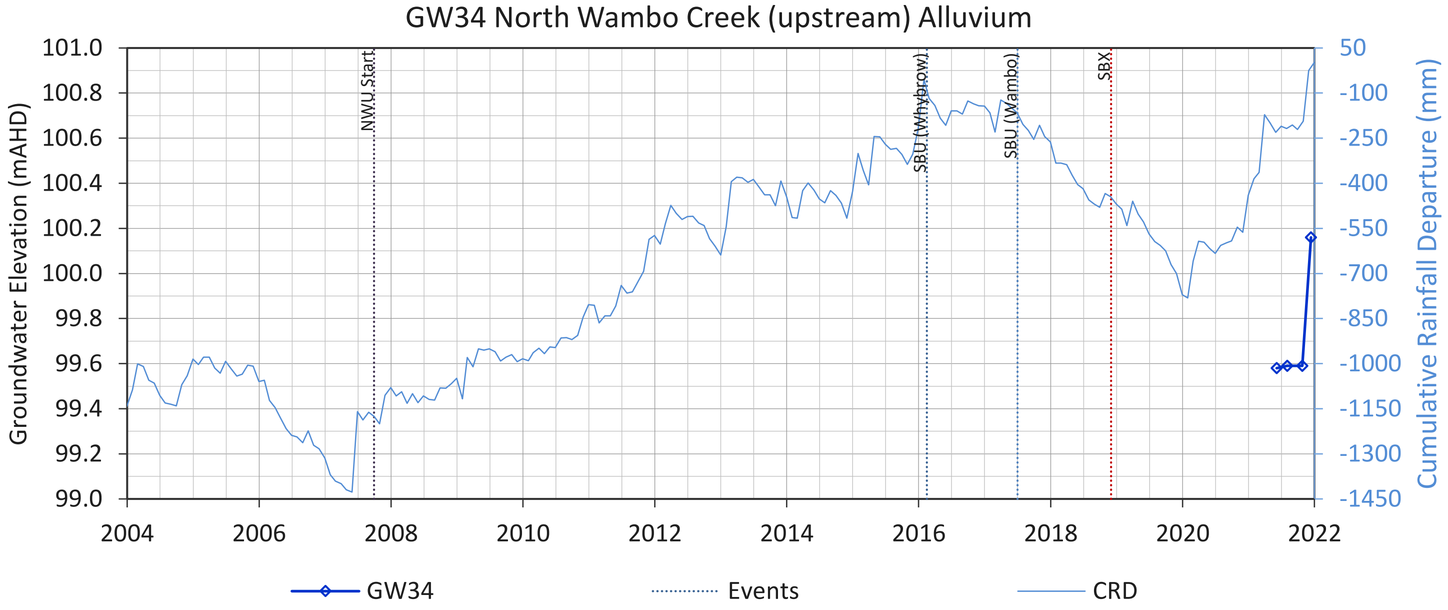


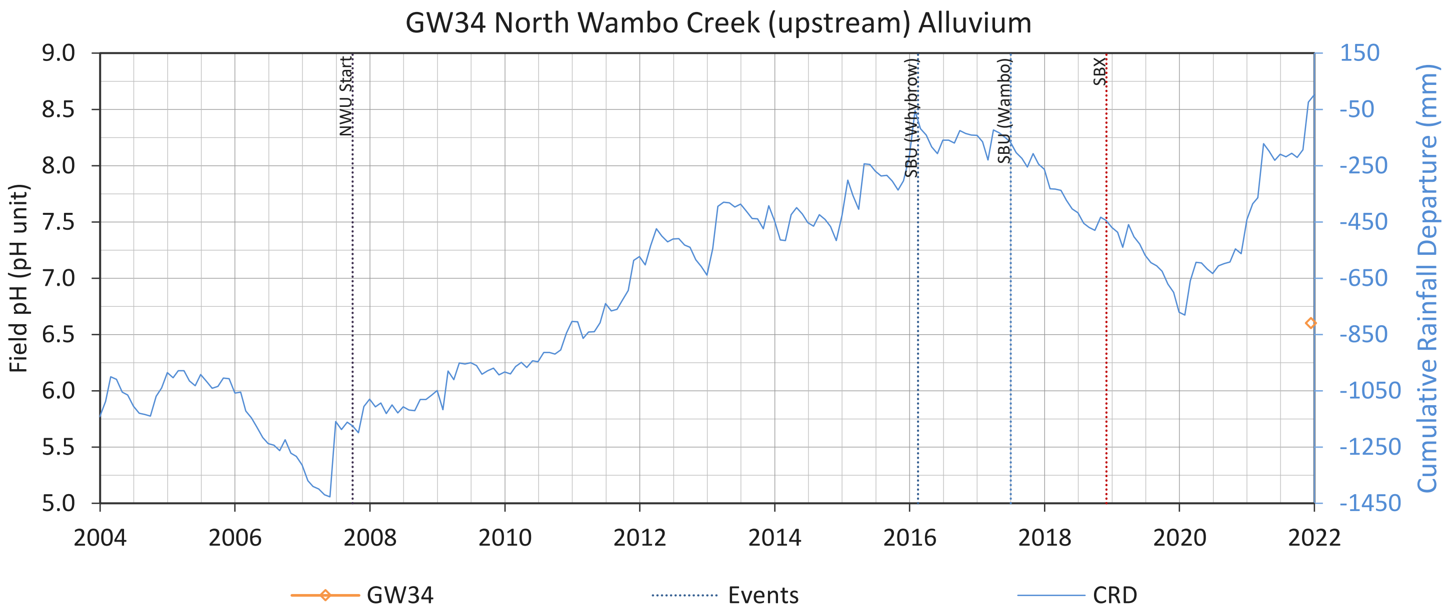
GW33 North Wambo Creek (upstream) Alluvium

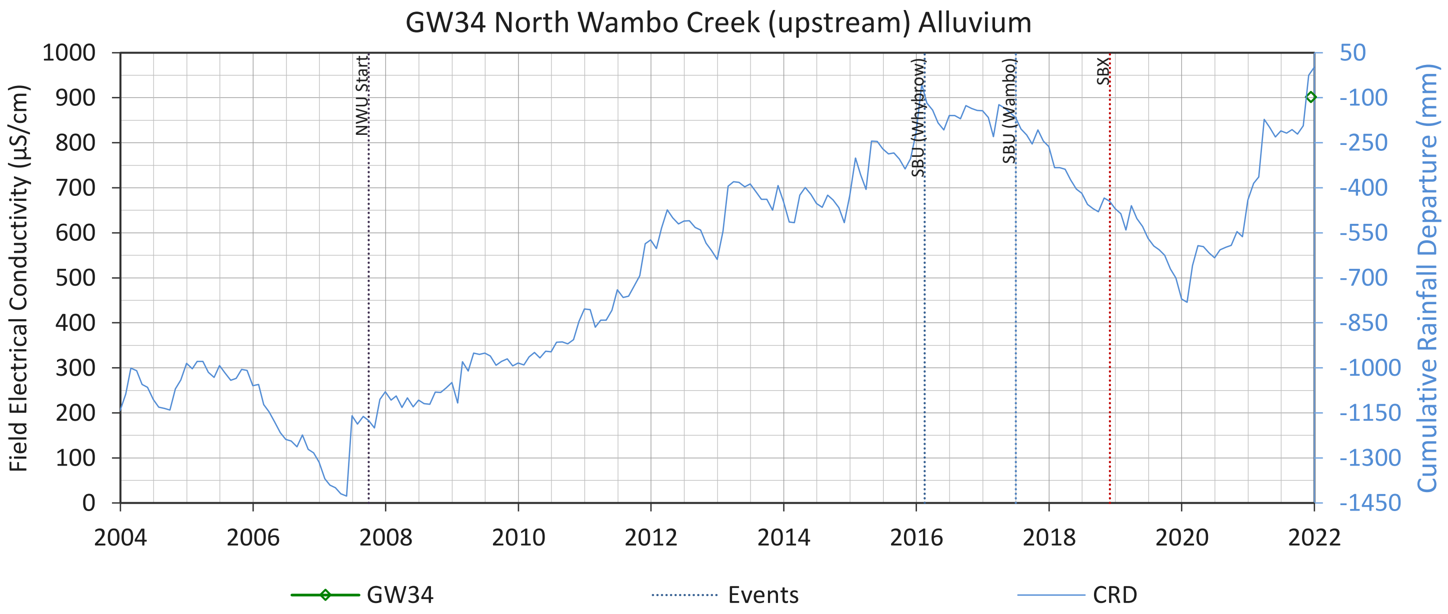


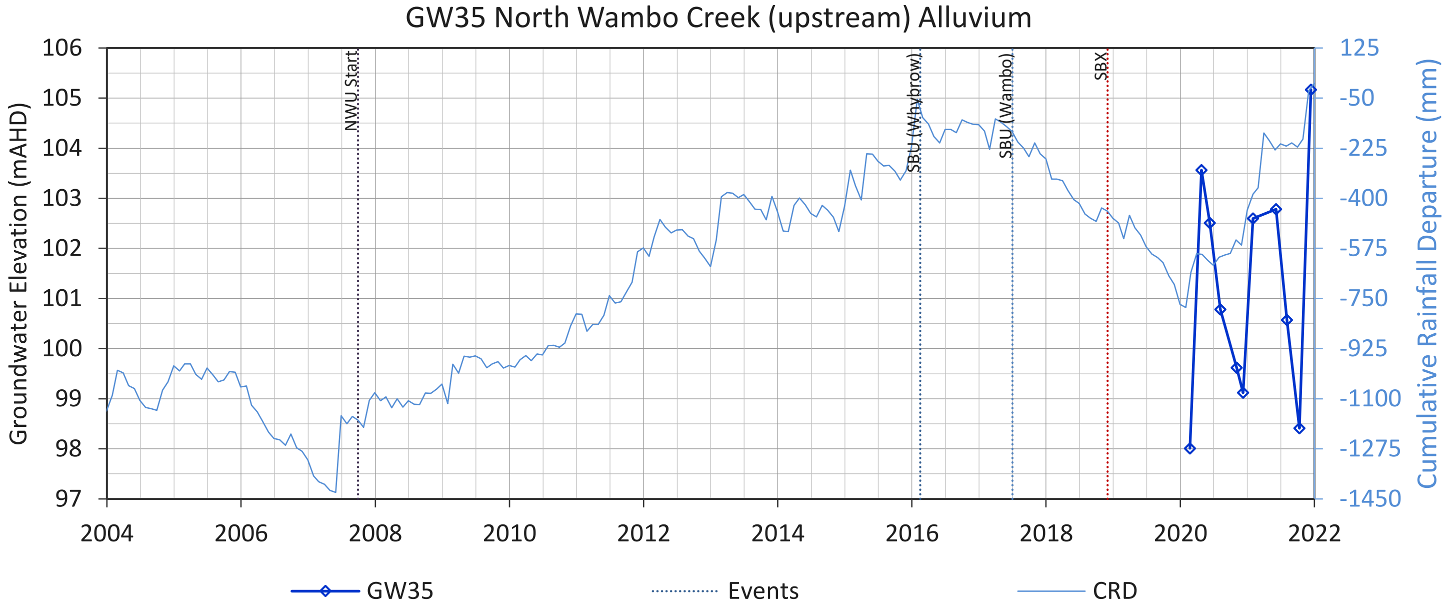
GW33 North Wambo Creek (upstream) Alluvium

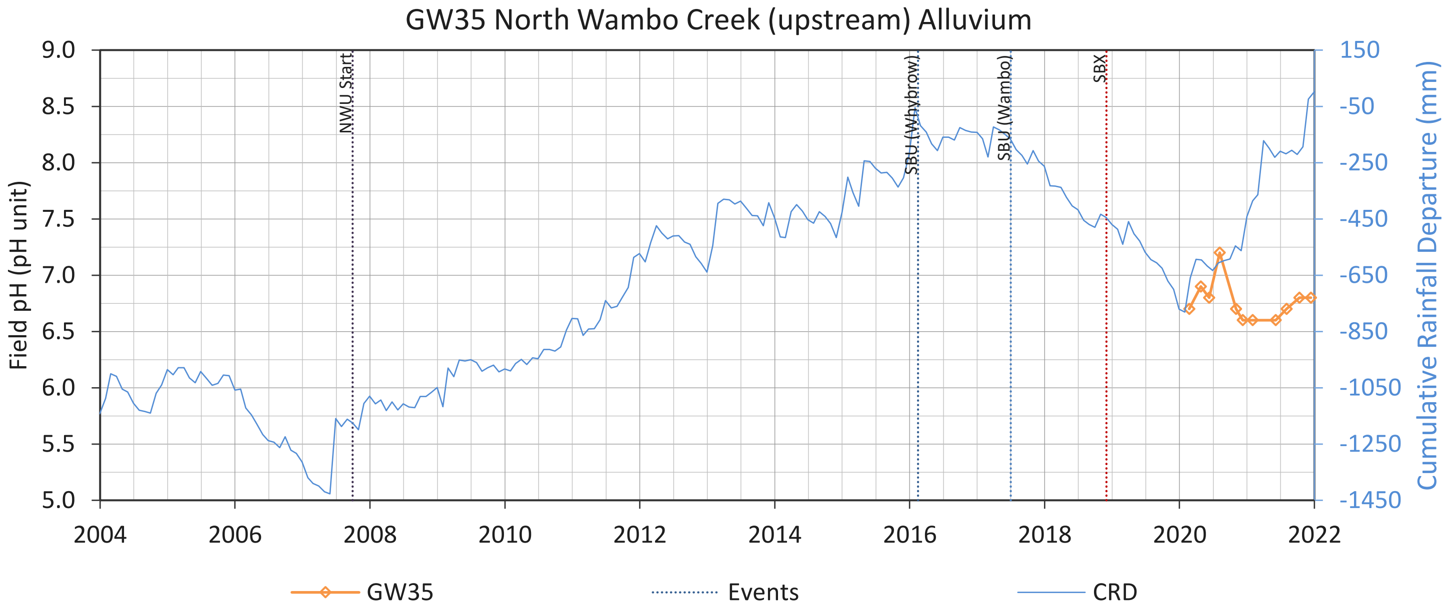


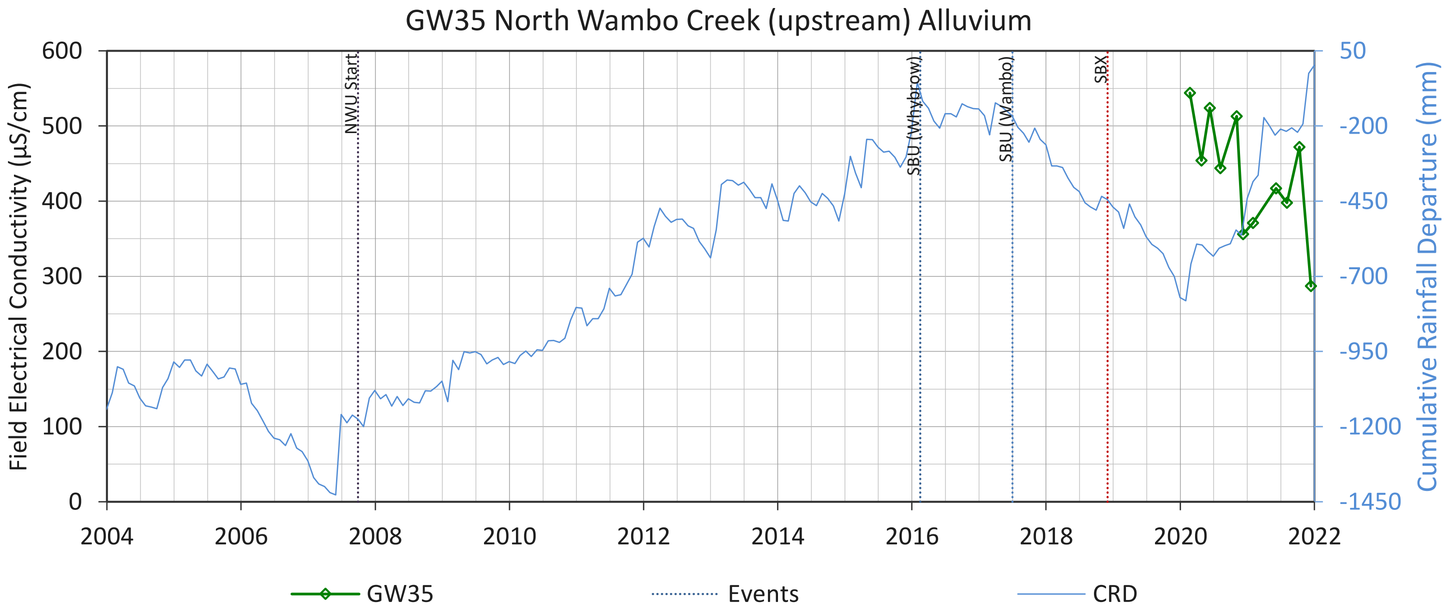

GW34 North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW34
Events
CRD

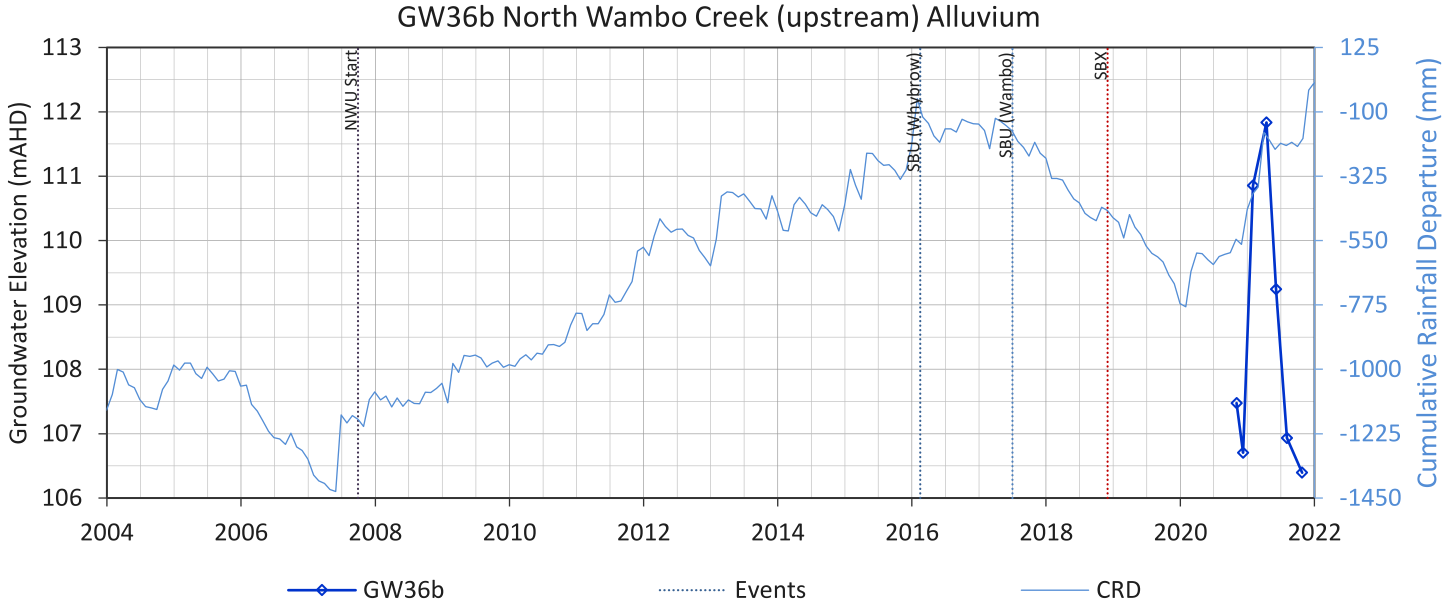

GW34 North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW34
Events
CRD

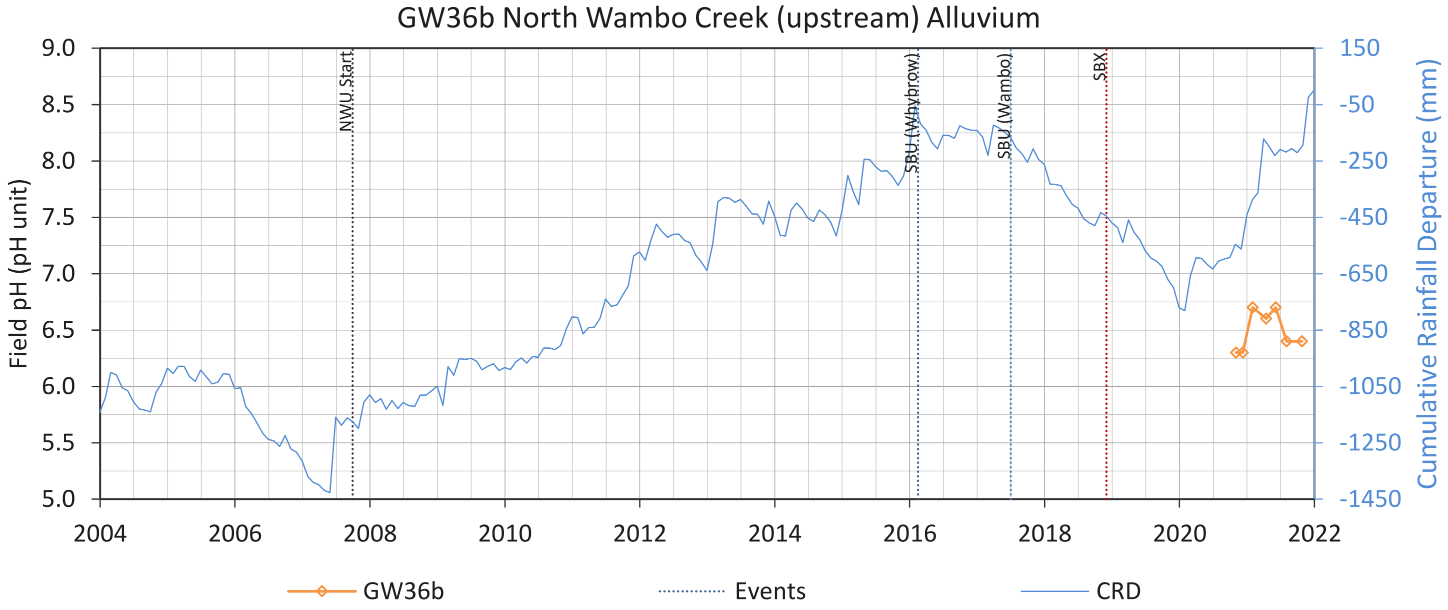

GW34 North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW34
Events
CRD

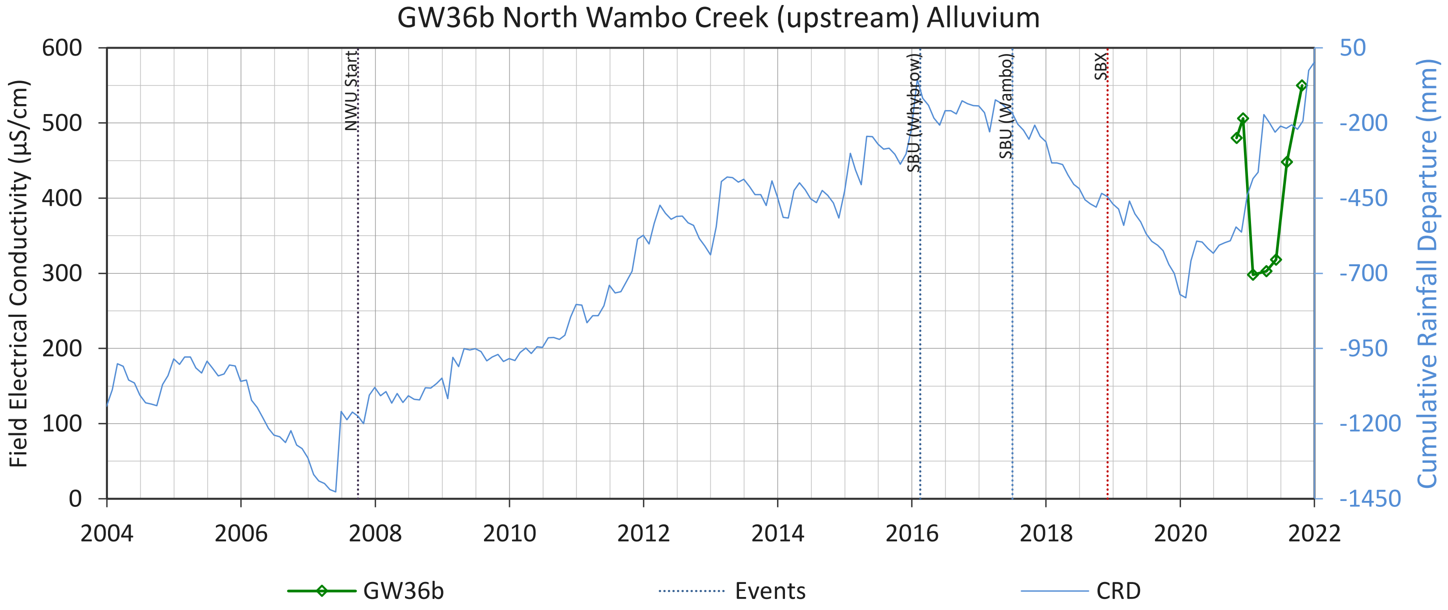

GW35 North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWJU Start
SBU (Whybrow)
SBU (Wambo)
SBX
106
105
104
103
102
101
100
99
98
97
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW35
Events
CRD

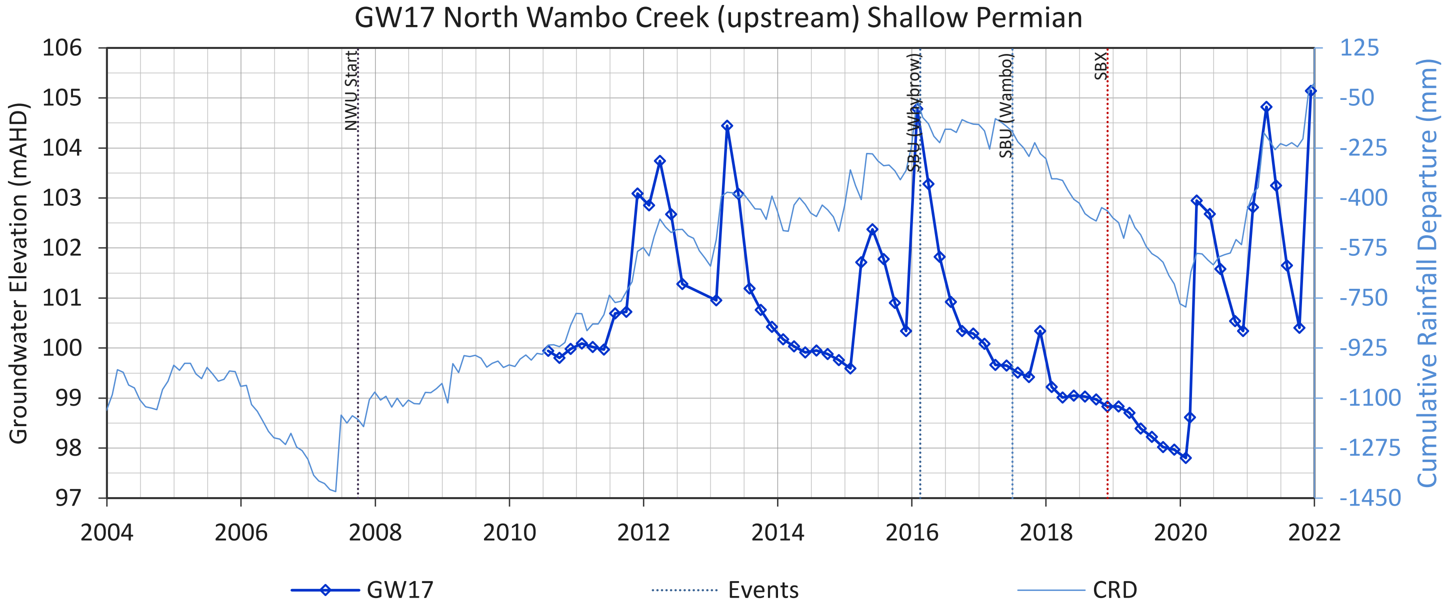

GW35 North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWJU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW35
Events
CRD

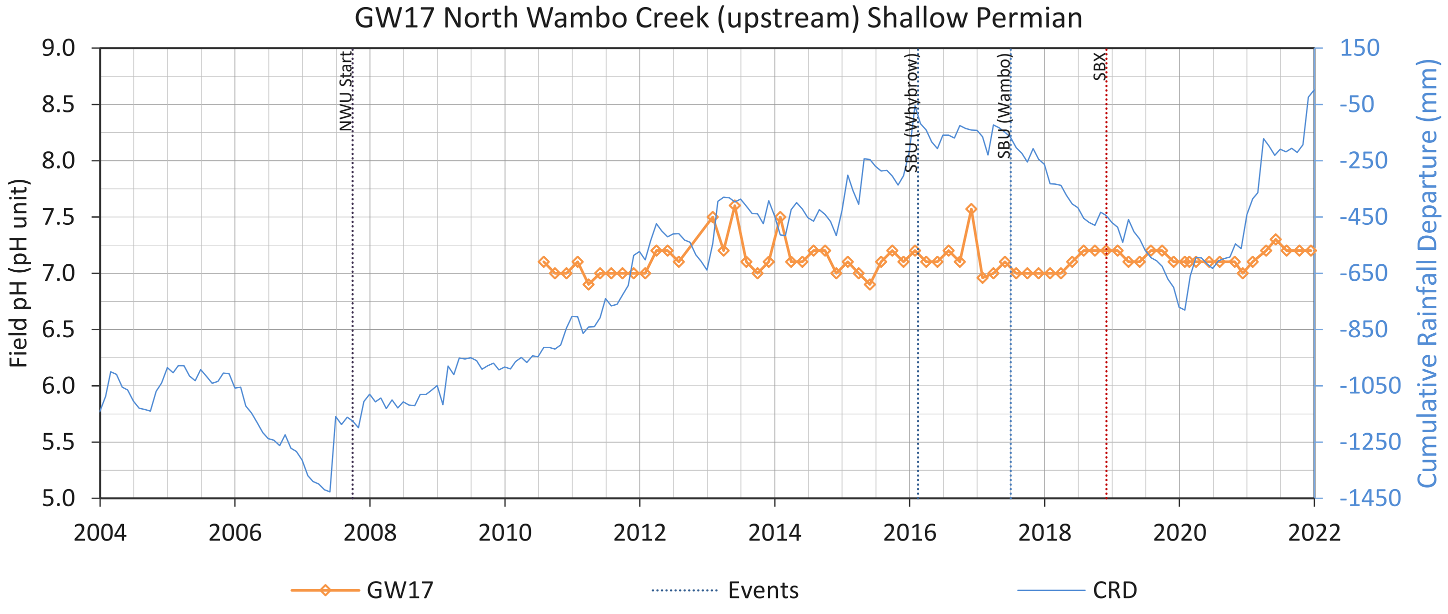

GW35 North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWJU Start
SBU (Whybrow)
SBU (Wambo)
SBX
600
500
400
300
200
100
0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW35
Events
CRD

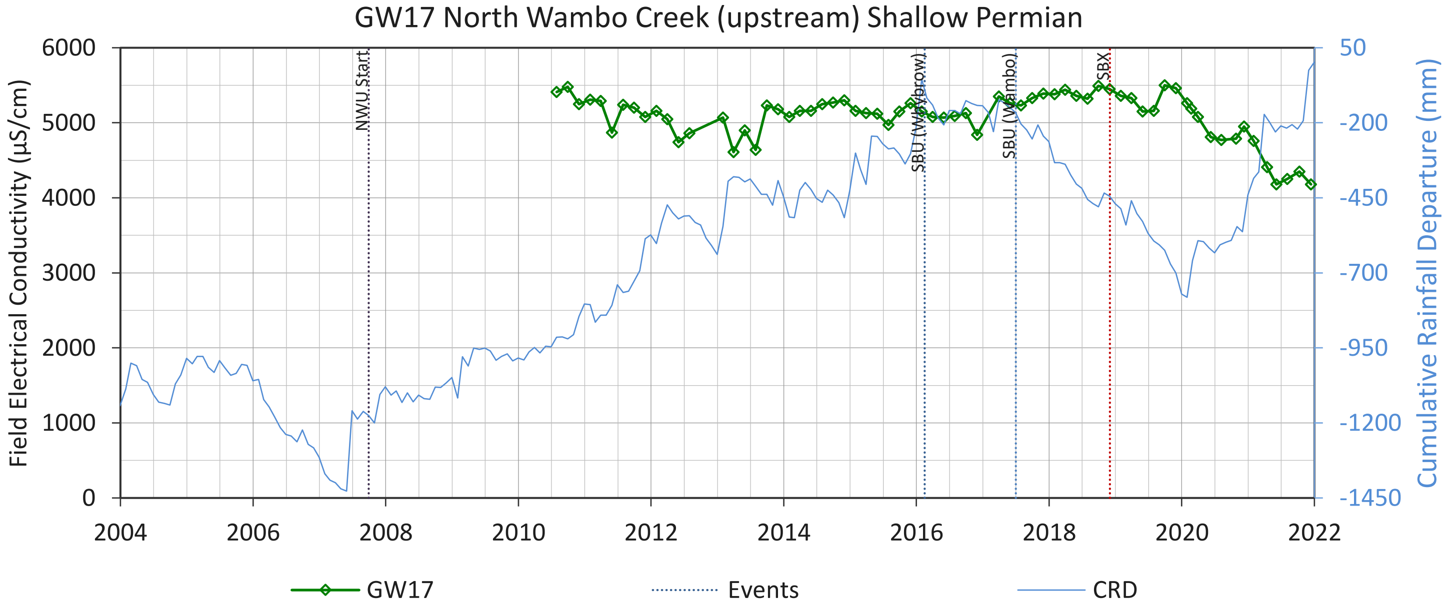

GW36b North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
113
112
111
110
109
108
107
106
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW36b
Events
CRD

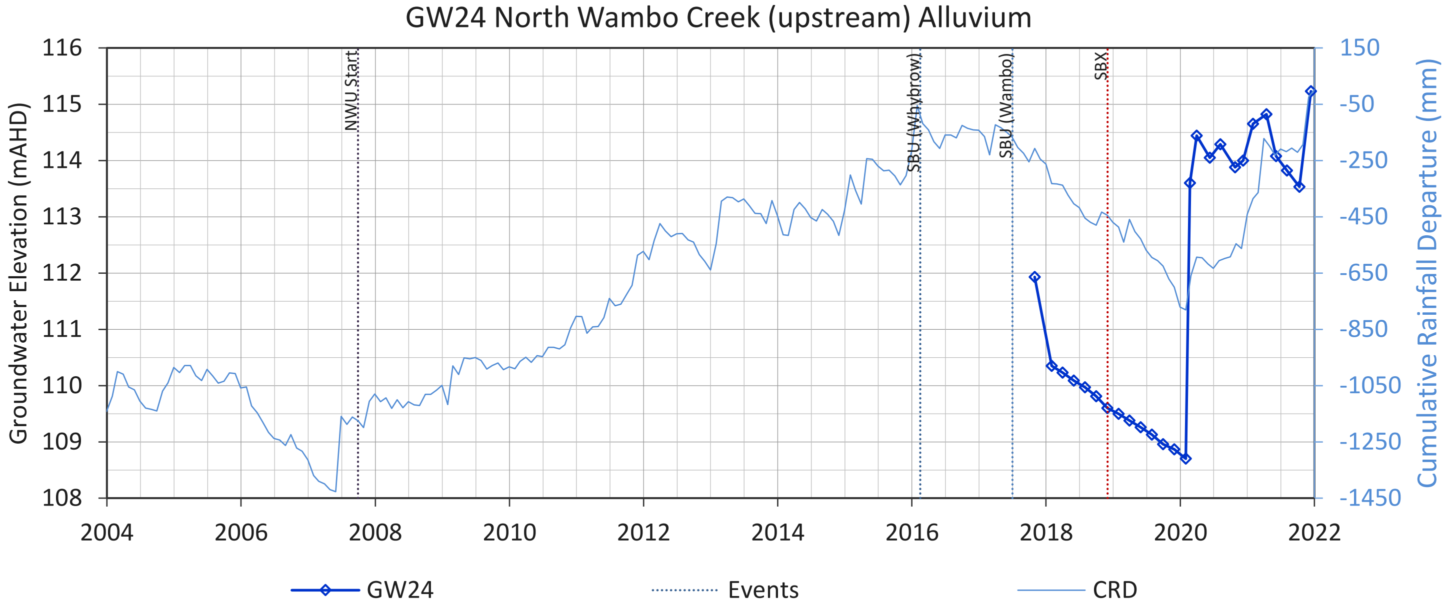

GW36b North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW36b
Events
CRD

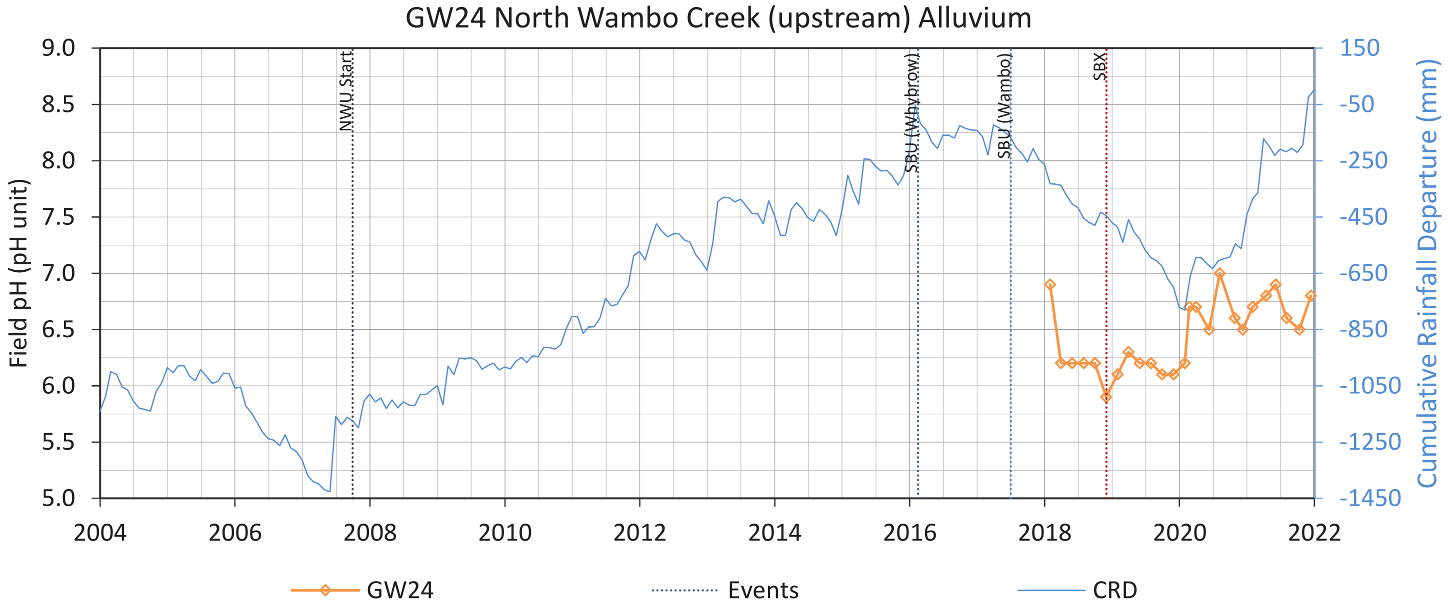

GW36b North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
600
500
400
300
200
100
0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW36b
Events
CRD

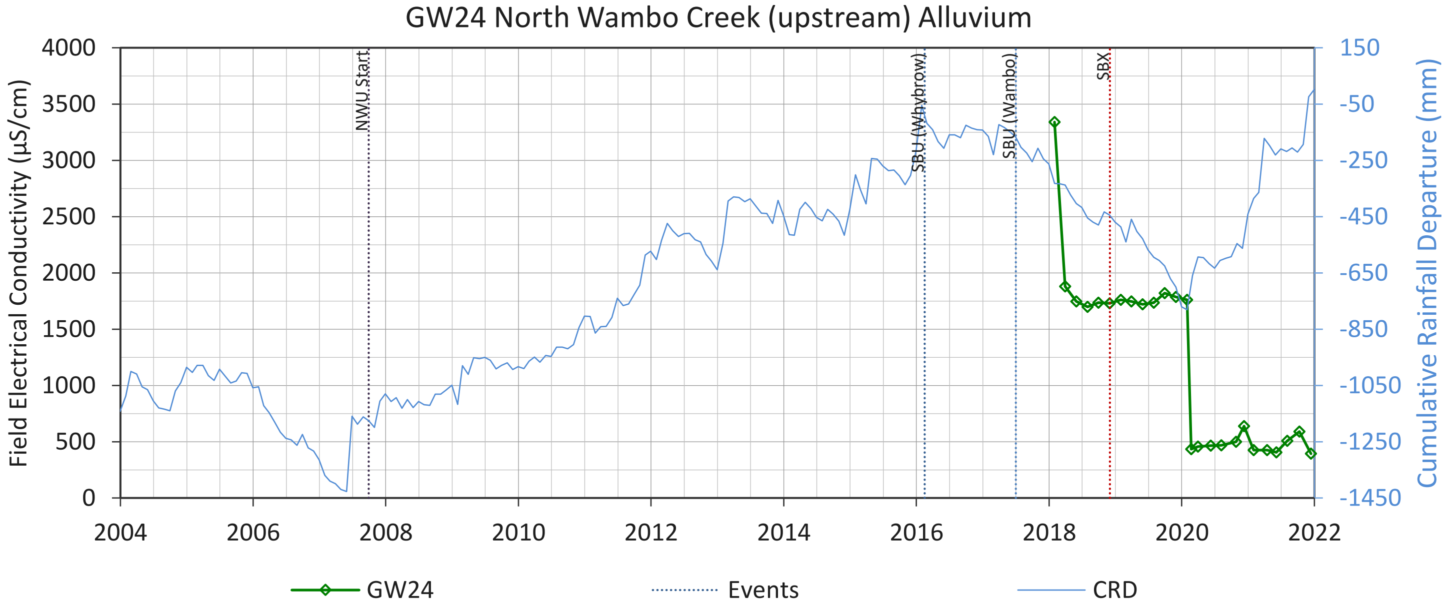

GW17 North Wambo Creek (upstream) Shallow Permian
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW17
Events
CRD

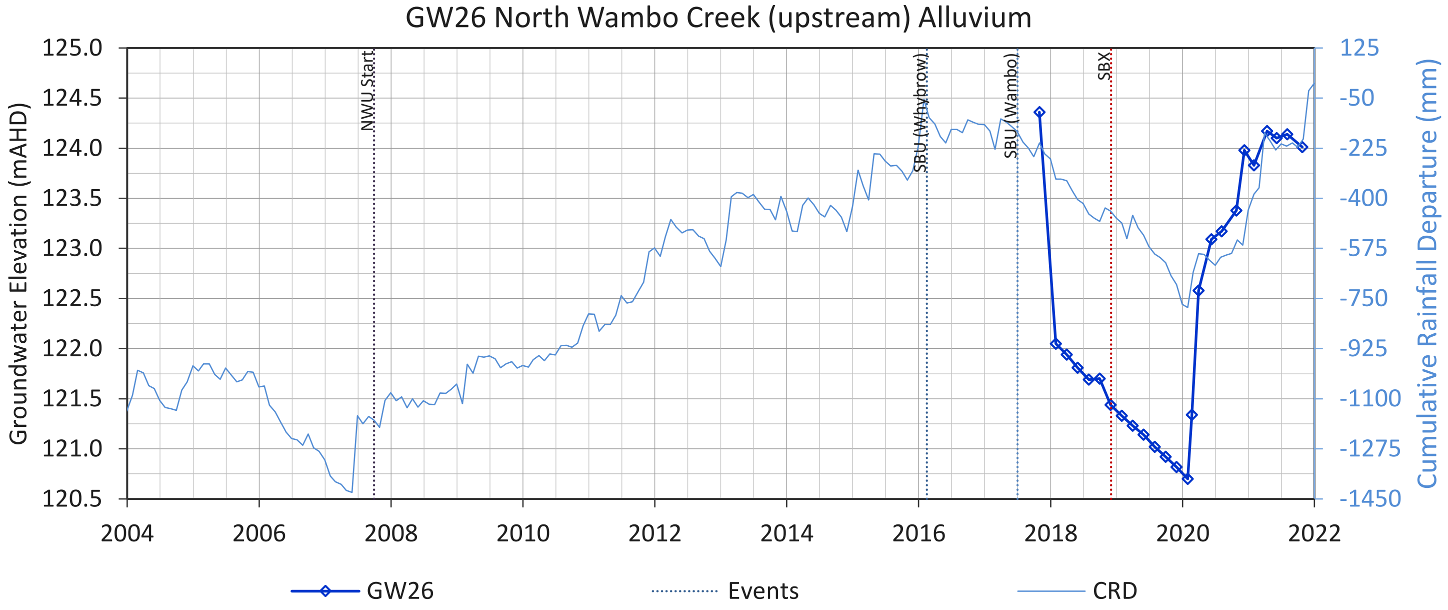

GW17 North Wambo Creek (upstream) Shallow Permian
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW17
Events
CRD

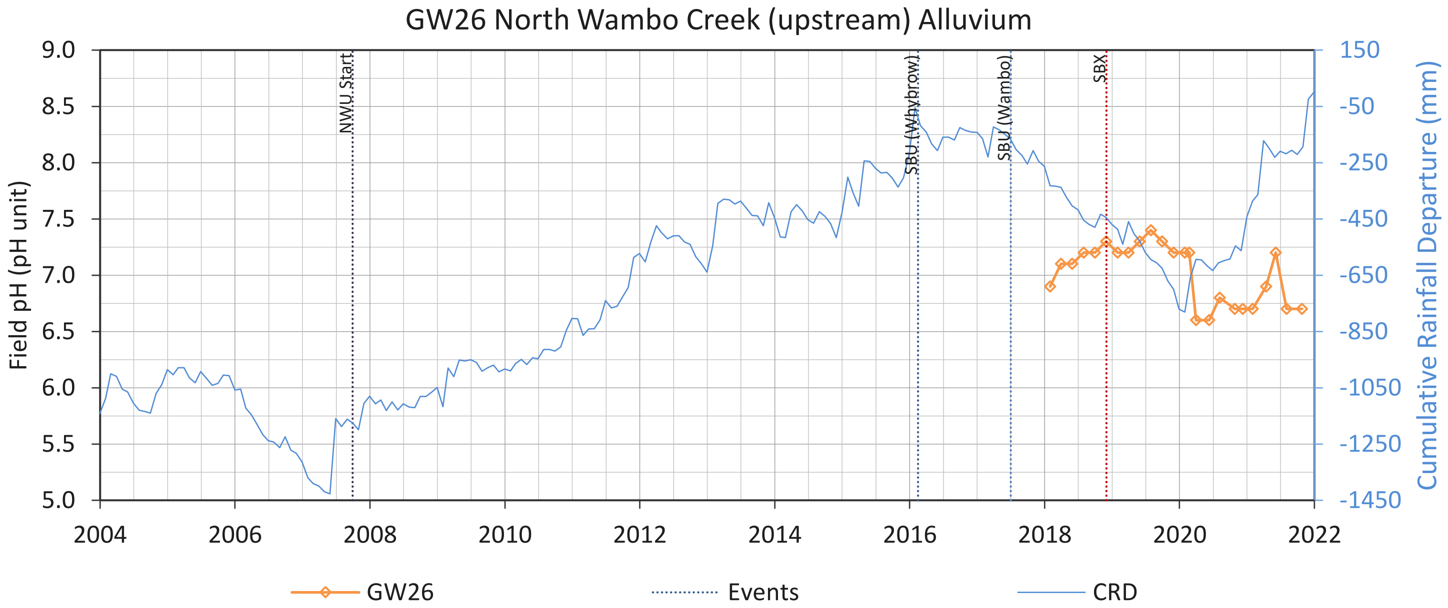

GW17 North Wambo Creek (upstream) Shallow Permian
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW17
Events
CRD

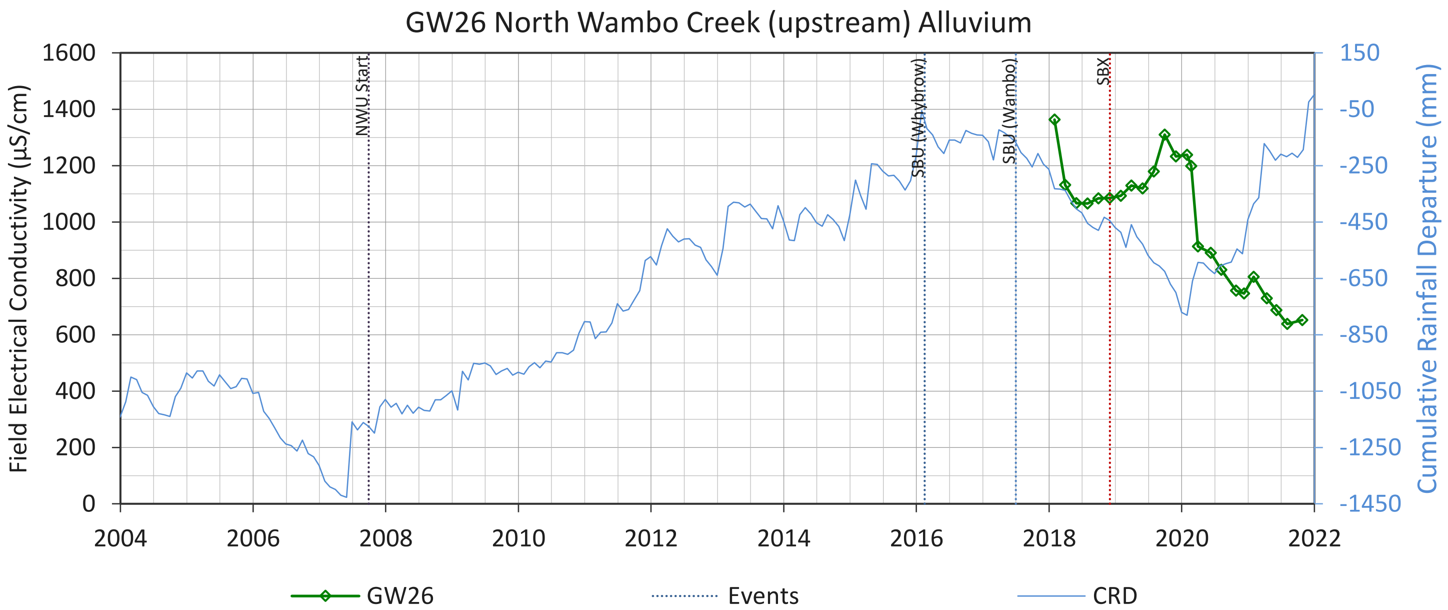

GW24 North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWIJ Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW24
Events
CRD

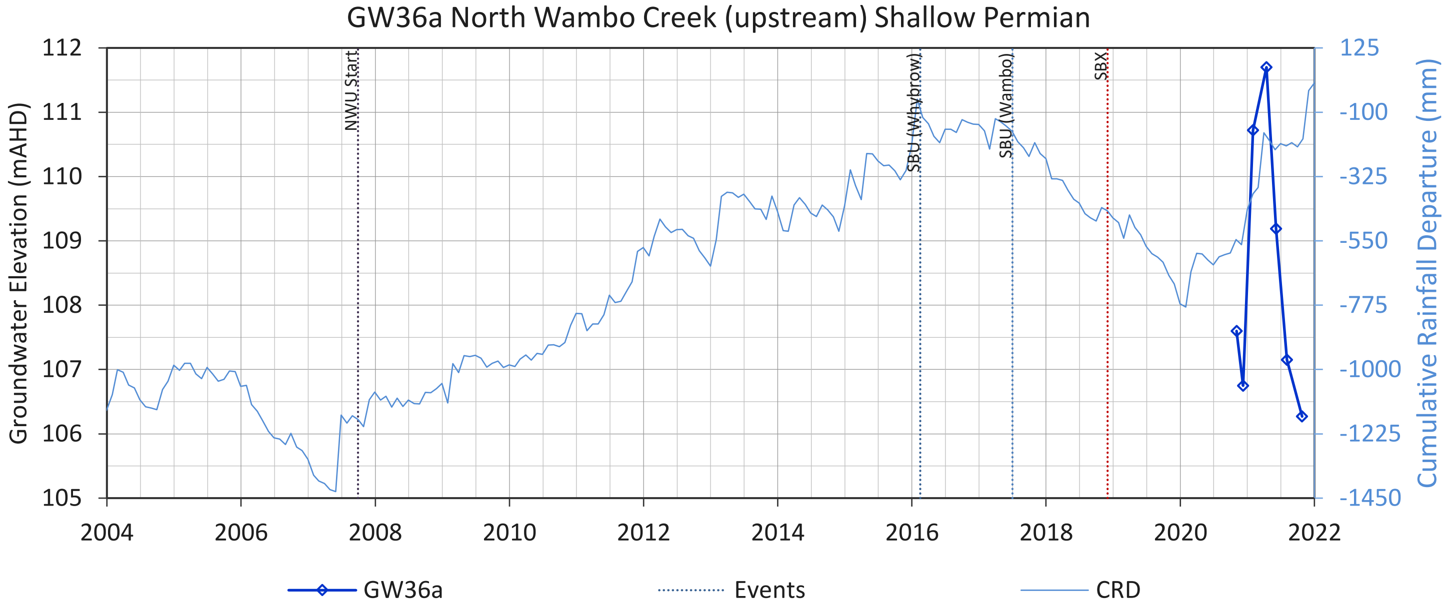

GW24 North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWIJ Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW24
Events
CRD

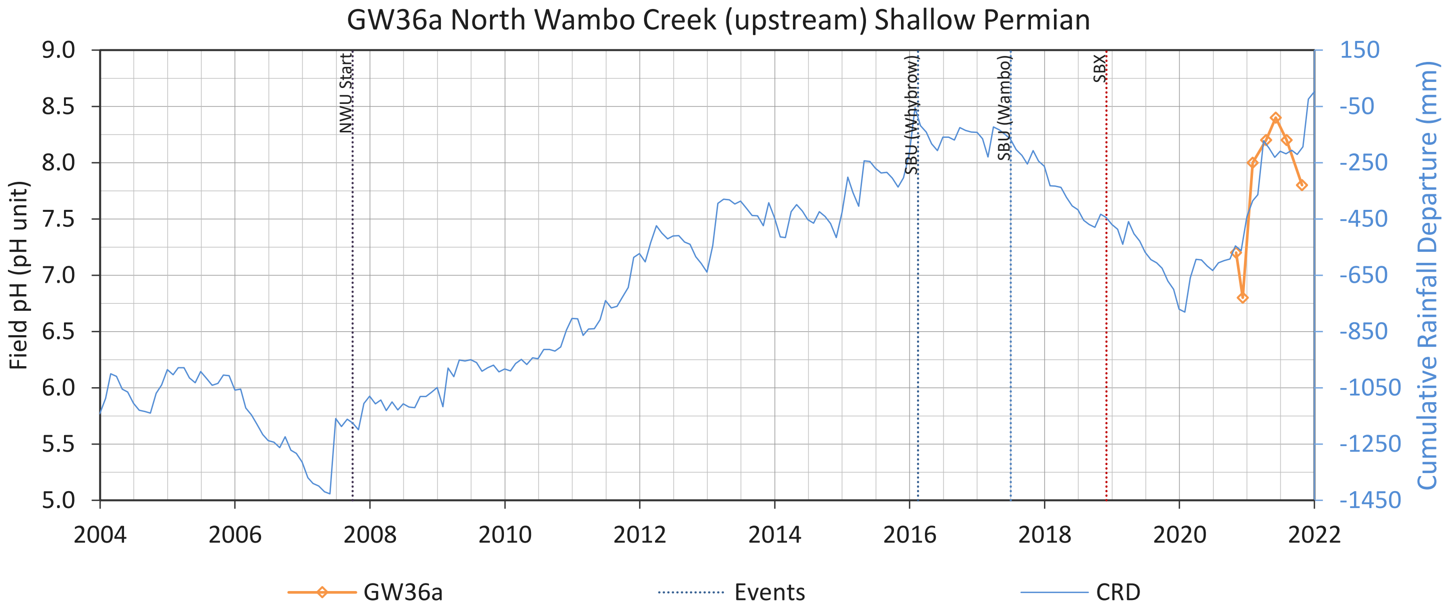

GW24 North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWIJ Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW24
Events
CRD

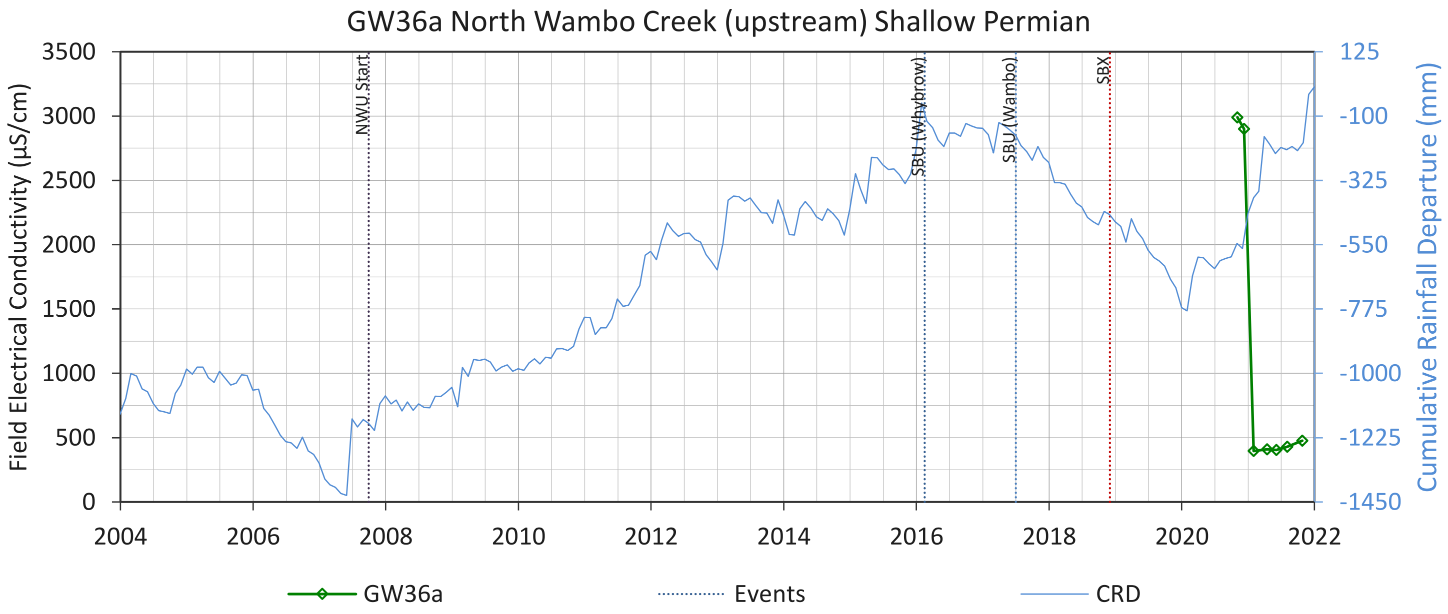

GW26 North Wambo Creek (upstream) Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW26
Events
CRD

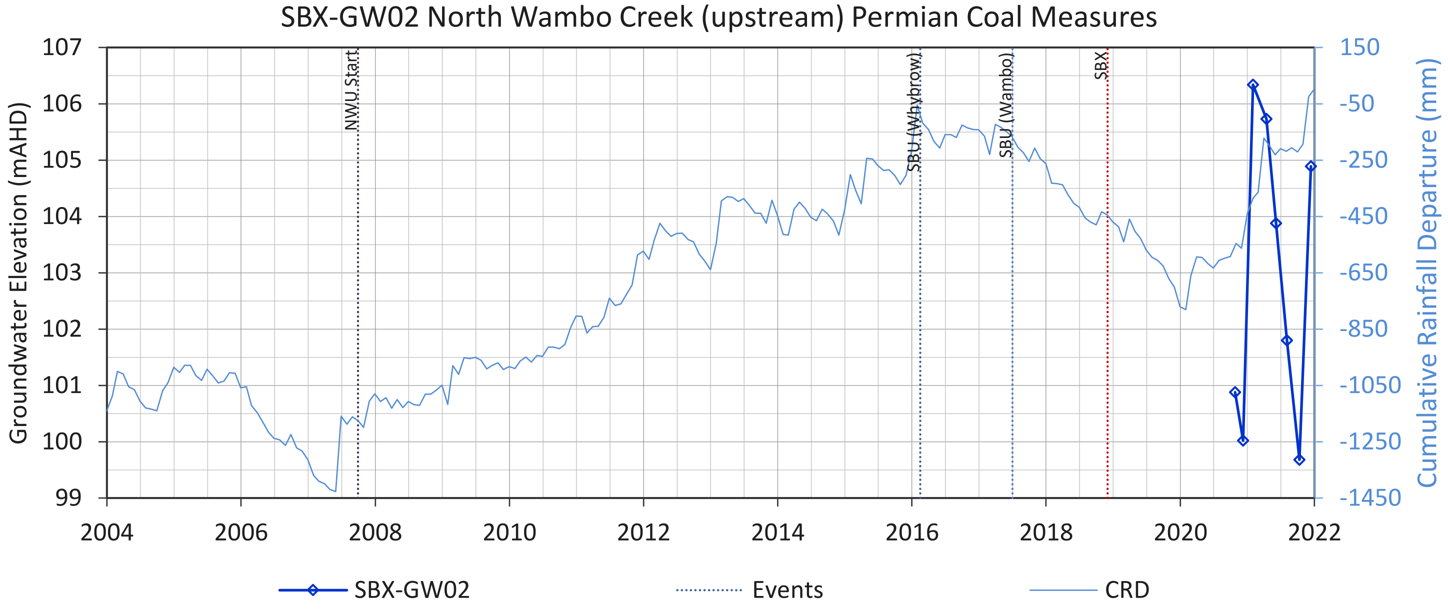

GW26 North Wambo Creek (upstream) Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW26
Events
CRD

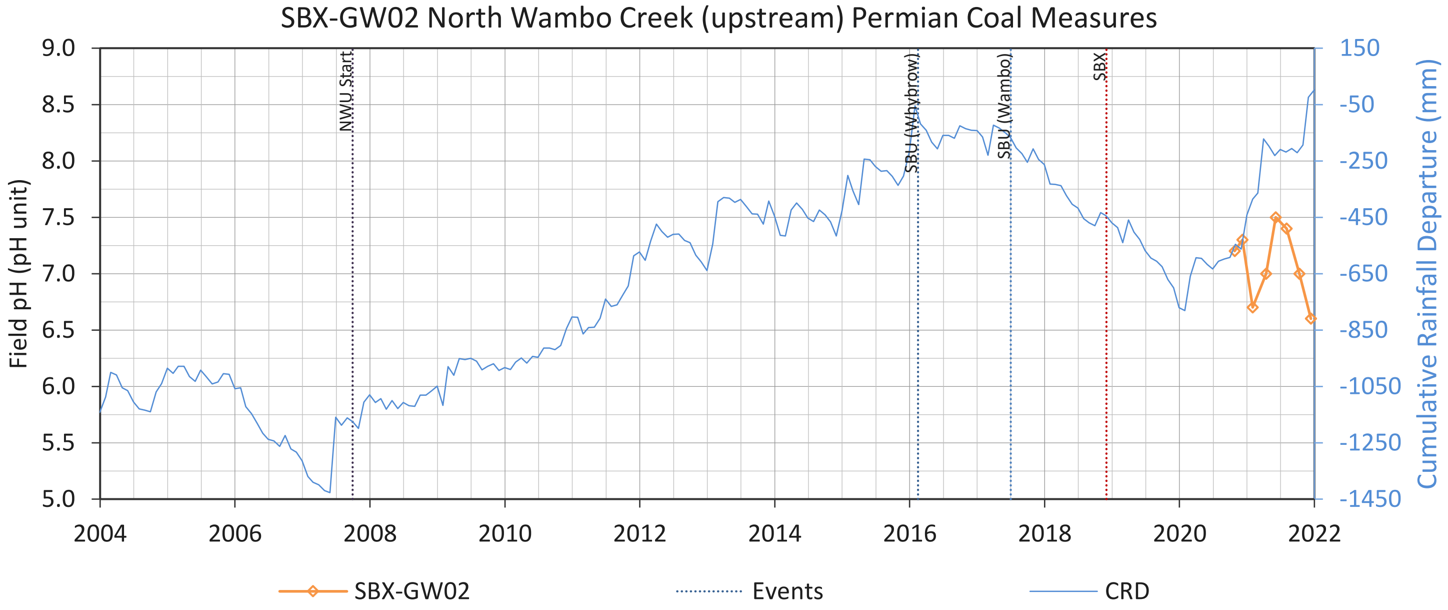

GW26 North Wambo Creek (upstream) Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW26
Events
CRD

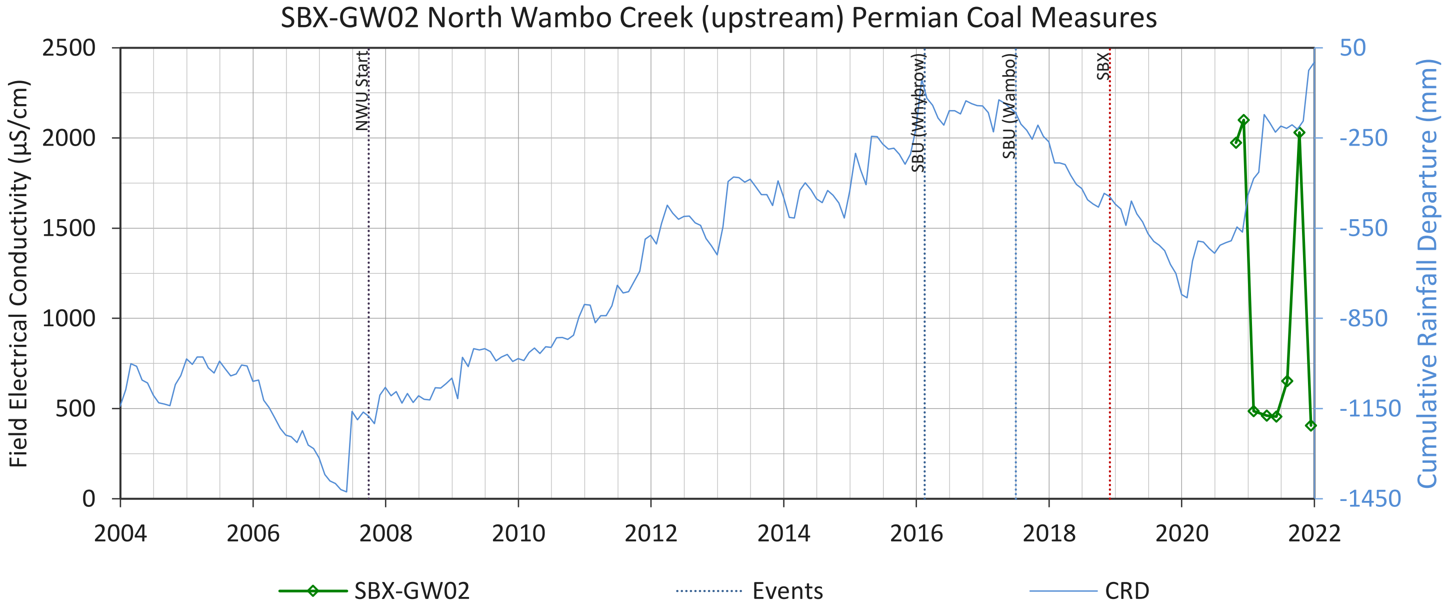

GW36a North Wambo Creek (upstream) Shallow Permian
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
112
111
110
109
108
107
106
105
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW36a
Events
CRD

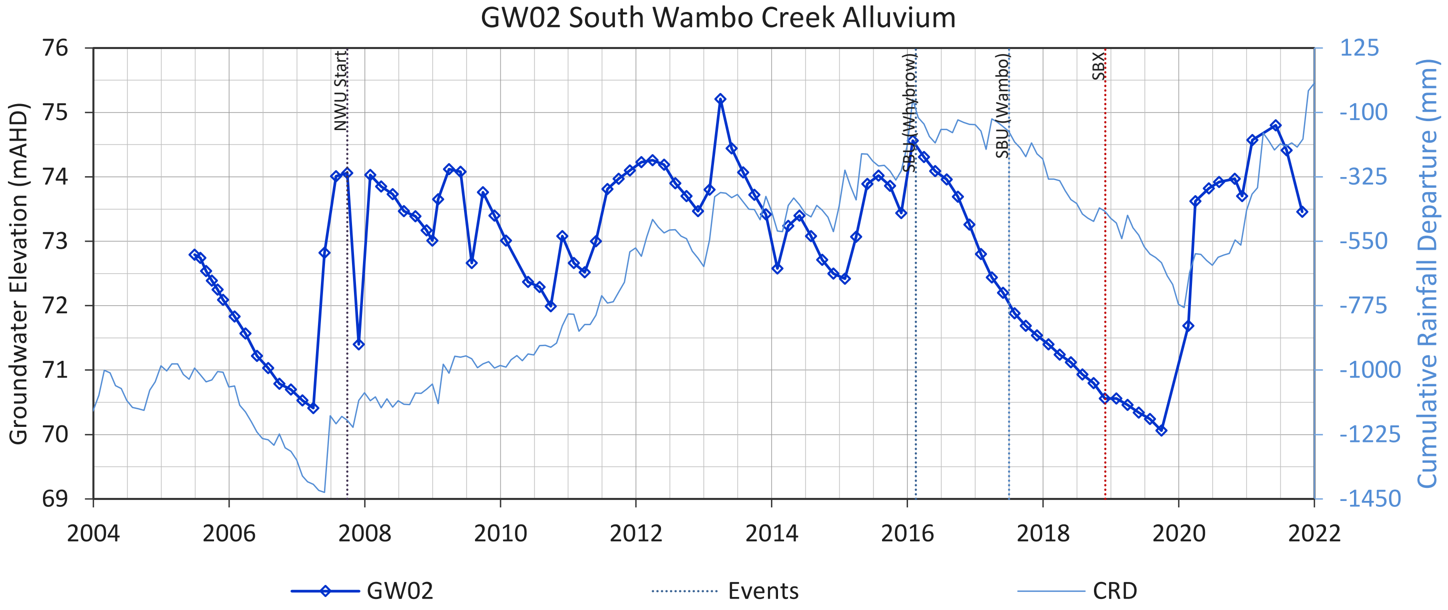

GW36a North Wambo Creek (upstream) Shallow Permian
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW36a
Events
CRD

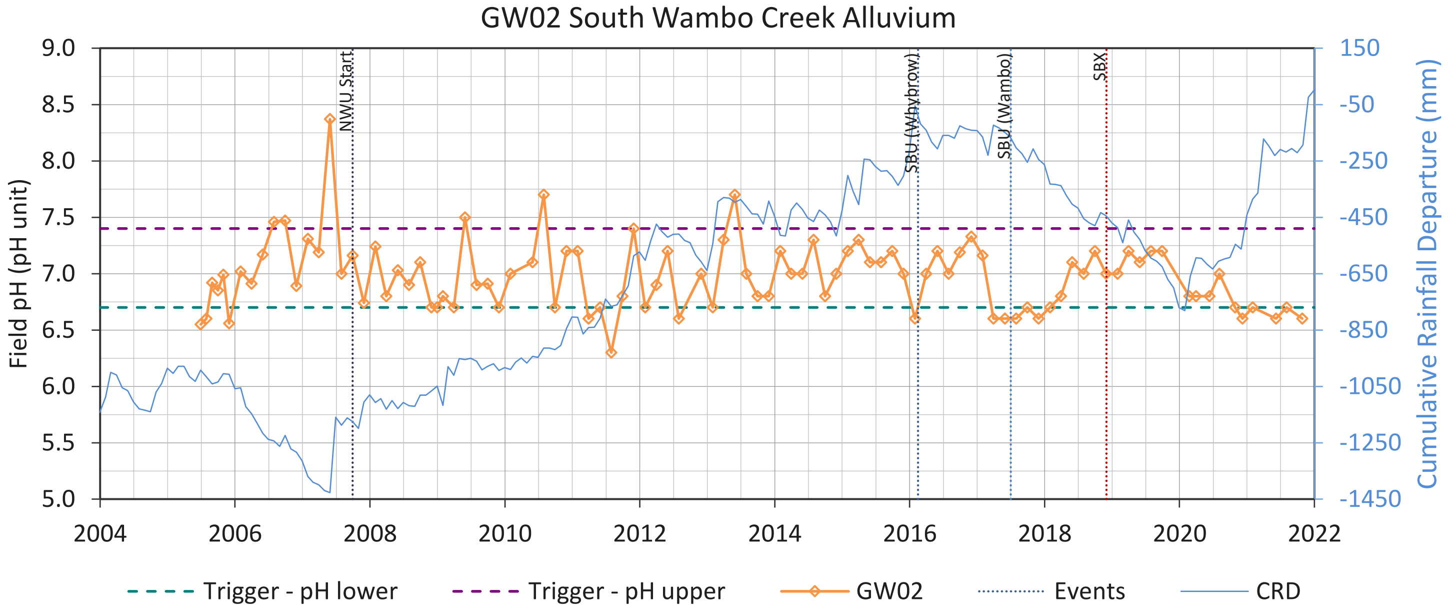

GW36a North Wambo Creek (upstream) Shallow Permian
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
3500
3000
2500
2000
1500
1000
500
0
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW36a
Events
CRD

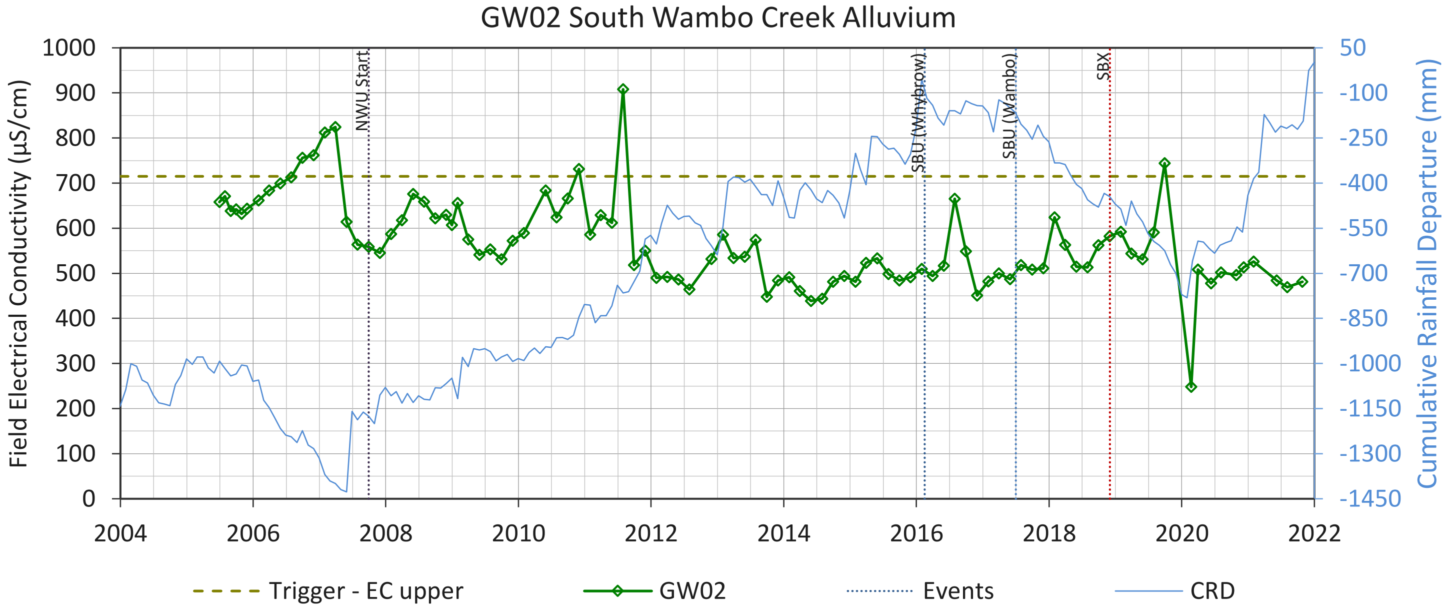

SBX-GW02 North Wambo Creek (upstream) Permian Coal Measures
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
SBX-GW02
Events
CRD

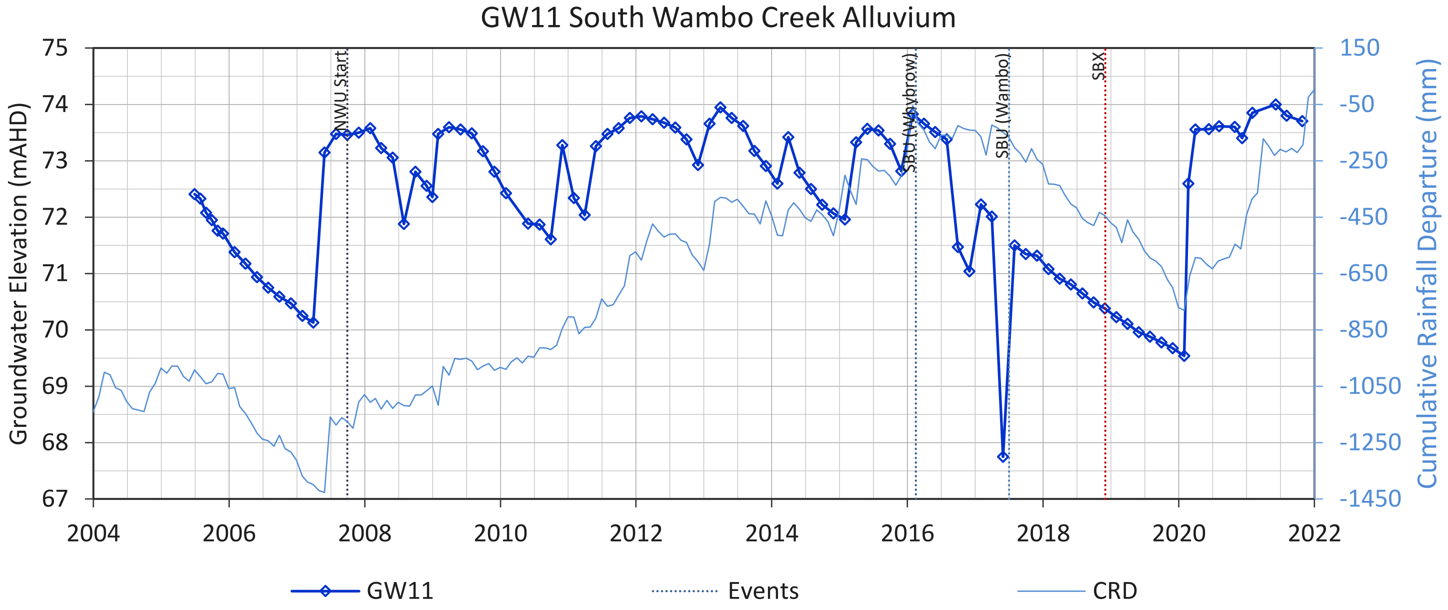

SBX-GW02 North Wambo Creek (upstream) Permian Coal Measures
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
SBX-GW02
Events
CRD

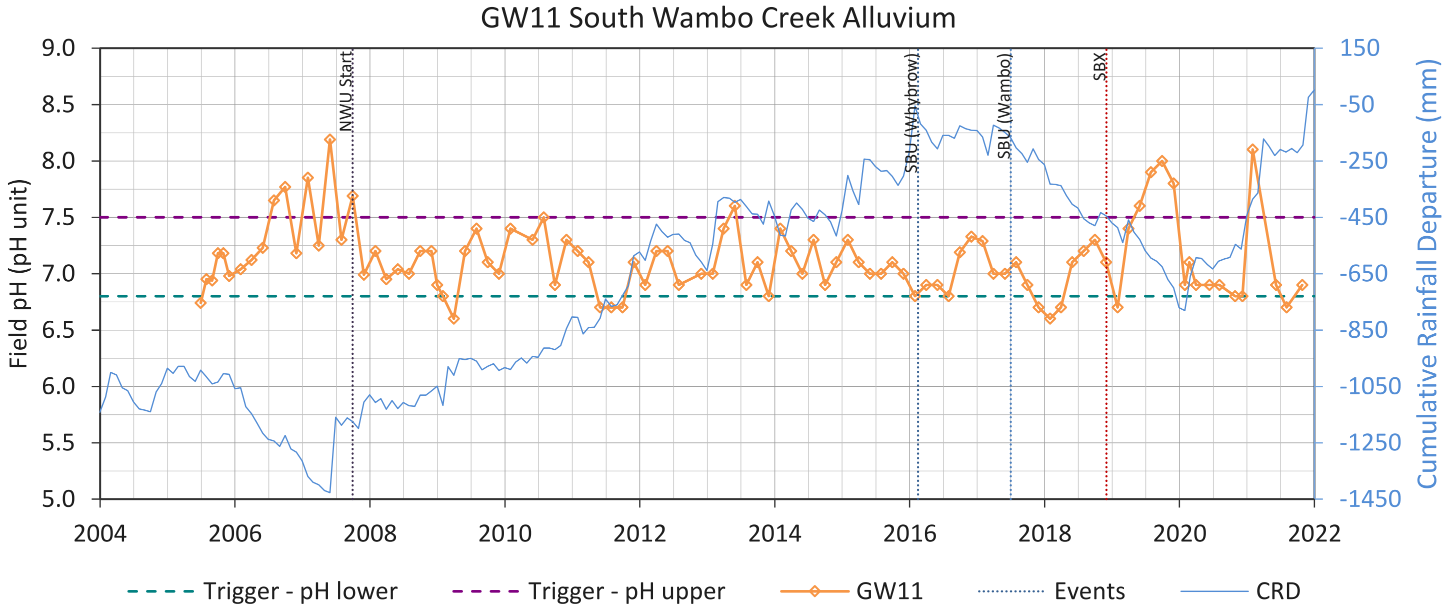

SBX-GW02 North Wambo Creek (upstream) Permian Coal Measures
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
SBX-GW02
Events
CRD

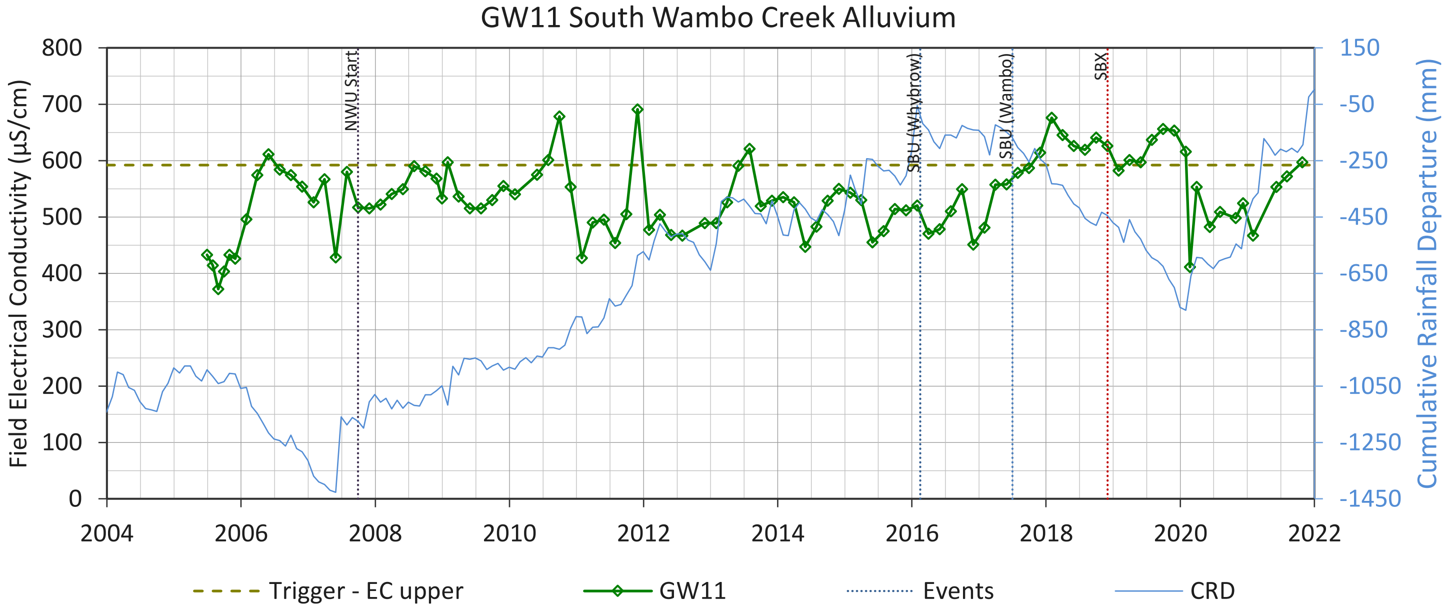

GW02 South Wambo Creek Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
76
75
74
73
72
71
70
69
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW02
Events
CRD

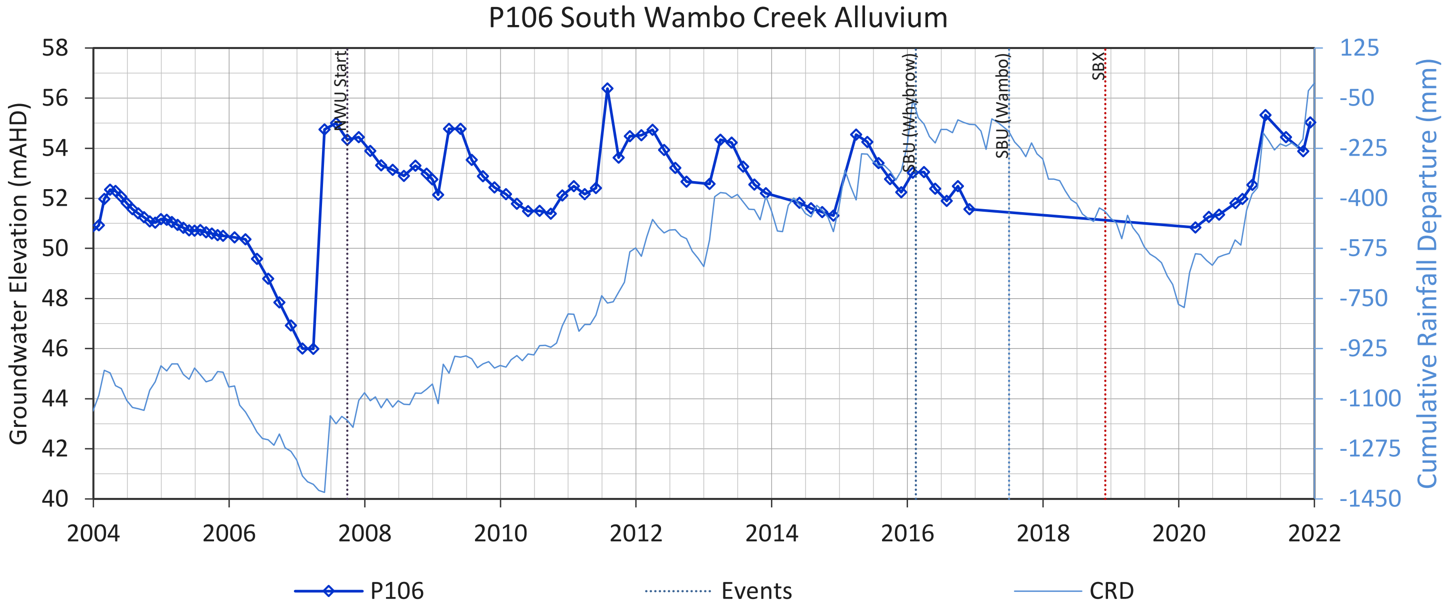

GW02 South Wambo Creek Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Trigger - pH lower
Trigger - pH upper
GW02
Events
CRD

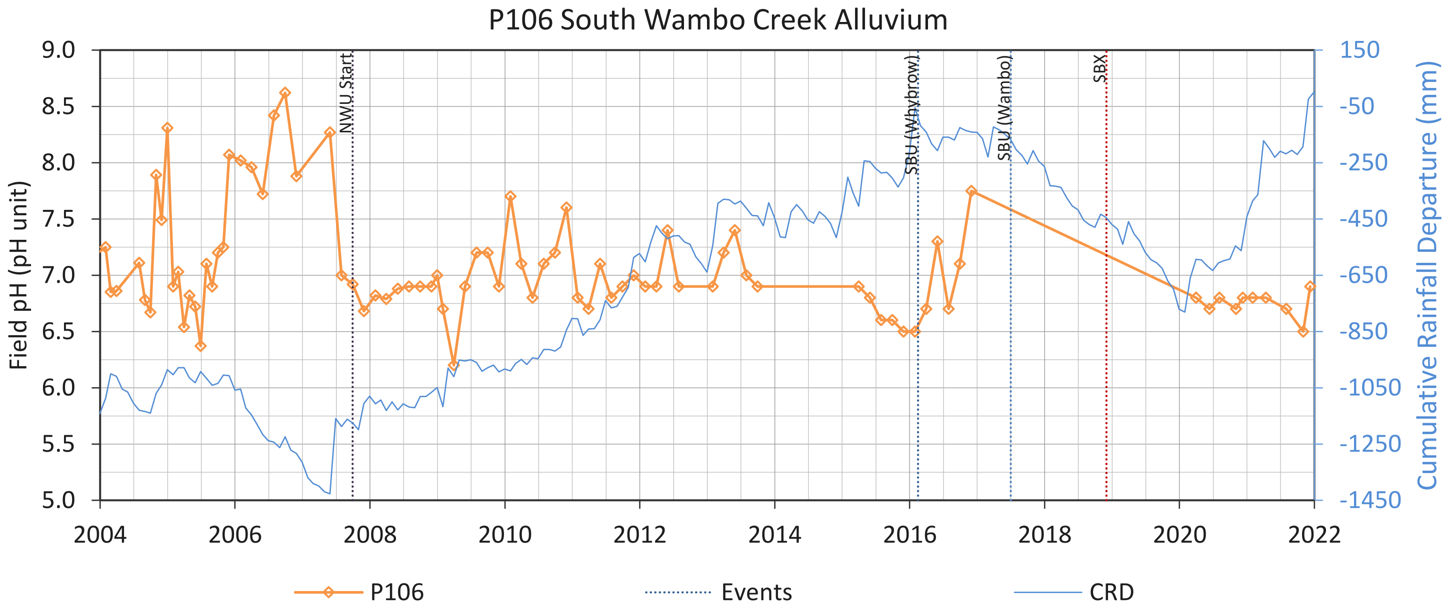

GW02 South Wambo Creek Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
1000
900
800
700
600
500
400
300
200
100
0
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Trigger - EC upper
GW02
Events
CRD

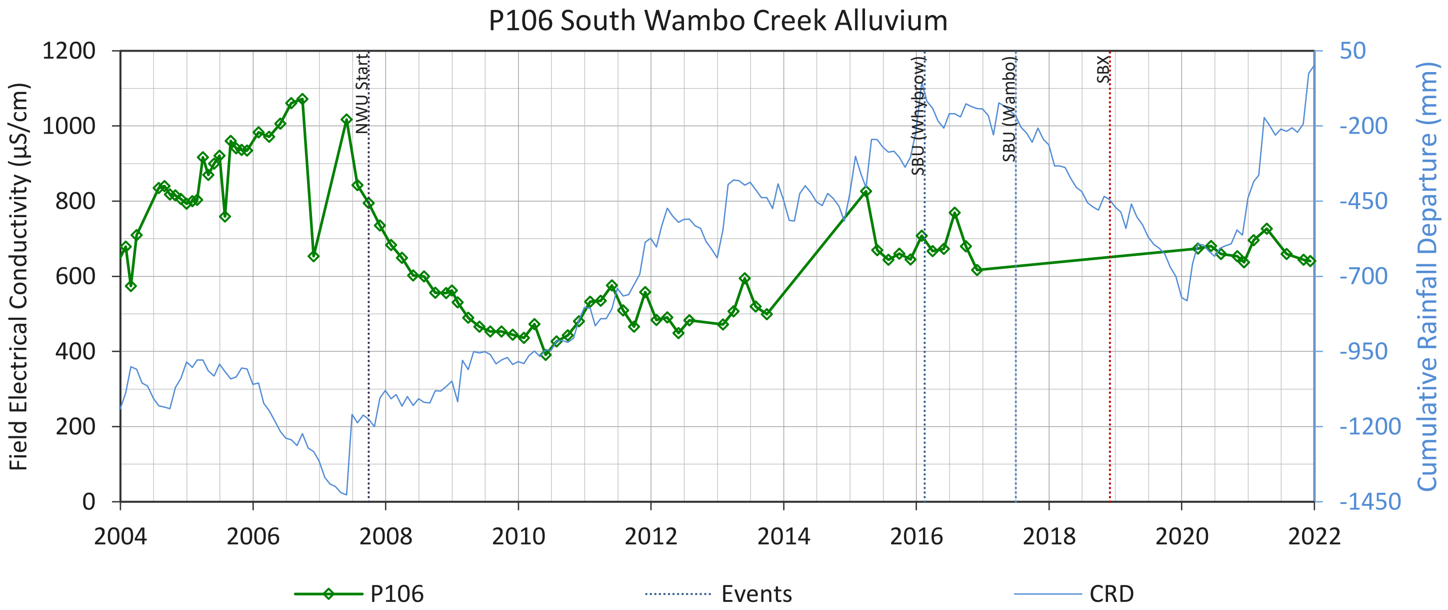

GW11 South Wambo Creek Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
75
74
73
72
71
70
69
68
67
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW11
Events
CRD

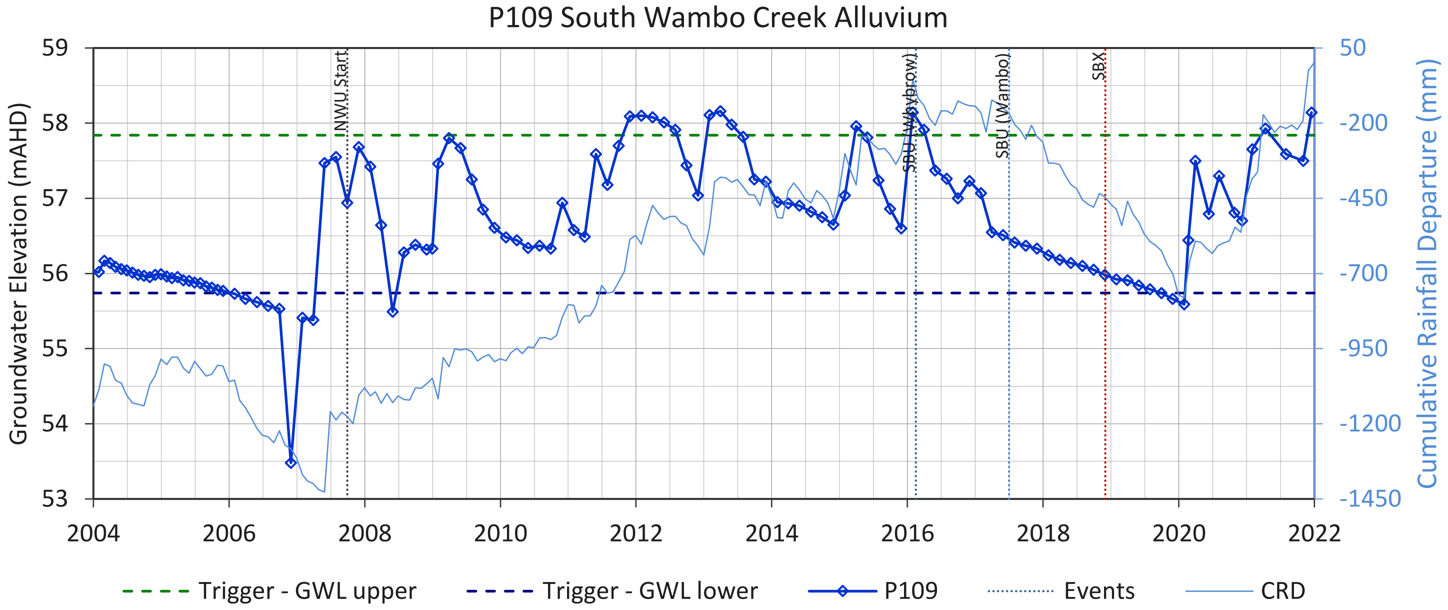

GW11 South Wambo Creek Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Trigger - pH lower
Trigger - pH upper
GW11
Events
CRD


GW11 South Wambo Creek Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
800
700
600
500
400
300
200
100
0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Trigger - EC upper
GW11
Events
CRD

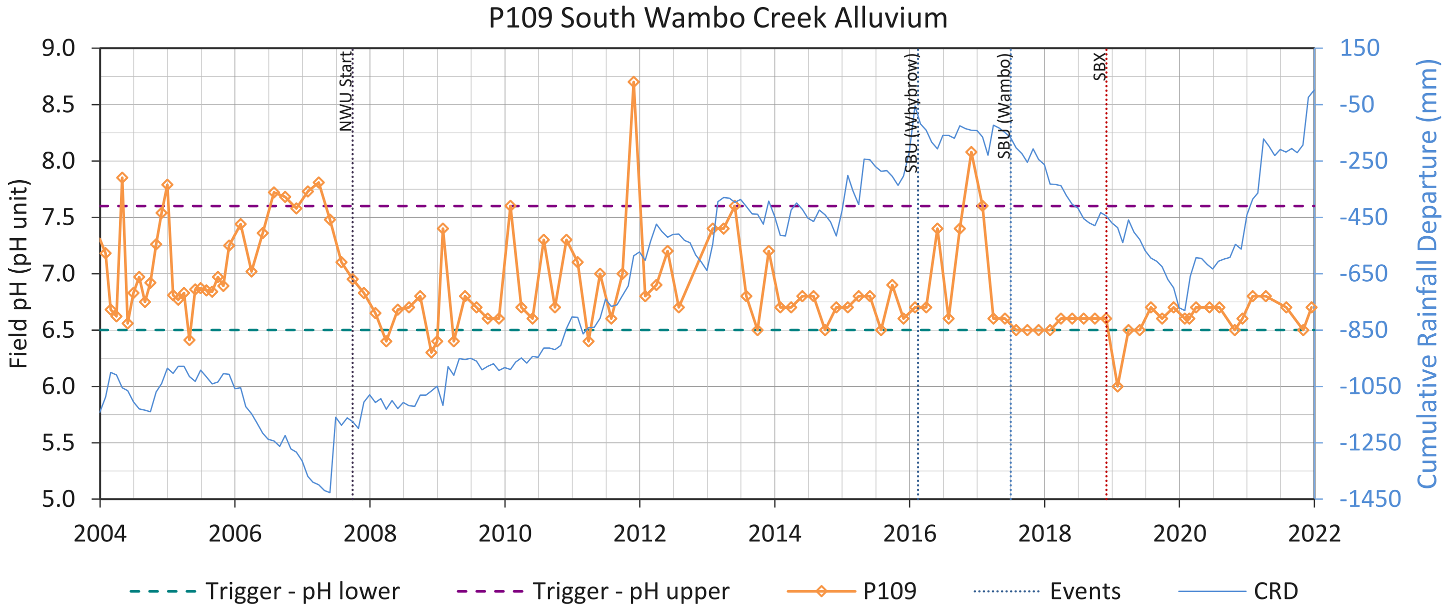

P106 South Wambo Creek Alluvium
Groundwater Elevation (mAHD)
58
56
54
52
50
48
46
44
42
40
Cumulative Rainfall Departure (mm)
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P106
Events
CRD


P106 South Wambo Creek Alluvium
Field pH (pH unit)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
Cumulative Rainfall Departure (mm)
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P106
Events
CRD

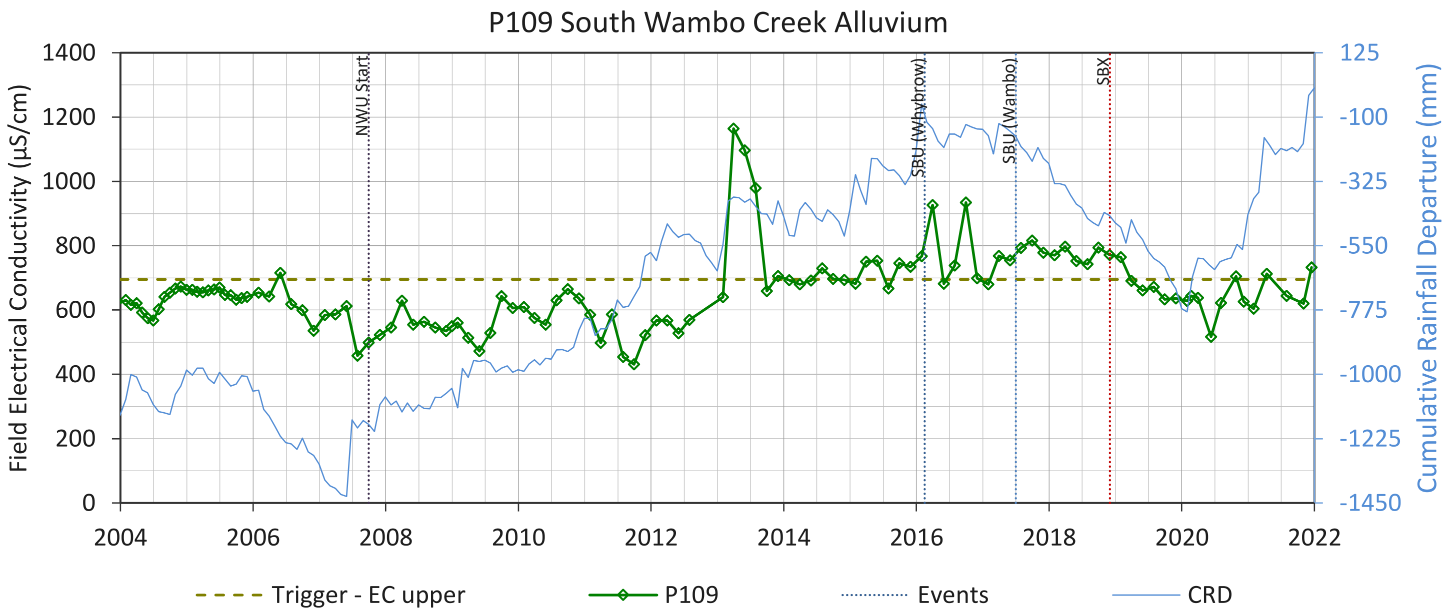

P106 South Wambo Creek Alluvium
Field Electrical Conductivity (µS/cm)
1200
1000
800
600
400
200
0
Cumulative Rainfall Departure (mm)
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P106
Events
CRD



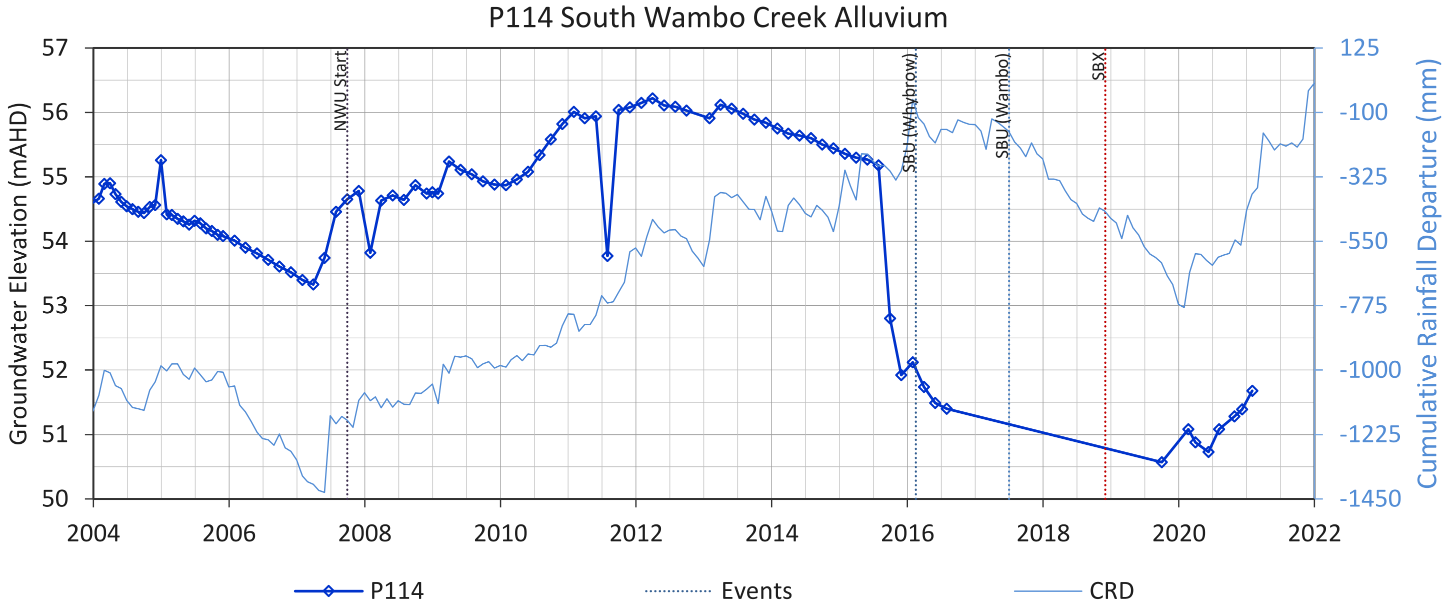
P109 South Wambo Creek Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - GWL upper
Trigger - GWL lower
P109
Events
CRD

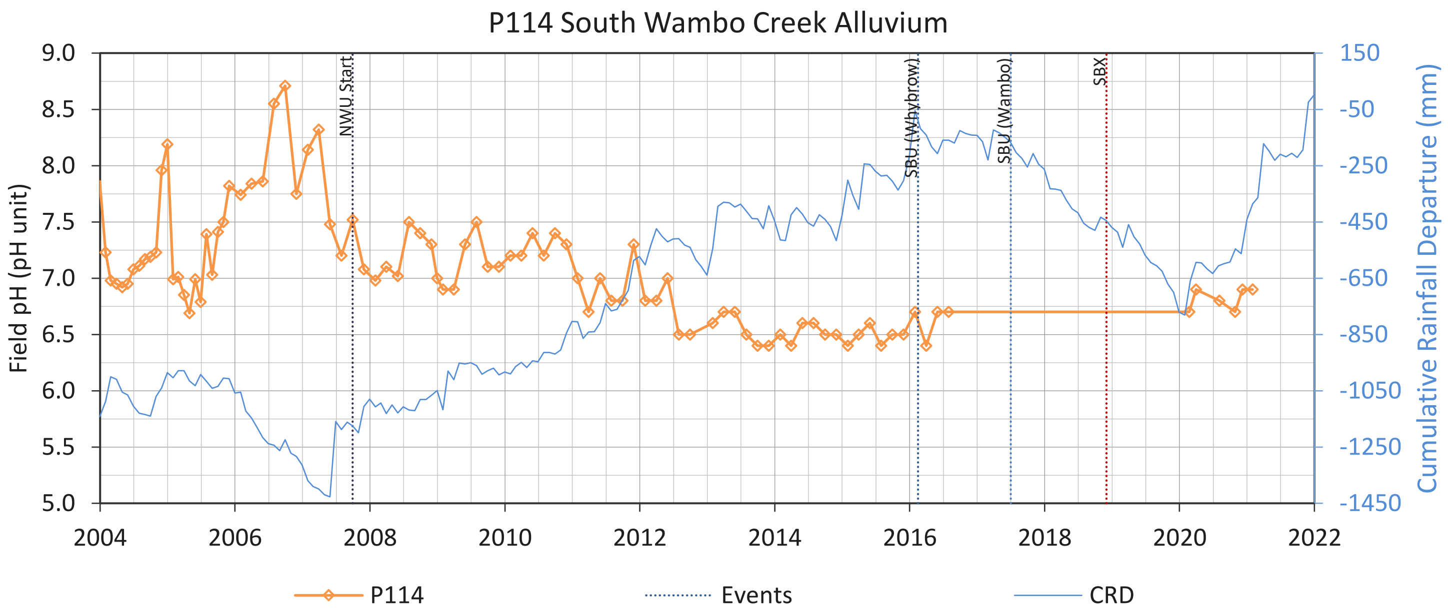


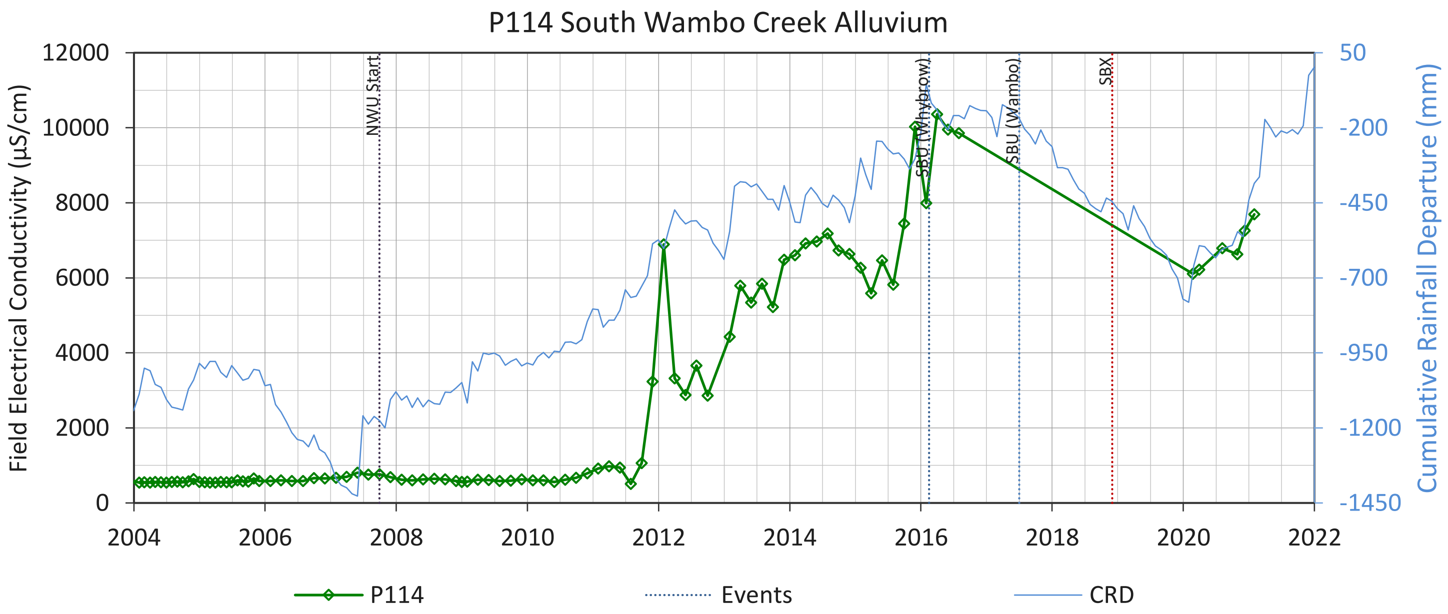
P109 South Wambo Creek Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - pH lower
Trigger - pH upper
P109
Events
CRD

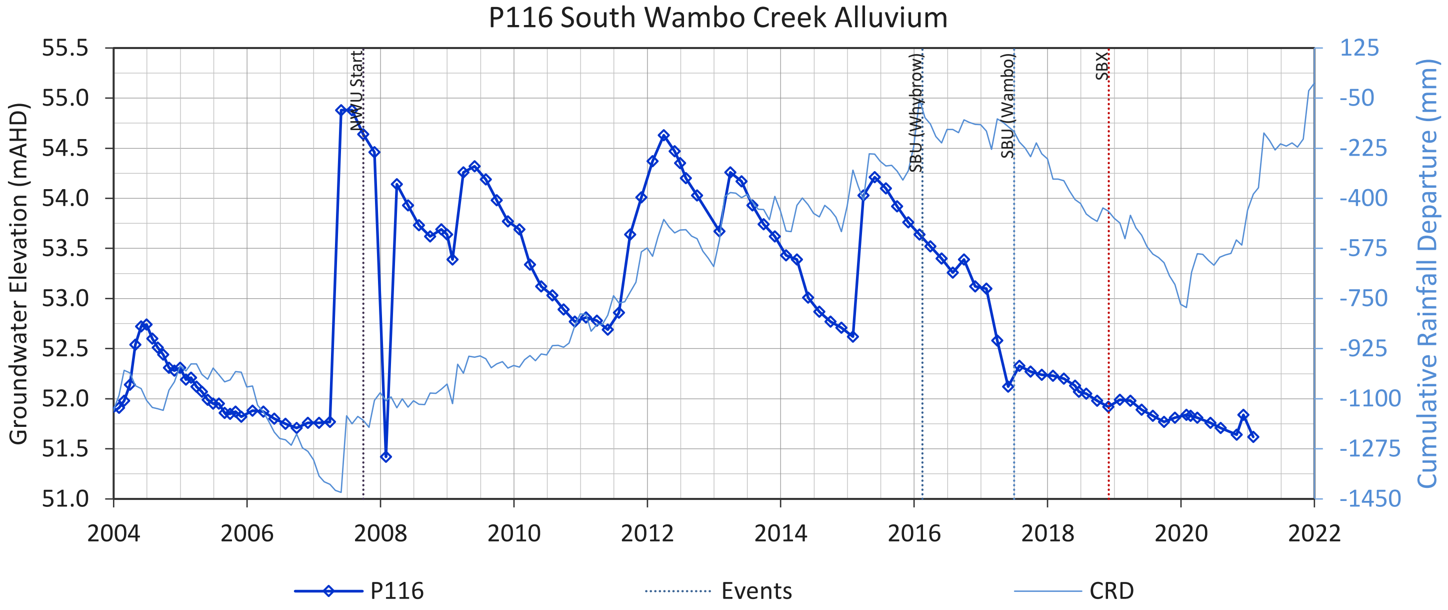


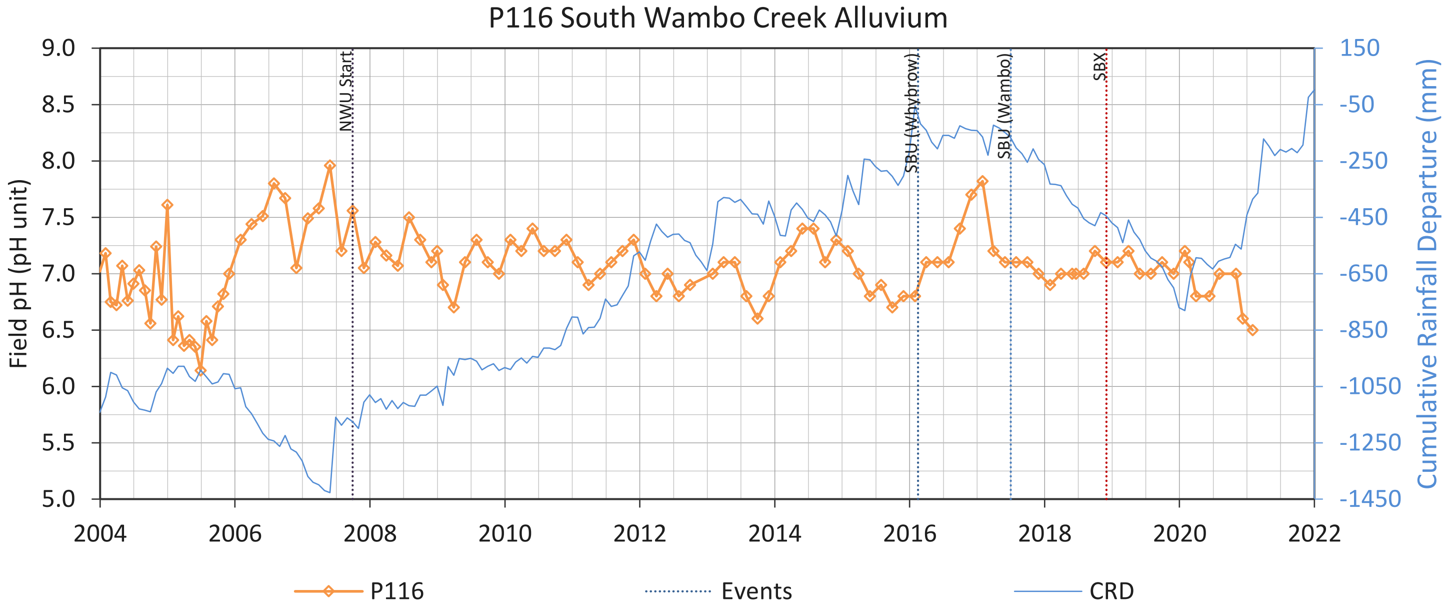
P109 South Wambo Creek Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - EC upper
P109
Events
CRD

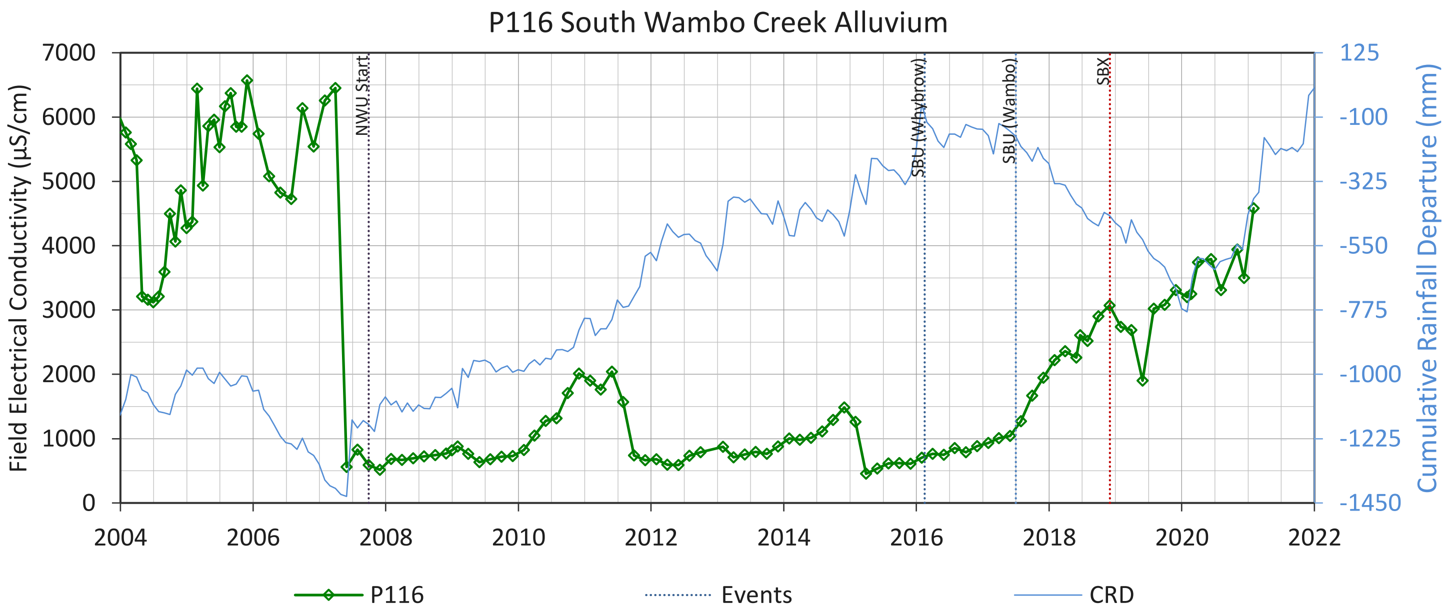

P114 South Wambo Creek Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
57
56
55
54
53
52
51
50
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P114
Events
CRD

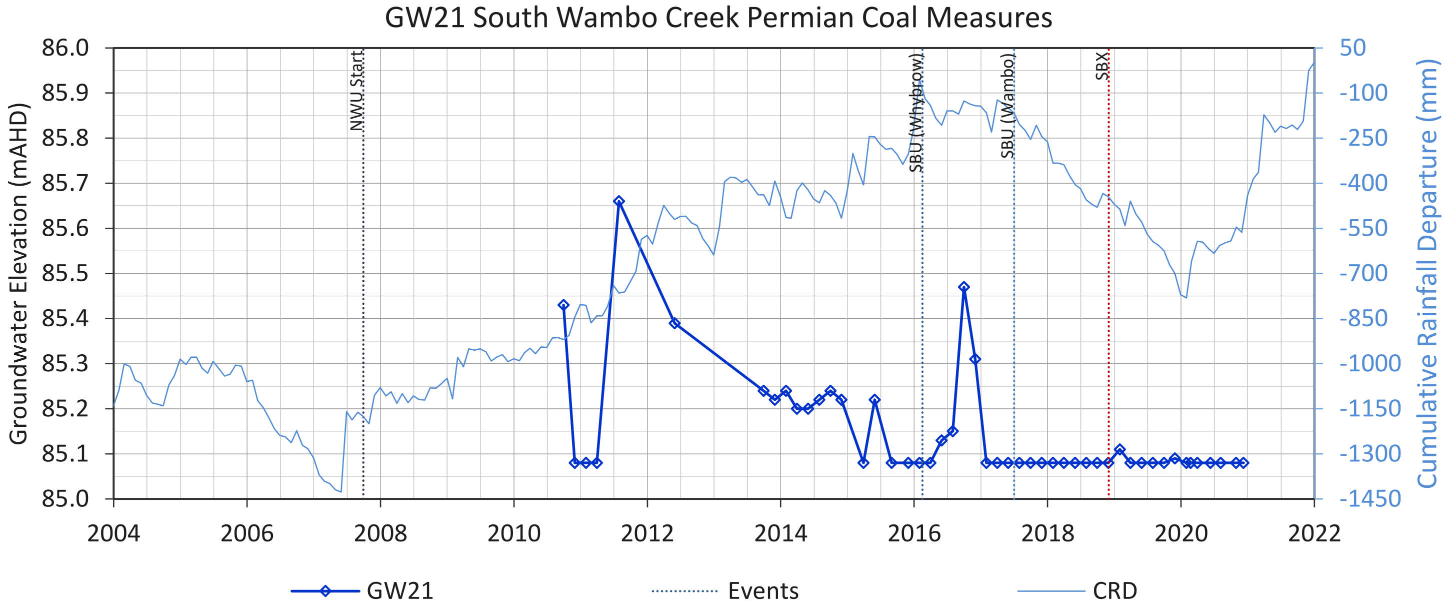

P114 South Wambo Creek Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P114
Events
CRD

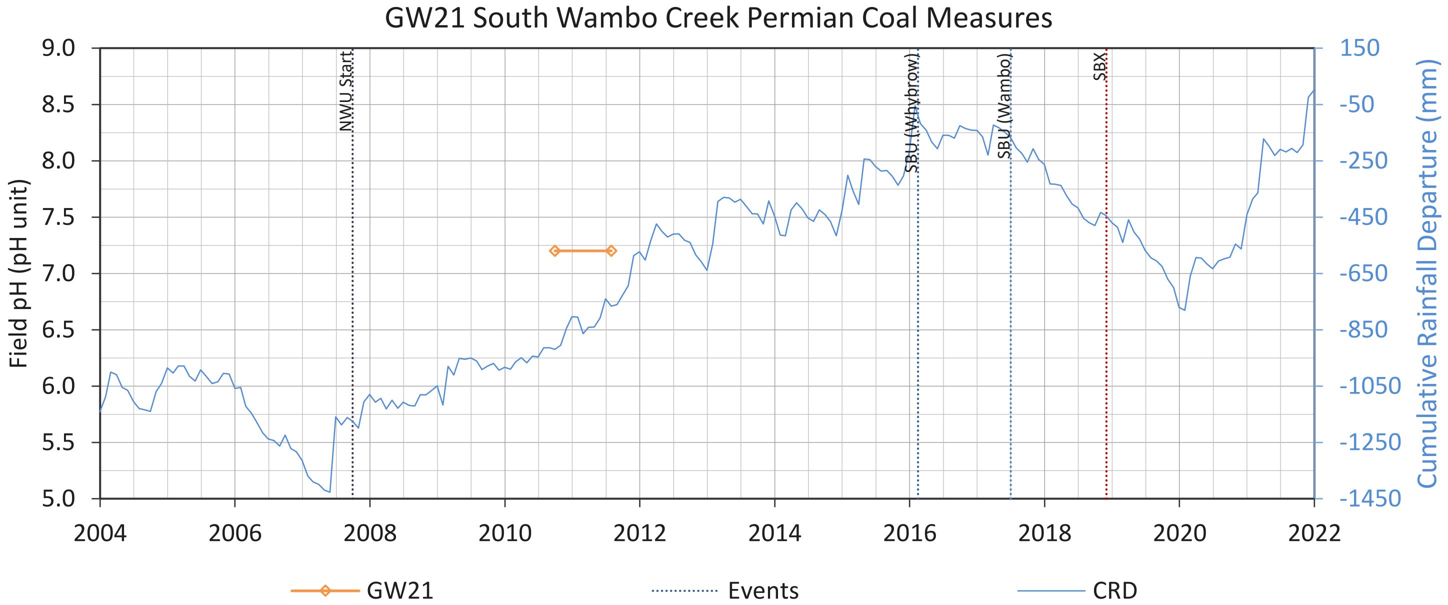

P114 South Wambo Creek Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
12000
10000
8000
6000
4000
2000
0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P114
Events
CRD

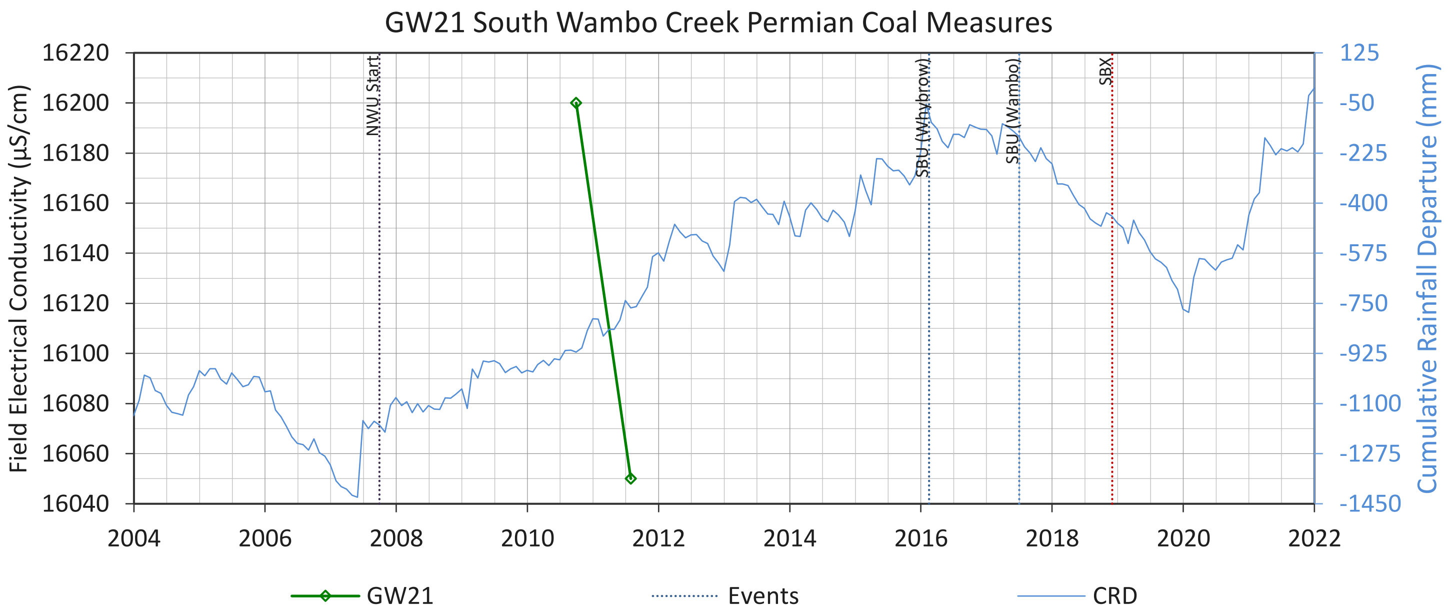

P116 South Wambo Creek Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P116
Events
CRD

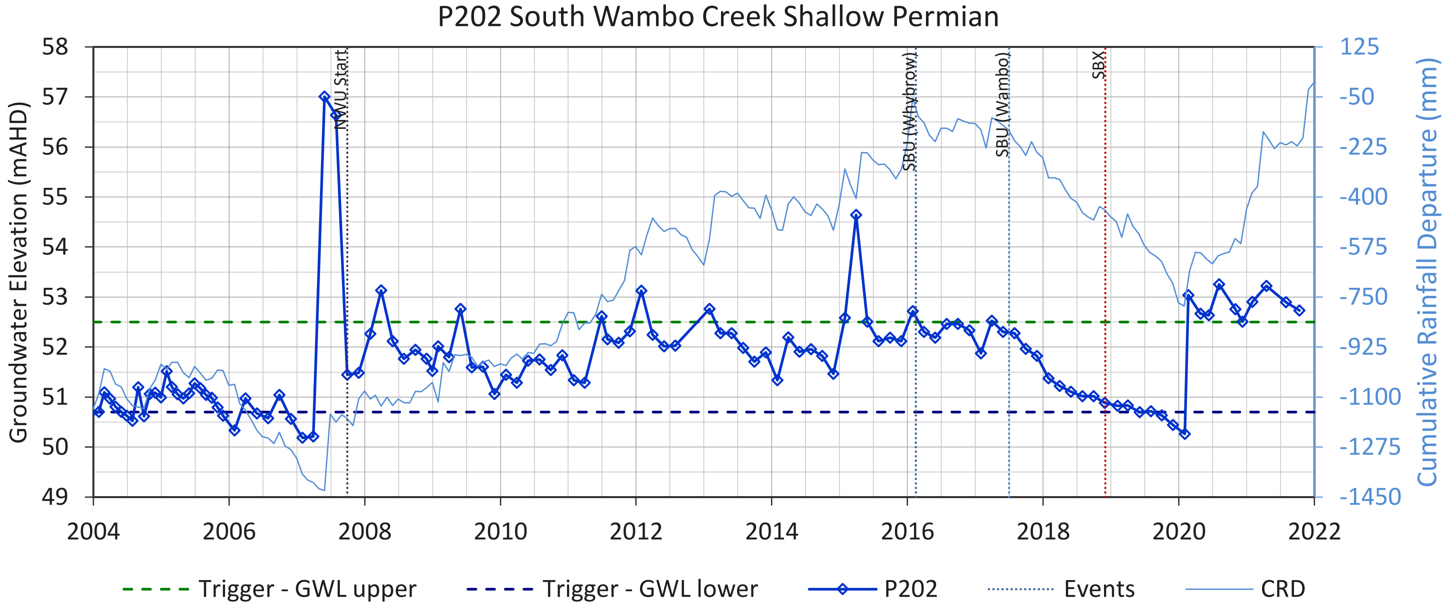

P116 South Wambo Creek Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P116
Events
CRD

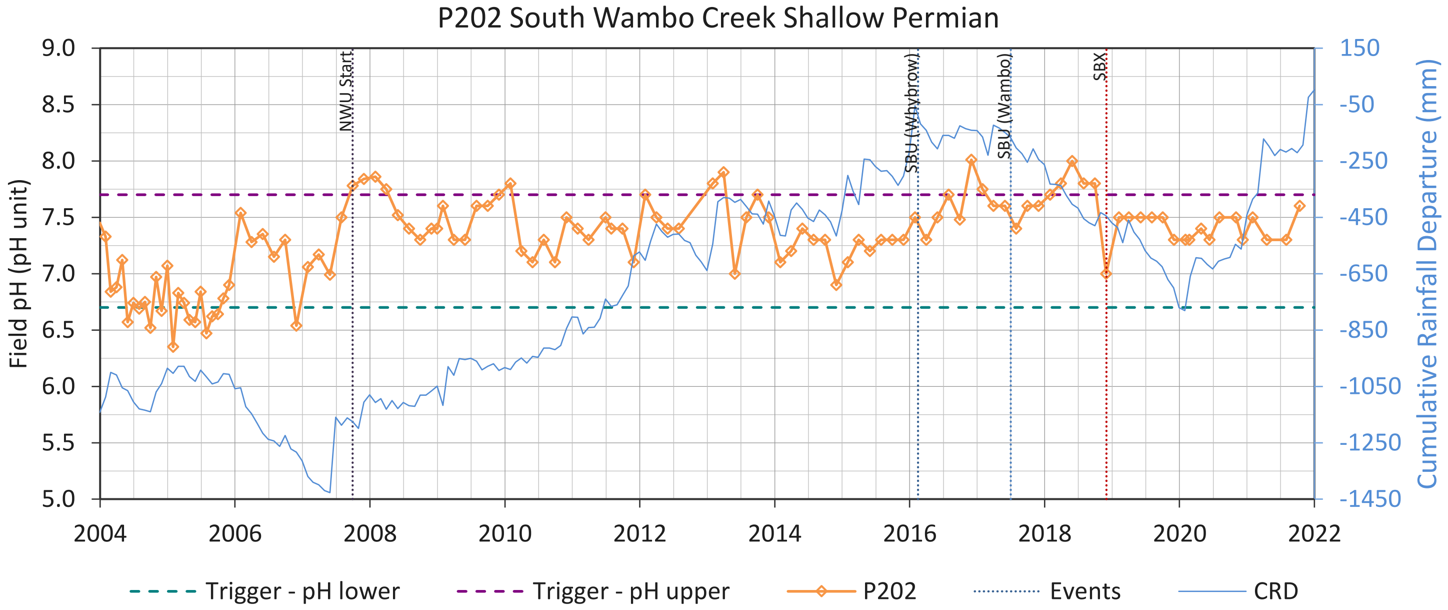

P116 South Wambo Creek Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P116
Events
CRD

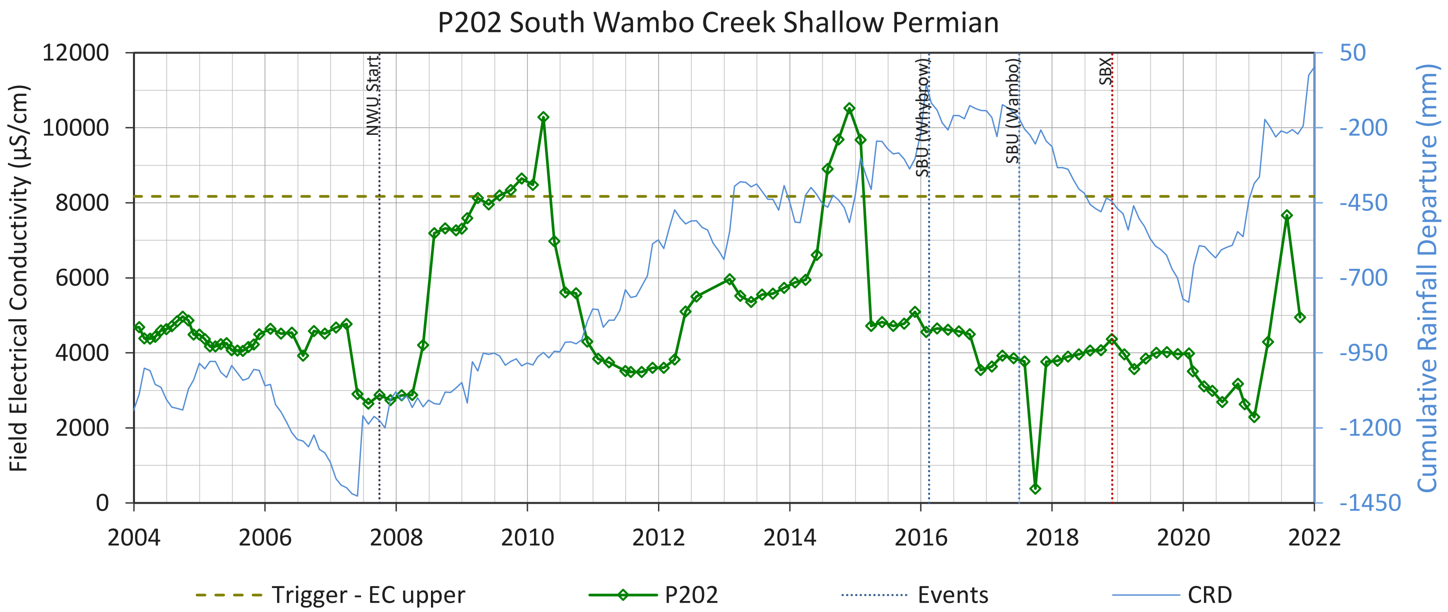

GW21 South Wambo Creek Permian Coal Measures
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW21
Events
CRD

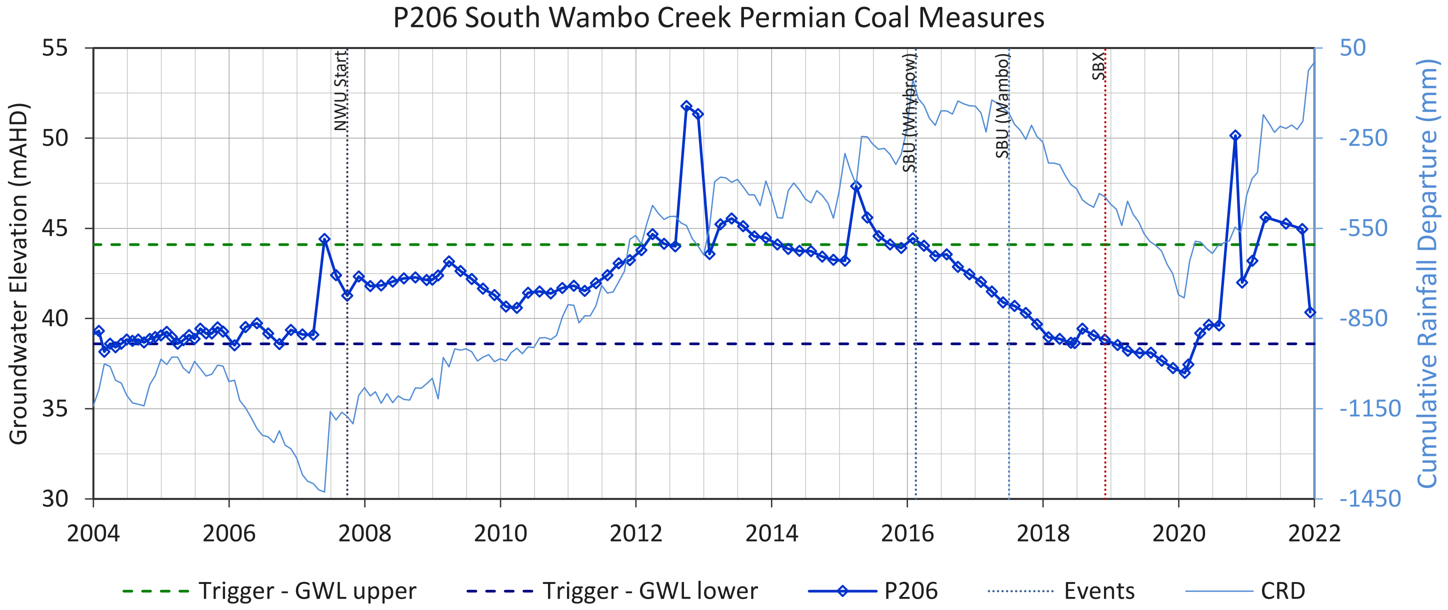

GW21 South Wambo Creek Permian Coal Measures
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW21
Events
CRD

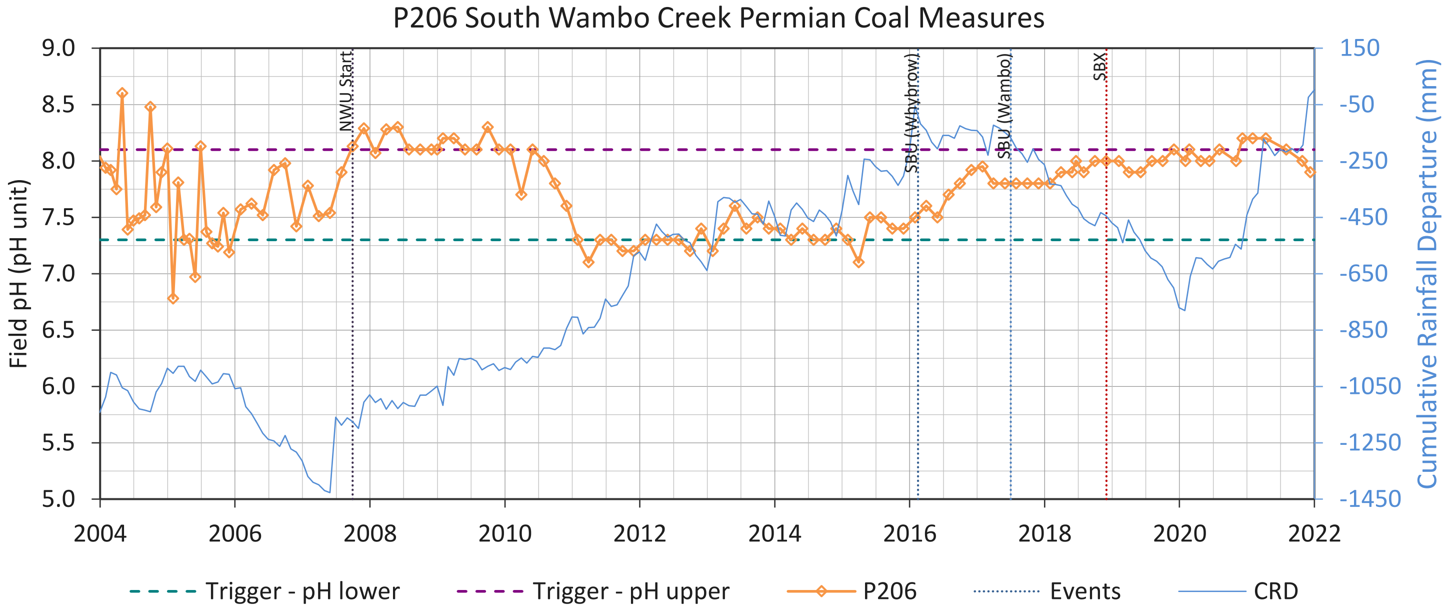

GW21 South Wambo Creek Permian Coal Measures
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW21
Events
CRD

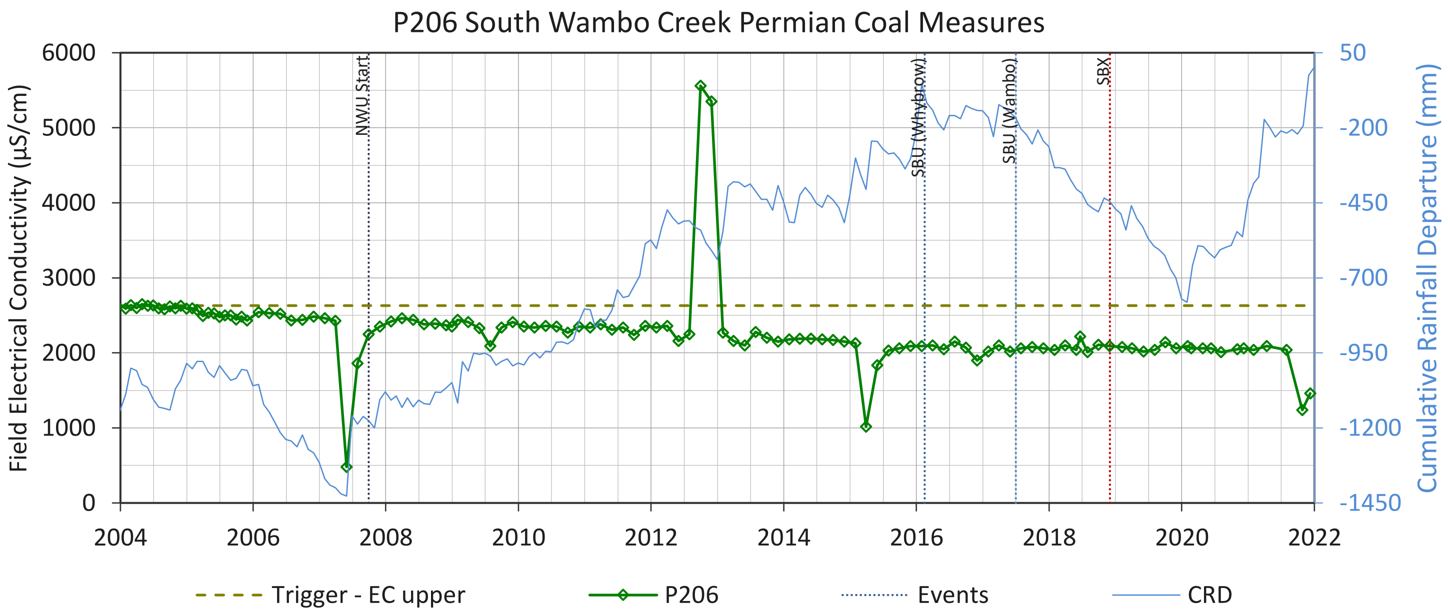

P202 South Wambo Creek Shallow Permian
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - GWL upper
Trigger - GWL lower
P202
Events
CRD

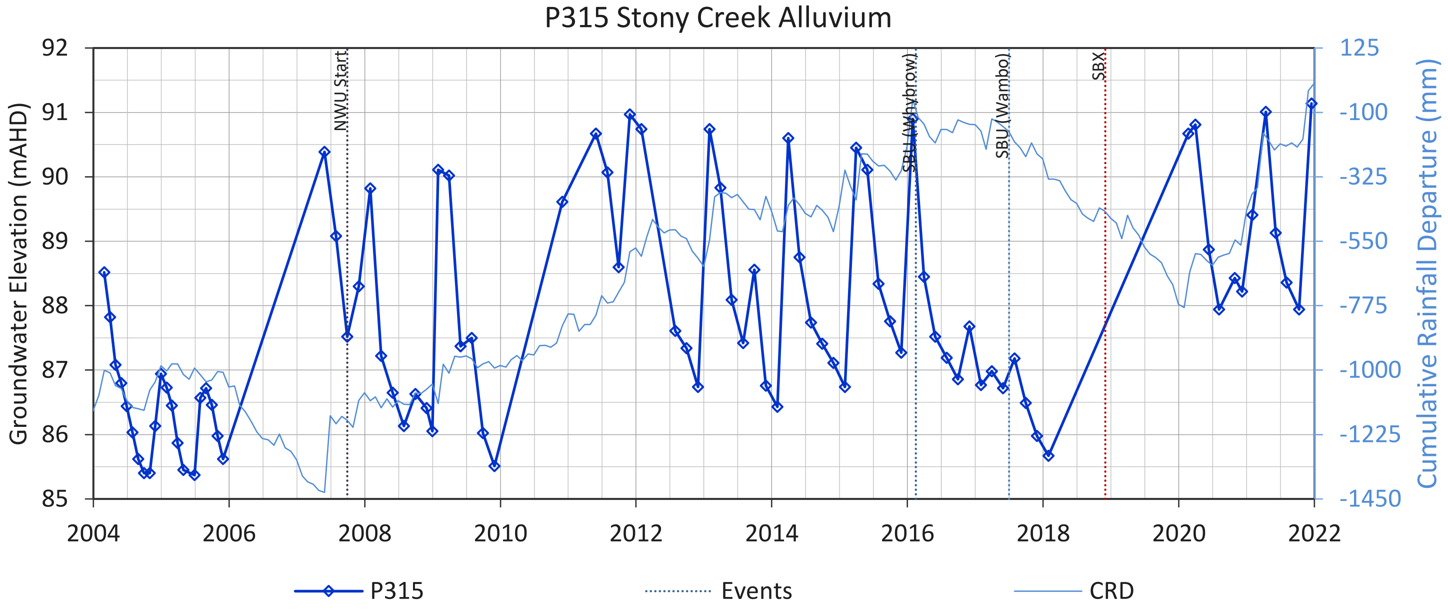

P202 South Wambo Creek Shallow Permian
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - pH lower
Trigger - pH upper
P202
Events
CRD

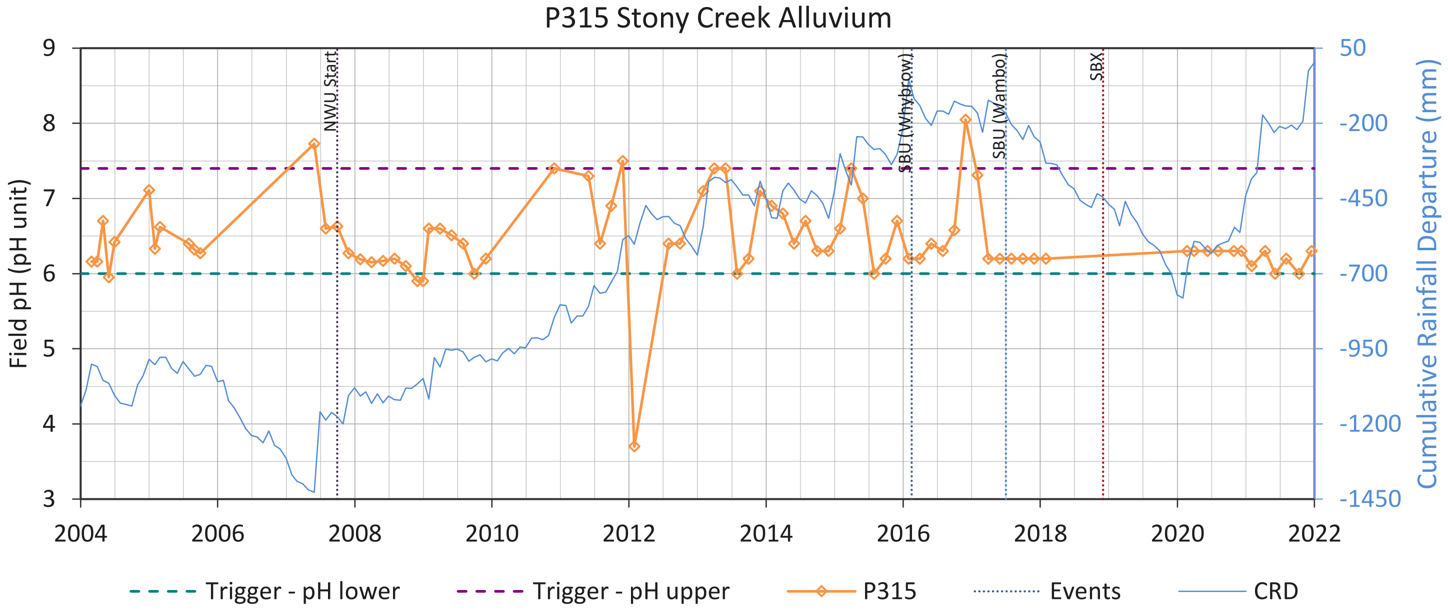

P202 South Wambo Creek Shallow Permian
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - EC upper
P202
Events
CRD

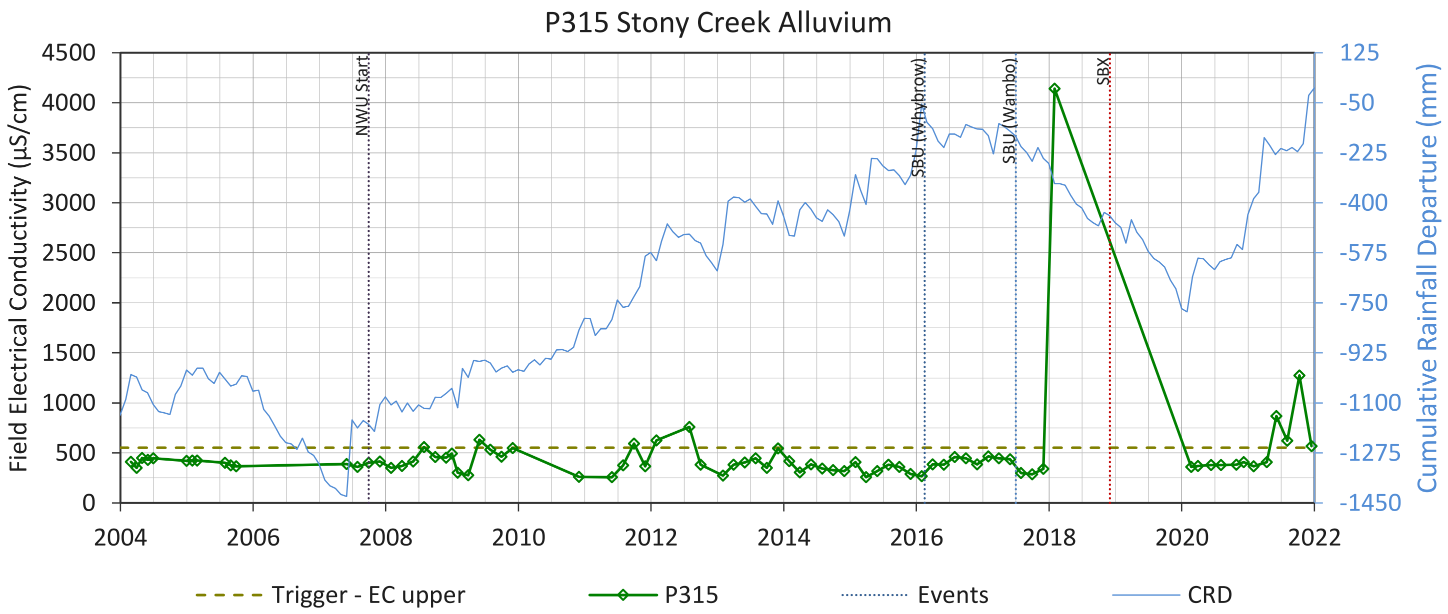

P206 South Wambo Creek Permian Coal Measures
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - GWL upper
Trigger - GWL lower
P206
Events
CRD

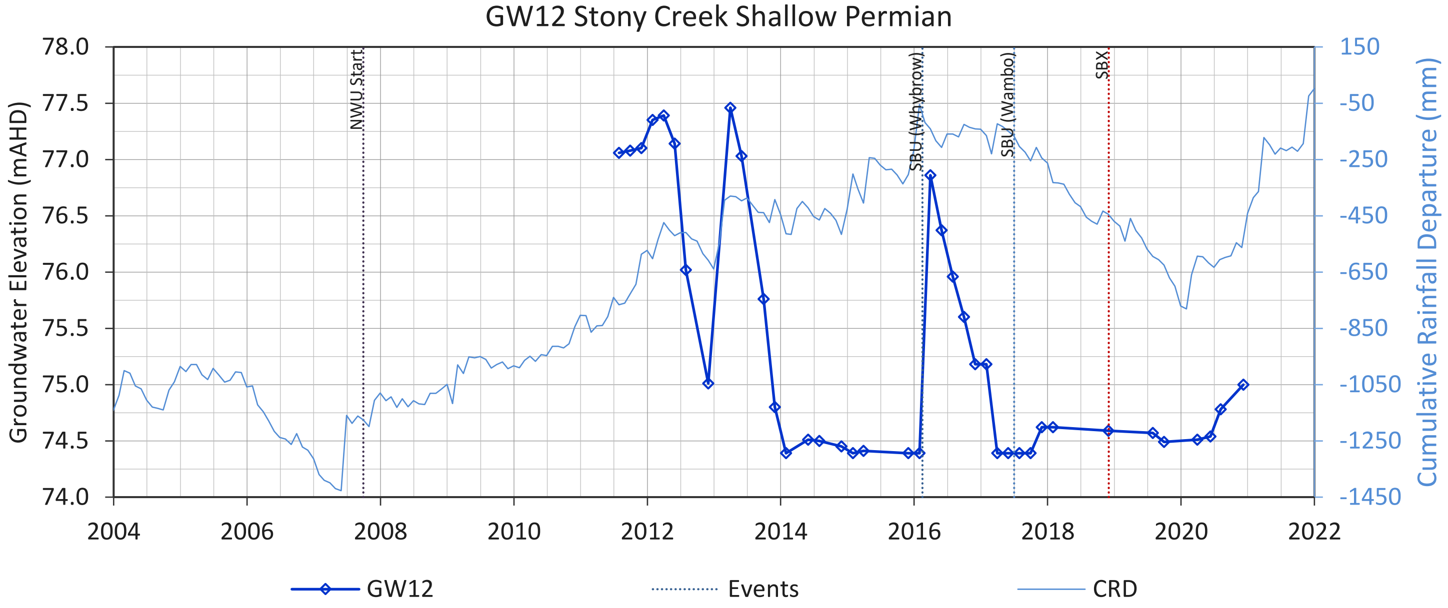

P206 South Wambo Creek Permian Coal Measures
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - pH lower
Trigger - pH upper
P206
Events
CRD

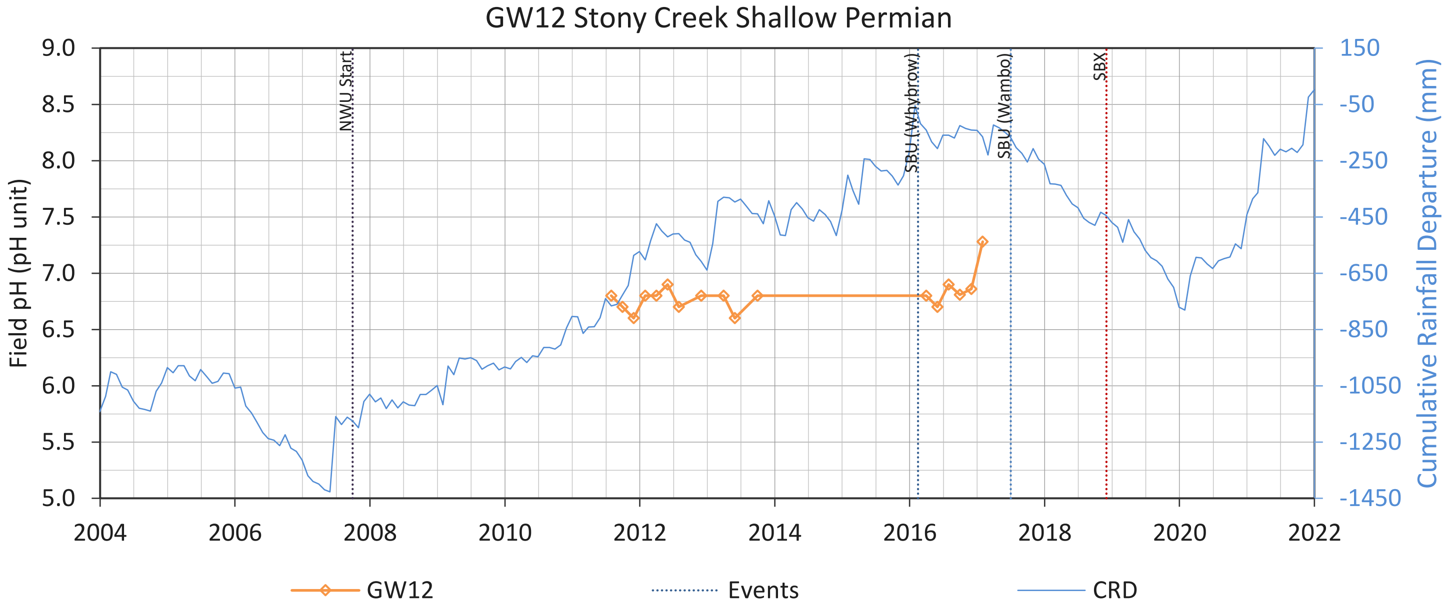

P206 South Wambo Creek Permian Coal Measures
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - EC upper
P206
Events
CRD

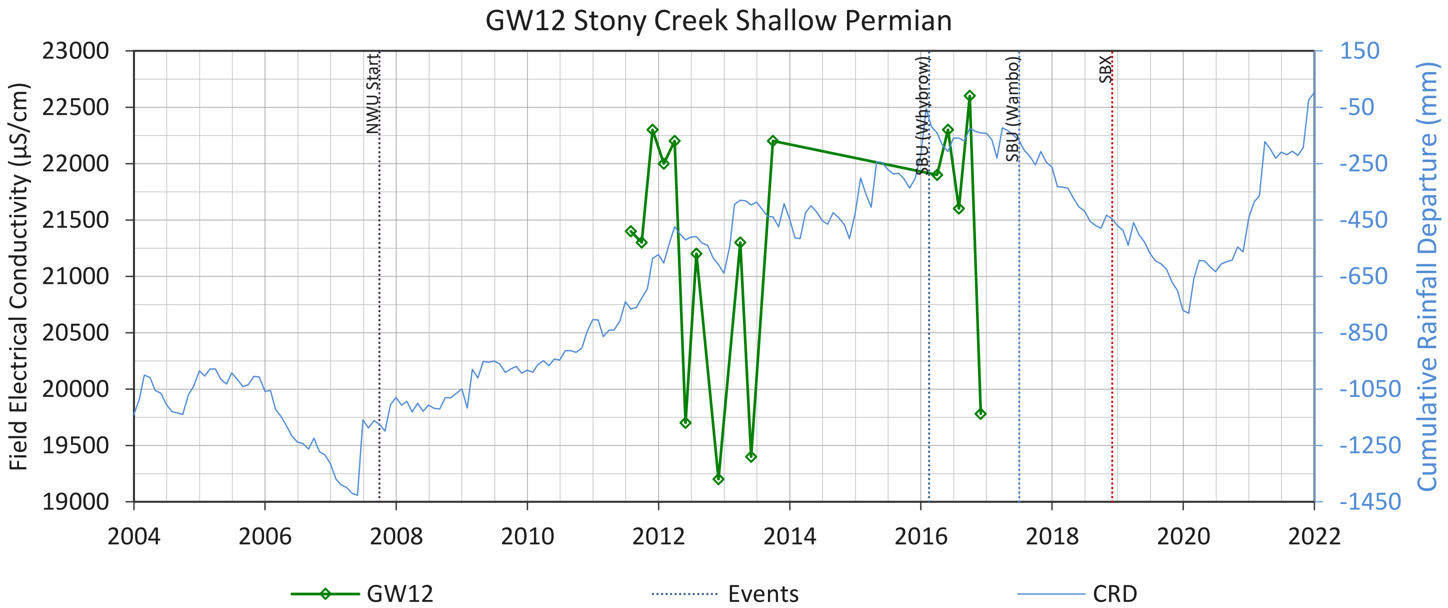

P315 Stony Creek Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P315
Events
CRD

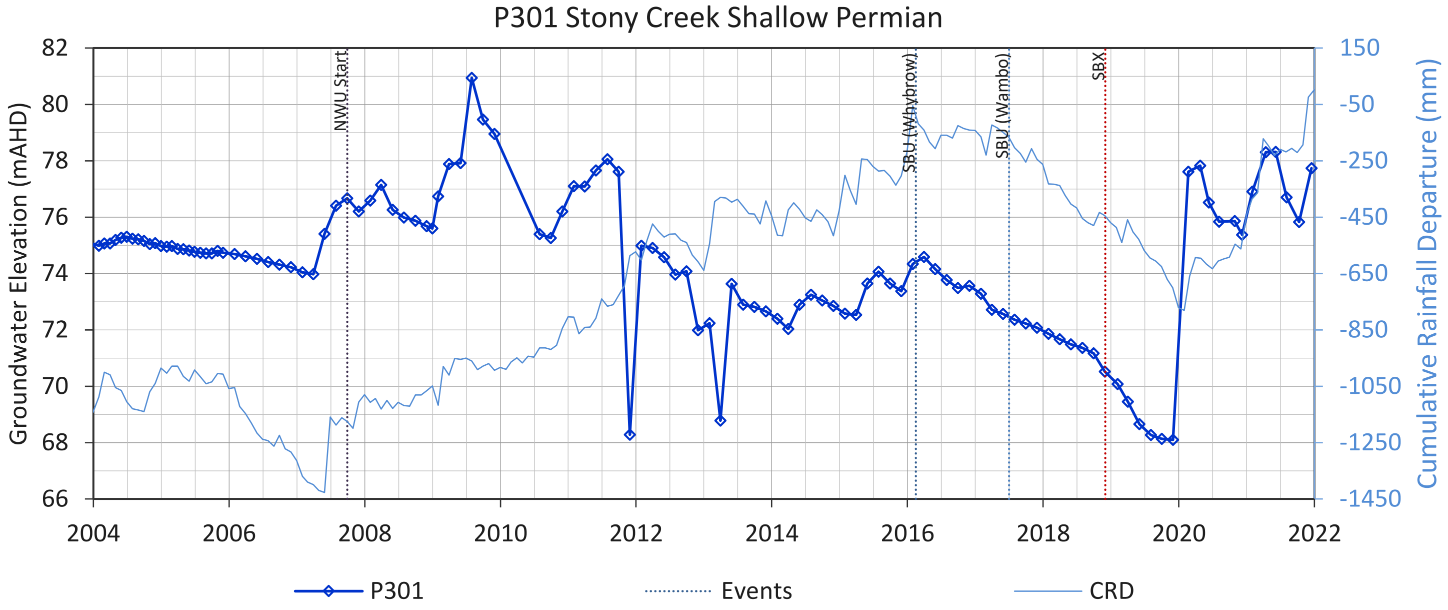

P315 Stony Creek Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - pH lower
Trigger - pH upper
P315
Events
CRD

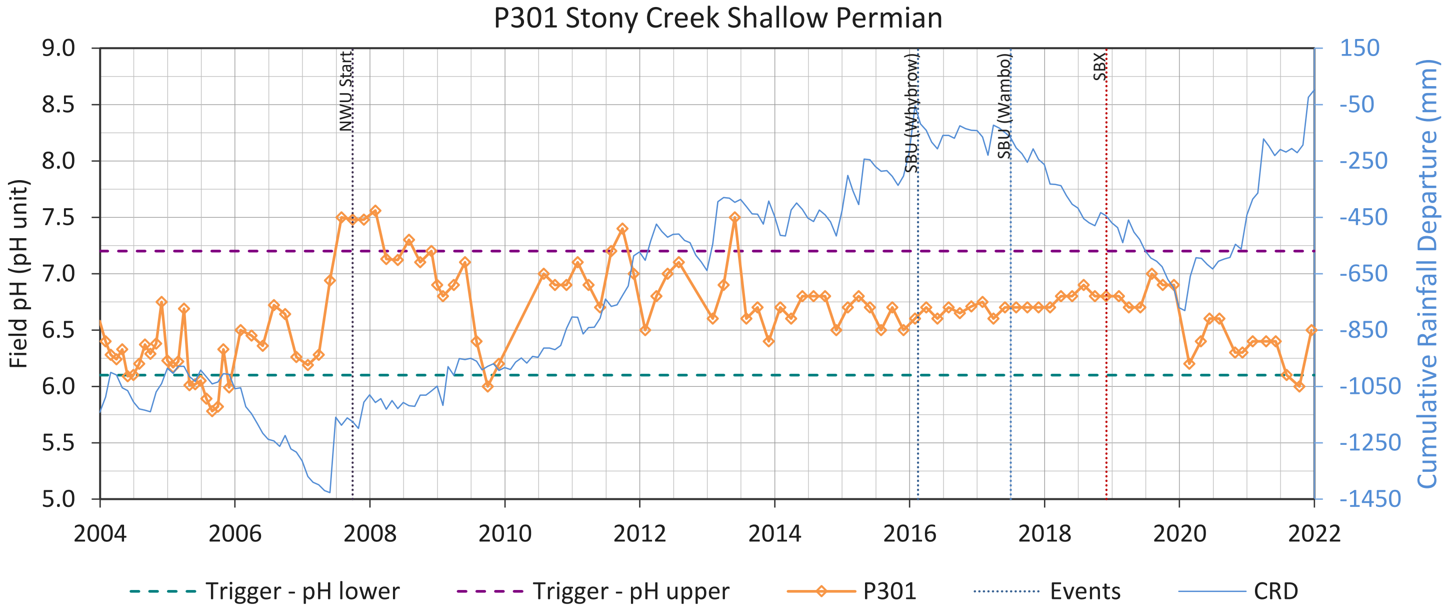

P315 Stony Creek Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - EC upper
P315
Events
CRD

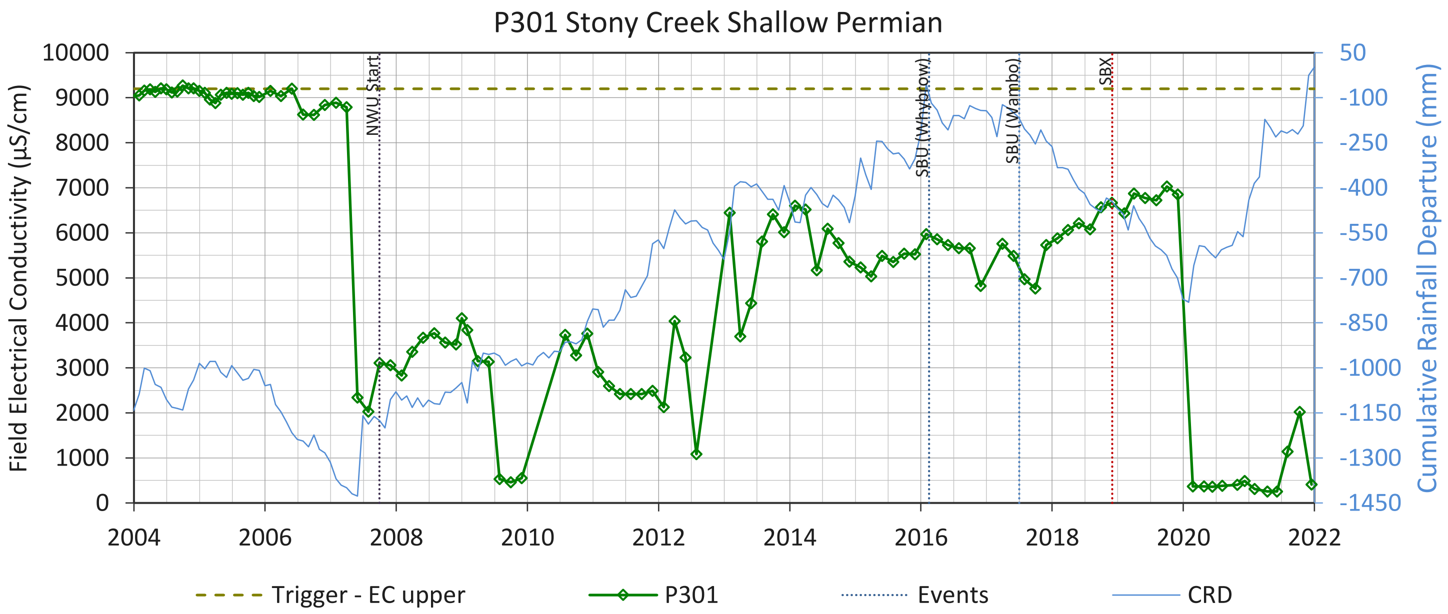

GW12 Stony Creek Shallow Permian
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
78.0
77.5
77.0
76.5
76.0
75.5
75.0
74.5
74.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW12
Events
CRD

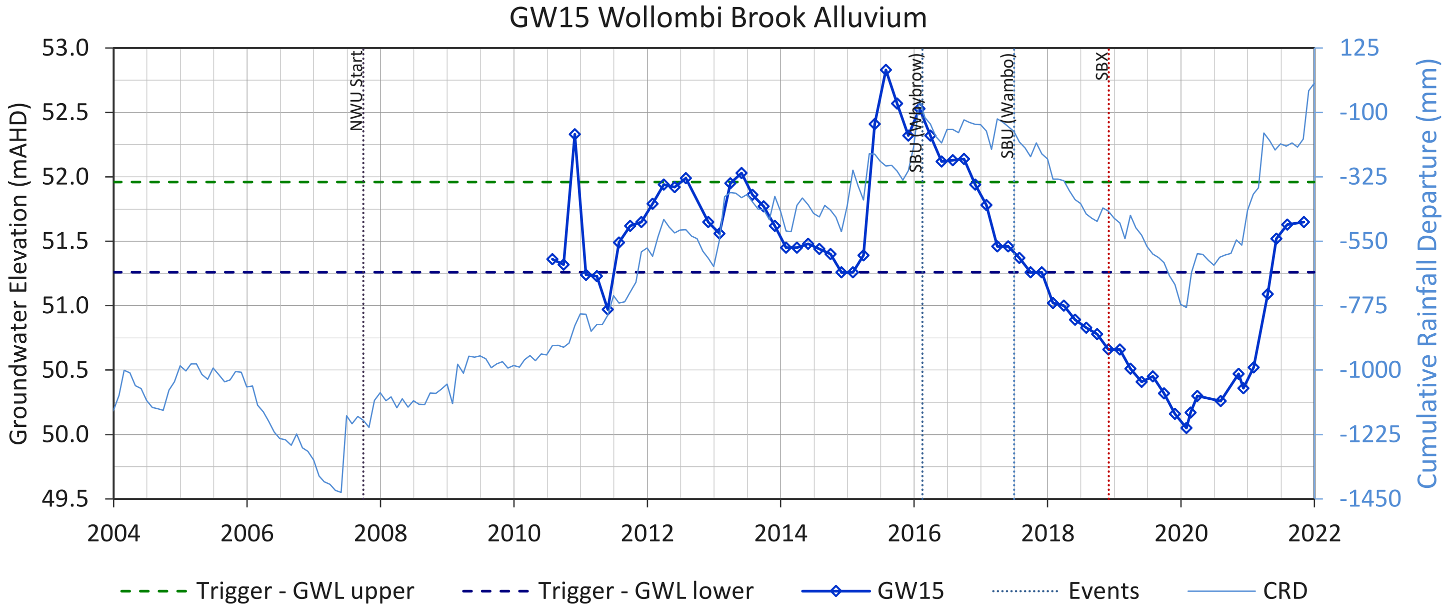

GW12 Stony Creek Shallow Permian
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW12
Events
CRD

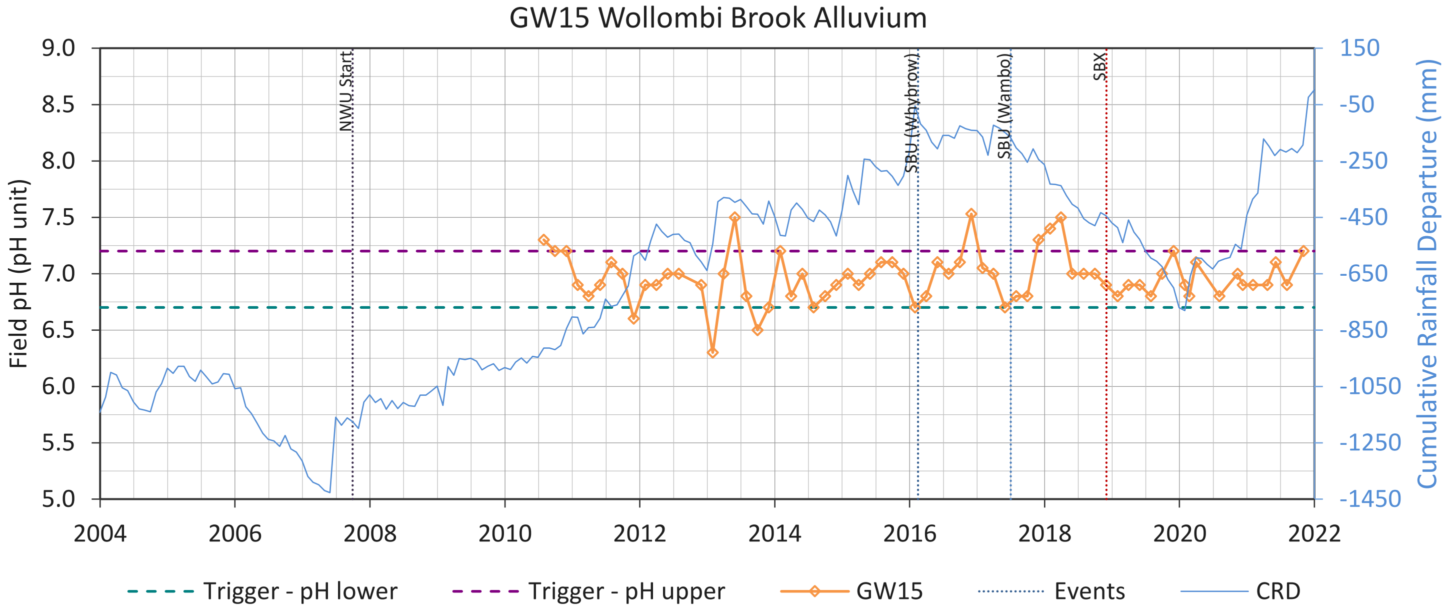

GW12 Stony Creek Shallow Permian
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
23000
22500
22000
21500
21000
20500
20000
19500
19000
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW12
Events
CRD

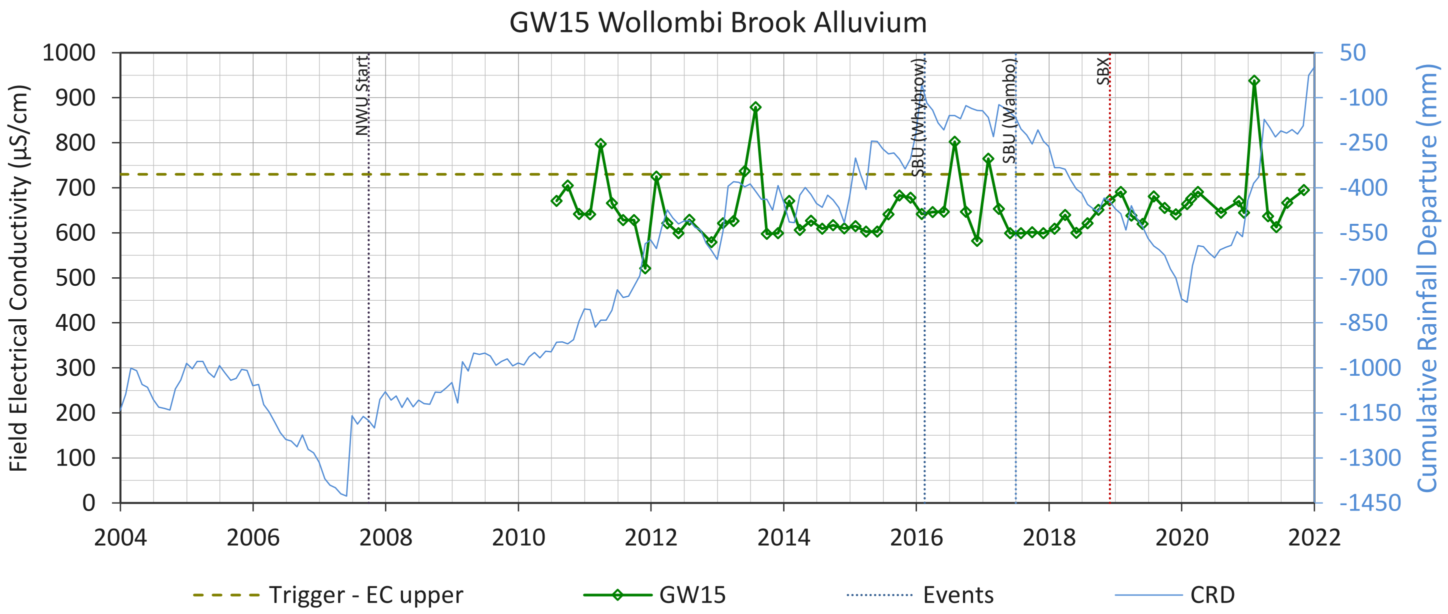

P301 Stony Creek Shallow Permian
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P301
Events
CRD

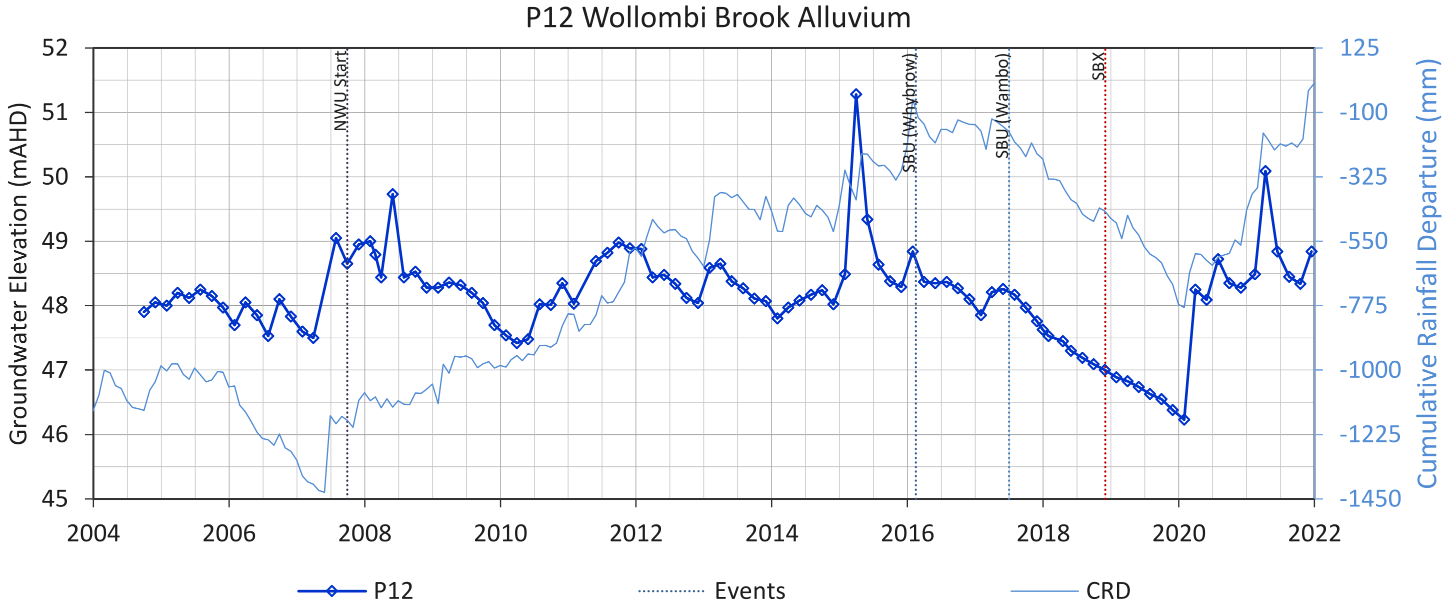

P301 Stony Creek Shallow Permian
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - pH lower
Trigger - pH upper
P301
Events
CRD

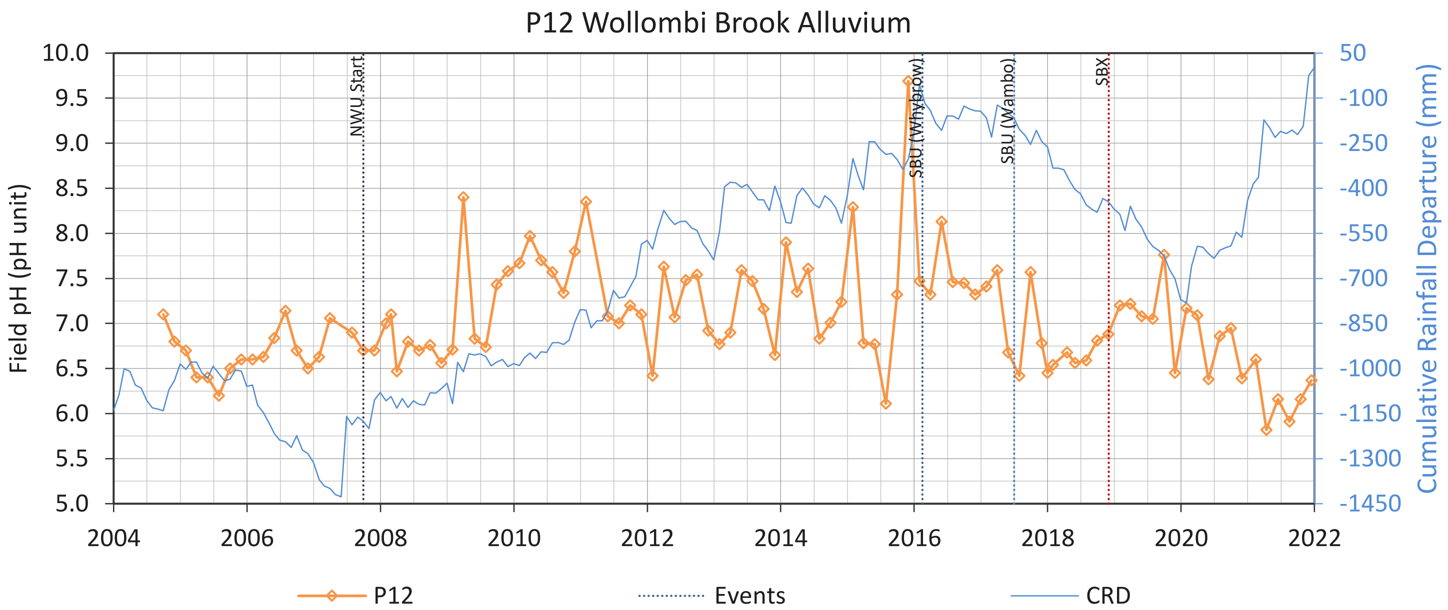

P301 Stony Creek Shallow Permian
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - EC upper
P301
Events
CRD

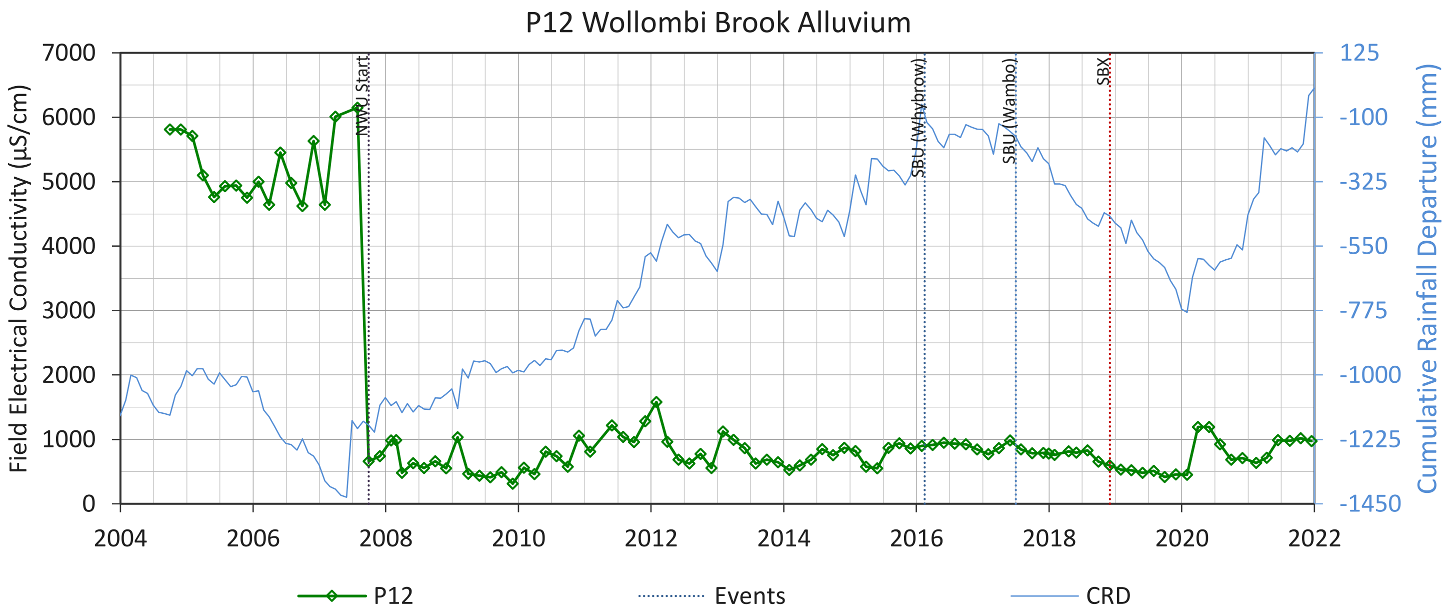

GW15 Wollombi Brook Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
53.0
52.5
52.0
51.5
51.0
50.5
50.0
49.5
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Trigger - GWL upper
Trigger - GWL lower
GW15
Events
CRD

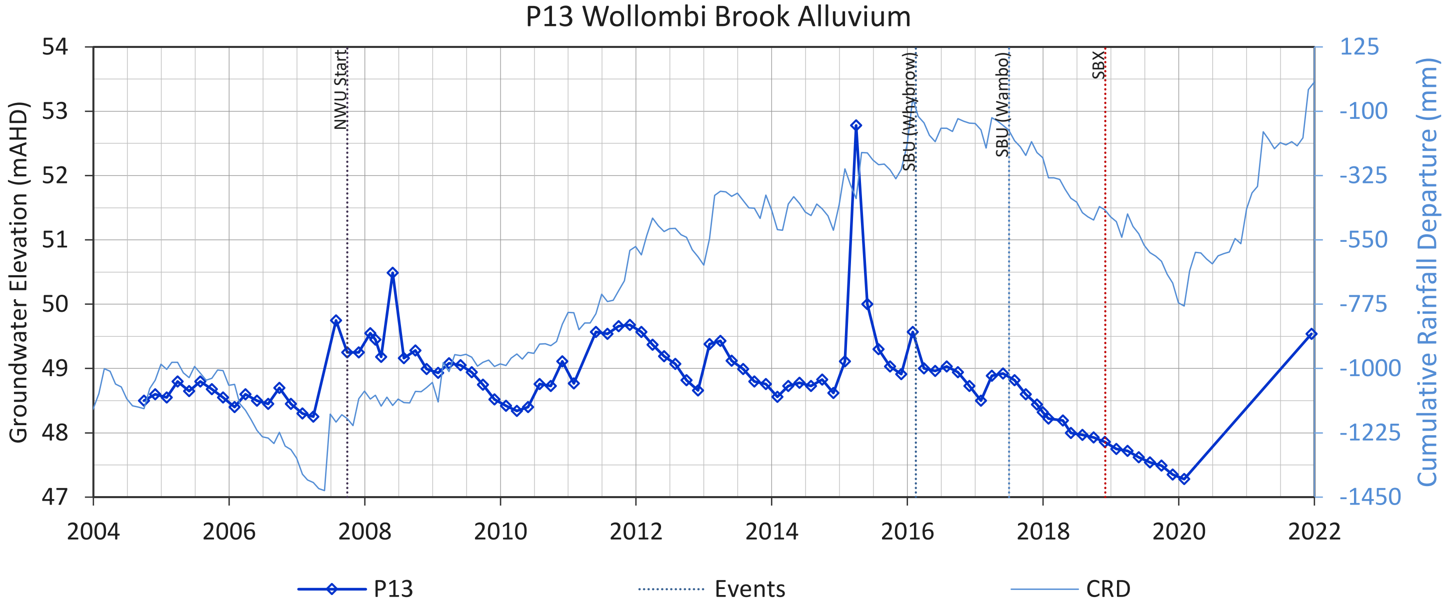

GW15 Wollombi Brook Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Trigger - pH lower
Trigger - pH upper
GW15
Events
CRD

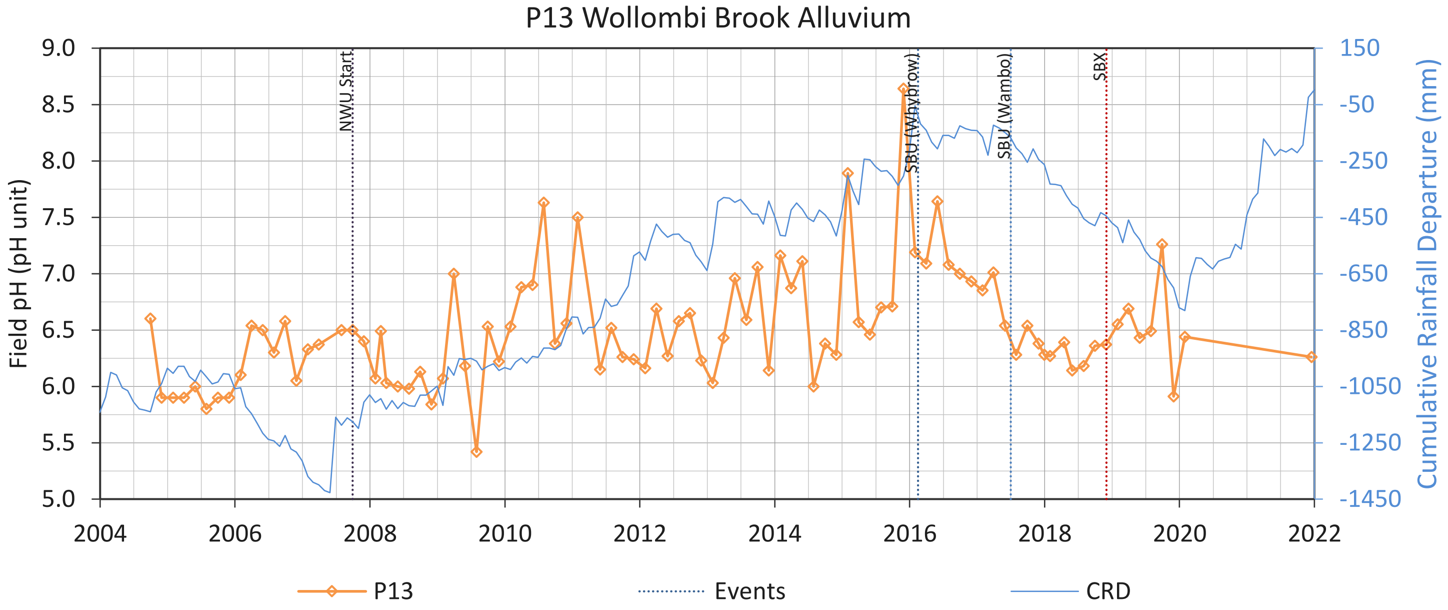

GW15 Wollombi Brook Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
1000
900
800
700
600
500
400
300
200
100
0
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Trigger - EC upper
GW15
Events
CRD

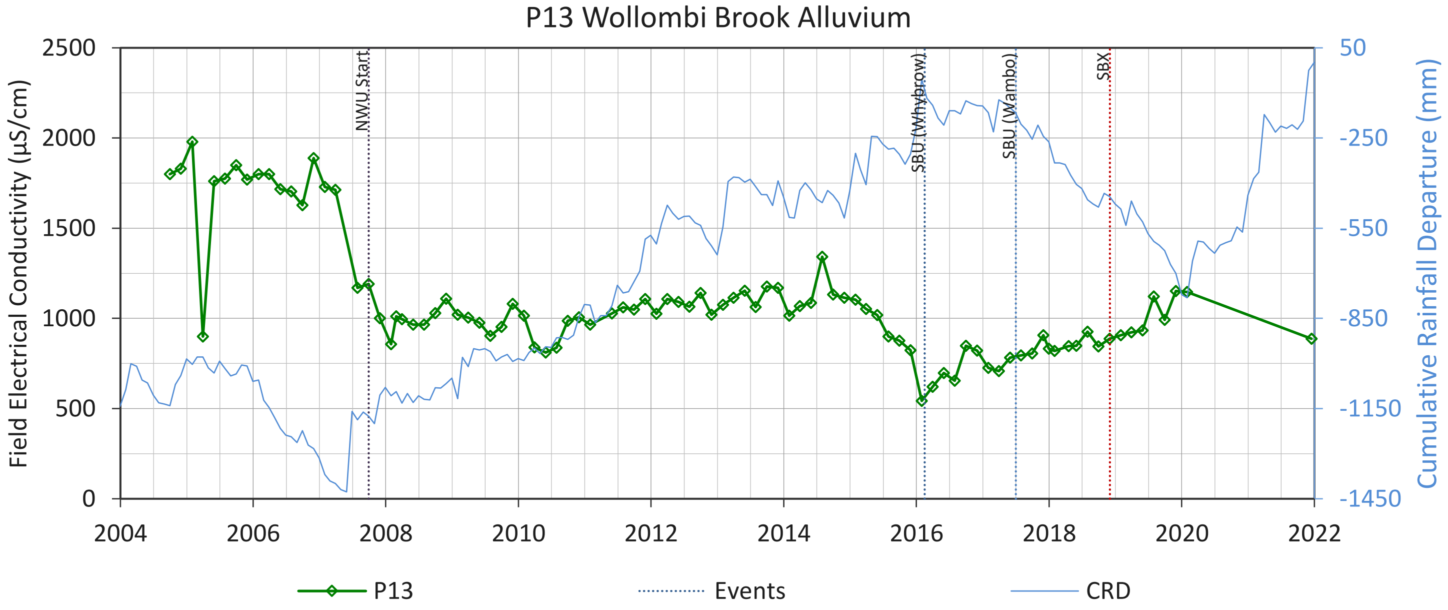

P12 Wollombi Brook Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P12
Events
CRD

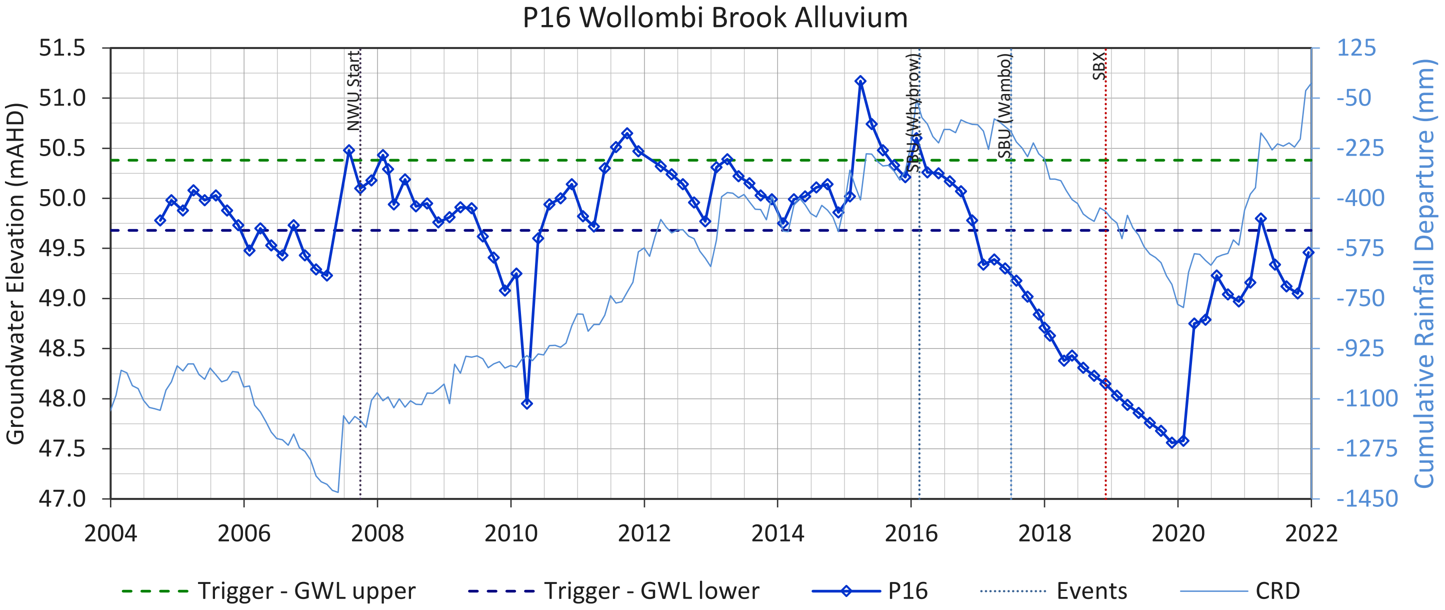

P12 Wollombi Brook Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P12
Events
CRD

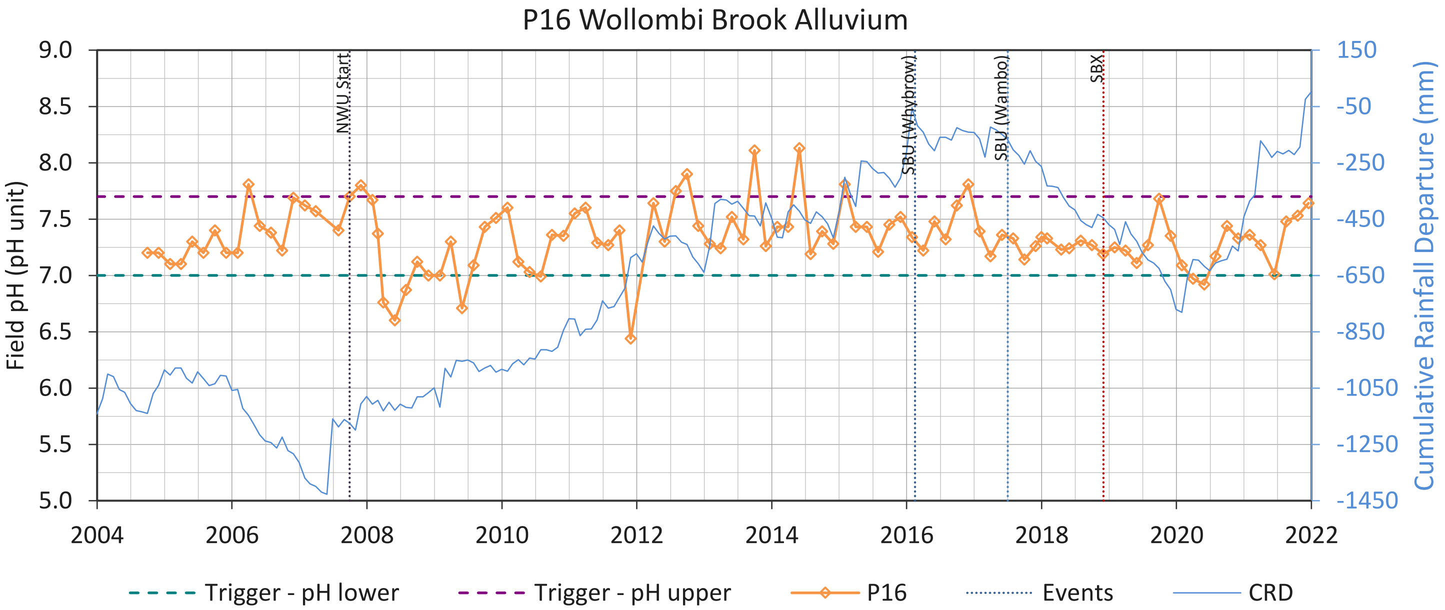

P12 Wollombi Brook Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P12
Events
CRD

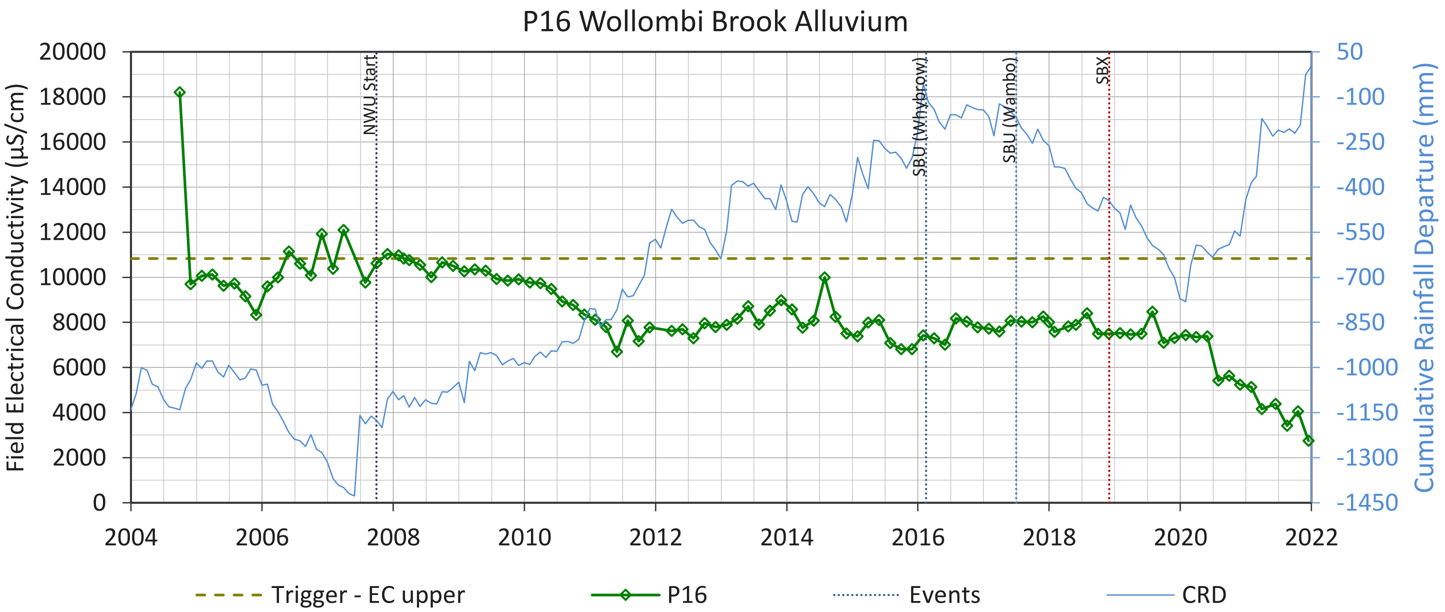

P13 Wollombi Brook Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
54
53
52
51
50
49
48
47
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P13
Events
CRD

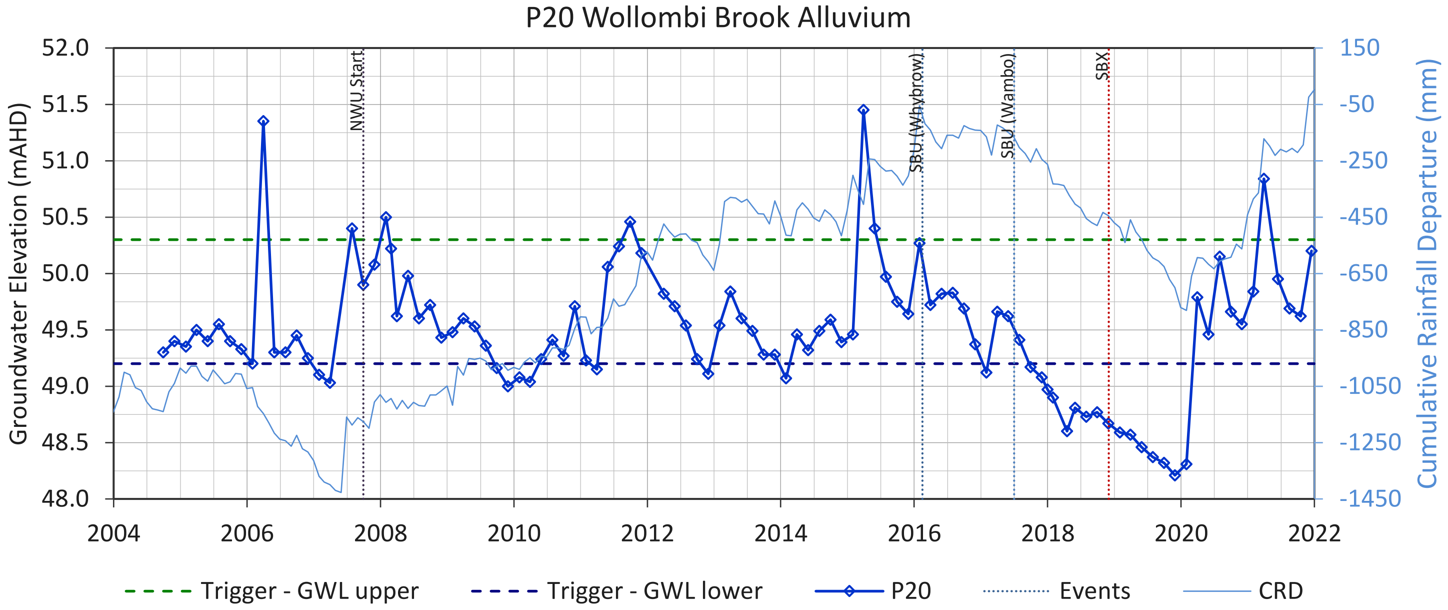

P13 Wollombi Brook Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P13
Events
CRD

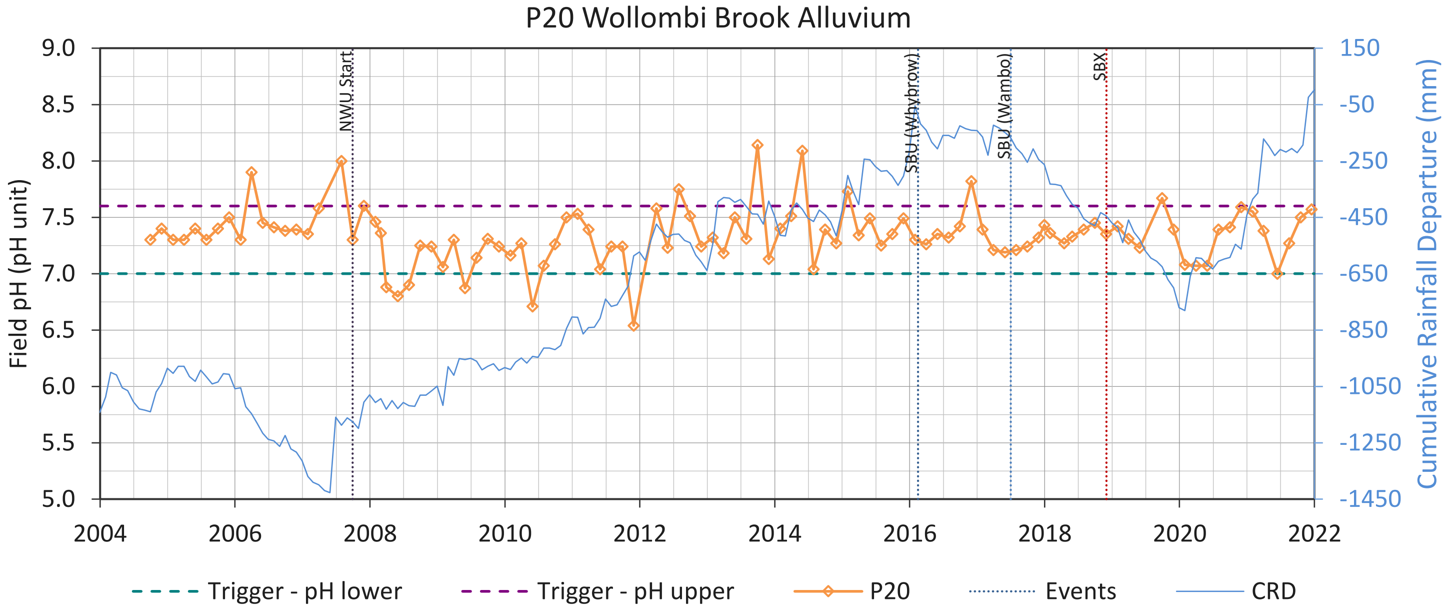

P13 Wollombi Brook Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
2500
2000
1500
1000
500
0
50
-250
-550
-850
-1150
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P13
Events
CRD

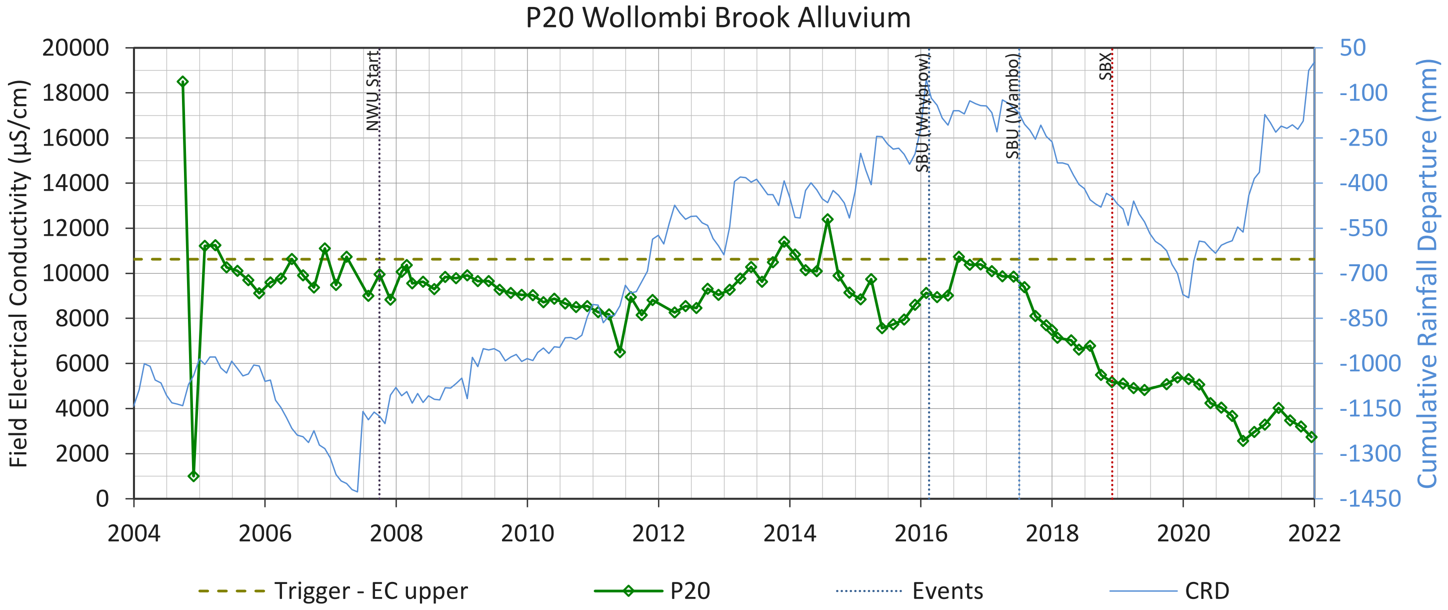

P16 Wollombi Brook Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - GWL upper
Trigger - GWL lower
P16
Events
CRD

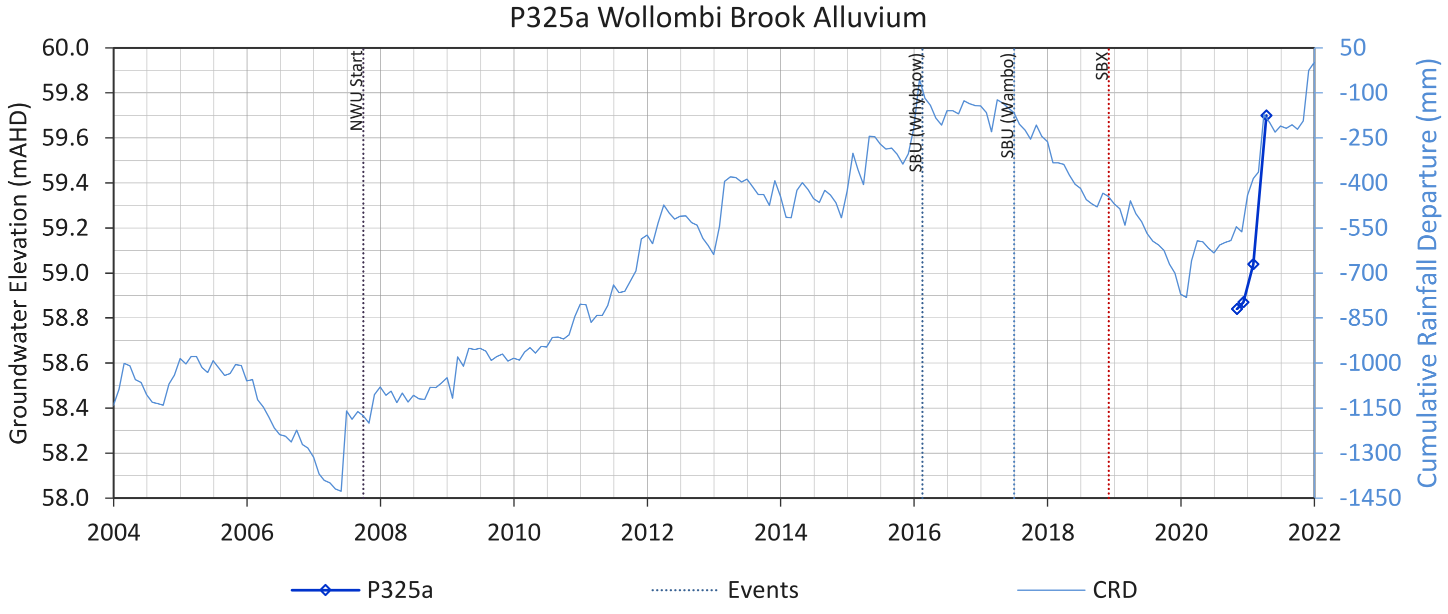

P16 Wollombi Brook Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - pH lower
Trigger - pH upper
P16
Events
CRD

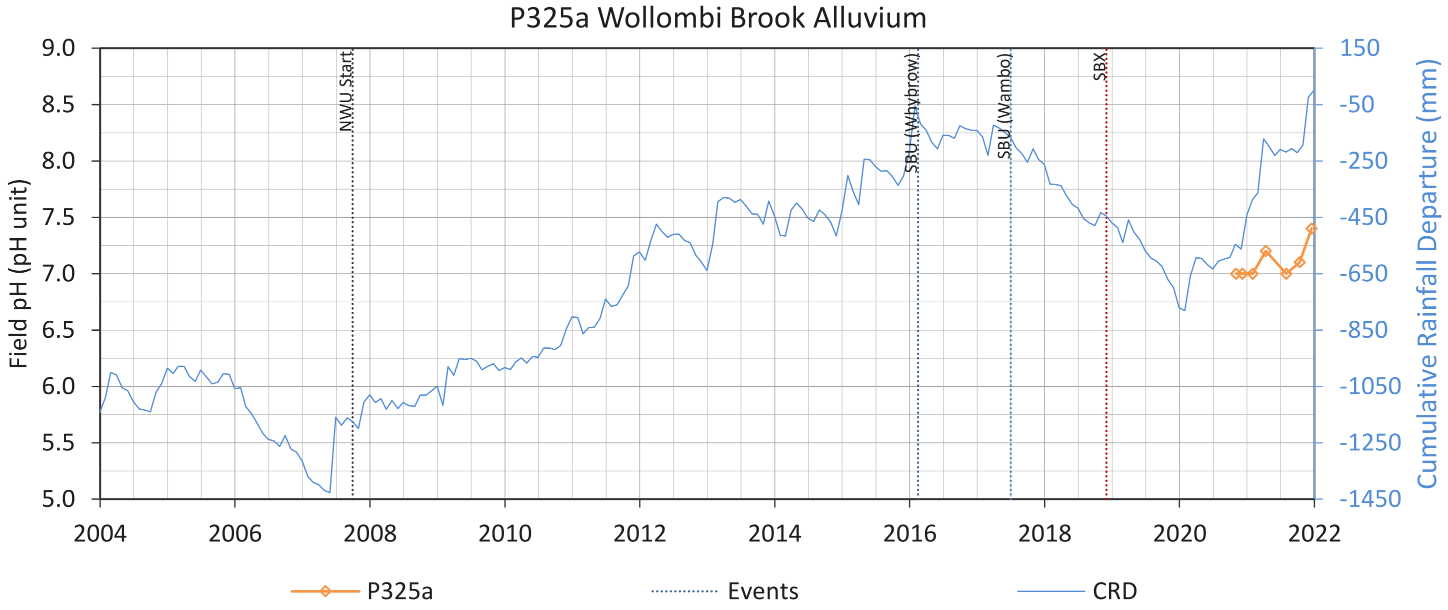

P16 Wollombi Brook Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - EC upper
P16
Events
CRD

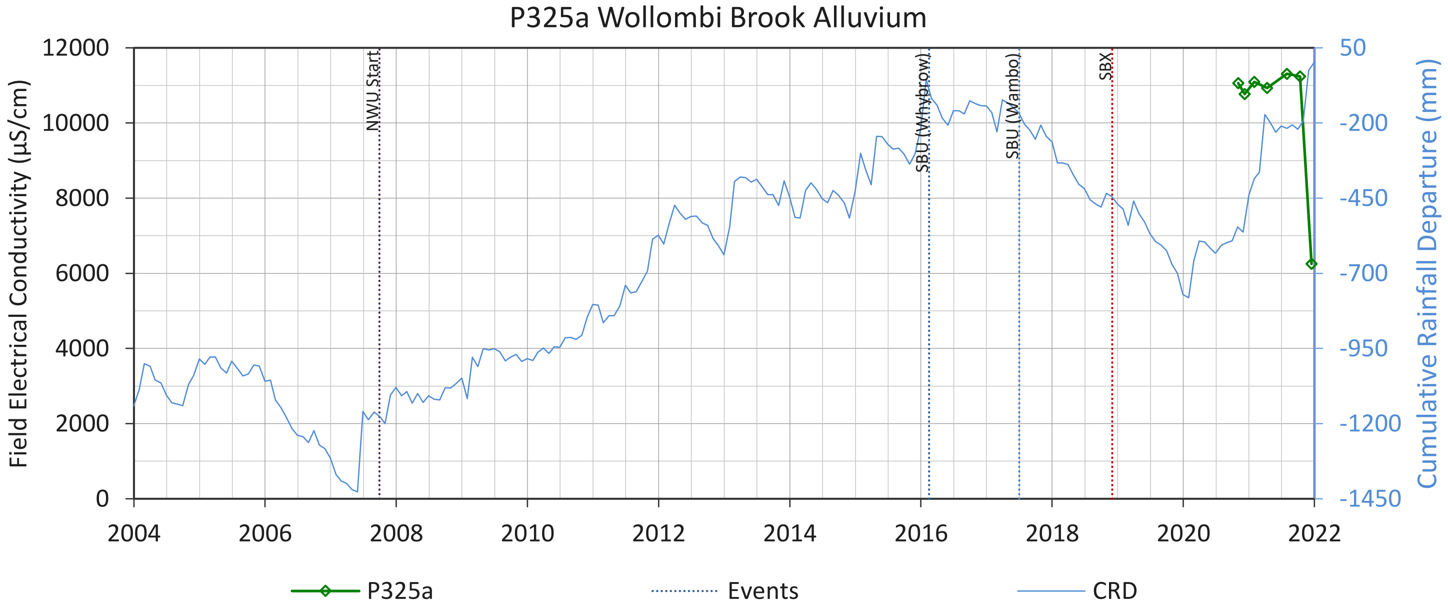

P20 Wollombi Brook Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - GWL upper
Trigger - GWL lower
P20
Events
CRD

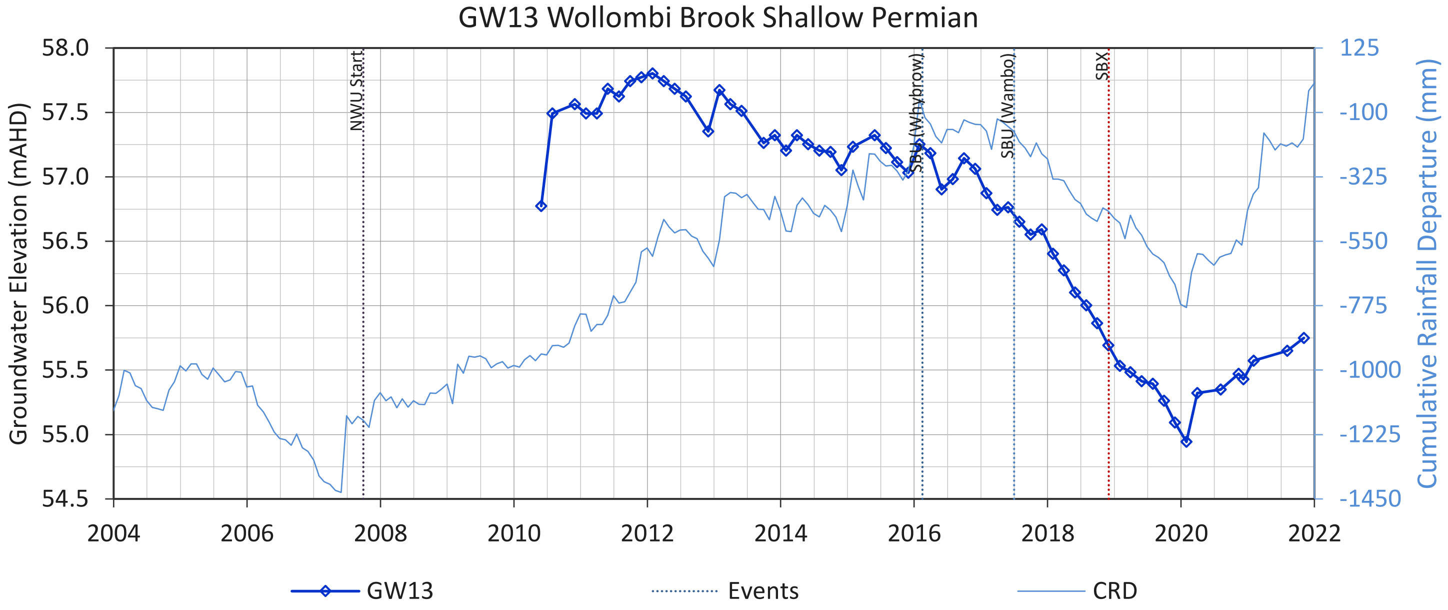

P20 Wollombi Brook Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - pH lower
Trigger - pH upper
P20
Events
CRD

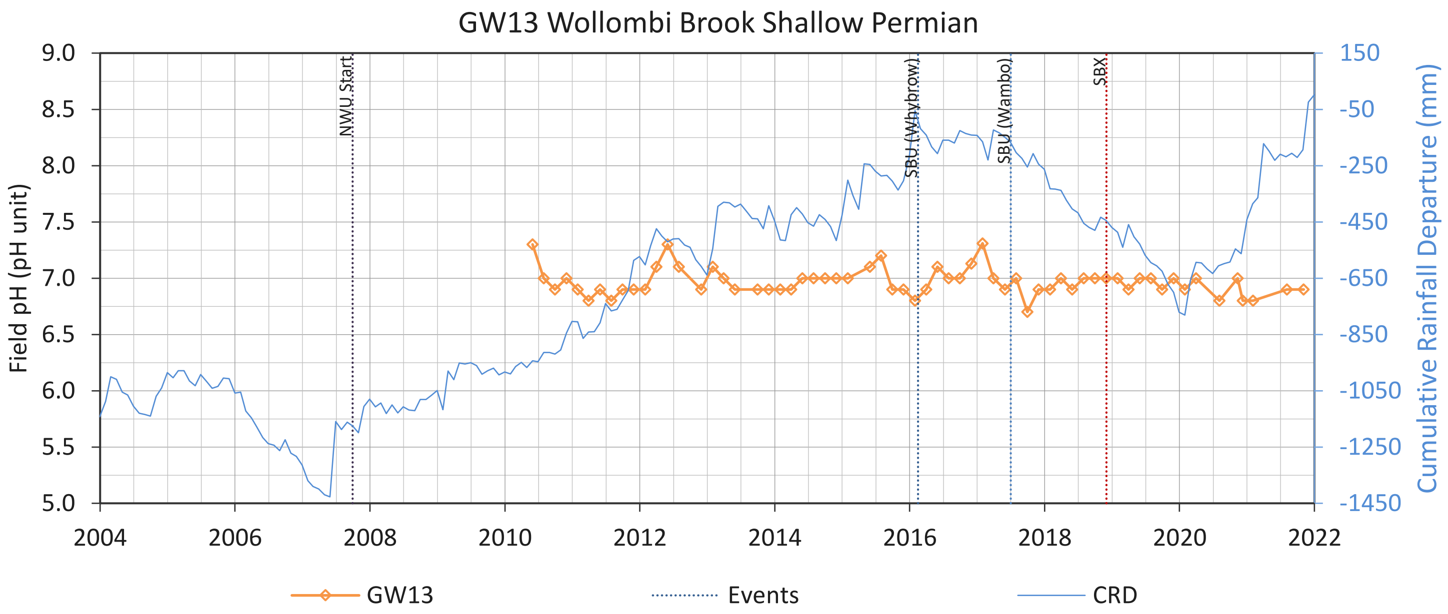

P20 Wollombi Brook Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
Trigger - EC upper
P20
Events
CRD

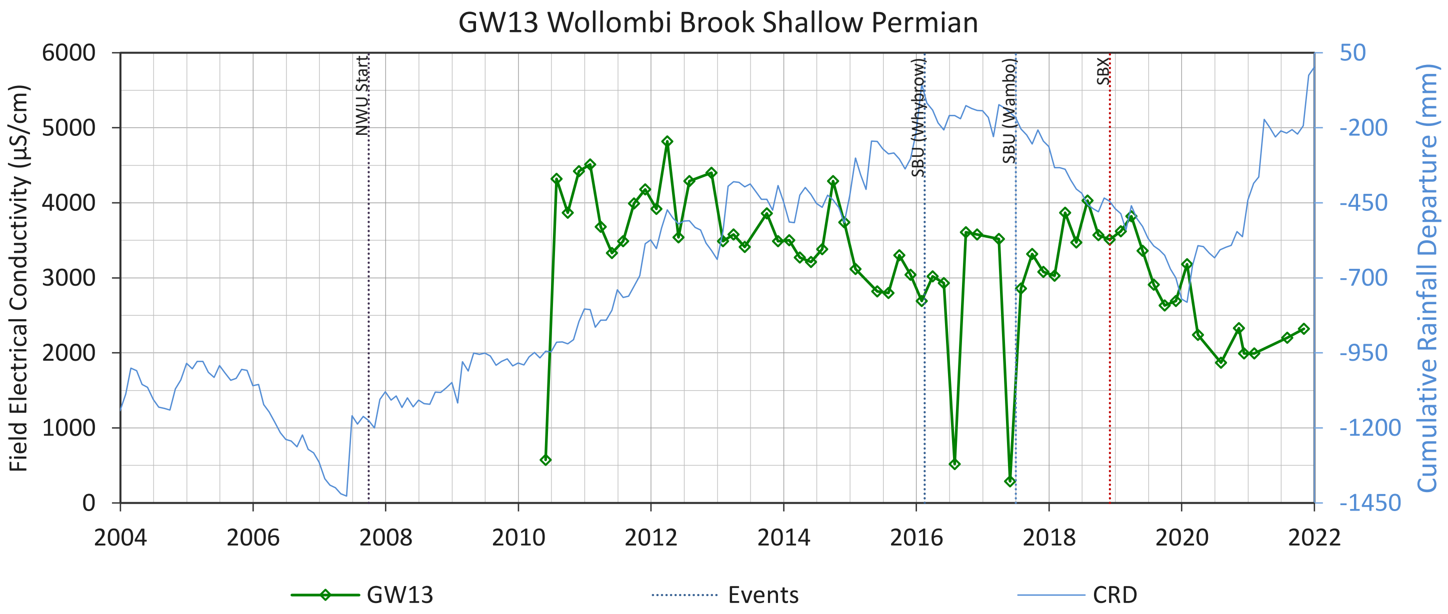

P325a Wollombi Brook Alluvium
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
60.0
59.8
59.6
59.4
59.2
59.0
58.8
58.6
58.4
58.2
58.0
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P325a
Events
CRD

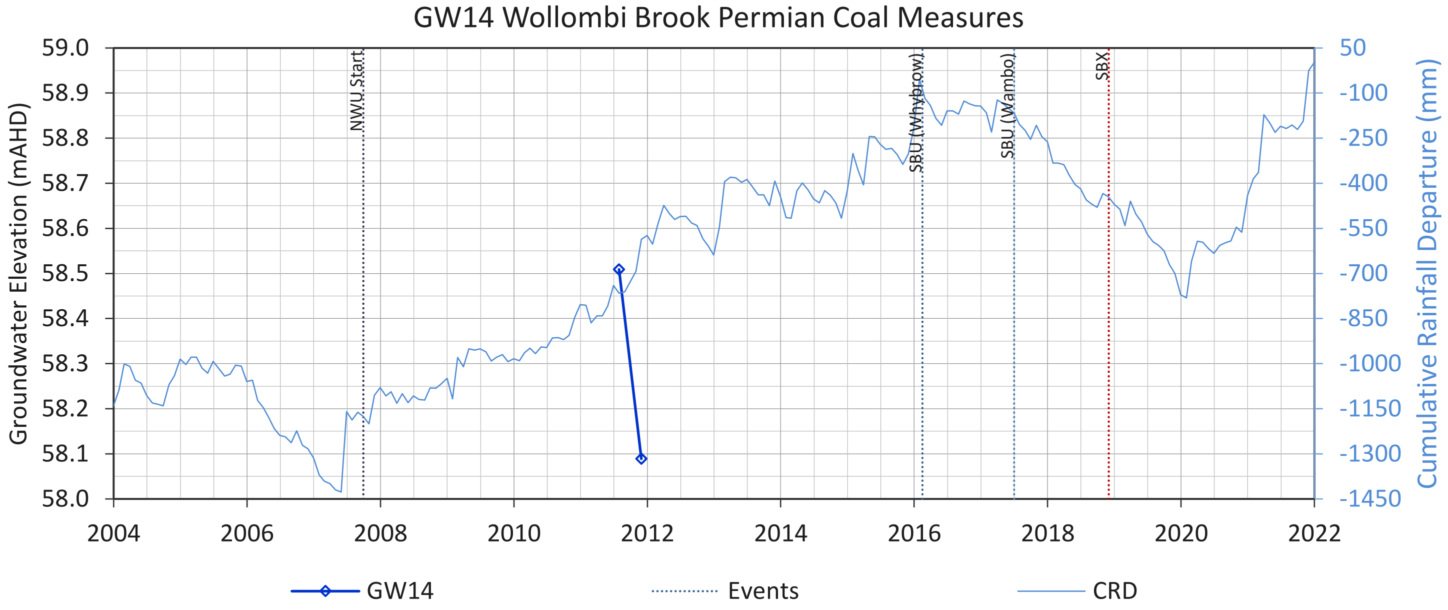

P325a Wollombi Brook Alluvium
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P325a
Events
CRD


P325a Wollombi Brook Alluvium
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
12000
10000
8000
6000
4000
2000
0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P325a
Events
CRD


GW13 Wollombi Brook Shallow Permian
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
58.0
57.5
57.0
56.5
56.0
55.5
55.0
54.5
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW13
Events
CRD

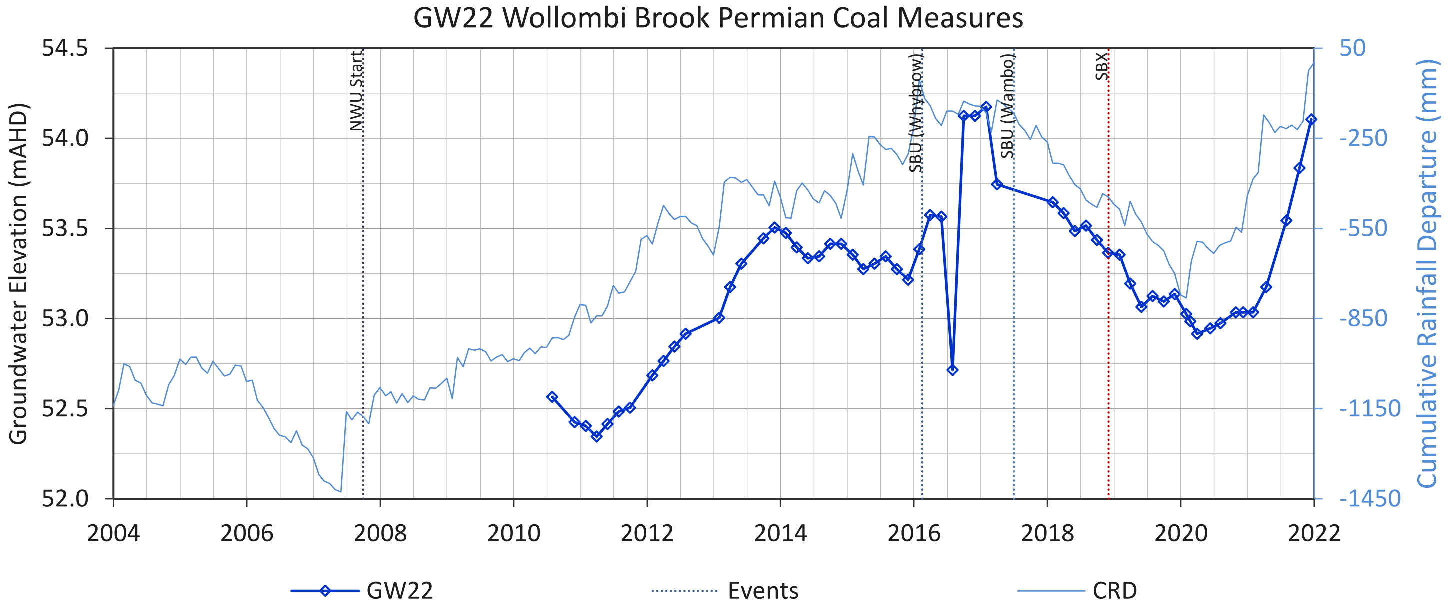

GW13 Wollombi Brook Shallow Permian
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW13
Events
CRD

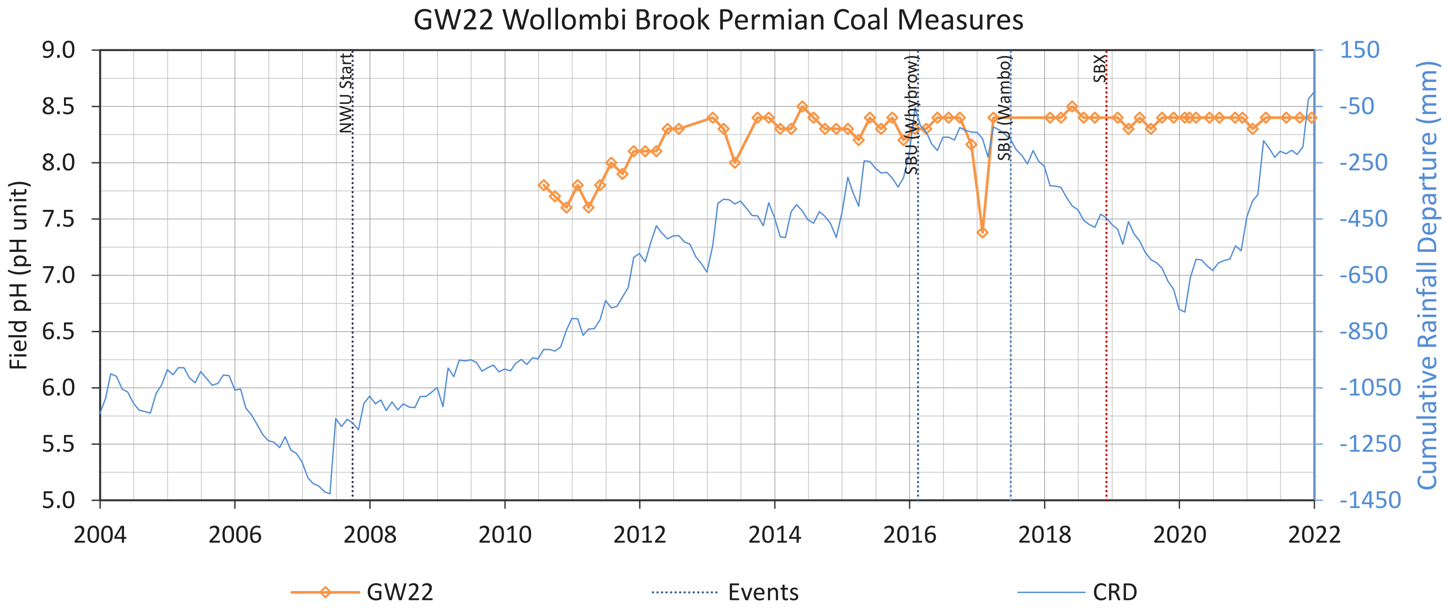

GW13 Wollombi Brook Shallow Permian
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
6000
5000
4000
3000
2000
1000
0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW13
Events
CRD

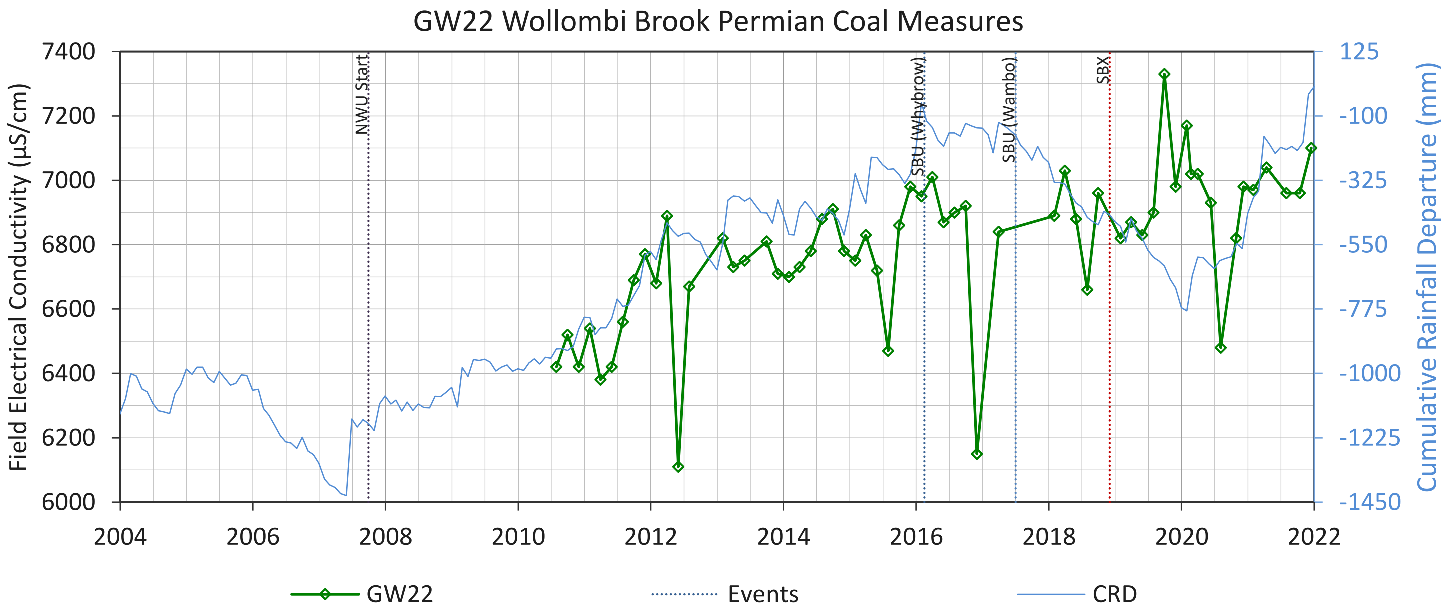


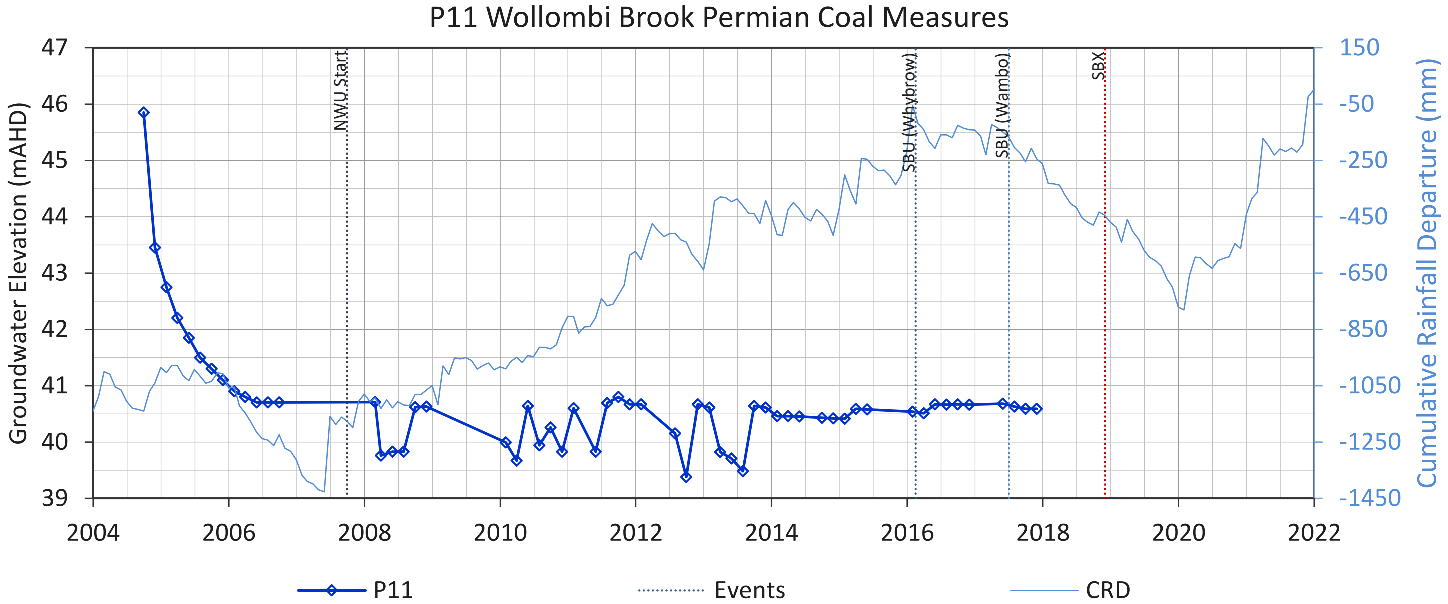
No Data Available for Field pH (pH unit)

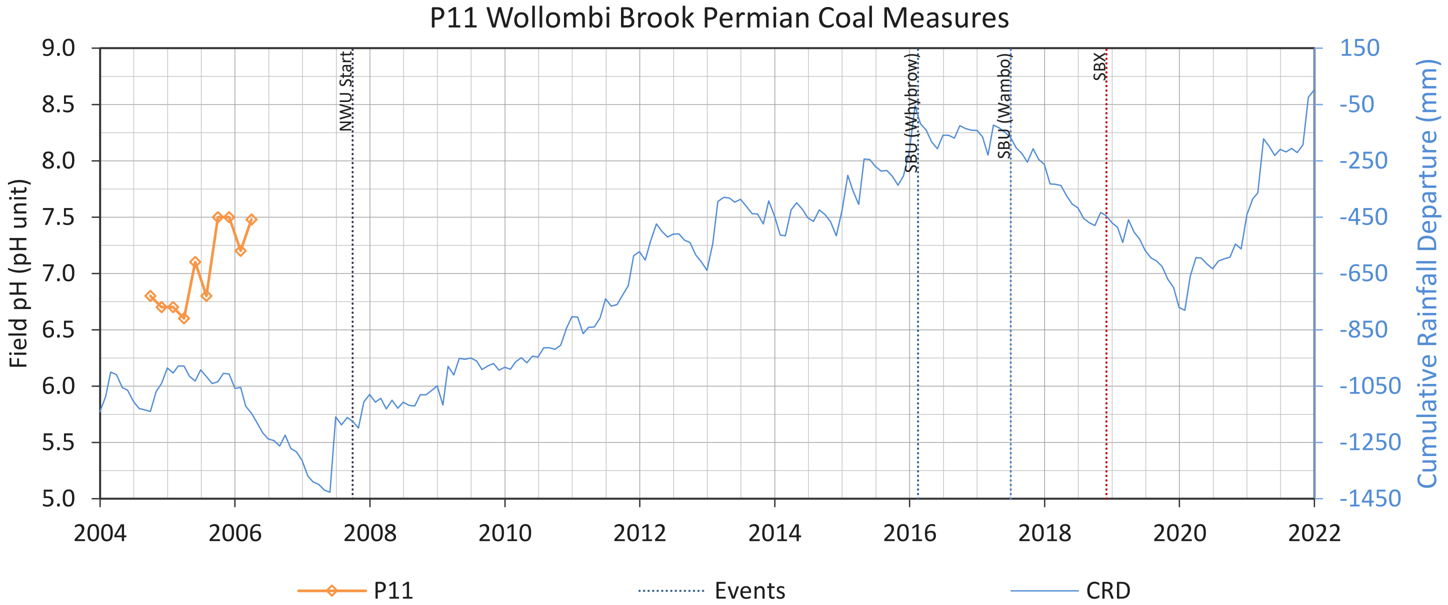
No Data Available for Field Electrical Conductivity (µS/cm)

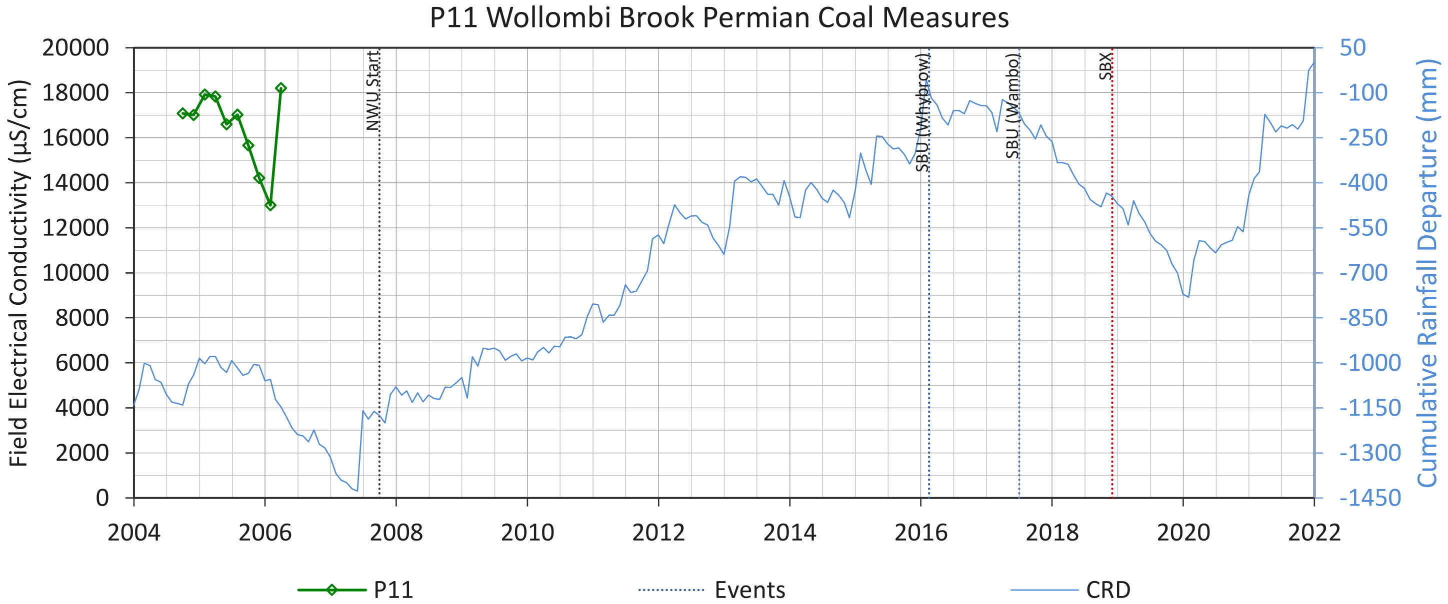

GW22 Wollombi Brook Permian Coal Measures
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
54.5
54.0
53.5
53.0
52.5
52.0
50
-250
-550
-850
-1150
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW22
Events
CRD


GW22 Wollombi Brook Permian Coal Measures
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW22
Events
CRD

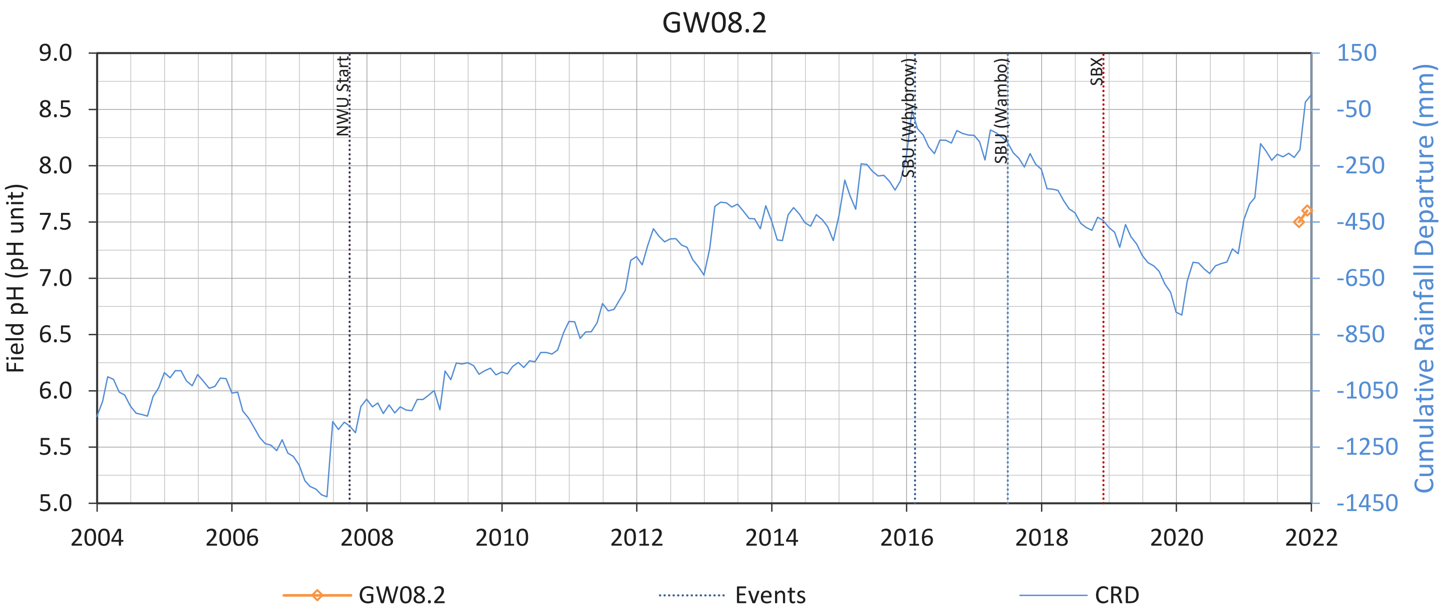

GW22 Wollombi Brook Permian Coal Measures
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
7400
7200
7000
6800
6600
6400
6200
6000
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW22
Events
CRD

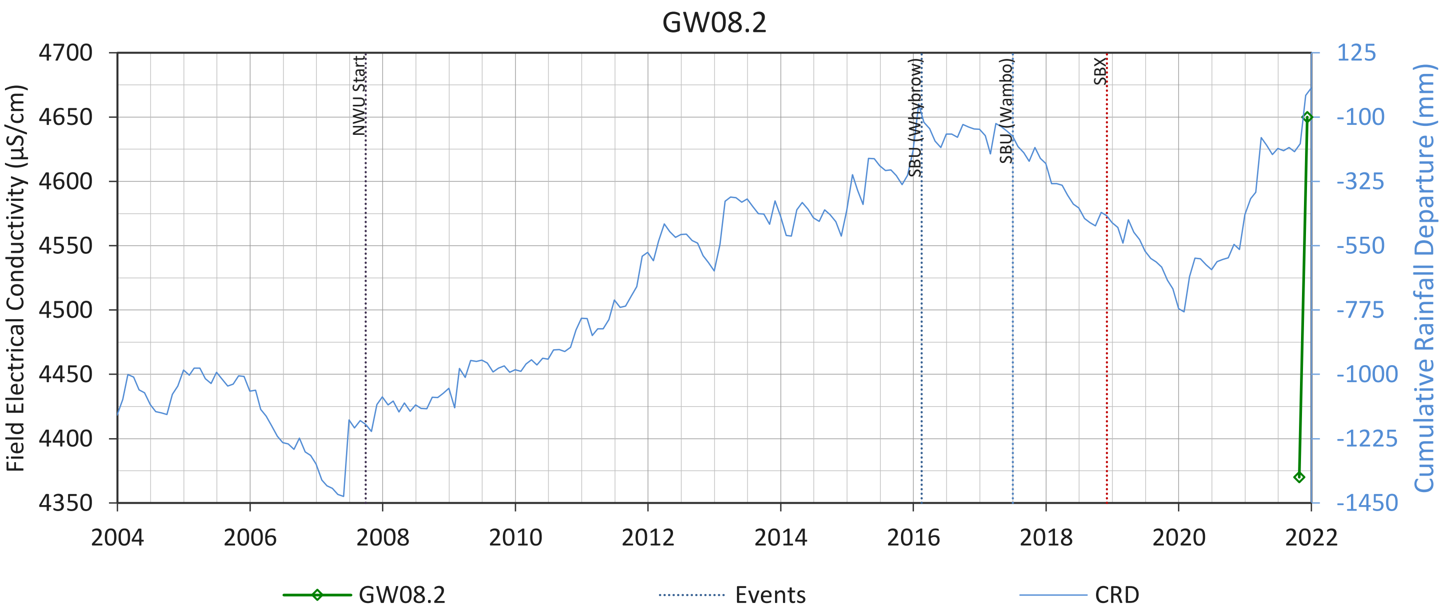

P11 Wollombi Brook Permian Coal Measures
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P11
Events
CRD

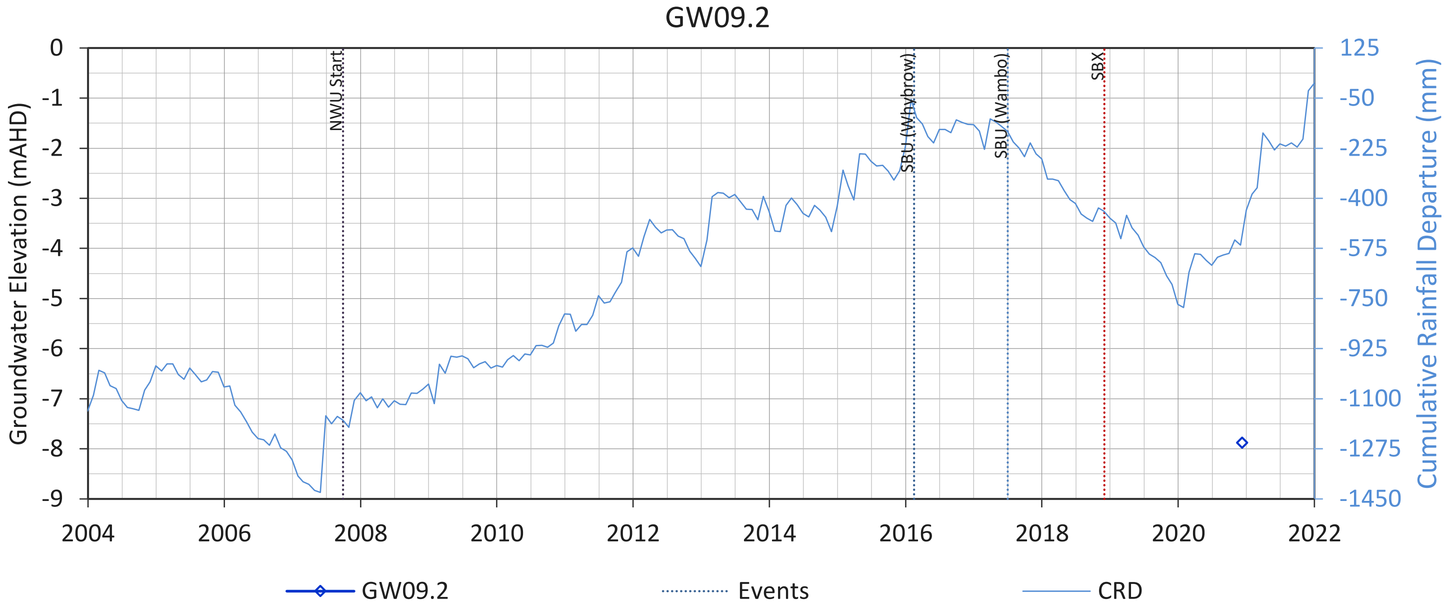

P11 Wollombi Brook Permian Coal Measures
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P11
Events
CRD

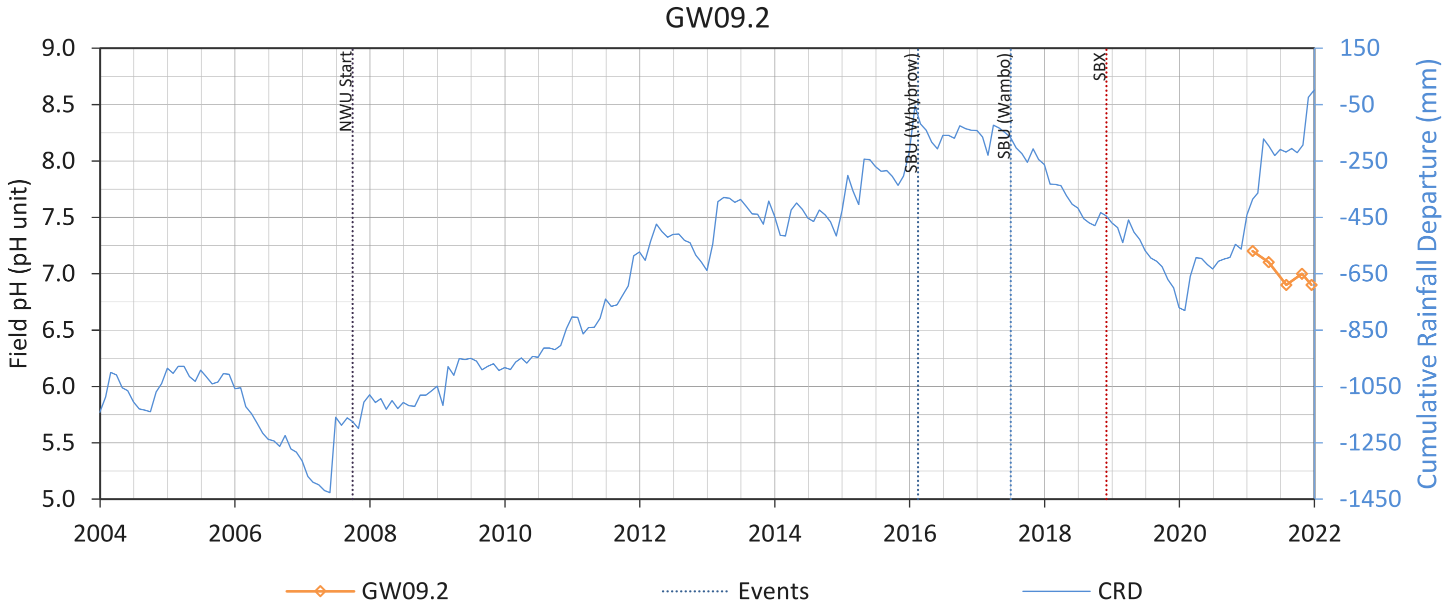

P11 Wollombi Brook Permian Coal Measures
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P11
Events
CRD

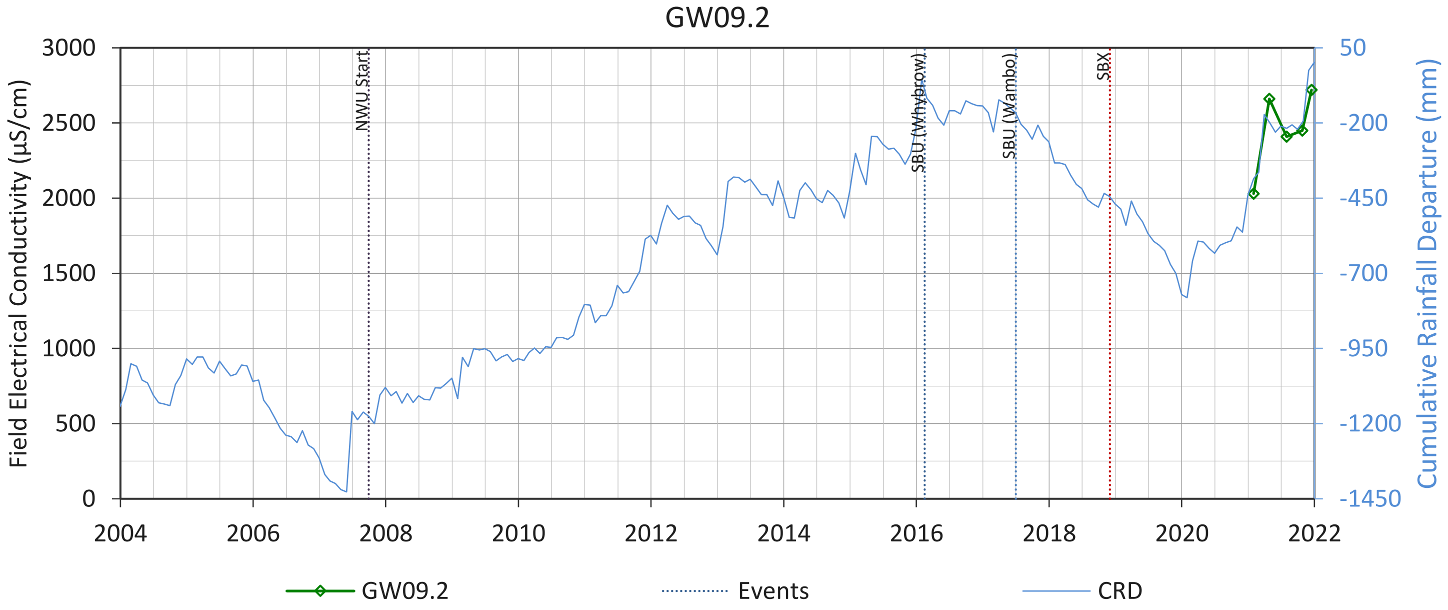
No Data Available for Groundwater Elevation (mAHD)

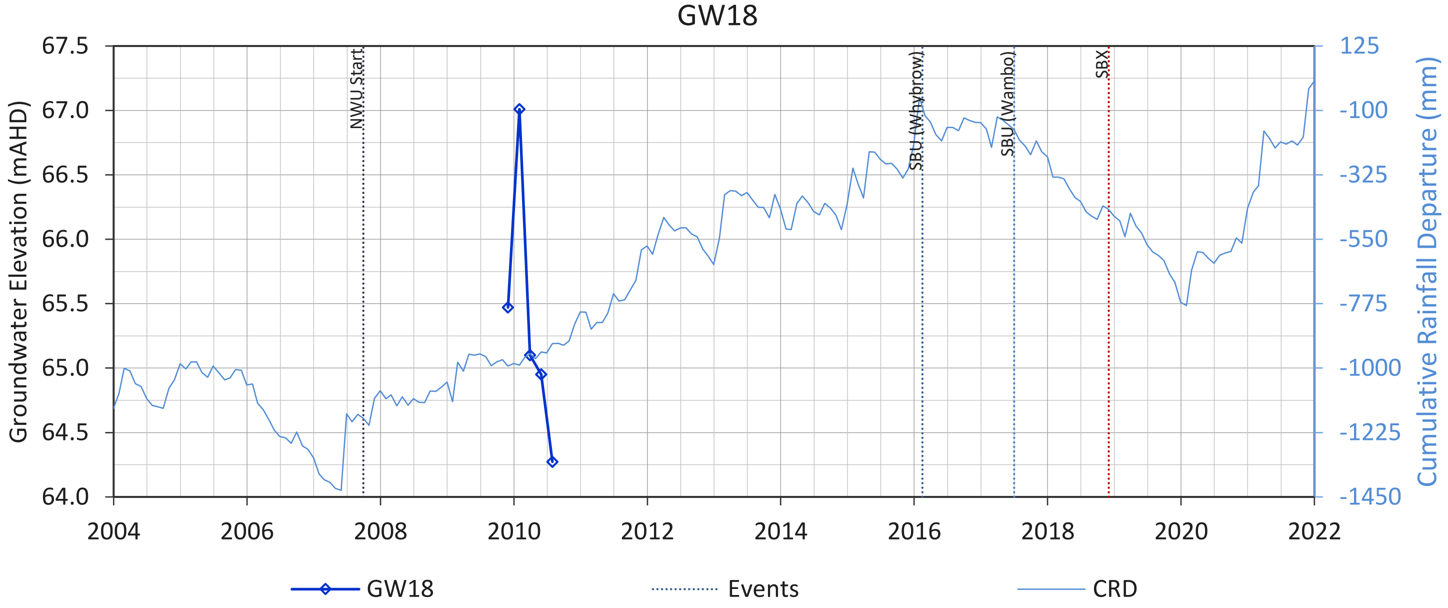


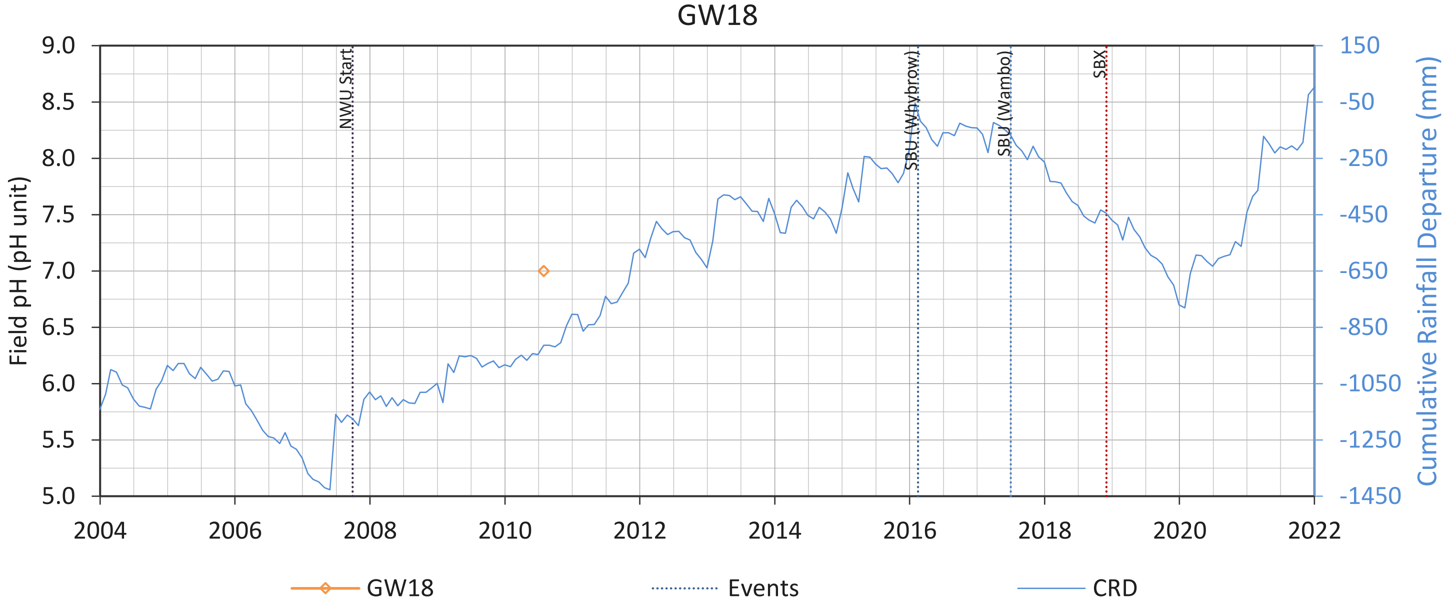


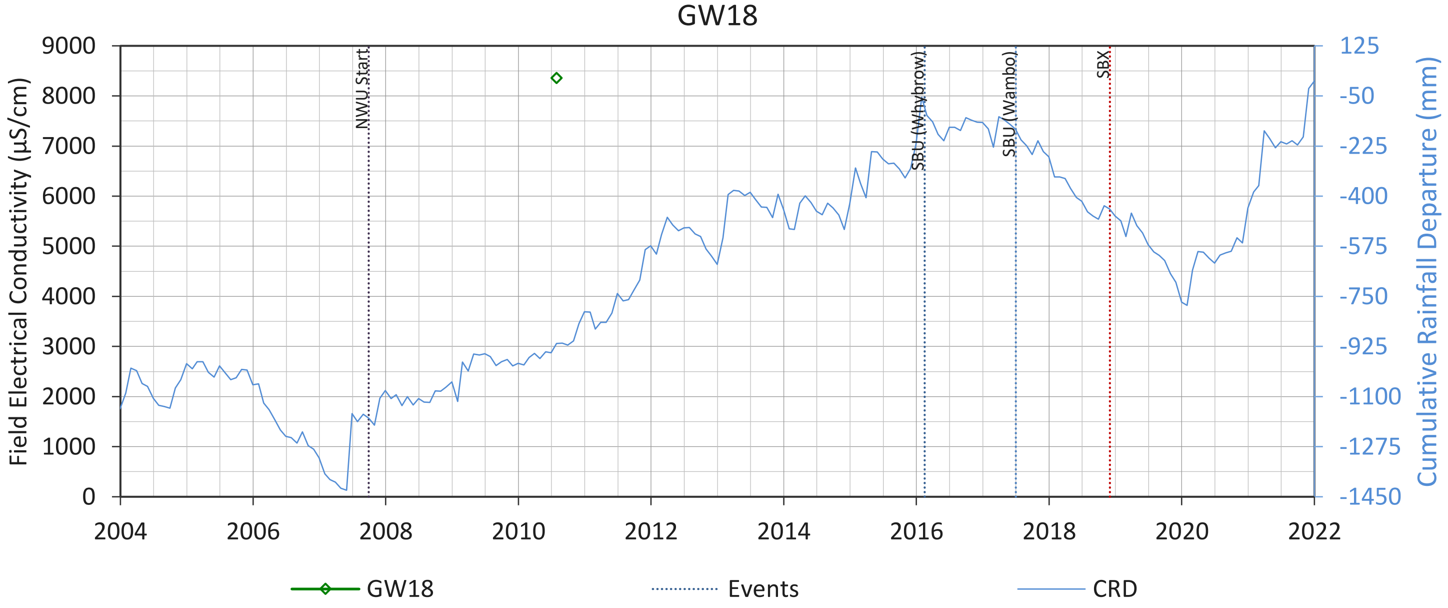

GW09.2
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW09.2
Events
CRD

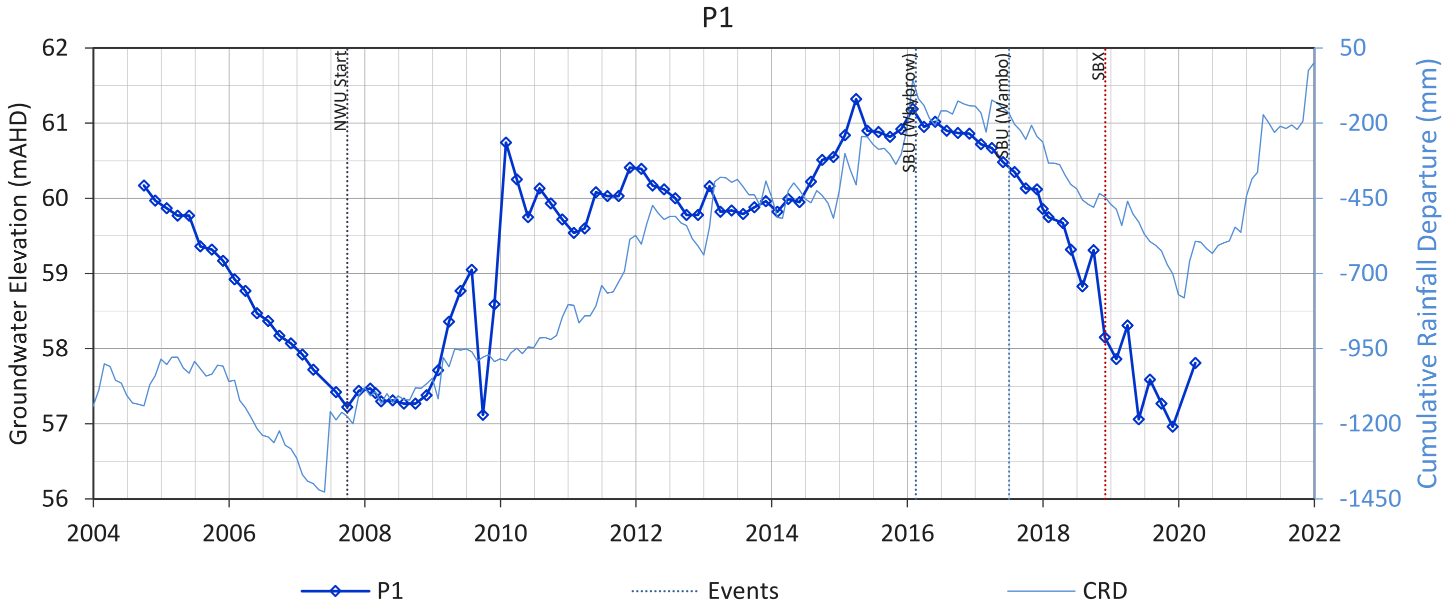

GW09.2
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW09.2
Events
CRD

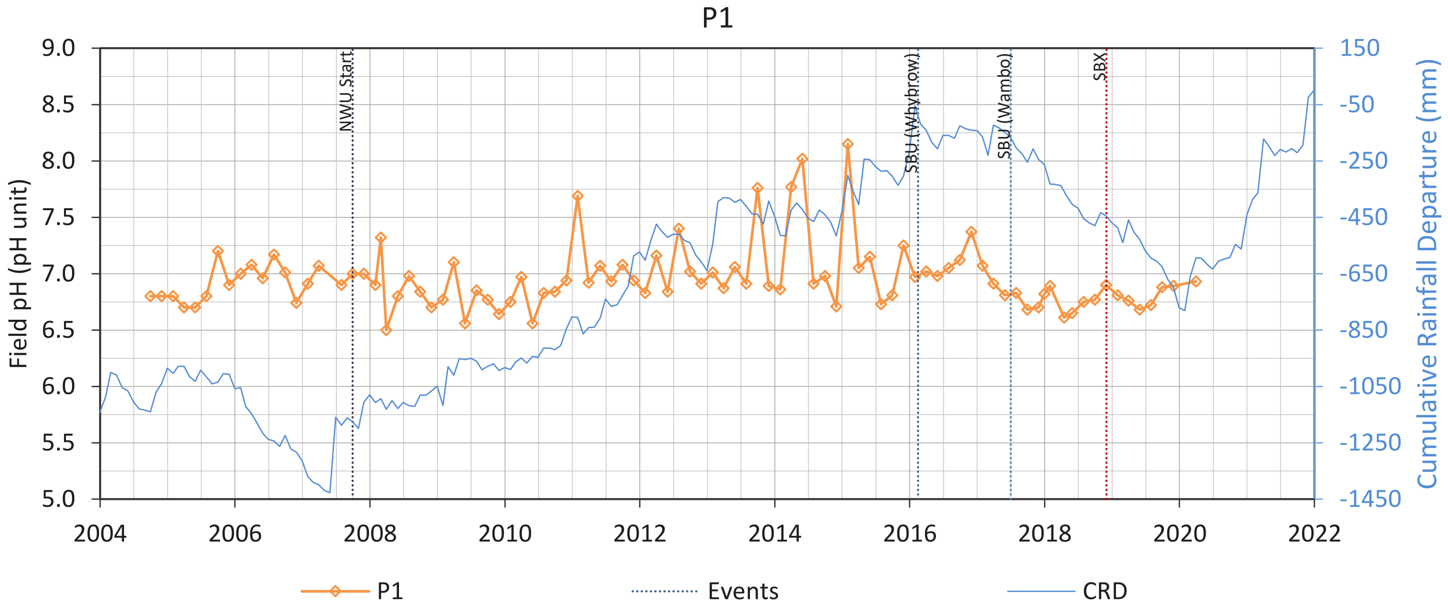

GW09.2
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
3000
2500
2000
1500
1000
500
0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
GW09.2
Events
CRD

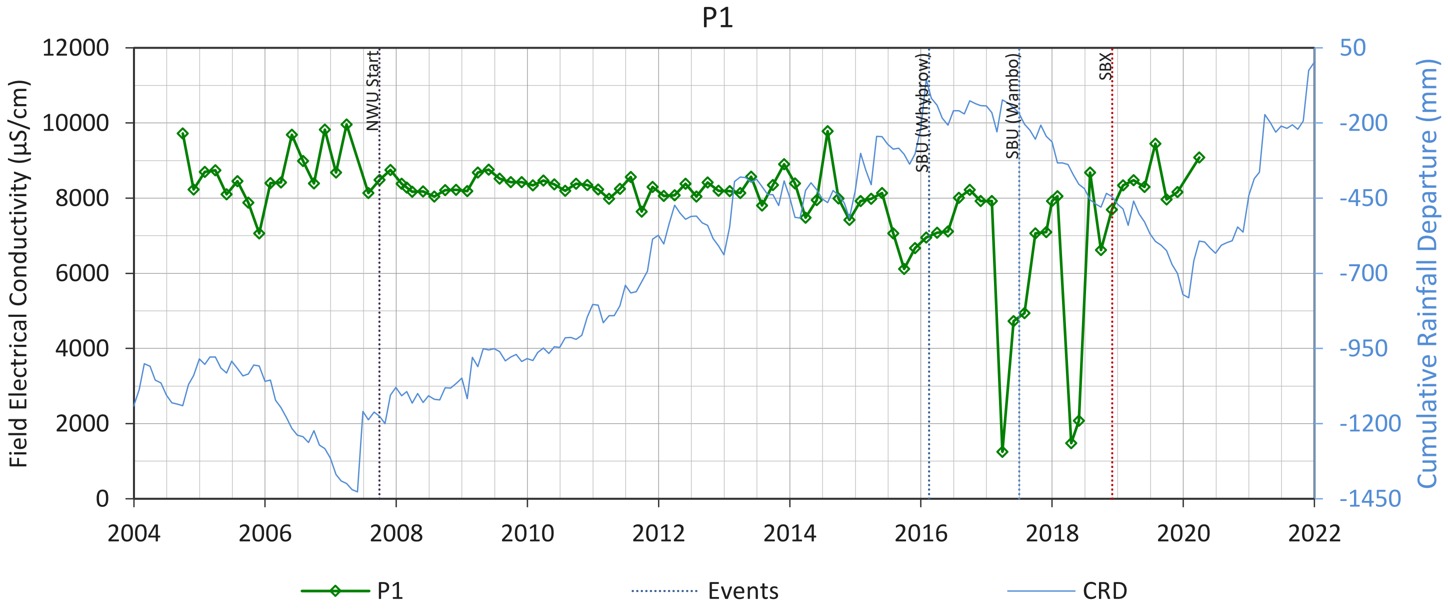

GW18
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
67.5
67.0
66.5
66.0
65.5
65.0
64.5
64.0
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW18
Events
CRD

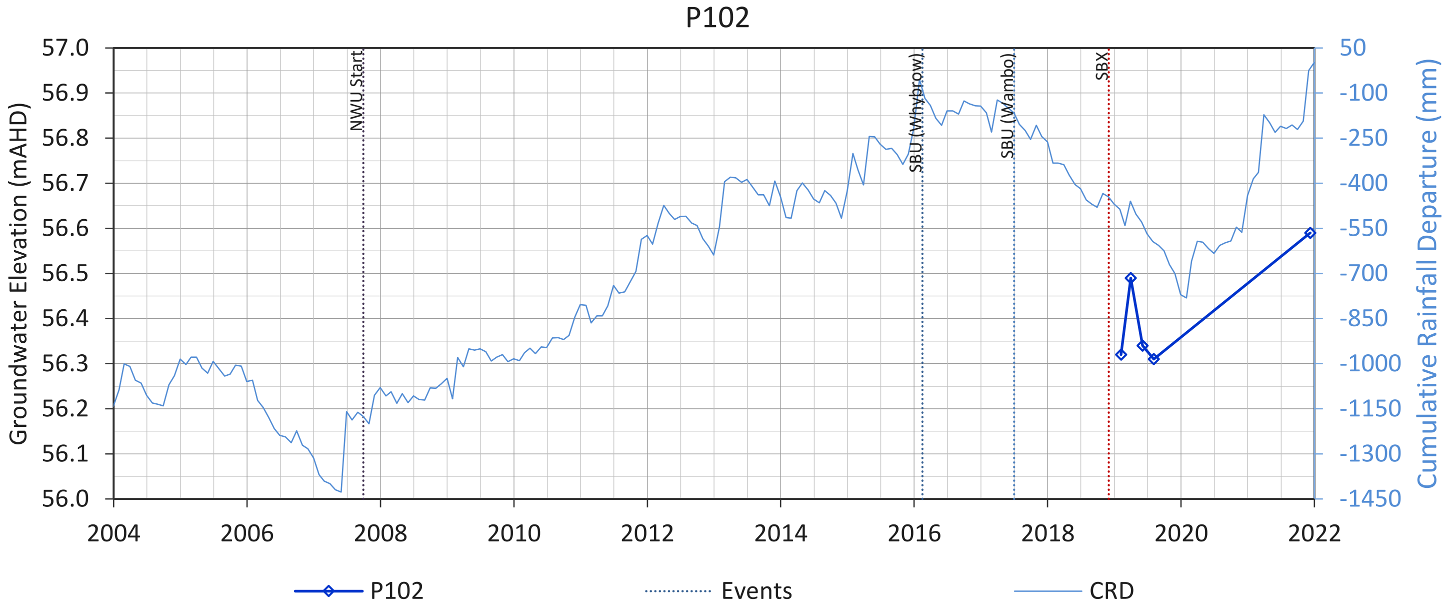

GW18
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW18
Events
CRD

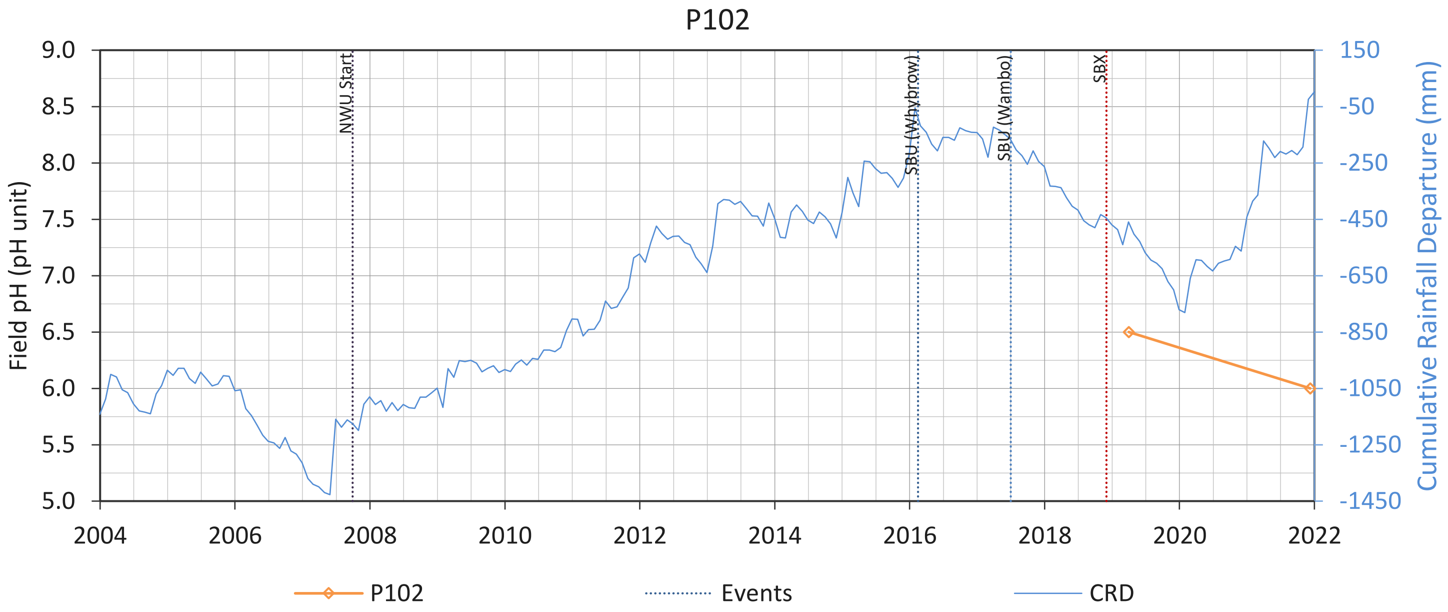

GW18
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
GW18
Events
CRD

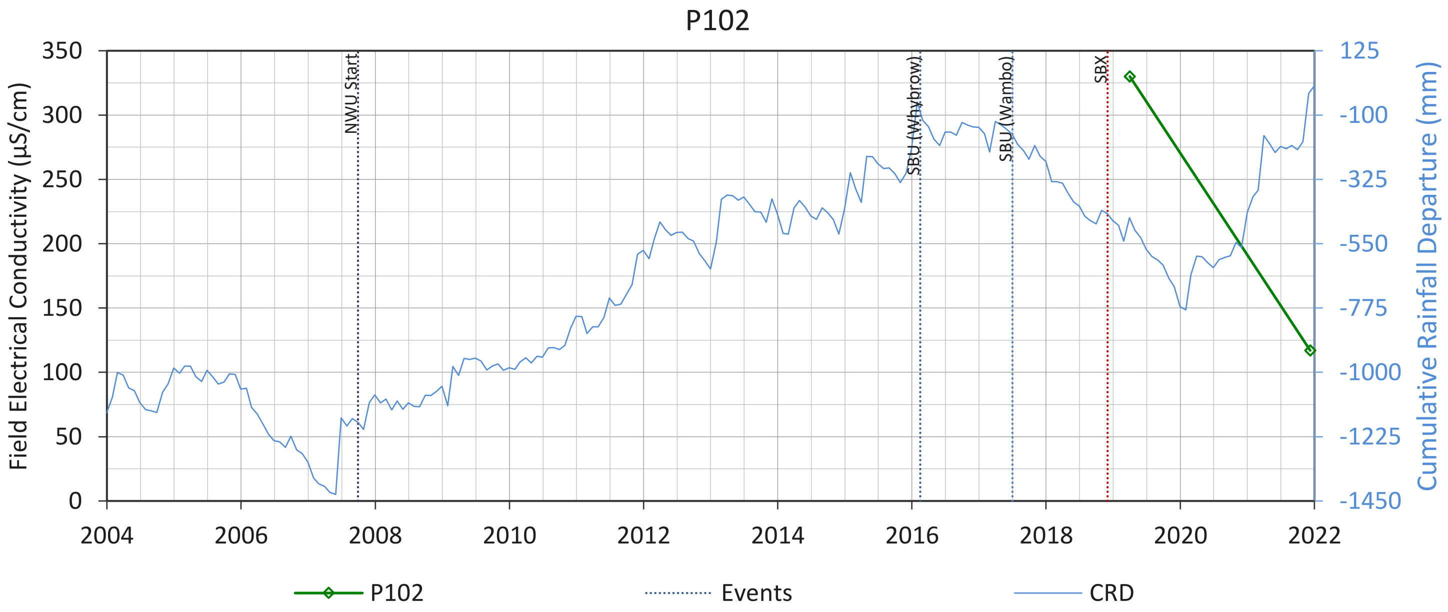

P1
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P1
Events
CRD

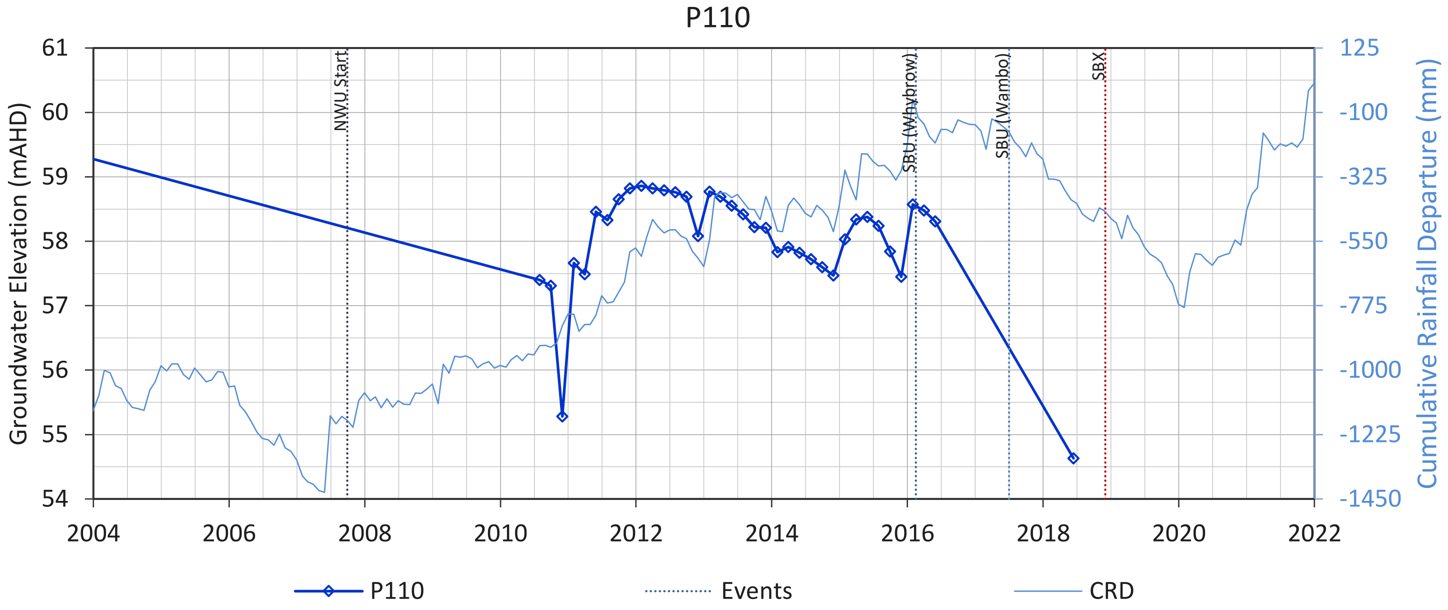

P1
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P1
Events
CRD

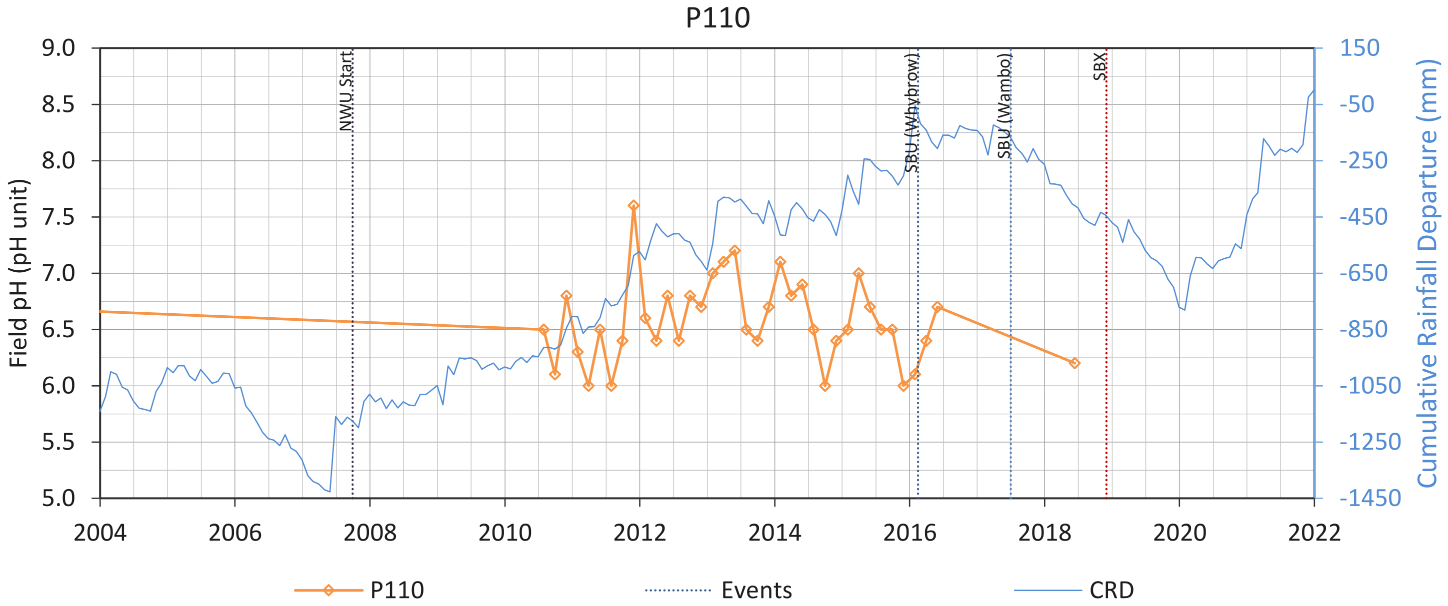

P1
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P1
Events
CRD

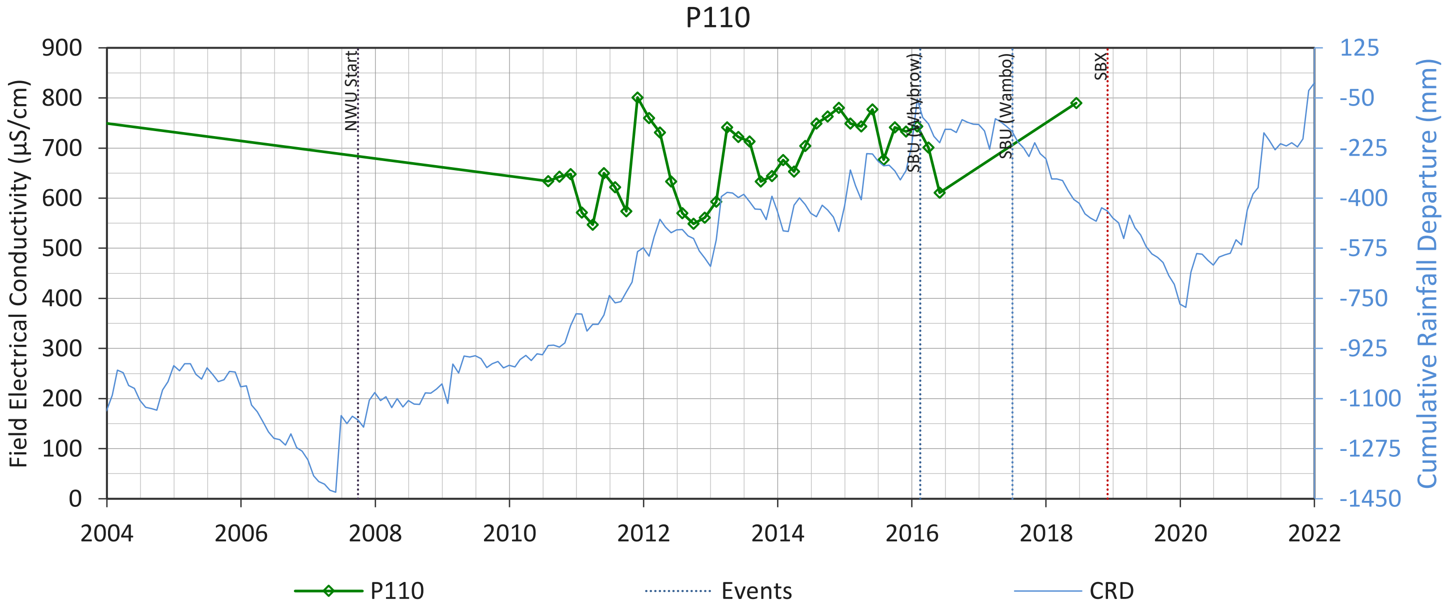

P102
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
57.0
56.9
56.8
56.7
56.6
56.5
56.4
56.3
56.2
56.1
56.0
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P102
Events
CRD

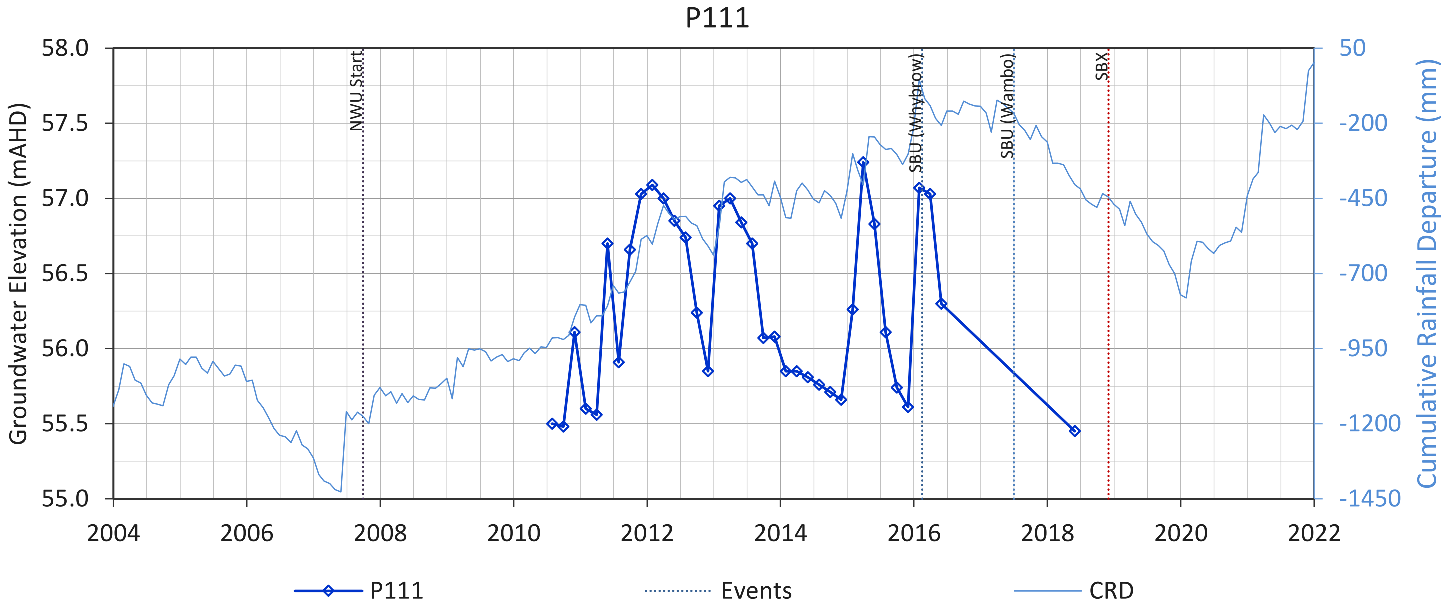

P102
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P102
Events
CRD

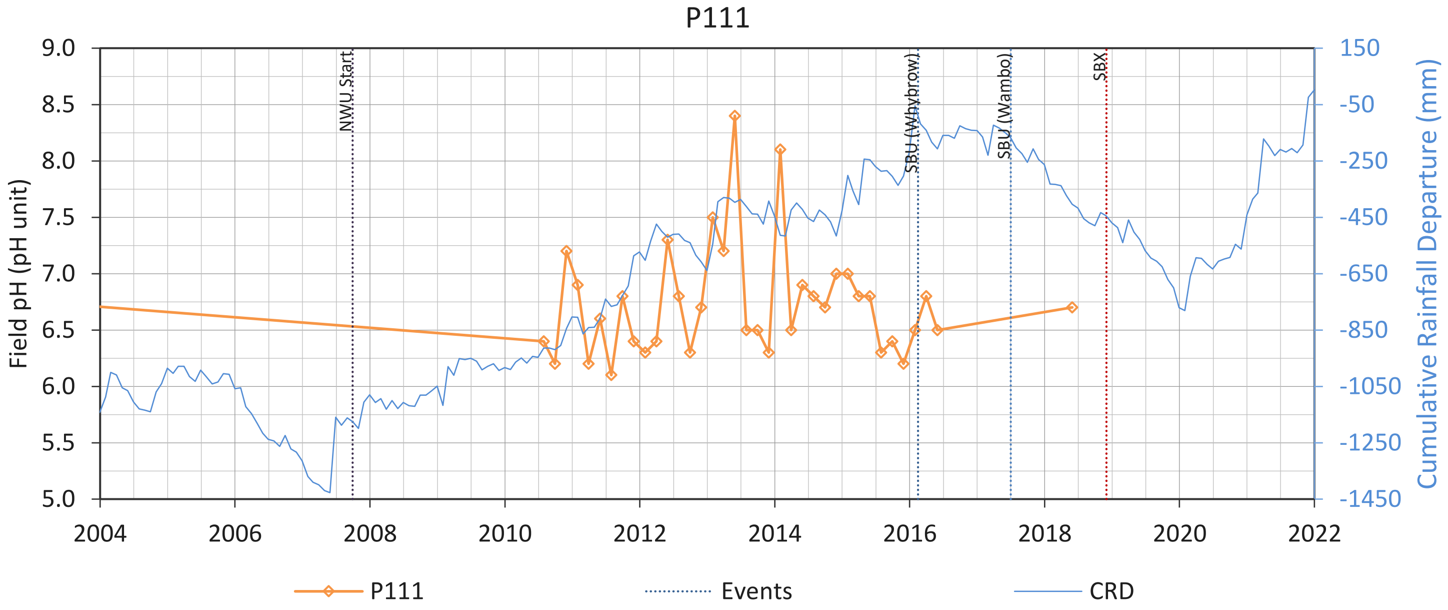

P102
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
350
300
250
200
150
100
50
0
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P102
Events
CRD

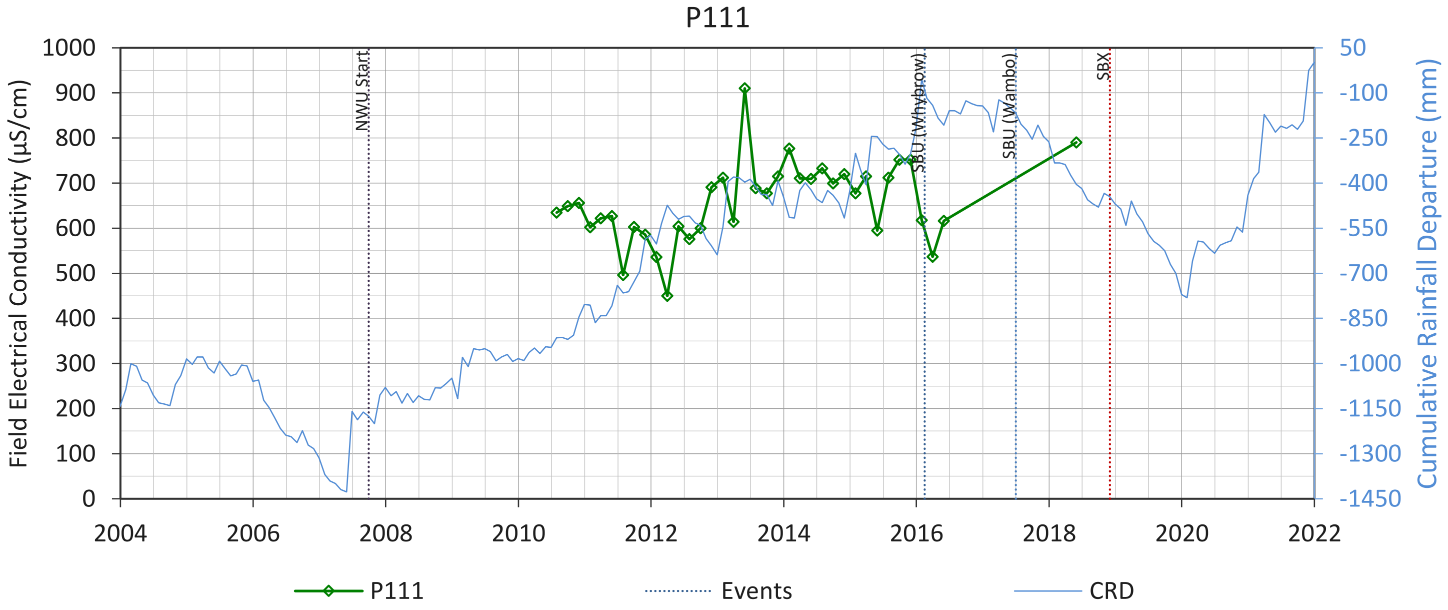

P110
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
61
60
59
58
57
56
55
54
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P110
Events
CRD

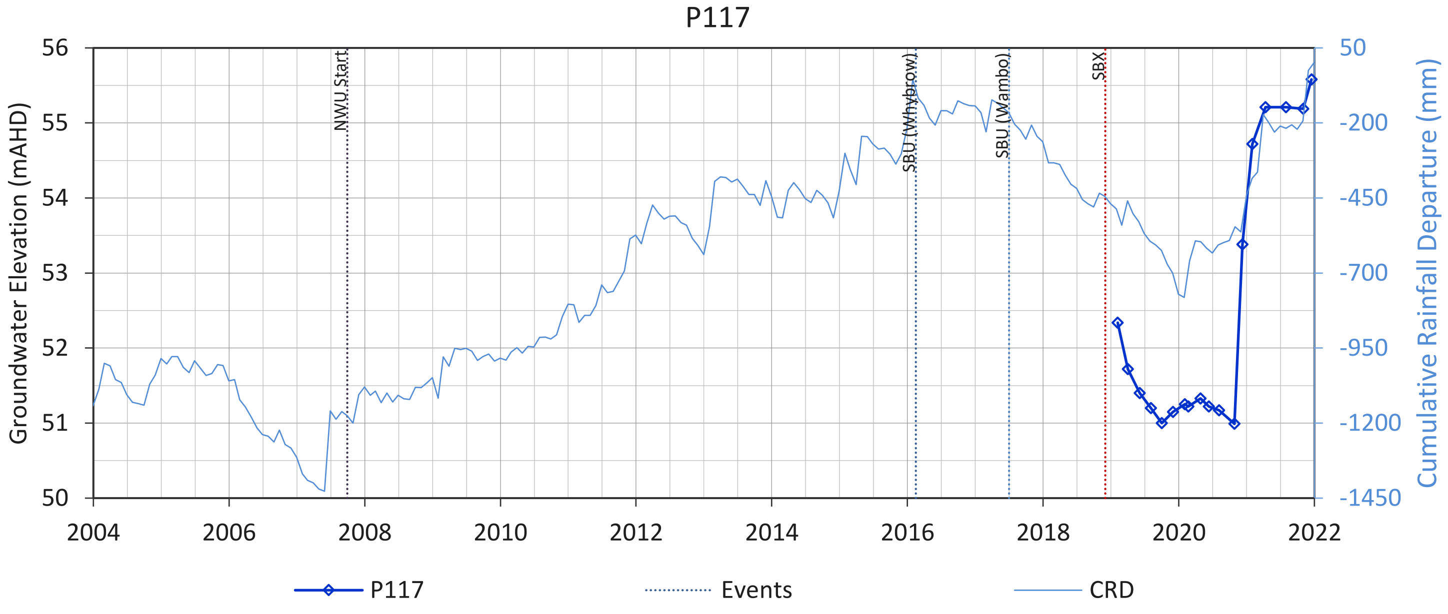

P110
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P110
Events
CRD

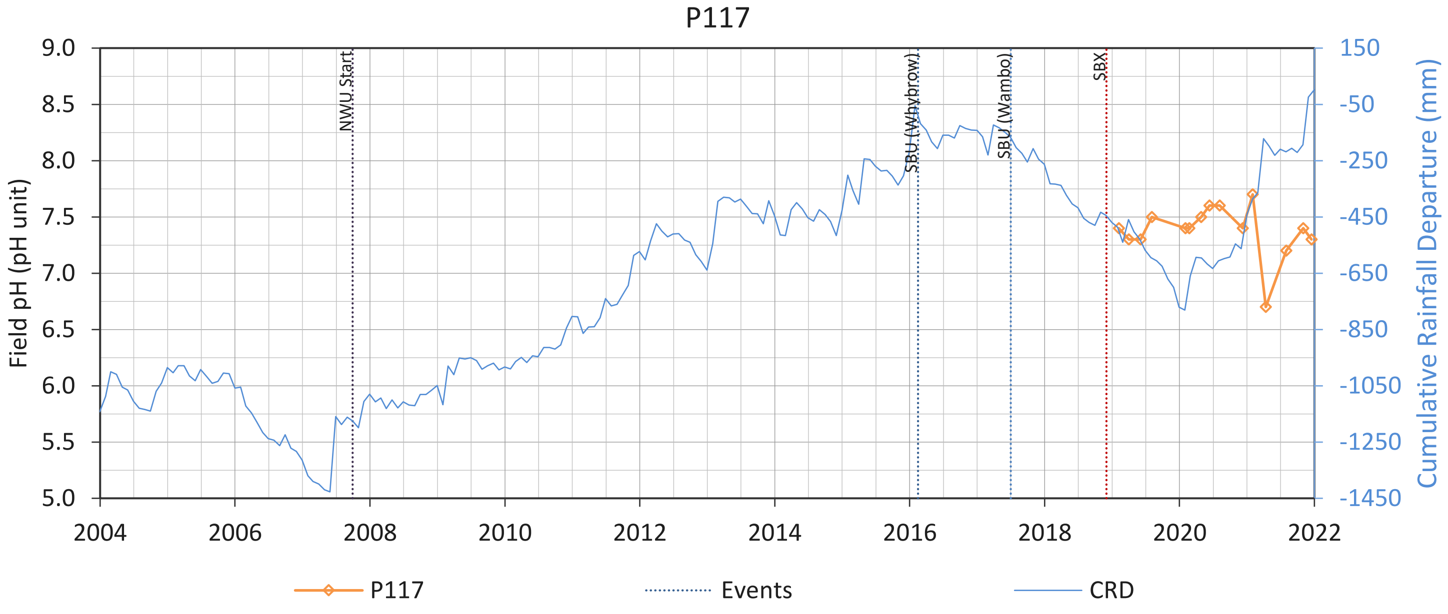

P110
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
900
800
700
600
500
400
300
200
100
0
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P110
Events
CRD

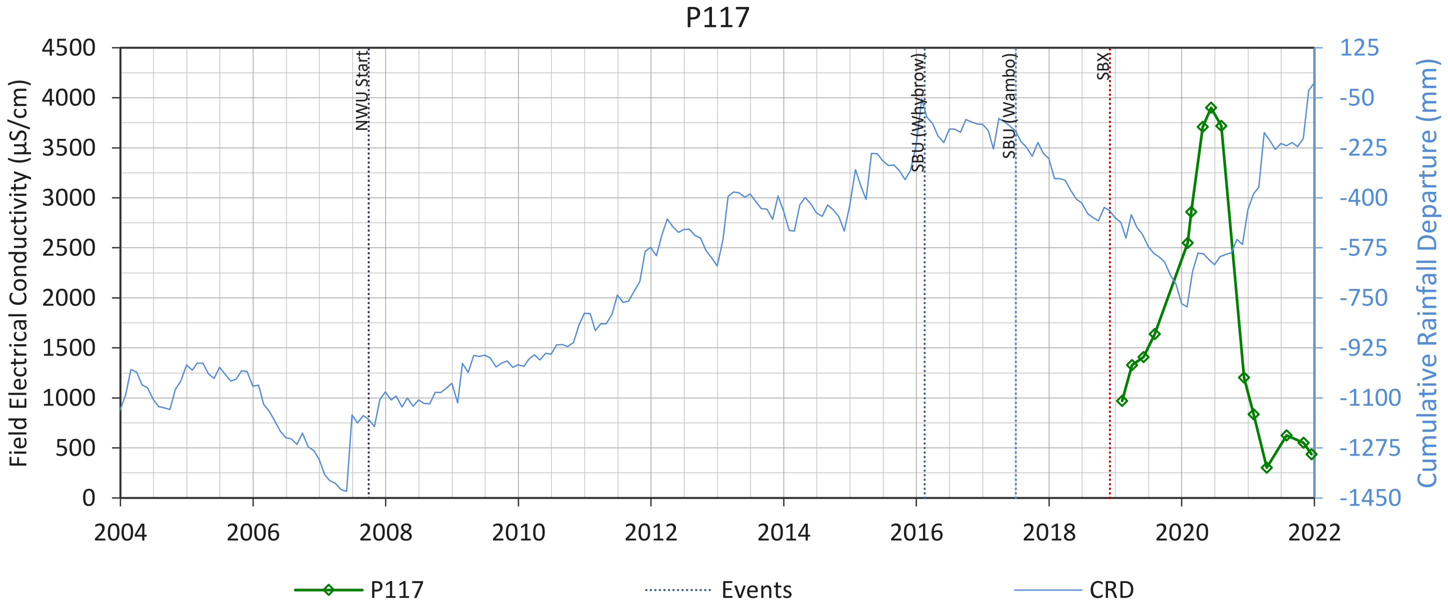

P111
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
58.0
57.5
57.0
56.5
56.0
55.5
55.0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P111
Events
CRD

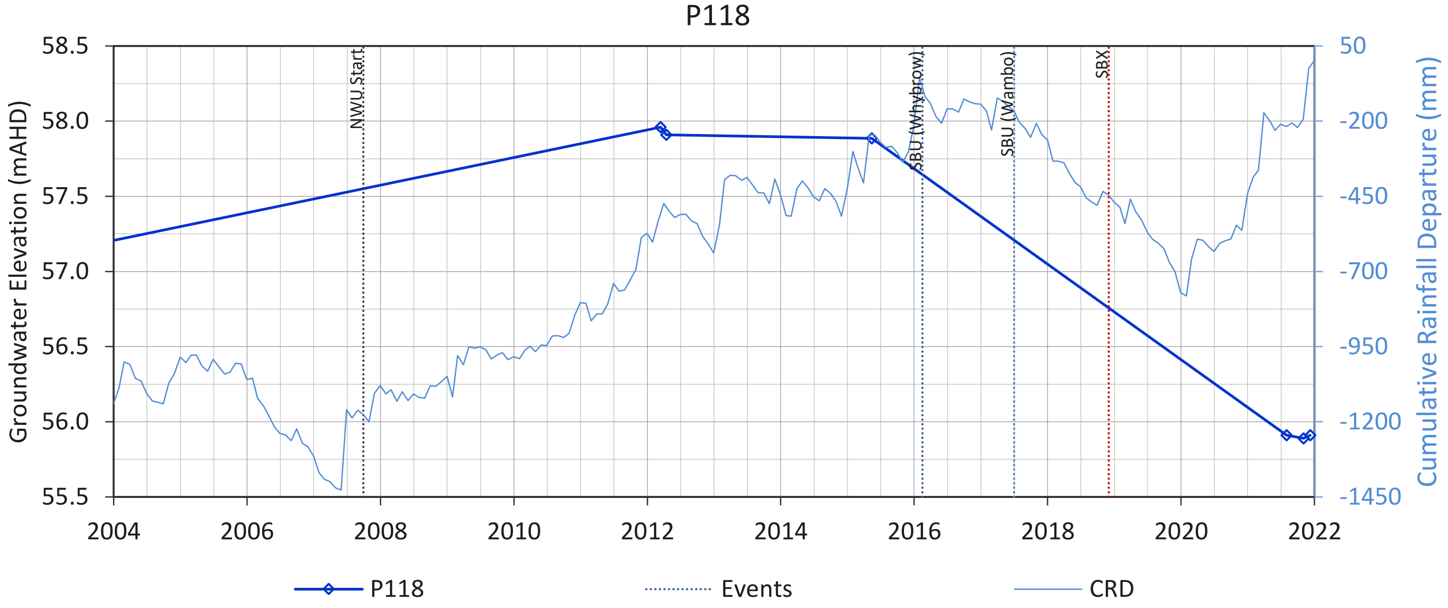

P111
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P111
Events
CRD


P111
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
1000
900
800
700
600
500
400
300
200
100
0
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P111
Events
CRD

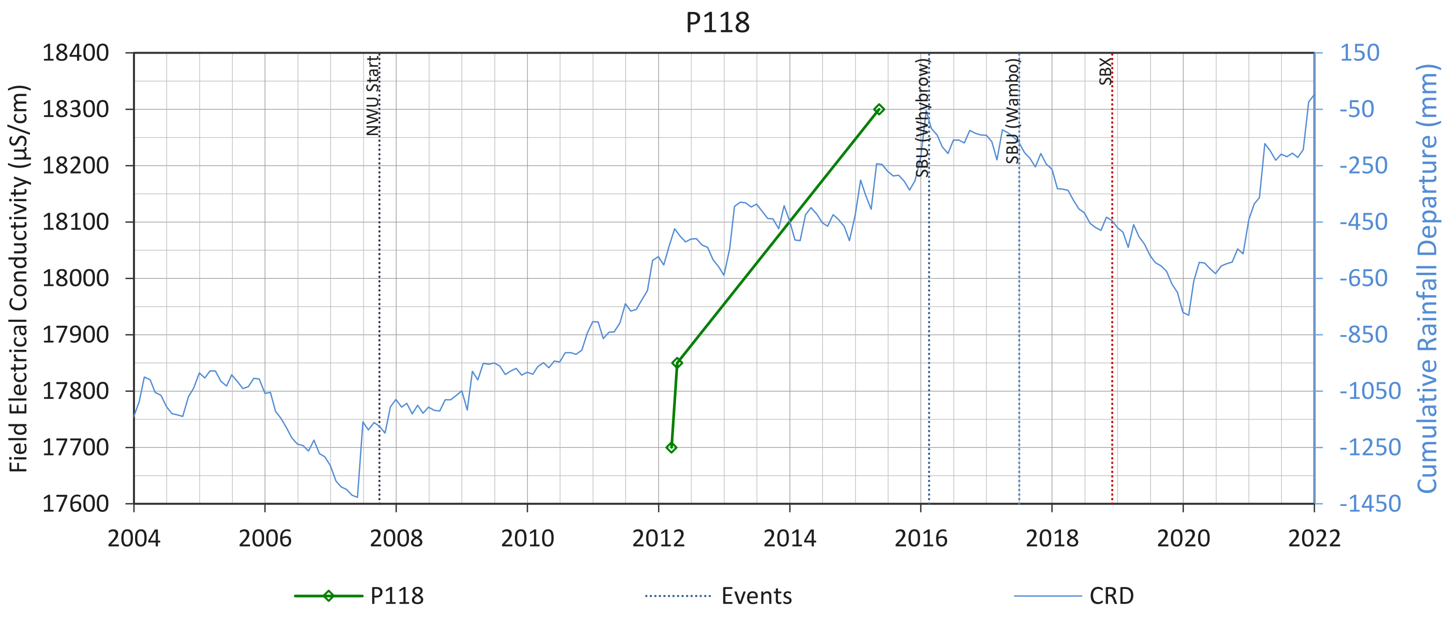

P117
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
56
55
54
53
52
51
50
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P117
Events
CRD

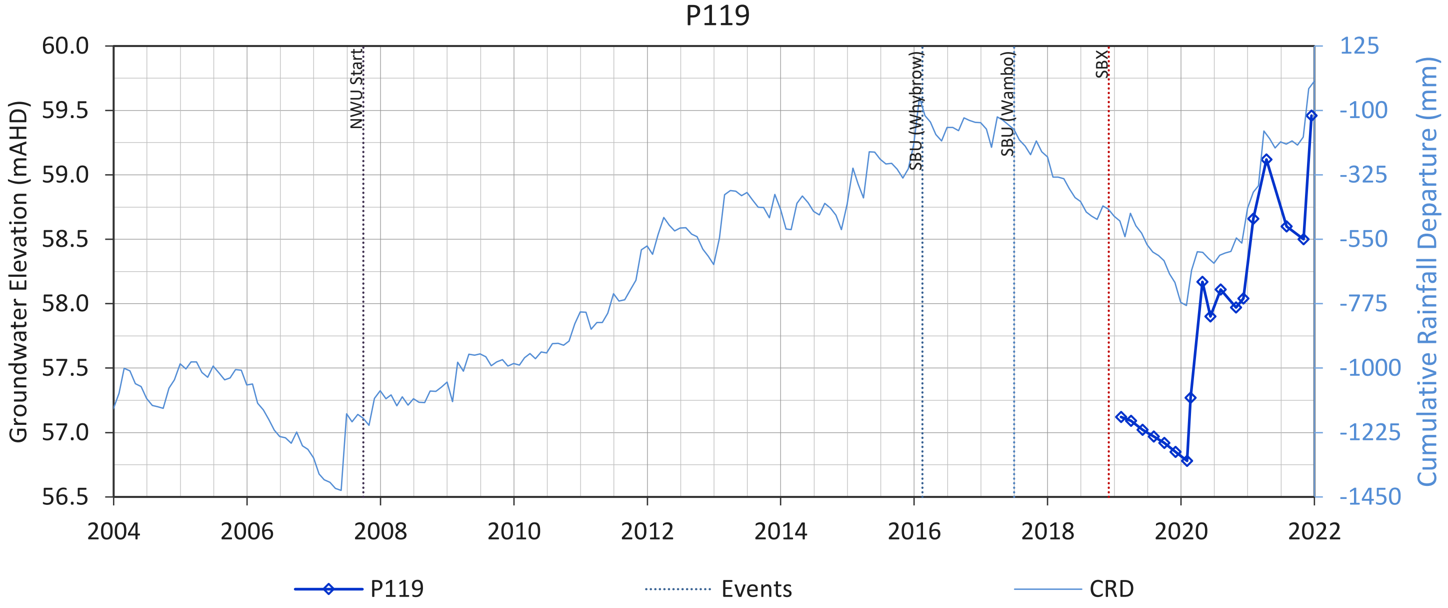

P117
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P117
Events
CRD

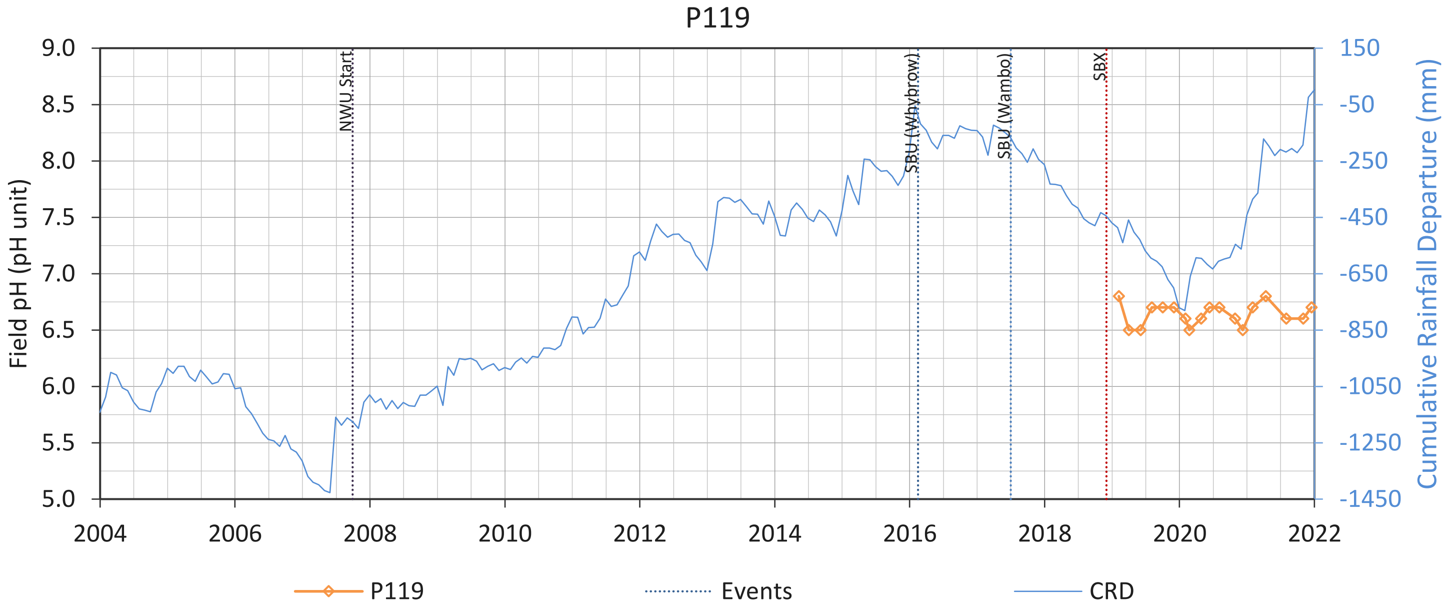

P117
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
4500
4000
3500
3000
2500
2000
1500
1000
500
0
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P117
Events
CRD

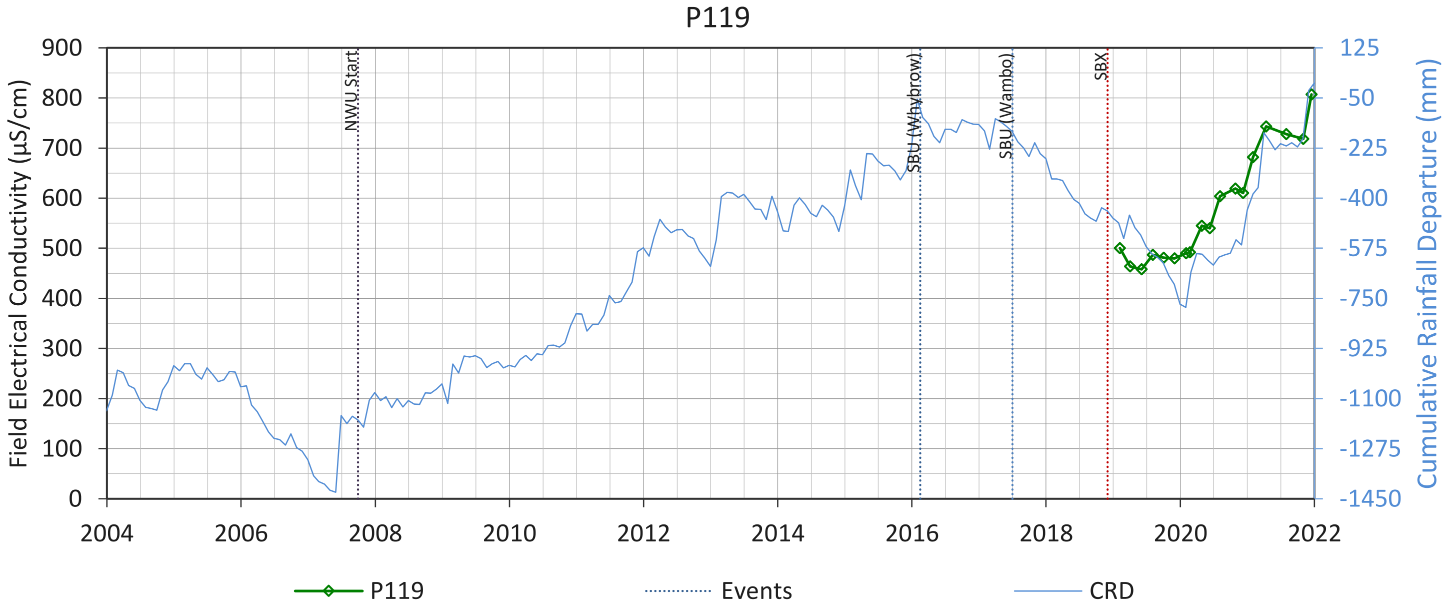


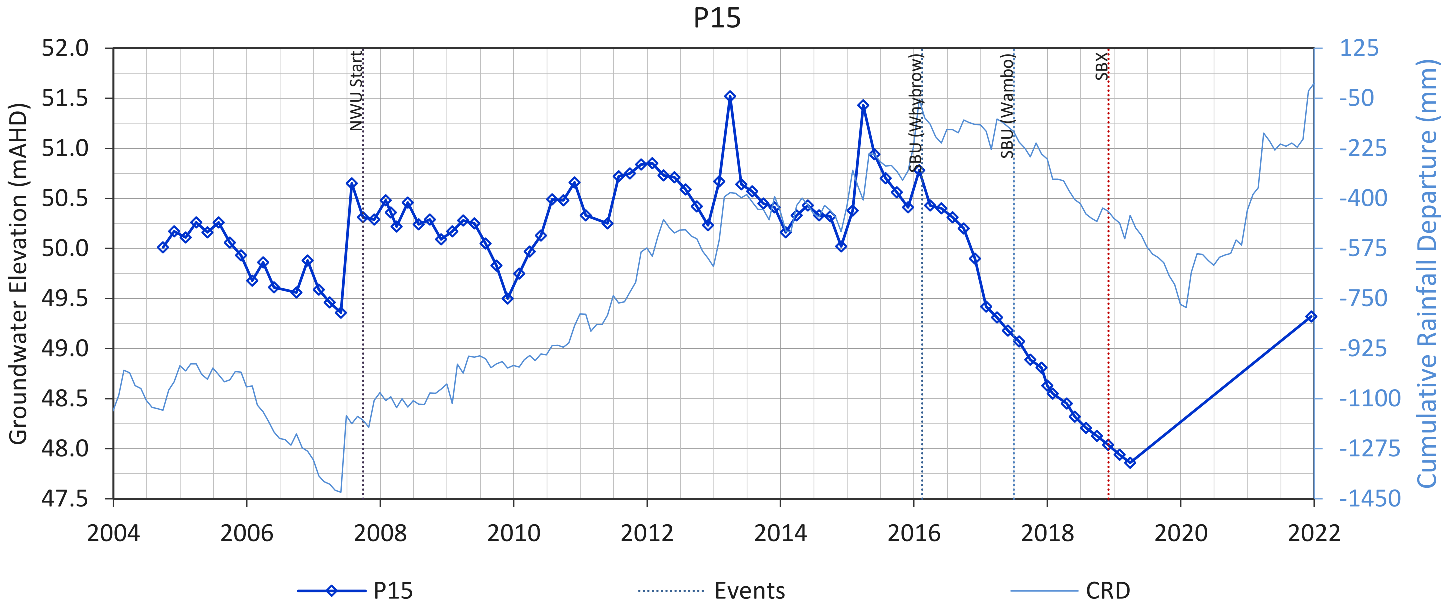
No Data Available for Field pH (pH unit)

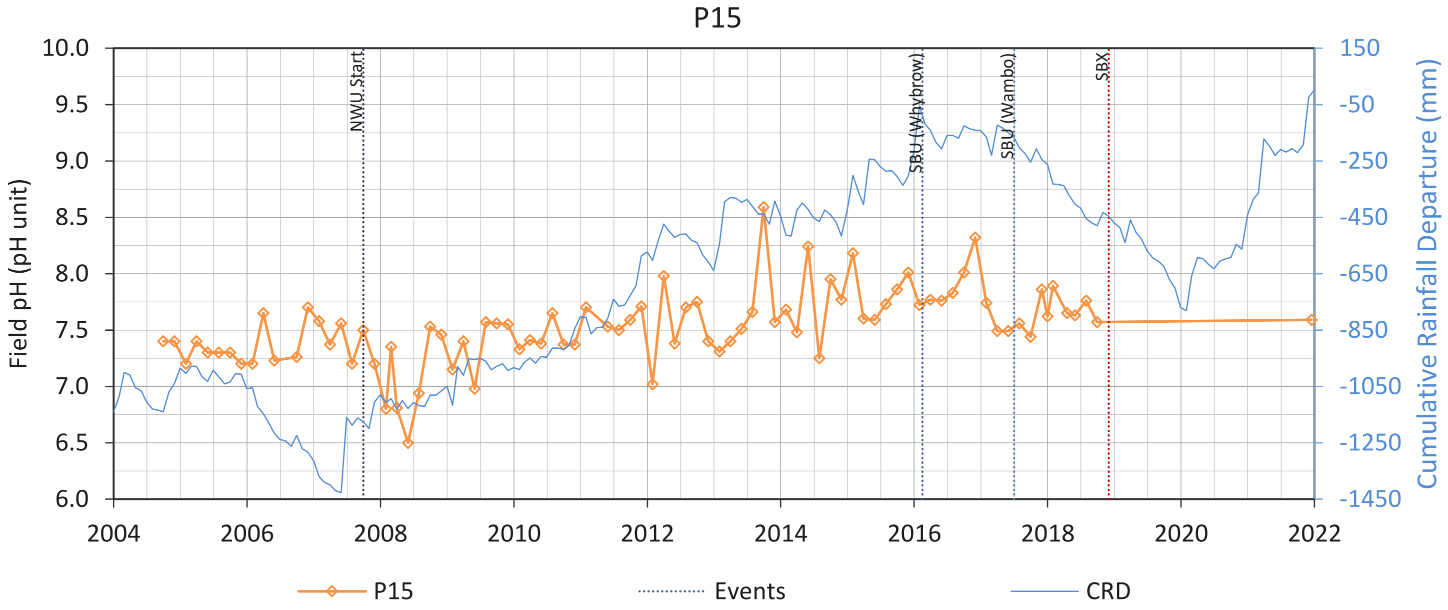


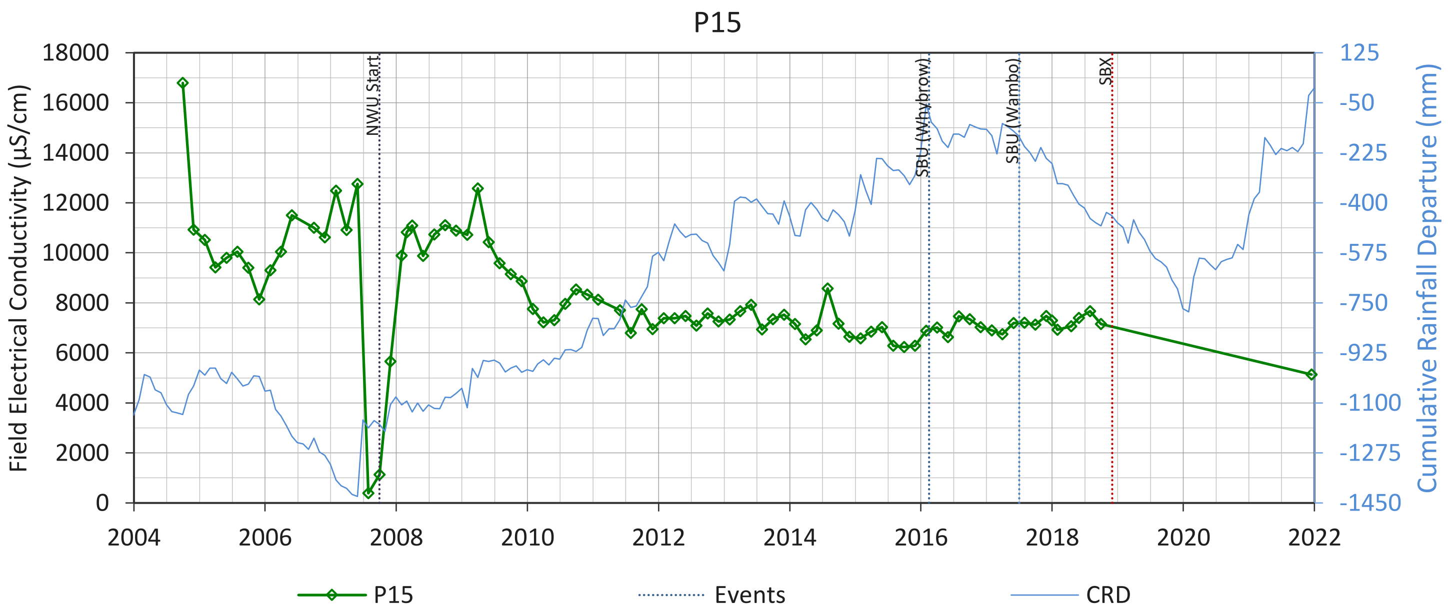

P119
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
60.0
59.5
59.0
58.5
58.0
57.5
57.0
56.5
125
-100
-325
-550
-775
-1000
-1225
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P119
Events
CRD

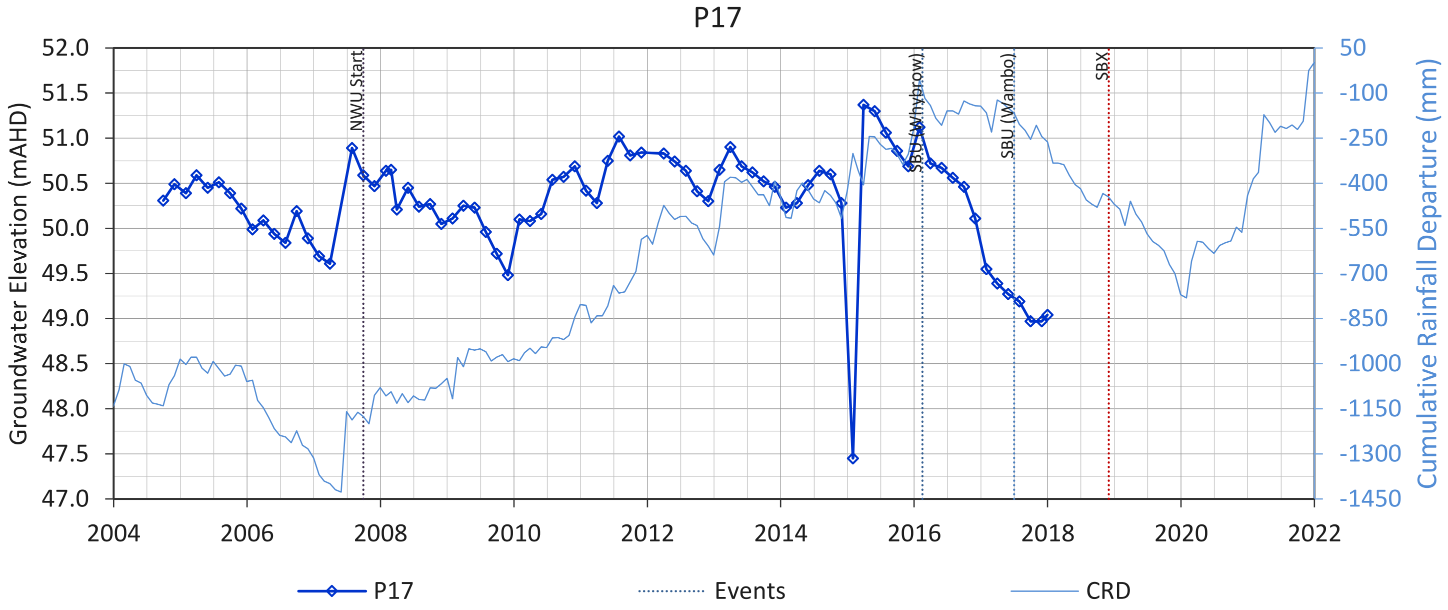

P119
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P119
Events
CRD

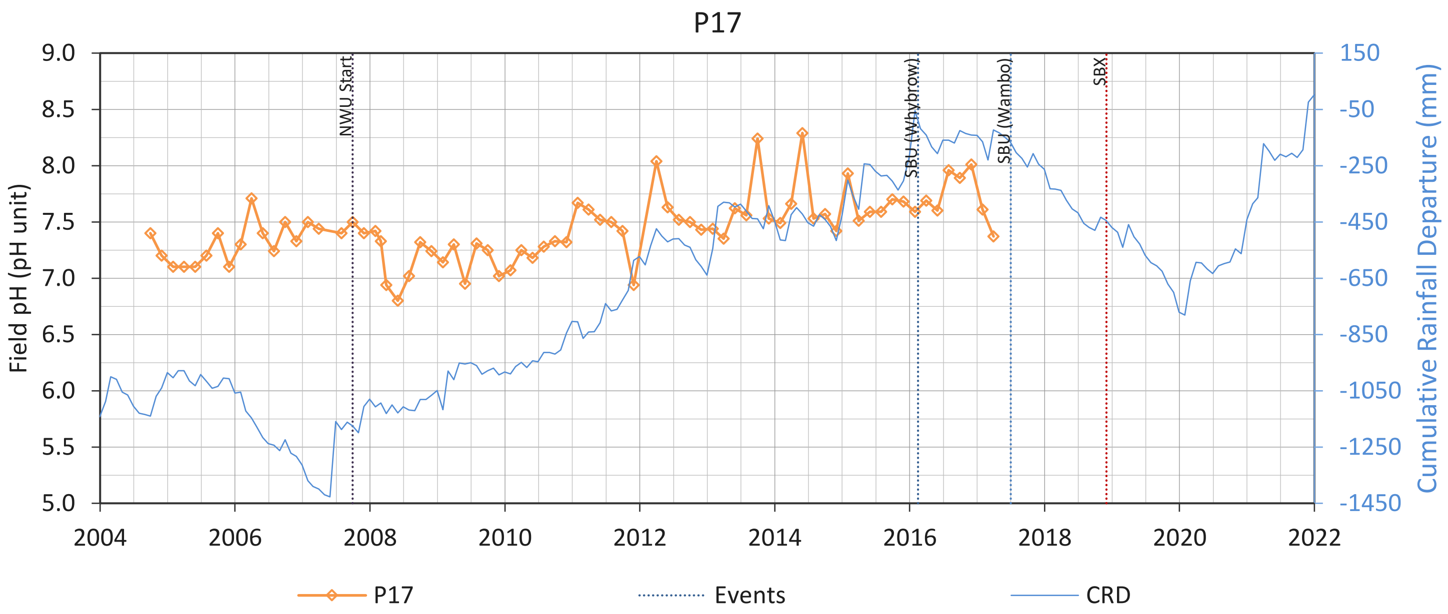

P119
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
900
800
700
600
500
400
300
200
100
0
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P119
Events
CRD

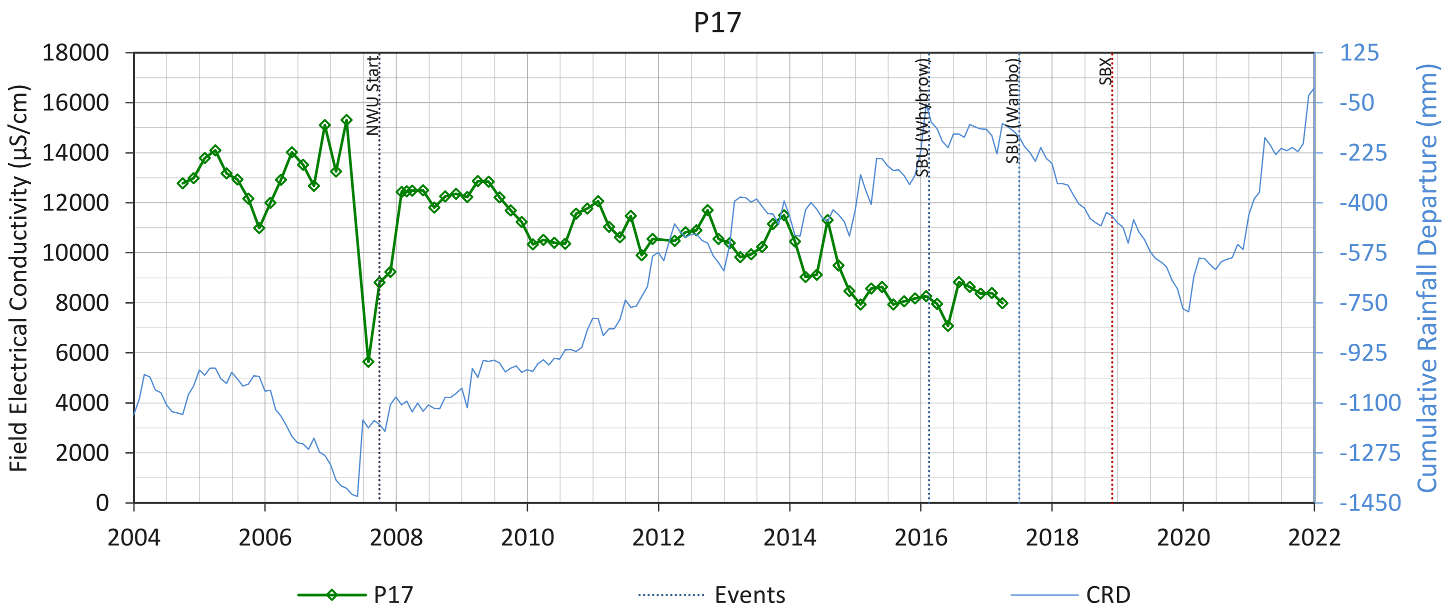

P15
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
52.0
51.5
51.0
50.5
50.0
49.5
49.0
48.5
48.0
47.5
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P15
Events
CRD

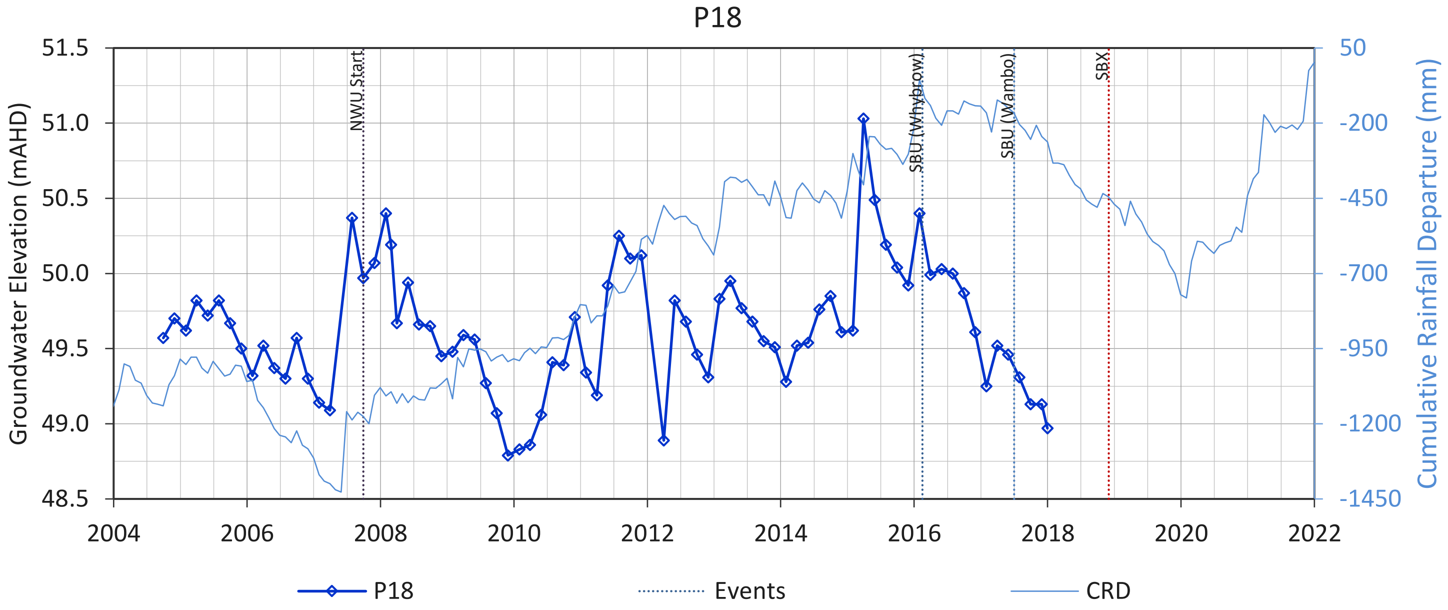

P15
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P15
Events
CRD

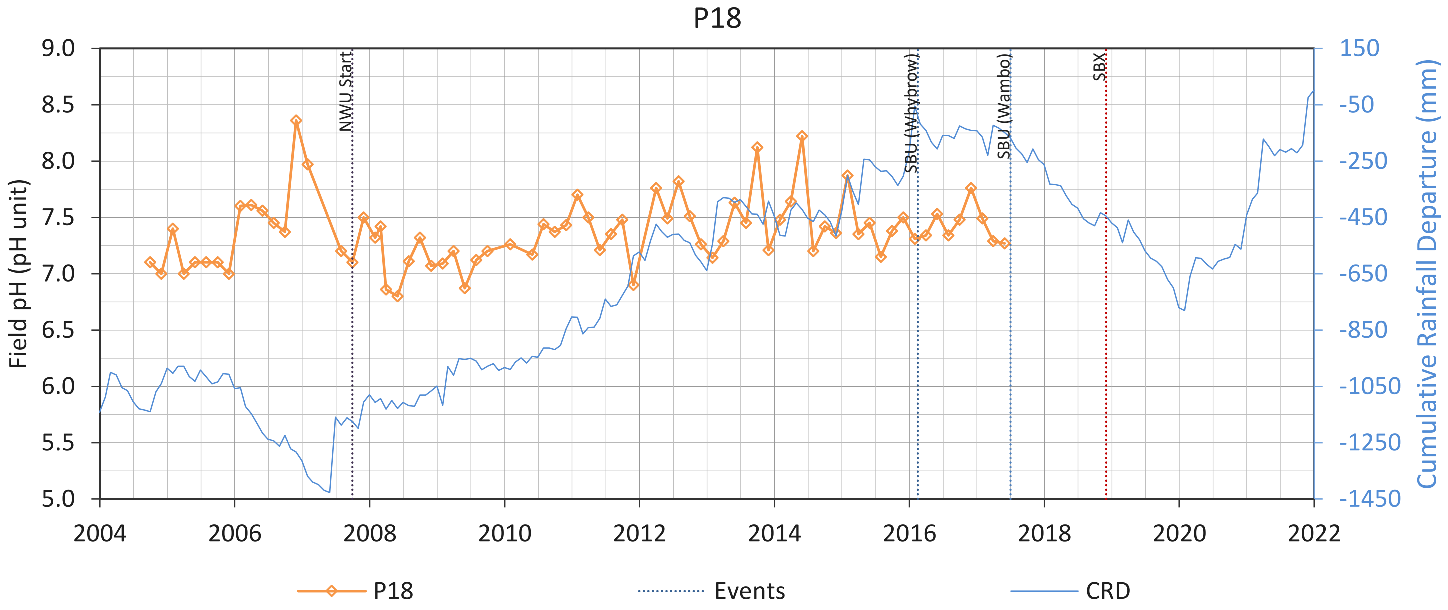

P15
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P15
Events
CRD

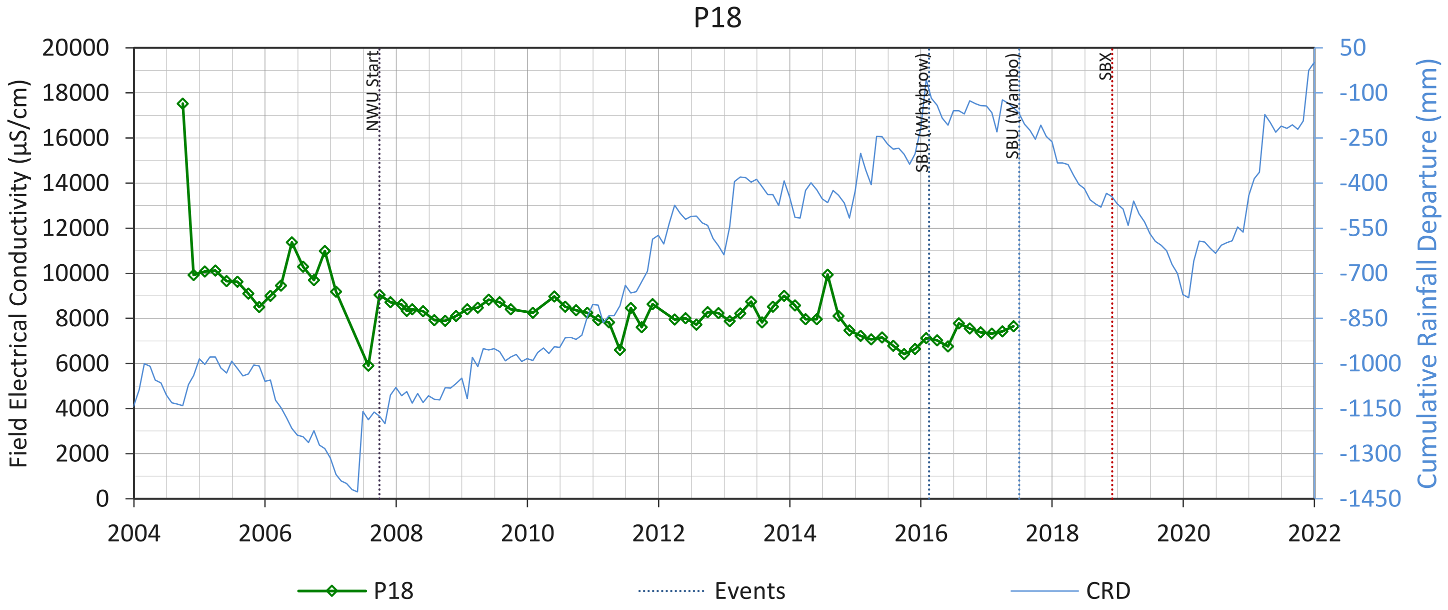

P17
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
52.0
51.5
51.0
50.5
50.0
49.5
49.0
48.5
48.0
47.5
47.0
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P17
Events
CRD

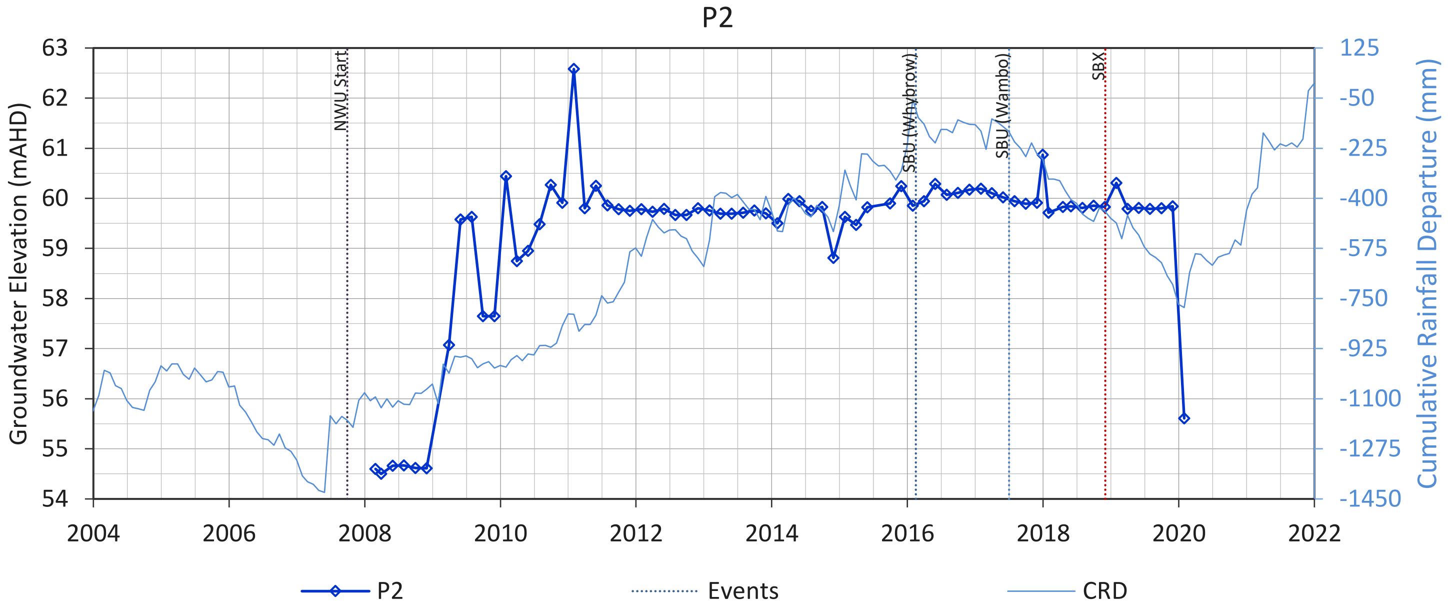

P17
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P17
Events
CRD

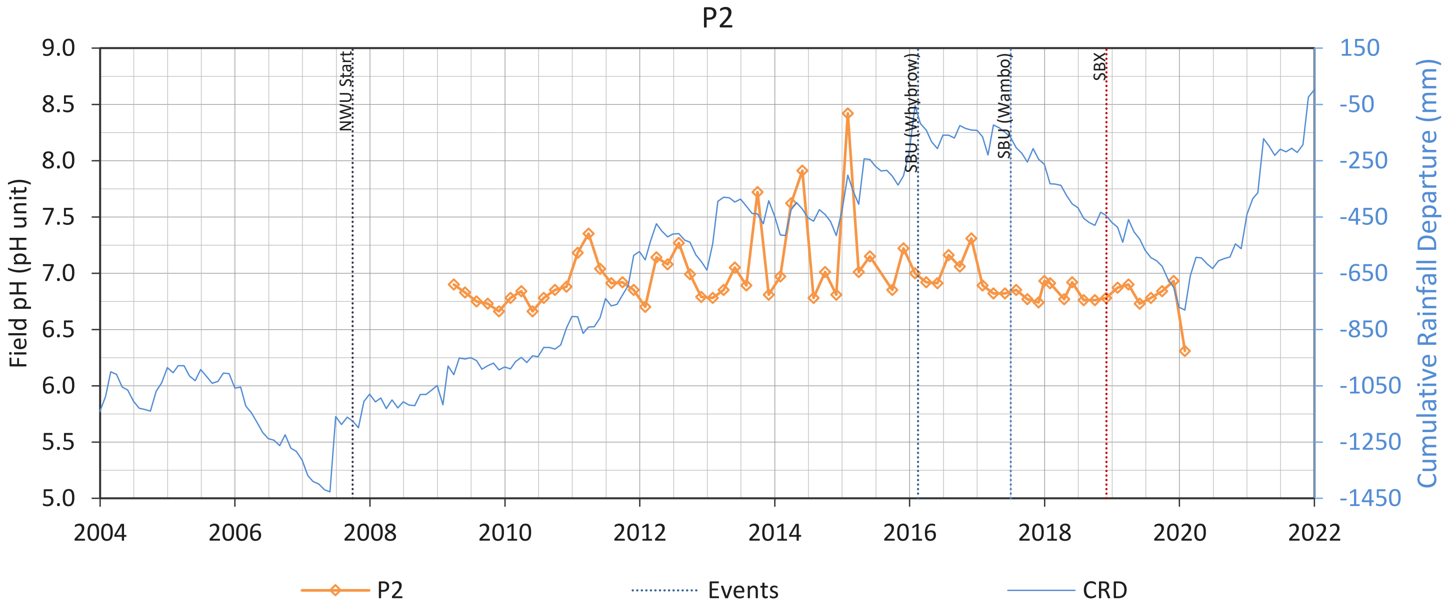

P17
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P17
Events
CRD

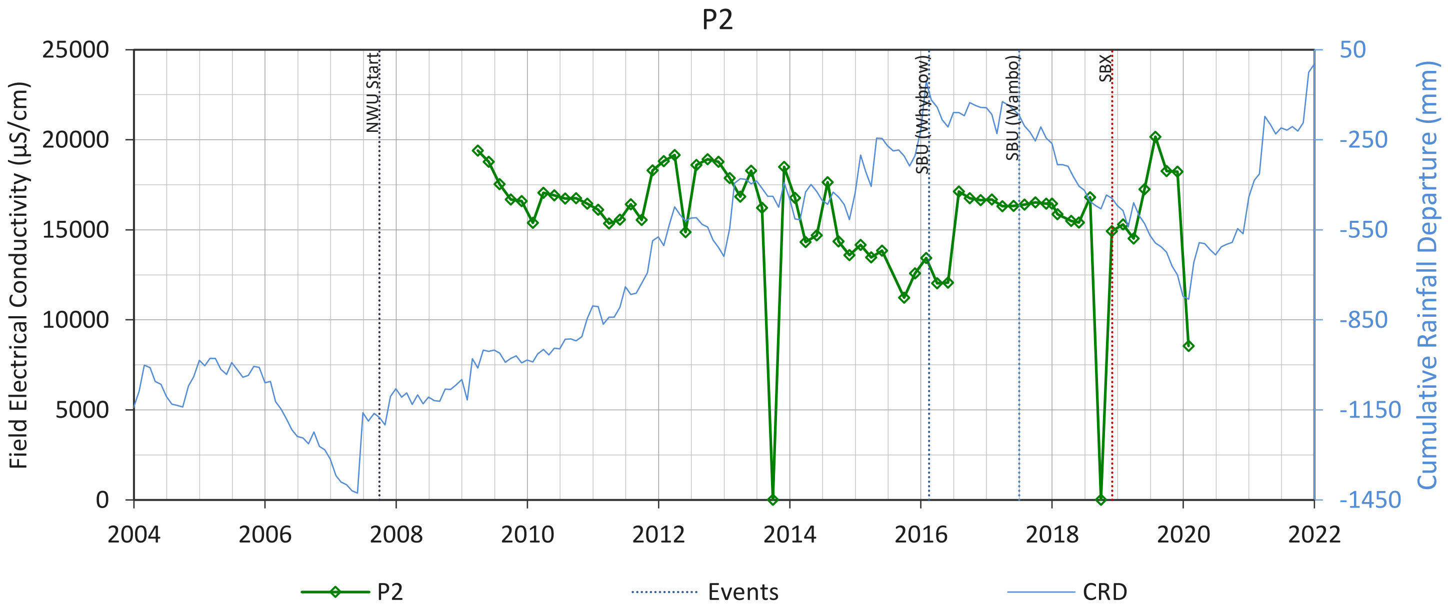

P18
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P18
Events
CRD

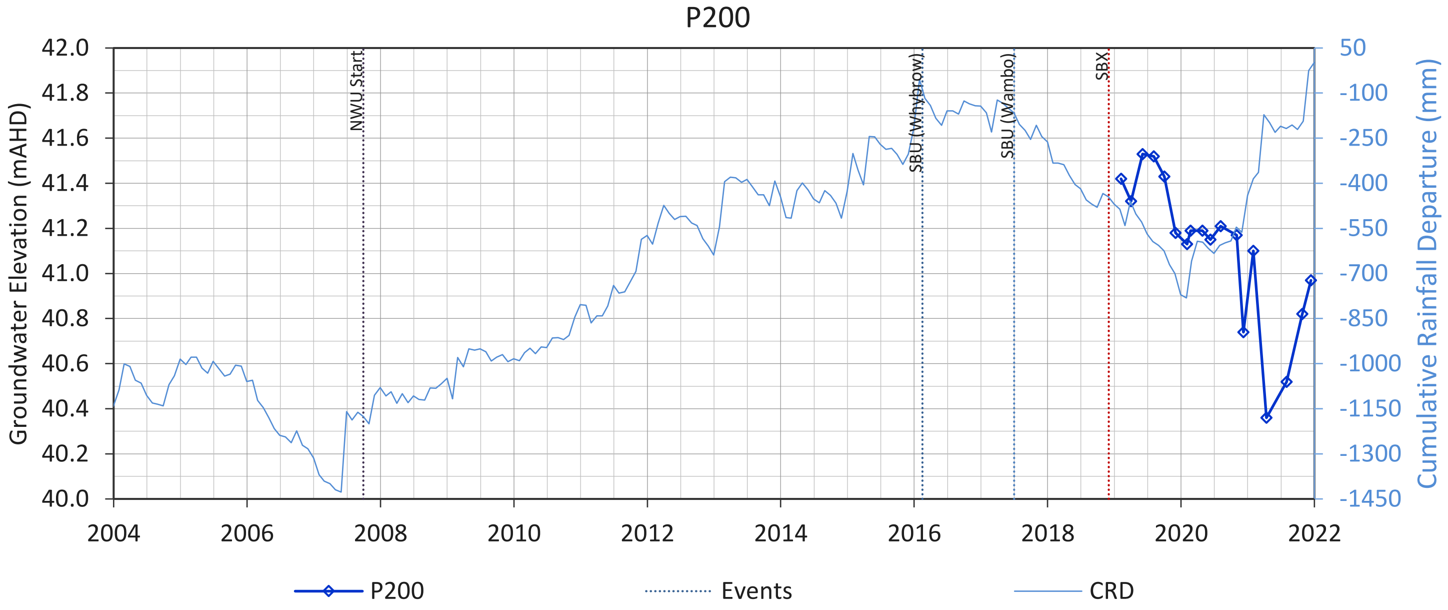

P18
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P18
Events
CRD

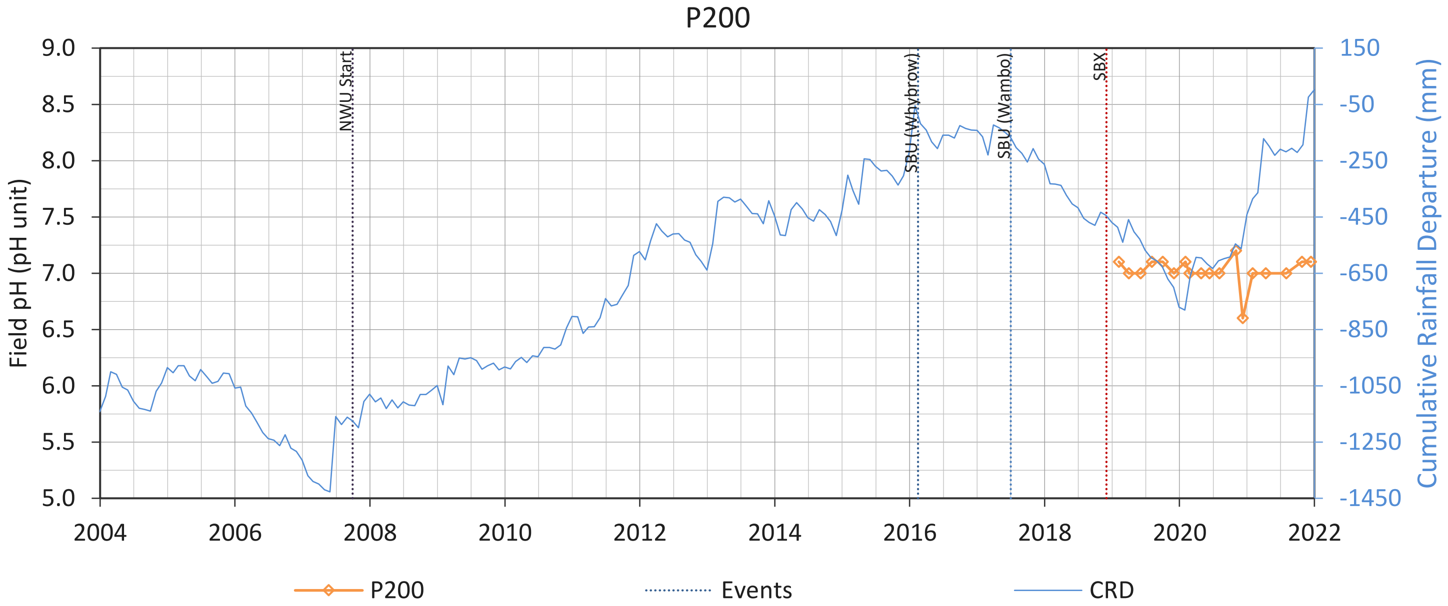

P18
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P18
Events
CRD

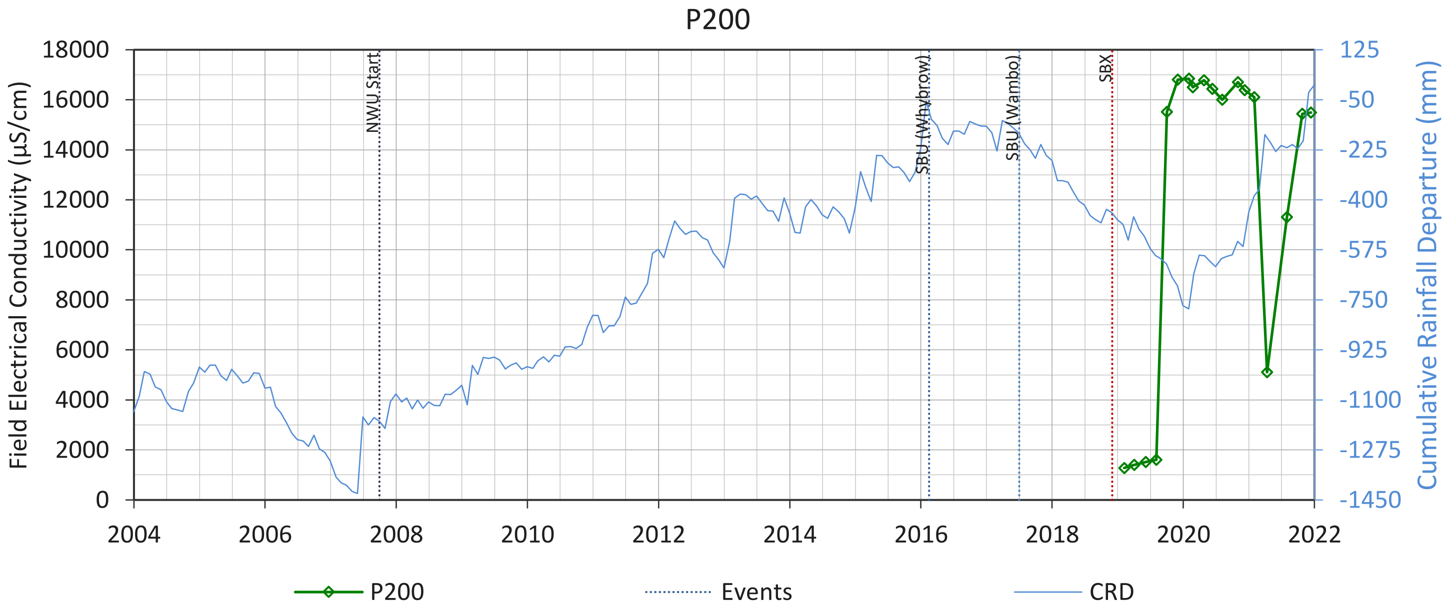

P2
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
63
62
61
60
59
58
57
56
55
54
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P2
Events
CRD

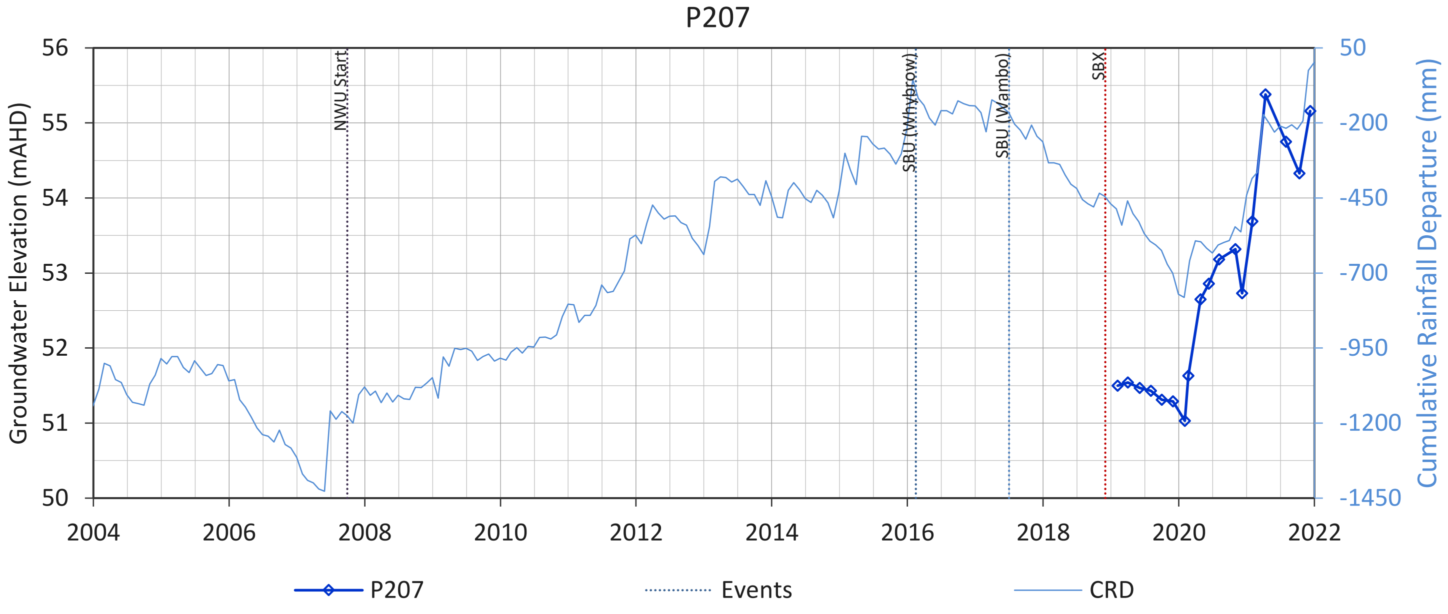

P2
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P2
Events
CRD

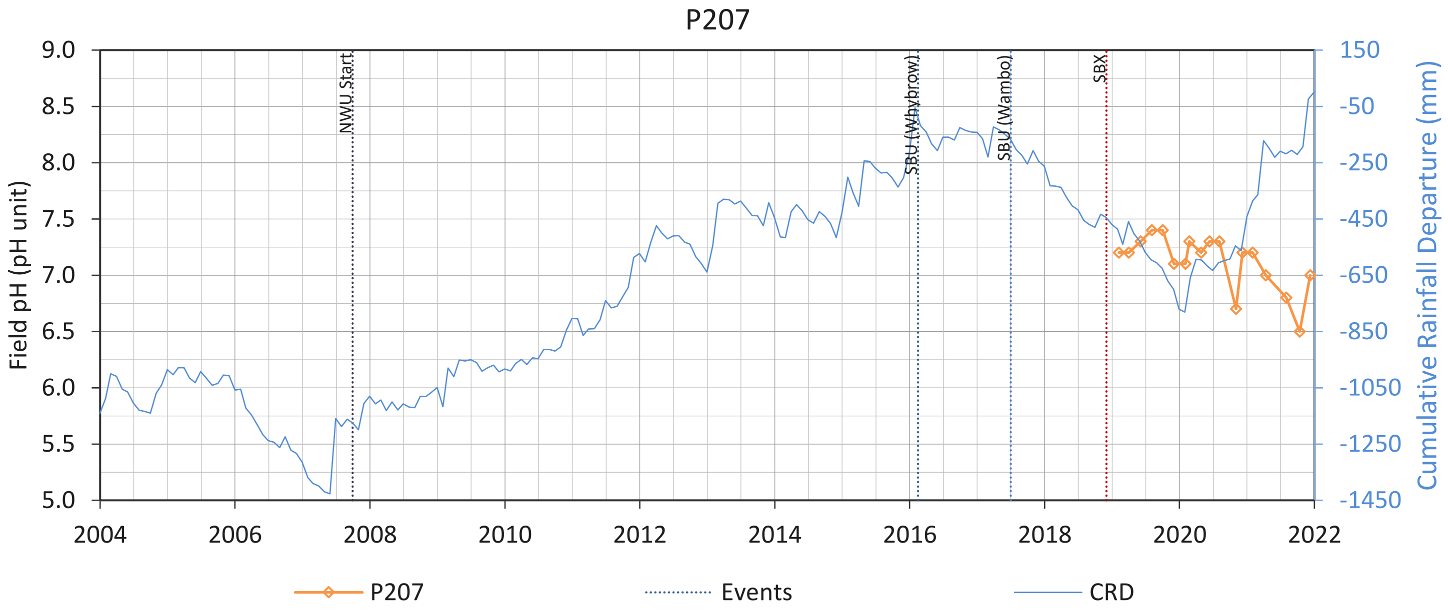

P2
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
25000
20000
15000
10000
5000
0
50
-250
-550
-850
-1150
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P2
Events
CRD

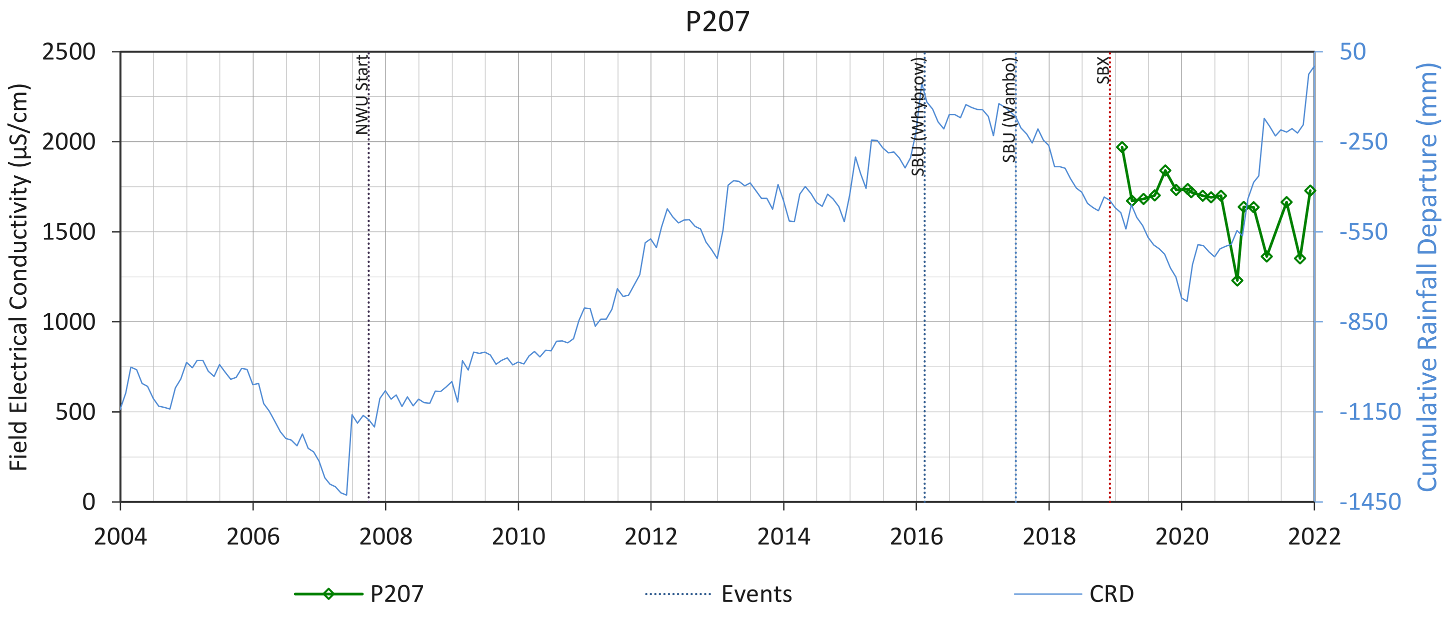

P200
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P200
Events
CRD

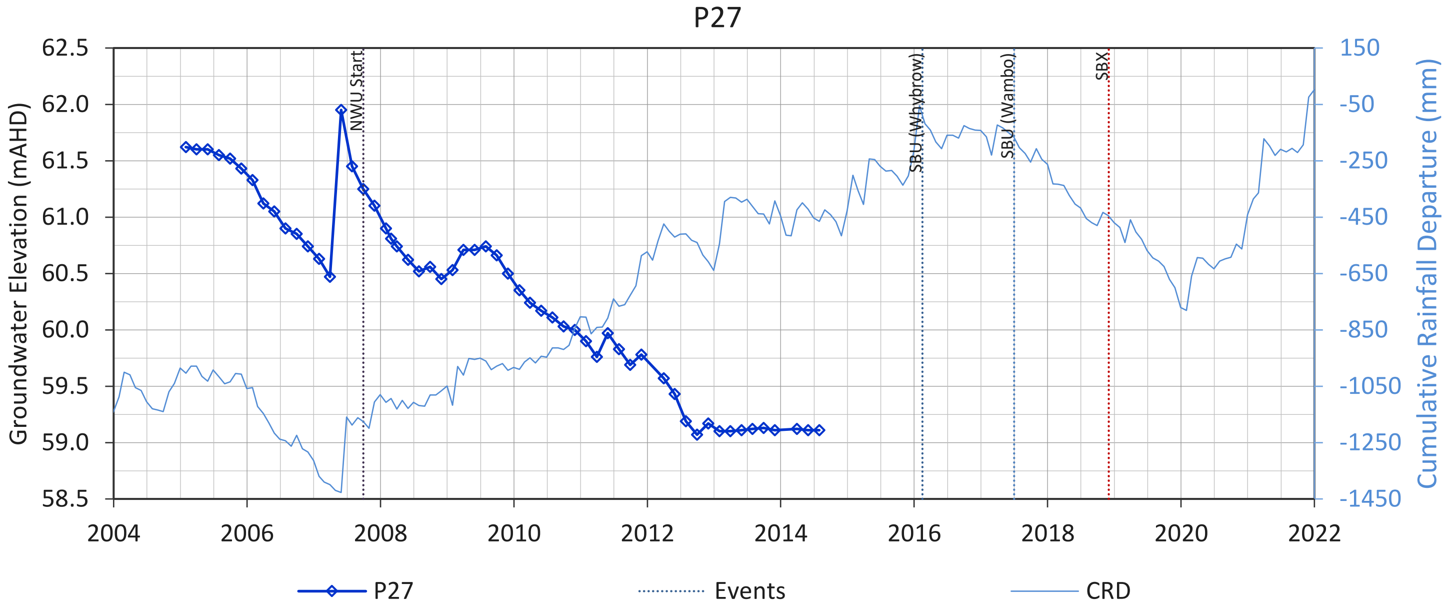

P200
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P200
Events
CRD

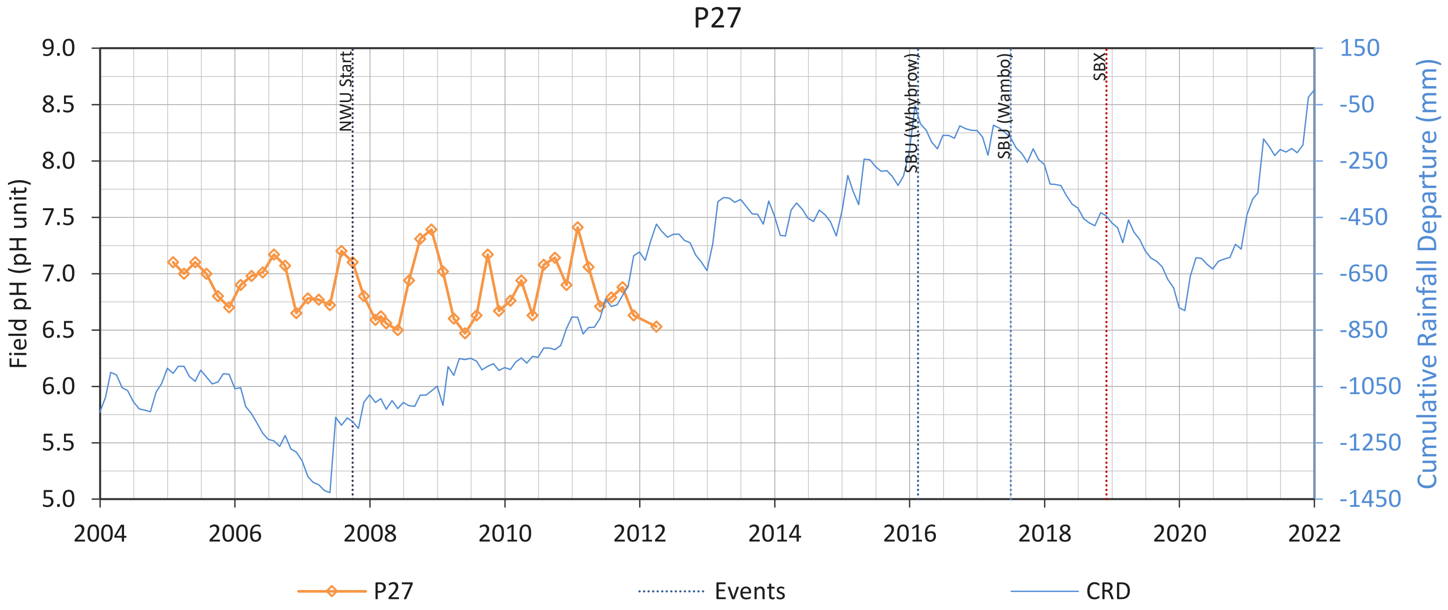

P200
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P200
Events
CRD

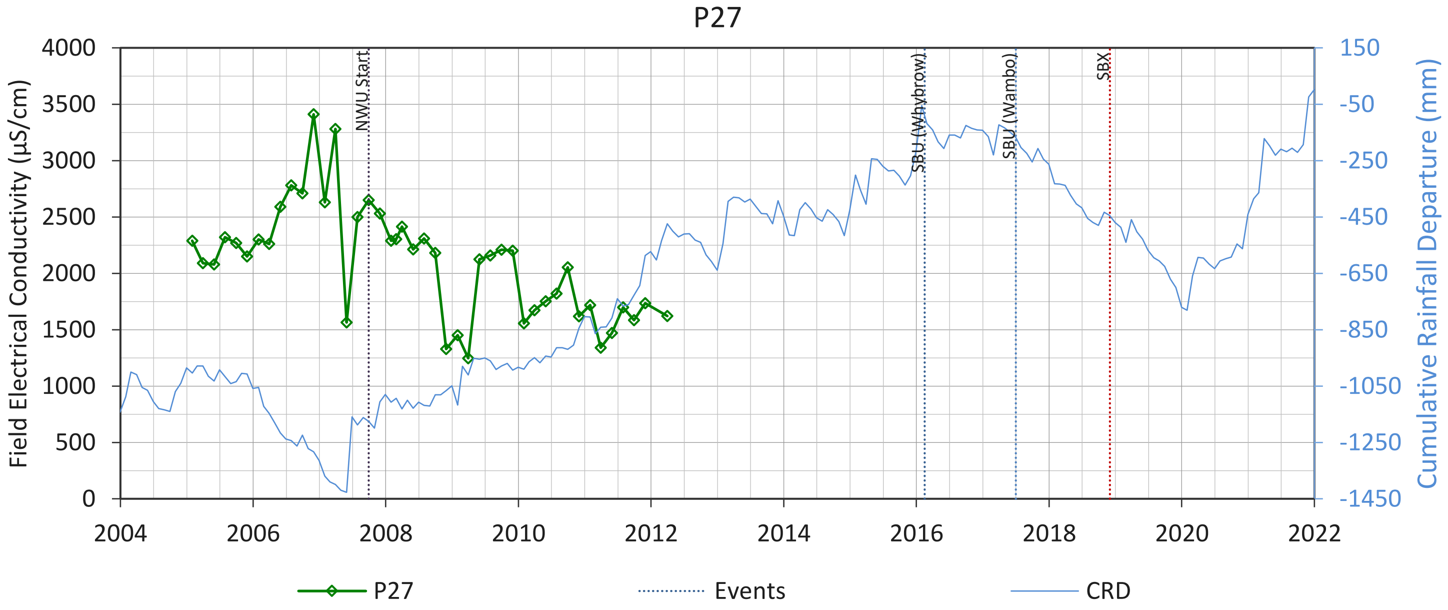

P207
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
56
55
54
53
52
51
50
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P207
Events
CRD

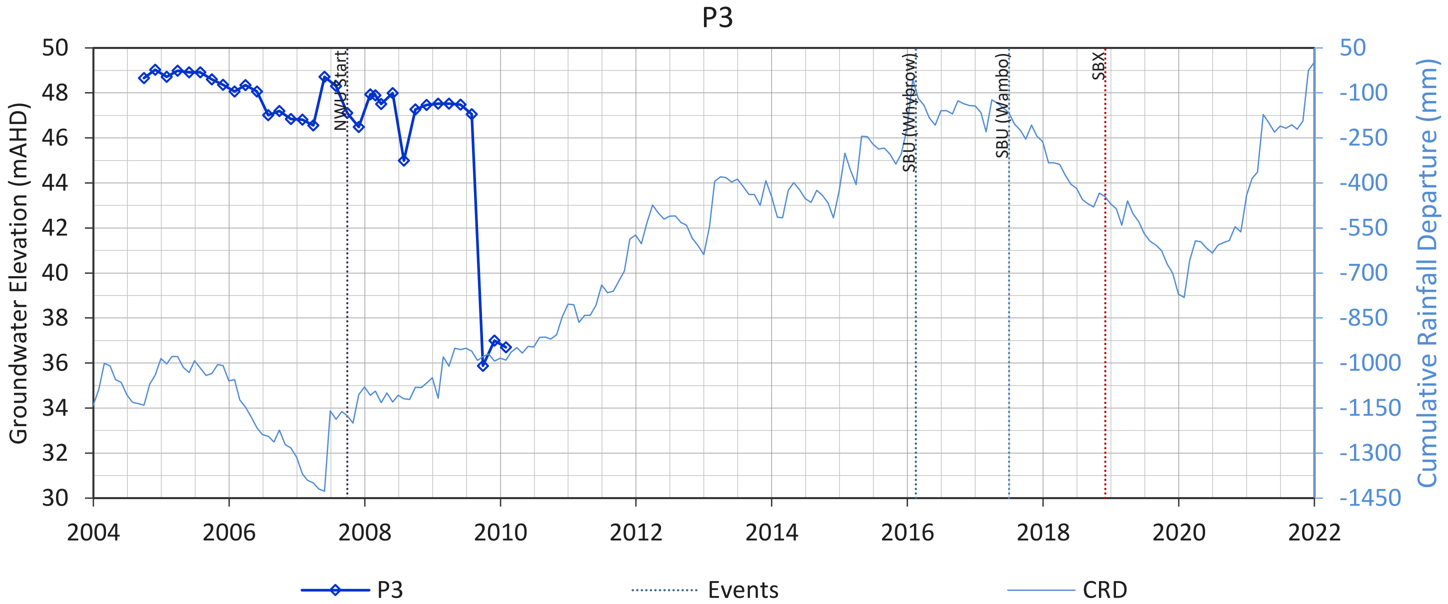

P207
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P207
Events
CRD

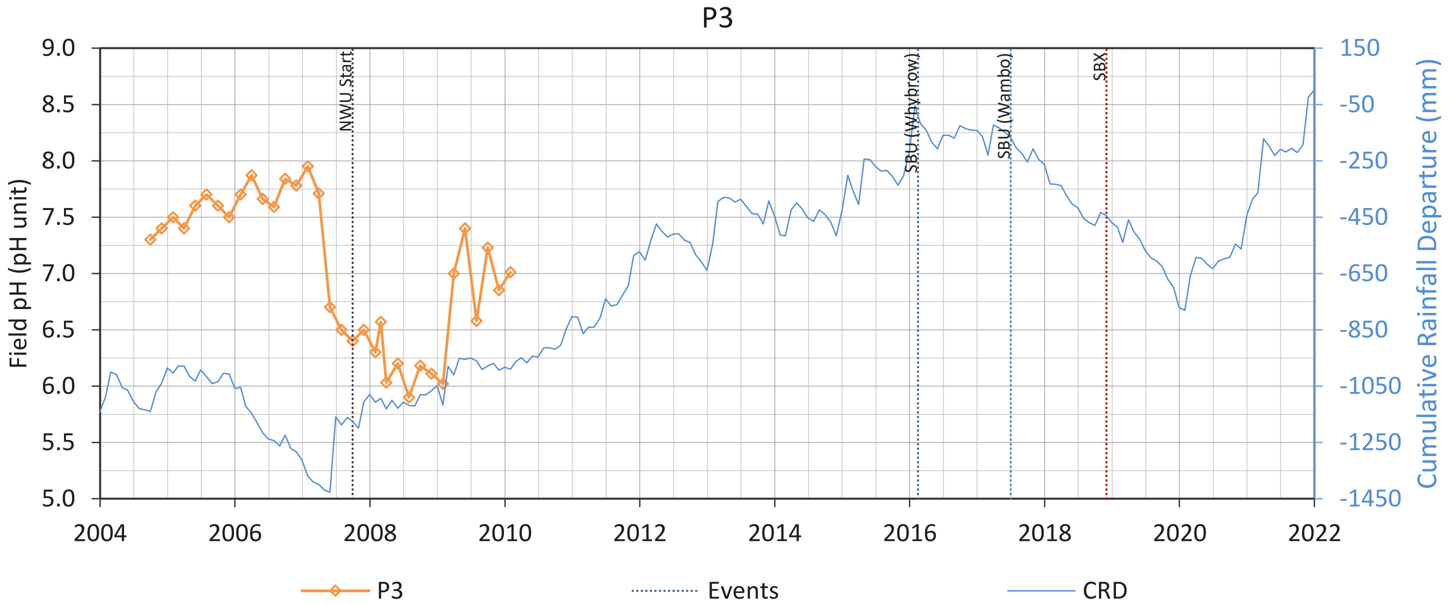

P207
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
2500
2000
1500
1000
500
0
50
-250
-550
-850
-1150
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P207
Events
CRD

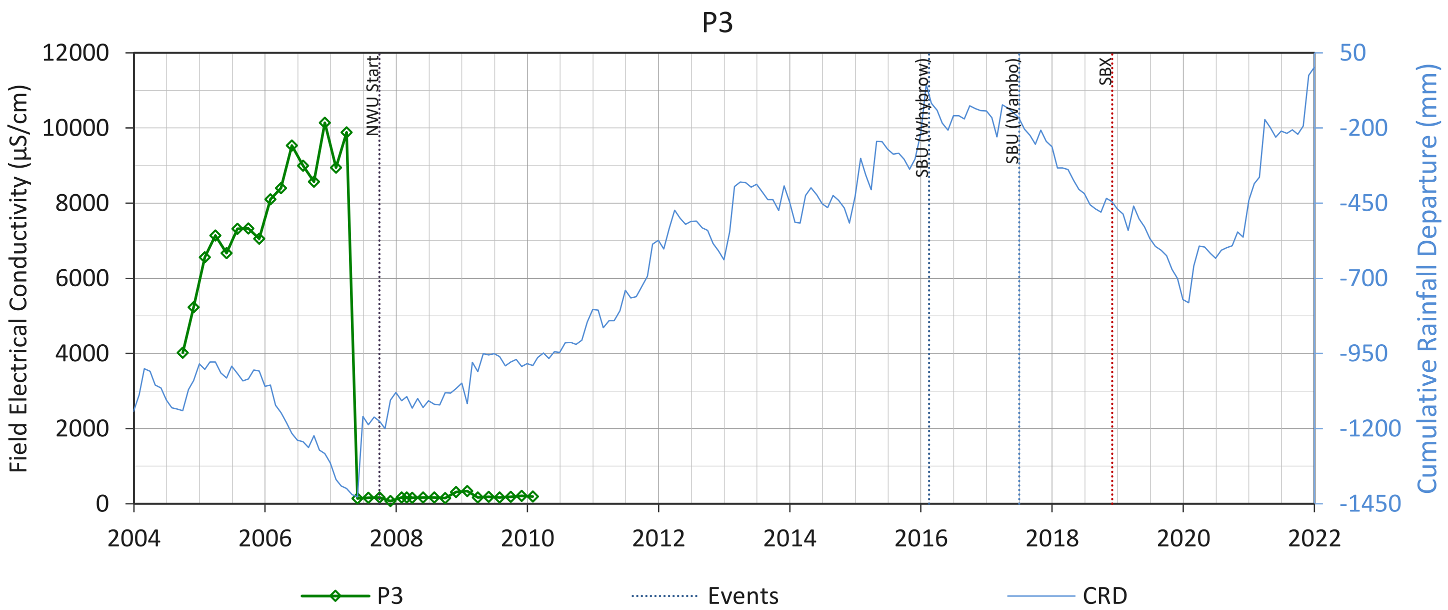

P27
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P27
Events
CRD


P27
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P27
Events
CRD

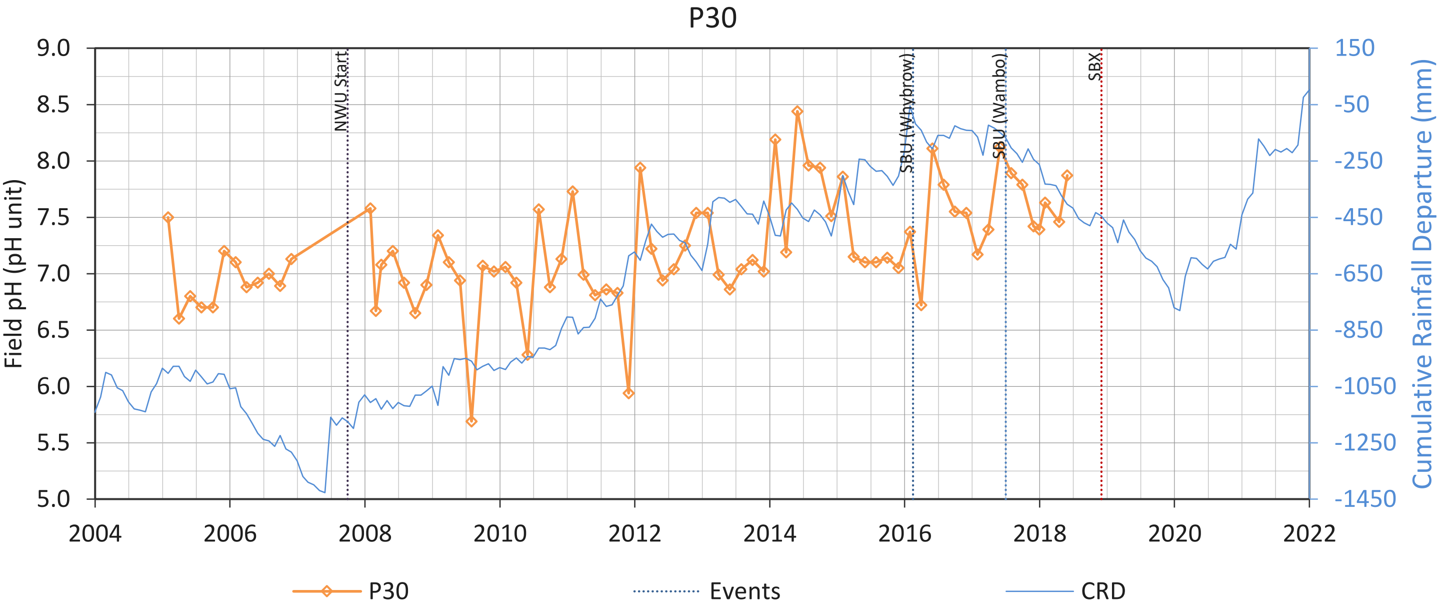

P27
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P27
Events
CRD

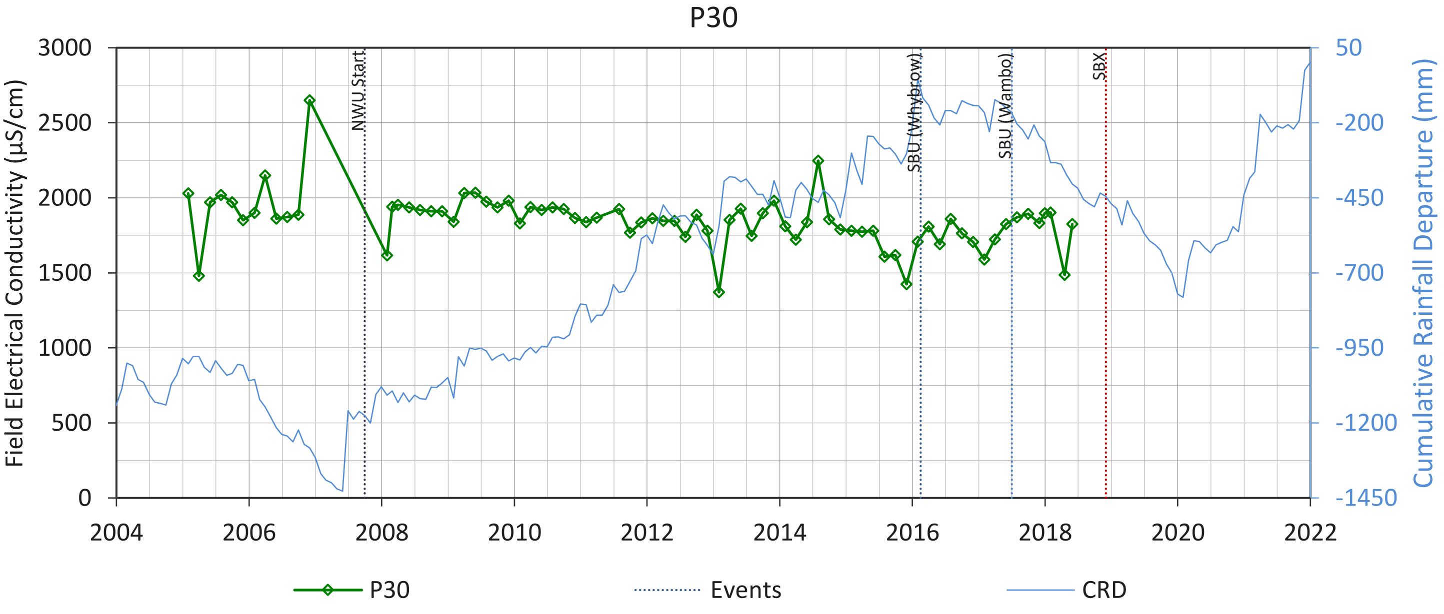

P3
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P3
Events
CRD


P3
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P3
Events
CRD

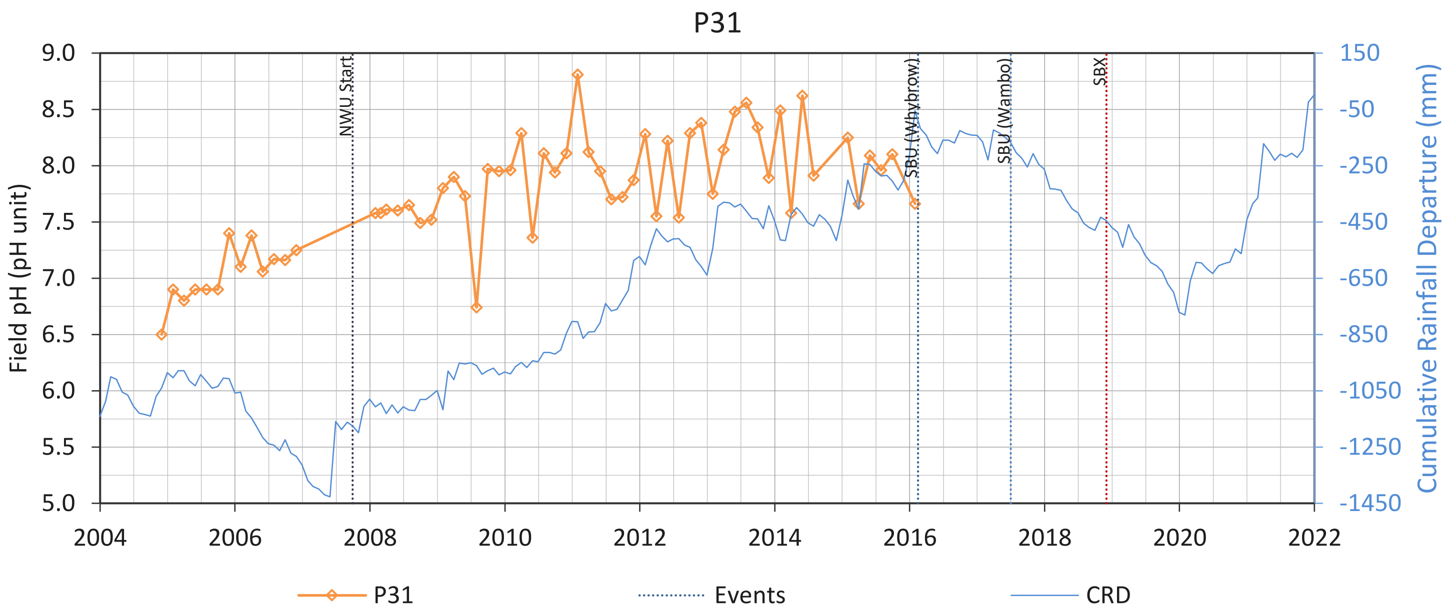

P3
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P3
Events
CRD

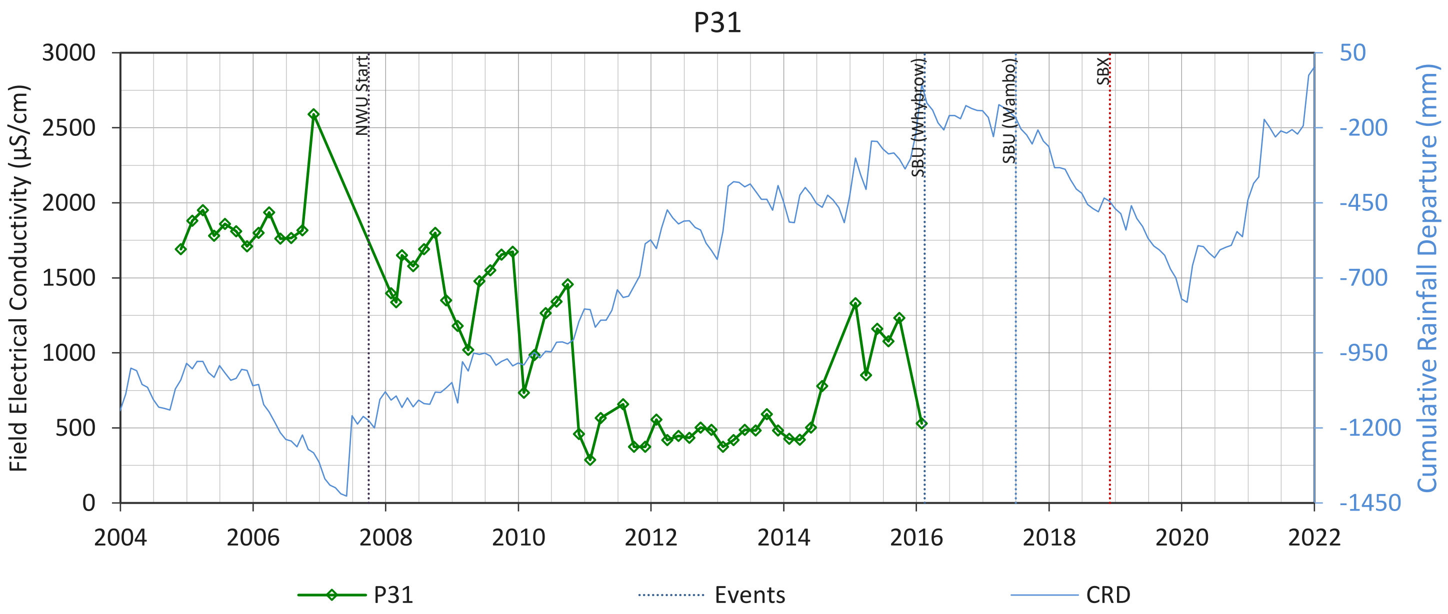
No Data Available for Groundwater Elevation (mAHD)

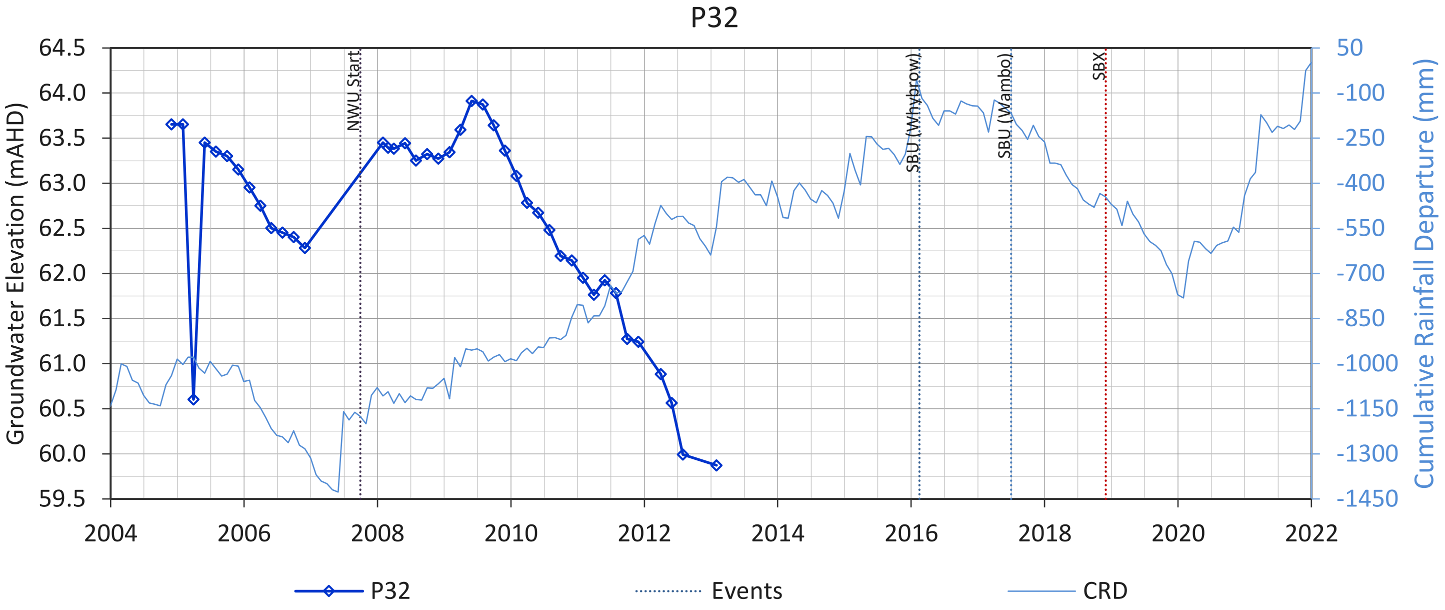


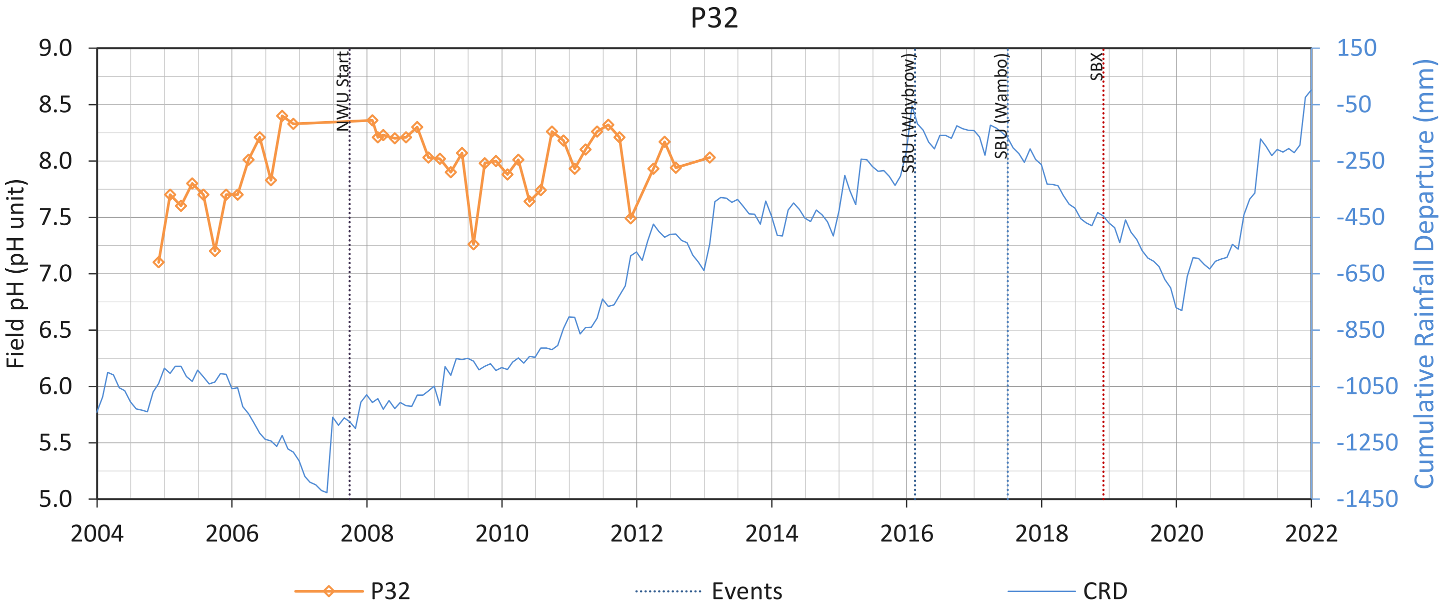


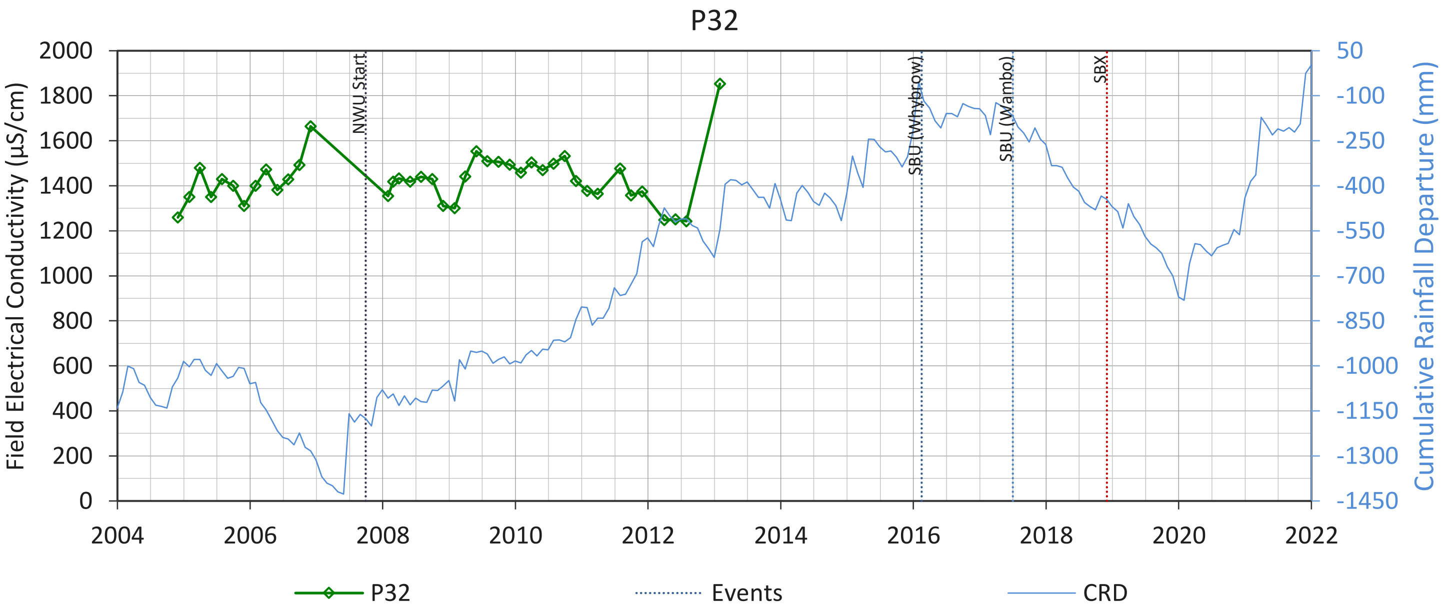
No Data Available for Groundwater Elevation (mAHD)

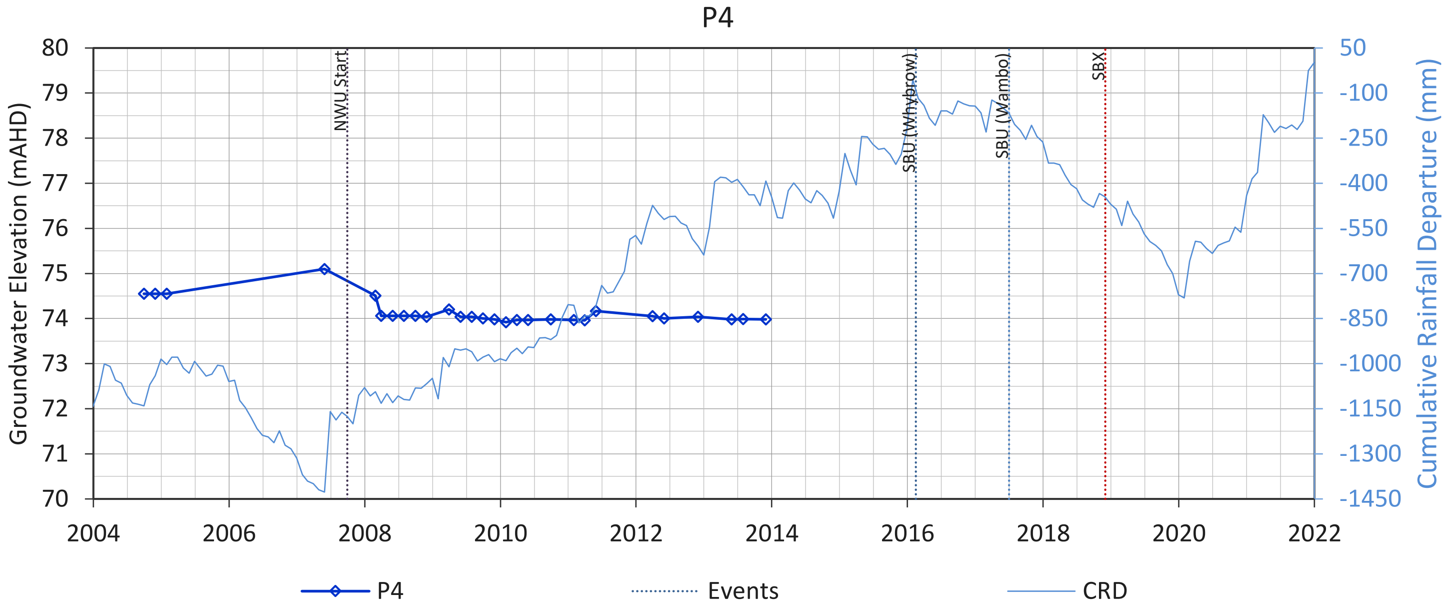


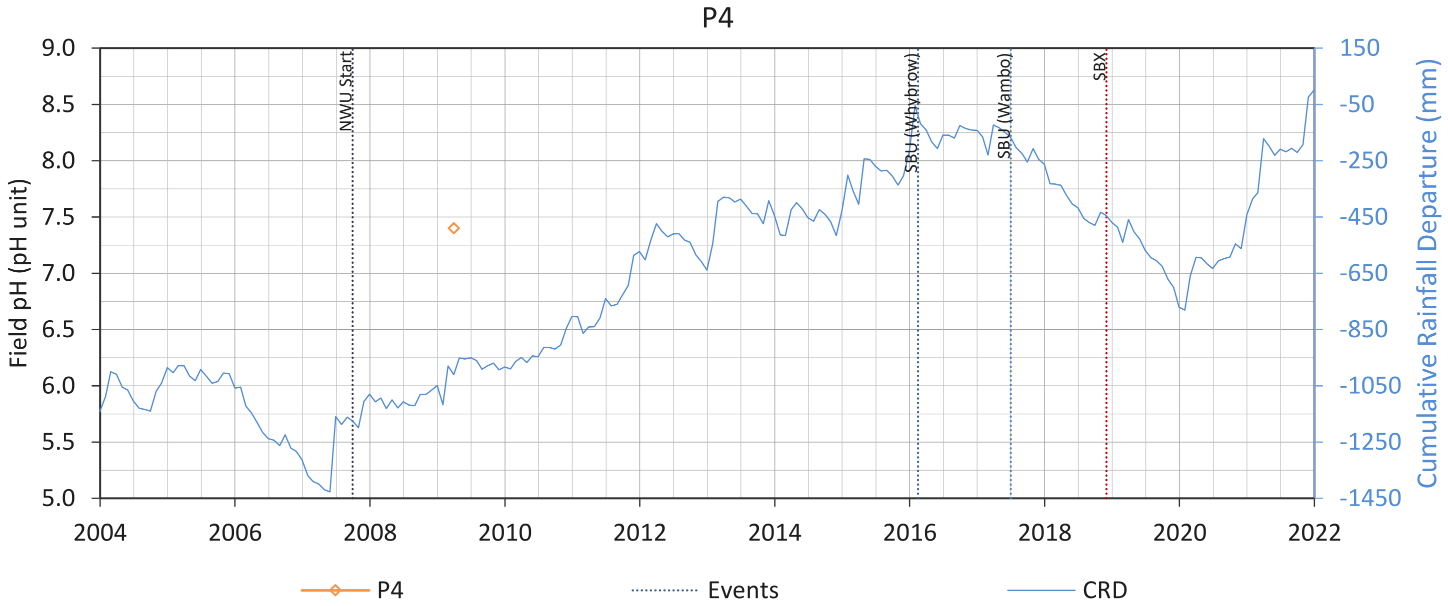


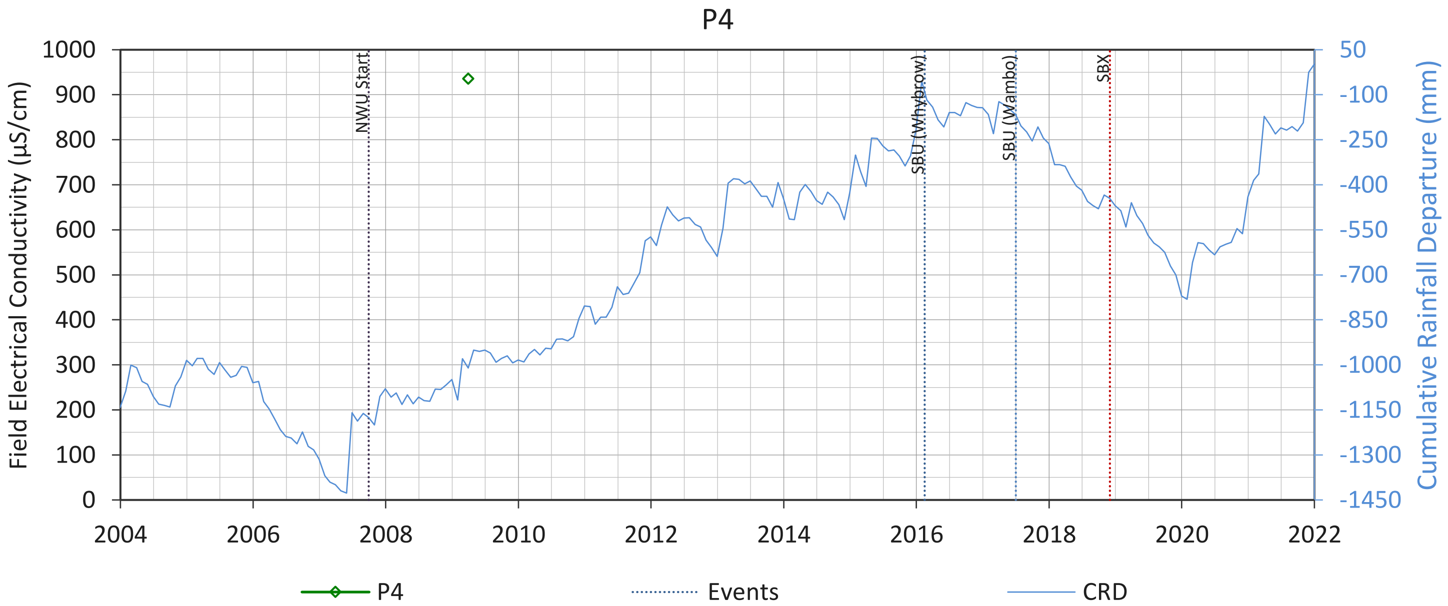

P32
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWIJ Start
SBU (Whybrow)
SBU (Wambo)
SBX
64.5
64.0
63.5
63.0
62.5
62.0
61.5
61.0
60.5
60.0
59.5
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P32
Events
CRD

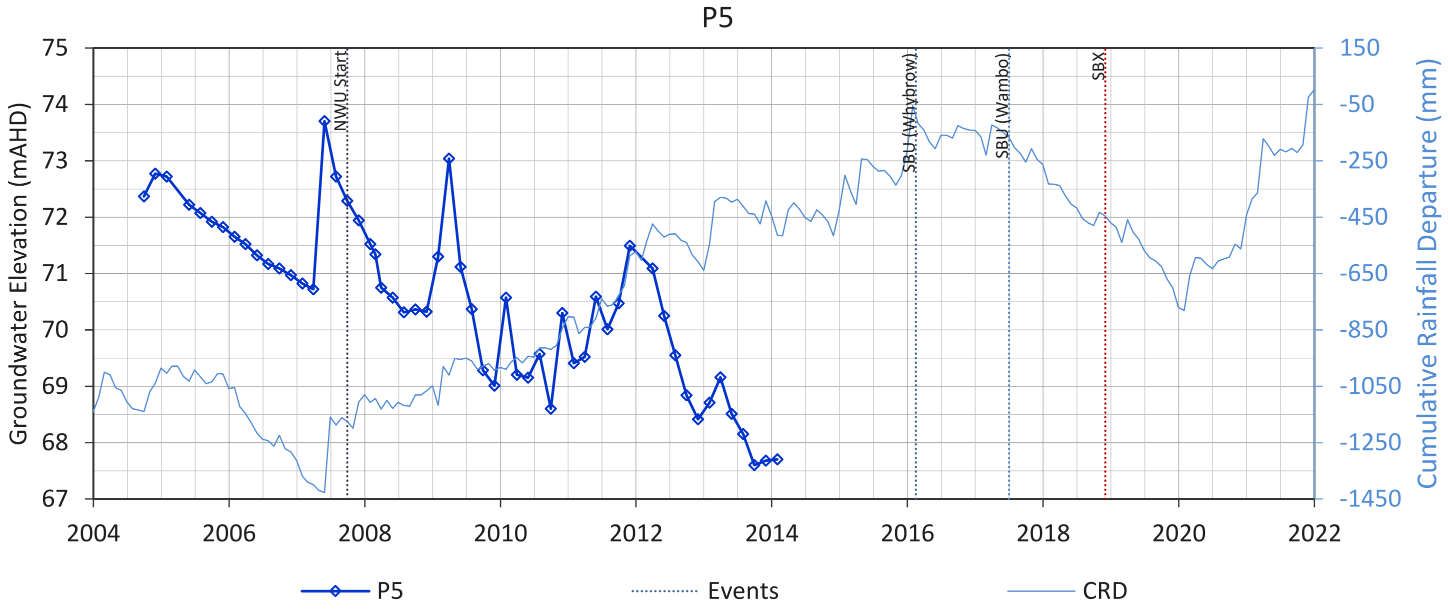

P32
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWIJ Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P32
Events
CRD

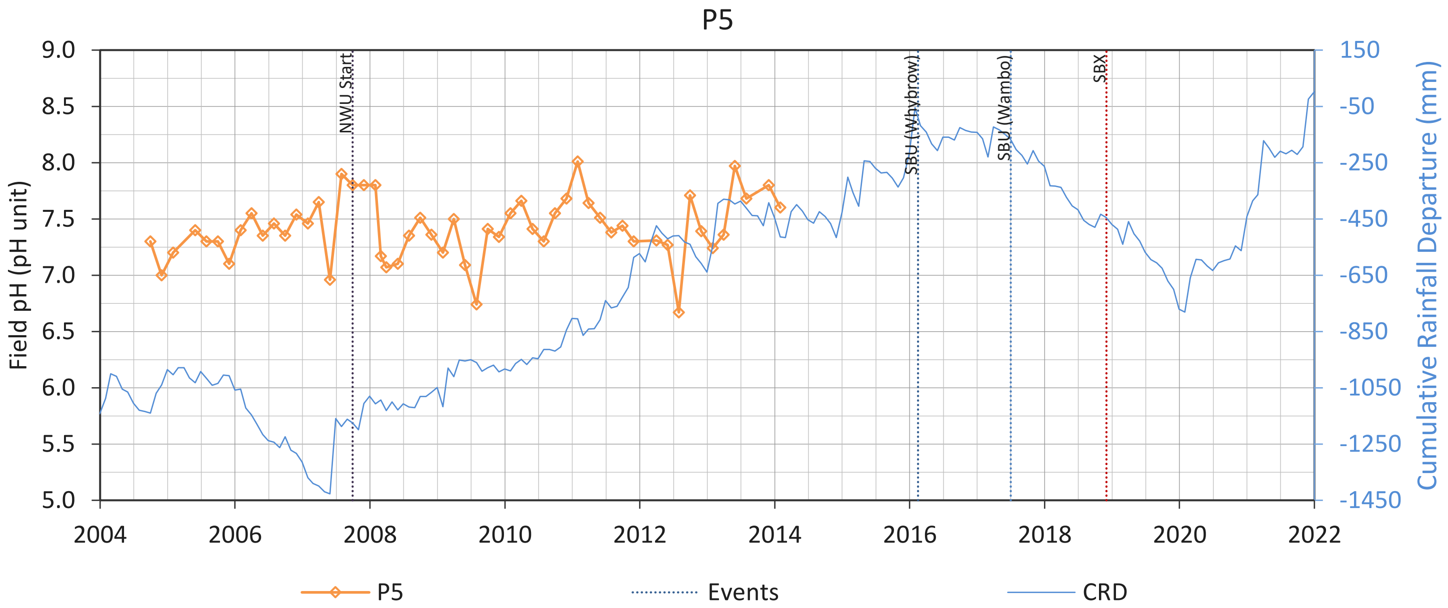

P32
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWIJ Start
SBU (Whybrow)
SBU (Wambo)
SBX
2000
1800
1600
1400
1200
1000
800
600
400
200
0
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P32
Events
CRD

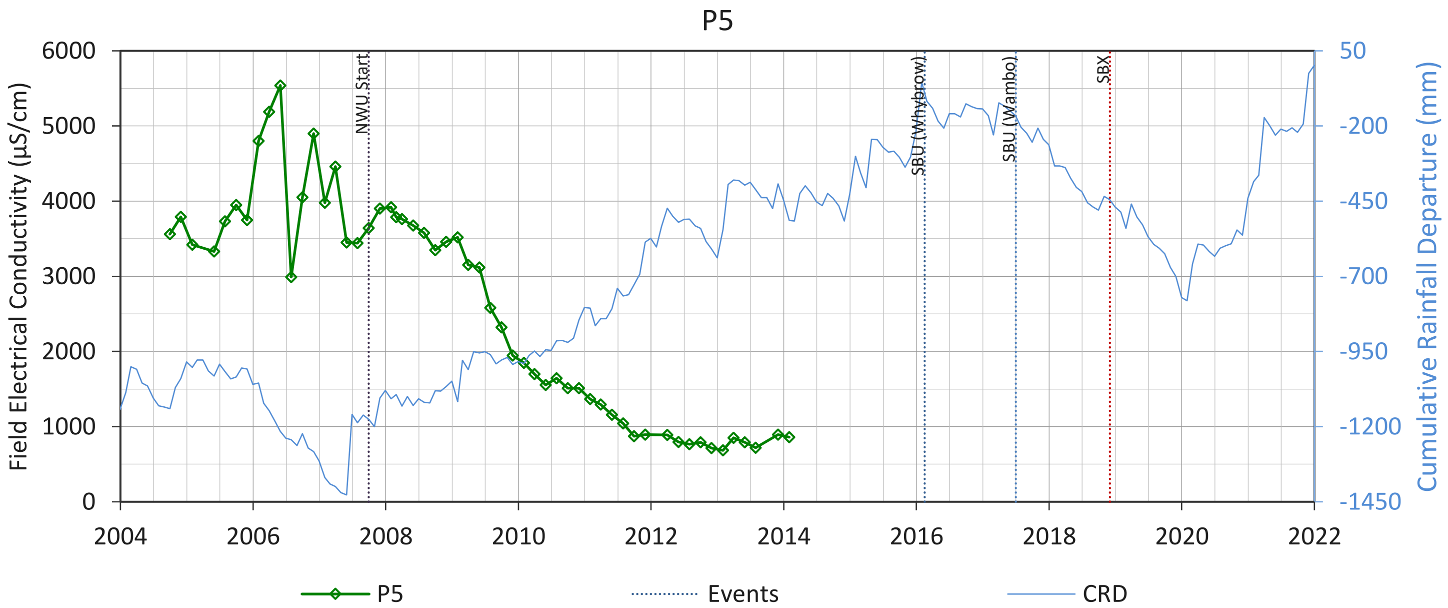

P4
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P4
Events
CRD

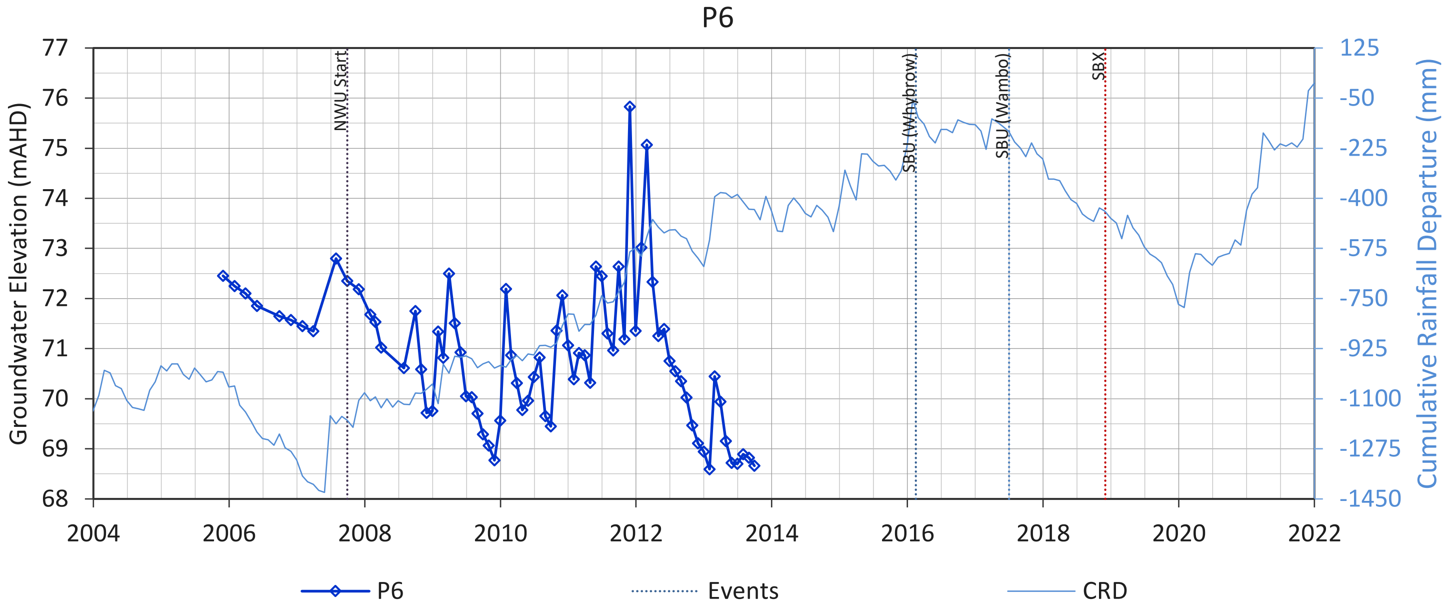

P4
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P4
Events
CRD

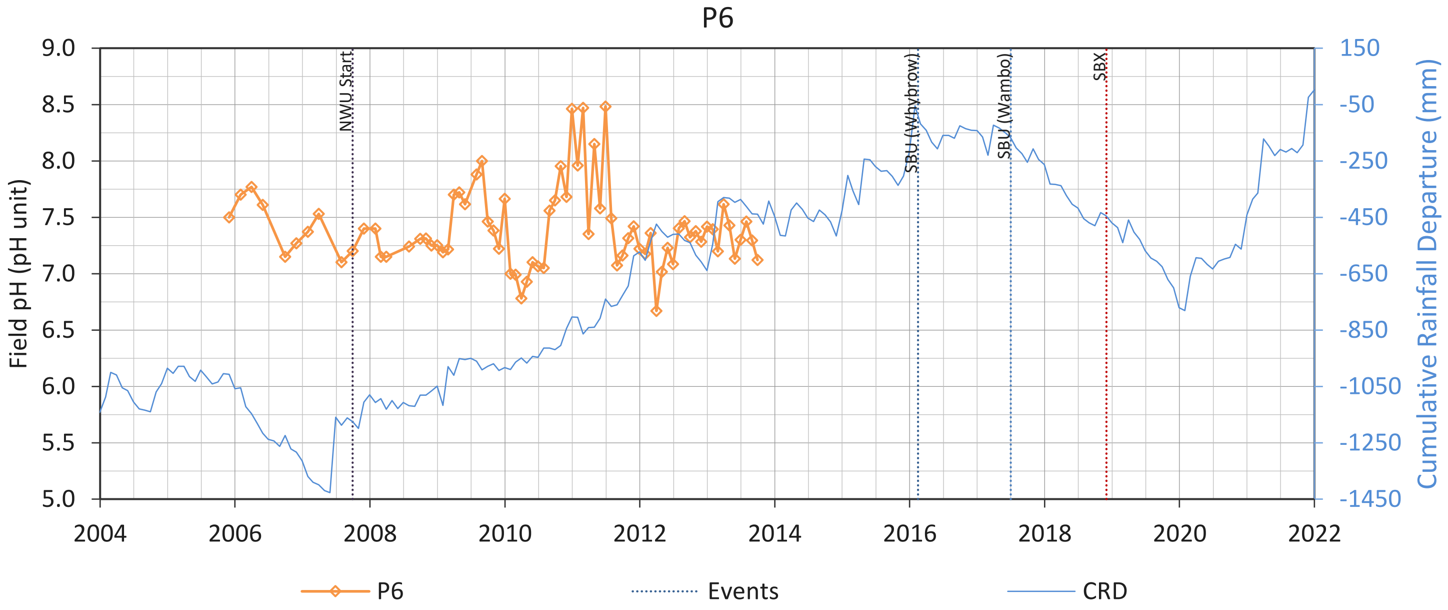

P4
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P4
Events
CRD

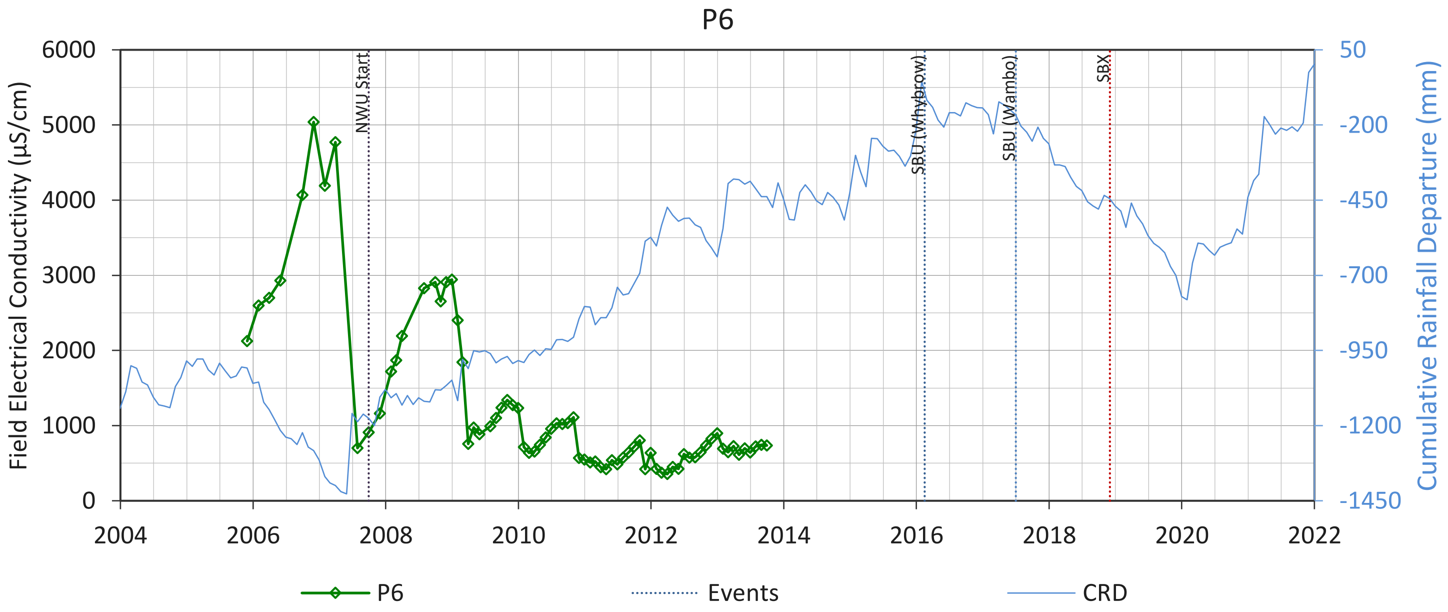

P5
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P5
Events
CRD

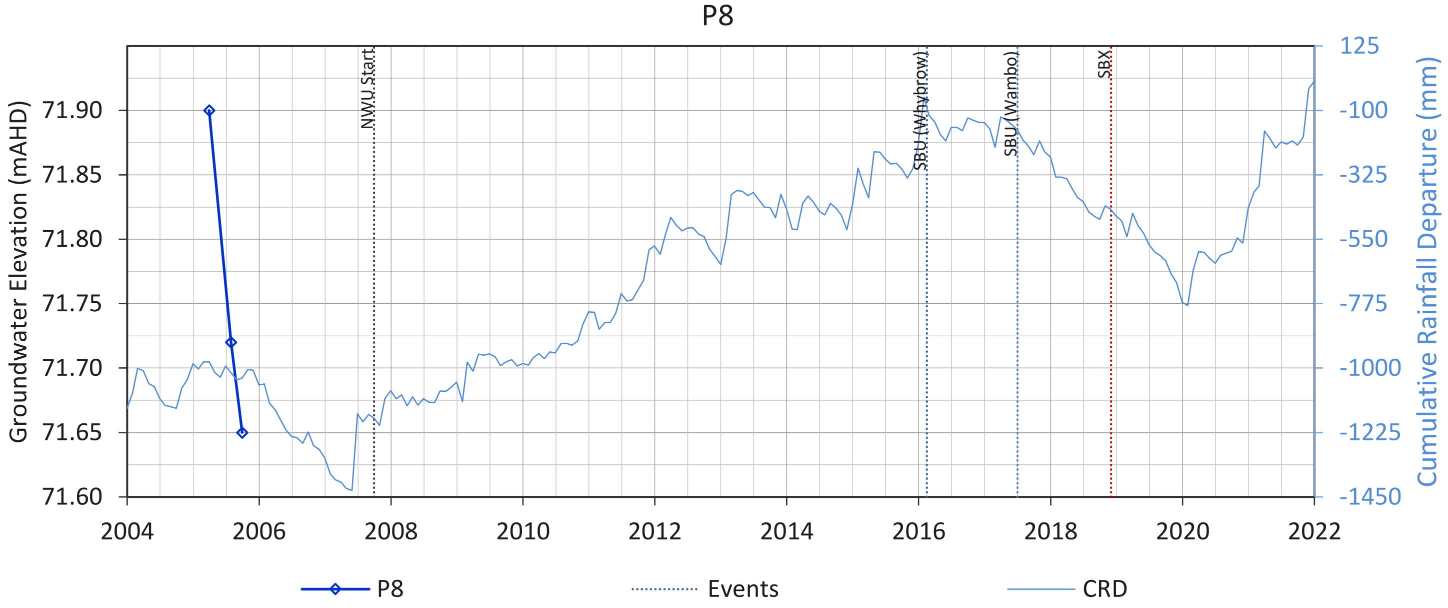

P5
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P5
Events
CRD


P5
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
P5
Events
CRD


P6
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
77
76
75
74
73
72
71
70
69
68
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P6
Events
CRD

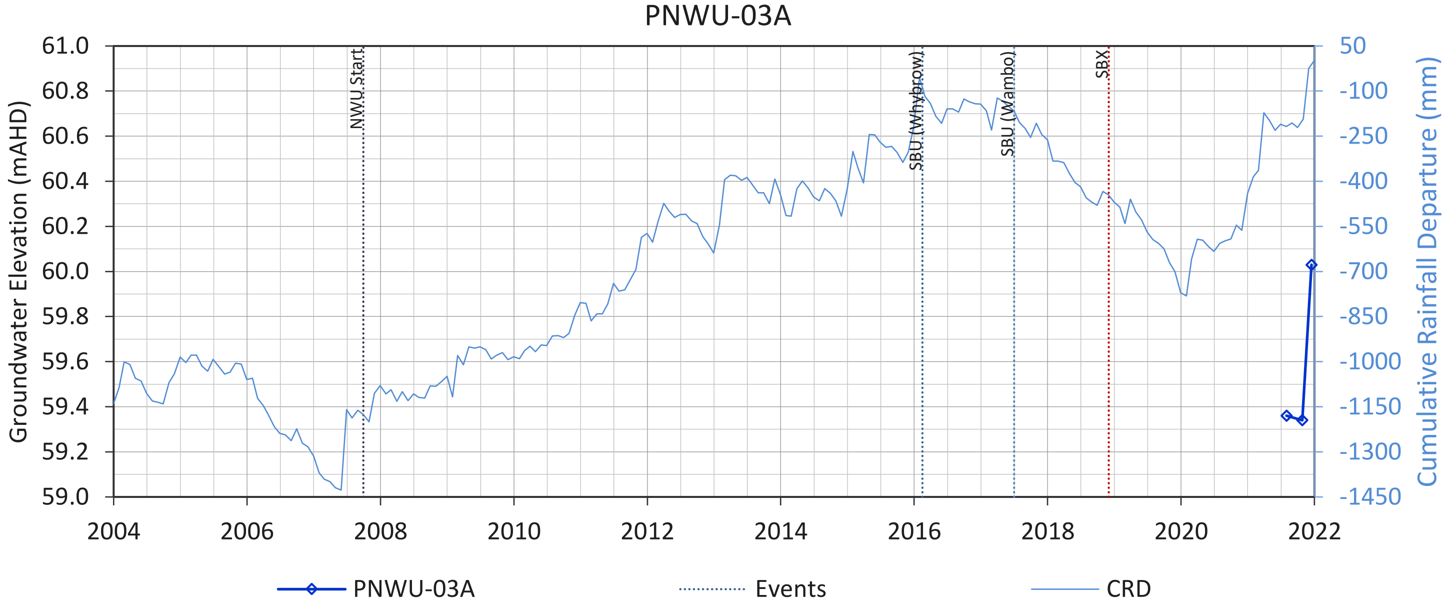

P6
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P6
Events
CRD

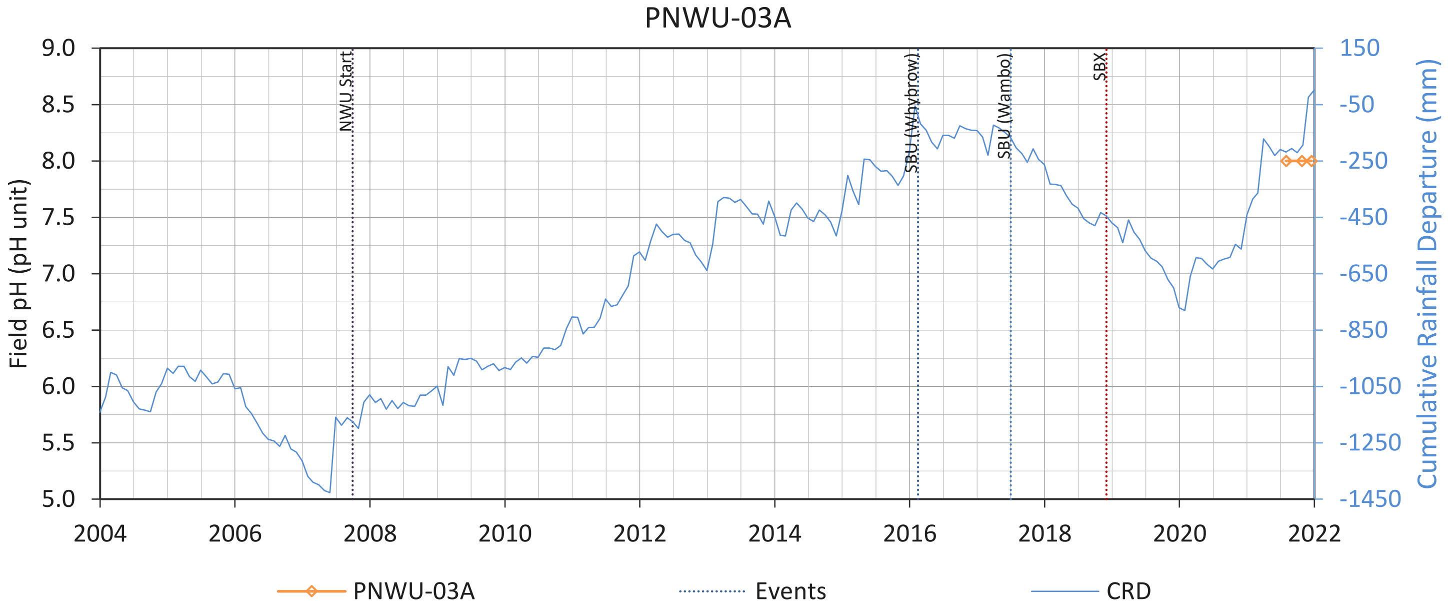

P6
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
6000
5000
4000
3000
2000
1000
0
50
-200
-450
-700
-950
-1200
-1450
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P6
Events
CRD

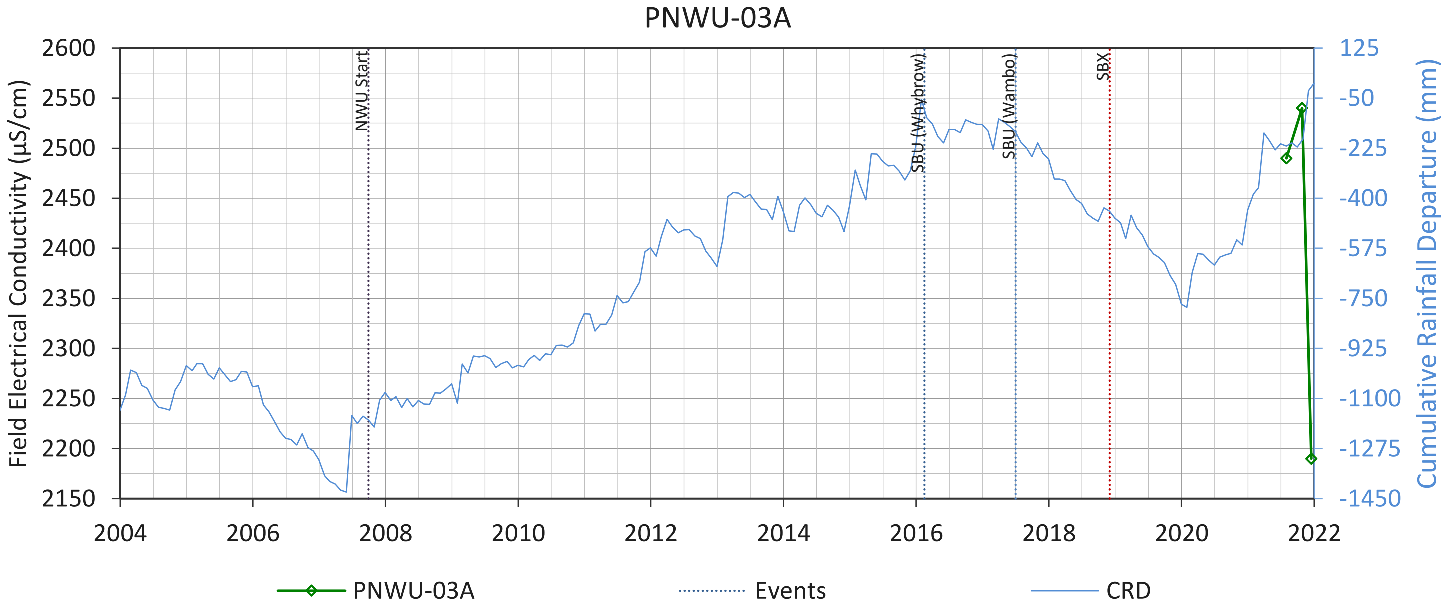


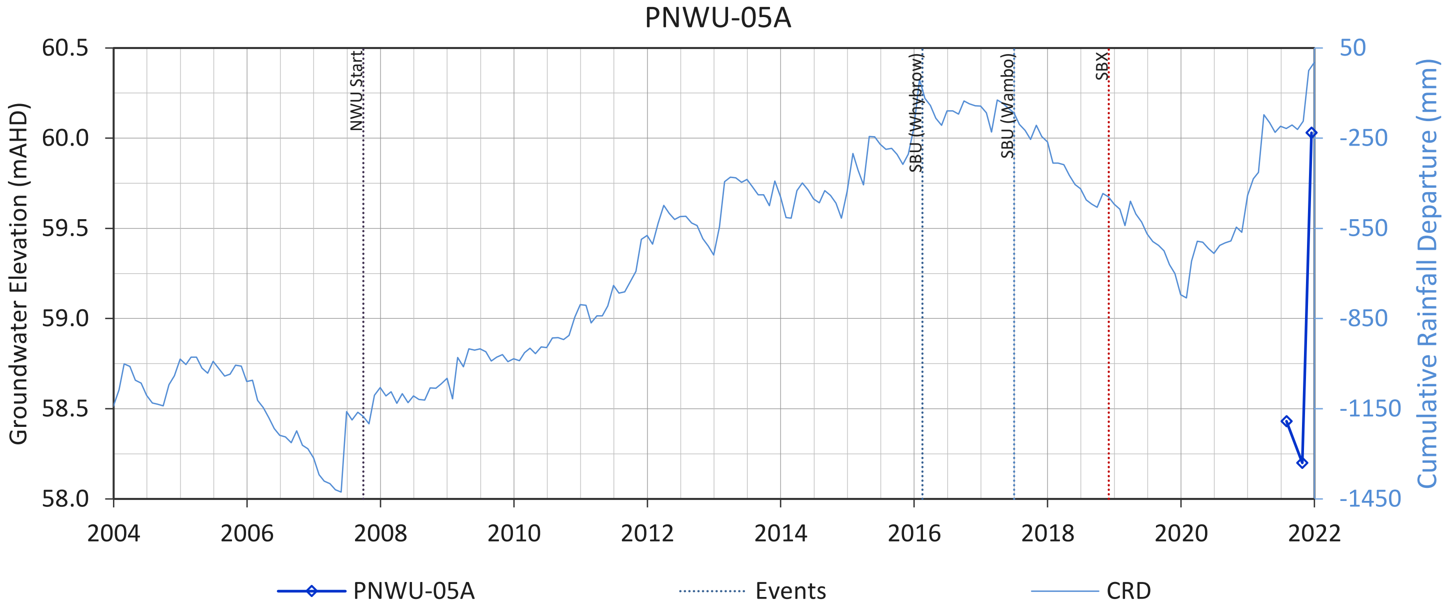
No Data Available for Field pH (pH unit)

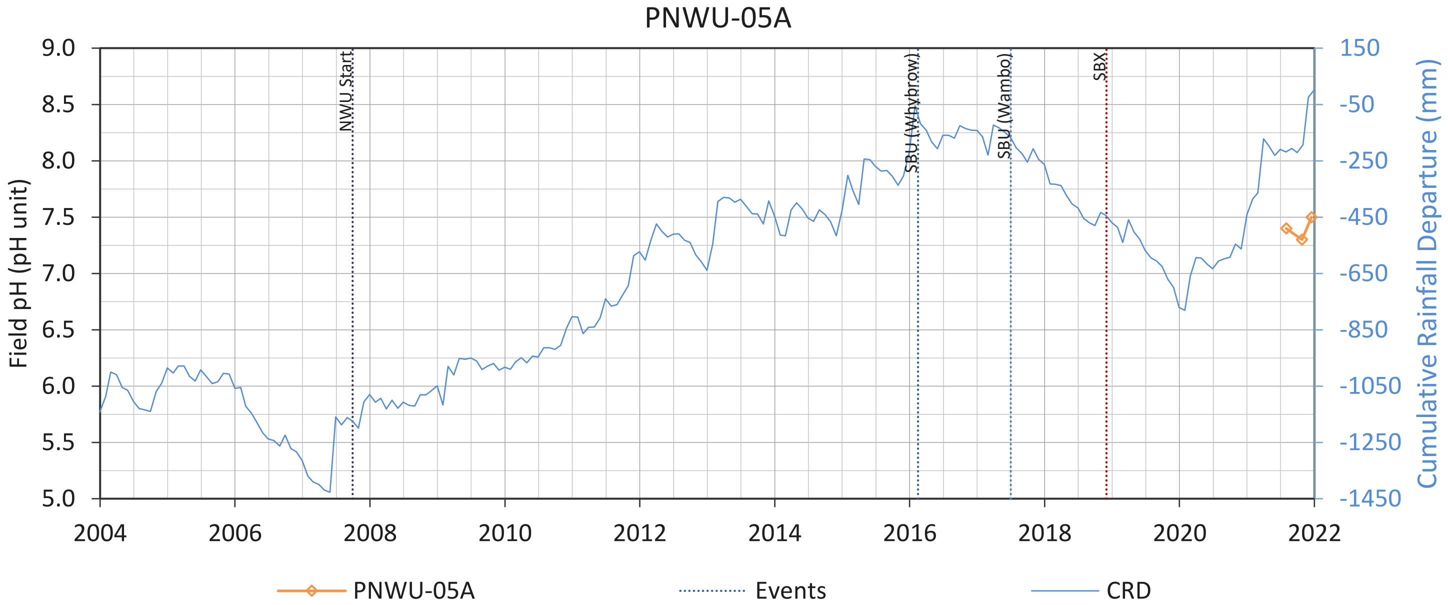
No Data Available for Field Electrical Conductivity (µS/cm)

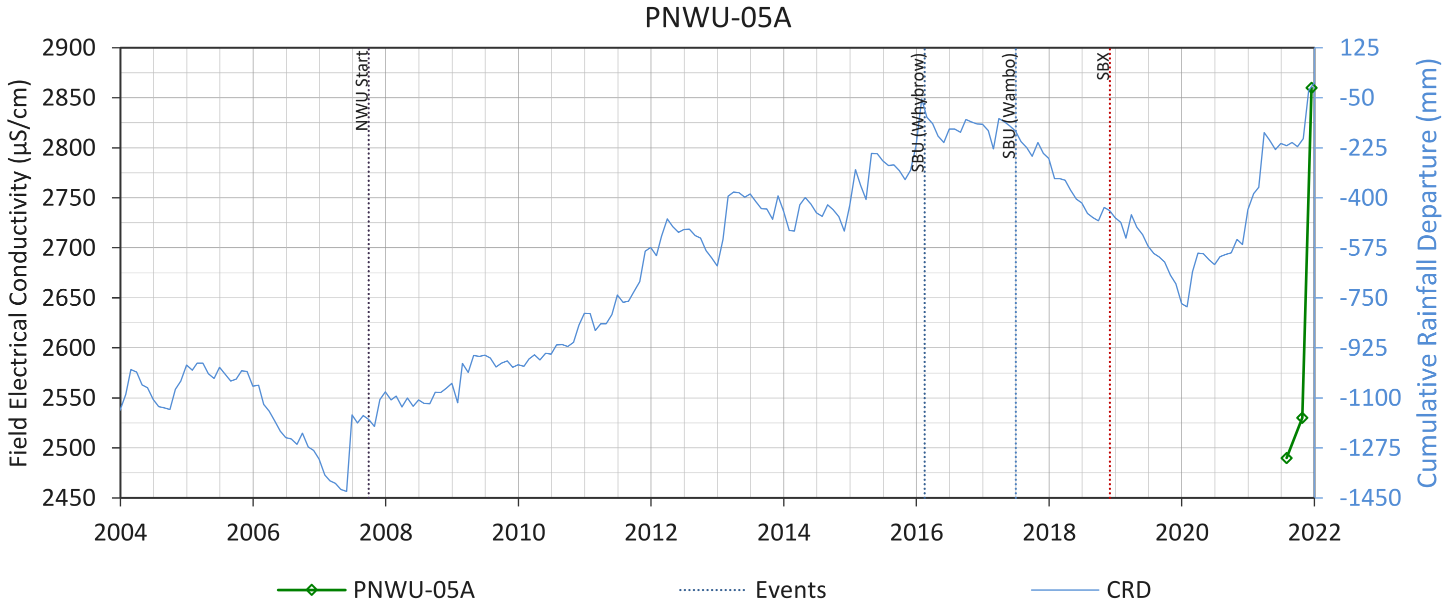

PNWU-03A
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
61.0
60.8
60.6
60.4
60.2
60.0
59.8
59.6
59.4
59.2
59.0
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004 2006 2008 2010 2012 2014 2016 2018 2020 2022
PNWU-03A
Events
CRD

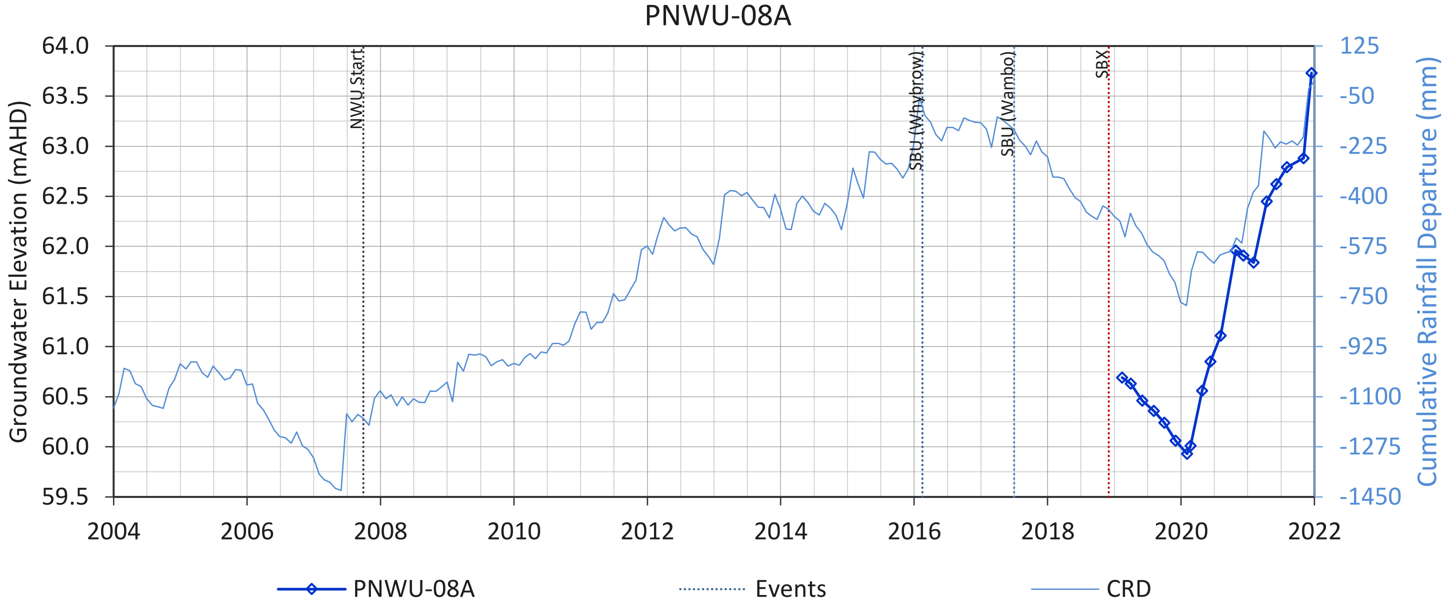

PNWU-03A
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004 2006 2008 2010 2012 2014 2016 2018 2020 2022
PNWU-03A
Events
CRD

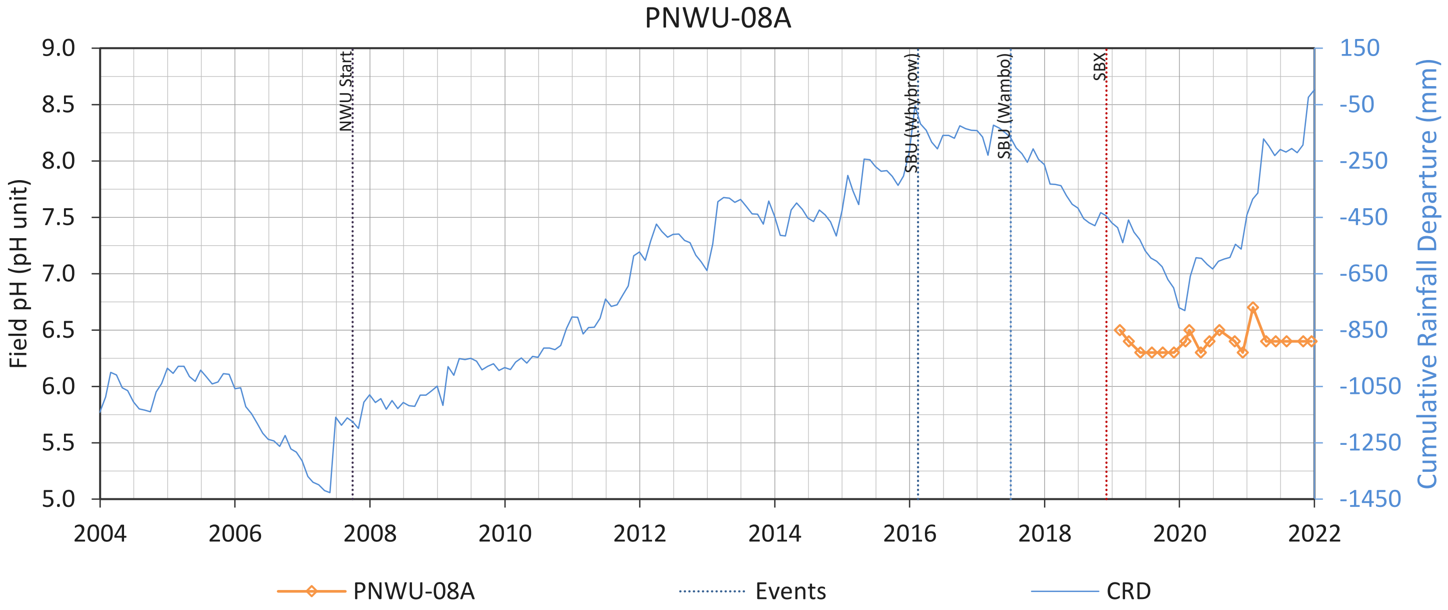

PNWU-03A
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
2600
2550
2500
2450
2400
2350
2300
2250
2200
2150
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004 2006 2008 2010 2012 2014 2016 2018 2020 2022
PNWU-03A
Events
CRD

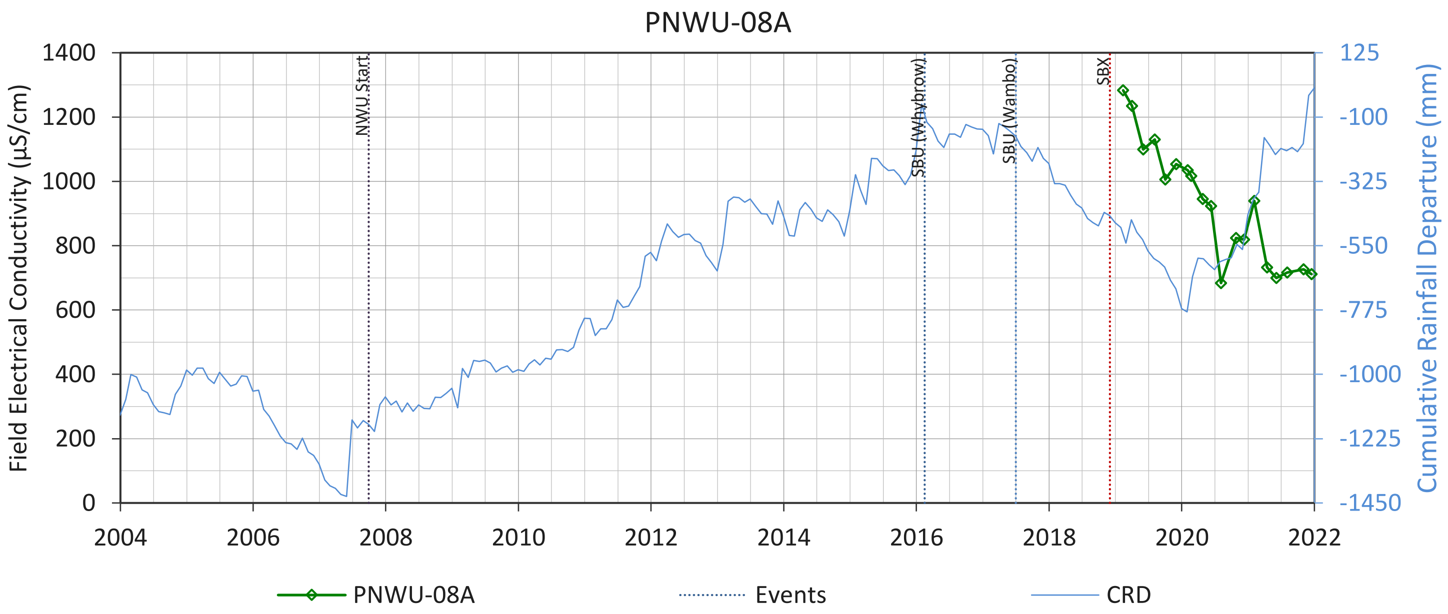

PNWU-05A
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
60.5
60.0
59.5
59.0
58.5
58.0
50
-250
-550
-850
-1150
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
PNWU-05A
Events
CRD

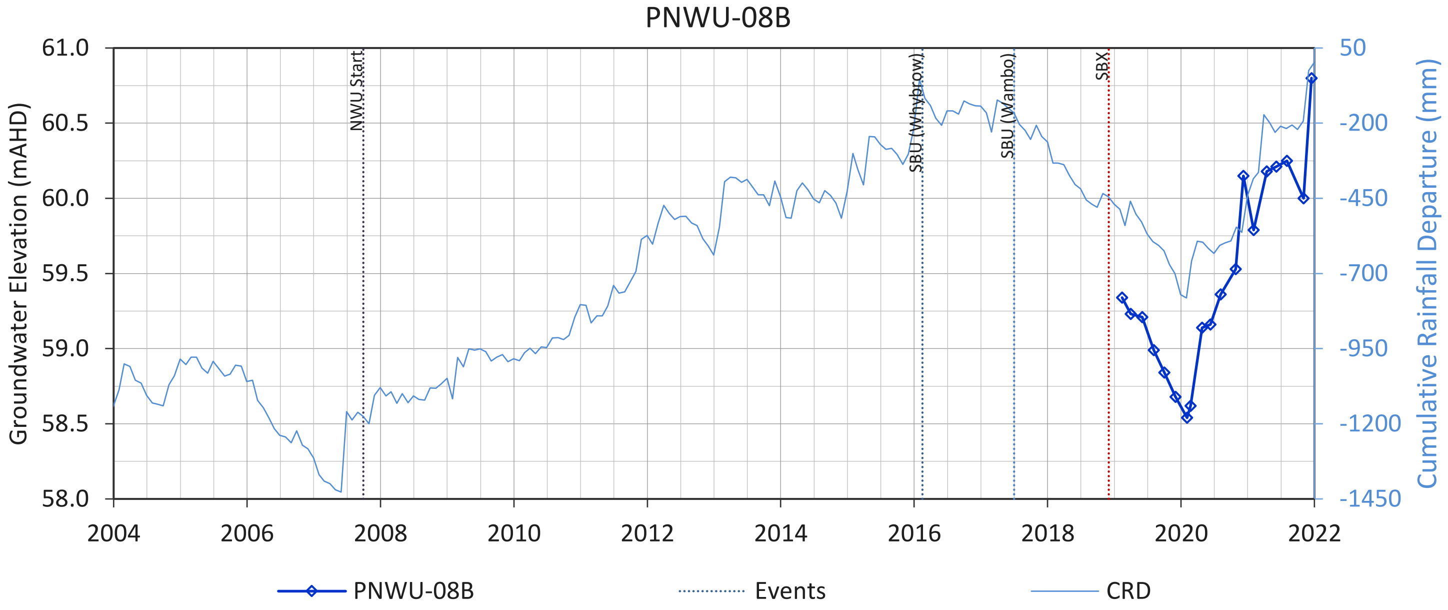

PNWU-05A
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
PNWU-05A
Events
CRD

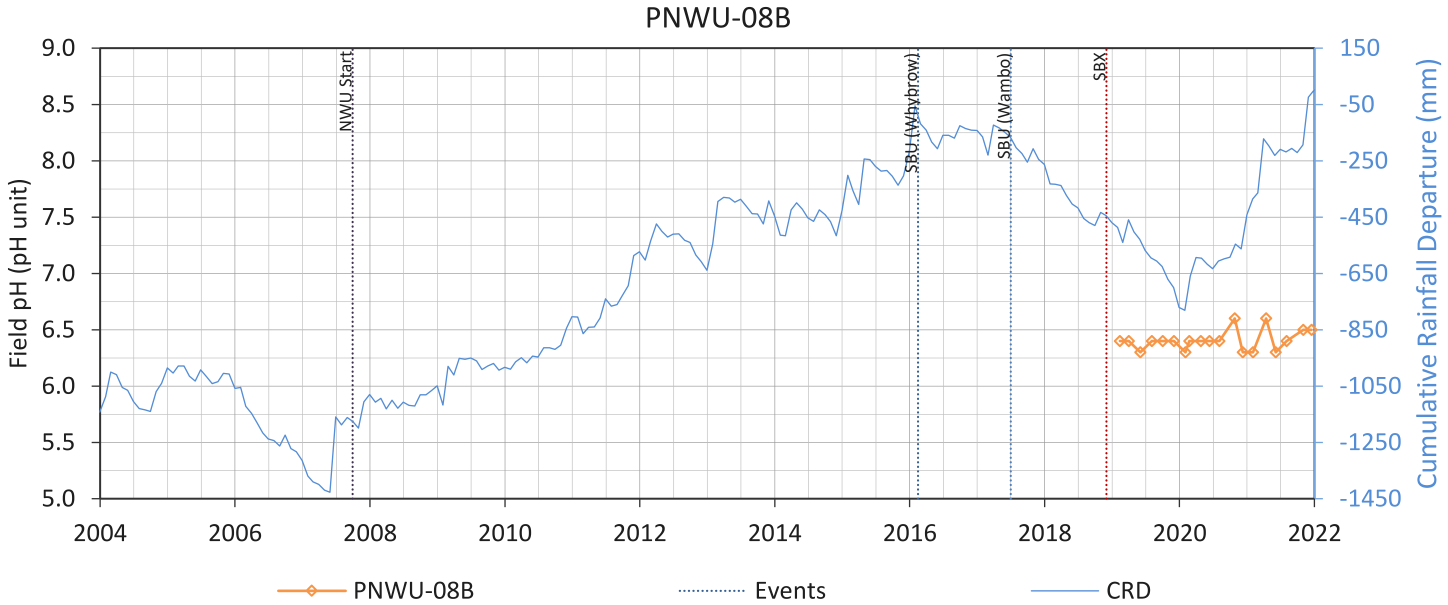

PNWU-05A
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
2900
2850
2800
2750
2700
2650
2600
2550
2500
2450
125
-50
-225
-400
-575
-750
-925
-1100
-1275
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
PNWU-05A
Events
CRD

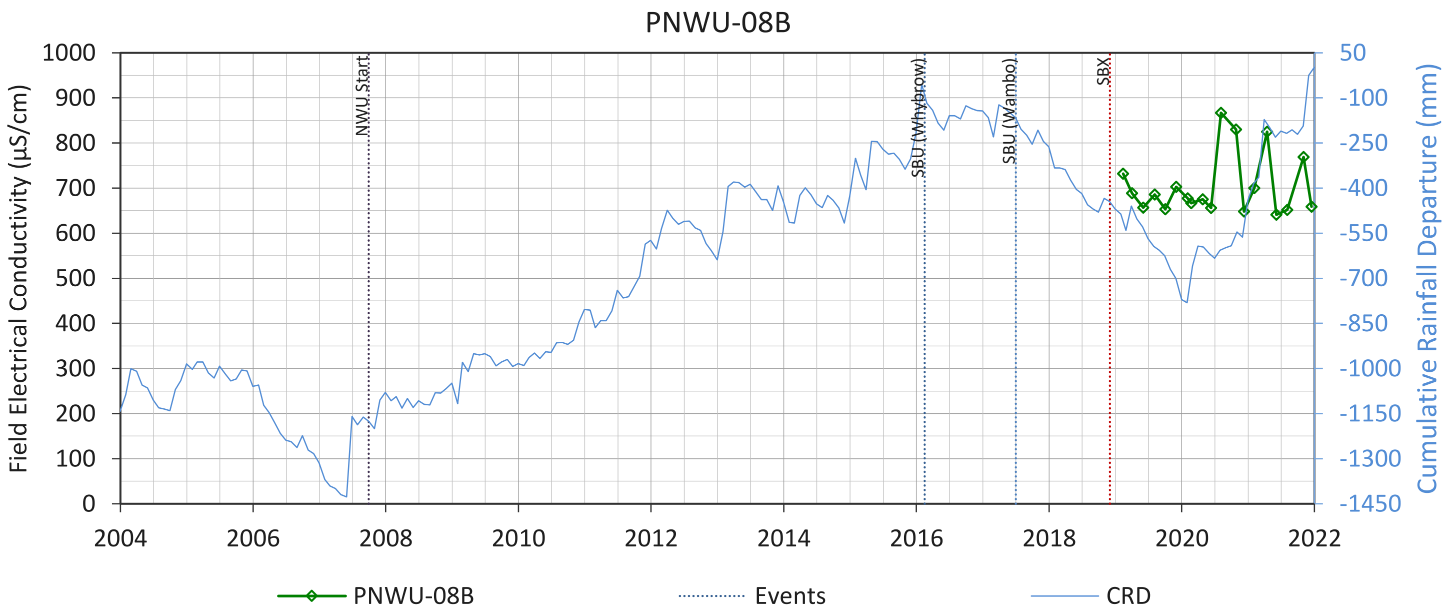

PNWU-08A
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
PNWU-08A
Events
CRD

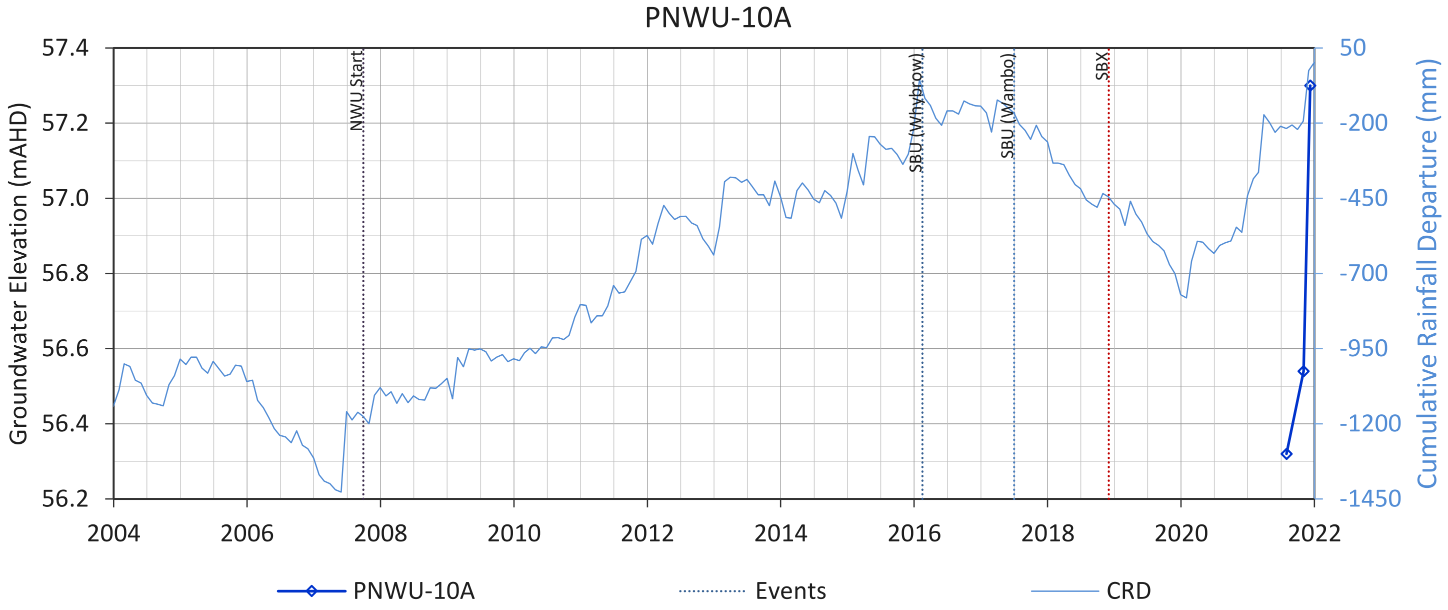

PNWU-08A
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
PNWU-08A
Events
CRD

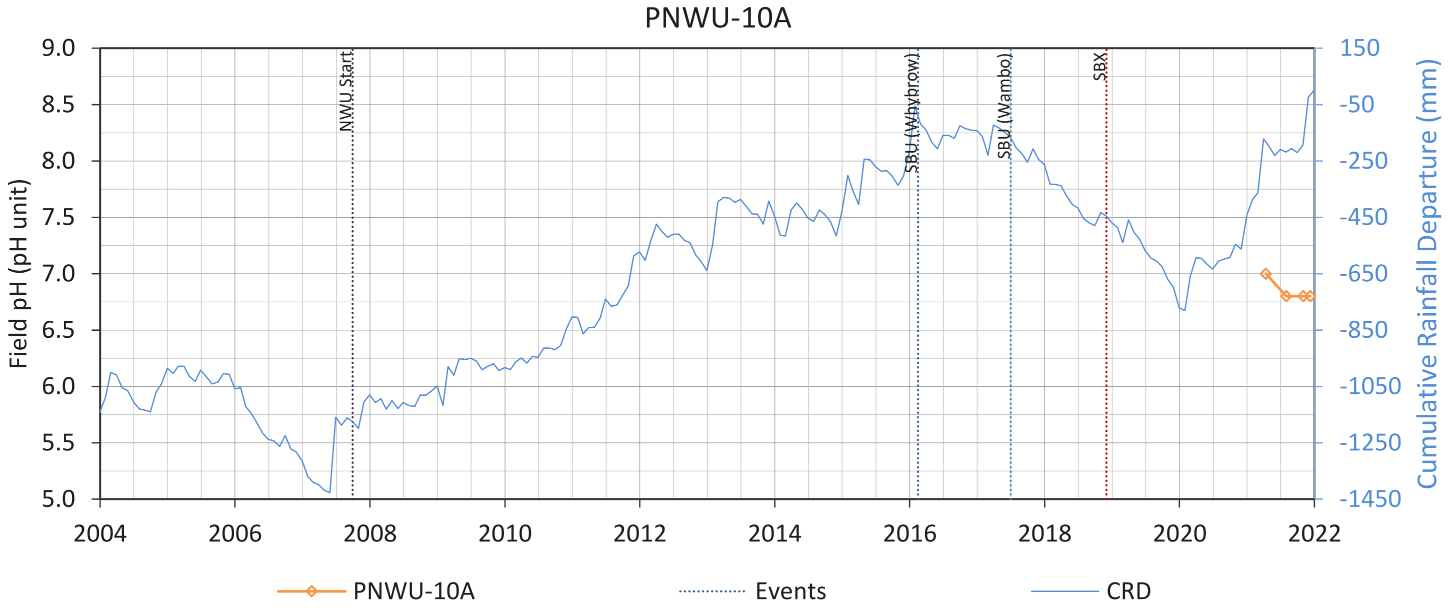

PNWU-08A
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
PNWU-08A
Events
CRD

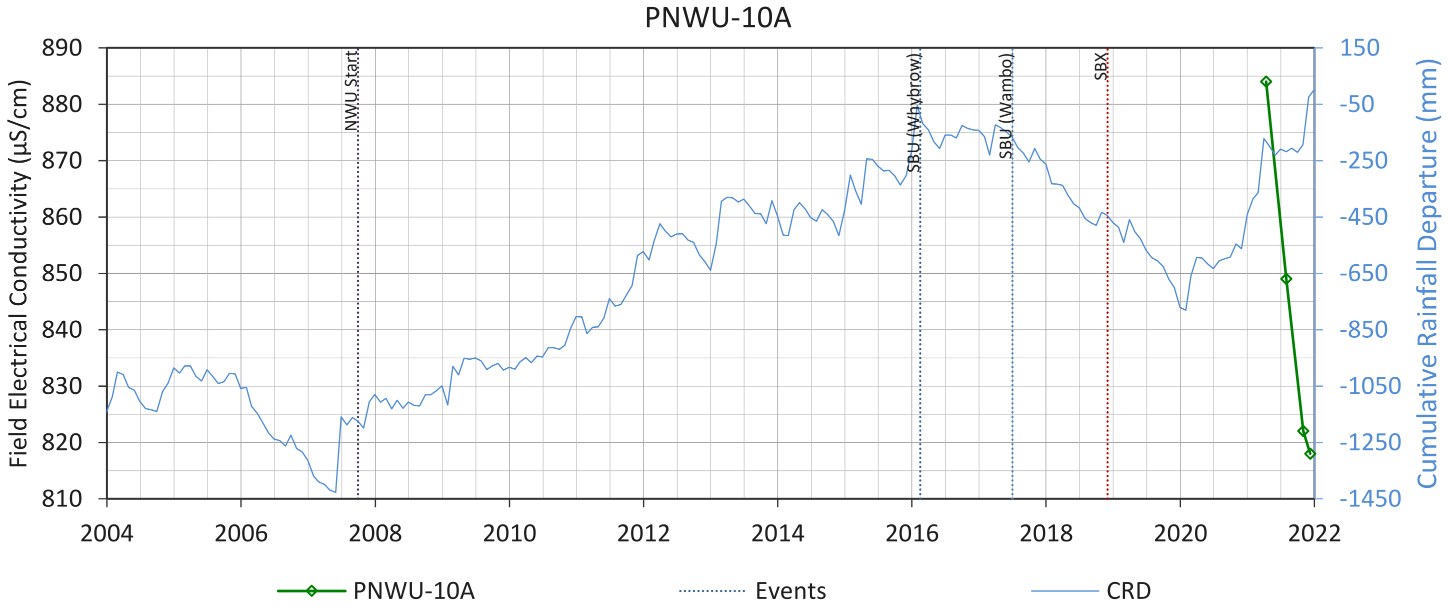

PNWU-08B
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
61.0
60.5
60.0
59.5
59.0
58.5
58.0
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
PNWU-08B
Events
CRD


PNWU-08B
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
PNWU-08B
Events
CRD


PNWU-08B
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
1000
900
800
700
600
500
400
300
200
100
0
50
-100
-250
-400
-550
-700
-850
-1000
-1150
-1300
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
PNWU-08B
Events
CRD


PNWU-10A
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
57.4
57.2
57.0
56.8
56.6
56.4
56.2
50
-200
-450
-700
-950
-1200
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
PNWU-10A
Events
CRD


PNWU-10A
Field pH (pH unit)
Cumulative Rainfall Departure (mm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
PNWU-10A
Events
CRD


PNWU-10A
Field Electrical Conductivity (µS/cm)
Cumulative Rainfall Departure (mm)
890
880
870
860
850
840
830
820
810
150
-50
-250
-450
-650
-850
-1050
-1250
-1450
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NWU Start
SBU (Whybrow)
SBU (Wambo)
SBX
PNWU-10A
Events
CRD

APPENDIX C

Vibrating Wire Piezometers – Data Quality Assessment

Install ID	Wambo ID	Easting	Northing	Ground Elevation (mAHD)	Sensor Depth (mBGL)	Sensor Elevation (mAHD)	Target Geology	Sensor Quality Assessment
EX06	P321	307999	6399498	110.39	31.8	78.6	Arrowfield Seam	No data since 2019
					72.1	38.3	Warkworth Seam	ok
					161.2	-50.8	Vaux Seam	ok
					187.8	-77.4	Bayswater Seam	ok
SW64	P319	311121	6391412	64.4	11.0	53.4	Regolith	Sensor dry - all obs
					74.9	-10.5	Whybrow Seam	Sensor dry - all obs
					161.3	-96.9	Wambo Seam	ok
					265.3	-200.9	Interburden Sandstone	ok
SW30	P325	312068	6390138	65.2	10.5	54.7	Regolith	ok
					32.5	32.7	Permian Overburden	No data since 21/7/2020
					82.0	-16.8	Whybrow Seam	No data since 27/7/2018
					159.5	-94.3	Wambo Seam	No data since 27/7/2018
					203.0	-137.8	Whynot Seam	ok
					251.5	-186.3	Woodlands Hill Seam	ok
					336.5	-271.3	Arrowfield Seam	ok
P408	P408	307000	6399500	74.62	138.8	-64.1	Vaux Seam	No data after 8/6/2019
					187.0	-112.4	Bayswater Seam	ok
					223.8	-149.1	Pikes Gully Seam	ok
WJ175	P320	307573	6398890	85.86	344.0	-258.1	Warkworth Seam	ok
					305.0	-219.1	Vaux Seam	ok
					263.0	-177.1	Bayswater Seam	ok
					217.5	-131.6	Pikes Gully Seam	ok
					191.0	-105.1	Lower Arties Seam	ok
					92.0	-6.1	Middle Barret Seam	ok
SW65	P324	310471	6391983	74.44	11.5	62.9	Regolith	sensor dry – all obs
					95.8	-21.3	Whybrow Seam	sensor dry – all obs
					157.0	-82.6	Wambo Seam	sensor near-dry
					269.8	-195.3	Woodlands Hill Seam	ok
					304.5	-230.1	Interburden	ok

Install ID	Wambo ID	Easting	Northing	Ground Elevation (mAHD)	Sensor Depth (mBGL)	Sensor Elevation (mAHD)	Target Geology	Sensor Quality Assessment
SW62	P326	310087	6392874	75.48	43.0	32.5	Overburden	Sensor dry - all obs until March 2021
					113.5	-38.0	Wambo Seam	ok
					234.0	-158.5	Woodlands Hill Seam	ok
					294.5	-219.0	Arrowfield Seam	ok
SW28	P318	312599	6388922	71.05	11.0	60.1	Regolith	Sensor dry
					150.8	-79.7	Whybrow Seam	ok
					205.3	-134.2	Wambo Seam	ok
					314.3	-243.2	Woodlands Hill Seam	ok
					357.0	-286.0	Arrowfield Seam	ok
SW12	P323	309798	6393429	76.64	23.0	53.6	Overburden siltstone	WL below sensor - all obs
					33.0	43.6	Whybrow Seam	WL below sensor - all obs
					85.5	-8.9	Wambo Seam	ok
					224.5	-147.9	Woodlands Hill Seam	ok
					273.5	-196.9	Arrowfield Seam	ok
ELA3	P307	302941	6399995	141.25	65.3	76.0	Overburden sandstone	ok
					228.3	-87.0	Whybrow Seam	ok
					301.1	-159.8	Wambo Seam	ok
					332.5	-191.2	Whynot Seam	ok
P114_116	P316	311252	6391128	60.39	10.0	50.5	Alluvium	WL below sensor - all obs
					25.0	35.5	Regolith	ok
					50.6	9.8	Regolith-overburden	WL below sensor - all obs
					71.0	-10.6	Whybrow Seam	WL below sensor - all obs
Hunter 1		307454	6400351	72.42	67.6	4.8	Vaux Seam	ok
					87.4	-15.0	Vaux Seam	ok
					117.5	-45.1	Bayswater Seam	ok
					150.5	-78.1	Pikes Gully Seam	ok
Hunter 2		306533	6400050	73.62	67.0	6.6	Vaux Seam	ok
					137.3	-63.6	Vaux Seam	ok
					201.5	-127.9	Pikes Gully Seam	ok

Install ID	Wambo ID	Easting	Northing	Ground Elevation (mAHD)	Sensor Depth (mBGL)	Sensor Elevation (mAHD)	Target Geology	Sensor Quality Assessment
P317	P317	307115	6394439	155.41	248.5	-93.1	Wambo Seam	No data since 2019
					213.0	-57.6	Wambo Rider Seam	No data since 2019
					174.0	-18.6	Whybrow Seam	No data since 2019
					100.0	55.4	Overburden	No data for short period in 2020, data ok otherwise
					35.0	120.4	Regolith	ok
ELA5		303160	6398870	131.89	43.0	88.9	Overburden	ok
					275.0	-143.1	Whybrow Seam	Poor quality data from sensors - all obs
					350.0	-218.1	Wambo Seam	ok
					388.0	-256.1	Whynot Seam	ok
SW06	P322	312572	6395026	110.13	56.0	54.1	Regolith	ok
					65.0	45.1	Whynot Seam	ok
					128.0	-17.9	Whynot – Woodlands Hill Interburden	ok
N5	N5	306753	6395960	110.78	133.0	-22.2	Permian Overburden	Some data gaps in 2021, otherwise ok
					89.5	21.3	Whybrow Seam	ok
					73.0	37.8	Interburden	ok
					30.0	80.8	Wambo Seam	ok
N3	N3	308313	6394574	104.968	190.0	-85.0	Permian Overburden	Sensor dry
					142.0	-37.0	Permian Overburden	Unreliable data since 2018
					108.5	-3.5	Permian Overburden	Unreliable data since 2016
					75.0	30.0	Whybrow Seam	Unreliable data since 2016
					55.0	50.0	Interburden	Unreliable data since 2016
N2	N2	308633	6393372	122.52	204.0	-81.5	Permian Overburden	ok
					172.5	-50.0	Permian Overburden	ok
					140.0	-17.5	Permian Overburden	ok
					100.0	22.5	Whybrow Seam	WL below sensor from Apr 2017
					70.0	52.5	Interburden	WL below sensor from Sept 2016
					40.0	82.5	Wambo Seam	WL below sensor from mid-2015
SBX_20 GW01	SBX_GW01	307009	6395884	107.9	43	65.0		Yet to be downloaded

Install ID	Wambo ID	Easting	Northing	Ground Elevation (mAHD)	Sensor Depth (mBGL)	Sensor Elevation (mAHD)	Target Geology	Sensor Quality Assessment
SBX_20 GW01	SBX_GW02	306909	6395939	108.9	65.8	43.1		Yet to be downloaded
					61.7	47.2		
					53.7	55.2		
MG08-01 (Unlabelled)	MG08-01	311054	6392670	65.35	9.0	56.4	Alluvium	
					37.0	28.4	Permian	
					46.0	19.4	Whybrow Seam	
					60.0	5.4	Interburden	
					77.3	-12.0	Redbank Seam	
					90.0	-24.7	Interburden	
					101.0	-35.7	Wambo Seam	
MG08-01 (Incorrect)	MG08-01	311618	6392876	66			4 sensors at site – installation data unavailable. Naming incorrect – not consistent with MG08 install report	
MG09-01	MG09-01	310539	6391186	69.75	9.0	60.8	Alluvium	pressure below sensor for all obs sensors failed Oct 2014
					30.0	39.8	Permian Upper	
					60.0	9.8	Permian Lower	
					103.0	-33.3	Whybrow Seam	
					130.0	-60.3	Interburden	
					153.0	-83.3	Redbank Seam	
					170.0	-100.3	Interburden	
					192.0	-122.3	Wambo Seam	
Unknown Fenwick	U/ Fenwick	310636	6390994	70				5 Sensors - no data
GW20	GW20	309075	6393949	91.31	9.3	82.0	Base of Colluvium/ Alluvium	data not collected, suggest check/ test download next time, installation report incomplete original template sheet only has data to 2011
					61.5	29.8	Whybrow Seam	
					93.0	-1.7	Redbank Seam	
					129.5	-38.2	Wambo Seam	
"Unknown 1"	MG06-01	310862	6392901	71.62	67.5	4.1	Wambo Seam	Data to June 2011 - none collected since then.
					69.5	2.1	Wambo Seam	
					71.0	0.6	Wambo Seam	
					74.0	-2.4	Interburden	

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Level 11, 176 Wellington Parade
East Melbourne VIC 3002
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
Tenancy 202 Submarine School
Sub Base Platypus
120 High Street
North Sydney NSW 2060
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
12 Cannan Street
South Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 404 939 922

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: 0800 757 695

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628

APPENDIX J
ANNUAL COMPLIANCE REPORT
(EPBC 2016/7636 AND EPBC 2016/7816)

WAMBO COAL PTY LTD
2021 ANNUAL COMPLIANCE REPORT

(EPBC 2016/7636 and EPBC 2016/7816)

1 January – 31 December 2021

Document Control

Title	Wambo Coal 2021 Annual Compliance Report (EPBC 2016/7636 and EPBC 2016/7816)
General Description	Review of compliance with the conditions of EPBC 2016/7636 and EPBC 2016/7816
Document Owner	Manager: Environment & Community

Revisions

Rev No	Date	Description	By	Checked	Signature
1	March 2021	Original	WCPL	ND	

This report addresses Condition 5 of the Wambo Coal Pty Limited (WCPL) Environment Protection and Biodiversity Conservation (EPBC) Approval 2016/7636 for the South Wambo Underground Mine, which states:

> *The person taking the action must publish a report on the website addressing compliance with each of the conditions of this approval, including implementation of any management plan, program, strategy and review required by condition 1. The reporting period and report publication must comply with conditions D10 and D15 of Schedule 2 of the **state development consent**. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the **Department** (by email to EPBCMonitoring@environment.gov.au or an address as stipulated by the **Department**) at the same time as the compliance report is published. The person taking the action must continue to publish the report until such time as agreed in writing by the **Minister**.*

Table 1 provides a reconciliation of the conditions of EPBC 2016/7636 and their compliance status.

This report also addressed Condition 5 of the WCPL EPBC Approval 2016/7816 for the South Bates Extension Underground Mine, which states:

> *The person taking the action must publish a report on the website addressing compliance with each of the conditions of this approval, including implementation of any management plan, program, strategy and review required by condition 1. The reporting period and report publication must comply with conditions D10 and D15 of Schedule 2 of the **state development consent**. Documentary evidence providing proof of the date of publication must be provided to the **Department** (by email to EPBCMonitoring@environment.gov.au or an address as stipulated by the **Department**) at the same time as the compliance report is published. The person taking the action must continue to publish the report until such time as agreed in writing by the **Minister**.*

Table 2 provides a reconciliation of the conditions of EPBC 2016/7816 and their compliance status.

Table 1: EPBC Approval 2016/7636 Compliance Summary

Condition	Status	Comment
1. The person taking the action must: a. Not clear more than 0.9 ha of Central Hunter Valley Eucalypt Forest and 3.4 ha of foraging habitat for the Regent Honeyeater *(Anthochaera phrygia).*	Compliant	The action has not yet been commenced. WCPL has not cleared more than 0.9 hectares (ha) of Central Hunter Valley Eucalypt Forest or more than 3.4 ha of foraging habitat for the Regent Honeyeater (*Anthochaera Phrygia*) as part of the action.
b. Implement conditions A1 and A2 of Schedule 2 of the **state development consent** to minimise the impacts of the action on **protected matters**.	Compliant	WCPL implements Conditions A1 and A2, Schedule 2 of the Development Consent (DA305-7-2003).
c. Implement environmental performance conditions B1-B11, B51-B55, B62-B73 and B75-B77 of Schedule 2 of the **state development consent**, where the conditions relate to avoiding, mitigating, managing, offsetting, monitoring or recording, or reporting on impacts to **protected matters**. In implementing these conditions, the approval holder must protect at least 18.3 ha of Central Hunter Valley Eucalypt Forest and at least 27.7 ha of foraging habitat for the Regent Honeyeater *(Anthochaera phrygia)* in perpetuity.	Compliant	WCPL implements Conditions B1-B11, B51-B55, B62-B73 and B75-B77 of Schedule 2 of the Development Consent (DA305-7-2003). WCPL has amended an existing VCA under the NSW *National Parks and Wildlife Act 1974* to conserve Remnant Woodland Enhancement Program Area E in perpetuity, which includes 18.3 ha of Central Hunter Valley Eucalypt Forest and Woodland and 27.7 ha of foraging habitat for the Regent Honeyeater.
2. Within 30 days after the **commencement of the action**, the person taking the action must advise the **Department** in writing of the actual date of **commencement of the action**.	Not applicable	The action has not yet been commenced. Mining at the approved South Wambo Underground Mine is planned to commence after completion of mining at the South Bates Extension Underground Mine. WCPL will advise the Department in writing of the commencement of the action within 30 days of commencement.
3. Unless otherwise agreed to in writing by the **Minister**, the person taking the action must publish all management plans, programs, strategies and reviews required by condition 1. Each management plan, program, strategy and review must be published on the **website**, and notification must be provided to the **Department**, within 1 month of being approved by the Secretary of the NSW Department of Planning & Environment (or nominee of the Secretary).	Compliant	Copies of all management plans, programs, strategies and reviews required by condition 1 of EPBC 2016/7636 are available to the public on the Peabody Energy website https://www.peabodyenergy.com/Operations/Australia-Mining/New-South-Wales-Mining/Wambo-Approvals,-Plans-Reports. Relevant management plans include the Site Water Management Plan and Biodiversity Management Plan. An Extraction Plan for areas related to the Action has not yet been prepared. Notification is provided to the Department within one month of the approval of any management plans, programs, strategies and reviews by the Secretary of the NSW Department of Planning & Environment (or nominee of the Secretary).

Condition	Status	Comment
4. The person taking the action must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement a management plan, program, strategy and review required by condition 1, and make them available upon request to the **Department**. Such records may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the **EPBC Act**, or used to verify compliance with the conditions of approval.	Compliant	WCPL maintains accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement a management plan, program, strategy and review required by condition 1. WCPL will make these records available upon request to the Department.
5. The person taking the action must publish a report on their **website** addressing compliance with each of the conditions of this approval, including implementation of any management plan, program, strategy and review required by condition 1. The reporting period and report publication must comply with conditions D10 and D15 of Schedule 2 of the **state development consent**. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the **Department** (by email to EPBCmonitoring@environment.gov.au or an address as stipulated by the **Department**) at the same time as the compliance report is published. The person taking the action must continue to publish the report until such time as agreed in writing by the **Minister**.	Compliant	The WCPL 2021 Annual Review (including this report) will be published on the Peabody Energy website https://www.peabodyenergy.com/Operations/Australia-Mining/New-South-Wales-Mining/Wambo-Approvals,-Plans-Reports.
6. Any potential or actual contravention of the conditions of this approval, including contravention of a commitment made in a management plan, program, strategy and review required by condition 1 must be reported to the **Department** within 7 days of the person taking the action becoming aware of the actual or potential contravention.	Not applicable	No events contravening (or potentially contravening) the conditions of this approval have occurred.
7. Upon the direction of the **Minister**, the person taking the action must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the **Minister**. The independent auditor and audit criteria must be approved by the **Minister** prior to the commencement of the audit. The audit report must address the criteria to the satisfaction of the **Minister**.	Not applicable	Upon the direction of the Minister, WCPL will ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the Minister.
8. If, at any time after 5 years from the date of this approval, the person taking the action has not substantially commenced the action, then the person taking the action must not substantially commence the action without the written agreement of the **Minister**.	Not applicable	WCPL has not yet commenced the action. Mining at the approved South Wambo Underground Mine is planned to commence after completion of mining at the South Bates Extension Underground Mine. If WCPL has not substantially commenced the South Wambo Underground Mine prior to 30 April 2022 (i.e. five years after the date EPBC 2016/7636 was granted), WCPL will seek the written agreement of the Minister prior to substantially commencing the action.

Table 2: EPBC Approval 2016/7816 Compliance Summary

Condition	Status	Comment
1. The person taking the action must: a. Implement administrative conditions A1 and A2 of Schedule 2 of the **state development consent** to minimise the impacts of the action on **protected matters**.	Compliant	WCPL implements Conditions A1 and A2, Schedule 2 of the Development Consent (DA305-7-2003).
b. Implement environmental performance conditions B1-B3, B7-B10, B51-B55 and B62- B68 of Schedule 2 of the **state development consent**, where the conditions relate to avoiding, mitigating, managing, offsetting, monitoring or recording, or reporting on impacts to **protected matters**.	Compliant	WCPL implements Conditions B1-B3, B7-B10, B51-B55 and B62-B68, Schedule 2 of the Development Consent (DA305-7-2003).
c. Notify the **Department** in writing of any proposed change to the **conditions** of the **state development consent**, referred to in conditions 1a and 1b, within 5 **business days** of formally proposing a change or becoming aware of any other proposed change.	Compliant	DA305-7-2003 Modification 16 associated with the proposed United Wambo Open Cut Coal Mine Project was lodged on 8 August 2016 and subsequently approved on 28 August 2019. The Referral for EPBC 2016/7816 was lodged on 22 November 2016 and described the changes proposed by the United Wambo Open Cut Coal Mine Project.
d. Notify the **Department** in writing of any change to conditions of the **state development consent**, referred to in conditions 1a to 1b, within 5 **business days** of a change to **conditions** being finalised.	Compliant	The Department was notified in writing of changes to the conditions in Development Consent (DA305-7-2003) (Modification 16) within the allocated time period following the conditions being finalised.
2. Within 25 **business days** after the **commencement of the action**, the person taking the action must advise the **Department** in writing of the actual date of **commencement of the action**.	Compliant	WCPL provided a notification to the Department of the actual date of commencement of the action (3 December 2018), however this was not completed within 30 days of the commencement of the action.
3. Unless otherwise agreed to in writing by the **Minister**, the person taking the action must publish all management plans and strategies required by conditions B1-B3, B7-B10, B51-B55 and B62-B68 of Schedule 2 of the **state development consent** on their website. Each management plan and strategy must be published on the **website** within 1 month of being approved by the **Secretary** and remain there for a period of no less than 5 years.	Compliant	Copies of all management plans, programs, strategies and reviews required by condition 1 of EPBC 2016/7636 are available to the public on the Peabody Energy website https://www.peabodyenergy.com/Operations/Australia-Mining/New-South-Wales-Mining/Wambo-Approvals,-Plans-Reports. Relevant management plans include the Extraction Plan for South Bates Extension Underground Mine Longwalls 21 to 24, Site Water Management Plan, Biodiversity Management Plan and Life of Mine Rejects Emplacement Strategy. Notification is provided to the Department within one month of the approval of any management plans, programs, strategies and reviews by the Secretary of the NSW Department of Planning & Environment (or nominee of the Secretary).

Condition	Status	Comment
4. The person taking the action must maintain accurate records substantiating all activities associated with or relevant to these conditions of **approval**, including measures taken to implement the management plans and strategies required by conditions B1-B3, B7-B10, B51-B55 and B62-B68 of Schedule 2 of the **state development consent**, and make them available upon request to the **Department**. Such records may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the **EPBC Act**, or used to verify compliance with the conditions of this **approval**.	Compliant	WCPL maintains accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement a management plan, program, strategy and review required by Conditions B1-B3, B7-B10, B51-B55 and B62-B68, Schedule 2. WCPL will make these records available upon request to the Department.
5. The person taking the action must publish a report on their website addressing compliance with each of the **conditions** of this **approval**, including implementation of any management plans and strategies required by condition 1. The reporting period and report publication must comply with conditions D10 and D15 of Schedule 2 of the **state development consent**. Documentary evidence providing proof of the date of publication must be provided to the **Department** (by email to EPBCMonitoring@environment.gov.au or an address as stipulated by the **Department**) at the same time as the compliance report is published. The person taking the action must continue to publish the report until such time as agreed in writing by the **Minister**.	Compliant	The WCPL 2021 Annual Review (including this report) will be published on the Peabody Energy website https://www.peabodyenergy.com/Operations/Australia-Mining/New-South-Wales-Mining/Wambo-Approvals,-Plans-Reports.
6. Any potential or actual contravention of the conditions of this **approval**, including contravention of a commitment made in a management plan or strategy required by condition 1 must be reported to the **Department** no later than 7 **business days** of the person taking the action becoming aware of the actual or potential contravention, by email to EPBCMonitoring@environment.gov.au or an address as stipulated by the **Department**.	Not applicable	No events contravening (or potentially contravening) the conditions of this approval have occurred.
7. Upon the direction of the **Minister**, the person taking the action must ensure that an independent audit of compliance with the conditions of **approval** is conducted and a report submitted to the **Minister**. The independent auditor and audit criteria must be approved by the **Minister** prior to the commencement of the audit. The audit report must address the criteria to the satisfaction of the **Minister**.	Not applicable	Upon the direction of the Minister, WCPL will ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the Minister.
8. If, at any time after 5 years from the date of this **approval**, the person taking the action has not substantially **commenced the action**, then the person taking the action must not **commence the action** without the written agreement of the **Minister**.	Compliant	WCPL commenced the action within five years of the date of the approval of EPBC 2016/7816.