REPORT

Ashton Coal Mine
Longwalls 205-208 Extraction Plan
Surface Water Technical Report

Prepared for: Ashton Coal Operations Pty Ltd

38a Nash Street
Rosalie QLD 4064
p (07) 3367 2388

PO Box 1575
Carindale QLD 4152
www.hecons.com
ABN 11 247 282 058

Revision	Description	Author	Reviewer	Approved	Date
a	Draft	CAW	TSM	TSM	26-Jun-20
b	Second draft	TSM	RS	TSM	30-Jun-20
c	Final	TSM	RS	TSM	10-Jul-20

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION AND BACKGROUND

1.1 PROJECT BACKGROUND

The Ashton Coal Project (ACP) is located in the Upper Hunter Valley of New South Wales (NSW), approximately 14 kilometres (km) north-west of Singleton, as shown in Figure 1. The site is operated by Ashton Coal Operations Pty Limited (ACOL); a wholly owned subsidiary of Yancoal Australia Limited (Yancoal).

The ACP comprises the following key components (ACOL, 2018a):

- An open cut pit (NEOC) that has been completed, with the final void remaining for the storage of coarse and fine reject;
- A four seam descending underground mine with approval to extract up to 5.45 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal;
- Surface mine infrastructure associated with the underground mine, including gas drainage bores, ventilation fans and mine dewatering infrastructure;
- A coal handling and preparation plant (CHPP) including rail siding and rail loading bin;
- Reject and tailings emplacements; and
- Administration, bathhouse and workshop buildings.

The underground mining operation comprises longwall mining of the Pikes Gully (PG), Upper Liddell (ULD), Upper Lower Liddell (ULLD) and Lower Barrett (LB) coal seams (in descending order). The general longwall layout consists of eight longwall panels in the PG seam (LW 1 to LW 8) and seven longwall panels in the ULD seam (LW 101 to LW 107). The PG seam was mined from 2006 to 2012 and the ULD seam from 2012 to 2017. Mining is currently being undertaken in the ULLD seam, with mining of LW 201 to LW 204 expected to be completed in April 2021. The longwall layout for the PG, ULD and ULLD seams are shown in Figure 2.

In May 2021, ACOL propose to commence mining of LW 205 to LW 208 in the ULLD seam. In accordance with Modification 6 (MOD6) to development consent DA 309-11-2001-i for the ACP, ACOL is required to prepare an Extraction Plan (EP) addressing secondary extraction of LW 205 to LW 208. In support of the EP, an assessment of the potential impacts to surface water resources from the proposed extraction of LW 205 to 208 is required.

1.2 PURPOSE AND SCOPE

Hydro Engineering & Consulting Pty Ltd (HEC) was commissioned by ACOL to prepare a Surface Water Technical Report (SWTR) necessary to support the EP for LW 205 to LW 208. The SWTR is specific to the EP Area associated with LW 205 to LW 208, as delineated in Figure 1.

The purpose of the SWTR is to describe the existing environment of the ACP and surrounding region, review the potential impacts associated with mining of LW 205 to LW 208 on surface water resources and surface water users and to provide recommendations of monitoring, mitigation and management strategies. In addition, previous assessments undertaken for the underground mining operations have been reviewed and the current predictions of potential surface water related impacts associated with mining of LW 205 to LW 208 have been assessed in comparison with previously predicted and approved impacts.

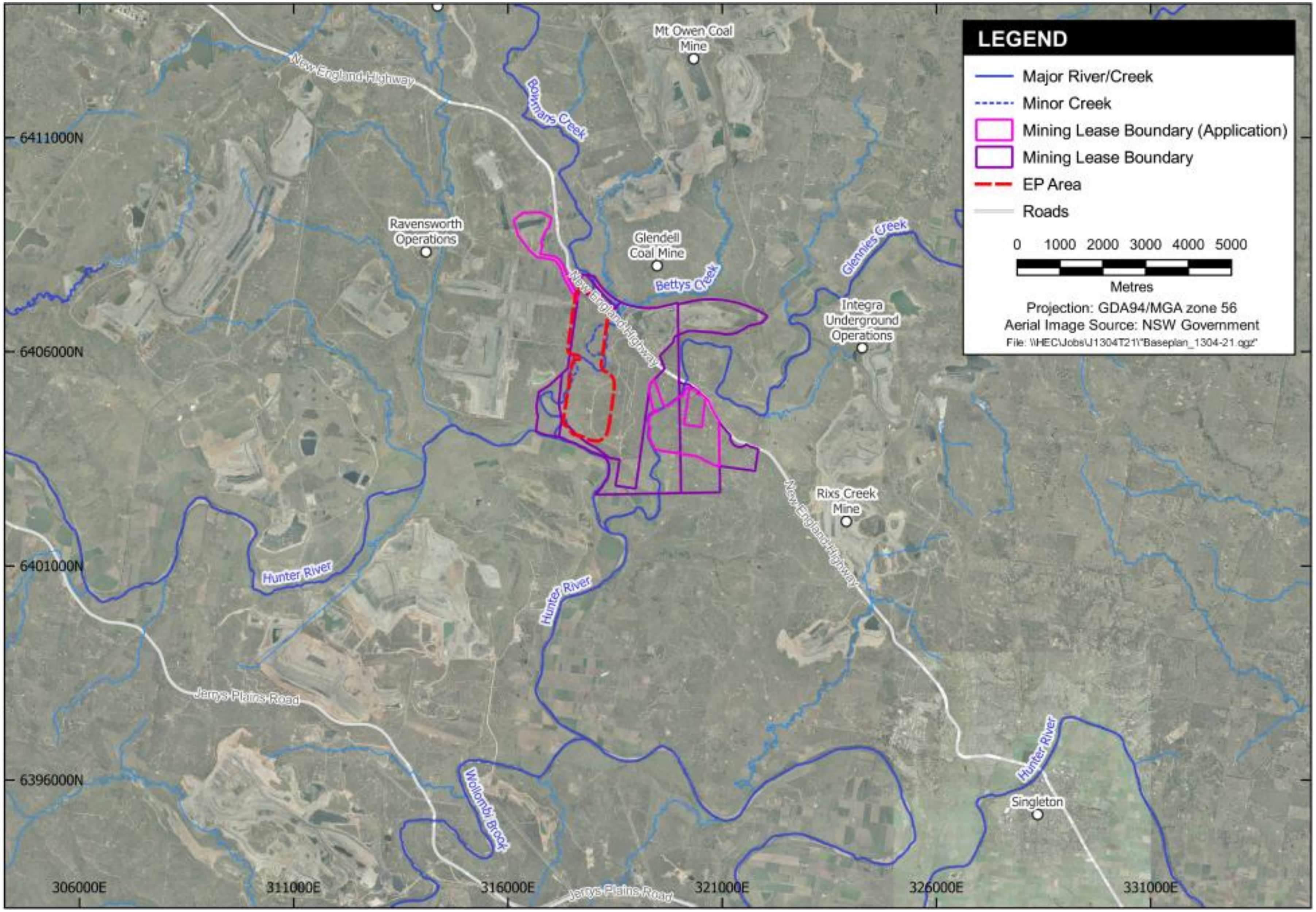

Figure 1 **Site Location Plan**

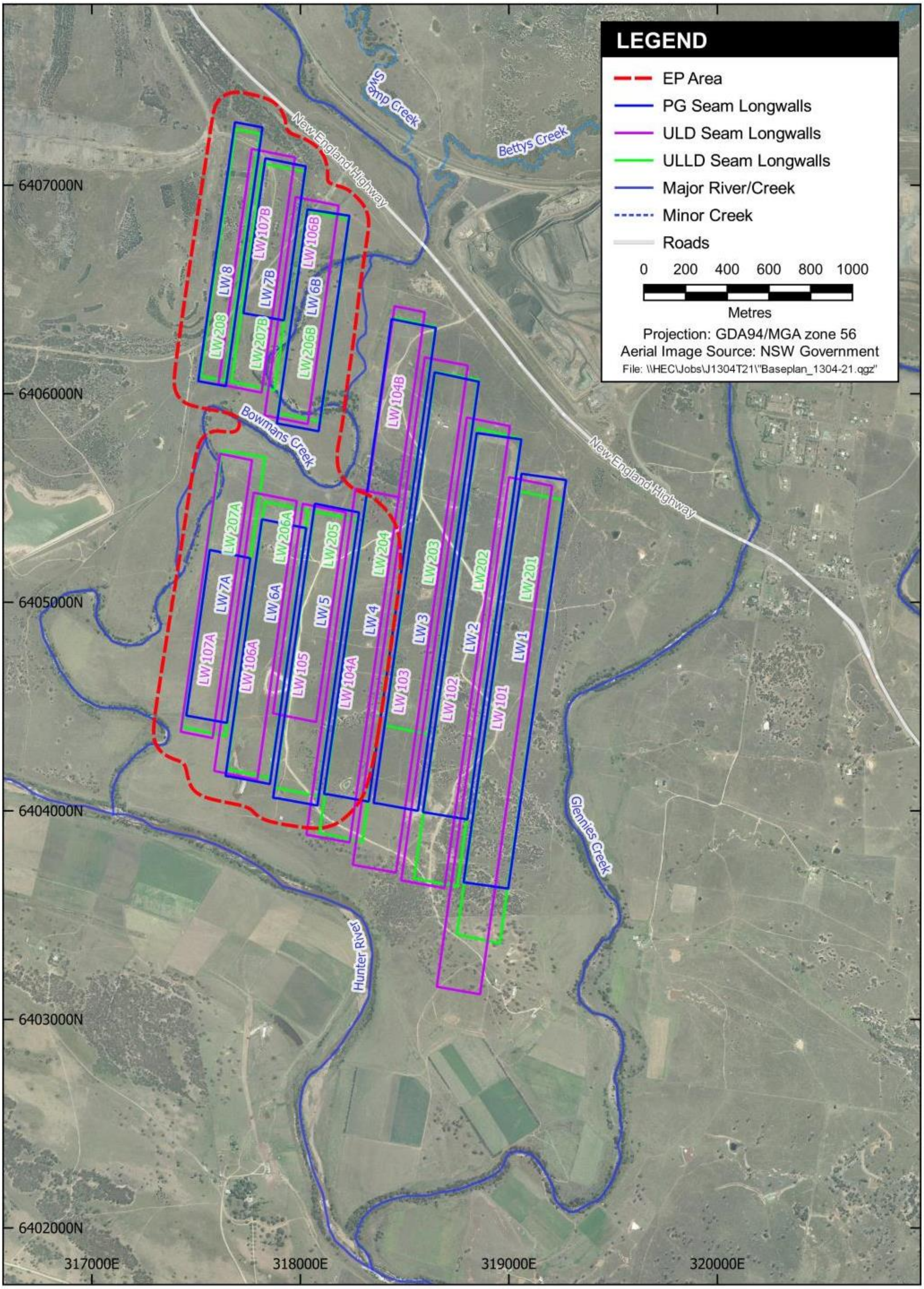

Figure 2 Longwall Layout Plan

2.0 STATUTORY REQUIREMENTS

2.1 RELEVANT REGULATION AND LEGISLATION

The SWTR has been prepared with consideration to the following NSW Government legislation, policies and guidelines for surface water:

- National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000).
- Australian and New Zealand Guidelines: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018).
- NSW Water Sharing Plan for the Hunter Regulated River Water Source 2004.
- NSW Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009.
- Water Management Act 2000 and Water Act 1912.

2.2 CONSENT CONDITIONS

In accordance with the Development Consent (DA No. 309-11-2001-i) Schedule 3, Condition 29, the Applicant must ensure that the development does not cause any exceedances of the performance measures relating to water listed in Table 1.

Table 1 Subsidence Impact Performance Measures – Watercourses

Watercourses	Performance Measures
Bowmans Creek	No greater subsidence impact or environmental consequences than predicted in the Environmental Assessment and the previous Environmental Impact Assessments.
Bowmans Creek – Eastern and Western Diversions	Hydraulically and geomorphologically stable.
Bowmans Creek alluvial aquifer	No greater subsidence impact or environmental consequences than predicted in the Environmental Assessment and the previous Environmental Impact Assessments.

2.3 WATER LICENSING

Entitlements for surface water and alluvial groundwater sources at the ACP are governed by the rules of the *Water Sharing Plan for the Hunter Regulated River Water Source 2004* and the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*, in accordance with the *Water Management Act 2000*. Non-alluvial groundwater licences are governed by the *Water Act 1912*.

Table 2 lists the water licences currently held by ACOL which amount to a combined total surface water and groundwater entitlement of 1,579.5 ML/year assuming full allocation. Groundwater seepage from the alluvial groundwater source and from the surface water source is also accounted for under these entitlements.

Table 2 Surface Water and Groundwater Licences

Licence	Category	Approved Extraction (ML/year)
Surface Water		
WAL 984 & WAL 15583	Glennies Creek (General Security)	363
WAL 997 & WAL 8404	Glennies Creek (High Security)	91
WAL 1358	Glennies Creek (Supplementary)	4
WAL 1121	Hunter River (General Security)	335
WAL 1120 & WAL 19510	Hunter River (High Security)	133
WAL 6346	Hunter River (Supplementary)	15.5
WAL 23912, WAL 36702 & WAL 36703	Bowmans Creek (Unregulated River)	280
Groundwater		
WAL 29566	Bowmans Creek (Aquifer Access)	358

3.0 EXISTING ENVIRONMENT

3.1 CLIMATE

The closest Bureau of Meteorology (BoM) rainfall station to the ACP with long-term rainfall records is located at Ravensworth (Hillview) Station No. (61028), located as shown in Figure 3. Data is available from 1911 to 1979 however contained periods of missing data. In order to provide a complete data set, the data gaps were infilled using the SILO Patched Point data system[1]. Table 3 provides a summary of the average monthly rainfall. Also shown is pan evaporation data which have been obtained for the station location from the SILO database.

Table 3 Average Monthly Rainfall and Evaporation

Month	Rainfall (mm)	Pan Evaporation (mm)
January	78	201
February	73	158
March	66	139
April	50	99
May	43	71
June	51	55
July	43	64
August	37	89
September	40	114
October	50	150
November	59	176
December	66	205
Annual Average	**656**	**1,522**

Note: Period of Data = January 1889 to May 2020 (inclusive).

The data summarised in Table 3 illustrates that rainfall tends to be higher in the summer months, peaking at an average of 78 mm in January. The long-term average annual rainfall was 656 mm. Average annual pan evaporation is more than two times greater than average annual rainfall in the vicinity of the ACP, with average pan evaporation exceeding average rainfall in all months.

Rainfall has also been recorded at the ACP by ACOL, with data available since September 2010. Table 4 presents a comparison of the Patched Point Data for Ravensworth (Hillview) and rainfall data recorded by ACOL at ACP, for the period January 2011 to December 2019.

---

[1] SILO is a database of Australian climate data from 1889 to the present. SILO uses mathematical interpolation techniques to infill gaps in existing rainfall data sets (Patched Point Data) and constructs spatial grids of data (Data Drill) across the continent. Refer https://www.longpaddock.qld.gov.au/silo/

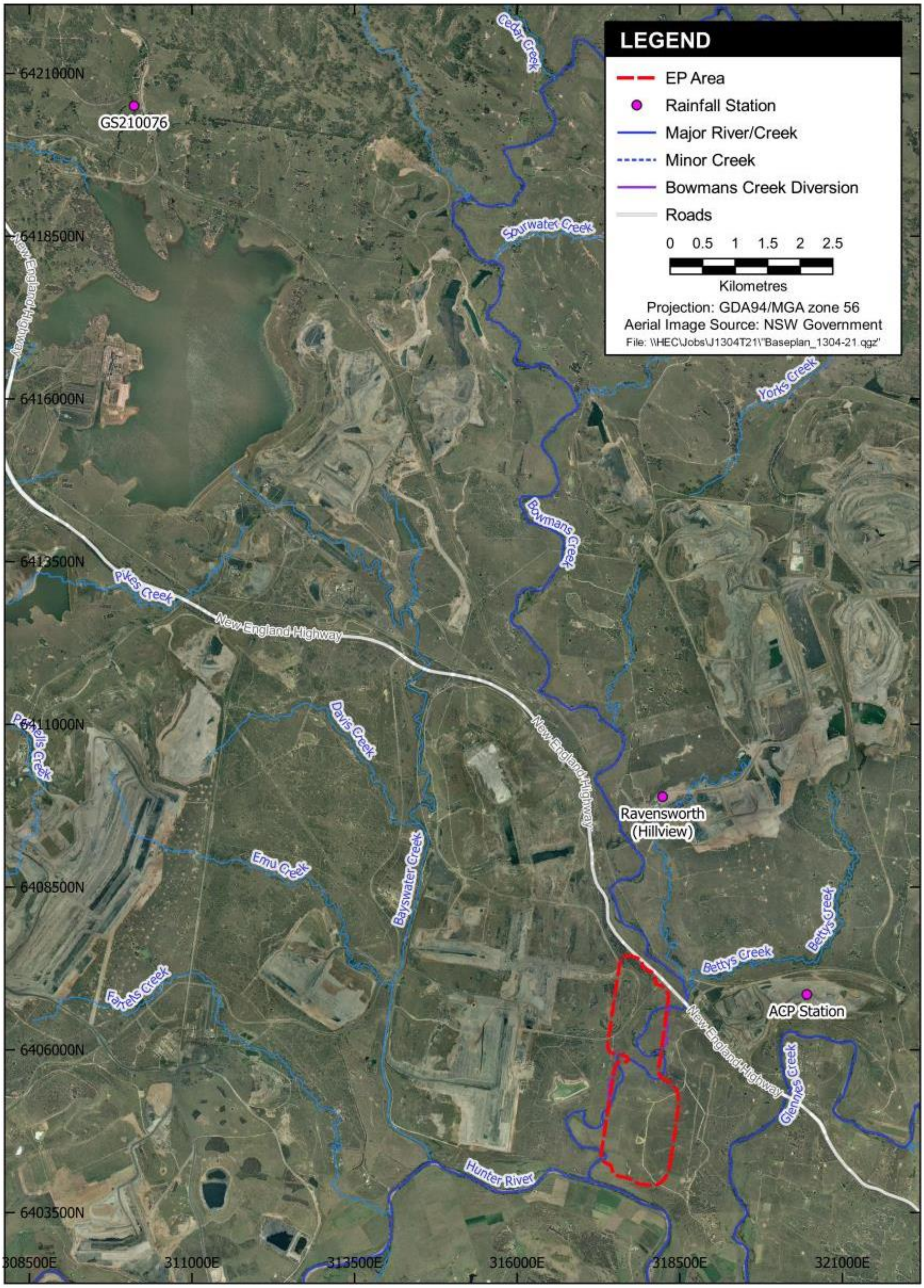

Figure 3 Location of Rainfall Stations

Table 4 Annual Rainfall – 2011 to 2019

Year	ACP Rainfall (mm)	Ravensworth (Hillview) Rainfall (mm)
2011	857	885
2012	493	589
2013	690	783
2014	700	611
2015	902	827
2016	754	684
2017	488	481
2018	535	457
2019	426	383
Annual Average	**649**	**633**

Table 4 illustrates that the annual rainfall recorded at the ACP was generally consistent with the Patched Point dataset for Ravensworth (Hillview) for the period 2011 to 2019. On average, annual rainfall recorded at the ACP was slightly higher (649 mm) than at Ravensworth (Hillview) (633 mm).

3.2 GEOLOGY AND GROUNDWATER

The ACP is situated within the Hunter Valley Coalfield of the Sydney Basin. The main stratigraphic units present at the ACP comprise quaternary alluvium and the Permian Wittingham Coal Measures. The quaternary alluvium ranges between 7 m and 15 m in thickness and is typically constrained to within 500 m of drainage lines associated with the Hunter River, Glennies Creek and Bowmans Creek floodplains (AGE, 2020). The quaternary alluvium comprises two main types: a coarser grained permeable alluvium and a fine grained low permeability colluvium.

Key units associated with the Wittingham Coal Measures comprise (from youngest to oldest) a regolith/weathered profile, a conglomerate profile (Lemington Conglomerate) and the four target coal seams (PG, ULD, ULLD and LB). The coal seams are separated by approximately 30 m of interburden comprising units of siltstone, sandstone and shale. The Wittingham Coal Measures dip west south-west in the ACP area with the PG seam subcropping under the Glennies Creek alluvium approximately 300 m to the east of the mine (AGE, 2020). The lowest target seam (LB) subcrops under regolith approximately 2 km to the east of the ACP. In the western portion of the ACP, the overburden above the PG seam ranges in thickness between 100 m (north end of LW 7) and 190 m (south end of LW 7).

Groundwater is present within the quaternary alluvium and the Wittingham Coal Measures; with regional groundwater flow occurring in a west south-west direction. In the ACP area, groundwater recharge occurs primarily via rainfall infiltration to the alluvium, direct infiltration to outcropping coal measures and indirect infiltration from the alluvium to the subcrop of the coal measures (AGE, 2020).

3.3 LANDFORM

The landform of the EP Area comprises alluvial floodplains with drainage occurring predominately west towards Bowmans Creek. Natural and subsidence related depressions are present in the current landform of the floodplain and a number of minor farm dams are located on drainage lines (SCT, 2020). Two natural ponds (billabongs) are located adjacent to the excised (diverted) reach of Bowmans Creek in the north and a large natural pond (billabong) in the south of EP Area was converted to a dam prior to mining. Overflow from the dam reports to the Hunter River (SCT, 2020).

3.4 SURFACE WATER RESOURCES

The ACP is located in the Hunter River catchment and is bounded by three main surface water features: Bowmans Creek to the west, Glennies Creek to the east and the Hunter River to the south (refer Figure 4).

3.4.1 Bowmans Creek

Bowmans Creek rises in the foothills of the Mount Royal Range and flows in a south-southwesterly direction before joining with the Hunter River near the southern boundary of the ACP mine lease area. Bowmans Creek has a catchment area of approximately 245 square kilometres (km^2) to the New England Highway at the northern boundary of the proposed LW 205. The northern portion of the catchment is predominately cleared pastoral land, with the Ravensworth State Forest located in the central portion of the catchment. In the southern portion of the catchment, coal mining operations have been developed, including the Glencore Mt Owen Glendell and Liddell operations. The creek is predominately perennial, although during extended low rainfall periods the creek is noted to cease flowing in some reaches, forming a series of disconnected pools (RPS, 2015) – refer also Section 5.2.

From the New England Highway to the Hunter River, the creek flows south-southwest traversing the ACP underground mine area. In this section, the channel is incised 2 – 5 m below the surrounding topography and comprises a series of ponds predominately controlled by vegetated cobble bars (RPS, 2015). Several minor ephemeral drainage lines are present within the EP Area and flow mainly into Bowmans Creek. Licensed discharge periodically occurs from Ravensworth Coal operations' Narama Dam to a small gully which flows into the lower reaches of Bowmans Creek.

The construction of two diversion structures on Bowmans Creek, named the Eastern and Western Diversions (refer Figure 4), were completed by ACOL in early 2013. The diversion structures were developed to mitigate the impact on flow in Bowmans Creek resulting from subsidence-induced connective cracking and associated drainage of the alluvium (Fluvial Systems, 2009). The diversion structures were designed to replicate the adjacent section of the creek with respect to channel cross section and slope. Block banks were constructed to divert water into the diversion channels and to prevent backwater flooding of the excised section of the existing creek channel. The block banks were designed so that flows in the diversion channel would overtop the block banks in a 1 in 5 year Average Recurrence Interval (ARI) flood event (approximately equal to a 20% Annual Exceedance Probability [AEP]) and enter the excised sections of the creek (Fluvial Systems, 2009).

Bowmans Creek is located within the Jerrys Management Zone of Jerrys Water Source and is legislated by the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*. In the 2019/2020 period (financial year), the total share component of unregulated river licences was 2,097 units/ML (WaterNSW, 2020a).

3.4.2 Glennies Creek

Glennies Creek has a catchment area of approximately 512 km^2 from its headwaters in the Mount Royal National Park to the confluence with the Hunter River just south of the EP Area. Approximately 225 km^2 of the catchment reports to Glennies Creek Dam (Lake St Clair); a regulated storage used to supply water for irrigation, environmental flows, industry and households in the Hunter Valley (WaterNSW, 2020b). Flow in Glennies Creek near the ACP is perennial with flow regulated by release from Glennies Creek Dam. Glennies Creek is located outside of the EP Area.

The section of Glennies Creek adjacent to the EP Area is located within Management Zone 3A (Glennies Creek) of the *Water Sharing Plan for the Hunter Regulated River Water Source 2016*.

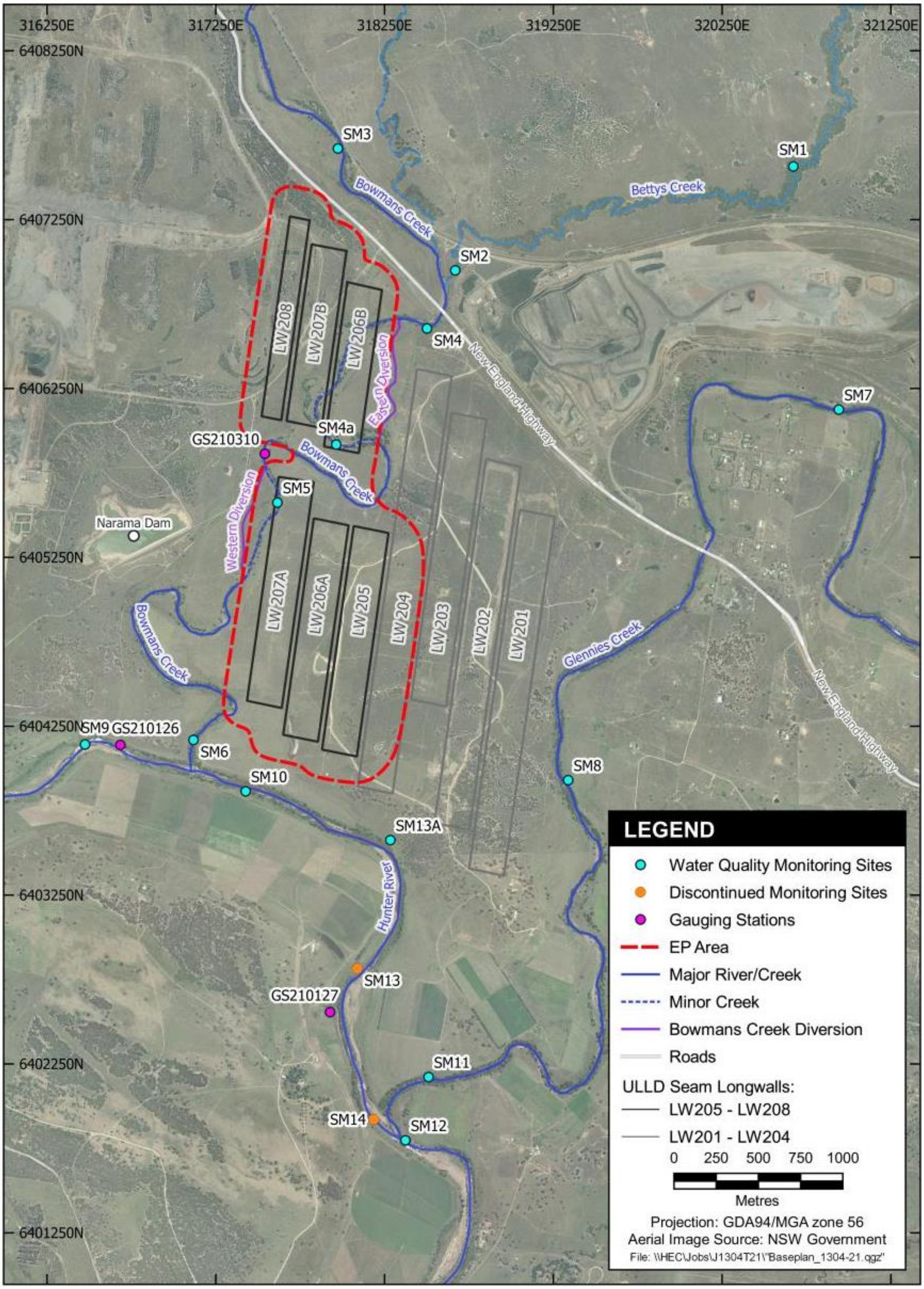

Figure 4 Surface Water Monitoring Sites

3.4.3 Hunter River

The Hunter River flows west to east adjacent to the southern boundary of the EP Area. The southern edge of the proposed LW 205 is approximately 350 m from the Hunter River at its closest point. The Hunter River downstream of the EP Area to the confluence with Glennies Creek is located within Management Zone 1B (Hunter River from Goulburn River Junction to Glennies Creek Junction) of the *Water Sharing Plan for the Hunter Regulated River Water Source 2016*.

4.0 PREVIOUS IMPACT ASSESSMENTS

4.1 INTRODUCTION

Two impact assessments have been previously undertaken for the ACP as part of the approval process for the underground and open cut mines – the ACP Environmental Impact Statement (ACP EIS; HLA, 2001) and the Bowmans Creek Diversion Environmental Assessment (BCD EA; Evans & Peck, 2009). Additionally, an EP was prepared for LW 1 – 8 in the ULD seam (ACOL and AECOM, 2012), LW 105 – 107 in the ULD seam (ACOL and SLR, 2015) and LW 201 – 204 in the ULLD seam (ACOL, 2016a).

Over this period, extensive monitoring was undertaken and site-specific information was obtained pertaining to subsidence behaviour and overburden characteristics. Changes in predicted mining influences on the groundwater and surface water system reflected the improved understanding of multi-seam subsidence behaviour at the underground since the ACP was approved, changes to the mining plan layout and variations in seam thickness or proposed mining heights (SCT, 2020).

4.2 SUBSIDENCE PREDICTIONS

The previous subsidence impact assessments undertaken for the ACP are detailed in SCT (2020). Table 5 presents a summary of the previously predicted subsidence, maximum tilt and maximum strain associated with mining of the various seams (SCT, 2020).

Table 5 Previously Predicted Subsidence Impacts

Assessment	Maximum Subsidence (m)	Maximum Tilt (mm/m)	Maximum Strain (mm/m)
ACP EIS (2001)	4.2^	123**	25†
BCD EA (2009) – PG, ULD & ULLD	5.8	240	110
LW 1 – 8 ULD EP (2012) – PG & ULD	4.5	132	53
LW 105 – 107 EP (2015) – PG & ULD	4.0	213	107

^ Maximum cumulative subsidence predicted (for LW 5 in ULLD Seam); ** maximum incremental tilt predicted (for LW 1 in PG seam); † maximum incremental strain predicted (for LW 1 in PG seam).

For the BCD EA, which included potential subsidence related effects associated with mining of the PG, ULD and ULLD seams, the maximum subsidence was predicted at 5.8 m, maximum tilt at 240 mm/m and maximum strain at 110 mm/m (SCT, 2009).

Subsidence from mining LW 201 to LW 204 in the ULLD seam was expected to result in additional incremental subsidence of up to 2.7 m (SCT, 2016). Consistent with the BCD EA, the total cumulative subsidence was expected to be up to 5.8 m in the central part of areas where there is overlap between longwall panels in three seams (SCT, 2016).

4.3 SURFACE WATER ASSESSMENT

Previous assessments of the potential for mining impacts on surface water resources of the ACP have focussed on the potential impacts to hydrology and geomorphology, specifically relating to the Bowmans Creek diversions and mining induced subsidence affects.

As documented in the BCD EA (Evans & Peck, 2009), modelling of flood conditions within the ACP area indicated that the diversion structures would generally contain Bowmans Creek flows for a 1 in 5 year ARI event (approximately a 20% AEP), with flood levels and velocities similar to existing conditions. In a 1% AEP flood event, the combined conveyance capacity of the Eastern Diversion channel and the existing channel was expected to provide increased attenuation of peak flows discharging to the Hunter River and thereby have no adverse impacts on flood levels downstream.

Subsidence impacts were predicted to introduce pondage areas that would result in storage of flow from local tributaries in smaller, more frequent events and attenuate peak flows entering the Hunter River in larger events including the 5% and 1% AEP. Filling and drainage works were proposed to be undertaken in order to maintain a free draining landscape within areas of subsidence (Evans & Peck, 2009).

The Eastern and Western Diversions were designed to reduce the risk of excessive geomorphic instability through the incorporation of rock grade control structures, rock bars, rock breaching, soft treatments (such as jute matting) and a thicker channel bed sediment layer where local scour holes were expected to form (Fluvial Systems, 2009). Fluvial Systems (2011) proposed that the revised subsidence predictions for ULD LW 101 to LW 108 were not expected to pose implications for fluvial geomorphological processes in Bowmans Creek or Glennies Creek and no perceptible impacts to Bowmans Creek were expected to occur as a result of mining ULLD LW 201 to LW 204 (SCT, 2016). Vegetation has established successfully throughout the diversions – refer Photo 1.

Photo 1 Eastern Diversion Looking Downstream

Previous subsidence impact assessments predicted the potential for occurrence of subsidence induced surface cracking above and surrounding the Ashton underground workings with potential for surface water-groundwater connectivity (AGE, 2020). However, while the underlying Permian strata have been depressurised due to the effects of subsidence, there has been no record to date of significant impacts to the alluvium water levels, during and post mining at the ACP (AGE, 2020).

A surface inspection survey identified that some areas of ponding created by subsidence impacts associated with mining of the PG and ULD seams were resulting in a modification of habitat and land use to create wetland habitat (SCT, 2016). SCT (2016) proposed a range of options for improving the drainage characteristics in these areas including construction of channels and diversion of overland flows away from areas of potential ponding. Some additional areas of potential ponding were predicted to occur after mining of LW 201 to LW 204 in the ULLD (SCT, 2016). A continuation of the current practices of reshaping the surface after subsidence and construction of drainage channels generally along the natural drainage lines to Bowmans Creek was recommended to manage further impacts relating to subsidence induced ponding (SCT, 2016).

4.4 GROUNDWATER ASSESSMENT

Table 6 presents the previously predicted groundwater impacts detailed in the BCD EA and ACP EIS and summarised in AGE (2020). The predictions considered mining of all seams at the ACP to the end of the mine life.

Table 6 Previously Predicted Groundwater Impacts

Potential Impact	Location	BCD EA (at end of mine life)	ACP EIS (at end of mine life)
Drawdown	Bowmans Creek Alluvium	< 3 m	No significant drawdown
	Glennies Creek Alluvium	< 2 m	2.5 m
	Hunter River Alluvium	< 1 m	No significant drawdown
Stream baseflow loss	Bowmans Creek	0.13 ML/d	0.4 – 1.4 ML/d
	Glennies Creek	0.23 ML/d	0.6 ML/d
	Hunter River	0.06 ML/d	0.3 ML/d
Salinity	Bowmans Creek	Likely decrease in salinity	Maximum increase of 70 µS/cm EC attributable to mining related impacts
	Glennies Creek		Similar quality to pre-mining
	Hunter River		N/A

Prior to mining influences, Bowmans Creek was, on average, a ‘gaining’ stream where groundwater from the alluvium and Permian formations discharged to the creek. The impacts on groundwater baseflows to Bowmans Creek were predicted to change Bowmans Creek from a ‘gaining’ stream to a ‘losing’ stream, where water from the creek infiltrated to the alluvium and/or Permian formations (Evans & Peck, 2009). The groundwater impact assessment for the BCD EA predicted a loss of 0.13 ML/d of streamflow from Bowmans Creek, 0.23 ML/d from Glennies Creek and 0.06 ML/d from the Hunter River after mining of the Lower Barrett seam at the ACP (Evans & Peck, 2009).

AGE (2016) revised the numerical groundwater flow model for prediction of impacts associated with mining of LW 201 to LW 204, with particular focus applied to the alluvium and its interaction with the regolith and shallow coal seams. The variance in the predictions presented in AGE (2016), as compared with the previous assessments, was primarily due to the improved capability of the model to simulate and represent the seam subcrop / alluvium interaction.

For the LW 201 to LW 204 EP, AGE (2016) estimated that the average baseflow gain rate in the modelled area of Bowmans Creek, assuming no mining at the ACP was 0.48 ML/d, declining to 0.42 ML/d at the end of mining of LW 204 (a cumulative reduction in baseflow of 0.06 ML/d). The baseflow gain rate in the modelled area of the Hunter River was estimated at an average of 0.53 ML/d assuming no mining at the ACP and decreasing to 0.505 ML/d at the end of mining LW 204. For Glennies Creek, the baseflow gain rate was estimated to be an average of 0.62 ML/d assuming no mining at the ACP and 0.57 ML/d following mining of LW 204 (AGE, 2016). The total mine inflows were predicted to increase from approximately 402 ML/year to 420 ML/year following mining of LW 204 which was within the limits of previous predictions and approved impacts (AGE, 2016). Note that calibration of the ACP water balance model by HEC has indicated that forecast groundwater inflow rates are approximately 1.8 times higher than indicated by recorded dewatering volumes.

At the time of preparation of the LW 201 – LW 204 EP, mining related impacts on groundwater quality had not been observed (AGE, 2016). Risks to water quality, including acid forming potential and heavy metal precipitation, were not predicted to be a potential issue associated with mining at the ACP, although a slight increase in salinity was initially predicted (HLA, 2001). Based on the improved conceptual understanding of the groundwater system and modelled directions of groundwater flow, more recent impact assessments predicted that salinity concentrations were expected to decrease.

5.0 SURFACE WATER MONITORING

5.1 BACKGROUND

Surface water monitoring for the ACP is undertaken in accordance with the Water Management Plan (WMP; ACOL, 2018a). As Bowmans Creek overlies the underground mining area and may potentially be impacted by mining activities at the ACP, review of streamflow monitoring data for Bowmans Creek is undertaken by ACOL. Streamflow gauging station GS 210310 on Bowmans Creek, maintained by WaterNSW, is located between the Eastern and Western Diversions, as shown in Figure 4. Two additional streamflow gauging stations are located on the Hunter River near the ACP.

Any effects on streamflow in the Hunter River downstream of the ACP are likely to be indiscernible in relation to the effect of releases from Glenbawn Dam the effect of inflow from the large upstream catchment, licensed extraction from and discharge to the Hunter River. Similarly, streamflow monitoring in Glennies Creek adjacent to the ACP is obviated by the effects of regulated flow releases from Glennies Creek Dam and licensed extraction (ACOL, 2018a).

Water quality monitoring is undertaken by ACOL at sites on Bowmans Creek, Glennies Creek and the Hunter River, as shown in Figure 4. Water quality monitoring commenced in 2003 with the baseline monitoring period extending to late 2011.

A summary of the surface water monitoring program is presented in Table 7.

Table 7 Surface Water Monitoring Program

Watercourse	Monitoring Site	Parameters	Frequency
Bowmans Creek	SM3, SM4, SM4A, SM5, SM6	Field measurements of pH, EC, TSS, TDS, flow (qualitative)‡	Monthly
		Laboratory suite†	Annual
Glennies Creek	SM7, SM8, SM11	Field measurements of pH, EC, TSS, TDS, flow (qualitative)‡	Monthly
		Laboratory suite†	Annual
Hunter River	SM9, SM10, SM12, SM13A#, SM14*	Field measurements of pH, EC, TSS, TDS, flow (qualitative)‡	Monthly
		Laboratory suite†	Annual

EC: electrical conductivity; TSS: total suspended solids; TDS: total dissolved solids

‡ Qualitative flow assessment at the time and location of sampling involves the designation of either zero flow (i.e. a stagnant pool), trickle, low, moderate or high flow.

† Total hardness, oil and grease, turbidity, calcium, magnesium, sodium, potassium, chloride, sulphate, bicarbonate, carbonate, aluminium, arsenic, cadmium, chromium, copper, iron, lead, manganese, silver, nickel, selenium, ammonia, nitrogen oxide, fluoride.

Monitoring at site SM13A commenced in March 2018. Prior to this date, site SM13 was in operation approximately 850 m downstream of SM13. The baseline monitoring data adopted for determination of impact assessment criteria for SM13 and SM13A comprised data recorded prior to the start of 2012 at SM13.

* Monitoring at site SM14 ceased in February 2018.

5.2 STREAMFLOW MONITORING

5.2.1 Streamflow Impact Assessment Criteria

Specific streamflow impact assessment criteria have not been developed for the ACP reach of Bowmans Creek, rather, a potential reduction in baseflow is assessed through monitoring of groundwater drawdown in the alluvium where drawdown that is greater than predicted may indicate a baseflow impact that is greater than predicted (ACOL, 2018a).

The streamflow monitoring data for gauging station GS 210310 on Bowmans Creek is reviewed by ACOL in order to assess potential impacts of the ACP on streamflow in Bowmans Creek. It should be noted that Bowmans Creek and some of its tributaries flow past, and in some cases have been diverted around, other coal mining operations upstream of the ACP.

5.2.2 Streamflow Assessment

Streamflow monitoring data for GS 210310 on Bowmans Creek is available for the period October 1993 to May 2020 and daily recorded flow rate is plotted in Figure 5 in comparison with the cumulative rainfall residual for the corresponding period. The rainfall data utilised for this assessment was taken mainly from the daily record at the WaterNSW station GS 210076 on Antiene Creek at Liddell (refer Figure 3) as this station is the closest to the Bowmans Creek catchment centroid (data gaps were infilled using the SILO Data Drill – refer Section 3.1). The cumulative rainfall residual is calculated as the cumulative deviation from the mean daily rainfall where positive (upward) residual slopes indicate periods of above average rainfall and negative (downward) slopes indicate periods of below average rainfall.

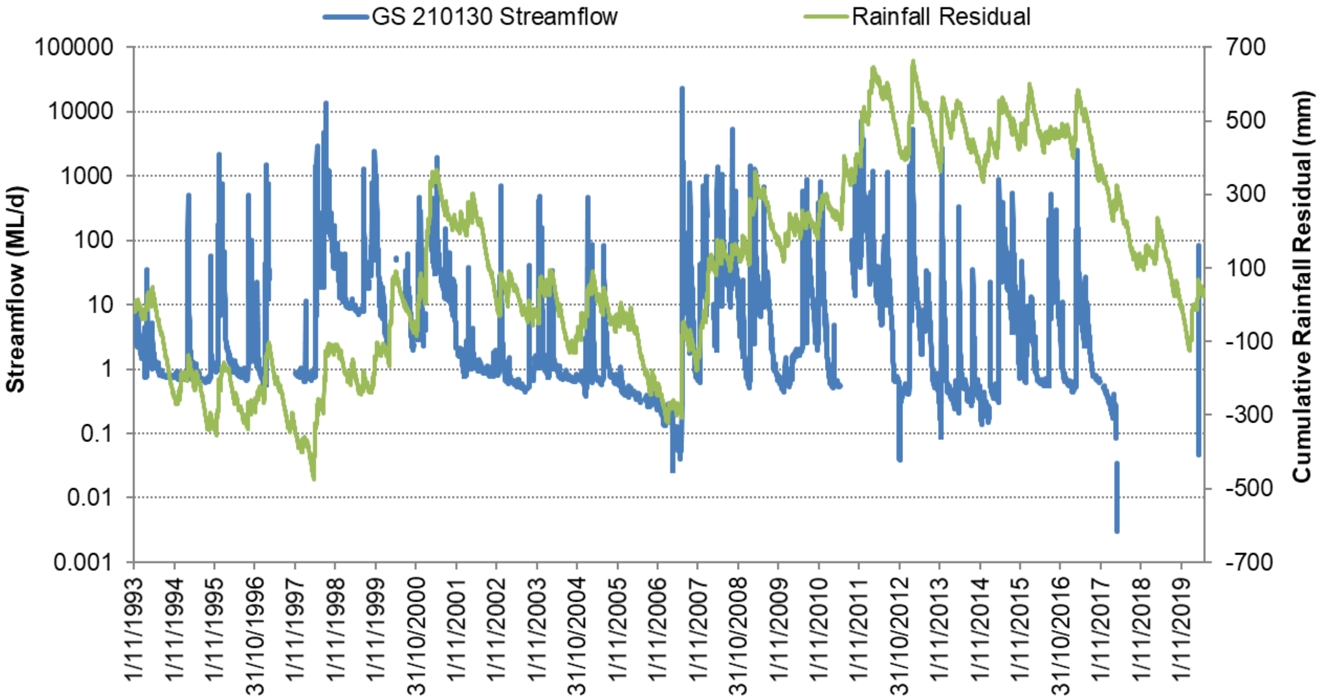

Figure 5 GS 210130 Streamflow and Rainfall Residual

Gaps in the streamflow records prior to 2017 are inferred to represent periods of loss of data rather than no flow whereas the data gap between March 2018 and April 2020 and from April to June 2020 represents a period of no flow. The no flow period between March 2018 and April 2020 corresponds with a substantial and steep decline in the cumulative rainfall residual commencing in April 2017 and continuing to mid-January 2020. The data presented in Figure 5 illustrates that the rainfall decline between March 2018 and April 2020 was the most extreme and prolonged period of below average rainfall that occurred during the streamflow monitoring period.

Figure 6 presents the cumulative deviation from the average daily streamflow (43 ML/d) for the period of record in comparison with the cumulative rainfall residual. Figure 6 illustrates that recorded streamflow in Bowmans Creek at GS 210130 is highly responsive to rainfall patterns with steep recessions in streamflow residual during periods of below average rainfall and short, sharp rises in streamflow during periods of above average rainfall. During mining of the PG seam (also indicated on Figure 6), a generally increasing trend in streamflow residual occurred, predominantely due to two large rainfall events in June/July 2007 and November 2011 to January 2012. During mining of the ULD seam, the streamflow residual generally declined due to fluctuating rainfall around the average. A steep and prolonged decline in streamflow residual between March 2017 and June 2020 is evident, corresponding with the significant decline in rainfall during the same period.

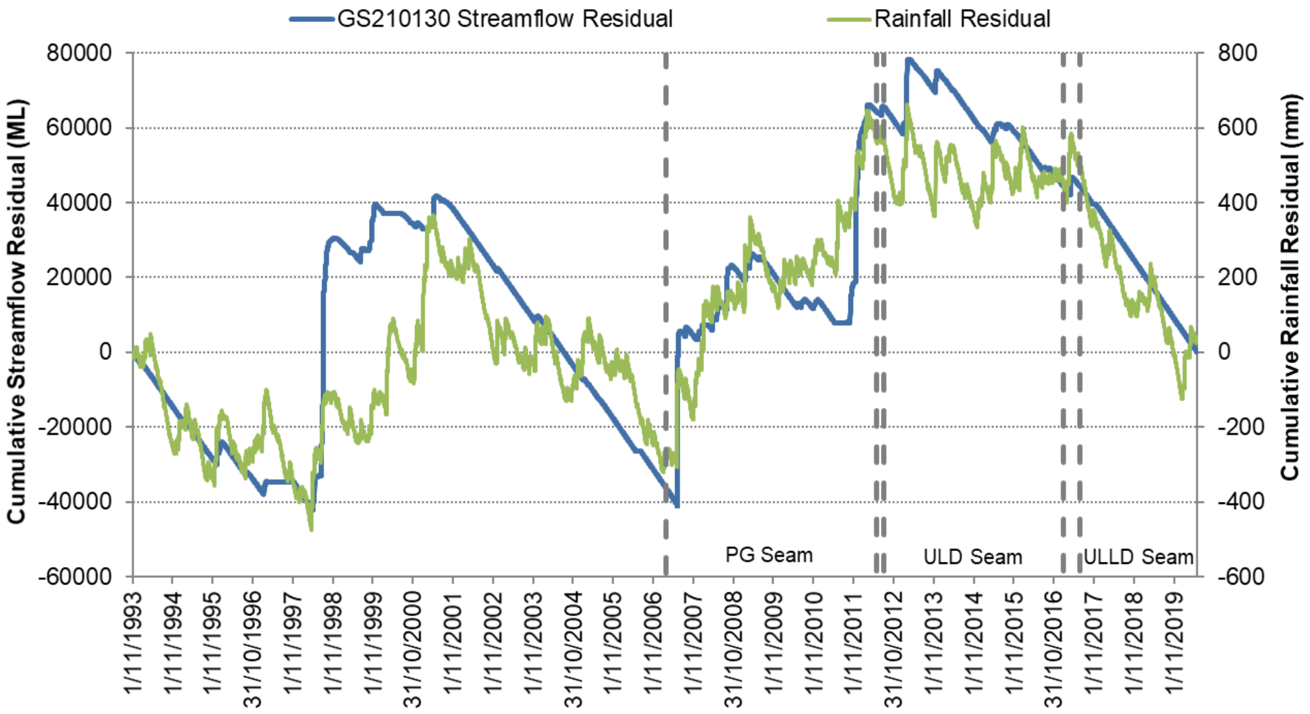

Figure 6 **Streamflow and Rainfall Residual**

The slope of the streamflow residual between March 2017 and June 2020 is equivalent to the slope of the streamflow residual from September 2001 to June 2007, prior to the commencement of longwall mining at the ACP. The streamflow and rainfall residual mass presented in Figure 6 indicates that there is no apparent evidence of an increased decline in streamflow at GS 210130 on Bowmans Creek since commencement of underground mining operations at the ACP and, as such, mining operations appear to have had no discernible impact on streamflow in Bowmans Creek.

This is also supported by AGE (2020) who stated that surface water bodies in the ACP area, including agricultural dams, have not shown subsidence-related water loss. The trends in monitored alluvium water level are consistent with trends in the cumulative rainfall residual and no correlation has been found between rainfall and changes in groundwater abstraction rates from the underground (AGE, 2020).

5.3 SURFACE WATER QUALITY MONITORING

5.3.1 Water Quality Impact Assessment Criteria

Surface water quality impact assessment criteria have been developed for each monitoring site on Bowmans Creek, Glennies Creek and the Hunter River which, if triggered, would lead to further investigation (ACOL, 2018a). Table 8 presents a summary of the impact assessment criteria.

Table 8 Surface Water Quality Impact Assessment Criteria

Parameter	Trigger
pH EC TSS TDS	*Either* If recorded value at a monitoring site is greater than the x^th^ percentile of baseline data for 3 consecutive readings or, for pH, less than the y^th^ percentile of baseline data for 3 consecutive readings, where: x = 80 during periods of flow; 95 during periods of no, trickle or low flow y = 20 during periods of flow; 5 during periods of no, trickle or low flow *Or* If a recorded value at a monitoring site differs extremely from the preceding 3 readings at that location and there are no unusual events that could have caused the difference.

5.3.2 Water Quality Assessment

Plots of the water quality monitoring data recorded in the vicinity of the underground mining operations at the ACP are presented in Appendix A. For reference, the impact assessment criteria for each site and the date of commencement of secondary extraction of each longwall are also presented. The following sections summarise the water quality records for the period of longwall mining in comparison with water quality trends recorded during the baseline period (to late 2011).

Bowmans Creek

A general increase in pH between the upstream monitoring site (SM3) and the downstream monitoring site (SM6) on Bowmans Creek was recorded consistently during the baseline and operational periods. On average, the pH values ranged from near neutral at the upstream site to slightly alkaline at the downstream site. The pH values recorded during the baseline period in comparison with the operational period indicate no obvious change, with the median pH values consistent for both periods at all monitoring sites on Bowmans Creek.

Climatic trends in EC values are evident at all monitoring sites on Bowmans Creek, especially at SM4, for both the baseline and operational monitoring period, with significant increases in EC during receding and low flow periods. The variance in EC values is attributed to the occurrence of evapoconcentration during low flow periods and the relative dominance of vertical leakage of more saline groundwater from the Permian lithologies (RPS, 2015). During the baseline period, the EC values ranged between 82 and 14,700 µS/cm at SM4, with a median value of 2,797 µS/cm, while during the operational period, the EC values at SM4 ranged between 329 and 5,620 µS/cm at SM4, with a median value of 1,428 µS/cm.

A historically high EC value of 2,240 µS/cm was recorded at SM6 in June 2019 during mining of LW 202. No data were available for any other stations on Bowmans Creek at that time except SM4 where the recorded EC was higher (4,090 µS/cm). The historically high SM6 EC value is attributed to evapoconcentration during an extended period of below average rainfall (refer Figure 5) rather than a mining related effect. An increase in EC values above the 80th percentile trigger value was also recorded at SM4 between September 2018 and June 2019, though the values did not exceed the historically recorded maximum value at this site. Monitoring sites SM4a and SM5 were dry at this time due to the prolonged period of below average rainfall.

Recorded TDS values at monitoring sites on Bowmans Creek are generally similar to EC. A historically high TDS was recorded at site SM4a in February 2018 (1,670 mg/L), however this occurred following an extended period of low rainfall in summer (73 days with less than 10 mm daily rainfall) and is therefore likely associated with evapoconcentration in the diverted creek channel.

At the upstream monitoring sites on Bowmans Creek (SM3 and SM4), the TSS concentrations ranged between 1 and 996 mg/L during the baseline monitoring period and between 1 and 818 mg/L during the operational monitoring period. The median TSS concentration recorded at both sites was higher during the baseline monitoring period than the operational monitoring period. At the central and downstream monitoring sites on Bowmans Creek (SM4A, SM5 and SM6), the TSS concentrations ranged from 1 to 163 mg/L during the baseline monitoring period and between 1 and 495 mg/L during the operational period.

The elevated TSS concentrations recorded at all sites in February 2012 are likely attributable to heavy rainfall occurring in the headwaters of the Bowmans Creek catchment (ACOL, 2013). Increases in TSS concentrations recorded at SM5 in 2014, 2015 and 2017, at SM4A in early to mid-2018 and at SM6 in 2019 and 2020 are likely attributable to sediment deposition and changing drainage patterns associated with declining rainfall and changes in surface runoff characteristics associated with subsidence and the construction of the Bowmans Creek diversion structures. It is noteworthy that the maximum TSS concentrations recorded at SM4A, SM5 and SM6 during the operational monitoring period were not in excess of that recorded at upstream sites (SM3 and SM4) during the baseline or operational monitoring period.

Glennies Creek

The pH values recorded at monitoring sites on Glennies Creek are fairly uniform along the length of the creek in the vicinity of the ACP. On average, the pH values indicated slightly alkaline conditions (pH 7.8 to pH 7.9). The pH values recorded during the baseline period in comparison with the operational period indicate no obvious change, with the median pH values consistent for both periods at all monitoring sites on Glennies Creek.

The EC values recorded at monitoring sites in Glennies Creek are also fairly uniform, with median concentrations between 347 and 353 µS/cm during the baseline monitoring period and between 348 and 361 µS/cm during the operational monitoring period. The substantially lower and relatively uniform EC values recorded in Glennies Creek in comparison with Bowmans Creek are likely due to regulated release from the Glennies Creek Dam (RPS, 2015). In 2015, a substantial rise in EC values was recorded at all monitoring sites in Glennies Creek, with a maximum value of 3,030 µS/cm recorded at the monitoring site upstream of the ACP (SM7). Internal investigations were undertaken by ACOL although the cause of the elevated EC values was unable to be identified (ACOL, 2016b). Apart from the 2015 rise in EC values, the EC values recorded during the baseline and operational monitoring period at monitoring sites in Glennies Creek have been relatively consistent. Recorded TDS values at monitoring sites in Glennies Creek are a reflection of the EC data.

The TSS concentrations recorded in Glennies Creek have generally been low and fairly uniform along the length of the creek in the vicinity of the ACP. The median concentrations ranged between 12 mg/L (SM7) and 14 mg/L (SM8) during the baseline monitoring period and between 8 mg/L (SM8) and 9 mg/L (SM7 and SM11) during the operational monitoring period. Irregular increases in TSS concentrations were recorded during the baseline and operational monitoring periods, with a maximum concentration of 226 mg/L recorded at SM7 during the baseline monitoring period in comparison with a maximum concentration of 147 mg/L recorded at this during the operational monitoring period.

Hunter River

The pH values recorded at monitoring sites in the Hunter River indicate alkaline conditions on average, with minimum values ranging from near neutral to slightly alkaline. Fairly consistent pH values were recorded at all sites during both the baseline and operational monitoring periods. Minimum historical pH values were recorded at monitoring sites SM9 (pH 6.9), SM10 (pH 7.3), SM12 (pH 7.2) and SM13 (pH 7.3) in the Hunter River in February 2020. During January and February 2020, the total rainfall recorded at the nearby Glennies Creek Dam[2] was 259 mm which equates to 70% of the total 2019 rainfall (368 mm). The irregular decline in pH values recorded at sites in the Hunter River, including at SM9 upstream of the ACP mining area, was likely due to substantial rainfall following a prolonged low rainfall period. The pH values have since returned to within the range of historical values at all sites. During 2019, pH values at SM13A fell below the surface water impact assessment criterion for four consecutive months. An assessment undertaken by HEC (2020) concluded that this may be related to discharge from the river alluvium, with little risk of an association with mine water migration.

A slight increase in recorded EC values between SM9 and SM14 in the Hunter River was evident during the baseline monitoring period and this trend has continued during the operational monitoring period. Median concentrations ranged between 744 µS/cm (SM9) and 802 µS/cm (SM14) during the baseline monitoring period and between 781 µS/cm (SM9) and 831 µS/cm (SM14) during the operational monitoring period. The EC values recorded at monitoring site SM12 in the Hunter River downstream of the confluence with Glennies Creek have been lower historically, with a median concentration of 561 µS/cm due to contribution of lower EC inflow from Glennies Creek. Recorded TDS values at Hunter River monitoring sites are generally a reflection of EC data.

In August 2017 a historically high EC value of 1,262 µS/cm was recorded at monitoring site SM13 in the Hunter River. An investigation instigated by ACOL indicated that the elevated EC was related to a reduction in the release of lower EC water from Glenbawn Dam during a period of naturally lower river flow, rather than any local effects (ACOL, 2018b).

The TSS concentrations recorded in the Hunter River have generally been low and fairly uniform along the length of the river in the vicinity of the ACP. The median concentrations ranged between 22 mg/L (SM9) and 36 mg/L (SM14) during the baseline monitoring period and between 19 mg/L (SM12) and 24 mg/L (SM14) during the operational monitoring period. Irregular increases in TSS concentrations were recorded during the baseline and operational monitoring periods, with maximum concentrations recorded at all sites between February and April 2020. During January to April 2020, the total rainfall recorded at Glennies Creek Dam[2] was 406 mm which equates to 110% of the total 2019 rainfall (368 mm). The substantial increase in TSS concentrations recorded at sites in the Hunter River, including at SM9 upstream of the ACP mining area, is likely due to substantial rainfall and sediment runoff following a prolonged period of low rainfall.

---

[2] Sourced from https://realtimedata.waternsw.com.au/

6.0 POTENTIAL IMPACT FOR LW 205 TO LW 208 EXTRACTION

6.1 SUBSIDENCE IMPACTS

The forecast subsidence impacts detailed in the Subsidence Assessment (SCT, 2020) are summarised in Table 9 and the following sub-sections. Figure 7 presents the predicted subsidence impacts for the EP Area shown as subsidence contours.

Table 9 Predicted Subsidence Impacts – LW 205 to LW 208

LW Seams		Maximum Subsidence (m)	Maximum Tilt (mm/m)	Maximum Strain (mm/m)
LW 205 – 208	PG & ULLD	4.4	177	88
	PG, ULD & ULLD	5.8	219	110

Comparison of Table 5 and Table 9 illustrates that the current predictions of cumulative subsidence impacts (PG, ULD and ULLD seams) are consistent with the predictions presented in the BCD EA.

6.1.1 Vertical Subsidence

Subsidence resulting from mining of LW 205 – 208 in the ULLD seam is expected to result in additional incremental vertical subsidence up to 2.8 m; with cumulative vertical subsidence in the central part of longwalls, where there is overlap between panels in three seams, expected to be generally less than 5.8 m (SCT, 2020).

Vertical and horizontal subsidence movements in the main channel of Bowmans Creek are expected to be less than 50 mm and 100 mm respectively. According to SCT (2020), no perceptible impacts are expected along the main channel of Bowmans Creek.

Valley closure effects are predicted to result in negligible impacts to the bed of Bowmans Creek as horizontal movements are expected to occur in a direction away from the creek. Parts of the remnant natural sections of Bowmans Creek which have been excised by the formation of the diversion channels are predicted to be lowered by vertical subsidence, forming features similar to other natural ponds in the floodplain. These sections would not be free draining; rather ponded water is expected to seep downward into the overburden strata and potentially from there into the mine (SCT, 2020).

6.1.2 Strain and Tilts

General background levels of maximum strain and tilt are expected over most of the longwall goaf areas where mining in two and three seam takes place whereas permanent strains and tilts are expected to occur at panel edges. Similar in nature to that observed previously above LW 201 – 203, cracks of up to 300 millimetres (mm) width are expected in areas where there is interaction and reworking of previous fractures from either the PG seam, ULD seam or both.

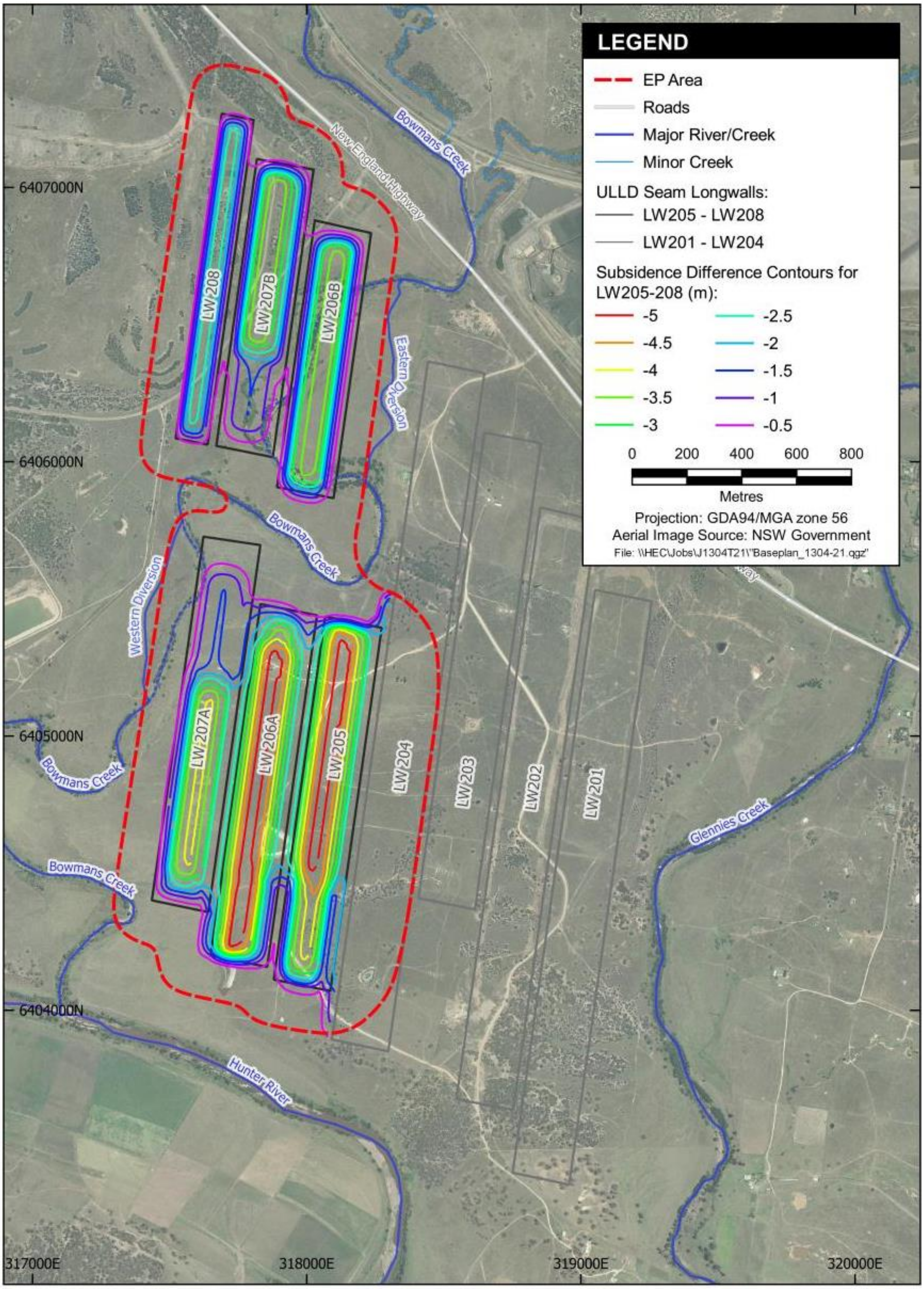

Figure 7 Predicted Subsidence Impacts

6.2 GROUNDWATER IMPACTS

The forecast groundwater impacts detailed in the Groundwater Impact Assessment (AGE, 2020) are summarised in Table 10 in comparison with previously observed impacts. The forecast groundwater impacts consider the influence of other mining operations in the vicinity of the ACP (AGE, 2000).

Table 10 Predicted Groundwater Impacts – LW 205 to LW 208

Potential Impact	Location	Observed	Cumulative	LW 205 – 208 EP
		Impact to April 2020 (to mid LW 203 ULLD)	Impact to end of LW 208 – ULLD (October 2023)	Impact to end of LW 208 – ULLD (October 2023)
Drawdown	Bowmans Creek Alluvium	No drawdown observed in WMP bores		< 1 m
	Glennies Creek Alluvium			< 1 m
	Hunter River Alluvium			< 1 m
Stream baseflow loss	Bowmans Creek		0.07 ML/d	0.013 ML/d
	Glennies Creek		0.06 ML/d	0.008 ML/d
	Hunter River		0.025 ML/d	negligible
Salinity	Bowmans Creek	No mining related impact observed in WMP bores	Likely decrease in salinity	Likely decrease in salinity
	Glennies Creek			
	Hunter River			

Comparison of Table 6 and Table 10 illustrates that the current predictions of drawdown, baseflow loss and salinity impacts associated with mining of LW 205 to LW 206 are consistent with previous modelling and are not expected to exceed the BCD EA approved impacts.

For LW 205 to LW 208 EP, AGE (2020) estimated that the average baseflow gain rate in the modelled area of Bowmans Creek assuming no mining at the ACP was 0.475 ML/d, declining to 0.405 ML/d at the end of mining LW 208 (a cumulative reduction in baseflow of 0.07 ML/d). The baseflow gain rate in the modelled area of the Hunter River was estimated at an average of 0.536 ML/d assuming no mining at the ACP and decreasing to 0.511 ML/d at the end of mining LW 204. For Glennies Creek, the baseflow gain rate was estimated to be an average of 0.63 ML/d assuming no mining at the ACP and 0.567 ML/d following mining of LW 204 (AGE, 2016).

Total mine inflows are predicted to range from approximately 410 ML/year in 2020 to 2021 and 2024 to 2025 to approximately 417 ML/year in 2022 to 2023. The total mine inflows are within the limits of the approved impacts and consistent with that presented in AGE (2016).

As predicted for LW 201 to LW 204, a decrease in the salinity of creeks and alluvial aquifers may occur as a result of the predicted reduction in discharge from the Permian strata following mining of LW 205 to LW 208 (AGE, 2020).

6.3 SURFACE WATER IMPACTS

6.3.1 Streamflow

The potential impact on streamflow due to the predicted baseflow loss associated with mining of LW 205 to LW 208 may be estimated through comparison of the flow duration curves[3] calculated from historical streamflow records and with consideration to the predicted baseflow loss rates. Figure 8 shows the potential impact of the predicted baseflow reduction (refer Section 6.2) associated with mining of LW 205 to LW 208 on streamflow in Bowmans Creek at GS 210130 assessed over the full period of available streamflow data (October 1993 to May 2020). The incremental baseflow loss predicted for LW 205 to LW 208 and the cumulative baseflow loss predicted for all ACP underground mining operations has been assessed.

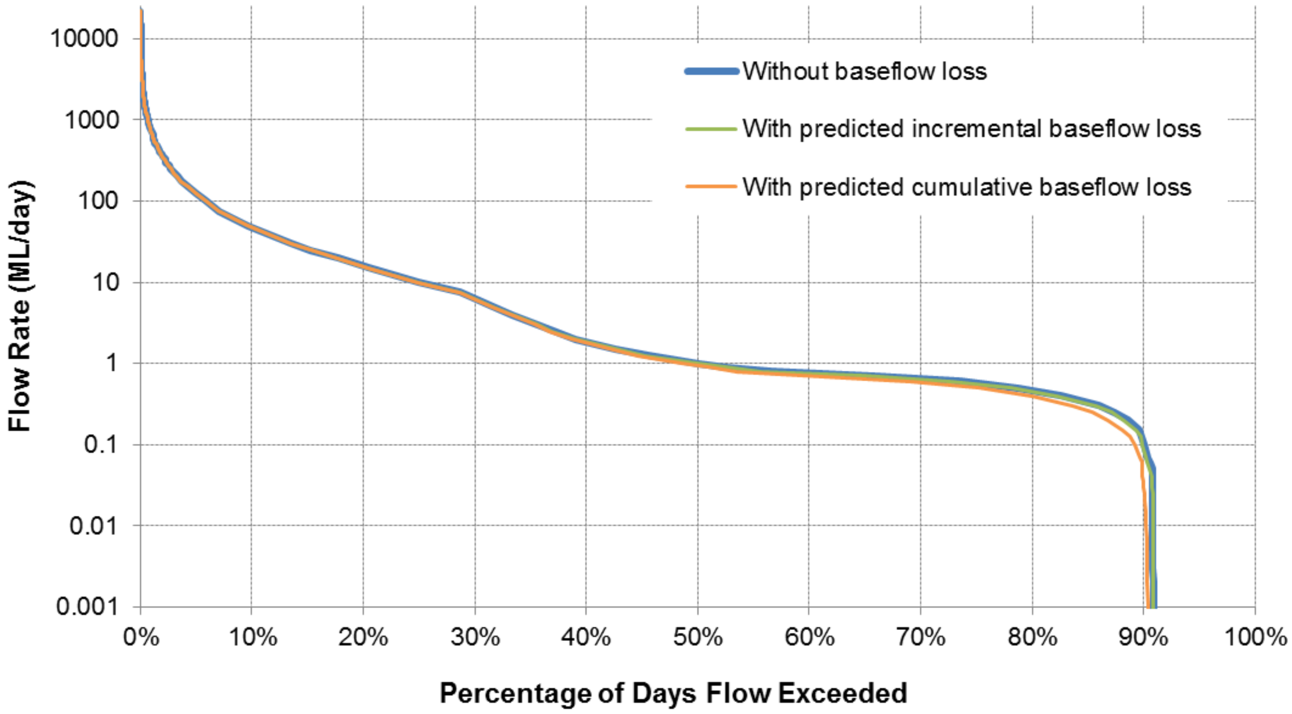

Figure 8 Flow Duration Curve for Bowmans Creek (GS 210130)

Figure 8 illustrates that there is little apparent effect on streamflow associated with the predicted incremental baseflow loss associated with mining of LW 205 to LW 208 (0.013 ML/d). The greatest effect (in terms of difference in flow duration curves) would occur for a flow rate of 0.7 ML/d, where the probability that flow would be greater than this would reduce from 66% to 65% of days. The effect would be less at other flow rates (both higher and lower). This level of change would be imperceptible and very small compared to natural variability in catchment conditions and is therefore considered to be negligible.

For the predicted cumulative baseflow loss associated with the ACP underground mining operations, Figure 8 shows that the effect on streamflow would also be greatest (in terms of difference in flow duration curves) for a flow rate of 0.7 ML/d, where the probability that flow would be greater than this would reduce from 66% to 59% of days. Alternatively expressed, the flow rate which would be exceeded on 66% of days would decrease from 0.7 ML/d to 0.63 ML/d. This level of change may be detectable during normal periods of low flow and distinguishable from natural variability in catchment

---

[3] A Flow Duration Curve is a plot of the proportion of time (days) flow is greater than a given flow rate based on a long period of record. In this report it has been calculated using daily flows over the entire modelled period. The flow duration curves produced in this report have been plotted on logarithmic scale to accentuate low flows.

conditions. However, as the historical streamflow records for Bowmans Creek inherently incorporate baseflow loss associated with mining at the ACP to date (from 2007 onwards), the estimate of cumulative impact to streamflow in Bowmans Creek is highly conservative.

The impact of baseflow loss on low flows in Glennies Creek and the Hunter River is expected to be indistinguishable from natural variability in catchment conditions based on the low rates of predicted baseflow loss presented in Table 10 and the effect of regulated flow releases from Glenbawn and Glennies Creek Dams.

6.3.2 Geomorphology and Flooding

According to SCT (2020), no perceptible impacts are expected along the main channel of Bowmans Creek as solid coal barriers are present in the PG seam and are planned in the ULD and ULLD seam. Vertical and horizontal subsidence movements in the main channel of Bowmans Creek are predicted to be less than 50 mm and 100 mm respectively and imperceptible.

Valley closure effects are expected to result in negligible impacts in the bed of Bowmans Creek as the majority of the creek bed comprises alluvium and horizontal movements are expected to occur generally in a direction away from the creek.

Parts of the natural reaches of Bowmans Creek which have been excised by the formation of the diversion channels are present above LW 206B and LW 207 (refer Figure 7). Based on the predicted vertical subsidence, these reaches are likely (without remedial measures) to form ponded areas which would contribute to downward seepage into the overburden strata and potentially from there into the mine (SCT, 2020). The effect of localised runoff draining to these areas on flow in Bowmans Creek is likely to be negligible given their small local catchments compared with the large catchment of Bowmans Creek (refer Section 3.4.1). Bowmans Creek flow is directed into the diversion channels (and away from the remnant natural reaches of Bowmans Creek) by the use of block banks which were designed so that flows in the diversion channel would overtop the block banks in greater than a 20% AEP flow, with overtopping flow entering the excised reaches of the creek. Such an event has a 20% chance of occurring in any year. In such an event or greater, the majority of flow would pass down the diversion channel, with only a minor portion flowing into the remnant creek. Once the capacity of the remnant creek pond was exceeded, flow would continue on and re-enter the diverted creek. Therefore the volume of flow lost during such an event would equate to the capacity of these ponded areas. The capacity of these ponded areas following mining of LW 205 to LW 208 has been estimated to be 687 ML (without the conduct of any remedial earthworks). This compares with an average annual flow rate in Bowmans Creek at GS 210130 over the full period of available data (October 1993 to May 2020) of 15,700 ML/year. Given this, and the fact that a 20% AEP flow would result in high flows in Bowmans Creek and the downstream Hunter River, it is considered that a loss of flow equal to the estimated pond volume would not be discernible downstream. As stated in SCT (2020), a continuation of the current practices of reshaping the surface after subsidence and the construction of drainage channels generally along the natural drainage lines to Bowmans Creek is proposed to create free draining areas and to limit the depth of natural ponds and the potential for ponding. These earthworks would limit the seepage of water into the overburden and potentially from there into the underground mine.

SCT (2020) have predicted that, within the subsidence troughs, zones of surface cracks, steps or steeper ground are likely to occur near the panel edges, especially where permanent stacked goaf edges are formed. Restriction of natural drainage and ponding in some areas is likely to occur as a result of the predicted subsidence impacts. Additional subsidence caused by LW 206B would result in steepening of the remnant natural reach of Bowmans Creek where it enters and leaves the subsidence pond caused by this (and previous) longwalls. There is therefore the potential for erosion caused by flow in this remnant reach of the creek where it enters the subsidence pond. Conversely there is the likelihood of accretion where the remnant creek leaves the subsidence pond. There is limited potential for this to occur as a result of subsidence associated with LW 207B and LW 207A because of the relative locations of the longwalls and the remnant creek channel. It is recommended that monitoring of remnant creek subsidence profiles occur during and following mining of these longwalls and that remediation measures to mitigate erosion risk be undertaken – these could include localised armouring (e.g. with rockfill), earthworks to flatten steepened areas, enhanced vegetation or a combination of these.

The predicted increased depth of subsidence (SCT, 2020 and Figure 7) means that there is unlikely to be any increase in flood levels.

6.3.3 Water Quality and Salinity

The comparison of baseline and operational water quality monitoring discussed in Section 5.3.2 indicates that there is no evidence of a notable or prolonged influence on water quality associated with mining at the ACP. Potential increased erosion associated with steepening of remnant creek channels due to subsidence could lead to an increase in suspended solids – remediation measures have been recommended to mitigate this risk (refer Section 6.3.2). Consistent with previous assessments, mining of LW 205 to LW 208 is not expected to result in detrimental impacts to surface water quality in the vicinity of the ACP.

As shown in Table 10, a decrease in the salinity of creeks and alluvial aquifers may occur as a result of the predicted reduction in discharge from the Permian strata following mining of LW 205 to LW 208 (AGE, 2020). As such, the only predicted influence of mining at the ACP is a potential reduction in the salinity of Bowmans Creek, Glennies Creek and the Hunter River in the vicinity of the ACP.

6.3.4 Water Allocation Licence Requirements

The AGE (2020) predicted underground mine inflow rates from the Hunter River, Bowmans Creek and Glennies Creek associated with mining at the ACP are presented in Table 11.

Table 11 Predicted ACP Underground Mine Inflows

Mine Inflow (ML/year)	2020 - 2021	2021 - 2022	2022 - 2023	2023 - 2024	2024 - 2025
Hunter River Channel	7.75	8.09	8.41	8.70	8.93
Bowmans Creek Channel	23.07	24.05	24.89	25.69	26.31
Glennies Creek Channel	21.30	22.43	23.42	24.28	25.22

Comparison of Table 2 and Table 11 indicates that the predicted underground mine inflows from the Hunter River, Bowmans Creek and Glennies Creek are substantially less than the current water licences held by ACOL for the ACP (refer Section 2.3). As such, the ACP has sufficient existing licences based on the predicted mine inflows and dewatering rates.

6.3.5 Other Water Users

In accordance with Schedule 3 Condition 26 (e) and (g) of the Development Consent, the impacts of the ACP operations on private water users is required to be monitored, assessed and responded to (ACOL, 2018a).

Table 12 summarises the WALs held by other water users between Bowmans Creek and the Hunter River junction with Glennies Creek. The associated properties with WALs are shown in Figure 9.

Table 12 Hunter Regulated River Water Source WAL Summary

Management Zone	Category	Unit Shares (ML)
Zone 1b (Hunter River from Goulburn River Junction to Glennies Creek Junction)	Regulated River (High Security)	28
	Regulated River (General Security)	1583
	Supplementary Water	92
Zone 2a (Hunter River from Glennies Creek Junction to Wollombi Brook Junction)	Regulated River (General Security)	48
Zone 3a (Glennies Creek)	Regulated River (General Security)	360
	Domestic And Stock	22
	Regulated River (High Security)	9

* Source: https://waterregister.waternsw.com.au

The limited streamflow impacts (refer Section 6.3.1) and the regulated nature of the WALs (water is released from the upstream regulating storages for extraction by the licence holders) mean that the impacts on licensed water users should be negligible.

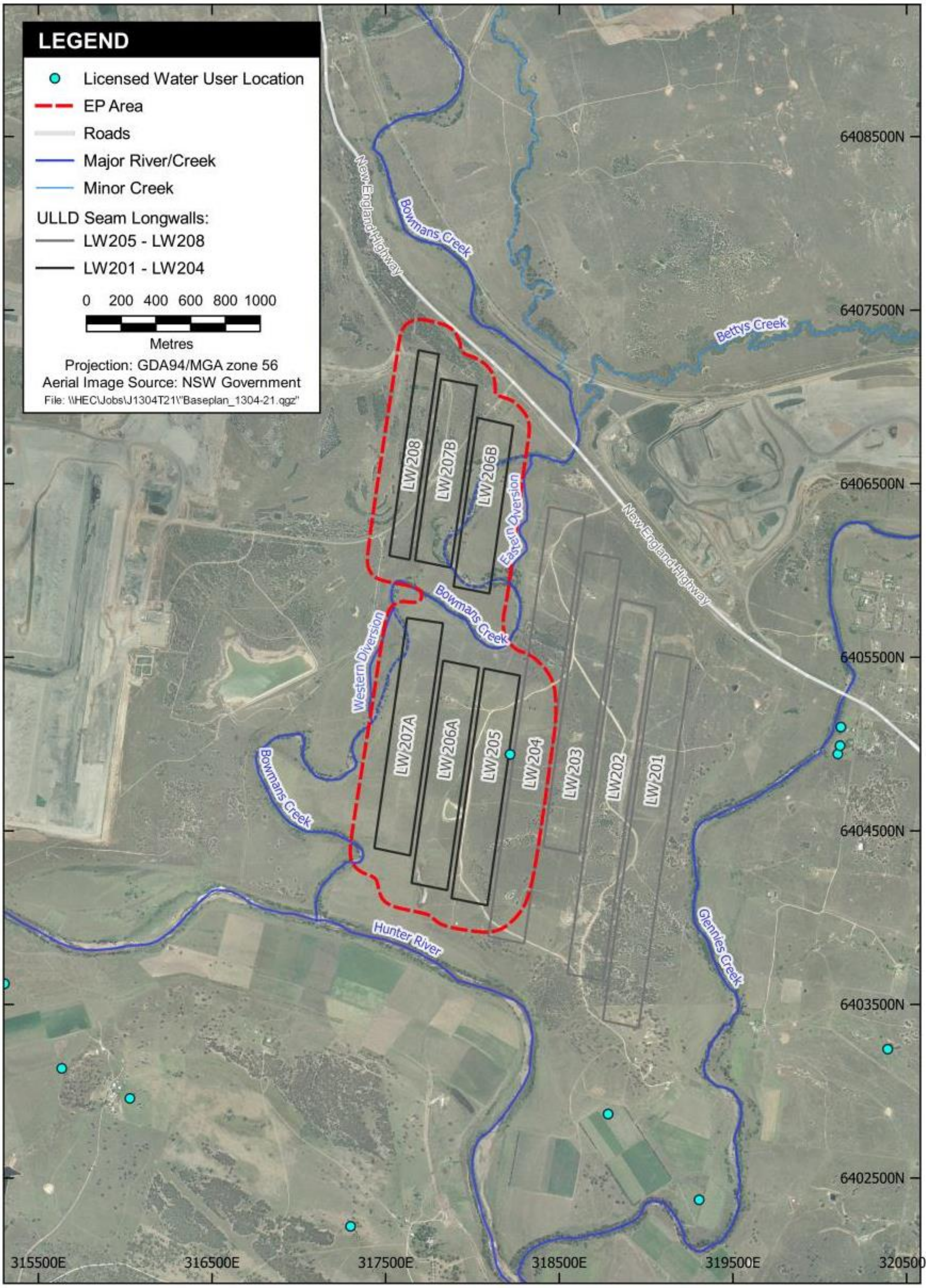

Figure 9 Location of Licenced Water Users

7.0 RECOMMENDED MONITORING, MITIGATION AND MANAGEMENT

Water management at the ACP is documented in the WMP (ACOL, 2018a). The WMP details the surface water monitoring program and Trigger Action Response Plans (TARPs) necessary to identify and respond to potential surface water impacts associated with the ACP. The water monitoring program and TARPs detailed in the WMP have been developed to ensure that the ACP complies with consent conditions and approved impacts.

The current surface water monitoring program for the ACP (ACOL, 2018a) is comprehensive and sufficient to enable potential surface water impacts associated with mining of LW 205 to LW 208 to be appropriately identified and managed. In addition and as indicated in Section 6.3.2, it is recommended that monitoring of remnant creek subsidence profiles occur during and following mining of LW 206B, LW 207B and LW 207A in order to assess erosion risk. This should involve survey of pre-defined lines in areas where subsidence predictions indicate steepening of surface profiles along remnant creek channels. The surveys should be conducted immediately following undermining of these areas at monthly intervals until survey indicates that no additional subsidence is occurring. Once this occurs, the erosion risk should be assessed by a geomorphic specialist and remedial measures designed as appropriate.

Baseflow impacts are unable to be directly measured, rather are assessed based on monitoring of drawdown in the alluvium. The impact assessment criteria for monitoring baseflow impacts as a result of groundwater drawdown is specified in the WMP (ACOL, 2018a).

As stated in SCT (2020), a continuation of the current practices of reshaping the surface after subsidence and the construction of drainage channels generally along the natural drainage lines to Bowmans Creek is proposed to create free draining areas and to limit the potential for ponding and depth of natural ponds. Monitoring of undermined areas should be undertaken following rainfall events to identify any significant areas of ponding, with further management activities to be determined based on the location and size of the ponding.

As per the WMP, if it was established that the ACP mining activities have adversely affected flows in Bowmans Creek, thereby affecting licensed private water users in the lower reaches of the creek (refer Section 6.3.5), ACOL would negotiate provision of an alternative water resource with the affected users (ACOL, 2018a).

The outcomes of the surface water monitoring program will continue to be reported in the ACOL Annual Review reports, in accordance with the WMP (ACOL, 2018a).

8.0 REFERENCES

ACOL (2013). *Ashton Coal Annual Environmental Management Report 2011/2012*. Prepared by Ashton Coal Operations Pty Ltd, June.

ACOL (2016a). *Ashton Coal Mine Longwalls 201-204 Extraction Plan*, November.

ACOL (2016b). *Ashton Coal 2015 Annual Review*. Prepared by Ashton Coal Operations Pty Ltd, March.

ACOL (2018a). *Ashton Coal Project Water Management Plan*. Prepared by Ashton Coal Operations Pty Ltd, March.

ACOL (2018b). *Ashton Coal 2017 Annual Review*. Prepared by Ashton Coal Operations Pty Ltd, March.

ACOL & AECOM (2012). *Ashton Coal Project Upper Liddell Seam Extraction Plan LW 1 - 8.* Prepared for Ashton Coal Operations Pty Ltd (ACOL), August.

ACOL & SLR (2015). *Ashton Coal Project Upper Liddell Seam Extraction Plan LW 105 - 107*. Prepared for Ashton Coal Operations Pty Ltd (ACOL), December.

AGE (2020). *Yancoal Ashton Longwalls 205-208 Extraction Plan Surface and Groundwater Impact Assessment*. Prepared by Australasian Groundwater and Environmental (AGE) Consultants Pty LTD for Yancoal Australia Limited, April.

ANZG (2018). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy, Paper No. 4. Volume 1. The Guidelines, Chapter 1-7.

Evans & Peck (2009). *Bowmans Creek Diversion Environmental Assessment*. Prepared by Evans & Peck Pty Ltd for Ashton Coal Operations Limited, December.

Fluvial Systems (2009). *Bowmans Creek Diversion Environmental Assessment: Flood Hydrology and Geomorphology*. Prepared by Fluvial Systems for Ashton Coal Operations Pty Ltd, October.

Fluvial Systems (2011). *Fluvial Geomorphology Technical Report: Upper Liddell Seam, Longwalls 1 - 8 Extraction Plan*. Prepared by Fluvial Systems for Ashton Coal Operations Pty Ltd, December.

HEC (2020). *Ashton Coal Mine – Assessment of Hunter River Lowered pH*. Hydro Engineering & Consulting Pty Ltd letterJ1304-16.lm3b to Ashton Coal Operations Pty Ltd, March.

HLA (2001). *Environmental Impact Statement Ashton Coal Project*. Prepared by HLA-Envirosciences for White Mining Limited, November.

RPS (2015). *Surface Water and Groundwater Assessment Upper Liddell Seam Extraction Plan Longwalls 105 to 107 Ashton Coal Project*. Prepared by RPS for Ashton Coal Operations Pty Limited, February.

SCT (2009). *Multi-Seam Subsidence Assessment for Ashton Coal Mine Longwalls 5 to 8*. Prepared by Strata Control Technology (SCT) for Ashton Coal Operations Pty Ltd, October.

SCT (2016). *Subsidence Assessment for the Extraction Plan for Longwalls 201-204 in the Upper Lower Liddell Seam*. Prepared by Strata Control Technology (SCT) for Ashton Coal Operations Pty Ltd, October.

SCT (2020). *Subsidence Assessment for the Extraction Plan for Longwalls 205-208 in the Upper Lower Liddell Seam*. Prepared by Strata Control Technology (SCT) for Ashton Coal Operations Pty Ltd, April.

WaterNSW (2020a). *NSW Water Register*. https://waterregister.waternsw.com.au/water-register-frame, accessed May 2020.

WaterNSW (2020b). *Water Operations: Glennies Creek Dam*. https://www.waternsw.com.au/supply/visit/glennies-creek-dam, accessed May 2020.

APPENDIX A – SURFACE WATER QUALITY MONITORING PLOTS

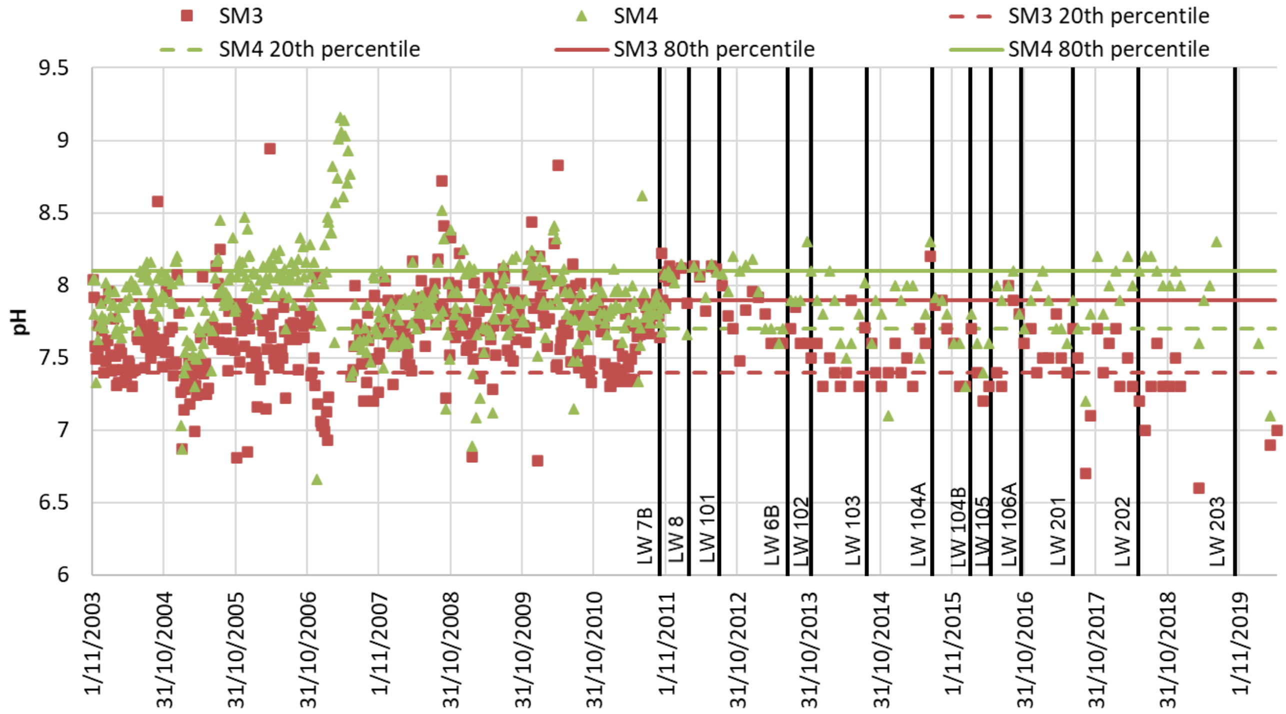

Figure A1 Bowmans Creek Upstream Sites – pH

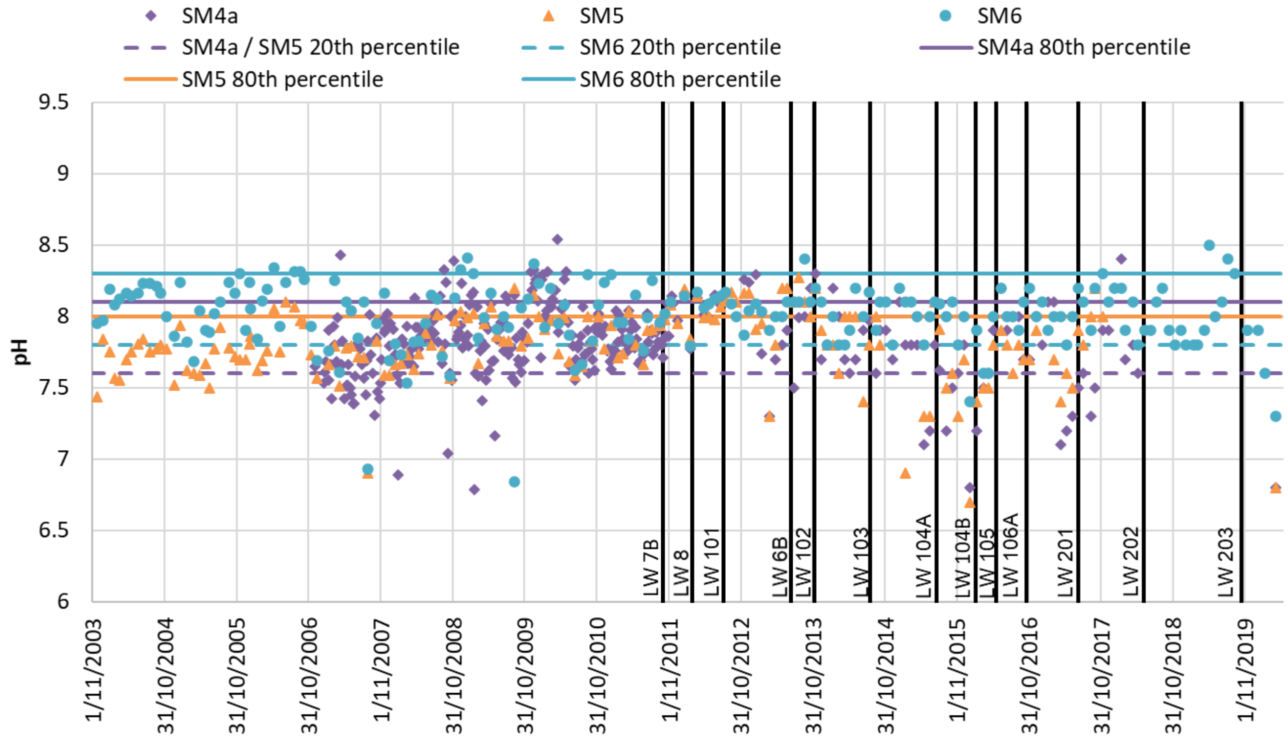

Figure A2 Bowmans Creek Downstream Sites – pH

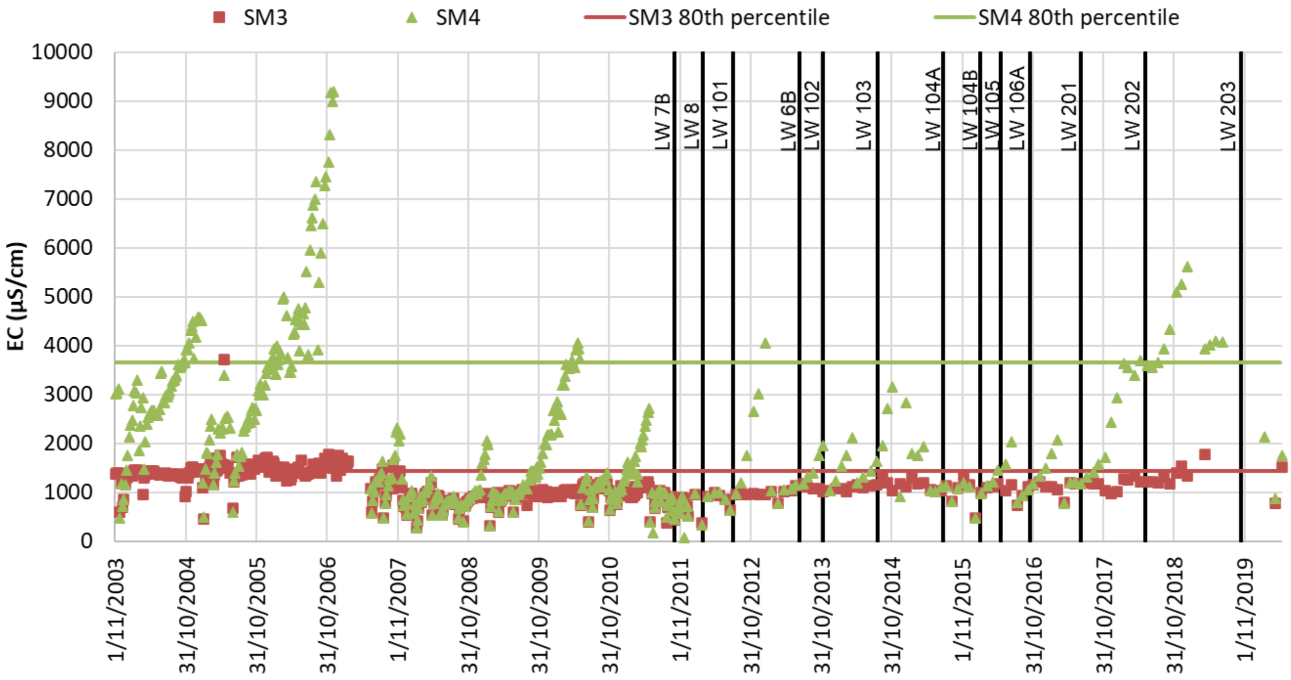

Figure A3 **Bowmans Creek Upstream Sites – EC**

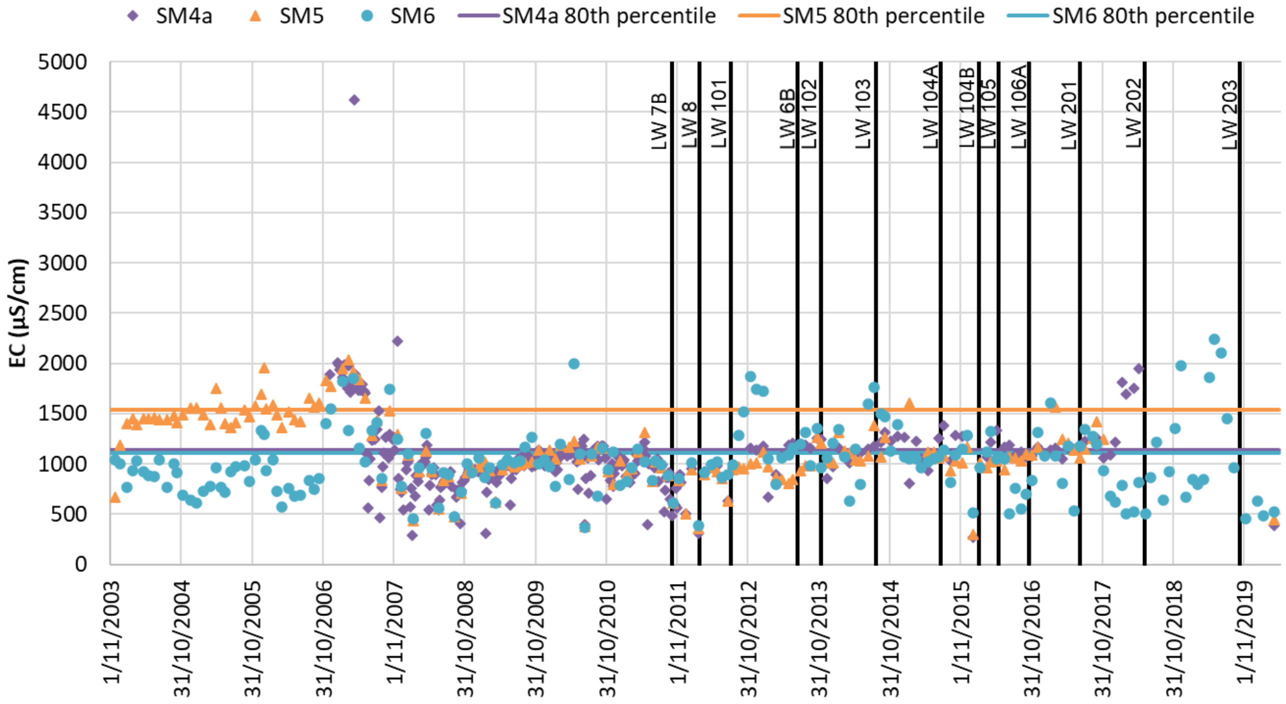

Figure A4 **Bowmans Creek Downstream Sites – EC**

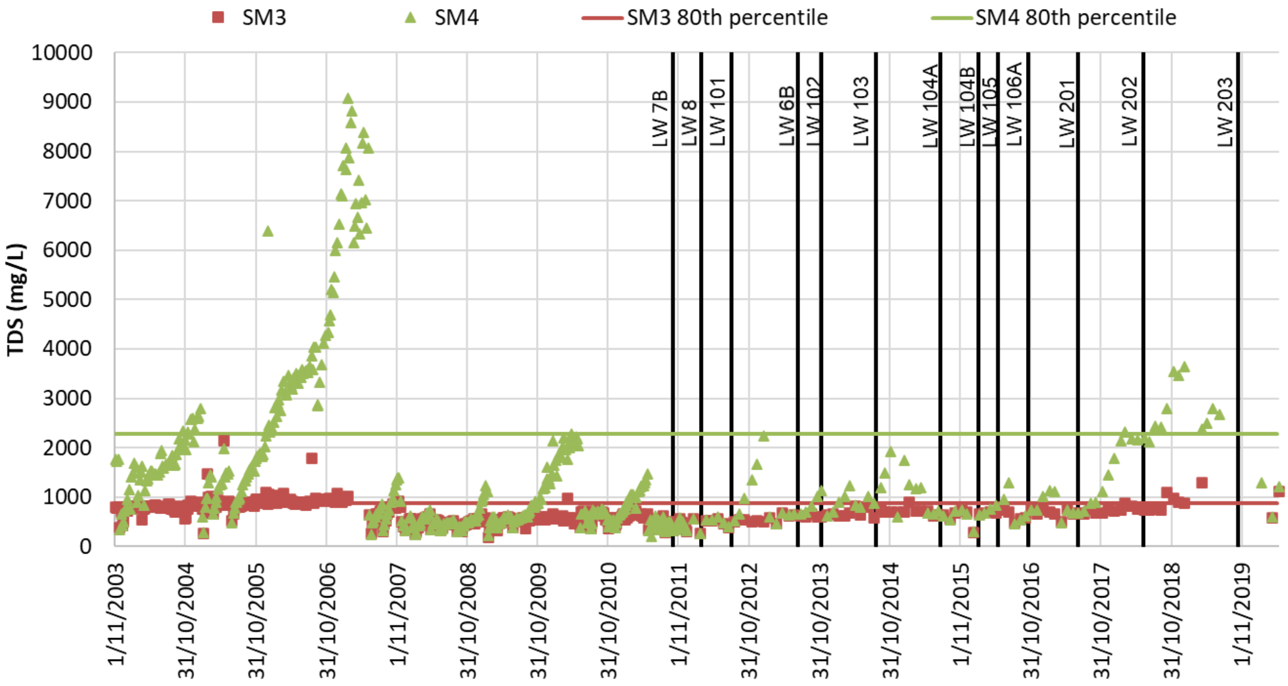

Figure A5 Bowmans Creek Upstream Sites – TDS

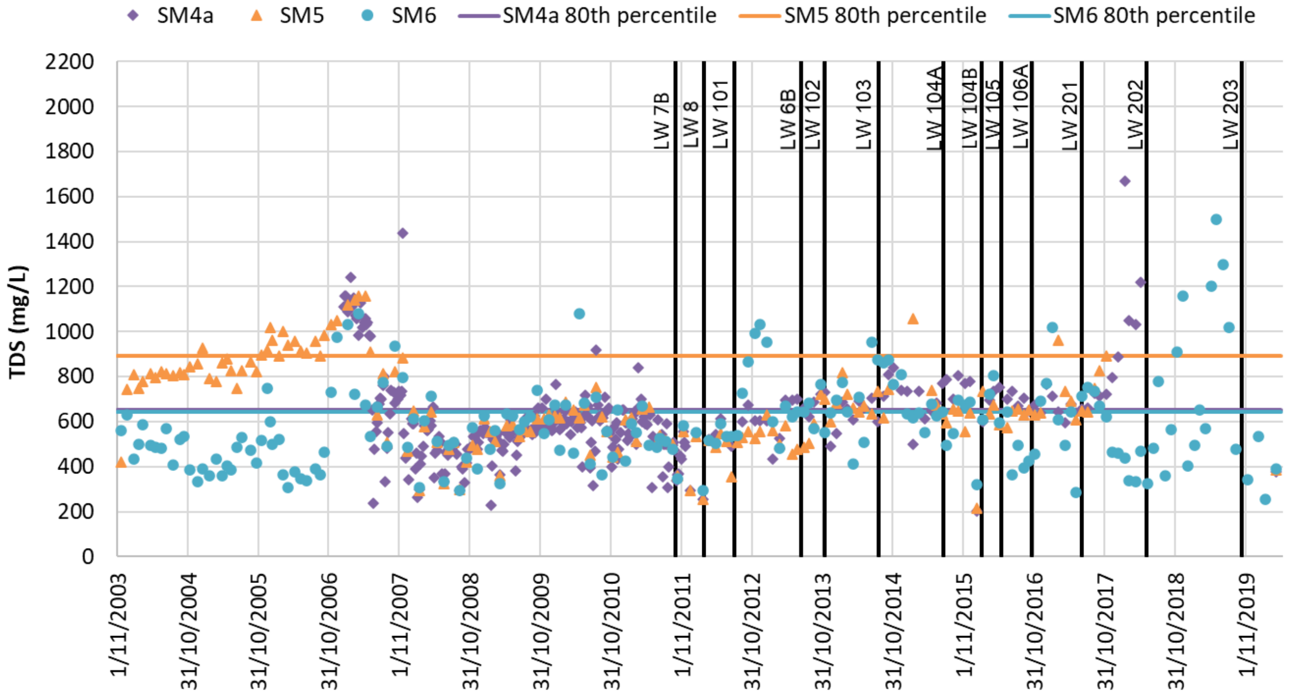

Figure A6 Bowmans Creek Downstream Sites – TDS

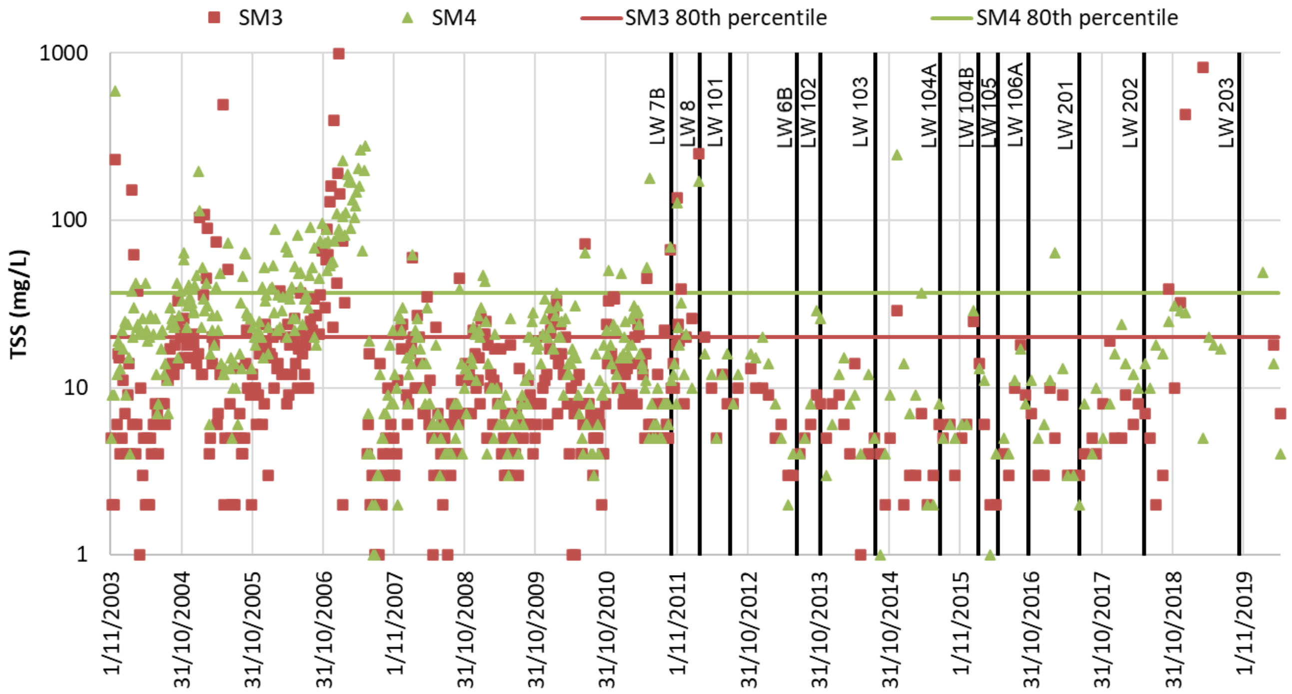

Figure A7 Bowmans Creek Upstream Sites – TSS

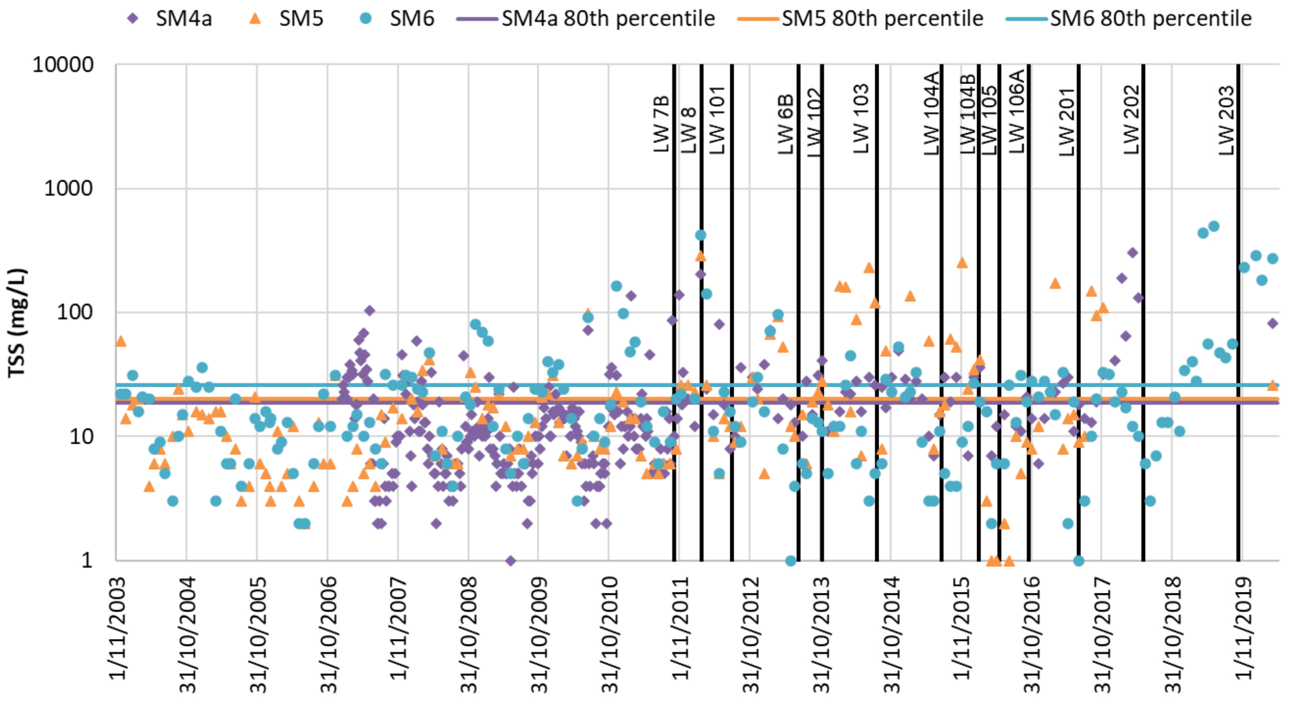

Figure A8 Bowmans Creek Downstream Sites – TSS

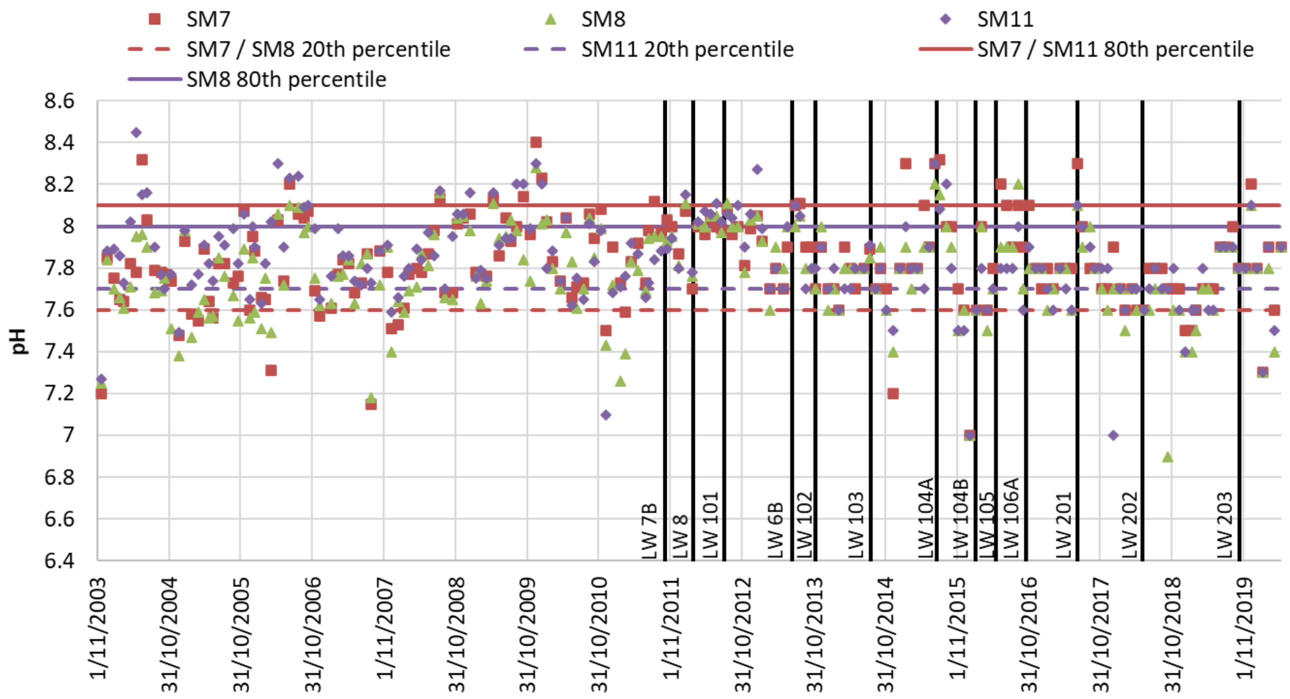

Figure A9 Glennies Creek Sites – pH

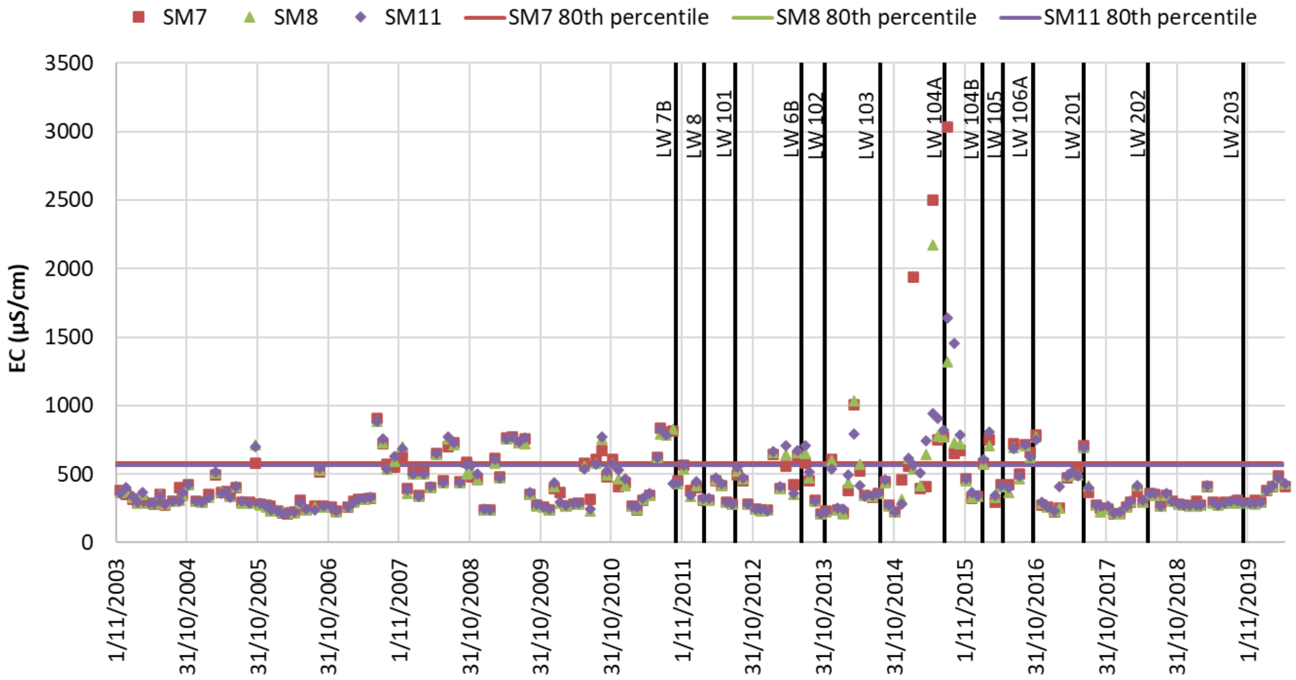

Figure A10 Glennies Creek Sites – EC

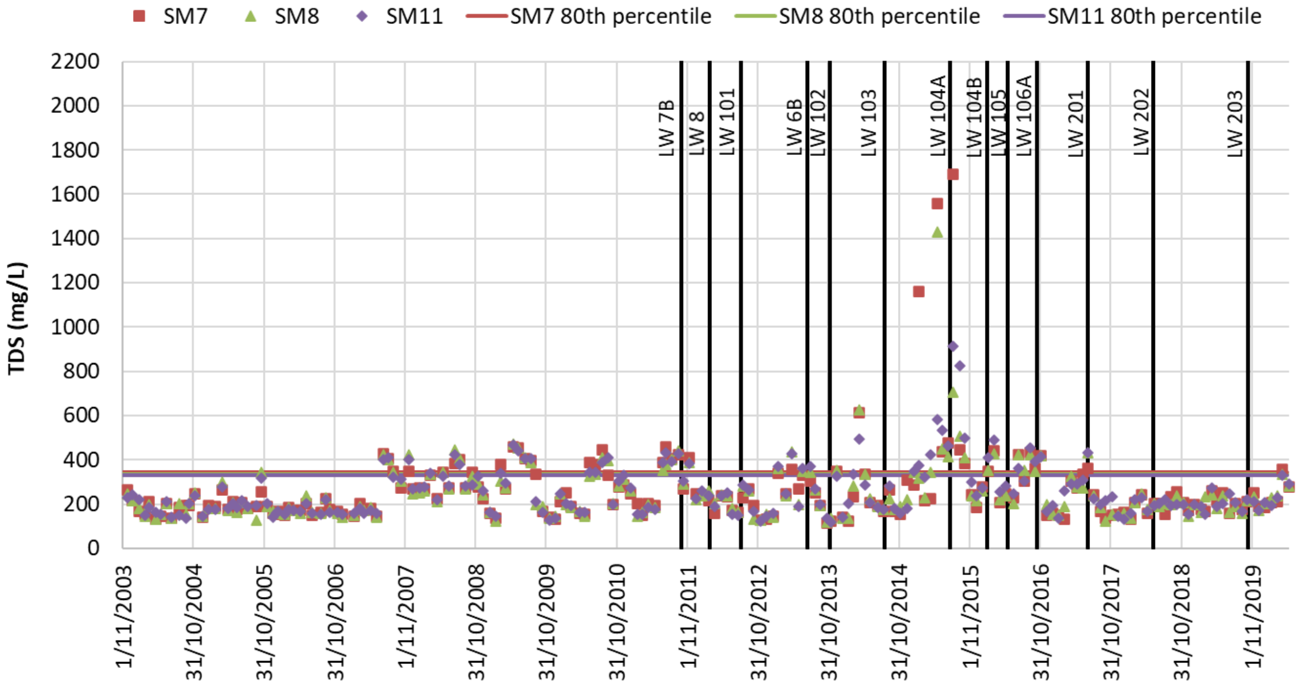

Figure A11 Glennies Creek Sites – TDS

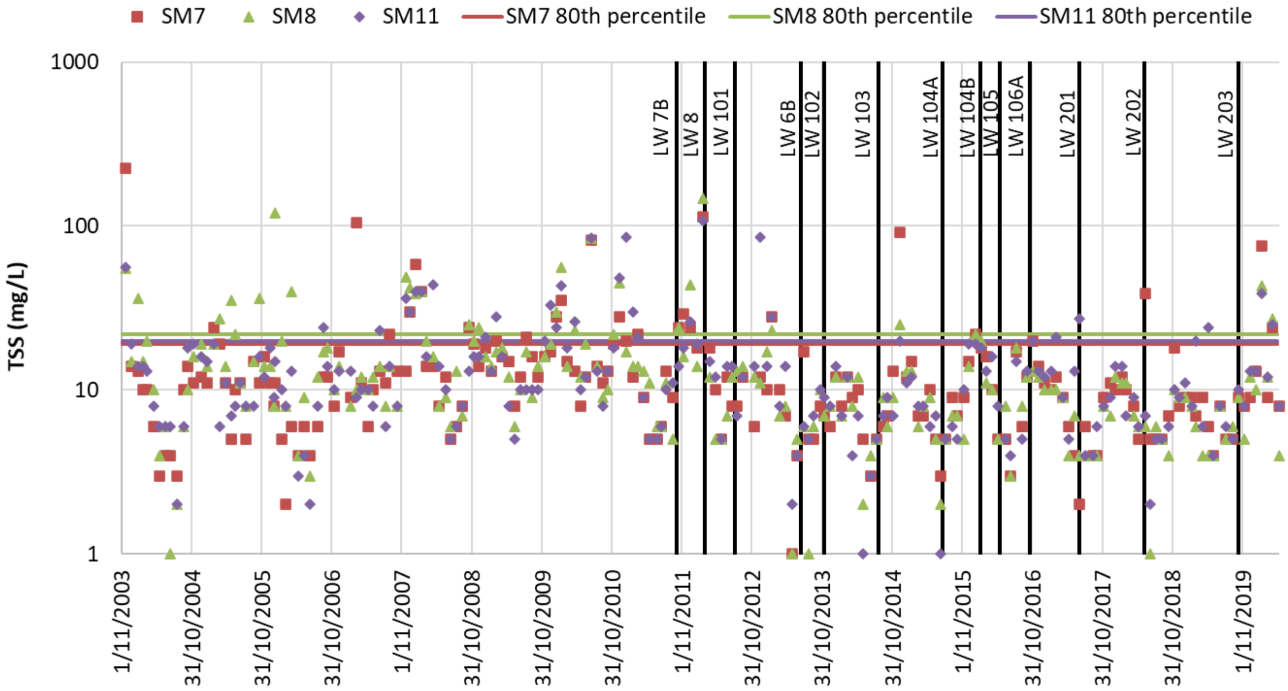

Figure A12 Glennies Creek Sites – TSS

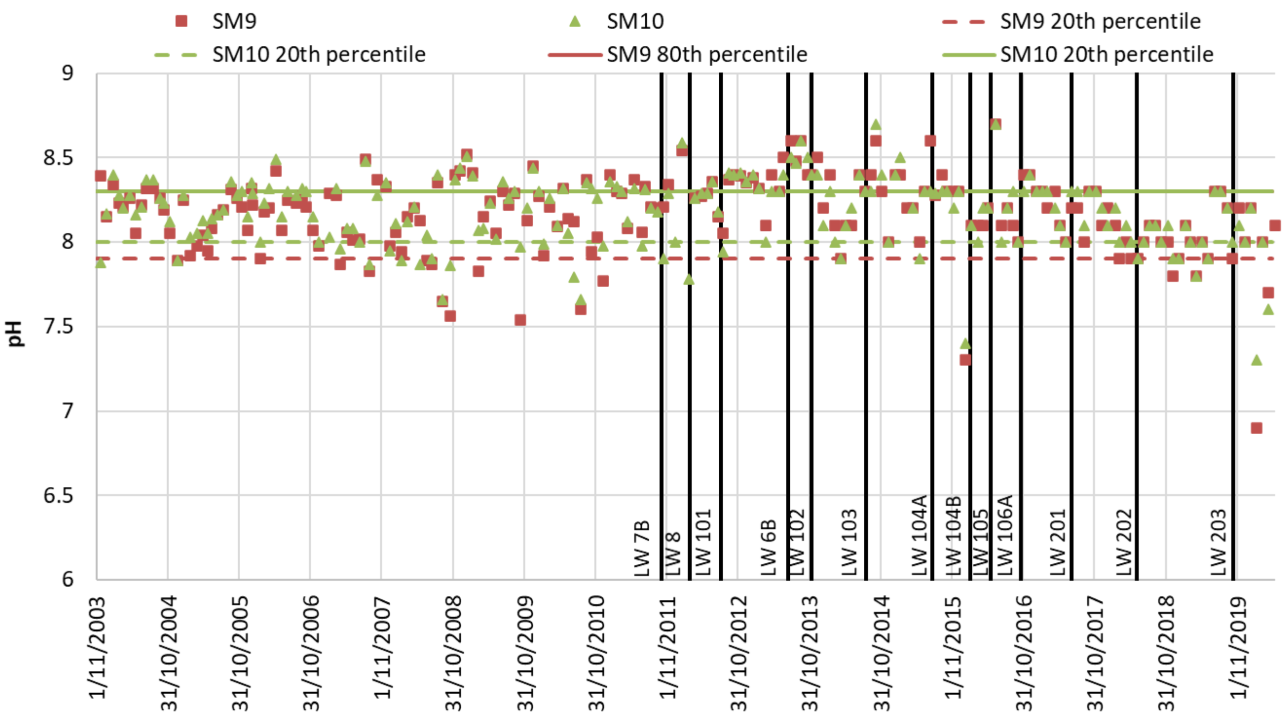

Figure A13 Hunter River Upstream Sites – pH

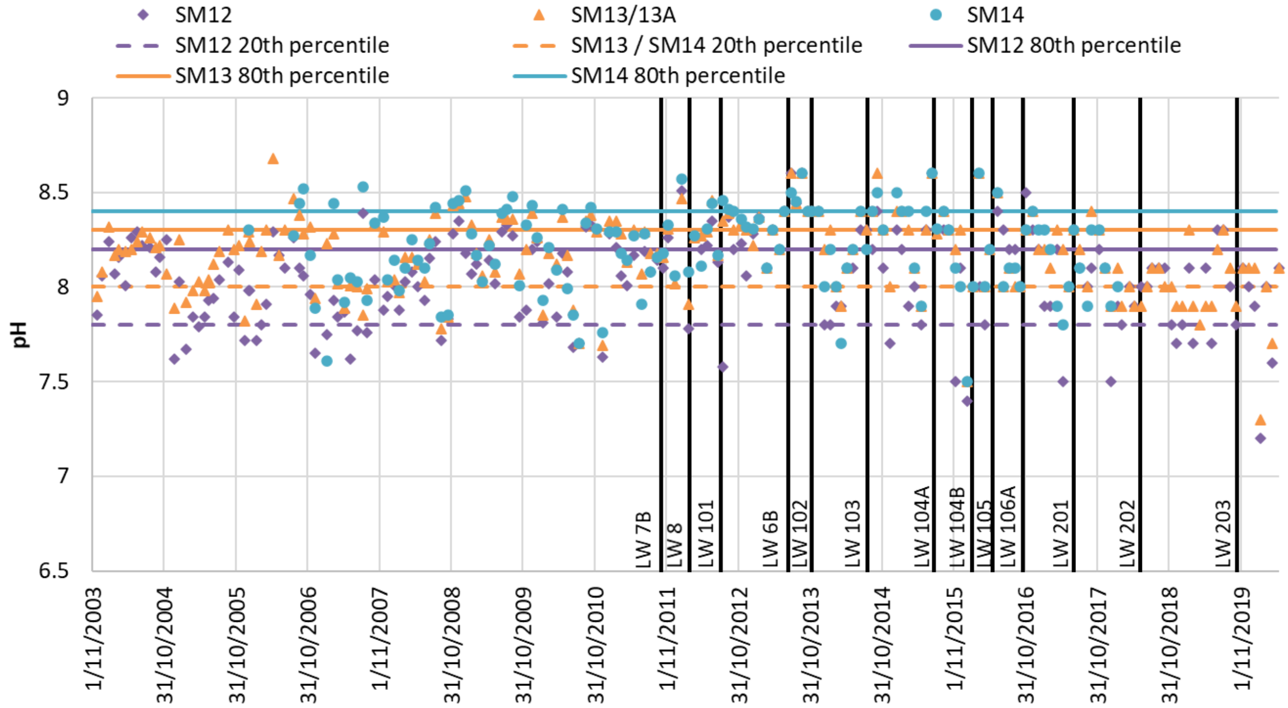

Figure A14 Hunter River Downstream Sites – pH

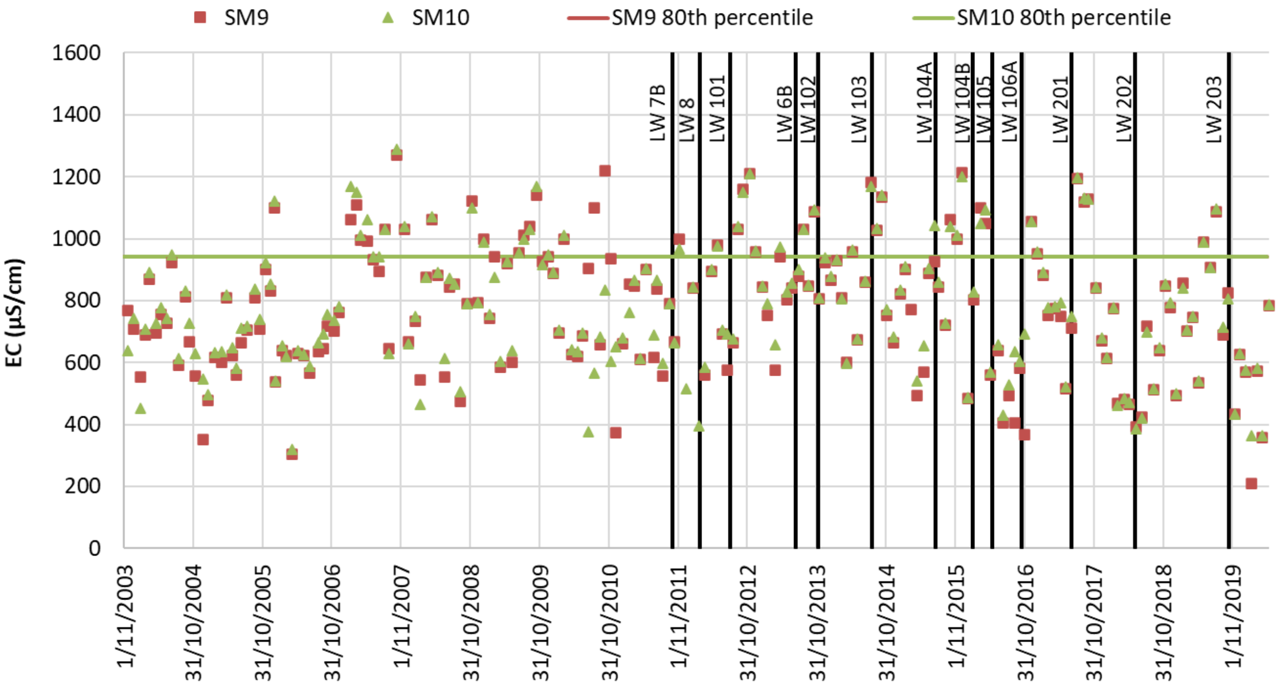

Figure A15 Hunter River Upstream Sites – EC

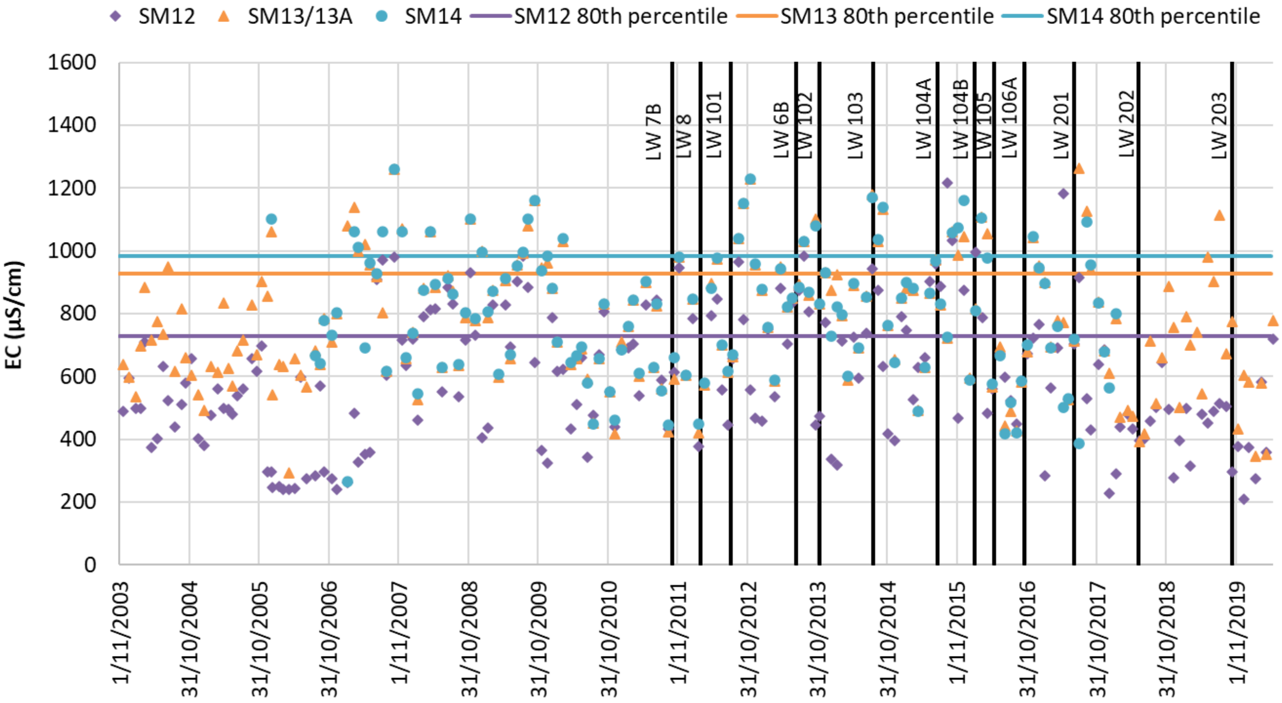

Figure A16 Hunter River Downstream Sites – EC

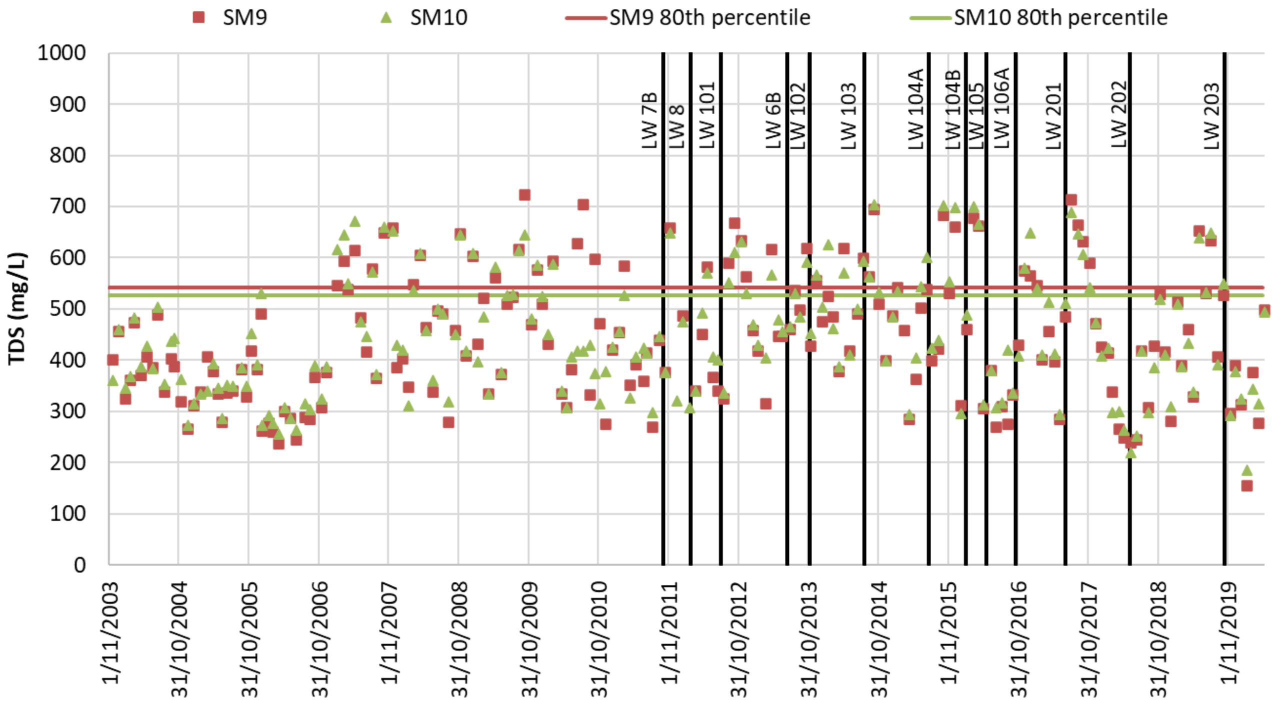

Figure A17 Hunter River Upstream Sites – TDS

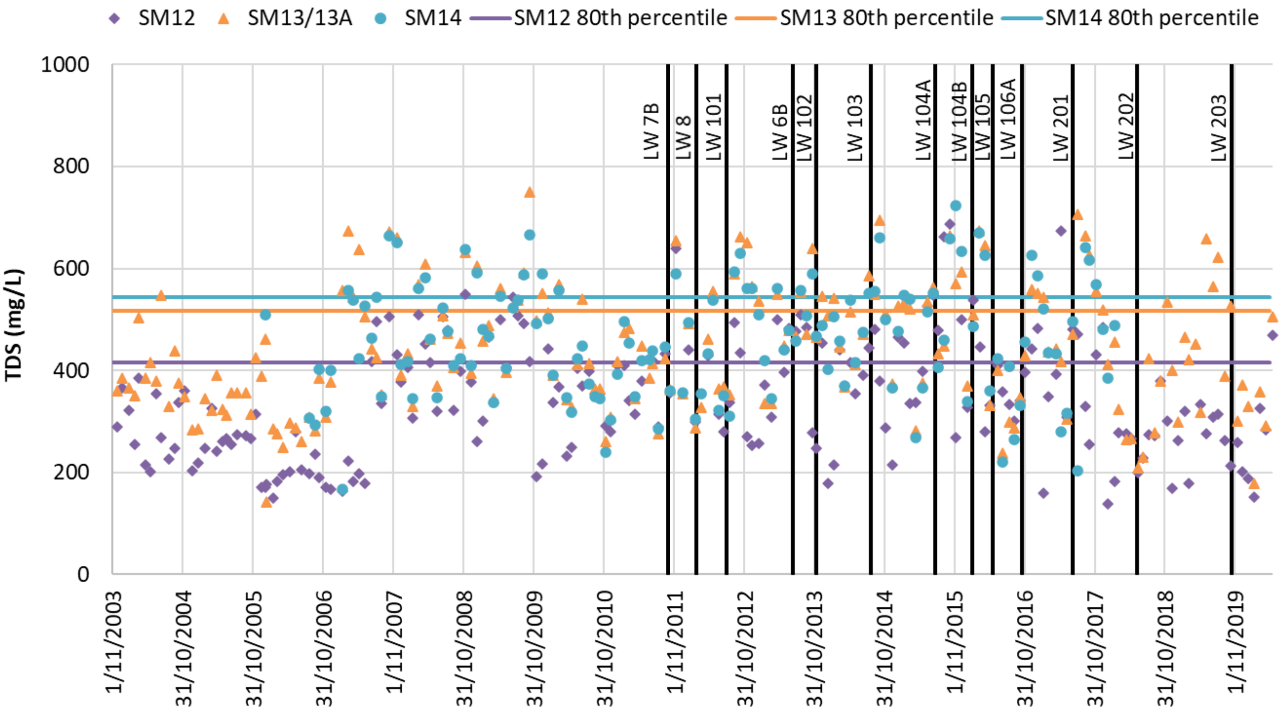

Figure A18 Hunter River Downstream Sites – TDS

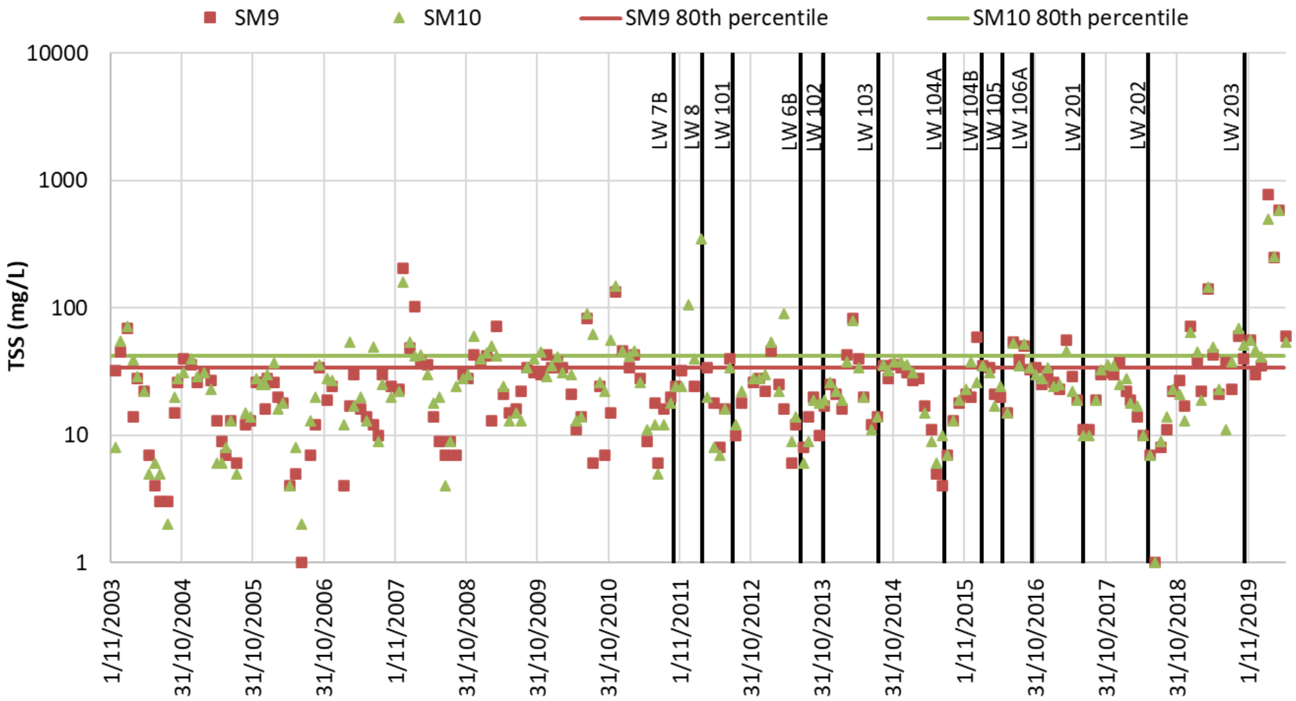

Figure A19 Hunter River Upstream Sites – TSS

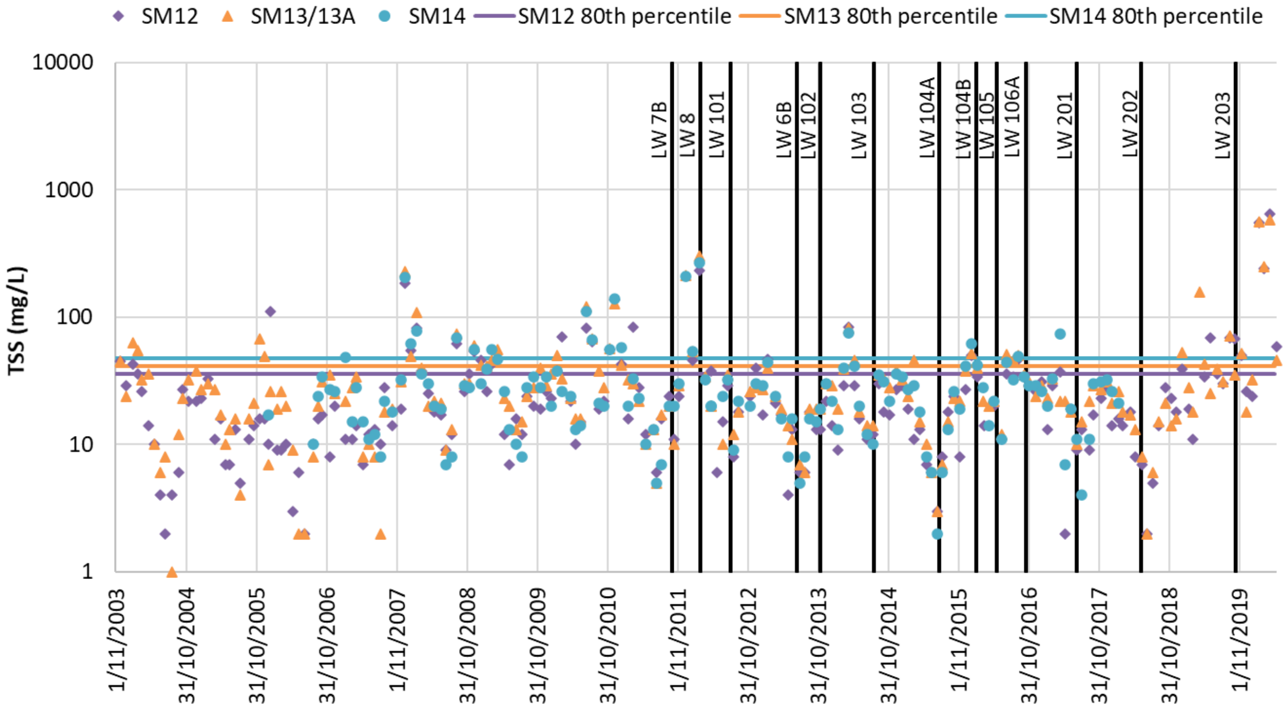

Figure A20 Hunter River Downstream Sites – TSS