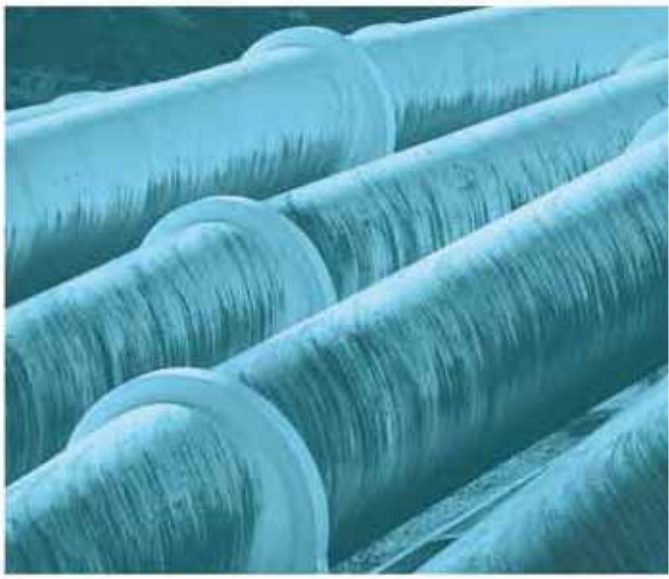



Hunter Valley Operations

2021 Annual groundwater monitoring review

Prepared for Hunter Valley Operations Pty Ltd
March 2022

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Hunter Valley Operations

2021 Annual groundwater monitoring review

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24 March 2022

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24 March 2022

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1 Introduction

1.1 Overview and scope

The Hunter Valley Operations mining complex (the complex) is a thermal and semi-soft metallurgical coal mine located approximately 25 kilometres (km) north-west of Singleton, New South Wales (NSW). Hunter Valley Operations Pty Ltd (HVO) manages the complex independently and as a joint venture between Yancoal Australia Ltd (with 51% ownership) and Glencore Australia Pty Ltd (with the remaining 49% ownership). The complex comprises the HVO North and HVO South operations, which are separated by the Hunter River and consist of multiple open cut mines.

As required under the 2018 Hunter Valley Operations water management plan (WMP) (HVO 2018), HVO engage a third party to undertake routine compliance monitoring of the groundwater bore network (the network) installed across the complex. HVO has engaged EMM Consulting Pty Limited (EMM) to undertake the 2021 annual groundwater reporting for the complex. Monitoring data are uploaded to the HVO Environmental Monitoring Databases (the EMD) and have been accessed by EMM for the 2021 annual report. This report documents the results of groundwater-related monitoring for the period 1 January to 31 December 2021 (the reporting period).

This report has been prepared in compliance with the WMP updated in 2018, with consideration of the draft updated WMP (HVO 2021), and in accordance with the following scope:

- collation of annual site groundwater data (groundwater levels and quality) and review of compliance with approval conditions;
- presentation of groundwater level and groundwater quality (pH and electrical conductivity [EC]) time series graphs and comparison to site trigger levels to identify any exceedances (in accordance with Appendix D of the WMP) or unexpected changes in trends; and
- a summary of results and any recommended management responses (as required) to address identified compliance issues which may indicate potential adverse groundwater impacts (in accordance with Section 9.5 of the WMP).

1.2 Site operations

Although HVO North and HVO South operations are approved under separate development consents (DA 450-10-2003 (HVO North) and PA 06_0261-24 (HVO South)), they are operated as one complex with fully integrated environmental management systems. Figure 1.1 to Figure 1.4 show the location of the complex, the various pits and monitoring areas.

For the purpose of environmental monitoring and consistent with the WMP, the complex is separated into nine areas comprising the:

- Carrington Pit area, previously mined area (HVO North);
- Carrington West Wing area, located west of the Carrington Pit and yet to be mined (HVO North);
- Cheshunt Pit area, located south of the Hunter River (HVO South);
- North Pit area, located in HVO North in a previously mined area that has been fully rehabilitated;
- North Void, located south of North Pit (HVO North);

- Cheshunt/North Pit area, located between the Cheshunt and North Pit areas;
- Lemington South area, located west and north of the Lemington South Pit 1, near Wollombi Brook;
- West Pit, located in HVO North; and
- Southern area, located east of the Lemington South Pit 1 (HVO South).

1.2.1 2021 mining related activities

Table 1.1 summarises the mining activities conducted in 2021 across the mine areas.

Table 1.1 Summary of activities conducted in 2021

Mine area	Approved life of mining	Mining approved to	Seam mined to	2021 activities
Carrington Pit	2000 to 2021	Bayswater seam	Bayswater seam	Inactive - commenced receiving tailings in January 2019
Carrington West Wing	Not commenced	Bayswater seam	Nil	Nil
North Pit	1979 to 2003	Vaux seam	Vaux seam	Inactive – fully rehabilitated
Alluvial Lands	1993 to 2003	Vaux seam	Vaux seam	Inactive – fully rehabilitated
Glider Pit	2016 to 2017	Vaux seam	Vaux seam	Inactive – fully rehabilitated
Lemington South Pits	1998 to 2006 2019 to 2030	Bowfield seam (mining complete) Warkworth seam (not commenced)	Bowfield seam	Inactive – rehabilitated with void used for water storage
Riverview Pit (HVO South)	1997 to 2030	Vaux & Bayswater seams	Bayswater seam	Mining active
Cheshunt Pit (HVO South)	2002 to 2030	Vaux & Bayswater seams	Bayswater seam	Mining active
West Pit (HVO North)	1949 to 2025	Bayswater to Hebden seams	Barrett seam	Mining active

Table 1.2 summarises the tailing storage facilities (TSFs) at the complex and their status in 2021.

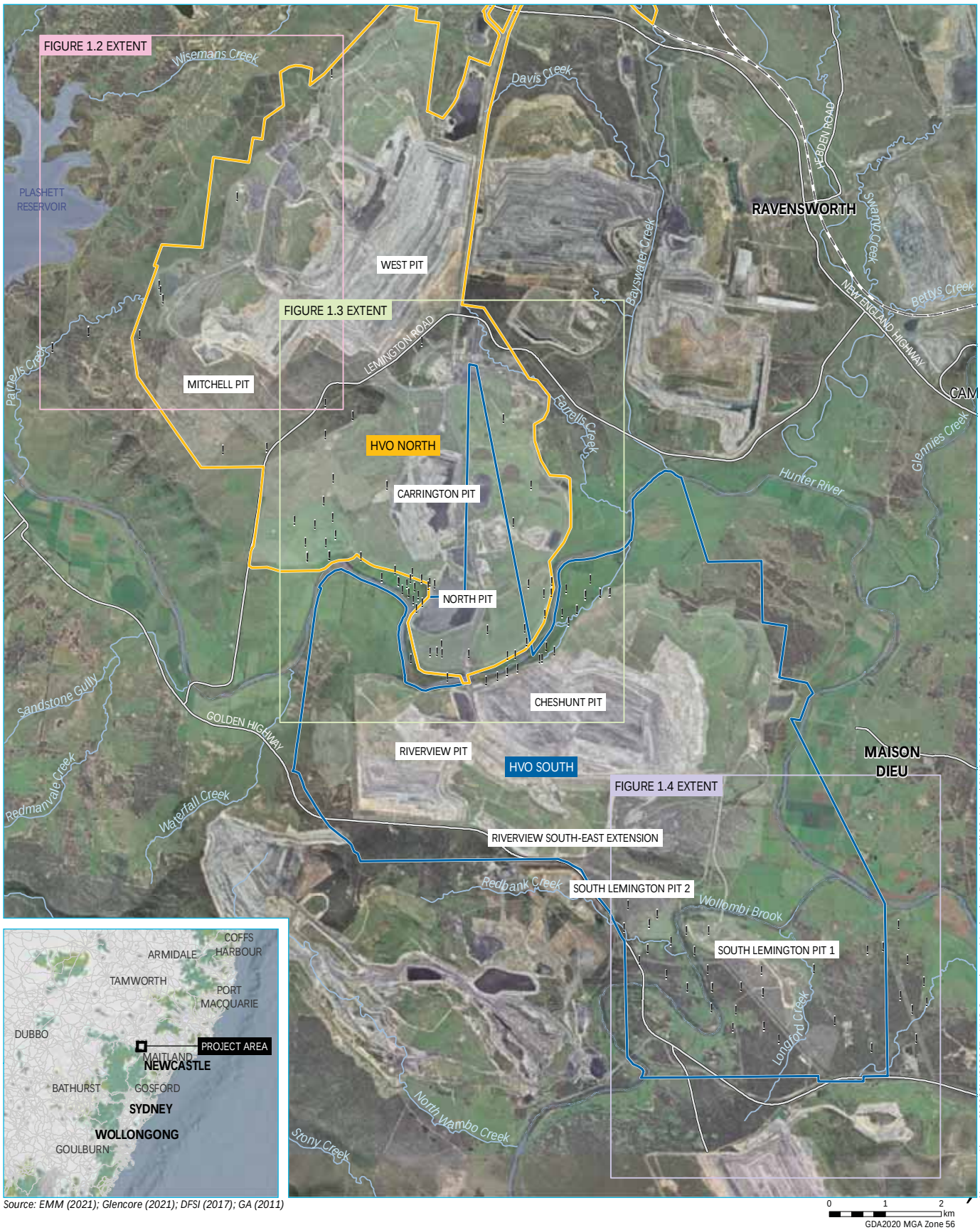
Table 1.2 Summary of TSF at HVO and status in 2021

TSF	Mine area	Status in 2021
Dam 20W	West Pit	Inactive
North Void TSF (DM6) (NV TSF)	North Pit	Inactive; tailings deposition ceased in January 2019
Central TSF (28N)	North Pit	Inactive
Southeast TSF (27N)	North Pit	Inactive, being rehabilitated
Carrington out-of-pit fine reject emplacement (COOP FRE)	Carrington Pit	Approved, not constructed

Table 1.2 Summary of TSF at HVO and status in 2021

TSF	Mine area	Status in 2021
Carrington in-pit fine reject emplacement (FRE)	Carrington Pit	Active. Receiving tailings since January 2019
Dam 6W	West Pit	Inactive (full, consolidating)

Groundwater was also abstracted from the LUG Bore during 2021. The LUG Bore is a production bore constructed into the historical Lemington Underground beneath HVO where mining of the Mt Arthur Seam of the Whittingham Coal Measures ceased in 1999. Abstraction from the LUG Bore is managed by Yancoal for the Mt Thorley Warkworth (MTW) operations.



Source: EMM (2021); Glencore (2021); DFSI (2017); GA (2011)

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KEY

- Existing HVO North development consent boundary (DA 450-10-2003)
- Existing HVO South project approval boundary (PA 06-0261)
- South Lemington Rail Loop and haul route (approved, not yet constructed)

Existing environment

- Groundwater monitoring bore
- Rail line
- Major road
- Named watercourse
- Named waterbody

- Figure 1.2 extent
- Figure 1.3 extent
- Figure 1.4 extent

INSET

- NPWS reserve
- State forest

HVO complex overview

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Figure 1.1

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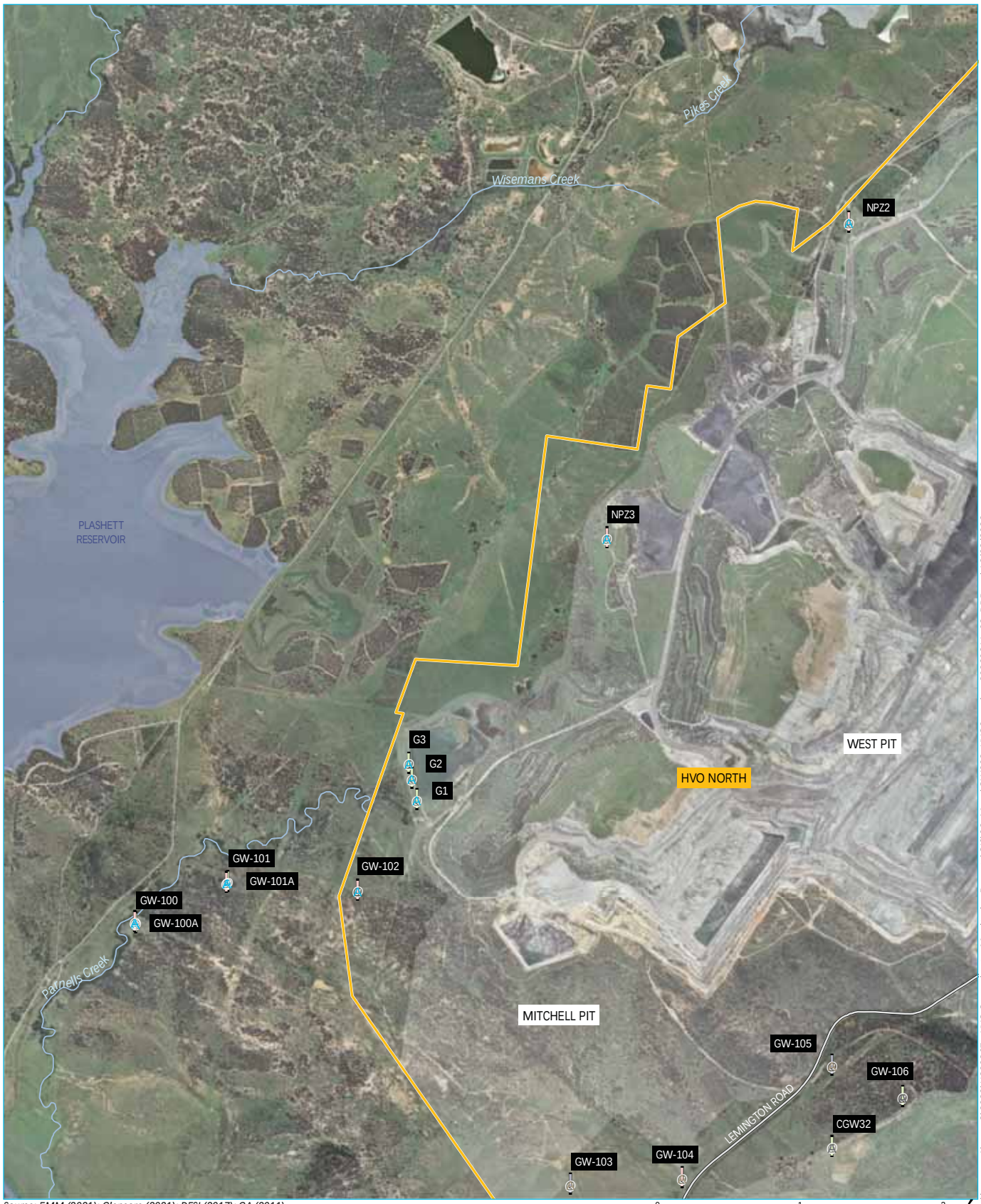

Source: EMM (2021); Glencore (2021); DFSI (2017); GA (2011)

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GDA2020 MGA Zone 56

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KEY

Existing HVO North development consent boundary (DA 450-10-2003)

Bore location
- Carrington
- Carrington West Wing
- West Pit

Generalised target lithology
- Alluvium
- Coal seam
- Interburden

Existing environment
- Major road
- Named watercourse
- Named waterbody

HVO North - Mitchell and West Pit area monitoring bores

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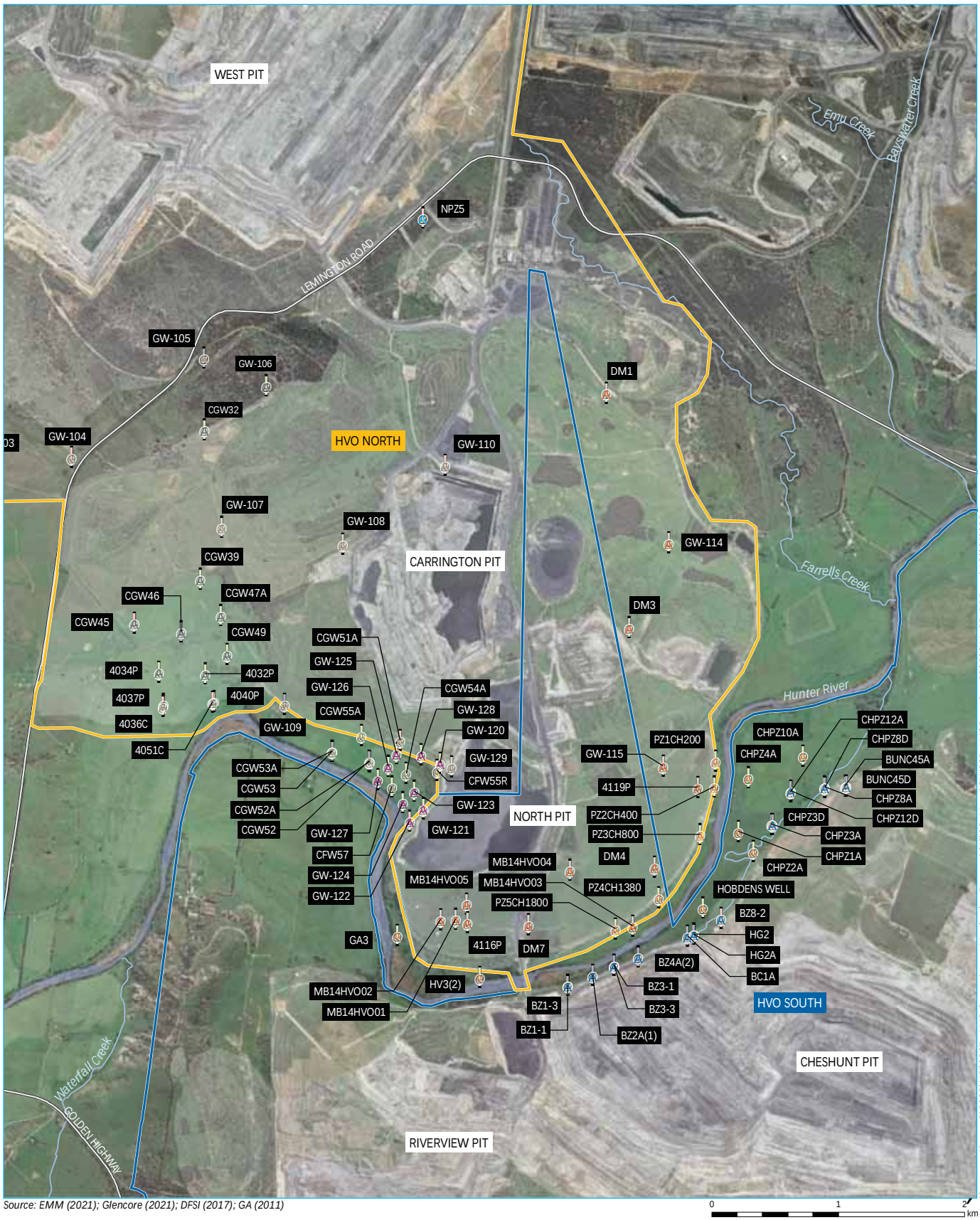
Figure 1.2

EMM creating opportunities



Source: EMM (2021); Glencore (2021); DFSI (2017); GA (2011)

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KEY

- Existing HVO North development consent boundary (DA 450-10-2003)
- Existing HVO South project approval boundary (PA 06-0261)
- South Lemington Rail Loop and haul route (approved, not yet constructed)

Bore location

- A Carrington
- A Carrington West Wing
- A Cheshunt
- A Cheshunt / North Pit
- A North Pit
- A North Void
- A West Pit

Generalised target lithology

- Alluvium
- Coal seam
- Interburden
- Spoil

Existing environment

- Major road
- Named watercourse
- Named waterbody

HVO North - North Pit area monitoring bores

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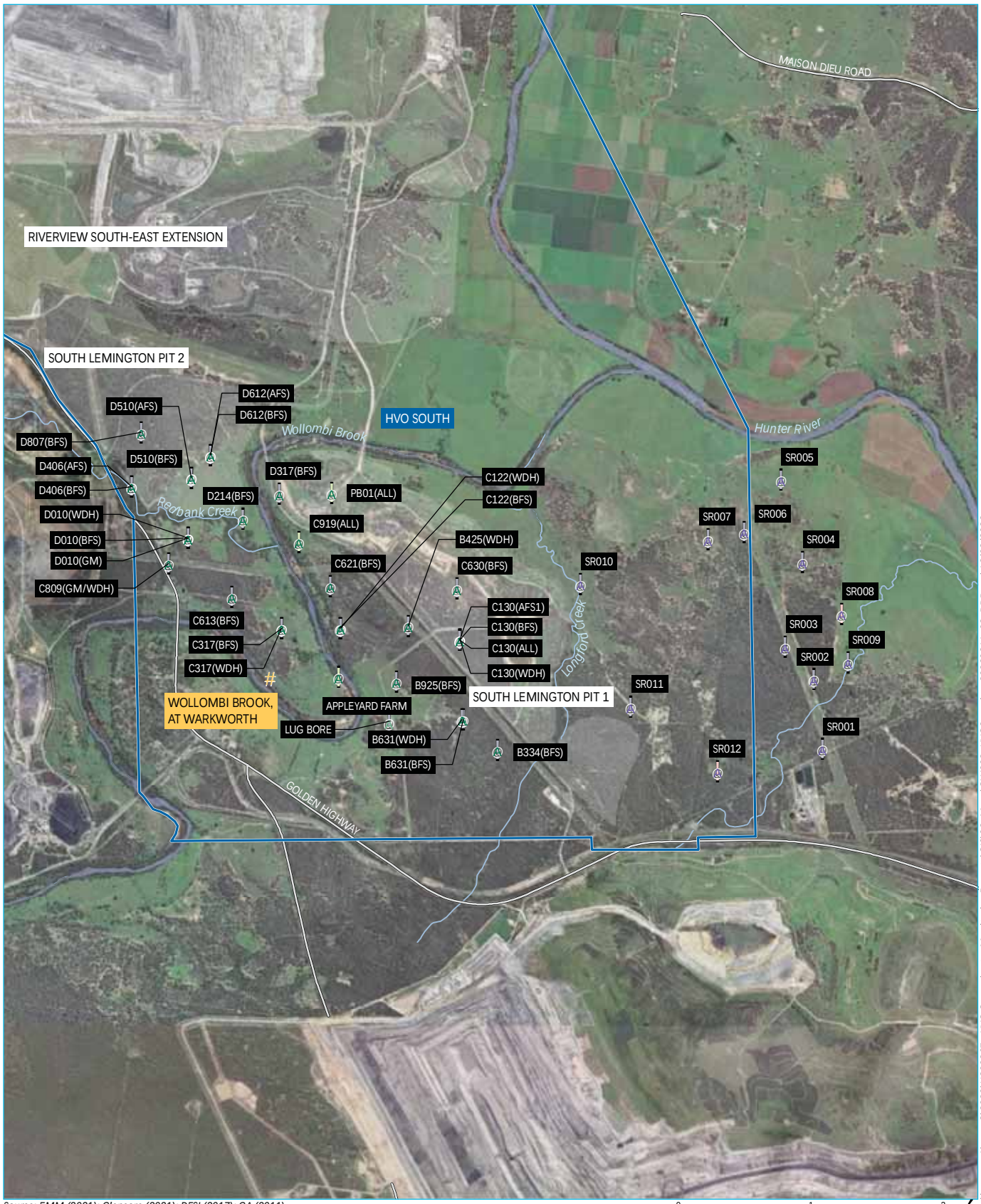
Figure 1.3

EMM creating opportunities



Source: EMM (2021); Glencore (2021); DFSI (2017); GA (2011)

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GDA2020 MGA Zone 56

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KEY

- Existing HVO South project approval boundary (PA 06-0261)
- # WaterNSW gauging station 210004

Bore location
- A Lemington
- A Lemington South
- A Southern

Generalised target lithology
- Alluvium
- Coal seam
- Interburden

Existing environment
- Major road
- Named watercourse
- Named waterbody

HVO South area monitoring bores

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Figure 1.4

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2 Regulatory requirements

2.1 Groundwater impact assessments

Groundwater impacts have been assessed throughout the life of the complex. Past groundwater assessments include:

- Alluvial Lands Project Groundwater Assessment (MMA 1992);
- Carrington Pit Groundwater Assessment (MER 1998);
- West Pit Extension Groundwater Assessment (MER 2003);
- Carrington Pit Extended Groundwater Assessment (MER 2005);
- HVO North Modification 3 Groundwater Assessment - Carrington West Wing Extension (MER 2010);
- HVO South Groundwater Assessment (ERM 2008);
- HVO North Modification 4 Groundwater Assessment – Carrington Out-of-Pit Fine Reject Emplacement (AGE 2013);
- HVO North Modification 6 Groundwater Assessment – Carrington In-Pit Fine Reject Emplacement (AGE 2016); and
- HVO South Modification 5 Groundwater Assessment (AGE 2017).

The groundwater assessment for HVO South Modification 5 (AGE 2017) included development of a numerical groundwater model that considered operations across both HVO North and HVO South. This is the most recent assessment for the approved operations; therefore, the results from the Modification 5 model have been used in this report. The groundwater model developed for HVO South Modification 5 was reviewed by SLR in 2020. AGE (2017) reported on predicted impacts associated with approved operations over 2021 (Modification 5 model Year 6). The approved operations included mining at Cheshunt Pit, Riverview Pit and West Pit, and abstraction from the LUG Bore. The groundwater model also included approved mining at Carrington West Wing until 2021; however, mining at Carrington West Wing has not commenced. Groundwater conditions and groundwater response to approved mining to the end of 2015 (which represents the end of the model calibration period), as reported by AGE (2017), indicated:

- Groundwater within the hard rock units of the Whittingham Coal Measures is directly intercepted by approved operations at the complex.
- Groundwater within the confined to semi-confined Permian coal measures has been depressurised around the area of active mining. Groundwater drawdown responses were observed around 2 km to 6 km from active mine areas within the Permian coal measures.
- Historically, the South Lemington Pit 1 footprint, Carrington Pit and North Pit directly intercepted groundwater within alluvium. The HVO North operations includes approval to mine into areas overlain by alluvium associated with a paleochannel in the Carrington West Wing area. However, mining is yet to commence in this area. Barrier walls were established at Alluvial Lands (North Pit area) and Carrington Pit to separate mined and backfilled areas from the alluvium closer to the Hunter River.

- With depressurisation of the coal measures, the model predicted a reduction in upward seepage to the alluvium, or an increase in downward leakage from the alluvium, that was referred to as 'indirect take'.

- These findings largely aligned with historical groundwater assessments conducted for the approved operations across the complex. HVO hold water access licences (WALs) for the approved operations. Management and monitoring requirements of potential groundwater related impacts from approved operations are captured within the development consent conditions. Schedule 3, Condition 27 of Development Consent (DA 450 10 2003) for HVO North, last updated January 2017 for Modification 6 and again in July 2017 (noting no changes to groundwater conditions in July 2017). Also, Schedule 3, Condition 28 of the Project Approval (PA 06 0261 24) for HVO South, last updated February 2018.

These conditions are addressed within the WMP (HVO 2018).

2.2 Groundwater conditions

HVO is required to prepare a WMP to the satisfaction of the Secretary. The WMP was prepared in accordance with Condition 27 of the HVO North and HVO South Approvals. Table 2.1 presents the consent conditions addressed in the current WMP that relate to groundwater.

Table 2.1 Groundwater conditions addressed in the WMP

Consent Condition	Groundwater-related condition	Where addressed
HVO North Consent (DA 450-10-2003)		
Sch. 3, Cond. 27(c)	The WMP must include a groundwater management plan, which includes:	
	• detailed baseline data on groundwater levels, yield and quality in the region, and privately owned groundwater bores, that could be affected by the development;	WMP No private bores are predicted to be impacted by approved operations
	• groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts;	Section 4.2 for trigger values
	• a program to monitor:	WMP
	– groundwater inflows to the open cut mining operations;	Section 4.1
	– the impacts of the development on:	Section 5
	▪ the alluvial aquifers, including additional groundwater monitoring bores as required by the Department of Planning, Environment (DPE) Water;	
	▪ the effectiveness of the low permeability barrier;	
	▪ base flows to the Hunter River;	
	▪ any groundwater bores on privately-owned land that could be affected by the development; and	
	▪ groundwater dependent ecosystems, including the River Red Gum Floodplain Woodland Endangered Ecological Community (EEC) located in the Hunter River alluvium;	
	– the seepage/leachate from water storages, backfilled voids and the final void;	
	• a program to validate and recalibrate (if necessary) the groundwater model for the development, including an independent review of the model every 3 years, and comparison of monitoring results with modelled predictions;	Section 5.5

Table 2.1 Groundwater conditions addressed in the WMP

Consent Condition	Groundwater-related condition	Where addressed
	• a plan to respond to any exceedances of the groundwater assessment criteria.	Section 5.2 Section 6.2
HVO South Consent (PA 06_0261)		
	The WMP must include a groundwater monitoring program that includes:	
	• additional baseline data of groundwater levels, yield and quality in the region, and privately-owned groundwater bores, which could be affected by the project;	WMP
	• groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts of the project; and	Section 4.2
	• a program to monitor: – groundwater inflows to the open cut mining operations; – impacts of the project on the region's aquifers, any groundwater bores, and surrounding watercourses, and in particular, the Hunter River and Wollombi Brook and adjacent alluvium; – impacts of the project on groundwater dependent ecosystems, riparian vegetation and River Red Gum populations; and	WMP Section 5
	– a plan to respond to any exceedances of the performance criteria or surface water impact assessment criteria, and repair, mitigate and/or offset any adverse groundwater impacts of the project.	Section 5.2 Section 6.2
HVO South, Modification 5		
	In addition to the mitigation measures undertaken at HVO for groundwater management, the following controls specific to the proposal will be implemented:	
	• groundwater flow to and from rivers: – development of protocols for monitoring and reporting of DPI Water stream gauge results to clearly record any reductions in flows that are attributed to mining. This will include monitoring Hunter River flows immediately up gradient and down gradient of the site. In addition, consideration will be given to tying in specific CNA water level recordings with current NSW Government gauging locations;	See WMP and Surface Water Review
	– monitoring of groundwater elevations within alluvium between the Hunter River and the Cheshunt Pit;	Section 5.2 and 5.3
	– measured groundwater elevations and river flow will be assessed against predictions to determine whether application of additional management measures is required; and	Section 5.5
	– offset seepage to pits in accordance with regulatory requirements.	WMP

The WMP also presents consent conditions for the Carrington West Wing extension at HVO North (Modification 3). However, as mining has not commenced in this area, the consent conditions are not yet applicable.

Groundwater monitoring is conducted in accordance with the Groundwater Monitoring Program outlined within Appendix A of the WMP. The program outlines groundwater monitoring frequency, parameters to be tested and groundwater triggers for EC and pH. The WMP was updated in October 2018, including updates to the monitoring network and trigger levels (refer Section 4). EMM understands the WMP has been updated (HVO 2021) and a draft has been provided to DPE Water for review and approval.

2.3 Groundwater licensing

HVO hold sufficient WALs for direct and indirect take associated with the approved operations, as per the requirements of the *Water Act 1912* and *Water Management Act 2000.* Table 2.2 lists the relevant entitlements held by HVO.

Table 2.2 HVO water access licences

WAL number	Nominated work approval(s)	WAL category	Water sharing plan (WSP)	Water source and management zone	Detail	Approved extraction[1] (units or ML)
WAL962 (20AL201237)	20WA201238	Regulated river	Hunter Regulated River Water Sources 2016	Hunter River (Zone 1b) - between Goulburn River junction and Glennies Creek junction	Surface water access – West Pit area	3,165
WAL970 (20AL201256)	20WA201257	Regulated river		Hunter River (Zone 2a) - between Glennies Creek junction and Wollombi Brook junction.	Surface water access – HVO North and HVO South areas	1,500 (500 each)
WAL1006 (20AL201337)	20WA201338					
WAL1070 (20AL201500)	20WA201501					
WAL23889	-	Aquifer	Hunter Unregulated and Alluvial Water Sources 2009	Hunter Regulated River Alluvial Water Source - Lower Wollombi Brook Management Zone	Greenleek	144
WAL36190 (20AL212712)	20CA212713	Aquifer		Hunter Regulated River Alluvial Water Source - Jerrys Management Zone	HVO North, old farm bore	120
WAL18327	20WA210985	Unregulated river		Jerrys Water Source - Jerrys Management Zone	HV Loading Point Pump Bayswater Creek (diversion works)	150
WAL18307	20WA210991	Unregulated river			HVO West – Parnells Creek Dam (Diversion Works Bywash)	500
WAL18158	-	Aquifer		Hunter Regulated River Alluvial Water Source – Upstream Glennies Creek management zone	Ollenberry	65
WAL18127	-	Aquifer			Carrington BB1	383
WAL39798	-	Aquifer	North Coast Fractured and Porous Rock Groundwater Sources 2016	Sydney Basin-North Coast Groundwater Source	LUG Bore	1,800
WAL41527	-	Aquifer			HVO North Carrington Pit	700
WAL41533	-	Aquifer			HVO North Pit Excavations	20
WAL40466	-	Aquifer				460

Table 2.2 HVO water access licences

WAL number	Nominated work approval(s)	WAL category	Water sharing plan (WSP)	Water source and management zone	Detail	Approved extraction[1] (units or ML)
WAL40463	-	Aquifer			HVO Pit Excavation – Alluvial Lands Bores	180
WAL40462	-	Aquifer				2,400

Note: 1. per water year (ie 1 July to 30 June)

3 Hydrogeological setting

3.1 Climate and drainage

3.1.1 Climate

The climate of the HVO region is temperate and is characterised by hot summers and mild dry winters.

Rainfall data were accessed from the Scientific Information for Landowners (SILO) database at latitude -32.50 and longitude 151.00. The SILO data are interpolations of climate records from Bureau of Meteorology (BoM) monitoring stations within 100 km of the search coordinates.

The reporting period of 2021 is considered a wet (La Niña) year, with the annual recorded rainfall 57% higher than the long-term average, as outlined in Table 3.1. March and November were particularly wet, with noticeable flood events recorded during both months. Daily rainfall totals are presented in Figure 3.1.

Table 3.1 2021 recorded and long-term average monthly rainfall data (SILO)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
[1]Actual rainfall (mm)	108.5	97.5	220.6	17.6	11.0	63.8	27.4	40.9	31.6	73.5	241.9	95.1	1029.4
[2]Average rainfall (mm)	80.5	76.4	69.6	42.8	41.2	44.3	31.9	35.2	39.5	53.7	67.5	71.2	653.9
Deviation (%)	+35	+28	+217	-59	-73	44	-14	+16	-20	+37	+258	+34	+57

Notes: 1. Data accessed from the SILO database;
2. Rainfall data averaged between January 1960 and December 2021

3.1.2 Stream gauge monitoring

Flows in the Hunter River, which separates HVO South and HVO North, are regulated by releases from Glenbawn Dam and Glennies Creek Dam. Wollombi Brook separates Lemington South pit from the Cheshunt pit at HVO South and meets the Hunter River downstream of Glennies Creek.

Stream gauge data were accessed from the WaterNSW real time-data website (WaterNSW 2022). Two gauging stations were chosen due to their proximity to the complex (see Figure 1.2 to Figure 1.4):

- Hunter River, at the Liddell gauging station (WaterNSW reference 210083), located on the Hunter River and upstream of HVO North; and
- Wollombi Brook, at the Warkworth gauging station (WaterNSW reference 210004), located on the Wollombi Brook (a tributary river to the Hunter River), and within the HVO South area.

Stream levels responded to major rainfall events such as those of March and November 2021, with river level rises up to 7.5 m in the Hunter River, and 5.5 m in the Wollombi Brook (noting however that the river stage in this area is affected during high flow events in the Hunter River, rather than flows from the Wollombi Brook catchment upstream). Between these noticeable rainfall events, river levels were relatively stable. Stream level and rainfall totals for the reporting period are presented in Figure 3.1.

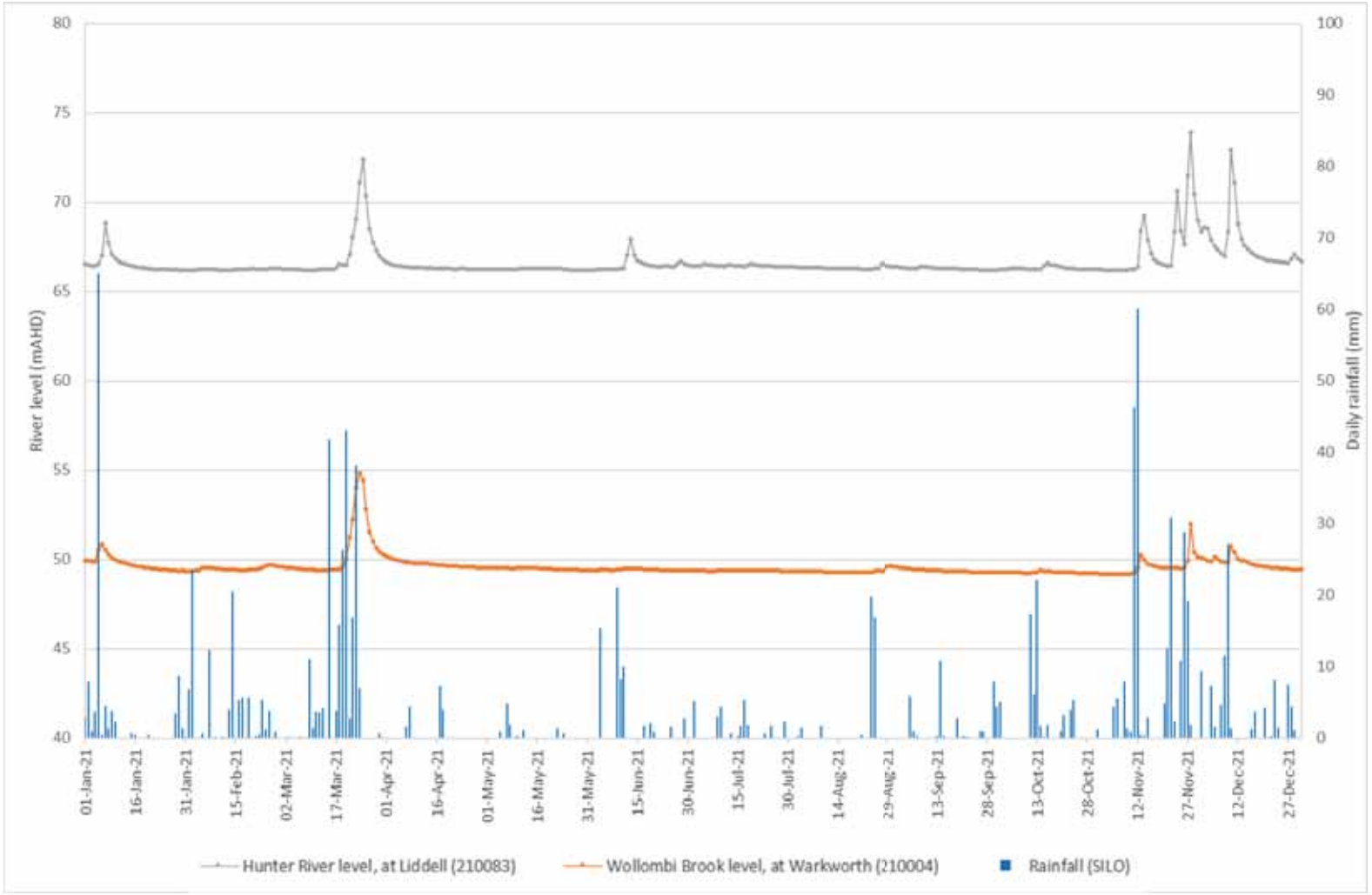


Figure 3.1 Rainfall and stream gauge data

3.2 Geology

The complex is located within the Sydney Basin which was formed via igneous rifting and crustal thinning in the Late Carboniferous – Early Permian. It comprises Permian and Triassic sedimentary sequences. HVO extracts coal from seams within the Permian Jerrys Plain and Vane subgroups.

The area is characterised by two distinct geological units, namely Quaternary alluvium occurring within the Hunter River flood plain (and some associated tributaries including Wollombi Brook) and the Permian coal measures that form the bedrock, where coal seams are present.

The Quaternary alluvium, mainly occurring along the Hunter River, contains two main depositional units; surficial fine-grained sediments (clay, silt and sand) overlying a coarser basal material (sand and gravel). At HVO North, an ancient river meander carved into the underlying Permian sediments. This was infilled with alluvial sediments and forms a paleochannel to the north of the Hunter River, in the Carrington West Wing and Carrington Pit area.

The Permian strata, underlying the Quaternary alluvium, comprise sequences of coal seams separated by overburden and interburden, consisting of sandstone, siltstone, tuffs and conglomerate. In the area of the complex, the Permian strata dip gently to the south-east. The coal seams subcrop to the north and east of the complex.

In the Hunter Coalfield, a group of smaller thrust faults running parallel to subparallel to the Hunter- (Mooki) thrust and a series of northerly trending folds displaces the Permian sequences. Two prominent folds occur in the Hunter Coalfield near HVO North and South; these are the Muswellbrook Anticline (to the west of HVO North), and the Bayswater Syncline north-west of Singleton (north and east of HVO North).

Previously mined areas at HVO North have been backfilled with spoil and fine rejects. The historical Alluvial Lands (North Pit) mining area has been rehabilitated. The spoil comprises a mix of Permian interburden and overburden material that is generated as waste from the open cut coal mining process.

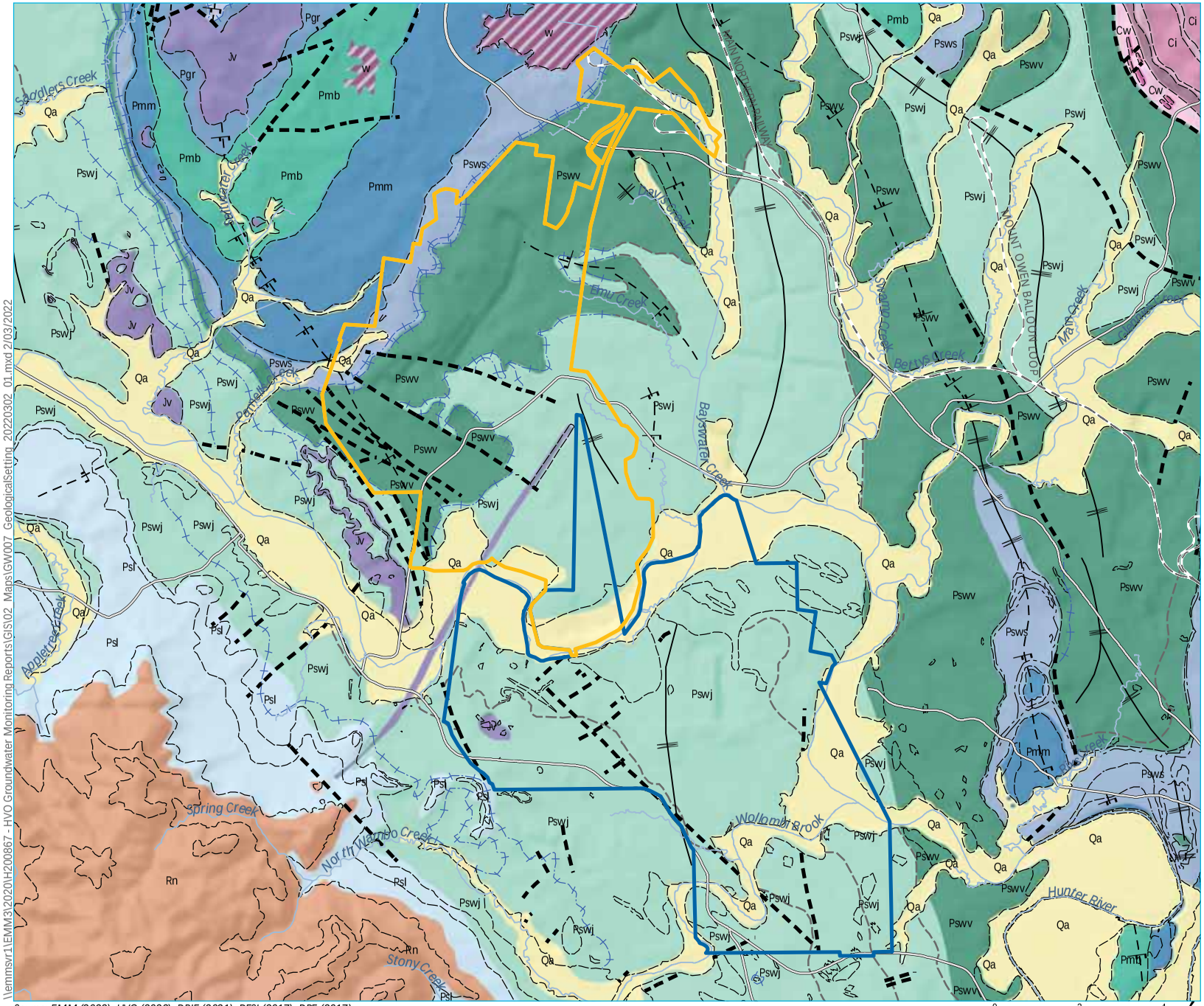
Table 3.2 presents the stratigraphy of the HVO complex area. Figure 3.2 shows the geological settings of the area.

Table 3.2 HVO complex stratigraphy

Age	Group	Subgroup	Description
Quaternary	Quaternary alluvial sediments (Qa)		Shallow sequences of clay, silty sand and sand
			Basal sands and gravels overlying surficial alluvium along major watercourses (ie Hunter River and Wollombi Brook)
Jurassic	Volcanics (Jv)		Flows, sills and dykes
Permian	Newcastle Coal Measures (Pne)		Coal seams, claystone (tuffaceous), siltstone, sandstone and conglomerate
	Watts Sandstone (Pihw)		Medium to coarse-grained sandstone
	Wittingham Coal Measures	Jerrys Plains Sub-group (Pswj)	Cyclic coal seam sequences with dark-grey to black laminated shale and siltstone. Coal seams, in the order of increasing age and depth, 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.

Table 3.2 HVO complex stratigraphy

Age	Group	Subgroup	Description
		Archerfield Sandstone (Pswv)	Bronze-coloured lithic sandstone
		Vane Sub-group (Pswv)	Coal bearing sequences with wedges of sandstone and siltstone. Coal seams, in the order of increasing age and depth, include Lemington Seam, Pikes Gully Seam, Arties Seam, Liddell Seam, Barrett Seam and Hebden Seam.
		Saltwater Creek Formation (Psws)	Sandstone and siltstone, minor coaly bands, siltstone towards base



Source: EMM (2022); HVO (2022); DPIE (2021); DFSI (2017); DPE (2017)

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Geological setting

Hunter Valley Operations Pty Ltd
2021 Annual groundwater review
Figure 3.2

EMM
creating opportunities

3.3 Hydrostratigraphic units

The main hydrostratigraphic units within the area are based on the geological units and their ability to store and transmit water, and include:

- Quaternary alluvium, which forms a relatively thin aquifer system where it occurs along the major creeks and rivers; and
- Permian strata that can be divided into:
  - thin and variably permeable weathered rock at the surface (regolith). They generally do not form aquifers due to limited saturated thickness;
  - non-coal interburden that forms aquitards; and
  - low, to moderately permeable, coal seams that act as the most transmissive strata within the coal measures, but which are still relatively poor transmissive aquifers.

The Regulated Hunter River is the dominant source of recharge to the Hunter River alluvium. The conceptual understanding is that the Hunter River is in hydraulic connection with the alluvium, thus maintains groundwater levels and saturated thickness within the alluvium. Generally, the groundwater flow direction is downward from the alluvium to the Permian, resulting in downward leakage slowly from the alluvium to the Permian.

Recharge also occurs via direct rainfall to the ground surface, infiltrating into the formations through the thin soil cover and weathered profile.

While “less productive” groundwater within the surficial alluvium does not meet the ANZECC (2000) water quality guidelines for stock water supply, the “highly productive” alluvium (basal sands and gravels) is considered suitable for stock water supply from a water quality perspective. However, most agricultural producers (crop and cattle) utilise surface water resources (Hunter River and Wollombi Brook) in preference to alluvial groundwater (SLR 2021).

The coal measures form unconfined groundwater systems at outcrop, becoming semi-confined as they dip towards the south-east. The direction of groundwater flow for the Permian Coal Measures is influenced by the local geomorphology and structural geology, as well as the long history of mining within the region. The beneficial use of groundwater sourced from the Permian Coal is limited due to the high salinity, and preferential access to water associated with regulated Hunter River and the more productive alluvial aquifer. Groundwater flow direction in the alluvial groundwater source is consistent with the Hunter River flow direction.

3.4 Groundwater dependent ecosystems

Ecosystems that could rely on either the surface or subsurface expression of groundwater within or surrounding the complex area are those associated with:

- watercourses, including the Hunter River, Wollombi Brook and their tributaries, where groundwater provides baseflow to the surface water system;
- shallow groundwater systems; and
- terrestrial vegetation overlying shallow groundwater (within the vegetation root zone).

Site-specific assessments of potential groundwater dependent ecosystems (GDEs) and the surrounding area have been conducted as part of environmental assessments for the complex. The following potential GDEs have been identified:

- subterranean fauna within aquifer ecosystems (eg stygofauna) of the Hunter River, Wollombi Brook and associated tributary aquifers, which are known to occur throughout the Hunter River;
- River Red Gum populations at Carrington Billabong, and along the Hunter River, which rely on flooding for germination;
- River Oak Grassy Riparian Woodland of the Hunter River riparian zone; and
- Warkworth Sands Woodland community, present in South Lemington Pits area, considered to intermittently rely on a perched watertable.

4 Groundwater monitoring

4.1 Monitoring activities

The network is monitored in accordance with Appendix D of the WMP (HVO 2018). Monitoring activities include:

- groundwater level monitoring;
- field water quality measurement: pH and EC;
- submission of water quality samples for laboratory analysis, which includes:
  - standard analytical suite: total dissolved solids (TDS), aluminium (Al), arsenic (As), boron (B), calcium (Ca), cadmium (Cd), chloride (Cl), carbonate (CO_3), copper (Cu), mercury (Hg), potassium (K), magnesium (Mg), sodium (Na), nickel (Ni), lead (Pb), selenium (Se), sulfate (SO_4), zinc (Zn) and alkalinity (total, carbonate, bicarbonate and hydroxide); or
  - alternate analytical suite: TDS, Al, As, B, Be, Ca, Cd, Cl, CO_3, Co, Cu, F, Fe, Hg, K, Mg, Mn, Na, Ni, ammonia (NH_3), nitrite (NO_2), nitrate (NO_3), phosphorus (P), Pb, rubidium (Rb), antimony (Sb), Se, SO_4, silicon dioxide (SiO_2), strontium (Sr), Zn, and alkalinity (total, carbonate, bicarbonate and hydroxide); or
  - alkalinity/acidity.

The groundwater monitoring schedule is provided in Section 5.1, Table 5.1.

4.2 Groundwater trigger values

As discussed in Section 1.2, the complex consists of multiple pits across the complex, of which eight have defined trigger values in the WMP (HVO 2018) as follows:

- seven areas have defined groundwater quality trigger values for pH and EC (refer Table 4.1); and
- one area has defined groundwater level trigger values (refer Table 4.2).

Each of the area is split into applicable geological groups (broadly comprising alluvium, Permian coal measures or interburden).

Groundwater quality and level trigger values are presented in Table 4.1 and Table 4.2, respectively.

Table 4.1 Groundwater quality trigger values

Pit location	Target geology	pH		Electrical conductivity (µS/cm)
		5th percentile	95th percentile	95th percentile
Carrington	Alluvium	7	8	6,154
Carrington	Interburden	6.7	7.4	10,824
Carrington	Broonie Seam	6.8	7.1	8,628
Carrington West Wing	Alluvium	7	7.5	2,775

Table 4.1 Groundwater quality trigger values

Pit location	Target geology	pH		Electrical conductivity (µS/cm)
		5th percentile	95th percentile	95th percentile
Carrington West Wing	LBL Seam	7.3	7.6	3,531
Carrington West Wing	Floodplain Alluvium	6.8	7.8	9,280
Cheshunt	Mt Arthur Seam	6.5	7.6	3,350
Cheshunt	Interburden	6.9	7.7	6,213
Cheshunt	Piercefield Seam	6.4	6.8	2,596
Cheshunt / North Pit	Alluvium	6.6	7.5	4,462
Lemington South	Bowfield Seam	6.7	7.9	12,440
Lemington South	Woodlands Hill Seam	6.6	7.6	20,240
Lemington South	Arrowfield Seam	6.8	7.5	15,324
[1]Lemington South	Alluvium	6.8 6.6	7.0 7.7	22,700 3,938
Lemington South	Glen Munro Seam	6.5	7.2	1,894
Lemington South	Interburden	6.7	7.1	11,408
North Pit	Spoil	6.5	7.8	12,460
West Pit	Interburden	6.9	8	13,428

Source: WMP (HVO 2018)

Notes: 1. Multiple values are provided within the WMP however, due to previous recommendations (SLR 2021) the underlined values were applied in this assessment.

Table 4.2 Carrington alluvium groundwater level trigger values

Bore	Groundwater level (mAHD)	
	5th percentile	95th percentile
CFW55R	57.06	59.41
CFW57	58.24	59.24
CGW52a	58.23	60.52
CGW53a	58.33	59.19
CGW55a	57.49	58.43

Source: WMP (HVO 2018)

As discussed in the HVO North Void Seepage Study (SLR 2019), groundwater levels and quality are monitored in bores targeting alluvium proximal to the North Void TSF (NV TSF). An assessment has been undertaken in this report respective of the groundwater level and quality trigger values presented in the 2020 annual groundwater monitoring review (SLR 2021). EMM understands that a draft updated WMP (HVO 2021) has been provided to DPE Water, and that this is currently under review. The draft updated WMP includes trigger values for the NV TSF that differ to the below; however, as these are still draft, EMM has reviewed the 2021 monitoring data against the SLR (2019) proposed trigger values. A summary of the SLR (2019) NV TSF trigger values is provided in Table 4.3.

Table 4.3 North Void TSF groundwater trigger values (proposed, after SLR (2019))

Bore	pH		Sulfate (mg/L)	Sulfate/Chloride (meq)	Trending water level (m)
	Lower value	Upper value	Upper value	Upper level	[1]Upper trend level
CFW55R	6.8	8.0	2,000	0.8	0.5
CFW57	6.8	8.0	680	0.5	0.5
CGW52A	6.8	8.0	-	-	0.5
CGW54A	6.8	8.0	680	0.5	0.5
CGW55A	6.8	8.0	-	-	0.5
GW-123	6.8	8.0	1,400	0.8	0.5
GW-124	6.8	8.0	680	0.5	0.5
GW-125	6.8	8.0	230	0.24	0.5
GW-126	6.8	8.0	230	0.24	0.5
GW-127	6.8	8.0	230	0.24	0.5
GW-129	6.8	8.0	-	-	0.5

Notes: 1. Water level assessed as rising trend over 12-month period (ie 0.5 m rising trend over 12 months)

meq = milliequivalents

5 Discussion

The 2021 groundwater monitoring results for groundwater level, EC, pH, SO_4 and SO_4/Cl ratio for the NV TSF area are provided in Appendix A. Appendix B and Appendix C present the groundwater time series graphs with and without trigger values, respectively.

The field monitoring reports are attached in Appendix D.

5.1 Data capture

A summary of the groundwater monitoring activity schedule and data capture in 2021 is provided in Table 5.1. Monitoring could not be undertaken at many locations in Q4/2021 due to the flooding events of November/ December 2021 affecting access.

Table 5.1 Groundwater monitoring activity schedule

Bore	Pit location - Target geology	Groundwater level monitoring			pH and electrical conductivity			Analytical suite			Alkalinity/Acidity suite			Comment
		[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	
Incomplete data capture														
4036C	Carrington - Interburden	Q	0	0%	Q	0	0%	See note 2	0	-	See note 2	0	-	Broken standpipe
4051C	Carrington - Interburden	Q	3	75%	Q	3	75%	See note 2	0	-	See note 2	0	-	No monitoring in Q4/2021 - bore blocked
GW-107	Carrington - Spoil	Q	2	50%	Q	0	0%	A	0	0%	See note 2	0	-	Insufficient water to sample in Q3/2021 No access due to flooding in Q4/2021
GW-108	Carrington - Spoil	Q	2	50%	Q	0	0%	A	0	0%	See note 2	0	-	Insufficient water to sample in Q3/2021 No access due to flooding in Q4/2021
CGW49	Carrington West Wing - Alluvium	Q	3	75%	Q	3	75%	See note 2	0	-	See note 2	0	-	No monitoring in Q4/2021 - maintenance required
CGW47A	Carrington West Wing - Floodplain Alluvium	Q	3	75%	Q	3	75%	6M	2	100%	See note 2	0	-	No monitoring in Q4/2021 - maintenance required
CGW45	Carrington West Wing - LBL	Q	0	0%	Q	0	0%	See note 2	0	-	See note 2	0	-	Blocked
BZ3-3	Cheshunt - Mt Arthur Seam	Q	4	100%	Q	3	75%	See note 2	0	-	See note 2	0	-	Insufficient water to sample in Q1/2021
BZ4A(2)	Cheshunt - Mt Arthur Seam	Q	4	100%	Q	3	75%	See note 2	0	-	See note 2	0	-	Insufficient water to sample in Q1/2021
CHPZ3D	Cheshunt - Mt Arthur Seam	Q	3	75%	Q	3	75%	6M	2	100%	See note 2	0	-	No monitoring in Q4/2021 - maintenance required
CHPZ8D	Cheshunt - Mt Arthur Seam	Q	3	75%	Q	3	75%	6M	2	100%	See note 2	0	-	No monitoring in Q4/2021 - maintenance required
CHPZ10A	Cheshunt / North Pit - Alluvium	Q	3	75%	Q	3	75%	6M	2	100%	See note 2	0	-	No monitoring in Q4/2021 - maintenance required
CHPZ2A	Cheshunt / North Pit - Alluvium	Q	3	75%	Q	3	75%	6M	2	100%	See note 2	0	-	No monitoring in Q4/2021 - maintenance required
CHPZ3A	Cheshunt / North Pit - Alluvium	Q	3	75%	Q	3	75%	6M	2	100%	See note 2	0	-	No monitoring in Q4/2021 - maintenance required
CHPZ8A	Cheshunt / North Pit - Alluvium	Q	3	75%	Q	3	75%	6M	2	100%	See note 2	0	-	No monitoring in Q4/2021 - maintenance required
GA3	Cheshunt / North Pit - Alluvium	Q	3	75%	Q	3	75%	See note 2	0	-	See note 2	0	-	No monitoring in Q4/2021 - no access due to flooding
HV3(2)	Cheshunt / North Pit - Alluvium	Q	3	75%	Q	3	75%	See note 2	0	-	See note 2	0	-	No monitoring in Q4/2021 - no access due to flooding
PZ1CH200	Cheshunt / North Pit - Alluvium	Q	3	75%	Q	3	75%	See note 2	0	-	See note 2	0	-	No monitoring in Q4/2021 - bore could not be located
C919(ALL)	Lemington South - Alluvium	M	12	100%	Q	1	25%	A	1	100%	See note 2	0	-	Insufficient water to sample pH and EC
D510(AFS)	Lemington South - Arrowfield Seam	6M	1	50%	6M	1	50%	See note 2	0	-	See note 2	0	-	No monitoring in Q4/2021 - no access
D612(AFS)	Lemington South - Arrowfield Seam	6M	2	100%	6M	0	0%	See note 2	0	-	See note 2	0	-	Insufficient water to sample in 2021
C122(BFS)	Lemington South - Bowfield Seam	Q	4	100%	Q	0	0%	See note 2	0	-	See note 2	0	-	Insufficient water to sample in 2021
C630(BFS)	Lemington South - Bowfield Seam	6M	1	50%	6M	1	50%	See note 2	0	-	See note 2	0	-	No monitoring in Q4/2021 - no access due to flooding
D214(BFS)	Lemington South - Bowfield Seam	Q	3	75%	[3]6M	1	-	See note 2	0	-	See note 2	0	-	No monitoring in Q4/2021 - no access
D510(BFS)	Lemington South - Bowfield Seam	6M	1	50%	6M	1	50%	See note 2	0	-	See note 2	0	-	No monitoring in Q4/2021 - no access
B425(WDH)	Lemington South - Woodlands Hill Seam	Q	3	75%	6M	0	0%	A	0	0%	See note 2	0	-	Insufficient water to sample in Q1, Q2 and Q3 No access due to flooding in Q4/2021
4116P	North Pit - Spoil	Q	3	75%	Q	3	75%	6M	2	100%	See note 2	0	-	No monitoring in Q4/2021 - no access due to high rainfall
DM1	North Pit - Spoil	Q	3	75%	Q	3	75%	A	1	100%	Q	4	100%	No monitoring in Q4/2021 - no access due to high rainfall
DM7	North Pit - Spoil	Q	0	0%	Q	0	0%	A	0	0%	Q	0	0%	Dry
GW-114	North Pit - Spoil	Q	3	75%	Q	2	50%	A	0	0%	See note 2	0	-	Requires survey No access due to high rainfall in Q4/2021
GW-115	North Pit - Spoil	Q	3	75%	Q	3	75%	A	1	100%	See note 2	0	-	No monitoring in Q4/2021 - no access due to high rainfall
MB14HVO01	North Pit - Spoil	Q	3	75%	Q	3	75%	A	2	200%	See note 2	0	-	No monitoring in Q4/2021 - no access due to high rainfall
MB14HVO02	North Pit - Spoil	Q	3	75%	Q	3	75%	A	2	200%	See note 2	0	-	No monitoring in Q4/2021 - no access due to high rainfall

Table 5.1 Groundwater monitoring activity schedule

Bore	Pit location - Target geology	Groundwater level monitoring			pH and electrical conductivity			Analytical suite			Alkalinity/Acidity suite			Comment
		[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	
MB14HVO05	North Pit - Spoil	Q	3	75%	Q	3	75%	A	2	200%	See note 2	0	-	No monitoring in Q4/2021 - no access due to high rainfall
GW-121	North Void - Alluvium	See note 4	10	-	See note 4	0	-	See note 4	0	-	See note 2	0	-	Insufficient water to sample in 2021
SR002	Southern - Bayswater Seam	6M	1	50%	6M	1	50%	See note 2	1	-	See note 2	0	-	No monitoring in Q4 - no access due to road flooding
SR003	Southern - Bayswater Seam	6M	1	50%	6M	1	50%	See note 2	1	-	See note 2	0	-	No monitoring in Q4 - no access due to road flooding
SR004	Southern - Bayswater Seam	6M	1	50%	6M	1	50%	See note 2	1	-	See note 2	0	-	No monitoring in Q4 - no access due to road flooding
SR005	Southern - Bayswater Seam	6M	1	50%	6M	1	50%	See note 2	1	-	See note 2	0	-	No monitoring in Q4 - no access due to road flooding
SR006	Southern - Bayswater Seam	6M	1	50%	6M	1	50%	See note 2	1	-	See note 2	0	-	No monitoring in Q4 - no access due to road flooding
GW-100	West Pit - Alluvium	Q	3	75%	Q	3	75%	A	1	100%	See note 2	0	-	No monitoring in Q4/2021 - no access due to flooding
GW-101	West Pit - Alluvium	Q	1	25%	Q	0	0%	A	0	0%	See note 2	0	-	Dry in Q1, Q2 and Q3/2021 No access due to flooding in Q4/2021
NPZ5	West Pit - Interburden	Q	0	0%	Q	0	0%	A	0	0%	See note 2	0	-	Destroyed, to be removed from WMP
Complete dataset														
CFW55R	Carrington - Alluvium	Q	12	300%	Q	12	300%	6M	13	650%	See note 2	0	-	
CFW57	Carrington - Alluvium	Q	12	300%	Q	12	300%	6M	11	550%	See note 2	0	-	
CGW52A	Carrington - Alluvium	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
CGW53A	Carrington - Alluvium	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
CGW55A	Carrington - Alluvium	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
CGW52	Carrington - Broonie Seam	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
CGW53	Carrington - Broonie Seam	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
CGW51A	Carrington - Interburden	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
GW-129	Carrington - Spoil	See note 4	12	-	See note 4	12	-	See note 4	13	-	See note 2	0	-	
4032P	Carrington West Wing - Alluvium	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
4034P	Carrington West Wing - Alluvium	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
4037P	Carrington West Wing - Alluvium	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
4040P	Carrington West Wing - Alluvium	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
CGW46	Carrington West Wing - Bayswater Seam	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
CGW32	Carrington West Wing - Floodplain Alluvium	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
CGW39	Carrington West Wing - Floodplain Alluvium	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
GW-106	Carrington West Wing - Floodplain Alluvium	Q	4	100%	Q	4	100%	A	2	200%	See note 2	0	-	
BZ3-1	Cheshunt - Interburden	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
BZ8-2	Cheshunt - Interburden	Q	4	100%	Q	4	100%	6M	3	150%	See note 2	0	-	
HG2	Cheshunt - Interburden	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
BC1a	Cheshunt - Mt Arthur Seam	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
BZ1-3	Cheshunt - Mt Arthur Seam	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
BZ2A(1)	Cheshunt - Mt Arthur Seam	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
CHPZ12D	Cheshunt - Mt Arthur Seam	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
HG2A	Cheshunt - Mt Arthur Seam	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
BUNC45D	Cheshunt - Piercefield Seam	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
BUNC45A	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
BZ1-1	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
CHPZ12A	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
CHPZ1A	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	[3]6M	2	-	See note 2	0	-	
CHPZ4A	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
Hobdens Well	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	A	1	100%	See note 2	0	-	

Table 5.1 Groundwater monitoring activity schedule

Bore	Pit location - Target geology	Groundwater level monitoring			pH and electrical conductivity			Analytical suite			Alkalinity/Acidity suite			Comment
		[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	
PZ2CH400	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	[3]6M	2	-	See note 2	0	-	
PZ3CH800	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	[3]6M	2	-	See note 2	0	-	
PZ4CH1380	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
PZ5CH1800	Cheshunt / North Pit - Alluvium	Q	4	100%	Q	4	100%	See note 2	0	-	See note 2	0	-	
Appleyard Farm	Lemington South - Alluvium	M	12	100%	Q	3	100%	A	1	100%	See note 2	0	-	
PB01(ALL)	Lemington South - Alluvium	M	12	100%	Q	3	100%	A	1	100%	See note 2	0	-	
C130(AFS1)	Lemington South - Arrowfield Seam	6M	2	100%	6M	2	100%	A	1	100%	See note 2	0	-	
D406(AFS)	Lemington South - Arrowfield Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
B334(BFS)	Lemington South - Bowfield Seam	Q	4	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
B631(BFS)	Lemington South - Bowfield Seam	Q	4	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
B925(BFS)	Lemington South - Bowfield Seam	Q	4	100%	6M	2	100%	A	1	100%	See note 2	0	-	
C130(BFS)	Lemington South - Bowfield Seam	6M	4	200%	6M	2	100%	See note 2	0	-	See note 2	0	-	
C317(BFS)	Lemington South - Bowfield Seam	Q	4	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
C613(BFS)	Lemington South - Bowfield Seam	Q	4	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
C621(BFS)	Lemington South - Bowfield Seam	Q	4	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
D010(BFS)	Lemington South - Bowfield Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
D317(BFS)	Lemington South - Bowfield Seam	Q	4	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
D406(BFS)	Lemington South - Bowfield Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
D612(BFS)	Lemington South - Bowfield Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
D807(BFS)	Lemington South - Bowfield Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
D010(GM)	Lemington South - Glen Munro Seam	6M	2	100%	6M	2	100%	A	1	100%	See note 2	0	-	
C130(ALL)	Lemington South - Interburden	Q	12	300%	Q	4	100%	A	1	100%	See note 2	0	-	
B631(WDH)	Lemington South - Woodlands Hill Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
C122(WDH)	Lemington South - Woodlands Hill Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
C130(WDH)	Lemington South - Woodlands Hill Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
C317(WDH)	Lemington South - Woodlands Hill Seam	Q	4	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
C809(GM/WDH)	Lemington South - Woodlands Hill Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
D010(WDH)	Lemington South - Woodlands Hill Seam	6M	2	100%	6M	2	100%	See note 2	0	-	See note 2	0	-	
LUG Bore	Lemington South - assumed to be coal seam	M	12	100%	Q	4	100%	A	1	100%	See note 2	0	-	
4119P	North Pit - Spoil	Q	4	100%	Q	4	100%	6M	2	100%	See note 2	0	-	
DM3	North Pit - Spoil	Q	4	100%	Q	4	100%	A	1	100%	Q	5	125%	
DM4	North Pit - Spoil	Q	4	100%	Q	4	100%	A	1	100%	Q	4	100%	
MB14HVO03	North Pit - Spoil	Q	4	100%	Q	4	100%	A	2	200%	See note 2	0	-	
MB14HVO04	North Pit - Spoil	Q	4	100%	Q	4	100%	A	2	200%	See note 2	0	-	
GW-120	North Void - Alluvium	See note 4	12	-	See note 4	12	-	See note 4	14	-	See note 2	0	-	
GW-123	North Void - Alluvium	See note 4	12	-	See note 4	12	-	See note 4	12	-	See note 2	0	-	
GW-124	North Void - Alluvium	See note 4	12	-	See note 4	12	-	See note 4	12	-	See note 2	0	-	
GW-125	North Void - Alluvium	See note 4	12	-	See note 4	12	-	See note 4	13	-	See note 2	0	-	
GW-126	North Void - Alluvium	See note 4	12	-	See note 4	12	-	See note 4	11	-	See note 2	0	-	
GW-127	North Void - Alluvium	See note 4	12	-	See note 4	12	-	See note 4	12	-	See note 2	0	-	
GW-128	North Void - Alluvium	See note 4	11	-	See note 4	9	-	See note 4	12	-	See note 2	0	-	
GW-122	North Void - Interburden	See note 4	12	-	See note 4	12	-	See note 4	13	-	See note 2	0	-	
SR001	Southern - Coal Seam	6M	2	100%	6M	2	100%	See note 2	2	-	See note 2	0	-	
SR010	Southern - Conglomerate and Warkworth Seam	6M	3	150%	6M	3	150%	A	1	100%	See note 2	0	-	
SR009	Southern - Lemington Seam	6M	3	150%	6M	3	150%	A	2	200%	See note 2	0	-	
SR011	Southern - Mt Arthur Seam and underburden	6M	4	200%	6M	4	200%	A	2	200%	See note 2	0	-	
SR012	Southern - Overburden conglomerate and sandstone	6M	3	150%	6M	3	150%	A	1	100%	See note 2	0	-	
SR007	Southern - Overburden and Vaux Seam coal	6M	3	150%	6M	3	150%	A	1	100%	See note 2	0	-	

Table 5.1 Groundwater monitoring activity schedule

Bore	Pit location - Target geology	Groundwater level monitoring			pH and electrical conductivity			Analytical suite			Alkalinity/Acidity suite			Comment
		[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	[1]Frequency	# records in 2021	Data recovery	
SR008	Southern - Siltstone/sandstone below Lemington Seam	6M	3	150%	6M	3	150%	A	1	100%	See note 2	0	-	
G1	West Pit - Alluvium	Q	11	275%	Q	11	275%	A	11	1100%	See note 2	0	-	
G2	West Pit - Alluvium	Q	11	275%	Q	11	275%	A	12	1200%	See note 2	0	-	
G3	West Pit - Alluvium	Q	11	275%	Q	11	275%	A	11	1100%	See note 2	0	-	
NPZ2	West Pit - Interburden	Q	4	100%	Q	4	100%	A	1	100%	See note 2	0	-	
NPZ3	West Pit - Interburden	Q	4	100%	Q	4	100%	A	1	100%	See note 2	0	-	

Notes:
1. M=monthly, Q= quarterly, 6M=six-monthly, A=annually
2. monitoring not required under the WMP (HVO 2018)
3. submitted for alternate analytical testing
4. bores presented as part of the North Void tailings storage facility assessment, for which the frequency of monitoring has not been defined

A total of 41 bores had incomplete monitoring data collected during the reporting period (Table 5.1). However, for 28 of these bores, the incomplete data capture is due the high rainfall of November/December 2021 hindering the access to the site/bore.

The remainder of the incomplete data capture comprise:

- one bore which was blocked (CGW45, within the Carrington West Wing area);
- one bore which had previously been destroyed (NPZ5, within the West Pit - Interburden);
- one bore (GW-114, within the North Pit – Spoil) which requires survey (to infer groundwater elevations in mAHD);
- four dry bores, including:
  - GW-101, within the West Pit - Alluvium;
  - 4036C, within the Carrington interburden;
  - DM7, within the West Pit – Interburden; and
  - D612(AFS), in Lemington South-Arrowfield Seam;
- seven bores containing sufficient water to obtain groundwater levels but not to satisfy complete sampling, including:
  - GW-107 and GW-108, within the Carrington - Spoil;
  - GW-121, within the North Void - Alluvium;
  - C919(ALL), within the Lemington South – Alluvium;
  - D612(AFS), within the Lemington South - Arrowfield Seam;
  - C122(BFS) within the Lemington South - Bowfield Seam; and
  - B425(WDH) within the Lemington South - Woodlands Hill Seam.

The six bores with insufficient water for sampling (GW-107, GW-108, GW-121, C919(ALL), D612(AFS), C122(BFS) and B425(WDH)) were further assessed using information provided within the field records, previous groundwater monitoring reviews (SLR 2020a) and sample site information accessed from the EMD. Groundwater levels were inferred to be below the screen in four of the seven bores (with incomplete information for two bores). A summary is provided in Table 5.2.

Table 5.2 Groundwater level comparison to bore construction detail

Bore	Target geology	Screen top (m depth)	Screen bottom (m depth)	[1]Water level (m depth)
GW-107	Carrington - Spoil	24.2	27.2	29.2
GW-108	Carrington - Spoil	52.5	58.5	60.8
GW-121	North Void - Alluvium	5	8	9.25
C919(ALL)	Lemington South - Alluvium	7.5	13.5	11.1
B425(WDH)	Lemington South - Woodlands Hill Seam	31.5	35.5	35.68
D612(AFS)	Lemington South - Arrowfield Seam	24.01 (Unknown top and bottom depths)		23.73
C122(BFS)	Lemington South - Bowfield Seam	Unknown		58.8

Notes: 1. Water level depth ranges recorded in the reporting period, assumed below the top of casing; shaded cells identify where water levels are below the bottom of the screened interval

It is likely that three bores are screened above the watertable (GW-107, GW-108 and GW-121), except during periods of high rainfall and associated inundation.

5.2 Trigger value exceedances

A summary of groundwater quality or level trigger value exceedances (exceedances) is provided in Table 5.3 and presented on Figure 5.1. Exceedances have been classified based on the action required ('investigate' or 'monitor'), in general accordance with Section 9.5 of the WMP which states:

> "HVO are required to initiate site specific investigations if … three consecutive measurements of EC, pH or standing water level (for specific groundwater sites only) exceed trigger values".

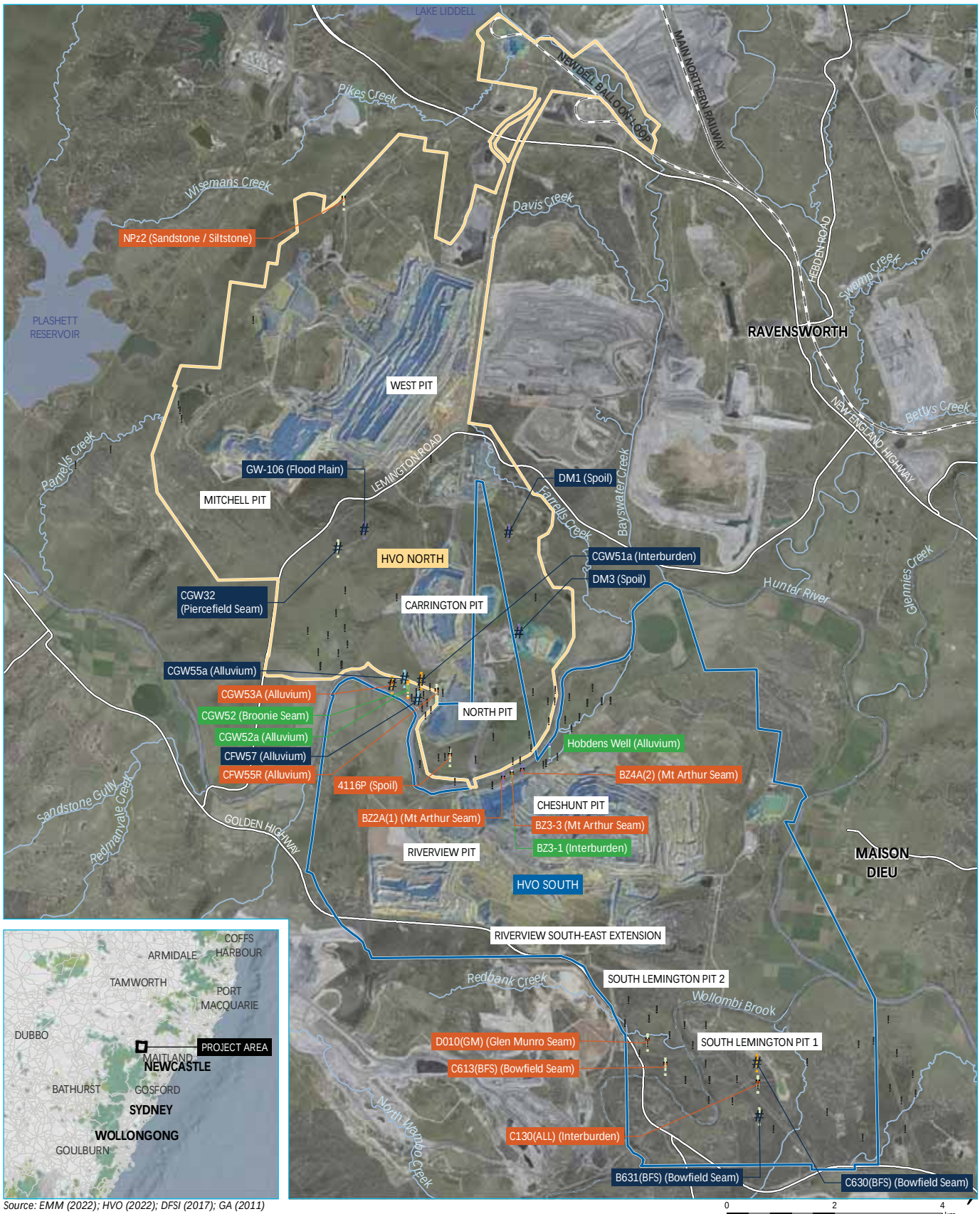
Table 5.3 Trigger value exceedance summary

Area	Geology (generalised)	Exceedance	Action required (HVO 2018)	Bore(s)	Discussion
Carrington	Alluvium	EC	Investigate	CFW55R	Section 5.2.1
		[1]Sulfate /chloride ratio	Investigation conducted (returned to acceptable value by end of 2021)		
		pH (upper limit)	None (returned to below trigger value by end of 2021)	CGW52A	
		Groundwater elevation	Monitor	CFW57 CGW55A	
			Investigate	CGW53A	
	Interburden	pH (upper limit)	Monitor	CGW51A	Section 5.2.2
	Permian coal measures (Broonie Seam)	pH (upper limit)	None (returned to below trigger value by end of 2021)	CGW52	Section 5.2.3

Table 5.3 Trigger value exceedance summary

Area	Geology (generalised)	Exceedance	Action required (HVO 2018)	Bore(s)	Discussion
			Monitor	CGW53	
Carrington West Wing	Floodplain Alluvium	EC	Monitor	CGW32	Section 5.2.4
		pH (lower limit)	Monitor	GW-106	
Cheshunt	Interburden	pH (upper limit)	None (returned to below trigger value by end of 2021)	BZ3-1	Section 5.2.5
Cheshunt	Permian coal measures (Mt Arthur Seam)	pH (lower limit)	Investigate	BZ2A[1] BZ3-3 BZ4A[2]	Section 5.2.6
Lemington South	Alluvium	pH (lower limit)	Monitor	Appleyard Farm	Section 5.2.7
	Interburden	EC	Investigate	C130(ALL)	Section 5.2.8
	Permian coal measures (Bowfield Seam)	EC	Monitor	B631(BFS)	Section 5.2.9
		pH (lower limit)	None (returned to above trigger value by end of 2021)	B631(BFS)	
		pH (upper limit)	Monitor	C630(BFS)	
	Permian coal measures (Glen Munro Seam)	EC	Investigate	D010(GM)	
	Permian coal measures (Woodlands Hill Seam)	EC	Investigate	C130(WDH)	
North Pit	Spoil	EC	Investigate	4116P	Section 5.2.10
		pH (lower limit)	Monitor	DM1 DM3	
West Pit	Interburden	EC	Investigate	NPz2	Section 5.2.11
Cheshunt/ North Pit	Alluvium	pH (lower limit)	None (returned to above trigger value by end of 2021)	Hobdens Well	Section 5.2.12

Notes: 1. Monitored as part of the NV TSF assessment, actions not yet defined



Source: EMM (2022); HVO (2022); DFSI (2017); GA (2011)

0 2 4 km

GDA2020 MGA Zone 56

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KEY

- Existing HVO North development consent boundary (DA 450-10-2003)
- Existing HVO South project approval boundary (PA 06-0261)

Groundwater bore

- " Investigate
- # Monitor
- ! Exceeded but returned to normal in 2021
- ! No exceedance

Exceedance type

- ! EC exceedance
- ! Low pH exceedance
- ! High pH exceedance
- ! Groundwater elevation (upper limit)

- Rail line
- Major road
- Named watercourse
- Named waterbody

INSET

- NPWS reserve
- State forest
- Major road

Carrington Alluvium - event based groundwater contours and EC

Hunter Valley Operations Pty Ltd
2021 Annual groundwater report
Figure 5.1

EMM creating opportunities

5.2.1 Carrington - Alluvium

i Groundwater elevation exceedances

During 2021, groundwater elevation exceedances were identified at three bores within the Carrington alluvium (Figure 5.2 and Figure 5.3):

1. CFW57, where the upper trigger level was exceeded on three occasions in 2021: by 5 cm in April, 4 cm in July and 0.46 m in December. The exceedances were recorded following high rainfall events and dropped below the upper trigger level between July and November 2021. As the cause of the higher groundwater levels relates to high rainfall and associated streamflow, no action is required; however future trends will continue to be monitored.

2. CGW55A, where the upper trigger level was exceeded on one occasion in December 2021, and is due to the very high rainfall and flood event of November and December 2021. No immediate action is required but future trends will be monitored.

3. CGW53A, where the upper trigger level was exceeded during each quarterly monitoring rounds in 2021. The exceedances are attributed to higher rainfall totals since late 2019/early 2020, following the end of the recent drought, and are not due to mining related activities. As such, further investigation is not required; however future trends will continue to be monitored.

ii Water quality exceedances

a EC

Consistent with historical observations and previous reporting, recorded salinity (as EC) at CFW55R in 2021 exceeded the EC trigger level that is defined in the 2018 WMP (Figure 5.2). As reported in SLR (2019) and the 2019 annual groundwater review (SLR 2020), the cause for the elevated EC at CFW55R is thought to be seepage from the NV TSF. The elevated EC coincided with when the height of tailings in the NV TSF rose above the alluvium in 2014, and groundwater flow directions in the alluvium were generally in a westerly direction (Figure 5.4).

As reported previously, tailings deposition at NV TSF ceased in January 2019 and HVO is implementing management measures as part of the pollution reduction program and in consultation with the regulatory authority. Monitoring results show EC is gradually declining at CFW55R and EC has remained below the trigger value at other alluvium monitoring bores in this area (Figure 5.2).

The monitoring results indicate management measures are being effective.

The updated draft WMP (2021) includes a revised EC trigger value for bore CFW55R; increased to 11,510 µS/cm. Based on historical data (June 2011–December 2021), it appears that there is low potential of exceeding the revised EC trigger value.

b pH

A lower trigger value exceedance was reported at CFW55R in January 2021. The exceedance was not repeated in subsequent measurements (Table A.3, Appendix A). The exceedance is considered an outlier and no further action or monitoring is required.

c Sulfate and sulfate/chloride ratio

The proposed sulfate/chloride ratio trigger value (0.8) was exceeded at CFW55R on five consecutive occasions (from May to October 2021). The sulfate/chloride ratio began to decline after June 2021, declining below the trigger value in November 2021. Based on historical data (March 2016–December 2021), the sulfate/chloride ratio at CFW55R has consistently been close to or above the trigger value since 2017 (Figure 5.5).

The sulfate/chloride ratio at other Carrington alluvium bores has generally been declining since late 2018/2019 and trigger value exceedances have not been observed in 2021 (Figure 5.5).

The proposed sulfate trigger value (Section 4.2) was exceeded at CFW55R on one occasion (May 2021) and the sulfate concentration has since declined below the trigger value (Figure 5.6). Monitoring shows sulfate concentrations have been gradually declining at this location since mid-2019. No further action is required; however, monitoring will continue.

Figure 5.4 and Figure 5.7 provide a comparison of groundwater flow direction and sulfate concentrations in the Carrington alluvium in June 2017 to June 2021, and June 2017 to December 2021 respectively.

In June 2021 (Figure 5.4):

- the groundwater flow direction was from the Hunter River towards the north/north-east; and
- sulfate concentrations were generally low, with higher concentrations observed at CFW55R, GW-120 (near CFW55R) and GW-129 (located in the spoil).

In December 2021 (Figure 5.7):

- the watertable was elevated (in comparison to earlier in the year) due to high rainfall and the groundwater flow direction was from the Hunter River towards the north/north-east; and
- the sulfate concentration at CFW55R declined and was in a similar concentration range to GW-120 and GW-129.

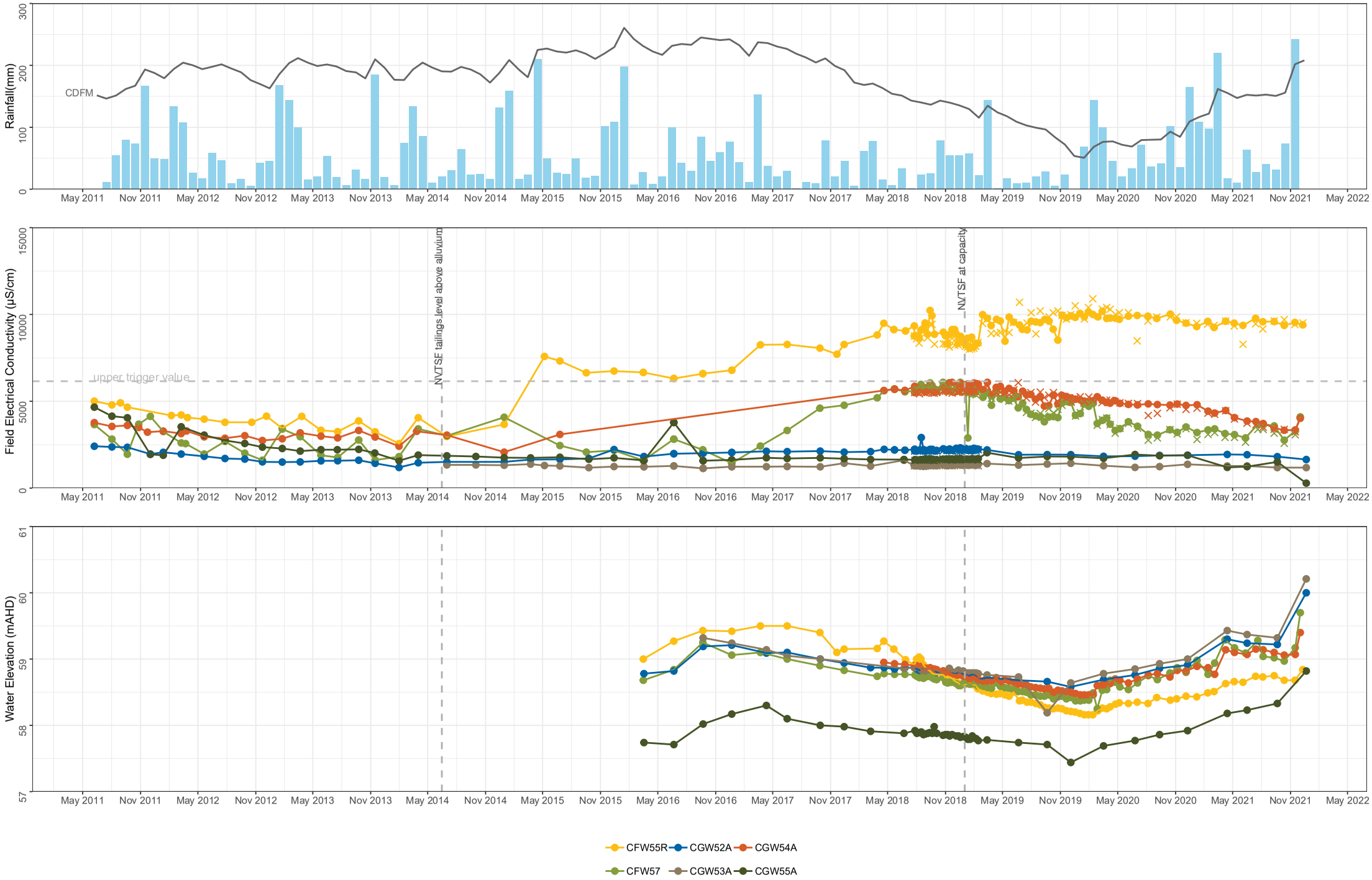
A conceptual diagram of this area and the associated hydrogeological processes is provided in Figure 5.8.

The cause for the sulfate/chloride exceedance at CFW55R in 2021 is due to a combination of an elevated sulfate reading in May 2021 and lower chloride concentrations, which are thought to fluctuate due to flushing of salts during high rainfall events.

Sulfate concentrations and EC are declining; and the hydraulic gradient from the Hunter River towards the Carrington Billabong and CFW55R is assisting with limiting the seepage moving towards the Hunter River. In addition, water level monitoring at GW-129 (located in the spoil adjacent to NV TSF) shows water levels have been declining, and have been at a lower water elevation than at CFW55R since mid-2019.

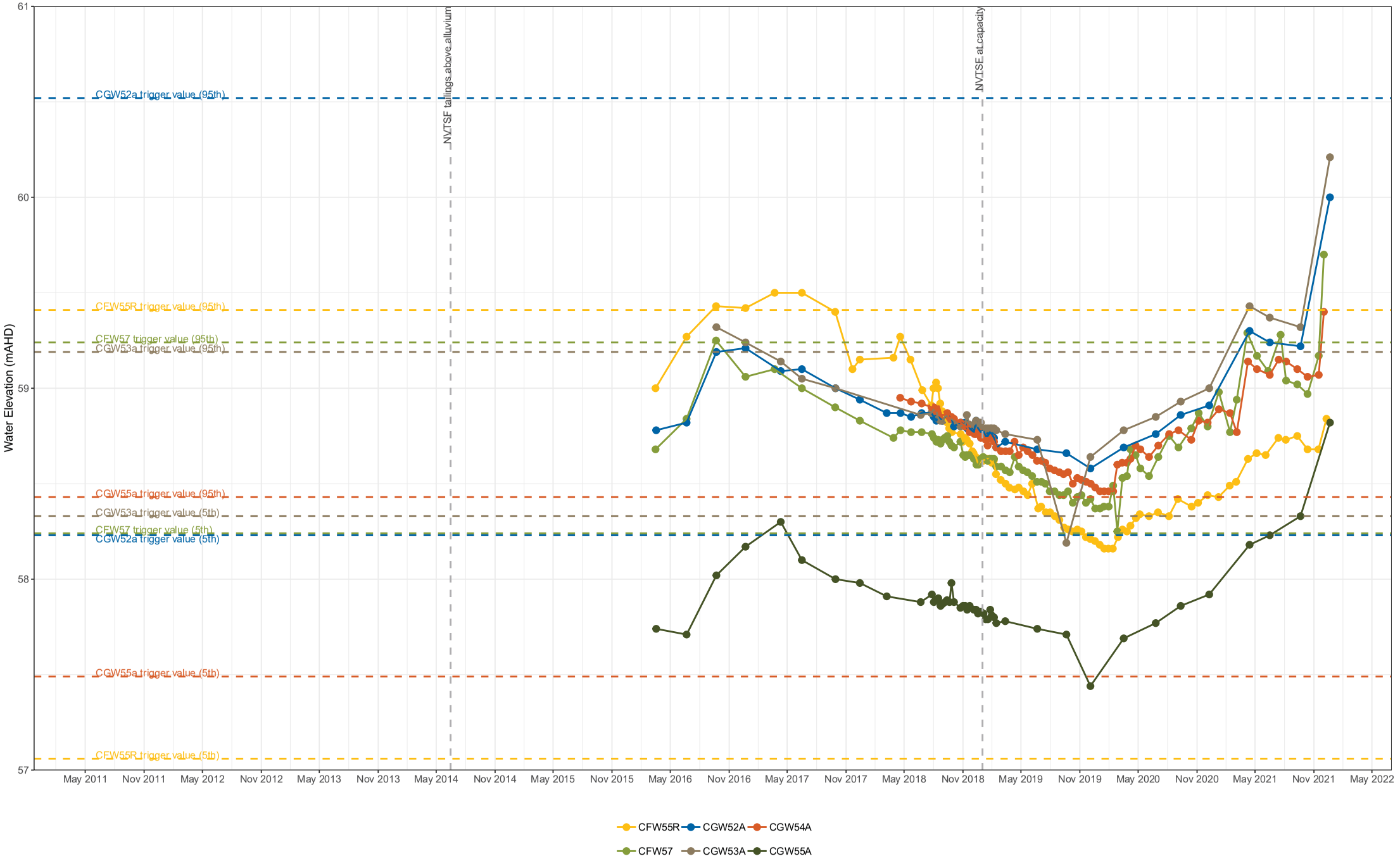
Monitoring indicates seepage from the NV TSF is reducing and management measures are being effective and HVO will continue to implement management measures as part of the pollution reduction program and in consultation with the regulatory authority.

EMM notes that the updated draft WMP (HVO 2021) includes the SLR (2020a) proposed sulfate/chloride ratio trigger values for the NV TSF Carrington alluvium bores.



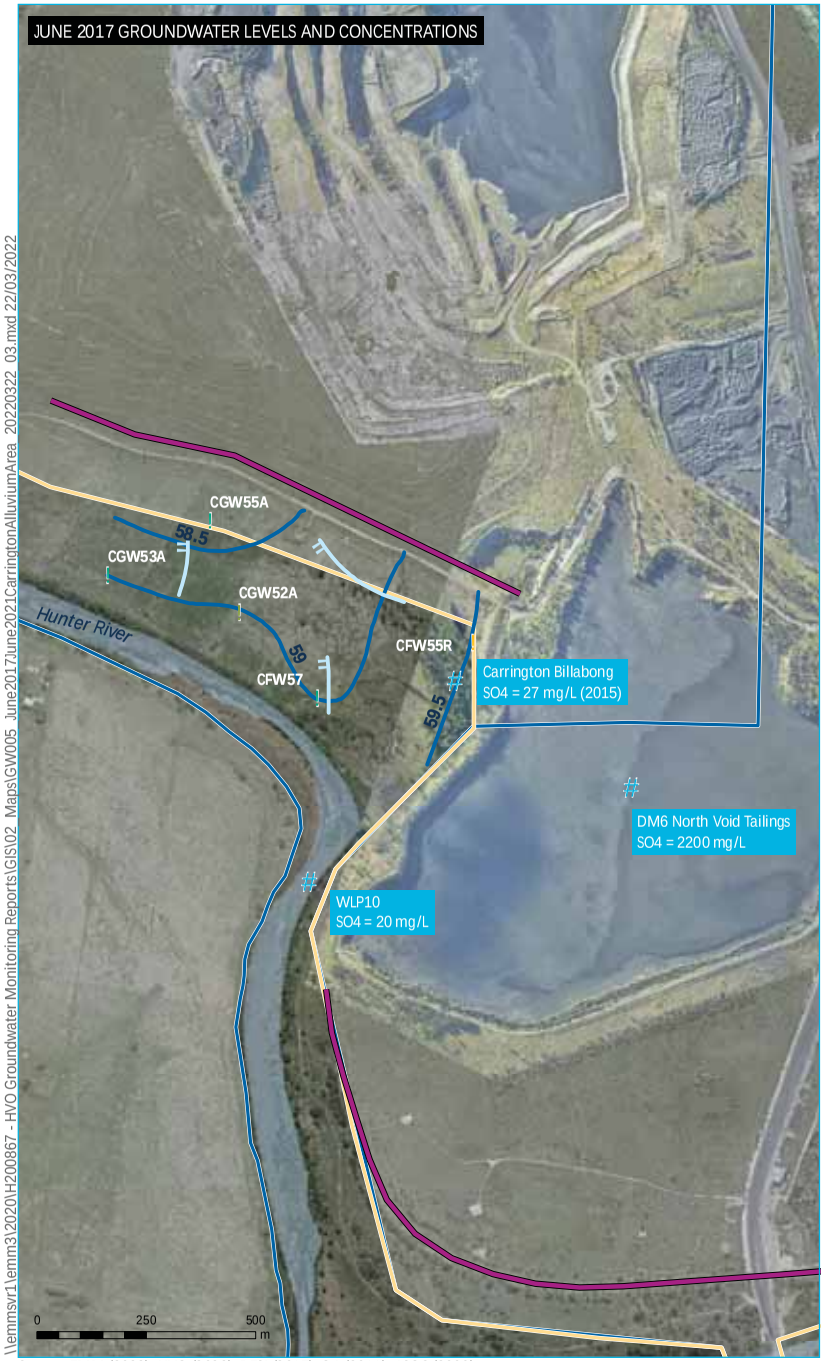
Notes
x denotes laboratory results
o denotes field results
Event dates are approximate only (SLR 2020)

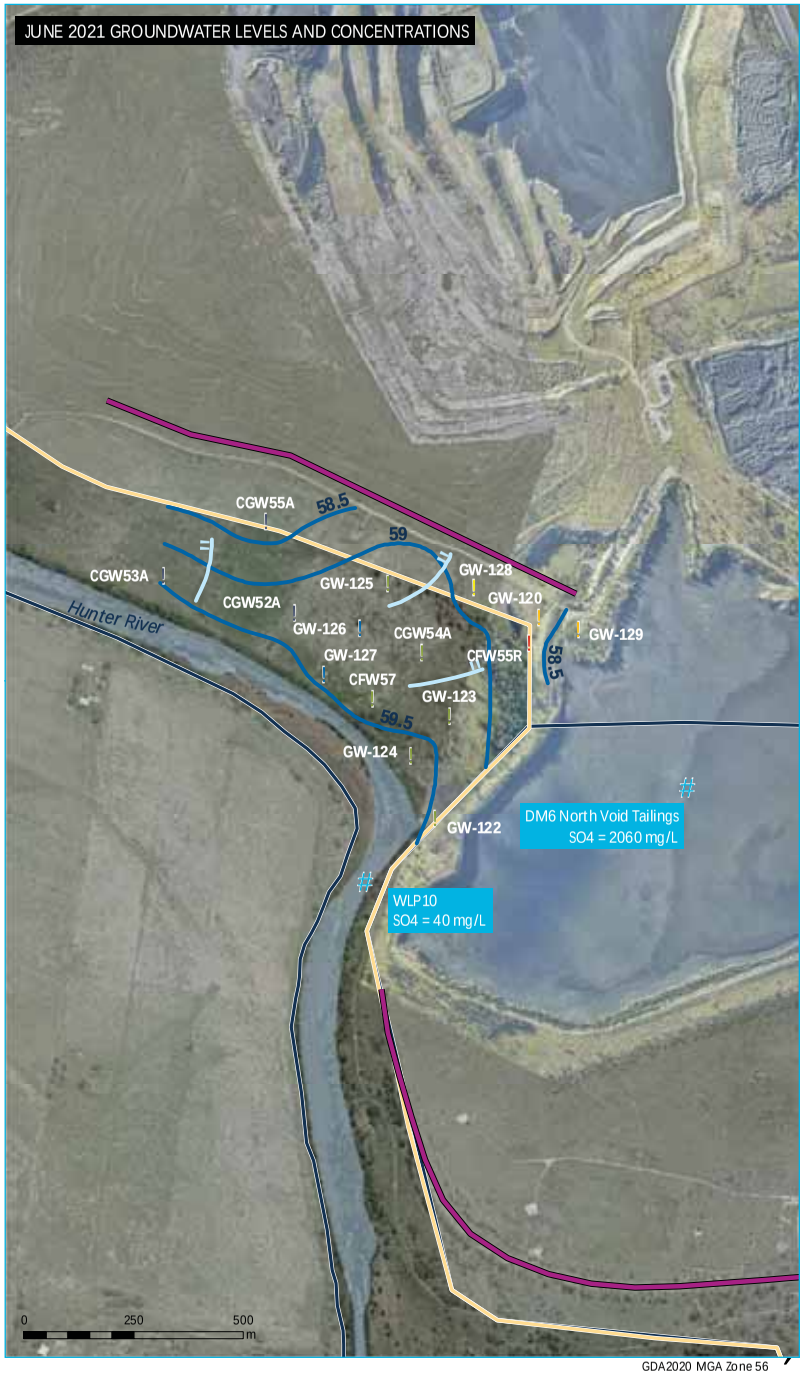
Carrington – Alluvium time series vs rainfall
Hunter Valley Operations
2021 Annual groundwater monitoring review
Figure 5.2

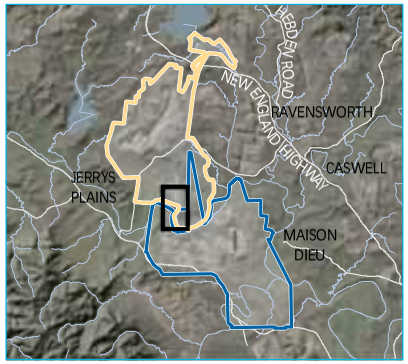


Notes

Carrington − Alluvium Water Elevation (mAHD)
Hunter Valley Operations
2021 annual groundwater monitoring report
Figure 13







KEY

- Existing HVO North development consent boundary (DA 450-10-2003)
- Existing HVO South project approval boundary (PA 06-0261)
- Named waterbody
- Named watercourse
- Barrier wall
- Groundwater flow direction
- Groundwater contour (mAHD)
- # Surface water chemistry sample

Sulfate concentration (mg/L)

- 0 - 40
- 41 - 100
- 101 - 1000
- 1001 - 1600
- 1601 - 2000
- > 2000
- Other bore

Carrington alluvium area - June 2017 and June 2021 comparison

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2021 Annual groundwater report
Figure 5.4

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Source: EMM (2022); HVO (2022); DFSI (2017); GA (2011); ASGC (2006)

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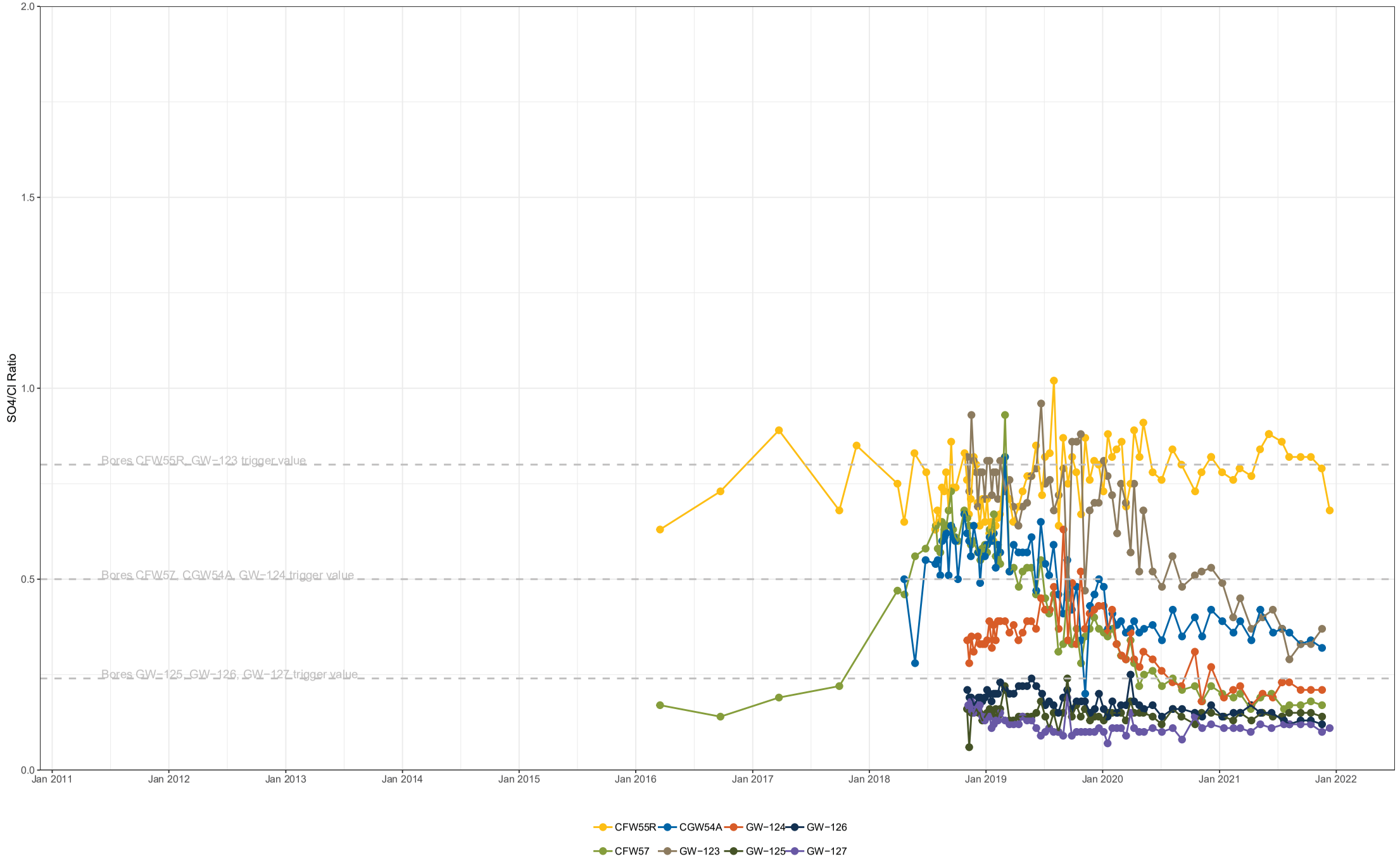


Carrington Alluvium - groundwater times series data (sulfate chloride ratio)

Hunter Valley Operations

2021 Annual Groundwater Monitoring Review

Figure 5.5

Notes

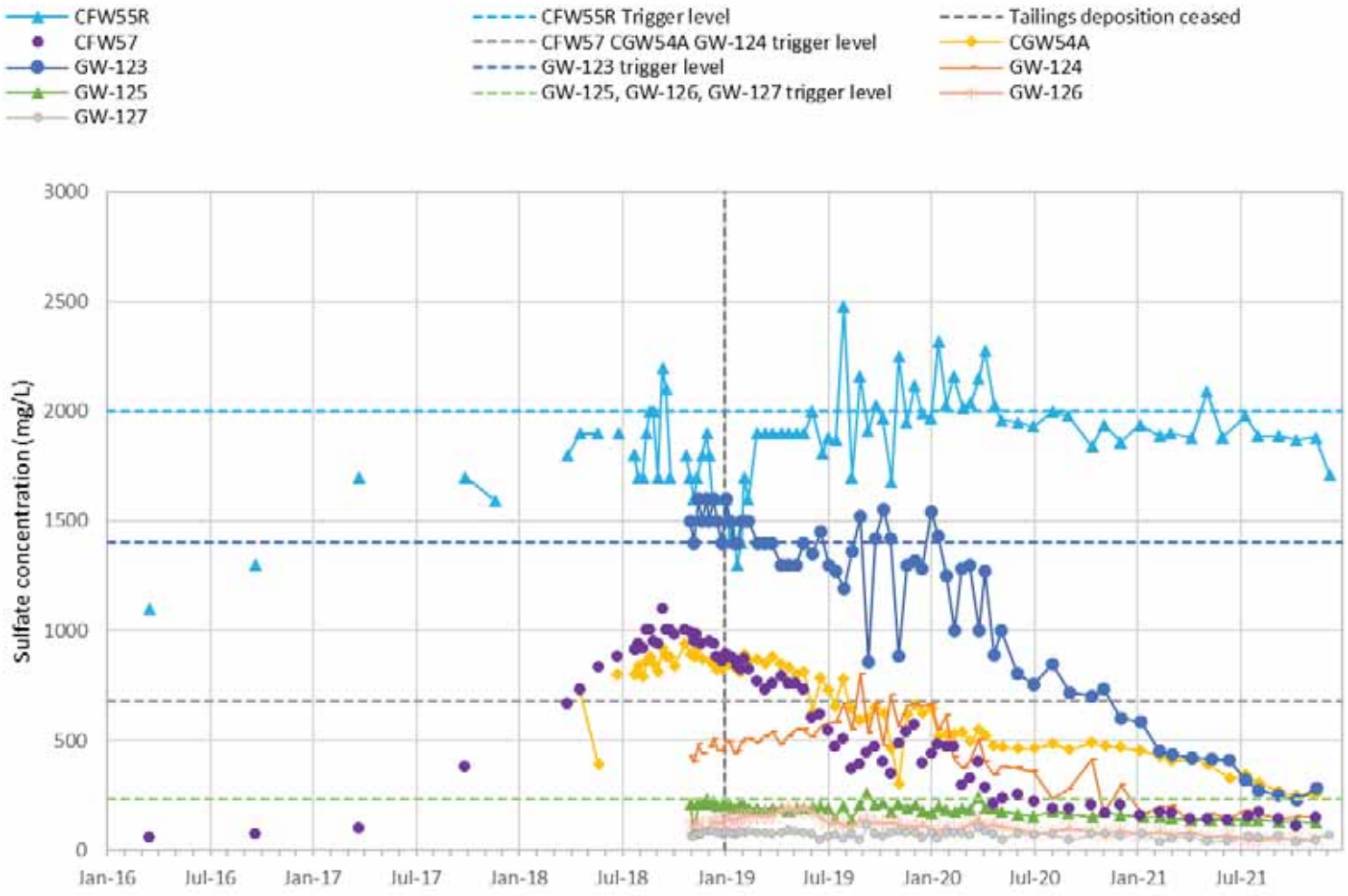
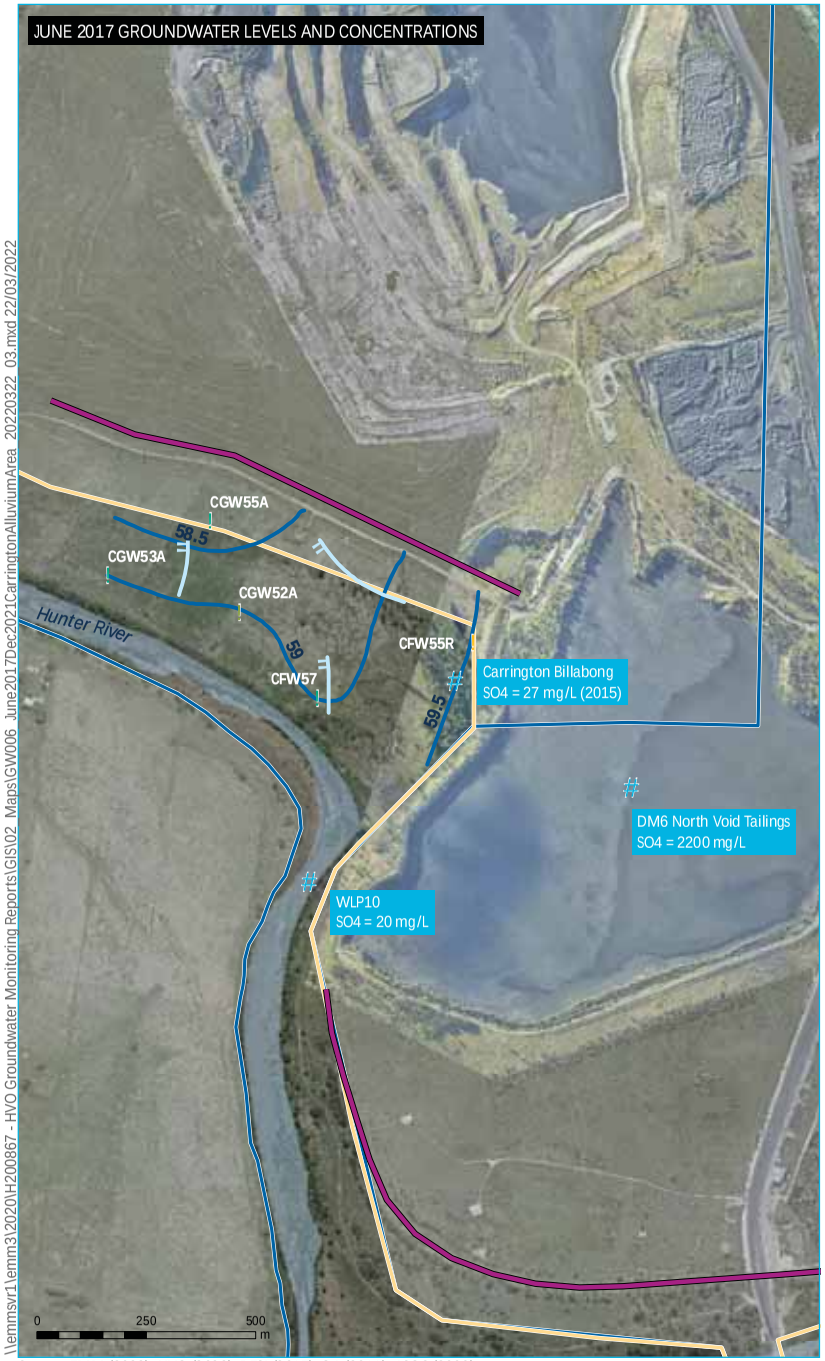
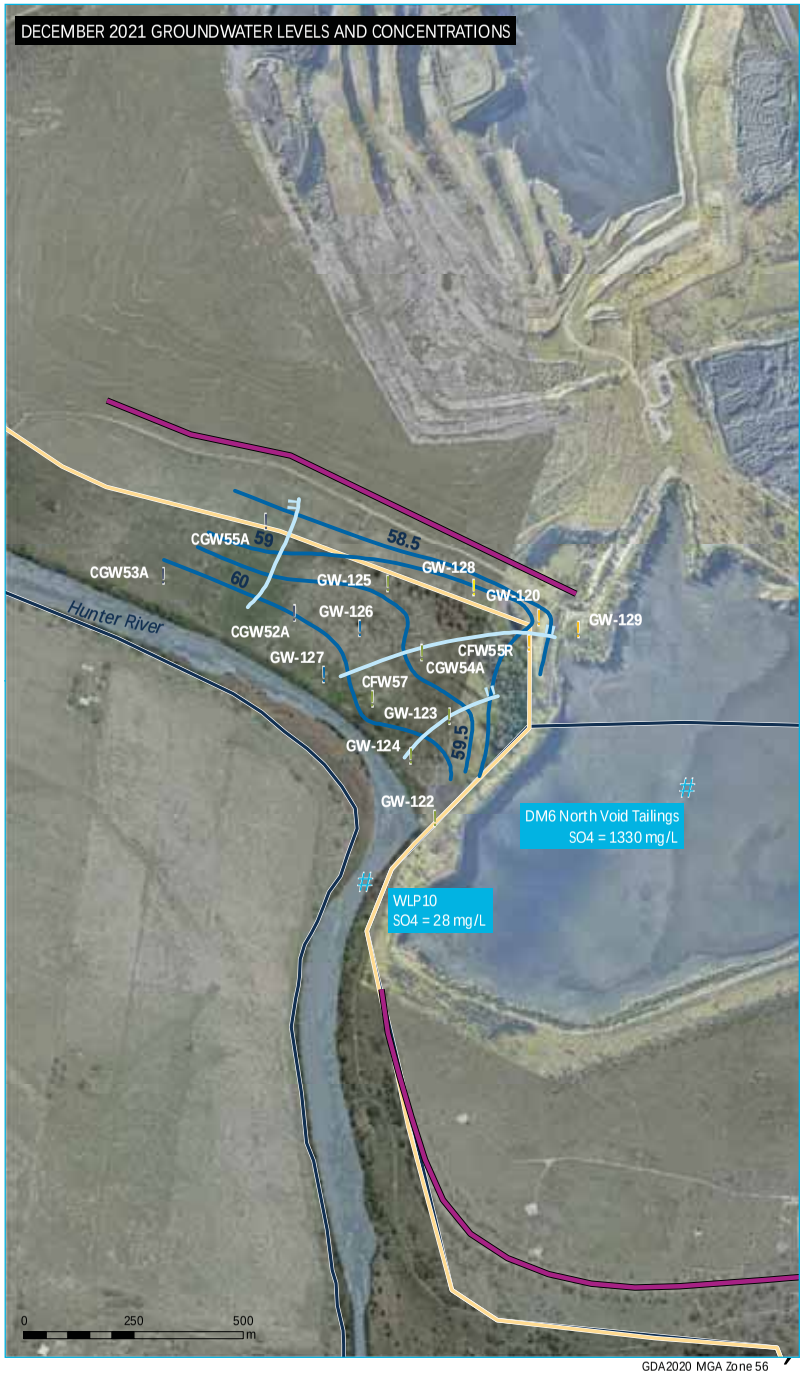
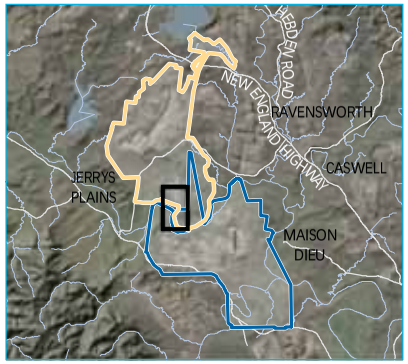


Figure 5.6 **Carrington Alluvium – sulfate concentration time series chart**







KEY

- Existing HVO North development consent boundary (DA 450-10-2003)
- Existing HVO South project approval boundary (PA 06-0261)
- Named waterbody
- Named watercourse
- Barrier wall
- Groundwater flow direction
- Groundwater contour (mAHD)
- # Surface water chemistry sample

Sulfate concentration (mg/L)

- ! 0 - 40
- ! 41 - 100
- ! 101 - 1000
- ! 1001 - 1600
- ! 1601 - 2000
- ! > 2000
- ! Other bore

Carrington alluvium area - June 2017 and December 2021 comparison

Hunter Valley Operations Pty Ltd
2021 Annual groundwater report
Figure 5.4

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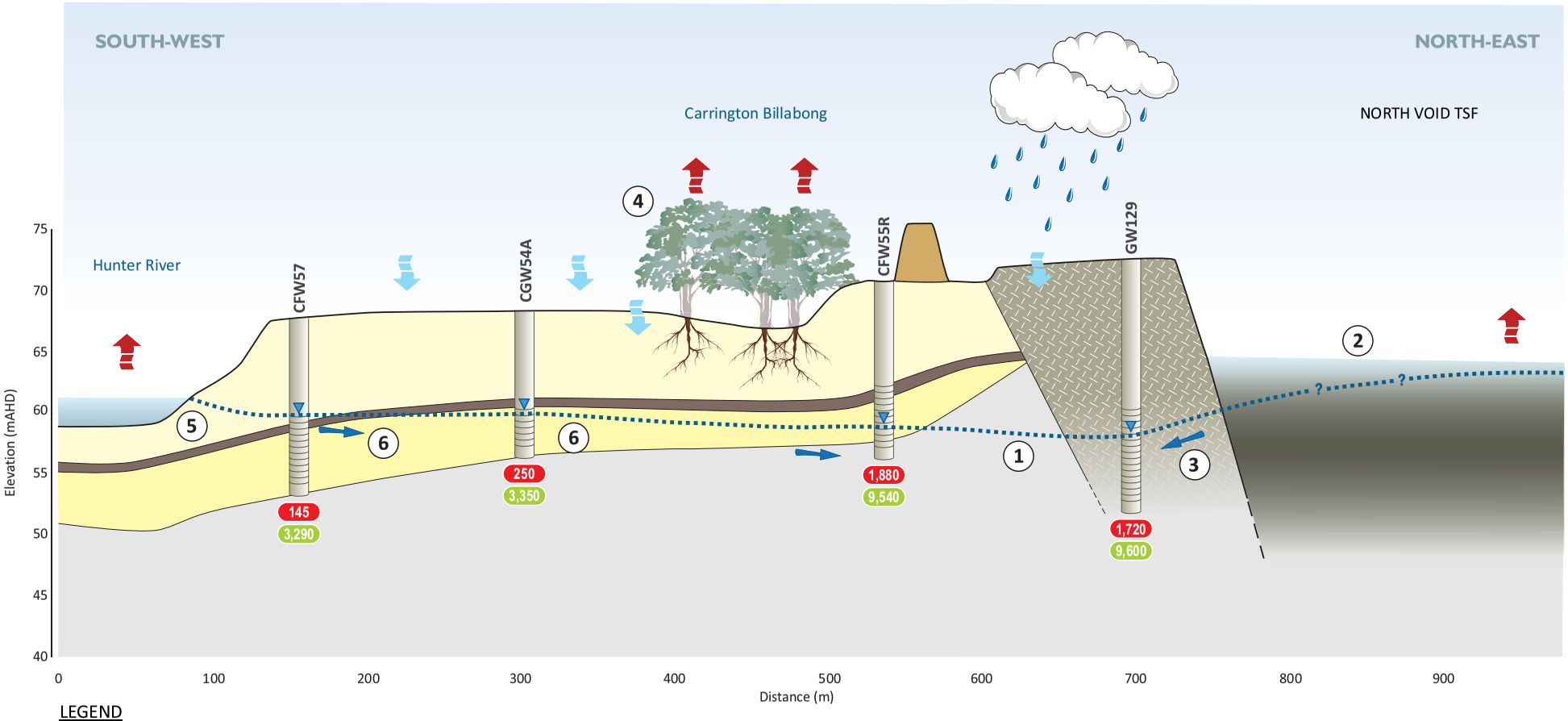
Source: EMM (2022); HVO (2022); DFSI (2017); GA (2011); ASGC (2006)

GDA2020 MGA Zone 56



Conceptual hydrogeological section (Carrington alluvium – NV TSF)

Hunter Valley Operations
2021 Annual groundwater review

Figure 5.8

5.2.2 Carrington – interburden

In 2021, pH results at bore CGW51A within the Carrington - Interburden exceeded the upper pH trigger value on two occasions (in June and December) (Figure 5.9). However, as reported in the 2020 annual groundwater review (SLR 2021), CGW51A is actually screened into the alluvium and a shallow coal seam. Water quality results from this bore are not considered representative of one groundwater unit. The revised WMP (2021) has removed this bore from the compliance monitoring network. As the revised WMP is still being reviewed, HVO is required to continue monitoring of this bore.

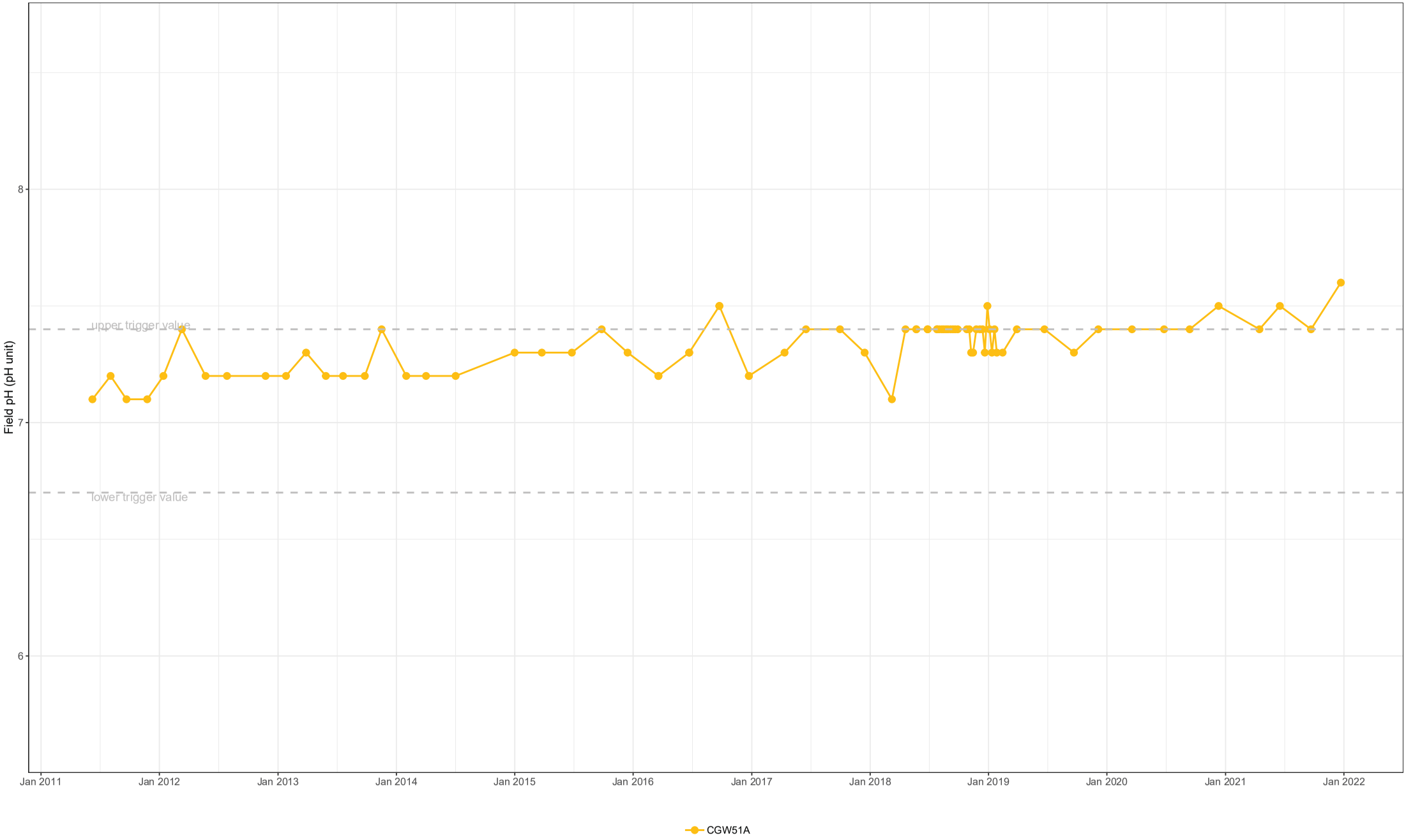
5.2.3 Carrington – Permian coal measures

In 2021, groundwater quality results at two bores (CGW52 and CGW53) within the Carrington - Broonie Seam exceeded the upper pH trigger values.

- CGW52, where the exceedance occurred in April 2021. The pH has since returned within acceptable range and no further action is required. Monitoring will continue in accordance with the WMP.

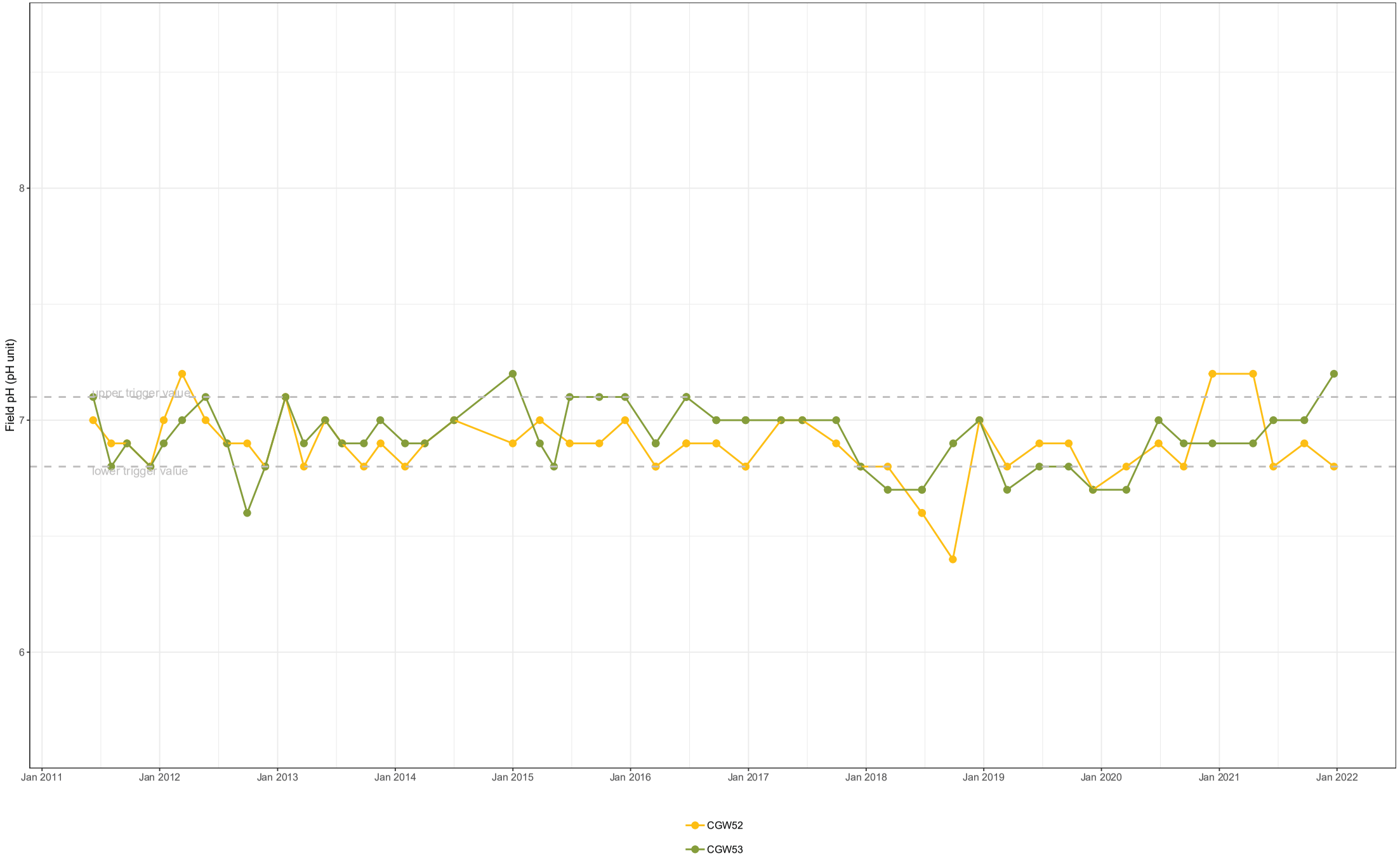
- CGW53, where the exceedance occurred in December 2021. As there has been only one exceedance, a site-specific investigation is not required (HVO 2018). The 2021 pH trend corresponds with declining groundwater elevations at this location (Appendix C). The cause for the water level decline (approximately 4 m) and higher pH is unclear. The recorded pH values are within the historical range. Monitoring will continue in accordance with the WMP and trends will be reviewed as part of the 2022 monitoring program.

Based on data from July 2011–December 2021 (Figure 5.10), prior exceedances of the upper pH trigger value have been recorded at bores CGW52 and CGW53.



Notes: Bore is actually screened in the alluvium and shallow coal seam

Carrington – Interburden groundwater time series (Field pH)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.9



EMM creating opportunities

Notes

Carrington – Broonie Seam groundwater time series (Field pH)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.10

5.2.4 Carrington West Wing – Floodplain Alluvium

a EC

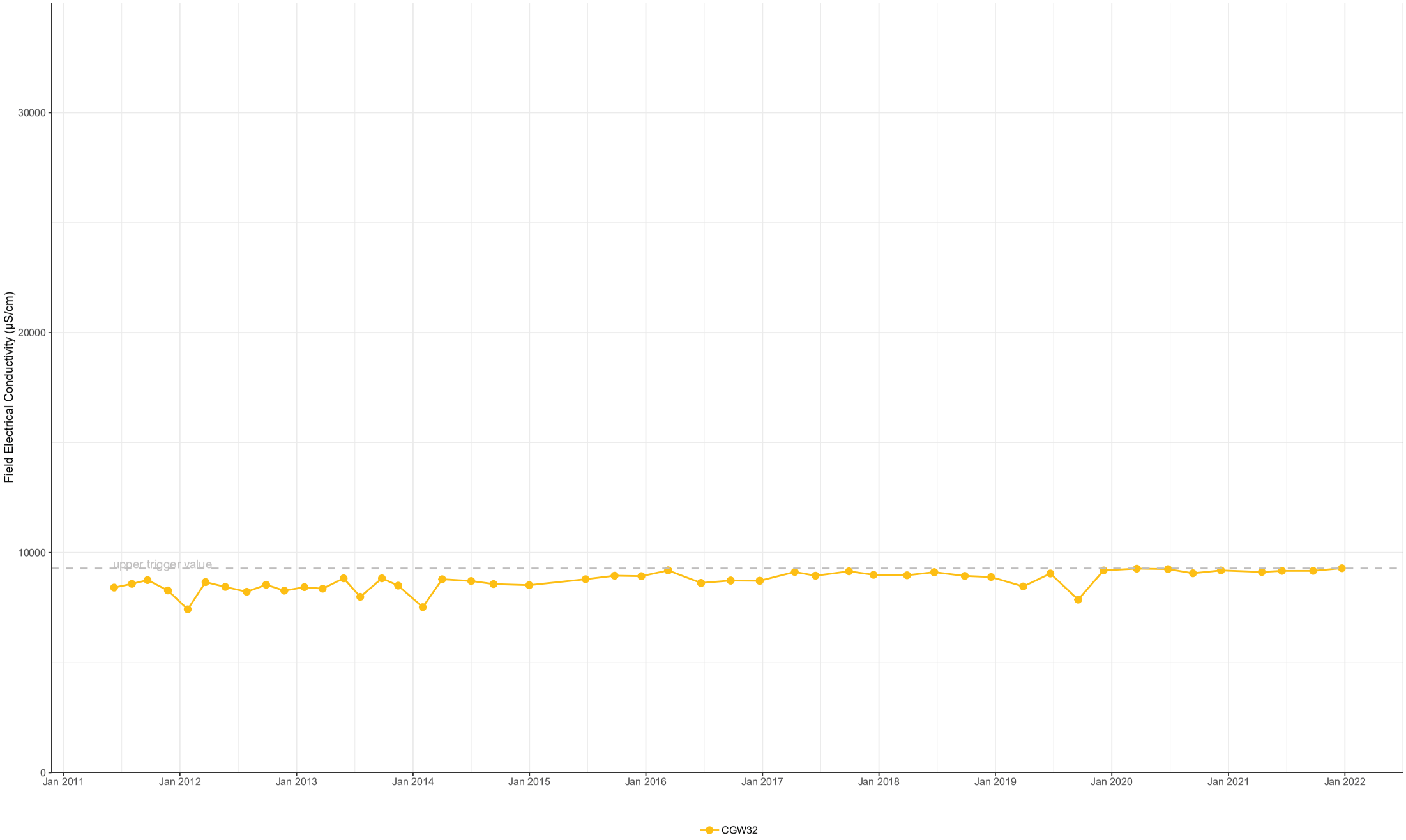
The EC trigger value was exceeded at bore CGW32 within the Carrington West Wing – Floodplain Alluvium on one occasion in 2021 (in December) (Figure 5.11). The exceedance was only 10 µS/cm above the trigger value of 9,280 µS/cm. Historically, EC has been close to the trigger value, however there is no apparent rising salinity trend. This bore is located in a remnant area of paleochannel alluvium between the West Pit and Carrington Pit (which has since been backfilled). The exceedance is considered minor; however, future trends should be monitored.

b pH

The lower pH value was exceeded at bore GW-106 within the Carrington West Wing – Floodplain Alluvium on one occasion in 2021 (in December) (Figure 5.12). Similar to CGW32, GW-106 intersects a remnant patch of paleochannel alluvium between West Pit and Carrington Pit (that has since been backfilled).

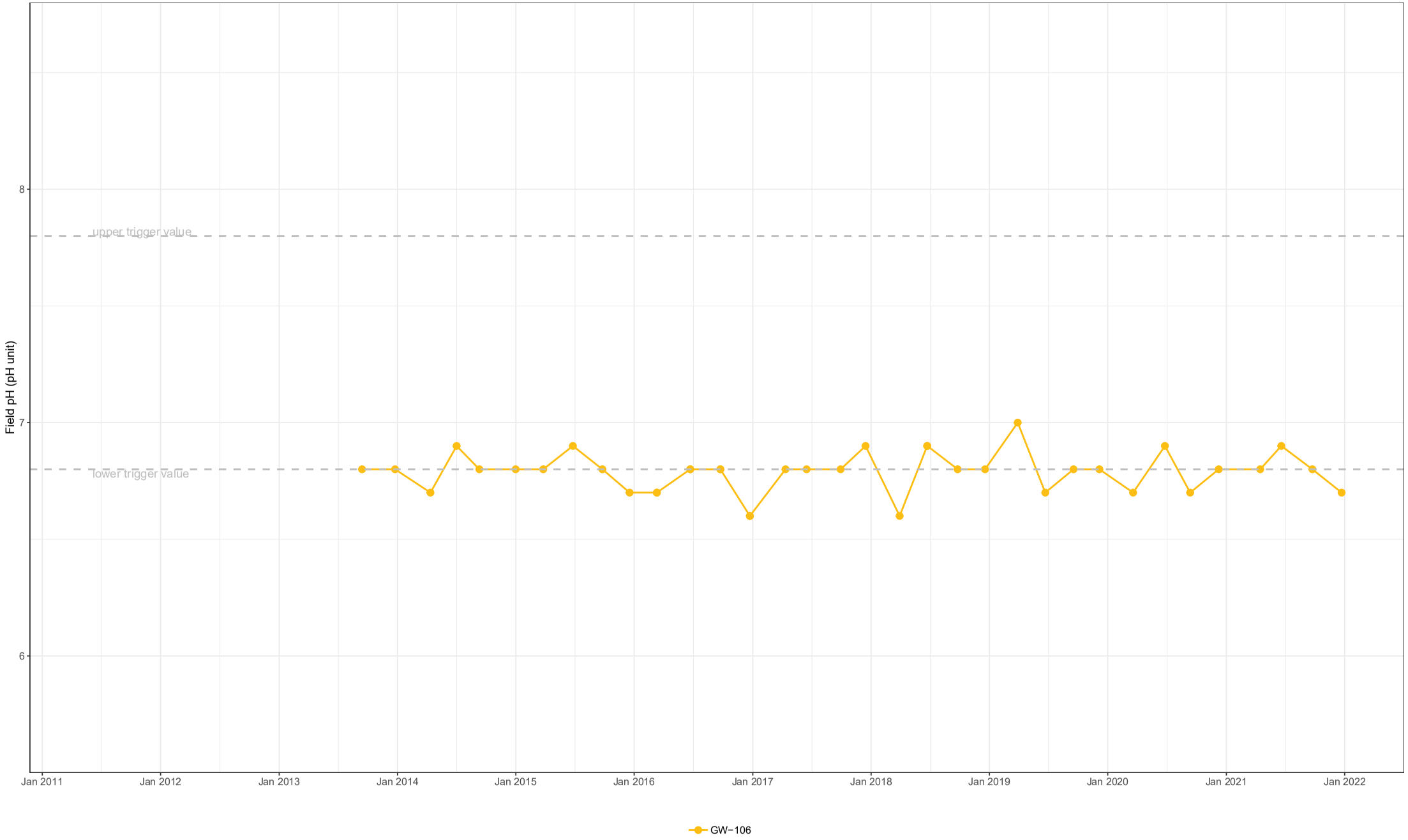
Since monitoring commenced in September 2013, bore GW-106 has recorded an average pH of 6.8 ranging between 6.6 and 7.0. The 2021 pH measurements are all within historical range.

It is recommended that the pH trigger levels be revised.



Notes

Carrington West Wing CGW32 field EC time series
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.11



Notes

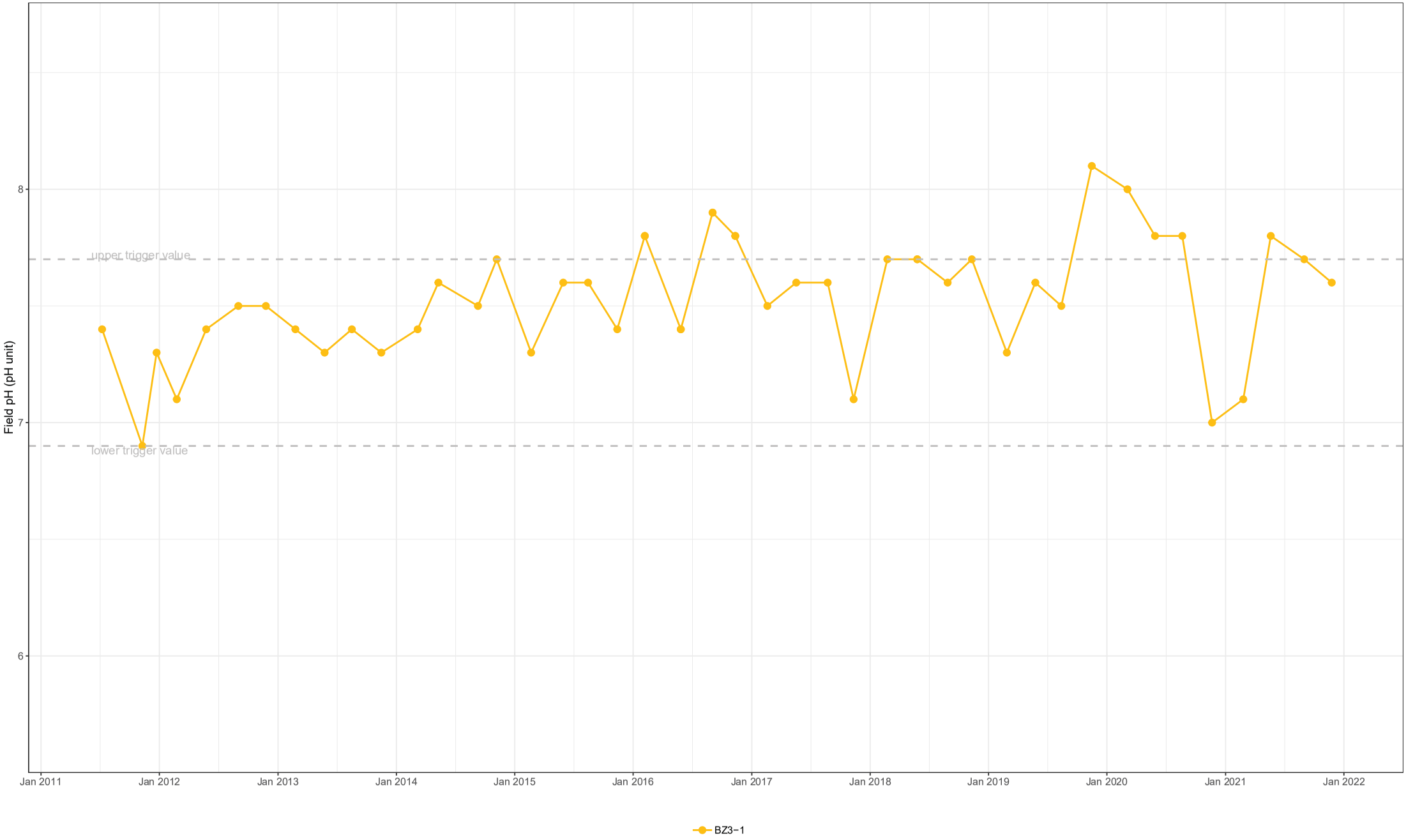
Carrington West Wing GW-106 field pH time series
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.12

5.2.5 Cheshunt – Interburden

In 2021, groundwater quality results at one bore (BZ3-1) within the Cheshunt - Interburden exceeded the upper pH trigger value in May 2021. Subsequent measurements returned below the upper trigger value. Therefore, no further investigation is required. The following discussion is provided to assist future assessment.

Based on data from July 2011–December 2021 (Figure 5.13), the following observations can be made:

- Occasional exceedances of the upper pH trigger value have been noted at bore BZ3-1.
- Field pH in bores BZ8-2 and HG2 (also within Cheshunt – Interburden) have fluctuated similarly, occasionally exceeding the lower pH trigger value. However, in 2021 the measured pH was within the trigger criteria.
- Due to the high variability of pH results, trends should continue to be assessed in accordance with the WMP.



Notes

Cheshunt − Interburden BZ3-1 field pH time series
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.13

5.2.6 Cheshunt – Permian coal measures

In 2021, groundwater quality results at three bores (BZ2A(1), BZ4A(2) and BZ3-3) within the Cheshunt - Permian coal measures all exceeded the lower pH trigger values (Figure 5.14). Due to prior and consecutive exceedances, a site-specific investigation is required in accordance with the WMP. The following discussion is provided to support the investigation.

Based on historical data, pH results from all three bores have been gradually trending downward since July 2011 (Figure 5.14). Field observations include odours of hydrogen sulfide within bores BZ2A(1), BZ4A(2) and BZ3-3, commonly associated with the oxidation of acid forming sulfides.

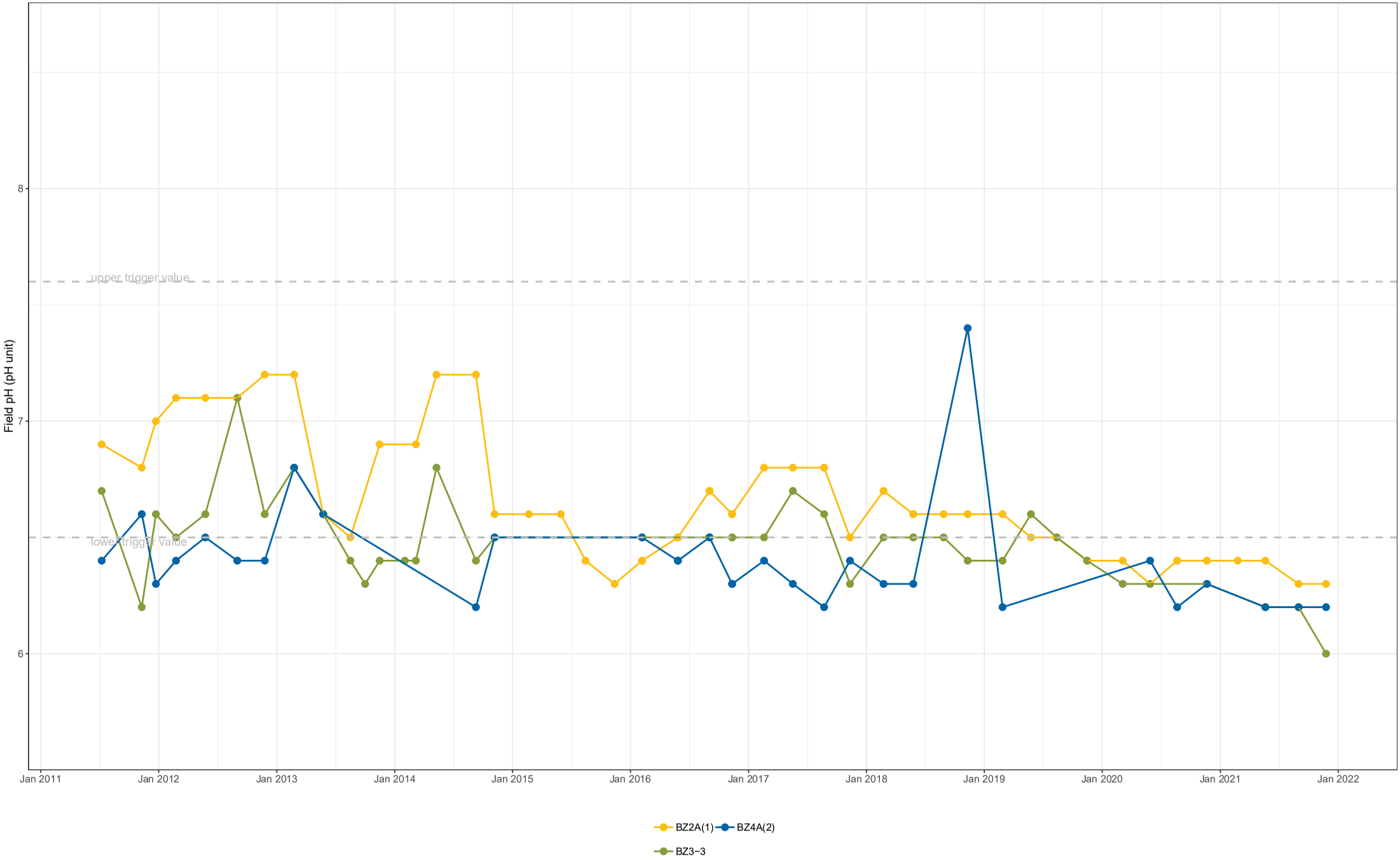
Geochemical characterisation assessments completed for environmental assessments for the complex indicates that oxidation of the Permian coal measures, including the Mt Arthur seam, could lead to a pH reduction (acidification).

The groundwater level measured at the bores has typically been within or below the screened section of bores BZ4A(2) and BZ3-3 (Figure 5.15). Purging/sample collection within bore BZ2A(1) and BZ3-3 may induce localised groundwater drawdown to within the screened section. This may be the cause of the reducing pH measured at these bores.

The updated draft WMP includes amendments to the Cheshunt - Mt Arthur seam groundwater monitoring, including:

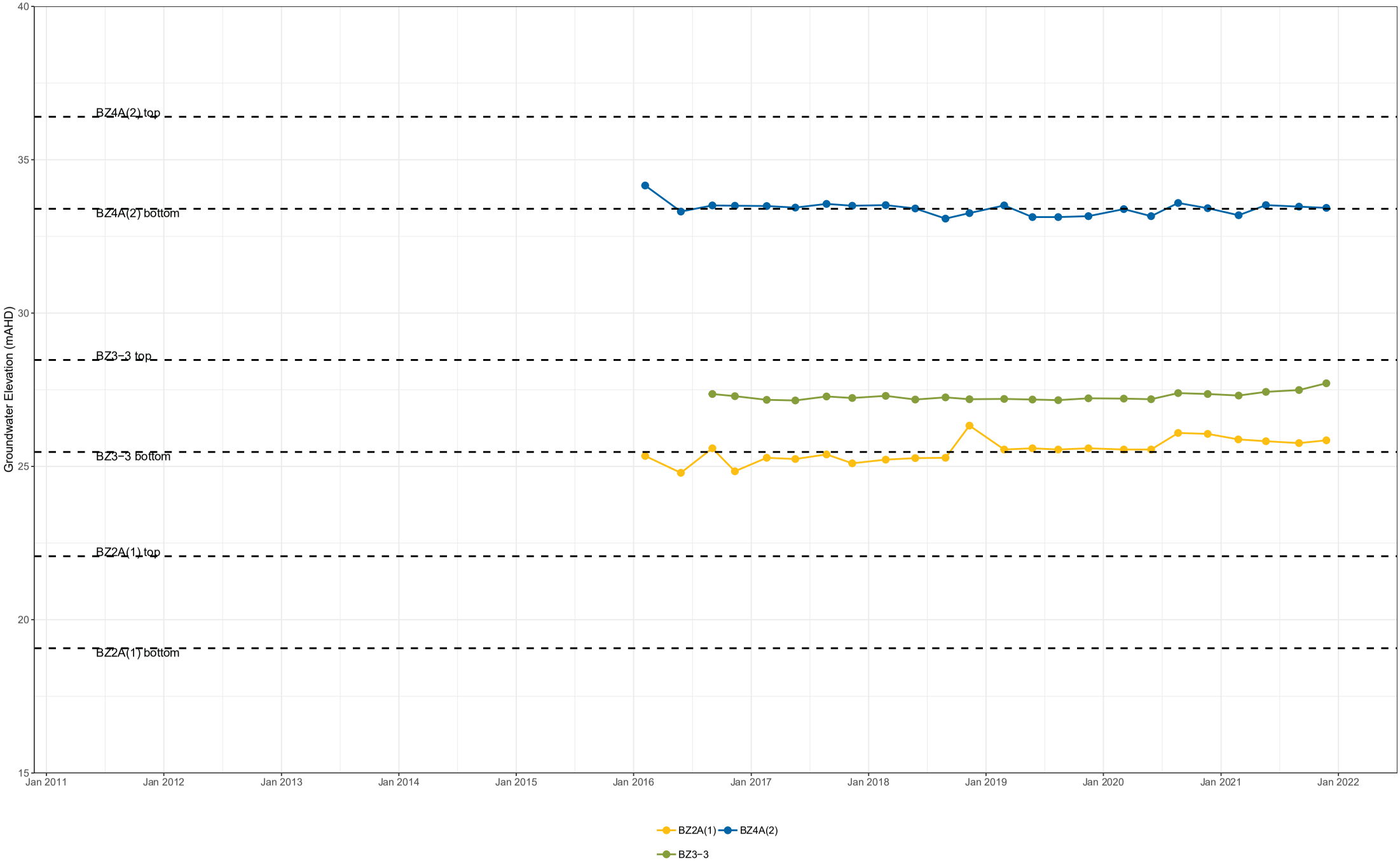
- BZ2A(1) and BZ3-3 being removed from trigger level assessment, with trigger values remaining for BZ4(A)2; and
- the pH trigger level value reducing to 6.4 (from the current value of 6.5) for all bores monitoring the Cheshunt - Mt Arthur Seam.

As the groundwater level measured at BZ4A(2) has been below the base of the screen, it is unlikely that the water sampled from this bore is representative of groundwater in the Mt Arthur seam. Based on this and the pH trend, exceedance of the pH lower trigger value and dry sampling events at BZ4A(2) is likely to continue. It is recommended that the pH trigger level for BZ4A(2) be revised and sampling (for water quality analysis) should not occur where the water level is below the base of the screen.



Notes

Cheshunt − Permian coal measures groundwater time series (Field pH)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.14



Notes

Cheshunt − Mt Arthur seam water levels and screen depths

Hunter Valley Operations

2021 Annual Groundwater Monitoring Review

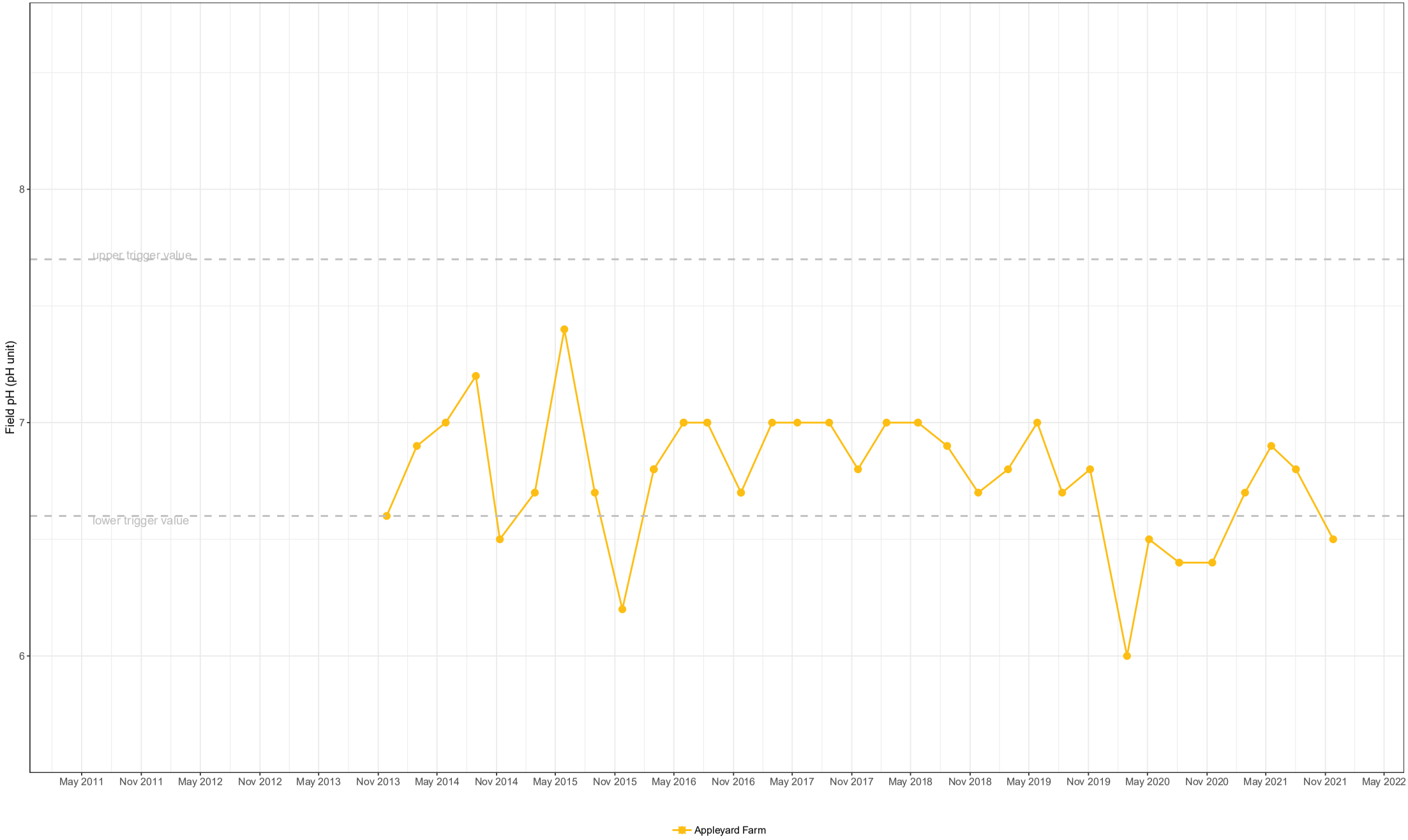
Figure 5.15

5.2.7 Lemington South – Alluvium (Appleyard Farm)

i pH

Sampling from the Appleyard Farm bore in December 2021 returned a pH reading below the lower pH trigger value (Figure 5.16). Prior pH readings in 2021 were within the trigger value range. Therefore, further investigation is not required at this stage. The following discussion is provided to assist future assessment.

The lower pH trigger value has been exceeded on several occasions since monitoring started in 2012. Appleyard Farm bore is located within 50 m of Wollombi Brook and, as such, groundwater levels at Appleyard Farm bore are influenced by flows in Wollombi Brook. As flow in Wollombi Brook is rainfall dependant, the recorded decrease in pH may be attributed to increased rainfall/streamflow recharge occurring in November and December 2021 (SLR 2020).



Notes

Lemington South − Alluvium groundwater time series (field pH)

Hunter Valley Operations

2021 Annual groundwater review

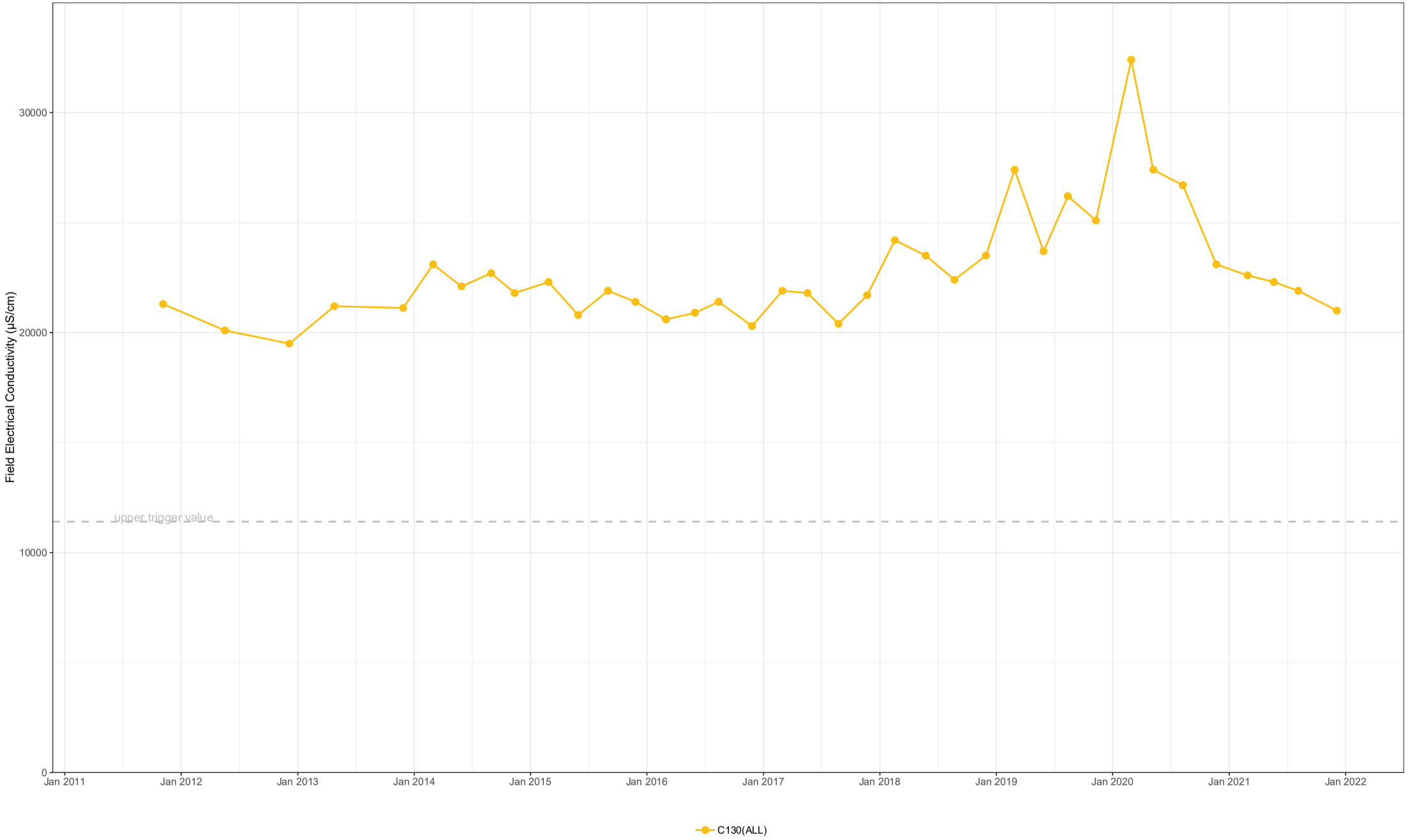
Figure 5.16

5.2.8 Lemington South – Interburden (C130[ALL])

i EC

As shown in Figure 5.17, all of the EC measurements in the period 2011-2021 have exceeded the trigger value of 11,408 µS/cm. Therefore, the EC trigger value for the Lemington South – Interburden is not considered appropriate to assess the potential impact of approved mining activity on groundwater at this bore location. EC values were consistently reported between 20,000 and 22,000 µS/cm from 2011 to 2017 and followed an increasing trend from 2018 to early 2020 reaching a maximum of 32,400 µS/cm in February 2020 as reported in previous annual groundwater reviews.

A downward trend has been observed since early 2020, which coincides with a period of increased rainfall following the recent drought. In the updated draft WMP (HVO 2021), C130(ALL) has been reassigned to Lemington South – Overburden, and the EC trigger value is proposed to increase to 23,500 µS/cm.



Notes

Lemington South − Interburden groundwater time series (Field EC)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.17

5.2.9 Lemington South - Permian coal measures

i EC

In 2021, groundwater quality results at three bores (B631(BFS), D010(GM) and C130(WDH)) screened within the Permian coal measures continued to exceed their EC trigger values.

The 2021 trigger value exceedance does not reflect a mining related impact. Historical monitoring data from July 2011–December 2021 shows that EC values have exceeded the trigger value at bores B631(BFS), D010(GM) and C130(WDH) for approximately 10 years (Figure 5.18). Therefore, the EC trigger value for the Lemington South - Bowfield Seam, Glen Munro Seam and Woodlands Hill Seam is not considered appropriate to assess mining activity induced groundwater impacts. The WMP (HVO 2021) has been updated to reflect this observation and the assignment of trigger values has been removed for bores B631(BFS) and D010(GM). The draft WMP includes a revised upper EC trigger value for all Woodlands Hill seam bores, including C130(WDH), to 20,900 µS/cm. However, future monitoring results may still exceed this trigger value and therefore may not be suitable for C130(WDH).

ii pH

In 2021, groundwater quality results at B631(BFS) within the Bowfield Seam exceeded the lower pH trigger value in May 2021. Subsequent measurement in December 2021 returned to above the lower trigger value.

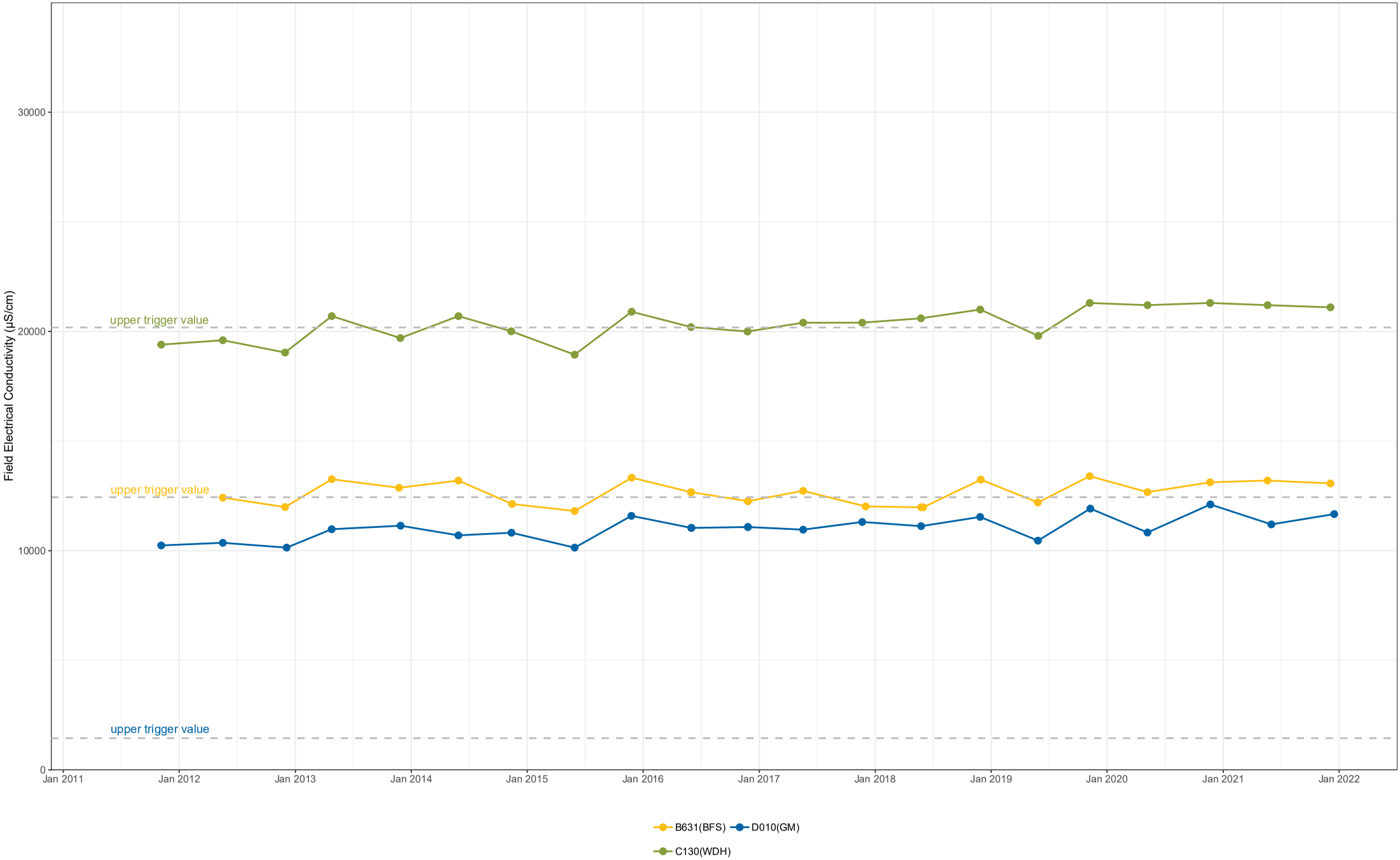
In 2021, groundwater quality results at C630(BFS) within the Bowfield Seam exceeded the upper pH trigger value. Historical pH data in bore C630(BFS) indicate (Figure 5.19):

- a slight upward pH trend between December 2017 to December 2020; followed by
- a downward pH trend, leading into Q2/2021.

Trends should continue to be assessed however, adjacent water storage within the underground workings at Lemington South may be affecting groundwater pH in the Bowfield seam in this area.

As stated above, trigger values are no longer assigned to B631(BFS) in the updated draft WMP. In addition, the upper pH trigger value has been increased to 8.0 (from 7.9) for all other Bowfield Seam bores (in the Lemington South area).

Based on historical data (Figure 5.19), exceedance of the revised pH trigger values at C630(BFS) may continue, despite the revised trigger value. pH trends will continue to be monitored.



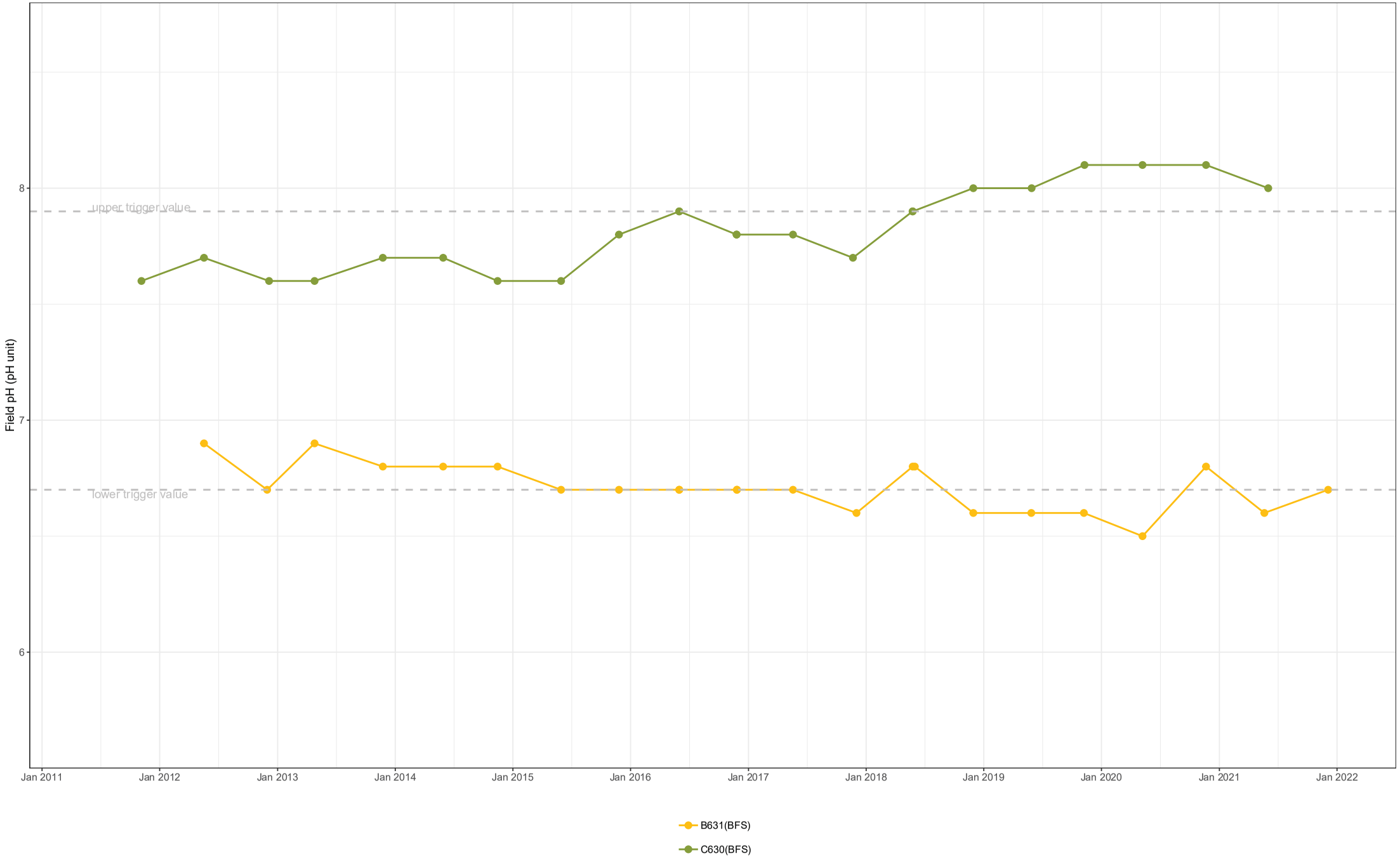
Notes

Lemington South − Permian coal measures groundwater time series (Field EC)

Hunter Valley Operations

2021 Annual Groundwater Monitoring Review

Figure 5.18



Lemington South − Permian coal measures groundwater time series (Field pH)

Hunter Valley Operations

2021 Annual Groundwater Monitoring Review

Figure 5.19

Notes

5.2.10 North Pit – Spoil

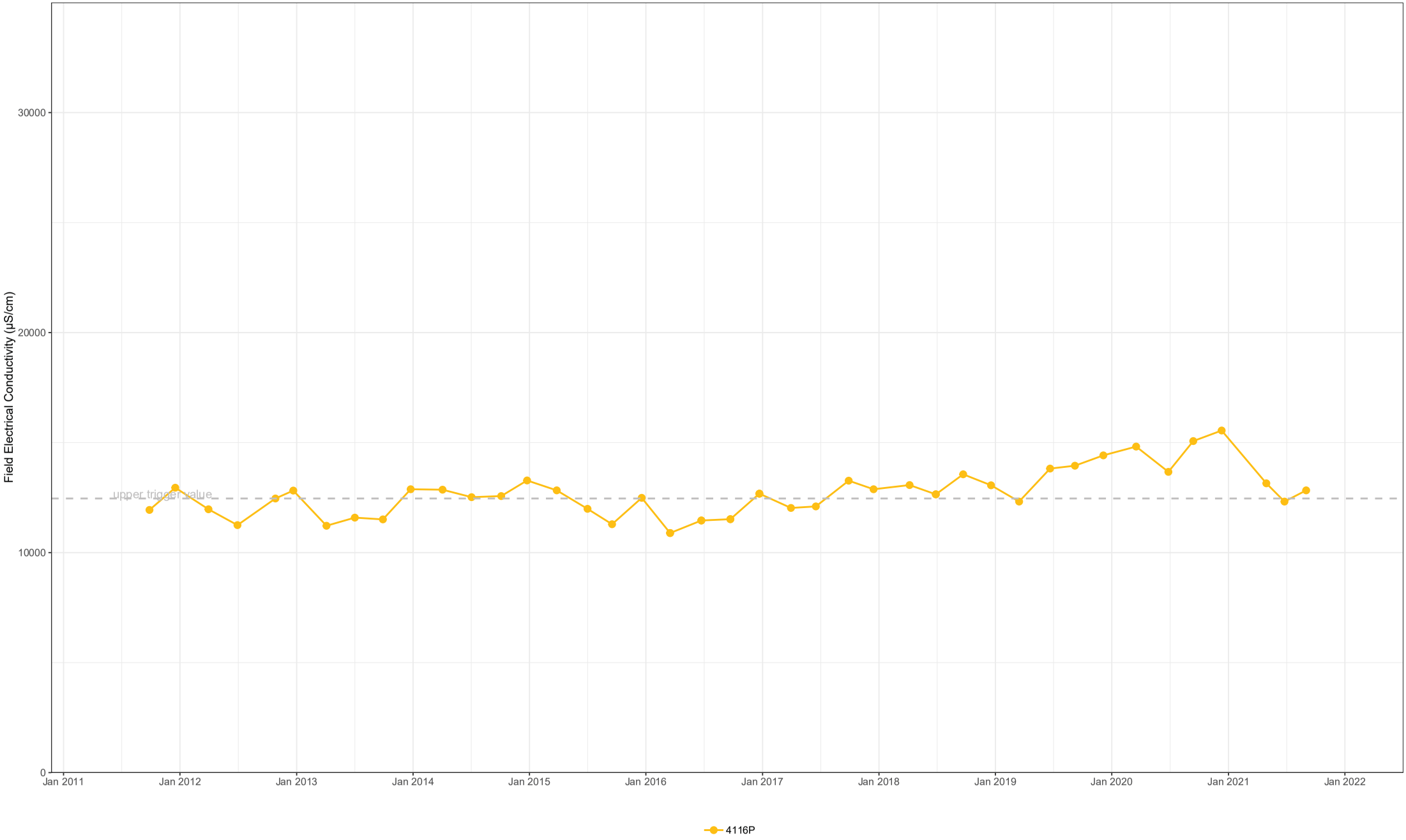
In 2021, groundwater quality results within the North pit - Spoil exceeded the:

- EC trigger level at 4116P (Figure 5.20); and
- lower pH trigger level at DM1 and DM3 (Figure 5.21).

Based on data from July 2011–December 2021:

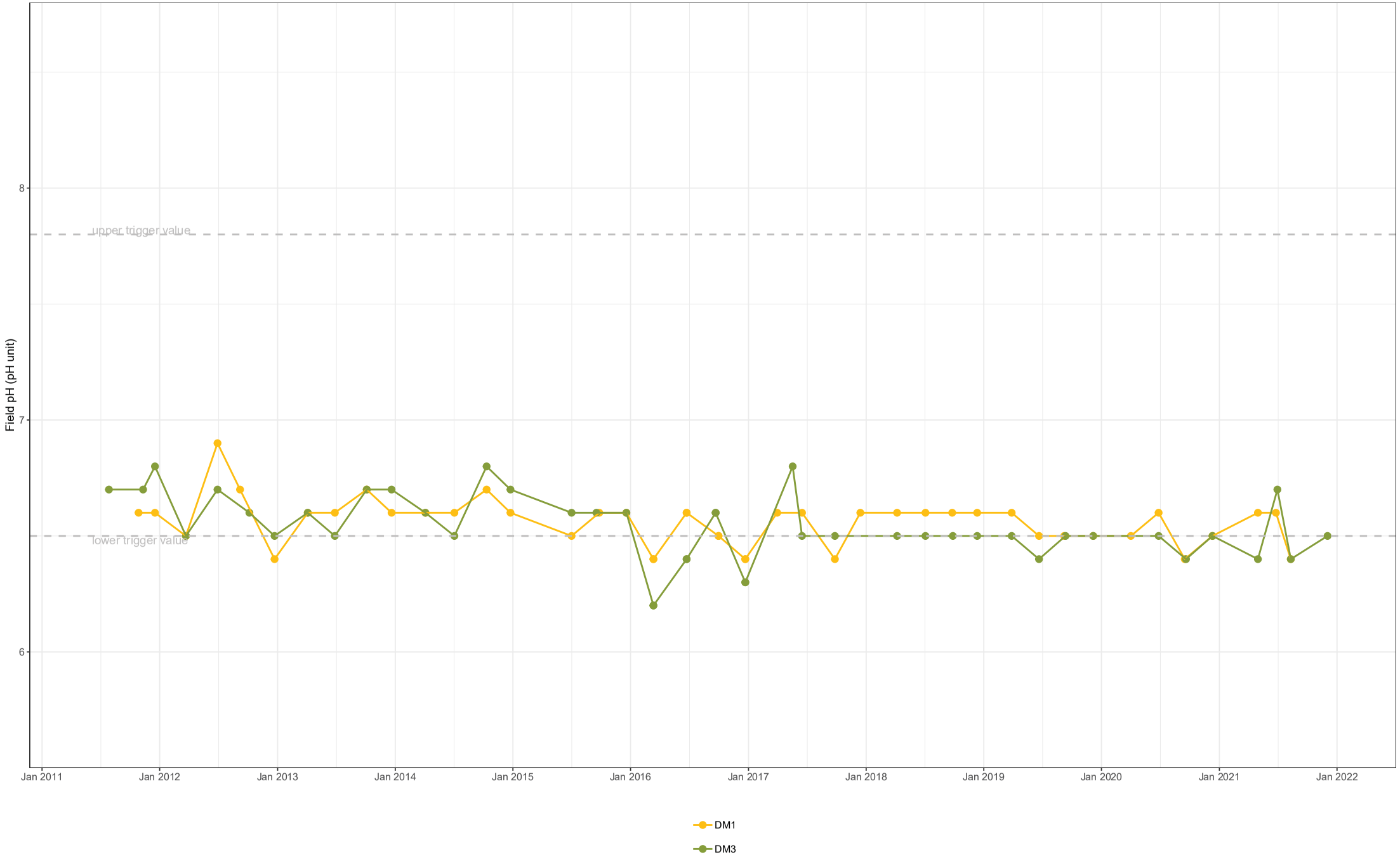
- EC trigger value exceedances within bore 4116P (Figure 5.20) have been occurring historically, with exceedances occurring prior to December 2013. Historically, water levels have been below the screened interval at this bore and it has had numerous blockages reported since 2015; and
- pH levels recorded at DM1 and DM3 have been consistently low, frequently being reported at the lower pH trigger value (Figure 5.21).

The groundwater in the spoil is not considered to be connected to the regional watertable. In addition, monitoring has shown the effectiveness of the Alluvial Lands Barrier Wall in this area. As such, the updated draft WMP (HVO, 2021) no longer includes trigger values for North Pit – spoil monitoring bores.



Notes

North Pit − Spoil (4116P) field EC time series
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.20



Notes

North Pit − Spoil groundwater time series (Field pH)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.21

5.2.11 West Pit - Interburden

In 2021, EC continued to exceed the trigger value at monitoring bore NPZ2 as shown in Figure 5.22.

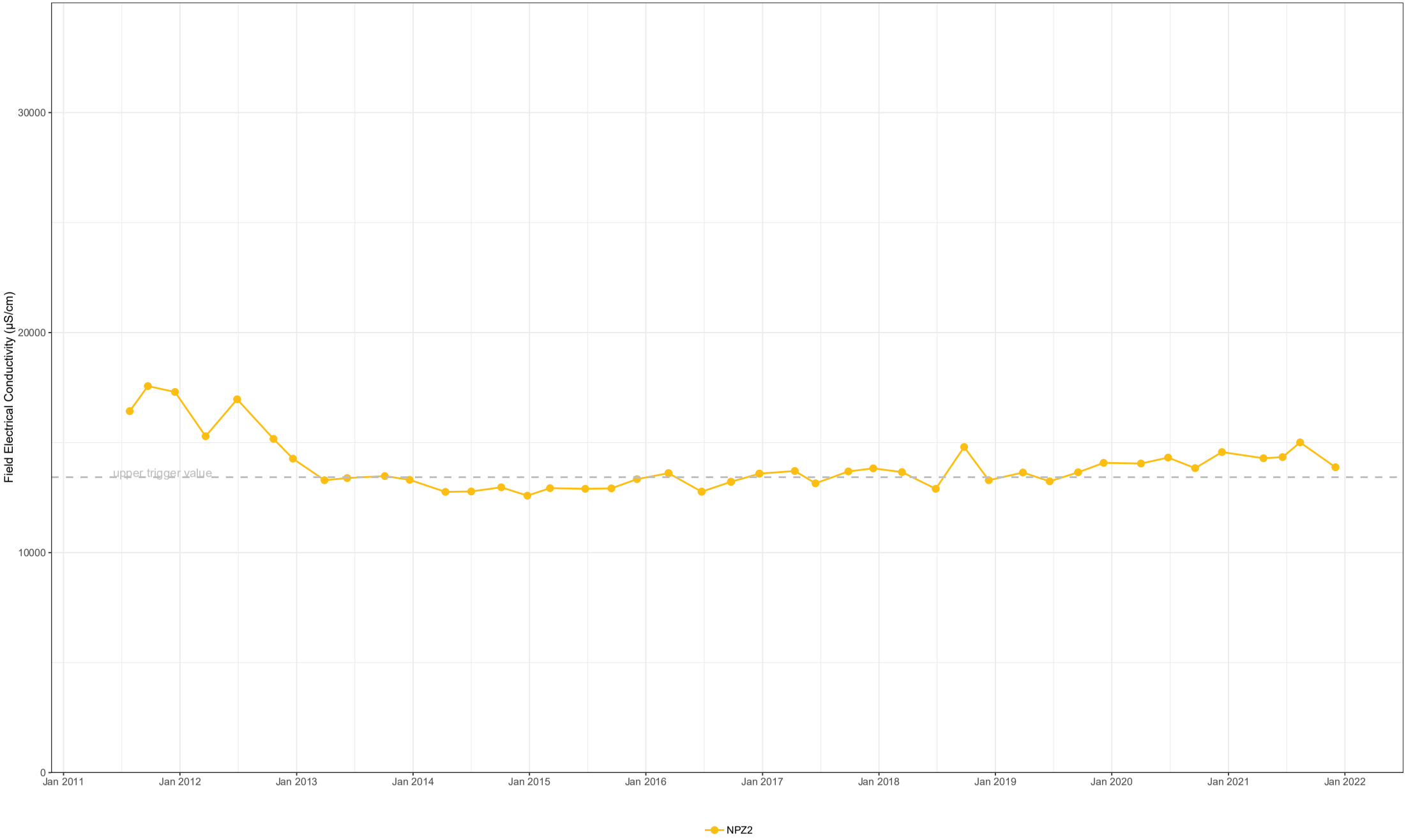
Historical data from July 2011–September 2021 shows that EC values have consistently been close to or above the EC trigger value at bore NPZ2 (Figure 5.22). Groundwater salinity (as EC) began gradually increasing from July 2019. Groundwater levels have been stable at this location. The cause for the increasing trend is unclear as the monitoring bore is located north-west of mining-related activity (such as tailings storage, waste emplacement or active mining).

The updated draft WMP (HVO 2021), no longer includes groundwater monitoring within the West Pit – Interburden. Therefore, assuming the draft WMP is accepted by DPE Water, further investigation is not required.

5.2.12 Cheshunt/ North Pit – Alluvium

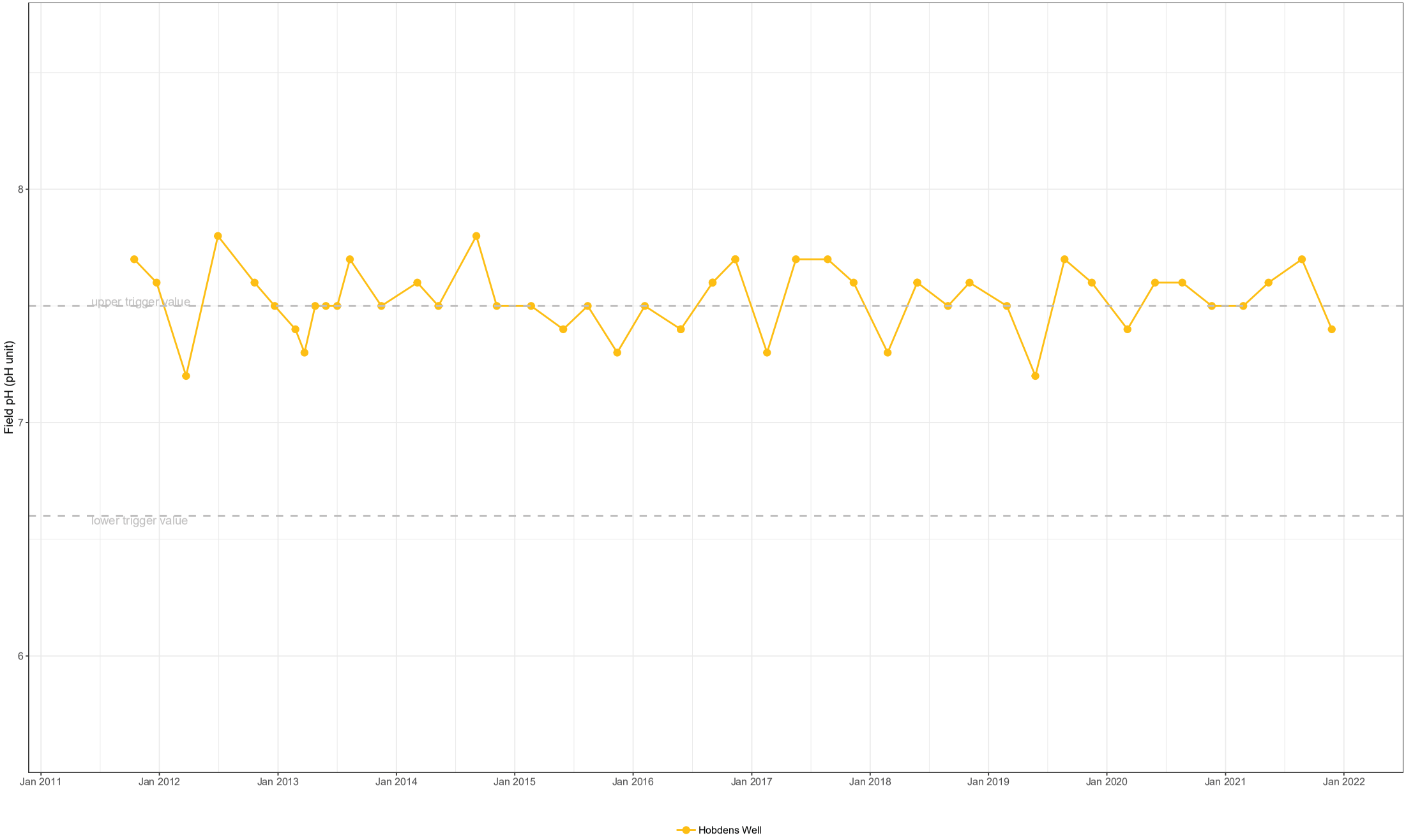
Groundwater quality samples collected from Hobdens Well located in the Cheshunt/North Pit monitoring area (and close to the Hunter River) exceeded the upper pH trigger value during the reporting period (Figure 5.23). Historical data from 2011 show that pH values have consistently been close to or above the pH upper trigger level value at Hobdens Well. The pH records are not indicative of a change in groundwater conditions at this bore and no adverse impacts have been identified.

The updated draft WMP (HVO 2021), no longer includes trigger levels for Hobdens Well. Therefore, assuming the draft WMP is accepted by DPE Water, further investigation is not required.



Notes

West Pit − Interburden (NPZ2) field EC time series
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.22



Notes

Chesthunt / North Pit − Alluvium field pH time series
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Figure 5.23

5.3 Trend analysis

This section summarises the data and trends for each of the monitoring areas.

5.3.1 Carrington

i Alluvium

There are six monitoring bores in the Carrington alluvium: CFW55R, CFW57, CGW52A, CGW53A, CGW54A and CGW55A.

Groundwater levels

Groundwater level trends observed at bores installed within the Carrington alluvium correlate with climatic variations (Figure 5.2), with groundwater levels generally increasing consistently with the high rainfall events of 2021 (particularly November and December 2021).

Water quality

- EC measurements in the Carrington alluvium were generally stable in 2021. CFW57 and CGW54A showed a slight increase towards the end of 2021 (Figure 5.2). However, measurements remained within historical ranges and long-term trends are stable to slightly decreasing. With the exception of CFW55R (which is discussed further in Section 5.2.1), EC readings were below trigger levels.

- In 2021, measured pH in the Carrington alluvium bores has fluctuated within historical ranges and does not show any adverse trends (Appendix B).

ii Permian coal measures

There are three bores in the Carrington area targeting the Permian interburden: 4036C, CGW51A and 4051C; and two bores in the Broonie Seam: CGW52 and CGW53.

Groundwater levels

In 2021, groundwater levels have been stable to slightly increasing in the Carrington interburden, consistent with the long-term trend (Appendix C).

Groundwater levels in bore CGW52 in the Carrington– Broonie Seam have been increasing, following the long-term trend (Appendix C). However, groundwater levels measured at CGW53 declined approximately 3 m between June and December 2021 (over two monitoring events). The measurements could be erroneous, however future trends should be monitored.

Water quality

- EC measurements have been relatively stable in 2021, with the exception of CGW51A (interburden) which continued to decline (Appendix B).

- Measured pH has been fluctuating within historical ranges in 2021 (Appendix B), with the exception of CGW51A (interburden) where an increase in pH was observed (refer to Section 5.2.2 for more details).

iii Spoil

There are three bores installed in spoil in the Carrington area: GW-107 (west of Carrington Pit), GW-108 (adjacent to Carrington Pit (on the west)) and GW-129 (adjacent to NV TSF (on the west)).

Groundwater levels

Bores GW-107 and GW-108 have been consistently dry since monitoring commenced (Appendix C).

Groundwater levels in bore GW-129 have been relatively stable in 2021, slightly increasing towards the end of the year following the very large rainfall events of November and December 2021.

Water quality

- EC measurements at GW-129 have been stable in 2021, showing no adverse trend (Appendix C).
- Measured pH has been stable over 2021, consistent with the long-term trend (Appendix C).

5.3.2 North Void

Nine additional groundwater monitoring bores (GW-120 to GW-128) were installed in 2018 to the west of the NV TSF; including eight bores in the alluvium and one (GW-122) installed in the interburden. A ninth bore (GW-129) was installed in the spoil adjacent to the NV TSF (trends are discussed above).

Groundwater levels

Bores near the NV TSF were installed in 2018 to delineate the extent of impacts associated with seepage from the NV TSF and monitor response to management practices. Monitoring began in October 2018. In 2021, groundwater levels to the west of the NV TSF followed climatic variation, generally increasing throughout the year, with a sharp rise following the high rainfall and flood events of November and December 2021 (Appendix C). The observed increase in groundwater levels is not indicative of seepage from the NV TSF.

Water quality

- EC measurements near the NV TSF at GW-120, GW-126, GW-127 and GW-128 have been relatively stable throughout 2021 (Appendix C).
- EC measurements at GW-123, GW-124, GW-125 show a declining trend, consistent with historical trends (Appendix C).
- Measured pH has been stable over 2021, consistent with the long-term trend (Appendix C).

5.3.3 Carrington West Wing

i Alluvium and Floodplain alluvium

There are five bores in the Carrington West Wing alluvium: 4032P, 4034P, 4037P, 4040P and CGW49; and four bores in the Carrington West Wing floodplain alluvium: CGW32, CGW39, CGW47A and GW-106.

Groundwater levels

Groundwater levels in bores in the Carrington West Wing alluvium and, to a lesser extent, the Carrington West Wing floodplain alluvium showed responses to climatic and stream flow variations in 2021 (Appendix C). There are two groundwater level measurements that are considered erroneous (data entry errors):

- the April 2021 reading CGW49, where the depth to water is thought to be 9.45 m instead of 5.45 m; and
- the June 2021 reading at GW-106, where the depth to water is thought to be 23.37 m instead of 28.37 m.

Subsequent readings were back within historical ranges.

Groundwater levels at CGW47A, located within the "floodplain alluvium" monitoring area continued to show an increasing trend in 2021, following re-saturation in December 2020.

Water quality

- EC readings have remained relatively stable since monitoring commenced in 2011 and during 2021, with the exception of GW-106 where a sharp decrease was observed in December 2021 (Appendix B). Flood water is thought to have leaked inside the bore during the high rainfall of November and December 2021 flooding the site and causing an erroneous EC reading.
- EC increased at 4032P in May 2021, however remained stable for the remainder of the year and below the trigger value (Appendix B).
- Measured pH was within historical ranges (Appendix B). Sampling at GW-106 in December 2021 recorded a decline in field pH. As with the EC reading, this pH value is thought to be erroneous and caused by the high rainfall and flooding that occurred in late 2021.

ii Permian coal measures

There are two bores in the Carrington West Wing – Bayswater Seam: CGW45 and CGW46. CGW45 is blocked and has not been monitored since 2018. CGW45 has been removed from the monitoring program in the draft WMP (HVO 2021).

Groundwater levels

Bore CGW46 intersects the shallow Bayswater Seam (approximately 13 m deep) underlying alluvium on the western limb of the paleochannel.

In 2021, groundwater levels increased approximately 0.5 m, probably in response to the high rainfall in 2021 (Appendix C).

Water quality

EC and pH measurements at CGW46 have been stable since monitoring started in 2012. The 2021 results followed this long-term trend (Appendix C).

5.3.4 Cheshunt

i Interburden

There are three bores in the Cheshunt area monitoring the interburden: BZ3-1, BZ8-2 and HG2.

Groundwater levels

For the three bores, groundwater levels have been recorded since 2016 (Appendix C). Groundwater levels increased slightly in 2021 at the three bores.

Water quality

- EC readings have remained relatively stable since monitoring commenced in 2011, with a slightly decreasing trend at HG2 since 2016 (Appendix B). No exceedances have been reported.
- Measured field pH in bores BZ8-2 and HG2 during 2021 was consistent with historical trends, with readings fluctuating around the lower trigger value between 2015 and 2020 (Appendix B).
- Measured field pH in BZ3-1 has fluctuated within the lower and upper trigger values, with 8 exceptions, where the upper trigger value has historically been exceeded (Appendix B). In 2021, there was one exceedance in Q2. However, the remainder of the measured pH was within the trigger criteria.

ii Permian Coal Measures

There are nine monitoring bores in the Cheshunt-Permian Coal Measures: BC1a, BZ1-3, BZ2A(1), CHPZ12D, HG2A, BZ3-3, BZ4A(2), CHPZ3D and CHPZ8D within the Mt Arthur Seam, and bore BUNC45D in the Piercefield Seam.

Groundwater levels

Groundwater elevations in the Mt Arthur Seam have historically displayed minimal fluctuation (Appendix C), suggesting minimal recharge from rainfall, or depressurisation from mining.

Groundwater levels at BUNC45D (installed in the Piercefield seam) have been displaying an overall slight increasing trend since early 2019.

Water quality

- EC readings from Mt Arthur Seam bores have remained relatively stable in 2021, and below the trigger value (Appendix B).
- In 2021, most Mt Arthur Seam bores displayed an overall declining trend. The lower pH trigger value was exceeded in bores BZ2A(1), BZ4A(2) and CHPZ3D during 2021. Since monitoring began in 2011, recorded field pH readings have consistently exceeded the minimum pH trigger in bores BZ2A(1), BZ4A(2) and BZ3-3 (Appendix B). This is discussed further in Section 5.2.6.

5.3.5 Cheshunt/North Pit

i Alluvium

There are 17 bores installed in alluvium in the Cheshunt/North Pit area: BUNC45A, BZ1−1, CHPZ10A, CHPZ12A, CHPZ1A, CHPZ2A, CHPZ3A, CHPZ4A, CHPZ8A, GA3, Hobdens Well, HV3(2), PZ1CH200, PZ2CH400, PZ3CH800, PZ4CH1380 and PZ5CH1800.

Water levels

Groundwater levels in the Cheshunt/North Pit – Alluvium generally showed an increasing trend towards the end of 2021 (Appendix C), correlating with high rainfall and associated high stream flow in the Hunter River.

Groundwater levels at PZ2CH400 decreased sharply in early 2021, displaying different trends to that observed at PZ1CH200 which is located a short distance upstream of PZ2CH400. Fluctuations in water elevations were previously noted and the bore was checked in 2020 (as recommended in the 2019 annual groundwater review (SLR 2020)). The investigation showed PZ2CH400 was collared at ground level, allowing surface water to enter the bore. Therefore, recorded water levels were not representative of actual groundwater elevations. The standpipe was extended in December 2020 to prevent surface water from entering the bore. Recorded groundwater levels returned to levels representative of the area in early 2021 (hence the sharp decrease).

Water quality

EC and pH measurements have been stable in 2021 and within historical ranges (Appendix B).

5.3.6 Lemington South

i Alluvium

There are three bores within the Lemington South – Alluvium: C919(ALL), Appleyard Farm and PB01(ALL).

Groundwater levels

Groundwater level trends in the Lemington South – Alluvium show strong correlation with the climatic variations (Appendix C). A declining trend was observed from 2016 to early 2020 (end of a severe drought). In 2020, water levels rose sharply, consistently with the high rainfall and associated flood event in March 2020, rising stream levels in the Wollombi Brook. Since then, groundwater levels have fluctuated with rainfall.

Appleyard Farm bore is the closest bore to the LUG Bore. It shows no clear impacts on the alluvium in response to abstraction from the LUG Bore.

Water quality

- EC readings have been relatively stable and below the trigger value in 2021 (Appendix B). Historically, EC exceedances were reported at PB01(ALL) until 2020. The sampling methodology was revised in 2019, therefore the change may be attributed to the collection of more representative samples. Alternatively, the response may be related to climatic variations.

- In 2021, pH readings were stable and within historical values (Appendix B).

ii Permian coal measures

There are 29 bores in the Permian coal measures in the Lemington South area:

- 1 bore in the shallow interburden material: C130(ALL);
- 4 bores in the Arrowfield Seam: C130(AFS1), D406(AFS), D510(AFS) and D612(AFS);
- 8 bores in the Glen Munro Seam and/or Woodlands Hill Seam: B425(WDH), B631(WDH), C122(WDH), C130(WDH), C317(WDH), C809(GM/WDH), D010(WDH) and D010(GM); and
- 16 bores in the Bowfield Seam: B334(BFS), B631(BFS), B925(BFS), C122(BFS), C130(BFS), C317(BFS), C613(BFS), C621(BFS), C630(BFS), D010(BFS), D214(BFS), D317(BFS), D406(BFS), D510(BFS), D612(BFS) and D807(BFS).

Groundwater levels

Groundwater elevations in the interburden at Lemington South (C130[ALL]) continued a gradual declining trend in 2021 (Appendix C).

Generally, groundwater levels in the Woodlands Hill seams were stable in 2021 (Appendix C). C317(WDH), C809(GM/WDH) and D010(GM) displayed a slight rising groundwater level trend in 2021.

Hydrographs for bores targeting the Arrowfield Seam (Appendix C) show a declining trend at D406(AFS) and D612(AFS), thought to be due to approved mining related activities to neighbouring operations. D612(AFS) was dry in December 2021. Groundwater levels at C130(AFS1) remained stable over 2021. D510(AFS) observed a rising trend in late 2020 that continued to June 2021; however due to access constraints, monitoring data for later in 2021 are not available.

Groundwater levels in the Bowfield Seam were relatively stable in 2021 (Appendix C). The following bores recorded a rising trend: C613(BFS), D317(BFS), D612(BFS) and D510(BFS), which may be in response to reduced abstraction from the LUG Bore.

Water quality

- Over 2021, the EC readings in the interburden at Lemington South (C130[ALL]) have been slightly decreasing (Appendix B). This declining trend has been observed since 2020 and may be due to higher rainfall totals and associated increased infiltration rates. Field pH records were within the historical range, however pH increased from late 2021. Future monitoring will confirm the long-term trend.
- EC measurements in the bores targeting the Lemington South – Permian coal seams (Arrowfield, Glen Munro, Woodlands Hill and Bowfield Seams) have been stable over 2021, consistent with the historical trends (Appendix B).
- In the bores targeting the Lemington South – Permian coal seam (Arrowfield, Glen Munro, Woodlands Hill and Bowfield Seams), pH has been relatively stable over 2021 and within historical ranges (Appendix B).

5.3.7 North Pit

i Spoil

Routine monitoring was conducted for 13 spoil monitoring bores over 2021 on a quarterly basis: 4116P, 4119P, DM1, DM3, DM4, DM7, GW-114, GW-115, MB14HV001, MB14HV002, MB14HV003, MB14HV004 and MB14HV005. Exceptions to the monitoring regime were:

- bore DM7, which was dry throughout the year; and
- seven bores for which there was no access in Q4 2021, due to high rainfall.

Over 2021, water levels within the spoil at North Pit have been stable, flowing in a southerly direction from DM1 (78 mAHD) to MB14HVO03 (33 mAHD).

Water quality

- During 2021, measured EC was relatively stable (Appendix B), ranging from approximately 2,000 µS/cm (4119P) to 13,000 µS/cm (4116P).
- During 2021, the pH measurements have been relatively stable and within historical ranges (Appendix B).

5.3.8 West Pit

i Alluvium

There are five bores within the West Pit – Alluvium: G1, G2, G3 (located adjacent to Parnells Dam [Dam 18W]), GW-100 and GW-101, and eight vibrating wire piezometers (VWPs): GW-100a, GW-101a, GW-102, GW-103, GW-104, GW-105, GW-109, and GW-110.

Groundwater levels

Bore GW-101 has been consistently dry since monitoring commenced. Groundwater levels in the other bores fluctuated within historical ranges (Appendix C), showing response to climatic variations and operation of Parnells Dam.

VWP data provided by HVO are presented in Figure 5.24. The VWPs that were functioning in 2021 are GW-100a, GW-101a, GW-102, GW-104, GW-105, GW-109 and GW-110. GW-103 stopped functioning in January 2020.

VWPs GW-100a, GW-101a and GW-102, located west of West Pit, recorded relatively stable levels in 2021. GW-104 and GW-105 are located south of West Pit. Groundwater levels at GW-104 VW1 targeting the Lower Pikes Gully Seam and VW2 targeting the Upper Liddell Seam continued to decline due to depressurisation from mining at West Pit. GW-104 VW3, targeting the deeper Barrett Seam, recorded stable groundwater levels. Groundwater levels at GW-105 VW1 and VW2 were stable over 2021. GW-105 VW3 failed in February 2020. GW-109 and GW-110 showed relatively stable levels in 2021.

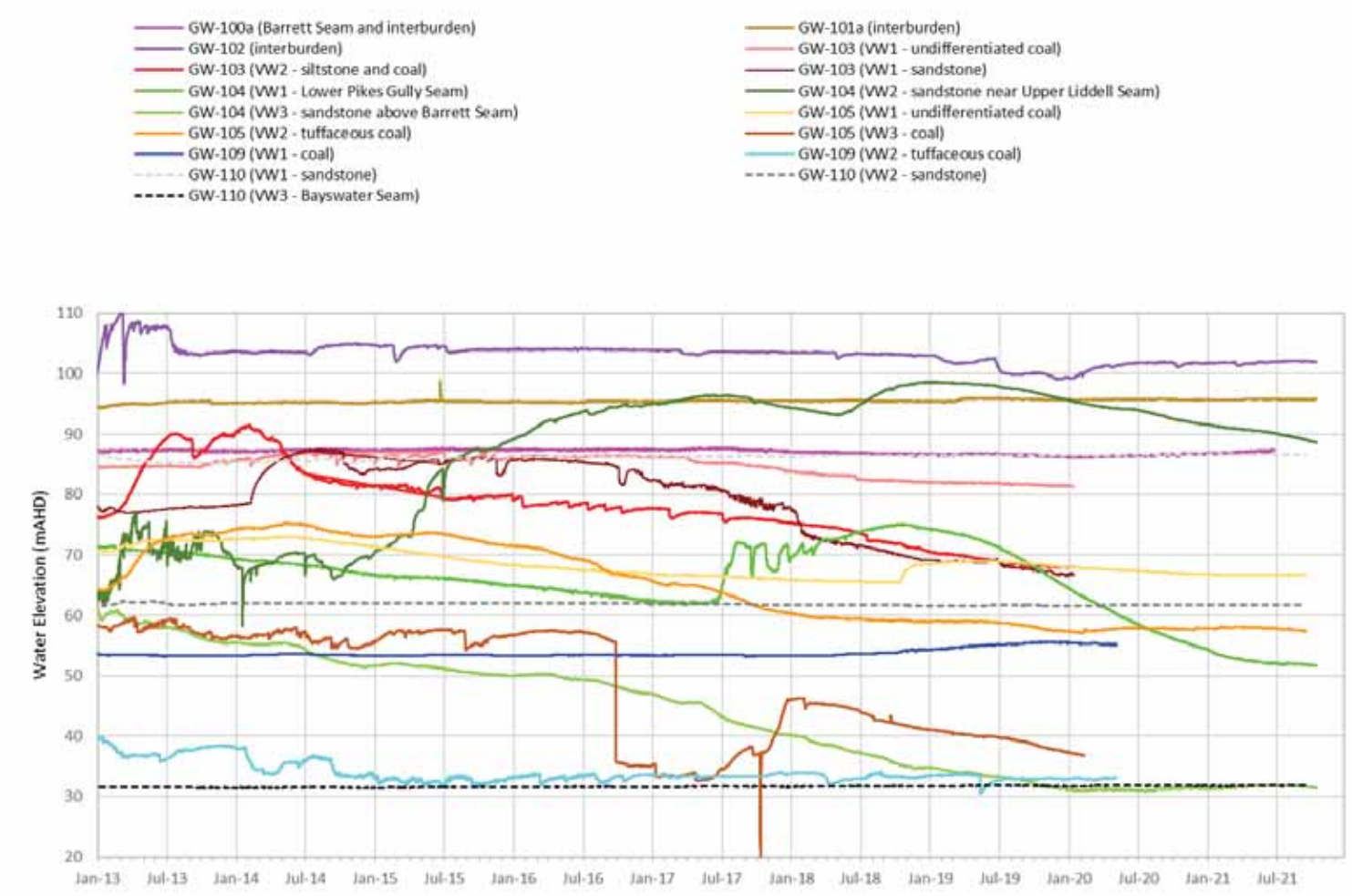


Figure 5.24 West Pit VWPs - hydrograph

Water quality

EC and pH measurements from bores G2, G3 and GW-100 have been relatively stable in 2021, following the long-term trends (Appendix B).

ii Interburden

There are three monitoring bores in the West Pit – Interburden: NPZ2, NPZ3 and NPZ5.

Groundwater levels

During four years of monitoring, groundwater levels have declined slightly at NPZ2 and NPZ3 (Appendix C). A steeper declining trend in groundwater levels was observed in bore NPZ5 from early 2016 to late 2019. Monitoring discontinued at NPZ5 in 2020 due to proximity to active mining areas. This bore has since been decommissioned.

Water quality

In 2021, EC measurements were relatively stable and within historical ranges (Appendix B). Measured pH has been fluctuating within historical ranges (Appendix B).

5.4 Groundwater take

The *Water Management Act 2000* and Aquifer Interference Policy (AIP) requires the accounting for all groundwater take, either directly or indirectly. Interception of groundwater occurs at site due to a range of activities. Groundwater takes can be classified as follows:

- **incidental water take** which is a category within the AIP for water directly intercepted within mine workings and extracted for safety;
- **indirect water take** which refers to water that occurs in aquifers or connected surface water sources that are not directly excavated by the mining activities but are predicted to experience some reduction in flow volume due to drawdown generated by the adjacent mining activity; and
- **consumptive water take** which occurs when water is pumped directly from a water source via bores in aquifers or pumps in rivers.

Groundwater takes are discussed below, and the estimated groundwater take for the various water sources.

5.4.1 Incidental and indirect water take

A numerical groundwater model was developed for the HVO South Modification 5 (AGE 2017). The model was calibrated up to December 2015 and replicates mine progression on a quarterly basis to the year 2039. Year 6 model results (predictive model) represent predicted groundwater conditions and take for the 2021 reporting period for inclusion in this report (Table 5.4). However, the model for HVO South Modification 5 did not include simulation of West Pit at HVO North. Groundwater take from West Pit was therefore taken from the West Pit Extension EIS groundwater assessment (MER 2003) and added to the total take from the North Coast Fractured and Porous Rock water source.

The peak take for the proposed modification has been disaggregated into the relevant water source in accordance with the AIP, comprising:

- Hunter Regulated Water WSP – Hunter River surface water;

- Hunter Unregulated WSP – alluvial groundwater; and
- North Coast Fractured and Porous Rock WSP - groundwater from the coal measures.

5.4.2 Consumptive water take

LUG Bore is an abstraction bore constructed into the abandoned LUG mine void underlying HVO. WAL 20BL173392 attached to the LUG Bore allows the abstraction of up to 1,800 ML of water from the Sydney Basin-North Coast Groundwater Source per water year. The bore is equipped with a flow meter to record total monthly abstraction. Based on the flow records provided by HVO, only 42 ML of water was abstracted from the LUG Bore in 2021 and 80 ML between July 2020 and June 2021 (water year). These volumes are well within the licensed allocation.

Figure 5.25 presents the hydrograph and daily abstraction volumes from the LUG bore since 2018. Dewatering volumes have significantly reduced since mid-2020 and groundwater levels are recovering accordingly.

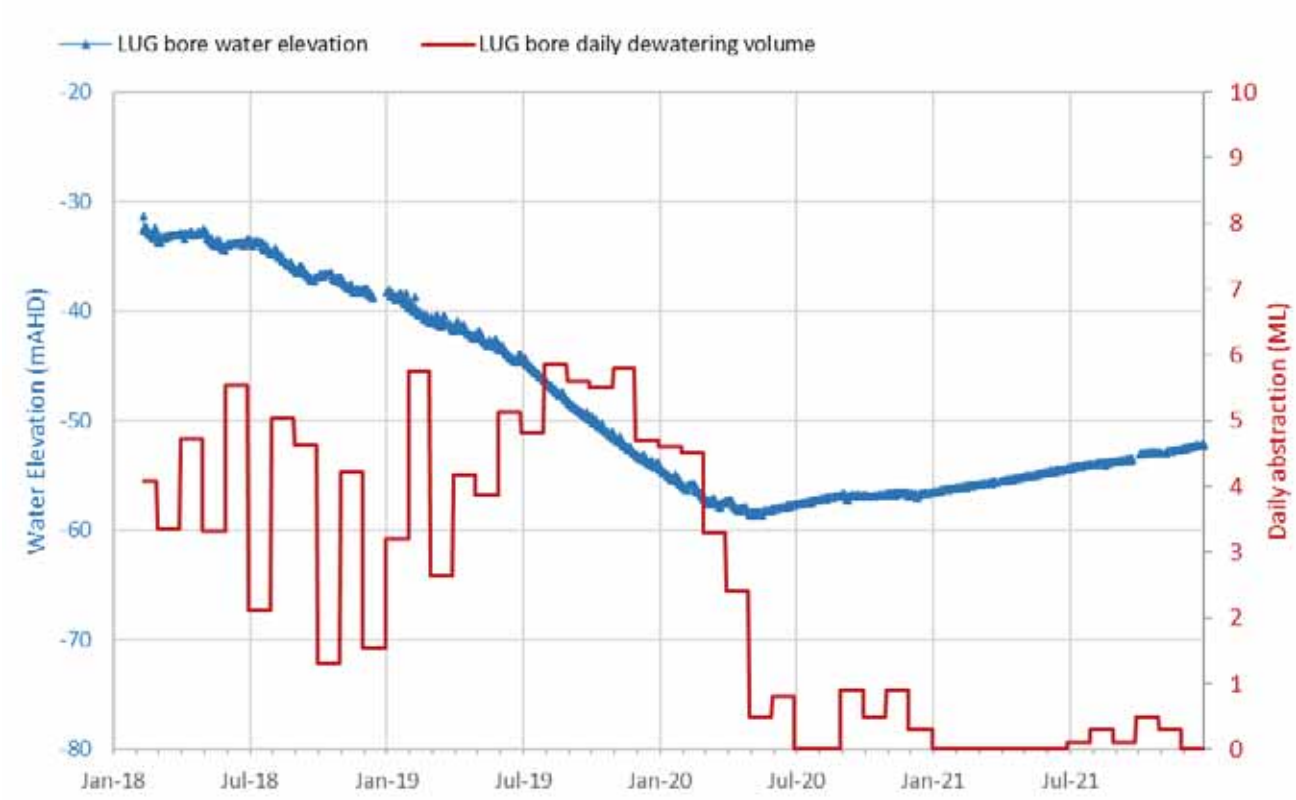


Figure 5.25 LUG bore hydrograph and daily abstraction

5.4.3 Summary of groundwater take

Table 5.4 summarises the estimated direct and indirect take for the 2021 reporting period, which are all within entitlement held for the operations.

Table 5.4 2021 groundwater take

Groundwater take (ML)	Hunter Regulated River WSP	Hunter Unregulated River and Alluvial Water Sources WSP	North Coast Fractured and Porous Rock WSP
HVO South and Carrington Pit (incidental and indirect)[1]	246	360	839
West Pit (incidental)[2]	0	0	193
LUG bore (Consumptive)	0	0	42
Total	**246**	**360**	**1,074**

Notes: 1. Source: HVO South MOD5 (AGE 2017)

2. Source: West Pit Extension EIS (MER 2003)

5.5 Verification of model predictions

In accordance with Schedule 4 Condition 27 (c) under DA 450-10-2003 (HVO North) and Schedule 3 Condition 27 (c) under PA 06_0261 (HVO South), the WMP includes requirements to validate and recalibrate (if necessary) the groundwater model for the development. This includes an independent review of the model every three years, and comparison of monitoring results with modelled predictions.

An independent review of the latest numerical groundwater model (developed by AGE for HVO South Modification 5 (2017)) was undertaken by SLR in early 2020 (SLR 2020d). The conceptual and numerical models have been reviewed and results were compared to actual data for the period January 2016 to December 2020. The review concluded the latest model calibration (AGE 2017) is still satisfactory.

6 Summary and recommendations

6.1 Summary

The 2021 annual groundwater review was undertaken for the complex in accordance with the following development consents and WAL conditions:

- Condition 27 of Development Consent (DA 450 10 2003) and individual bore licence conditions (20BL173587-89 and 20BL173847) for HVO North;
- Condition 28 of the Project Approval (PA 06 0261 24) and licence conditions for the LUG Bore (20BL173392) for HVO South; and
- individual bore licence conditions (20BL173587-89, 20BL173847 and 20BL173392).

In 2021, mining was active at Riverview Pit and Cheshunt Pit at HVO South, and West Pit at HVO North. Tailings were placed in Carrington TSF and Dam 6W TSF.

The year 2021 was a particularly wet year, with annual rainfall 62% above the long-term average. Consistently, the stream levels were relatively high throughout 2021, with two noticeable flood events in March and November-December.

Groundwater levels were monitored from the extensive monitoring bore network installed in the HVO area. Review of groundwater levels show responses to high rainfall throughout 2021. Groundwater level exceedances were reported following the flood events of March and November-December. These trends are primarily driven by climatic variations and are not attributed to any adverse impacts from the mining activities. Groundwater levels within the Permian coal measures remained relatively stable.

Groundwater quality monitoring was also undertaken from the monitoring bore network, as per the WMP. Review of water quality results and comparison to trigger levels for EC, pH and sulfate/chloride ratio in the Carrington alluvium and NV TSF area identified trigger value exceedances in 2021. However, sulfate concentrations and EC are declining; and the hydraulic gradient from the Hunter River towards the Carrington Billabong and CFW55R is assisting with limiting the seepage from moving towards the Hunter River. In addition, water level monitoring at GW-129 (located in the spoil adjacent to NV TSF) shows water levels have been declining, and have been at a lower water elevation than at CFW55R since mid 2019. Monitoring indicates seepage from the NV TSF is reducing and management measures are being effective and HVO will continue to implement management measures as part of the pollution reduction program and in consultation with the regulatory authority.

In 2021, monitoring was largely conducted in accordance with the WMP. However, data capture was incomplete from some of the bores due to dry or blocked bore conditions or access restrictions because of road flooding.

Groundwater takes were estimated based on the most recent numerical model results (HVO South Modification 5 and HVO North Modification 3) and metered water extraction from the LUG Bore. The estimated volumes were all within licensed allocation for each groundwater source.

6.2 Recommendations

The following recommendations are made with consideration of the WMP (HVO 2018) and the updated draft WMP (HVO 2021):

- The relevance of the lower pH trigger value assigned to the - Mt Arthur Cheshunt Seam bores should be validated, specifically:

- It is recommended that pH trigger levels be removed for bores BZ2A(1) and BZ3-3 (consistent with the updated draft WMP).

- As the groundwater levels measured in BZ4A(2) are at the base of the screen in this bore, with continuous pH/EC trigger value exceedance, BZ4A(2) is not considered representative of groundwater in the Mt Arthur seam. Further to this, the dry sampling events at BZ4A(2) are likely to continue. Hence it is recommended that bore BZ4A(2) be removed as a monitoring bore in the revised WMP.

- It is recommended that the pH trigger level value be lowered to 6.4 (from the current value of 6.5) for all of the remaining bores monitoring the Cheshunt - Mt Arthur Seam (consistent with the updated draft WMP).

- It is recommended the proposed EC and pH trigger values at bores C130(WDH) and C630(BFS) in the updated draft WMP be revised, as historical monitoring data suggest that trigger value exceedances may continue despite being revised in the draft WMP.

- It is recommended that the ground elevation and bore construction be reviewed for some monitoring bores (including D406(AFS), D612(AFS) and D612(BFS)).

- The 95th percentile groundwater level trigger value for CGW53A should be reviewed as the bore has been showing an increasing trend since the drought ended in late 2019 / early 2020.

- Trigger values that were exceeded at the end of 2021, yet do not require action (Section 5.2) should be reviewed in the subsequent groundwater data review.

- An assessment should be undertaken (potentially using a submersible inspection camera or similar) of bore CGW45 to determine the depth of blockage and assess options for re-instating the bore as an effective monitoring location. In addition, the monitoring records noted that this bore could not be located.

- If monitoring continues at GW-114, survey data should be obtained and provided via the EMD.

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Appendix A

2021 monitoring results

Table A.1 2021 groundwater monitoring results assessed against trigger values – groundwater elevation

Bore	Pit Location - Target geology	Groundwater level trigger values (mAHD)		2021 Groundwater levels (mAHD)											
		5th	95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Exceedances															
CGW53a	Carrington - Alluvium	58.33	59.19	-	-	-	59.43	-	59.37	-	-	59.32	-	-	60.21
CGW55a	Carrington - Alluvium	57.49	58.43	-	-	-	58.18	-	58.23	-	-	58.33	-	-	58.82
CFW57	Carrington - Alluvium	58.24	59.24	58.98	58.77	58.94	59.29	59.17	59.09	59.28	59.04	59.02	58.97	59.17	59.70
Incomplete data capture															
4036C	Carrington - Interburden	-	-	-	-	-	dry	-	dry	-	-	dry	-	-	Blocked
4051C	Carrington - Interburden	-	-	-	-	-	55.03	-	55.45	-	-	55.56	-	-	No access
GW-107	Carrington - Spoil	-	-	-	-	-	44.30	-	dry	-	-	44.20	-	-	No access
GW-108	Carrington - Spoil	-	-	-	-	-	23.56	-	dry	-	-	23.58	-	-	No access
CGW49	Carrington West Wing - Alluvium	-	-	-	-	-	64.12	-	59.63	-	-	60.21	-	-	Blocked
CGW47a	Carrington West Wing - Floodplain Alluvium	-	-	-	-	-	59.83	-	59.95	-	-	60.09	-	-	Blocked
CGW45	Carrington West Wing - LBL	-	-	-	-	-	Blocked	-	Blocked	-	-	Blocked	-	-	Blocked
CHPZ3D	Cheshunt - Mt Arthur Seam	-	-	-	53.82	-	-	54.23	-	-	54.10	-	-	Blocked	-
CHPZ8D	Cheshunt - Mt Arthur Seam	-	-	-	54.51	-	-	55.35	-	-	54.87	-	-	Blocked	-
CHPZ10A	Cheshunt / North Pit - Alluvium	-	-	-	54.49	-	-	55.03	-	-	54.79	-	-	Blocked	-
CHPZ2A	Cheshunt / North Pit - Alluvium	-	-	-	54.98	-	-	55.42	-	-	55.22	-	-	Blocked	-
CHPZ3A	Cheshunt / North Pit - Alluvium	-	-	-	54.75	-	-	55.31	-	-	55.13	-	-	Blocked	-
CHPZ8A	Cheshunt / North Pit - Alluvium	-	-	-	54.52	-	-	55.28	-	-	54.89	-	-	Blocked	-
GA3	Cheshunt / North Pit - Alluvium	-	-	-	-	-	59.35	-	59.27	-	59.11	-	-	-	No access
HV3(2)	Cheshunt / North Pit - Alluvium	-	-	-	-	-	56.99	-	57.56	-	57.19	-	-	-	No access
PZ1CH200	Cheshunt / North Pit - Alluvium	-	-	-	54.90	-	-	55.12	-	-	55.20	-	-	Blocked	-
D510(AFS)	Lemington South - Arrowfield Seam	-	-	-	-	-	-	30.48	-	-	-	-	-	-	No access
C630(BFS)	Lemington South - Bowfield Seam	-	-	-	-	-	-	23.87	-	-	-	-	-	-	No access
D214(BFS)	Lemington South - Bowfield Seam	-	-	-	28.60	-	-	29.33	-	-	29.39	-	-	-	No access
D510(BFS)	Lemington South - Bowfield Seam	-	-	-	-	-	-	34.90	-	-	-	-	-	-	No access
B425(WDH)	Lemington South - Woodlands Hill Seam	-	-	-	22.68	-	-	22.51	-	-	22.54	-	-	-	No access
4116P	North Pit - Spoil	-	-	-	-	-	48.11	-	48.48	-	48.62	-	-	-	No access
DM1	North Pit - Spoil	-	-	-	-	-	77.88	-	NA	-	77.88	-	-	-	No access
DM7	North Pit - Spoil	-	-	-	-	-	dry	-	dry	-	dry	-	-	-	Dry
GW-114	North Pit - Spoil	-	-	-	-	-	Top RL not provided	-	Top RL not provided	-	-	Top RL not provided	-	-	No access
GW-114	North Pit - Spoil	-	-	-	-	-	Top RL not provided	-	Top RL not provided	-	-	Top RL not provided	-	-	No access
GW-115	North Pit - Spoil	-	-	-	-	-	54.11	-	54.13	-	-	54.22	-	-	No access
MB14HVO01	North Pit - Spoil	-	-	-	-	-	35.37	-	35.84	-	35.79	-	-	-	No access

Table A.1 2021 groundwater monitoring results assessed against trigger values – groundwater elevation

Bore	Pit Location - Target geology	Groundwater level trigger values (mAHD)		2021 Groundwater levels (mAHD)											
		5th	95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MB14HVO02	North Pit - Spoil	-	-	-	-	-	35.69	-	35.77	-	35.79	-	-	-	No access
MB14HVO05	North Pit - Spoil	-	-	-	-	-	35.69	-	35.87	-	35.81	-	-	-	No access
GW-121	North Void - Alluvium	-	-	59.33	dry	59.34	59.34	59.33	59.33	59.33	59.32	59.33	59.33	59.33	dry
GW-100	West Pit - Alluvium	-	-	-	-	-	84.71	-	84.90	-	-	85.17	-	-	No access
GW-101	West Pit - Alluvium	-	-	-	-	-	NA	-	dry	-	-	dry	-	-	No access
NPz5	West Pit - Interburden	-	-	-	-	-	Destroyed	-	Destroyed	-	Destroyed	-	-	-	Destroyed
Compliant data															
CFW55R	Carrington - Alluvium	57.06	59.41	58.43	58.49	58.51	58.63	58.66	58.65	58.74	58.73	58.75	58.68	58.68	58.84
CGW52a	Carrington - Alluvium	58.23	60.52	-	-	-	59.30	-	59.24	-	-	59.22	-	-	60.00
CGW52	Carrington - Broonie Seam	-	-	-	-	-	35.41	-	35.51	-	-	35.68	-	-	35.80
CGW53	Carrington - Broonie Seam	-	-	-	-	-	38.02	-	37.34	-	-	35.66	-	-	34.17
CGW51a	Carrington - Interburden	-	-	-	-	-	55.82	-	55.94	-	-	56.18	-	-	56.31
4032P	Carrington West Wing - Alluvium	-	-	-	-	-	60.15	-	60.42	-	-	60.15	-	-	60.87
4034P	Carrington West Wing - Alluvium	-	-	-	-	-	59.33	-	59.42	-	-	59.52	-	-	59.82
4037P	Carrington West Wing - Alluvium	-	-	-	-	-	60.25	-	60.28	-	-	60.33	-	-	60.84
4040P	Carrington West Wing - Alluvium	-	-	-	-	-	60.27	-	60.42	-	-	60.22	-	-	61.21
CGW46	Carrington West Wing - Bayswater Seam	-	-	-	-	-	57.47	-	57.66	-	-	57.73	-	-	58.14
CGW32	Carrington West Wing - Floodplain Alluvium	-	-	-	-	-	59.55	-	59.54	-	-	59.55	-	-	59.54
CGW39	Carrington West Wing - Floodplain Alluvium	-	-	-	-	-	58.98	-	59.08	-	-	59.21	-	-	59.36
GW-106	Carrington West Wing - Floodplain Alluvium	-	-	-	-	-	58.88	-	53.89	-	-	-	-	-	58.88
BZ3-1	Cheshunt - Interburden	-	-	-	52.80	-	-	52.94	-	-	53.29	-	-	56.62	-
BZ8-2	Cheshunt - Interburden	-	-	-	47.99	-	-	48.41	-	-	48.85	-	-	48.82	-
HG2	Cheshunt - Interburden	-	-	-	55.04	-	-	55.13	-	-	55.19	-	-	55.18	-
BC1a	Cheshunt - Mt Arthur Seam	-	-	-	48.86	-	-	48.87	-	-	48.88	-	-	49.16	-
BZ1-3	Cheshunt - Mt Arthur Seam	-	-	-	25.10	-	-	25.16	-	-	25.16	-	-	25.23	-
BZ2A(1)	Cheshunt - Mt Arthur Seam	-	-	-	25.88	-	-	25.82	-	-	25.76	-	-	25.85	-
BZ3-3	Cheshunt - Mt Arthur Seam	-	-	-	27.31	-	-	27.43	-	-	27.49	-	-	27.71	-
BZ4A(2)	Cheshunt - Mt Arthur Seam	-	-	-	33.19	-	-	33.52	-	-	33.47	-	-	33.43	-
CHPZ12D	Cheshunt - Mt Arthur Seam	-	-	-	54.49	-	-	55.10	-	-	54.82	-	-	54.82	-
HG2a	Cheshunt - Mt Arthur Seam	-	-	-	41.70	-	-	41.75	-	-	41.78	-	-	41.82	-
BUNC45D	Cheshunt - Piercefield Seam	-	-	-	48.46	-	-	48.63	-	-	48.66	-	-	48.64	-
BUNC45A	Cheshunt / North Pit - Alluvium	-	-	-	52.19	-	-	52.38	-	-	52.68	-	-	52.67	-
BZ1-1	Cheshunt / North Pit - Alluvium	-	-	-	54.57	-	-	54.67	-	-	54.58	-	-	57.49	-

Table A.1 2021 groundwater monitoring results assessed against trigger values – groundwater elevation

Bore	Pit Location - Target geology	Groundwater level trigger values (mAHD)		2021 Groundwater levels (mAHD)											
		5th	95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CHPZ12A	Cheshunt / North Pit - Alluvium	-	-	-	54.67	-	-	55.19	-	-	54.99	-	-	54.91	-
CHPZ1A	Cheshunt / North Pit - Alluvium	-	-	-	54.85	-	-	55.30	-	-	55.14	-	-	55.55	-
CHPZ4A	Cheshunt / North Pit - Alluvium	-	-	-	54.76	-	-	55.21	-	-	55.04	-	-	55.16	-
Hobdens Well	Cheshunt / North Pit - Alluvium	-	-	-	55.35	-	-	55.74	-	-	55.51	-	-	56.08	-
PZ2CH400	Cheshunt / North Pit - Alluvium	-	-	-	59.73	-	-	54.73	-	-	54.41	-	-	55.10	-
PZ3CH800	Cheshunt / North Pit - Alluvium	-	-	-	55.09	-	-	55.10	-	-	55.27	-	-	57.02	-
PZ4CH1380	Cheshunt / North Pit - Alluvium	-	-	-	55.27	-	-	55.38	-	-	55.59	-	-	56.40	-
PZ5CH1800	Cheshunt / North Pit - Alluvium	-	-	-	55.61	-	-	55.76	-	-	56.18	-	-	57.94	-
Appleyard Farm	Lemington South - Alluvium	-	-	48.93	48.84	50.62	49.42	48.73	48.59	48.50	48.48	48.59	48.39	48.73	49.38
C919(ALL)	Lemington South - Alluvium	-	-	46.53	46.61	46.68	46.82	47.10	47.23	47.29	47.30	47.80	47.29	47.30	47.51
PB01(ALL)	Lemington South - Alluvium	-	-	47.06	46.83	48.11	47.69	47.09	47.00	46.82	46.74	46.77	46.67	46.82	47.67
C130(AFS1)	Lemington South - Arrowfield Seam	-	-	-	-	-	-	45.27	-	-	-	-	-	-	45.10
D406(AFS)	Lemington South - Arrowfield Seam	-	-	-	-	-	-	35.17	-	-	-	-	-	-	34.03
D612(AFS)	Lemington South - Arrowfield Seam	-	-	-	-	-	-	38.82	-	-	-	-	-	-	dry
B334(BFS)	Lemington South - Bowfield Seam	-	-	-	21.64	-	-	21.07	-	-	20.85	-	-	-	20.96
B631(BFS)	Lemington South - Bowfield Seam	-	-	-	21.93	-	-	22.59	-	-	22.90	-	-	-	22.14
B925(BFS)	Lemington South - Bowfield Seam	-	-	-	-0.19	-	-	1.86	-	-	1.61	-	-	-	1.13
C122(BFS)	Lemington South - Bowfield Seam	-	-	-	-0.06	-	-	-0.08	-	-	0.00	-	-	-	0.02
C130(BFS)	Lemington South - Bowfield Seam	-	-	-	8.78	-	-	10.39	-	-	9.82	-	-	-	8.87
C317(BFS)	Lemington South - Bowfield Seam	-	-	-	6.07	-	-	7.81	-	-	7.94	-	-	-	6.96
C613(BFS)	Lemington South - Bowfield Seam	-	-	-	34.95	-	-	36.32	-	-	36.48	-	-	-	36.85
C621(BFS)	Lemington South - Bowfield Seam	-	-	-	14.46	-	-	15.03	-	-	14.58	-	-	-	14.65
D010(BFS)	Lemington South - Bowfield Seam	-	-	-	-	-	-	30.95	-	-	-	-	-	-	31.12
D317(BFS)	Lemington South - Bowfield Seam	-	-	-	26.47	-	-	27.68	-	-	27.81	-	-	-	29.87
D406(BFS)	Lemington South - Bowfield Seam	-	-	-	-	-	-	35.43	-	-	-	-	-	-	33.43
D612(BFS)	Lemington South - Bowfield Seam	-	-	-	-	-	-	34.77	-	-	-	-	-	-	34.86
D807(BFS)	Lemington South - Bowfield Seam	-	-	-	-	-	-	38.71	-	-	-	-	-	-	36.47
D010(GM)	Lemington South - Glen Munro Seam	-	-	-	-	-	-	48.66	-	-	-	-	-	-	49.09
C130(ALL)	Lemington South - Interburden	-	-	47.35	47.33	47.32	47.33	47.33	47.34	47.30	47.32	47.32	47.33	47.30	47.31
B631(WDH)	Lemington South - Woodlands Hill Seam	-	-	-	-	-	-	46.02	-	-	-	-	-	-	46.03
C122(WDH)	Lemington South - Woodlands Hill Seam	-	-	-	-	-	-	47.06	-	-	-	-	-	-	47.44
C130(WDH)	Lemington South - Woodlands Hill Seam	-	-	-	-	-	-	47.23	-	-	-	-	-	-	47.24
C317(WDH)	Lemington South - Woodlands Hill Seam	-	-	-	46.41	-	-	47.08	-	-	46.84	-	-	-	48.07

Table A.1 2021 groundwater monitoring results assessed against trigger values – groundwater elevation

Bore	Pit Location - Target geology	Groundwater level trigger values (mAHD)		2021 Groundwater levels (mAHD)												
		5th	95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
C809(GM/WDH)	Lemington South - Woodlands Hill Seam	-	-	-	-	-	-	47.93	-	-	-	-	-	-	48.16	
D010(WDH)	Lemington South - Woodlands Hill Seam	-	-	-	-	-	-	46.96	-	-	-	-	-	-	46.94	
4119P	North Pit - Spoil	-	-	-	-	-	54.38	-	54.45	-	54.55	-	-	54.35	-	
DM3	North Pit - Spoil	-	-	-	-	-	64.17	-	64.34	-	64.31	-	-	-	-	
DM4	North Pit - Spoil	-	-	-	-	-	47.53	-	47.73	-	47.74	-	-	47.77	-	
MB14HVO03	North Pit - Spoil	-	-	-	-	-	33.04	-	33.12	-	33.19	-	-	33.14	-	
MB14HVO04	North Pit - Spoil	-	-	-	-	-	37.19	-	37.44	-	37.60	-	-	37.69	-	
G1	West Pit - Alluvium	-	-	106.50	106.37	106.41	106.24	106.36	106.57	106.83	106.93	106.95	106.66	107.71	dry	
G2	West Pit - Alluvium	-	-	107.22	107.08	107.18	106.94	dry	107.37	107.62	107.71	107.61	107.51	107.41	dry	
G3	West Pit - Alluvium	-	-	108.09	107.70	107.77	107.50	107.75	107.96	108.21	108.27	108.17	108.11	108.00	dry	
NPz2	West Pit - Interburden	-	-	-	-	-	161.23	-	161.05	-	160.87	-	-	-	-	
NPz3	West Pit - Interburden	-	-	-	-	-	123.31	-	123.54	-	123.06	-	-	-	-	

Notes: Trigger value exceedances are highlighted in red and bold text
mAHD = metres Australian Height Datum

Table A.2 2021 groundwater monitoring results assessed against trigger values - field EC

Bore	Pit Location - Target geology	EC trigger value (µS/cm)	2021 EC results											
		95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Exceedances														
CFW55R	Carrington - Alluvium	6,154	**9,300**	**9,600**	**9,250**	**9,610**	**9,500**	**9,370**	**9,780**	**9,580**	**9,590**	**9,370**	**9,540**	**9,400**
CGW32	Carrington West Wing - Floodplain Alluvium	9,280	-	-	-	9,120	-	9,170	-	-	9,170	-	-	**9,290**
B631(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	**13,200**	-	-	-	-	-	-	**13,070**
D010(GM)	Lemington South - Glen Munro Seam	1,894	-	-	-	-	**11,200**	-	-	-	-	-	-	**11,670**
C130(ALL)	Lemington South - Interburden	11,408		**22,600**	-	-	**22,300**	-	-	**21,900**	-	-	-	**21,000**
4116P	North Pit - Spoil	12,460	-	-	-	**13,150**	-	12,320	-	**12,830**	-	-	-	No access
C130(WDH)	Lemington South - Woodlands Hill Seam	20,240	-	-	-	-	**21,200**	-	-	-	-	-	-	**21,100**
NPz2	West Pit - Interburden	13,428	-	-	-	**14,290**	-	**14,340**	-	**15,010**	-	-	-	-
Incomplete data capture														
4036C	Carrington - Interburden	10,824	-	-	-	Blocked	-	Blocked	-	-	Blocked	-	-	Blocked
4051C	Carrington - Interburden	10,824	-	-	-	2270	-	1934	-	-	2280	-	-	Blocked

Table A.2 2021 groundwater monitoring results assessed against trigger values - field EC

Bore	Pit Location - Target geology	EC trigger value (µS/cm)	2021 EC results											
		95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GW-107	Carrington - Spoil	-	-	-	-	Insufficient water	-	Insufficient water	-	-	Insufficient water	-	-	No access
GW-108	Carrington - Spoil	-	-	-	-	Insufficient water	-	Insufficient water	-	-	Insufficient water	-	-	No access
CGW49	Carrington West Wing - Alluvium	2,775	-	-	-	2100	-	2060	-	-	2070	-	-	Blocked
CGW47a	Carrington West Wing - Floodplain Alluvium	9,280	-	-	-	4920	-	4740	-	-	4580	-	-	Blocked
CGW45	Carrington West Wing - LBL	3,531	-	-	-	Blocked	-	Blocked	-	-	Blocked	-	-	Blocked
BZ3-3	Cheshunt - Mt Arthur Seam	3,350	-	Insufficient water	-	-	1,143	-	-	1,159	-	-	1,176	-
BZ4A(2)	Cheshunt - Mt Arthur Seam	3,350	-	Insufficient water	-	-	890	-	-	1,047	-	-	1,495	-
CHPZ3D	Cheshunt - Mt Arthur Seam	3,350	-	1016	-	-	1024	-	-	996	-	-	Blocked	-
CHPZ8D	Cheshunt - Mt Arthur Seam	3,350	-	1576	-	-	927	-	-	613	-	-	Blocked	-
CHPZ10A	Cheshunt / North Pit - Alluvium	4,462	-	728	-	-	574	-	-	725	-	-	Blocked	-
CHPZ2A	Cheshunt / North Pit - Alluvium	4,462	-	861	-	-	830	-	-	887	-	-	Blocked	-
CHPZ3A	Cheshunt / North Pit - Alluvium	4,462	-	716	-	-	684	-	-	708	-	-	Blocked	-
CHPZ8A	Cheshunt / North Pit - Alluvium	4,462	-	1643	-	-	1098	-	-	1796	-	-	Blocked	-
GA3	Cheshunt / North Pit - Alluvium	4,462	-	-	-	996	-	983	-	1022	-	-	-	No access
HV3(2)	Cheshunt / North Pit - Alluvium	4,462	-	-	-	810	-	795	-	803	-	-	-	No access
PZ1CH200	Cheshunt / North Pit - Alluvium	4,462	-	648	-	-	802	-	-	845	-	-	-	Blocked
C919(ALL)	Lemington South - Alluvium	3,939	-	Insufficient water	-	-	Insufficient water	-	-	791	-	-	-	Insufficient water
D510(AFS)	Lemington South - Arrowfield Seam	15,324	-	-	-	-	13860	-	-	-	-	-	-	No access
D612(AFS)	Lemington South - Arrowfield Seam	15,324	-	-	-	-	Insufficient water	-	-	-	-	-	-	Insufficient water
C122(BFS)	Lemington South - Bowfield Seam	12,440	-	Insufficient water	-	-	Insufficient water	-	-	Insufficient water	-	-	-	Insufficient water
C630(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	4610	-	-	-	-	-	-	No access
D214(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	7610	-	-	-	-	-	-	No access
D510(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	11610	-	-	-	-	-	-	No access
B425(WDH)	Lemington South - Woodlands Hill Seam	20,240	-	Insufficient water	-	-	Insufficient water	-	-	Insufficient water	-	-	-	No access
DM1	North Pit - Spoil	12,460	-	-	-	10580	-	Insufficient water	-	10290	-	-	-	No access
DM7	North Pit - Spoil	12,460	-	-	-	Dry	-	Dry	-	Dry	-	-	-	Dry
GW-114	North Pit - Spoil	12,460	-	-	-	8870	-	8450	-	-	Insufficient water	-	-	No access
GW-115	North Pit - Spoil	12,460	-	-	-	7620	-	7450	-	-	7890	-	-	No access
MB14HVO01	North Pit - Spoil	12,460	-	-	-	7520	-	7270	-	7570	-	-	-	No access
MB14HVO02	North Pit - Spoil	12,460	-	-	-	7450	-	7080	-	7380	-	-	-	No access

Table A.2 2021 groundwater monitoring results assessed against trigger values - field EC

Bore	Pit Location - Target geology	EC trigger value (µS/cm)	2021 EC results											
		95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MB14HVO05	North Pit - Spoil	12,460	-	-	-	8200	-	7940	-	8240	-	-	-	No access
GW-121	North Void - Alluvium	-	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water
GW-100	West Pit - Alluvium	10,751	-	-	-	10070	-	10060	-	-	10380	-	-	No access
GW-101	West Pit - Alluvium	10,751	-	-	-	Dry	-	Dry	-	-	Dry	-	-	No access
NPz5	West Pit - Interburden	13,428	-	-	-	Destroyed	-	Destroyed	-	Destroyed	-	-	-	Destroyed
Compliant data														
CGW53	Carrington - Broonie Seam	8,628	-	-	-	7,630	-	7,600	-	-	7,410	-	-	7,810
CGW51a	Carrington - Interburden	10,824	-	-	-	6,800	-	7,150	-	-	6,680	-	-	5,950
4032P	Carrington West Wing - Alluvium	2,775	-	-	-	1,377	-	2,110	-	-	2,160	-	-	2,070
4034P	Carrington West Wing - Alluvium	2,775	-	-	-	1,492	-	1,437	-	-	1,371	-	-	1,365
4037P	Carrington West Wing - Alluvium	2,775	-	-	-	985	-	991	-	-	935	-	-	942
4040P	Carrington West Wing - Alluvium	2,775	-	-	-	986	-	889	-	-	911	-	-	987
CGW46	Carrington West Wing - Bayswater Seam	-	-	-	-	2,370	-	2,350	-	-	2,390	-	-	2,160
CGW39	Carrington West Wing - Floodplain Alluvium	9,280	-	-	-	6,100	-	5,930	-	-	5,980	-	-	6,530
GW-106	Carrington West Wing - Floodplain Alluvium	9,280	-	-	-	9,040	-	9,050	-	-	NA	-	-	1,101
BZ3-1	Cheshunt - Interburden	6,213	-	1,250	-	-	1,406	-	-	1,466	-	-	1,552	-
BZ8-2	Cheshunt - Interburden	6,213	-	1,125	-	-	1,152	-	-	1,119	-	-	1,230	-
HG2	Cheshunt - Interburden	6,213	-	3,870	-	-	3,590	-	-	3,530	-	-	3,470	-
BC1a	Cheshunt - Mt Arthur Seam	3,350	-	851	-	-	865	-	-	851	-	-	847	-
BZ1-3	Cheshunt - Mt Arthur Seam	3,350	-	1,238	-	-	1,233	-	-	1,217	-	-	1,184	-
BZ2A(1)	Cheshunt - Mt Arthur Seam	3,350	-	1,165	-	-	1,195	-	-	1,136	-	-	1,111	-
CHPZ12D	Cheshunt - Mt Arthur Seam	3,350	-	1,287	-	-	1,358	-	-	1,318	-	-	1,291	-
HG2a	Cheshunt - Mt Arthur Seam	3,350	-	1,222	-	-	1,238	-	-	1,374	-	-	1,449	-
BUNC45D	Cheshunt - Piercefield Seam	2,596	-	2,420	-	-	2,390	-	-	2,450	-	-	2,410	-
BUNC45A	Cheshunt / North Pit - Alluvium	4,462	-	2,080	-	-	2,060	-	-	2,110	-	-	2,180	-
BZ1-1	Cheshunt / North Pit - Alluvium	4,462	-	2,710	-	-	2,460	-	-	2,550	-	-	2,550	-
CHPZ12A	Cheshunt / North Pit - Alluvium	4,462	-	999	-	-	946	-	-	996	-	-	933	-
CHPZ1A	Cheshunt / North Pit - Alluvium	4,462	-	780	-	-	669	-	-	714	-	-	671	-
CHPZ4A	Cheshunt / North Pit - Alluvium	4,462	-	748	-	-	631	-	-	671	-	-	658	-
Hobdens Well	Cheshunt / North Pit - Alluvium	4,462	-	945	-	-	1,039	-	-	1,017	-	-	994	-
PZ2CH400	Cheshunt / North Pit - Alluvium	4,462	-	1,104	-	-	828	-	-	866	-	-	916	-
PZ3CH800	Cheshunt / North Pit - Alluvium	4,462	-	1,044	-	-	979	-	-	905	-	-	900	-
PZ4CH1380	Cheshunt / North Pit - Alluvium	4,462	-	895	-	-	829	-	-	820	-	-	802	-

Table A.2 2021 groundwater monitoring results assessed against trigger values - field EC

Bore	Pit Location - Target geology	EC trigger value (µS/cm)	2021 EC results											
		95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PZ5CH1800	Cheshunt / North Pit - Alluvium	4,462	-	262	-	-	210	-	-	348	-	-	306	-
Appleyard Farm	Lemington South - Alluvium	3,938	-	522	-	-	543	-	-	526	-	-	-	291
PB01(ALL)	Lemington South - Alluvium	3,940	-	2940	-	-	3010	-	-	2690	-	-	-	3440
C130(AFS1)	Lemington South - Arrowfield Seam	15,324	-	-	-	-	13,930	-	-	-	-	-	-	13,460
D406(AFS)	Lemington South - Arrowfield Seam	15,324	-	-	-	-	12,210	-	-	-	-	-	-	11,970
B334(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	6,830	-	-	-	-	-	-	7,620
B925(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	4,650	-	-	-	-	-	-	4,600
C130(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	4,570	-	-	-	-	-	-	5,720
C317(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	10,400	-	-	-	-	-	-	10,730
C613(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	9,450	-	-	-	-	-	-	9,410
C621(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	7,850	-	-	-	-	-	-	7,780
D010(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	10,490	-	-	-	-	-	-	10,020
D317(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	2,370	-	-	-	-	-	-	3,330
D406(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	7,400	-	-	-	-	-	-	7,130
D612(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	11,480	-	-	-	-	-	-	11,490
D807(BFS)	Lemington South - Bowfield Seam	12,440	-	-	-	-	10,030	-	-	-	-	-	-	11,570
B631(WDH)	Lemington South - Woodlands Hill Seam	20,240	-	-	-	-	12,840	-	-	-	-	-	-	12,860
C122(WDH)	Lemington South - Woodlands Hill Seam	20,240	-	-	-	-	14,290	-	-	-	-	-	-	14,260
C317(WDH)	Lemington South - Woodlands Hill Seam	20,240	-	-	-	-	7,940	-	-	-	-	-	-	9,420
C809(GM/WDH)	Lemington South - Woodlands Hill Seam	20,240	-	-	-	-	9,980	-	-	-	-	-	-	10,580
D010(WDH)	Lemington South - Woodlands Hill Seam	20,240	-	-	-	-	9,180	-	-	-	-	-	-	9,270
4119P	North Pit - Spoil	12,460	-	-	-	2,140	-	2,660	-	2,190	-	-	2,900	-
DM3	North Pit - Spoil	12,460	-	-	-	8,430	-	9,400	-	10,040	-	-	-	-
DM4	North Pit - Spoil	12,460	-	-	-	6,340	-	6,060	-	6,280	-	-	6,180	-
MB14HVO03	North Pit - Spoil	12,460	-	-	-	6,430	-	6,100	-	6,270	-	-	5,290	-
MB14HVO04	North Pit - Spoil	12,460	-	-	-	6,080	-	5,800	-	6,060	-	-	5,870	-
G1	West Pit - Alluvium	10,751	6,710	7,130	7,650	6,040	5,440	5,960	7,880	6,150	3,000	5,130	5,780	**dry**
G2	West Pit - Alluvium	10,751	5,780	5,640	5,900	5,930	NA	5,870	5,830	5,910	5,890	6,080	6,150	**dry**
G3	West Pit - Alluvium	10,751	5,330	5,210	5,390	5,400	5,350	5,290	5,380	5,440	5,420	5,620	5,770	**dry**
NPz3	West Pit - Interburden	13,428	-	-	-	13,090	-	12,840	-	12,880	-	-	-	-

Notes: Trigger value exceedances are highlighted in red and bold text

EC = Electrical conductivity

Table A.3 2021 groundwater monitoring results assessed against trigger values - field pH

Bore	Pit Location - Target geology	pH trigger values		2021 pH results											
		5th	95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
								Exceedances							
CFW55R	Carrington - Alluvium	7.0	8.0	**6.9**	7.0	7.1	7.1	7.0	7.1	7.1	7.1	7.1	7.1	7.1	7.1
CGW52a	Carrington - Alluvium	7.0	8.0	-	-	-	7.6	-	**8.2**	-	-	7.8	-	-	8.0
CGW52	Carrington - Broonie Seam	6.8	7.1	-	-	-	**7.2**	-	6.8	-	-	6.9	-	-	6.8
CGW53	Carrington - Broonie Seam	6.8	7.1	-	-	-	6.9	-	7.0	-	-	7.0	-	-	**7.2**
CGW51a	Carrington - Interburden	6.7	7.4	-	-	-	7.4	-	**7.5**	-	-	7.4	-	-	**7.6**
GW-106	Carrington West Wing - Floodplain Alluvium	6.8	7.8	-	-	-	6.8	-	6.9	-	-	NA	-	-	**6.7**
BZ2A(1)	Cheshunt - Mt Arthur Seam	6.5	7.6	-	**6.4**	-	-	**6.4**	-	-	**6.3**	-	-	**6.3**	-
BZ3-1	Cheshunt - Interburden	6.9	7.7	-	7.1	-	-	**7.8**	-	-	7.7	-	-	7.6	-
BZ3-3	Cheshunt - Mt Arthur Seam	6.5	7.6	-	Insufficient water	-	-	**6.2**	-	-	**6.2**	-	-	**6.0**	-
BZ4A(2)	Cheshunt - Mt Arthur Seam	6.5	7.6	-	Insufficient water	-	-	**6.2**	-	-	**6.2**	-	-	**6.2**	-
Hobdens Well	Cheshunt / North Pit - Alluvium	6.6	7.5	-	7.5	-	-	**7.6**	-	-	**7.7**	-	-	7.4	-
Appleyard Farm	Lemington South - Alluvium	6.6	7.7	-	6.7	-	-	6.9	-	-	6.8	-	-	-	**6.5**
B631(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	**6.6**	-	-	-	-	-	-	6.7
C630(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	**8.0**	-	-	-	-	-	-	No access
DM1	North Pit - Spoil	6.5	7.8	-	-	-	6.6	-	NA	-	**6.4**	-	-	-	No access
DM3	North Pit - Spoil	6.5	7.8	-	-	-	**6.4**	-	6.7	-	**6.4**	-	-	-	-
								Incomplete data capture							
4036C	Carrington - Interburden	6.7	7.4	-	-	-	Blocked	-	Blocked	-	-	Blocked	-	-	Blocked
4051C	Carrington - Interburden	6.7	7.4	-	-	-	7.2	-	7.4	-	-	7.3	-	-	Blocked
GW-107	Carrington - Spoil	-	-	-	-	-	Insufficient water	-	Insufficient water	-	-	Insufficient water	-	-	No access
GW-108	Carrington - Spoil	-	-	-	-	-	Insufficient water	-	Insufficient water	-	-	Insufficient water	-	-	No access
CGW49	Carrington West Wing - Alluvium	7.0	7.5	-	-	-	7.5	-	7.4	-	-	7.5	-	-	Blocked
CGW47a	Carrington West Wing - Floodplain Alluvium	6.8	7.8	-	-	-	7.6	-	7.6	-	-	7.5	-	-	Blocked
CGW45	Carrington West Wing - LBL	7.3	7.6	-	-	-	Blocked	-	Blocked	-	-	Blocked	-	-	Blocked
CHPZ3D	Cheshunt - Mt Arthur Seam	6.5	7.6	-	6.5	-	-	6.7	-	-	6.5	-	-	Blocked	-
CHPZ8D	Cheshunt - Mt Arthur Seam	6.5	7.6	-	7.0	-	-	7.1	-	-	7.2	-	-	Blocked	-
CHPZ10A	Cheshunt / North Pit - Alluvium	6.6	7.5	-	6.8	-	-	6.9	-	-	6.9	-	-	Blocked	-
CHPZ2A	Cheshunt / North Pit - Alluvium	6.6	7.5	-	7.1	-	-	7.0	-	-	7.0	-	-	Blocked	-
CHPZ3A	Cheshunt / North Pit - Alluvium	6.6	7.5	-	6.9	-	-	6.9	-	-	7.0	-	-	Blocked	-
CHPZ8A	Cheshunt / North Pit - Alluvium	6.6	7.5	-	7.0	-	-	7.1	-	-	7.0	-	-	Blocked	-
GA3	Cheshunt / North Pit - Alluvium	6.6	7.5	-	-	-	6.8	-	7.0	-	6.9	-	-	-	No access
HV3(2)	Cheshunt / North Pit - Alluvium	6.6	7.5	-	-	-	6.9	-	7.0	-	6.9	-	-	-	No access

Table A.3 2021 groundwater monitoring results assessed against trigger values - field pH

Bore	Pit Location - Target geology	pH trigger values		2021 pH results											
		5th	95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PZ1CH200	Cheshunt / North Pit - Alluvium	6.6	7.5	-	7.0	-	-	7.0	-	-	7.2	-	-	-	Blocked
C919(ALL)	Lemington South - Alluvium	6.7	7.8	-	Insufficient water	-	-	Insufficient water	-	-	7.5	-	-	-	Insufficient water
D510(AFS)	Lemington South - Arrowfield Seam	6.8	7.5	-	-	-	-	6.9	-	-	-	-	-	-	No access
D612(AFS)	Lemington South - Arrowfield Seam	6.8	7.5	-	-	-	-	Insufficient water	-	-	-	-	-	-	Insufficient water
C122(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	Insufficient water	-	-	Insufficient water	-	-	Insufficient water	-	-	-	Insufficient water
D214(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	NA	-	-	7.7	-	-	NA	-	-	-	No access
D510(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	7.3	-	-	-	-	-	-	No access
B425(WDH)	Lemington South - Woodlands Hill Seam	6.6	7.6	-	NA	-	-	NA	-	-	NA	-	-	-	No access
4116P	North Pit - Spoil	6.5	7.8	-	-	-	7.1	-	7.0	-	7.0	-	-	-	No access
DM7	North Pit - Spoil	6.5	7.8	-	-	-	Dry	-	Dry	-	Dry	-	-	-	Dry
GW-114	North Pit - Spoil	6.5	7.8	-	-	-	6.5	-	6.6	-	-	Insufficient water	-	-	No access
GW-115	North Pit - Spoil	6.5	7.8	-	-	-	6.9	-	6.8	-	-	6.8	-	-	No access
MB14HVO01	North Pit - Spoil	6.5	7.8	-	-	-	6.7	-	6.7	-	6.8	-	-	-	No access
MB14HVO02	North Pit - Spoil	6.5	7.8	-	-	-	6.8	-	6.8	-	6.9	-	-	-	No access
MB14HVO05	North Pit - Spoil	6.5	7.8	-	-	-	6.8	-	6.8	-	6.9	-	-	-	No access
GW-121	North Void - Alluvium	-	-	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water	Insufficient water
GW-100	West Pit - Alluvium	7.1	8.6	-	-	-	7.4	-	7.4	-	-	7.5	-	-	No access
GW-101	West Pit - Alluvium	7.1	8.6	-	-	-	Dry	-	Dry	-	-	Dry	-	-	No access
NPz5	West Pit - Interburden	6.9	8.0	-	-	-	Destroyed	-	Destroyed	-	Destroyed	-	-	-	Destroyed
Compliant data															
CFW57	Carrington - Alluvium	7.0	8.0	7.4	7.4	7.4	7.4	7.4	7.5	7.3	7.3	7.4	7.5	7.4	7.2
CGW55a	Carrington - Alluvium	7.0	8.0	-	7.0	-	-	6.9	-	-	6.9	-	-	6.9	-
4032P	Carrington West Wing - Alluvium	7.0	7.5	-	7.1	-	-	7.1	-	-	7.0	-	-	7.0	-
4034P	Carrington West Wing - Alluvium	7.0	7.5	-	7.5	-	-	7.5	-	-	7.4	-	-	7.2	-
4037P	Carrington West Wing - Alluvium	7.0	7.5	-	7.0	-	-	6.9	-	-	6.6	-	-	6.9	-
4040P	Carrington West Wing - Alluvium	7.0	7.5	-	-	-	-	-	-	-	-	-	-	-	-
CGW46	Carrington West Wing - Bayswater Seam	-	-	-	6.4	-	-	6.7	-	-	6.6	-	-	6.7	-
CGW32	Carrington West Wing - Floodplain Alluvium	6.8	7.8	-	6.9	-	-	6.9	-	-	7.0	-	-	7.0	-
CGW39	Carrington West Wing - Floodplain Alluvium	6.8	7.8	-	6.6	-	-	6.6	-	-	6.7	-	-	6.6	-
BZ8-2	Cheshunt - Interburden	6.9	7.7	-	-	-	-	-	-	-	-	-	-	-	-
HG2	Cheshunt - Interburden	6.9	7.7	-	6.7	-	-	6.8	-	-	6.8	-	-	6.8	-

Table A.3 2021 groundwater monitoring results assessed against trigger values - field pH

Bore	Pit Location - Target geology	pH trigger values		2021 pH results											
		5th	95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BC1a	Cheshunt - Mt Arthur Seam	6.5	7.6	-	7.0	-	-	7.0	-	-	7.1	-	-	6.9	-
BZ1-3	Cheshunt - Mt Arthur Seam	6.5	7.6	-	-	-	-	-	-	-	-	-	-	-	-
CHPZ12D	Cheshunt - Mt Arthur Seam	6.5	7.6	-	-	-	-	-	-	-	-	-	-	-	-
HG2a	Cheshunt - Mt Arthur Seam	6.5	7.6	-	-	-	-	-	-	-	-	-	-	-	-
BUNC45D	Cheshunt - Piercefield Seam	6.4	6.8	-	-	-	-	-	-	-	-	-	-	-	-
BUNC45A	Cheshunt / North Pit - Alluvium	6.6	7.5	-	-	-	-	-	-	-	-	-	-	-	-
BZ1-1	Cheshunt / North Pit - Alluvium	6.6	7.5	-	6.6	-	-	6.7	-	-	7.1	-	-	6.9	-
CHPZ12A	Cheshunt / North Pit - Alluvium	6.6	7.5	-	6.9	-	-	6.8	-	-	7.0	-	-	6.9	-
CHPZ1A	Cheshunt / North Pit - Alluvium	6.6	7.5	-	6.8	-	-	7.0	-	-	7.2	-	-	7.2	-
CHPZ4A	Cheshunt / North Pit - Alluvium	6.6	7.5	-	-	-	-	-	-	-	-	-	-	-	-
PZ2CH400	Cheshunt / North Pit - Alluvium	6.6	7.5	-	-	-	-	-	-	-	-	-	-	-	-
PZ3CH800	Cheshunt / North Pit - Alluvium	6.6	7.5	-	-	-	-	-	-	-	-	-	-	-	-
PZ4CH1380	Cheshunt / North Pit - Alluvium	6.6	7.5	-	NA	-	-	7.2	-	-	NA	-	-	-	7.3
PZ5CH1800	Cheshunt / North Pit - Alluvium	6.6	7.5	-	NA	-	-	7.0	-	-	NA	-	-	-	7.1
PB01(ALL)	Lemington South - Alluvium	6.8	7.9	-	6.9	-	-	6.8	-	-	6.9	-	-	-	7.1
C130(AFS1)	Lemington South - Arrowfield Seam	6.8	7.5	-	-	-	-	7.1	-	-	-	-	-	-	7.3
D406(AFS)	Lemington South - Arrowfield Seam	6.8	7.5	-	-	-	-	-	-	-	-	-	-	-	-
B334(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	7.4	-	-	-	-	-	-	7.1
B925(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	-	-	-	-	-	-	-	-
C130(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	6.9	-	-	-	-	-	-	6.9
C317(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	6.9	-	-	-	-	-	-	6.8
C613(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	7.2	-	-	-	-	-	-	6.9
C621(BFS)	Lemington South - Bowfield Seam	6.7	7.9	NA	6.9	NA	NA	6.8	NA	NA	7.0	NA	NA	NA	7.1
D010(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	-	-	-	-	-	-	-	-
D317(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	7.0	-	-	-	-	-	-	7.1
D406(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	6.7	-	-	-	-	-	-	6.7
D612(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	7.0	-	-	-	-	-	-	6.9
D807(BFS)	Lemington South - Bowfield Seam	6.7	7.9	-	-	-	-	6.9	-	-	-	-	-	-	6.9
D010(GM)	Lemington South - Glen Munro Seam	6.5	7.2	-	-	-	-	-	-	-	-	-	-	-	-
C130(ALL)	Lemington South - Interburden	6.7	7.1	-	-	-	7.5	-	7.5	-	-	7.7	-	-	7.2
B631(WDH)	Lemington South - Woodlands Hill Seam	6.6	7.6	-	-	-	6.9	-	6.9	-	6.8	-	-	7.0	-
C122(WDH)	Lemington South - Woodlands Hill Seam	6.6	7.6	-	-	-	-	-	-	-	-	-	-	-	-
C130(WDH)	Lemington South - Woodlands Hill Seam	6.6	7.6	-	-	-	7.0	-	7.1	-	7.0	-	-	7.0	-
C317(WDH)	Lemington South - Woodlands Hill Seam	6.6	7.6	-	-	-	-	-	-	-	-	-	-	-	-

Table A.3 2021 groundwater monitoring results assessed against trigger values - field pH

Bore	Pit Location - Target geology	pH trigger values		2021 pH results											
		5th	95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C809(GM/WDH)	Lemington South - Woodlands Hill Seam	6.6	7.6	-	-	-	-	-	-	-	-	-	-	-	-
D010(WDH)	Lemington South - Woodlands Hill Seam	6.6	7.6	-	-	-	-	-	-	-	-	-	-	-	-
4119P	North Pit - Spoil	6.5	7.8	-	-	-	-	-	-	-	-	-	-	-	-
DM4	North Pit - Spoil	6.5	7.8	-	-	-	-	-	-	-	-	-	-	-	-
MB14HVO03	North Pit - Spoil	6.5	7.8	7.4	7.4	7.3	7.4	7.5	7.4	7.4	7.4	7.5	7.4	7.3	-
MB14HVO04	North Pit - Spoil	6.5	7.8	7.4	7.5	7.4	7.6	-	7.4	7.5	7.5	7.5	7.4	7.5	-
G1	West Pit - Alluvium	7.1	8.6	-	-	-	7.2	-	7.4	-	7.5	-	-	-	dry
G2	West Pit - Alluvium	7.1	8.6	-	-	-	-	-	-	-	-	-	-	-	dry
G3	West Pit - Alluvium	7.1	8.6	-	-	-	7.8	-	7.8	-	7.9	-	-	-	dry
NPz2	West Pit - Interburden	6.9	8.0	-	-	-	-	-	-	-	-	-	-	-	-
NPz3	West Pit - Interburden	6.9	8.0	-	-	-	-	-	-	-	-	-	-	-	-

Notes: Trigger value exceedances are highlighted in red and bold text

As part of the ongoing groundwater assessment associated with the NV TSF, groundwater monitoring results for this area are presented in Table A.4 to Table A.7.

Table A.4 North Void TSF groundwater monitoring results – groundwater elevation

Bore	Pit Location - Target geology	Trending groundwater level trigger	Groundwater level over 12-months (mAHD)		
		Upper trend level (m)	Jan-21	Dec-21	Trend (m)
Exceedances					
CFW57	Carrington - Alluvium	0.5	58.98	59.7	**0.72**
CGW54A	[1]Carrington - Alluvium	0.5	58.89	59.4	**0.51**
GW-123	North Void - Alluvium	0.5	59.1	59.64	**0.54**
GW-124	North Void - Alluvium	0.5	59.55	61.16	**1.61**
GW-126	North Void - Alluvium	0.5	59.07	59.65	**0.58**
GW-127	North Void - Alluvium	0.5	59.29	60.28	**0.99**
Compliant data					
CFW55R	Carrington - Alluvium	0.5	58.43	58.84	0.41
GW-125	North Void - Alluvium	0.5	59.1	59.46	0.36

Table A.5 North Void TSF groundwater monitoring results – field pH

Bore	Pit Location - Target geology	pH trigger values		2021 pH results											
		5th	95th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Compliant data															
CFW55R	Carrington - Alluvium	**6.8**	**8**	6.9	7.0	7.1	7.1	7.0	7.1	7.1	7.1	7.1	7.1	7.1	7.1
CFW57	Carrington - Alluvium	6.8	8	7.4	7.4	7.4	7.4	7.4	7.5	7.3	7.3	7.4	7.5	7.4	7.2
CGW54A	[1]Carrington - Alluvium	6.8	8	7.5	7.5	7.6	7.5	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
GW-123	North Void - Alluvium	6.8	8	7.3	7.4	7.4	7.3	7.4	7.5	7.5	7.6	7.5	7.5	7.5	7.5
GW-124	North Void - Alluvium	6.8	8	7.6	7.6	7.6	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
GW-125	North Void - Alluvium	6.8	8	7.6	7.6	7.6	7.6	7.6	7.7	7.6	7.7	7.7	7.6	7.6	7.7
GW-126	North Void - Alluvium	6.8	8	7.6	7.6	7.4	7.5	7.5	7.7	7.7	7.7	7.6	7.7	7.7	7.7
GW-127	North Void - Alluvium	6.8	8	7.2	7.2	7.3	7.2	7.2	7.3	7.2	7.2	7.2	7.2	7.3	7.2

Table A.6 North Void TSF groundwater monitoring results – sulfate

Bore	Pit Location - Target geology	Sulfate trigger level (mg/L) Upper bound	2021 sulfate results (mg/L)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Exceedances														
CFW55R	Carrington - Alluvium	2,000	1940	1890	1900	1880	**2090**	1880	1980	1890	1890	1870	1880	1710
Compliant data														
CFW57	Carrington - Alluvium	680	157	173	166	144	142	137	154	173	142	110	145	NA
CGW54A	[1]Carrington - Alluvium	680	454	430	406	414	393	330	343	307	269	250	252	NA
GW-123	North Void - Alluvium	1,400	585	453	438	420	413	408	321	271	252	229	284	NA
GW-124	North Void - Alluvium	680	161	195	200	122	164	143	180	168	143	152	150	NA
GW-125	North Void - Alluvium	230	150	150	145	138	137	138	138	138	131	132	124	NA
GW-126	North Void - Alluvium	230	73	83	68	84	59	65	47	44	52	52	48	NA
GW-127	North Void - Alluvium	230	74	36	53	58	39	39	62	56	67	36	48	68

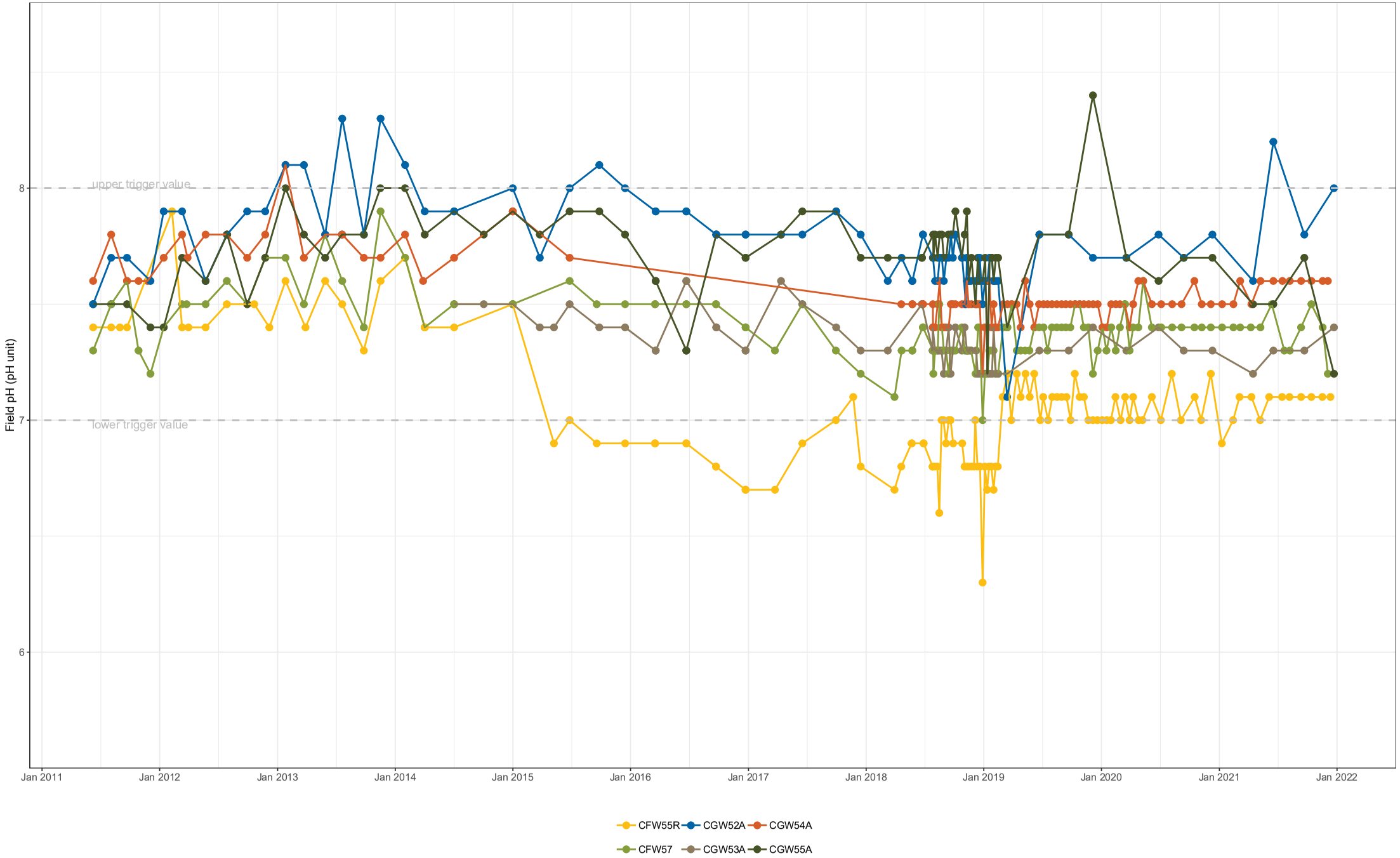
Table A.7 North Void TSF groundwater monitoring results – sulfate/chloride ratio

Bore	Pit Location - Target geology	Trigger level (meq) Upper bound	2021 sulfate/chloride ratio results (meq)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Exceedances														
CFW55R	Carrington - Alluvium	0.8	0.78	0.76	0.79	0.77	**0.84**	**0.88**	**0.86**	**0.82**	**0.82**	**0.82**	0.79	0.68
Compliant data														
CFW57	Carrington - Alluvium	0.5	0.20	0.19	0.20	0.16	0.19	0.20	0.16	0.17	0.17	0.18	0.17	NA
CGW54A	[1]Carrington - Alluvium	0.5	0.39	0.36	0.39	0.34	0.42	0.36	0.37	0.36	0.33	0.34	0.32	NA
GW-123	North Void - Alluvium	0.8	0.49	0.40	0.45	0.37	0.40	0.42	0.37	0.29	0.33	0.33	0.37	NA
GW-124	North Void - Alluvium	0.5	0.19	0.21	0.22	0.17	0.20	0.19	0.23	0.23	0.21	0.21	0.21	NA
GW-125	North Void - Alluvium	0.24	0.14	0.13	0.15	0.13	0.15	0.14	0.14	0.15	0.15	0.15	0.14	NA
GW-126	North Void - Alluvium	0.24	0.14	0.15	0.15	0.17	0.15	0.15	0.13	0.12	0.13	0.13	0.12	NA
GW-127	North Void - Alluvium	0.24	0.11	0.11	0.11	0.10	0.12	0.11	0.12	0.12	0.12	0.12	0.10	0.11

Notes: 1. bore is installed within alluvium in the Carrington area, it is not assessed as part of the Carrington Alluvium WMP designation
Trigger value exceedances are highlighted in red and bold text
EC = Electrical conductivity

Appendix B

Groundwater time series data - sites with trigger levels



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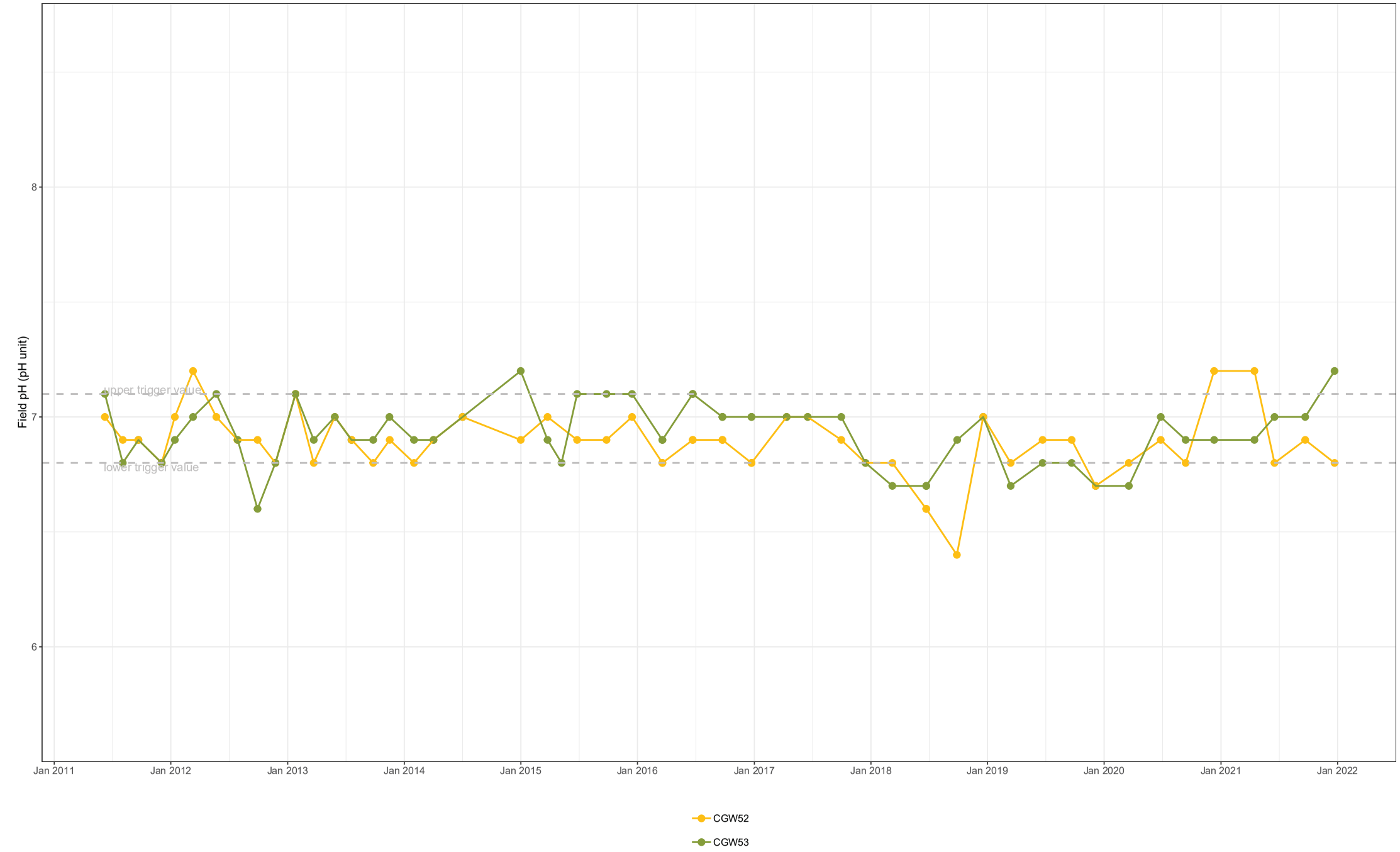
Notes

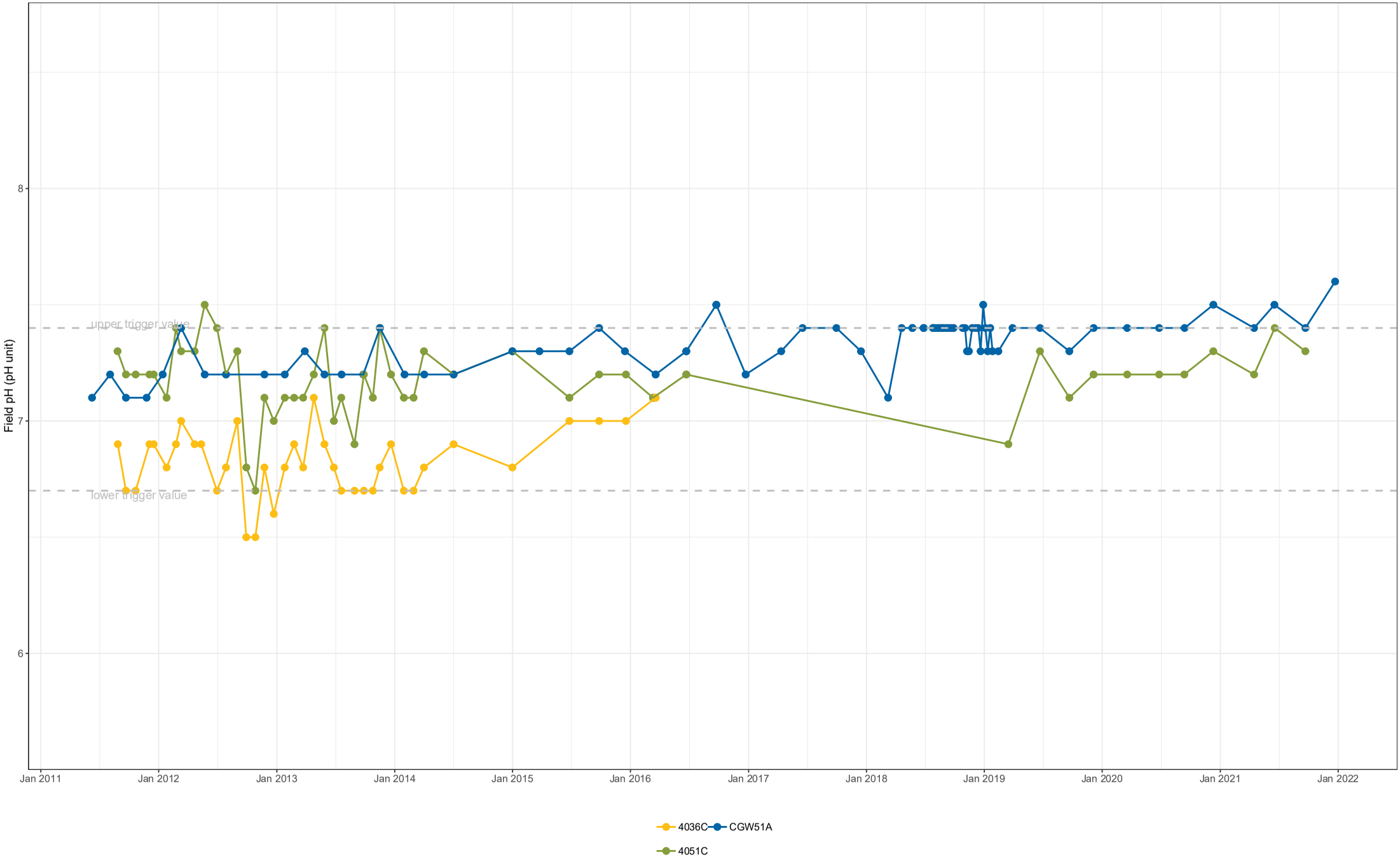
Carrington − Alluvium Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 1



EMM creating opportunities

Notes

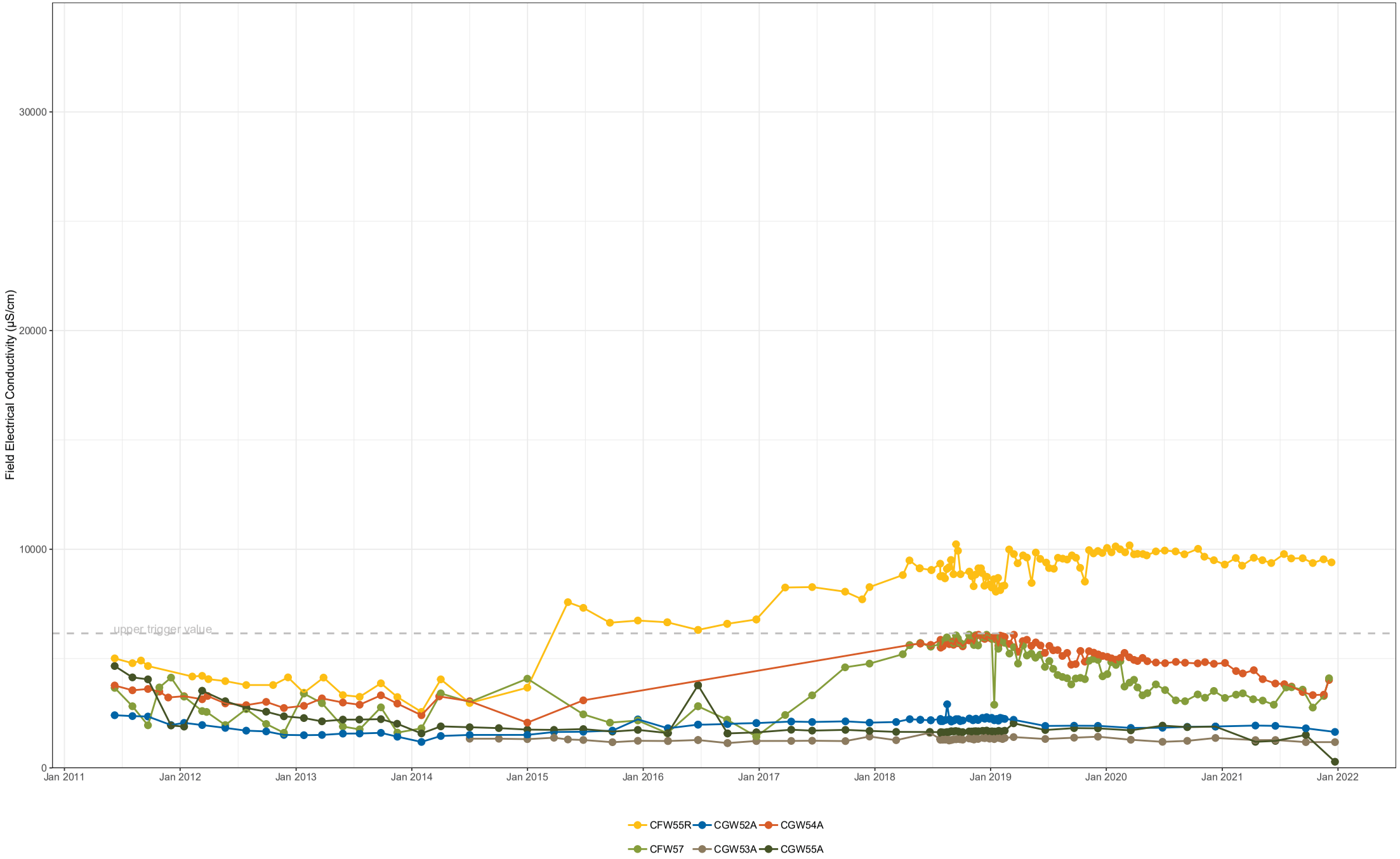
Carrington − Broonie Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 2



EMM creating opportunities

Notes

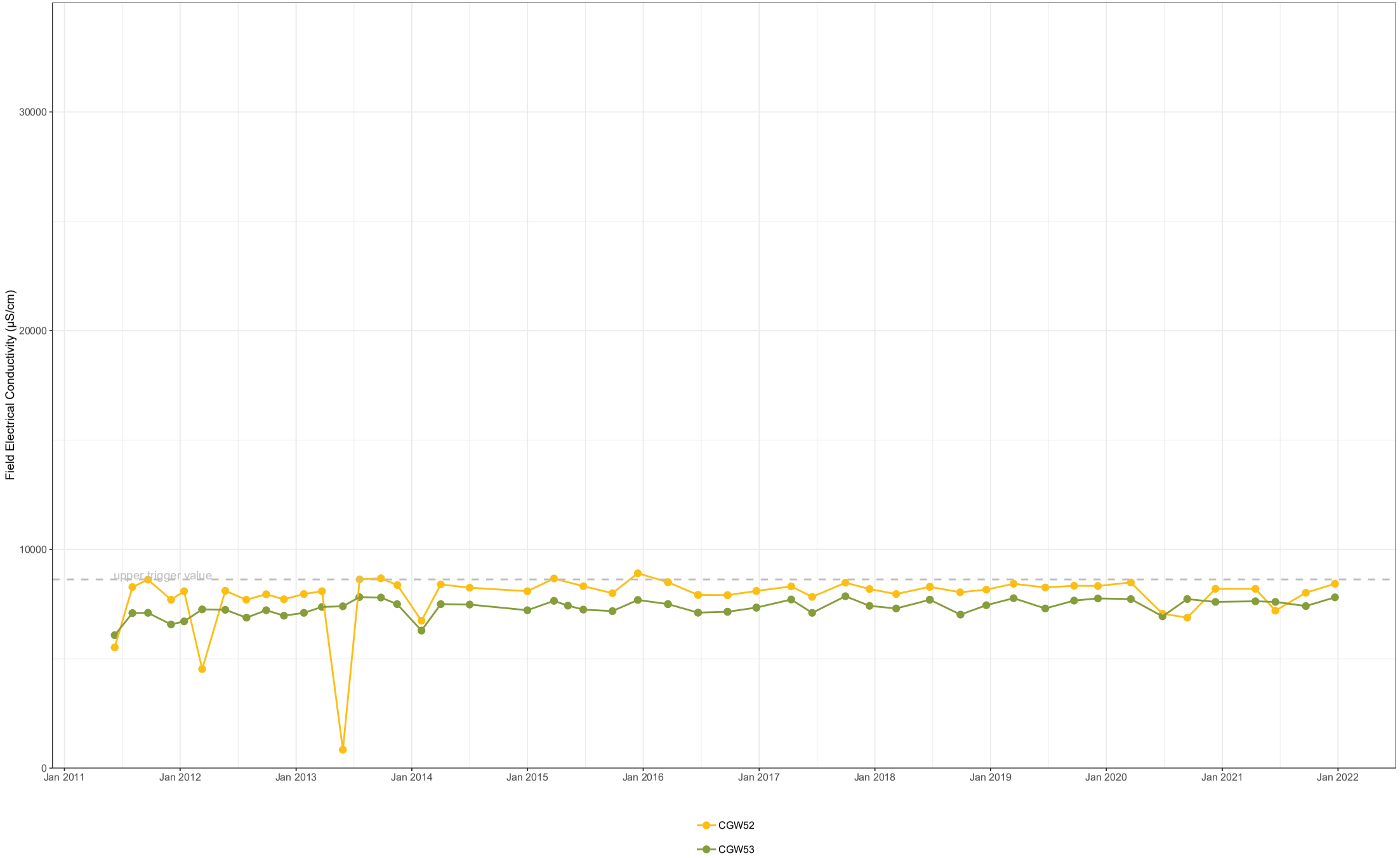
Carrington − Interburden Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 3



EMM creating opportunities

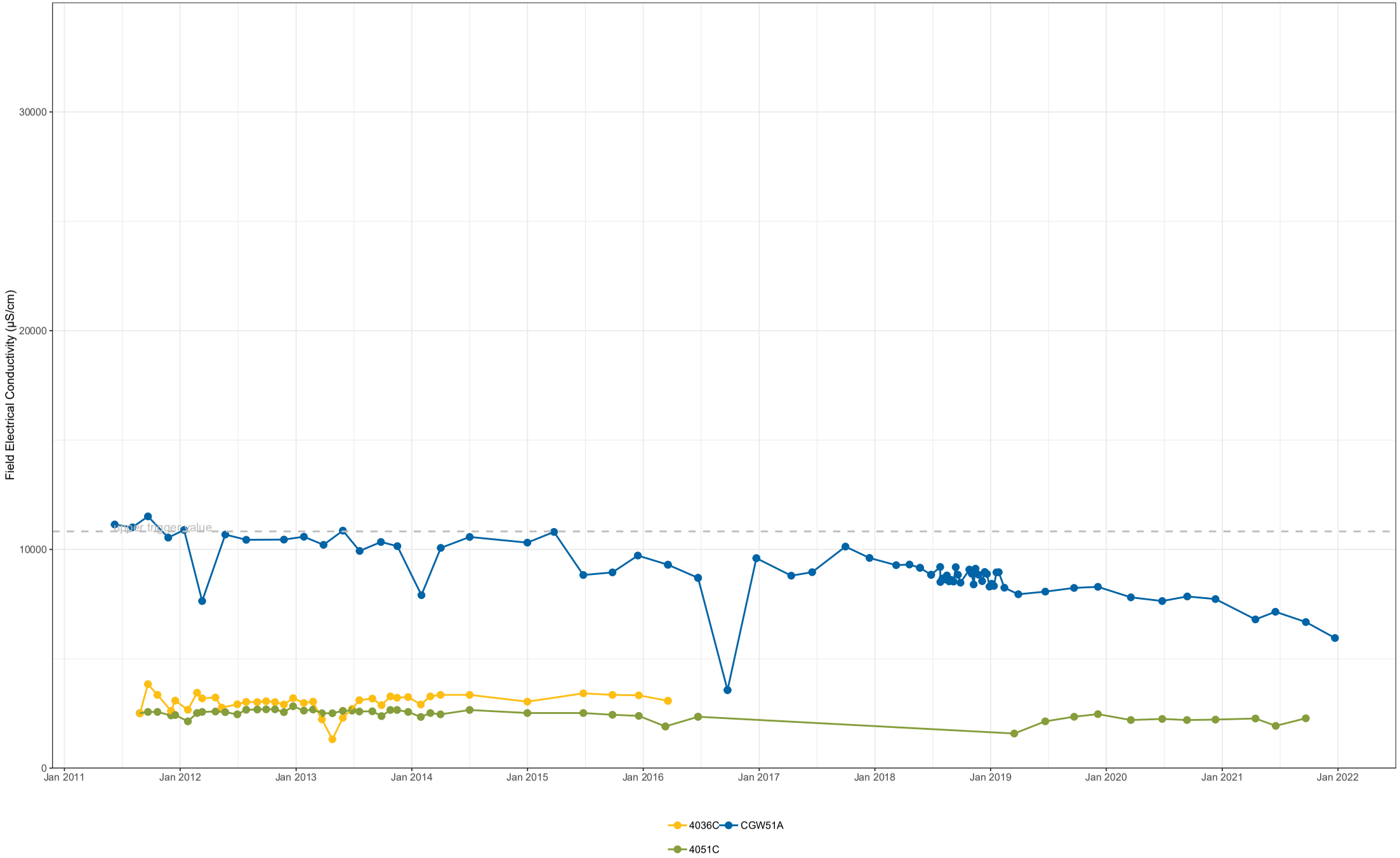
Notes

Carrington − Alluvium Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 4



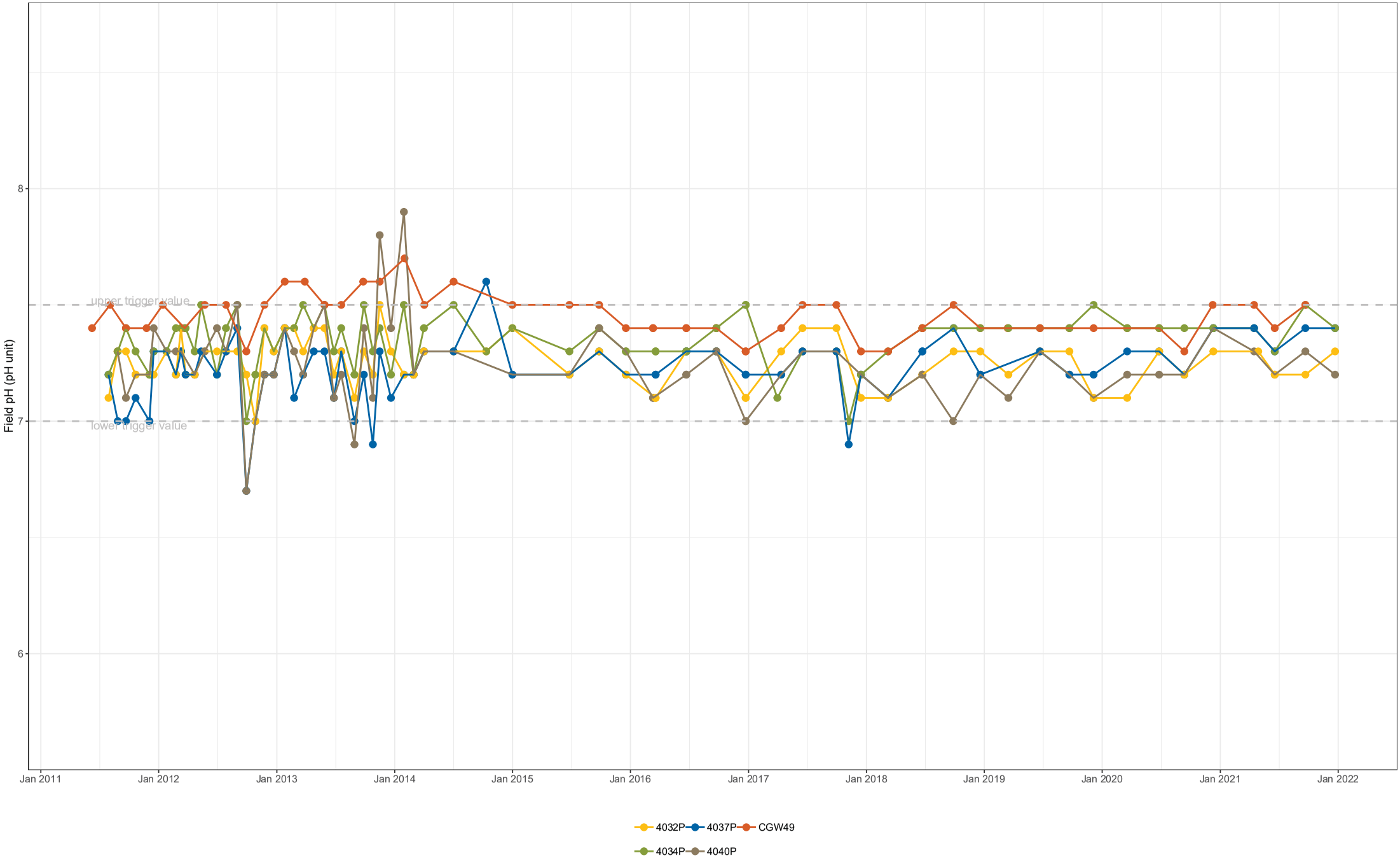
Notes

Carrington − Broonie Seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 5



Notes

Carrington − Interburden Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 6

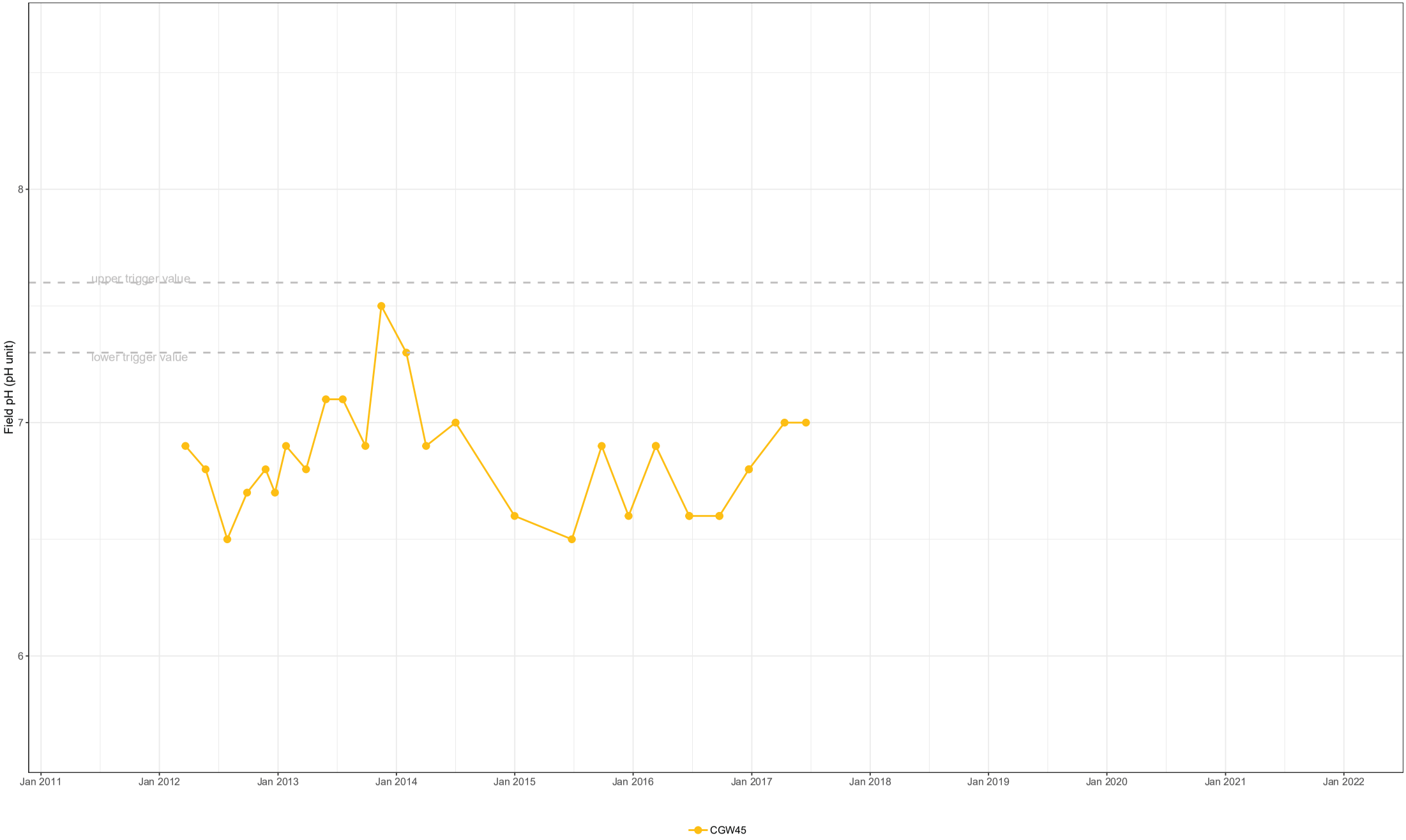


Notes

Carrington West Wing − Alluvium Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 7

Notes

Carrington West Wing − Floodplain Alluvium Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 8



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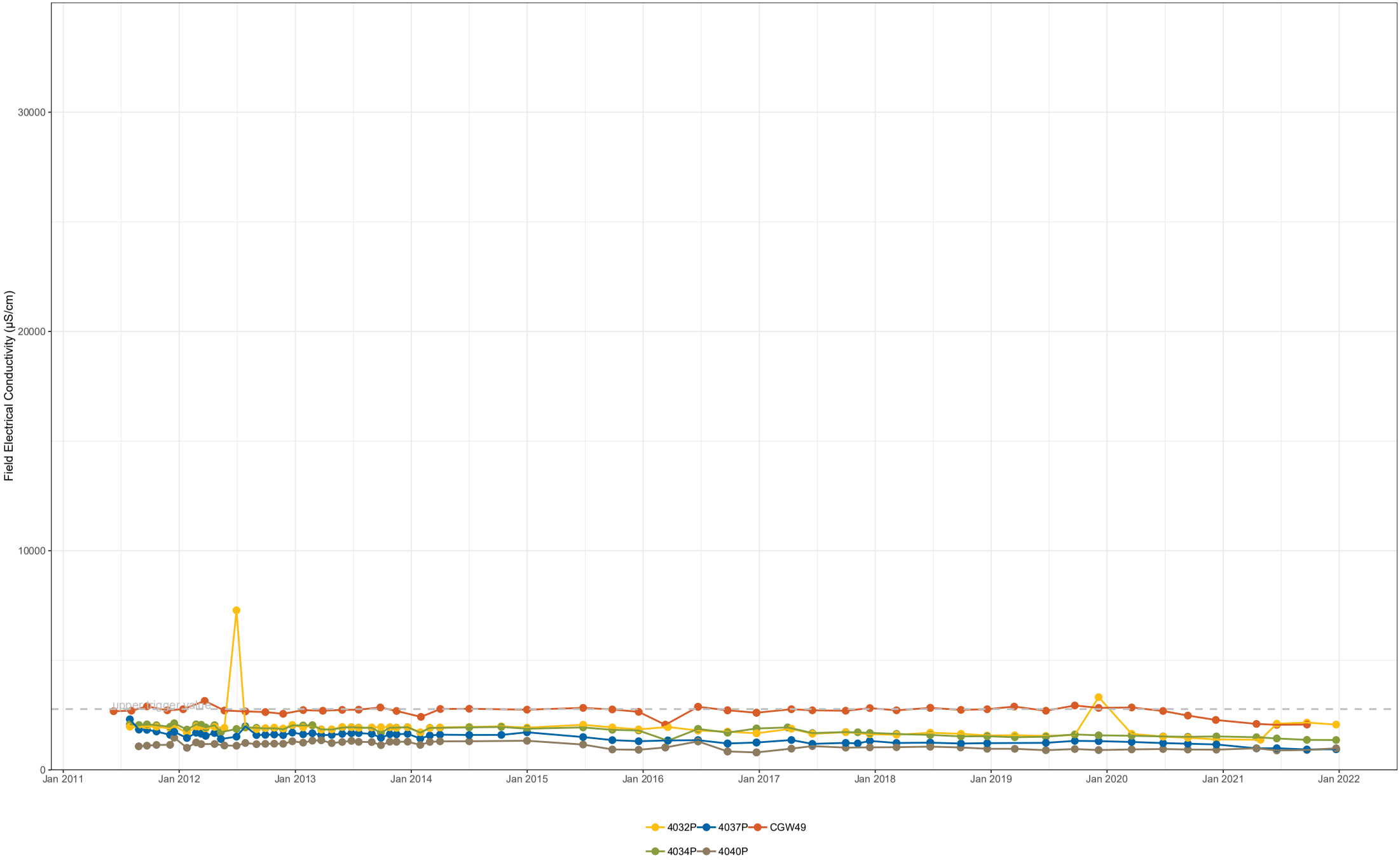
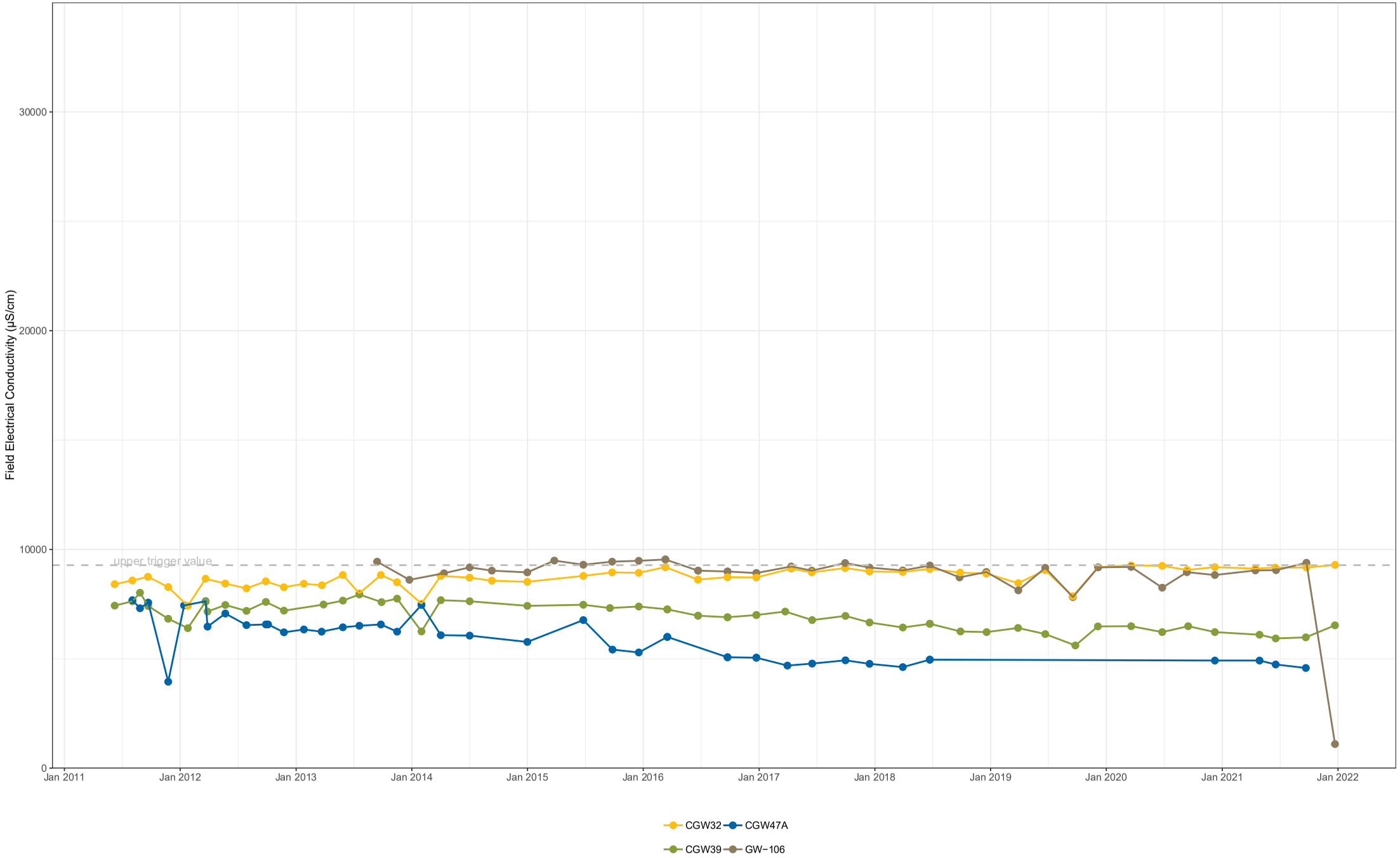
Notes

Carrington West Wing − LBL Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 9



Notes

Carrington West Wing − Alluvium Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 10



Carrington West Wing − Floodplain Alluvium Field Electrical Conductivity (µS/cm)

Hunter Valley Operations

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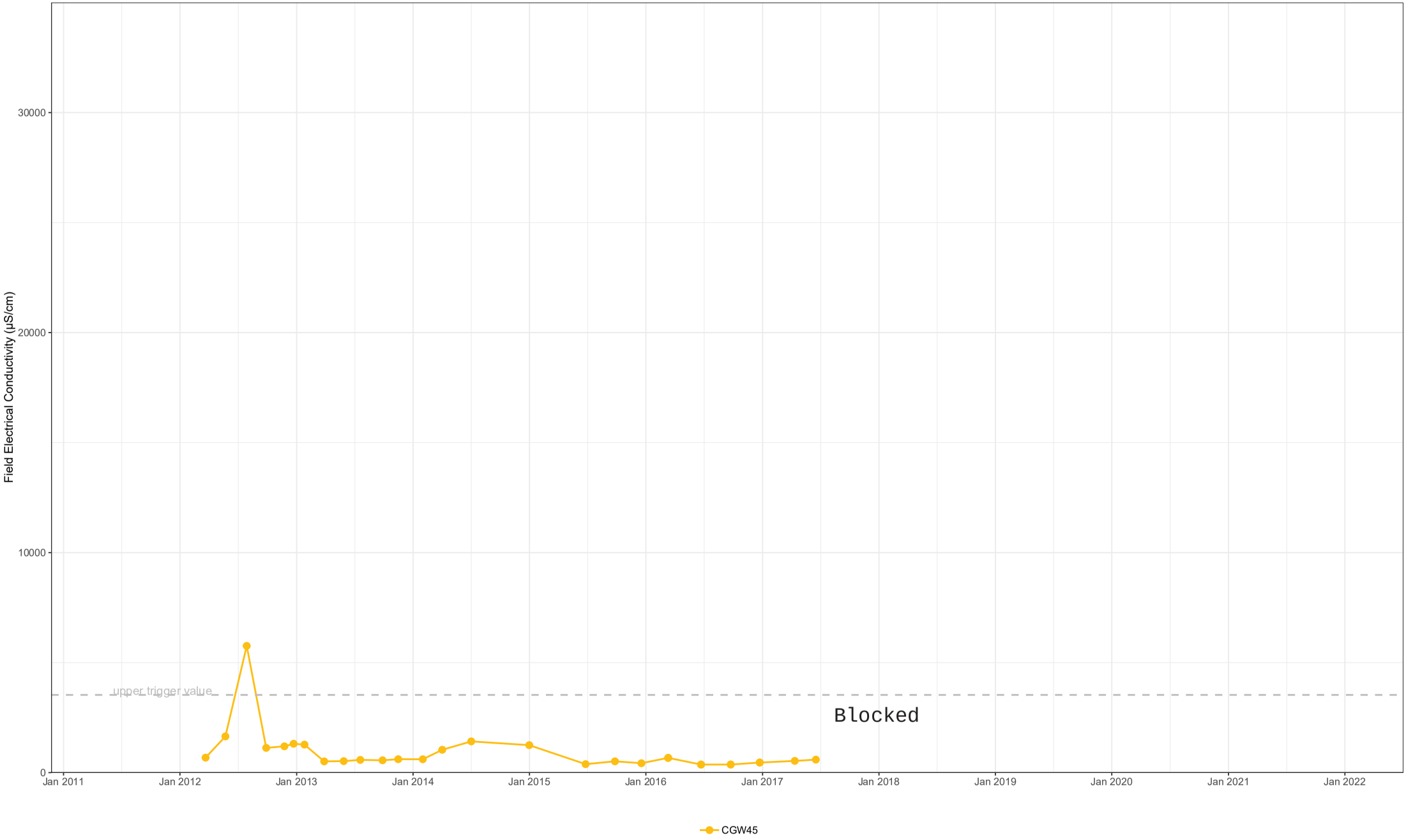
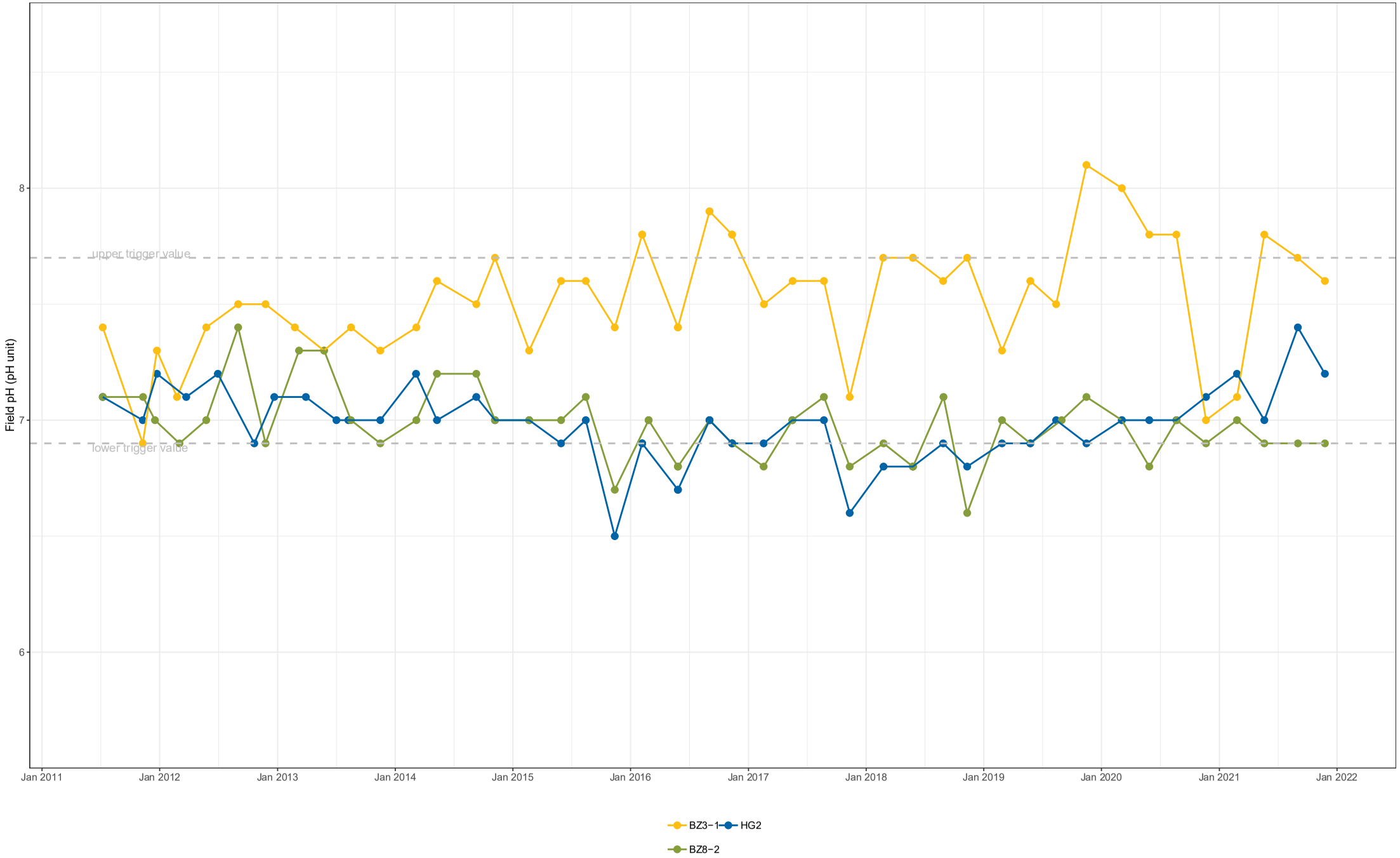
Appendix B Figure 11

Notes



Notes

Carrington West Wing − LBL Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 12



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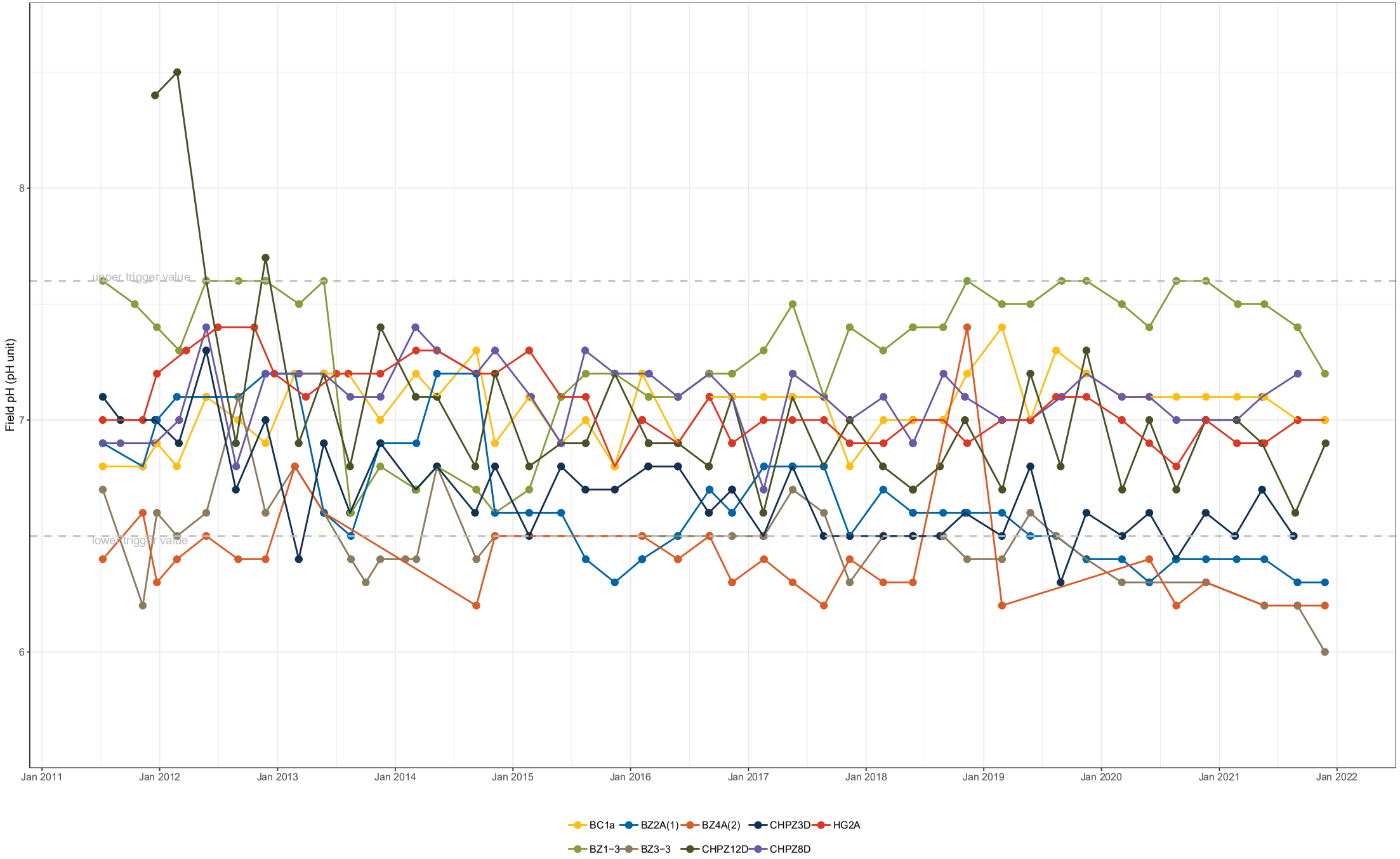
Notes

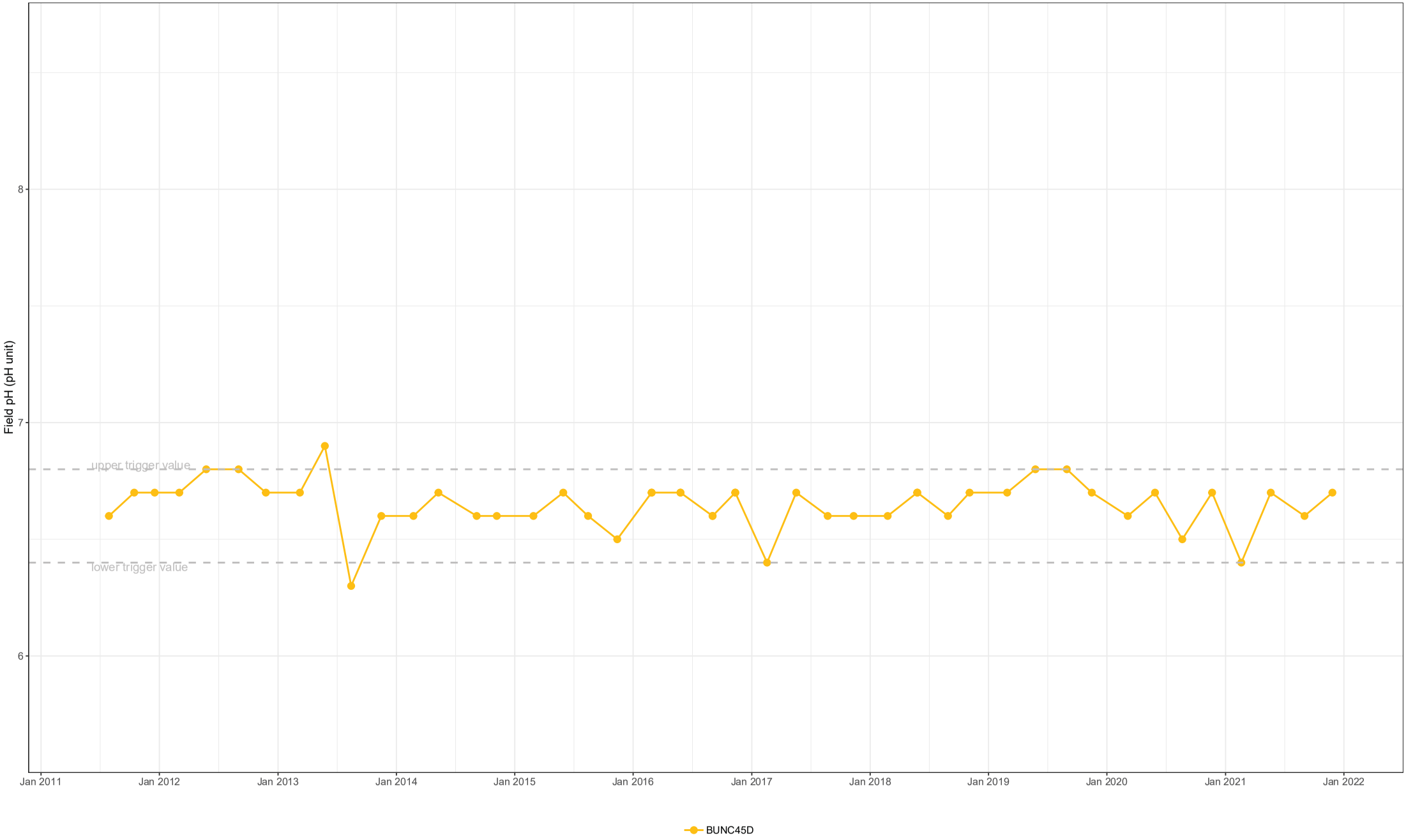
Cheshunt − Interburden Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 13



EMM creating opportunities

Notes

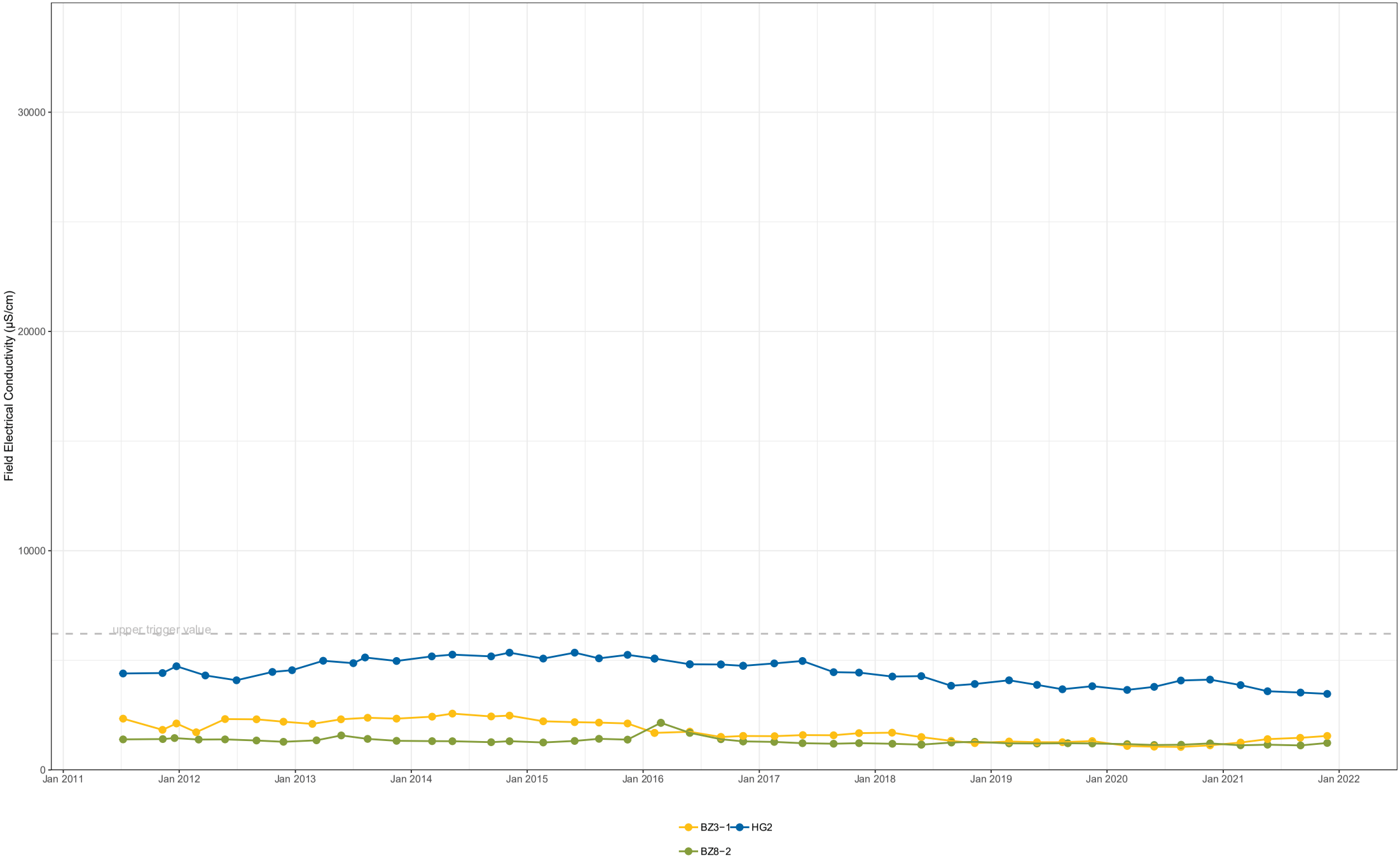
Cheshunt − Mt Arthur Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 14



EMM creating opportunities

Notes

Cheshunt − Piercefield Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 15



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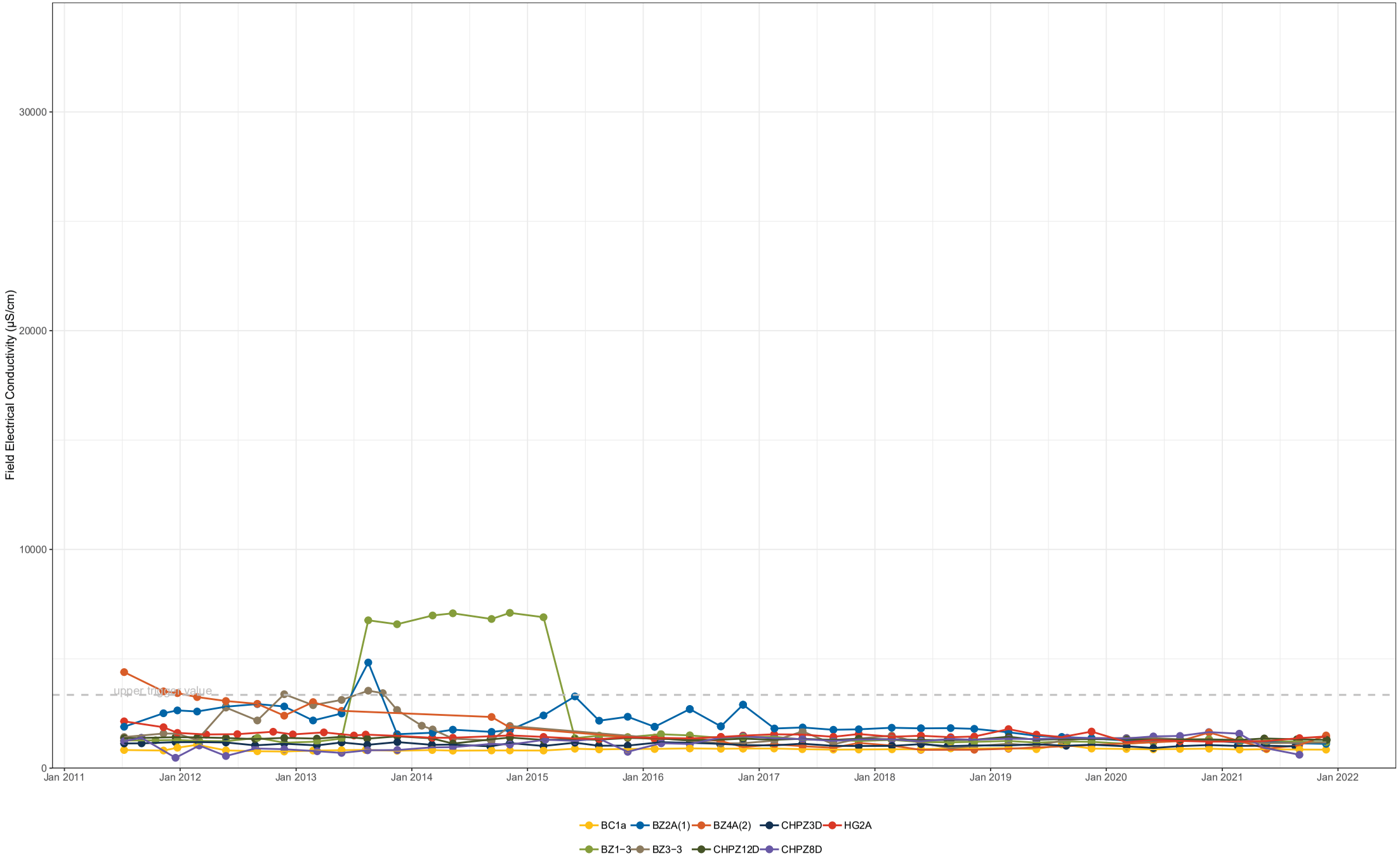
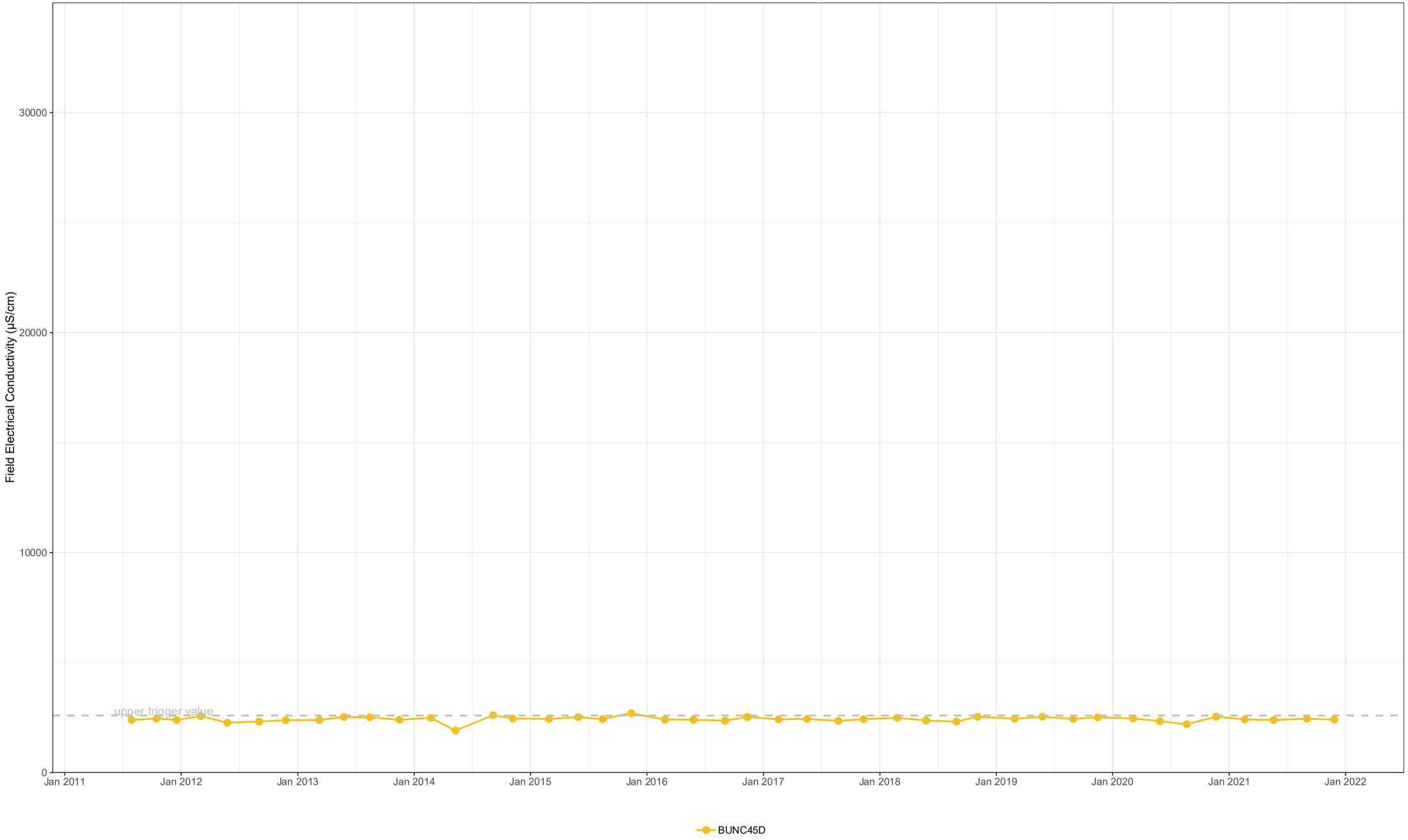
Notes

Cheshunt − Interburden Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 16



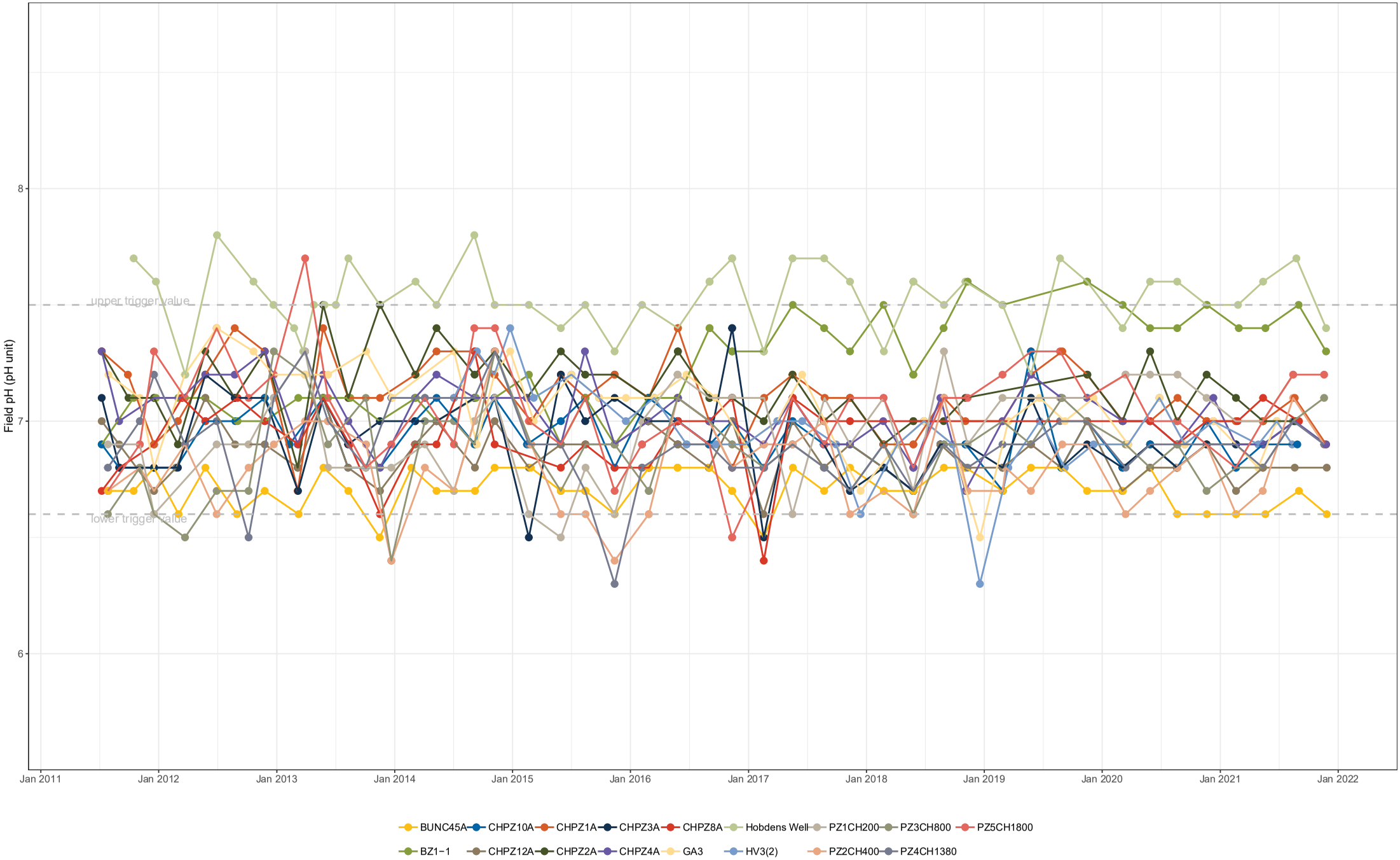
Notes

Cheshunt − Mt Arthur Seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 17



Notes

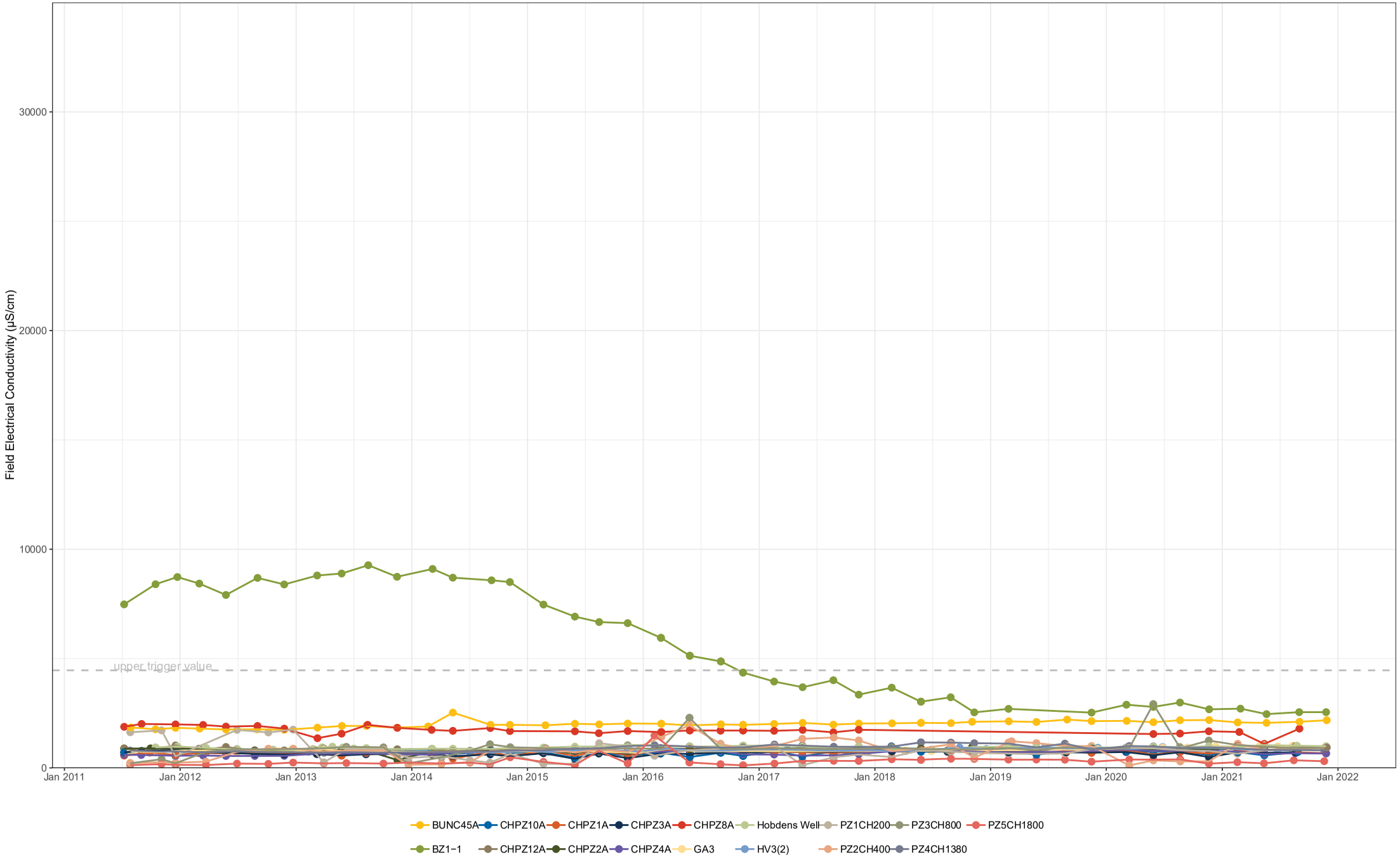
Cheshunt − Piercefield Seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 18



EMM creating opportunities

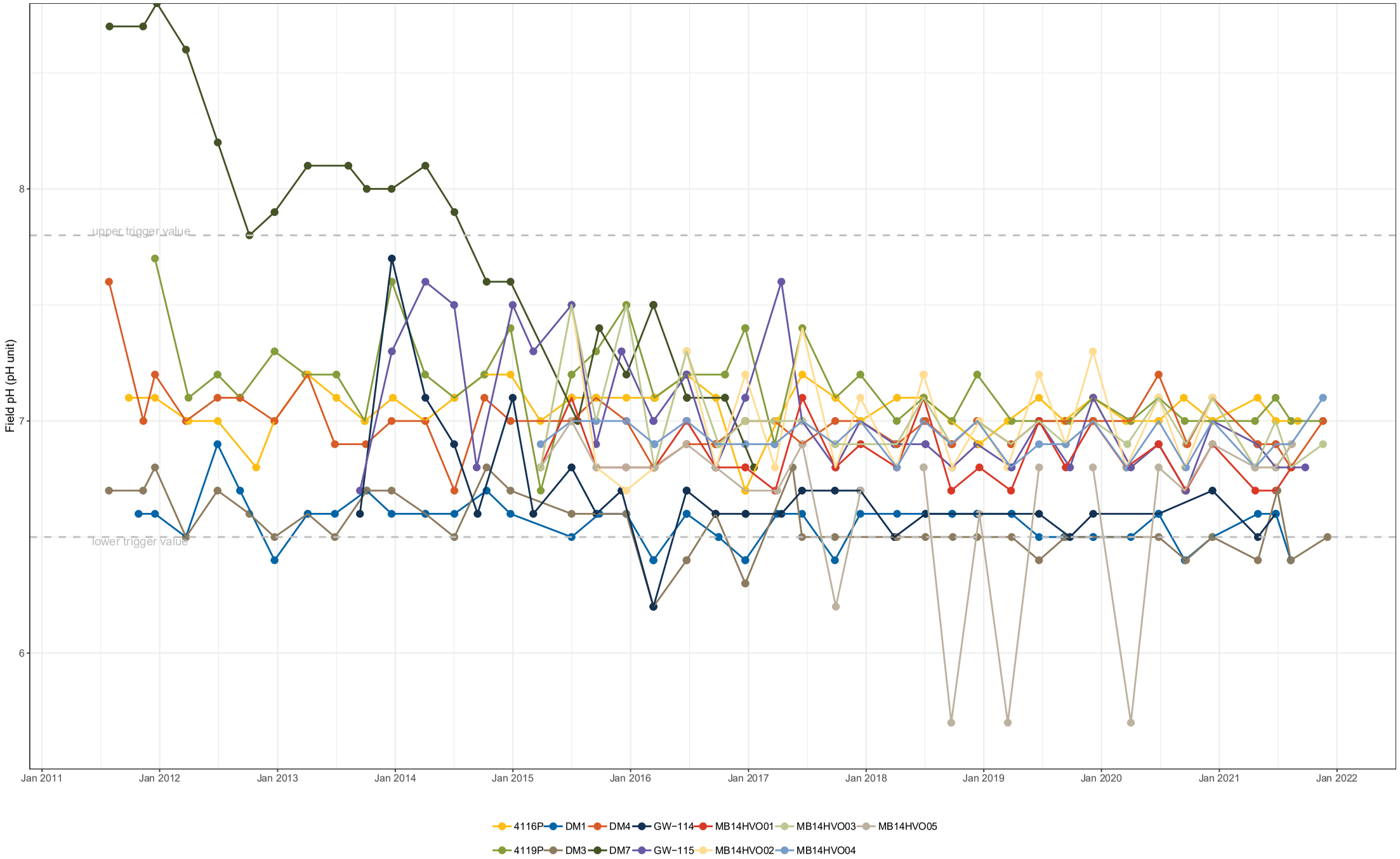
Notes

Cheshunt / North Pit − Alluvium Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 19



Notes

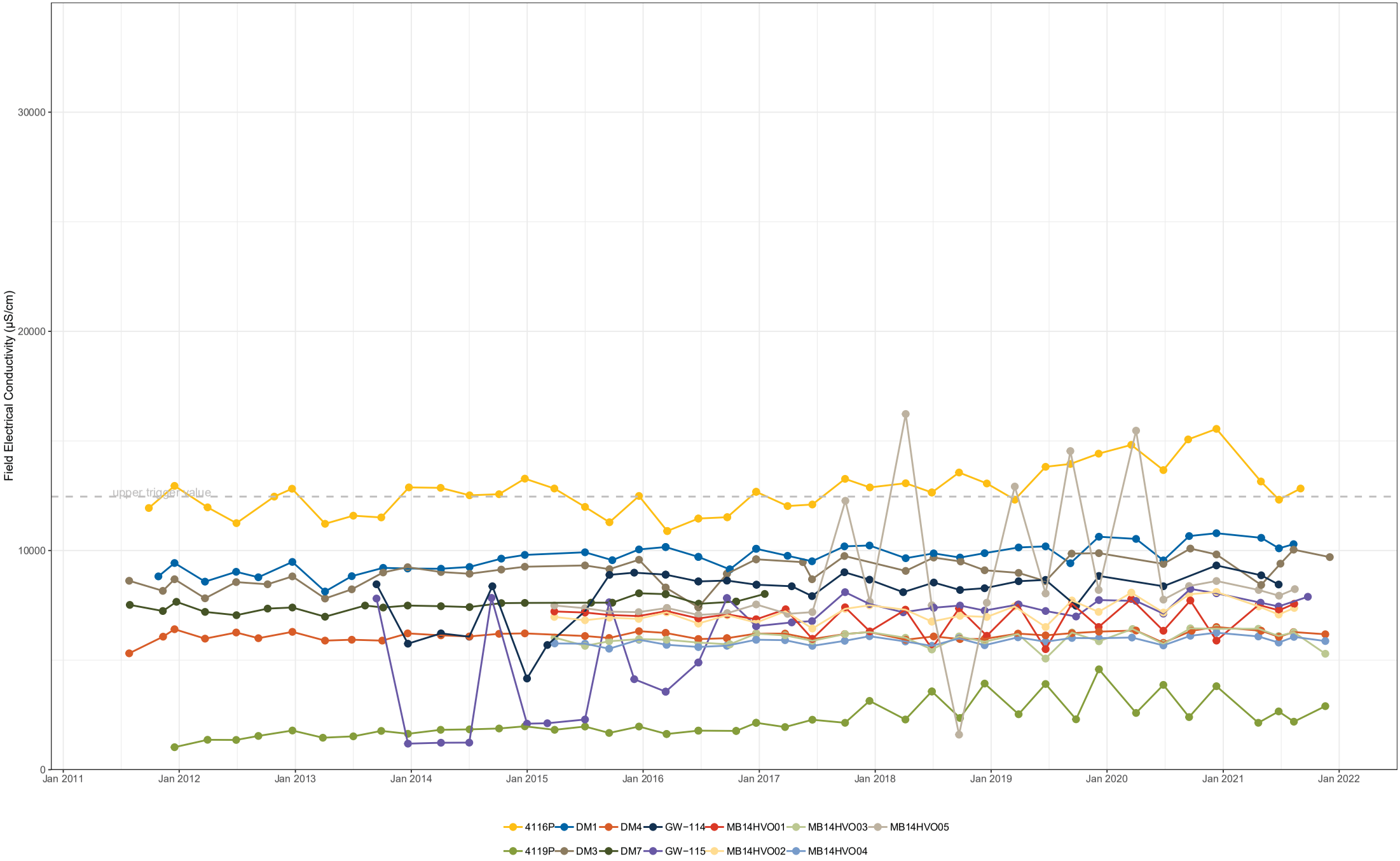
Cheshunt / North Pit − Alluvium Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 20



EMM creating opportunities

Notes

North Pit − Spoil Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 21



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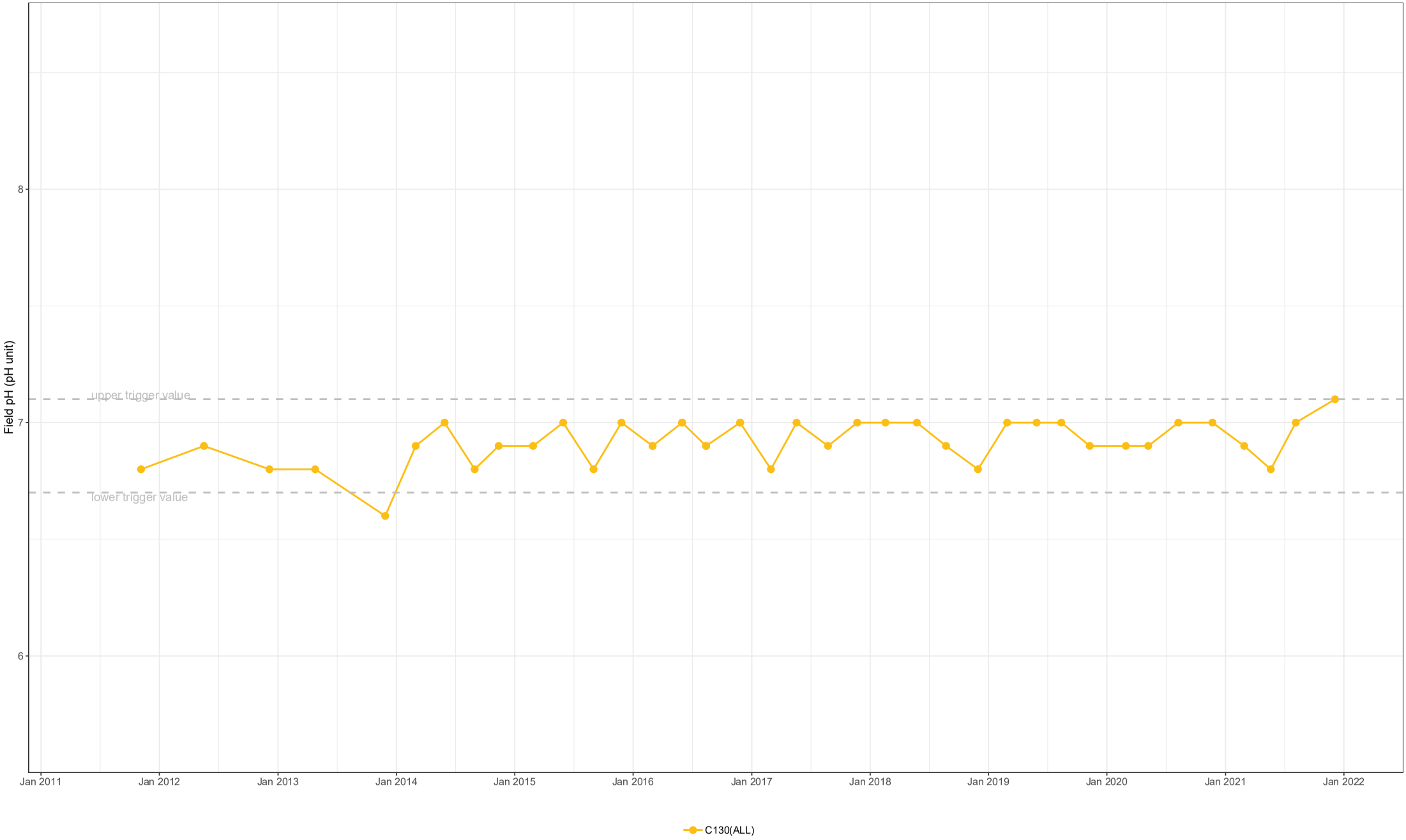
Notes

North Pit − Spoil Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 22

Notes: C919(ALL) was dry in 2019 and 2020

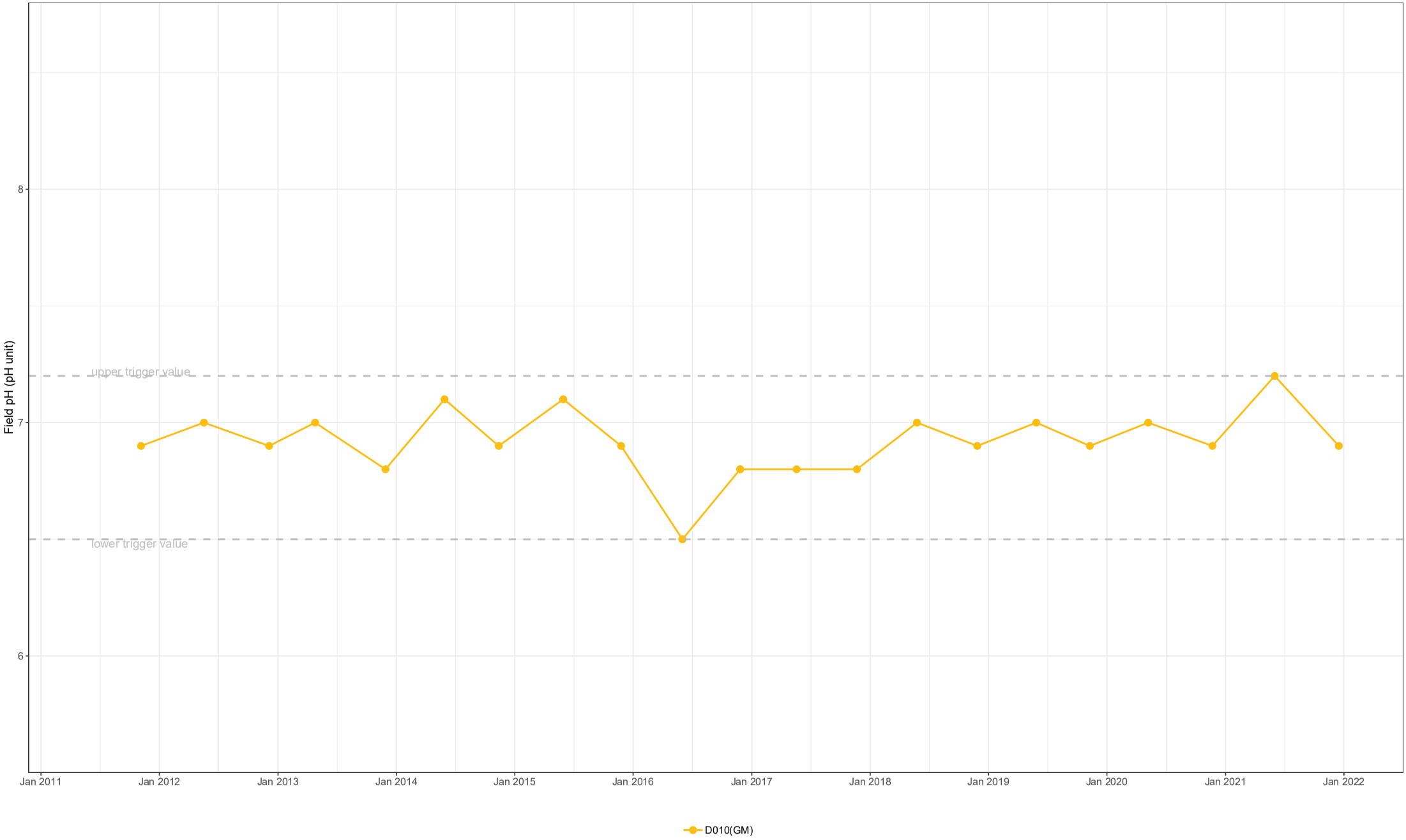
Lemington South − Alluvium Field pH (pH unit)
Hunter Valley Operations
2021 Annual groundwater review
Appendix B, Figure 23



EMM creating opportunities

Notes

Lemington South − Interburden Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 24



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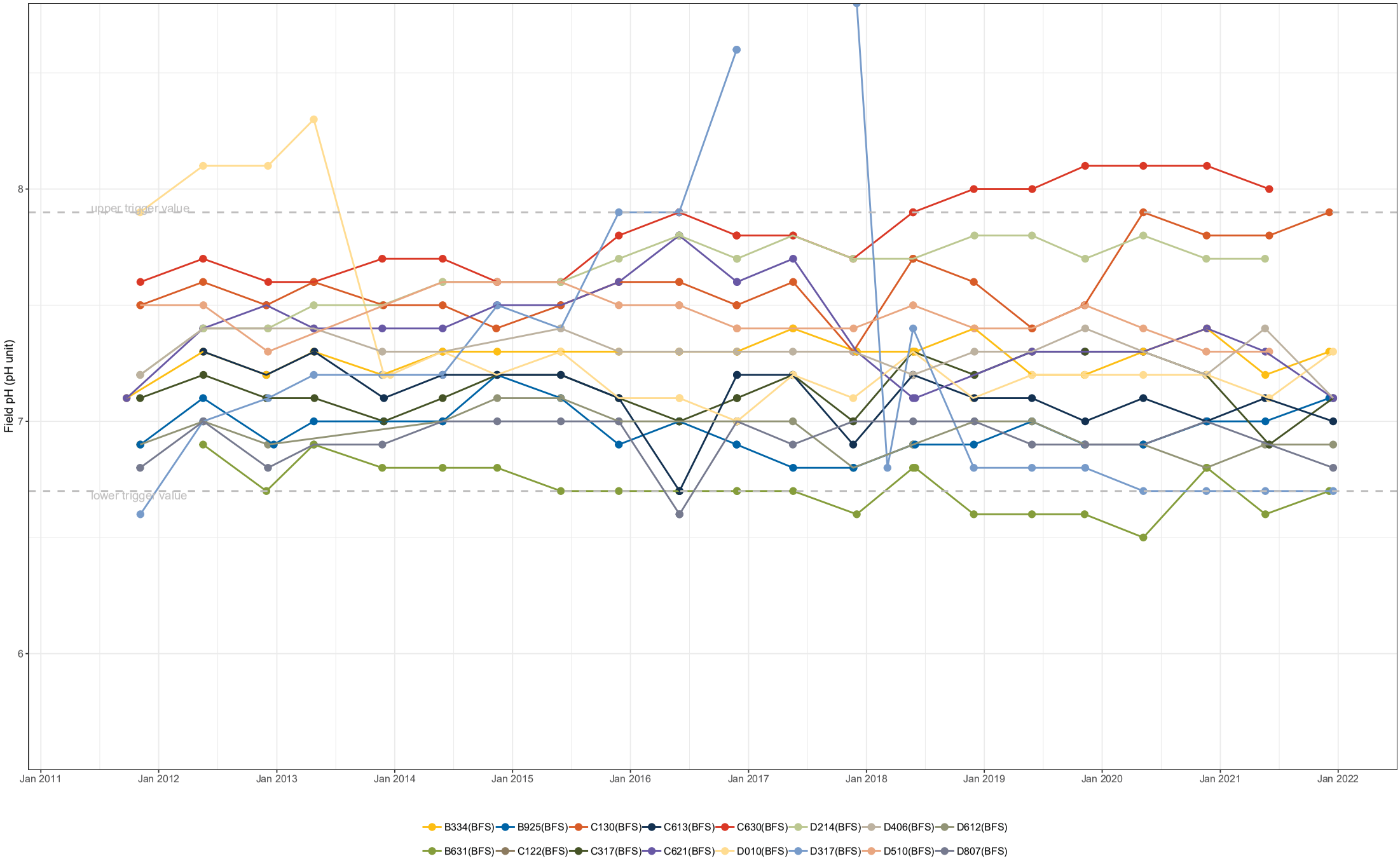
Notes

Lemington South − Glen Munro Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 25



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Notes

Lemington South − Bowfield Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 26

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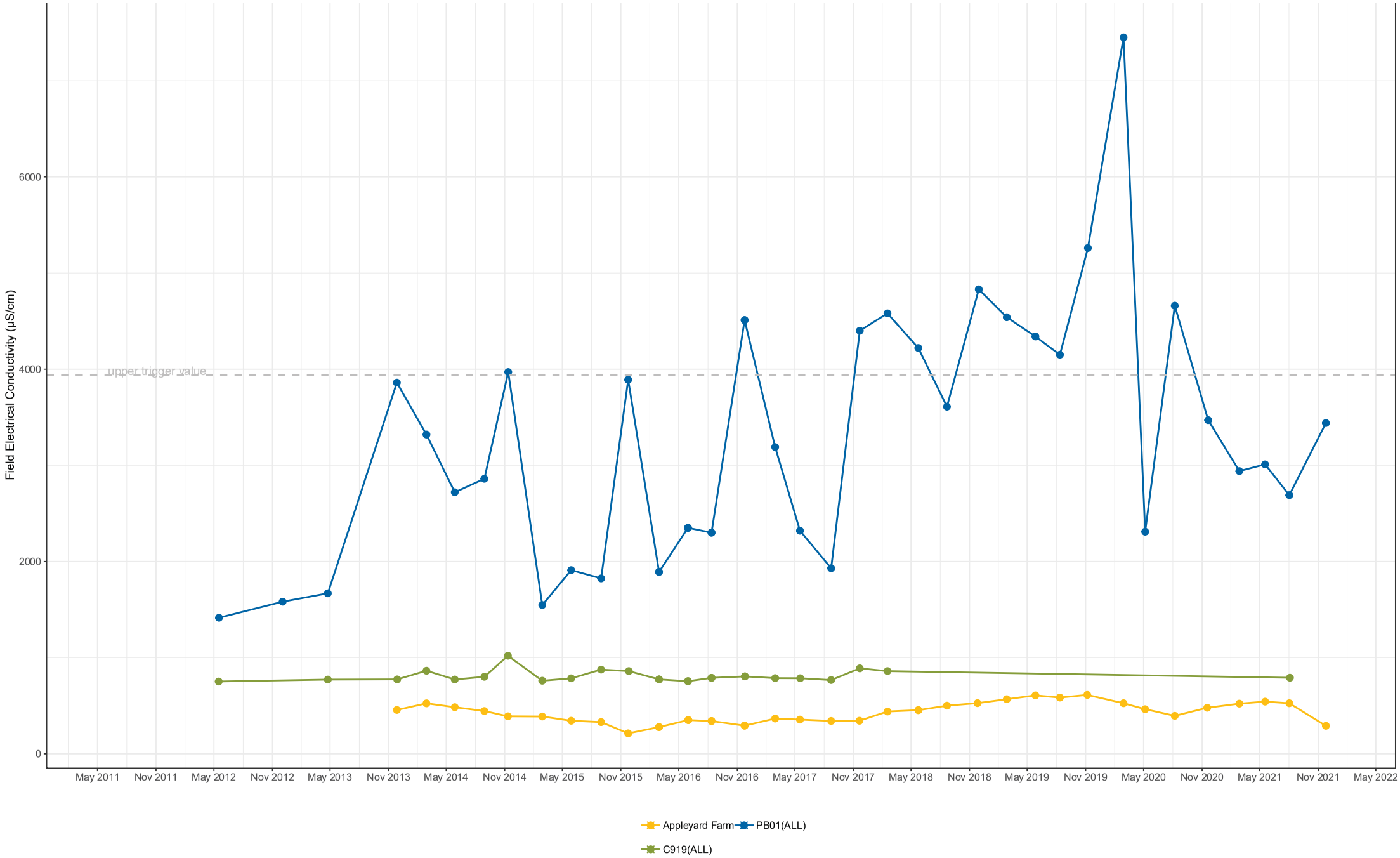
Notes

Lemington South − Arrowfield Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 27



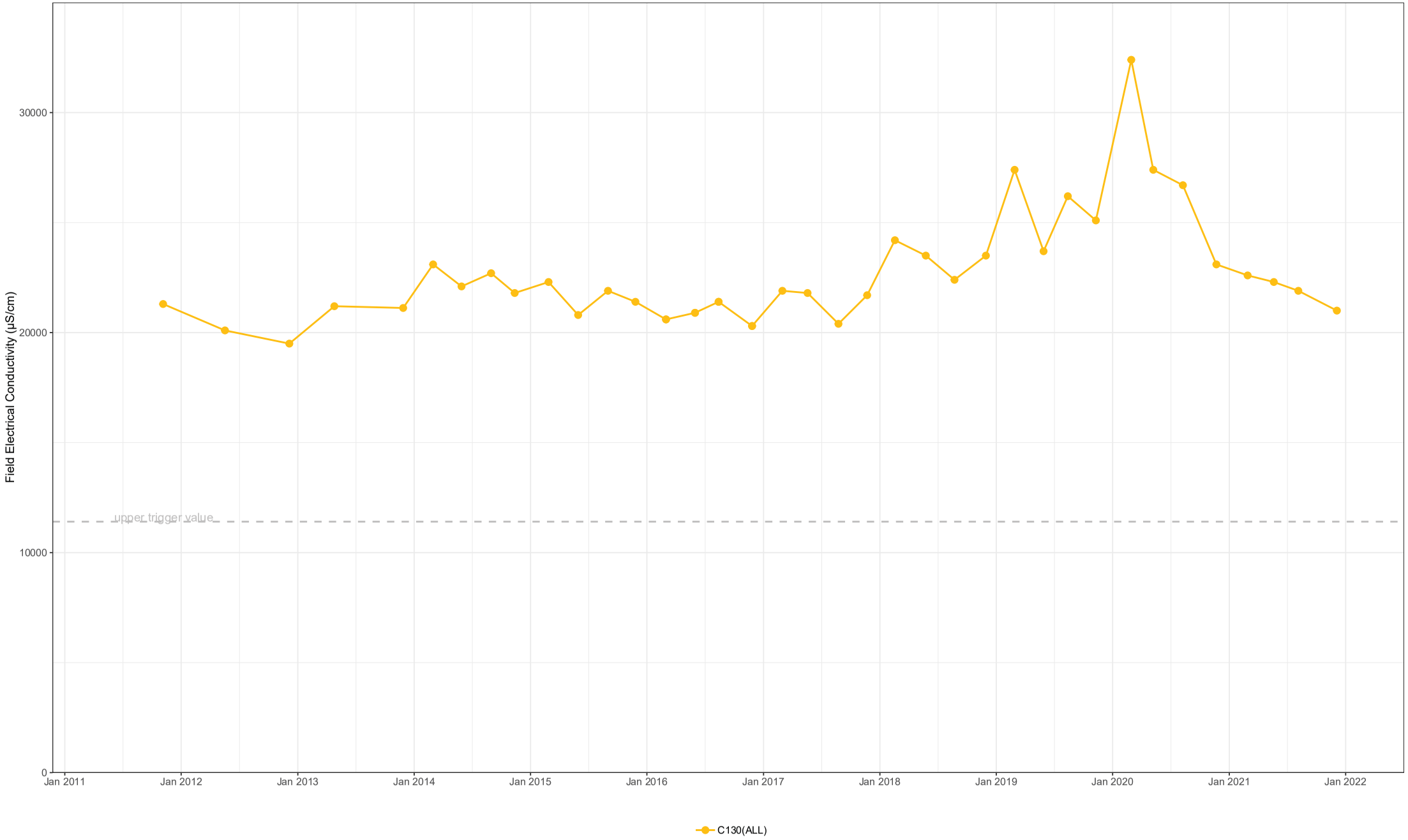
Notes: C919(ALL) was dry in 2019 and 2020

Lemington South − Alluvium Field Electrical Conductivity (µS/cm)

Hunter Valley Operations

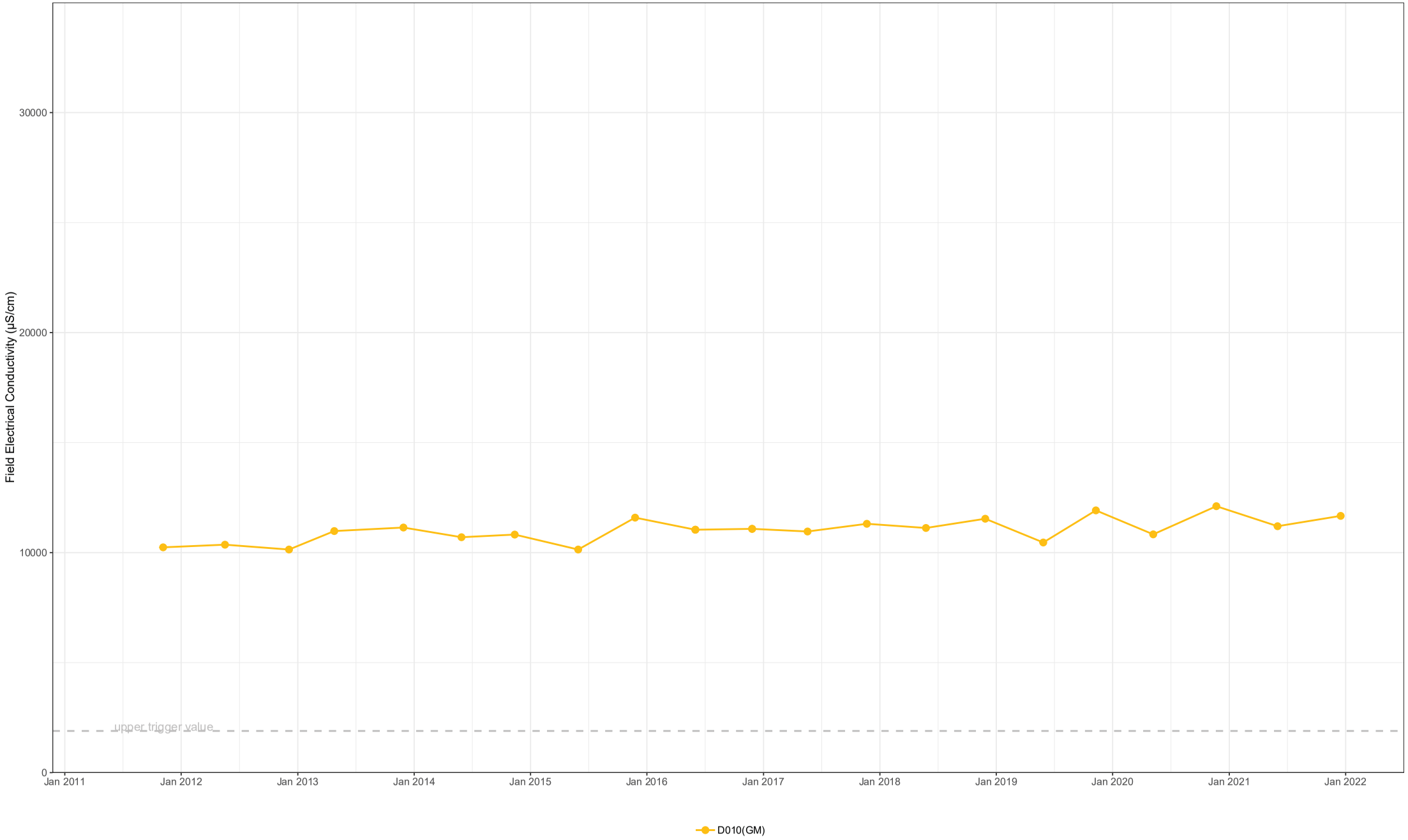
2021 Annual groundwater review

Appendix B, Figure 28



Notes

Lemington South − Interburden Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 29



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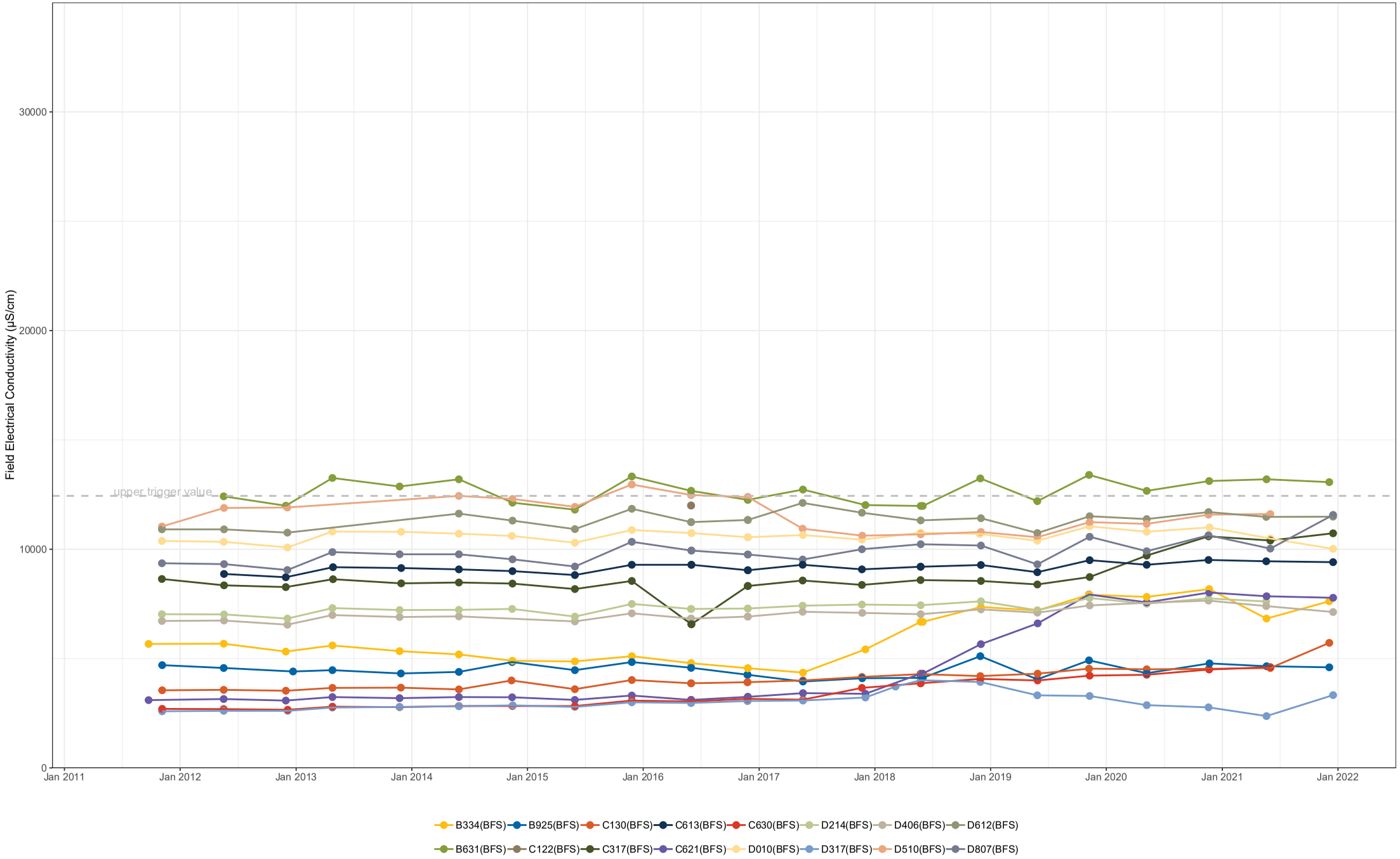
Notes

Lemington South − Glen Munro Seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 30



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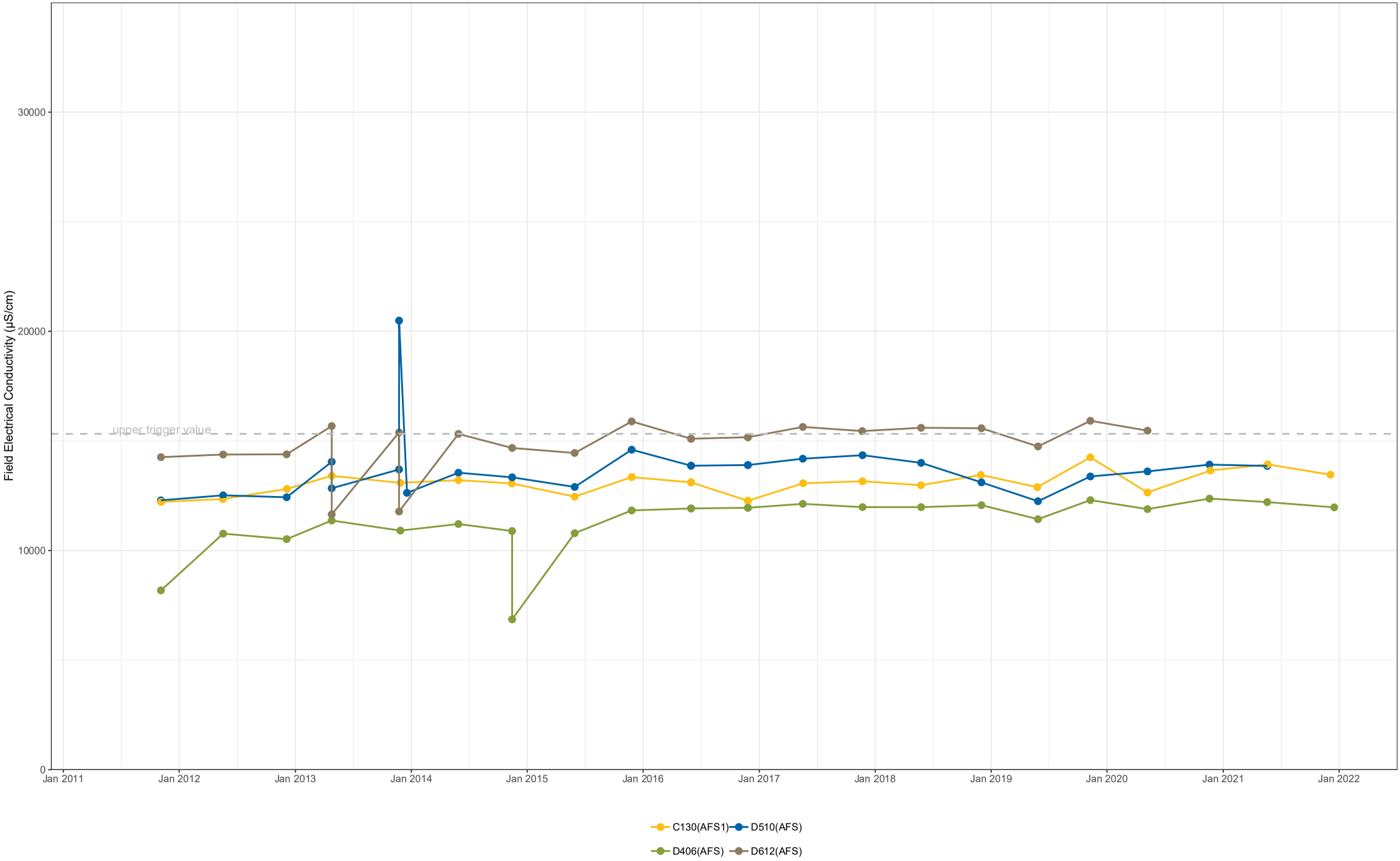
Notes

Lemington South − Bowfield Seam Field Electrical Conductivity (µS/cm)

Hunter Valley Operations

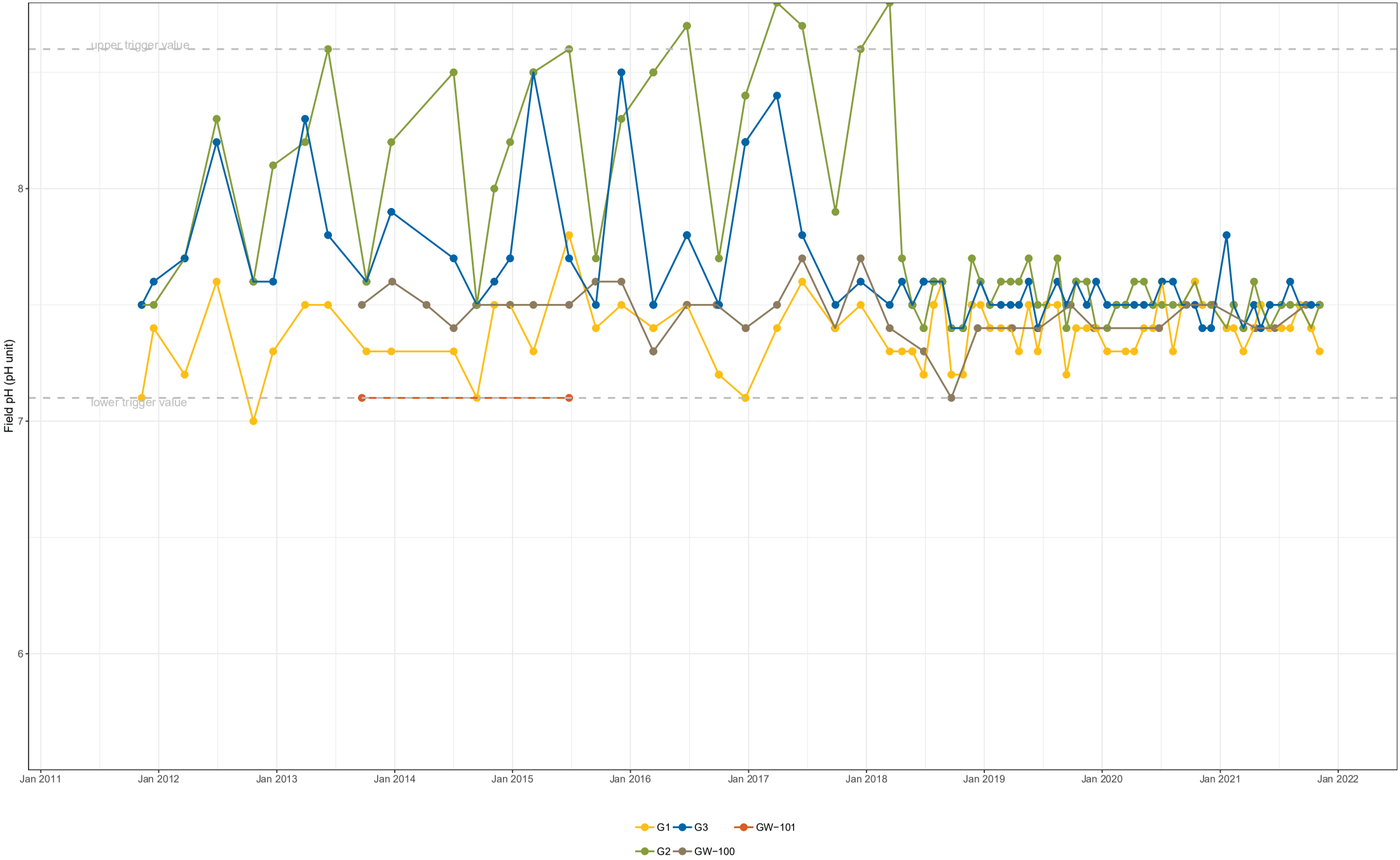
2021 Annual Groundwater Monitoring Review

Appendix B Figure 31



Notes

Lemington South − Arrowfield Seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 32



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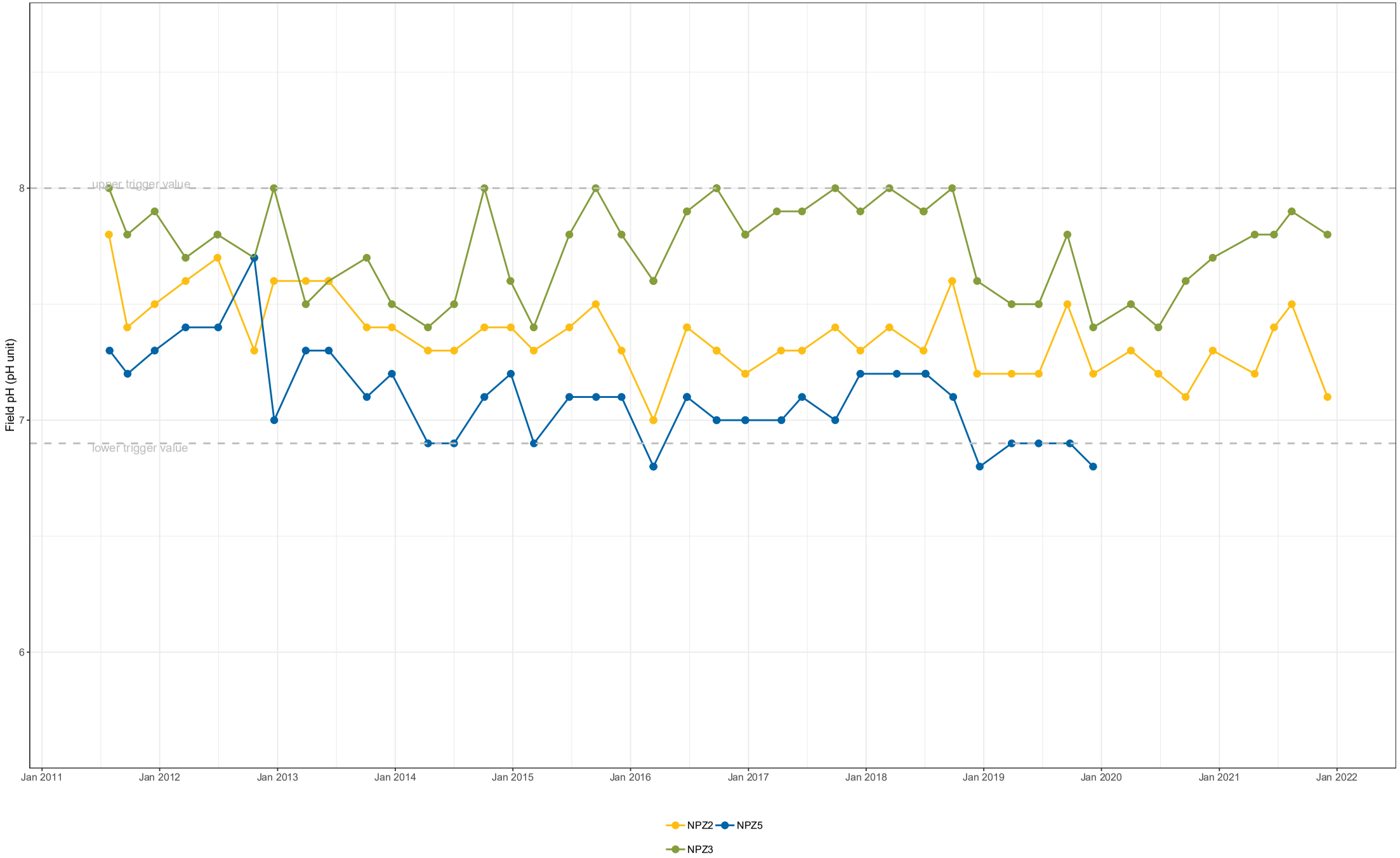
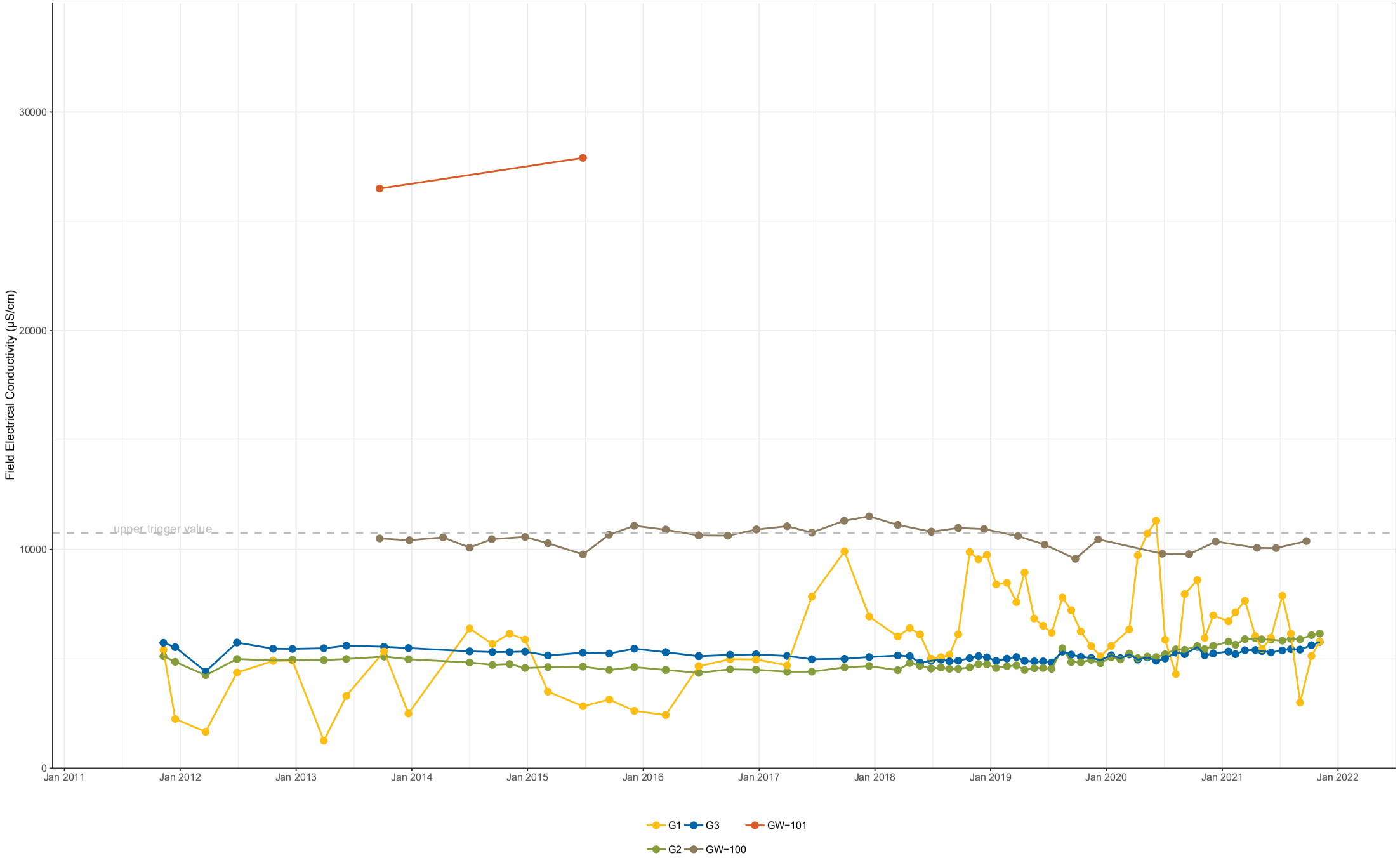
Notes

West Pit − Alluvium Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 33



Notes: Monitoring at NPZ5 ceased in 2020 due to proximity to mining

West Pit − Interburden Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 34



West Pit − Alluvium Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
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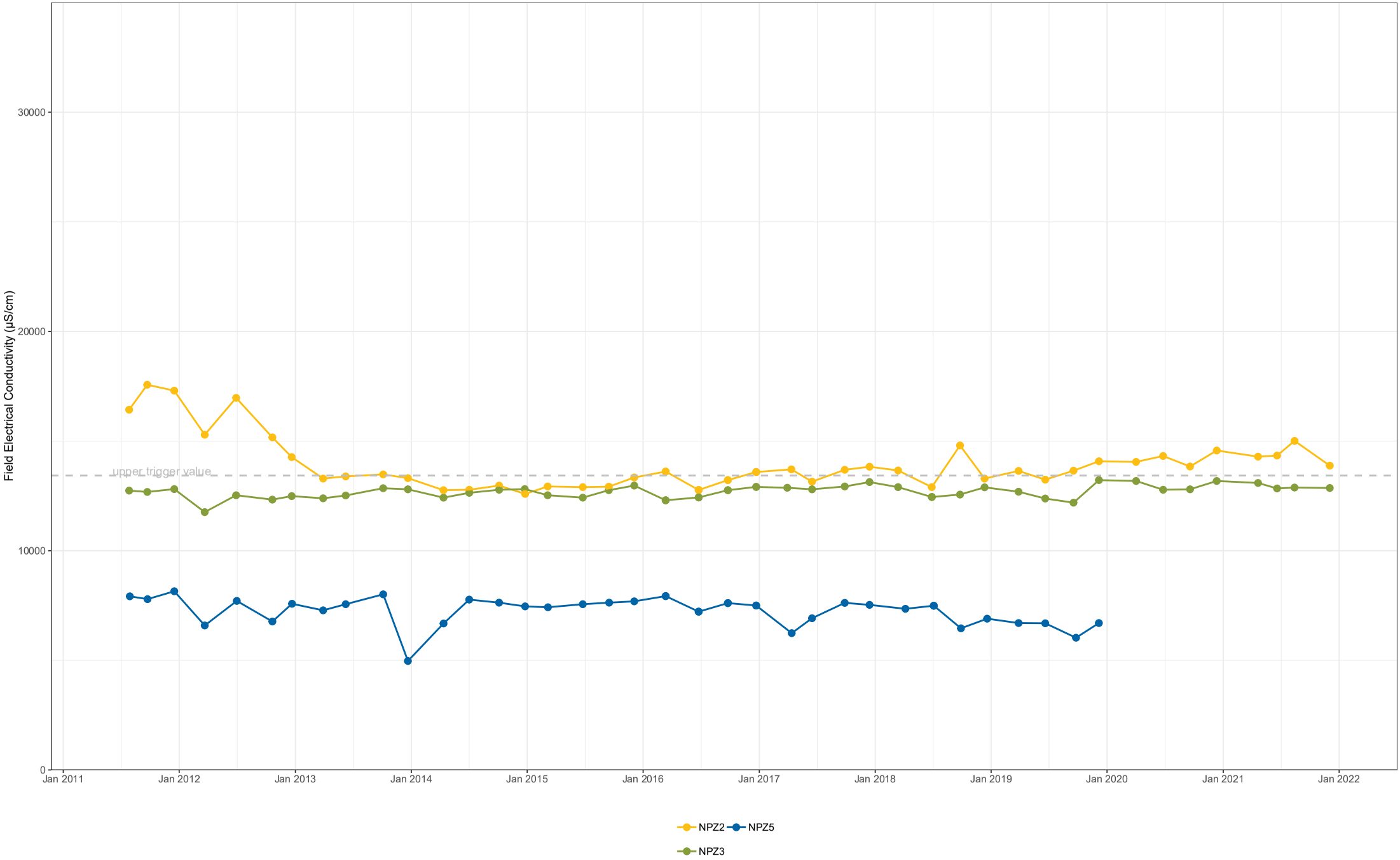
Appendix B Figure 35

Notes: GW-101 is dry

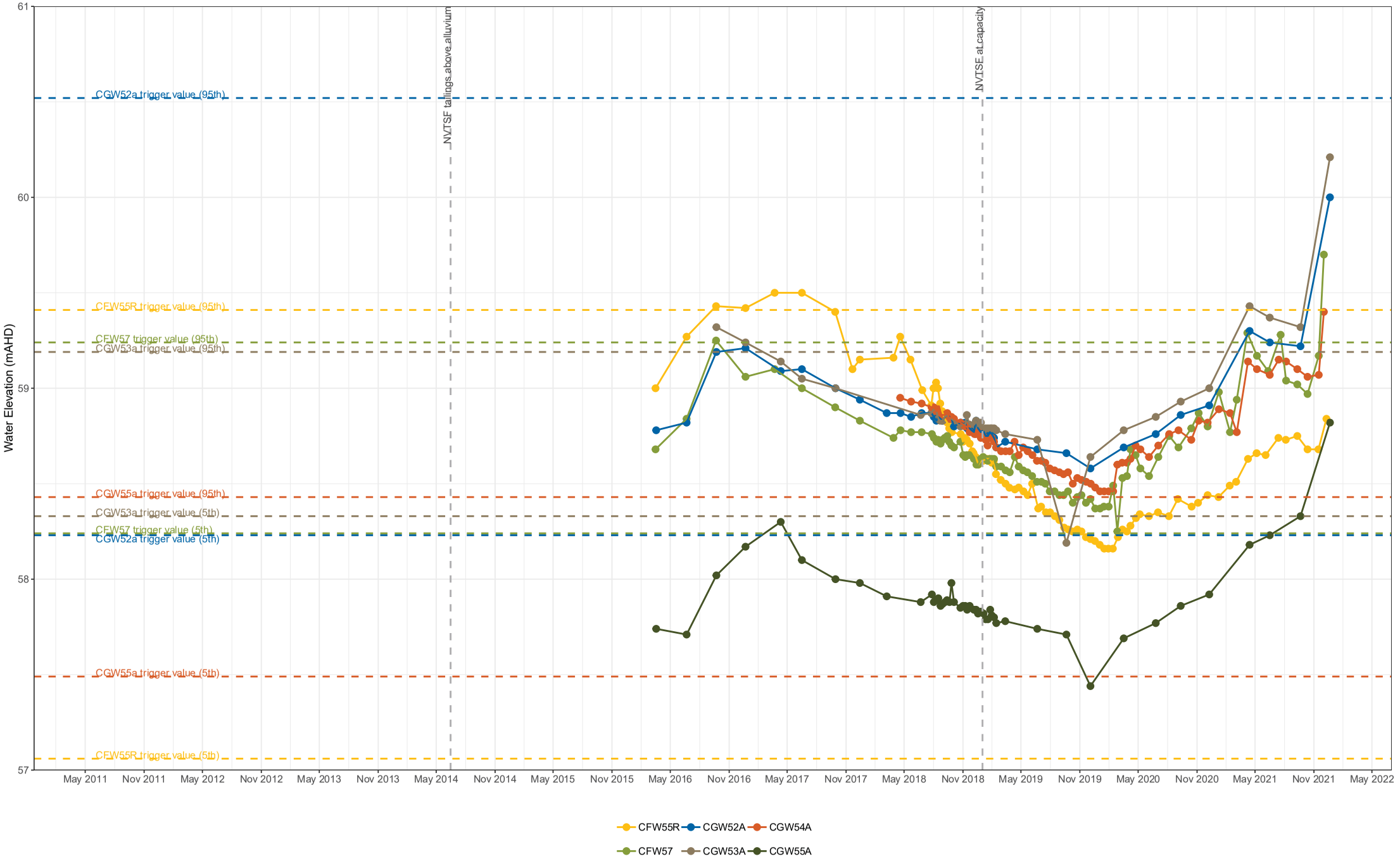


Notes: Monitoring at NPZ5 ceased in 2020 due to proximity to mining

West Pit − Interburden Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix B Figure 36

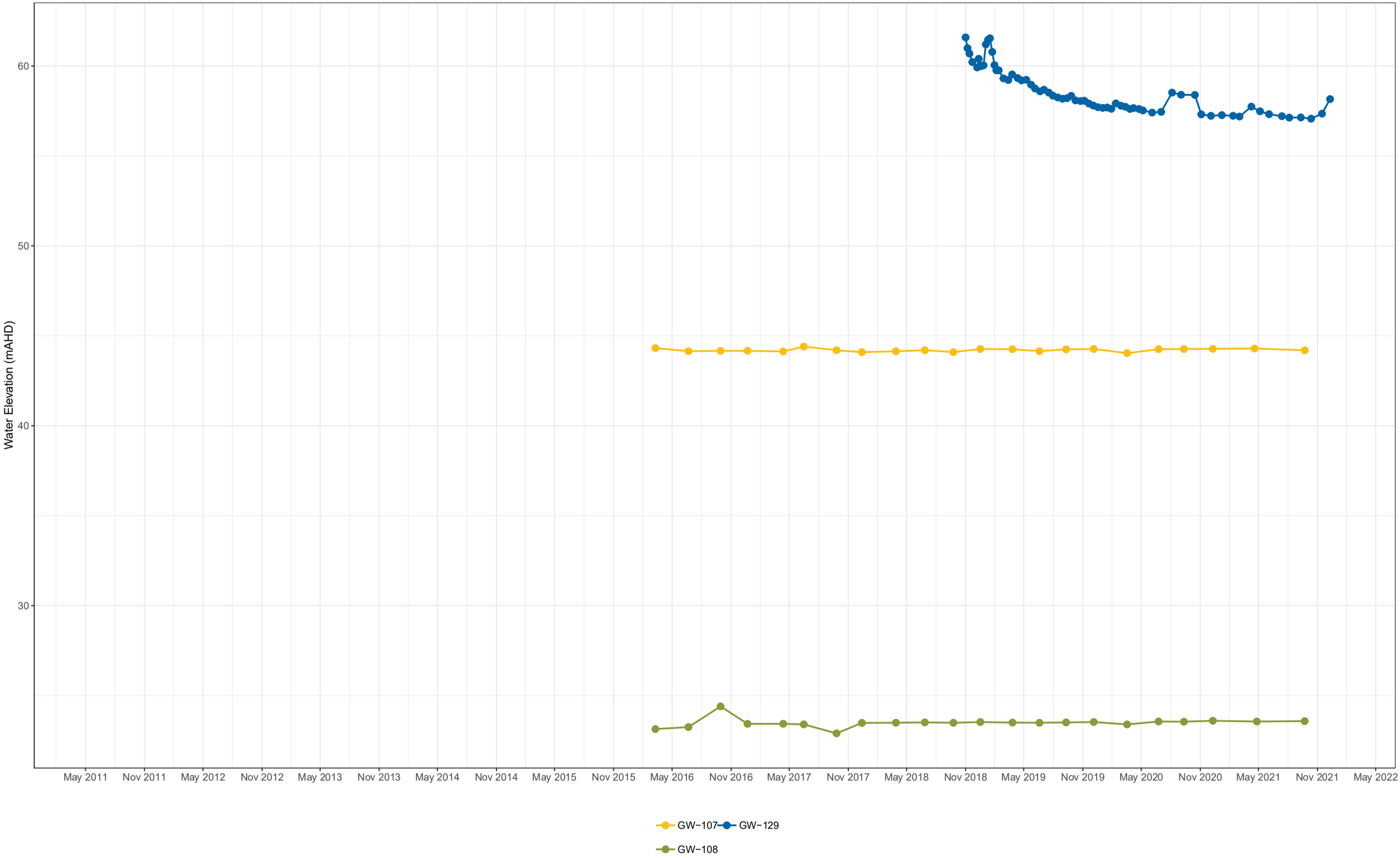
Appendix C

Groundwater time series data - all other sites



Notes

Carrington − Alluvium Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 1



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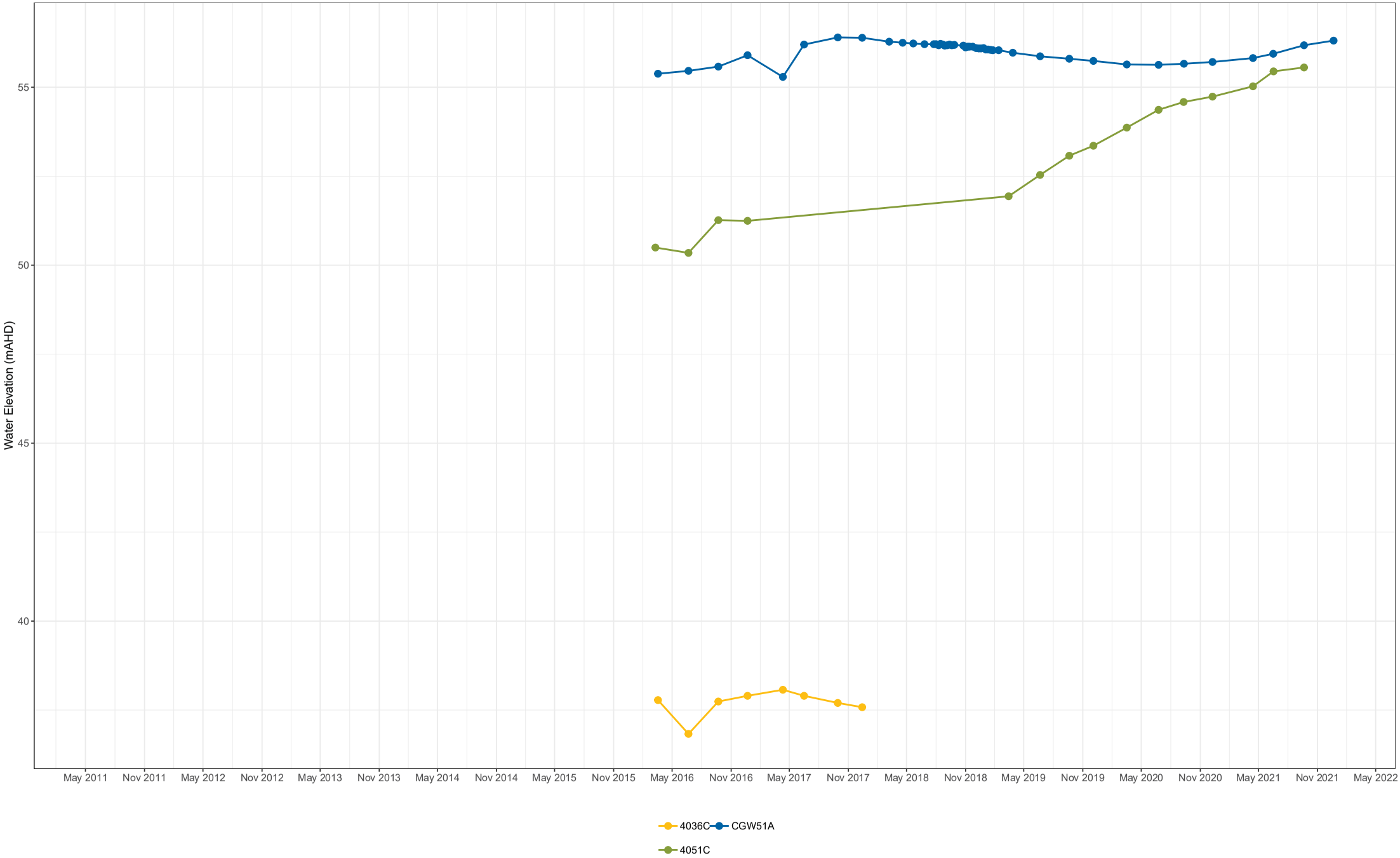
Notes

Carrington − Spoil Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 2



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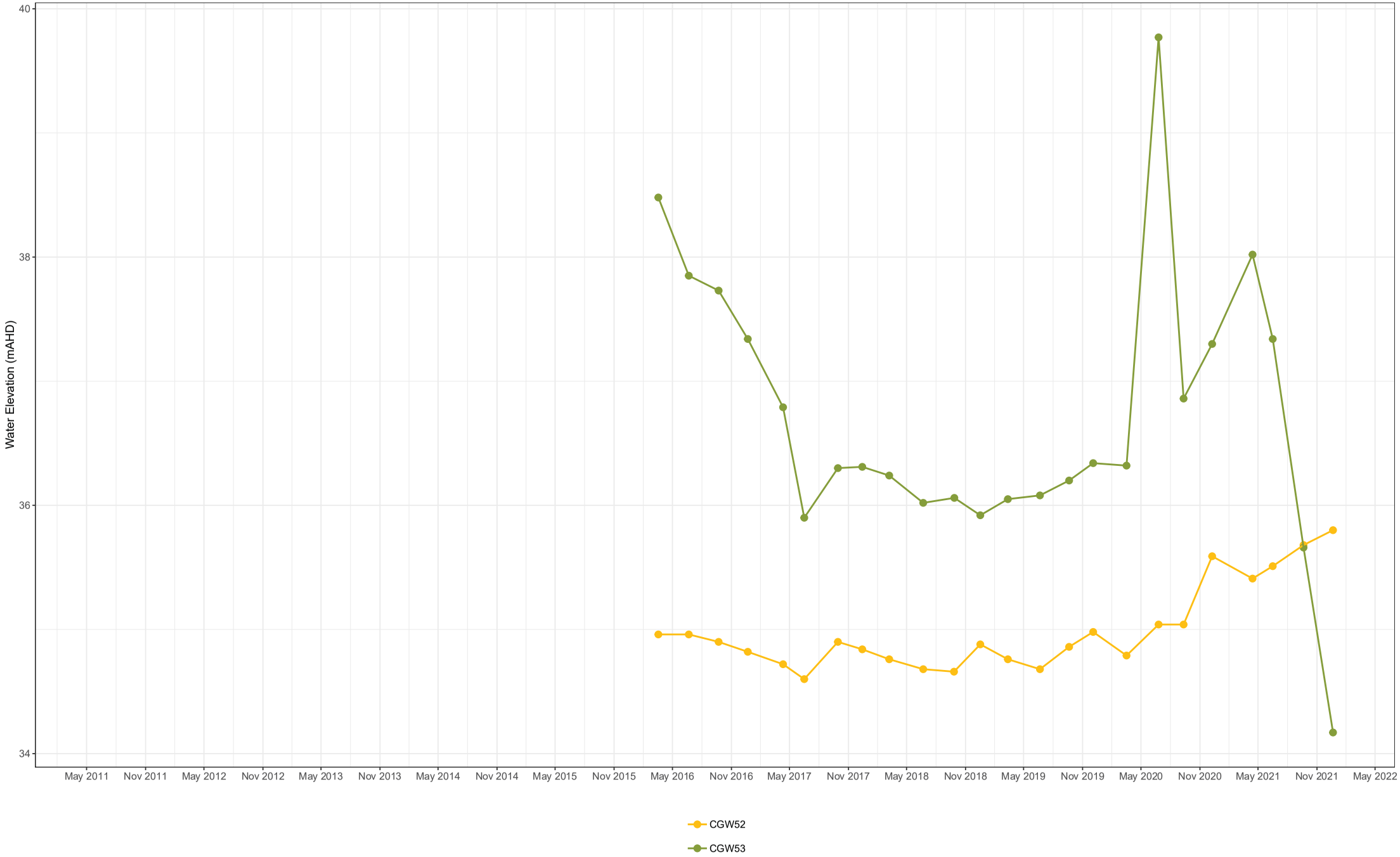
Notes

Carrington − Interburden Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 3



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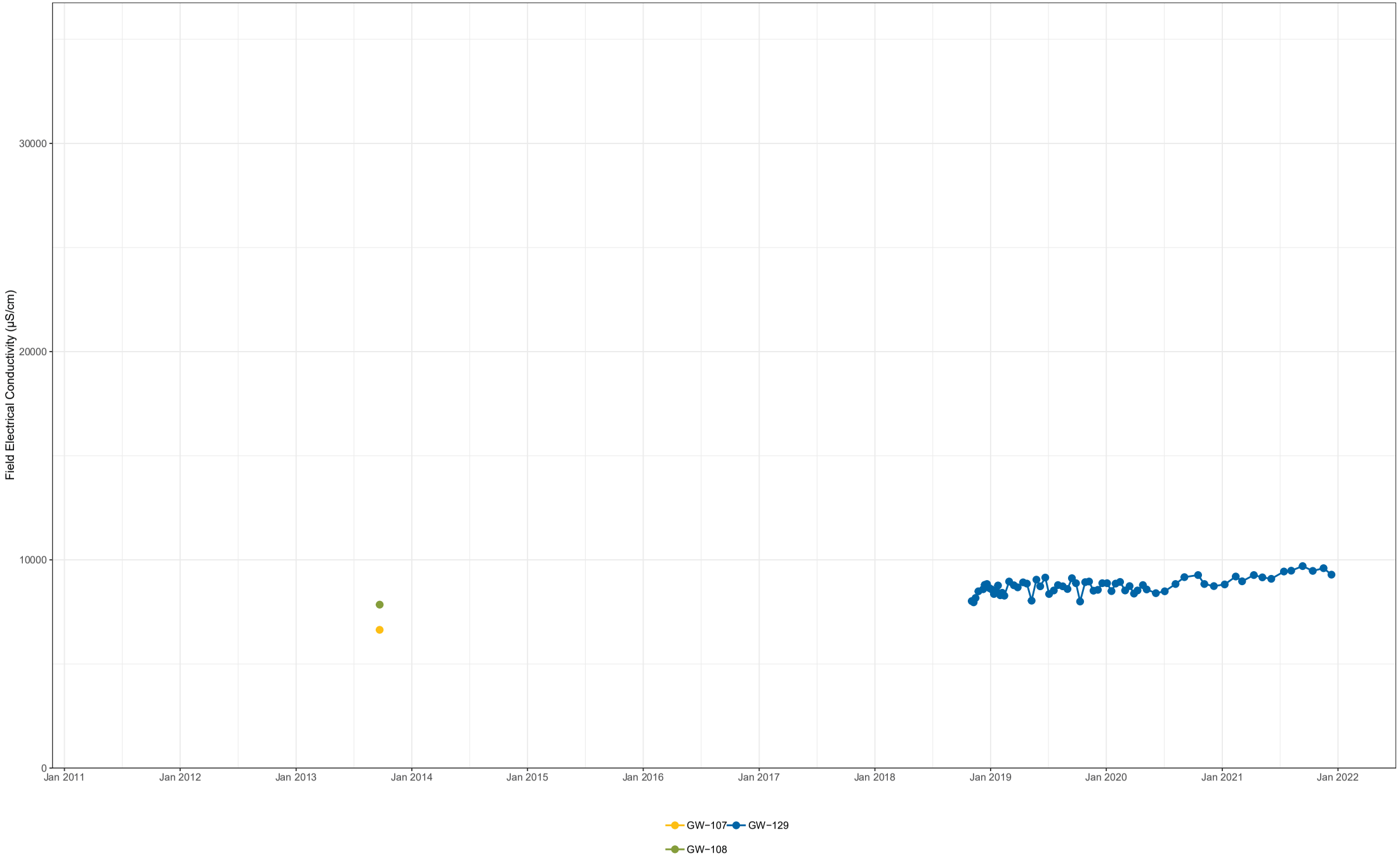
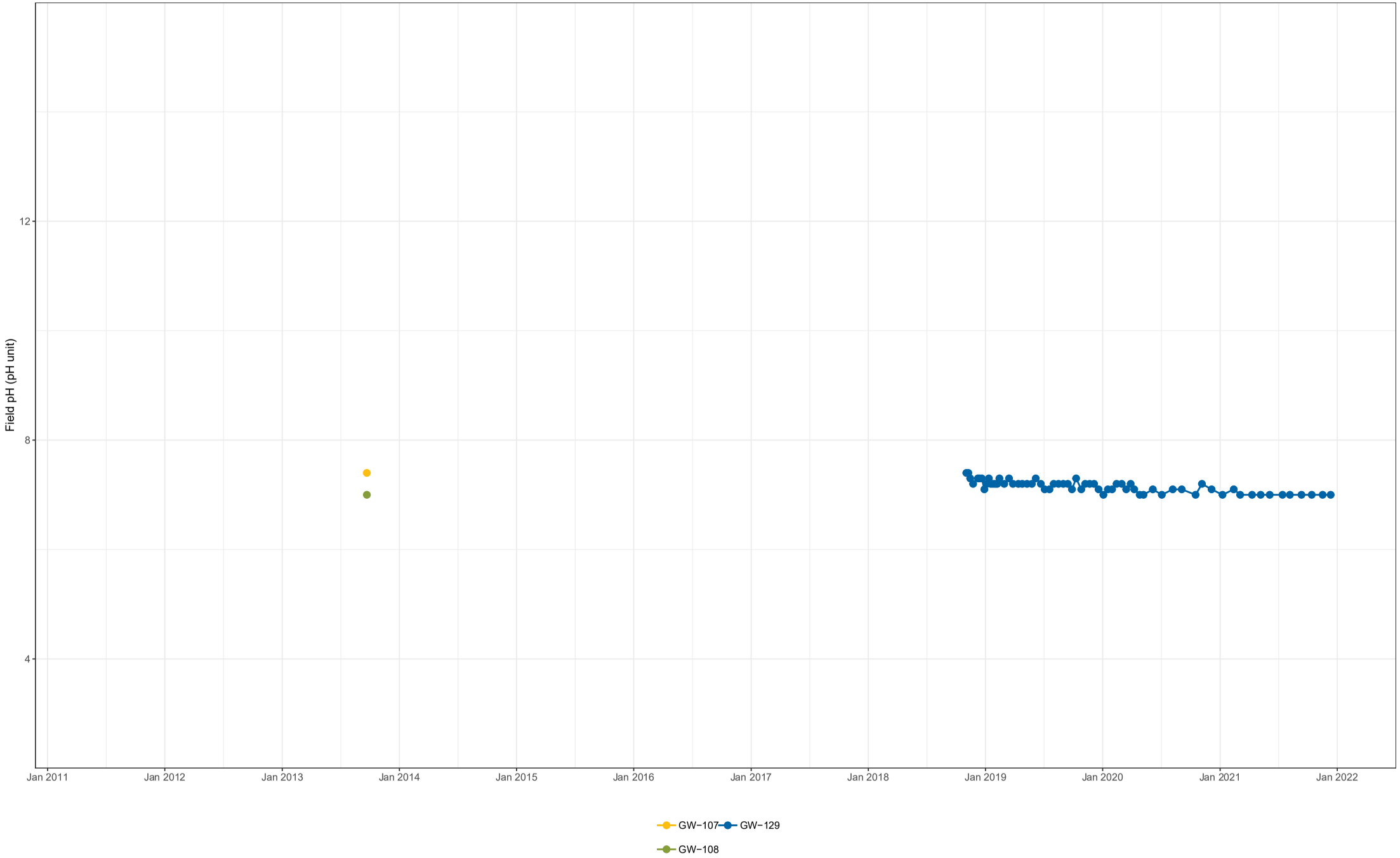
Notes

Carrington − Broonie Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 4



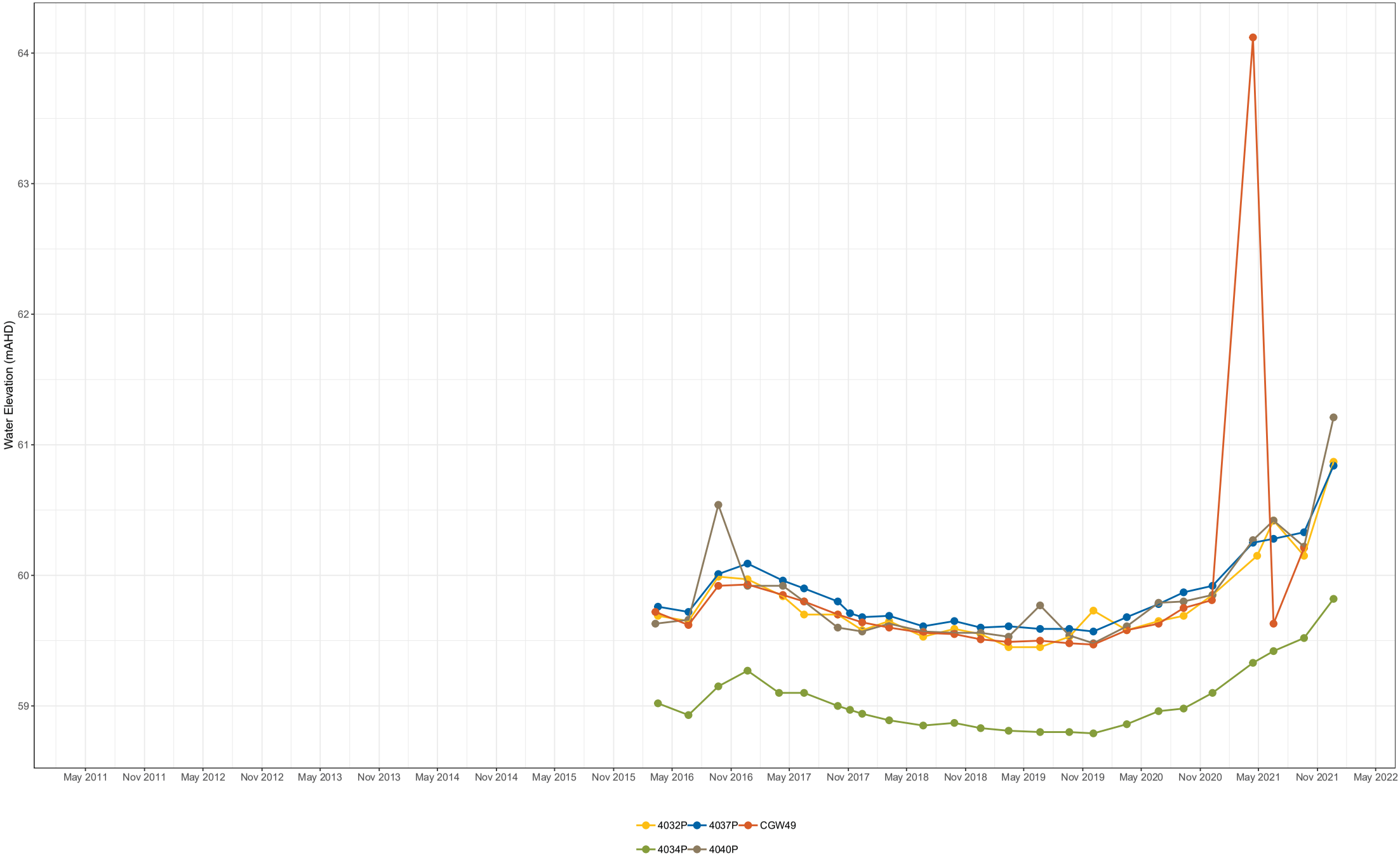
Notes

Carrington − Spoil Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 5



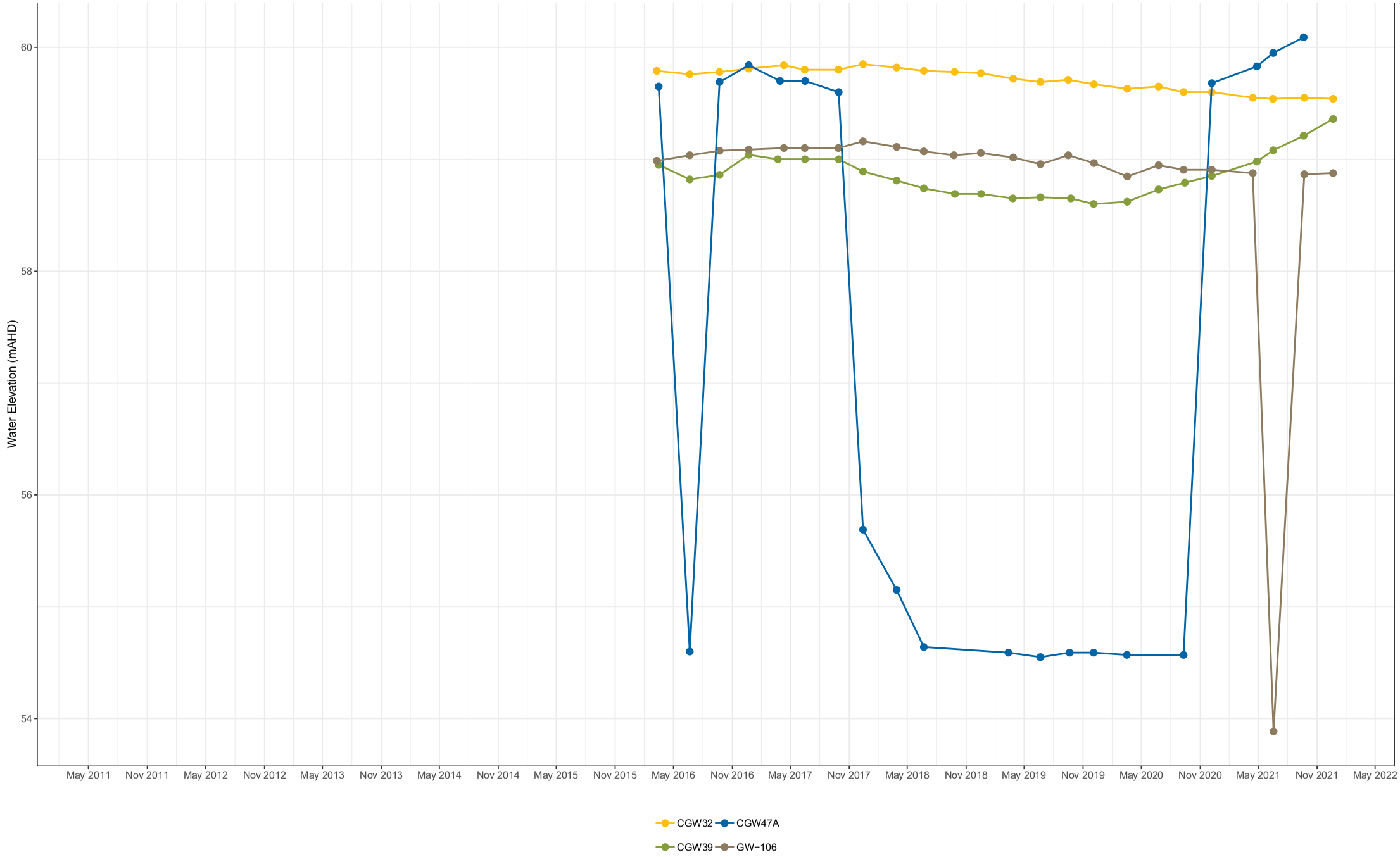
Notes

Carrington − Spoil Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 6



Notes

Carrington West Wing − Alluvium Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 7



Notes

Carrington West Wing − Floodplain Alluvium Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 8

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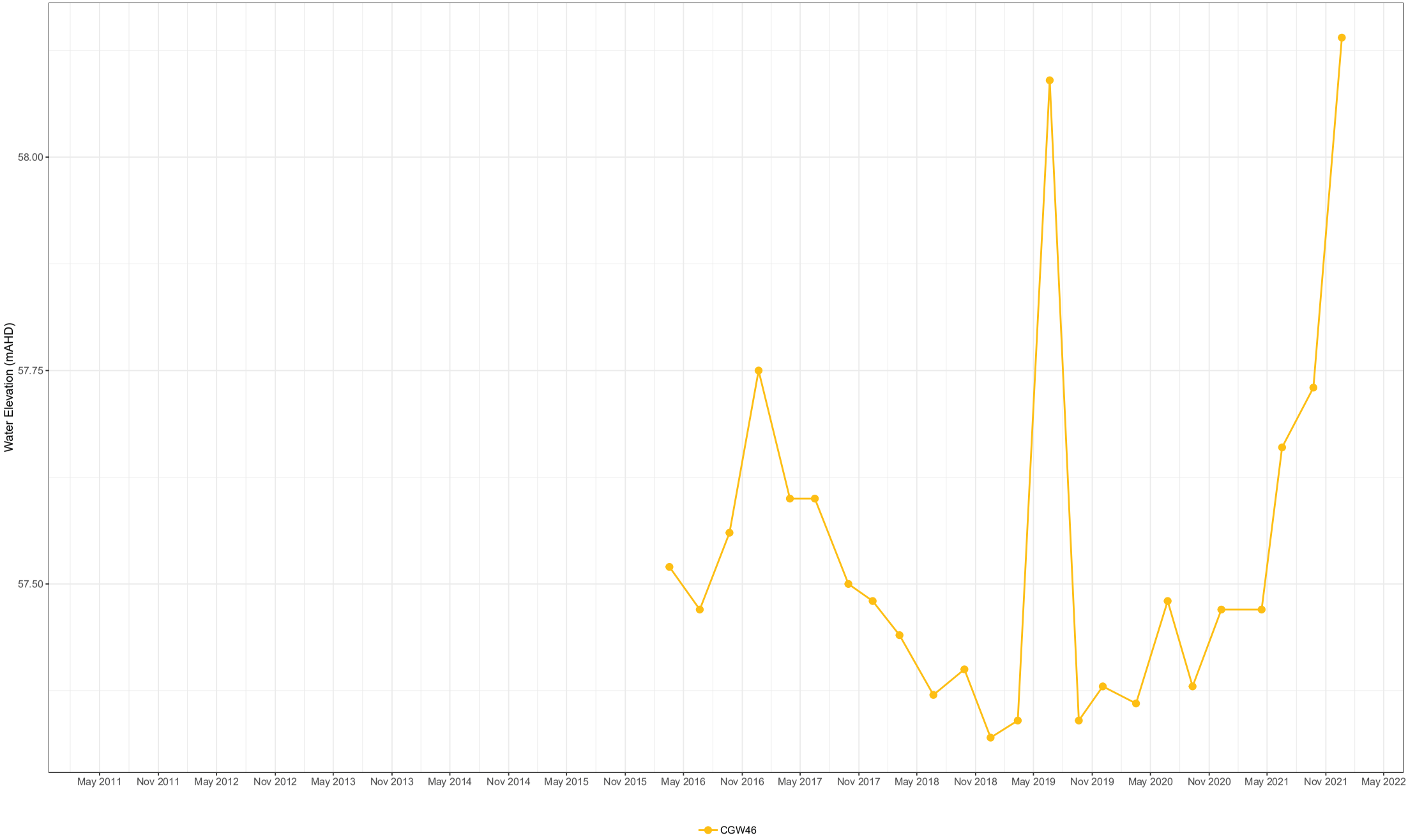
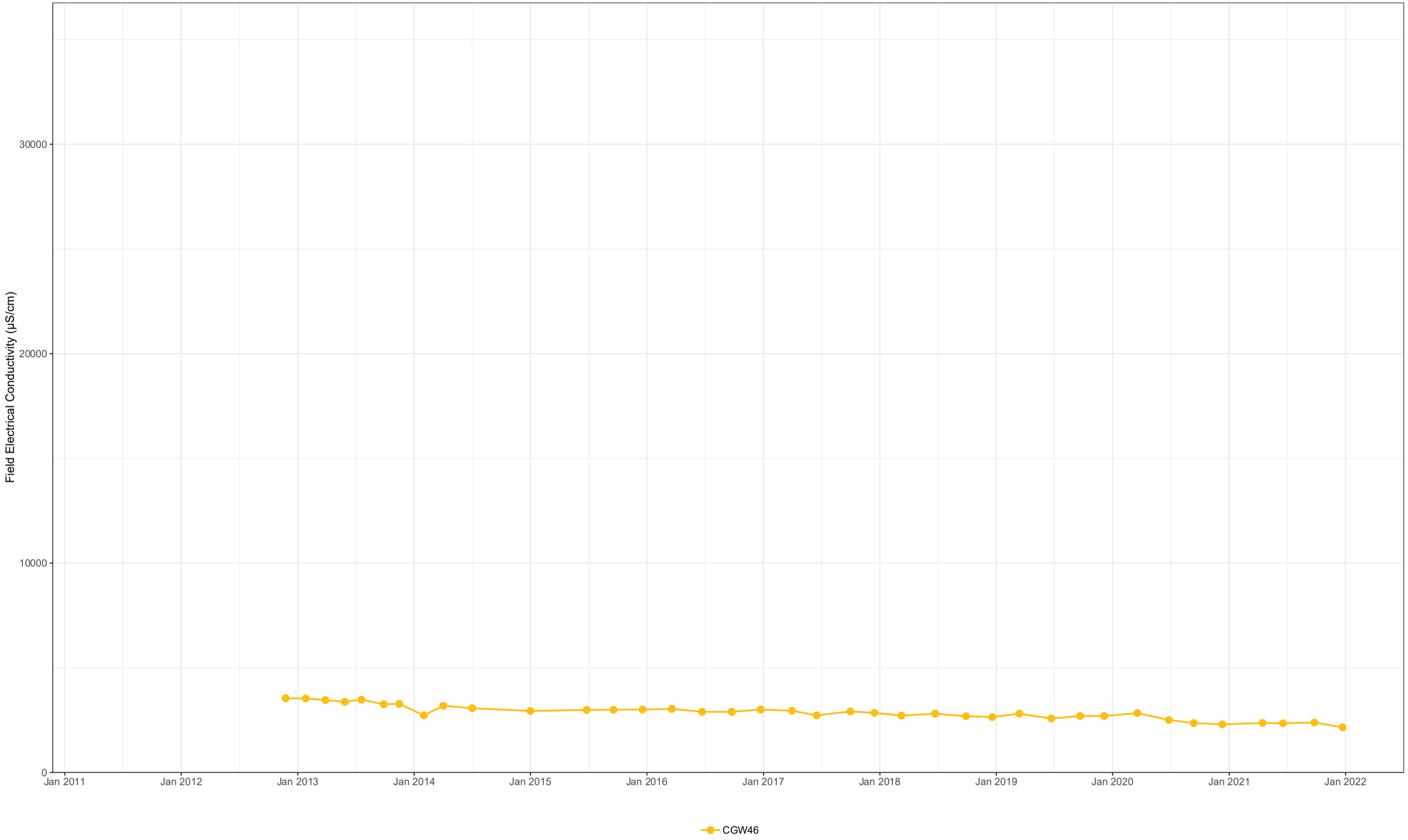
Carrington West Wing − LBL Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 9



Notes

Carrington West Wing − Bayswater Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 10



Notes

Carrington West Wing − Bayswater Seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
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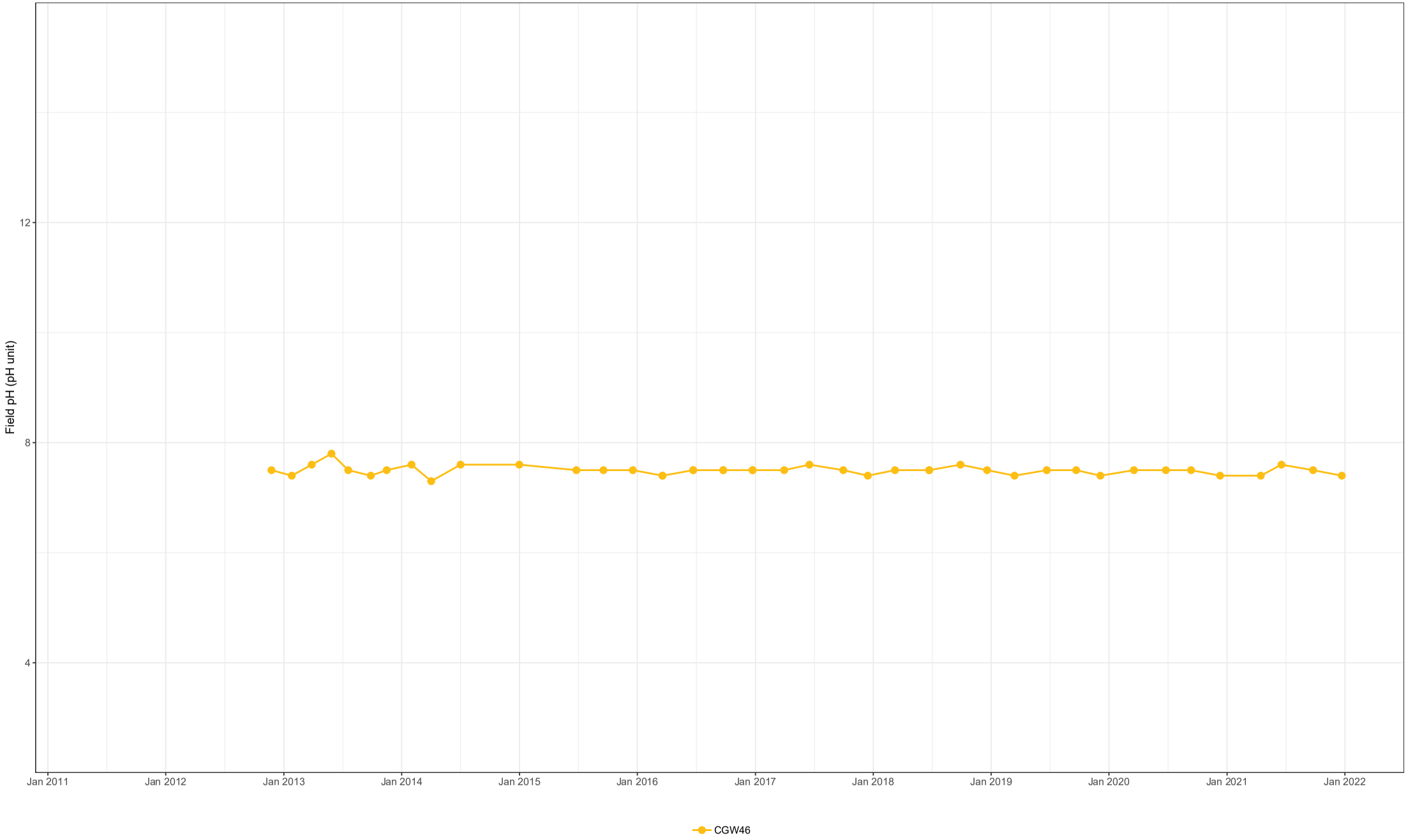
Appendix C Figure 11



Notes

Carrington West Wing − Bayswater Seam Field pH (pH unit)
Hunter Valley Operations
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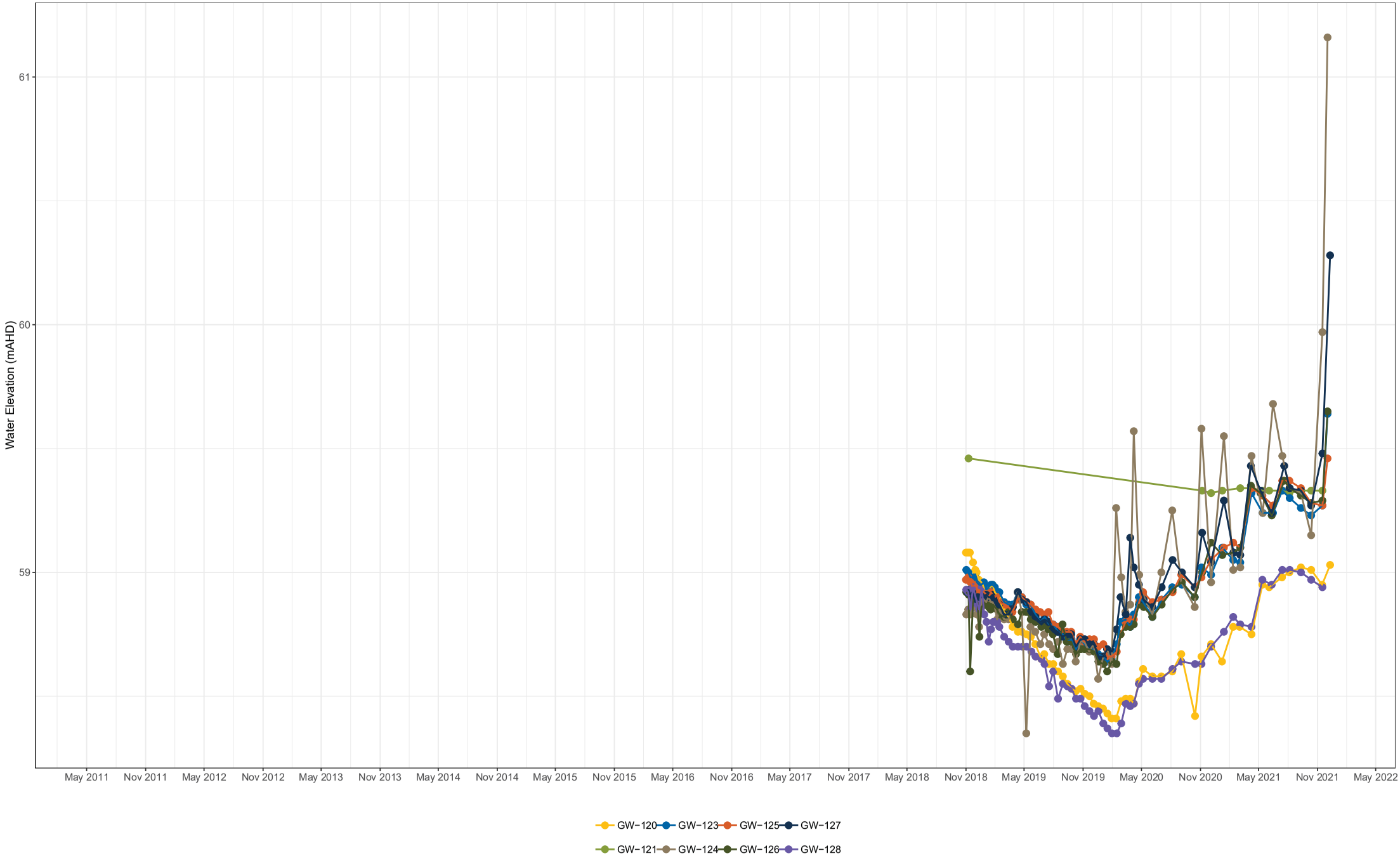
Appendix C Figure 12



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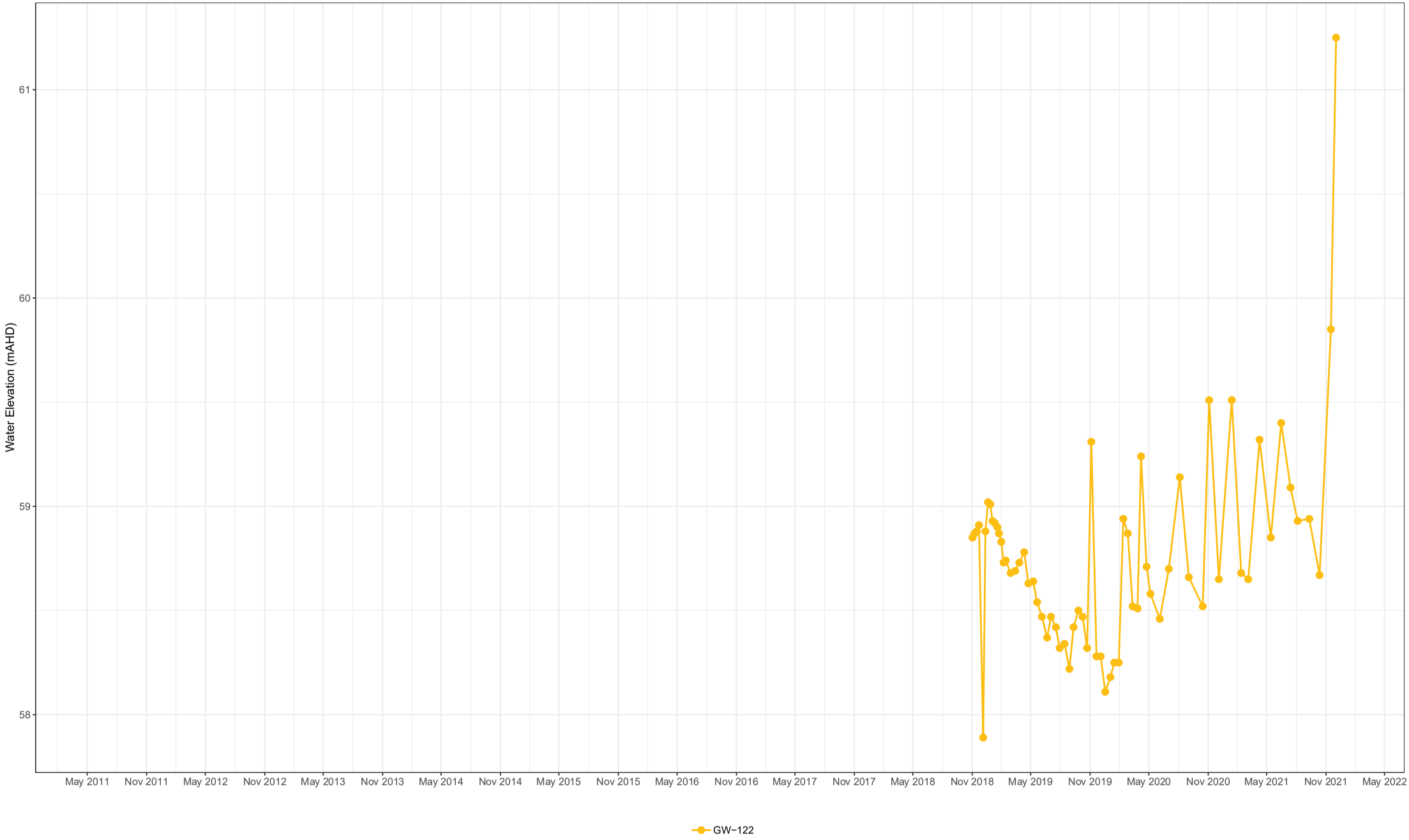
Notes

North Void − Alluvium Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 13



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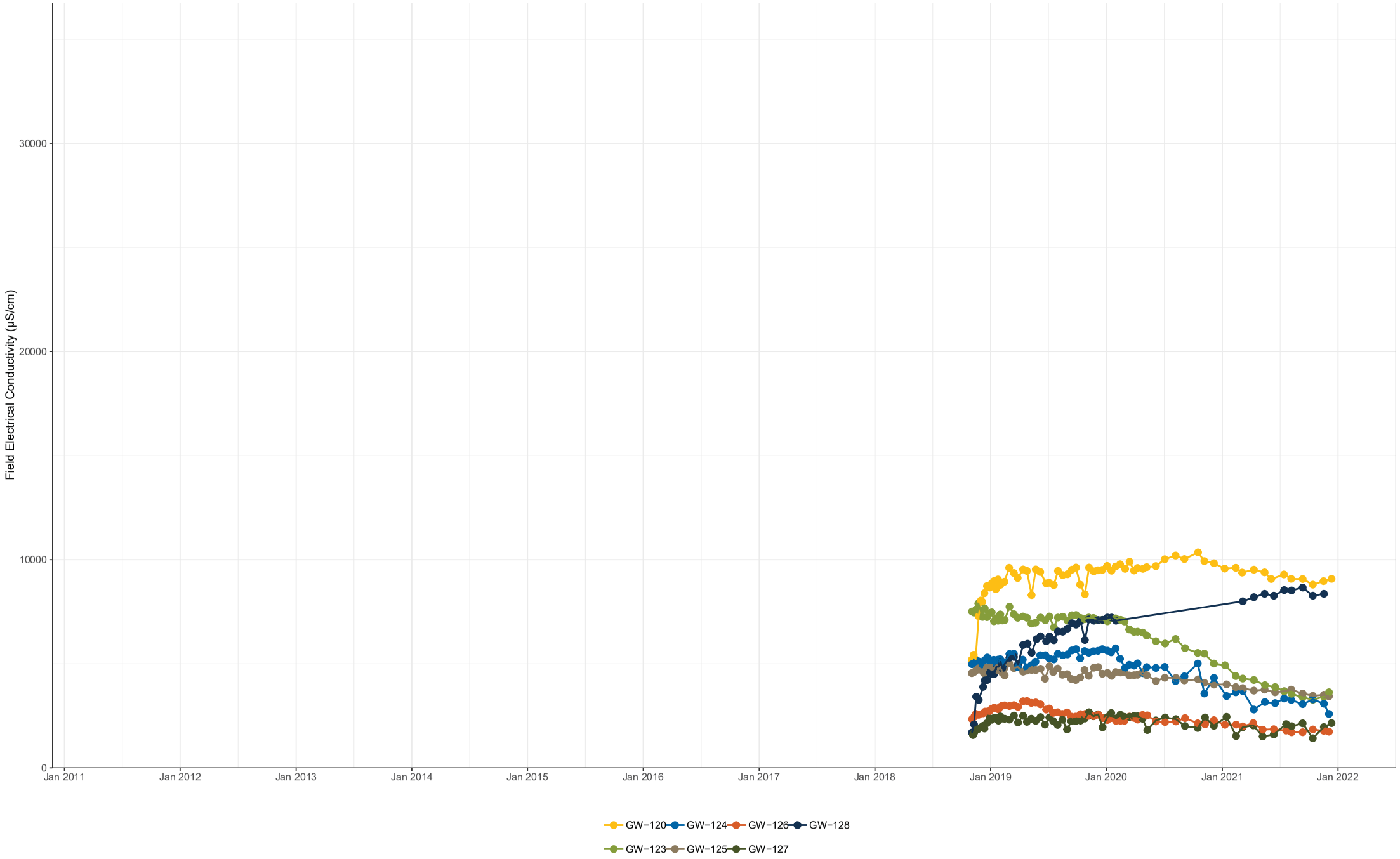
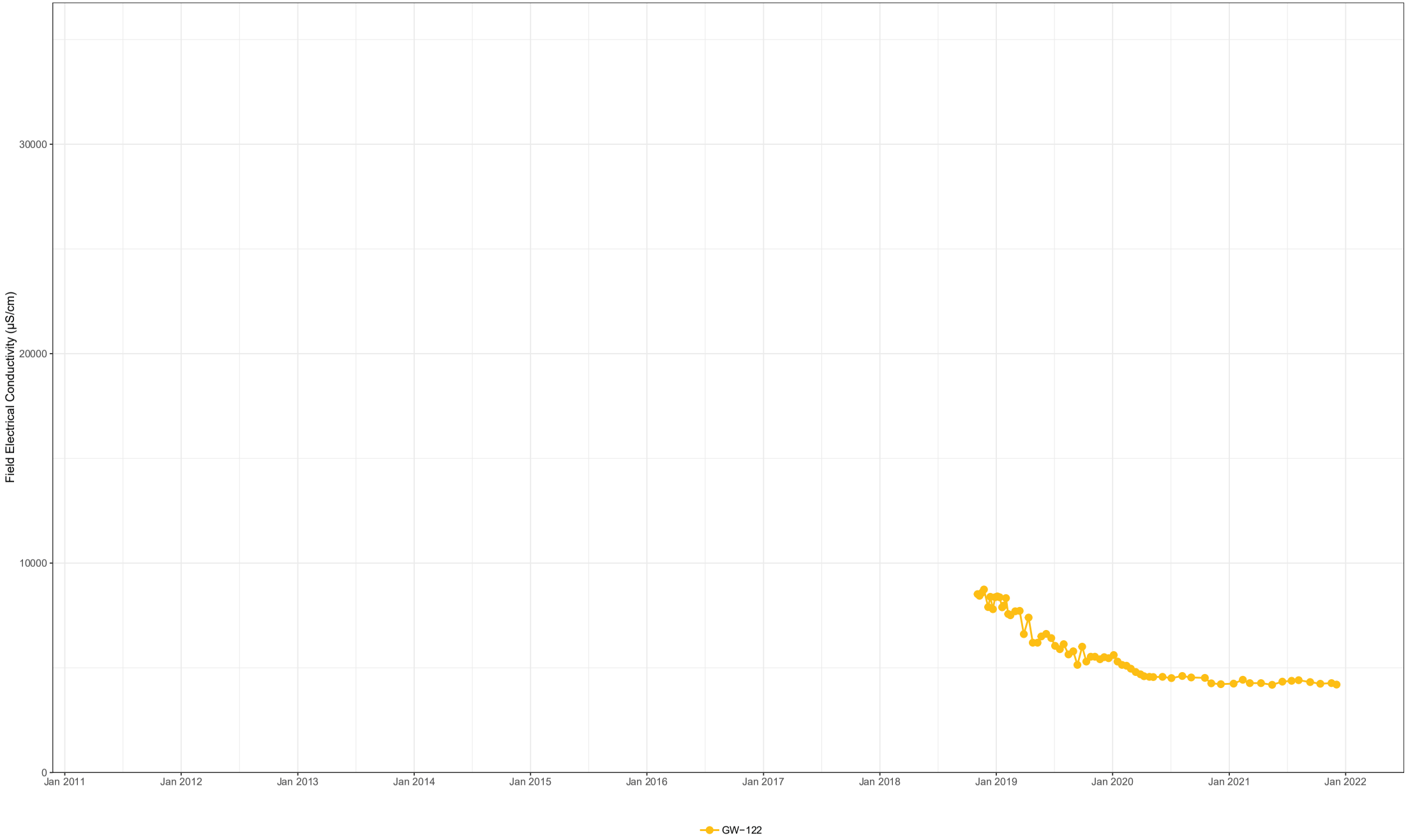
Notes

North Void − Interburden Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 14



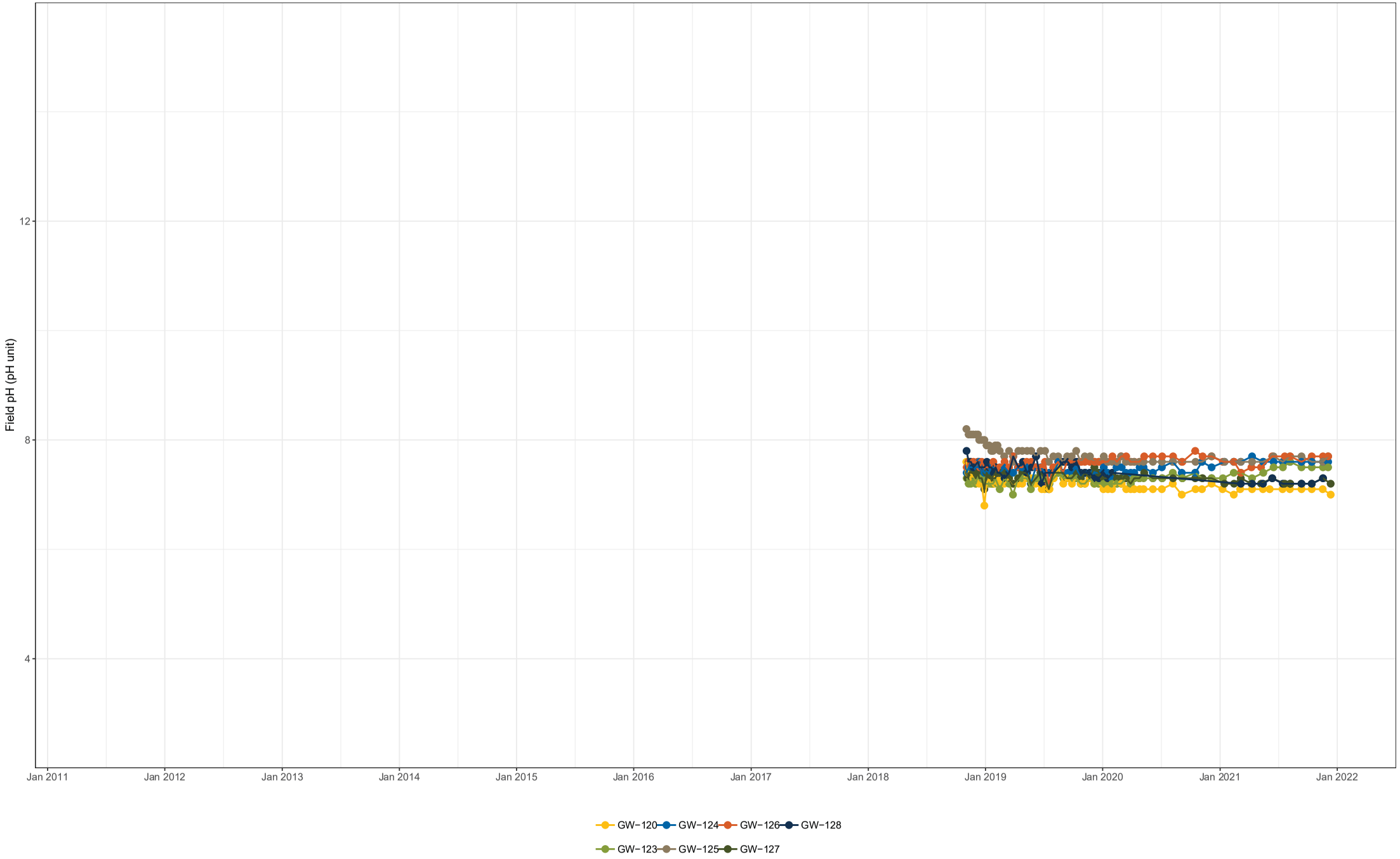
Notes

North Void − Alluvium Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 15



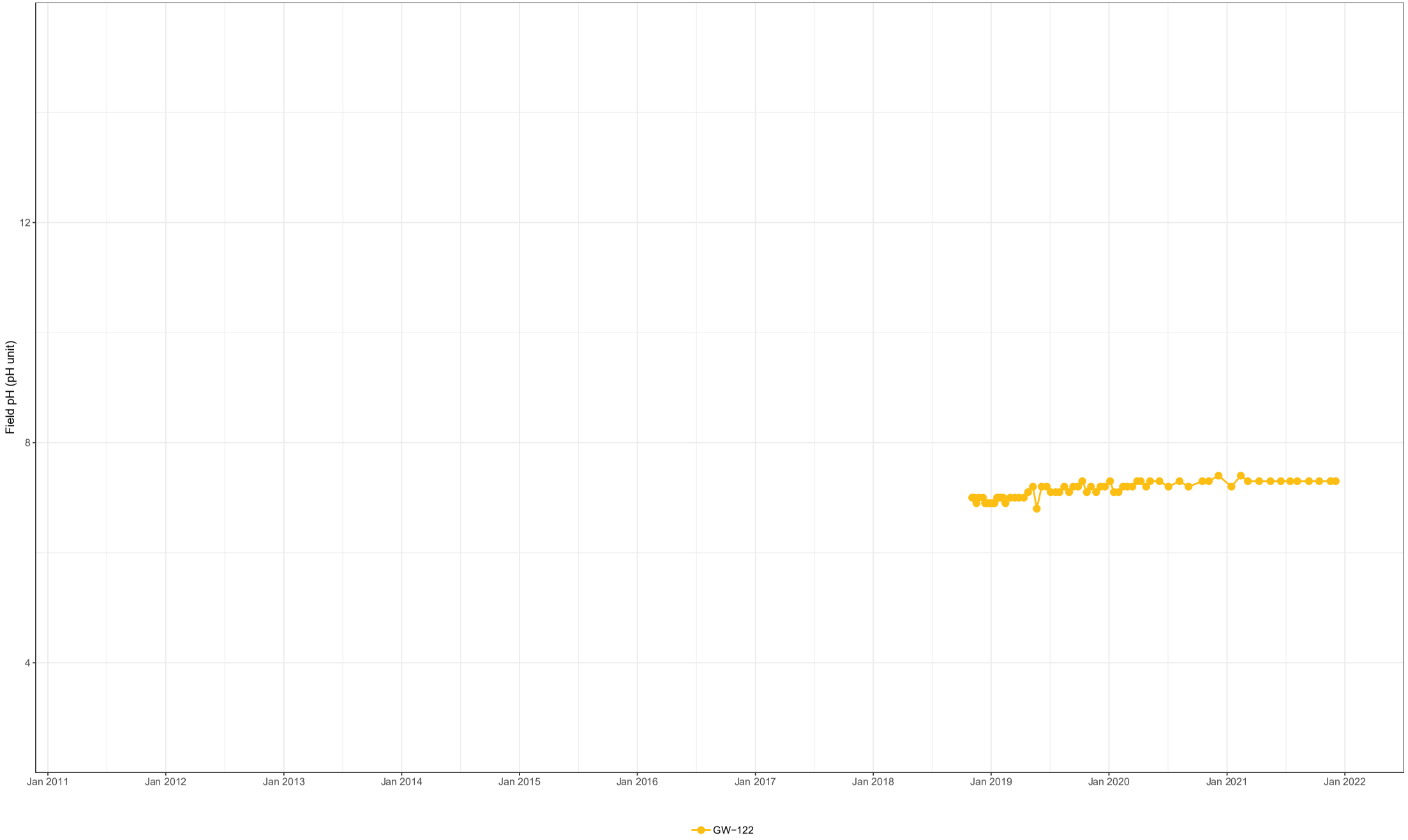
Notes

North Void − Interburden Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 16



Notes

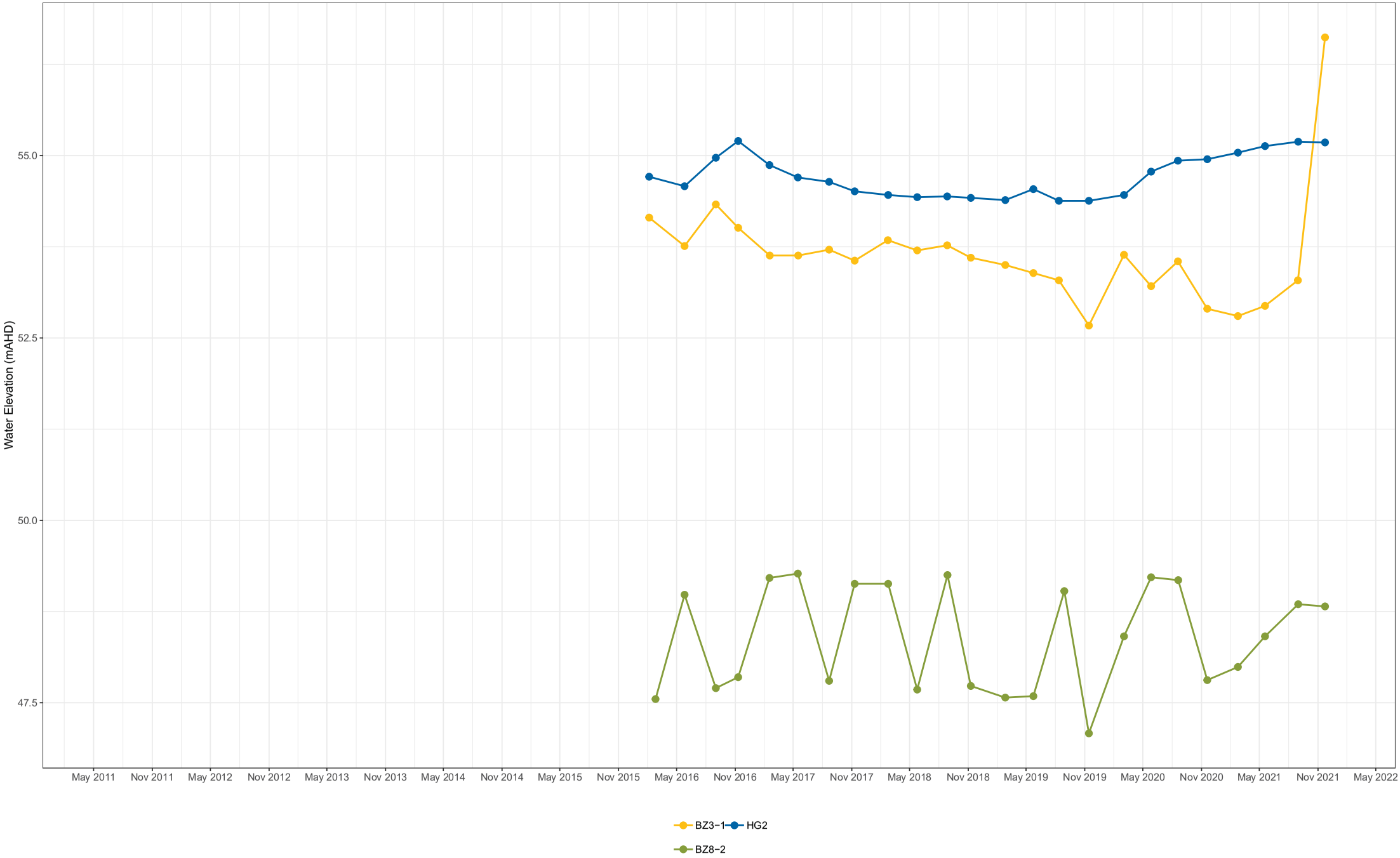
North Void − Alluvium Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 17



EMM creating opportunities

Notes

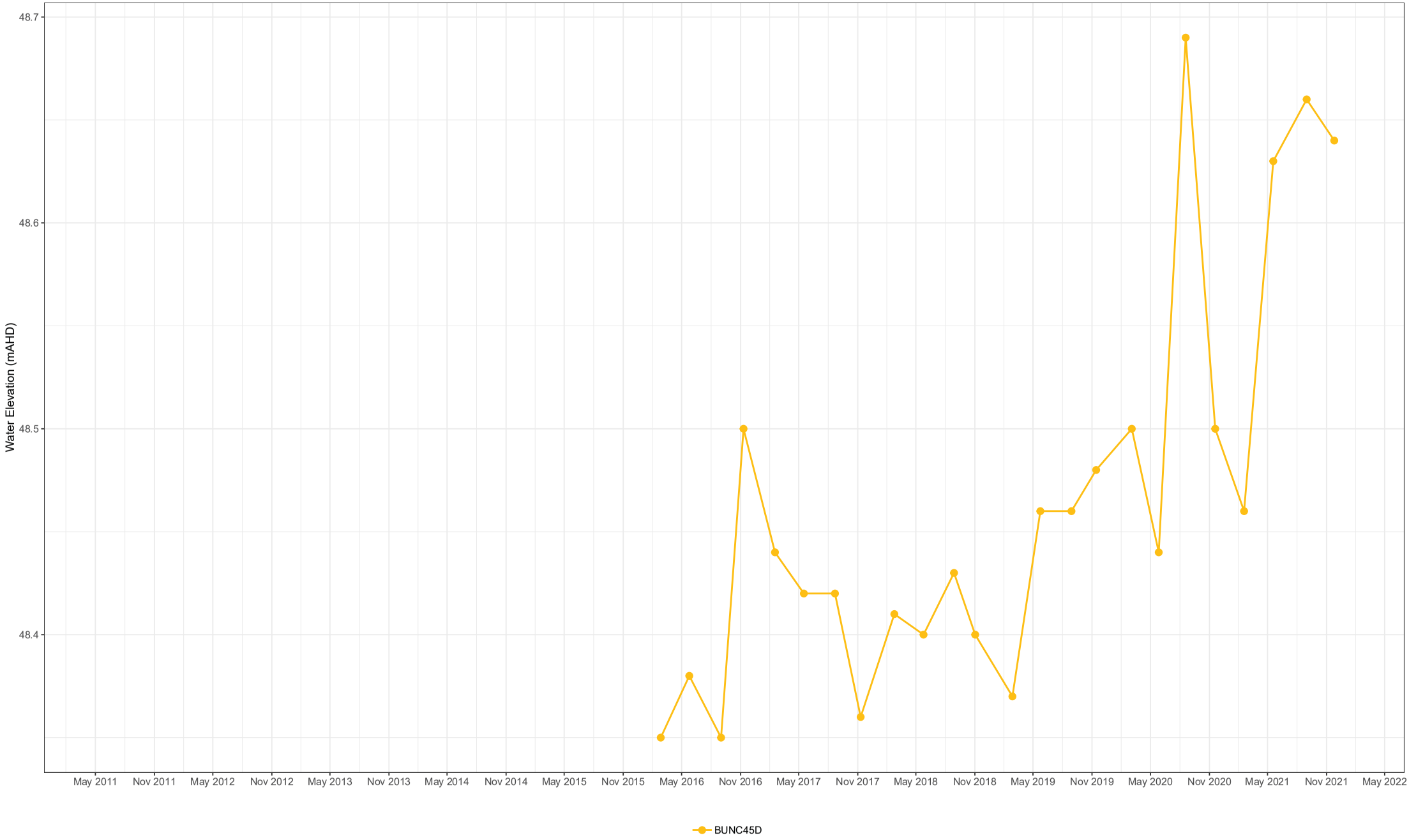
North Void − Interburden Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 18



EMM creating opportunities

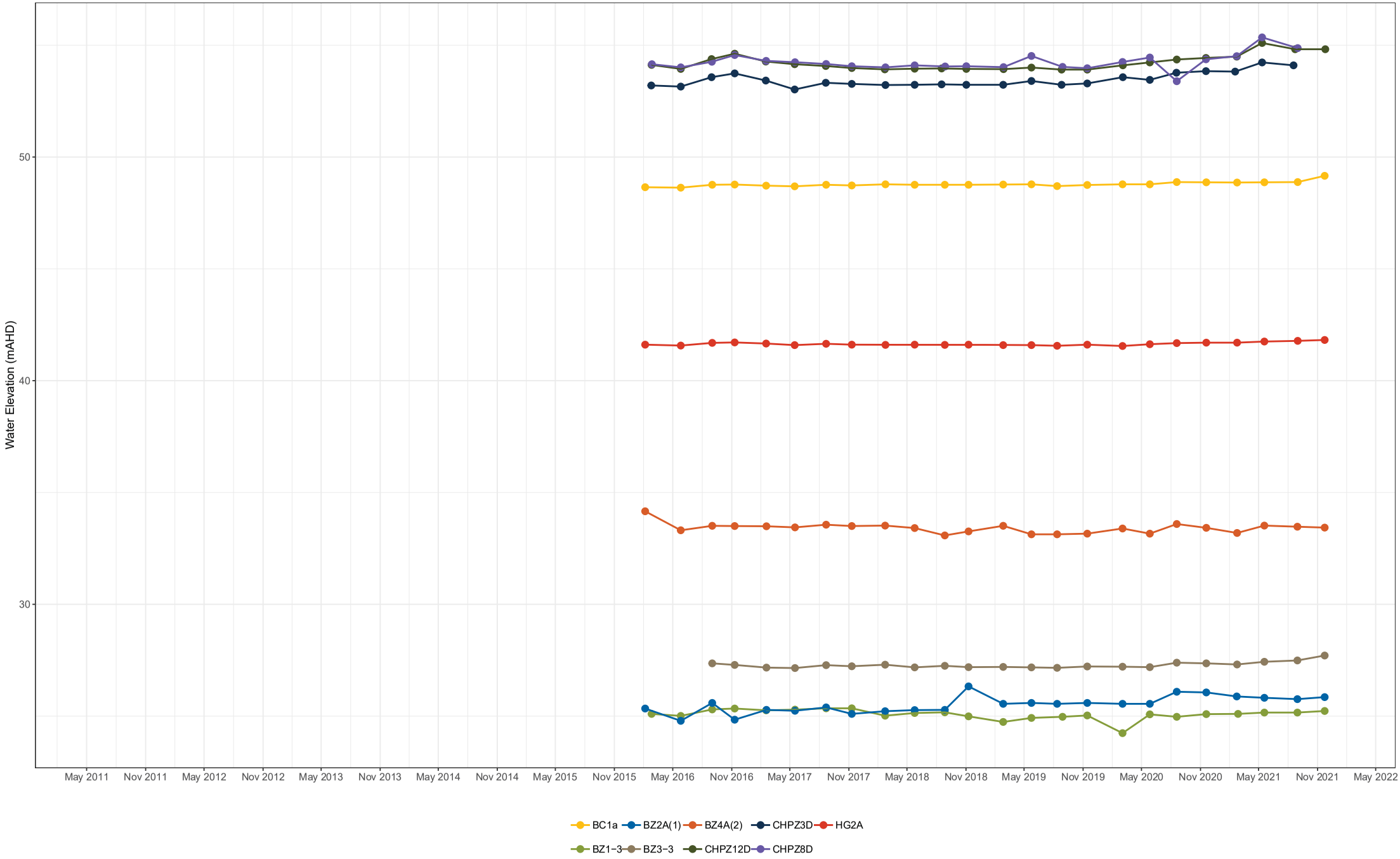
Notes

Cheshunt − Interburden Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 19



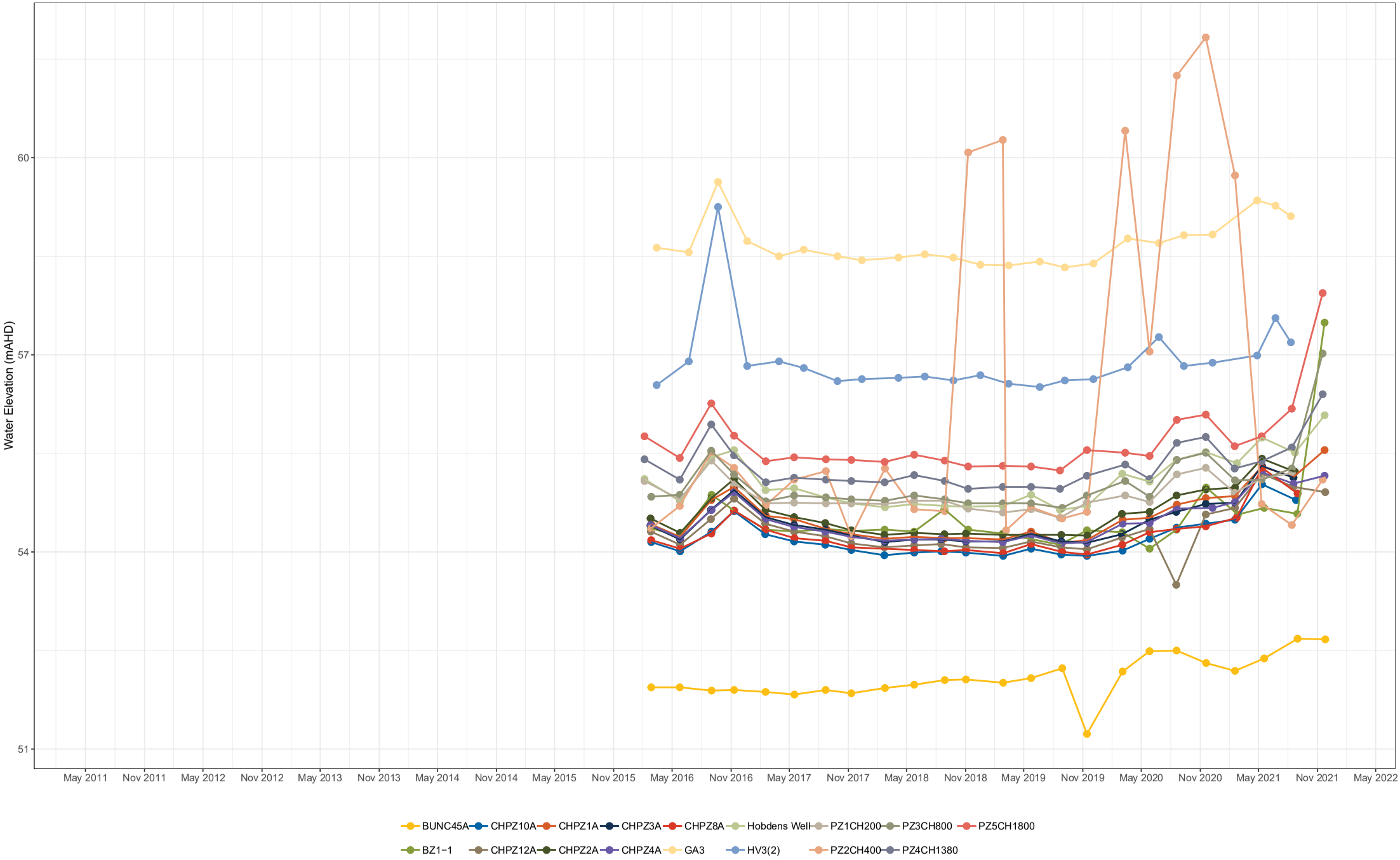
Notes

Cheshunt − Piercefield Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 20



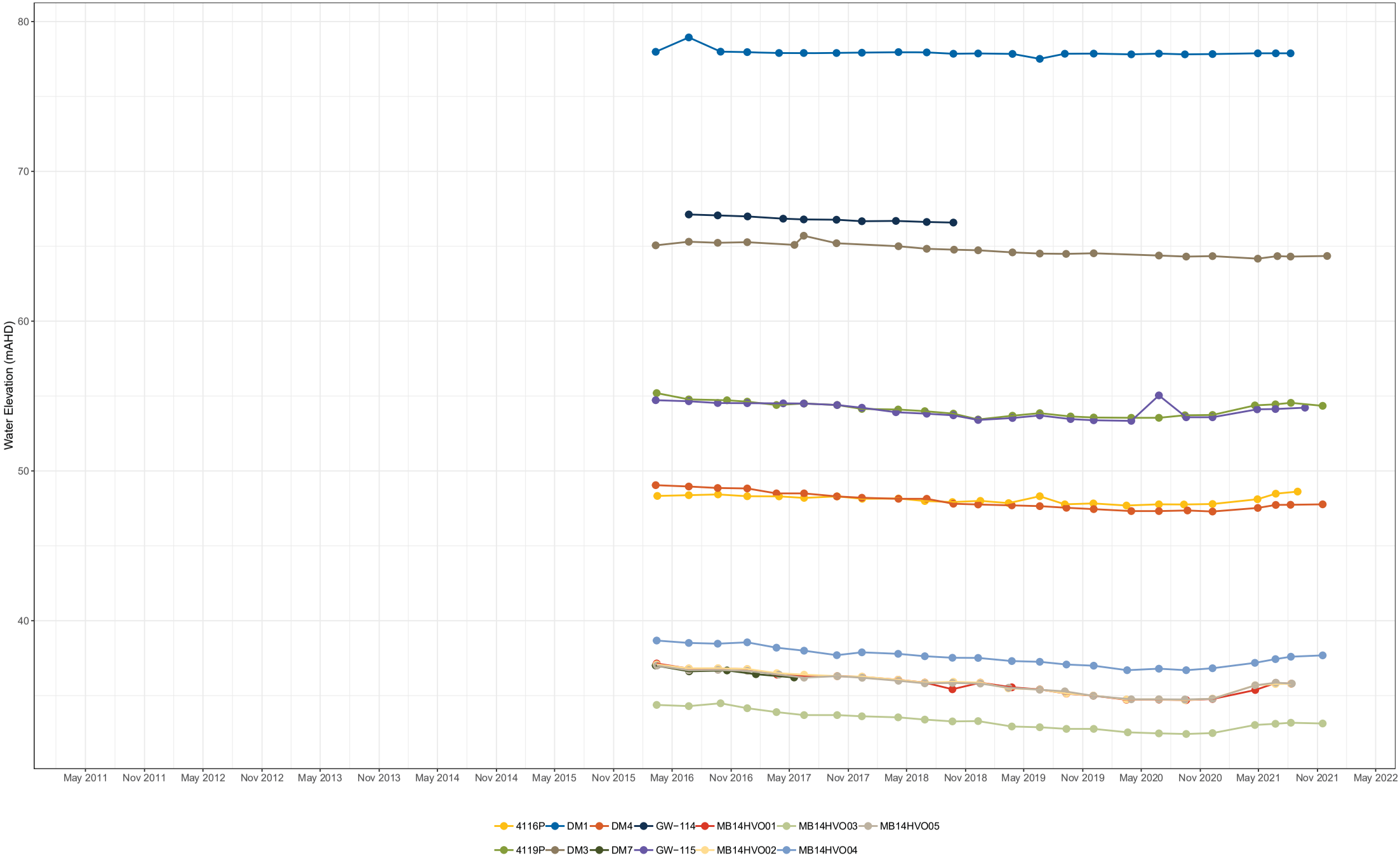
Notes

Cheshunt − Mt Arthur Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 21



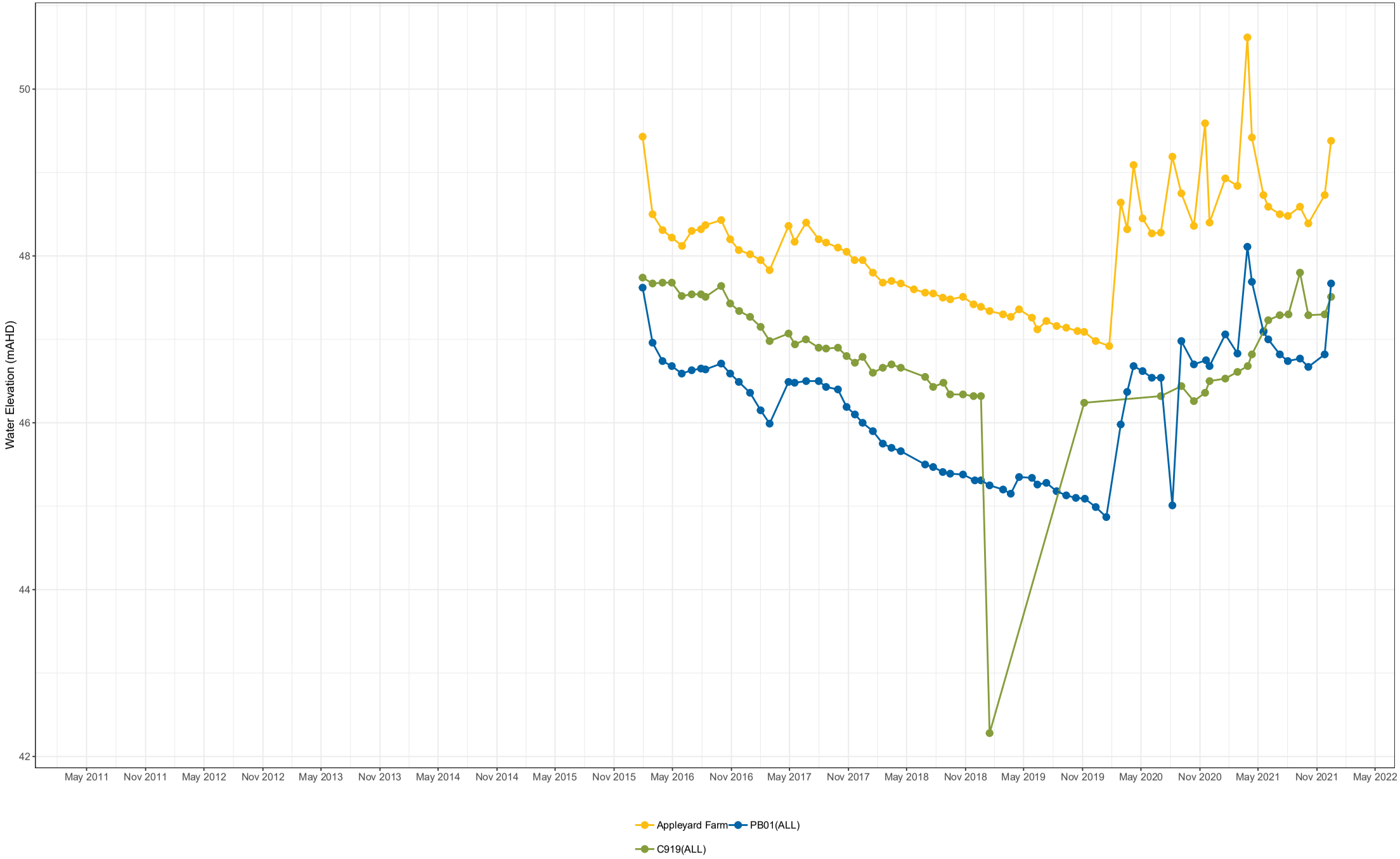
Notes

Cheshunt / North Pit − Alluvium Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 22



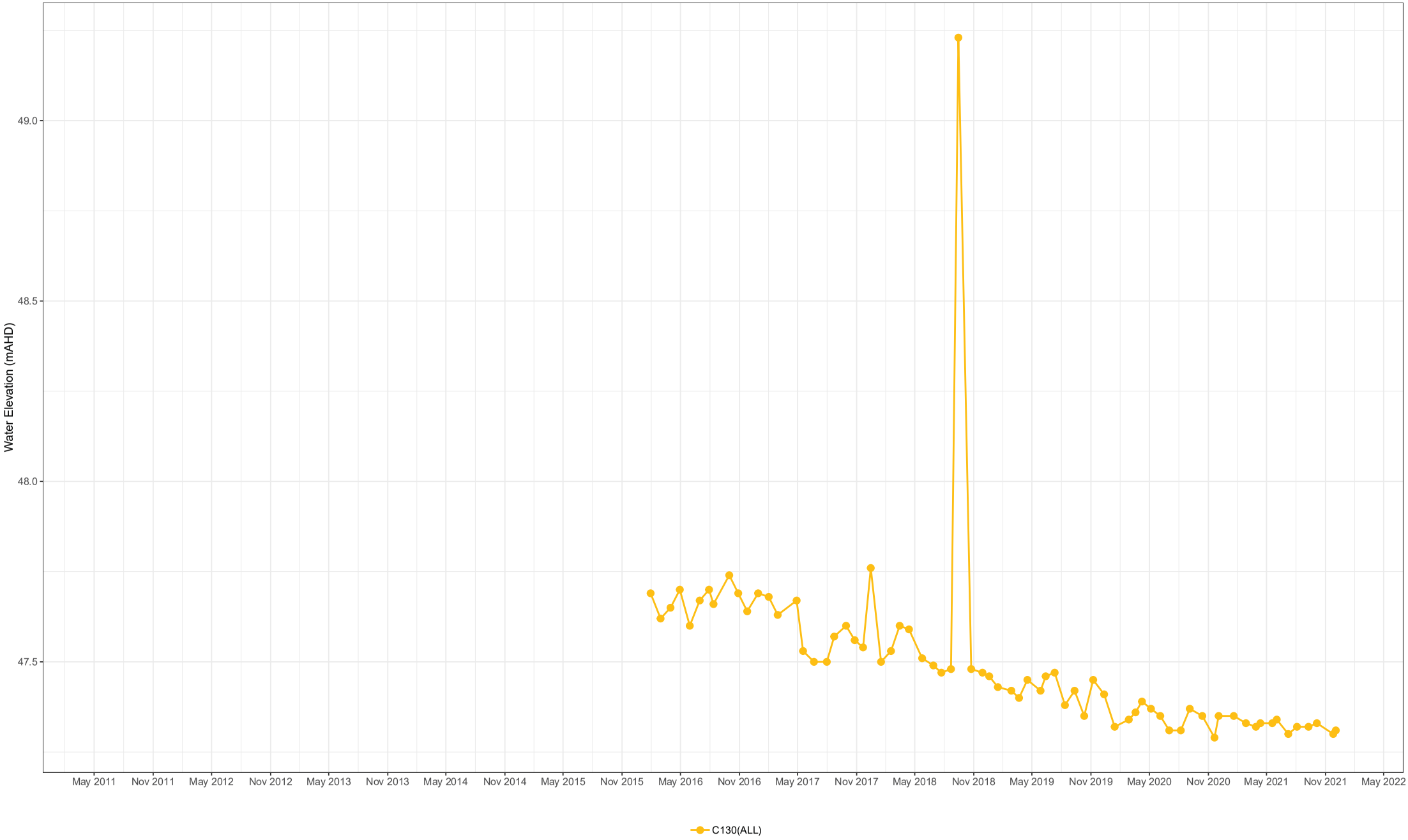
Notes

North Pit − Spoil Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 23



Notes: C919(ALL) was dry in 2019 and 2020

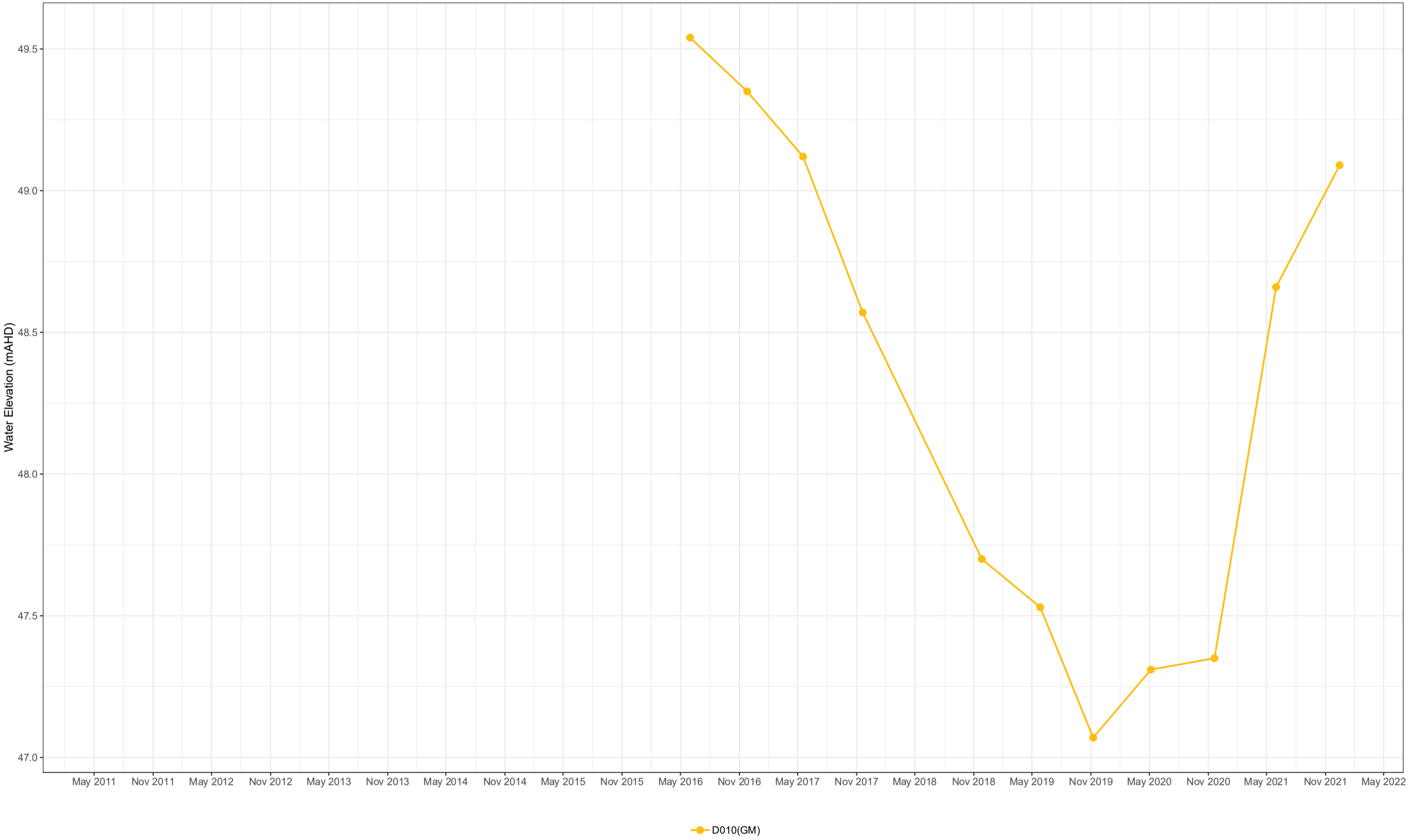
Lemington South − Alluvium Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 24



creating opportunities

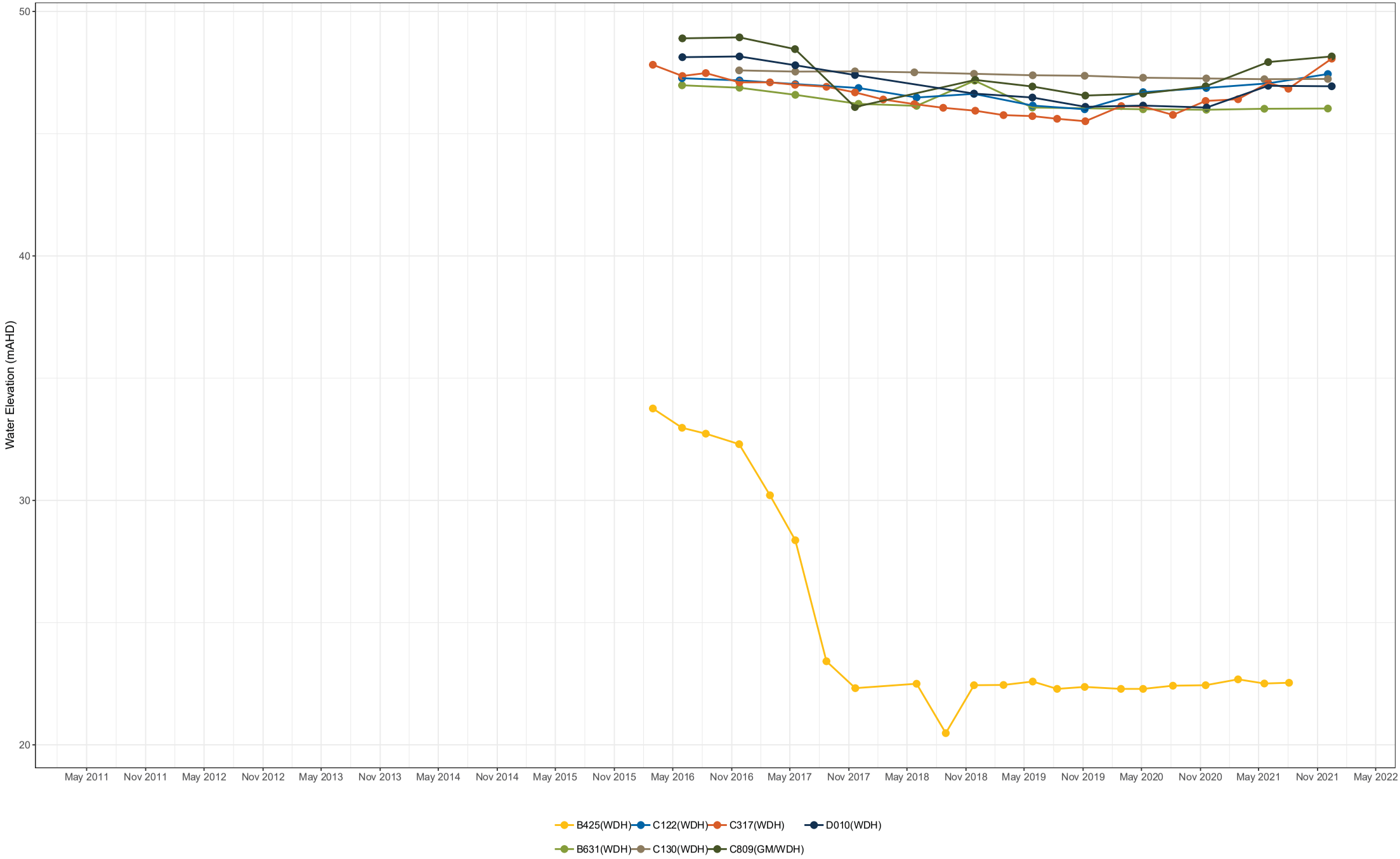
Notes

Lemington South − Interburden Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 25



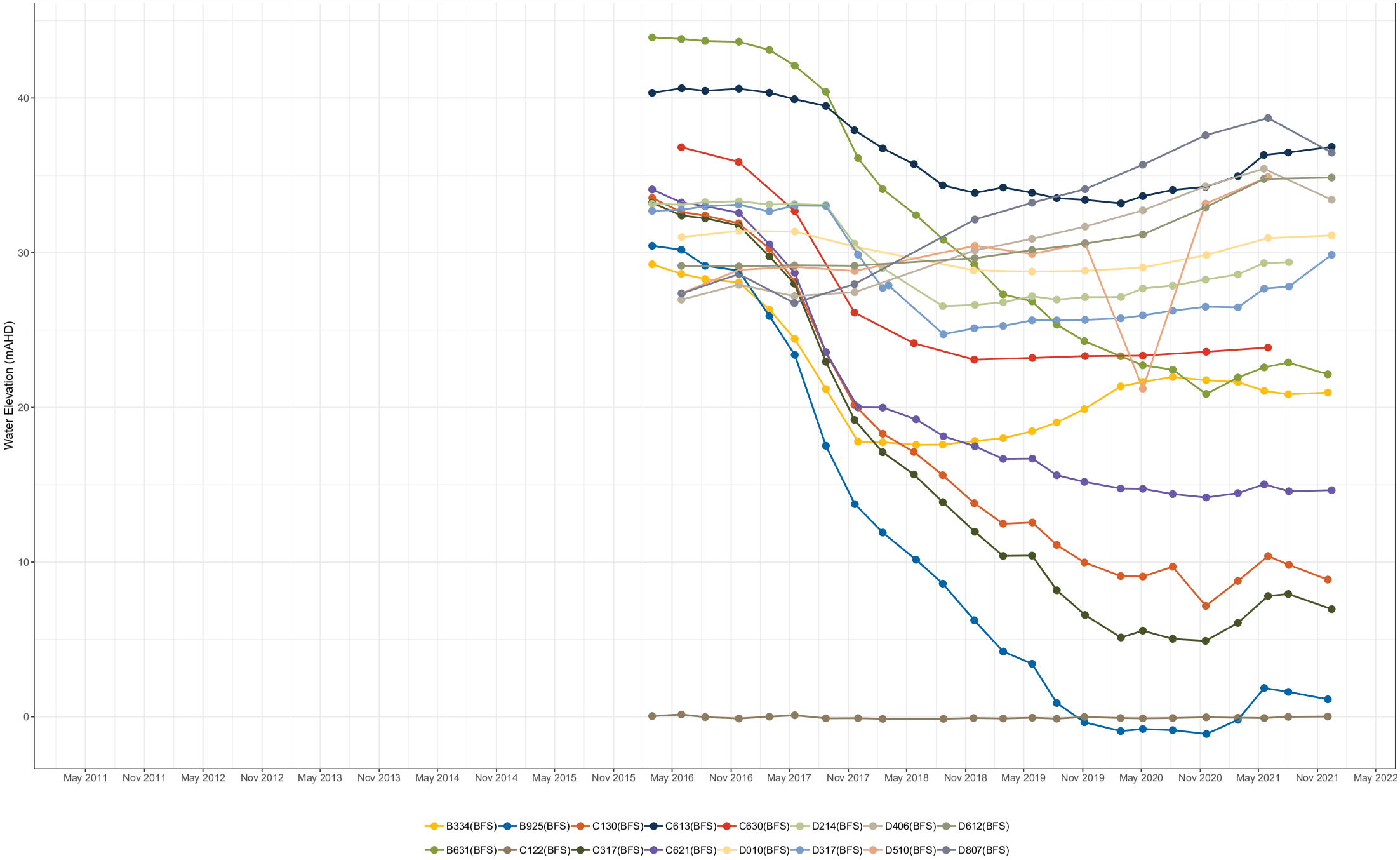
Notes

Lemington South − Glen Munro Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 26



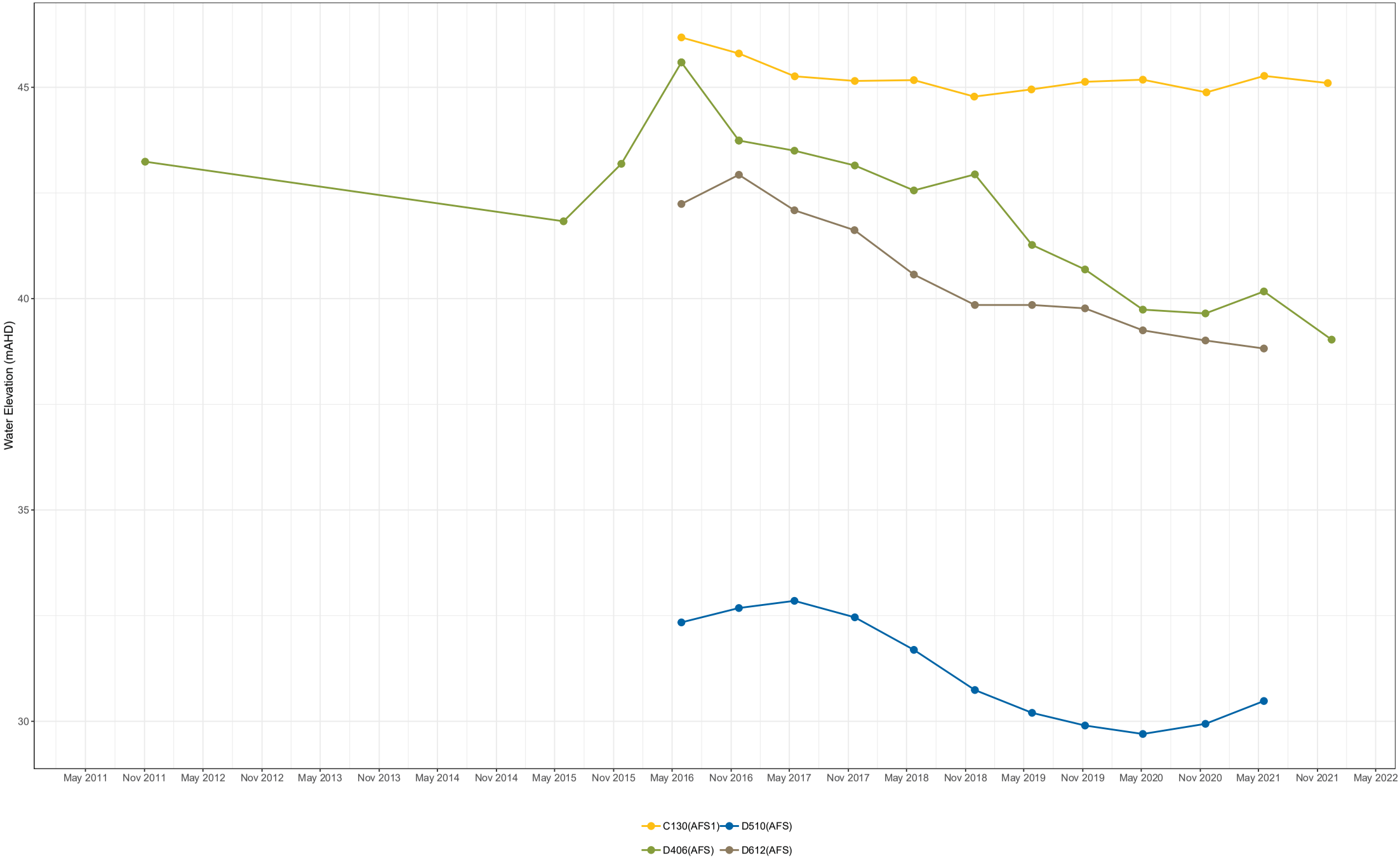
Notes

Lemington South − Woodlands Hill Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 27



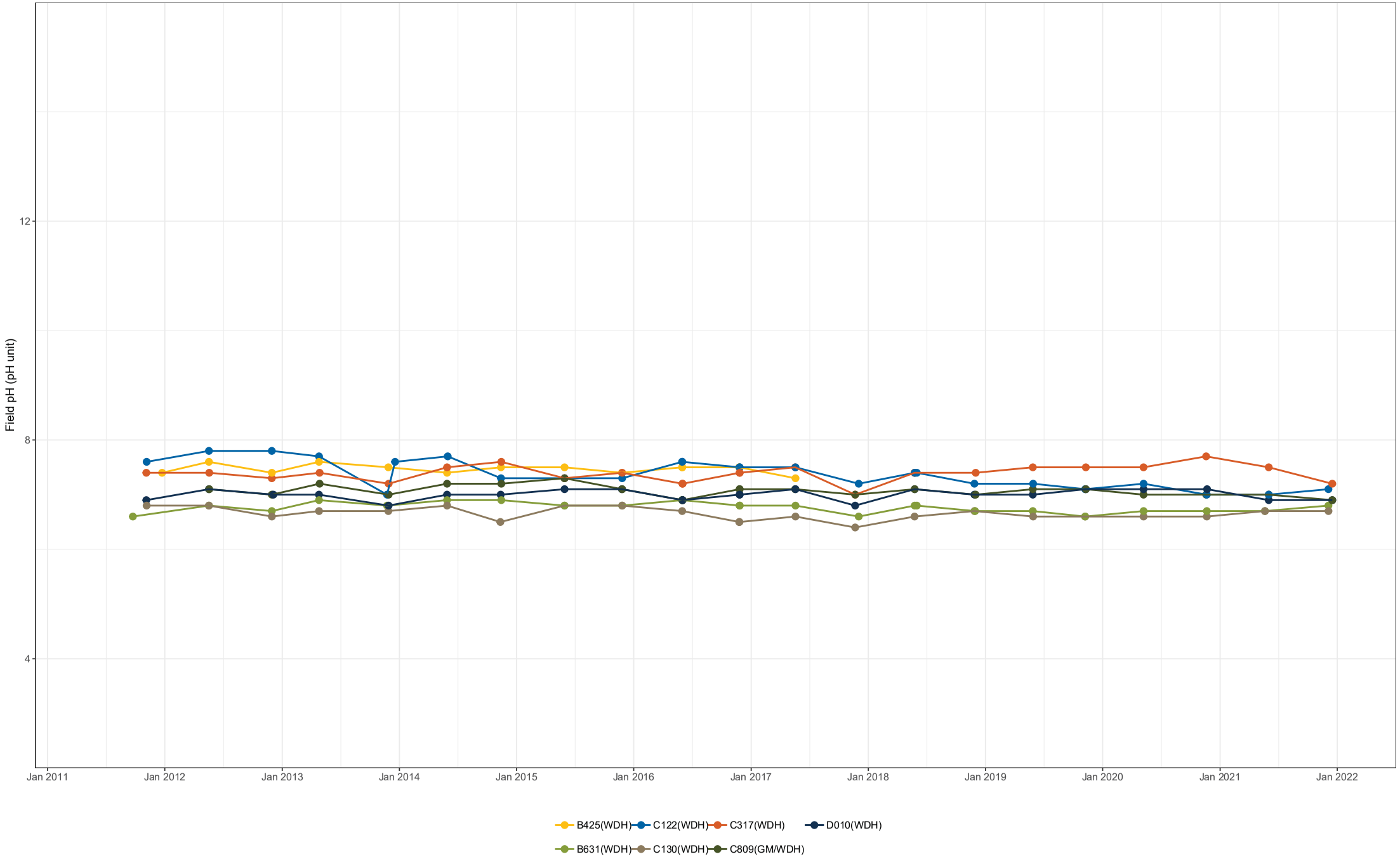
Notes

Lemington South − Bowfield Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 28



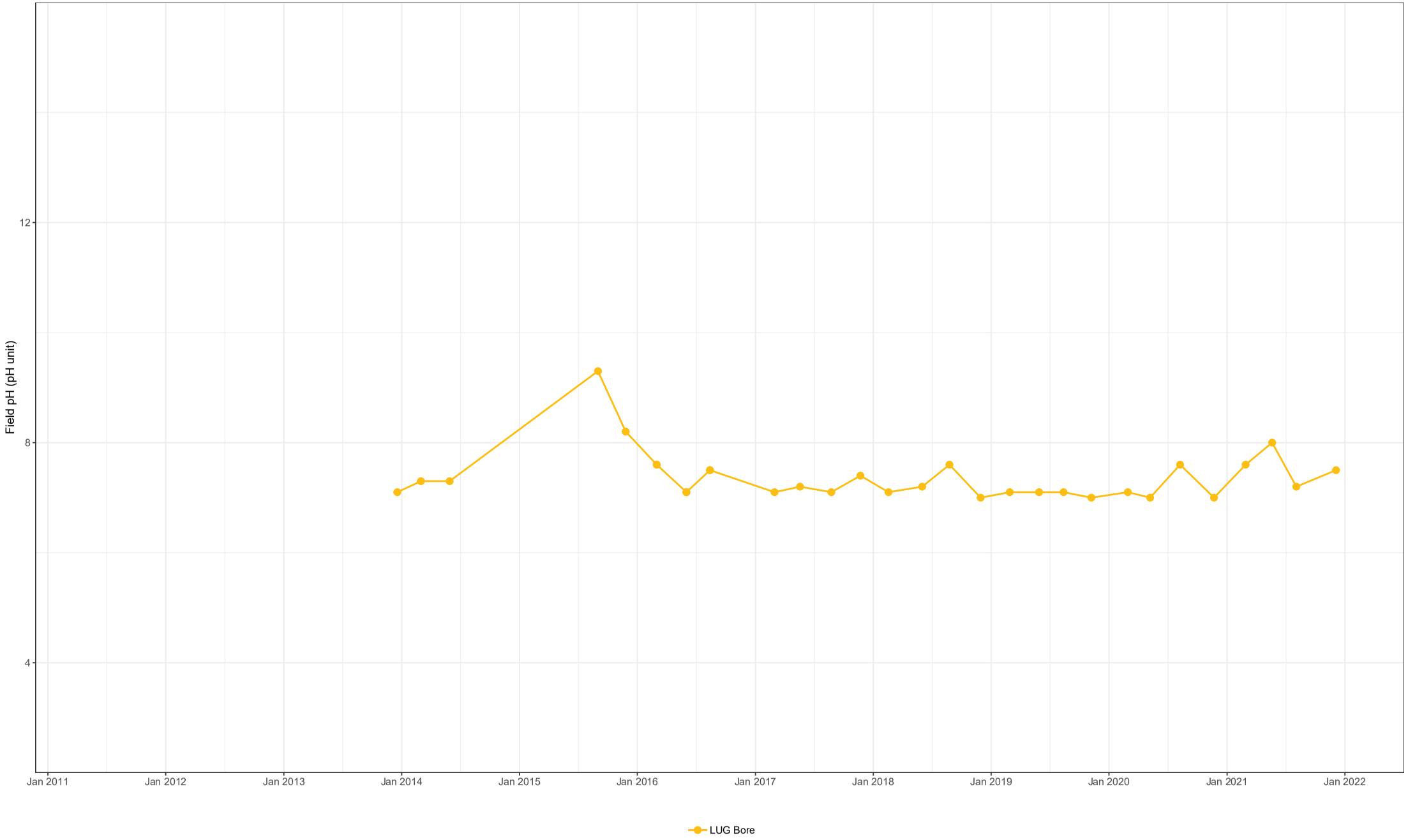
Notes: D612(AFS) dry in December 2021 and no access to D510(AFS) in December 2021

Lemington South − Arrowfield Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 29



Notes

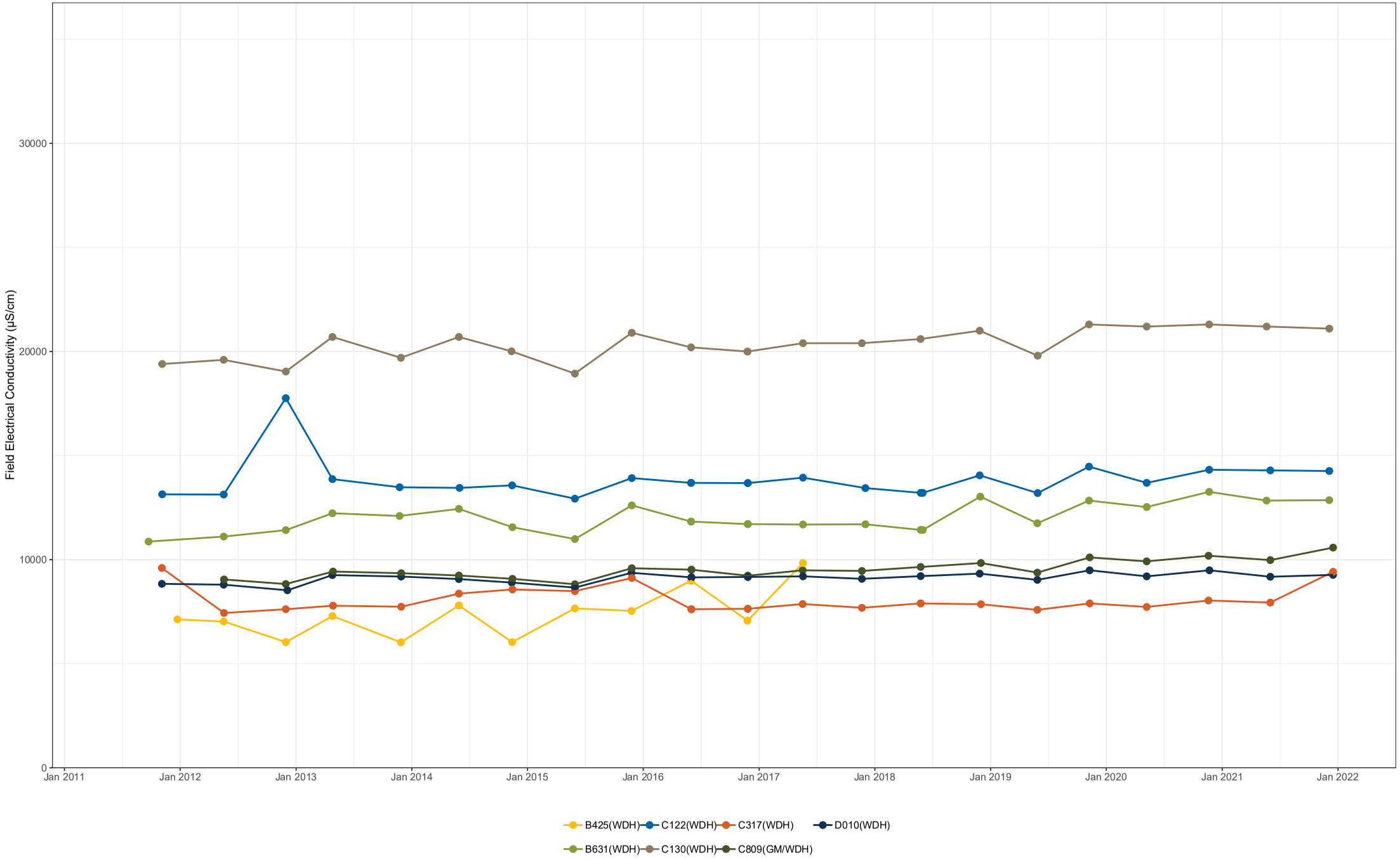
Lemington South − Woodlands Hill Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 30



EMM creating opportunities

Notes

Lemington − Coal seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 31



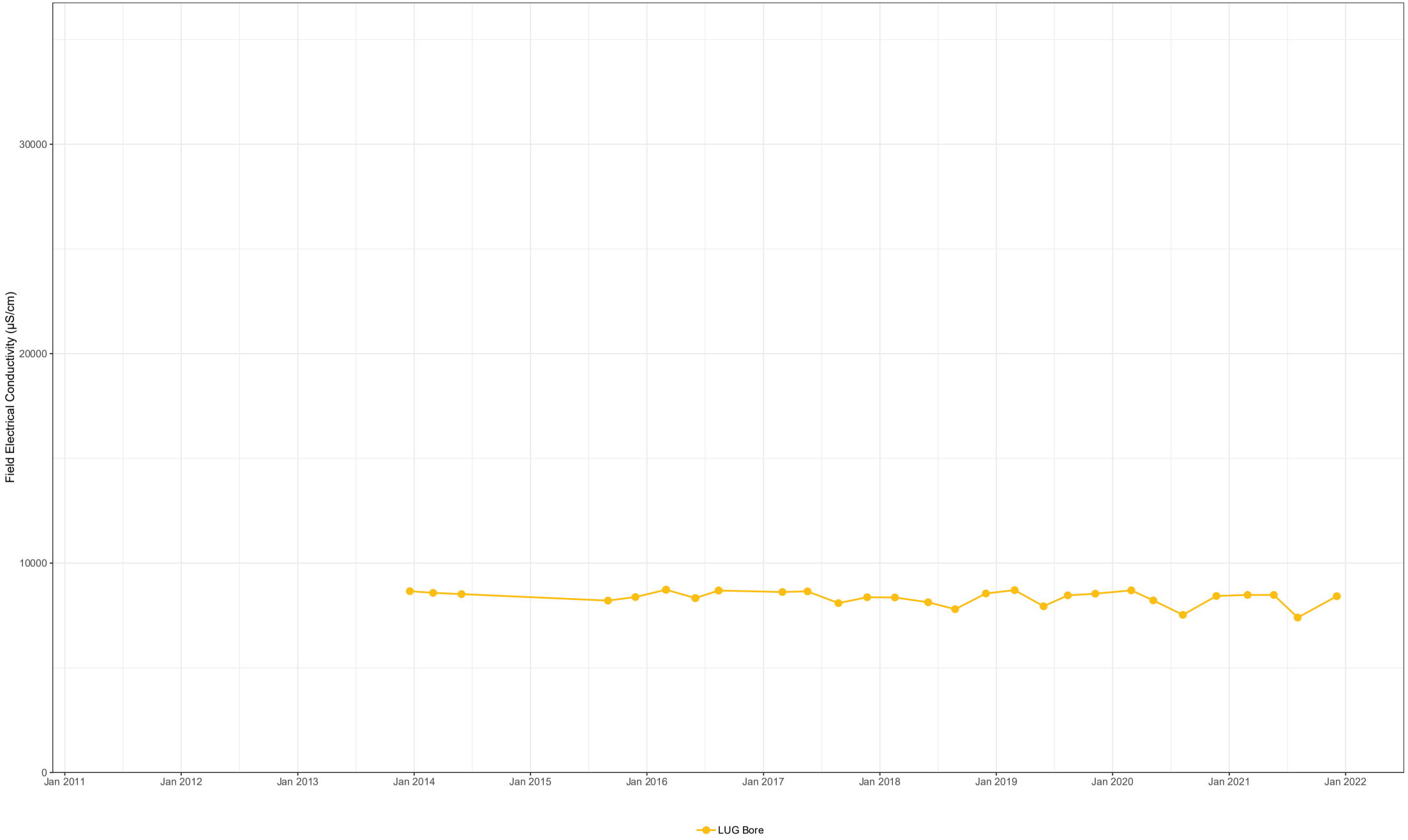
Lemington South − Woodlands Hill Seam Field Electrical Conductivity (µS/cm)

Hunter Valley Operations

2021 Annual Groundwater Monitoring Review

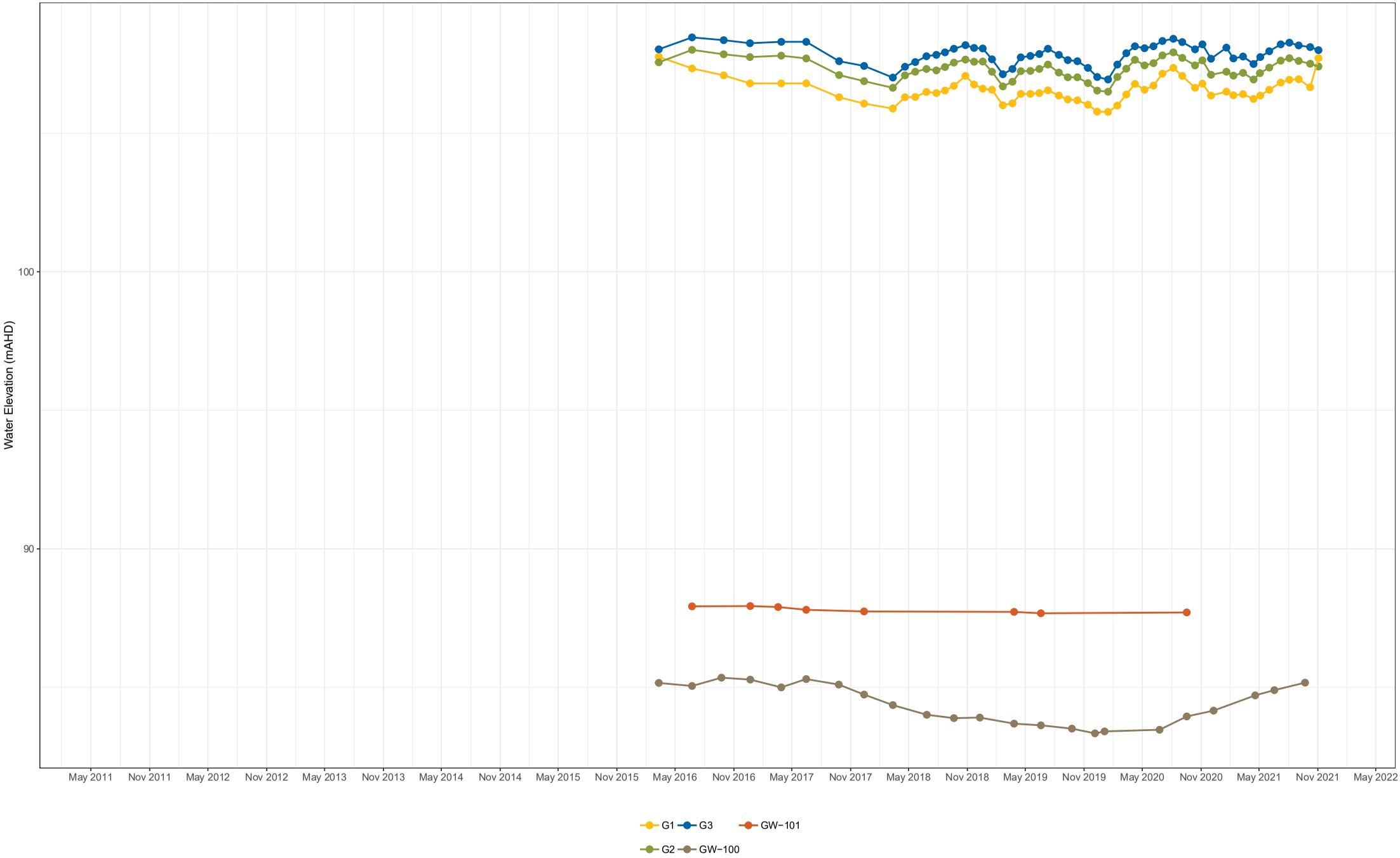
Appendix C Figure 32

Notes



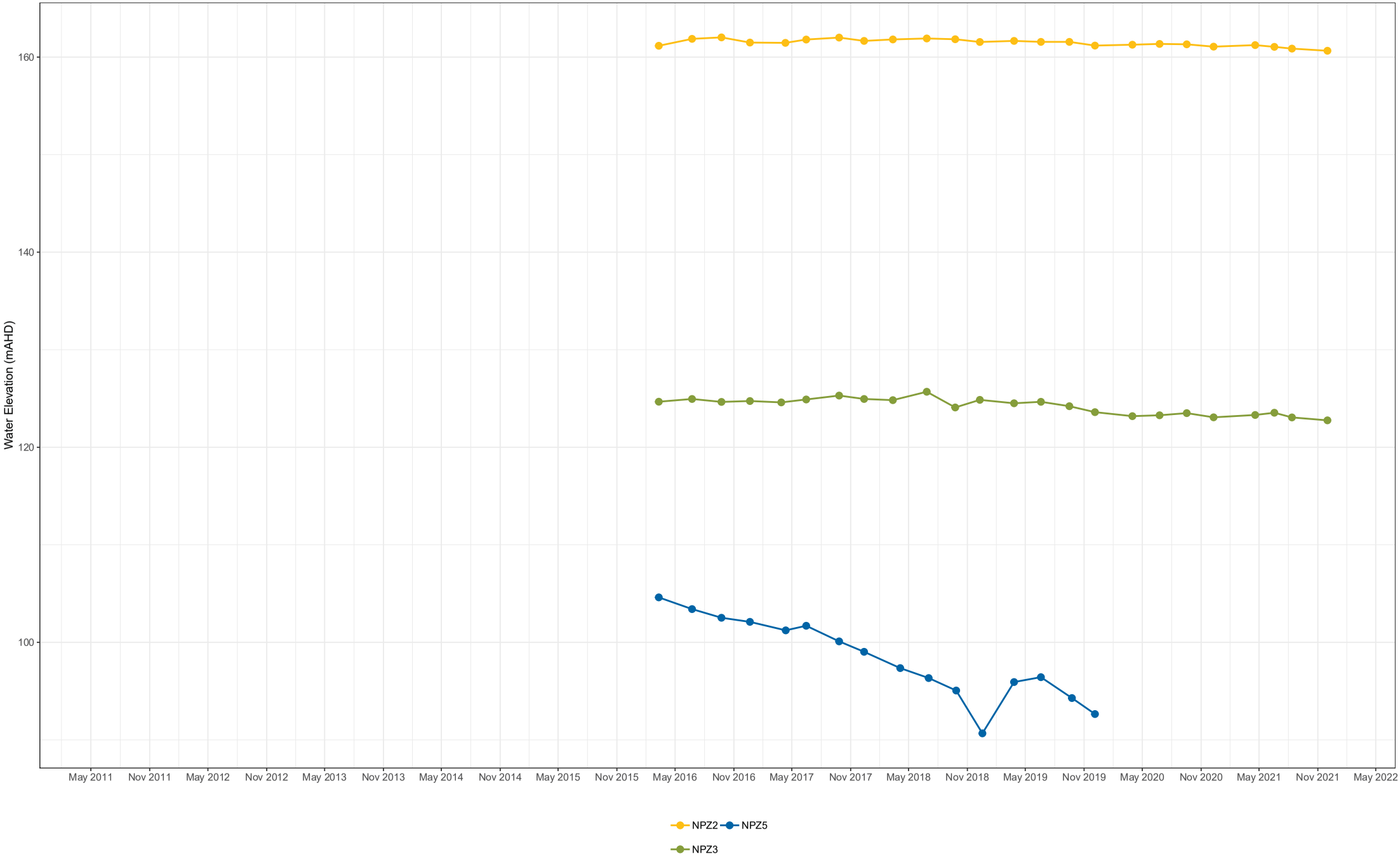
Notes

Lemington − Coal seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 33



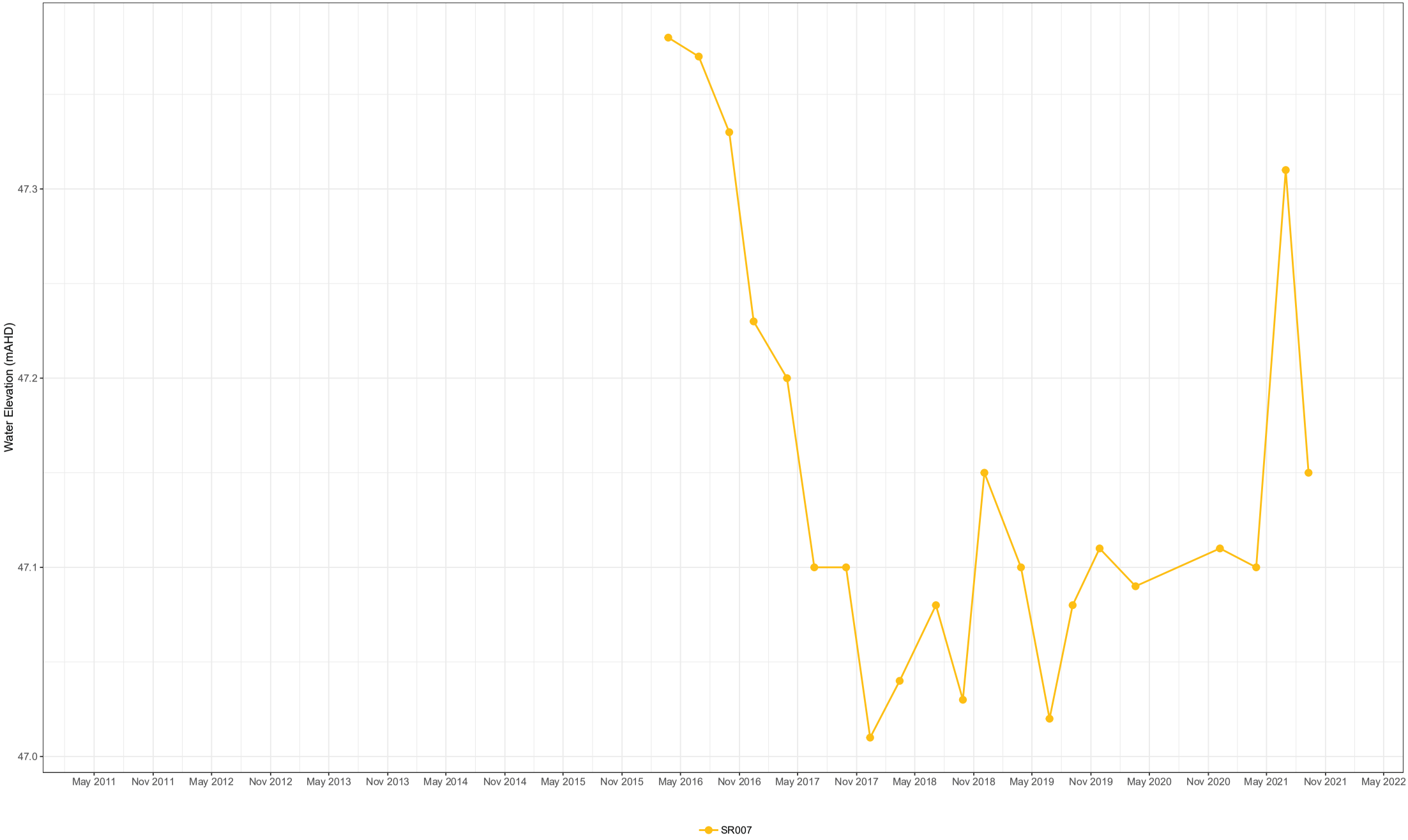
Notes: GW-101 dry in Q1, Q2 and Q3 2021. Access constraints due to flooding in Q4 2021 prevented monitoring

West Pit − Alluvium Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 34



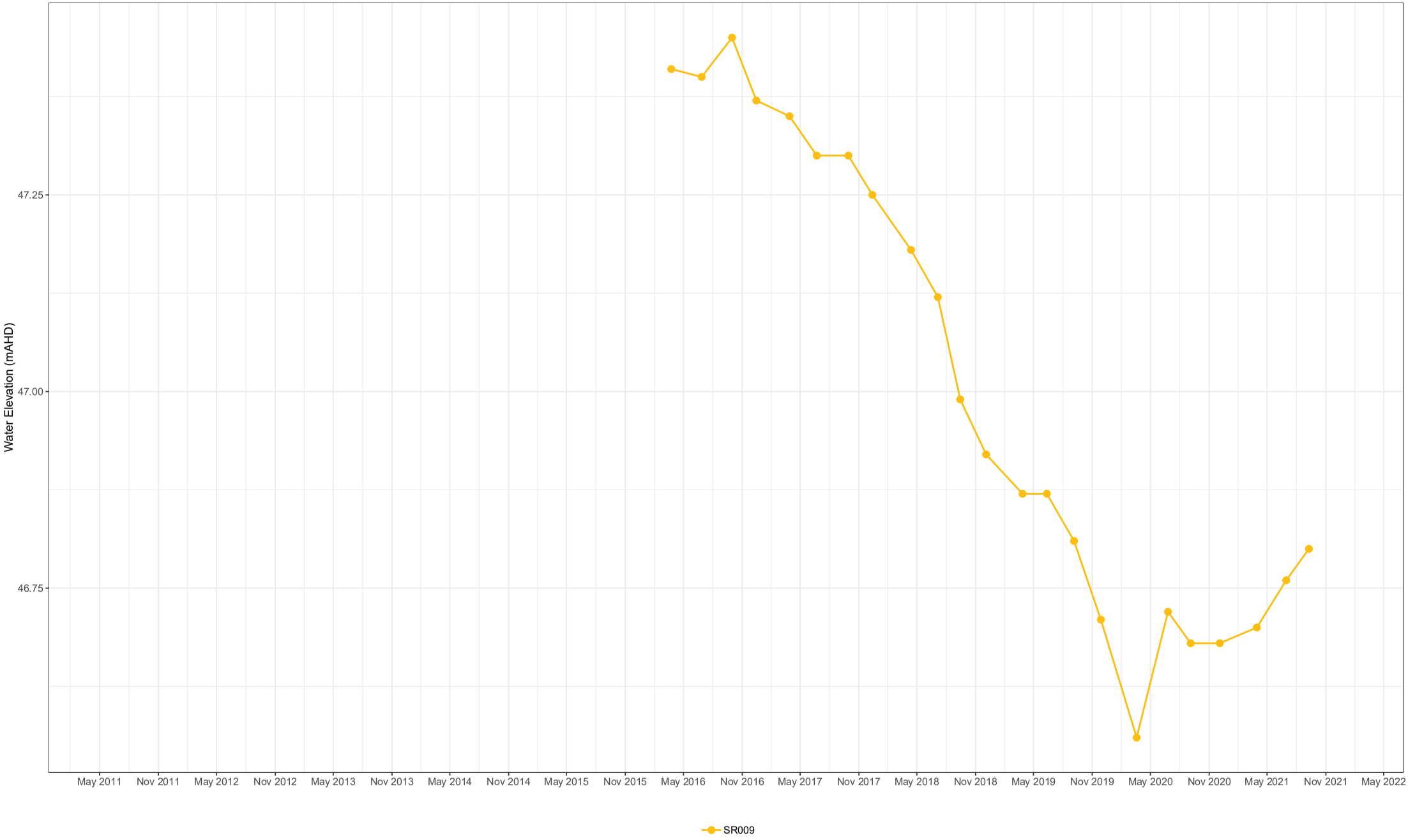
Notes: NPZ5 was destroyed in 2020.

West Pit − Interburden Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 35



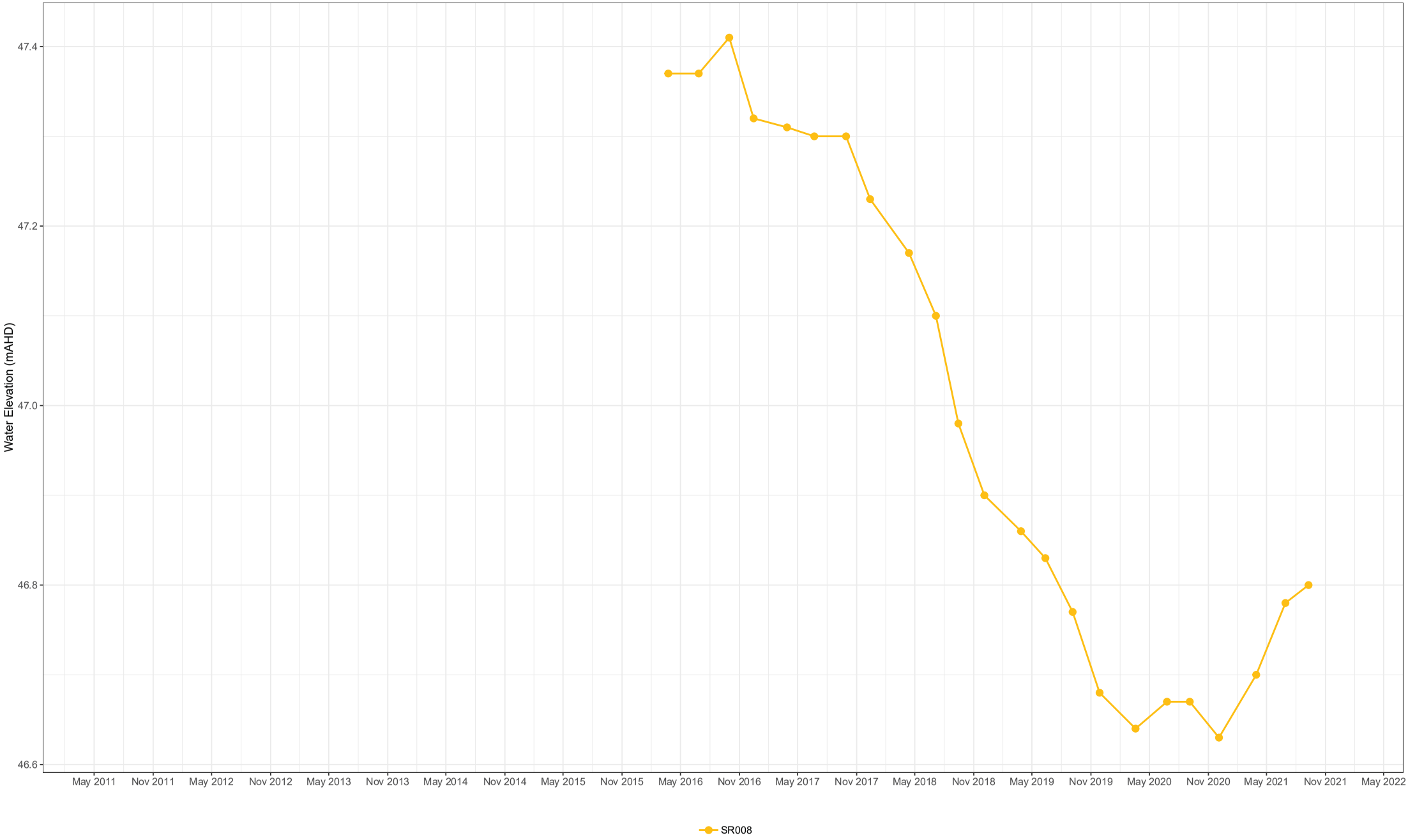
Notes

Southern − Overburden and Vaux Seam coal Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 36



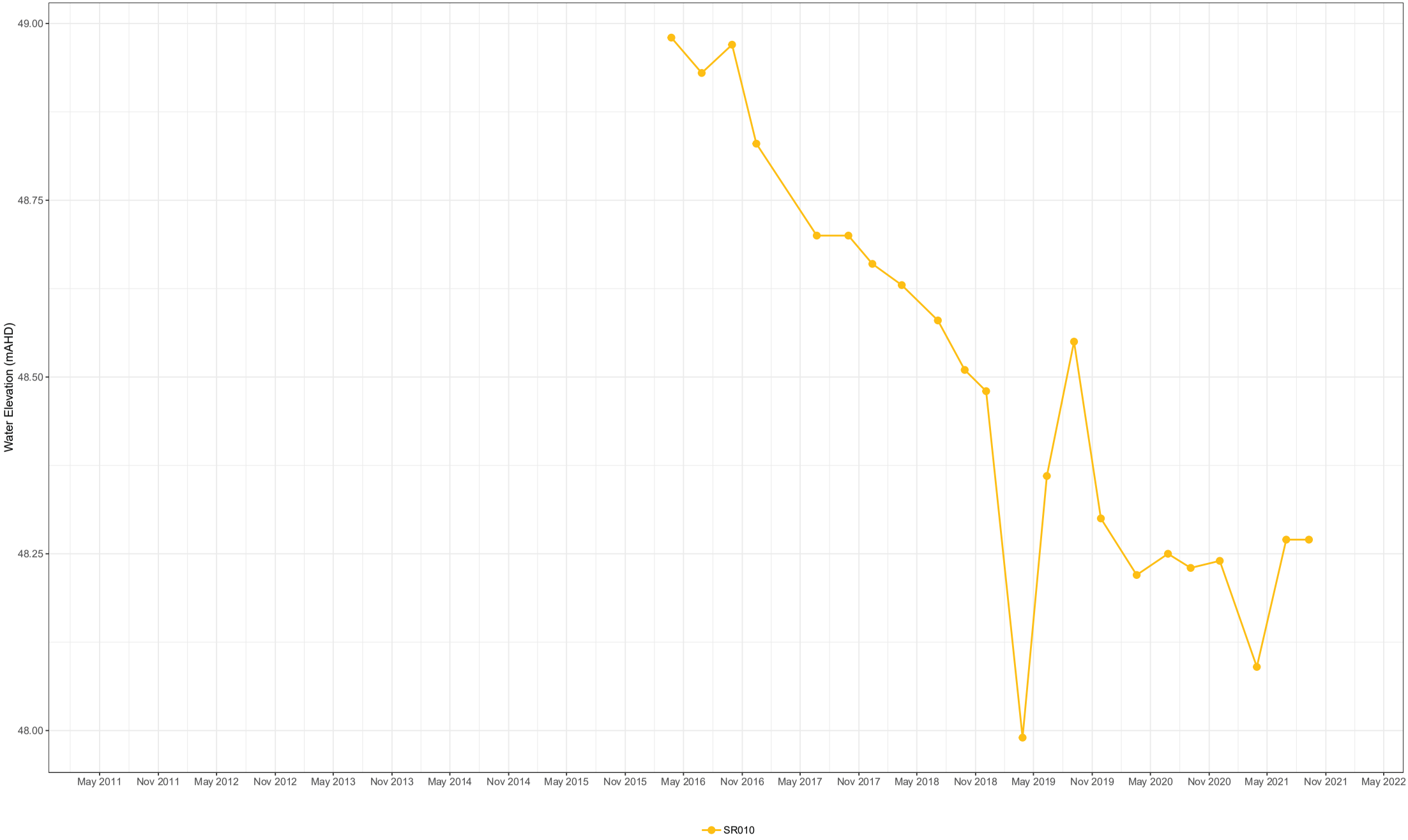
Notes

Southern − Lemington Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 37



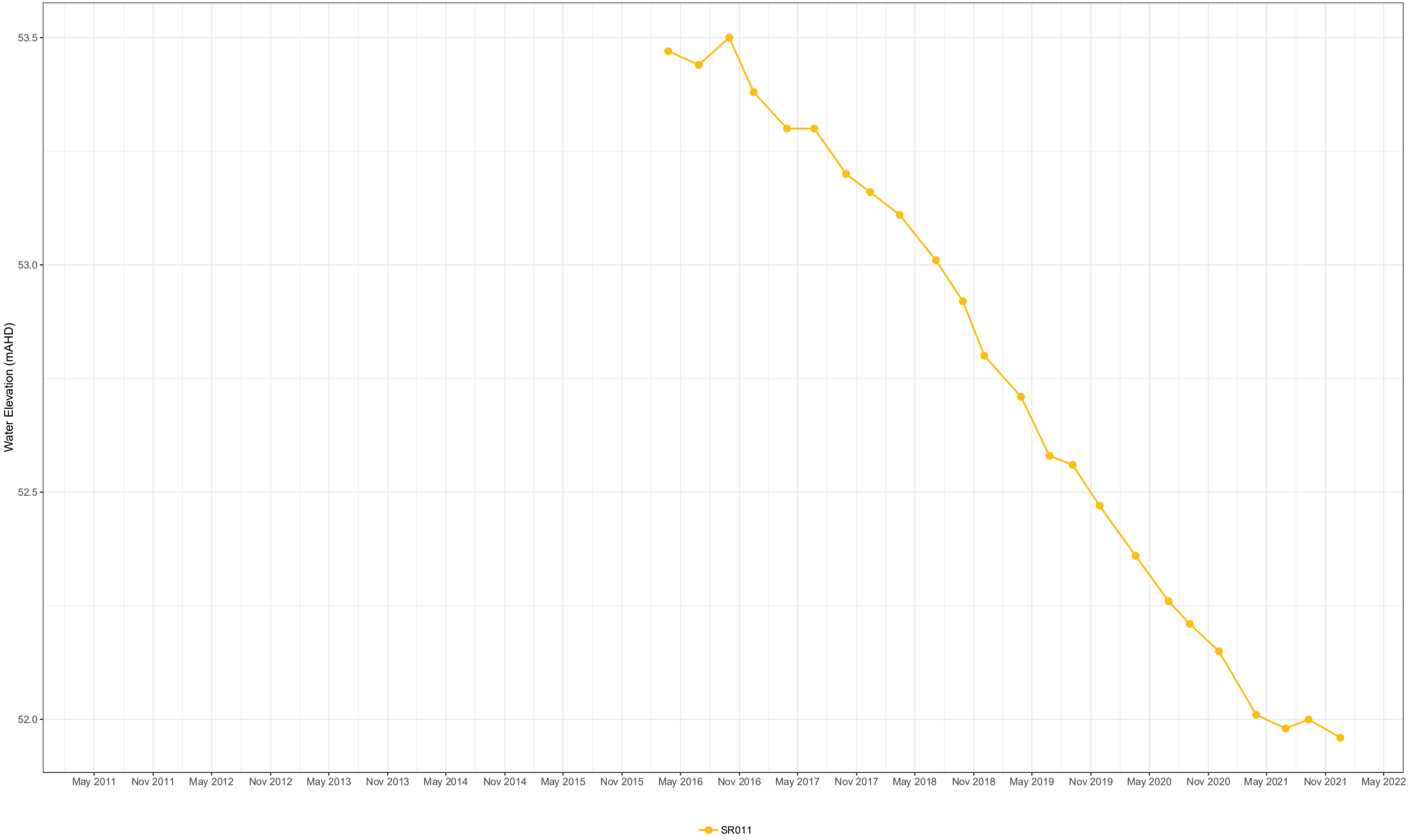
Notes

Southern − Siltstone/sandstone below Lemington Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 38



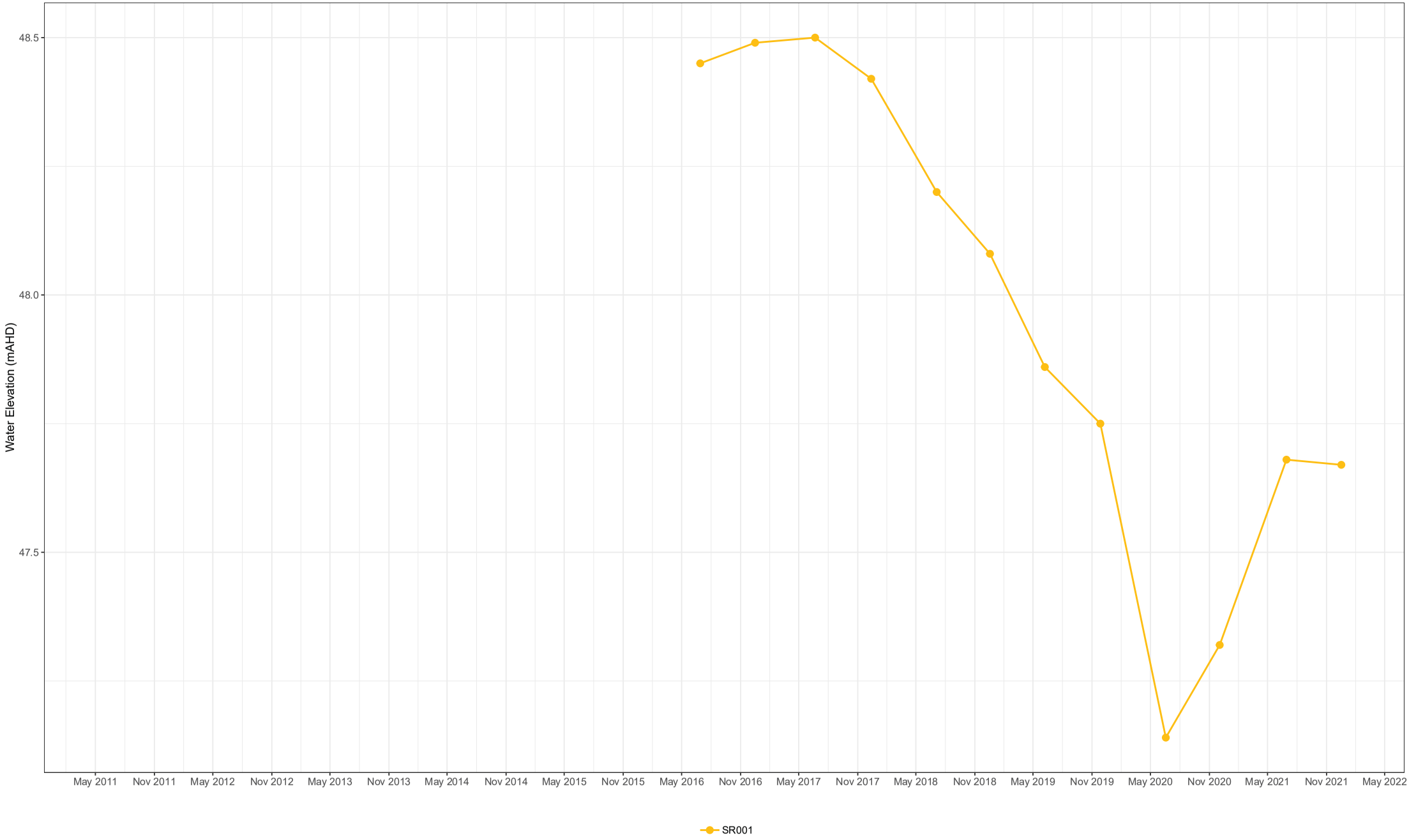
Notes

Southern − Conglomerate and Warkworth Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 39



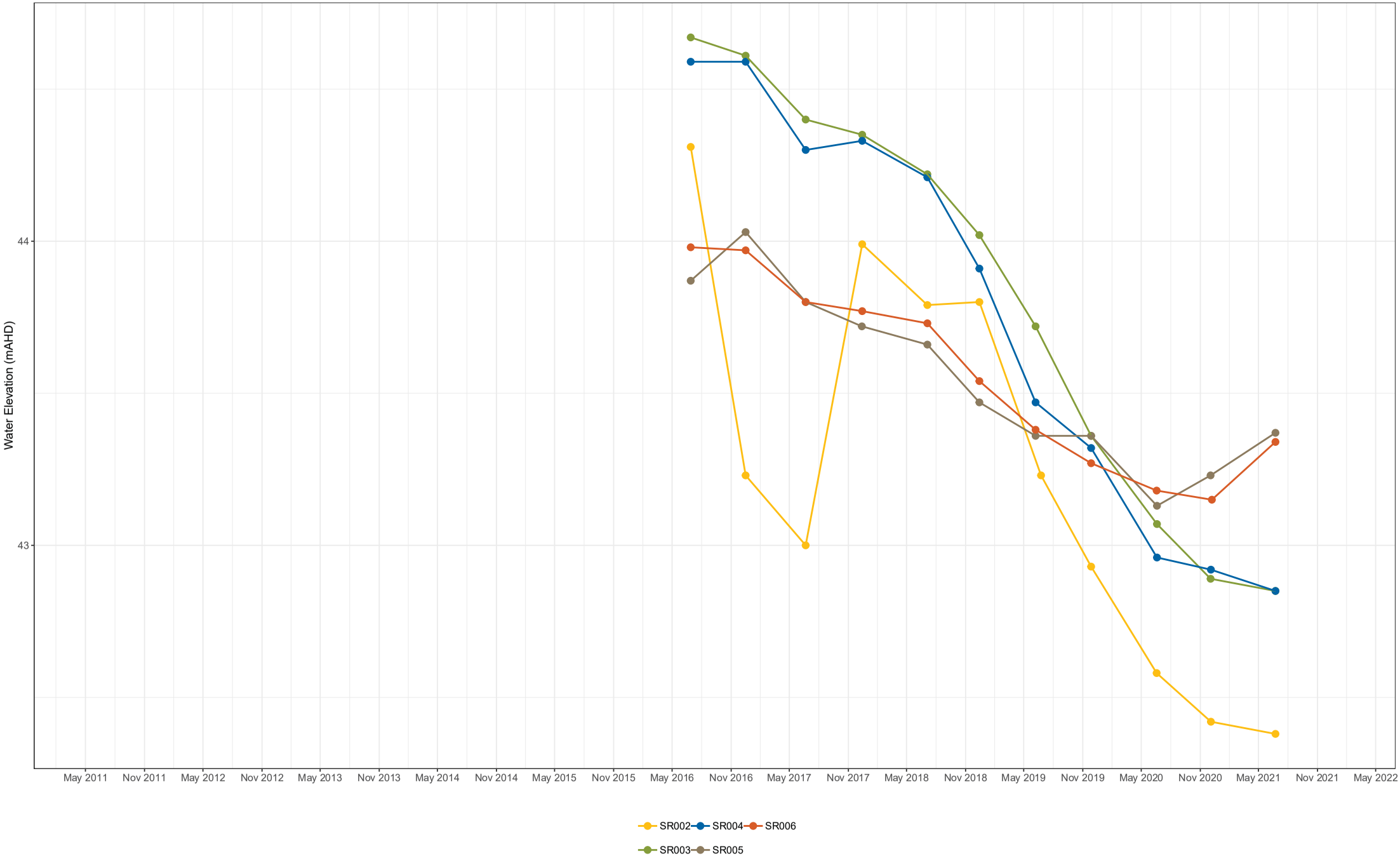
Notes

Southern − Mt Arthur Seam and underburden Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 40



Notes

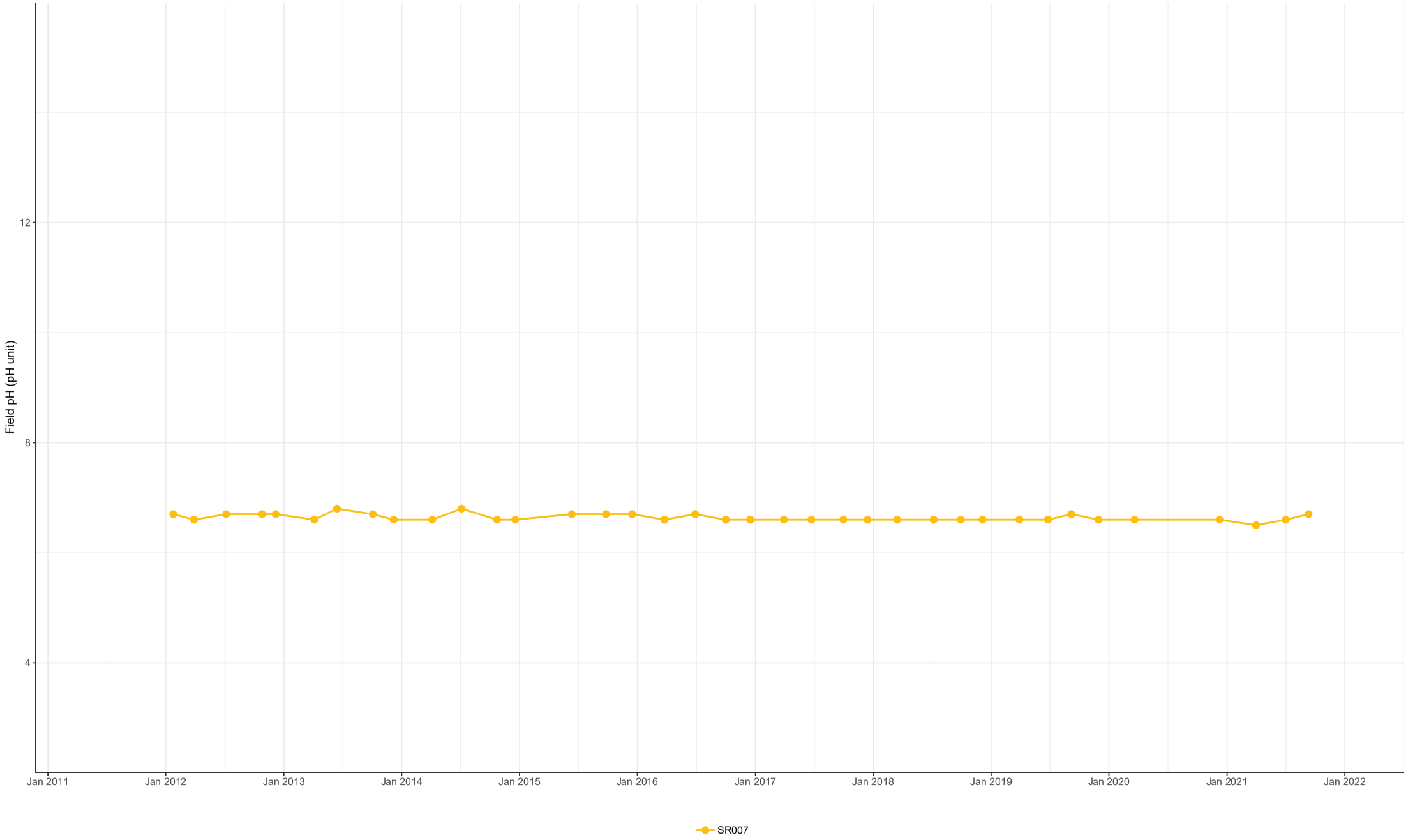
Southern − Coal Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 41



EMM creating opportunities

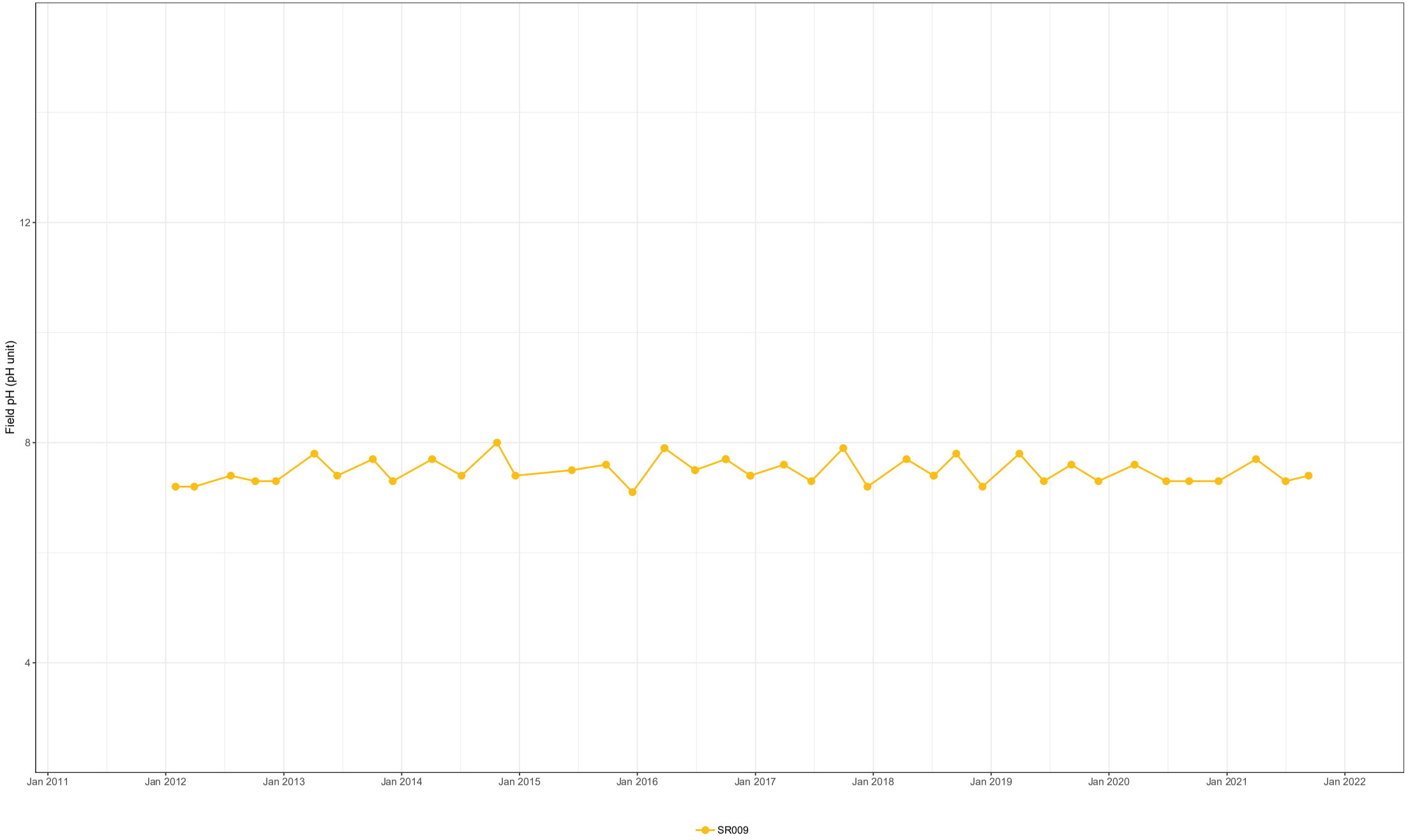
Notes

Southern − Bayswater Seam Water Elevation (mAHD)
Hunter Valley Operations
2021 Annual groundwater review
Appendix C, Figure 42



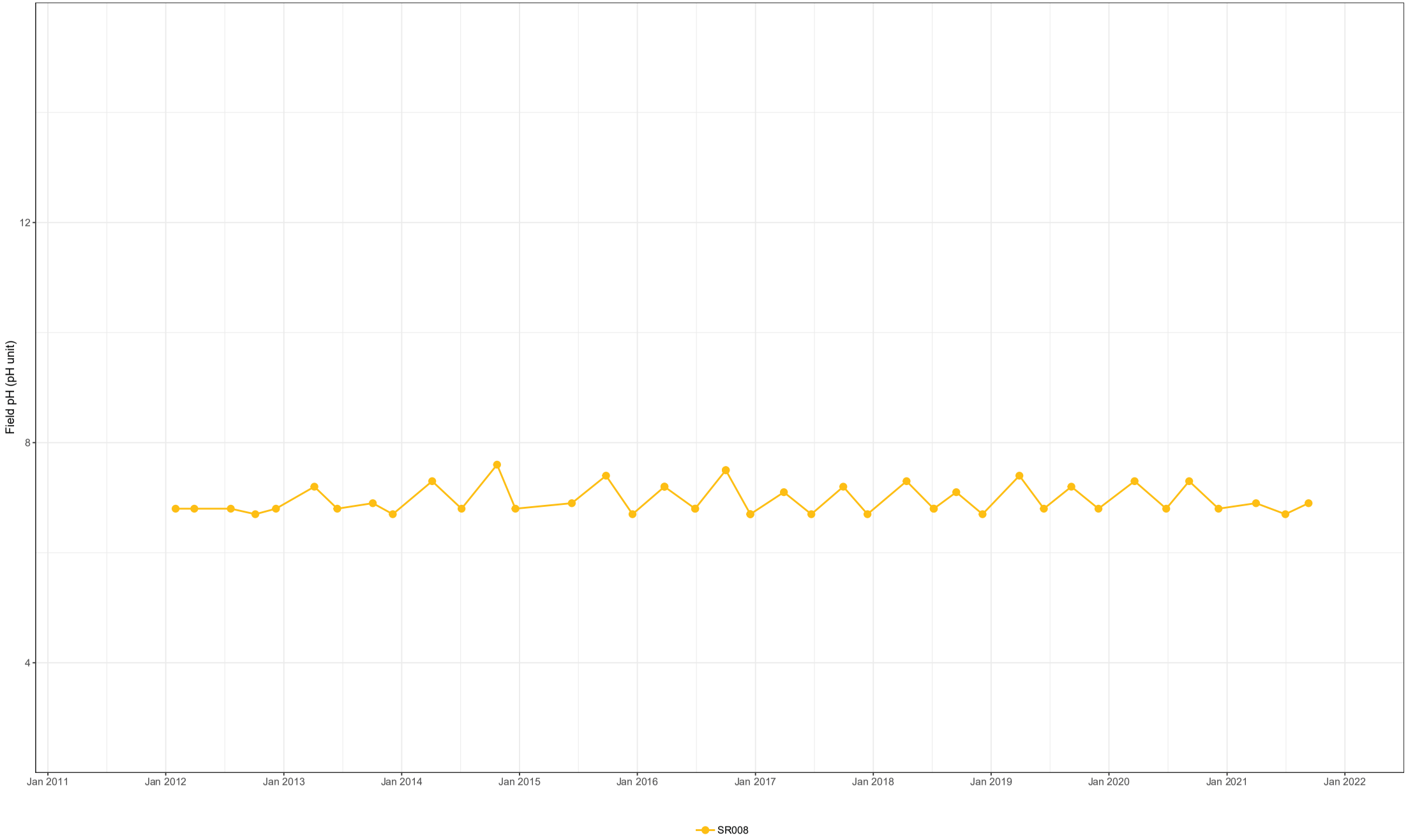
Notes

Southern − Overburden and Vaux Seam coal Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 43



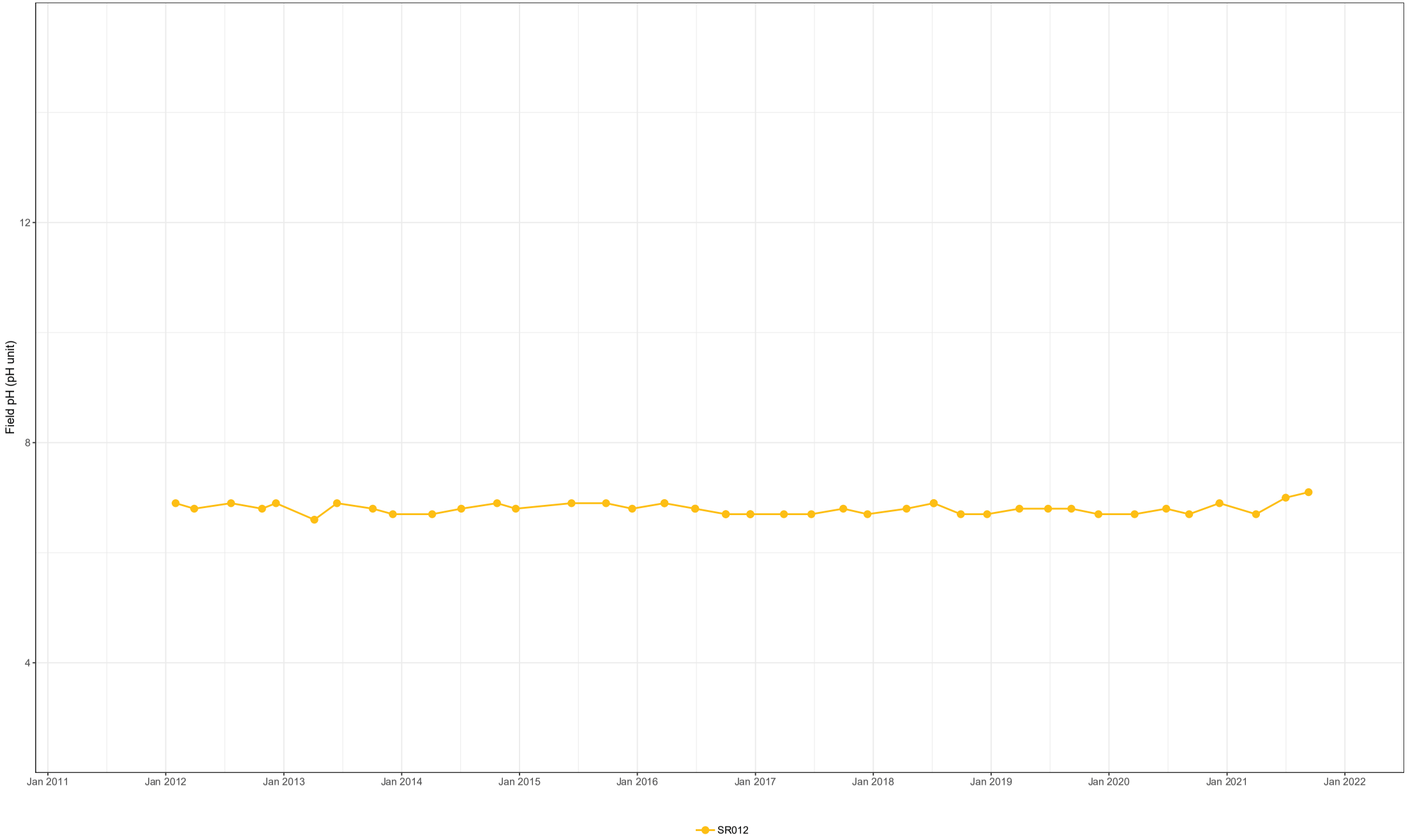
Notes

Southern − Lemington Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 44



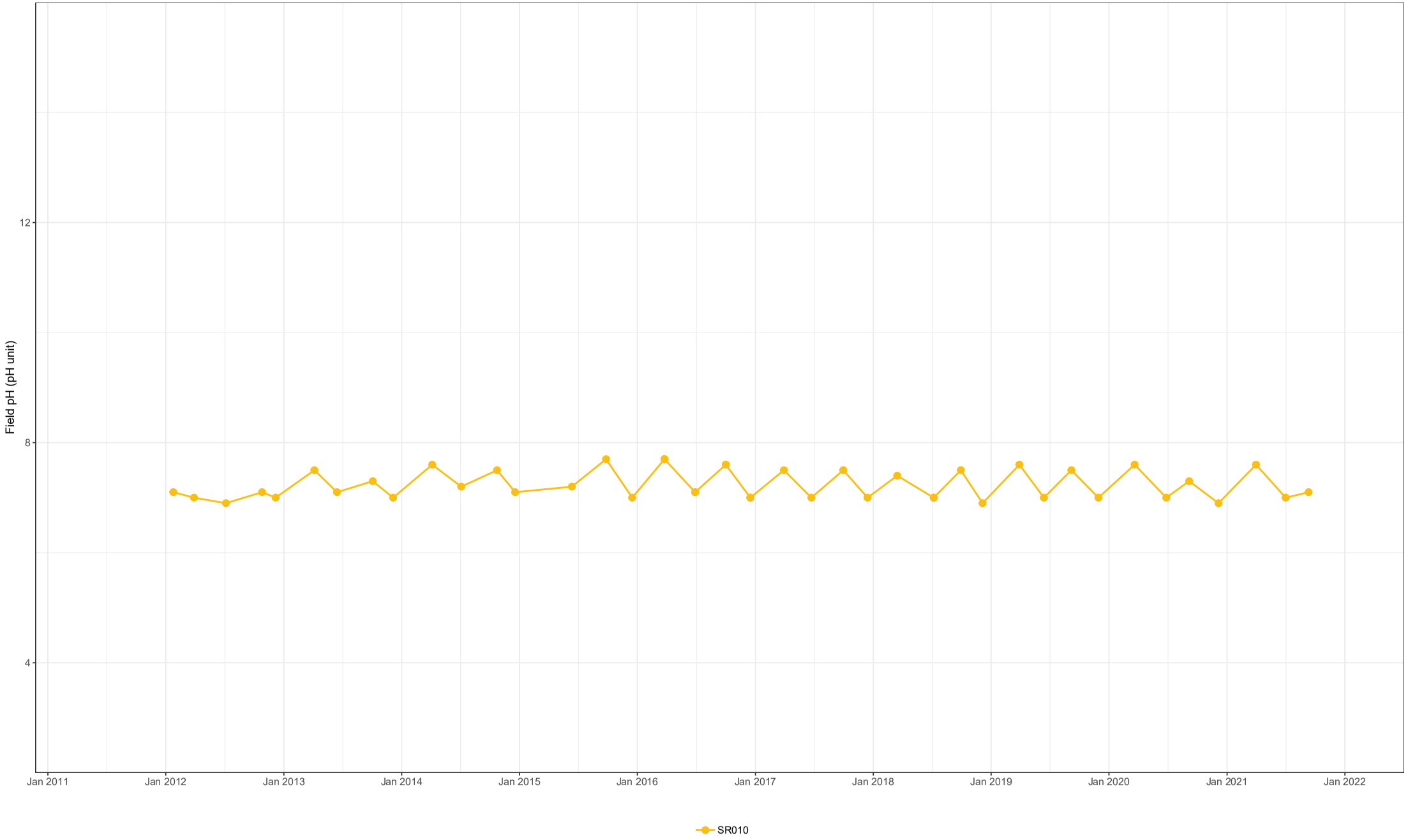
Notes

Southern − Siltstone/sandstone below Lemington Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 45



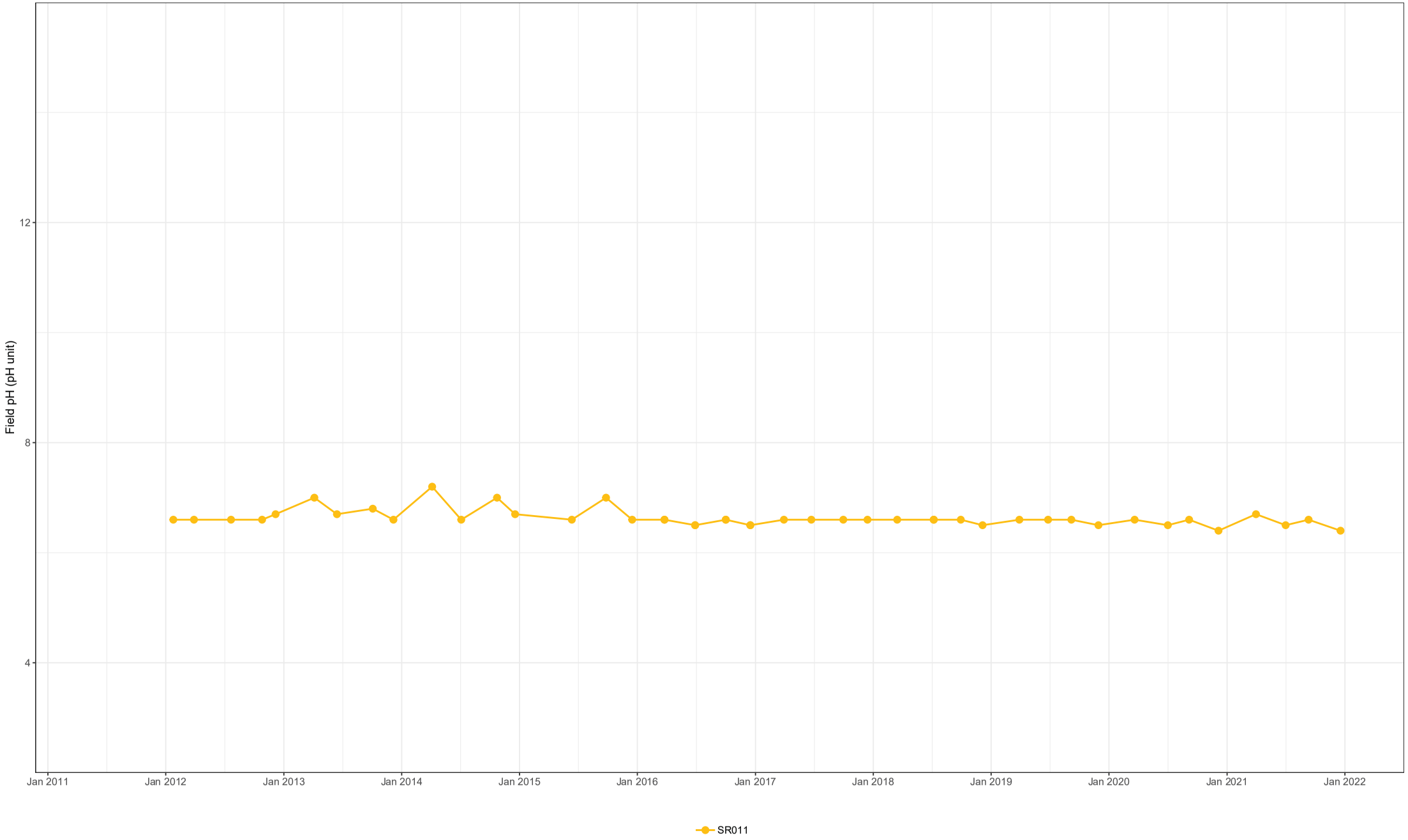
Notes

Southern − Overburden conglomerate and sandstone Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 46



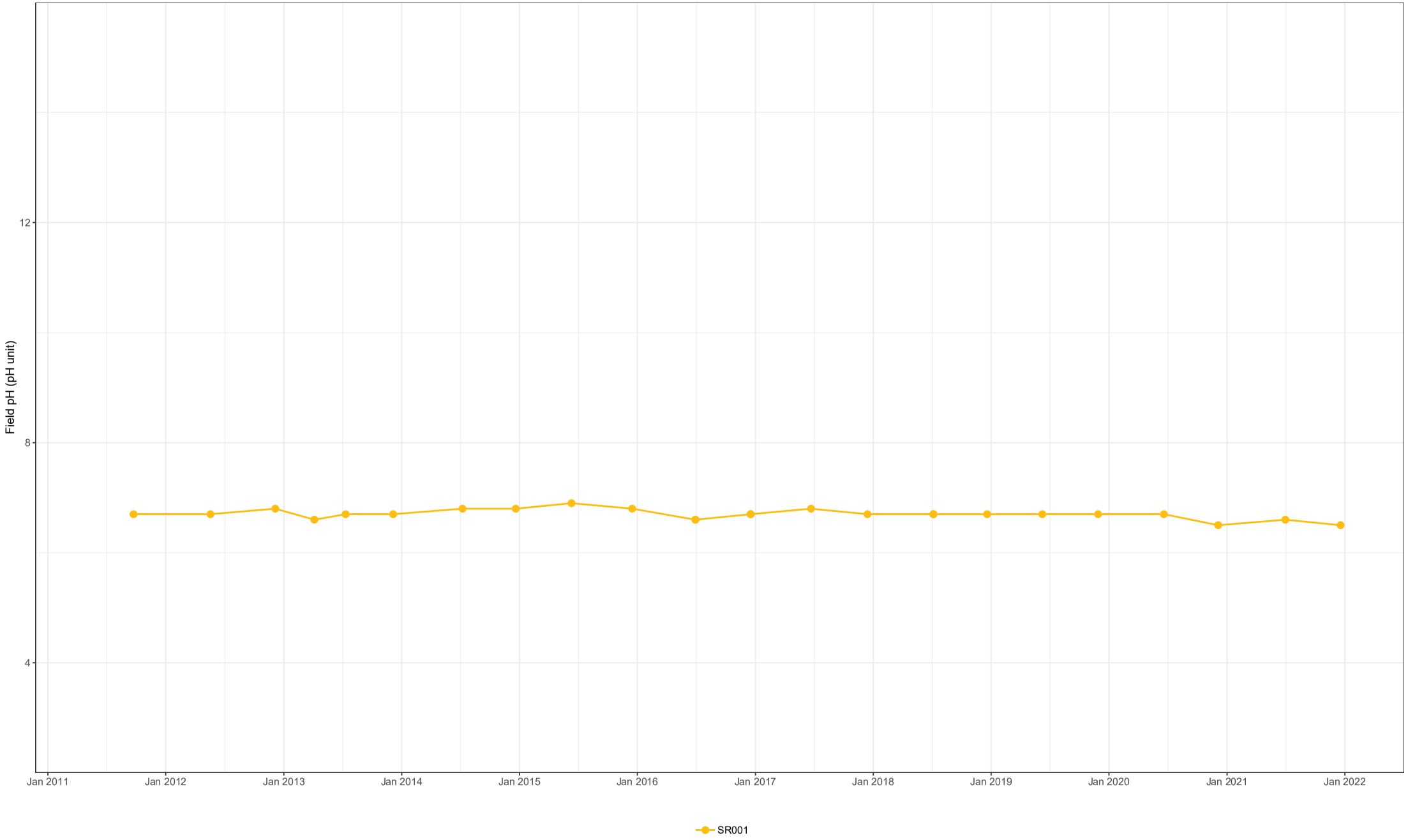
Notes

Southern − Conglomerate and Warkworth Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 47



Notes

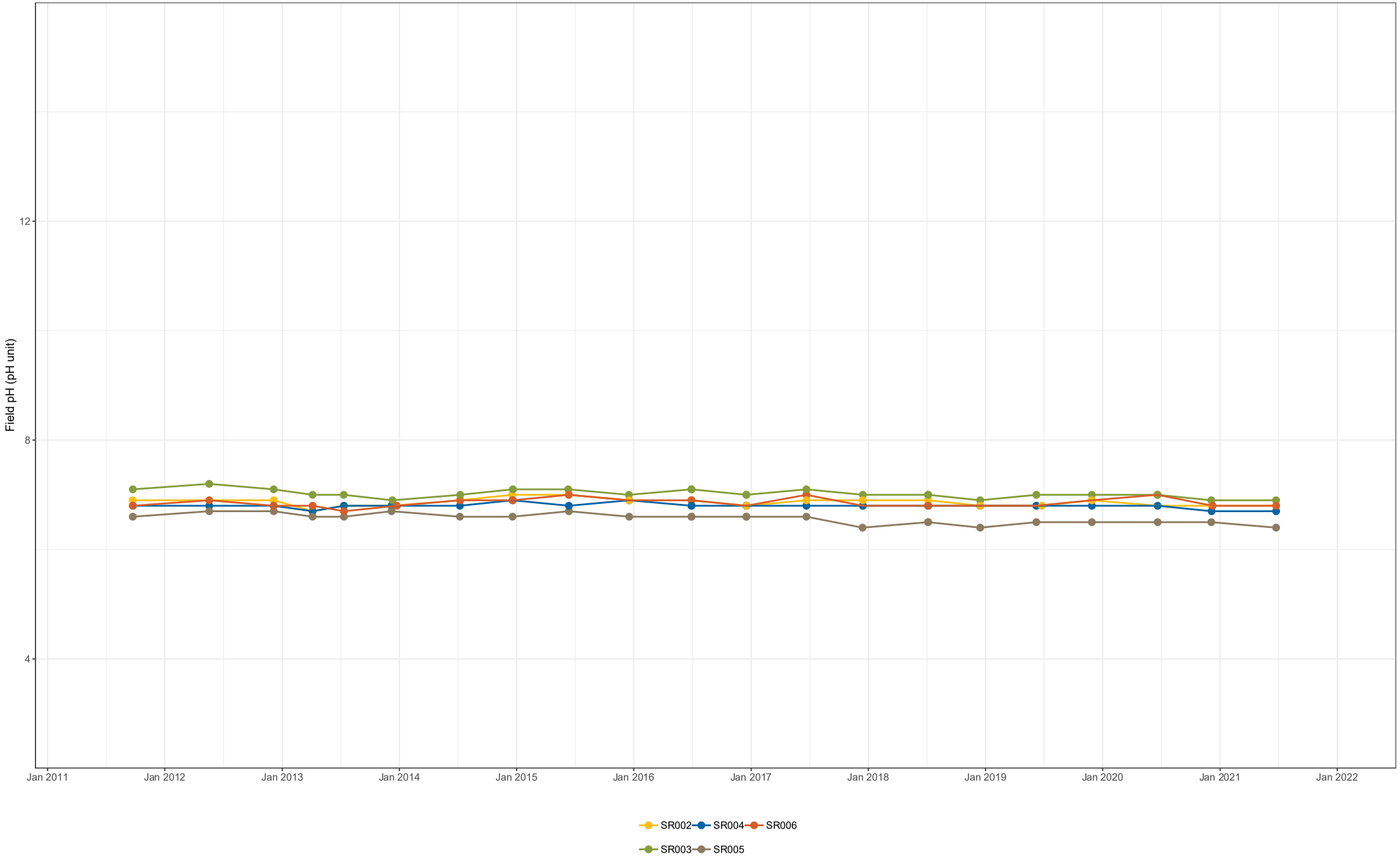
Southern − Mt Arthur Seam and underburden Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 48



EMM creating opportunities

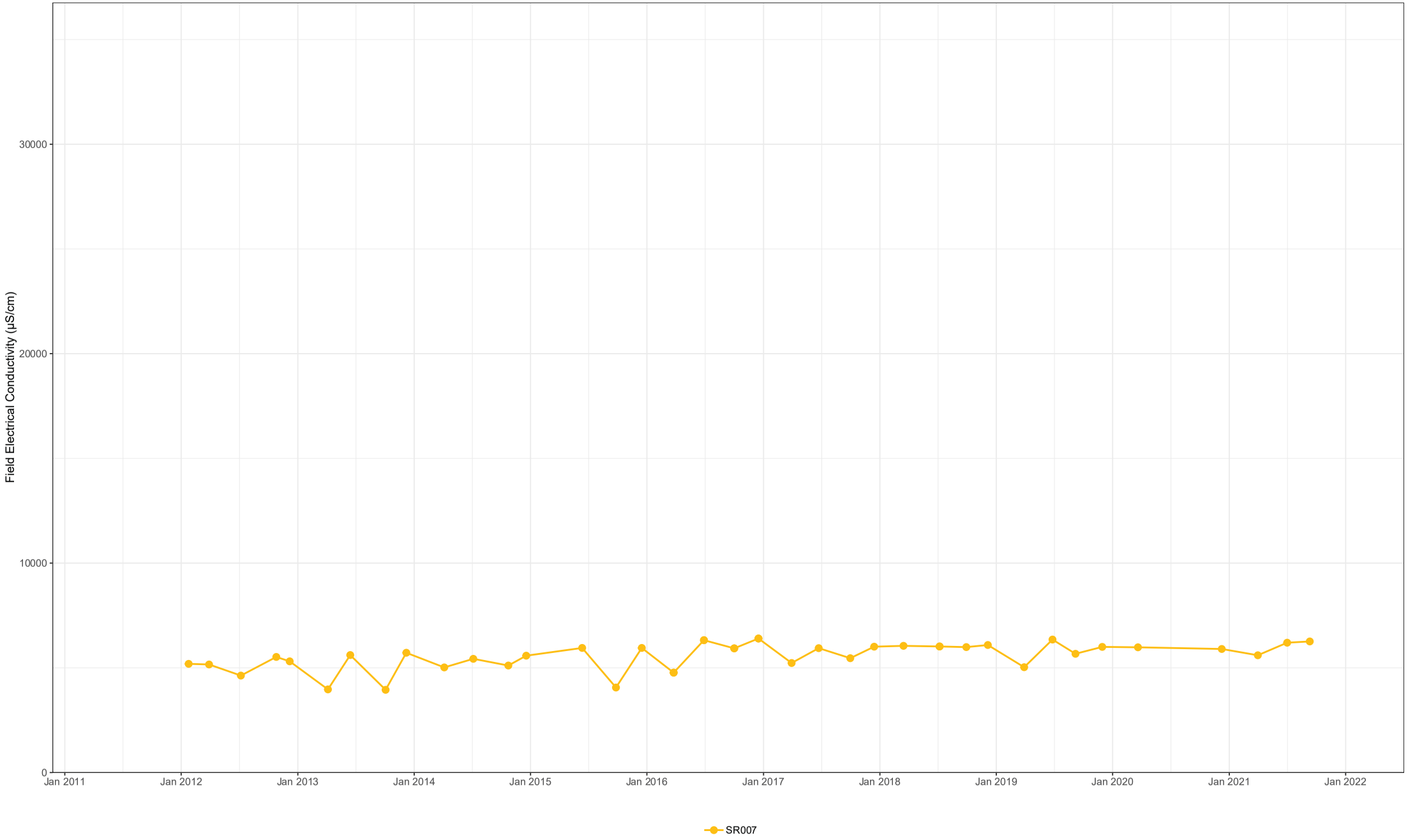
Notes

Southern − Coal Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 49



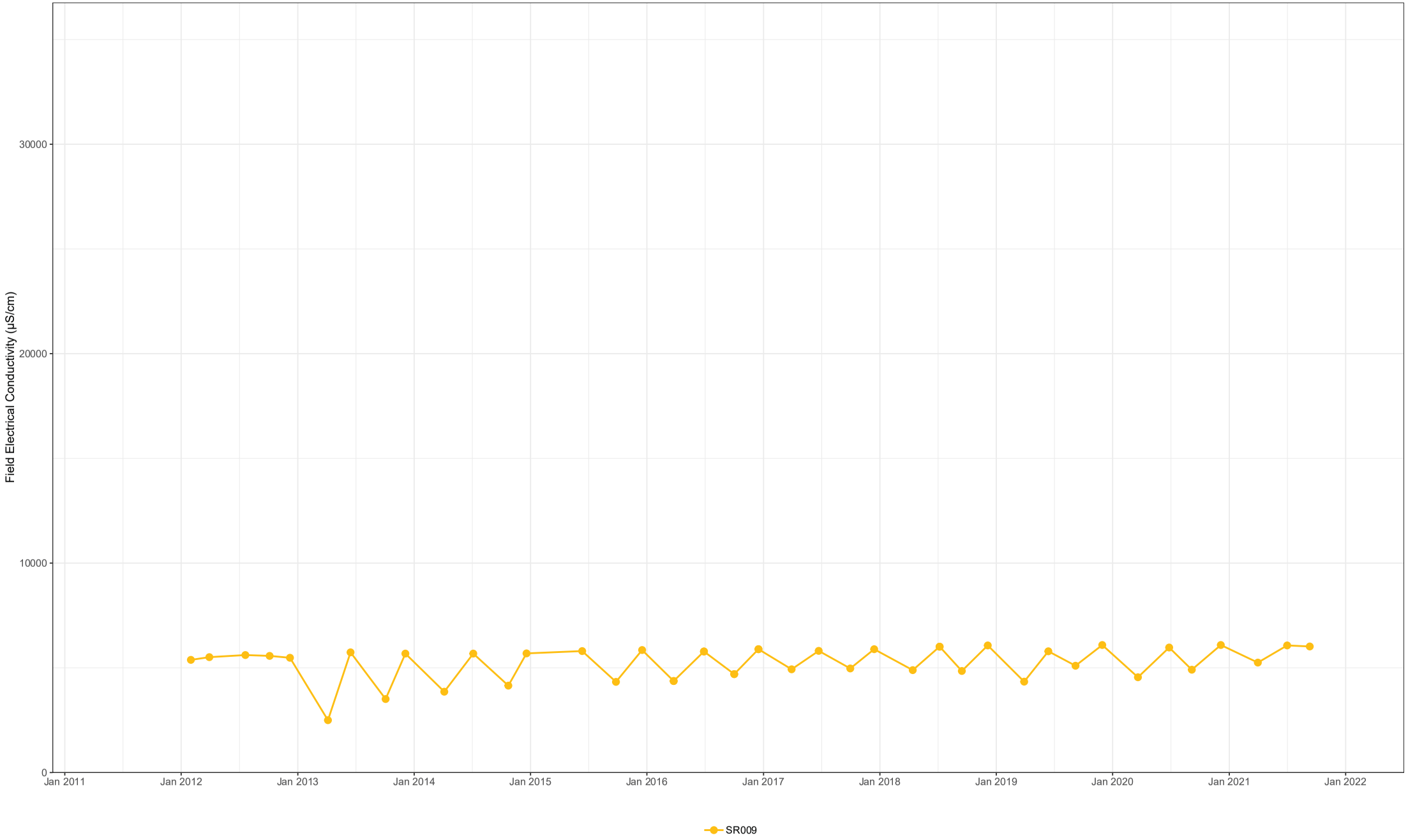
Notes

Southern − Bayswater Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 50



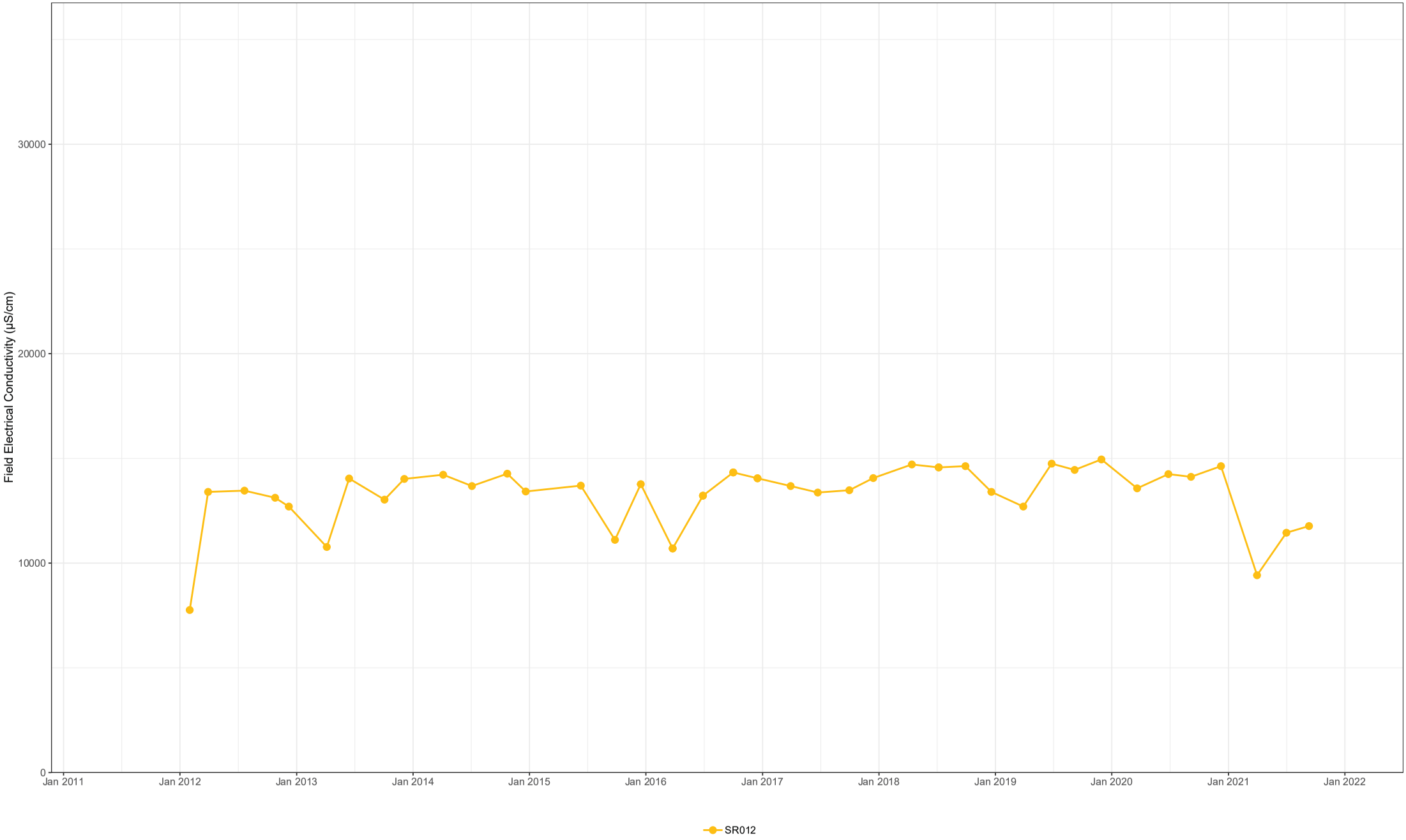
Notes

Southern − Overburden and Vaux Seam coal Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 51



Notes

Southern − Lemington Seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 52



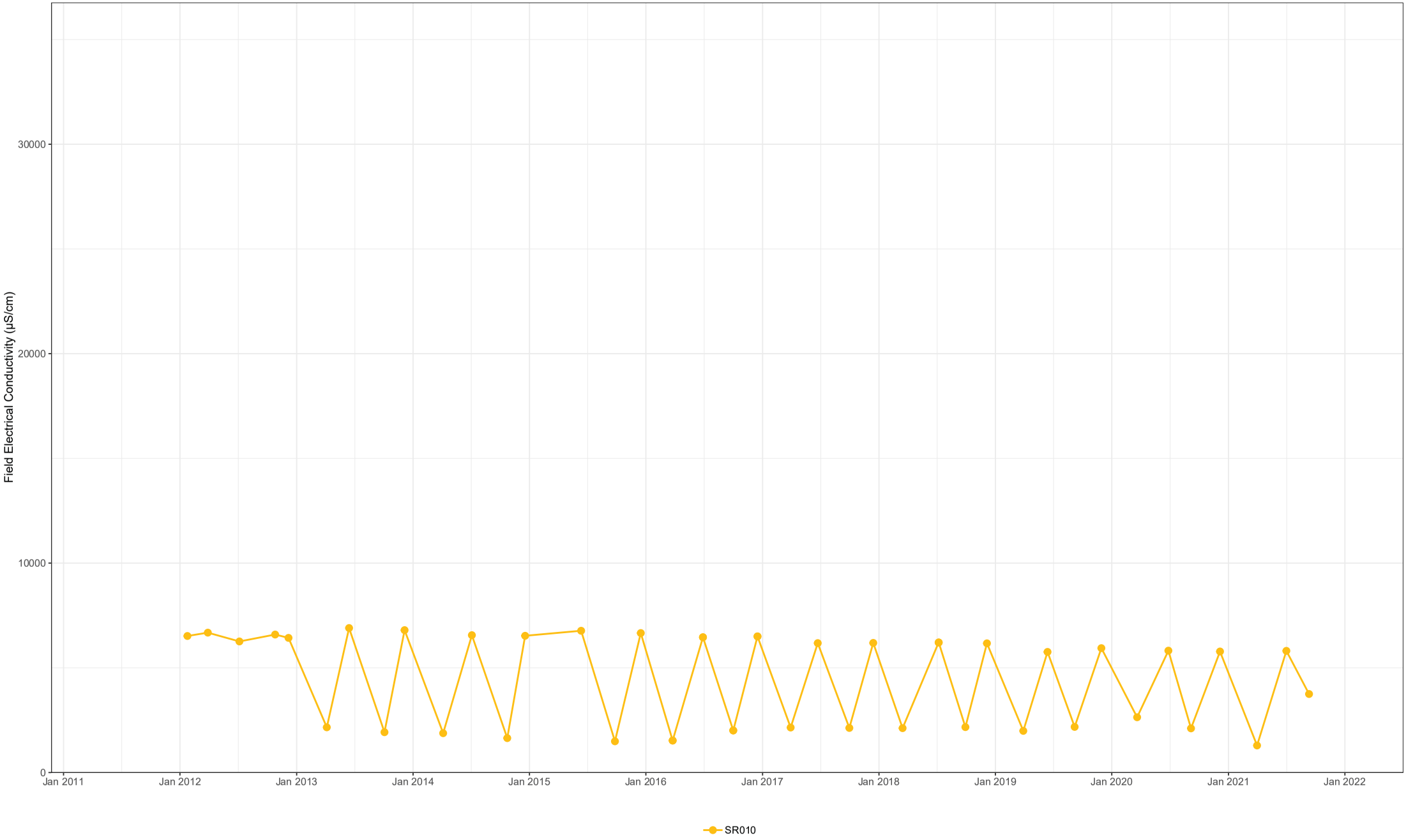
Notes

Southern − Overburden conglomerate and sandstone Field Electrical Conductivity (µS/cm)

Hunter Valley Operations

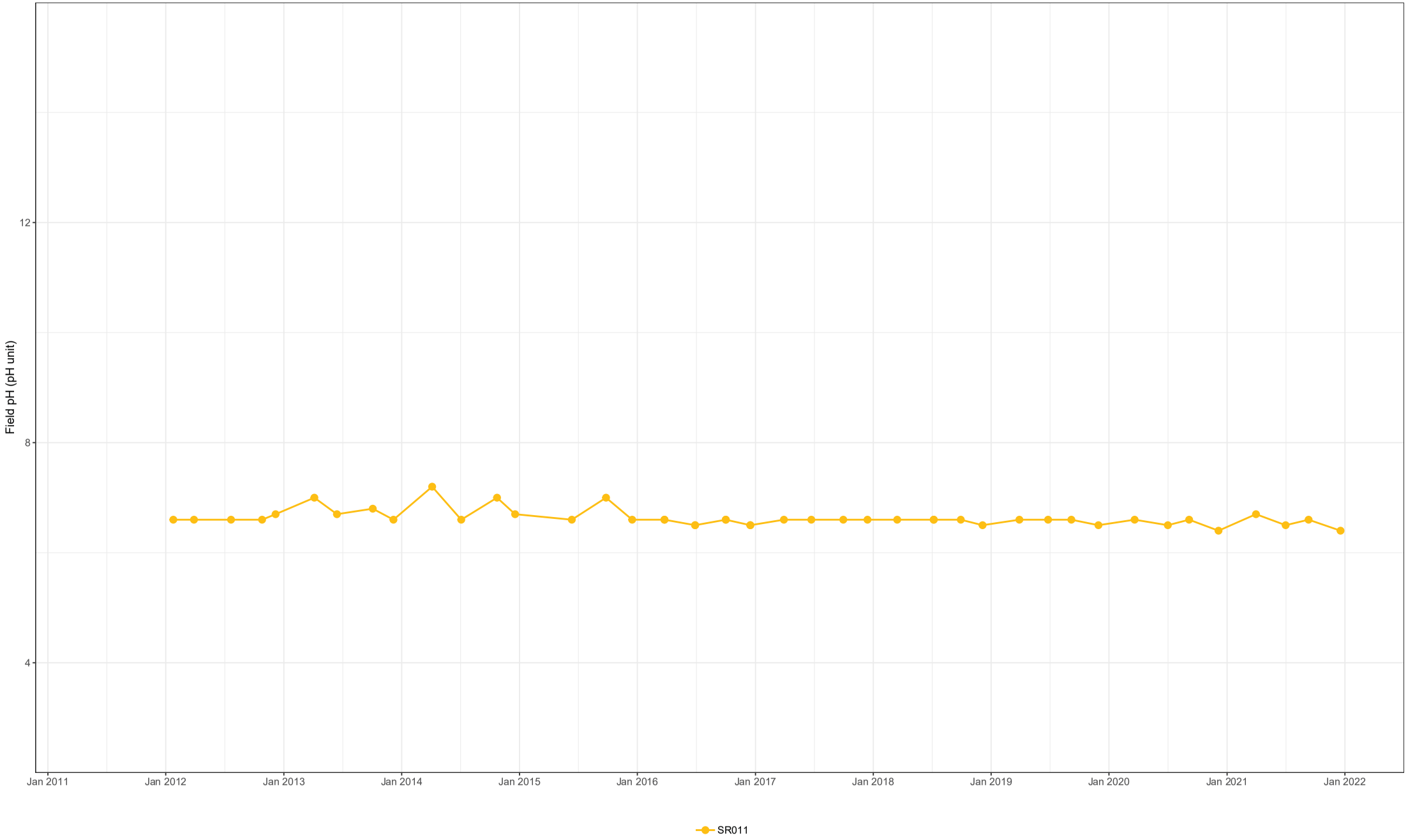
2021 Annual Groundwater Monitoring Review

Appendix C Figure 53



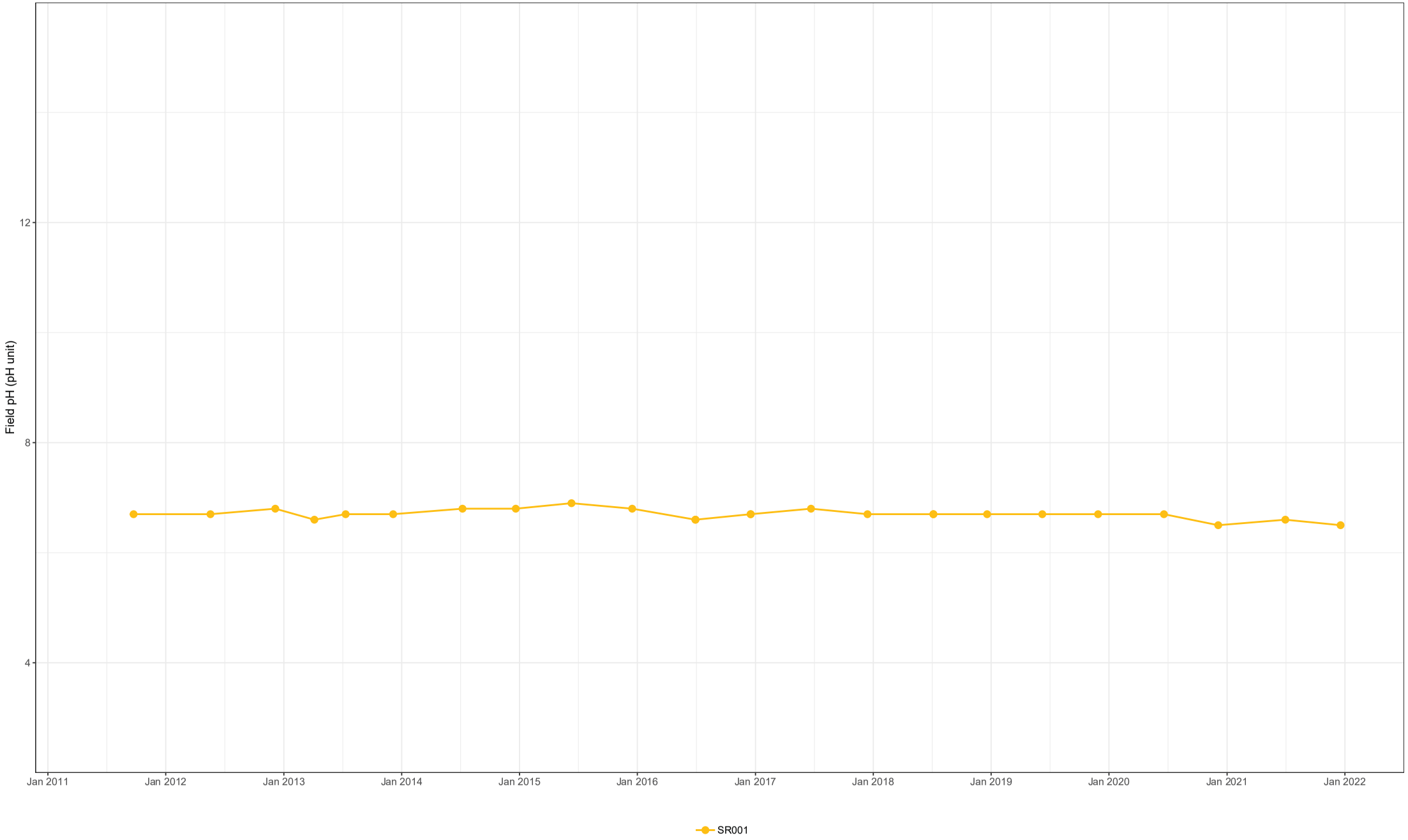
Notes

Southern − Conglomerate and Warkworth Seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 54



Notes

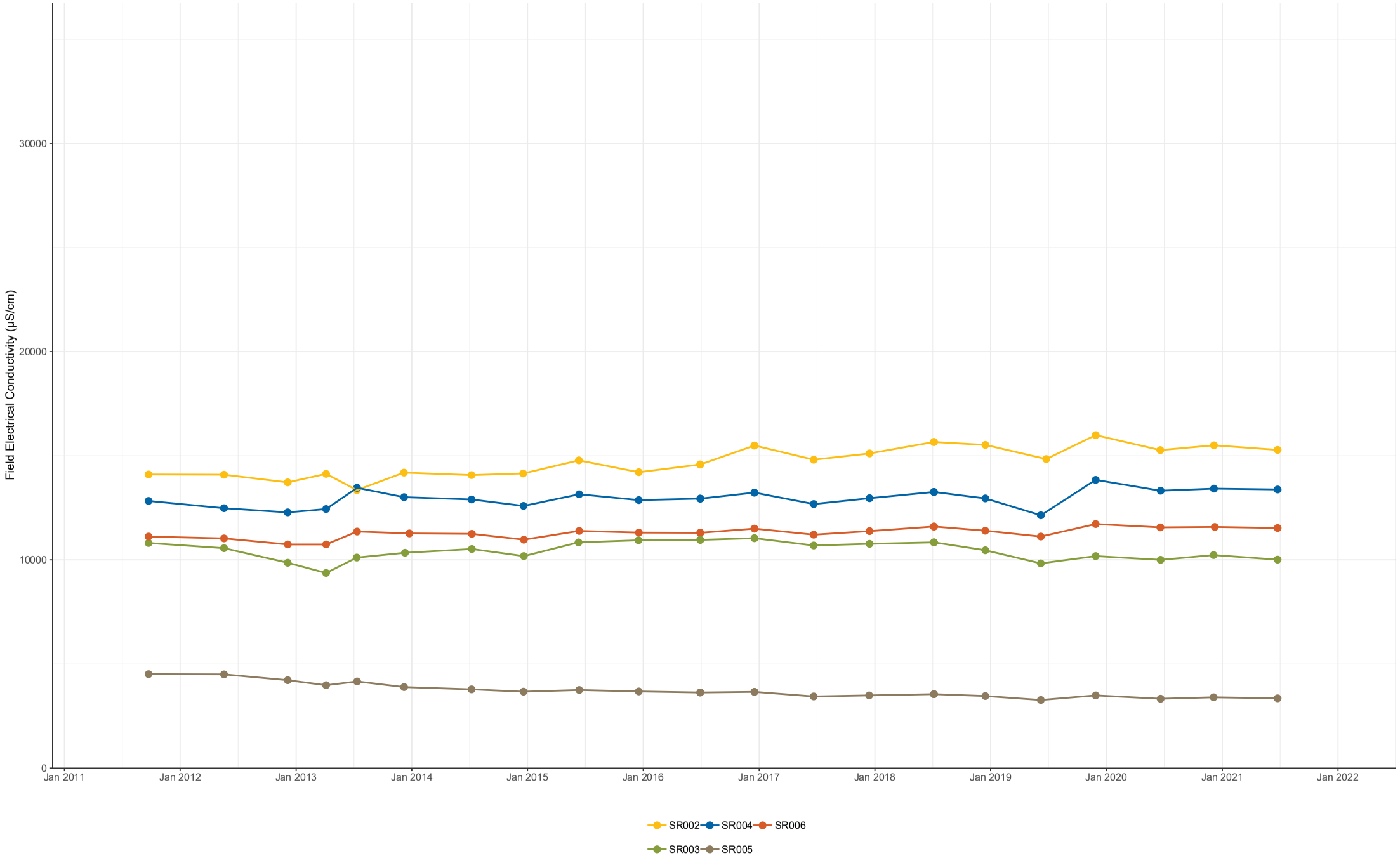
Southern − Mt Arthur Seam and underburden Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 55



EMM creating opportunities

Notes

Southern − Coal Seam Field pH (pH unit)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 56



Notes

Southern − Bayswater Seam Field Electrical Conductivity (µS/cm)
Hunter Valley Operations
2021 Annual Groundwater Monitoring Review
Appendix C Figure 57